INTERSECTION CONTROL EVALUATION REPORT
APPROVAL DOCUMENTATION

Project Name: SR 9 (N. Township St.)/John Liner Rd./McGarigle Rd. Intersection Improvements

1. This Intersection Control Evaluation (ICE) Report was prepared by WSDOT or Design Consultant staff working under my direct supervision, consistent with the requirements of WSDOT Design Manual Sections 300 and 1300.

Robert M. Herman 3-30-23

Robert M. Herman, P.E., P.T.O.E. Date
Herman Traffic Engineering, Inc.
Design Consultant Principal-in-Charge

Responsible PE Seal and Signature

2. Approved By:

Mark P. Leth Digitally signed by Mark P. Leth Date: 2023.03.31 13:03:57 -07'00'

Mark Leth, P. E. Date
NWR Traffic Engineer

3. Concurrence By:

Brian J Walsh 2023.03.31 13:06:30 -07'00'

Brian Walsh *(signature required)* Date
State Traffic Design Engineer

EXECUTIVE SUMMARY

This Intersection Control Evaluation (ICE) was prepared for the SR 9 (N. Township St.)/John Liner Rd./McGarigle Rd. intersection in the City of Sedro-Woolley, WA in accordance with Chapter 1300 of the Washington State Department of Transportation (WSDOT) Design Manual.

The subject intersection is the eastern terminus of the City's proposed Jones Rd./John Liner Rd./Trail Rd. Corridor project which aims to decrease traffic volumes on SR 20 within the City. Improvements to the intersection will mark the first step in establishing the new corridor. The intersection is situated adjacent to Evergreen Elementary School and Cascade Middle School.

Potential intersection control alternatives were identified as follows:

- Traffic signal
  A fully-actuated traffic signal system interconnected with the adjacent traffic signal to the south at the SR 9 (N.Township St.)/SR 20 (Moore St.) intersection. Left turn lanes would be constructed on all four approaches to the intersection. ADA-compliant signalized marked crosswalks would be provided on all four intersection legs. A new illumination system would be provided.

- Compact urban roundabout
  The Inscribed Circle Diameter (ICD) of the single-lane roundabout would be 90 feet with a fully traversable central island. Splitter islands would provide refuge for all pedestrian crossings. A shared-use path would be constructed around the roundabout. It is anticipated that one or more pedestrian crossings would be enhanced with Rectangular Rapid Flash Beacons (RRFB) due to the school presence near the intersection. A new illumination system would be provided.

Both alternatives provide good level of service, and within the LOS D standard set by WSDOT for SR 9. The roundabout slightly outperforms the traffic signal in LOS and delay.

Based on a Highway Safety Manual (HSM) analysis, both action alternatives are predicted to provide lower crash rates for fatal and injury crashes than the base condition, with the roundabout outperforming the traffic signal.

The intersection is situated in a residential area with elementary and middle schools nearby. Vehicular speeds on the intersecting streets are low to moderate. Pedestrian traffic is high at school begin and end times with predominant elementary and middle school age pedestrians.

The estimated construction cost of the roundabout alternative is $4.3M while the traffic signal alternative is estimated at $3.1M. The cost of the roundabout is $1.2M (39%) higher than the traffic signal.

The benefit/cost ratios for both action alternatives are low and well below 1.0. This is because the existing stop-controlled intersection has a good safety record with only two

reported crashes for the period from 2013 to 2017. No fatalities and only one injury crash occurred during that time period. By 2036, traffic volumes are expected to increase by 70% over 2019 levels with vehicle-vehicle and vehicle-pedestrian/bicycle conflicts increasing substantially. Therefore, regardless of the economic analysis, the City needs to improve the intersection to support the new corridor planned to be constructed in the near future. The roundabout benefit/cost ratio is 200% higher than that of the traffic signal.

Recommendation: A single-lane roundabout is the recommended intersection control type for the SR 9 (N. Township St.)/John Liner Rd./McGarigle Rd. intersection.

INTRODUCTION

The City of Sedro-Woolley proposes to construct a new parallel corridor to SR 20 to alleviate SR 20 congestion through the City. It is known as the Jones/John Liner/Trail Rd. Corridor. The first step of the new corridor will be to address the intersection control type for the SR 9 (N. Township St.)/John Liner Rd./McGarigle Rd. intersection. The intersection currently operates satisfactorily as a stop sign-controlled intersection, but the new corridor improvements will increase traffic and degrade operations to deficient.

The figure below shows the proposed corridor route in yellow and the subject intersection noted as S17 at the east end of the corridor:

The purpose of this Intersection Control Evaluation (ICE) is to determine the most compatible intersection control type for this intersection. The ICE uses operations, safety, context and benefit/cost analyses to determine a recommended alternative.

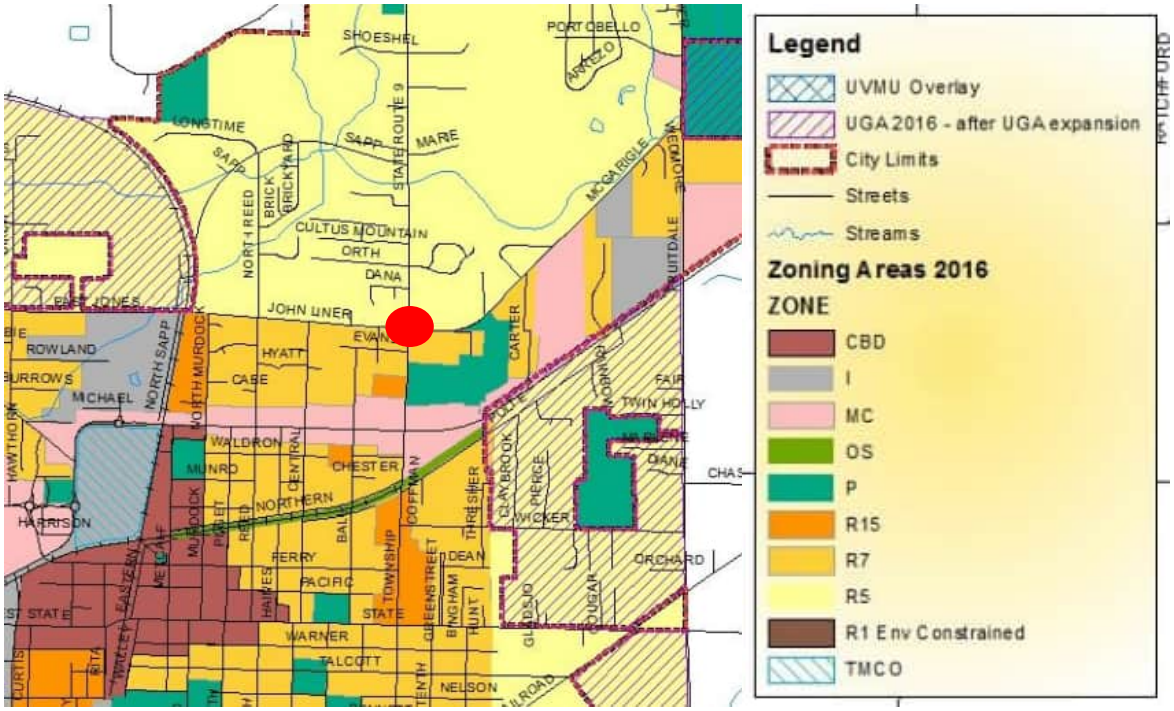
The majority of the analysis needed for an ICE has already been prepared as part of the scoping study for the new corridor. Therefore, this ICE document will be brief, only filling in information and analysis gaps in previous work. The previous work has been included in the Appendices to this document. They include:

Appendix A: "City of Sedro-Woolley Jones/John Liner/Trail Rd. Scoping Study Report", by Reichhardt & Ebe Engineering, Inc., Amended February 11, 2020. The traffic analysis can be found in **Appendix B** of that document. Several unrelated Appendices have been omitted.

Appendix B: "Citywide Transportation Concurrency Review", by Transportation Solutions, Inc., dated January 7, 2020.

PROJECT CONTEXT

The project site is surrounded by residential and school land uses. Property north of the intersection is designated R-5 (or five houses per acre). Property to the south of the intersection is designated as R-7. The school properties (designated as P for Public) lie east and south of the subject intersection. Excerpts from the City's Comprehensive Plan Land Use Map are shown below:



The intersection experiences high pedestrian volumes during morning and afternoon periods when children are walking to/from the nearby schools. A 24-hour pedestrian count revealed that 296 pedestrians used the intersection on Thursday, June 2, 2022. The peak pedestrian times were 8:30-9:30 AM (68 peds) and 3:00-4:00 PM (74 peds). Bicycle use was low. The raw count data and peak hour summaries can be found in **Appendix C**.

Refer to the **Appendices A and B** for other discussion regarding transportation context.

PROJECT DESIGN CONTROLS

Design Year

The design year for the previous work shown in **Appendix A** is 2036, consistent with the City's of Sedro-Woolley's Comprehensive Plan transportation model. The horizon year for the work shown in **Appendix B** is 2025 which coincides with the year of opening for the selected improvement.

Modal Priorities

The following modal priorities are based on existing and future anticipated users of the intersection:

	Existing	2036
Automobiles	1	1
Freight	2	2
Pedestrians	3	3
Transit	4	4
Bicycles	5	5

To give perspective, a 24-hour manual count of the intersection conducted on Thursday, June 2, 2022 showed the following traffic volumes:

Automobiles	9,133	(not including heavy vehicles)
Heavy vehicles	495	
Pedestrians	296	
Bicycles	11	

The existing shared-use path located on the north side of McGarigle Rd. is planned to be extended to the west as part of the new Jones/John Liner/Trail corridor project. Therefore, pedestrian and bicycle use is expected to increase at the intersection, but not expected to change any modal priorities.

EXISTING PHYSICAL CONDITIONS

The intersection has four legs with good alignment geometry. The surrounding terrain is fairly flat. The intersection currently has single-lane approaches on all legs with stop-control on the eastbound and westbound approaches and free-flow for the northbound and southbound approaches. The speed limit is 35 MPH on SR 9 and 25 MPH on John Liner Rd. and McGarigle Road.

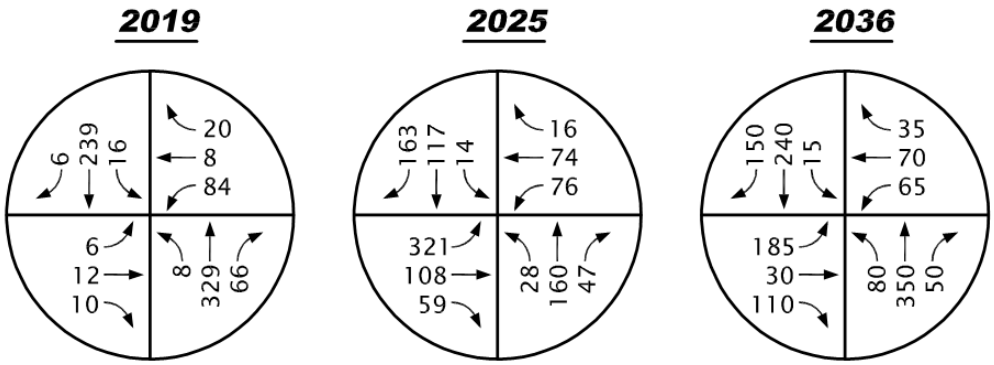
Sidewalks exist on all four corners of the intersection and along both sides of SR 9. McGarigle has sidewalk on the south side of the road and a shared-use path on the north side of the road. John Liner Rd. has only gravel shoulder on both sides of the road.

There are marked crosswalks on the east, west and south legs of the intersection with a Rectangular Rapid Flash Beacon (RRFB) enhancing the south leg crosswalk. Luminaires on the northeast and southwest corners light the intersection.

Refer to **Appendices A and B** for other existing conditions information for the intersection.

TRAFFIC VOLUMES

The PM peak hour traffic volumes shown below are the basis for the capacity, Level of Service (LOS) and queuing analyses attached in **Appendices A and B**.



The 2025 and 2036 traffic volume projections were based on separate modeling efforts by the City of Sedro-Woolley. The 2025 forecasts resulted from a 2019 model calibration effort for Growth Management Act and transportation concurrency. The 2036 forecasts resulted from a 2015 travel demand model calibration effort for the City's Comprehensive Plan. Among other major changes, the 2019 model incorporated more refined, HCM-based volume-delay functions, as opposed to the more traditional planning-level delay functions in the 2015 model.

In general, the travel demand models indicate the planned new corridor will pull demand away from the SR 20 corridor. The reduction in SR 9 through volumes reflect this forecast. The 2025 model forecasts the new corridor to have greater utility and therefore greater travel demand than did the 2036 model. This is a result of the various changes in modeling approach between the 2015 and 2019 model calibration efforts.

Appendix G contains travel demand modeling notes for the various efforts.

EXISTING LEVEL OF SERVICE

Refer to **Appendices A and B** for all capacity, LOS and queuing standards, analysis and results.

The existing intersection configuration and control yields a PM peak hour LOS C operation which meets the LOS D standard for this intersection set by WSDOT.

EXISTING SAFETY ANALYSIS

The Interactive Highway Design Safety Model (IHSDM) software, 2021 release, version 17.0.0 was used to analyze existing safety at the intersection. The IHSDM is a software implementation of the Highway Safety Manual (HSM) methods.

The IHSDM uses crash histories at other similar sites to predict crash rates for the subject site. The predicted crash rate calculated by the IHSDM uses crash data collected at similar sites. The expected crash rate incorporates historical crash data for the subject site, and is

considered more reliable. If the expected crash rate is higher than the predicted crash rate, it would suggest that the intersection is not operating as safely as other similar sites.

Appendix A shows a five-year crash history for the intersection. Only two crashes (both enter at angle) were reported during the five-year period (2013-2017), one injury crash and one property damage only crash. No fatalities were reported.

For fatal and injury crashes, the expected crash rate for the existing intersection was calculated as 0.3890 crashes per year (cpy) while the predicted crash rate was 0.6034 cpy. This indicates that the intersection is operating more safely than similar sites.

Appendix D contains the IHSDM analysis inputs and results.

PROJECT NEEDS

Operational

The intersection currently operates at a satisfactory LOS C during the PM peak hour. However, the City's planned new Jones/John Liner/Trail corridor will degrade the operation to LOS F, beyond the LOS D standard set by WSDOT.

Metric: Level of Service
Target: LOS D or better for the 2036 horizon year

Safety

The intersection's expected fatal and injury crash rate of 0.3890 cpy is lower than the predicted crash rate of 0.6034 cpy. This means that the intersection is operating safer than similar intersections. However, there is still room for improvement.

Metric: Expected fatal and injury crash rate
Target: Reduce the expected fatal and injury crash rate below 0.3890 cpy

Context

The intersection is located in a residential area with high pedestrian traffic at certain times of the day. Most of the pedestrians are young school children.

SR 9 within Sedro-Woolley has a mix of traffic signal systems and roundabouts. The closest intersection with either type of control is a traffic signal at the SR 9 (N. Township St.)/SR 20 (Moore St.) intersection located approximately ¼ mile to the south of the subject intersection. That intersection is currently being upgraded from an older span wire system to a modern mast arm pole system with ADA improvements.

The properties adjacent to the intersection are all existing single-family houses with driveways that are in close proximity to the intersection. Most notably, the houses on the northeast and southwest corners have driveways that are both within approximately 12' of the approach stop lines.

Metric: Private property impacts, compatibility with users and street network
Target: Minimize private property impacts, provide full pedestrian facilities, compatible with existing street network

ALTERNATIVES

The only practical traffic control alternatives that would serve the needs for the intersection are a traffic signal or a roundabout. An all-way stop solution would not be expected to serve the operational or safety needs. Therefore, traffic signal and roundabout alternatives are analyzed in this report.

Traffic Signal

A conceptual traffic signal plan is attached in **Appendix E**. It shows a fully-actuated traffic signal system that would be interconnected with the adjacent traffic signal to the south at the SR 9 (N.Township St.)/SR 20 (Moore St.) intersection. Left turn lanes would be constructed on all four approaches to the intersection. ADA-compliant signalized marked crosswalks would be provided on all four intersection legs. A new illumination system would be provided.

Roundabout

A conceptual roundabout plan is attached in **Appendix E**. An urban compact roundabout is shown. The Inscribed Circle Diameter (ICD) of the single-lane roundabout would be 90 feet with a fully traversable central island. Splitter islands would provide refuge for pedestrian crossings. A shared-use path would be constructed around the roundabout. It is anticipated that one or more pedestrian crossings would be enhanced with Rectangular Rapid Flash Beacons (RRFB) due to the school presence near the intersection. A new illumination system would be provided.

Design Life

The design life for both alternatives is expected to exceed 20 years. Therefore, 20 years is used in the benefit-cost analysis.

Cost Estimates

Construction cost estimates for both action alternatives can be found in **Appendix F**. The estimated construction cost, including right of way acquisition, for the alternatives is as follows:

Traffic Signal	$3.1M
Roundabout	$4.3M

FUTURE LEVEL OF SERVICE

Refer to **Appendices A and B** for all capacity, LOS and queuing standards, analysis and results. Key tables are shown below for convenience.

Table 4. Queuing and LOS, No Build Alternative (2036 PM Peak Hour)

Intersection	Eastbound		Westbound		Northbound		Southbound		Overall[1]
	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	LOS (Delay)
Cook Rd & Trail Rd	25	A (9.1)	0	A (8.6)	1,450	F* (>999)	800	F* (>999)	F* (>999)
SR 9 & John Liner	775	F (691)	250	F (175)	0	A (8.7)	0	A (8.5)	F (691)

[1]For TWSC intersections, overall LOS and delay represent the worst (highest delay) movement. For all other intersection control types, overall LOS and delay represent the intersection average.
[2]Control delay in seconds per vehicle
*Delay exceeds the limits of the HCM2010 methodology

Table 5. Queuing and LOS, Roundabout Alternative (2036 PM Peak Hour)

Intersection	Eastbound		Westbound		Northbound		Southbound		Overall[1]
	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	LOS (Delay)
Cook Rd & Trail Rd	125	A (7.6)	125	A (11.6)	150	B (13.9)	50	A (7.8)	B (10.1)
SR 9 & John Liner	50	A (9.1)	50	A (5.6)	75	A (6.3)	75	A (9.8)	A (7.2)

[1]For TWSC intersections, overall LOS and delay represent the worst (highest delay) movement. For all other intersection control types, overall LOS and delay represent the intersection average.
[2]Control delay in seconds per vehicle

Table 6. Queuing and LOS, Signal Alternative (2036 PM Peak Hour)

Intersection	Eastbound		Westbound		Northbound		Southbound		Overall[1]
	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	LOS (Delay)
Cook Rd & Trail Rd	L: 275 Th: 275	B (18.3)	L: 75 Th: 225	B (13.8)	400	C (26.6)	175	B (17.0)	B (19.1)
SR 9 & John Liner	L: 100 Th: 75	B (13.2)	L: 50 Th: 50	B (11.9)	L: 50 Th: 175	A (8.5)	L: 0 Th: 175	A (8.2)	A (9.9)

[1]For TWSC intersections, overall LOS and delay represent the worst (highest delay) movement. For all other intersection control types, overall LOS and delay represent the intersection average.
[2]Control delay in seconds per vehicle

The existing intersection configuration and control is expected to degrade to LOS F by 2036 due to the increase in traffic volumes caused by the new corridor project, pipeline development and background growth.

Appendix A shows that the traffic signal alternative is expected to operate at LOS A in 2036 with the new corridor. However, **Appendix B** shows the traffic signal alternative is expected to operate at LOS B in 2025 with the new corridor and pipeline development built out. **Appendix A** work pre-dates **Appendix B** work so LOS B is used. The LOS table from **Appendix B** is shown below for convenience.

Table 6. Pipeline (2025) Intersection Level of Service Deficiencies

ID	Location	Control Type[1]	2025 Baseline LOS (Delay)[2]	2025 Pending LOS (Delay)[2]
11	SR 20 & Reed St			
	w/o Jones/John Liner Rd Crossing	TWSC	F (154)	F (204)
	w/ Jones/John Liner Rd Crossing	TWSC	F (54.8)	F (58.5)
	w/ crossing + right-in/right-out (Project S2)	RIRO	C (17.9)	C (17.8)
17	Cook Rd & Trail Rd			
	w/o Trail Rd Extension / TWSC	TWSC	E (35.3)	E (39.5)
	w/ Trail Rd Extension / TWSC	TWSC	F (493)	F (>999)
	w/ Trail Rd Ext. / roundabout (Project C3)	RAB	A (7.9)	B (9.6)
29	Township St (SR 9) & John Liner/McGarigle Rd			
	w/o Jones/John Liner Rd Crossing	TWSC	C (22.6)	D (28.5)
	w/ crossing & two-way stop control	TWSC	F (50.2)	F (181)
	w/ crossing & roundabout (Project S17)	RAB	A (7.5)	A (7.8)
	w/ crossing & signal control (Project S17)	Signal	A (9.3)	B (10.7)

[1]TWSC = minor approach stop control; AWSC = all-way stop control; Signal = signalized; RAB=roundabout
[2]For TWSC intersections, delay is reported for the worst (i.e. highest-delay) movement; for all other control types, average intersection delay is reported.

Appendices A and B both show that the roundabout alternative is expected to operate at LOS A in 2025 and 2036 with the new corridor and pipeline developments.

SAFETY PERFORMANCE

The IHSDM software was used to evaluate the safety performance of the traffic signal and roundabout alternatives. Two notable changes were made in running the IHSDM software as follows:

- At the request of WSDOT, the IHSDM default annual societal costs were replaced with costs provided by WSDOT.
- At the request of WSDOT, a user-defined Crash Modification Factor (CMF) was used in lieu of the IHSDM roundabout model because WSDOT has had some concerns about the model overestimating crashes. CMF 234 was used which has a value of 0.22.

The IHSDM results are shown in the table below for fatal and serious injury crashes and fatal and all injury crashes. The roundabout alternative outperforms the traffic signal for both fatal and serious injury crashes and fatal and all injury crashes.

Alternative	Crash Summary				Benefit/Cost Summary			
	Fatal and Serious Injury Crashes		Fatal and All Injury Crashes					
	Predicted Crash Rate (cpy)	Crash Rate Change (%)	Predicted Crash Rate (cpy)	Crash Rate Change (%)	Annual Societal Cost (in thousands)	Annual Societal Benefit (in thousands)	Annualized Construction Cost (in thousands)	Benefit/Cost Ratio
No Build (Base Case)	0.0328	--	0.3890	--	$186	--	--	--
Traffic Signal	0.0279	-15%	0.3316	-15%	$162	$24	$274	**0.1**
Roundabout	0.0112	-66%	0.1328	-66%	$76	$110	$360	**0.3**

The IHSDM was also used to determine societal costs for each alternative including a No Build or base case alternative. As shown in the table above, the roundabout is expected to result in a higher annual societal benefit (over 450%) than the traffic signal alternative.

An economic cost analysis was performed by the IHSDM to determine benefit/cost ratios. Construction and operating and maintenance (O&M) costs were used in the analysis. Construction costs for each action alternative were annualized using a 5.6% annual inflation rate over a 20-year period. The following annual O&M costs were used:

- No Build $200
- Traffic Signal $10,000
- Roundabout $1,000

Benefit/cost ratios were calculated for each alternative. The benefit/cost ratio for the roundabout is 200% higher than that of the traffic signal.

The Economic Analysis Report can be found in **Appendix C**.

PERFORMANCE COMPARISON

The metrics listed in the table below were used to rank the action alternatives.

Metric	Action Alternative	
	Traffic Signal	Roundabout
Degree of Saturation (v/c)	+	++
Delay and LOS	+	++
Safety Need	+	++
Contextual Need	++	+
Construction Cost	3.1M	4.3M
Benefit/Cost Ratio	0.1	0.3
Overall Rank	2	1
++ Optimal + Benefit o Neutral - Impact -- Deterioration		

Both action alternatives meet project need targets, and are therefore, viable alternatives.

The roundabout outperforms the traffic signal in capacity and LOS, but both are comparable operationally for the projected traffic volumes.

Roundabouts significantly reduce fatal and serious injury crashes over traffic signals by reducing conflict points and slowing vehicular speeds at the intersection. Vehicle-to-vehicle conflict points are reduced from 32 with a traffic signal to only eight with a roundabout for a four-legged intersection. Vehicle-to-pedestrian conflicts are reduced from 24 with a traffic signal to only eight with a roundabout. The right angle, high-severity crashes typically seen at signalized intersections are essentially eliminated in a roundabout.

Speeds within a roundabout are in the 15-25 MPH range, whereas the speeds through this intersection if signalized would be expected to regularly exceed 30 MPH on a green signal. Not only advantageous for roundabout vehicle-vehicle crashes, but pedestrian survivability in vehicle-pedestrian crashes is also severely impacted by vehicle speed. The Seattle Department of Transportation says that nine out of ten pedestrians can survive a crash with a vehicle traveling 20 MPH. However, only five out of ten will survive at 30 MPH. With the high level of school-age pedestrian activity at the subject intersection, the roundabout is more suitable when safety is considered.

The estimated construction cost of the roundabout alternative is $4.3M while the traffic signal alternative is estimated at $3.1M. The cost of the roundabout is $1.2M (39%) higher than the traffic signal.

The benefit/cost ratios for both action alternatives are low and well below 1.0. This is because the existing stop-controlled intersection has a good safety record with only two reported crashes for the period from 2013 to 2017. No fatalities and only one injury crash occurred during that time period. Regardless of the economic analysis the City needs to improve the intersection to support the new corridor planned to be constructed in the near future. The roundabout benefit/cost ratio is 200% higher than that of the traffic signal.

RECOMMENDATION

A single-lane roundabout is the recommended intersection control type for the SR 9 (N. Township St.)/John Liner Rd./McGarigle Rd. intersection.

TECHNICAL APPENDIX A

City of Sedro-Woolley Jones/John Liner/Trail Rd.
Corridor Scoping Study Report

City of Sedro-Woolley
Jones / John-Liner / Trail Rd.
Scoping Study Report

January 2020

Amended February 11, 2020

Prepared By:

Reichhardt & Ebe
ENGINEERING INC

423 Front St., Lynden, WA 98264
(360) 354-3687

City of Sedro-Woolley
Jones / John-Liner / Trail Rd. Scoping Study Report

Amended February 11, 2020

The following amendments are included in this report:

1. Section 10.1, paragraph 1, the figure reference is corrected to reference Figure 10.1.1
2. Section 10.1, paragraph 2, the reference to a Type F stream with 200 ft. buffers is corrected to a Type 3 stream with 110 ft. buffers.
3. Section 10.1, Figure 10.1 was mislabeled and has been correctly labeled Figure 10.1.1
4. Section 10.1, Figure 10.1.2 is corrected to reflect the 110 ft. buffer noted in item 2 above. The table within Figure 10.1.2 is also updated to reflect the 110 ft. buffer impacts.
5. Section 11, the label for Table 10 has been corrected to be labeled Table 11, and the costs within the table have been updated to reflect the 110 ft. buffer noted in item 2 above. Cost for projects C1A, C1B, C9A, and C19 are updated along with the corridor total.
6. The draft report contained in Appendix G titled “Geotechnical Engineering Services - Jones John-Liner Trail Road Corridor, Patrick Street Extension” is replaced with the final version of the report.
7. The draft watermark has been removed from the pages of Appendix L.
8. The cost estimates for projects C1A, C1B, C9A, and C19 are updated in Appendix N.

1. Introduction

The Jones / John-Liner / Trail Rd. Corridor consist of a network of existing and proposed roadways generally located west of N. Township St. (SR9), north and west of Moore St. (SR20) and north of Cook Rd. as depicted in Figure 1 and as described in Table 1. The limits of the corridor include Trail Rd. from Cook Rd. to Jones Rd., including the intersection of Trail Dr. and Cook Rd., Jones Rd. from F&S Grade Rd. to the BNSF RR, John-Liner Rd. from the BNSF RR to N. Township St. (SR9) including the intersection of John-Liner and N. Township St., and Patrick St. from Moore St. (SR20) to Jones Rd.

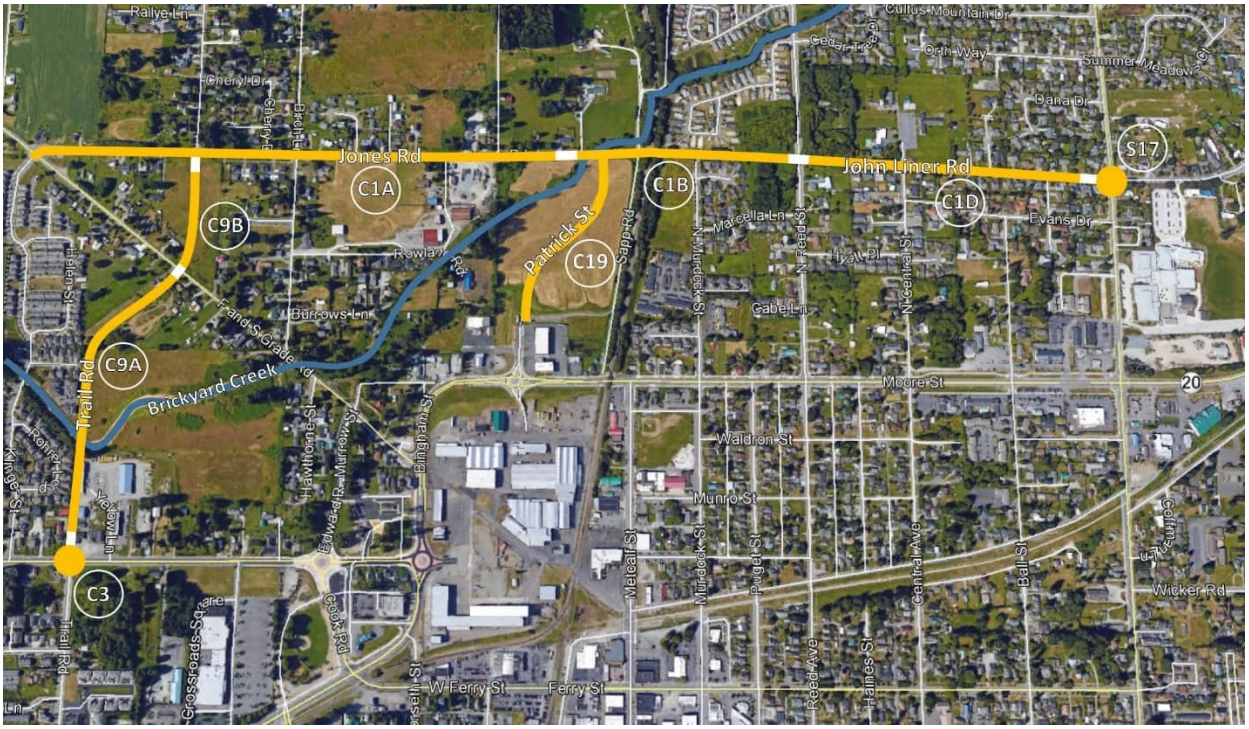


Figure 1: Jones / John-Liner / Trail Rd. Corridor Improvement Projects

Table 1: Jones / John-Liner / Trail Rd. Corridor Improvement Projects`

TIP ID	Project Name	Project Limits	Description
C1A	Jones Rd. Improvements	F&S Grade Rd. / Sapp Rd.	Reconstruct to arterial section, including sidewalk & shared use path
C1B	Jones / John-Liner RR Undercrossing	Sapp Rd. / Reed St.	New BNSF undercrossing and new arterial connecting Jones Rd. and John-Liner Rd.
C1D	John-Liner Rd. Arterial Improvements	Reed St. / Township St.	Reconstruct to arterial section, including sidewalk & shared use path
C9A	Trail Rd. Arterial Extension	Cook Rd. / F&S Grade Rd.	New minor arterial including sidewalk & shared use path
C9B	Trail Rd. – Garden of Eden Rd. Extension	F&S Grade Rd. / Jones Rd.	New minor arterial including sidewalk & shared use path
C19	Patrick St. Extension	Michael St. / Jones Rd.	New major collector with sidewalks
S17	Township St. (SR9) & John-Liner / McGarigle Rd. Intersection	Township St. (SR9) & John-Liner / McGarigle Int.	Reconstruct intersection to roundabout or signalized int.
C3	Cook Rd. / Trail Rd. Intersection Improvements	Cook & Trail Rd. Int.	Reconstruct intersection to roundabout or signalized int.

This scoping study generally consists of the evaluation of the corridor for roadway, intersection and BNSF undercrossing alternatives as well as associated drainage and utility improvements including the development of conceptual level design plans and cost estimates.

The scoping study team consists of the following firms:

1. Prime Consultant – Reichhardt & Ebe Engineering, Inc.
2. Surveyor – Larry Steele & Associates
3. BNSF Coordination / Environmental Process & Permitting – Widener & Associates
4. Geotechnical – GeoEngineers
5. Traffic Analysis – Transportation Solutions, Inc.
6. Intersection Design – Herman Traffic Engineering
7. Hydraulics and Hydrology – Indicator Engineering
8. Right of Way Consultant – Abeyta & Associates

The purpose of the scoping study is to review conceptual project designs in more detail, review project alternatives, and update projects costs; all so as to develop the corridor in a planned manner, seek opportunities for project funding, and provide a basis for design for future City Capital or Developer projects.

2. Executive Summary

2.1 Project Definition & Purpose

The Jones / John-Liner / Trail Rd. Corridor projects will create a new east-west alternative route to SR20. As noted in the Traffic Analysis discussed later in this report, the new corridor will reduce PM peak hour demand on SR20 by approximately 1,350 vehicles per day (vpd) and 135 vehicles per hour (vph) during the PM peak. The new corridor will also reduce turning movement demand on SR20 by 230 vph during the PM peak. The reduction in turning movement and overall demand on SR20 will improve safety and operations on the state route.

In addition, to reduced demand and increased safety on SR20, the new corridor will also provide better overall access to new and existing neighborhoods north of SR20, make fish passage improvements to existing culvert crossings, provide opportunity for economic development, and add a new multimodal 10 ft. shared use path along the entire corridor. The shared use path will increase multimodal transportation opportunities from residential generators to Cascade Middle School, Evergreen Elementary School, and to commercial services to the south as well as connect to the existing shared use path on McGarigle Rd.

Of the 8 total projects making up the Jones / John-Liner / Trail Rd. Corridor, the priority project necessary for making the initial east-west connection is project C1B, the Jones / John-Liner BNSF Undercrossing. Completion of this segment of the corridor will open access to the existing Jones Rd. and John-Liner Rd. between N. Township St. (SR9) and F&S Grade Rd. Subsequent improvements will be necessary to Jones Rd. and John-Liner Rd. to improve mobility, safety, increase multimodal function and improve the roadways to arterial standards. The addition of Trail Rd. will provide a needed connection from Jones Rd. to Cook Rd. and will be necessary to fully realize the benefits of the corridor. The addition of the Patrick St. connection between SR20 and Jones Rd. will provide a direct link between SR20 and the east-west corridor and will also provide access to anticipated future commercial development.

2.2 Background Research & Mapping

The City of Sedro-Woolley provided an extensive list of background documentation for review and use during the course of this scoping study. The complete list is provided in Appendix A. Additional information has been obtained throughout the course of this scoping study not shown in the list. Such additional information includes property research and parcel information obtained from the Skagit County Assessor's office through the iMap system. Additional information was also provided by the City through the City's GIS system.

Survey for the scoping study was provided by Larry Steele & Associates (LSA). ROW lines and property boundary lines are based on limited research conducted by LSA. The original scope of work included limited topographic survey of existing culvert crossings on Brickyard Creek and limited topographic survey at the BNSF undercrossing. The project base map used for the initial conceptual design was based on the limited topographic survey described above, LiDAR, and aerial imagery. As a part of supplemental agreement no. 1 to the scoping study contract, additional topographic field survey has been conducted including John-Liner Rd. from N. Township St. to the BNSF railroad, the John-Liner & N. Township intersection, Jones Rd. from the BNSF railroad to Jones Estates, Patrick St., and Sapp Rd. north of Jones Rd., including the Sapp Rd. undercrossing of the BNSF railroad. Additionally, the topographic survey

included field survey of existing utility poles on Jones Rd. from Jones Estates to F&S Grade Rd. The additional topographic information and utility pole survey has been incorporated in to the project base map and is reflected in the conceptual design plans included in this report.

2.3 Potential Pending Development

Through the course of the scoping study, the City has made the scoping study team aware of interest from developers in two portions of the corridor. There is interest from a developer in Patrick St between Michael St. and Jones Rd. The developer has prepared a conceptual layout including roadway and site development concepts. As requested by the City and in accordance with supplemental agreement no. 1 to the scoping study contract, the Patrick St. alignment and sanitary sewer layout has been updated to reflect the conceptual plan.

We understand that interest has also been expressed in that portion of Trail Rd. between F&S Grade Rd. and Jones Rd. The developer has prepared a preliminary plat layout and preliminary drainage report for the proposed 28-lot long plat (Ravnik 2019). The preliminary roadway layout generally follows the prosed alignment shown in the conceptual plans of this report, but with a slight westerly shift. We understand that the developer has prepared the alignment such that the center of the intersections with Trail Rd. and Jones Rd. as well as Trail Rd. and F&S Grade Rd. match the conceptual plans in this report.

As indicated in the preliminary drainage report for the plat, stormwater mitigation is planned through the use of two stormwater infiltration trenches, one at the north and south end near Jones Rd. and Trail Rd. respectively. The stormwater conceptual plans contained in this report do not account for the infiltration trenches as proposed by the developer and as such, if the proposed development proceeds, adjustments to the scoping study stormwater mitigation plans will be necessary.

For purposes of this report, both Patrick St. and Trail Rd. are presented as if the projects are completed as capital projects by the City.

2.4 Project Cost Summary

The following table provides a project cost summary for the 8 proposed projects making up the corridor. Costs presented below for projects C3 and S17 are presented as the roundabout option. Costs are inclusive of capital project construction cost, right of way cost, and professional services.

Table 2.4: Jones / John-Liner / Trail Rd. Corridor Cost Summary

TIP ID	Project Name	Project Cost
C1A	Jones Rd. Improvements	$4,994,980
C1B	Jones / John-Liner RR Undercrossing	$9,796,031
C1D	John-Liner Rd. Arterial Improvements	$1,900,137
C9A	Trail Rd. Arterial Extension	$5,531,183
C9B	Trail Rd. – Garden of Eden Rd. Extension	$1,430,128
C19	Patrick St. Extension	$3,538,740
S17	Township St. (SR9) & John-Liner / McGarigle Rd. Intersection	$3,224,910
C3	Cook Rd. / Trail Rd. Intersection Improvements	$4,312,923
TOTAL CORRIDOR PROJECT COST		**$34,729,030**

3. Traffic Analysis

Traffic analysis for the scoping study was performed by Transportation Solutions, Inc. (TSI) and is summarized below. The full technical memorandum "Jones / John-Liner / Trail Road Corridor Projects Traffic Analysis; Updated 2019-01-02" is contained in Appendix B.

TSI completed travel demand forecasting generated by the Sedro-Woolley 2036 citywide travel demand model. The travel demand model accounts for improvements completed as a part of the Jones / John-Liner / Trail Rd. Corridor improvements.

Outside of this scope of work, TSI is currently in the process of completing an update to the travel demand model for the City. Based on recent phone conversations with TSI, indications are that there has been significant growth in traffic volumes over recent years. Existing traffic count data near the N. Township St. (SR9) and John-Liner / McGarigle intersection indicates a 12% growth between traffic counts conducted in April 2015 and November 2019. The updated travel demand model will include projected traffic volumes to design year 2025. Early indications are that intersections such as N. Township St. (SR9) and John-Liner / McGarigle may reach level of service (LOS) F by 2025 in their current configuration.

3.1 Intersection Control

The traffic analysis considered the impact of the intersection control alternatives at the intersections of:

- Cook Rd. and Trail Rd.
- N. Township St. (SR9) and John-Liner / McGarigle Rd.

The intersection control considered three future alternatives in the full-build condition identified in the Jones / John-Liner / Trail Rd. Corridor:

- *No Build (existing minor approach stop control)* - The no-build intersection control results in both intersections operating at LOS F on the worst movement.
- *Roundabout* – Roundabouts are assumed to be single lane, 120 ft. inscribed circle diameter with 20 ft. circulating lanes. The intersection of Cook Rd. and Trail Rd. will operate at LOS B and N. Township St. (SR9) and John-Liner Rd. will operate at LOS A.
- *Signal* – Both intersections satisfy signal warrants. The intersection of N. Township St. (SR9) and John-Liner Rd. will operate at LOS A when providing left turn lanes on all approaches. The intersection of Cook Rd. and Trail Rd. will operate at LOS B with left turn lanes on the east and west approaches only.

3.2 Turn Lane Analysis

The traffic analysis evaluated left turn lane improvements for each of the stop-controlled intersections:

- Trail Rd. and F&S Grade Rd.
- Trail Rd. and Jones Rd.
- Jones Rd. and Patrick St.

Left turn lanes are warranted only on the east leg of the Trail Rd. and Jones Rd. intersection and the east leg of the Jones Rd. and Patrick St. intersection. Subsequent to the traffic analysis, the City requested that mini roundabouts be presented at the intersections of Trail Rd. and Jones Rd. as well as Trail Rd. and F&S

Grade Rd. The mini roundabouts are shown in the conceptual design plans, and represent a conceptual design only. Future design phases will need to more closely evaluate the design geometrics. The turn lane indicated in the traffic analysis is shown at the intersection of Jones Rd. and Patrick St.

3.3 Recommendations

The traffic analysis recommends single lane roundabouts as the preferred intersection control alternative at the intersections of Cook Rd. / Trail Rd., and N. Township St. (SR9) / John-Liner / McGarigle Rd. Additionally, left-turn lanes are warranted on the east legs of both the Trail Rd. / Jones Rd., and Jones Rd. / Patrick St. intersections in a stop-controlled configuration.

4. Roadway / Transportation Design

4.1 Design Criteria / Roadway Geometry

The design criteria for the roadway design and roadway geometry is summarized in Appendix C. Information contained in the design criteria includes applicable portions of the WSDOT Design Manual and Standard Plans, as well as applicable portions of the City of Sedro-Woolley Public Works Department Standards. In addition to the published materials, documentation is included indicating direction provided by City staff during the course of this work.

4.2 Pedestrian and Multimodal Facilities

Pedestrian and multimodal facilities within the corridor consist of conventional sidewalk and shared use path. The proposed sidewalk width is 5 ft. when a buffer is present and 6 ft. when adjacent to curb. The shared use path provides opportunity for multimodal options within the corridor.

The shared use path connects with the existing path on the north side of McGarigle Rd. at N. Township St. and is continuous east-west through the corridor and extends south on Trial Rd. from Jones Rd. to Cook Rd. The shared use path is located on the north side of John-Liner Rd. between N. Township St. and Reed St. and then transitions to the south side of John-Liner Rd. west of Reed St. continuing on the south side along Jones Rd. The location of the north south transition point was considered, noting the residential areas to the north and west of the BNSF railroad, and also noting the desire to provide multimodal connection to the south via Trail Rd. Ultimately Reed St. was chosen as the transition point. Crosswalks will be located at all intersections to provide ample access to the shared use path from either the north or south.

4.3 Jones Rd.

The Jones Rd. typical section is shown below in Figure 4.3 and consists of two 13 ft. travel lanes, curb and gutter, 4.5 ft. buffers, 5 ft. sidewalk on the north, and 10 ft. shared use path to the south. The Jones Rd. horizontal alignment has been positioned to so as to avoid conflicts with the existing overhead power system to the maximum extent possible while also attempting to place the new roadway within the bounds of the existing roadway section.

Changes in horizontal alignment are necessary at intersections such as Jones Rd. / Trail Rd. and Jones Rd. / Garden of Eden Rd. The shared use path shifts significantly to the south east of the proposed Trial Rd. to Garden of Eden Rd. so as to be positioned where a section of shared use path presently exists. The buffers on the north and south are eliminated in the vicinity of the BNSF undercrossing due to the widening of the roadway to accommodate turn lanes and the undercrossing structure, while minimizing right of way takes.

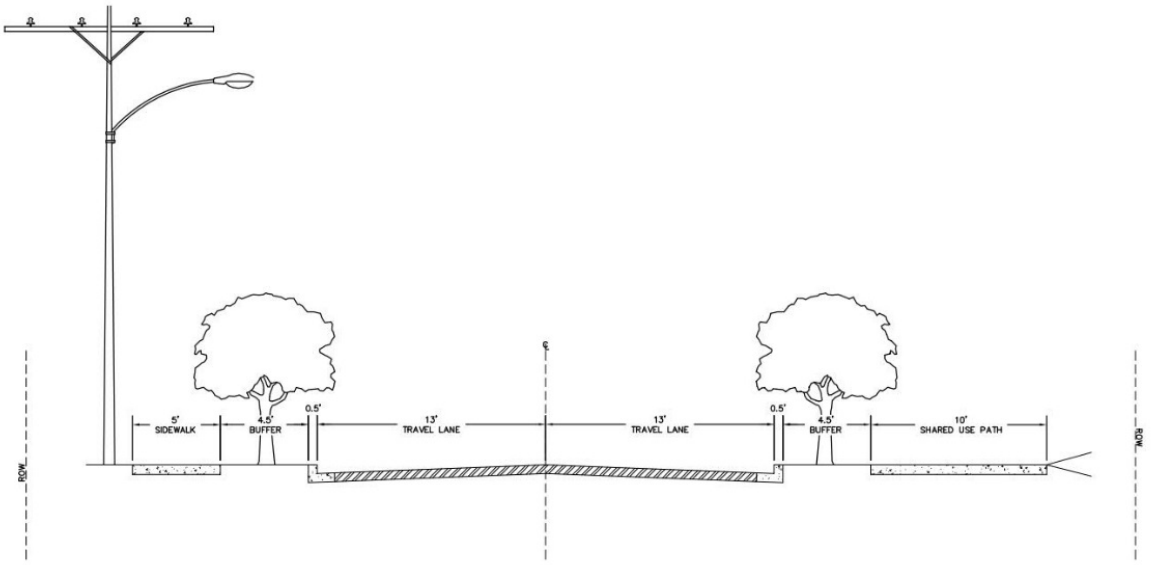


Figure 4.3: Jones Rd. / John-Liner Rd. Typical Section

4.4 John-Liner Rd.

The John-Liner Rd. typical section is shown in Figures 4.3 and 4.4 and consists of two 13 ft. travel lanes, curb and gutter, 4.5 ft. buffers (where feasible), 5 ft. sidewalk, and 10 ft. shared use path. That portion of John-Liner Rd. from the BNSF undercrossing to Reed St. is a new section of roadway. As with Jones Rd., buffers are eliminated in the vicinity of the BNSF undercrossing to Murdock St. Sufficient right of way exists to include a buffer to the north from Murdock St. to Reed St., however minor conflicts appear to exist with existing utility poles, and thus the buffer width or localized deviations may be desired to maintain full sidewalk width while not relocating existing overhead utilities.

The location of the shared use path transitions from south to north at Reed Street ultimately in anticipation of matching the shared use path on the north side of McGarigle Rd. at the N. Township St. intersection. A buffer is maintained on the south, while no buffer is provided to the north due to right of way constraints and conflicts with existing utility poles. As with Jones Rd., the horizontal alignment of John-Liner Rd. from Reed St. to N. Township St. is positioned so as to avoid conflicts with existing utility poles to the maximum extent possible while also placing the new roadway within the bounds of the existing roadway section.

During final design, the City may wish to consider moving the shared use path to the south side of John-Liner Rd. from Reed St. to N. Township St. Although the shared use path is on the north side, east of N. Township St., the transition could occur through the John-Liner / N. Township / McGarigle intersection. This decision may be driven by the intersection type ultimately chosen at this location (roundabout or conventional signal). The east/west pedestrian crossing of N. Township St. on the south leg may also make sense in that both schools are located to the south and there may be a desire to eliminate one east/west pedestrian crossing of N. Township St.

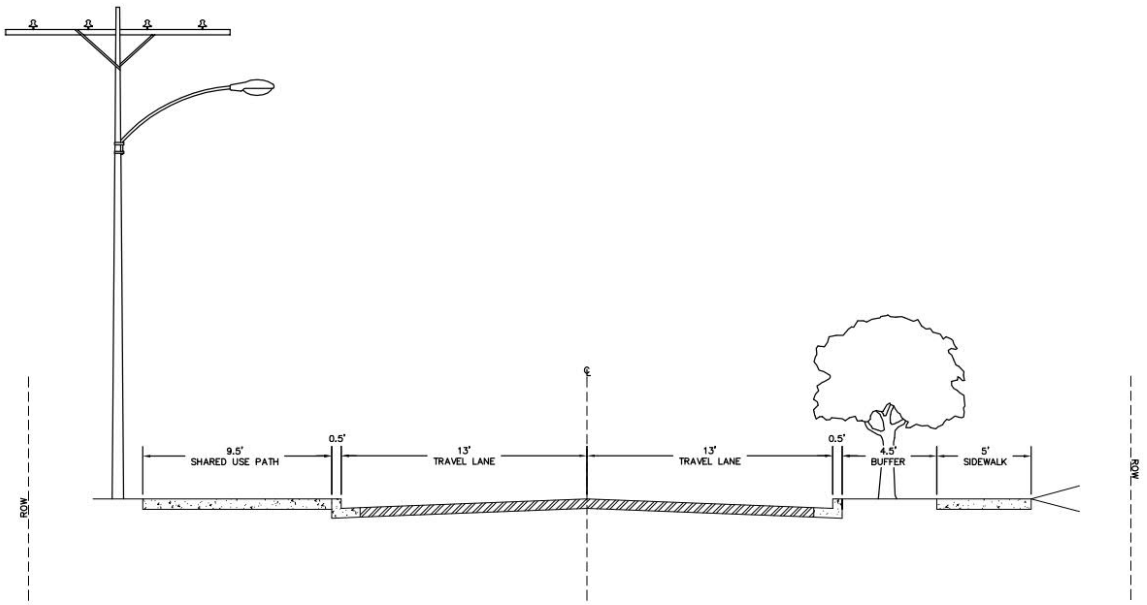


Figure 4.4: John-Liner Rd. Typical Section

4.5 Trail Rd.

The Trail Rd. typical section is shown in Figure 4.5.1 and generally matches the Jones Rd. typical section with the shared use path on the east, however street lighting will be on standalone street light poles. As Trail Rd. is a new roadway section, the right of way is limited to 65 ft. in areas of strip takes.

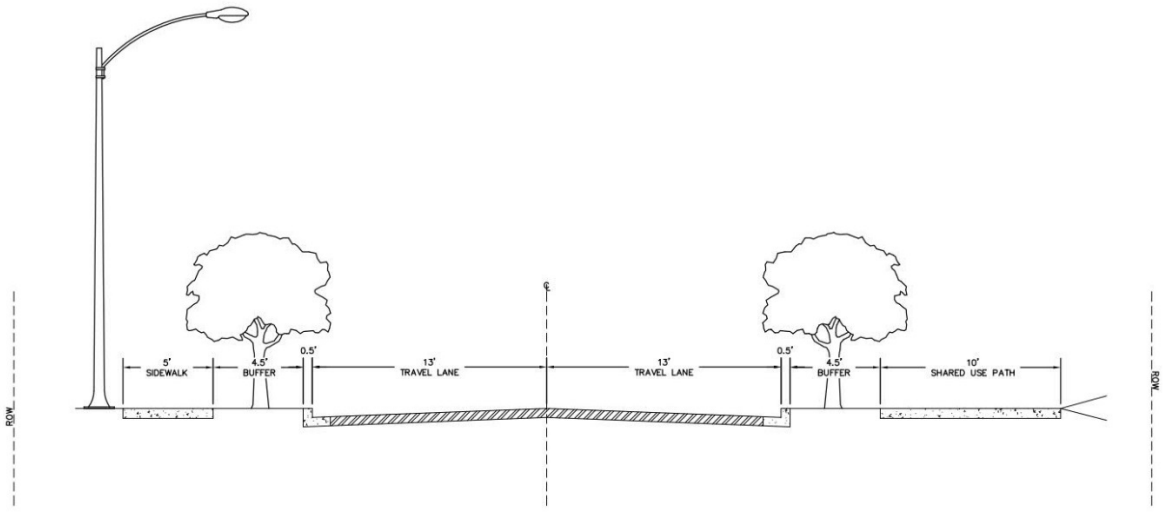


Figure 4.5.1: Trail Rd. Typical Section

Four Trail Rd. alignments were evaluated during the course of the scoping study as shown in Figures 4.5.2, 4.5.3, 4.5.4 and 4.5.5. The scoping study team along with the City evaluated the four options as briefly

described below, ultimately settling on Option 2 as the preferred option which is reflected in the conceptual design plans contained in Appendix D.

Option 1
Option 1 consists of larger 500 ft. radius horizontal curves and provides for a 100-degree intersection skew angle at F&S Grade Rd. with tangents extending north and south of the intersection. As with all four options, four Sedro-Woolley School district structures are impacted near Cook Rd., while two residential structures and three outbuildings are impacted near F&S Grade Rd.

Option 2
Option 2 consists of smaller 250 ft. radius horizontal curves and provides for a 94-degree intersection skew angle at F&S Grade Rd., and includes a horizontal curve on the north leg of the intersection. Impacted Sedro-Woolley School District structures remain the same, while one residential structure and three outbuildings are impacted near F&S Grade Rd.

Option 3
Option 3 shifts the Trail Rd. alignment to the northwest of Option 1 and 2, and includes larger 500 ft. radius horizontal curves, provides for a 79-degree intersection skew angle at F&S Grade Rd, and also includes a horizontal curve on the north leg of the intersection. One residential structure and one outbuilding are impacted near F&S Grade Rd.

Option 4
Option 4 shifts the Trail Rd. alignment to the southeast of Option 1 and 2, and includes larger 500 ft. radius horizontal curves, provides for a 77-degree intersection skew angle at F&S Grade Rd., and includes a horizontal curve through the intersection. One residential structure is impacted near F&S Grade Rd.

GRAPHIC SCALE

100 0 50 100

(IN FEET)

1"=100' (22x34), 1"=200' (11x17)

NATHAN J. ZYLSTRA STATE OF WASHINGTON 41884 REGISTERED PROFESSIONAL ENGINEER PRELIMINARY

Figure 4.5.2

DESIGNED BY	IDH/OAM
DRAWN BY	IDH/OAM
CHECKED BY	NZ

Reichhardt & Ebe ENGINEERING INC
P.O. Box 978 | 423 Front Street
Lynden, WA 98264 (360) 354-3687

NO.	DATE	DESCRIPTION	BY

CITY OF SEDRO WOOLLEY
325 METCALF STREET
SEDRO WOOLLEY, WA 98284

JONES / JOHN-LINER / TRAIL RD CORRIDOR
SCOPING STUDY
TRAIL ROAD OPTION #1

DWG 18002 PROBASE | DATE 1/23/2019
JOB # 18002 | SCALE H: 1"=100' V: N/A | SHEET XX of 14

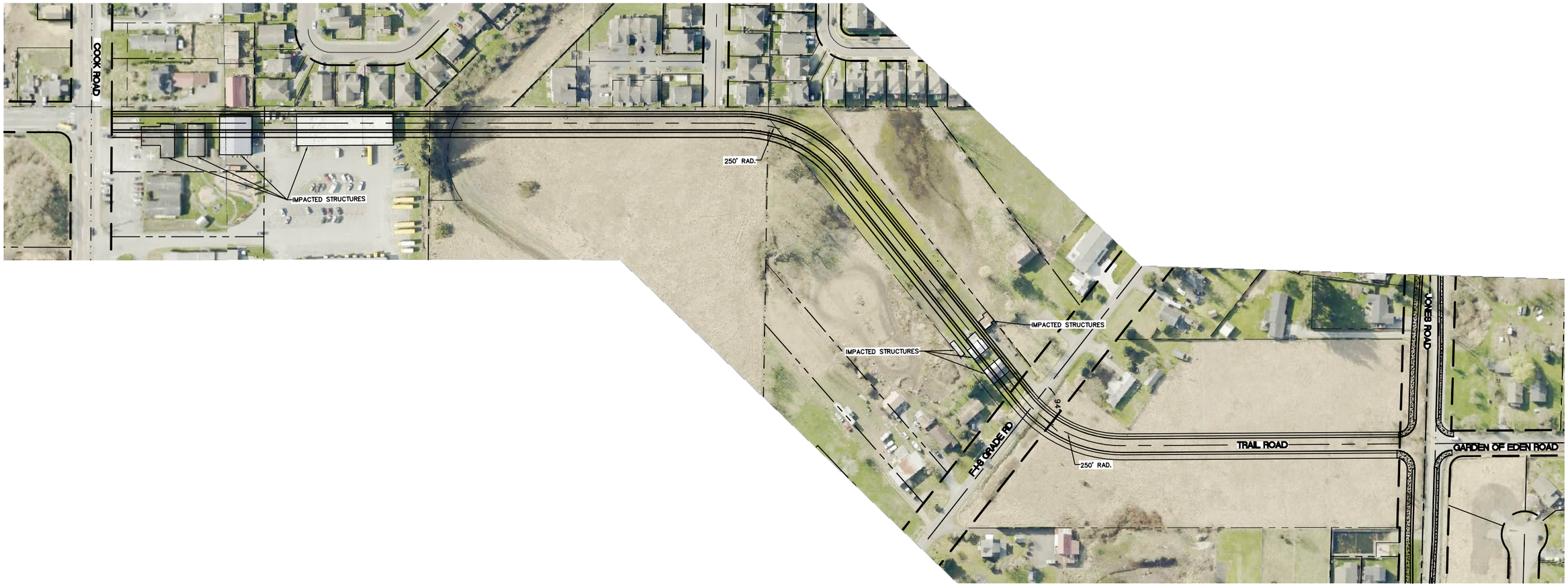
P:\Projects\18002\Civil 3D 2018\18002PROBASE.dwg, Trail Rd Opt 1, 1/23/2019 4:45:21 PM, PDF-ACDmpp Standard

GRAPHIC SCALE

100 0 50 100

(IN FEET)

1"=100' (22x34), 1"=200' (11x17)



NATHAN J. ZYLSTRA
STATE OF WASHINGTON
41884
REGISTERED
PROFESSIONAL ENGINEER
PRELIMINARY

Figure 4.5.3

DESIGNED BY	IDH/OAM
DRAWN BY	IDH/OAM
CHECKED BY	NZ

Reichhardt & Ebe ENGINEERING INC
P.O. Box 978 | 423 Front Street
Lynden, WA 98264 (360) 354-3687

NO.	DATE	DESCRIPTION	BY

CITY OF SEDRO WOOLLEY
325 METCALF STREET
SEDRO WOOLLEY, WA 98284

JONES / JOHN-LINER / TRAIL RD CORRIDOR
SCOPING STUDY
TRAIL ROAD OPTION #2

DWG 18002 PROBASE			DATE 1/23/2019
JOB # 18002	SCALE H: 1"=100'	V: N/A	SHEET XX of 14

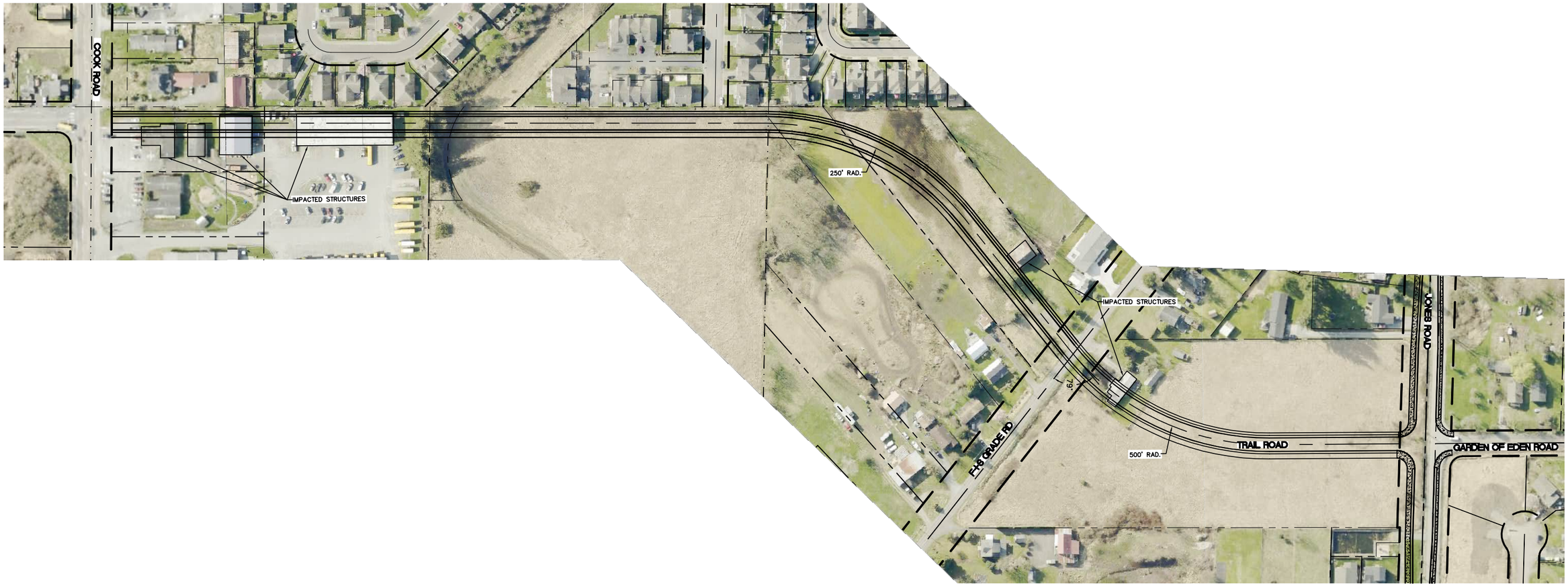
P:\Projects\18002\Civil 3D 2018\18002PROBASE.dwg, Trail Rd Opt 2, 1/23/2019 4:56:06 PM, PDF-XChange Standard

GRAPHIC SCALE

100 0 50 100

(IN FEET)

1"=100' (22x34), 1"=200' (11x17)



NATHAN J. ZYLSTRA
STATE OF WASHINGTON
41884
REGISTERED
PROFESSIONAL ENGINEER
PRELIMINARY

Figure 4.5.4

DESIGNED BY	IDH/OAM
DRAWN BY	IDH/OAM
CHECKED BY	NZ

Reichhardt & Ebe ENGINEERING INC
P.O. Box 978 | 423 Front Street
Lynden, WA 98264 (360) 354-3687

NO.	DATE	DESCRIPTION	BY

CITY OF SEDRO WOOLLEY
325 METCALF STREET
SEDRO WOOLLEY, WA 98284

JONES / JOHN-LINER / TRAIL RD CORRIDOR
SCOPING STUDY
TRAIL ROAD OPTION #3

DWG 18002 PROBASE			DATE 1/23/2019
JOB # 18002	SCALE H: 1"=100'	V: N/A	SHEET XX of 14

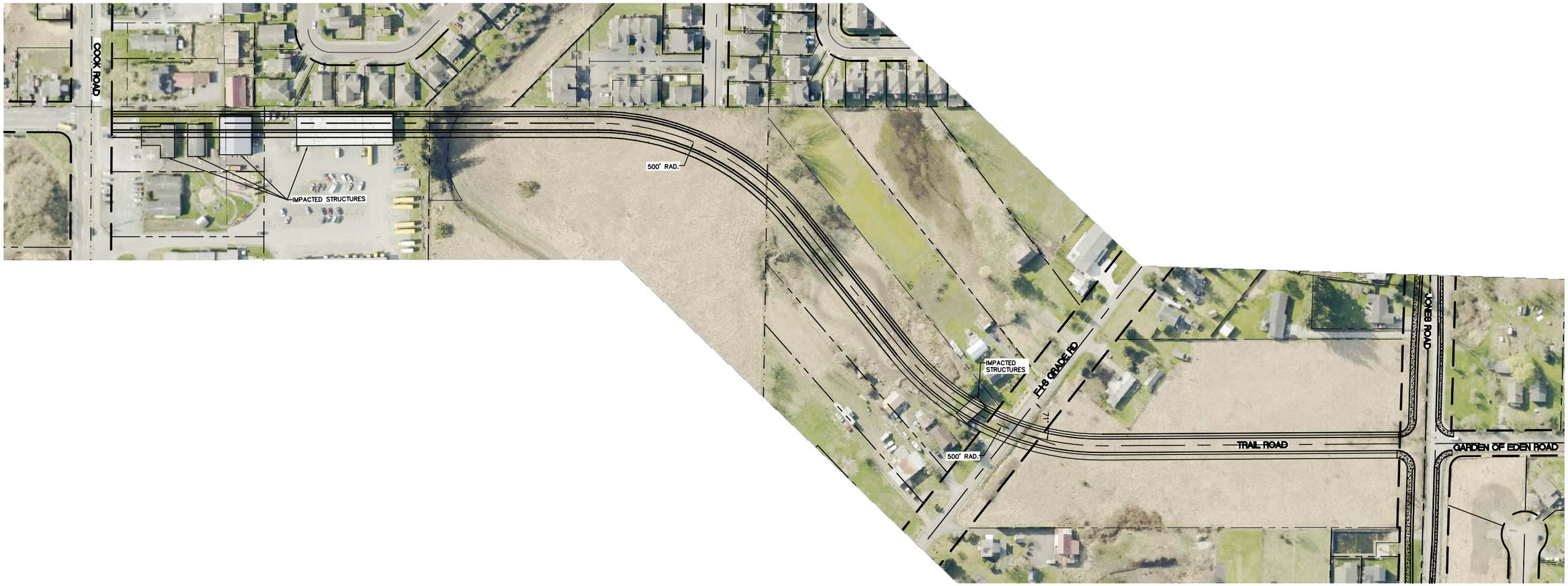
P:\Projects\18002\Civil 3D 2018\18002-PROBASE.dwg, Trail Rd Opt 3, 1/23/2019 4:57:44 PM, PDF-XChange Standard

GRAPHIC SCALE

100 0 50 100

(IN FEET)

1"=100' (22x34), 1"=200' (11x17)



PRELIMINARY

NATHAN J. ZYLSTRA
STATE OF WASHINGTON
41884
REGISTERED
PROFESSIONAL ENGINEER

Figure 4.5.5

DESIGNED BY	IDH/OAM
DRAWN BY	IDH/OAM
CHECKED BY	NZ

R&E Reichhardt & Ebe ENGINEERING INC
P.O. Box 978 | 423 Front Street
Lynden, WA 98264 (360) 354-3687

NO.	DATE	DESCRIPTION	BY

CITY OF SEDRO WOOLLEY
325 METCALF STREET
SEDRO WOOLLEY, WA 98284

JONES / JOHN-LINER / TRAIL RD CORRIDOR
SCOPING STUDY
TRAIL ROAD OPTION #4

DWG 18002 PROBASE			DATE 1/23/2019
JOB # 18002	SCALE H: 1"=100'	V: N/A	SHEET XX of 14

P:\Projects\18002\Civil 3D 2018\18002PROBASE.dwg, Trail Rd Opt 4, 1/23/2019 4:59:18 PM, PDF-XChange Standard

4.6 Patrick Street

The Patrick St. typical section is shown in Figure 4.6.1 and consists of two 12 ft. travel lanes, 3 ft. shoulders, curb and gutter, 4.5 ft. buffers and 5 ft. sidewalks. As Patrick St. is a new roadway section and contains only conventional sidewalks, the right of way is limited to 60 ft.

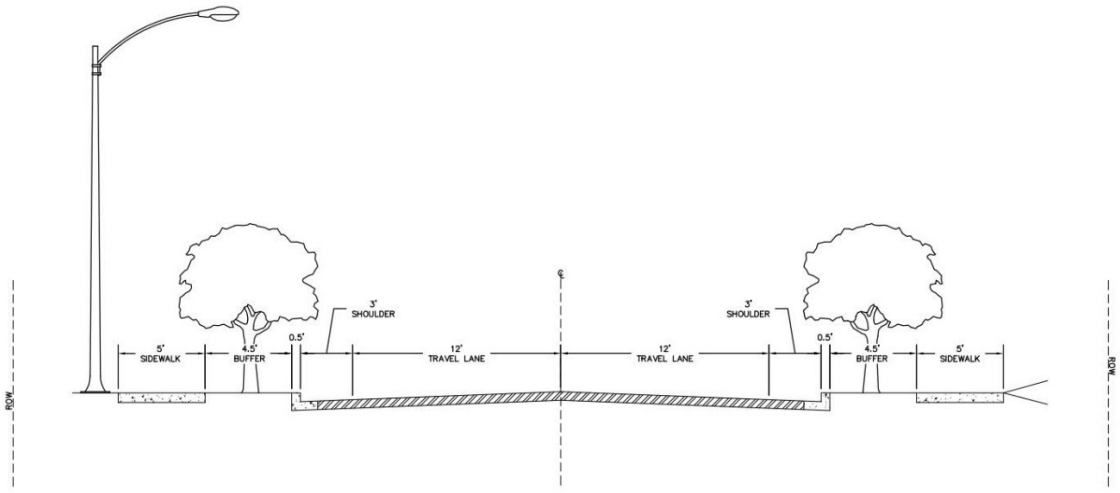


Figure 4.6.1: Patrick St. Typical Section

The original Patrick St. alignment extended the existing Patrick St. stub north of SR20, in a straight alignment to Jones Rd. and included a new crossing of Brickyard Creek. Through the course of the scoping study, the City has made the scoping study team aware of interest from a developer to create a commercial development on the property through which Patrick St. will be placed. The developer has prepared a conceptual layout including roadway and site development concepts as depicted in Figure 4.6.2. As requested by the City and in accordance with supplemental agreement no. 1 to the scoping study contract, the Patrick St. alignment has been updated to reflect the conceptual plan and is reflected in the design concept drawings.

TRICO

GOLDSMITH
LAND DEVELOPMENT SERVICES

UNDERWOOD
& ASSOCIATES, LLC

Project Schooner

Conceptual Site Plan
May 9th, 2019

Figure 4.6.2

4.7 Sapp Road

Sapp Rd. north of Jones Rd. is currently contained in a 60 ft. roadway easement paralleling the BNSF railroad. Approximately 450 ft. north of Jones Rd., Sapp Rd. crosses under the BNSF railroad at a wooden trestle. The underpass is a stop controlled single lane narrow roadway immediately adjacent to Brickyard Creek.

As a part of the proposed improvements, BNSF will close the Sapp Rd. undercrossing, remove the wooden trestle, and install a culvert for Brickyard Creek. Sapp Rd. will continue to extend approximately 450 ft. north of Jones Rd. in the roadway easement to provide access to a residential property. Hammerheads for emergency vehicle turnaround will be installed at the new Sapp Rd. dead ends east and west of the BNSF railroad.

The Sapp Rd. section is designed as a minimal roadway section 26 ft. in total width of paved roadway with sidewalk a 6 ft. sidewalk adjacent to the curb line on the west side only. Curb and gutter may be added to the east side if necessary, to contain roadway drainage. The sidewalk on the west side of Sapp Rd. will provide pedestrian access to approximately 15 acres of developable property north of Jones Rd. and adjacent to Sapp Rd.

A new box culvert will be installed to accommodate the realigned and widened Sapp Rd. crossing of Brickyard Creek. A minor realignment of Brickyard Creek itself is envisioned to reduce the skew angle of the crossing and limit the length of the proposed culvert.

4.8 Intersection Preliminary Design

The following is a brief discussion of intersections of interest, including but not limited to the two major intersection improvements identified in the project corridor.

4.8.1 W. Jones / F&S Grade Rd.

The W. Jones Rd. / F&S Grade Rd. intersection is proposed in the same configuration as exists today. The configuration adequately accounts for the high skew angle and accommodates the proposed W. Jones Rd. improvements. Stop control is provided on the W. Jones Rd. and Klinger St. approaches.

Subsequent stages of design will need to add at least one pedestrian crossing of F&S Grade Rd. likely from the south side of Jones Rd. to Klinger St. The high skew angle of the intersection of Jones Rd. and F&S Grade Rd. is also of concern especially when accommodating larger design vehicles such as WB-67. Realignment of the intersection to reduce skew angle should be considered in a future intersection study.

4.8.2 W. Jones / Garden of Eden / Trail Rd. Mini Roundabout

As discussed in Section 3, the traffic analysis indicates that a left turn lane is warranted for the westbound to southbound movement at this intersection in a conventional intersection configuration. At the request of the City, a mini roundabout has been included in the conceptual design. The mini roundabout is presented as an 85 ft. inscribed circle diameter (ICD). The mini roundabout should be further evaluated for optimum ICD and function in the design phase of the project.

4.8.3 E. Jones / Patrick St.

As discussed in Section 3, the traffic analysis indicates that a left turn lane is warranted for the westbound to southbound movement at this intersection in a conventional intersection configuration. The intersection

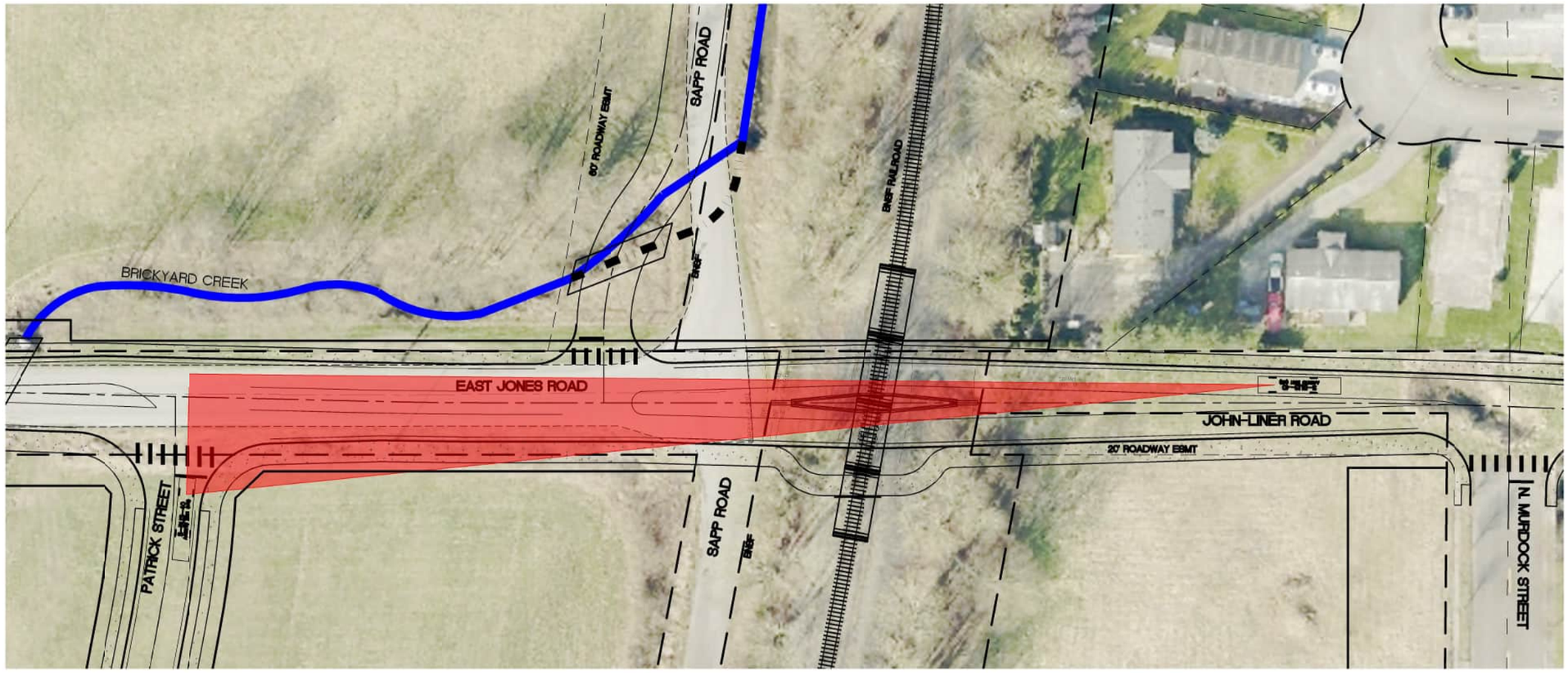
is stop controlled on the minor approach (Patrick St.). The revised Patrick St. horizontal alignment moved the intersection location easterly, closer to Sapp Rd. and the BNSF undercrossing, therefore a preliminary sight distance evaluation has been prepared to check for potential sight obstructions, particularly with respect to the proposed undercrossing structure. See Figure 4.8.3 for the sight distance exhibit. Sufficient sight distance is provided; however, care should be taken when evaluating the piers for the BNSF undercrossing to provide a slender column as the center piers will be contained within the sight triangle. Alternatively, elimination of the center pier would completely eliminate any concern with respect to sight distance.

GRAPHIC SCALE

30 0 15 30

(IN FEET)

1"=30' (22x34), 1"=60' (11x17)



PRELIMINARY

Figure 4.8.3	DESIGNED BY IDH/OAM DRAWN BY IDH/OAM CHECKED BY NZ	R&E Reichhardt & Ebe ENGINEERING INC P.O. Box 978 | 423 Front Street Lynden, WA 98264 (360) 354-3687	NO.	DATE	DESCRIPTION	BY	CITY OF SEDRO WOOLLEY 325 METCALF STREET SEDRO WOOLLEY, WA 98284	JONES / JOHN-LINER / TRAIL RD CORRIDOR SCOPING STUDY PATRICK STREET / JONES RD SIGHT DISTANCE EXHIBIT	DWG 18002 PLOT JOB# 18002 SCALE H: 1"=30' V: N/A	DATE 11/27/2019 SHEET of 42

4.8.4 E. Jones / Sapp Rd.

The center of the revised Patrick St. intersection is also approximately 200 ft. from the center of the Sapp Rd. intersection with E. Jones Rd. Again, careful consideration should be made with respect to eastbound left turn movements to northbound Sapp Rd. as insufficient distance exists to accommodate back to back left turn lanes while also meeting the minimum left turn storage length as recommended by the WSDOT Design Manual.

4.8.5 N. Township St. (SR9) / John-Liner / McGarigle Roundabout

Herman Traffic Engineering (HTE) prepared a conceptual roundabout (RAB) design for the intersection of N. Township St. (SR9) and John-Liner / McGarigle Rd. A conceptual layout of the RAB is shown in Figure 4.8.5-1.

As recommended by the TSI traffic analysis, the RAB is designed as a single lane RAB, however the inscribed circle diameter (ICD) is designed at 90 ft., rather than 120 ft. as assumed in the traffic analysis. The ICD was reduced to limit right of way impacts to private properties at the intersection. Even at an ICD of 90 ft., right of way impacts cannot be avoided and would only increase with a larger ICD. The design concept has been prepared assuming a fully mountable central island.

The 90 ft. ICD is governed by a school bus design vehicle. The RAB will accommodate a school bus in all movements, however the RAB was also designed to accommodate a WB-67 design vehicle in the north and southbound directions on SR9. See Figure 4.8.5-2 for turning movement exhibits. Outer truck aprons at the northbound and southbound entries are necessary to facilitate the WB-67 through movements.

The RAB is shifted to the northeast to obtain proper deflection for the southbound entry so as to control the approach speed. The shift, then dictates property impacts on the north leg and results in the full take of one residential property in the northeast quadrant, and eliminates a take in the northwest quadrant. Right of way takes are also anticipated in the southwest and southeast quadrants.

Splitter islands on the north and south legs are designed to meet ADA requirements and provide pedestrian refuge within the splitter island. Pedestrian crossings on the east and west legs do not include refuge areas in the splitter islands, which in accordance with WSDOT guidance is acceptable when the crossing distance is 30 ft. or less. As Cascade Middle School is located just south of the intersection and Evergreen Elementary School is located just to the east, the accommodation of pedestrians through the intersection will be of concern during the design engineering phase especially due to the residential generators to the north and west. Early discussion has included the possible use of rapid rectangular flashing beacons (RRFB's) to help safely accommodate the pedestrian movements.

Two existing residential driveways are in very close proximity to the RAB. These driveways are located in the southwest and northeast quadrants, and further drive the RAB location to the northeast so as to avoid access conflicts and to avoid placing the crosswalk at a driveway location.

GRAPHIC SCALE

40 0 20 40

(IN FEET)

1"=40' (22x34), 1"=80' (11x17)

Figure 4.8.5-1

DESIGNED BY	IDH/OAM
DRAWN BY	IDH/OAM
CHECKED BY	NZ

R&E Reichhardt & Ebe ENGINEERING INC
P.O. Box 978 | 423 Front Street
Lynden, WA 98264 (360) 354-3687

NO.	DATE	DESCRIPTION	BY

CITY OF SEDRO WOOLLEY
325 METCALF STREET
SEDRO WOOLLEY, WA 98284

JONES / JOHN-LINER / TRAIL RD CORRIDOR
SCOPING STUDY
JJL + SR9 INTERSECTION

DWG 18002 PLOT		DATE 6/5/2019
JOB# 18002	SCALE H: 1"=40' V: N/A	SHEET 15 of 24

NATHAN J. ZYLSTRA STATE OF WASHINGTON 41884 REGISTERED PROFESSIONAL ENGINEER

PRELIMINARY

P:\Projects\18002\Civil 3D 2018\18002 PLOT.dwg, JJL SR9 RAB, 7/31/2019 3:00:7:05 AM, PDF-XChange Standard

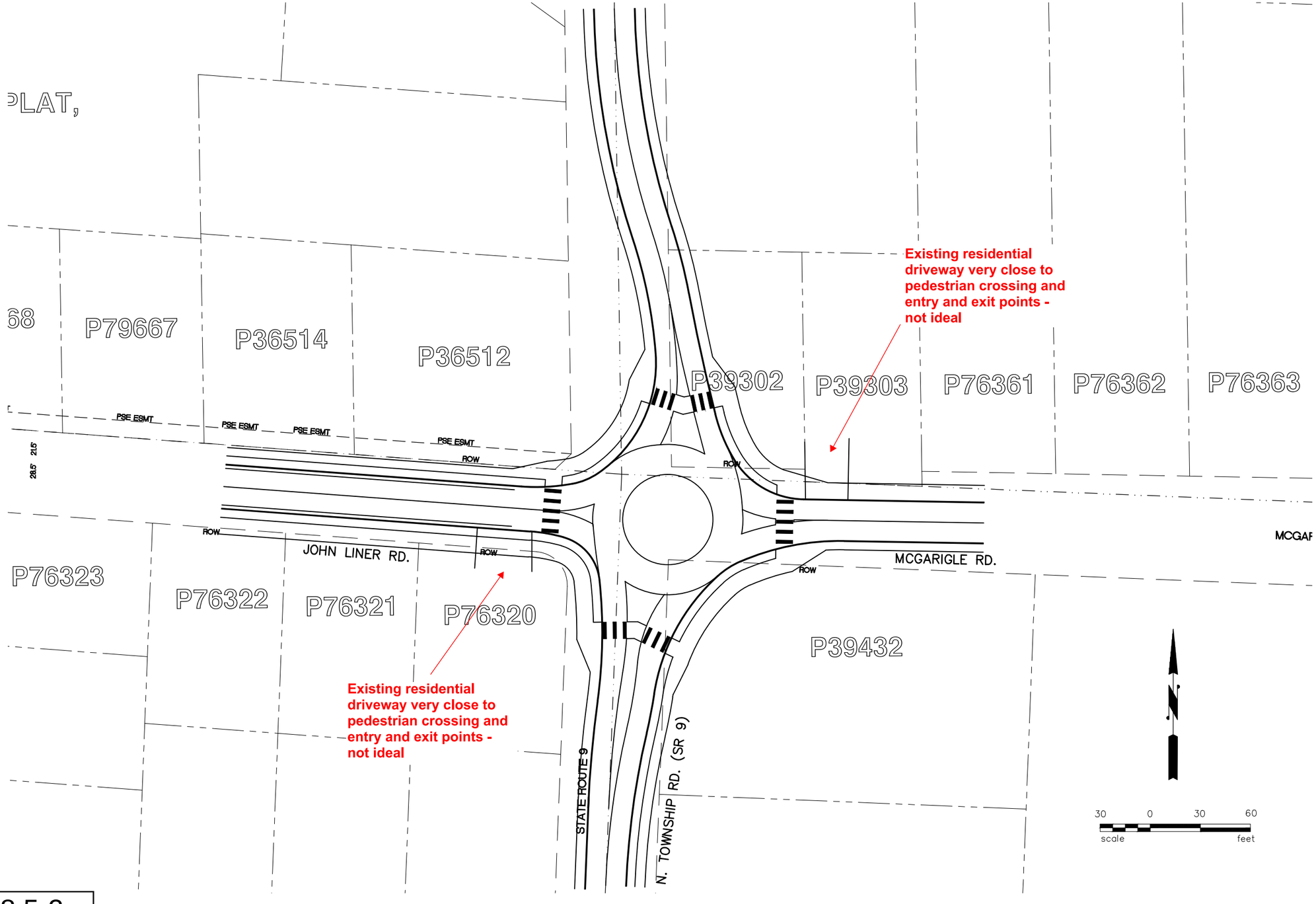


Figure 4.8.5-2

PRELIMINARY - NOT FOR CONSTRUCTION

DRAWN	RMH				
DESIGNED	RMH				
CHECKED	3/26/19 RMH				
PROJ. ENGR.					
DRAWING FILE	C_rev1.DWG				
		DATE	REVISION	BY	APP'D

FOR:

REICHHARDT & EBE ENGINEERING, INC.
423 FRONT ST.
LYNDEN, WA 98264

ROBERT MARTIN HERMAN — STATE OF WASHINGTON — 30730 — REGISTERED PROFESSIONAL ENGINEER

HTE HERMAN TRAFFIC ENGINEERING
11215 Southeast 220th Place, Kent, Washington 98031
253-236-4941 tel. hte@comcast.net

CITY OF SEDRO–WOOLLEY WASHINGTON

N TOWNSHIP ST./JOHN LINER RD./MCGARIGLE RD.

90' ICD COMPACT ROUNDABOUT CONCEPT

R1

SHEET OF SHEETS

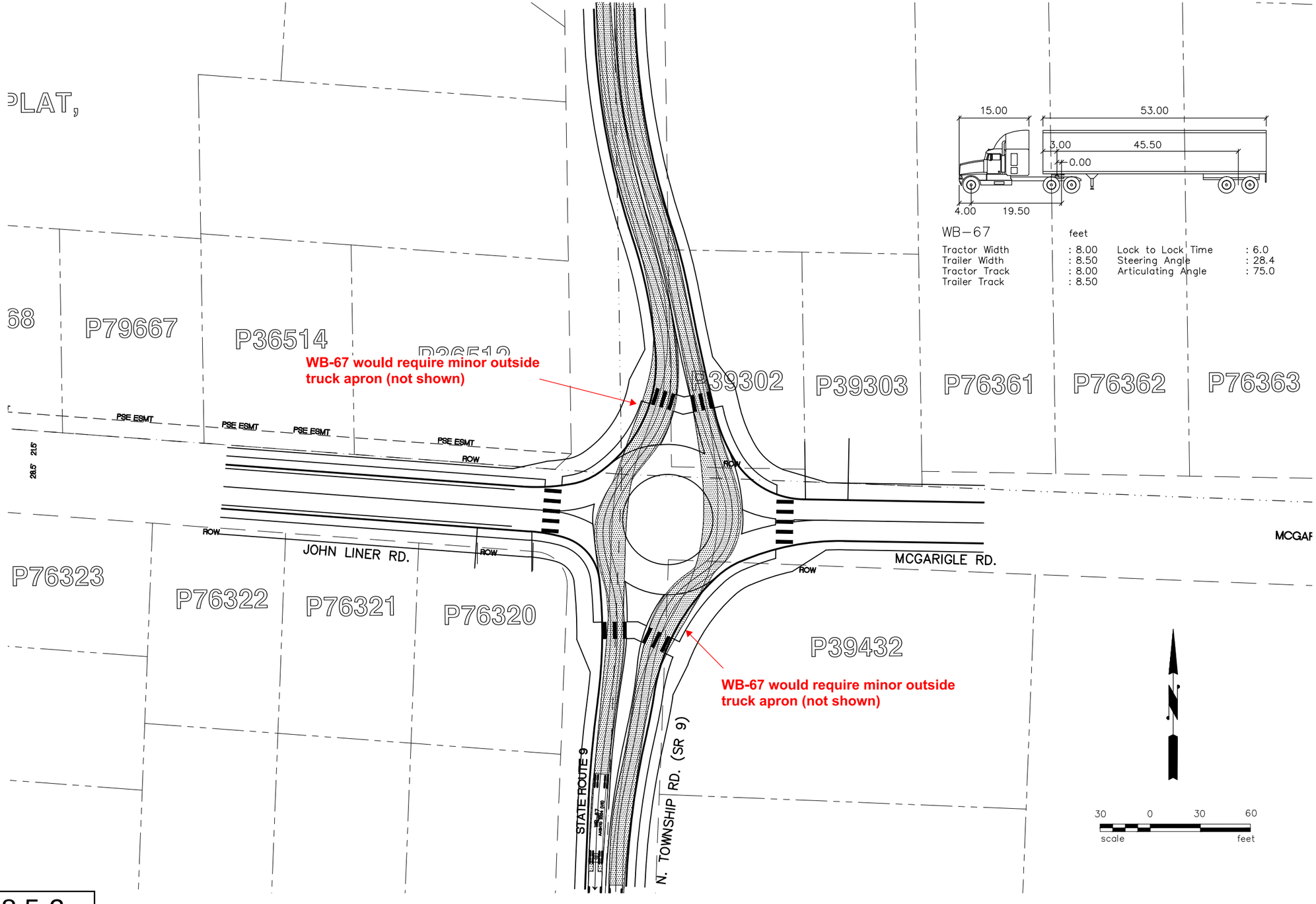


Figure 4.8.5-2

PRELIMINARY - NOT FOR CONSTRUCTION

DRAWN	RMH				
DESIGNED	RMH				
CHECKED	3/26/19 RMH				
PROJ. ENGR.					
DRAWING FILE	C_rev1.DWG				
		DATE	REVISION	BY	APP'D

FOR:

REICHHARDT & EBE ENGINEERING, INC.
423 FRONT ST.
LYNDEN, WA 98264

ROBERT MARTIN HERMAN
STATE OF WASHINGTON
30730
REGISTERED
PROFESSIONAL ENGINEER

HTE HERMAN TRAFFIC ENGINEERING
11215 Southeast 220th Place, Kent, Washington 98031
253-236-4941 tel. hte@comcast.net

CITY OF SEDRO-WOOLLEY WASHINGTON

N TOWNSHIP ST./JOHN LINER RD./MCGARIGLE RD.

90' ICD COMPACT ROUNDABOUT CONCEPT

R2

SHEET OF SHEETS

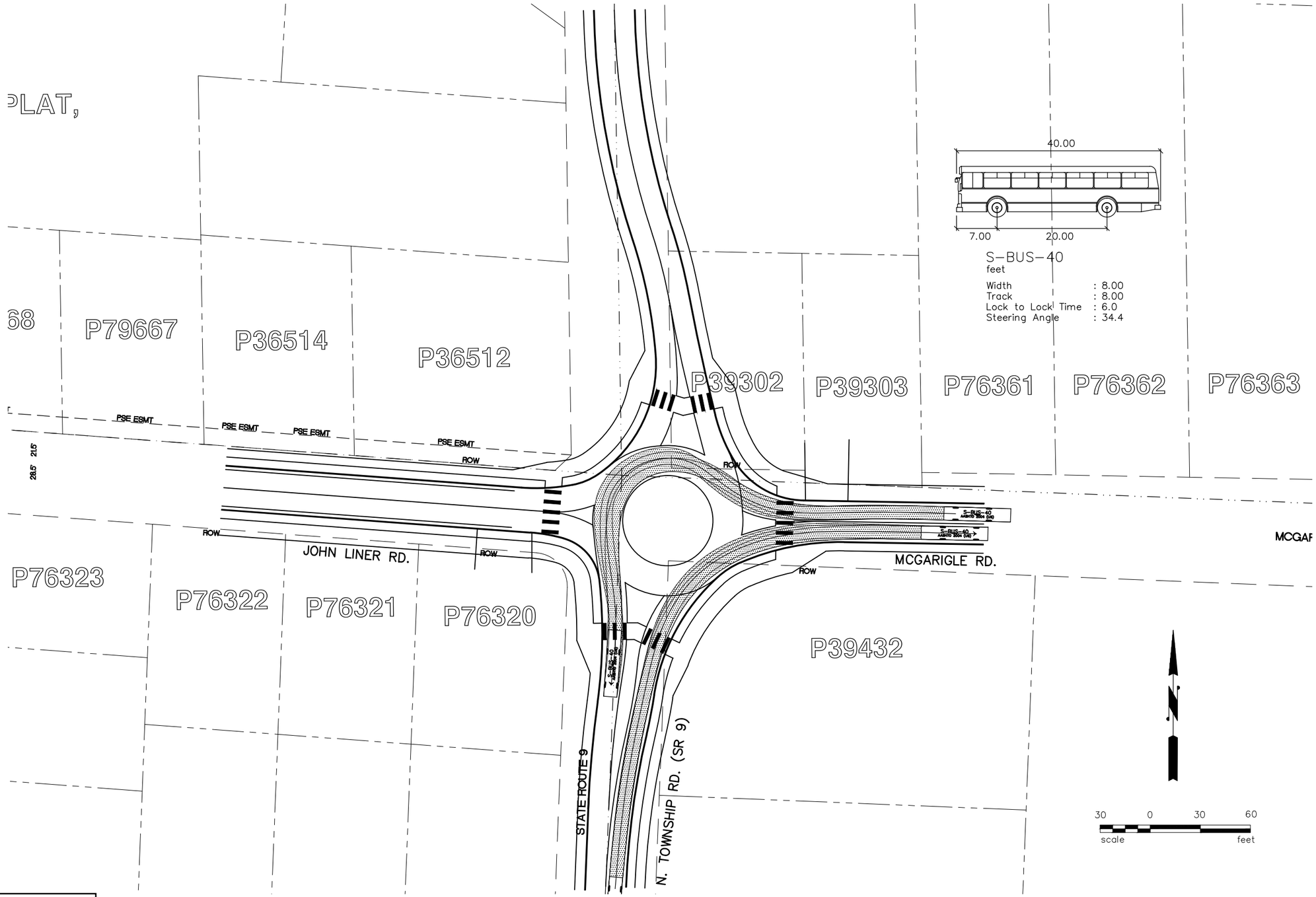


Figure 4.8.5-2

PRELIMINARY - NOT FOR CONSTRUCTION

DRAWN	RMH				
DESIGNED	RMH				
CHECKED	3/26/19 RMH				
PROJ. ENGR.					
DRAWING FILE	C_rev1.DWG				
		DATE	REVISION	BY	APP'D

FOR:

REICHHARDT & EBE ENGINEERING, INC.
423 FRONT ST.
LYNDEN, WA 98264

ROBERT MARTIN HERMAN
STATE OF WASHINGTON
30730
REGISTERED
PROFESSIONAL ENGINEER

HTE HERMAN TRAFFIC ENGINEERING

11215 Southeast 220th Place, Kent, Washington 98031
253-236-4941 tel. hte@comcast.net

CITY OF SEDRO-WOOLLEY WASHINGTON

N TOWNSHIP ST./JOHN LINER RD./MCGARIGLE RD.

90' ICD COMPACT ROUNDABOUT CONCEPT

R3

SHEET OF SHEETS

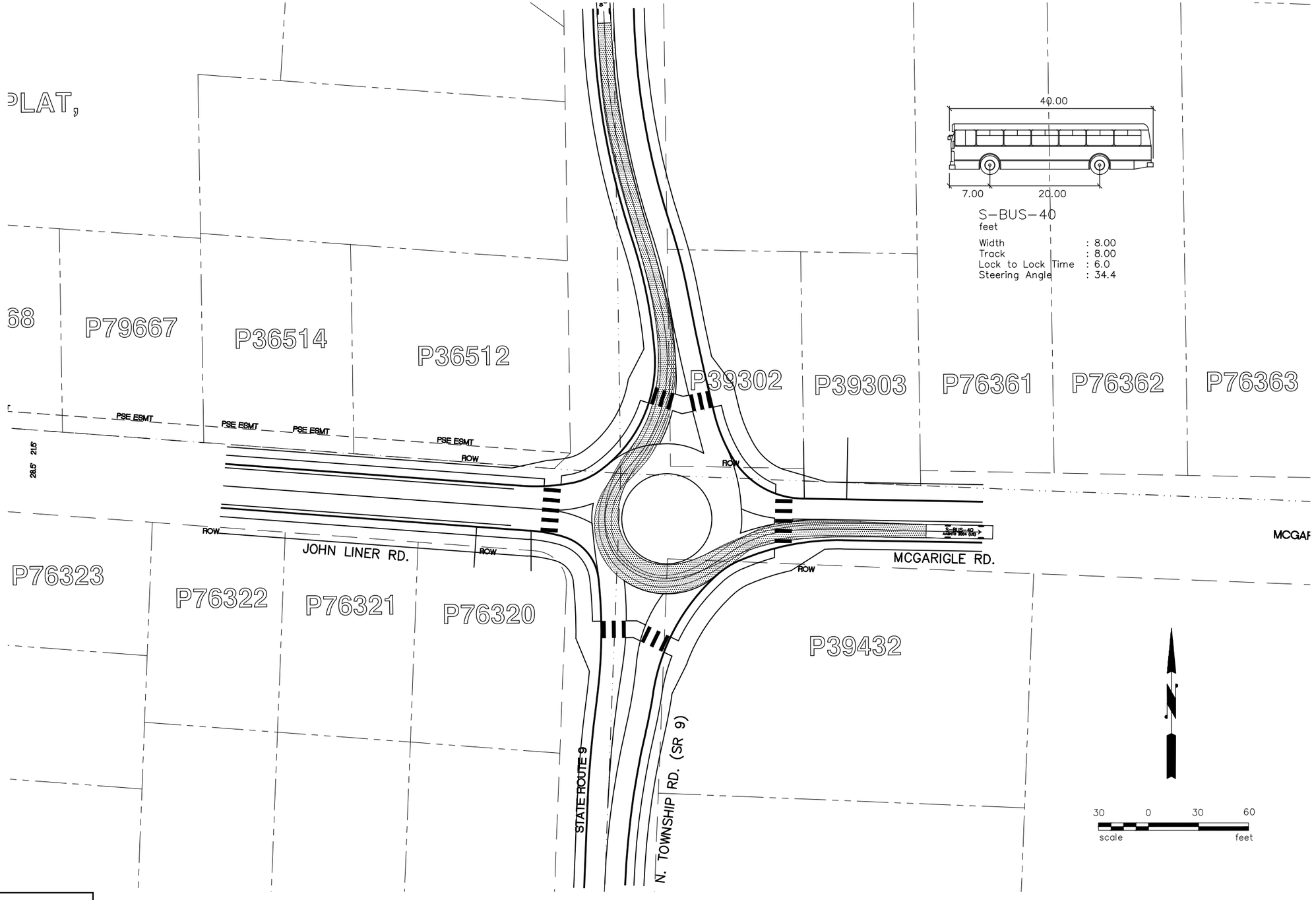


Figure 4.8.5-2

PRELIMINARY - NOT FOR CONSTRUCTION

DRAWN	RMH				
DESIGNED	RMH				
CHECKED	3/26/19 RMH				
PROJ. ENGR.					
DRAWING FILE	C_rev1.DWG				
		DATE	REVISION	BY	APP'D

FOR:

REICHHARDT & EBE ENGINEERING, INC.
423 FRONT ST.
LYNDEN, WA 98264

ROBERT MARTIN HERMAN
STATE OF WASHINGTON
30730
REGISTERED
PROFESSIONAL ENGINEER

HTE HERMAN TRAFFIC ENGINEERING

11215 Southeast 220th Place, Kent, Washington 98031
253-236-4941 tel. hte@comcast.net

CITY OF SEDRO-WOOLLEY WASHINGTON

N TOWNSHIP ST./JOHN LINER RD./MCGARIGLE RD.

90' ICD COMPACT ROUNDABOUT CONCEPT

R4

SHEET OF SHEETS

N. Township St. (SR9) / John-Liner Rd. / McGarigle Rd. Roundabout Peer Review
At the request of the City of Sedro-Woolley, a peer review of the conceptual design was completed by TSI. The full peer review memorandum "Sedro-Woolley SR9 McGarigle Road Roundabout Peer Review" is contained in Appendix E.

Recommendations made in the peer review are summarized below:

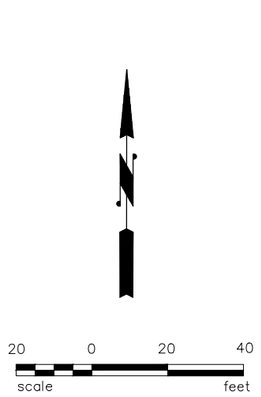
- Add pedestrian refuge in the splitter islands on the east and west legs.
- Move the RAB to a more central location in the intersection and control approach speed with longer splitter islands containing landscaping and sinuous geometry.
- As a result of the more central RAB location, add additional driveway access off SR9 for the affected properties in the northeast and southwest quadrants.
- End the bike lanes on SR9 prior to the RAB and provide wider, multi-use sidewalks around the perimeter of the RAB.
- If insufficient right of way is available for buffer adjacent to the circulating lane, add ADA roundabout detectable edge treatment along the circulating lane.

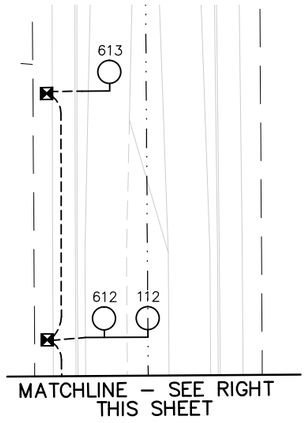
It is clear from both the conceptual design and the peer review that the RAB design at this location will be severely constrained by property and driveway accesses while attempting to accommodate vehicular movements, and needing to strongly consider pedestrian movements through the intersection. The design engineering phase of this project will need to strongly consider pedestrian refuge on the east and west legs, including the potential overlap of crosswalk locations and existing residential driveways. The southbound approach geometry will also be a primary focus, so as to determine the most effective and safe approach to controlling entry speeds, considering also that the shared use path may cross the north leg of the intersection.

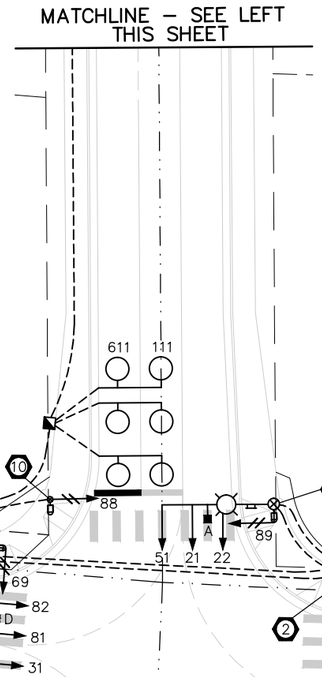
4.8.6 N. Township St. (SR9) / John-Liner / McGarigle Signalized Intersection

A signalized intersection alternative was evaluated for the Township St. (SR9) / John-Liner Rd. / McGarigle Rd. intersection. A conceptual layout of the signalized intersection is shown in Figure 4.8.6. The signalized intersection is shown as a conventional 4-leg intersection with left turn storage provided on each leg. Crosswalks are provided across each leg of the intersection with a preferred two ramp configuration meeting the requirements of an Accessible Pedestrian Signal (APS). Some right of way acquisition will be required on each corner albeit far less impact than the roundabout alternative.

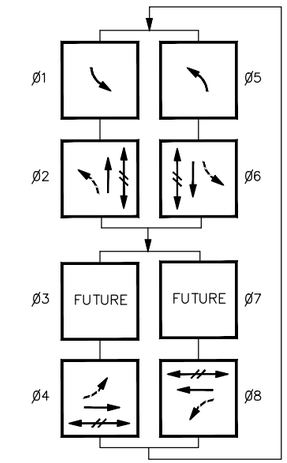
Due to the limited scope of work of this study, no speed studies were performed to determine advance loop locations. The locations shown on the concept are approximate based on posted speed limits and past experience. The loop locations can be refined during the design engineering phase if the signalized intersection is chosen as the preferred alternative.







SIGNAL PHASING DIAGRAM



EMERGENCY VEHICLE PREEMPTION SCHEDULE

DETECTOR	PHASE
A	2+5
B	4
C	1+6
D	8

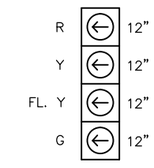
OVERHEAD POWER NOTE:

THIS PLAN ASSUMES ALL OVERHEAD POWER LINES WILL BE MODIFIED TO MEET REQUIRED CLEARANCES FROM TRAFFIC SIGNAL/ILLUMINATION EQUIPMENT.

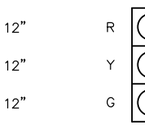
VEHICLE DETECTION NOTE:

ALL ADVANCE VEHICLE DETECTOR LOOP LOCATIONS ARE APPROXIMATE. EXACT LOCATIONS WILL BE DETERMINED DURING DETAILED DESIGN.

SIGNAL DISPLAY SCHEDULE



VEHICLE HEAD NO.
11,31,51,71



VEHICLE HEAD NO.
21,22,41,42,
61,62,81,82

PEDESTRIAN HEAD NO.
28,29,48,49,
68,69,88,89

SIGNAL DISPLAY NOTES:

1. ALL VEHICLE SIGNAL HEADS SHALL BE CONVENTIONAL HEADS WITH ALL LED INDICATIONS, TUNNEL VISORS AND BACKPLATES. ALL MAST ARM–MOUNTED HEADS SHALL USE MOUNTING TYPE M. USE J–75 SERIES STANDARD PLANS.
2. ALL PEDESTRIAN SIGNAL HEADS SHALL BE COUNTDOWN TYPE AND HAVE LED SYMBOLIC LEGENDS AND 'Z' CRATE VISORS. ALL HEADS SHALL USE MOUNTING TYPE D EXCEPT HEADS 69 AND 89 WHICH SHALL USE MOUNTING TYPE E. USE STANDARD PLAN J–75.10–00.

Figure 4.8.6

PRELIMINARY - NOT FOR CONSTRUCTION

DRAWN	RMH				
DESIGNED	RMH				
CHECKED	11/22/19 RMH				
PROJ. ENGR.					
DRAWING FILE	TS.DWG				
		DATE	REVISION	BY	APP'D

FOR:

REICHHARDT & EBE ENGINEERING, INC.
423 FRONT ST.
LYNDEN, WA 98264

HTE HERMAN TRAFFIC ENGINEERING, INC.
11215 Southeast 220th Place, Kent, Washington 98031
253-236-4941 tel. hte@comcast.net

CITY OF SEDRO–WOOLLEY WASHINGTON

N TOWNSHIP ST./JOHN LINER RD./MCGARIGLE RD.

TRAFFIC SIGNAL SYSTEM CONCEPT

TS1

SHEET OF SHEETS

4.8.7 Cook Rd. / Trail Rd. Roundabout

Herman Traffic Engineering (HTE) prepared a conceptual roundabout (RAB) design for the intersection of Cook Rd. and Trail Rd. A conceptual layout of the RAB is shown in Figure 4.8.7-1.

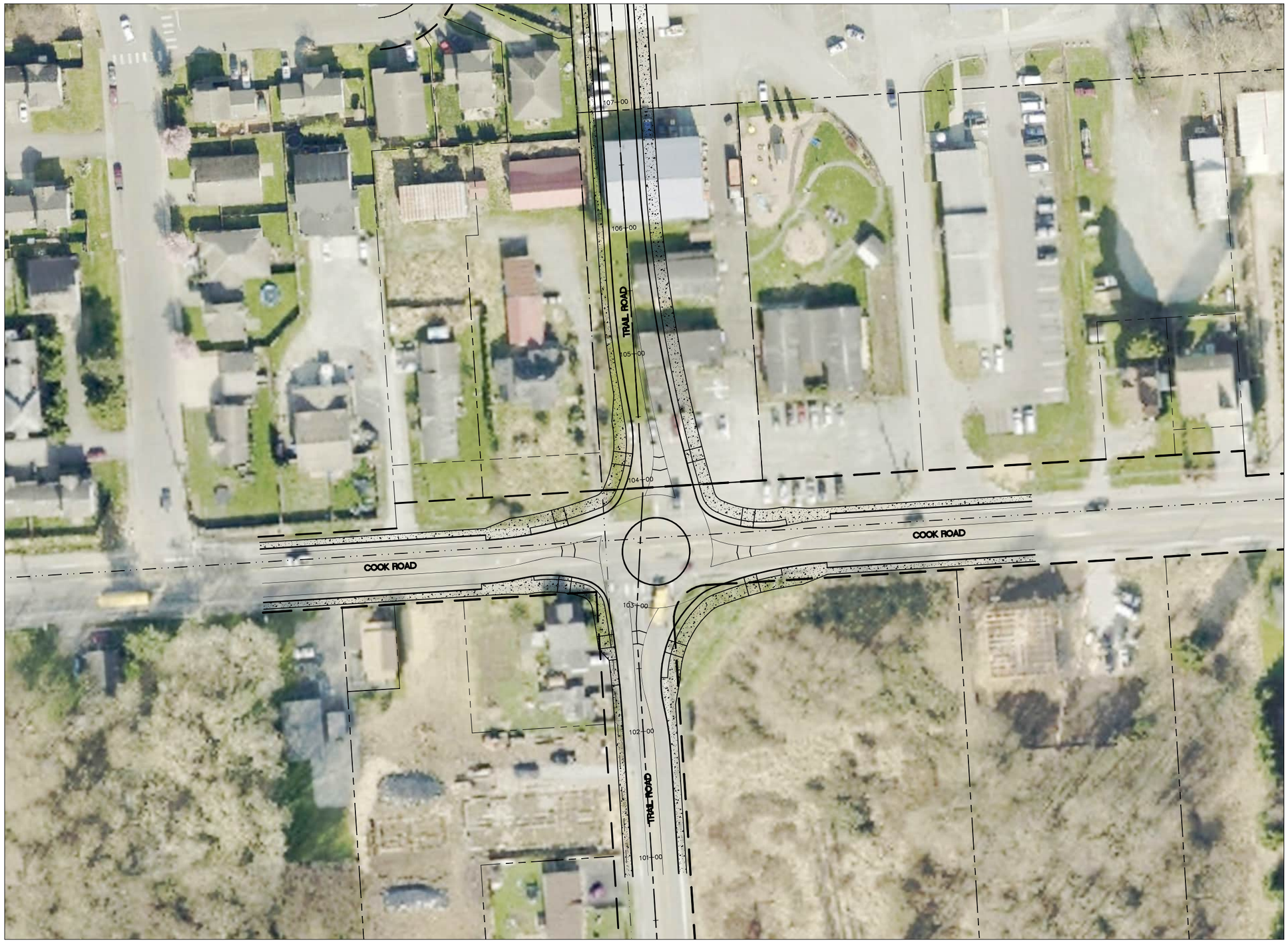
As recommended by the TSI traffic analysis, the RAB is designed as a single lane RAB, however the inscribed circle diameter (ICD) is designed at 90 ft., rather than 120 ft. as assumed in the traffic analysis. The design concept is designed as a full urban roundabout which is appropriate for the fully improved Cook Rd. and Trail Rd. and is consistent with the corridor to the east.

The 90 ft. ICD is governed by a school bus design vehicle. The RAB will accommodate a school bus in all movements, however the RAB was also designed to accommodate a WB-67 design vehicle in the east and westbound directions on Cook Rd. See Figure 4.8.7-2 for turning movement exhibits. Outer truck aprons at the eastbound and westbound entries are necessary to facilitate the WB-67 through movements.

The envelope of improvements encroaches onto private property in the southwest quadrant in the current design concept. These improvements are in close proximity to an existing home. During the design engineering phase of work, it may be beneficial to consider a northeasterly shift to provide separation between the improvement envelope and the existing residence. Such a shift will also potentially lessen the right of way impact in the southeast quadrant. The right of way acquisition necessary for Trail Rd. north of the intersection will accommodate the RAB.

Splitter islands on all four legs of the RAB are design to meet ADA requirements and provide the minimum 6 ft. of pedestrian refuge.

One existing residential driveway is in close proximity to the RAB. The driveway is located in on the south leg of the intersection accessing the property to the west. A gap in the splitter island or termination of the splitter island will be necessary to accommodate left turns out of the driveway.



GRAPHIC SCALE

40 0 20 40

(IN FEET)

1"=40' (22x34), 1"=80' (11x17)

PRELIMINARY

NATHAN J. ZYLSTRA
STATE OF WASHINGTON
41684
REGISTERED
PROFESSIONAL ENGINEER

Figure 4.8.7-1

DESIGNED BY	IDH/OAM
DRAWN BY	IDH/OAM
CHECKED BY	NZ

R&E Reichhardt & Ebe ENGINEERING INC
P.O. Box 978 | 423 Front Street
Lynden, WA 98264 (360) 354-3687

NO.	DATE	DESCRIPTION	BY

CITY OF SEDRO WOOLLEY
325 METCALF STREET
SEDRO WOOLLEY, WA 98284

JONES / JOHN-LINER / TRAIL RD CORRIDOR
SCOPING STUDY
TRAIL + COOK INTERSECTION

DWG 18002 PLOT
DATE 6/5/2019
JOB# 18002
SCALE H: 1"=40' V: N/A
SHEET 16 of 24

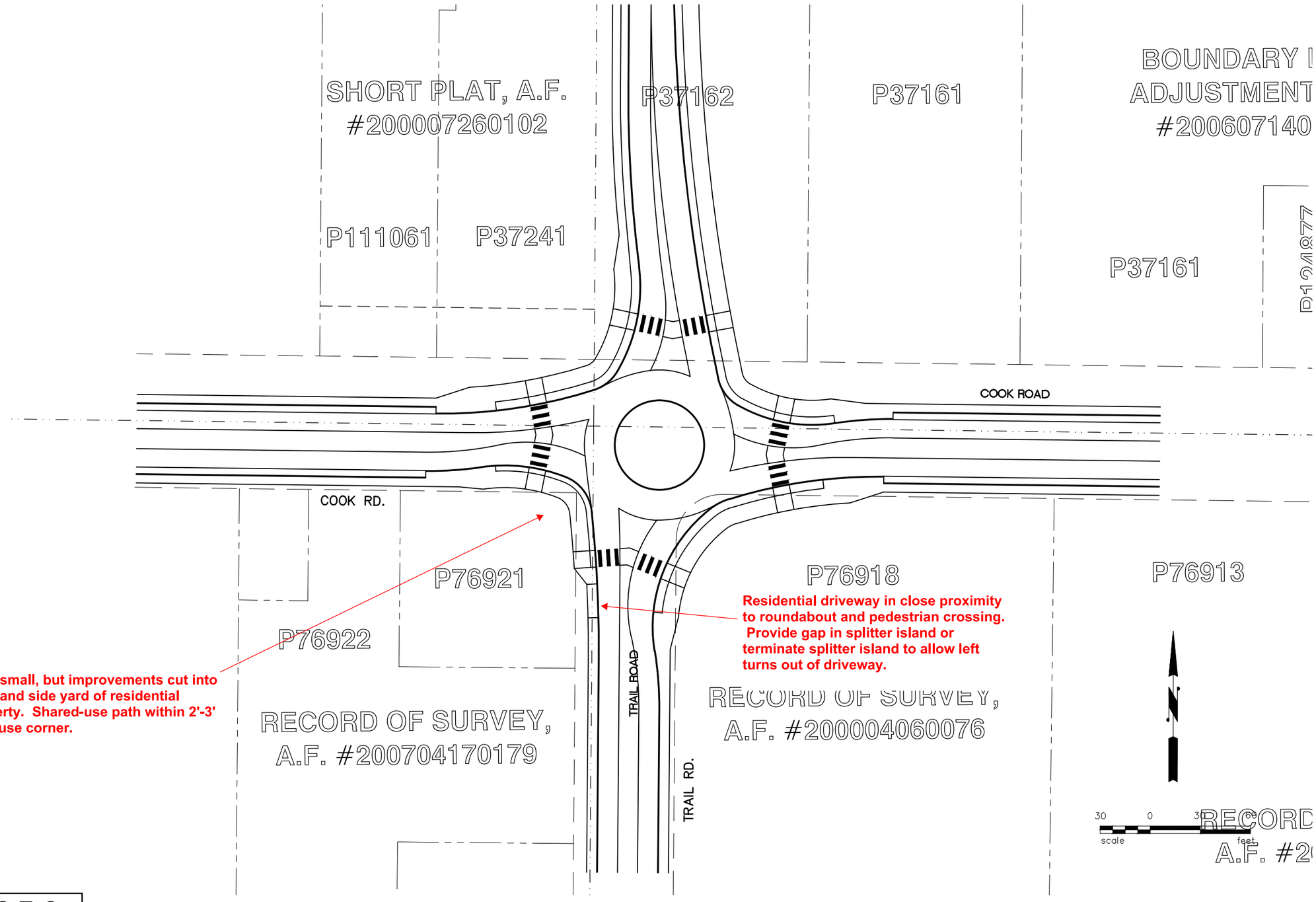


Figure 4.8.7-2

PRELIMINARY - NOT FOR CONSTRUCTION

DRAWN	RMH				
DESIGNED	RMH				
CHECKED	4/18/19 RMH				
PROJ. ENGR.					
DRAWING FILE	C_rev1.DWG				
		DATE	REVISION	BY	APP'D

FOR:

REICHHARDT & EBE ENGINEERING, INC.
423 FRONT ST.
LYNDEN, WA 98264

ROBERT MARTIN HERMAN — STATE OF WASHINGTON — 30730 — REGISTERED PROFESSIONAL ENGINEER

HTE HERMAN TRAFFIC ENGINEERING
11215 Southeast 220th Place, Kent, Washington 98031
253-236-4941 tel. hte@comcast.net

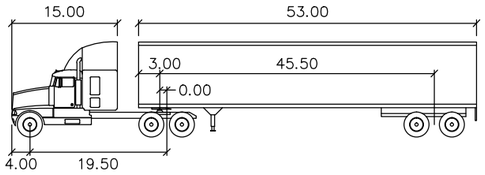
CITY OF SEDRO-WOOLLEY WASHINGTON

COOK RD./TRAIL RD.

90' ICD COMPACT ROUNDABOUT CONCEPT

R5

SHEET OF SHEETS



WB–67 feet

Tractor Width	: 8.00	Lock to Lock Time	: 6.0
Trailer Width	: 8.50	Steering Angle	: 28.4
Tractor Track	: 8.00	Articulating Angle	: 75.0
Trailer Track	: 8.50		

SHORT PLAT, A.F.
#200007260102

P37162

P37161

BOUNDARY I
ADJUSTMENT
#200607140

P111061

P37241

P37161

P14967

WB-67 would require minor outside truck apron (not shown)

COOK ROAD

COOK RD.

WB-67 would require minor outside truck apron (not shown)

P76921

P76918

P76913

P76922

TRAIL ROAD

TRAIL RD.

RECORD OF SURVEY,
A.F. #200704170179

RECORD OF SURVEY,
A.F. #200004060076

30 0 30 60
scale feet

RECORD
A.F. #2

PRELIMINARY - NOT FOR CONSTRUCTION

DRAWN	RMH
DESIGNED	RMH
CHECKED	4/18/19 RMH
PROJ. ENGR.	
DRAWING FILE	C_rev1.DWG

DATE	REVISION	BY	APP'D

FOR:

REICHHARDT & EBE ENGINEERING, INC.
423 FRONT ST.
LYNDEN, WA 98264

ROBERT MARTIN HERMAN
STATE OF WASHINGTON
30730
REGISTERED
PROFESSIONAL ENGINEER

HTE HERMAN TRAFFIC ENGINEERING
11215 Southeast 220th Place, Kent, Washington 98031
253-236-4941 tel. hte@comcast.net

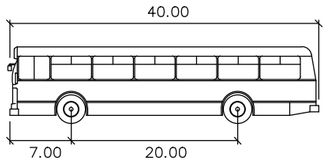
CITY OF SEDRO–WOOLLEY WASHINGTON

COOK RD./TRAIL RD.

90' ICD COMPACT ROUNDABOUT CONCEPT

R6

SHEET OF SHEETS



S–BUS–40
feet

Width	: 8.00
Track	: 8.00
Lock to Lock Time	: 6.0
Steering Angle	: 34.4

SHORT PLAT, A.F.
#200007260102

P37162

P37161

BOUNDARY I
ADJUSTMENT
#200607140

P111061

P37241

P37161

P76921

P76922

P76918

P76913

RECORD OF SURVEY,
A.F. #200704170179

RECORD OF SURVEY,
A.F. #200004060076

RECORD
A.F. #2

COOK ROAD

COOK RD.

TRAIL ROAD

TRAIL RD.

30 0 30 60
scale feet

PRELIMINARY - NOT FOR CONSTRUCTION

DRAWN	RMH			
DESIGNED	RMH			
CHECKED	4/18/19 RMH			
PROJ. ENGR.				
DRAWING FILE	C_rev1.DWG			
	DATE	REVISION	BY	APP'D

FOR:

REICHHARDT & EBE ENGINEERING, INC.
423 FRONT ST.
LYNDEN, WA 98264

ROBERT MARTIN HERMAN
STATE OF WASHINGTON
30730
REGISTERED
PROFESSIONAL ENGINEER

HTE HERMAN TRAFFIC ENGINEERING
11215 Southeast 220th Place, Kent, Washington 98031
253-236-4941 tel. hte@comcast.net

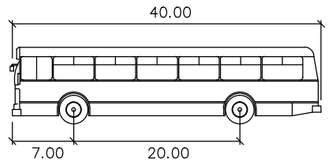
CITY OF SEDRO–WOOLLEY WASHINGTON

COOK RD./TRAIL RD.

90' ICD COMPACT ROUNDABOUT CONCEPT

R7

SHEET OF SHEETS



S–BUS–40
feet

Width	: 8.00
Track	: 8.00
Lock to Lock Time	: 6.0
Steering Angle	: 34.4

SHORT PLAT, A.F.
#200007260102

P37162

P37161

BOUNDARY I
ADJUSTMENT
#200607140

P111061

P37241

P37161

P1376477

COOK ROAD

COOK RD.

P76921

P76918

P76913

P76922

TRAIL ROAD

TRAIL RD.

RECORD OF SURVEY,
A.F. #200704170179

RECORD OF SURVEY,
A.F. #200004060076

RECORD
A.F. #2

30 0 30 60
scale feet

PRELIMINARY - NOT FOR CONSTRUCTION

DRAWN	RMH			
DESIGNED	RMH			
CHECKED	4/18/19 RMH			
PROJ. ENGR.				
DRAWING FILE	C_rev1.DWG			
	DATE	REVISION	BY	APP'D

FOR:

REICHHARDT & EBE ENGINEERING, INC.
423 FRONT ST.
LYNDEN, WA 98264

ROBERT MARTIN HERMAN
STATE OF WASHINGTON
30730
REGISTERED
PROFESSIONAL ENGINEER

HTE HERMAN TRAFFIC ENGINEERING

11215 Southeast 220th Place, Kent, Washington 98031
253-236-4941 tel. hte@comcast.net

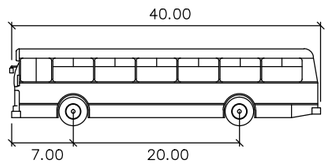
CITY OF SEDRO–WOOLLEY WASHINGTON

COOK RD./TRAIL RD.

90' ICD COMPACT ROUNDABOUT CONCEPT

R8

SHEET OF SHEETS



S–BUS–40
feet

Width	: 8.00
Track	: 8.00
Lock to Lock Time	: 6.0
Steering Angle	: 34.4

SHORT PLAT, A.F.
#200007260102

P37162

P37161

BOUNDARY I
ADJUSTMENT
#200607140

P111061

P37241

P37161

P37477

COOK ROAD

COOK RD.

P76921

P76918

P76913

P76922

TRAIL ROAD

TRAIL RD.

RECORD OF SURVEY,
A.F. #200704170179

RECORD OF SURVEY,
A.F. #200004060076

30 0 30 60
scale feet

RECORD
A.F. #2

PRELIMINARY - NOT FOR CONSTRUCTION

DRAWN RMH					
DESIGNED RMH					
CHECKED 4/18/19 RMH					
PROJ. ENGR.					
DRAWING FILE C_rev1.DWG					
	DATE	REVISION	BY	APP'D	

FOR:

REICHHARDT & EBE ENGINEERING, INC.
423 FRONT ST.
LYNDEN, WA 98264

ROBERT MARTIN HERMAN
STATE OF WASHINGTON
30730
REGISTERED
PROFESSIONAL ENGINEER

HTE HERMAN TRAFFIC ENGINEERING

11215 Southeast 220th Place, Kent, Washington 98031
253-236-4941 tel. hte@comcast.net

CITY OF SEDRO–WOOLLEY WASHINGTON

COOK RD./TRAIL RD.

90' ICD COMPACT ROUNDABOUT CONCEPT

R9

SHEET
OF
SHEETS

4.8.8 Cook Rd. / Trail Rd. Signalized Intersection

A signalized intersection alternative was evaluated for the Cook Rd. / Trail Rd. intersection. A conceptual layout of the signalized intersection is shown in Figure 4.8.8. The signalized intersection is shown as a conventional 4-leg intersection with left turn storage provided on each leg. Although the TSI Traffic Analysis does not call for left turn pockets on the northbound and southbound approaches, they are included in the conceptual plan.

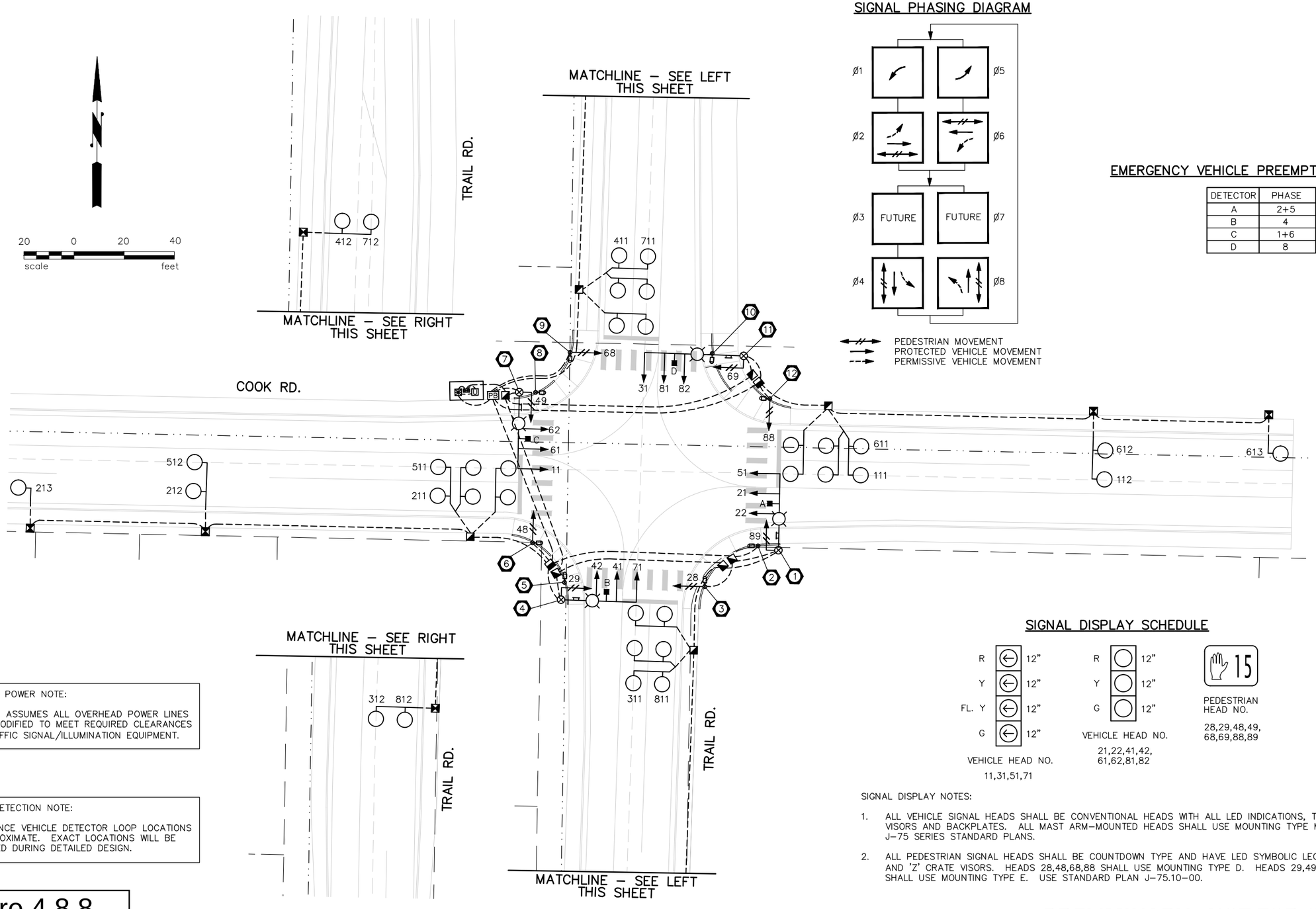
The projected year 2036 traffic volumes, especially the northbound left turn and it's opposing thru and right movements, show a northbound LOS C and a queue of 400 ft indicating the need for a protected left turn movement. Current WSDOT policy and practice is to treat signal phasing the same for opposing left runs due to driver expectation, thus both northbound and southbound left turn pockets are provided. Further, the northbound left turn pocket transitions well with the two-way-left turn lane south of the intersection on Trail Rd. Protected left turn signal phasing would not need to be implemented immediately post-construction, but could be added at a later date.

Crosswalks are provided across each leg of the intersection with a preferred two ramp configuration meeting the requirements of an Accessible Pedestrian Signal (APS). Some right of way acquisition will be required on the southwest and southeast corners. Right-of-way acquisition for the new segment of Trail Rd. to the north will accommodate the northeast and northwest quadrants.

Due to the limited scope of work of this study, no speed studies were performed to determine advance loop locations. The locations shown on the concept are approximate based on posted speed limits and past experience. The loop locations can be refined during the design engineering phase if the signalized intersection is chosen as the preferred alternative. Additionally, queue calculations should be revisited during the design engineering phase as the addition of the northbound and southbound left turn pockets and left turn phasing (if pursued) will change the queue calculations.

4.8.9 Trail Rd. / F&S Grade Rd. Mini RAB

The traffic analysis at this location does not indicate a left turn lane is warranted for a conventional intersection. At the request of the City, a mini roundabout has been included in the conceptual design. The mini roundabout is presented as an 85 ft. inscribed circle diameter (ICD). The mini roundabout should be further evaluated for optimum ICD and function in the design phase of the project.



SIGNAL PHASING DIAGRAM

PEDESTRIAN MOVEMENT
PROTECTED VEHICLE MOVEMENT
PERMISSIVE VEHICLE MOVEMENT

EMERGENCY VEHICLE PREEMPTION SCHEDULE

DETECTOR	PHASE
A	2+5
B	4
C	1+6
D	8

OVERHEAD POWER NOTE:

THIS PLAN ASSUMES ALL OVERHEAD POWER LINES WILL BE MODIFIED TO MEET REQUIRED CLEARANCES FROM TRAFFIC SIGNAL/ILLUMINATION EQUIPMENT.

VEHICLE DETECTION NOTE:

ALL ADVANCE VEHICLE DETECTOR LOOP LOCATIONS ARE APPROXIMATE. EXACT LOCATIONS WILL BE DETERMINED DURING DETAILED DESIGN.

SIGNAL DISPLAY SCHEDULE

SIGNAL DISPLAY NOTES:

1. ALL VEHICLE SIGNAL HEADS SHALL BE CONVENTIONAL HEADS WITH ALL LED INDICATIONS, TUNNEL VISORS AND BACKPLATES. ALL MAST ARM–MOUNTED HEADS SHALL USE MOUNTING TYPE M. USE J–75 SERIES STANDARD PLANS.
2. ALL PEDESTRIAN SIGNAL HEADS SHALL BE COUNTDOWN TYPE AND HAVE LED SYMBOLIC LEGENDS AND 'Z' CRATE VISORS. HEADS 28,48,68,88 SHALL USE MOUNTING TYPE D. HEADS 29,49,69,89 SHALL USE MOUNTING TYPE E. USE STANDARD PLAN J–75.10–00.

Figure 4.8.8

PRELIMINARY - NOT FOR CONSTRUCTION

DRAWN	RMH				
DESIGNED	RMH				
CHECKED	11/22/19 RMH				
PROJ. ENGR.					
DRAWING FILE	TS.DWG				
		DATE	REVISION	BY	APP'D

FOR:
REICHHARDT & EBE ENGINEERING, INC.
423 FRONT ST.
LYNDEN, WA 98264

ROBERT MARTIN HERMAN — STATE OF WASHINGTON — 30730 — REGISTERED PROFESSIONAL ENGINEER
11-22-19

HTE HERMAN TRAFFIC ENGINEERING, INC.
11215 Southeast 220th Place, Kent, Washington 98031
253-236-4941 tel. hte@comcast.net

CITY OF SEDRO–WOOLLEY WASHINGTON
COOK RD. / TRAIL RD.
TRAFFIC SIGNAL SYSTEM CONCEPT

TS2
SHEET OF SHEETS

4.9 Street Lighting and Landscaping

4.9.1 Street Lighting

Some street lighting presently exists as cobra heads attached to wood poles on Jones Rd. as well as John-Liner Rd. We recommend that the City work with Puget Sound Energy, Pole Services (Formerly IntoLight) to review existing and desired lighting levels and add additional lighting where necessary, especially at intersections.

As newly constructed streets, Puget Sound Energy Pole Services can also review proposed designs to provide standalone lighting on steel, fiberglass, or precast concrete poles. Again, lighting levels can be tailored for the particular design. Typically, conduit, junction boxes and street light tubes are installed by the contractor during construction. After construction is complete or nearly complete, PSE then sets the street light poles, installs the necessary wiring and energizes the system.

4.9.2 Landscaping

Somewhat minimal landscaping is anticipated within the project corridor. It is anticipated that where present, buffers will be landscaped with lawn and street trees can be planted if desired, taking into consideration the presence of overhead power lines. Where street trees are planted, the use of a root barrier is recommended to prevent future damage to adjacent pavement and sidewalks.

Roundabout central islands are all anticipated as fully mountable and thus no significant landscaping is anticipated.

Landscaping typical of residential development is preset within the corridor. Future designs should account for restoration of lawn and planter beds that will be impacted by the roadway improvements. Notes should be taken if existing irrigation systems exist within the right of way which may be impacted by proposed improvements. Residential irrigation systems which are known or suspected to be impacted by the proposed improvements are often best dealt with on a time and materials basis for repair and testing as system design and function is often not well documented or available to the designers.

5. BNSF Railway

Of the 8 total projects making up the Jones / John-Liner / Trail Rd. Corridor, the priority project necessary for making the initial east-west connection is project C1B, the Jones / John-Liner BNSF Undercrossing. Completion of this segment of the corridor will open access to the existing Jones Rd. and John-Liner Rd. between N. Township St. (SR9) and F&S Grade Rd.

5.1 Existing Conditions

At the proposed location of the BNSF undercrossing, the BNSF railroad tracks are elevated on a fill embankment approximately 23 ft. above the surrounding grade. The tracks cross the proposed extension of Jones and John-Liner Rd. at an approximate 10-degree skew angle.

Figure 5.1: BNSF RR Grade, From Jones Rd. Looking East

Sapp Rd. extends approximately 450 ft. north of Jones Rd. on the west side of the tracks, where it crosses under the BNSF railroad tracks at an existing wood trestle. The Sapp Rd. crossing is a single lane stop controlled crossing. Brickyard Creek also passes under the tracks at the trestle.

5.2 Scope and Basis of Design

The Union-Pacific Railroad – BNSF Railway, Guidelines for Railroad Grade Separated Projects was used to help inform the conceptual undercrossing concepts. This scoping study is intended to develop conceptual undercrossing concepts for review and selection of a preferred alternative. The preferred alternative is then submitted to BNSF who will be responsible for the undercrossing superstructure and substructure design and eventual construction, the cost for which will be borne by the City. The City will be responsible for the roadway design and construction through the undercrossing.

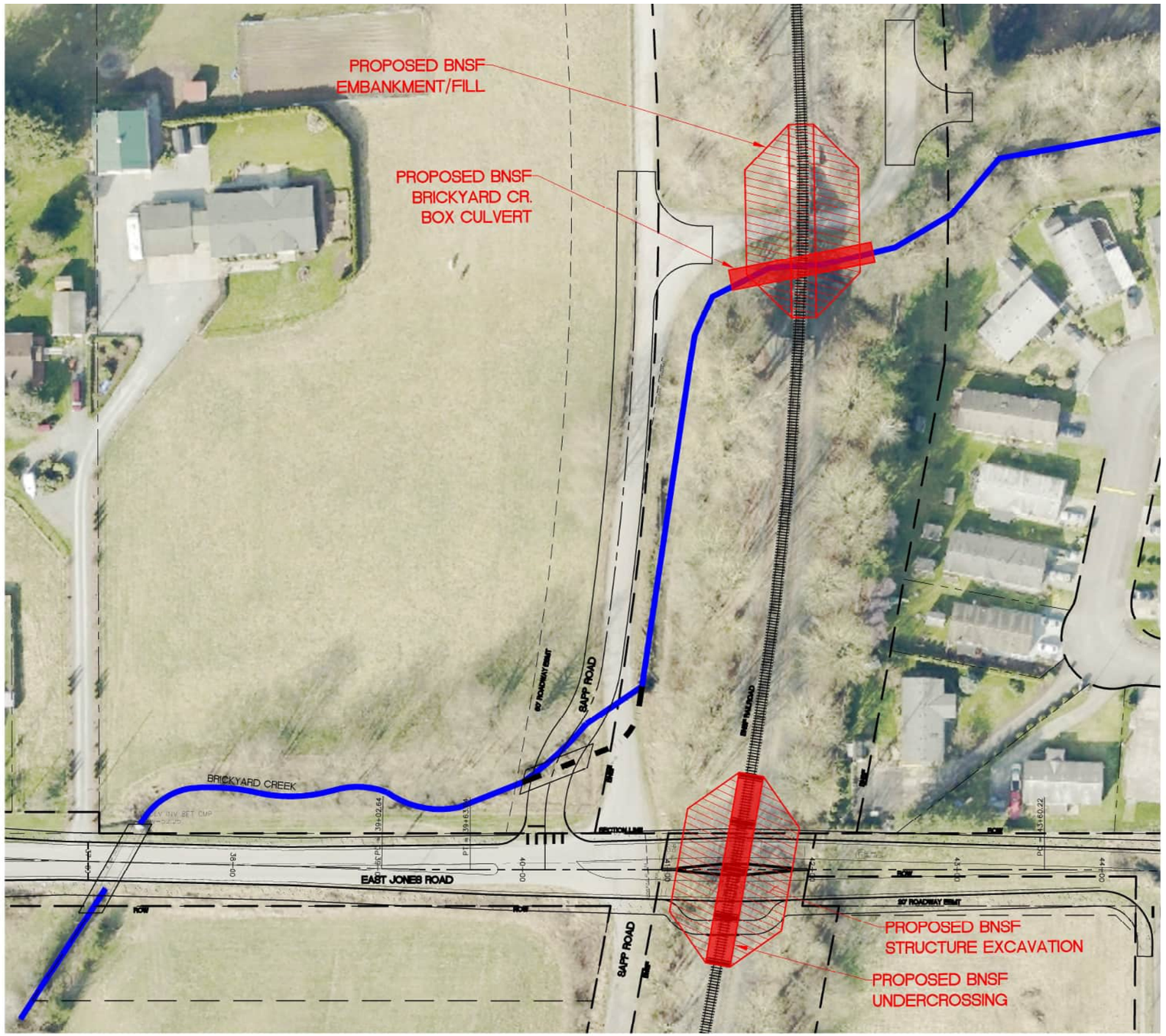
Based on preliminary conversations with BNSF through scoping study team member Widener & Associates, the working concept will be that material excavated for the proposed undercrossing at Jones Rd. will remain in the BNSF right of way and will be used to create the fill embankment when closing Sapp Rd., at the existing wood trestle. This work would then include the installation of a culvert where Brickyard Creek crosses the BNSF tracks at the trestle. See Figure 5.2.

GRAPHIC SCALE

40 0 20 40

(IN FEET)

1"=40' (22x34), 1"=80' (11x17)



NATHAN J. ZYLSTRA
STATE OF WASHINGTON
41884
REGISTERED
PROFESSIONAL ENGINEER

PRELIMINARY

Figure 5.2

DESIGNED BY	IDH/OAM
DRAWN BY	IDH/OAM
CHECKED BY	NZ

R&E Reichhardt & Ebe ENGINEERING INC
P.O. Box 978 | 423 Front Street
Lynden, WA 98264 (360) 354-3687

CITY OF SEDRO WOOLLEY
325 METCALF STREET
SEDRO WOOLLEY, WA 98284

JONES / JOHN-LINER / TRAIL RD CORRIDOR
SCOPING STUDY
BNSF UNDERCROSSING

DWG 18002 PROBASE
DATE 1/31/2019
JOB # 18002
SCALE H: 1"=40' N/A
SHEET 1 of 1

5.3 Horizontal and Vertical Alignment

Because of the 10-degree skew angle between the roadway and the tracks, some initial effort was spent to explore options to realign the roadway for a more perpendicular crossing to the tracks. This was driven by the relatively short 32 ft. standard span length for BNSF structures in an attempt to maximize the roadway improvements beneath a single span.

It was quickly realized that realignment of the roadway resulted in significant right of way impacts with minimal realized benefit, and thus the roadway alignment will remain in the existing available right of way to the maximum extent possible crossing the tracks at the existing skew angle.

The existing tracks are elevated above the surrounding grade by approximately 23 ft. In accordance with WSDOT Design Manual Chapter 720.03(5), the minimum vertical clearance for a new bridge over a roadway is 16.5 ft., leaving approximately 6.5 ft. of available superstructure depth from top of rail to low chord. Ultimately additional survey, design level roadway profile, and preliminary superstructure depth should be developed to confirm the required minimum vertical clearance can be met.

5.4 Structure Alternatives

The scoping study team reviewed 3-span and 4-span superstructure options to accommodate the proposed new roadway, concepts of which are shown in Figure 5.4.1. A 4-span option is used to place one travel lane within one single shorter span, leaving the two outer approach spans to contain the embankment fill and pedestrian or multimodal facilities. A 3-span option would be a more conventional option where the travel lanes are both within one single larger center span and the approach spans contain the embankment fill and pedestrian or multimodal facilities.

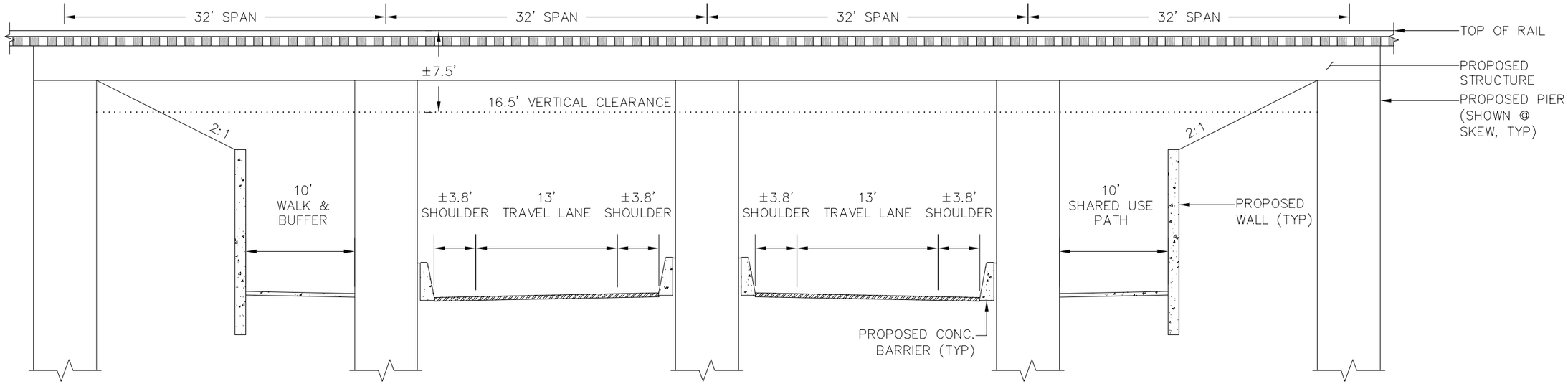
The skew angle of the roadway to the tracks causes additional complications in that the structure abutments or piers are presumed to also be skewed to the roadway. Hence what may be a relatively slender pier becomes wider relative to passing traffic. Superstructure piers also require added protection from errant vehicles in the form of guardrail or concrete barrier. As shown in Figure 5.4.1, consideration needs to be given to the additional guardrail or concrete barrier that may be necessary in a 4-span structure in order to protect the piers, whereas the amount of pier protection necessary in a 3-span structure may be reduced.

The site is further complicated by the location of Sapp Rd. to the proposed undercrossing. As shown in Figure 5.4.2 sufficient sight distance must be provided to accommodate safe movements from Sapp Rd. onto Jones Rd. The sight distance may be limited by the embankment fill within the approach spans.

Ultimately the scoping study team settled on a proposed 4-span structure alternative which utilizes standard 32 ft. span superstructure as depicted in Figure 5.4.3. The 4-span structure provides adequate sight distance for turning movements from both Sapp Rd. and Patrick St., while minimizing the pier protection barrier needed in the roadway. The northern most approach span contains only the embankment fill while the southern approach span contains the embankment fill and accommodates the shared use path by utilizing a retaining wall. This configuration is reflected in the conceptual design drawings within this report.

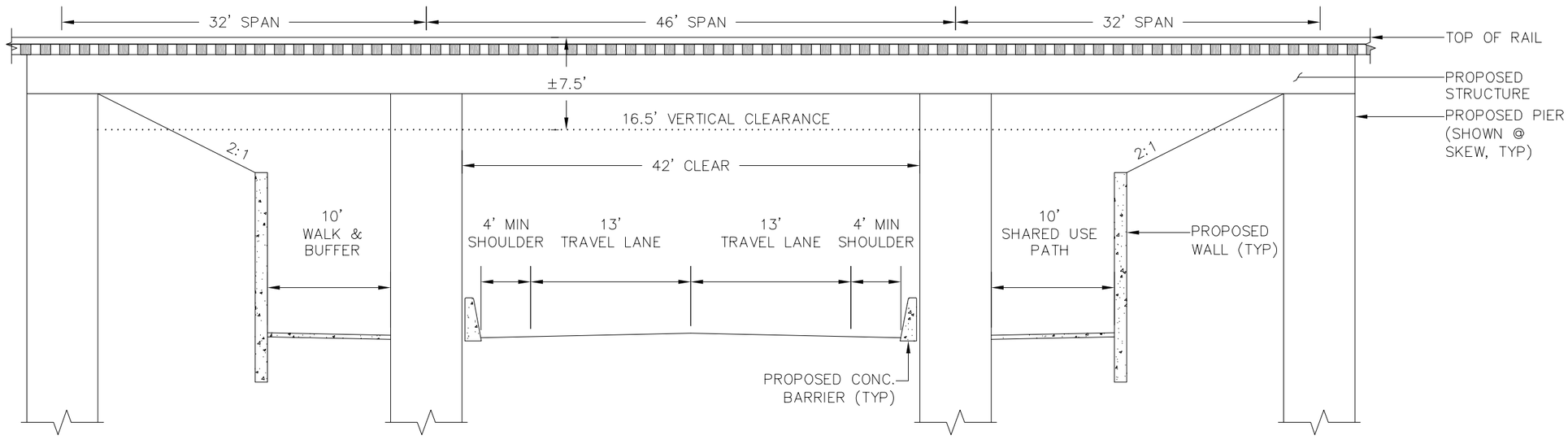
In recent coordination with BNSF, the City has provided the conceptual design plans, geotechnical information gathered during the course of this scoping study and topographic survey gathered as a part of

supplemental agreement no. 1 to this scoping study. We understand that recent discussion has occurred whereby a 3-span structure with a longer center span may be explored. We agree that the 3-span structure should be explored in more detail evaluating available standard span lengths, sight distance for Sapp Rd. and Patrick St.



4-SPAN CONCEPTUAL SECTION

NTS



LONGER CENTER SPAN CONCEPTUAL SECTION

NTS

NATHAN J. ZYLSTRA — STATE OF WASHINGTON — 41884 — REGISTERED PROFESSIONAL ENGINEER — PRELIMINARY

Figure 5.4.1

DESIGNED BY	IDH/OAM
DRAWN BY	IDH/OAM
CHECKED BY	NZ

Reichhardt & Ebe ENGINEERING INC
P.O. Box 978 | 423 Front Street
Lynden, WA 98264 (360) 354-3687

NO.	DATE	DESCRIPTION	BY

CITY OF SEDRO WOOLLEY
325 METCALF STREET
SEDRO WOOLLEY, WA 98284

JONES / JOHN-LINER / TRAIL RD CORRIDOR
SCOPING STUDY
ALTERNATE SECTIONS

DWG 18002 DETAILS			DATE 10/19/2018
JOB# 18002	SCALE H: N/A V: N/A		SHEET 1 of 1

P:\Projects\18002\Civil 3D 2015\18002 DETAILS.dwg, Alternate Sections, 11/20/2018 4:39:18 PM

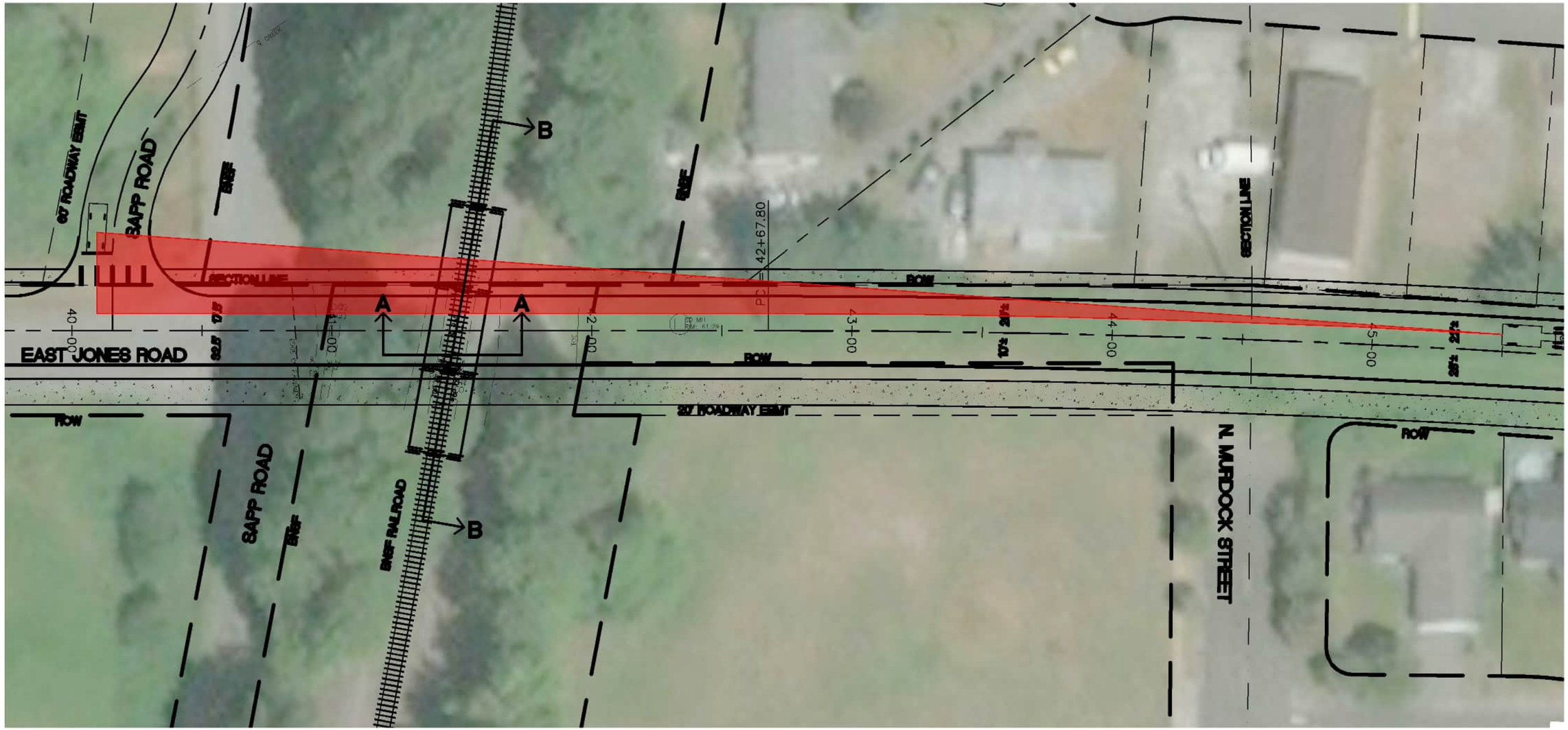


Figure 5.4.2

DESIGNED BY	IDH/OAM
DRAWN BY	IDH/OAM
CHECKED BY	NZ

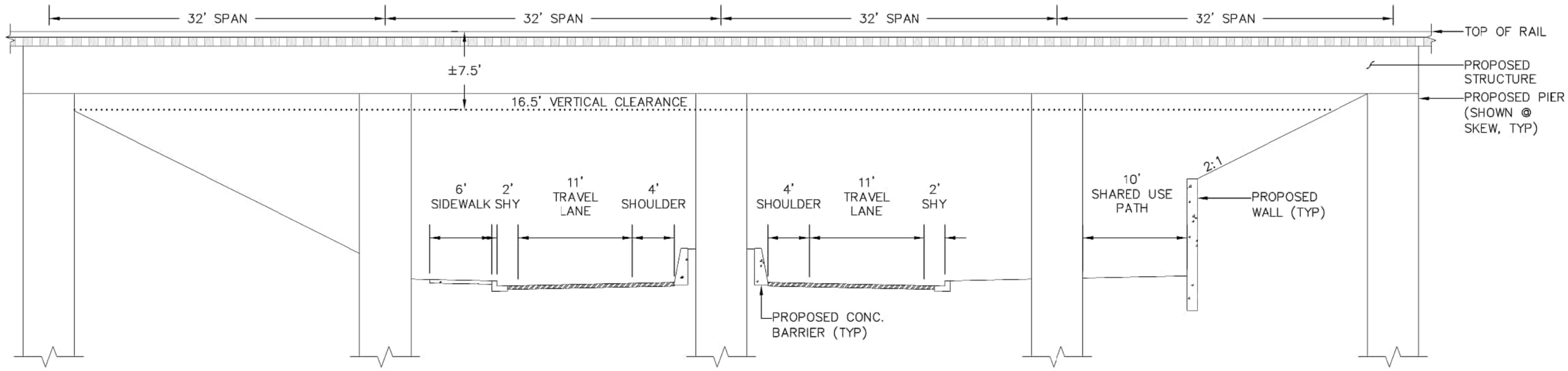
R&E Reichhardt & Ebe ENGINEERING INC
P.O. Box 978 | 423 Front Street
Lynden, WA 98264 (360) 354-3687

CITY OF SEDRO WOOLLEY
325 METCALF STREET
SEDRO WOOLLEY, WA 98284

JONES / JOHN-LINER / TRAIL RD CORRIDOR
SCOPING STUDY
CONCEPTUAL PLAN VIEW

DWG	18002 PROBASE
DATE	10/17/2018
JOB #	18002
SCALE	H: N/A V: N/A
SHEET	1 of 2

P:\Projects\18002\Civil 3D 2015\18002 PROBASE.dwg, Conceptual Plan View, 10/19/2018 1:24:24 PM



4-SPAN CONCEPTUAL SECTION

NTS

Figure 5.4.3

DESIGNED BY	IDH/OAM
DRAWN BY	IDH/OAM
CHECKED BY	NZ

R&E Reichhardt & Ebe ENGINEERING INC
P.O. Box 978 | 423 Front Street
Lynden, WA 98264 (360) 354-3687

NO.	DATE	DESCRIPTION	BY

CITY OF SEDRO WOOLLEY
325 METCALF STREET
SEDRO WOOLLEY, WA 98284

JONES / JOHN-LINER / TRAIL RD CORRIDOR
SCOPING STUDY
BNSF ALTERNATE SECTIONS

DWG 18002 DETAILS			DATE 10/30/19
JOB# 18002	SCALE H: N/A V: N/A		SHEET 1 of 1

P:\Projects\18002\Civil 3D 2015\18002 DETAILS.dwg, 10/30/2019 3:45:28 PM

6. Geotechnical Considerations

Geotechnical analysis for the scoping study was performed by GeoEngineers and is summarized below. Initially the geotechnical scope of work was limited to the review of available geotechnical information in the area. The scope of services was later expanded based on potential future private development of Patrick St. and the surrounding property. The memorandum "Existing Information Review and Preliminary Project Considerations, Jones John-Liner Trail Road Corridor Study" is contained in Appendix F. The draft geotechnical report "Jones John-Liner Trail Road Corridor, Patrick Street Extension" is contained in Appendix G.

6.1 Existing Information Review and Preliminary Project Considerations

GeoEngineers reviewed seven existing geotechnical reports or letter reports for projects within the area of interest. The reports are dated between 1998 and 2010.

The typical subsurface conditions consisted of fill soils overlying lahar deposits and alluvium. Where fill is present, the thickness can be variable and will depend on historical land use. In the explorations reviewed, granular fill was encountered extending 1 to 4 ft. below the existing ground surface (bgs) with localized areas with greater thicknesses or areas with little or no fill encountered (Geo June 2019). Previous utility excavations in the corridor have encountered logs during excavation. As such, areas of deeper exploration should be thoroughly investigated prior to construction.

Groundwater was typically encountered between 4 and 15 ft. bgs, with seasonal fluctuation in the range of 7 ft. Structures such as bridges and the BNSF undercrossing are likely to required piles or ground improvement to support the proposed structures.

Roadway subgrade conditions should be expected to be variable. Most areas will require removal of unsuitable surface soils including topsoil and organic materials. Existing roadway sections should be investigated further to verify the pavement, base and subbase materials and thickness. New roadway sections should utilize a geotextile fabric for separation, along with a free draining base material, crushed surfacing and pavement section.

Below grade utilities located within the corridor may encounter variable subgrade conditions. Dewatering will be required depending on the depth of the utility and due to the variable subgrade conditions backfill with imported granular material may be required, especially beneath roadway sections. Groundwater conditions should be expected to vary throughout the corridor and the need for dewatering will depend on the time of year for construction and the proposed depth of the utility.

Relatively shallow groundwater table and variable subgrade soils will limit effective infiltration rates and function for low-impact development (LID) stormwater management methods. The Washington Department of Ecology's Stormwater Management Manual for Western Washington requires a minimum of 5 feet of separation from the seasonal high groundwater table for infiltration facilities. This separation may be reduced to 3 feet if a groundwater mounding analysis is performed. The location of LID stormwater management facilities will likely need to be targeted to specific locations with suitable subsurface soil and groundwater conditions.

Future geotechnical investigations will be necessary within the project corridor including at the BNSF undercrossing, all future crossings of Brickyard Creek, at the locations of proposed stormwater facilities, and where limited to no prior geotechnical investigations have been previously performed.

6.2 Patrick St. Extension

On November 22, 2019 GeoEngineers provided a draft geotechnical report for the Patrick St. Extension. The geotechnical analysis included the advancement of two geotechnical borings on September 3, 2019, drilled to depths of 21.5 ft. and 26.5 ft. bgs. Piezometers were installed in the two borings at the time of the explorations. R&E subsequently installed pressure transducer data loggers on September 27, 2019 which are intended to continue recording groundwater data throughout the wet season.

Subsurface soil conditions were consistent with that reported in the existing geotechnical information review. Both borings encountered a sod layer of 2 to 4 inches, below which a reworked loose silty fine to medium sand agricultural layer extending to 1.5 ft. to 2 ft. bgs was encountered. Below the agricultural layer, the borings encountered what was interpreted to be the native lahar/alluvium deposits. The borings were terminated in the lahar/alluvial unit.

Groundwater seepage was observed at 3.5 ft. to 5.5 ft. at the time of drilling. Manual groundwater measurements were taken on October 21, 2019 in borings B-1 and B-2 and were reported at 7.1 ft. and 8.6 ft. bgs respectively. On December 19, 2019 data was collected from the pressure transducer data loggers representing all data recorded between September 27 and December 19, 2019 and is represented graphically in Figures 6.2.1 and 6.2.2. The pressure transducers were reinstalled on December 19 and data will be collected again in the spring of 2020.

The soils encountered in the borings have a low potential for infiltration as they consist of silt, clay and silty sand with high fines content. As discussed in the prior section, separation of infiltration facilities from the seasonal high groundwater table to a minimum of 3 ft. is required with a groundwater mounding analysis. Groundwater data collected between September 27 and December 19, 2019 indicates the groundwater is continuing to rise with the most recent measurements on December 19, 2019 at 2.25 ft. and 6.30 ft. bgs in borings B-1 and B-2 respectively. Due to the soil and groundwater conditions encountered, we do not believe infiltration to be feasible at this site.

Dewatering is anticipated to be necessary for sanitary sewer installation within the Patrick Street Corridor. The draft report presents a discussion on options for dewatering including pumped wells, well points, and open pumping. Ultimately the method for dewatering is best left to the construction contractor and dewatering requirements will vary based on the time of year.

It is anticipated that the Patrick Street roadway section will include the complete removal of the sod and agricultural layer. A woven geotextile fabric for stabilization should be placed over the lahar/alluvial deposits prior to placement of granular structural fill such as gravel base and crushed surfacing, and completed with an appropriate pavement section.

Figure 6.2.1 South Well B-1
Groundwater Level Measurements

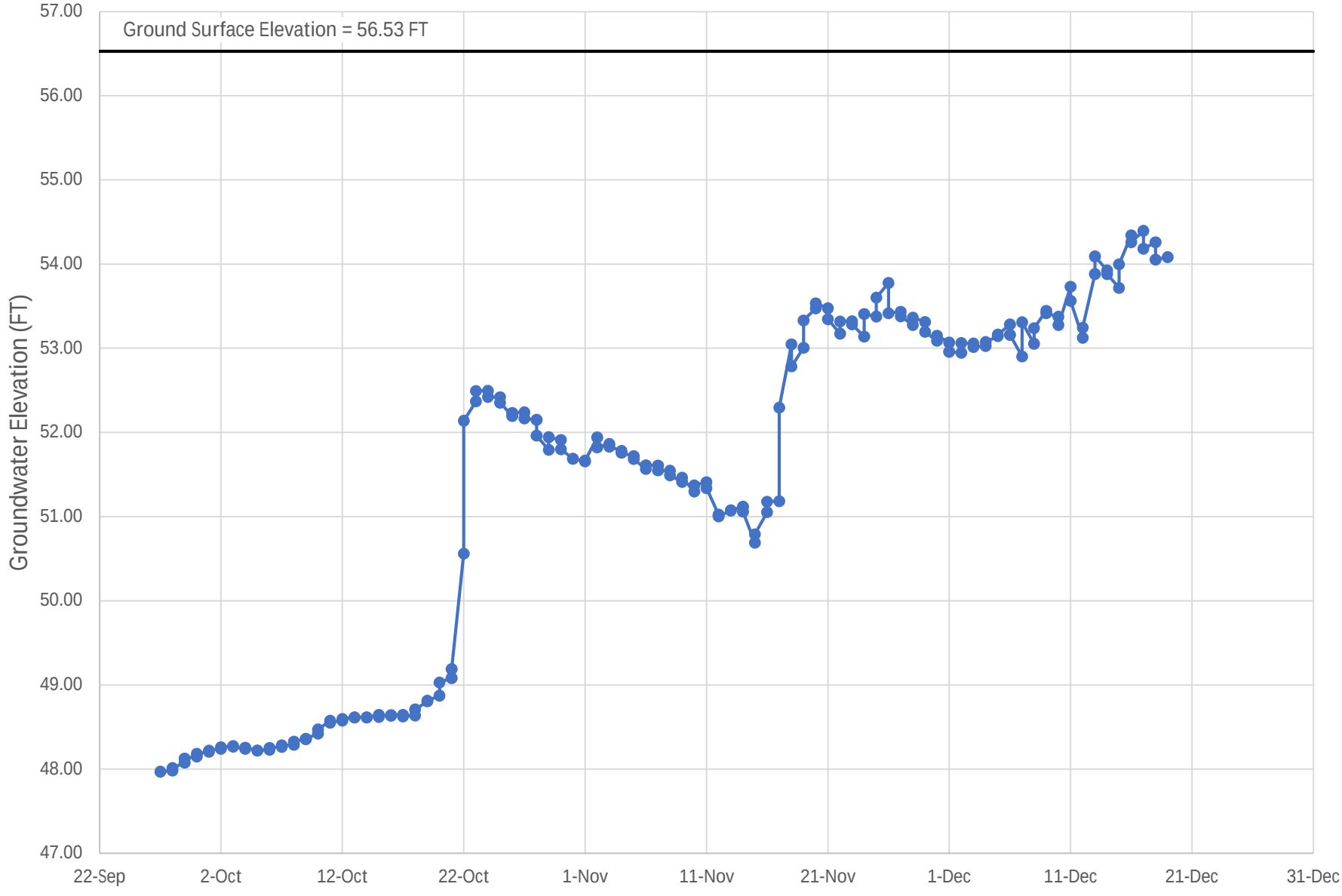
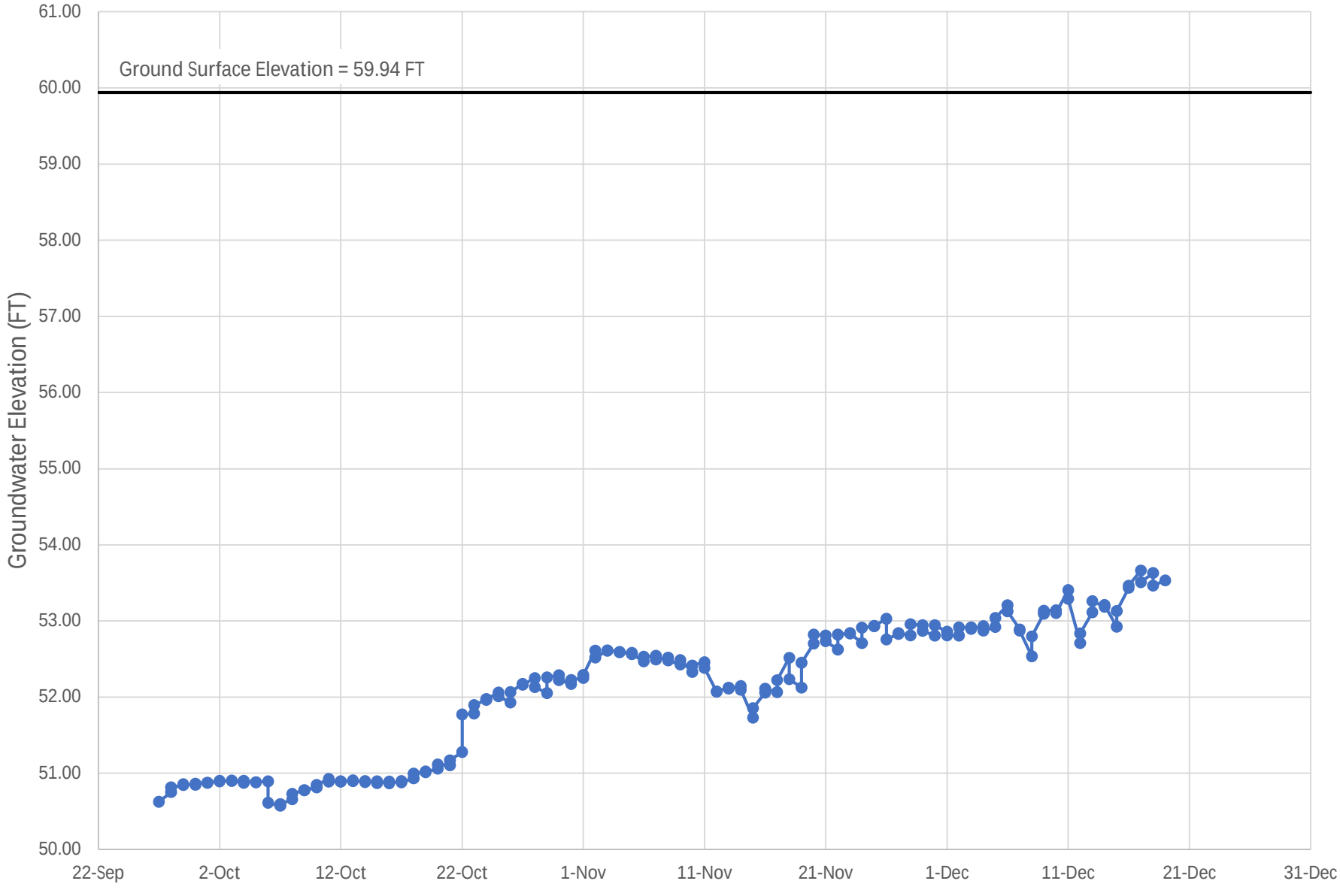


Figure 6.2.2 North Well B-2
Groundwater Level Measurements



7. Right of Way Needs

Based on the existing right of way identified in the project base map and the proposed roadway and intersection alternatives, we identified the right of way needs associated with each segment or alternative for the corridor. The proposed right of way is shown in the conceptual design plans which can be found in Appendix D. In addition, a preliminary right of way plan was developed as a part of the supplemental agreement no. 1 to this scoping study. The preliminary right of way plan is shown in Appendix H.

The preliminary right of way plan identifies in detail the affected parcel by Parcel No., Property Owner, Lot Address, Lot Area, ROW take, Remaining Area, and Easement Area if applicable. The purpose of the preliminary right of way plan is to identify the project right of way needs and to aid in evaluating the anticipated right of way acquisition costs. This right of way plan is preliminary and will need to be updated during the design engineering phase prior to initiating negotiations with property owners as the current conceptual design is based on limited topographic survey, LiDAR, and aerial imagery. Future phases of design engineering will require full topographic survey and will likely result in adjustments to the conceptual design, resulting in the need to update the right of way plan. All property rights are assumed as fee title acquisitions for the purposes of this scoping study. Future phases of work should consider if an easement is a more appropriate means of property rights acquisition in certain situations.

Abeyta & Associates has completed a "Real Property Acquisition Cost Estimate" based on the current right of way plan. Work was performed based on field inspections of each acquisition. Values are based on recent comparable sales and a parcel worksheet has been prepared for each affected parcel. The real property acquisition cost estimate is broken down by project number and provides a comprehensive summary of the acquisition costs for each project within the corridor.

The real property acquisition cost estimate consists of estimated costs as follows:

- Just Compensation – The compensation provided to the property owner.
- Appraisal Fee Cost or AOS – The estimated cost to prepare the required appraisal or the estimated cost to prepare an Administrative Offer Summary (AOS). An AOS is used when the estimated just compensation is less than $25,000.
- Appraisal Review Costs – The estimated cost to prepare the required appraisal review. Note that appraisal review is not required for an AOS.
- Negotiation Fee Costs – The estimated cost to negotiate the acquisition.
- Title, Escrow Costs – The estimated cost of title and escrow fees.
- Property Management – The estimated property management costs.
- Relocation Services – The estimated cost to prepare a relocation plan.
- Relocation Payments – The estimated cost of required relocation payments to cover the property owners' costs to relocate.
- Condemnation Contingency – The estimated cost of condemnation should negotiations fail.
- Offer Evaluation Fee Per RCW 8.25.020 – Referred to as the statutory evaluation allowance, this is an allowance provided to each property owner to offset the costs of legal, appraisal, or other permitted costs to assist the owner in evaluating the offer for just compensation.

The real property acquisition cost estimate and parcel worksheets are included in Appendix I along with comparable sales information. The costs presented in Appendix I are included in the project cost estimates discussed in Section 11 and assume City acquisition of all subject property rights at current market value.

Highlights of the right of way acquisition are as follows:

- There are right of way takes from 27 individual parcels, some under common ownership.
- The total area of acquisition is 544,882 square feet or 12.51 acres.
- There are two complete residential takes, one for Trail Rd. south of F&S Grade Rd. and one for the N. Township St. (SR9) / John-Liner roundabout.
- There is one complete commercial property take for the Patrick St. extension. There are no relocations associated with this take and it may be viewed as a larger parcel since it is under common ownership as the adjacent parcel.
- The total estimated acquisition costs including relocation benefits, cost to cure, and right of way consultant is $6,379,875.

Right of way acquisition represents a significant project cost as well as significant project risk in terms of time for acquisition and negotiation with third party entities. As such, right of way acquisition should be minimized or avoided if and where possible. The cost for right of way acquisition can be reduced in cases where proposed land use actions may require the dedication of right of way to the City as a condition of development.

8. Stormwater / Drainage

8.1 Stormwater Comprehensive Plan

The 1997 City of Sedro-Woolley Stormwater Comprehensive Plan was used to aid in the evaluation of stormwater and drainage within the project corridor. The plan identifies the existing stormwater conveyance deficiencies, such as Brickyard Creek's limited capacity. It also provides sub-basin areas and existing stormwater drainage patterns.

8.2 Stormwater Management

We have delineated five sub-basins in which the proposed transportation improvement projects are located. These five sub-basins determine the drainage patterns of each of the 8 proposed project areas. As shown in Appendix J, the drainage patterns for each project site determines the Threshold Discharge Areas (TDAs) of the project.

Table 9.2 shows each project area, the TDAs associated with it, and what Minimum Requirements are required per the Washington State Department of Ecology 2014 Stormwater Management Manual for Western Washington (2014 SWMMWW). Minimum Requirements for each TDA were determined using the flow charts provided in Figures I-2.4.1 and Figure I-2.4.2 of the 2014 Stormwater Management Manual for Western Washington (2014 SWMMWW). Each TDA's land use quantities and flow charts are provided in Appendix K, Stormwater Minimum Requirements.

Table 9.2: Minimum Requirements

			>35% Ex Imp Coverage?				>50% Added to Ex HS?		Mitigation Requirements		Minimum Requirement #5	
Project	TDA	Existing Impervious	% Ex Imp.	Yes or No	New Hard Surface	New + Replaced Hard Surface	% HS Added	Yes or No	New or N&R	Minimum Requirements	List #1	List #2
C1A - Jones Rd	1	109,378	45.6%	Yes	16,643	126,021	15.2%	No	New	1-9		X
	2	38,070	57.7%	Yes	10,194	48,264	26.8%	No	New	1-9		X
C1B - RR Undercrossing	1	29,165	25.6%	No	12,200	41,365	41.8%	No	N&R	1-9		X
	2	7,226	11.6%	No	44,432	51,658	614.9%	Yes	N&R	1-9		X
C1D - John-Liner Rd	1	49,530	50.9%	Yes	22,363	71,893	45.2%	No	New	1-9		X
C3 - Cook Rd Intersection	1	68,674	71.6%	Yes	4,370	73,044	6.4%	No	N&R	1-5	X	
	2	8,466	74.0%	Yes	309	8,775	3.6%	No	N&R	1-5	X	
C9A - Trail Rd (F&S to Cook)	1	20,914	15.9%	No	48,819	69,733	233.4%	Yes	N&R	1-9		X
C9B - Trail Rd (Jones to F&S)	1	4,487	7.2%	No	35,428	39,915	789.6%	Yes	N&R	1-9		X
C19 - Patrick St	1	-	0.0%	No	5,040	5,040	100.0%	Yes	N&R	1-9		X
	2	4,062	4.1%	No	50,865	54,927	1252.2%	Yes	N&R	1-9		X
S17 - SR9 Intersection	1	36,930	70.3%	Yes	285	37,215	0.8%	No	N&R	1-5	X	
	2	8,851	62.0%	Yes	624	9,475	7.1%	No	N&R	1-5	X	

Six of the proposed projects (C1A, C1B, C1D, C9A, C9B, and C19) must meet Minimum Requirements 1-9, which means treatment and flow control are required. For these projects, List #2 of the 2014 SWMMWW was utilized to determine which BMPs are feasible. Two projects (C3 and S17) only have to meet minimum requirements 1-5, which does not include treatment or flow control. List #1 of the 2014 SWMMWW was utilized to determine which BMPs are feasible.

Please note, the minimum requirements for both intersection projects (C3- Cook Rd Intersection and S17-SR9 Intersection) were based off of the roundabout designs for the intersections. Minimum requirements may differ for the alternative intersection designs.

BMP's from List #1 and #2 have been condensed below. Please note, no Roof BMPs are listed below because there are no roofs proposed for any of these road project areas.

BMPs from List #1 and List #2

BMP T5.11: Concentrated Flow Dispersion

This BMP is infeasible for all of the proposed projects because there is inadequate space for the vegetative flow path within the ROW of each project.

BMP T5.12: Sheet Flow Dispersion

This BMP is infeasible for all of the proposed projects because there is inadequate space for the vegetative buffer within the ROW of each project.

BMP T5.13: Post-Construction Soil Quality and Depth

This BMP is feasible and will be applied to all the proposed projects.

BMP T5.14: Rain Gardens

Rain Gardens are not feasible for projects that must meet minimum requirements #1-9. Rain Gardens were considered for the two projects that must meet minimum requirements #1-5, but were found infeasible due to uncertainty of infiltration capacity and groundwater elevations on each project site.

BMP T5.15: Permeable Pavement

Permeable pavement is infeasible for all of the proposed projects due to uncertainty of infiltration capacity and groundwater elevations on each project site.

BMP T5.30: Full Dispersion

Full dispersion is infeasible for all of the proposed projects because there is inadequate space for the vegetative buffer within the ROW of each project.

BMP T7.30: Bioretention

Bioretention is infeasible for all of the proposed projects due to uncertainty of infiltration capacity and groundwater elevations on each project site.

When determining Minimum Requirements for each project area, it was assumed each project would be built independently from neighboring projects. If neighboring project areas are designed and constructed together in the future, it should be noted that some minimum requirements may change. For example, if projects C1A (Jones Rd) and C9B (Trail Road – Jones to F&S) are built together both project areas would be required to follow MR#1-9 for all new hard surfaces. This doesn't change the minimum requirements for Project C1A, but changes the minimum requirements for Project C9B (from N&R 1-9 to New 1-9). There are several more scenarios just like this. Some potential areas of concern have been identified and are addressed in the "Potential Complications to Mitigation Requirements" document and calculations provided in Appendix K.

8.2.1 Traffic Analysis Report

TSI's traffic analysis includes traffic demand predictions for the 2036 full build design year. The average daily traffic (ADT) volume forecast for each end of the corridor is 7,000 vehicles per day (vpd) on Trail Road north of the Cook Road intersection, as well as 6,300 vpd on John-Liner Road west of the SR9 intersection. Both of these predicted ADT volumes are less than the 7,500 vpd threshold for enhanced treatment given in Vol. V, Section 2.1 of the 2014 SWMMWW, thus requiring a basic treatment level. See Appendix B for TSI's Traffic Analysis.

8.2.2 Geotechnical Report

The Existing Information Review and Preliminary Project Considerations Memorandum provided by GeoEngineers, Inc. compiles geotechnical information from several nearby projects (See Appendix F). The

geotechnical memorandum suggests that point-source infiltration systems be used when feasible. However, due to the potential for high groundwater and the limited subsurface soils information, including infiltration information for all the project areas, infiltration facilities should be considered on a project-by-project basis during the design engineering phase.

Also included in Appendix G is a Geotechnical Report for the Patrick Street Extension project. This Geotechnical Report has similar conclusions to the Existing Information Review Memorandum mentioned above, but focuses only on the Patrick Street project area. It is found that the groundwater is high and the soils are not suitable for treatment or infiltration, and concludes that "on-site infiltration of stormwater in below-grade facilities will likely not be feasible at the site".

Due to the scoping nature of this study, we do not have all the project-by-project groundwater levels and infiltration rates, and therefore, do not know that infiltration and bioretention systems would work for each project. However, we are certain that combined detention/wetpool ponds would work on-site if the bioretention facilities are found to be infeasible after further analysis of each project area. We have decided to move forward with the conservative assumption that combined detention/wetpool ponds will be used across the whole scoping area, and encourage a full geotechnical evaluation of each project site in the future to determine feasibility of infiltration and LID facilities.

8.2.3 Combined Detention / Wetpool Ponds

There is a total of 6 proposed combined detention/wetpool ponds. The size and placement of all 6 ponds allows for the appropriate detention and/or treatment of the stormwater runoff from all 8 projects. The project areas draining to each pond are shown in Table 8.2.3.

Table 8.2.3: Pond Areas and Dimensions

	Area Flowing to Pond (AC)	Pond Depth (FT)	Top of Pond Width (FT)	Top of Pond Length (FT)	Pond Top Area + 20% (SF)	Pond Top Area + 20% (AC)
Pond #1	6.95	10.75	125.98	295.03	44601.57	1.02
Pond #2	1.51	10.75	53.25	90.07	5756.12	0.13
Pond #3	9.50	10.75	160.05	391.05	75104.34	1.72
Pond #4	0.56	10.75	40.45	53.99	2620.70	0.06
Pond #5	2.47	10.75	66.00	126.00	9979.96	0.23
Pond #6	2.25	10.75	63.07	183.32	13873.47	0.32

Due to the scoping nature of this project, Pond #5 was sized via WWHM 2012 (see Appendix L), but the other 5 ponds were sized assuming a linear relationship between the flow demand and dimensions of Pond #5 and applying that same ratio to each pond. For example, to size Pond #1, we compared Pond #1's flow demand (Area flowing to the Pond) to Pond #5's flow demand, then applied that ratio to find Pond #1's dimensions compared to the dimensions of Pond #5.This method of sizing each pond is an efficient way to find the approximate necessary size of each pond. However, due to the approximate nature of this strategy, 20% was added to each pond top area (as shown in Table 9.2.3) as a factor of safety.

It has been assumed pump systems will be necessary for the detention/wetpool storm facilities due to the lack of gradient between the pond and outfall. With pump systems utilized to transport the stormwater from the ponds to the outfalls, it is assumed each pond will have 1 foot of sediment storage, 4.25 feet of retention (Water Quality), 4.5 feet of detention, and 1 foot of freeboard, for a total pond depth of 10.75 feet with 3:1 side slopes. By utilizing pumps and a deep pond depth, we are able to minimize the estimated

ROW acquisition area for the storm pond facilities. The ROW acquisitions are addressed in Section 7 of this report.

8.3 Drainage and Stormwater Conveyance

For all projects in the corridor, we propose stormwater be collected via conventional gravity stormwater pipe and catch basin networks and transported to the appropriate stormwater treatment/flow control facilities, before being pumped to an outfall.. Pumping post developed mitigated stormwater flows from the ponds will also be more cost effective than pumping post developed unmitigated flows to the ponds both in terms of initial capital cost and ongoing operational costs. Ponds have been cited near the outfall locations in an attempt to take advantage of the natural gradient toward the pond and to minimize the pumped distance from the pond to the outfall.

Please note, stormwater from projects east of the railroad will be routed, via gravity, under the proposed railroad undercrossing into Pond #3 and pumped into Brickyard Creek. These project areas currently flow south along the railroad to an outfall into Brickyard Creek at F&S Grade Road. See the Brickyard Creek Hydraulic Review Technical Memo provided in Appendix M for the flow analysis and discussion of this outfall adjustment into Brickyard Creek.

The City of Sedro Woolley Public Works Department Standards (SWPWDS) state “Storm pipe within the public right-of-way shall be a minimum of twelve-inch (12”) diameter. Eight-inch (8”) diameter may be permitted on cross street laterals…” For each of the projects, it is assumed either 12-inch or 24-inch storm sewer pipes will be utilized for the main line, and 8-inch storm sewer pipes will be utilized for the cross-street laterals.

The SWPWDS also states “Catch basins shall be spaced no greater than one-hundred fifty feet (150’) for gutter grades less than one percent (<1%)”. It is assumed that the project areas are flat enough to warrant less than 1% gutter grades in most areas, and therefore it was assumed a Type 1 or Type 2 catch basin is necessary every 150 feet of roadway.

For the purpose of this study, it is assumed that runoff from all impervious areas created (new or replaced) will be directed to the proposed stormwater facilities via conventional gravity stormwater conveyance networks. Any other methods of drainage such as existing stormwater conveyance networks, were not considered, and would need to be evaluated for feasibility on a project-by-project basis.

9. Utilities

9.1 Franchise Utilities

Franchise utilities known to be within the project corridor are listed below and include:

- Puget Sound Energy – Power
- Puget Sound Energy Pole Services - Illumination
- Comcast Cable – TV, Internet, and Phone
- Frontier Communications – TV, Internet, and Phone
- Cascade Natural Gas – Natural Gas
- Public Utility District No. 1 of Skagit County (Skagit PUD) – Potable Water

A cursory search of other franchise utilities which may be located or may wish to service the corridor include:

- Wave Broadband
- Century Link

Dry utilities within the existing portions of Jones and John-Liner Rd. are located overhead. Cascade Natural Gas and Skagit PUD are both buried within the existing right of way. All franchise utilities are anticipated to be located underground within or adjacent to the proposed new Patrick St. and Trail Rd. Often such utilities are located within a dedicated easement adjacent to the right of way if a sufficient corridor is not available within the proposed right of way.

It is our experience that franchise utilities such as power, natural gas, and communications don't typically install new infrastructure within a roadway corridor unless there is a demand from a paying customer. Costs for franchise utilities are not accounted for in the project cost estimates with the exception of illumination.

As noted in Section 4.9, illumination is anticipated to be added to existing wood poles on Jones Rd. and John-Liner Rd., while new standalone illumination poles and luminaires are anticipated to be installed on Patrick St. and Trail Rd., the cost of which are included in the project cost estimates and which are anticipated to be borne by the City.

9.2 Sanitary Sewer

This sanitary sewer evaluation is based on the City of Sedro-Woolley 2005 Comprehensive Sewer System Plan (Comp. Plan). The Comp. Plan can be found on the City of Sedro-Woolley website: https://www.ci.sedro-woolley.wa.us/departments/engineering/wastewater.php

An update to the Sewer System Plan is currently in progress and is anticipated to be complete in 2020. The updated Sewer System Plan should be consulted in future stages of design to ensure the proposed projects follow the recommendations of the updated plan.

Figure 9.2 indicates the proposed sanitary sewer system improvements associated with the corridor improvements and which are described in further detail below. The proposed sanitary sewer conveyance

system layout including anticipated rim and invert elevations is contained in the conceptual design plans in Appendix D. Sewer system conveyance design criteria are in accordance with Washington State Department of Ecology, Criteria for Sewage Works Design, August 2008, and the City of Sedro-Woolley Public Works Department Standards, Updated 3/6/2017.

CITY OF SEDRO-WOOLLEY
GATEWAY TO THE NORTH CASCADES

2005 Comprehensive Sewer System Plan Map

Legend

- 3 — PROJECT NUMBER
- PS — PROPOSED PUMP STATION
- PROPOSED MAINS
- SEWER CLEAN OUTS
- SEWER MANHOLES
- SEWER SYSTEM PIPES
- PS — EXISTING PUMP STATION
- CITY LIMITS
- UGA
- COLLECTION SYSTEM SUB-BASINS

PACE Pentlington Associates Consulting Engineers, Inc.

EXISTING SEWER EXTENSION TO CAMBRIDGE COURT

PROJECT C1B, JONES ROAD SEWER EXTENSION

PROJECT C9B, TRAIL ROAD SEWER EXTENSION

PROJECT C9A, TRAIL ROAD SEWER EXTENSION NORTH OF BRICKYARD CREEK

PROJECT C9A, TRAIL ROAD SEWER EXTENSION SOUTH OF BRICKYARD CREEK

PROJECT C19, PATRICK STREET SEWER EXTENSION

Mountain View Pump Station
John Liner Rd Pump Station
West Jones Rd Pump Station
Klinger Street Pump Station
Cook Rd. Pump Sta.
Hodgin Rd Pump Sta
West State St. Pump Station
Holtcomp Pump Station
Wastewater Treatment Plant
WTP

Alternative

SKAGIT RIVER

N W E S

0 1,000 2,000 4,000 Feet

Figure 9.2

9.2.1 John-Liner Road (Basin E)

No new sewer was added to John-Liner Road between Reed Street and N. Township Street. The residences in the vicinity of the proposed John Liner Road are currently served with sanitary sewer and no system upgrades are identified in the Comp. Plan. Any proposed development or urban infill is fronted by an existing sewer main providing service to the subject property.

9.2.2 Jones Road (Basin R)

The proposed Jones Road sewer was extended along the centerline of the road from the existing manhole at the intersection of Cambridge Street and Jones Road, east to Brickyard Creek, then extending along the north side of Brickyard Creek terminating near Sapp Rd. The proposed gravity sewer main is estimated as 8-inch polyvinylchloride (PVC), and was designed at minimum slope of 0.004 ft./ft. The new main will flow west to its connection at the Cambridge Street and Jones Road intersection. The proposed sewer is approximately 14 ft. deep at its west connection near Cambridge St. and approximately 8 ft. deep at its east terminus.

9.2.3 Patrick Street (Basin P)

The proposed gravity sewer main is designed as 8-inch PVC at a minimum slope of 0.004 ft./ft. and approximately follows the centerline of the proposed roadway. The proposed sewer flows south to connect to an existing manhole approximately 100 feet north of the Michael Street and Patrick St. intersection. The invert of the existing sewer at the manhole near Michael St. and Patrick St. is only 4 ft. below the rim elevation. Extension of the sewer main by gravity to the north along the proposed Patrick St. alignment results in depth of cover which does not meet the Sedro-Woolley Public Works Department Standards. The Patrick St. sewer extension is further bound to the west by Brickyard Creek, the thalweg of which is below the proposed sewer invert. Therefore, it is recommended that the proposed gravity sewer be installed at approximately 8 ft. below ground surface (bgs) and a small lift station be placed at the south end of Patrick St. near Michael St. A short gravity sewer main also extends approximately 300 feet to the west along the centerline of the proposed Rowland Road extension.

9.2.4 Trail Road (Basin R & S)

The proposed gravity sewer main is designed as 8-inch PVC and at a minimum slope of 0.004 ft./ft. The northern section of the proposed sewer main (Basin R, north of Brickyard Creek) flows to the north from Brickyard creek, follows the centerline of the proposed Trail Road extension, and connects to an existing manhole at the proposed intersection of Trail Road and Jones Road. The proposed sewer is approximately 15 ft. deep at the northern connection and ends with minimum cover at the south terminus. Flows in Basin R north of Brickyard Creek are routed through the West Jones Rd. Pump Station.

Although not reflected in the conceptual design plans in Appendix D, an alternate to the northern section (Basin R, north of Brickyard Creek) is to extend the sewer stub east from Thurmond Ave to connect to Trail Rd. This would result in a sewer system that is roughly 3 ft. deeper than the above described option in the vicinity of Thurmond Ave. and is roughly equivalent in depth approximately 300 ft. south of F&S Grade Rd. Sewer flows from about F&S Grade Rd. north, would be routed north toward the intersection of Trail Rd. and Jones Rd. as described in the paragraph above, however the sewer main could be installed slightly shallower since the main would no longer need to extend to the vicinity of Brickyard Creek.

The additional depth may better serve the future development of property east of the proposed Trail Rd., but sewer flows would be routed through both the Klinger Street and Cook Rd. Pump Stations. The capacities and operating costs of these two pump stations should be checked and weighed against the

added benefit of the deeper sewer. Additionally, the record drawing information available for this study appears to be on a different vertical datum and thus rim and invert elevations should be checked at the outset of the design phase to verify the additional depth. In the interest of preserving both alternatives to the greatest extent possible, it is recommended that the sewer between F&S Grade Rd. and Jones Rd. be installed at the maximum possible depth.

The southern section of the proposed Trail Road sewer main flows to the south along the centerline of the proposed roadway, and connects to an existing sewer main approximately 50' north of the proposed intersection at Trail Road and Cook Road. The proposed sewer is approximately 12 ft. deep at the southern connection and approximately 9 ft. deep at the northern terminus.

10. Environmental Process and Permitting

10.1 Critical Areas

Widener & Associates reviewed the conceptual plans for impacts to critical areas noted in the National Wetlands inventory of the U.S. Fish and Wildlife Service as well as other pertinent documentation. Of note, there is one mapped wetland in the Trail Rd. alignment, one mapped wetland in the Patrick St. alignment, and the ditch along F&S Grade Rd. is also shown on the National Wetlands Inventory, see Figure 10.1.1

The Shoreline Master Plan was reviewed, and although Brickyard Creek is not identified in the Shoreline Master Plan, from a critical area's standpoint, it is a Type 3 stream and has a standard 110 ft. buffer. Other roadside ditches within the corridor may also qualify as being jurisdictional even though they are not currently identified in the National Wetlands Inventory.

For those projects in the corridor that have mapped wetlands or those where wetlands may be suspected, delineation of the wetlands should occur early in the design process so as to confirm the presence and extent of potential wetlands and to develop strategies for avoidance and/or mitigation.

For purposes of this report, we have assumed the wetlands mapped in the National Wetlands Inventory are correct and represent the extend of wetlands contained within the corridor. It should be noted that Widener & Associates suspects that the wetland in the Patrick St. project near SR20 may no longer exist, however as that has not yet been confirmed by field reconnaissance, for purposes of this report, we are assuming it does still exist.

Wetland buffers vary depending on the category of wetland. The National Wetlands Inventory does not identify the category of wetland, however based on knowledge of the site during the course of this work, we have assumed the wetlands to be Category III, and thus a 50 ft. buffer would apply. Wetland and buffer impacts are shown in Figure 10.1.2. The wetland and buffer mitigation are identified in the table shown in Figure 10.1.2. Wetland and critical area mitigation costs are presented in the detailed cost analysis discussed in Section 11.

U.S. Fish and Wildlife Service
National Wetlands Inventory

Figure 10.1.1
National Wetlands Inventory Map
Jones / John-Liner / Trail Rd. Corridor

December 3, 2019

Wetlands

- Estuarine and Marine Deepwater
- Estuarine and Marine Wetland
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Other
- Riverine

This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

National Wetlands Inventory (NWI)
This page was produced by the NWI mapper

GRAPHIC SCALE
200 0 100 200
(IN FEET)
1"=200' (22x34), 1"=400' (11x17)

JONES RD
JOHN LINER RD
TRAIL RD
FFS GRADE RD
PATRICK RD
BRICKYARD CREEK
COOK RD
C1A
C1B
C1D
C9A
C9B
C19
S17
C3
50.00'
110.00'

LEGEND
= EXISTING WETLAND
= BRICKYARD CREEK
= WETLAND BUFFER (50')
= BRICKYARD CREEK BUFFER (110')
= WETLAND/CREEK IMPACTS
= WETLAND BUFFER IMPACTS
= BRICKYARD CREEK BUFFER IMPACTS

TIP ID	Project Name	Wetland Impacts (SF)	Wetland Mitigation Area (SF, 2:1 Mitigation Ratio)	Wetland Buffer Impacts (SF)	Wetland Buffer Mitigation Area (SF, 1:1 Mitigation Ratio)	Brickyard Creek Impacts (SF)	Brickyard Creek Buffer Impacts (SF)	Brickyard Creek Buffer Mitigation Area (SF, 1:1 Mitigation Ratio)
C1A	Jones Rd. Improvements						20,914.04	20,914.04
C1D	Jones / John Liner RR Undercrossing					7,480.12	86,231.37	86,231.37
C1D	John Liner Rd. Arterial Improvements							
C9A	Trail Rd. Arterial Extension	2,097.52	4,195.04			4,497.75	40,487.27	40,487.27
C9b	Trail Rd. – Garden of Eden Rd. Extension	810.78	1,621.56	9,761.07	9,761.07			
C19	Patrick St. Extension	11,700.42	23,400.84	14,685.24	14,685.24			
S17	Township St. (SR9) & John-Liner / McGenigle Rd. Intersection							
C3	Cook Rd. / Trail Rd. Intersection Improvements							

NATHAN J. ZYLSTRA
STATE OF WASHINGTON
41884
REGISTERED PROFESSIONAL ENGINEER
PRELIMINARY

FIGURE 10.1.2

DESIGNED BY IDH/OAM
DRAWN BY IDH/OAM
CHECKED BY NZ

R&E Reichhardt & Ebe ENGINEERING INC
P.O. Box 978 | 423 Front Street
Lynden, WA 98264 (360) 354-3687

NO.	DATE	DESCRIPTION	BY

CITY OF SEDRO WOOLLEY
325 METCALF STREET
SEDRO WOOLLEY, WA 98284

JONES / JOHN-LINER / TRAIL RD CORRIDOR
SCOPING STUDY
WETLAND IMPACTS

DWG 18002 PLOT
DATE 2/10/2020
JOB# 18002
SCALE H: 1"=200' V: N/A
SHEET 1 of 1

P:\Projects\18002\Civil 3D 2019\18002PLOT.dwg, WETLAND IMPACTS, 2/10/2020 1:58:02 PM, PDF4CAD by Bluebeam

10.2 Permits

R&E and Widener & Associates reviewed the permits anticipated for the corridor under the assumption that the projects are completed as federally funded projects. The list of anticipated permits is as follows:

Local Permits:

- State Environmental Policy Act (SEPA)
- Fill and Grade Permit

State Permits

- Hydraulic Project Approval (HPA)
- NPDES Construction Stormwater General Permit

Federal Permits

- EPA 401 Certification
- USACE Section 404 Permit
- National Historic Preservation Act, Section 106
- National Environmental Policy Act, Categorical Exemption (NEPA CE)

Permit requirements for individual projects within the corridor will vary by project with major permitting drivers being impacts to waters of the state such as projects containing culvert replacements as well as projects which impact wetlands or wetland buffers. Permitting reports and studies such as wetland delineation(s), noise studies, biological assessments, and cultural resource surveys may be necessary for individual projects to support the permitting efforts.

It is also important to note that with the anticipated federal funding coupled with the need for right of way acquisition, obtaining NEPA approval is required prior to entering into negotiations for acquisition of property rights. Some exceptions apply for early (pre-NEPA) acquisitions. If the City desires to pursue any early acquisitions, it is recommended that you contact WSDOT Local Programs and your WSDOT Local Agency Coordinator prior to beginning the early acquisition process.

11. Cost Analysis

Before presenting the project costs, it is important for the reader to understand the basis of all of the costs presented in this report. All costs are presented in 2019 dollars and are assumed to be completed as City sponsored capital projects. As the completed corridor represents significant capital investment, consideration will need to be made to develop a funding strategy to complete the corridor over time and which accounts for inflation and changes in project cost over time.

Cost estimates are presented as complete standalone projects for each of the 8 individual projects within the overall corridor. Combining projects may result in economy of scale and an overall cost reduction compared to completion of the projects individually. Combining projects or altering individual project termini will also affect project costs, not only by changing the overall quantity of work to be performed, but also as mentioned on Section 8, by potentially altering the stormwater requirements.

The project costs are estimated based on quantities of work calculated from the conceptual designs completed to date. Unit costs are applied to the calculated quantities of work and are based on historical and recent similar pricing records. The BNSF undercrossing structure costs were provided by Widener & Associates based on information provided to them by BNSF. Water main improvement costs are not provided in these cost estimates as the Skagit PUD operates as an independent public utility within the City and is responsible for water main improvements and extensions within its service area. Illumination costs are included in the cost estimates and are based on recent pricing information provided by the City.

As discussed in Section 8.2.3 wetpond sizing was completed for pond #5 only and other pond sizes were scaled according to the pond #5 baseline. A similar approach was taken to estimate the cost of stormwater mitigation for each project. Baseline quantities were estimated for pond #5 and then scaled to each of the other ponds based on size. Stormwater mitigation costs are then presented in each cost estimate as a lump sum price.

Contingency has been set at 25% of the construction subtotal and is relatively high due to the preliminary level of design presented for each project. In accordance with WAC 458-20-170 and 171, sales tax is charged on sanitary sewer elements at the current 8.5% sales tax rate.

Professional services such as engineering and construction management are calculated as a percentage of the construction cost after the contingency has been applied. The percentage for the professional services is typical within the industry and has been set at 15% for both design engineering and construction management.

Right-of-way costs presented in this report have been prepared by Abeyta & Associates who have completed a “Real Property Acquisition Cost Estimate” based on the current right of way plan. Work was performed based on field inspections of each acquisition. Values are based on recent comparable sales and a parcel worksheet has been prepared for each affected parcel. A full discussion of the right-of way costs is presented in Section 7.

The following table provides a project cost summary for the 8 proposed projects making up the corridor. Costs presented below for projects C3 and S17 are presented as the roundabout option. Costs are

inclusive of capital project construction cost, right of way cost, and professional services. Detailed cost estimates are presented in Appendix N.

Table 11: Jones / John-Liner / Trail Rd. Corridor Cost Summary

TIP ID	Project Name	Project Cost
C1A	Jones Rd. Improvements	$4,946,264
C1B	Jones / John-Liner RR Undercrossing	$9,653,365
C1D	John-Liner Rd. Arterial Improvements	$1,900,137
C9A	Trail Rd. Arterial Extension	$5,447,568
C9B	Trail Rd. – Garden of Eden Rd. Extension	$1,430,128
C19	Patrick St. Extension	$3,537,313
S17	Township St. (SR9) & John-Liner / McGarigle Rd. Intersection	$3,224,910
C3	Cook Rd. / Trail Rd. Intersection Improvements	$4,312,923
TOTAL CORRIDOR PROJECT COST		**$34,452,608**

It is important to note that right of way acquisition represents approximately $6.4 million of the total corridor cost and presents significant overall project risk in terms of cost and negotiations for acquisition. The right of way for Patrick St. alone is currently estimated at approximately $619,000 and therefore strong consideration should be made to encouraging that particular segment to develop as a private project. The City has already taken steps to promote private interest in that particular project and the scoping study team encourages that continued effort.

Storm drain flow control and treatment options have been generalized in this report due to the limited available subsurface and groundwater conditions. It will be worth the investment in the early stages of the design phase to complete a targeted subsurface and groundwater investigation. Such an investigation may find opportunity to optimize the stormwater management design by including infiltration or LID facilities, thus reducing right of way acquisition and the cost of pumping stormwater.

12. References

Geo June 2019. GeoEngineers Memorandum – Existing Information Review and Preliminary Project Considerations, Jones John-Liner Trail Road Corridor Study, Sedro-Woolley, Washington, June 11, 2019.

Ravnik 2019. Ravnik & Associates, Inc. – Preliminary Drainage Report for Garden Meadows Residential Development (28-lot Preliminary Long Plat), December 4, 2019

Appendix A – Background Documents

April 19, 2018

Background Documents for Jones/John Liner/Trail Road Corridor Scoping Study

Available on the city website at: www.ci.sedro-woolley.wa.us/

- 2017 Sedro-Woolley Comprehensive Plan Chapter 3 Transportation Element: http://www.ci.sedro-woolley.wa.us/Departments/Planning/Comprehensive%20Plan/Comp_Plan_Ch_3_Transportation.pdf
- 2018-2023 Transportation Improvement Program: http://www.ci.sedro-woolley.wa.us/Departments/Engineering/Comp_Plans/2017_2022_six_year_tip_res_944_16.pdf
- 1997 Stormwater Management Plan: http://www.ci.sedro-woolley.wa.us/departments/engineering/stormwater.php
- 2005 Comprehensive Sewer System Plan: http://www.ci.sedro-woolley.wa.us/departments/engineering/wastewater.php

Scanned files available at https://1drv.ms/f/s!AhISKOhYBHi2gSEHpm1jnkwZJVm8

- Ordinance 1852-16 2016 Transportation Impact Fee Update
- 2017 Traffic Count Data (also available at: http://www.ci.sedro-woolley.wa.us/departments/engineering/traffic_counts.php#
- Cook Road No 63000 Improvement Project Record Drawings, Skagit County
- Cook Road Transportation Study Final Report, 1997
- Fruitdale/McGarigle Road Project Record Drawings (John Liner Road and Storm Plan and Profile), Leonard, Budinot & Skodge, 2008
- Fruitdale/McGarigle Road - Traffic Analysis, TSI, 2007
- Fruitdale/McGarigle Road -Geotechnical report
- F&S Grade Road, West Jones Road and Garden of Eden Road Engineering Report, Semrau, 2006
- Garden of Eden Road Area Sewage Facilities Feasibility Study, Final Report, 2002
- Garden of Eden Road Area Sewage Facilities Record Drawings
- Garden of Eden Road Area Sewage Facilities Initial Construction Geotechnical Data Report, 2004
- John Liner Road Ditch and Culvert Improvements, Preliminary Design, Reichhardt & Ebe Engineering, 2009
- Northern States Gateway Center (now Swift Center) EIS Appendix G Traffic Analysis, TSI, 2015
- Trail Road Street Improvements Record Drawings, CH2M Hill, 1999
- Trail Road Street Improvements Design Report, CH2M Hill, 1999
- Jones Road Sewer Geotechnical Report 2006

Pending documents:

- Jones Road Sewer Extension Record Drawings, Azure Green, 2017 – requested
- PSE #4 Rebuild PSE – requested from PSE
- PSE #4 Rebuild RW plans – provided by PSE via FTP
- PUD Jones Road Water Main Relocation for CNG – requested from PUD
- CNG Anacortes Lateral Rebuild Project, Prosource – requested from CNG

Appendix B – Traffic Analysis

TSI
Transportation Solutions, Inc.
8250 - 165th Avenue NE
Suite 100
Redmond, WA 98052-6628
T 425-883-4134
F 425-867-0898
www.tsinw.com

Technical Memorandum

January 2, 2019

TO: Mark A. Freiberger, PE, City of Sedro-Woolley

FROM: Andrew L. Bratlien, PE, TSI

COPY: Nathan Zylstra, PE, Reichhardt & Ebe Engineering, Inc.

SUBJECT: **JONES / JOHN LINER / TRAIL ROAD CORRIDOR PROJECTS**
TRAFFIC ANALYSIS; UPDATED 2019-01-02

The purpose of this memorandum is to document the traffic analysis for the Jones Road / John Liner Road / Trail Road corridor improvement projects in Sedro-Woolley, Washington.

PROJECT DESCRIPTION

The City of Sedro-Woolley 2018-2023 Six-Year Transportation Improvement Program identifies six projects, summarized in **Table 1**, which will create a new arterial corridor. The new corridor will consist of Trail Road, a north-south connection between SR 20 and Jones Road, and Jones Road / John Liner Road, an east-west connection from F&S Grade Road to N Township Road (SR 9). The corridor will include a new grade-separated railroad crossing east of the existing Jones Road terminus.

Table 1. Jones / John Liner / Trail Road Corridor Improvement Projects

TIP ID	Project Name	Project Limits	Description
C1A	Jones Rd Improvements	F&S Grade Rd / Sapp Rd	Reconstruct to arterial section, including sidewalk & shared use path
C1B	Jones/John Liner RR Undecrossing	Sapp Rd / Reed St	New BNSF undercrossing and new arterial from E Jones Rd to John Liner Rd
C1D	John Liner Rd Arterial Improvement	Reed St / Township St	Reconstruct to arterial section
C9A	Trail Rd Arterial Extension	Cook Rd / F&S Grade	Construct new minor arterial
C9B	Trail Rd – Garden of Eden Rd Extension	F&S Grade / Jones Rd	Construct new minor arterial
C19	Patrick St Extension	Michael St / E Jones St	New major collector w/sidewalks

This analysis will consider the impacts of intersection control alternatives at the intersections of:

- Cook Road and Trail Road
- N Township Street (SR 9) and John Liner Road/McGarigle Road

This analysis will also evaluate the following three intersections for possible left turn lane improvements:

- Trail Road / F&S Grade Road
- Trail Road / Jones Road
- Jones Road / Patrick Street

ANALYSIS METHODS AND ASSUMPTIONS

Analysis Software

Signalized and stop-controlled intersections were evaluated in Synchro 9 software using Highway Capacity Manual 2010 (HCM2010) methods. Roundabouts were evaluated in Sidra Intersection 7 software using the HCM6 capacity model and HCM2000 LOS thresholds, per Washington State Department of Transportation (WSDOT) policy guidance.

Travel Demand Forecasting

The travel demand forecasts used in this analysis were generated by the Sedro-Woolley 2036 citywide travel demand model, which includes all land use growth and transportation network improvements identified in the Sedro-Woolley 2016 Comprehensive Plan. Truck percentages are based on 2015 intersection turning movement counts.

The 2036 travel demand model identifies anticipated traffic redistribution resulting from the improvement projects identified in Table 1. For the purposes of travel demand forecasting, the completed Jones/John Liner Road corridor was modeled as an urban section with 30 mph free-flow speed.

By 2036, assuming completion of the corridor improvement projects, the Jones/John Liner Road corridor is anticipated to serve between 600 and 700 vehicles per hour (vph) during the PM peak hour. Average daily traffic volume forecasts at each end of the corridor include:

- 7,000 vehicles per day (vpd) (695 vph during PM peak hour) on Trail Road north of Cook Rd
- 6,300 vpd (625 vph during PM peak hour) on John Liner Rd west of SR 9

The Jones/John Liner Road improvement projects will create a new east-west corridor, providing an alternative to SR 20 to the south. The new corridor will reduce PM peak hour demand on SR 20 by approximately 1,350 vpd (135 vph during PM peak hour). By providing a continuous east-west connection, the Jones/John Liner Road corridor will also reduce turning movement demand along SR 20 by approximately 230 vpd (230 vph during the PM peak hour). The reduction in turning demand and overall demand along SR 20 will improve safety and operations on the state route.

Analysis Period

Travel demand forecasts represent the PM peak hour, defined as the highest four consecutive 15-minute intervals from 4:00 – 6:00 PM.

INTERSECTION CONTROL ANALYSIS

Existing Conditions

Cook Road and Trail Road

Cook Road is an east-west three-lane minor arterial within city limits. It connects I-5 to the west with SR 20 within city limits. Posted speed limit is 35 mph within city limits. Cook Road currently serves approximately 13,000 vehicles per day.

Trail Road is currently a three-lane north-south major collector which connects SR 20 with Cook Road. Existing volume is approximately 4,300 vehicles per day.

The intersection of Cook Road and Trail Road currently includes stop control on the northbound (Trail Road) approach and a continuous two-way left-turn lane through the intersection along Cook Road.

N Township Street (SR 9) and John Liner Road / McGarigle Road

N Township Street (State Route 9) is a two-lane north-south principal arterial in the vicinity of John Liner Road. SR 9 connects Sedro-Woolley with Mount Vernon to the south and with Whatcom County to the north. SR 9 is classified a Highway of Statewide Significance (HSS) by WSDOT. The route is also a designated school zone in the vicinity of John Liner Road. Posted speed limit is 20 mph during school hours and 35 mph during non-school hours. N Township Street serves approximately 8,000 vehicles per day.

John Liner Road is a two-lane east-west major collector which begins at N Reed Street to the west. The street becomes McGarigle Road at the N Township Street intersection. John Liner Road includes a 24-foot paved width with unpaved shoulders. No sidewalk or curb & gutter currently exist. John Liner Road serves approximately 700 vehicles per day. Posted speed is 25 mph.

McGarigle Road is an east-west major collector which continues from John Liner Road at N Township Street to connect to Fruitdale Road to the east. McGarigle Road consists of two 12-foot paved travel lanes with curb and gutter on both sides, a five-foot sidewalk on the south side, and a 11-foot multi-use path on the north side. McGarigle Road serves approximately 2,000 vpd. Posted speed is 25 mph.

The intersection of SR 9 and John Liner Road / McGarigle Road includes stop control on the east and west approaches.

Crash History

A collision history was compiled from incidents reported between January 1, 2013 and December 31, 2017 at both intersections.

Cook Road and Trail Road

Collision data for the intersection of Cook Road and Trail Road is summarized in **Table 2**. From 2013 through 2017, there were 13 collisions reported at the intersection. Two collisions resulted in possible injuries. No pedestrian or bicycle injuries and no fatalities were reported. The predominant collision type at the intersection is vehicles entering at angle.

Table 2. Cook Road & Trail Road Crash History, 2013-2017

Year	Fixed Object	Rear-End	Enter at Angle	Side-swipe	Backing	Ped/ Bike	PDO	Injury	Fatal	Total
2013	0	1	2	0	1	0	4	0	0	4
2014	0	0	2	0	1	0	3	0	0	3
2015	0	0	0	0	0	0	0	0	0	0
2016	0	0	2	1	0	0	2	1	0	3
2017	1	2	0	0	0	0	2	1	0	3
5-yr Total	**1**	**3**	**6**	**1**	**2**	**0**	**11**	**1**	**0**	**13**
Avg. Annual	**0.2**	**0.6**	**1.2**	**0.2**	**0.4**	**0**	**2.2**	**0.2**	**0**	**2.6**

N Township Street (SR 9) and John Liner Road / McGarigle Road

Collision data for the intersection of N Township Street and John Liner Road / McGarigle Road is summarized in **Table 3**. From 2013 through 2017, there were 2 collisions reported at the intersection. Both collisions were related to vehicles entering at angle.

Table 3. N Township St (SR 9) & John Liner Road / McGarigle Road Road Crash History, 2013-2017

Year	Fixed Object	Rear-End	Enter at Angle	Side-swipe	Backing	Ped/ Bike	PDO	Injury	Fatal	Total
2013	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0
2016	0	0	1	0	0	0	1	0	0	1
2017	0	0	1	0	0	0	0	1	0	1
5-yr Total	**0**	**0**	**2**	**0**	**0**	**0**	**1**	**1**	**0**	**2**
Avg. Annual	**0**	**0**	**0.4**	**0**	**0**	**0**	**0.2**	**0.2**	**0**	**0.4**

Intersection Control Alternatives

Three future alternatives were studied at each intersection. All future alternatives assume construction of new street connections identified along the Trail Road / Jones Road / John Liner Road corridor, including Trail Road (Cook Road to Jones Road) and the Jones Road undercrossing.

Travel demand was assumed to be consistent across each of the alternatives, with only intersection control changing. Alternatives included:

- No Build (existing minor approach stop control)
- Roundabout
- Signal

No Build

The No Build Alternative assumes no change in intersection channelization or control. No Build delay and 95th percentile queues are summarized in **Table 4.**

Table 4. Queuing and LOS, No Build Alternative (2036 PM Peak Hour)

Intersection	Eastbound		Westbound		Northbound		Southbound		Overall[1]
	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	LOS (Delay)
Cook Rd & Trail Rd	25	A (9.1)	0	A (8.6)	1,450	F* (>999)	800	F* (>999)	F* (>999)
SR 9 & John Liner	775	F (691)	250	F (175)	0	A (8.7)	0	A (8.5)	F (691)

[1]For TWSC intersections, overall LOS and delay represent the worst (highest delay) movement. For all other intersection control types, overall LOS and delay represent the intersection average.
[2]Control delay in seconds per vehicle
*Delay exceeds the limits of the HCM2010 methodology

Both intersections will operate with LOS F on the worst movement. Northbound and southbound delay at the intersection of Cook Road and Trail Road will exceed the limits of the Highway Capacity Manual delay calculation methodology. At SR 9 and John Liner Road, eastbound (John Liner Road) delay will exceed 11 minutes per entering vehicle. These delays will limit access to and from the new corridor during most of the PM peak hour.

Roundabout

The Roundabout alternative assumed single-lane roundabouts at both intersections. Roundabout analysis assumed a 120-foot inscribed circle diameter with a single 20-foot circulating lane for each roundabout. Conceptual roundabout layouts for each intersection are attached.

Under roundabout control, the intersection of Cook Road and Trail Road will operate at LOS B with 10.1 seconds of delay per vehicle. The intersection of SR 9 and John Liner Road will operate at LOS A with 7.2 seconds of delay per vehicle. 95th percentile queues will measure 150 feet (6 vehicles) or less on all approaches of both intersections. Roundabout delay and queueing for each intersection are summarized in **Table 5.**

Table 5. Queuing and LOS, Roundabout Alternative (2036 PM Peak Hour)

Intersection	Eastbound		Westbound		Northbound		Southbound		Overall[1]
	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	LOS (Delay)
Cook Rd & Trail Rd	125	A (7.6)	125	A (11.6)	150	B (13.9)	50	A (7.8)	B (10.1)
SR 9 & John Liner	50	A (9.1)	50	A (5.6)	75	A (6.3)	75	A (9.8)	A (7.2)

[1]For TWSC intersections, overall LOS and delay represent the worst (highest delay) movement. For all other intersection control types, overall LOS and delay represent the intersection average.
[2]Control delay in seconds per vehicle

Signal

The intersection of Cook Road and Trail Road will satisfy Manual on Uniform Traffic Control Devices Signal Warrant 1 (Eight Hour Volume), Signal Warrant 2 (Four Hour Volume), and Signal Warrant 3 (Peak Hour). The intersection of N Township Road (SR 9) and John Liner Road/McGarigle Road will satisfy MUTCD Signal Warrants 2 and 3. Signal warrant reports are attached.

Intersection capacity analysis for the Signal alternative assumed widening of the SR 9 and John Liner Road intersection to provide left-turn lanes on all approaches. At the Cook Road and Trail Road intersection, analysis indicated that left-turn lanes on the north and south (Trail Road) approaches are not warranted.

Delay and queueing for each signalized intersection are summarized in **Table 6.** The intersection of Cook Road and Trail Road operates at LOS B while the intersection of SR 9 and John Liner Road/McGarigle Road operates at LOS A.

Table 6. Queuing and LOS, Signal Alternative (2036 PM Peak Hour)

Intersection	Eastbound		Westbound		Northbound		Southbound		Overall[1]
	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	95th Q (ft)	LOS (Delay)[2]	LOS (Delay)
Cook Rd & Trail Rd	L: 275 Th: 275	B (18.3)	L: 75 Th: 225	B (13.8)	400	C (26.6)	175	B (17.0)	B (19.1)
SR 9 & John Liner	L: 100 Th: 75	B (13.2)	L: 50 Th: 50	B (11.9)	L: 50 Th: 175	A (8.5)	L: 0 Th: 175	A (8.2)	A (9.9)

[1]For TWSC intersections, overall LOS and delay represent the worst (highest delay) movement. For all other intersection control types, overall LOS and delay represent the intersection average.
[2]Control delay in seconds per vehicle

TURN LANE ANALYSIS

Left-turn lane warrants were analyzed for each of three planned stop-controlled intersections along the future Trail Road / Jones Road / John Liner Road corridor:

- Trail Road and F&S Grade Road (stop control on north and south approaches)
- Trail Road and Jones Road (stop control on east and west approaches)
- Jones Road and Patrick Street (stop control on south approach)

WSDOT Design Manual left-turn lane warrants (attached) were evaluated for each of the three intersections identified above. The turn lane analysis is summarized in **Table 7**.

Table 7. Left-Turn Lane Analysis

Intersection	Approach Leg	Total DHV[1]	% Total DHV Turning Left	2036 PM LOS (Delay)[2]		Left-Turn Lane Warranted
				Without LT Lane	With LT Lane	
Trail Road & F&S Grade Road	West (EB)	50	10.0%	B (13.3)	B (14.7)	No
	East (WB)	125	24.0%	C (15.8)	B (14.5)	No
	South (NB)	665	0.8%	A (0.1)	A (0.1)	No
	North (SB)	645	3.1%	A (0.8)	A (0.8)	No
Trail Road & Jones Road	West (EB)	185	8.1%	A (1.1)	A (1.1)	No
	East (WB)	660	22.0%	A (4.5)	A (4.5)	**Yes**
	South (NB)	660	0.8%	D (27.1)	D (25.4)	No
	North (SB)	315	11.1%	D (32.7)	C (24.2)	No
Jones Road & Patrick Street	East (WB)	840	10.1%	A (2.1)	A (2.1)	**Yes**
	South (NB)	290	12.1%	B (16.1)	B (12.8)	No

[1]Design hourly volume (both directions)
[2]Average LOS and delay by approach

Left-turn lanes are warranted on the east (Jones Rd) approach of the Trail Road and Jones Road intersection, and the east (Jones Rd) approach of the Jones Road and Patrick Street intersection.

FINDINGS AND RECOMMENDATIONS

Findings and recommendations are summarized below.

- Single-lane roundabouts are the preferred intersection control alternative at the intersections of:
  - Cook Road and Trail Road
  - N Township Road (SR 9) and John Liner Road/McGarigle Road.
- A left-turn lane is warranted at the following two locations:
  - East (Jones Rd) approach of Trail Road and Jones Road intersection.
  - East (Jones Rd) approach of Jones Road and Patrick Street intersection.

Attachment 1. Conceptual Roundabout Layouts

Attachment 2. Signal Warrant Reports

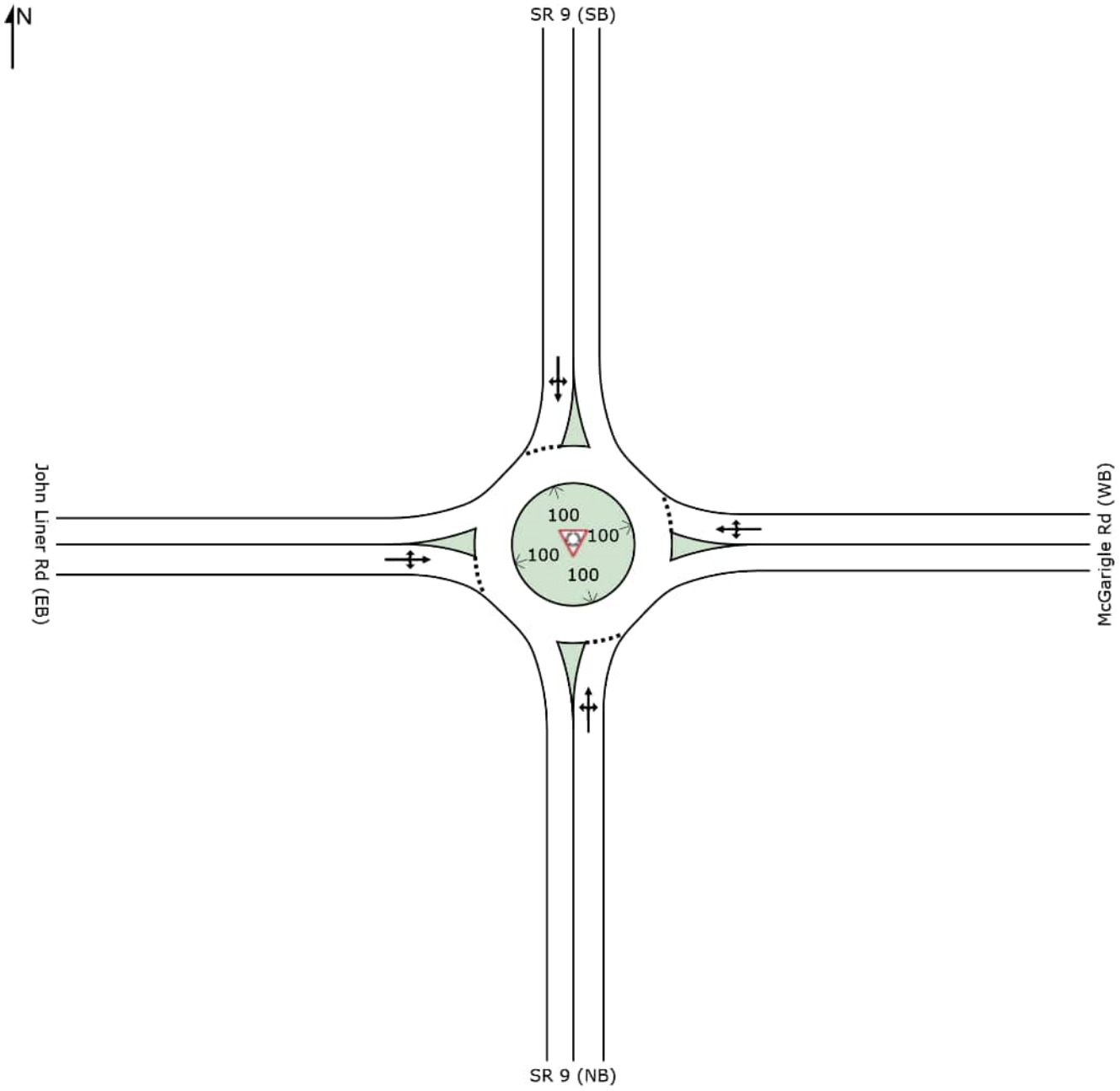
Attachment 3: Intersection LOS Reports

Attachment 4: Left-Turn Storage Guidelines

SITE LAYOUT

Site: [208. SR 9 & John Liner Rd]

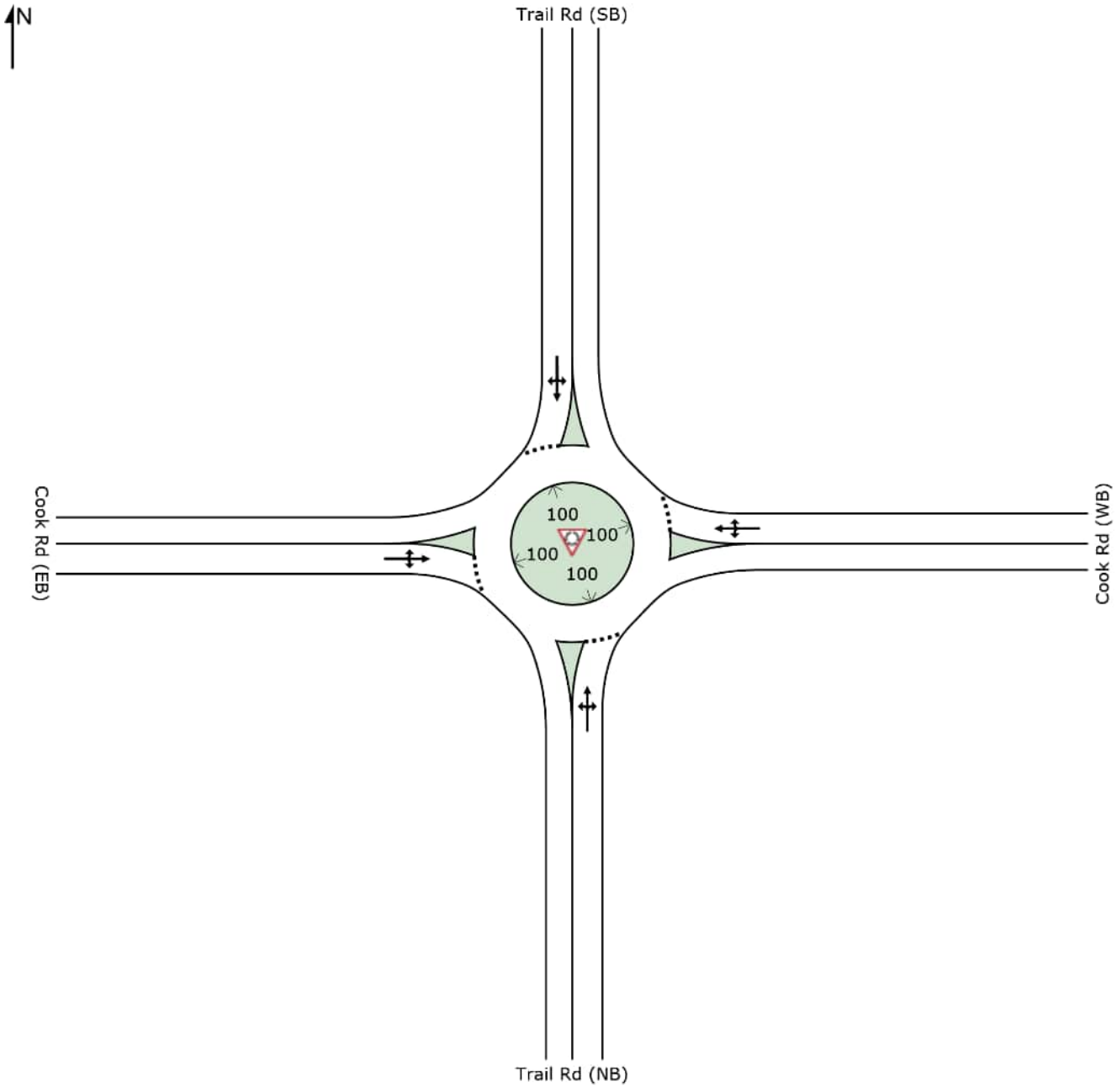
2036 With Improvement
Roundabout



SITE LAYOUT

Site: [303. Cook Rd & Trail Rd]

2036 With Improvement
Roundabout



Signal Warrants Report For Intersection 1: Cook Rd & Trail Rd

Warrants Summary

Warrant	Name	Met?
#1	Eight Hour Vehicular Volume	Yes
#2	Four Hour Vehicular Volume	Yes
#3	Peak Hour	Yes

Intersection Warrants Parameters

Major Approaches	E, W
Minor Approaches	S, N
Speed > 40mph	No
Population < 10,000	No
Warrant Factor	100%

Warrant Analysis Traffic Volumes

Hour	Major Streets		Minor Streets	
	E	W	S	N
1	430	740	450	225
2	413	710	432	216
3	404	696	423	212
4	344	592	360	180
5	327	562	342	171
6	292	503	306	153
7	271	466	284	142
8	258	444	270	135
9	206	355	216	108
10	194	333	203	101
11	194	333	203	101
12	185	318	194	97
13	168	289	176	88
14	155	266	162	81
15	155	266	162	81
16	151	259	158	79
17	86	148	90	45
18	47	81	50	25
19	43	74	45	23
20	17	30	18	9
21	13	22	14	7
22	13	22	14	7
23	9	15	9	5
24	9	15	9	5

Warrant Analysis by Hour

Hour	Major Lanes		Minor Lanes		Warrant 1 Condition A				Warrant 1 Condition B				Warrant 2	Warrant 3
	Number	Volume	Number	Volume	100%	80%	70%	56%	100%	80%	70%	56%		Condition B
1	4	1170	2	675	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	4	1123	2	648	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	4	1100	2	635	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	4	936	2	540	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	4	889	2	513	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
6	4	795	2	459	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
7	4	737	2	426	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
8	4	702	2	405	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No
9	4	561	2	324	No	Yes	Yes	Yes	No	No	No	Yes	No	No
10	4	527	2	304	No	Yes	Yes	Yes	No	No	No	Yes	No	No
11	4	527	2	304	No	Yes	Yes	Yes	No	No	No	Yes	No	No
12	4	503	2	291	No	Yes	Yes	Yes	No	No	No	No	No	No
13	4	457	2	264	No	No	Yes	Yes	No	No	No	No	No	No
14	4	421	2	243	No	No	Yes	Yes	No	No	No	No	No	No
15	4	421	2	243	No	No	Yes	Yes	No	No	No	No	No	No
16	4	410	2	237	No	No	No	Yes	No	No	No	No	No	No
17	4	234	2	135	No	No	No	No	No	No	No	No	No	No
18	4	128	2	75	No	No	No	No	No	No	No	No	No	No
19	4	117	2	68	No	No	No	No	No	No	No	No	No	No
20	4	47	2	27	No	No	No	No	No	No	No	No	No	No
21	4	35	2	21	No	No	No	No	No	No	No	No	No	No
22	4	35	2	21	No	No	No	No	No	No	No	No	No	No
23	4	24	2	14	No	No	No	No	No	No	No	No	No	No
24	4	24	2	14	No	No	No	No	No	No	No	No	No	No
Hours Met					8	12	15	16	4	7	8	11	8	5

Warrant 3 Condition A

Orientation	S	N
Total Stopped Delay Per Vehicle on Minor Approach (s)	7302.8	10000
Number of Lanes on Minor Street Approach	1	1
VehicleHours of Stopped Delay on Minor Approach ([h]h:mm)	912:50	625:00
Delay Condition Met	Yes	Yes
Volume on Minor Street Approach During Same Hour	450	225
High Minor Volume Condition Met	Yes	Yes
Total Entering Volume on All Approaches During Same Hour	1845	1845
Number of Approaches on Intersection	4	4
Total Volume Condition Met	Yes	Yes
Warrant Met for Approach	Yes	Yes
Warrant Met for Intersection	**Yes**	

Signal Warrants Report For Intersection 2: SR 9 & John Liner Rd

Warrants Summary

Warrant	Name	Met?
#1	Eight Hour Vehicular Volume	No
#2	Four Hour Vehicular Volume	Yes
#3	Peak Hour	Yes

Intersection Warrants Parameters

Major Approaches	S, N
Minor Approaches	E, W
Speed > 40mph	No
Population < 10,000	No
Warrant Factor	100%

Warrant Analysis Traffic Volumes

Hour	Major Streets		Minor Streets	
	S	N	E	W
1	480	405	170	325
2	461	389	163	312
3	451	381	160	306
4	384	324	136	260
5	365	308	129	247
6	326	275	116	221
7	302	255	107	205
8	288	243	102	195
9	230	194	82	156
10	216	182	77	146
11	216	182	77	146
12	206	174	73	140
13	187	158	66	127
14	173	146	61	117
15	173	146	61	117
16	168	142	59	114
17	96	81	34	65
18	53	45	19	36
19	48	41	17	33
20	19	16	7	13
21	14	12	5	10
22	14	12	5	10
23	10	8	3	7
24	10	8	3	7

Warrant Analysis by Hour

Hour	Major Lanes		Minor Lanes		Warrant 1 Condition A				Warrant 1 Condition B				Warrant 2	Warrant 3
	Number	Volume	Number	Volume	100%	80%	70%	56%	100%	80%	70%	56%		Condition B
1	2	885	2	495	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
2	2	850	2	475	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
3	2	832	2	466	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
4	2	708	2	396	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No
5	2	673	2	376	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	No
6	2	601	2	337	Yes	Yes	Yes	Yes	No	No	No	Yes	No	No
7	2	557	2	312	No	Yes	Yes	Yes	No	No	No	Yes	No	No
8	2	531	2	297	No	Yes	Yes	Yes	No	No	No	Yes	No	No
9	2	424	2	238	No	No	Yes	Yes	No	No	No	No	No	No
10	2	398	2	223	No	No	No	Yes	No	No	No	No	No	No
11	2	398	2	223	No	No	No	Yes	No	No	No	No	No	No
12	2	380	2	213	No	No	No	Yes	No	No	No	No	No	No
13	2	345	2	193	No	No	No	Yes	No	No	No	No	No	No
14	2	319	2	178	No	No	No	No	No	No	No	No	No	No
15	2	319	2	178	No	No	No	No	No	No	No	No	No	No
16	2	310	2	173	No	No	No	No	No	No	No	No	No	No
17	2	177	2	99	No	No	No	No	No	No	No	No	No	No
18	2	98	2	55	No	No	No	No	No	No	No	No	No	No
19	2	89	2	50	No	No	No	No	No	No	No	No	No	No
20	2	35	2	20	No	No	No	No	No	No	No	No	No	No
21	2	26	2	15	No	No	No	No	No	No	No	No	No	No
22	2	26	2	15	No	No	No	No	No	No	No	No	No	No
23	2	18	2	10	No	No	No	No	No	No	No	No	No	No
24	2	18	2	10	No	No	No	No	No	No	No	No	No	No
Hours Met					6	8	9	13	0	3	5	8	4	0

Warrant 3 Condition A

Orientation	E	W
Total Stopped Delay Per Vehicle on Minor Approach (s)	128.8	551.6
Number of Lanes on Minor Street Approach	1	1
VehicleHours of Stopped Delay on Minor Approach ([h]h:mm)	6:04	49:47
Delay Condition Met	Yes	Yes
Volume on Minor Street Approach During Same Hour	170	325
High Minor Volume Condition Met	Yes	Yes
Total Entering Volume on All Approaches During Same Hour	1380	1380
Number of Approaches on Intersection	4	4
Total Volume Condition Met	Yes	Yes
Warrant Met for Approach	Yes	Yes
Warrant Met for Intersection	**Yes**	

MOVEMENT SUMMARY

Site: [208. SR 9 & John Liner Rd]

2036 With Improvement
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: SR 9 (NB)											
3	L2	90	3.0	0.464	11.3	LOS B	3.2	82.4	0.55	0.57	35.9
8	T1	393	3.0	0.464	5.3	LOS A	3.2	82.4	0.55	0.57	35.8
18	R2	56	3.0	0.464	5.4	LOS A	3.2	82.4	0.55	0.57	34.7
Approach		539	3.0	0.464	6.3	LOS A	3.2	82.4	0.55	0.57	35.7
East: McGarigle Rd (WB)											
1	L2	73	3.0	0.228	13.5	LOS B	1.4	35.7	0.71	0.77	34.6
6	T1	79	3.0	0.228	7.5	LOS A	1.4	35.7	0.71	0.77	34.6
16	R2	39	3.0	0.228	7.6	LOS A	1.4	35.7	0.71	0.77	33.6
Approach		191	3.0	0.228	9.8	LOS A	1.4	35.7	0.71	0.77	34.4
North: SR 9 (SB)											
7	L2	17	9.0	0.410	11.3	LOS B	2.6	70.1	0.51	0.56	36.2
4	T1	270	9.0	0.410	5.3	LOS A	2.6	70.1	0.51	0.56	36.2
14	R2	169	9.0	0.410	5.4	LOS A	2.6	70.1	0.51	0.56	35.1
Approach		455	9.0	0.410	5.6	LOS A	2.6	70.1	0.51	0.56	35.8
West: John Liner Rd (EB)											
5	L2	208	3.0	0.339	11.7	LOS B	2.0	52.4	0.57	0.70	34.9
2	T1	34	3.0	0.339	5.7	LOS A	2.0	52.4	0.57	0.70	34.9
12	R2	124	3.0	0.339	5.8	LOS A	2.0	52.4	0.57	0.70	33.8
Approach		365	3.0	0.339	9.1	LOS A	2.0	52.4	0.57	0.70	34.5
All Vehicles		1551	4.8	0.464	7.2	LOS A	3.2	82.4	0.56	0.62	35.3

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 6).
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: [303. Cook Rd & Trail Rd]

2036 With Improvement
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Trail Rd (NB)											
3	L2	214	7.0	0.601	17.1	LOS B	5.7	150.0	0.89	1.01	32.7
8	T1	141	7.0	0.601	11.1	LOS B	5.7	150.0	0.89	1.01	32.7
18	R2	115	7.0	0.601	11.2	LOS B	5.7	150.0	0.89	1.01	31.8
Approach		469	7.0	0.601	13.9	LOS B	5.7	150.0	0.89	1.01	32.5
East: Cook Rd (WB)											
1	L2	89	5.0	0.559	16.3	LOS B	5.0	128.8	0.86	0.96	33.8
6	T1	333	5.0	0.559	10.4	LOS B	5.0	128.8	0.86	0.96	33.8
16	R2	26	5.0	0.559	10.4	LOS B	5.0	128.8	0.86	0.96	32.8
Approach		448	5.0	0.559	11.6	LOS B	5.0	128.8	0.86	0.96	33.8
North: Trail Rd (SB)											
7	L2	21	2.0	0.278	13.2	LOS B	1.8	45.9	0.74	0.76	35.7
4	T1	57	2.0	0.278	7.3	LOS A	1.8	45.9	0.74	0.76	35.6
14	R2	156	2.0	0.278	7.3	LOS A	1.8	45.9	0.74	0.76	34.5
Approach		234	2.0	0.278	7.8	LOS A	1.8	45.9	0.74	0.76	34.9
West: Cook Rd (EB)											
5	L2	323	2.0	0.610	11.0	LOS B	5.2	132.7	0.55	0.59	35.4
2	T1	339	2.0	0.610	5.1	LOS A	5.2	132.7	0.55	0.59	35.3
12	R2	109	2.0	0.610	5.1	LOS A	5.2	132.7	0.55	0.59	34.2
Approach		771	2.0	0.610	7.6	LOS A	5.2	132.7	0.55	0.59	35.2
All Vehicles		1922	3.9	0.610	10.1	LOS B	5.7	150.0	0.73	0.80	34.1

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 6).
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Intersection	
Int Delay, s/veh	2.2

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	5	10	5	30	10	35	5	405	20	20	190	5
Future Vol, veh/h	5	10	5	30	10	35	5	405	20	20	190	5
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	100	-	-	100	-	-	100	-	-	100	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	5	11	5	33	11	38	5	440	22	22	207	5

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	740	726	210	723	717	451	212	0	0	462	0	0
Stage 1	254	254	-	461	461	-	-	-	-	-	-	-
Stage 2	486	472	-	262	256	-	-	-	-	-	-	-
Critical Hdwy	7.12	6.52	6.22	7.12	6.52	6.22	4.12	-	-	4.12	-	-
Critical Hdwy Stg 1	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.518	4.018	3.318	3.518	4.018	3.318	2.218	-	-	2.218	-	-
Pot Cap-1 Maneuver	333	351	830	342	355	608	1358	-	-	1099	-	-
Stage 1	750	697	-	581	565	-	-	-	-	-	-	-
Stage 2	563	559	-	743	696	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	299	343	830	326	346	608	1358	-	-	1099	-	-
Mov Cap-2 Maneuver	299	343	-	326	346	-	-	-	-	-	-	-
Stage 1	747	683	-	579	563	-	-	-	-	-	-	-
Stage 2	516	557	-	712	682	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	14.7	14.5	0.1	0.8
HCM LOS	B	B		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	EBLn2	WBLn1	WBLn2	SBL	SBT	SBR
Capacity (veh/h)	1358	-	-	299	426	326	520	1099	-	-
HCM Lane V/C Ratio	0.004	-	-	0.018	0.038	0.1	0.094	0.02	-	-
HCM Control Delay (s)	7.7	-	-	17.3	13.8	17.3	12.6	8.3	-	-
HCM Lane LOS	A	-	-	C	B	C	B	A	-	-
HCM 95th %tile Q(veh)	0	-	-	0.1	0.1	0.3	0.3	0.1	-	-

Intersection	
Int Delay, s/veh	16.7

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	15	85	5	145	65	40	5	150	290	35	65	10
Future Vol, veh/h	15	85	5	145	65	40	5	150	290	35	65	10
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	100	-	-	100	-	-	100	-	-	100	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	16	92	5	158	71	43	5	163	315	38	71	11

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	114	0	0	97	0	0	577	557	95	775	538	93
Stage 1	-	-	-	-	-	-	127	127	-	409	409	-
Stage 2	-	-	-	-	-	-	450	430	-	366	129	-
Critical Hdwy	4.12	-	-	4.12	-	-	7.12	6.52	6.22	7.12	6.52	6.22
Critical Hdwy Stg 1	-	-	-	-	-	-	6.12	5.52	-	6.12	5.52	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.12	5.52	-	6.12	5.52	-
Follow-up Hdwy	2.218	-	-	2.218	-	-	3.518	4.018	3.318	3.518	4.018	3.318
Pot Cap-1 Maneuver	1475	-	-	1496	-	-	428	439	962	315	450	964
Stage 1	-	-	-	-	-	-	877	791	-	619	596	-
Stage 2	-	-	-	-	-	-	589	583	-	653	789	-
Platoon blocked, %		-	-		-	-						
Mov Cap-1 Maneuver	1475	-	-	1496	-	-	334	388	962	131	398	964
Mov Cap-2 Maneuver	-	-	-	-	-	-	334	388	-	131	398	-
Stage 1	-	-	-	-	-	-	867	782	-	612	533	-
Stage 2	-	-	-	-	-	-	452	521	-	344	780	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	1.1	4.5	25.4	24.2
HCM LOS			D	C

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1	SBLn2
Capacity (veh/h)	334	639	1475	-	-	1496	-	-	131	432
HCM Lane V/C Ratio	0.016	0.748	0.011	-	-	0.105	-	-	0.29	0.189
HCM Control Delay (s)	16	25.5	7.5	-	-	7.7	-	-	43.4	15.3
HCM Lane LOS	C	D	A	-	-	A	-	-	E	C
HCM 95th %tile Q(veh)	0.1	6.7	0	-	-	0.4	-	-	1.1	0.7

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	185	30	110	65	70	35	80	350	50	15	240	150
Future Volume (veh/h)	185	30	110	65	70	35	80	350	50	15	240	150
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	0.98		0.96	0.97		0.98	1.00		0.98	0.99		0.99
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1845	1845	1900	1845	1845	1900	1845	1845	1900	1743	1743	1900
Adj Flow Rate, veh/h	208	34	124	73	79	39	90	393	56	17	270	169
Adj No. of Lanes	1	1	0	1	1	0	1	1	0	1	1	0
Peak Hour Factor	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Percent Heavy Veh, %	3	3	3	3	3	3	3	3	3	9	9	9
Cap, veh/h	499	108	395	454	371	183	454	781	111	451	495	310
Arrive On Green	0.32	0.32	0.32	0.32	0.32	0.32	0.50	0.50	0.50	0.50	0.50	0.50
Sat Flow, veh/h	1236	338	1234	1181	1158	572	933	1574	224	870	998	625
Grp Volume(v), veh/h	208	0	158	73	0	118	90	0	449	17	0	439
Grp Sat Flow(s),veh/h/ln	1236	0	1573	1181	0	1730	933	0	1799	870	0	1623
Q Serve(g_s), s	6.4	0.0	3.3	2.2	0.0	2.2	3.2	0.0	7.3	0.6	0.0	8.1
Cycle Q Clear(g_c), s	8.6	0.0	3.3	5.5	0.0	2.2	11.3	0.0	7.3	7.9	0.0	8.1
Prop In Lane	1.00		0.78	1.00		0.33	1.00		0.12	1.00		0.38
Lane Grp Cap(c), veh/h	499	0	503	454	0	554	454	0	893	451	0	806
V/C Ratio(X)	0.42	0.00	0.31	0.16	0.00	0.21	0.20	0.00	0.50	0.04	0.00	0.54
Avail Cap(c_a), veh/h	1040	0	1191	970	0	1310	1040	0	2023	998	0	1825
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	13.9	0.0	11.2	13.3	0.0	10.8	11.5	0.0	7.4	10.0	0.0	7.6
Incr Delay (d2), s/veh	0.6	0.0	0.4	0.2	0.0	0.2	0.2	0.0	0.4	0.0	0.0	0.6
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(95%),veh/ln	4.1	0.0	2.6	1.3	0.0	1.9	1.5	0.0	6.5	0.3	0.0	6.6
LnGrp Delay(d),s/veh	14.5	0.0	11.5	13.4	0.0	11.0	11.7	0.0	7.8	10.0	0.0	8.2
LnGrp LOS	B		B	B		B	B		A	B		A
Approach Vol, veh/h		366			191			539			456	
Approach Delay, s/veh		13.2			11.9			8.5			8.2	
Approach LOS		B			B			A			A	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6		8
Phs Duration (G+Y+Rc), s		25.6		17.9		25.6		17.9
Change Period (Y+Rc), s		4.0		4.0		4.0		4.0
Max Green Setting (Gmax), s		49.0		33.0		49.0		33.0
Max Q Clear Time (g_c+I1), s		13.3		10.6		10.1		7.5
Green Ext Time (p_c), s		8.3		2.9		8.4		2.9

Intersection Summary	
HCM 2010 Ctrl Delay	9.9
HCM 2010 LOS	A

HCM 2010 analysis cannot be performed with phasing conflicts.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	147	437	70	70	450	99	275	305	150	72	70	125
Future Volume (veh/h)	147	437	70	70	450	99	275	305	150	72	70	125
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1827	1827	1900	1810	1810	1900	1792	1792	1900	1810	1810	1810
Adj Flow Rate, veh/h	155	460	74	74	474	104	289	321	158	76	74	132
Adj No. of Lanes	1	1	0	1	1	0	1	1	0	1	1	1
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Percent Heavy Veh, %	4	4	4	5	5	5	6	6	6	5	5	5
Cap, veh/h	264	625	100	281	537	118	549	370	182	213	402	342
Arrive On Green	0.07	0.41	0.41	0.04	0.37	0.37	0.15	0.33	0.33	0.05	0.22	0.22
Sat Flow, veh/h	1740	1536	247	1723	1438	316	1707	1135	559	1723	1810	1538
Grp Volume(v), veh/h	155	0	534	74	0	578	289	0	479	76	74	132
Grp Sat Flow(s),veh/h/ln	1740	0	1783	1723	0	1754	1707	0	1694	1723	1810	1538
Q Serve(g_s), s	4.7	0.0	22.4	2.3	0.0	27.2	10.9	0.0	23.5	3.0	2.9	6.4
Cycle Q Clear(g_c), s	4.7	0.0	22.4	2.3	0.0	27.2	10.9	0.0	23.5	3.0	2.9	6.4
Prop In Lane	1.00		0.14	1.00		0.18	1.00		0.33	1.00		1.00
Lane Grp Cap(c), veh/h	264	0	725	281	0	655	549	0	552	213	402	342
V/C Ratio(X)	0.59	0.00	0.74	0.26	0.00	0.88	0.53	0.00	0.87	0.36	0.18	0.39
Avail Cap(c_a), veh/h	273	0	788	288	0	715	604	0	710	213	512	436
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	19.7	0.0	22.2	18.2	0.0	25.9	19.7	0.0	28.0	26.1	27.9	29.2
Incr Delay (d2), s/veh	3.1	0.0	3.3	0.5	0.0	11.8	0.8	0.0	9.1	1.0	0.2	0.7
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(95%),veh/ln	4.4	0.0	17.2	2.0	0.0	21.7	8.9	0.0	18.1	2.7	2.7	5.1
LnGrp Delay(d),s/veh	22.8	0.0	25.5	18.7	0.0	37.7	20.5	0.0	37.0	27.1	28.1	29.9
LnGrp LOS	C		C	B		D	C		D	C	C	C
Approach Vol, veh/h		689			652			768			282	
Approach Delay, s/veh		24.9			35.5			30.8			28.7	
Approach LOS		C			D			C			C	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	8.0	32.8	7.6	39.9	17.2	23.6	10.5	37.0
Change Period (Y+Rc), s	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Max Green Setting (Gmax), s	4.0	37.0	4.0	39.0	16.0	25.0	7.0	36.0
Max Q Clear Time (g_c+I1), s	6.7	25.5	4.3	24.4	12.9	8.4	6.7	29.2
Green Ext Time (p_c), s	0.0	3.3	0.0	6.3	0.3	4.0	0.0	3.8

Intersection Summary	
HCM 2010 Ctrl Delay	30.1
HCM 2010 LOS	C

Intersection	
Int Delay, s/veh	3.6

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	75	404	0	0	416	434	20	0	255	0	0	0
Future Vol, veh/h	75	404	0	0	416	434	20	0	255	0	0	0
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	0	-	50	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	-	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	89	89	89	89	89	89	89	89	89	89	89	89
Heavy Vehicles, %	4	4	0	0	7	7	7	0	7	0	0	0
Mvmt Flow	84	454	0	0	467	488	22	0	287	0	0	0

Major/Minor	Major1			Major2			Minor1		
Conflicting Flow All	955	0	-	-	-	0	1333	1577	454
Stage 1	-	-	-	-	-	-	622	622	-
Stage 2	-	-	-	-	-	-	711	955	-
Critical Hdwy	4.14	-	-	-	-	-	6.47	6.5	6.27
Critical Hdwy Stg 1	-	-	-	-	-	-	5.47	5.5	-
Critical Hdwy Stg 2	-	-	-	-	-	-	5.47	5.5	-
Follow-up Hdwy	2.236	-	-	-	-	-	3.563	4	3.363
Pot Cap-1 Maneuver	712	-	0	0	-	-	166	111	596
Stage 1	-	-	0	0	-	-	526	482	-
Stage 2	-	-	0	0	-	-	478	339	-
Platoon blocked, %		-			-	-			
Mov Cap-1 Maneuver	712	-	-	-	-	-	140	0	596
Mov Cap-2 Maneuver	-	-	-	-	-	-	140	0	-
Stage 1	-	-	-	-	-	-	443	0	-
Stage 2	-	-	-	-	-	-	478	0	-

Approach	EB	WB	NB
HCM Control Delay, s	1.7	0	17.9
HCM LOS			C

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBL	EBT	WBT	WBR
Capacity (veh/h)	140	596	712	-	-	-
HCM Lane V/C Ratio	0.161	0.481	0.118	-	-	-
HCM Control Delay (s)	35.6	16.5	10.7	0	-	-
HCM Lane LOS	E	C	B	A	-	-
HCM 95th %tile Q(veh)	0.6	2.6	0.4	-	-	-

Intersection	
Int Delay, s/veh	74.3

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	0	250	5	324	107	0	0	0	0	229	0	20
Future Vol, veh/h	0	250	5	324	107	0	0	0	0	229	0	20
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	0	-	50
Veh in Median Storage, #	-	0	-	-	0	-	-	-	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	93	93	93	93	93	93	93	93	93	93	93	93
Heavy Vehicles, %	0	5	5	9	9	0	0	0	0	3	0	3
Mvmt Flow	0	269	5	348	115	0	0	0	0	246	0	22

Major/Minor	Major1			Major2			Minor2		
Conflicting Flow All	-	0	0	274	0	0	1083	1085	115
Stage 1	-	-	-	-	-	-	811	811	-
Stage 2	-	-	-	-	-	-	272	274	-
Critical Hdwy	-	-	-	4.19	-	-	6.43	6.5	6.23
Critical Hdwy Stg 1	-	-	-	-	-	-	5.43	5.5	-
Critical Hdwy Stg 2	-	-	-	-	-	-	5.43	5.5	-
Follow-up Hdwy	-	-	-	2.281	-	-	3.527	4	3.327
Pot Cap-1 Maneuver	0	-	-	1250	-	0	~ 239	218	935
Stage 1	0	-	-	-	-	0	435	396	-
Stage 2	0	-	-	-	-	0	771	687	-
Platoon blocked, %		-	-		-				
Mov Cap-1 Maneuver	-	-	-	1250	-	-	~ 168	0	935
Mov Cap-2 Maneuver	-	-	-	-	-	-	~ 168	0	-
Stage 1	-	-	-	-	-	-	435	0	-
Stage 2	-	-	-	-	-	-	542	0	-

Approach	EB	WB	SB
HCM Control Delay, s	0	6.8	267.1
HCM LOS			F

Minor Lane/Major Mvmt	EBT	EBR	WBL	WBT	SBLn1	SBLn2
Capacity (veh/h)	-	-	1250	-	168	935
HCM Lane V/C Ratio	-	-	0.279	-	1.466	0.023
HCM Control Delay (s)	-	-	9	0	289.7	8.9
HCM Lane LOS	-	-	A	A	F	A
HCM 95th %tile Q(veh)	-	-	1.1	-	15.7	0.1

Notes			
~: Volume exceeds capacity	$: Delay exceeds 300s	+: Computation Not Defined	*: All major volume in platoon

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	310	325	105	85	320	25	205	135	110	20	55	150
Future Volume (veh/h)	310	325	105	85	320	25	205	135	110	20	55	150
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		0.98	1.00		1.00	1.00		0.99	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1863	1863	1900	1810	1810	1900	1900	1776	1900	1900	1863	1900
Adj Flow Rate, veh/h	323	339	109	89	333	26	214	141	115	21	57	156
Adj No. of Lanes	1	1	0	1	1	0	0	1	0	0	1	0
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	2	2	2	5	5	5	7	7	7	2	2	2
Cap, veh/h	477	676	217	398	834	65	298	172	131	80	191	441
Arrive On Green	0.50	0.50	0.50	0.50	0.50	0.50	0.39	0.39	0.39	0.39	0.39	0.39
Sat Flow, veh/h	1018	1343	432	911	1657	129	586	436	331	75	483	1116
Grp Volume(v), veh/h	323	0	448	89	0	359	470	0	0	234	0	0
Grp Sat Flow(s),veh/h/ln	1018	0	1775	911	0	1787	1353	0	0	1675	0	0
Q Serve(g_s), s	22.7	0.0	13.2	5.6	0.0	9.8	17.5	0.0	0.0	0.0	0.0	0.0
Cycle Q Clear(g_c), s	32.5	0.0	13.2	18.8	0.0	9.8	25.3	0.0	0.0	7.8	0.0	0.0
Prop In Lane	1.00		0.24	1.00		0.07	0.46		0.24	0.09		0.67
Lane Grp Cap(c), veh/h	477	0	894	398	0	900	601	0	0	711	0	0
V/C Ratio(X)	0.68	0.00	0.50	0.22	0.00	0.40	0.78	0.00	0.00	0.33	0.00	0.00
Avail Cap(c_a), veh/h	534	0	994	449	0	1000	720	0	0	851	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	22.2	0.0	13.0	19.2	0.0	12.1	21.9	0.0	0.0	16.8	0.0	0.0
Incr Delay (d2), s/veh	2.9	0.0	0.4	0.3	0.0	0.3	4.7	0.0	0.0	0.3	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(95%),veh/ln	11.0	0.0	10.6	2.6	0.0	8.5	15.4	0.0	0.0	6.5	0.0	0.0
LnGrp Delay(d),s/veh	25.2	0.0	13.4	19.5	0.0	12.4	26.6	0.0	0.0	17.0	0.0	0.0
LnGrp LOS	C		B	B		B	C			B		
Approach Vol, veh/h		771			448			470			234	
Approach Delay, s/veh		18.3			13.8			26.6			17.0	
Approach LOS		B			B			C			B	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6		8
Phs Duration (G+Y+Rc), s		35.0		43.6		35.0		43.6
Change Period (Y+Rc), s		4.0		4.0		4.0		4.0
Max Green Setting (Gmax), s		38.0		44.0		38.0		44.0
Max Q Clear Time (g_c+I1), s		27.3		34.5		9.8		20.8
Green Ext Time (p_c), s		3.8		5.1		5.8		8.4

Intersection Summary	
HCM 2010 Ctrl Delay	19.1
HCM 2010 LOS	B

Intersection	
Int Delay, s/veh	0

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Traffic Vol, veh/h	0	0	0	0	0	0	0	0	0	0	0	0
Future Vol, veh/h	0	0	0	0	0	0	0	0	0	0	0	0
Conflicting Peds, #/hr	0	0	0	3	0	3	0	0	3	3	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	90	90	90	94	90	94	90	94	94	94	94	90
Heavy Vehicles, %	2	2	2	0	2	0	2	4	4	1	1	2
Mvmt Flow	0	0	0	0	0	0	0	0	0	0	0	0

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	4	4	4	7	4	6	1	0	0	3	0	0
Stage 1	1	1	-	3	3	-	-	-	-	-	-	-
Stage 2	3	3	-	4	1	-	-	-	-	-	-	-
Critical Hdwy	7.12	6.52	6.22	7.1	6.52	6.2	4.12	-	-	4.11	-	-
Critical Hdwy Stg 1	6.12	5.52	-	6.1	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.12	5.52	-	6.1	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.518	4.018	3.318	3.5	4.018	3.3	2.218	-	-	2.209	-	-
Pot Cap-1 Maneuver	1017	891	1080	1018	891	1083	1622	-	-	1626	-	-
Stage 1	1022	895	-	1025	893	-	-	-	-	-	-	-
Stage 2	1020	893	-	1024	895	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	1015	889	1078	1013	889	1078	1622	-	-	1622	-	-
Mov Cap-2 Maneuver	1015	889	-	1013	889	-	-	-	-	-	-	-
Stage 1	1022	895	-	1023	891	-	-	-	-	-	-	-
Stage 2	1018	891	-	1022	895	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0	0	0	0
HCM LOS	A	A		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1622	-	-	-	-	1622	-	-
HCM Lane V/C Ratio	-	-	-	-	-	-	-	-
HCM Control Delay (s)	0	-	-	0	0	0	-	-
HCM Lane LOS	A	-	-	A	A	A	-	-
HCM 95th %tile Q(veh)	0	-	-	-	-	0	-	-

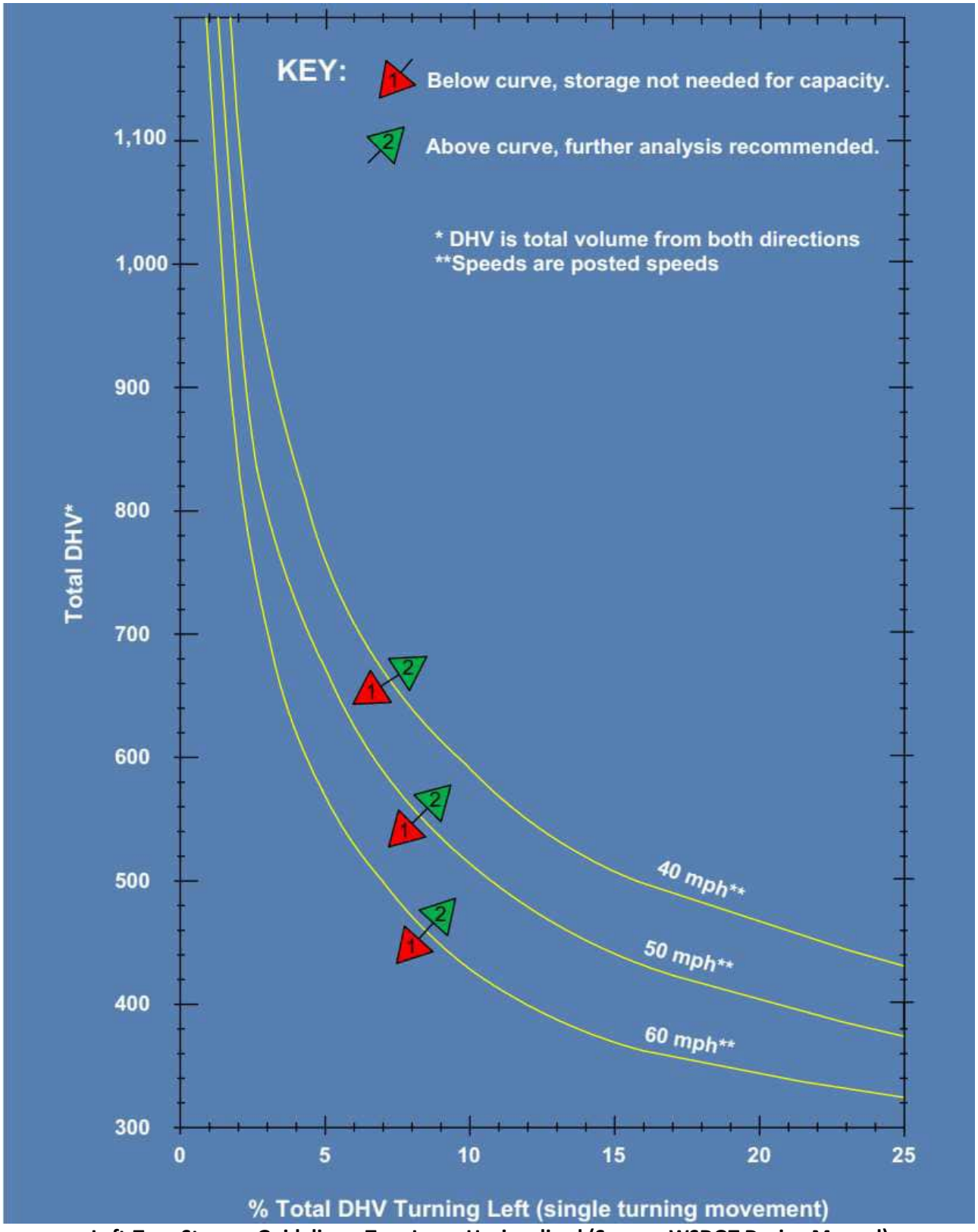
Intersection	
Int Delay, s/veh	3.1

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	365	40	85	260	35	130
Future Vol, veh/h	365	40	85	260	35	130
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	150	-	150	0
Veh in Median Storage, #	0	-	-	0	1	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	397	43	92	283	38	141

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	440	0	886	419
Stage 1	-	-	-	-	419	-
Stage 2	-	-	-	-	467	-
Critical Hdwy	-	-	4.12	-	6.42	6.22
Critical Hdwy Stg 1	-	-	-	-	5.42	-
Critical Hdwy Stg 2	-	-	-	-	5.42	-
Follow-up Hdwy	-	-	2.218	-	3.518	3.318
Pot Cap-1 Maneuver	-	-	1120	-	315	634
Stage 1	-	-	-	-	664	-
Stage 2	-	-	-	-	631	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	1120	-	289	634
Mov Cap-2 Maneuver	-	-	-	-	413	-
Stage 1	-	-	-	-	664	-
Stage 2	-	-	-	-	579	-

Approach	EB	WB	NB
HCM Control Delay, s	0	2.1	12.8
HCM LOS			B

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBT	EBR	WBL	WBT
Capacity (veh/h)	413	634	-	-	1120	-
HCM Lane V/C Ratio	0.092	0.223	-	-	0.082	-
HCM Control Delay (s)	14.6	12.3	-	-	8.5	-
HCM Lane LOS	B	B	-	-	A	-
HCM 95th %tile Q(veh)	0.3	0.8	-	-	0.3	-



Left-Turn Storage Guidelines: Two-Lane, Unsignalized (Source: WSDOT Design Manual)

Appendix E – N. Township St. (SR9) / John-Liner & McGarigle Rd. Roundabout Peer Review

TSI
Transportation Solutions, Inc.
8250 - 165th Avenue NE
Suite 100
Redmond, WA 98052-6628
T 425-883-4134
F 425-867-0898
www.tsinw.com

November 20, 2019

TO: Nathan Zylstra, PE
Principal
Reichhardt & Ebe

FROM: Michelle Mach, PE, TSI
Andrew Bratlien, PE, TSI

SUBJECT: Sedro-Woolley SR9 McGarigle Road Roundabout Peer Review

This memo is intended to provide peer review for the proposed roundabout design at the intersection of SR9 and McGarigle Road in Sedro-Woolley.

Operational Review

- Verify the pedestrian crossing on the north leg is sized to accommodate the bike/ped trail traffic. The splitter island crossing opening should match the trail width, and if geometrics allow, a refuge area longer than the ADA six foot minimum is preferred to serve users such as a cyclist with a trailer.
- How will the existing bike lanes on SR9 be treated at the roundabout? We recommend the bike lanes are terminated prior to the crosswalks with a ramp accessing the widened sidewalk. It is recommended to use an ADA roundabout detectable edge treatment to denote that the bicycle ramp is not a pedestrian ramp. See Access Board guidelines section R305.6.1 and **Figure 1**. We have found that cyclist often use a driveway as a transition between roadway and multi-use sidewalk. This may be an option where driveways are located near the intersection and space is limited.

Figure 1. Sample ADA Roundabout Detectable Edge Treatment at Bicycle Ramp

- I assume with the adjacent school in relationship to the bike/ped trail, there is significant north/south pedestrian movements on the east leg. Knowing this, WSDOT will want all the pedestrian crossings to be full pedestrian refuges and meet ADA requirements.

- A single lane roundabout meets operational requirements for the proposed future volumes.
- Utility poles with wires in both directions and a fire hydrant will need relocating as well as possibly other utilities.

Safety Review

- It is understood that the outside truck aprons are not yet shown. Sidewalks cannot be located where trucks are intended to track. It is possible to have a crosswalk in conjunction with a truck apron. See **Figure 2** for truck apron integrated with a crosswalk.

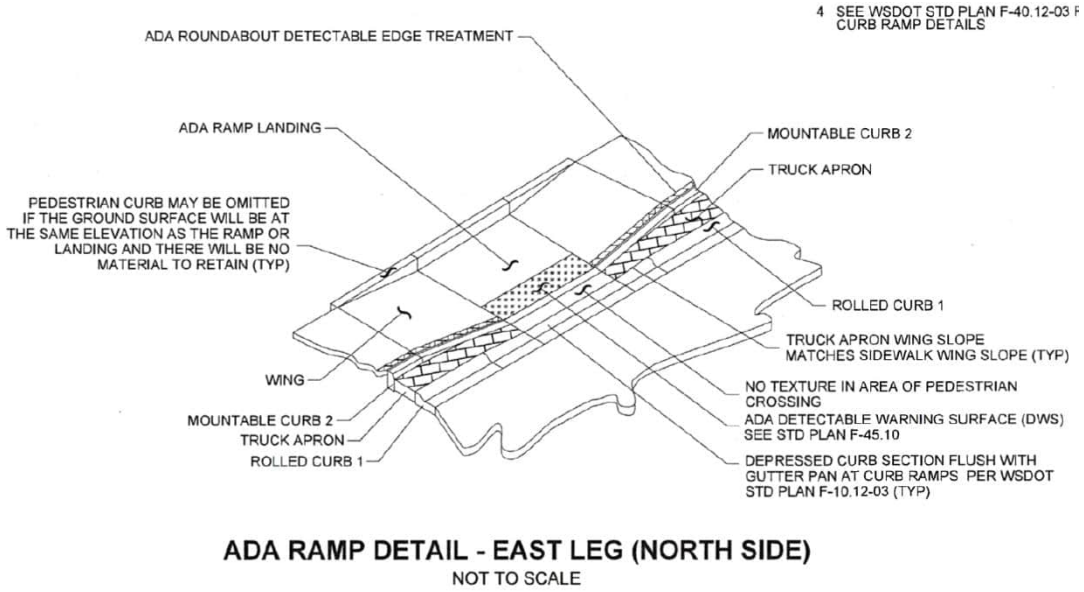


Figure 2. Truck Apron Integrated with Crosswalk

- With the adjacent school, all splitter islands should be full width pedestrian refuges and meet ADA requirements.

Design Vehicle Selection and WSDOT Design Consistency Review

- Accommodating a WB-67 is accurate for N-S thru movements. School bus is a valid design vehicle for all turning movements. Is there also a need to accommodate a WB-40 or other vehicle for the turns on and off the east/west legs? Please note the difference between design vehicle and accommodating a vehicle, as a design vehicle remains in the lane but accommodating a vehicle allows it to physically navigate the turn using aprons, shoulders and/or other means.
- WSDOT prefers all crossings to be ADA compliant when possible. Is there a reason other than driveway access that the splitter islands on the east/west legs are not larger?

Geometric Design Review

- Is the intention to only impact property on the east side of the intersection instead of partial takes on all of the corners or is there another driving force for the center location? If the primary reason is to create enough deflection for southbound vehicles, there are several options to reduce speed and still accommodate large vehicles including long splitter islands with landscaping, narrow lanes and horizontal curvature.

- Is it acceptable to impact property on the west side of the intersection? If so, it may be possible to have a design that does not require a complete property take on the NE corner.

Recommendations for Modifications

- Add splitter islands large enough to have pedestrian refuges on the east and west legs.
- Add additional driveway access off SR9 for properties on the NE and SW corners if needed (ie if the splitter island length limits driveway access) to allow full access to/from all directions.
- End bike lanes prior to roundabout and provide a wider sidewalk for multiuse where bikes will travel
- If there is not enough right-of-way width for a buffer and sidewalk adjacent the circulating lane, an ADA roundabout detectable edge treatment may be an option instead of a buffer. See Access Board guidelines section R305.6.1 and **Figure 2**.
- Longer splitter islands with landscaping for target value may be an effective speed control measure if right-of-way constraints limit horizontal geometry. This is especially true for the southbound movement.
- It may be geometrically possible to have a more centered roundabout that reduces speeds, accommodates large vehicles, provides ADA refuges on all four splitter islands, and has only small right-of-way takes on all four corners. **Figure 3** is a design concept in relationship to a 60 foot right-of-way. Bike lanes and sidewalk are not depicted in this graphic. The design vehicle for this design is a school bus and it accommodates a WB-67 for the north-south through movements with truck aprons. The entire central island can be mountable, but with further analysis of the turning movements, may allow for some central landscaping. The splitter island lengths can be shortened to allow full driveway access to adjacent properties (if multiple access points mentioned above is not an option). Or the splitter islands can be lengthened where driveways are not present.

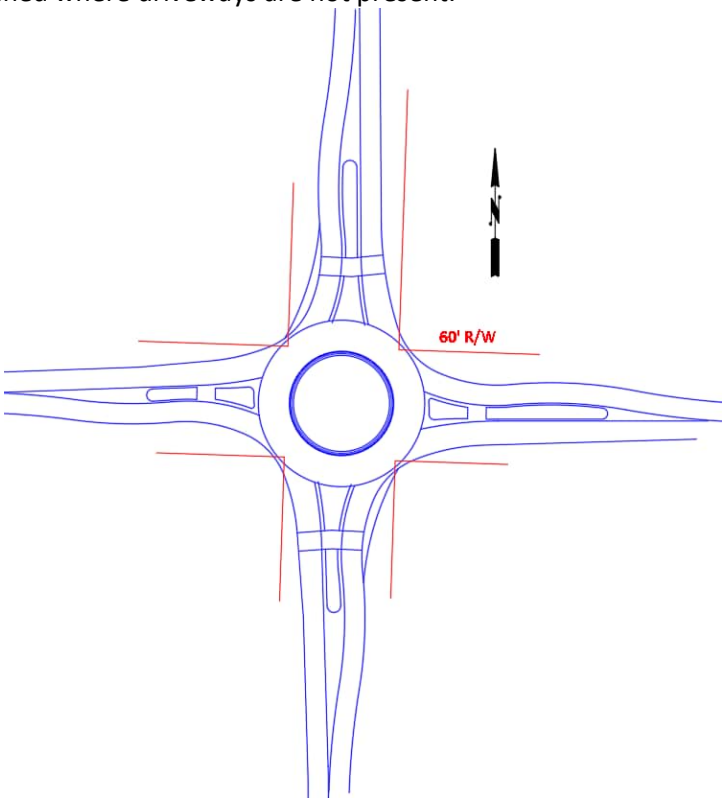


Figure 3. Sample Centered Roundabout Design

TECHNICAL APPENDIX B

Citywide Transportation Concurrency Review

TSI
Transportation Solutions, Inc.
8250 - 165th Avenue NE
Suite 100
Redmond, WA 98052-6628
T 425-883-4134
F 425-867-0898
www.tsinw.com

2021 TIB UAP APPLICATION ATTACHMENT 9: TRAFFIC ANALYSIS

January 7, 2020

TO: Mark Freiberger, PE
Director of Public Works
City of Sedro-Woolley

FROM: Andrew Bratlien, PE

SUBJECT: Citywide Transportation Concurrency Review

INTRODUCTION

This memorandum describes the methods, assumptions, and findings of the Sedro-Woolley Citywide Transportation Concurrency Review. This includes a review of intersection and segment Levels of Service (LOS) in 2019 and for two pipeline (2025) development scenarios as well as mitigation recommendations to maintain minimum LOS standards.

CONCURRENCY MANAGEMENT BACKGROUND

Concurrency is mandated under the 1990 Growth Management Act (GMA) passed by the Washington State legislature to address and mitigate problems associated with growth. The GMA requires that transportation improvements or strategies necessary to accommodate development must be made concurrently with land development. Concurrency requires transportation improvements to be either (a) in place at the time of development or (b) that a financial commitment is in place to complete the improvements within six years of development (RCW 36.70A.070(6)(b)).

Transportation concurrency requires that the transportation impacts of land use development actions do not reduce transportation Level of Service (LOS) below the responsible agency's adopted LOS standards. If it is determined during the development review process that the proposed land use action would reduce LOS below the adopted standard, the development must be modified to reduce its transportation impact or provide corrective transportation improvements. Transportation improvements, which may include project funding, must be identified and programmed within a six-year period from development permitting. Should any of these requirements fail to be met, the development proposal cannot be granted approval.

2019 CONDITIONS

Traffic Counts

Traffic counts were collected at 45 intersections in and near Sedro-Woolley on non-holiday weekdays in April 2015. Updated traffic counts were collected in 2019 at the following five intersections:

- SR 20 & Township St (October 2019)
- SR 20 & Fruitdale Rd (October 2019)
- SR 9 & John Liner Rd/McGarigle Rd (April 2019)
- Fruitdale Rd & McGarigle Rd (April 2019)
- Fruitdale Rd & Portobello Ave (October 2019)

Intersection turning movement counts were collected from 4:00 – 6:00 PM to capture the PM peak period of travel. Counts were then reviewed to identify the PM peak hour of travel, defined as the highest four consecutive fifteen-minute volume intervals during the PM peak period. The PM peak hour represents the one-hour period when traffic volumes are typically at their peak, and generally corresponds to the period of rush hour traffic with commuters returning home from work. The Sedro-Woolley travel demand and intersection LOS models reflect conditions during the PM peak hour of travel.

Travel Demand Model

The Sedro-Woolley travel demand model was most recently updated in 2015 to reflect PM peak hour traffic volumes in April 2015. As part of this analysis, the travel demand model was updated to include significant land use changes and transportation network improvements which occurred between April 2015 and November 2019.

A list of recently completed (2015-2019) developments was provided by City staff and input to the travel demand model. Recent development growth included a total of 215 new PM peak hour trips internal to the City of Sedro-Woolley. Regional (external) travel demand growth was updated based on 2019 PM peak hour traffic counts.

The updated travel demand model was used to estimate traffic volume growth at intersections which were most recently counted in April 2015.

2019 Level of Service

Level of Service Definition

Level of service (LOS) is a qualitative description of the operating performance of an element of transportation infrastructure such as a roadway or an intersection. LOS is typically expressed as a letter score from LOS A, representing free flow conditions with minimal delays, to LOS F, representing breakdown flow with high delays.

Intersection LOS is based on the average delay experienced by a vehicle traveling through an intersection. Delay at a signalized intersection can be caused by waiting for the signal or waiting for the queue ahead to clear the signal. Delay at roundabouts and stop-controlled intersections is caused by waiting for a gap in traffic or waiting for a queue to clear the intersection or roundabout.

Delay for signalized and stop-controlled intersections was calculated in Synchro 9 software using Highway Capacity Manual 2010 (HCM2010) methodology. Roundabout delay was calculated in Sidra Intersection 8 software using the Sidra capacity model and signalized level of service thresholds, per WSDOT October 2019 Sidra policy guidelines.

Delay is defined differently for signalized and all-way stop controlled intersections than for two-way stop controlled (i.e. stop control on minor approach) intersections. For signalized and all-way stop controlled intersections, level of service thresholds are based upon average control delay for all vehicles (on all approach legs) entering the intersection. For minor-approach-only stop controlled intersections, delay is reported for the movement with the worst (highest) delay. **Table 1** shows the amount of delay used to determine LOS for signalized and unsignalized intersections.

Table 1. Level of Service Thresholds

LOS	Signalized and Roundabout Delay (sec/veh)	Unsignalized Delay (sec/veh)	Segment V/C Ratio
A	≤10	≤10	≤ 0.60
B	>10 – 20	>10 – 15	> 0.60 – 0.70
C	>20 – 35	>15 – 25	> 0.70 – 0.80
D	>35 – 55	>25 – 35	> 0.80 – 0.90
E	>55 – 80	>35 – 50	> 0.90 – 1.00
F	>80	>50	> 1.00

Segment LOS was evaluated for each of 75 arterial segments, as identified in the Transportation Element. Street segment LOS is based on the ratio of traffic volume to street capacity. The Transportation Element defines local standards for street capacity based on functional classification, number of lanes, and other physical characteristics, as shown in **Table 2.**

Table 2. Sedro-Woolley Segment Capacity Standards

Functional Classification	Base Peak Hr Capacity (vphpl)	Has Left-Turn Lane (vph)	Has Access Management (vph)	No Bike Lane (vph)	No Sidewalk (vph)	On-Street Parking (vph)
Principal Arterial	900	+450	+540	-90	-180	-45
Minor Arterial	800	+400	+480	-40	-80	-40
Major Collector	600	+300	+360	-30	-60	-30
Local Access	400	0	0	0	0	0

Level of Service Policy

The Sedro-Woolley Comprehensive Plan defines minimum LOS standards as LOS D on principal and LOS C on all other streets.

Minimum LOS standards for State facilities are set by the Washington State Department of Transportation (WSDOT). SR 20 and SR 9 are both designated by WSDOT as Highways of Statewide Significance (HSS) with minimum LOS D through Sedro-Woolley. In order to maintain consistency with WSDOT LOS standards, the City of Sedro-Woolley has similarly adopted a minimum LOS D standard for both routes.

2019 Level of Service Deficiencies

Existing LOS deficiencies are summarized in **Table 3**.

Table 3. 2019 Intersection LOS Deficiencies

ID	Location	Control Type[1]	2019 LOS (Delay)[2]
11	SR 20 & Reed St	TWSC	F (131)
17	Cook Rd & Trail Rd	TWSC	D (31.9)

[1]TWSC = minor approach stop control; AWSC = all-way stop control; Signal = signalized; RAB=roundabout
[2]For TWSC intersections, delay is reported for the worst (i.e. highest-delay) movement; for all other control types, average intersection delay is reported.

The intersection of SR 20 and Reed St operates with high delay on the stop-controlled (Reed St) approaches during the PM peak hour due to high volumes along SR 20. Mitigation may include prohibition of left-turn

movements from Reed St during the PM peak hour. Mitigation options are described in greater detail later in this document.

The intersection of Cook Rd and Trail Rd currently operates at LOS D, which is below the minimum LOS C standard. The intersection will be impacted by the Trail Rd extension, identified as project C3 in the Sedro-Woolley Transportation Element.

The intersection of Township St (SR 9) and John Liner Rd/McGarigle Rd currently operates at LOS C with 20.5 seconds of delay on the westbound (McGarigle Rd) approach. Minimum LOS D is satisfied.

No street segments currently operate below minimum LOS standards. Full intersection and segment LOS summaries are provided in **Attachment 1**.

2025 PIPELINE CONDITIONS

Scenario Design

Pipeline conditions were analyzed for two development scenarios, as shown below. The land use and network improvement assumptions for each scenario are described in greater detail in the following sections.

1. 2025 with Approved Development (**2025 Baseline**):
   - **1A**. Without Jones Rd/John Liner Rd/Trail Rd corridor project
   - **1B**. With Jones/John Liner/Trail Rd corridor project
2. 2025 with Additional Development (**2025 Pending Applications**):
   - **2A**. Without Jones Rd/John Liner Rd/Trail Rd corridor project
   - **2B**. With Jones/John Liner/Trail Rd corridor project

The 2025 Baseline land use scenario included developments which were permitted but not occupied as of November 2019. Two network improvement scenarios were evaluated under the 2025 Baseline development scenario: without (1A) and with (1B) the Jones/John Liner/Trail Rd corridor projects. Transportation network improvement assumptions are described in greater detail later in this document.

The 2025 Pending Applications land use scenario included developments which have submitted permit applications but have not been approved as of November 2019. The 2025 Pending Applications scenarios also included development-constructed transportation improvement projects which were identified by City staff, as described in the following section. Similar to the 2025 Baseline scenarios, the 2025 Pending Applications scenarios included two transportation network improvement scenarios: without (2A) and with (2B) the Jones/John Liner/Trail Rd corridor projects.

Land Development

2025 Baseline

A 2025 Baseline travel demand forecast was calculated based on the sum of local (internal) and regional (external) growth forecasts. Sedro-Woolley staff developed a list of four “pipeline” developments which have permitted but not occupied as of November 2019, representing a total of 115 new PM peak hour trips in the City. Pipeline regional travel demand growth was calculated based on SCOG regional travel demand forecasts for arterials at the City boundaries.

2025 Pending Applications

Sedro-Woolley staff provided a list of five development applications which are pending approval. The developments, identified in **Table 4**, constitute a total of 362 new PM peak hour trips.

Table 4. Pipeline Developments Pending Approval

Name	Description	New PM Trips
Dukes Hill Subdivision	201 single-family units	179
McGarigle Subdivision	85 age-restricted single-family units	70
Gateway Golf Course Subdivision	99 single-family detached units; 16 townhome units	76
F&S Grade Rd Subdivision	31 single-family detached units	31
Debbie Dr Subdivision	6 single-family detached units	6
	Total New PM Peak Hour Trips	**362**

Two of the developments identified in **Table 4** include construction of new roadways which are identified in the Sedro-Woolley Transportation Element. Dukes Hill Subdivision will construct project C18, an extension of Portobello Ave from its existing terminus west to Township St (SR 9). F&S Grade Rd Subdivision will construct project C9B, an extension of Garden of Eden Rd from Jones Rd to intersect F&S Grade Rd to the south. Transportation improvement project assumptions are described in greater detail in the following section.

Transportation Improvement Projects

Sedro-Woolley staff provided a list of 14 capacity-related transportation improvement projects which are planned for construction by 2026. Per Sedro-Woolley segment LOS policy, capacity-related projects include nonmotorized improvements on arterial routes. **Table 5** summarizes transportation improvement projects which were assumed for each scenario of this analysis.

Development-driven improvement projects, including the Trail Rd/Garden of Eden Rd extension and the Portobello Ave arterial extension, were assumed to be constructed in both 2025 Pending Applications scenarios (2A, 2B).

The six-year transportation improvement project list included four intersection improvements, as identified in **Table 5**, which were evaluated and modeled as necessary to mitigate intersection LOS deficiencies. The necessity of these intersection improvement projects is described in the following section.

Table 5. 2020-2026 Transportation Capacity Improvement Projects by Scenario

ID	Project Name	From/To	Description	Expected Cn Year
2025 Baseline Transportation Capacity Improvement Projects (All Scenarios)				
S16	SR 20 & Township St (SR 9) Intersection Imp.		Signal & channelization impr.	2021
S14C	SR 20/Cascade Trail West Extension Phase 2A	Holtcamp Rd to Hodgin Rd	Shared use path	2022
C1C	John Liner Rd Bike/Ped Imp.	Reed St to SR 9	Shared use path	2023
Jones/John Liner/Trail Rd Corridor Projects (Scenarios 1B, 2B)				
C19	Patrick St Arterial Extension	Michael St to Jones St	New major collector w/sidewalks	2021
C1B	Jones/John Liner RR Crossing	Sapp Rd to Reed St	New RR undercrossing and new major collector street	2022
C1D	John Liner Rd Arterial Imp.	Reed St to Township St	Reconstruct to major collector section	2024
C9A	Trail Rd Arterial Extension	Cook Rd to F&S Grade Rd	New major collector	2025
C1A	Jones Rd Arterial Imp.	F&S Grade Rd to Sapp Rd	Reconstruct to major collector including sidewalk	2026
2025 Development-Driven Transportation Capacity Improvement Projects (Scenarios 2A, 2B)				
C9B	Trail Rd – Garden of Eden Rd Extension	F&S Grade Rd to Jones Rd	New major collector	TBD
C18	Portobello Ave Arterial Extension	Township St to Cascadia Dr	New major collector	TBD
Intersection Capacity Improvement Projects (Applied as Necessary)				
S2	SR 20 & Reed St Intersection Imp.		Restrict minor approaches to right-in/right-out only	2021
S17	Township St (SR 9) & John Liner Rd/McGarigle Rd Intersection Imp.		New signal or roundabout	2023
S18	SR 9 & State St Intersection Imp.		Add dedicated right-turn lane on west leg	2024
C3	Cook Rd & Trail Rd Intersection Imp.		Intersection improvements	2025

2025 Level of Service

Intersection and segment LOS were analyzed for the 2025 Baseline and 2025 Pending Applications scenarios. Intersection LOS deficiencies are summarized in **Table 6**.

Table 6. Pipeline (2025) Intersection Level of Service Deficiencies

ID	Location	Control Type[1]	2025 Baseline LOS (Delay)[2]	2025 Pending LOS (Delay)[2]
11	SR 20 & Reed St			
	w/o Jones/John Liner Rd Crossing	TWSC	F (154)	F (204)
	w/ Jones/John Liner Rd Crossing	TWSC	F (54.8)	F (58.5)
	w/ crossing + right-in/right-out (Project S2)	RIRO	C (17.9)	C (17.8)
17	Cook Rd & Trail Rd			
	w/o Trail Rd Extension / TWSC	TWSC	E (35.3)	E (39.5)
	w/ Trail Rd Extension / TWSC	TWSC	F (493)	F (>999)
	w/ Trail Rd Ext. / roundabout (Project C3)	RAB	A (7.9)	B (9.6)
29	Township St (SR 9) & John Liner/McGarigle Rd			
	w/o Jones/John Liner Rd Crossing	TWSC	C (22.6)	D (28.5)
	w/ crossing & two-way stop control	TWSC	F (50.2)	F (181)
	w/ crossing & roundabout (Project S17)	RAB	A (7.5)	A (7.8)
	w/ crossing & signal control (Project S17)	Signal	A (9.3)	B (10.7)

[1]TWSC = minor approach stop control; AWSC = all-way stop control; Signal = signalized; RAB=roundabout
[2]For TWSC intersections, delay is reported for the worst (i.e. highest-delay) movement; for all other control types, average intersection delay is reported.

The intersection of SR 20 and Reed St will continue to operate at LOS F with high minor-approach delay during the PM peak hour. The traffic redistribution associated with the Jones/John Liner Rd undercrossing will reduce delay but will not mitigate the LOS deficiency. Prohibiting left-turns from Reed St onto SR 20 during the PM peak hour will allow the intersection to satisfy minimum LOS standards. This is consistent with improvement project S2 identified in Transportation Element.

The intersection of Cook Rd and Trail Rd will degrade to LOS E in the 2025 Baseline Without-Trail Rd scenario. The 2025 Pending Applications scenario will result in slightly higher delay but no reduction in LOS. After the construction of the Trail Rd extension, the intersection will operate at LOS F with very high delay on the north and south approaches. Mitigation may include a single-lane roundabout, which is consistent with improvement project C3 identified in the Transportation Element.

The intersection of Township St (SR 9) and John Liner Rd/McGarigle Rd will operate at LOS C in the 2025 Baseline Without Trail Rd scenario. The addition of pending applications will increase delay, resulting in LOS D, but will not trigger an LOS deficiency. The construction of the Jones/John Liner Rd undercrossing will result in LOS F, with very high delays on the John Liner Rd approach. Mitigation may include a single-lane roundabout or signal, which is consistent with project S17 identified in the Transportation Element.

The intersection of SR 9 and State St is identified for improvement in the Transportation Element, but the improvement will not be necessary in the six-year concurrency horizon. The intersection operates at LOS D in all 2025 analysis scenarios and satisfies the minimum LOS D standard for SR 9.

No segment LOS deficiencies will occur by 2025. 2025 Baseline intersection and segment LOS results are summarized in Attachment 2. 2025 Pending Applications LOS results are summarized in Attachment 3. Full intersection LOS reports may be provided upon request.

FINDINGS

- Pending development will generate 362 new PM peak hour trips.
- Trips associated with pending development will increase delay at several intersections but will not cause any new LOS deficiencies.
- Township St (SR 9) and John Liner Rd/McGarigle Rd intersection:
    - The intersection of Township St (SR 9) and John Liner Rd/McGarigle Rd currently satisfies minimum LOS D standard but will reach LOS F by 2025, assuming the construction of the Jones/John Liner Rd corridor projects.
- Cook Rd and Trail Rd intersection:
    - Currently operates at LOS D, below the minimum LOS C standard.
    - Will degrade to LOS E by 2025, assuming no extension of Trail Rd
    - Will degrade to LOS F including very high minor-approach delays with the planned Trail Rd extension.
- SR 20 and Reed St intersection:
    - Currently operates at LOS F.
    - Will continue to operate at LOS F with high minor-approach delay during PM peak hour.
- All Comprehensive Plan street segments will satisfy minimum LOS standards through 2025.

RECOMMENDATIONS

- Township St (SR 9) and John Liner Rd/McGarigle Rd intersection: A single-lane roundabout or signal is recommended concurrent with the Jones Rd/John Liner Rd undercrossing to maintain minimum LOS
- Cook Rd and Trail Rd intersection: A single-lane roundabout or traffic signal is recommended to mitigate the existing LOS deficiency.
- SR 20 and Reed St intersection: Prohibit left turn movements from Reed St during PM peak hour.

Attachment 1. 2019 LOS Results

Attachment 2. 2025 LOS Results

TSI
Transportation Solutions, Inc.

2019 Intersection LOS Results

ID	Location	Control Type[1]	2019 LOS (Delay)[2]	Deficient?
1	SR 20 & Collins Rd	Signal	B (11.3)	
2	SR 20 & Rhodes Rd	Signal	B (10.8)	
3	SR 20 & Trail Rd	Signal	C (26.7)	
4	SR 20 & SR 9 (west)	Signal	B (14.4)	
5	SR 20 & Ferry St	Signal	B (15.8)	
6	SR 20 & Cook Rd	RAB	A (9.5)	
7	SR 20 & F&S Grade Rd	TWSC	C (16.3)	
8	SR 20 & Patrick St	RAB	A (4.4)	
9	SR 20 & Metcalf St	TWSC	D (25.1)	
10	SR 20 & Murdock St	TWSC	D (26.1)	
11	SR 20 & Reed St	TWSC	D (31.3)	
12	SR 20 & Central Ave	TWSC	C (23.2)	
13	SR 20 & Ball St	TWSC	C (21.4)	
14	SR 20 & Township St (SR 9)	Signal	D (48.8)	
15	SR 20 & Fruitdale Rd	Signal	B (10.8)	
16	SR 20 & Helmick Rd	TWSC	B (10.4)	
17	Cook Rd & Trail Rd	TWSC	D (31.9)	Yes
18	Cook Rd & Ferry St	RAB	A (6.8)	
19	SR 9 & State St	Signal	D (40.9)	
20	State St & Metcalf St	AWSC	B (14.1)	
21	State St & Reed St	TWSC	B (13.2)	
22	State St & Township St	AWSC	B (13)	
23	State St & Railroad St	AWSC	A (8.1)	
24	Hoehn Rd & Fruitdale Rd	TWSC	A (9.3)	
26	Ferry St & Metcalf St	AWSC	B (12.2)	
27	Ferry St & Reed St	TWSC	B (11.8)	
28	Ferry St & Township St	TWSC	C (16.4)	
29	Township St (SR 9) & John Liner Rd	TWSC	C (20.5)	
30	SR 9 & Kalloch Rd	TWSC	B (11.2)	
31	Jameson St & 3rd St	AWSC	A (8.7)	
32	Jameson St & Township St	TWSC	B (12.7)	
33	John Liner Rd & Reed St	TWSC	B (10.7)	
34	McGarigle Rd & Carter St	TWSC	A (8.8)	
36	Fruitdale Rd & McGarigle Rd	TWSC	B (10)	
37	Fruitdale Rd & Portobello Ave	TWSC	B (10.6)	
41	Fruitdale Rd & Kalloch Rd	TWSC	A (8.6)	
42	Minkler Rd & Fruitdale Rd	TWSC	B (11.1)	
43	SR 9 & Jameson St	RAB	A (6.1)	

[1]TWSC = minor approach stop control; AWSC = all-way stop control; Signal = signalized; RAB = roundabout

[2]For TWSC intersections, delay is reported for the worst (i.e. highest-delay) movement; for all other control types, average intersection delay is reported.

TSI
Transportation Solutions, Inc.

2019 Segment LOS Results

ID	Name	Limits	Functional Classification	2019 V/C	2019 LOS
2001	SR 20	Collins Rd to Rhodes Rd	Principal Art.	0.82	D
2002	SR 20	Rhodes Rd to W State St	Principal Art.	0.80	D
2003	SR 20	State St to SR 9	Principal Art.	0.48	A
2004	SR 20	SR 9 to W Ferry St	Principal Art.	0.59	A
2005	SR 20	W Ferry St to Cook Rd	Principal Art.	0.45	A
2006	SR 20	Cook Rd to F&S Grade Rd	Principal Art.	0.76	C
2007	SR 20	F&S Grade Rd to Patrick St	Principal Art.	0.79	C
2008	SR 20	Patrick St to Metcalf St	Principal Art.	0.75	C
2009	SR 20	Metcalf St to Reed St	Principal Art.	0.80	D
2010	SR 20	Reed St to Township St	Principal Art.	0.73	C
3001	SR 20	Township St to Fruitdale	Minor Art.	0.57	A
3002	SR 20	Fruitdale Rd to Helmick Rd	Minor Art.	0.39	A
3003	SR 9	City Limit to W Nelson St	Minor Art.	0.76	C
3004	[reserved]			0.00	-
3005	SR 9	W Nelson St to W State St	Minor Art.	0.58	A
3006	SR 9	W State St to SR 20	Minor Art.	0.25	A
3007	[reserved]			0.00	-
3008	[reserved]			0.00	-
3009	[reserved]			0.00	-
3010	Cook Rd	City Limit to Trail Rd	Minor Art.	0.59	A
3011	Cook Rd	Trail Rd to Ferry St	Minor Art.	0.55	A
3012	Cook Rd	Ferry St to SR 20	Minor Art.	0.42	A
3013	F&S Grade Rd	City Limit to Murrow St	Minor Art.	0.09	A
3014	F&S Grade Rd	Murrow St to SR 20	Minor Art.	0.10	A
3015	[reserved]			0.00	-
3016	[reserved]			0.00	-
3017	Ferry St	SR 20 to Metcalf St	Minor Art.	0.42	A
3018	Ferry St	Metcalf St to Reed St	Minor Art.	0.28	A
3019	Ferry St	Reed St to Township St	Minor Art.	0.20	A
3020	State St	SR 20 to SR 9	Minor Art.	0.48	A
3021	State St	SR 9 to Metcalf St	Minor Art.	0.58	A
3022	State St	Metcalf St to 3rd St	Minor Art.	0.46	A
3023	State St	3rd St to Reed St	Minor Art.	0.45	A
3024	State St	Reed St to Township St	Minor Art.	0.45	A
3025	[reserved]			0.00	-
3026	Township St	State St to Ferry St	Minor Art.	0.32	A
3027	Township St	Ferry St to Wicker Rd	Minor Art.	0.38	A
3028	Township St	Wicker Rd to SR 20	Minor Art.	0.35	A
3029	Township St (SR 9)	SR 20 to McGarigle Rd	Minor Art.	0.51	A
3030	Township St (SR 9)	McGarigle Rd to Sapp Rd	Minor Art.	0.45	A
3031	Township St (SR 9)	Sapp Rd to Bassett Rd	Minor Art.	0.38	A
3032	Township St (SR 9)	Bassett Rd to Kalloch	Minor Art.	0.31	A
3033	[reserved]			0.00	-

TSI
Transportation Solutions, Inc.

ID	Name	Limits	Functional Classification	2019 V/C	2019 LOS
3034	[reserved]			0.00	-
4001	3rd St	Sterling St to Jameson St	Major Coll.	0.19	A
4002	3rd St	Jameson St to State St	Major Coll.	0.00	-
4003	Batey Rd	W Nelson St to Jameson St	Major Coll.	0.09	A
4004	Fruitdale Rd	River Rd to Hoehn Rd	Major Coll.	0.04	A
4005	Fruitdale Rd	Hoehn Rd to Minkler Rd	Major Coll.	0.05	A
4006	Fruitdale Rd	Minkler Rd to Wicker Rd	Major Coll.	0.14	A
4007	Fruitdale Rd	Wicker Rd to SR 20	Major Coll.	0.13	A
4008	Fruitdale Rd	SR 20 to McGarigle Rd	Major Coll.	0.18	A
4009	Fruitdale Rd	McGarigle to Thompson Dr	Major Coll.	0.20	A
4010	Fruitdale Rd	Thompson Dr to Kalloch	Major Coll.	0.01	A
4011	Jameson St	Batey Rd to 3rd St	Major Coll.	0.28	A
4012	Jameson St	3rd St to 6th St	Major Coll.	0.13	A
4013	Jameson St	6th St to Township St	Major Coll.	0.11	A
4014	Jameson St	Township St to Railroad Ave	Major Coll.	0.07	A
4015	John Liner Rd	Reed St to Township St	Major Coll.	0.06	A
4016	[reserved]			0.00	-
4017	McGarigle Rd	Township St to Fruitdale	Major Coll.	0.17	A
4018	Metcalf St	State St to Ferry St	Major Coll.	0.24	A
4019	Metcalf St	Ferry St to SR 20	Major Coll.	0.22	A
4020	Minkler Rd	State St to Fruitdale Rd	Major Coll.	0.13	A
4021	Nelson St	SR 9 to Batey Rd	Major Coll.	0.28	A
4022	Railroad Ave	Jameson St to State St	Major Coll.	0.20	A
4023	Reed St	State St to Ferry St	Major Coll.	0.02	A
4024	Reed St	Ferry St to SR 20	Major Coll.	0.02	A
4025	Reed St	SR 20 to John Liner Rd	Major Coll.	0.20	A
4026	Reed St	John Liner Rd to Sapp Rd	Major Coll.	0.18	A
4027	Rhodes Rd	SR 20 to SR 9	Major Coll.	0.05	A
4028	[reserved]			0.00	-
4029	Sapp Rd	Reed St to Township Rd	Major Coll.	0.09	A
4030	State St	Township to Railroad Ave	Major Coll.	0.19	A
4031	Sterling St	3rd St to 6th St	Major Coll.	0.09	A
4032	Sterling St	6th St to Township St	Major Coll.	0.02	A
4033	Township St	River Rd to Sterling St	Major Coll.	0.21	A
4034	Township St	Sterling St to Jameson St	Major Coll.	0.23	A
4035	Township St	Jameson St to State St	Major Coll.	0.25	A
4036	Trail Road	SR 20 to Cook Rd	Major Coll.	0.27	A
4037	Wicker Rd	Township St to Fruitdale	Major Coll.	0.30	A
4038	[reserved]			0.00	-
5001	Jones Rd	F&S Grade Rd to Garden of Eden	Local	0.24	A
5002	Jones Rd	Garden of Eden to Sapp Rd	Local	0.05	A
5003	Garden of Eden Rd	F&S Grade Rd to Jones Rd	Local	0.19	A
5004	Garden of Eden Rd	Jones Rd to Kiens Ln (Pvt)	Local	0.31	A
5005	[reserved]		Local	0.00	-

ID	Name	Limits	Functional Classification	2019 V/C	2019 LOS
5006	[reserved]			0.00	-
5007	Bassett Rd	Eikleberry Ct (Pvt) to SR 9	Local	0.03	A
5008	[reserved]			0.00	-
5009	[reserved]			0.00	-
5010	[reserved]			0.00	-
5011	[reserved]			0.00	-

TSI
Transportation Solutions, Inc.

2025 Intersection LOS Results

ID	Location	Control Type[1]	2025 LOS (Delay)[2]		Deficient?	
			Baseline	Alternative	Baseline	Alternative
1	SR 20 & Collins Rd	Signal	B (13.7)	B (13.6)		
2	SR 20 & Rhodes Rd	Signal	B (11.1)	B (10.7)		
3	SR 20 & Trail Rd	Signal	C (25.1)	C (23.8)		
4	SR 20 & SR 9 (west)	Signal	B (16.7)	B (16.8)		
5	SR 20 & Ferry St	Signal	B (15.6)	B (16.1)		
6	SR 20 & Cook Rd	RAB	B (11.8)	B (11.4)		
7	SR 20 & F&S Grade Rd	TWSC	C (16)	C (15.7)		
8	SR 20 & Patrick St	RAB	A (6.5)	A (6.5)		
9	SR 20 & Metcalf St	TWSC	D (25.7)	D (25.1)		
10	SR 20 & Murdock St	TWSC	C (23)	C (23)		
11	SR 20 & Reed St	TWSC	C (24.8)	D (25.3)		
12	SR 20 & Central Ave	TWSC	C (22.8)	C (22.6)		
13	SR 20 & Ball St	TWSC	C (21.2)	C (21)		
14	SR 20 & Township St (SR 9)	Signal	B (19.9)	C (21)		
15	SR 20 & Fruitdale Rd	Signal	B (11)	B (11.6)		
16	SR 20 & Helmick Rd	TWSC	B (10.6)	B (10.6)		
17	Cook Rd & Trail Rd	TWSC	F (492.8)	F (999)	Yes	Yes
18	Cook Rd & Ferry St	RAB	A (5.7)	A (5.6)		
19	SR 9 & State St	Signal	D (44.5)	D (43.6)		
20	State St & Metcalf St	AWSC	B (12.1)	B (12)		
21	State St & Reed St	TWSC	B (11.9)	B (11.9)		
22	State St & Township St	AWSC	B (11)	B (11.4)		
23	State St & Railroad St	AWSC	A (8.1)	A (8.1)		
24	Hoehn Rd & Fruitdale Rd	TWSC	A (9.4)	A (9.4)		
26	Ferry St & Metcalf St	AWSC	B (10.9)	B (10.6)		
27	Ferry St & Reed St	TWSC	B (11.4)	B (11.2)		
28	Ferry St & Township St	TWSC	B (12.7)	B (12.7)		
29	Township St & John Liner Rd	TWSC	F (50.2)	F (178.7)	Yes	Yes
30	SR 9 & Kalloch Rd	TWSC	B (12.1)	B (12.3)		
31	Jameson St & 3rd St	AWSC	A (8.2)	A (8.2)		
32	Jameson St & Township St	TWSC	B (11.6)	B (11.7)		
33	John Liner Rd & Reed St	TWSC	C (18.1)	C (21.8)		
34	McGarigle Rd & Carter St	TWSC	A (8.9)	A (9.8)		
36	Fruitdale Rd & McGarigle Rd	TWSC	B (10.3)	B (10.9)		
37	Fruitdale Rd & Portobello Ave	TWSC	B (13.9)	B (14.7)		
41	Fruitdale Rd & Kalloch Rd	TWSC	A (8.8)	A (8.8)		
42	Minkler Rd & Fruitdale Rd	TWSC	B (11.3)	B (11.2)		
43	SR 9 & Jameson St	RAB	A (6.7)	A (5.4)		
44	F&S Grade Rd & Trail Rd	TWSC	A (9.8)	C (15.2)		
45	Jones Rd & Garden of Eden Rd	TWSC	B (10.1)	C (16.4)		
46	Jones Rd & Patrick St	TWSC	B (11.6)	B (13.3)		

[1]TWSC = minor approach stop control; AWSC = all-way stop control; Signal = signalized; RAB = roundabout

[2]For TWSC intersections, delay is reported for the worst (i.e. highest-delay) movement; for all other control types, average intersection delay is reported.

TSI
Transportation Solutions, Inc.

2025 Segment LOS Results

ID	Name	Limits	Functional Classification	2025 V/C		2025 LOS	
				Base	Alt.	Base	Alt.
2001	SR 20	Collins Rd to Rhodes Rd	Principal Art.	0.72	0.72	C	C
2002	SR 20	Rhodes Rd to W State St	Principal Art.	0.80	0.80	D	D
2003	SR 20	State St to SR 9	Principal Art.	0.48	0.48	A	A
2004	SR 20	SR 9 to W Ferry St	Principal Art.	0.59	0.59	A	A
2005	SR 20	W Ferry St to Cook Rd	Principal Art.	0.45	0.45	A	A
2006	SR 20	Cook Rd to F&S Grade Rd	Principal Art.	0.76	0.76	C	C
2007	SR 20	F&S Grade Rd to Patrick St	Principal Art.	0.79	0.79	C	C
2008	SR 20	Patrick St to Metcalf St	Principal Art.	0.75	0.75	C	C
2009	SR 20	Metcalf St to Reed St	Principal Art.	0.80	0.80	D	D
2010	SR 20	Reed St to Township St	Principal Art.	0.73	0.73	C	C
3001	SR 20	Township St to Fruitdale	Minor Art.	0.57	0.57	A	A
3002	SR 20	Fruitdale Rd to Helmick Rd	Minor Art.	0.39	0.39	A	A
3003	SR 9	City Limit to W Nelson St	Minor Art.	0.76	0.76	C	C
3004	[reserved]			0.00	0.00	-	-
3005	SR 9	W Nelson St to W State St	Minor Art.	0.58	0.58	A	A
3006	SR 9	W State St to SR 20	Minor Art.	0.25	0.25	A	A
3007	[reserved]			0.00	0.00	-	-
3008	[reserved]			0.00	0.00	-	-
3009	[reserved]			0.00	0.00	-	-
3010	Cook Rd	City Limit to Trail Rd	Minor Art.	0.59	0.59	A	A
3011	Cook Rd	Trail Rd to Ferry St	Minor Art.	0.55	0.55	A	A
3012	Cook Rd	Ferry St to SR 20	Minor Art.	0.42	0.42	A	A
3013	F&S Grade Rd	City Limit to Murrow St	Minor Art.	0.09	0.09	A	A
3014	F&S Grade Rd	Murrow St to SR 20	Minor Art.	0.10	0.10	A	A
3015	[reserved]			0.00	0.00	-	-
3016	[reserved]			0.00	0.00	-	-
3017	Ferry St	SR 20 to Metcalf St	Minor Art.	0.42	0.42	A	A
3018	Ferry St	Metcalf St to Reed St	Minor Art.	0.28	0.28	A	A
3019	Ferry St	Reed St to Township St	Minor Art.	0.20	0.20	A	A
3020	State St	SR 20 to SR 9	Minor Art.	0.48	0.48	A	A
3021	State St	SR 9 to Metcalf St	Minor Art.	0.58	0.58	A	A
3022	State St	Metcalf St to 3rd St	Minor Art.	0.46	0.46	A	A
3023	State St	3rd St to Reed St	Minor Art.	0.45	0.45	A	A
3024	State St	Reed St to Township St	Minor Art.	0.45	0.45	A	A
3025	[reserved]			0.00	0.00	-	-
3026	Township St	State St to Ferry St	Minor Art.	0.32	0.32	A	A
3027	Township St	Ferry St to Wicker Rd	Minor Art.	0.38	0.38	A	A
3028	Township St	Wicker Rd to SR 20	Minor Art.	0.35	0.35	A	A
3029	Township St (SR 9)	SR 20 to McGarigle Rd	Minor Art.	0.51	0.51	A	A
3030	Township St (SR 9)	McGarigle Rd to Sapp Rd	Minor Art.	0.45	0.45	A	A
3031	Township St (SR 9)	Sapp Rd to Bassett Rd	Minor Art.	0.43	0.50	A	A
3032	Township St (SR 9)	Bassett Rd to Kalloch	Minor Art.	0.31	0.31	A	A
3033	[reserved]			0.00	0.00	-	-

TSI
Transportation Solutions, Inc.

ID	Name	Limits	Functional Classification	2025 V/C		2025 LOS	
				Base	Alt.	Base	Alt.
3034	[reserved]			0.00	0.00	-	-
4001	3rd St	Sterling St to Jameson St	Major Coll.	0.19	0.19	A	A
4002	3rd St	Jameson St to State St	Major Coll.	0.11	0.11	A	A
4003	Batey Rd	W Nelson St to Jameson St	Major Coll.	0.08	0.07	A	A
4004	Fruitdale Rd	River Rd to Hoehn Rd	Major Coll.	0.04	0.04	A	A
4005	Fruitdale Rd	Hoehn Rd to Minkler Rd	Major Coll.	0.05	0.05	A	A
4006	Fruitdale Rd	Minkler Rd to Wicker Rd	Major Coll.	0.14	0.14	A	A
4007	Fruitdale Rd	Wicker Rd to SR 20	Major Coll.	0.13	0.13	A	A
4008	Fruitdale Rd	SR 20 to McGarigle Rd	Major Coll.	0.18	0.18	A	A
4009	Fruitdale Rd	McGarigle to Thompson Dr	Major Coll.	0.20	0.20	A	A
4010	Fruitdale Rd	Thompson Dr to Kalloch	Major Coll.	0.01	0.01	A	A
4011	Jameson St	Batey Rd to 3rd St	Major Coll.	0.28	0.28	A	A
4012	Jameson St	3rd St to 6th St	Major Coll.	0.13	0.13	A	A
4013	Jameson St	6th St to Township St	Major Coll.	0.11	0.11	A	A
4014	Jameson St	Township St to Railroad Ave	Major Coll.	0.07	0.07	A	A
4015	John Liner Rd	Reed St to Township St	Major Coll.	0.06	0.06	A	A
4016	[reserved]			0.00	0.00	-	-
4017	McGarigle Rd	Township St to Fruitdale	Major Coll.	0.17	0.17	A	A
4018	Metcalf St	State St to Ferry St	Major Coll.	0.24	0.24	A	A
4019	Metcalf St	Ferry St to SR 20	Major Coll.	0.22	0.22	A	A
4020	Minkler Rd	State St to Fruitdale Rd	Major Coll.	0.13	0.13	A	A
4021	Nelson St	SR 9 to Batey Rd	Major Coll.	0.28	0.28	A	A
4022	Railroad Ave	Jameson St to State St	Major Coll.	0.20	0.20	A	A
4023	Reed St	State St to Ferry St	Major Coll.	0.02	0.02	A	A
4024	Reed St	Ferry St to SR 20	Major Coll.	0.02	0.02	A	A
4025	Reed St	SR 20 to John Liner Rd	Major Coll.	0.20	0.20	A	A
4026	Reed St	John Liner Rd to Sapp Rd	Major Coll.	0.18	0.18	A	A
4027	Rhodes Rd	SR 20 to SR 9	Major Coll.	0.05	0.05	A	A
4028	[reserved]			0.00	0.00	-	-
4029	Sapp Rd	Reed St to Township Rd	Major Coll.	0.07	0.07	A	A
4030	State St	Township to Railroad Ave	Major Coll.	0.19	0.19	A	A
4031	Sterling St	3rd St to 6th St	Major Coll.	0.09	0.09	A	A
4032	Sterling St	6th St to Township St	Major Coll.	0.02	0.02	A	A
4033	Township St	River Rd to Sterling St	Major Coll.	0.21	0.21	A	A
4034	Township St	Sterling St to Jameson St	Major Coll.	0.23	0.23	A	A
4035	Township St	Jameson St to State St	Major Coll.	0.25	0.25	A	A
4036	Trail Road	SR 20 to Cook Rd	Major Coll.	0.27	0.27	A	A
4037	Wicker Rd	Township St to Fruitdale	Major Coll.	0.35	0.33	A	A
4038	[reserved]			0.00	0.00	-	-
5001	Jones Rd	F&S Grade Rd to Garden of Eden Rd	Local	0.24	0.10	A	A
5002	Jones Rd	Garden of Eden to Sapp Rd	Local	0.25	0.38	A	A
5003	Garden of Eden Rd	F&S Grade Rd to Jones Rd	Local	0.48	0.14	A	A

ID	Name	Limits	Functional Classification	2025 V/C		2025 LOS	
				Base	Alt.	Base	Alt.
5004	Garden of Eden Rd	Jones Rd to Kiens Ln (Pvt)	Local	0.24	0.26	A	A
5005	[reserved]		Local	0.00	0.00	-	-
5006	[reserved]			0.00	0.00	-	-
5007	Bassett Rd	Eikleberry Ct (Pvt) to SR 9	Local	0.03	0.03	A	A
5008	[reserved]			0.00	0.00	-	-
5009	[reserved]			0.00	0.00	-	-
5010	[reserved]			0.00	0.00	-	-
5011	[reserved]			0.00	0.00	-	-

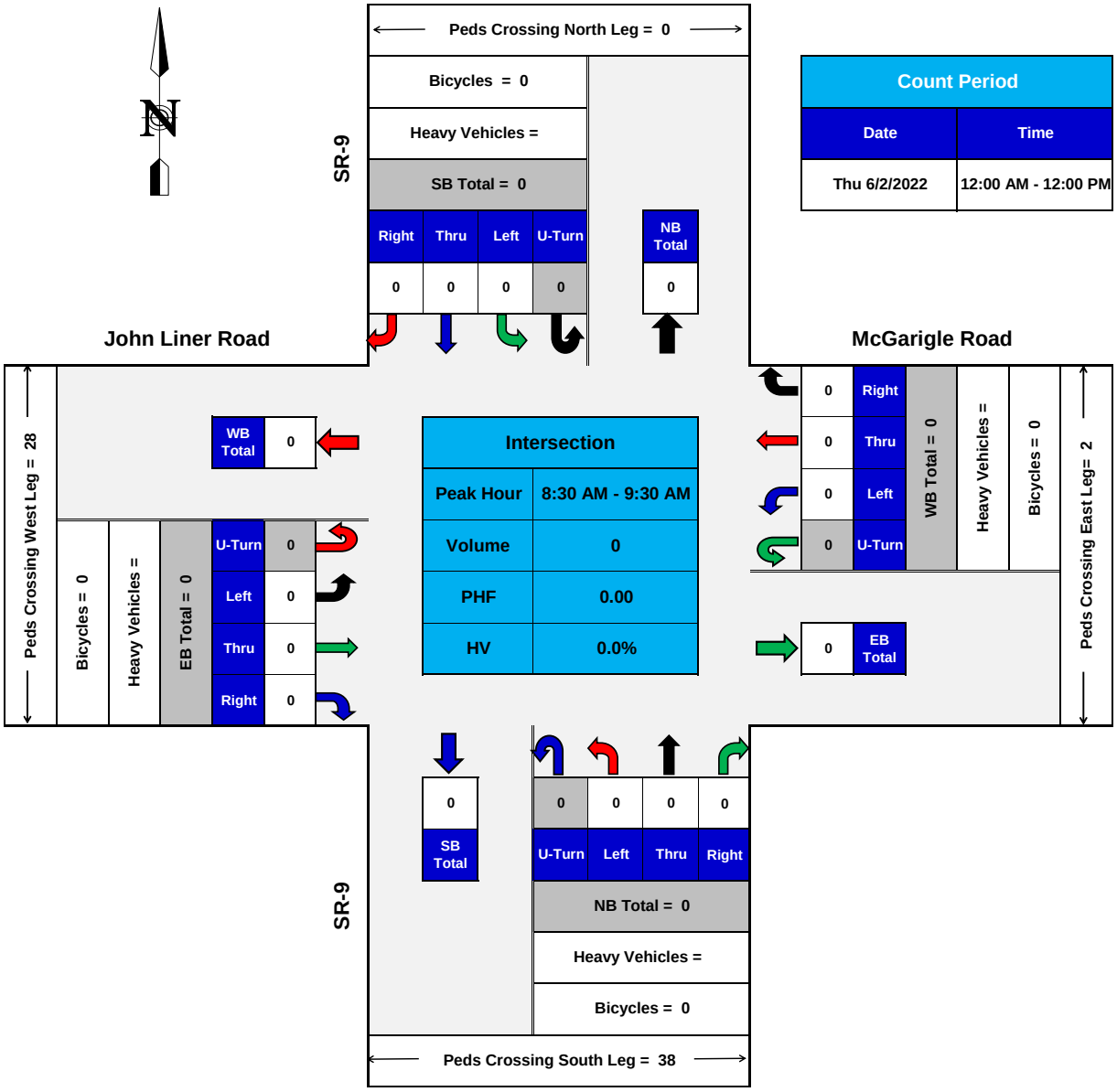
TECHNICAL APPENDIX C

Count Data

Pedestrian Volumes only

SR-9 @ John Liner Road

Sedro Woolley, WA



TURNING MOVEMENTS DIAGRAM

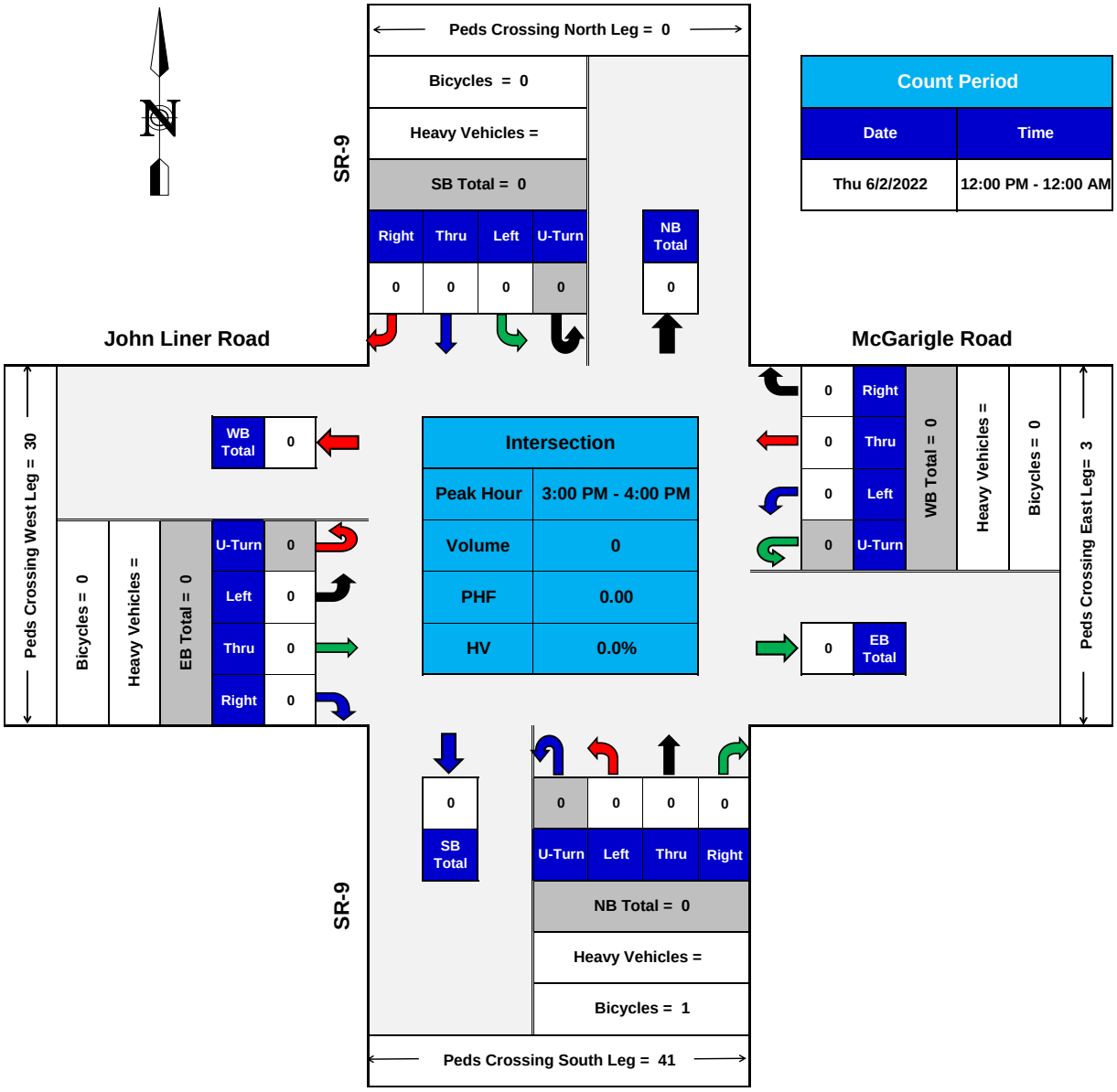
PEAK HOUR SUMMARY

DTG *TRAFFIC DATA GATHERING*

Pedestrian Volumes only

SR-9 @ John Liner Road

Sedro Woolley, WA



TURNING MOVEMENTS DIAGRAM

PEAK HOUR SUMMARY

DTG *TRAFFIC DATA GATHERING*

INTERSECTION TURNING MOVEMENTS ENTRY FORM

LOCATION: SR-9 @ John Liner Road
Sedro Woolley, WA

DATE OF COUNT: Thu. 6/2/22
TIME OF COUNT: 12:00 AM - 12:00 AM

COUNTED BY: TDG

	FROM NORTH ON SR-9							FROM SOUTH ON SR-9							FROM EAST ON McGarigle Road							FROM WEST ON John Liner Road						
TIME INTERVAL	Peds	Bicycle	HV	U-Turn	Left	Thru	Right	Peds	Bicycle	HV	U-Turn	Left	Thru	Right	Peds	Bicycle	HV	U-Turn	Left	Thru	Right	Peds	Bicycle	HV	U-Turn	Left	Thru	Right
12:00 AM	0	0	1	0	0	2	0	0	0	0	0	0	3	2	0	0	0	0	1	0	0	0	0	0	0	0	0	1
12:15 AM	0	0	1	0	0	4	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12:30 AM	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
12:45 AM	0	0	1	0	2	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
01:00 AM	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01:15 AM	0	0	1	0	0	3	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01:30 AM	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01:45 AM	0	0	1	0	0	2	0	0	0	1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02:00 AM	0	0	0	0	0	1	0	0	0	2	0	0	5	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
02:15 AM	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02:30 AM	0	0	0	0	0	5	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02:45 AM	0	0	3	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
03:00 AM	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
03:15 AM	0	0	0	0	0	2	0	0	0	0	0	0	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
03:30 AM	0	0	0	0	0	6	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03:45 AM	0	0	2	0	0	7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:00 AM	0	0	2	0	1	11	0	0	0	2	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:15 AM	0	0	3	0	0	16	0	0	0	1	0	0	5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
04:30 AM	0	0	1	0	0	32	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
04:45 AM	0	0	1	0	1	32	0	0	0	2	0	0	9	1	0	0	0	0	0	0	0	1	0	0	0	0	2	1
05:00 AM	0	0	2	0	0	27	0	0	0	3	0	0	10	2	0	0	0	0	3	1	0	0	0	0	0	0	0	0
05:15 AM	0	0	3	0	0	46	0	0	0	0	0	1	4	1	0	0	0	0	3	1	0	0	0	0	0	0	2	1
05:30 AM	0	0	4	0	0	38	0	1	0	0	0	0	6	1	1	0	0	0	2	0	0	0	0	0	0	0	0	2
05:45 AM	0	1	3	0	0	37	0	0	0	0	0	1	13	1	1	0	0	0	1	0	2	0	0	1	0	2	0	1
06:00 AM	0	0	7	0	1	62	0	1	0	0	0	0	9	2	0	0	0	0	3	0	1	0	0	0	0	0	0	1
06:15 AM	0	0	2	0	1	43	0	0	0	1	0	0	10	4	0	0	0	0	4	0	0	0	0	1	0	0	1	1
06:30 AM	0	0	3	0	3	58	0	0	0	5	0	0	17	8	0	0	0	0	7	0	4	1	1	0	0	1	1	1
06:45 AM	0	0	6	0	5	64	0	0	0	0	0	1	18	11	0	0	3	0	13	1	1	1	0	0	0	0	0	0
07:00 AM	0	0	5	0	14	79	2	0	0	2	0	0	17	29	1	0	0	0	13	4	1	2	0	0	0	0	4	0
07:15 AM	0	0	7	0	27	67	2	3	0	2	0	0	14	53	0	0	2	0	25	9	8	4	0	1	0	1	7	3
07:30 AM	0	0	8	0	22	80	0	3	0	1	0	2	20	65	0	0	1	0	24	15	12	1	0	0	0	1	11	1
07:45 AM	0	0	7	0	2	66	1	0	0	9	0	0	41	20	0	0	0	0	16	6	0	1	0	1	0	0	1	3
08:00 AM	0	0	8	0	5	47	1	3	0	6	0	0	24	27	0	0	3	0	5	2	3	2	0	1	0	0	3	2
08:15 AM	0	0	10	0	2	66	2	0	0	3	0	0	15	15	0	0	3	0	13	1	1	1	0	1	0	0	0	1
08:30 AM	0	0	8	0	5	61	2	3	0	2	0	0	21	6	0	0	1	0	10	3	2	0	0	0	0	0	1	1
08:45 AM	0	0	9	0	10	64	0	10	0	3	0	0	24	34	0	0	2	0	13	5	3	13	0	1	0	0	5	3
09:00 AM	0	0	7	0	26	78	2	22	0	2	0	1	36	47	0	0	3	0	17	13	20	14	0	1	0	0	7	3
09:15 AM	0	0	3	0	12	43	1	3	0	7	0	2	35	25	2	0	6	0	36	7	6	1	0	1	0	0	9	1
09:30 AM	0	0	2	0	4	42	0	0	0	1	0	1	32	6	1	0	1	0	17	2	9	0	0	0	0	0	3	3
09:45 AM	0	0	9	0	4	60	2	0	0	7	0	3	40	5	0	0	1	0	3	4	3	0	0	0	0	0	0	1
10:00 AM	0	0	3	0	2	55	1	0	0	4	0	0	32	6	0	0	0	0	7	2	1	0	0	1	0	0	3	2
10:15 AM	0	0	4	0	2	42	0	0	0	6	0	2	35	13	0	0	3	0	12	1	1	0	0	0	0	1	1	9
10:30 AM	0	0	2	0	2	55	0	0	0	2	0	0	29	5	0	0	1	0	7	1	2	0	0	2	0	1	1	3
10:45 AM	0	0	2	0	3	36	0	0	0	4	0	1	43	7	1	0	0	0	7	2	2	0	0	0	0	0	1	2
11:00 AM	0	0	0	0	0	43	2	0	0	1	0	4	35	6	0	0	1	0	13	3	2	0	0	0	0	0	0	0
11:15 AM	0	0	5	0	3	47	2	0	0	2	0	1	43	8	0	0	1	0	12	0	1	0	0	0	0	0	2	7
11:30 AM	0	1	12	0	1	43	1	0	0	3	0	2	49	9	0	0	0	0	4	2	1	0	0	0	0	0	0	1
11:45 AM	0	1	7	0	4	49	1	3	0	5	0	3	47	11	0	0	1	0	10	2	3	0	0	0	0	1	1	6
12:00 PM	0	0	3	0	2	58	0	1	0	2	0	2	42	12	0	0	2	0	16	4	2	2	0	0	0	1	1	3
12:15 PM	0	0	8	0	0	55	0	0	0	0	0	1	40	10	0	0	0	0	11	1	0	1	0	1	0	0	2	2
12:30 PM	0	0	5	0	3	52	1	0	0	2	0	2	51	10	0	0	1	0	14	2	4	0	0	0	0	1	1	5
12:45 PM	0	1	2	0	6	43	1	1	0	2	0	0	44	10	0	0	0	0	9	1	1	2	0	0	0	1	8	4
01:00 PM	0	0	8	0	2	42	0	0	0	1	0	1	51	9	0	0	1	0	5	2	4	0	0	0	0	2	1	2
01:15 PM	0	0	3	0	0	61	0	0	0	5	0	2	58	14	1	0	0	0	6	2	3	0	0	1	0	1	0	3
01:30 PM	0	0	7	0	2	43	2	1	0	3	0	0	49	13	0	0	0	0	9	4	2	1	0	0	0	0	2	2
01:45 PM	0	0	1	0	6	48	2	2	0	0	0	1	49	14	0	0	0	0	10	2	1	1	0	0	0	0	2	1
02:00 PM	0	0	3	0	6	51	0	5	0	3	0	3	45	16	1	0	0	0	6	4	0	2	0	0	0	1	2	4
02:15 PM	0	0	1	0	2	45	2	28	1	2	0	3	65	14	5	0	0	0	21	3	11	16	0	0	0	1	2	2
02:30 PM	0	0	2	0	2	44	2	2	0	7	0	5	73	13	0	0	0	0	9	1	4	3	0	0	0	1	0	3
02:45 PM	0	1	3	0	14	50	1	0	0	2	0	1	62	17	0	0	1	0	15	4	6	1	0	0	0	2	4	2
03:00 PM	0	0	3	0	5	68	0	4	0	3	0	1	61	17	2	0	0	0	11	2	1	7	0	0	0	2	1	4
03:15 PM	0	0	5	0	12	69	4	15	0	2	0	2	58	24	1	0	3	0	27	10	15	6	0	0	0	3	4	7
03:30 PM	0	0	3	0	4	51	2	21	1	0	0	3	84	14	0	0	2	1	24	13	16	14	0	0	0	0	7	3
03:45 PM	0	0	5	0	3	50	2	1	0	4	0	3	74	9	0	0	2	0	21	4	13	3	0	0	0	2	0	3
04:00 PM	1	0	3	0	3	63	1	3	0	3	0	2	80	8	0	0	0	0	16	2	4	1	0	0	0	3	2	4
04:15 PM	0	0	10	0	7	75	1	4	0	3	0	2	96	7	1	0	1	0	15	1	5	2	0	0	0	0	0	5
04:30 PM	0	0	4	0	3	73	1	3	0	1	0	3	94	11	4	0	0	0	8	2	5	2	0	1	0	1	2	6
04:45 PM	0	0	5	0	6	53	2	3	0	2	0	2	73	11	0	0	4	0	11	6	7	4	1	0	0	1	2	7
05:00 PM	0	0	4	0	2	76	1	0	0	3	0	2	82	14	0	1	1	0	6	4	1	2	0	0	0	3	2	4
05:15 PM	0	0	2	0	5	63	0	0	0	0	0	5	73	19	0	0	0	0	14	4	3	0	0	0	0	1	1	5
05:30 PM	0	0	1	0	6	61	0	0	0	0	0	1	72	18	0	0	0	0	11	4	4	0	0	0	0	0	4	9
05:45 PM	0	0	4	0	5	53	2	0	0	1	0	4	65	13	0	0	0	0	15	3	2	0	0	0	0	2	1	5
06:00 PM	0	0	2	0	7	41	1	1	0	0	0	5	74	16	1	0	0	0	13	0	2	0	0	0	0	3	2	3
06:15 PM	0	0	2	0	10	40	2	0	0	0	0	3	58	37	0	0	1	0	4	4	4	0	0	0	0	1	4	4
06:30 PM	0	0	0	0	7	56	0	1	1	1	0	1	62	32	0	0	0	0	11	3	1	0	0	0	0	0	0	5
06:45 PM	0	0	4	0	9	38	0	1	0	3	0	0	72	33	1	0	0	0	3	1	1	0	0	0	0	1	2	7
07:00 PM	0	0	1	0	5	28	0	1	0	0	0	1	47	11	0	0	0	0	6	1	2	0	0	0	0	2	0	1
07:15 PM	0	0	0	0	2	26	0	1	0	1	0	4	63	7	0	0	0	0	16	1	1	2	0	0	0	1	1	2
07:30 PM	0	0	1	0	2	27	1	0	0	0	0	2	55	7	0	0	0	0	7	1	5	0	0	0	0	0	0	2
07:45 PM	0	0	3	0	1	27	0	0	0	1	0	1	43	6	0	0	0	0	4	2	2	0	0	0	0	0	0	3
08:00 PM	0	0	0	0	0	26	0	0	0	0	0	3	51	7	0	0	0	0	1	1	5	0	0	0	0	0	2	3
08:15 PM	0	0	0	0	2	20	1	0	0	1	0	5	45	4	0	0	0	0	26	1	9	0	0	1	0	0	3	4
08:30 PM	0	0	0	0	3	24	0	1	0	0	0	0	40	4	0	0	0	0	54	5	11	0	0	0	0	0	1	0
08:45 PM	0	0	2	0	1	17	1	0	0	0	0	0	36	3	0	0	0	0	6	0	2	0	0	0	0	1	0	2
09:00 PM	0	0	1	0	0	18	1	0	0	0	0	1	21	5	0	0	0	0	4	1	2	2	0	0	0	1	1	0
09:15 PM	0	0	2	0	1	11	0	0	0	0	0	1	32	3	2	0	0	0	1	1	1	0	0	0	0	0	0	1
09:30 PM	0	0	0	0	0	9	0	0	0	0	0	2	24	2	0	0	0	0	0	0	1	0	0	0	0	0	0	1
09:45 PM	0	0	0	0	0	10	1	0	0	0	0	0	20	3	0	0	0	0	1	1	0	0	0	0	0	0	0	0
10:00 PM	0	0	1	0	0	10	0	0	0	0	0	0	10	0	0	0	0	0	1	0	0	0	0	0	0	0	1	2
10:15 PM	0	0	1	0	0	10	0	0	0	0	0	1	12	2	0	0	0	0	4	2	0	0	0	0	0	0	0	2
10:30 PM	0	0	0	0	0	7	0	0	0	0	0	0	12	1	0	0	0	0	2	0	0	0	0	0	0	0	1	1
10:45 PM	0	0	0	0	1	3	0	0	0	0	0	1	13	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
11:00 PM	0	0	0	0	0	3	0	0	0	0	0	0	12	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
11:15 PM	0	0	0	0	0	4	1	0	0	0	0	0	5	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0
11:30 PM	0	0	0	0	0	2	0	0	0	0	0	1	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:45 PM	0	0	0	0	0	1	0	0	0	0	0	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	1	5	280	0	321	3443	58	153	3	147	0	108	3140	934	26	1	52	1	785	197	253	116	2	16	0	50	137	201

TECHNICAL APPENDIX D

IHSDM Safety Analysis

Interactive Highway Safety Design Model

Crash Prediction Evaluation Report

December 29, 2022

Disclaimer

The Interactive Highway Design Model (IHSDM) software is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its content or use thereof. This document does not constitute a standard, specification, or regulation.

The United States Government does not endorse products or manufacturers. Trade and manufacturers' names may appear in this software and documentation only because they are considered essential to the objective of the software.

Limited Warranty and Limitations of Remedies

This software product is provided "as-is," without warranty of any kind-either expressed or implied (but not limited to the implied warranties of merchantability and fitness for a particular purpose). The FHWA do not warrant that the functions contained in the software will meet the end-user's requirements or that the operation of the software will be uninterrupted and error-free.

Under no circumstances will the FHWA be liable to the end-user for any damages or claimed lost profits, lost savings, or other incidental or consequential damages rising out of the use or inability to use the software (even if these organizations have been advised of the possibility of such damages), or for any claim by any other party.

Notice

The use of the IHSDM software is being done strictly on a voluntary basis. In exchange for provision of IHSDM, the user agrees that the Federal Highway Administration (FHWA), U.S. Department of Transportation and any other agency of the Federal Government shall not be responsible for any errors, damage or other liability that may result from any and all use of the software, including installation and testing of the software. The user further agrees to hold the FHWA and the Federal Government harmless from any resulting liability. The user agrees that this hold harmless provision shall flow to any person to whom or any entity to which the user provides the IHSDM software. It is the user's full responsibility to inform any person to whom or any entity to which it provides the IHSDM software of this hold harmless provision.

Table of Contents

List of Tables

Report Overview

Report Generated: Dec 29, 2022 10:45 AM
Report Template: System: Multi-Page [System] (sscpm2, Mar 17, 2022 10:26 AM)

Evaluation Date: Thu Dec 15 08:31:01 PST 2022
IHSDM Version: v17.0.0 (Sep 22, 2021)
Site Set Crash Prediction Module: v|ModuleInfo.moduleVersion| (|ModuleInfo.moduleDate|)

User Name: hte
Organization Name:
Phone:
E-Mail:

Project Title: SR 9/John Liner Rd./McGarigle Rd.
Project Comment: Created using wizard
Project Unit System: U.S. Customary

Site Set: No Build
Site Set Comment: Created Mon Jun 20 13:52:11 PDT 2022
Site Set Version: v4

Evaluation Title: Evaluation 14
Evaluation Comment: Created Thu Dec 15 08:30:31 PST 2022
Policy for Superelevation: AASHTO 2011 U.S. Customary
Calibration: HSM Configuration
Crash Distribution: HSM Configuration
Model/CMF: HSM Configuration

First Year of Analysis: 2019
Last Year of Analysis: 2019
Empirical-Bayes Analysis: Site-Specific
Crash History Siteset: No Build
Crash History Siteset Comment: Created Mon Jun 20 13:52:11 PDT 2022
Crash History Siteset Version: 4
First Year of Observed Crashes: 2013
Last Year of Observed Crashes: 2017

Disclaimer Regarding Crash Prediction Method

IMPORTANT NOTICE ABOUT COMPARING RESULTS FROM HIGHWAY SAFETY MANUAL FIRST EDITION (2010) MODELS TO RESULTS FROM NEW MODELS DEVELOPED UNDER NCHRP PROJECTS 17-70, 17-58, AND 17-68

Since the publication of the Highway Safety Manual - First Edition (HSM-1), in 2010 by the American Association of State Highway and Transportation Officials (AASHTO), multiple research efforts have been undertaken through the National Cooperative Highway Research Program (NCHRP) to develop safety performance models for road segment and intersection facility types that were not initially reflected in the HSM-1, in order to expand the breadth and depth of the HSM in the future.

The IHSDM Crash Prediction Module (CPM) is intended as a faithful implementation of HSM Part C predictive methods. As NCHRP projects to develop new predictive methods for the HSM are completed, FHWA works to incorporate the new methods into IHSDM, sometimes in advance of publication in the HSM. The following new crash predictive methods have been accepted by NCHRP project panels and incorporated into IHSDM, while pending AASHTO's approval for incorporation into a future edition of the HSM:

- Roundabouts: completed in 2018 under NCHRP Project 17-70, the new methods will provide improved outcomes for the safety analysis of roundabouts.
- 6+ lane and one-way urban/suburban arterials (including models for segments and intersections): completed under NCHRP Project 17-58.
- Intersection crash prediction methods for some intersection configurations and traffic control types not currently addressed in the HSM (e.g., all-way stop; rural 3-leg signalized; 3-leg stop-controlled where the major leg turns; urban 5-leg signalized; urban high-speed intersections): completed in 2021 under NCHRP Project 17-68.

However, in the absence of local calibration factors (see HSM-1 Part C, Appendix A for guidance on calibration of the predictive models), it is neither appropriate nor advisable to directly compare the results from new models (from NCHRP Projects 17-58, 17-68, and 17-70) to results from HSM-1 models, as the models were not calibrated to the same base state data sets, and consequently can produce unexpected results. If local calibration factors are available and applied to both new models and HSM-1 models, then it may be appropriate to directly compare the results.*[Note: Work being performed under NCHRP Project 17-72 (Update of Crash Modification Factors for the Highway Safety Manual) is expected to re-calibrate many of the old (HSM-1) and new (e.g., NCHRP 17-70) models to data from a single (or small number of) states, that would allow results from all models to be directly compared.]*

The models produced for NCHRP Project 17-70 have independent value in terms of informing the design of a roundabout and assessing the effects of different design characteristics on the expected safety performance of a roundabout.

The HSM-1 interim method previously included in IHSDM for evaluating roundabouts on urban/suburban arterials (i.e., evaluating an existing intersection and then applying a Crash Modification Factor for replacing the existing intersection with a roundabout) has been deactivated in IHSDM, to minimize any confusion with the new roundabout methodology.

Section Types

Urban Arterial Site Set CPM Evaluation

Site Type

Type: 4ST
Calibration Factor: 1

Table 1. Observed Crashes Used in the Evaluation (4ST)

Year	Observed Crashes	Total Crashes Used	FI Crashes	FI no/C Crashes	PDO Crashes
2013	0	0	0	0	0
2014	0	0	0	0	0
2015	0	0	0	0	0
2016	1	1	0	0	1
2017	1	1	1	1	0
All Years	2 [1]	2	1	1	1

Footnotes

[1] Note: Observed crash data that does not comply with the associated CPM model requirements may not be used in EB processing.

Table 2. Evaluation and Crash Data (CSD) (if applicable) Intersection Sites

Site No.	Type	Highway	Major AADT	Minor AADT	Presence of Lighting
1	4ST2x2le5	CSD:	2013-2017: 8000	2013-2017: 2000	yes
1	4ST2x2le5		2019: 8000	2019: 2000	yes

Table 3. Expected Crash Frequencies and Rates by Site

Site No.	Type	Highway	Site Description	Total Expected Crashes for Evaluation Period	Total Predicted Crashes for Evaluation Period	Expected Total Crash Frequency (crashes/yr)	Expected FI Crash Frequency (crashes/yr)	Expected PDO Crash Frequency (crashes/yr)	Predicted Total Crash Frequency (crashes/yr)	Predicted FI Crash Frequency (crashes/yr)	Predicted PDO Crash Frequency (crashes/yr)	(Expected - Predicted) Total Crash Frequency (crashes/yr)	(Expected - Predicted) FI Crash Frequency (crashes/yr)	(Expected - Predicted) PDO Crash Frequency (crashes/yr)	Expected Intersection Travel Crash Rate (crashes/million veh)	Intersection Crash Rate (crashes/yr)
1	4ST			0.841	1.597	0.8405	0.3890	0.4515	1.5965	0.6034	0.9931	-0.7560	-0.2145	-0.5416	0.23	0.8405
		Total	Total	0.841	1.597	0.8405	0.3890	0.4515	1.5965	0.6034	0.9931	-0.7560	-0.2145	-0.5416	0.23	0.8405

Table 4. Predicted Crash Frequencies by Year (4ST)

Year	Total Crashes	FI Crashes	Percent FI (%)	PDO Crashes	Percent PDO (%)
2019	1.60	0.60	37.798	0.99	62.202
Total	1.60	0.60	37.798	0.99	62.202
Average	1.60	0.60	37.798	0.99	62.202

Note: *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Table 5. Expected Crash Frequencies by Year (4ST)

Year	Total Crashes	FI Crashes	Percent FI (%)	PDO Crashes	Percent PDO (%)
2019	0.84	0.39	46.282	0.45	53.718
Total	0.84	0.39	46.282	0.45	53.718
Average	0.84	0.39	46.282	0.45	53.718

Note: *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Table 6. Comparing Predicted and Expected Crashes for the Evaluation Period (4ST)

Scope	Total Crashes	FI Crashes	Percent FI (%)	PDO Crashes	Percent PDO (%)
Predicted	1.60	0.60	37.798	0.99	62.202
Expected	0.84	0.39	46.282	0.45	53.718
Expected - Predicted	-0.76	-0.21		-0.54	
Percent Difference	-89.96	-55.13		-119.96	

Note: *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Table 7. Expected 4ST Crash Type Distribution

Element Type	Crash Type	Fatal and Injury		Property Damage Only		Total	
		Crashes	Crashes (%)	Crashes	Crashes (%)	Crashes	Crashes (%)
Intersection	Collision with Animal	0.00	0.0	0.00	0.2	0.00	0.2
Intersection	Collision with Bicycle	0.03	3.3	0.00	0.0	0.03	3.3
Intersection	Collision with Fixed Object	0.03	3.9	0.07	7.9	0.10	11.7
Intersection	Non-Collision	0.01	1.0	0.00	0.5	0.01	1.5
Intersection	Collision with Other Object	0.00	0.5	0.01	0.7	0.01	1.2
Intersection	Other Single-vehicle Collision	0.00	0.3	0.00	0.1	0.00	0.4
Intersection	Collision with Parked Vehicle	0.00	0.0	0.00	0.0	0.00	0.0
Intersection	Collision with Pedestrian	0.03	4.0	0.00	0.0	0.03	4.0
Intersection	Total Intersection Single Vehicle Crashes	0.11	13.0	0.08	9.3	0.19	22.3
Intersection	Angle Collision	0.12	14.6	0.12	14.9	0.25	29.5
Intersection	Head-on Collision	0.01	1.4	0.01	1.3	0.02	2.7
Intersection	Other Multi-vehicle Collision	0.02	2.0	0.08	9.6	0.10	11.6
Intersection	Rear-end Collision	0.09	11.2	0.14	16.6	0.23	27.9
Intersection	Sideswipe	0.03	4.0	0.02	2.0	0.05	6.0
Intersection	Total Intersection Multiple Vehicle Crashes	0.28	33.3	0.37	44.4	0.65	77.7
Intersection	Total Intersection Crashes	0.39	46.3	0.45	53.7	0.84	100.0
	Total Crashes	0.39	46.3	0.45	53.7	0.84	100.0

Note: *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Interactive Highway Safety Design Model

Crash Prediction Evaluation Report

December 29, 2022

Disclaimer

The Interactive Highway Design Model (IHSDM) software is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its content or use thereof. This document does not constitute a standard, specification, or regulation.

The United States Government does not endorse products or manufacturers. Trade and manufacturers' names may appear in this software and documentation only because they are considered essential to the objective of the software.

Limited Warranty and Limitations of Remedies

This software product is provided "as-is," without warranty of any kind-either expressed or implied (but not limited to the implied warranties of merchantability and fitness for a particular purpose). The FHWA do not warrant that the functions contained in the software will meet the end-user's requirements or that the operation of the software will be uninterrupted and error-free.

Under no circumstances will the FHWA be liable to the end-user for any damages or claimed lost profits, lost savings, or other incidental or consequential damages rising out of the use or inability to use the software (even if these organizations have been advised of the possibility of such damages), or for any claim by any other party.

Notice

The use of the IHSDM software is being done strictly on a voluntary basis. In exchange for provision of IHSDM, the user agrees that the Federal Highway Administration (FHWA), U.S. Department of Transportation and any other agency of the Federal Government shall not be responsible for any errors, damage or other liability that may result from any and all use of the software, including installation and testing of the software. The user further agrees to hold the FHWA and the Federal Government harmless from any resulting liability. The user agrees that this hold harmless provision shall flow to any person to whom or any entity to which the user provides the IHSDM software. It is the user's full responsibility to inform any person to whom or any entity to which it provides the IHSDM software of this hold harmless provision.

Table of Contents

List of Tables

Report Overview

Report Generated: Dec 29, 2022 10:47 AM
Report Template: System: Multi-Page [System] (sscpm2, Mar 17, 2022 10:26 AM)

Evaluation Date: Thu Dec 15 08:29:14 PST 2022
IHSDM Version: v17.0.0 (Sep 22, 2021)
Site Set Crash Prediction Module: v|ModuleInfo.moduleVersion| (|ModuleInfo.moduleDate|)

User Name: hte
Organization Name:
Phone:
E-Mail:

Project Title: SR 9/John Liner Rd./McGarigle Rd.
Project Comment: Created using wizard
Project Unit System: U.S. Customary

Site Set: Traffic Signal
Site Set Comment: Created Thu Mar 17 11:09:50 PDT 2022
Site Set Version: v2

Evaluation Title: Evaluation 9
Evaluation Comment: Created Thu Dec 15 08:28:40 PST 2022
Policy for Superelevation: AASHTO 2011 U.S. Customary
Calibration: HSM Configuration
Crash Distribution: HSM Configuration
Model/CMF: HSM Configuration

First Year of Analysis: 2019
Last Year of Analysis: 2019
Empirical-Bayes Analysis: None

Disclaimer Regarding Crash Prediction Method

IMPORTANT NOTICE ABOUT COMPARING RESULTS FROM HIGHWAY SAFETY MANUAL FIRST EDITION (2010) MODELS TO RESULTS FROM NEW MODELS DEVELOPED UNDER NCHRP PROJECTS 17-70, 17-58, AND 17-68

Since the publication of the Highway Safety Manual - First Edition (HSM-1), in 2010 by the American Association of State Highway and Transportation Officials (AASHTO), multiple research efforts have been undertaken through the National

Cooperative Highway Research Program (NCHRP) to develop safety performance models for road segment and intersection facility types that were not initially reflected in the HSM-1, in order to expand the breadth and depth of the HSM in the future.

The IHSDM Crash Prediction Module (CPM) is intended as a faithful implementation of HSM Part C predictive methods. As NCHRP projects to develop new predictive methods for the HSM are completed, FHWA works to incorporate the new methods into IHSDM, sometimes in advance of publication in the HSM. The following new crash predictive methods have been accepted by NCHRP project panels and incorporated into IHSDM, while pending AASHTO's approval for incorporation into a future edition of the HSM:

- Roundabouts: completed in 2018 under NCHRP Project 17-70, the new methods will provide improved outcomes for the safety analysis of roundabouts.
- 6+ lane and one-way urban/suburban arterials (including models for segments and intersections): completed under NCHRP Project 17-58.
- Intersection crash prediction methods for some intersection configurations and traffic control types not currently addressed in the HSM (e.g., all-way stop; rural 3-leg signalized; 3-leg stop-controlled where the major leg turns; urban 5-leg signalized; urban high-speed intersections): completed in 2021 under NCHRP Project 17-68.

However, in the absence of local calibration factors (see HSM-1 Part C, Appendix A for guidance on calibration of the predictive models), it is neither appropriate nor advisable to directly compare the results from new models (from NCHRP Projects 17-58, 17-68, and 17-70) to results from HSM-1 models, as the models were not calibrated to the same base state data sets, and consequently can produce unexpected results. If local calibration factors are available and applied to both new models and HSM-1 models, then it may be appropriate to directly compare the results.*[Note: Work being performed under NCHRP Project 17-72 (Update of Crash Modification Factors for the Highway Safety Manual) is expected to re-calibrate many of the old (HSM-1) and new (e.g., NCHRP 17-70) models to data from a single (or small number of) states, that would allow results from all models to be directly compared.]*

The models produced for NCHRP Project 17-70 have independent value in terms of informing the design of a roundabout and assessing the effects of different design characteristics on the expected safety performance of a roundabout.

The HSM-1 interim method previously included in IHSDM for evaluating roundabouts on urban/suburban arterials (i.e., evaluating an existing intersection and then applying a Crash Modification Factor for replacing the existing intersection with a roundabout) has been deactivated in IHSDM, to minimize any confusion with the new roundabout methodology.

Section Types

Urban Arterial Site Set CPM Evaluation

Site Type

Type: 4SG
Calibration Factor: 1

Table 1. Evaluation and Crash Data (CSD) (if applicable) Intersection Sites

Site No.	Type	Highway	Site Description	Major AADT	Minor AADT	Number of Approaches with Left-Turn Lanes	Number of Approaches with Right-Turn Lanes	Presence of Lighting	Number of Approaches with Permissive Left-Turn Phasing	Number of Approaches with Permissive/Protected or Protected/Permissive Left-Turn Phasing	Number of Approaches with Protected Left-Turn Phasing	Number of Approaches on which Right Turn on Red is Prohibited	Presence of Red-Light Cameras	Pedestrian Volumes Crossing all Intersection Legs (crossings/day)	Max. Number of Lanes Crossed by Pedestrians	Number of Bus Stops within 1000 ft of Intersection	Number of Schools within 1000 ft of Intersection	Number of Alcohol Sales Establishments within 1000 ft of Intersection
1	4SG2x2le5			2019: 8000	2019: 2000	4	0	yes	0	4	0	0	no	296	3	0	2	0

Table 2. Predicted Crash Frequencies and Rates by Site

Site No.	Type	Highway	Site Description	Total Predicted Crashes for Evaluation Period	Predicted Total Crash Frequency (crashes/yr)	Predicted FI Crash Frequency (crashes/yr)	Predicted PDO Crash Frequency (crashes/yr)	Predicted Intersection Travel Crash Rate (crashes/million veh)	Intersection Crash Rate (crashes/yr)
1	4SG			0.968	0.9677	0.3316	0.6361	0.27	0.9677
		Total	Total	0.968	0.9677	0.3316	0.6361	0.27	0.9677

Table 3. Predicted Crash Frequencies by Year (4SG)

Year	Total Crashes	FI Crashes	Percent FI (%)	PDO Crashes	Percent PDO (%)
2019	0.97	0.33	34.266	0.64	65.734
Total	0.97	0.33	34.266	0.64	65.734
Average	0.97	0.33	34.266	0.64	65.734

Note: *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived

independently.

Table 4. Predicted 4SG Crash Type Distribution

Element Type	Crash Type	Fatal and Injury		Property Damage Only		Total	
		Crashes	Crashes (%)	Crashes	Crashes (%)	Crashes	Crashes (%)
Intersection	Collision with Animal	0.00	0.0	0.00	0.0	0.00	0.0
Intersection	Collision with Bicycle	0.01	1.4	0.00	0.0	0.01	1.4
Intersection	Collision with Fixed Object	0.02	1.8	0.04	4.6	0.06	6.4
Intersection	Non-Collision	0.00	0.3	0.00	0.2	0.01	0.5
Intersection	Collision with Other Object	0.00	0.2	0.00	0.4	0.01	0.5
Intersection	Other Single-vehicle Collision	0.00	0.1	0.00	0.1	0.00	0.2
Intersection	Collision with Parked Vehicle	0.00	0.0	0.00	0.0	0.00	0.0
Intersection	Collision with Pedestrian	0.04	4.1	0.00	0.0	0.04	4.1
Intersection	Total Intersection Single Vehicle Crashes	0.08	8.0	0.05	5.2	0.13	13.2
Intersection	Angle Collision	0.09	9.1	0.14	14.8	0.23	23.9
Intersection	Head-on Collision	0.01	1.3	0.02	1.8	0.03	3.1
Intersection	Other Multi-vehicle Collision	0.01	1.4	0.12	12.8	0.14	14.2
Intersection	Rear-end Collision	0.11	11.8	0.28	29.2	0.40	41.0
Intersection	Sideswipe	0.03	2.6	0.02	1.9	0.04	4.5
Intersection	Total Intersection Multiple Vehicle Crashes	0.25	26.3	0.58	60.5	0.84	86.8
Intersection	Total Intersection Crashes	0.33	34.3	0.64	65.7	0.97	100.0
	Total Crashes	0.33	34.3	0.64	65.7	0.97	100.0

Note: *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Interactive Highway Safety Design Model

Crash Prediction Evaluation Report

December 29, 2022

Disclaimer

The Interactive Highway Design Model (IHSDM) software is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its content or use thereof. This document does not constitute a standard, specification, or regulation.

The United States Government does not endorse products or manufacturers. Trade and manufacturers' names may appear in this software and documentation only because they are considered essential to the objective of the software.

Limited Warranty and Limitations of Remedies

This software product is provided "as-is," without warranty of any kind-either expressed or implied (but not limited to the implied warranties of merchantability and fitness for a particular purpose). The FHWA do not warrant that the functions contained in the software will meet the end-user's requirements or that the operation of the software will be uninterrupted and error-free.

Under no circumstances will the FHWA be liable to the end-user for any damages or claimed lost profits, lost savings, or other incidental or consequential damages rising out of the use or inability to use the software (even if these organizations have been advised of the possibility of such damages), or for any claim by any other party.

Notice

The use of the IHSDM software is being done strictly on a voluntary basis. In exchange for provision of IHSDM, the user agrees that the Federal Highway Administration (FHWA), U.S. Department of Transportation and any other agency of the Federal Government shall not be responsible for any errors, damage or other liability that may result from any and all use of the software, including installation and testing of the software. The user further agrees to hold the FHWA and the Federal Government harmless from any resulting liability. The user agrees that this hold harmless provision shall flow to any person to whom or any entity to which the user provides the IHSDM software. It is the user's full responsibility to inform any person to whom or any entity to which it provides the IHSDM software of this hold harmless provision.

Table of Contents

List of Tables

Report Overview

Report Generated: Dec 29, 2022 10:48 AM
Report Template: System: Multi-Page [System] (sscpm2, Mar 17, 2022 10:26 AM)

Evaluation Date: Thu Dec 15 08:32:50 PST 2022
IHSDM Version: v17.0.0 (Sep 22, 2021)
Site Set Crash Prediction Module: v|ModuleInfo.moduleVersion| (|ModuleInfo.moduleDate|)

User Name: hte
Organization Name:
Phone:
E-Mail:

Project Title: SR 9/John Liner Rd./McGarigle Rd.
Project Comment: Created using wizard
Project Unit System: U.S. Customary

Site Set: Roundabout
Site Set Comment: Created Wed Dec 14 18:32:18 PST 2022
Site Set Version: v2

Evaluation Title: Evaluation 3
Evaluation Comment: Created Thu Dec 15 08:32:23 PST 2022
Policy for Superelevation: AASHTO 2011 U.S. Customary
Calibration: HSM Configuration
Crash Distribution: HSM Configuration
Model/CMF: HSM Configuration

First Year of Analysis: 2019
Last Year of Analysis: 2019
Empirical-Bayes Analysis: None

Disclaimer Regarding Crash Prediction Method

IMPORTANT NOTICE ABOUT COMPARING RESULTS FROM HIGHWAY SAFETY MANUAL FIRST EDITION (2010) MODELS TO RESULTS FROM NEW MODELS DEVELOPED UNDER NCHRP PROJECTS 17-70, 17-58, AND 17-68

Since the publication of the Highway Safety Manual - First Edition (HSM-1), in 2010 by the American Association of State Highway and Transportation Officials (AASHTO), multiple research efforts have been undertaken through the National

Cooperative Highway Research Program (NCHRP) to develop safety performance models for road segment and intersection facility types that were not initially reflected in the HSM-1, in order to expand the breadth and depth of the HSM in the future.

The IHSDM Crash Prediction Module (CPM) is intended as a faithful implementation of HSM Part C predictive methods. As NCHRP projects to develop new predictive methods for the HSM are completed, FHWA works to incorporate the new methods into IHSDM, sometimes in advance of publication in the HSM. The following new crash predictive methods have been accepted by NCHRP project panels and incorporated into IHSDM, while pending AASHTO's approval for incorporation into a future edition of the HSM:

- Roundabouts: completed in 2018 under NCHRP Project 17-70, the new methods will provide improved outcomes for the safety analysis of roundabouts.
- 6+ lane and one-way urban/suburban arterials (including models for segments and intersections): completed under NCHRP Project 17-58.
- Intersection crash prediction methods for some intersection configurations and traffic control types not currently addressed in the HSM (e.g., all-way stop; rural 3-leg signalized; 3-leg stop-controlled where the major leg turns; urban 5-leg signalized; urban high-speed intersections): completed in 2021 under NCHRP Project 17-68.

However, in the absence of local calibration factors (see HSM-1 Part C, Appendix A for guidance on calibration of the predictive models), it is neither appropriate nor advisable to directly compare the results from new models (from NCHRP Projects 17-58, 17-68, and 17-70) to results from HSM-1 models, as the models were not calibrated to the same base state data sets, and consequently can produce unexpected results. If local calibration factors are available and applied to both new models and HSM-1 models, then it may be appropriate to directly compare the results.*[Note: Work being performed under NCHRP Project 17-72 (Update of Crash Modification Factors for the Highway Safety Manual) is expected to re-calibrate many of the old (HSM-1) and new (e.g., NCHRP 17-70) models to data from a single (or small number of) states, that would allow results from all models to be directly compared.]*

The models produced for NCHRP Project 17-70 have independent value in terms of informing the design of a roundabout and assessing the effects of different design characteristics on the expected safety performance of a roundabout.

The HSM-1 interim method previously included in IHSDM for evaluating roundabouts on urban/suburban arterials (i.e., evaluating an existing intersection and then applying a Crash Modification Factor for replacing the existing intersection with a roundabout) has been deactivated in IHSDM, to minimize any confusion with the new roundabout methodology.

Section Types

Urban Arterial Site Set CPM Evaluation

Site Type

Type: 4ST
Calibration Factor: 1

Table 1. User Defined CMF Used in the Intersection CPM Evaluation (SSCPMUrbanArterial)

Site No.	Name	Severity	CMF Value
1	CMF 234	Fatal and Injury	0.2200

Table 2. Evaluation and Crash Data (CSD) (if applicable) Intersection Sites

Site No.	Type	Major AADT	Minor AADT	Presence of Lighting
1	4ST2x2le5	2019: 8000	2019: 2000	yes

Table 3. Predicted Crash Frequencies and Rates by Site

Site No.	Type	Highway	Site Description	Total Predicted Crashes for Evaluation Period	Predicted Total Crash Frequency (crashes/yr)	Predicted FI Crash Frequency (crashes/yr)	Predicted PDO Crash Frequency (crashes/yr)	Predicted Intersection Travel Crash Rate (crashes/million veh)	Intersection Crash Rate (crashes/yr)
1	4ST			1.126	1.1258	0.1328	0.9931	0.31	1.1258
		Total	Total	1.126	1.1258	0.1328	0.9931	0.31	1.1258

Table 4. Predicted Crash Frequencies by Year (4ST)

Year	Total Crashes	FI Crashes	Percent FI (%)	PDO Crashes	Percent PDO (%)
2019	1.13	0.13	11.792	0.99	88.208
Total	1.13	0.13	11.792	0.99	88.208
Average	1.13	0.13	11.792	0.99	88.208

Note: *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Table 5. Predicted 4ST Crash Type Distribution

Element Type	Crash Type	Fatal and Injury		Property Damage Only		Total	
		Crashes	Crashes (%)	Crashes	Crashes (%)	Crashes	Crashes (%)
Intersection	Collision with Animal	0.00	0.0	0.00	0.3	0.00	0.3
Intersection	Collision with Bicycle	0.01	0.5	0.00	0.0	0.01	0.5
Intersection	Collision with Fixed Object	0.01	0.9	0.13	11.2	0.14	12.0
Intersection	Non-Collision	0.00	0.2	0.01	0.6	0.01	0.9
Intersection	Collision with Other Object	0.00	0.1	0.01	0.9	0.01	1.0
Intersection	Other Single-vehicle Collision	0.00	0.1	0.00	0.1	0.00	0.2
Intersection	Collision with Parked Vehicle	0.00	0.0	0.00	0.0	0.00	0.0
Intersection	Collision with Pedestrian	0.01	0.7	0.00	0.0	0.01	0.7
Intersection	Total Intersection Single Vehicle Crashes	0.03	2.5	0.15	13.2	0.18	15.7
Intersection	Angle Collision	0.05	4.1	0.28	25.1	0.33	29.2
Intersection	Head-on Collision	0.00	0.4	0.03	2.3	0.03	2.6
Intersection	Other Multi-vehicle Collision	0.01	0.6	0.18	16.3	0.19	16.8
Intersection	Rear-end Collision	0.04	3.1	0.32	28.1	0.35	31.2
Intersection	Sideswipe	0.01	1.1	0.04	3.3	0.05	4.4
Intersection	Total Intersection Multiple Vehicle Crashes	0.10	9.3	0.84	75.0	0.95	84.3
Intersection	Total Intersection Crashes	0.13	11.8	0.99	88.2	1.13	100.0
	Total Crashes	0.13	11.8	0.99	88.2	1.13	100.0

Note: *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Interactive Highway Safety Design Model

Economic Analysis Report

December 29, 2022

Disclaimer

The Interactive Highway Design Model (IHSDM) software is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its content or use thereof. This document does not constitute a standard, specification, or regulation.

The United States Government does not endorse products or manufacturers. Trade and manufacturers' names may appear in this software and documentation only because they are considered essential to the objective of the software.

Limited Warranty and Limitations of Remedies

This software product is provided "as-is," without warranty of any kind-either expressed or implied (but not limited to the implied warranties of merchantability and fitness for a particular purpose). The FHWA do not warrant that the functions contained in the software will meet the end-user's requirements or that the operation of the software will be uninterrupted and error-free.

Under no circumstances will the FHWA be liable to the end-user for any damages or claimed lost profits, lost savings, or other incidental or consequential damages rising out of the use or inability to use the software (even if these organizations have been advised of the possibility of such damages), or for any claim by any other party.

Notice

The use of the IHSDM software is being done strictly on a voluntary basis. In exchange for provision of IHSDM, the user agrees that the Federal Highway Administration (FHWA), U.S. Department of Transportation and any other agency of the Federal Government shall not be responsible for any errors, damage or other liability that may result from any and all use of the software, including installation and testing of the software. The user further agrees to hold the FHWA and the Federal Government harmless from any resulting liability. The user agrees that this hold harmless provision shall flow to any person to whom or any entity to which the user provides the IHSDM software. It is the user's full responsibility to inform any person to whom or any entity to which it provides the IHSDM software of this hold harmless provision.

Table of Contents

List of Tables

Economic Analysis Report

Economic Analysis Report Overview

Report Generated: Dec 29, 2022 10:58 AM
Report Template: System: Multi-Page [System] (eam2, Mar 17, 2022 10:26 AM)

Evaluation Title: EAAnalysis 31
Evaluation Comment: Created Thu Dec 15 08:35:03 PST 2022
Evaluation Date: Thu Dec 15 08:35:07 PST 2022

User Name: hte
Organization Name:
Phone:
E-Mail:

Project Title: Traffic Signal vs. Roundabout
Project Comment: Created Thu Mar 17 12:58:36 PDT 2022

Configuration Summary

Crash Cost Configuration: WSDOT Version
Configuration Comment: June, 2019 WSDOT Societal Cost Values

Table 1. Economic Analysis Configuration

Configuration Data	
Crash Unit Cost Zero Year	**2019**
Crash Cost Index	**0.02**
Discount Rate	**0.03**
KABCO Unit Costs	
K Cost ($/Crash)	**3,423,400.00**
A Cost ($/Crash)	**3,423,400.00**
B Cost ($/Crash)	**237,400.00**
C Cost ($/Crash)	**142,300.00**
O Cost ($/Crash)	**14,800.00**

Table 2. RTL Segment FI Proportion Data

Segment Type	Fatal Crash (K) Proportion of FI (%)	Incapacitating Injury Crash (A) Proportion of FI (%)	Non-incapacitating Injury Crash (B) Proportion of FI (%)	Possible Injury Crash (C) Proportion of FI (%)
RTL 2U Two-Lane Undivided	4.050	16.820	33.960	45.170

Table 3. RTL Intersection FI Proportion Data

Intersection Type	Fatal Crash (K) Proportion of FI (%)	Incapacitating Injury Crash (A) Proportion of FI (%)	Non-incapacitating Injury Crash (B) Proportion of FI (%)	Possible Injury Crash (C) Proportion of FI (%)
RTL Three-Legged w/STOP control	4.100	9.640	40.000	46.260
RTL Three-Legged Signalized	0.268	6.434	38.338	54.960
RTL Three-Legged w/STOP control where major road turns	0.833	16.667	48.056	34.444
RTL Four-Legged w/STOP control	4.180	9.980	37.590	48.250
RTL Four-Legged w/All-way STOP control	1.091	13.091	40.727	45.091
RTL Four-Legged Signalized	2.650	6.180	30.880	60.290

Table 4. RML Segment FI Proportion Data

Segment Type	Fatal Crash (K) Proportion of FI (%)	Incapacitating Injury Crash (A) Proportion of FI (%)	Non-incapacitating Injury Crash (B) Proportion of FI (%)	Possible Injury Crash (C) Proportion of FI (%)
RML Four-Lane Undivided	3.560	18.210	40.900	37.330
RML Four-Lane Divided	3.560	18.210	40.900	37.330

Table 5. RML Intersection FI Proportion Data

Intersection Type	Fatal Crash (K) Proportion of FI (%)	Incapacitating Injury Crash (A) Proportion of FI (%)	Non-incapacitating Injury Crash (B) Proportion of FI (%)	Possible Injury Crash (C) Proportion of FI (%)
RML Three-Legged w/STOP control	0.000	9.090	42.660	48.250
RML Three-Legged Signalized	0.000	9.090	42.660	48.250
RML Four-Legged w/STOP control	0.000	9.090	42.660	48.250
RML Four-Legged Signalized	0.000	9.090	42.660	48.250

Table 6. USA Segment FI Proportion Data

Segment Type	Fatal Crash (K) Proportion of FI (%)	Incapacitating Injury Crash (A) Proportion of FI (%)	Non-incapacitating Injury Crash (B) Proportion of FI (%)	Possible Injury Crash (C) Proportion of FI (%)
USA Two-Lane Undivided	2.760	11.300	41.720	44.220
USA Three-Lane w/Center TWLTL	2.680	9.990	38.550	48.780
USA Four-Lane Undivided	1.400	11.290	37.740	49.570
USA Four-Lane Divided	2.030	10.840	39.450	47.680
USA Five-Lane w/Center TWLTL	2.080	9.910	37.460	50.550

Table 7. USA Intersection FI Proportion Data

Intersection Type	Fatal Crash (K) Proportion of FI (%)	Incapacitating Injury Crash (A) Proportion of FI (%)	Non-incapacitating Injury Crash (B) Proportion of FI (%)	Possible Injury Crash (C) Proportion of FI (%)
USA Three-Legged w/STOP control	0.070	8.350	43.840	47.740
USA Three-Legged w/All-Way STOP control	0.070	8.350	43.840	47.740
USA Three-Legged STOP control where major road turns	0.070	8.350	43.840	47.740
USA Three-Legged Signalized	0.070	8.350	43.840	47.740
USA Four-Legged w/STOP control	0.070	8.350	43.840	47.740
USA Four-Legged w/All-Way STOP control	0.070	8.350	43.840	47.740
USA Four-Legged Signalized	0.070	8.350	43.840	47.740
USA Five-Legged Signalized	0.070	8.350	43.840	47.740
USA Three-Legged w/STOP control	0.070	8.350	43.840	47.740
USA Three-Legged Signalized	0.070	8.350	43.840	47.740
USA Four-Legged w/STOP control	0.070	8.350	43.840	47.740
USA Four-Legged Signalized	0.070	8.350	43.840	47.740

Analysis Output Summary

Analysis Type: Benefit/Cost

Table 8. Case Cost Summary

Is Base Case	Title	Present Value of Crash Cost ($)	Present Value of Other Cost ($)	Net Present Value of Benefits (B) ($)	Net Present Value of Costs (C) ($)	Present Value of Net Benefit (B-C) ($)	Benefit Cost Ratio (B/C)
Yes	No Build	185,713.10	200.00				
	Traffic Signal	162,034.21	296,875.00	23,678.90	296,675.00	-272,996.10	0.0798
	Roundabout	75,800.03	456,525.00	109,913.08	456,325.00	-346,411.92	0.2409

Table 9. Case Crash Summary

Is Base Case	Title	Fatal (K) Crashes (crashes)	Incapacitating Injury (A) Crashes (crashes)	Non-Incapacitating Injury (B) Crashes (crashes)	Possible Injury (C) Crashes (crashes)	No Injury (O) Crashes (crashes)	Total Crashes (crashes)
Yes	No Build	0.0003	0.0325	0.1705	0.1857	0.4515	0.8405
	Traffic Signal	0.0002	0.0277	0.1454	0.1583	0.6361	0.9677
	Roundabout	0.0001	0.0111	0.0582	0.0634	0.9931	1.1258

Crash Cost Data

Traffic Signal Data

Case Title: Traffic Signal
Is Base Case: false
Present Value of Crash Cost: 162,034.21
Present Value of Other Cost: 296,875.00

Table 10. Traffic Signal Evaluation Cost

Project or Interchange	Selected Facility	Selected Evaluation	Present Value of Crash Cost ($)
SR 9/John Liner Rd./McGarigle Rd.	Traffic Signal	Evaluation 9	162,034.21
Total			162,034.21

Table 11. Traffic Signal Evaluation Crashes

Project or Interchange	Selected Facility	Selected Evaluation	Fatal (K) Crashes (crashes)	Incapacitating Injury (A) Crashes (crashes)	Non-Incapacitating Injury (B) Crashes (crashes)	Possible Injury (C) Crashes (crashes)	No Injury (O) Crashes (crashes)	Total Crashes (crashes)
SR 9/John Liner Rd./McGarigle Rd.	Traffic Signal	Evaluation 9	0.0002	0.0277	0.1454	0.1583	0.6361	0.9677
Total			0.0002	0.0277	0.1454	0.1583	0.6361	0.9677

Table 12. Traffic Signal Facility Type Crashes

Facility Type	Fatal (K) Crashes (crashes)	Incapacitating Injury (A) Crashes (crashes)	Non-Incapacitating Injury (B) Crashes (crashes)	Possible Injury (C) Crashes (crashes)	No Injury (O) Crashes (crashes)	Total Crashes (crashes)
Urban/Suburban Arterial Intersection (5 Lanes or Fewer)	0.0002	0.0277	0.1454	0.1583	0.6361	0.9677
Total	0.0002	0.0277	0.1454	0.1583	0.6361	0.9677

Roundabout Data

Case Title: Roundabout
Is Base Case: false
Present Value of Crash Cost: 75,800.03
Present Value of Other Cost: 456,525.00

Table 13. Roundabout Evaluation Cost

Project or Interchange	Selected Facility	Selected Evaluation	Present Value of Crash Cost ($)
SR 9/John Liner Rd./McGarigle Rd.	Roundabout	Evaluation 3	75,800.03
Total			75,800.03

Table 14. Roundabout Evaluation Crashes

Project or Interchange	Selected Facility	Selected Evaluation	Fatal (K) Crashes (crashes)	Incapacitating Injury (A) Crashes (crashes)	Non-Incapacitating Injury (B) Crashes (crashes)	Possible Injury (C) Crashes (crashes)	No Injury (O) Crashes (crashes)	Total Crashes (crashes)
SR 9/John Liner Rd./McGarigle Rd.	Roundabout	Evaluation 3	0.0001	0.0111	0.0582	0.0634	0.9931	1.1258
Total			0.0001	0.0111	0.0582	0.0634	0.9931	1.1258

Table 15. Roundabout Facility Type Crashes

Facility Type	Fatal (K) Crashes (crashes)	Incapacitating Injury (A) Crashes (crashes)	Non-Incapacitating Injury (B) Crashes (crashes)	Possible Injury (C) Crashes (crashes)	No Injury (O) Crashes (crashes)	Total Crashes (crashes)
Urban/Suburban Arterial Intersection (5 Lanes or Fewer)	0.0001	0.0111	0.0582	0.0634	0.9931	1.1258
Total	0.0001	0.0111	0.0582	0.0634	0.9931	1.1258

No Build Data

Case Title: No Build
Is Base Case: true
Present Value of Crash Cost: 185,713.10
Present Value of Other Cost: 200.00

Table 16. No Build Evaluation Cost

Project or Interchange	Selected Facility	Selected Evaluation	Present Value of Crash Cost ($)
SR 9/John Liner Rd./McGarigle Rd.	No Build	Evaluation 14	185,713.10
Total			185,713.10

Table 17. No Build Evaluation Crashes

Project or Interchange	Selected Facility	Selected Evaluation	Fatal (K) Crashes (crashes)	Incapacitating Injury (A) Crashes (crashes)	Non-Incapacitating Injury (B) Crashes (crashes)	Possible Injury (C) Crashes (crashes)	No Injury (O) Crashes (crashes)	Total Crashes (crashes)
SR 9/John Liner Rd./McGarigle Rd.	No Build	Evaluation 14	0.0003	0.0325	0.1705	0.1857	0.4515	0.8405
Total			0.0003	0.0325	0.1705	0.1857	0.4515	0.8405

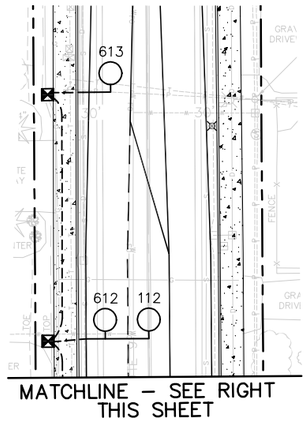
Table 18. No Build Facility Type Crashes

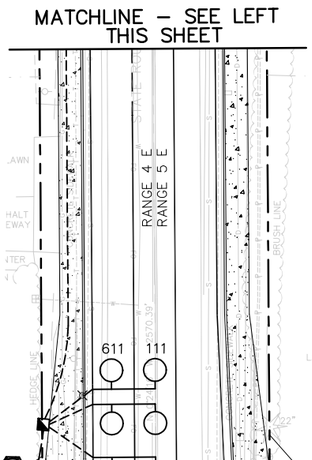
Facility Type	Fatal (K) Crashes (crashes)	Incapacitating Injury (A) Crashes (crashes)	Non-Incapacitating Injury (B) Crashes (crashes)	Possible Injury (C) Crashes (crashes)	No Injury (O) Crashes (crashes)	Total Crashes (crashes)
Urban/Suburban Arterial Intersection (5 Lanes or Fewer)	0.0003	0.0325	0.1705	0.1857	0.4515	0.8405
Total	0.0003	0.0325	0.1705	0.1857	0.4515	0.8405

TECHNICAL APPENDIX E

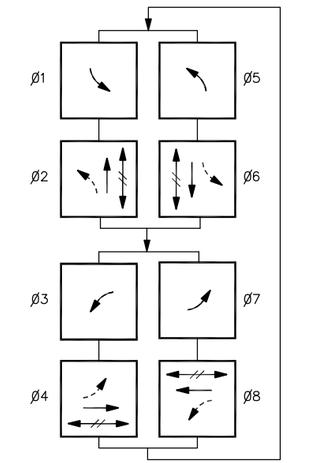
Alternative Conceptual Plans

20 0 20 40
scale feet



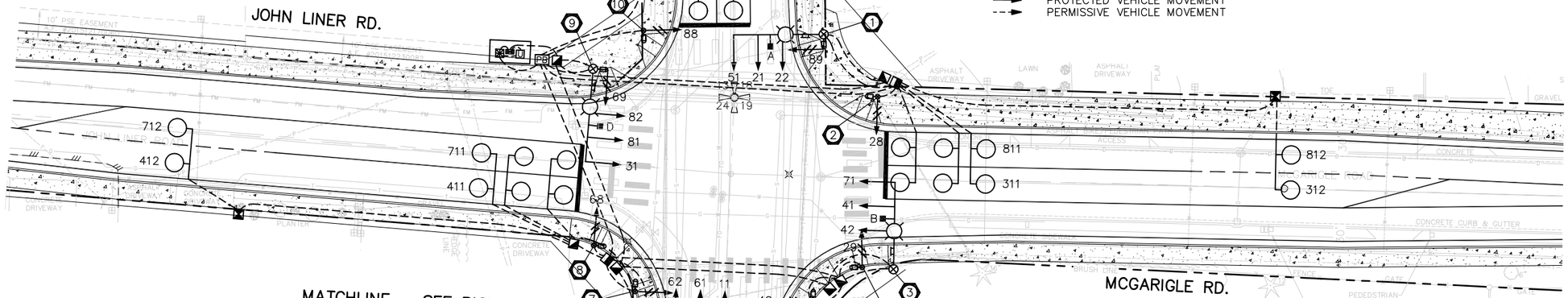


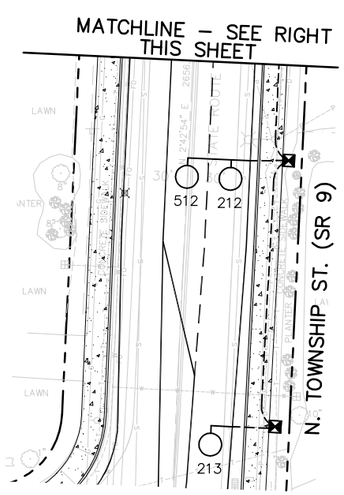
SIGNAL PHASING DIAGRAM

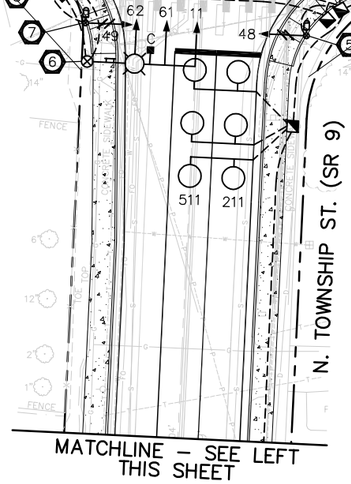


EMERGENCY VEHICLE PREEMPTION SCHEDULE

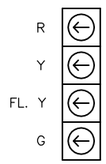
DETECTOR	PHASE
A	2+5
B	4+7
C	1+6
D	3+8



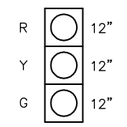




SIGNAL DISPLAY SCHEDULE



VEHICLE HEAD NO.
11,31,51,71



VEHICLE HEAD NO.
21,22,41,42,
61,62,81,82

PEDESTRIAN HEAD NO.
28,29,48,49,
68,69,88,89

SIGNAL DISPLAY NOTES:

1. ALL VEHICLE SIGNAL HEADS SHALL BE CONVENTIONAL HEADS WITH ALL LED INDICATIONS, TUNNEL VISORS AND BACKPLATES. ALL MAST ARM–MOUNTED HEADS SHALL USE MOUNTING TYPE M. USE J–75 SERIES STANDARD PLANS.
2. ALL PEDESTRIAN SIGNAL HEADS SHALL BE COUNTDOWN TYPE AND HAVE LED SYMBOLIC LEGENDS AND 'Z' CRATE VISORS. ALL HEADS SHALL USE MOUNTING TYPE D EXCEPT HEADS 69 AND 89 WHICH SHALL USE MOUNTING TYPE E. USE STANDARD PLAN J–75.10–00.

OVERHEAD POWER NOTE:

THIS PLAN ASSUMES ALL OVERHEAD POWER LINES WILL BE MODIFIED TO MEET REQUIRED CLEARANCES FROM TRAFFIC SIGNAL/ILLUMINATION EQUIPMENT.

VEHICLE DETECTION NOTE:

ALL ADVANCE VEHICLE DETECTOR LOOP LOCATIONS ARE APPROXIMATE. EXACT LOCATIONS WILL BE DETERMINED DURING DETAILED DESIGN.

PRELIMINARY - NOT FOR CONSTRUCTION

DRAWN	RMH				
DESIGNED	RMH				
CHECKED	6/29/22 RMH				
PROJ. ENGR.					
DRAWING FILE	RAB.DWG				
		DATE	REVISION	BY	APP'D

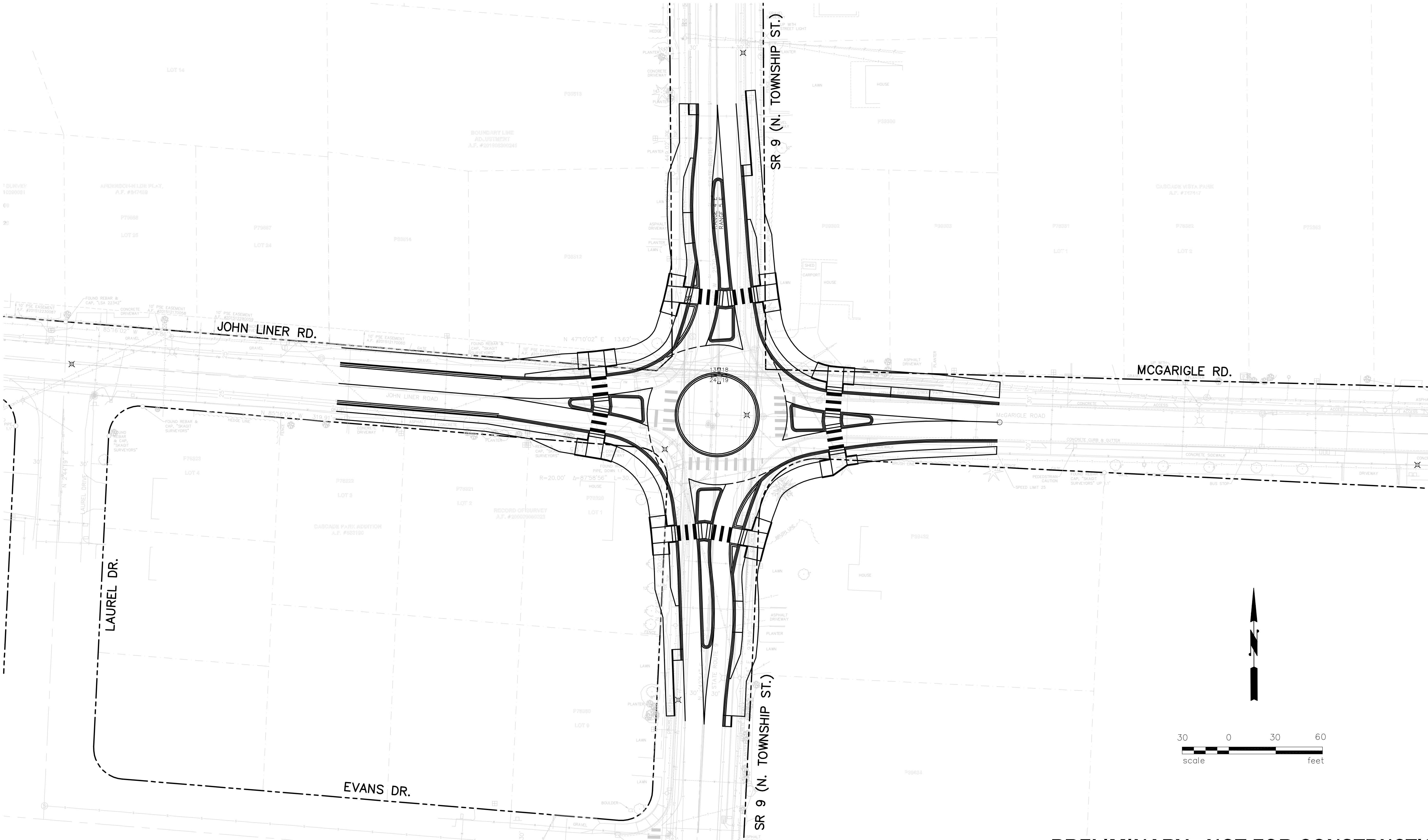
FOR:
REICHHARDT & EBE ENGINEERING, INC.
P.O. Box 978
Lynden, WA 98264

ROBERT MARTIN HERMAN — STATE OF WASHINGTON — 30730 — REGISTERED PROFESSIONAL ENGINEER — 6-29-22

HTE HERMAN TRAFFIC ENGINEERING, INC.
11215 Southeast 220th Place, Kent, Washington 98031
253-236-4941 tel. hte@comcast.net

CITY OF SEDRO–WOOLLEY WASHINGTON
SR 9 (N. TOWNSHIP ST.)/JOHN LINER RD./ MCGARIGLE RD.
TRAFFIC SIGNAL SYSTEM CONCEPT

TS1
SHEET 1 OF 1 SHEETS



PRELIMINARY - NOT FOR CONSTRUCTION

DRAWN	RMH			
DESIGNED	RMH			
CHECKED	6/29/22 RMH			
PROJ. ENGR.				
DRAWING FILE	RAB.DWG			
	DATE	REVISION	BY	APP'D

FOR:

REICHHARDT & EBE ENGINEERING, INC.
P.O. Box 978
Lynden, WA 98264

ROBERT MARTIN HERMAN
STATE OF WASHINGTON
30730
REGISTERED PROFESSIONAL ENGINEER
6-29-22

HTE HERMAN TRAFFIC ENGINEERING, INC.

11215 Southeast 220th Place, Kent, Washington 98031
253-236-4941 tel. hte@comcast.net

CITY OF SEDRO-WOOLLEY WASHINGTON

SR 9 (N. TOWNSHIP ST.)/JOHN LINER RD./
MCGARIGLE RD.

CONCEPTUAL ROUNDABOUT HORIZONTAL LAYOUT

C1

SHEET 1 OF 1 SHEETS

TECHNICAL APPENDIX F

Cost Estimates

Reichhardt & Ebe
ENGINEERING INC
423 Front Street
Lynden, WA 98264
Phone: (360) 354-3687

Called By:	City of Sedro-Woolley
For:	**N. TOWNSHIP ST. (SR9) & JOHN-LINER INTERSECTION IMPROVEMENT - SIGNALIZED** **CITY PROJECT NO. XXXXX** 325 Metcalf St Sedro-Woolley, WA 98284
	CONCEPTUAL ENGINEER'S ESTIMATE
By:	EJV / OAM / NZ
Date:	December 15, 2022

Item No.	Item Description	Quantity	Unit	Unit Price	Amount
1	Mobilization	1	LS	$ 160,000.00	$ 160,000.00
2	SPCC Plan	1	LS	$ 1,000.00	$ 1,000.00
3	Project Temporary Traffic Control	1	LS	$ 32,500.00	$ 32,500.00
4	Traffic Control Supervisor	1	LS	$ 7,150.00	$ 7,150.00
5	Flaggers	2,600	HR	$ 65.00	$ 169,000.00
6	Other Traffic Control Labor	260	HR	$ 65.00	$ 16,900.00
7	Clearing and Grubbing	1	LS	$ 22,400.00	$ 22,400.00
8	Removal of Structures and Obstructions	1	LS	$ 25,000.00	$ 25,000.00
9	Roadway Excavation Incl. Haul	975	CY	$ 25.00	$ 24,375.00
10	Gravel Borrow Incl. Haul	950	TON	$ 25.00	$ 23,750.00
11	Water	50	M GAL.	$ 50.00	$ 2,500.00
12	Shoring or Extra Excavation Class B	9,500	SF	$ 1.00	$ 9,500.00
13	Crushed Surfacing Top Course	575	TON	$ 40.00	$ 23,000.00
14	HMA Cl. 1/2", PG 64-22	1,075	TON	$ 135.00	$ 145,125.00
15	Corrugated Polyethylene Storm Sewer Pipe 12 In. Diam.	1,900	LF	$ 65.00	$ 123,500.00
16	Catch Basin Type 1	24	EA	$ 2,500.00	$ 60,000.00
17	Catch Basin Type 2 48 In. Diam.	4	EA	$ 4,200.00	$ 16,800.00
18	Adjustments to Finished Grade	1	LS	$ 5,000.00	$ 5,000.00
19	Erosion/Water Pollution Control	1	EST	$ 10,000.00	$ 10,000.00
20	ESC Lead	20	DAY	$ 150.00	$ 3,000.00
21	Silt Fence	1,400	LF	$ 5.50	$ 7,700.00
22	Inlet Protection	12	EA	$ 120.00	$ 1,440.00
23	Street Cleaning	130	HR	$ 175.00	$ 22,750.00
24	Topsoil Type A	1,600	SY	$ 11.00	$ 17,600.00
25	Seeded Lawn Installation	1,600	SY	$ 10.00	$ 16,000.00
26	Landscape Restoration	1	EST	$ 10,000.00	$ 10,000.00
27	Cement Conc. Traffic Curb and Gutter	2,980	LF	$ 30.00	$ 89,400.00
28	Cement Conc. Pedestrian Curb	80	LF	$ 30.00	$ 2,400.00
29	Cement Conc. Driveway Entrance	510	SY	$ 80.00	$ 40,800.00
30	Cement Conc. Sidewalk	1,770	SY	$ 65.00	$ 115,050.00
31	Cement Conc. Curb Ramp Type Parallel A	8	EA	$ 2,200.00	$ 17,600.00
32	Cement Conc. Curb Ramp Type Perpendicular A	4	EA	$ 2,200.00	$ 8,800.00
33	Mailbox Support, Type 1	26	EA	$ 500.00	$ 13,000.00
34	Traffic Signal System	1	LS	$ 400,000.00	$ 400,000.00
35	Interconnect System	1	LS	$ 70,000.00	$ 70,000.00
36	Paint Line	6,015	LF	$ 1.00	$ 6,015.00
37	Plastic Stop Line	100	LF	$ 12.00	$ 1,200.00
38	Plastic Crosswalk Line	576	SF	$ 12.00	$ 6,912.00
39	Plastic Traffic Arrow	8	EA	$ 650.00	$ 5,200.00
40	Pothole Existing Underground Utility	10	EA	$ 500.00	$ 5,000.00
41	Repair Existing Public and Private Facilities	1	EST	$ 15,000.00	$ 15,000.00

Subtotal	$	1,752,367.00
Contingency (25%)	$	438,091.75
Construction Total	**$**	**2,190,458.75**

Right-of-Way Acquisition

Parcel No.	Property Owner		Acquisition Area (SF)		Amount
P79668	Alan L. Fox		170	$	17,340.00
P79667	Paul St. Julien		425	$	33,685.00
P36514	Mavis J. Spradlin		450	$	34,560.00
P36512	Ian M. Walker		1,550	$	73,060.00
P39302	Feba R. Totino		555	$	38,235.00
P76322	Mikki R. Spadlin		160	$	16,990.00
P76321	Mavis J. Spadlin		160	$	16,990.00
P76320	Vickie L. Bennett		475	$	35,435.00
P39432	Anthony A. Hanses		210	$	18,740.00
	Right of Way Acquisition Total			**$**	**285,035.00**

Professional Services		
Design Completion (15%)	$	328,568.81
Construction Management (15%)	$	328,568.81
Professional Services Total	**$**	**657,137.62**

TOTAL PROJECT COST	**$**	**3,132,631.37**

Reichhardt & Ebe
ENGINEERING INC
423 Front Street
Lynden, WA 98264
Phone: (360) 354-3687

Called By:	City of Sedro-Woolley
For:	**N. TOWNSHIP ST. (SR9) & JOHN-LINER INTERSECTION IMPROVEMENT - ROUNDABOUT (Central Geometry)** **CITY PROJECT NO. XXXXX** 325 Metcalf St Sedro-Woolley, WA 98284
	CONCEPTUAL ENGINEER'S ESTIMATE
By:	EJV / OM / NZ
Date:	December 15, 2022

Item No.	Item Description	Quantity	Unit	Unit Price	Amount
1	Mobilization	1	LS	$ 140,000.00	$ 140,000.00
2	SPCC Plan	1	LS	$ 1,000.00	$ 1,000.00
3	Project Temporary Traffic Control	1	LS	$ 20,000.00	$ 20,000.00
4	Traffic Control Supervisor	1	LS	$ 10,000.00	$ 10,000.00
5	Flaggers	2,400	HR	$ 65.00	$ 156,000.00
6	Other Traffic Control Labor	440	HR	$ 65.00	$ 28,600.00
7	Clearing and Grubbing	1	LS	$ 22,400.00	$ 22,400.00
8	Removal of Structures and Obstructions	1	LS	$ 20,000.00	$ 20,000.00
9	Roadway Excavation Incl. Haul	1,375	CY	$ 25.00	$ 34,375.00
10	Gravel Borrow Incl. Haul	4,075	TON	$ 25.00	$ 101,875.00
11	Water	30	M GAL.	$ 50.00	$ 1,500.00
12	Shoring or Extra Excavation Class B	8,000	SF	$ 1.00	$ 8,000.00
13	HMA Cl. 1/2", PG 64-22	1,200	TON	$ 135.00	$ 162,000.00
14	Planing Bituminous Pavement	180	SY	$ 20.00	$ 3,600.00
15	Textured Cement Concrete Pavement	530	SY	$ 200.00	$ 106,000.00
16	Corrugated Polyethylene Storm Sewer Pipe 12 In. Diam.	1,000	LF	$ 65.00	$ 65,000.00
17	Catch Basin Type 1	16	EA	$ 2,500.00	$ 40,000.00
18	Catch Basin Type 2 48 In. Diam.	1	EA	$ 4,200.00	$ 4,200.00
19	Adjustments to Finished Grade	1	LS	$ 7,500.00	$ 7,500.00
20	Erosion/Water Pollution Control	1	EST	$ 10,000.00	$ 10,000.00
21	ESC Lead	60	DAY	$ 150.00	$ 9,000.00
22	Silt Fence	1,250	LF	$ 5.50	$ 6,875.00
23	Inlet Protection	4	EA	$ 120.00	$ 480.00
24	Street Cleaning	200	HR	$ 175.00	$ 35,000.00
25	Topsoil Type A	460	SY	$ 11.00	$ 5,060.00
26	Seeded Lawn Installation	1,750	SY	$ 10.00	$ 17,500.00
27	Sod Installation	465	SY	$ 15.00	$ 6,975.00
28	Landscape Restoration	1	EST	$ 5,000.00	$ 5,000.00
29	Cement Conc. Traffic Curb and Gutter	100	LF	$ 35.00	$ 3,500.00
30	Cement Conc. Pedestrian Curb	415	LF	$ 30.00	$ 12,450.00
31	Roundabout Truck Apron Cem. Conc. Curb and Gutter	275	LF	$ 35.00	$ 9,625.00
32	Roundabout Cement Concrete Curb and Gutter	1,895	LF	$ 30.00	$ 56,850.00
33	Roundabout Splitter Island Nosing Curb	4	EA	$ 1,500.00	$ 6,000.00
34	Cement Conc. Driveway Entrance	110	SY	$ 80.00	$ 8,800.00
35	Cement Conc. Sidewalk	1,070	SY	$ 65.00	$ 69,550.00
36	Cement Conc. Curb Ramp Type Parallel A	8	EA	$ 2,200.00	$ 17,600.00
37	Mailbox Support, Type 1	4	EA	$ 500.00	$ 2,000.00
38	Illumination System	1	LS	$ 150,000.00	$ 150,000.00
39	Rectangular Rapid Flashing Beacon System	1	LS	$ 90,000.00	$ 90,000.00

40	Permanent Signing	1	LS	$ 30,000.00	$ 30,000.00
41	Paint Line	1,575	LF	$ 1.50	$ 2,362.50
42	Plastic Crosswalk Line	480	SF	$ 12.00	$ 5,760.00
43	Plastic Traffic Arrow	4	EA	$ 650.00	$ 2,600.00
44	Plastic Yield Line Symbol	16	EA	$ 200.00	$ 3,200.00
45	Plastic Yield Ahead Symbol	4	EA	$ 80.00	$ 320.00
46	Pothole Existing Underground Utility	5	EA	$ 500.00	$ 2,500.00
47	Repair Existing Public and Private Facilities	1	EST	$ 10,000.00	$ 10,000.00
	Subtotal				$ 1,511,057.50
	Contingency (25%)				$ 377,764.38
	Construction Total				**$ 1,888,821.88**

Right-of-Way Acquisition				
Parcel No.	Property Owner	Acquisition Type	Acquisition Area (SF)	Amount
P76320	Robert & Vickie Bennett	Full		$ 1,016,674.00
P39302	Feva R. Totino	Full		$ 587,014.00
P36512	Ian M. Walker	Partial	2,000	$ 88,810.00
P39432	Anthony Hanses & Nicole Desrosiers	Partial	2,000	$ 88,810.00
P39303	Jean & Courtney Holcomb	Partial	200	$ 18,390.00
	Right-of-Way Acquisition Total			**$ 1,799,698.00**

Professional Services		
Design Completion (15%)	$	283,323.28
Construction Management (15%)	$	283,323.28
Professional Services Total	**$**	**566,646.56**

TOTAL PROJECT COST	**$**	**4,255,166.44**

TECHNICAL APPENDIX G

Travel Demand Modeling Notes

SR 9 / John Liner / McGarigle Rd -- TSI volume notes

	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	EB Total	WB Total	NB Total	SB Total	Total
2015	7	6	19	69	17	33	15	327	62	16	301	7	32	119	404	324	879
2036	185	30	110	65	70	35	80	350	50	15	240	150	325	170	480	405	1380
Difference	178	24	91	-4	53	2	65	23	-12	-1	-61	143	293	51	76	81	501

Comments
EB growth due to JJLT corridor
Reduction in SBT volume due to same (vehicles using JJLT corridor instead of SR 20

	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	EB Total	WB Total	NB Total	SB Total	Total
2019	6	12	10	84	8	20	8	329	66	16	239	6	28	112	403	261	804
2025	321	108	59	76	74	16	28	160	47	14	117	163	488	166	235	294	1183
Difference	315	96	49	-8	66	-4	20	-169	-19	-2	-122	157	460	54	-168	33	379

Comments
EB growth due to JJLT corridor
Reduction in NBT volume due to same (vehicles using JJLT corridor instead of SR 20 to access Township Rd)
Model predicts higher demand redistribution (greater utility) related to JJLT corridor completion, relative to 2036 model -- due to refinements in network architecture

	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	EB Total	WB Total	NB Total	SB Total	Total
2015	7	6	19	69	17	33	15	327	62	16	301	7	32	119	404	324	879
2019	6	12	10	84	8	20	8	329	66	16	239	6	28	112	403	261	804
Difference	-1	6	-9	15	-9	-13	-7	2	4	0	-62	-1	-4	-7	-1	-63	-75

Comments
2019 counts indicated lower SBT demand than 2015 counts
Other movements showed relatively consistent demand

	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	EB Total	WB Total	NB Total	SB Total	Total
2025	321	108	59	76	74	16	28	160	47	14	117	163	488	166	235	294	1183
2036	185	30	110	65	70	35	80	350	50	15	240	150	325	170	480	405	1380
Difference	-136	-78	51	-11	-4	19	52	190	3	1	123	-13	-163	4	245	111	197

Comments
Caution must be used when comparing 2025 and 2036 forecasts because 2025 forecast comes from a more recent (more refined) travel demand model