DESIGN REPORT

Larch Way/Logan Rd & Locust Way
Intersection Improvements

RC 1591
UPI# 16-0037

3/8/19

Snohomish County
Public Works
Engineering Services
DESIGN REPORT

Larch Way/Logan Rd & Locust Way Intersection Improvements
RC1591, UPI# 16-0037

APPROVED BY:  
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3/13/19  

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3/13/2019  

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3/8/19  

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Fact Sheet: Larch Way/Logan Rd & Locust Way Intersection Improvements

Project Proposal
Snohomish County proposes to construct an urban single lane roundabout at the intersection of Larch Way/Logan Rd and Locust Way. In addition to the roundabout, roadway improvements consisting of curbs, gutters, and a shared use path will be constructed. The proposed improvements aim to maintain traffic flow and improve safety for pedestrians, bicyclists, and motorists.

Project Benefits
- Improved traffic flow by reducing delay
- Pedestrian facilities and marked crosswalks

Project Cost

<table>
<thead>
<tr>
<th></th>
<th>30% Cost Estimate Summary</th>
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<tbody>
<tr>
<td>Construction Sub-Total</td>
<td>$1,582,000</td>
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<tr>
<td>Contingency</td>
<td>$396,000</td>
</tr>
<tr>
<td>Design Eng.</td>
<td>$240,000</td>
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<td>Construction Eng.</td>
<td>$240,000</td>
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<td>R/W</td>
<td>$536,100</td>
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<td><strong>Total</strong></td>
<td><strong>$2,994,100</strong></td>
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Project Schedule

<table>
<thead>
<tr>
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<tr>
<td>Environmental</td>
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<td>Design (PS&amp;E)</td>
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<tr>
<td>Right of Way</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction</td>
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</table>

Potential Permits
- National Pollution Discharge Elimination System (NPDES)
- State Environmental Policy Act (SEPA)
- Critical Area Regulations (CAR)
- Land Disturbing Activities (LDA)
- Washington State Archeological Laws
- Construction Stormwater General Permit
- Drainage Approval

Project Contacts
Matthew Feeley, P.E., Project Manager
Kalika Caley, E.I.T., Project Engineer
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APPENDIX I: 30% Right-of-Way True Cost Estimate

APPENDIX J: 30% Project Cost Estimate
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1. **EXECUTIVE SUMMARY**

Snohomish County proposes to construct an urban single-lane roundabout at the intersection of Larch Way/Logan Rd and Locust Way. This intersection has been identified in the 2015 Snohomish County Transportation Element as one of the County's recommended intersection improvement projects. The proposed improvements aim to maintain traffic flow and improve safety for pedestrians, bicyclists, and motorists.

This report assesses the existing project site conditions and evaluates the design alternatives for this project. This intersection is located in the Alderwood Manor area of south Snohomish County between the cities of Bothell, Brier, and Lynwood. Locust Way and Larch Way are two-lane urban minor arterials that run north to south and east to west, respectively. Logan Road is classified as an urban minor collector and runs east to west, east of Locust Way. Frontage improvements consisting of curbs, gutters, and a shared use path will be constructed as part of this project. Stormwater facilities will be constructed for flow control and water quality treatment. The proposed intersection improvements and construction of stormwater facilities will require right-of-way acquisition from approximately six parcels adjacent to the intersection. One of these parcels includes Logan Park that is owned and managed by the Snohomish County Parks Department.

This project has been programmed for construction in the 2019-2024 Transportation Improvement Program (TIP). Table 1-1 below summarizes the breakdown of the estimated project cost.

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Construction Sub-Total</td>
<td>$1,582,000</td>
</tr>
<tr>
<td>Contingency</td>
<td>$396,000</td>
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</tr>
<tr>
<td>Right of Way</td>
<td>$536,100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$2,994,100</strong></td>
</tr>
</tbody>
</table>
2. INTRODUCTION

This design report summarizes the existing project site conditions and evaluates the design alternatives for the Larch Way/Logan Rd and Locust Way intersection improvement project. A traffic study in conjunction with an intersection alternative analysis was completed. It was determined that the intersection improvements will consist of constructing an urban single-lane roundabout. This roundabout will include bike lanes, curbs, gutters, and a shared use path. The proposed improvements will maintain traffic flow and provide a safer environment for pedestrians, bicyclists, and motorists. See Appendix A for project location vicinity map.

3. EXISTING CONDITIONS

The intersection of Larch Way/Logan Rd and Locust Way is located in the Alderwood Manor area of south Snohomish County between the cities of Bothell, Brier, and Lynwood. Larch Way/Logan Rd and Locust Way are two-lane roads that intersect to create a four leg intersection. The intersection is currently all-way stop controlled. Travel lane widths on Larch Way and Logan Rd vary between 11’ and 13’. Travel lanes on Locust Way are 10’ wide. Pedestrian access is currently being provided by paved shoulders on Larch Way. On the southeast corner of the intersection there is paved path that provides pedestrian access around Logan Park. There are no existing crosswalk markings, sidewalks, or curb ramps. There is an existing Community Transit bus stop just east of the intersection on Logan Rd. Refer to the site photos in Appendix B for existing site conditions.

4. PROPOSED IMPROVEMENTS

The proposed design consists of constructing an urban single-lane roundabout with a right turn slip lane for vehicles traveling from northbound Locust Way to eastbound Logan Rd. The roundabout will have a 140’ inscribed circle diameter. A 10’ shared use path will be constructed for pedestrians and bicyclists. In order to minimize the amount of right-of-way required, the 5’ buffer strip adjacent to the shared use path will be eliminated. The horizontal alignment of Larch Way/Logan Rd and Locust Way will need to be adjusted in order to create a desirable entry speed for vehicles entering the roundabout. See Figure 4-1, Figure 4-2, and Figure 4-3 below for the proposed typical roadway sections. A copy of the preliminary channelization plan is located in Appendix D.

Figure 4-1. Single Lane Roundabout Typical Section
5. TRAFFIC

Locust Way and Larch Way are two-lane urban minor arterials that run north to south and east to west, respectively. Logan Road is classified as an urban minor collector and runs east to west, east of Locust Way. The existing average daily traffic (ADT) and 85th percentile speed for the roads are summarized in Table 5-1 below.

<table>
<thead>
<tr>
<th>ROAD NAME/DIRECTION</th>
<th>AVERAGE DAILY TRAFFIC (ADT)</th>
<th>85th Percentile Speed (MPH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larch Way (EB)</td>
<td>9,850</td>
<td>37</td>
</tr>
<tr>
<td>Logan Rd (WB)</td>
<td>8,020</td>
<td>39</td>
</tr>
<tr>
<td>Locust Way (NB)</td>
<td>4,266</td>
<td>37</td>
</tr>
<tr>
<td>Locust Way (SB)</td>
<td>2,150</td>
<td>33</td>
</tr>
</tbody>
</table>

Three alternatives were identified and analyzed for this project. Summaries of each alternative are described below.

5.1. Alternative 1 – No Build Option

Currently this intersection operates with an overall Level of Service (LOS) F. If no intersection improvements were constructed the intersection would continue to operate at a LOS F for the design year of 2035.
5.2. Alternative 2 – Traffic Signal

Snohomish County Traffic Operations analyzed the following items for a traffic signal:

- Traffic signal warrants
- Turn lane warrants
- Queue lengths for turn lanes
- Level of Service (LOS)

A traffic signal warrant analysis was initially performed in 2006 and revealed that three signal warrants were met. In addition to the signal warrant analysis, a turn warrant analysis was also conducted. The results from these two analyses recommended signalizing the intersection and provide an eastbound left and right turn lane and a westbound left turn lane. In 2016 another traffic signal warrant analysis was conducted and revealed that three signal warrants were met. The warrants that were met in both 2006 and 2016 include: Four Hour Volume, Peak Hour Delay, and Peak Hour Volume.

In addition to the 2016 traffic signal warrant analysis, a turn warrant and queue analysis was performed using forecasted volumes for the year 2035. The results of these analyses recommended left and right turn lanes be provided on each leg of the intersection. The left and right turn pocket lengths on the east leg of the intersection would need to be less than the lengths recommended in the queue analysis due to the existing width of Bridge 459 over Swamp Creek. Bridge 459 is not wide enough to accommodate the roadway widening that would be required to construct the recommended lengths of the eastbound left and right turn pockets. Figure 5-1 shows the conceptual layout of the signalized intersection alternative.
5.3. Alternative 3 – Urban Single-Lane Roundabout (Preferred Alternative):

An urban single-lane roundabout was evaluated as a third alternative. Snohomish County completed a preliminary analysis for a roundabout using Synchro and Sim Traffic software. After a review of this preliminary analysis and upon completion of an alternatives review meeting with Department of Public Works (DPW) traffic operations group, a decision was made to analyze the roundabout alternative using Sidra Intersection 6.1 software. Gibson Traffic Consultants, Inc. (GTC, Inc.) completed this analysis. This analysis consisted of evaluating a series of roundabout configurations and determining queue lengths, volume to capacity ratio (v/c), and the LOS that each configuration would provide for the design year of 2035. The roundabout configurations that were evaluated included:

- 80’ diameter center island with a northbound slip lane
- 100’ diameter center island with a northbound slip lane
- 80’ diameter center island with dual northbound lanes

The roundabout analysis report that was prepared by GTC, Inc. is located in Appendix E. Figure 5-2 shows the conceptual layout of the urban single lane roundabout.
Upon review of the alternatives analysis and meeting with DPW traffic operations group, a single-lane urban roundabout with a 100’ diameter center island and a northbound right turn slip lane was selected to be the preferred alternative for this project. Table 5-2 below summarizes the advantages and disadvantages that were considered for each alternative.

<table>
<thead>
<tr>
<th>#</th>
<th>ALTERNATIVE</th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
</table>
| 1 | No-Build     | - No right-of-way acquisition.  
    |              | - Minimal maintenance required. | - LOS F in 2035. |
Table 5-2. Alternative Summary. Comparison of advantages and disadvantages for each alternative.

<table>
<thead>
<tr>
<th>#</th>
<th>ALTERNATIVE</th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Traffic Signal</td>
<td>Improved LOS compared to alternative 1. LOS C in 2035.</td>
<td>Operations and maintenance cost associated with signal equipment.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Timing can be adjusted to allow for greater throughput on high volume</td>
<td>Swamp Creek stream buffer impact from widening the road to accommodate turn</td>
</tr>
<tr>
<td></td>
<td></td>
<td>approaches during peak hours.</td>
<td>lanes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Requires significant realignment of Logan Road and Larch Way to allow the</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>intersection with Locust Way to be at least 85 degrees.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Requires more right-of-way acquisition to construct turn lanes and realign</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Single-Lane Urban Roundabout</td>
<td>Fewer conflict points compared to signalized intersection.</td>
<td>Greater right-of-way acquisition from parcels immediately adjacent to the</td>
</tr>
<tr>
<td></td>
<td>(Preferred Alternative)</td>
<td>Less right-of-way acquisition compared to signalized intersection.</td>
<td>existing intersection.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Allows for vehicles to flow continuously through the roundabout with minimal</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>delay.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>LOS C in 2035 design year.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Avoids Swamp Creek buffer impacts.</td>
<td></td>
</tr>
</tbody>
</table>

6. ENVIRONMENTAL AND REQUIRED PERMITS

Swamp Creek is located approximately 400 feet west of the Larch Way/Logan Rd and Locust Way intersection. This stream has a 150’ buffer. The intersection improvements will not extend into the stream buffer.

The permits required for this project are listed in the Preliminary Environmental Review Memo in Appendix H. Potential permits will include the following:

- National Pollution Discharge Elimination System (NPDES)
- Construction Stormwater General Permit
- State Environmental Policy Act (SEPA)
- Washington State Archeological Laws
- Land Disturbing Activity (LDA)

7. SOILS

The Soil Survey of Snohomish County Area (SCS, 1983) classifies the soils in the project area as:

- Alderwood gravelly sandy loam, 8-15% slopes
- Alderwood gravelly sandy loam, 15-30% slopes
- Alderwood-Everett gravelly sandy loams, 25-70% slopes
- Alderwood-Urban land complex, 2-8 percent slopes
- Everett very gravelly sandy loam, 0-8 percent slopes
- Everett very gravelly sandy loam, 8-15 percent slopes
- Everett very gravelly sandy loam, 15-30 percent slopes
- Kitsap silt loam, 25 to 30 percent slopes

A geotechnical investigation and memo was completed by the Snohomish County Public Works Geotechnical Group in 2017 to provide site specific recommendations for pavement design, and infiltration rates for LID feasibility. A copy of this memo is located in Appendix G.

8. PUBLIC INVOLVEMENT

A project webpage has been developed to share project information. Postcards will be sent out during the environmental review and design phases of the project. A public open house was held on June 15, 2017 at Mountlake Terrace High School. Exhibits were prepared and placed on display to show preliminary proposed channelization, typical roadway sections, and highlights of the proposed improvements. Additional public involvement needs will be determined as the project proceeds forward with design.

Project website address:


9. DESIGN CRITERIA

The applicable roadway and intersection design standards for this project include the current editions of the following documents:

- Manual of Uniform Traffic Control Devices (MUTCD), 2009
- Snohomish County Drainage Manual, November 2017
- Snohomish County Engineering Design and Development Standards (EDDS), 2018
- WSDOT Design Manual, July 2018
- WSDOT Standards Plans, August 2018

<table>
<thead>
<tr>
<th>DESIGN ELEMENT</th>
<th>CRITERIA</th>
<th>DESIGN REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Access Points</td>
<td>1 per residential parcel</td>
<td>Section 2-02A (EDDS 2018)</td>
</tr>
<tr>
<td>Access Point Types</td>
<td>Residential width = 10'-30'</td>
<td>Sections 2-03A,3 (EDDS 2018) Drawings 2-010 and 2-020</td>
</tr>
<tr>
<td>Access Point Location, separation andSpacing</td>
<td>10' Separation between adjoining residential parcels</td>
<td>Section 2-04B (EDDS 2018)</td>
</tr>
<tr>
<td>Horizontal Alignment of Access points</td>
<td>90 degrees to adjacent road</td>
<td>Section 2-06 (EDDS 2-06)</td>
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</tbody>
</table>
Table 9-1. Design Criteria

<table>
<thead>
<tr>
<th>DESIGN ELEMENT</th>
<th>CRITERIA</th>
<th>DESIGN REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical Alignment of Access Points</td>
<td>15’ landing width, +/- 15% max grade</td>
<td>Section 2-07 (EDDS 2018) Drawing 2-070 for urban residential to non-arterial</td>
</tr>
<tr>
<td>Right-of-Way Standard Width 3 - Lane Width</td>
<td>60’ for collector road</td>
<td>Section 3-03A (EDDS 2018) Table 3-1/Drawing 3-030B</td>
</tr>
<tr>
<td>Vertical Alignment – Maximum Grade</td>
<td>Arterial (minor or collector) @10%; Residential/Subcollector @12%; Local Access 15%</td>
<td>Section 3-07A (EDDS 2018) Table 3-5</td>
</tr>
<tr>
<td>Stopping Sight Distance (SSD)</td>
<td>SSD = 250’ for 35 mph (85th percentile)</td>
<td>Section 3-08B,C (EDDS 2018) Table 3-6, Table 3-7 used for effect of grades</td>
</tr>
<tr>
<td>Intersection Sight Distance (ISD)</td>
<td>ISD varies from 305’ to 449’ depending on the side street ADT (40 mph operating speed)</td>
<td>Section 3-08D (EDDS 2018) Table 3-8 ISD (&lt;80 ADT) Table 3-9 ISD (&gt;80 ADT) Drawing 3-140</td>
</tr>
<tr>
<td>Angle of Intersection</td>
<td>90 degrees +/- degrees for exiting intersections</td>
<td>Section 3-09A (EDDS 2018)</td>
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<tr>
<td>Rockeries – Fences and handrails</td>
<td>Required when wall height is 30” or greater</td>
<td>Section 4-171 (EDDS 2018)</td>
</tr>
<tr>
<td>Intersections – Radius Returns</td>
<td>35’ minimum radius return for any road intersecting with arterial</td>
<td>Section 3-09, Table 3-10 (EDDS 2018)</td>
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<tr>
<td>Left Turn Lanes</td>
<td>Storage L = 95% queue for signalized or 100’ minimum for non-signalized. 50’ for minimum left turn radii</td>
<td>Section 3-11 (EDDS 2018) WSDOT Design Manual Chapter 1270 (July 2016) Figure 1270-8 (July 2011)</td>
</tr>
<tr>
<td>Transit Stops</td>
<td>Pullout required if posted speed is 35 mph or higher – located on far side of all I/S</td>
<td>Section 3-13A (EDDS 2018) Drawing 3-160</td>
</tr>
<tr>
<td>Concrete Sidewalks – Width and Cross Slope</td>
<td>2% Maximum cross slope 5’ width for sidewalks</td>
<td>Sections 4-05A,B (EDDS 2018) WSDOT Standard Plan F Series</td>
</tr>
<tr>
<td>Concrete Shared Use Path – Width and Cross Slope</td>
<td>2% Maximum cross slope 10’ width for shared use path</td>
<td>Sections 4-05A,B (EDDS 2018) WSDOT Standard Plan F Series</td>
</tr>
<tr>
<td>Concrete Sidewalks – Curb Ramps</td>
<td>4’ minimum landing 4’ minimum width</td>
<td>Section 4-05D (EDDS 2018) WSDOT Standard Plans F Series</td>
</tr>
<tr>
<td>Side Slopes</td>
<td>3H:1V or flatter for fill slopes 2H:1V or flatter for all cut slopes</td>
<td>Sections 4-14 A (EDDS 2018)</td>
</tr>
<tr>
<td>Pedestrian (Safety) Railing</td>
<td>Required when vertical drop-off behind the sidewalk in 2.5’ or greater</td>
<td>Section 4-16 (EDDS 2018) WSDOT Design Manual (2018), Chapter 1515</td>
</tr>
<tr>
<td>Clear Zone</td>
<td>10’ from edge of traveled way</td>
<td>Section 4-15 (EDDS 2018)</td>
</tr>
</tbody>
</table>

10. DEVIATIONS

Any deviations to the Snohomish County Public Works Engineering Design and Development Standards (EDDS) will be documented and approved by the County Engineer. Anticipated deviations include:
Elimination of planter/buffer strip between the curb and shared use path.

11. DRAINAGE

A drainage report will be developed in compliance with the Snohomish County Engineering Design and Development Standards (EDDS), the 2017 edition of the Snohomish County Drainage Manual, and Snohomish County Code (SCC). Stormwater flow control and water quality treatments will be designed according to the 2017 Snohomish County Drainage Manual.

The project site is located in the Swamp Creek sub-basin within the Lake Washington/Cedar/Sammamish watershed. Roadway drainage at the intersection is currently provided by a combination of ditches and enclosed storm drain systems. A portion of roadway drainage from Locust Way has been routed into two infiltration chambers located under the baseball field in the southwest corner of Logan Park. This project was completed by Snohomish County Surface Water Management (SWM) in 2013 and was designed to improve stormwater infiltration and prevent flooding on Locust Way (south of Larch Way and Logan Road) and private property adjacent to the road.

Based on preliminary field investigations and a review of existing drainage inventory maps, two Threshold Discharge Areas (TDA) were identified. TDA 1 consists of the area south of Larch Way and Logan Road. Water sheet flows into the enclosed storm drain system located on the east side of Locust Way and is conveyed to a corrugated metal pipe 50 feet north of 212th St SE. The pipe crosses under Locust Way and outfalls on the west side of the road. The water follows a natural drainage path down to Swamp Creek. TDA 2 consists of the Larch Way and Logan Rd roadway area between Swamp Creek and 14th PI W and extends 500 feet to the north on Larch Way. Water from this TDA sheet flows off the roadway into a ditch and enters an enclosed storm drain system through a catch basin on the southeast corner of the intersection. This catch basin is connected to a pipe that outfalls into Swamp Creek. A TDA delineation exhibit is located in Appendix D. Table 11-1, Table 11-2, and Table 11-3 below summarize the new impervious areas for both TDAs.

<table>
<thead>
<tr>
<th>Table 11-1. TDA Summary</th>
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<tbody>
<tr>
<td>ITEM</td>
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<tr>
<td>New Effective Impervious Surface (ft²)</td>
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<tr>
<td>Water Quality</td>
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<tr>
<td>Flow Control</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 11-2. TDA 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>SURFACE TYPE</td>
</tr>
<tr>
<td>Existing Hard Surface</td>
</tr>
<tr>
<td>Replaced Hard Surface</td>
</tr>
<tr>
<td>New Pollution Generating Hard Surface</td>
</tr>
<tr>
<td>New Non-Pollution Generating Hard Surface</td>
</tr>
</tbody>
</table>
### Table 11-3. TDA 2

<table>
<thead>
<tr>
<th>SURFACE TYPE</th>
<th>AREA (ft²)</th>
<th>AREA (Acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Hard Surface</td>
<td>42,783</td>
<td>0.98</td>
</tr>
<tr>
<td>Replaced Hard Surface</td>
<td>38,390</td>
<td>0.88</td>
</tr>
<tr>
<td>New Pollution Generating Hard Surface</td>
<td>19,337</td>
<td>0.44</td>
</tr>
<tr>
<td>New Non-Pollution Generating Hard Surface</td>
<td>6,670</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Water quality and flow control treatment will be required for TDA 1 and 2. The following water quality treatment and flow control BMPs were selected as the preferred potential stormwater BMPs for this project:

- Bioretention Cells (grass lined)
- Pervious concrete (for shared use path)
- Infiltration Chambers
- Modular Wetland System
- Enclosed Detention Vault

The flow control and water quality treatment BMPs listed above will be designed and sized using the continuous hydrologic simulation program, MGS Flood. The proposed intersection and roadway improvements adds less than 50% additional impervious surface to the existing hard surface areas within the project limits. Therefore, only the new hard surfaces and new pollution generating impervious surfaces will be subject to flow control and water quality treatment requirements.

### 12. RIGHT OF WAY

The existing right-of-way (R/W) widths vary between 52 feet and 65 feet on Larch Way and Logan Rd. and between 50 feet and 60 feet on Locust Way within the project limits. Per Table 3-1 in the Snohomish County EDDS, a minimum of 70 feet of right-of-way will be required on Logan road and a minimum of 80 feet of a right-of-way will be required for Larch Way and Locust Way.

This project will impact approximately six parcels. The majority of the right-of-way acquisition will be from the parcels that are located on each corner of the existing intersection. Additional right-of-way may be required for stormwater facilities. There are no anticipated total parcel acquisitions.

A right-of-way plan will be developed. See Appendix I for 30% R/W True Cost Estimates.

### 13. UTILITIES

The following utilities have been identified within the project location:
- Snohomish County PUD (Electrical)
- Puget Sound Energy (Natural Gas)
- Alderwood Water and Waste Water District
- Comcast Communications
- Frontier/Verizon Communications
- King County Metro (Sanitary Sewer)

Utility as-built records have been requested and coordination with each utility company will be ongoing during the design phase of this project. Snohomish County PUD poles will need to be relocated outside the road side clear zone. Additional overhead and underground utilities will need to be relocated to accommodate the widening of the road for the roundabout approach legs and the construction of the roundabout itself. Utility coordination will be ongoing throughout the project.

14. FUNDING AND CONSTRUCTION COSTS

Snohomish County Road Funds and Developer Mitigation Funds are currently programmed for preliminary engineering and right-of-way. A 30% preliminary engineer’s estimate is located in Appendix J.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Sub-Total</td>
<td>$1,582,000</td>
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<tr>
<td>Contingency</td>
<td>$396,000</td>
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<td>Design Eng.</td>
<td>$240,000</td>
</tr>
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<td>Construction Eng.</td>
<td>$240,000</td>
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<tr>
<td>Right of Way</td>
<td>$536,100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$2,994,100</strong></td>
</tr>
</tbody>
</table>
APPENDIX A

Vicinity Map
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APPENDIX B

Project Area Photos
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Figure B - 1. Project Area Photo Key Map
Figure B - 2. Looking south on Locust Way, north of Larch Way and Logan Rd.

Figure B - 3. Looking west on Logan Rd, north of Locust Way.
Figure B - 4. Looking east on Larch Way, west of Locust Way.

Figure B - 5. Looking north on Locust Way, south of Larch Way and Logan Rd. Logan Park is to the left.
APPENDIX C

Typical Sections
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SECTION #, T. #, N. #, E., W.M.

ROUNDABOUT TYPICAL SECTION

LOGAN RD/LOCUST WAY/LARCH WAY TYPICAL LEG SECTION (SINGLE LANE ENTRY)

LOGAN RD/LOCUST WAY/LARCH WAY TYPICAL LEG SECTION (DUAL LANE ENTRY)
APPENDIX D

Preliminary Channelization Plan
(This page is intentionally blank)
APPENDIX E

Traffic Analysis
Memorandum

Date: Thursday, June 1, 2017

To: Bin Lee, P.E., P.T.O.E., Traffic Signal Operations Engineer

From: Don Wisehart, Engineer I, TES-Traffic Operations

Subject: Existing Signal Warrant for Larch Way, Logan Road @ Locust Way

Attached you will find an existing 2017 signal warrant completed based on a request from Matthew Feeley in Engineering Services.

The location is a 4-legged all-way stop controlled intersection. More than 14,000 vehicles per day enter the intersection based on 2017 traffic counts. There were 10 reported collisions during the 3-year time frame of 1/1/2014 to 12/31/2016. Four of the collisions were correctable by a signal within a 12-month period.

The following signal warrants were met with existing volumes.

- Warrant 2: 4-Hour Vehicular Volume (met 6 hours)
- Warrant 3A: Peak Hour Delay (met 8 hours)
- Warrant 3B: Peak Hour Volume (met 2 hours)

For an all-way stop this is a fairly strong warrant considering the warrant was run without the benefit of the high-speed treatment which you would often get with a two-way stop condition. All three of the 8-hour warrants might possibly met also if this was a two-way stop and mainline traffic was not slowed for the queue.

Please complete the following statement, sign where indicated, and return it to me as soon as possible. The attached analysis shows that a signal is not warranted.

Comments: A signal on a multi-lane roundabout (see attached) is recommended.

Signed: ___________________________ Date: 6/8/17

Title: Traffic Signal Operations Engineer

If you have any questions or need additional information, please e-mail or call me on extension 4593.
Bin Lee, P.E., P.T.O.E.; Traffic Signal Operations Engineer
Thursday, June 1, 2017

dw

Attachments

cc: Mohammad Uddin, P.E., P.T.O.E, PW Supervisor III, TES-Traffic Operations
    Theam Ong, TADM Supervisor: TES-Traffic Operations
    Stephanie Prescott, P.E., Engineer II, TES-Traffic Operations
    Matthew Feeley, P.E., Engineer II, Engineering Services
    Tracy McMillan, Funding Coordinator: TES-Program Planning
**SIGNAL WARRANTS CHECKLIST**

<table>
<thead>
<tr>
<th>Warrant</th>
<th>Description</th>
<th>Met/Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>Minimum Volume</td>
<td>Not Met</td>
</tr>
<tr>
<td>1B</td>
<td>Interruption</td>
<td>Not Met</td>
</tr>
<tr>
<td>1C</td>
<td>Combination of Warrants</td>
<td>Not Met</td>
</tr>
<tr>
<td>2</td>
<td>Four Hour Volumes</td>
<td>Met</td>
</tr>
<tr>
<td>3A</td>
<td>Peak Hour Delay</td>
<td>Met</td>
</tr>
<tr>
<td>3B</td>
<td>Peak Hour Volume</td>
<td>Met</td>
</tr>
<tr>
<td>4</td>
<td>Pedestrian Volume</td>
<td>N/A</td>
</tr>
<tr>
<td>5</td>
<td>School Crossing</td>
<td>N/A</td>
</tr>
<tr>
<td>6</td>
<td>Coordinated Signal System</td>
<td>N/A</td>
</tr>
<tr>
<td>7</td>
<td>Crash Experience</td>
<td>Not Met</td>
</tr>
<tr>
<td>8</td>
<td>Roadway Network</td>
<td>N/A</td>
</tr>
<tr>
<td>9</td>
<td>Intersection Near Grade Crossing</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**All-Way Stop (AWS) Warrant**

*Met

*AWS WARRANT MET, CONDITIONS A, C & D, ALREADY INSTALLED*
### TEAPAC[Ver 9.01.01] - MUTCD Warrant Analysis

#### Conditions Used for Warrant Analysis

<table>
<thead>
<tr>
<th>2009 MUTCD</th>
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</thead>
</table>

#### Intersection # 1

<table>
<thead>
<tr>
<th>Major Street Direction</th>
<th>EastWest</th>
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<tbody>
<tr>
<td>Number of Lanes in North-South direction</td>
<td>1</td>
</tr>
<tr>
<td>Number of Lanes in East-West direction</td>
<td>1</td>
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<tr>
<td>Approach speed on major street is greater than 40 mph</td>
<td>No</td>
</tr>
<tr>
<td>Isolated community has population less than 10,000</td>
<td>No</td>
</tr>
<tr>
<td>Signal will not seriously disrupt progressive traffic flow</td>
<td>Yes</td>
</tr>
<tr>
<td>Trials of other remedies have failed to improve conditions</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of accidents correctable by a signal</td>
<td>4</td>
</tr>
<tr>
<td>Peak hour stop sign delay for worst minor approach (veh-hours)</td>
<td>20</td>
</tr>
<tr>
<td>Number of accidents correctable by a multi-way stop</td>
<td>4</td>
</tr>
<tr>
<td>Peak hour average delay for all minor approaches (sec/veh)</td>
<td><strong>143</strong></td>
</tr>
</tbody>
</table>

### TEAPAC[Ver 9.01.01] - Warrant Analysis for Traffic Signal

#### Warrant 1A Analysis - 8-Hour Minimum Vehicular Volume

<table>
<thead>
<tr>
<th>Start Time</th>
<th>1700</th>
<th>1600</th>
<th>1800</th>
<th>700</th>
<th>800</th>
<th>1500</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
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</thead>
<tbody>
<tr>
<td>Minor Volume</td>
<td>351</td>
<td>311</td>
<td>274</td>
<td>256</td>
<td>213</td>
<td>185</td>
<td>164</td>
<td>145</td>
<td>150</td>
</tr>
<tr>
<td>Major Volume</td>
<td>980</td>
<td>854</td>
<td>740</td>
<td>662</td>
<td>684</td>
<td>788</td>
<td>566</td>
<td>606</td>
<td>500</td>
</tr>
<tr>
<td>Warrant Met?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>8</td>
</tr>
</tbody>
</table>

- Number of 1-hour periods meeting the warrant: 7
- Signal will not seriously disrupt progressive traffic flow: Yes

**> WARRANT 1A IS NOT MET <<

#### Warrant 1B Analysis - 8-Hour Interruption of Continuous Traffic

<table>
<thead>
<tr>
<th>Start Time</th>
<th>1700</th>
<th>1600</th>
<th>1500</th>
<th>1800</th>
<th>700</th>
<th>800</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Volume</td>
<td>351</td>
<td>311</td>
<td>185</td>
<td>274</td>
<td>256</td>
<td>213</td>
<td>164</td>
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<td>75</td>
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<tr>
<td>Major Volume</td>
<td>980</td>
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<td>788</td>
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<td>662</td>
<td>684</td>
<td>566</td>
<td>606</td>
<td>750</td>
</tr>
<tr>
<td>Warrant Met?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>8</td>
</tr>
</tbody>
</table>

- Number of 1-hour periods meeting the warrant: 3
- Signal will not seriously disrupt progressive traffic flow: Yes

**> WARRANT 1B IS NOT MET <<
**TEAPAC [Ver 9.01.01] - Warrant Analysis for Traffic Signal**

**Warrant 1A Analysis (80%) - 8-Hour Minimum Vehicular Volume**

<table>
<thead>
<tr>
<th>Start Time</th>
<th>1700</th>
<th>1600</th>
<th>1800</th>
<th>700</th>
<th>800</th>
<th>1500</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
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</thead>
<tbody>
<tr>
<td>Minor Volume</td>
<td>351</td>
<td>311</td>
<td>274</td>
<td>256</td>
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<td>185</td>
<td>164</td>
<td>145</td>
<td>120</td>
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<td>566</td>
<td>606</td>
<td>400</td>
</tr>
<tr>
<td>Warrant Met?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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Number of 1-hour periods meeting the warrant 12

**Warrant 1B Analysis (80%) - 8-Hour Interruption of Continuous Traffic**

<table>
<thead>
<tr>
<th>Start Time</th>
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<th>1800</th>
<th>700</th>
<th>800</th>
<th>1500</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
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</thead>
<tbody>
<tr>
<td>Minor Volume</td>
<td>351</td>
<td>311</td>
<td>274</td>
<td>256</td>
<td>213</td>
<td>185</td>
<td>164</td>
<td>145</td>
<td>60</td>
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<tr>
<td>Major Volume</td>
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<td>854</td>
<td>740</td>
<td>662</td>
<td>684</td>
<td>788</td>
<td>606</td>
<td>566</td>
<td>600</td>
</tr>
<tr>
<td>Warrant Met?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>8</td>
</tr>
</tbody>
</table>

Number of 1-hour periods meeting the warrant 7

**Warrant 1C Analysis - 8-Hour Combination of Warrants**

80% of Warrants 1A and 1B are met No
Signal will not seriously disrupt progressive traffic flow Yes
Trials of other remedies have failed to reduce delays Yes

>> WARRANT 1C IS NOT MET <<

**Warrant 2 Analysis - 4-Hour Vehicular Volume**

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<th>Start Time</th>
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<th>1800</th>
<th>700</th>
<th>800</th>
<th>1500</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Volume</td>
<td>351</td>
<td>311</td>
<td>274</td>
<td>256</td>
<td>213</td>
<td>185</td>
<td>164</td>
<td>145</td>
<td>---</td>
</tr>
<tr>
<td>Minor Reqmt</td>
<td>105</td>
<td>139</td>
<td>170</td>
<td>193</td>
<td>186</td>
<td>158</td>
<td>230</td>
<td>213</td>
<td>---</td>
</tr>
<tr>
<td>Warrant Met?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>4</td>
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</table>

Number of 1-hour periods meeting the warrant 6
Signal will not seriously disrupt progressive traffic flow Yes

>> WARRANT 2 IS MET <<
TEAPAC [Ver. 9.01.01] - Warrant Analysis for Traffic Signal

### Warrant 3A Analysis - Peak Hour Delay

<table>
<thead>
<tr>
<th>Start Time</th>
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<th>1600</th>
<th>1800</th>
<th>700</th>
<th>800</th>
<th>1500</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Volume</td>
<td>351</td>
<td>311</td>
<td>274</td>
<td>256</td>
<td>213</td>
<td>185</td>
<td>164</td>
<td>145</td>
<td>100</td>
</tr>
<tr>
<td>Total Volume</td>
<td>1439</td>
<td>1264</td>
<td>1085</td>
<td>1034</td>
<td>1018</td>
<td>1068</td>
<td>814</td>
<td>829</td>
<td>800</td>
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<tr>
<td>Warrant Met?</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>1</td>
</tr>
</tbody>
</table>

Number of 1-hour periods meeting the warrant: 8
Signal will not seriously disrupt progressive traffic flow: Yes
Delay for worst minor approach (must be at least 4 veh-hours): 20

>> WARRANT 3A IS MET <<

### Warrant 3B Analysis - Peak Hour Volume

<table>
<thead>
<tr>
<th>Start Time</th>
<th>1700</th>
<th>1600</th>
<th>1800</th>
<th>700</th>
<th>800</th>
<th>1500</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Volume</td>
<td>351</td>
<td>311</td>
<td>274</td>
<td>256</td>
<td>213</td>
<td>185</td>
<td>164</td>
<td>145</td>
<td></td>
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<tr>
<td>Minor Reqmt</td>
<td>211</td>
<td>256</td>
<td>304</td>
<td>339</td>
<td>328</td>
<td>285</td>
<td>385</td>
<td>367</td>
<td>&lt;--</td>
</tr>
<tr>
<td>Warrant Met?</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>1</td>
</tr>
</tbody>
</table>

Number of 1-hour periods meeting the warrant: 2
Signal will not seriously disrupt progressive traffic flow: Yes

>> WARRANT 3B IS MET <<

### Warrant 7 Analysis - Crash Experience

- 80% of Warrant 1A or 1B is met: Yes
- Signal will not seriously disrupt progressive traffic flow: Yes
- Trials of other remedies have failed to reduce accidents: Yes
- Number of correctable accidents (must be 5 or more per year): 4

>> WARRANT 7 IS NOT MET <<

### Summary of MUTCD Traffic Signal Warrant Analysis

- Warrant 1A 8-Hour Minimum Vehicular Volume: NOT MET
- Warrant 1B 8-Hour Interruption of Continuous Traffic: NOT MET
- Warrant 1C 8-Hour Combination of Warrants: NOT MET
- Warrant 2 4-Hour Vehicular Volume: MET
- Warrant 3A Peak Hour Delay: MET
- Warrant 3B Peak Hour Volume: MET
- Warrant 7 Crash Experience: NOT MET

>> Traffic Signal Warrant is MET <<
**TEAPAC[Ver 9.01.04] - Warrant Analysis for Multi-way Stop**

**Warrant A Analysis - Interim Measure for Signal**

If signal warrants are met, a temporary multi-way stop is allowed

>> WARRANT A IS MET <<

**Warrant B Analysis - Crash Experience**

Number of correctable accidents (must be 5 or more per year) 4

>> WARRANT B IS NOT MET <<

**Warrant C Analysis - 8-Hour Minimum Vehicular Volume**

<table>
<thead>
<tr>
<th>Start Time</th>
<th>1700</th>
<th>1600</th>
<th>700</th>
<th>1800</th>
<th>800</th>
<th>1500</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
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<tbody>
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<td>410</td>
<td>372</td>
<td>345</td>
<td>334</td>
<td>280</td>
<td>248</td>
<td>223</td>
<td>200</td>
</tr>
<tr>
<td>Major Volume</td>
<td>980</td>
<td>854</td>
<td>662</td>
<td>740</td>
<td>684</td>
<td>788</td>
<td>566</td>
<td>606</td>
<td>300</td>
</tr>
<tr>
<td>Warrant Met?</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Average minor volume for 8 highest minor hours 334
Average major volume for 8 highest minor hours 735
Delay for all minor approaches (must be at least 30 sec/veh) 143

>> WARRANT C IS MET <<

**Warrant D Analysis - 8-Hour Combination of Warrants**

<table>
<thead>
<tr>
<th>Start Time</th>
<th>1700</th>
<th>1600</th>
<th>700</th>
<th>1800</th>
<th>800</th>
<th>1500</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
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<tbody>
<tr>
<td>Minor Volume</td>
<td>459</td>
<td>410</td>
<td>372</td>
<td>345</td>
<td>334</td>
<td>280</td>
<td>248</td>
<td>223</td>
<td>160</td>
</tr>
<tr>
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<td>854</td>
<td>662</td>
<td>740</td>
<td>684</td>
<td>788</td>
<td>566</td>
<td>606</td>
<td>240</td>
</tr>
<tr>
<td>Warrant Met?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Average minor volume for 8 highest minor hours 334
Average major volume for 8 highest minor hours 735
Number of correctable accidents (must be 4 or more per year) 4
Delay for all minor approaches (must be at least 24 sec/veh) 143

>> WARRANT D IS MET <<

**Summary of MLTCD Multi-way Stop Warrant Analysis**

| Warrant A Interim Measure for Signal | MET |
| Warrant B Crash Experience | NOT MET |
| Warrant C 8-Hour Minimum Vehicular Volume | MET |
| Warrant D 8-Hour Combination of Warrants | MET |

>> Multi-way Stop Warrant is MET <<
Memorandum

Date: Friday, June 5, 2017

To: Bin Lee, P.E., P.T.O.E., Traffic Signal Operations Engineer

From: Don Wisehart, Engineer I, TES-Traffic Operations

Subject: Supplemental Forecast Signal Warrant 2023 for Larch Way, Logan Road @ Locust Way

Attached you will find a forecast 2023 signal warrant completed based on a supplemental request from Stephanie Prescott in Traffic Operations.

The following signal warrants were met with added pipeline volumes.

- Warrant 1C: 8-Hour Combination of Warrants (Met 12 hours of part 1A and 9 hours of part 1B)
- Warrant 2: 4-Hour Vehicular Volume (met 6 hours)
- Warrant 3A: Peak Hour Delay (met 8 hours)
- Warrant 3B: Peak Hour Volume (met 3 hours)

In addition, the analysis fell only 2 vehicles short of meeting warrant 1A (8-Hour Minimum Vehicular Volume).

Please complete the following statement, sign where indicated, and return it to me as soon as possible. The attached analysis shows that a signal is not warranted based on added pipeline volumes.

Comments: A signal or a multi-lane roundabout is recommended.

Signed: ___________________________ Date: 6/8/17

Title: Traffic Signal Operations Engineer

If you have any questions or need additional information, please e-mail or call me on extension 4593.

dw

Attachments
Bin Lee, P.E., P.T.O.E.; Traffic Signal Operations Engineer
Monday, June 5, 2017

cc: Mohammad Uddin, P.E., P.T.O.E, PW Supervisor III, TES-Traffic Operations
Theam Ong, TADM Supervisor: TES-Traffic Operations
Stephanie Prescott, P.E., Engineer II, TES-Traffic Operations
Matthew Feeley, P.E., Engineer II, Engineering Services
Tracy McMillan, Funding Coordinator: TES-Program Planning
## SIGNAL WARRANTS CHECKLIST

**Location:** LARCH WAY/LOGAN RD @ LOCUST WAY  
**Forecast Warrant (2023)**

<table>
<thead>
<tr>
<th>Date of Counts: 5/23/17, W-LEG &amp; TMC's 2016</th>
<th>Date of Analysis: 6/5/17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyzed By: D. WISEHART</td>
<td>Checked By: SW</td>
</tr>
<tr>
<td>Date Checked: 6/13/17</td>
<td>Reviewed By: JY</td>
</tr>
<tr>
<td>Date Reviewed: 6/18/17</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Warrant</th>
<th>Description</th>
<th>Met/Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>Minimum Volume</td>
<td>Not Met</td>
</tr>
<tr>
<td>1B</td>
<td>Interruption</td>
<td>Not Met</td>
</tr>
<tr>
<td>1C</td>
<td>Combination of Warrants</td>
<td>Met</td>
</tr>
<tr>
<td>2</td>
<td>Four Hour Volumes</td>
<td>Met</td>
</tr>
<tr>
<td>3A</td>
<td>Peak Hour Delay</td>
<td>Met</td>
</tr>
<tr>
<td>3B</td>
<td>Peak Hour Volume</td>
<td>Met</td>
</tr>
<tr>
<td>4</td>
<td>Pedestrian Volume</td>
<td>N/A</td>
</tr>
<tr>
<td>5</td>
<td>School Crossing</td>
<td>N/A</td>
</tr>
<tr>
<td>6</td>
<td>Coordinated Signal System</td>
<td>N/A</td>
</tr>
<tr>
<td>7</td>
<td>Crash Experience</td>
<td>Not Met</td>
</tr>
<tr>
<td>8</td>
<td>Roadway Network</td>
<td>N/A</td>
</tr>
<tr>
<td>9</td>
<td>Intersection Near Grade Crossing</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**All-Way Stop (AWS) Warrant**

| Met     |

*AWS WARRANT MET, CONDITIONS A, C & D, ALREADY INSTALLED*  

Warrants in 2009 MUTCD  
6/5/2017
### TEAPAC[Ver 9.01.01] - MUTCD Warrant Analysis

**Conditions Used for Warrant Analysis**

2009 MUTCD

**Intersection #** 1

<table>
<thead>
<tr>
<th>Major Street Direction</th>
<th>East/West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Lanes in North-South direction</td>
<td>1</td>
</tr>
<tr>
<td>Number of Lanes in East-West direction</td>
<td>1</td>
</tr>
<tr>
<td>Approach speed on major street is greater than 40 mph</td>
<td>No</td>
</tr>
<tr>
<td>Isolated community has population less than 10,000</td>
<td>No</td>
</tr>
<tr>
<td>Signal will not seriously disrupt progressive traffic flow</td>
<td>Yes</td>
</tr>
<tr>
<td>Trials of other remedies have failed to improve conditions</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of accidents correctable by a signal</td>
<td>4</td>
</tr>
<tr>
<td>Peak hour stop sign delay for worst minor approach (veh-hours)</td>
<td>20</td>
</tr>
<tr>
<td>Number of accidents correctable by a multi-way stop</td>
<td>4</td>
</tr>
<tr>
<td>Peak hour average delay for all minor approaches (sec/veh)</td>
<td><strong>226</strong></td>
</tr>
</tbody>
</table>

### TEAPAC[Ver 9.01.01] - Warrant Analysis for Traffic Signal

**Warrant 1A Analysis - 8-Hour Minimum Vehicular Volume**

<table>
<thead>
<tr>
<th>Start Time</th>
<th>1700</th>
<th>1600</th>
<th>1800</th>
<th>700</th>
<th>800</th>
<th>1500</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Volume</td>
<td>358</td>
<td>318</td>
<td>280</td>
<td>256</td>
<td>213</td>
<td>189</td>
<td>164</td>
<td>148</td>
<td>150</td>
</tr>
<tr>
<td>Major Volume</td>
<td>1087</td>
<td>948</td>
<td>821</td>
<td>735</td>
<td>761</td>
<td>874</td>
<td>631</td>
<td>672</td>
<td>500</td>
</tr>
<tr>
<td>Warrant Met? Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>8</td>
</tr>
</tbody>
</table>

Number of 1-hour periods meeting the warrant | 7
Signal will not seriously disrupt progressive traffic flow | Yes

> **WARRANT 1A IS NOT MET <<

**Warrant 1B Analysis - 8-Hour Interruption of Continuous Traffic**

<table>
<thead>
<tr>
<th>Start Time</th>
<th>1700</th>
<th>1600</th>
<th>1800</th>
<th>800</th>
<th>1500</th>
<th>700</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Volume</td>
<td>358</td>
<td>318</td>
<td>280</td>
<td>213</td>
<td>189</td>
<td>256</td>
<td>164</td>
<td>148</td>
<td>75</td>
</tr>
<tr>
<td>Major Volume</td>
<td>1087</td>
<td>948</td>
<td>821</td>
<td>761</td>
<td>735</td>
<td>874</td>
<td>631</td>
<td>672</td>
<td>750</td>
</tr>
<tr>
<td>Warrant Met? Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>8</td>
</tr>
</tbody>
</table>

Number of 1-hour periods meeting the warrant | 5
Signal will not seriously disrupt progressive traffic flow | Yes

> **WARRANT 1B IS NOT MET <<
**TEAPAC[Ver 9.01.01] - Warrant Analysis for Traffic Signal**

**Warrant 1A Analysis (80%) - 8-Hour Minimum Vehicular Volume**

<table>
<thead>
<tr>
<th>Start Time</th>
<th>1700</th>
<th>1600</th>
<th>1800</th>
<th>700</th>
<th>800</th>
<th>1500</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Volume</td>
<td>358</td>
<td>318</td>
<td>280</td>
<td>256</td>
<td>213</td>
<td>189</td>
<td>164</td>
<td>148</td>
<td>120</td>
</tr>
<tr>
<td>Major Volume</td>
<td>1087</td>
<td>948</td>
<td>821</td>
<td>735</td>
<td>761</td>
<td>874</td>
<td>631</td>
<td>672</td>
<td>400</td>
</tr>
<tr>
<td>Warrant Met?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>8</td>
</tr>
</tbody>
</table>

Number of 1-hour periods meeting the warrant: **12**

**Warrant 1B Analysis (80%) - 8-Hour Interruption of Continuous Traffic**

<table>
<thead>
<tr>
<th>Start Time</th>
<th>1700</th>
<th>1600</th>
<th>1800</th>
<th>700</th>
<th>800</th>
<th>1500</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Volume</td>
<td>358</td>
<td>318</td>
<td>280</td>
<td>256</td>
<td>213</td>
<td>189</td>
<td>164</td>
<td>148</td>
<td>60</td>
</tr>
<tr>
<td>Major Volume</td>
<td>1087</td>
<td>948</td>
<td>821</td>
<td>735</td>
<td>761</td>
<td>874</td>
<td>631</td>
<td>672</td>
<td>600</td>
</tr>
<tr>
<td>Warrant Met?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>8</td>
</tr>
</tbody>
</table>

Number of 1-hour periods meeting the warrant: **9**

**Warrant 1C Analysis - 8-Hour Combination of Warrants**

- 80% of Warrants 1A and 1B are met: **Yes**
- Signal will not seriously disrupt progressive traffic flow: **Yes**
- Trials of other remedies have failed to reduce delays: **Yes**

>> WARRANT 1C IS MET <<

**Warrant 2 Analysis - 4-Hour Vehicular Volume**

<table>
<thead>
<tr>
<th>Start Time</th>
<th>1700</th>
<th>1600</th>
<th>1800</th>
<th>700</th>
<th>800</th>
<th>1500</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Volume</td>
<td>358</td>
<td>318</td>
<td>280</td>
<td>256</td>
<td>213</td>
<td>189</td>
<td>164</td>
<td>148</td>
<td>---</td>
</tr>
<tr>
<td>Minor Reqmt</td>
<td>87</td>
<td>113</td>
<td>149</td>
<td>171</td>
<td>165</td>
<td>133</td>
<td>204</td>
<td>190</td>
<td>---</td>
</tr>
<tr>
<td>Warrant Met?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>4</td>
</tr>
</tbody>
</table>

Number of 1-hour periods meeting the warrant: **6**

Signal will not seriously disrupt progressive traffic flow: **Yes**

>> WARRANT 2 IS MET <<
**TEAPAC[Ver.9.01.01] - Warrant Analysis for Traffic Signal**

**Warrant 3A Analysis - Peak Hour Delay**

<table>
<thead>
<tr>
<th>Start Time</th>
<th>1700</th>
<th>1600</th>
<th>1800</th>
<th>700</th>
<th>800</th>
<th>1500</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Volume</td>
<td>358</td>
<td>318</td>
<td>280</td>
<td>256</td>
<td>213</td>
<td>189</td>
<td>164</td>
<td>148</td>
<td>100</td>
</tr>
<tr>
<td>Total Volume</td>
<td>1555</td>
<td>1367</td>
<td>1173</td>
<td>1114</td>
<td>1102</td>
<td>1160</td>
<td>884</td>
<td>899</td>
<td>800</td>
</tr>
<tr>
<td>Warrant Met?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>1</td>
</tr>
</tbody>
</table>

Number of 1-hour periods meeting the warrant: 8
Signal will not seriously disrupt progressive traffic flow: Yes
Delay for worst minor approach (must be at least 4 veh-hours): 20

>> WARRANT 3A IS MET <<

**Warrant 3B Analysis - Peak Hour Volume**

<table>
<thead>
<tr>
<th>Start Time</th>
<th>1700</th>
<th>1600</th>
<th>1800</th>
<th>700</th>
<th>800</th>
<th>1500</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Volume</td>
<td>358</td>
<td>318</td>
<td>280</td>
<td>256</td>
<td>213</td>
<td>189</td>
<td>164</td>
<td>148</td>
<td></td>
</tr>
<tr>
<td>Minor Reqmt</td>
<td>179</td>
<td>221</td>
<td>271</td>
<td>306</td>
<td>296</td>
<td>247</td>
<td>355</td>
<td>334</td>
<td></td>
</tr>
<tr>
<td>Warrant Met?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Number of 1-hour periods meeting the warrant: 3
Signal will not seriously disrupt progressive traffic flow: Yes

>> WARRANT 3B IS MET <<

**Warrant 7 Analysis - Crash Experience**

80% of Warrant 1A or 1B is met: Yes
Signal will not seriously disrupt progressive traffic flow: Yes
Trials of other remedies have failed to reduce accidents: Yes
Number of correctable accidents (must be 5 or more per year): 4

>> WARRANT 7 IS NOT MET <<

**Summary of MUTCD Traffic Signal Warrant Analysis**

- Warrant 1A 8-Hour Minimum Vehicular Volume: NOT MET
- Warrant 1B 8-Hour Interruption of Continuous Traffic: NOT MET
- Warrant 1C 8-Hour Combination of Warrants: MET
- Warrant 2 4-Hour Vehicular Volume: MET
- Warrant 3A Peak Hour Delay: MET
- Warrant 3B Peak Hour Volume: MET
- Warrant 7 Crash Experience: NOT MET

>> Traffic Signal Warrant is MET <<
TEAPAC[Ver 9.01.01] - Warrant Analysis for Multi-way Stop

Warrant A Analysis - Interim Measure for Signal

If signal warrants are met, a temporary multi-way stop is allowed

>> WARRANT A IS MET <<

Warrant B Analysis - Crash Experience

Number of correctable accidents (must be 5 or more per year) 4

>> WARRANT B IS NOT MET <<

Warrant C Analysis - 8-Hour Minimum Vehicular Volume

<table>
<thead>
<tr>
<th>Start Time</th>
<th>1700</th>
<th>1600</th>
<th>700</th>
<th>1800</th>
<th>800</th>
<th>1500</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Volume</td>
<td>468</td>
<td>419</td>
<td>379</td>
<td>352</td>
<td>341</td>
<td>286</td>
<td>253</td>
<td>227</td>
<td>200</td>
</tr>
<tr>
<td>Major Volume</td>
<td>1087</td>
<td>948</td>
<td>735</td>
<td>821</td>
<td>761</td>
<td>874</td>
<td>631</td>
<td>672</td>
<td>300</td>
</tr>
<tr>
<td>Warrant Met?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>8</td>
</tr>
<tr>
<td>Average minor volume for 8 highest minor hours</td>
<td>341</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average major volume for 8 highest minor hours</td>
<td>816</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delay for all minor approaches (must be at least 30 sec/veh)</td>
<td>226</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

>> WARRANT C IS MET <<

Warrant D Analysis - 8-Hour Combination of Warrants

<table>
<thead>
<tr>
<th>Start Time</th>
<th>1700</th>
<th>1600</th>
<th>700</th>
<th>1800</th>
<th>800</th>
<th>1500</th>
<th>600</th>
<th>1400</th>
<th>Req.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Volume</td>
<td>468</td>
<td>419</td>
<td>379</td>
<td>352</td>
<td>341</td>
<td>286</td>
<td>253</td>
<td>227</td>
<td>160</td>
</tr>
<tr>
<td>Major Volume</td>
<td>1087</td>
<td>948</td>
<td>735</td>
<td>821</td>
<td>761</td>
<td>874</td>
<td>631</td>
<td>672</td>
<td>240</td>
</tr>
<tr>
<td>Warrant Met?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>8</td>
</tr>
<tr>
<td>Average minor volume for 8 highest minor hours</td>
<td>341</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average major volume for 8 highest minor hours</td>
<td>816</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of correctable accidents (must be 4 or more per year)</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delay for all minor approaches (must be at least 24 sec/veh)</td>
<td>226</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

>> WARRANT D IS MET <<

Summary of MUTCD Multi-way Stop Warrant Analysis

<table>
<thead>
<tr>
<th>Warrant</th>
<th>Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Interim Measure for Signal</td>
<td>MET</td>
</tr>
<tr>
<td>B</td>
<td>Crash Experience</td>
<td>NOT MET</td>
</tr>
<tr>
<td>C</td>
<td>8-Hour Minimum Vehicular Volume</td>
<td>MET</td>
</tr>
<tr>
<td>D</td>
<td>8-Hour Combination of Warrants</td>
<td>MET</td>
</tr>
</tbody>
</table>

>> Multi-way Stop Warrant is MET <<
Memorandum

Date: 6/14/17

To: File

From: Stephanie Prescott, P.E.

Subject: Locust Way and Larch Way and Logan Way Intersection Traffic Control

An analysis was done using Synchro and SimTraffic of the intersection at Locust Way/Larch Way and Logan Way for future operations. The intersection currently meets signal warrants. A roundabout was investigated as another option. The analysis used the 2016 turning movement counts.

For the 2016 analysis, the LOS for the two operate at LOS B, with a slight benefit of the roundabout. The Queuing analysis shows that the queues for the roundabout would be less than the signal.

2016 LOS and Delay (seconds)

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>EB</th>
<th>WB</th>
<th>NB</th>
<th>SB</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS</td>
<td>F (54.4)</td>
<td>F (94.2)</td>
<td>D (27.6)</td>
<td>D (31.9)</td>
<td>B (14.5)</td>
</tr>
<tr>
<td>Roundabout</td>
<td>F (10.2)</td>
<td>B (11.7)</td>
<td>B (18.0)</td>
<td>C (17.4)</td>
<td>B (12.9)</td>
</tr>
<tr>
<td>Signal</td>
<td>B (12.6)</td>
<td>B (12.7)</td>
<td>B (13.1)</td>
<td>B (10.8)</td>
<td>B (12.9)</td>
</tr>
</tbody>
</table>

2016 95TH % Queuing Analysis (ft)

<table>
<thead>
<tr>
<th></th>
<th>EB</th>
<th>WB</th>
<th>NB</th>
<th>SB</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS</td>
<td>577</td>
<td>150</td>
<td>107</td>
<td>59</td>
</tr>
<tr>
<td>Roundabout</td>
<td>108</td>
<td>101</td>
<td>129</td>
<td>67</td>
</tr>
<tr>
<td>Signal</td>
<td>224</td>
<td>130</td>
<td>0</td>
<td>69</td>
</tr>
</tbody>
</table>

The 2035 volumes provided from the 14th Ave W project were used to analysis the future scenarios. There were two types of roundabout considered, a single lane and a double lane roundabout as well as the signal. The overall operations of the double lane roundabout would be LOS B and the single lane would operate at LOS F. However, the analysis showed almost a quarter of a mile queues, potentially impacting the intersection at 14th Ave W, if the two approaching lanes were less than 400 ft long or the exit lanes were less than 400 ft. If the outgoing lanes are not long enough for a proper merge, than people will tend to stay in one lane. Which is what Synchro showed resulting in long queues. WSDOT design manual, exhibit 1310-14 shows the minimum acceleration length for the design speeds of the roadway and they match what Synchro produced. Once the lanes were more than 500 ft the queues would be smaller. (As shown in the table below.) It should also be noted that the right of way would be much larger than a signal with a four lane cross section. Resulting in a 4 lane cross section plus a roundabout that is at least 150 ft diameter. Therefore, I would not recommend a roundabout for this intersection.
### 2035 LOS and Delay (seconds)

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>EB</th>
<th>WB</th>
<th>NB</th>
<th>SB</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS with turn pockets</td>
<td>F (247.8)</td>
<td>F (501.5)</td>
<td>F (247.3)</td>
<td>F (59.5)</td>
<td>F (94.9)</td>
</tr>
<tr>
<td>Single Lane Roundabout</td>
<td>F (172.1)</td>
<td>F (78.6)</td>
<td>E (42.2)</td>
<td>F (411.9)</td>
<td>E (36.9)</td>
</tr>
<tr>
<td>Double lane roundabout with 500ft merge lanes</td>
<td>E (44.9)</td>
<td>D (10.6)</td>
<td>E (10.2)</td>
<td>C (24.5)</td>
<td>E (10.2)</td>
</tr>
<tr>
<td>Signal</td>
<td>C (34.2)</td>
<td>D (40.5)</td>
<td>C (29.8)</td>
<td>[<strong>[27.5]</strong>]</td>
<td>D (50.3)</td>
</tr>
</tbody>
</table>

### 2035 95th % Queuing Analysis (ft)

<table>
<thead>
<tr>
<th></th>
<th>EB</th>
<th>WB</th>
<th>NB</th>
<th>SB</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS</td>
<td>776</td>
<td>749</td>
<td>1289</td>
<td>442</td>
</tr>
<tr>
<td>Single Lane Roundabout</td>
<td>288</td>
<td>131</td>
<td>1398</td>
<td>269</td>
</tr>
<tr>
<td>Double lane roundabout with less than 500ft merge lanes</td>
<td>637</td>
<td>176</td>
<td>1665</td>
<td>104</td>
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<tr>
<td>Double lane roundabout with 500 ft + merge lanes</td>
<td>[<strong>[10]</strong>]</td>
<td>[<strong>[10]</strong>]</td>
<td>378</td>
<td>[<strong>[10]</strong>]</td>
</tr>
<tr>
<td>Signal</td>
<td>540</td>
<td>335</td>
<td>233</td>
<td>234</td>
</tr>
</tbody>
</table>

There may be a need for more analysis using Sidra or other HCM approved software for roundabout with double lanes roundabouts. Queues are the important factor in this design.

Attached are the analysis results.
Locust Way at Larch Way
Locust Way at 14th Avenue W Extension Roundabout Analysis

Prepared for Snohomish County

January 2018
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1. INTRODUCTION

Gibson Traffic Consultants, Inc. (GTC) has been retained to analyze roundabouts at two intersections:

- Locust Way at Larch Way and
- Locust Way at the planned 14th Avenue W Extension.

Brad Lincoln, responsible for this report, is a licensed professional engineer (Civil) in the State of Washington and member of the Washington State section of the Institute of Transportation Engineers (ITE).

2. METHODOLOGY

Snohomish County staff provided weekday PM peak-hour turning movement volumes, including existing and 2035 future volumes. Snohomish County identified that the weekday PM peak-hour is the critical timeframe for the roundabout analysis and provided preliminary roundabout designs for the two study locations. The roundabout analysis performed by Gibson Traffic Consultants utilizes the Sidra Intersection 6.1 software and is based on the guidelines for roundabout analysis provided in the WSDOT Sidra Policy Settings (November 2015). It is important to note that the volumes included in the Sidra results printouts account for the peak-hour factor, the volumes in the printouts are not the input volumes.

The results for the roundabout analysis have been evaluated based on the queue lengths, the volume-to-capacity (v/c) ratio and the level of service. WSDOT evaluates roundabouts on a pass-fail basis, with a v/c ratio of 0.92 being the threshold. Snohomish County does not have a threshold for intersection operations, but LOS E is usually Snohomish County’s standard for urban arterial operations.

3. LOCUST WAY AT LARCH WAY

The intersection at Locust Way at Larch Way is currently an all-way stop-controlled intersection. Snohomish County has evaluated whether the intersection should be converted to signal or roundabout control. The preliminary design for a signal includes separate channelization for left-turns on each approach, as well as separate right-turn lanes for the eastbound and northbound movements. The preliminary design for a roundabout is a single-lane roundabout with a 100-foot island diameter and one 20-foot circulating lane. The existing and future operations with the Snohomish County proposed signal and roundabout are summarized in Table 1.
Table 1: Larch Way at Locust Way – Snohomish County Proposals

<table>
<thead>
<tr>
<th>Timeframe</th>
<th>Alternative</th>
<th>Total Intersection</th>
<th>Critical Approaches</th>
<th>95th Percentile Queue Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LOS Delay</td>
<td>Approach</td>
<td>LOS Delay</td>
</tr>
<tr>
<td>2016</td>
<td>Signal</td>
<td>B 13 sec</td>
<td>Eastbound</td>
<td>B 13 sec</td>
</tr>
<tr>
<td>Existing</td>
<td>100' Island Diameter Roundabout</td>
<td>A 7 sec</td>
<td>Northbound</td>
<td>B 12 sec</td>
</tr>
<tr>
<td>2035</td>
<td>Signal</td>
<td>C 34 sec</td>
<td>Eastbound</td>
<td>D 50 sec</td>
</tr>
<tr>
<td>Future</td>
<td>100' Island Diameter Roundabout</td>
<td>E 70 sec</td>
<td>Northbound</td>
<td>D 41 sec</td>
</tr>
</tbody>
</table>

The analysis of the Snohomish County proposed signal and roundabout are likely to have detrimental impacts, either due to the level of service, v/c ratio or queue lengths.

GTC has evaluated a series of alternative roundabout configurations that could be considered and would be similar in size to the Snohomish County proposed roundabout. The alternatives were developed to determine what level of improvement would be necessary for the roundabout to operate acceptably during the weekday PM peak-hour. The alternatives are:

3.1 GTC Alternative #1

GTC Alternative #2 includes an 80-foot island diameter with a northbound to eastbound right-turn slip lane. This alternative has a similar size footprint to the Snohomish County proposal with the reduced island diameter and additional lane. Snohomish County staff will need to evaluate the reduced island diameter to determine if it is sufficient for the design vehicle.

3.2 GTC Alternative #2

GTC Alternative #2 includes a 100-foot island diameter with a northbound to eastbound right-turn slip lane. This alternative provides additional channelization for the northbound movement, but included a larger diameter to match the Snohomish County design.

1 The signal v/c ratio is based on the maximum v/c ratio and the roundabout v/c ratio is based on the critical approach.
3.3 GTC Alternative #3

GTC Alternative #3 includes an 80-foot island diameter with dual northbound lanes through the roundabout. This alternative has a similar size footprint to the Snohomish County proposal with the reduced island diameter and additional northbound lane through the roundabout. Snohomish County staff will need to evaluate the reduced island diameter to determine if it is sufficient for the design vehicle.

A summary of the operations with the Snohomish County proposed roundabout and the roundabout alternatives developed and evaluated by GTC is included in Table 2.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Dimensions</th>
<th>2035 Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snohomish County</td>
<td>100-foot Island Diameter</td>
<td>LOS E</td>
</tr>
<tr>
<td>Proposed Design</td>
<td>Single 20-foot Circulating Lane</td>
<td>1.38 v/c</td>
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<tr>
<td></td>
<td></td>
<td>Northbound is Critical Approach</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,265-foot 85th Percentile Queue Length</td>
</tr>
<tr>
<td>GTC Alternative #1</td>
<td>80-foot Island Diameter</td>
<td>LOS C</td>
</tr>
<tr>
<td></td>
<td>Single 20-foot Circulating Lane</td>
<td>1.10 v/c</td>
</tr>
<tr>
<td></td>
<td>Northbound to Eastbound Slip-Lane</td>
<td>Northbound is Critical Approach</td>
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<tr>
<td></td>
<td></td>
<td>815-foot 85th Percentile Queue Length</td>
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<tr>
<td>GTC Alternative #2</td>
<td>100-foot Island Diameter</td>
<td>LOS C</td>
</tr>
<tr>
<td></td>
<td>Single 20-foot Circulating Lane</td>
<td>1.02 v/c</td>
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<tr>
<td></td>
<td>Northbound to Eastbound Slip-Lane</td>
<td>Northbound is Critical Approach</td>
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<tr>
<td></td>
<td></td>
<td>606-foot 85th Percentile Queue Length</td>
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<tr>
<td>GTC Alternative #3</td>
<td>80-foot Island Diameter</td>
<td>LOS B</td>
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<tr>
<td></td>
<td>Dual Northbound Lanes</td>
<td>0.80 v/c</td>
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<td></td>
<td>15-foot Northbound Lanes</td>
<td>Eastbound is Critical Approach</td>
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<tr>
<td></td>
<td>20-foot Lanes for Other Movements</td>
<td>293-foot 85th Percentile Queue Length</td>
</tr>
</tbody>
</table>

The alternative recommended by GTC is Alternative #3. This alternative would provide dual northbound lanes through the roundabout, would meet level of service and v/c thresholds and would have queue lengths less than 300 feet. This alternative would require widening to 2 northbound lanes south of the roundabout and tapering to 1 northbound lane north of the roundabout. Snohomish County staff will need to evaluate the reduced diameter to determine if it sufficient for the design vehicle.

There are not strict guidelines on when the widening south of the roundabout or tapering north of the roundabout should occur. However, GTC evaluated several different channelization scenarios using the tools without the Sidra 6.1 software that evaluate the effect on the roundabout operations with widening south of the roundabout and tapering north of the roundabout. GTC recommends the following minimums:
- South of the roundabout yield bar—2 northbound lanes for at least 250 feet
- North of the roundabout exit—2 northbound lanes for at least 500 feet

These lengths are in addition to the transition tapers. It is important to note that the length of the 2-lane section north of the roundabout could arguably be based on the length of the decision sight distance identified in the American Association of State Highway and Transportation Official (AASHTO) A Policy on Geometric Design of Highways and Streets. AASHTO Table 3-3 identifies decision sight distance of 625 feet for 35 mph. However, the typical exiting speed from a roundabout is closer to 25mph. AASHTO does not make it clear if these distances are from the advisory sign regarding the taper to one northbound lane or from the roundabout exit. Snohomish County staff will need to evaluate what distance should be utilized for the taper from 2 lanes to 1 lane north of the roundabout.

The roundabout layouts, which are preliminary based on the Sidra software, and the operation summary for the intersection of Locust Way at Larch Way are included in the attachments.

4. LOCUST WAY AT 14th AVENUE W EXTENSION

Snohomish County provided future 2035 weekday PM peak-hour volumes and a proposed roundabout design for the future Locust Way at 14th Avenue W Extension. The proposed roundabout design includes a 100-foot island and one 20-foot circulating lane. It is important to note that the proposed 14th Avenue W Extension will reassign trips from the south leg of Locust Way to the south leg of the 14th Avenue W Extension. The analysis shows that the proposed roundabout would operate at LOS A with a v/c ratio of 0.57 and queue lengths less than 135 feet. The critical approach is the northwest approach of the 14th Avenue W Extension.

GTC did evaluate the Snohomish County proposed roundabout with a smaller island diameter, which would decrease the size and environmental impacts of the roundabout. A roundabout with an 80-foot island diameter will operate similarly to the Snohomish County proposed roundabout, but with a minor increase in v/c ratio (0.57 to 0.59) and queue length on the critical approach (133 feet to 143 feet). Snohomish County staff will need to evaluate the reduced diameter to determine if it sufficient for the design vehicle.

The roundabout layouts, which are preliminary based on the Sidra software, and the operation summary for the intersection of Locust Way at 14th Avenue W Extension are included in the attachments.
5. SUMMARY

5.1 Locust Way at Larch Way

The analysis shows that the Snohomish County proposed single-lane roundabout for the intersection of Locust Way at Larch Way will operate inefficiently by the year 2035, based on Snohomish County’s projected 74% increase in traffic volumes and using WSDOT 0.92 v/c recommended threshold and queue length evaluation. Several additional roundabout capacity alternatives were evaluated. The most effective improvements are for the northbound approach. The recommended improvement for the roundabout option is to provide an 80-foot island diameter with dual northbound through lanes with at the dual northbound lanes extending at least 250 feet south of the roundabout and 500 feet north of the roundabout. The recommended roundabout alternative would have better operations and shorter queue lengths than the signal that was evaluated by Snohomish County.

5.2 Locust Way at 14th Avenue W Extension

The analysis of the Snohomish County proposed roundabout for the intersection of Locust Way at the 14th Avenue W Extension shows that it is anticipated to operate acceptably under the 2035 future conditions. Additional analysis shows that the roundabout island diameter could be decreased to an 80-foot island diameter without significantly impacting the operations.

It is important to note that the alternatives evaluated by GTC for this report are preliminary and final engineering design will need to be completed for whichever design is chosen by Snohomish County staff to ensure the design vehicle and circulating/existing design speeds are achieved.
WSDOT Roundabout Analysis Guidelines
Model Settings Dialog

Model Parameters Tab – Use the following settings for the Delay and Queue parameters (if the recommended parameters for the Roundabouts dialog were followed, these parameters should already be unchecked):

- Exclude Geometry Delay: uncheck
- HCM Delay Formula: uncheck

Additional considerations

- **MOE:** Unlike other intersection control types, the MOE for roundabouts is not primarily LOS. Instead, it is a mix of MOEs. For operational modeling, first ensure each lane group generates no more than about 0.85 - 0.9 v/c with reasonable queues given local conditions (keeping in mind RAB queues are moving queues, which are not perceived by drivers to be as negative as signal queues). MOE’s in order of importance are v/c, percent stopped, queues, and then LOS. Ensure that you conduct sensitivity analysis by adjusting volumes and geometrics. If v/c => 0.9, consider microsimulation and closely examine volumes. In addition, 20 year analyses need not consider queues.

- **Network Function:** The network function allows a user to evaluate how multiple, closely spaced intersections will interact. The control types can be any combination of roundabout, signal, two way stop control, and pedestrian midblock crossing. Sidra is a good tool for evaluating closely spaced intersections containing one or more roundabouts if it is determined that microsimulation is not warranted (based on the complexity of the project, scope, or budget). Although as of Sidra version 6.1, WSDOT does not recommend using Sidra to produce MOE’s for intersection control types other than roundabouts.

This Brochure provides a reference guide for WSDOT policy settings needed to complete an analysis of a roundabout using Sidra 6.1 for WSDOT projects or projects affecting state owned or state interest facilities. Any adjustments to either the settings or Sidra defaults (remaining parameters not discussed in this Brochure) should be documented in a Method and Assumptions type document.

If you have questions about the content in this Brochure, please contact:

LisaRene Schilperoort
WSDOT HQ Traffic
360-705-7295
schipl@wsdot.wa.gov

The latest version of this Brochure is located on the WSDOT Traffic Analysis website (http://www.wsdot.wa.gov/Design/Traffic/Analysis/).

November 2015
Lane Geometry Dialog

Lane Configuration Tab - Unless the roundabout being analyzed already exists or there is a detailed drawing available, use the following Lane Widths:

- Single lane approach: minimum 15 ft
- Multi-lane approach: minimum 14 ft (each lane)

Roundabouts Dialog

Options Tab – Use the following settings for Roundabout Model Options parameters:

- Roundabout Capacity Model – Sidra Standard
- Roundabout LOS Method – Same as Signalized Intersections
- Delay Model – uncheck both Exclude Geometric Delay and HCM Delay Formula

Roundabouts Dialog

Roundabout Data Tab – Use the following settings:

- Circulating width: single lane RB minimum 18'-20', multi-lane 15' ea
- Entry Radius: 90’ – 110’ (unless a site specific design is available)
- Environment Factor: 1.1 for opening year and 1.0 for horizon year.

Model Settings Dialog

Options Tab – Use the following settings for the General Options parameters:

- Level of Service Method: Delay (HCM 2000)
Locust Way at Larch Way – Snohomish County Proposed Designs
### Intersection: 3: Locust Way & Larch Way/Logan Way

<table>
<thead>
<tr>
<th>Movement</th>
<th>EES</th>
<th>ESB</th>
<th>WES</th>
<th>WSB</th>
<th>NE</th>
<th>NE</th>
<th>NE</th>
<th>NE</th>
<th>SB</th>
<th>SB</th>
</tr>
</thead>
<tbody>
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<td><strong>L</strong></td>
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<td>354</td>
<td>175</td>
<td>64</td>
<td>152</td>
<td>136</td>
<td>136</td>
<td>65</td>
<td>106</td>
<td>31</td>
</tr>
<tr>
<td><strong>T</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>R</strong></td>
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<tr>
<td><strong>L</strong></td>
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</table>

<table>
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<th>175</th>
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<th>152</th>
<th>136</th>
<th>136</th>
<th>65</th>
<th>106</th>
<th>31</th>
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<tbody>
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<td>Average Queue (ft)</td>
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<td>32</td>
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<tr>
<td>95th Queue (ft)</td>
<td>80</td>
<td>224</td>
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<td>130</td>
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<tr>
<td>Upstream Blk Time (%)</td>
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<tr>
<td>Queuing Penalty (veh)</td>
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<td></td>
<td></td>
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<td>Storage Bay Dist (ft)</td>
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<td>Queuing Penalty (veh)</td>
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<tr>
<td>Lane Group</td>
<td>ESB</td>
<td>EBT</td>
<td>EBR</td>
<td>WBL</td>
<td>WBT</td>
<td>WBR</td>
<td>NEB</td>
<td>NET</td>
<td>NBR</td>
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<tr>
<td>Traffic Volume (vph)</td>
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<td>481</td>
<td>48</td>
<td>21</td>
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<td>107</td>
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<td>22</td>
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<td>Future Volume (vph)</td>
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<td>481</td>
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<td>312</td>
<td>19</td>
<td>141</td>
<td>107</td>
<td>130</td>
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</tr>
<tr>
<td>Ideal Flow (vphpl)</td>
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<td>1900</td>
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<td>Grade (%)</td>
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<tr>
<td>Frt</td>
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<td>Flt Protected</td>
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<tr>
<td>Sld. Flow (prot)</td>
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### Intersection Summary

- Area Type: Other
- Cycle Length: 70
- Actuated Cycle Length: 41.5
- Natural Cycle: 70
- Control Type: Actuated-Uncoordinated
- Maximum v/c Ratio: 0.49
- Intersection Signal Delay: 12.6
- Intersection LOS: B
- Intersection Capacity Utilization 54.2%
- ICU Level of Service A
- Analysis Period (min) 15

### Splits and Phases: 3: Locust Way & Larch Way/Logan Way
# Queuing and Blocking Report

## 2035 PM Peak

### Intersection: 3: Locust Way & Larch Way/Logan Way

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## Network Summary

Network wide Queuing Penalty: 124
### Lanes, Volumes, Timings

#### 3: Locust Way & Larch Way/Logan Way

**06/12/2017**

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2035 PM Peak 14th Ave W Ext 07/13/2016 2035 PM Peak

Synchro 9 Report
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**06/12/2017**

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#### Intersection Summary

- **Area Type:** Other
- **Cycle Length:** 120
- **Actuated Cycle Length:** 104.1
- **Natural Cycle:** 90
- **Control Type:** Actuated-Uncoordinated
- **Maximum v/c Ratio:** 0.90
- **Intersection Signal Delay:** 34.2
- **Intersection LOS:** C
- **Intersection Capacity Utilization:** 88.5%
- **ICU Level of Service:** E
- **Analysis Period (min):** 15

**Splits and Phases:** 3: Locust Way & Larch Way/Logan Way

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2035 PM Peak 14th Ave W Ext 07/13/2016 2035 PM Peak

---

Synchro 9 Report
Page 2
SITE LAYOUT

Site: 2016 Existing PM - Sno Co Alternative
Locust Way at Larch Way/Logan Way
Roundabout
### Movement Summary

**Site:** 2016 Existing PM - Sno Co Alternative

**Locust Way at Larch Way/Logan Way Roundabout**

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Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
HV (%) values are calculated for All Movement Classes of All Heavy Vehide Model Designation.

SIDRA INTERSECTION 61 | Copyright © 2000-2015 Akcelik and Associates Pty Ltd | sidrasolutions.com
Organisation: GIBSON TRAFFIC CONSULTANTS | Processed: Friday, January 12, 2018, 11 08 51 AM
Project: H:\2017\17-26\Locust at Larch\Sidra\Larch at Locust RAB - Final sip6
SITE LAYOUT

Site: 2035 Future PM - Sno Co Alternative
Locust Way at Larch Way/Logan Way
Roundabout
# MOVEMENT SUMMARY

**Site:** 2035 Future PM - Sno Co Alternative

**Locust Way at Larch Way/Logan Way Roundabout**

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<th>95% Back of Queue Vehicles veh</th>
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- **Level of Service (LOS) Method:** Delay (HCM 2000).
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Locust Way at Larch Way –
GTC Proposed Designs
Site: 2035 Future PM - GTC Alternative #1

Locust Way at Larch Way/Logan Way
NB RT Slip and 80' Island Diameter Roundabout
## MOVEMENT SUMMARY

**Site: 2035 Future PM - GTC Alternative #1**

Locust Way at Larch Way/Logan Way  
NB RT Slip and 80’ Island Diameter  
Roundabout

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SIDRA INTERSECTION 6.1 | Copyright © 2000-2015 Akcelik and Associates Pty Ltd | sidrasolutions.com  
Organisation: GISBON TRAFFIC CONSULTANTS | Processed: Friday, January 12, 2018 11:26 56 AM  
Project: H:\2017\17-2611\Locust at Larch\SidraLarch @ Locust RAB - Final.rpt8  
C - 2
SITE LAYOUT

Site: 2035 Future PM - GTC Alternative #2
Locust Way at Larch Way/Logan Way
NB RT Slip and 100' Island Diameter
Roundabout

North Orientation

Locust Way (SB)
## Movement Summary

**Site: 2035 Future PM - GTC Alternative #2**

Locust Way at Larch Way/Logan Way
NB RT Slip and 100' Island Diameter
Roundabout

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**Level of Service (LOS) Method:** Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.
Site: 2035 Future PM - GTC Alternative #3

Locust Way at Larch Way/Logan Way
2-lane NB Lanes and 80' Island Diameter
Roundabout
## MOVEMENT SUMMARY

**Site: 2035 Future PM - GTC Alternative #3**

Locust Way at Larch Way/Logan Way
2-lane NB Lanes and 80’ Island Diameter
Roundabout

### Movement Performance - Vehicles

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<tr>
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Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

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Project: H:\2017\11-26\Locust at Larch\SidraLarch @ Locust RAB - Final.sql
Locust Way at 14th Avenue W Extension
SITE LAYOUT

Site: 2035 Future PM - Sno Co Alternative

Locust Way at 14th Avenue W Extension
Roundabout
**MOVEMENT SUMMARY**

**Site: 2035 Future PM - Sno Co Alternative**

Locust Way at 14th Avenue W Extension
Roundabout

### Movement Performance - Vehicles

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<th>Average Delay [sec]</th>
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<th>Prop. Queued [%]</th>
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Level of Service (LOS) Method: Delay (HCM 2000).
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D - 2
SITE LAYOUT

Site: 2035 Future PM - GTC Alternative

Locust Way at 14th Avenue W Extension
80' Island Diameter
Roundabout
### Movement Summary

**Site:** 2035 Future PM - GTC Alternative

Locust Way at 14th Avenue W Extension
80' Island Diameter
Roundabout

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**Gap-Acceptance Capacity:** SIDRA Standard (Akcelik M3D).
**HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Mode Designation.**

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**Project: H.2017.11.17-281|Locust at 14th Ave ExitSidra|14th Ave W Ext @ Locust RAB sip6**
APPENDIX F

Drainage
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APPENDIX G

Geotechnical Memo
MEMORANDUM

DATE: January 9, 2018

TO: Matt Feeley, P.E., Project Manager

FROM: Roland Maynard, P.E., Geotechnical Engineer
       Dale Topham, P.E., Geotechnical Engineer

SUBJECT: Geotechnical Memorandum
          Intersection Improvements
          Larch Way/Logan Road & Locust Way
          RC 1591

General

This memorandum contains the results of our preliminary geologic site investigation and the geotechnical engineering recommendations for proposed improvements to the intersection of Larch Way/Logan Road & Locust Way. The intersection of Larch Way/Logan Road & Locust Way is located between the cities of Brier and Bothell in the south central area of Snohomish County. In the rectangular survey system the site is located in the NW ¼, SE ¼, Sec. 23, T27N, R4E, WM. Larch Way, Logan Road and Locust Way are two-lane urban minor arterials. These improvements are being made to improve traffic flow and expand mobility for bicyclists and pedestrians. It is our understanding that options being considered for the intersection include signalization of the intersection or the construction of a roundabout and associated improvements.

The purpose of this investigation was to evaluate and expand upon existing soil and geologic information in the project area and provide geologic assessment and geotechnical
recommendations to be utilized during the permitting, design and construction phases of the project. The scope of our work included: a review of readily available geologic reports and maps relevant to the project site; a review of readily available geologic and geotechnical reports from other projects located in the general vicinity of the project site; a geologic reconnaissance of the project site and surrounding area; the geologic investigation of the project site included the excavation of 2 test pits along the alignment with an excavator (TP-1 & TP-2); and the drilling of 1 test boring (B-1). This investigation has been completed in general accordance with professional geologic and geotechnical standards currently utilized in the Puget Sound Region for a project of this scope and size. The conclusions and recommendations contained in this report are based upon our understanding of the project at the time this report was written. If changes are made to the project after this date, the recommendations may need to be updated.

**Geologic Setting**

The project site is located within the Puget Sound Lowland Physiographic Province. The Puget Sound Lowland Physiographic Province is a north-south trending structural and topographic depression. It is here-in-after referred to as the Puget Lowland in this report. Most of Snohomish County is located within the Puget Lowland, including all areas west of the Cascade Mountain foothills to Puget Sound and the river basins/river valleys that extend up into the foothills. In general, the Puget Lowland is bounded by the Olympic Mountains to the west and the Cascade Mountains to the east. Less pronounced uplands define the southern boundary, and to the north it extends into southern British Columbia to merge with the Fraser Lowland and the Strait of Georgia. The Puget Lowland is underlain by Tertiary volcanic and sedimentary bedrock and has been filled to the present day land surface with Pleistocene aged glacial and non-glacial sediments.

The low undulating plains that are characteristic of the Puget Lowland are the result of repeated advances (stades) and retreats (interstades) of the Puget Lobe of the Cordilleran (continental) ice sheets during the Pleistocene Epoch (a geologic time period dating from approximately 10,000 to
2 million years ago) and to a lesser degree glacial advances and retreats from local alpine glaciers out of the Cascade and Olympic Mountains during this same time period. Current land surfaces in the vicinity of the project site reflect surficial topographic changes directly related to the most recent glacial advance and retreat through Snohomish County – the Vashon Stade of the Fraser Glaciation. The Vashon Stade of the Fraser Glaciation covered the low lying areas of Snohomish County, including the project site, with thousands of feet of glacial ice. The estimated time period for this latest glacial advance and retreat is between 20,000 and 13,000 years ago.

Surficial geology of the project area has been mapped by the USGS and is shown on the *Surficial Geologic Map of the Edmonds East and Part of the Edmonds West Quadrangle, Snohomish County, Washington, James P. Minard, 19853, MF-1541*. The area is primarily mapped as Recessional Outwash ($Q_{wr}$). The northeast corner of the intersection and the area along Logan Road to the east of the intersection is mapped as Advance Outwash ($Q_{wm}$). The $Q_{wr}$ deposits lie in and along present streams near the water table, and are subject to seasonal flooding. These deposits typically consist of gray to oxidized, mostly clean, loose, permeable, well drained, stratified sand and gravel. These deposits were deposited by meltwater flowing from the receding Vashon glacier. A copy of Department of the Interior U.S. Geological Survey compilation *Geologic Map* is attached to this report.

The primary mapped SCS soils classification for the project site is the Everett gravelly sandy loam. This very deep, well-drained soil is found on terraces and outwash plains and was formed in glacial outwash with 0 to 8 percent slopes.
Subsurface Conditions

The subsurface conditions at this site were explored with 2 test pits (TP-1 & TP-2) and one test boring (B-1).

The soil removed from the ground at the exploration locations was visually observed at the time of excavation and classified by a Geotechnical Engineer from SCPW-Engineering Services following the Unified Soil Classification System (USCS) in general accordance with ASTM D2488, Standard Recommended Practice for Description of Soil (Visual-Manual Procedures). Standard Penetration Test samples of representative soils were taken for laboratory testing. The approximate location of the explorations were measured from existing features in the field and were plotted on the attached Geotechnical Exploration Site Map. Copies of the Test Pit and Boring Logs are attached to this memorandum.

The site stratigraphy has been interpreted from the soil encountered within geotechnical borings and correlated with the mapped geology of the area as described on the Geologic Map. In general, a good correlation was observed between the mapped geology of the area and the soil types found in the project explorations.

The observed soil conditions presented on the subsurface test pit and test boring logs are as interpreted and recorded at the time and placement of exploration. Subsurface soil conditions may vary considerably between exploration locations and with time according to the prevailing climate, rainfall or other factors and are otherwise dependent on the duration of and methods used in the exploration program. Actual soil conditions encountered at the time of construction may vary from those found and presented in this report.

Sound engineering judgment was exercised in preparing the subsurface information presented herein. This information was prepared and is intended for County design and estimation purposes. Its presentation on plans or elsewhere is for the purpose of providing intended users
with access to the same information available to the County. This subsurface information interpretation is presented in good faith, and is not intended as a substitute for personal investigation, independent interpretations or judgment by the County, independent design consultants or by the Contractor.

The first test pit (TP-1) is located at the approximate location shown on the attached Geotechnical Exploration Site Map along the east side of Locust Way within the ballfield playing area at Logan Park. At the location of this test pit we encountered 0.17 of a dark brown topsoil that consisted of a fine- to medium-grained silty sand that contained organics and was loose and moist. At 0.17 we encountered a light brown to gray fine- to coarse-grained sandy gravel with cobbles up to 12” in diameter (Recessional Outwash). This strata was medium dense to dense and moist. This sandy gravel layer extended to a depth of 2.5’ below the existing ground surface (bgs). At 2.5 feet we encountered a tan, medium- to coarse-grained sand (Advance Outwash) that contained mottling in the top two feet. This strata was medium dense to dense. The test pit was terminated at 7.0 feet bgs. No groundwater was encountered at the location of this test pit.

The second test pit (TP-2) is located at the approximate location shown on the attached Geotechnical Exploration Site Map east of the proposed centerline along the east side of Locust Way within the ballfield area at Logan Park. At this location we encountered 1.0’ of a dark brown topsoil that consisted of a fine- to medium-grained silty sand that contained organics and was loose and moist. Below this strata we encountered 3.0’ of a fine- to coarse-grained light brown to gray sandy gravel with cobbles up to 12” in diameter (Recessional Outwash). This strata contained roots and was medium dense to dense and moist. At 4.0’ we encountered a tan, medium- to coarse-grained sand (Advance Outwash). This strata is medium dense to dense and moist. The test pit was terminated at 8.0 feet bgs. No groundwater was encountered at the location of this test pit.
Boring B-1 is located at the approximate location shown on the attached *Geotechnical Exploration Site Map* in northwest corner of the intersection of Locust Way and Larch Way. At the location of boring B-1 we encountered 0.17' of a crushed recycled asphalt product at the surface. At 0.17' we encountered a light brown to brown, fine- to coarse-grained sandy gravel with cobbles (*Recessional Outwash*). This layer was medium dense to dense and moist. At 8.5' we encountered a perched water table. The water is perched on top of a very fine-grained gray silty sand (*Advance Outwash*) layer that we encountered from 10.5' to 15.5'. This layer was medium dense to dense and moist. At 15.5' we encountered a reddish brown to tan, medium- to coarse-grained sand (*Advance Outwash*) that was dense to very dense and moist to damp. The boring was terminated at 31.5 feet bgs. No groundwater other than the perched water was encountered at the location of this boring.

**Laboratory Testing**

Representative grab samples from the test pits were tested for grain size, and moisture content. These tests were performed in accordance with applicable *ASTM* testing procedures. Copies of the *Laboratory Test Results* are attached to this memorandum.

**Ground Water**

The geohydrologic framework describes the boundaries and lithology of the geohydrologic units (*aquifers and confining beds*) of the area. Regional ground water studies have been undertaken for Snohomish County by Sweet-Edwards/EMCON, Inc. dated 1991; *Golder Associates* dated 1996 and the *USGS* dated 1997. Geohydrologic units within the County have been defined by these studies. In general, ground water throughout the County occurs in a few different aquifers that are in most areas separated from each other by confining beds. Depending upon topography and location, ground water occurs in both confined and unconfined conditions within the County's aquifers. The most extensive aquifers are found below the plateau areas of the County, others occur within and along the river valleys that bisect the plateaus. Unconsolidated geologic units permeable enough to transmit significant quantities of ground water throughout
the County are Recent Alluvium (Qva), Recessional Outwash (Qvr) and Advance Outwash (Qva). Confining beds are geologic units that are generally fine-grained and do not transmit significant quantities of water. Confining beds include Glacial Till (Qvt), Transitional Beds (Qtb) and Tertiary Bedrock (Tb) according to the 1997 USGS report. Some of these geologic units are found in the vicinity of the project site as shown on the Geologic Map. The project site is located within the Swamp Creek Basin which is part of the Intercity Aquifer. The Intercity Aquifer occurs within the Advance Outwash deposits and underlies the project site.

In the immediate vicinity of the project alignment, a regional ground water aquifer is present at depth within the Advanced Outwash (Qva). Recharge of the unconfined aquifer is direct, primarily resulting from infiltration through the overlying Qva and Qvr materials.

A search of the registered water well logs in the Washington State Department of Ecology’s data base indicates that there are 2 registered resource protection wells located in the general area of the proposed project. One of the wells is located west of Swamp Creek and should not be affected by the proposed project due to its location on the other side of Swamp Creek. The other resource protection well within the limits of Logan Park located at the southeast corner of the proposed intersection project. It does not appear that either well is being utilized for potable water. For reference purposes, copies of the Water Well Logs are attached to this memorandum. It is unlikely that the proposed project improvements would impact these resource protection wells. This issue will need to be addressed further in the Hydrogeologic Report that will be issued for this project.
Geotechnical Recommendations

The proposed improvements include the realignment of the intersection, signalization of the intersection or installation of a roundabout, turn lanes, bicycle lanes, and curb and sidewalk. The geotechnical design elements that will be addressed within this memorandum are: Site Work, Structural Fill, Pavement Section Recommendations, Signal Pole Foundations, Retaining Walls, and Geologic Hazards.

Site Work

Clearing, grubbing and any over excavation procedures should be performed in accordance with the applicable sections of the WSDOT Standard Specification section 2-01, Clearing, Grubbing and Roadside Cleanup. Disposal of unsuitable materials and debris should be handled in accordance with WSDOT Standard Specification section 2-03.3(7), Disposal of Surplus Materials and in accordance with the guidelines and specifications of Snohomish County’s GSP140, “Disposal of Surplus Materials”.

Initial site preparation will include clearing and grubbing along portions of the alignment. Excavation and grading should be done in accordance with the appropriate recommendations contained in this report. Topsoil and/or materials that contain a significant amount of roots removed during these tasks will not be suitable for use elsewhere on site and will need to be disposed of as surplus materials in accordance with the specifications given above. All other excavated materials (Advance and Recessional sands and gravels) should meet the requirements for structural fill and may be utilized within fill sections on this project.

Site preparation should comply with applicable sections of WSDOT Standard Specification section 2-06, Subgrade Preparation. In areas to receive new embankment fill, surficial topsoil and loose fill should be removed from within the embankment/roadway prism. Depths of these
materials varied from 0.17' to 1.0' at the locations of our explorations. Topsoil and other organic rich soils removed during site preparation may be re-used in non-structural areas of the project with some amendment – as approved at the time of construction by the Construction Engineer or the Geotech Group.

Prior to the placement of any structural fill or embankment fill, the subgrade should be leveled, compacted and/or proof rolled as required in section 2-03.3(3), Excavation Below Grade of the Standard Specifications. Proof rolling is especially important in those areas where uncontrolled and/or fill has been exposed. Soft spots found during proof rolling or during the site preparation process should be over-excavated under the direction of the Construction Engineer or the Geotech Group in accordance with WSDOT Standard Specification section 2-03.3(14)E, Unsuitable Foundation Excavation, and be filled in with a suitable granular borrow material. In this case, the Geotech Group should be contacted to view the subgrade and provide recommendations based on the observed site conditions at the time of construction. If gap graded or bony soils are exposed in the subgrade excavation, a separation geotextile should be placed over the exposed subgrade materials prior to raising grades.

If significant areas of saturated or otherwise unsuitable soil are encountered at design subgrade depths, the Geotech Group should be contacted to develop recommendations based upon the observed site conditions at the time of construction. To maintain cost effectiveness, over excavation of unsuitable materials during site preparation should not exceed two-(2) ft. below surrounding subgrade elevations unless directed to do so by the Construction Engineer or a representative of the Geotech Group. If yielding or saturated soils exist at this depth, the Geotech Group should be contacted to develop suitable recommendations based upon the observed site conditions. These recommendations may include the use of a strong, durable geotextile over the yielding subgrade materials, the use of Railroad Ballast, over excavation to approved bearing soils or a combination of all of the above. The entire area should be brought up to grade using structural fill.
Excavated materials (*sandy gravels and sands*) may meet the requirements for structural fill and may be used after testing to verify that they meet the required specification for structural/embankment fill.

**Cuts and Excavations**

Small and large cuts and excavations will be required to complete this project according to the cross sections reviewed during the preparation of this report. All cuts and excavations should conform to *Washington Department of Labor and Industries, chapter 296-155 part N, Safety Standards for Construction Work*. Excavations and cuts above the water table along this alignment will stand in near vertical side walls/slopes of up to four-(4) feet in total depth/height for short periods of time if protected from weather and not effected by shallow ground water or surface water seepage. Extra care will need to be exercised by the contractor if seepage is encountered within a cut or excavation. Sloughing of sidewalls may occur where moderate to heavy ground water or surface water seepage are encountered or where fill is encountered within a cut or excavation area. All cuts and excavations over four-(4) feet in total depth/height should be retained by suitable designed retaining systems or digging boxes unless the side slopes are laid back to a minimum 1:1(*H:V*) slope. Temporary cuts and excavations are the contractors’ responsibility. Permanently exposed side slopes should be laid back to slopes no steeper than 2:1(*H:V*) unless otherwise approved by the Geotechnical Group.

**Structural Fill**

Structural fill should be used in any area requiring fill within the roadway and sidewalk areas. Structural fill should consist of a well-graded, free-draining, granular soil free of organic and deleterious materials. The material for gravel borrow spelled out in *WSDOT Standard Specification section 9-03.14(1), Gravel Borrow*, will meet the requirements for structural fill on this project except the fines portion of the gradations should not exceed 5% passing the #200 sieve.
In general, on-site materials (*sandy gravels and sands*) may meet the requirements for structural fill and may be used after testing to verify that they meet the required specification for structural/embankment fill. All structural fill should be placed in accordance with WSDOT Standard Specification section 2-03.3(14)B, *Earth Embankment Construction* and be compacted in accordance with WSDOT Standard Specification section 2-03.3(14)C – method C, *Compacting Earth Embankments* using a minimum 10 ton vibratory roller or other as approved by the Construction Engineer or the Geotech Group. Testing of all fill as it is being placed should be performed in accordance with WSDOT Standard Specification section 2-03.3(14)D, *Compaction and Moisture Control Tests* using the ASTM D1557 modified proctor. Fills planned for sloping areas greater than 5:1 (H:V) should be constructed only on properly benched and keyed soil, as specified in WSDOT Standard Specification section 2-03.3(14)B, *Embankment Construction*. Exposed fill slopes less than eight-(8) feet in height should be graded to a maximum 2:1(H:V) slope. Exposed fill slopes over eight-(8) feet in height should be graded to a maximum 2.5:1(H:V) slope.

The contractor should control surface and subsurface seepage during the placement of any site improvements and during the placement of all structural fill. Where this is not possible, the contractor should use a granular material that does not require compaction in accordance with WSDOT Standard Specification section 2-03.3(14)G, *Backfilling* until the embankment has been constructed a minimum of six-(6) inches above the prevailing ground water table. A geotextile for soil stabilization should be placed at the bottom of any fill placed under these conditions and/or between the granular materials and the structural fill if a change in fill materials is made within the roadway embankment. Material used as outlined above should meet the minimum material specifications for Railroad Ballast given in Table 1 below. Railroad Ballast used within the embankment section should be placed in accordance with WSDOT Standard Specification section 2-03.3(14)A, *Rock Embankment Construction*. Due to the sensitivity of some of the underlying soils, thin lifts of Railroad Ballast should be compacted to a non-yielding state by the rolling of construction equipment if vibration will cause pumping of the basal soil.
<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing by Weight (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2</td>
<td>90 to 100</td>
</tr>
<tr>
<td>1-1/2</td>
<td>50 to 90</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>10 to 50</td>
</tr>
<tr>
<td>1/2 inch</td>
<td>0 to 10</td>
</tr>
</tbody>
</table>

**Pavements**

A pavement design was performed for this project in accordance with *AASHTO* design guidelines, and based on our review of current traffic counts at the intersection, project growth rate and the soils present at the location of the site. Based on our design in areas where the pavement is to be replace or areas to receive a new pavement section, the pavement section should consist of the following:

- **0.6' HMA**
- **0.5' CSBC/CSTC**

Existing asphalt surfaces left in-place should be overlaid with a minimum of **0.2' HMA**.
All road subgrade work should comply with WSDOT Standard Specification section 2-06, Subgrade Preparation and meet all applicable recommendations given in section 4.3.2, Subgrade Preparation of this report. Aggregate used for HMA shall meet WSDOT Standard Specification section 9-03.8, Aggregates for Hot Mix Asphalt and WSDOT Standard Specification section 9-03.8(2), HMA Test Requirements. Where grades are raised, we recommend that the existing pavement section be pulverized in place or be prepared in accordance with WSDOT Standard Specification section 5-04.3(5)A, Preparation of Existing Surface. Pre-leveling of uneven or broken surfaces over which HMA is to be placed may be accomplished by using an asphalt paver, a motor patrol grader, or by hand raking, as approved by the Construction Engineer. All cracks and joints ¼" and greater in width shall be cleaned with a stiff-bristled broom and compressed air and then shall be filled completely with sand slurry. The sand slurry shall be placed and meet WSDOT Standard Specification section 5-04.3(5)C, Crack Sealing. HMA overlay shall not be placed until the sand slurry has fully cured. All pavement work and products should meet applicable sections of WSDOT Standard Specification section 5-04, Hot Mix Asphalt.

**Signal Pole Foundations**

One of the options being considered is signalization of the intersection. At this time the exact location and size of the signals has not been determined. This information will need to be provided to the Geotech Group if it is determined that the intersection will be signalized.

If preliminary information based on the soils encountered, we estimate that the signal pole foundations will need to extend to a depth of between 12-14 feet below the finished ground elevation. This assumes a 3 foot diameter round shaft for the signal pole foundation.
Erosion Control

Adequate erosion control measures should be installed during earthwork on this project to ensure limited siltation impacts into the adjacent surface water drainages and drainage systems. Best Management Practices, as outlined in the Washington Department of Ecology's Storm Water Management Manual for the Puget Sound Basin should be applied. Erosion control measures should also comply with WSDOT Standard Specification section 8-01, Erosion Control. In addition, drainage ways should be protected from siltation by filter fences, straw bale filters or settling ponds. Run-off should not be allowed to flow uncontrolled over site slopes or embankments. Permanent erosion control should be installed as soon as possible after completion of work in an area. Hydro seeding and placement of Excelsior matting or straw should be performed in accordance with methods described in the standard specifications.

Retaining Wall Recommendations

Retaining walls will be utilized to realign the intersection and to provide for turning lanes and sidewalks. It appears that most of the retaining walls will be only a couple of feet tall. Taller retaining walls will be need along the east side of Locust Way in the area of the ballfield for Logan Park. Based on the current design information available, the maximum height of the wall will be approximately 10’ or less. We understand that the location, length and height of the retaining walls may change as the design process proceeds. The retaining wall recommendations are meant to be used as a guideline for the project design, plan and specification development. Final design and use of retaining walls should be confirmed and approved by the Geotech Group prior to the start of construction. Design calculations, construction sections and/or alternative types of wall systems submitted by the contractor should be reviewed and approved by the Geotech Group and the Construction Engineer prior to the start of construction of any wall along the project alignment. Retaining wall recommendations take into account soil types found at the proposed wall locations as well as whether or not the walls will retain fill or protect undisturbed in-place soils.
Based on the results of the site explorations and our review of the wall proposed wall locations we recommend that all retaining walls be constructed utilizing Structural Earth Walls (SEW), Gravity Block Walls or Geosynthetic Retaining Walls (GRW). Structural Earth Walls should be designed and constructed following the appropriate sections contained in WSDOT Standard Specification section 6-13, Structural Earth Walls and appropriate sections of WSDOT Standard Specification section 9-33, Construction Geosynthetic. Recommended facings for Structural Earth Walls include: Type A Concrete Block (Keystone or similar as approved), Type B Concrete Block (Lock Block or similar as approved) and Welded Wire (Hilficker or similar as approved). Gravity Block Walls may be constructed using the Ultrablock System or approved equivalent, designed following the manufacturer recommendations. Geosynthetic Retaining Walls should be designed and constructed following the appropriate sections contained in WSDOT Standard Specification section 6-14, Geosynthetic Retaining Walls and appropriate sections of WSDOT Standard Specification section 9-33, Construction Geosynthetic. Geotechnical Soil Parameters for Retaining Walls are given below.
<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>DESIGN VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backfill Soil Parameters (free draining)</td>
<td>$\gamma = 125$ pcf  $K_s = 0.28$  $K_r = 3.54$, $K_n = 0.44$  $\varnothing = 34^\circ$</td>
</tr>
<tr>
<td>Base Soil Parameters (railroad ballast)</td>
<td>$\gamma = 120$ pcf  $K_s = 0.22$  $K_r = 4.60$  $\varnothing = 40^\circ$</td>
</tr>
<tr>
<td>Maximum Slope Above Wall</td>
<td>$\alpha = 26.5^\circ$  2:1 (H:V)</td>
</tr>
<tr>
<td>Vertical Loading Above Wall (not to exceed)</td>
<td>250 psf</td>
</tr>
<tr>
<td>Wall Batter (minimum)</td>
<td>$\theta = 5^\circ$  $\beta = 85^\circ$  1:10 (H:V)</td>
</tr>
<tr>
<td>Soil Bearing (maximum)</td>
<td>- Recessional Outwash ($Q_{rn}$)  $q_{atl} = 3000$ psf</td>
</tr>
<tr>
<td></td>
<td>- Advance Outwash ($Q_{ao}$)  $q_{atl} = 2500$ psf</td>
</tr>
<tr>
<td></td>
<td>- Gravel Borrow (fill)  $q_{atl} = 2000$ psf</td>
</tr>
<tr>
<td></td>
<td>- Uncontrolled fill  not acceptable</td>
</tr>
<tr>
<td>Resistance factor (bearing)</td>
<td>0.45</td>
</tr>
<tr>
<td>Resistance Factor (sliding)</td>
<td>0.90</td>
</tr>
</tbody>
</table>

Site preparation for the construction of retaining walls will require the removal of unsuitable base soils for wall support. Bearing soils for retaining wall support will need to be confirmed by the Geotech Group prior to the placement of any wall components. Suitable bearing soils will consist of undisturbed, medium dense to dense, light brown sandy gravel (Recessional Outwash) or undisturbed, dense to very dense, reddish brown to tan sand (Advance Outwash)). Walls should not be placed on uncontrolled fill. Where retaining walls will be placed along cuts in slopes, the front toe of the retaining wall will need to be placed no closer than three-(3) feet to the face of the slope. We recommend that all over-excavated areas be brought up to base wall elevations utilizing 2" to 4" quarry spalls compacted to a non-yielding condition. This subgrade
pad should extend a minimum 12” beyond the wall base in all directions. A strong and durable separation geotextile should be placed on top of the quarry spalls and a 4” to 6” thick railroad ballast leveling pad placed to facilitate a good base for the start of a wall system.

We understand that the structural design for the proposed improvement within the project limits will be done in accordance with the 2012 Standard Specification for the Design of Highways as outlined by the American Association of State Highway and Transportation Officials (AASHTO) 2010 Guide Specifications. AASHTO 2010 Guide Specifications require that structure design be based on earthquake ground motions with a 7% chance of exceedance in 75 years – with a 1000 year return period. Under the new guidelines, Peak Ground Accelerations (PGA) are adjusted for Site Class which is determined based on the shear wave velocities and/or soil strength profiles of the subgrade soils and/or rock to a maximum depth of 100 feet. Shear wave analyses where not performed for this project. Based on the subsurface soil conditions observed during this investigation, assumed soil strength profiles for the subgrade soils and the mapped geology of the area as shown on the Geologic Map we recommend that the seismic parameters given below be utilized for any seismic analyses relating to public works portions this project (i.e.: roads, walls). AASHTO LRFD Seismic Design Input Criteria are given below:

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Horizontal Ground Acceleration (PGA)</td>
<td>PGA = 0.53</td>
</tr>
<tr>
<td>Horizontal Response Spectral Acceleration at a Period of 0.20 Second (S₁)</td>
<td>S₁ = 1.296g</td>
</tr>
<tr>
<td>Horizontal Response Spectral Acceleration at a Period of 1.0 Second (S₁)</td>
<td>S₁ = 0.505g</td>
</tr>
<tr>
<td>Site Class Definition</td>
<td>SCD = D</td>
</tr>
<tr>
<td>1.0 Second Design Spectral Acceleration (S₁₀)</td>
<td>S₁₀ = 0.505g</td>
</tr>
<tr>
<td>Seismic Zone</td>
<td>3</td>
</tr>
</tbody>
</table>

17
| Site Coefficient for Peak Ground Acceleration ($F_{pga}$) | $F_{PGA} = 1.00$ |
| Site Coefficient for Short Period Spectral Acceleration ($F_s$) | $F_s = 1.00$ |
| Site Coefficient for Long Period Spectral Acceleration ($F_r$) | $F_r = 1.50$ |

Lateral pressures on walls will increase during an earthquake. Utilizing the Mononobe-Okabe (M-O) analysis method that assumes that a wall is free to yield outwardly at the top equal to an amount of 10A in inches (where “A” is the acceleration coefficient $A=PGA=0.53g$ and $10A = 5.3''$). This means that a wall should be designed to yield approximately 5.3” during a seismic event. Allowing a wall to yield significantly reduces the dynamic lateral loading as compared to a wall where no displacement is permitted. For a yielding wall, the horizontal acceleration coefficient ($K_h$) used in the M-O analysis is 0.5A or approximately $K_h=0.27g$. Under these conditions, we recommend that a dynamic rectangular pressure increment be added to the static equivalent fluid pressure for the wall in the form of $4H$ psf, where “H” is the height of the wall. A non-yielding wall or a wall constrained by its stiffness or other structural constraints will experience significantly higher lateral earth pressures during an earthquake. The horizontal acceleration coefficient for a non-yielding wall is 1.5A or approximately $K_h=0.80g$. Under these conditions we recommend that a dynamic rectangular pressure increment be added to the static equivalent fluid pressure in the form of $12H$ psf.

**Porous pavement sidewalks**

Porous pavements may be utilized for sidewalks along this alignment. If porous sidewalks are utilized, they should be designed utilizing a hydraulic conductivity ($K_{td}$) of 2 inches/hour. We recommend utilizing as a minimum, 0.35' thickness of porous cement sidewalk placed over a minimum thickness of 0.25' of CSBC. The entire section should be placed over a recharge/reservoir bed consisting of a minimum thickness of 1.0' of free draining fill materials meeting WSDOT Standard Specification section 9-03.12(4), Gravel Backfill for Drains wrapped on three sides with a construction geotextile meeting the requirements of WSDOT.
Standard Specification section 9-33.2(1), Geotextile Properties, Table 1 for Moderate Survivability, nonwoven. Cation-Exchange Capacity (CEC) for the project area soils range between 1-5 millequivalents/100g\textsuperscript{-1}. It is important that the existing subgrade materials under the pavement section not be compacted to insure that the value of $K_{cd}$ used is valid.

**Geologic Hazard Areas**

There are no seismically active faults, landslide hazard areas, mine hazard areas, tsunami hazard areas, volcanic hazard areas or erosion hazards found or identified within 200 feet of the project alignment during the course of this investigation. Site is designated as having a Medium Aquifer Sensitivity. *SCC Chapter 30.62C.140 - Hydrogeologic Report*, requires that a hydrogeologic report is required for any activity or use requiring a project permit that falls within the boundaries of an area that has a medium aquifer sensitivity. If any federal, state or local permits are required for this project, a hydrogeologic report will be required. A Geologic Hazards Map is attached to this memorandum.

If you have questions or need more information, please call Rollie at 425-530-8179.

*Attachments: Vicinity Map, Geologic Map, Geotechnical Exploration Site Map, Test Pit & Boring Logs, Laboratory Test Results, Geologic Hazards Map, Well Logs*
VICINITY MAP
Larch Way/Logan Road - Locust Way
RC 1591

Project Area
## TEST PIT LOGS

### TEST PIT LOG TP-1

<table>
<thead>
<tr>
<th>Notes</th>
<th>Depth (feet)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approx. station 13+35, 55' Rt. of centerline</td>
<td>0.0'-0.17' <strong>Silty Sand</strong>: Dark brown fine-to coarse-grained, roots and grass, loose, moist (<em>Topsoil</em>)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.17'-2.5' <strong>Sandy Gravel</strong>: Light brown to gray, fine-to coarse-grained, cobbles up to 12&quot;, roots, medium dense to dense, moist (<em>gp, Recessional Outwash</em>)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.5'-7.0' <strong>Sand</strong>: Tan, medium-to coarse-grained, mottling in the top 2 feet, medium dense to dense, moist (<em>sp, Advance Outwash</em>)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>T.D. = 7.0'</strong></td>
<td></td>
</tr>
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### TEST PIT LOG TP-2

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<td>Approx. station 12+50, 40' Rt. of centerline</td>
<td>0.0'-1.0' <strong>Silty Sand</strong>: Dark brown, fine-to coarse-grained, roots and grass, loose, moist (<em>Topsoil</em>)</td>
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<td></td>
<td>1.0'-4.0' <strong>Sandy Gravel</strong>: Light brown to gray, mottling, fine-to coarse-grained, cobbles up to 12&quot;, roots to 3.5&quot;, medium dense to dense, moist (<em>gp, Recessional Outwash</em>)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.0'-8.0' <strong>Sand</strong>: Tan, medium-to coarse-grained, medium dense to dense, moist (<em>sp, Advance Outwash</em>)</td>
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</tr>
<tr>
<td></td>
<td><strong>T.D. = 8.0'</strong></td>
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**Snohomish County Public Works**

**PROJECT:** Larch Way/Logan Road - Locust Way

**NUMBER:** RC1591
**DATE:** 11/2/17
<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>INTERVAL</th>
<th>BLOW</th>
<th>STRATA</th>
<th>SOIL DESCRIPTION</th>
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<tbody>
<tr>
<td>S1</td>
<td>5/10/10</td>
<td>5</td>
<td></td>
<td>0.0'-0.17' <em>Recycled Asphalt</em></td>
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<td>S2</td>
<td>20/16/2</td>
<td>5</td>
<td></td>
<td>0.17'-10.5' <em>Sandy Gravel</em>: Light brown to brown, fine- to coarse-grained with cobbles, loose to medium dense, moist to wet (gp, Recessional Outwash)</td>
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<tr>
<td>S3</td>
<td>5/32/3</td>
<td>10</td>
<td></td>
<td>Blow counts overstated due to coarseness of material</td>
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<tr>
<td>S4</td>
<td>2/5/15</td>
<td>10</td>
<td></td>
<td>Perched water table encountered at 8.5'</td>
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<td>S5</td>
<td>4/20/35</td>
<td>15</td>
<td></td>
<td>10.5'-15.5' <em>Silty Sand</em>: Gray, very fine-grained, medium dense to dense, moist (sm, Advance Outwash)</td>
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<tr>
<td>S6</td>
<td>10/16/2</td>
<td>15</td>
<td></td>
<td>15.5'-31.5' <em>Sand</em>: Reddish brown to tan, medium- to coarse-grained, dense to very dense, moist to damp (sp, Advance Outwash)</td>
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<tr>
<td>S7</td>
<td>0/20/3</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S8</td>
<td>3/25/5</td>
<td>30</td>
<td></td>
<td></td>
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</tbody>
</table>

T.D. = 31.5'

Soil samples were taken in accordance with ASTM D1586-84 standards and specifications. Soil classifications were developed in the field in general accordance with ASTM D2488 and following the Unified Classification system.

Boring was backfilled with bentonite pellets upon completion.
**Particle Size Distribution Report**

### GRAIN SIZE - mm.

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<thead>
<tr>
<th>% +3&quot;</th>
<th>% Gravel</th>
<th>% Sand</th>
<th>% Fines</th>
</tr>
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<tbody>
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<td></td>
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<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
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### TEST RESULTS

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<th>Spec. (%)</th>
<th>Pass? (X=Fail)</th>
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</thead>
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<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>2&quot;</td>
<td>91</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 1/2&quot;</td>
<td>84</td>
<td></td>
<td></td>
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<tr>
<td>1&quot;</td>
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<td>3/4&quot;</td>
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<td></td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>60</td>
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<td></td>
</tr>
<tr>
<td>3/8&quot;</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>#4</td>
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<td></td>
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<tr>
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<tr>
<td>#16</td>
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</tr>
<tr>
<td>#200</td>
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</tr>
</tbody>
</table>

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**Material Description**

**Atterberg Limits (ASTM D 4318)**
- PL = NF
- LL = NV
- PI = NP

**USCS (D 2487)** = GP
**AASHTO (M 145)** = A-1-a

**Coefficients**
- D<sub>0.5</sub> = 48.3585
- D<sub>0.05</sub> = 40.0393
- D<sub>0.10</sub> = 12.7050
- D<sub>0.25</sub> = 2.2893
- D<sub>0.40</sub> = 0.8410
- Cu<sub>g</sub> = 24.27
- Cc<sub>g</sub> = 0.79

**Remarks**
- Moisture content 2.0%

**Date Received:** 11/28/17
**Tested By:** EL
**Checked By:** CH
**Title:** Materials Lab Senior Lead

---

**Source of Sample:** TP-1
**Depth:** 2'
**Sample Number:** S1
**Date Sampled:** 10/2/17

---

**client:** Rollie Maynard
**Project:** Larch Way/Locust Way Intersection Improvements
**Project No:** RC1591
**Figure:** 313-17

---

Snohomish County
Dept. of Public Works
Everett, Washington
Particle Size Distribution Report

GRAIN SIZE - mm.

<table>
<thead>
<tr>
<th>% +3&quot;</th>
<th>% Gravel</th>
<th>% Sand</th>
<th>% Fines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coarse</td>
<td>Fine</td>
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<tr>
<td>0</td>
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<td>0</td>
<td>0</td>
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</table>

**TEST RESULTS**

<table>
<thead>
<tr>
<th>Opening Size</th>
<th>Percent Finer</th>
<th>Spec.* (Percent)</th>
<th>Pass? (X=Fail)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8&quot;</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#4</td>
<td>100</td>
<td></td>
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<td>#8</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>#50</td>
<td>99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#100</td>
<td>29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#200</td>
<td>3.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Material Description**

Atterberg Limits (ASTM D 4318)
- PL = NP
- LL = NV
- PL = NP

**Classification**
- USCS (D 2487) = SP
- AASHTO (M 145) = A-3

**Coefficients**
- \( D_{10} = 0.2601 \)
- \( D_{50} = 0.2462 \)
- \( D_{10} = 0.1973 \)
- \( D_{20} = 0.1816 \)
- \( D_{30} = 0.1509 \)
- \( D_{15} = 0.1217 \)
- \( C_U = 1.83 \)
- \( C_C = 1.07 \)

**Remarks**
- Moisture content: 10.2%

**Date Received:** Date Tested: 11/28/17
- Tested By: EL
- Checked By: CH
- Title: Materials Lab Senior Lead Tech

**Source of Sample:** TP-1
**Depth:** 5.0'
**Sample Number:** 2
**Date Sampled:** 10/2/17

Snohomish County
Dept. of Public Works
Everett, Washington

Client: Rollie Maynard
Project: Larch Way/Locust Way Intersection Improvements

Project No: RC1591
Figure: 314-17
RESOUREN PROTECTION WELL REPORT
(SUBMIT ONE WELL REPORT PER WELL INSTALLED)

Consulting Firm
Unique Ecology Well ID Tag No. BHE 953

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to the best of my knowledge and belief.

Driller □ Engineer □ Trainee
Name (Print Last, First Name) Wesc. Mark
Driller/Engineer/Trainee Signature
Driller's or Trainee License No. 2432

If trainee, licensed driller's Signature and License Number:

Construction Design

Drilled and cased 6" to 212'.
Cut casings at 100'.
Installed PSE anodes assembly.
Pull and grout top 100'.

Well Data

Formation Description

0'-15' Brownish-gray cobbles, sand, gravel, wet.
15'-20' Gray gravel, silty sand.
20'-175' Gray gravel, sand, silt, water.
175'-212' Gray clay, trace gravel.

SCALE: 1" = 1'  PAGE OF
APPENDIX H

Preliminary Environmental Review
DATE: February 15, 2019

TO: Matthew Feeley, P.E., Project Manager
    Public Works – Engineering Services, M/S 607

FROM: Crilly Ritz, Senior Planner II, Ext. CR 2476

SUBJECT: Environmental Review Memo-
Preliminary Assessment of Larch and Locust Way
Intersection Improvement Project (RC 1591)

This memo documents Environmental Services (ENVS) Section’s preliminary assessment of
your proposed project referenced above. The determination of permit and approval requirements
is based on information provided in the project’s design report.

A. Summary of Permits and Approvals Required

Our assessment may be subject to revision in the event of future design alterations or changes
in scope of work, scheduling or funding.

FEDERAL
☐ ESA Section 7 Compliance
☐ NEPA Compliance
    ☐ NEPA CE Form
    ☐ Section 106 Compliance
    ☐ Air Study
    ☐ Noise Study
    ☐ Environmental Justice
    ☐ Section 4(f)
    ☐ Section 6(f)
☐ Corps Permit, Section 404-Nationwide
☐ Corps Permit, Section 404-Individual
☐ Corps Permit, Section 10

STATE
☐ Forest Practice Permit
☐ HPA (potentially) ☐ HPA (Fish
    Enhancement)
☐ NPDES - Construction Stormwater
    General Permit if ground disturbance
    is one acre or greater
☐ Aquatic Land Use Authorization
☐ Section 401, Water Quality Certification
☐ CZM Certification

LOCAL
☐ CAR Compliance
☐ SEPA Compliance
☐ Flood Hazard Permit
☐ Shoreline Exemption Permit
☐ Noise Ordinance Compliance
☐ Land Disturbing Activity Permit
☐ Drainage Compliance
☐ LID Compliance

☐ OTHER: _____
B. Project Narrative

Project Description

Snohomish County Public Works proposes to provide improvements at the intersection that include constructing an urban single lane roundabout at the intersection of Larch Way/Logan Rd and Locust Way. In addition to the roundabout, roadway improvements consisting of curbs, gutters, and a shared use path will be constructed. The proposed improvements would maintain traffic flow and improve safety for pedestrians, bicyclists, and motorists. The purpose of this project is to reduce delay, reduce pedestrian conflicts, and increase the overall intersection level of service.

The proposed design consists of constructing an urban single-lane roundabout with a right turn slip lane for vehicles traveling from northbound Locust Way to eastbound Logan Rd. The roundabout will have a 145’ inscribed circle diameter. In order to minimize the amount of right-of-way acquisition required, the 5-foot buffer strip adjacent to the shared use path will be eliminated. The horizontal alignment of Larch Way/Logan Rd and Locust Way will need to be adjusted in order to create a desirable entry speed for vehicles entering the roundabout.

Project Location

The project site is located at the intersection of Larch Way and Locust Way in south Snohomish County, northeast of Brier. Larch Way becomes Logan Road east of the intersection. The project site is located in Section 23, Township 27 North, Range 4 East, W.M. of Snohomish County.

Site Description

The project site is located in south Snohomish County, approximately 400 feet west of the Snohomish County Swamp Creek Bridge #459 crossing of Swamp Creek. The surrounding area slopes relatively steeply as Larch Way heads from east to west downward to the Swamp Creek riparian corridor. The north-south Locust Way roadway has a more moderate profile.

There are no wetlands or streams located immediately adjacent to the proposed roundabout. Swamp Creek (WRIA 08-0059), a 10.9 mile long Type F stream that is a tributary to the Sammamish River, flows under Snohomish County Swamp Creek Bridge #459, and as noted above is located approximately 400 feet west from the intersection. The Bridge #459 Swamp Creek crossing is located approximately 5.2 stream miles from the stream’s outlet to the Sammamish River, which then flows to its outlet at Lake Washington in Kenmore. The project limits are not located in a mapped floodplain. A mapped floodplain is located at Swamp Creek.

C. Potential Environmental Impacts and Issues

There will be no wetland or wetland buffer impacts associated with the proposed intersection reconfiguration. There will be no in-stream habitat impacts. As currently proposed, there will be
stream buffer impacts associated with the project’s improvements west of the intersection. Project work may require an HPA from the Washington State Department of Fish and Wildlife if stormwater facility construction requires modifying an existing outfall located at Swamp Creek. ENVS will coordinate with the Washington Department of Fish and Wildlife to determine if an HPA would be required for the project.

While much of the project’s improvements would occur within existing right-of-way, intersection improvements and anticipated stormwater facility siting would require additional right-of-way. The preliminary analysis indicated that acquisition would affect six parcels, including Logan Park, a Snohomish County park.

A review of Title VI/Environmental Justice information for the project area has identified a Hispanic population above the 5% threshold. When data analysis indicates that populations are at or above the 5% threshold, it is recommended that notices, public outreach, and other documents as applicable provide text in Spanish notifying the public that project communications can be provided in Spanish if requested. It is recommended that the project coordinate with the Communications Group on these outreach efforts.

It is expected that onsite restoration of temporary land disturbing activities would be required requiring seeding of bare soil areas. Stormwater flow control and quality treatment will be provided by the project within Logan Park.

The full extent of site disturbance is not known at this time but it appears that more than one acre may be disturbed. If the project disturbs one acre or greater, the project will be required to seek coverage under the NPDES Construction Stormwater General Permit.

Considerations to Reduce Environmental Impacts

Alternative project designs included evaluating intersection signalization and other roundabout design configurations as part of the preliminary engineering efforts that are summarized in the design report. Other alternatives that were rejected had similar impacts or greater impacts. It is recommended that the project pursue the design report recommended alternative because the roadway tapers associated with the roundabout alternatives avoids impacts to Swamp Creek stream buffers.

D. ENVS’ Recommendations for Project Cost Savings

ENVS recommends that the project footprint be minimized to the extent practicable to reduce the amount of new impervious surface area and evaluate the feasibility of pervious surface treatments for the proposed shared use area.
E. What ENVS Needs

ENVS would work with the design team to further refine the level of design and associated impacts so that information is available to move forward with SEPA review, and other reviews that may be required. This includes:

- Identifying stormwater flow control and quality treatment that will be used for the project and the outfalls that may or may not be required
APPENDIX I

30% Right-of-Way True Cost Estimate
(This page is intentionally blank)
<table>
<thead>
<tr>
<th></th>
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| 453,800 | 24,000 | 10,000 | 10,000 | 6,000 | 1,300 | 3,500 | 0 | 27,500 |

Total R/W Costs: $536,100
APPENDIX J

30% Project Cost Estimate
(This page is intentionally blank)
## Project Estimating Data

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<thead>
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<th>Item</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Cost</th>
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# Project Estimating Data

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