SR 161 Traffic Signal Coordination Report

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Overview

This summary was prepared in response to legislative direction provided in the 2010 supplemental transportation budget. Specifically, ESSB 6381 Section 218 (6) states "To the extent practicable, the department shall synchronize traffic lights on state route 161 in the vicinity of Puyallup."

This summary is an overview of the traffic signal coordination history for the corridor from the intersection of State Route (SR) 161 and 176th Street to the intersection of SR 161 and the west bound off ramp from SR 512. Included is a discussion of operational strategies and recommendations for future infrastructure improvements that would improve traffic signal operations within the existing roadway geometry.

The Science of Signal Timing

The most important elements of a coordinated traffic control system are a common cycle length and the ability to keep the internal time clocks synchronized at each of the coordinated signals. Early on in signal timing, a decision has to be made regarding how the corridor is to operate. Generally, one of two options is the focus:

Option A –minimize delay along the corridor so that side street and left turn traffic is impacted equally to main line; this option tends to yield a shorter cycle length.

Option B –favor moving mainline by providing additional "Green" time, which impacts side street and left turn traffic, and tends to increase cycle length.

Public Perception

Traffic signal coordination means different things to different people. To some it means that starting with a green signal at one intersection will result in a green signal at each successive intersection. To others it may mean experiencing a minimal amount of delay while progressing through the coordinated signal system. In actuality, what often happens is that queues of traffic form at the beginning of the coordinated system and move through the coordinated system in a platoon fashion.

A more realistic definition may be a blend of these configurations resulting in a motorist moving through the system along with other vehicles in its platoon, experiencing the least amount of delay possible. Because of the unique characteristics of any signalized intersection and other factors causing impacts, it is difficult to eliminate all stops as

traffic progresses through a system of coordinated traffic signals, especially when two way progression competes against each other.

Progressing traffic through a coordinated system, whereby the signals go green as traffic approaches each intersection, seems to be most drivers' perception of a coordinated traffic signal system. While to some degree this is achievable when travelling on a one-way street (the first signal is green, and each successive signal goes green as it is approached), the same cannot be said about traffic progressing along a two-way street. Progression along a corridor with two-way signal systems of varying complexity is very challenging. While providing efficient two-way progression is the ultimate goal, it is more feasible to provide the overall best progression with a minimum amount of delay for all traffic in the system including side streets, left turns and mainline traffic.

Synchronizing Signals

The ability to keep the internal time clocks for each signal controller synchronized is provided by a master controller that sends a pulse to each of the local intersection controllers. Tying all the signals together with the interconnect cable, allows the master controller to send the pulse to each of the local intersection controllers at the same time. Keeping the controllers in synch controls when each signal turns green, this is how progression through the corridor from one signal to the next is provided.

The complexity of the signal operation at any given intersection is the greatest factor driving the cycle length. The more movements (straight through, right turns, left turns) at the intersection, the more time it takes to serve each movement.

Other Factors Impacting Traffic Movement through a Corridor

Many other factors impact the ability to move traffic through a corridor:

- **Spacing of Signalized Intersections**
  The amount of space between signalized intersections plays an important role in moving traffic. Common experience shows that intersections spaced more than ½ mile apart are less responsive to signal coordination, so in general should not be coordinated. Along the SR 161 corridor some of the intersections exceed the ½ mile spacing, but traffic engineers believed that coordinating signals would still be beneficial.

- **Amount of Traffic Entering the System**
  The amount of traffic entering the system from driveways, road approaches and un-signalized intersections all influence the operation of the coordination.

- **Construction**
  Construction on city streets and county roads may affect traffic patterns along the SR 161 corridor. In the case of SR 161, the Washington State Department of Transportation (WSDOT) works cooperatively with the City of Puyallup and Pierce County to mitigate the traffic impacts on the highway from construction activity on their facilities.

- **Emergency Vehicle Activity**
  Emergency vehicle activity along a corridor may have major impacts on the progression of traffic through the system. Emergency vehicles are allowed to pre-empt signals, which provides a green light to go through the signal. In order to provide the green light as soon as possible, the pre-emption knocks signals out of coordination which frequently takes several cycles for the system to get back in synch.

- **Length of the pedestrian crossings**
  To stay in signalized coordination when pedestrians are active, the pedestrian crossing times cannot be longer than the time allotted to serve the vehicular traffic. The vehicle green time has to be at least as long as the "Walk" plus "Flashing Don't Walk" time for pedestrians. Many times pedestrian movements that cross the mainline require more time than is needed to serve the vehicular traffic from the side street traffic associated with that pedestrian movement. Side street movements tend to have the longest pedestrian crossing times because the main highway tends to be wide. While side streets require the longest pedestrian times, in most cases, a shorter vehicle time could be applied.

Coordinating Signals on SR 161

SR 161 is a principal arterial highway that begins at the intersection of SR 7 in rural Pierce County near Eatonville, and traverses the county in a North/South orientation until it reaches its northern terminus at SR 18 in King County.

The section of SR 161 passing through the South Hill area and the City of Puyallup has an average daily traffic count (ADT) of 48,000 vehicles. This section is managed by two separate coordinated traffic control systems (See the Vicinity Map). The first system controls the traffic signals from 120th street to the SR 512 westbound off ramp, the second controls signals from 176th street to 128th street.

120th Street to SR 512 Westbound Off Ramp

Records indicate that WSDOT has been coordinating traffic signals on SR 161 from 120th street to the SR 512 westbound off ramp since at least June of 1993. Periodic reviews of this coordinated system have been performed on an approximate two year cycle. As part of this review, manual turning movement count data is collected, accident history and changes to roadway geometrics are reviewed, computer modeling is performed in the "Synchro" signal timing software, and field observations are made.

Since this section of SR 161 is densely populated commercial area, Option A (minimize delay along the corridor so that side street and left turn traffic is impacted equally to main line) was chosen for the operation. Option A allows for better access to local businesses which minimizes the overall delay along the corridor and provides a good degree of progression along the SR 161 corridor. Although Option A was chosen, a slightly heavier weight is given to mainline through traffic during peak travel times.

The cycle length from 120th street to SR 512 west bound off ramp system is directed by the amount of traffic at the intersection of SR 512 and 112th street. Depending on the time of day, the coordinated cycle lengths are 100, 125 or 140 seconds. Overall the signals are in coordination from 6:15 AM to 8:00 PM. The varying cycle lengths are used during different time periods for fluctuating traffic flow patterns. In the morning northbound traffic heading towards SR 512 is favored. During the midday two-way northbound-southbound progression is the goal while in the afternoon the south bound direction is favored. Favoring one direction of travel in the morning and another in the afternoon, doesn't neglect the need to have two way progression, where favoring one direction doesn't adversely affect the opposing direction.

176th Street to 128th Street

In January of 2007, WSDOT completed Contract 6804, a safety project involving implementing electronics for the intersections from 176th to 128th streets. As part of this contract, conduit and interconnect cable was installed. Completion of this work allowed signals to be coordinated from 176th to 128th streets. In June of 2007, ten traffic signals in this section were placed into coordination. The coordinated operation begins at 6:15 AM and runs until 6:15 PM. Analysis shows that by 6:15 PM traffic volumes have dropped to the point where continuing coordination would only delay the side street and left turn traffic unnecessarily.

This section of SR 161 has some slightly different roadway, roadside and operational characteristics than other sections. For example, while the 120th street to SR 512 westbound off ramp is a highly developed commercial area with many midblock road approaches, the 176th to 128th street section has less commercial development, acts as access to many residential developments and spacing of traffic signals is farther apart.

Option A was also selected for this portion of SR 161. Option A allows delay to be minimized for the heavy side street volumes at 128th, 136th and 160th streets. Both 128th and 136th street are used as school bus routes. The school district contacted WSDOT expressing their concerns about moving traffic in and out of these streets during school start and end times. In addition, school start and end times overlap with periods of heavy mainline flow, so providing additional side street green time to accommodate the needs of the school district impacts SR 161 coordination.

Signals with Exceptions

One of the more challenging requirements of this section of SR 161 is the operation of two traffic signals, one at the intersection of SR 161 and 176th street and the other at SR 161 and the entrance to Fred Meyer. Because of the close spacing of these two intersections and the heavy demand at 176th street these two traffic signals operate on a different cycle than the other intersections throughout this section of SR 161. While the signal at the Fred Meyer entrance has been limited to mainline through traffic and traffic exiting the Fred Meyer, the traffic exiting Fred Meyer is significantly delayed waiting for a green light.

One other intersection that has different coordinated operation in this section of the corridor is the intersection of SR 161 and 156th street. Originally, this intersection was in coordination during the same 6:15 AM to 6:15 PM time frame as the rest of the corridor. Shortly after placing this section into coordination WSDOT began receiving complaints about the long delays being experienced by the residents that live on the west side of SR 161 off of 156th street. The complaints resulted in changing the signal at 156th street to operate in an uncoordinated mode until 10:00 AM when the midday coordination plan for the corridor begins. This reduced side street traffic delay before 10:00 AM.

Overall Corridor Performance

Since portions of this corridor have only been in coordination since the early 1990's, reduced vehicle delay as a result of signal retiming is minimal. When a corridor has run in an uncoordinated mode and is then placed into a coordinated mode, there may be a substantial decrease in vehicle delay. If the corridor is coordinated and then retimed, there may be a minimal decrease in total intersection delay, but the likelihood of improved vehicle delay is minimal at best.

Delay is not likely to decrease as the corridor becomes more developed and traffic increase without infrastructure improvements. Even with the completion of the 176th to 128th safety project, the highway capacity cannot handle the traffic volume that occurs during peak traffic times.

As per the Highway Capacity Manual 2000, Level of Service (LOS) for signalized intersections is defined in terms of control delay, which is a measure of driver discomfort and frustration, fuel consumption and lost travel time. Specifically, LOS criteria are stated in terms of the average control delay per vehicle for a 15-min analysis period. Delay is a complex measure and is dependent upon a number of variables, including the quality of progression, the cycle length, the green ratio and the volume to capacity ratio for the given lane group.

In the SR 161 corridor, there are two intersections with a poor Level of Service (LOS) that act as bottlenecks during peak travel times impeding the flow of traffic; these are 128th (LOS F, 83 seconds), and the SR 512 west bound off ramp (LOS F, 86 seconds).

Next Steps

WSDOT is continually looking to improve the way signals are operated along this heavily congested corridor. Recent improvements to the corridor include the replacement of twenty-five year old technology from 176th to 128th streets, with new 2070 type traffic signal controllers and cabinets. Installation of the new controllers was completed in November of 2010 which added more robust features to improve the flow of traffic along the corridor.

Despite the benefits of the new technology from 176thth to128th streets, there are still a few unfunded pieces of the picture that would provide a complete interconnected, coordinated system of traffic signals for the entire length of this corridor.

First, updating WSDOT owned signal controllers and cabinets from SR 512 westbound off ramp to 120th street along with a simultaneous upgrade of the signal controllers and cabinets owned by the City of Puyallup (See the Vicinity Map). If WSDOT were to upgrade its equipment without upgrading the City of Puyallup signal equipment it would no longer be possible to provide communications to keep the signal systems in synch which would inhibit the ability to maintain coordination.

Another missing piece is the need for installation of an interconnect cable between 120th and 128th streets (See the Vicinity Map). To provide this link a conduit would need to be installed between these two intersections. The interconnect cable could then be installed combining these two systems into one, with a single master time clock.

WSDOT has collected turning movement count data for each of the signalized intersections from SR 512 westbound off ramp to 176th street. The *Synchro* traffic model built for the entire corridor has been updated by entering the current count data and revising the pedestrian crossing parameters.

New national standards are requiring longer pedestrian crossing times. The major requirement is to change the standard pedestrian walking speed from 4 feet per second to 3.5 feet per second and to revise how the distance to cross the street is measured. This change will reflect the amount of green time allotted to mainline traffic.

Conclusion

To address the intent of the 2010 legislative session WSDOT has completed a comprehensive and thorough review of the coordinated traffic signals on SR 161 from the SR 512 west bound off ramp to 176th street. This review includes updating all current timing parameters to meet the guidance provided by the new national standards, incorporating any available technology enhancements from the new 2070 controllers while continuing to provide the best traffic flow throughout the SR 161 corridor.

- Table 1 outlines the **Annual** Cost / Benefit Analysis for the SR 161 Coordination work completed by WSDOT. **Vehicle Delay was reduced by 4,000 hours** which resulted in **75,000 gallons of fuel savings** with a resultant **carbon dioxide equivalent reduction of 670 metric tons.**

- The **2 year societal cost of delay savings is estimated at $664,000** which when compared to the **$75,000 needed to perform the coordination work for a 2 year period** results in a **9:1** benefit/cost ratio.

- In order to maximize the signal operations performance for the corridor, WSDOT and the City of Puyallup are pursuing funding to allow for the replacement of the signal controllers and cabinets between 120th street and the SR 512 WB off ramp along with the missing portion of the interconnect system between 120th street and 128th street (See the Vicinity Map).

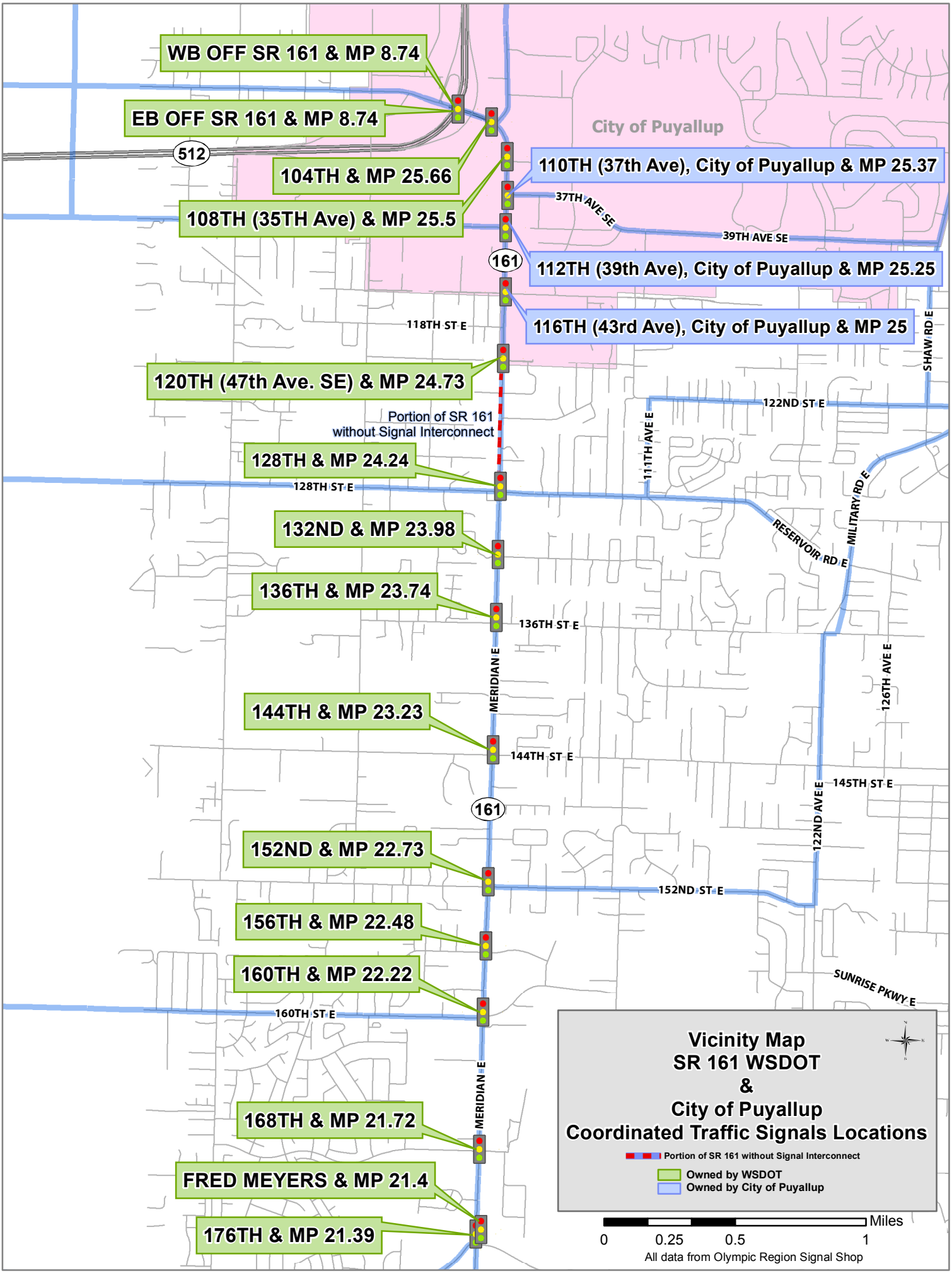
Table 1: Annual Cost / Benefit Analysis - SR 161 Corrdination

	Total Vehicle Delay (hrs)	*Total Fuel Usage (gals)	**Carbon Dioxide Equivalent (Metric Tons)	***Societal Cost of Delay = Travel Time Delay + Fuel Cost (Dollars)
Before Corrdination	30,000	1,439,000	12,800	$5,774,000
After Corrdination	26,000	1,364,000	12,130	$5,442,000
Annual Benefits (Savings)	**4,000**	**75,000**	**670**	**$332,000**
		Cost of Corrdination Year 1		$66,000
		Cost of Corrdination Year 2		$9,000
		Benefit / Cost Ratio After Year 2		**9:1**

* Source: Snychro Model - Estimated Fuel Usage

** Source: http://www.epa.gov/cleanenergy/energy-resources/calculator.html

*** Source: Estimating Cost of Travel Annual Update of the Unit Costs, WSDOT Urban Planning Office and Frieght Office, April 2009, Assumptions (2% Mixed Trucks - $22.2/hr for Travel Time Delay, 98% Autos at $12.4/hr for Travel Time Delay, Central Puget Sound Data, Fuel = $3.75/gal)


WB OFF SR 161 & MP 8.74
EB OFF SR 161 & MP 8.74
512
104TH & MP 25.66
108TH (35TH Ave) & MP 25.5
City of Puyallup
110TH (37th Ave), City of Puyallup & MP 25.37
37TH AVE SE
39TH AVE SE
161
112TH (39th Ave), City of Puyallup & MP 25.25
116TH (43rd Ave), City of Puyallup & MP 25
118TH ST E
SHAW RD E
120TH (47th Ave. SE) & MP 24.73
122ND ST E
Portion of SR 161
without Signal Interconnect
111TH AVE E
128TH & MP 24.24
128TH ST E
MILITARY RD E
RESERVOIR RD E
132ND & MP 23.98
136TH & MP 23.74
136TH ST E
MERIDIAN E
126TH AVE E
144TH & MP 23.23
144TH ST E
145TH ST E
122ND AVE E
161
152ND & MP 22.73
152ND ST E
156TH & MP 22.48
160TH & MP 22.22
SUNRISE PKWY E
160TH ST E
MERIDIAN E
168TH & MP 21.72
FRED MEYERS & MP 21.4
176TH & MP 21.39
Vicinity Map
SR 161 WSDOT
&
City of Puyallup
Coordinated Traffic Signals Locations
Portion of SR 161 without Signal Interconnect
Owned by WSDOT
Owned by City of Puyallup
Miles
0
0.25
0.5
1
All data from Olympic Region Signal Shop