City of Federal Way Adaptive Signal Control

CONCEPT OF OPERATIONS

Prepared for:
City of Federal Way

Prepared by:
Transpo Group

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Chapter 1: Project Scope

1.1 Scope

The scope of this document covers the considerations for the deployment of an Adaptive Signal Control (ASC) system by the City of Federal Way along the major corridors of S 320th Street and Pacific Highway S/SR 99. The segments of roadways identified are located within City of Federal Way, King County Road Services, and Washington State Department of Transportation (WSDOT) jurisdictions. The findings of this Systems Engineering process will potentially result in the implementation of ASC at 44 signalized intersections along the identified roadways. Future expansion of ASC technology may be City-wide totaling approximately 85 signals, and possibly up to 100 or more due to potential annexations and development in the City Center.

This document describes and provides a rationale for the expected operations of the proposed adaptive system. It documents the outcomes of stakeholder discussions and consensus building that has been undertaken to ensure the implemented system is operationally feasible and has the support of the stakeholders. In total, three stakeholder workshops conference calls were held with representation from the following organizations:

- City of Federal Way – Public Works
- City of Federal Way – IT
- City of Federal Way – Emergency Management
- King County Road Services Division
- WSDOT
- King County Metro
- Pierce Transit

Stakeholder participation resulted in a collaborative approach to identify the operational needs, system requirements, goals and objectives, operational scenarios, and support systems.

The intended audience of this document includes: system operators, administrators, decision-makers, elected officials, ASC manufacturers, non-technical readers and other stakeholders who will share the operation of the system or be directly affected by it.

1.2 Project Purpose and Scope

An adaptive traffic signal system is one in which some or all the signal timing parameters are modified in response to changes in the traffic conditions, in real time. The purpose of providing adaptive control in this area is to better accommodate several of the key challenges within the project limits, including:

- Variable traffic demands as a result of surrounding retail establishments, residential neighborhoods, event centers, amusement parks, and healthcare service providers.
- Unpredictable surges in traffic demand on City arterials as a result of I-5 incidents.
- Transit Signal Priority (TSP) for the existing and proposed transit routes along the project corridors.

Adaptive signal control will be deployed for signals currently operated by City of Federal Way, King County Roads, and WSDOT. The City intends to obtain operation of WSDOT traffic signals as outlined in a General Operation and Maintenance Agreement and maintain existing Service Level Agreements (SLA) with King County Roads as it relates to signal maintenance of all project traffic signals. Signal operation of the ASC system will be the responsibility of the City. The project limits and proposed adaptive signalized intersections shown in Figure 1, along with the current signal system owners:

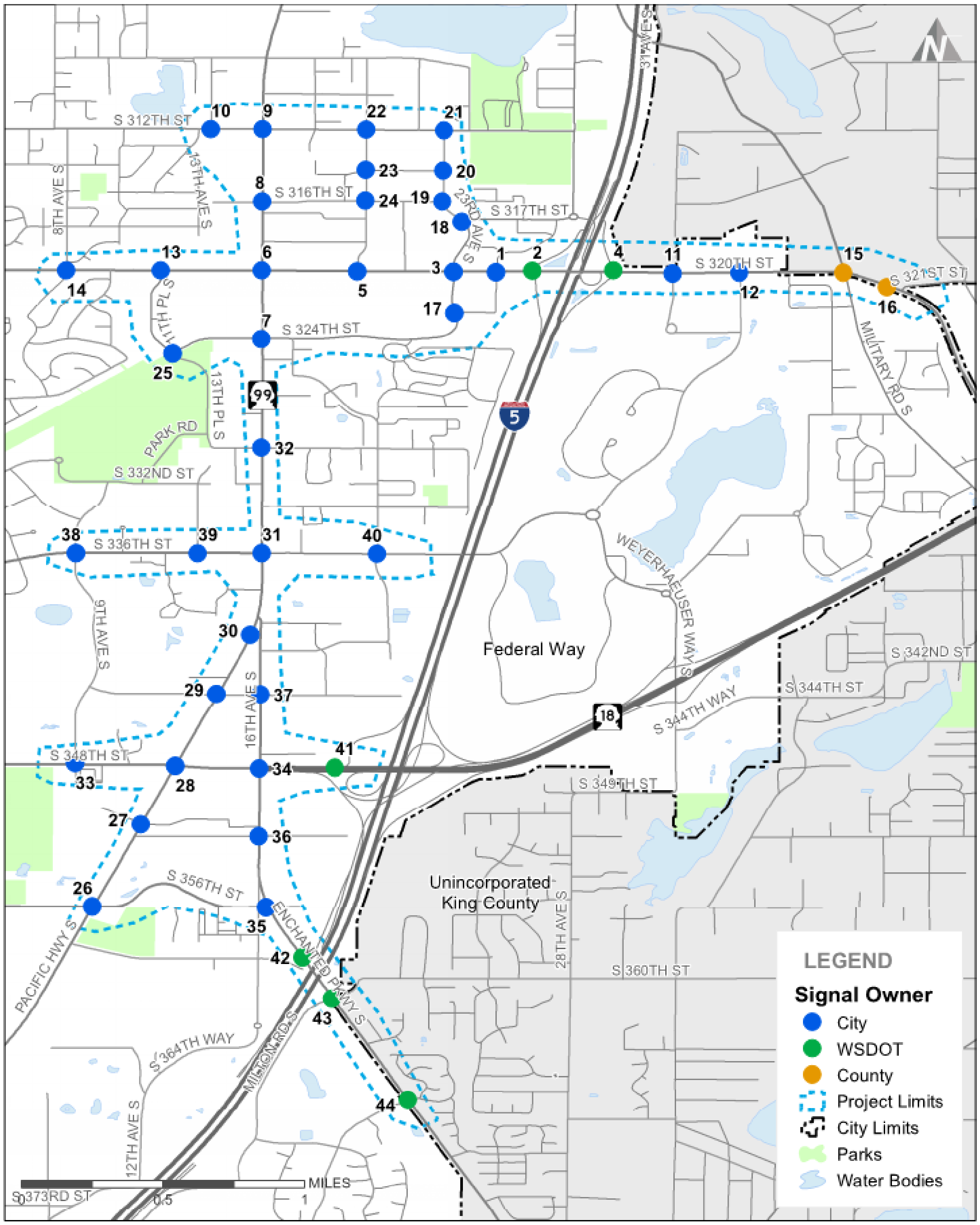


Figure 1: Project Limits and Signalized Intersections

A key consideration of the ASC project includes Sound Transit's Federal Way Link Extension that will begin operations in 2024. Peak hour volumes are anticipated to increase as the regional growth center near SR 99 and S 320th St becomes a major public transportation hub. Sound Transit is also starting its environmental process to extend light rail to Tacoma by 2030, which would include another light rail station in the vicinity of SR 161 / Enchanted Parkway S at S 352nd Street.

Other mass transit considerations include a proposed King County Metro RapidRide route along 320th and a proposed Pierce Transit high frequency route along SR 99. Both routes plan to support Transit Signal Priority (TSP) which would work in conjunction with the adaptive signal system sharing the goal of increasing person throughput along the corridors.

Within the ASC project boundaries, there are also two major WSDOT freeway interchanges at the I-5/S 320th St and I-5/S 348th St junctions. Another key goal of the project is to ensure ASC coordination with freeway operations such as with existing ramp meters and on- and off-ramp queue management.

Other unique features the adaptive signal system is desired to support include:

- Signal Phase and Timing (SPaT) messaging in support of Connected Vehicle/Autonomous Vehicle (CV/AV) environments.
- SPaT Application Programming Interface (API) for interfacing with other central systems in support of Integrated Corridor Management (ICM).
- Automated traffic signal performance measures (ATSPMs).
- Variable lane use.

1.3 Procurement

The ASC system will be procured using a best value procurement process based on responses to a Request for Proposal (RFP). An RFP will be issued to solicit written proposals and system cost proposals from ASC system manufacturers. The selected system will be the one that provides the best value, subject to financial and schedule constraints.

Chapter 2: Referenced Documents

The following documents supported the preparation of this Concept of Operations and stakeholder discussions. Some of these documents provide policy guidance for traffic signal operation in this area; some are standards with which the system must comply; while others report the conclusions of discussions, workshops, and other research used to define the needs of the project and subsequently identify project requirements.

Adaptive Signal Control

- FHWA-HOP-11-027: "Model Systems Engineering Documents for Adaptive Signal Control Technology (ASCT) Systems", August 2012
- FHWA-HOP-13-031: "Measures of Effectiveness and Validation Guidance for Adaptive Signal Control Technologies", July 2013

ITS, Operations, Architecture, Procurement

- Regional ITS Architecture Document: "Intelligent Transportation Systems (ITS) Regional Architecture", Puget Sound Regional Council, December 2008

City of Federal Way Documents

- Federal Way Comprehensive Plan Appendix III-D "ITS Master Plan", City of Federal Way, June 2015
- "PSRC Funding Application", City of Federal Way, April 2016.
- "Energy Efficiency Community Block Grants Signal Timing/Optimization Project", City of Federal Way, May 2012.

Washington State Department of Transportation (WSDOT) Documents

- Northwest Regional Traffic Management Center Best Study, Final Report, WSDOT, May 2012.
- Northwest Region Traffic Management Center & Emergency Operations Center Project, Predesign Study, WSDOT, March 2012.

King County Metro Transit

- King County Metro, METRO CONNECTS Long Range Plan. Adopted January 2017. Available online at http://www.kcmetrovision.org/view-plan/
- King County Metro, King County Metro Transit Signal Priority Replacement Project: Concept Operations. Adopted March 2017.

Pierce Transit

- Destination 2040 Long Range Plan. Adopted April 2016. Available online at http://www.kcmetrovision.org/view-plan/
- Destination 2040 Long Range Plan Appendices. Adopted April 2016. Available online at https://www.piercetransit.org/file_viewer.php?id=2722

Chapter 3: User-Oriented Operational Description

This section presents the current conditions (existing situation); the City of Federal Way's goals and objectives for signal system operations; and describes other non-adaptive strategies considered.

3.1 The Existing Situation

This subsection describes each corridor and their signal operational characteristics.

3.1.1 Network Characteristics

3.1.1.1 Arterial

The ASC system is proposed on five major arterials in Federal Way: S 320th Street, S 336th Street, Pacific Highway S/SR 99, S 348th Street/SR 18, and Enchanted Parkway S/SR 161. Spacing between intersections varies between approximately 500 feet to half a mile. Most signals are spaced at approximately 1/4 mile. Denser spacing typically exists near retail areas where signalized intersections provide access into adjacent businesses. Conversely, intersections are sparser outside of the main retail areas.

Each major arterial is described below:

S 320th Street

The section of S 320th Street through the project area is 2 miles long and has 12 signalized intersections within the project limits. The spacing between major intersections ranges between 500 and 1500 feet. S 320th Street serves a mix of adjacent land uses including undeveloped parcels, retail, and commercial. Retail is densely spaced west of I-5. During the peak hours, the S 320th St/I-5 interchange experiences long queues for the southbound I-5 on-ramp, and lesser queues west of I-5 on S 320th St, for access to on-ramps to northbound I-5. The S 320th St corridor is also very sensitive to incidents on SR 18, as drivers use S 320th St and Peasley Canyon Rd S as an alternate route.

Heavy pedestrian activity occurs at the S 320th St/25th Ave S intersection during the lunch hour of nearby businesses, at S 320th St and 11th Pl S during high school lunch breaks, and at S 320th St/SR 99 which is a popular transit stop being in close proximity to the mall.

By time of ASC implementation, the signalized intersections along S 320th St will be connected to the City of Federal Way communications network including those currently owned by WSDOT and King County Roads.

S 336th Street

The section of S 336th Street through the project area is 0.75 miles long and currently has four signalized intersections. The spacing between major intersections is approximately every quarter mile. The S 336th St and 13th Pl S intersection is surrounded by a multi-service center and low-income housing to the south. Transit riders typically access this area from stops at the west side of the intersection.

The S 336th Street and 20th Avenue S intersection serves Christian Faith Center, a church with a 2200-seat sanctuary that hosts large special events in addition to church services.

All of the signalized intersections along S 336th St are connected to the City of Federal Way communications network.

S 348th Street/SR 18

The section of S 348th Street is 0.75 miles long and includes four signalized intersections within the project limits. The spacing between major intersections is approximately every quarter mile. S 348th St is a major arterial connecting I-5 and SR 18 and serves a mix of adjacent land uses including multi-family, office park, single family, and commercial. S 348th St experiences the most vehicular traffic between I-5 and 16th Ave S/SR 161 intersections. During the peak hours, the S 348th St corridor is very sensitive to incidents on I-5, as the corridor is used as a connection to SR 99 by both passenger vehicles and trucks bypassing the weigh stations on I-5.

During the lunch hour, employees from the medical offices and St. Francis Hospital at 9th Ave and 1st Ave increase pedestrian activity along the S 348th St corridor. Throughout the day, S 348th St and Enchanted Parkway S/16th Ave S intersection pedestrian pushbuttons are almost continually activated, despite relatively low pedestrian volumes. It is hypothesized that transients are activating pedestrian pushbuttons for north-south crossing which reduces green time for east-west movement. Also long-haul truck operators park near the Red Lion Inn at the northeast corner of S 348th and Enchanted Parkway which can also add to pedestrian activity in the area.

The City-owned signalized intersections along S 348th St are connected to the City of Federal Way communications network where within the City limits. The signalized intersection at the I-5 off-ramp is not connected to the WSDOT communications network, but will be added to the City network prior to adaptive signal control implementation.

Pacific Highway S/SR 99

The section of SR 99, within project limits, is 3.2 miles long and has a total of 11 intersections. Spacing varies between 1300 and 1500 feet. During the peak hours, vehicle trips are variable and dependent on I-5 incidents as SR 99 serves as the incident management corridor.

The S 330th St and SR 99 intersection has many adjacent apartments and transit stops. Condominiums and apartments exists on the east side of the intersection, with commercial development on the west. The land uses create heavy pedestrian traffic.

The S 324th St and SR 99 intersection includes a Rectangular Rapid Flashing Beacon (RRFB), the Department of Licensing, and transit stops. The existing RRFB, located east of the intersection at 17th Avenue S and at Belmor Park, experiences heavy usage especially during the summer months.

shows the locations of existing RRFBs within the project area. The Washington State Department of Social Health and Services and Celebration Park are typically accessed through this intersection.

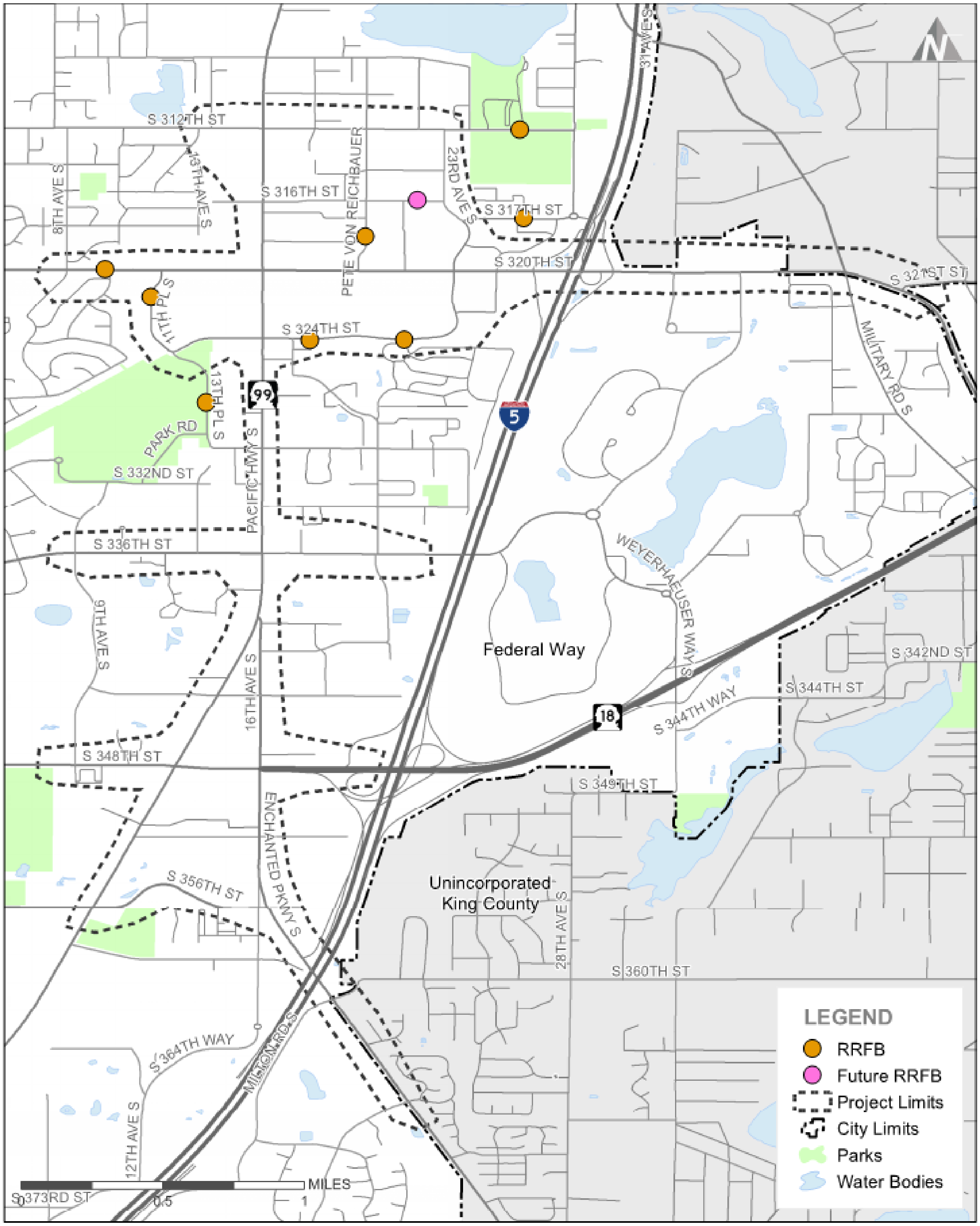


Figure 2: RRFB Locations

At the S 312th St and SR 99 intersection, queues form north (upstream) along SR 99 during the PM peak period including those looking to turn east into the retail area. This intersection experiences high pedestrian activity. During high school lunch breaks, the S 312th St and 14th Ave S intersection sees many pedestrians heading to local fast-food restaurants.

All of the signalized intersections along SR 99 are connected to the City of Federal Way communications network.

Enchanted Parkway S/SR 161/16th Avenue S

The section of SR 161 (Enchanted Parkway S), within the project limits, extends from SR 99 to 19th Way S. This arterial is 1.3 miles long and currently has 7 signalized intersections. The signalized intersections are spaced at approximately every 1/4 mile. SR 161 serves commercial sites, office parks, and the Wild Waves theme park.

The intersection of Enchanted Parkway S / SR 161 at S 356th Street and 16th Avenue S is planned to be replaced with a roundabout by 2027 as part of WSDOT's project adding a southbound off-ramp from I-5 to the east leg of this intersection.

Sound Transit plans to construct a light rail station in the vicinity of Enchanted Parkway S / SR 161 at S 352nd Street as part of its extension to Tacoma by 2030.

The City-owned signalized intersections along SR 161 are connected to the City of Federal Way communications network. The signalized intersections at the SR 18 off-ramp, Milton Rd S, and 19th Way S are currently connected to WSDOT's communications network; however, these signals will be connected to the City's network before adaptive deployment.

3.1.1.2 Grid

The arterials within this project do not operate within a uniform grid network. An adaptive system that is primarily used in a grid setting would not provide the most appropriate traffic signal control strategy for this project.

3.1.1.3 Isolated Intersection or Small Group

There are 7 intersections classified as a small group located around the Federal Way Transit Center at the north end of the project boundaries.

20th Ave S and 23rd Ave S

The 20th Ave S and 23rd Ave S intersections operate on a separate timing plan compared to the SR 99 and S 320th St corridors. The spacing between signalized intersections ranges between 500 and 1500 feet. This area consists of mixed-use zones of city center core and frame. The Federal Way Transit Center and senior housing are located in this area which creates high pedestrian volumes. Current signal timing operates on shorter cycle lengths compared to other project intersections to accommodate high pedestrian activity. The future light rail station within this area will only increase pedestrian volumes along 23rd Ave S and at the S 320th St crossing.

The intersection of S 317th Street and 23rd Avenue S will be replaced with a roundabout by 2024 as part of Sound Transit's light rail station improvements.

All of the signalized intersections along 20th Ave S and 23rd Ave S are connected to the City of Federal Way communications network.

3.1.1.4 Freeway Interchange

There are three major interchanges within the project boundaries: two closely-spaced intersections at S 320th St/I-5, one at S 348th St/I-5, and one at Enchanted Parkway S/SR 18. Each have a high volume of turning movements and require careful management of queue lengths with the highest volume movement occurring at the S 320th St eastbound right turn.

3.1.1.5 Jurisdictions

The signals are currently owned, operated, and maintained by several separate agencies. Signal ownership is depicted on Figure 1 and maintenance responsibilities are summarized in accordance with the Table 1 below.

Table 1: Traffic Signal Operations and Maintenance Responsibility Matrix

Agency	**Responsibility**
City of Federal Way	City Signal Operations
King County Roads	City Signal Maintenance, County Signal Operations and Maintenance
WSDOT Signals	State Signal Operations and Maintenance

The City of Federal Way intends to gain operational control of WSDOT and King County signals within the project limits to support adaptive signal operations. All project signals will be maintained by King County Roads. An interlocal agreement between King County and the City of Federal Way will be updated to distinguish operational and maintenance responsibilities. A general operations and maintenance agreement will be developed between WSDOT and the City.

King County Roads Agreement

The agreement between King County and the City of Federal Way will include information on this ASC project as background for the purpose of the agreement. Signals included in this agreement are listed below:

- S 320th St / S Peasley Canyon Rd and Military Rd S
- S Peasley Canyon Rd and S 321st St
- Six (6) WDOT owned signals within the project limits
- All 36 City of Federal Way owned signals within the project limits (existing agreement)

Engineers and technicians at King County Roads are trained to perform preventative maintenance and repairs for the proposed signalized intersections. They have unique knowledge of ITS components and can provide on-call services. Federal Way shall reimburse King County Roads for all services, materials, labor, and equipment necessary to maintain and operate the adaptive signal system. Expenses for maintenance and operation services performed by King County Roads shall be reimbursed with 15% administrative overhead.

The City and County agree to hold each other harmless from and against all claims, demands, and causes of action of every kind in connection with this agreement. A maintenance plan for monthly and annual preventative procedures will be included in the agreement.

The adaptive signal system server will be protected within the City firewalls while providing control and viewing privilege to King County Roads.

WSDOT Agreement

A General Operation and Maintenance Agreement between the City of Federal Way and WSDOT will be agreed upon to allow Federal Way (in partnership with the County) to maintain WSDOT owned signals within the project area. Signals included in the agreement are listed below:

- SR 18 and I-5 southbound off-ramp signal
- SR 18 westbound off-ramp and SR 161 / Enchanted Pkwy S
- SR 161 / Enchanted Pkwy S and Milton Rd S
- SR 161 / Enchanted Pkwy S and 19th Way S
- S 320th St and I-5 southbound ramp signal
- S 320th St and I-5 northbound ramp signal

Like King County Roads, WSDOT shall have monitoring and reporting access to the adaptive signal system. Off-hour access will be available from a workstation located at WSDOT's NW Region TMC in Shoreline, WA. WSDOT staff may monitor signal timing operations, retrieve data related to I-5 interchange operations within project limits, and adjust ASC operations as agreed upon with the City.

Special consideration will be given to on and off ramp operational requirements. Federal Way must make every possible effort to not gridlock the intersection of the on-ramp and the arterial. Any improvements to the WSDOT owned intersections should use WSDOT designated vehicle detection.

Federal Way (in partnership with the County) will perform bi-monthly preventative maintenance. Major preventative maintenance will be performed annually. Unplanned maintenance calls will be responded to within two hours.

All preventative, routine, and non-routine maintenance will be completed at the expense of Federal Way. The City receives no cash reimbursement, and instead benefits from having one agency operate both City and WSDOT signals in a corridor.

3.1.2 Traffic Characteristics

3.1.2.1 Overview

Federal Way roadways are often used as a diversion from I-5. As such, traffic volumes are sensitive to incidents on I-5. As of 2010, S 348th St/SR 18 and S 320th St served over 35,000 vehicles per day near their respective I-5 interchanges. The S 320th St Average Daily Traffic (ADT) ranges from 30,000 to 45,000. As of 2010, the following traffic counts were observed:

- Pacific Hwy/SR 99 served 25,000 to 35,000 vehicles per day.
- S 336th St served 15,000-25,000 west of SR 99, and 5,000-15,000 east of SR 99.
- S 312th St served 15,000-25,000 vehicles per day west of SR 99, and 5,000-15,000 vehicles per day east of SR 99.
- Enchanted Parkway/SR 161 served 25-000-35,000 vehicles north of I-5, and 15,000-25,000 south of I-5.
- 20th Ave S and 23rd Ave S each served 5,000-15,000 vehicles per day.

3.1.2.2 Peak Periods

All project corridors experience heavy directional commuter peaks as described below:

- On S 320th St, traffic volumes are highest in the east direction during the AM peak, and highest in the west direction during the PM peak. There is no clear direction for mid-day traffic flow. Often, S 320th St is used as a diversion from SR 18. The heaviest turning movement for the S 320th St on-ramps is the eastbound right turn movement onto I-5 South.
- On S 312th St from 8th Ave S to 23rd Ave S, the majority of AM peak traffic is headed eastbound while PM peak traffic is headed westbound.
- The majority of Enchanted Parkway AM traffic travels northbound while PM traffic travels southbound.
- The I-5 on and off ramps at S 320th St and S 348th St are the most trafficked of any area in the project in the AM and PM peak periods.
- The S 336th St and 13th Pl S intersection is popular with pedestrians due to nearby transit access, and low-income housing.
- S 348th St sees heavy peak commute traffic eastbound in the morning, and westbound in the evening.
- S 336th St has mainly westbound traffic throughout the day. Westbound volumes are highest in the AM peak. Volumes are balanced mid-day and during the PM peak.

3.1.2.3 Business Hours

The S 320th St and SR 99 area, compared to other corridors, experiences the most traffic volume fluctuation throughout business hours. Minor peaks can also be observed during the lunchtime period. This is most likely due to the concentrated retail center and restaurants near the intersection which attracts pass-by trips from the nearby I-5 interchange.

Traffic volumes between the AM and PM peaks vary throughout the different project corridors. S 348th St sees many pedestrians during the lunch hour due to medical offices at 9th Ave S and 1st Ave S. In the summer months, S 324th St and 13th Ave S is trafficked by those travelling to the BPA trail and ball fields. Also during the summer months, Wild Waves at Enchanted Parkway S and Milton Rd S affects nearby intersections as vehicles queue from the parking lot entrance during morning opening hours.

3.1.2.4 Evenings

Evening peak hour traffic is considerably heavier than morning peak hour traffic. Evening traffic is highly dependent on incidents occurring on I-5. I-5 incidents mainly impact S 348th St, S 320th St, and SR 99. Shift changes at the Amazon Kent fulfilment center, Boeing facilities in Kent and Auburn, and SeaTac Airport also impact the broad transportation system.

3.1.2.5 Travel Time Variation

Travel time data helps measure the travel time reliability along the project corridors. Peak hour travel times can be compared against the average daily travel time to indicate corridor segments undergoing high variability. As variability increases, reliability decreases. Figures 3 through 5 show the percent increase in travel time along the project corridors during the 2-hour AM peak, mid-day, and PM peak. Travel time data along project corridors show that longer travel times are experienced during PM peak hours specifically along SR 99 (southbound) and S 348th St (westbound).

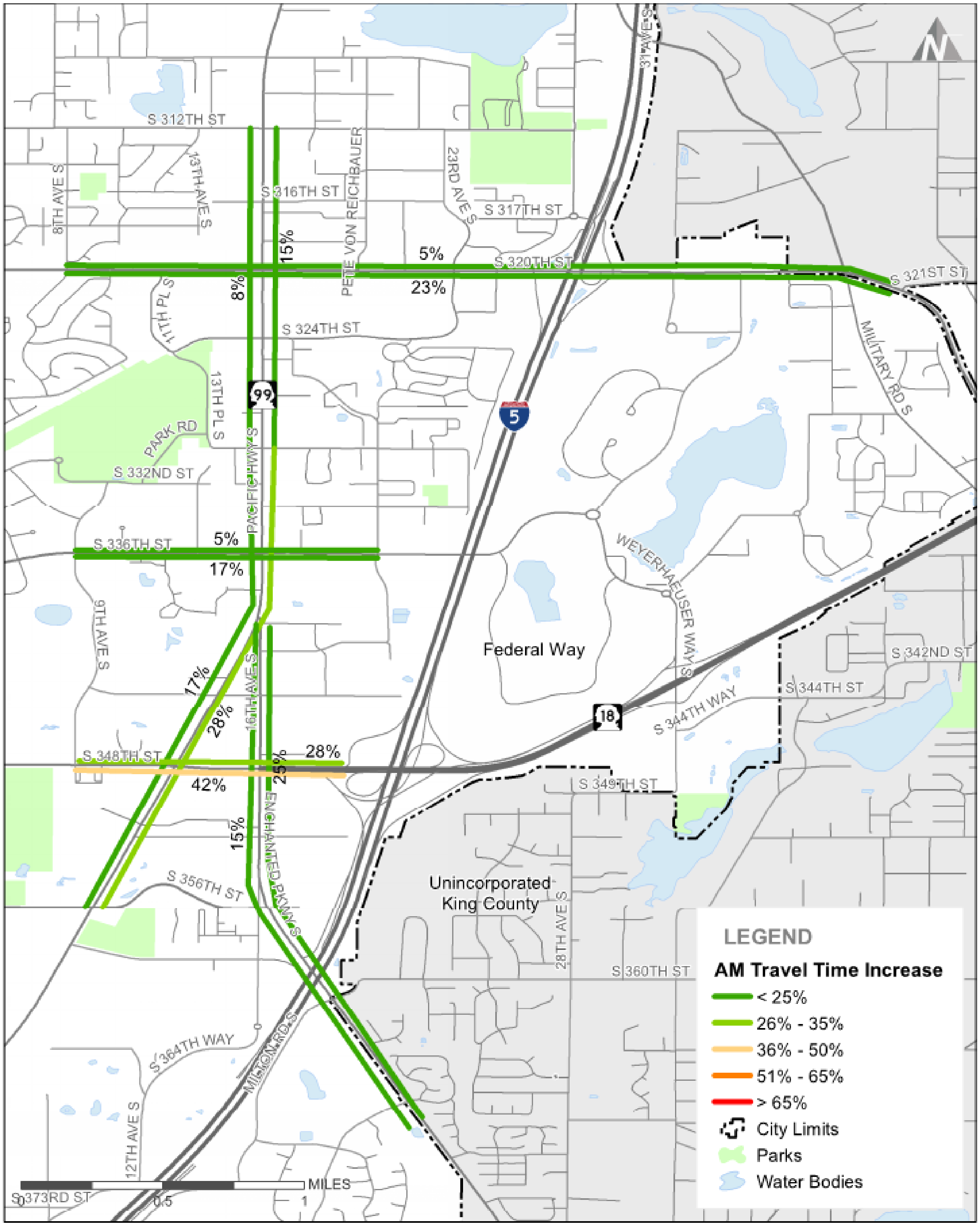


Figure 3: AM Peak Travel Time Increase

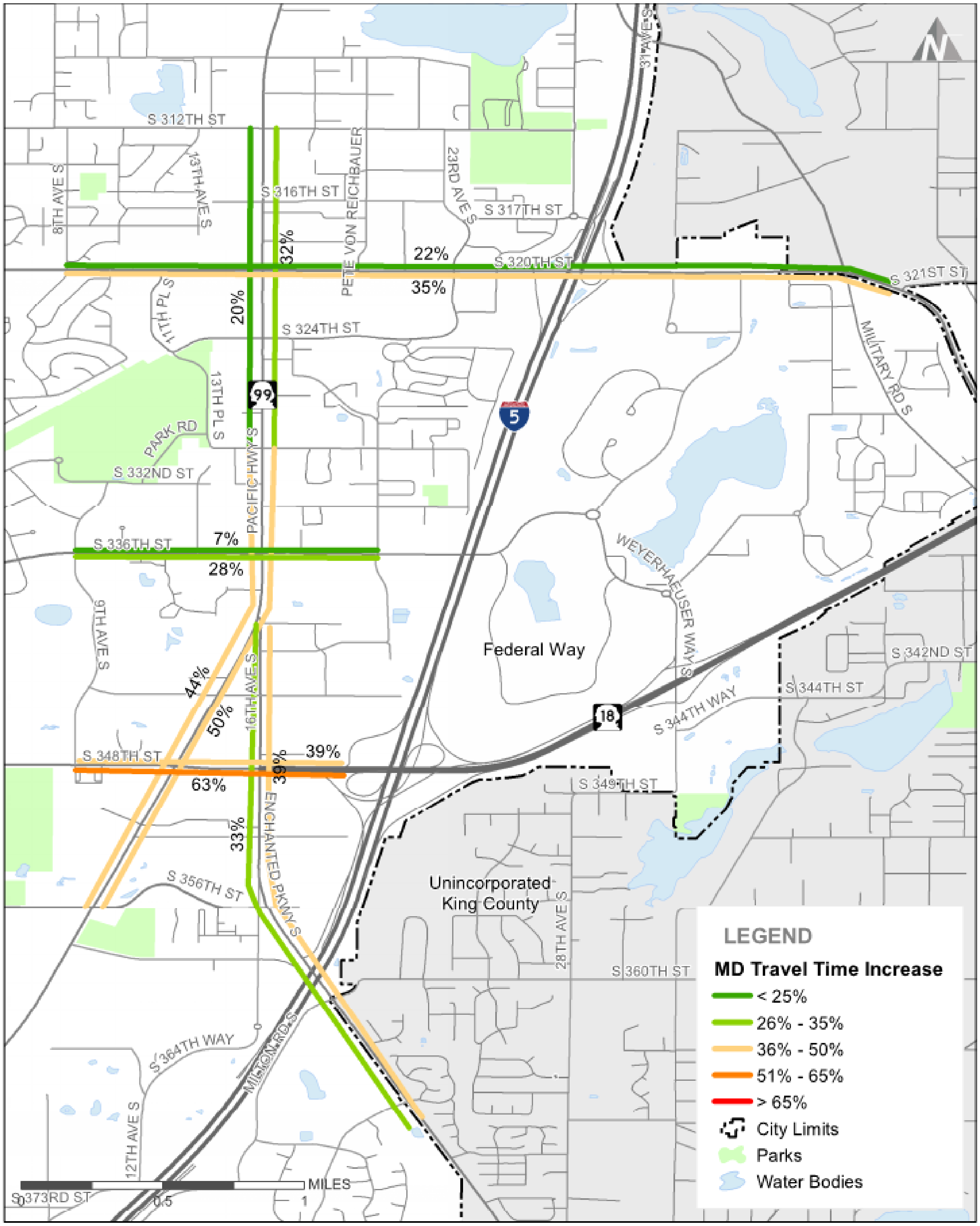


Figure 4: Mid Day Peak Travel Time Increase

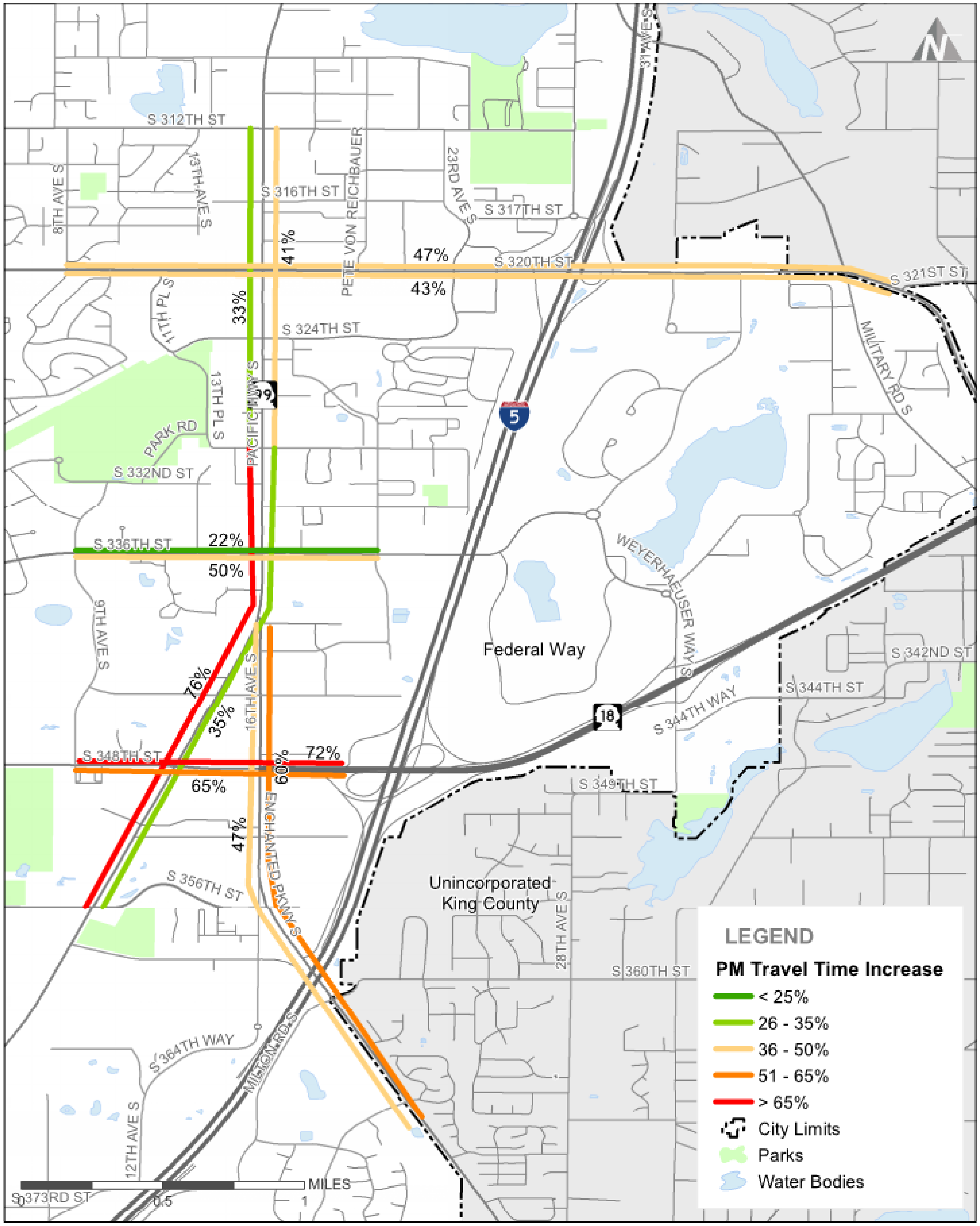


Figure 5: PM Peak Travel Time Increase

3.1.2.6 Weekends

During the weekends, the traffic flows are generally higher on Friday evenings with travelers leaving the metro area. Highest volumes are generally seen during the Friday PM peak times. Westbound Peasley Canyon Rd S is also often congested with Friday afternoon traffic.

Retail uses near I-5 interchanges generate large weekend volumes with little directionality

3.1.2.7 Events and Incidents

Occasional heavy directional event traffic is experienced within the project area. Known events take place at the Federal Way Performing Arts Center, Federal Way Community Center, Federal Way High School, King County Aquatic Center on S 348th St, Christian Faith Center on S 336th St, and at Celebration Park.

The Performing Arts Center directly affects S 320th St and the northern project intersections. Celebration Park, Olympic Trials Park, and medical centers along S 348th St create increased volumes along S 348th St. The Fourth of July fireworks at Celebration Park are a large draw from the surrounding community. The Kent Amazon fulfilment center on S 212th St impacts the greater Kent and Federal Way region. The Federal Way Transit Center is a large draw for riders travelling to University of Washington and Seahawks football games. Football games at Federal Way High School on Friday evenings also draw a large crowd.

Seasonal traffic also effects the project area. During summer months, consistent traffic is generated by families traveling to the Wild Waves theme park on Enchanted Parkway. Queues for entry and site parking often extend down Enchanted Parkway to S 348th St and SR 18. Summer Movies in the Park also draw evening travelers to Town Square Park off of S 316th St. Around Veteran’s Day and the holiday season, traffic increases around the mall and Costco. Heavy shopping days such as Black Friday results in heavy traffic volumes along the west portion of S 320th St.

In addition to directional events traffic, incident-related traffic congestion is often experienced within the project corridors. S 348th St, S 320th St, S 316th St, SR 18, Peasley Canyon Rd S, and northern portions of SR 99 are often affected incident on I-5 incidents, depending on where the backup begins. Pacific Highway S/SR 99 becomes a primary detour route for drivers avoiding incidents on northbound or southbound I-5 as this corridor runs parallel to the interstate. When diverting from I-5, interchanges at S 320th St and S 348th St often become congested. Southbound SR 99 also typically experience heavy congestion from S 348th St south for travelers headed to a Tacoma Dome event.

3.1.2.8 General

The general characteristics of S 320th St within the project limits are listed below:

- The project area currently sees up to 4% freight truck traffic. Greater amounts of truck traffic are anticipated as S 320th St densifies.
- S 320th St is a principal east-west arterial corridor connecting to I-5 and commercial areas. S 320th St is classified as T-3 in the WSDOT Freight and Goods Transportation System.

- As of 2012, S 320th St sees an ADT of approximately 37,500 vehicles.

The general characteristics of S 336th St within the project limits are listed below:

- The S 336th St and 13th Pl S intersection is surrounded by a multi-service center, low income housing to the south. Transit riders may access this area from stops at the west side of the intersection.
- S 336th St serves office space at the western edge of the project.
- Residential and business traffic is also prevalent along this corridor.

The general characteristics of S 348th St/SR 18 within the project limits are listed below:

- The S 348th St corridor is very sensitive to incidents on I-5, as the corridor is used as a connection to SR 99.
- During lunch peak times, employees from the medical offices and St. Francis Hospital at 9th Ave and 1st Ave impact S 348th St.
- The S 348th St and Enchanted Parkway S/16th Ave S intersection pedestrian pushbuttons are almost continually activated, despite low pedestrian volumes (excluding the lunch period).
- Greater amounts of truck traffic are anticipated as S 348th St densifies.

The general characteristics of Pacific Highway S/SR 99 within the project limits are listed below:

- High levels of truck traffic, as SR 99 is an alternate route to I-5 for freight movement.
- SR 99 serves the City Center and central business district.
- SR 99 is classified as T-3 in the WSDOT Freight and Goods Transportation System, (T-2 south of SR 18).

The general characteristics of S 312th St within the project limits are listed below:

- S 312th Street serves a mix of adjacent land uses including multi-family, mixed-use, community business, and single family.
- In the PM peak, queues extend from the S 312 St and SR 99 intersection north up SR 99.
- During high school lunch breaks, the S 312th St and 14th Ave S intersection sees many pedestrians heading to local fast-food locales.

The general characteristics of Enchanted Parkway/SR 161 within the project limits are listed below:

- SR 161 serves commercial sites, and single- and multi-family housing.
- Wild Waves/Enchanted Park is a regional amusement park located between Milton Road and 19th Way S which generates large volumes of traffic varying with summer temperatures and days of the week.
- SR 161 at S 356th Street / 16th Avenue S provides access to Todd Beamer High School, generating peak flows during the morning peak and mid-afternoon.

The general characteristics of 20th Ave S and 23rd Ave S within the project limits are listed below:

- Corridors consist of mixed-use zones of city center core and frame.
- The Federal Way Transit Center is located in this area.
- Senior housing is located in this area.
- Future light rail connection at the Federal Way Transit Center will increase pedestrian volumes along the corridors and crossing S 320th St.

3.1.2.9 Future Traffic Conditions

The project corridors are located in a rapidly growing area in King County. As of Summer 2016, 49 new major projects were listed as in progress within the city limits, with many within the adaptive signal control project limits. By 2040, the City of Federal Way anticipates the population to increase from 96,757 to 106,000 (+9.6%), with 50,000 workers and 44,000 housing units. Goals include expansion of employment units from 3,389 to 6,823. Known improvements within the project limits include the following:

- Belmor Park may include redevelopment of a large mobile home park to 10,000 residential units and 2.5 million square feet of commercial space
- Reconstruction of Federal Way High School Stadium
- Future light rail extension and light rail station
- Construction of 300 low income residences
- Expanded use of Town Square Park
- Potential redevelopment of former Weyerhaeuser East Campus Area
- Construction of a new hotel

Several planned capital improvement projects will influence existing signals. The Enchanted Parkway S/S 356th St and S 317th St/23rd Ave S intersections are planned to be replaced with roundabouts. The SR 18 and Enchanted Parkway off ramp signal is planned to be replaced with a full diamond interchange.

3.1.3 Signal Grouping

In general, groupings are effectively divided by King County Roads, Federal Way, and WSDOT owned signals.

Between agencies, coordination is currently achieved through time-based coordination using a common cycle length. Cycle lengths vary from 110 seconds during AM commute hours, to 160 seconds during the PM commute hours. Several signals have shorter cycle lengths mid-day. Cycle lengths are as short as 55 seconds, mainly at off-ramp signals.

Within the groups of signals owned by the City of Federal Way, intersections are currently coordinated along the major arterials: SR 99, 16th Ave S/SR 161, S 320th St, S 336th St (full and half cycles), and S 348th St. The existing cycle lengths on weekdays during non-holiday periods are shown in Tables 2 through 8 below.

Table 2: SR 99 (north segment): Weekday Cycle Lengths

Intersection	5:30am-6:00am	6:00am-9:00am	9:00am-1:30pm	1:30pm-4:30pm	4:30pm-6:30pm	6:30pm-7:00pm	7:00pm-8:00pm	8:00pm-9:00pm	9:00pm-10:00pm	10:00pm-11:30pm	11:30pm-5:30am
S 312th St & SR 99	Free	110	130	140	160	140	140	Free	Free	Free	Free
S 316th St & SR 99	Free	110	130	140	160	140	140	130	130	Free	Free
S 320th St & SR 99	110	110	130	140	160	140	140	130	130	130	Free
S 324th St & SR 99	Free	110	130	140	160	140	140	130	Free	Free	Free
SR 99 & S 330th St	Free	110	130	140	160	140	140	Free	Free	Free	Free
SR 99 & S 336th St	Free	110	130	140	160	140	140	Free	Free	Free	Free
SR 99 & 16th Ave S	Free	110	130	140	160	140	Free	Free	Free	Free	Free

Table 3: SR 99 (south segment): Weekday Cycle Lengths

Intersection	5:00am-6:00am	6:00am-2:45pm	2:45pm-6:45pm	6:45pm-8:00pm	8:00pm-9:00pm	9:00pm-5:00am
SR 99 & S 348th St	150	150	160	150	150	Free
SR 99 & S 352nd St	Free	150	160	150	Free	Free
SR 99 & S 356th St	Free	150	160	150	Free	Free

Table 4: 16th Ave S/SR 161: Weekday Cycle Lengths

Intersection	5:00am-6:00am	6:00am-1:00pm	1:00pm-2:30pm	2:30pm-2:45pm	2:45pm-3:45pm	3:45pm-4:00pm	4:00pm-4:30pm	4:30pm-4:45pm	4:45pm-8:00pm	8:00pm-10:00pm	10:00pm-5:00am
16th Ave S & S 344th St	75	75	75	75	80	80	160	160	Free	Free	Free
SR 18 & SR 161	150	150	150	150	160	160	160	160	150	130	Free
SR 161 & S 352nd St	Free	150	150	150	160	160	160	160	150	Free	Free
SR 161 & S 356th St	Free	150	Free	150	150	160	160	160	150	Free	Free
SR 18 WB Off-Ramp & SR 161	Free	55	60	60	60	60	60	55	55	Free	Free
SR 161 & Milton Rd S	Free	120	120	120	120	120	120	120	120	Free	Free
SR 161 & 19th Way S	Free	120	60	60	60	60	60	120	120	Free	Free

Table 5: S 320th St: Weekday Cycle Lengths

Intersection	5:30am-6:00am	6:00am-9:00am	9:00am-1:30pm	1:30pm-4:30pm	4:30pm-6:30pm	6:30pm-8:00pm	8:00pm-9:00pm	9:00pm-10:00pm	10:00pm-11:00pm	11:00pm-5:30am
S 320th St & 8th Ave S	Free	110	130	140	160	Free	Free	Free	Free	Free
S 320th St & 11th Place S	Free	110	130	140	160	140	140	140	Free	Free
S 320th St & SR 99	110	110	130	140	160	140	130	130	130	130
S 320th St & 20th Ave S	Free	110	130	140	160	140	130	Free	Free	Free
S 320th St & 23rd Ave S	Free	110	130	140	160	140	130	130	130	Free
S 320th St & 25th Ave S	Free	110	130	140	160	140	Free	Free	Free	Free
S 320th St & I-5 SB Ramps	Free	110	130	140	160	140	120	120	Free	Free
S 320th St & I-5 NB Ramps	Free	110	Free	140	160	140	120	120	Free	Free
S 320th St & 32nd Ave S	Free	110	120	140	160	140	Free	Free	Free	Free
S 320th St & Weyerhau. Way S	Free	110	120	140	160	140	Free	Free	Free	Free
S 320th St & Military Rd S	Free	Free	120	160	160	160	120	120	Free	Free
S Peas. Canyon Rd & S 321st St	Free	110	120	160	160	160	120	120	Free	Free

Table 6: S 336th St: Weekday Cycle Lengths

Intersection	6:00am-7:00am	7:00am-9:00am	9:00am-1:30pm	1:30pm-2:45pm	2:45pm-4:30pm	4:30pm-6:30pm	6:30pm-6:45pm	6:45pm-7:00pm	7:00pm-8:00pm	8:00pm-6:00am
9th Ave S & S 336th St	Free	55	65	70	70	80	70	70	Free	Free
13th Pl S & S 336th St	110	110	130	140	140	160	140	140	140	Free
SR 99 & S 336th St	110	110	130	140	140	160	140	140	Free	Free
20th Ave S & S 336th St	Free	55	65	70	70	80	Free	Free	Free	Free

Table 7: S 348th St: Weekday Cycle Lengths

Intersection	5:00am-6:00am	6:00am-1:00pm	1:00pm-2:45pm	2:45pm-4:30pm	4:30pm-6:45pm	6:45pm-8:00pm	8:00pm-9:00pm	9:00pm-10:00pm	10:00pm-5:00am
S 348th St & 9th Ave S	150	150	150	160	160	150	130	Free	Free
SR 99 & S 348th St	150	150	150	160	160	150	130	Free	Free
S 348th St & SR 161	150	150	150	160	160	150	130	130	Free
I-5 SB Off-ramp & SR 18	Free	120	60	60	90	90	Free	Free	Free

3.1.4 Land Use Characteristics

3.1.4.1 Existing Land Uses

Land use in the project area includes commercial, mixed-use, multi-family, and single-family zoning. The project area also has multiple public parks and private and public schools. Federal Way High School is located just north of the project limits at SR 99 and S 308th St, but still has a major impact on signal operations for the northern project signals. Similarly, Todd Beamer High School traffic affects the S 356th Street intersections at SR 99 and SR 161.

Commercial and retail establishments range from isolated retail establishments to retail concentrations including The Commons at Federal Way, Town Square Park, Federal Way Marketplace, and a large corporate park that once housed the Weyerhaeuser Headquarters. Commercial land use includes large corporations such as Lowe's Home Improvement, The Home Depot, Costco Wholesale, and Walmart.

Figure 6 shows the land use zoning of the study area.

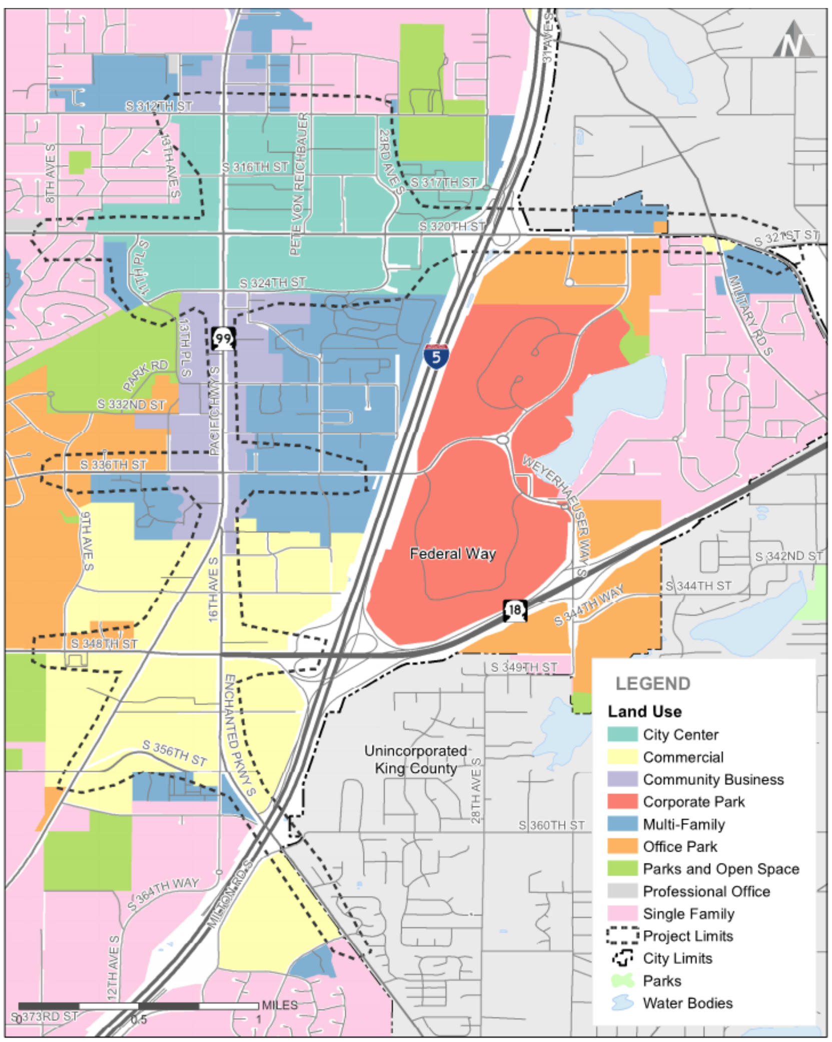


Figure 6: Land Use Map

3.1.4.2 Future Land Use Changes

A number of future projects are planned within and adjacent to the study area that will add more commercial, residential, and retail services. The largest expected changes include the re-construction of Federal Way High School, additional high-turnover restaurants including Chick-Fil-A, multiple multi-family projects including Celebration Senior living off of SR 99 near S 328th St, and High Point Mixed Use off of S 320th St which includes 308 dwelling units and over 15,000 square feet of commercial space.

The re-development of the former Weyerhaeuser headquarters will have a large effect on roadway usage. The preliminary plans, submitted to the City of Federal Way in November 2017, show five proposed warehouses totaling over a million square feet. Traffic impact analysis expects an additional 1,200 freight vehicle trips and 4,600 vehicle trips daily. S 320th St could see an additional 750 daily freight vehicle trips, while Highway 18 could see and additional 450 daily freight vehicle trips.

The I-5/SR 161/SR 18 Triangle Improvements project will impact study intersections near the S 348th and S 356th corridors. The improvements will include new access ramps to SR 161 (Enchanted Parkway) terminating at the S 356th Street intersection. Impacts to study intersections include changes in traffic patterns at the intersections of Enchanted Parkway with S 348th Street and S 356th Street. It is also anticipated that the Enchanted Way/ S 356th Street intersection will be converted to a roundabout.

Future plans propose an additional access to I-5 to accommodate planned growth in the City Center and East Campus.

3.1.4.3 Pedestrians and Public Transit

Pedestrian delays are a factor in selecting phasing and timing parameters especially at signals near park and rides and mixed-use urban centers. Within the project limits, pedestrian activity is greatest at the S 320th St/SR 99 intersection. Higher pedestrian volumes at this intersection is a direct result of mall traffic and transit availability.

Within the project limits, public transit is operated by King County Metro, Sound Transit, and Pierce Transit along the major corridors. Figure 7 shows existing and proposed mass transit routes that will have the greatest impact on adaptive operations mostly due to Transit Signal Priority (TSP) and frequency of transit service. The Sunrise United Methodist Church, South Federal Way, Federal Way/S 320th St, Our Savior's Baptist Church park and rides are major transit hubs that are utilized by King County Metro riders. They are also highly utilized for commuter peak hours and result in higher traffic volumes surrounding these locations.

King County Metro

The only transit route currently serving TSP is the RapidRide A line route at the north end of the project limits running along SR 99. As part of King County Metro's METRO CONNECTS plan, the existing Route 181 along S 320th St will be converted to a RapidRide route also providing TSP service.

Pierce Transit

Pierce Transit plans to eventually increase Route 500 peak frequency to 15 minutes or higher and would benefit from TSP optimization along SR 99.

Sound Transit

Sound Transit is in the midst of designing the Federal Way Link light rail extension. The line will end at 23rd Ave S and S 320th St as an interim terminus. Construction is scheduled to begin in 2019, with the line set to open in 2024.

The extension of light rail to Tacoma is scheduled to begin construction in 2025 and completed in 2030. A station is planned to be constructed near SR 161 and S 352nd Street.

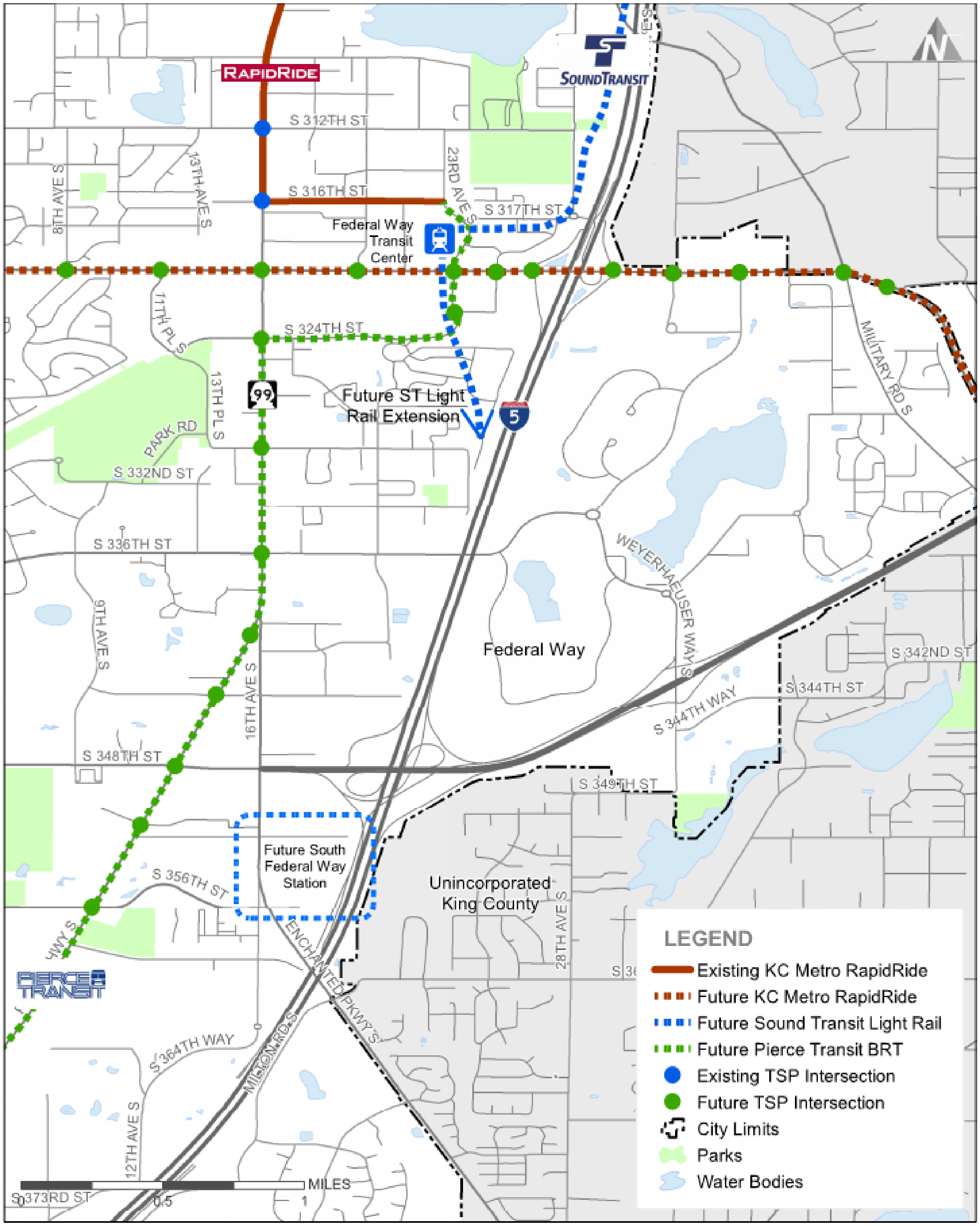


Figure 7: Major Transit Routes and Signal Priority Intersections

3.1.4.4 Agencies

The existing signal systems are owned and operated by the City of Federal Way, WSDOT, and King County Roads. Figure 1 identifies which signals are owned and operated by each agency. Signal operation can affect transit agencies (i.e., Sound Transit, King County Metro, Pierce Transit) and emergency first responders (i.e., South King Fire & Rescue) that utilize the corridors.

3.1.5 Existing Traffic Signal Infrastructure

The majority of project traffic signal controller cabinets are NEMA cabinets with Econolite Cobalt or ASC/3 controllers, except for those at WSDOT signalized intersections which utilize Caltrans 332 cabinets with 2070 controllers running NextPhase software. Table 8 provides a complete list of intersections, controller type, and cabinet type.

Existing vehicle detection at signalized intersections within the project area consists primarily of inductive loops, with a small subset, primarily along SR 99, utilizing stop bar video detection. At almost all locations, intermediate/advance detectors are located approximately 200 feet in advance of the stop bar. The majority of these intermediate/advance detectors provide per-lane detection, but a handful only provide per-phase detection. As for stop bar detection, approximately half of the presence detection is separated per lane. Figure 8 shows the City of Federal Way's current standard detail for loop splicing. For additional information, see Appendix A for a summary of detection technologies present at each of the project intersections.

SERIES CONNECTED
LOOP 1-2
COUNT DETECTOR LOOP 3
(DRAWING NOT TO SCALE)

POSTED SPEED (MPH)	* S1(FT)	* S2(FT)
25	--	105
30	--	140
35	--	185
40	115	230
45	155	285
50	195	340

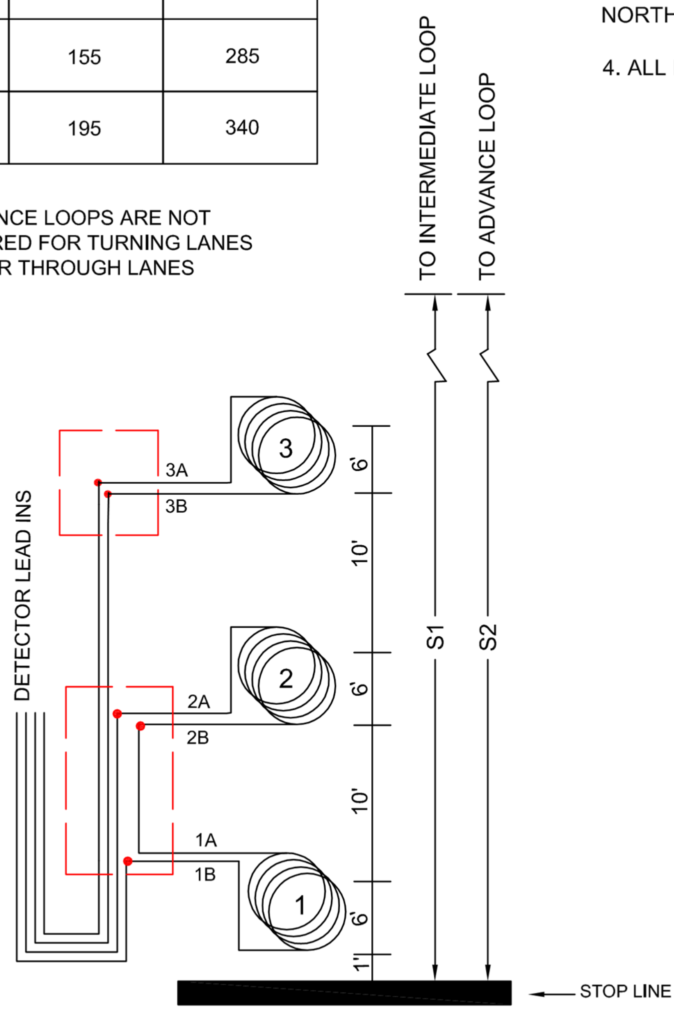
* ADVANCE LOOPS ARE NOT REQUIRED FOR TURNING LANES & MINOR THROUGH LANES

NOTES:
1. USE XYZ LOOP NUMBERING SCHEMATIC, WHERE:
X IS THE PHASE #
Y IS LANE # FROM INSIDE
Z IS LOOP # FROM STOPBAR

2. USE 3' X 25' LOOP FOR BIKE LANES

3. PHASE 2 IS ALWAYS NORTHBOUND THRU DIRECTION

4. ALL LOOPS SHALL BE CIRCULAR



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CITY OF Federal Way PUBLIC WORKS | SIGNAL LOOP SCHEMATIC | DWG. NO. 3-44

Figure 8: Federal Way Signal Loop Schematic

All project intersections have pedestrian push button detection for all pedestrian crossings.

The existing and proposed communication infrastructure to support an adaptive signal control system is described and illustrated in

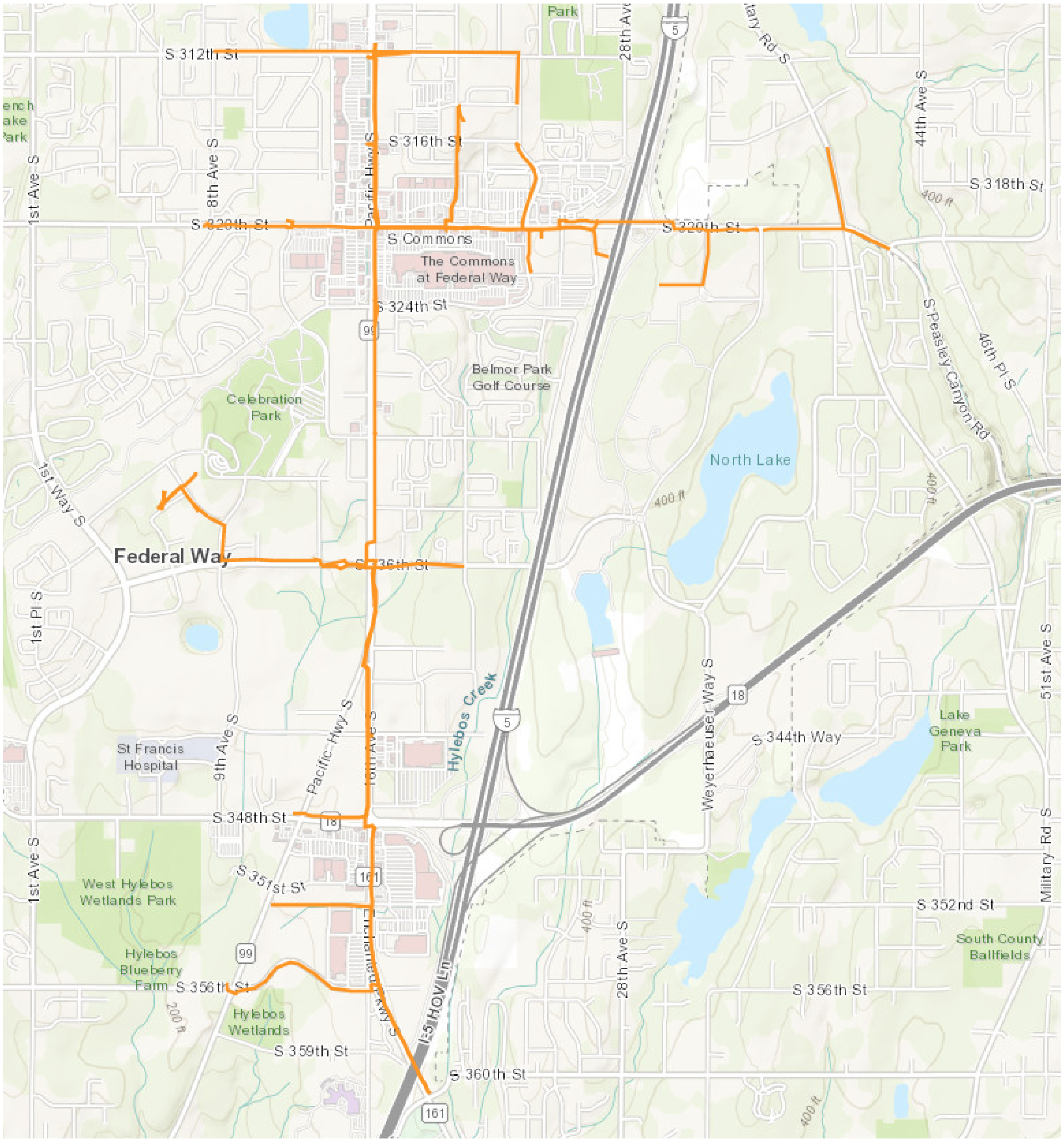

Figure 9. As a prerequisite to the adaptive signal control system that is envisioned, a complete communication system is required to support two-way communications between controllers and the central server.

At the time of installation of the ASC system, all but 5 of the included intersections will be outfitted with fiber communications. The remaining 5 intersections will have Ethernet access over copper wire. There is potential to replace copper wire with fiber within the same conduit, if budget allows.

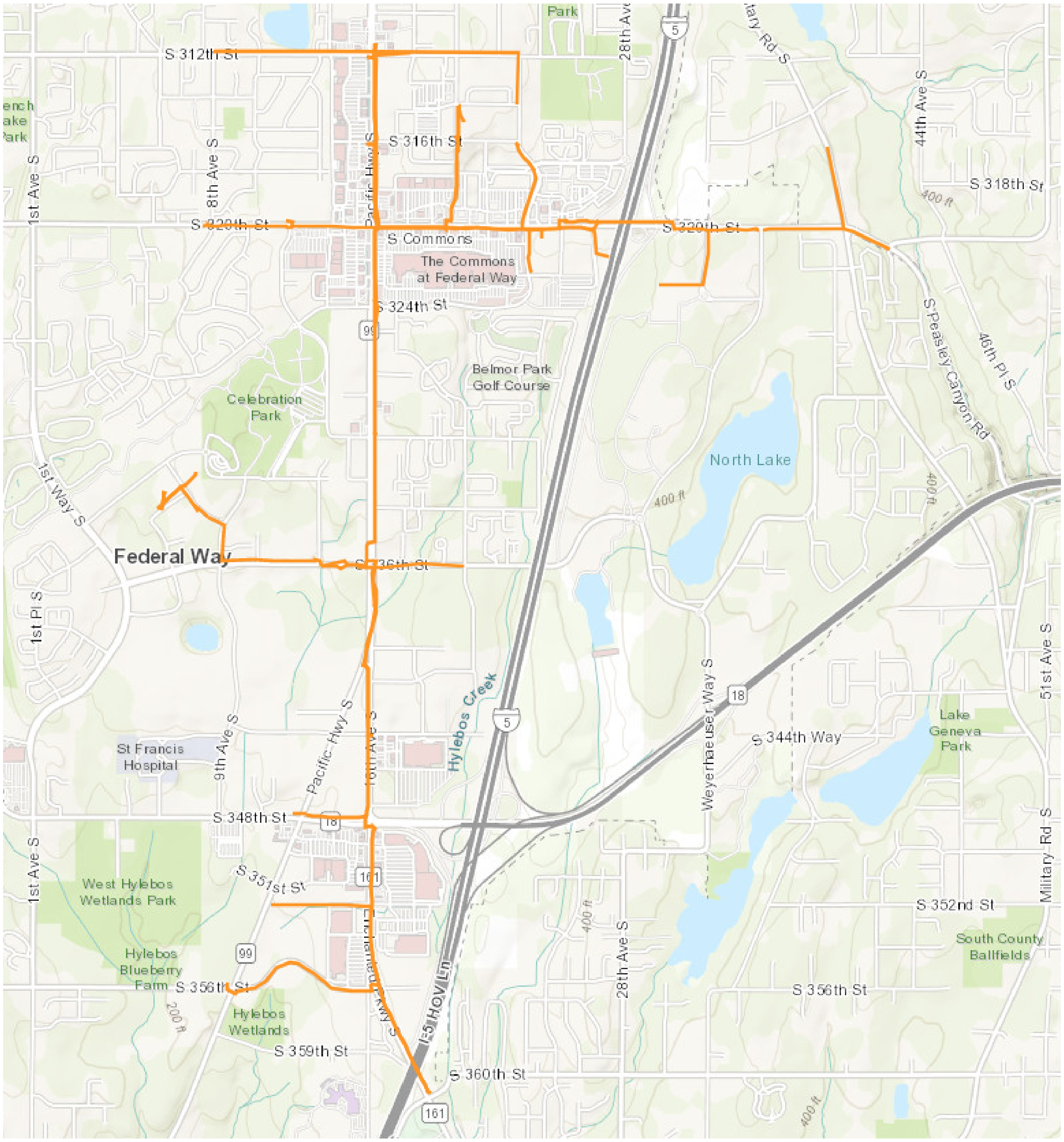

Figure 9: Existing and Proposed Communication Infrastructure

Table 8: Traffic Signal Infrastructure and Locations

Intersection	***Controller Software***	***TS2?***
S 320th Street & 25th Avenue S / Gateway Center Boulevard	Econolite ASC/3	No
S 320th Street & I-5 Southbound Ramps	NextPhase 1.7.5	NA; 332
S 320th Street & 23rd Avenue S	Econolite ASC/3	Yes
S 320th Street & I-5 Northbound Ramps	NextPhase 1.7.6	NA; 332
S 320th Street & Pete von Reichbauer Way S / 20th Avenue S	Econolite ASC/3	Yes
S 320th Street & SR 99	Econolite ASC/3	Yes
S 324th Street & SR 99	Econolite ASC/3	Yes
S 316th Street & SR 99	Econolite ASC/3	Yes
S 312th Street & SR 99	Econolite ASC/3	No
S 312th Street & 14th Avenue S	Econolite ASC/3	No
S 320th Street & 32nd Avenue S	Econolite ASC/3	Yes
S 320th Street & Weyerhaeuser Way S	Econolite ASC/3	Yes
S 320th Street & 11th Place S	Econolite ASC/3	Yes
S 320th Street & 8th Avenue S	Econolite ASC/3	No
S 320th Street / S Peasley Canyon Road & Military Road S	Econolite ASC/3	No
S Peasley Canyon Road & S 321st Street	Econolite ASC/3	No
23rd Avenue S & S 322nd Street	Econolite ASC/3	Yes
23rd Avenue S & S 317th Street	Econolite ASC/3	Yes
23rd Avenue S & S 316th Street	Econolite ASC/3	Yes
23rd Avenue S & S 314th Street	Econolite ASC/3	Yes
S 312th Street & 23rd Avenue S	Econolite Cobalt	Yes
S 312th Street & Pete von Reichbauer Way S / 20th Avenue S	Econolite ASC/3	No
Pete von Reichbauer Way S / 20th Avenue S & S 314th Street	Econolite ASC/3	Yes
Pete von Reichbauer Way S / 20th Avenue S & S 316th Street	Econolite ASC/3	No
11th Place S / 13th Place S & S 324th Street	Econolite ASC/3	No
SR 99 & S 356th St	Econolite ASC/3	Yes
SR 99 & S 352nd St	Econolite ASC/3	Yes
SR 99 & SR 18 / S 348th St	Econolite Cobalt	Yes
SR 99 & S 344th St (under construction)	Econolite Cobalt	Yes
SR 99 & 16th Ave S / S 340th Pl	Econolite Cobalt	Yes
SR 99 & S 336th St	Econolite ASC/3	Yes
SR 99 & S 330th St	Econolite ASC/3	Yes
S 348th St & 9th Ave S	Econolite ASC/3	Yes
SR 18 / S 348th St & SR 161 / Enchanted Pkwy S / 16th Ave S	Econolite ASC/3	Yes
SR 161 / Enchanted Pkwy S & S 356th St & 16th Ave S	Econolite ASC/3	Yes
SR 161 / Enchanted Pkwy S & S 352nd St	Econolite ASC/3	No
16th Ave S & S 344th St	Econolite ASC/3	Yes
9th Ave S & S 336th St	Econolite ASC/3	No
13th Pl S & S 336th St	Econolite ASC/3	Yes
20th Ave S & S 336th St	Econolite ASC/3	Yes
I-5 Southbound Off-ramp & SR 18	Unknown	NA; 332
SR 18 Westbound Off-Ramp & SR 161 / Enchanted Pkwy S	Unknown	NA; 332
SR 161 / Enchanted Pkwy S & Milton Rd S	Unknown	NA; 332
SR 161 / Enchanted Pkwy S & 19th Way S	Unknown	NA; 332

3.2 Limitations of the Existing system

The following statements summarize the limitations of the existing system that prevent it from satisfactorily accommodating the traffic situations described above:

- The existing system cannot recognize the onset of peak periods, so the peak period coordination plan introduction times are set conservatively to ensure they cover the normal variation in duration and intensity of the peak. This means that the timing is often less efficient during the early and late parts of the peak periods.
- The signal operation will need to react and accommodate existing and future transit signal priority. An adaptive system may be expected to recover from these disruptions more quickly or adjust phasing to accommodate the TSP request while maintaining coordination.
- The existing system cannot detect unexpected changes in traffic demand as a result of incidents on the adjacent interstate and special events (i.e. Wild Waves). As a result, the congestion on the arterials is greater than would be the case if the signal timing could automatically adjust to the unexpected conditions. This would also eventually reduce the need for manual intervention by operators when the incident or special event is brought to their attention.
- The existing system cannot detect high pedestrian volumes at park and ride facilities, major transit stops, and commercial areas. An adaptive system must be able to respond to high pedestrian demand.
- Existing TOD schedules cannot update based on real-time traffic information.
- The current system cannot communicate between City signals and I-5 interchange signals operated by WSDOT. An adaptive signal will detect queueing along interstate off-ramps and react appropriately.
- Without a central system linking signal clocks, the TOD plans are not changed over simultaneously, causing corridor delays. The City has noticed regular clock drift amongst signal controllers.

3.3 Proposed Improvements to the System

This section describes in broad terms the improvements that are desirable in order to address the limitations described above. The main improvements that are desired are:

- Recognize changes in traffic conditions and react quickly and automatically to accommodate those changes.
- Overcome the institutional boundaries that currently prevent the signals under the control of the different jurisdictions from operating in a coordinated fashion.
- More efficiently accommodate the speed and reliability of emergency vehicles and transit vehicles and more quickly recover from or adapt to preemption and priority.
- Improve the management of queues within the network.
- Recognize the existence of differing traffic conditions in various parts of the network and react in each section appropriately.
- Improve the productivity of staff by automating many of the routine processes.

- Keep signal timing current rather than letting its efficiency deteriorate between periodic signal re-timing efforts.
- Improve network efficiency for all modes including pedestrians, cyclist, and transit.
- Provide the ability to adjust cycle lengths with the intent of keeping the cycle length as low as possible to support pedestrian movements.
- Provide real time specified performance measures and automatic alarms alerting of signal faults.
- Ability to seamlessly fallback to existing TOD programming & return to ASC seamlessly via manual and automated methods.

3.4 Vision, Goals and Objectives for the Proposed System

3.4.1 Vision

The vision of the ASC system is to provide an advanced traffic control system that responds to changing traffic conditions; improves safety by reducing crashes; serves event traffic conditions (planned and unplanned); and reduces vehicle emissions, delays, and corridor travel times, while balancing multimodal transportation needs such as pedestrians and transit service speed and reliability.

3.4.2 Goals

The goals of the ASC system are:

- Support safety and environmental policy objectives
- Support vehicle, pedestrian and transit traffic mobility
- Provide measurable improvements in personal mobility
- Support interoperability between agencies
- Support regional systems
- Manage vehicle incidents
- Meet a timely project implementation schedule

3.4.3 User Objectives

The objectives of the adaptive system that support the stated goals are:

To support safety and environmental policy objectives:

- Reduce vehicle emissions through improvements in appropriate determinants, such as vehicle stops and delays
- Reduce collisions, including fatal and serious injury crashes through the improvement of traffic mobility

To support vehicle, pedestrian and transit traffic mobility:

- Be capable of supporting priority operations for existing and proposed TSP intersections
- Allow effective use of all controller features currently in use or proposed to be used
- Minimize adverse effects caused by preemption and unexpected events and incidents

- Minimize adverse effects cause by foreseeable events including construction activities and maintenance
- Allow for variable cycle lengths to support intersections with high pedestrian activity

To support measurable improvements in personal mobility:

- Adjust operations to changing conditions
- Reduce delays at intersections, number of stops, and manage queue lengths
- Reduce travel times, maximize green time utilization, and mitigate phase failures
- Maintain transit schedules and/or headways
- Decrease transit travel times
- Provide, at minimum, the same level of safety provided by the existing system to vehicles, pedestrians and transit

To support agency interoperability:

- Provide data exchange between systems such as transit and signal operations data
- Provide control between systems such as TSP incorporation and pedestrian calls
- Allow remote monitoring and control
- Provide a user-friendly interface that allows remote monitoring and control
- Adhere to applicable traffic signal and ITS design standards

To support regional systems:

- Be compliant with the regional ITS architecture (Puget Sound Regional Council)
- Be compatible with Layer 3 IP Scheme architecture
- Allow center-to-center and system-to-system communication
- Accommodate regional traffic control system objectives such as ramp meter queuing by deploying ramp detection or integrating with WSDOT ramp meter cabinets to mitigate on-ramp queues spilling onto City roadways
- Operate with existing signal systems with minimal re-wiring
- Have the ability to report traffic conditions for mobile applications and third-party use (i.e., Google maps)
- Compatible with WSDOT ITS systems and able to integrate with future City owned ITS systems.

Manage vehicle incidents:

- Be able to adjust operation for incidents within the system that impact capacity of the system
- Be able to adjust operation for incidents outside the system that impact the traffic volume of the system

To support a timely schedule:

- Be sufficiently mature and robust that risk is low and little or no development time will be required
- Be ready for full operation by June 2020

3.4.4 Operational Objectives

The operational objectives of the ASC system will be to:

- Smooth the flow of traffic along coordinated routes minimizing number of stops
- Maximize the throughput of people including those using personal, commercial, and transit vehicles along coordinated routes
- Minimize transit delay
- Equitably serve adjacent land uses while maintaining flow along the coordinated route
- Manage queues, to prevent excessive queuing from reducing efficiency
- Control operation using a combination of these objectives
- Control operation by changing the objectives under various circumstances
- For a critical isolated intersection, maximize intersection efficiency
- During peak periods, maximize the throughput of traffic along coordinated routes in the direction with the heaviest flow and provide smooth flow in the opposing direction between critical intersections
- During non-peak periods, equitably serve phase times at critical intersections
- Accommodate pedestrian and cyclist movements
- Improve air quality
- Reduce collision rate
- Reduce collision severity
- Improve LOS, arrivals on green, and travel time reliability
- Reduce delay, arrivals on red, and travel times

3.5 Strategies to be Applied by the Improved System

The adaptive coordination and control strategies that may be employed to achieve the operational objectives are:

- Provide a pipeline along a coordinated route to maximize the person throughput during periods of high demand
- Provide a pipeline along a coordinated route to smooth the flow of traffic in one or both directions
- Distribute phase times in a way that equitably shares the green time between various movements and minimizes the risk of phase failures
- Manage queues so they do not exceed the available storage capacity and are located so they do not affect the capacity of other movements
- Manage the distribution of green times for vehicles (including transit) and pedestrians in an equitable manner

- Recognize major influx of vehicles (such as during an incident on I-5) and support clearing of these vehicles
- Employ a combination of these strategies when they are compatible

3.6 Alternative Non-Adaptive Strategies Considered

3.6.1 Enhanced Time-Based Coordination

The current signal system operates on time-based plans that change throughout the day based on a set schedule. To enhance the coordination of these time-based plans, GPS time synchronization components can be installed at each controller. Regular timing maintenance will be accomplished using traffic counts and updated timing plans.

The signal upgrade costs for this strategy is less expensive than an adaptive system, however, pre-defined timing plans are conservative for large blocks of time and cannot accommodate variations in traffic volumes leading to wasted green time. The system also cannot be accessed remotely for monitoring and timing adjustment. Therefore, the strategy does not satisfy the vision and goals of the stakeholders.

3.6.2 Traffic Responsive Plan Selection

A Traffic Responsive Plan Selection (TRPS) system is a closed-loop traffic control system with plan decision logic built into a master controller. The master controller uses vehicle detection data to measure vehicle traffic and selects a pre-configured plan accordingly. The timing plan change is then communicated to all signals associated with the master. Typically, a TRPS system begins a change after 10 minutes of vehicle data collection, then enacts the change to the local controllers over a period of 1 to 3 cycles. The new plan typically remains in place for a minimum of 10 minutes.

The City of Federal Way has considered TRPS implementation, but has ruled out the strategy due to the limitations of effectiveness. The main disadvantage of TRPS is its slow reaction time to changing traffic conditions. If the system changes too often as expected along the proposed corridors, the signal operation is in a constant transition period between signal plans that are no longer relevant leading to minimal progression. City of Federal Way has identified this as a major concern and therefore TRPS is not ideal for the changing traffic conditions of the corridors.

3.6.3 Complex Coordination Features

The following features are currently used in coordination patterns. These features will need to remain available in fallback operation should the ASC fail.

- Multiple (repeat) phases or phase reservice
- Variable phase sequence
- Omit phase under some circumstances, such as flashing yellow arrow
- Detector switching
- Coordinate different phases at different times
- Coordinate turning movement phases

- Coordinate beginning or end of green
- Hold the position of uncoordinated phases
- Rest-in-walk
- Double cycle or half cycle
- Transit signal priority, including:
    - Phase extensions
    - Early green
    - Omitting a phase in a cycle

The following features have not been used in the current coordination patterns, however, these features may be accommodated in the future.

- Dynamic message signs
- Early release of hold
- Hold the position of uncoordinated phases
- Dynamic max
- Dynamic lane configurations

The following features have not been used in the current coordination patterns.

- Late phase introduction

Chapter 4: Operational Needs

This chapter describes the operational needs of the users that should be satisfied by the proposed ASC system. Each of these statements describes something that the system operators need to be able to achieve. Each of these needs will be satisfied by compliance with one or more system requirements. In the attached list of requirements, each one is linked to one or more of these needs statements.

Con Ops Reference #	Concept of Operations Statement
4.1	4.1 Adaptive Strategies
4.1.0-1	The system operator needs the ability to implement different strategies individually or in combination to suit different prevailing traffic conditions. These strategies include:
4.1.0-1.0-1	• Maximize the person throughput on coordinated routes in the primary mainline direction during peak commute periods while also providing smooth flow in the secondary mainline direction.
4.1.0-1.0-2	• Provide smooth flow along coordinated routes.
4.1.0-1.0-3	• Distribute phase times in an equitable fashion to accommodate demand.
4.1.0-1.0-4	• Manage the lengths of queues.
4.1.0-1.0-5	• Manage the locations of queues within the network.
4.1.0-1.0-6	• At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives). For example, the signal at 11th Pl S and S 324th St may operate as a standalone signal based on the season.
4.1.0-1.0-7	• Integrate TSP technology to support transit vehicle speed and reliability.
4.1.0-2	The system operator needs to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections.
4.1.0-3	The system operator needs to change the operational strategy (for example, from smooth flow to maximizing person throughput or managing queues) based on changing traffic conditions.
4.1.0-4	The system operator needs to detect repeated phase failures and control signal timing to prevent phase failures building up queues. The operator in this case is trying to prevent a routine queue from forming where it will block another movement in the cycle unnecessarily. For example, the operator may need to prevent a queue resulting from the trailing end of the through green from blocking the storage needed by an entering side-street left turn in the subsequent phase.
4.1.0-5	The system operator needs to minimize the chance that a queue forms at a specified location.
4.1.0-6	The system operator needs to modify the sequence of phases to support the various operational strategies.
4.1.0-7	The system operator needs to fix the sequence of phases at any specified location. For example, the operator may need to fix the phase order at a diamond interchange.
4.1.0-8	The system operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.
4.1.0-9	The system operator needs to set signal timing parameters (such as minimum green, maximum green and extension time) to comply with agency policies. The controller

Con Ops Reference #	Concept of Operations Statement
	could initiate changes based on time-of-day limitations or boundaries, changing when measured demand fluctuates.
4.2	4.2 Network characteristics
4.2.0-1	The system operator needs to adaptively control 44 signals as part of this project. The adaptive system shall be capable of expanding to accommodate up to 100 signals.
4.2.0-2	The system operator shall be able to adaptively control a user-defined, variable number of signal groups. The agencies envision 6 signal groups for this current deployment as shown in Figure 10.
4.2.0-3	The system operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.
4.3	4.3 Coordination across boundaries
4.3.0-1	The system operator needs to adaptively control signals currently owned by multiple agencies including the City of Federal Way, King County, and WSDOT. The City of Federal Way's signals are operated by the City, but maintained by the County. The existing ownership of signals has been identified in Figure 1. The intent of this project is to reach a general operations and maintenance agreement with WSDOT to support adaptive signal operations across all project signalized intersections. King County Roads will still maintain a maintenance agreement with the City.
4.3.0-2	The system operator needs to detect and accommodate vehicles entering and exiting the primary corridor at interstate interchanges.
4.3.0-3	The system operator needs to adaptively coordinate signals on two crossing routes simultaneously including, but not limited to, the following locations: S 320th St and SR 99, S 336th St and SR 99, S 348th St and SR 161, and S 348th St and SR 99.
4.3.0-5	The system operator needs the ability to constrain the adaptive system to operate a cycle length compatible with the crossing arterial.
4.4	4.4 Security
4.4.0-1	The system operator needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the City's access and network infrastructure security policies. WSDOT and King County access levels and security requirements will be negotiated and stated in an interagency agreement.
4.5	4.5 Queuing interactions
4.5.0-1	The system operator needs to detect and mitigate queues from outside the system and modify the ASC operation to accommodate the queuing. For example, the system operator shall be able to detect queues on off-ramps and can modify signal timing of crossing arterials to minimize queuing onto the mainline of these facilities. Another example would be detecting large volumes of egressing traffic from park and rides such as at the Federal Way Transit Center.
4.5.0-2	The system operator needs to detect queues within the system's boundaries and modify the ASC operation to accommodate the queuing. Detection at intersections adjacent to the adaptive signal system boundaries may be utilized for this purpose.
4.5.0-3	The system operator needs to detect queues propagating outside its boundaries from within the ASC boundaries, and modify its operation to accommodate the queuing.

Con Ops Reference #	Concept of Operations Statement
4.5.0-4	The system operator needs to store queues in locations where they can be accommodated without adversely affecting adaptive operation.
4.5.0-5	The system operator needs to prevent queues forming at user-specified locations.
4.6	4.6 Pedestrians
4.6.0-1	The system needs to adaptively recover after infrequent pedestrian calls.
4.6.0-2	The system operator needs to accommodate infrequent pedestrian operation while maintaining adaptive operation.
4.6.0-3	The system operator needs to incorporate frequent pedestrian operation into routine adaptive operation. Frequent pedestrian operation will occur at: • Intersection grouping near the Federal Way Transit Center • Intersections just south of Federal Way High School • Intersections near Truman High School • Intersections near Todd Beamer High School • Intersections near social service agencies and retail uses • SR 99/S 320th St, SR 99/S 348th St, and 16th Ave S/S348th St intersections
4.6.0-4	The system operator needs to accommodate the following custom pedestrian features: • Walk extension – not currently used • Pedestrian recycle/reservice • Rest-in-walk • Negative pedestrian overlap • Early start of walk • Late start of walk • No pedestrian service on FYA (hold the call, but don't service until FYA is omitted) • Pedestrian recall • Secondary walk (for bike off loop)
4.6.0-5	The system operator needs to accommodate leading pedestrian intervals.
4.6.0-6	The left turn permissive phase may be altered to not allow vehicles through when the pedestrian phase is active.
4.7	4.7 Non-adaptive situations
4.7.0-1	The system operator needs to detect traffic conditions during which adaptive control is not the preferred operation, and implement a pre-defined operation while that condition is present (e.g., run free during late-night hours when volumes are low).
4.7.0-2	The system operator needs to schedule pre-determined operation by time-of-day.
4.7.0-3	The system operator needs to over-ride adaptive operation.
4.8	4.8 System responsiveness
4.8.0-1	The system operator needs to modify the ASC operation to closely follow changes in traffic conditions.
4.8.0-2	The system operator needs to constrain the selection of cycle lengths to those that provide acceptable operations, such as when resonant progression solutions are desired.
4.8.0-3	The system operator needs to respond quickly to sudden large shifts in traffic conditions.
4.9	4.9 Complex coordination and controller features

Con Ops Reference #	Concept of Operations Statement
4.9.0-1	The system operator needs to implement the following advanced controller features while maintaining adaptive operation:
4.9.0-1.0-1	• Service a phase more than once per cycle
4.9.0-1.0-2	• Operate at least 8 overlap phases, 4 rings, 16 phases, and a user-specified number of phases per ring for consistency with the NEMA standard.
4.9.0-1.0-3	• Permit different phase sequences under different traffic conditions and by TOD.
4.9.0-1.0-4	• Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.
4.9.0-1.0-5	• Protected/permissive, flashing yellow protected/permissive, and permissive only phasing for left turn phase sequences. In regards to FYA permissive operations, the operator needs to turn off the FYA based on occupancy of opposing through lanes (e.g. omit flashing yellow arrow when opposing movement occupancy is 90% or greater).
4.9.0-1.0-6	• Allow flashing yellow arrow to change to protected-only, activated by pedestrian call. Return to flashing yellow arrow after pedestrian phase ends.
4.9.0-1.0-7	• Allow delay in the flashing yellow arrow during a permissive left turn.
4.9.0-1.0-8	• Prevent one or more phases being skipped under certain traffic conditions or signal states.
4.9.0-1.0-9	• Allow the operator to permit phases or overlaps by TOD or external input.
4.9.0-1.0-10	• Allow any phase to be designated as the coordinated phase.
4.9.0-1.0-11	• Allow the controller to respond independently to individual lanes of an approach.
4.9.0-1.0-12	• Allow the coordinated phase to terminate early under prescribed traffic conditions.
4.9.0-1.0-13	• Allow flexible timing of non-coordinated phases (such as late start of a phase) while maintaining coordination.
4.9.0-1.0-14	• Allow dynamic max green time to increase or decrease the max green time dynamically based on max out or gap out termination.
4.9.0-1.0-15	• Allow variable cycle operation (i.e., double, double asymmetrical, or half) to better serve pedestrians.
4.9.0-1.0-16	• Allow operation of external devices using discrete signal outputs (e.g., dynamic lane and blank-out signs).
4.9.0-1.0-17	• Service side streets and pedestrian phases at minor locations more often than at adjacent signals when this can be done without compromising the quality of the coordination (e.g., double-cycle mid-block pedestrian crossing signals).
4.9.0-1.0-18	• Allow detector logic at an intersection to be varied depending on local signal states.
4.9.0-1.0-19	• Allow the operator to specify which phase receives unused time from preceding phases.
4.9.0-1.0-20	• Run free, adaptive, and set timing plans based on set thresholds, external input, and

Con Ops Reference #	Concept of Operations Statement
	TOD at a signal group or isolated intersection basis.
4.9.0-1.0-21	• Operate within various style cabinets, including but not limited to 332 cabinets, 332D, and NEMA, operating along a corridor with multiple lanes and disproportionate lane utilization.
4.9.0-1.0-22	• Allow mid-block pedestrian crossing integration that may include RRFBs and HAWK Signals.
4.9.0-1.0-24	• Allow negative pedestrian phasing to prevent an overlap conflicting with a pedestrian walk/don't walk.
4.9.0-1.0-25	• Allow pedestrian re-cycle or rest in walk capabilities under coordination and free operation.
4.9.0-1.0-26	• Support extended pedestrian walk/FDW timing.
4.9.0-1.0-27	• Support accessible pedestrian signals (APS).
4.9.0-1.0-31	• Provide conditional service for all phases including phase selections outside of the standard ring structure.
4.9.0-1.0-32	• Run fully actuated coordination.
4.9.0-1.0-33	• Alternate cycle coordination with variable cycles.
4.9.0-1.0-34	• Export average cycle lengths, offsets, and splits to Synchro for selected time periods.
4.9.0-1.0-35	• Run split monitoring to produce monitoring and reporting data (i.e., phase termination codes, pedestrian calls, coordinator status, plan transition times and average cycle lengths). Splits may be determined from the most trafficked lane.
4.9.0-1.0-38	• Maintain coordination while running trailing greens with overlaps and after preemption events.
4.9.0-1.0-39	• Variable Lane Assignment – Ability to dynamically group and ungroup lanes such as a shared left-thru lane with split phasing during the morning peak, changing to a through lane only at all other times. Examples include: 1. S 348th St and Enchanted Pkwy northbound direction may alternate through and left turn lane allocation based on queue detection. 2. 11th Pl S and S 320th St intersection may operate under split phase. 3. SR 99 and S 324th St intersection may support dynamic lane grouping.
4.10	**4.10 Monitoring and control**
4.10.0-1	The system operator needs to monitor and control all required features of adaptive operation from the following locations:
4.10.0-1.0-1	• Federal Way TMC located at Federal Way City Hall
4.10.0-1.0-2	• WSDOT NW Region TMC located in Shoreline, WA

Con Ops Reference #	Concept of Operations Statement
4.10.0-1.0-3	• King County TMC located in Seattle, WA
4.10.0-1.0-4	• WSDOT Maintenance Facilities
4.10.0-1.0-5	• King County Maintenance Facilities
4.10.0-1.0-6	• Workstations on City's LAN or WAN including connection for interagency monitoring and data sharing purposes with WSDOT, King County Roads, and King County Metro
4.10.0-1.0-7	• Full control of signal operations at local signal controller
4.10.0-1.0-8	• Mobile workstations/handheld devices – including those used by King County signal technicians
4.10.0-1.0-9	• Capability of displaying on a web browser
4.10.0-2	WSDOT and King County Roads (signal operations) shall have monitoring and reporting access. Operators need to access to the database management, monitoring and reporting features, log files, and functions of the signal controllers and any related signal management system from the access points defined for those system components. Privileges shall be defined further in interagency agreements.
4.10.0-3	The system operator needs a time stamp log of all changes to the system by the associated user/agency.
4.10.0-4	The system operator needs to allow features of the system to be accessible and configurable by agencies with control rights of the associated signalized intersection(s).
4.10.0-5	The system operator needs to provide read-only privileges to specified agencies (e.g. King County Metro).
4.11	4.11 Performance reporting
4.11.0-1	The system operator needs to store and report high-resolution enumeration data used to calculate signal timing performance measures and have the data available for subsequent analysis.
4.11.0-2	The system operator needs to monitor Automated Traffic Signal Performance Measures (ATSPMs) and provide this information to invested stakeholders.
4.11.0-3	The system operator needs to store and report data that can be used to measure traffic performance under adaptive control.
4.11.0-4	The system operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data using UTDF format to Synchro and also export selected data using .txt, .csv, .xml, MS SQL, PDF, or MS Excel.
4.11.0-5	The system operator shall be capable of reporting performance data in real time to an Application Programming Interface (API).
4.11.0-6	The system operator needs to be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.
4.11.0-7	The system operation needs the ability to generate historic and real-time reports that effectively support operation, maintenance, reporting, and validation of system performance and traffic conditions.
4.11.0-8	The system operator needs a user-friendly GUI which provides easy and quick access to real time and historical graphical representations and spreadsheets of the performance measures.
4.11.0-9	The system operator needs all parameters, variables and constants, and intermediate

Con Ops Reference #	Concept of Operations Statement
	calculations to be easily and promptly accessible and exportable in a .txt, .csv, .xml, PDF, or MS Excel format.
4.12	4.12 Failure notification
4.12.0-1	The system operator needs to immediately notify maintenance and operations staff of alarms and alerts.
4.12.0-2	The system operator shall be capable of immediately and automatically pass alarms and alerts by designated means as desired by the agency for future external systems.
4.12.0-3	The system operator needs to maintain a complete log of alarms and failure events.
4.13	4.13 Preemption and priority
4.13.0-2	The system operator needs to accommodate emergency vehicle IR and GPS preemption.
4.13.0-3	The system operator needs to accommodate transit signal priority via existing King County Metro roadside Transit Priority Request Generator (TPRG), proposed King County Metro detector card (Center-to-Infrastructure), proposed King County Metro TSP System Server (Center-to-Center), existing Pierce Transit IR phase selector card, and proposed Pierce Transit GPS-based TSP system. Note that Pierce Transit's proposed system has not yet been fully determined, but is envisioned to utilize radio-based communications that communicate to the signal controller via standard discrete inputs.
4.14	4.14 Failure and fallback
4.14.0-1	The system operator needs the system to fall back to central system control, TOD, or isolated free operation, as specified by the operator, without causing disruption to traffic flow in the event of equipment, communications, and software failure. Base timings used in fallback operations will be user specified or based on historical data. The controller will respond to failure by returning to base timings within 3 to 4 cycles.
4.15	4.15 Constraints
4.15.0-1	The system operator is constrained to use the following equipment:
4.15.0-1.0-1	Controller type: • 2070 • NEMA – Econolite ASC/3 and Cobalt
4.15.0-1.0-2	Detector type: • Inductive Loop • Video Detection, including fisheye, 360 cameras • Radar/Microwave
4.15.0-1.0-3	Communication system • Fiber (Point-to-Point and Redundant Ring) • Fiber patch panels • Fiber (Ethernet) switches • Copper (Point-to-Point and Redundant Ring) • Copper to Fiber Converter
4.15.0-1.0-4	Cabinet type and size • Type 332 Cabinets – 67" H x 24" W x 30" D • Type 332D Cabinets – 67" H x 49" W x 30" D

Con Ops Reference #	Concept of Operations Statement
	• NEMA – R Cabinets – 77" H x 44" W x 26", D Cabinet – SR 161 and S 352nd St
4.15.0-1.0-5	Signal management system (ACST software can run in coordination with, independently, or replace the existing signal management systems.) • Siemens TACTICS Central Traffic Management Software • Siemens i2TMS Central Traffic Management Software • Intelight MaxView ATMS Software • Econolite Centracs and Centracs Lite
4.15.0-2	The system operator needs to use equipment and software acceptable under current City IT policies and procedures.
4.16	4.16 Training and support
4.16.0-1	Federal Way, King County, and WSDOT need all staff involved in operation and maintenance to receive appropriate training.
4.16.0-2	Federal Way, King County, and WSDOT need the system to fulfill all requirements for the life of the system. Therefore, the system needs to be maintained to repair faults that are not defects in materials and workmanship.
4.16.0-3	Federal Way, King County, and WSDOT need the system to fulfill all requirements for the life of the system. Therefore, the system needs to remain free of defects in materials and workmanship that result in requirements no longer being fulfilled.
4.16.0-4	Federal Way, King County, and WSDOT need the system to fulfill all requirements for the life of the system. The agencies therefore need support to keep software and software environment updated as necessary to prevent requirements no longer being fulfilled.
4.17	4.17 External interfaces and special functions
4.17.0-1	The system operator needs to be able to activate dynamic lane signs, variable message signs, and blank-out signs that control traffic or provide driver information when specific traffic conditions occur, when needed to support the adaptive operation, when congestion is detected at critical locations or according to a time-of-day schedule.
4.17.0-2	The system operator needs to react to external inputs such as Center-to-Center TSP request messages from King County Metro that are based on the NTCIP 1211 standard, and data from the Sound Transit parking management system installed at the Federal Way Transit Center parking garage facility.
4.17.0-3	The system operator needs to support deployment of Signal, Phase, and Timing (SPaT) and MAP messaging.
4.18	4.18 Maintenance
4.18.0-1	King County Roads needs all applicable equipment to be readily accessible for replacement and repairs.

Chapter 5: Envisioned Adaptive System Overview

This section describes the envisioned adaptive system. The envisioned adaptive system is defined by the size and grouping of intersections, operational objectives, fallback operation, crossing routes and adjacent systems, operator access, and complex coordination and controller operation.

5.1 Size and grouping

The City has plans to adaptively control up to 44 intersections under this project with a potential to add on an additional 40 intersections or more at a later date. Considering current traffic conditions, the City prefers to maintain 6 signal groups with 3 signals tied to their nearby group, as shown in Figure 10. The three primary groups include S 320th St, SR 99, and Enchanted Parkway S. These groups however can change based on grouping defined by the operator. A group of intersections may be comprised of simply one intersection, or up to the total number of intersections that are sufficiently close to warrant coordination under the prevailing traffic conditions. During some traffic conditions, there may be separate groups of intersections operating with different characteristics (e.g., different cycle lengths, some coordinated some not, offsets in different directions). During periods when traffic conditions are similar or operating characteristics (such as cycle length) are similar, or traffic volumes on the coordinated route are heavier, different groups may be formed or specified by the operator.

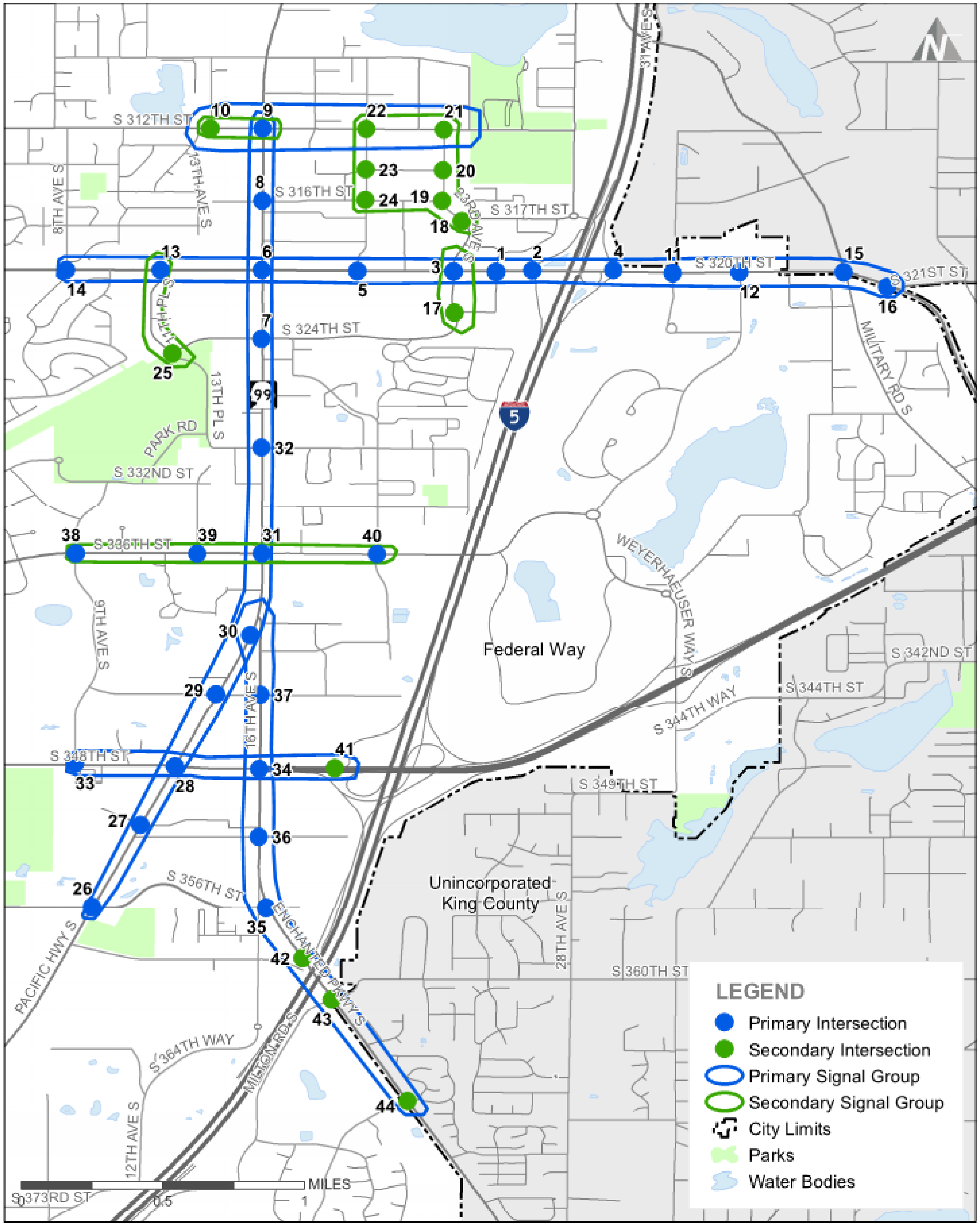

Figure 10: Envisioned Adaptive Signal Grouping

5.2 Operational objectives

The objective of the coordination will vary depending on traffic conditions, signal grouping, and public transit operation. These objectives could include:

- Provide for smooth flow along the corridors, minimizing the number of stops experienced by vehicles traveling along the road. Where "natural" cycle lengths exist that permit two-way progression, the system will generally operate at one of those cycle lengths unless longer phase lengths are required to accommodate the demand.
- Maximize the person throughput along the coordinated route. This may involve a tradeoff that increases delay to cross streets that are not coordinated and turning movements in order to maximize the green time provided to coordinated traffic flows. This also intends to incorporate transit vehicle ridership into signal operation such as through NTCIP 1211 messaging.
- Control traffic in a manner that equitably serves the adjacent land uses. The delays experienced by the traffic entering and leaving the coordinated route will be balanced with the delays and stops experienced by other traffic traveling along the route.
- Manage the lengths of queues stored at critical locations within the coordinated group so that long queues do not block upstream intersections or otherwise reduce the capacity available during the green phases. This will involve controlling phase lengths so that the size of platoons entering a downstream block does not exceed the storage length if the platoon will be stopped. It will also involve control of offsets and phase lengths so that queues may be stored in locations where they will not adversely affect capacity of the system.

The system, or the operator, will select the appropriate coordination objective, depending on the current traffic conditions. For example, during commuter peaks the primary objective may be to maximize the person throughput along the road in the peak direction. Then during the business hours the objective may be to balance delays between traffic associated with the adjacent activity and traffic simply traveling through the system.

The operator will be able to define for each group of intersections the appropriate operational objective. For example, near a freeway interchange or in a location with heavy turning movements, the queue management strategy may be specified, while on an arterial with long signal spacing the smooth flow objective may be specified.

During moderate to light traffic conditions, one or more phases may be omitted (e.g., a protected phase if protected/permissive left turns are operated), in order to more efficiently serve other movements, provided it is safe to do so. This may be accomplished through a time-of-day schedule or based on the measured traffic conditions.

Depending on the particular ASC system, it may be possible for the operator or system to redistribute unused green time. For example, if a phase is to be skipped, the operator or system can specify that the spare time will be added to the existing phase, the following phase or the next coordinated phase.

At an isolated intersection with widely varying traffic patterns and a high degree of saturation during peak times, the system will calculate the optimum cycle length, phase sequence and phase times in real time to match the changing traffic conditions.

At a small group of intersections, with the user defining one as being critical, while the adjacent intersections require a lower cycle length or progression must be provided for specific phases to minimize the formation of queues on the approaches to the critical intersection, the phase lengths of the critical intersection will be determined by the system based on the current traffic conditions. The operation of the adjacent intersections will then be set so that platoons departing the critical intersection are progressed through the non-critical intersections, or platoons arriving at the critical intersection do so at a time when they will have little or no delay waiting for the appropriate phase.

The ASC system will work in conjunction with existing and planned Transit Signal Priority (TSP) systems to provide prioritized green time distribution while striving to meet the user-defined schedules and/or headways. The TSP system could be deployed locally at the intersection using TSP equipment or established through a Center-to-Center (C2C) connection between a centralized TSP system and the ASC system.

5.3 Fallback operation

The system shall have a fallback state that allows coordination using a common cycle length for all signals within a coordinated group or run the operation based on historical operation data for the same time-of-day and day of the week.

5.4 Crossing routes and adjacent systems

A coordinated group will be able to include more than one coordinated route, such as two crossing arterials. The system will be able to maintain coordination along both roads. The major crossing arterials occur at Enchanted Parkway S/S 348th St, SR 99/S 348th St, SR 99/S 336th St, and SR 99/S 320th St.

The operating agency also needs the adaptive system to maintain coordination with another adjacent system either by sensing arriving traffic or by using constraints on cycle length. At WSDOT interchanges (located at SR 18/SR 161, I-5/S 336th St, and I-5/S 320th St), the ASC system will need to incorporate non-intrusive detection at the on-ramp terminals to optimize signal timing at the ramp signals. Under a congested scenario, the ASC will provide green time for other phases, where possible, to avoid overloading the ramp and wasted green time.

5.5 Operator access

Operators, traffic engineering, and maintenance staff will be assigned different levels of authority, and access to equipment and software for which they are authorized, based on their roles and responsibilities. This will allow them to control, view, monitor, and analyze the operation of the system as appropriate.

The system will be connected to City of Federal Way's LAN, allowing access to all authorized users within City of Federal Way as well as partner agencies including WSDOT and King County Roads. King County Roads signal technicians will require local and remote access to make modifications and respond to system failures and faults. WSDOT and King County Roads signal operators will be given remote monitoring and reporting access using a desktop interface. Interagency agreements will be set in place to determine how changes are to be made to the system.

5.6 Complex coordination and controller operation

The agency will use the following complex coordination and controller features:

1. The ability to repeat a phase, such as running a left turn phase before and after its opposing through movement.
2. Provision for the required number of rings, phases, phases per ring, and overlap phases.
3. The ability to operate different phase sequences based on different traffic conditions or by time-of-day.
4. The ability to omit a phase under some traffic conditions or based on external input to allow a shorter cycle length to operate, or to provide additional time to other phases.
5. The ability to use protected/permissive, flashing yellow protected/permissive, and permissive only phasing based on adaptive operation, TOD, and monitoring congestion/headway values.
6. The ability to delay the permissive left turn of a flashing yellow arrow until the conflicting pedestrian movement has cleared.
7. Ability to delay flashing yellow arrow based on occupancy of opposing lanes.
8. The ability to maintain coordination with external movements by preventing phases from being skipped, or by omitting phases, based on time-of-day, external input or when certain phase sequences are in operation.
9. The ability to permit certain phases or overlaps by time-of-day schedule or external input.
10. The ability to designate any appropriate phases as coordinated phases.
11. The ability to separately monitor each lane on an approach and take different action depending on the conditions measured in each lane. The most congested lane would determine splits. This may be implemented in the signal controller using extension/passage timers, which may be assignable to each vehicle detector input channel. This may allow the adaptive operation to be based on data from a specific detector, or by excluding specific detectors.
12. The ability to allow the coordinated phase to terminate early if the coordinated platoon is short.
13. The ability to introduce a non-coordinated phase later than its normal starting point within a cycle, if it can be served with minimum green within the remaining time available.
14. The support for variable cycle operation (i.e., double or half) to better serve pedestrians.
15. Ability to accommodate asymmetrical double cycle with 12 phases.
16. The agency may operate external devices using discrete signal outputs from the ASC including occupancy on a detector, cycle length, and time-of-day. Example external devices could include "no turn on red" blank-out signs and dynamic lane assignment signs.
17. The ability to service side streets and pedestrian phases at minor locations more often than at adjacent signals when this can be done without compromising the quality of the coordination (e.g., double-cycle mid-block pedestrian crossing signals).
18. Ability to vary detector logic at an intersection depending on local signal states.
19. Ability to specify which phases receive unused time from preceding phases.

20. Ability to run free, adaptive, and set timing plans based on set thresholds, external input, and TOD at a signal group or isolated intersection basis.
21. Ability to operate within various style cabinets including but not limited to 332 cabinets, 332D, and NEMA, operating along a corridor with multiple lanes and disproportionate lane utilization.
22. Support mid-block pedestrian crossing integration that may include RRFBs and Hawk Signals.
23. Leading pedestrian intervals at user defined locations.
24. Ability to use negative pedestrian phasing to prevent an overlap conflicting with a pedestrian walk/don't walk under FYA and free operation.
25. Pedestrian re-cycle or rest in walk capabilities under coordination and free operation.
26. Ability to support extended pedestrian walk/FDW timing.
27. Ability to support accessible pedestrian signals (APS).
28. Ability to support transit priority and preemption, including but not limited to light rail and bus.
29. Ability to support exclusive bike phasing.
30. Support for arterial flow map, data capture and smoothing.
31. Ability to provide conditional service.
32. Ability to run fully actuated coordination.
33. Ability to alternate cycle coordination with variable cycles.
34. Ability to export average cycle lengths, offsets, and splits to Synchro for selected time periods.
35. Ability to run split monitoring to produce data (i.e., phase termination codes, pedestrian calls, coordinator status, plan transition times and average cycle lengths).
36. Support emergency vehicle pre-emption.
37. Ability to maintain coordination while running trailing greens with overlaps and after preemption events.
38. Ability to dynamically group and ungroup lanes such as a shared left-thru lane with split phasing during the morning peak, changing to a through lane only at all other times.

Chapter 6: Adaptive Operational Environment

6.1 Operating Environment

The adaptive signal control system will be installed, operated, and monitored from the Federal Way City Hall. King County Roads and WSDOT will have remote access for operation and monitoring purposes as described in the interagency Service Level Agreement. WSDOT will have remote access to the system for monitoring and reporting purposes of signals not under WSDOT ownership. The City of Federal Way, as part of this project, is constructing a Traffic Management Center (TMC) at their City Hall. The TMC will include a workstation supporting a user interface to the ASC system. The City has an environmentally-controlled equipment room suitable for housing the ASC system. Remote access to operate and monitor the system shall also be available at King County Road's signal shop and signal technician mobile workstations.

In addition to the operating environments at City of Federal Way, off-hour access will be available from a workstation located at WSDOT's NW Region TMC in Shoreline, WA. This will allow WSDOT staff to monitor the signal timing operations, retrieve data related to I-5 interchange operations within the project limits, and adjust ASC signal operations described in an interagency agreement.

6.2 Equipment Compatibility Constraints

The central server will be a standard platform maintained by Federal Way's IT Department and able to be replaced independently from the software. The ASC vendor could also a propose a cloud-based server solution.

The adaptive signal control technology will not be constrained by the existing signal controllers; however, the City envisions the Vendor utilizing existing signal system equipment when feasible to reduce deployment cost. The Vendor shall install the required software on Vendor-supplied server hardware in accordance with Federal Way's IT server minimum standards, policy, and procedures. The Vendor shall program, configure and commission the central system in a complete and fully operational system. The Vendor will provide a real-time updating, customized graphical map interface including all adaptive intersections and all equipment (e.g. vehicle detection, TSP) providing information to the system.

The adaptive signal control system ideally will be compatible with existing detection and controller systems currently operated by Federal Way and WSDOT. The existing traffic signal infrastructure is described in Section 3.1.5. Federal Way currently operates Econolite controllers and WSDOT operates 2070 controllers. For intersections currently managed and operated by Federal Way, video or induction loop detection is used at stop bar locations while induction loops are installed for advance detection. WSDOT uses induction loops for both stop bar and advance detection zones. Modifications to existing vehicle detection systems may include modifications to video detection zones and the separation of existing loop detectors to provide per-lane vehicle detection at stop bar and advance detection locations. Additional detection requirements will be coordinated between the ASC vendor and the City. Detection upgrade design will be the responsibility of the City.

6.3 System Access

City signal operators and County signal technicians will be able to have full access to the system from each local controller.

Specified City, County, and WSDOT staff will have the ability to log into the system from remote locations via the Internet and have functionality consistent with their access level.

The ASC's operation and access levels will be able to be customized to suit the different situations and the different areas of operation. As an example, admin users can be assigned ability to modify configurations and settings within the ASC system, while system operators can be assigned the ability to modify and edit timing related functions, and limited access personnel will have read-only privileges.

6.4 Set-up and Maintenance

The City, County, and State operators are experienced in setting up and fine tuning traditional coordinated signal systems. They will require training specific to the adaptive system, sufficient to allow them to set up, adjust and fine tune all aspects of the system, efficiently and effectively.

Initial set-up, coding, calibration, timing optimization, fine tuning, and training will be included in the scope of the contract RFP. The Vendor for the selected system shall suggest changes that could be made to better optimize system performance. Those changes shall be implemented and the system shall immediately provide performance measures (specified by the agency) to validate the effectiveness of those changes. A review of the system's operation will be performed as detailed in a maintenance contract with the Vendor.

The set up and fine tuning of the system will be the responsibility of the Vendor. A review of the system's operation will be performed and reviewed against performance metrics outlined in the verification and validation plan. In addition to the initial set up and fine tuning, the system Vendor should also provide all participating agency operators and system managers with on-site training before and after implementation, adequate to support self-sufficient operations, maintenance and system expansion needs.

Complaints or requests for changes in operation will be directed to the Vendor by Federal Way. King County Roads and WSDOT operators will be notified of changes on an as-needed basis.

Maintenance of all field equipment installed as part of the ASC system will be performed by King County Roads, following the initial maintenance contract which will be incidental to the cost of the system.

Funding for maintenance of the adaptive system will be outlined in an interagency agreement between King County Roads, WSDOT, and Federal Way.

The City expects the following warranty services for a minimum length of 2 years after system commissioning, for which the Vendor will be responsible for:

- Replacement or repair of defective or failed equipment by the manufacturers' warranties. The labor cost of replacement during this period (included in the purchase price).

- Maintenance of Vendor-supplied parts and equipment (included in the purchase price).

The agency expects the following maintenance services for a length of 2 years after system commissioning, for which the Vendor will be responsible for:

- Maintenance of all adaptive system software (included in the purchase price).
- 24/7/365 phone support for system troubleshooting of the ASC system and software.
- Response to system failures and faults within a contracted time period.

The agency may seek technical support from the Vendor for assistance in using the adaptive software following commissioning and training maintenance and support contract which will be incidental to the maintenance contract.

Chapter 7: Adaptive Support Environment

This section describes the stakeholders, facilities, constraints, capabilities, and equipment that will support the ASC system.

7.1 Institutions and Stakeholders

Existing stakeholders of the traffic signal system include:

- City of Federal Way – Public Works and IT Departments, and Emergency Management Division
- Washington State Department of Transportation (WSDOT)
- King County Road Services Division
- Puget Sound Regional Council (PSRC)
- Local fire departments
- Local police departments
- Transit agencies including Sound Transit, King County Metro, and Pierce Transit
- Federal Highway Administration (FHWA)

The stakeholders who will be affected by or have a direct interest in the adaptive system are users of the local park & rides (Sunrise United Methodist Church, South Federal Way, Federal Way/S 320th St, Our Savior's Baptist Church), regional growth centers (The Commons at Federal Way, Federal Way Crossings, and commuters along major arterials (SR 99, S 320th St, and S 348th).

The activities that will be undertaken by the City of Federal Way, WSDOT, and King County Roads include: preparation of timing parameters, implementation and fine tuning, system monitoring and adjustment, system performance monitoring and evaluation.

7.2 Facilities

The City of Federal Way, as part of this project, is constructing a Traffic Management Center (TMC) to be located at the City Hall. The TMC will include monitoring capabilities and upgraded signal communications to support the ASC system.

Access to the LAN will be required at the TMC server room to integrate the traffic signal controllers on the existing communications network with the ASC system. Depending on the ASC technology, access to the LAN may also be required at the local traffic signal cabinets as well.

The TMC design shall consider existing staff facilities, fire control facilities, and secure access to the server room. Air conditioning exists in the existing server room to regulate temperature in a server and hardware environment for signal and ITS devices. Utilities for the TMC are the responsibility of Federal Way IT Department.

A separate back-up server will be located at the Federal Way TMC for server replacement if the main server fails. Routine maintenance will be required to ensure that the back-up system mimics the database settings of the main server.

7.3 System Architecture Constraints

The adaptive server will be protected within the City firewalls while providing control and viewing privileges to King County Roads and WSDOT according to interagency agreements. The City IT Department will provide resources, equipment and system management so that operators will have appropriate access to the system locally, from within the agency's LAN and from remote locations. The IP schema will follow Layer 3 architecture.

The Regional ITS Architecture is published by the Puget Sound Regional Council and is accessible online at: http://www.psrc.org/transportation/its/itsarch. The City's ITS Master Plan is described in Appendix III-D of the City's Comprehensive Plan and is accessible online at: http://www.cityoffederalway.com/sites/default/files/Documents/Department/CD/Comprehensive%20Plan/Final_Chapter_3_with_appendix.pdf

7.4 Equipment

Any additional equipment (i.e. detection) required to support the adaptive system needs to be identified and furnished by the Vendor, however, design will be the responsibility of the City. The Vendor shall specify any hardware that needs to be replaced to support the proposed ASC system, including vehicle detection equipment, communication equipment, signal controllers, and cabinets. It is anticipated that under a separate contract, a Contractor will replace the equipment and do any rewiring required in the cabinet, as per Vendor recommendations. Loop detector re-splicing and video detection re-alignment may be done by King County Roads, as necessary to support the ASC system.

7.5 Computing hardware

The Vendor is responsible for providing minimum requirements regarding additional computing equipment (i.e., server, storage, monitors, etc.). The City of Federal Way IT Department will specify what to purchase to meet Federal Way IT standards requirements. The server and computing hardware shall be able to integrate with existing workstations.

The Federal Way IT Department is responsible for troubleshooting, maintenance, and repair of the central computing equipment that communicates to the adaptive system and remote workstations. They are also responsible for the replacement of the computing equipment when it reaches the end of its useful life. Replacement typically occurs in 5 to 8 year equipment lifecycles

7.6 Software

The Vendor is responsible for providing software updates and software licenses. Interagency policy documentation shall determine who has the administrative rights governing software use and availability on remote workstations and other supporting interfaces. The ASC system must meet industry integration standards and adapt to Federal Way's IT support structure. Interoperability with existing software investments will be a consideration in the procurement process.

7.7 Personnel

The City of Federal Way, King County Roads, and WSDOT will each have available staff available to observe routine operations. WSDOT operators will have access to the ASC system outside of City business hours to implement I-5 alternate routing plans during major incidents.

Staff who will operate and maintain the adaptive signal system will require signal system training provided by the Vendor as part of the maintenance contract. The amount of training required will depend on the selected system. The agencies anticipate training before and after installation of the adaptive system. Maintenance support provided by the Vendor will be detailed in the maintenance contract.

7.8 Operating procedures

The Federal Way IT department will be ultimately responsible for backing up system databases per existing IT policies. A back-up server shall be configured and stored next to the primary server for operator switchover if main system server failure occurs. The server system should have the ability to periodically sync with other agency's archival systems such that the ASC database can be periodically backed-up in the event of primary server failure. In such a case, the database can be retrieved from the established archive system.

7.9 Maintenance

Federal Way signal operators will perform routine maintenance of the ASC system in regards to the head-end equipment stored at the TMC. Local, roadside signal equipment will be maintained by King County Roads. Each agency will have dedicated maintenance staff available for routine maintenance. A post-warranty maintenance and support contract will be provided in the RFP.

7.10 Disposal

All salvageable equipment shall be returned to the King County Roads signal shop. Material that will be disposed of shall be in accordance with the applicable laws at the end of service life.

Chapter 8: Operational Scenarios

8.1 Overview

The following operational scenarios describe how the system is expected to operate under various conditions. The proposed ASC system is expected to be able to manage the following operational scenarios and issues envisioned for both the current and future project locations.

The following operational conditions are discussed:

- General Objectives and Strategies
- Demand affecting event (holiday traffic)
- Capacity affecting event (arterial and freeway incidents, and temporary lane closures)
- Fault conditions (communications, detection, adaptive processor)
- Priority and preemption
- Scheduled events
- Pedestrians
- Installation

8.2 General Objectives and Strategies

8.2.1 Operational Objectives

City of Federal Way's objective for the arterials under this ASC system are to:

- Maximize the person throughput and progression along the major arterials; SR 99, S 320th St, and S 348th St.
- Accommodate the traffic at all intersections included in the ASC system with a minimum of phase failures.
- Provide an optimal distribution of green time for all intersection approaches included in the ASC system.
- Prevent queue spillback into upstream intersections and other impeded movements.
- Provide smooth flow along as many routes as possible through the network.
- Reduce delay by improving the efficiency of each phase.
- Optimize signal operations to service all modes along the corridor including transit, pedestrian, bicycles, heavy vehicles and cars.
- Coordinate ASC operations with freeway operations and ramp meter objectives to optimize overall throughput.

8.2.2 Coordination and Signal Timing Strategies

To meet the operational objectives described, the ASC system will need to optimize the green-band in accordance with the network's traffic demands. Signal timing strategies that can be applied by the ASC system to meet this need are as follows:

Interchanges:

- In the AM peak, maximize progression bandwidth in the direction approaching the freeway interchange
- In the PM peak, maximize progression bandwidth in the direction leaving the freeway interchange.
- To avoid queuing on freeway off-ramps, utilize new detector inputs to actively monitor the off-ramp demand and use input to terminate the arterial phase.
- To avoid traffic spillback from ramp meter equipped on-ramps, utilize detector inputs (separate from the existing ramp meter system) to actively monitor on-ramp demand and adjust signal timing to service other arterial phases and optimize meter rate.

Arterial Intersections:

- Provide sufficient time to serve all turning and side street traffic with minimal phase failures.
- Select phase times (or offsets) that provide smooth flow and progression along the major arterial in both directions. For intersections where two major arterials meet, smooth flow for all approaches needs to be achieved.
- Select phase sequence that provides smooth flow along the arterial.
- Select phase times that minimize instances where the storage length is exceeded (i.e., left turn bays)
- At intersections with known high pedestrian demands, select phase times that will accommodate frequent use of all pedestrian phases.
- At other intersections, select phase times that will adapt to occasional use of pedestrian phases.

8.3 Demand Affecting Event

8.3.1 High travel day (e.g., Holiday Travel)

During periods of major activity within or close to the ASC's area of operation, the traffic characteristics are often similar to the peak periods, either oversaturated or unsaturated. The system will behave in a similar fashion to those periods, and the detection system will determine whether unsaturated or oversaturated conditions prevail. If there is heavily directional traffic before or after the activity or event, the system will determine the predominant direction and coordinate accordingly, with an appropriate cycle length and offset. If the event traffic is not as heavy as peak hours, but the traffic on the corridor is still highly directional, then the system will recognize this and provide coordination predominantly in the heaviest direction, even though the cycle length may be similar to business hours (with balanced flows) cycle lengths.

The entire corridor may be set by the operator to operate as one or more coordinated groups under this condition, or the system may have the freedom to operate it as one or more groups subject to user-specified criteria, such as similar required cycle lengths in different parts of the corridor, or the volume of traffic at key locations exceeds a threshold.

Within the project area, holiday congestion is most representative of a high travel day. The day after Thanksgiving and the day before Christmas are examples of high travel days. In addition to the general increase in traffic, the locations most susceptible to localized impacts from high travel days are the intersections closest to major retail centers and high traffic-generating retail establishments (i.e., big box retail stores and shopping centers such as The Commons at Federal Way). At the intersections that provide immediate access to retail, turn lanes are known to exceed capacity during high travel days.

8.3.2 Freeway Incidents

During incident events on I-5, traffic data indicates that vehicles commonly divert to alternative arterial routes within the boundaries of this project. The amount of vehicle diversions vary with incident location and severity . Among project corridors, the following arterials are frequented by travelers in the event of incidents on the freeways:

- S 320th St – provides access to/from I-5
- SR 99 – runs parallel to I-5
- S 348th St – provides access to/from I-5
- SR 161/Enchanted Parkway – runs parallel to I-5

When the incidents occur in the peak hours of the day, traffic conditions quickly reach a point of over-saturation at the 348th St/I-5 and/or S 320th St/I-5 interchange, which already experience regular peak hour congestion under normal traffic conditions.

When incidents occur outside of City business hours, WSDOT and King County shall have the ability to actuate pre-configured I-5 incident management signal timing plans along project arterials. A remote connection to the adaptive system shall support this functionality. The intent of the incident management signal timing plans is to improve throughput for vehicles using alternate routes.

8.4 Capacity Affecting Event

8.4.1 Incident within the system (construction, maintenance, fire)

When an incident occurs on the coordinated route and temporarily reduces the capacity of the route (such as emergency vehicles stopped, unscheduled construction/maintenance, or traffic crash), there will typically be congestion upstream of the blockage, and lighter than normal traffic downstream. In such a situation, it is appropriate for the downstream signals to operate with different characteristics from the upstream signals.

If the downstream signals experience lighter traffic as a result of the blockage, those signals should be coordinated as a group, with cycle length, splits and/or offsets that react to the measured traffic. If the blockage is in the peak direction, then it may be appropriate to coordinate in the opposite direction if that traffic is similar to or greater than the normal peak direction. If the blockage is in the non-peak direction, there may be no need to depart from the normal operation.

While intersections upstream from the blockage may register increased congestion, the appropriate response would not be to increase the capacity in the congested direction. On the contrary, the approach should be to match the capacity for phases in the direction towards the bottleneck to the actual capacity of the bottleneck, and prevent this movement from adversely affecting cross street traffic and the flow in the non-affected direction.

The system will recognize the presence of an abnormal obstruction and modify the signal operation to react to the changed traffic conditions in an efficient manner. The system must be capable of instituting an override. This override should also allow for variable message/blankout signs to display graphics and/or messages to modify lane assignments.

8.5 Fault Conditions

8.5.1 Communications Fault Condition

If a communication failure prevents the adaptive system from communicating between the signals and the central server or from continuing to control one or more intersections within a defined group, all signals within the group will revert to an appropriate, user-specified fallback mode of operation. The fallback mode will be specified by the user based on location and time-of-day. Prior to implementing the new system, historical data will be used to update time-of-day plans. All communication failure alarms will be automatically transmitted to maintenance and operations staff for appropriate attention.

During power loss, the central system will draw from the City Hall backup power. When communication is completely lost between the central server and signals, the signals will revert to time of day programming. The City will establish communication redundancy to prevent total communication failure.

8.5.2 Detection Fault Condition

The system will recognize a detector failure and take appropriate action to accommodate the missing data. For a local detector failure, the local controller will place a minimum recall, soft recall, or maximum recall (to be user-specified) on the appropriate phase, and issue an alarm. For a detector that influences the adaptive operation (e.g. a system detector), the system will use data from an alternate (user-specified) detector, such as in an adjacent lane or at an appropriate upstream or downstream location. If the number of detector failures within a specified group exceeds a user-specified threshold, the system will cease adaptive operation and go to a fallback operation specified by the user (such as time-of-day operation or free operation). The fallback operation will be specified by the user, based on location and time-of-day. All detector failure alarms will be automatically transmitted to maintenance and operations staff for appropriate attention.

8.6 Priority and Preemption

8.6.1 Transit Signal Priority (TSP)

King County Metro currently operates TSP along the SR 99 corridor between the Tukwila International Blvd Station and Federal Way Transit Center. Within the project boundaries, SR 99/S 312th St and SR 99/S 316th St are currently equipped with TSP which includes a wireless access point antenna, separate TSP equipment cabinet, King County Metro communications equipment, and a transit priority request generator (TPRG). Pierce Transit also plans to deploy TSP along the SR 99 corridor. They currently use an optical IR TSP system.

The system will have the capability to extend existing green time, introduce an early green by shortening or skipping other phases while never shortening or skipping pedestrian interval timings, and run a phase called exclusively by the transit vehicle (i.e. queue jump).

The Vendor shall coordinate TSP and ASC integration with King County Metro oversight. King County Metro envisions a mandatory TSP feature that utilizes TSP roadside equipment that outputs a pulsing or steady-state to signal cabinet TSP inputs (Center-to-Infrastructure Configuration). The proposed and ultimate configuration involves center-to-center communication integrating the transit TSP System Server and the ASC server (Center-to-Center Configuration).

Center-to-Infrastructure Configuration

The decision to provide priority will be determined within the local controller, based on user-definable and settable rules. These rules will include such items as: length of time or number of cycles since last priority was provided and priority level if there are competing requests.

The decision on whether to serve a coach arriving on green or only provide an early green with normal green time will be determined by the controller. The controller shall have the ability to recognize check-in and check-out call from the TSP system.

Center-to-Center Configuration

The decision to provide priority will be determined by the ASC system using RapidRide coach location information from TSP request messages (based on NTCIP 1211) from all RapidRide coaches along the corridor. Once all locations are registered, the ASC shall grant TSP calls based on a negotiated Service Level Agreement with King County Metro.

8.6.2 Emergency Vehicle Preemption

When an intersection responds to an EV preemption, other signals within the coordinated group shall continue to operate adaptively. The system should support adaptive preparation in order to avoid overrunning a visual call. The preempted signal returns to adaptive control once the preemption is released. GPS signal preemption may be implemented at a future date.

8.7 Scheduled Events

The system will recognize the increasing traffic as patrons arrive for the event (e.g. summer mornings at Wild Waves) and adopt an appropriate mode of operation. During the event, when there is little associated traffic, the system will recognize the traffic conditions and operate normally, then recognize the changing traffic pattern as patrons begin to leave the event and adopt the appropriate mode of operation until the traffic clears. Events may include game day travel to park and ride locations, and events at the Performing Arts and Events Center, King County-Weyerhaeuser Aquatic Center, Federal Way High School stadium, and Christian Faith Center. The system will then return to normal operation.

8.8 Pedestrians

Pedestrian crossing times must be accommodated. At locations with wide pedestrian crosswalks and a history of conflicts between turning vehicles and pedestrians, the pedestrian walk is displayed a user-configured amount of seconds before the compatible vehicle green. At crosswalks with high pedestrian volumes, a pedestrian recall is used during the periods when the pedestrian volumes are high. Pedestrian recall is used for pedestrian phases that are adjacent to the coordinated movements.

When side street traffic is light and no pedestrian is present, a vehicle may arrive on the side street shortly after the point at which its phase would normally be initiated. Typically, it would then wait an entire cycle before being served. However, it is often possible to serve one or two side street vehicles within the remaining green time. The system will be able to start a phase later than normal when there is no pedestrian call for that phase, provided it can be completed before the time the phase would normally end.

8.9 Installation

During installation and fine tuning, the operator will work alongside the Vendor to calibrate all the user-defined values in the system. In order to understand the response of the system to changes in traffic conditions, it is necessary to examine the results of intermediate calculations, in addition to the overall outputs and changes of state commanded by the system.

For example, if a cycle length is calculated based on a calculated parameter, such as level of saturation of detectors in critical lanes on critical movements, then the state of that calculated parameter must be available for inspection for each detector. This will allow the operator to properly calibrate each detector, and then separately calibrate the parameters in the cycle length calculation or look-up table.

Appendix A: Existing Detection Inventory

		Major Street						Minor Street						Phase 1			Phase 2			Phase 3			Phase 4			Phase 5			Phase 6			Phase 7			Phase 8		
		Detection Technology (L=Loops, V=Video)			Detection Grouping (PL=Per Lane, PP=Per Phase)			Detection Technology (L=Loops, V=Video)			Detection Grouping (L=Per Lane, P=Per Phase)																										
	Intersection	Stop Bar	Intermediate	Advance	Stop Bar	Intermediate	Advance	Stop Bar	Intermediate	Advance	Stop Bar	Intermediate	Advance	Stop Bar (Yes/No)	Intermediate (Distance from Stop Bar)	Advance (Distance from Stop Bar)	Stop Bar (Yes/No)	Intermediate (Distance from Stop Bar)	Advance (Distance from Stop Bar)	Stop Bar (Yes/No)	Intermediate (Distance from Stop Bar)	Advance (Distance from Stop Bar)	Stop Bar (Yes/No)	Intermediate (Distance from Stop Bar)	Advance (Distance from Stop Bar)	Stop Bar (Yes/No)	Intermediate (Distance from Stop Bar)	Advance (Distance from Stop Bar)	Stop Bar (Yes/No)	Intermediate (Distance from Stop Bar)	Advance (Distance from Stop Bar)	Stop Bar (Yes/No)	Intermediate (Distance from Stop Bar)	Advance (Distance from Stop Bar)	Stop Bar (Yes/No)	Intermediate (Distance from Stop Bar)	Advance (Distance from Stop Bar)
1	S 320th Street & 25th Avenue S / Gateway Center Boulevard	L	L	L	PL	PL	PL	L	N/A	N/A	PL	N/A	N/A	Y	48	N/A	Y	73	139	Y	N/A	N/A	Y	N/A	N/A	Y	48	N/A	Y	73	139	N	N/A	N/A	N	N/A	N/A
2	S 320th Street & I-5 Southbound Ramps	L	N/A	L	PL	N/A	PL	L	L	L	PL	PL	PL	Y	N/A	N/A	Y	N/A	200	N/A	N/A	N/A	Y	135	275	Y	135	275	Y	N/A	200	N/A	N/A	N/A	N/A	N/A	N/A
3	S 320th Street & 23rd Avenue S	V	N/A	N/A	PL	N/A	N/A	V	N/A	N/A	PL	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A
4	S 320th Street & I-5 Northbound Ramps	L	L	L	PL	PP	PL	L	L	N/A	PL	PL	N/A	N/A	N/A	N/A	Y	?	?	N/A	N/A	N/A	Y	140	N/A	N/A	N/A	N/A	Y	270	390	N/A	N/A	N/A	N/A	N/A	N/A
5	S 320th Street & Pete von Reichbauer Way S / 20th Avenue S	V	N/A	N/A	PL	N/A	N/A	V	N/A	N/A	PL	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A
6	S 320th Street & SR 99	V	N/A	N/A	PL	N/A	N/A	V	N/A	N/A	PL	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A
7	S 324th Street & SR 99	V	N/A	L	PL	N/A	PL	V	N/A	N/A	PL	N/A	N/A	Y	N/A	N/A	Y	N/A	230	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	230	N/A	N/A	N/A	N/A	N/A	N/A
8	S 316th Street & SR 99	V	N/A	L	PL	N/A	PL	V	N/A	N/A	PL	N/A	N/A	Y	N/A	N/A	Y	N/A	230	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	230	Y	N/A	N/A	Y	N/A	N/A
9	S 312th Street & SR 99	L	N/A	L	PL	N/A	PL	L	L	N/A	PL	PL	N/A	Y	N/A	N/A	Y	N/A	230	Y	200	N/A	Y	115	N/A	Y	N/A	N/A	Y	N/A	230	N/A	N/A	N/A	N/A	N/A	N/A
10	S 312th Street & 14th Avenue S	L	L	N/A	PP	PP	N/A	L	N/A	N/A	PP	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	160	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	N/A	N/A	Y	165	N/A
11	S 320th Street & 32nd Avenue S	L	L	L	PP	PP	PL	L	L	N/A	PL	N/A	N/A	N	N/A	N/A	N	N/A	N/A	Y	N/A	N/A	Y	115	230	Y	140	N/A	N	N/A	N/A	Y	N/A	N/A	Y	115	230
12	S 320th Street & Weyerhaeuser Way S	L	L	L	PP	PP	PP	L	L	N/A	PL	PL	N/A	Y	N/A	N/A	Y	115	230	N/A	N/A	N/A	Y	150	N/A	N/A	N/A	N/A	Y	100	235	N/A	N/A	N/A	N/A	N/A	N/A
13	S 320th Street & 11th Place S	L	L	L	PP	PP	PP	L	L	L	PP	PP	PP	N/A	N/A	N/A	Y	139	240	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	N/A	Y	139	240	N/A	N/A	N/A	Y	139	N/A
14	S 320th Street & 8th Avenue S	N/A	N/A	N/A	N/A	N/A	N/A	L	N/A	N/A	PP	N/A	N/A	N	N/A	N/A	Y	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15	S 320th Street / S Peasley Canyon Road & Military Road S	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
16	S Peasley Canyon Road & S 321st Street	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
17	23rd Avenue S & S 322nd Street	L	L	N/A	PL	PL	N/A	L	N/A	N/A	PL	N/A	N/A	N/A	N/A	N/A	Y	140	N/A	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	N/A	Y	140	N/A	N/A	N/A	N/A	Y	N/A	N/A
18	23rd Avenue S & S 317th Street	L	L	N/A	PL	PL	N/A	L	L	N/A	PL	PL	N/A	N/A	N/A	N/A	Y	140	N/A	N/A	N/A	N/A	Y	185	N/A	N/A	N/A	N/A	Y	140	N/A	N/A	N/A	N/A	Y	N/A	N/A
19	23rd Avenue S & S 316th Street	L	L	N/A	PL	PL	N/A	L	L	N/A	PL	PL	N/A	N/A	N/A	N/A	Y	110	N/A	N/A	N/A	N/A	Y	110	N/A	N/A	N/A	N/A	Y	110	N/A	N/A	N/A	N/A	Y	110	N/A
20	23rd Avenue S & S 314th Street	L	L	N/A	PL	PL	N/A	L	N/A	N/A	PL	N/A	N/A	N/A	N/A	N/A	Y	105	N/A	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	N/A	Y	105	N/A	N/A	N/A	N/A	N	N/A	N/A
21	S 312th Street & 23rd Avenue S	L	L	N/A	PL	PL	N/A	L	L	N/A	PL	PL	N/A	N/A	N/A	N/A	Y	155	N/A	N/A	N/A	N/A	Y	110	N/A	Y	N/A	N/A	Y	155	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22	S 312th Street & Pete von Reichbauer Way S / 20th Avenue S	L	N/A	L	PL	N/A	PL	L	N/A	L	PL	N/A	PL	Y	N/A	N/A	Y	N/A	285	N/A	N/A	N/A	Y	N/A	180	Y	N/A	N/A	Y	N/A	235	N/A	N/A	N/A	Y	N/A	180
23	Pete von Reichbauer Way S / 20th Avenue S & S 314th Street	L	L	N/A	PL	PL	N/A	L	N/A	N/A	PL	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	105	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	105	N/A
24	Pete von Reichbauer Way S / 20th Avenue S & S 316th Street	L	L	N/A	PL	PL	N/A	L	L	N/A	PL	PL	N/A	N/A	N/A	N/A	Y	110	N/A	N/A	N/A	N/A	Y	110	N/A	N/A	N/A	N/A	Y	110	N/A	N/A	N/A	N/A	Y	110	N/A
25	11th Place S / 13th Place S & S 324th Street	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
1	SR 99 & S 356th St	V	L	L	PL	PL	PL	V	L	N/A	PL	PL	N/A	Y	N/A	N/A	Y	190	340	Y	N/A	N/A	Y	180	N/A	Y	N/A	N/A	Y	N/A	230	Y	N/A	N/A	Y	180	N/A
2	SR 99 & S 352nd St	V	V	N/A	PL	PL	N/A	V	N/A	N/A	PL	N/A	N/A	Y	N/A	N/A	Y	110	N/A	Y	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	125	N/A	N/A	N/A	N/A	Y	N/A	N/A
3	SR 99 & SR 18 / S 348th St	V	V	L	PL	PL	PL	V	V	L	PL	PL	PL	Y	N/A	N/A	Y	115	220	Y	N/A	N/A	Y	115	190	Y	N/A	N/A	Y	115	220	Y	N/A	N/A	Y	115	190
4	SR 99 & S 344th St	V	V	L	PL	PL	PL	V	N/A	N/A	PL	N/A	N/A	Y	N/A	N/A	Y	115	220	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	115	220	Y	N/A	N/A	Y	N/A	N/A
5	SR 99 & 16th Ave S / S 340th Pl	V	V	L	PL	PL	PL	V	V	N/A	PL	PL	N/A	Y	N/A	N/A	Y	120	230	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	120	230	Y	N/A	N/A	Y	120	N/A
6	SR 99 & S 336th St	V	N/A	L	PL	N/A	PL	V	N/A	N/A	PL	N/A	N/A	Y	N/A	N/A	Y	N/A	230	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	230	Y	N/A	N/A	Y	N/A	N/A
7	SR 99 & S 330th St	V	N/A	L	PL	N/A	PL	V	N/A	N/A	PL	N/A	N/A	Y	N/A	N/A	Y	N/A	230	N/A	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	230	N/A	N/A	N/A	Y	N/A	N/A
8	S 348th St & 9th Ave S	?	?	?	?	?	N/A	L	L	N/A	PP	PL	N/A	N/A	N/A	N/A	?	?	?	?	?	N/A	Y	200	N/A	N/A	N/A	N/A	?	?	?	Y	N/A	N/A	?	?	N/A
9	SR 18 / S 348th St & SR 161 / Enchanted Pkwy S / 16th Ave S	L	L	L	PL	PL	PL	L	N/A	N/A	PL	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	300	Y	185	260	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	300
10	SR 161 / Enchanted Pkwy S & S 356th St & 16th Ave S	L	L	L	PL	PP	PP	L	L	N/A	PL	PP	N/A	Y	N/A	N/A	Y	N/A	240	Y	140	N/A	Y	185	N/A	Y	N/A	N/A	Y	115	230	Y	115	230	Y	N/A	N/A
11	SR 161 / Enchanted Pkwy S & S 352nd St	V	L	L	PL	PL	PL	V	N/A	N/A	PL	N/A	N/A	Y	N/A	N/A	Y	N/A	215	Y	N/A	N/A	Y	N/A	N/A	Y	N/A	N/A	Y	100	200	Y	N/A	N/A	Y	N/A	N/A
12	16th Ave S & S 344th St	L	N/A	L	PL	N/A	PL	L	N/A	L	PL	N/A	PL	N/A	N/A	N/A	Y	N/A	185	N/A	N/A	N/A	Y	N/A	105	N/A	N/A	N/A	Y	N/A	185	N/A	N/A	N/A	Y	N/A	105
13	9th Ave S & S 336th St	L	L	L	PP	PP	PL	L	L	L	PP	PP	PP	Y		N/A	Y	139	210	N/A	N/A	N/A	Y	139	N/A	Y	94	N/A	Y	139	210	N/A	N/A	N/A	Y	139	N/A
14	13th Pl S & S 336th St	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
15	20th Ave S & S 336th St	L	N/A	L	PL	N/A	PL	L	N/A	L	PL	N/A	PL	Y	N/A	N/A	Y	N/A	105	Y	N/A	N/A	Y	N/A	185	Y	N/A	N/A	Y	N/A	105	Y	N/A	N/A	Y	N/A	185
16	I-5 Southbound Off-ramp & SR 18	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
17	SR 18 Westbound Off-Ramp & SR 161 / Enchanted Pkwy S	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
18	SR 161 / Enchanted Pkwy S & Milton Rd S	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
19	SR 161 / Enchanted Pkwy S & 19th Way S	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?