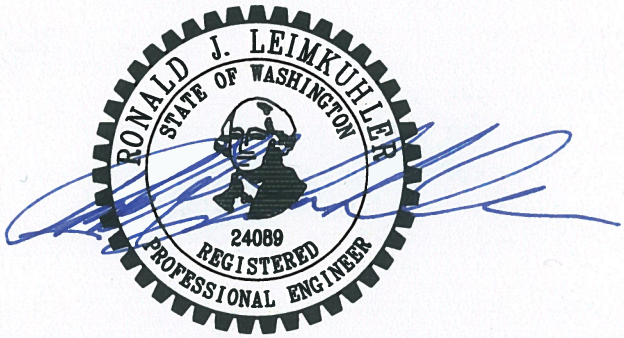
DESIGN REPORT

43rd Ave SE

SR 524 - Sunset Rd at 180 St SE

RC 1592

UPI# 16-0040



Snohomish County
Public Works
Engineering Services

kpff

August 29, 2019

FACT SHEET: 43RD AVE SE : SR 524 - SUNSET RD AT 180 ST SE

Project Proposal

Snohomish County Public Works proposes to construct arterial improvements to approximately 1.7 miles of 43rd Ave SE from SR 524 (Maltby Rd) to Sunset Rd and 180th St SE. The existing corridor consists of a mix of urban and rural arterial roads, one single-lane dirt road, barricades closing the route to through traffic at the urban growth boundary, and one unimproved segment.

The proposed improvements will widen the roadway and construct pedestrian facilities from SR 524 to 200th St SE (approximately 1/3 mile), construct a new rural arterial roadway with pedestrian facilities from 200th St SE to 196th St SE (approximately 1/4 mile), widen the roadway and construct pedestrian facilities from 196th St SE to 188th St SE (approximately 1/2 mile), widen the roadway and construction pedestrian facilities between 188th St SE and 184th St SE (approximately 1/8 mile), construct a new urban roadway with pedestrian facilities between 184th St SE and 42nd Drive SE (approximately 1/8 mile). Additional improvements are proposed at the intersection of 43rd Ave / SR 524 and 43rd Ave SE / 196th St SE by the construction of two-single lane roundabouts. A traffic signal with turn pockets is proposed at the intersection of Sunset Rd and 180th St SE with widening for each approach to the intersection.

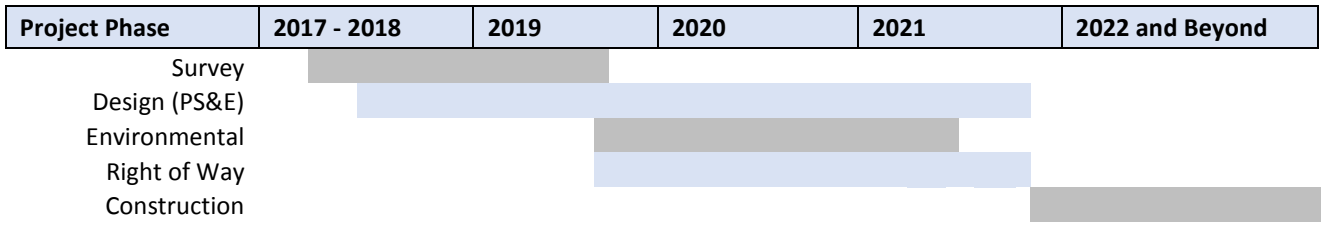
Project Benefits

- The complete corridor improvements will provide an alternate route for traffic and add capacity to the transportation network
- Constructing two roundabouts and a traffic signal along the corridor improves intersection operations and reduces delay and congestion
- Bike lanes, sidewalks, and shoulders will provide non-motorized facilities along the corridor

Project Cost

30% Cost Estimate Summary	
Construction Sub-Total	$15,800,000
Right-of-Way	$3,100,000
Design Eng.	$2,400,000
Construction Eng.	$2,400,000
Total	**$23,700,000**

Project Schedule



Required Permits

State Environmental Policy Act (SEPA), Land Disturbing Activity Permit, Critical Areas Report Compliance, and Drainage Compliance, Hydraulic Project Approval (HPA) and Army Corps of Engineers Permit

Project Contacts

Michael Randall, P.E., Project Manager

DESIGN REPORT

43rd Ave SE
SR 524 - Sunset Rd at 180 St SE
RC1592, UPI# 16-0040

APPROVED BY: Douglas W. McCormick, P.E. — Snohomish County Engineer — 10/4/19 Date

RECOMMENDED BY: Janice Fahning, P.E. — Director of Engineering Services — 9-25-19 Date

CONCURRED BY: Mohammad Uddin, P.E. — Snohomish County Traffic Engineer — 9/19/19 Date

PREPARED BY: Michael Randall, P.E. — Project Manager — 9-11-19 Date

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EXECUTIVE SUMMARY

43rd Ave SE : Design Report

The purpose of the 43rd Ave SE project is to construct arterial improvements along the 43rd Ave SE / Sunset Rd corridor which is currently closed to through traffic. Opening this corridor will add to the transportation network and provide an alternate route for traffic. Additionally the project will improve safety, provide pedestrians and bicycle facilities, and will improve the intersection operations along the corridor. This design report will document the alternatives analysis process used to develop recommendations for improvements along 43rd Ave SE/Sunset Rd between SR 524 and 180th St SE.

The corridor currently crosses the Urban Growth Boundary (UGB). For this reason, the existing improvements consists of a mix of urban and rural arterial roads, one single-lane private-access dirt road, barricades closing the route to through traffic at the UBG, and one unimproved segment.

The Corridor was evaluated by segments. These segments all have different general characteristics described within the body of this report. The initial scope of this Design Report included three alternatives. The alternatives for each segment started with the County's standard road cross section as Alternative 1. The second alternative is a modification that deviates slightly from the county standard to match a design parameter within the segment. The third alternative explored other approaches including a constant paved width along 43rd Ave SE. Note that the typical section of the alternative varied from one segment to the next.

A value engineering study was conducted after the initial selection of three alternatives. It was determined that two more alternatives should be considered. Alternative 4 and Alternative 5 were added after the value engineering study was conducted in order to explore a broader range of roadway configurations.

The preferred alternative selected is Alternative 4, as it provides the best performance based on the selection criteria noted later in this report.

Intersections were evaluated with standard traffic signals and with roundabout configurations. Roundabouts were found preferable at SR 524 and at 196th St SE. At 180th St SE, a signal intersection was found to be preferred because of the reduction in impacts to the adjacent properties.

1. INTRODUCTION

This Design Report documents the alternative analysis process used to develop recommendations for improvements along 43rd Ave SE/Sunset Rd between SR 524 (Maltby Rd) and 180th St SE. The 43rd Ave SE corridor is a unique transportation route in Snohomish County due to the corridor crossing the Urban Growth Boundary, mandating design to both urban and rural standards.

The work included in this report include:

- Description of the current conditions
- Descriptions of proposed improvement and alternatives
- Evaluation of traffic and intersection capacity and layout
- Evaluation of environmental impacts
- Soils report
- Assumptions for design criteria
- List of identified deviations to design standards
- Stormwater evaluation
- Evaluation of right-of-way needs
- Evaluation of existing and proposed utilities
- Estimated construction costs

See **Appendix A** for Vicinity Map and site location.

1.1 PROJECT PURPOSE AND NEED

43rd Ave SE / Sunset Road between SR524 and 180th St SE is 1.7 miles in length and will serve as a north/south transportation in Southwest Snohomish County. The purpose of the 43rd Ave SE project is to improve the existing roadway section to arterial standard, reduce delay, improve safety, improve intersection operations and promote multi-modal mobility throughout the corridor. Improvements to 43rd Ave SE are needed to accommodate recent growth in the area. The existing corridor also lacks consistent pedestrian and bicycle facilities, which are needed to provide non-motorized accessibility to the Fernwood Elementary, North Creek High School, Tambark Creek Elementary School, and existing land uses along the corridor.

Alternatives Development Process

In order to establish the alternative best suited to address the long-term transportation needs along the 43rd Ave SE/Sunset Rd corridor, the study team initiated an alternatives screening process, which included the following steps:

- Identification of Alternatives
- Development of Screening Criteria
- Preparation of a Traffic Study
- Comparative Evaluation of Alternatives

Each step of the process involved analysis, recommendations, and validation from a multi-disciplinary team of traffic, engineering, and environmental professionals. The results of this process are documented in this report.

2. 43RD AVE SE / SUNSET ROAD EXISTING CONDITIONS

The 43rd Ave SE/Sunset Rd roadway corridor being evaluated begins as 43rd Ave SE at SR 524 at the south limit of the corridor. The roadway becomes Sunset Rd at 184th Ave SE, and ends as Sunset Rd at 180th St SE, which is the north limit of the corridor.

This two-lane paved rural road begins at SR 524 and continues north to 200th St SE where the main roadway turns to the east, becoming 200th St SE. The 43rd Ave SE corridor north of 200th St SE is an undeveloped dirt road serving as a private access between 200th St SE and 196th St SE. 43rd Ave SE returns as a paved two-lane rural road from 196th St SE to 188th St SE. 43rd Ave SE corridor crosses the Urban Growth Boundary at 188th St SE, where it is closed to through traffic with multiple permanently anchored type 2 barricades. North of the Urban Growth Boundary, 43rd Ave SE is currently a full three-lane urban section from 188th St SE to 186th St SE, and a half-street improvement of a three-lane urban section from 186th St SE to 184th St SE. The corridor name changes to Sunset Rd north of 184th St SE and is nonexistent as the alignment sweeps to the northwest under the Seattle City Light (SCL) transmission power lines. West of the SCL transmission lines, Sunset Rd exists as a two-lane urban arterial with a sidewalk on the east side only, and continues north on a curvilinear alignment that sweeps northwest to 180th St SE.

The alignment has been broken into segments for evaluation, and are generally described in detail below.

Segment	Limits	Existing Condition
43rd Ave. SE Corridor		
Segment A	SR 524 to 200th St SE	two-lane paved rural road
Segment B	200th St SE to 196th St SE	private gravel access
Segment C	196th St SE to 186th St SE	paved two-lane rural road with walkway
Segment D	186th St SE to 184th St SE	paved/partial paved three-lane urban road
Segment E	184th St SE to 42nd Dr SE	unimproved powerline right-of-way
Segment F	42nd Dr SE to 180th St SE	paved two-lane urban road sidewalk on one side
Segment G	180th St SE to 178th Pl SE	paved three-lane rural road
180th St. SE Corridor		
Segment H	road west of Sunset Rd	rural three-lane road
Segment I	road east of Sunset Rd	incomplete three-lane urban road

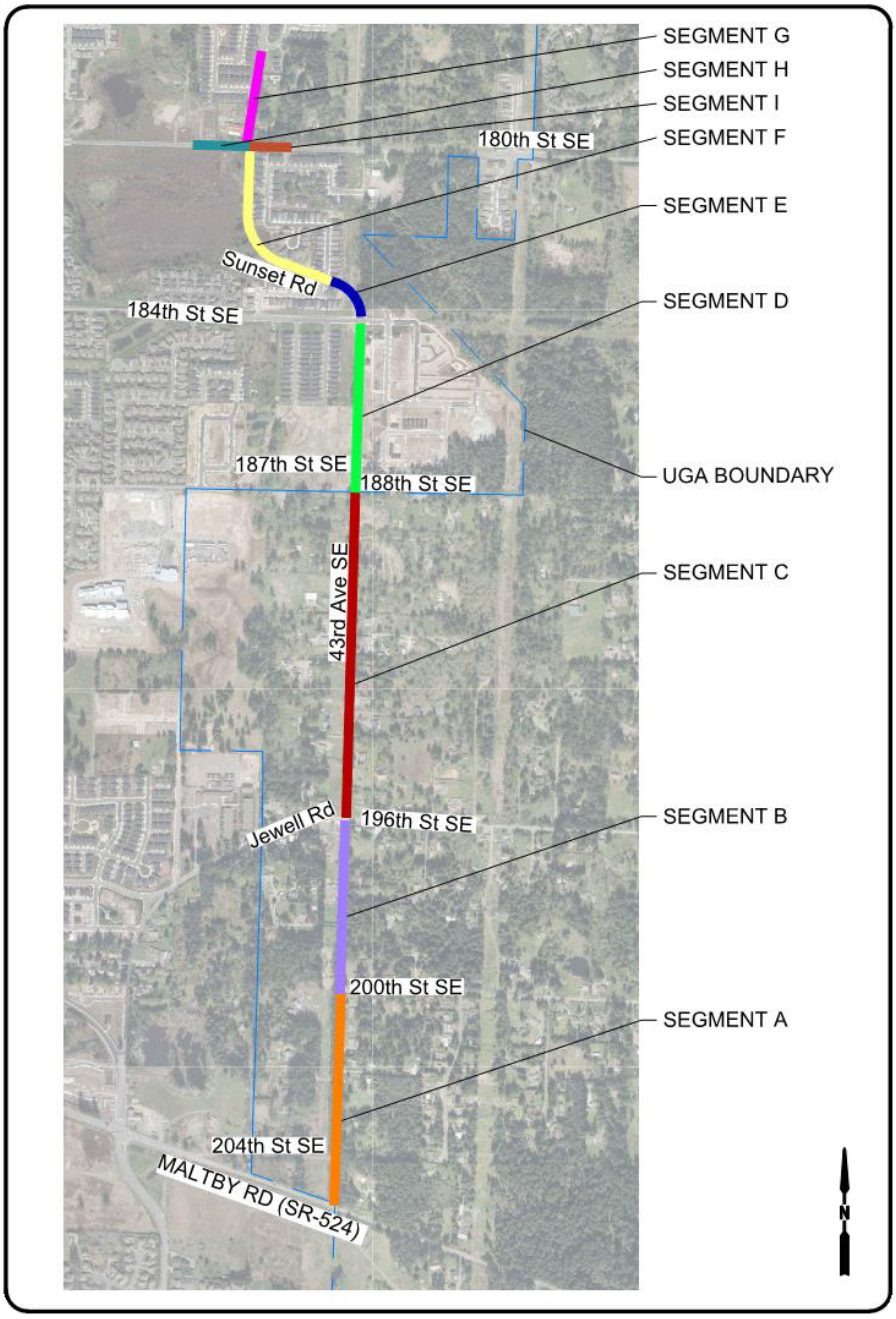


Figure 2-1. 43rd Ave SE/Sunset Rd Segment Definitions

Existing posted speed limits for each segment are listed below. Sections listed as not applicable are currently unimproved.

Existing Posted Speed	
43rd Ave SE	
Segment A	35 mph
Segment B	Not Applicable
Segment C	25 mph
Segment D	25 mph *
Sunset Rd	
Segment E	Not Applicable
Segment F	25 mph
Segment G	35 mph
SR 524 / Maltby Rd	35 mph
196th Ave SE / Jewell Rd	35 mph
180th St SE	
Segment H	40 mph
Segment I	40 mph

*Corridor speed not posted on 43rd Ave SE north of 186th St SE. 25 mph posted speed assumed from posted speed of adjacent streets (184th St SE and 180th St SE).

Each segment is described in more detail below.

SR 524 (Maltby Road)

SR524 is a two-lane rural asphalt road. Lane widths are approximately 12 feet wide. The shoulder along both sides is gravel with an approximate width of 2 feet. Small ditches exist along both sides of the roadway behind the shoulders for storm water conveyance.

Overhead power and communication utilities are located behind the south shoulder.

Figure 2-2. SR524 at 43rd Ave SE (looking east)

Segment A, 43rd Ave SE (SR524 to 200th Street SE)

43rd Ave SE is a two-lane rural asphalt road. Lane widths are approximately 12 feet wide. The east shoulder is paved with a width of approximately 6 feet. The west shoulder typically has 1 foot of asphalt, and then an additional 4 feet of gravel. Grades slope to match adjacent parcels beyond the shoulders.

Figure 2-3. 43rd Ave SE, Segment A (looking north)

Adjacent grades are mostly flat. There are no apparent roadside ditches adjacent to the shoulder. There is a slight depression to the west, which coincides with the SCL transmission powerline corridor.

Utilities constructed along this segment include overhead power and communication utilities on wood poles – as well as fire hydrants – located behind the east shoulder of this segment.

Mailboxes are located behind the east shoulder.

There are significant trees behind the shoulders on both sides. The trees on the west side appear to be a narrow swath of older fir trees within or directly adjacent to the roadway right-of-way (ROW) boundary. The type and density of trees on the east side varies; the south half is heavily treed with large fir trees similar to the west side, and the north half being fairly clear due to the residential development along the east side.

Segment B, 43rd Ave SE (200th Street SE to 196th Street SE)

The beginning of Segment B is a poorly maintained gravel road existing only on the west side of the alignment, as the main roadway currently turns east at 200th St SE.

Figure 2-4. 43rd Ave SE, just south of 200th St SE, Segment A (looking north)

The extension of 43rd Ave SE is signed as "Closed To Through Traffic" and "Not County Maintained Road."

This corridor is currently a gravel road about 14 feet wide. There are no shoulders or roadside ditches constructed along this segment.

Figure 2-5. 43rd Ave SE, Segment B (looking south)

There is a substantial vertical element in this segment as the road drops significantly into a ravine south of 196th St SE, and then rises to meet the grade of 196th St SE.

The adjacent parcel grades to the east vary greatly from being several feet above to several feet below the grade of the dirt road. Adjacent grades to the west are typically at or slightly lower than the grades of the existing dirt road.

Utilities constructed along this segment include overhead power and communication utilities on wood poles, located east of the road edge.

There are currently large concrete blocks along the edges with signs.

There are no mailboxes within this segment.

There are significant trees at the edges of the road, with much more significant trees on the east side, which includes the east half of the proposed alignment. There are fewer trees on the west side, which have been partially cleared with adjacent residential development.

Segment C, 43rd Ave SE (196th Street SE to 188th Street SE)

This road segment is currently a two-lane asphalt road. Lane widths are approximately 10 feet wide. The east shoulder is a 6-foot-wide asphalt shoulder in the south portion of this segment, transitioning to an intermittent 5-foot-wide concrete sidewalk for most of this segment. The west shoulder is typically a 1-foot-wide gravel shoulder.

Figure 2-6. 43rd Ave SE, Segment C (looking north)

Drainage ditches exist behind the west shoulder along the entire segment.

There is no significant vertical grade issue but generally appear to slope gradually from north to south.

Adjacent parcels are generally at or slightly below the grade of the roadway along this segment.

Fire hydrants and water meters are located behind the east shoulder/sidewalk, as well as overhead power and communication utilities.

Mailboxes are located behind the west shoulder.

There are some trees at the edges of the road, but most have been cleared for adjacent development.

Segment D, 43rd Ave SE (188th Street SE to 184th Street SE)

This segment of 43rd Ave SE appears to be an urban two-lane roadway, with 13-foot lanes and 8-foot parking areas and planters and sidewalks along both sides.

The pavement width for the south half from curb to curb is about 41.5 feet wide (21.6 feet west and 20.0 feet east). There are 5-foot-wide planter strips and 5-foot sidewalks along both sides. Behind the west sidewalk is a wide ditch for stormwater conveyance.

Figure 2-7. 43rd Ave SE, south half of Segment D (looking north)

The north half is a half street improvement of the same section. The total width is about 21 feet with the distance from ROW centerline to face of curb on the east side to be 20 feet. There is a 5-foot planter and a 5-foot sidewalk behind the east curb.

The west half of this ROW is currently grass with a dirt trail. Grade is above the road grade by a few feet. There are a few large trees in the grass area.

There are no significant vertical alignment issues, with roadway grade appearing to slope gradually from north to south.

Adjacent parcel grades to the east essentially match elevations at the back of sidewalk. Along the west side, adjacent grades begin matching grades of the sidewalk but rise to the north, with the adjacent parcel (SCL transmission line easement area) being up to 5 feet above the grade of the roadway.

Figure 2-8. 43rd Ave SE, north half of Segment D (looking north)

There are no overhead utilities within this segment. Franchise communication and power utilities appear to be in an underground facility along the east side of this segment, behind the sidewalk. There also are no mailboxes within this segment.

Segment E, Sunset Road (184th Street SE to 42nd Drive SE)

There is currently no road along the road alignment within this segment. The area is a cleared grassy area under the powerline easement.

Grade rises from 184th Street SE to a high point at the powerlines, then drops to match at 42nd Dr SE, where the curb returns are already constructed for the extension of Sunset Rd.

Road width is just under 28 feet (13.7 feet south and 14.0 feet north).

Figure 2-9. 43rd Ave SE, Segment E (looking north)

There is a graveled access off 184th St SE that appears to be access for SCL transmission line maintenance.

Anticipated utilities within this segment other than the SCL transmission power lines are water system and Northwest Pipeline, both assumed to run along the north side of 184th St SE.

At the south end of this segment, north of 184th St SE, there is a small cluster of tall, mixed-variety trees, just west of an adjacent multi-family development. The rest of this segment has minimal grass growth, and is mostly a clear gravelly hilltop that is within the easement for the SCL power transmission lines.

Segment F, Sunset Rd (42nd Drive SE to 180th Street SE)

This segment is an existing urban asphalt roadway. Total width is 28 feet (19.0 feet southwest and 9.0 feet northeast of centerline).

There is a 5-foot planter and a 5-foot sidewalk behind the curb on the northeast side for the south half, and on the north half, the sidewalk joins the curb and the planted area is behind the sidewalk.

Behind the curb on the southwest side is a wood rail fence and a large wide landscape area in the south half, and a 15-foot-wide planted area with black chain link fence is at the west side of the north half of this segment, adjacent to wetlands.

Adjacent parcel grades along this segment generally match. A majority of the land to the south and west of Sunset Rd is classified as a Critical Area.

Figure 2-10. Sunset Rd north of 42nd Dr SE, Segment F (looking north)

This segment is illuminated with street lights along only the east side, located within the planter on the east side. No other overhead utilities or hydrants are apparent within this segment.

Segment G, Sunset Road (180th Street SE to 178th Place SE)

The road in this segment is a three-lane asphalt road. It has one delineated lane north, and two lanes for southbound traffic, a through/left turn lane, and a separate right turn-only lane. At the north terminus, the street has been improved with curb, planter, and sidewalk. The curb is 23 feet from ROW centerline.

A significant drainage ditch exists just east of the east edge of pavement. There appears to be no shoulder.

The west side appears to have a paved shoulder, but there is no delineation of the edge of travel lane.

Vertical grade rises gradually to the north.

Adjacent parcel grades match well along the east side, but the west side parcels are lower than the road grade.

Figure 2-11. Sunset Rd, Segment G (looking north)

Overhead power and communication utilities are located behind the west shoulder of this segment.

There are a few significant trees located at the back of the drainage ditch along the east side.

Segment H, 180th Street SE (West Leg)

Existing roadway is a three-lane asphalt roadway. Lane width is approximately 12 feet. Curb and sidewalk exist on the north side only.

Vertical grade is flat.

Figure 2-12. 180th St SE, Segment H (looking west)

Adjacent parcel grades are generally flat and lower than the road grade. It is anticipated that the area to the south and some to the north of the roadway is wetland and/or buffer.

Overhead power and communication utilities are located along the south side of this segment.

Segment I, 180th Street SE (East Leg)

The existing roadway is a three-lane asphalt roadway. Lane width is approximately 12 feet. Curb and sidewalk exist on the south side only.

Vertical grade rises significantly to the east approaching the maximum allowable grade of 10%.

Figure 2-13. 180th St SE, Segment I (looking east)

Overhead utilities are located along the south side of the roadway within existing planter strips.

A group of tall fir trees are located behind the north shoulder.

Intersection of SR 524 and 204th St SE

Existing roadway is an unstriped two-lane asphalt roadway. The roadway width is approximately 24 feet. There are narrow grassy shoulders along both sides.

Vertical grade rises slightly to meet SR 524 on the west and also rises to meet 43rd Ave SE on the east.

Adjacent parcels are generally at grade, matching the roadway grade. There are no apparent roadside ditches for stormwater conveyance.

Figure 2-14. 204th St SE at SR 524 (looking east)

Overhead utilities are located along the north side of the roadway behind the shoulder.

Mailboxes are located behind the shoulders on the south side of the road.

3. PROPOSED ROAD DESIGN ALTERNATIVES

3.1 CONSTRAINTS

The County provided road Right-of-Way (ROW) centerline and existing ROW boundaries.

The corridor is identified as a County Bikeway on the Countywide Bicycle Facility System Map, adding the need for bike facilities.

Pedestrian and/or multi-use trail facilities were requested for the segments outside (south) of the Urban Growth Boundary.

There are a few parcels with challenging access requirements. The access grades are below desired and existing road grade. Existing survey data is limited in these locations, but has been supplemented by the County with GIS data. The parcels with challenging access requirements are:

Segment B

19729 43rd Ave SE, Parcel No. 270521.001.018.00
19707 43rd Ave SE, Parcel No. 270521.001.057.00
19705 43rd Ave SE, Parcel No. 270521.001.055.00

Segment G

17914 Sunset Rd, Parcel No. 270509.003.025.00

3.2 APPROACH

The approach to the alternatives evaluation was to start with the County standard configurations, and then adjust the configuration within each segment to address constraints.

Intersection layouts at SR 524 and 180th St SE were evaluated based on traffic study results. Further evaluation of roundabout configurations for those intersections as well as the intersection at 196th St SE/Jewell Rd was requested.

3.3 ROADWAY ALTERNATIVES

Segment A, 43rd Ave SE (SR524 to 200th Street SE)

Alternative A-1:

County standard arterial road configuration for rural areas is two 12-foot lanes and two 8-foot shoulders with one pedestrian facility separated by a vegetation-lined ditch.

Alternative A-2:

This alternative provides a 40-foot pavement width that includes two 12-foot lanes and two 8-foot shoulders with pedestrian facilities on both sides of the road. Bioretention swales along both sides of the roadway are forward compatible with an urban pavement section that includes three travel lanes and two bike lanes.

Alternative A-3:

This alternative provides a 44-foot pavement width that includes two 12-foot lanes and two 10-foot shoulders with pedestrian facilities on both sides of the road. The 44-foot pavement width would provide a continuous pavement width along the entire roadway corridor to interface with the face of concrete gutter for an urban pavement section that includes three travel lanes and two bike lanes.

Bioretention swales along both sides of the roadway are forward compatible with an urban pavement section width that includes three travel lanes and two bike lanes.

Alternative A-4

This alternative provides a 32-foot pavement width that includes two 11-foot lanes and two 5-foot shoulders with pedestrian facilities on one side of the road. Bioretention swales along both sides of the roadway satisfy drainage and LID requirements and provide future flexibility.

Alternative A-5
This alternative provides a 32-foot pavement width that includes two 11-foot lanes and two 5-foot shoulders with pedestrian facilities on one side of the road. A bioretention swale is located on one side of the roadway. The roadway is super-elevated to drain into the swale.

Segment B, 43rd Ave SE (200th Street SE to 196th Street SE)

Alternative B-1:

County standard arterial road configuration for rural areas is two 12-foot lanes and two 8-foot shoulders with one pedestrian facility separated by a vegetation-lined ditch. .

Alternative B-2:

This alternative provides a 40-foot pavement width that includes two 12-foot lanes and two 8-foot shoulders with pedestrian facilities on both sides of the road. Some of this segment includes a forward compatible bioretention swale but in areas of significant cut and/or fill, the bioretention swale is replaced with a standard planter strip.

Alternative B-3:

This alternative provides a 44-foot pavement width that includes two 12-foot lanes and two 10-foot shoulders with pedestrian facilities on both sides of the road. The 44-foot pavement width would provide a continuous pavement width along the entire roadway corridor to interface with the face of concrete gutter for an urban pavement section that includes three travel lanes and two bike lanes.

Some of this segment includes a forward-compatible bioretention swale, but in areas of significant cut and/or fill the bioretention swale is replaced with a standard planter strip.

Alternative B-4

This alternative provides a 32-foot pavement width that includes two 11-foot lanes and two 5-foot shoulders with pedestrian facilities on one side of the road.

Some of this segment includes bioretention swales along both sides of the roadway, but in areas of significant cut and/or fill the bioretention swale is replaced with a thickened edge or curb and gutter to convey runoff to stormwater facilities.

Alternative B-5

This alternative provides a 32-foot pavement width that includes two 11-foot lanes and two 5-foot shoulders with pedestrian facilities on one side of the road.

Some of this segment includes a bioretention swale along one side of the roadway, but in areas of significant cut and/or fill the bioretention swale is replaced with a thickened edge or curb and gutter to convey runoff to stormwater facilities.

Segment B Vertical Alignment

The vertical profile was also evaluated for Segment B. One evaluation tried to minimize vertical curves south of 196th St SE which resulted in a lot of fill. Another evaluation dropped as much as possible for the design speed to reduce the fill. A third alternative was developed, which provided access grades to three residences adjacent to the alignment. This alignment drops significantly just north of 200th St SE, and results in a significant cut. This third alignment was chosen as the preferred vertical alignment within this segment solely because it provided access to the adjacent residential parcels.

Segment C, 43rd Ave SE (196th Street SE to 188th Street SE)

Alternative C-1:

County standard arterial road configuration for rural areas is two 12-foot lanes and 2 8-foot shoulders with one pedestrian facility separated by a vegetation-lined ditch. .

Alternative C-2:

This alternative provides a 40-foot pavement width that includes two 12-foot lanes and two 8-foot shoulders with pedestrian facilities on both sides of the road. Bioretention swales along both sides of the roadway are forward compatible with an urban pavement section that includes three travel lanes and two bike lanes.

Alternative C-3:

This alternative provides a 44-foot pavement width that includes two 12-foot lanes and two 10-foot shoulders with pedestrian facilities on both sides of the road. The 44-foot pavement width would provide a continuous pavement width along the entire roadway corridor to interface with the face of concrete gutter for an urban pavement section that includes three travel lanes and two bike lanes.

Bioretention swales along both sides of the roadway are forward compatible with an urban pavement section width that includes three travel lanes and two bike lanes.

Alternative C-4

This alternative provides a 32-foot pavement width that includes two 11-foot lanes and two 5-foot shoulders with pedestrian facilities on one side of the road. Bioretention swales along both sides of the roadway satisfy drainage and LID requirements and provide future flexibility.

Alternative C-5
This alternative provides a 32-foot pavement width that includes two 11-foot lanes and two 5-foot shoulders with pedestrian facilities on one side of the road. A bioretention swale is located on one side of the roadway. The roadway is super-elevated to drain into the swale.

Segment D, 43rd Ave SE (188th Street SE to 184th Street SE)

Segment D is within the Urban Growth Boundary so the County arterial road section for urban areas is applicable. Much of Segment D is already constructed by developments adjacent to the corridor. Along the south half of this segment 43rd Ave SE is constructed to a full width of 42 feet. Along the north half of this segment, the east side of the road has been constructed and the west side is unimproved.

Alternative D-1:

County standard arterial road configuration for urban areas is three 12-foot travel lanes, 5-foot bike lanes, curb and gutter (46 feet curb to curb), 5-foot planter, and 5-foot concrete sidewalk.

Alternative D-2, D-4, and D-5:

This alternative matches existing road width to south (42 feet wide), resulting in a reduction of the center lane from 12 feet to 10 feet, and narrowing the through lanes from 12 feet to 11 feet, maintaining a 5-foot bike lane on both sides.

Alternative D-3:

This alternative matches existing road width and associated curb alignment to south (42 feet wide), resulting in 12-foot through lanes, 5-foot bike lanes, and a 7-foot planted median.

Segment E, Sunset Road (184th Street SE to 42nd Drive SE)

Segment E is within the Urban Growth Boundary, so the County arterial urban section is applicable. Since this section is under the SCL transmission lines, the center turn lane is only needed for the intersection turn pocket. This will be a transition area from bicycle lanes to shared lanes.

Alternative E-1:

County standard arterial road configuration for urban areas is two 12-foot travel lanes, 5-foot bike lanes, curb and gutter, 5-foot planters, and 5-foot concrete sidewalks.

Alternative E-2, E-3, E-4, and E-5:

This alternative transitions from three 12-foot travel lane and 5-foot bike lanes to 14-foot shared lanes to match existing configuration along Segment F.

Segment F, Sunset Road (42nd Drive SE to 180th Street SE)

Segment F is within the Urban Growth Boundary so the standard arterial road configuration for rural areas is applicable. Both sides of Segment F are already constructed to a typical width of 28 feet. The improvements along Segment F were constructed prior to 43rd Ave SE / Sunset Rd corridor being identified as a bicycle route, so bike lanes are not included in most of this segment.

The horizontal geometry for Segment F conforms to a design speed of 30 mph or a posted speed of 25 mph. Though county arterials are to be designed to a posted speed of 35 mph, this segment was not evaluated to be reconstructed to accommodate a 10 mph increase in posted speed.

Alternative F-1:

County standard arterial road configuration for urban areas is 12-foot travel lanes, 5-foot bike lanes, curb and gutter, 5-foot planters, and 5-foot concrete sidewalks. Approach evaluated was reconstruction where necessary to widen for the intersection south leg turn pocket only, providing tapers to 12-foot travel/turn lanes and 5-foot bike lanes with planters and sidewalks, widening to the west.

Alternative F-2, F-3, F-4, and F-5:

This alternative maintained the existing shared lane widths and did not incorporate dedicated bicycle lanes, rather maintained 2-14-foot shared lanes, with sidewalk and planter on the east side only.

Segment G, Sunset Road (180th Street SE to 178th Place SE)

Segment G is within the Urban Growth Boundary so the County standard arterial road configuration for urban areas is applicable. Only the standard road section alternative was evaluated for Sunset Rd north of 180th St SE at this time.

Alternative G-1, G-2, G-3, G-4, and G-5:

The standard section is three 12-foot travel lanes, 5-foot bike lanes, curb and gutter, 5-foot planters, and 5-foot concrete sidewalks.

At the location of the access for 17914 Sunset Rd (Sta 52+25 Lt), the planter has been removed.

Segment H, 180th Street SE (West of Sunset Road)

Segment H is within the Urban Growth Boundary so the County standard arterial road configuration for urban areas is applicable.

Alternative H-1:

The County standard arterial road configuration is 12-foot travel lanes, 5-foot bike lanes, curb and gutter, 5-foot planters, and 5-foot concrete sidewalks.

Alternative H-2, H-3, H-4, and H-5:

This alternative eliminated planters and reduced interior lane widths from 12 feet to 11 feet.

Segment I, 180th Street SE (East of Sunset Road)

Segment I is within the Urban Growth Boundary so the County standard arterial road configuration for urban areas is applicable.

Alternative I-1:

The County standard arterial road configuration is 12-foot travel lanes, 5-foot bike lanes, curb and gutter, 5-foot planters, and 5-foot concrete sidewalks.

Alternative I-2, I-3, I-4, and I-5:

This alternative eliminated planters and reduced interior lane widths from 12 feet to 11 feet.

3.4 INTERSECTION ALTERNATIVES

SR 524 (Maltby Road) and 43rd Ave SE

This intersection was initially laid out for a traffic signal. Due to the extreme length for an east-bound left-turn pocket, the County requested that it also be evaluated for a roundabout.

The traffic report showed that a single-lane roundabout operated satisfactorily. Once future improvements to SR 524 and the 43rd Ave SE extension to the south were included, a single-lane roundabout did not operate satisfactorily, and a two-lane roundabout was necessary.

Alternative roundabout layouts included:

- One-lane roundabout centered in the existing ROW.
- Two-lane roundabout centered in the existing ROW.
- One-lane roundabout offset north to eliminate ROW need from south parcel.

- Two-lane roundabout centered on the location of the one-lane offset roundabout.

196th Street SE (Jewell Road) and 43rd Ave SE

This intersection was initially laid out for a four-way stop. The traffic report showed that the intersection met warrants for a signal, so that was developed instead.

Additional alternative of a roundabout was also laid out, that being a single-lane roundabout.

180th Street SE and Sunset Road

This intersection was initially laid out for a traffic signal which exists there now.

Alternatives laid out included:

- One-lane roundabout centered in the existing ROW.
- Two-lane roundabout centered in the existing ROW.

SR 524 (Maltby Road) and 204th Street SE

This current intersection layout is nonstandard. The eastbound traffic can currently take a left turn across traffic to access 204th St SE, however, this often results in blocking of eastbound traffic due to the westbound traffic que. This intersection was therefore evaluated for the following alternatives:

- Realignment of 204th St SE so the centerline intersects at least 75 degrees from the mainline.
- Remove the access to 204th St SE and replace the access with a cul-de-sac.
- Remove the access to 204th St SE and replace the access with a hammerhead turnaround.

3.5 ALTERNATIVE LAYOUT PLANS

See **Appendix C-1** for Plan Layout of Alternative 1 County Standard Configurations.
See **Appendix C-2** for Plan Layout of Alternative 2.
See **Appendix C-3** for Plan Layout of Alternative 3.
See **Appendix C-4** for Plan Layout of Alternative 4.
See **Appendix C-5** for Plan Layout of Alternative 5.
See **Appendix C-6** for Plan Layout of Intersection Configurations.

4. TRAFFIC ANALYSIS

A traffic report was prepared by Fehr & Peers, forecasting years 2025 and 2045. It is summarized below.

See **Appendix E** for the full traffic report.

The report addressed some anticipated improvements outside of this project, including SR 524 being widened from two lanes to four lanes, and 43rd Ave SE being extended south.

SR 524

The report showed that a signalized intersection operates at a Level-of-Service (LOS) E or F by 2045. Storage length requirements for the current two-lane configuration of SR 524 were substantial, showing needs of 2,100 feet for PM west-bound traffic.

A single-lane roundabout also fails with a PM LOS F in 2045. However, a two-lane roundabout was shown with a 2045 LOS A for both AM and PM Storage lengths for a two-lane roundabout were minor, the longest being 199 feet for westbound traffic.

The County and the Design Team met with WSDOT on December 4, 2018, at the Northwest Region's Dayton Office. Attendees were:

WSDOT
- Peter Alm
- Kaitlynn Pecha
- Chris Santiago
- Leslie Berger-Price
- Frank Gunderson

Snohomish County
- Michael Randall
- Sam Filetti
- Mohammad Uddin

KPFF
- Lloyd Wind

Fehr & Peers
- Chris Grgich
- Sarah Keenan

WSDOT consensus was a very high preference for the roundabout, complementary to another proposed directly to the east of the 43rd Ave SE intersection for the Northshore School District's Maltby Elementary School at SR 524 and 51st Ave SE.

Next steps include preparation of a Basis of Design form for the intersection configuration, and setting up accounts to reimburse WSDOT for their review time.

180th Street SE

The traffic report showed that the LOS for a signalized intersection operates at LOS D in 2045 with the current two-lane configuration of SR 524. LOS moves to E if SR 524 is widened and 43rd Ave SE is extended south. The single-lane roundabout fails in 2045 with an LOS F, however, a larger double-lane roundabout operates satisfactorily at LOS C.

180th St SE operates acceptably with either a signal or a roundabout, but the roundabout has a higher impact to adjacent parcels, and the grades would require raising the intersection.

196th Street SE/Jewell Road

This intersection operates best as a single-lane roundabout.

Initially, this intersection was anticipated to be a four-way stop, but the traffic study found that it met warrants for a signal. The traffic report found that a signalized intersection operates satisfactorily in 2045 with an LOS B.

The County wanted this intersection also evaluated with a roundabout intersection. That evaluation showed the roundabout operates at an LOS A for 2045.

There were County concerns about traffic impacts due to the proximity of the Northshore School District's Fernwood Elementary School just east of this intersection. However, projected 2045 LOS for the roundabout is LOS A, and impact of school traffic was deemed minor enough not to impact delay significantly. However there may be slight decrease in LOS from this event at this location.

SR 524 at 204th Street SE

This intersection is included in the traffic report, showing a worst case LOS C in 2045. Volumes are very low.

WSDOT expressed a desire to close this intersection. The close proximity to the signal at 39th Ave SE also makes it desirable to restrict eastbound left turns across SR 524. Maintaining this intersection, even in a right-in/right-out configuration, would encourage traffic to bypass the 43rd Ave SE intersection and would significantly impact the current traffic LOS along this street. WSDOT staff recommended a cul-de-sac or hammerhead configuration to replace the current access onto SR 524.

5. ALTERNATIVES EVALUATION

The project team undertook a comparative evaluation of the alternatives that considered different criteria to identify a recommended alternative. The alternative evaluations have been discussed with County Staff throughout the entirety of the production of the design report. The results of the evaluation are documented in the alternatives evaluation matrix in Table 8. Criteria were selected to help the project team identify the alternative that best met the purpose and need of the project, while minimizing costs and impacts. The alternatives were scored with a scale of Best, Good, and Fair.

Screening Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Non-Motorized Operations	Good	Best	Best	Good	Good
Traffic Calming	Good	Good	Good	Best	Best
Future Intersection LOS	Best	Best	Best	Best	Best
Project Construction Cost (Weighted with a factor of 2)	Good	Fair	Fair	Good	Best
Right-of-Way Impacts	Good	Fair	Fair	Good	Good
Environmental Impacts	Good	Good	Good	Best	Best
Forward Compatibility (Weighted with a factor of 2)	Good	Best	Best	Good	Fair
Sustainability	Good	Best	Best	Best	Good
Total	**21**	**22**	**22**	**24**	**23**

Best = 3, Good = 2, Fair = 1

Typical Rural Section
Alternative 1: 40’ paved section with a bioretention swale and a separated walkway on the west side
Alternative 2: 40’ paved section with bioretention swales and separated walkways on both sides
Alternative 3: 44’ paved section with bioretention swales and separated walkways on both sides
Alternative 4: 32’ paved section with bioretention swales on both sides and a separated walkway on the east side
Alternative 5: 32’ paved section with a bioretention swale and a separated walkway on the east side

SCREENING CRITERIA

The following discussion provides the rationale behind the alternative scoring for each of the criteria.

Non-Motorized Operations considers how effectively and safely non-motorized users can navigate the corridor including pedestrian and bicyclists. Alternative 2 and 3 were ranked as Best since they provides a buffered bike lanes resulting in a safe and efficient route through the corridor. Alternative 1, 4, and 5 were ranked as Good since they provide a separated walkway on only one side of the roadway.

Traffic Calming considers the potential for vehicles to exceed the designated speed limit on the corridor. Wider corridors and intersections encourage higher speeds, while narrower corridors and roundabouts reduce excessive speeding. Lower speeds promote pedestrian and bicycle usage. Alternative 4 and 5 are ranked as Best as they provide narrower travel lanes than the other alternatives.

Future Intersection LOS considers the future (2045) operation of intersections along the corridor. As discussed in the Intersections section above, all the alternatives substantially improve the operation of intersections along the corridor, which will reduce congestion and delay. This results in a Good ranking for all the alternatives.

Project Construction Cost ranges from **$15 million to $18 million** in 2019 dollars and excludes right-of-way. Alternatives with lower construction costs were ranked as best while the higher constructions costs were ranked at fair. Alternative 5 with the lowest construction cost is ranked as Best. Alternative 1 and 4 are ranked as Good with a higher construction cost and Alternative 2 and 3 are ranked as fair with the highest construction costs. A detailed construction cost estimate for each alternative is shown in Appendix O.

Right-of-Way Impacts considers the impacts of the new roadway on adjacent properties. Alternatives with a narrower cross-section were ranked at best because of the reduced impact to adjacent homes and wetlands. Alternatives 2 and 3 are ranked at fair as they have the widest cross section.

Environmental Impacts considers the impacts of the new roadway on adjacent wetlands and the quantity of new impervious surface. Alternatives with a narrower cross section were rated higher because of the reduced disturbance. Alternative 4 and 5 are ranked as Best as they have the smallest cross-section and incorporate LID which reduces environmental impact.

Forward Compatibility considers the potential for future reallocation of pavement to increase vehicle capacity along the corridor. Alternative 2 and 3 were ranked as Best. Both provide LID stormwater facilities compatible with a urban section for Segments A-C. Alternative 1 and 4 are ranked as Good because some modification would be required for a change to an urban section and Alternative 5 is ranked as fair because major modification would be required.

Sustainability considers the green space available to help reduce the carbon footprint along the corridor. Alternative 2, 3 and 4 were ranked as best because they provide large bioretention swales along each side of the road. Alternative 1 and 5 only provide a large swale on one side.

6. ENVIRONMENTAL AND REQUIRED PERMITS

Preliminary critical area reconnaissance in 2017 identified potentially 14 wetlands and 7 streams along the 43rd Ave SE corridor and is outlined in the Environmental Review Memo in **Appendix B**. Construction impacts can be reduced by adhering to mitigation sequencing in accordance with SCC 30.62A.300 and U.S. Army Corps of Engineers permit conditions.

Alternative project designs should be considered that would avoid or minimize environmental impacts associated with this proposal. Construction of walls instead of fill slopes and eliminating planter strips adjacent to wetlands and streams and within buffers would reduce the amount of impacts. Low-impact development (LID) elements, such as pervious pavement or bioretention swales, should be used where appropriate within the project corridor. The extent of impacts would be determined at 60% design. The required mitigation would be done at the 17-acre Little Bear Creek Advance Mitigation Site.

Environmental Services staff will develop an expanded SEPA checklist in order to make a SEPA threshold determination. A noise analysis will be completed to support the SEPA checklist.

PERMITS

The permits required for this project are listed in **Appendix B** (ERM). If federal funds are secured through FHWA, additional NEPA compliance will be required.

- US Army Corps of Engineers Section 404
- National Historic Preservation Act Section 106
- Endangered Species Act Section 7
- Washington State Water Quality Certification Section 401
- Washington State Department of Ecology NPDES Construction Stormwater General Permit
- State Environmental Policy Act
- Washington State Governor's Executive Order 05-05 Archaeological and Cultural Resources
- County Critical Area Regulation Compliance
- County Land Disturbing Activity Compliance

7. SOILS

The geology and hydrogeology of the project corridor were assessed and reported on by the Snohomish County of Public Works. The *Hydrogeologic Report* (Snohomish County Public Works, May 30, 2018) and *Geotechnical Memorandum* (Snohomish County Public Works, May 31, 2018) provide design recommendations based on nine borings taken in the project corridor. The boring logs generated at these locations were interpreted to determine characteristics of the native soils, the anticipated depth to groundwater, and suitability for infiltration BMPs.

The project corridor is situated above the Cross Valley Sole Source Aquifer, which is predominantly confined by the corridor's underlying glacial till except at the low points, the points where 43rd Ave SE intersects with SR 524 and 196th St SE, where sandy outwash materials were observed. The confined condition of the aquifer was reported as having low sensitivity to pollutants that may be introduced by the planned development, except where the corridor intersects 196th St SE. The report states that infiltration of stormwater should not be permitted due to nearby water supply wellheads, and geologic conditions which make the area highly sensitive to pollutants found in runoff.

See **Appendix F** for Preliminary Geotechnical Memorandum.

See **Appendix G** for Hydrogeologic Report.

8. CLIMATE CHANGE

Snohomish County is exploring how to predict and plan for future impacts of climate change. Snohomish County Public Works Department has developed a preliminary tool to evaluate the effects of climate change on County infrastructure projects. The tool has been applied for this project and the County will be evaluating how to proceed with the data. The County's goal is to strengthen the resiliency of infrastructure, to extend the life of transportation systems, and provide safe travel routes for Snohomish County citizens.

See **Appendix H** for Climate Change Tool Outputs.

9. ACCESSIBILITY

This project provides an opportunity to improve pedestrian accessibility. All pedestrian elements will be designed to comply with current ADA (Americans with Disabilities Act) standards.

10. PUBLIC INVOLVEMENT

A project website has been established and will be maintained with updated information/documents throughout the life of the project.

Project website address: https://www.snohomishcountywa.gov/3669/43rd-Ave-SE---Bothell-2022

Public Works began working on the design study for improvements along 43rd Ave SE in summer to fall 2016. A postcard mailer was sent out to residents in July 2016 with this information. Additional postcards will be sent out as needed.

An open house was held in June 2017 for this and three other proposed roadway projects in the vicinity. A summary of frequently asked questions can be found at: https://www.snohomishcountywa.gov/DocumentCenter/View/44659/FAQ-June-2017?bidId=

An additional open house will be scheduled prior to the SEPA determination.

11. DESIGN CRITERIA

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

- AASHTO – A Policy on Geometric Design of Highways and Streets, 6th Edition, 2011
- Manual of Uniform Traffic Control Devices (MUTCD), 2009
- Snohomish County Drainage Code 30.63A
- Snohomish County Drainage Manual, November 2017
- Snohomish County Engineering Design and Development Standards (EDDS), 2018
- WSDOT Design Manual, July 2018
- WSDOT Highway Runoff Manual, February 2016
- WSDOT Standards Plans, August 2017
- WDFW 2013 Water Crossing Design Guidelines

Table 1. Design Criteria

DESIGN ELEMENT	CRITERIA	DESIGN REFERENCE
Road Classification	See **Appendix I** for supplemental Design Criteria Information	Section 3-02A (EDDS 2018) Arterial circulation map County Road Log – Mobility Software
Access - Number of access points	1-2 per parcel for rural residential area, 2 may be allowed if conditions met 1-2 way access or 2-1 way access points for commercial or industrial	Section 2-02A,B (EDDS 2018)
Access - Access point types	Residential driveway width = 10' – 30' Commercial: 2-1 ways. Inbound min/max = 15ft/30ft. Outbound min/max = 20ft/35ft. 1- 2 way access arterial min/max = 35ft/40ft	Sections 2-03 (EDDS 2018) Drawings 2-010, 2-020, 2-022, 2-024, 2-030, 2-035, 2-045 (EDDS 2018)
Access - Access point location, separation and spacing	10' separation between adjoining residential parcel accesses (match existing driveways). 150' separation between adjoining commercial or industrial accesses.	Section 2-04B,C (EDDS 2018) Drawing 2-050
Access - Horizontal alignment of access points	90 degrees to adjacent road	Section 2-06 (EDDS 2018)
Access - Vertical alignment of access points	Residential: 15' landing width Commercial: 30' Residential: ± 7 % max grade Commercial: ± 5 %	Section 2-07 (EDDS 2018) Drawing 2-030 for rural residential arterial (EDDS 2018)
Right-of-Way -	70’ Minor Collector Arterial (Rural) (2 lane section) 70' Collector Arterial (Urban)	Section 3-03A (EDDS 2018) Table 3-1 / Drawing 3-010, 3-030A, 3-030B(EDDS 2018)
Horizontal Alignment - Design speed (DS)	Operating speed = 43 MPH based on operating speed modifier, posted speed 35 MPH, 20 MPH advised on curves	Section 3-06A Table 3-3 (EDDS 2018)
Vertical Alignment - Minimum/Maximum grade	Min: 0.5 % Max: Arterial: 10% ; Max: Non-Arterial (Local Access) @ 15%	Section 3-07A (EDDS 2018) Table 3-5
Pedestrian Circulation – Walkway Width	5’ min for single family residential development 7’ min for commercial, industrial or other development not single family residential	Section 4-06A (EDDS 2018) Drawing 3-030A&B, 4-160
Side Slopes	3H:1V or flatter for fill slopes 2H:1V or flatter for cut slopes	Section 4-14A (EDDS 2018) Drawing 3-010 (EDDS 2018)
Roadside Obstacles clear zone	Clear zone distances for roads with posted speeds of 35mph or less shall be 10’ beyond the edge of traveled way	Section 4-15A (EDDS 2018)
Sight Distance – Stopping sight distance (SSD)	Flat road grades, SSD = 305’ minimum. For grade ≥ 3%, SSD shall refer to Table 3-7 of EDDS 2018, For Crest vertical curve, SSD shall refer to drawing 3-110 of EDDS 2018 For Sag vertical curve, SSD shall refer to drawing 3-120 of EDDS 2018	Section 3-08B&D (EDDS 2018) Table 3-6 (Flat Road Grade), Table 3-7 (Grade ≥ 3%), Drawing 3-110 (Crest Curve), Drawing 3-120 (Sag Curve) (EDDS 2018)
Intersections - Angle of intersection	90 degrees +/- 5 degrees for new intersections 90 degrees +/- 15 degrees for existing intersections	Section 3-09A (EDDS 2018)
Sight Distance - Intersection sight distance (ISD) Sight triangles	ISD = 390' for 35 mph posted speed	Section 3-08A&D (EDDS 2018) Table 3-9 (EDDS 2018)
Guardrails	Where appropriate pursuant to AASHTO Roadside Design Guide	

12. DEVIATIONS

Any deviations to the Snohomish County Public Works Engineering Design and Development Standards (EDDS) will be documented and approved by the County Engineer. Anticipated deviations include:

Segment A, 43rd Ave SE (SR524 to 200th St SE)

- Deviation of rural cross-section standard to reduce pavement width.

Segment B, 43rd Ave SE (200th St SE to 196th St SE)

- Deviation of rural cross-section standard to reduce pavement width.
- Deviation of entering sight distance for accesses due to retaining wall barrier.

Segment C, 43rd Ave SE (196th St SE to 188th Street SE)

- Deviation of rural cross-section standard to reduce pavement width.

Segment D, 43rd Ave SE (188th Street SE to 184th Street SE)

- Travel lane width reduction from 12 feet to 11 feet.
- Turn lane width reduction from 12 feet to 10 feet.

Segment E, Sunset Rd (184th Street SE to 42nd Drive SE)

- Travel lane modification/bike lane elimination to shared lane of 15-foot width.

Segment F, Sunset Rd (42nd Drive SE to 180th St SE)

- Travel lane width modification/bike lane elimination to shared lane of 14-foot width.
- Elimination of planter strip.
- Elimination of sidewalk.

Segment G, Sunset Rd (180th St SE to 178th Place SE)

- Elimination of bike lane on west side.
- Elimination of planter strip on west side.
- Replacement of concrete sidewalk with 6-foot paved shoulder.
- Max driveway grade for 17914 Sunset Rd will exceed 15%. Current slope is 18%, widening will increase grade.

Segment H, 180th St SE (West of Sunset Rd)

- Elimination of planter strip on south side.
- Reduction of interior travel lane widths from 12 feet to 11 feet.
- Reduction in posted speed from 40 mph to 35 mph.

Segment I, 180th St SE (East of Sunset Rd)

- Reduction of interior travel lane widths from 12 feet to 11 feet.
- County agreement that intersection is not a reconstruction triggering upgrade to current PROWAG requirements for crosswalk slope.
- Reduction in posted speed from 40 mph to 35 mph.

13. DRAINAGE

An alternatives evaluation was performed for stormwater management approaches along the length of the project corridor and documented in the *43rd Ave SE and Sunset Road: SR 524 to 180th Street SE - Draft Stormwater Concept Alternatives Analysis for Proposed and Future Road Widening*. Alternatives were selected based on site suitability and the following standards:

- Snohomish County Code (SCC) Chapter 30.63, May 9, 2018.
- Snohomish County Drainage Manual (Last updated November, 2017).
- Snohomish County Engineering Design and Development Standards (EDDS), December, 2017.

A total of 11 Threshold Discharge Areas (TDAs) were defined along the project corridor based upon existing drainage patterns. Stormwater requirements were defined within each TDA in accordance with SCC Chapter 30. Alternatives were developed based upon the site topography, soils, and proposed roadway improvements. These were then evaluated for each situation considering impacts to critical areas, private property, construction costs, and other criteria. Preferred alternatives were identified for each TDA.

See ***Appendix J*** *for 43rd Ave SE and Sunset Rd: SR 524 to 180th St SE - Draft Stormwater Concept Alternatives Analysis for Proposed and Future Road Widening*.

DRAINAGE SUMMARY

The Snohomish County Department of Public Works Surface Water Management Division has published Drainage Needs Reports (DNRs) for the watersheds to which the project corridor contributes. DNR No. 9 (Little Bear Creek Watershed) and DNR No. 10 (North Creek Watershed) were each completed in December 2002, to document known hydrologic, hydraulic, and water quality problems and possible solutions within the respective watersheds. Neither report indicated that the project corridor crossed any of the known problem areas.

The existing drainage patterns were analyzed to define the threshold discharge areas (TDAs) for the corridor. In total, 11 TDAs make up the full Project corridor. Existing drainage was assessed with existing topographic survey prepared by Snohomish County Department of Public Works, 2017 LiDAR data from Washington Department of Natural Resources, the Snohomish County PDS GIS Portal, and as-built drawings from the Nature's Ridge, Lidera, Woodcress, Timber Creek, and Brookfield Lane communities. Discharge points and stormwater facilities were verified in site walks. The 1/4 mile points, or points of compliance, were measured along the paths of flow as determined from the resources listed above. TDAs 1-9 drain to an unnamed tributary of Little Bear Creek, while TDAs 10 and 11 comingle in a wetland system that drains to Tambark Creek which crosses 180th Street SE just west of the project limits

The geology and hydrogeology along corridor were assessed and reported on by the Snohomish County of Public Works. The Hydrogeologic Report (Snohomish County Public Works, May 30,

2018) and Geotechnical Memorandum (Snohomish County Public Works, May 31, 2018) provide design recommendations based on nine borings taken in the project corridor. The boring logs generated at these locations were interpreted to determine characteristics of the native soils, the anticipated depth to groundwater and suitability for infiltration BMPs. The native soils are generally conducive to infiltration in the southern limits of the corridor with relatively high infiltration rates anticipated. Elsewhere, infiltration is expected to be limited due to till soils, with rates on the order of a 1/4 inch per hour expected.

The project corridor is situated above the Cross Valley Sole Source Aquifer, which is predominantly confined by the corridor's underlying glacial till except at the low points, the points where 43rd Ave SE intersects with SR524 and 196th St SE, where sandy outwash materials were observed. The confined condition of the aquifer was reported as having low sensitivity to pollutants that may be introduced by the planned development, except where the corridor intersects 196th St SE. The report states that infiltration of stormwater should not be permitted within this area due to nearby water supply wellheads, and geologic conditions which make the area highly sensitive to pollutants found in runoff.

The stormater evaluation assumed pavement widths that match the County standard urban arterial section. South of 188th St SE the roadway section to be constructed will incorporate a reduced pavement area compared to the County rural section, however, the evaluation of stormwater alternatives includes conceptual designs that will be forward compatible with the ultimate buildout of this rural section to an arterial section. The horizon year for that improvement is not known at this time. Stormwater management solutions have focused on implementation of LID approaches including bioretention and infiltration where appropriate and suitable.

14. RIGHT-OF-WAY

14.1 EXISTING CONDITIONS

Existing Right-of-Way (ROW) mapping was provided by Snohomish County in 2018.

Alignment line for 43rd Ave SE provided by Snohomish County generally follows the north-south centerline for Sections 16 and 21, Township 27 North, Range 5 East, Willamette Meridian.

The existing ROW widths are based on dimensions from the 43rd Ave SE road alignment line provided. Existing ROW width for 43rd Ave SE varies from 40 to 70 feet. Existing ROW width for Sunset Rd SE varies from 45 to 60 feet. Existing ROW widths for SR 524, 200th St SE, 196th St, and Jewell Road are typically 60 feet. Existing ROW widths for 184th St vary from 65 to 70 feet.

14.2 PROPOSED RIGHT-OF-WAY

The current County standard for urban Arterials is a 70-foot ROW, typically 35 feet on each side of roadway centerline. The rural collector arterial also has a 70-foot ROW, assumed to be offset to accommodate the grassy ditch on one side.

Areas for water quality treatment and detention were identified. Some flexibility exists in the detention areas noted. Detention areas can be adjusted to minimize impacts to the parcels by shifting and adjusting areas within adjacent parcels if desired.

The location of existing wells and septic fields limited the locations where infiltration facilities could be located.

The area south of 196th St SE was noted by the County as being tributary to the USEPA designated Cross Valley Sole Source Aquifer and associated Cross Valley Water Association. The hydrogeologic report also notes interests with Alderwood Water District, Silverlake Water and Sewer District, City of Snohomish, City of Everett, and Woodinville Water District. This therefore is an area where infiltration of roadway runoff is not allowed. All water quality features are to be lined to prohibit infiltration.

See **Appendix K** for 30% Roadway Plan with parcel needing acquisition highlighted.

See **Appendix L** for 30% R/W True Cost Estimates.

15. UTILITIES

Existing Utilities

The 43rd Ave SE Improvements work will impact existing utilities throughout the project corridor including those owned and operated by Alderwood Water and Wastewater District (AWWD), Seattle City Light (SCL), and the Bonneville Power Administration (BPA) as well as franchise utilities owned and operated by Puget Sound Energy (PSE), US Sprint, Frontier, and Comcast.

Septic fields along 43rd Ave SE between SR524 and 188th St SE may be impacted by the improvements.

Water

AWWD operates water mains throughout the length of the project corridor, including a 16-inch ductile iron transmission main running along the western edge of 43rd Ave SE from south of Maltby Road (SR-524) to 180th St SE. An 8-inch ductile iron distribution main runs along the eastern edge of 43rd Ave SE from 204th St SE to 200th St SE where it turns to the east and continues outside of the project corridor. Another 8-inch ductile iron distribution main runs along the eastern edge of 43rd Ave SE from 196th SE to 187th St SE. Multiple distribution mains cross the project corridor including a 12-inch main to the west at 204th St SE, an 8-inch main at 196th St SE, an 8-inch main at 187th St SE, an 8-inch main to the west at 184th St SE, and a main at 180th St SE. While minor adjustments can be made by AWWD maintenance and operations personnel, more significant adjustments or relocations may require an interlocal agreement with Snohomish County.

A water meter in the middle of 43rd Ave SE just south of 196th St SE will need to be relocated to the eastern ROW. A water manhole at this location will be adjusted to grade. Throughout the project corridor, valve boxes will be adjusted to proposed grade, and relocation of water meters will require new service connections to be constructed from their current connection point at the main.

It is also anticipated that a new water service will need to be provided to the parcel served by a private well at the northeast corner of 43rd Ave SE and 180th St SE that will be impacted by proposed stormwater facilities.

Sewer

AWWD operates an 8-inch PVC sanitary sewer main from approximately 220 feet south of 187th St SE to 187th St SE with an 8-inch main crossing at 187th St SE. Per email correspondence in October 2018, AWWD does not have any plans to extend sewer to areas not currently served within the project corridor and are limited to providing sewer to properties within the Urban Growth Area boundary.

There are several existing septic drain fields throughout the project corridor that may be impacted by the proposed roadway and drainage improvements per data obtained from the Snohomish Health District Records Center in May 2018. Where impacts are unavoidable and

public sewer is available, it will be desirable to connect these customers to the conveyance system. Impacts outside the Urban Growth Boundary should be avoided.

Power

Snohomish County PUD overhead power lines run along the eastern edge of 43rd Ave SE from SR 524 to 187th St SE. SCL power transmission towers follow the western edge of the project from south of SR 524 to 184th St SE. Per email correspondence with SCL in August 2018, SCL accepts proposed drainage facilities in their right-of-way that do not interfere with access to their right of way. Facilities are required to be below grade and rated for utility truck loading. Ditches, wetlands, or other open-water facilities are not permitted. Coordination with SCL will be required to relocate any overhead transmission lines along the eastern edge of 43rd Ave SE from SR 524 to 185th St SE and along the southern edge of 180th St SE at 43rd Ave SE.

BPA maintains power transmission towers to the south of SR 524. A point of contact at BPA has been established pertaining to potential acquisition of right-of-way to accommodate the proposed roundabout at the intersection of 43rd Ave SE and SR 524.

Telecommunication and Gas Utilities

Frontier and Comcast overhead telecommunications lines appear to run along the eastern edge of 43rd Ave SE from 200th St SE to 196th St SE and will need to be relocated with the SCL power lines. These same utilities are also located south of SR 524. While the roundabout configuration significantly reduced the relocation effort as opposed to that for a signal, there will likely also be some relocation issues at the new intersection improvement.

PSE gas is present along the northern edge of 187th St SE where it crosses 43rd Ave SE and along the northern edge of 184th St SE where it crosses 43rd Ave SE.

Northwest Pipeline recently upgraded the existing 16-inch gas pipeline to a 20-inch pipeline crossing 43rd Ave SE along the northern edge of 184th St SE as part of the North Seattle Lateral Upgrade Project.

A US Sprint buried fiber optic line marked at the northwest corner of the intersection of SR-524 with 43rd Ave SE crosses 43rd Ave SE along the northern edge of SR-524.

List of Utilities Contacts				
Utility	**Contact**	**Title**	**Phone**	**Email**
Alderwood Water and Wastewater District	Paul Richart			PRichart@Alderwoodwater.com
Seattle City Light	Jimmy Lin	Transmission Engr.	(206) 733-9289	Jimmy.Lin@seattle.gov
Bonneville Power Administration	Michelle Doiron	Realty Specialist	(360) 563-3641	medoiron@bpa.gov
Puget Sound Energy	Dennis Booth	Senior Project Mgr.	(425) 417-9188	Dennis.Booth@PSE.com
Frontier	David Collins	Network Engineer	(425) 263-4020	david.a.collins@ftr.com

16. FUNDING AND CONSTRUCTION COSTS

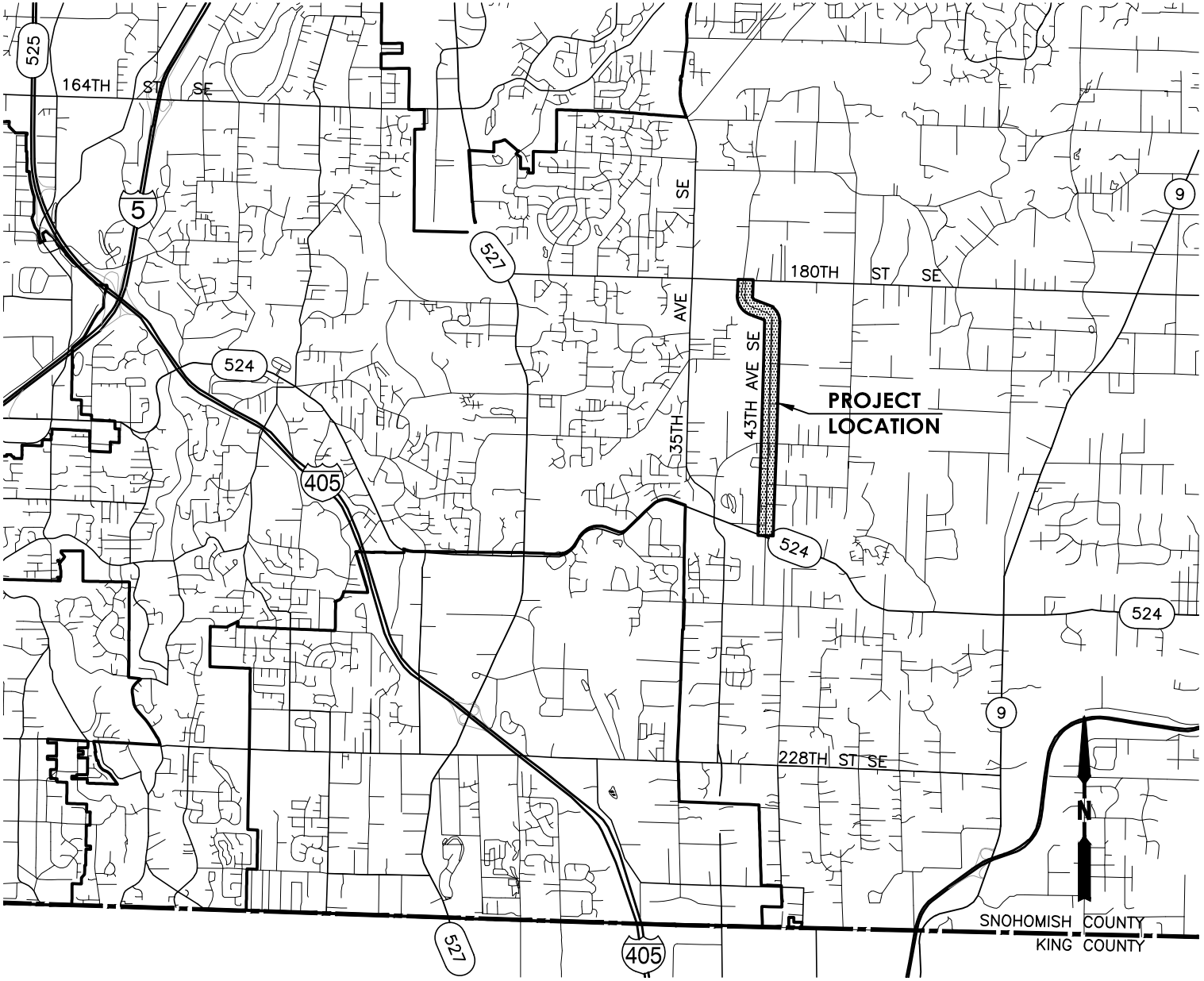
The project is currently funded with County founds Snohomish County Public Works plans on applying for Grants in 2020 for construction funding. A summary of the project costs for the recommended alternative is shown below.

30% Cost Estimate Summary	
Construction Sub-Total	$15,800,000
Right-of-Way	$3,100,000
Design Eng.	$2,400,000
Construction Eng.	$2,400,000
Total	**$23,700,000**

See **Appendix M** for 30% Cost Estimate.

APPENDIX A

Vicinity Map


525
164TH ST SE
5
527
180TH ST SE
9
524
405
35TH AVE SE
43TH AVE SE
PROJECT LOCATION
524
524
9
228TH ST SE
N
527
405
SNOHOMISH COUNTY
KING COUNTY

APPENDIX B

Draft Preliminary Environmental Review Memo

Snohomish County Public Works
Transportation and Environmental Services Division

DATE: May 11, 2017

TO: Brook Chesterfield, Engineer III
Public Works – Engineering Services, M/S 607

FROM: Darla Boyer, Sr. Environmental Planner, Ext. 2480

SUBJECT: Environmental Review Memo- RC1592
Preliminary Assessment of 43rd Ave. SE (SR524 to Sunset Road @ 180th St. SE)

This memo documents Environmental Services (ENVS) Section's preliminary assessment of 43rd Ave. SE (SR524 to Sunset Road @ 180th St. SE). The determination of permit and approval requirements are based on information received through a final scoping meeting (March 7, 2017) and from a March 2017 site visit by ENVS staff.

A. Summary of Permits and Approvals Required

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

FEDERAL

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

STATE

- ☒ Forest Practice Permit
- ☒ HPA ☐ HPA (Fish Enhancement)
- ☒ NPDES - Construction Stormwater General Permit
- ☐ Aquatic Land Use Authorization
- ☒ Section 401, Water Quality Certification
- ☒ CZM Certification

LOCAL

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

- ☐ OTHER: _____

B. Project Narrative

Project Description

Snohomish County Public Works proposes to construct arterial improvements to approximately 1.7 miles of 43rd Ave. SE from SR524 (Maltby Road) to Sunset Road at 180th St. SE. Construction includes:

- Widening 43rd Ave. SE from SR524 to 188th St. SE to a 2-lane rural section
- Add approximately 1,400 LF of new county road to connect 200th St. SE and 196th St. SE
- Improve the urban section from 188th St. SE to 180th St. SE
- Add approximately 450 LF of new county road connection between 43rd Ave. SE and Sunset Road

The above improvements include adding turn lanes, traffic signals, planting strips, sidewalks, curb and gutter, and retaining walls in appropriate areas.

Project Location

The project is located northeast of the City of Bothell in T27N R05E Sections 16 and 21. The project site is located in the Mill Creek urban growth area (UGA) and adjacent rural areas.

Site Description

The proposed improvements span two sub-basins within the Lake Washington/Cedar/Sammamish (WRIA 8) watershed. Most of the northern ½ mile of the site drains westerly and northwesterly to the North Creek basin. The remaining alignment is located in the Little Bear Creek basin. Natural drainage south of 188th flows south-southeasterly except where re-directed through the road ditches. The topography adjacent to the road is gently sloping to gently rolling (between 196th St SE and 200th St SE).

The northern portion of the alignment (north of 188th St. SE) is located within the Mill Creek UGA boundary (Residential 9,600 SF and 7,200 SF). Land use on both sides of the alignment consists of high density subdivisions and planned residential developments except for the large wetland tract located southwest of the intersection of 180th St. SE and Sunset Road.

South of 188th St. SE. land-use is characterized by rural lot residential properties (Rural 5 acre). These more rural parcels are comprised of mixed lawn, pasture, and patches of forest comprised primarily of large conifer trees and mixed red alder, big-leaf maple, and black cottonwood.

A site investigation was conducted by Snohomish County TES Environmental Services staff on March 15 and April 11, 2017 to identify potential critical areas within the project vicinity and to identify which parcels will need rights of entry in order to conduct stream and wetland delineations. This report summarizes the approximate location and description of known (delineated through previous land development activities) and potential wetlands, streams, fish and wildlife habitat conservation areas, and critical slopes located within 200 feet of the project

boundaries (as identified in the design plans). No delineations or ordinary high water mark determinations were conducted during this reconnaissance assessment. A delineation is needed to determine where actual resources are located and the classification of these resources.

Aquatic Resources

There may be as many as 14 wetlands, 3 mapped streams, and 4 unnamed streams in or within 200 feet of the proposed improvements. Known and potential wetlands and streams are described as they occur from north to south within three road sections. Unverified streams and wetlands are named in quotes ("_") to distinguish them from streams and wetlands that are known to occur on site.

180th to 188th St SE

Three known wetlands (A, A3, and A4) and one potential wetland ("Wetland A2") and Tambark Creek are located in the northern project area within the UGA.

Wetland A is a Category 2 palustrine emergent and palustrine scrub-shrub wetland that is part of a larger fragmented wetland complex that extends north and west of Wetland A and is associated with Tambark Creek (Appendix A, Figure 1; Appendix B). It is located in a private tract at the southwest corner of the intersection of 180th St. SE and Sunset Road (43rd Ave. SE). The wetland has been delineated, surveyed, and recorded as a separate Native Growth Protection Area tract in conjunction with the residential development of Tambark Springs Condominium (previously Tambark Estates).

Potential "Wetland A2" is located in the northwest corner of the intersection of 180th St. SE and Sunset Road in the extreme southwest corner of a low, overgrazed pasture on parcel 27050900305000 (17914 Sunset Rd). Hydrology was observed during the site visit and vegetation growing along the perimeter of the fence includes cattail (*Typha sp.*), willows (*Salix sp.*), curly dock (*Rumex crispus*), and reed canarygrass (*Phalaris arundinacea*), all species associated with wetlands (Appendix A, Figure 2; Appendix B).

Wetland A3 (Wetland A3) is located on the north side of 180th St SE immediately north of the sidewalk (Appendix A, Figure 3; Appendix B). The area is seasonally flooded and is vegetated with reed canarygrass, Douglas spirea (*Spiraea douglasii*), and scattered willow. This wetland is located in the Kings III Condo parcel (no parcel or tract number was available).

Wetland A4 is a Category 2 palustrine scrub-shrub wetland located on the north side of 180th St SE immediately north of 180th St SE (Appendix A, Figure 4; Appendix B). The area is seasonally flooded and is vegetated with dense Douglas spirea and patches of reed canarygrass and willow. This wetland was delineated as part of the development for Kings Corner Condo (no parcel or tract number was available). Snohomish County Public Works constructed a mitigation wetland along the western border of this wetland for intersection improvements at 35th Ave SE and 180th St SE.

Tambark Creek is a fish bearing (Type F) stream that crosses 180th St SE from north to south, approximately 800 feet west of the intersection with Sunset Road. This stream supports both anadromous salmon and resident fish. Chinook salmon, an ESA listed species, are documented to occur in Silver Creek approximately 2 stream miles downstream of the 180th St SE crossing

(WDFW).

188th to 196th St SE

This project section contains five potential wetlands, one known unnamed stream, and four potential unnamed streams.

Potential "Wetland B" appears to be a palustrine emergent wetland located on the east side of 43rd Ave. SE, immediately south of 188th St., SE (Appendix A, Figures 5 and 6; Appendix B). Vegetation consists of over grazed pasture grasses, soft rush (*Juncus effusus*), and scattered black cottonwood (*Populus balsamifera*) seedlings. Inundation was observed during the site visit. This wetland is located on parcel 27051600402500 (18823 43rd Ave. SE.). The wetland abuts the edge of sidewalk within the project area.

Potential "Wetland C" appears to be a mixed palustrine forested and palustrine emergent wetland complex that was historically connected to potential "Wetland B" and is located on the same parcel (Appendix A, Figures 5, 6, and 7; Appendix B). A private driveway now separates the two wetlands. The northern and eastern portion of this wetland is dominated by heavily grazed pasture grasses, soft rush, and scattered patches of Douglas spirea and willow. The southern portion of the wetland is forested with red alder (*Alnus rubra*) and black cottonwood trees. Himalayan blackberry (*Rubus armeniacus*) and scattered reed canarygrass dominate the western wetland edge along the existing sidewalk. Shallow pockets of flooding were observed during the site visit.

Potential "Wetland D" appears to be a palustrine forested and scrub shrub wetland located on the west side of 43rd Ave. SE (Appendix A, Figures 6 and 7; Appendix B). It is located primarily on parcel 27051600300100 (18820 43rd Ave. SE and is immediately west of "Wetland B". It is likely that "Wetland D" was part of "Wetlands B and C" prior to construction of the roads. The extent of this wetland is not easily discerned due to the dense vegetation adjacent to the road shoulder. Vegetation consist of red alder, Douglas spirea, salmonberry (*Rubus spectabilis*), and willow. Flooding was observed during the site visit. Stream 1 appears to originate as a roadside ditch at the downstream edge of this wetland.

Potential "Wetland E" appears to be a palustrine emergent wet pasture located on the east side of 43rd Ave. SE (Appendix A, Figures 8 and 15). It is located on parcel 27051600400200 (19005 43rd Ave. SE) and is dominated by closely grazed grasses except in the extreme southwest corner where Himalayan blackberry and reed canarygrass are dominant. Pockets of inundation were observed within the suspected wetland area, and Stream 2 flows along the extreme western edge of the wetland at the toe of road slope.

Potential "Wetland F" appears to be a narrow Palustrine emergent wetland located in a roadside ditch, on the west side of 43rd Ave. SE (Appendix A, Figures 8 and 14; Appendix B). "Stream 1" flows through the potential wetland and provides the primary source of hydrology. Vegetation consists of reed canarygrass, other mixed grasses, soft rush, and scattered red alder and willow saplings.

"Stream 1" is an Ns (non fish-bearing, seasonal) drainage that appears to originate in "Wetland C" (Appendix A; Figures 3, 5, and 7; Appendix B). It flows through a ditch on the west side of

43rd Ave. SE and joins unnamed Stream 3 at the east edge of parcel 27051600302400 (19316 43rd Ave. SE). Flow appears to be seasonally supported by groundwater as evidence in the orange flocculent present in sections of the ditch that is usually associated with groundwater seepage.

"Stream 2" is an Ns drainage that originates in the SW corner of potential "Wetland B" (Appendix A; Figure 8; Appendix B). It flows south for approximately 0.3 miles through an alternating series of ditches and pipes on the east side of 43rd Ave. SE before joining the left bank of Stream 3. Portions of the channel are undiscernible or ill-defined as it flows through reed canarygrass ditches and heavily trampled pasture. For example, in potential "Wetland E" the bed is very disturbed, ill-defined, and consists of primarily fine sediments with minor gravel sorting. Low seasonal flows, over grazing, and hoof compaction have contributed to a poorly defined flow path.

Unnamed Stream 3 is mapped as an Np (non fish-bearing, perennial) watercourse that flows northwest to southeast through the project area (Appendix A; Figures 9, 10, and 11; Appendix B). This is the only stream within this project section that is identified in the Snohomish County stream inventory. Stream 3 continues southeasterly approximately 0.8 miles to Little Bear Creek (right bank tributary). Fall Chinook, Coho, and sockeye salmon as well as steelhead utilize the stream below 196th St. SE (SalmonScape). No fish use is mapped within the project area, however Stream 3 appears to have suitable seasonal habitat for Coho and resident trout and will be treated as fish bearing until consultation with WDFW verifies its classification.

"Stream 4" is a very small (1 foot wide) Ns drainage that flows west into Unnamed Stream 5 at the north side of the driveway of Parcel 27051600303600 (19328 43rd Ave. SE). The channel is well hidden under dense brush and is only discernable when it is flowing. The source of water is unknown. Utilization by fish is unlikely due to the less than 1 foot wide, shallow channel and seasonal flow.

"Stream 5" is a ditched Ns drainage that flows north through a road ditch on the west side of 43rd Ave. SE (Appendix A; Figures 20a and 20b; Appendix B). It originates approximately 70 feet north of 196th St. SE and is a right bank tributary to Stream 3. The drainage varies from less than 1 foot to approximately 3 feet wide and portions of the drainage are vegetated with wetland plant species. The source of water appears to be runoff from the road and adjacent upland. There were no signs of groundwater input (springs or flocculant). A portion of the drainage is piped along some of the property frontages.

196th to SR524

There is one stream, one spring, and four potential wetlands located south of 196th within the project site.

Potential "Wetland G" may be a Palustrine emergent wetland located on the east side of the alignment (Appendix A; Figures 6, and 14; Appendix B) approximately 120 feet south of 196th St. SE. Hydrology is primarily provided by seasonal unnamed Stream 6. The stream exits the east outlet of a culvert under the existing gravel road and flows broadly eastward through the wetland across parcel 00647300000100 (4306 196th St. SE). The suspect area is dominated by Himalayan blackberry along its extreme western edge near the road, and closely grazed pasture

grasses and creeping buttercup east of the project area. Mature conifer trees border the northern and southern suspect wetland edges within the alignment.

Potential "Wetland H" is located on the north side of 204th St. SE (Appendix A, Figure 10; Appendix B). It is located in a topographically depressed area that is dominated by mature black cottonwood trees. Presence or absence of surface hydrology was not visible from the road due to dense understory vegetation.

Potential "Wetland I" and Spring A are located in a roadside ditch along the south side of 204th St. SE (Appendix A, Figures 11, 12a and 12b; Appendix B). Spring A surfaces in the ditch behind a bank of mailboxes located in front of residence 4022 204th St. SE. Drainage from the spring flows east through the driveway culvert and into potential "Wetland I" which may be a Palustrine emergent wetland created by a widened section of ditch. It is vegetated with creeping buttercup and salmonberry. The ditch was inundated east of the driveway during the site visit.

Potential "Wetland J" is located on the south side of Maltby Road just west of the intersection of 204th St. SE (Appendix A, Figure 13; Appendix B). It is located in a topographically depressed area surrounded by upland. It is likely that this area was created by road run off and will not be a regulated feature.

Unnamed Stream 6 crosses the alignment immediately south of 196th St. SE (Appendix A, Figures 6, 21a, 21b, and 22; Appendix B). This stream is mapped as Type U (unknown) on the Snohomish County Inventory indicating that the utilization by fish is unknown. The stream flows underground (piped) upstream of the project limits and does not daylight until the eastern edge of the existing gravel road. During the site visit flow was gushing from the pipe. Himalayan blackberry masks the water flow. The stream is tributary to Stream 3 approximately 1,000 feet east of the project area, and appears to be the primary source of hydrology for "Wetland G".

C. Potential Environmental Impacts and Issues

Aquatic Resources

Up to seven streams and 10 – 14 wetlands may be impacted by this project as currently proposed. A delineation is needed to determine where resources are located and the classification of these resources. The figures in Appendix B are provided to depict preliminary potential impacts with the project as proposed.

Unnamed ditched "Streams 1, 2, and 5" may serve as unwanted attractive nuisances to resident fish near their confluences with Stream 3 during high flows. Fish may wander into these roadside ditches in search of refuge or upstream habitat. Undersized driveway culverts help to discourage potential fish access upstream of the confluences, however, fish exclusion may be needed if work occurs before the ditches are dry.

Wildlife

There are no mapped priority habitats or species mapped within the site. Land on both sides of the alignment has been deforested and developed in very recent years, leaving little habitat for wildlife except in the wetlands and their limited buffers.

None of these projects sections are ideal for fish and wildlife however moderate utilization by wildlife adapted to suburban environments is supported in this area. Further loss of habitat would result in long term impacts to the wildlife that remain. As currently designed, the project will impact wetlands, streams, and their buffers (Appendix B). The project will also increase the difficulty for wildlife movements within the utility corridor and remove large remnant trees that serve as wildlife refuge, roosting, and nesting habitat. Avoidance and minimization of habitat loss is recommended, especially where adjacent to aquatic habitats.

Support of Hydrology to Aquatic Habitats

Effective impervious surface within the buffer of streams and wetlands must not increase per SCC 30.62A.320(1)(c).

D. Considerations to Reduce Environmental Impacts

Every effort should be made to avoid impacts to critical areas, especially wetlands and buffers.

Construction impacts can be reduced by adhering to mitigation sequencing in accordance with SCC 30.62A.300 and U.S. Army Corps of Engineers (USCOE) permit conditions. The prescribed sequence includes:

- Avoiding the impacts altogether by not taking a certain action or parts of an action
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action
- Compensating for the impact by replacing, enhancing, or providing substitute resources or environments, or
- Monitoring the impact and taking appropriate corrective measures.

Alternative project designs should be considered that would avoid or minimize environmental impacts associated with this proposal. Construction of walls instead of fill slopes adjacent to wetlands, streams, and within buffers would reduce the amount of impacts. Use of soil-wrap rather than block walls would be preferred. Low impact development (LID) elements, such as pervious pavement or bioswales, should be used where appropriate within the project corridor.

Road widening, lengthening existing culverts, installing new culverts, or other activities that will impact streams or wetlands would trigger the need for an HPA and a Section 404 Corps permit.

E. ENVS' Recommendations for Project Cost Savings

Mitigation opportunities in southwest Snohomish County are limited and expensive. Avoiding and limiting impacts to critical areas and relocating ditched streams within the new ROW (reducing piped sections and improving channel condition) would decrease mitigation costs substantially.

Mitigation for the project impacts to buffers and streams may be addressed through the King County In-Lieu Fee program (ILF). Temporary impacts should be mitigated on site. Comparison of costs for the ILF, the upcoming Keller Farm Mitigation Bank (not yet approved by the agencies), or on-site mitigation could be evaluated once project design reaches 60% and critical area impacts are identified.

F. What ENVS Needs

Currently

- ENVS will need rights of entry (ROE) on all parcels with known or potential critical areas to confirm presence/absence of critical areas, to delineate critical area boundaries and to verify drainage classifications within the project area.
- ROE should include permission to explore for critical areas within 300 feet; and to dig soil test pits, tie flags, and survey within 200 feet of the proposed land disturbing activities.

Table 1 lists all parcels where ROEs are still needed. These parcels did not reflect access permission on the ROE spreadsheet provided in the 5/10/17 coordination meeting notes. Table 2 lists parcels where ROEs were previously approved but need to be verified to confirm that ENVS still has permission to complete necessary work. A map showing all parcels that are needed for environmental assessment is located in Appendix C.

Future

This project will need a CAS and mitigation plan for unavoidable impacts to critical areas and their buffers. Support that will be needed includes:

- 60% Design report identifying location and size of permanent and temporary impacts, staging areas, construction techniques, construction machinery, and schedule.
- If On-site Mitigation is used: Mitigation property and mitigation design plans

Table 1 - Parcels with known or suspected critical areas - ROE for CA verification/delineation is needed.

PARCEL_ID	TAXPRNAME	TAXPRLINE1	COMMENT	USECODE	GIS_ACRES
27051600300100	CONCORD REALTY II LLC	18907 43RD AVE SE		910 Undeveloped (Vacant) Land	2.4
27051600402500	BALDWIN CLAY R & MARTA J	18823 43RD AVE SE		111 Single Family Residence - Detached	2.5
27051600300200	MARTIN JOEL W	18808 43RD AVE SE		111 Single Family Residence - Detached	2.4
27051600304000	CAREY JESS R	19210 43RD AVE SE		910 Undeveloped (Vacant) Land	2.4
27051600302900	CAREY JESS R	19210 43RD AVE SE		111 Single Family Residence - Detached	2.4
27051600400200	SCHULTZ JEFF	19005 43RD AVE SE		111 Single Family Residence - Detached	5.1
27051600400800	ZAPARA JAMES	19505 43RD AVE SE		111 Single Family Residence - Detached	2.9
			Private Tract - Tambark Springs Condominium		35.1
01136100099200	NATURES RIDGE HOA	12910 TOTEM LAKE BLVD STE 220		910 Undeveloped (Vacant) Land	3.1
27052100300100	GREEN CURTIS & MORGAN LESLIE	20924 SE 155TH PL		122 Two Family Residence (Duplex)	2.8
27051600401800	FOLEY MICHAEL & LESLIE	19107 43RD AVE SE		111 Single Family Residence - Detached	1.3
27051600400900	PETERS ROY	19309 43RD AVE SE		111 Single Family Residence - Detached	1.0
27051600401300	HOLLIMAN SCOTT D	19207 43RD AVE SE		111 Single Family Residence - Detached	2.4
27051600401900	KATHRYN LAURA	19131 43RD AVE SE		111 Single Family Residence - Detached	0.8
27051600403300	BAESMAN MORRIS W & JANICE K	19123 43RD AVE SE	AFN 201503260421	456 Local Access Streets (Inc. Private Roads)	0.1
27052100203300	CUMMINGS LINDA T	20312 42ND DR SE		111 Single Family Residence - Detached	3.4
27050900305000	LINDBLOOM CAROL A	17914 SUNSET RD		183 Non Residential Structure	0.6
			Private Tract – Kings Corner		12.6
			Private Tract - Kings III Condominium		5.1

Table 2 - Parcels with known or suspected critical areas – verification of ROE for delineation is needed.

PARCEL_ID	TAXPRNAME	TAXPRLINE1	COMMENT	USECODE	GIS_ACRES
27051600303100	AUSTIN CHARLES K	18930 43RD AVE SE		183 Non Residential Structure	3.7
27051600300300	AUSTIN CHARLES K	18930 43RD AVE SE		111 Single Family Residence - Detached	1.2
27051600301000	MELANIE GROUP LLC	9805 NE 116TH ST		111 Single Family Residence - Detached	4.8
27051600300700	ATWOOD MICHAEL	19106 43RD AVE SE		111 Single Family Residence - Detached	4.9
27051600401000	DERU DEVAN D/PAIGE M	19329 43RD AVE SE		111 Single Family Residence - Detached	2.4
00647300000100	MORRISON PHILLIP D	4306 196TH ST SE		111 Single Family Residence - Detached	0.7
27051600302400	JOHNSON RONALD & LINDA	19316 43RD AVE S		111 Single Family Residence - Detached	2.2
27051600200101	DRH ENERGY INC	301 COMMERCE ST STE 500	AFN 201207160371 (Mineral Rights)	850 Mining Claims, Mineral Rights or Mining NEC	9.4
27051600303600	JOHNSON ALAN R & MICHELE H	19328 43RD AVE SE		111 Single Family Residence - Detached	5.4
27051600303400	VAJDIK STEPHEN M	4131 JEWELL RD		111 Single Family Residence - Detached	1.9
27051600302800	JOHNSON JOHN/ALAINA	19412 43RD AVE SE	AFN 200205230736	111 Single Family Residence - Detached	1.0
27051600303700	ENG ALYSSA	3824 207TH PL SE	AFN 200205230736	111 Single Family Residence - Detached	1.1
27051600400700	HAWKER SHAWN / WILLIARD KELLIE	19317 43RD AVE SE		111 Single Family Residence - Detached	1.4
27051600401200	JOHNSON ROGER & MARY ANN	19225 43RD AVE SE		111 Single Family Residence - Detached	2.4
27051600405300	HASENYAGER GARY L	19029 43RD AVE SE		111 Single Family Residence - Detached	7.2

Appendix A
Wetland and Stream Photos

Figure 1 - Wetland A looking west from Sunset Road. This wetland is protected in a private NGPA tract.

Figure 2 – Potential **"**Wetland A2" looking north from 180th St SE (Google Earth).

Figure 3 – Wetland A3 looking north from 180th St SE (Google Earth).

Figure 4 – Wetland A4 looking north from 180th St SE (Google Earth).

Figure 5 - Potential **"**Wetlands B and C" looking east from 43rd Ave SE.

Figure 6 - Potential **"**Wetlands B, C, and D" and the northern extent of "Stream 1" looking south from 43rd Ave. SE.

Figure 7 - Potential **"**Wetland D" looking northwest from 43rd Ave. SE.

Figure 8 - Potential **"**Wetland F", "Wetland E", and "Stream 1" looking south along 43rd Ave SE. "Stream 2" is located at the toe of road fill along the west edge of "Wetland E".

Figure 9 – Potential **"**Wetland G" and Stream 6 looking east from 43rd Ave. SE

Figure 10 – Potential "Wetland H" located on the north side of 204th St SE (Google Maps).

Figure 11 – "Spring A" looking west from the driveway on the south side of 204th St. SE

Figures 12a and 12b – Potential "Wetland I" looking east from the driveway along the south side of 204th St. SE

Figure 13 – Potential “Wetland J” located on the south side of Maltby Rd in a roadside swale.

Figure 14 – “Stream 1” and potential **“**Wetland F” looking south along the west side of 43rd Ave. SE.

Figure 15 – “Stream 2” and potential **“**Wetland E” looking south along the east side of 43rd Ave. SE.

Figure 16 – Stream 3 looking west from 43rd Ave. SE.

Figure 17 - Stream 3 on the west side of 43rd Ave. SE.

Figure 18 - Stream 3 looking east from the east side of 43rd Ave. SE.

Figure 19 – "Stream 4" looking north along the east side of 43rd Ave. SE.

Figures 20a and 20b – "Stream 5" looking south then north along the west side of 43rd Ave. SE.

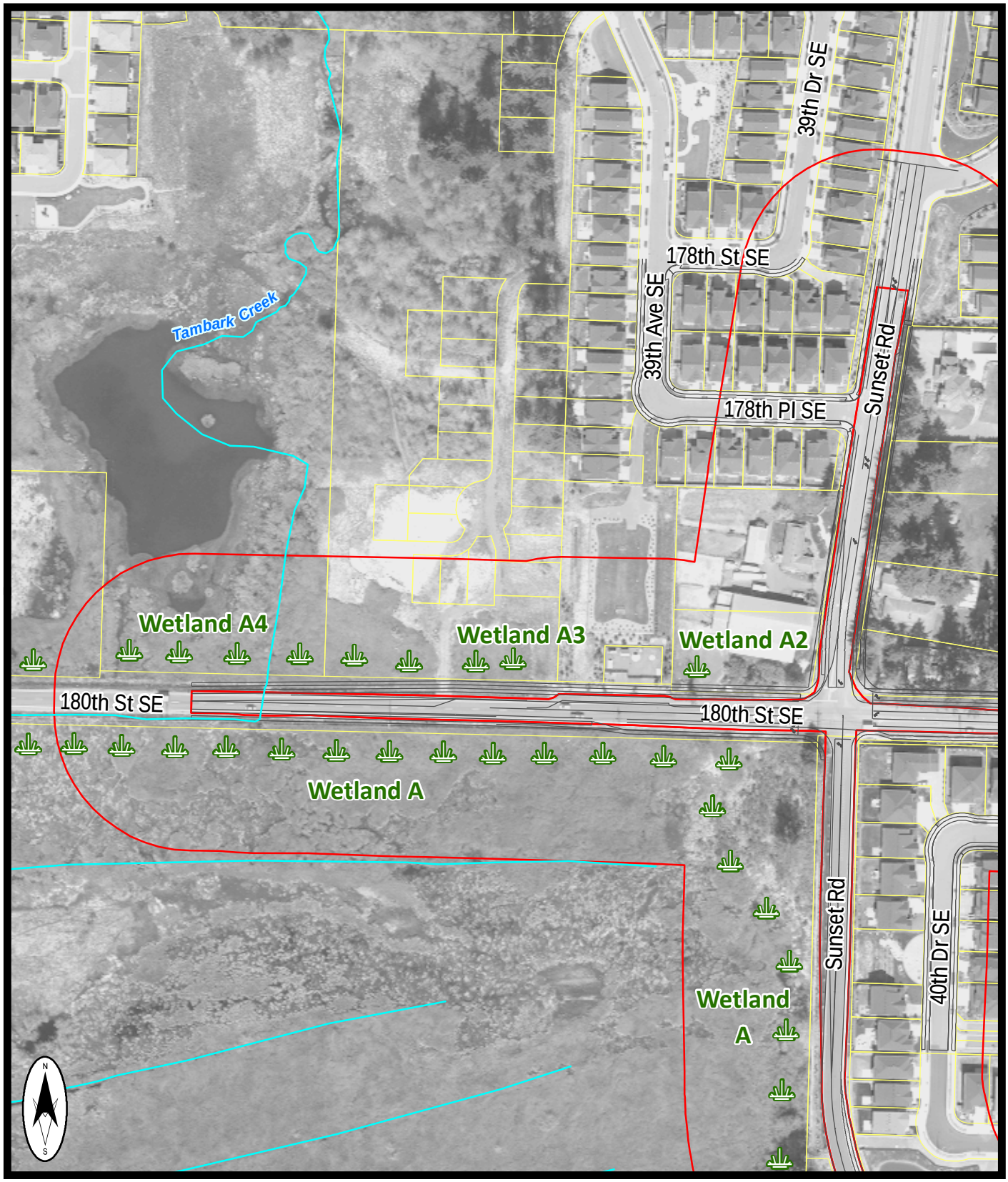
Figures 21a and 21b - Stream 6 looking east from the east side of 43rd Ave. SE, south of 196th St SE.

Figure 22 - Approximate location of Stream 6 crossing looking south from 196th St SE. "Wetland G" is not visible.

Appendix B

Approximate Location of Critical Areas

Note: A field delineation is needed to determine where actual resources are located and what their classification may be.



Key to Features:

- Wetlands
- Parcels
- Proposed Improvements
- Streams
- 200' Site Buffer

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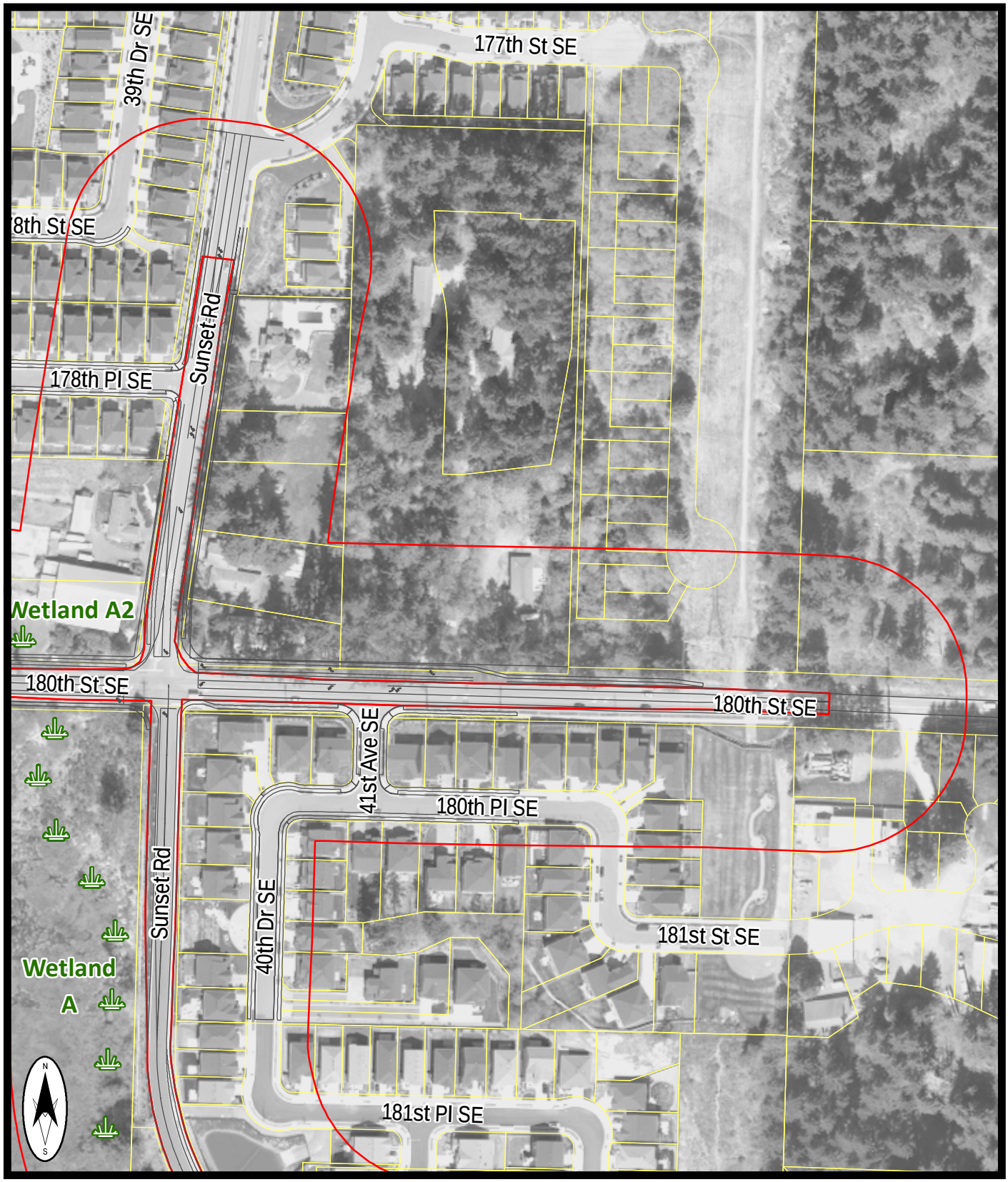
0 100 200 Feet

Airphoto Source: *GeoTerra, Inc, 2015*

Snohomish County

43rd Ave SE Corridor Improvement (RC1592)
Wetlands and Streams



Key to Features:

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- Streams
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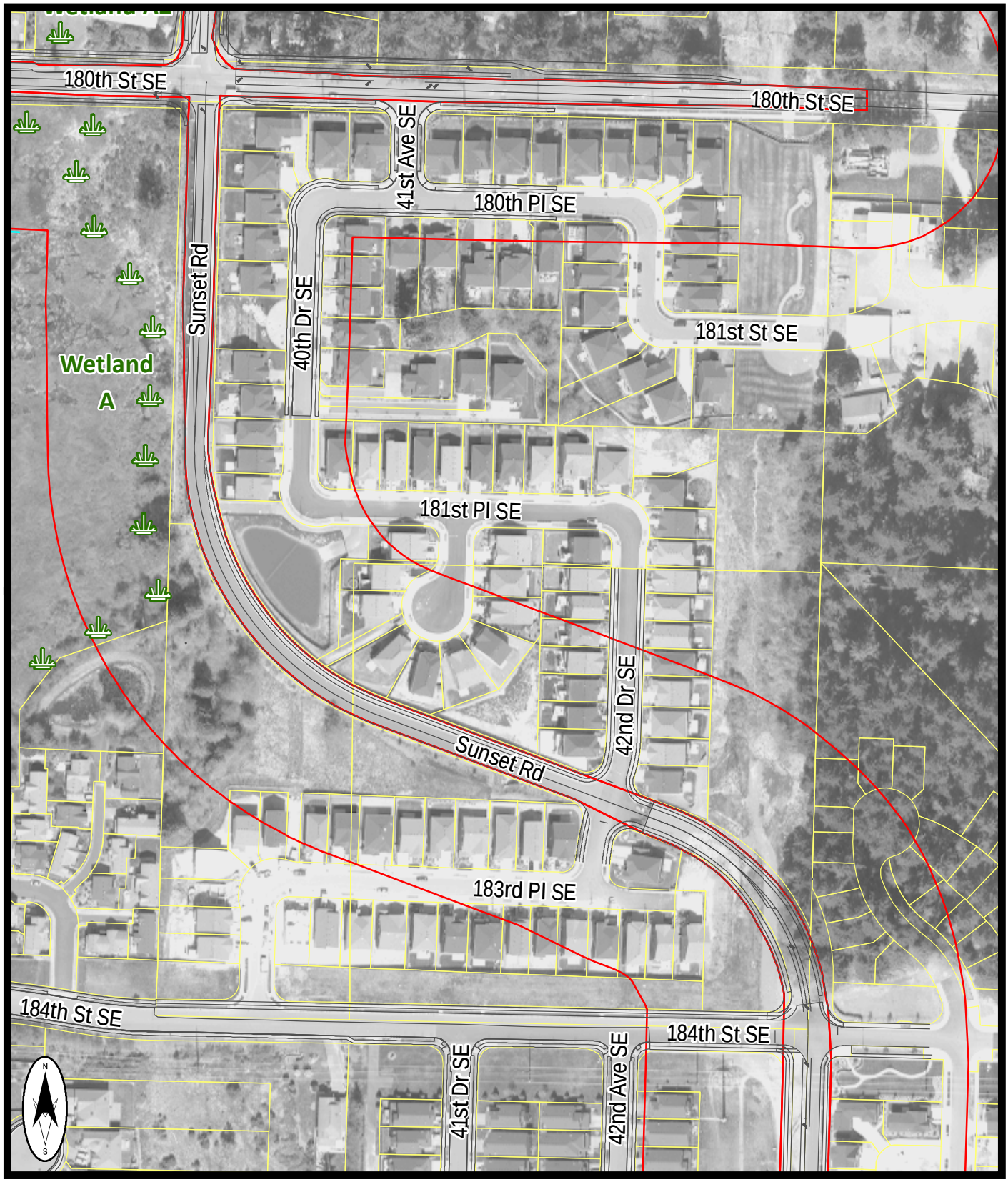
Airphoto Source: *GeoTerra, Inc, 2015*

Snohomish County

43rd Ave SE Corridor Improvement (RC1592)
Wetlands and Streams



Key to Features:

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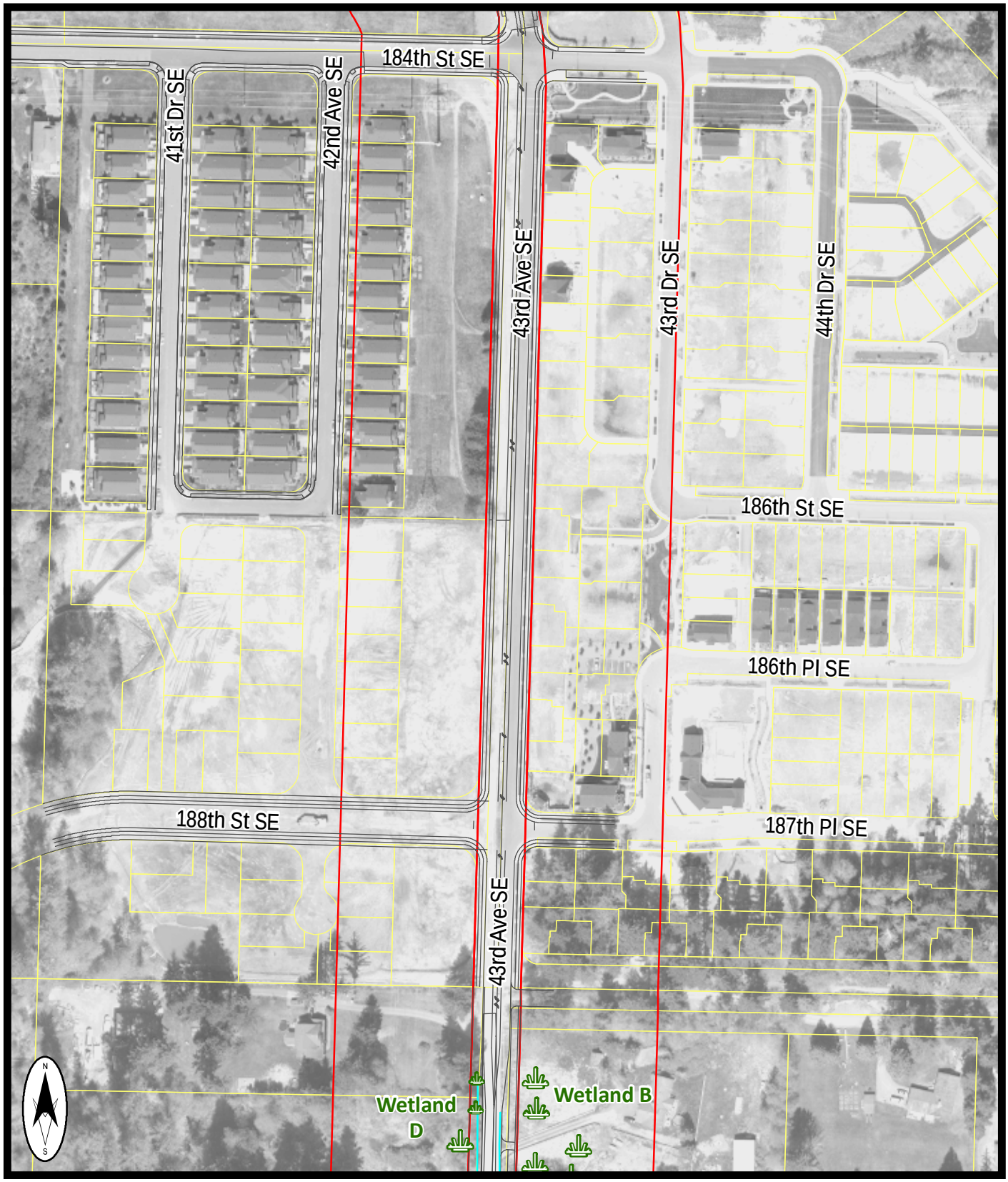
Airphoto Source: *GeoTerra, Inc, 2015*

Snohomish County

43rd Ave SE Corridor Improvement (RC1592)
Wetlands and Streams



Key to Features:

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- Parcels
- Proposed Improvements
- Streams
- 200' Site Buffer

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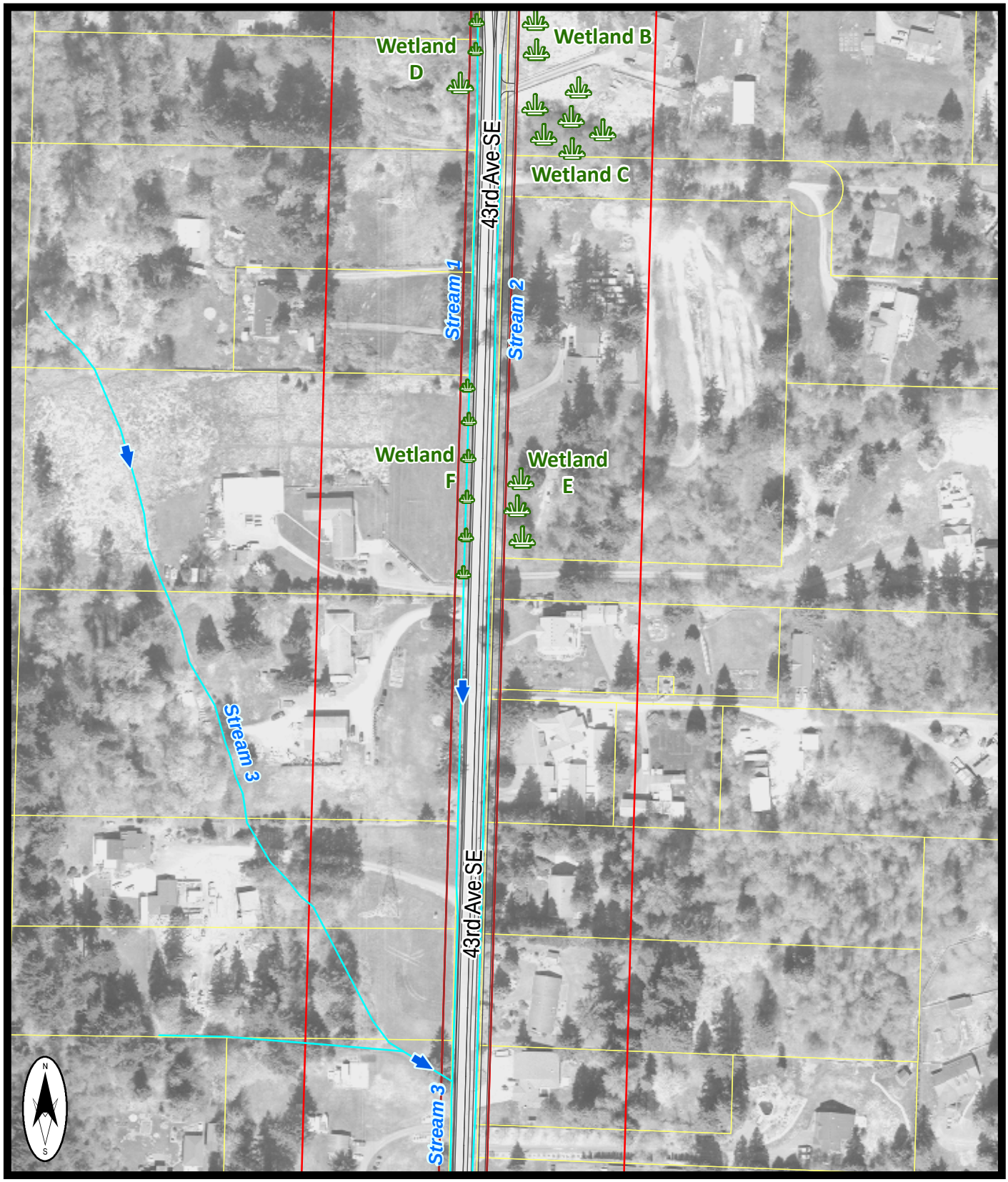
0 100 200 Feet

Airphoto Source: *GeoTerra, Inc, 2015*

Snohomish County

43rd Ave SE Corridor Improvement (RC1592)
Wetlands and Streams



Key to Features:

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- Streams
- 200' Site Buffer

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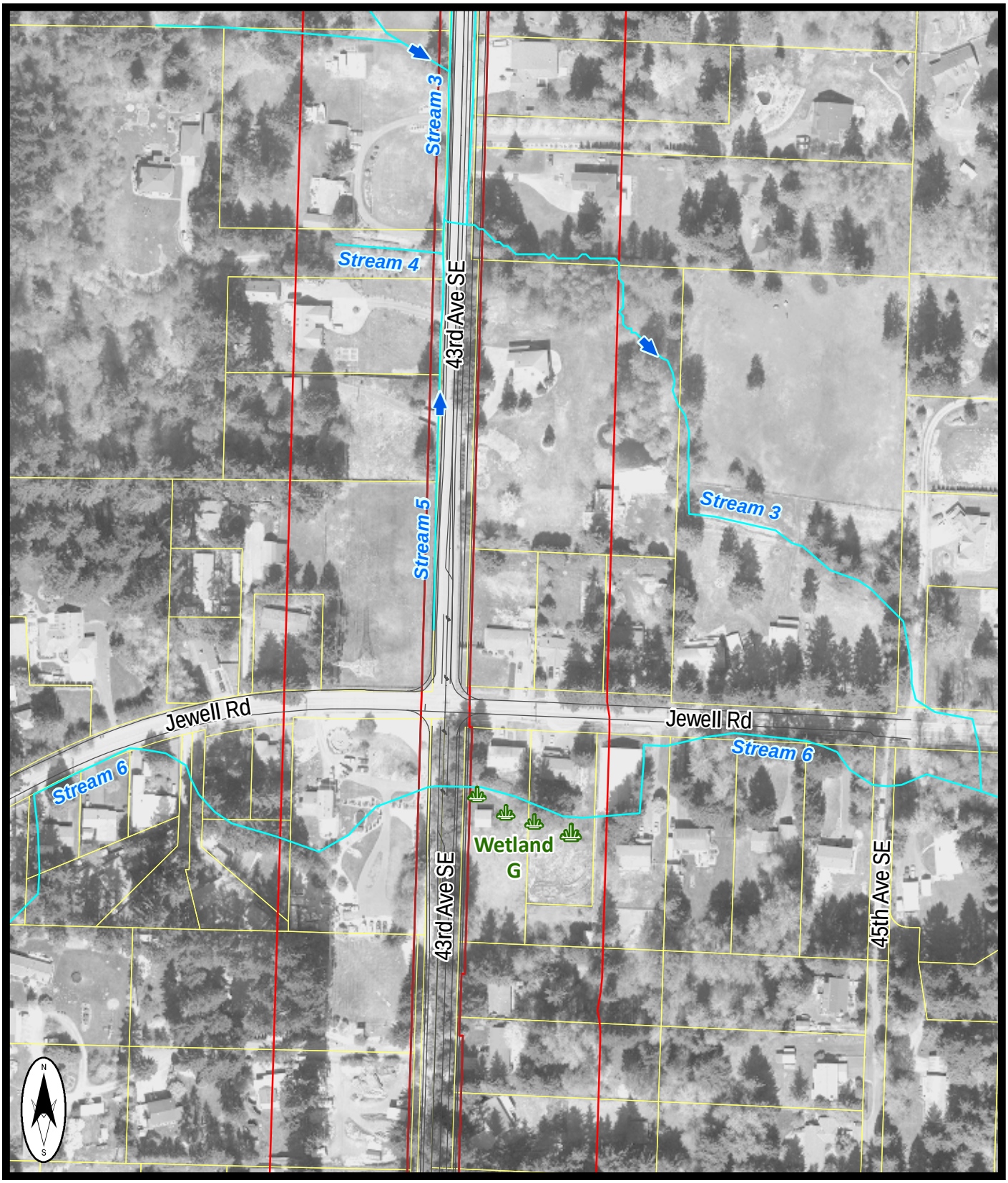
Airphoto Source: *GeoTerra, Inc, 2015*

Snohomish County

43rd Ave SE Corridor Improvement (RC1592)
Wetlands and Streams



Key to Features:

- Wetlands
- Parcels
- Proposed Improvements
- Streams
- 200' Site Buffer

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0 100 200 Feet

Airphoto Source: *GeoTerra, Inc, 2015*

Snohomish County

43rd Ave SE Corridor Improvement (RC1592)
Wetlands and Streams

Key to Features:

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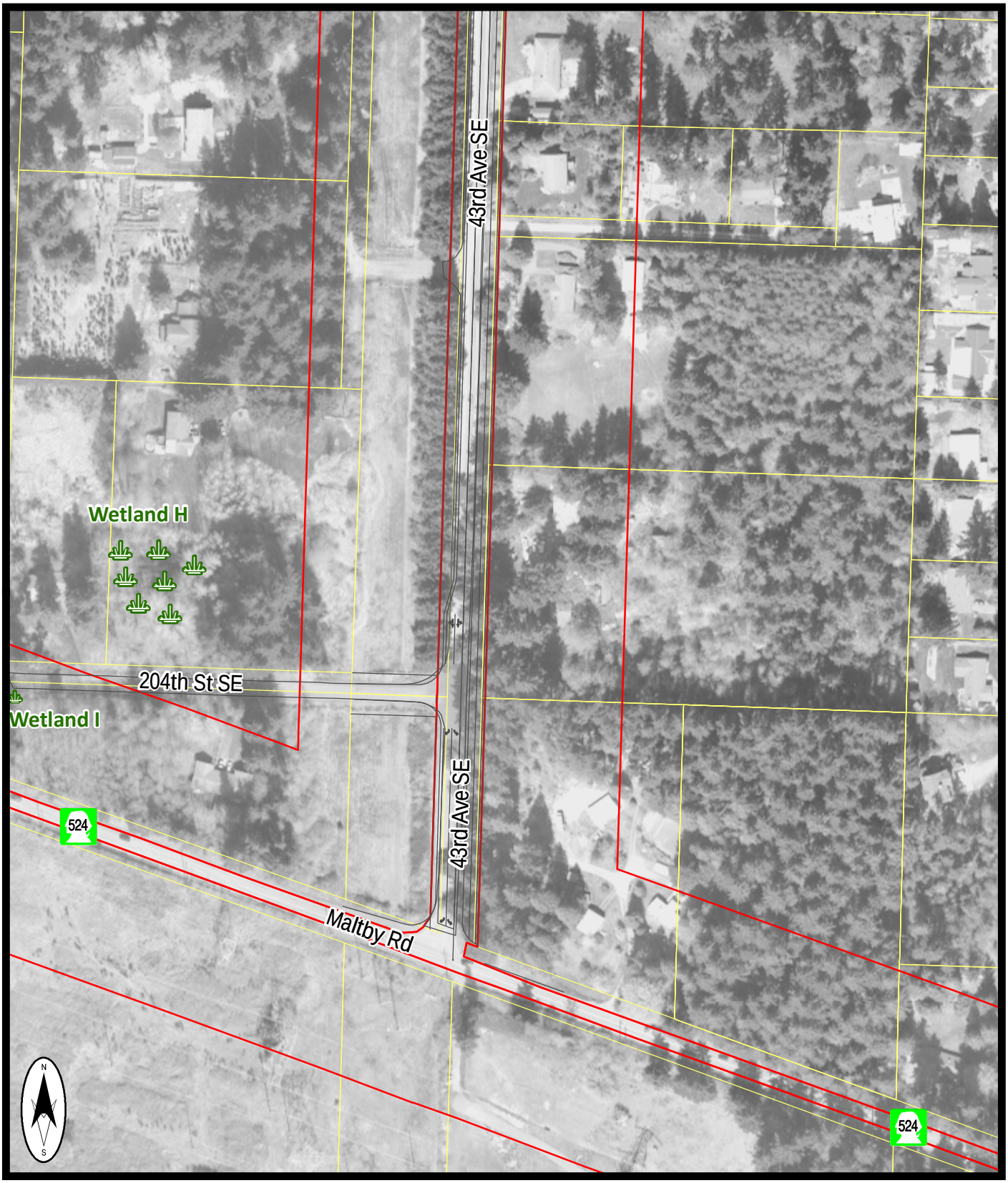
0 100 200 Feet

Airphoto Source: *GeoTerra, Inc, 2015*

Snohomish County

43rd Ave SE Corridor Improvement (RC1592)
Wetlands and Streams



Key to Features:

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- Proposed Improvements
- Streams
- 200' Site Buffer

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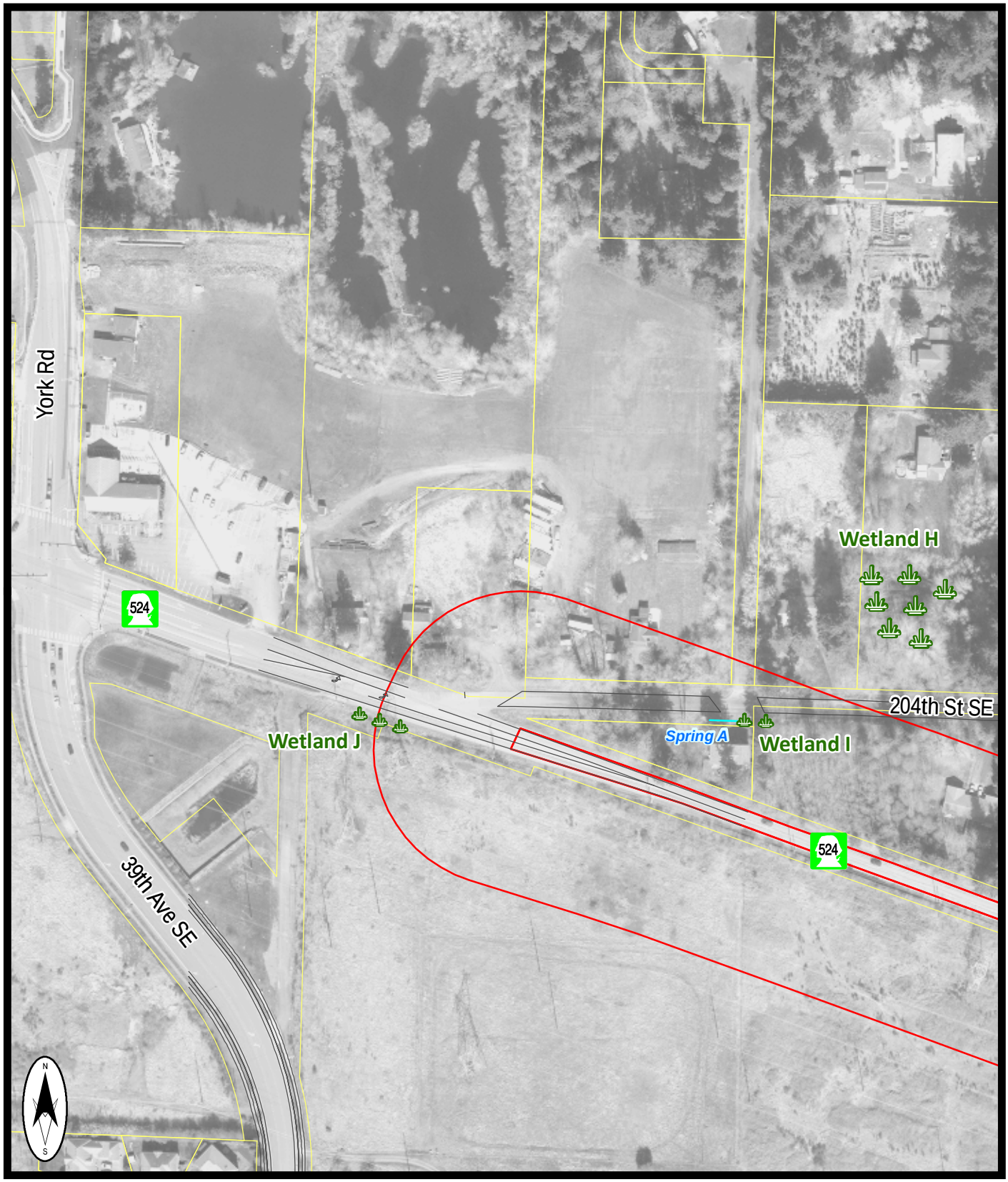
0 100 200 Feet

Airphoto Source: *GeoTerra, Inc, 2015*

Snohomish County

43rd Ave SE Corridor Improvement (RC1592)
Wetlands and Streams



Key to Features:

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- Parcels
- Proposed Improvements
- Streams
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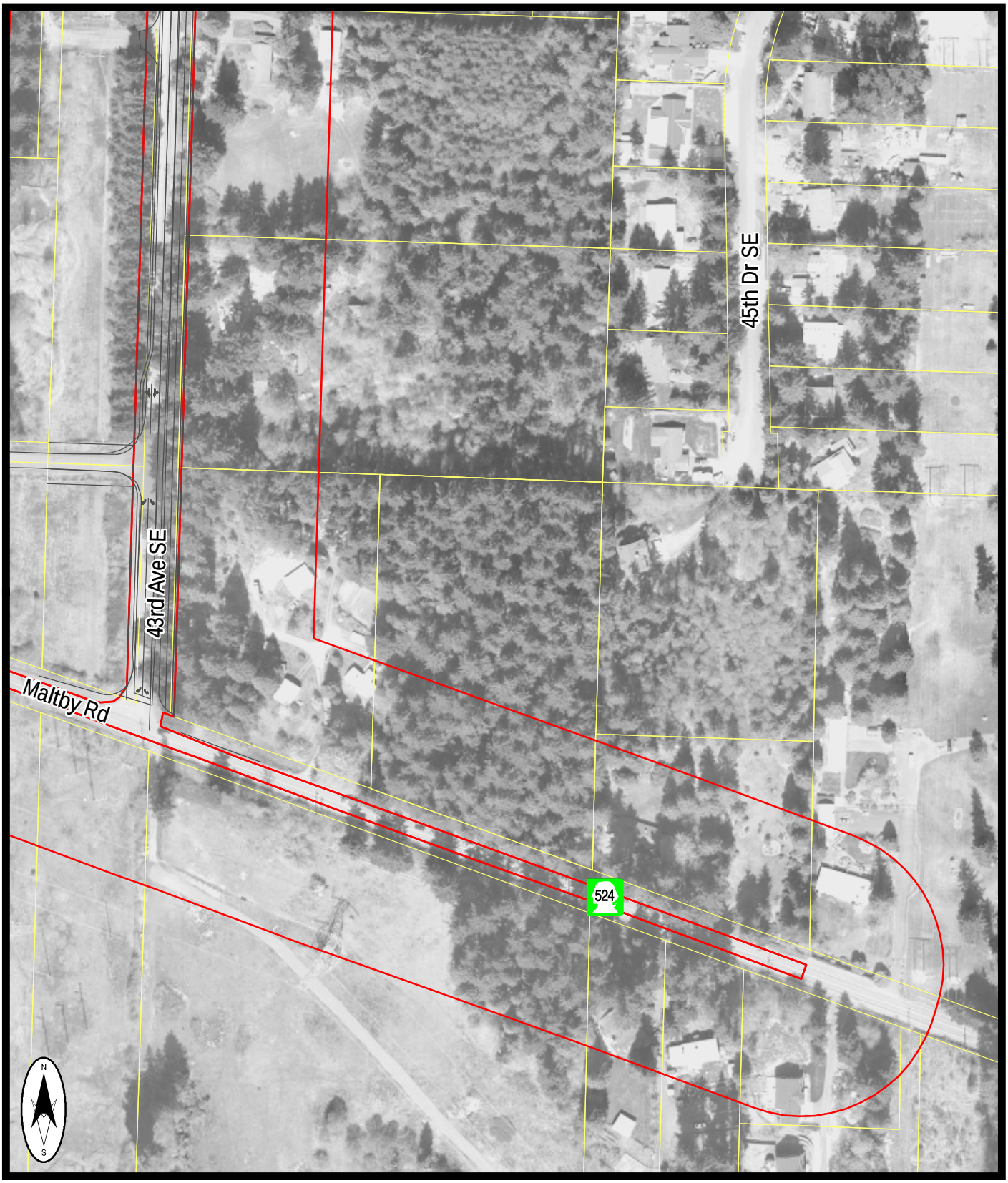
0 100 200 Feet

Airphoto Source: *GeoTerra, Inc, 2015*

Snohomish County

43rd Ave SE Corridor Improvement (RC1592)
Wetlands and Streams



Key to Features:

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- Streams
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0 100 200 Feet

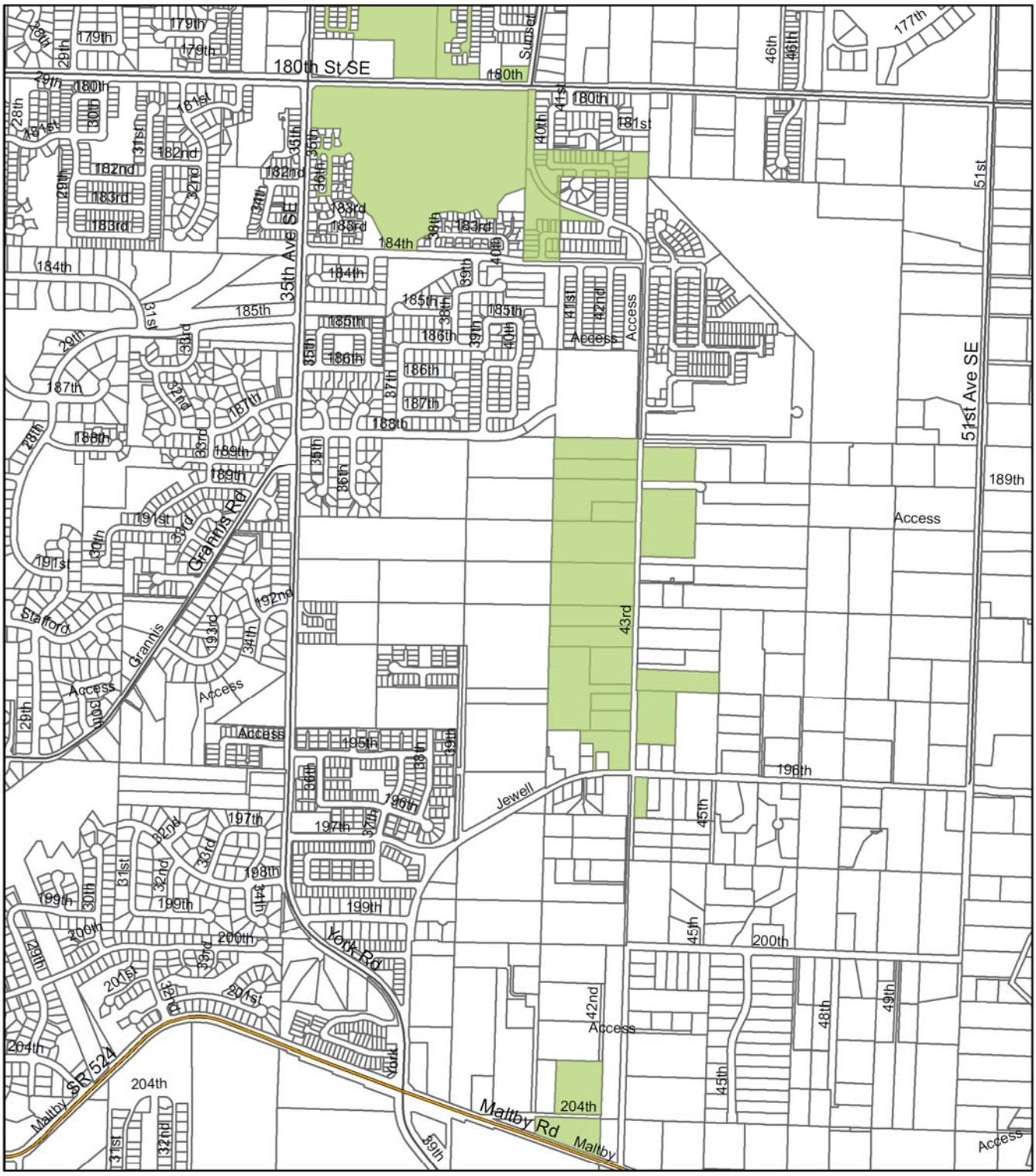
Airphoto Source: *GeoTerra, Inc, 2015*

Snohomish County

43rd Ave SE Corridor Improvement (RC1592)
Wetlands and Streams

Appendix C

Map of Parcels Needing ROE for Environmental Review



3rd Ave SE Critical Area - ROE Needs for Environmental Review

N

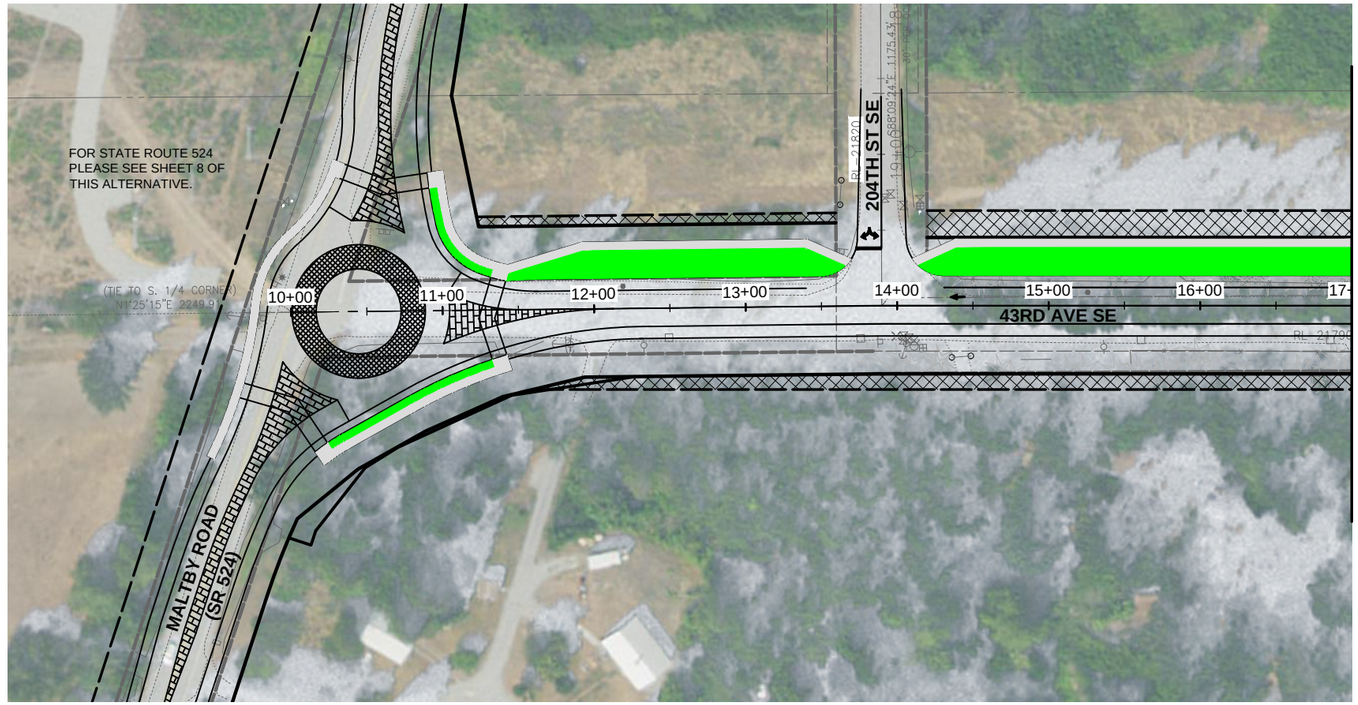
ROE Needed for Environmental Assessment

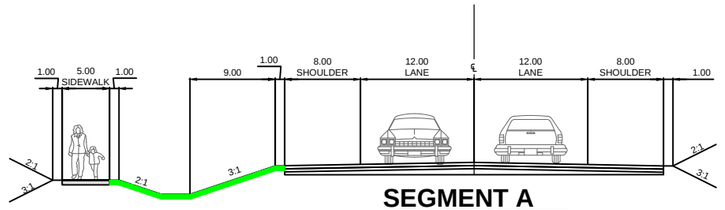
0 500 1,000 2,000 Feet

APPENDIX C-1

Plan Layout of Alternative 1, County Standard

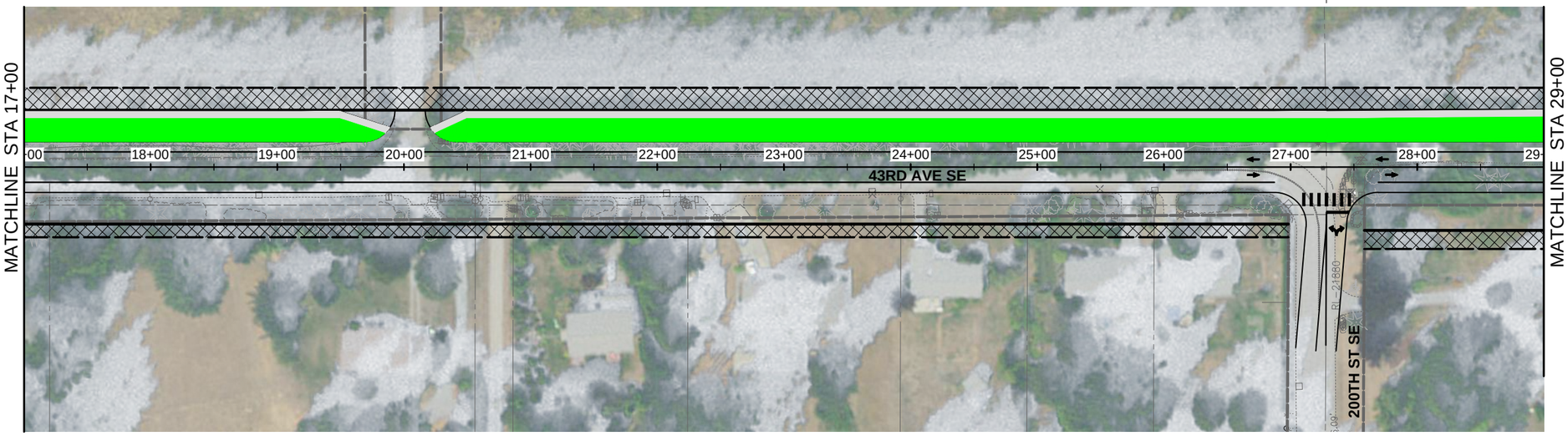
SECTION 29, T. 29 N, R. 5 E., W.M.





SEGMENT A
SR 524 TO 200TH ST. SE
ALTERNATIVE 1 – RURAL

SEG A ◄ | ► **SEG B**



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50 0 50 100
SCALE IN FEET

DATE	NO.	REVISION	BY

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43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 1
CHANNELIZATION PLAN

REFERENCE SHEET NO. CH01

SHEET 1 OF 8 SHEETS

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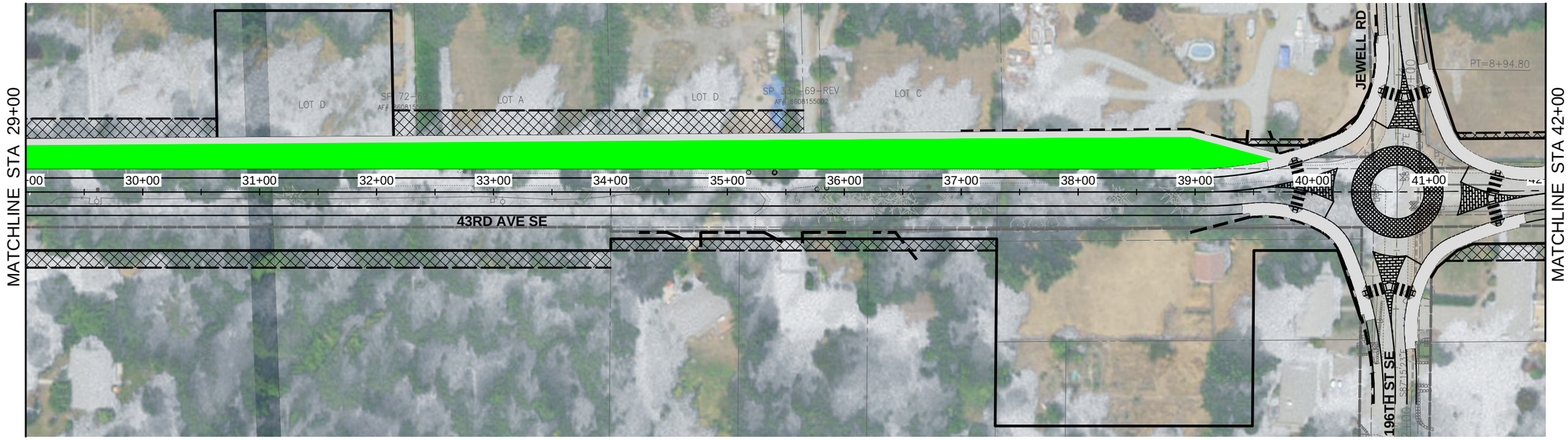
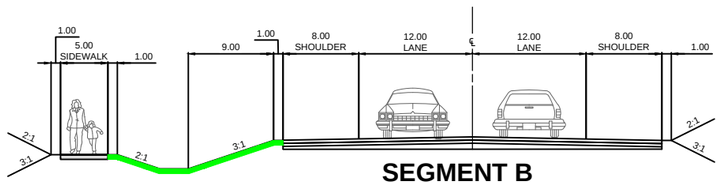
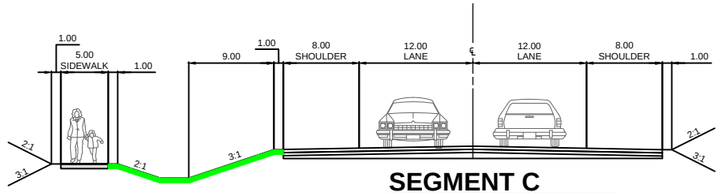
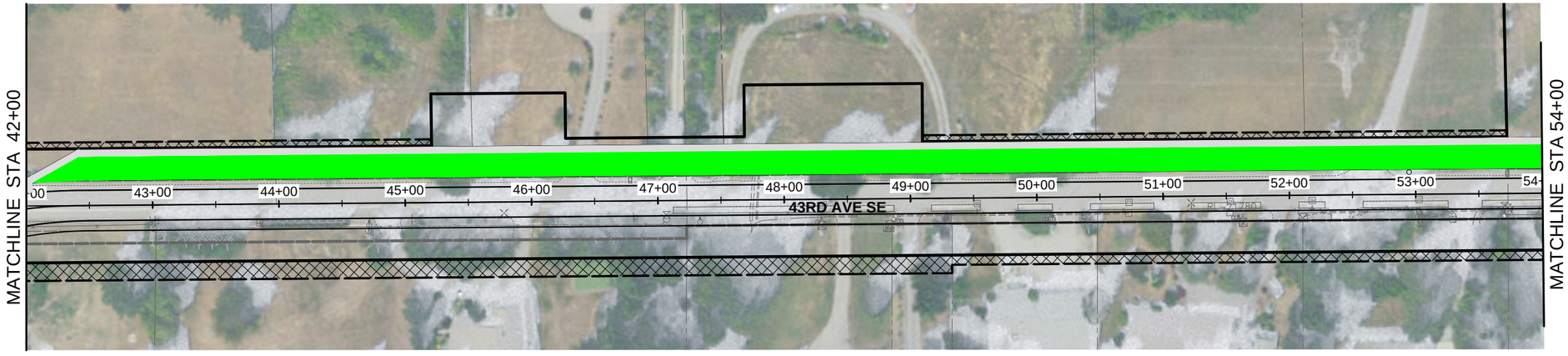




SEGMENT B
200TH ST. SE TO 196TH ST. SE
ALTERNATIVE 1 – RURAL



SEGMENT C
196TH ST. SE TO 188TH ST. SE
ALTERNATIVE 1 – RURAL



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SCALE IN FEET

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43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 1

CHANNELIZATION PLAN

REFERENCE SHEET NO. CH02

SHEET 2 OF 8 SHEETS

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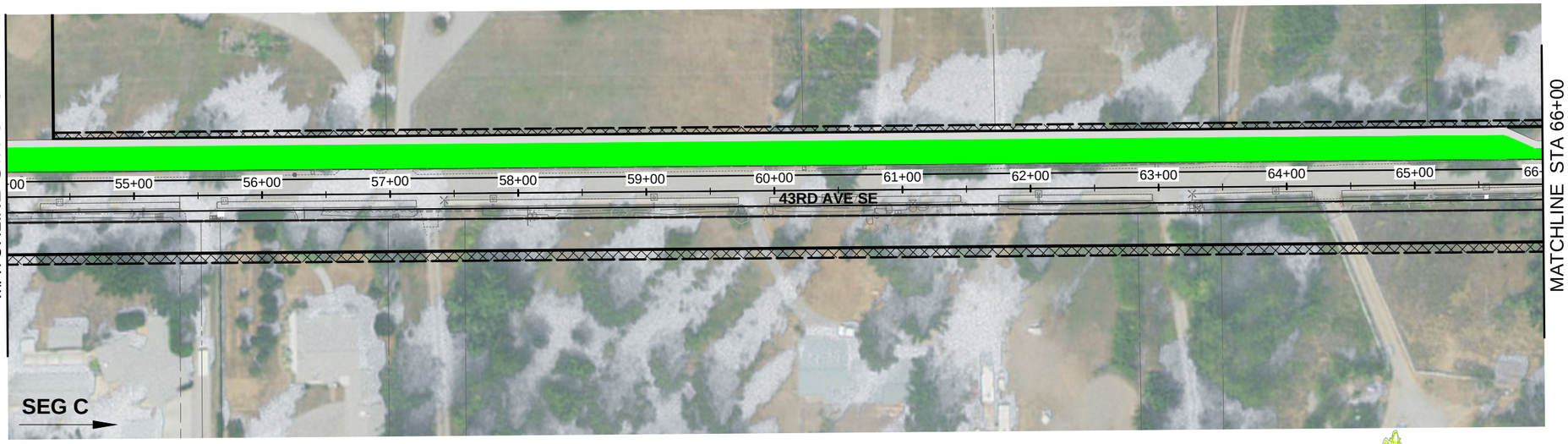
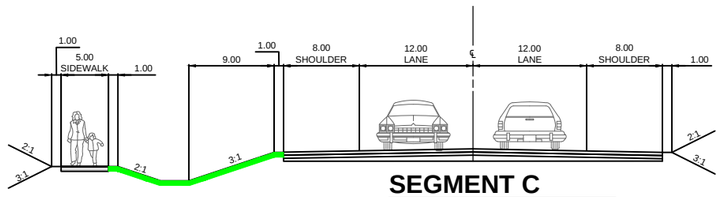
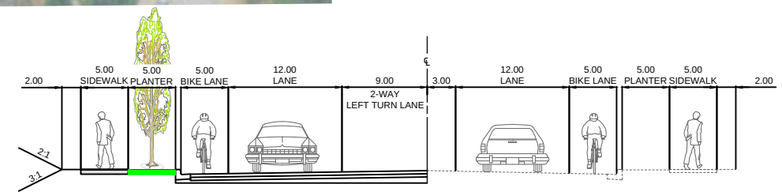
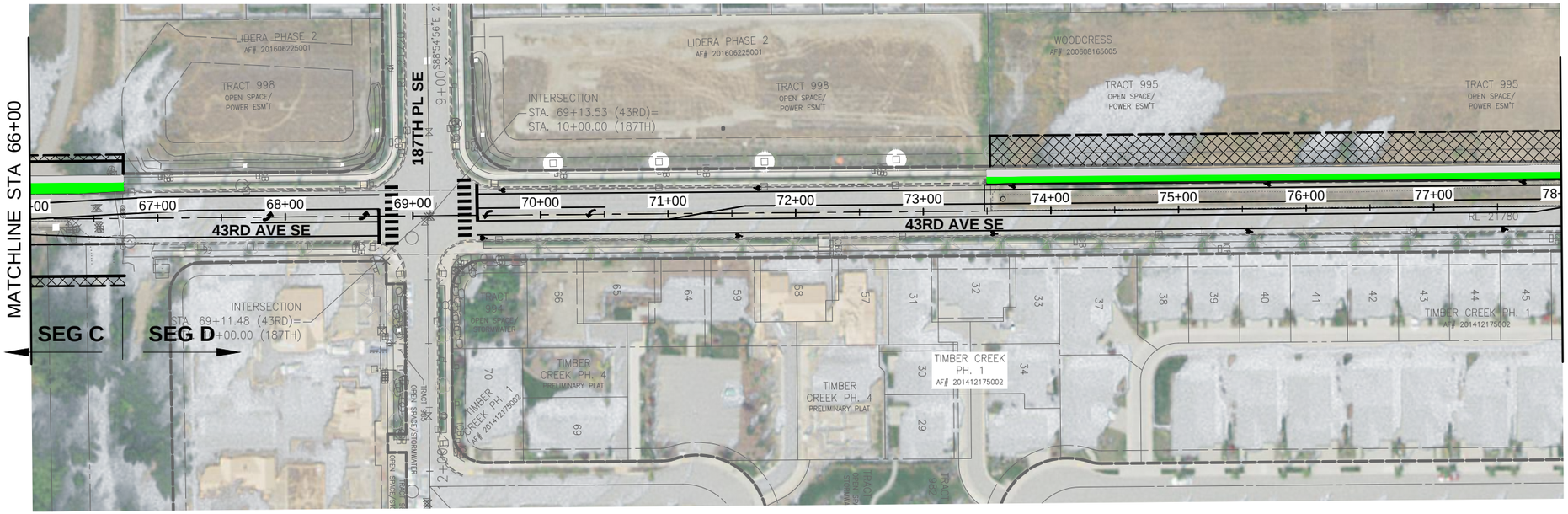




SEGMENT C
196TH ST. SE TO 188TH ST. SE
ALTERNATIVE 1 – RURAL



SEGMENT D
186TH ST. SE TO 184TH ST. SE
ALTERNATIVE 1



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FUNDING NO. 1800175

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 1
CHANNELIZATION PLAN

REFERENCE SHEET NO. CH03

SHEET 3 OF 8 SHEETS

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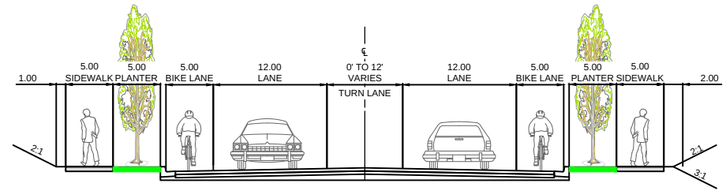
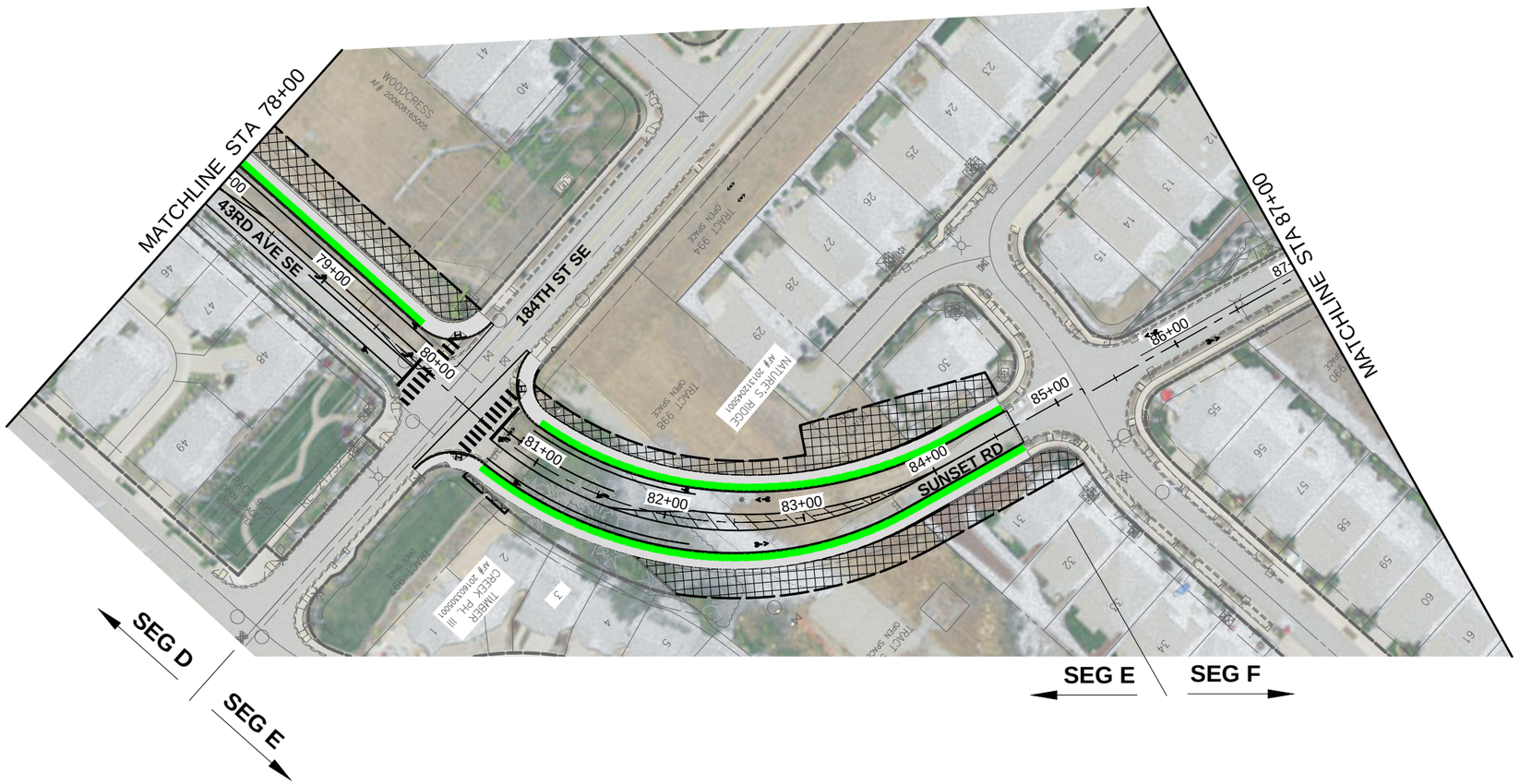
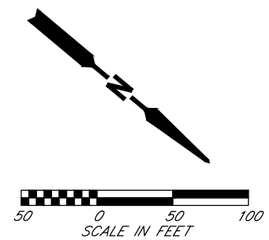


SEGMENT E

184TH ST. SE TO 43RD DR. SE
ALTERNATIVE 1





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SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 1

CHANNELIZATION PLAN

REFERENCE SHEET NO. CH04

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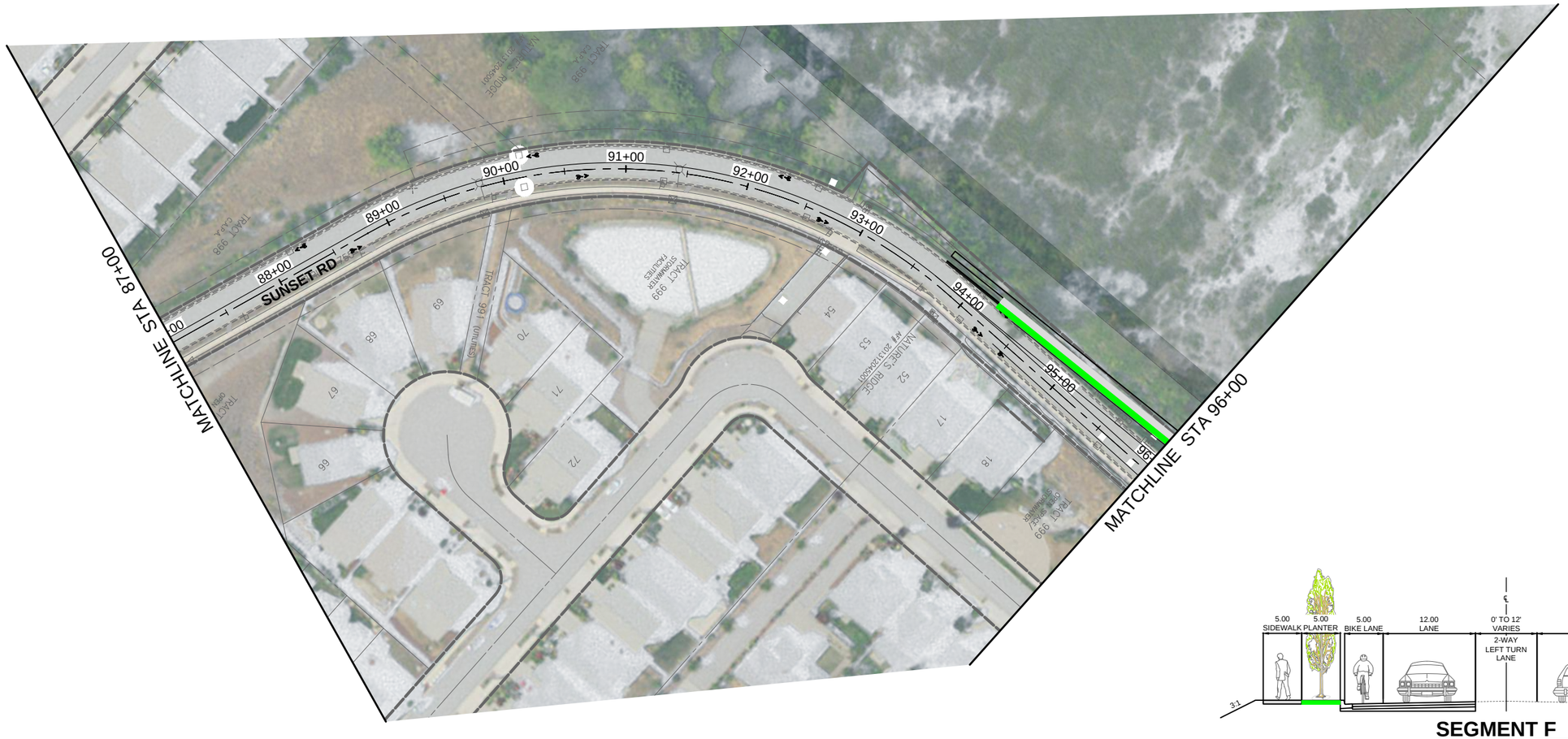
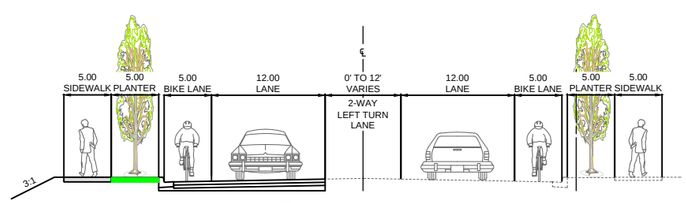
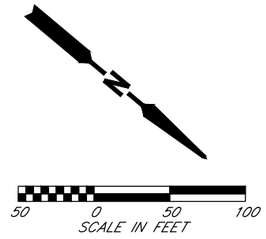




SEGMENT F

42ND DR. SE TO 180TH ST. SE
ALTERNATIVE 1



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SR 524 TO 180TH STREET SE
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ALTERNATIVE 1

CHANNELIZATION PLAN

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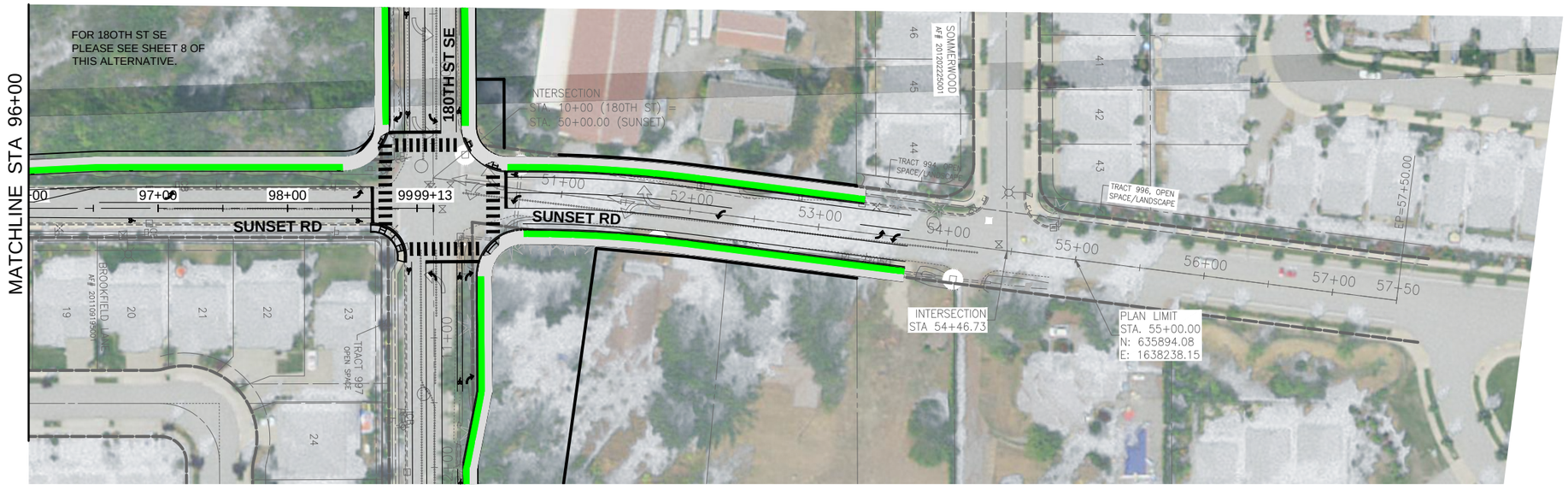

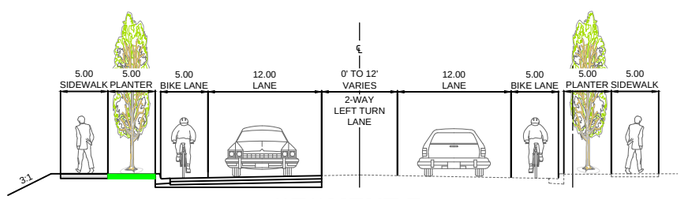

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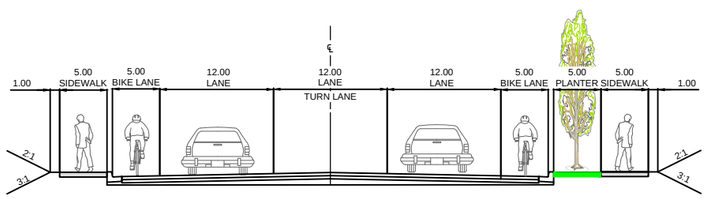
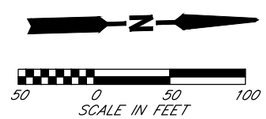
42ND DR. SE TO 180TH ST. SE
ALTERNATIVE 1



SEGMENT G
180TH ST. SE TO 178TH ST. SE
ALTERNATIVE 1



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SNOHOMISH COUNTY STANDARD
ALTERNATIVE 1

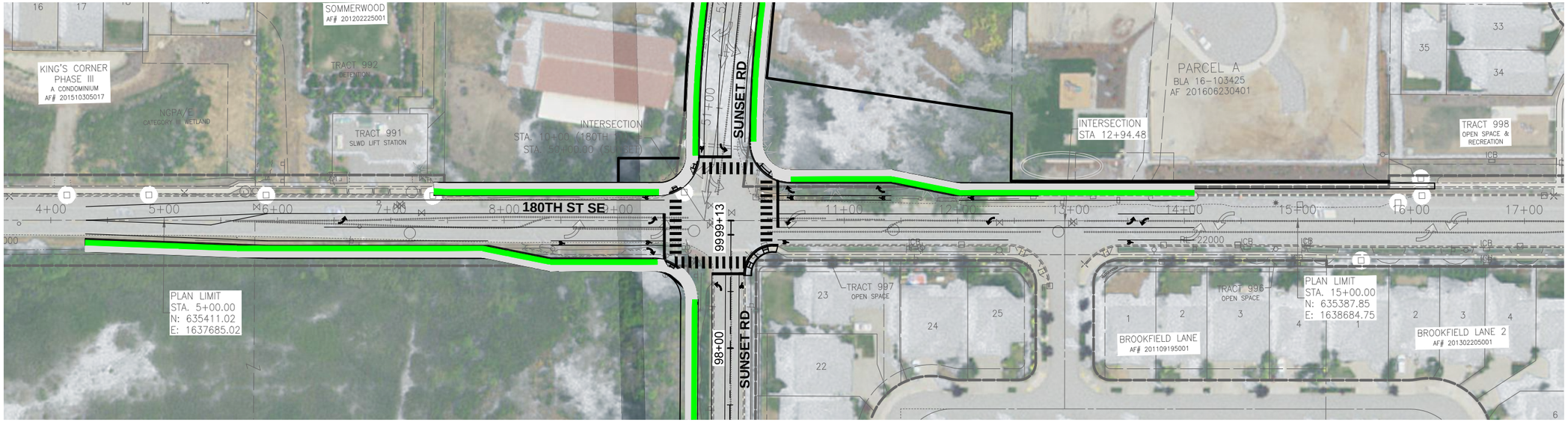
CHANNELIZATION PLAN

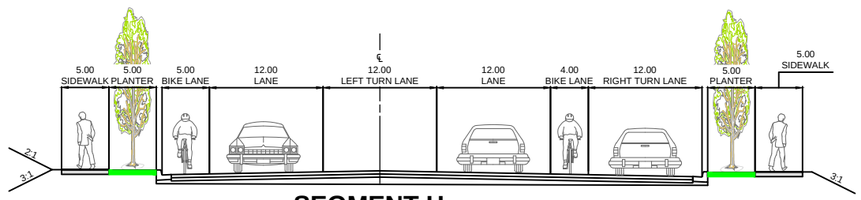
REFERENCE SHEET NO. CH06

SHEET 6 OF 8 SHEETS

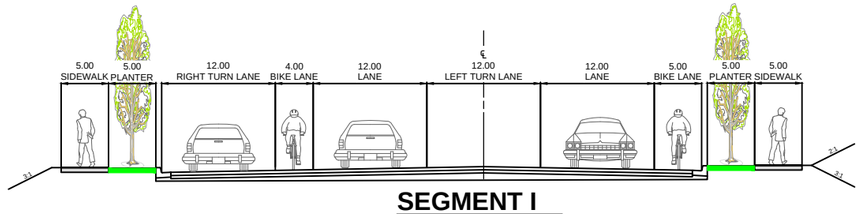
May 23, 2019 - 2:27 PM - ANGELM - \\KPFF.COM\CIVIL\1800001-1800999\1800175 43RD AVE SE\CADD\FIGURES\ROADWAY ALT\16-0040-CH_ALT1.DWG - Layout Name: 16-0040-CH6

SECTION 29, T. 29 N, R. 5 E., W.M.

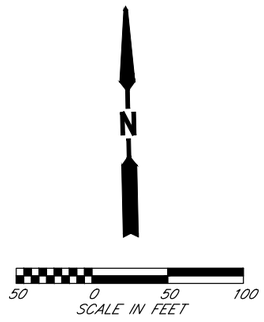




SEGMENT H
WEST OF SUNSET ROAD
ALTERNATIVE 1



SEGMENT I
EAST OF SUNSET ROAD
ALTERNATIVE 1



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FUNDING NO. 1800175

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 1
CHANNELIZATION PLAN

REFERENCE SHEET NO.
CH07

SHEET 7 OF 8 SHEETS

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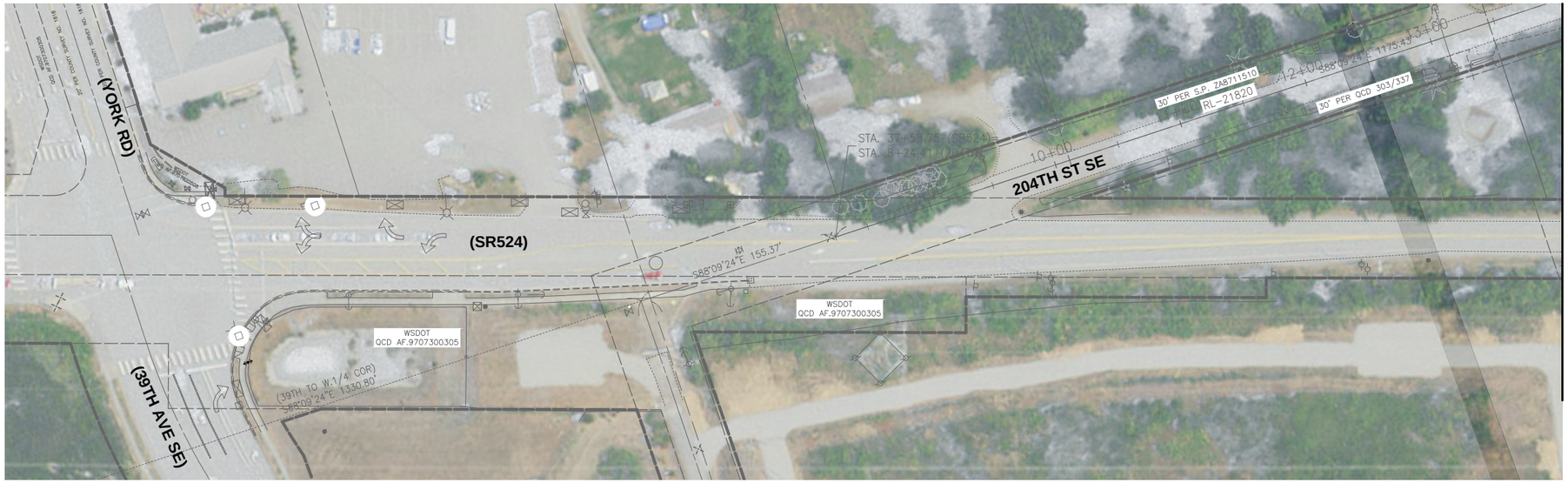

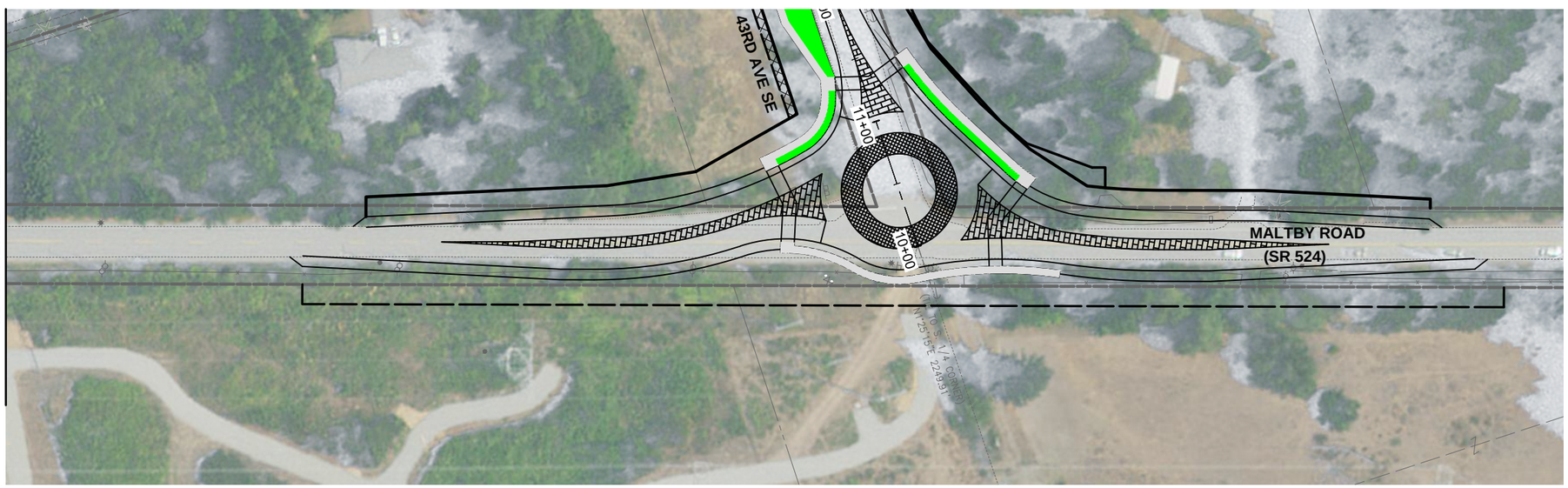

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43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 1

CHANNELIZATION PLAN

REFERENCE SHEET NO. CH08

SHEET 8 OF 8 SHEETS

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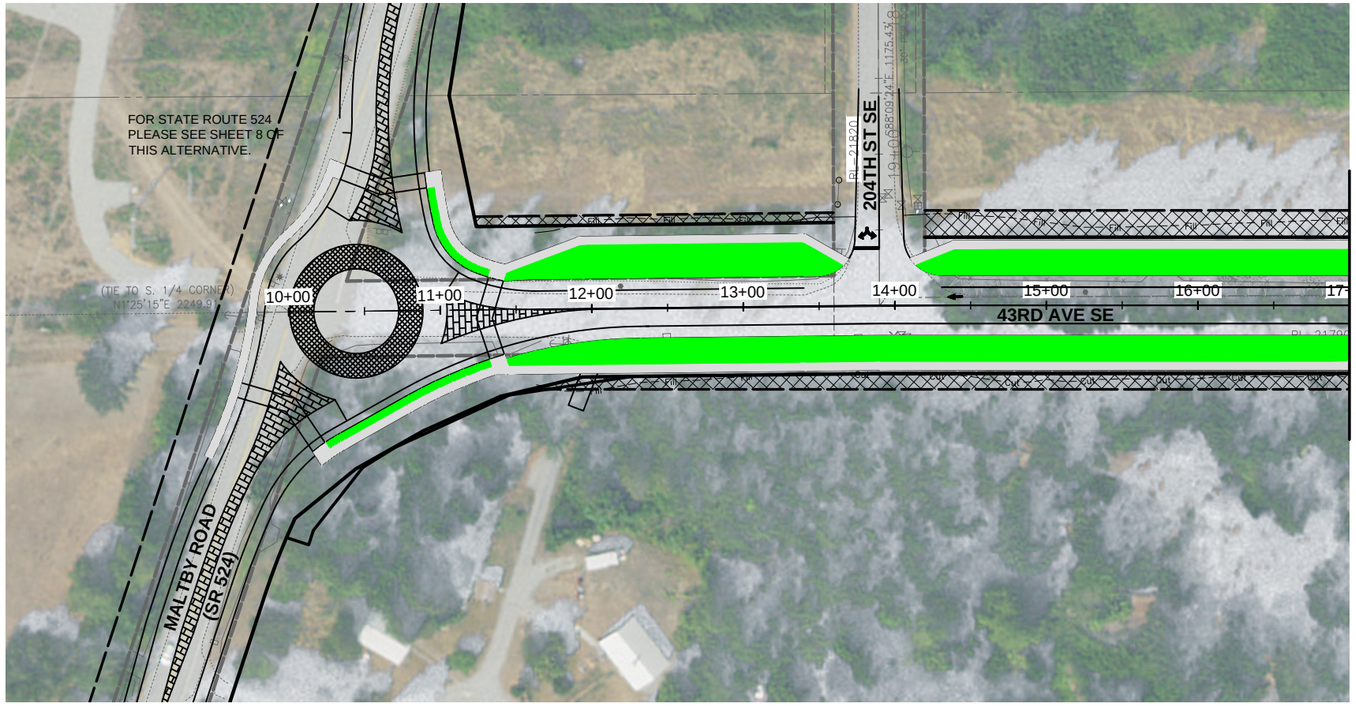
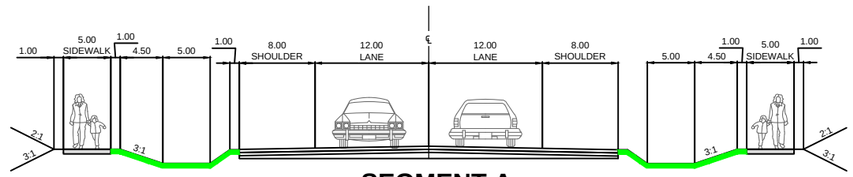
APPENDIX C-2

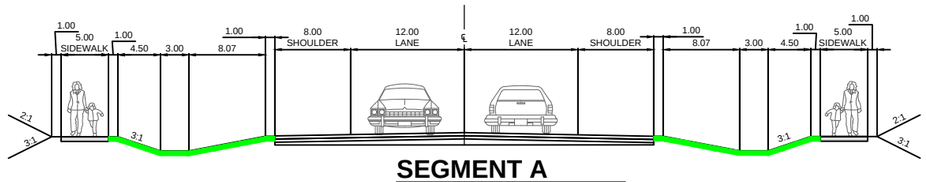
Plan Layout of Alternative 2

SECTION 29, T. 29 N, R. 5 E., W.M.

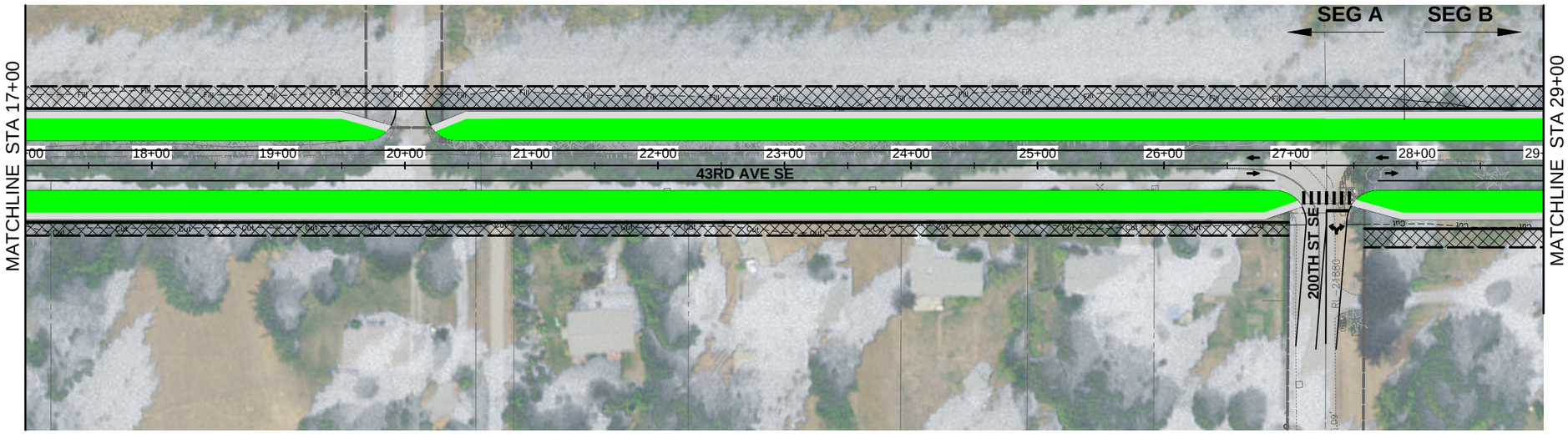


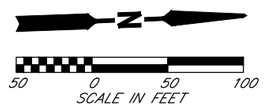


SEGMENT A
SR 524 TO 204TH ST. SE
ALTERNATIVE 2



SEGMENT A
204TH ST. SE TO 200TH ST. SE
ALTERNATIVE 2





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43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 2

CHANNELIZATION PLAN

REFERENCE SHEET NO. CH01

SHEET 1 OF 8 SHEETS

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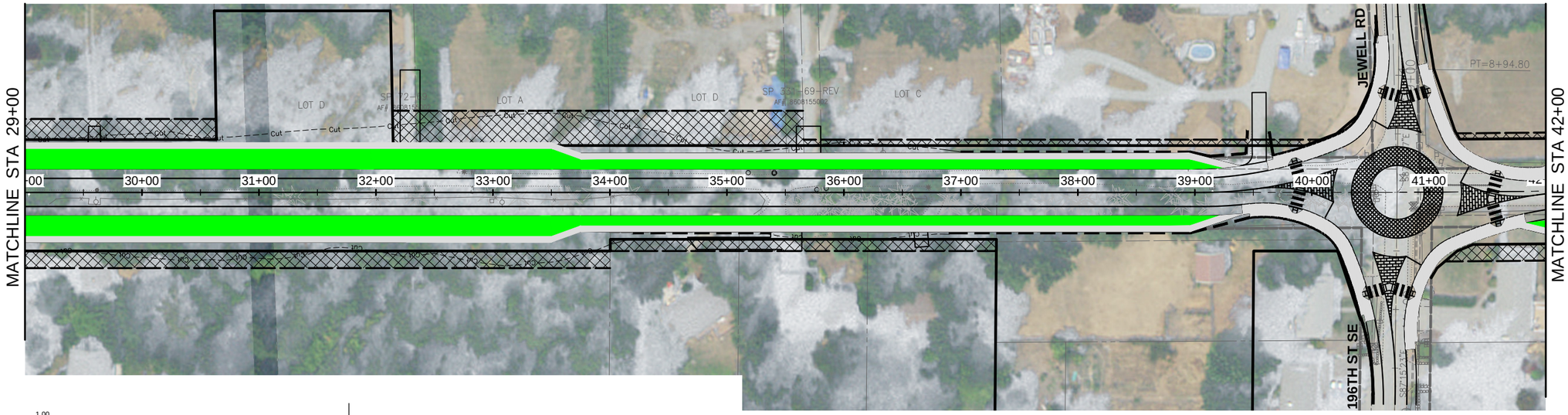
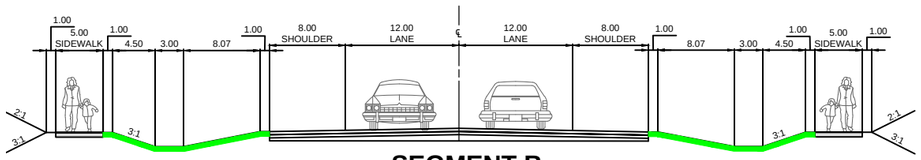
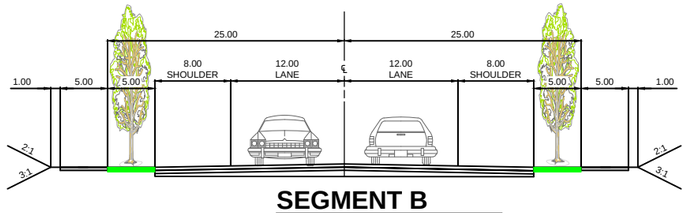




SEGMENT B
200TH ST. SE TO 198TH ST. SE
ALTERNATIVE 2

SEG B | **SEG C**



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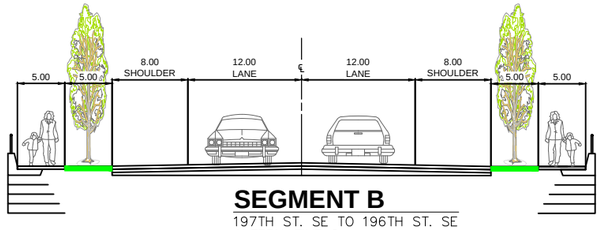
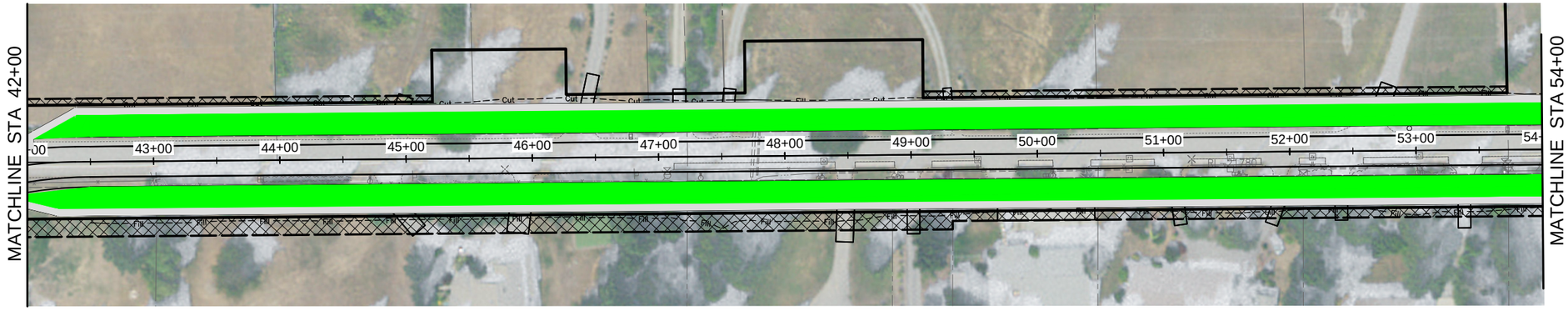
198TH ST. SE TO 197TH ST. SE
ALTERNATIVE 2



SEGMENT B
197TH ST. SE TO 196TH ST. SE
ALTERNATIVE 2



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43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 2

CHANNELIZATION PLAN

REFERENCE SHEET NO. CH02

SHEET 2 OF 8 SHEETS

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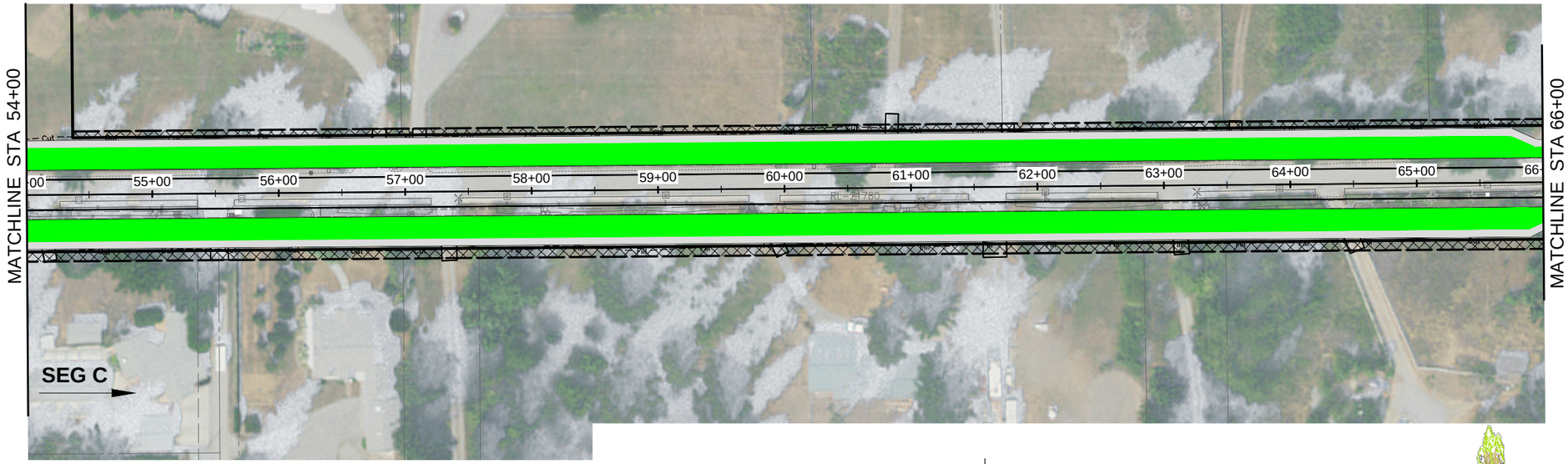

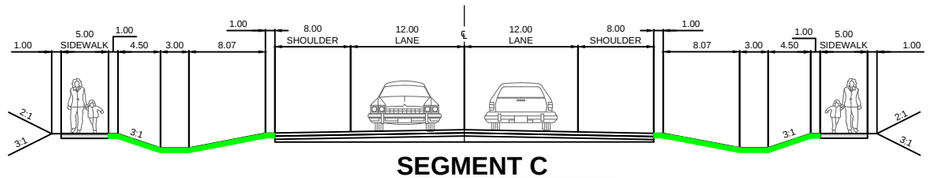

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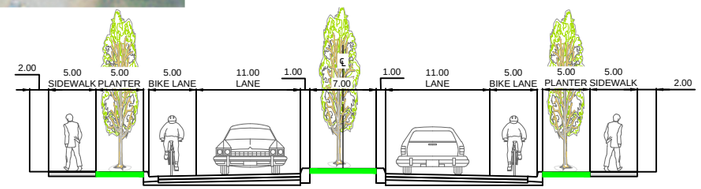
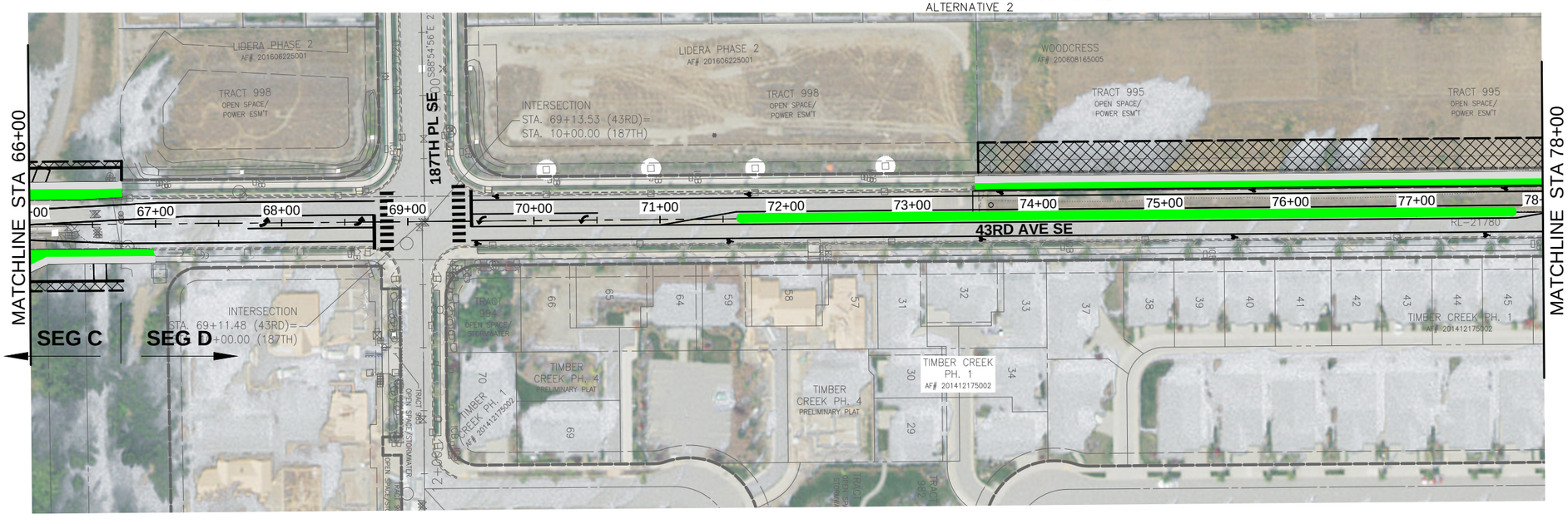
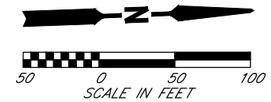
196TH ST. SE TO 188TH ST. SE
ALTERNATIVE 2



SEGMENT D
188TH STREET SE TO 184TH STREET SE
ALTERNATIVE 2





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43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 2

CHANNELIZATION PLAN

REFERENCE SHEET NO. CH03

SHEET 3 OF 8 SHEETS

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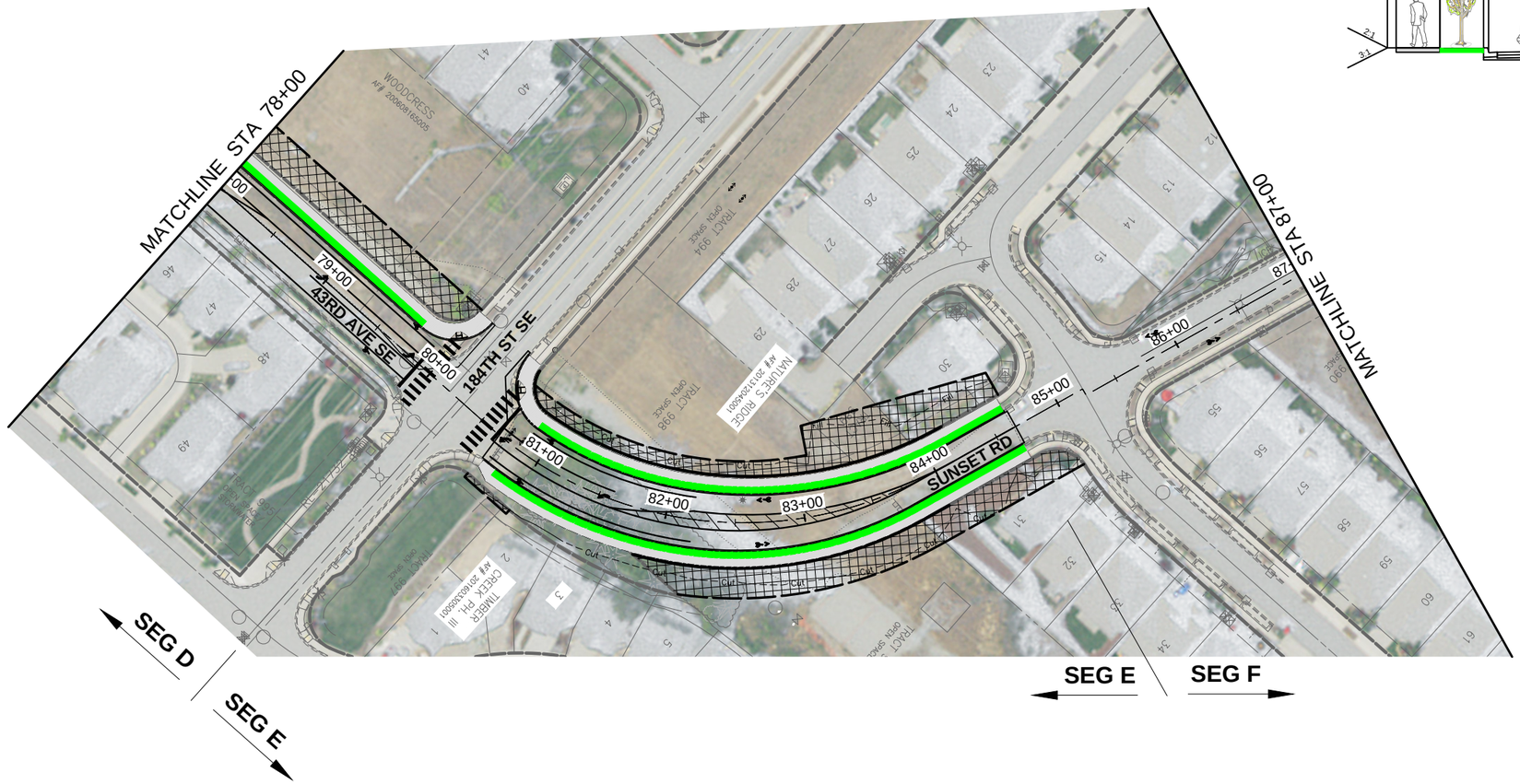

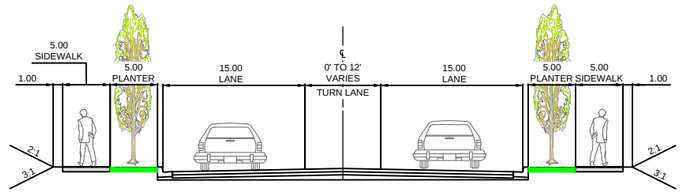

SEGMENT E
184TH STREET SE TO 43RD DRIVE SE
ALTERNATIVE 2

N

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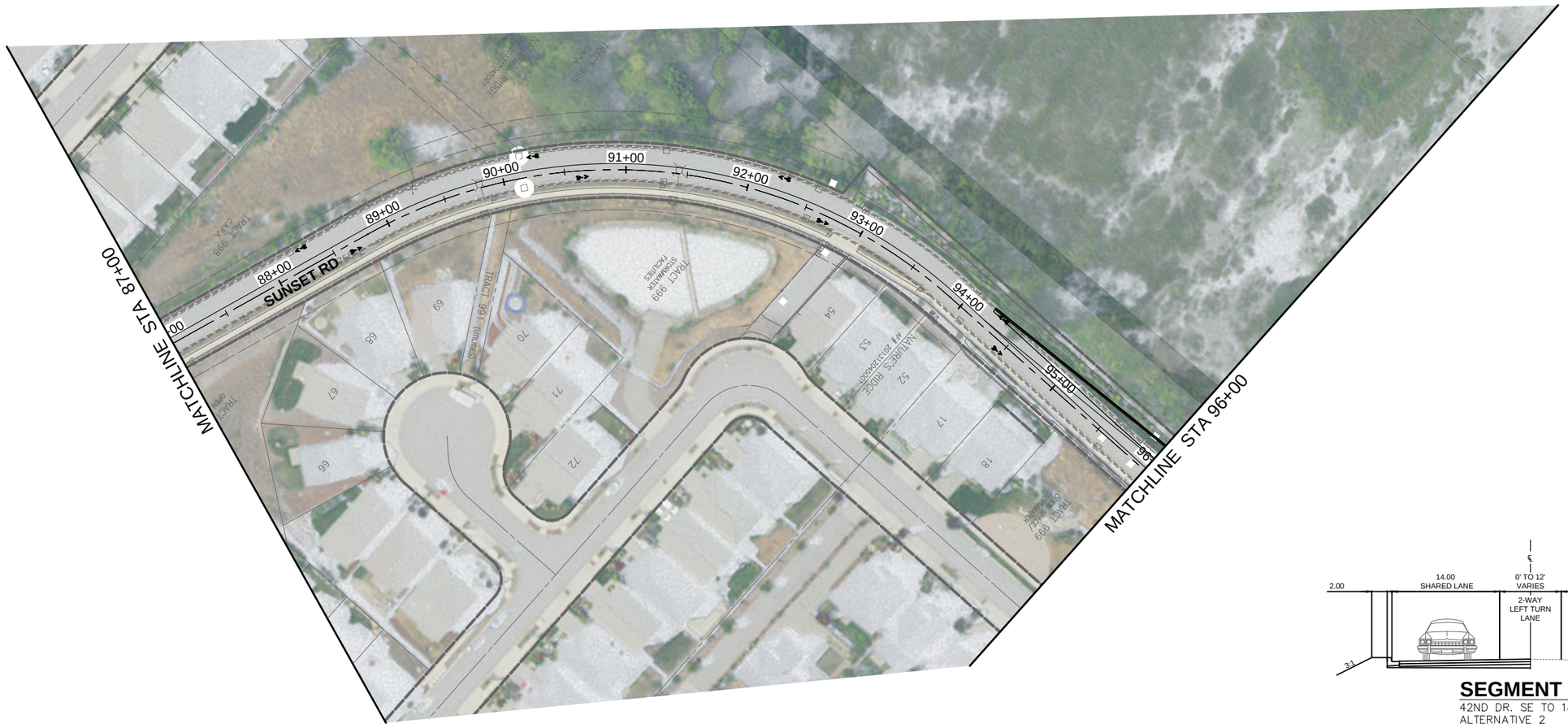
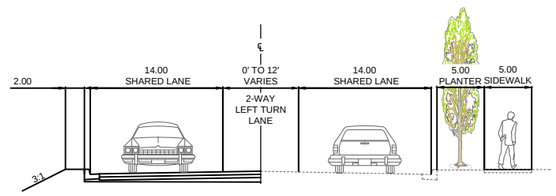
43RD AVE SE
SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 2
CHANNELIZATION PLAN

REFERENCE SHEET NO. CH04

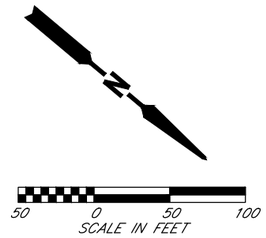
SHEET 4 OF 8 SHEETS

SECTION 29, T. 29 N, R. 5 E., W.M.





SEGMENT F
42ND DR. SE TO 180TH ST. SE
ALTERNATIVE 2



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43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 2
CHANNELIZATION PLAN

REFERENCE SHEET NO. CH05

SHEET 5 OF 8 SHEETS

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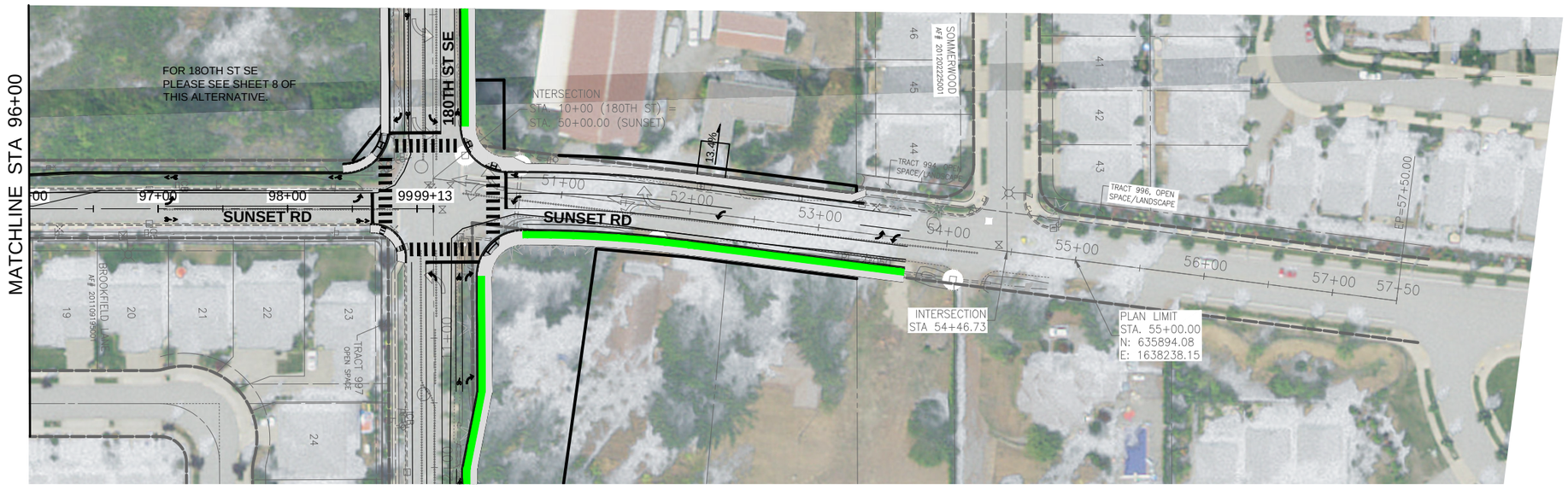
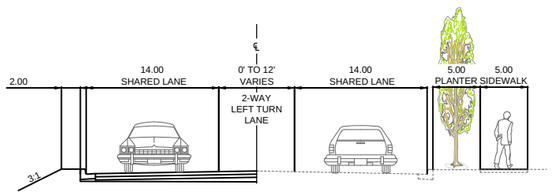
SECTION 29, T. 29 N, R. 5 E., W.M.





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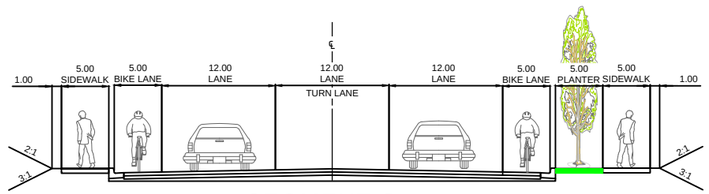
42ND DR. SE TO 180TH ST. SE
ALTERNATIVE 2



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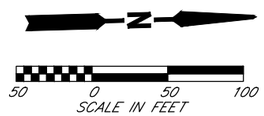
180TH ST. SE TO 178TH ST. SE
ALTERNATIVE 2



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43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 2

CHANNELIZATION PLAN

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SHEET 6 OF 8 SHEETS

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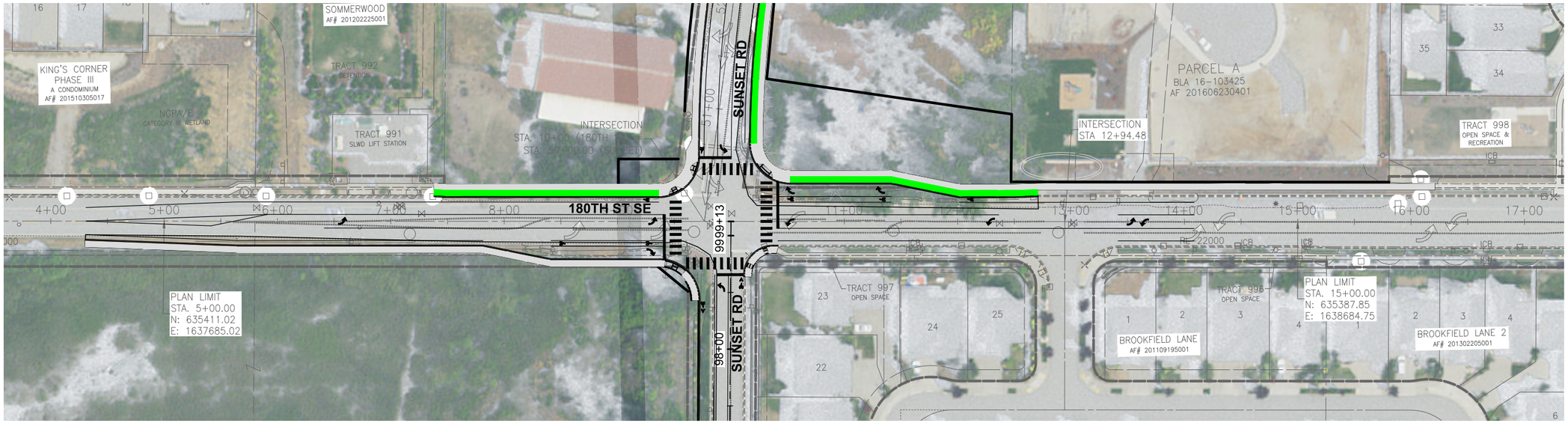
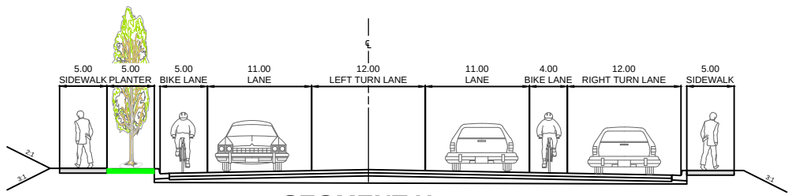
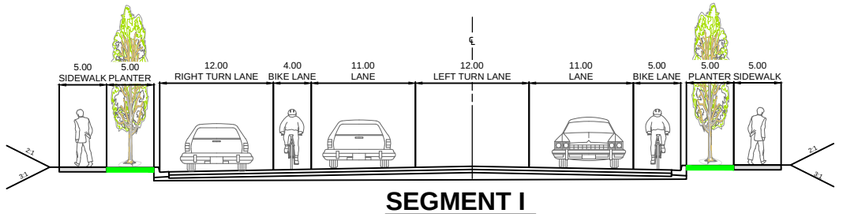




SEGMENT H
WEST OF SUNSET RD.
ALTERNATIVE 2



SEGMENT I
EAST OF SUNSET RD.
ALTERNATIVE 2

N

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SCALE IN FEET

DATE	NO.	REVISION	BY

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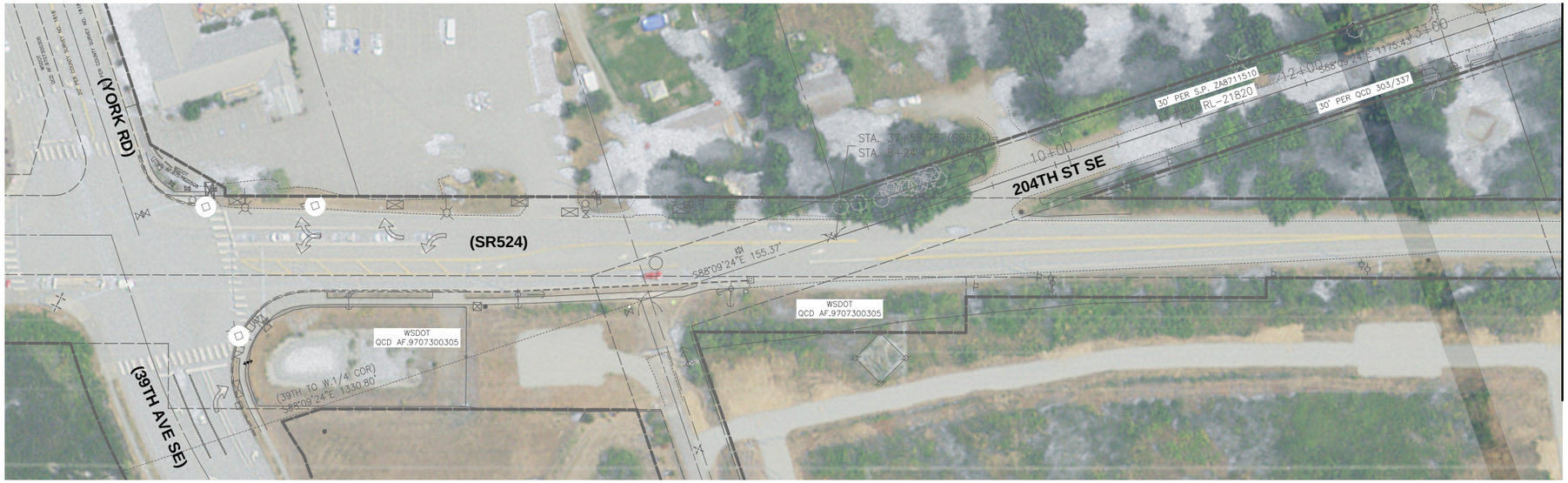
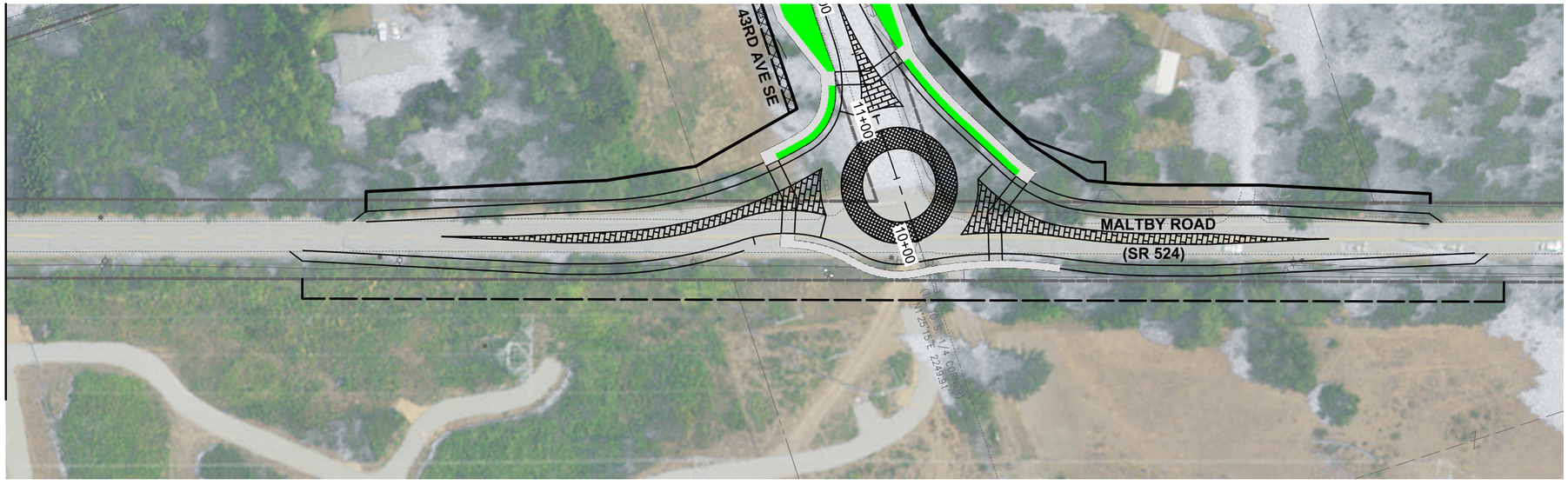
SHEET 7 OF 8 SHEETS

May 23, 2019 - 2:35 PM - CORYM - \\KPFF.COM\CIVIL\1800001-1800999\1800175 43RD AVE SE\CADD\FIGURES\ROADWAY ALT\16-0040-CH_ALT2.DWG - Layout Name: 16-0040-CH7

SECTION 29, T. 29 N, R. 5 E., W.M.



MATCHLINE SEE BELOW



MATCHLINE SEE ABOVE

N

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SCALE IN FEET

DATE	NO.	REVISION	BY

Know what's below. Call 811 before you dig.

UPI NO.: 16-0040	FED. AID PROJ. NO.: ###########
SURVEY NO.: -	FIELD BOOK(S): ####
HORZ. DATUM: NAD -	VERT. DATUM: NADV -
DESIGNED BY: LAW	DRAWN BY: TAJ

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SNOHOMISH COUNTY ENGINEER
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DATE APPROVED:

SNOHOMISH COUNTY DEPARTMENT OF PUBLIC WORKS

FUNDING NO. 1800175

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 2

CHANNELIZATION PLAN

REFERENCE SHEET NO. CH08

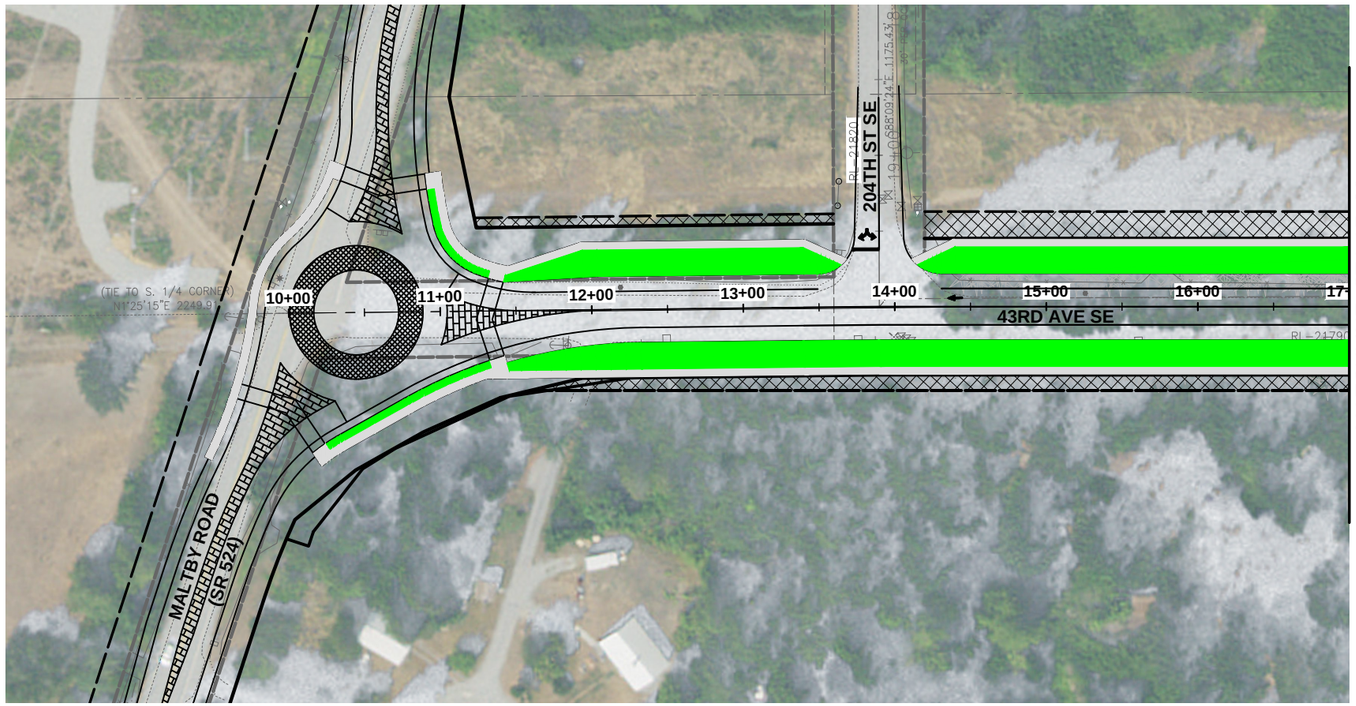
SHEET 8 OF 8 SHEETS

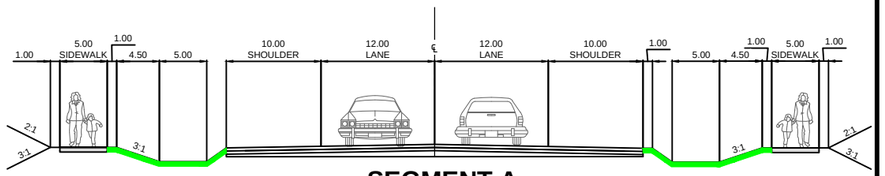
May 23, 2019 - 2:35 PM - CORYM - \\KPFF.COM\CIVIL\1800001-1800999\1800175 43RD AVE SE\CADD\FIGURES\ROADWAY ALT\16-0040-CH_ALT2.DWG - Layout Name: 16-0040-CH8

APPENDIX C-3

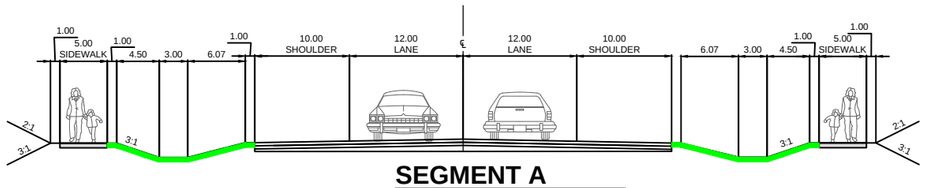
Plan Layout of Alternative 3

SECTION 29, T. 29 N, R. 5 E., W.M.

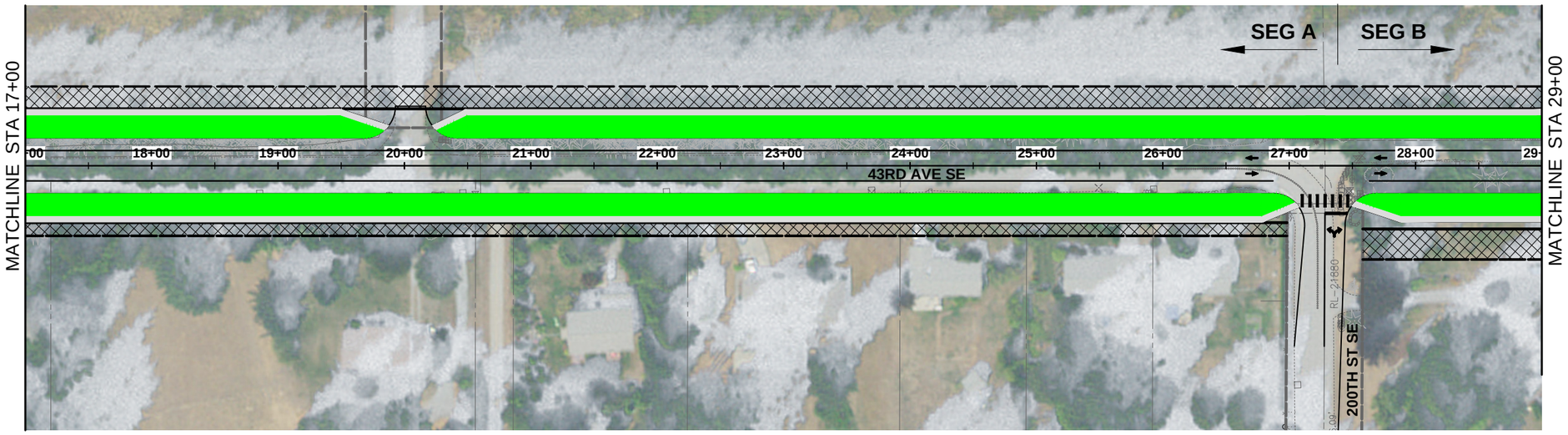


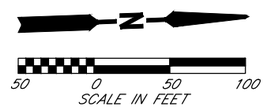


SEGMENT A
SR 524 TO 204TH ST. SE
ALTERNATIVE 3



SEGMENT A
204TH ST. SE TO 200TH ST. SE
ALTERNATIVE 3





DATE	NO.	REVISION	BY

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UPI NO.: 16-0040	FED. AID PROJ. NO.: ###########
SURVEY NO.: -	FIELD BOOK(S): ####
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FUNDING NO. 1800175

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATE 3

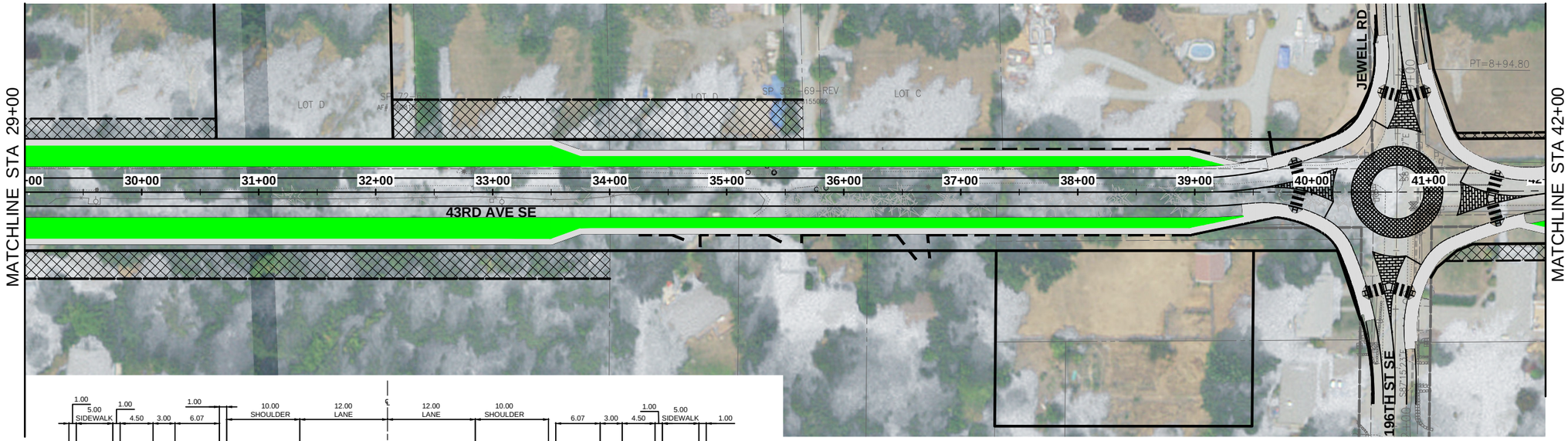
CHANNELIZATION PLAN

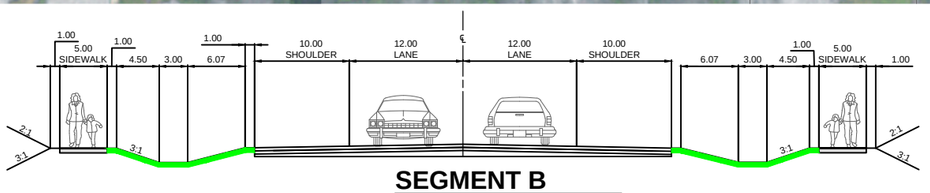
REFERENCE SHEET NO. CH01

SHEET 1 OF 3 SHEETS

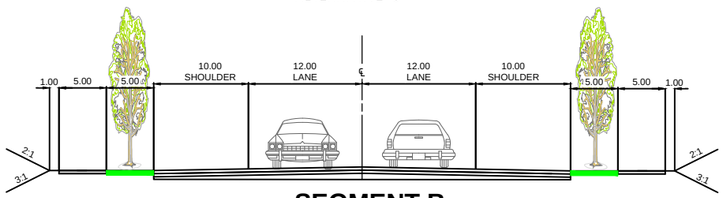
May 20, 2019 - 9:53 AM - ANGELM - \\KPFF.COM\CIVIL\1800001-1800999\1800175 43RD AVE SE\CADD\FIGURES\ROADWAY ALT\16-0040-CH_ALT3.DWG - Layout Name: 16-0040-CH1

SECTION 29, T. 29 N, R. 5 E., W.M.



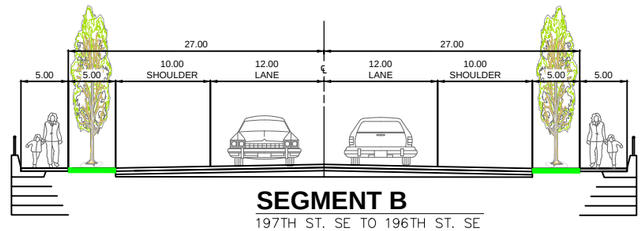


SEGMENT B
200TH ST. SE TO 198TH ST. SE
ALTERNATIVE 3

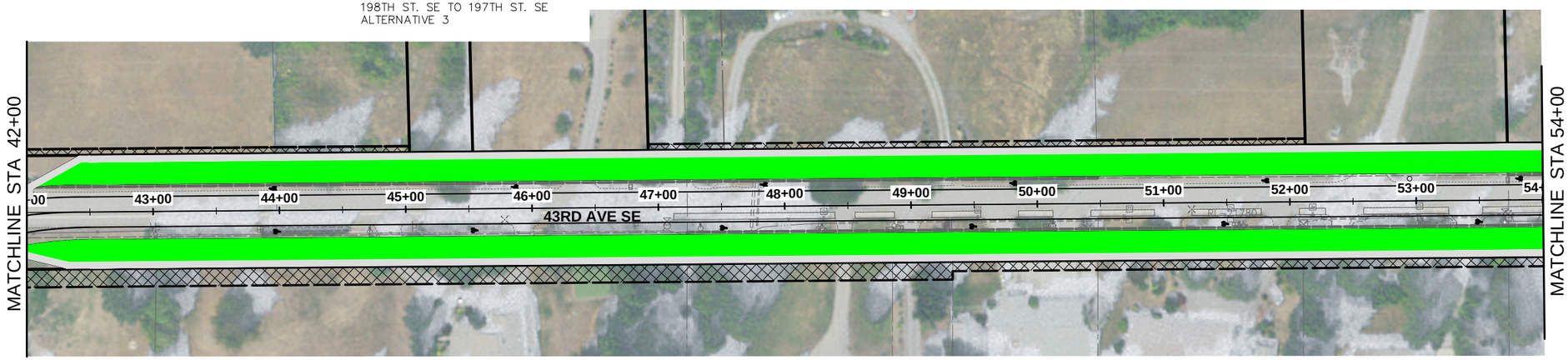


SEGMENT B
198TH ST. SE TO 197TH ST. SE
ALTERNATIVE 3

SEG B | SEG C



SEGMENT B
197TH ST. SE TO 196TH ST. SE
ALTERNATIVE 3



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SCALE IN FEET

DATE	NO.	REVISION	BY

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SNOHOMISH COUNTY DEPARTMENT OF PUBLIC WORKS

FUNDING NO. 1800175

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATE 3

CHANNELIZATION PLAN

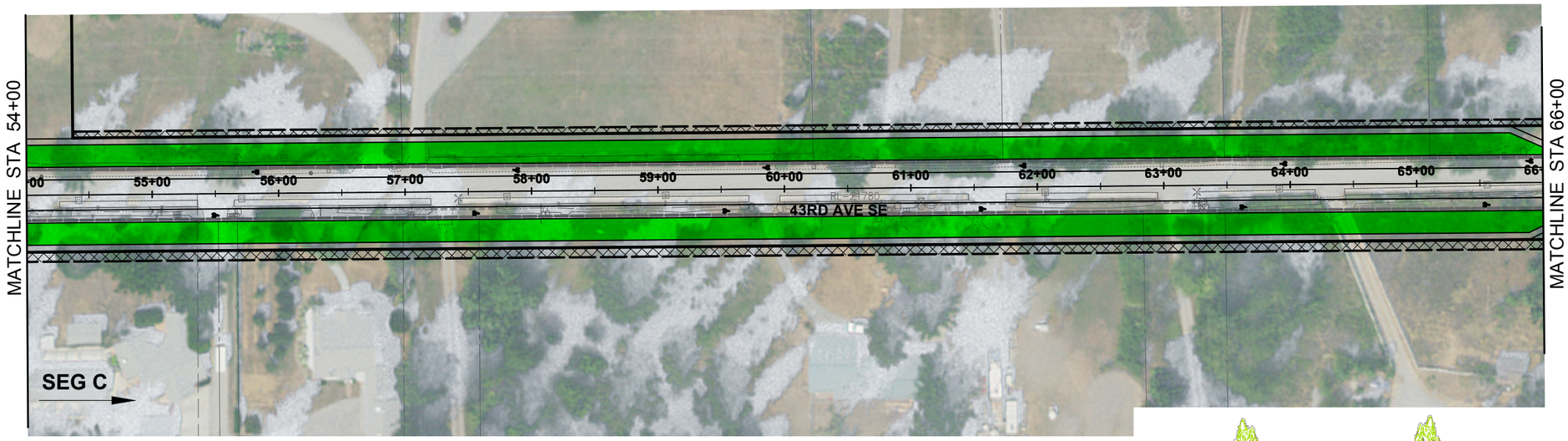
REFERENCE SHEET NO. CH02

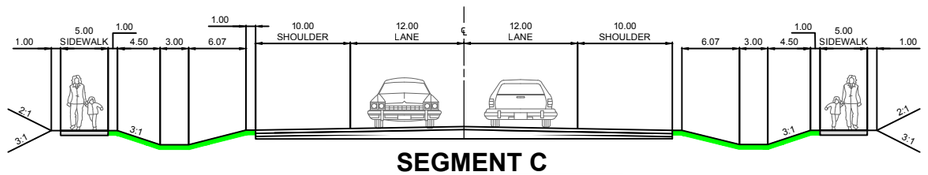
SHEET 2 OF 3 SHEETS

May 20, 2019 - 9:54 AM - ANGELM - \\KPFF.COM\CIVIL\1800001-1800999\1800175 43RD AVE SE\CADD\FIGURES\ROADWAY ALT\16-0040-CH_ALT3.DWG - Layout Name: 16-0040-CH2

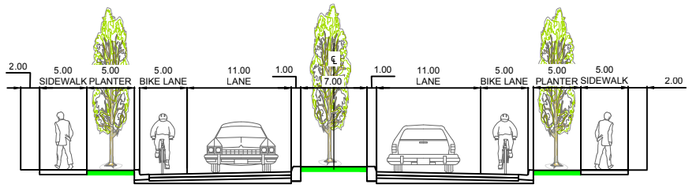
SECTION 29, T. 29 N, R. 5 E., W.M.

NOTE:
ALTERNATIVE 3 MATCHES ALTERNATIVE 2 NORTH OF SEGMENT D

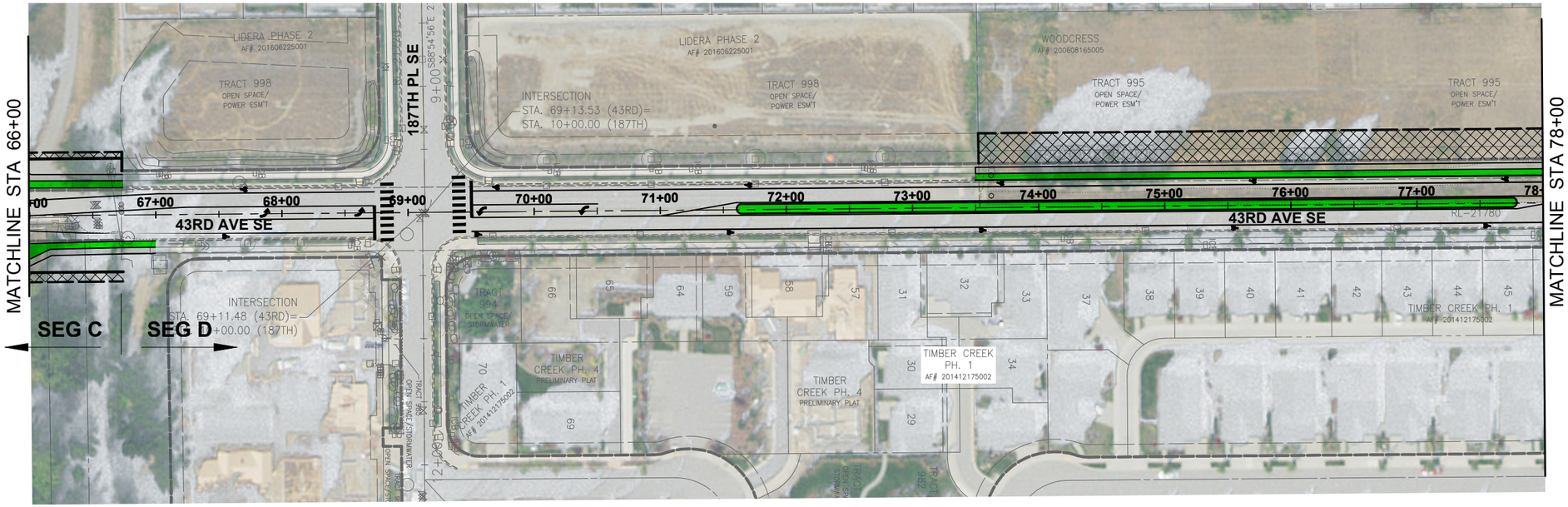


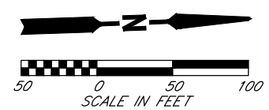


SEGMENT C
196TH ST. SE TO 188TH ST. SE
ALTERNATIVE 3



SEGMENT D
188TH STREET SE TO 184TH STREET SE
ALTERNATIVE 3





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SNOHOMISH COUNTY ENGINEER
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FUNDING NO. 1800175

43RD AVE SE
SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATE 3
CHANNELIZATION PLAN

REFERENCE SHEET NO. CH03

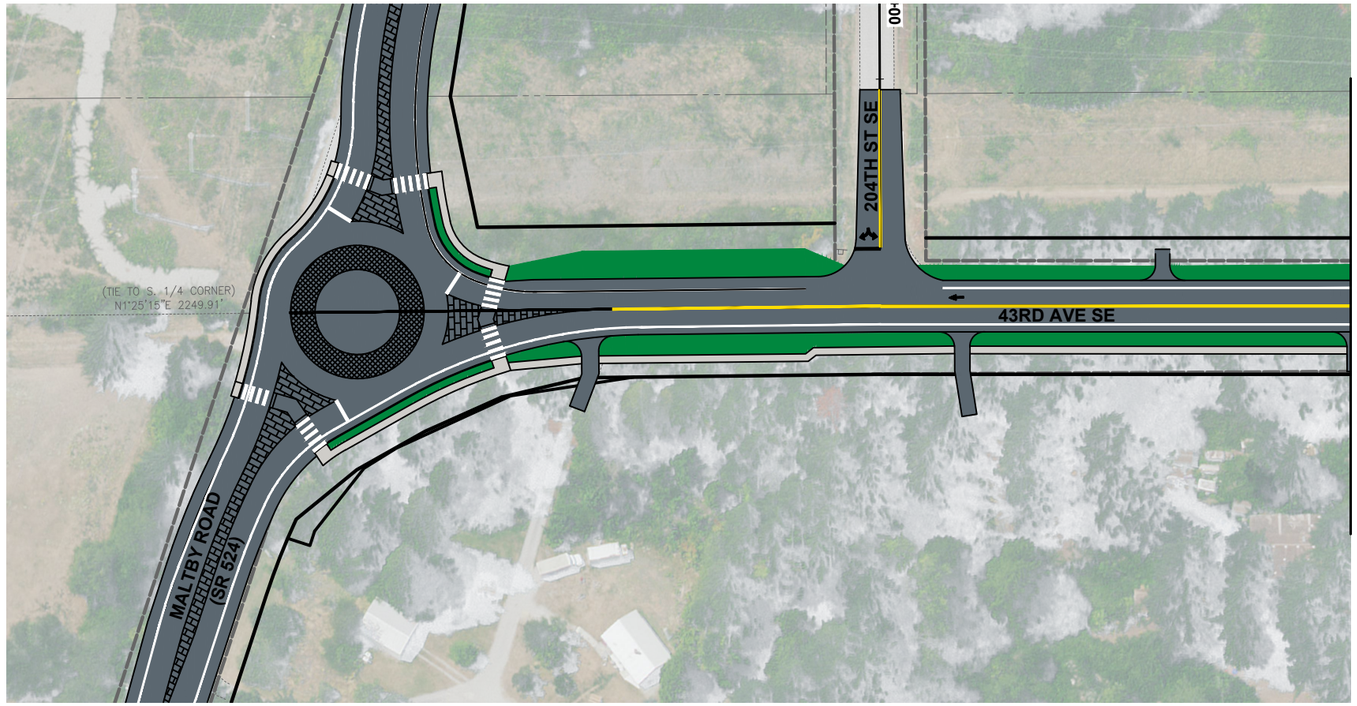
SHEET 3 OF 3 SHEETS

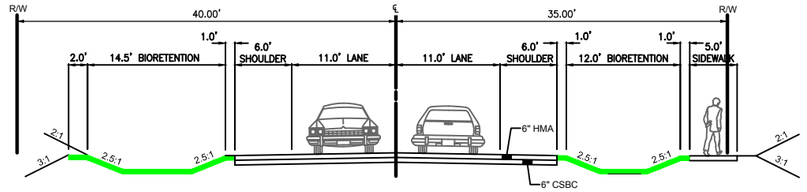
May 29, 2019 - 2:00 PM - ANGELM - Z:\1800001-1800999\1800175 43RD AVE SE\CADD\FIGURES\ROADWAY ALT\16-0040-CH_ALT3.DWG - Layout Name: 16-0040-CH3

APPENDIX C-4

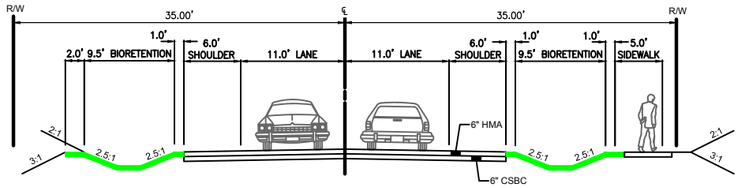
Plan Layout of Alternative 4

SECTION 29, T. 29 N, R. 5 E., W.M.





SEGMENT A
SR 524 TO 204TH ST. SE
ALTERNATIVE 4



SEGMENT A
204TH ST. SE TO 200TH ST. SE
ALTERNATIVE 4

SEG A | **SEG B**

N

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SCALE IN FEET

DATE	NO.	REVISION	BY

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SURVEY NO.:	FIELD BOOK(S):
HORZ. DATUM:	VERT. DATUM:
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DOUGLAS W. McCORMICK, P.E.
SNOHOMISH COUNTY ENGINEER

DATE APPROVED:

SNOHOMISH COUNTY DEPARTMENT OF PUBLIC WORKS

FUNDING NO. RC1592

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 4

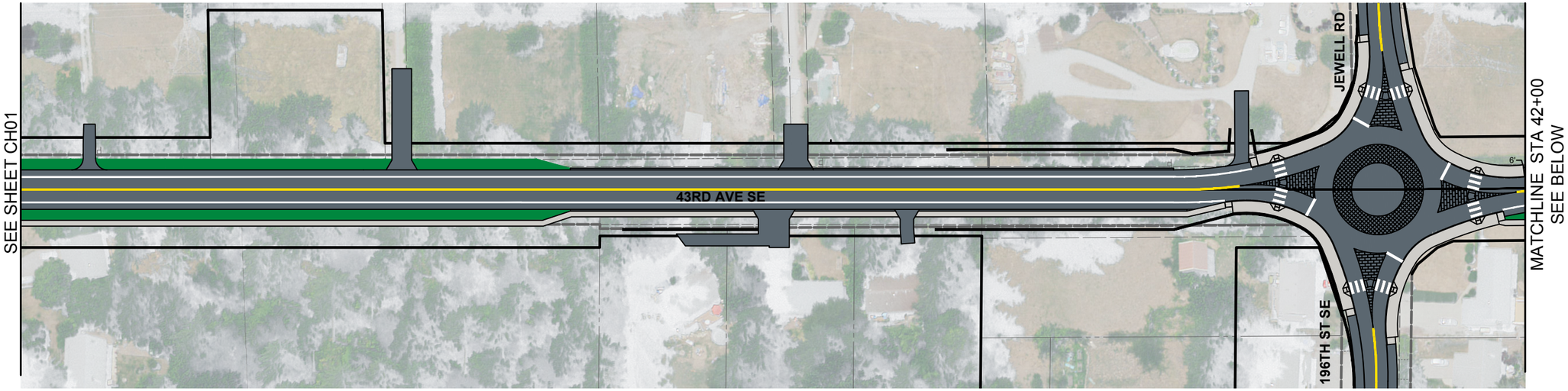
CHANNELIZATION PLAN

REFERENCE SHEET NO. CH01

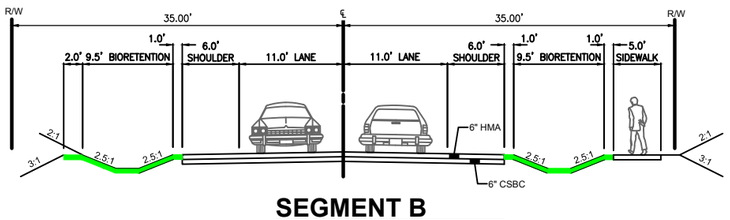
SHEET 1 OF 8 SHEETS

October 2, 2019 - 7:47 AM - SPWEFP - S:\PW_PROJECT_DATA_MANAGEMENT\6-PROJECTS_UPI YEAR_2016\16-0040\02_CADD\DESIGN\PSE\16-0040-CH_ALT4-RURAL.DWG - Layout Name: 16-0040-CH1

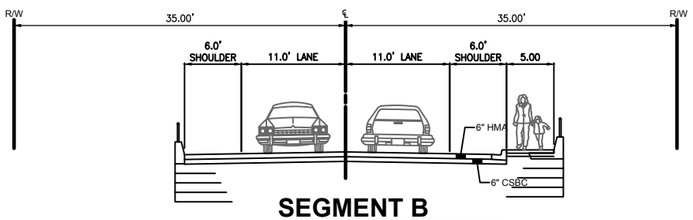
SECTION 29, T. 29 N, R. 5 E., W.M.



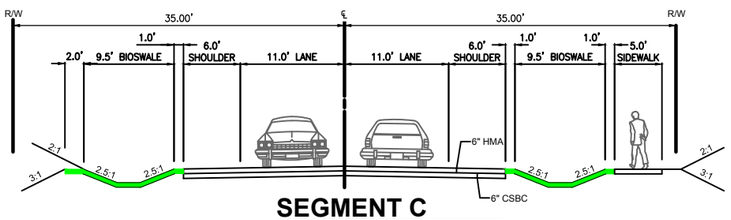
SEG B | **SEG C**



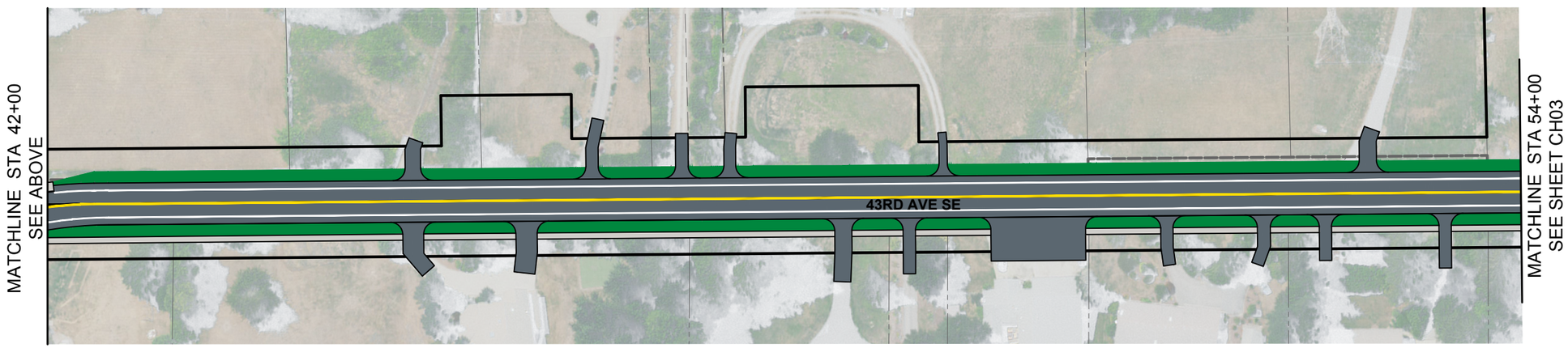
SEGMENT B
200TH ST SE TO 198TH ST SE
ALTERNATIVE 4

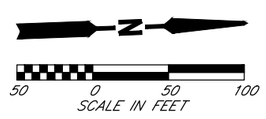


SEGMENT B
198TH ST SE TO 196TH ST SE
ALTERNATIVE 4



SEGMENT C
196TH ST SE TO 187TH ST SE
ALTERNATIVE 4





DATE	NO.	REVISION	BY

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SURVEY NO.:	FIELD BOOK(S):
HORZ. DATUM:	VERT. DATUM:
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SNOHOMISH COUNTY ENGINEER

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FUNDING NO. RC1592

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 4

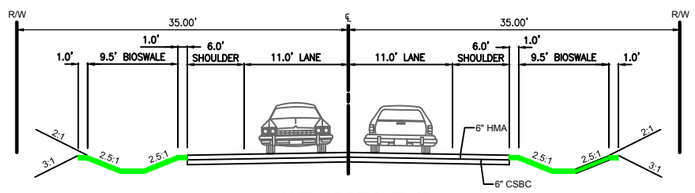
CHANNELIZATION PLAN

REFERENCE SHEET NO. CH02

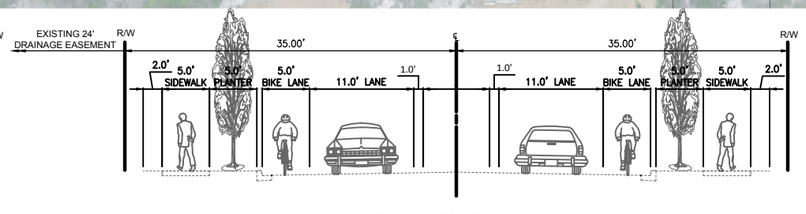
SHEET 2 OF 8 SHEETS

October 2, 2019 - 7:47 AM - SPWEFP - S:\PW_PROJECT_DATA_MANAGEMENT\16-PROJECTS_UPI YEAR_2016\16-0040\02_CADD\DESIGN\PSE\16-0040-CH_ALT4-RURAL.DWG - Layout Name: 16-0040-CH2

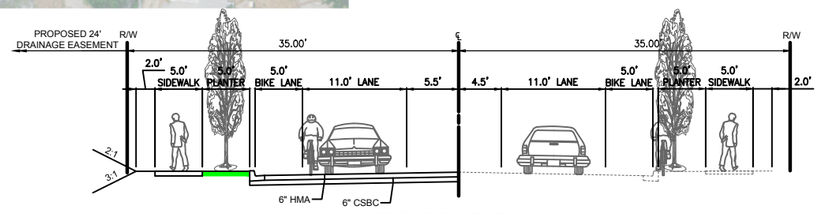
SECTION 29, T. 29 N, R. 5 E., W.M.



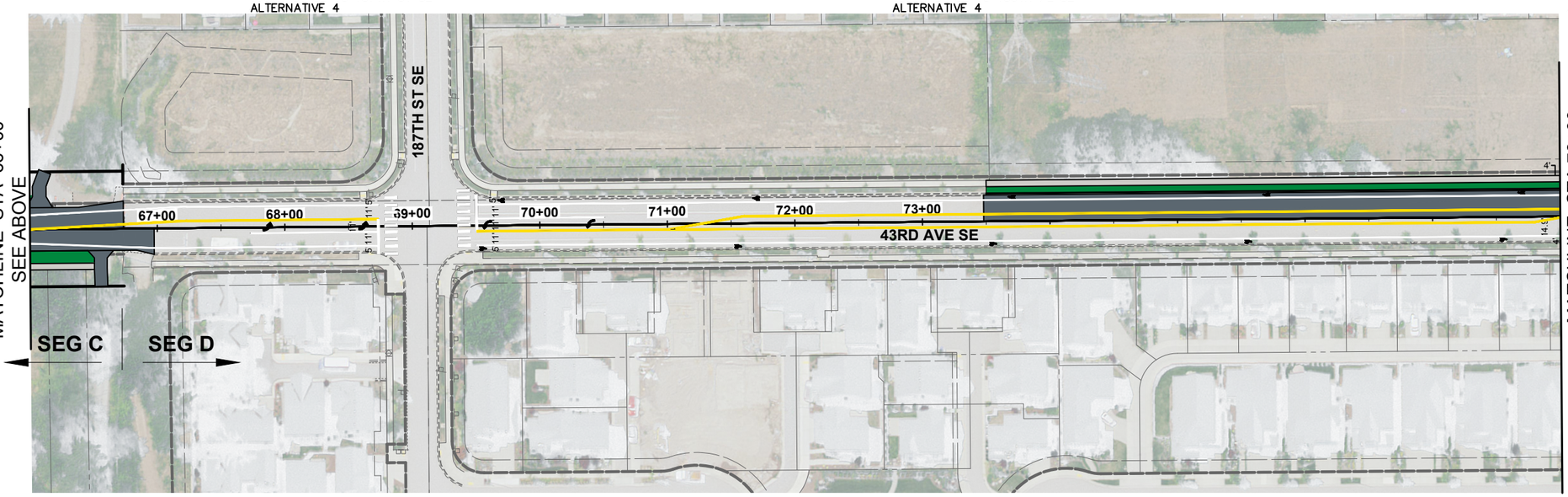
SEGMENT C
196TH ST SE TO 187TH ST SE
ALTERNATIVE 4



SEGMENT D
187TH ST SE TO 186TH PL SE
ALTERNATIVE 4



SEGMENT D
186TH PL SE TO 184TH ST SE
ALTERNATIVE 4



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SCALE IN FEET

DATE	NO.	REVISION	BY

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SURVEY NO.:	FIELD BOOK(S):
HORZ. DATUM:	VERT. DATUM:
DESIGNED BY:	DRAWN BY:

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DOUGLAS W. McCORMICK, P.E.
SNOHOMISH COUNTY ENGINEER

DATE APPROVED:

SNOHOMISH COUNTY DEPARTMENT OF PUBLIC WORKS

FUNDING NO. RC1592

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD ALTERNATIVE 4

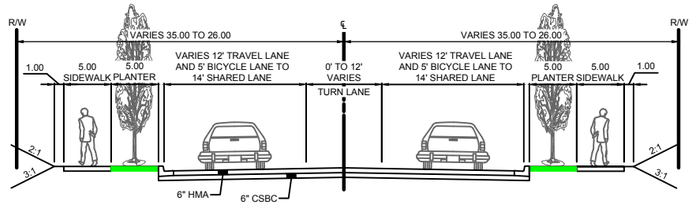
CHANNELIZATION PLAN

REFERENCE SHEET NO.
CH03

SHEET 3 OF 8 SHEETS

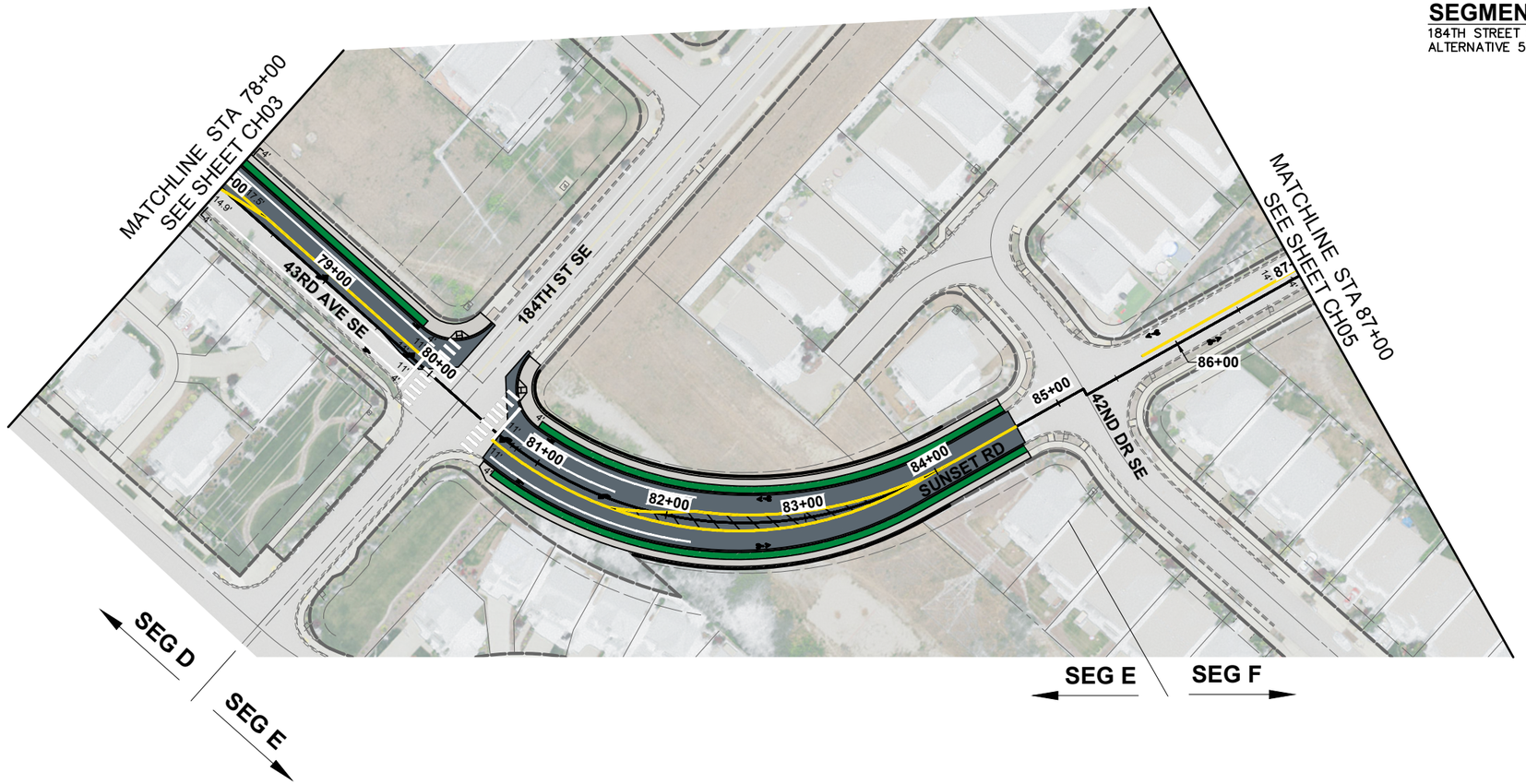
October 2, 2019 - 7:47 AM - SPWEFP - S:\PW_PROJECT_DATA_MANAGEMENT\6-PROJECTS_UPI YEAR_2016\16-0040\02_CADD\DESIGN\PSE\16-0040-CH_ALT4-RURAL.DWG - Layout Name: 16-0040-CH3

SECTION 29, T. 29 N, R. 5 E., W.M.



SEGMENT E

184TH STREET SE TO 43RD DRIVE SE
ALTERNATIVE 5



DATE	NO.	REVISION	BY

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SURVEY NO.: -	FIELD BOOK(S): -
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SNOHOMISH COUNTY DEPARTMENT OF PUBLIC WORKS

FUNDING NO. RC1592

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD ALTERNATIVE 4

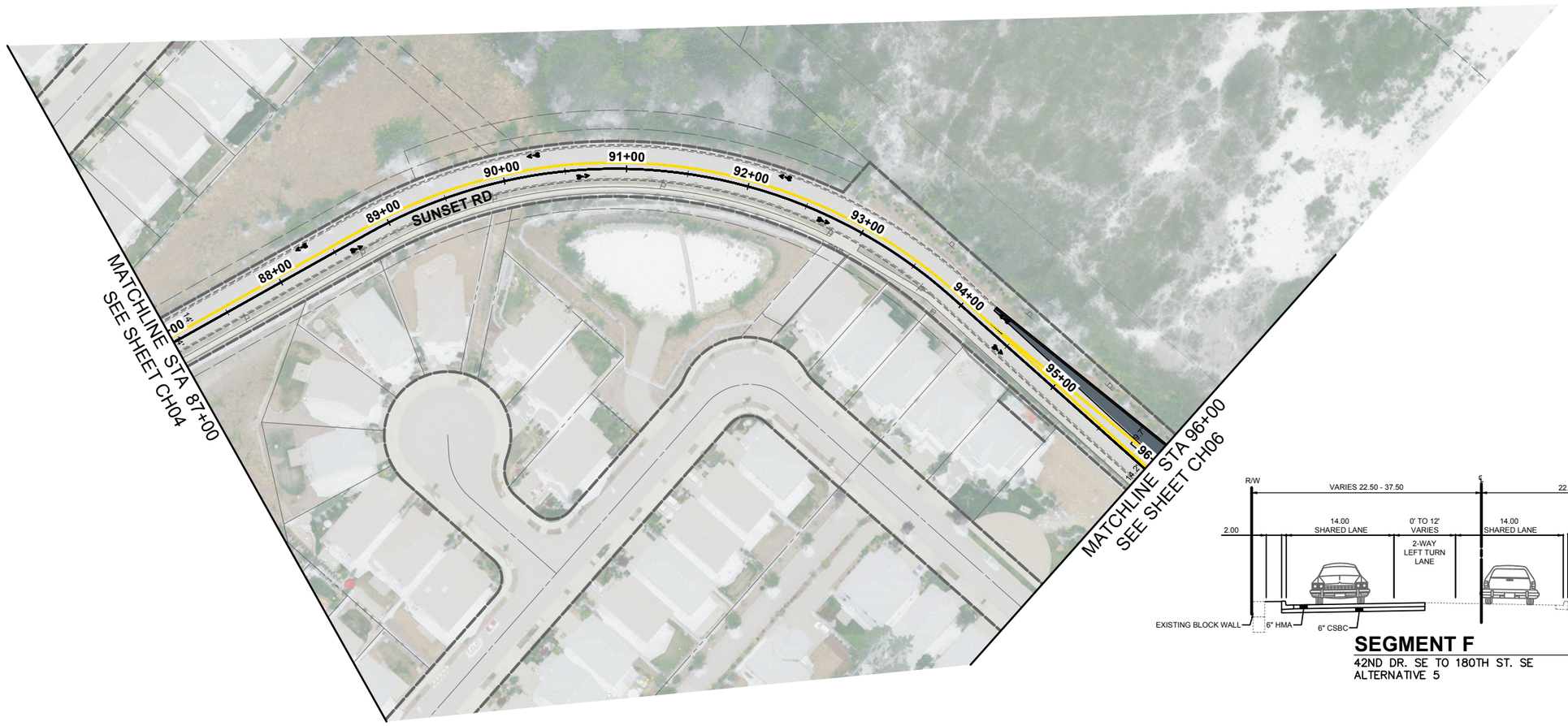
CHANNELIZATION PLAN

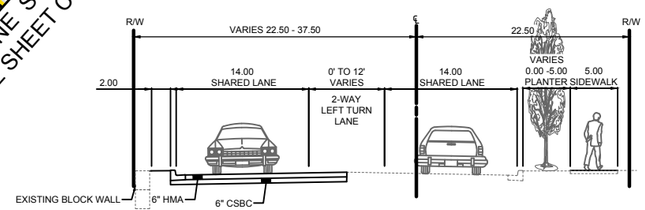
REFERENCE SHEET NO. CH04

SHEET 4 OF 8 SHEETS

October 7, 2019 - 9:32 AM - SPWMCR - \\SNOCO\SDRIVES\SPW_DATA\PW_PROJECT_DATA_MANAGEMENT\6-PROJECTS_UPI YEAR_2016\16-0040\02_CADD\DESIGN\PSE\16-0040-CH_ALT4-URBAN2.DWG - Layout Name: 16-0040-CH4

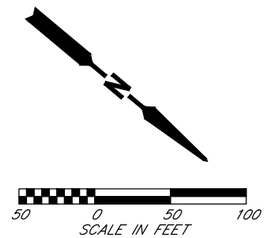
SECTION 29, T. 29 N, R. 5 E., W.M.





SEGMENT F

42ND DR. SE TO 180TH ST. SE
ALTERNATIVE 5



DATE	NO.	REVISION	BY

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SURVEY NO.: -	FIELD BOOK(S): -
HORZ. DATUM: -	VERT. DATUM: -
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REVIEWED AND APPROVED FOR CONSTRUCTION

DOUGLAS W. McCORMICK
SNOHOMISH COUNTY ENGINEER

DATE APPROVED:

SNOHOMISH COUNTY DEPARTMENT OF PUBLIC WORKS

FUNDING NO. RC1592

43RD AVE SE

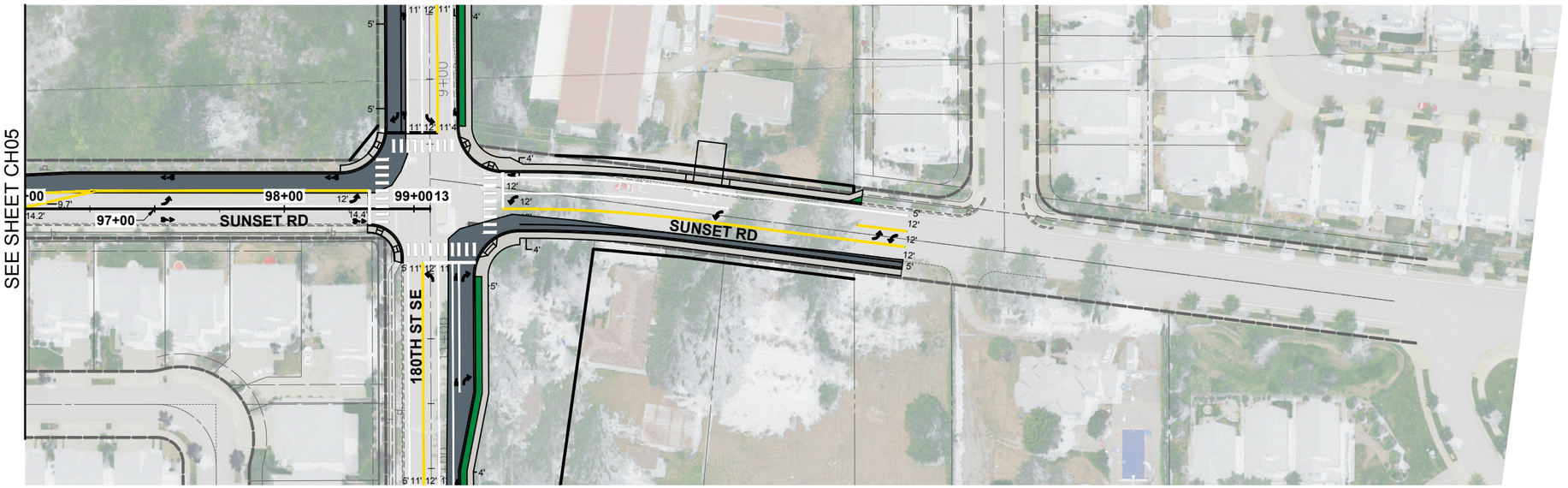
SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD ALTERNATIVE 4

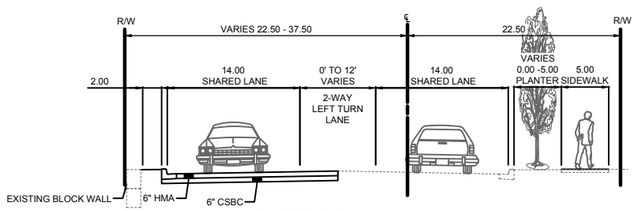
CHANNELIZATION PLAN

REFERENCE SHEET NO. CH05

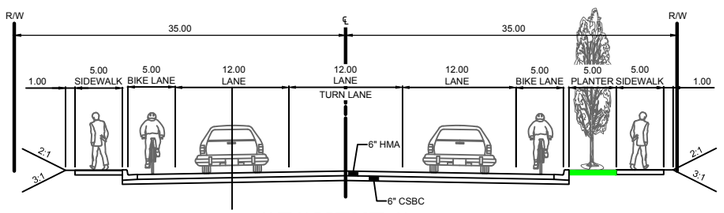
SHEET 5 OF 8 SHEETS

October 7, 2019 - 9:32 AM - SPWMCR - \\SNOCO\SDRIVES\SPW_DATA\PW_PROJECT_DATA_MANAGEMENT\6-PROJECTS_UPI YEAR_2016\16-0040\02_CADD\DESIGN\PSE\16-0040-CH_ALT4-URBAN2.DWG - Layout Name: 16-0040-CH5

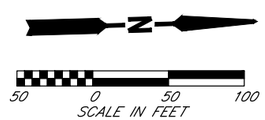




SEGMENT F
42ND DR. SE TO 180TH ST. SE
ALTERNATIVE 5



SEGMENT G
180TH ST. SE TO 178TH ST. SE
ALTERNATIVE 5



DATE	NO.	REVISION	BY

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FUNDING NO. RC1592

43RD AVE SE
SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 4
CHANNELIZATION PLAN

REFERENCE SHEET NO. CH06

SHEET 6 OF 8 SHEETS

October 7, 2019 - 9:32 AM - SPWMCR - \\SNOCO\SDRIVES\SPW_DATA\PW_PROJECT_DATA_MANAGEMENT\6-PROJECTS_UPI YEAR_2016\16-0040\02_CADD\DESIGN\PSE\16-0040-CH_ALT4-URBAN2.DWG - Layout Name: 16-0040-CH6

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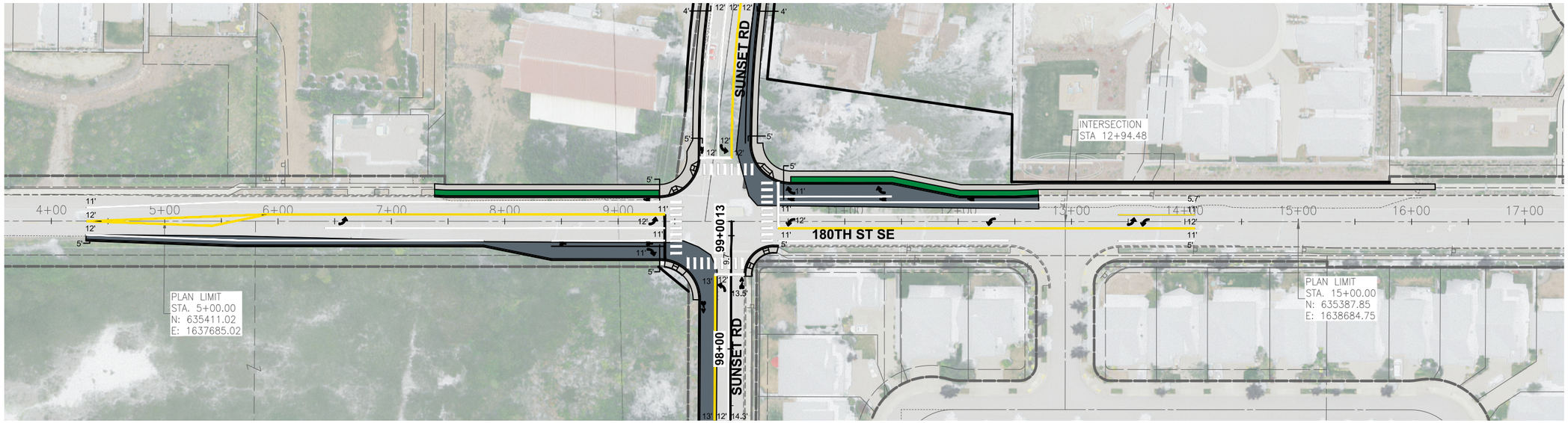
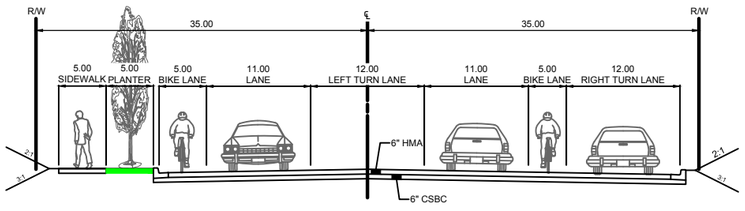
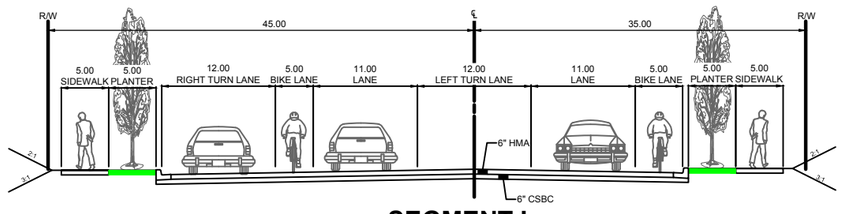




SEGMENT H
WEST OF SUNSET RD.
ALTERNATIVE 5



SEGMENT I
EAST OF SUNSET RD.
ALTERNATIVE 5

N

50 0 50 100
SCALE IN FEET

DATE	NO.	REVISION	BY

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43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD ALTERNATIVE 4

CHANNELIZATION PLAN

REFERENCE SHEET NO. CH07

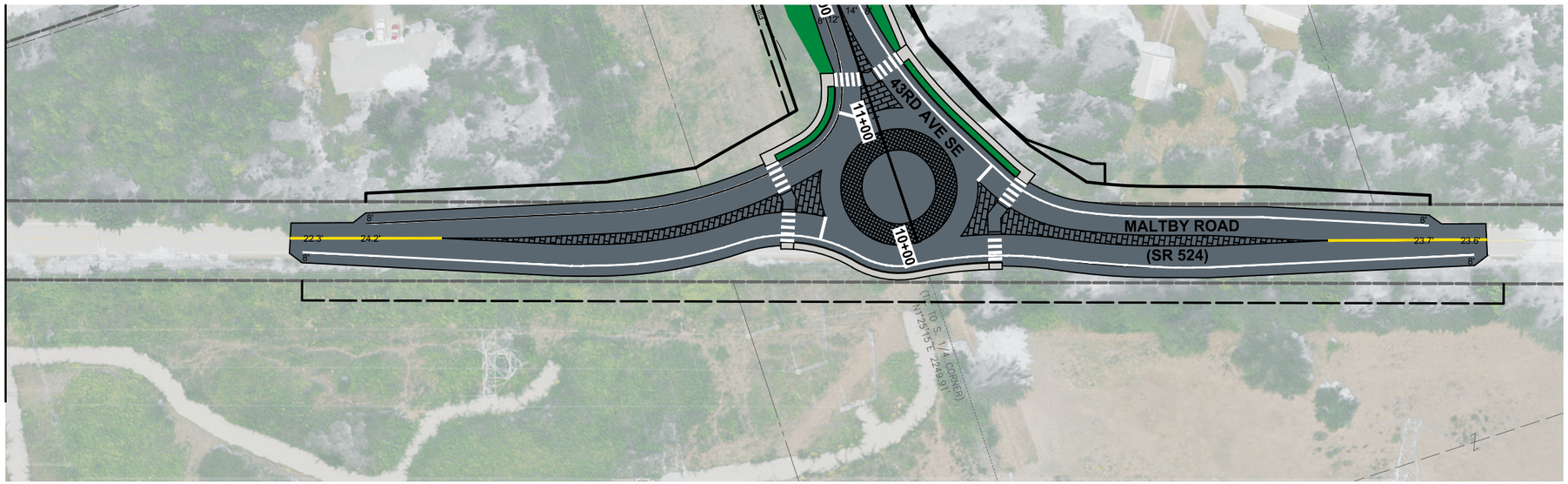
SHEET 7 OF 8 SHEETS

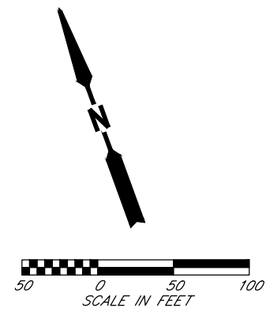
October 7, 2019 - 9:33 AM - SPWMCR - \\SNOCO\SDRIVES\SPW_DATA\PW_PROJECT_DATA_MANAGEMENT\6-PROJECTS_UPI YEAR_2016\16-0040\02_CADD\DESIGN\PSE\16-0040-CH_ALT4-URBAN2.DWG - Layout Name: 16-0040-CH7

SECTION 29, T. 29 N, R. 5 E., W.M.

MATCHLINE SEE BELOW

MATCHLINE SEE ABOVE





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FUNDING NO. RC1592

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD ALTERNATIVE 4

CHANNELIZATION PLAN

REFERENCE SHEET NO. CH08

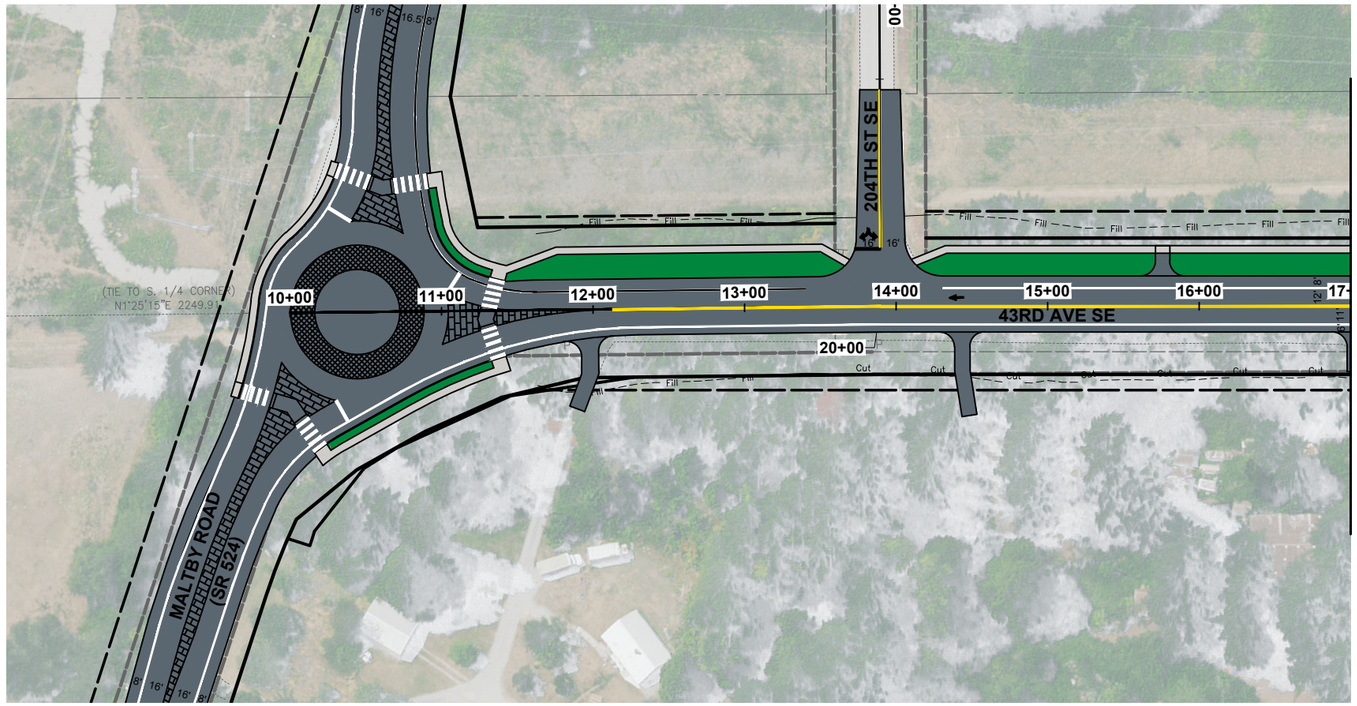
SHEET 8 OF 8 SHEETS

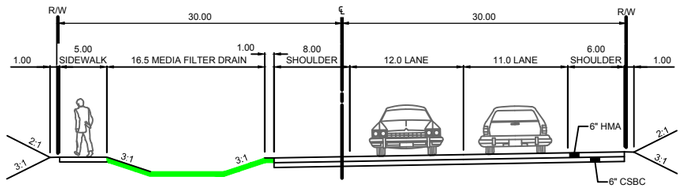
October 7, 2019 - 9:33 AM - SPWMCR - \\SNOCO\SDRIVES\SPW_DATA\PW_PROJECT_DATA_MANAGEMENT\6-PROJECTS_UPI YEAR_2016\16-0040\02_CADD\DESIGN\PSE\16-0040-CH_ALT4-URBAN2.DWG - Layout Name: 16-0040-CH8

APPENDIX C-5

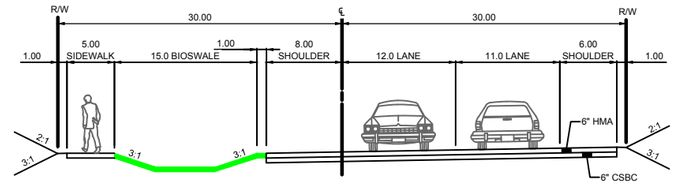
Plan Layout of Alternative 5

SECTION 29, T. 29 N, R. 5 E., W.M.



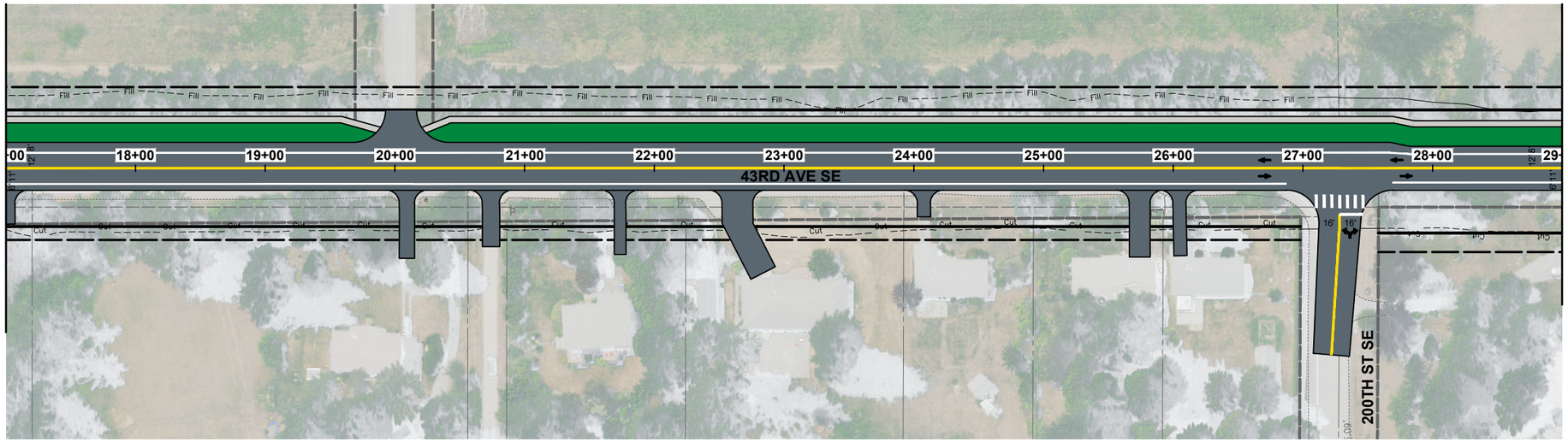


SEGMENT A
SR 524 TO 204TH ST. SE
ALTERNATIVE 5



SEGMENT A
204TH ST. SE TO 200TH ST. SE
ALTERNATIVE 5

SEG A | SEG B



N

50 0 50 100
SCALE IN FEET

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43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 5

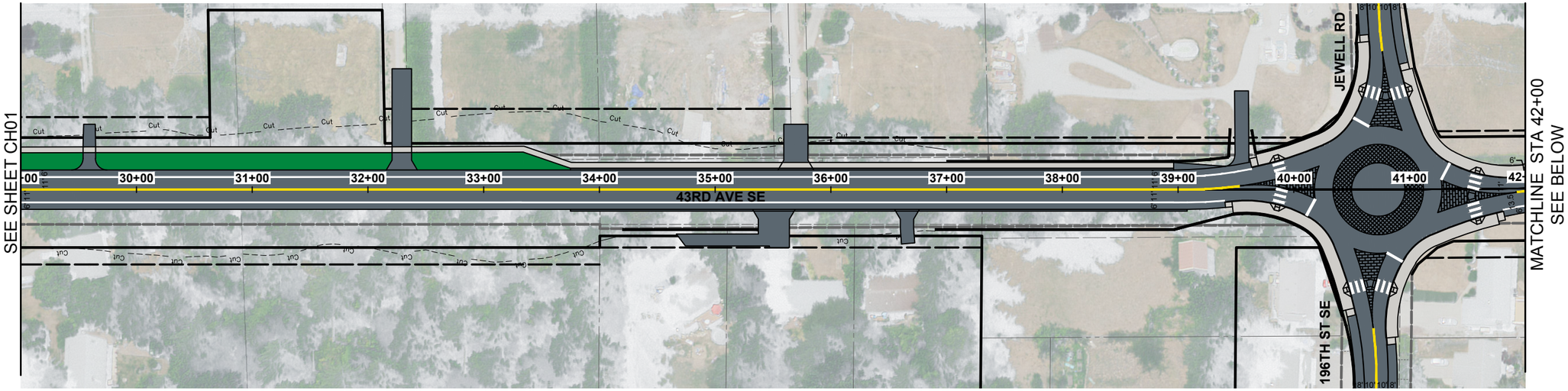
CHANNELIZATION PLAN

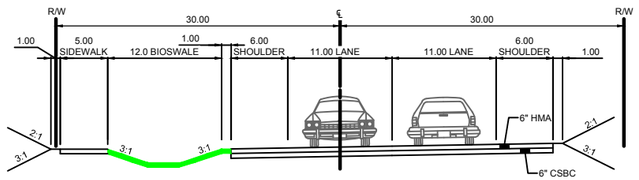
REFERENCE SHEET NO. CH01

SHEET 1 OF 8 SHEETS

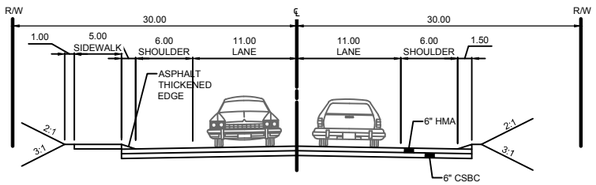
August 1, 2019 - 8:59 AM - SPWEFP - S:\PW_PROJECT_DATA_MANAGEMENT\6-PROJECTS_UPI YEAR_2016\16-0040\02_CADD\DESIGN\PSE\16-0040-CH_ALT5.DWG - Layout Name: 16-0040-CH1

SECTION 29, T. 29 N, R. 5 E., W.M.

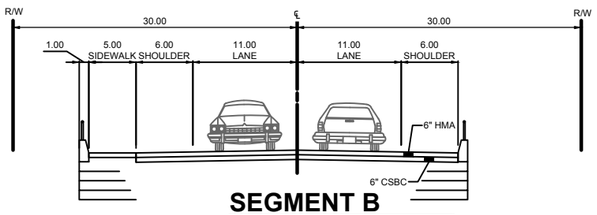




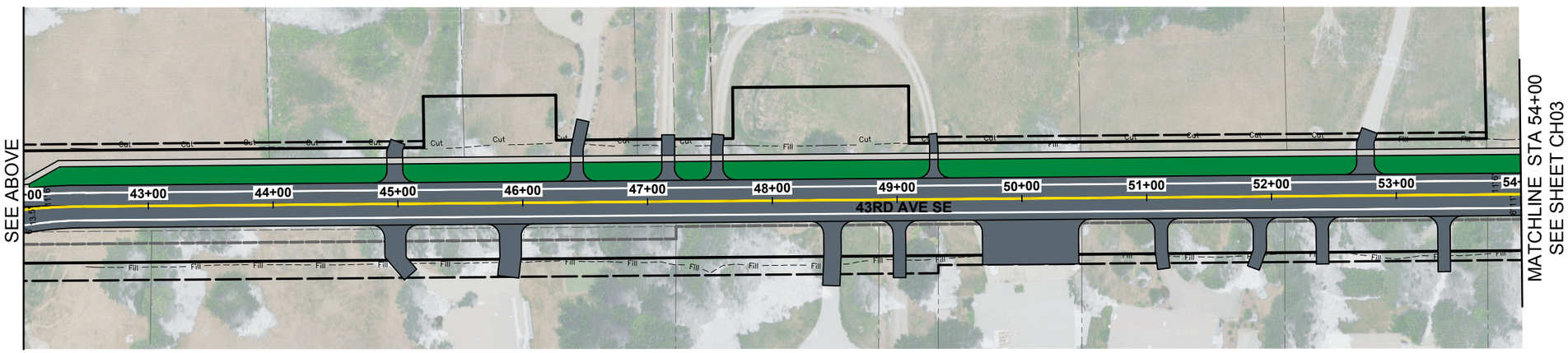
SEGMENT B
200TH ST. SE TO 198TH ST. SE
ALTERNATIVE 5

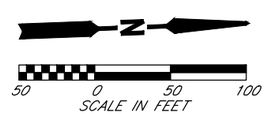


SEGMENT B
198TH ST. SE TO 197TH ST. SE
ALTERNATIVE 5



SEGMENT B
197TH ST. SE TO 196TH ST. SE
ALTERNATIVE 5





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43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 5

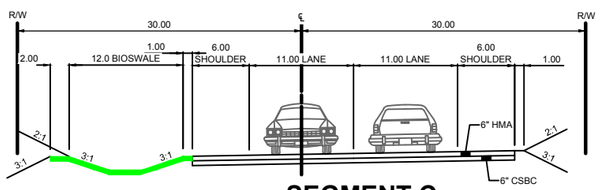
CHANNELIZATION PLAN

REFERENCE SHEET NO.
CH02

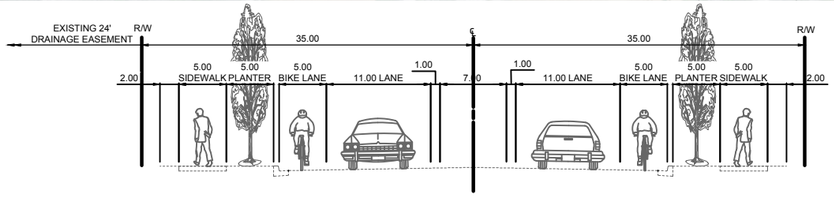
SHEET 2 OF 8 SHEETS

August 1, 2019 - 9:02 AM - SPWEFP - S:\PW_PROJECT_DATA_MANAGEMENT\16-PROJECTS_UPI YEAR_2016\16-0040\02_CADD\DESIGN\PSE\16-0040-CH_ALT5.DWG - Layout Name: 16-0040-CH2

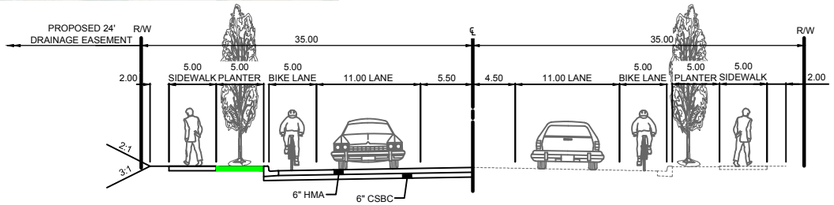
SECTION 29, T. 29 N, R. 5 E., W.M.



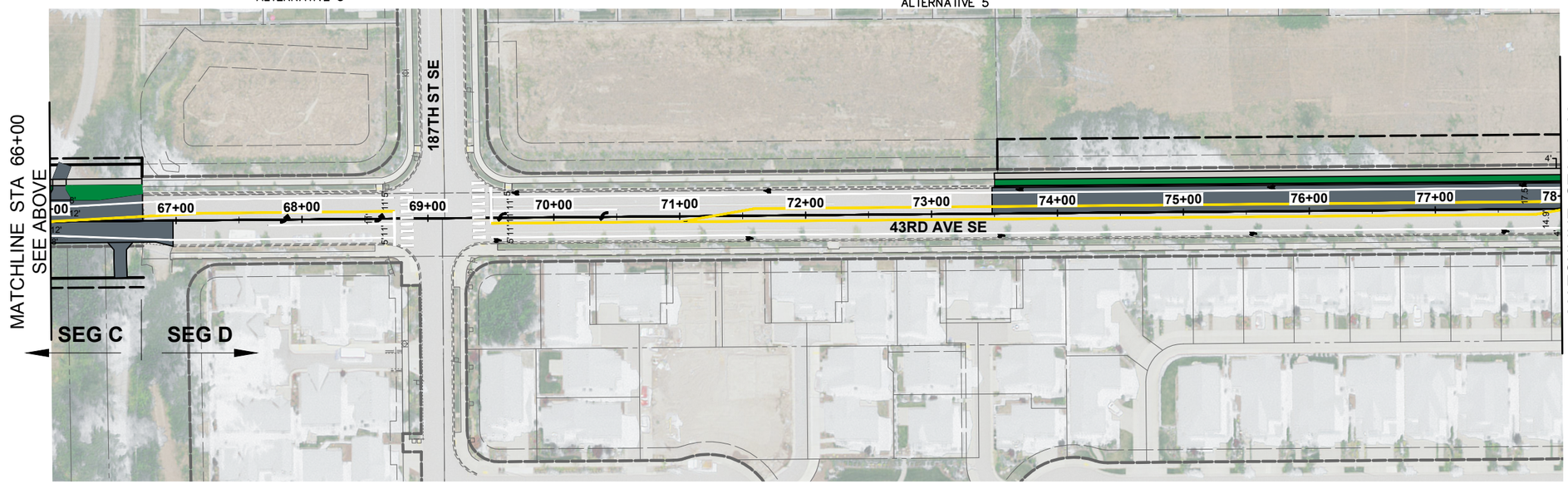
SEGMENT C
196TH ST. SE TO 188TH ST. SE
ALTERNATIVE 5

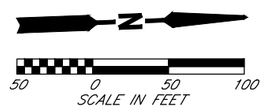


SEGMENT D
188TH ST. SE TO 186TH ST. SE
ALTERNATIVE 5



SEGMENT D
186TH STREET SE TO 184TH STREET SE
ALTERNATIVE 5





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SNOHOMISH COUNTY ENGINEER

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FUNDING NO. RC1592

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD ALTERNATIVE 5

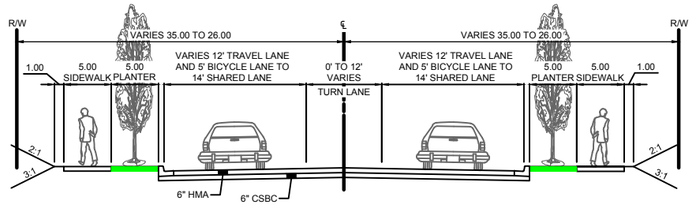
CHANNELIZATION PLAN

REFERENCE SHEET NO. CH03

SHEET 3 OF 8 SHEETS

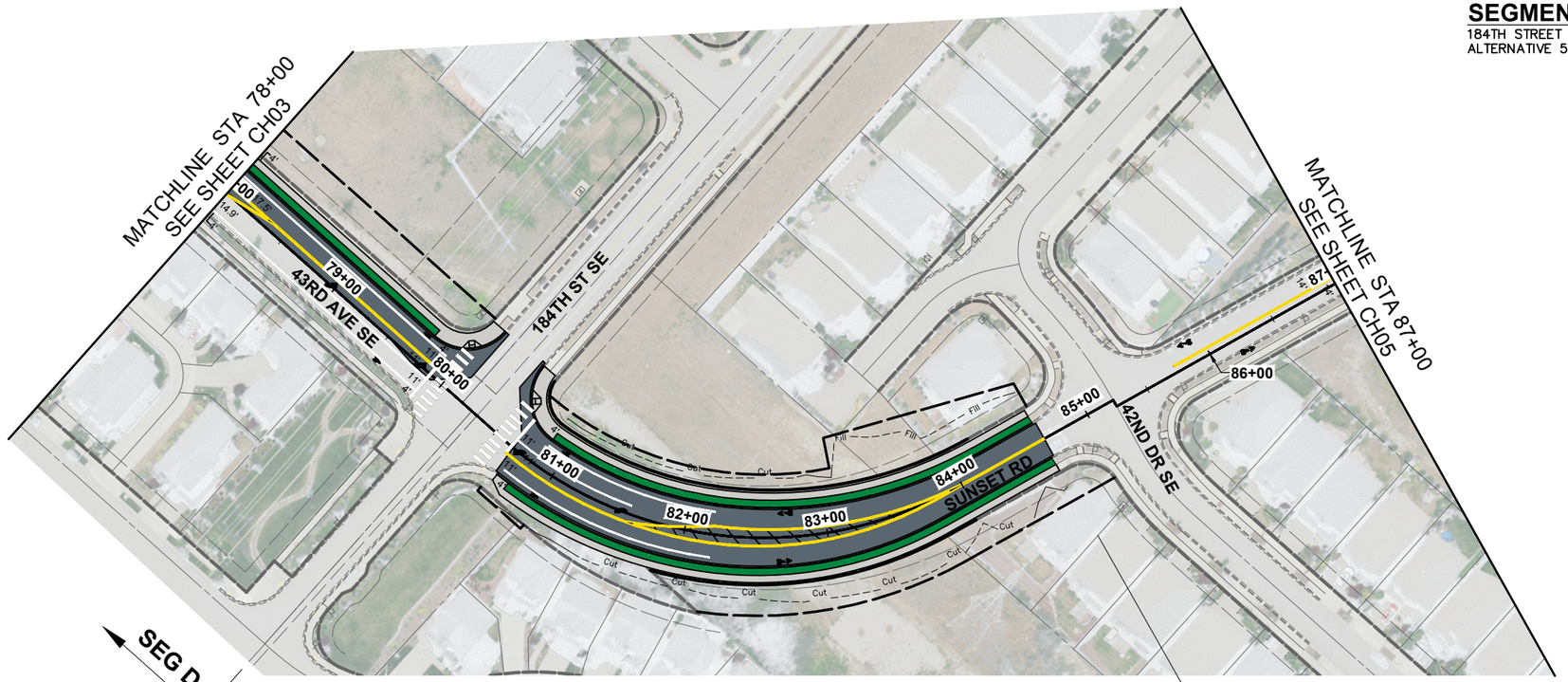
August 1, 2019 - 9:05 AM - SPWEFP - S:\PW_PROJECT_DATA_MANAGEMENT\16-PROJECTS_UPI YEAR_2016\16-0040\02_CADD\DESIGNPSE\16-0040-CH_ALT5.DWG - Layout Name: 16-0040-CH3

SECTION 29, T. 29 N, R. 5 E., W.M.



SEGMENT E

184TH STREET SE TO 43RD DRIVE SE
ALTERNATIVE 5



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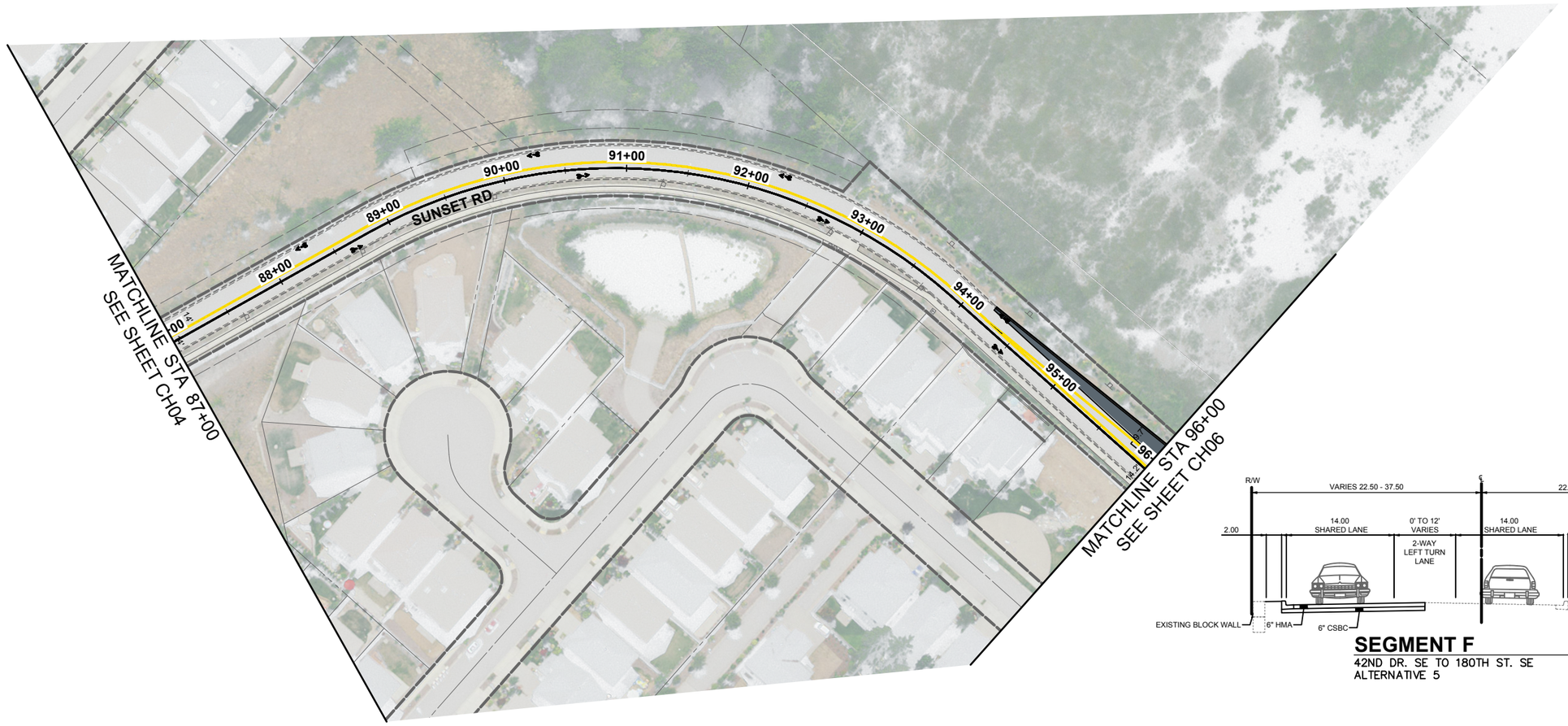
43RD AVE SE
SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD ALTERNATIVE 5
CHANNELIZATION PLAN

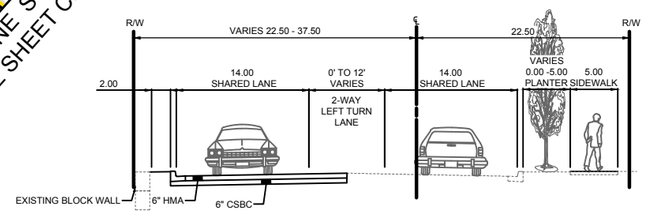
REFERENCE SHEET NO. CH04

SHEET 4 OF 8 SHEETS

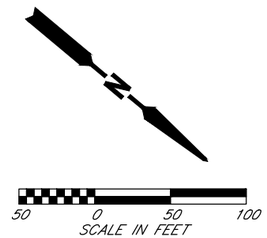
August 1, 2019 - 9:06 AM - SPWEFP - S:\PW_PROJECT_DATA_MANAGEMENT\16-PROJECTS_UPI YEAR_2016\16-0040\02_CADD\DESIGN\PSE\16-0040-CH_ALT5.DWG - Layout Name: 16-0040-CH4

SECTION 29, T. 29 N, R. 5 E., W.M.





SEGMENT F
42ND DR. SE TO 180TH ST. SE
ALTERNATIVE 5



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CHANNELIZATION PLAN

REFERENCE SHEET NO. CH05

SHEET 5 OF 8 SHEETS

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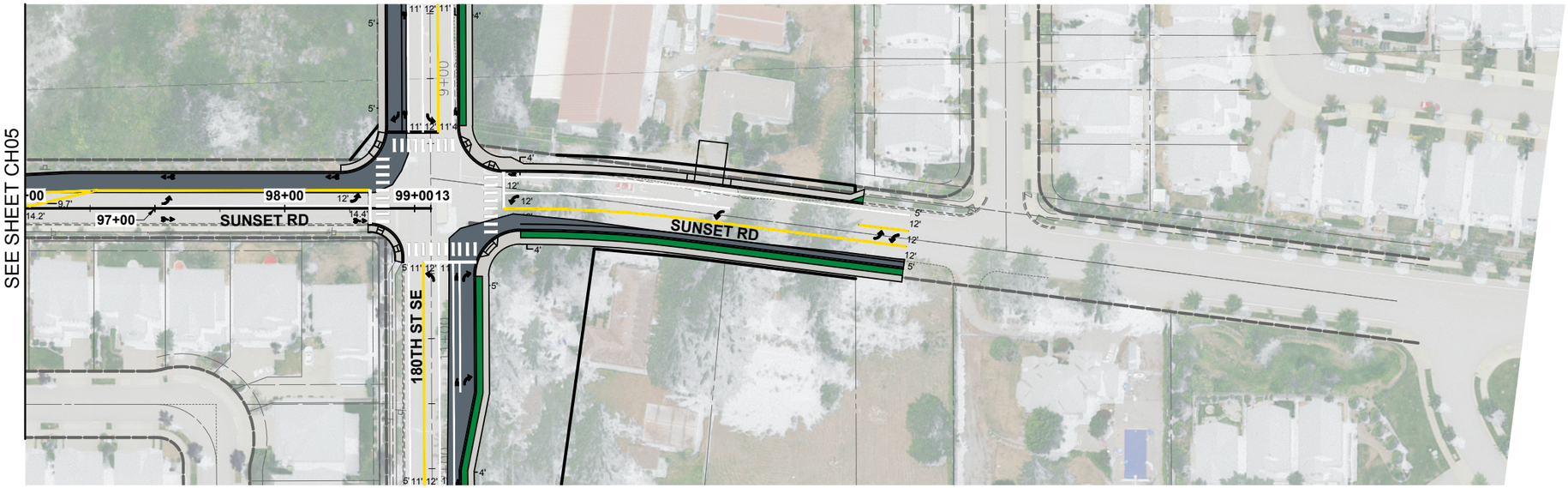
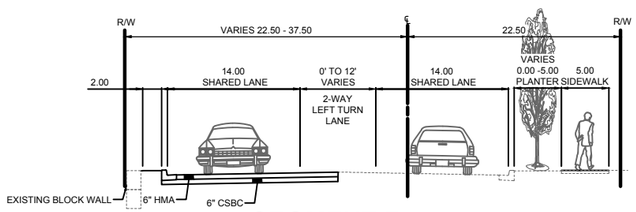
MATCHLINE STA 96+00
SEE SHEET CH05





SEGMENT F
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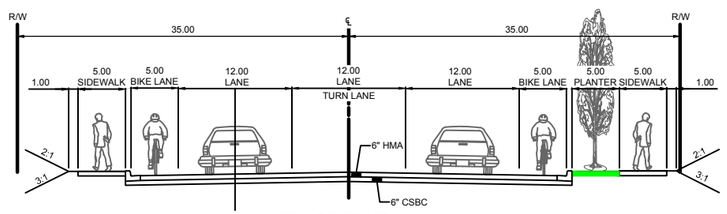
ALTERNATIVE 5



SEGMENT G
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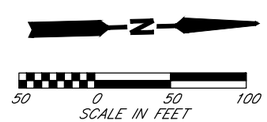
ALTERNATIVE 5



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43RD AVE SE
SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD
ALTERNATIVE 5
CHANNELIZATION PLAN

REFERENCE SHEET NO. CH06

SHEET 6 OF 8 SHEETS

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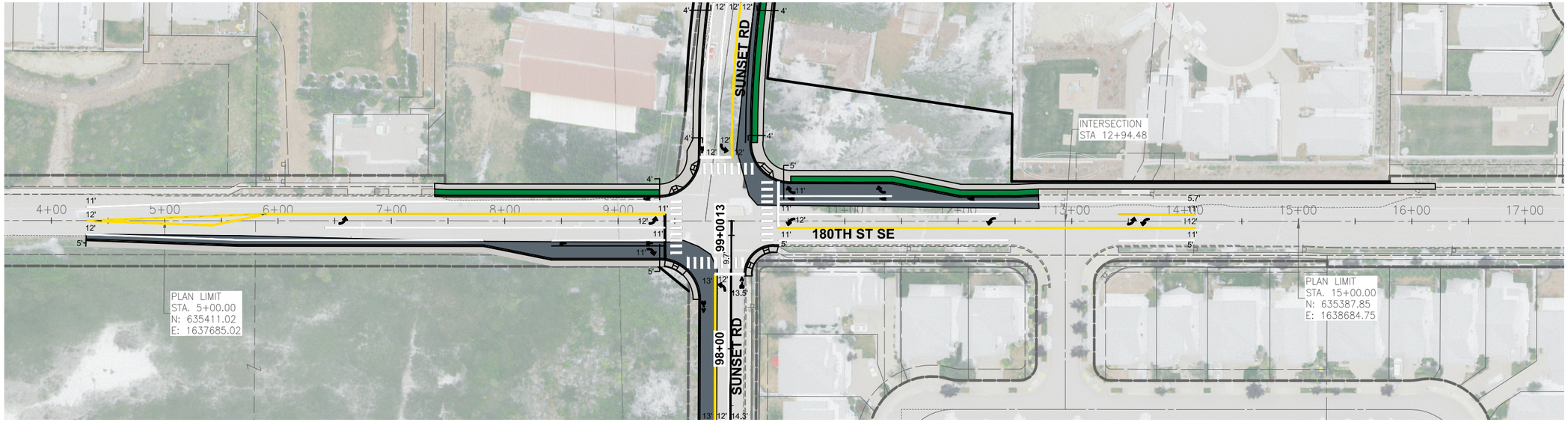
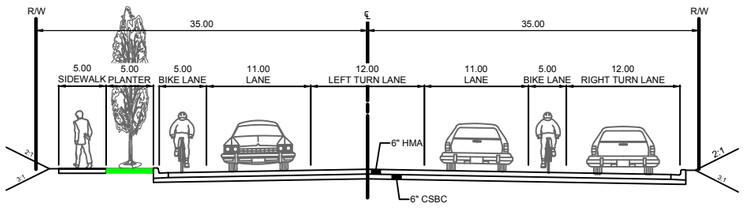
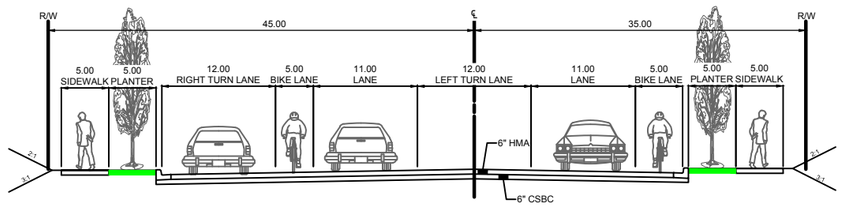




SEGMENT H
WEST OF SUNSET RD.
ALTERNATIVE 5



SEGMENT I
EAST OF SUNSET RD.
ALTERNATIVE 5

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DATE	NO.	REVISION	BY

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SURVEY NO.: -	FIELD BOOK(S): -
HORZ. DATUM: -	VERT. DATUM: -
DESIGNED BY: -	DRAWN BY: -

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REVIEWED AND APPROVED FOR CONSTRUCTION

DOUGLAS W. McCORMICK, P.E.
SNOHOMISH COUNTY ENGINEER

DATE APPROVED:

SNOHOMISH COUNTY DEPARTMENT OF PUBLIC WORKS

FUNDING NO. RC1592

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD ALTERNATIVE 5

CHANNELIZATION PLAN

REFERENCE SHEET NO. CH07

SHEET 7 OF 8 SHEETS

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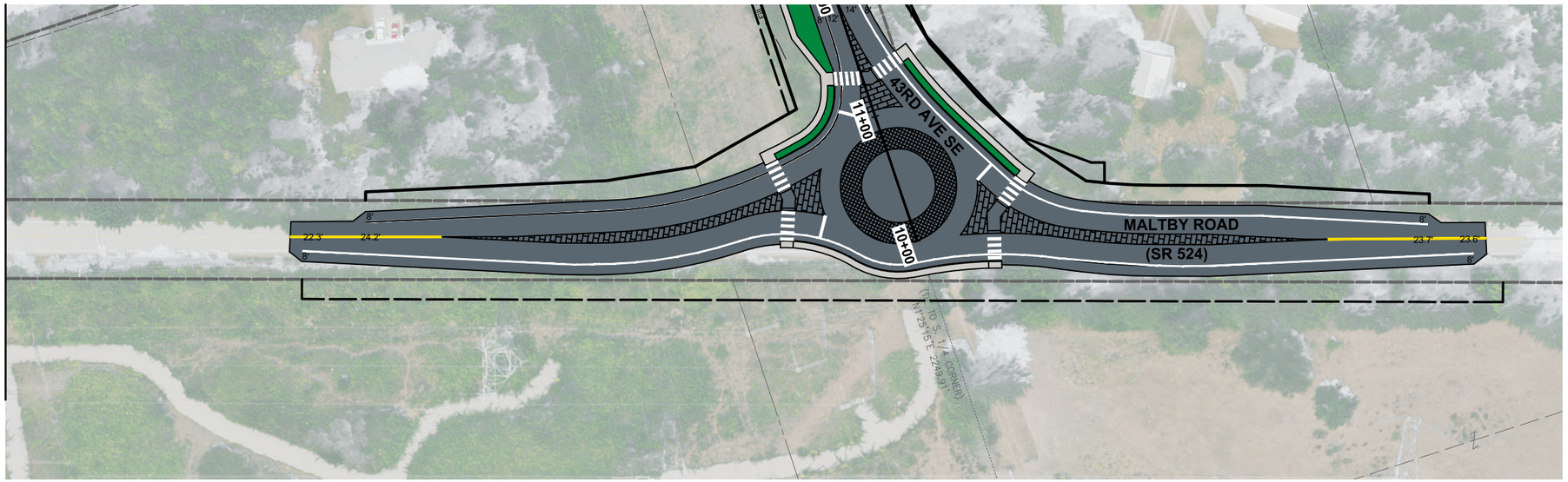
SECTION 29, T. 29 N, R. 5 E., W.M.

MATCHLINE SEE BELOW



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DESIGNED BY: -	DRAWN BY: -

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SUBMITTAL

REVIEWED AND APPROVED FOR CONSTRUCTION

DOUGLAS W. McCORMICK, P.E.
SNOHOMISH COUNTY ENGINEER

DATE APPROVED:

SNOHOMISH COUNTY DEPARTMENT OF PUBLIC WORKS

FUNDING NO. RC1592

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD ALTERNATIVE 5

CHANNELIZATION PLAN

REFERENCE SHEET NO. CH08

SHEET 8 OF 8 SHEETS

August 1, 2019 - 9:12 AM - SPWEFP - S:\PW_PROJECT_DATA_MANAGEMENT\6-PROJECTS_UPI YEAR_2016\16-0040\02_CADD\DESIGNPSE\16-0040-CH_ALT5.DWG - Layout Name: 16-0040-CH8

APPENDIX C-6

Plan Layout of Intersection Configurations

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EXHIBIT

43RD AVE SE ROAD ALTERNATIVES

SIGNAL INTERSECTION
SR 524 (MALTBY RD)

SHEET 1 OF 13

May 16, 2019 - 9:33 AM - JONC - Z:\1800001-1800999\1800175 43RD AVE SE\CADD\FIGURES\ROADWAY ALT\16-0040-CH-INTERSECTIONS.DWG - Layout Name: SR524_SIGNAL

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FUNDING NO.

EXHIBIT

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1-LANE ROUNDABOUT - CENTERED
SR 524 (MALTBY RD)

SHEET 2 OF 13

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SECTION 21, T. 27 N, R. 5 E., W.M.

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EXHIBIT

43RD AVE SE ROAD ALTERNATIVES

1-LANE ROUNDABOUT -OFFSET

SR 524 (MALTBY RD)

SHEET 4 OF 13

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EXHIBIT

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2-LANE ROUNDABOUT - OFFSET
SR 524 (MALTBY RD)

SHEET 5 OF 13

May 16, 2019 - 9:33 AM - JONC - Z:\1800001-1800999\1800175 43RD AVE SE\CADD\FIGURES\ROADWAY ALT\16-0040-CH-INTERSECTIONS.DWG - Layout Name: SR524_ROUND_2-LANE OFFSET

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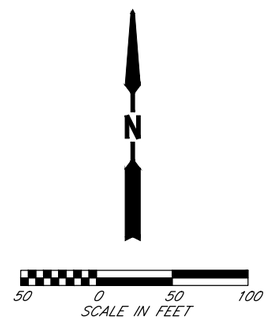

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SECTION 16,21 T. 27 N, R. 5 E., W.M.

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43RD AVE SE ROAD ALTERNATIVES

SINGLE LANE ROUNDABOUT
196TH ST SE

SHEET 7 OF 13

May 16, 2019 - 9:34 AM - JONC - Z:\1800001-1800999\1800175 43RD AVE SE\CADD\FIGURES\ROADWAY ALT\16-0040-CH-INTERSECTIONS.DWG - Layout Name: 196TH ST SE ROUNDABOUT_1LANE

SECTION 9,16 T. 27 N, R. 5 E., W.M.

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SCALE IN FEET

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EXHIBIT

43RD AVE SE ROAD ALTERNATIVES

SIGNAL INTERSECTION
180TH ST SE

SHEET 8 OF 13

May 16, 2019 - 9:34 AM - JONC - Z:\1800001-1800999\1800175 43RD AVE SE\CADD\FIGURES\ROADWAY ALT\16-0040-CH-INTERSECTIONS.DWG - Layout Name: 180TH ST SE INTS

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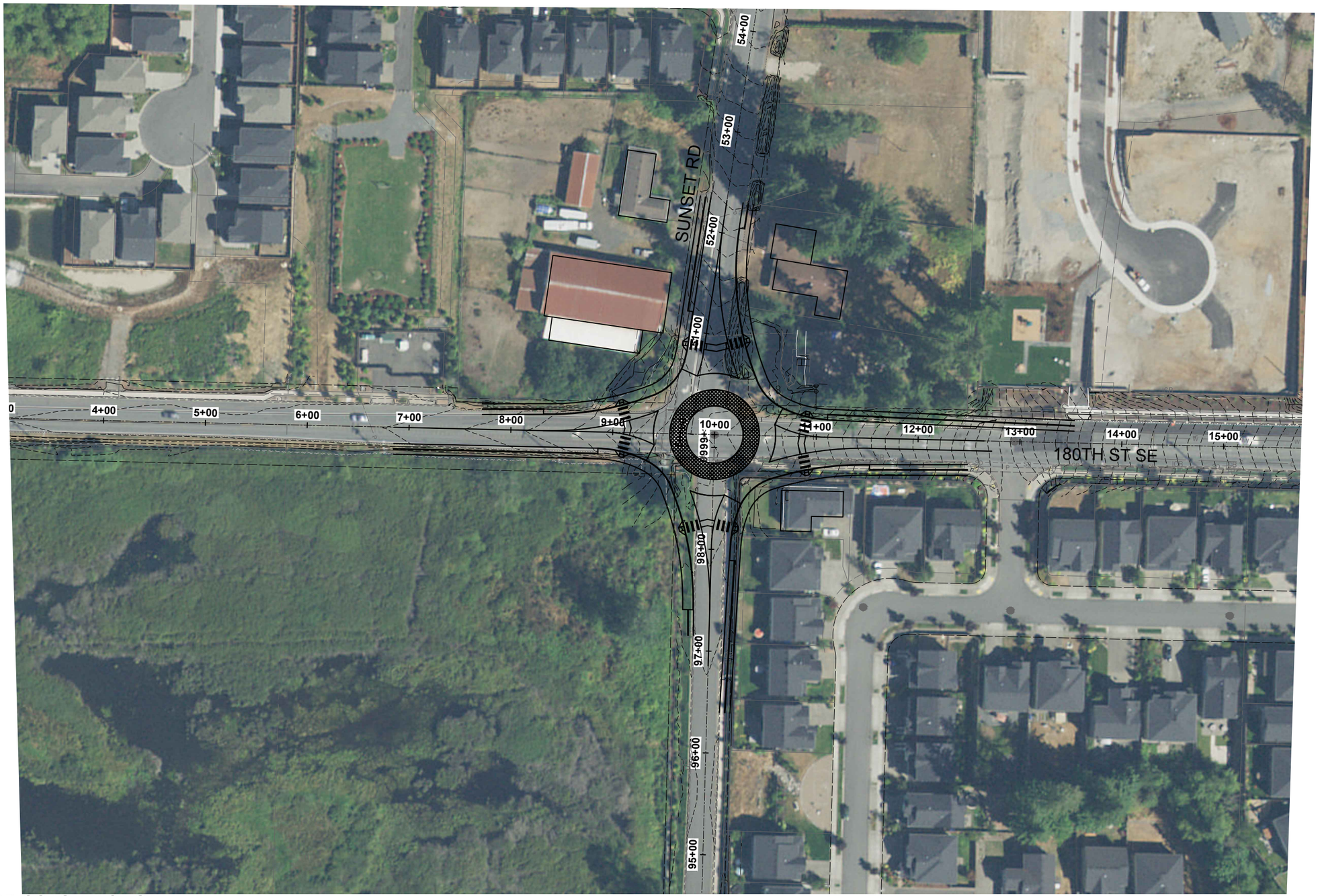

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EXHIBIT

43RD AVE SE ROAD ALTERNATIVES

SINGLE LANE ROUNDABOUT
180TH ST SE

SHEET 9 OF 13

May 16, 2019 - 9:34 AM - JONC - Z:\1800001-1800999\1800175 43RD AVE SE\CAD\FIGURES\ROADWAY ALT\16-0040-CH-INTERSECTIONS.DWG - Layout Name: 180TH ST SE ROUNDABOUT_1 LANE

SECTION 9,16 T. 27 N, R. 5 E., W.M.

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43RD AVE SE ROAD ALTERNATIVES

2-LANE ROUNDABOUT
180TH ST SE

SHEET 10 OF 13

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May 16, 2019 - 9:34 AM - JONC - Z:\1800001-1800999\1800175 43RD AVE SE\CADD\FIGURES\ROADWAY ALT\16-0040-CH-INTERSECTIONS.DWG - Layout Name: 204TH ST SE INTS

SECTION 21, T. 27 N, R. 5 E., W.M.

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May 16, 2019 - 9:34 AM - JONC - Z:\1800001-1800999\1800175 43RD AVE SE\CADD\FIGURES\ROADWAY ALT\16-0040-CH-INTERSECTIONS.DWG - Layout Name: 204TH ST SE CULDESAC

SECTION 21, T. 27 N, R. 5 E., W.M.

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May 16, 2019 - 9:34 AM - JONC - Z:\1800001-1800999\1800175 43RD AVE SE\CADD\FIGURES\ROADWAY ALT\16-0040-CH-INTERSECTIONS.DWG - Layout Name: 204TH ST SE HAMMERHEAD

APPENDIX D

NOT USED

APPENDIX E

Traffic Analysis

MEMORANDUM

Date: 01/28/2019

To: Lloyd Wind, KPFF

From: Sarah Keenan, Fehr & Peers

Subject: 43rd Avenue SE - Sunset Road Connection Traffic Analysis

SE18-0606

INTRODUCTION

The 43rd Avenue SE - Sunset Road traffic analysis was completed in support of the design for the connection of 43rd Avenue SE-Sunset Road between 180th Street SE and SR 524. The analysis considered the following study intersections:

1. Sunset Road/180th Street SE (signal warrants met for 2040)
2. 43rd Avenue SE/196th Street SE (signal warrants met for 2040)
3. 43rd Avenue SE/204th Street SE
4. 43rd Avenue SE/SR 524 (signal warrants met for 2040)
5. 204th Street SE/ SR 524

Sunset Road/180th Street SE, 43rd Avenue SE/196th Street SE, and 43rd Avenue SE/SR 524 all meet warrants for the installation of traffic signals in the future and were assumed to be signals or roundabouts in all analysis scenarios. Analysis was completed for the AM and PM peak hour for construction year (2025) and design year (2045).

VOLUME FORECASTING

Volumes were forecasted based on the Snohomish County travel demand model and the following data provided by Snohomish County:

- Small Area Transportation Study- 35th Avenue SE (September 2016)
- Traffic Forecasts and Analysis on 43rd Ave SE Corridor
- Turn Warrant Analysis provided for several intersections

One 2025 scenario and two 2045 scenarios were analyzed:

- **2025 AM and PM**
- **2045 AM and PM Scenario 1** – SR 524 is assumed to be 2 lanes with no northbound approach at 43rd Avenue SE
- **2045 AM and PM Scenario 2** - SR 524 is assumed to be 4 lanes with a northbound approach at 43rd Avenue SE

In each scenario a signalized and roundabout alternatives were considered at locations where the signal warrant was met. The forecasted volumes for the entire study area and channelization for Sunset Road/180th Street SE, 43rd Avenue SE/196th Street SE, and 43rd Avenue SE/SR 524 for each scenario is included in Attachment A.

SIGNALIZED ALTERNATIVE

Level of Service Analysis

The Level of Service (LOS) analysis was completed using Synchro/SimTraffic version 9.0, and based on Highway Capacity Manual (HCM) 2010. The results of the LOS analysis are shown in Table 1.

Table 1: Delay (seconds) by Approach and Intersection Level of Service (LOS); Signalized Alternative

2025							
		EB	WB	NB	SB	Overall	LOS
AM Peak Hour	Sunset Rd/ 180th St SE	16	26	10	20	20	B
	43rd Ave SE/ 196th St SE	9	9	4	5	6	A
	43rd Ave SE/ 204th St SE	11	-	-	-	11	B
	43rd Ave SE/ SR 524	7	7	-	17	10	A
	204th St SE/ SR 524	-	-	-	14	14	B
PM Peak Hour	Sunset Rd/ 180th St SE	19	35	17	22	24	C
	43rd Ave SE/ 196th St SE	13	11	6	5	8	A
	43rd Ave SE/ 204th St SE	11	-	-	-	11	B
	43rd Ave SE/ SR 524	14	4	-	73	14	B
	204th St SE/ SR 524	-	-	-	16	16	C
2045 Scenario 1							
		EB	WB	NB	SB	Overall	LOS
AM Peak Hour	Sunset Rd/ 180th St SE	37	19	28	28	28	C
	43rd Ave SE/ 196th St SE	11	11	5	7	8	A
	43rd Ave SE/ 204th St SE	14	-	-	-	14	B
	43rd Ave SE/ SR 524	13	13	-	46	23	C
	204th St SE/ SR 524	-	-	-	26	26	D
PM Peak Hour	Sunset Rd/ 180th St SE	35	61	51	53	49	D
	43rd Ave SE/ 196th St SE	12	8	12	7	11	B
	43rd Ave SE/ 204th St SE	22	-	-	-	22	C
	43rd Ave SE/ SR 524	63	178	-	127	129	**F**
	204th St SE/ SR 524	-	-	-	32	32	D
2045 Scenario 2							
		EB	WB	NB	SB	Overall	LOS
AM Peak Hour	Sunset Rd/ 180th St SE	27	57	24	63	48	D
	43rd Ave SE/ 196th St SE	13	13	5	14	12	B
	43rd Ave SE/ 204th St SE	17	-	-	-	17	C
	43rd Ave SE/ SR 524	20	20	18	33	24	C
	204th St SE/ SR 524	-	-	-	12	12	B
PM Peak Hour	Sunset Rd/ 180th St SE	35	61	79	58	57	**E**
	43rd Ave SE/ 196th St SE	13	10	18	7	14	B
	43rd Ave SE/ 204th St SE	16	-	-	-	16	C
	43rd Ave SE/ SR 524	44	80	83	36	68	**E**
	204th St SE/ SR 524	-	-	-	14	14	B

Source: Fehr & Peers, 2018

The analysis shows high delay in 2045 at the intersection of 43rd Avenue SE/ SR 524 in the PM peak hour and at Sunset Rd/ 180th Street SE in the PM peak hour. Assuming two lanes on SR 524 and a fourth leg at 43rd Avenue SE/ SR 524 does decrease delay at this intersection but operations are still at an LOS E both here and at Sunset Road/180th Street in the PM.

Additional analysis considering a second eastbound left turn pocket and northbound right turn pocket at Sunset Road and 180th Street SE were tested in the 2045 scenarios. While this did reduce intersection delay in both the AM and PM, right of way constraints at Sunset Road and 180th Street SE would make adding these turn pockets difficult and costly to construct. Attachment A details the intersection layout and LOS results for this additional analysis.

Queue Analysis

Queue analysis estimates the 95th percentile queues for the intersections of 43rd Avenue SE/SR 524, Sunset Road/180th Street SE, and 43rd Avenue SE/196th Street SE. With the exception of 2045 PM, the side street stop controlled intersections show queues of less than 2 vehicles. The results are summarized in Table 2.

Table 2: 95th Percentile Queue Lengths (feet)

2025												
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	SBL	SBT	SBR
AM Peak Hour	Sunset Rd/ 180th St SE	26	197	27	101	236*	0	21	44	135	258*	-
	43rd Ave SE/ 196th St SE	-	36	-	-	35	-	12	35	7	119	-
	43rd Ave SE/ SR 524	-	245	-	-	193	-	-	-	156	-	45
PM Peak Hour	Sunset Rd/ 180th St SE	167*	216	24	55	364*	40	78	171	52	98	-
	43rd Ave SE/ 196th St SE	-	93	-	-	19	-	26	110	5	64	-
	43rd Ave SE/ SR 524	-	519*	-	-	209	-	-	-	84*	-	51
2045 Scenario 1												
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	SBL	SBT	SBR
AM Peak Hour	Sunset Rd/ 180th St SE	53	481*	50	145*	270	10	50	110	172*	344*	-
	43rd Ave SE/ 196th St SE	-	47	-	-	48	-	18	63	9	270*	-
	43rd Ave SE/ SR 524	171*	278	-	-	387	-	-	-	231	-	167
PM Peak Hour	Sunset Rd/ 180th St SE	290*	328	25	80	587*	75	158*	496*	131*	189	-
	43rd Ave SE/ 196th St SE	-	147*	-	-	25	-	42	293*	5	95	-
	43rd Ave SE/ SR 524	561*	216	-	-	2155*	-	-	-	345*	-	54
2045 Scenario 2												
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	SBL	SBT	SBR
AM Peak Hour	Sunset Rd/ 180th St SE	57	527	82	339*	492	9	42	118	312	855*	-
	43rd Ave SE/ 196th St SE	-	47	-	-	48	-	21	60	10	380*	-
	43rd Ave SE/ SR 524	151*	166	-	92*	187	-	29	48	123*	526*	-
PM Peak Hour	Sunset Rd/ 180th St SE	290*	328	25	80	587*	80	181*	587*	131*	189	-
	43rd Ave SE/ 196th St SE	-	147*	-	-	25	-	42	362*	6	93	-
	43rd Ave SE/ SR 524	329*	261	-	104	757*	-	117	787*	75*	200	-

* Queue length is greater than capacity so queue may be longer than reported
Source: Fehr & Peers, 2018

ROUNDABOUT ANALYSIS

Roundabout analysis was completed for the three study intersections which met signal warrants:

- Sunset Road/ 180th Street SE
- 43rd Avenue SE/ 196th Street SE
- 43rd Avenue SE/ SR 524

A single-lane roundabout was analyzed for all three intersections in 2025 and 2045, and a two-lane roundabout was also analyzed for 2045 at 43rd Avenue SE/ SR 524 and Sunset Road/180th Street SE.

Level of Service Analysis

The analysis was completed using SIDRA 7 and HCM 10 methodology for both single and two-lane roundabouts. The LOS and delay results are presented in Table 3 below.

Table 3: Roundabout Delay (seconds) by approach and Intersection LOS

2025 Single Lane Roundabout							
		EB	WB	NB	SB	Overall	LOS
AM Peak Hour	Sunset Rd/ 180th St SE	17	5	8	14	12	B
	43rd Ave SE/ 196th St SE	8	5	4	4	5	A
	43rd Ave SE/ SR 524	6	4	-	11	7	A
PM Peak Hour	Sunset Rd/ 180th St SE	10	34	26	9	21	C
	43rd Ave SE/ 196th St SE	7	6	5	3	5	A
	43rd Ave SE/ SR 524	6	11	-	11	9	A
2045 Single Lane Roundabout- Scenario 1							
		EB	WB	NB	SB	Overall	LOS
AM Peak Hour	Sunset Rd/ 180th St SE	106	7	10	178	93	**F**
	43rd Ave SE/ 196th St SE	10	6	4	4	5	A
	43rd Ave SE/ SR 524	12	5	-	81	31	C
PM Peak Hour	Sunset Rd/ 180th St SE	84	174	407	12	183	**F**
	43rd Ave SE/196th St SE	8	8	10	4	8	A
	43rd Ave SE/ SR 524	48	330	-	13	194	**F**
2045 Two-Lane Roundabout – Scenario 2							
		EB	WB	NB	SB	Overall	LOS
AM Peak Hour	Sunset Rd/ 180th St SE	12	5	8	8	9	A
	43rd Ave SE/ SR 524	8	4	6	9	7	A
PM Peak Hour	Sunset Rd/ 180th St SE	6	52	11	8	21	C
	43rd Ave SE/ SR 524	6	10	7	8	8	A

Source: Fehr & Peers, 2018

Queue Analysis

Queue estimates for the 95th percentile queues for the intersections of 43rd Avenue SE/ SR 524 and Sunset Road/180th Street SE were completed using SIDRA. The queues for two-lane roundabouts are summarized in Table 4 to assist in the sizing of the turn-pocket storage lengths. Single lane roundabouts have no auxiliary turning lanes, and therefore queues are not reported. These results are included in the attached model outputs.

Table 4: 95th Percentile Queue Lengths (feet) for Two-Lane Roundabout

2045 Scenario 2									
		EBL	EBR	WBL	WBR	NBL	NBR	SBL	SBR
AM Peak Hour	Sunset Rd/ 180th St SE	11	253	21	59	9	31	43	127
	43rd Ave SE/ SR 524	87	95	44	45	4	13	18	181
PM Peak Hour	Sunset Rd/ 180th St SE	41	119	19	987	42	180	19	54
	43rd Ave SE/ SR 524	48	50	186	199	19	103	17	39

Safety

Delay and LOS are not the only metrics when deciding whether to install a signalized intersection or a roundabout, safety is also an important consideration. Signals have been shown to decrease angle crashes but increase rear end collisions. This can lower the severity of collisions at the intersection but not necessarily the frequency. Roundabouts lower the number of conflict points in an intersection and changing a signalized intersection to a roundabout has been shown to reduce severe crashes by 78%[1].

CONCLUSION

The LOS and delay for the alternative lay outs and control types of the study intersections for 2045 are summarized in Table 5. The table compares PM peak hour, as it was found to be the critical hour of analysis.

[1] https://safety.fhwa.dot.gov/provencountermeasures/roundabouts/

Table 5: Summary of Delay (seconds) and LOS Analysis Results (PM Peak Hour)

Study Intersection	Proposed Lay Out	Scenario 1		Scenario 2	
		LOS	Delay	LOS	Delay
Sunset Road/ 180th St SE	Signal	D	49	D[1]	48
	Signal with Additional Turn Lanes	C	27	E	57
	Single Lane Roundabout	F[2]	183	-	-
	Two Lane Roundabout	-	-	C	21
43rd Ave SE/ 196th St SE	Signal	B	11	B	14
	Single Lane Roundabout	A	8	-	-
43rd Ave SE/ 204th St SE	Two-Way Stop Controlled (at 204th St SE)	C	22	C	16
43rd Ave SE/ SR 524	Signal	F[3]	129	E[4]	68
	Single Lane Roundabout	F[5]	194	-	-
	Two-Lane Roundabout	-	-	A	8
204th St SE/ SR 524	Right-In/Right-Out Control	D	32	B	14

1) Expected to perform at LOS E starting in 2040
2) Expected to perform at LOS E through 2035
3) Expected to perform at LOS E through 2035
4) Expected to perform at LOS E starting in 2040
5) Expected to perform at LOS E through 2035

A two-lane roundabout at 43rd Avenue SE/ SR 524 and at Sunset Road/180th Street SE result in less delay than a signalized intersection at these locations. If SR 524 is not widened the intersections will still perform well for the next 15 to 20 years with current growth assumptions. With signalized intersections, in Scenario 1 43rd Avenue SE/ SR 524 does not reach LOS E until 2035, and in Scenario 2 43rd Avenue SE/ SR 524 and Sunset Road/180th Street SE do not reach LOS E until the year 2040. A single lane roundabout reaches LOS E at 43rd Avenue SE/ SR 524 and at Sunset Road/180th Street SE between 2030 and 2035 so a signal or single lane roundabout will be sufficient for the near future. These intersections should be constructed so that they can be widened by 2045, or when 43rd Avenue is extended to the south of SR 524.

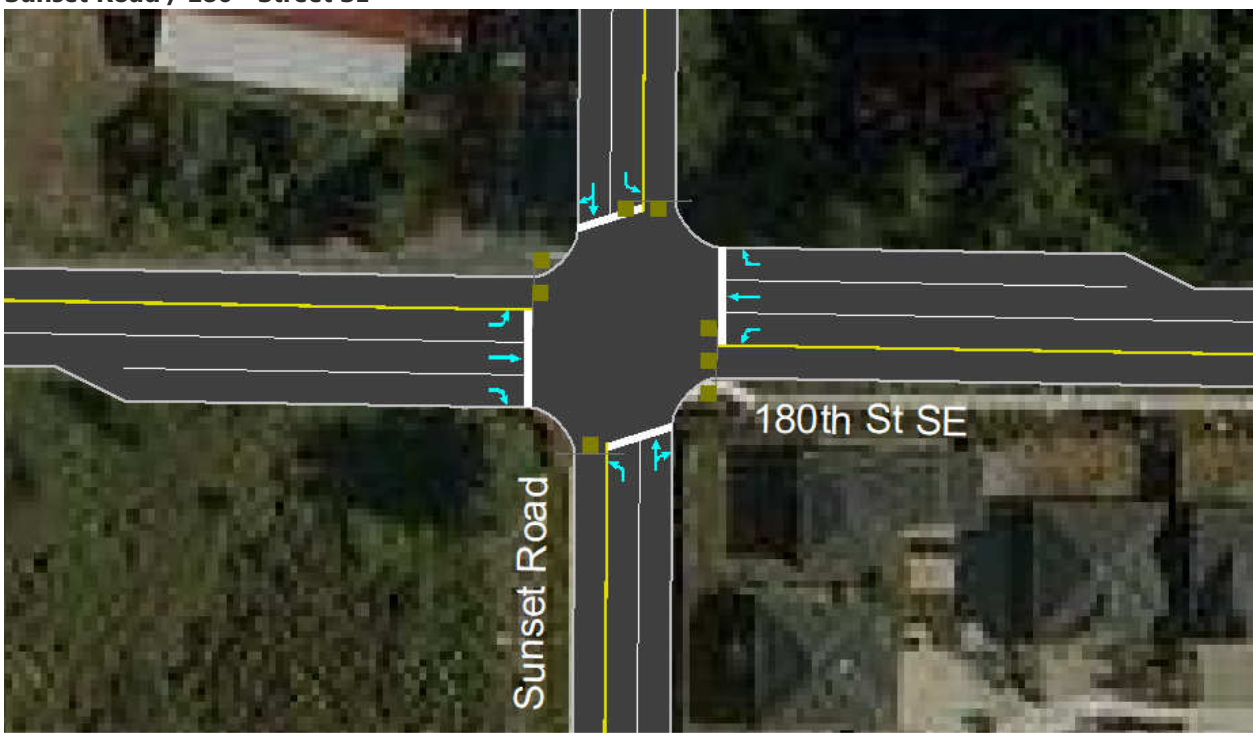
The County will be proposing a Traffic signal at Sunset Road/180th Street SE due to right of way limitations and critical area impacts west of the intersection. A single lane roundabout will be proposed at 43rd Avenue SE/196th Street SE. The County will be proposing a single lane roundabout at 43rd Avenue/SR 524 as an interim improvement with a design year 2035 to WSDOT. The intersection will be reevaluated for the future projects in this area. The County is looking into buying the right of way necessary for a two lane roundabout with this project.

Attachment A

- 2025 Intersection Geometry
- 2025 Volumes
- 2045 Scenario 1 Intersection Geometry
- 2045 Scenario 1 Volumes
- 2045 Scenario 2 Intersection Geometry
- 2045 Scenario 2 Volumes
- Sunset Road/ 180th Street SE Intersection Geometry and LOS with Additional Turn Pockets
- Recommended Lane Layout for Single Lane roundabout
- Recommended Lane Layout for Two Lane roundabout

2025 Intersection Geometry

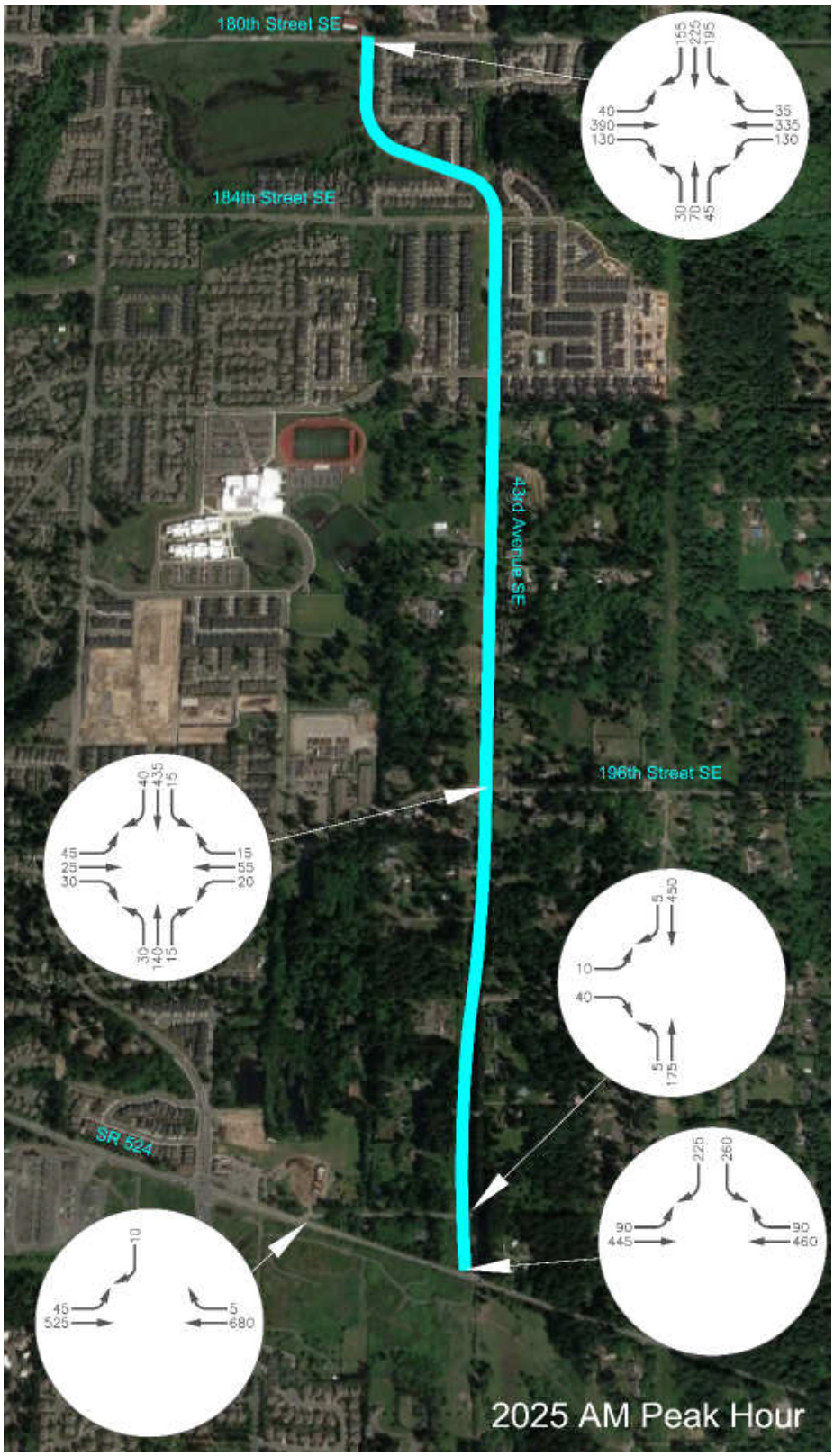
Sunset Road / 180th Street SE

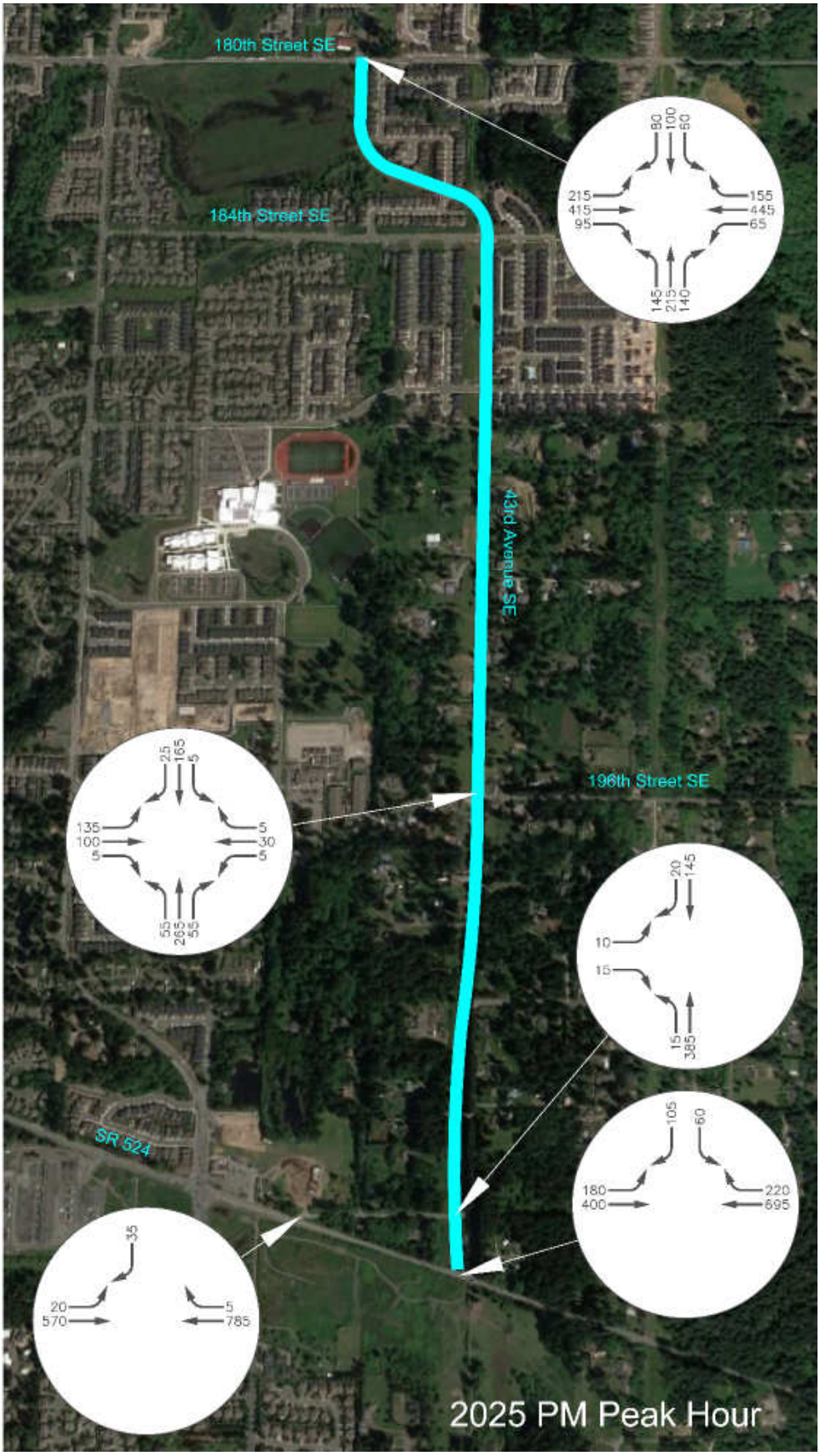


43rd Avenue SE / 196th Street SE

43rd Avenue SE / SR 524

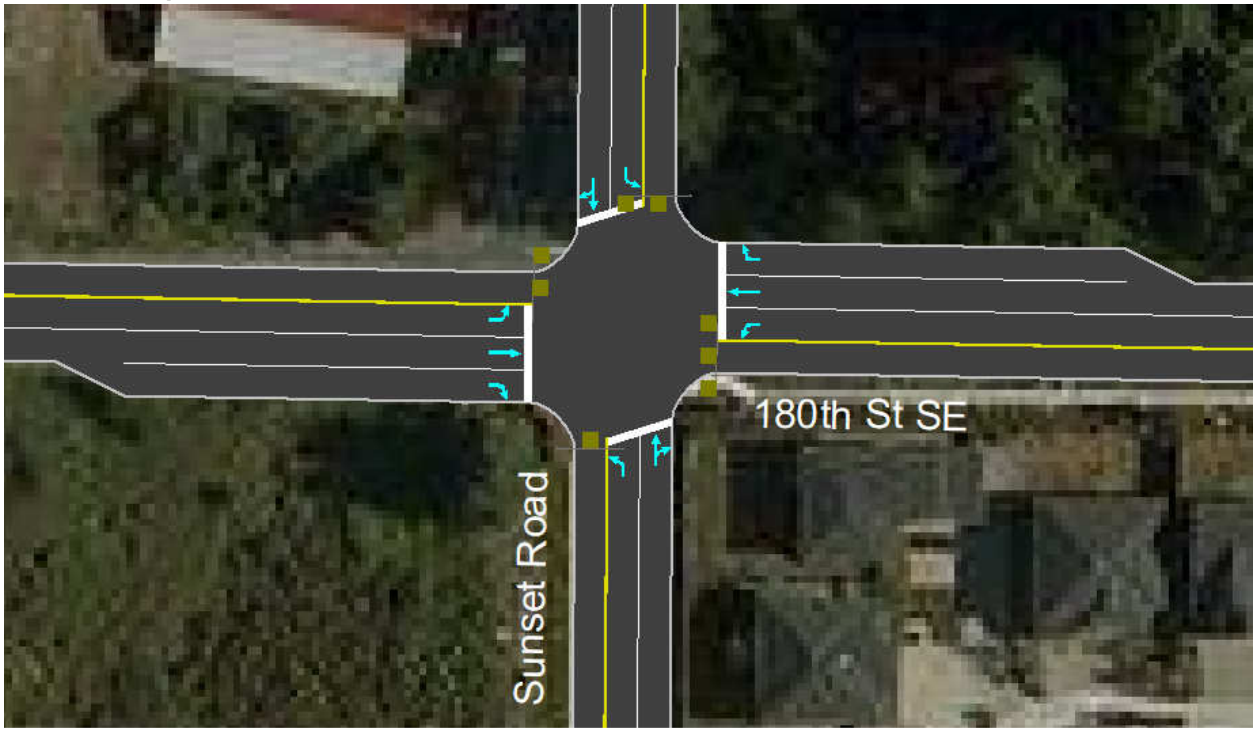
2025 Volumes




180th Street SE
184th Street SE
43rd Avenue SE
196th Street SE
SR 524
80
100
60
215
415
95
155
445
65
145
215
140
25
165
5
135
100
5
5
30
5
55
265
55
20
145
10
15
15
385
105
60
180
400
220
695
35
20
570
5
785
2025 PM Peak Hour

2045 Scenario 1 Intersection Geometry

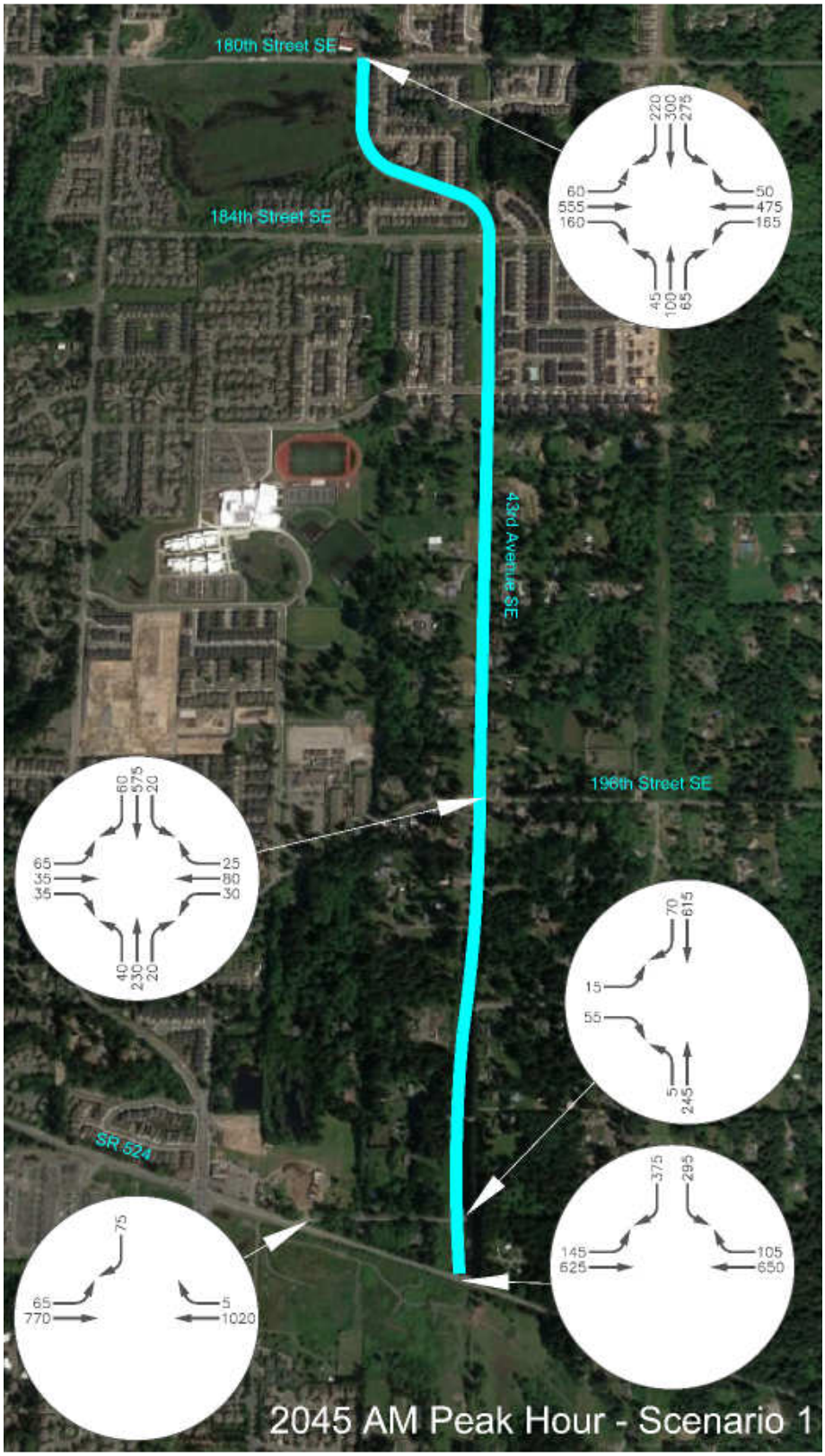
Sunset Road / 180th Street SE

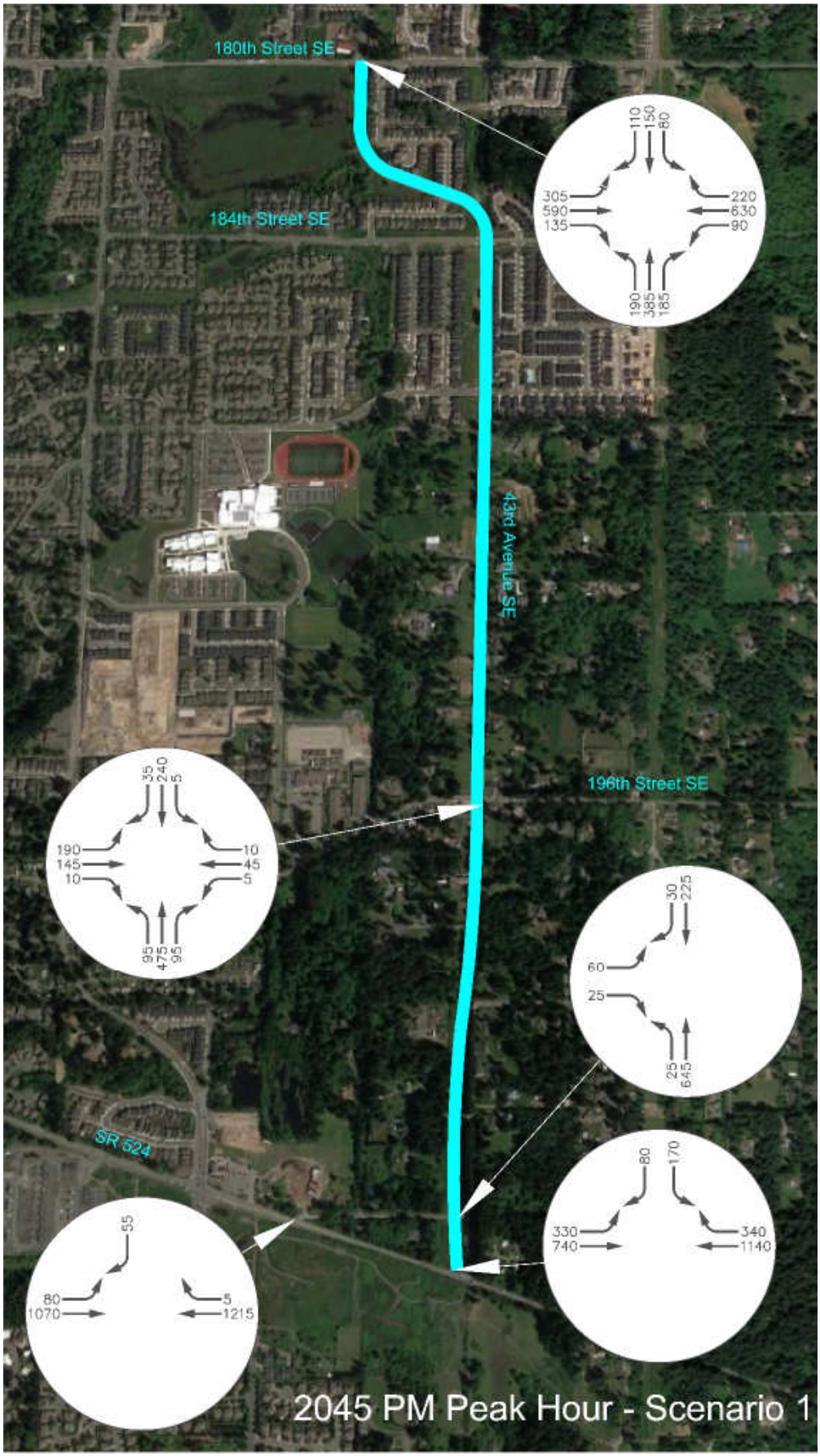


43rd Avenue SE / 196th Street SE

43rd Avenue SE / SR 524

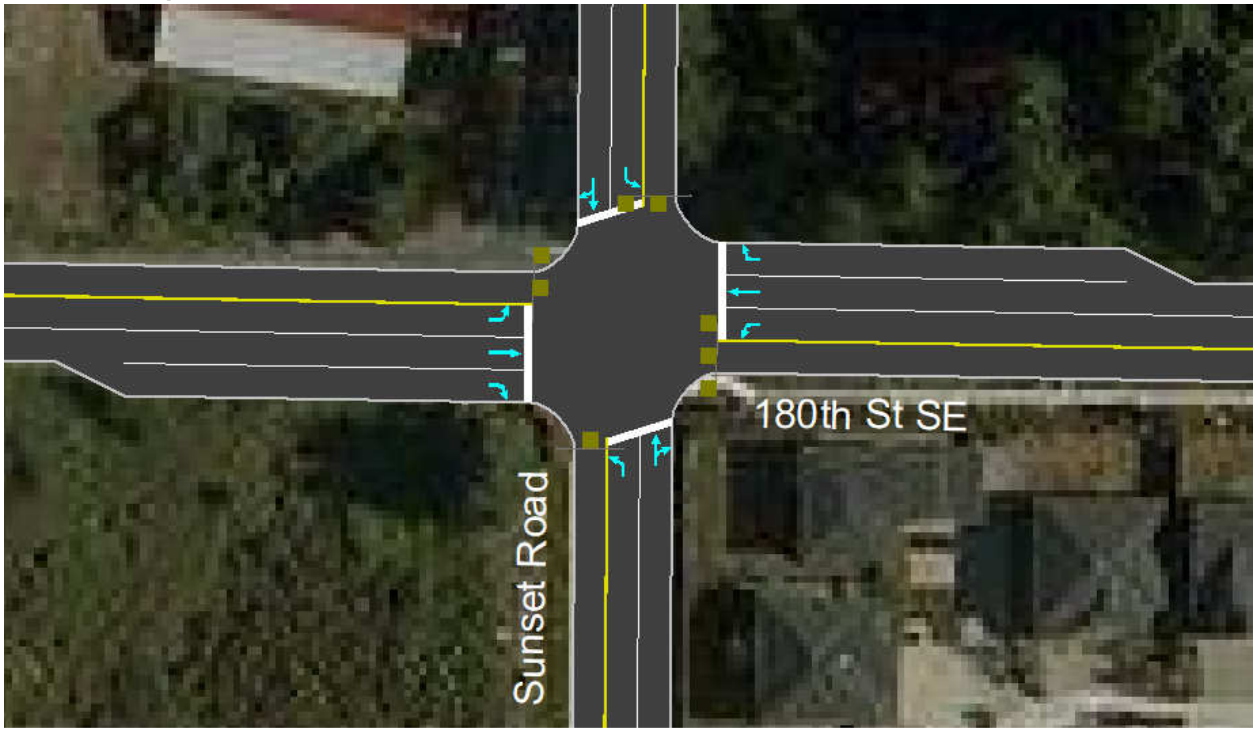
2045 Scenario 1 Volumes




180th Street SE
184th Street SE
43rd Avenue SE
196th Street SE
SR 524
110
150
80
305
590
135
220
630
90
190
385
185
35
240
5
190
145
10
10
45
5
95
475
95
30
225
60
25
25
645
80
170
330
740
340
1140
55
80
1070
5
1215
2045 PM Peak Hour - Scenario 1

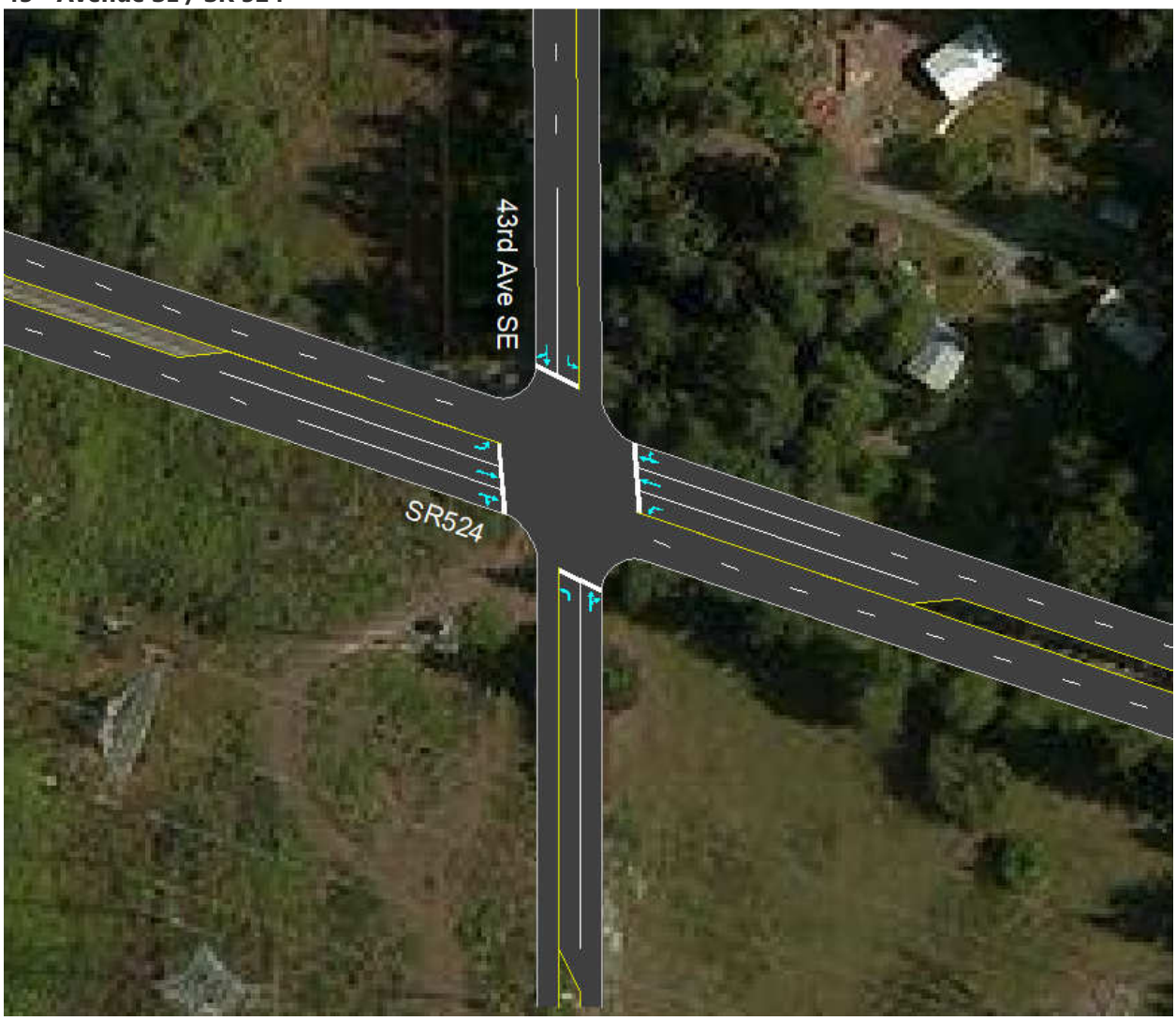
2045 Scenario 2 Intersection Geometry

Sunset Road / 180th Street SE

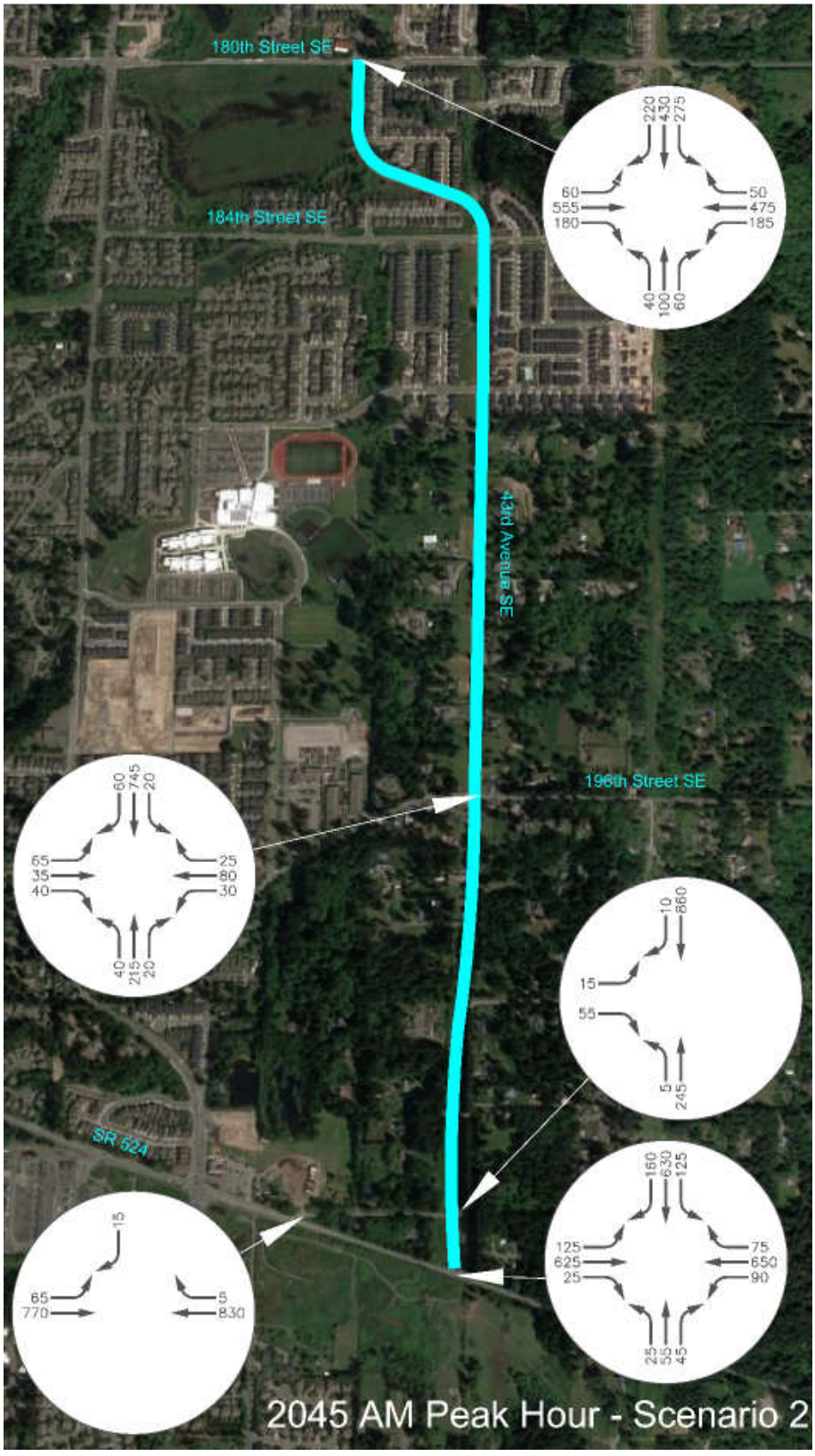


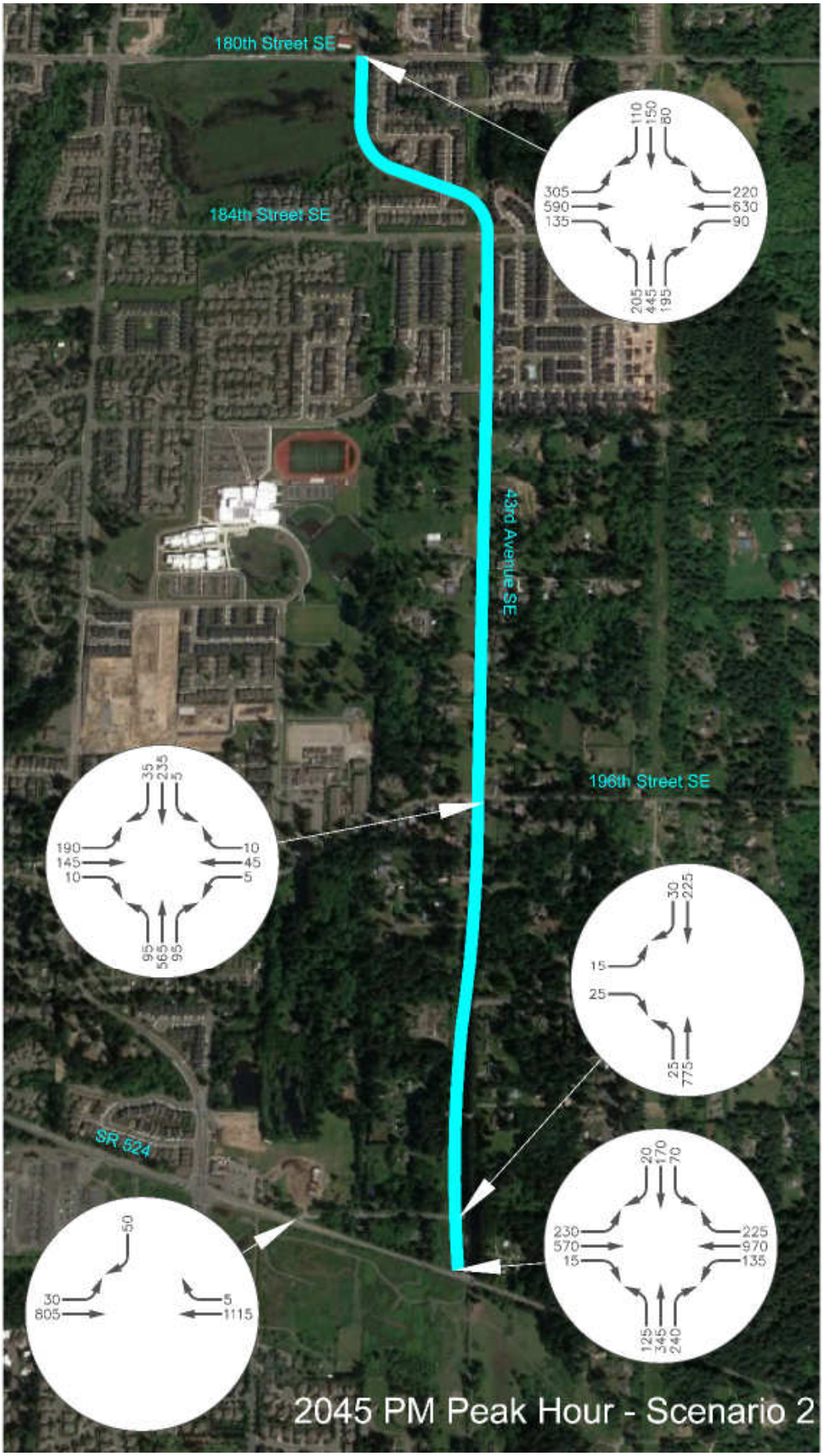
43rd Avenue SE / 196th Street SE

43rd Avenue SE / SR 524



2045 Scenario 2 Volumes




180th Street SE
184th Street SE
43rd Avenue SE
196th Street SE
SR 524
110
150
80
305
590
135
220
630
90
205
445
195
35
235
5
190
145
10
10
45
5
95
565
95
30
225
15
25
25
775
20
170
70
230
570
15
225
970
135
125
345
240
50
30
805
5
1115
2045 PM Peak Hour - Scenario 2

Sunset Road/ 180th Street SE Intersection Geometry with Additional Turn Pockets

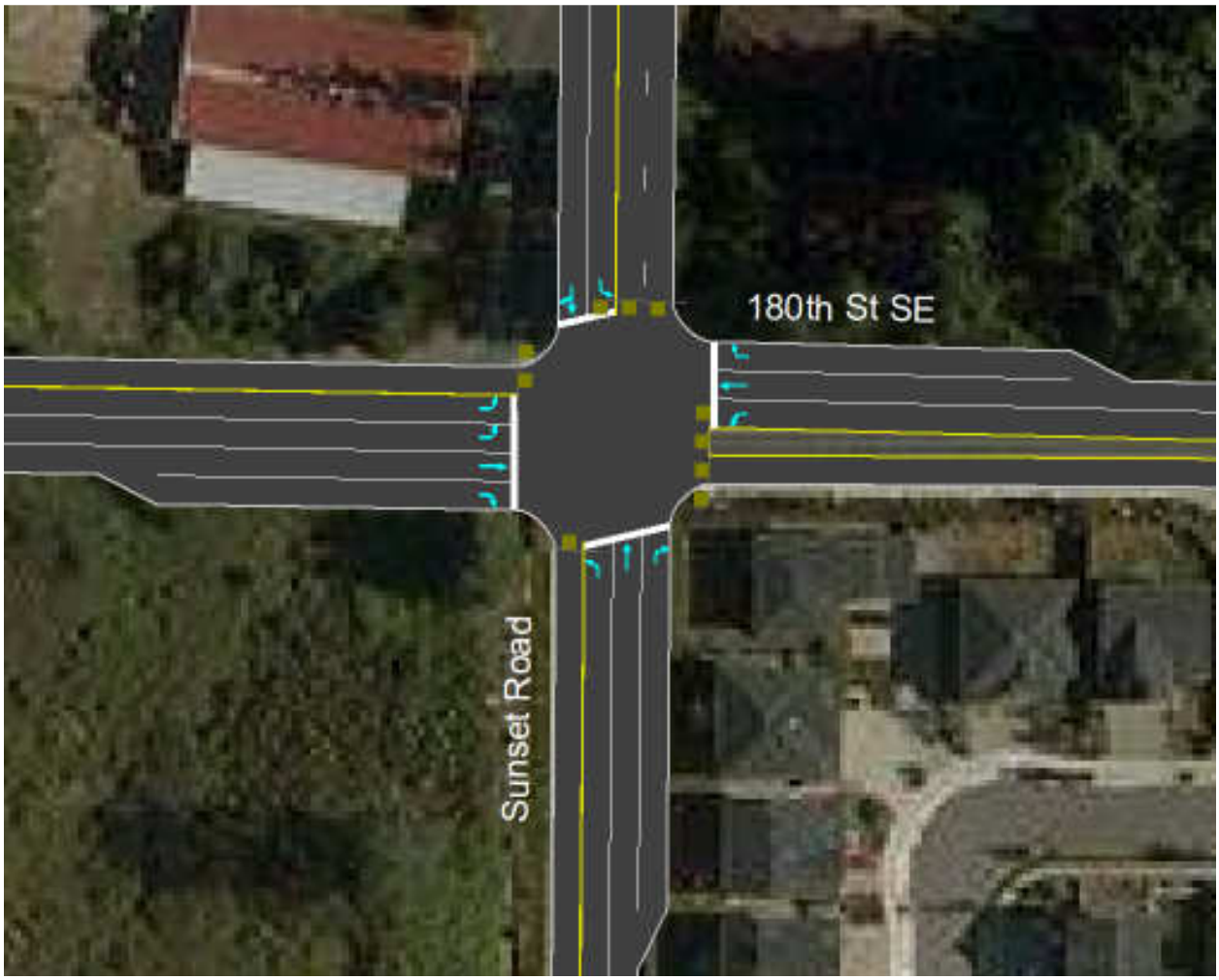


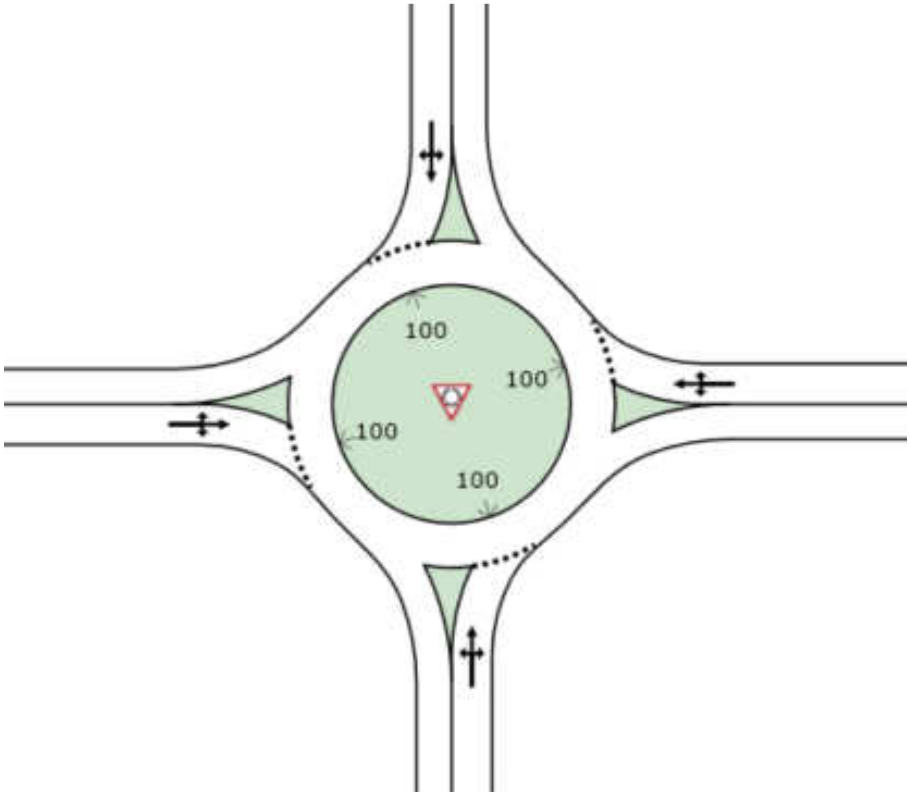
Table 5: 2045 Delay (seconds) by Approach and Intersection LOS;
Sunset Road/ 180th Street SE Additional Turn Pockets

2045 Scenario 1							
		EB	WB	NB	SB	Overall	LOS
AM Peak Hour	Sunset Rd/180th St SE	18	23	22	23	21	C
PM Peak Hour	Sunset Rd/180th St SE	18	36	24	34	27	C
2045 Scenario 2							
		EB	WB	NB	SB	Overall	LOS
AM Peak Hour	Sunset Rd/180th St SE	42	22	29	42	35	D
PM Peak Hour	Sunset Rd/180th St SE	18	36	26	35	27	C

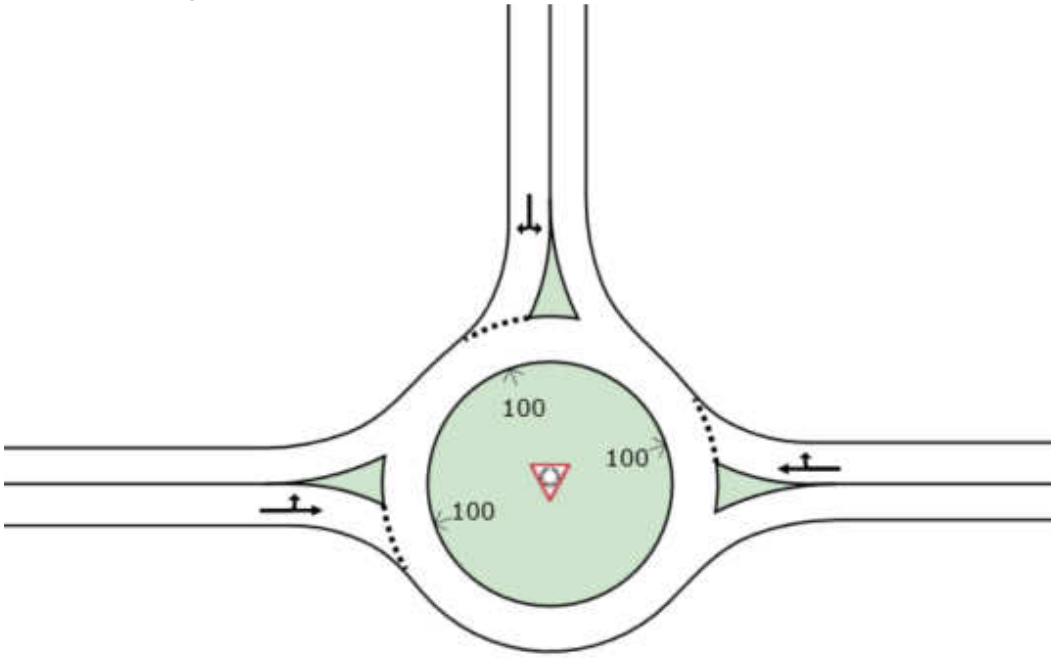
Source: Fehr & Peers, 2018

Recommended Lane Layout for Single Lane Roundabout

Sunset Road / 180th Street SE

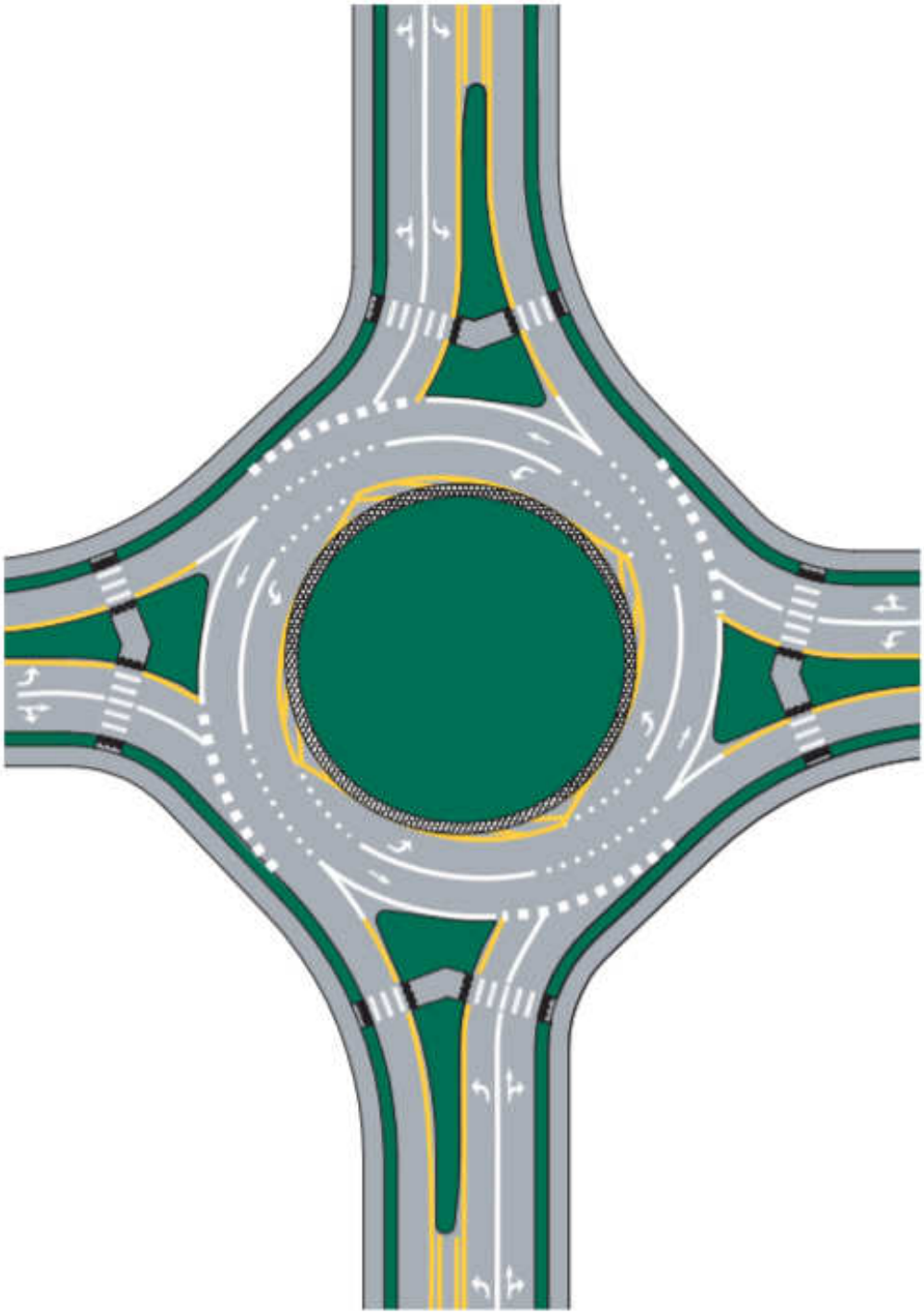


43rd Avenue SE/ SR 524



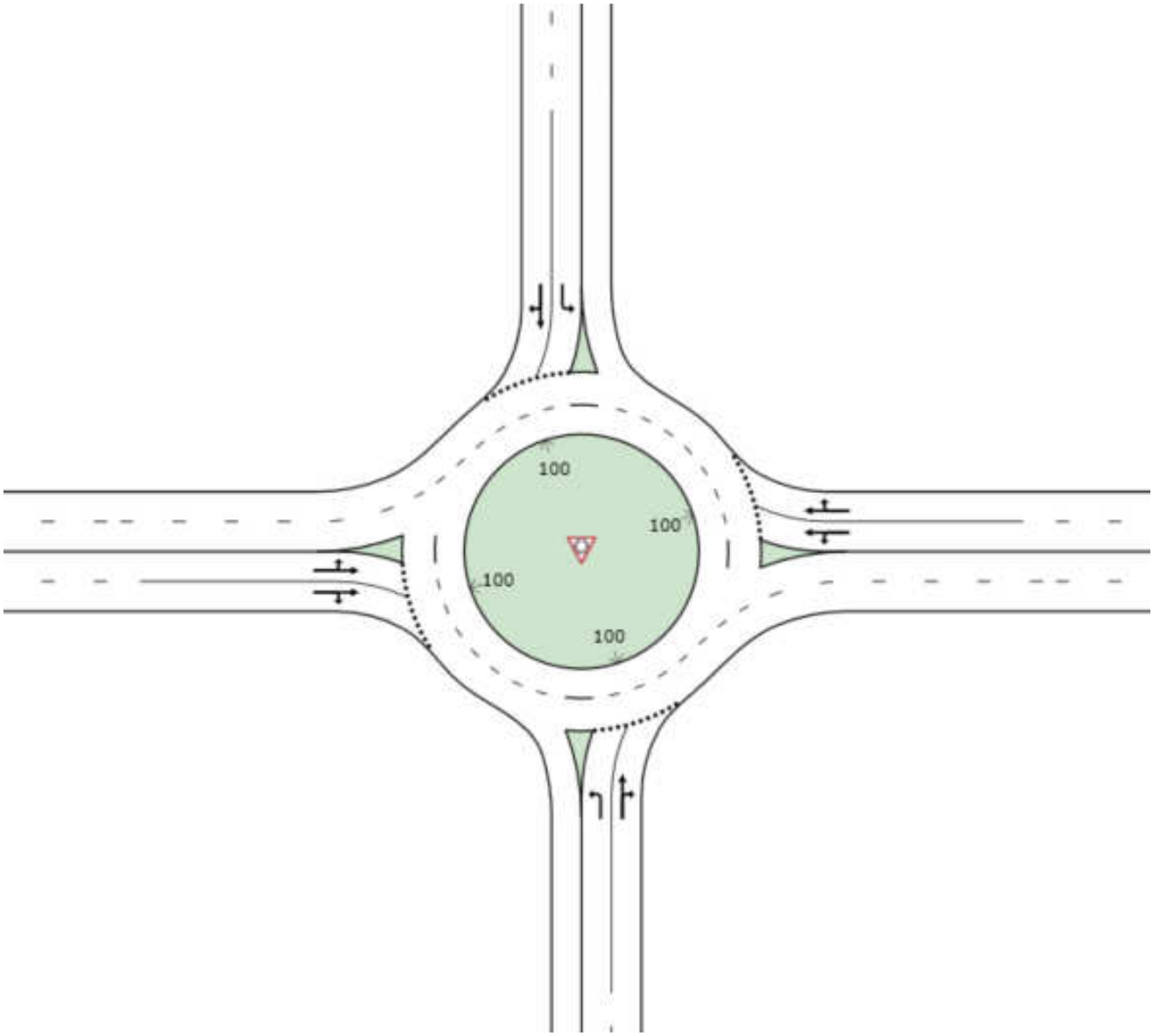
Recommended Lane Layout for Two-Lane Roundabout

Sunset Road / 180th Street SE



Graphic Source: FHWA Roundabouts, an information guide (2010).

43rd Avenue SE/ SR 524



APPENDIX F

Preliminary Geotechnical Memorandum

SNOHOMISH COUNTY
Public Works

MEMORANDUM

DATE: **May 31, 2018**

TO: **Michael Randall, P.E., Project Manager**

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

SUBJECT: **Preliminary Geotechnical Memorandum**
43rd Avenue SE/Sunset Road: 180th Street SE to SR524
RC 1592

General

We understand that this project includes the widening and improvement of 43rd Avenue SE from SR524 to north of 180th Street SE. A 2-lane rural roadway design section will be utilized for the section from SR524 to 188th Street SE. This section includes a new public road connection (approximately 1400 feet) between 200th Street SE and 196th Street SE. North of 188th Street SE, an urban roadway design section will be used. This section will include a connection between 188th Street SE and Sunset Road and improvements to the intersection of 180th Street SE and Sunset Road. In addition, the existing concrete sidewalks between 188th Street SE and Jewell Road/196th Street SE are to be replaced with rural pedestrian facilities. The purpose of this memorandum is to provide preliminary supporting geologic, hydrogeologic, and potential geologic hazards information to be utilized during the preparation of the design report, initial permit applications and preliminary design preparations. A *"Geotechnical Memorandum"* will be completed as the project design progresses to the 30% level.

For reference purposes a ***Vicinity Map*** is included at the end of this memorandum showing the approximate location of the project site relative to existing municipal improvements.

The purpose of this investigation was to evaluate and expand upon existing soil and geologic information in the project area and provide geologic assessment and geotechnical recommendations to be utilized during the permitting, design and construction phases of the project. Borings for this preliminary phase of exploration were spaced to help determine the overall geology along the proposed alignment, to provide preliminary subsurface soils information throughout the corridor and to provide preliminary design parameters to be used to develop the project towards the 30% design level. The scope of our work included: a review of readily available geologic reports and maps relevant to the project site; a review of readily available geologic and geotechnical reports from other projects located in the general vicinity of the project site; a geologic reconnaissance of the project site and surrounding area; a geologic investigation of the project site including the excavation of 9 borings (B-01 thru B-09). This investigation has been completed in general accordance with professional geologic and geotechnical standards currently utilized in the Puget Sound Region for a project of this scope and size. The conclusions and recommendations contained in this report are based upon our understanding of the project at the time this report was written. If changes are made to the project after this date, the recommendations may need to be updated

Geologic Setting

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

and has been filled to the present-day land surface with Pleistocene aged glacial and non-glacial sediments.

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

Surficial Geology of the project area has been mapped by the ***USGS*** and is shown on the ***Geologic Map of the Bothell 7.5-minute Quadrangle, King and Snohomish Counties, Washington*** by Minard dated 1985, MF-1747. The portion of this ***Geologic Map*** including the project site is included at the end of this memorandum for reference purposes. In general, the engineering characteristics of the soils found within the project area reflect their depositional mode.

According to the ***Geologic Map***, mapped surficial geology in the immediate vicinity of the project site consists of Vashon Glacial Till (Q_{vt}), Vashon Advanced Outwash (Q_{va}), and Vashon Recessional Outwash (Q_{vr}). 43rd Ave SE generally north of 200th Street SE to the northern end of the new connection with Sunset Road is mapped as being underlain by Glacial Till (Q_{vt}). The soil underlying Sunset Road north of the proposed connection is mapped as being underlain by Advanced Outwash (Q_{va}). The soil underlying 43rd Ave SE south of 200th Ave SE is mapped as Recessional Outwash (Q_{vr}).

The mapped ***SCS*** soil classifications are all soils formed on till plains of varying slopes. Mapped units of Alderwood gravelly sandy loam (units 1 & 2) and Alderwood-Everett gravelly sandy loam (unit 4) are mapped along the 43rd Street SE alignment. Unit 1 is mapped with 2 to 8 percent slopes, unit 2 with 8 to 15 percent slopes, and unit 4 with 25 to 70 percent slopes.

Subsurface Conditions

The subsurface conditions at this site were explored with 9 borings *(B-01 thru B-05, B-06W, B-07 thru B-09).* The borings were advanced with a Mobile B-58 drill rig to a depth of 26.5' each. The soil removed from the ground at the exploration locations was visually observed at the time of excavation and classified by a Geotechnical Engineer from *SCPW-Engineering Services* following the ***Unified Soil Classification System*** *(USCS)* in general accordance with ***ASTM D2488***, Standard Recommended Practice for Description of Soil *(Visual-Manual Procedures)*. Standard Penetration Test samples of representative soils were taken for laboratory testing. The approximate location of the explorations was measured from existing features in the field and were plotted on the attached ***Soil Explorations Map***. Copies of the ***Boring Logs*** are attached to this memorandum.

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

The observed soil conditions presented on test boring logs are as interpreted and recorded at the time and placement of exploration. Subsurface soil conditions may vary considerably between exploration locations and with time according to the prevailing climate, rainfall or other factors

and are otherwise dependent on the duration of and methods used in the exploration program. Actual soil conditions encountered at the time of construction may vary from those found and presented in this report.

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

At the location of B-01 we encountered 0.5' of asphaltic concrete pavement overlying 2.5' of fill. The fill consisted of a brown, fine- to coarse-grained gravelly sand with a trace of silt. This fill was loose to medium dense and moist. Underlying this stratum of fill we encountered 4' of weathered glacial till overlying unweathered glacial till. The weathered till consisted of a reddish brown to gray, fine- to coarse-grained silty sand with a trace of gravel. Mottling was present within this layer. This layer was medium dense to dense and moist. The unweathered till consisted of a gray, fine- to coarse-grained silty sand with gravel and occasional mottling. This layer of soil is dense to very dense and moist to wet. This stratum extended to the bottom of the boring at 26.5'. Perched water was encountered at 15'.

At the location of B-02 we encountered 0.33' of grass and topsoil overlying unweathered glacial till. The unweathered glacial till was encountered to the bottom of the boring at 26.5'. The unweathered glacial till consisted of a gray, fine- to coarse-grained silty sand with gravel and occasional mottling. This glacial till stratum was medium dense to very dense. Increased gravel and perched water was encountered between 15'-16'.

At the location of B-03 we encountered 0.33' of grass and topsoil overlying fill. It appears that this fill was placed behind the gravity retaining wall that is located to the west of B-02. The fill consisted of a reddish brown to gray, fine- to coarse-grained silty sand with gravel. This layer of fill was loose to medium dense and damp. The fill layer extended to a depth of 10' below the existing ground surface (bgs). At 10' we encountered 0.5' of an old topsoil layer that consisted of a dark brown silty sand that was loose and damp. Underlying this buried topsoil layer we encountered unweathered glacial till to the bottom of the boring at 26.5'. This unweathered glacial till layer consisted of a gray, fine-grained silty sand to sandy silt with occasional mottling. This stratum was medium dense to very dense and moist to wet. A layer of perched water was encountered at 21'.

At the location of B-04 we encountered 1.0' of a brown, fine- to coarse-grained sandy gravel fill that was loose to medium dense and moist to damp. Underlying the fill we encountered unweathered glacial till. This till layer consisted of a gray, fine- to coarse-grained silty sand with gravel and occasional mottling. This stratum was medium dense to very dense and moist to wet. A zone of gravel and perched water was encountered from 24.5'-25.5'.

At the location of B-05 we encountered 0.17' of crushed rock at the surface. Under the crushed rock we encountered fill to a depth of 3.0'. This fill consisted of a brown, fine- to coarse-grained gravelly sand fill layer that contained a trace of silt and was loose to medium dense and wet. Underlying the fill and extending to the bottom of the boring at 26.5' we encountered unweathered glacial till. This glacial till stratum consisted of a gray, fine- to coarse-grained silty sand with gravel and some mottling within the upper 1' of the stratum. This layer was dense to very dense and moist to wet. A zone of gravel and perched water was encountered between 19.0'-23.5'.

At the location of B-06W we encountered 2.2' of crushed rock at the surface. Below the crushed rock we encountered weathered Advance Outwash to a depth of 8.0'. This weathered layer consisted of a reddish brown, fine- to coarse-grained sand that contained a trace of silt and was loose and moist. At 8.0' and extending to the bottom of the boring at 26.5' we encountered unweathered Advance Outwash that consisted of a gray, fine- to coarse-grained sand with fine-grained gravel and a trace of silt. This layer was dense to very dense and moist to wet. Perched water was encountered at 13.0' and 18.0'. The silt content of this material increased between 15.0'-16.0' and below 25.0'. A 2" diameter monitoring well and surface monument was installed at the location of this boring. The well was screened (#10 slotted screen) between 10.0'-20.0' below the ground surface.

At the location of B-07 we encountered 0.67' of crushed rock at the surface. Below the crushed rock we encountered fill to a depth of 4.0'. This fill consisted of a light brown, fine- to coarse-grained gravelly sand with a trace of silt. This layer was medium dense and moist. Underlying the fill and extending to the bottom of the boring at 26.5' we encountered unweathered Glacial Till. This material consisted of an olive gray to gray, fine- to coarse-grained silty sand with gravel. This stratum was very dense and moist. The stratum graded to a gravelly sand with silt at 25.0'. No groundwater was encountered at the time of drilling.

At the location of B-08 we encountered 0.5' of asphaltic concrete pavement. Below the pavement section we encountered fill to a depth of 3.0'. This fill material consisted of a brown, fine- to coarse-grained gravelly sand with a trace of silt. This fill layer was medium dense and moist. Underlying the fill we encountered unweathered Glacial Till to the bottom of the boring at 26.5'. This unweathered layer consisted of an olive gray to gray, fine- to coarse-grained silty sand with gravel up to 1" in diameter. This material was dense to very dense and moist. A zone of gravel and perched water was encountered from 15.0'-15.5'. A zone of sand and perched water was encountered between 20.0'-22.0'.

At the location of B-09 we encountered 0.17' of crushed rock. Below the crushed rock we encountered Recessional Outwash that consisted of a light brown to brown, fine- to coarse-grained, gravelly sand with a trace of silt. This layer of Recessional Outwash was medium dense to dense and moist. A coarse gravel layer was encountered at the contact with the underlying unweathered Glacial Till stratum. This Glacial Till layer consisted of a gray, fine- to coarse-grained silty sand that contained a trace of gravel. This stratum was very dense and moist. The boring was terminated at 26.5'. No groundwater was encountered at the time of drilling.

Laboratory Testing

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

Ground Water

The geohydrologic framework describes the boundaries and lithology of the geohydrologic units (*aquifers and confining beds*) of the area. Regional ground water studies have been undertaken for **Snohomish County** by **Sweet-Edwards/EMCON, Inc**. dated 1991; **Golder Associates** dated 1996 and the **USGS** dated 1997. Geohydrologic units within the County have been defined by these studies. In general, ground water throughout the County occurs in a few different aquifers that are in most areas separated from each other by confining beds. Depending upon topography and location, ground water occurs in both confined and unconfined conditions within the County's aquifers. The most extensive aquifers are found below the plateau areas of the County, others occur within and along the river valleys that bisect the plateaus. Unconsolidated geologic units permeable enough to transmit significant quantities of ground water throughout the County are Recent Alluvium (Q_{yal}), Recessional Outwash (Q_{vr}) and Advance Outwash (Q_{va}).

Confining beds are geologic units that are generally fine-grained and do not transmit significant quantities of water. Confining beds include Glacial Till (Q_{vt}), Transitional Beds (Q_{tb}) and Tertiary Bedrock (T_b) according to the 1997 **USGS** report. The geologic unit Glacial Till (Q_{vt}) is found in the vicinity of the project site as shown on the attached **Geologic Map**. The project site is located on the Intercity Plateau, a topographic feature that extends from Everett southward into King County. Below the Intercity Plateau, sands of the Advance Outwash (Q_{va}) are the thickest and most productive aquifer – extending from the northern edge of the plateau (*bounded by the Snohomish River*) southward through the project site to Lake Washington. Within the Intercity Plateau, the Advance Outwash (Q_{va}) aquifer supports surface water base flow through ground water discharge into three-(*3*) different drainage basins: Bear Creek, North Creek and Swamp Creek. The project site is located within both the North Creek and the Bear Creek basins. It appears that the alignment mostly south of approximately 185th Street SE drains to the east into the Bear Creek Basin. The portion of the alignment generally north of 185th Street SE appears to drain into the west into the North Creek basin. The purple line on the attached ***Geologic Hazards Map*** represents the approximate dividing line between the two drainage basins.

In the immediate vicinity of the project alignment, a regional ground water aquifer is present within the Advance Outwash (Q_{va}) sands and gravels, most likely being expressed in and along Tambar Creek, directly west of the project alignment. Where it is expressed at the surface to the west of the northern portion of project alignment, the Advance Outwash (Q_{va}) aquifer is unconfined. Recharge of the confined aquifer is indirect, primarily resulting from infiltration through the overlying low permeable Glacial Till (Q_{vt}) aquitard. Localized perched groundwater can be anticipated in the recessional sands that sit on top of the glacial till south of the intersection of 43rd Avenue SE and 200th Street SE and within pockets of sand and gravel within the glacial till.

A search of the registered water well logs in the Washington State ***Department of Ecology's*** data base indicates five-(*5*) registered water wells within the area of the proposed project alignment. Within these wells, water bearing soils were encountered at depths greater than 89 feet below the

ground surface. For reference purposes, copies of the ***Water Well Logs*** are attached to this memo.

According to *"The Ground-Water System and Ground-Water Quality in Western Snohomish County, Washington (Report #96-4312, 1997)"* report, the project alignment is located within a designated ***Critical Aquifer Recharge Area.*** Based on this map, the alignment is in an area that is considered to have a low (north of 200th Street SE and south of the new Sunset Road/43th Avenue SE connection) aquifer recharge sensitivity to moderate (south of 200th Street SE and north of Maltby Road) aquifer recharge sensitivity. These areas are mapped as either Recessional Outwash or Advanced Outwash sands.

There are no ***Wellhead Protection Areas (WHPA's)*** within an approximate one-(*1*) mile radius of the project alignment.

The project alignment is located within the margins of an ***Environmental Protection Agency*** designated ***Sole Source Aquifer (SSA) – the Cross Valley Sole Source Aquifer***. A ***SSA*** is an area where 50% or more of the drinking water supply is from a ground water aquifer and there is no economic alternate source for drinking water within the petition area. The purpose of the SSA designation is to protect the aquifer from potential contamination from land uses.

Per ***Snohomish County Code Section 30.62C.140 (1)*** *Hydrogeologic Report* – a Hydrogeologic Report is required for any activity or use requiring a project permit regulated under ***Snohomish County Code Part 300*** – *Standards and Requirements,* and proposed within a designated Sole Source Aquifer, Group A Wellhead Protection Area or Critical Aquifer Recharge Area with high or moderate groundwater sensitivity. Two of these conditions (a Critical Recharge Area within an area of moderate groundwater sensitivity and a designated Sole Source Aquifer) are present within the project area as discussed in the previous paragraphs. ***Therefore, a Hydrogeologic Report will be required for this project***. A Hydrogeologic Report will be prepared under separate cover.

As part of geotechnical/geologic work performed for this project, we installed an observation well at the location of boring *B-06W*. The well was screened between 10'-20'. The water level in this well will be monitored on a monthly basis prior to construction to help evaluate the groundwater system in the area of the proposed pond. The last reading on April 16, 2018 indicated that the groundwater was at 14.83'.

The scope of the project as proposed does not include any prohibited elements as defined in ***Snohomish County Code Section 30.62C.330*** *Prohibited Uses.*

Seismicity

The Puget Lowland is located within a seismically active region where the effects of large-magnitude subduction zone earthquakes can be felt and a history of moderate seismicity has been recorded. In the last 15 years several different fault systems have been identified throughout western Washington in Thurston, Pierce, King, Snohomish, Island and Skagit Counties that are the result of tectonic activity that has taken place between the late Pleistocene (*<1 million years*) to recent time periods (*Holocene, < 10,000 years*). Recent investigations by the ***USGS*** and others have postulated late Pleistocene to Holocene movements on the **Olympic Fault** (*Thurston County*), the ***Tacoma Fault*** (*Pierce County*) and the ***Seattle Fault*** (*King County*). Across Snohomish County, tectonic activity resulted in the ***Darrington-Devils Mountain Fault Zone*** (*DDMFZ*) and the ***Straight Creek Fault Zone*** (*SCFZ*) approximately 40 to 50 million years ago (*Eocene Period*) and more recently the ***Strawberry Point Fault,*** the ***Utsalady Point Fault, Cherry Creek Fault Zone,*** and the ***South Whidbey Island Fault Zone*** (*SWIFZ*). Offsets along some of these faults and fault zones are significant. Geologic and geophysical information concerning these faults and the other postulated fault-related lineations in the vicinity of Snohomish County and the project site are the subject of on-going studies and interpretation by the **USGS** and others at this time. Geologic and geophysical information concerning these faults and postulated fault related lineations in the vicinity of the project site are limited. On-going

investigations of these features have led to recent conclusions that portions of these faults are still active.

The project site is located within the projected landward extension of the ***South Whidbey Island Fault Zone*** (*SWIFZ*). Recent geologic investigations for the Brightwater Project have resulted in additional information and further interpretation of the ***South Whidbey Island Fault*** **Zone** (*SWIFZ*). The mainland extensions of the SWIFZ that were modeled and proposed during the Brightwater investigations are shown in red on the attached ***Geologic Hazards Map***.

The northwest-southeast trending SWIFZ consists of three-(*3*) subparallel faults or splays, estimated to be 4 to 7 miles across. Estimated slip rates along the various SWIFZ elements range between 0.2 and 0.6 mm/yr. according to *Table H-1, Pacific Northwest Fault Parameters by State* of the ***2008 Update for the United States National Seismic Map***. As shown on the attached ***Geologic Hazards Map***, the project alignment may be crossed just to the north of 196th Street SE/Jewell Road by a splay of the *SWIFZ*.

Several types of ground motion may be associated with earthquakes. Hazards such as seismically induced landslides, soil liquefaction and rupture due to earthquakes have been historically documented in various areas around the Puget Sound. Geologic information regarding the *SWIFZ* is limited but it is currently thought that the potential recurrence interval for larger design sized earthquakes ($M > +7.0$) on the *SWIFZ* is likely to be on the order of 1000 years – with the last design level earthquake occurring approximately 750 years ago. This is based on mapped soil deformations in the Snohomish River slough north of Everett and in tidal zones on the south side of Whidbey Island.

As indicated on the exploration logs for the project, the majority of the soils encountered and observed during the site investigations are glacial in origin (*Qvt*) and have been over-consolidated by thousands of feet of glacial ice. The high density of these glacially consolidated soils results in a very low susceptible to seismically induced landslides or soil liquefaction or soil rupture during a seismic event. ***Due to the very low potential for seismically induced hazards along the alignment, mitigation of these soils for seismically induced movements is not required according to current WSDOT Geotechnical Manual design guidelines. However, it would be preferable if no above or underground structures are planned within this general area of the mapped splay.***

Property Uses

Property along and adjacent to the project alignment consists of residential and rural residential, and utility corridors. Improvements within the proposed acquisition areas consist primarily of road shoulder, landscaped areas, fences and driveways. Public and private underground utilities servicing the adjacent residences may be found within the proposed acquisition areas as well. ***Environmental Risk Assessments*** (*RA*) will need to be performed for right-of-way acquisitions along the alignment. Once the Right-of-Way plan has been approved, copies of the title reports for the parcels that will need to be purchased should be sent to Kirk Bailey of the ***Geotech Group*** so that a *RA* can be perform for those parcels..

Geotechnical Recommendations

Proposed improvements includes the widening and improvement of 43rd Avenue SE from SR524 to north of 180th Street SE. A 2-lane rural roadway design section will be utilized for the section from SR524 to 188th Street SE. This section includes a new public road connection

(approximately 1400 feet) between 200th Street SE and 196th Street SE. North of 188th Street SE, an urban roadway design section will be used. This section will include a connection between 188th Street SE and Sunset Road and improvements to the intersection of 180th Street SE and Sunset Road. In addition, the existing concrete sidewalks between 188th Street SE and Jewell Road/196th Street SE are to be replaced with rural pedestrian facilities. At this time we understand that the only signal that is being proposed is one at the 180th Street SE and Sunset Road intersection. The only identified large retaining walls at this time will be located within the low area just to the south of 196th Street SE/Jewell. Other minor retaining walls (<10' in height) might be required as the design process progresses. These will be addressed as the project design progresses and it is determined where walls might be required. The geotechnical design elements that will be addressed within this memorandum are: *Site Work, Cuts & Excavations, Structural Fill, Storm Water Treatment, Porous Pavement Sidewalk, Retaining Walls, Pavement Section Recommendations, Signal Pole Foundations, Erosion Control, and Geologic Hazards.*

Site Work

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

Initial site preparation will include clearing and grubbing along portions of the alignment. Excavation and grading should be done in accordance with the appropriate recommendations contained in this report. Materials removed during these tasks will not be suitable for use elsewhere on site and will need to be disposed of as surplus materials in accordance with the specifications given above.

Site preparation should comply with applicable sections of **WSDOT Standard Specification section 2-06**, *Subgrade Preparation.* In areas to receive new embankment fill, surficial topsoil and loose fill should be removed from within the embankment/roadway prism. During our explorations we did not encountered any significant amounts of loose fill and/or topsoil. Within the existing pavement prism just standard subgrade preparation will be required. In areas were widening takes place we would anticipate 1'-3' of topsoil/loose fill will need to be stripped prior to placing the structural pavement section (see the attached boring logs for specific depths encountered). Topsoil and other organic rich soils removed during site preparation may be re-used in non-structural areas of the project with some amendment – as approved at the time of construction by the Construction Engineer or the **Geotech Group.**

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

If significant areas of saturated or otherwise unsuitable soil are encountered at design subgrade depths, the **Geotech Group** should be contacted to develop recommendations based upon the observed site conditions at the time of construction. To maintain cost effectiveness, over

excavation of unsuitable materials during site preparation should not exceed two-(*2*) ft. below surrounding subgrade elevations unless directed to do so by the Construction Engineer or a representative of the **Geotech Group**. If yielding or saturated soil exist at this depth, the **Geotech Group** should be contacted to develop suitable recommendations based upon the observed site conditions. These recommendations may include the use of a strong, durable geotextile over the yielding subgrade materials, the use of Railroad Ballast, over excavation to approved bearing soils or a combination of all of the above. The entire area should be brought up to grade using structural fill.

Cuts and Excavations

Small and large cuts and excavations will be required to complete this project according to the cross sections reviewed during the preparation of this report. All cuts and excavations should conform to **Washington Department of Labor and Industries**, *chapter 296-155 part N, Safety Standards for Construction Work*. Excavations and cuts above the water table along this alignment will stand in near vertical side walls/slopes of up to four-(*4*) feet in total depth/height for short periods of time if protected from weather and not effected by shallow ground water or surface water seepage. Extra care will need to be exercised by the contractor if seepage is encountered within a cut or excavation. Sloughing of sidewalls may occur where moderate to heavy ground water or surface water seepage are encountered or where fill is encountered within a cut or excavation area. All cuts and excavations over four-(*4*) feet in total depth/height should be retained by suitable designed retaining systems or digging boxes unless the side slopes are laid back to a minimum 1½:1 (*H:V*) slope. Temporary cuts and excavations are the contractors' responsibility. Permanently exposed side slopes should be laid back to slopes no steeper than 2:1(*H:V*) unless otherwise approved by the **Geotechnical Group**.

Structural Fill

Structural fill should be used in any area requiring fill within the roadway and sidewalk areas. Structural fill should consist of a well-graded, free-draining, granular soil free of organic and deleterious materials. The material for gravel borrow spelled out in **WSDOT Standard Specification section 9-03.14(1)**, *Gravel Borrow*, will meet the requirements for structural fill on this project except the fines portion of the gradations should not exceed 5% passing the #200 sieve.

In general, most of the on-site materials will not meet the above specification for Structural Fill and should only be substituted for structural fill if so approved by the ***Geotech Group*** at the time of construction.

All structural fill should be placed in accordance with **WSDOT Standard Specification section 2-03.3(14)B**, *Earth Embankment Construction* and be compacted in accordance with **WSDOT Standard Specification section 2-03.3(14)C – method C**, *Compacting Earth Embankments* using a minimum 10 ton vibratory roller or other as approved by the Construction Engineer or the **Geotech Group**. Testing of all fill as it is being placed should be performed in accordance with **WSDOT Standard Specification section 2-03.3(14)D**, *Compaction and Moisture Control Tests* using the **ASTM D1557** *modified proctor*. Fills planned for sloping areas greater than 5:1 (H:V) should be constructed only on properly benched and keyed soil, as specified in **WSDOT Standard Specification section 2-03.3(14)B**, *Embankment Construction*. Exposed fill slopes less than eight-(*8*) feet in height should be graded to a maximum 2:1(*H:V*) slope. Exposed fill slopes over eight-(*8*) feet in height should be graded to a maximum 2.5:1(*H:V*) slope.

The contractor should control surface and subsurface seepage during the placement of any site improvements and during the placement of all structural fill. Where this is not possible, the

contractor should use a granular material that does not require compaction in accordance with **WSDOT Standard Specification section 2-03.3(14)G**, *Backfilling* until the embankment has been constructed a minimum of six-(*6*) inches above the prevailing ground water table. A geotextile for soil stabilization should be placed at the bottom of any fill placed under these conditions and/or between the granular materials and the structural fill if a change in fill materials is made within the roadway embankment. Material used as outlined above should meet the minimum material specifications for Railroad Ballast given in *Table 1* below. Railroad Ballast used within the embankment section should be placed in accordance with **WSDOT Standard Specification section 2-03.3(14)A**, *Rock Embankment Construction*. Due to the sensitivity of some of the underlying soils, thin lifts of Railroad Ballast should be compacted to a non-yielding state by the rolling of construction equipment if vibration will cause pumping of the basal soil.

TABLE 1
Railroad Ballast Material Specification

Sieve Size	***Percent Passing by Weight (%)***
2-1/2	90 to 100
1-1/2	50 to 90
¾ inch	10 to 50
½ inch	0 to 10

Storm Water Treatment

Typically storm water is collected in one of the following ways:

- *Collection through a closed storm drainage system*
- *Collection into underground detention vaults*
- *Collection into retention/detention ponds*
- *Infiltrated utilizing porous concrete sidewalks*

We anticipate that storm water drainage for this project will be addressed during the Design Report phase of this project. We will address specific drainage issues as the project progresses. In order to provide proper mitigation, we will work with the project's drainage design engineer to ensure that project improvements will significantly improve drainage treatment and controls over existing conditions through collecting and treating storm water within improved areas along the alignment before it is released.

Porous Pavement Sidewalks

Porous pavements may be considered for sidewalks along this alignment. If porous sidewalks are utilized, they should be designed utilizing a design hydraulic conductivity *(K_{sd})* of 0.25 in/hr. We recommend utilizing as a minimum, 0.35' thickness of porous cement sidewalk placed over a minimum thickness of 0.25' of CSBC. The entire section should be placed over a recharge/reservoir bed consisting of a minimum thickness of 1.0' of free draining fill materials meeting **WSDOT Standard Specification section 9-03.12(4)**, *Gravel Backfill for Drains* wrapped on three sides with a construction geotextile meeting the requirements of **WSDOT Standard Specification section 9-33.2(1)**, *Geotextile Properties,* Table 1 for Moderate

Survivability, nonwoven. It is important that the existing subgrade materials under the pavement section not be compacted to ensure that the value of K_{sd} used is valid.

Cation-Exchange Capacity (CEC) for the glacial till soils will range between 5-10 millequivalents/$100g^{-1}$.

Retaining Walls

In order to fit the proposed site improvements within the constraints of the project site, fill and cut walls may be required. Based on the profile of the sidewalk at the time of this memorandum it is anticipated that required retaining walls along the alignment will be less than 10 feet in height. We understand that the location, length and height of the retaining walls may change as the design process proceeds. The retaining wall recommendations are meant to be used as a guideline for the project design, plan and specification development. Final design and use of retaining walls should be confirmed and approved by the ***Geotech Group*** prior to the start of construction. Retaining wall recommendations take into account soil types and conditions encountered at the location of the 9 borings advanced for this preliminary memorandum at the proposed wall locations as well as whether or not the wall will retain fill or protect undisturbed in-place soils. Specific design recommendations will be provided once the wall locations and heights have been determined.

Site Classification and Seismic Design Parameters

Seismic site class is used to estimate ground motion at a site during a design earthquake and dictates the level of design effort with respect to seismic design. We understand that the seismic design of the proposed improvements will be in accordance with the 2014 American Association of State Highway and Transportation Officials (AASHTO) LRFD Bridge Design Specifications (AASHTO 2014). The seismic design parameters presented below in Table 2 were obtained

from USGS seismic design maps of the AASHTO 975-year (7 percent in 75-year exceedance probability) design earthquake and site class D.

TABLE 2
Seismic Design Parameters

Site Class	PGA (g)	S_s (g)	S_1 (g)	F_a	F_v	F_{PGA}
D	0.522	1.337	0.522	1.000	1.500	1.100

F_a, F_v = acceleration (0.2-second period) and velocity (1.0-second period) site coefficients, respectively.
F_{PGA} = peak ground acceleration coefficient.
PGA = peak ground acceleration.
S_s, S_1 = 0.2-second and 1.0-second period spectral accelerations, respectively

Pavements

A pavement design was performed for this project in accordance with ***AASHTO*** design guidelines, and based on our review of current traffic counts, project growth rate and the soils present at the location of the site. Based on our design we recommend that the pavement section consist of the following:

0.65' HMA
0.5' CSBC/CSTC

Existing asphalt surfaces left in-place should be overlaid with a minimum of ***0.15' HMA***

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

Signal Pole Foundations

We understand that the only signal being proposed at this time is located at the intersection of 180th Street SE and Sunset Road. Once the location and length of the mast arms is determine we can address the specific foundation design. Based on the soils encountered, a typical signal pole foundation will need to extend to a depth somewhere between 12 to 14 feet below the finished ground elevation. This assumes a 3 foot diameter round shaft for the signal pole foundation.

Erosion Control

Adequate erosion control measures should be installed during earthwork on this project to ensure limited siltation impacts into the adjacent surface water drainages and drainage systems. **Best Management Practices**, as outlined in the Washington Department of Ecology's Storm Water

Management Manual for the Puget Sound Basin should be applied. Erosion control measures should also comply with **WSDOT Standard Specification section 8-01**, *Erosion Control.* In addition, drainage ways should be protected from siltation by filter fences, straw bale filters or settling ponds. Run-off should not be allowed to flow uncontrolled over site slopes or embankments. Permanent erosion control should be installed as soon as possible after completion of work in an area. Hydro seeding and placement of Excelsior matting or straw should be performed in accordance with methods described in the standard specification.

Geologic Hazard Areas

There are no landslide hazard areas, mine hazard areas, tsunami hazard areas, volcanic hazard areas or erosion hazard areas found or identified within 200 feet of the project alignment during the course of this investigation. As stated earlier, a splay of the South Whidbey fault crosses the alignment somewhere north of 196th Street SE/Jewell Road

There are no ***Wellhead Protection Areas (WHPA)*** within an approximate one-(*1*) mile radius of the project alignment. The project alignment is located within the margins of an ***Environmental Protection Agency*** designated ***Sole Source Aquifer (SSA)*** –Additionally the area underneath the project alignment is classified as a Critical Recharge Area having a Aquifer Sensitivity of medium or higher.

Per ***Snohomish County Code Section 30.62C.140 (1)*** *Hydrogeologic Report* – a Hydrogeologic Report is required for any activity or use requiring a project permit regulated under ***Snohomish County Code Part 300*** – *Standards and Requirements,* and proposed within a designated Sole Source Aquifer, Group A Wellhead Protection Area or Critical Aquifer Recharge Area with high

or moderate groundwater sensitivity. Two of these conditions exist along the proposed alignment. ***Therefore, a Hydrogeologic Report will be required for this project.***

The scope of the project as proposed does not include any prohibited elements as defined in ***Snohomish County Code Section 30.62C.330*** *Prohibited Uses.*

A ***Geologic Hazards Map*** is attached to this memorandum.

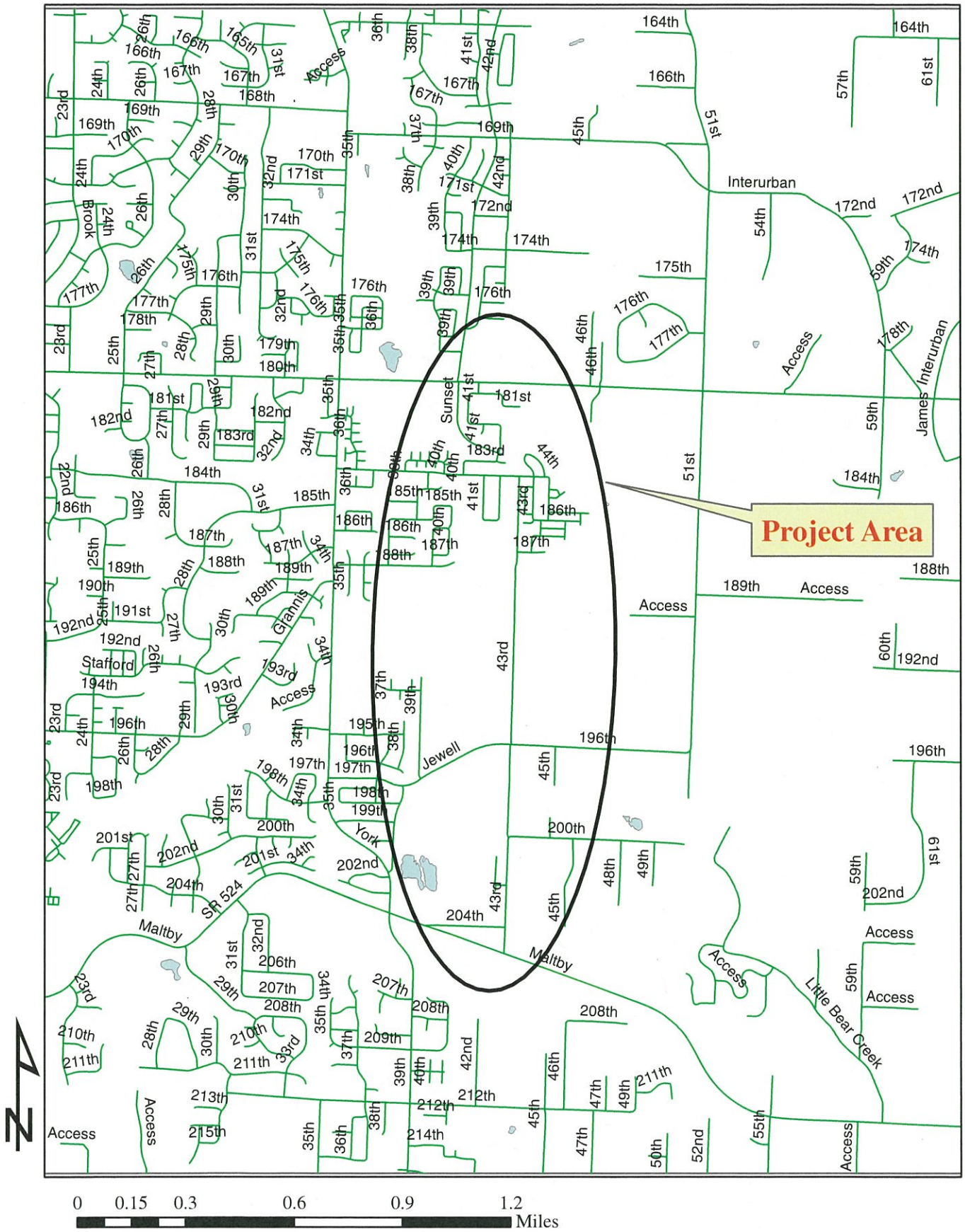
If you have questions or need more information, please call Rollie at 425-530-8179.

Attachments: Vicinity Map, Geologic Map, Soil Explorations Map, Boring Logs, Laboratory Test Results, Geologic Hazards Map, Well Logs

VICINITY MAP

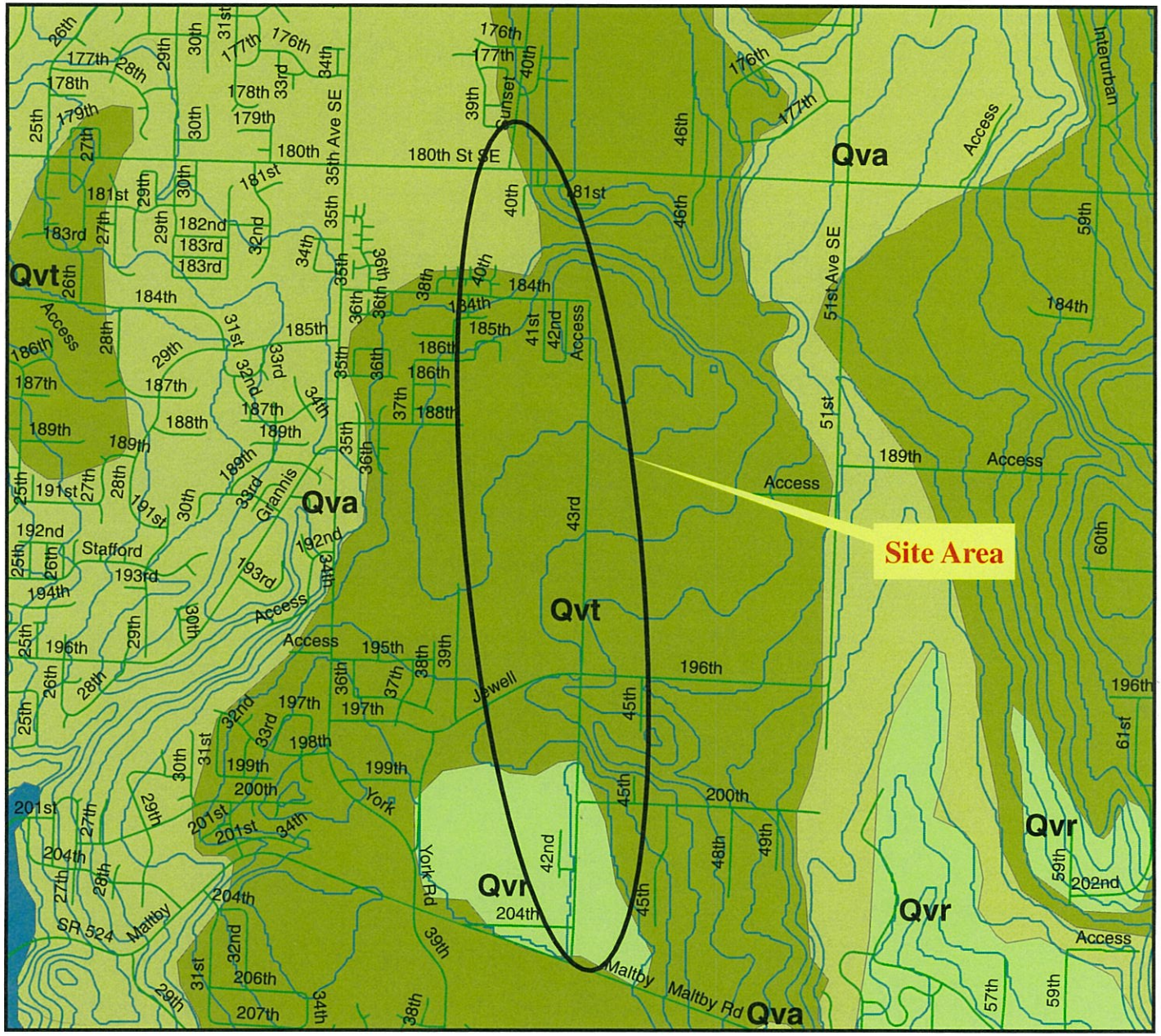
43rd Avenue SE
RC 1592

Snohomish County



GEOLOGIC MAP
43rd Avenue SE
RC 1592

Snohomish County



Legend

ice	
Fill	Manmade deposit
Lahars	Volcanic Mudflow
Qal	Alluvium
Qgd	Glacial drift, undivided
Qmw	Mass wasting deposit
Qp	Peat
Qva	Vashon Advance Outwash
Qvr	Vashon Recessioinal Outwash
Qvrl	Vashon Recessional Lacustrine
Qvt	Vashon Till
Qvtm	Vashon Till - Marine
Qpf	Pre-Fraser deposits
Qpfg	Pre Fraser - glacial
Qtb	Pre-Fraser Transitional beds
Ti	Tertiary Intrusive
Ts	Tertiary Sandstone
Tv	Tertiary Volcanic
Ptm	Pre-Teriary bedrock
water	

THE PRELIMINARY ROAD LAYOUT DRAWN BASED ON SCOPING LEVEL INFORMATION IS INTERNED TO SERVE AS A GUIDELINE FOR DETERMINING THE LOCATION OF SOIL EXPLORATION.

RW, PROPERTY LINES, AND SURFACE FEATURES ARE FROM GIS DATA AND ONLY APPROXIMATELY REPRESENT ACTUAL CONDITIONS. GROUND IMAGE FROM SNOHOMISH COUNTY 2015 SID IMAGES.

⊗ BORE-HOLE LOCATION

PROPOSED SHARED USE PATH

PROPOSED SIDEWALK

N

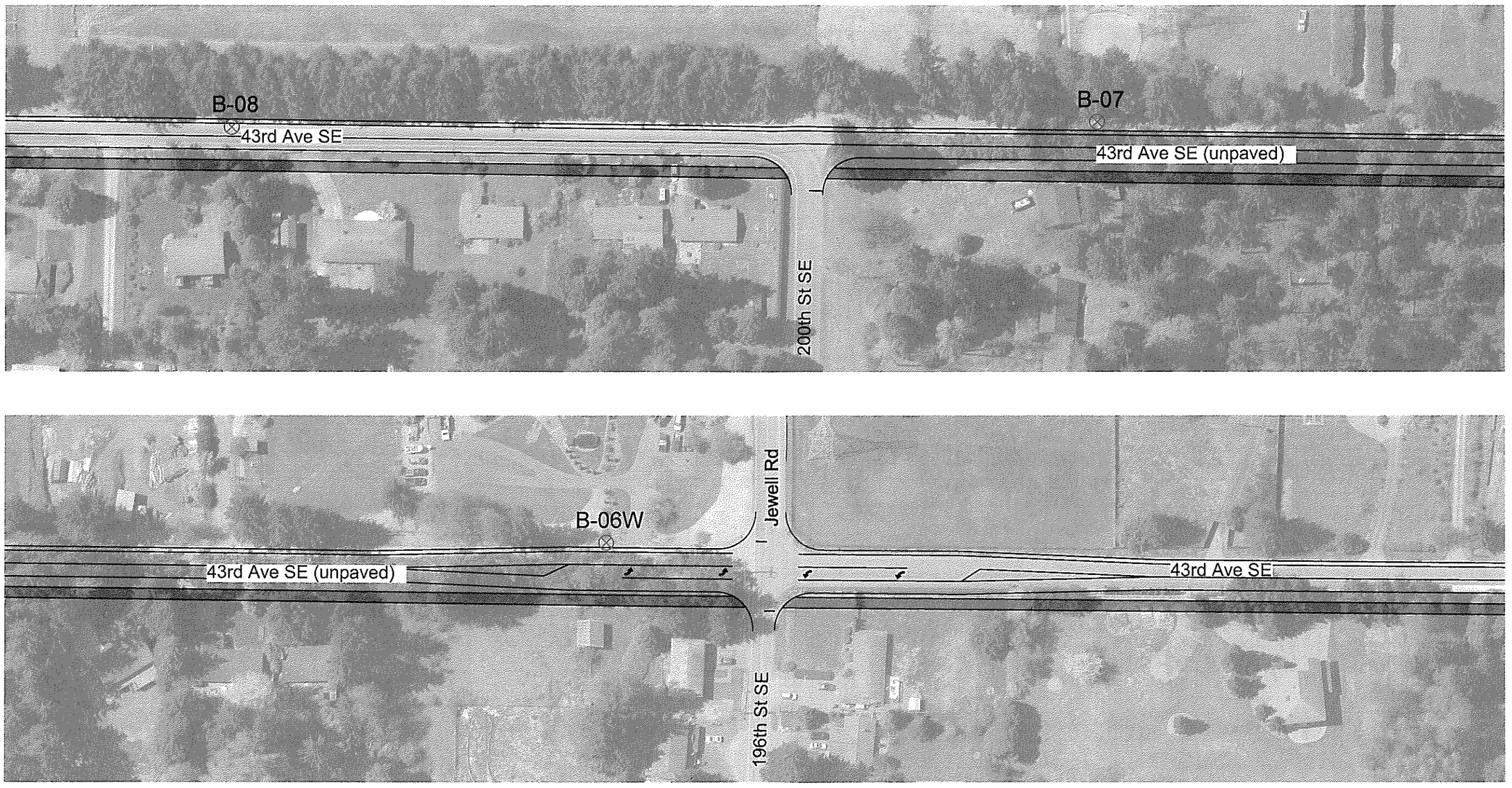
43RD AVE SE/SUNSET RD

SR524 to 180th St SE RC1592

SOIL EXPLORATION MAP
1 of 5

50 0 50 100
SCALE IN FEET

Snohomish County
Public Works



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⊗ BORE-HOLE LOCATION

PROPOSED SHARED USE PATH

PROPOSED SIDEWALK

43RD AVE SE/SUNSET RD

SR524 to 180th St SE RC1592

SOIL EXPLORATION MAP
2 of 5

50 0 50 100
SCALE IN FEET

Snohomish County
Public Works

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⊗ BORE-HOLE LOCATION

PROPOSED SHARED USE PATH

PROPOSED SIDEWALK

43RD AVE SE/SUNSET RD

SR524 to 180th St SE RC1592

SOIL EXPLORATION MAP
3 of 5

50 0 50 100
SCALE IN FEET

Snohomish County
Public Works

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⊗ BORE-HOLE LOCATION

PROPOSED SHARED USE PATH

PROPOSED SIDEWALK

N

43RD AVE SE/SUNSET RD

SR524 to 180th St SE RC1592

SOIL EXPLORATION MAP
4 of 5

50 0 50 100
SCALE IN FEET

Snohomish County
Public Works

THE PRELIMINARY ROAD LAYOUT DRAWN BASED ON SCOPING LEVEL INFORMATION IS INTERNED TO SERVE AS A GUIDELINE FOR DETERMINING THE LOCATION OF SOIL EXPLORATION.

RW, PROPERTY LINES, AND SURFACE FEATURES ARE FROM GIS DATA AND ONLY APPROXIMATELY REPRESENT ACTUAL CONDITIONS. GROUND IMAGE FROM SNOHOMISH COUNTY 2015 SID IMAGES.

⊗ BORE-HOLE LOCATION

PROPOSED SHARED USE PATH

PROPOSED SIDEWALK

N

43RD AVE SE/SUNSET RD

SR524 to 180th St SE RC1592

SOIL EXPLORATION MAP
5 of 5

50 0 50 100
SCALE IN FEET

Snohomish County
Public Works

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-01**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592**	AUGER TYPE:	**4" HSA**
STATION:		FLUID:	**none**
GEO./ENGR.:	**rmaynard**	TOTAL DEPTH:	**26.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	NOTES
					0.0'-0.5' **Asphaltic Concrete Pavement**	
					0.5'-3.0' **Gravelly Sand:** Brown, fine- to coarse-grained, trace silt, loose to medium dense, moist *(sp, fill)*	
X	S1	3/4/17				
X	S2	12/14/20		5	3.0'-7.0' **Silty Sand:** Reddish brown to gray, fine- to coarse-grained, trace gravel. occassional mottling, medium dense to dense, moist *(sm, Weathered Glacial Till)*	
X	S3	10/17/34			7.0'-26.5' **Silty Sand:** Gray, fine- to coarse-grained, with gravel, occassional mottling, dense to very dense, moist to wet *(sm, Glacial Till)*	
X	S4	16/20/20		10		
X	S5	50-5"		15	Perched water at 15'	
X	S6	50-6"		20		
X	S7	50-5"		25		
					T.D. = 26.5'	

NOTES: **Lat.: 47.836613 Long.: -122.177384**

Snohomish County Public Works

TEST BORING LOG B-01

PAGE 1 OF 1

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-02**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592**	AUGER TYPE:	**4" HSA**
STATION:		FLUID:	**none**
GEO./ENGR.:	**rmaynard**	TOTAL DEPTH:	**26.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	NOTES
					0.0'-0.33' **Grass and Topsoil**	
					0.33'-26.5' **Silty Sand:** Gray, fine- to coarse-grained, with gravel, occassional mottling, medium dense to very dense, moist to wet *(sm, Glacial Till)*	
X	S1	8/13/15		5		
X	S2	20/26/23		10		
X	S3	10/30/50-5"		15	Increased gravel and perched water from 15'-16'	
X	S4	35/50-3"		20		
X	S5	45/50-3"		25		
					T.D. = 26.5'	

NOTES: **Lat.: 47.834206 Long.: -122.178613**

Snohomish County Public Works

TEST BORING LOG B-02

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-03**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592**	AUGER TYPE:	**4" HSA**
STATION:		FLUID:	**none**
GEO./ENGR.:	**rmaynard**	TOTAL DEPTH:	**26.50**
DATE:	**3/5/18**	ELEV.:	**359.00**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	NOTES
					0.0'-0.33' **Grass and Topsoil**	
					0.33'-10.0' **Silty Sand:** Reddish brown to gray, fine- to coarse-grained, with gravel, loose to medium dense, damp *(sp-sm, fill)*	
X	S1	7/6/5		5		
X	S2	3/5/6		10	10.0'-10.5' **Topsoil:** Old topsoil layer consisting of a dark brown, silty sand, loose, damp *(sm, fill)*	
					10.5'-26.5' **Silty Sand to Sandy Silt:** Gray, fine-grained, occassional mottling, medium dense to very dense, moist to wet *(sm, Glacial Till)*	
X	S3	6/11/15		15		
X	S4	15/24/30		20	Perched water at 21'	
X	S5	19/19/19		25		
					T.D = 26.5'	

NOTES: **Lat.: 47.833364 Long.: -122.178681**

Snohomish County Public Works

TEST BORING LOG B-03

PAGE **1** OF **1**

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-04**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592**	AUGER TYPE:	**4" HSA**
STATION:		FLUID:	**none**
GEO./ENGR.:	**rmaynard**	TOTAL DEPTH:	**26.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	NOTES
					0.0'-1.0' **Sandy Gravel:** Brown, fine- to coarse-grained, trace silt, loose to medium dense, moist to damp *(gp, fill)*	
					1.0'-26.5' **Silty Sand:** Gray, fine- to coarse-grained, with gravel up to 1", occassional mottling, medium dense to very dense, moist to wet *(sm, Glacial Till)*	
X	S1	7/7/8		5		
X	S2	5/13/26		10		
X	S3	27/50-6"		15		
X	S4	50-6"		20		
X	S5	16/26/50-6"		25	Zone of gravel and perched water from 24.5'-25.5'	
					T.D. = 26.5'	

NOTES: **Lat.: 47.831380 Long.: -122.175238**

Snohomish County Public Works

TEST BORING LOG B-04

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-05**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592**	AUGER TYPE:	**4" HSA**
STATION:		FLUID:	**none**
GEO./ENGR.:	**rmaynard**	TOTAL DEPTH:	**26.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	NOTES
					0.0'-0.17' **Crushed Rock**	
					0.17'-3.0' **Gravelly Sand:** Brown, fine- to coarse-grained, trace silt, loose to medium dense, wet *(sp, fill)*	
X	S1	5/14/24			3.0'-26.5' **Silty Sand:** Gray, fine- to coarse-grained, with gravel, some mottling in upper 1', dense to very dense, moist to wet *(sm, Glacial Till)*	
X	S2	17/21/21		5		
X	S3	10/21/24		10		
X	S4	40/50-4"		15		
X	S5	23/34/35		20	Zone of gravel and perched water between 19.0'-23.5'	
X	S6	50-5"		25		
					T.D. = 26.5'	

NOTES: **Lat.: 47.822878 Long.: -122.175105**

Snohomish County Public Works

TEST BORING LOG B-05

PAGE **1** OF **1**

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-06W**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592** DATE: **3/1/18**	AUGER TYPE:	**4" HSA**
LOCATION:		FLUID:	**none**
GEO./ENGR.:	**rmaynard** ELEV.: **364.00**	TOTAL DEPTH:	**26.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	WELL DETAIL
					0.0'-2.2' **Crushed Rock**	Observation well installed upon completion including 2" schedule 40 pvc riser pipe with flush surface casing. Permaplug bentonite seal. Backfilled with 10-20 Colorado Silica Sand.
X	S1	3/3/4			2.2'-8.0' **Sand:** Reddish brown, fine- to coarse-grained, trace silt, loose, moist *(sp-sm, Weathered Advance Outwash)*	
X	S2	3/2/5		5		
X	S3	13/18/26			8.0'-26.5' **Sand:** Gray, fine- to coarse-grained, with fine-grained gravel, trace silt, dense to very dense, moist to wet *(sp-sm, Advance Outwash)*	
X	S4	17/18/21		10	Perched water at 13'	2" schedule 40 pvc #10 slotted screen.
X	S5	10/19/28		15	Increased silt from 15'-16" Mottling Perched/ water encountered at 18'	
X	S6	19/28/35		20		
X	S7	22/30/35		25	Increased silt	
					T.D = 26.5'	

NOTES: **Lat.: 47.819577 Long.: -122.175158**

Snohomish County Public Works

TEST BORING LOG B-06W

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-07**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592**	AUGER TYPE:	**4" HSA**
STATION:		FLUID:	**none**
GEO./ENGR.:	**rmaynard**	TOTAL DEPTH:	**26.50**

SAMPLE	INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	NOTES
						0.0'-0.67' **Crushed Rock**	
						0.67'-4.0' **Gravelly Sand:** Light brown, fine- to coarse-grained, trace silt, medium dense, moist *(sp, fill)*	
X		S1	22/32/37		5	4.0'-26.5' **Silty Sand:** Olive gray to gray, fine- to coarse-grained, with gravel, very dense, moist *(sm, Glacial Till)*	
X		S2	30/50-4"		10		
X		S3	50-5"		15		
X		S4	21/50-5"		20		
X		S5	50-5"		25	Grading to a gravelly sand with silt (sp-sm)	
						T.D. = 26.5'	

NOTES: **Lat.: 47.817152 Long.: -122.175314**

Snohomish County Public Works

TEST BORING LOG B-07

PAGE 1 OF 1

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-08**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592**	DATE:	**2/28/18**
		AUGER TYPE:	**4" HSA**
STATION:		OFFSET:	
		FLUID:	**none**
GEO./ENGR.:	**rmaynard**	ELEV.:	**426.00**
		TOTAL DEPTH:	**26.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	NOTES
					0.0'-0.5' **Asphaltic Concrete Pavement**	
					0.5'-3.0' **Gravelly Sand:** Brown, fine- to coarse-grained, trace silt, medium dense, moist *(sp, fill)*	
X	S1	8/17/19			3.0'-26.5' **Silty Sand:** Olive gray to gray, fine- to coarse-grained, with gravel up to 1", dense to very dense, moist *(sm, Glacial Till)*	
X	S2	12/18/18		5		
X	S3	30/37/50-5.5"		10		
X	S4	22/37/47		15	Zone of gravel and perched water from 15'-15.5'	
X	S5	23/29/46		20	Zone of sand and perched water from 20'-22'	
X	S6	10/34/50-5"		25		
					T.D. = 26.5'	

NOTES: **Lat.: 47.814929 Long.: -122.175236**

Snohomish County Public Works

TEST BORING LOG B-08

PAGE 1 OF 1

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-09**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592**	AUGER TYPE:	**4" HSA**
STATION:		FLUID:	**none**
GEO./ENGR.:	**rmaynard**	TOTAL DEPTH:	**26.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	NOTES
					0.0'-0.17' **Crushed Rock**	
					0.17'-17.0' **Gravelly Sand:** Light brown to brown, fine- to medium-grained, trace silt, medium dense to dense, moist *(sp, Resessional Outwash)*	
X	S1	9/12/9				
X	S2	6/13/15		5		
X	S3	10/15/18				
X	S4	12/16/22		10		
X	S5	11/20/40		15	Coarse gravel layer between 15'-16.5' Blow counts overstated due to coarseness of gravel	
					17.0'-26.5' **Silty Sand:** Gray, fine- to coarse-grained, trace gravel, very dense, moist *(sm, Glacial Till)*	
X	S6	21/20/30		20		
X	S7	21/31/39		25		
					T.D. = 26.5'	

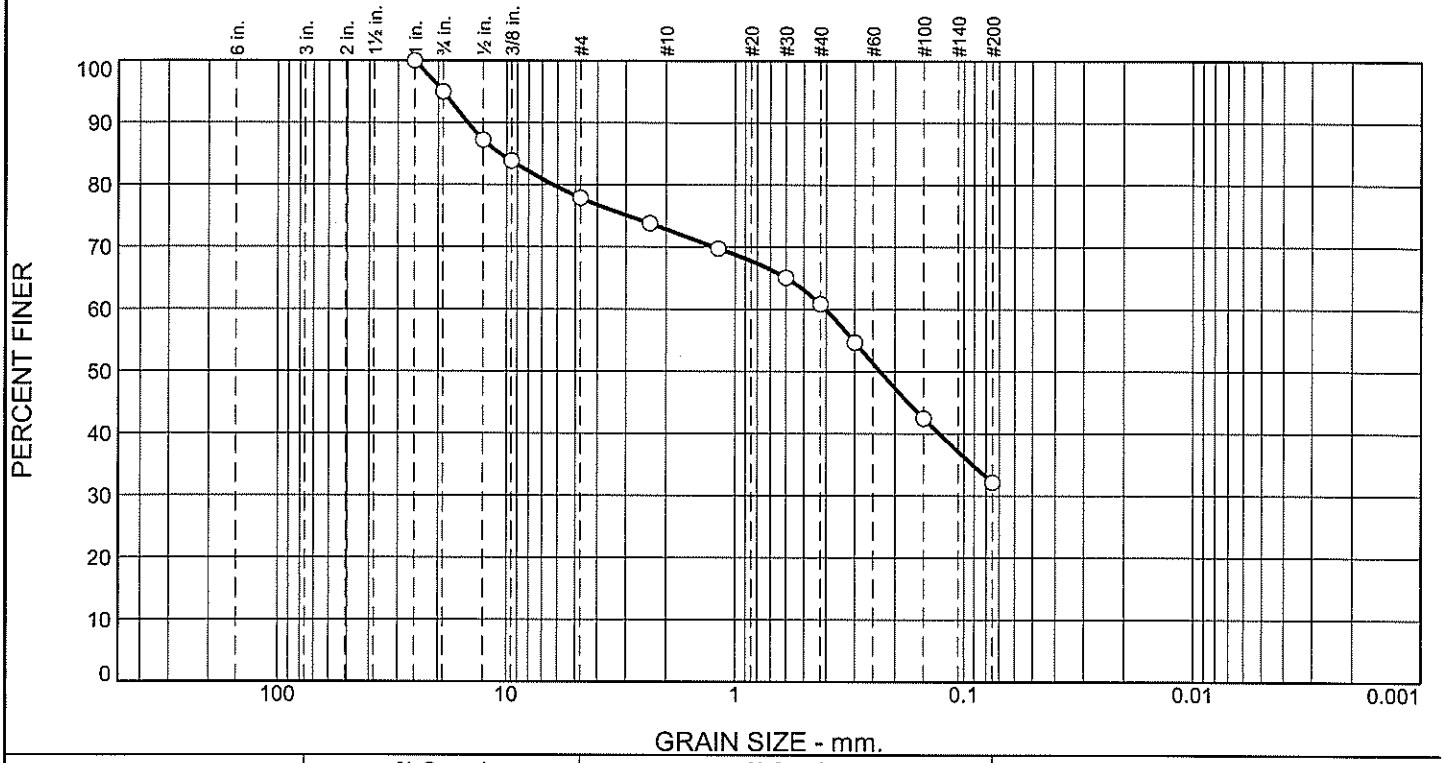
NOTES: **Lat.: 47.812168 Long.: -122.175316**

Snohomish County Public Works

TEST BORING LOG B-09

PAGE **1** OF **1**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	5	17	5	12	29	32	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100		
.75"	95		
.5"	87		
.375	84		
#4	78		
#8	74		
#16	70		
#30	65		
#40	61		
#50	55		
#100	42		
#200.	32		

* (no specification provided)

Material Description

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SM AASHTO (M 145)= A-2-4(0)

Coefficients

D_{90}= 14.8430 D_{85}= 10.6712 D_{60}= 0.4031
D_{50}= 0.2326 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Moisture content. 8.5%

Date Received: 3/15/18 **Date Tested:** 3/16/18

Tested By: CH

Checked By: CH

Title: Materials Lab Senior Lead Tech

Source of Sample: B-02 **Depth:** 10' - 11.5' **Date Sampled:** 2/28/18

Sample Number: 2

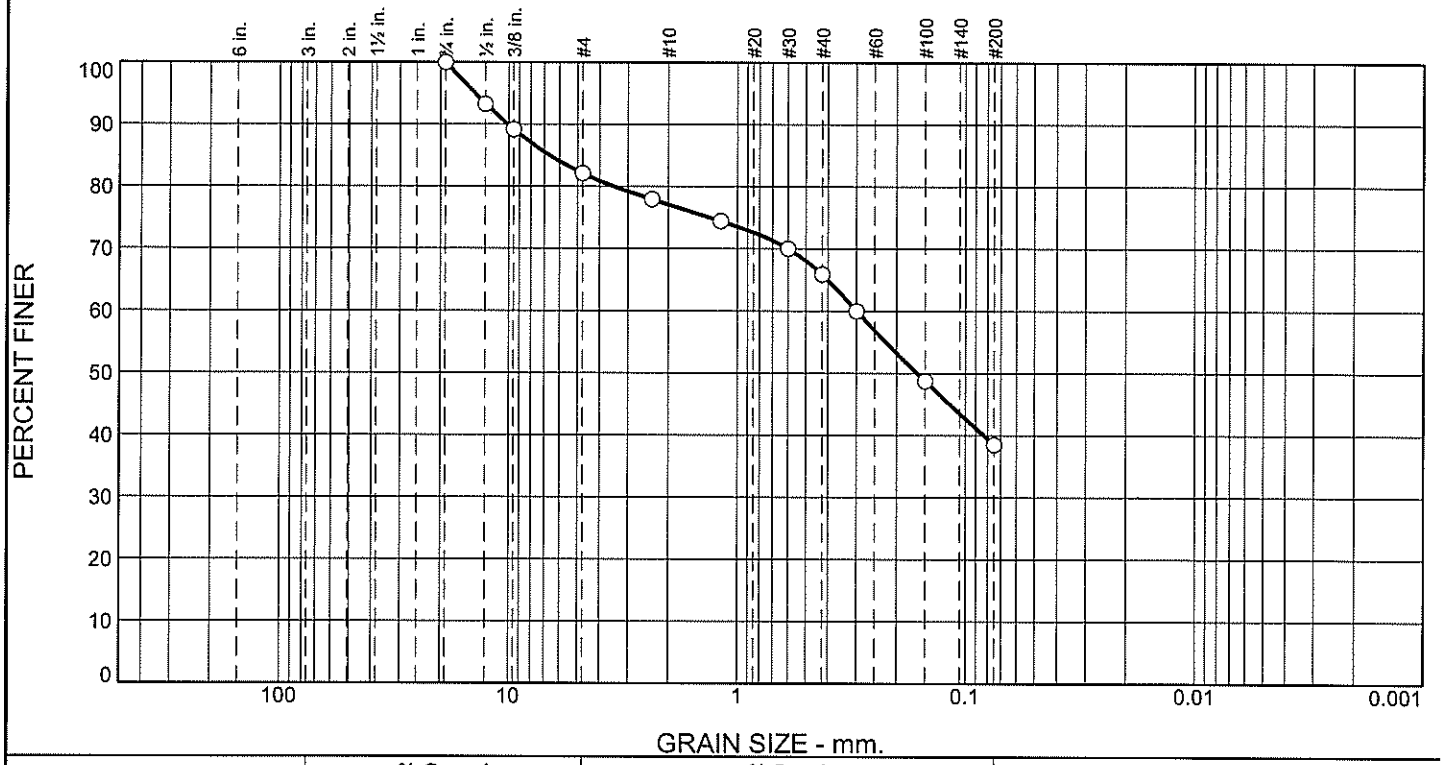
Snohomish County Dept. of Public Works Everett, Washington

Client: Rollie Maynard

Project: 43rd Ave SE SR524 to Sunset Rd.

Project No: RC1592 **Figure** 60-18

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	18	5	11	27	39	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75"	100		
.5"	93		
.375	89		
#4	82		
#8	78		
#16	74		
#30	70		
#40	66		
#50	60		
#100	49		
#200	39		

* (no specification provided)

Material Description

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SM AASHTO (M 145)= A-4(0)

Coefficients

D_{90}= 10.1368 D_{85}= 6.6132 D_{60}= 0.3001
D_{50}= 0.1628 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Moisture content. 9.8%

Date Received: 3/15/18 **Date Tested:** 3/16/18

Tested By: CH

Checked By: CH

Title: Materials Lab Senior Lead Tech

Source of Sample: B-05 **Depth:** 10' - 11.5' **Date Sampled:** 2/28/18

Sample Number: 3

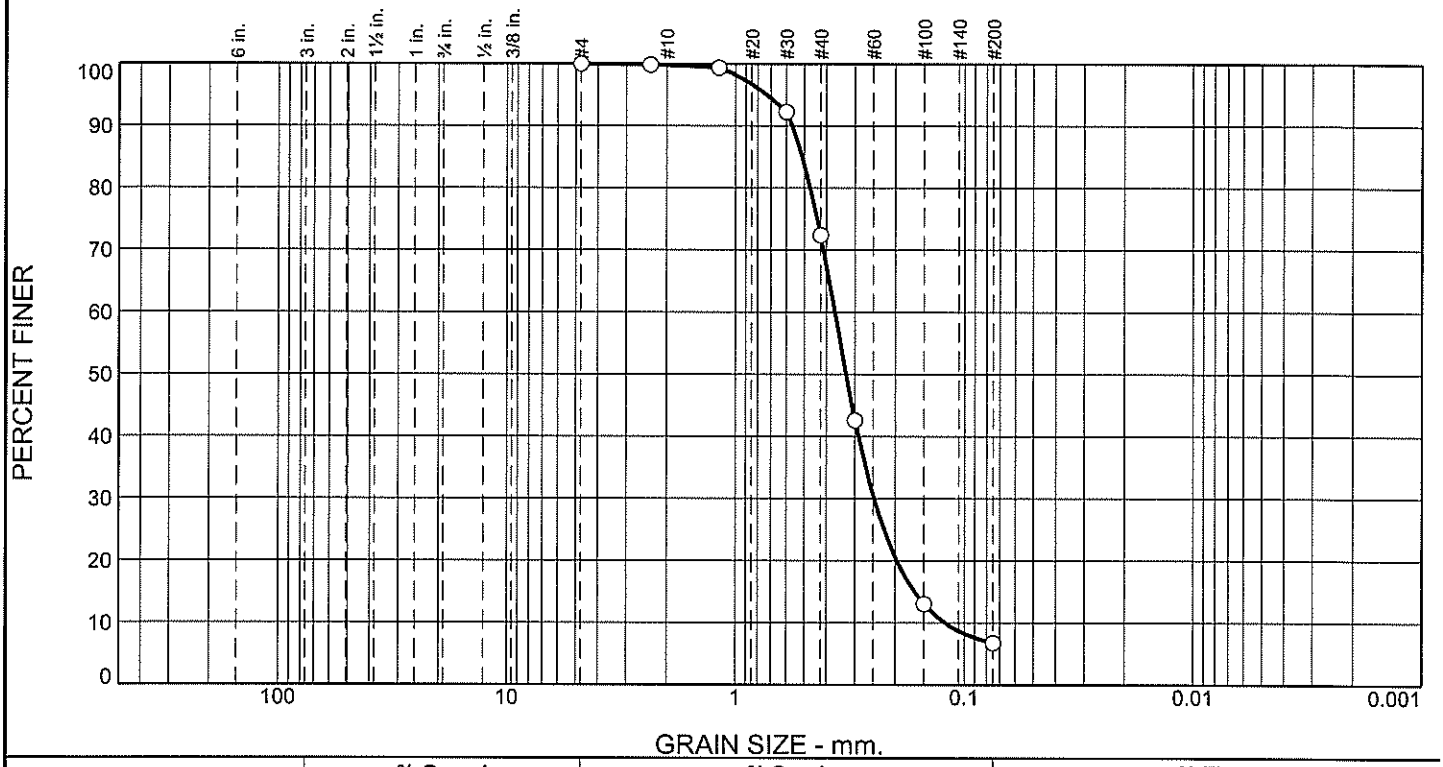
Snohomish County Dept. of Public Works Everett, Washington

Client: Rollie Maynard

Project: 43rd Ave SE SR524 to Sunset Rd.

Project No: RC1592 **Figure** 61-18

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	0	0	28	65	7	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100		
#8	100		
#16	99		
#30	92		
#40	72		
#50	43		
#100	13		
#200	6.7		

* (no specification provided)

Material Description

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

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

Coefficients

D_{90}= 0.5667 D_{85}= 0.5126 D_{60}= 0.3676
D_{50}= 0.3284 D_{30}= 0.2479 D_{15}= 0.1651
D_{10}= 0.1215 C_u= 3.02 C_c= 1.38

Remarks

Moisture content. 8.5%

Date Received: 3/15/18 **Date Tested:** 3/16/18

Tested By: CH

Checked By: CH

Title: Materials Lab Senior Lead Tech

Source of Sample: B-06W **Depth:** 7.5' - 9.0 **Date Sampled:** 2/28/18

Sample Number: 3

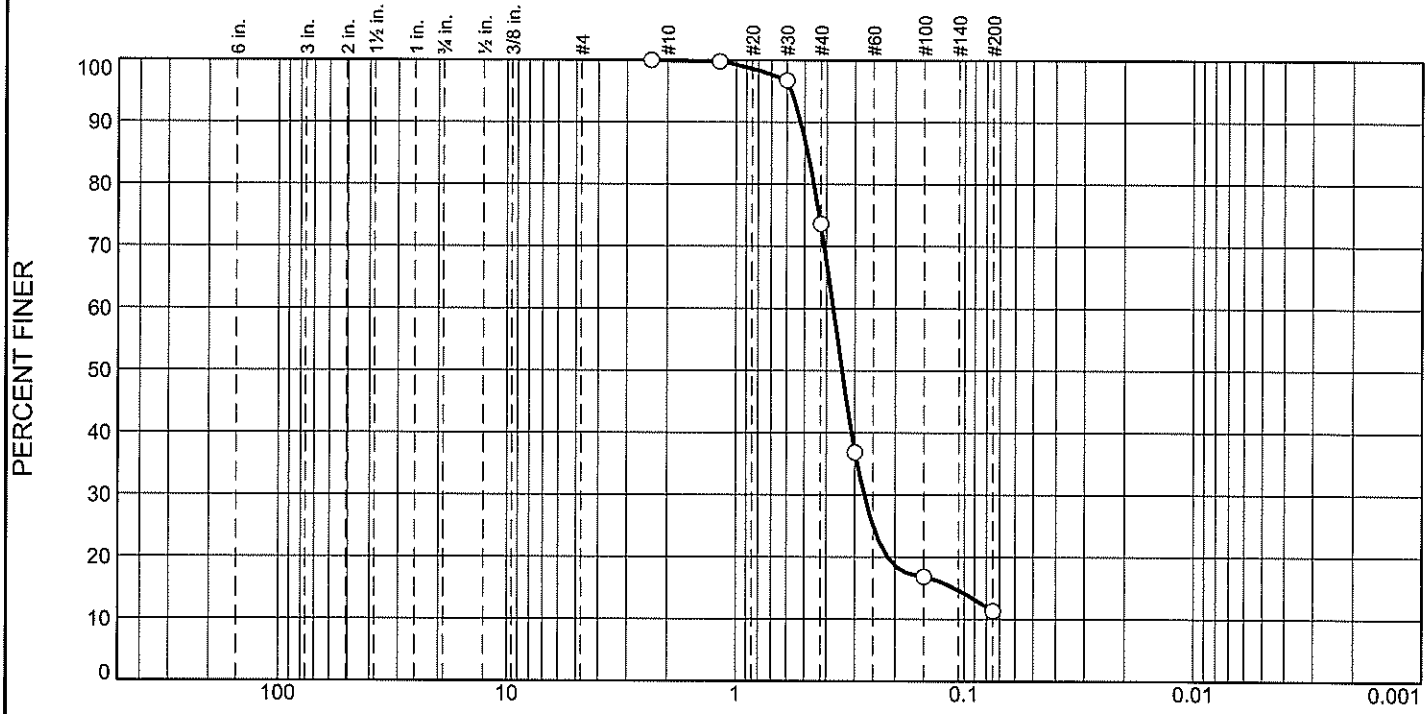
Snohomish County
Dept. of Public Works
Everett, Washington

Client: Rollie Maynard

Project: 43rd Ave SE SR524 to Sunset Rd.

Project No: RC1592 **Figure** 62-18

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	0	0	26	63	11	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#8	100		
#16	100		
#30	97		
#40	74		
#50	37		
#100	17		
#200	11		

* (no specification provided)

Material Description

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SP-SM AASHTO (M 145)= A-2-4(0)

Coefficients

D_{90}= 0.5225 D_{85}= 0.4850 D_{60}= 0.3742
D_{50}= 0.3422 D_{30}= 0.2739 D_{15}= 0.1101
D_{10}= C_u= C_c=

Remarks

Moisture content. 10.8%

Date Received: 3/15/18 **Date Tested:** 3/16/18

Tested By: CH

Checked By: CH

Title: Materials Lab Senior Lead Tech

Source of Sample: B-06W **Depth:** 20' - 21.5' **Date Sampled:** 2/28/18

Sample Number: 6

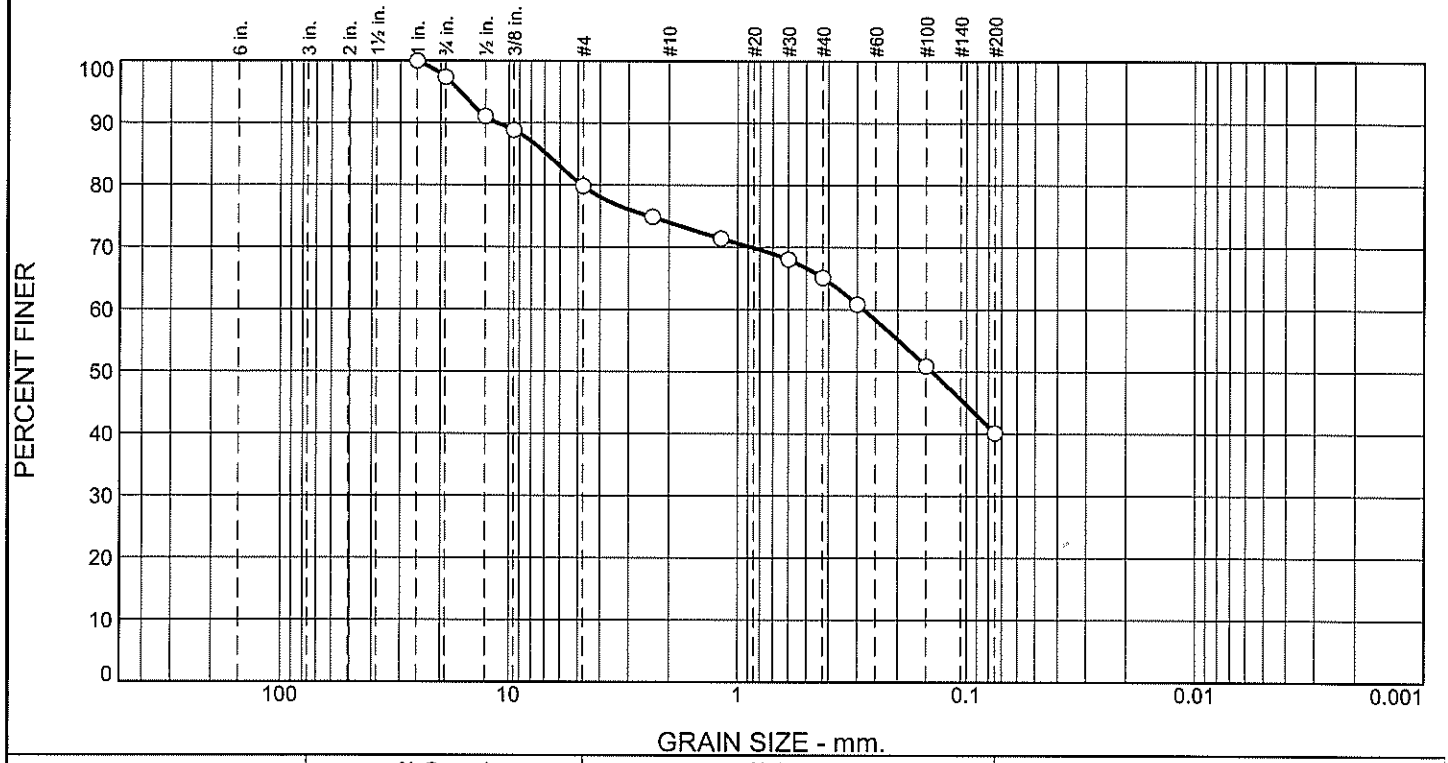
Snohomish County
Dept. of Public Works
Everett, Washington

Client: Rollie Maynard

Project: 43rd Ave SE SR524 to Sunset Rd.

Project No: RC1592 **Figure** 63-18

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	3	17	6	9	25	40	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100		
.75"	97		
.5"	91		
.375	89		
#4	80		
#8	75		
#16	71		
#30	68		
#40	65		
#50	61		
#100	51		
#200	40		

* (no specification provided)

Material Description

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SM AASHTO (M 145)= A-4(0)

Coefficients

D_{90}= 11.2293 D_{85}= 6.8734 D_{60}= 0.2817
D_{50}= 0.1412 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Moisture content. 9.3%

Date Received: 3/15/18 **Date Tested:** 3/16/18

Tested By: CH

Checked By: CH

Title: Materials Lab Senior Lead Tech

Source of Sample: B-07 **Depth:** 5' - 6.5' **Date Sampled:** 2/28/18

Sample Number: 1

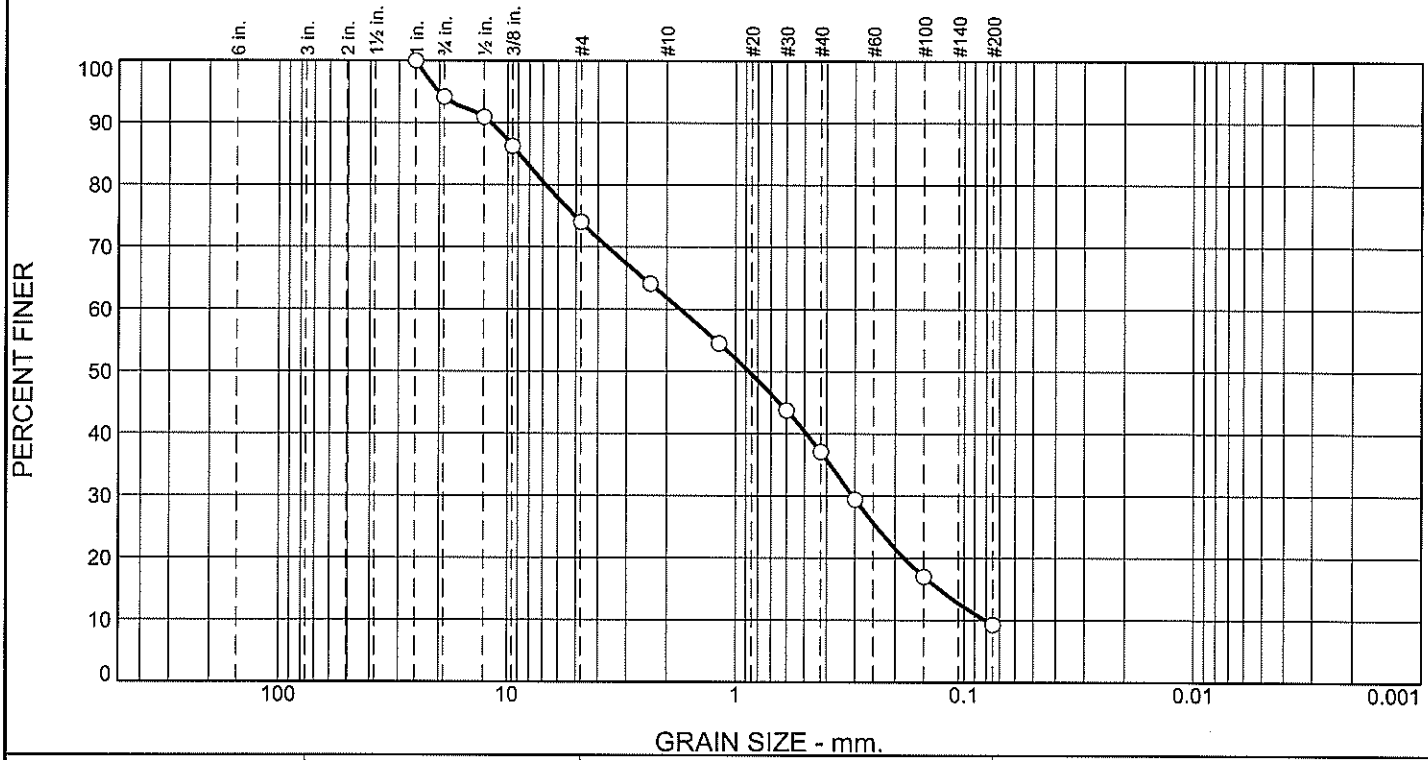
Snohomish County
Dept. of Public Works
Everett, Washington

Client: Rollie Maynard

Project: 43rd Ave SE SR524 to Sunset Rd.

Project No: RC1592 **Figure** 64-18

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	6	20	12	25	28	9	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100		
.75"	94		
.5"	91		
.375	86		
#4	74		
#8	64		
#16	55		
#30	44		
#40	37		
#50	29		
#100	17		
#200	9.3		

* (no specification provided)

Material Description

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 11.8049 D_{85}= 8.9176 D_{60}= 1.7467
D_{50}= 0.8735 D_{30}= 0.3083 D_{15}= 0.1285
D_{10}= 0.0808 C_u= 21.62 C_c= 0.67

Remarks

Moisture content. 4.2%

Date Received: 3/15/18 **Date Tested:** 3/16/18

Tested By: CH

Checked By: CH

Title: Materials Lab Senior Lead Tech

Source of Sample: B-07 **Depth:** 25' - 26.5' **Date Sampled:** 2/28/18

Sample Number: 5

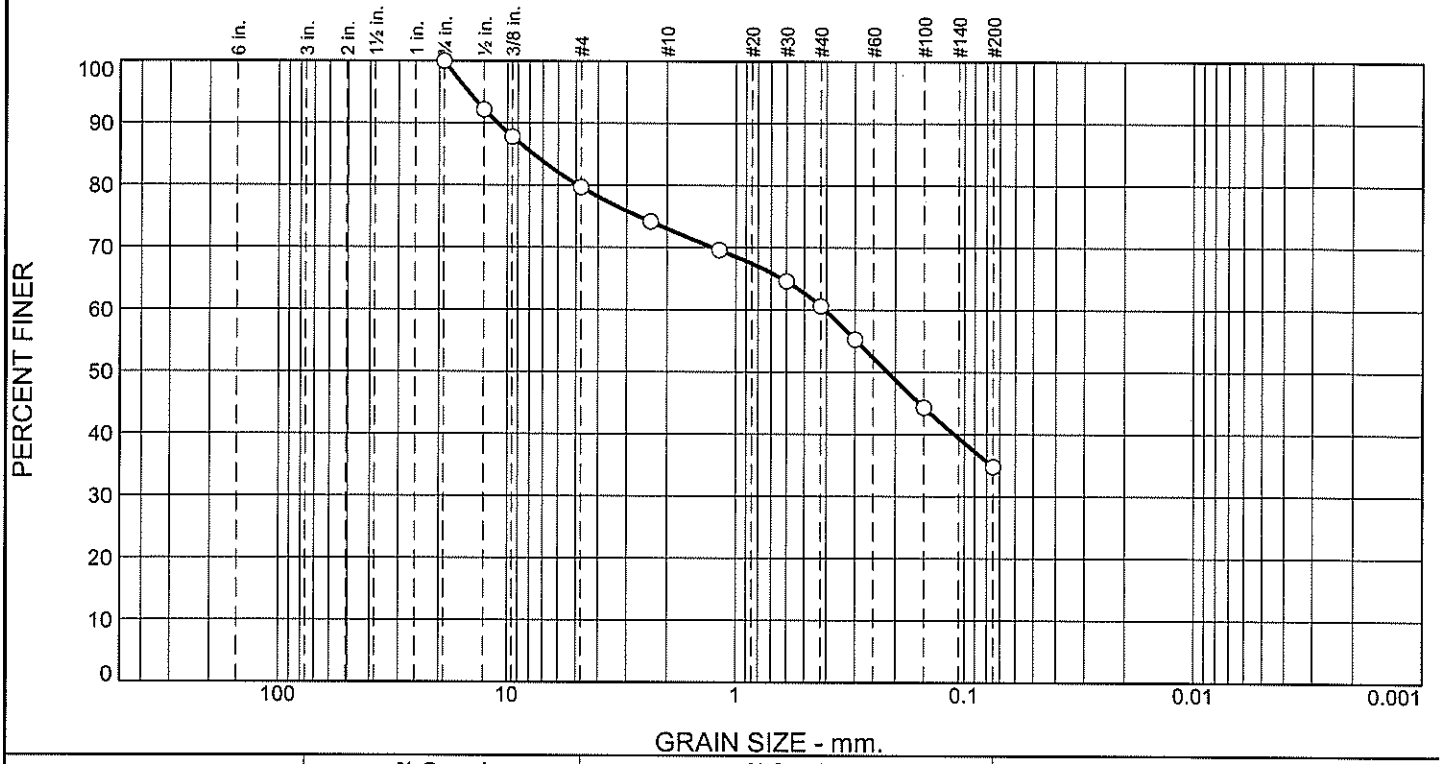
Snohomish County
Dept. of Public Works
Everett, Washington

Client: Rollie Maynard

Project: 43rd Ave SE SR524 to Sunset Rd.

Project No: RC1592 **Figure** 65-18

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	20	7	12	26	35	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75"	100		
.5"	92		
.375	88		
#4	80		
#8	74		
#16	70		
#30	65		
#40	61		
#50	55		
#100	44		
#200	35		

* (no specification provided)

Material Description

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 11.0973 D_{85}= 7.6919 D_{60}= 0.4071
D_{50}= 0.2167 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Moisture content. 9.6%

Date Received: 3/15/18 **Date Tested:** 3/16/18

Tested By: CH

Checked By: CH

Title: Materials Lab Senior Lead Tech

Source of Sample: B-08 **Depth:** 5' - 6.5' **Date Sampled:** 2/28/18

Sample Number: 2

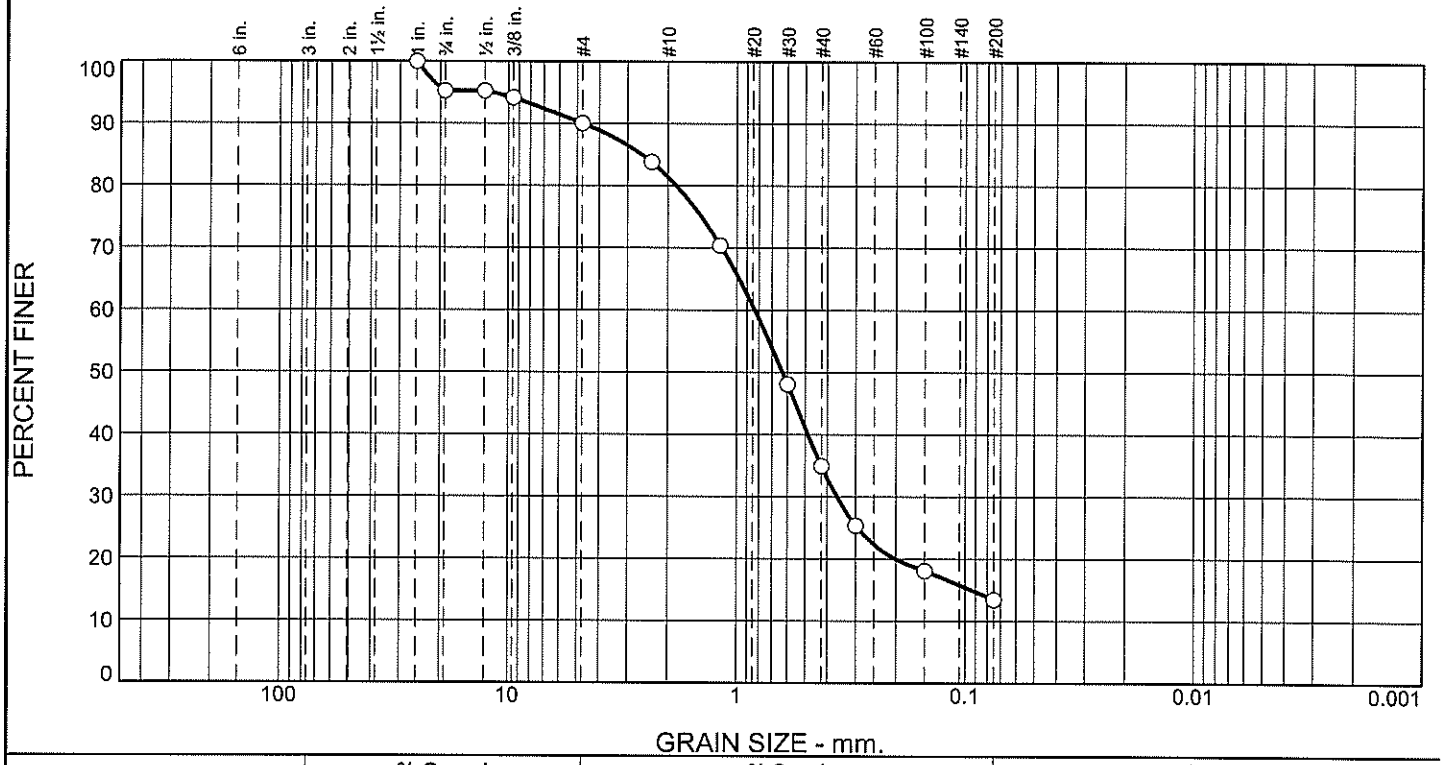
Snohomish County
Dept. of Public Works
Everett, Washington

Client: Rollie Maynard

Project: 43rd Ave SE SR524 to Sunset Rd.

Project No: RC1592 **Figure** 66-18

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	5	5	9	46	22	13	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100		
.75"	95		
.5"	95		
.375	94		
#4	90		
#8	84		
#16	70		
#30	48		
#40	35		
#50	25		
#100	18		
#200	13		

* (no specification provided)

Material Description

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SM AASHTO (M 145)= A-1-b

Coefficients

D_{90}= 4.6956 D_{85}= 2.5966 D_{60}= 0.8344
D_{50}= 0.6308 D_{30}= 0.3633 D_{15}= 0.0935
D_{10}= C_u= C_c=

Remarks

Moisture content. 13.1%

Date Received: 3/15/18 **Date Tested:** 3/16/18

Tested By: CH

Checked By: CH

Title: Materials Lab Senior Lead Tech

Source of Sample: B-08 **Depth:** 20' - 21.5' **Date Sampled:** 2/28/18

Sample Number: 5

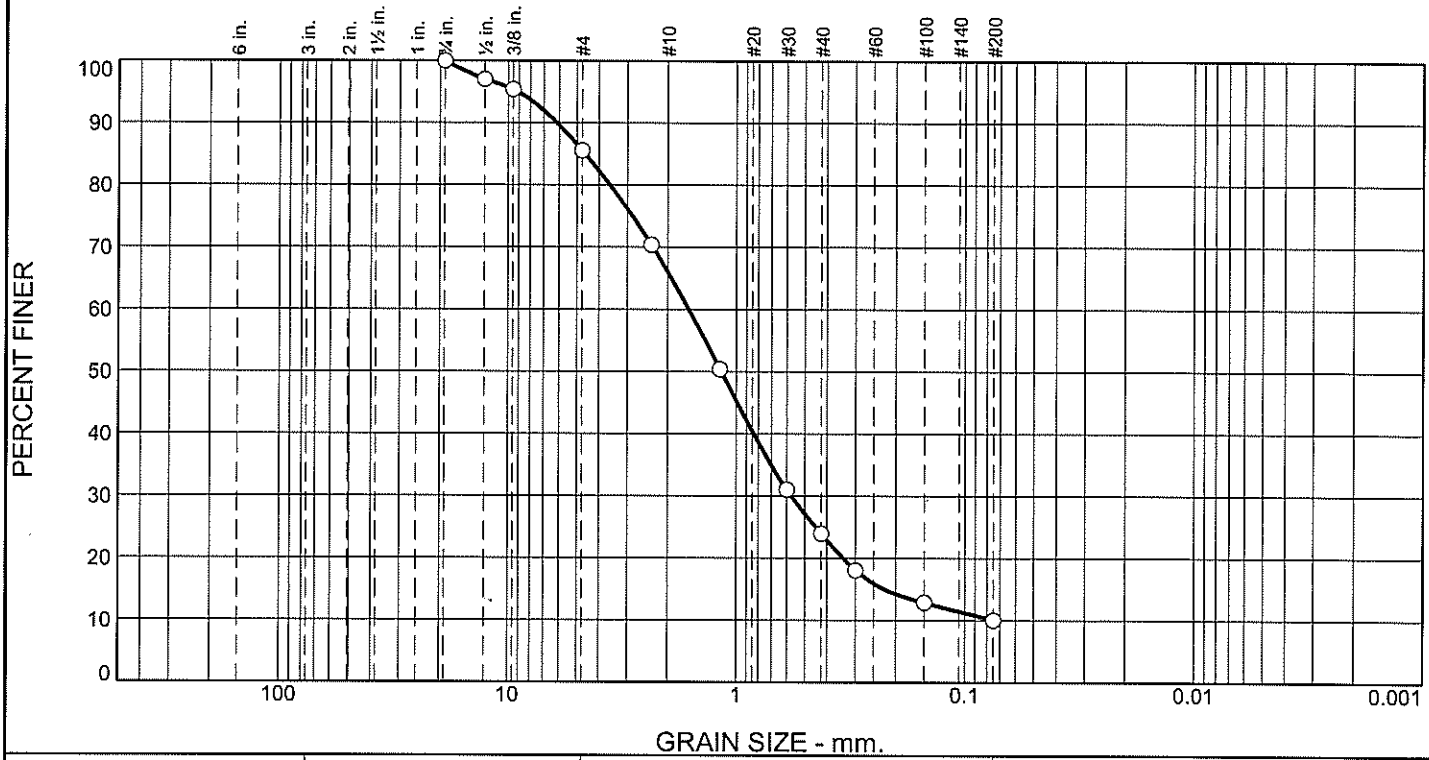
Snohomish County
Dept. of Public Works
Everett, Washington

Client: Rollie Maynard

Project: 43rd Ave SE SR524 to Sunset Rd.

Project No: RC1592 **Figure** 67-18

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	14	20	42	14	10	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75"	100		
.5"	97		
.375	95		
#4	86		
#8	70		
#16	50		
#30	31		
#40	24		
#50	18		
#100	13		
#200	10		

* (no specification provided)

Material Description

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SP-SM AASHTO (M 145)= A-1-b

Coefficients

D_{90}= 6.1182 D_{85}= 4.6065 D_{60}= 1.6205
D_{50}= 1.1647 D_{30}= 0.5739 D_{15}= 0.2237
D_{10}= C_u= C_c=

Remarks

Moisture content. 9.0%

Date Received: 3/15/18 **Date Tested:** 3/16/18

Tested By: CH

Checked By: CH

Title: Materials Lab Senior Lead Tech

Source of Sample: B-09 **Depth:** 10' - 11.5' **Date Sampled:** 2/28/18

Sample Number: 4

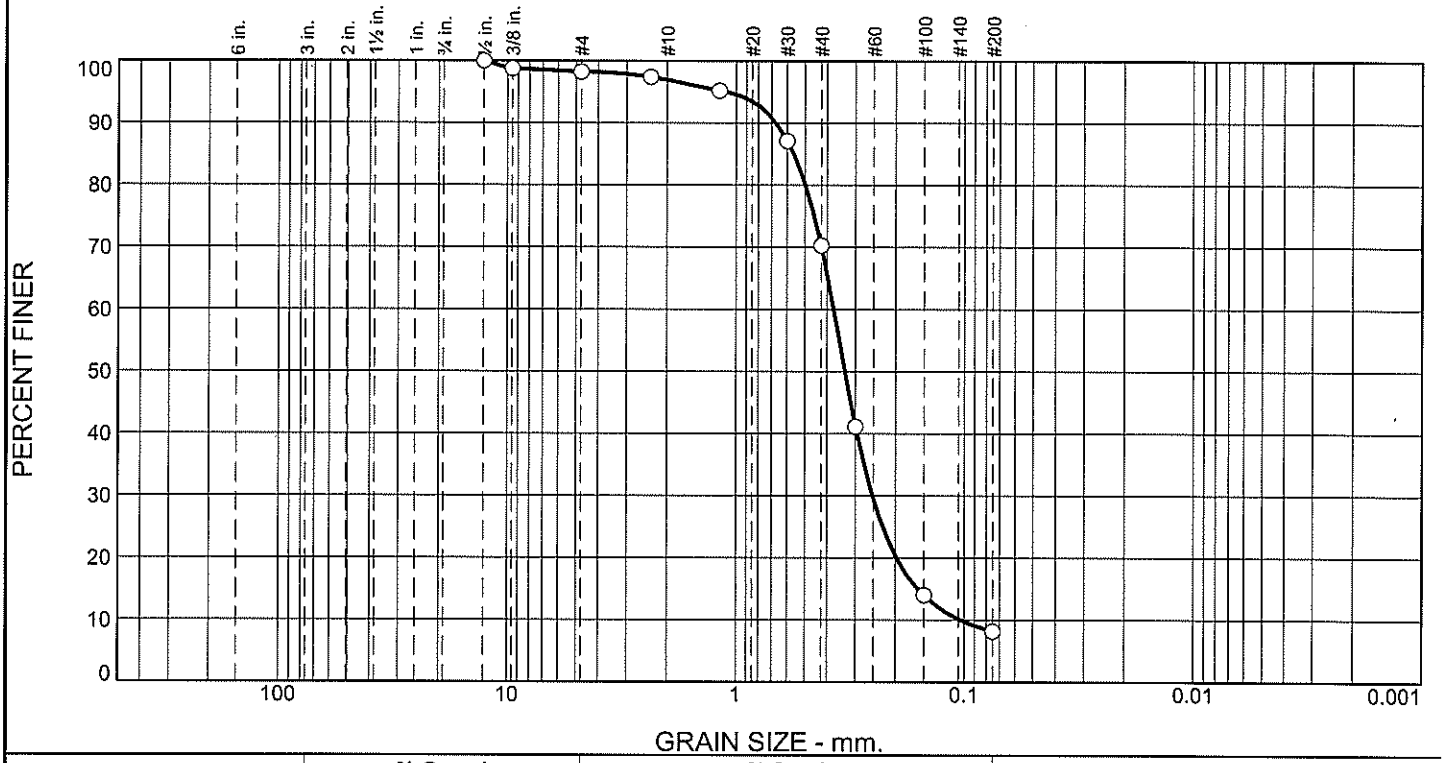
Snohomish County
Dept. of Public Works
Everett, Washington

Client: Rollie Maynard

Project: 43rd Ave SE SR524 to Sunset Rd.

Project No: RC1592 **Figure** 68-18

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	2	1	27	62	8	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.5"	100		
.375	99		
#4	98		
#8	97		
#16	95		
#30	87		
#40	70		
#50	41		
#100	14		
#200	8.2		

* (no specification provided)

Material Description

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

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

Coefficients

D_{90}= 0.6709 D_{85}= 0.5622 D_{60}= 0.3743
D_{50}= 0.3341 D_{30}= 0.2526 D_{15}= 0.1595
D_{10}= 0.1032 C_u= 3.63 C_c= 1.65

Remarks

Moisture content. 8.2%

Date Received: 3/15/18 **Date Tested:** 3/16/18

Tested By: CH

Checked By: CH

Title: Materials Lab Senior Lead Tech

Source of Sample: B-09 **Depth:** 25' - 26.5' **Date Sampled:** 2/28/18

Sample Number: 7

Snohomish County Dept. of Public Works Everett, Washington

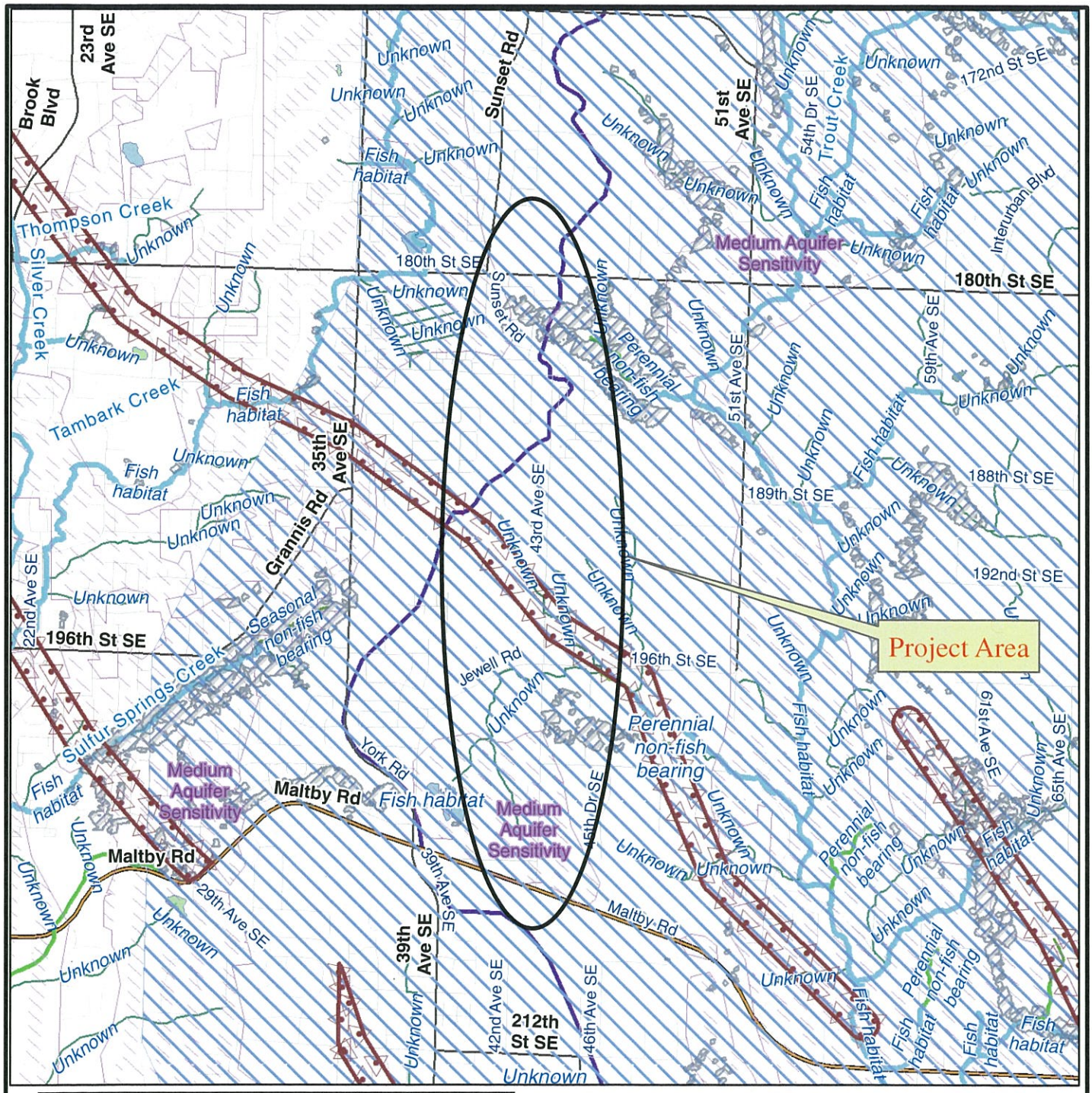
Client: Rollie Maynard

Project: 43rd Ave SE SR524 to Sunset Rd.

Project No: RC1592 **Figure** 69-18

GEOLOGIC HAZARDS MAP
43rd Avenue SE
RC 1592

Snohomish County



Seismic Active Faults w/ Notice 200 ft. (SCC 30.62B.350)
- Seismic Active Faults w/ Notice 200 ft. (SCC 30.62B.350)

Landslide Hazard Areas (as defined in SCC 30.91L.040)
- Landslide Hazard Areas (as defined in SCC 30.91L.040)

Hydro Basins - ESA
- Hydro Basins - ESA

Aquifer Sensitivity (30.62C)
- 3 = High Aquifer Sensitivity
- 2 = Moderate Aquifer Sensitivity
- Aquifer_SoleSource (30.62C)

Major Roads
- County Arterial
- Freeway
- State Route

Local Roads
- Local Roads

Snohomish County Water Bodies
- S-State Shoreline
- F-Fish-Bearing Waterbody
- Np-Non Fish-Bearing Perennial Waterbody
- Ns-Non Fish-Bearing Seasonal Waterbody
- U-Undefined Waterbody

Snohomish County Water Courses
- S-State Shoreline
- F-Fish-Bearing Watercourse
- Np-Non Fish-Bearing Perennial Watercourse
- Ns-Non Fish-Bearing Seasonal Watercourse
- U-Undefined Watercourse

Major Waterbodies
- Bays
- Flats (tidal
- Lake or pond
- Sand or gravel in open water
- Stream

All maps, data, and information set forth herein ("Data"), are for illustrative purposes only and are not to be considered an official citation to, or representation of, the Snohomish County Code. Amendments and updates to the Data, together with other applicable County Code provisions, may apply which are not depicted herein. Snohomish County makes no representation or warranty concerning the content, accuracy, currency, completeness or quality of the Data contained herein and expressly disclaims any warranty of merchantability or fitness for any particular purpose. All persons accessing or otherwise using this Data assume all responsibility for use thereof and agree to hold Snohomish County harmless from and against any damages, loss, claim or liability arising out of any error, defect or omission contained within said Data. Washington State Law, Ch. 42.56 RCW, prohibits state and local agencies from providing access to lists of individuals intended for use for commercial purposes and, thus, no commercial use may be made of any Data comprising lists of individuals contained herein.

2,000 1,000 0 2,000 Feet

2/25/16F

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. —

Permit No. —

(1) OWNER: Name John Sundstrom Address 3831 188th St SW Lynnwood

(2) LOCATION OF WELL: County Snohomish S. ½ N.W.¼ – S.E.¼ N.W.¼ Sec. 16 T. 27 N., R. 5 E. W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic [X] Industrial [ ] Municipal [ ]
Irrigation [ ] Test Well [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one)
New well [X] Method: Dug [ ] Bored [ ]
Deepened [ ] Cable [X] Driven [ ]
Reconditioned [ ] Rotary [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6" inches.
Drilled 101 ft. Depth of completed well 101' ft.

(6) CONSTRUCTION DETAILS:

Casing installed: ..." Diam. from .. ft. to .. ft.
Threaded [ ] ..." Diam. from .. ft. to .. ft.
Welded [X] 6" Diam. from +1 ft. to 101' ft.

Perforations: Yes [ ] No [X]
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [ ] No [X]
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [X] Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes [X] No [ ] To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name NONE
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 61 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [X] No [ ] If yes, by whom? AAA Pump
Yield: 10 gal./min. with 10' ft. drawdown after 4 hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 10 gal./min. with 5 ft. drawdown after 4 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [X]

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Brown Top Soil	0	10'
Brown Hard Sandy clay	10	31'
Brown Sandy clay (WATER)	31'	48'
Sand – medium	48	95'
Brown Gravel (Big Size) & Hard	95	101'

Work started Dec 19 85 Completed Feb 15 19 86

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME AAA Pump Service & Drilling
(Person, firm, or corporation) (Type or print)

Address P.O. Box 654 Bothell, Wash. 98041

[Signed] Mike Harmon
(Well Driller)

License No. 1178 Date 2-15 19 86

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

Home address 328 N.W. 177th Seattle, WN. 27/05-16

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. .....
Permit No. .....

(1) OWNER: Name Ralph W Everett Address 328 NW 177th Seattle WN 98177

(2) LOCATION OF WELL: County Snohomish ¼ ¼ Sec. 16 T. 27 N. R. 5 W.M.
Bearing and distance from section or subdivision corner address of Prop 3709 Terrell Rd Bothell Wn

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 109 ft. Depth of completed well 109 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: ..." Diam. from .. ft. to .. ft.
Threaded ☐ ..." Diam. from .. ft. to .. ft.
Welded ☒ ..." Diam. from .. ft. to .. ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations .... in. by .... in.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☒ No ☐ Johnson
Manufacturer's Name ....
Type Stainless Model No. ....
Diam. 6" Slot size 14 from 104 ft. to 109 ft.
Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level .... ft.
Static level 70 ft. below top of well Date 10/24-87
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ....
Yield: .... gal./min. with .... ft. drawdown after .... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test 4-23-87
Bailer test 15 gal./min. with 10 ft. drawdown after 45 hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:
Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
yellow clay	0	4
some gravel	4	8
some water at 8 ft		
Sandy & some clay yellow	8	20
dry sand & small gr. yellow	30	74
dry gravel	74	89
Water at 89 ft		
Sand no heads		
Sand with thin layers of yellow clay. Water Bearing	89	105
Water up to 80 ft		
Water Bearing gravels starting to Reave	105	109
I did not go to Bottom of Hole - but we had a good Supply as stopped drilling		
Water clear so we could drink it		

RECEIVED
APR 28 1987
DEPARTMENT OF ECOLOGY
NORTHWEST REGION

Work started 4-8 19 87 Completed 4-23- 19 87

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME H.O Meyer Drlg Co
(Person, firm, or corporation) (Type or print)
Address 6424 Lake Wa Blvd N.E Kirkland, Wash 98033
[Signed] H.O Meyer (Well Driller)
License No. 0308 Date April 23, 1987

(USE ADDITIONAL SHEETS IF NECESSARY)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. 27/05-16

Permit No.

(1) OWNER: Name Ron Carlson Address Present address 14126-196th SE Bothell Wash 98012

(2) LOCATION OF WELL: County Snohomish Co ¼ ¼ Sec 16 T 27 N., R 5E W.M.

Bearing and distance from section or subdivision corner E 1/2 of the N 1/2 of S 1/2

(3) PROPOSED USE: Domestic ☑ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)

New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☑ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 124 ft. Depth of completed well 124 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: " Diam. from ft. to ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☑ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☑
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☑
Manufacturer's Name Johnson
Type stainless Model No.
Diam. 6 Slot size 30 from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☑ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☑ No ☐ To what depth? 19 ft.
Material used in seal Bentonite 65 gals
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name Well
Type: Will Be a 1½ HP Sub H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level (70) ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☑ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 30 gal./min. with 6 Ft ft. drawdown after 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Topsoil & sd	0	3
Coarse grvl & water sd SA	3	6
Very Coarse gr & larg Rocks	6	18
Glacial till & Coarse		
Till Brown tan color	18	55
Tapioca Color Till	55	73
Yellow sand & clay & Some Water in it	73	100
100' 119 open hole drilly But Contain water		
Layers of yellow Clay & sand	108	119
Bailey Coarse sand & gravel	119	124
We Will Test Pump The well When Pump is Installed and get Water Samples I feel that the well will pump over 30 GPM		

Work started 5-20 1987. Completed May 30 1987

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME H.O. Meyer Drlg Co (Person, firm, or corporation) (Type or print)

Address 6424 Lake Wn Blvd. NE Kirkland Wash 98033

[Signed] H O Meyer (Well Driller)

License No. 0308 Date May 31, 1987

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

3745 64

WATER WELL REPORT

Original & 1st copy - Ecology, 2nd copy - owner, 3rd copy - driller

Submit by Email

27-5E-16L

CURRENT Notice of Intent No. WE11443

Construction/Decommission ("x" in circle)

[X] Construction

[ ] Decommission *ORIGINAL INSTALLATION*

Notice of Intent Number _____

Unique Ecology Well ID Tag No. ALS-790

Water Right Permit No. Exempt

Property Owner Name Val Goermaere

Well Street Address 3722 188 TH ST SE

City Bothell County Snohomish

Location NE 1/4-1/4 SW 1/4 Sec 16 Twn 27 R 05E EWM [ ] Check or WWM [X] One

(s, t, r Still REQUIRED)

Lat/Long Lat Deg _____ Lat Min/Sec _____

Long Deg _____ Long Min/Sec _____

Tax Parcel No. (Required) 27051600300600

PROPOSED USE: [X] Domestic [ ] Industrial [ ] Municipal [ ] DeWater [ ] Irrigation [ ] Test Well [ ] Other _____

TYPE OF WORK: Owner's number of well (if more than one) _____

[X] New well [ ] Reconditioned [ ] Deepened

Method: [ ] Dug [ ] Bored [ ] Driven [ ] Cable [X] Rotary [ ] Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 156 ft.

Depth of completed well 143 ft.

CONSTRUCTION DETAILS

Casing Installed: [X] Welded 6 " Diam. from +2 ft. to 135 ft.

[ ] Liner installed _____ " Diam. from _____ ft. to _____ ft.

[ ] Threaded _____ " Diam. From _____ ft. to _____ ft.

Perforations: [ ] Yes [X] No

Type of perforator used _____

SIZE of perfs _____ in. by _____ in. and no. of perfs _____ from _____ ft. to _____ ft.

Screens: [X] Yes [X] No [ ] K-Pac Location 132

Manufacturer's Name Johnson

Type Telescopic Model No. _____

Diam. 5 Slot size 20 from 143 ft. to 133 ft.

Diam. _____ Slot size _____ from _____ ft. to _____ ft.

Gravel/Filter packed: [ ] Yes [X] No Size of gravel/sand _____

Materials placed from _____ ft. to _____ ft.

Surface Seal: [X] Yes [ ] No To what depth? 18 ft.

Material used in seal Bentonite chips

Did any strata contain unusable water? [ ] Yes [X] No

Type of water? _____ Depth of strata _____

Method of sealing strata off _____

PUMP: Manufacturer's Name _____

Type: _____ H.P. _____

WATER LEVELS: Land-surface elevation above mean sea level _____ ft.

Static level 72 ft. below top of well Date 05-19-10

Artesian pressure _____ lbs. per square inch Date _____

Artesian water is controlled by _____ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? [X] Yes [X] No If yes, by whom? John Arfman

Yield: 60 gal./min. with 20 ft. drawdown after 1 hrs.

Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.

Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test 05-14-10

Bailer Test _____ gal./min. with _____ ft. drawdown after _____ hrs.

Airtest 35 gal./min. with stem set at 135 ft. for 1 hrs.

Artesian flow _____ g.p.m. Date _____

Temperature of water _____ Was a chemical analysis made? [ ] Yes [X] No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Brown silty sand	0	8
Light brown silty gravels	8	20
Light brown sand gravel	20	36
Compact angular light brown gravels	36	65
Gray silty gravels	65	70
Dry sand	70	72
Sand silt small gravels –WB	72	80
Gray angular gravel dense silty	80	105
Gray soft silt	105	127
Gray sand trace gravels	127	132
Gray sand -active WB	132	148
Gray soft silt small angular gravels	148	156

RECEIVED
MAY 27 2010
Dept of Ecology
WR-NWRO

Start Date 05-11-10 Completed Date 05-14-10

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

[X] Driller [ ] Engineer [X] Trainee Name (Print) John Arfman

Driller/Engineer/Trainee Signature _____

Driller or trainee License No. 2673

IF TRAINEE: Driller's License No: _____

Driller's Signature: _____

Drilling Company JKA Enterprises, Inc.

Address 21703 195th AVE SE
Monroe, WA 98272-8831

Contractor's Registration No. JKENTI*945QC Date 05-20-10

ECY 050-1-20 (Rev 4/07)

www.jkawelldrilling.com

Ecology is an Equal Opportunity Employer

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

Norman Crooks

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

27/05-21K
Application No.

Permit No.

Norman Crooks

(1) OWNER: Name [redacted] Address 4303 Maltby Road Bothell Wash 98012

(2) LOCATION OF WELL: County Snohomish — NW ¼ SW ¼ Sec. 21 T. 27 N., R. 5E W.M.

Bearing and distance from section or subdivision corner Rt 1 6-A was NWly SE¼ Ly N of county Road

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ......
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☒ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 262 ft. Depth of completed well 262 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: ......" Diam. from ...... ft. to ...... ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☒ 6" Diam. from +1 ft. to 262 ft.

Perforations: Yes ☐ No ☒ Mrs Crooks Recalls Pres was did Perforate When well
Type of perforator used ......
SIZE of perforations ...... in. by Was drilled in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☒ —
Manufacturer's Name Johnson
Type Stainless Model No. ......
Diam. ...... Slot size 14 from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☒ — Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☒ To what depth? 20 ft.
Material used in seal 6 sacks ......
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ...... Depth of strata ......
Method of sealing strata off ......

(7) PUMP: Manufacturer's Name ......
Type: Sub ...... H.P. ......

(8) WATER LEVELS: Land-surface elevation above mean sea level ...... ft.
Static level 117 ft. below top of well Date Aug 1988
Artesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Owner
Yield: gal./min. with ft. drawdown after hrs.
" 15 " " 10 hrs "
" But no data on DD "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

SEP 0? 1988

Date of test ......
Bailer test 15 gal./min. with 2 ft. drawdown after 1 hrs.
Artesian flow ...... g.p.m. Date Aug
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Not when we started		
It was deep		127 Ft
Has been a fair well for 25 years But was down to about 2 gpm.		
Sand & gravel with thin layers yellow clay.	127	135
Water Bearing		
Sand	135	138
But now it has an 8-6' Screen with a 2 Ft Riser		
Pipe drops very hard for 10 Ft and hard Bed very hard Sand at the Point of Removal		
It took over 2 days to do the work		
"Well seal"		
Well was drilled 30 years ago So all that could be done was to Put Bentonite along side of casing and Pour a cement slab around a 2 Ft Piece of 8" pipe		
water from Bailing did not go onto the area around the well it just Ran off		

Work started Aug 19 1988 Completed Aug 24 1988

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME H.O. Meyer Drlg Co (Person, firm, or corporation) (Type or print)

Address 6424 Lake Wn Blvd NE

[Signed] Kirkland Wa. 98033 H O Meyer (Well Driller)

License No. 0308 Date Aug 28 1988

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

Repair & deepening well

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. ______ 27-05-21

Water Right Permit No. ______

(1) OWNER: Name NORMAN & HAZEL Clark   Address 4303 Maltby Road

(2) LOCATION OF WELL: County SNO   Por. of Sect 21 ___ ¼ ___ ¼ Sec 21 T 27 N., R 5E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) 4303 Maltby Road Bothell Wash

(3) PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ______
Abandoned ☐ New well ☐ Deepened ☒ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 137 feet. Depth of completed well 137 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from + ft. to 133 ft.
Welded ☒ ___ " Diam. from ___ ft. to ___ ft.
Liner installed ☐ ___ " Diam. from ___ ft. to ___ ft.
Threaded ☐

Perforations: Yes ☒ No ☒
Type of perforator used Mills Knife in 1955
SIZE of perforations 1/4 X 1" in. by ___ in.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.

Screens: Yes ☒ No ☒
Manufacturer's Name Johnson Total Length 8 Ft
Type Stainless St. Model No. ______
Diam. 6 Slot size 14 from ___ ft. to ___ ft.
Diam. ___ Slot size ___ from ___ ft. to ___ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ______
Gravel placed from ___ ft. to ___ ft.

Surface seal: Yes ☐ No ☒ To what depth? ______
Material used in seal ______
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name goulds
Type: Sub H.P. 1

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 120 ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ______
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
Pump has Been Run For 4 to 8 hrs
To Irrigate Orchard
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test 15 gal./min. with 2 ft. drawdown after 1½ hrs.
Airtest ___ gal./min. with stem set at ___ ft. for ___ hrs.
Artesian flow ___ g.p.m. Date ______
Temperature of water ___ Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Well was originally drilled in 1955 to	128	
Course sand & gravel to 1" dia	128	136
Fine sand & some gr.	136	139
drilled to set screen		
Pipe drove very slow		
Used about 8 hrs to move it 11 FT		
Took 4 hours to Pull Pipe Back 3'-8"		
We always did put the drill cuttings along side the pipe as we drilled. The [illegible] So there would Be Some [illegible] around the well.		

OCT 06 1988
DEPARTMENT OF ECOLOGY
NORTHWEST REGION

Work started Aug 20, 1988 Completed Aug 23, 1988

WELL CONSTRUCTOR CERTIFICATION:

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

NAME H.O. MEYER Drlg Co (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 6924 Lake Wn Blvd NE. Kirkland, Wash 98033
(Signed) H.O. Meyer (WELL DRILLER) License No. 0368
Contractor's Registration No. 232-01-227 Date Aug 25, 1988

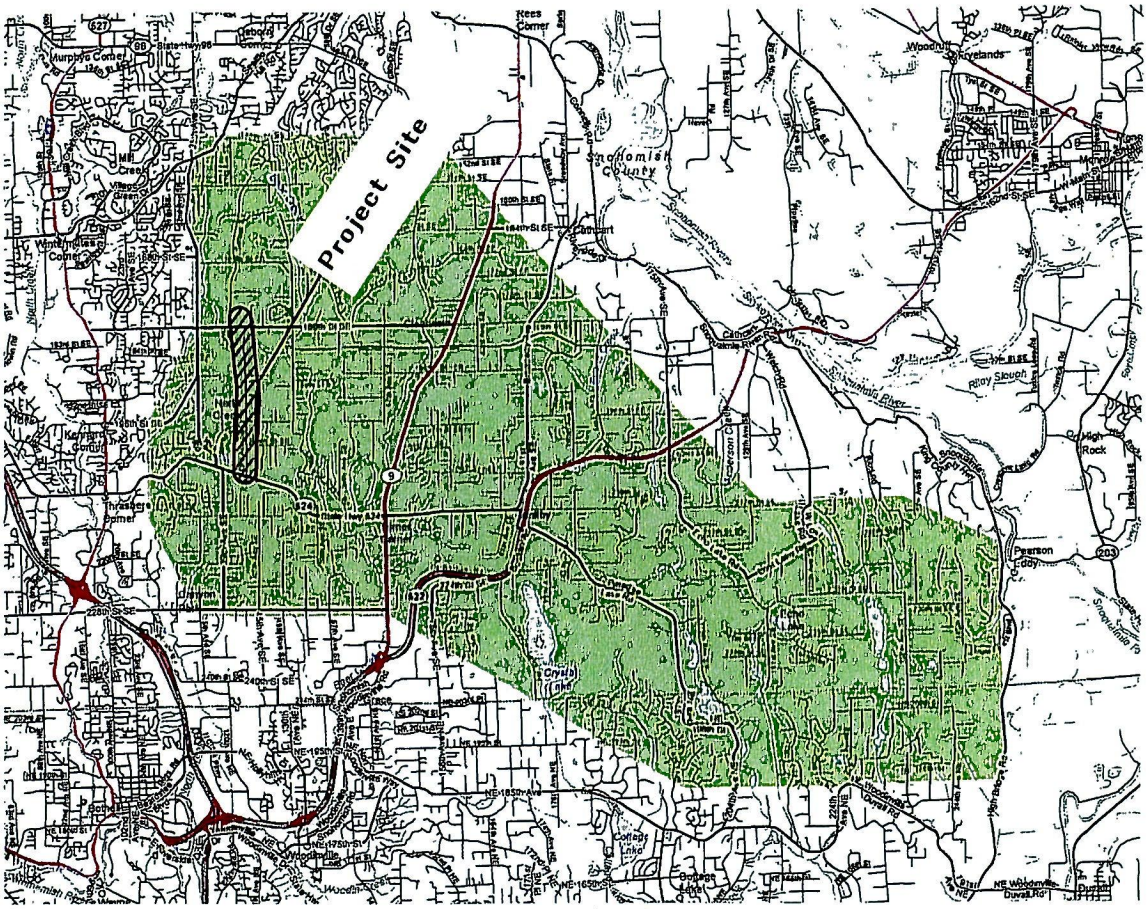
(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329-

APPENDIX G

Hydrogeologic Report

PREPARED BY SNOHOMISH COUNTY
DEPARTMENT OF PUBLIC WORKS



HYDROGEOLOGIC REPORT

43rd Ave SE/Sunset Road: 180th St SE to SR542

RC1592-115-37

SNOHOMISH COUNTY
DIRECTOR OF PUBLIC WORKS
STEVEN E. THOMSEN, P.E.

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1.0 INTRODUCTION

1.1 *Background*

This report contains the results of a focused hydrogeological investigation for the proposed improvements to 43rd Av SE/Sunset Road between 180th St SE and SR524 (*site, project site*) located in southwestern unincorporated Snohomish County Washington (*T27N, R5E, sections 16 and 21*). As checked at various locations along the project alignment latitude and longitude ranged between 47.812°N to 47.836°N, -122.175°W to -122.177°W. A **Vicinity Map** showing the location of the project site relative to existing municipal improvements is included in *Appendix A* of this report.

The purpose of this project is to provide an additional north/south arterial route that will help relieve existing traffic pressures along 35th Ave SE in southwestern unincorporated Snohomish County. The proposed project will include: improvements to the intersections of 180th St SE and Sunset Road and 43rd Ave SE and SR524; a new rural public road connection along 43rd Ave SE between 200th St SE and 196th St SE (SR524); new urban road sections along 43rd Ave SE and new sidewalks and stormwater collection and detention systems throughout the entire alignment. A **Site Map** showing the proposed road alignment is included in *Appendix B* of this report.

We understand that the proposed project improvements may require permits that are regulated under Part 300 Standards and Requirements of **Snohomish County** *Code 30.62C* Critical Aquifer Recharge Area. Per **Snohomish County** *Code Section 30.62C.140* **Hydrogeologic Report** - a hydrogeologic report is required for any activity or use requiring a project permit regulated under Part 300 and proposed within a designated Sole Source Aquifer Area, Group A Wellhead Protection Area or Critical Aquifer Recharge Area with high or moderated groundwater sensitivity. Portions of the project alignment are located within a Critical Aquifer Recharge Area of moderate to high groundwater sensitivity and the entire proposed alignment is located within a designated Sole Source Aquifer Area.

1.2 *Purpose and Scope*

The purpose of this investigation was to evaluate and expand upon existing soil, hydrogeological and geologic information in the vicinity of the project site and based on this information prepare a **Hydrogeologic Report** that meets **Snohomish County** *Code Section 30.62C.140* requirements. This report will provide permitting, design and construction phase information and recommendations related to the sites hydrogeological characteristics and may be used in conjunction with the projects *Geotechnical Memorandum* which will be prepared at a later date. Work performed during this investigation included: a review of the project design elements and requirements as of January 2018; a review of the projects *Preliminary Geotechnical Memorandum* dated April 2018; a review of geologic maps, hydrogeologic maps and hydrogeologic reports prepared for **Snohomish County** by consultants, the **USGS** and others; a review of hydrogeologic information on file with the **Washington State Department of**

Ecology (*DOE*) and at the **Snohomish County Health Department;** a review of water system data and well logs on file with the **Washington State Department of Health** (*DOH*); and the preparation of this Hydrogeologic Report. This investigation has been completed and the report has been prepared by a Washington State licensed Hydrogeologist in general accordance with professional geologic and hydrogeologic standards of care currently utilized in the Puget Sound region and meets the requirements established by **Snohomish County** *Critical Area Ordinance section 30.62C.140.*

2.0 SITE CHARACTERISTICS

The site is located just south of the City of Mill Creek and just north of the City of Bothell in unincorporated Snohomish County. The area around the project site is rapidly developing consisting of a mixture of old acreage parcels and small ranches surrounded by new medium to high density residential neighborhoods. The existing road system consists of a network of old country roads, lanes and new residential streets. Main east/west arterials are 180th St SE at the north end and SR524 at the south end of the project alignment. The only main north/south arterial in the area is 35th Ave SE, located west of the project alignment.

The general topography in the immediate vicinity of the project site is typical of glaciated landscapes in western Washington State – broad fairly flat landscapes bisected by seasonal and/or year round small drainages and creeks. The project alignment is located within the Little Bear Creek Sub-basin in the Cedar-Sammamish Watershed. The project alignment follows along a fairly broad topographic high that serves as a drainage divide between Bear Creek to the east and North Creek to the west. Elevations along the alignment as taken from the **USGS** *Bothell Quadrangle Topographic Map* (*1953*) range from approximately el. 350 at the north end of the alignment to approximately el. 400 at the south end of the alignment.

3.0 GEOLOGIC SETTING

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

The low undulating plains that are characteristic of the Puget Lowland are the result of repeated advances (*stades*) and retreats (*interstades*) of the Puget Lobe of the cordilleran (*continental*) ice sheets that flowed into and out of this area from the north during the Pleistocene Epoch (*a*

geologic time period dating from approximately 1 million years ago to the present). Within the river valleys that extend into the foothills, these repeated cordilleran ice sheet advances and retreats were supplemented by localized alpine glacier advances and retreats resulting in a more complex and longer lasting ice contact depositional history. Current land surfaces in the vicinity of the project site reflect surficial topographic changes directly related to the most recent glacial advance and retreat through Snohomish County – the Vashon Stade of the Fraser Glaciation. The Vashon Stade of the Fraser Glaciation covered the low lying areas of Snohomish County with thousands of feet of glacial ice between 20,000 and 13,000 years ago and achieved a maximum thickness in the vicinity of the project site between 18,000 to 16,000 years ago. The geologically mapped units of Vashon Advance Outwash (*Qva*), Vashon Glacial Till (*Qvt*), and Vashon Recessional Outwash (*Qvr*) were all deposited in this area as a result of the latest glacial advance and retreat during this time period. Since the last retreat of glacial ice out of the Snohomish County area approximately 13,000 years ago, existing topography in the area of the project site has been altered through erosional processes related to weathering. In the vicinity of the project site, processes related to weathering have deposited Younger Alluvium (*Qal, Qyal*) in and along local drainages and in topographic low areas along the alignment.

Surficial geology of the project area has been mapped by the **USGS** and is shown on the "**Geologic Map of the Bothell 7.5-minute Quadrangle, King and Snohomish Counties, Wa.**" by J.P. Minard dated 1985, MF-1747. A copy of a portion of this **Geologic Map** that includes the project site and surrounding area has been included in *Appendix C* of this report. Mapped surficial geology along the majority of the project alignment consists of Vashon Glacial Till (*Qvt*) along with smaller areas of Vashon Advanced Outwash (*Qva*) at the north end of the alignment and Vashon Recessional Outwash (*Qvr*) at the south end of the alignment.

The primary mapped **NRCS** soils classification for the project site consist of Alderwood gravelly sandy loam (*units 1 and 2*) and Alderwood-Everett gravelly sandy loam (*unit 4*).

4.0 SITE GEOLOGY

Subsurface soil conditions below the project site were investigated through the drilling of nine-(*9*) borings along the length of the proposed alignment improvements. The borings were all advanced with a truck mounted Mobile B-58 drill rig to a maximum depth of 26.5 ft. below ground surface (*bgs*) at each location. Test boring locations are shown on the **Site Map** included in *Appendix B* of this report. Soils removed at each exploration location were visually observed upon removal from the ground and classified by a Geotechnical Engineering from *SCPW-Engineering Services* following the **Unified Soil Classification System** (*U.S.C.S*) in general accordance with **ASTM D2488**, Standard Recommended Practice for the Description of Soil *(Visual-Manual Procedures)*. **Test Boring Logs** are contained in *Appendix D* of this report. For reference purposes, a copy of the **Unified Soil Classification System** is contained in *Appendix E* of this report.

Site stratigraphy has been interpreted from the test boring logs and correlated with the mapped geology of the area as described on the **Geologic Map** in *Appendix C*. In general, good correlations were observed between the mapped geology and the soil types found in the test borings. Detailed soil descriptions and interpretations are included on the projects **Geotechnical Memorandum**. See the **Test Boring Logs**, *Appendix D* for further details.

5.0 HYDROGEOLOGY

5.1 Snohomish County Hydrogeology

Regional groundwater studies have been undertaken for **Snohomish County** by **Economic and Engineering Services, Inc./Sweet-Edwards/EMCON, Inc**. dated 1991; **Golder Associates** dated 1996 and the **USGS** dated 1997. Hydrogeologic units within the County have been identified and defined by these studies. In general, groundwater throughout the County occurs in a few different aquifers that are in most areas separated from each other by confining beds. Depending upon topography and location, groundwater occurs in both confined and unconfined conditions within the County's aquifers. The most extensive aquifers are found below the plateau areas of the County. Aquifers may also be found below the larger river systems within the County such as along the Stillaguamish River in north County and the Skykomish/Snohomish River that flows through the central portion of the County. According to the above referenced studies, unconsolidated geologic units permeable enough to transmit significant quantities of ground water (*aquifers*) throughout the County are Recent Alluvium or Younger Alluvium (*Qyal,Qa)*, Recessional Outwash (*Qvr*), Advance Outwash (*Qva*) and Olympia Gravels (*Qog*).

Confining beds are geologic units that are generally fine-grained and do not transmit significant quantities of water. According to the 1997 **USGS** report, confining beds or aquitards found throughout the County include Glacial Till (*Qvt*), Transitional Beds (*Qtb*), Older Till (*Qtu*), and portions of the Olympia Gravel (*Qog)*, Possession Drift (*Qpd*) and Tertiary Bedrock (*Tb*).

As described above and as shown on the **Geologic Map** (*Appendix C*), some of the geologic units described above are found in the immediate vicinity of and/or below the project alignment.

5.2 Sole Source Aquifer

The project alignment is located within the southwest corner of the **USEPA** designated Cross Valley Sole Source Aquifer. The irregular shaped boundaries of the Cross Valley Sole Source Aquifer are shown on the attached **Sole Source Aquifer Map** included in *Appendix F* of this report. There are no significant rivers or streams that cross the Cross Valley Sole Source Aquifer. Several of the small streams that originate within the sole source aquifer area or cross the land surface above the aquifer (*Bear Creek, Swamp Creek, North Creek*) obtain base flow from the aquifer and/or recharge the aquifer during different times of the year. Little Lake, Crystal Lake and Echo Lake are all found within the Cross Valley Sole Source Aquifer area.

The primary source of groundwater within the Cross Valley Sole Source Aquifer is found in the Advance Outwash (*Qva*) sands and gravels. Aquifer recharge within the Cross Valley Sole Source Aquifer is primarily from precipitation, is estimated to range between 50 to 75 inches per year according to the **USGS** (*1997*). Groundwater flow within the Cross Valley Sole Source Aquifer is shown on the **Ground Water Flow Direction Map** contained in *Appendix G* of this report.

5.3 Aquifer Sensitivity

The project site is located on a topographic feature known as the Intercity Plateau in an area that is underlain by the Cross Valley Sole Source Aquifer. Based on the projects geotechnical explorations surficial soils along the majority of the proposed alignment consists of weathered to unweathered Glacial Till (*Qvt*) at depth (*section 4.0* ***SITE GEOLOGY***). As indicated in section 5.1 *Snohomish County Hydrogeology* above, Glacial Till (*Qvt*) is considered to be an aquitard or confining unit which due to its composition and density does not readily transmit groundwater through it. In addition, Recessional Outwash (*Qvr*), consisting of gravelly sand, was encountered at the south end of the alignment in the immediate vicinity of SR524 (*see Test Boring B-09, Appendix D*). As indicated in *section 5.1* above, Recessional Outwash (*Qvr*) may be considered a potential aquifer where there is sufficient thickness of permeable soils and significant amounts of groundwater are present. Where groundwater is present within the Recessional Outwash (*Qvr*), it is found in an unconfined condition and usually is perched on top of Glacial Till (*Qvt*).

As shown on the **Aquifer Sensitivity Map,** a copy of which is contained in *Appendix H* of this report, the majority of project alignment is located in an area of low sensitivity for the confined, Advance Outwash (*Qva*) aquifer. Low aquifer sensitivity is found in areas where the groundwater table is deep and generally confined from surficial sources of contamination by impermeable soils (*Glacial Till, Qvt*). The portion underlain by Recessional Outwash (*Qvr*) gravelly sands at the south end of alignment is mapped as high sensitivity, being unconfined and exposed to potential surficial sources of contamination.

In addition, Test Boring B-06W (*see Test Boring Log B-06W, Appendix D*), encountered weathered to unweathered Advance Outwash (*Qva*) sands from the ground surface to its full depth of exploration. The area surrounding this boring location would also be considered highly sensitive due to the surficial exposure of the Advance Outwash (Qva) aquifer.

6.0 GROUNDWATER

6.1 Water Systems

The Cross Valley Water Association is the primary water purveyor utilizing the Cross Valley Sole Source Aquifer. The Cross Valley Water Association service area is primarily located east of the project alignment. Public water along the project alignment is supplied by the Alderwood

Water District and the Silver Lake Water and Sewer Districts. Besides the Cross Valley Water Association, adjacent public water supply systems to those listed above include the City of Snohomish, the City of Everett and the Woodinville Water District.

Group A water well systems are water systems that have more than 15 private residential connections per well serving 25 or more people 60 or more days per year. There are no Group A water well systems located within a two-(2) mile radius of the project alignment. Group A water wells and their associated 10 year travel time are shown on the **Group A Water Well/Travel Time Map** located in *Appendix I* of this report. As well as the Cross Valley Water District wells, these Group A water wells also include the East Crystal Lake Community well, the Crystal Lake Inc. well, the Morning Glory well and the Woodlane Water System well.

Group B water well systems are water wells that have less than 15 private residential connections per well serving fewer than 25 people and includes wells providing water to public facilities such as schools, meeting halls, churches, etc. There are two-(2) Group B water system wells located in the immediate vicinity of the project site. The North Creek Homes Water System is located approximately ½ mile east of the alignment along 51st Ave SE and the Lazy Eight Water System is located immediately adjacent to the alignment at the southeast corner of 196th St SE and 43rd Ave SE. Group B water systems and their wellhead protection areas within the proximity of the project alignment are shown on the **Group B Water Well/Travel Time Map** located in *Appendix J* of this report.

6.2 Private Wells

According to the **Washington State Department of Health** (*DOH*) records, domestic water supply in the vicinity of the project site is primarily provided by the Alderwood Water District and the Silver Lake Water and Sewer District. According to our data search, it appears that there are five-(5) private water wells in the vicinity of the project alignment that are registered with **DOE** or with the **DOH**. A list of **Registered Water Wells** within one-half mile of the project site found in the **DOH** and/or **DOE** databases is given in *Table 1* below.

TABLE 1
Registered Wells in the Immediate Vicinity of the Project Site

DOE Well ID #	Physical Address	Depth Drilled (ft. bgs)	Screened Interval (ft.)	Static Level* (ft. bgs)
na/1986	3831-188th St SE	101	none	61
na/1987	3709 Jewell Rd.	109	104-109	70
na/1988	4303 Maltby Rd.	138	none	117
ALS-790	3722-188th St SE	156	133-143	72
na/1987	4426-196th St SE	124	none	70

*as measured at the time of initial well development by the drilling contractor

Water Well Reports are filled out by the driller and provide a rough correlation of the subsurface soil profile at the well location, but may not be indicative of actual geologic conditions.

Groundwater depths are as measured by the driller at the time of initial well development. The static water levels shown are not indicative of any water pressures within the screened intervals of the well, but instead indicate a more generalized piezometric water elevation at the well location. For reference purposes copies of the **Water Well Reports** listed in *Table 1* above (*drillers' logs submitted to DOE*) are contained in *Appendix K* of this report.

Given the relatively age of the small farms and single family residences in the vicinity of the project site, a windshield reconnaissance was performed where we were specifically looking for water wells (*hand dug, concrete cased, shallow wells and regular cased drilled wells*) and pump houses that were visible from County owned right-of-way. There were no wells, pump houses or other site improvements noted during this reconnaissance that would indicate the presence of private groundwater wells on properties immediately adjacent to the project alignment.

6.3 Local Ground Water Regime

Nine-(*9*) test borings have been drilled along the project alignment. Copies of the **Test Boring Logs** are contained in *Appendix D* of this report. The locations of the borings are shown on the **Site Map** contained in *Appendix B* of this report. In general, a good correlation was found between the mapped geology of the project alignment and those found at the test boring locations. At the test boring locations, perched ground water was encountered at depths ranging between 13 feet below ground surface (*bgs*) to 24.5 feet bgs within discontinuous lenses of sand and gravel within the Glacial Till (*Qvt*). No ground water was found within the exploration depths at the B-07 and B-09 locations. Advance Outwash (*Qva*) sands were encountered at the Test Boring B-06W location. See **Test Boring Log B-06W** located in *Appendix L* of this report for detailed descriptions of the encountered soils at this location. This test boring was placed at the topographically lowest point along the alignment at an approximate topographic elevation of el. 345. An observation well was placed within the test boring upon completion. Details of the installation of the observation well are contained on the **Test Boring Log B-06W**. Groundwater depth measurements taken from the observation well are contained in *Table 2*, **B-06W Groundwater Readings** below.

This entire area including and surrounding the project alignment is located within the Little Bear Creek Sub-basin of the Cedar-Sammamish Watershed. Surficial soils within the immediate vicinity of the project alignment consist primarily of Glacial Till (*Qvt*), a very dense mixture of sands, silts and gravels that has a consistency similar to concrete - except at the boring B-06W location (*see above*) and at the very southern end of the alignment where Recessional Outwash (*Qvr*) sands were encountered (*see **Geologic Map**, Appendix C*). As such, surface water run-off is very high along the majority of the alignment and any infiltration will be slow. Surface water run-off in the southern portion of the alignment underlain by Recessional Outwash (*Qvr*) and/or Advance Outwash (*Qva*) located south of 196th St SE will be an order higher than the rest of the alignment due to the higher permeability rates of these soils. Surface water run-off and precipitation that infiltrates into the shallow surficial soils along this alignment will move

laterally following the general topography of the area towards either Bear Creek or North Creek, similar to the deeper groundwater flow gradients of the Cross Valley Sole Source Aquifer (*Groundwater Flow Direction Map, Appendix G*).

TABLE 2
B-06W Groundwater Readings

Well Number	Monument Elevation	Reading Date	Depth to Ground Water	Ground Water elevation
B-6W	355.0*	3/23/18	dry	na
		4/16/18	14.83	340.17
		5/17/18	dry	na

*estimated off of topographic map

Groundwater found in the discontinuous sandy lenses within the Glacial Till (*Qvt*) is considered unconfined and is not a reliable source of ground water. Recharge of these discontinuous lenses is hard to predict and will be subject to prevailing precipitation, ground cover and topography. In general, conductivity of the Glacial Till (*Qvt*) is low to very low, averaging approximately 0.04 ft./day (***USGS**, 1997*). The area of the alignment in the immediate vicinity of B-06W that is underlain by Advance Outwash (*Qva*) sands will exhibit a significantly higher conductivity rate than the surround area underlain by Glacial Till (*Qvt*), averaging approximately 3.4 ft./dy.(***USGS**, 1997*). Where exposed at the ground surface in the immediate vicinity of B-06W, the Advance Outwash (*Qva*) groundwater aquifer is unconfined. In areas along the alignment where it is overlain by Glacial Till (*Qvt*), groundwater within the Advance Outwash (*Qva*) aquifer will be confined. Observation well B-06W is 20 feet deep. Groundwater was found in the well during one-(*1*) of the three-(*3*) sampling events to date, at a depth of 14.83 feet below the ground surface (*see Table 2, B-06W Groundwater Readings, above*).

6.4 Local Groundwater Use

Local groundwater use appears to be mixed based on our review of the registered groundwater wells in the vicinity of the project site. The majority of the project alignment is covered with public water supplies as discussed in *section 6.1*, **Water Systems** above. Private **DOE** registered groundwater wells located in the vicinity of the project alignment are discussed in *section 6.2*, **Private Wells** above and are listed in *Table 1*, **Registered Wells in the Immediate Vicinity of the Project Site.** None of the registered private wells are located or screened within an area of influence of the project alignment.

A windshield reconnaissance of the project alignment looking for any signs of unregistered water wells resulted in no additional information. There were no water wells observed from County right-of-way during this reconnaissance of the alignment.

There are no Group A ground water systems located within an area of influence of the project alignment as discussed in *section 6.1* above. There is one-(*1*) Group B water well system located within an area of influence of the project alignment. The Lazy Eight Water System is located in the southeast corner of the intersection of 43rd Ave SE and 196th St SE and is immediately down-gradient from the project alignment. It consists of two-(2) wells, designated Well A and Well B. Well A is 95 feet deep and Well B is 110 feet deep. Susceptibility of these wells to contamination from surficial source is considered high according to the **DOH**. The assigned 600 ft. travel time wellhead protection area is located approximately 40 ft. east of the project alignment at its closest point, see the **Group B Water Well/Travel Time Map** in *Appendix J* of the report for location details. Given the medium horizontal hydraulic conductivity rate of 40 feet/year, this assigned wellhead protection area represents an approximate 15 year travel time radius. Well logs for the Lazy Eight Water System were not available on **DOE's** registered water well data base. Based on the high susceptibility rating that the **Department of Health** (*DOH*) has placed on the wells, we believe that they must have been drilled through Advance Outwash (*Qva*) sands for their entire depth. Observation well B-06W is located immediately adjacent to the wellhead protection area of the Lazy Eight Water System on the project alignment. According to the B-06W well log, Advance Outwash (*Qva*) sand was encountered from the ground surface to the total depth of the boring at this location. The well is 20 feet deep and ground water is found in it intermittently, after extended periods of wet weather (*see Table 2 above*).

7.0 DESIGN MITIGATIONS FOR POTENTIAL GROUNDWATER IMPACTS

As outlined above, the project as proposed will have limited impact potential to the Cross Valley Sole Source Aquifer. Identified impact potentials will be mitigated per the following discussions.

7.1 Design Elements

The proposed improvements to 43rd Ave SE include: a new roadway alignment through currently unimproved portions of the alignment, widening of the existing roadways to including curb, gutter and sidewalks, turn pockets at major intersections, signalization of major intersections, and appropriate storm water controls.

7.2 Potential Design Element Ground Water Impacts

That portion of the alignment located north of 196th St SE is underlain by Glacial Till (*Qvt*), where run-off will be high and any soils exposed to the elements will be moisture sensitive. Indirect impacts to the groundwater quality may occur during grading operations through siltation and possible run-off impacts to adjacent wetlands that act as a recharge source for the underlying groundwater aquifer.

The portion of the project alignment located south of 196th St SE is underlain by either Advance Outwash (*Qva*) and/or Recessional Outwash (*Qvr*) sands. Where these groundwater aquifers are unconfined and exposed at the ground surface, they are considered to have a high susceptibility to contamination from surficial sources. Indirect impacts to the groundwater quality may occur during grading operations through siltation and run-off impacts to adjacent wetlands that recharge the underlying groundwater aquifer. In addition, the unconfined aquifers would be highly susceptible to contamination from inadvertent spills of construction fluids such as petroleum, oils, grease and solvents and by daily traffic use once the project has been completed.

Due to increased impermeable surfaces as the result of the proposed new roadway alignments, stormwater run-off will be collected and directed into detention or retention ponds for treatment and discharge. According to the test boring logs, the shallowest evidence of groundwater at the boring locations is 13 feet bgs.

7.3 Mitigation Measures for Potential Impacts

Grading and excavation for the proposed project improvements will not result in any potential groundwater impacts provided environmentally friendly engineering practices and BMP's are specified in the project plans and specifications and implemented during construction. Because the entire project is located within an **EPA** designated sole source aquifer area and portions of the alignment are located above the unconfined aquifer and to help insure the success of these BMP practices during the construction of the project, we highly recommend that these operations only take place during extended periods of dry weather or during the dryer months of the year – generally between May and October.

Retention and/or detention ponds will be located along the alignment as necessary to collect, store and release storm water. Storm water ponds located along the alignment north of 196th St SE will be underlain by Glacial Till (*Qvt*) according to test borings B-01 thru B-05, all located along this portion of the alignment (*see **Test Boring Logs**, Appendix D*). We recommend that retention be utilized for collected storm water along this portion of the alignment. The minimum depth to groundwater based on the test boring logs is 13 feet bgs and the minimum amount of separation between the bottom of a retention pond and the top of the groundwater table is five-(*5*) feet by **Snohomish County** code – resulting in a maximum recommended retention pond bottom depth of seven-(*7*) feet bgs along this portion of the alignment.. All collected storm water should be treated prior to introduction into a retention pond. Retention ponds along this portion of the alignment should be sized and designed utilizing a maximum infiltration rate of 0.24 in./hr.

A portion of the alignment between 196th St SE and 200th St SE is underlain by Advance Outwash (*Qva*) according to test boring B-06W. This is the primary aquifer formation for the Cross Valley Sole Source Aquifer. Because of this and the proximity of the Lazy Eight Water System to the project alignment and its high susceptibility to contamination from surficial

sources according to the **DOH**, we recommend that detention be utilized for collected storm water in this area of the alignment. We recommend that the detention pond be lined with an engineered liner or a minimum of two-(2) feet of impermeable soil with a fines content greater than 25% passing the #200 sieve. Some Glacial Till's (*Qvt*) will meet this general requirement.

According to the test boring logs (*B-07, B-08*), the portion of the alignment south of 200th St SE to 204th St SE is underlain by Glacial Till (*Qvt*) (*the transition out of Glacial Till (Qvt) is currently unknown and has arbitrarily placed at 204th St SE for convenience*). We recommend that retention be utilized for collected storm water along this portion of the alignment. The minimum depth to groundwater based on the test boring logs is 15 feet bgs and the minimum amount of separation between the bottom of a retention pond and the top of the groundwater table is five-(5) feet by **Snohomish County** code – resulting in a maximum recommended retention pond bottom depth of 10 feet bgs along this portion of the alignment. All collected storm water should be treated prior to introduction into a retention pond. Retention ponds along this portion of the alignment should be sized and designed utilizing a maximum infiltration rate of 0.24 in./hr.

From approximately 204th St SE southward to the end of the project alignment at Maltby Road, the roadway is underlain by Recessional Outwash (*Qvr*) according to test boring B-09. According to the **Geologic Map** (*Appendix X*), the aerial extent of the Recessional Outwash (*Qvr*) is limited. Based on our records search and site reconnaissance there is no current private groundwater use along this portion of the alignment. Due to this, we believe that retention may be utilized for collected storm water. The estimated depth to seasonal groundwater based on the B-09 test boring log is 15 feet bgs and the minimum amount of separation between the bottom of a retention pond and the top of the ground water table is five-(5) feet by **Snohomish County** code – resulting in a maximum recommended retention pond bottom depth of 10 feet bgs along this portion of the alignment. All collected storm water should be treated prior to introduction into a retention pond. Retention ponds along this portion of the alignment should be sized and designed utilizing a maximum infiltration rate of 9 in./hr. (*25th percentile, table 4, pg. 43, USGS, 1996*).

Once the retention pond locations have been set along the entire alignment we recommend that specific site investigation be performed at each location to verify the design parameters recommended above.

The only other type of potential impact to the underlying ground water resource and its groundwater quality will be from construction practices themselves. Due to the project alignments location within the Cross Valley Sole Source Aquifer, we recommend that the contractor treat the entire alignment as sensitive. Care needs to be taken to ensure strict compliance with all project BMP's including erosion control, storm water control and spill prevention. We recommend that the contractor be required to submit to **SCPW** for approval a

Spill Prevention and Response Plan for the project which will be fully implemented and enforced by the construction engineer over the course of the project.

8.0 CONCLUSIONS

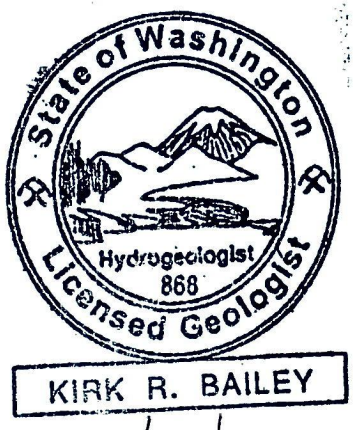
There are no Class A and only two-(2) Class B Water Systems within the immediate vicinity of the project alignment. There were no **DOE** or **DOH** registered water wells within the immediate vicinity of the project alignment. During the site reconnaissance, there were no observed unregistered water wells within the defined area of influence of the project site.

The project alignment is immediately up-gradient from and just outside of the assigned 600 foot 15 year travel time wellhead protection area of the Lazy Eight Water System, a Class B DOE registered water system. Project elements as mitigated in this memorandum will not impact this water system.

Along the majority of the project alignment, treated collected storm water can be discharged into properly sized and designed retention ponds. In the vicinity of the Lazy Eight Water System, just south of 196th St SE, collected storm water may be discharge into a properly sized and designed detention pond. We recommend that this proposed storm water detention pond be lined with either a manufactured liner or with an engineered low permeability fill material.

The recommended project elements outlined in this report have been designed to eliminate or mitigate any potential impacts to the aquifer, groundwater quality and to adjacent private water systems. All project BMP's and the application and use of a contractor submitted and **SCPW** approved *Spill Prevention and Response Plan* will need to be incorporated and followed during construction in order to maintain a no impact policy to the underlying sole source aquifer. It is also recommended that grading and filling operations along the alignment only take place during extended periods of dry weather.

8.1 Signature and License



5/30/18

Kirk R. Bailey, LEG, LHG
SCPW – Engineering Services

date

SELECTED REFERENCES

1) **Economic and Engineering Services, Inc.**; Snohomish County Groundwater Characterization Study, 1991
2) **Freeze, R.A. and Cheney, J.A.**; Groundwater, Prentice and Hall, 1979
3) **Golder and Associates, Inc.**; Geohydrology Memorandum - Snohomish County Groundwater Management Program, 1996
4) **Golder and Associates, Inc.**; Little Bear Creek Hydrogeologic Overview, 2005
5) **National Resource Conservation Service**; Soil Survey of Snohomish County, 1983
6) **Snohomish County**; Critical Area Regulation 30.62C, 2016
7) **Snohomish County Public Works**; Aquifer Recharge/Wellhead Protection Map, 2001
8) **Snohomish County Public Works**; Draft Geotechnical Memorandum, 43rd Ave SE/Sunset Road: 180th St SE to SR 524, 2018
9) **Todd, D.K.**; Groundwater Hydrology, John Wiley and Sons, 1980
10) **United States Geologic Survey**; "Geologic Map of the Bothell 7.5-Minute Quadrangle, King and Snohomish Counties, Wa." by J. P. Minard, 1985
11) **United States Geologic Survey**; The Ground-Water System and Ground-Water Quality in Western Snohomish County, Washington, Water Resources Investigations Report 96-4312, 1994
12) **United States Geologic Survey**; "Topographic Map of the Bothell 7.5-Minute Quadrangle, King and Snohomish Counties, WA." 1953
13) **Washington State Department of Ecology**; Well Logs, https://fortress.wa.gov/ecy/waterresources/map/WCLSWebMap/Default.aspx, 2018
14) **Washington State Department of Health**; Water Well Systems, https://doh.wa.gov/dataandstatisticalreports, Environmental Health, 2018

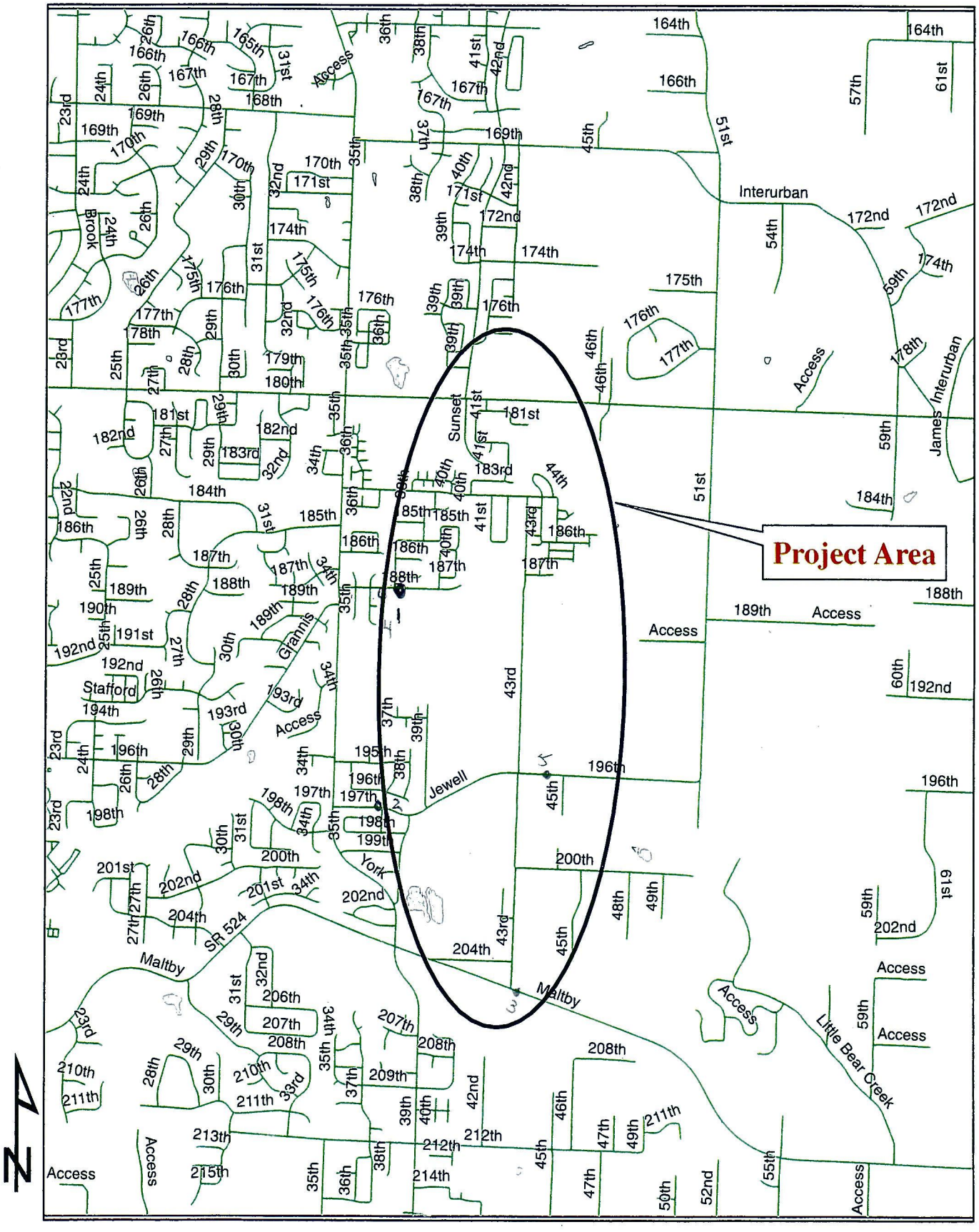
APPENDIX A

Vicinity Map

VICINITY MAP

43rd Avenue SE
RC 1592

Snohomish County

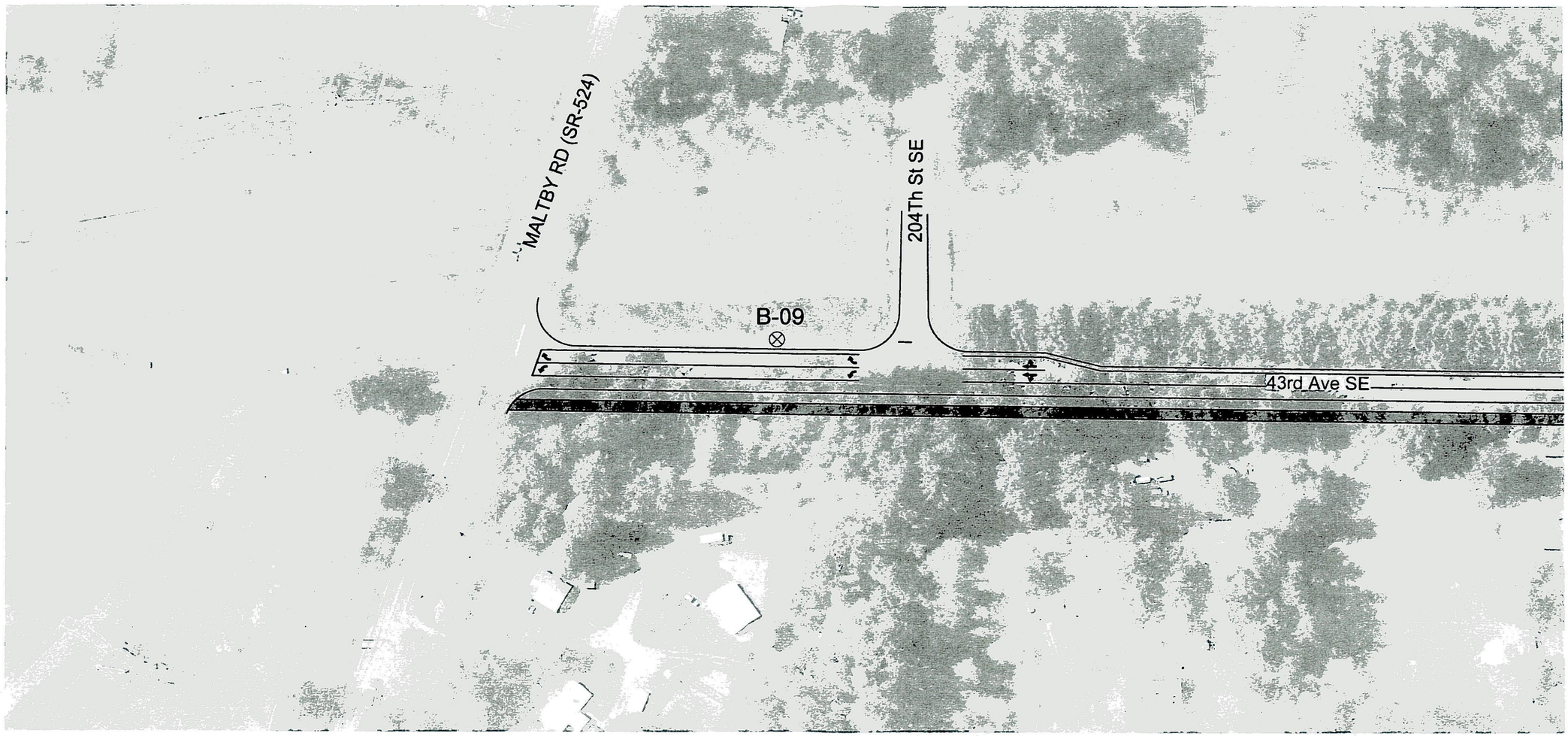


APPENDIX B

Site Map

Hydrogeologic Report
43rd Ave SE/Sunset Road: 180th St SE to SR542

RC1592-115-37



THE PRELIMINARY ROAD LAYOUT DRAWN BASED ON SCOPING LEVEL INFORMATION IS INTERNED TO SERVE AS A GUIDELINE FOR DETERMINING THE LOCATION OF SOIL EXPLORATION.

RW, PROPERTY LINES, AND SURFACE FEATURES ARE FROM GIS DATA AND ONLY APPROXIMATELY REPRESENT ACTUAL CONDITIONS. GROUND IMAGE FROM SNOHOMISH COUNTY 2015 SID IMAGES.

⊗ BORE-HOLE LOCATION

PROPOSED SHARED USE PATH

PROPOSED SIDEWALK

N

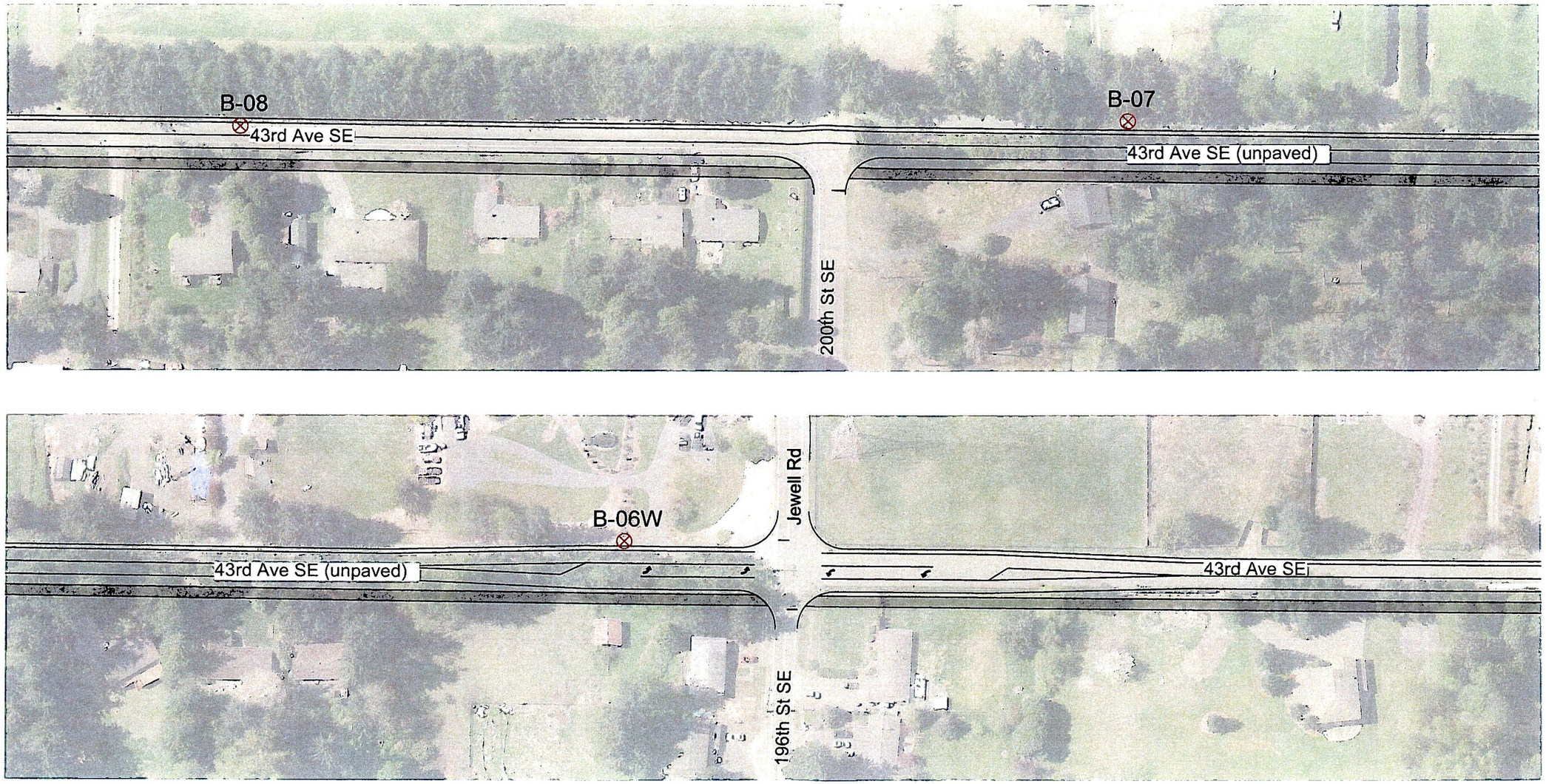
43RD AVE SE/SUNSET RD

SR524 to 180th St SE RC1592

SOIL EXPLORATION MAP
1 of 5

50 0 50 100
SCALE IN FEET

Snohomish County
Public Works



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RW, PROPERTY LINES, AND SURFACE FEATURES ARE FROM GIS DATA AND ONLY APPROXIMATELY REPRESENT ACTUAL CONDITIONS. GROUND IMAGE FROM SNOHOMISH COUNTY 2015 SID IMAGES.

⊗ BORE-HOLE LOCATION

PROPOSED SHARED USE PATH

PROPOSED SIDEWALK

43RD AVE SE/SUNSET RD

SR524 to 180th St SE RC1592

SOIL EXPLORATION MAP
2 of 5

50 0 50 100
SCALE IN FEET

Snohomish County
Public Works

THE PRELIMINARY ROAD LAYOUT DRAWN BASED ON SCOPING LEVEL INFORMATION IS INTERNED TO SERVE AS A GUIDELINE FOR DETERMINING THE LOCATION OF SOIL EXPLORATION.

RW, PROPERTY LINES, AND SURFACE FEATURES ARE FROM GIS DATA AND ONLY APPROXIMATELY REPRESENT ACTUAL CONDITIONS. GROUND IMAGE FROM SNOHOMISH COUNTY 2015 SID IMAGES.

⊗ BORE-HOLE LOCATION

PROPOSED SHARED USE PATH

PROPOSED SIDEWALK

N

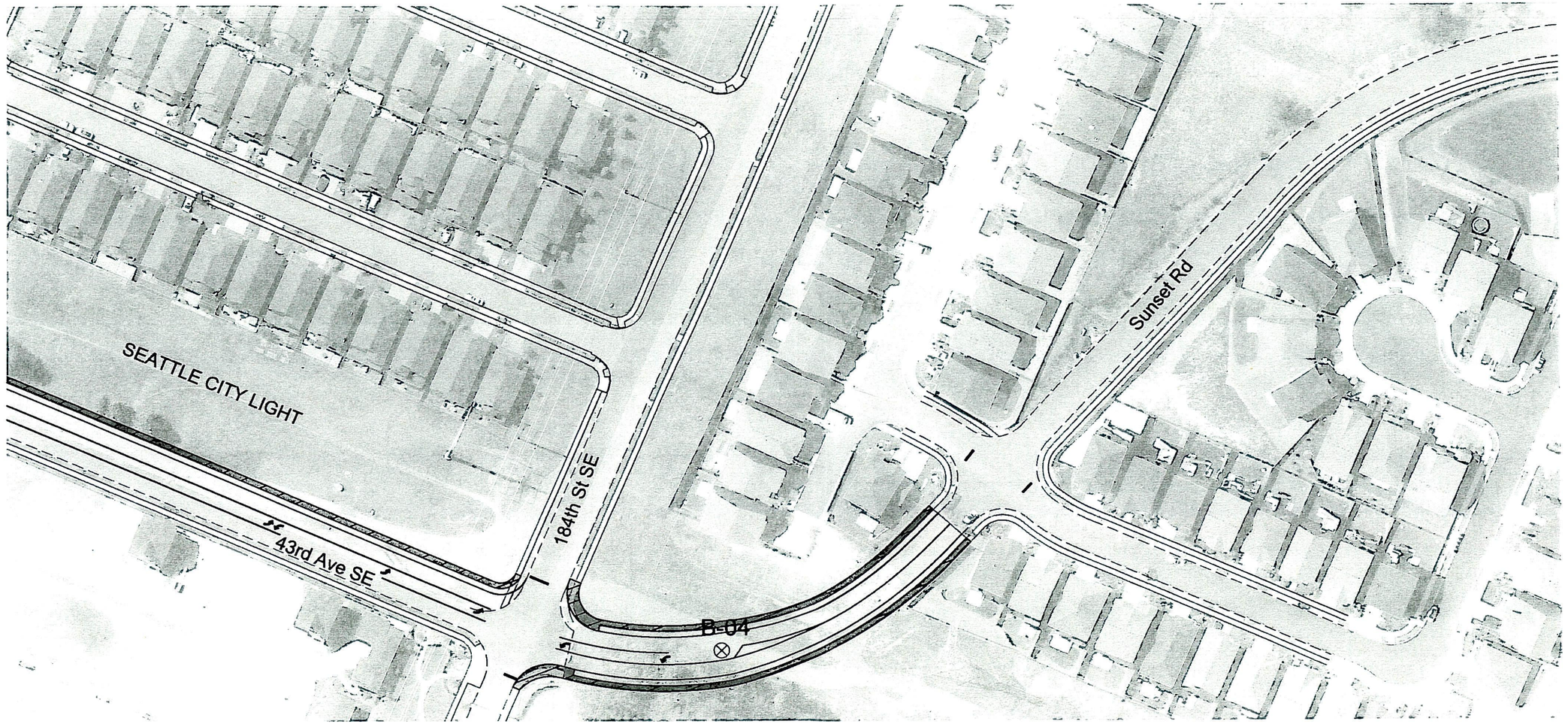
43RD AVE SE/SUNSET RD

SR524 to 180th St SE RC1592

SOIL EXPLORATION MAP
3 of 5

50 0 50 100
SCALE IN FEET

Snohomish County
Public Works



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⊗ BORE-HOLE LOCATION

PROPOSED SHARED USE PATH

PROPOSED SIDEWALK

N

43RD AVE SE/SUNSET RD

SR524 to 180th St SE RC1592

SOIL EXPLORATION MAP
4 of 5

50 0 50 100
SCALE IN FEET

Snohomish County
Public Works

THE PRELIMINARY ROAD LAYOUT DRAWN BASED ON SCOPING LEVEL INFORMATION IS INTERNED TO SERVE AS A GUIDELINE FOR DETERMINING THE LOCATION OF SOIL EXPLORATION.

RW, PROPERTY LINES, AND SURFACE FEATURES ARE FROM GIS DATA AND ONLY APPROXIMATELY REPRESENT ACTUAL CONDITIONS. GROUND IMAGE FROM SNOHOMISH COUNTY 2015 SID IMAGES.

⊗ BORE-HOLE LOCATION

PROPOSED SHARED USE PATH

PROPOSED SIDEWALK

N

43RD AVE SE/SUNSET RD

SR524 to 180th St SE RC1592

SOIL EXPLORATION MAP
5 of 5

50 0 50 100
SCALE IN FEET

Snohomish County
Public Works

APPENDIX C

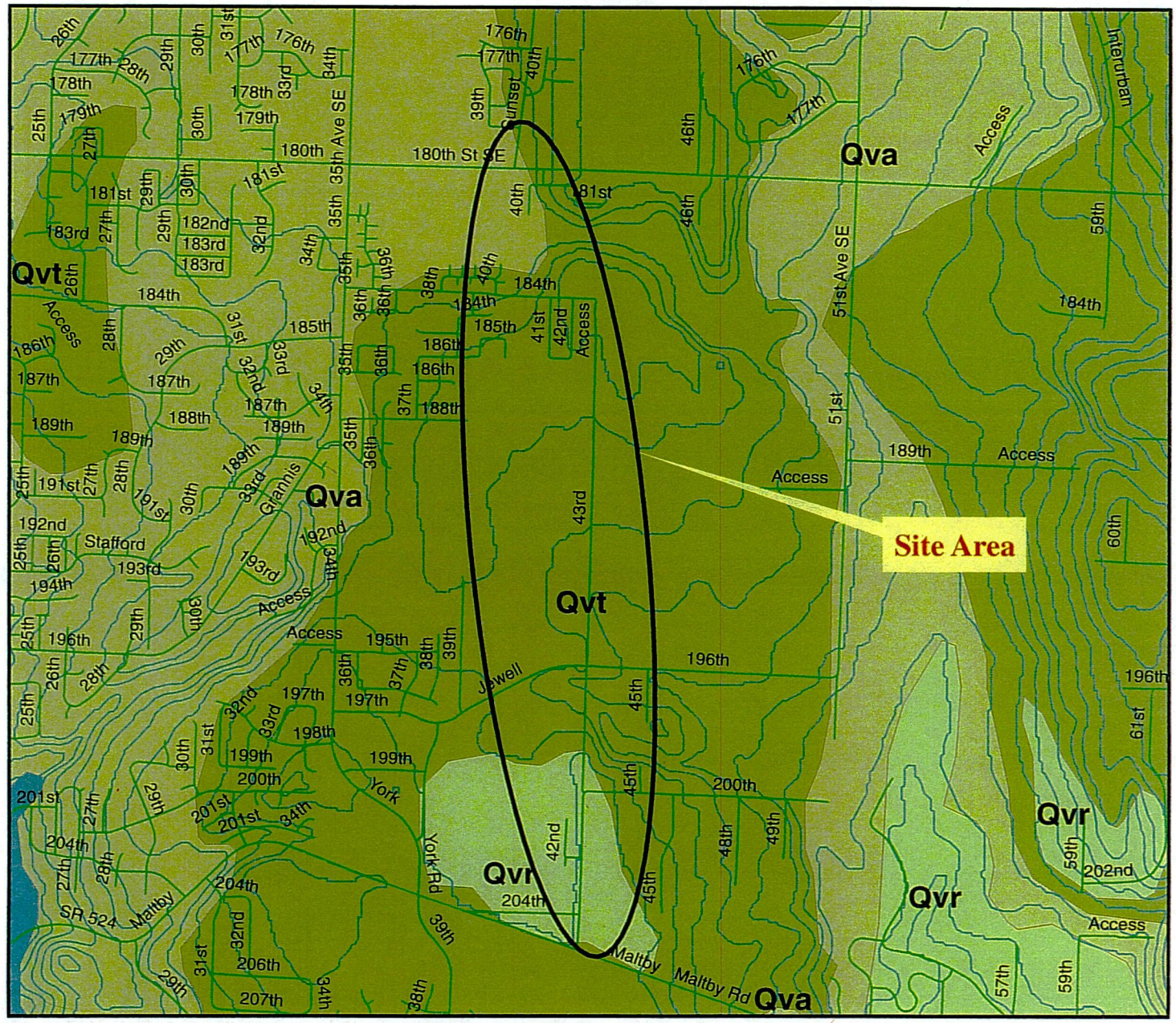
Geologic Map

Hydrogeologic Report
43rd Ave SE/Sunset Road: 180th St SE to SR542

RC1592-115-37

GEOLOGIC MAP
43rd Avenue SE
RC 1592

Snohomish County



Legend

- ice
- Fill — Manmade deposit
- Lahars — Volcanic Mudflow
- Qal — Alluvium
- Qgd — Glacial drift, undivided
- Qmw — Mass wasting deposit
- Qp — Peat
- Qva — Vashon Advance Outwash
- Qvr — Vashon Recessioinal Outwash
- Qvrl — Vashon Recessional Lacustrine
- Qvt — Vashon Till
- Qvtm — Vashon Till - Marine
- Qpf — Pre-Fraser deposits
- Qpfg — Pre Fraser - glacial
- Qtb — Pre-Fraser Transitional beds
- Ti — Tertiary Intrusive
- Ts — Tertiary Sandstone
- Tv — Tertiary Volcanic
- Ptm — Pre-Teriary bedrock
- water

N

APPENDIX D

Test Boring Logs

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-01**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592**	AUGER TYPE:	**4" HSA**
STATION:		FLUID:	**none**
GEO./ENGR.:	**rmaynard**	TOTAL DEPTH:	**26.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	NOTES
					0.0'-0.5' **Asphaltic Concrete Pavement**	
					0.5'-3.0' **Gravelly Sand:** Brown, fine- to coarse-grained, trace silt, loose to medium dense, moist *(sp, fill)*	
X	S1	3/4/17				
					3.0'-7.0' **Silty Sand:** Reddish brown to gray, fine- to coarse-grained, trace gravel. occassional mottling, medium dense to dense, moist *(sm, Weathered Glacial Till)*	
X	S2	12/14/20		5		
					7.0'-26.5' **Silty Sand:** Gray, fine- to coarse-grained, with gravel, occassional mottling, dense to very dense, moist to wet *(sm, Glacial Till)*	
X	S3	10/17/34				
X	S4	16/20/20		10		
X	S5	50-5"		15	Perched water at 15'	
X	S6	50-6"		20		
X	S7	50-5"		25		
					T.D. = 26.5'	

NOTES: **Lat.: 47.836613 Long.: -122.177384**

Snohomish County Public Works

TEST BORING LOG B-01

PAGE **1** OF **1**

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-02**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592**	DATE: **3/5/18**	AUGER TYPE: **4" HSA**
STATION:		OFFSET:	FLUID: **none**
GEO./ENGR.:	**rmaynard**	ELEV.:	TOTAL DEPTH: **26.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	NOTES
					0.0'-0.33' **Grass and Topsoil**	
					0.33'-26.5' **Silty Sand:** Gray, fine- to coarse-grained, with gravel, occassional mottling, medium dense to very dense, moist to wet *(sm, Glacial Till)*	
X	S1	8/13/15		5		
X	S2	20/26/23		10		
X	S3	10/30/50-5"		15	Increased gravel and perched water from 15'-16'	
X	S4	35/50-3"		20		
X	S5	45/50-3"		25		
					T.D. = 26.5'	

NOTES: **Lat.: 47.834206 Long.: -122.178613**

Snohomish County Public Works

TEST BORING LOG B-02

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-03**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592**	DATE:	**3/5/18**
STATION:		OFFSET:	
GEO./ENGR.:	**rmaynard**	ELEV.:	**359.00**
		AUGER TYPE:	**4" HSA**
		FLUID:	**none**
		TOTAL DEPTH:	**26.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	NOTES
					0.0'-0.33' **Grass and Topsoil**	
					0.33'-10.0' **Silty Sand:** Reddish brown to gray, fine- to coarse-grained, with gravel, loose to medium dense, damp *(sp-sm, fill)*	
X	S1	7/6/5		5		
X	S2	3/5/6		10	10.0'-10.5' **Topsoil:** Old topsoil layer consisting of a dark brown, silty sand, loose, damp *(sm, fill)*	
					10.5'-26.5' **Silty Sand to Sandy Silt:** Gray, fine-grained, occassional mottling, medium dense to very dense, moist to wet *(sm, Glacial Till)*	
X	S3	6/11/15		15		
X	S4	15/24/30		20	Perched water at 21'	
X	S5	19/19/19		25		
					T.D = 26.5'	

NOTES: **Lat.: 47.833364 Long.: -122.178681**

Snohomish County Public Works

TEST BORING LOG B-03

PAGE **1** OF **1**

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-04**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592**	AUGER TYPE:	**4" HSA**
STATION:		FLUID:	**none**
GEO./ENGR.:	**rmaynard**	TOTAL DEPTH:	**26.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	NOTES
					0.0'-1.0' **Sandy Gravel:** Brown, fine- to coarse-grained, trace silt, loose to medium dense, moist to damp *(gp, fill)*	
					1.0'-26.5' **Silty Sand:** Gray, fine- to coarse-grained, with gravel up to 1", occassional mottling, medium dense to very dense, moist to wet *(sm, Glacial Till)*	
X	S1	7/7/8		5		
X	S2	5/13/26		10		
X	S3	27/50-6"		15		
X	S4	50-6"		20		
X	S5	16/26/50-6"		25	Zone of gravel and perched water from 24.5'-25.5'	
					T.D. = 26.5'	

NOTES: **Lat.: 47.831380 Long.: -122.175238**

Snohomish County Public Works

TEST BORING LOG B-04

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-05**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592**	AUGER TYPE:	**4" HSA**
STATION:		FLUID:	**none**
GEO./ENGR.:	**rmaynard**	TOTAL DEPTH:	**26.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	NOTES
					0.0'-0.17' **Crushed Rock**	
					0.17'-3.0' **Gravelly Sand:** Brown, fine- to coarse-grained, trace silt, loose to medium dense, wet *(sp, fill)*	
X	S1	5/14/24			3.0'-26.5' **Silty Sand:** Gray, fine- to coarse-grained, with gravel, some mottling in upper 1', dense to very dense, moist to wet *(sm, Glacial Till)*	
X	S2	17/21/21		5		
X	S3	10/21/24		10		
X	S4	40/50-4"		15		
X	S5	23/34/35		20	Zone of gravel and perched water between 19.0'-23.5'	
X	S6	50-5"		25		
					T.D. = 26.5'	

NOTES: **Lat.: 47.822878 Long.: -122.175105**

Snohomish County Public Works

TEST BORING LOG B-05

PAGE **1** OF **1**

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-06W**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592** DATE: **3/1/18**	AUGER TYPE:	**4" HSA**
LOCATION:		FLUID:	**none**
GEO./ENGR.:	**rmaynard** ELEV.: **364.00**	TOTAL DEPTH:	**26.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	WELL DETAIL
					0.0'-2.2' **Crushed Rock**	Observation well installed upon completion including 2" schedule 40 pvc riser pipe with flush surface casing. Permaplug bentonite seal. Backfilled with 10-20 Colorado Silica Sand.
X	S1	3/3/4			2.2'-8.0' **Sand:** Reddish brown, fine- to coarse-grained, trace silt, loose, moist *(sp-sm, Weathered Advance Outwash)*	
X	S2	3/2/5		5		
X	S3	13/18/26			8.0'-26.5' **Sand:** Gray, fine- to coarse-grained, with fine-grained gravel, trace silt, dense to very dense, moist to wet *(sp-sm, Advance Outwash)*	
X	S4	17/18/21		10		2" schedule 40 pvc #10 slotted screen.
					Perched water at 13'	
X	S5	10/19/28		15	Increased silt from 15'-16" Mottling	
					Perched/ water encountered at 18'	
X	S6	19/28/35		20		
X	S7	22/30/35		25	Increased silt	
					T.D = 26.5'	

NOTES: **Lat.: 47.819577 Long.: -122.175158**

Snohomish County Public Works

TEST BORING LOG B-06W

PAGE **1** OF **1**

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-07**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592**	AUGER TYPE:	**4" HSA**
STATION:		FLUID:	**none**
GEO./ENGR.:	**rmaynard**	TOTAL DEPTH:	**26.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	NOTES
					0.0'-0.67' **Crushed Rock**	
					0.67'-4.0' **Gravelly Sand:** Light brown, fine- to coarse-grained, trace silt, medium dense, moist *(sp, fill)*	
				5	4.0'-26.5' **Silty Sand:** Olive gray to gray, fine- to coarse-grained, with gravel, very dense, moist *(sm, Glacial Till)*	
X	S1	22/32/37				
X	S2	30/50-4"		10		
X	S3	50-5"		15		
X	S4	21/50-5"		20		
X	S5	50-5"		25	Grading to a gravelly sand with silt (sp-sm)	
					T.D. = 26.5'	

NOTES: **Lat.: 47.817152 Long.: -122.175314**

Snohomish County Public Works

TEST BORING LOG B-07

PAGE **1** OF **1**

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-08**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592**	AUGER TYPE:	**4" HSA**
STATION:		FLUID:	**none**
GEO./ENGR.:	**rmaynard**	TOTAL DEPTH:	**26.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	NOTES
					0.0'-0.5' **Asphaltic Concrete Pavement**	
					0.5'-3.0' **Gravelly Sand:** Brown, fine- to coarse-grained, trace silt, medium dense, moist *(sp, fill)*	
	S1	8/17/19			3.0'-26.5' **Silty Sand:** Olive gray to gray, fine- to coarse-grained, with gravel up to 1", dense to very dense, moist *(sm, Glacial Till)*	
	S2	12/18/18		5		
	S3	30/37/50-5.5"		10		
	S4	22/37/47		15	Zone of gravel and perched water from 15'-15.5'	
	S5	23/29/46		20	Zone of sand and perched water from 20'-22'	
	S6	10/34/50-5"		25		
					T.D. = 26.5'	

NOTES: **Lat.: 47.814929 Long.: -122.175236**

Snohomish County Public Works

TEST BORING LOG B-08

PAGE **1** OF **1**

PROJECT:	**43rd Avenue SE/Sunset Road: 180th Street SE to SR524**	BORING NO.:	**B-09**
		DRILLER:	**Holt**
		DRILL TYPE:	**Mobile B-58**
C.R.P.#:	**RC1592**	AUGER TYPE:	**4" HSA**
STATION:		FLUID:	**none**
GEO./ENGR.:	**rmaynard**	TOTAL DEPTH:	**26.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	NOTES
					0.0'-0.17' **Crushed Rock**	
					0.17'-17.0' **Gravelly Sand:** Light brown to brown, fine- to medium-grained, trace silt, medium dense to dense, moist *(sp, Resessional Outwash)*	
X	S1	9/12/9				
X	S2	6/13/15		5		
X	S3	10/15/18				
X	S4	12/16/22		10		
X	S5	11/20/40		15	Coarse gravel layer between 15'-16.5' Blow counts overstated due to coarseness of gravel	
					17.0'-26.5' **Silty Sand:** Gray, fine- to coarse-grained, trace gravel, very dense, moist *(sm, Glacial Till)*	
X	S6	21/20/30		20		
X	S7	21/31/39		25		
					T.D. = 26.5'	

NOTES: **Lat.: 47.812168 Long.: -122.175316**

Snohomish County Public Works

TEST BORING LOG B-09

APPENDIX E

Unified Soil Classification System

Hydrogeologic Report
43rd Ave SE/Sunset Road: 180th St SE to SR542

RC1592-115-37

UNIFIED SOILS CLASSIFICATION SYSTEM

MAJOR DIVISIONS			SYMBOL	LETTER	DESCRIPTION
COARSE GRAINED SOILS	GRAVEL & GRAVELLY SOILS	CLEAN GRAVELS		GW	WELL-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
				GP	POORLY GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
		GRAVELS W/FINES		GM	SILTY GRAVELS OR GRAVEL-SAND SILT MIXTURES.
				GC	CLAYEY GRAVELS OR GRAVEL-SAND-CLAY MIXTURES.
	SAND & SANDY SOILS	CLEAN SANDS		SW	WELL-GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES.
				SP	POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES.
		SANDS W/FINES		SM	SILTY SANDS OR SAND-SILT MIXTURES.
				SC	CLAYEY SANDS OR SAND-CLAY MIXTURES.
FINE GRAINED SOILS	SILTS AND CLAYS Liquid Limit Less Than 50			ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS, OR CLAYEY SILTS W/SLIGHT PLASTICITY.
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, OR LEAN CLAYS.
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.
	SILTS AND CLAYS Liquid Limit Greater Than 50			MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS.
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.
				OH	ORGANIC CLAYS OR MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS.
HIGHLY ORGANIC SOILS				PT	PEAT OR OTHER HIGHLY ORGANIC SOILS.

TOPSOIL		Humus and duff layer
FILL		Uncontrolled, with highly variable constituents.

SYMBOL	DATUM	NOTE	SYMBOL	DATUM	NOTE
I	2"O.D. SPLIT SPOON SAMPLER	SAMPLE INTERVAL		WATER LEVEL	DATE RECORDED
II	SHELBY SAMPLE	SAMPLE INTERVAL	Ts	TORVANE READING	
*	CUTTING SAMPLE	SAMPLE INTERVAL	Vs	VANE READING	
LL	LIQUID LIMIT			WATER OBSERVATION WELL	TIP ELEVATION
PI	PLASTICITY INDEX		MC	MOISTURE CONTENT	

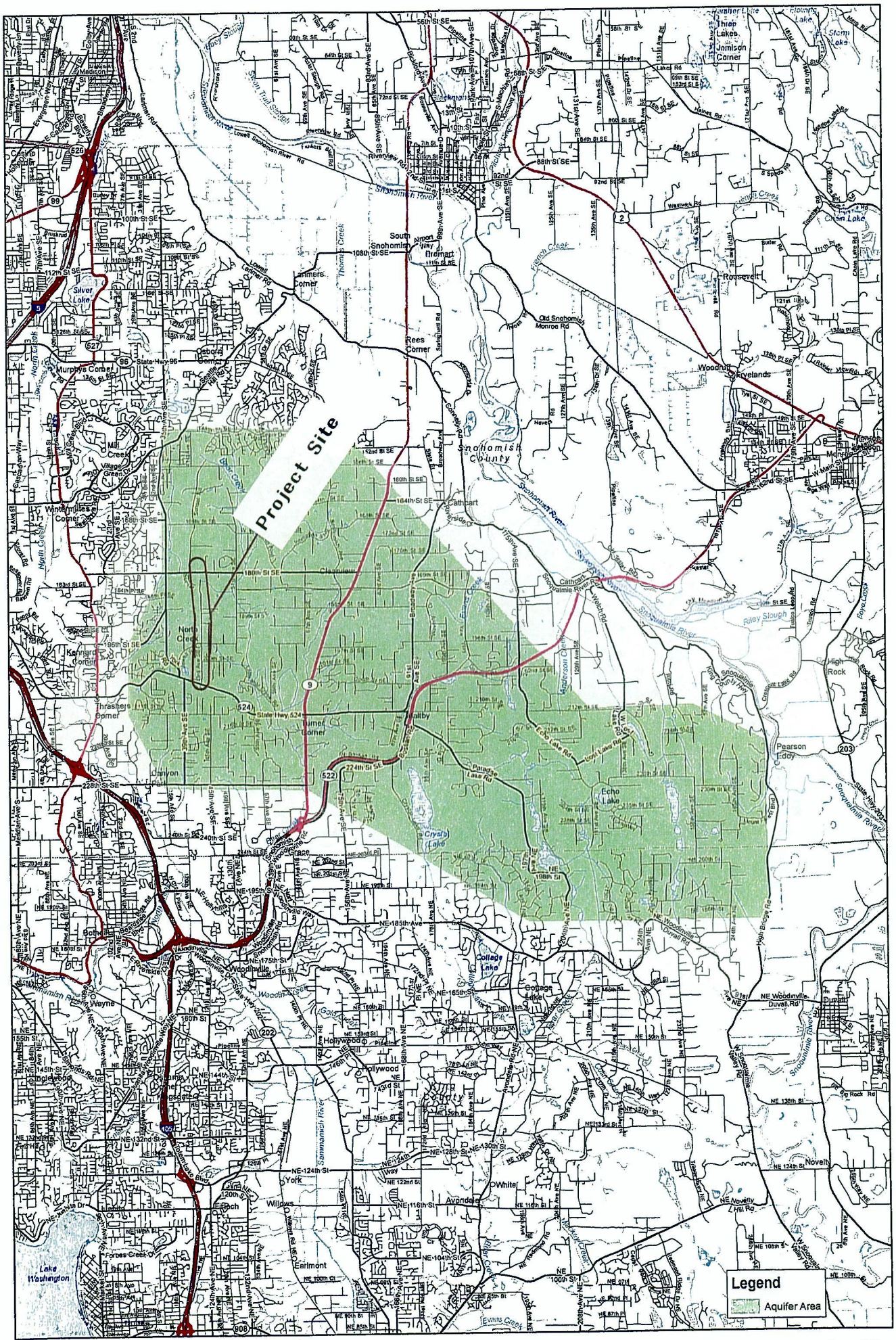
SNOHOMISH COUNTY
DEPARTMENT OF PUBLIC WORKS

KEY CHART

(DWG3:MATRDR2)

APPENDIX F

Sole Source Aquifer Map



The U.S. Environmental Protection Agency (EPA) has compiled this computer representation from data or information sources that may not have been verified by the EPA. This data is offered here as a general representation only, and is not to be re-used without verification by an independent professional qualified to verify such data or information. The EPA does not guarantee the accuracy, completeness, or timeliness of the information shown, and shall not be liable for any loss or injury resulting from reliance upon the information shown.

Cross Valley Sole Source Aquifer

0 0.5 1 2 3 4 5 Kilometers

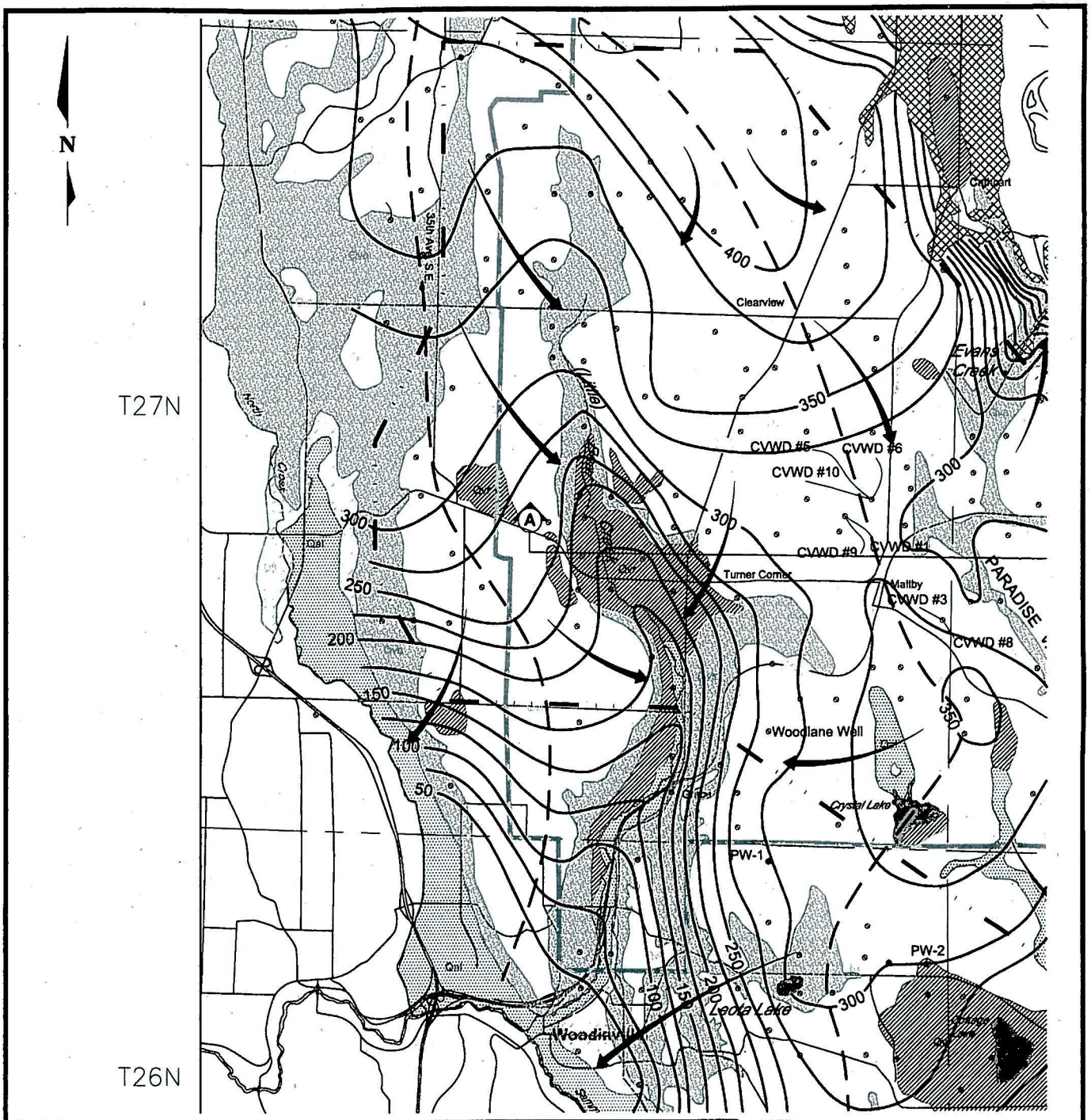
Map Created 12/04/2006 EPA Region 10

APPENDIX G

Groundwater Flow Direction Map

Hydrogeologic Report
43rd Ave SE/Sunset Road: 180th St SE to SR542

RC1592-115-37



LEGEND:

- 200 — GROUNDWATER ELEVATION CONTOUR
- INFERRED GROUNDWATER FLOW DIRECTION IN THE CROSS VALLEY AQUIFER
- WATER WELL
- PW-1 — WOODINVILLE WATER DISTRICT WELL LOCATION AND DESIGNATION
- CVWD #1 — CROSS VALLEY WATER DISTRICT WELL LOCATION AND DESIGNATION
- A A' — GEOLOGIC CROSS SECTION LOCATION
- CVWD SERVICE AREA BOUNDARY
- SOLE SOURCE AQUIFER BOUNDARY
- INTERPRETED GROUNDWATER DIVIDE

GEOLOGIC UNITS:

- ORGANIC DEPOSITS (Qm)
- ALLUVIUM (Qal)
- RECESSIONAL OUTWASH (Qvr)
- TILL (Qvt)
- ADVANCE OUTWASH (Qva)
- TRANSITIONAL BEDS (Qtb)
- UNDIFFERENTIATED DEPOSITS (Qu)
- BEDROCK (Tb)

OTHER SYMBOLS:

- WATER
- LAND OUTSIDE OF PROJECT AREA

NOTE:
This map was developed from existing maps prepared by the U.S. Geological Survey.

0 6000 1200
SCALE IN FEET

FIGURE 7
GROUNDWATER FLOW IN THE CROSS Qva AQUIFER
J&S/10 YR PLAN & EIS UPDATE/WA

0331027000F06.dwg | Layout: Layout1 | Modified: 10/27/2005, 09:59 | Plotted: 10/28/2005, 14:10

Golder Associates

APPENDIX H

Aquifer Sensitivity Map

Hydrogeologic Report
43rd Ave SE/Sunset Road: 180th St SE to SR542

1592-115-37

SNOHOMISH COUNTY

Aquifer Recharge/ Wellhead Protection

OCTOBER 1, 2007

CAR Map Disclaimer: This map is meant for illustrative purposes only. Data collection is an on-going process and the information shown should not be considered complete. This map is not intended for regulatory purposes as scale, accuracy and completeness are not adequate to determine regulatory implications at a site-specific level. Presence of environmental features and critical areas, as defined in the Growth Management Act, must be verified at the site specific level. These maps are intended to provide a generalized overview of the extent and distribution of key environmental features and critical areas throughout the county. This map represents the best available data at the time of publication.

USGS Aquifer Sensitivity with Depth to Aquifer

- Low, Over 100ft.
- Moderate, 40 to 100ft.
- High, 0 to 40ft.
- USEPA Sole Source Aquifer
- Calculated Fixed Radius Buffer (with blue tint showing overlaps)
- U. S. National Forest Land
- Incorporated City
- Tribal Trust Land
- Urban Growth Area Boundary
- Major Road
- WSDOH GPS Wellhead

Source Data:

Sole Source Aquifers
U.S. Environmental Protection Agency, "Support Document for the EPA Designation of the Cross Valley Aquifer as a Sole Source Aquifer" (1987) and "Support Document for the EPA Designation of the Newberg Area Aquifer as a Sole Source Aquifer" (1987).

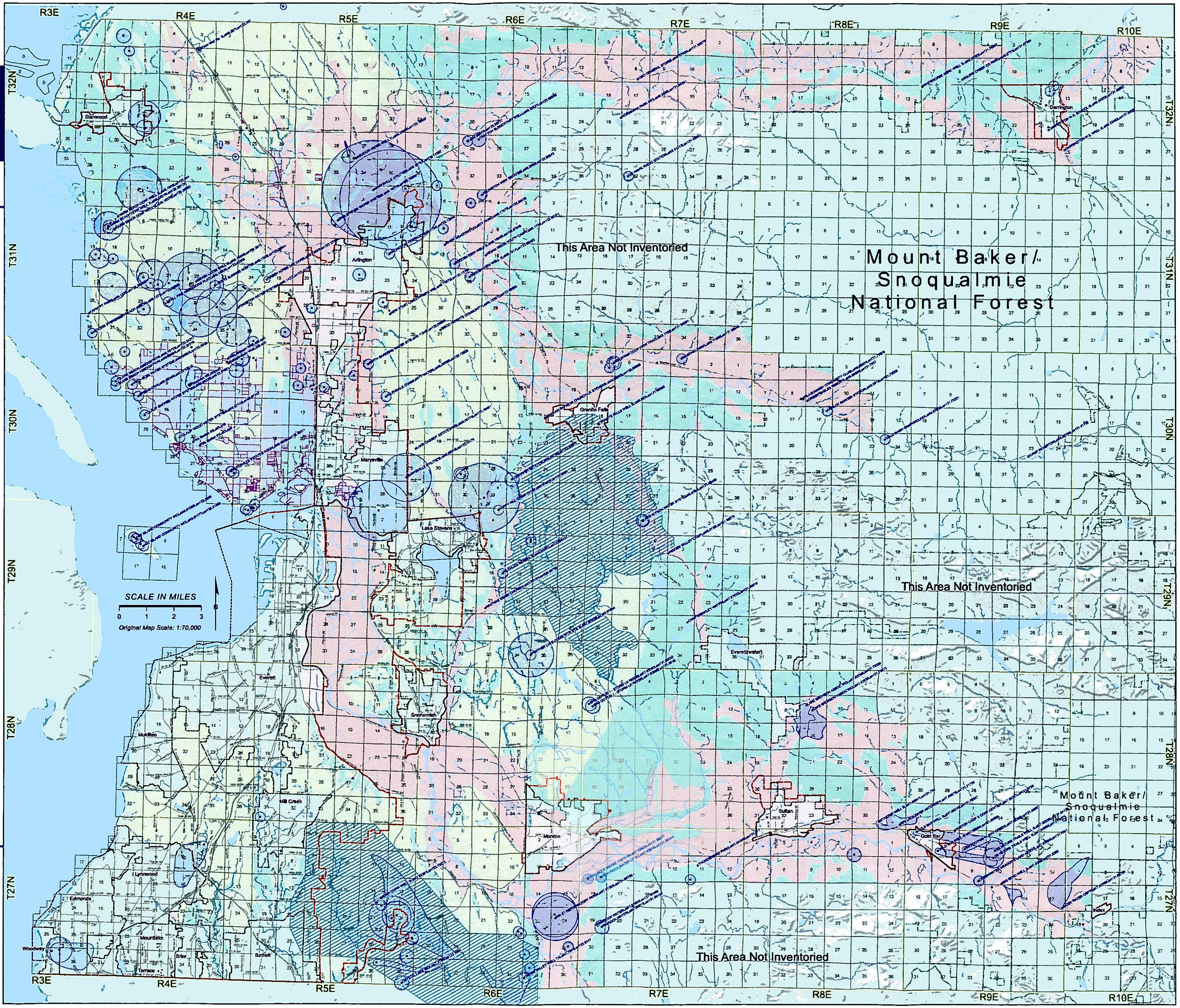
USGS Aquifer Sensitivity
U.S. Geological Survey, "The Ground-Water System and Ground-Water Quality in Western Snohomish County, Washington" (1997).

Wellhead Protection Areas
Washington Department of Health, "Ground Water Contamination Susceptibility Assessment Survey Forms" (2001) and Snohomish Health District GPS Points of Well Locations (2001)

Snohomish County disclaims any warranty of merchantability or warranty of fitness of this data (or map) for any particular purpose, either express or implied. No representation or warranty is made concerning the accuracy, currency, completeness or quality of data depicted. Any user of this data (or map) assumes all responsibility for use thereof, and further agrees to hold Snohomish County harmless from and against any damage, loss, or liability arising from any use of this data (or map).

Produced by Snohomish County Planning and Development Services, GIS-Cartography Section.

Snohomish County



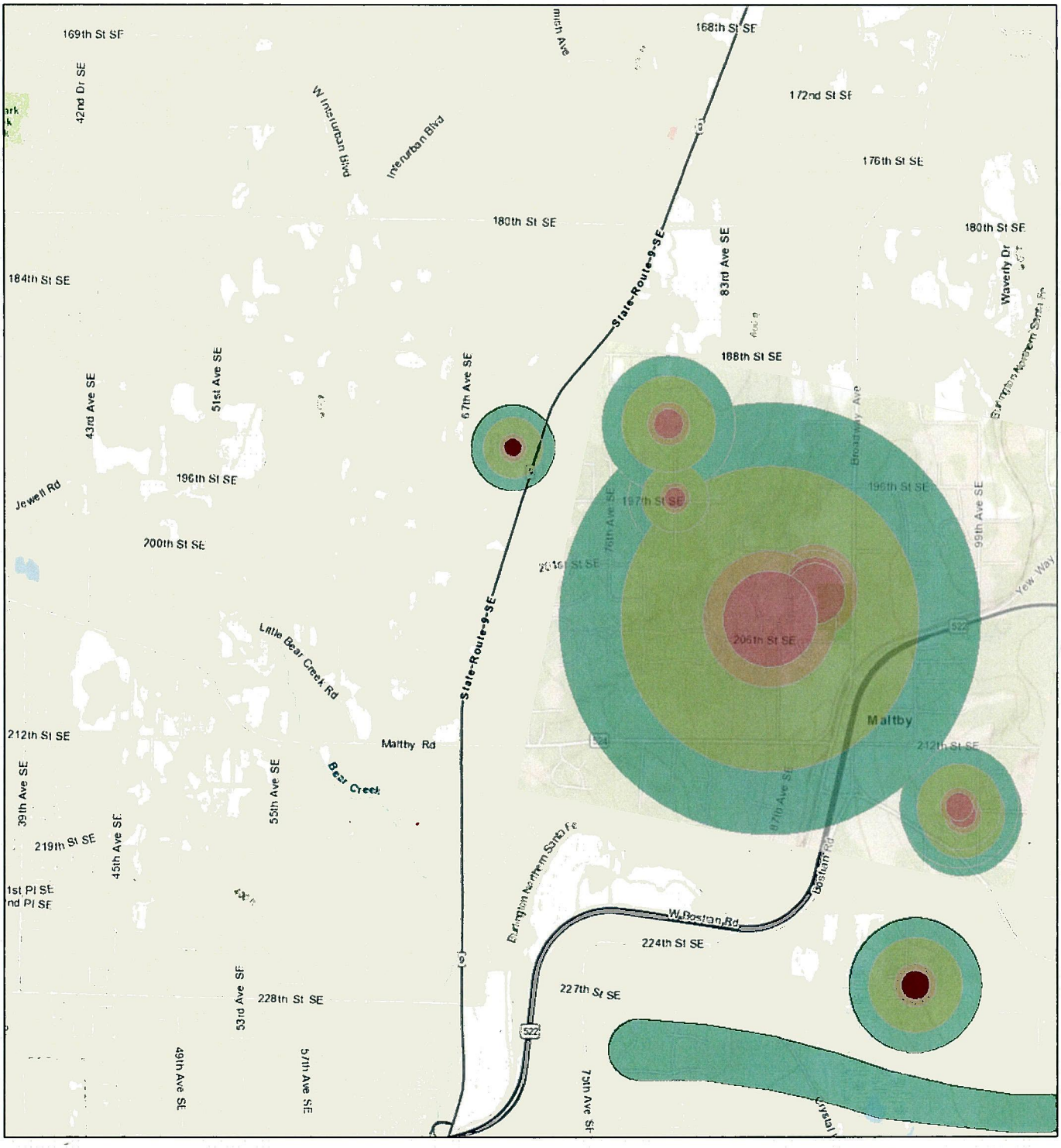
APPENDIX I

Group A Water Well/Travel Time Map

Hydrogeologic Report
43rd Ave SE/Sunset Road: 180th St SE to SR542

RC1592-115-37

Source Water Assessment Program



May 7, 2018

1:36,112

- 6 Month Time of Travel
- 1 Year Time of Travel
- 5 Year Time of Travel
- 10 Year Time of Travel
- Assigned Time of Travel
- County Boundaries

0 0.425 0.85 1.7 mi

0 0.5 1 2 km

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

The Washington State Department of Health does not warrant the accuracy, reliability or timeliness of any information published in this map and assumes no responsibility for errors in the content of the information provided. Persons or entities that rely on any information obtained from this map do so at their own risk.

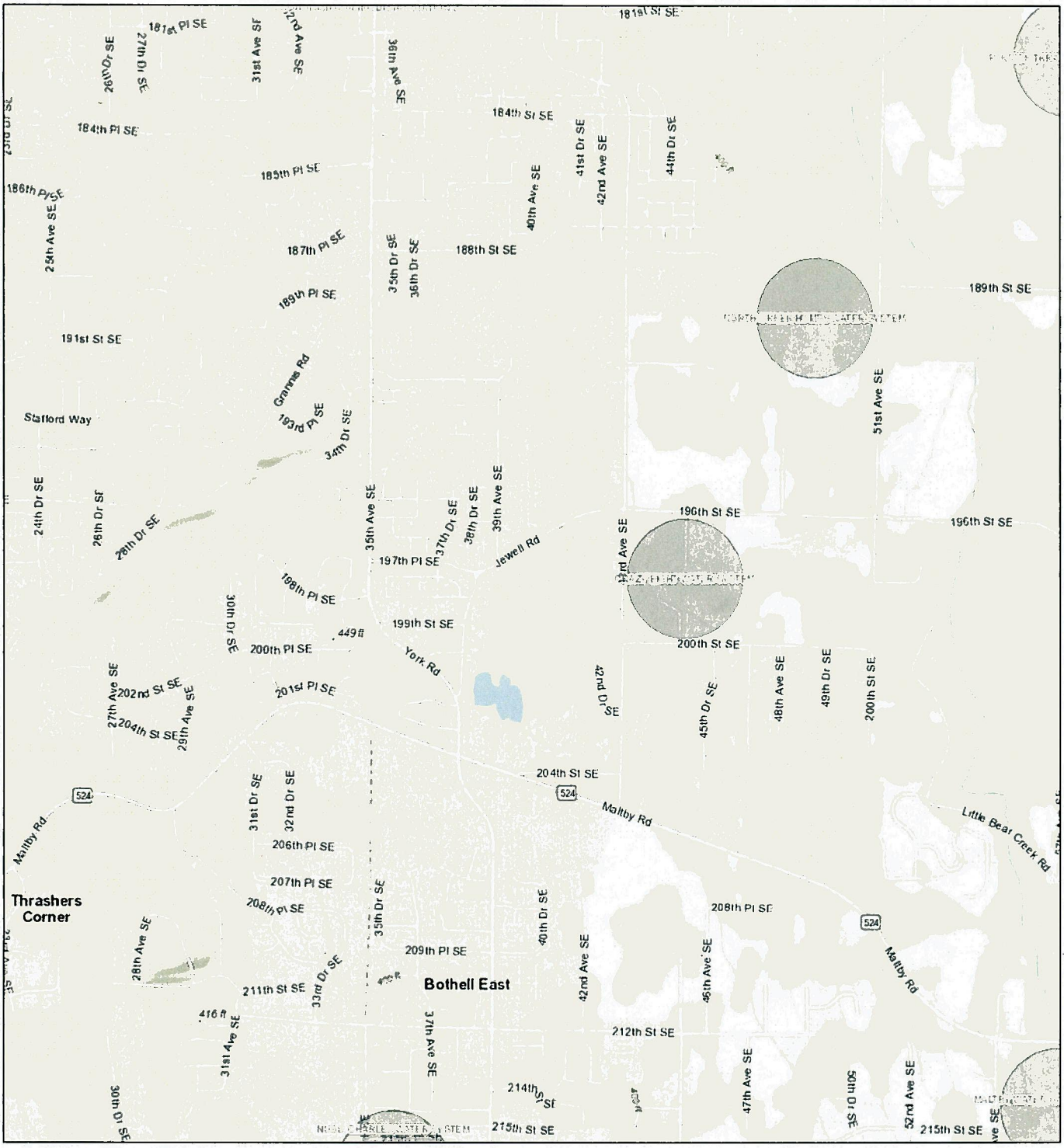
APPENDIX J

Group B Water Well/Travel Time Map

Hydrogeologic Report
43rd Ave SE/Sunset Road: 180th St SE to SR542

RC1592-115-37

Source Water Assessment Program



May 7, 2018

1:18,056

All Group B Time of Travel

Labels

County Boundaries

0 0.2 0.4 0.8 mi

0 0.325 0.65 1.3 km

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

The Washington State Department of Health does not warrant the accuracy, reliability or timeliness of any information published in this map and assumes no responsibility for errors in the content of the information provided. Persons or entities that rely on any information obtained from this map do so at their own risk.

APPENDIX K

Water Well Reports

Hydrogeologic Report
43rd Ave SE/Sunset Road: 180th St SE to SR542

RC1592-115-37

27/25/16F

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. —

Permit No. —

RECEIVED

FEB 24 1986

(1) OWNER: Name John Sundstrom Address 3831 18th St NW Everett

(2) LOCATION OF WELL: County Snohomish S. ½ N.W.¼ – S.E.¼ N.W.¼ Sec. 16 T. 27 N. R. 5 E. W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic [X] Industrial [ ] Municipal [ ]
Irrigation [ ] Test Well [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one)
New well [X] Method: Dug [ ] Bored [ ]
Deepened [ ] Cable [X] Driven [ ]
Reconditioned [ ] Rotary [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6" inches.
Drilled 101 ft. Depth of completed well 101' ft.

(6) CONSTRUCTION DETAILS:

Casing installed: ..." Diam. from ... ft. to ... ft.
Threaded [ ] ..." Diam. from ... ft. to ... ft.
Welded [X] 6" Diam. from +1 ft. to 101' ft.

Perforations: Yes [ ] No [X]
Type of perforator used
SIZE of perforations ... in. by ... in.
... perforations from ... ft. to ... ft.
... perforations from ... ft. to ... ft.
... perforations from ... ft. to ... ft.

Screens: Yes [ ] No [X]
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [X] Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes [X] No [ ] To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name NONE
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ... ft.
Static level 67 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [X] No [ ] If yes, by whom? AAA Pump
Yield: 10 gal./min. with 10' ft. drawdown after 4 hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 10 gal./min. with 5 ft. drawdown after 4 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [X]

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
OVER TOP Soil	0	10'
Brown – Very Hard Sandy clay	10	31'
Brown Sandy clay (WATER)	31'	48'
Sand – medium	48	95'
Gravel (Pea Size) & Hard	95	101'

Work started Dec 85 Completed Feb 15 86

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME AAA Pump Service & Drilling
(Person, firm, or corporation) (Type or print)

Address P.O. Box 654 Bothell, Wash. 98041

[Signed] Mike Harmon
(Well Driller)

License No. 1178 Date 2-15, 1986

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

Home address 328 N.W. 177th Seattle, Wn. 27/05-16

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. ...

Permit No. ...

(1) OWNER: Name Ralph W Everett Address 328 NW 177th Seattle WA 98177

(2) LOCATION OF WELL: County Snohomish ¼ ¼ Sec 16 T 27 N. R 5 W.M.

Bearing and distance from section or subdivision corner address of Prop 3709 Jewell Rd Bothell Wa

(3) PROPOSED USE: Domestic [X] Industrial [ ] Municipal [ ]
Irrigation [ ] Test Well [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well [X] Method: Dug [ ] Bored [ ]
Deepened [ ] Cable [X] Driven [ ]
Reconditioned [ ] Rotary [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 109 ft. Depth of completed well 109 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: ..." Diam. from .. ft. to .. ft.
Threaded [ ] ..." Diam. from .. ft. to .. ft.
Welded [X] ..." Diam. from .. ft. to .. ft.

Perforations: Yes [ ] No [X]
Type of perforator used ...
SIZE of perforations ... in. by ... in.
... perforations from ... ft. to ... ft.
... perforations from ... ft. to ... ft.
... perforations from ... ft. to ... ft.

Screens: Yes [X] No [ ] Johnson
Manufacturer's Name ...
Type Stainless Model No ...
Diam. 6 Slot size .14 from 104 ft. to 109 ft.
Diam. ... Slot size ... from ... ft. to ... ft.

Gravel packed: Yes [ ] No [X] Size of gravel: ...
Gravel placed from ... ft. to ... ft.

Surface seal: Yes [X] No [ ] To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [ ]
Type of water? ... Depth of strata ...
Method of sealing strata off ...

(7) PUMP: Manufacturer's Name ...
Type: ... H.P. ...

(8) WATER LEVELS: Land-surface elevation above mean sea level ... ft.
Static level 70 ft. below top of well Date 4/24/87
Artesian pressure ... lbs. per square inch Date ...
Artesian water is controlled by ... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [X] If yes, by whom? ...
Yield: ... gal./min. with ... ft. drawdown after ... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test 4-23-87
Bailer test 15 gal./min. with 10 ft. drawdown after 4 hrs.
Artesian flow ... g.p.m. Date ...
Temperature of water ... Was a chemical analysis made? Yes [ ] No [X]

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Yellow Clay	0	4
Some Gravel	4	8
Some water at 8 ft		
Sandy & some clay yellow	8	20
Clay sand & small gravel yellow	30	74
clay sand	74	89
Water at 89 ft		
Sand with thin layers of yellow clay & blue clay Water up to 88 ft	89	105
Hard Brown Gravel Starting to Loose	105	109
I did not go to Bottom of Hole - felt we had a good Supply so stopped drilling		
Water clear so we could drink it		

RECEIVED
APR 28 1987
DEPARTMENT OF ECOLOGY
NORTHWEST REGION

Work started 4-8 19 87 Completed 4-23- 19 87

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME H.A Meyer Drlg Co (Person, firm, or corporation) (Type or print)
Address 6424 Lake Wa Blvd N.E Kirkland, Wash 98033
[Signed] H.A Meyer (Well Driller)
License No. 0306 Date April 23, 1987

(USE ADDITIONAL SHEETS IF NECESSARY)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

Norman Crooks

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No 27/05-21K

Permit No ....

Norman Crooks

(1) OWNER: Name ~~[illegible]~~ Address 4303 Melt By Road Bothell Wash 98012

(2) LOCATION OF WELL: County Snohomish — NW ¼ SE ¼ Sec. 21 T. 27 N., R. 5E W.M.

Bearing and distance from section or subdivision corner Rt 1 6-A Wyle NW ¼ SE ¼ Ly N of county Road

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☒ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 262 ft. Depth of completed well 262 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: ....." Diam. from ..... ft. to ..... ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ 6" Diam. from +1 ft. to 253 ft.

Perforations: Yes ☐ No ☒ Mrs. Crooks Recalls they Would Perforate When well
Type of perforator used ....
SIZE of perforations ..... in. by Was drilled in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name Johnson
Type Stainless Model No. ....
Diam. ..... Slot size 14 from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☒ To what depth? 20 ft.
Material used in seal 6 sacks ....
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ..... Depth of strata ....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name [redacted]
Type: Sub ..... HP [redacted]

(8) WATER LEVELS: Land-surface elevation above mean sea level ..... ft.
Static level 117 ft. below top of well Date Aug 28 88
Artesian pressure ..... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Owner
Yield: ..... gal./min. with ..... ft. drawdown after ..... hrs.
15 " " 10 hrs "
" But no data on DD "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

SEP 06 1988

Date of test ....
Bailer test 15 gal./min. with 2 ft. drawdown after 1 hrs.
Artesian flow ..... g.p.m. Date Aug
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Sent when she started		
to deepen		127 Ft
Has been a fair well for 25 years But was down to about		2 gpm.
Cemented gravel with thin layers yellow clay	127	135
Water bearing		
[illegible] sand	135	138
But now it has an 8-6" screen with a 2 Ft Riser		
Pipe drove very hard for 10 ft and Pulled Back Very hard [illegible] at the Point of Refusal		
It took over 2 days to do the work		
"Well seal"		
[illegible] 25 years ago		
So all that could be done was to Put Bentonite along side of Casing and Pour a Cement Slab around a 2 Ft Piece of 8" pipe		
water from Bailing did not go only the area around the well it just Ran off		

Work started Aug 23, 1988. Completed Aug 24, 1988.

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME H.O. Meyer Drlg Co (Person, firm, or corporation) (Type or print)

Address 6424 Lake Wn Blvd NE

[Signed] Kirkland Wa 98033 H.O. Meyer (Well Driller)

License No. 0308 Date Aug 28, 1988

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

Repair & deepening well

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 27-05-21

Water Right Permit No.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

(1) OWNER: Name NORMAN & HAZEL CROOK Address 4303 Maltby Road

(2) LOCATION OF WELL: County SNO POR of Sect 21 ¼ ¼ Sec. 21 T. 27 N., R. 5 E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) 4303 Maltby Road Bothell WASH

(3) PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)
Abandoned ☐ New well ☐ Deepened ☒ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 137 feet. Depth of completed well 137 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from + ft. to 133 ft.
Welded ☒ " Diam. from ft. to ft.
Liner installed ☐ " Diam. from ft. to ft.
Threaded ☐

Perforations: Yes ☒ No ☒
Type of perforator used Mills Knife in 1955
SIZE of perforations 1/4 X 1" in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☒
Manufacturer's Name Johnson Total Length 8 Ft
Type Stainless St Model No.
Diam. 6 Slot size 14 from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☐ No ☒ To what depth? ft.
Material used in seal
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name goulds
Type: Sub H.P. 1

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 120 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
Pump has Been Run For 4 to 5 hrs To Irrigate Orchard
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 15 gal./min. with 2 ft. drawdown after 1/2 hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Well was originally drilled in 1955 to		128
Course sand & gravel to 1" dia	128	136
Fine sand & some gr.	136	139
drilled to set screen		
Pipe drove very slow		
Used about 8 hrs to move it 11 FT		
Took 4 hours to Pull Pipe Back 3'-8"		
We always did put the drill cuttings along side the pipe as we drilled the well. So there would be some seal around the well.		

OCT 06 1988
DEPARTMENT OF ECOLOGY NORTHWEST REGION

Work started Aug 22, 1988 Completed Aug 23, 1988

WELL CONSTRUCTOR CERTIFICATION:

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

NAME H.O. MEYER Drlg Co (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address 16924 Lake Wn Blvd NE. Kirkland. Wash 98033

(Signed) H.O. Meyer (WELL DRILLER) License No. 0308

Contractor's Registration No. 222-01-227 Date Aug 25, 1988

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329-

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

3745 64

WATER WELL REPORT

Original & 1st copy - Ecology, 2nd copy - owner, 3rd copy - driller

Submit by Email

27-5E-16L

Construction/Decommission ("x" in circle)

☒ Construction

☐ Decommission *ORIGINAL INSTALLATION*

Notice of Intent Number _____

CURRENT Notice of Intent No. WE11443

Unique Ecology Well ID Tag No. ALS-790

Water Right Permit No. Exempt

Property Owner Name Val Goermaere

Well Street Address 3722 188 TH ST SE

City Bothell County Snohomish

Location NE 1/4-1/4 SW 1/4 Sec 16 Twn 27 R 05E EWM ☐ Check or WWM ☒ One

(s, t, r Still REQUIRED)

Lat/Long Lat Deg _____ Lat Min/Sec _____

Long Deg _____ Long Min/Sec _____

Tax Parcel No. (Required) 27051600300600

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other _____

TYPE OF WORK: Owner's number of well (if more than one) _____

☒ New well ☐ Reconditioned ☐ Deepened Method: ☐ Dug ☐ Bored ☐ Driven ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 156 ft. Depth of completed well 143 ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 6 " Diam. from +2 ft. to 135 ft.

☐ Liner installed _____ " Diam. from _____ ft. to _____ ft.

☐ Threaded _____ " Diam. From _____ ft. to _____ ft.

Perforations: ☐ Yes ☒ No

Type of perforator used _____

SIZE of perfs _____ in. by _____ in. and no. of perfs _____ from _____ ft. to _____ ft.

Screens: ☒ Yes ☒ No ☐ K-Pac Location 132

Manufacturer's Name Johnson

Type Telescopic Model No. _____

Diam. 5 Slot size 20 from 143 ft. to 133 ft.

Diam. _____ Slot size _____ from _____ ft. to _____ ft.

Gravel/Filter packed: ☐ Yes ☒ No Size of gravel/sand _____

Materials placed from _____ ft. to _____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft.

Material used in seal Bentonite chips

Did any strata contain unusable water? ☐ Yes ☒ No

Type of water? _____ Depth of strata _____

Method of sealing strata off _____

PUMP: Manufacturer's Name _____

Type: _____ H.P. _____

WATER LEVELS: Land-surface elevation above mean sea level _____ ft.

Static level 72 ft. below top of well Date 05-19-10

Artesian pressure _____ lbs. per square inch Date _____

Artesian water is controlled by _____ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? ☒ Yes ☒ No If yes, by whom? John Arfman

Yield: 60 gal./min. with 20 ft. drawdown after 1 hrs.

Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.

Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test 05-14-10

Bailer Test _____ gal./min. with _____ ft. drawdown after _____ hrs.

Airtest 35 gal./min. with stem set at 135 ft. for 1 hrs.

Artesian flow _____ g.p.m. Date _____

Temperature of water _____ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Brown silty sand	0	8
Light brown silty gravels	8	20
Light brown sand gravel	20	36
Compact angular light brown gravels	36	65
Gray silty gravels	65	70
Dry sand	70	72
Sand silt small gravels –WB	72	80
Gray angular gravel dense silty	80	105
Gray soft silt	105	127
Gray sand trace gravels	127	132
Gray sand -active WB	132	148
Gray soft silt small angular gravels	148	156

RECEIVED
MAY 27 2010
Dept of Ecology
WR-NWRO

Start Date 05-11-10 Completed Date 05-14-10

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

☒ Driller ☐ Engineer ☒ Trainee Name (Print) John Arfman

Driller/Engineer/Trainee Signature _____

Driller or trainee License No. 2673

IF TRAINEE: Driller's License No: _____

Driller's Signature: _____

Drilling Company JKA Enterprises, Inc.

Address 21703 195th AVE SE Monroe, WA 98272-8831

Contractor's Registration No. JKENTI*945QC Date 05-20-10

ECY 050-1-20 (Rev 4/07)

www.jkawelldrilling.com

Ecology is an Equal Opportunity Employer

27/05-16

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No.

Permit No.

(1) OWNER: Name Ron Carlson Address Present address 14124-196th Ave SE Bothell Wash 98012

(2) LOCATION OF WELL: County Snohomish Co ¼ ¼ Sec. 16 T. 27 N., R. 5E W.M.

Bearing and distance from section or subdivision corner E cept the N½ of S½

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 124 ft. Depth of completed well 124 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: " Diam. from ft. to ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name Johnson
Type stainless Model No.
Diam. 6 Slot size 30 from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 19 ft.
Material used in seal Bentonite 65 gals
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name Well
Type: Will Be a 1½ HP Sub H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 70 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 30 gal./min. with 6 Ft ft. drawdown after 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Top soil + sd	0	3
Course grvl + water at 5 ft	3	6
Very course gr + larg rock	6	18
Glacial till + course		
Till Brown tan color	18	55
Lighter color till	55	73
Yellow sand + clay	73	100
Some water in it		
100' 119 open hole drilly		
But contain water		
layers of yellow clay + sand	108	119
The Bailer course sand + gravel	119	124

We will test pump the well when pump is installed and get water samples. I feel that the well will pump over 30 GPM

Work started 5-20, 1987 Completed May 30, 1987

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME H.O. Meyer Drlg Co (Person, firm, or corporation) (Type or print)

Address 6424 Lake Wn Blvd. NE Kirkland Wash 98033

[Signed] H O Meyer (Well Driller)

License No. 0308 Date May 31, 1987

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

APPENDIX H

Climate Change Tool Output

Project Exposure

43rd Ave SE - SR524 to Sunset Rd @ 180th St SE

PLANNING HORIZON

2040-2059

What are the coordinates of your project area?

X (negative value): -13600483.70520

Y (positive value): 6077246.96117

CLICK HERE TO VIEW ALL CLIMATE MAPS FOR CHOSEN TIME PERIOD

STEP 6:
Click on your project area in each map to find data to be entered on this page.

TEMPERATURE

Average Ambient Temperature Increase (in degrees F):

	low-end		high-end	
Annual	4.2	to	5.5	degrees F increase compared to historic baseline conditions
Summer	5.1	to	6.9	degrees F increase compared to historic baseline conditions
Winter	3.8	to	4.9	degrees F increase compared to historic baseline conditions
Growing Degree Days	929	to	1282	degree-days compared to historic baseline conditions

Stream Temperature Increase (in degrees C):

Is there a stream associated with your project? (see stream temperature map) Yes

Mean August temperature for measured streams closest to this project is projected to be approximately 14.9 degrees C by the selected time period, which is at the range for increased disease risk in adult salmon.

Wildfire Risk:

Currently, this project is located in a No Fire Hazard Zone. This risk may increase with projected climate change.

WATER QUALITY/AVAILABILITY

Precipitation Change (percent):

	low-end		high-end	
Annual	3	to	4	percent change in monthly precipitation compared to historic baseline conditions
Dry Season	-8	to	-8	percent change in monthly precipitation compared to historic baseline conditions
Wet Season	8	to	9	percent change in monthly precipitation compared to historic baseline conditions

Seasonal Timing of Streamflow:

Historically, this project was located within a mixed rain-snow dominant watershed.

Project Exposure

43rd Ave SE - SR524 to Sunset Rd @ 180th St SE

By the selected time period, the project may be be within a rain-dominant watershed under the high-end scenario.

Project Exposure

43rd Ave SE - SR524 to Sunset Rd @ 180th St SE

FLOODING

Note: Projections for flooding take into account changes in sea level and peak river flows, and may not acccurately represent changes in extreme flood risk. For more information, click on the help button above.

In which watershed is your project located? Other

DON'T KNOW THE WATERSHED OF YOUR PROJECT? CLICK HERE TO VIEW WATERSHED MAP

100-Year Flood Risk:

The project IS NOT within the historic 100-year flood zone.

500-Year Flood Risk:

The project IS NOT within the historic 500-year flood zone.

Discharge:

At the nearest examined stream gauge, on the None of the above ,

the 10-year storm is projected to become a -year return interval under the high-end scenario.

Sea Level Rise:

My project IS NOT within a 1-ft sea level rise inundation area.

(Note: although map shows 1-ft sea level rise, sea level rise is expected to be less than one foot within the project timeframe.)

To your understanding, the project area IS NOT currently at risk of inundation during extreme high tide events.

Note: *For the sea level rise maps, low-lying areas in green indicate areas that could be at risk of flooding under future sea level rise, but are not hydrologically connected to sea level rise impacts. Areas that are indicated as "low-lying" in earlier time periods (e.g., 2040) may switch to being inundated under a later time period (e.g., 2080). Click the "Help" icon for more information.*

EROSION

Landslide Risk:

Currently, this project is not within a landslide hazard or potential area .

Landslide risk may increase with projected changes in winter and extreme precipitation.

Temperature Impacts

43rd Ave SE - SR524 to Sunset Rd @ 180th St SE - 2040-2059

Tip! Scroll down

Projected Impacts

Project Area

The below projected impacts are based on downscaled climate projections that are specific to the project area, as identified in the climate impact maps.

- ANNUAL AMBIENT: Climate models project that annual temperature in this project area will be, on average, between 4.2 and 5.5 degrees F higher under the low and high emissions scenarios, respectively, compared to the historic baseline time period (1970-1999).
- SUMMER AMBIENT: Climate models project that summer temperature in this project area will be, on average, between 5.1 and 6.9 degrees F higher under the low and high emissions scenarios, respectively, compared to the historic baseline time period (1970-1999).
- WINTER AMBIENT: Climate models project that winter temperature in this project area will be, on average, between 3.8 and 4.9 degrees F higher under the low and high emissions scenarios, respectively, compared to the historic baseline time period (1970-1999).
- GROWING SEASON: Climate models project that the annual number of growing degree days in this project area will be, on average, between 929 and 1282 degree-days higher under the low and high emissions scenarios, respectively, compared to the historic baseline time period (1970-1999).
- STREAM TEMPERATURE: Climate models project that average August stream temperature in this project area will be, on average, 14.89 degrees C under the moderate emissions scenario compared to the historic baseline time period (1970-1999). This is at the range for increased disease risk in adult salmon.
- WILDFIRE: This project is currently located in a No Fire Hazard Zone. This risk will likely increase with higher temperatures and drier summer conditions projected under future climate change.

Snohomish County

The below projected impacts are summarized from downscaled climate projections that are averaged across Snohomish County.

- ANNUAL AMBIENT: Climate models project that annual temperature in Snohomish County in the 2050s will be, on average, +4.3 (+4.1 to +4.5) degrees F higher under the low emissions scenario and +5.7 (+5.4 to +5.9) degrees F higher under the high emissions scenario compared to the historic baseline time period (1970-1999).
- SUMMER AMBIENT: Climate models project that summer air temperature in Snohomish County in the 2050s will be, on average, +5.3 (+5.0 to +5.6) degrees F higher under the low emissions scenario and +7.1 (+6.7 to +7.4) degrees F higher under the high emissions scenario compared to the historic baseline time period (1970-1999).
- WINTER AMBIENT: Climate models project that winter temperature in Snohomish County in the 2050s will be, on average, +4.0 (+3.8 to +4.2) degrees F higher under the low emissions scenario and +5.0 (+4.8 to +5.3) degrees F higher under the high emissions scenario compared to the historic baseline time period (1970-1999).
- GROWING DAYS: Climate models project that the annual number of growing days in Snohomish County in the 2050s will be, on average, +721 (+164 to +994) deg-days higher under the low emissions scenario and +1,002 (+269 to +1,366) deg-days higher under the high emissions scenario compared to the historic baseline time period (1970-1999).

Puget Sound Region

The below projected impacts are summarized from climate projections for the Puget Sound area.

- HOTTEST DAYS: Climate models project that the hottest days in the Puget Sound region will be, on average, +6.5 (+4.0 to +10.2) degrees F higher by the 2050s under low and high emissions scenarios compared to the historic baseline time period (1970-1999).
- COOLEST NIGHTS: Climate models project that the coolest nights in the Puget Sound region will be, on average, +5.4 (+1.3 to +10.4) degrees F higher by the 2050s under low and high emissions scenarios compared to the historic baseline time period (1970-1999).
- EXTREME HEAT EVENTS: Extreme heat events will become more frequent while extreme cold events will become less frequent in the Pacific Northwest.
- STREAM TEMPERATURE: Climate models project that stream temperatures in the Puget Sound region will be, on average, +4.0 to +4.5 degrees F higher by the 2080s under a moderate emissions scenario compared to the historic baseline time period (1970-1999), due to increasing air temperature and reduced summer streamflow.

Temperature Impacts

43rd Ave SE - SR524 to Sunset Rd @ 180th St SE - 2040-2059

Tip! Scroll down

Transportation Planning Impact Summary

Increased Ambient Temperature

- Segments with high volumes of truck traffic may be more sensitive to rutting as temperatures increase. [25, p. 2]
- Higher temperatures with more heat waves may increase rutting and concrete cracking in roadway pavement. [36, p. 11]
- A greater frequency of very hot days may lead to greater need for maintenance of roads/asphalt pavement and rail facilities due to degradation of materials. [53, p. 128]

- Increased temperatures could overheat rail and roadway electrical systems and communications equipment and cause thermal expansion and buckling of railway joints. [66]
- Increased occurrence and severity of extreme temperature events in a changing climate could cause equipment failure and overheating. [6]
- Certain vehicles will not be able tolerate extreme temperatures, thus limiting transport options for freight, etc. [6]
- At higher temperatures, expansion joints on bridges and highways are stressed and some asphalt pavements deteriorate more rapidly. [45, p. 132]
- Extreme temperatures may impact the reliability of mechanical equipment, potentially affecting performance and causing malfunctions or damage. [5, p. 134]
- Higher temperatures will: 1) increase O&M costs due to the need for more frequent breaks and potential OSHA/WSHA stop work orders for crews, 2) accelerate asphalt deterioration and cause buckling, rutting, or cracking of pavements—especially in areas with high volumes of truck traffic, 3) require more frequent maintenance of pavement, and 4) trigger a need to address heat-induced degradation of materials. [36]
- Increased temperatures can soften asphalt and lengthen asphalt curing time, increasing time needed to perform paving and repairs and lengthening delays until traffic can be allowed on those roads. [36]
- Increased temperatures will likely increase electricity costs for cooling transit stations and other facilities. [6]
- Increased temperatures may increase demand by bicyclists and motorists for shaded roads. [6]
- Stress from higher temperatures may degrade lifespans of infrastructure. [6]

Transportation Planning Guidance Information

Increased Ambient Temperature

Planning

- Expand canopy cover along transportation corridors to minimize urban heat island and flooding. Develop new landscape standards if needed. [66, p. 77]
- Higher temperatures will increase urban heat island effects in dense developments with few trees and limited water. [6]

Design

- Consider developing design standards that would afford higher protection to transportation infrastructure for increased average and extreme temperatures. [6]
- Utilize asphalt and concrete mixes and/or designs that perform well under high temperatures. [6]
- Consider using highly reflective pavement (e.g. concrete) to deflect heat and reduce warming effects on the underlying soil layer. [39, p. 155]

Operations and Maintenance

Temperature Impacts

Tip! Scroll down

43rd Ave SE - SR524 to Sunset Rd @ 180th St SE - 2040-2059

- During very hot days, shift construction and maintenance activities towards cooler times of the day. [21, p. 15]

- Deploy “quick maintenance” patrols to check for and repair potholes during extremely hot days. [21, p. 15]

- Schedule more frequent servicing and/or anticipate more frequent replacement of service equipment to ensure optimal maintenance schedules given reduced equipment lifespans. [6]

Water Quality and Availability Impacts

43rd Ave SE - SR524 to Sunset Rd @ 180th St SE - 2040-2059

Tip! Scroll down

Projected Impacts and Exposure

Project Area

The below projected impacts are based on downscaled climate projections that are specific to the project area, as identified in the climate impact maps.

- ANNUAL PRECIPITATION: Climate models project that annual precipitation in your project area will increase by between 3 and 4 percent under the low and high emissions scenarios, respectively, compared to the historic baseline time period (1970-1999).
- DRY SEASON PRECIPITATION: Climate models project that DRY SEASON precipitation in your project area will decrease by between -8 and -8 percent under the low and high emissions scenarios, respectively, compared to the historic baseline time period (1970-1999).
- WET SEASON PRECIPITATION: Climate models project that WET SEASON precipitation in your project area will increase by between 8 and 9 percent under the low and high emissions scenarios, respectively, compared to the historic baseline time period (1970-1999).
- STREAMFLOW TIMING: Your project is currently located in a mixed rain-snow dominant watershed. By the 2050s, your project will be within a rain-dominant watershed.

Snohomish County

The below projected impacts are summarized from downscaled climate projections that are averaged across Snohomish County.

- ANNUAL PRECIPITATION: Climate models project that annual precipitation in Snohomish County in the 2050s will be, on average, +3.7 (+2.2 to +2.8) percent higher under the low emissions scenario and +4.6 (+2.8 to +6.6) percent higher under the high emissions scenario compared to the historic baseline time period (1970-1999).
- DRY SEASON PRECIPITATION: Climate models project that precipitation in Snohomish County in the 2050s will be, on average, -8.2 (-9.8 to -5.6) percent lower under the low emissions scenario and -7.3 (-9.9 to -4.7) percent lower under the high emissions scenario compared to the historic baseline time period (1970-1999).
- WET SEASON PRECIPITATION: Climate models project that winter precipitation in Snohomish County in the 2050s will be, on average, +8.3 (+7.6 to +8.9) percent higher under the low emissions scenario and +9.4 (+8.6 to +10.2) percent higher under the high emissions scenario compared to the historic baseline time period (1970-1999).

Puget Sound Region

The below projected impacts are summarized from climate projections for the Puget Sound area.

- SNOWPACK: Climate models project that average spring snowpack in the Puget Sound region will be, on average, 37 percent lower under the low (RCP 4.5) emissions scenario and 55 percent lower under the high (RCP 8.5) emissions scenario compared to the historic baseline time period (1970-1999).
- STREAMFLOW TIMING: Changes in streamflow timing are unknown for your project watershed. Howevever, climate models project peak streamflow in the Snohomish watershed will be, on average, 29 to 49 days earlier by the 2080s under the moderate emissions scenario (A1B) compared to the historic baseline time period (1970-1999).

- STREAMFLOW VOLUME: Climate models project that annual streamflow in the Puget Sound regon will be, on average, +6 percent higher by the 2080s under the low emissions scenario and +7 percent higher under the moderate emissions scenario compared to the historic baseline time period (1970-1999).
- WINTER STREAMFLOW: Climate models project that winter streamflow in the Puget Sound region will be, on average, +28 percent higher under the low emissions scenario and +34 percent higher under the high emissions scenario compared to the historic baseline time period (1970-1999).
- SUMMER STREAMFLOW: Climate models project that summer streamflow in the Puget Sound will be, on average, -24 percent lower under the low emissions scenario and -31 percent lower under the high emissions scenario compared to the historic baseline time period (1970-1999).

Transportation Planning Impact Summary

Water Quality and Availability Impacts

43rd Ave SE - SR524 to Sunset Rd @ 180th St SE - 2040-2059

Tip! Scroll down

Decreased Streamflow

- Streamflows based on increasingly more frequent and intense rainfall instead of slower snowmelt could increase the likelihood of bridge damage from faster-flowing streams. [45, p. 132]

Decreased Water Quality/Availability

- Source water shortages and increased frequency of short- and long-term drought will reduce surface water flows. [6]
- Less precipitation will arrive in the form of snow, reducing spring snowmelt and in-stream water flows during the summer months. [64]
- Increased stormwater runoff may result in surface water quality changes, including increased turbidity, increased total organic content, and color and alkalinity changes. [6]

Transportation Planning Guidance Information

Decreased Streamflow

Planning

- Protect and restore the connections between rivers and their floodplains. Identify existing or potential connections between rivers and floodplains with high habitat value during low flow periods for protection. Allowing streams and side channels to flow across a greater proportion of their historical floodplain to reconnect with freshwater and estuarine wetlands can improve low flows. [15, p. 75]
- Minimize low-flow withdrawals to ensure that minimum ecological flow requirements are met. [6]

Design

- Integrate upstream water flow management with downstream water management to reduce vulnerabilities due to changing water regimes. [6]

Decreased Water Quality/Availability

Design

- Consider retrofitting existing detention ponds to provide water quality treatment. [57]
- To reduce risks to water quality and quantity due to changes in precipitation, enhance infiltration, promote groundwater recharge, and enlarge and improve protection of catchment areas in infrastructure projects. [6]

Operations and Maintenance

- Convert existing landscaping to encourage or require native and/or drought-tolerant landscaping. [6]

Flooding Impacts

43rd Ave SE - SR524 to Sunset Rd @ 180th St SE - 2040-2059

Tip! Scroll down to

Projected Impacts and Exposure

Project Area

The below projected impacts are based on downscaled climate projections that are specific to the project area, as identified in the climate impact maps.

- Your project IS NOT within the historic 100-year flood zone.
- Your project IS NOT within the historic 500-year flood zone. If future 100-year floodplain information is not available, some organizations use the current 500-year floodplain as a proxy for the future 100-year floodplain.
- Limited available data prevents determination of changes in extreme precipitation return intervals at your location.
- Sea level rise is expected to be less than 1 foot by your chosen timeframe. Your project area IS NOT within a 1-ft sea level rise inundation area. Local knowledge indicates that the project area IS NOT currently at risk of inundation during extreme high tide events.

Snohomish County

The below projected impacts are from downscaled climate projections that are averaged across Snohomish County.

- FLOODED AREAS: Climate models project that the area flooded by the 10-year flood event in the Snohomish river floodplain will be, on average, +19 to +69 percent larger under the moderate (A1B) emissions scenario compared to the historic baseline time period (1970-1999).

Puget Sound Region

The below projected impacts are summarized from climate projections for the Puget Sound area.

- PEAK FLOWS: Climate models project that peak flows in the Puget Sound will be, on average, +18 to +55 percent higher under the moderate emissions scenario compared to the historic baseline time period (1970-1999).

Transportation Planning Impact Summary

Temporary Inundation

- Increased rain causes reduced visibility and increased hydroplaning of vehicles on freeways. [39, p. 142]
- More high wind events would require increased emergency response to downed power lines and trees on roads and bridges. [36, p. 11]
- More frequent and heavy rainfall events can lead to landslides, erosion, and flash flooding, with associated destruction of housing, street networks, and urban infrastructure. [6]
- Earlier spring snowmelt and increased rain during winter may create earlier and higher peak river flows, which in turn may cause increased erosion/scour at bridge piers/abutments, and reduce bridge clearance river-transport. [39, p. 113]
- Extended precipitation and flooding can threaten the structural stability of bridges and culverts. [39, p. 121]
- Overwhelmed urban drainage systems can cause flooding, affecting the life expectancy of pavement structures and road foundations. [6]
- Nuisance flooding is likely to become more common on road sections that already have a history of chronic flooding. [29, p. 28]
- Increasing floods and landslides may increase pipeline corrosion, damage, and destruction. [10]
- More frequent and intense storm events may increase wind and water damage to signs, navigational equiptment, signals, and light fixtures along transportation routes. [6]

Flooding Impacts

43rd Ave SE - SR524 to Sunset Rd @ 180th St SE - 2040-2059

- Secondary impacts of storm surge on transportation facilities from storm surges can include damage caused by the force of water and collisions with debris. [53, p. 132]
- More frequent and severe flooding events could disrupt commercial transportation activities. [6]
- More frequent and more severe precipitation events and flooding may inundate and damage transportation and flood protection infrastructure such as roads, bridges, tunnels, flood walls, and underpass pump stations; the risk is greater for infrastructure that is underground or in low-lying areas. [6]
- Following wildfires, rainstorms can increase debris flow and block or flood culverts and drainage systems. [23, p. 54]
- Monitoring equipment (e.g., cameras, loop detectors) is sensitive to weather extremes and flooding, and is susceptible to corrosion by water infiltration. [23, p. 51]
- Changes in the frequency of short-term rainfall events can influence traffic demand, requiring varied operational responses. [23, p. 55]

Permanent Inundation

- Transportation infrastructure that was designed without considering increased future flooding risks may impede drainage. [5, p. 87]
- Higher water table may limit use of certain stormwater quality and quantity facilities (i.e., infiltration and pond depth). [56]
- Increasing floods due to sea level rise and precipitation changes may present challenges for drainage and ground leveling projects, including earthwork planning and natural and built drainage system design and maintenance. [6]
- Future floods may exceed the capacity and protective abilities of existing flood protection facilities. [32, p. 203]

Transportation Planning Guidance Information

Temporary Inundation

Planning

- Maintain an electronic database of project worksheets and detailed damage inspection reports to better identify vulnerable infrastructure and speed the post-disaster federal funding process. [16, p. 3]
- Develop joint transportation strategies with adjacent jurisdictions, regional entities, and the State to prepare for and accommodate changing conditions. [44]
- According to research for King County in the Green River basin, Level 2 stormwater pond volumes may need to be sized up to 11 percent larger than under current rainfall conditions. [35, p. vii]
- Capital improvement projects and investments should be considered based on features that will reduce climate risks (e.g., reduce flooding). [23, p. 51]
- Develop redundant services to accommodate system disruptions due to flooding and more frequent storms, such as building “rescue roads" and redundant power and communications systems. [68]
- Following a flooding event, conduct an after-action review and create an after-action report to assess what worked and what did not. Revise plans based on lessons learned. [23, p. 36]
- Consider ways to provide increased river and stream conveyance at bridge crossings (or culverts). [6]
- Preserve floodplain connectivity (e.g., when developing new roadways) to avoid increased flooding depths in adjacent areas. [6]
- Ensure that services provided by critical facilities, including medical and emergency services, are available to at-risk communities, particularly communities at risk of isolation. [32, p. 309]

Flooding Impacts

43rd Ave SE - SR524 to Sunset Rd @ 180th St SE - 2040-2059

Design

- To assess whether design standards may need to be updated, consider comparing the hydraulic capacity of bridges and culverts using the older rainfall data versus more recent rainfall data. [21, p. 13]
- In designing storm water management facilities for roadways, bridges, culverts, ports, and rail, considering the projected increase in the intensity or frequency of heavy precipitation events. [53, p. 128-9]
- Revisit design standards for stormwater infrastructure such as stormwater detention infrastructure, culverts, and temporary erosion and sediment control infrastructure; assessments of future Puget Sound streamflows suggest that concern over present design standards is warranted and some adaptation to changing conditions is already probably prudent. [52, p. 341]
- Add cross-drains to roads to reduce routing of water directly from road ditches to streams. [65, p. 14]
- Increase urban water absorption capacity by minimizing paved surfaces, increasing planting strip width/green space, and using pervious pavement/materials. [6]
- Build culverts and bridges to allow for the passage of aquatic organisms and enhance stream connectivity. A co-benefit of these investments is that the larger culverts will prevent catastrophic failures during floods. [21, p. 12]
- If needed, considering building new levees to channel flood waters away from abutments of important bridges. [21, p. 13]
- Consider whether the design assumptions encompass an adequate historical period and whether that historical period might have been unusually wet or dry. Consider designing to a less frequent design event (100yr flood/storm instead of 50yr; or 500yr instead of 100yr). [21, p. 12]
- Increase stormwater facility sizing to account for future potential changes in precipitation patterns; for example, research for King County recommended a 10 percent increase as a conservative, planning-level estimate. [35, p. vii]
- Expand bridge apertures within flood-draining channels to improve drainage and reduce potential for channel clogging. [6]
- Expand use of low impact development, bioswales, and other green stormwater managemen infrastructure to add design robustness to hard infrastructure and reduce stormwater treatment volumes during high rainfall events. [5, p. 68]

Operations and Maintenance

- Ensure that primary and alternate transportation routes can continue to provide everyday access, emergency vehicle access, and evacuation in a safe and effective manner, in the context of a changing climate. Identify routes at risk and develop alternatives [64, p. 3]
- Develop a "bridge alerts database" that will monitor flooding conditions and send automatic notifications of hazardous conditions to maintenance personnel. [29, p. 27]
- Increase maintenance and cleaning of urban levee and culvert systems to reduce road and rail flood risk. [45, p. 139]
- Consider more regular maintenance of culverts, especially in high vulnerability areas. [21, p. 8]
- Consider climate-resilient operations and maintenance practices such as debris removal, early warning systems, prepositioning materials, damage repairs, and performance monitoring. [19, p. 3]
- Prioritize maintenance activities that reduce damage during extreme weather events, such as tree trimming and culvert cleaning. [21, p. 15]
- Implement operations and maintenance strategies such as more frequent storm-drain and culvert cleaning, debris removal, and performance monitoring. [19, p. 3]
- When extreme weather can be anticipated, stockpile materials and equipment and stage them in strategic areas prior to the event. [23, p. 40]
- Enhance traveler information systems and early warning systems through electronic message boards, upgrading manual message systems to wireless/telemetry systems, and pre-positioning wireless message boards before flood events. [6]

Flooding Impacts

43rd Ave SE - SR524 to Sunset Rd @ 180th St SE - 2040-2059

- Improve weather emergency plans and pre-position materials in response to forecasts and early warnings. [6]
- Strengthen relationships and communication with WSDOT, and include climate change considerations on meeting agendas. [6]
- Team with other agencies to provide flood mitigation/protection around critical infrastructure (e.g., repurpose transportation agencies' right-of-way to provide additional flood storage and/or increased conveyance). [6]

Permanent Inundation

Planning

- To extend the life of infrastructure and reduce damage and pollution risks due to flooding, locate structures and equipment at higher elevations. In new construction areas, consider revising ground level requirements to accommodate increased winter flooding, [66, p. 77]
- Identify new funding sources for relocating infrastructure. [44]
- Modify design standards to provide a higher level of flood protection for equipment that must be located in areas where drainage could be an issue. [5, p. 87]
- More right-of-way may be required for infrastructure/stormwater facilities. [56]
- Consider FEMA flood zone maps or similarly informative maps when siting and designing sites for equipment. [23, p. 34]

Design

- In response to reduced snowpack, consider shifting budgets away from snow response and re-allocate to flood response. [6]
- Modify design standards to provide higher level of flood protection for equipment that must be located in areas where drainage could be an issue. [5, p. 68]
- Build dikes or raise the elevation of existing dikes that protect roads located in the inundation risk zone, particularly low-lying roads and bridge approaches. [64, p. 22]

Operations and Maintenance

- Distribute microsensors throughout a structure, to monitor of the structure's subsurface conditions and provide data on performance. [39, p. 154]
- Develop modular traffic features and road sign systems for easier replacement to respond to more frequent and extensive damage due to extreme weather conditions. [6]

Erosion Impacts

43rd Ave SE - SR524 to Sunset Rd @ 180th St SE - 2040-2059

Tip! Scroll down

Projected Impacts and Exposure

Project Area

The below projected impacts are based on Snohomish County's Hazard Mitigation Plan.

- Your project is not within a landslide hazard or potential area. The risk of landslides may increase with projected changes in seasonal preciptiation.

Puget Sound Region

The below projected impacts are summarized from climate projections for the Puget Sound area.

- Changes in rainfall, snowpack, and streamflow may lead to an increase in landslide risk, erosion, and sediment transport in fall, winter, and spring, while reducing the rates of these processes in summer.
- Quantitative projections of the likely changes in sediment transport and landslides are limited, in part because it is challenging to distinguish climate change effects from non-climatic factors such as development patterns and forest management.

Transportation Planning Impact Summary

Inland Erosion

- Increased wet season precipitation is likely to cause riverbank erosion, increased frequency and extents of inundation, and structural damage to nearby infrastructure. [20, p. 9-10]
- Roads in mountainous areas may experience increased landslide risk due to increased wet season rainfall and flood risk. [10]
- An increase in water table level or increased surface water runoff can cause erosion or slumping (collapse) of the soil surface. [53, p. 170]
- Landslide zones that are not currently active could be activated by increased erosion, precipitation, and/or sea level rise. [29, p. 15]

Transportation Planning Guidance Information

Inland Erosion

Planning

- Inventory and rate all landslides, rockfalls, and other types of unstable slopes affecting roadway infrastructure and consider climate change as a factor in rating these landlside areas. [29]

Design

- Increase design standards/safety factor for erosion protection features. [6]
- Consider improved approaches for repairing slope sections adjacent to rivers, such as building the slope to match stable channel dimensions rather than placing stone to stabilize the slope. [21, p. 13]
- Consider using hydrologic and hydraulic modeling and slope mapping to incorporate stream and slope stability into road design. [21, p. 13]
- Increase erosion protection at bridge crossings (piers and abutments). [6]

Erosion Impacts

43rd Ave SE - SR524 to Sunset Rd @ 180th St SE - 2040-2059

■ Strengthen existing structures and build protective infrastructure, including slope control structures to prevent landslides along elevated and exposed transportation routes. [6]

Operations and Maintenance

■ Plant drought and heat-resistant plant species for erosion control. [21, p. 15]

■ Prohibit road and utility construction in areas subject to excessive erosion and/or accretion. [64, p. 4]

■ To cope with soil erosion and landslides, consider installing subsurface drainage facilities, constructing rock buttresses, inserting reinforcement bars to stabilize steep slopes, and planting erosion control grasses where erosion risk is especially high. [21, p. 15]

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Climate Data

Data Presented in the Tool Output Tabs

The climate projections presented in this tool are from the 2015 *State of Knowledge: Climate Change in Puget Sound* report by the University of Washington Climate Impacts Group (UW CIG) and other peer-reviewed research, as available. This 2015 UW CIG report represents the most recent comprehensive climate change projection data for the Pacific Northwest. These data are presented for the new **RCP 4.5 and 8.5 scenarios**, which represent low to high future greenhouse gas emission scenarios (for more information on emission scenarios, visit the Intergovernmental Panel on Climate Change [IPCC] website).These scenarios represent varying assumptions about future greenhouse gas emissions. In cases in which these newer scenario models were not available, the old IPCC scenarios (e.g., A1B, B1, A1FI) were used. Comparisons among these new and old scenarios are summarized below:

New scenarios	*Scenario characteristics*	*Comparison to old scenarios*	*Description used in this report*
RCP 2.6	An extremely low scenario that reflects aggressive greenhouse gas reduction and sequestration efforts	No analogue in previous scenarios	"Very Low"
RCP 4.5	A low scenario in which greenhouse gas emissions stabilize by mid-century and fall sharply thereafter	Very close to B1 by 2100, but higher emissions at mid-century	"Low"
RCP 6.0	A medium scenario in which greenhouse gas emissions increase gradually until stabilizing in the final decades of the 21st century	Similar to A1B by 2100, but closer to B1 at mid-century	"Medium"
RCP 8.5	A high scenario that assumes continued increases in greenhouse gas emissions until the end of the 21st century	Nearly identical to A1FI[B]	"High"

Which Scenario to Use?

Irreducible uncertainty in both climate and future greenhouse gas emissions means that projections of future climate will always involve a range of scenarios:

- We can't know which scenario is more likely. Since we are unable to predict the future, we can't say with certainty which scenario is more likely to occur.

- It is important to consider a range of potential outcomes. There is no "best" scenario, and the appropriate range of scenarios depends on the specific climate impact under consideration. Deciding which scenario to use involves clarifying how climate affects a particular decision and what level of risk is acceptable.

- Projections will continue to be updated over time. As the science of climate change progresses, new greenhouse gas scenarios and updated climate models will inevitably replace the current climate projections.

Downscaling Techniques

Projections for temperature and precipitation in this tool were developed by taking global climate models (GCMS) and statistically downscaling them so that they provide more locally-specific information.

There are two approaches for downscaling GCM simulations (Hamlet et al. 2010):

- Statistical downscaling takes broad scale model data from the GCMs and relates it to local meteorological observations to arrive at localized projections.

- Dynamical downscaling uses finer scale regional climate models rather than GCMs to simulate meteorological processes and arrive at localized projections.

Because of their finer spatial scales and detail, dynamical downscaling can take into account more fine-scale topographic features such as the Cascade mountain range. GCMs are too coarse to take into account these features. However, statistical downscaling is a realistic approach to develop a specific, local-level climate prediction (Laflamme et al. 2016).

APPENDIX I

Supplemental Design Criteria

43rd Avenue SE

SR 524 to 180th Street SE
Snohomish County, WA

DESIGN CRITERIA

DRAFT

Prepared for:

Snohomish County
Department of Public Works

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Prepared by:
Lloyd A. Wind, PE

KPFF Project No. 1800175

March, 2019

Reference Sources

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F. Snohomish County Drainage Code 30.63A.
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H. Washington State Department of Transportation (WSDOT) Highway Runoff Manual (M31-16.04), February 2016
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K. WSDOT Standards Plans, August 2017

ROADWAY ELEMENTS

Road Classification

Street	Classification	Max Grade
43rd Ave. SE (SR 524 – 188 St SE	Rural Minor Collector	10%
43rd Ave. SE (188th St SE – 184th St SE	Urban Collector Arterial	10%
43rd Ave. SE (188th St SE – 184th St SE	Urban Collector Arterial	10%
Sunset Road (184th St. SE – 180th St. SE	Urban Collector Arterial	10%
Sunset Road (180th St. SE – 176th St. SE	Urban Collector Arterial	10%
SR 524 (Maltby Rd.)	Rural Minor Arterial	10%
204th St. SE	Local Access Rd	15%
200th St. SE	Local Access Rd	15%
Jewell Rd. / 196th St. SE	Rural Minor Collector	10%
188th St. SE	Urban Collector Arterial	10%
184th St. SE	Urban Residential	12%
42nd Dr. SE	Urban Residential	12%
180th St. SE	Urban Minor Arterial	10%
178th St. SE	Urban Residential	12%
40th Dr. SE	Urban Residential	12%
41st Ave. SE	Urban Residential	12%

Design Speed

Street	Design Speed (MPH)	Posted Speed (MPH)	Max Cross Slope
43rd Ave. SE (SR 524 – 188 St SE	43	35	6%
43rd Ave. SE (188th St SE – 184th St SE	43	35	6%
43rd Ave. SE (188th St SE – 184th St SE	43	35	6%
Sunset Road (184th St. SE – 180th St. SE	30	25	4%
Sunset Road (180th St. SE – 176th St. SE	43	35	6%
SR 524 (Maltby Rd.)	43	35	6%
204th St. SE	25	25	2%
200th St. SE	25	25	2%
Jewell Rd. / 196th St. SE	43	35	6%
188th St. SE	35	30	6%
184th St. SE	30	25	4%
42nd Dr. SE	25	25	2%
180th St. SE	43	35	6%
178th St. SE	25	25	2%
40th Dr. SE	25	25	2%
41st Ave. SE	25	25	2%

Curb Return Radius

Street	Roadway Classification	Curb Return Radius (ft)
43rd Ave. SE (SR 524 – 188 St SE	Rural Minor Collector	35
43rd Ave. SE (188th St SE – 184th St SE	Urban Collector Arterial	35
43rd Ave. SE (188th St SE – 184th St SE	Urban Collector Arterial	35
Sunset Road (184th St. SE – 180th St. SE	Urban Collector Arterial	35
Sunset Road (180th St. SE – 176th St. SE	Urban Collector Arterial	35
SR 524 (Maltby Rd.)	Rural Minor Arterial	35
204th St. SE	Local Access Rd	25
200th St. SE	Local Access Rd	25
Jewell Rd. / 196th St. SE	Rural Minor Collector	30
188th St. SE	Urban Collector Arterial	25
184th St. SE	Urban Residential	25
42nd Dr. SE	Urban Residential	25
180th St. SE	Urban Minor Arterial	25
178th St. SE	Urban Residential	25
40th Dr. SE	Urban Residential	25
41st Ave. SE	Urban Residential	25

Stopping Sight Distance

Street	Design Speed (MPH)	Stopping Sight Distance (ft)	Rate of Vertical Curve (K) (Crest/Sag)	Note
43rd Ave. SE (SR 524 – 188 St SE	43	340	/40	
43rd Ave. SE (188th St SE – 184th St SE	43	340		
43rd Ave. SE (188th St SE – 184th St SE	43	340		
Sunset Road (184th St. SE – 180th St. SE	35	250	29/	
Sunset Road (180th St. SE – 176th St. SE	43	340		
SR 524 (Maltby Rd.)	43	340		
204th St. SE	35	250		
200th St. SE	35	250		
Jewell Rd. / 196th St. SE	43	340		
188th St. SE	35	250		
184th St. SE	35	250		
42nd Dr. SE	35	250		
180th St. SE	43	340		
180th St. SE @3% downhill	43	340		
180th St. SE @ 6% downhill	43	340		
178th St. SE	35	250		
40th Dr. SE	35	250		
41st Ave. SE	35	250		

K values calculated for grades under 3%. K values for steeper grades will be adjusted per Snohomish County EDDS Table 3-7

The intersection is anticipated to be illuminated. Sag Curve SSD not reduced to comfort criteria.

VERTICAL ALIGNMENT

BY Nick Jarrell

Eye Height	H1	3.5
Object Heig	H2	2
	Direction	Two Way

DATE 18-Mar-19

PROJECT 43rd Ave SE

ALIGNMENT 43rd-Ave-RWCL

Curve Criteria					[A]Comfort Criteria	Required		Design Curve				Comments
PVI	Speed	CURVE	Grade In	Grade Out	Sag Only	[B]SSD	Length	SSD	Length	PVC	PVT	
STA	MPH	TYPE	%	%		FT	FT	FT	FT	STA	STA	
14+26.01	43	SAG	-2	2		336	278	356	300	12+76.01	15+76.01	
17+90.72	43	CREST	2	0.5		342	129	819	200	16+90.72	18+90.72	
23+43.52	43	SAG	0.5	1		340	129	1154	150	22+68.52	24+18.52	
25+96.00	43	CREST	1	-0.5		337	129	794	150	25+21.00	26+71.00	
29+90.59	43	CREST	-0.5	-9		364	522	364	522	27+29.59	32+51.59	
34+25.00	43	SAG	-9	-3	y	n/a	239	215	240	33+05.00	35+45.00	
39+58.89	43	SAG	-3	2	y	n/a	199	215	200	38+58.89	40+58.89	
46+52.88	43	SAG	-1	1.5		337	129	1100	500	44+02.88	49+02.88	
51+68.69	43	SAG	1.5	4		351	129	600	200	50+68.69	52+68.69	
54+86.05	43	SAG	0.4	2.5		343	129	1171	200	53+86.05	55+86.05	
56+74.09	43	CREST	2.5	0.84		345	129	715	130	56+09.09	57+39.09	
58+43.03	43	SAG	0.84	3.77		348	144	393	180	57+53.03	59+33.03	
60+82.81	43	CREST	3.77	1		349	129	490	200	59+82.81	61+82.81	
62+95.85	43	CREST	1	-0.2		338	129	974	150	62+20.85	63+70.85	
64+89.55	43	SAG	-0.2	3	y	n/a	128	303	150	64+14.55	65+64.55	
68+51.63	43	CREST	3	1		347	129	605	130	67+86.63	69+16.63	
72+81.18	43	SAG	1	2		344	129	550	130	72+16.18	73+46.18	
77+16.42	43	CREST	2	1.1		344	129	1274	150	76+41.42	77+91.42	
80+22.62	43	CREST	1.7	-0.5		339	129	556	130	79+57.62	80+87.62	
82+76.09	43	CREST	-0.5	-4		348	129	373	130	82+11.09	83+41.09	
84+91.56	43	CREST	-4	-9.3		378	349	334	260	83+61.56	86+21.56	
89+54.53	43	SAG	-9.3	-1.57	y	n/a	308	310	500	87+04.53	92+04.53	
95+45.00	43	SAG	-1.57	1.1	y	n/a	107	580	250	94+20.00	96+70.00	

VERTICAL ALIGNMENT

Eye Height	H1	3.5
Object Hei	H2	2
	Direction	Two Way

BY Nick Jarrell

DATE 18-Mar-19

PROJECT 43rd Ave SE

ALIGNMENT 180th-ST-SE-RWCL

Curve Criteria					[A]Comfort Criteria	Required		Design Curve				Comments
PVI	Speed	CURVE	Grade In	Grade Out	Sag Only	[B]SSD	Length	SSD	Length	PVC	PVT	
STA	MPH	TYPE	%	%		FT	FT	FT	FT	STA	STA	
8+40.09	43	SAG	0.44	5	y	n/a	182	315	300	6+90.09	9+90.09	
11+25.14	43	SAG	5	8.61	y	n/a	144	268	165	10+42.64	12+07.64	

A Comfort criteria in accordance with DM 1220.03 (2)

B Stopping sight distance calculated using DM exhibit 1260-4

ROADWAY CRITERIA

A. Design Vehicle

1. Roundabout at SR 524 was designed for WB 76 vehicle.

B. Road Taper and Transitions

1. $L=WS^2/60$ where L is the length of taper in feet, W is the lane offset in feet, and S is the design speed in miles per hour
   (Source: Seattle ROW Improvements Manual, v2.0, 9/2008, Ch. 4.6.2)

C. Clearances

Clearances defined for closest part of any fixed object, excluding traffic control signs and parking meter posts.

1. Lateral clearance
   a. County Clear Zone is 10’ from edge of traveled way.
2. Vertical Clearance
   a. Not Applicable.

APPENDIX J

43rd Avenue SE and Sunset Road:
SR 524 to 180th Street SE
Draft Stormwater Concept Alternatives Analysis for
Proposed and Future Road Widening

MEMO

Date: May 29, 2019

To: Michael Randall, P.E. – Snohomish County Project Manager

From: Patrick Sloan, P.E.

Subject: 43rd Avenue SE and Sunset Road: SR 524 to 180th Street SE
Draft Stormwater Concept Alternatives Analysis for Proposed and Future Road Widening

This technical stormwater memorandum evaluates the minimum requirements and stormwater mitigation options for the proposed improvements of the 43rd Avenue SE and Sunset Road Roadway Improvement Project (Project) in Snohomish County. Per request of Snohomish County, the alternatives evaluated in this report are intended to be forward-compatible and facilitate the drainage needs of the future condition, which assumes that the entire project corridor will eventually be within the limits of Snohomish County's urban growth boundary.

Project Overview

The Project is a transportation redevelopment project spanning a 1.7-mile section of roadway in unincorporated Snohomish County along the 43rd Avenue SE and Sunset Road rural and urban minor collector corridor from Maltby Road (SR 524) to 180th Avenue SE. The Project proposes improvements to the roadway by widening and reconstructing parts of the corridor where roadway alignment, intersection layout, surface type, bicycle facilities, and pedestrian facilities, or lack thereof, impede or prevent the safe and efficient travel of the corridor by drivers in the rapidly growing urban and rural communities. Alternatives are being concurrently evaluated to propose the addition of a combination of sidewalks and pedestrian facilities, bicycle lanes, planter strips, turn pockets, shoulders, vertical and horizontal realignments, and drainage improvements. Additionally, three intersections are being assessed to evaluate the construction of roundabouts.

Design Criteria

The following manuals, codes, and standards were used for this analysis:

- Snohomish County Code (SCC) Chapter 30.63, May 9, 2018.
- Snohomish County Drainage Manual (Last updated November, 2017).
- Snohomish County Engineering Design and Development Standards (EDDS), December, 2017.

The stormwater mitigation options evaluated in this report were selected with guidance from the Snohomish County Drainage Manuals, Volumes I, III, and V. The Drainage Manual provides interpretation of regulations set forth in the SCC for applicability of Minimum Requirements, application of minimum requirements, and acceptable BMPs to meet them.

MEMO

Existing Conditions

The Project corridor serves as a north/south connector for a diverse rural and urban area, while also providing local connections to schools, neighborhoods, and residential driveways along the road. The existing road is a single lane in each direction and includes some sections with shoulders and sidewalk. As residential development has occurred along the corridor, private developers have constructed sidewalks, planter strips, and widened the shoulders. These improvements are sporadic and inconsistent throughout the corridor, resulting in significant variation in the roadway cross section. Between 200th Street and 196th Street SE 43rd Avenue SE is a private unimproved gravel roadway.

The urban growth boundary is delineated on 43rd Avenue SE by a physical barricade across the roadway with "Road Closed" signage, blocking through-traffic crossing the northern leg of the intersection at 188th St SE.

Adjacent land uses are primarily single-family residential tracts, ranging from low density in the rural area south of 188th St SE to medium-high density in the urban area north of 188th Street SE. Along the western right of way of 43rd Avenue SE, there is a Seattle City Light (SCL) easement 150 feet in width. Along the south right of way line of SR 542 is a large tract of land owned by Bonneville Power Administration (BPA). These areas will have limitations to development and potential stormwater management approaches.

Within the rural limits of the Project corridor, storm drainage is managed by ditches, conveyance pipes, and sheet flow dispersion. Further north, within the UGA limits, roadway has been constructed to the urban standard section. Storm drainage includes collection and conveyance systems, water quality treatment and flow control.

The Snohomish County Department of Public Works Surface Water Management Division has published Drainage Needs Reports (DNRs) for the watersheds to which the project corridor contributes. DNR No. 9 (Little Bear Creek Watershed) and DNR No. 10 (North Creek Watershed) were each completed in December, 2002, to document known hydrologic, hydraulic, and water quality problems and possible solutions within the respective watersheds. Neither report indicated that the project corridor crossed any of the known problem areas. There is one area noted in DNR No. 10 indicating an undersized culvert where Tambark Creek crosses 180th Avenue SE approximately 850 feet west of the intersection with the project corridor. There is an area described in DNR No. 9 where a property near an unnamed tributary to Little Bear Creek was experiencing flooding issues, west of the project corridor near the intersection of 196th Street SE and 199th Street SE. Other regional problems were noted along the Tambark Creek corridor that pertained to agriculture, fish spawning pools, channel erosion, and sediments, and were not considered relevant to the scope of this project or impacted by the proposed work.

The existing drainage patterns were analyzed to define the threshold discharge areas (TDAs) for the corridor. In total, eleven TDAs make up the full Project corridor. Existing drainage was assessed with existing topographic survey prepared by Snohomish County Department of Public Works, 2017 LiDAR data from Washington Department of Natural Resources, the Snohomish County PDS GIS Portal, and as-built drawings from the Nature's Ridge, Lidera, Woodcress, Timber Creek, and Brookfield Lane communities. Discharge points and stormwater facilities were verified

in site walks. The ¼-mile points, or points of compliance, were measured along the paths of flow as determined from the resources listed above. TDA Figures can be found in Appendix A.

TDAs 1-9 drain to an unnamed tributary of Little Bear Creek, while TDAs 10 and 11 comingle in a wetland system that drains to Tambark Creek which crosses 180th Street SE just west of the project limits.

Site Geology

The geology and hydrogeology of the Project corridor were assessed and reported on by the Snohomish County of Public Works. The Hydrogeologic Report (Snohomish County Public Works, May 30, 2018) and Geotechnical Memorandum (Snohomish County Public Works, May 31, 2018) provide design recommendations based on nine borings taken in the project corridor. The boring logs generated at these locations were interpreted to determine characteristics of the native soils, the anticipated depth to groundwater and suitability for infiltration BMPs. The project corridor is situated above the Cross Valley sole source aquifer, which is predominantly confined by the corridor's underlying glacial till except at the low points, where 43rd Avenue SE intersects with SR524 and 196th Street SE, sandy outwash materials were observed. The confined condition of the aquifer was reported as having low sensitivity to pollutants that may be introduced by the planned development, except where the corridor intersects 196th Street SE. The report states that infiltration of stormwater should not be permitted due to nearby water supply wellheads, and geologic conditions which make the area highly sensitive to pollutants found in runoff.

Proposed Conditions

This Project will widen 43rd Avenue SE north of 196th Street SE to match the existing roadway section north of 188th Street SE which is the County standard urban arterial section. South of 196th Street SE the roadway section will follow the County rural section; however, this evaluation of stormwater alternatives includes conceptual designs that will be forward compatible with the ultimate buildout of this rural section to an arterial section. The horizon year for that improvement is not known at this time but is on the order of 10 years from the construction of this current project.

Portions of the corridor have been developed prior to this study as part of the Lidera, Nature's Ridge, Timber Creek, and Woodcress developments. This project will complete the connection of Sunset Road to 43rd Avenue SE as well as improvements to the intersection at Sunset Road and 180th Avenue SE.

A traffic analysis was performed by Fehr and Peers forecasting traffic volumes to grow from 4000 vehicles per day to 4900 between 2020 and 2040 from SR 524 to 196th St SE. Within the UGA (north of 196th Street SE), volumes are projected to grow from 7700 to 9300 in the same time period.

Applicable Minimum Requirements

Following the flow chart in Figure 1.3 of the Snohomish County Drainage Manual (Volume I, page 19) for road-related redevelopment projects, the applicable minimum requirements were identified for the anticipated future condition in each of the eleven TDAs in the project corridor. Minimum requirements (MRs) 1-9 were triggered for all TDAs that encompass areas of anticipated work in the anticipated future condition. Per Snohomish County Code, for road-related redevelopment projects adding 5,000 square-feet or more hard of surface to a given TDA, MRs 1-9 will apply to the new hard surface and converted pervious areas. Additionally, if the total added hard surface totals 50 percent or more of the existing hard surface, MRs 1-9 will apply to the replaced hard surface in addition to the added hard surface and converted pervious areas. The applicability of MRs 1-9 to the TDAs is summarized below in Table 1.

Table 1 Summary of Minimum Requirements

TDA	Minimum Requirements	Applicable Areas[1]
1	1-9	New HS, Replaced HS, CP
2	1-9	New HS, CP
3	1-9	New HS, Replaced HS, CP
4	N/A	N/A
5	1-9	New HS, Replaced HS, CP
6	1-9	New HS, Replaced HS, CP
7	1-9	New HS, CP
8	N/A	N/A
9	N/A	N/A
10	1-9	New HS, CP
11	1-9	New HS, CP

Notes:
1. Area Types
   - N/A – Not Applicable (no proposed work anticipated in TDA)
   - HS – Hard Surface
   - CP – Converted Pervious

MR 5: On-site Stormwater Management

While only 43rd Avenue SE north of 196th St SE is currently within the Urban Growth Area (UGA), on-site stormwater management BMPs have been selected to meet the requirements of MR 5 for the entire length of project due to the fact that the project is looking at stormwater management that is forward compatible with the ultimate build out in anticipation of the UGA limits being extended in the future.

MEMO

MR 6: Stormwater Treatment

Water quality treatment is required within a TDA if MRs 1-9 are triggered and the applicable pollution-generating hard surface (PGHS) of the proposed improvements is greater or equal to the threshold area of 5,000 square feet.

Enhanced treatment is required for any TDAs occurring within ¼ mile of sensitive waters as listed in Step 5e of the Drainage Manual's BMP and Facility Selection Process for Permanent Stormwater Control Plans (Chapter 4.2, Snohomish County Drainage Manual, Volume I; November, 2017), or having any road with an ADT of 7,500 or greater. Fehr and Pierce provided a preliminary ADT estimate for the corridor in the future condition of 9,300 north of 196th Road SE and 4,900 south of 196th Road SE. Because TDAs 6-11 exist north of 196th Rd SE and/or discharge to the wetlands bordering 180th Avenue SE, enhanced treatment will be required.

The receiving waters were also assessed for other pollutant sensitivities requiring oil or phosphorus control BMPs, per Steps 5a-5d of the BMP Selection Process (referenced above). A review of available resources determined that there was no need for phosphorus or oil control mitigation in any of the TDAs within project limits.

A summary of the level of treatment for proposed pollution-generating surfaces is shown below in Table 2. A detailed accounting of the project areas is included in Appendix B.

Table 2 MR 6: Water Quality Treatment Applicability

TDA	Applicable PGHS[1] (SF)	Treatment Required? (Y/N)	Treatment Types Required (B/E/PC/O or N/A)[2]
1	12,047	Y	E
2	112,405	Y	B & E
3	33,046	Y	B
4	0	N	N/A
5	79,139	Y	B
6	170,212	Y	E
7	18,056	Y	E
8	0	N	N/A
9	0	N	N/A
10	23,881	Y	E
11	23,386	Y	E

Notes:

1. Applicable PGHS was calculated conservatively with the assumption that, in the anticipated future condition, sidewalks will be impervious and will drain into the same facilities as polluted roadway runoff.
2. Treatment Types
   - Basic (B)
   - Enhanced (E)
   - Phosphorus Control (PC)
   - Oil Control (OC)
   - Not Applicable (N/A)

The BMPs listed below in Table 3 have been screened as feasible approaches to management of the stormwater and were considered on a TDA-based level.

Table 3 MR 6: Water Quality Treatment BMP Alternatives

Alternative	LID Facility	Enhanced Treatment
SNOCO T9.30 Biofiltration Swale	✔	
SNOCO T9.30, T7.30 Compost Amended Biofiltration Swale (CABFS)	✔	✔
SNOCO T8.40 Media Filter Drain[1] (MFD), with underdrain	✔	✔
SNOCO T7.10 Infiltration Ponds	✔	✔
SNOCO T5.11 Concentrated Flow Dispersion	✔	✔
SNOCO T5.12 Sheet Flow Dispersion	✔	✔
SNOCO T5.30 Full Dispersion	✔	✔
WSDOT IN.06 Dry Well	✔	
SNOCO T10.10 Wet Pond		
Other Proprietary Treatment Alternatives		✔

Notes:

1. Media Filter Drain was referred to as the "Ecology Embankment," in previous versions of the Snohomish County Drainage Manual.

MR 7: Flow Control

Flow control is required within a TDA if one or more of the following thresholds are met:

- The applicable total of effective impervious surfaces is 10,000 square feet or more in a TDA
- The combined applicable areas of proposed hard and pervious surfaces within a TDA causes a 0.15 cubic feet per second or greater increase in the 100-year flow frequency from the existing condition, as estimated by MGS Flood V4.43 (equivalent to WWHM, approved by the Washington Department of Ecology and Snohomish County) using 15-minute time steps.

A summary of the applicable effective impervious surfaces and change in 100-year flood frequency within the individual TDAs is shown below in Table 4:

Table 4 MR 7: Flow Control Applicability

TDA	Effective Impervious Surface[1] (SF)	Flow Control Required? (Y/N)
1	12,047	Y
2	47,275	Y
3	33,046	Y
4	0	N
5	79,139	Y
6	170,212	Y
7	18,056	Y
8	0	N
9	0	N

10	23,881	Y
11	23,386	Y

Notes:

1. Effective impervious surface was conservatively calculated with the assumption that impervious sidewalks are used in the anticipated future condition.

It should be noted that, for the applicability of MR 7, effective impervious area was calculated with the assumption that the anticipated future condition would use impervious concrete sidewalks. In the Geotechnical Memorandum (prepared by Snohomish County Department of Public Works; May 31, 2018), design recommendations are made for the implementation of porous concrete sidewalks in site conditions observed in the nine test borings along the project corridor. If porous concrete sidewalks are implemented in lieu of typical impervious sidewalks in the anticipated future condition, flow control will still be required within all TDAs where hard surface is proposed.The BMPs listed below in Table 5 are considered feasible BMPs for flow control to mitigate impacts of the anticipated future condition. As each individual TDA was assessed, only the most suitable alternatives were considered for the specific conditions present.

Table 5 MR 7: Flow Control BMP Alternatives

Alternative	LID Facility
SNOCO T7.10 Infiltration Ponds/Basins	✔
SNOCO T7.20 Infiltration Trench	✔
SNOCO T5.11 Concentrated Flow Dispersion	✔
SNOCO T5.12 Sheet Flow Dispersion	✔
WSDOT IN.06 Porous Concrete Sidewalks	✔
WSDOT FC.03 Detention Pond	
WSDOT IN.04 Underground Detention Pipes/Vaults	✔
SNOCO T5.16 Tree Retention / Planting Credits	✔
SNOCO T5.13 Soils Amendments	✔

MR 8: Wetlands Protection

If a TDA discharges to a stream that leads to a wetland, or to a wetland that has an outflow to a stream, both MRs 7 and 8 will apply to the areas applicable to MRs 1-9. Wetlands have not been formally identified at this phase of the project, but are shown at a concept-level in the Snohomish County PDS Portal GIS viewer. The GIS sources show that there are probably wetlands located within proximity to several TDAs triggering MRs 1-9 as part of the anticipated future condition, and will be protected in accordance with guidelines prepared in Appendix D of the Snohomish County Drainage Manual, Volume 1 (November, 2017).

MR 9: Operations and Maintenance

Operations and Maintenance (O&M) is taken into consideration quantitatively when evaluating the various alternatives. Addressing the specific requirements of Snohomish County Code and the Drainage Manual will be part of the final design.

MEMO

LID Feasibility Assessment

In accordance with Snohomish County Drainage Requirements, the feasibility of Low Impact Development (LID) facilities was evaluated for all TDAs triggering minimum requirements for on-site stormwater management, water quality treatment and flow control (MRs 5, 6 and 7). The objective of LID is to mimic natural drainage patterns in the project area that were present prior to development. The project corridor exists in the southwesterly quadrant of Snohomish County, where subsurface soil conditions vary with glacial outwash present in the southern limits of the project and glacial till in the northern half.

Preference has been given to any feasible non-proprietary LID BMPs, so assessments of these mitigation alternatives are emphasized in the following sections. Proprietary LID BMPs will be assessed when the non-proprietary alternatives are determined to be infeasible

Site Assessment and LID Feasibility

TDAs were numbered sequentially from south to north beginning at the intersection of 43rd Avenue SE and SR 524 (Maltby Road). TDA boundaries were defined by measuring from the furthest downstream point where runoff leaves the right of way to a point one quarter mile along the flow path.

Each TDA has been assessed for a number of feasible alternatives to address Minimum Requirements 6 and 7 based on the following:

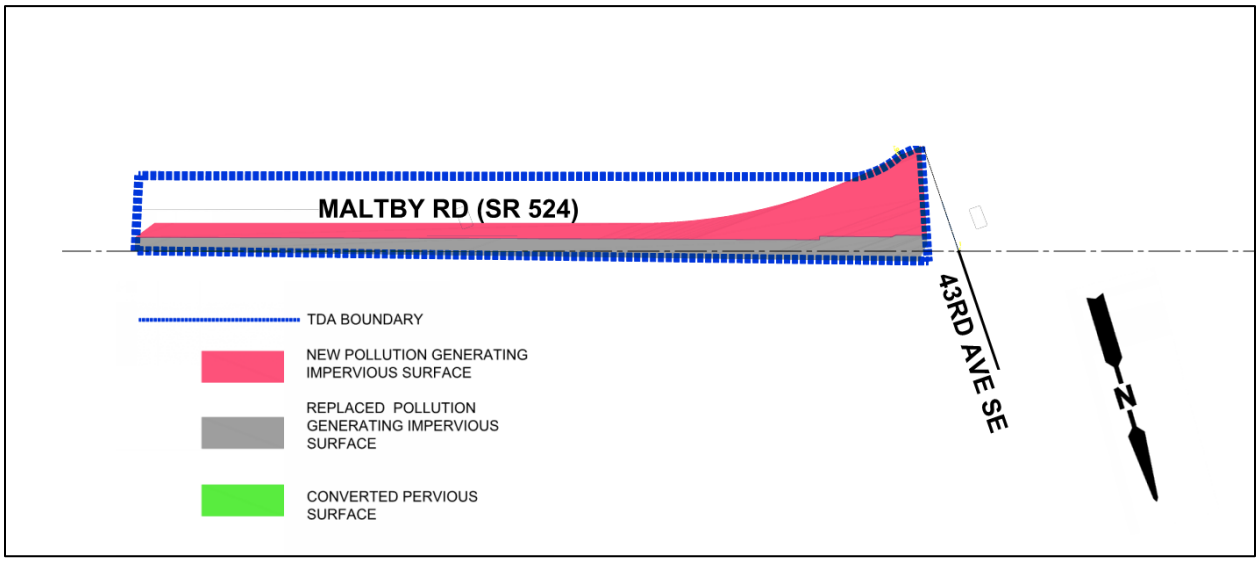
- Topography – position within the basin, available relief and positive drainage
- Soil Conditions – ability to infiltrate runoff, or conversely, do estimated rates exceed the allowable maximum.
- Critical Areas – proximity to environmentally sensitive areas
- Existing Land Use – existing easements may preclude some stormwater options
- Wellheads, Septic Fields and Aquifer Recharge Area restrictions – consideration for proximity to private facilities that may result in adverse impacts

TDA 1 Assessment

TDA 1 is a small area comprised of the southeast quadrant of the intersection of 43rd Avenue SE and SR 524. SR 524 is two-lane roadway and improvements that were evaluated were a two-lane roundabout and a signalized intersection. The roundabout was ultimately selected as the preferred alternative.

The roadway in TDA 1 appears to have been raised at least six feet above natural grade, and will remain so in the anticipated future condition. Runoff drains to a roadside ditch and either infiltrates or meanders through shallow ditches via overland flow until converging with an unnamed tributary to Little Bear Creek. Based on observations made at the nearest boring location B-09 (Hydrogeologic Report; prepared by Snohomish County Department of Public Works, May 30, 2018), the site soils consist of recessional outwash sands and gravels, which has the capacity to infiltrate runoff at a rate of 9 inches per hour, to a depth of approximately 15-feet below ground surface (bgs). The treatment capacity of these soils was not analyzed in the geotechnical study

referenced by this analysis. For the purpose of this alternatives study, it was assumed that treatment would be required in advance of infiltration. Subsequent design will require additional laboratory testing to confirm whether the native soils are adequate to provide the treatment.



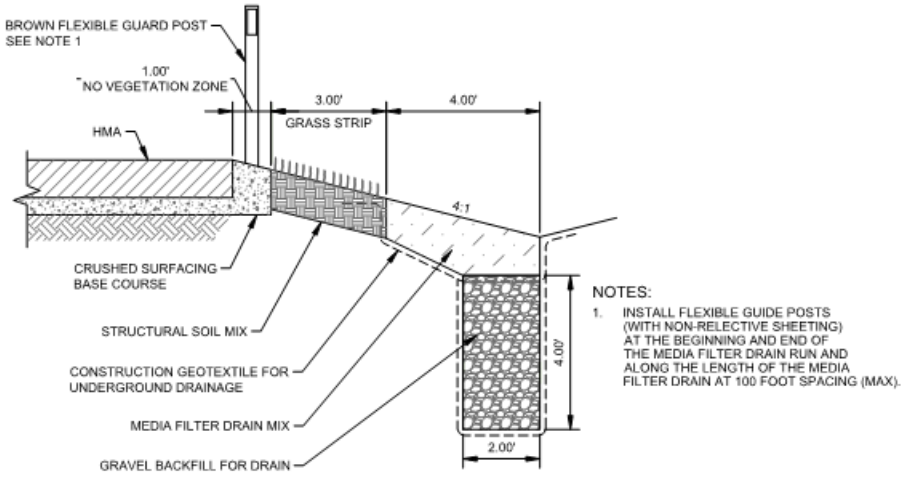
TDA 1 Limits

The adjacent parcel to the south is 11.3 acres in size and classified by Snohomish County as 910-Undeveloped (Vacant) Land. A transmission line owned and maintained by Bonneville Power Administration crosses this parcel running parallel to the State's. A 16-inch water main owned by Alderwood Water and Wastewater District runs along the west side of 43rd Avenue SE. from the south side of SR 524 to 184th Street SE.

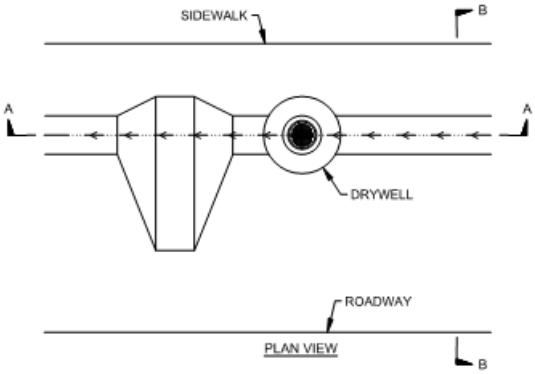
The anticipated improvements within TDA 1 trigger MRs 1-9, and include enhanced water quality treatment, and flow control for all new and replaced hard surfaces and converted pervious areas. Because soils are conducive in this area, LID strategies incorporating infiltration are most desirable. The following alternatives have been considered for TDA 1:

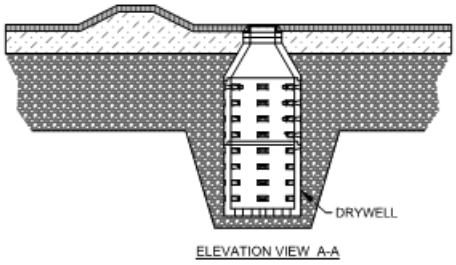
Alternative 1 – MFD (with underlying Infiltration Trench) The Media Filter Drain is a feasible LID roadside BMP that provides enhanced treatment and infiltrative flow control to meet MRs 6 and 7. SR 524 will not include a curb in the anticipated future condition aside from the roundabout itself, therefore the MFD can be installed at the edge of the anticipated future roadway footprint in order to be forward compatible. The MFD will have a cross-sectional width of 7 feet. In place of an underdrain pipe beneath, an infiltration trench would be installed beneath the 12-inch layer of filter media. Collection and treatment of runoff within the roundabout will be impractical due to the presence of a curb, and therefore an equivalent area along SR 524 would be treated to compensate for those pollution-generating surfaces within the roundabout.

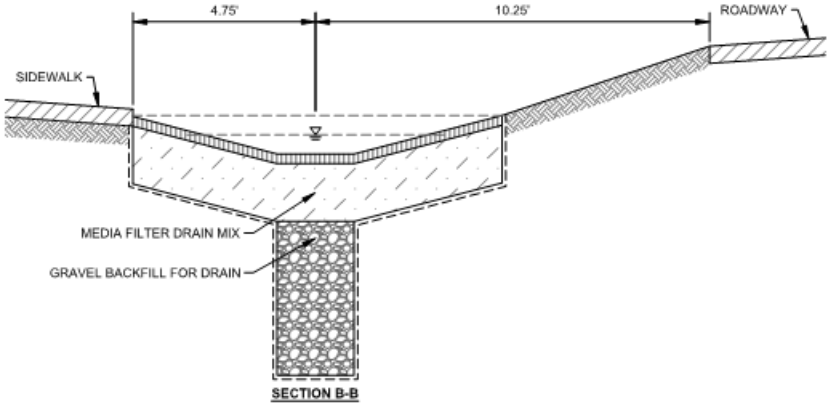
MEMO



Alternative 2 – CABFS with Drywell The CABFS is a feasible roadside BMP alternative that provides enhanced treatment to meet MR 6. This CABFS can be designed with a point discharge which makes it better suited to collect and treat channelized or pipe-conveyed runoff from the curbed roundabout. From the CABFS, treated runoff would drain to a drywell for infiltration. Additional analysis would be required to design an infiltration gallery to meet the flow control durations as a single drywell may not be adequate.





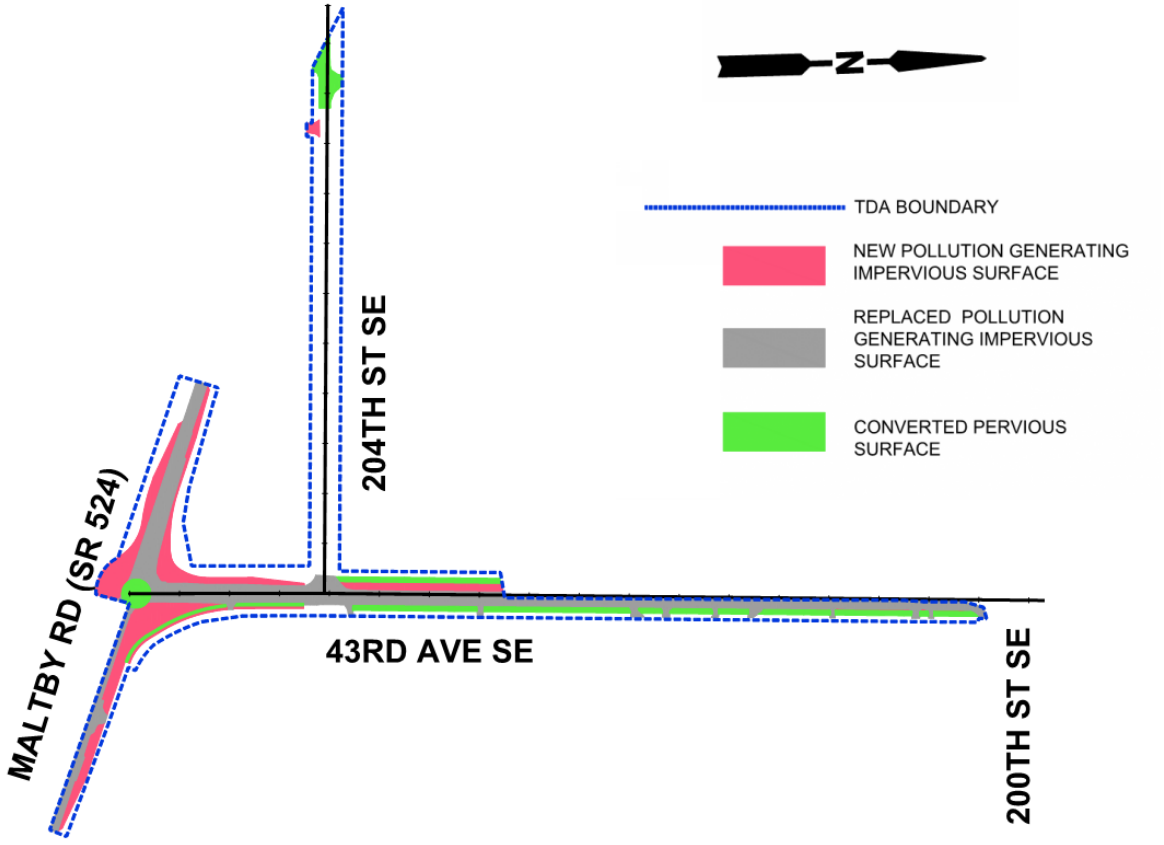


Other alternatives such as infiltration ponds, while feasible, were not evaluated for TDA 1 as they would result in significant property impacts and inhibit continuous access to the overhead power transmission lines by comparison to these linear alternatives.

TDA 2 Assessment

TDA 2 comprises a triangular footprint formed by the three intersections formed by 43rd Avenue SE, SR 524, and 204th Street SE (with the exception of the area draining to TDA 1), in addition to the eastern half of 43rd Avenue SE between 204th Street SE and 200th Street SE. Roadway improvements include evaluation of restricting access to SR 524 from 204th Street SE. A cul-de-sac or a hammerhead would be installed at the west end of 204th Street SE.

MEMO



TDA 2 Limits

43rd Avenue SE south of 196th Street SE is beyond the County's UGA limits. Therefore the immediate project improvements are to improve the roadway to a rural section with sidewalk on either side. The sidewalk would be offset from the roadway to accommodate an urban section in anticipation of this area being incorporated into the UGA at some point in the future. Stormwater management alternatives evaluated for these limits must be forward compatible with this future condition.

Drainage in the existing condition is collected and conveyed in a combination of roadside ditches, storm drain systems, and culverts. Runoff sheet flows off of SR 524 into roadside ditches. On the south side of SR 524, there is no apparent outlet from the existing shallow roadside ditch. It is believed that the runoff infiltrates into the native soils and travels north as subsurface flow. Along the east side of 43rd Avenue SE, a storm drain system collects runoff from the roadway discharging to a ditch on the west side of the road south of 204th Street SE. Runoff then flows west along 204th Street SE and drains to an upper tributary of Little Bear Creek that flows north.

The neighboring properties on the east side of 43rd Avenue SE are residential parcels. Records indicate drinking water wells and septic drain fields on each of the adjacent properties. To the west, Seattle City Light maintains a 150-foot easement for power transmission lines. A condition of any

stormwater facilities to be installed within the easement is that they not interfere with access to their infrastructure. Therefore open water ponds would not be permitted. Underground facilities that could accommodate maintenance vehicles are considered feasible.

The potential conflicts found in the assessment of potential roadside BMP sites were property/right-of-way impacts to small residential plots, cut/fill requirements on slopes exceeding the required grades for the alternatives, and proximity of infiltrative BMPs to known or probable septic fields and private wellheads.

The anticipated improvements within TDA 2 trigger MRs 1-9, and require basic water quality treatment along 43rd Ave SE and enhanced water quality treatment along SR 524, and flow control for all new hard surfaces and converted pervious area. Soils are conducive to infiltration within this TDA however testing of the native soils for cation exchange capacity (CEC) has not yet been performed. In areas where till soil is present it can safely be assumed that the CEC will be adequate, however in the areas of outwash soils all proposed solutions for this study assume that treatment will be provided to the required standards prior to infiltration. Subsequent design efforts shall include laboratory testing for CEC to validate the selection. The following alternatives have been evaluated for TDA 2:

Alternative 1 – MFD (with underlying Infiltration Trench) As described in TDA 1 above, the media filter drain could be installed within the limits of TDA 2. The main consideration for application within these limits is the forward compatibility with the ultimate urban arterial section which is discussed in greater detail in the following section on evaluation of alternatives. If the future roadway section incorporates a curb, the ability to function will be compromised.

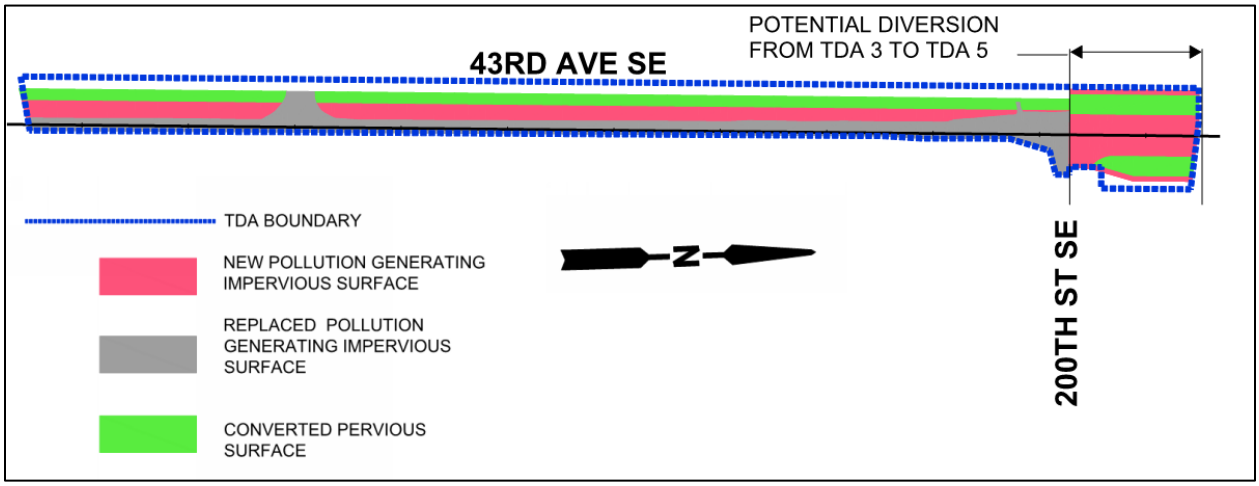
Alternative 2 – Biofiltration Swale with Drywell. Similar to the CABFS described in TDA 1, the biofiltration swale would be installed with an infiltration trench below. The primary difference is that along 43rd Ave SE, only basic water quality treatment is required and therefore compost amended soils would not be required in the swale section. The swale would be installed in a fashion that would be compatible with an urban section and the longitudinal slope of the swale maintained at a moderate level to promote infiltration. Check dams and drywells would be installed periodically to act as a backstop for flows in excess of what can be infiltrated by a hydraulically connected infiltration trench. An overflow from the drywells would connect to a conveyance system in the roadway to serve as an emergency overflow for large events that exceed the capacity of the infiltration trench.

Additional alternatives were not evaluated as they would result in significant property impacts by comparison and inhibit continuous access to the overhead power transmission lines.

TDA 3 Assessment

TDA 3 is comprised of the westerly half of 43rd Avenue SE from a point approximately five hundred feet north of the intersection of 204th Street SE and the intersection with 200th Street SE. The existing roadway is a paved, 2-lane roadway with narrow shoulders and no pedestrian or bicycle facilities. While the east half of the roadway drains to a collection and conveyance system as described in TDA 2, runoff from the western half of the roadway sheets off and disperses over the adjacent land that is the Seattle City Light easement. There exists a stand of mature trees immediately adjacent to the roadway, beyond which is open field of grass pasture.

The proposed roadway profile at this phase of the design includes a crest curve at the intersection of 200th Street SE. The high point along that curve defines the division between TDAs 3 and 5 and moves south relative to where it exists today. This results in a diversion of runoff from the former to the latter. This has implications for the stormwater management and is addressed in further detail in the assessment of TDA 5.



TDA 3 Limits

The proposed improvements will continue the roadway section proposed as described above in TDA 2. The roadway profile will not change considerably from existing.

Boring BH-08 was obtained within the limits of TDA 3 as part of the *Hydrogeologic Report*. The upper three feet of the profile are pavement and engineered fill. Found beneath that was dense to very dense coarse-grained silty sand with some gravel. While the anticipated infiltration rate is on the order of one quarter inch per hour within these limits, stormwater retention was still recommended in the *Hydrogeologic Report*.

The anticipated improvements within TDA 3 trigger MRs 1-9, and require basic water quality treatment and flow control for new hard surfaces, replaced hard surfaces, and converted pervious surfaces. CEC testing has not been performed to date, however it is anticipated that the till soils present here will be effective for treatment. As with other areas of the project where infiltration is proposed, additional subsurface investigations will be required to validate the initial recommendations of the Hydrogeologic Report.

The following options were evaluated for these limits:

Alternative 1 – Dispersion Maintain the existing drainage patterns and design the roadway section to allow for runoff to sheet flow directly from the pavement edge or provide for engineered dispersion. As described in TDA.

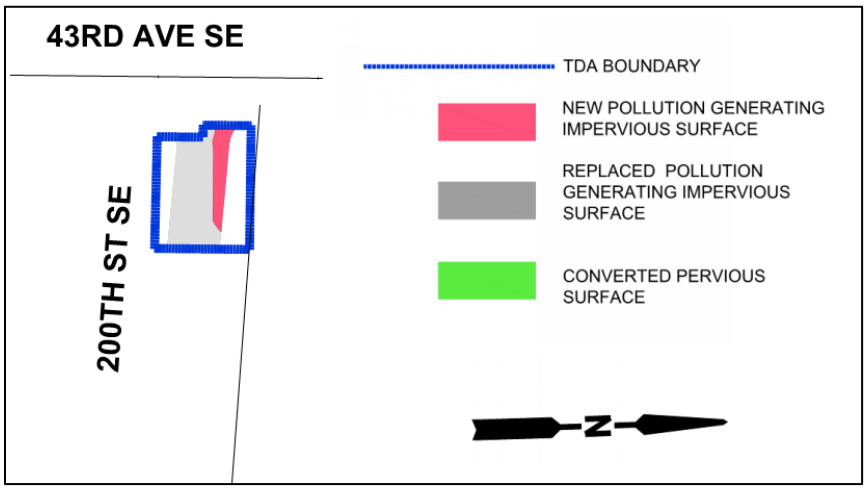
Alternative 2 – MFD (with underlying Infiltration Trench) Same as described for TDA 2 although the below grade infiltration trench will need to be considerably larger.

Alternative 3 – Biofiltration Swale with Drywell Same as described for TDA 2.

For the latter two alternatives, a detention tank will be provided as needed to supplement the infiltration BMPS to meet the flow control durations for the TDA.

TDA 4 Assessment

TDA 4 limits are contained to 200th Street SE, to the east of the 43rd Avenue SE alignment. The scope of improvements within this TDA is limited to intersection improvements necessary for the widening of 43rd Avenue SE. No stormwater mitigation is required for TDA 4. Conveyance of runoff from the roadway is provided by a combination of conveyance pipes and roadside ditches draining east.



TDA 4 Limits

TDA 5 Assessment

TDA 5 encompasses the full width section of 43rd Avenue SE north of 200th Street SE to 196th Street SE (Jewell Road). Within these limits, 43rd Avenue SE is an unimproved gravel roadway with a steep longitudinal grade and a sag curve approximately 150 feet south of 196th Street SE.

In the immediate future condition, 43rd Avenue SE will be widened to resemble a full-width rural collector roadway section. The intersection of 196th Street SE will be improved with a roundabout and the vertical profile of 43rd Avenue SE will be altered significantly to ameliorate the steep grades and sight distance issues that exist today. Walls will be needed to limit the impacts to private properties where the profile changes are greatest. Conveyance pipes are proposed within the wall limits in order to prevent water from entering the wall backfill.

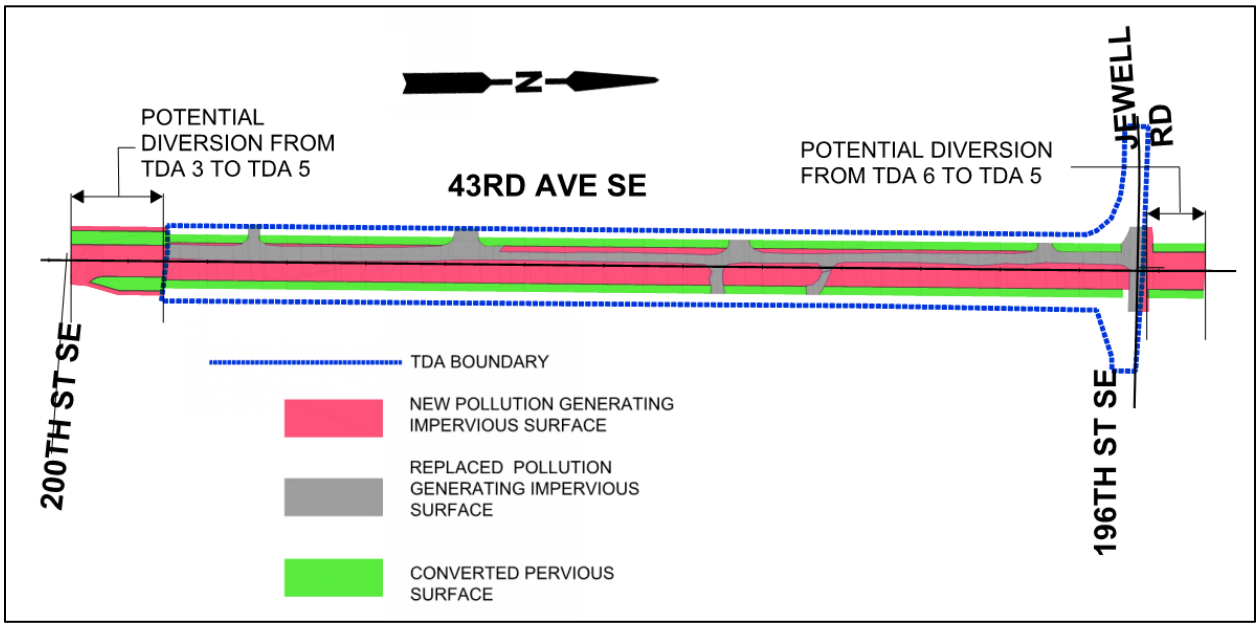
The alignment in these limits is underlain with advance outwash soils that are very conducive to infiltration (as indicated by analyses for boring B-06W, Hydrogeologic Report); however, due to the Lazy Eight wellhead located in the southeast quadrant of the 43rd Avenue SE and 196th Street SE intersection, infiltration will not be implemented. Stormwater facilities within this TDA will require a liner. Due to the increase in impervious area, the detention volumes required for TDA 5 are significant. The most suitable location for a facility near the low point is constrained by structures, septic fields, and other natural drainage features. For that reason, dividing the stormwater

mitigation into multiple facilities has been evaluated. Near the low point of the roadway alignment, closest to the wellhead, an engineered liner will be required. For facilities placed further from the wellhead a compacted till liner has been deemed to be adequate based on input from the project geotechnical engineer.

The roadway profile, as designed at 30%, will result in relocation of the boundaries of TDA 5 at both adjacent TDAs – 3 and 6. Approximately 9,665 square feet will be diverted into TDA 5 from the south (TDA 3) and another 5,654 square feet from the north (TDA 6), thus resulting in an additional 15,319 square feet draining to TDA 5. The diverted drainage may generate additional flows in excess of the allowable limit, 0.10 cubic feet per second in the 100-year storm event. This issue has not been resolved at this time and will need to be addressed in the subsequent design by one of two methods:

1. Adjust profile such that the total change in area is less than 10,000 square feet and 0.10 cfs at the 100-year flow, or
2. Address through additional mitigation.

Given the inability to infiltrate runoff within these limits, the latter may be a challenging and potentially costly approach. Refinement of the proposed roadway vertical geometry is recommended.



TDA 5 Limits

The proposed improvements within TDA 5 trigger MRs 1-9, and require basic water quality treatment and flow control for new hard surfaces, replaced hard surfaces, and converted pervious surfaces. Within this TDA infiltration is not preferred due to the presence of the well. The following have been evaluated for water quality treatment:

Alternative 1 – Biofiltration swales Beyond the limits of the retaining walls, biofiltration swales would be suitable although infiltration into native soils will not be permitted. Depending upon the proximity to the wellhead, a liner may be required.

Alternative 2 – Wetpond with liner A wetpond would provide basic treatment. The installation of the liner would need to take into consideration groundwater elevations and consideration for buoyancy.

Alternative 3 – Wetvault A wetvault would be an appropriate alternative for areas that are within the Seattle City Light easement.

Alternative 4 – Stormfilter Stormfilter is a proprietary treatment system and is not a LID solution, however the constraints of this area preclude infiltration as an approach to management of the runoff. Stormwater is treated by filtration through cartridges within a precast concrete unit.

Alternative 5 – Modular Wetlands A Modular Wetland is also a proprietary system that operates through filtration.

Flow control options considered include:

Alternative 1 – Detention Pond with liner A compacted till liner or an engineered geomembrane liner will be required depending on proximity to wellhead. Over excavation and surcharge will need to be considered in the evaluation to address potential buoyancy.

Alternative 2 – Detention Tank or Vault Facilities sited on the west side of the road will need to be underground facilities due to the SCL easement. A Precast concrete vault would be suitable on the west side of the corridor within the Seattle City Light easement. Liners are not necessary; however, groundwater elevations should be considered to address buoyancy.

Alternative 3 – StormChamber Modular plastic bottomless pipe storage systems. Similar in concept to a tank system, but the bottomless feature makes this ideal for groundwater recharge; however, in this particular TDA the facility would require a liner. This product is also useful in low-head environments and has the advantage over tanks of taking advantage of the void space between the pipes.

Facilities have been sited with a priority to avoid impacts to existing structures. As feasibility of maintaining access to private parcels is further assessed, opportunities may arise for siting facilities on the east, in which case open pond concepts will be more cost effective.

TDA 6 Assessment

North of the 196th Street SE intersection, as 43rd Avenue SE climbs out of the low lying area in TDA 5, the topography flattens out. The existing roadway is a 30-foot wide two-lane rural section with a sidewalk on the east side that was installed as a condition of the development to the north. Ditches are located on each side of the road and cross the road via culverts at two locations. These two drainages meet up approximately 300 feet east of the right of way which is why the entire segment is considered to be a single TDA. The limits of TDA 6 extend from 196th Street SE to a point 2,800 feet north to the intersection of 188th Street SE.

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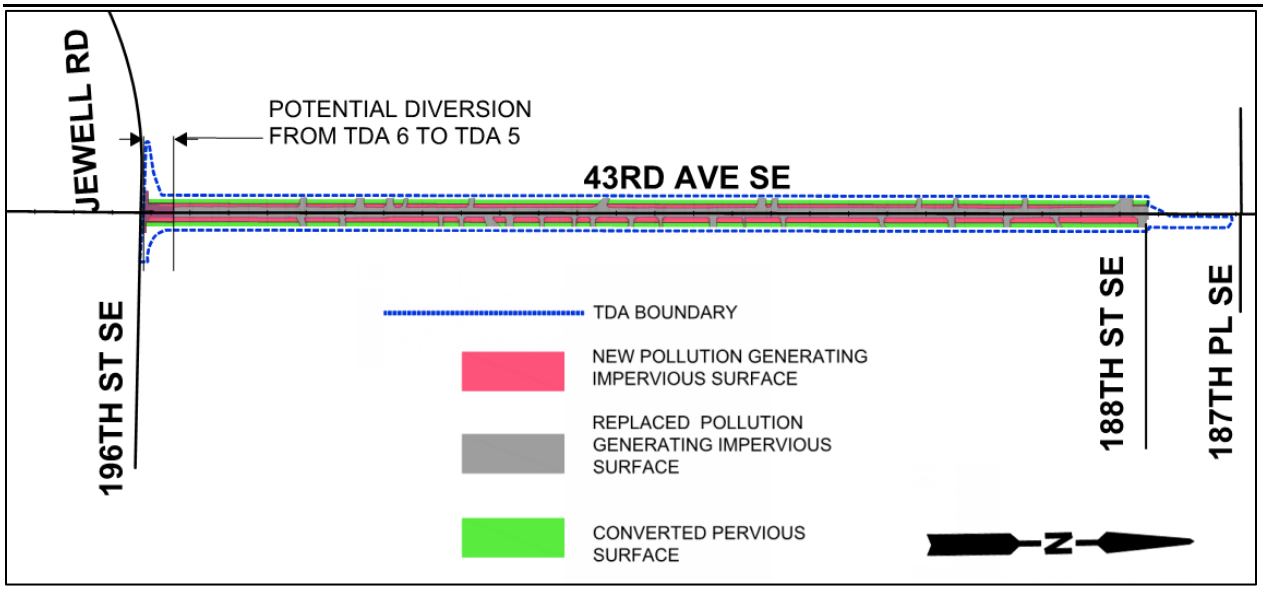


TDA 6 Limits

Proposed improvements are as a rural section in the interim. The existing walking path on the east side off the road will be removed with a sidewalk installed offset to the east. The ultimate buildout is anticipated to be for a 5-lane arterial section.

Geotechnical investigations indicate the achievable infiltration within these limits is considerably lower than for the areas south of 200th Street SE at 0.24 inches per hour. A single boring, B-05, was obtained within these limits showing a depth to groundwater of 19.0 to 23.5 feet below ground surface. Additional investigations will be needed in subsequent design to confirm this is the case for the specific locations where facilities are sited, particularly if infiltration is proposed.

The anticipated improvements within TDA 6 will also trigger MRs 1-9, but because of the higher design year ADTs, enhanced water quality treatment will be required as well as flow control for new hard surfaces, replaced hard surfaces and converted pervious areas.

The approach to the stormwater management within these limits is constrained by the existing topography. The vertical relief from the low point along the roadway centerline to the streams where drainage will leave the site is on the order of 2.5 feet.

The location of facilities for detention or infiltration has been focused on the west side of the roadway. Due to the Seattle City Light easement there is far more open space on this side of the road. Facility siting prioritizes maintaining setbacks from homes and other private features, however some impacts will be unavoidable and septic fields may need to be relocated. The facilities will also need to be below grade and not inhibit access of vehicles and equipment to the Seattle City Light easement.

The following have been evaluated for water quality treatment:

Alternative 1 – MFD (with underlying Infiltration Trench) Similar concept as described previously.

Alternative 2 – CABFS The compost-amended biofiltration swale is capable of providing enhanced treatment. The feasibility of providing infiltration with drywells and or trenches beneath to minimize the size of the detention facility will be considered but is not expected to be economical.

Alternative 3 – Bioretention A series of cells would incorporate underdrains connected to a conveyance system in the roadway.

Alternative 4 – Infiltration Native soils are till with a modest infiltration rate of 0.24 inches per hour. The CEC of these soils, however, is expected to be adequate for treatment. Pretreatment would be provided in the some form to remove larger sediment prior to entering the infiltration facility.

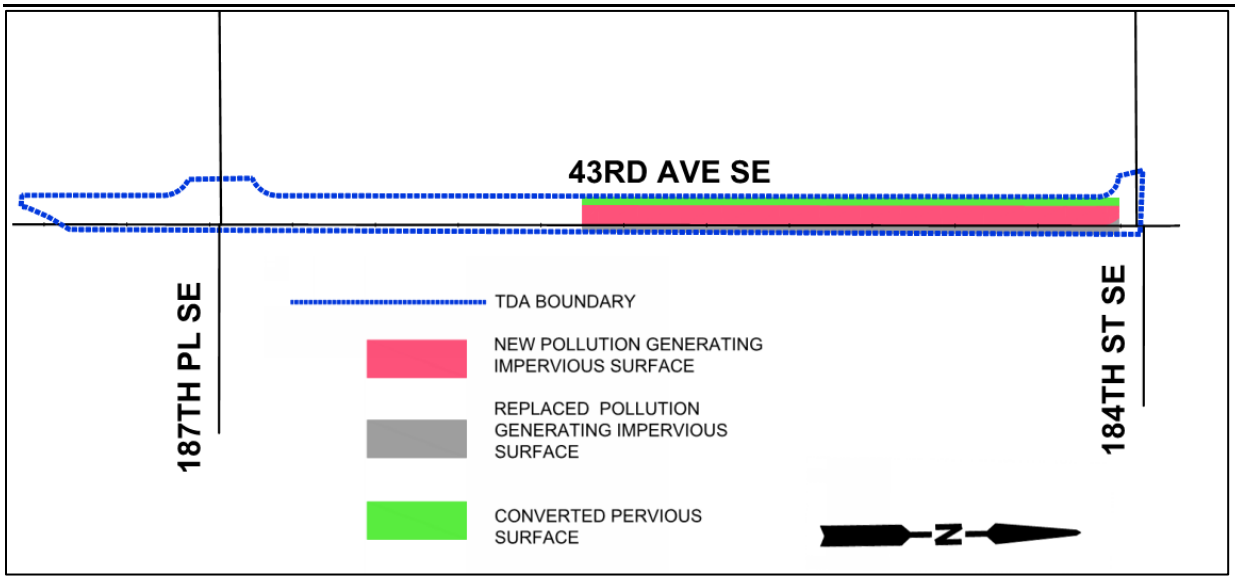
Alternative 5 – Treatment Wetland A shallow pond designed to treat stormwater through the biological processes associated with emergent aquatic plants. Feasibility will be dependent upon the possibility of infiltration and the ability to maintain hydroperiods to sustain the plants.

Flow control options considered include:

Alternative 1 – StormChamber The StormChamber was deemed the only feasible alternative for evaluation in this area. An underground facility is required because it is within the Seattle City Light easement; a vault or tank would not be a cost effective approach because of the limited vertical relief in the basin. The StormChamber system is ideal for the low-head environment and has the added benefit of allowing for infiltration.

TDA 7 Assessment

The southern limits of TDA 7 begin at 187th Street SE and extend approximately 1300 feet north to 184th Street SE. The TDA contains only the western half of the roadway section in these limits. Between 187th Street SE and station 73+50, the roadway has already been constructed to the full arterial section as part of the adjacent Lidera development including bioretention cells that have been constructed behind the sidewalk. North of this point, the roadway improvements are to be completed as part of this project.



TDA 7 Limits

Within the improved limits, stormwater from the western half of the roadway is collected in catch basins along the curb line and discharged to bioretention cells behind the sidewalk via bubble-up energy dissipater structures. These swales provide treatment and some infiltration into the native soils and convey runoff south to an enclosed conveyance system in 188th Street SE which drains to a detention pond.

The proposed improvements will match the design of this existing roadway section including the approach to handling stormwater. The available design documentation of the existing bioretention is not definitive on the sizing and we were unable to confirm whether the developers of the Lidera community accounted for upstream contribution from this undeveloped portion of the roadway. This preliminary design assumes that a conveyance system will be necessary to bypass the treated stormwater from this portion of the roadway around the existing bioretention built for the Lidera development, and a detention tank installed in the roadway or within the SCL easement to provide flow control. Subsequent analysis will be necessary to determine if the bypass can be eliminated.

TDA 8 Assessment

TDA 8 is the eastern counterpart of TDA 7. The roadway improvements were constructed by the Timber Creek development in its entirety. No work is proposed within this TDA as part of the 43rd Avenue SE improvements. Stormwater on the east half of the roadway is collected by catch basins and conveyed to 188th Street SE where it flows to the east to an infiltration vault that is part of the Timber Creek development.

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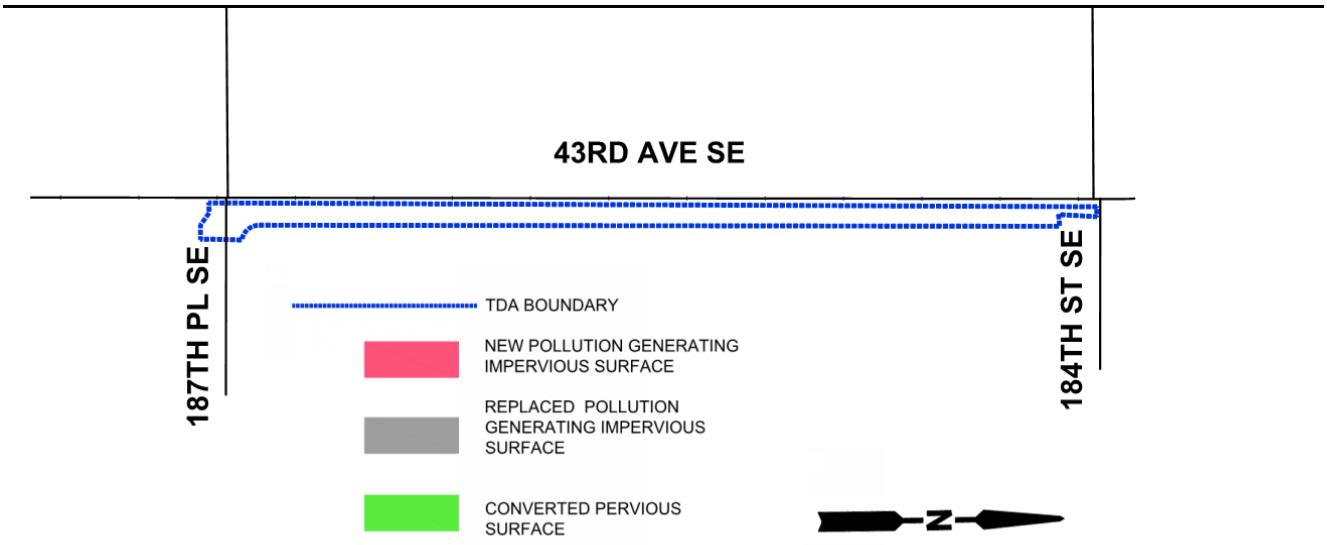
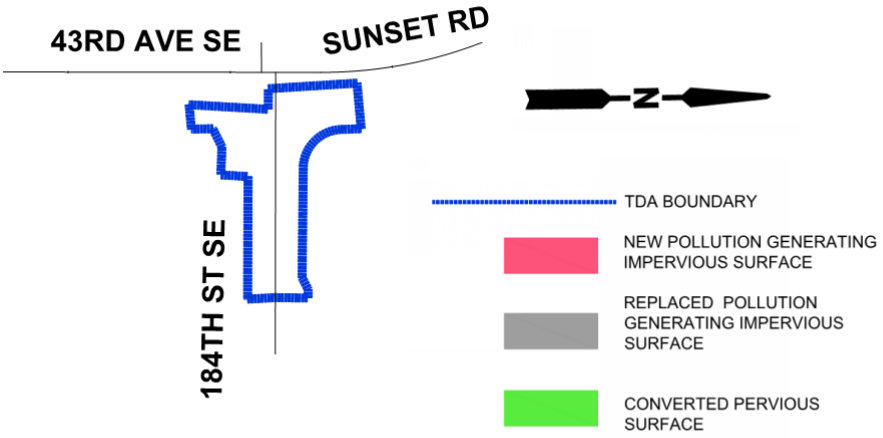


TDA 8 Limits

TDA 9 Assessment

TDA 9 comprises a small footprint of the eastern leg of the intersection of 43rd Avenue SE and 184th Street SE. The curb returns have already been constructed in this portion and no work is needed as part of this project.



TDA 9 Limits

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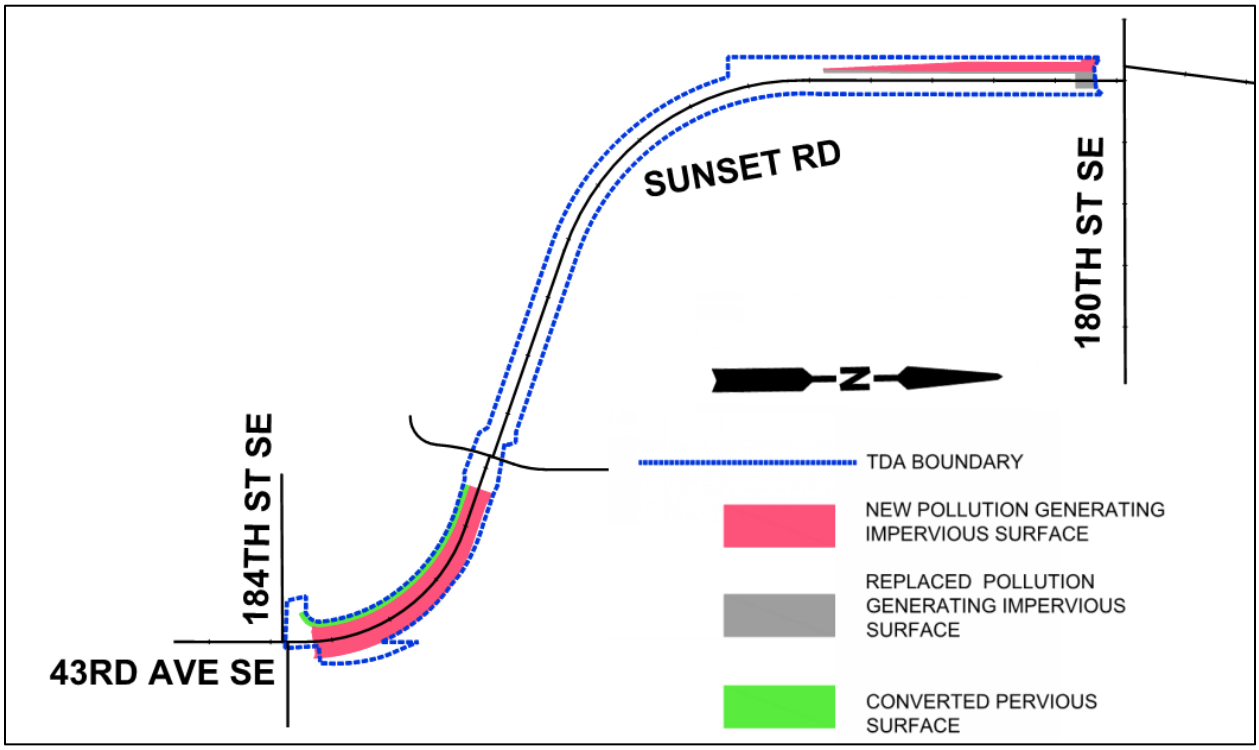
TDA 10 Assessment

TDA 10 limits begin at the north end of the intersection of 43rd Avenue SE and 184th Street SE, where 43rd Avenue SE continues north as Sunset Road, extending to the intersection of 180th Street SE. Much of Sunset Road on this segment has been constructed as a part of the Nature's Ridge development. The scope of work for this project includes completion of the roadway between 184th Street SE and 42nd Drive SE and installation of a left turn pocket on the south approach to 180th Street SE. The stormwater facilities constructed in the Nature's Ridge development are documented in the Full Drainage Report, and were designed to account for the former segment's impervious area in the design of the detention pond. The left turn pocket was not accounted for, however it is less than 5,000 square feet of new hard surface and therefore MRs 6 and 7 are not applicable. Subsequent design should evaluate the existing flow control structure for any modifications necessary to optimize for the additional flow that will enter the pond.



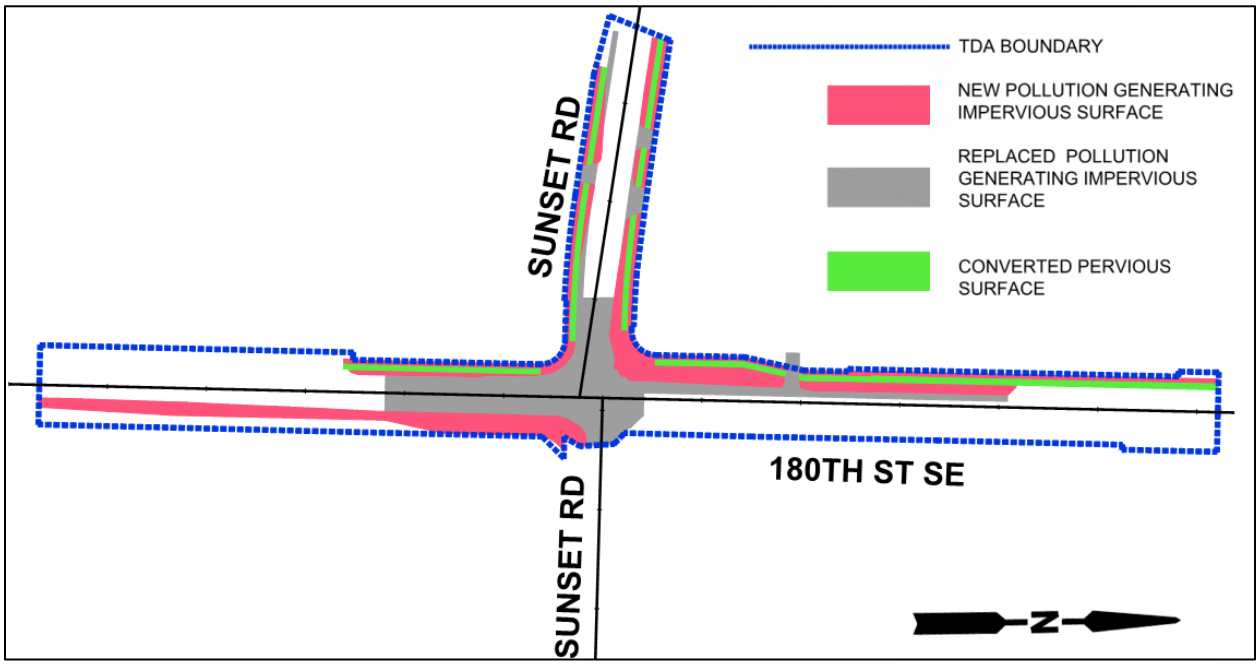
TDA 10 Limits

TDA 11 Assessment

TDA 11 encompasses the east, west, and north legs of the Sunset Road and 180th Street SE intersection beyond TDA 10.The existing roadways from each leg of the intersection are three lanes, with sidewalk and planter strip on one side of the roadway. Sidewalk and planter strip has been constructed on both sides beginning 260 feet east of the intersection along 180th Street SE.

There are ditches along Sunset Road and 180th Street SE which intersect at the northeast corner of the intersection and cross Sunset Road to a series of ditches and culverts that discharge to the wetland area. A closed pipe system originating in the Nature's Ridge development collects inflow to catch basins along the south side of 180th Street SE and discharges to the wetland area near the southeast corner of the intersection of Sunset Road.

Improvements will include widening to install turn lanes, sidewalks and a signal.



TDA 11 Limits

Water quality treatment must be provided to the Enhanced level due to the traffic volumes. Flow control will be required for new hard surfaces and converted pervious surfaces only. Infiltration rates are anticipated to be 0.24 inches per hour.

There is little real estate that is vacant in the area of the intersection. To the south is the relatively new development of Nature's Ridge and wetland buffers. The parcel in the northeast corner provides the best opportunity for acquisition for a facility. It is small, however, and walls will likely be required. Additional Right of Way take is needed in the northwest quadrant, but efforts will be made to minimize the property impacts.

The following alternatives have been evaluated for water quality. Because the geometry of the intersection has limited space between the curb and sidewalk, the following treatment alternatives have been considered downstream of a detention facility:

Alternative 1 – CABFS The compost-amended biofiltration swale is capable of providing enhanced treatment. Additional work may look into the feasibility of providing infiltration with drywells and or trenches beneath, to minimize the size of the detention facility.

Alternative 2 – Bioretention Series of cells would incorporate underdrains connecting to a conveyance system in 180th Street SE.

Alternative 3 – Treatment Wetland Shallow pond designed to treat stormwater through the biological processes associated with emergent aquatic plants.

Alternative 4 – Detention/Infiltration Native soils are till with a modest infiltration rate of 0.24 inches per hour. The CEC of these soils has not been tested, but is expected to be adequate for treatment. Pretreatment would be provided in the some form to remove larger sediment prior to entering the infiltration facility.

Alternatives Evaluation

The stormwater management alternatives identified above were evaluated based on the following criteria:

- Topography – This criterion considers the grade of the roadway and adjacent areas and whether they are compatible with the design of the particular BMP. For example, longitudinal grades within the allowable range for swales.
- Critical Areas – Alternatives that would result in impacts, direct or indirect, would be considered unfavorable. This criterion also looks at critical areas that may be downstream of the facility and if there would be any adverse impacts.
- Existing Land Use – Facilities located beyond the right of way should consider the current land use and if the facilities will be compatible.
- Position in Basin – Detention facilities are best sited near the lower elevations in a basin; however often there are critical areas that make an otherwise ideal location infeasible.
- Forward Compatibility – Alternatives were evaluated for compatibility with two scenarios:
    - Immediate improvements—to an urban arterial or rural arterial (for those areas beyond the UGA limits).
    - Future improvements—to an urban arterial section.
- Right of Way Impacts - Impacts to private property are minimized to the extent possible, but impacts to structures are considered fatal flaws unless the parcel was already considered to be adversely impacted due to the project.
- Construction Cost - Planning level estimates were developed to assist in selecting preferred BMP site locations.
- Effectiveness – This criterion compares the specific alternatives for a TDA in relation to each other in terms of ability to meet the stated objectives.
- Maintenance Considerations – Alternatives with significant maintenance needs and high life cycle costs receive a negative rating.

TDA 1

TDA 1 is entirely within the WSDOT Right of Way. Two alternatives were evaluated for this area: Media Filter Drain and Compost-amended Biofiltration Swale. They share similarities but the primary factor in the evaluation is that WSDOT is very familiar with MFD and has used it

throughout the state on their highways. For this reason it is considered favorable in terms of long term maintenance.

CABFS may also result in more right of way impact. While not expected to be significant, the ability to grade in the swale may require the need for construction easements. The MFD was selected as the preferred alternative in this location.

	Criteria								
	Topography	Critical Areas	Existing Land Use	Position in Basin	Forward Compatibility	ROW Impacts	Construction Cost	Effectiveness	Maintenance Considerations
Alternative									
MFD (with underlying Infiltration Trench)	↑	↑	↑	↑	↑	↑	↑	↑	↑
CABFS with Drywell	↑	↑	↑	↑	↑	↓	↑	↑	↓

TDA 2

The subsurface characteristics of TDA 2 are similar to TDA 1 and therefore the two approaches evaluated were the same. TDA 2, however, encompasses both the State Route as well as County right of way. As these two alternatives pertain to SR 542, the evaluation is the same as above and the MFD is preferred at that location.

Along 43rd Avenue SE, however, there are other factors that come in to play, namely the forward compatibility with the future urban roadway section. The MFD requires sheet flow over the BMP which is difficult to incorporate into a curbed roadway section. Furthermore the County Maintenance staff is less familiar with MFD. Along 43rd Avenue SE within TDA 2, Biofiltration swale that is hydraulically connected to an infiltration trench is the preferred approach.

	Criteria								
	Topography	Critical Areas	Existing Land Use	Position in Basin	Forward Compatibility	ROW Impacts	Construction Cost	Effectiveness	Maintenance Considerations
Alternative									
MFD (with underlying Infiltration Trench)	↑	↑	↑	↑	↓	↑	↑	↑	↓
Biofiltration Swale with Drywell	↑	↑	↑	↑	↑	↑	↑	↑	↑

TDA 3

The proposed improvements in TDA 3 are the same as proposed in TDA 2 and along a County road. The primary differentiator is the subsurface conditions which are till soils and not expected to provide the same ability to infiltrate runoff. The other difference is that the land adjacent to the right of way is conducive to dispersion of runoff. For the same reasons above, biofiltration swales would be preferable to MFD. Dispersion, however, would be preferable to the swales except for the two factors: forward compatibility and right of way impacts. With a sidewalk offset from the roadway, it is difficult to provide runoff length for dispersion. If the shared use path were provided along the shoulder, dispersion would be a more viable option.

In terms of property rights, SCL has an easement on the property, and dispersion would be permissible based on conversations with SCL. Dispersion would require that the County obtain an easement to set aside this parcel to be maintained in its undeveloped condition. This easement could be costly given the area needed, so is therefore not recommended.

Biofiltration swales with drywells to promote infiltration are the preferred option for TDA 3. A detention tank will be provided to supplement the infiltration for flow control.

	Criteria								
	Topography	Critical Areas	Existing Land Use	Position in Basin	Forward Compatibility	ROW Impacts	Construction Cost	Effectiveness	Maintenance Considerations
Alternative									
Dispersion	↑	↑	↑	↑	↓	↓	↑	↓	↑
MFD (with underlying Infiltration Trench)	↑	↑	↑	↑	↓	↑	↑	↑	↓
Biofiltration Swale with Drywell	↑	↑	↑	↑	↑	↑	↑	↑	↑

TDA 4

No evaluation was performed for TDA 4 as the improvements within this TDA did not exceed 5,000 square feet of new impervious.

TDA 5

TDA 5 is beyond the UGA limit similar to the previous two. The most significant differentiators are limitations on infiltration and the fill walls to contain the roadway within the right of way. Generally speaking, between a wetpond and a wetvault, the former would typically be the preferred alternative simply due to construction costs. Given that this particular site would require a liner beneath ponds, a precast vault becomes more attractive. Biofiltration swales are preferred for treatment, but have a limited number of feasible sites due to the topography and roadway geometry. The proprietary products, Stormfilter and Modular Wetlands, would be used only as a last resort to address a particularly difficult design scenario.

Similar challenges are faced in development of flow control alternatives. A pond a with liner and a precast concrete vault were evaluated. In spite of the need for a liner and the associated overexcavation that may be required to counteract buoyancy, the open pond is still considered to be better overall once the size of the vault needed for both detention and treatment is accounted for.

TDA 5 will employ a combination of these options to address the various opportunities and constraints unique within these limits of the corridor. The volume required for detention is large enough that it makes sense to provide for two separate facilities within the TDA rather than a single very large facility at the low point. Suitable locations are on the east side of the road at the natural low point and on the west side at the approximate midpoint of the TDA. Pending the final determination of private property impacts, there may be opportunities to move a facility to the location of a total property take.

The detention facility at the low point is proposed as a combination wetpond/detention pond with a compacted till liner. An alternative to this would be a precast concrete vault with a proprietary filter treatment system. While a vault typically costs more than a pond, this could be a cost-competitive solution if it could be installed in a way that avoided measures to counteract buoyancy. This could be done by taking advantage of the elevation between the finish grade of the roadway and the existing grade on the east side of the road. Essentially, if the bottom of vault was installed at or just below existing grade with borrow placed above it, there would be no need to mitigate for buoyancy. For the combination wetpond/detention pond, additional evaluation is necessary to determine the necessary depth of excavation to install the compacted till liner. The cost of this excavation and the engineered liner would need to be compared against the cost of the vault to determine if it is cost effective.

The second facility, located near the midpoint, is within the SCL easement. To prevent access to the power lines, it would need to be an underground precast concrete vault or a StormChamber system. The StormChamber would need to be lined with an engineered geotextile or compacted till liner to prevent infiltration. While the StormChamber system will have a larger footprint, concrete vaults are typically more expensive. Additional analysis is needed to make a final determination considering construction costs and property acquisition costs.

	Criteria								
	Topography	Critical Areas	Existing Land Use	Position in Basin	Forward Compatibility	ROW Impacts	Construction Cost	Effectiveness	Maintenance Considerations
Alternative									
WQ Treatment									
Infiltration	↑	↑	↑	↑	↑	↑	↑	↑	↑
Biofiltration Swale	↑	↑	↑	↑	↑	↓	↑	↓	↑
Wetpond with liner	↓	↑	↑	↑	↑	↓	↓	↑	↑
Wetvault	↓	↑	↑	↑	↑	↓	↓	↑	↑

Stormfilter	↑	↑	↑	↑	↑	↑	↓	↓	↓
Modular Wetlands	↑	↑	↑	↑	↑	↑	↓	↓	↓
Flow Control									
Detention Pond with liner	↓	↑	↑	↑	↑	↓	↓	↑	↑
Detention Tank or Vault	↓	↑	↑	↑	↑	↑	↓	↑	↓
StormChamber	↑	↑	↑	↑	↑	↓	↑	↓	↓

TDA 6

TDA 6 is hydraulically limited. The vertical drop between the roadway grade and the existing stream to which TDA 6 drains precluded any options other than using a StormChamber system for detention. The west side of the road within the SCL easement is the preferred location because of impacts to homes on the east. Therefore, an open pond is not an option due to the aforementioned SCL easement. A vault designed for minimum height would be partially to mostly submerged at all times which is not an economical solution. StormChambers operate in a low-head environment and have the added benefit of promoting infiltration to reduce the footprint of the system.

The BMP selected for treatment should consider the hydraulic head required through the system. For that reason, infiltration through the native soils would be the preferred option. That said, the effectiveness of this method for treatment is predicated on the opinion of the geotechnical engineer that the till soils in this region will have adequate cation exchange capacity. The approach to managing stormwater in this TDA relies heavily on infiltration with infiltration trenches running the length on either side of the roadway and beneath the detention facility. The geotechnical investigations performed to date include a single boring located within these limits. Additional testing will be required with the subsequent design in accordance with the Stormwater Manual to validate these initial estimates and the assumption regarding the cation exchange capacity.

Due to these uncertainties, two versions of the modeling were performed to provide an understanding of the potential range of detention volumes that may be required. One version of the model assumed that infiltration of 0.24 inches per hour will be achievable both within infiltration beneath the roadside swales and beneath a StormChamber detention system. A more conservative version assumes infiltration only beneath the detention system, with none beneath the swales. For the highest and lowest detention volumes (low end = 21,375 cubic feet, high end = 46,875 cubic feet), detention facilities were prorated for three preferred sites. The 30% design reflects the less conservative (low end) approach.

	Criteria								
	Topography	Critical Areas	Existing Land Use	Position in Basin	Forward Compatibility	ROW Impacts	Construction Cost	Effectiveness	Maintenance Considerations
Alternative									
WQ Treatment									

MFD (with underlying Infiltration Trench)	↑	↑	↑	↑	↓	↑	↑	↑	↓
CABFS	↑	↑	↑	↑	↑	↑	↑	↑	↑
Bioretention	↑	↑	↑	↑	↑	↑	↑	↑	↓
Infiltration	↑	↑	↑	↑	↑	↑	↑	-	↑
Treatment Wetland	↑	↑	↓	↑	↑	↓	↓	↓	↓
Flow Control									
StormChamber	↑	↑	↓	↑	↑	↓	↑	↑	↓

TDA 7

An evaluation was not performed for TDA 7. The work within these limits of the project is limited to building out to 35 feet from the roadway on the west side of the road. The logical approach is to mimic the current roadway section. Modeling has been performed for bioretention cells between the curb and sidewalk the will match the existing roadway section. A detention tank is proposed within the roadway.

TDA 8

No evaluation was performed for TDA 8 as the improvements within this TDA did not exceed 5,000 square feet of new impervious.

TDA 9

No evaluation was performed for TDA 9 as the improvements within this TDA did not exceed 5,000 square feet of new impervious.

TDA 10

No evaluation was performed for TDA 10 as the improvements within this TDA did not exceed 5,000 square feet of new impervious.

TDA 11

The topographic challenges of TDA 11 include the relatively steep gradient of 180th Street SE. A property at the northeast corner of the intersection has been identified as suitable for a total take. Minor infiltration is feasible at 0.24 inches per hour, however subsequent design will need to address impacts to a private well and septic system.

Pending the final determination of private property impacts along the west side of Sunset Drive to make driveway connections, there may be opportunities to place a detention pond in the northwest quadrant of the intersection as well.

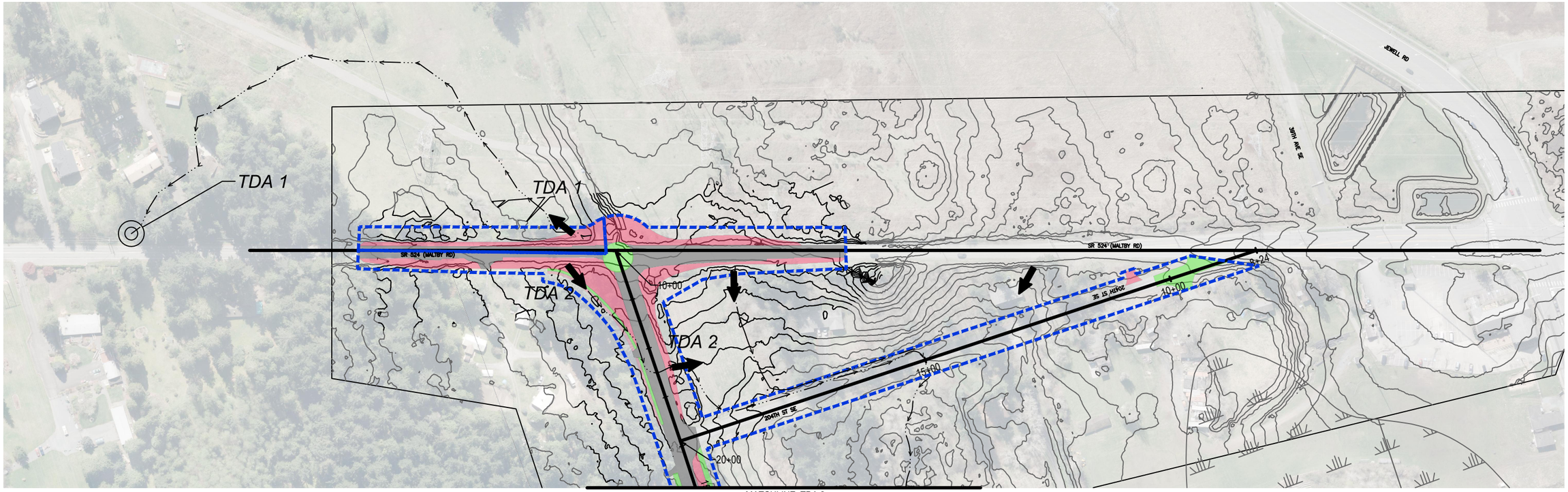
The proposed roadway section includes a 5-foot planter strip, but the longitudinal grades and the narrow strip will make it infeasible to implement swales for treatment of runoff. A treatment wetland that is combined with the detention facility would be an alternative, although the long term

maintenance associated with plant establishment can be costly. CABFS was considered to be installed downstream of the detention pond, however the longitudinal grades along 180th Street SE exceed the allowable maximums. The preferred solution for the improvements in this intersection is to install CABFS or bioretention cells in the northwest quadrant, downstream of the detention facility in the northeast quadrant, parallel to 180th Street SE.

	Criteria								
	Topography	Critical Areas	Existing Land Use	Position in Basin	Forward Compatibility	ROW Impacts	Construction Cost	Effectiveness	Maintenance Considerations
Alternative									
WQ Treatment									
CABFS	↓	↑	↑	↑	↓	↑	↑	↑	↑
Bioretention	↑	↑	↑	↑	↑	↑	↑	↑	↑
Treatment Wetland	↑	↑	↑	↑	↑	↑	↑	↑	↓
Flow Control									
Detention/Infiltration	↓	↑	↑	-	↑	↓	↑	↑	↑

MEMO

Appendix A
TDA Maps



TDA BOUNDARY

TDA — POINT OF COMPLIANCE (1/4 MILE POINT)

TDA — POINT OF DISCHARGE

EX. RIGHT OF WAY

FLOW PATH

SNOHOMISH COUNTY TAMBARK CREEK

NEW PGIS POLLUTION GENERATING IMPERVIOUS SURFACE
(FORESTED/LANDSCAPE TO PAVEMENT)

REPLACED IMPERVIOUS SURFACE
(RESURFACED PAVEMENT)

CONVERTED PERVIOUS SURFACE
(FORESTED TO LANDSCAPE / POROUS CONCRETE SIDEWALK)

N

100 0 100 200
SCALE IN FEET

DATE	NO.	REVISION	BY

Know what's below. Call 811 before you dig.

DESIGNED BY:	DRAWN BY:
CHA	ARM
REVIEWED BY:	
PDS	

PRELIMINARY

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Seattle, WA 98101
206.622.5822
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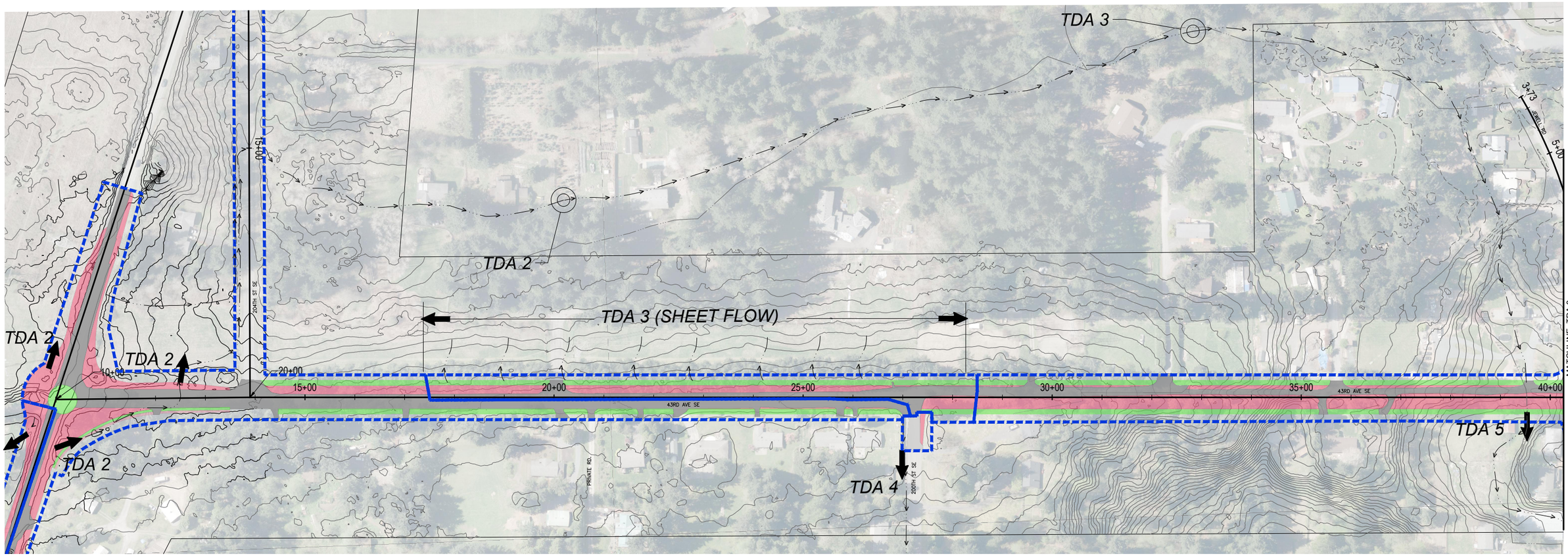
THRESHOLD DISCHARGE AREA FIGURES

-

REFERENCE SHEET NO. TDA1

SHEET 1 OF 6 SHEETS

May 29, 2019 - 2:34 PM - CHARLIEA - Z:\1800001-1800999\1800175 43RD AVE SE\CADD\EXHIBITS\DRAINAGE\TDA FIGURES.DWG - Layout Name: 01 PLAN



TDA BOUNDARY

POINT OF COMPLIANCE (1/4 MILE POINT)

POINT OF DISCHARGE

EX. RIGHT OF WAY

FLOW PATH

SNOHOMISH COUNTY TAMBARK CREEK

NEW PGIS POLLUTION GENERATING IMPERVIOUS SURFACE (FORESTED/LANDSCAPE TO PAVEMENT)

REPLACED IMPERVIOUS SURFACE (RESURFACED PAVEMENT)

CONVERTED PERVIOUS SURFACE (FORESTED TO LANDSCAPE / POROUS CONCRETE SIDEWALK)

NOTES:

1. POINT OF DISCHARGE FOR TDA'S 3 REPRESENTS THE FURTHEST DOWNSTREAM POINT OF SHEET-FLOW RUNOFF WITHIN TDA LIMITS AND POINT OF BEGINNING FOR MEASURING 1/4 MILE DOWNSTREAM LIMITS.
2. ANECDOTAL INFORMATION FROM RESIDENT SUGGESTS STORMWATER IS CONVEYED VIA PIPE FROM THE NEIGHBORING PARCELS TO THE SOUTHWEST. DOWNSTREAM END OF CULVERT WAS LOCATED SOUTH OF JEWELL ROAD, BUT UPSTREAM END COULD NOT BE FOUND.

N

100 0 100 200
SCALE IN FEET

DATE	NO.	REVISION	BY

Know what's below. Call 811 before you dig.

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DRAWN BY: ARM
REVIEWED BY: PDS

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THRESHOLD DISCHARGE AREA FIGURES

-

REFERENCE SHEET NO. TDA2

SHEET 2 OF 6 SHEETS

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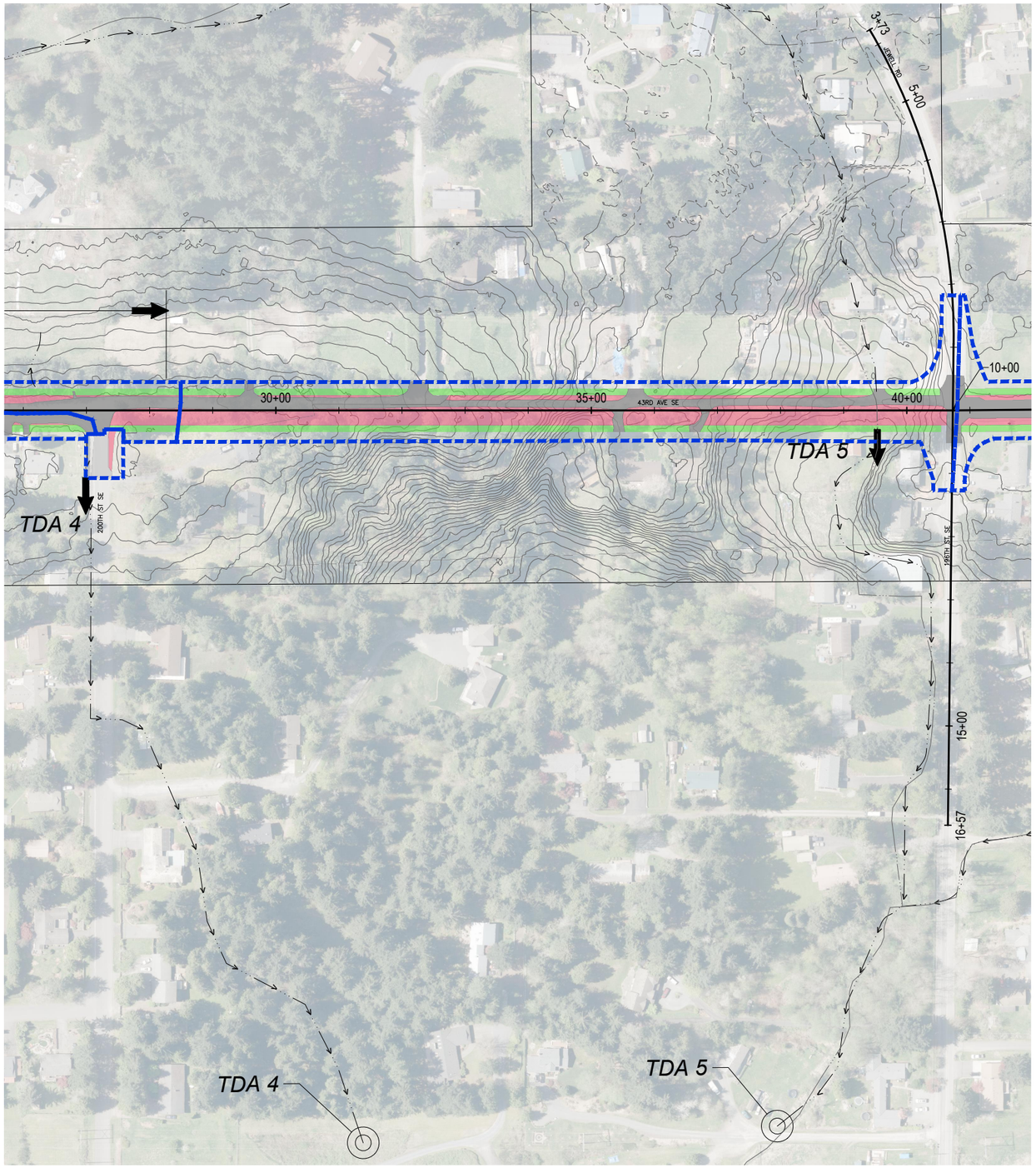

TDA BOUNDARY

TDA — POINT OF COMPLIANCE (1/4 MILE POINT)

TDA — POINT OF DISCHARGE

EX. RIGHT OF WAY

FLOW PATH

SNOHOMISH COUNTY TAMBARK CREEK

NEW PGIS POLLUTION GENERATING IMPERVIOUS SURFACE (FORESTED/LANDSCAPE TO PAVEMENT)

REPLACED IMPERVIOUS SURFACE (RESURFACED PAVEMENT)

CONVERTED PERVIOUS SURFACE (FORESTED TO LANDSCAPE / POROUS CONCRETE SIDEWALK)

NOTES:

1. POINT OF DISCHARGE FOR TDA'S 3 REPRESENTS THE FURTHEST DOWNSTREAM POINT OF SHEET-FLOW RUNOFF WITHIN TDA LIMITS AND POINT OF BEGINNING FOR MEASURING 1/4 MILE DOWNSTREAM LIMITS.
2. ANECDOTAL INFORMATION FROM RESIDENT SUGGESTS STORMWATER IS CONVEYED VIA PIPE FROM THE NEIGHBORING PARCELS TO THE SOUTHWEST. DOWNSTREAM END OF CULVERT WAS LOCATED SOUTH OF JEWELL ROAD, BUT UPSTREAM END COULD NOT BE FOUND.

N

100 0 100 200
SCALE IN FEET

DATE	NO.	REVISION	BY

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REVIEWED BY: PDS	

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THRESHOLD DISCHARGE AREA FIGURES

-

REFERENCE SHEET NO. TDA3

SHEET 3 OF 6 SHEETS

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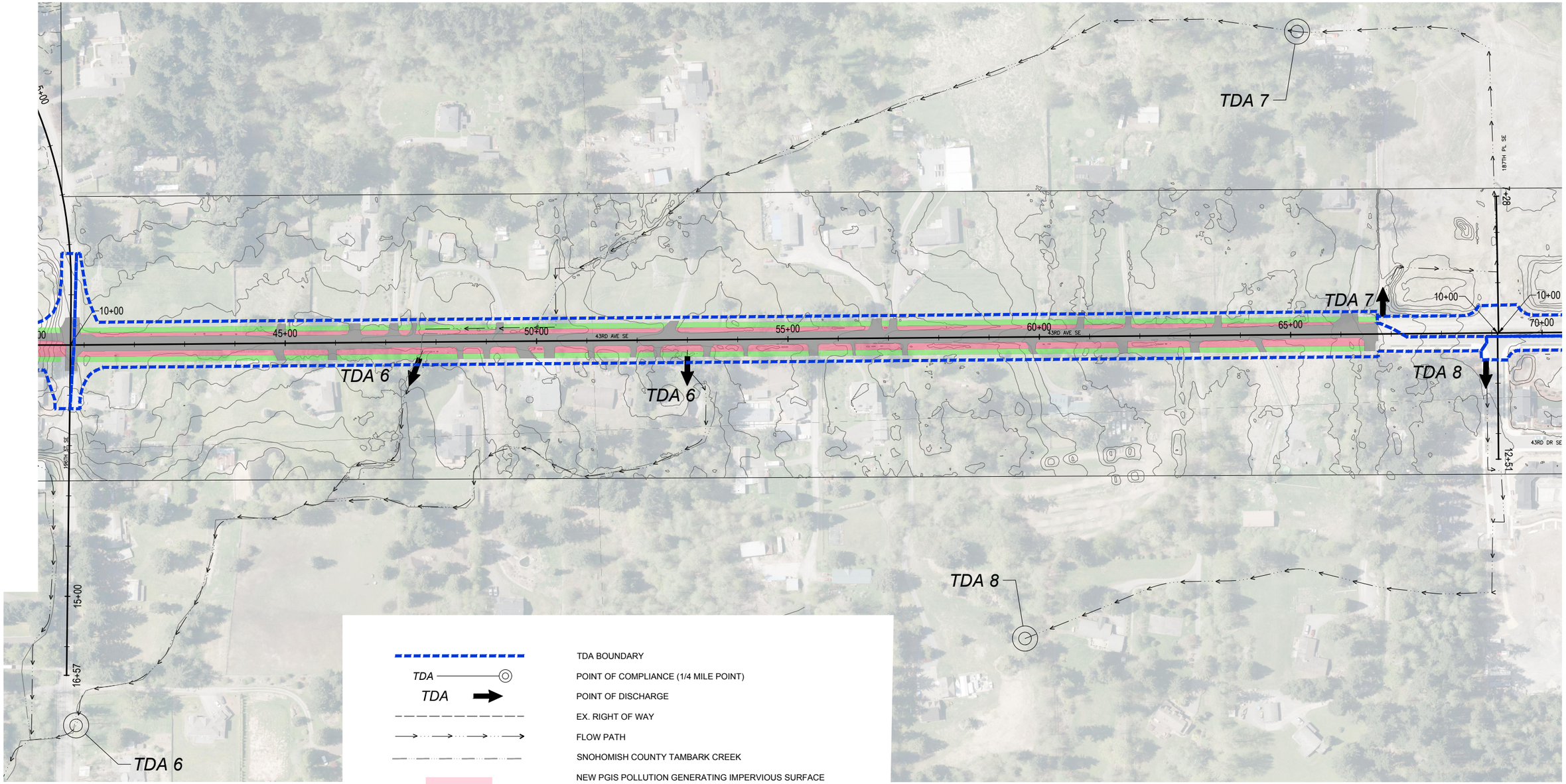

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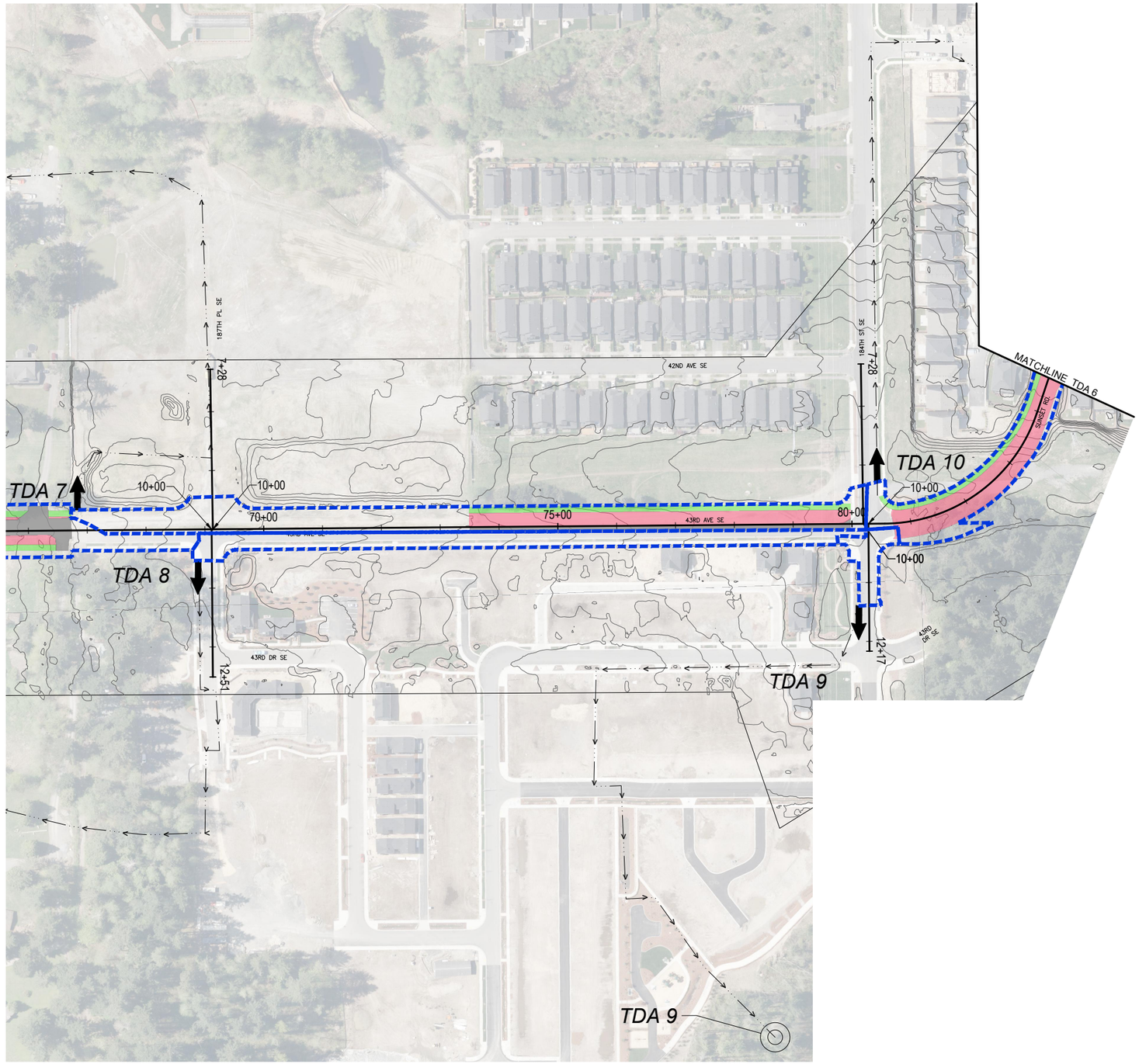
THRESHOLD DISCHARGE AREA FIGURES

-

REFERENCE SHEET NO. TDA4

SHEET 4 OF 6 SHEETS



TDA BOUNDARY

TDA — POINT OF COMPLIANCE (1/4 MILE POINT)

TDA → POINT OF DISCHARGE

EX. RIGHT OF WAY

FLOW PATH

SNOHOMISH COUNTY TAMBARK CREEK

NEW PGIS POLLUTION GENERATING IMPERVIOUS SURFACE
(FORESTED/LANDSCAPE TO PAVEMENT)

REPLACED IMPERVIOUS SURFACE
(RESURFACED PAVEMENT)

CONVERTED PERVIOUS SURFACE
(FORESTED TO LANDSCAPE / POROUS CONCRETE SIDEWALK)

N

100 0 100 200
SCALE IN FEET

DATE	NO.	REVISION	BY

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REVIEWED BY: PDS	

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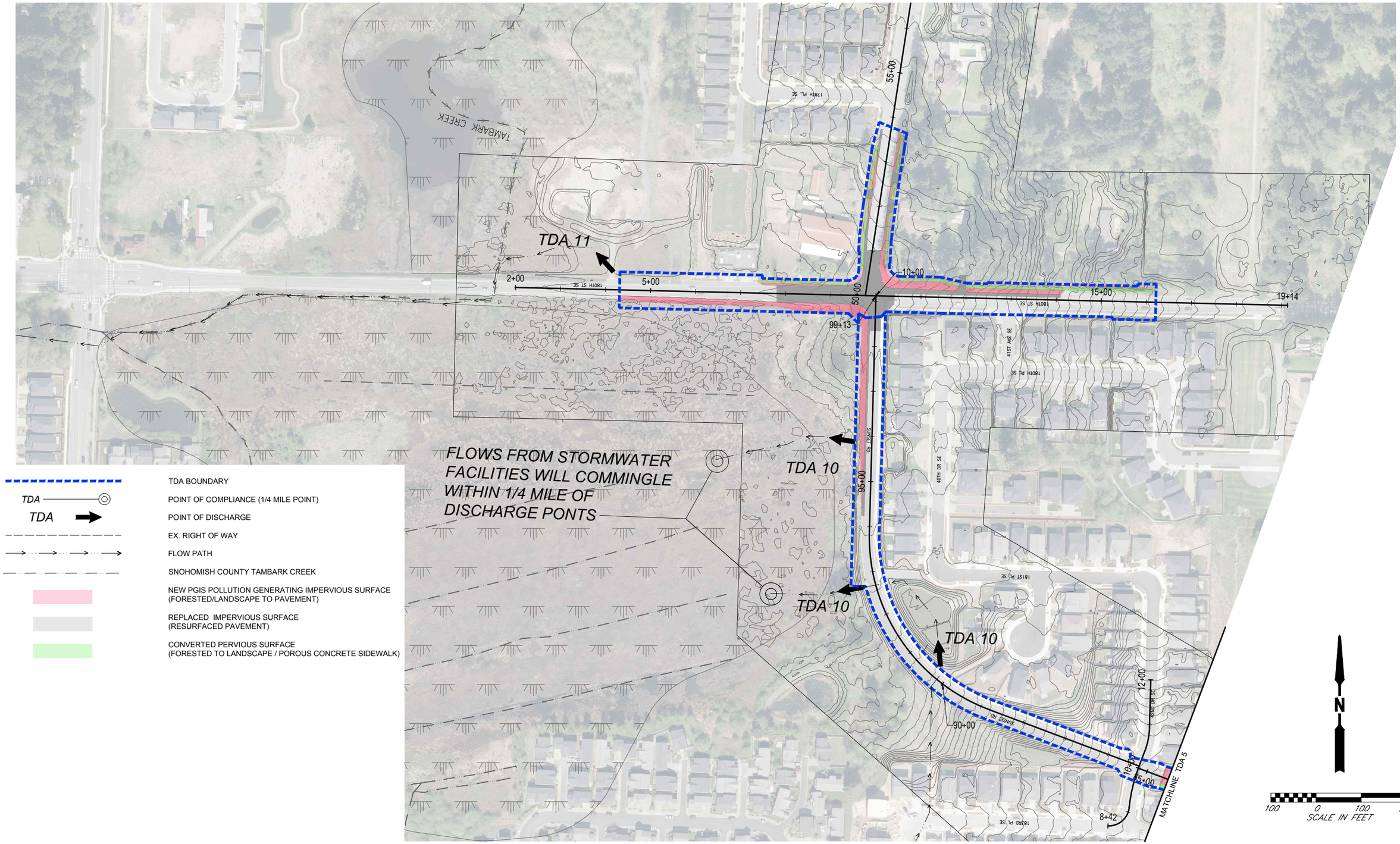
THRESHOLD DISCHARGE AREA FIGURES

-

REFERENCE SHEET NO. TDA5

SHEET 5 OF 6 SHEETS

May 29, 2019 - 2:35 PM - CHARLIEA - Z:\1800001-1800999\1800175 43RD AVE SE\CADD\EXHIBITS\DRAINAGE\TDA FIGURES.DWG - Layout Name: 05 PLAN



TDA — ◎ TDA BOUNDARY

TDA → POINT OF COMPLIANCE (1/4 MILE POINT)

POINT OF DISCHARGE

EX. RIGHT OF WAY

FLOW PATH

SNOHOMISH COUNTY TAMBARK CREEK

NEW PGIS POLLUTION GENERATING IMPERVIOUS SURFACE (FORESTED/LANDSCAPE TO PAVEMENT)

REPLACED IMPERVIOUS SURFACE (RESURFACED PAVEMENT)

CONVERTED PERVIOUS SURFACE (FORESTED TO LANDSCAPE / POROUS CONCRETE SIDEWALK)

May 29, 2019 - 2:35 PM - CHARLIEA - Z:\1800001-1800999\1800175 43RD AVE SE\CADD\EXHIBITS\DRAINAGE\TDA FIGURES.DWG - Layout Name: 06 PLAN

DATE	NO.	REVISION	BY

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PDS	

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THRESHOLD DISCHARGE AREA FIGURES

-

REFERENCE SHEET NO.
TDA6

SHEET 6 OF 6 SHEETS

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Appendix B
MGS Flood Modeling Output and Area Accounting

Land Cover Accounting

		Existing Condition			Proposed Condition			
RECEIVING WATER BODY	**TDA**	**PGHS (SF)**	**Pervious (SF)**	**Total Area (SF)[1]**	**Total New HS (SF)**	**Sidewalk (SF)[2]**	**Replaced Roadway (Overlay Existing HS)(SF)**	**Converted Pervious (SF)**
Little Bear Creek	1	6,437	16,860	23,297	6,932	-	5,115	-
	2	95,408	144,476	239,884	47,275	9,174	65,130	15,842
	3	17,630	42,143	59,773	22,029	5,897	17,755	11,872
	4	2,380	1,960	4,340	509	-	1,869	-
	5	31,162	96,847	128,009	49,260	11,357	23,101	11,356
	6	80,550	160,646	241,196	71,192	23,279	99,020	23,279
	7	40,000	20,120	60,120	18,056	3,238	6,230	3,238
	8	20,550	10,150	30,700	-	-	-	-
	9	5,780	540	6,320	-	-	-	-
North Creek	10	56,640	42,631	99,240	23,881	1,946	-	1,946
	11	68,830	45,130	113,960	23,386	7,260	20,382	6,546

[1]TDA Area Calculated as Drainage Area as measured by Roadway Length x Proposed ROW Width

[2]To remain conservative during the preliminary design phase, proposed sidewalk is being considered as PGIS (included in Total New HS column).

MGS Flood Results

RECEIVING WATER BODY	TDA	Detention Volume at Riser Crest (cf)	Water Quality Volume (cf)	Water Quality Flow (Online, cfs)
Little Bear Creek	1	-	1,462.0	0.05
	2	-	12,487.0	0.40
	3	-	3,840.0	0.12
	4	-	-	-
	5	53,063.0	10,151.0	0.32
	6	21,375.0	22,596.0	0.61
	7	6,174.0	2,757.0	0.18
	8	-	-	-
	9	-	-	-
North Creek	10	-	-	-
	11	7,946.0	4,123.0	0.11

MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.46
Program License Number: 200410007
Project Simulation Performed on: 05/17/2019 11:56 AM
Report Generation Date: 05/17/2019 11:56 AM

Input File Name: TDA 1.fld
Project Name: 43rd Ave SE TDA 1
Analysis Title: TDA 1
Comments: 2 LN ROUNDABOUT
MFD with underlying infiltration trench
Treat all New + Replaced HS and CP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 16

Full Period of Record Available used for Routing
Precipitation Station : 96004405 Puget East 44 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961044 Puget East 44 in MAP
Evaporation Scale Factor : 0.750

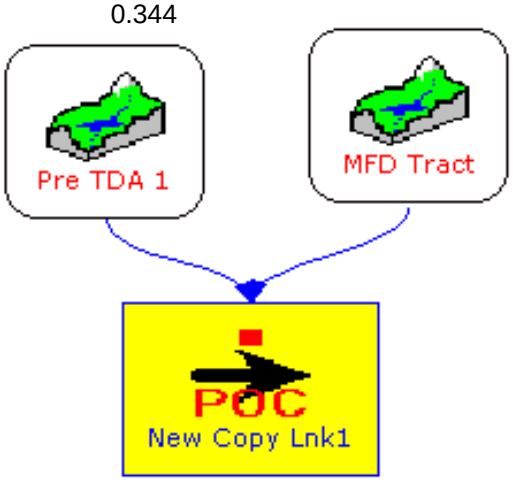
HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) **********

********** WATERSHED DEFINITION **********

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.344	0.344
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	0.344	0.344



----------SCENARIO: PREDEVELOPED
Number of Subbasins: 2

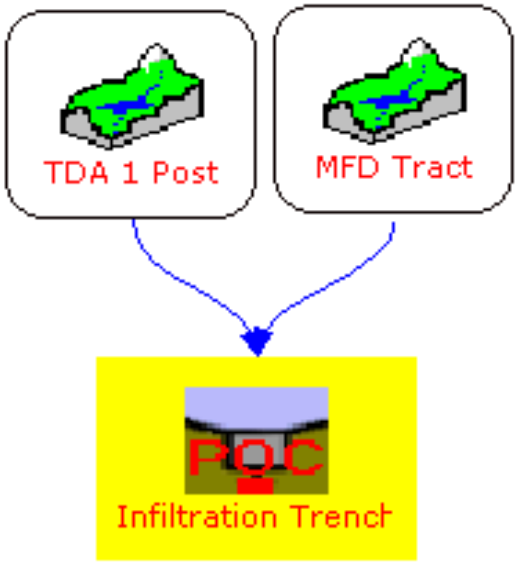
---------- Subbasin : Pre TDA 1 ----------
-------Area (Acres) --------
Outwash Forest 0.138
Impervious 0.148

Subbasin Total 0.285

---------- Subbasin : MFD Tract ----------
-------Area (Acres) --------
Outwash Forest 0.059

Subbasin Total 0.059

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 2



---------- Subbasin : TDA 1 Post ----------
-------Area (Acres) --------
Impervious 0.285

Subbasin Total 0.285

---------- Subbasin : MFD Tract ----------
-------Area (Acres) --------
Till Grass 0.051
Impervious 0.007

Subbasin Total 0.059

********** **LINK DATA** **********

----------SCENARIO: PREDEVELOPED
Number of Links: 1

Link Name: New Copy Lnk1
Link Type: Copy
Downstream Link: None

********** **LINK DATA** **********

----------SCENARIO: POSTDEVELOPED
Number of Links: 1

Link Name: Infiltration Trench
Link Type: Infiltration Trench
Downstream Link: None

Trench Type : Trench at Toe of Embankment
Trench Length (ft) : 320.00
Trench Width (ft) : 2.00

Trench Depth (ft) : 4.00
Trench Bottom Elev (ft) : 100.00
Trench Rockfill Porosity (%) : 30.00

Constant Infiltration Option Used
Infiltration Rate (in/hr): 9.00

**************************FLOOD FREQUENCY AND DURATION STATISTICS********************

----------SCENARIO: PREDEVELOPED
Number of Subbasins: 2
Number of Links: 1

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 2
Number of Links: 1

*************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

Model Element		Recharge Amount (ac-ft)
Subbasin: Pre TDA 1	42.997	
Subbasin: MFD Tract	18.356	
Link: New Copy Lnk1	0.000	
Total:		61.353

Total Post Developed Recharge During Simulation

Model Element		Recharge Amount (ac-ft)
Subbasin: TDA 1 Post	0.000	
Subbasin: MFD Tract	6.620	
Link: Infiltration Trench	159.501	
Total:		166.121

Total Predevelopment Recharge is Less than Post Developed
Average Recharge Per Year, (Number of Years= 158)
Predeveloped: 0.388 ac-ft/year, Post Developed: 1.051 ac-ft/year

*************Water Quality Facility Data ***************

----------SCENARIO: PREDEVELOPED

Number of Links: 1

********** Link: New Copy Lnk1 **********

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 74.25

Inflow Volume Including PPT-Evap (ac-ft): 74.25
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 74.25
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

----------SCENARIO: POSTDEVELOPED

Number of Links: 1

********** Link: Infiltration Trench **********

Basic Wet Pond Volume (91% Exceedance): 1462. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 2193. cu-ft

2-Year Discharge Rate : 0.000 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.05 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.03 cfs

Time to Infiltrate 91% Treatment Volume, (Hours): 0.94

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 159.50
Inflow Volume Including PPT-Evap (ac-ft): 159.50
Total Runoff Infiltrated (ac-ft): 159.50, 100.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.00
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 100.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Link: New Copy Lnk1
Scenario Postdeveloped Compliance Link: Infiltration Trench

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	5.738E-02	2-Year	0.000
5-Year	7.515E-02	5-Year	0.000
10-Year	8.735E-02	10-Year	0.000
25-Year	0.105	25-Year	0.000
50-Year	0.128	50-Year	0.000
100-Year	0.156	100-Year	0.000
200-Year	0.163	200-Year	0.000

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

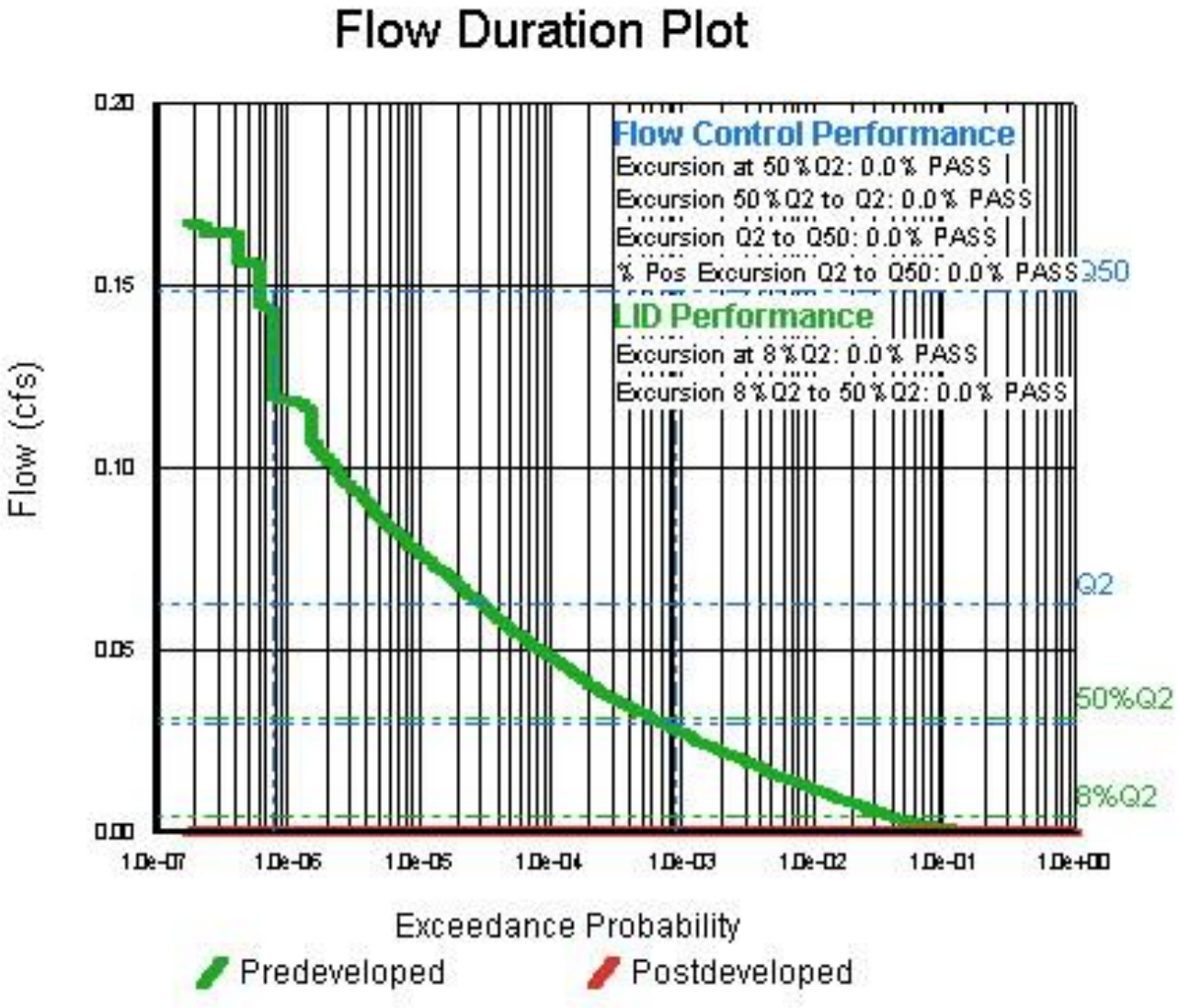
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):	0.0%	PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	0.0%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	0.0%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%):	0.0%	PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):	0.0%	PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS



MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.46
Program License Number: 200410007
Project Simulation Performed on: 05/17/2019 2:09 PM
Report Generation Date: 05/17/2019 2:10 PM

Input File Name: TDA 2.fld
Project Name: 43rd Ave SE TDA 2
Analysis Title: TDA 2
Comments: 2 LN ROUNDABOUT
Treat only new HS & CP
Split areas to MFD along SR524 swales with underlying infiltration trench along 43rd in varying soils
Sidewalk entered as impervious

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 16

Full Period of Record Available used for Routing
Precipitation Station : 96004405 Puget East 44 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961044 Puget East 44 in MAP
Evaporation Scale Factor : 0.750

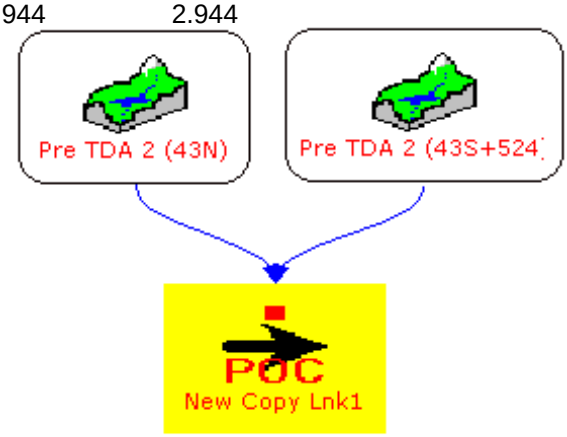
HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) **********

********** WATERSHED DEFINITION **********

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	2.944	2.944
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	2.944	2.944



----------SCENARIO: PREDEVELOPED
Number of Subbasins: 2

---------- Subbasin : Pre TDA 2 (43S+524) ----------
-------Area (Acres) --------
Outwash Forest 1.337

Impervious 1.147

Subbasin Total 2.484

---------- Subbasin : Pre TDA 2 (43N) ----------
-------Area (Acres) --------
Till Forest 0.112
Impervious 0.348

Subbasin Total 0.460

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 3

---------- Subbasin : TDA 2 (43N) Post ----------
-------Area (Acres) --------
Outwash Grass 0.112
Impervious 0.640

Subbasin Total 0.752

---------- Subbasin : TDA 2 (SR 524) Post ----------
-------Area (Acres) --------
Outwash Grass 0.078
Impervious 1.166

Subbasin Total 1.244

---------- Subbasin : TDA 2 (43S) Post ----------
-------Area (Acres) --------
Outwash Grass 0.173
Impervious 0.775

Subbasin Total 0.948

********** **LINK DATA** **********

----------SCENARIO: PREDEVELOPED
Number of Links: 1

Link Name: New Copy Lnk1
Link Type: Copy
Downstream Link: None

********** **LINK DATA** **********

----------SCENARIO: POSTDEVELOPED

Number of Links: 4

Link Name: Infiltration Trench(43N)
Link Type: Infiltration Trench
Downstream Link Name: Infiltration Trench(43S)

Trench Type	:	Trench at Toe of Embankment
Trench Length (ft)	:	978.00
Trench Width (ft)	:	2.00
Trench Depth (ft)	:	4.00
Trench Bottom Elev (ft)	:	100.00
Trench Rockfill Porosity (%)	:	30.00

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.24

Link Name: Infiltration Trench (524)
Link Type: Infiltration Trench
Downstream Link Name: New Copy Lnk3

Trench Type	:	Trench at Toe of Embankment
Trench Length (ft)	:	660.00
Trench Width (ft)	:	2.00
Trench Depth (ft)	:	4.00
Trench Bottom Elev (ft)	:	100.00
Trench Rockfill Porosity (%)	:	30.00

Constant Infiltration Option Used
Infiltration Rate (in/hr): 9.00

Link Name: New Copy Lnk3
Link Type: Copy
Downstream Link: None

Link Name: Infiltration Trench(43S)
Link Type: Infiltration Trench
Downstream Link Name: New Copy Lnk3

Trench Type	:	Trench at Toe of Embankment
Trench Length (ft)	:	1027.00
Trench Width (ft)	:	2.00
Trench Depth (ft)	:	4.00
Trench Bottom Elev (ft)	:	100.00
Trench Rockfill Porosity (%)	:	30.00

Constant Infiltration Option Used
Infiltration Rate (in/hr): 9.00

**************************FLOOD FREQUENCY AND DURATION STATISTICS********************

----------SCENARIO: PREDEVELOPED
Number of Subbasins: 2
Number of Links: 1

************ Subbasin: Pre TDA 2 (43S+524) ************

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.445
5-Year	0.583
10-Year	0.678
25-Year	0.816
50-Year	0.990
100-Year	1.213
200-Year	1.268

************ Subbasin: Pre TDA 2 (43N) ************

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.137
5-Year	0.178
10-Year	0.211
25-Year	0.257
50-Year	0.313
100-Year	0.370
200-Year	0.386

********** Link: New Copy Lnk1 ********** Link Outflow 1 Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.582
5-Year	0.762
10-Year	0.884
25-Year	1.067
50-Year	1.301
100-Year	1.583
200-Year	1.654

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 3
Number of Links: 4

********** **Subbasin: TDA 2 (43N) Post** **********

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.249
5-Year	0.327
10-Year	0.387
25-Year	0.469
50-Year	0.552
100-Year	0.676
200-Year	0.708

********** **Subbasin: TDA 2 (SR 524) Post** **********

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.453
5-Year	0.592
10-Year	0.692
25-Year	0.840
50-Year	1.006
100-Year	1.232
200-Year	1.289

********** **Subbasin: TDA 2 (43S) Post** **********

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.302
5-Year	0.396
10-Year	0.468
25-Year	0.570
50-Year	0.669
100-Year	0.819
200-Year	0.857

********** Link: Infiltration Trench(43N) ********** Link Inflow Frequency Stats

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.249
5-Year	0.327
10-Year	0.387
25-Year	0.469

50-Year	0.552
100-Year	0.676
200-Year	0.708

********** Link: Infiltration Trench(43N) ********** Link Outflow 1 Frequency Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	1.837E-05
5-Year	0.111
10-Year	0.167
25-Year	0.234
50-Year	0.279
100-Year	0.301
200-Year	0.334

********** Link: Infiltration Trench (524) ********** Link Inflow Frequency Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.453
5-Year	0.592
10-Year	0.692
25-Year	0.840
50-Year	1.006
100-Year	1.232
200-Year	1.289

********** Link: Infiltration Trench (524) ********** Link Outflow 1 Frequency Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	1.878E-06
5-Year	3.632E-06
10-Year	5.066E-06
25-Year	6.324E-06
50-Year	9.000E-06
100-Year	9.406E-06
200-Year	1.195E-05

********** Link: New Copy Lnk3 ********** Link Inflow Frequency Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)

2-Year	1.937E-06
5-Year	3.811E-06
10-Year	5.609E-06
25-Year	7.292E-06
50-Year	1.090E-05
100-Year	1.150E-05
200-Year	1.483E-05

********** Link: Infiltration Trench(43S) ********** Link Inflow Frequency Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.317
5-Year	0.447
10-Year	0.530
25-Year	0.689
50-Year	0.778
100-Year	0.874
200-Year	0.906

********** Link: Infiltration Trench(43S) ********** Link Outflow 1 Frequency Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	5.960E-08
5-Year	8.941E-08
10-Year	4.768E-07
25-Year	1.814E-06
50-Year	2.286E-06
100-Year	3.078E-06
200-Year	3.218E-06

*************Groundwater Recharge Summary **************

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

Model Element	Recharge Amount (ac-ft)
Subbasin: Pre TDA 2 (43S+524)	417.994
Subbasin: Pre TDA 2 (43N)	21.364
Link: New Copy Lnk1	0.000
Total:	439.358

Total Post Developed Recharge During Simulation

Model Element	Recharge Amount (ac-ft)
Subbasin: TDA 2 (43N) Post	42.829

Subbasin: TDA 2 (SR 524) Post		29.824
Subbasin: TDA 2 (43S) Post		65.864
Link:	Infiltration Trench(	319.994
Link:	Infiltration Trench	585.351
Link:	New Copy Lnk3	0.000
Link:	Infiltration Trench(	390.979
Total:		1434.839

Total Predevelopment Recharge is Less than Post Developed
Average Recharge Per Year, (Number of Years= 158)
Predeveloped: 2.781 ac-ft/year, Post Developed: 9.081 ac-ft/year

*************Water Quality Facility Data ***************

----------SCENARIO: PREDEVELOPED

Number of Links: 1

********** Link: New Copy Lnk1 **********

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 764.61
Inflow Volume Including PPT-Evap (ac-ft): 764.61
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 764.61
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

----------SCENARIO: POSTDEVELOPED

Number of Links: 4

********** Link: Infiltration Trench(43N) **********

Basic Wet Pond Volume (91% Exceedance): 3084. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 4626. cu-ft

2-Year Discharge Rate : 0.000 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.10 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.06 cfs

Time to Infiltrate 91% Treatment Volume, (Hours): 28.21

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 321.35
Inflow Volume Including PPT-Evap (ac-ft): 321.35
Total Runoff Infiltrated (ac-ft): 319.99, 99.58%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 1.69

Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 99.58%

********** Link: Infiltration Trench (524) **********

Basic Wet Pond Volume (91% Exceedance): 5614. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 8421. cu-ft

2-Year Discharge Rate : 0.000 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.18 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.10 cfs

Time to Infiltrate 91% Treatment Volume, (Hours): 1.48

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 585.35
Inflow Volume Including PPT-Evap (ac-ft): 585.35
Total Runoff Infiltrated (ac-ft): 585.35, 100.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.00
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 100.00%

********** Link: New Copy Lnk3 **********

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 0.00
Inflow Volume Including PPT-Evap (ac-ft): 0.00
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.00
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

********** Link: Infiltration Trench(43S) **********

Basic Wet Pond Volume (91% Exceedance): 3789. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 5683. cu-ft

2-Year Discharge Rate : 0.000 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.12 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.07 cfs

Time to Infiltrate 91% Treatment Volume, (Hours): 0.82

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 390.98
Inflow Volume Including PPT-Evap (ac-ft): 390.98
Total Runoff Infiltrated (ac-ft): 390.98, 100.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%

Primary Outflow To Downstream System (ac-ft): 0.00
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 100.00%

************Compliance Point Results **************

Scenario Predeveloped Compliance Link: New Copy Lnk1
Scenario Postdeveloped Compliance Link: New Copy Lnk3

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	0.582	2-Year	0.000
5-Year	0.762	5-Year	0.000
10-Year	0.884	10-Year	0.000
25-Year	1.067	25-Year	0.000
50-Year	1.301	50-Year	0.000
100-Year	1.583	100-Year	0.000
200-Year	1.654	200-Year	0.000

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):	0.0%	PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	0.0%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	0.0%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

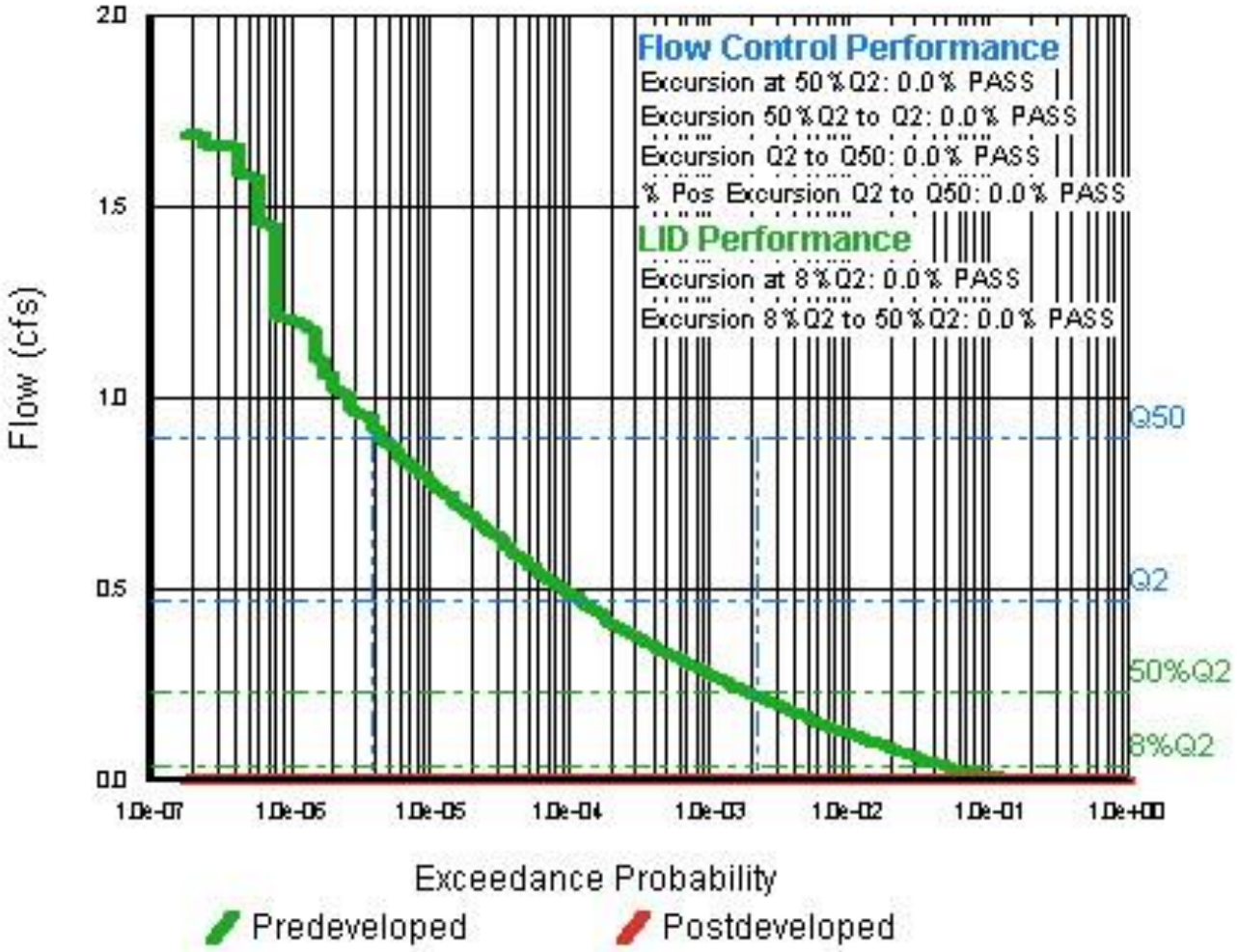
****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%):	0.0%	PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):	0.0%	PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

NOTE: INFILTRATION TRENCHES HAVE BEEN SIZED AND OPTIMIZED IN THIS MODEL WITH AN ASSUMPTION THAT SITE SOILS TRANSITION FROM GLACIAL OUTWASH TO GLACIAL TILL AT A BOUNDARY APPROXIMATELY HALFWAY BETWEEN SOIL BORINGS WHERE THESE CONDITIONS WERE OBSERVED (SEE HYDROGEOLOGIC REPORT).

Flow Duration Plot



MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.46
Program License Number: 200410007
Project Simulation Performed on: 05/17/2019 4:28 PM
Report Generation Date: 05/17/2019 4:29 PM

Input File Name: DOWNSTREAM OUTWASH.fld
Project Name: 43rd Ave SE TDA 3
Analysis Title: TDA 3
Comments: Swale with underlying infiltration trench along 43rd
Outwash soils transition to till--infiltration rate varies.
Sidewalk entered as impervious
Treat all New + Replaced HS, CP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 16

Full Period of Record Available used for Routing
Precipitation Station : 96004405 Puget East 44 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961044 Puget East 44 in MAP
Evaporation Scale Factor : 0.750

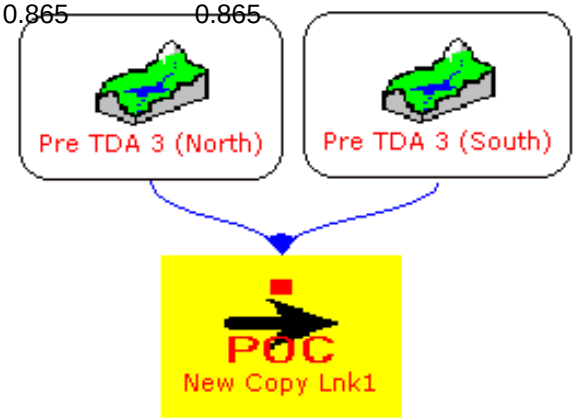
HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) **********

********** WATERSHED DEFINITION **********

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.865	0.865
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	0.865	0.865



----------SCENARIO: PREDEVELOPED
Number of Subbasins: 2

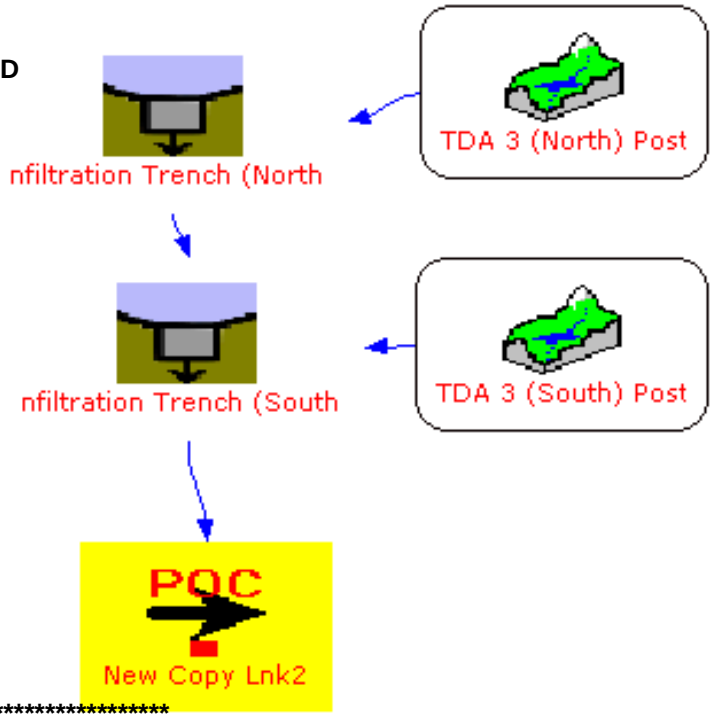
---------- Subbasin : Pre TDA 3 (North) ----------
-------Area (Acres) --------
Till Forest 0.772

Subbasin Total 0.772

---------- Subbasin : Pre TDA 3 (South) ----------
-------Area (Acres) --------
Outwash Forest 0.093

Subbasin Total 0.093

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 2



---------- Subbasin : TDA 3 (North) Post ----------
-------Area (Acres) --------
Till Grass 0.098
Impervious 0.674

Subbasin Total 0.772

---------- Subbasin : TDA 3 (South) Post ----------
-------Area (Acres) --------
Outwash Grass 0.012
Impervious 0.081

Subbasin Total 0.093

********** **LINK DATA** **********

----------SCENARIO: PREDEVELOPED
Number of Links: 1

Link Name: New Copy Lnk1
Link Type: Copy
Downstream Link: None

********** **LINK DATA** **********

----------SCENARIO: POSTDEVELOPED
Number of Links: 3

Link Name: Infiltration Trench (North)
Link Type: Infiltration Trench
Downstream Link Name: Infiltration Trench (South)

Trench Type : Trench at Toe of Embankment
Trench Length (ft) : 883.00

Trench Width (ft) : 2.85
Trench Depth (ft) : 4.00
Trench Bottom Elev (ft) : 100.00
Trench Rockfill Porosity (%) : 30.00

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.24

Link Name: Infiltration Trench (South)
Link Type: Infiltration Trench
Downstream Link Name: New Copy Lnk2

Trench Type : Trench at Toe of Embankment
Trench Length (ft) : 105.00
Trench Width (ft) : 2.85
Trench Depth (ft) : 4.00
Trench Bottom Elev (ft) : 95.00
Trench Rockfill Porosity (%) : 30.00

Constant Infiltration Option Used
Infiltration Rate (in/hr): 9.00

Link Name: New Copy Lnk2
Link Type: Copy
Downstream Link: None

**************************FLOOD FREQUENCY AND DURATION STATISTICS********************

----------SCENARIO: PREDEVELOPED
Number of Subbasins: 2
Number of Links: 1

************ Subbasin: Pre TDA 3 (North) ************

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	1.985E-02
5-Year	3.181E-02
10-Year	4.148E-02
25-Year	5.702E-02
50-Year	7.169E-02
100-Year	7.607E-02
200-Year	0.122

************ Subbasin: Pre TDA 3 (South) ************

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	7.228E-05
5-Year	7.454E-05
10-Year	7.508E-05
25-Year	2.822E-04
50-Year	3.529E-04
100-Year	5.113E-04
200-Year	7.680E-04

********** Link: New Copy Lnk1 ********** Link Outflow 1 Frequency Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	1.985E-02
5-Year	3.182E-02
10-Year	4.178E-02
25-Year	5.708E-02
50-Year	7.203E-02
100-Year	7.607E-02
200-Year	0.122

----------SCENARIO: POSTDEVELOPED

Number of Subbasins: 2

Number of Links: 3

********** Subbasin: TDA 3 (North) Post **********

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.274
5-Year	0.351
10-Year	0.425
25-Year	0.521
50-Year	0.628
100-Year	0.773
200-Year	0.804

********** Subbasin: TDA 3 (South) Post **********

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	3.167E-02
5-Year	4.148E-02
10-Year	4.917E-02
25-Year	5.948E-02

50-Year	7.024E-02
100-Year	8.604E-02
200-Year	9.001E-02

********** Link: Infiltration Trench (North) ********** Link Inflow Frequency Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.274
5-Year	0.351
10-Year	0.425
25-Year	0.521
50-Year	0.628
100-Year	0.773
200-Year	0.804

********** Link: Infiltration Trench (North) ********** Link Outflow 1 Frequency Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	1.666E-05
5-Year	9.119E-02
10-Year	0.153
25-Year	0.219
50-Year	0.282
100-Year	0.304
200-Year	0.332

********** Link: Infiltration Trench (South) ********** Link Inflow Frequency Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	3.590E-02
5-Year	0.107
10-Year	0.178
25-Year	0.251
50-Year	0.323
100-Year	0.345
200-Year	0.377

********** Link: Infiltration Trench (South) ********** Link Outflow 1 Frequency Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)

2-Year	5.588E-08
5-Year	3.073E-06
10-Year	9.492E-06
25-Year	1.475E-05
50-Year	3.254E-02
100-Year	9.051E-02
200-Year	9.136E-02

********** Link: New Copy Lnk2 ********** Link Inflow
Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	5.588E-08
5-Year	3.073E-06
10-Year	9.492E-06
25-Year	1.475E-05
50-Year	3.254E-02
100-Year	9.051E-02
200-Year	9.136E-02

*************Groundwater Recharge Summary **************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

Model Element		Recharge Amount (ac-ft)
Subbasin: Pre TDA 3 (North)		146.808
Subbasin: Pre TDA 3 (South)		29.144
Link:	New Copy Lnk1	0.000
Total:		175.952

Total Post Developed Recharge During Simulation

Model Element		Recharge Amount (ac-ft)
Subbasin: TDA 3 (North) Post		12.635
Subbasin: TDA 3 (South) Post		4.500
Link:	Infiltration Trench	360.998
Link:	Infiltration Trench	42.505
Link:	New Copy Lnk2	0.000
Total:		420.637

Total Predevelopment Recharge is Less than Post Developed
Average Recharge Per Year, (Number of Years= 158)
Predeveloped: 1.114 ac-ft/year, Post Developed: 2.662 ac-ft/year

*************Water Quality Facility Data **************

----------SCENARIO: PREDEVELOPED

Number of Links: 1

********** Link: New Copy Lnk1 **********

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 93.95
Inflow Volume Including PPT-Evap (ac-ft): 93.95
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 93.95
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

----------SCENARIO: POSTDEVELOPED

Number of Links: 3

********** Link: Infiltration Trench (North) **********

Basic Wet Pond Volume (91% Exceedance): 3348. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 5023. cu-ft

2-Year Discharge Rate : 0.000 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.10 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.06 cfs

Time to Infiltrate 91% Treatment Volume, (Hours): 30.53

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 362.22
Inflow Volume Including PPT-Evap (ac-ft): 362.22
Total Runoff Infiltrated (ac-ft): 361.00, 99.66%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 1.63
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 99.66%

********** Link: Infiltration Trench (South) **********

Basic Wet Pond Volume (91% Exceedance): 473. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 710. cu-ft

2-Year Discharge Rate : 0.000 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.02 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.01 cfs

Time to Infiltrate 91% Treatment Volume, (Hours): 0.90

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 42.50
Inflow Volume Including PPT-Evap (ac-ft): 42.50
Total Runoff Infiltrated (ac-ft): 42.50, 100.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.01
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 100.00%

********** Link: New Copy Lnk2 **********

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 0.01
Inflow Volume Including PPT-Evap (ac-ft): 0.01
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.01
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Link: New Copy Lnk1
Scenario Postdeveloped Compliance Link: New Copy Lnk2

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	1.985E-02	2-Year	0.000
5-Year	3.182E-02	5-Year	0.000
10-Year	4.178E-02	10-Year	0.000
25-Year	5.708E-02	25-Year	0.000
50-Year	7.203E-02	50-Year	3.254E-02
100-Year	7.607E-02	100-Year	9.051E-02
200-Year	0.122	200-Year	9.136E-02

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):	-100.0%	PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	-99.9%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	-23.1%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

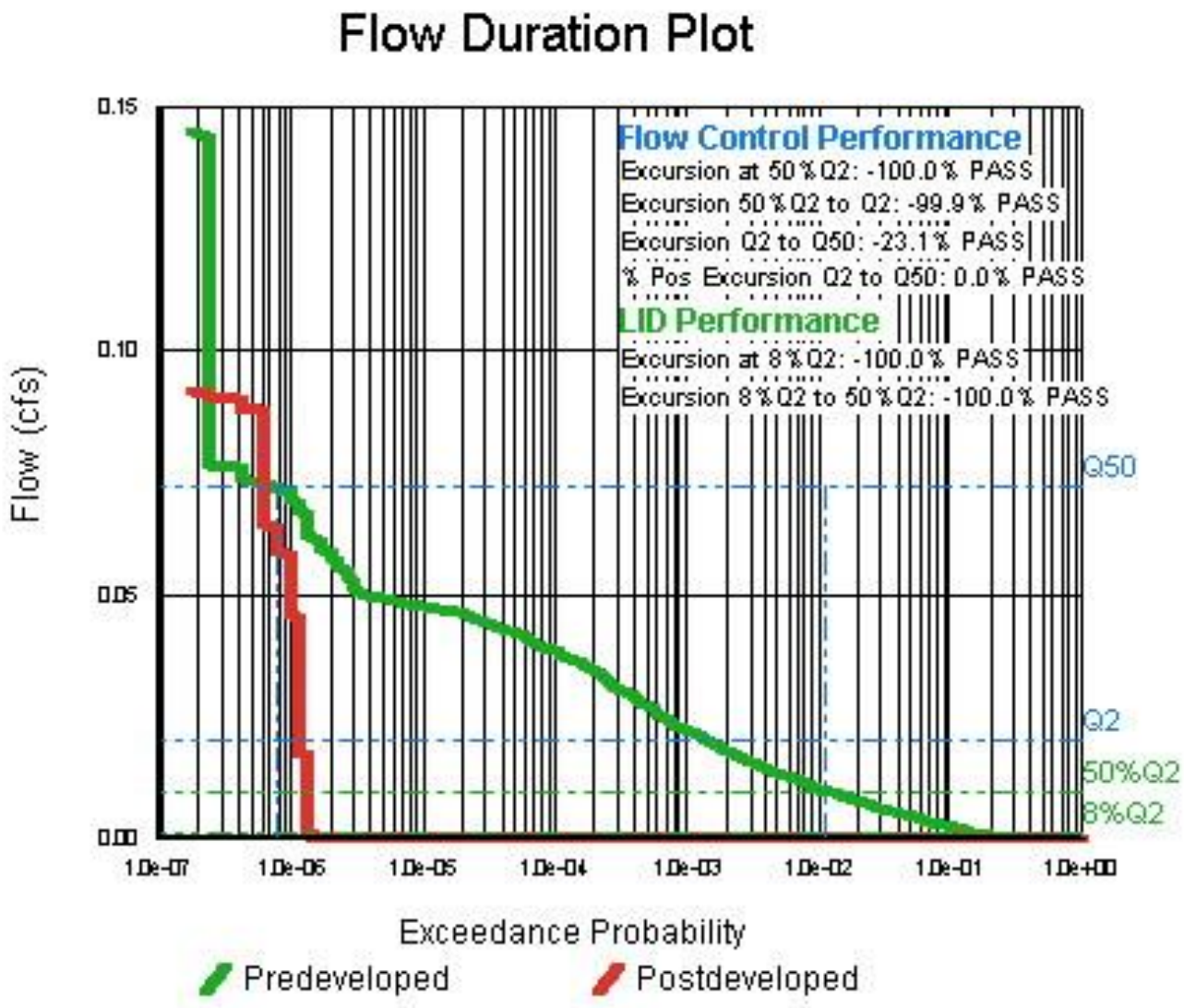
****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%):	-100.0%	PASS

Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%): -100.0% PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

NOTE: INFILTRATION TRENCHES HAVE BEEN SIZED AND OPTIMIZED IN THIS MODEL WITH AN ASSUMPTION THAT SITE SOILS TRANSITION FROM GLACIAL OUTWASH TO GLACIAL TILL AT A BOUNDARY APPROXIMATELY HALFWAY BETWEEN SOIL BORINGS WHERE THESE CONDITIONS WERE OBSERVED (SEE HYDROGEOLOGIC REPORT).



MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.46
Program License Number: 200410007
Project Simulation Performed on: 05/17/2019 4:45 PM
Report Generation Date: 05/17/2019 4:46 PM

Input File Name: TDA 5.FLD
Project Name: 43rd Ave SE TDA 5
Analysis Title: TDA 5
Comments: Total Detention Vol Calc
Stormchmber (Non-infiltrative)+ Wetpond
Treat all New + Repl HS, CP
Sidewalks modeled as impervious

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 16

Full Period of Record Available used for Routing
Precipitation Station : 96004405 Puget East 44 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961044 Puget East 44 in MAP
Evaporation Scale Factor : 0.750

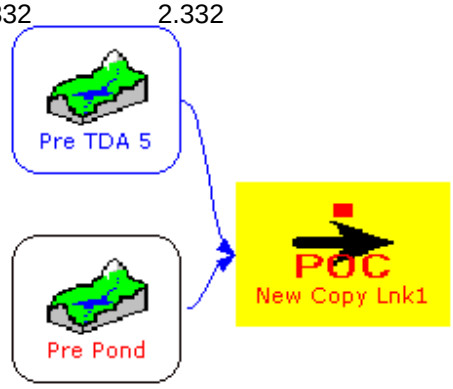
HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) **********

********** WATERSHED DEFINITION **********

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	2.332	2.332
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	2.332	2.332



----------SCENARIO: PREDEVELOPED
Number of Subbasins: 2

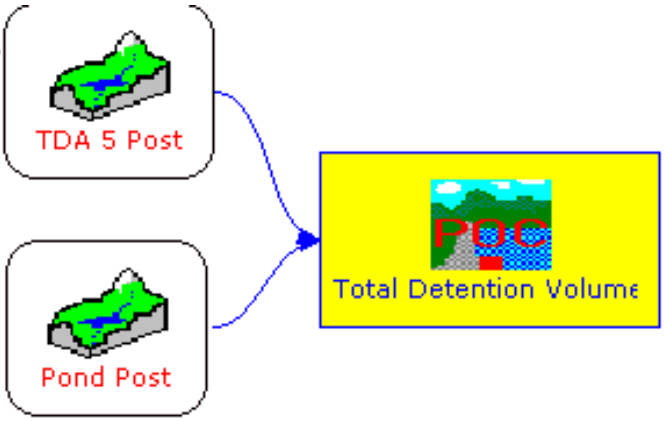
---------- Subbasin : Pre TDA 5 ----------
-------Area (Acres) --------
Till Forest 1.946

Subbasin Total 1.946

---------- Subbasin : Pre Pond ----------
-------Area (Acres) --------
Till Forest 0.386

Subbasin Total 0.386

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 2



---------- Subbasin : TDA 5 Post ----------
-------Area (Acres) --------
Till Grass 0.285
Impervious 1.661

Subbasin Total 1.946

---------- Subbasin : Pond Post ----------
-------Area (Acres) --------
Impervious 0.386

Subbasin Total 0.386

********** **LINK DATA** **********

----------SCENARIO: PREDEVELOPED
Number of Links: 1

Link Name: New Copy Lnk1
Link Type: Copy
Downstream Link: None

********** **LINK DATA** **********

----------SCENARIO: POSTDEVELOPED
Number of Links: 1

Link Name: Total Detention Volume
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 102.50

Max Pond Elevation (ft) : 103.00
Storage Depth (ft) : 2.50
Pond Bottom Length (ft) : 210.0
Pond Bottom Width (ft) : 90.0
Pond Side Slopes (ft/ft) : L1= 3.00 L2= 3.00 W1= 3.00 W2= 3.00
Bottom Area (sq-ft) : 18900.
Area at Riser Crest El (sq-ft) : 23,625.
(acres) : 0.542
Volume at Riser Crest (cu-ft) : 53,063.
(ac-ft) : 1.218
Area at Max Elevation (sq-ft) : 24624.
(acres) : 0.565
Vol at Max Elevation (cu-ft) : 65,124.
(ac-ft) : 1.495

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.00

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 18.00
Common Length (ft) : 0.070
Riser Crest Elevation : 102.50 ft

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---
Device Type : Circular Orifice
Control Elevation (ft) : 100.00
Diameter (in) : 0.99
Orientation : Horizontal
Elbow : No

--- Device Number 2 ---
Device Type : Vertical Rectangular Orifice
Control Elevation (ft) : 101.60
Length (in) : 0.66
Height (in) : 7.00
Orientation : Vertical
Elbow : No

**************************FLOOD FREQUENCY AND DURATION STATISTICS********************

----------SCENARIO: PREDEVELOPED
Number of Subbasins: 2
Number of Links: 1

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 2
Number of Links: 1

********** Link: Total Detention Volume ********** Link WSEL Stats

WSEL Frequency Data(ft)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	WSEL Peak (ft)
1.05-Year	100.825
1.11-Year	100.881
1.25-Year	101.015
2.00-Year	101.275
3.33-Year	101.537
5-Year	101.756
10-Year	102.040
25-Year	102.165
50-Year	102.224
100-Year	102.251

*************Groundwater Recharge Summary **************

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

Model Element	Recharge Amount (ac-ft)
Subbasin: Pre TDA 5	370.188
Subbasin: Pre Pond	73.509
Link: New Copy Lnk1	0.000
Total:	443.696

Total Post Developed Recharge During Simulation

Model Element	Recharge Amount (ac-ft)
Subbasin: TDA 5 Post	36.668
Subbasin: Pond Post	0.000
Link: Total Detention Volu	0.000
Total:	36.668

Total Predevelopment Recharge is Greater than Post Developed
Average Recharge Per Year, (Number of Years= 158)
Predeveloped: 2.808 ac-ft/year, Post Developed: 0.232 ac-ft/year

*************Water Quality Facility Data **************

----------SCENARIO: PREDEVELOPED

Number of Links: 1

********** Link: New Copy Lnk1 **********

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 283.87
Inflow Volume Including PPT-Evap (ac-ft): 283.87

Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 283.87
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

----------SCENARIO: POSTDEVELOPED

Number of Links: 1

********** Link: Total Detention Volume **********

Basic Wet Pond Volume (91% Exceedance): 10151. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 15226. cu-ft

2-Year Discharge Rate : 0.029 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.32 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.18 cfs

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 1097.76
Inflow Volume Including PPT-Evap (ac-ft): 1097.76
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 1097.53
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

*************Compliance Point Results **************

Scenario Predeveloped Compliance Link: New Copy Lnk1
Scenario Postdeveloped Compliance Link: Total Detention Volume

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	5.999E-02	2-Year	2.935E-02
5-Year	9.614E-02	5-Year	4.360E-02
10-Year	0.125	10-Year	8.016E-02
25-Year	0.172	25-Year	0.101
50-Year	0.217	50-Year	0.111
100-Year	0.230	100-Year	0.117
200-Year	0.367	200-Year	0.134

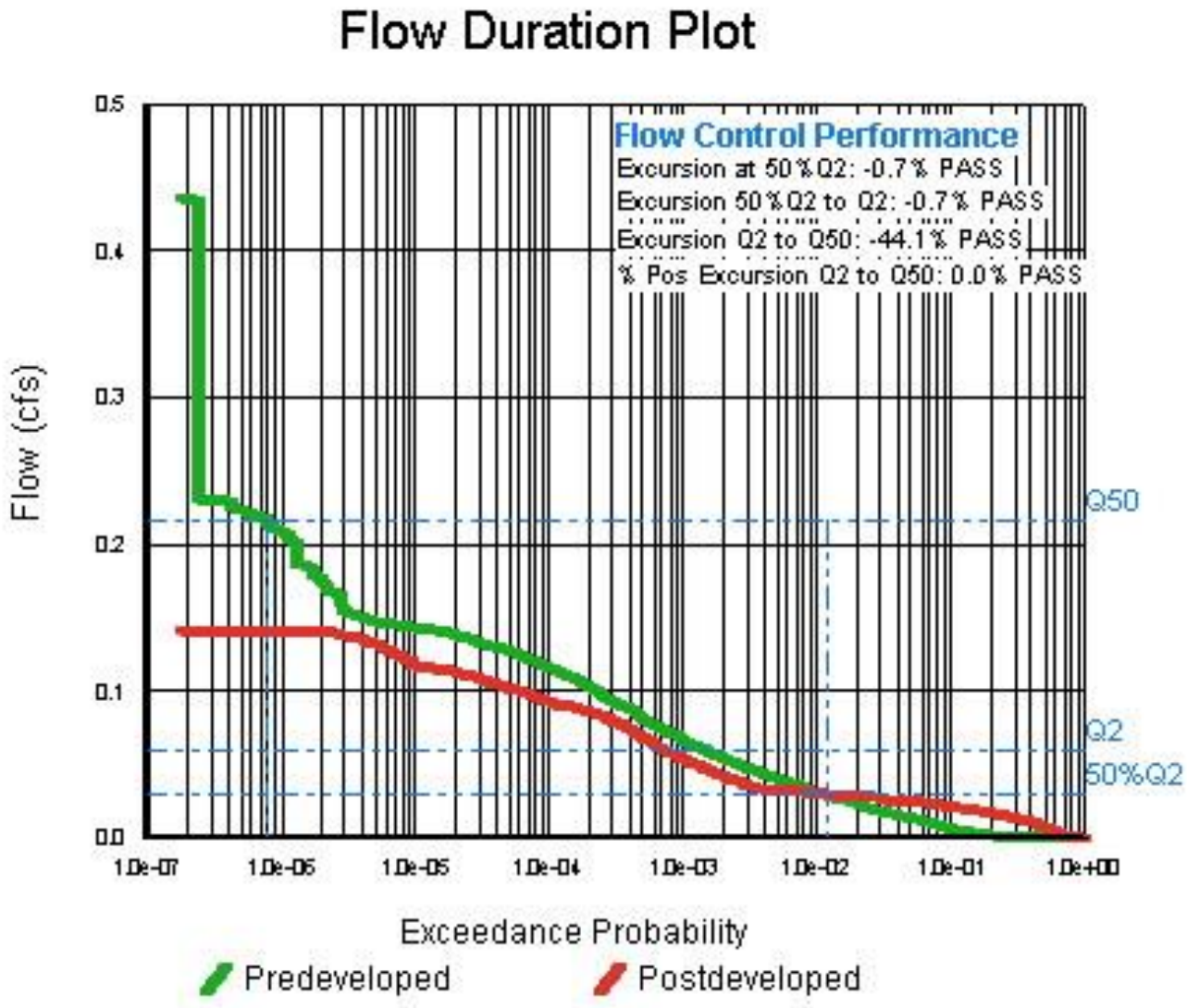
** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%): -0.7% PASS

Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	-0.7%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	-44.1%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

NOTE: THIS MODEL REPRESENTS DETENTION AND WATER QUALITY VOLUMES FOR THE ENTIRE TDA 5 AREA. VOLUMES TO EACH FACILITY HAVE BEEN PRORATED BASED ON PERCENTAGE OF ROADWAY DRAINING TO EACH.



MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.46
Program License Number: 200410007
Project Simulation Performed on: 05/08/2019 5:20 PM
Report Generation Date: 05/08/2019 5:20 PM

Input File Name: TDA 6_Infilt Stormchamber + Infilt Trench.fld
Project Name: 43rd Ave SE TDA 6
Analysis Title: TDA 6 Stormchamber & Infiltration Trench
Comments: Total Detention Volume
Stormchamber+Infiltration Trenches
Treat all New + Replaced HS, CP
Proposed sidewalks entered as impervious

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 16

Full Period of Record Available used for Routing
Precipitation Station : 96004405 Puget East 44 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961044 Puget East 44 in MAP
Evaporation Scale Factor : 0.750

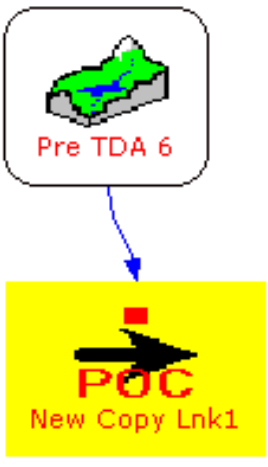
HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) **********

********** WATERSHED DEFINITION **********

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	4.442	4.442
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	4.442	4.442

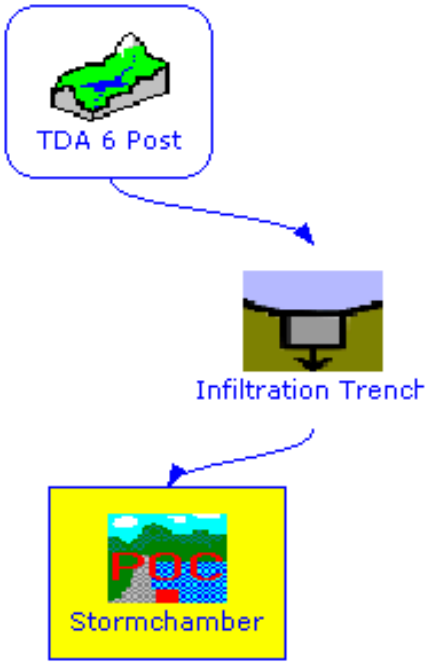


----------SCENARIO: PREDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Pre TDA 6 ----------
-------Area (Acres) --------
Till Forest 4.442

Subbasin Total 4.442

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1



---------- Subbasin : TDA 6 Post ----------
-------Area (Acres) --------
Till Grass 0.534
Impervious 3.908

Subbasin Total 4.442

********** LINK DATA **********

----------SCENARIO: PREDEVELOPED
Number of Links: 1

Link Name: New Copy Lnk1
Link Type: Copy
Downstream Link: None

********** LINK DATA **********

----------SCENARIO: POSTDEVELOPED
Number of Links: 2

Link Name: Stormchamber
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 95.00
Riser Crest Elevation (ft) : 98.00
Max Pond Elevation (ft) : 98.50
Storage Depth (ft) : 3.00
Pond Bottom Length (ft) : 95.0
Pond Bottom Width (ft) : 75.0
Pond Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 7125.
Area at Riser Crest El (sq-ft) : 7,125.
(acres) : 0.164
Volume at Riser Crest (cu-ft) : 21,375.
(ac-ft) : 0.491
Area at Max Elevation (sq-ft) : 7125.
(acres) : 0.164
Vol at Max Elevation (cu-ft) : 24,938.
(ac-ft) : 0.572

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.24

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 36.00
Common Length (ft) : 0.000
Riser Crest Elevation : 98.00 ft

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---
Device Type : Circular Orifice
Control Elevation (ft) : 95.00
Diameter (in) : 2.42
Orientation : Horizontal
Elbow : Yes

--- Device Number 2 ---
Device Type : Horizontal Rectangular Orifice
Control Elevation (ft) : 97.60
Length (in) : 1.60
Height (in) : 2.00
Orientation : Horizontal
Elbow : Yes

Link Name: Infiltration Trench
Link Type: Infiltration Trench
Downstream Link Name: Stormchamber

Trench Type : Trench at Toe of Embankment
Trench Length (ft) : 4600.00
Trench Width (ft) : 2.00
Trench Depth (ft) : 4.00
Trench Bottom Elev (ft) : 100.00
Trench Rockfill Porosity (%) : 30.00

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.24

**************************FLOOD FREQUENCY AND DURATION STATISTICS*********************

----------SCENARIO: PREDEVELOPED
Number of Subbasins: 1
Number of Links: 1

************ Subbasin: Pre TDA 6 ************

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.114
5-Year	0.183
10-Year	0.239
25-Year	0.328
50-Year	0.413
100-Year	0.438
200-Year	0.699

********** Link: New Copy Lnk1 ********** Link Outflow 1 Frequency Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.114
5-Year	0.183
10-Year	0.239
25-Year	0.328
50-Year	0.413
100-Year	0.438
200-Year	0.699

----------SCENARIO: POSTDEVELOPED

Number of Subbasins: 1

Number of Links: 2

********** Subbasin: TDA 6 Post **********

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	1.586
5-Year	2.031
10-Year	2.455
25-Year	3.007
50-Year	3.629
100-Year	4.464
200-Year	4.641

********** Link: Stormchamber ********** Link Inflow Frequency Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.499
5-Year	1.043
10-Year	1.250

25-Year	1.566
50-Year	1.882
100-Year	1.993
200-Year	2.357

********** Link: Stormchamber ********** Link WSEL Stats

WSEL Frequency Data(ft)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	WSEL Peak (ft)
1.05-Year	95.000
1.11-Year	95.000
1.25-Year	95.013
2.00-Year	95.299
3.33-Year	95.599
5-Year	95.908
10-Year	96.334
25-Year	97.220
50-Year	97.548
100-Year	97.784

********** Link: Infiltration Trench ********** Link Inflow Frequency Stats

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	1.586
5-Year	2.031
10-Year	2.455
25-Year	3.007
50-Year	3.629
100-Year	4.464
200-Year	4.641

********** Link: Infiltration Trench ********** Link Outflow 1 Frequency Stats

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.499
5-Year	1.043
10-Year	1.250
25-Year	1.566
50-Year	1.882
100-Year	1.993
200-Year	2.357

*************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

Model Element		Recharge Amount (ac-ft)
Subbasin:	Pre TDA 6	845.026
Link:	New Copy Lnk1	0.000
Total:		845.026

Total Post Developed Recharge During Simulation

Model Element		Recharge Amount (ac-ft)
Subbasin:	TDA 6 Post	68.829
Link:	Stormchamber	12.208
Link:	Infiltration Trench	2057.579
Total:		2138.615

Total Predevelopment Recharge is Less than Post Developed
Average Recharge Per Year, (Number of Years= 158)
Predeveloped: 5.348 ac-ft/year, Post Developed: 13.536 ac-ft/year

*************Water Quality Facility Data ***************

----------SCENARIO: PREDEVELOPED

Number of Links: 1

********** Link: New Copy Lnk1 **********

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 540.64
Inflow Volume Including PPT-Evap (ac-ft): 540.64
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 540.64
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

----------SCENARIO: POSTDEVELOPED

Number of Links: 2

********** Link: Stormchamber **********

Basic Wet Pond Volume (91% Exceedance): 22596. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 33894. cu-ft

2-Year Discharge Rate : 0.081 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 1.08 cfs

Off-line Design Discharge Rate (91% Exceedance): 0.64 cfs

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 35.93
Inflow Volume Including PPT-Evap (ac-ft): 35.93
Total Runoff Infiltrated (ac-ft): 12.21, 33.98%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 23.73
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 33.98%

********** Link: Infiltration Trench **********

Basic Wet Pond Volume (91% Exceedance): 19345. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 29018. cu-ft

2-Year Discharge Rate : 0.499 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.61 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.34 cfs

Time to Infiltrate 91% Treatment Volume, (Hours): 33.56

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 2092.71
Inflow Volume Including PPT-Evap (ac-ft): 2092.71
Total Runoff Infiltrated (ac-ft): 2057.58, 98.32%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 35.93
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 98.32%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Link: New Copy Lnk1
Scenario Postdeveloped Compliance Link: Stormchamber

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	0.114	2-Year	8.113E-02
5-Year	0.183	5-Year	0.141
10-Year	0.239	10-Year	0.171
25-Year	0.328	25-Year	0.221
50-Year	0.413	50-Year	0.246
100-Year	0.438	100-Year	0.292
200-Year	0.699	200-Year	0.932

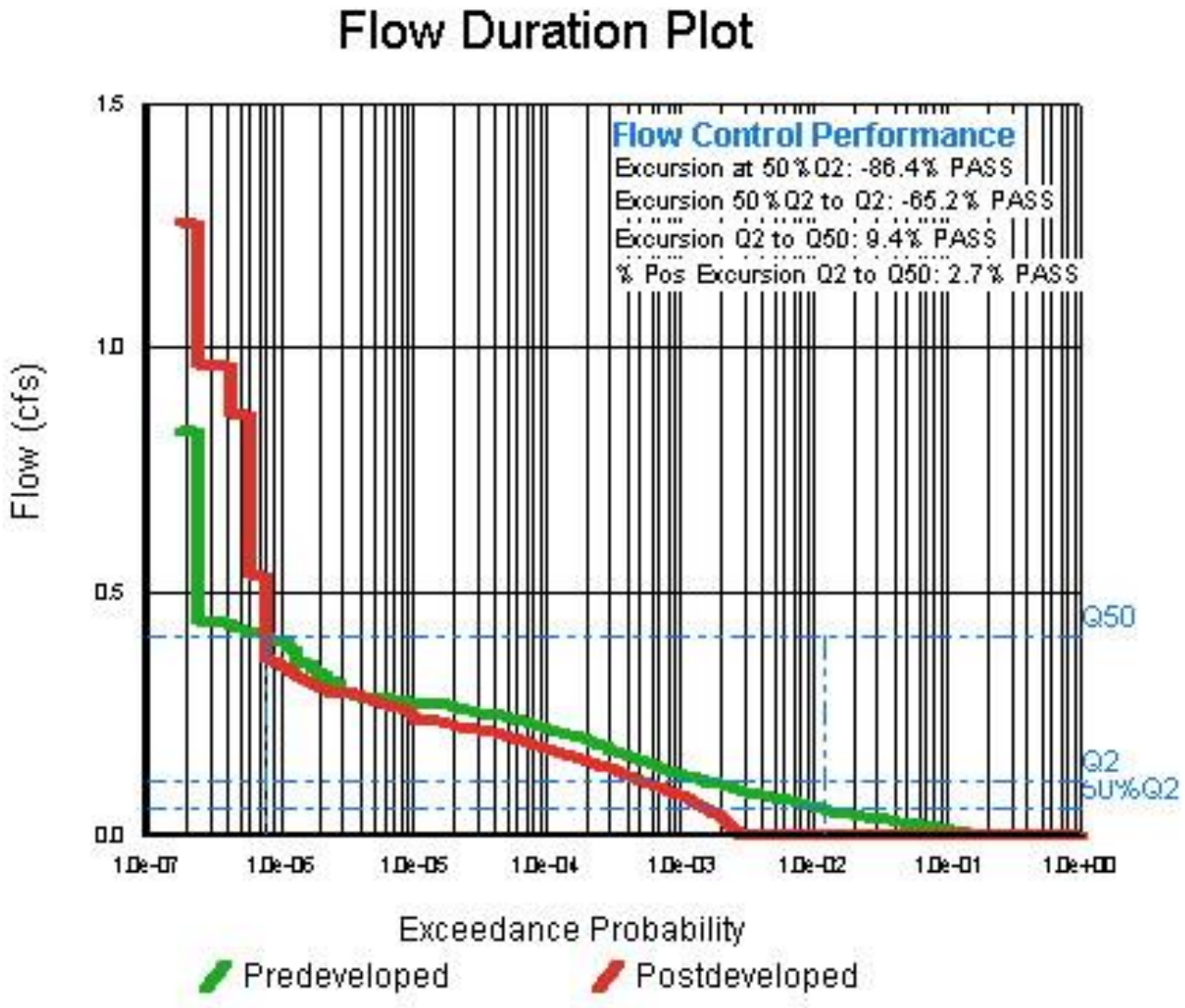
** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):	-86.4%	PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	-65.2%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	9.4%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	2.7%	PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

<u>NOTE</u>: THIS MODEL REPRESENTS DETENTION AND WATER QUALITY VOLUMES FOR THE ENTIRE TDA 6 AREA. VOLUMES TO EACH FACILITY HAVE BEEN PRORATED BASED ON PERCENTAGE OF ROADWAY DRAINING TO EACH.



MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.46
Program License Number: 200410007
Project Simulation Performed on: 05/09/2019 12:08 PM
Report Generation Date: 05/09/2019 12:08 PM

Input File Name: TDA 6_Infilt Stormchamber + non-infilt WQ Swale.fld
Project Name: 43rd Ave SE TDA 6
Analysis Title: TDA 6 Stormchamber + Non-Infiltrative WQ Swales
Comments: Total Detention Volume
Stormchamber, non-infiltrative WQ Swales
Treat all New + Replaced HS, CP
Proposed sidewalks entered as impervious

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 16

Full Period of Record Available used for Routing
Precipitation Station : 96004405 Puget East 44 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961044 Puget East 44 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) **********

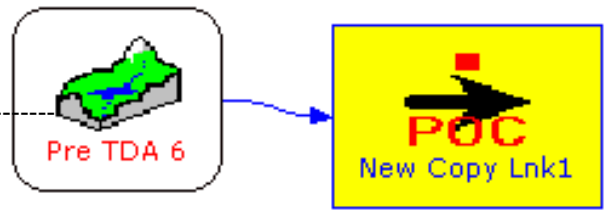
********** WATERSHED DEFINITION **********

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	4.442	4.442
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	4.442	4.442

----------SCENARIO: PREDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Pre TDA 6 ----------
-------Area (Acres) --------
Till Forest 4.442

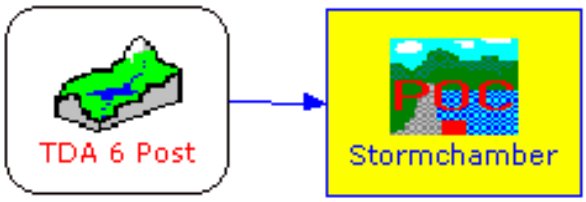


Subbasin Total 4.442

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1

---------- Subbasin : TDA 6 Post ----------
-------Area (Acres) --
Till Grass 0.534
Impervious 3.908

Subbasin Total 4.442



********** LINK DATA **********

----------SCENARIO: PREDEVELOPED
Number of Links: 1

Link Name: New Copy Lnk1
Link Type: Copy
Downstream Link: None

********** LINK DATA **********

----------SCENARIO: POSTDEVELOPED
Number of Links: 1

Link Name: Stormchamber
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 95.00
Riser Crest Elevation (ft) : 98.00
Max Pond Elevation (ft) : 98.50
Storage Depth (ft) : 3.00
Pond Bottom Length (ft) : 125.0
Pond Bottom Width (ft) : 125.0
Pond Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 15625.
Area at Riser Crest El (sq-ft) : 15,625.
(acres) : 0.359
Volume at Riser Crest (cu-ft) : 46,875.
(ac-ft) : 1.076
Area at Max Elevation (sq-ft) : 15625.
(acres) : 0.359
Vol at Max Elevation (cu-ft) : 54,688.
(ac-ft) : 1.255

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.24

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 18.00
Common Length (ft) : 0.040
Riser Crest Elevation : 98.00 ft

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---
Device Type : Circular Orifice
Control Elevation (ft) : 95.00
Diameter (in) : 1.67
Orientation : Horizontal
Elbow : No

--- Device Number 2 ---
Device Type : Vertical Rectangular Orifice
Control Elevation (ft) : 96.70
Length (in) : 3.20
Height (in) : 1.33
Orientation : Vertical
Elbow : No

**************************FLOOD FREQUENCY AND DURATION STATISTICS********************

----------SCENARIO: PREDEVELOPED
Number of Subbasins: 1
Number of Links: 1

************ Subbasin: Pre TDA 6 ************

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.114
5-Year	0.183
10-Year	0.239
25-Year	0.328
50-Year	0.413
100-Year	0.438
200-Year	0.699

********** Link: New Copy Lnk1 ********** Link Outflow 1 Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)
Tr (yrs) Flood Peak (cfs)

2-Year	0.114
5-Year	0.183
10-Year	0.239
25-Year	0.328
50-Year	0.413
100-Year	0.438
200-Year	0.699

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1
Number of Links: 1

********** **Subbasin: TDA 6 Post** **********

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	1.586
5-Year	2.031
10-Year	2.455
25-Year	3.007
50-Year	3.629
100-Year	4.464
200-Year	4.641

********** Link: Stormchamber ********** Link Inflow Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	1.586
5-Year	2.031
10-Year	2.455
25-Year	3.007
50-Year	3.629
100-Year	4.464
200-Year	4.641

********** Link: Stormchamber ********** Link WSEL Stats
WSEL Frequency Data(ft)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	WSEL Peak (ft)
1.05-Year	95.622
1.11-Year	95.730
1.25-Year	95.854

2.00-Year	96.110
3.33-Year	96.416
5-Year	96.664
10-Year	97.028
25-Year	97.501
50-Year	97.675
100-Year	97.834

*************Groundwater Recharge Summary ***************

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

Model Element		Recharge Amount (ac-ft)
Subbasin: Pre TDA 6		845.026
Link:	New Copy Lnk1	0.000
Total:		845.026

Total Post Developed Recharge During Simulation

Model Element		Recharge Amount (ac-ft)
Subbasin: TDA 6 Post		68.829
Link:	Stormchamber	1604.748
Total:		1673.576

Total Predevelopment Recharge is Less than Post Developed
Average Recharge Per Year, (Number of Years= 158)
Predeveloped: 5.348 ac-ft/year, Post Developed: 10.592 ac-ft/year

*************Water Quality Facility Data ***************

----------SCENARIO: PREDEVELOPED

Number of Links: 1

********** Link: New Copy Lnk1 **********

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 540.64
Inflow Volume Including PPT-Evap (ac-ft): 540.64
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 540.64
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

----------SCENARIO: POSTDEVELOPED

Number of Links: 1

********** Link: Stormchamber **********

Basic Wet Pond Volume (91% Exceedance): 19345. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 29018. cu-ft

2-Year Discharge Rate : 0.078 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.61 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.34 cfs

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 2092.71
Inflow Volume Including PPT-Evap (ac-ft): 2092.71
Total Runoff Infiltrated (ac-ft): 1604.75, 76.68%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 492.54
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 76.68%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Link: New Copy Lnk1
Scenario Postdeveloped Compliance Link: Stormchamber

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	0.114	2-Year	7.840E-02
5-Year	0.183	5-Year	9.599E-02
10-Year	0.239	10-Year	0.178
25-Year	0.328	25-Year	0.236
50-Year	0.413	50-Year	0.253
100-Year	0.438	100-Year	0.268
200-Year	0.699	200-Year	0.423

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

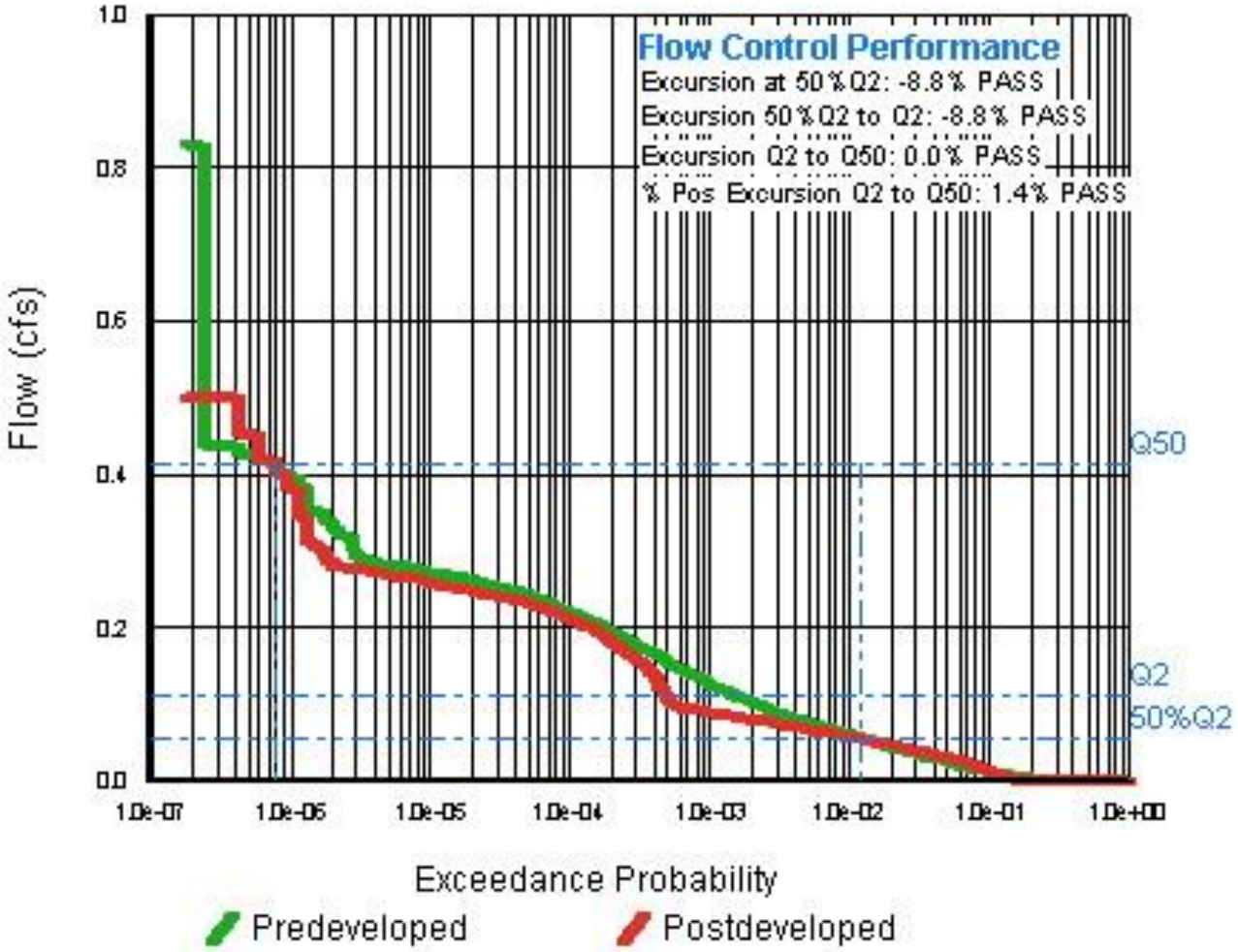
****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):	-8.8%	PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	-8.8%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	0.0%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	1.4%	PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

<u>NOTE</u>: THIS MODEL REPRESENTS DETENTION AND WATER QUALITY VOLUMES FOR THE ENTIRE TDA 6 AREA. VOLUMES TO EACH FACILITY HAVE BEEN PRORATED BASED ON PERCENTAGE OF ROADWAY DRAINING TO EACH.

Flow Duration Plot



MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.46
Program License Number: 200410007
Project Simulation Performed on: 05/08/2019 4:27 PM
Report Generation Date: 05/08/2019 4:27 PM

Input File Name: TDA 7_Bioretention and Vault/Tank.fld
Project Name: 43rd Ave SE TDA 7
Analysis Title: TDA 7
Comments: Bioretention with Minor Infiltration
Detention Vault/Tank
Input proposed sidewalks as impervious
Treat only New HS and CP

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 16

Full Period of Record Available used for Routing
Precipitation Station : 96004405 Puget East 44 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961044 Puget East 44 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) **********

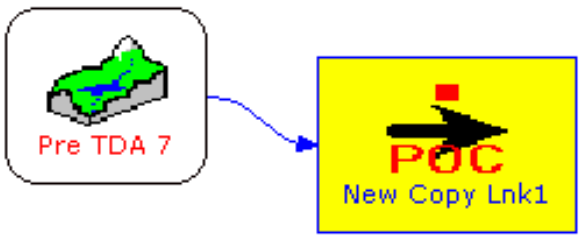
********** WATERSHED DEFINITION **********

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.489	0.489
Area of Links that Include Precip/Evap (acres)	0.000	0.040
Total (acres)	0.489	0.529

----------SCENARIO: PREDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Pre TDA 7 ----------
-------Area (Acres) --------
Till Forest 0.489



Subbasin Total 0.489

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1

---------- Subbasin : TDA 7 Post ----------
-------Area (Acres) --------
Till Grass 0.074
Impervious 0.415

Subbasin Total 0.489

Bioretention Cells

********** **LINK DATA** **********

----------SCENARIO: PREDEVELOPED
Number of Links: 1

Link Name: New Copy Lnk1
Link Type: Copy
Downstream Link: None

********** **LINK DATA** **********

----------SCENARIO: POSTDEVELOPED
Number of Links: 2

Link Name: Bioretention Cells
Link Type: Bioretention Facility
Downstream Link Name: TDA 7 Vault

Base Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 101.00
Storage Depth (ft) : 1.00
Bottom Length (ft) : 580.0
Bottom Width (ft) : 3.0
Side Slopes (ft/ft) : L1= 3.00 L2= 3.00 W1= 3.00 W2= 3.00
Bottom Area (sq-ft) : 1740.
Area at Riser Crest El (sq-ft) : 5,274.
(acres) : 0.121
Volume at Riser Crest (cu-ft) : 4,284.
(ac-ft) : 0.098

Infiltration on Bottom only Selected

Soil Properties
Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00

Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 101.50
Native Soil Hydraulic Conductivity (in/hr) : 0.24

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 12.00
Common Length (ft) : 0.000
Riser Crest Elevation : 101.00 ft

Hydraulic Structure Geometry

Number of Devices: 0

Link Name: TDA 7 Vault
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 95.00
Riser Crest Elevation (ft) : 98.50
Max Pond Elevation (ft) : 99.00
Storage Depth (ft) : 3.50
Pond Bottom Length (ft) : 27.0
Pond Bottom Width (ft) : 20.0
Pond Side Slopes (ft/ft) : L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft) : 540.
Area at Riser Crest El (sq-ft) : 540.
(acres) : 0.012
Volume at Riser Crest (cu-ft) : 1,890.
(ac-ft) : 0.043
Area at Max Elevation (sq-ft) : 540.
(acres) : 0.012
Vol at Max Elevation (cu-ft) : 2,160.
(ac-ft) : 0.050

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.00

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 18.00
Common Length (ft) : 0.010
Riser Crest Elevation : 98.50 ft

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---
Device Type : Circular Orifice
Control Elevation (ft) : 95.00
Diameter (in) : 0.70

Orientation : Horizontal
Elbow : No

--- Device Number 2 ---
Device Type : Vertical Rectangular Orifice
Control Elevation (ft) : 97.55
Length (in) : 0.25
Height (in) : 3.00
Orientation : Vertical
Elbow : No

**************************FLOOD FREQUENCY AND DURATION STATISTICS*********************

----------SCENARIO: PREDEVELOPED
Number of Subbasins: 1
Number of Links: 1

************ Subbasin: Pre TDA 7 ************

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	1.257E-02
5-Year	2.015E-02
10-Year	2.627E-02
25-Year	3.612E-02
50-Year	4.541E-02
100-Year	4.818E-02
200-Year	7.697E-02

********** Link: New Copy Lnk1 ********** Link Outflow 1 Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	1.257E-02
5-Year	2.015E-02
10-Year	2.627E-02
25-Year	3.612E-02
50-Year	4.541E-02
100-Year	4.818E-02
200-Year	7.697E-02

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1
Number of Links: 2

************ Subbasin: TDA 7 Post ************

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.170
5-Year	0.219
10-Year	0.264
25-Year	0.327
50-Year	0.394
100-Year	0.485
200-Year	0.503

********** Link: Bioretention Cells ********** Link Inflow

Frequency Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.170
5-Year	0.219
10-Year	0.264
25-Year	0.327
50-Year	0.394
100-Year	0.485
200-Year	0.503

********** Link: Bioretention Cells ********** Link Outflow 1

Frequency Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	2.421E-06
5-Year	5.688E-06
10-Year	9.585E-06
25-Year	7.575E-02
50-Year	0.105
100-Year	0.159
200-Year	0.167

********** Link: Bioretention Cells ********** Link WSEL Stats

WSEL Frequency Data(ft)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	WSEL Peak (ft)
1.05-Year	99.638
1.11-Year	99.819
1.25-Year	99.996
2.00-Year	100.242
3.33-Year	100.411
5-Year	100.569

10-Year	100.958
25-Year	101.037
50-Year	101.046
100-Year	101.061

********** Link: TDA 7 Vault ********** Link Inflow Frequency Stats

Flood Frequency Data(cfs)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	2.421E-06
5-Year	5.688E-06
10-Year	9.585E-06
25-Year	7.575E-02
50-Year	0.105
100-Year	0.159
200-Year	0.167

********** Link: TDA 7 Vault ********** Link WSEL Stats

WSEL Frequency Data(ft)

(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	WSEL Peak (ft)
1.05-Year	95.000
1.11-Year	95.000
1.25-Year	95.000
2.00-Year	95.000
3.33-Year	95.000
5-Year	95.000
10-Year	95.000
25-Year	96.520
50-Year	96.924
100-Year	97.609

*************Groundwater Recharge Summary ***************

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

Model Element	Recharge Amount (ac-ft)
Subbasin: Pre TDA 7	92.989
Link: New Copy Lnk1	0.000
Total:	92.989

Total Post Developed Recharge During Simulation

Model Element	Recharge Amount (ac-ft)

Subbasin:	TDA 7 Post	9.570
Link:	Bioretention Cells	245.159
Link:	TDA 7 Vault	0.000
Total:		254.728

Total Predevelopment Recharge is Less than Post Developed
Average Recharge Per Year, (Number of Years= 158)
Predeveloped: 0.589 ac-ft/year, Post Developed: 1.612 ac-ft/year

*************Water Quality Facility Data ***************

----------SCENARIO: PREDEVELOPED

Number of Links: 1

********** Link: New Copy Lnk1 **********

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 59.49
Inflow Volume Including PPT-Evap (ac-ft): 59.49
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 59.49
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

----------SCENARIO: POSTDEVELOPED

Number of Links: 2

********** Link: Bioretention Cells **********

Basic Wet Pond Volume (91% Exceedance): 2071. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 3107. cu-ft

2-Year Discharge Rate : 0.000 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.06 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.04 cfs

Time to Infiltrate 91% Treatment Volume, (Hours): 82.85

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 226.32
Inflow Volume Including PPT-Evap (ac-ft): 245.85
Total Runoff Infiltrated (ac-ft): 245.16, 99.72%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.49
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 99.72%

********** Link: Detention Vault **********

Basic Wet Pond Volume (91% Exceedance): 2331. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 3496. cu-ft

2-Year Discharge Rate : 0.000 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.12 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.06 cfs

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 0.49
Inflow Volume Including PPT-Evap (ac-ft): 0.49
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.49
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Link: New Copy Lnk1
Scenario Postdeveloped Compliance Link: TDA 7 Vault

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	1.257E-02	2-Year	0.000
5-Year	2.015E-02	5-Year	0.000
10-Year	2.627E-02	10-Year	0.000
25-Year	3.612E-02	25-Year	1.612E-02
50-Year	4.541E-02	50-Year	1.813E-02
100-Year	4.818E-02	100-Year	2.226E-02
200-Year	7.697E-02	200-Year	3.362E-02

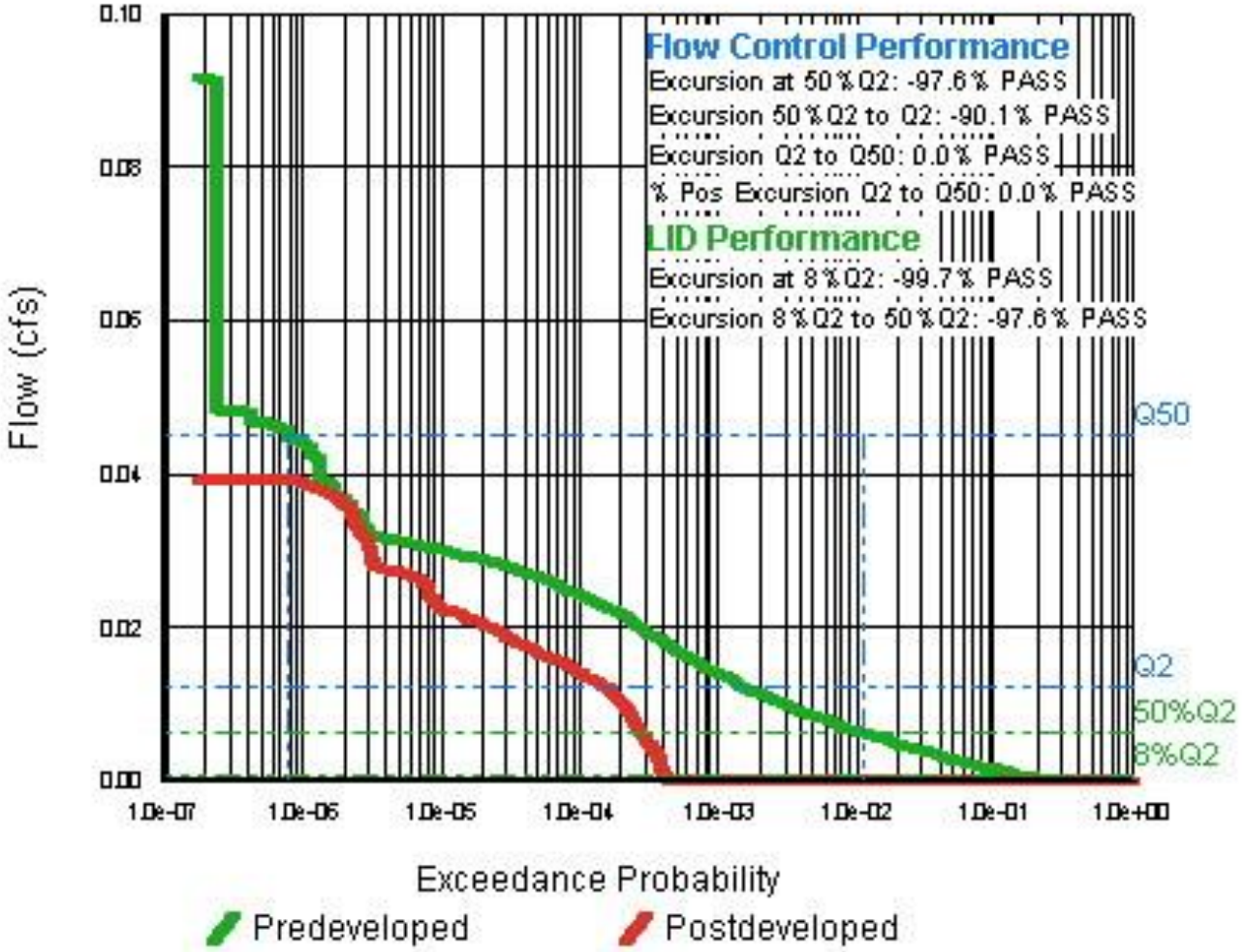
** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):	-97.6%	PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	-90.1%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	0.0%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

Flow Duration Plot



MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.46
Program License Number: 200410007
Project Simulation Performed on: 05/17/2019 11:14 AM
Report Generation Date: 05/17/2019 11:16 AM

Input File Name: TDA 11 WQ.fld
Project Name: 43rd Ave SE TDA 11
Analysis Title: TDA 11 Pond w Bioretention WQ
Comments: TDA 11 Detention Pond and offline WQ Bioretention
Treat only CP and New HS
Enter Sidewalk as Impervious

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 16

Full Period of Record Available used for Routing
Precipitation Station : 96004405 Puget East 44 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961044 Puget East 44 in MAP
Evaporation Scale Factor : 0.750

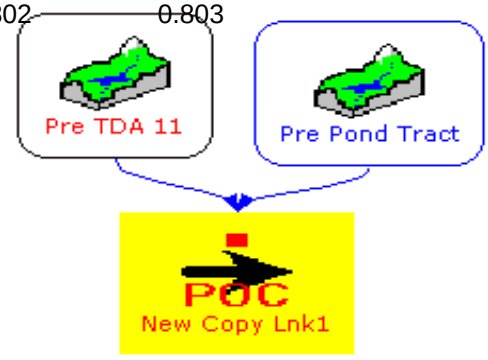
HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) **********

********** WATERSHED DEFINITION **********

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	0.802	0.802
Area of Links that Include Precip/Evap (acres)	0.000	0.001
Total (acres)	0.802	0.803



----------SCENARIO: PREDEVELOPED
Number of Subbasins: 2

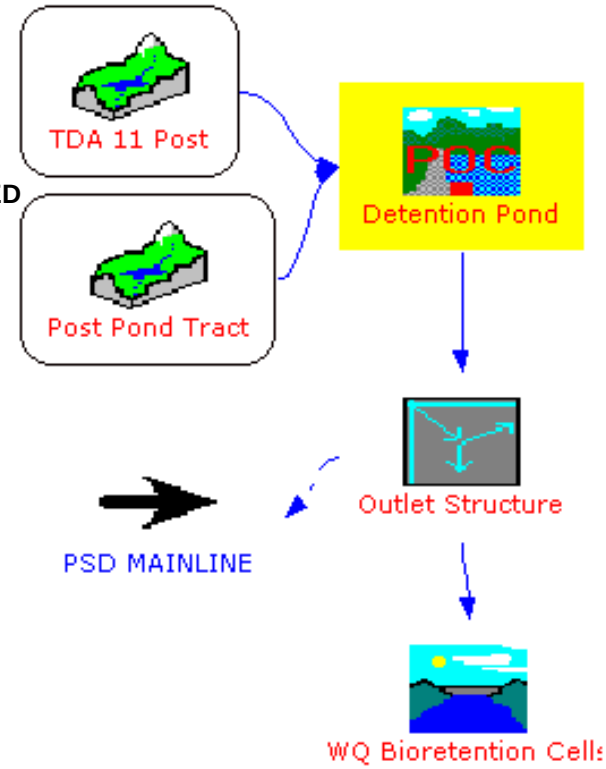
---------- Subbasin : Pre TDA 11 ----------
-------Area (Acres) --------
Till Forest 0.687

Subbasin Total 0.687

---------- Subbasin : Pre Pond Tract ----------
-------Area (Acres) --------
Till Forest 0.115

Subbasin Total 0.115

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 2



---------- Subbasin : TDA 11 Post ----------
-------Area (Acres) --------
Till Grass 0.150
Impervious 0.537

Subbasin Total 0.687

---------- Subbasin : Post Pond Tract ----------
-------Area (Acres) --------
Impervious 0.115

Subbasin Total 0.115

********** **LINK DATA** **********

----------SCENARIO: PREDEVELOPED
Number of Links: 1

Link Name: New Copy Lnk1
Link Type: Copy
Downstream Link: None

********** **LINK DATA** **********

----------SCENARIO: POSTDEVELOPED
Number of Links: 4

Link Name: Detention Pond
Link Type: Structure
Downstream Link Name: Outlet Structure

Prismatic Pond Option Used
Pond Floor Elevation (ft) : 100.00
Riser Crest Elevation (ft) : 102.00
Max Pond Elevation (ft) : 103.00

Storage Depth (ft) : 2.00
Pond Bottom Length (ft) : 144.0
Pond Bottom Width (ft) : 20.0
Pond Side Slopes (ft/ft) : L1= 3.00 L2= 3.00 W1= 3.00 W2= 3.00
Bottom Area (sq-ft) : 2880.
Area at Riser Crest El (sq-ft) : 4,992.
(acres) : 0.115
Volume at Riser Crest (cu-ft) : 7,824.
(ac-ft) : 0.180
Area at Max Elevation (sq-ft) : 6156.
(acres) : 0.141
Vol at Max Elevation (cu-ft) : 13,392.
(ac-ft) : 0.307

Constant Infiltration Option Used
Infiltration Rate (in/hr): 0.24

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 18.00
Common Length (ft) : 0.010
Riser Crest Elevation : 102.00 ft

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---
Device Type : Circular Orifice
Control Elevation (ft) : 100.00
Diameter (in) : 0.70
Orientation : Horizontal
Elbow : No

--- Device Number 2 ---
Device Type : Vertical Rectangular Orifice
Control Elevation (ft) : 101.20
Length (in) : 0.25
Height (in) : 6.00
Orientation : Vertical
Elbow : No

Link Name: WQ Bioretention Cells
Link Type: Bioretention Facility
Downstream Link: None

Base Elevation (ft) : 97.50
Riser Crest Elevation (ft) : 98.50
Storage Depth (ft) : 1.00
Bottom Length (ft) : 13.8
Bottom Width (ft) : 3.0
Side Slopes (ft/ft) : L1= 3.00 L2= 3.00 W1= 3.00 W2= 3.00
Bottom Area (sq-ft) : 41.
Area at Riser Crest El (sq-ft) : 178.

(acres) : 0.004
Volume at Riser Crest (cu-ft) : 122.
(ac-ft) : 0.003

Infiltration on Bottom only Selected

Soil Properties
Biosoil Thickness (ft) : 1.50
Biosoil Saturated Hydraulic Conductivity (in/hr) : 6.00
Biosoil Porosity (Percent) : 30.00
Maximum Elevation of Bioretention Soil : 99.00
Native Soil Hydraulic Conductivity (in/hr) : 0.24

Underdrain Present
Orifice NOT Present in Under Drain

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 8.00
Common Length (ft) : 0.000
Riser Crest Elevation : 98.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

Link Name: Outlet Structure
Link Type: Flow Splitter

Outflow 1 Connected to Link: Lnk2 - WQ Bioretention Cells
Outflow 2 Connected to Link: Lnk4 - PSD MAINLINE

Splitter Rating Table

Inflow (cfs)	Outflow 1 (cfs)	Ouflow 2 (cfs)
0.000	0.000	0.000
0.015	0.015	0.000
0.020	0.015	0.005
0.100	0.015	0.085
0.120	0.015	0.105
0.200	0.015	0.185
1.000	0.016	0.985
10.000	0.016	9.985
100.000	0.016	99.985

Link Name: PSD MAINLINE
Link Type: Copy
Downstream Link: None

**************************FLOOD FREQUENCY AND DURATION STATISTICS*********************

----------SCENARIO: PREDEVELOPED
Number of Subbasins: 2
Number of Links: 1

********** Subbasin: Pre TDA 11 **********

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	1.767E-02
5-Year	2.832E-02
10-Year	3.693E-02
25-Year	5.077E-02
50-Year	6.383E-02
100-Year	6.773E-02
200-Year	0.108

********** Subbasin: Pre Pond Tract **********

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	2.958E-03
5-Year	4.740E-03
10-Year	6.182E-03
25-Year	8.497E-03
50-Year	1.068E-02
100-Year	1.134E-02
200-Year	1.811E-02

********** Link: New Copy Lnk1 ********** Link Outflow 1 Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	2.063E-02
5-Year	3.306E-02
10-Year	4.312E-02
25-Year	5.926E-02
50-Year	7.452E-02
100-Year	7.906E-02
200-Year	0.126

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 2
Number of Links: 4

********** Subbasin: TDA 11 Post **********

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.226
5-Year	0.294
10-Year	0.354
25-Year	0.448
50-Year	0.537
100-Year	0.661
200-Year	0.684

********** **Subbasin: Post Pond Tract** **********

Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	4.465E-02
5-Year	5.839E-02
10-Year	6.794E-02
25-Year	8.184E-02
50-Year	9.922E-02
100-Year	0.122
200-Year	0.127

********** Link: Detention Pond ********** Link Inflow Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	0.271
5-Year	0.350
10-Year	0.424
25-Year	0.530
50-Year	0.636
100-Year	0.783
200-Year	0.811

********** Link: Detention Pond ********** Link WSEL Stats
WSEL Frequency Data(ft)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	WSEL Peak (ft)
1.05-Year	100.492
1.11-Year	100.565
1.25-Year	100.646
2.00-Year	100.831

3.33-Year	101.044
5-Year	101.147
10-Year	101.407
25-Year	101.692
50-Year	101.783
100-Year	101.867

********** Link: WQ Bioretention Cells ********** Link Inflow
Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	1.192E-02
5-Year	1.400E-02
10-Year	1.510E-02
25-Year	1.512E-02
50-Year	1.513E-02
100-Year	1.514E-02
200-Year	1.514E-02

********** Link: WQ Bioretention Cells ********** Link Outflow 1
Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	1.217E-02
5-Year	1.430E-02
10-Year	1.583E-02
25-Year	1.696E-02
50-Year	1.743E-02
100-Year	1.771E-02
200-Year	1.830E-02

********** Link: WQ Bioretention Cells ********** Link WSEL
Stats
WSEL Frequency Data(ft)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	WSEL Peak (ft)
1.05-Year	98.503
1.11-Year	98.504
1.25-Year	98.505
2.00-Year	98.507
3.33-Year	98.508
5-Year	98.509
10-Year	98.511
25-Year	98.512
50-Year	98.513

100-Year 98.513

********** Link: Outlet Structure ********** Link Inflow
Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	1.192E-02
5-Year	1.400E-02
10-Year	2.078E-02
25-Year	3.617E-02
50-Year	4.220E-02
100-Year	4.801E-02
200-Year	5.215E-02

********** Link: Outlet Structure ********** Link Outflow 1
Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	1.192E-02
5-Year	1.400E-02
10-Year	1.510E-02
25-Year	1.512E-02
50-Year	1.513E-02
100-Year	1.514E-02
200-Year	1.514E-02

********** Link: PSD MAINLINE ********** Link Inflow
Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	4.657E-10
5-Year	4.657E-10
10-Year	5.680E-03
25-Year	2.105E-02
50-Year	2.707E-02
100-Year	3.287E-02
200-Year	3.701E-02

********** Link: PSD MAINLINE ********** Link Outflow
1 Frequency Stats
Flood Frequency Data(cfs)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	Flood Peak (cfs)
2-Year	4.657E-10
5-Year	4.657E-10
10-Year	5.680E-03
25-Year	2.105E-02
50-Year	2.707E-02
100-Year	3.287E-02
200-Year	3.701E-02

************Groundwater Recharge Summary **************

Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

Model Element		Recharge Amount (ac-ft)
Subbasin: Pre TDA 11		130.714
Subbasin: Pre Pond Tract		21.878
Link:	New Copy Lnk1	0.000
Total:		152.591

Total Post Developed Recharge During Simulation

Model Element		Recharge Amount (ac-ft)
Subbasin: TDA 11 Post		19.358
Subbasin: Post Pond Tract		0.000
Link:	Detention Pond	293.111
Link:	WQ Bioretention Cell	0.000
Link:	Outlet Structure	0.000
Link:	PSD MAINLINE	0.000
Total:		312.469

Total Predevelopment Recharge is Less than Post Developed
Average Recharge Per Year, (Number of Years= 158)
Predeveloped: 0.966 ac-ft/year, Post Developed: 1.978 ac-ft/year

************Water Quality Facility Data **************

----------SCENARIO: PREDEVELOPED

Number of Links: 1

********** Link: New Copy Lnk1 **********

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 97.63
Inflow Volume Including PPT-Evap (ac-ft): 97.63
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 97.63
Secondary Outflow To Downstream System (ac-ft): 0.00

Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

----------SCENARIO: POSTDEVELOPED

Number of Links: 4

********** Link: Detention Pond **********

Basic Wet Pond Volume (91% Exceedance): 3287. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 4930. cu-ft

2-Year Discharge Rate : 0.012 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.10 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.06 cfs

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 364.10
Inflow Volume Including PPT-Evap (ac-ft): 364.10
Total Runoff Infiltrated (ac-ft): 293.11, 80.50%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 71.79
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 80.50%

********** Link: WQ Bioretention Cells **********

Basic Wet Pond Volume (91% Exceedance): 836. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 1254. cu-ft

2-Year Discharge Rate : 0.012 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.01 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.01 cfs

Time to Infiltrate 91% Treatment Volume, (Hours): 40.53

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 71.35
Inflow Volume Including PPT-Evap (ac-ft): 71.96
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 65.53, 91.06%
Primary Outflow To Downstream System (ac-ft): 71.96
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 91.06%

********** Link: Outlet Structure **********

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 71.79
Inflow Volume Including PPT-Evap (ac-ft): 71.79

Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 71.35
Secondary Outflow To Downstream System (ac-ft): 0.43
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

********** Link: PSD MAINLINE **********

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 0.43
Inflow Volume Including PPT-Evap (ac-ft): 0.43
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.43
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

*************Compliance Point Results **************

Scenario Predeveloped Compliance Link: New Copy Lnk1
Scenario Postdeveloped Compliance Link: Detention Pond

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	2.063E-02	2-Year	1.192E-02
5-Year	3.306E-02	5-Year	1.400E-02
10-Year	4.312E-02	10-Year	2.078E-02
25-Year	5.926E-02	25-Year	3.617E-02
50-Year	7.452E-02	50-Year	4.220E-02
100-Year	7.906E-02	100-Year	4.801E-02
200-Year	0.126	200-Year	5.215E-02

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

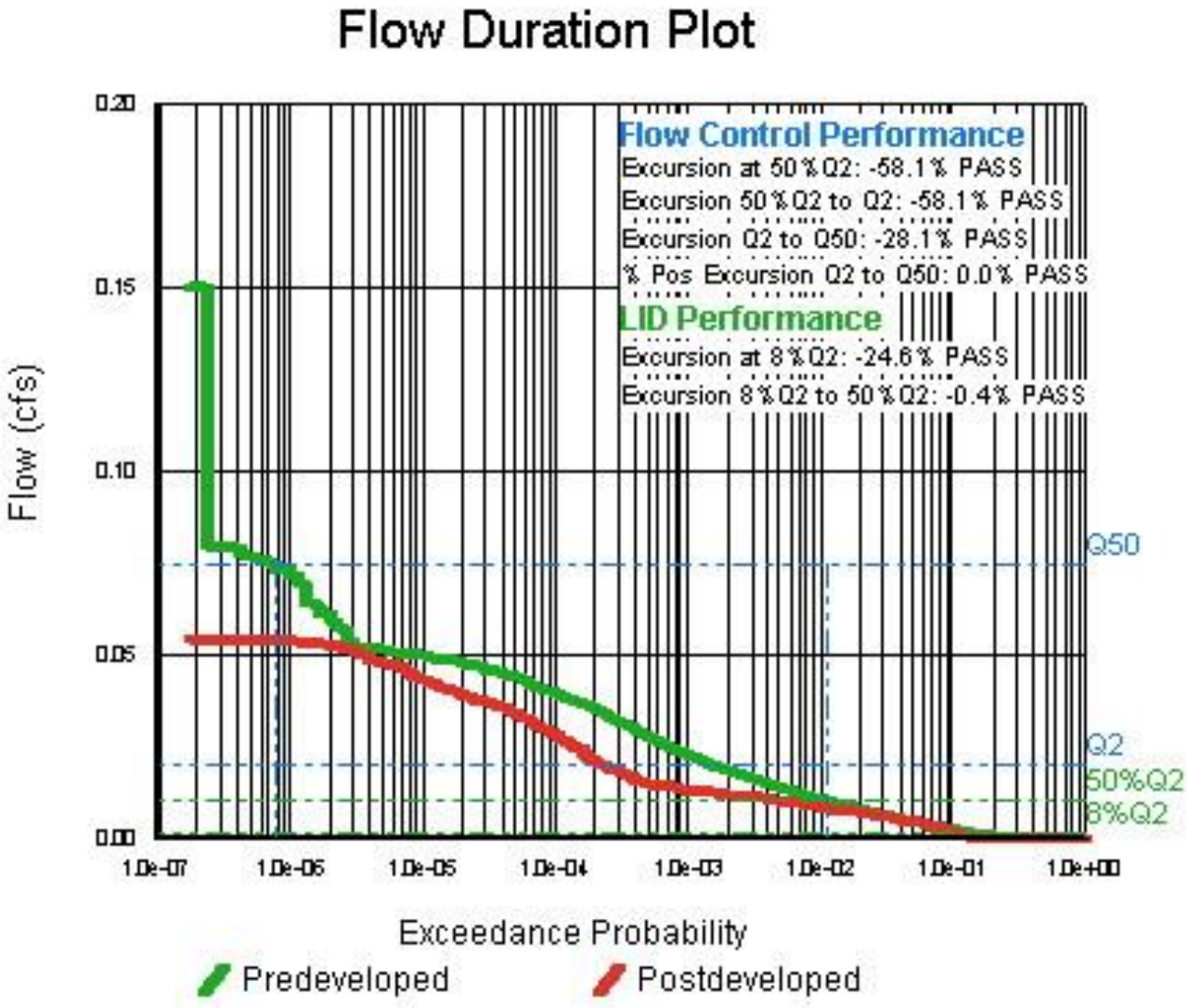
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):	-58.1%	PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	-58.1%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	-28.1%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%):	-24.6%	PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):	-0.4%	PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS


Flow Duration Plot
Flow Control Performance
Excursion at 50%Q2: -58.1% PASS
Excursion 50%Q2 to Q2: -58.1% PASS
Excursion Q2 to Q50: -28.1% PASS
% Pos Excursion Q2 to Q50: 0.0% PASS
LID Performance
Excursion at 8%Q2: -24.6% PASS
Excursion 8%Q2 to 50%Q2: -0.4% PASS
Flow (cfs)
0.20
0.15
0.10
0.05
0.00
Q50
Q2
50%Q2
8%Q2
1.0e-07
1.0e-06
1.0e-05
1.0e-04
1.0e-03
1.0e-02
1.0e-01
1.0e+00
Exceedance Probability
Predeveloped
Postdeveloped

MEMO

Appendix C
Soils Maps

Soil Map—Snohomish County Area, Washington
(43rd Ave SE)

Map Scale: 1:21,300 if printed on A portrait (8.5" x 11") sheet.

N

Meters
0 300 600 1200 1800

Feet
0 1000 2000 4000 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Snohomish County Area, Washington
Survey Area Data: Version 20, Sep 10, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 7, 2014—Jul 8, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

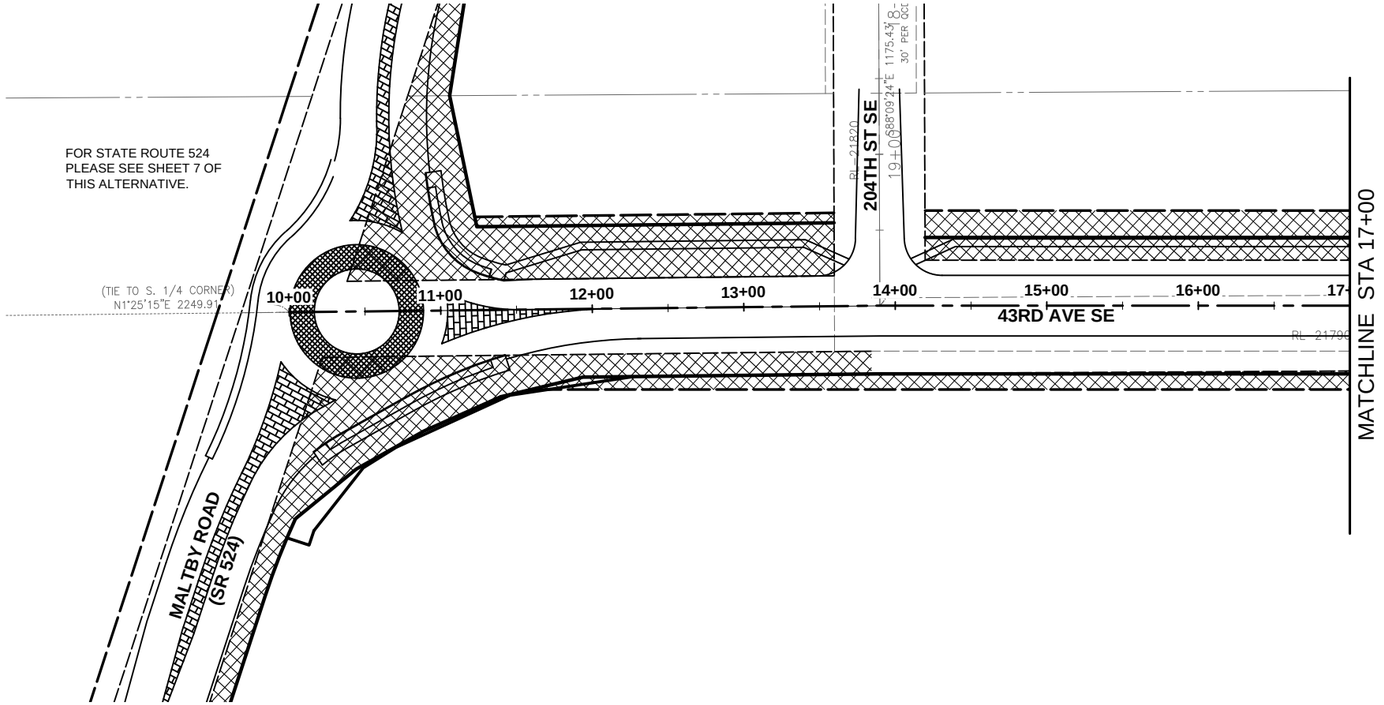
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Alderwood gravelly sandy loam, 0 to 8 percent slopes	1,214.3	73.0%
2	Alderwood gravelly sandy loam, 8 to 15 percent slopes	132.5	8.0%
3	Alderwood gravelly sandy loam, 15 to 30 percent slopes	25.6	1.5%
4	Alderwood-Everett gravelly sandy loams, 25 to 70 percent slopes	52.1	3.1%
7	Bellingham silty clay loam	21.0	1.3%
17	Everett very gravelly sandy loam, 0 to 8 percent slopes	42.4	2.6%
32	McKenna gravelly silt loam, 0 to 8 percent slopes	44.2	2.7%
34	Mukilteo muck	51.5	3.1%
39	Norma loam	61.3	3.7%
69	Terric Medisaprists, nearly level	15.5	0.9%
83	Water	2.4	0.1%
Totals for Area of Interest		**1,663.0**	**100.0%**

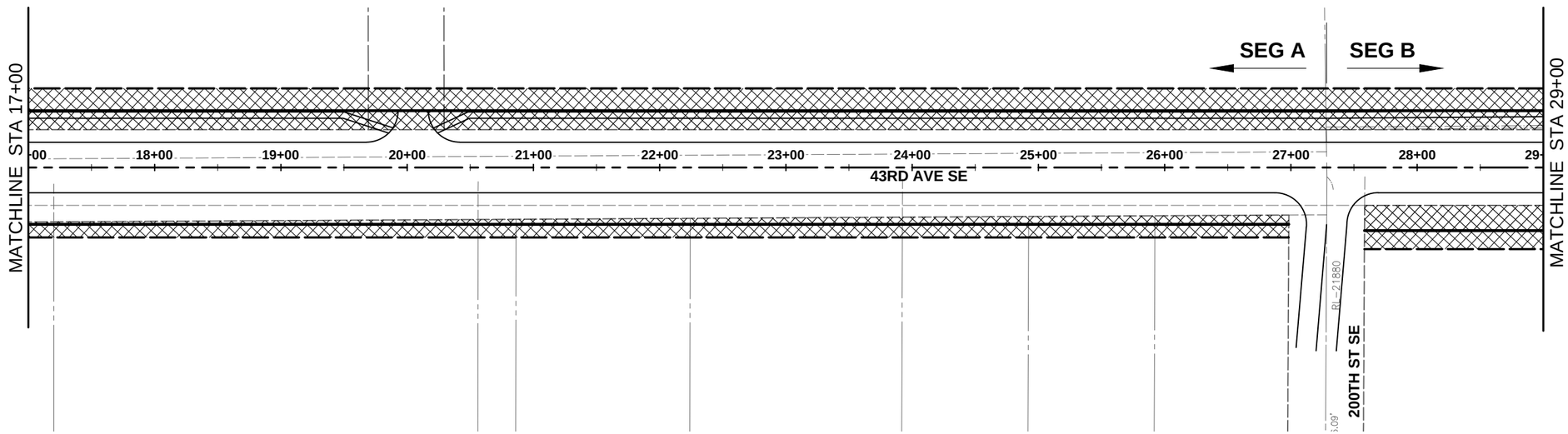
MEMO

APPENDIX K

30% Roadway Plan with Parcels Needing Acquisition Highlighted

SECTION 21, T. 27 N, R. 5 E., W.M.





LEGEND:

- OWNERSHIP LINE
- SECTION LINE
- SIXTEENTH SECTION LINE
- EXISTING EDGE OF PAVEMENT LINE
- EXISTING FENCE LINE
- RIGHT-OF-WAY (EXISTING)
- RIGHT-OF-WAY (EX. HISTORICAL)
- RIGHT-OF-WAY CL (EXISTING)
- RIGHT-OF-WAY (PROPOSED)
- PROPERTY LINE
- EASEMENT (EXISTING)
- EASEMENT (PROPOSED)
- NEW CONSTRUCTION PERMIT LINE
- -XXX — PROPERTY OWNERSHIP NUMBERS
- EXISTING BUILDING
- FOUND BRASS SURFACE DISK (SEE TABLE)
- FOUND REBAR (SEE TABLE)
- FOUND MONUMENT (SEE TABLE)

N

50 0 50 100
SCALE IN FEET

DATE	NO.	REVISION	BY

Know what's below. Call 811 before you dig.

UPI NO.: 18-0001	FED. AID PROJ. NO.: ###########
SURVEY NO.: #	FIELD BOOK(S): ####
HORZ. DATUM: ######	VERT. DATUM: #######
DESIGNED BY: ###	DRAWN BY: ###

30%

SUBMITTAL

REVIEWED AND APPROVED FOR CONSTRUCTION

###############
SNOHOMISH COUNTY ENGINEER
##########
DATE APPROVED:

SNOHOMISH COUNTY DEPARTMENT OF PUBLIC WORKS

FUNDING NO. ########

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD ALTERNATIVE 2

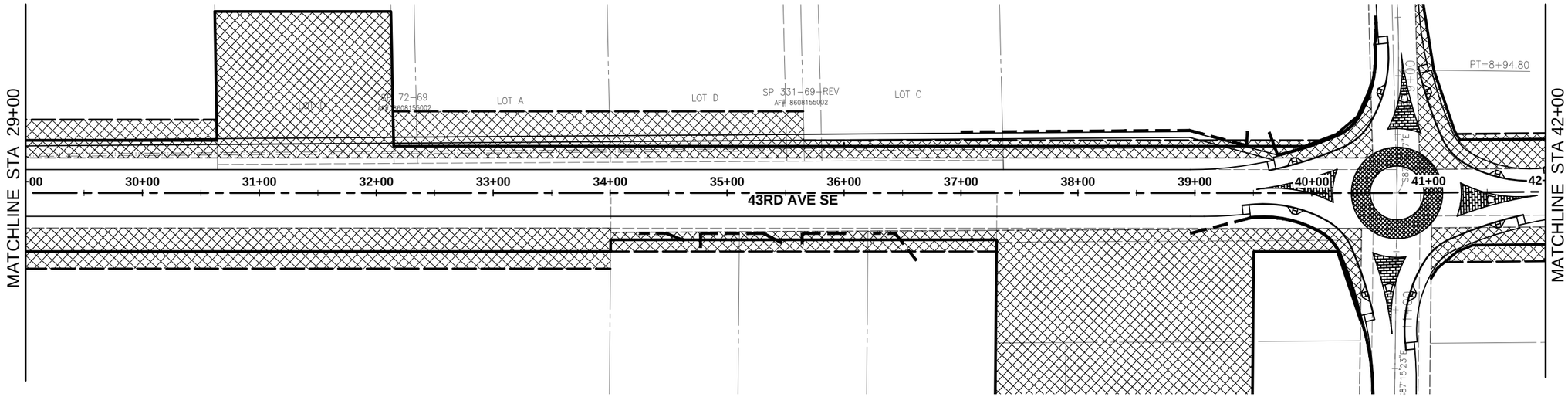
RIGHT OF WAY PLAN

REFERENCE SHEET NO. RW01

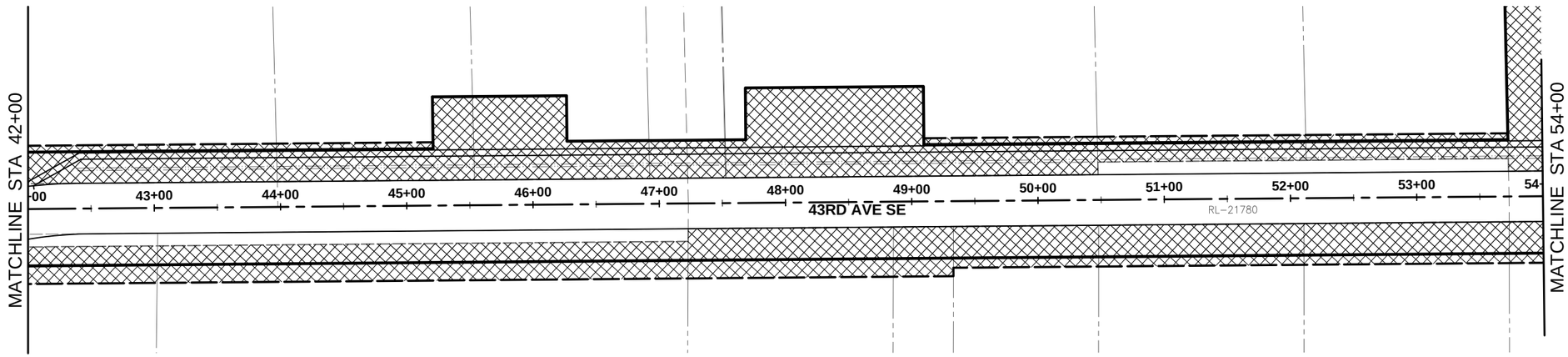
SHEET 9 OF 56 SHEETS

May 29, 2019 - 3:19 PM - ANGELM - \\KPFF.COM\CIVIL\18000001-18009991\800175 43RD AVE SE\CADD\DRAWINGS\16-0040-RW.DWG - Layout Name: 16-0040-RW01

SECTION 16, 21 T. 27 N, R. 5 E., W.M.



SEG B | SEG C



LEGEND:

- OWNERSHIP LINE
- SECTION LINE
- SIXTEENTH SECTION LINE
- EXISTING EDGE OF PAVEMENT LINE
- EXISTING FENCE LINE
- RIGHT-OF-WAY (EXISTING)
- RIGHT-OF-WAY (EX. HISTORICAL)
- RIGHT-OF-WAY CL (EXISTING)
- RIGHT-OF-WAY (PROPOSED)
- PROPERTY LINE
- EASEMENT (EXISTING)
- EASEMENT (PROPOSED)
- NEW CONSTRUCTION PERMIT LINE
- -XXX PROPERTY OWNERSHIP NUMBERS
- EXISTING BUILDING
- FOUND BRASS SURFACE DISK (SEE TABLE)
- FOUND REBAR (SEE TABLE)
- FOUND MONUMENT (SEE TABLE)

N

50 0 50 100
SCALE IN FEET

DATE	NO.	REVISION	BY

Know what's below. Call 811 before you dig.

UPI NO.: 18-0001	FED. AID PROJ. NO.: ###########
SURVEY NO.: #	FIELD BOOK(S): ####
HORZ. DATUM: #####	VERT. DATUM: ######
DESIGNED BY: ###	DRAWN BY: ###

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SUBMITTAL

REVIEWED AND APPROVED FOR CONSTRUCTION

###############
SNOHOMISH COUNTY ENGINEER
##########
DATE APPROVED:

SNOHOMISH COUNTY DEPARTMENT OF PUBLIC WORKS

FUNDING NO. ########

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD ALTERNATIVE 2

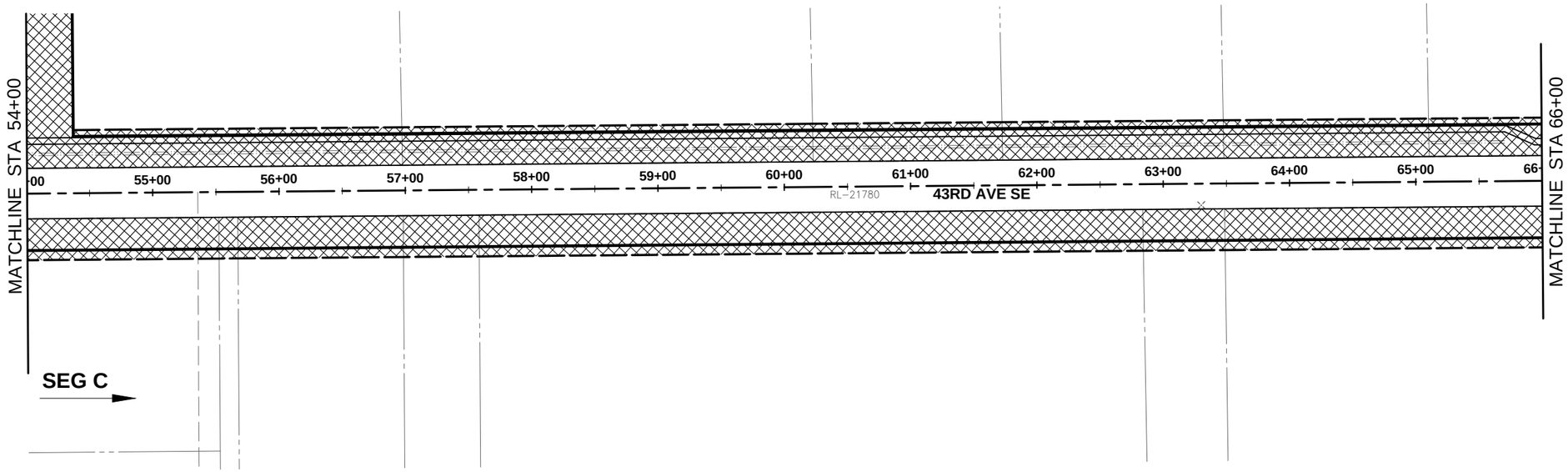
RIGHT OF WAY PLAN

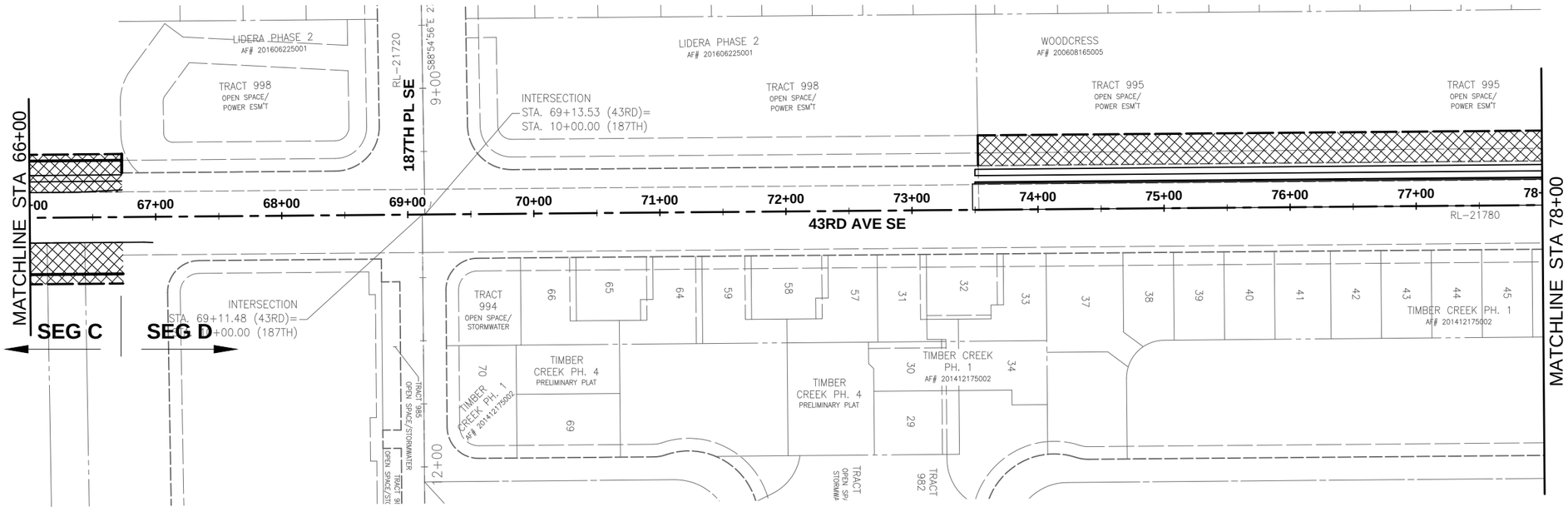
REFERENCE SHEET NO. RW02

SHEET 10 OF 56 SHEETS

May 29, 2019 - 3:19 PM - ANGELM - \\KPFF.COM\CIV\IL\1800001-1800999\1800175 43RD AVE SE\CADD\DRAWINGS\16-0040-RW.DWG - Layout Name: 16-0040-RW02

SECTION 16, T. 27 N, R. 5 E., W.M.





LEGEND:

- OWNERSHIP LINE
- SECTION LINE
- SIXTEENTH SECTION LINE
- EXISTING EDGE OF PAVEMENT LINE
- EXISTING FENCE LINE
- RIGHT-OF-WAY (EXISTING)
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- EXISTING BUILDING
- FOUND BRASS SURFACE DISK (SEE TABLE)
- FOUND REBAR (SEE TABLE)
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SCALE IN FEET

DATE	NO.	REVISION	BY

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SURVEY NO.: #	FIELD BOOK(S): ####
HORZ. DATUM: #####	VERT. DATUM: ######
DESIGNED BY: ###	DRAWN BY: ###

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SNOHOMISH COUNTY ENGINEER
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DATE APPROVED:

SNOHOMISH COUNTY DEPARTMENT OF PUBLIC WORKS

FUNDING NO. ########

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD ALTERNATIVE 2

RIGHT OF WAY PLAN

REFERENCE SHEET NO. RW03

SHEET 11 OF 56 SHEETS

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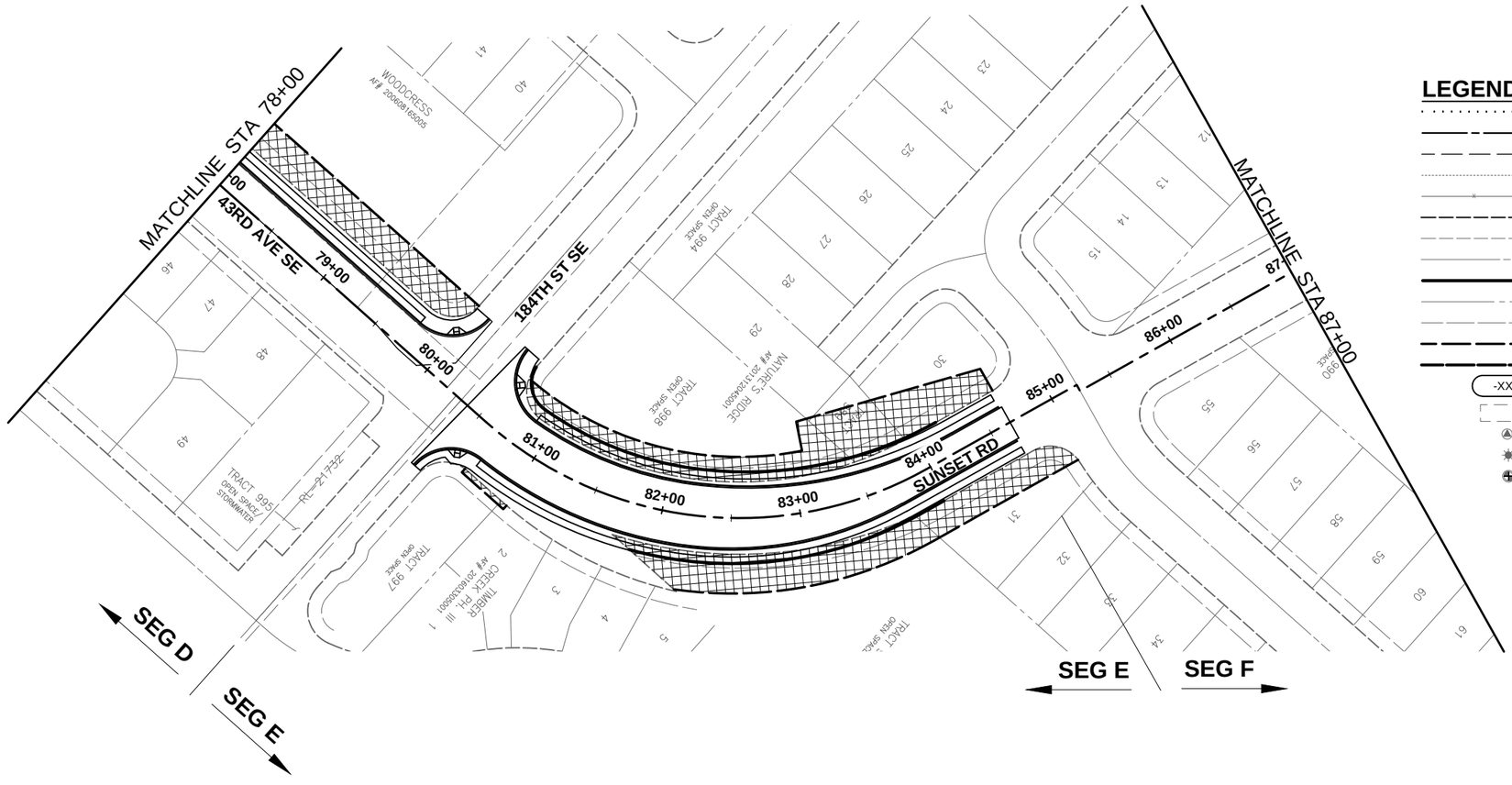
SECTION 9, 16 T. 27 N, R. 5 E., W.M.



LEGEND:

- OWNERSHIP LINE
- SECTION LINE
- SIXTEENTH SECTION LINE
- EXISTING EDGE OF PAVEMENT LINE
- EXISTING FENCE LINE
- RIGHT-OF-WAY (EXISTING)
- RIGHT-OF-WAY (EX. HISTORICAL)
- RIGHT-OF-WAY CL (EXISTING)
- RIGHT-OF-WAY (PROPOSED)
- PROPERTY LINE
- EASEMENT (EXISTING)
- EASEMENT (PROPOSED)
- NEW CONSTRUCTION PERMIT LINE
- -XXX — PROPERTY OWNERSHIP NUMBERS
- EXISTING BUILDING
- FOUND BRASS SURFACE DISK (SEE TABLE)
- FOUND REBAR (SEE TABLE)
- FOUND MONUMENT (SEE TABLE)

N

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SCALE IN FEET

DATE	NO.	REVISION	BY

Know what's below. Call 811 before you dig.

UPI NO.: 18-0001	FED. AID PROJ. NO.: ##########
SURVEY NO.: #	FIELD BOOK(S): ####
HORZ. DATUM: #####	VERT. DATUM: ######
DESIGNED BY: ###	DRAWN BY: ###

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REVIEWED AND APPROVED FOR CONSTRUCTION

##########
SNOHOMISH COUNTY ENGINEER
##########
DATE APPROVED:

SNOHOMISH COUNTY DEPARTMENT OF PUBLIC WORKS

FUNDING NO. #######

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD ALTERNATIVE 2

RIGHT OF WAY PLAN

REFERENCE SHEET NO. RW04

SHEET 12 OF 56 SHEETS

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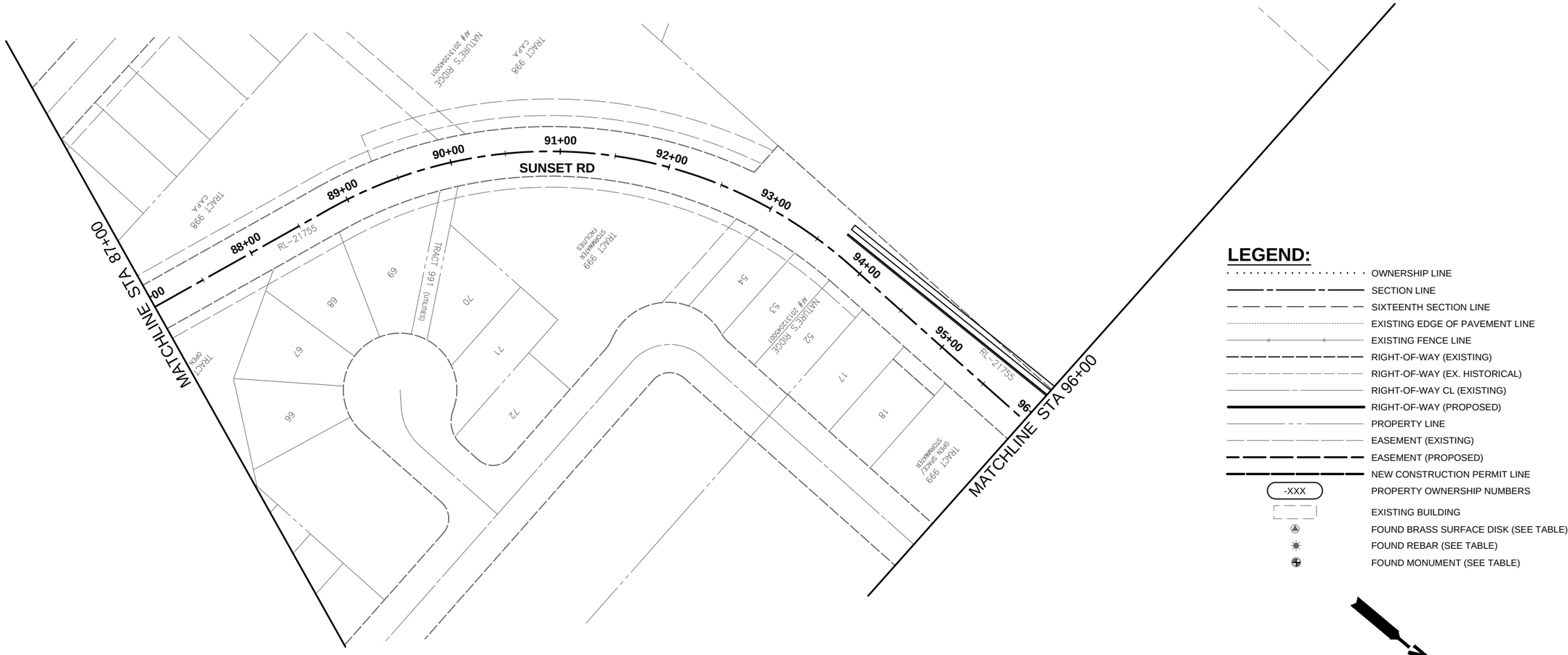

LEGEND:

- OWNERSHIP LINE
- SECTION LINE
- SIXTEENTH SECTION LINE
- EXISTING EDGE OF PAVEMENT LINE
- EXISTING FENCE LINE
- RIGHT-OF-WAY (EXISTING)
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- FOUND REBAR (SEE TABLE)
- FOUND MONUMENT (SEE TABLE)

N

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SCALE IN FEET

DATE	NO.	REVISION	BY

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SURVEY NO.: #	FIELD BOOK(S): ####
HORZ. DATUM: #####	VERT. DATUM: ######
DESIGNED BY: ###	DRAWN BY: ###

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SNOHOMISH COUNTY ENGINEER
###########
DATE APPROVED:

SNOHOMISH COUNTY DEPARTMENT OF PUBLIC WORKS

FUNDING NO. ########

43RD AVE SE

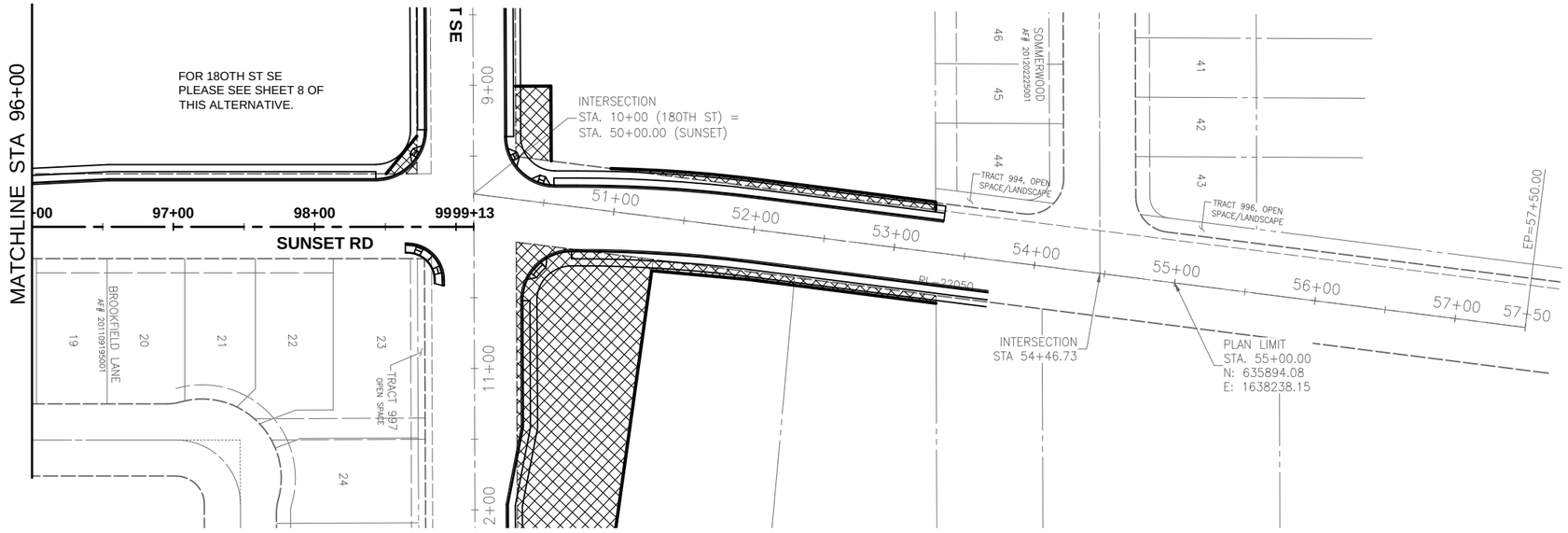
SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD ALTERNATIVE 2

RIGHT OF WAY PLAN

REFERENCE SHEET NO.
RW05

SHEET 13 OF 56 SHEETS

May 29, 2019 - 3:19 PM - ANGELM - \\KPFF.COM\CIVIL\L1800001-1800999\1800175 43RD AVE SE\CADD\DRAWINGS\16-0040-RW.DWG - Layout Name: 16-0040-RW05



LEGEND:

- OWNERSHIP LINE
- SECTION LINE
- SIXTEENTH SECTION LINE
- EXISTING EDGE OF PAVEMENT LINE
- EXISTING FENCE LINE
- RIGHT-OF-WAY (EXISTING)
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- FOUND REBAR (SEE TABLE)
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SCALE IN FEET

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SURVEY NO.: #	FIELD BOOK(S): ####
HORZ. DATUM: #####	VERT. DATUM: ######
DESIGNED BY: ###	DRAWN BY: ###

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SNOHOMISH COUNTY ENGINEER
##########
DATE APPROVED:

SNOHOMISH COUNTY DEPARTMENT OF PUBLIC WORKS

FUNDING NO. ########

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD ALTERNATIVE 2

RIGHT OF WAY PLAN

REFERENCE SHEET NO. RW06

SHEET 14 OF 56 SHEETS

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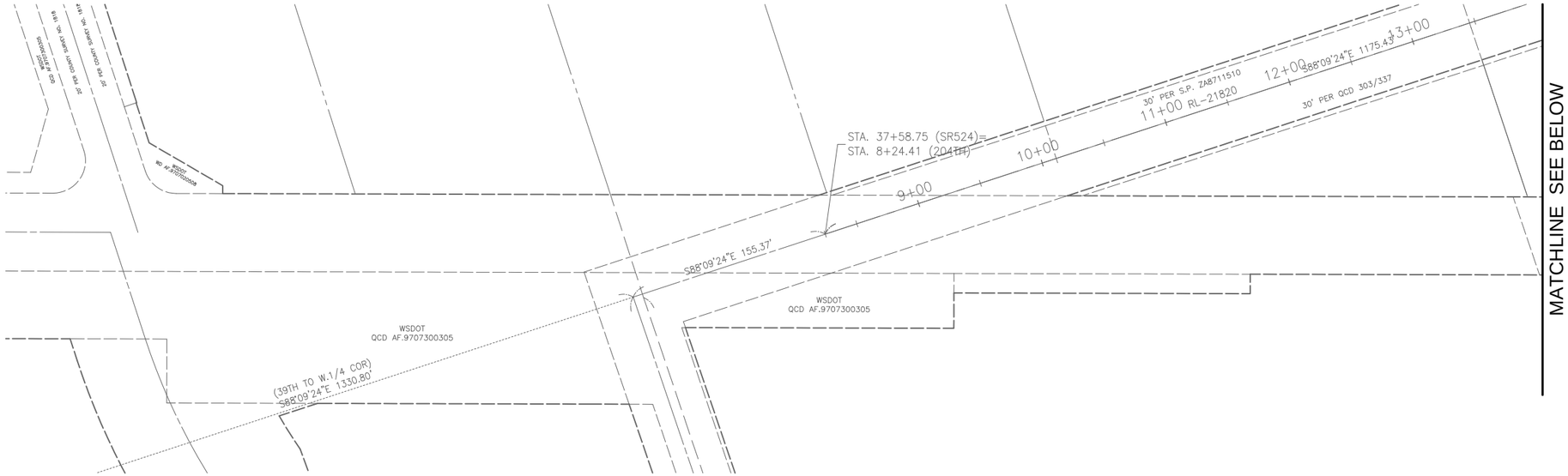
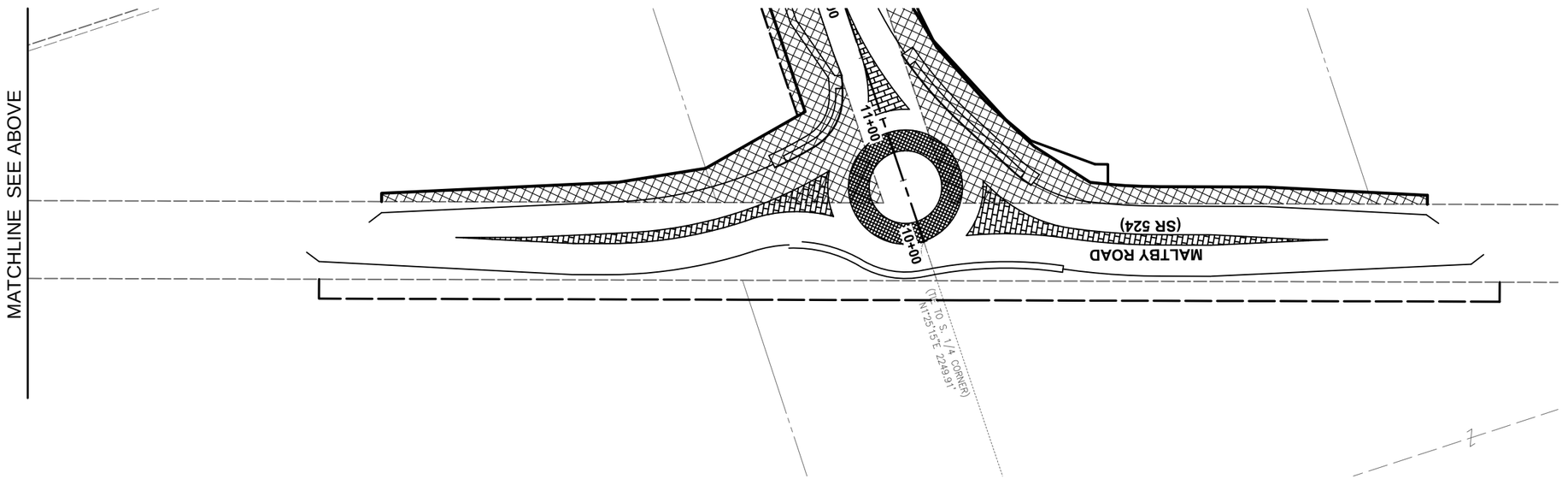
SECTION 21, T. 27 N, R. 5 E., W.M.





LEGEND:

- OWNERSHIP LINE
- SECTION LINE
- SIXTEENTH SECTION LINE
- EXISTING EDGE OF PAVEMENT LINE
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- RIGHT-OF-WAY (EXISTING)
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SCALE IN FEET

DATE	NO.	REVISION	BY

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SURVEY NO.: #	FIELD BOOK(S): ####
HORZ. DATUM: #####	VERT. DATUM: ######
DESIGNED BY: ###	DRAWN BY: ###

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SUBMITTAL

REVIEWED AND APPROVED FOR CONSTRUCTION

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SNOHOMISH COUNTY ENGINEER
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DATE APPROVED:

SNOHOMISH COUNTY DEPARTMENT OF PUBLIC WORKS

FUNDING NO. ########

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD ALTERNATIVE 2

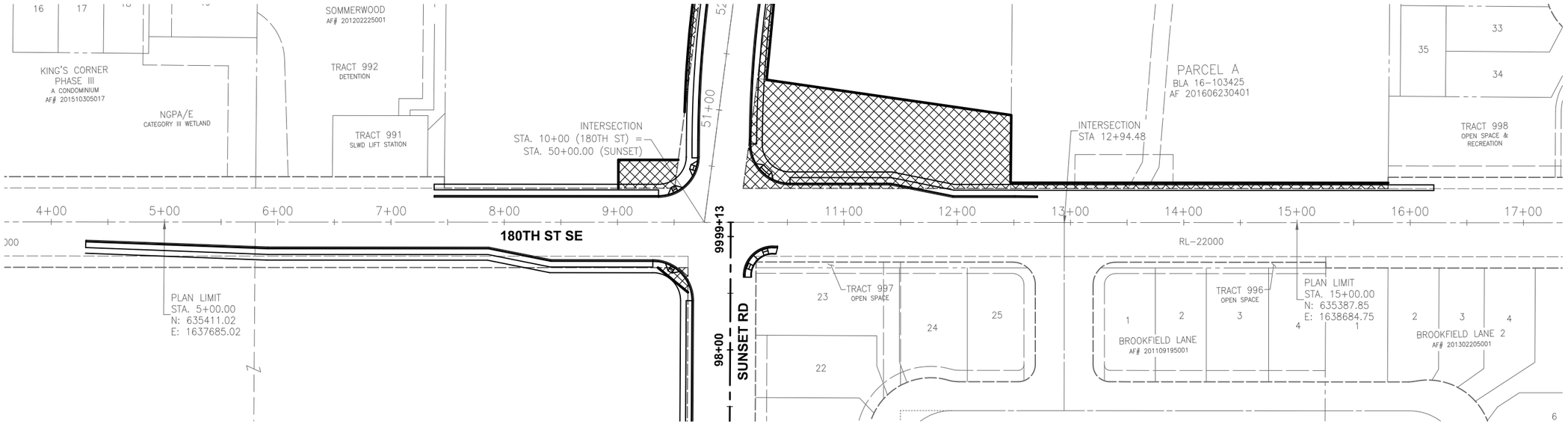
RIGHT OF WAY PLAN

REFERENCE SHEET NO. RW07

SHEET 15 OF 56 SHEETS

May 29, 2019 - 3:19 PM - ANGELM - \\KPFF.COM\CIVIL\1800001-1800999\1800175 43RD AVE SE\CADD\DRAWINGS\16-0040-RW.DWG - Layout Name: 16-0040-RW07

SECTION 9, 16 T. 27 N, R. 5 E., W.M.



LEGEND:

- OWNERSHIP LINE
- SECTION LINE
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- EXISTING EDGE OF PAVEMENT LINE
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SCALE IN FEET

DATE	NO.	REVISION	BY

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SURVEY NO.: #	FIELD BOOK(S): ####
HORZ. DATUM: #####	VERT. DATUM: ######
DESIGNED BY: ###	DRAWN BY: ###

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SNOHOMISH COUNTY ENGINEER
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DATE APPROVED:

SNOHOMISH COUNTY DEPARTMENT OF PUBLIC WORKS

FUNDING NO. ########

43RD AVE SE

SR 524 TO 180TH STREET SE
SNOHOMISH COUNTY STANDARD ALTERNATIVE 2

RIGHT OF WAY PLAN

REFERENCE SHEET NO. RW08

SHEET 16 OF 56 SHEETS

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APPENDIX L

30% R/W True Cost Estimates

True Cost Estimate Summary Worksheet

Project: **Date:** **FA #:**

1	2	3	4	5	6	7	8	9	10	11	12
Parcel Number	Owner Name	Acquisition Just Compensation (Offer)	Appraisal Fee Costs	Appraisal Review Fee Costs	Negotiation Fee Costs	Title, Escrow Costs	Prop. Mgmt. Service Costs	Relocation Service Costs	Relocation Payments	Condemnation and Incid. Costs (insert % - 25% is an example)	Total
										15%	
1		19,949	5,000	1,500	3,000	1,500				$ 4,642.00	$ 35,591
2		4,041	5,000	1,500	3,000	1,500				$ 2,256.00	$ 17,297
3		57,874	5,000	1,500	3,000	1,500				$ 10,331.00	$ 79,205
4		1,363	5,000	1,500	3,000	1,500				$ 1,854.00	$ 14,217
5		3,864	5,000	1,500	3,000	1,500				$ 2,230.00	$ 17,094
6		3,664	5,000	1,500	3,000	1,500				$ 2,200.00	$ 16,864
7		3,325	5,000	1,500	3,000	1,500				$ 2,149.00	$ 16,474
8		3,000	5,000	1,500	3,000	1,500				$ 2,100.00	$ 16,100
9		9,960	5,000	1,500	3,000	1,500				$ 3,144.00	$ 24,104
10		4,508	5,000	1,500	3,000	1,500				$ 2,326.00	$ 17,834
11		11,135	5,000	1,500	3,000	1,500				$ 3,320.00	$ 25,455
12		12,613	5,000	1,500	3,000	1,500				$ 3,542.00	$ 27,155
13		13,891	5,000	1,500	3,000	1,500				$ 3,734.00	$ 28,625
14		12,126	5,000	1,500	3,000	1,500				$ 3,469.00	$ 26,595
15		80,356	5,000	1,500	3,000	1,500				$ 13,703.00	$ 105,059
16		112,193	5,000	1,500	3,000	1,500				$ 18,479.00	$ 141,672
17		3,966	5,000	1,500	3,000	1,500				$ 2,245.00	$ 17,211
18		20,305	5,000	1,500	3,000	1,500				$ 4,696.00	$ 36,001
19		15,581	5,000	1,500	3,000	1,500				$ 3,987.00	$ 30,568
20		21,002	5,000	1,500	3,000	1,500				$ 4,800.00	$ 36,802
21		20,333	5,000	1,500	3,000	1,500				$ 4,700.00	$ 36,033
22		14,882	5,000	1,500	3,000	1,500				$ 3,882.00	$ 29,764
23		22,498	5,000	1,500	3,000	1,500				$ 5,025.00	$ 38,523
24		291,272	5,000	1,500	3,000	1,500				$ 45,341.00	$ 347,613
25		178,249	5,000	1,500	3,000	1,500				$ 28,387.00	$ 217,636
26		44,993	5,000	1,500	3,000	1,500				$ 8,399.00	$ 64,392
27		30,354	5,000	1,500	3,000	1,500				$ 6,203.00	$ 47,557
28		45,186	5,000	1,500	3,000	1,500				$ 8,428.00	$ 64,614
29		65,288	5,000	1,500	3,000	1,500				$ 11,443.00	$ 87,731
30		29,494	5,000	1,500	3,000	1,500				$ 6,074.00	$ 46,568
31		98,259	5,000	1,500	3,000	1,500				$ 16,389.00	$ 125,648
32		213,479	5,000	1,500	3,000	1,500				$ 33,672.00	$ 258,151
33		1,878	5,000	1,500	3,000	1,500				$ 1,932.00	$ 14,810
34		20,585	5,000	1,500	3,000	1,500				$ 4,738.00	$ 36,323
35		32,260	5,000	1,500	3,000	1,500				$ 6,489.00	$ 49,749

36		9,211	5,000	1,500	3,000	1,500				$ 3,032.00	$ 23,243
37		31,584	5,000	1,500	3,000	1,500				$ 6,388.00	$ 48,972
38		22,585	5,000	1,500	3,000	1,500				$ 5,038.00	$ 38,623
39		10,542	5,000	1,500	3,000	1,500				$ 3,231.00	$ 24,773
40		117,763	5,000	1,500	3,000	1,500				$ 19,314.00	$ 148,077
41		21,060	5,000	1,500	3,000	1,500				$ 4,809.00	$ 36,869
42		60,791	5,000	1,500	3,000	1,500				$ 10,769.00	$ 82,560
43		91,863	5,000	1,500	3,000	1,500				$ 15,429.00	$ 118,292
44		568	5,000	1,500	3,000	1,500				$ 1,735.00	$ 13,303
45		29,481	5,000	1,500	3,000	1,500				$ 6,072.00	$ 46,553
46		3,488	5,000	1,500	3,000	1,500				$ 2,173.00	$ 16,661
47		23,080	5,000	1,500	3,000	1,500				$ 5,112.00	$ 39,192
48		39,195	5,000	1,500	3,000	1,500				$ 7,529.00	$ 57,724
49		13,845	5,000	1,500	3,000	1,500				$ 3,727.00	$ 28,572
50		15,979	5,000	1,500	3,000	1,500				$ 4,047.00	$ 31,026
51		4,860	5,000	1,500	3,000	1,500				$ 2,379.00	$ 18,239
51A		6,063	5,000	1,500	3,000	1,500				$ 2,559.00	$ 19,622
52		36,023	5,000	1,500	3,000	1,500				$ 7,053.00	$ 54,076
53		19,312	5,000	1,500	3,000	1,500				$ 4,547.00	$ 34,859
54		16,764	5,000	1,500	3,000	1,500				$ 4,165.00	$ 31,929
55		3,809	5,000	1,500	3,000	1,500				$ 2,221.00	$ 17,030
56		2,768	5,000	1,500	3,000	1,500				$ 2,065.00	$ 15,833
57		15,500	5,000	1,500	3,000	1,500				$ 3,975.00	$ 30,475
58		3,000	5,000	1,500	3,000	1,500				$ 2,100.00	$ 16,100
59 & 59A		107,208	5,000	1,500	3,000	1,500				$ 17,731.00	$ 135,939
60		309,043	5,000	1,500	3,000	1,500				$ 48,006.00	$ 368,049
61		10,838	5,000	1,500	3,000	1,500				$ 3,276.00	$ 25,114
62		14,896	5,000	1,500	3,000	1,500				$ 3,884.00	$ 29,780
63		1,652	5,000	1,500	3,000	1,500				$ 1,898.00	$ 14,550
64		1,323	5,000	1,500	3,000	1,500				$ 1,848.00	$ 14,171
65		1,254	5,000	1,500	3,000	1,500				$ 1,838.00	$ 14,092
66										$ -	$ -
67										$ -	$ -
68										$ -	$ -
69										$ -	$ -
70										$ -	$ -
	Subtotals	$ 2,569,074	$ 330,000	$ 99,000	$ 198,000	$ 99,000	$ -	$ -	$ -	$ 494,259	
										Total R/W Costs	$ 3,789,333

APPENDIX M

43rd Avenue SE 30% Construction Cost Estimates

kpff Consulting Engineers

Client: Snohomish County Public Works
Project: 43rd Ave SE
Estimated % Complete 30
By: TJT
Date: 6/6/2019

Engineer's Estimate of Probable Cost

Alternative 1 - All Segments

STD Item No.	Item Description	Quantity	Unit	Unit Cost	Cost	% of Total
	Preparation					
	Mobilization (7%)	1	LS	$ 871,845	$ 871,845	7.0%
	Clearing and Grubbing	10.5	AC	$ 20,000	$ 210,000	1.7%
	Removing Cement Conc. Sidewalk	7545	SY	$ 10	$ 75,450	0.6%
	Removing Cement Conc. Curb and Gutter	565	LF	$ 8	$ 4,520	0.0%
	Removing Fence	6300	LF	$ 10	$ 63,000	0.5%
	Removing Structures and Obstructions	1	LS	$ 10,000	$ 10,000	0.1%
	Removing Drainage Structure	25	EA	$ 1,000	$ 25,000	0.2%
	Removing Storm Pipe	3370	LF	$ 35	$ 117,950	0.9%
	Grading					
	Roadway Excavation Incl. Haul	25865	CY	$ 40	$ 1,034,600	8.3%
	Gravel Borrow Incl. Haul	12240	CY	$ 30	$ 367,200	2.9%
	Unsuitable Foundation Excavation Incl. Haul	315	CY	$ 25	$ 7,875	0.1%
	Gravel Borrow for Unsuitable Foundation Excavation	580	TN	$ 35	$ 20,300	0.2%
	Drainage					
	Precast Concrete Drywell	21	EA	$ 6,500	$ 136,500	1.1%
	Bioswale	1740	LF	$ 40	$ 69,600	0.6%
	Bioswale with Infiltration Trench	3700	LF	$ 45	$ 166,500	1.3%
	Media Filter Drain with Infiltration Trench	1300	LF	$ 50	$ 65,000	0.5%
	Underdrain Pipe 6 In. Diam	1220	LF	$ 45	$ 54,900	0.4%
	Storm Sewer					
	Catch Basin Type 1	23	EA	$ 2,000	$ 46,000	0.4%
	Catch Basin Type 2 - 48"	35	EA	$ 4,500	$ 157,500	1.3%
	Catch Basin Type 2 - 54"	6	EA	$ 5,000	$ 30,000	0.2%
	Catch Basin Type 2 - 60"	1	EA	$ 6,000	$ 6,000	0.0%
	Hydrodynamic Separator	4	EA	$ 10,000	$ 40,000	0.3%
	Schedule A Storm Sewer Pipe 12 In. Diam.	5630	LF	$ 55	$ 309,650	2.5%
	Stormwater Detention	1	LS	$ 750,000	$ 750,000	6.0%
	Structure					
	Structural Earth Wall	7870	SF	$ 40	$ 314,800	2.5%
	Moment Slab Barrier	1265	LF	$ 500	$ 632,500	5.1%
	BP Railing	1265	LF	$ 200	$ 253,000	2.0%
	Surfacing					
	Crushed Surfacing Top Course	14550	TON	$ 40	$ 582,000	4.7%
	Crushed Surfacing Base Course	130	TON	$ 40	$ 5,200	0.0%
	Hot Mix Asphalt					
	HMA CL. 1/2 IN. PG 58H-22	16900	TON	$ 85	$ 1,436,500	11.5%
	Erosion Control and Roadside Planting					
	Erosion/Water Pollution Control	1	LS	$ 487,417	$ 487,417	3.9%
	Seeding, Fertilizing, and Mulching	4.53	AC	$ 8,000	$ 36,240	0.3%
	Topsoil Type A	4.53	AC	$ 36,000	$ 163,080	1.3%
	Landscape Planting	12400	LF	$ 12	$ 148,800	1.2%
	High Visibility Silt Fence	17350	LF	$ 7	$ 121,450	1.0%

	Traffic					
	Cement Conc. Traffic Curb and Gutter	5790	LF	$ 25	$ 144,750	1.2%
	Painted Wide Lane Line	1400	LF	$ 3	$ 4,200	0.0%
	Painted Lane Line	36090	LF	$ 2	$ 72,180	0.6%
	Plastic Crosswalk Line	2480	SF	$ 10	$ 24,800	0.2%
	Plastic Stop Line	420	LF	$ 27	$ 11,340	0.1%
	Plastic Traffic Arrow	38	EA	$ 115	$ 4,370	0.0%
	Plastic Bicycle Lane Symbol	41	EA	$ 240	$ 9,840	0.1%
	Raised Pavement Marker Type 2	11	HUND	$ 335	$ 3,685	0.0%
	Traffic Signal System	1	LS	$ 500,000	$ 500,000	4.0%
	Permanent Signing	1	LS	$ 15,000	$ 15,000	0.1%
	Construction Signs Class A	1	LS	$ 7,500	$ 7,500	0.1%
	Project Temporary Traffic Control	1	LS	$ 650,000	$ 650,000	5.2%
	Uniformed Officer Traffic Control	850	HR	$ 150	$ 127,500	1.0%
	Flaggers	4160	HR	$ 75	$ 312,000	2.5%
	Other Items					
	Type B Progress Schedule	1	LS	$ 10,000	$ 10,000	0.1%
	Structure Excavation Class B Incl. Haul	9710	CY	$ 35	$ 339,850	2.7%
	Shoring or Extra Excavation Class B	34250	SF	$ 2	$ 68,500	0.5%
	Gravel Backfill for Drywell	150	CY	$ 60	$ 9,000	0.1%
	Connection to Drainage Structure	7	EA	$ 1,200	$ 8,400	0.1%
	Roadway Surveying	1	LS	$ 206,604	$ 206,604	1.7%
	Roundabout Truck Apron	800	SY	$ 600	$ 480,000	3.8%
	Splitter Island	950	SY	$ 55	$ 52,250	0.4%
	Cement Conc. Sidewalk	5980	SY	$ 40	$ 239,200	1.9%
	Cement Conc. Driveway Entrance Type __	1730	SY	$ 85	$ 147,050	1.2%
	Coated Chain Link Fence Type 3	450	LF	$ 55	$ 24,750	0.2%
	Field Office Building	1	LS	$ 20,000	$ 20,000	0.2%
	Adjust Valve Box	69	EA	$ 500	$ 34,500	0.3%
	Adjust Manhole	2	EA	$ 1,000	$ 2,000	0.0%
	Mailbox Support Type 1	52	EA	$ 900	$ 46,800	0.4%
	Curb Ramp Type __	20	EA	$ 5,000	$ 100,000	0.8%
	Subtotal				$ 12,496,445	
	Design Contingency	1	EST	25%	$ 3,124,111	
				Total Construction Cost	**$ 15,620,557**	

kpff Consulting Engineers

Client: Snohomish County Public Works
Project: 43rd Avenue SE
Estimated % Complete 30
By: TJT
Date: 6/6/2019

Engineer's Estimate of Probable Cost

Alternative 2 - All Segments

STD Item No.	Item Description	Quantity	Unit	Unit Cost	Cost	% of Total
	Preparation					
	Mobilization (7%)	1	LS	$ 950,682	$ 950,682	7.0%
	Clearing and Grubbing	10.5	AC	$ 20,000	$ 210,000	1.5%
	Removing Cement Conc. Sidewalk	7545	SY	$ 10	$ 75,450	0.6%
	Removing Cement Conc. Curb and Gutter	565	LF	$ 8	$ 4,520	0.0%
	Removing Fence	6300	LF	$ 10	$ 63,000	0.5%
	Removing Structures and Obstructions	1	LS	$ 10,000	$ 10,000	0.1%
	Removing Drainage Structure	25	EA	$ 1,000	$ 25,000	0.2%
	Removing Storm Pipe	3370	LF	$ 35	$ 117,950	0.9%
	Grading					
	Roadway Excavation Incl. Haul	28340	CY	$ 40	$ 1,133,600	8.3%
	Gravel Borrow Incl. Haul	12240	CY	$ 30	$ 367,200	2.7%
	Unsuitable Foundation Excavation Incl. Haul	315	CY	$ 25	$ 7,875	0.1%
	Gravel Borrow for Unsuitable Foundation Excavation	580	TN	$ 35	$ 20,300	0.1%
	Drainage					
	Precast Concrete Drywell	39	EA	$ 6,500	$ 253,500	1.9%
	Bioswale	2840	LF	$ 40	$ 113,600	0.8%
	Bioswale with Infiltration Trench	7500	LF	$ 45	$ 337,500	2.5%
	Media Filter Drain with Infiltration Trench	1300	LF	$ 50	$ 65,000	0.5%
	Underdrain Pipe 6 In. Diam	1840	LF	$ 45	$ 82,800	0.6%
	Storm Sewer					
	Catch Basin Type 1	34	EA	$ 2,000	$ 68,000	0.5%
	Catch Basin Type 2 - 48"	35	EA	$ 4,500	$ 157,500	1.2%
	Catch Basin Type 2 - 54"	6	EA	$ 5,000	$ 30,000	0.2%
	Catch Basin Type 2 - 60"	1	EA	$ 6,000	$ 6,000	0.0%
	Hydrodynamic Separator	4	EA	$ 10,000	$ 40,000	0.3%
	Schedule A Storm Sewer Pipe 12 In. Diam.	6370	LF	$ 55	$ 350,350	2.6%
	Stormwater Detention	1	LS	$ 1,000,000	$ 1,000,000	7.3%
	Structure					
	Structural Earth Wall	7870	SF	$ 40	$ 314,800	2.3%
	Moment Slab Barrier	840	LF	$ 500	$ 420,000	3.1%
	BP Railing	840	LF	$ 200	$ 168,000	1.2%
	Surfacing					
	Crushed Surfacing Top Course	14730	TON	$ 40	$ 589,200	4.3%
	Crushed Surfacing Base Course	130	TON	$ 40	$ 5,200	0.0%
	Hot Mix Asphalt					
	HMA CL. 1/2 IN. PG 58H-22	16900	TON	$ 85	$ 1,436,500	10.5%
	Erosion Control and Roadside Planting					
	Erosion/Water Pollution Control	1	LS	$ 534,253	$ 534,253	3.9%
	Seeding, Fertilizing, and Mulching	4.21	AC	$ 8,000	$ 33,680	0.2%
	Topsoil Type A	4.21	AC	$ 36,000	$ 151,560	1.1%
	Landscape Planting	12405	LF	$ 12	$ 148,860	1.1%
	High Visibility Silt Fence	17345	LF	$ 7	$ 121,415	0.9%

	Traffic					
	Cement Conc. Traffic Curb and Gutter	5790	LF	$ 25	$ 144,750	1.1%
	Painted Wide Lane Line	1395	LF	$ 3	$ 4,185	0.0%
	Painted Lane Line	36090	LF	$ 2	$ 72,180	0.5%
	Plastic Crosswalk Line	2474	SF	$ 10	$ 24,740	0.2%
	Plastic Stop Line	420	LF	$ 27	$ 11,340	0.1%
	Plastic Traffic Arrow	38	EA	$ 115	$ 4,370	0.0%
	Plastic Bicycle Lane Symbol	41	EA	$ 240	$ 9,840	0.1%
	Raised Pavement Marker Type 2	11	HUND	$ 335	$ 3,685	0.0%
	Traffic Signal System	1	LS	$ 500,000	$ 500,000	3.7%
	Permanent Signing	1	LS	$ 15,000	$ 15,000	0.1%
	Construction Signs Class A	1	LS	$ 7,500	$ 7,500	0.1%
	Project Temporary Traffic Control	1	LS	$ 700,000	$ 700,000	5.1%
	Uniformed Officer Traffic Control	850	HR	$ 150	$ 127,500	0.9%
	Flaggers	4160	HR	$ 75	$ 312,000	2.3%
	Other Items					
	Type B Progress Schedule	1	LS	$ 10,000	$ 10,000	0.1%
	Structure Excavation Class B Incl. Haul	17990	CY	$ 35	$ 629,650	4.6%
	Shoring or Extra Excavation Class B	93750	SF	$ 2	$ 187,500	1.4%
	Gravel Backfill for Drywell	296	CY	$ 60	$ 17,760	0.1%
	Connection to Drainage Structure	7	EA	$ 1,200	$ 8,400	0.1%
	Roadway Surveying	1	LS	$ 224,199	$ 224,199	1.6%
	Roundabout Truck Apron	800	SY	$ 600	$ 480,000	3.5%
	Splitter Island	950	SY	$ 55	$ 52,250	0.4%
	Cement Conc. Sidewalk	7280	SY	$ 40	$ 291,200	2.1%
	Cement Conc. Driveway Entrance Type __	1730	SY	$ 85	$ 147,050	1.1%
	Coated Chain Link Fence Type 3	450	LF	$ 55	$ 24,750	0.2%
	Field Office Building	1	LS	$ 20,000	$ 20,000	0.1%
	Adjust Valve Box	69	EA	$ 500	$ 34,500	0.3%
	Adjust Manhole	2	EA	$ 1,000	$ 2,000	0.0%
	Mailbox Support Type 1	52	EA	$ 900	$ 46,800	0.3%
	Curb Ramp Type __	20	EA	$ 5,000	$ 100,000	0.7%
	Subtotal				$ 13,626,445	
	Design Contingency	1	EST	25%	$ 3,406,611	
				Total Construction Cost	**$ 17,033,056**	

kpff Consulting Engineers

Client: Snohomish County Public Works
Project: 43rd Avenue SE
Estimated % Complete 30
By: TJT
Date: 6/6/2019

Engineer's Estimate of Probable Cost

Alternative 3 - All Segments

STD Item No.	Item Description	Quantity	Unit	Unit Cost	Cost	% of Total
	Preparation					
	Mobilization (7%)	1	LS	$ 975,690	$ 975,690	7.0%
	Clearing and Grubbing	10.5	AC	$ 20,000	$ 210,000	1.5%
	Removing Cement Conc. Sidewalk	7545	SY	$ 10	$ 75,450	0.5%
	Removing Cement Conc. Curb and Gutter	570	LF	$ 8	$ 4,560	0.0%
	Removing Fence	6300	LF	$ 10	$ 63,000	0.5%
	Removing Structures and Obstructions	1	LS	$ 10,000	$ 10,000	0.1%
	Removing Drainage Structure	25	EA	$ 1,000	$ 25,000	0.2%
	Removing Storm Pipe	3380	LF	$ 35	$ 118,300	0.8%
	Grading					
	Roadway Excavation Incl. Haul	27715	CY	$ 40	$ 1,108,600	7.9%
	Gravel Borrow Incl. Haul	12740	CY	$ 30	$ 382,200	2.7%
	Unsuitable Foundation Excavation Incl. Haul	315	CY	$ 25	$ 7,875	0.1%
	Gravel Borrow for Unsuitable Foundation Excavation	580	TN	$ 35	$ 20,300	0.1%
	Drainage					
	Precast Concrete Drywell	39	EA	$ 6,500	$ 253,500	1.8%
	Bioswale	2840	LF	$ 40	$ 113,600	0.8%
	Bioswale with Infiltration Trench	8800	LF	$ 45	$ 396,000	2.8%
	Media Filter Drain with Infiltration Trench	0	LF	$ 50	$ -	0.0%
	Underdrain Pipe 6 In. Diam	1770	LF	$ 45	$ 79,650	0.6%
	Storm Sewer					
	Catch Basin Type 1	34	EA	$ 2,000	$ 68,000	0.5%
	Catch Basin Type 2 - 48"	35	EA	$ 4,500	$ 157,500	1.1%
	Catch Basin Type 2 - 54"	6	EA	$ 5,000	$ 30,000	0.2%
	Catch Basin Type 2 - 60"	1	EA	$ 6,000	$ 6,000	0.0%
	Hydrodynamic Separator	4	EA	$ 10,000	$ 40,000	0.3%
	Schedule A Storm Sewer Pipe 12 In. Diam.	6370	LF	$ 55	$ 350,350	2.5%
	Stormwater Detention	1	LS	$ 1,000,000	$ 1,000,000	7.2%
	Structure					
	Structural Earth Wall	7870	SF	$ 40	$ 314,800	2.3%
	Moment Slab Barrier	1265	LF	$ 500	$ 632,500	4.5%
	BP Railing	1265	LF	$ 200	$ 253,000	1.8%
	Surfacing					
	Crushed Surfacing Top Course	15545	TON	$ 40	$ 621,800	4.4%
	Crushed Surfacing Base Course	130	TON	$ 40	$ 5,200	0.0%
	Hot Mix Asphalt					
	HMA CL. 1/2 IN. PG 58H-22	16740	TON	$ 85	$ 1,422,900	10.2%
	Erosion Control and Roadside Planting					
	Erosion/Water Pollution Control	1	LS	$ 549,858	$ 549,858	3.9%
	Seeding, Fertilizing, and Mulching	4.53	AC	$ 8,000	$ 36,240	0.3%
	Topsoil Type A	4.53	AC	$ 36,000	$ 163,080	1.2%
	Landscape Planting	12410	LF	$ 12	$ 148,920	1.1%
	High Visibility Silt Fence	17350	LF	$ 7	$ 121,450	0.9%

	Traffic					
	Cement Conc. Traffic Curb and Gutter	5790	LF	$ 25	$ 144,750	1.0%
	Painted Wide Lane Line	1400	LF	$ 3	$ 4,200	0.0%
	Painted Lane Line	36090	LF	$ 2	$ 72,180	0.5%
	Plastic Crosswalk Line	2480	SF	$ 10	$ 24,800	0.2%
	Plastic Stop Line	420	LF	$ 27	$ 11,340	0.1%
	Plastic Traffic Arrow	38	EA	$ 115	$ 4,370	0.0%
	Plastic Bicycle Lane Symbol	41	EA	$ 240	$ 9,840	0.1%
	Raised Pavement Marker Type 2	11	HUND	$ 335	$ 3,685	0.0%
	Traffic Signal System	1	LS	$ 500,000	$ 500,000	3.6%
	Permanent Signing	1	LS	$ 15,000	$ 15,000	0.1%
	Construction Signs Class A	1	LS	$ 7,500	$ 7,500	0.1%
	Project Temporary Traffic Control	1	LS	$ 700,000	$ 700,000	5.0%
	Uniformed Officer Traffic Control	850	HR	$ 150	$ 127,500	0.9%
	Flaggers	4160	HR	$ 75	$ 312,000	2.2%
	Other Items					
	Type B Progress Schedule	1	LS	$ 10,000	$ 10,000	0.1%
	Structure Excavation Class B Incl. Haul	17990	CY	$ 35	$ 629,650	4.5%
	Shoring or Extra Excavation Class B	93750	SF	$ 2	$ 187,500	1.3%
	Gravel Backfill for Drywell	296	CY	$ 60	$ 17,760	0.1%
	Connection to Drainage Structure	7	EA	$ 1,200	$ 8,400	0.1%
	Roadway Surveying	1	LS	$ 229,946	$ 229,946	1.6%
	Roundabout Truck Apron	800	SY	$ 600	$ 480,000	3.4%
	Splitter Island	950	SY	$ 55	$ 52,250	0.4%
	Cement Conc. Sidewalk	7295	SY	$ 40	$ 291,800	2.1%
	Cement Conc. Driveway Entrance Type __	1730	SY	$ 85	$ 147,050	1.1%
	Coated Chain Link Fence Type 3	450	LF	$ 55	$ 24,750	0.2%
	Field Office Building	1	LS	$ 20,000	$ 20,000	0.1%
	Adjust Valve Box	69	EA	$ 500	$ 34,500	0.2%
	Adjust Manhole	2	EA	$ 1,000	$ 2,000	0.0%
	Mailbox Support Type 1	52	EA	$ 900	$ 46,800	0.3%
	Curb Ramp Type __	20	EA	$ 5,000	$ 100,000	0.7%
	Subtotal				$ 13,984,894	
	Design Contingency	1	EST	25%	$ 3,496,223	
				Total Construction Cost	**$ 17,481,117**	

kpff Consulting Engineers

Client: Snohomish County Public Works
Project: 43rd Avenue SE
Estimated % Complete 30
By: TJT
Date: 8/15/2019

Engineer's Estimate of Probable Cost

Alternative 4 - All Segments

STD Item No.	Item Description	Quantity	Unit	Unit Cost	Cost	% of Total
	Preparation					
	Mobilization (7%)	1	LS	$ 882,104	$ 882,104	7.0%
	Clearing and Grubbing	8.6	AC	$ 20,000	$ 172,000	1.4%
	Removing Cement Conc. Sidewalk	7545	SY	$ 10	$ 75,450	0.6%
	Removing Cement Conc. Curb and Gutter	565	LF	$ 8	$ 4,520	0.0%
	Removing Fence	6300	LF	$ 10	$ 63,000	0.5%
	Removing Structures and Obstructions	1	LS	$ 10,000	$ 10,000	0.1%
	Removing Drainage Structure	25	EA	$ 1,000	$ 25,000	0.2%
	Removing Storm Pipe	3370	LF	$ 35	$ 117,950	0.9%
	Grading					
	Roadway Excavation Incl. Haul	27043.86	CY	$ 40	$ 1,081,754	8.6%
	Gravel Borrow Incl. Haul	9670.699	CY	$ 30	$ 290,121	2.3%
	Unsuitable Foundation Excavation Incl. Haul	315	CY	$ 25	$ 7,875	0.1%
	Gravel Borrow for Unsuitable Foundation Excavation	580	TN	$ 35	$ 20,300	0.2%
	Drainage					
	Precast Concrete Drywell	39	EA	$ 6,500	$ 253,500	2.0%
	Bioswale	640	LF	$ 40	$ 25,600	0.2%
	Bioswale with Infiltration Trench	7500	LF	$ 45	$ 337,500	2.7%
	Media Filter Drain with Infiltration Trench	1300	LF	$ 50	$ 65,000	0.5%
	Underdrain Pipe 6 In. Diam	1840	LF	$ 45	$ 82,800	0.7%
	Storm Sewer					
	Catch Basin Type 1	34	EA	$ 2,000	$ 68,000	0.5%
	Catch Basin Type 2 - 48"	35	EA	$ 4,500	$ 157,500	1.2%
	Catch Basin Type 2 - 54"	6	EA	$ 5,000	$ 30,000	0.2%
	Catch Basin Type 2 - 60"	1	EA	$ 6,000	$ 6,000	0.0%
	Hydrodynamic Separator	4	EA	$ 10,000	$ 40,000	0.3%
	Schedule A Storm Sewer Pipe 12 In. Diam.	6370	LF	$ 55	$ 350,350	2.8%
	Stormwater Detention	1	LS	$ 1,000,000	$ 1,000,000	7.9%
	Structure					
	Structural Earth Wall	7870	SF	$ 40	$ 314,800	2.5%
	Moment Slab Barrier	840	LF	$ 500	$ 420,000	3.3%
	BP Railing	840	LF	$ 200	$ 168,000	1.3%
	Surfacing					
	Crushed Surfacing Top Course	14200.72	TON	$ 40	$ 568,029	4.5%
	Crushed Surfacing Base Course	20	TON	$ 40	$ 800	0.0%
	Hot Mix Asphalt					
	HMA CL. 1/2 IN. PG 58H-22	15032.94	TON	$ 85	$ 1,277,800	10.1%
	Erosion Control and Roadside Planting					
	Erosion/Water Pollution Control	1	LS	$ 502,146	$ 502,146	4.0%
	Seeding, Fertilizing, and Mulching	4.15	AC	$ 8,000	$ 33,200	0.3%
	Topsoil Type A	4.15	AC	$ 36,000	$ 149,400	1.2%
	Landscape Planting	11505	LF	$ 12	$ 138,060	1.1%
	High Visibility Silt Fence	17345	LF	$ 7	$ 121,415	1.0%

	Traffic					
	Cement Conc. Traffic Curb and Gutter	5790	LF	$ 25	$ 144,750	1.1%
	Painted Wide Lane Line	1395	LF	$ 3	$ 4,185	0.0%
	Painted Lane Line	36090	LF	$ 2	$ 72,180	0.6%
	Plastic Crosswalk Line	2474	SF	$ 10	$ 24,740	0.2%
	Plastic Stop Line	420	LF	$ 27	$ 11,340	0.1%
	Plastic Traffic Arrow	38	EA	$ 115	$ 4,370	0.0%
	Plastic Bicycle Lane Symbol	41	EA	$ 240	$ 9,840	0.1%
	Raised Pavement Marker Type 2	11	HUND	$ 335	$ 3,685	0.0%
	Traffic Signal System	1	LS	$ 500,000	$ 500,000	4.0%
	Permanent Signing	1	LS	$ 15,000	$ 15,000	0.1%
	Construction Signs Class A	1	LS	$ 7,500	$ 7,500	0.1%
	Project Temporary Traffic Control	1	LS	$ 502,696	$ 502,696	4.0%
	Uniformed Officer Traffic Control	850	HR	$ 150	$ 127,500	1.0%
	Flaggers	4160	HR	$ 75	$ 312,000	2.5%
	Other Items					
	Type B Progress Schedule	1	LS	$ 10,000	$ 10,000	0.1%
	Structure Excavation Class B Incl. Haul	17990	CY	$ 35	$ 629,650	5.0%
	Shoring or Extra Excavation Class B	93750	SF	$ 2	$ 187,500	1.5%
	Gravel Backfill for Drywell	296	CY	$ 60	$ 17,760	0.1%
	Connection to Drainage Structure	7	EA	$ 1,200	$ 8,400	0.1%
	Roadway Surveying	1	LS	$ 181,373	$ 181,373	1.4%
	Roundabout Truck Apron	800	SY	$ 600	$ 480,000	3.8%
	Splitter Island	950	SY	$ 55	$ 52,250	0.4%
	Cement Conc. Sidewalk	5974.444	SY	$ 40	$ 238,978	1.9%
	Cement Conc. Driveway Entrance Type __	115	SY	$ 85	$ 9,775	0.1%
	Coated Chain Link Fence Type 3	450	LF	$ 55	$ 24,750	0.2%
	Field Office Building	1	LS	$ 20,000	$ 20,000	0.2%
	Adjust Valve Box	69	EA	$ 500	$ 34,500	0.3%
	Adjust Manhole	2	EA	$ 1,000	$ 2,000	0.0%
	Mailbox Support Type 1	52	EA	$ 900	$ 46,800	0.4%
	Curb Ramp Type __	20	EA	$ 5,000	$ 100,000	0.8%
	Subtotal				$ 12,643,497	
	Design Contingency	1	EST	25%	$ 3,160,874	
				Total Construction Cost	**$ 15,804,371**	