

# Site and Reach Assessment Union River At SR 300



**Work Order MT 0100**

**Garrett W. Jackson, Hydrologist**

**WSDOT Environmental Services, Watershed Management Program**

**January, 2008**



**Site and Reach Assessment, Union River At SR 300**

Site and Reach Assessment, Union River At SR 300

Table of Contents

**Figures..... v**

**Tables ..... vi**

**Summary..... vii**

**1.0. Introduction..... 1**

**2.0. Methods..... 3**

**3.0. Site Assessment..... 4**

    3.1. Union River Bridge and Vicinity ..... 4

    3.2 Wetlands Section ..... 10

**4.0. Reach Assessment ..... 14**

    4.1 Watershed Conditions and Land Cover ..... 14

    4.2. Geology and Soils ..... 19

    4.3 Geomorphology ..... 19

    4.4 Hydrology and Flow Conditions..... 20

    4.5. Channel Alignment and Profile ..... 22

    4.8. Channel Migration and Avulsion Risk ..... 22

    4.8. Local Scour ..... 25

    4.9. Riparian Conditions ..... 25

    4.10. Large Woody Debris (LWD) ..... 26

    4.11. Water Quality..... 26

    4.13. Fish Utilization and Habitat Availability..... 26

    4.14. Wetlands ..... 27

**5.0. Evaluation of Treatment Alternatives ..... 30**

    5.1. Mechanisms and Causes of Geomorphic Failure..... 30

    5.2. Site-Reach Based Failure Mechanism Interaction..... 30

**6.0. Treatment Alternatives ..... 32**

    6.1. Introduction and Objectives..... 32

    6.2. Bridge Alternatives Considered, Union River Section ..... 37

    6.3. Embankment Alternatives Considered, Union River Section..... 38

    6.4. Alternatives Considered, Wetlands Section..... 39

    6.5. Road Relocation Alternative (Union River and Wetlands Sections)..... 39

**Site and Reach Assessment, Union River At SR 300**

6.6. Preferred Alternative..... 42

**7.0. Conclusions..... 43**

**8.0. References..... 44**

## Site and Reach Assessment, Union River At SR 300

### Figures

|  |    |
|--|----|
| Figure 1. Location Map .....   | 2  |
| Figure 2. Union River bridge and vicinity .....                                | 6  |
| Figure 3. Cottonwood on upstream side of bridge.....                           | 7  |
| Figure 4. View looking downstream toward Union River bridge. ....              | 7  |
| Figure 5. Wood debris on upstream side of Union River Bridge .....             | 8  |
| Figure 6. Union River, downstream from bridge, eroding highway embankment. ... | 8  |
| Figure 7. Close-up of Union River Section with annotated features.....         | 9  |
| Figure 8. Wetland section of SR 300 .....                                      | 10 |
| Figure 9. Wetlands section map.....  | 11 |
| Figure 10. Ditch along north side of SR 300 in the wetland section.....        | 13 |
| Figure 11. Elevation profiles across SR 300, wetlands section. ....            | 13 |
| Figure 12. Map of land cover in Union River watershed .....                    | 15 |
| Figure 13. Geology of Union River Watershed. ....                              | 17 |
| Figure 14. Soil series map of the Union River Watershed .....                  | 18 |
| Figure 15. Mean monthly hydrograph, Union River near Bremerton. ....           | 20 |
| Figure 16. Longitudinal profile, Union River at SR 300. ....                   | 23 |
| Figure 17. Union River Channel Migration 1884 to 2006. ....                    | 24 |
| Figure 18. Cross-section changes at the Union River bridge, SR 300.....        | 25 |
| Figure 19. Wetlands and Hydric soils of the project area.....                  | 28 |
| Figure 20. Preferred Alternative Conceptual Relocation .....                   | 40 |

**Site and Reach Assessment, Union River At SR 300**

**Tables**

**Table 1. Peak flood flow statistics for the project area. .... 21**

**Table 2. Tidal statistics for Union, Washington..... 21**

**Table 3. Salmonid utilization and stock/Endangered Species Act status for the  
assessment reach. .... 27**

**Table 4. Alternative Comparison Matrix ..... 33**

## Site and Reach Assessment, Union River At SR 300

### Summary

State Route (SR) 300) is a short segment of highway that connects SR 3 and the City of Belfair to Belfair State Park. The highway crosses the Union River floodplain, which contains the river and a complex of estuarine and freshwater wetlands. Three sites of continued maintenance were grouped together for this report, due their close proximity to each other. These sites are the Union River bridge; the embankment 300 feet downstream from the bridge; and the wetlands complex between milepost 2.0 and 2.7. The following list describes key findings of this assessment.

#### Report findings:

- The Union River at SR 300 has abundant sources of woody debris.
- The highway is parallel to and within the historic channel migration zone of the Union River, and meander migration is affecting the road embankment.
- The bridge over the Union River has multiple wood piers that inhibit passage of large woody debris.
- The river cross-section has aggraded at the bridge, exacerbating the debris problem.
- The highway through the wetland section is very low, only 1.5 feet above the surrounding wetlands.
- The Union River section and the wetlands section of the project area are both susceptible to rises in sea level.

#### Report recommendations:

- Reroute the highway to minimize maintenance and avoid closures.
- Rerouting will allow more contiguous estuarine wetland habitat.
- Rerouting will improve connectivity.
- Rerouting provides the best alternative in the long run.

**Site and Reach Assessment, Union River At SR 300**



## **1.0. Introduction**

This report presents a site and reach assessment of a one-mile section of State Route (SR) 300, including the crossing of the Union River at about river mile (RM) 2.84 (see Figure 1). The Union River estuary defines the ‘head’ of Hood Canal (the area is also known as Lynch Cove). The project site runs from milepost (MP) 2.0 to MP 2.9. The site has three different issues. First, at the Union River bridge (MP 2.84), woody debris must be removed after nearly every significant runoff event. The wood and other debris is associated with an area of scour adjacent to and upstream from the east end of the bridge. Second, the Union River is eroding the road embankment about 300 feet west of the bridge. These first two areas are linked by the Union River, and are grouped in the ‘‘Union River’’ section of this report. Third, sections of the road west of the junction with Sandhill Road are periodically flooded between fall and spring. This typically closes the road at least two to three times each year, and requires frequent repair of cracked and subsided sections of pavement. The section of highway is located at a low elevation in the middle of an estuarine wetland complex and is referred to as the ‘‘wetlands’’ section. The Union River and the wetlands sections are shown in Figure 2.

This report describes the methods used to investigate these issues, followed by the site analysis, the reach analysis, mechanisms of failure, alternatives considered, and the recommended alternative.

Site and Reach Assessment, Union River At SR 300

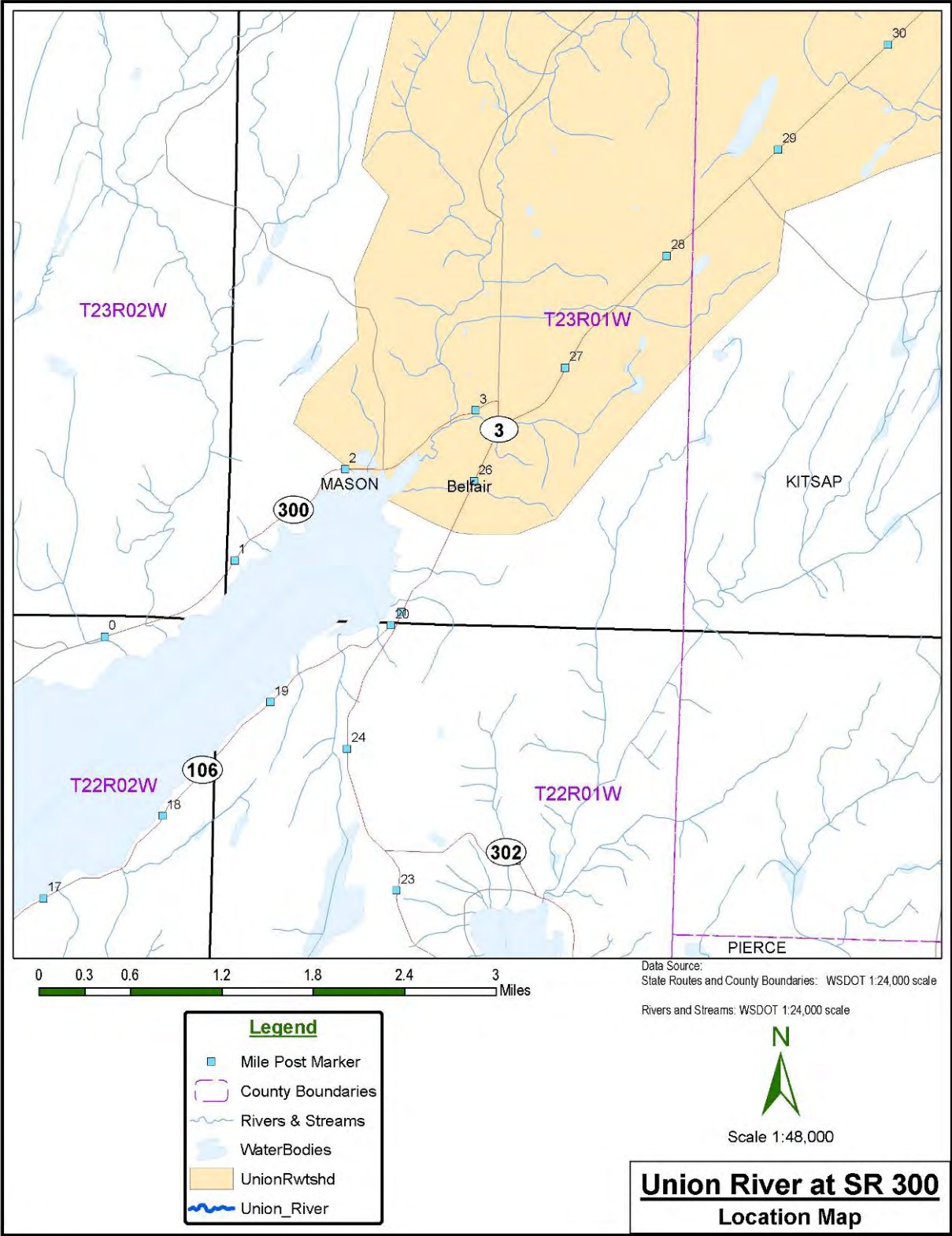


Figure 1. Location Map.

## Site and Reach Assessment, Union River At SR 300

### 2.0. Methods

This study included literature and data review and field data collection. We also examined aerial photos, ground photos taken at the site, topographic maps, geology maps and reports, LIDAR data, fish distribution data, tidal data, and hydrologic data. Sources of information include:

- Aerial photographs taken in 1944 and 2006.
- Ground photos obtained by environmental staff during a site visit in November, 2007.
- GIS coverages of 1:24,000 Scale USGS topographic maps for this area.
- Existing literature and data, as listed in the “References” section of this report.
- Tidal information available on-line from National Oceanic and Atmospheric Administration (NOAA).
- Fish distribution information available from the Washington Lakes and Rivers Information System (WLRIS).

Field reconnaissance and data collection included:

- Cross-sections upstream and downstream from the bridge were surveyed using self-leveling level, tape, and stadia rod. Longitudinal profile was also surveyed. The surveys were timed so that there would be minimal influence from tides.
- Cross-sections across the highway (“profiles”) were also surveyed.
- Observations during high flows were taken during the flood of early December, 2007, along with velocity measurements using a buoyant object.
- Water elevation was surveyed during the flood.

### 3.0. Site Assessment

This assessment includes analysis and discussions of two sections (the “Union River” section, and the “wetlands” section), each of which could be considered a separate “site.” However, because of their proximity to each other, they have been included in the same assessment.

#### 3.1. Union River Bridge and Vicinity

SR 300 crosses the Union River and its floodplain, using WSDOT bridge number 00300-3. The Union River site is defined by the area within 100 feet upstream and downstream of the bridge. The Union River is a moderately meandering stream. The site lies in a section of the river that is very low gradient (less than 0.5 percent). The river is a riffle-pool stream in this reach (Montgomery and Buffington, 1993). The river is subject to tidal influence at the site.

The bridge is situated between two river meanders (Figure 2). The underside of the bridge deck is about seven feet above the streambed. The bridge deck is supported by two rows of wooden piers, making a three-span bridge. Each row has four individual creosote-treated timbers. The piles are driven into the floodplain between 30 and 44 feet (State Department of Highways 1960). The approaches are supported by timber cribbing. The west bridge approach also has a concrete abutment wall with a spread footer that is located in front of the timber cribbing. There are sawn-off piles in the channel under the bridge, indicating that an older bridge was located here, or that the current bridge has been modified from its original configuration.

This bridge was built in 1960, but a bridge existed at this location prior to that. On the 1884 historic topographic sheet (U.S. Coast and Geodetic Survey 1884), a railroad is shown, crossing the Union River in nearly the same location as the current bridge. The railroad continued several hundred feet downstream, to a dock on the river. There have been no scour repairs on this bridge, although local scour of one foot was noted in several WSDOT maintenance inspection reports. Debris accumulates on the upstream side of the bridge with every winter storm, according to WSDOT maintenance crews. Much of the debris accumulates on the left bank just upstream, although due to the low bridge deck height and close spacing of piles, it could accumulate anywhere on the upstream side of the bridge. Aggradation was observed on pile 3A between the westernmost span and the middle span of the bridge.

About eight feet upstream from the bridge railing, a cottonwood leaning into the stream channel acts as a prominent obstruction during high flows. The trunk of the cottonwood is nearly horizontal (see Figure 3). On the right bank immediately upstream from the bridge, a riprap revetment has been installed to keep the flow from attacking the road embankment (Figure 4). The river flows at an angle that directly attacks the revetment. The rip rap is being undermined; some of it has been moved downstream past the bridge. The water bends nearly 90 degrees at the revetment before passing under the bridge. This bend often trap debris (Figure 5). On the left bank, adjacent to the bridge, scour from the eddy current circulation during high flows has removed a portion of the embankment and adjacent floodplain terrace.

## Site and Reach Assessment, Union River At SR 300

About 500 feet downstream from the bridge, the river is wider and flows past a series of relatively small debris jams that spread flow. The debris is forcing the thalweg against the highway embankment about 300 feet west of the bridge (Figure 6). Riprap has been placed along the road embankment, but it is being undermined. The road fill adjacent to the pavement edge is slumping, as indicated by tension cracks and small scarps (up to six inches). About 325 feet of road embankment are threatened by erosion. Riprap is not present along this entire length. Figure 7 shows a close-up of the Union River section and key features.

Site and Reach Assessment, Union River At SR 300

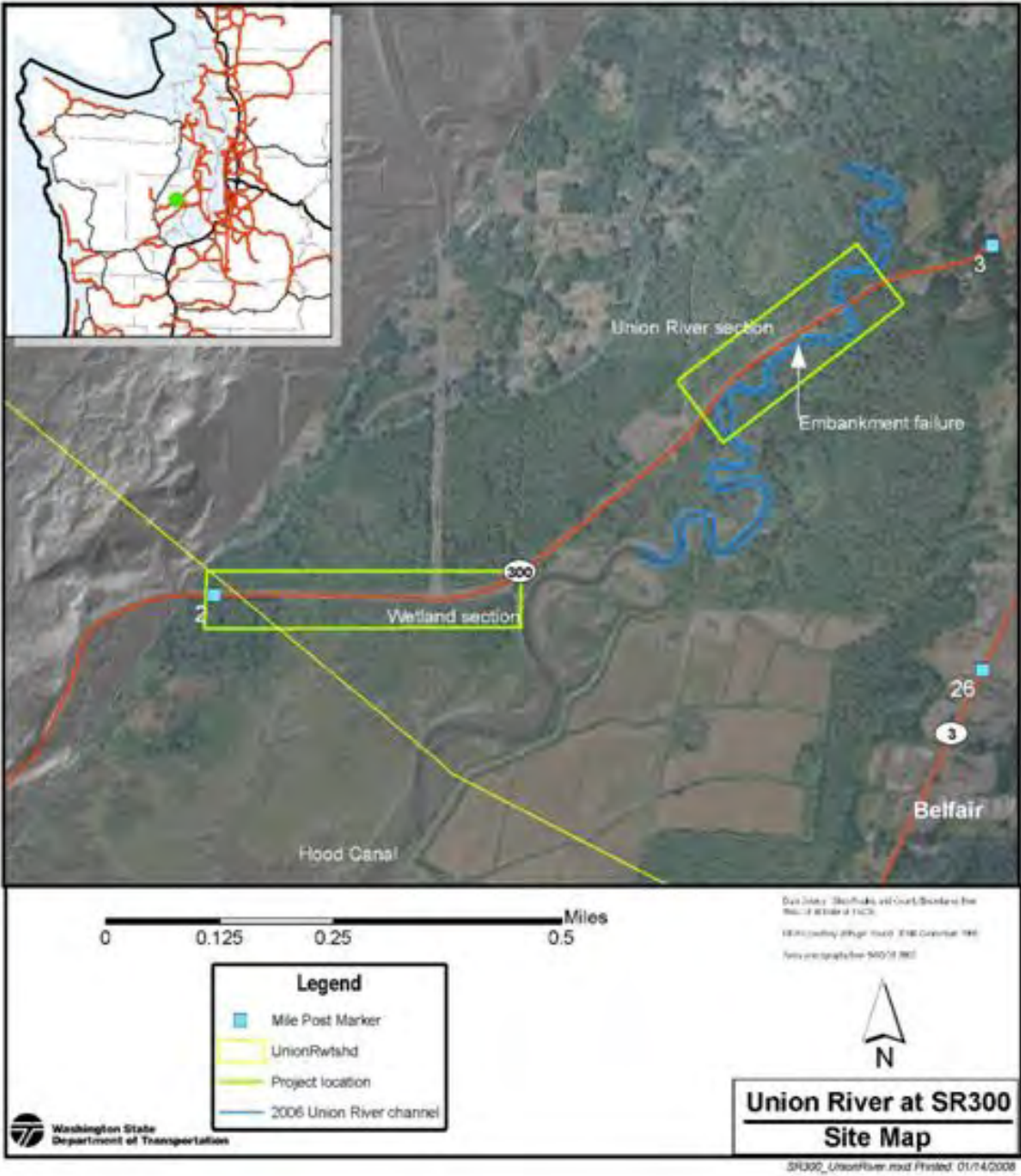


Figure 2. Union River bridge and vicinity

## Site and Reach Assessment, Union River At SR 300



**Figure 3. Cottonwood on upstream side of bridge.**

Picture was taken standing underneath bridge, looking upstream. Utility conduit is visible near the top of the picture.



**Figure 4. View looking downstream toward Union River bridge.**

Note angle of attack on revetment. Red arrows indicate direction of flow.

**Site and Reach Assessment, Union River At SR 300**



**Figure 5. Wood debris on upstream side of Union River Bridge.**  
Note utility conduit paralleling the bridge.



**Figure 6. Union River, downstream from bridge, eroding highway embankment.**



Site and Reach Assessment, Union River At SR 300

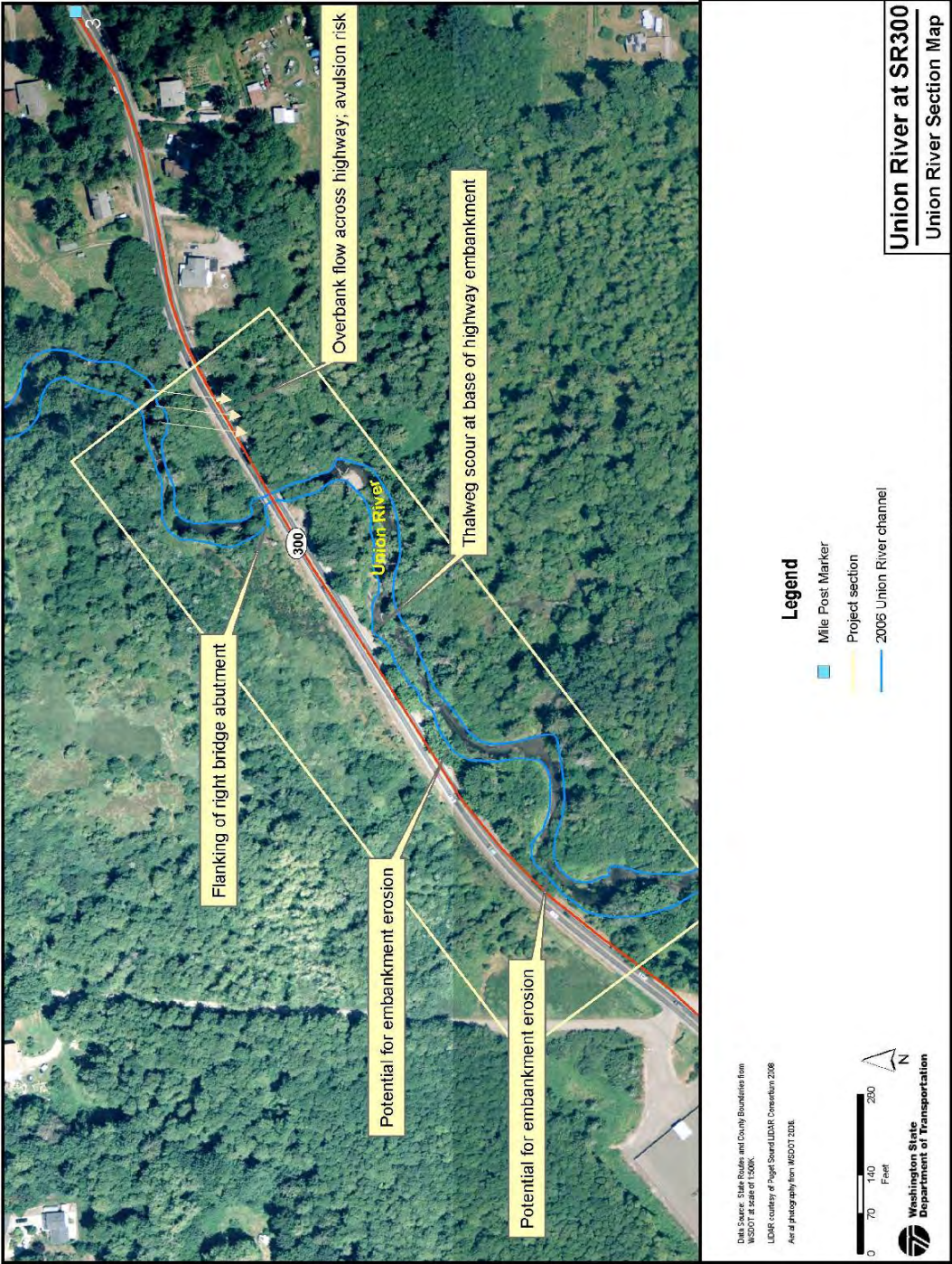


Figure 7. Close-up of Union River Section with annotated features.

Note: Union River estuary is in the lower portion of the photo. Sandhill Road is in the upper right portion.

Source: Washington Dept of Natural Resources.

## Site and Reach Assessment, Union River At SR 300

### 3.2 Wetlands Section

About 1000 feet west of the Union River Bridge, SR 300 crosses a wetland complex on fill (Figure 8). This section is defined by the length of highway that bisects the wetlands, between approximately MP 2.0 and 2.35. The road is periodically flooded in this section, closing off access to communities to the west. Additionally, there is damage (cracking, dips) to the pavement that is likely related to the saturated substrate. The wetland complex is part of the Union River floodplain and estuary. LIDAR imagery indicates that the river has occupied these areas before.

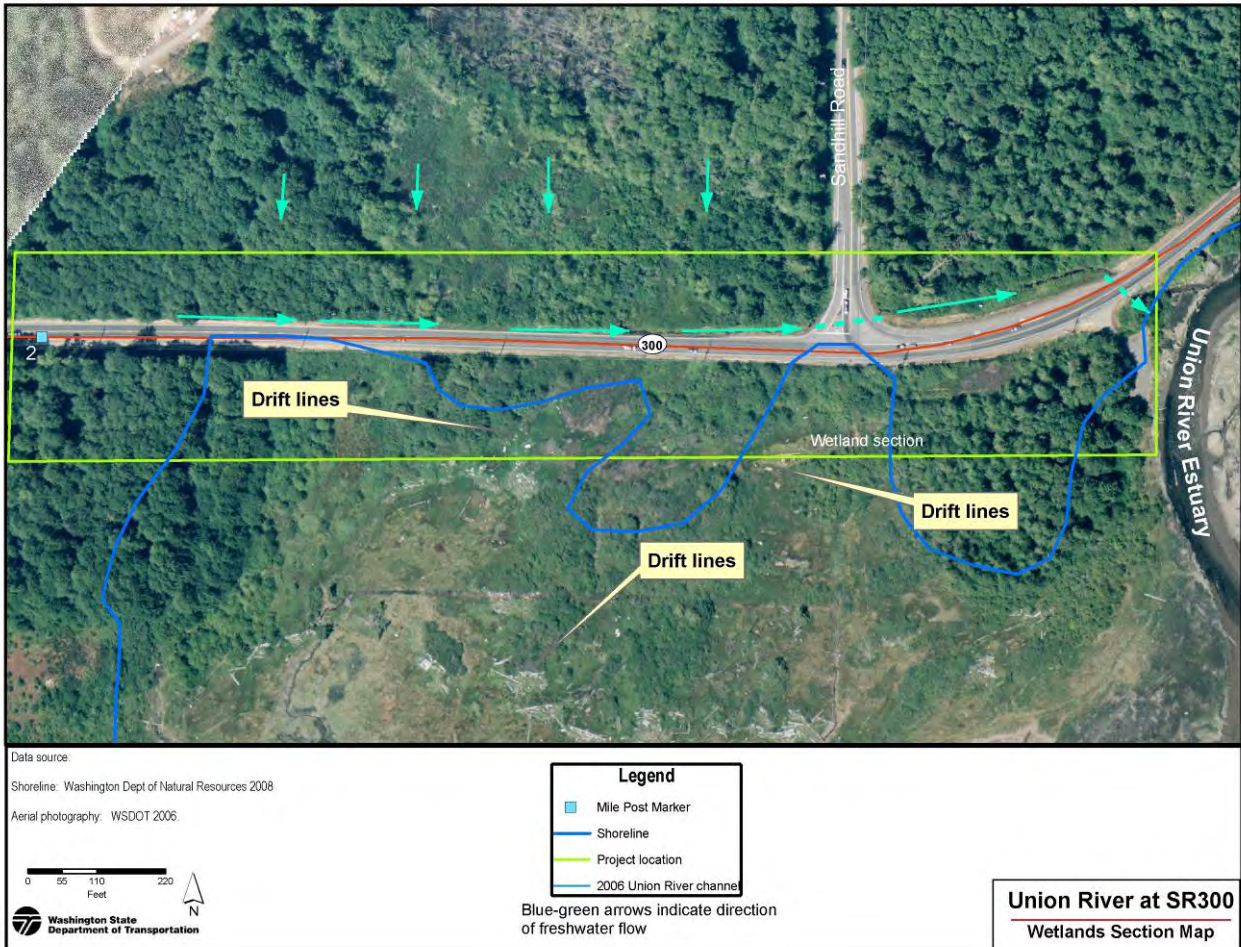


**Figure 8. Wetland section of SR 300.**

Figure 9 shows a generalized picture of the runoff in the area. Drainage from the upstream side of the highway (the north side) is collected in a ditch that parallels the roadway. This ditch carries water eastward toward Sandhill Road, then under the road through two eight-inch culverts. East of Sandhill Road, an embankment approximately three feet high separates the ditch from the highway. The ditch leads to a culvert under the highway, which outfalls to the Union River estuary. The downstream side of the embankment has been shored up with steel sheet piling and quarry spalls, apparently due to sloughing of the road embankment when saturated.

The drainage ditch is variable in depth and width, ranging from one foot to more than three feet deep and up to 10 feet wide. Vegetation has encroached on the ditch cross-section throughout the length of the ditch between the west end of the wetlands (where the ditch begins) to Sandhill Road. On the south side of the highway lie the estuarine wetlands. During a site visit, the ditch was nearly full, while the estuarine wetlands had no standing water within 30 feet of the road embankment. The highway and the associated ditch divert water to the east that would otherwise flow diffusely out towards Hood Canal.

## Site and Reach Assessment, Union River At SR 300



**Figure 9. Wetlands section map.**

The pavement of SR 300 was only a few inches above the water in the ditch during the site visit on December 4, 2007 (Figure 10). Grass on the south side of the road embankment had been flattened by water flow, and road closure signs had recently been in place across this section of the highway.

Elevation profiles were surveyed across the highway at two locations in the wetlands section in January, 2008. These profiles are located approximately 200 and 300 feet west of the intersection with Sandhill Road. We set the elevation of the pavement equal to the USGS benchmark at the Sandhill Road/SR 300 intersection (7 feet NGVD1927). Comparing the elevation of the roadway to the mean higher high water (MHHW) and extreme high tide (EHT) from the tide gage at Union on Hood Canal, we find that the roadway is only 1.5 feet above MHHW, and is entirely below the EHT (Figure 11). This information is consistent with the observation of the presence of *Carex lyngbyei*, a salt tolerant sedge, adjacent to the highway on the south side. It is also consistent with the shoreline layer compiled by the Department of Natural Resources, which is shown in Figure 9. In addition, in aerial photographs, drift lines can be seen near the highway. This debris was carried into the estuarine wetlands by high tides. WSDOT maintenance supervisor Larry Deemer states that the highway floods under EHT conditions, even without other factors.

## **Site and Reach Assessment, Union River At SR 300**

Considering storm runoff from Sandhill Road and the hills to the north, it is clear why the highway is subject to frequent flooding.

Site and Reach Assessment, Union River At SR 300



Figure 10. Ditch along north side of SR 300 in the wetland section.

Note water on pavement.

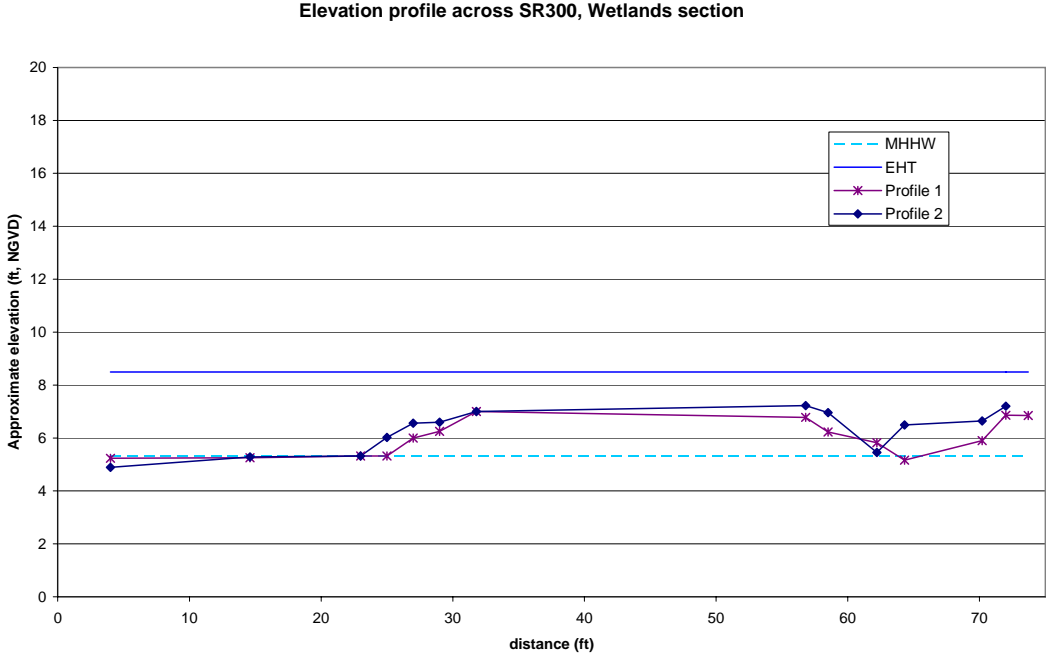


Figure 11. Elevation profiles across SR 300, wetlands section.

MHHW = mean higher high water; EHT = extreme high tide; both are from the tide gage at Union, Hood Canal.

## 4.0. Reach Assessment

### 4.1 *Watershed Conditions and Land Cover*

The watershed area totals about 15,712 acres at the SR 300 bridge. The watershed has two distinct areas, the hilly Gold Mountain area west of the city of Bremerton and the relatively flat lower Union River area. Although the entire watershed is relatively low elevation, the highest elevation areas are on 1761 foot Gold Mountain. Most of the tributaries originate in the higher northern half of the basin. These tributaries include Hazel Creek, Bear Creek, and Courtney Creek. The City of Bremerton water supply is located at Union River Reservoir behind Casad Dam. An area of 4.7 square miles (20 percent of the Union River watershed) drains to Union River Reservoir. While primarily for water supply, this dam can be used for flood control purposes. In the December 2007 flood, the City withheld water until the reservoir level was several feet below the overflow elevation (City of Bremerton website).

While the river gradients are high in the Gold Mountain area, the lower Union River area is a broad river valley with relatively low stream gradients. Some tributaries enter the Union River from the plateau of glacial drift to the west of the main valley, while a few enter from the plateau on the east.

Most of the watershed has been logged several times, including the portions of the Gold Mountain State Forest which are located in the watershed. The lower portions of the watershed (including the floodplain) are dominated by low-density rural residential and small farm properties.

Land cover is predominately mixed conifer forest (80 percent). Figure 11 shows the distribution of land cover. The remaining portions of the watershed are in conifer forest (15 percent) and developed areas (5 percent). This watershed is mostly private land, and in a fast-developing area. It is likely that the watershed will experience considerable development in the near future. Within the two sites under consideration, the state owns most of the land on either side of the highway. The Cascade Land Conservancy owns a portion of the estuary adjacent to the highway.

Site and Reach Assessment, Union River At SR 300

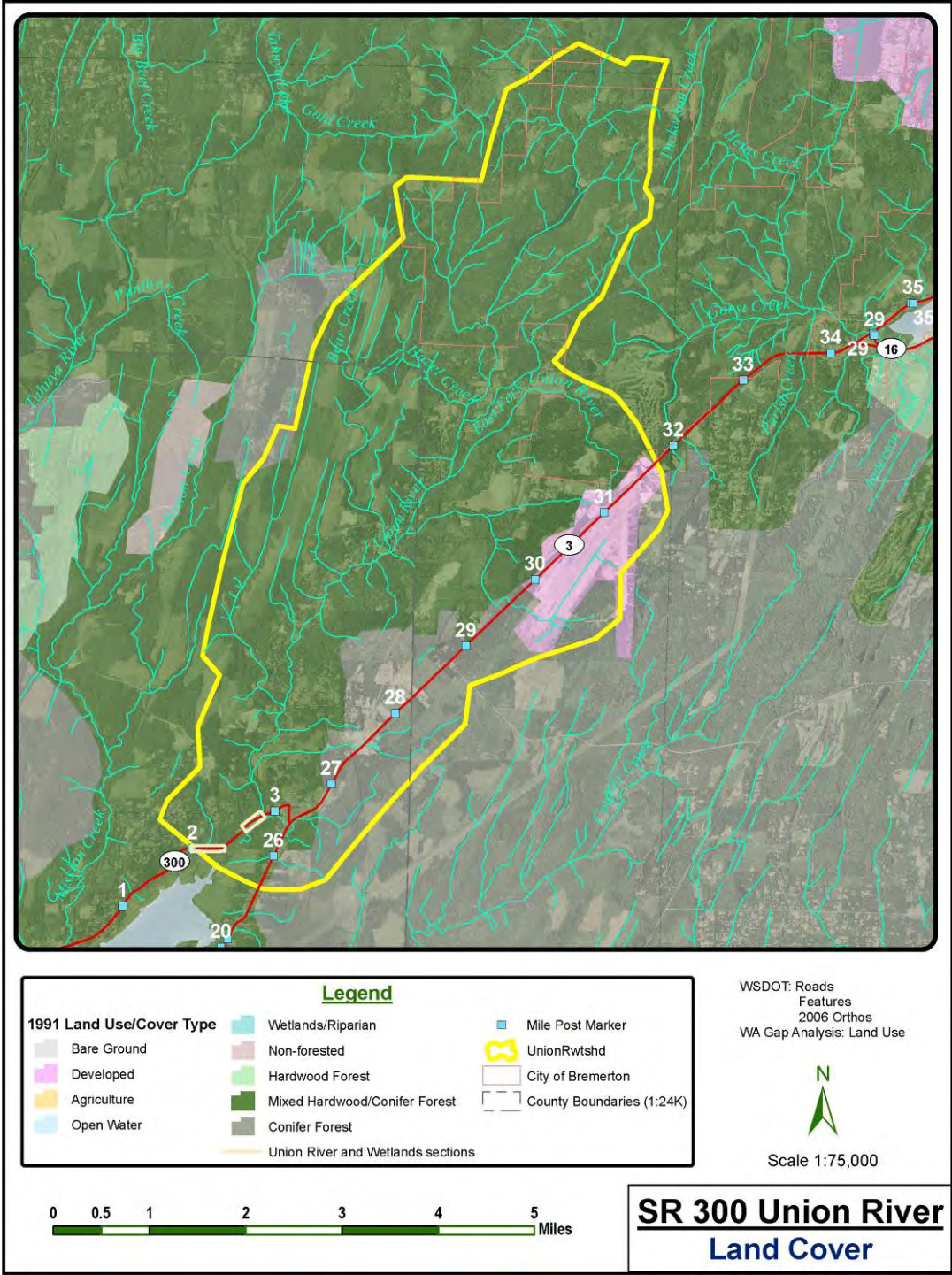


Figure 12. Map of land cover in Union River watershed

**Site and Reach Assessment, Union River At SR 300**



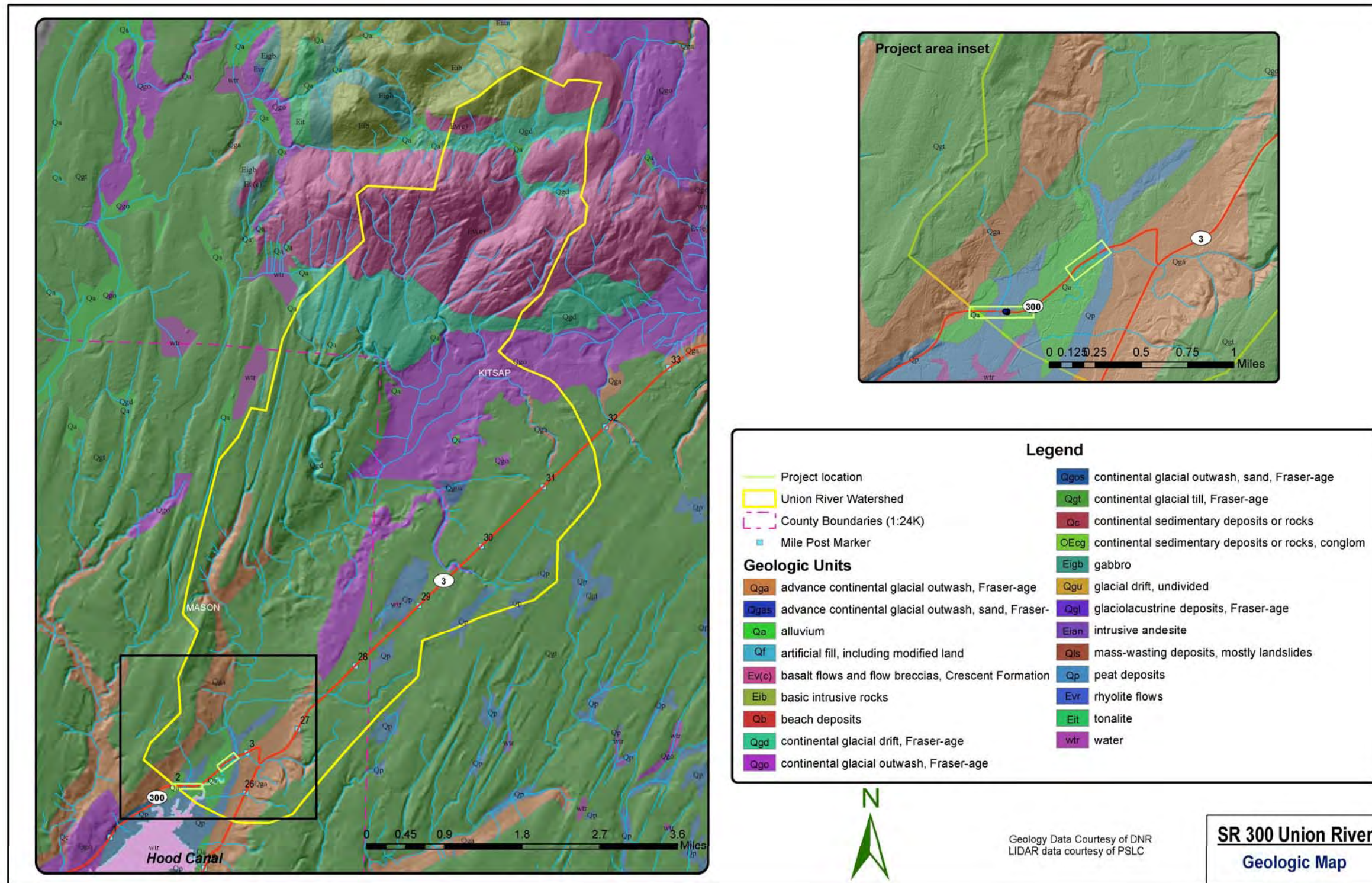


Figure 13. Geology of Union River Watershed.

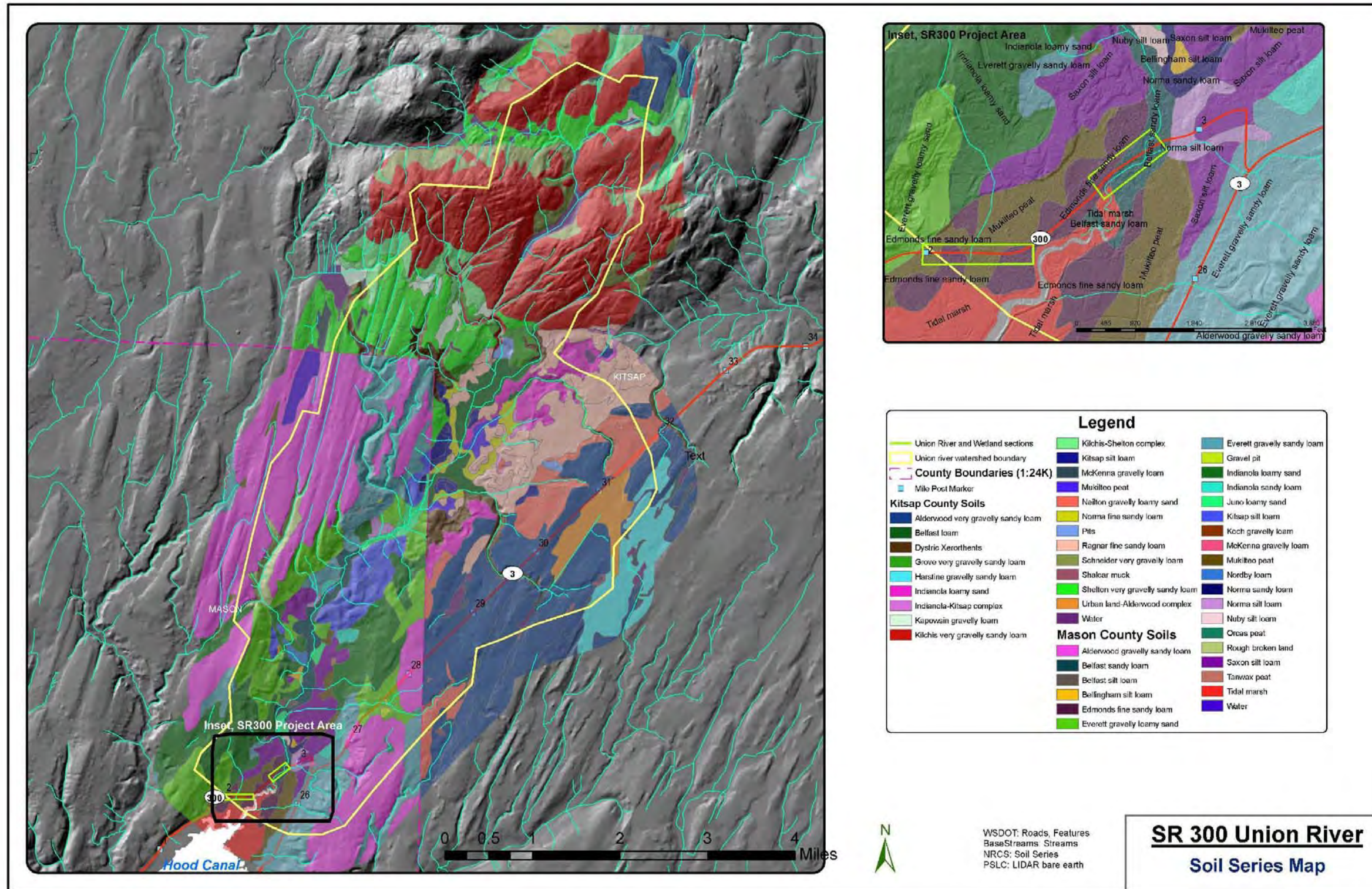


Figure 14. Soil series map of the Union River Watershed.

## Site and Reach Assessment, Union River At SR 300

### *4.2. Geology and Soils*

The upper portion of the watershed is underlain by Eocene volcanic rocks of the Crescent Formation (see Figure 13 for geologic details). These rocks consist of tholeiitic basalt flows, flow breccia, and volcanoclastic conglomerate; gabbro dikes and sills; locally contains thin interbeds of basaltic tuff, chert, red argillite, limestone, and siltstone; rare andesite, dacite, and rhyolite. The lower portion of the watershed is underlain by glacial drift, till, and outwash from the most recent advance and retreat of the Cordilleran Ice Sheet. Holocene alluvium is present in the floodplain of the Union River, and in the alluvial fans of small tributary streams entering the floodplain from the plateaus on either side. In both the Union River section and the wetlands section, the highway crosses peat deposits (see inset in Figure 13). Between the peat deposits, Quaternary alluvium (probably floodplain deposits of the Union River) are present. The floodplain is inset into advance glacial outwash.

Basin soils consist of a highly erodible mix of glacial outwash silt, sand, and gravel. Most eroded material is deposited near the river mouth as alluvial floodplain and mudflat sediments. Not surprisingly, soils of the project area are dominated by hydric soils, as shown in Figure 14. Soils of the area include shallow peat over gravel, tidal marsh (in the downslope direction), sandy loam in the river floodplain, and fine sandy loam at the base of the valley sidewall. The upper watershed is dominated by silt loam in the Gold Mountain area, and by gravelly loam on the plateaus. Reflecting the geology of the project site, the Union River floodplain soils are dominated by peat, indicative of the wetlands, and by sandy loam, which is indicative of the floodplain deposits (see inset in Figure 14).

### *4.3 Geomorphology*

The project reach is situated at the southern end of the Kitsap Peninsula. The Union River occupies the upper end of the Hood Canal trough. The trough was created by subglacial meltwater channels during the Vashon stade of the most recent glaciation (Booth, 1994). The Union River estuary forms the uppermost end of Hood Canal. The width of the floodplain of the Union River is nearly equal to the width of Hood Canal. The Union River is thus an “underfit” stream, in that the floodplain is relict of glacial processes, and not solely created by the river itself.

The Union River is a low gradient pool and riffle stream within the project area, according to the Montgomery and Buffington (1993) classification. Based on relatively uniform banks, sediment, and bedforms, the river appears to be in a state of dynamic equilibrium. Although slopes were not measured in the upper watershed, the topography indicates moderate to steep gradients in the bedrock (upper) portions of the watershed.

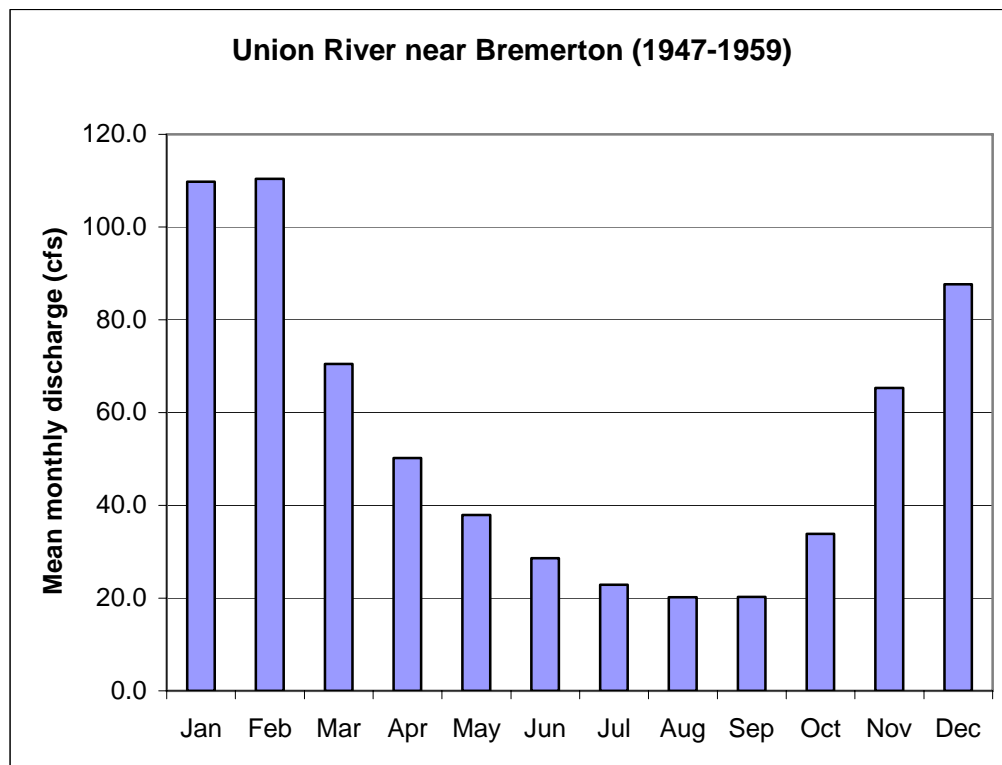
The channel substrate is a mixture of sand and gravel. Downstream of the bridge, sand is dominant, and gravel subdominant. Upstream from the bridge, gravel dominates and sand is subdominant. The largest observed particle size that was transported by the river was about eight centimeters in diameter. During the December 2007 flood, large gravel bedforms were deposited in various locations, most notably immediately downstream from the bridge. As evidenced by silt deposits in the floodplain, overbank deposition of fines occurs relatively frequently.

## Site and Reach Assessment, Union River At SR 300

Upstream and downstream from the bridge, the river is sinuous and moderately incised. The average bankfull width is estimated to be about 43 feet. Average bankfull depth is estimated at 4.2 feet, yielding a width to depth ratio of 9.6. No significant difference was observed between the river channel upstream and downstream of the bridge.

### 4.4 Hydrology and Flow Conditions

The Union River drains about 24 square miles of Puget Sound lowland and hills. The watershed is a rain-dominated system, not influenced by snowmelt or by rain-on-snow events. As such, the peak flows occur during the winter rainy season. The United States Geological Survey (USGS) maintained a gage approximately three miles upstream from the bridge for 12 years, between 1947 and 1959. The mean monthly hydrograph is shown in Figure 15. Because the gage location is upstream, and because the period of record is short, we used U.S. Geological Survey's StreamStats program to estimate the peak flows for the Union River at the SR 300 bridge; the results are shown in Table 1. The two-year flow event is about 700 cubic feet per second (cfs), while the 100-year flow is about 2000 cfs.



**Figure 15. Mean monthly hydrograph, Union River near Bremerton.**

Source: USGS gage 12363500.

The hydrology at the Union River bridge is complicated by tidal influences. While the tides at the project site are not precisely known, rapid rise and fall of the water in the stream channel was observed in the field. At Union, the location of the nearest historical tidal gage (NOAA Fisheries, 2003), tides are weakly diurnal, with a maximum tidal range of about 15 feet through the year (Table 2). Mean higher high water (MHHW) is about 12

## Site and Reach Assessment, Union River At SR 300

feet. While this provides the best available record of local tide elevations, these are subject to change, due to sea level change. We assume the apparent sea level trend in the Belfair area has been similar to the three millimeters per year that has been estimated for Seattle (Canning, 2001). Projections for Seattle include a sea level rise of about one foot by 2050 (Canning, 2001), taking into account subsidence. While there is uncertainty about the exact amount of sea level rise, planning for it is essential (Petersen, 2007). Planning for a range of sea level rise between 1 and 3 feet is suggested (Hugh Shipman, coastal geologist, Department of Ecology, personal communication, 2008).

**Table 1. Peak flood flow statistics for the project area.**

| Return interval (years) | Discharge (cfs) |
|-------------------------|-----------------|
| 2                       | 692             |
| 10                      | 1230            |
| 25                      | 1510            |
| 50                      | 1780            |
| 100                     | 1990            |

*Source: USGS StreamStats 2008*

**Table 2. Tidal statistics for Union, Washington**

| Datum Plane            | MLLW          | NGVD  | NAVD88 |
|------------------------|---------------|-------|--------|
| Highest Estimated Tide | 15.00 +/- 0.5 |       |        |
| Mean Higher High Water | 11.84         | 5.33  | 8.82   |
| Mean High Water        | 10.86         | 4.35  | 7.84   |
| Mean (Half) Tide Level | 6.93          | 0.42  | 3.91   |
| NGVD                   | 6.51          | 0     | 3.49   |
| Mean Low Water         | 3             | -3.51 | -0.02  |
| Mean Lower Low Water   | 0             | -6.51 | -3.02  |
| Lowest Estimated Tide  | -4.50 +/- 0.5 |       |        |

## Site and Reach Assessment, Union River At SR 300

During the December, 2007 flood, we were able to measure the water surface elevation at three locations: at cross-section one, upstream of the bridge; at the upstream side of the bridge; and at the downstream side. The water surface slope above the bridge was about 0.3 percent, while the water surface slope at the bridge was much steeper, at 1.2 percent. This indicates that the water is ponding against the bridge during high flows.

Between MP 2.0 and 2.7, wetlands are found on either side of the highway. A ditch that parallels the highway along the north side collects water from the wetlands. The water is carried eastward, first underneath Sandhill Road and then under SR 300. Beyond SR 300 there is a tide gate which leads to Hood Canal. On each of three field visits, flow in the ditch was estimated to be greater than one cubic foot per second. No discharge measurements were taken, however.

### ***4.5. Channel Alignment and Profile***

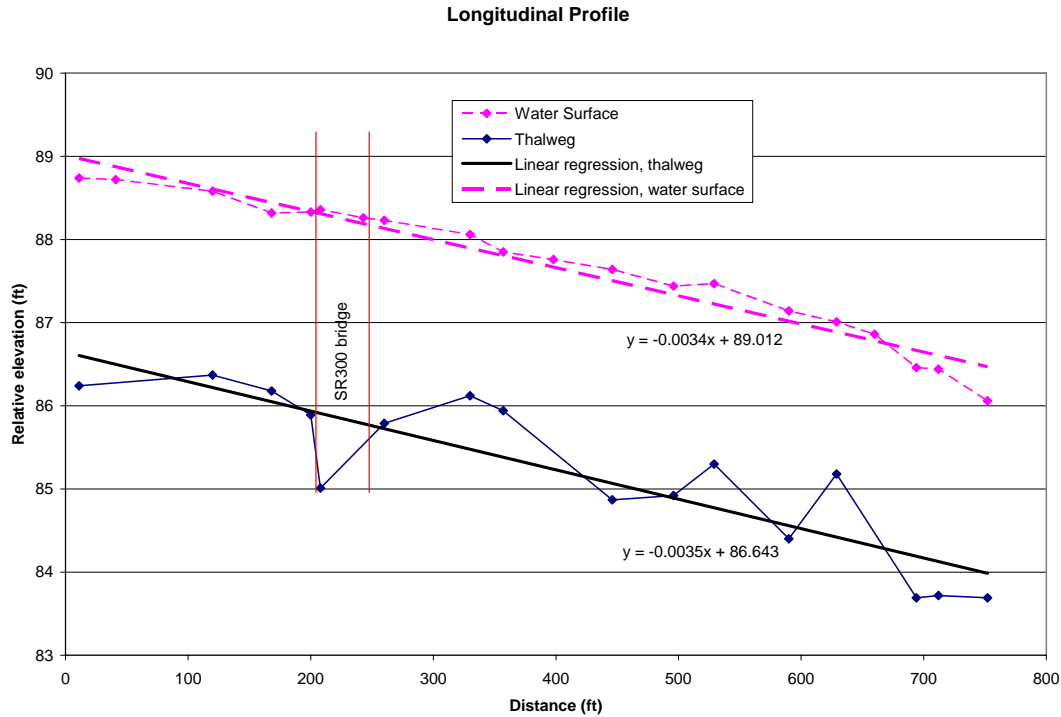
Using the historical shoreline survey (US Coast and Geodetic Survey, 1884), we were able to calculate the sinuosity of the river prior to extensive settlement of the area, and compare it to the present day sinuosity. For the reach extending 1500 feet along the valley axis, we calculated the 1884 sinuosity at 1.7, while the current sinuosity is 1.5. The curves that were present immediately downstream from the bridge seem to have been smoothed out, while those upstream and those farther downstream appear not to have changed significantly.

The longitudinal profile of the reach is shown in Figure 16. We fitted a trend line (based on linear regression) to both the water surface profile and the thalweg profile. The slope, based on the regression equation, is about 0.0035. The water surface slope was slightly lower, at 0.0034, however, this is within the amount of error associated with the survey technique used. Both the water surface slope and the thalweg slope increase rapidly at the downstream end of the surveyed profile. This corresponds to where the thalweg has migrated against the road prism. The thalweg profile also exhibits a drop at the bridge, suggesting constriction scour.

### ***4.8. Channel Migration and Avulsion Risk***

Based on the LIDAR imagery and aerial photographs, the highway crosses and parallels the channel migration zone of the Union River. The Holocene channel migration zone extends to the toes of the hillslopes flanking the Union River floodplain. These features are evident in the LIDAR imagery included in Figure 14. The Union River formerly migrated in a zone about 1600 feet wide. The historic channel migration zone is narrower, at about 500 feet. The highway crosses and parallels the historic channel, as discussed below.

## Site and Reach Assessment, Union River At SR 300



**Figure 16. Longitudinal profile, Union River at SR 300.**

There is some risk of channel avulsion in the project area. During the December, 2007 flood flow crossed over the highway upstream and east of the bridge. The thickness of the riparian vegetation may have prevented avulsion from occurring. Immediately upstream of the bridge the river makes a very sharp left turn, impinging on the road right-of-way embankment. At high flow, a side channel was observed on the floodplain terrace that arcs to the right then back to left, an indication that the river is in the process of flanking the bridge.

Figure 17 shows the channel planform change over time. The earliest available survey is from 1884 (US Coast and Geodetic Survey 1884). We compared the planform from the 1884 shoreline map to 2006 aerial photographs. The channel has not migrated a great deal in over 120 years. A maximum of 150 feet of channel change was measured from the channel migration map. The greatest amount of migration occurred at the outside of meander bends that had migrated in the down-valley direction.

Site and Reach Assessment, Union River At SR 300

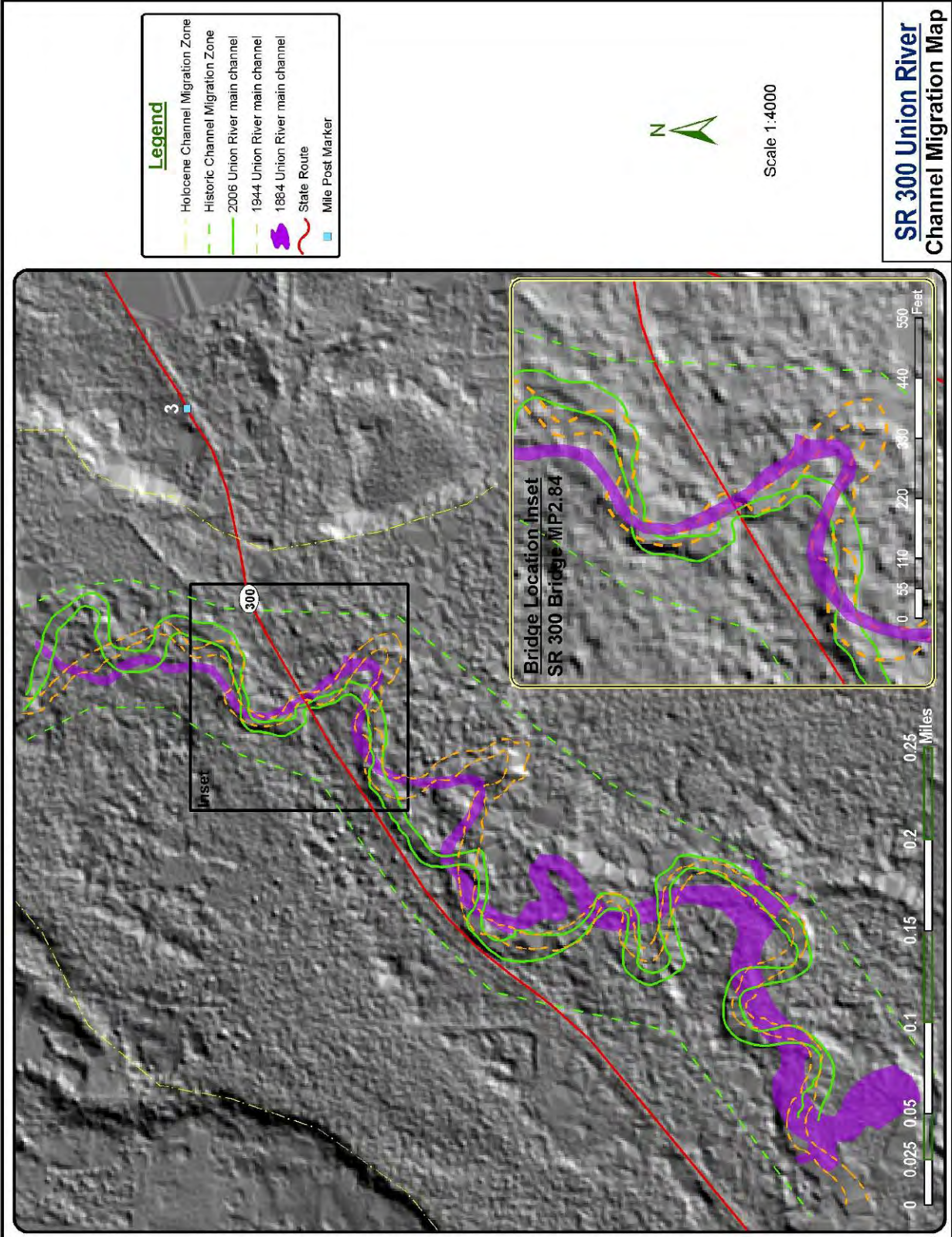


Figure 17. Union River Channel Migration 1884 to 2006.



## Site and Reach Assessment, Union River At SR 300

### 4.8. Local Scour

The right concrete abutment of the bridge has been scoured. During high flows on December 4, 2007, a strong jet of current was observed focused on the right pier. Ripraprevetment extends about 30 feet upstream of the right pier along the outside of a relatively small meander bend. The riprap has been undermined and has shifted.

The most recent bridge survey was conducted in 1994. The results are shown in Figure 18. While the survey done for this study is not at the same level of accuracy as those of 1994 and 1960, it is useful to show general patterns of scour and deposition. Surveying of the west abutment, a concrete wall, matched the 1994 survey quite well. The cross-sections show that over the last 48 years, the channel thalweg has migrated to the right, up against the western abutment. In addition, the channel appears to have aggraded by as much as three feet in places. It is also important to note that the western abutment was not part of the original design. There have been no reported scour problems at the bridge.

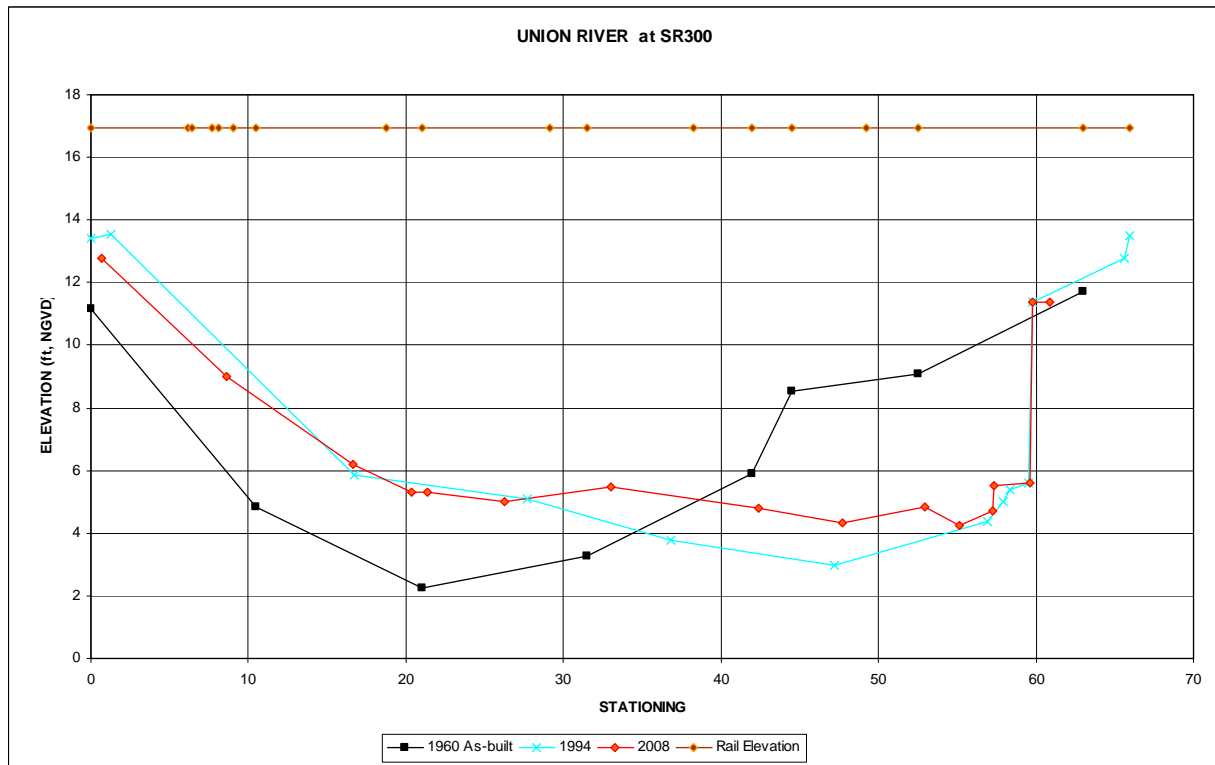


Figure 18. Cross-section changes at the Union River bridge, SR 300.

### 4.9. Riparian Conditions

Riparian canopy cover is between 40 and 80 percent upstream of the bridge. Cover decreases downstream as the influence of brackish water and tide levels increases. The canopy consists predominantly of Sitka spruce (*Picea sitchensis*), western red cedar (*Thuja plicata*), and red alder (*Alnus rubra*). The riparian zone is relatively healthy in this location. There are no recent disturbances upstream or downstream that affect riparian function.

## Site and Reach Assessment, Union River At SR 300

However, the riparian understory is dominated by noxious weeds. Invasive species include Japanese Knotweed (*Polygonum cuspidatum*), Scotch Broom (*Cytisus scoparius*), and lesser amounts of Himalayan blackberry (*Rubus discolor*).

The wetland section has minimal canopy cover, being mostly shrubs and herbaceous plants, although red alder are present in patches. Reed canary grass (*Phalaris arundinacea*) is present, but not at infestation levels.

### **4.10. Large Woody Debris (LWD)**

The project reach has relatively abundant woody material. LWD was not mapped for this study, but aerial photographs indicate a fairly wide, moderately intact riparian zone extending up from the bridge for at least a mile. The reconnaissance of the reach, which extended 2000 feet upstream and downstream of the bridge, found frequent key pieces of LWD, contributing to pool formation. These key pieces are allowing other pieces of LWD to accumulate and contribute to complexity. Just downstream of the bridge, the canopy structure begins to open up, as the forest gives way to tidal marsh. There is somewhat less LWD in this sub-reach. However, the recent floods (December, 2007) caused two clumps of western red cedar to fall into the channel. Maintenance records also indicate a steady supply of floating LWD, which has to be removed several times a year. Pieces of LWD in the stream are up to 100 feet in length, and up to three feet in diameter.

### **4.11. Water Quality**

The Union River basin is largely rural with few prominent urban areas or major point sources. Belfair is the largest urban area in the basin. Belfair is currently working to meet requirements of the Growth Management Act, which include sewerage. Casad Dam, located above McKenna Falls (a natural fish barrier), impounds the headwaters of the Union River to form the 93-acre Union River Reservoir in the upper watershed. The reservoir provides 65 percent of the drinking water for the City of Bremerton. The city maintains very strict water quality controls at the reservoir because it is one of the few unfiltered systems in the country. These water quality controls for drinking water area more restrictive than Washington State water quality fecal coliform standards. No public access is allowed in the Bremerton watershed above McKenna Falls.

The Union River is on Ecology's 303(d) list of impaired waters. It is listed for dissolved oxygen (Category 5), fecal coliform (Category 4A), Ammonia-N (Category 1), pH (Category 1), and temperature (Category 1). There are a total of 23 segments listed for water quality violations. A total maximum daily load (TMDL) study has been conducted (Ecology, 2001) on fecal coliform. A segment at and above the bridge is listed for fecal coliform. In addition, Lynch Cove, downstream from the reach, is listed for fecal coliform. Shellfish beds in Lynch Cove have been closed to harvesting by Ecology, due to fecal coliform levels (Ecology, 2001).

### **4.13. Fish Utilization and Habitat Availability**

This portion of the Union River has been designated as critical habitat for Hood Canal summer chum salmon (WDFW, 2006). However, it also is home to the Union River summer chum. Farther downstream, the river and estuary are designated as critical habitat for Puget Sound Chinook salmon (WDFW, 2006). The lower Union River also contains habitat for small runs of chum (fall), coho, cutthroat, and steelhead (Concurrent Tech-

## Site and Reach Assessment, Union River At SR 300

nologies Corporation, 2000). Lynch Cove contains shellfish beds. Table 3 indicates the species of salmonids present, and their status.

**Table 3. Salmonid utilization and stock/Endangered Species Act status for the assessment reach.**

| Species                                       | Run      | Utilization | SSASI Status | ESA Status |
|---|----------|-------------|--------------|------------|
| Chinook ( <i>Oncorhynchus tshawytscha</i> )   | Fall     | S*, R*, M*  | Critical     | Threatened |
| Coho ( <i>O. kisutch</i> )                    | N/A      | S*, M*      | Unknown      | Candidate  |
| Chum ( <i>O. keta</i> )                       | Summer   | S*          | Depressed    | Threatened |
|   | Fall     | S*          | Healthy      | None       |
| Pink ( <i>O. gorbuscha</i> )                  | Odd-year | Present     | Depressed    | None       |
| Steelhead ( <i>O. mykiss</i> )                | Winter   | S*, R*, M*  | Depressed    | None       |
| Rainbow Trout (resident) ( <i>O. mykiss</i> ) | N/A      | R*, M*      | N/A          | N/A        |
| Bull Trout ( <i>Salvelinus confluentus</i> )  | N/A      | H           | N/A          | Threatened |
| Cutthroat trout ( <i>O. clarkii</i> )         | N/A      | S*, R*, M*  | Unknown      | None       |

S = Spawning R = Rearing M = Migration H = Historic \* - indicates utilization at assessment site.

The wetlands along MP 2.0-2.7 are home to resident coast cutthroat trout, according to the WLRS (2008).

### **4.14. Wetlands**

Both sections of the site have considerable wetlands present. Figure 19 shows the wetlands from the National Wetland Inventory. This map gives a basic understanding of the types of wetlands present, and indicate the great extent of wetland in the project area.

Site and Reach Assessment, Union River At SR 300

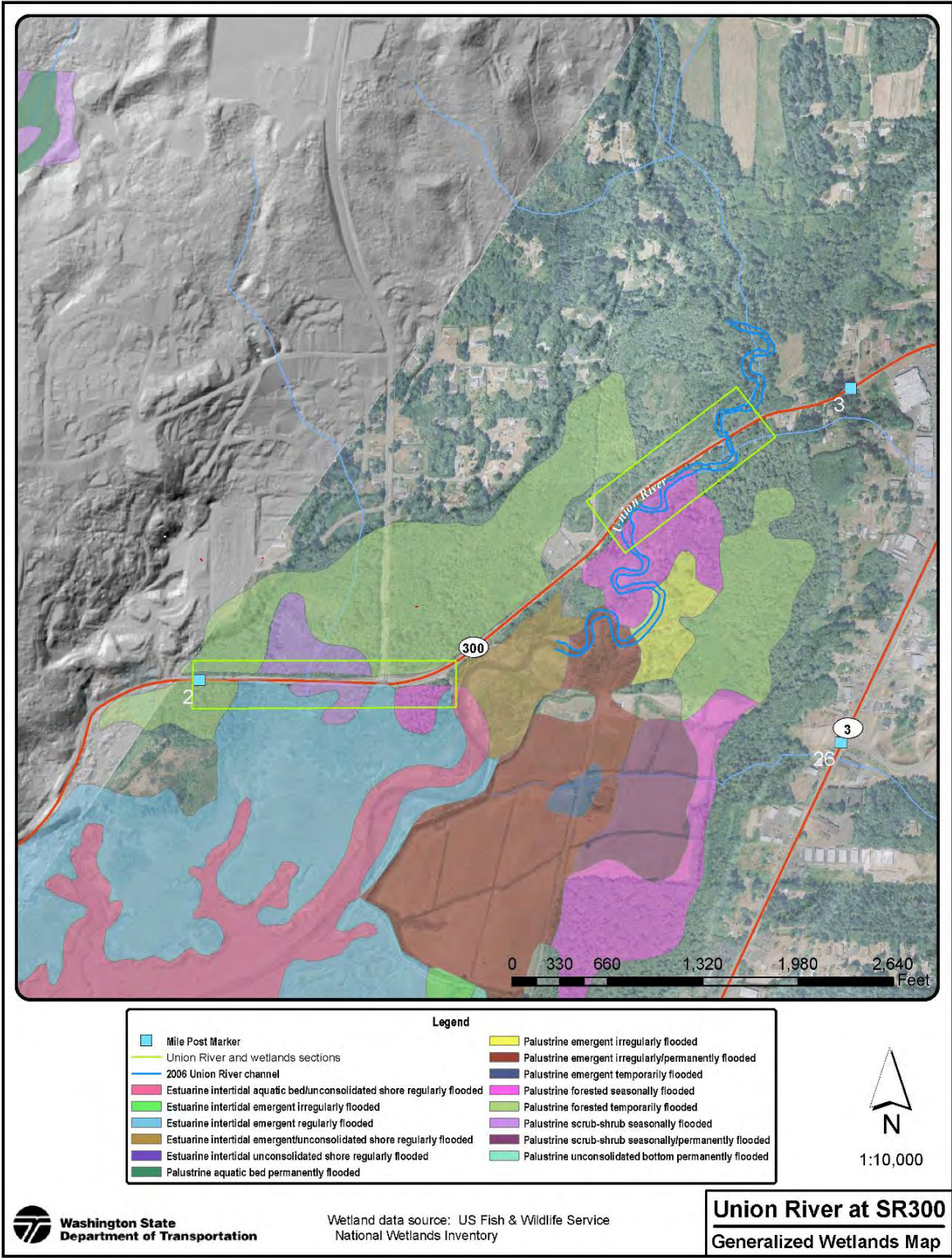


Figure 19. Wetlands and Hydric soils of the project area.

## Site and Reach Assessment, Union River At SR 300

In the wetlands section, the road prism is about 1.5 feet higher than the surrounding wetland area. Two cross-sections were surveyed across the highway; these cross-sections indicate that the bottom of the ditch on the north side of the road prism is at about the same elevation as the wetlands south of the road prism. At the time of the site visit, the water level in the ditch was up to three feet higher than ground level on the south side of the highway. There is also a distinct difference in vegetation between the two sides of the road. The south side of the road has slough sedge (*Carex lyngbyei*), while the north side is dominated by cattails (*Typha* sp.) and Nootka rose (*Rosa nutkana*). The wetlands on the south side of the highway are estuarine in nature, being affected by high tides coming in from Hood Canal. The wetlands on the north side of the highway appear to be more freshwater in nature. The GIS database indicates that a small stream feeds the wetlands from the hill above, adjacent to Sandhill Road.

The Union River section also has wetlands. These are primarily riverine wetlands (see Figure 19).

## **5.0. Evaluation of Treatment Alternatives**

### ***5.1. Mechanisms and Causes of Geomorphic Failure***

The first type of failure is not a geomorphic failure, but rather a design failure. The Union River bridge acts as a sieve for debris. The bridge deck is placed low, and the pilings are closely spaced. Additionally, the cottonwood tree immediately upstream from the bridge (see Figure 3) appears to help funnel wood debris toward the left bank during floods. The upstream meander is outflanking the constriction caused by the bridge and is impinging on the highway embankment. Furthermore, there is a risk of avulsion at the meander upstream from the right of way. Several small channels in the upstream floodplain aim at the highway east of the bridge. During the flood on December 3, 2007, the river flowed through these channels and over the highway immediately east of the bridge (see Figure 7).

The channel cross-sections indicate that aggradation has occurred at the bridge. This would compound the issues of debris-catching and flooding of the roadway, as there is still less room to pass debris, and the water levels are higher.

The second failure is the erosion of the embankment downstream from the bridge. The cause is ongoing channel migration, and the mechanism, or trigger, is debris spanning the stream channel, forcing side channels against the road embankment. The farthest side channel to the right impinges on the embankment, removing lateral support for the fill prism. The integrity of the pavement is threatened.

In the wetlands section of the site, interruption of the wetland flow paths and hydrology by the highway fill prism are the primary cause of flooding. In addition, the roadway surface is low, making it susceptible to flooding. The road base traverses a large wetland complex and is probably underlain by peat soils that provide a poor road foundation. Although no hydrogeologic data have been collected, it is likely that subsurface and surface flow used to be directed to the southwest. The highway was built perpendicular to the flow direction. There is only one culvert allowing water to pass to the southwest, and this is located after it flows underneath Sandhill Road. The road bed does not appear to allow any passage of water through seepage. Shortly after the flood of December 3, 2007, the water level on the north side of SR 300 was clearly higher than the south side. Along the north side, the drainage ditch was filled to capacity with water (see Figure 9).

Based on the profiles surveyed, extreme high tide (EHT) alone is enough to subject the roadway to flooding, without even considering the impacts of stormwater runoff.

### ***5.2. Site-Reach Based Failure Mechanism Interaction***

The placement of the road in the estuary of the Union River has set up this section of road for a number of problems. We suspect that the river may have been straightened immediately downstream from the bridge, during the construction of the highway. The river has since regained some of its sinuosity, but is likely to continue to erode the embankment at MP 2.79. Aggradation of the riverbed upstream of the bridge further reduces its ability to pass debris.

Notably, the effects of sea level rise will exacerbate the existing failure mechanisms. Sea level rise will affect flooding of the roadway directly, by inhibiting drainage of the wet-

## **Site and Reach Assessment, Union River At SR 300**

lands and river during storms. It will also affect flooding and lateral erosion indirectly due to aggradation. Aggradation that already occurs in the Union River estuary will increase because the base level (sea level) will rise.

## 6.0. Treatment Alternatives

### 6.1. Introduction and Objectives

This section presents a suite of alternatives that could potentially address both sections of the project. Allowing wood debris to pass is the primary means by which to minimize the maintenance issues at the bridge. However, there are several other issues which require attention. The erosion at MP 2.79 will require some form of bank protection. The tendency for flooding to occur east of the Union River bridge should be addressed.

The flooding that occurs on the western portion of the site occurs because of the location of the road in the wetland complex, and because of the low elevation of the road surface. The primary means to fix this problem would be to elevate the road, and allow water to pass. Re-routing the road through a different area would also abate the problem.

The primary objectives in any project to abate these problems are to:

- Minimize highway closures due to flooding.
- Minimize future maintenance costs.
- Ensure the safety and integrity of the highway.
- Maximize natural movement of sediment, woody-debris, and water through the reach.
- Maximize hydrologic connectivity in the Union River estuary area.
- Minimize impacts to listed and sensitive fish and wildlife species.
- Account for potential sea level rise.

Table 4 provides a summary of the alternatives considered, the advantages and risks, the potential habitat effects, and relative cost. Details follow below.



**Site and Reach Assessment, Union River At SR 300**

**Table 4. Alternative Comparison Matrix**

| <b>Location</b>                     | <b>Alternative</b>                       | <b>Description</b>   | <b>Advantages</b>   | <b>Risks</b>  | <b>Habitat Effects</b>   | <b>Relative Costs</b> |
|-------------------------------------|--|--|---|---|--|-----------------------|
| <b>Union River Section (bridge)</b> | No Action                                | Highway configuration remains the same; existing maintenance practices continue; mitigation required                     | No permitting   | Continued maintenance activity; more frequent road closures; avulsion; mitigation costs | Wood removed from system, incremental decrease in pool forming potential, downstream of brig   | Low (short term)      |
|                                     | Replace bridge                           | Remove existing bridge; replace with single span bridge 130 feet long; set bridge and approaches higher                  | Decrease frequency of debris removal; eliminate scour of footing  | Channel avulsion; continued maintenance of embankment downstream                        | Wood recruitment improved over existing conditions; temporary effects (turbidity) due to bridge construction                               | Moderate              |
|                                     | Replace bridge and elevate east approach | Remove existing bridge; replace with single span bridge 130 feet long; elevate east approach from base of hill to bridge | Decrease frequency of debris removal; eliminate scour of footing; eliminate threat of avulsion; allow for meander migration | Mitigation costs  | Wood recruitment improved over existing conditions; temporary effects (turbidity) due to bridge construction; increased channel complexity | High                  |

**Site and Reach Assessment, Union River At SR 300**

| <b>Location</b>                         | <b>Alternative</b>  | <b>Description</b>   | <b>Advantages</b>   | <b>Risks</b>  | <b>Habitat Effects</b>   | <b>Relative Costs</b> |
|---|---------------------|--|---|---|--|-----------------------|
| <b>Union River Section (embankment)</b> | No Action           | Highway configuration remains the same; existing maintenance practices continue; mitigation required                                     | No permitting   | Continued maintenance activity; more frequent road closures; avulsion; mitigation costs | Local decrease in riparian canopy cover and wood for recruitment; scour and higher velocity against embankment; local habitat simplification | Low (short term)      |
|   | Install ELJ groins  | Clear existing vegetation, rebuild embankment; install large wood flow deflectors in specific locations after hydraulic analysis         | Moves flow away from road embankment                          | Limited lifespan; aggradation could limit deflector effectiveness                       | Increase habitat complexity  | Moderate              |
|   | Install rock groins | Clear vegetation, rebuild embankment; install flow deflectors of appropriately sized rock in specific locations after hydraulic analysis | Moves flow away from road embankment; potential long lifespan | Permitting difficulty; aggradation could limit deflector effectiveness                  | Decrease habitat complexity  | Moderate              |

**Site and Reach Assessment, Union River At SR 300**

| <b>Location</b>  | <b>Alternative</b> | <b>Description</b>  | <b>Advantages</b>   | <b>Risks</b>   | <b>Habitat Effects</b>   | <b>Relative Costs</b> |
|------------------|--------------------|---|---|--|--|-----------------------|
| Wetlands section | No Action          | Highway configuration remains the same; existing maintenance practices continue; mitigation required  | No permitting   | Periodic road closures; closure frequency may go up with time              | Freshwater and estuarine wetlands remain cut off from each other           | Low (short term)      |
|                  | Elevate roadway    | Raise highway to appropriate level to avoid flooding (extreme high tide plus at least two feet); install culverts to allow drainage under roadway | Reduces flooding of highway; partially restores hydrologic connectivity | Highway may settle due to soil conditions; costly repairs may be necessary | Freshwater wetlands would have better connectivity with estuarine wetlands | High                  |

**Site and Reach Assessment, Union River At SR 300**

| <b>Location</b> | <b>Alternative</b> | <b>Description</b>  | <b>Advantages</b>   | <b>Risks</b>  | <b>Habitat Effects</b>   | <b>Relative Costs</b> |
|-----------------|--------------------|---|---|---|--|-----------------------|
| All locations   | Highway relocation | Construct new highway segment, crossing the Union River about 500 feet upstream | Permits passage of all debris and sediment; averts flooding of roadway; avoids damage to road prism from channel migration; minimizes potential effects of sea level rise; provides more contiguous wetland habitat | Some wetlands will be destroyed; may be self-mitigating | Restores habitat connectivity; restores hydrologic connectivity between wetlands; increases riparian habitat | High                  |

## Site and Reach Assessment, Union River At SR 300

### *6.2. Bridge Alternatives Considered, Union River Section*

#### *1) No Action*

This alternative would continue operations as they are now. During future storm events, additional erosion of the road embankment would be expected. Occasional repairs to cracked pavement would be needed. The highway would occasionally close due to flooding. The frequency of closure would likely increase over time, although the rate of increase is unknown. The risk of channel avulsion just east of the Union River bridge would not be addressed. With sea-level rise, aggradation of the Union River at the mouth could increase the risk of avulsion.

Under this alternative, all necessary actions to protect the road, such as excavation, and placement of rock, would be addressed under emergency conditions. Under these conditions, habitat impacts may occur that require subsequent mitigation or correction.

#### *2) Replace Union River bridge with single short span*

The Union River bridge could be elevated and replaced with a single span bridge. The wood piers would be removed completely from the stream bed; this would include removing the sawn-off piers from the previous bridge. The span length would be 130 feet, giving more clearance horizontally for LWD coming from upstream, and also allowing for channel migration from the right upstream side. The bridge deck elevation could be increased to give more clearance vertically, although the approaches on each side would need to be expanded as well, which would encroach further into the channel migration zone of the Union River. The underside of the bridge should be at an elevation at least seven feet higher than the current bridge, to allow for passage of floodwaters that can currently overtop the roadway, and to accommodate passage of LWD. One foot of sea level rise is accounted for in this recommended elevation. A more conservative approach would include 3 feet of sea level rise (Hugh Shipman, coastal geologist, Dept of Ecology, personal communication, 2008).

Replacement with a single span bridge would allow much larger cross-sectional area under the bridge deck through which wood and other debris could pass. However, the low point east of the bridge would probably still get flooded during storms, and the risk of channel avulsion would be moderate.

#### *3) Replace Union River bridge with single long span*

This alternative would include the removal of the existing bridge and construction of a new bridge. The bridge would include an approach from the east that would be elevated on concrete pilings so that side channel flow during floods would not cover the highway. The span across the river would be at least 130 feet, as suggested in the previous alternative. The elevated east approach would be approximately 330 feet. The elevation of the bridge would be the same as the previous alternative, a minimum of six feet above the existing elevation.

The bridge configuration under this alternative would allow debris to pass, prevent flooding of the roadway, would avoid effects of sea level rise, and could be designed to minimize the effects of possible future channel avulsion.

**6.3. Embankment Alternatives Considered, Union River Section**

*1) No Action (rock revetment)*

Under this alternative, standard maintenance and repair practices would be followed. The road embankment would be repaired by removal of fill dirt and installation of rock riprap, sized appropriately for the hydraulic conditions at the site. Riprap would protect the toe of the embankment from erosion due to the river. Mitigation would be required for loss of riparian habitat and/or wetlands. Installation of riprap would cause scour and transfer of stream energy downstream, accelerating erosion in areas not protected. Because there are several places where the river is encroaching on the road embankment, additional repairs, possibly extensive, would be anticipated. Aggradation of the river at this site could render these repairs useless.

*2) Install log groins/engineered log jams*

To address the erosion of the highway embankment downstream of the bridge, pieces of large wood (or engineered log jams) could be used as groins. Engineered log jams (ELJs) are collections of large woody debris that redirect flow and provide stability to a stream-bank. ELJs are designed to function in a manner similar to naturally occurring clusters of wood in streams. ELJs extend above the water surface even at bankfull depth. From the bank, ELJ groins project at a slight upstream angle into the channel. These groins function by redirecting flow away from the bank, helping to control erosion. Flow passes over and through the ELJ toward the center of the channel, reducing the water velocity near the bank. Sediment deposition occurs between groins, to a degree dependent on design and specific site conditions. ELJ groins could be installed at several locations along the threatened length of road embankment to change the momentum of the stream back toward the channel centerline. The groins would be appropriately sized and spaced, taking into consideration sediment transport, hydraulics, and tidal influences.

The sediment deposited between the ELJ groins would provide substrate for riparian plants, which would in turn help protect the embankment toe from erosion. Wood groins would cause local scour but maintain aquatic habitat complexity. ELJs also create cover for aquatic species. However, aggradation of the river at this site could reduce the effectiveness of ELJ groins. Additionally, some erosion of the opposite bank could occur, leading to complex interactions downstream.

*3) Install Rock Groins*

Rock groins would serve a similar purpose as wood groins, to protect the toe of the embankment and to redirect flow away from it. However, rock groins tend to simplify stream habitat due to the rigid nature and lack of vegetation. Rock groins provide little if any cover. Mitigation would be required for loss of riparian habitat and/or wetlands. Aggradation of the river at this site could reduce the effectiveness of the groins. Additionally, some erosion of the opposite bank could occur, leading to complex interactions downstream.

## Site and Reach Assessment, Union River At SR 300

### ***6.4. Alternatives Considered, Wetlands Section***

#### *No Action*

Under this alternative, the highway would remain as currently configured. Flood closures would continue and likely increase in frequency over the long term. Repairs to pavement and to maintain consistent grade would be needed periodically.

#### *Elevate roadway on fill and provide multiple wetland drainage structures*

Elevating the roadway would apply to the wetland section. This could restore hydrologic flow paths to their original direction. However, achieving this would either require building up the road base by several feet, or by building an elevated structure. An elevated structure is probably too expensive to consider seriously. Instead, we recommend elevating the road on fill and reestablishing hydrologic connectivity by installing appropriately spaced culverts or sets of culverts. To accommodate installation of culverts, the roadway surface would need to be elevated uniformly across this section of highway, to maintain constant grade.

However, raising the elevation of the highway by raising the embankment would necessitate filling of adjacent road prism to accommodate the increased height of the road embankment. To minimize grade changes at the intersection, Sandhill Road would also have to be elevated, causing additional filling of wetlands on either side of that road. Although the surveying conducted as part of this study should be considered as preliminary, it does indicate that the road surface would need to be at least 1.5 feet higher than it is now, and probably two feet or more higher if runoff is considered. The elevation of the road would need to be the height of the diameter of the culverts, plus two feet, for fill on top of the culvert. Considering the effects of sea level rise, extreme high tide could be 1 to 3 feet higher in the future. Culverts would need to be sized not only to take into account the runoff but also the change in sea level. If the culverts were 60 inches (which includes 3 feet for sea level rise), considering the extra fill required, the highway surface would be seven feet above the adjacent wetlands.

Depending on the hydrology of upstream, the highway would possibly need to be higher. To minimize the effect of the fill prism on adjacent wetlands, the road could be flanked by rock-filled gabions. However, this would add substantially to the cost of elevating the highway. Furthermore, the soils underlying the highway could prohibit the addition of further weight. These soils are wet and contain layers of peat. The geotechnical characteristics of the soils are unknown, but this type of soil is subject to settling when loads are applied. In fact, the low elevation of the highway may be a result of settling. If this is the case, the potential for settling, and major repairs, make elevation of the roadway using fill and gabions impractical.

### ***6.5. Road Relocation Alternative (Union River and Wetlands Sections)***

One alternative was examined that addresses both the Union River section and the wetlands section, road relocation. Road relocation would involve finding a new route that would cross the Union River farther upstream, and avoid impacting wetlands (see Figure 19). The road would be abandoned and the wetland section restored. The existing bridge would be removed. The highway east of the Union River bridge to the intersection with NE Old Belfair Highway would remain in place to provide local access.

Site and Reach Assessment, Union River At SR 300

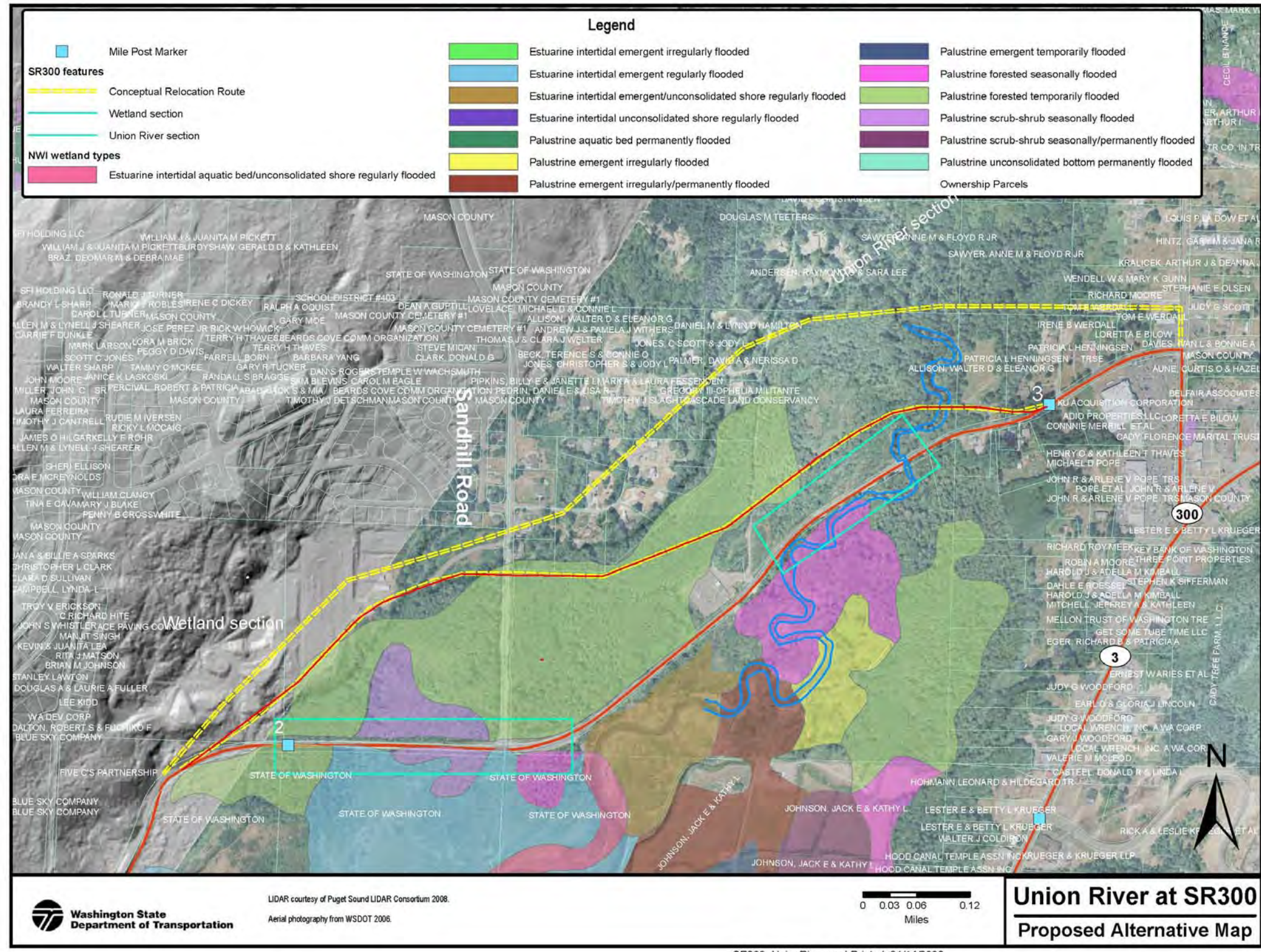


Figure 20. Preferred Alternative Conceptual Relocation





## Site and Reach Assessment, Union River At SR 300

Road relocation appears to be the best long-term solution. With its current location, the road will be subjected to continued flooding in the wetland section, and further attack from the Union River, both upstream and downstream from the bridge. Flooding around the east side of the bridge would also continue to be a problem. Furthermore, some amount of sea level rise is likely to occur in the future. Because the road is situated in an estuarine wetland, it will be subjected to more frequent flooding, with any amount of sea level rise. In addition, the Union River will begin aggrading, in response to sea level rise, which will make the stream channel unstable and likely accelerate erosion of the road embankment, and increase flooding in that section.

An example of road relocating is shown in Figure 20. A precise route for relocation would be obtained after extensive mapping of wetlands, discussions with property owners, examination of cut-and-fill, and other considerations. Relocation would involve property acquisition, disturbance of wetlands, construction of a new bridge, and extensive permitting. Along the conceptual route, there are a total of six landowners, a relatively small number. At this time, only information from the National Wetlands Inventory is available to assess the potential wetland disturbance. There are large areas of forested wetlands along the conceptual route, and likely along any practical route through the area. Although loss of forested wetland would occur with relocation, the project could be self-mitigating because of the wetland restoration and enhancement along the existing corridor. A new bridge would be constructed under this alternative, crossing the Union River upstream from the current bridge. This bridge would be adequately elevated, with a single span wide enough to accommodate large woody debris. Permitting such a route would include delineation of wetlands, wetland filling permitting, water quality permitting, and SEPA (possibly NEPA) documentation, among others. The permitting requirements, however, would not necessarily be more onerous than Alternative 4, above.

Road relocation would reduce or eliminate seasonal closures due to flooding, and minimize maintenance related to debris removal. Relocation would also minimize the effects of sea level rise on the highway. Additionally, removing the highway from the wetland section would restore connectivity between the wetland complexes. Between MP 2.3 to 2.9, both sides of the existing right-of-way are managed for wildlife (Washington Dept of Fish and Wildlife and the Cascade Land Conservancy). Removal of the highway from this area could improve conditions for wildlife (possibly reducing road kill), and provide a larger contiguous block of habitat.

### ***6.6. Preferred Alternative***

Highway relocation, while initially requiring significant capital, will provide the most benefit in the long term, through decreased closures, decreased maintenance costs, and improved habitat conditions. We recommend relocating the section of highway between about MP 1.8 and 3.0, similar to the route shown in Figure 20. The route location would be determined by balancing the cost and difficulty of construction, property acquisition, and permitting; for example, relocation of the highway farther to the north than shown Figure 20 could avoid most of the forested wetlands, but would require more property acquisition, and would involve more property owners.

## **7.0. Conclusions**

This investigation revealed that the main causes for maintenance issues along this section of SR 300 are flaws in the design and location of the highway. The bridge over the Union River is low in elevation relative to the stream bed, and contains two sets of in-stream piers. Combined with the abrupt change in flow direction upstream, and a large amount of recruitable woody debris, the bridge is set up to efficiently trap all large pieces of wood debris coming downstream. The road parallels the river's channel migration zone, and is being affected by erosion downstream from the bridge. Furthermore, the highway is subject to increased flooding, with incremental sea level rise, and also with continued aggradation on the Union River.

Relocating this portion of the highway, while involving substantial up-front investment, would reduce maintenance costs in the long term, improve fish and wildlife habitat, and likely would be self-mitigating.

## Site and Reach Assessment, Union River At SR 300

### 8.0. References

- Booth, D. B., 1994, Glaciofluvial infilling and scour of the Puget Lowland, Washington, during ice-sheet glaciation: *Geology*, v. 22, p. 695-698.
- Canning, D.J., 2001. Climate Variability, Climate Change, and Sea-level Rise in Puget Sound: Possibilities for the Future; Proceedings of 2001 Puget Sound Research Conference, Olympia, WA.
- City of Bremerton, 2008. <http://www.ci.bremerton.wa.us/display.php?id=730>.
- Concurrent Technologies Corporation, 2000. Kitsap Peninsula Salmonid Refugia Study, prepared for Kitsap County.
- Ecology, 2001. Total Maximum Daily Load Study, Dept of Ecology Report 1-03-038, Olympia, WA.
- NOAA Fisheries. 2003. On-line tidal data. <http://www.co-ops.nos.noaa.gov>.
- Petersen, A.W., 2007. Anticipating Sea Level Rise Response in Puget Sound; University of Washington master's thesis, 86 p.
- U.S. Geologic Survey. StreamStats. <http://water.usgs.gov/osw/streamstats>.
- Washington State Conservation Commission, 2004. Salmonid Habitat Limiting Factors report, Water Resource Inventory Areas 15 (West), Kitsap Basin, and 14 (North), Kennedy-Goldsborough.
- Washington State Department of Ecology. 2006. 2004 Statewide Water Quality Assessment 303(d) Report. <http://www.ecy.wa.gov/programs/wq/303d/2002/2002-index.html>.
- Washington State Department of Ecology. Shoreline Aerial Photos. <http://apps.ecy.wa.gov/shorephotos/>.
- Washington State Department of Fish and Wildlife. 2003. Integrated Streambank Protection Guidelines. Aquatic Habitat Guidelines Program. <http://www.wdfw.wa.gov/hab/ahg/ispgdoc.htm>.
- Washington State Department of Fish and Wildlife. 2006. Washington Lakes and Rivers Information System (WLRIS).
- Washington State Department of Highways, 1960. Layout drawing of Union River Bridge No. 21-C/1.
- Washington State Department of Transportation, 2006. List of endangered species in Washington. Environmental Services Office Biology website [http://www.wsdot.wa.gov/environment/biology/bio\\_esa.htm](http://www.wsdot.wa.gov/environment/biology/bio_esa.htm).
- Washington State Department of Transportation, 2006a. 2006 Fish Passage Inventory, Progress Performance Report.
- Washington State Department of Transportation. Bridge Engineering Information System (BEIST).