EVALUATION OF PRIORITY AREAS FOR RETROFIT

Hood Canal Regional Stormwater Retrofit Project

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CONTENTS

TABLES

FIGURES

Introduction

Stormwater runoff from developed land uses is a known cause of water quality degradation and associated adverse effects on aquatic habitat throughout the Puget Sound (Herrera 2011). The Hood Canal Coordinating Council (HCCC) is leading a study of stormwater management facility retrofits in the Hood Canal Action Area that can cost-effectively improve upon existing water quality problems in Hood Canal and its tributary streams. A secondary consideration in this effort is reducing high flows that erode stream channels and contribute to degraded water quality. Figure 1 presents a map of the Action Area, which comprises approximately 1,158 square miles. With such a large area to consider, it is necessary to begin by prioritizing geographic areas that should be the focus of the study. It would be cost-prohibitive and largely unnecessary to attempt to retrofit stormwater treatment and/or flow control facilities in much of the Action Area where stormwater runoff is not causing problems.

The goals of the overall study are important to bear in mind in evaluating priority areas in which to focus detailed retrofit analyses. As defined by the HCCC and its project partners in the Hood Canal Stormwater and Land Use Practices Workgroup (Workgroup), these goals are:

- Goal 1 – Develop a regional stormwater retrofit plan that will contribute to improving watershed processes and restoring impaired ecological functions, and to supporting economic health in the Hood Canal Action Area
- Goal 2 - Establish regional collaboration and coordination regarding stormwater retrofits within the Hood Canal region
- Goal 3 - Ensure that limited funding is directed to projects that deliver the best return on investment
- Goal 4 - Ensure that the Hood Canal Regional Stormwater Retrofit Plan is implementable and sustainable in the long-term
- Goal 5 - Develop a regional stormwater retrofit plan that serves as a model for other Puget Sound Action Areas
- Goal 6 – Provide the Hood Canal community with opportunities to see and understand the benefits of stormwater retrofits

This report presents an analysis of priority areas for further retrofit study based upon a three-step process that is summarized below.

Step 1

Overlay of the Puget Sound Characterization assessments for water quality (Stanley et al. 2011), freshwater habitat (Wilhere et al. 2011), and marine shoreline habitat (Wilhere et al. 2012) with estimated pollutant loadings in stormwater runoff to identify areas that should be prioritized for restoration of natural watershed processes coinciding with areas of relatively high stormwater pollutant loading. This step is a coarse-level screening based on consistent data applicable to a variety of land use types that exist throughout the Action Area.

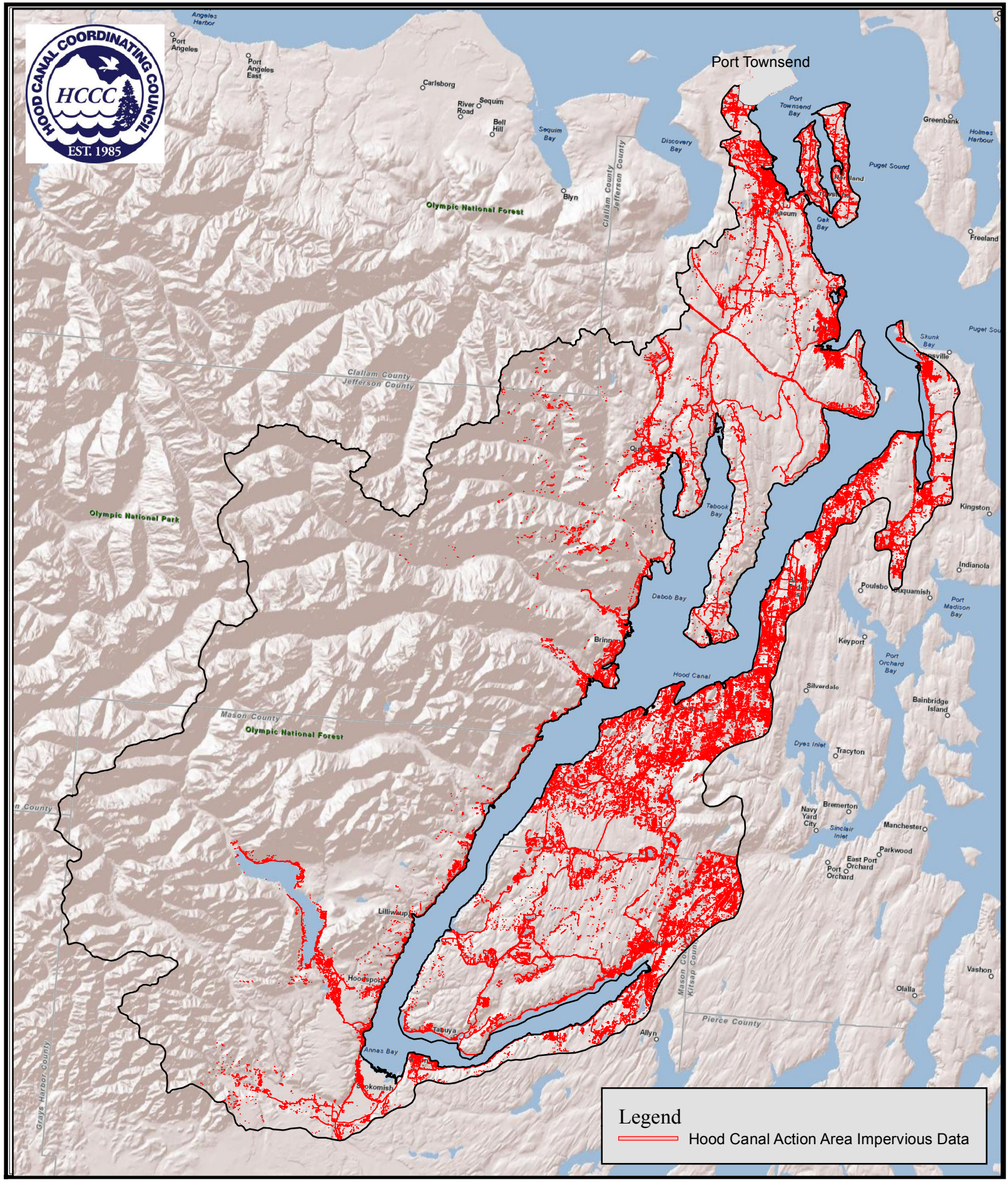

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Figure 1. Hood Canal Regional Stormwater Retrofit Project Map
Hood Canal Action Area

Cartographer: Luke Cherney 11/11/11

Step 2

Compare those geographic areas identified in Step 1 with the following receiving water characteristics:

- Clean Water Act Section 303(d) listings
- Benthic index of biotic integrity (B-IBI) scores
- Shellfish growing areas impaired by bacterial contamination
- Well-head protection areas for drinking water supply
- Failing on-site-septic system hot spots from Pollution Identification and Control (PIC) projects in the Hood Canal watershed

While still at a relatively coarse level, this step further refines the geographic prioritization to focus on drainage areas that may be contributing to significant receiving water problems and/or that could affect drinking water quality.

Step 3

Gather input from representatives of Mason, Jefferson and Kitsap counties on the areas identified in Steps 1 and 2 and to identify additional areas that should be targeted for further stormwater retrofit study based on local knowledge and concerns. The purpose of this step was to take advantage of local institutional knowledge that may provide a more accurate assessment of potential retrofit sites than the coarse-level analyses in Steps 1 and 2 in terms of understanding where stormwater runoff is degrading the environment.

The geographic areas defined via this three step process will be analyzed in a variety of ways to yield specific locations where stormwater retrofits are determined to be of most potential benefit relative to estimated implementation cost.

The remainder of this report presents the methods of analysis used in applying the three-step geographic prioritization process, followed by the analysis results, and then a brief discussion of recommendations and associated information that will be incorporated in ongoing retrofit analyses for the project.

Methods of Analysis

The specific methods of analysis and associated data sources used in each of the three steps followed to prioritize areas for further stormwater retrofit study within the Hood Canal Action Area are described below.

Step 1. Overlay Watershed Characterization Assessments with Stormwater Runoff Pollutant Loading Estimates

Overview of Watershed Characterization Assessment

The following is a brief overview of a recently developed characterization approach developed in a collaborative effort led by the Washington State Department of Ecology

(Ecology), the US Environmental Protection Agency, the Washington Department of Fish and Wildlife, and the Puget Sound Partnership (Stanley et al. 2011).

> "The Puget Sound Characterization is a set of water and habitat assessments that compare areas within a watershed for restoration and protection value. It is a coarse-scale decision-support tool that provides information for regional, county, and watershed-based planning. The information it provides will allow local and regional governments, as well as NGOs, to base their decisions regarding land use on a systematic analytic framework that prioritizes specific geographic areas on the landscape as focus areas for protection, restoration, and conservation of our region's natural resources, and that also identifies areas that are likely more suitable for development."

The water quality, marine shoreline, and freshwater habitat assessments created as analysis tools supporting this regional characterization approach were applied to this project. As a first step in the stormwater retrofit geographic area prioritization process, the results of these three assessments specific to the Hood Canal Action Area provided a uniform, unbiased foundation upon which to prioritize areas. The water quality and freshwater habitat assessments are performed at the scale of what are called Assessment Units (AUs), with each AU typically ranging in size from 1 to 10 square miles. The marine shoreline assessment is performed at the scale of shoreline segments, averaging 0.24 miles in length, and accounting for conditions extending 400 meters landward and 400 meters seaward, or the distance to extreme low tide, whichever is greater.

Water Quality Assessment

Those areas identified in the water quality assessment model as appropriate for "restoration" were considered higher priority for potential stormwater retrofits than those identified for protection, conservation, or development. As stated in the Puget Sound Characterization report (Stanley et al. 2011):"The most intensive strategies (broadly denoted "Restoration") apply to those AUs judged most important to restoring water-resource functions but that also have experienced the greatest degradation." The default water quality assessments can be used to evaluate watershed conditions at the Water Resource Inventory Area (WRIA) and Puget Sound scales. Ecology had not previously generated assessment results at the Action Area scale, and thus ran underlying models for just the Hood Canal Action Area for this project. While assessment results can be obtained for sediments, phosphorus, metals, nitrogen, and pathogens, for this study only metals, nitrogen, and pathogens (bacteria) were used, as these parameters are considered indicative of the types of water quality degradation occurring in Hood Canal and its tributary streams.

In the Puget Sound Characterization, the Hood Canal Action Area is represented by 325 AUs. Each of these AUs was assigned a score of 0, 1, 2, or 3 depending on the water quality assessment results; a score of 0 meant the results did not indicate the AU should be targeted for restoration for any of the three parameters modeled, and a score of 3 meant the AU should be targeted for restoration for all three of the parameters assessed. Scores of 1 or 2 were assigned to AUs for which one or two of the assessed parameters indicated they should be targeted for restoration. For more detail on the water quality assessment, see Appendix C to the Puget Sound Characterization report.

Marine Shoreline Assessment

The shoreline areas of Hood Canal and adjacent uplands near the shorelines are generally the most developed and thus collectively generate the majority of the stormwater runoff pollution in the Action Area. Thus, it is important to carefully consider marine shoreline habitats that may be impacted by stormwater runoff in this study. The purpose of the marine shoreline assessment component of the Puget Sound Characterization is to define the relative value of shorelines for the conservation of fish and wildlife habitats. The marine shoreline assessment uses extensive data for shoreline areas of Puget Sound and the Hood Canal to provide a credible indicator of shoreline conservation value (Wilhere et al. 2012). However, unlike results from the water quality assessment that were generated at the Action Area scale, results from the marine shoreline assessment are only available at the Puget Sound scale.

To develop the marine shoreline assessment, relative habitat values were assigned to each distinct shoreline segment based on ecosystem conditions for a variety of aquatic and wetland plant species and fish and wildlife species. These conditions were quantified based on nearshore processes and structures, such as sediment size, wave energy, nearshore topography, toxic pollution, beach profile, littoral drift, and water temperature. Marine shorelines with low habitat values indicate areas of shoreline degradation, moderate values indicate areas that are good candidates for shoreline restoration, and high values indicate areas where shorelines should be conserved due to high-performing natural functions. For more information on the technical basis for the conceptual model that yields these index values, see Wilhere et al. (2012)

The results of the marine shoreline assessment were overlain with the water quality assessment results to attempt to define upland areas of greater concern for water quality degradation that are draining to the highest quality Hood Canal shoreline habitats.

Freshwater Assessment

The freshwater assessment component of the Puget Sound Characterization seeks to define salmon habitat quality in a stream reach with consideration of processes occurring upstream and within the reach that affect habitat quality downstream. As stated by Wilhere et al. (2011): “assessing the conservation value of a particular reach entails both an assessment of conditions upstream and an assessment of habitats downstream. A stream reach is valuable when: 1) it contains valuable habitat, which is greatly influenced by upstream conditions; and 2) downstream reaches contain valuable habitat.” If stormwater runoff from a particular location within the Hood Canal Action Area drains to a stream reach that is defined as high quality habitat for salmonids, then that area should be a greater priority for potential stormwater retrofit than a comparable area that drains to a stream that has lower quality habitat, or that is not accessible to salmonids. Thus, the freshwater assessment results were used in combination with the water quality assessment results to define drainage areas of concern, at a coarse scale, for potential effects on salmon habitat.

The freshwater assessment is also applied at the AU scale as described above for the water quality assessment. It established a salmonid habitat index value from 1 to 10 for each AU, with 1 assigned to stream reaches with the least habitat conservation value and 10 assigned

to stream reaches with the greatest habitat conservation value. Like the marine shoreline assessment, results from the freshwater assessment are only available at the Puget Sound scale. For more information on the technical basis for the conceptual model that yields these index values, see Wilhere et al. (2011). Stream reaches in the Hood Canal Action Area with relative habitat conservation values between 7 and 10 were considered to be those of more importance for potentially reducing stormwater runoff impacts in their respective AUs. Screening to determine the stream reaches in approximately the upper third of the habitat quality spectrum was considered reasonable for this study.

Stormwater Runoff Pollutant Loading Estimates

Average annual stormwater runoff pollutant loadings were calculated for the entire Hood Canal Action Area based on land uses and available data characterizing pollutant loadings from those land uses. A geographic information system (GIS) database model was prepared to automate the pollutant loading calculations as a function of land use category and associated pollutant loading rates. The data sources used for land uses and pollutant loading rates are described below.

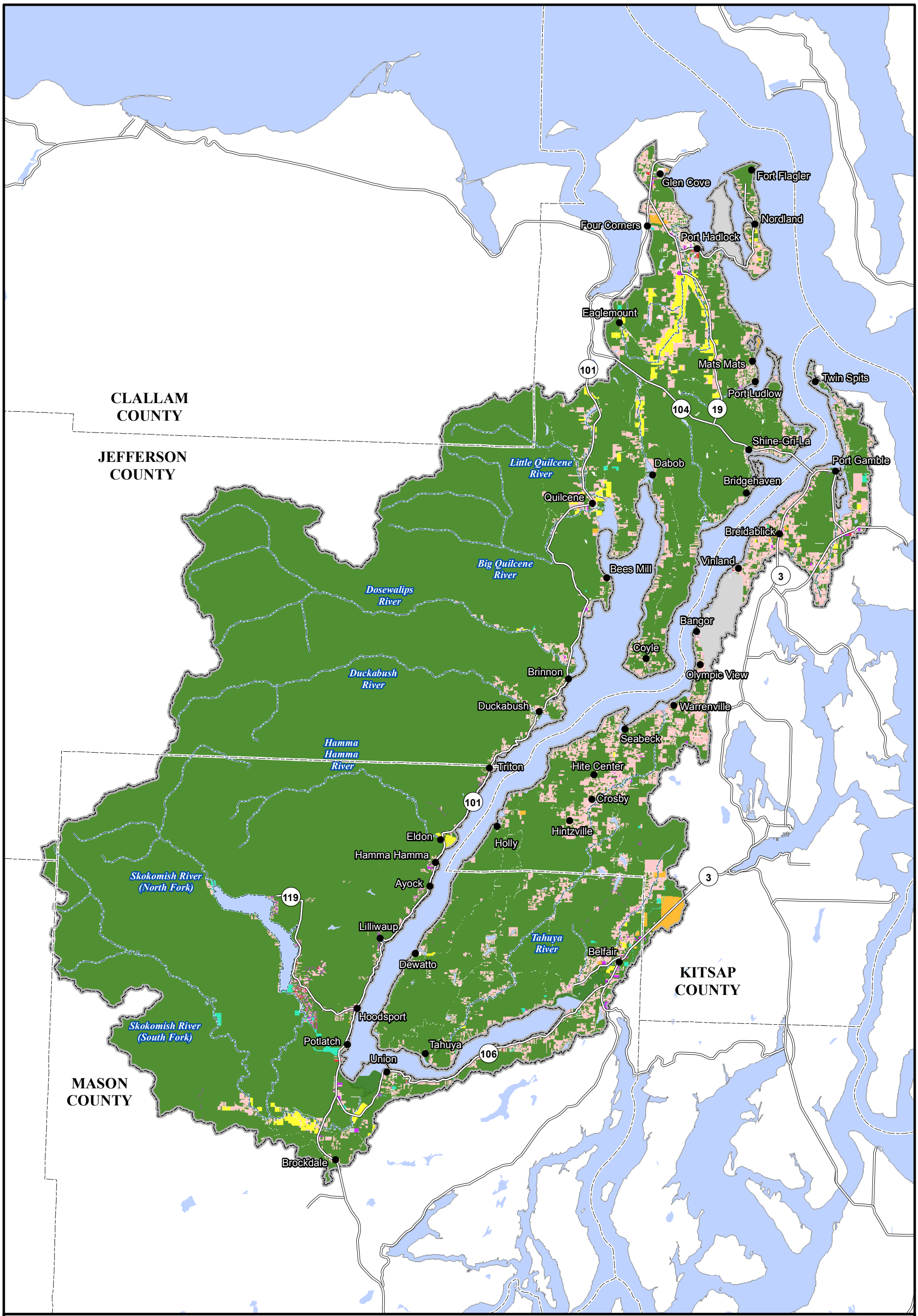
Land Use Categorization

The Hood Canal Action Area was classified into the following eight land use types to support this analysis:

- Agriculture
- Commercial
- Forest
- Governmental services
- Low density residential
- High density residential
- Industrial
- Transportation

These land use types were determined using 2010 parcel-scale land use data from the Department of Ecology that combines county parcel data, two-digit Department of Revenue (DOR) land use codes, and aerial photography to classify the Hood Canal Action Area into more than 60 detailed land use types. These categories were aggregated into the eight land use types listed above and then spot-checked against aerial photography for accuracy.

Figure 2 presents a map that breaks down the entire Action Area into these land use categories. Military lands – specifically Naval Station Kitsap – Bangor and Indian Island east of Port Townsend (shown as "Governmental Services" land use in Figure 2) were not included in the pollutant loading calculations or otherwise considered in the prioritization of areas for retrofit. This is because they are subject to other governmental regulatory programs and stormwater retrofits on military lands would not be pursued by HCCC or its non-military partners in the Workgroup.



Legend

- Town or city
- Highway
- River
- County boundary
- Hood Canal watershed boundary

Land Use (Ecology 2010)

- Agricultural
- Commercial
- Forest
- Governmental Services
- Low Density Residential
- High Density Residential
- Industrial
- Transporation

Figure 2. Land Uses in the Hood Canal Action Area.

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Pollutant Loading Rates

Existing stormwater monitoring data were used to develop estimates of average annual pollutant loadings (mass quantity per unit area) for each of the land use categories described above. Loadings from forest lands and agricultural lands were only calculated for fecal coliform bacteria because available loading data for the other pollutants from these land use types are lacking, and runoff pollution from forest and agricultural lands can be addressed in more effective ways than retrofitting stormwater controls. Fecal coliform bacteria loadings from these land uses were of interest for context in comparison to estimated loadings from the other land use types, at the larger scale of the entire Action Area. Although pollutant loadings in stormwater runoff from roadways are definitely a concern for receiving water quality degradation that they contribute to, roadway runoff loadings were not calculated separately from the surrounding land use because the roadside drainage systems are typically a conduit for runoff that is generated from surrounding land uses; therefore, monitoring data are generally not available for characterizing pollutant loadings from only the roadway surface (Herrera 2008).

Average annual loadings in stormwater runoff were estimated for the following pollutant parameters:

- Total suspended solids (TSS)
- Total nitrogen
- Total phosphorus
- Total copper
- Dissolved copper
- Total zinc
- Dissolved zinc
- Fecal coliform bacteria

These parameters were selected for the analysis because they are among the various pollutants known to be typically entrained in stormwater runoff in western Washington (Herrera 2005, 2011) and also because they are collectively representative of the types of pollutants that are causing water quality degradation in Hood Canal and its tributary streams. Total suspended solids (TSS) is often used as an indicator of stormwater quality because many of the pollutants typically found in stormwater runoff (e.g., heavy metals, organic pollutants) tend to bind to the particulate material carried in runoff. Excess nitrogen loading to marine waters can increase biological productivity in the water body that in turn causes depressed oxygen levels. Given the concerns for low dissolved in many areas of Hood Canal, nitrogen is an important pollutant to capture in this analysis. Similarly, excess loading of phosphorus to fresh waters can increase biological productivity in the water body that in turn causes depressed oxygen levels. Zinc and copper are common pollutants in urban and highway runoff and are known to be toxic to fish and other aquatic organisms (Davis et al. 2001; Herrera 2005; Kayhanian et al. 2008; Oregon Department of Transportation 2011). Portions of Hood

Canal are designated as impaired by the Washington State Department of Ecology due to elevated fecal coliform bacteria concentrations. High fecal coliform bacteria levels can trigger closure of shellfish growing areas for human health protection, as has happened in some areas of Hood Canal.

The contribution of any of these pollutants to stormwater runoff is a function of land use, drainage area, soil characteristics, natural (e.g., wetlands) or human-made features (e.g., a stormwater treatment facility) that can trap a portion of the pollutants before the stormwater reaches a stream or the Hood Canal shoreline. At the coarse scale of the entire Hood Canal Action Area, the pollutant loading analysis did not attempt to distinguish soil characteristics or features that may provide some form of pollutant capture (either incidentally or on purpose). Those two issues, in particular, will be addressed in subsequent phases of this study after the priority geographic areas have been defined and agreed upon by the Workgroup.

The pollutant loading data used in this analysis for commercial and residential land uses were taken from monitoring efforts performed in the region, specifically by the following NPDES Phase I municipal stormwater permittees:

- City of Seattle (2010 and 2011 annual monitoring reports submitted to Ecology)
- Clark County (2011 annual report)
- King County (2010 and 2011 annual reports)
- Port of Seattle (2009 and 2010 annual reports)
- Port of Tacoma (2010 annual report)
- Snohomish County (2010 and 2011 annual reports)
- Tacoma (2010 and 2011 annual reports)

All data collected in this effort was found online or through correspondence with a municipal permittee representative. All these data were derived from monitoring required pursuant to the NPDES Phase I Municipal Stormwater Permit (Ecology 2007) which required Phase I counties to sample stormwater runoff from outfalls draining representative areas for commercial, low density residential, or high density residential land use, and Phase I cities to sample stormwater runoff from outfalls draining representative areas for commercial, high density residential, and industrial land use. At least 80 percent of the area serving each monitoring site must be comprised of the appropriate land use type for the site to be considered representative of that particular land use. Each of the jurisdictions listed above submitted Annual Stormwater Outfall Monitoring Reports to Ecology during water years 2009, 2010, and/or 2011. Each jurisdiction was required to calculate event mean pollutant concentrations, total annual pollutant loads, and seasonal pollutant loads based on the pollutant concentration and total stormwater discharge for each storm event sampled. The pollutant loads (in pounds per acre per year) were calculated following the procedures outlined in Ecology's Standard Operating Procedures (Ecology 2009) or an Ecology-approved Quality Assurance Project Plan. Appendix A of this report includes data collected from the

Outfall Monitoring Annual Reports used in the pollutant loading model for the Hood Canal Action Area.

Although the Phase I permitees measured fecal coliform bacteria at the designated outfalls, most did not calculate the associated annual bacteria loads. Therefore, the pollutant loading model incorporated typical fecal coliform bacteria loads applied to different land uses based on a recent study in King County. The mean loading rates for fecal coliform bacteria listed in Table 1 (in billions of colony-forming units (CFU) per acre) were reported in the Water Quality Statistical and Pollutant Loading Analysis for the Green-Duwamish Water Quality Assessment (Herrera 2006). Note that these loading rates were measured in streams whereas the loading rates presented in Appendix A for other pollutants were measured in stormwater conveyance systems. Fecal coliform bacteria loading rates for stormwater conveyance systems may be higher than those presented in Table 1 because some dilution likely occurs after the stormwater has been discharged to a receiving water. Fecal coliform bacteria concentrations also typically exhibit a high degree of variability. This variability was not captured in the loading rates presented in Table 1.

Table 1. Fecal Coliform Bacteria Loading Rates Applied to Hood Canal Action Area.

Land Use Type	Fecal Coliform Bacteria (billion CFU/ac/year)
Residential [a]	154.44
Commercial [b]	276.76
Agriculture	116.39
Forest	11.37

[a] Originally described as low-density residential land use for the Green-Duwamish watershed.
[b] Originally described as high-density residential land use for the Green-Duwamish watershed.

The land use types in the Green-Duwamish Water Quality Assessment, which are specific to that watershed, were tailored to better fit land use types within the Hood Canal Action Area. Specifically, land use types categorized as low-density residential and high-density residential in the Green-Duwamish Water Quality Assessment are better represented by residential and commercial land use types, respectively, in the Hood Canal watershed. The Green-Duwamish Water Quality Assessment generally provides representative data for estimating fecal coliform bacteria loading rates from the Hood Canal Action Area from common sources in these land types (e.g., pet wastes). However, it should be noted that centralized systems are typically used for wastewater treatment in the Green-Duwamish watershed whereas septic systems are prevalent in the Hood Canal Action Area. Therefore, fecal coliform bacteria loading rates in surface drainage in the Hood Canal Action Area may be underestimated in this analysis in areas where failing septic systems are common.

Step 2. Receiving Water Characterization

The various bays and shorelines within Hood Canal and Puget Sound (at the northern tip of the Action Area) and tributary streams draining to these marine waters were characterized based upon the following sources of information:

- Clean Water Act Section 303(d) listings published by the Washington State Department of Ecology (Ecology), specifically those resulting from Ecology's 2010 Marine Water Quality Assessment. Waterbodies on Ecology's 303(d) list are degraded, and thus could benefit from stormwater retrofit(s) in the tributary drainage area.
- Impaired shellfish growing areas associated with bacterial contamination (Washington State Department of Health 2012). Shellfish growing areas are closed if a sanitary survey indicates fecal matter, pathogenic organisms, or poisonous and harmful substances are present and may pose a threat to human health if consumed. A waterbody on the Section 303(d) list that also has an impaired shellfish growing area suggests a greater need for stormwater quality improvement or treatment prior to runoff entering the waterbody.
- Designated wellhead protection areas. Wellhead protection areas are designated zones around drinking water wells in which land use activities are regulated to protect groundwater quality. If a potential pollutant source is located in close proximity to the wellhead protection zone, this area may be considered a priority for stormwater quality improvement.
- Benthic index of biotic integrity (B-IBI) scores (Puget Sound Stream Benthos 2013a). The benthic index of biotic integrity (B-IBI) quantitatively compares the biological condition of streams. A higher score represents an undisturbed stream with high diversity of species and predators. Each B-IBI score is associated with one of the following biological conditions: excellent, good, fair, poor, or very poor (Puget Sound Stream Benthos 2013b). Pollutants and/or high flows in stormwater runoff are often stressors that reduce the presence of benthic organisms in streams.

The relative value and thus priority of stormwater retrofits in different geographic areas within the Hood Canal Action Area identified in Step 1 were refined by evaluating their proximity to receiving waters with characteristics described above.

Jefferson County, Mason County and Kitsap County have identified Pollutant Identification and Correction (PIC) areas, which are locations where fecal coliform bacteria pollution is occurring due to failing septic systems and inadequate animal waste management. While these areas are of definite concern for adverse effects in Hood Canal and some of its tributary streams, the identified areas are typically on the scale of a single residence or a few residences. After review of these reports it was determined that they will aid in the prioritization of smaller scale pollution control efforts, but are not useful for defining larger areas for focusing stormwater retrofits in this project. Therefore, the PIC reports and related information generated by the three counties were not factored into Step 2.

Step 3. County Input

A preliminary map displaying the results of Steps 1 and 2 was shared with Chris May of Kitsap County, Loretta Swanson of Mason County, and Donna Frostholm of Jefferson County (each of whom are members of the Workgroup) to get their reaction on whether all areas that they are concerned about in regard to potential, probable, or certain stormwater runoff impacts on receiving water quality and habitat were captured in the resultant prioritization. This review

resulted in the addition of numerous, relatively small areas being added to create a final map of prioritized areas for further stormwater retrofit study as described in the following section.

Results

The step-wise results of the geographic area prioritization process for further stormwater retrofit analysis are described below.

Step 1. Overlay Watershed Characterization Assessments with Stormwater Runoff Pollutant Loading Estimates

A map showing the overlay of Puget Sound Characterization model outputs for water quality and freshwater habitat assessments is provided in Appendix B. The water quality assessment results reflected on that map were specifically run by Ecology for the Hood Canal Action Area to support this project. The freshwater habitat assessment results reflected on that map are taken from a Puget Sound-wide analysis.

As it turned out, the marine shoreline habitat assessment did not add any value or clarity to designating priority retrofit areas and therefore the map for this portion of the assessment is not included in Appendix B. However, it is of interest to note some of the findings of this assessment. The marine shoreline assessment for Hood Canal resulted in the following shorelines being defined as having the highest habitat value (Wilhere et al. 2012):

- Mouth of Quilcene River and Quilcene Bay
- Mouth of Dosewallips River
- Mouth of Skokomish River and Annas Bay
- Mouth of Duckabush River
- Coves east and west of Sun Beach along the north shore of the "hook" near Belfair

Maps depicting the results of the pollutant loading calculations are included in Appendix B. The majority of the Hood Canal Action Area is dominated by forest, with some pockets of agricultural areas in the north and south. Most of the residential, commercial, and industrial development is in the eastern side of the watershed spanning from Union to Port Gamble, paralleling the shoreline along the west side of the Hood Canal between Union and Quilcene, and in the upper tip of the western portion of the watershed near Port Hadlock and Port Ludlow. As expected based on the available pollutant loading data incorporated in these calculations, the greatest pollutant loadings are coming from these areas of denser development.

There is general agreement in the upland areas identified for restoration and habitat conservation in the Puget Sound Characterization assessment outputs for water quality and freshwater habitat and in the pollutant loading model prepared for this project. The five marine shorelines deemed of most value within the Action Area are also generally located near these resultant upland areas of concern, with the exception of the shoreline in the Sun Beach area. Thus, the outcome of this coarse level analysis step, relying upon modeling

methods, is definition of eight distinct geographic subareas within the entire Action Area that should be carried forward to the next step. These are listed in Table 2, with unique identifiers beginning with the letters J, K, and M in relation to their locations within Jefferson, Kitsap, and Mason counties, respectively. Some areas of moderate development density and associated pollutant loadings, such as in the Skokomish River valley southwest of Union, are not included in these priority geographic subareas because they do not score higher for habitat restoration focus in Ecology's watershed assessment model results.

Step 2. Receiving Water Characterization

The receiving water concerns associated with each of the eight areas that were identified in Step 1 are listed in Table 2. As can be seen in this information, the results do not reveal notable differences that would be cause for clearly eliminating some of the eight areas, nor for clearly prioritizing some for greater emphasis in ongoing work of this project. Maps showing receiving water areas with Section 303(d) listings, wellhead protection areas, and shellfish closure areas due to bacterial contamination within the Action Area are provided in Appendix C. Two of the eight areas, J1 and J2, are not associated with any specific concerns for receiving water characteristics. However, neither of these two should be removed from consideration for the following reasons:

- Area J1 is sandwiched between the mouths of the Duckabush and Dosewallip rivers. These are among the highest quality marine shoreline habitats in the study area, warranting careful consideration of options to reduce stormwater pollutant loadings to the nearshore environment
- Area J2 includes Port Ludlow, which is the one distinct urban area of Jefferson County within the Action Area for which previous comprehensive stormwater management planning has been done (Gray & Osborne 2003) to address stormwater quality and quantity concerns for receiving water protection and drainage infrastructure operations and maintenance.

Therefore, it is recommended that each of the eight areas listed in Table 2 be carried forward for further stormwater retrofit study in this project.

Step 3. County Input

Following review of preliminary Step 1 results, areas of concern for known or potential stormwater runoff impacts identified based on County input provided to HCCC were considered independent from the results of Step 2. These areas were added to create a final list of priority areas to be carried forward (Table 3 and Figure 3). The additional areas to be considered based on County input are briefly summarized below.

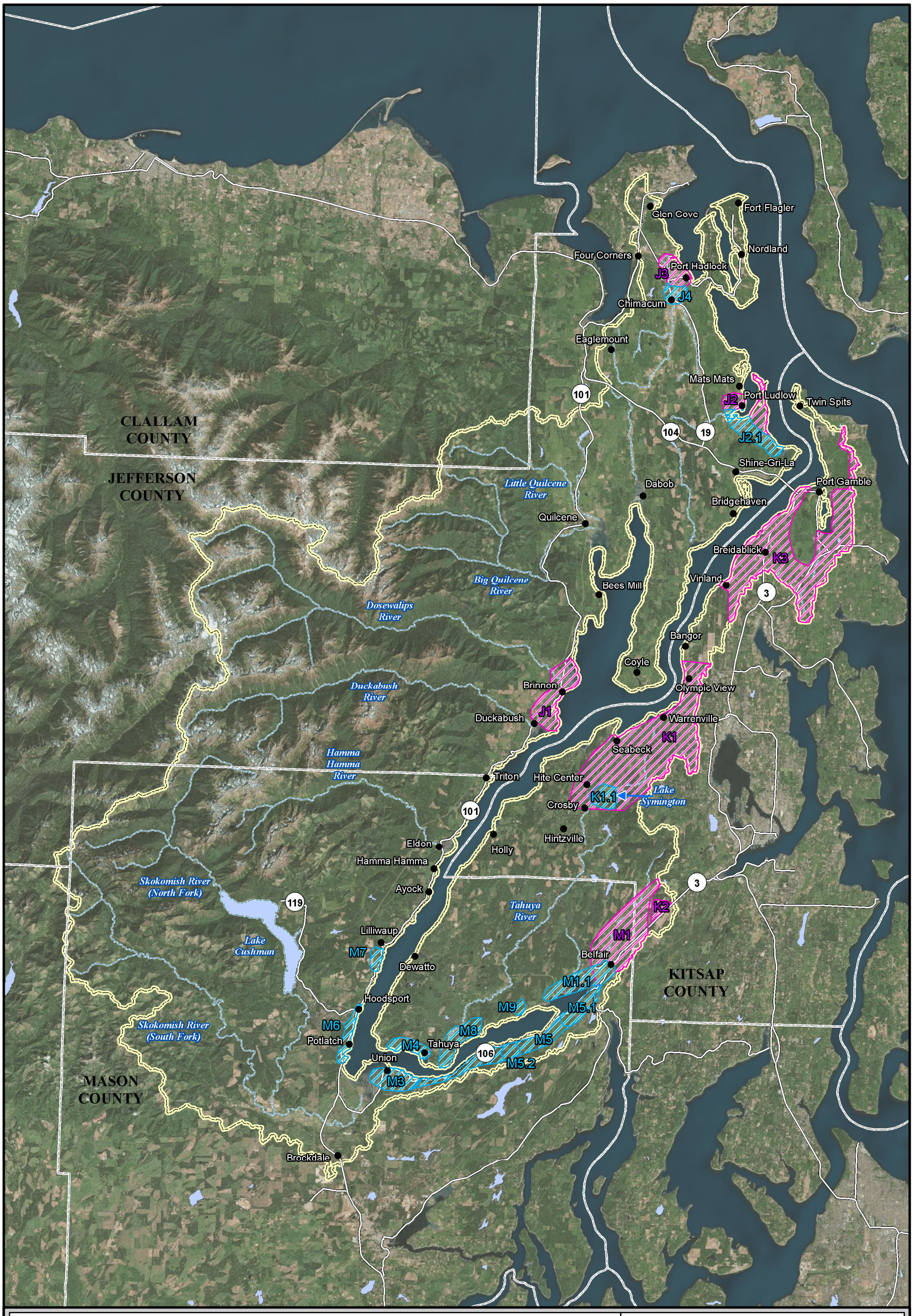
Jefferson County

- Area within the community of Chimacum
- Area southeast of Port Ludlow

Table 2. Preliminary Areas Identified for Stormwater Retrofits Resulting from Step 1.

ID	Priority Area Description	303(d) Listed Waterbodies Within Priority Area [a]	303(d) Listed Areas of Hood Canal Downstream of Priority Area [a]	Drains to Impaired Shellfish Growing Area [b]	Drains to Stream with Impaired B-IBI Score	Priority Area Contains Well Head Protection Area(s) [d]
M1	Community of Belfair to north in Union River valley	• Union River – Dissolved Oxygen • Deveraux Creek – Fecal Coliform • Holyoke Creek – Fecal Coliform • Trails End Creek – Fecal Coliform • Little Mission Creek – Fecal Coliform • Great Bend/Lynch Cove – Fecal Coliform	• Great Bend/Lynch Cove – Fecal Coliform	No	• Hood Canal Basin – Fair/ Poor	Yes
K1	Community of Seabeck vicinity, extending north to Warrenville and south to Lake Symington area	• Big Beef Creek – Temperature • Seabeck Creek – Dissolved Oxygen	• Hood Canal (South) – Dissolved Oxygen	No	• Seabeck Creek – Fair/ Poor	Yes
K2	Port of Bremerton Industrial Park west of Bremerton Airport	None	• Union River, North E.F. – Dissolved Oxygen • Great Bend/ Lynch Cove – Fecal Coliform	No	No	No
M2	Community of Hoodsport to Lake Cushman	None	• Great Bend/ Lunch Cove– Dissolved Oxygen • Skokomish River – Fecal Coliform	No	• Enatai Creek – Fair/ Poor • Skokomish River Basin – Fair/ Poor	Yes
J1	Area encompassing Brinnon and extending to Duckabush	• Dosewallips River-- Temperature	None [c]	No	No	Yes
J2	Port Ludlow southeast to Bywater Bay	None	None	No	No	Yes
J3	Port Hadlock	• Chimicum Creek – Temperature, Fecal Coliform	None	No	No	Yes
K3	Area north of Naval Base Kitsap - Bangor wrapping around the east and west sides of the northern tip of Kitsap County	• Martha-John Creek – Dissolved Oxygen • Jumpoff Joe Creek – Dissolved Oxygen • Gamble Creek – Temperature, Dissolved Oxygen	• Hood Canal (North)– Dissolved Oxygen	No	No	Yes

Notes:
[a] Only Category 5 section 303(d) listings considered in this analysis.
[b] Impaired shellfish growing areas only considered if due to fecal coliform contamination or another water quality concern linked to stormwater runoff.
[c] The marine shorelines at the mouths of the Duckabush and Dosewallip rivers adjacent to this area are among highest quality shoreline habitats in Hood Canal.
[d] 10-year wellhead protection areas occupying a significant portion of land within priority area.



Legend

- Areas identified based on Ecology Watershed Characterization and pollution loading overlay
- Areas identified based on local stakeholder input
- Town or city
- Highway
- River
- County boundary
- Hood Canal watershed boundary

Figure 3. Priority Areas Identified for Stormwater Retrofits Based on Puget Sound Characterization Methods, Pollutant Loading Model, and County Input.

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Table 3. Additional Areas of Concern for Stormwater Runoff Impacts Identified by Jefferson, Mason, and Kitsap County Representatives.	
ID	**Area Description**
M3	Union
M4	Tahuya area
J4	Chimacum area south of Port Townsend
M5	Southern shoreline of Hood Canal between Union and Belfair
J2.1	Area southeast of Port Ludlow where relatively high pollutant loadings estimated
K1.1	Lake Symington area
M6	Hoodsport to boat launch south of Potlach (not inlcuding area around Lake Cushman)
M7	South of Lilliwaup to Miller Creek along US Highway 101
M5.1	South shore: from Trails End Road to E. Rasor Road
M5.2	South Shore: Twanoh Falls area along State Route 106
M8	North shore: lower Tahuya River valley
M9	North shore: on the Tahuya peninsula along Landon Road
M1.1	North shore: on the Tahuya peninsula from NE Sandhill Road to NE Belfair-Tahuya Road

Kitsap County

- Development surrounding Lake Symington

Mason County

- Area within and immediately surrounding the community of Union
- Area between the community of Hoodsport and the boat launch south of the community of Potlatch
- Area south of the community of Lilliwaup to Miller Creek along US Highway 101
- Development along E. Rasor Road corridor east of Trails End Road, to the south/southwest of Belfair
- Development along State Route 106 corridor paralleling the south shore of Hood Canal in the Twanoh Falls area
- Three areas on the Tahuya Peninsula: 1) E. North Shore Road corridor from the mouth of the Tahuya River to the mouth of Shoofly Creek, 2) Landon Road corridor west of Belfair, and 3) area between NE Sandhill Road and NE Belfair-Tahuya Road
- Additionally, upon further consideration Mason County determined that area M2 should be removed from retrofit analyses (L. Swanson, personal communication, February 28, 2013). This is because most of the development within this area is tributary to Lake Cushman or Lake Kokanee. Retrofitting stormwater facilities in this area would likely have minimal effects on downstream flow rates or water quality given the size of these two reservoirs.

Discussion

Based upon a coarse scale screening process using modeling approaches supplemented by local knowledge and concerns, numerous areas are recommended for subsequent stormwater retrofit analysis in the Hood Canal Action Area. The next phases of analysis will include characterizing stormwater infiltration potential, gathering additional information at finer spatial scale as may be available from the counties and other entities, and field reconnaissance of candidate retrofit sites within the targeted areas listed in Tables 2 and 3. It is recommended that agricultural lands located within these geographic subareas not be targeted for potential stormwater retrofits because runoff impacts associated with agricultural practices are generally best handled through pollutant source reduction, rather than treatment or flow control, and other regulatory and educational programs are already being implemented for those lands.

It is important to reiterate that the analyses described in this report did not specifically focus on highways or other roads. The effects of roads are implicitly captured within the Puget Sound Characterization assessment models and pollutant loading estimates used in Step 1, but specific sections of roads or highways that could be quite important in the context of selected stormwater management retrofits cannot be identified using these tools. Some road corridor segments were identified in Step 3 based on County input, and will thus be evaluated in the ongoing work of the project. However, other road segments within the Action Area have not been defined as specific locations to focus on. At the time this report was written, the Washington State Department of Transportation (WSDOT) was in the midst of completing a study to prioritize locations in the highway network around Puget Sound where stormwater treatment retrofits could have the most benefit relative to cost. Preliminary results of WSDOT's prioritization process indicate that there are numerous medium-level priority highway segments in the Hood Canal watershed (D. Gersib, personal communication, March 5, 2013). Ongoing work in this retrofit study being led by HCCC will be coordinated with WSDOT as it proceeds.

Additional information to be sought for consideration in the ongoing stormwater retrofit study for the Hood Canal Action Area includes, but will not be limited to, the following:

- Impervious surface cover
- Existing drainage infrastructure, including locations of existing stormwater treatment and/or flow control facilities
- Locations of other utility infrastructure that could be in conflict with a retrofit project
- Drainage complaints
- Locations of community gathering places that could offer associated educational opportunities
- Locations of wetlands and other natural features that could be reducing delivery of stormwater runoff pollution to Hood Canal and its tributary streams

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APPENDIX A

Data Sources Used to Calculate Annual Stormwater Pollutant Loadings

Table A-1. Summary of Pollutant Loadings Used in the Pollutant Loading Model.								
Parameter	Land Use	n	Median (lbs/acre or billion CFU/acre)	25th Percentile (lbs/acre or billion CFU/acre)	75th Percentile (lbs/acre or billion CFU/acre)	Minimum (lbs/acre or billion CFU/acre)	Maximum (lbs/acre or billion CFU/acre)	Source
Copper, dissolved	LDR	11	0.012	0.002	0.020	0.001	0.260	Phase I Reports
Copper, dissolved	HDR	8	0.007	0.003	0.012	0.003	0.021	Phase I Reports
Copper, dissolved	COMM	4	0.046	0.026	0.056	0.008	0.127	Phase I Reports
Copper, dissolved	IND	5	0.016	0.011	0.024	0.009	0.027	Phase I Reports
Copper, total	LDR	11	0.010	0.004	0.015	0.002	0.030	Phase I Reports
Copper, total	HDR	8	0.021	0.011	0.066	0.008	0.093	Phase I Reports
Copper, total	COMM	4	0.155	0.090	0.238	0.018	0.368	Phase I Reports
Copper, total	IND	5	0.080	0.048	0.110	0.038	0.118	Phase I Reports
Zinc, dissolved	LDR	11	0.018	0.010	0.220	0.004	0.290	Phase I Reports
Zinc, dissolved	HDR	8	0.069	0.010	0.185	0.001	0.503	Phase I Reports
Zinc, dissolved	COMM	4	0.181	0.104	0.285	0.059	1.300	Phase I Reports
Zinc, dissolved	IND	5	0.204	0.094	0.396	0.080	0.491	Phase I Reports
Zinc, total	LDR	11	0.043	0.018	0.090	0.009	0.370	Phase I Reports
Zinc, total	HDR	8	0.156	0.055	0.277	0.041	0.465	Phase I Reports
Zinc, total	COMM	4	0.503	0.370	0.862	0.101	2.300	Phase I Reports
Zinc, total	IND	5	0.326	0.174	0.516	0.088	0.639	Phase I Reports
Total Phosphorus	LDR	12	0.310	0.136	0.752	0.082	0.890	Phase I Reports
Total Phosphorus	HDR	9	0.180	0.150	0.674	0.080	1.210	Phase I Reports
Total Phosphorus	COMM	4	0.480	0.350	1.230	0.101	3.120	Phase I Reports
Total Phosphorus	IND	5	0.930	0.670	1.110	0.540	1.160	Phase I Reports
Total Phosphorus	Forest	24	0.137	0.068	0.203	0.038	1.187	King County 2006

Table A-1 (continued). Summary of Pollutant Loadings Used in the Pollutant Loading Model.								
Parameter	**Land Use**	**n**	**Median (lbs/acre or billion CFU/acre)**	**25th Percentile (lbs/acre or billion CFU/acre)**	**75th Percentile (lbs/acre or billion CFU/acre)**	**Minimum (lbs/acre or billion CFU/acre)**	**Maximum (lbs/acre or billion CFU/acre)**	**Source**
Total Nitrogen	LDR	12	3.08	0.85	6.55	0.35	8.00	Phase I Reports
Total Nitrogen	HDR	9	3.16	1.45	5.91	0.90	10.90	Phase I Reports
Total Nitrogen	COMM	4	4.81	2.00	13.40	0.10	17.99	Phase I Reports
Total Nitrogen	IND	5	4.27	2.90	5.61	2.48	5.99	Phase I Reports
Total Suspended Solids	LDR	12	32.4	23.9	153.5	13.0	160.0	Phase I Reports
Total Suspended Solids	HDR	9	72.3	49.4	262.0	35.0	656.0	Phase I Reports
Total Suspended Solids	COMM	4	311.0	92.2	550.0	0.1	1910.0	Phase I Reports
Total Suspended Solids	IND	5	290.6	227.9	357.4	197.4	392.0	Phase I Reports
Fecal	LDR/ HDR	NA	154.44	--	--	--	--	King County 2006
Fecal	COM	NA	276.76	--	--	--	--	King County 2006
Fecal	AG	NA	116.39	--	--	--	--	King County 2006
Fecal	Forest	NA	11.37	--	--	--	--	King County 2006

Notes:
1- LDR= low density residential
2- HDR = high density residential
3- COMM= commercial
4- IND= industrial
5- n= number of samples
6- lbs/acre = pounds per acre
7- CFU/acre = colony forming units per acre
8- The median value of pollutant load was used in the pollutant load model

Sources

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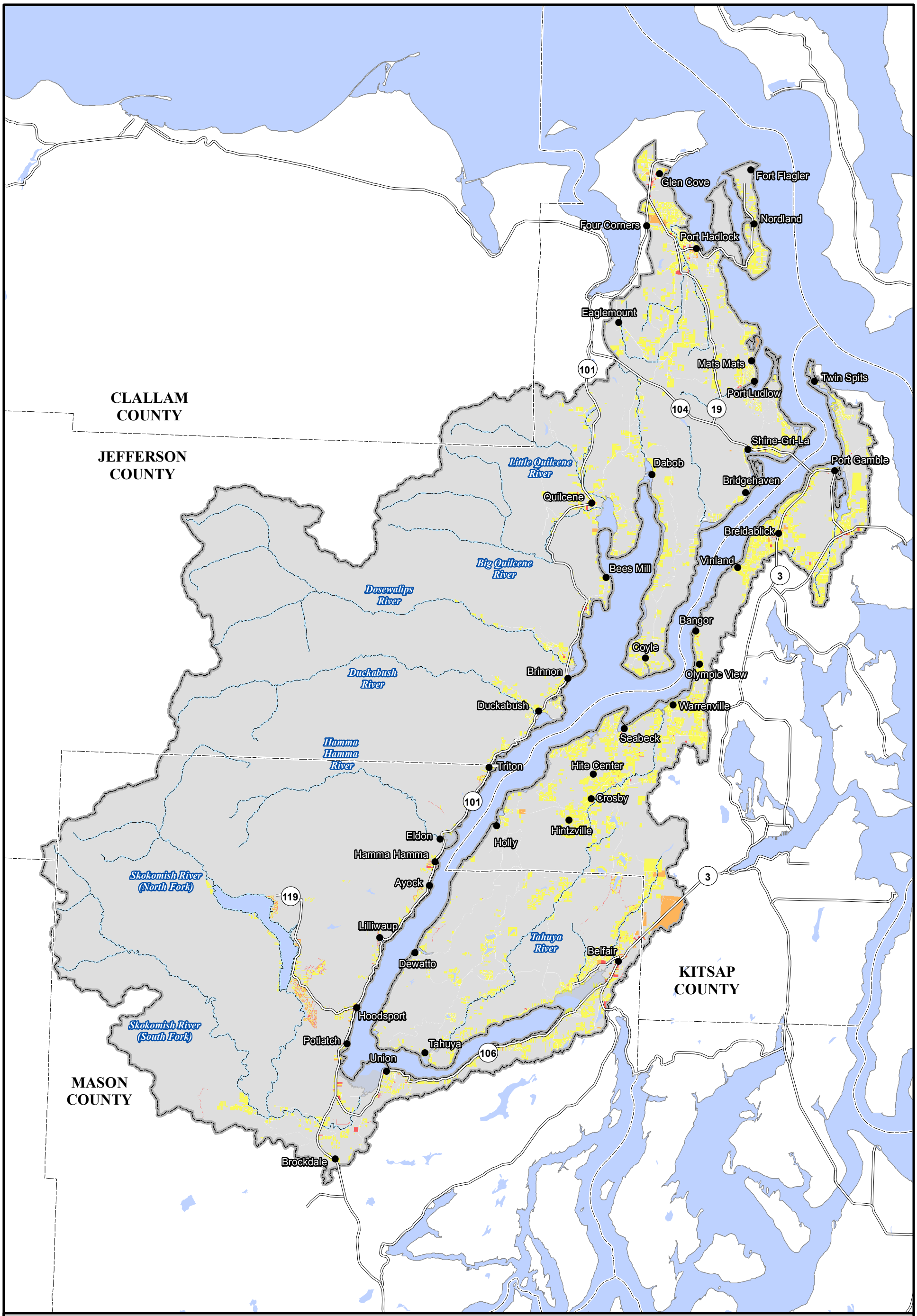
APPENDIX B

Watershed Characterization and Pollutant Loading Estimate Results Maps



Legend

- Town or city
- Highway
- River
- County boundary
- Hood Canal watershed boundary

Total Suspended Solids Median lbs/acre

- 0
- 0 to 32
- 32 to 72
- 72 to 291
- > 291

Pollutant Loads: Total Suspended Solids

N

0 13,500 27,000 54,000 Feet

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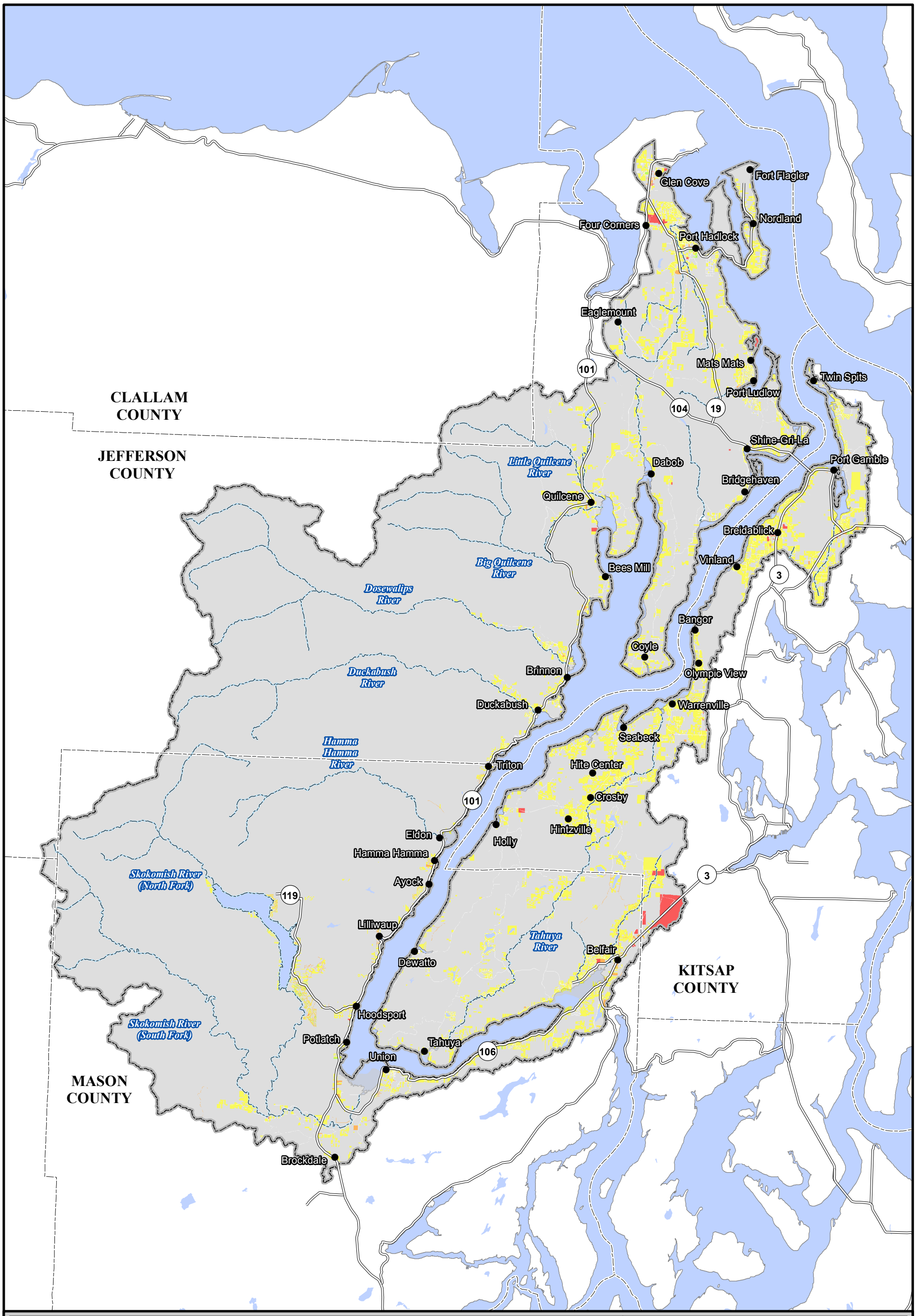

Legend

- Town or city
- Highway
- River
- County boundary
- Hood Canal watershed boundary

Total Phosphorus
Median lbs/acre

- 0
- 0 to 0.18
- 0.18 to 0.31
- 0.31 to 0.48
- > 0.48

Pollutant Loads: Total Phosphorus

N

0 13,500 27,000 54,000 Feet

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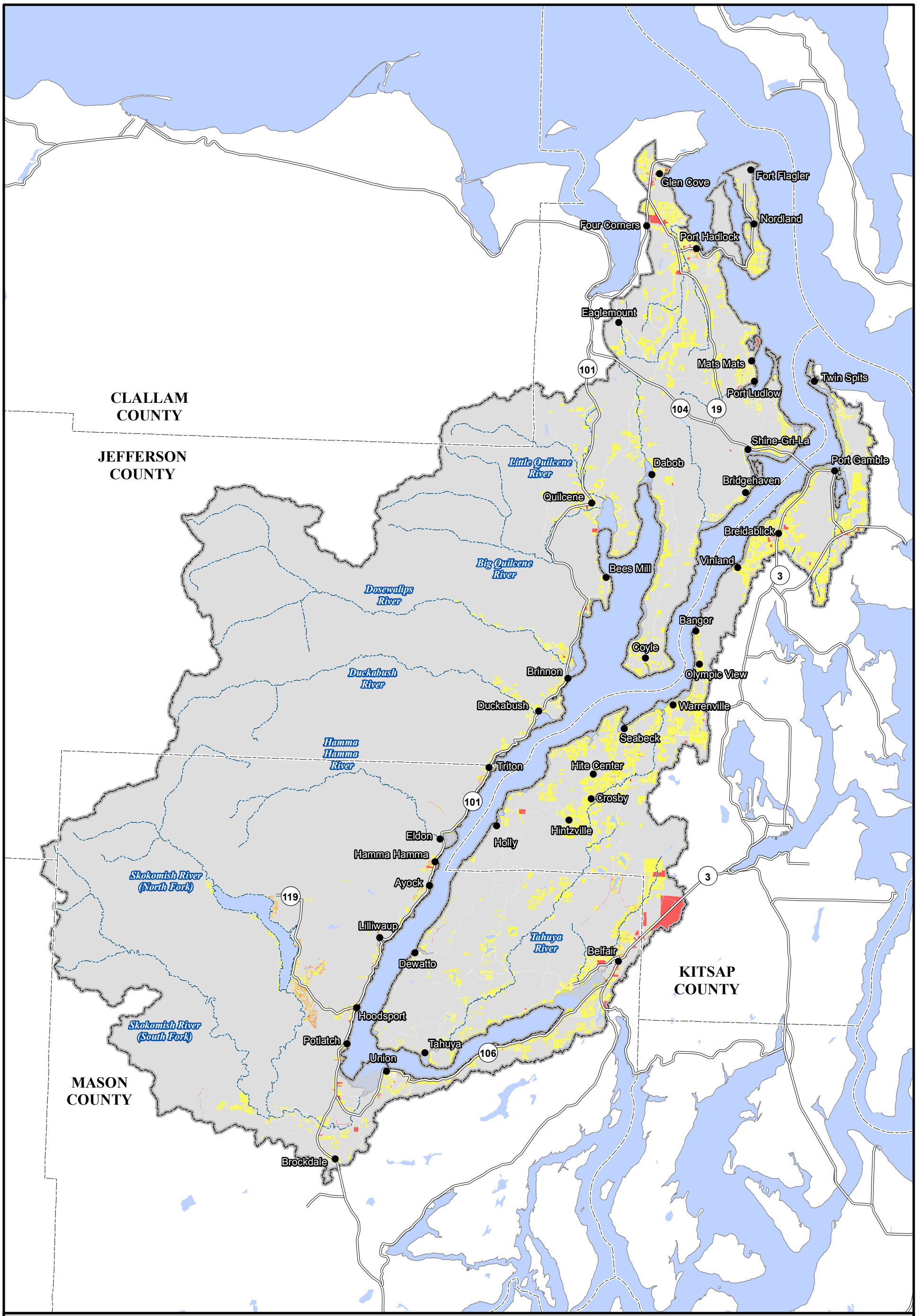

Legend

- Town or city
- Highway
- River
- County boundary
- Hood Canal watershed boundary

Total Nitrogen
Median lbs/acre

- 0
- 0 to 3
- 3 to 3.15
- 3.15 to 4.25
- > 4.25

Pollutant Loads: Total Nitrogen

N

0 13,500 27,000 54,000 Feet

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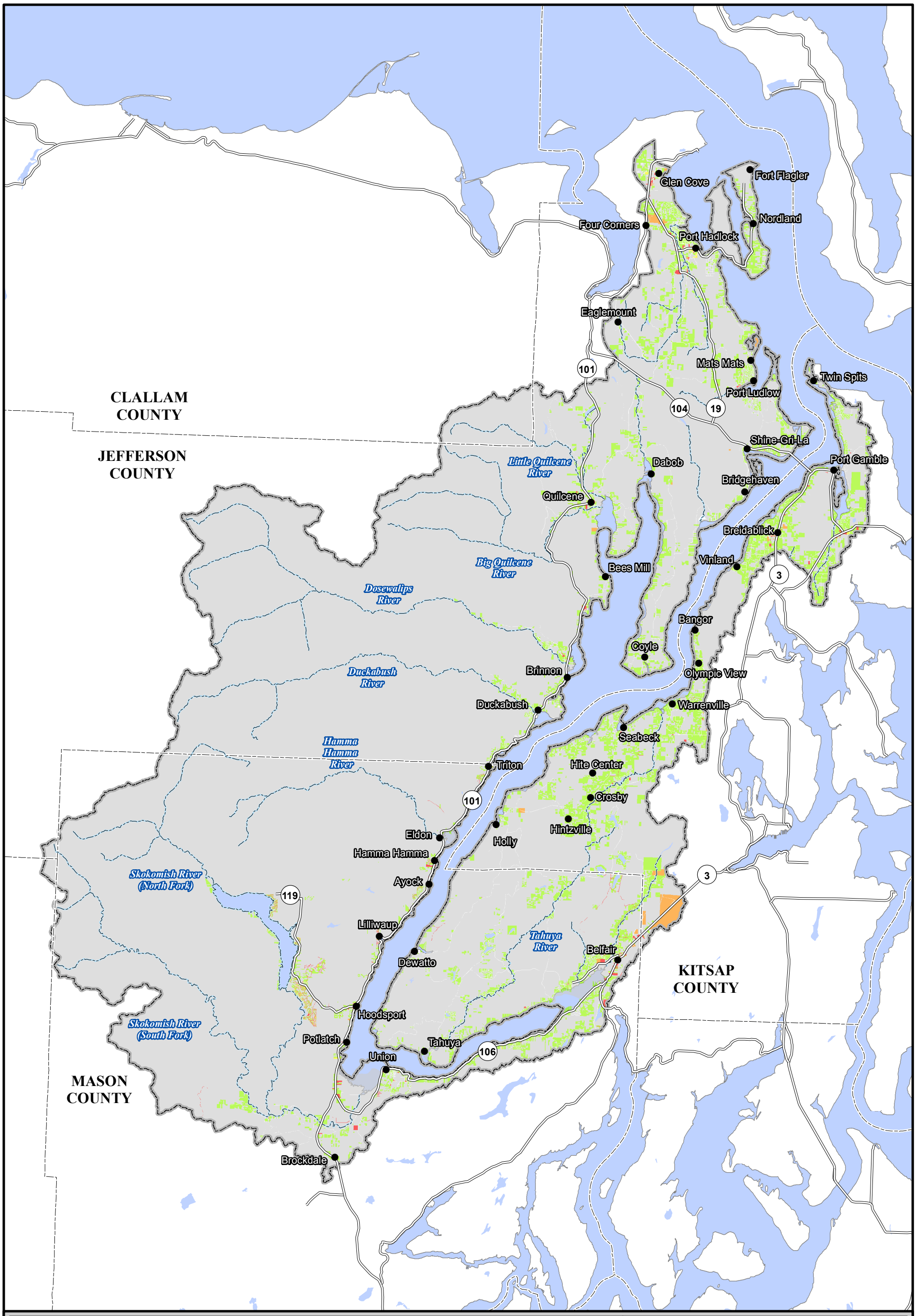

Legend

- Town or city
- Highway
- River
- County boundary
- Hood Canal watershed boundary

Copper, Total
Median lbs/acre

- 0
- 0 to 0.01
- 0.01 to 0.02
- 0.02 to 0.08
- > 0.08

Pollutant Loads: Total Copper

N

0 13,500 27,000 54,000 Feet

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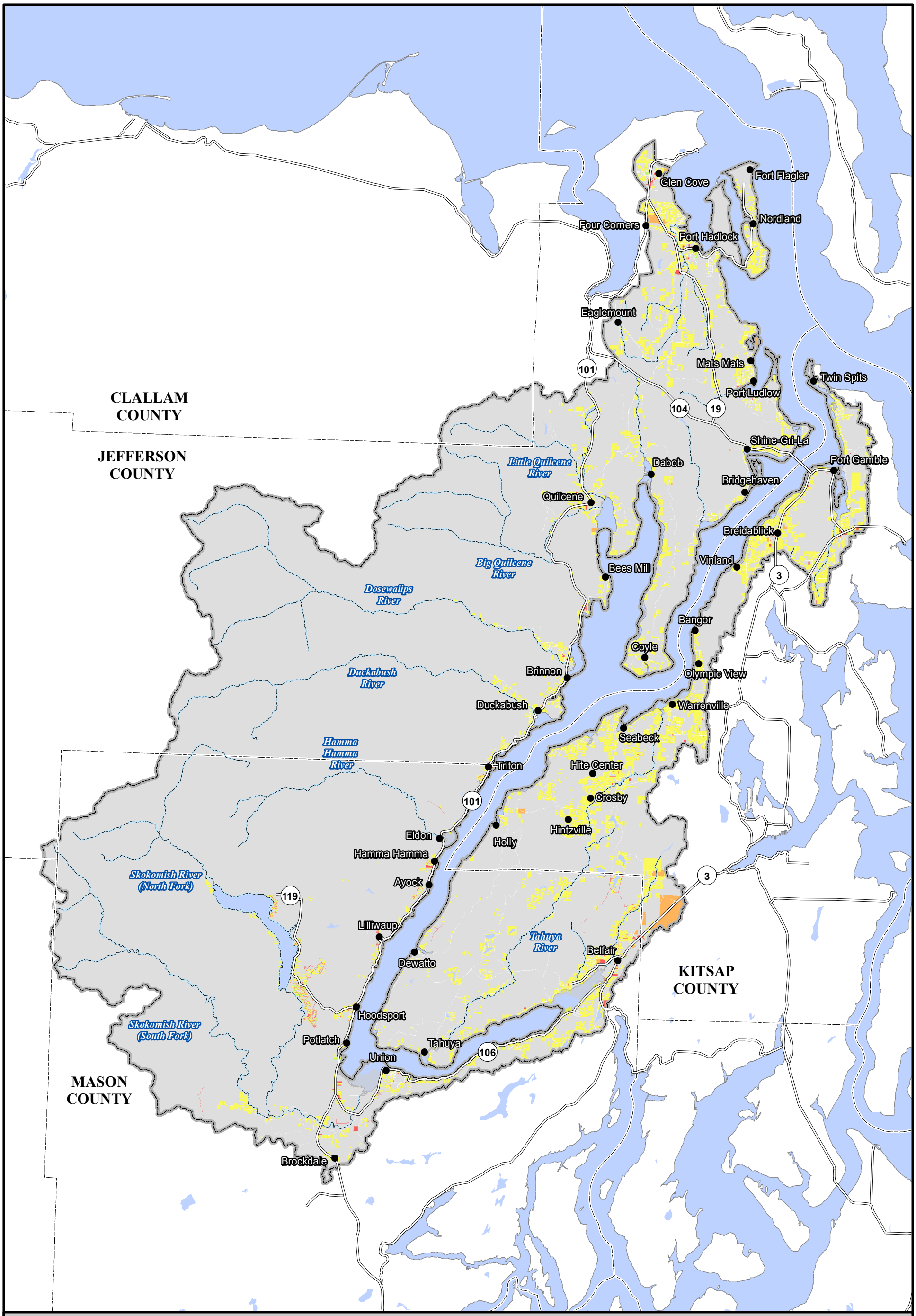

Legend

- Town or city
- Highway
- River
- County boundary
- Hood Canal watershed boundary

Copper, Dissolved
Median lbs/acre

- 0
- 0 to 0.007
- 0.007 to 0.01
- 0.01 to 0.02
- > 0.02

Pollutant Loads: Dissolved Copper

N

0 13,500 27,000 54,000 Feet

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CLALLAM COUNTY

JEFFERSON COUNTY

KITSAP COUNTY

MASON COUNTY

Glen Cove
Fort Flagler
Nordland
Four Corners
Port Hadlock
Eaglemount
Mats Mats
Twin Spits
Port Ludlow
Shine-Gri-La
Dabob
Port Gamble
Bridgehaven
Quilcene
Breidablick
Vinland
Bees Mill
Bangor
Coyle
Olympic View
Brinnon
Warrenville
Duckabush
Seabeck
Triton
Hite Center
Crosby
Hintzville
Holly
Eldon
Hamma Hamma
Ayock
Lilliwaup
Dewatto
Belfair
Hoodsport
Potlatch
Tahuya
Union
Brockdale

Little Quilcene River
Big Quilcene River
Dosewalips River
Duckabush River
Hamma Hamma River
Skokomish River (North Fork)
Skokomish River (South Fork)
Tahuya River

101
104
19
3
119
106

Legend

- Town or city
- Highway
- River
- County boundary
- Hood Canal watershed boundary

Zinc, Total
Median lbs/acre

- 0
- 0 to 0.4
- 0.4 to 0.16
- 0.16 to 0.33
- > 0.33

Pollutant Loads: Total Zinc

N

0 13,500 27,000 54,000 Feet

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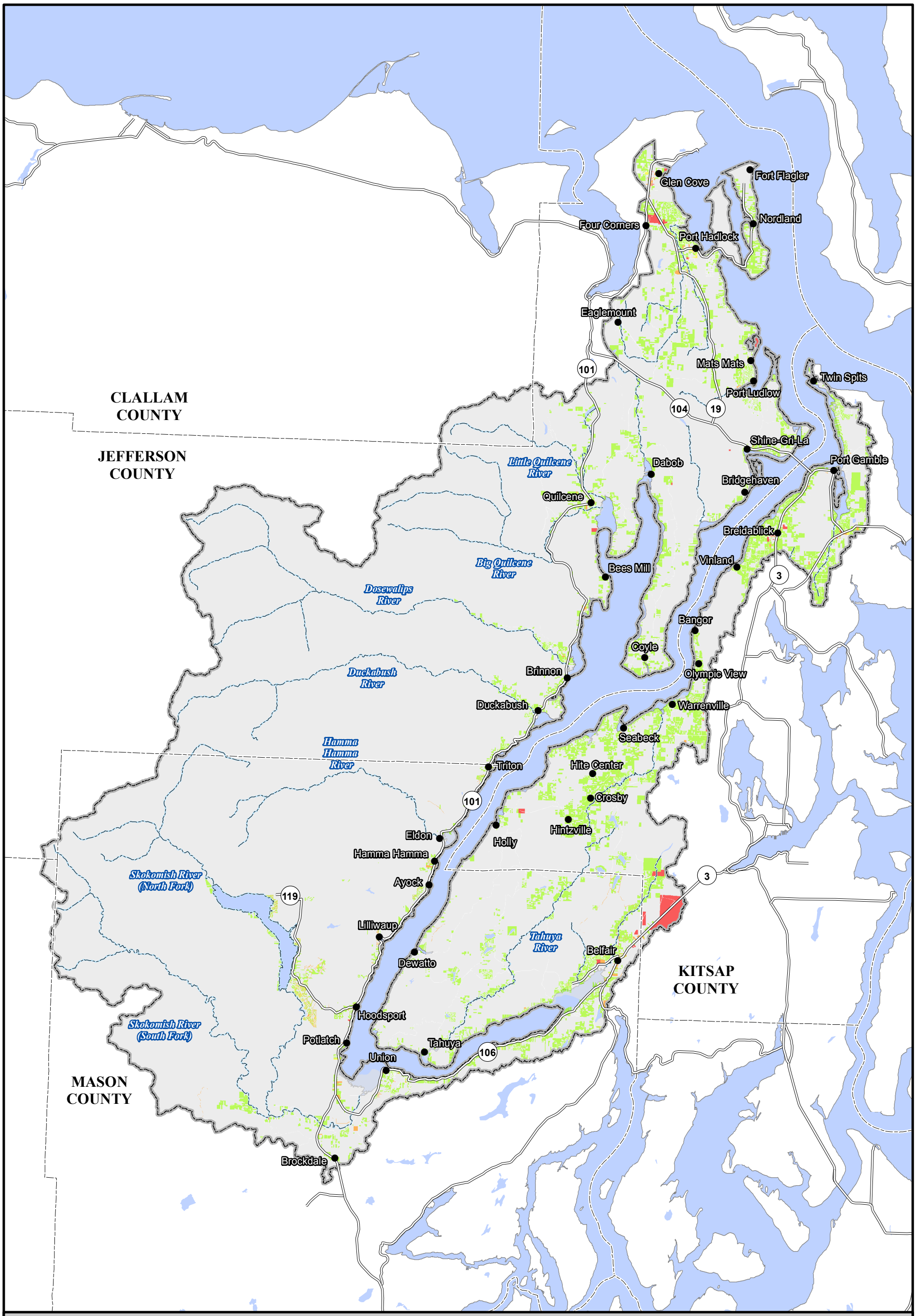
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Twin Spits
Port Ludlow
Shine-Gri-La
Port Gamble
Dabob
Bridgehaven
Quilcene
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Vinland
Bees Mill
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Olympic View
Brinnon
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Hoodsport
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Brockdale
Little Quilcene River
Big Quilcene River
Dosewallips River
Duckabush River
Hamma Hamma River
Skokomish River (North Fork)
Skokomish River (South Fork)
Tahuya River
101
104
19
3
119
106
Legend
Town or city
Highway
River
County boundary
Hood Canal watershed boundary
Zinc, Dissolved
Median lbs/acre
0
0 to 0.018
0.018 to 0.07
0.07 to 0.18
> 0.18
Pollutant Loads: Dissolved Zinc
N
0
13,500
27,000
54,000
Feet
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Glen Cove
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CLALLAM COUNTY
JEFFERSON COUNTY
Shine-Gri-La
Little Quilcene River
Dabob
Port Gamble
Bridgehaven
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Bees Mill
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Duckabush River
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Olympic View
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Warrenville
Seabeck
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Hintzville
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Eldon
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Skokomish River (North Fork)
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Lilliwaup
Tahuya River
Belfair
KITSAP COUNTY
Dewatto
Hoodsport
Skokomish River (South Fork)
Potlatch
Tahuya
106
Union
MASON COUNTY
Brockdale
Legend
Town or city
Highway
River
County boundary
Hood Canal watershed boundary
Fecal coliform
Billion CFU/ac/year
0
0 to 11.4
11.4 to 116.4
116.4 to 154.4
> 154.4
Pollutant Loads: Fecal Coliform
N
0
13,500
27,000
54,000
Feet
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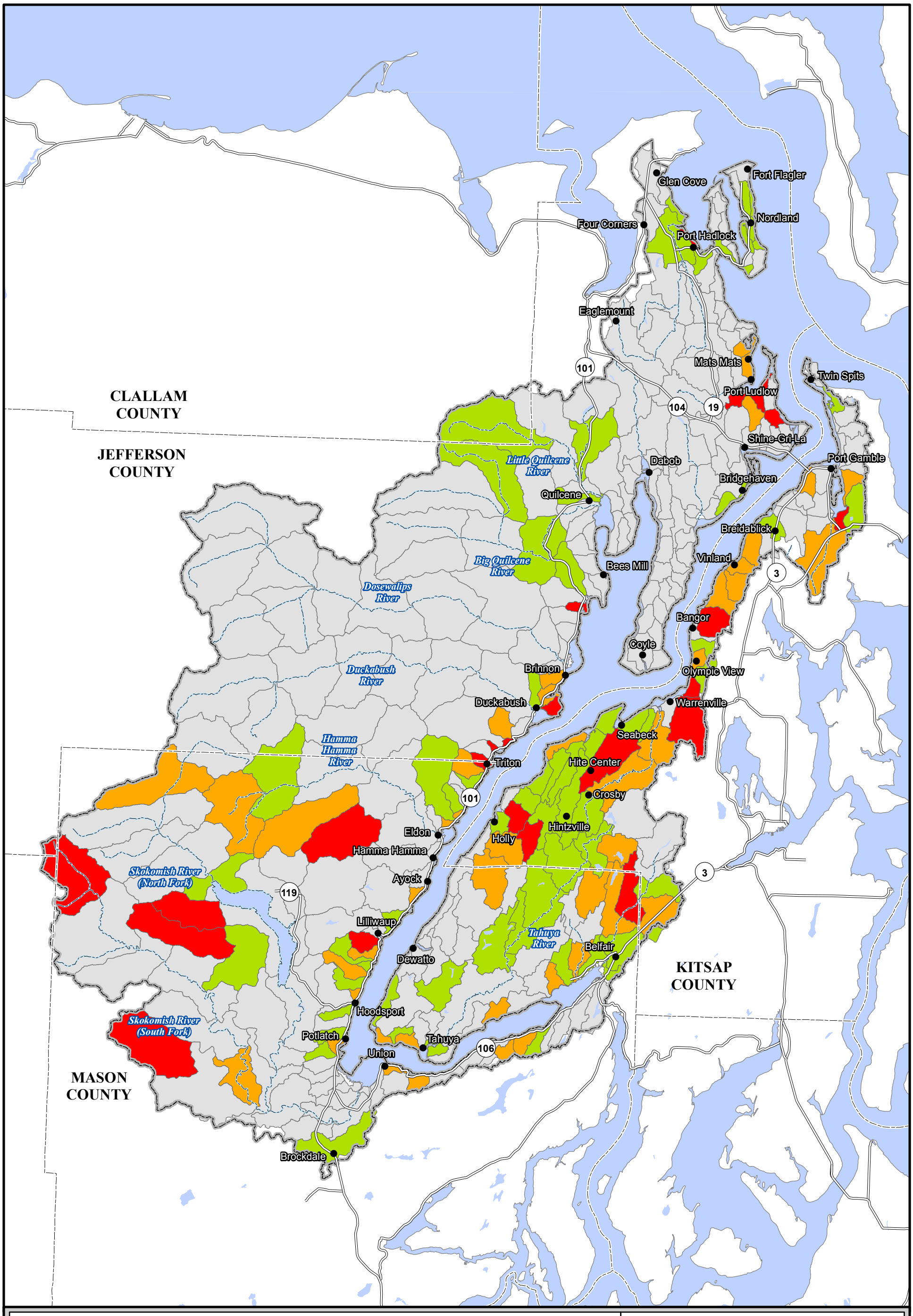
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Twin Spits
Port Ludlow
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Belfair
Dewatto
Hoodsport
Potlatch
Tahuya
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Brockdale
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CLALLAM COUNTY
JEFFERSON COUNTY
KITSAP COUNTY
MASON COUNTY
Little Quilcene River
Big Quilcene River
Dosewallips River
Duckabush River
Hamma Hamma River
Skokomish River (North Fork)
Skokomish River (South Fork)
Tahuya River
Legend
None
1 pollutant category of concern
2 pollutant categories of concern
3 pollutant categories of concern
Town or city
Highway
River
County boundary
Hood Canal watershed boundary
Restoration Potential for Metals, Nitrogren, or Pathogens
N
0
13,500
27,000
54,000
Feet
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CLALLAM COUNTY

JEFFERSON COUNTY

MASON COUNTY

KITSAP COUNTY

Glen Cove
Fort Flagler
Nordland
Four Corners
Port Hadlock
Eaglemount
Mats Mats
Twin Spits
Port Ludlow
Shine-Gri-La
Dabob
Port Gamble
Bridgehaven
Quilcene
Breidablick
Vinland
Bees Mill
Bangor
Coyle
Olympic View
Brinnon
Duckabush
Warrenville
Seabeck
Triton
Hite Center
Crosby
Hintzville
Holly
Eldon
Hamma Hamma
Ayock
Lilliwaup
Dewatto
Belfair
Hoodsport
Potlatch
Tahuya
Union
Brockdale

Little Quilcene River
Big Quilcene River
Dosewalips River
Duckabush River
Hamma Hamma River
Skokomish River (North Fork)
Skokomish River (South Fork)
Tahuya River

101
104
19
3
119
106

Legend

- FI >= 7 and RP = 3
- FI >= 7 and RP = 2
- FI >= 7 and RP = 1
- FI < 7 and RP = 3
- FI < 7 and RP = 2
- FI < 7 and RP = 1
- FI < 7 and RP = 0
- FI >= 7 and RP = 0
- Town or city
- Highway
- River
- County boundary
- Hood Canal watershed boundary

Restoration Potential and Freshwater Index Overlay

N

0 13,500 27,000 54,000 Feet

HERRERA

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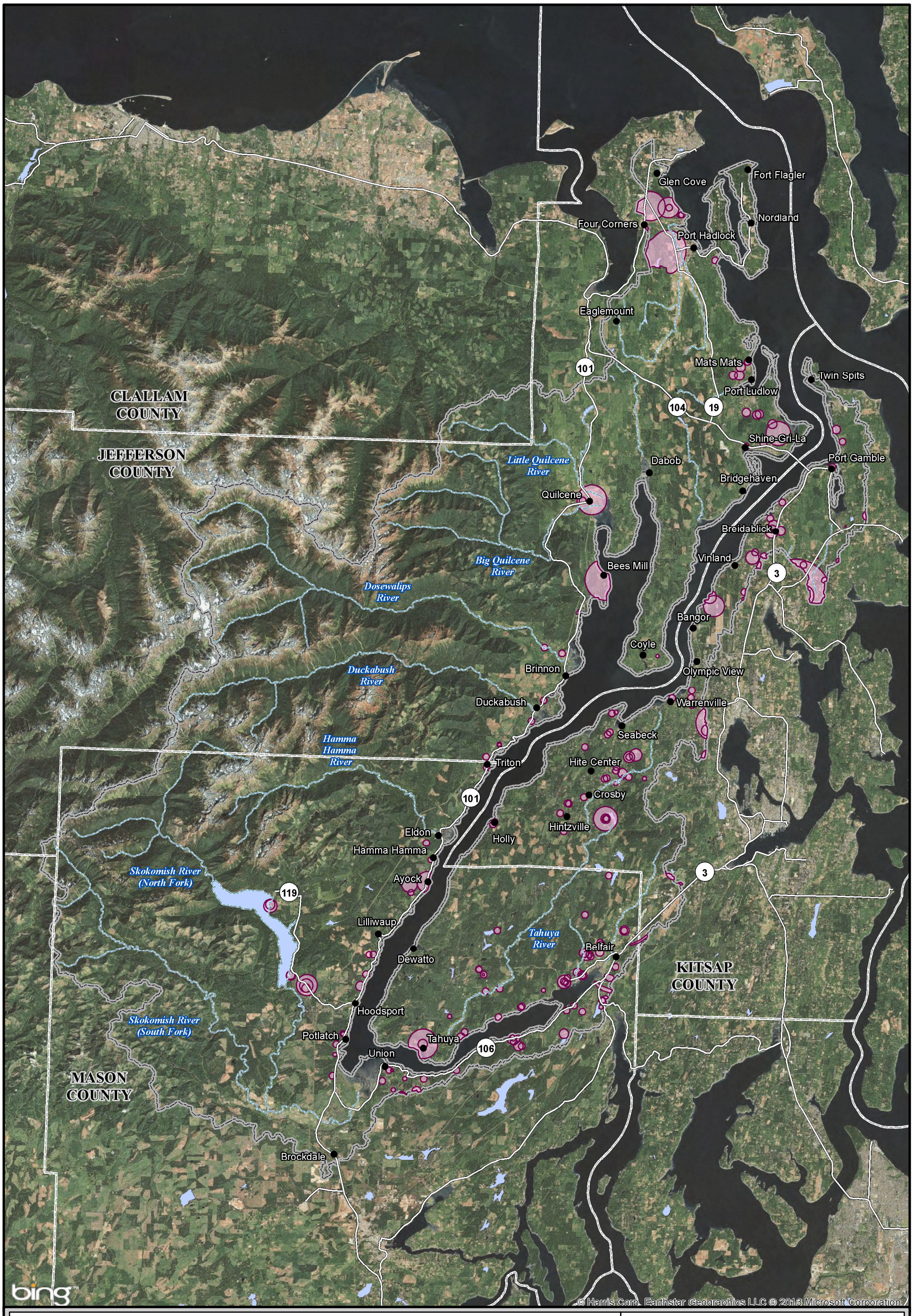
APPENDIX C

Receiving Water Characterization Information



Legend

- Town or city
- Highway
- River
- County boundary
- Hood Canal watershed boundary
- 10-year wellhead protection area

Wellhead Protection Areas in the Hood Canal Action Area

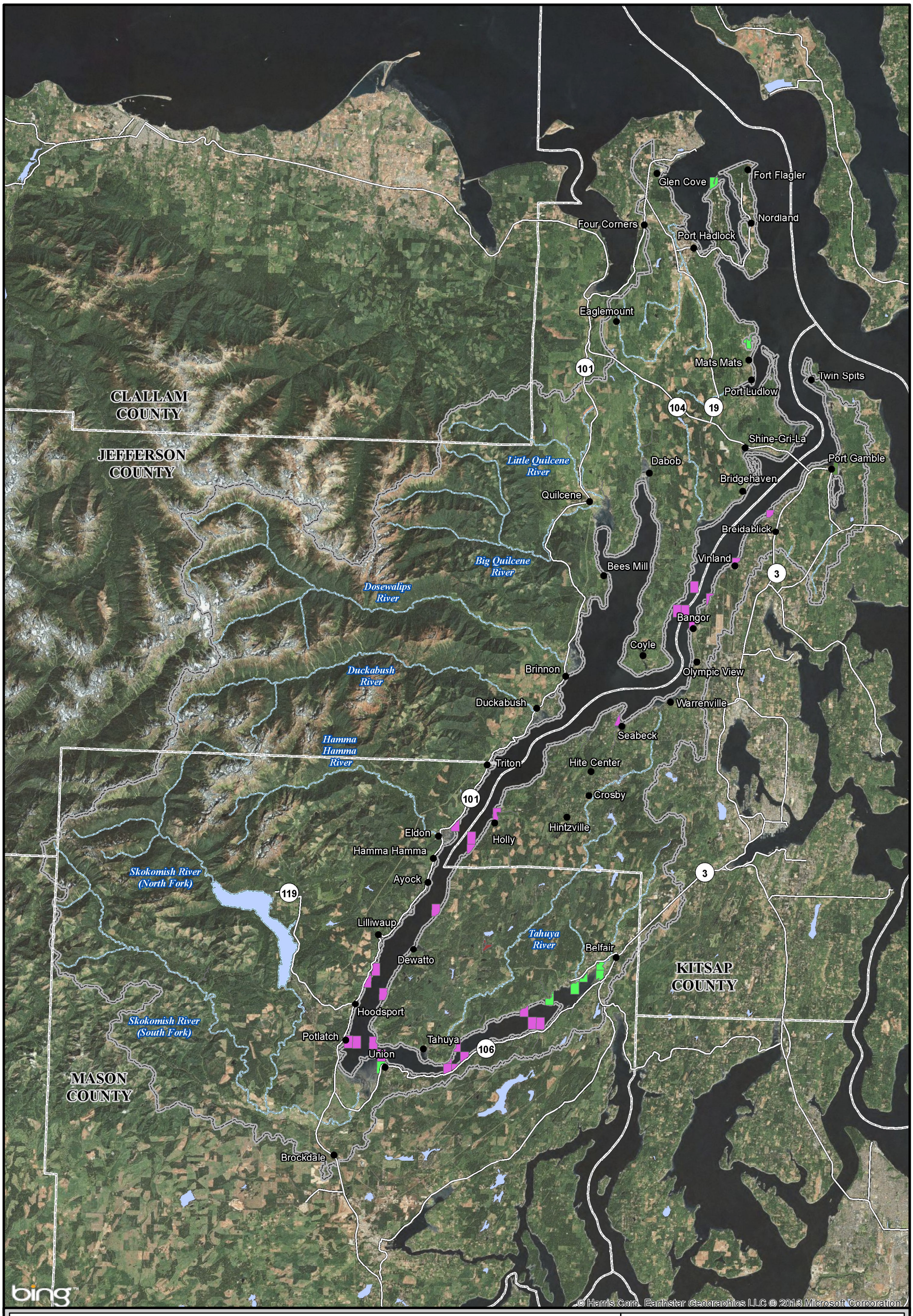
N

0 13,500 27,000 54,000 Feet

HERRERA

Aerial: Bing (2008)

K:\Projects\11-05408-000\Project\10-year_wellhead_protect.mxd (1/31/2013)



Legend

- Town or city
- Highway
- River
- County boundary
- Hood Canal watershed boundary

303(d) listings

- 2,3,7,8-TCDD
- Dissolved oxygen
- Fecal coliform
- Hexachlorobenzene
- Mercury
- PCB
- Sediment bioassay
- Temperature
- Total phosphorus
- pH

303(d) Category 5 listings in the Hood Canal Action Area

N

0 13,500 27,000 54,000 Feet

HERRERA

Aerial: Bing (2008)

K:\Projects\11-05408-000\Project\303d_listings.mxd (1/31/2013)