Strategies for Protecting and Restoring Puget Sound B-IBI Basins

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King County

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Prepared for:

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[1] Reports, presentations, and relevant documents are available on the Restoration Priorities project page of the PSSB: http://pugetsoundstreambenthos.org/Projects/Restoration-Priorities-2014.aspx.

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EXECUTIVE SUMMARY

This project implements priority work consistent with the Puget Sound Partnership (PSP) Action Agenda for the protection and restoration of Puget Sound by addressing the PSP's Ecosystem Recovery Target associated with freshwater benthic macroinvertebrates. Benthic macroinvertebrates, often referred to as "stream bugs," are animals such as insects, crustaceans, worms, snails, and clams that can be seen with the naked eye, do not have backbones and live in the stream benthos—in or near the streambed. Macroinvertebrates play a crucial role in streams and rivers and are good indicators of ecological health. The multimetric Puget Lowland Benthic Index of Biotic Integrity (B-IBI) is a standardized scoring system that uses the types and relative abundances of benthic macroinvertebrates collected from streams and rivers to assess water quality and habitat conditions. B-IBI is currently used by over 20 cities, counties, tribes and state and federal agencies in their assessment of streams throughout the entire Puget Sound region.

The B-IBI is a PSP vital sign indicator used to evaluate whether progress is being made towards restoring Puget Sound. The PSP has two ecosystem recovery targets related to freshwater benthic macroinvertebrates: one involves protecting all streams and small rivers throughout Puget Sound currently with "excellent" B-IBI scores and the second calls for improving conditions in 30 streams with "fair" B-IBI scores. This report is the final product of a larger project funded by the Washington State Department of Ecology to develop strategies to address the two stream benthic macroinvertebrate targets. The report identifies potential stream and river basins, proposes restoration and protection strategies and actions to achieve these PSP targets, presents relative costs of recommended actions and suggests several next steps toward achieving the targets, and improving the scientific knowledge base and future use of the B-IBI.

From thousands of macroinvertebrate monitoring sites across Puget Sound, 101 stream basins were identified for protection and 54 for restoration. Proposed restoration and protection strategies were developed for each of these basins after engaging local experts and conducting desktop reconnaissance of existing data. These outreach meetings and data exploration efforts aimed to (1) understand key basin stressors and local conditions, (2) determine what types of restoration and protection actions may be needed, (3) identify potential overlapping restoration or conservation efforts, and (4) initiate engagement with partners who will be critical in future restoration/conservation implementation. Section 1 provides an introduction and overview of the project. Section 2 briefly describes the data and regional resources used in this process. Section 3 describes recommendations for basins identified for protection, and section 4 and an associated appendix includes recommendations for restoration basins. Relative cost estimates for most recommended strategies are in section 5 and next steps are summarized in section 6.

<u>Protection</u>

The 101 protection basins were grouped into categories based on shared characteristics regarding existing land cover, land protection status, and risk of development or anthropogenic changes (approximated by zoning information). Land protection strategies

were identified for each category that provide reasonable assurance that current land cover or land use would be maintained or future changes would be mitigated allowing the B-IBI score to remain in the "excellent" range. Strategies with the most assurance of protection involve conserving land so that it cannot be developed for urban or agricultural purposes and where forest harvest and mining are prohibited. These include land purchase, conservation easements, and purchasing of development rights. We emphasize that to maintain "excellent" B-IBI scores in the future as forecasted development occurs, additional measures to address impacts from stormwater, forestry, or agricultural practices may be required in addition to the land conservation strategies. Also, compliance with existing standards, rules, and codes such as clearing and grading restrictions and maintaining intact buffers around critical areas is essential.

Restoration

Basin-specific restoration recommendations were made for each of the 54 "fair" basins based on our understanding of the ecological conditions and processes that are important to maintain diverse and sensitive aquatic macroinvertebrate communities. We emphasize that the specific recommended actions are not necessarily proven to increase B-IBI scores as few studies have made that direct link. Instead, recommendations stem from information about the site regarding which potential stressors may have impacted each basin and the assumption, based on available research and best professional judgment, that certain actions may alleviate or "fix" those stressors. Restoration strategies are varied and include in-stream actions that increase the complexity and quality of benthic habitats, riparian actions that stabilize banks and protect riparian functions, agricultural best management practices (BMPs) that limit livestock and cultivation impacts, forest BMPs that minimize the effects of forest harvest, and stormwater BMPs that reduce the impacts of stormwater runoff on receiving waters. There also are a variety of non-structural actions that aim to limit the impacts of human activities on streams and are part of the restoration tool kit. These include implementation incentives, education and outreach, and active recolonization of benthic macroinvertebrates.

Costs

Rough cost estimates for the recommended protection and restoration actions were provided, including for instream restoration and riparian planting, stormwater retrofits, agricultural best management practices (BMPs) and land conservation actions (e.g., purchase and easements). We note that the report does not provide an overall or basin-specific cost estimate for achieving the targets. However, the information sheds light on the relative costs of different strategies and can serve as a starting point towards implementation, including developing funding strategies. Cost figures were based on previous studies, and in some cases best professional judgement.

In summary, this document describes potential management, restoration, and conservation actions to meet PSP's protection and restoration targets associated with B-IBI. It also describes the process for identifying which actions may be appropriate for each basin, and the rough cost of these actions. These steps are only the beginning of what will ultimately have to be a multi-phased effort with broad buy-in and engagement if the restoration and protection targets are to be met. We recognize that the actions outlined in this report are a

broad brush – the 30,000 foot view. Additional investigations and information on the effectiveness of specific actions are needed to provide information necessary for detailed planning, identification of individual site-specific restoration and protection projects, and basin-specific cost estimates for achieving the targets. Additional experts with local knowledge need to be engaged as they know their watersheds best and will likely be the champions to carry some of the initial ideas presented in this report forward towards more intensive planning and implementation.

<u>Next Steps</u>

We urge consideration of the following recommendations to move towards achieving the PSP restoration and protection targets related to stream benthic macroinvertebrates.

1. Implementation and funding
    - Establish a two phased process (planning and implementation) in a few basins; information gathered from these pilot basins should lead the way for other basins.
    - Continue the broad stakeholder support built by this and previous B-IBI projects and increasingly shift the focus to implementation.
    - Develop statistically valid effectiveness monitoring guidelines that include pre- and post-project monitoring for restoration efforts that will allow for adaptive management.
    - In developing implementation plans, identify, evaluate, and pursue a mix of appropriate implementation incentives.
    - Implement existing regulations and continue current BMP programs.
    - Develop a comprehensive and integrated funding strategy to pay for the necessary actions, along with other actions to achieve other PSP vital sign targets.
2. Increasing the scientific knowledge base
    - Continue experimenting with restoration and protection actions in order to build scientifically credible cause and effect relationships supporting BMP effectiveness.
    - Look for and understand the applicability of related regional efforts (e.g. the Regional Stormwater Monitoring Program and Total Maximum Daily Load work on 2 Puget Sound streams) and incorporate new information into project implementation as appropriate.
    - Investigate the basins with higher-than-expected B-IBI scores and determine if there are any lessons to be learned from these basins.
    - Evaluate the extent to which existing regulations are being implemented and complied with (such as stormwater manual guidelines, critical areas ordinance requirements, and forest practice rules), and estimate the impact on the targets associated with full compliance.

- Maintain funding for ongoing status and trends B-IBI monitoring and PSSB database activities in order to track progress toward achieving the targets.

3. Adapting the B-IBI target
   - Change the B-IBI target language from the 10-50 to the 0-100 B-IBI score range to reflect best available science.
   - Modify the B-IBI target language so that restoration goals are not tied to specific condition categories (e.g., "fair" or "good").
   - Model and predict B-IBI results across Puget Sound streams to identify candidate basins for restoration or protection currently in locations lacking readily available B-IBI data stored in the PSSB.
   - Analyze and report on B-IBI data every 5 years and re-evaluate candidate stream basins for restoration and protection.

1.0 BACKGROUND

1.1 Introduction

This project, titled "Strategies for Preserving and Restoring Small Puget Sound Drainages," implements priority work consistent with the Puget Sound Action Agenda for the protection and restoration of Puget Sound by addressing the Puget Sound Partnership's (PSP) near-term actions (NTA) C2.1 NTA 2 and C2.3 NTA 2[2] (PSP 2012). Many streams that drain into Puget Sound are threatened from pollutant runoff, habitat degradation, and altered flow regimes. Such threats may result in extinction of aquatic species, declines in biodiversity, and water quality degradation that negatively affect recreational opportunities and fish use in these valued resources.

Two of the PSP's Ecosystem Recovery Targets are based on freshwater benthic macroinvertebrates. Benthic macroinvertebrates play a crucial role in stream ecosystems and are good indicators of overall basin health. The multimetric Puget Lowland Benthic Index of Biotic Integrity (B-IBI) is an established scoring system applied to benthic macroinvertebrate samples collected from streams. The B-IBI was developed in the early 1990s and has been recently standardized and updated (Fore et al. 2013, King County 2014a). The B-IBI is now commonly accepted and used to report stream biological health by over 20 cities, counties, tribes and state and federal agencies in the Puget Sound Basin. The B-IBI is also now being used in state water quality assessments for 303(d) listings.

The two PSP freshwater benthic macroinvertebrate targets address both protection and restoration goals:

1) Protection: By 2020, 100 percent of Puget Sound lowland stream drainage areas monitored with baseline B-IBI scores of 42-46 or better retain these "excellent" scores.
2) Restoration: By 2020, mean B-IBI scores of 30 Puget Sound lowland drainage areas improve from "fair" to "good" (PSP 2012).

These targets focus on the stream macroinvertebrate community as indicators of overall basin ecological health. Actions that succeed in retaining "excellent" scores and improving "fair" scores at monitored stream sites will likely result in overall improvements to water quality, stream habitat conditions for a variety of taxa, and instream flow conditions. The focus of this report is to develop strategies and planning level cost estimates to address these two indicator targets.

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[2] C2.1 NTA 2 is managing urban runoff at the basin and watershed scale; C2.3 NTA 2 is map, prioritize, and restore degraded streams.

A first step in this effort was to identify stream and river[3] basins[4] that have "excellent" B-IBI scores, and also to select the basins with "fair" scores for further analysis of how they could be improved. Based on stakeholder and client (Ecology) input, we put substantial effort into identifying and prioritizing the "fair" basins and the steps of this process are explained in two previous reports (King County 2014b, King County 2014c).

This document describes potential management, restoration, and conservation actions, the process for identifying which actions may be appropriate for each basin, and the relative cost of these actions. The remainder of this introductory section discusses the B-IBI ecosystem recovery targets. The second section outlines the data sources this project relied upon to develop protection and restoration strategies. The third and fourth sections explain the development of and the recommendations for protection and restoration strategies, respectively. Section five summarizes cost estimates for various protection and restoration strategies, and section six includes the conclusions and recommended next steps.

Some caveats to this study merit mention at the outset. The analysis should be considered rough or a "first cut." To develop strategies and costs, we relied on existing data and models and a great deal of "best professional judgment." We conducted desktop reconnaissance and solicited input from regional stakeholders to identify potential limiting factors for each "fair" or "excellent" basin. Ecology's Puget Sound Watershed Characterization models were used to help identify the appropriate scale of potential actions. Based on this information we identified standard management, restoration, and/or conservation actions specific for each basin, that if implemented could have the potential to result in B-IBI scores that increase from "fair" to "good" or are maintained as "excellent."

Due to the limited budget and scope, this project did not include a field work component or an in depth analysis of costs (King County 2013a). The authors recognize that site visits and additional investigations are needed to provide information necessary to verify existing conditions and limiting factors. This information will be critical for developing more detailed descriptions of individual site specific restoration and protection projects including implementation plans and associated cost estimates. Development of such detailed plans is a logical next step to build on the basin selection and coarse-level protection and restoration strategies recommended in this project. These detailed plans will need to weigh cost, effectiveness, and risk to prescribe a particular set of basin specific actions which are feasible, affordable and successful; only then can total basin costs be estimated with any confidence.

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[3] B-IBI data in the PSSB are available for both streams and rivers. Basin area can be used to approximate stream or river size and it was used in this project to filter potential restoration basins which were limited to a basin area of 200-3,000 acres. Basin area for protection basins was not filtered and basin size ranges from 48-36,100 acres for these. Throughout the report, the term stream will be used to refer to both streams and rivers.

[4] Throughout the report, the term basin is used to describe the drainage area or upstream watershed area contributing to the sample location point.

We also note that restoration and protection strategies discussed in this report focus primarily on physical measures and do not include implementation incentives, regulatory strategies, or institutional or financial arrangements necessary for implementation. In addition, we did not prioritize which basins or projects to start with first. Such decisions will likely be influenced by the overarching priorities of local and state agencies and funding availability.

This project is the first step towards achieving the B-IBI recovery targets for stream restoration and protection in Puget Sound. It provides a scientifically based, transparent framework for basin selection and it outlines broad planning level recommendations for restoration and protection actions in those basins along with rough, order-of-magnitude cost estimates were provided, including for instream restoration and riparian planting, stormwater retrofits, agricultural best management practices (BMPs) and land conservation actions (e.g., purchase and easements). The recommendations for next steps (section 6.0) build off of the foundation this project provides. Action on these next steps, including more detailed restoration planning, is critical for achieving the B-IBI targets and ultimately restoring Puget Sound.

1.2 Significance of B-IBI Targets

Running waters are critical components of the Puget Sound ecosystem. From a human perspective, streams provide drinking water, recreation and a pleasing aesthetic. Streams are conduits in the water cycle, transporting excess precipitation to estuaries and oceans and contributing to groundwater recharge. Intact stream ecosystems and adjacent riparian buffers are home to fish and wildlife that connect fragmented habitats and conserve biodiversity. They also play a key role in nutrient cycling and organic matter decomposition. Yet, streams are subject to multiple stressors including stormwater runoff, invasive species, loss of natural land cover, habitat degradation, water withdrawal, overharvesting of resources, and impacts of climate change. These multiple, interacting threats have caused greater declines in freshwater biodiversity than seen in most terrestrial ecosystems (Sala et al. 2000, Dudgeon et al. 2006).

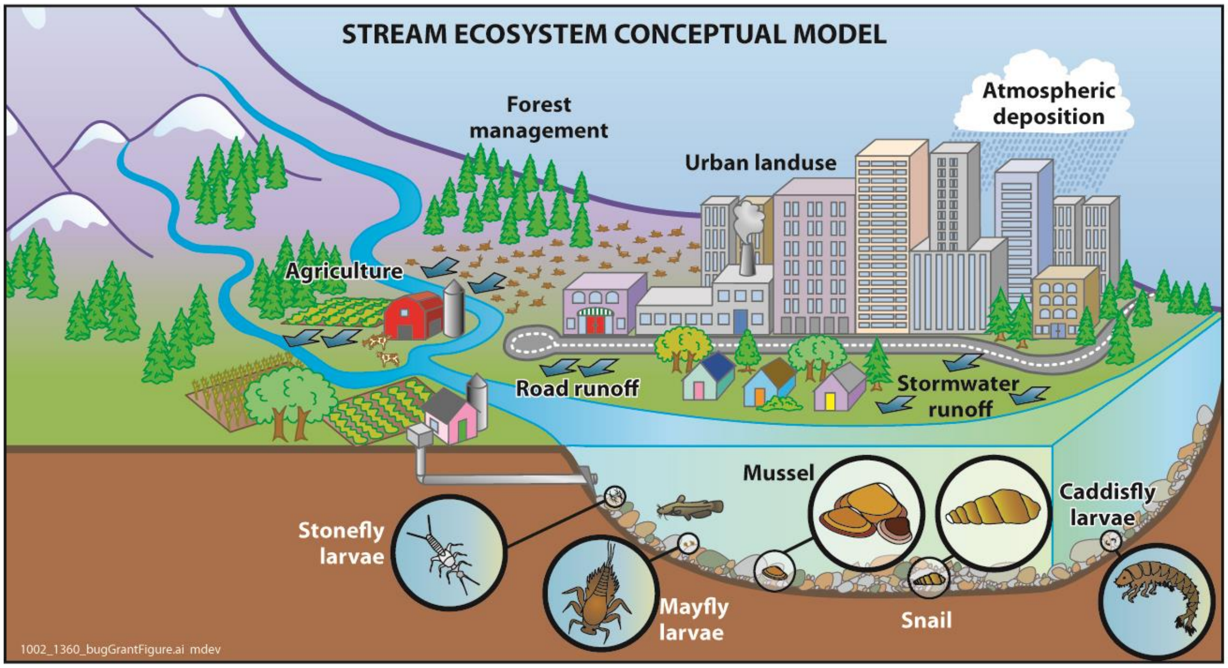

Figure 1. Stream ecosystem conceptual model.
Stream macroinvertebrate communities as measured by the B-IBI integrate a variety of watershed stressors.

As illustrated in the conceptual model above, a key threat to Puget Sound and its freshwater resources is modification of land and water resources for human uses (e.g., urban development, loss off pervious surfaces, stormwater runoff, and land use conversion). These stressors result in alteration of the quality and quantity of water flowing in a stream channel such that organisms are exposed to flashier hydrographs, elevated levels of contaminants and nutrients, and altered channel stability and morphology (Karr and Chu 1999, Walsh et al. 2005). These alterations are typically reflected in impacts to benthic communities which are key components of lotic ecosystems providing a functional link between organic matter and fish in aquatic food webs. Biological measures have the advantage of providing a time and stressor-integrated response because biological communities, such as macroinvertebrates, integrate the effects of multiple stressors and reflect cumulative impacts (e.g., hydrologic and habitat alteration, water quality degradation) (Barbour et al. 1999; Karr 1991). Biological assessments provide an early warning signal by responding to intermittent stressors and subtle disruptions likely missed by periodic chemical analyses.

Macroinvertebrates are routinely used in biomonitoring programs to assess and report the ecological condition of streams. Their utility in this capacity is due to their high abundance and taxonomic diversity, limited migration patterns, and response to environmental disturbances (Fore et al. 1996; Rosenberg and Resh 1993). A 2009 assessment of monitoring programs in the Puget Sound region identified 21 local, state, and federal agencies, citizen and non-profit groups, and tribes that collect macroinvertebrate data (King County 2009a).

1.3 Current B-IBI Target Status

According to the 2013 State of the Sound Report (PSP 2013), overall biological condition of small streams has not improved. Of 128 sites sampled multiple times between 2007 and 2011, only 11 sites showed improved B-IBI scores (shifted from "fair" to "good" or "excellent"). During the same period, 26 stream sites declined with a change of status from "fair" to "poor" or "very poor." To our knowledge, no local restoration projects have been implemented with a primary goal of achieving the B-IBI restoration target, though at least two upcoming projects that aim to evaluate the effectiveness of stormwater management actions have included B-IBI as one of the responses to be measured[5].

No assessment of the protection target (maintain all "excellent" scores) had been made at the time of the 2013 State of the Sound Report. However, similar to the restoration target, we do not know of any actions that have been implemented thus far with the primary goal of achieving the B-IBI protection target.

Given projected population growth and development likely to occur in the Puget Sound region, in-stream conditions (and B-IBI scores) are likely to decline in the absence of additional restoration or protection actions.

[5] See descriptions of studies in Redmond and Federal Way at http://www.ecy.wa.gov/programs/wq/stormwater/municipal/rsmp/effective.html

2.0 DATA AND REGIONAL RESOURCES

A number of different data sources and venues for stakeholder input were incorporated into this project. The following sections provide an overview of these data sources and outreach efforts which were used to inform recommended restoration and protection actions.

2.1 Macroinvertebrate Data Sources

This project utilized existing benthic macroinvertebrate monitoring data from streams throughout the Puget Sound Basin (Water Resource Inventory Areas [WRIA] 1-19) and did not include collection of new benthic macroinvertebrate data. All publicly available data were considered equally even though each program and agency has their own goals and questions they are addressing. Because of differences among programs, the location of existing sampling sites may have been determined using a targeted approach or may have been random.

B-IBI scores[6] were downloaded on November 18, 2013 and again on April 30, 2015 from a regional database maintained by King County, the Puget Sound Stream Benthos (PSSB) data management system[7]. The PSSB contains over 5,000 sampling events for over 1,100 Puget Sound streams ranging from 1994 to present and is considered a pretty complete repository of B-IBI data in the Puget Sound region. B-IBI score data were used to identify the subset of "fair" and "excellent" sites for further consideration.

Due to the numerous steps required to identify the subset of "fair" sites to be considered for further analysis (King County 2014c), subsequent restoration analyses are based on the 2013 data download, utilizing B-IBI data collected through 2012[8]. The protection target specifies *all* excellent sites be considered; therefore protection analyses for the "excellent" sites utilize B-IBI data collected through 2014 where available. See King County 2014b for maps, descriptions, and further breakdown of the downloaded B-IBI data, and King County 2014c for information on the decision making framework used to prioritize "fair" sites.

2.2 Landscape Analysis

Contributing basins were delineated for the selected "fair" and "excellent" sites following the automated methods laid out by Leinenbach (2011a, 2011b) and King County (2013b) based on the 30 meter National Elevation Dataset (Gesch 2007, Gesch et al. 2002) available from the National Hydrography Dataset. Quality assurance/quality control work evaluating

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[6] The PSSB has several user-defined options for determining how the B-IBI scores are calculated. For this project, the following were chosen for the data download: (1) streams *and* rivers in Puget Sound, (2) all projects, (3) B-IBI_{10-50}, (4) replicates combined, (5) taxonomic resolution as defined by project metadata, (6) Wisseman 1998 attributes, (7) subsampling at 500 organisms, (8) all years with available data.

[7] The PSSB can be found at http://www.pugetsoundstreambenthos.org/

[8] 2013 B-IBI scores were not included because the majority of samples had not been processed for taxonomic identification at the time of download (i.e., November 2013).

the basin boundaries identified some delineation errors. There were also "excellent" sites that were new and therefore had not been delineated previously. Where necessary, basin delineations were created or corrected by adjusting the basin pour points to the true stream location and tracing basin boundaries based on elevation hillshade raster and isoline resources (Appendix A).

Various landscape data sources accessible via desktop reconnaissance were consulted for the basins identified as having "fair" or "excellent" B-IBI scores. In some cases landscape metrics were calculated using geographic information systems (GIS) at buffer and watershed scales; in other cases basin specific conditions were visually estimated from data readily available on public web sites. Details of all landscape metrics calculated can be found in King County 2014b, however landscape data consistently evaluated to identify limiting factors and develop strategies for protecting and restoring basins are briefly summarized here.

2.2.1 Land Cover and Ownership

Current land cover conditions for the final "fair" and "excellent" basins were evaluated using the 2011 Coastal Change Analysis Program (C-CAP) regional land data (NOAA 2011). C-CAP classifies 25 different land cover types, which were collapsed into urbanization, agriculture, and natural categories for the purposes of this project. High-, medium-, and low- intensity development categories were totaled to produce percent urbanization. Cultivated and pasture/hay categories were evaluated individually and were combined to create percent agriculture. Forest, estuarine aquatic and emergent, grass, palustrine, and shrub land covers were summed to generate a percent natural category. Land cover conditions were used to understand limiting conditions for each basin and recommended restoration or protection actions were strongly tied to the type and extent of land covers within each basin.

Impervious area is also calculated by C-CAP by applying an impervious coefficient to the four developed land categories (high-, medium-, low- intensity development and developed open space) (NOAA 2015). The change in percent impervious area between 2001 and 2011 helped indicate where recent development and density increases were concentrated. National Agriculture Imagery Program (NAIP) orthophotos from 2006 and 2013 were referenced to provide a visual overview of each basin and to evaluate historic and current stressors (NAIP 2006, 2013).

Public land ownership was estimated across Puget Sound from the Washington Department of Natural Resources (DNR) lands and non-DNR public lands GIS data sets. The public land layer was broken down into the following government categories: city or municipal, county, state (DNR and non-DNR), or US federal. The public lands layer likely underestimates the amount of local government land, but public lands were assumed to be less likely to be developed than privately held lands. Land ownership may be helpful in the future to help assess the feasibility of implementing recommended management actions.

2.2.2 Zoning and Urban Growth Areas

Patterns of land use are bound to change over time, especially in the Central Puget Sound region where population growth is expected to increase from about 3.8 million people in April 2014 to 5 million people by 2040 (Puget Sound Regional Council 2009). Zoning data can yield insight into how land use may change in particular locations though it should be noted that zoning can and will change over time too. Each city and county develops planning and zoning categories to meet their specific needs and summarizing the zoning across all of Puget Sound is challenging because the individualized categories do not easily align across jurisdictions.

The Washington State Department of Commerce has consolidated zoning data from across Puget Sound as part of the Puget Sound Mapping Project (Department of Commerce 2013, 2015). This process required applying a consolidation strategy to reduce hundreds of zoning categories to a dozen sharing common characteristics (Table 1).

Table 1. Consolidated zoning categories.
Zoning data from Puget Sound cities and counties were consolidated into 12 master categories, each with 1 to 4 sub-categories (Department of Commerce 2015).

Master Category	Subcategory
Active Open Space and Recreation	National Park
	Active Recreation (Urban or State Parks)
	Other Active Open Space/Recreation (Cemetery, Surface Water Detention)
	Campground or Small Resort
Industrial	Light Industrial
	Heavy Industrial
	Airport/Seaport
Intensive Urban	Residential (12+ Units/Acre)
	Mixed Use
	Commercial/Office
	Institutional Uses (Hospital, Campus)
Military	Intensively Developed Military
	Undeveloped Military Lands
Natural Preservation and Conservation	Federal Preservation (i.e. National Wildlife Refuge)
	State and Local Preservation (Watershed, Greenbelt)
	Long Term Private Preservation (Trust, Preserved Sensitive Areas)
Resource Agriculture	Designated Agricultural Resource
	Other Active Agricultural
	Low Intensity Rural Agriculture (i.e. Nurseries, Hobby Farms)
Resource Forest	Designated Forest Resource
	National Forest
	Other Forest Lands
Resource Mineral	Mining or Mineral Resource
Rural Character Residential	Urban Edge (1 unit per acre up to 1 unit per 4.9 acres)
	Rural Transition (1 unit per 5 acres to 1 unit per 9.9 acres)
	Large Lot Residential (1 unit per 10 acres to 1 unit per 19.9 acres)
	Very Large Lot Residential (1 unit per 20 acres or more)
Tribal	Tribal Reservation
	Tribal Inholding Lands
Urban Character Residential	Low Density Urban Residential (1.1-3 Units/acre)
	Traditional Single Family Residential (3-12 Units/Acre)
	Mixed Use/Planned Neighborhood (3-12 Units/Acre)
Water	Tidal Waters
	Major Lakes
	Other Water Features

The Washington Department of Commerce shared its February 2015 consolidated zoning shapefiles[9] with our project team. These zoning categorizations were used to estimate risk of future development which was one consideration in defining the protection category for the "excellent" basins (see section 3.5 for more details) and estimating the risk of future degradation for the "fair" basins.

The state of Washington adopted the Growth Management Act (GMA) in 1990 to mandate coordinated and planned growth. Under the GMA, local governments are required to designate Urban Growth Areas (UGAs) within which urban growth is encouraged and outside of which growth can only occur if it is not urban in nature. The UGAs are delineated to focus and accommodate projected urban growth for twenty-year periods. The zoning within UGAs presumably reflects primarily intensive urban and urban character residential categories, but the proportion of basins within UGAs was used on its own as a quick snap shot to assess the likelihood of future growth and development.

2.2.3 Protected Lands

The USGS National Gap Analysis Program (GAP) has developed GIS data available for download for each state for landcover and protected areas (USGS 2011, USGS 2012). The GAP program identifies four protection levels which provide a measurement of management intent for long-term biodiversity conservation:

Level 1: Permanent protection, natural disturbance events[10] permitted

Level 2: Permanent protection, natural disturbance events suppressed

Level 3: Permanent protection, extractive or multiple uses permitted

Level 4: No known mandate for protection

Level 1 tends to be wilderness areas and national parks. Level 2 are state parks and natural areas. Level 3 are national and state forests. Not all regional, county, and city/town level protections are included in the GAP data (PAD-US 2009), however those that are included can be classified in any of the protection levels. The state of Washington's largest conservation organization, Forterra, has enhanced the GAP data by assigning GAP status protection levels[11] for many of these local protected areas (e.g., Seattle's Cedar River or Tolt Watersheds) for a four County region: Snohomish, King, Pierce, and Kittatas (Forterra 2013). The enhanced Forterra GAP data were used for our analyses where available, however areas not within Snohomish, King, or Pierce counties likely underestimate the amount of city or county protected lands.

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[9] This February 2015 consolidated zoning layer is considered draft and is undergoing review by individual jurisdictions before it becomes finalized.

[10] Disturbance events include natural processes such as fires, floods, insect outbreaks, etc. Whether these are natural disturbance events are permitted or suppressed dictates whether an area is classified in protection level 1 or 2.

[11] GAP status protection level assignments to county, municipal, and private lands are estimates using best professional judgement; Forterra did not consult individual parcel management plans.

For the purposes of this project, lands designated as protection level 1 or 2 were considered protected. Level 3 lands routinely have large amounts of forest harvest or mining and these activities are known for having impacts to stream macroinvertebrate communities and likely could cause a decline in B-IBI scores. For the "excellent" basins, the type and extent of protected lands within each basin was used along with zoning to estimate risk of future development which was one consideration in defining the protection category for each basin (see section 3.5 for more details).

2.2.4 Puget Sound Watershed Characterization

Ecology's Puget Sound Watershed Characterization (PSWC) is a regional scale tool that integrates landscape-scale measures of landcover and hydrology in a novel way that other metrics do not capture. The water flow processes model of the PSWC was used in the restoration decision framework to filter potential "fair" sites (King County 2014c). For this phase of the project (i.e., identifying potential limiting factors and determining appropriate restoration and protection strategies), the upstream contributing basins for the final "fair" and "excellent" sites were run through PSWC's water flow and water quality models. Results were generated for individual model components, or "processes," including water delivery, surface storage, recharge, and discharge for the water flow model and phosphorus, metals, nitrogen, and pathogens for the water quality model. The results of the PSWC model runs helped inform which water flow and water quality processes were degraded at the basin-scale. Such degradation could potentially be impacting macroinvertebrate communities and therefore restoration of these processes might result in improved B-IBI scores. The PSWC results are mentioned in several individual-basin restoration portfolio summaries and frequently verified best professional judgement of limiting factors (see section 4.4.2).

The Department of Ecology has also used the PSWC to determine which watersheds in Puget Sound would receive the greatest benefit from stormwater restoration actions. This designation, "target" or "non-target", helped inform our assessment of potential stormwater actions for individual basins (section 2.3.2, Appendix K).

See Stanley (2010) and Stanley and others (2012) for details of the PSWC models. See Appendix B for more details of PSWC relevant to this project.

2.2.5 Water Quality

Washington's Water Quality Assessment lists the water quality status for water bodies in the state and the 303(d) list includes waters where beneficial uses such as drinking, recreation, aquatic habitat, and industrial use are impaired by pollution (Ecology 2012). Impairment listings from the 2008 303(d)[12] list were summarized for the final "fair" and "excellent" basins to provide a snapshot of potential areas of water quality degradation.

[12] The 2012 303(d) has not been finalized.

303(d) listings indicate the existence of additional data related to water quality, but they did not generally influence our recommendations for restoration or protection actions.

2.3 Regional Priorities

Considerable regional resources are focused on two related and interconnected high priority efforts: salmon recovery[13] and stormwater management[14]. Identifying overlap between B-IBI and fish and/or stormwater priorities will help leverage existing funding and target areas where a mutually beneficial outcome for both invertebrates and fish may be likely. This information could be used to prioritize where to start implementing restoration or conservation actions.

2.3.1 Fish Intrinsic Potential

Intrinsic potential (IP) is a unique index modeled for individual salmonid species that indicates the potential habitat quality of a stream reach for that particular species (Burnett et al. 2007). Protecting threatened and endangered salmon species is often the primary goal driving many restoration and conservation activities. However, due to the difficulty of compiling and synthesizing priorities and plans for salmon restoration projects throughout Puget Sound, we are using intrinsic potential (IP) models to indicate potential salmonid habitat.

We obtained high resolution GIS data for Puget Sound streams from the PSWC project (Wilhere et al. 2013) and the Puget Sound and Interior Columbia Steelhead Intrinsic Potential (NOAA 2012). These data contain unique IP values for each fine-scale stream segment for three salmonid species: Chinook salmon, coho salmon, and steelhead. These species were selected because (1) intrinsic potential models were available for these species, (2) two of these species (Chinook and steelhead) are listed as threatened and are considered important for protection and conservation, and (3) intrinsic potential for these species likely has a high overlap with other anadromous salmonids frequently present in our basins of interest (e.g., cutthroat trout or chum salmon). The steelhead and coho IP were adapted from modeling for juvenile salmon in western Oregon, and are based on inputs including mean annual flow, valley width, and channel gradient (Burnett et al. 2007). The Chinook IP was based on two models: one for fall Chinook in the lower Columbia (Busch et al. 2013), and one for spring/summer Chinook in the interior Columbia

[13] The Puget Sound Salmon Recovery Board has a 2013-2015 capital budget of $259 million (RCO 2015a) to implement projects identified in the $1.42 billion 10-year salmon recovery plan (Shared Strategy 2005, RCO 2015b) and well over 50 organizations including government, tribes, and community groups are actively involved and contributing to salmon recovery efforts (PSP 2015).

[14] Addressing stormwater problems throughout Puget Sound to rehabilitate stream flows and water quality to near-pre-development is estimated to cost up to $14 billion per year for 30 years or $650 million per year for 100 years (in 2013 dollars, King County 2014d). Specialized state funding including a proposed $229 million in 2016 is available to target stormwater retrofits and is being utilized by many jurisdictions throughout Puget Sound to reach stormwater management goals and reduce detrimental impacts of stormwater from past development.

basin (Cooney and Holzer 2006). The Chinook models incorporate habitat factors such as bankfull width, valley width, and channel gradient.

To calculate a unique IP score for each of the restoration and protection basins, we calculated a basin-averaged IP. This value incorporates all unique IP values and segments found within each basin, and provides an average to assess the overall potential value each basin has for the given species. Average values were then summed for coho, steelhead, and Chinook for each basin to produce a single score that represents the estimated value of each basin for these three species and provides a relative ranking of available fish habitat. Chinook IP values were fairly low which is not surprising given that the size of streams targeted in this project are generally too small for Chinook to utilize. In contrast, these streams have much higher coho and steelhead intrinsic potential, indicating the importance of these types of streams for these species.

2.3.2 Stormwater

Because polluted stormwater has been identified as the leading threat to Puget Sound rivers and streams (Ecology 2011), preventing pollution from urban stormwater runoff is one of PSPs three strategic initiatives in the 2014/2015 Action Agenda (PSP 2014). In addition to water quality impacts, high stormwater flows contribute to stream habitat simplification and biological degradation (Booth and Jackson 1997). B-IBI scores have been shown to decline as impervious area increases at all spatial scales throughout Puget Sound (Booth et al. 2004), with urban stormwater runoff being one of the major drivers of biological response. Increasingly, stormwater retrofits are designed to reduce the hydrologic stress and pollutant loadings that are contributing to declines in B-IBI scores in urban basins. It is anticipated that as more retrofits are constructed, B-IBI scores and overall stream health will improve (e.g., King County 2014d). In addition, aligning B-IBI focused restoration with regional stormwater management efforts could help utilize existing plans to achieve B-IBI restoration targets, as well as increase the potential for future opportunities and funding.

Ecology has been using a watershed targeting assessment based on the PSWC to both rate and rank potential retrofit projects and identify high priority basins. These assessments have been and are likely to continue to be used to direct various funding sources towards retrofit planning and implementation. In addition to Ecology's ranking systems, King County recently began identifying and implementing small stream retrofit projects to restore stream health and water quality. This Small Basin Stormwater Retrofit program[15] focuses on small stream basins in unincorporated King County where biological health and/or water quality are degraded and stormwater runoff is the likely culprit.

We utilized GIS layers from Ecology and King County of priority watersheds and existing stormwater retrofit projects to identify where B-IBI restoration and protection basins

[15] http://www.kingcounty.gov/depts/dnrp/wlr/sections-programs/stormwater-services-section/capital-services-unit/small-stream-basin-retrofit.aspx

overlapped with stormwater retrofit priorities or existing projects. For now this information is noted, however it will be helpful for prioritizing basins for restoration or protection actions in the future.

2.4 Regional Outreach

The expertise of regional stakeholders was invaluable at various stages of this project, but particularly in providing basin-specific information regarding appropriate restoration and protection actions. Feedback was solicited directly during a series of small group meetings across the regions and a stakeholder workshop open to the entire B-IBI and restoration community.

2.4.1 Small Group Meetings with Regional Experts

Fifty-three people from 13 agencies were contacted to identify stakeholders knowledgeable about the priority "fair" and "excellent" basins selected for further analysis. We then conducted ten small group regional outreach meetings in February, March, and April 2015 meeting with 32 WRIA coordinators, tribal staff, and local, regional, and national agency personnel from 11 organizations[16] in an attempt to harness local knowledge about the basins of interest. Attendees were presented with a set of questions (Appendix C) and maps for the basins at each meeting. Feedback was primarily focused on restoration basins from local experts and was used to inform best professional judgement where appropriate.

2.4.2 Stakeholder Workshop

King County hosted a "Strategies for Restoring and Protecting B-IBI Watersheds" stakeholder workshop on May 12, 2015. The workshop was attended by 40 stakeholders representing 18 entities[17]. During the workshop we recapped the project purpose, summarized the restoration framework criteria, presented protection and restoration strategies, and solicited suggestions and feedback on basin restoration recommendations. All workshop presentations and handout materials are available online at the PSSB Restoration Priorities project page[18] (Appendix D). See Appendix E for the workshop agenda.

[16] Staff from the following organizations met with us in small outreach meetings: Ecology, EPA, King, Kitsap, Snohomish and Pierce Counties, PSP, Snoqualmie Forum/WRIA 7, Snoqualmie Indian Tribe, WRIAs 8, and 9.
[17] Staff from the following organizations attended: Cities of Bellingham, Everett, Kirkland, Redmond, Seattle, Shoreline, Bainbridge Island; King, Kitsap, Pierce Counties; EPA, PSP, Quileute Nation, Snoqualmie Indian Tribe, Snoqualmie Forum, Ecology, Washington State University Extension, and WRIA 8.
[18] PSSB Restoration Priorities project page: http://pugetsoundstreambenthos.org/Projects/Restoration-Priorities-2014.aspx

3.0 PROTECTION BASINS

One of the two 2020 B-IBI PSP Ecosystem Recovery Targets is to protect all basins with "excellent" B-IBI scores. This section describes which basins were included and recommends applicable protection strategies.

3.1 "Excellent" Site Selection

Candidate sites for protection to achieve the PSP Ecosystem Recovery Target of maintaining "excellent" scores were initially identified in 2013 (King County 2014). However, a new PSSB data download was done on April 30, 2015 to include any new sampling locations that might meet the "excellent" criteria. The PSP Ecosystem Recovery Target defines "excellent" as B-IBI scores extending from 42 to 50[19].

The April 2015 PSSB download included B-IBI scores from 1,294 stream and river sampling locations within Puget Sound, 160 of which had B-IBI scores greater than or equal to 42 at least once (Figure 2). Fifteen of these 160 "excellent" sites were also on the final list of 54 "fair" sites. One of the criteria to be placed on the final "fair" list was having a median B-IBI score of "fair" (B-IBI 28-36; see section 4.1 of this report for more information on "fair" site selection) which indicates these sites frequently score below the "excellent" threshold and may require considerable restoration actions to maintain "excellent" scores and meet the PSP target. Rather than treat these fifteen sites as both "excellent" and "fair" basins, we chose to omit them from the "excellent" list and they will be discussed in the restoration section in more detail (see Appendix G for a list of these fifteen sites).

The PSP target specifies that 100 percent of Puget Sound lowland stream drainage areas monitored with baseline B-IBI scores of 42-46 or higher retain these "excellent" scores. Three criteria were applied in sequential order that we believe highlight sites that should be considered in the "excellent" category by any definition of excellent (see Appendix H for the B-IBI data for all remaining 145 candidate "excellent" sites). First, any sites with a median B-IBI score of "excellent" were included. This included any site that has only been sampled once if that one visit had a B-IBI score of 42 or more; 56 sites met this criterion. Second, any site that scored "excellent" between 2012 and 2014 at least once was also included. This is an indicator that an invertebrate community exists in very recent history that is sufficiently intact to achieve an "excellent" score regardless of the previous sampling history; 38 remaining sites met this criterion. Third, also included were sites scoring "excellent" 50% of the time. This includes sites with an even number of site visits where half of the visits had "excellent" scores; seven remaining sites met this criterion. 101 sites met at least one of these three criteria; 44 sites remained.

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[19] The B-IBI condition classes for the 10 to 50 B-IBI define "good" as 38 to 44 and "excellent" as 46 to 50. However, for the Ecosystem Recovery Target, PSP defined "excellent" as areas with baseline B-IBI scores of 42-46 or higher. Therefore, the term "excellent" for the purposes of this project extends from 42 to 50 and includes part of the B-IBI "good" condition class. See Appendix F for the B-IBI condition categories.

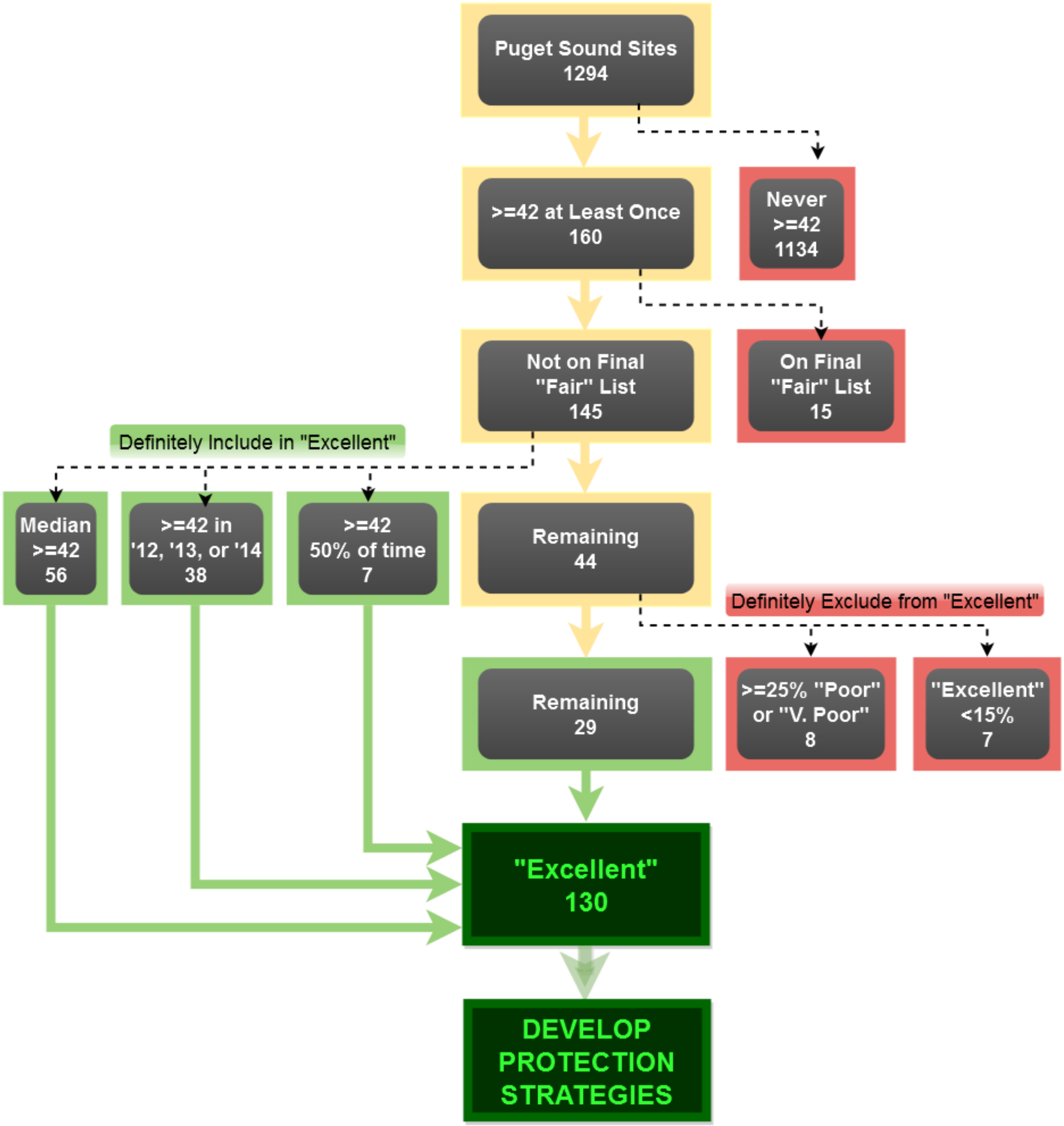

Figure 2. Filtering process to identify "excellent" sites for which protection strategies were developed.

The intent was to be very conservative in omitting any sites that scored "excellent" at least once from the final sites considered for protection strategies. However, some sites had B-IBI scores that did not seem reflective of a truly "excellent" site. Therefore, we applied two criteria to the remaining 44 sites that if met, excluded sites from the final "excellent" list. First, sites that were "poor" or "very poor" (B-IBI < 27) at least a quarter of the time were excluded. Eight sites met this criterion, and each had B-IBI scores for six or more years between 1999 and 2014 of which at least two scores were "poor" or "very poor."

None of these sites scored "excellent" more recently than 2008. Second, sites that scored "excellent" less than 15% of the time were excluded. Seven sites met this criterion and each of these had only a single "excellent" B-IBI score despite B-IBI records from 7 to 12 years. These fifteen sites were excluded from further consideration because their B-IBI scores indicate considerable degradation and therefore they should not be among those prioritized for protection.

Following the application of the 3 inclusion and 2 exclusion criteria described above, 29 sites still remained. These sites have variable histories of B-IBI scores; they were sampled between 3 and 12 times and scored "excellent" 16.7 to 45.5% of the time. B-IBI scores for most of these sites (20) were never in the "poor" or "very poor" range. The remaining sites (9) ranged from 8.3 to 20% of scores in the lowest condition categories. These 29 sites may not warrant high prioritization when it comes time to allocate limited resources to protection; however they were included in the list of "excellent" sites.

Over 35% (49) of the final 130 "excellent" sites were located on the same stream. These were identified visually using 2013 orthophotos overlaid with stream and basin boundaries to determine the distance between sites and to decide whether land use and zoning were homogeneous or heterogeneous between locations. When protection strategies were likely to be the same for multiple sites on a single stream they were collapsed into one location for further consideration. However, if basin land use or zoning was heterogeneous then sites on the same stream were kept separate and considered individually or as a separate group for further consideration. The majority of these sites were collapsed into one basin for further consideration. However, two groupings were maintained for Coal, French, East Fork Issaquah, Issaquah, and Newaukum Creeks (Table H-2 in Appendix H summarizes the groupings of sampling locations from the same streams.). These groupings reduced the total number of unique basins to 101, which are shown in Figure 3. These are the subset of basins in Puget Sound that have excellent B-IBI scores. Protection strategies were developed for these basins.

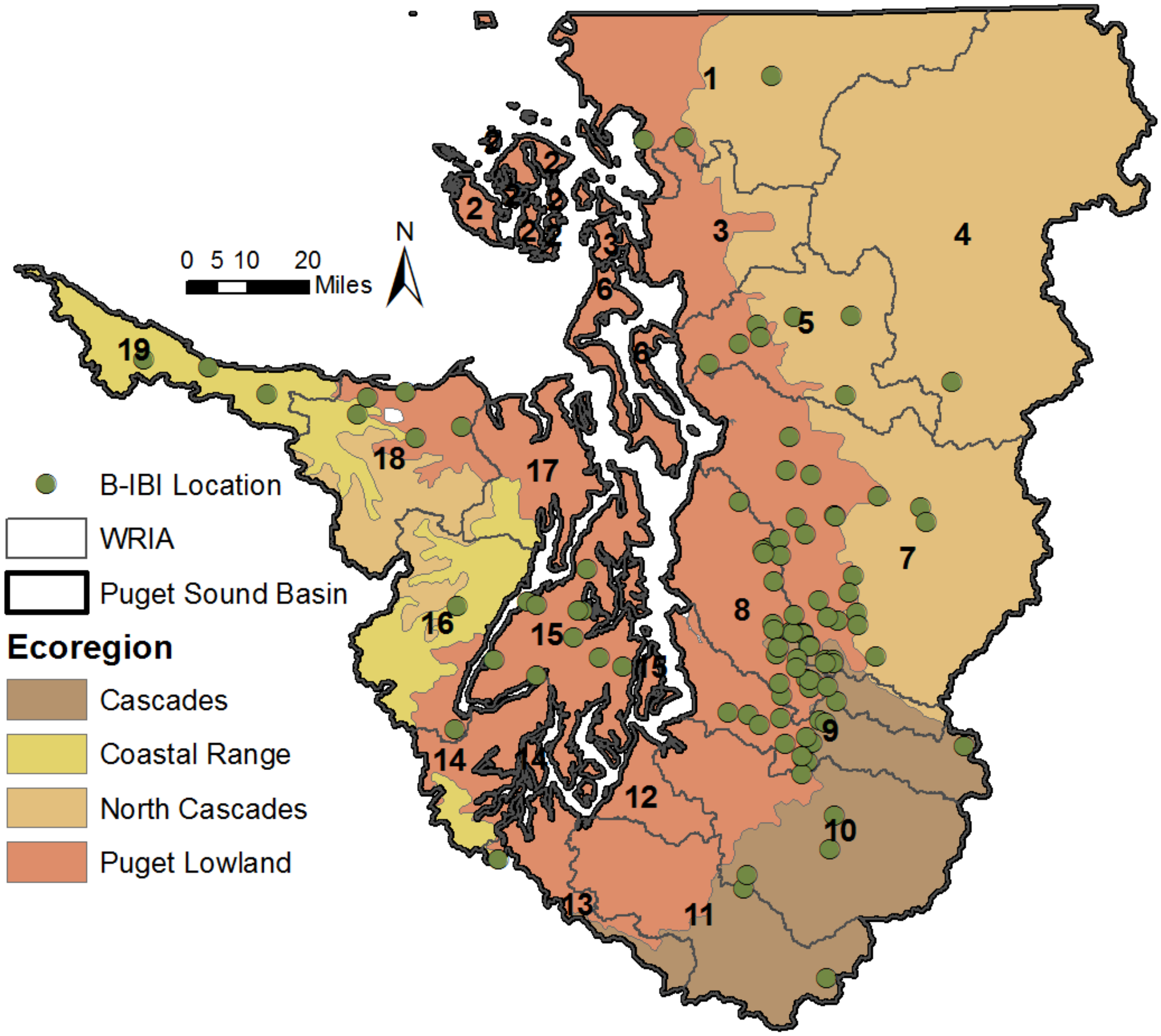

Figure 3. Regional distribution of the 101 "excellent" basins.

3.2 Current Conditions in "Excellent" Basins

Cumulatively, the 101 "excellent" basins encompass an area of 1,650 km^2, or 5.2% of the Puget Sound watershed. The "excellent" basins consist primarily of relatively undeveloped, forested land. The "average" land cover for the "excellent" basins is nearly 90% natural[20], 5.6% urban, and 1.5% agriculture (Figure 4). However, there are a few basins that are exceptions to this pattern; these basins had a greater degree of moderate urban or agricultural development. Basin urbanization ranges from 0 to 43% in the "excellent" basins, but is less than 10% in all but 19 of 101 basins. The percentage of agricultural land use ranges from 0 to 26.6% and is less than 6% in all but 5 of 101 basins.

[20] Natural is the combination of forest, shrub, grass, and wetland landcover classifications; see section 2.2.1 for more information.

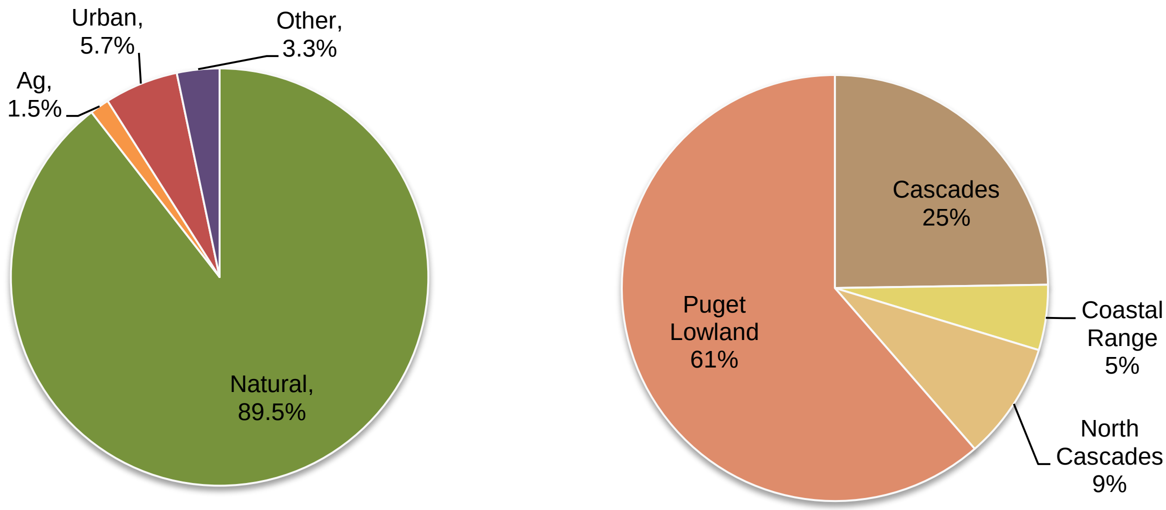

Figure 4. Average land cover characteristics (left) and distribution of ecoregions for "excellent" basins.

The "excellent basins" are found throughout the Puget Sound watershed and vary greatly in size. Basin size was highly variable and ranged from 48 to 36,098 acres with a median basin area of 1,497 acres. Ecoregions denote areas within which ecosystems are generally similar based on geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. These biotic and abiotic phenomena can affect or reflect differences in ecosystem quality and integrity (Omernik 1987, 1995). The Puget Sound Basin includes four Level III ecoregions derived from Omernik (1987) and refined by the US EPA ecoregion framework (EPA 2013): North Cascades, Coastal Range, Cascades, and Puget Lowland. The "excellent" basins are located predominantly in the Puget Lowland ecoregion (61%), with numerous sites in the Cascades (25%) or North Cascades (9%) ecoregions (Figures 4 and 5).

It should be noted that even though these basins had "excellent" B-IBI scores, several of them had documented water quality impairments. These water quality impairments could be unrelated to B-IBI scores or they could indicate some degree of degradation that could influence future B-IBI scores and they are noted here to describe current basin conditions. There were 49 total 303(d) impairment listings within 28 of the 101 "excellent" basins. Listings were for temperature (12), dissolved oxygen (11), fecal coliform (9), pH (3), and total phosphorus (3). Appendix I includes a table of the 2008 303(d) listings within "excellent" basins.

3.3 Future Conditions in "Excellent" Basins

In order to develop an effective strategy for protecting B-IBI scores in basins currently assessed as "excellent," it is necessary to project future conditions. This is because the strategies need to be robust enough to accommodate future conditions, such as increased

population growth and development pressure. We interpreted near-term future conditions from the Puget Sound Mapping consolidated zoning information[21] by assuming that areas will build out per their zoning designation. For example, for a plot of land where the current land cover is entirely forested but the zoning is urban character residential, we assume that without implementation of appropriate protection actions the land will convert to urban residential. Actual population growth, rather than projections, combined with local, state, and federal regulations will ultimately drive future zoning and land use modifications (Department of Commerce 2013), however our coarse-level analysis allows a rapid assessment of risk of land use change and helps identify what actions may be appropriate to protect "excellent" basins.

In "excellent" basins, resource forest and rural character zoning both range from 0 to 100%, urban character zoning ranges from 0 to 72%, and urban zoning ranges from 0 to 62%. More than half of the area in 62% of the basins is zoned as resource forest indicating they are designated for timber harvest. More than half of the area in 35% of the basins is zoned urban, urban character, and/or rural character indicating they are designated for increased development. Over 10% of the area in 11 basins is within the UGA, including four basins with over half of their area inside UGA boundaries. These basins are likely to be developed and densified in compliance with Washington State's GMA (Washington State RCW 36.70 1990).

There are a few anomalies when it comes to the "excellent" basin zoning. For example, one basin has 100% active open space zoning; two basins have military zoning of 6 and 87%; two basins have notable resource agricultural zoning of 6 and 11%; three basins have resource military zoning of at least 7% (with a maximum of 33%). These unique situations will be described as appropriate in the sections that follow. No basins have any tribal reservations or inholding lands of note.

3.4 Protection Strategies

Section 3.5 that follows describes various groupings of "excellent" sites and briefly summarizes the types of actions that are likely to be necessary to maintain "excellent" B-IBI in these basins. Strategies with the most assurance of protection involve setting aside land in conservation so that it cannot be developed for urban or agricultural purposes and where forest harvest and mining are prohibited. Land purchase, conservation easements, and purchasing of development rights are forms of land protection with land purchase being the most expensive. Based on past experience with habitat restoration projects, it is likely that protecting "excellent" B-IBI scores (an intact basin) is likely orders of magnitude less expensive than attempting to improve a B-IBI score that requires restoring a degraded basin.

[21] One "excellent" basin on the Nisqually River (site ID 1648, site code BIO06600-BIGC04) was outside of the consolidated zoning boundaries and therefore zoning information was not considered for this site.

To maintain "excellent" B-IBI scores as forecasted development occurs, land protection will generally need to be combined with implementation of other measures such as stormwater, forestry, or agricultural best management practices (BMPs) and compliance with existing standards, rules, and codes such as clearing and grading restrictions and maintaining intact buffers around critical areas. These BMPs and regulatory protections are intended to mitigate the effects of landscape stressors on streams. Agricultural BMPs include fencing livestock away from streams, rotating crops, minimizing excessive fertilizer and pesticide use, and maintaining intact riparian buffers. Forestry BMPs include selective harvest (as opposed to clear cutting), maintaining sufficient buffers around streams and wetlands, road decommissioning, maintaining culvert passage, and replanting soon after harvest. Stormwater BMPs are described in detail in the Washington or King County stormwater manuals and include a wide variety of techniques including storage and treatment ponds, bioretention facilities, green roofs, and permeable pavement (Ecology 2014, King County 2009b). These BMPs may be required by law and noncompliance carries legal or financial ramifications, or they may be merely guidelines encouraged with landowner outreach and incentives. In addition, in areas where urban and residential uses, agricultural areas, and forestry are already present, some restoration actions may be required to maintain "excellent" B-IBI.

3.5 Protection Categories

The 101 "excellent" basins were grouped into categories based on current and likely future conditions that suggest similar protection strategies are warranted (Table 2). These categories and subsequent divisions are described in the subsections that follow. Stream names are used when referring to characteristics of specific basins. Some streams have more than one protection basin and in these cases the stream name will be followed by the unique PSSB site ID to distinguish them. Landscape descriptions are for the contributing basin for each sampling location. Tables throughout section 3.5 are sorted by WRIA and then stream name.

Table 2. Protection categories and number of sites within each category.

Category	Subcategory	# of Basins
Forest	Protected	8
	Partial Protection	8
	Harvest - Vulnerable	37
Higher-than-expected B-IBI	Tier 1	10
	Tier 2	9
Development	Stormwater Permit	7
	No Stormwater Permit	8
Combination Zoning	Urban Influences	6
	Rural/Forest Mix	2
Unique	Forest - Protected	1
	Forest - Partial Protection	2
	Mining	2
	Forest - Vulnerable	1
Total		***101***

3.5.1 Forest

Many "excellent" basins occur on lands zoned as resource forest. Basins with more than 70% resource forest zoning are classified in the forest protection category. 53 of the 101 basins meet this criterion.

Lands designated for timber harvest fall under different types of ownership that can be managed and harvested quite differently, therefore having notable differences in their potential impacts to B-IBI scores and stream health. The major timberland ownership groups that occur in the "excellent" basins include the United States Forest Service (USFS), DNR, and private industrial forest land. See Appendix J for a summary of forest ownership and logging intensity in Washington State.

All of the basins classified in the forest protection category are predominantly in forested condition with negligible agricultural or urban development. Only three basins have agricultural land covering more than 0.4% of the basin area (Newaukum N. Fork 2.6% pasture, Newaukum-259 2.1% pasture, and Tumwater 2.8% pasture); and only four basins have urbanization covering more than 2% of the basin area (Ten 2.7% urban, Peoples 2.3% urban, Twentyfive Mile 2.3%, and Newaukum N. Fork 2.0%). The "excellent" basins with more than 70% area zoned resource forest are divided into three subcategories based on the level of protection or the perceived likelihood of forest harvest activities (estimated based on ownership).

In the forest protection sections that follow, land protection actions (purchasing or conservation easements) and forestry BMPs are recommended in unprotected forest lands to maintain high B-IBI scores. The exact balance between these tactics is not spelled out at this time, but will likely depend on considerations of cost and likelihood of protection to

B-IBI scores. For example, land protection actions have the highest assurance of protecting streams and benthic macroinvertebrate communities, but such actions are much more expensive than implementation and enforcement of BMPs. In contrast, relying on BMPs is more risky for maintaining high B-IBI scores, but has a lower cost. The effectiveness of BMPs to maintain high B-IBI scores will be an important consideration as detailed basin planning is done to recommend the exact prescription of protection actions.

3.5.1.1 Forest – Protected

The eight basins placed in the protected forest harvest category are characterized by having at least 90% of the basin area classified in category 1 or 2 protected lands which are managed for biodiversity conservation and prohibit logging activities (Table 3). Five of these basins are within Seattle Public Utilities' Cedar River Watershed which is managed to protect the City of Seattle's drinking water supply (Webster, Rock Upper, Hotel, Williams, and Taylor). Two basins are in or adjacent to federal wilderness areas (Barclay in Wild Sky wilderness and Sauk adjacent to Glacier Peak wilderness)[22] which are managed according to the Wilderness Act to restrain human influences. The remaining basin is in the Tiger Mountain Natural Resources Conservation Area (NRCA) which is part of Washington State's Natural Areas program managed to protect examples of Washington's natural heritage and to protect native biodiversity. Each of these eight basins are entirely or nearly entirely within highly protected areas that are not likely to be impacted by human activities including urban or agricultural development or any form of resource extraction.

If existing protections are maintained in these basins, "excellent" B-IBI scores are likely to continue and therefore no additional actions are recommended.

[22] Sauk River does have some evidence of logging on National Forest lands in the downstream portions of the basin.

Table 3. "Excellent" basins in protected forest land. All values are percentages.

	2011 Land Cover (C-CAP)					Consolidated Zoning				Ownership				
Stream (WRIA)	Urban WS	Urban 1km	Pasture/Hay WS	Natural WS	Natural WS 90	Resource Forest	Total Urban/Rural	Recreation	Resource Ag	Federal	State DNR	Private	Protected Lands	Within SW Permit Area
Sauk R (4)	0.0	0.0	0.0	98.9	98.9	100	0.0	0.0	0.0	100	0.0	0.0	90.3	100
Barclay Ck (7)	0.1	0.6	0.0	97.8	97.8	100	0.0	0.0	0.0	98.6	0.0	1.4	93.1	100
High Point Ck (8)	0.0	0.0	0.0	100	100	99.0	1.0	0.0	0.0	0.0	93.7	6.3	93.1	100
Hotel Ck (8)	0.0	0.0	0.0	100	100	97.5	0.0	0.0	0.0	0.0	0.0	100	97.5	100
Rock Ck (8, U Cedar)	0.1	0.3	0.0	99.9	99.8	99.8	0.0	0.0	0.0	0.0	0.0	100	99.8	100
Taylor Ck (8)	1.2	0.5	0.0	98.8	99.1	100	0.0	0.0	0.0	0.0	0.1	99.9	99.7	100
Webster Ck Upper (8)	0.0	0.0	0.0	100	100	100	0.0	0.0	0.0	0.0	1.0	99.0	98.9	100
Williams Ck (8)	0.5	0.0	0.0	99.5	98.8	94.2	0.0	0.0	0.0	0.0	2.4	97.6	97.0	100

3.5.1.2 Forest – Partial Protection

Eight "excellent" basins have forested lands that are a mix of protected and potentially vulnerable to forest harvest activities (Table 4). These are basins with 40-60% of their lands in protected land categories 1 or 2 indicating strong levels of protection. Two are partially within watersheds protected for drinking water supplies (Raging tributary-2218 in Seattle's Cedar River Watershed and Sunday Creek, headwaters of the City of Tacoma watershed[23]). Five basins are partially within and adjacent to wilderness areas or national parks (French in the Boulder River wilderness; Canyon and Carbon in the Clearwater Wilderness, May in the Wild Sky Wilderness, Hamma Hamma in Olympic National Park). One basin is partially within a local NRCA (Issaquah E. Fork-928 in Tiger Mountain NRCA).

Evidence of recent forest harvest is visible from 2013 orthophotos within all eight basins. The areas outside of protected lands vary in ownership. Three basins have over 80% federal land ownership (Carbon, French, and Hamma Hamma). One basin has over 80% state DNR lands (Issaquah E. Fork-928). The remaining four basins (Canyon, Carbon, Raging River tributary-2218, and Sunday) have a mix of federal, state DNR, and private ownership.

No actions are recommended within the protected areas of these basins, however land protection actions (purchasing or conservation easements) are recommended for the unprotected areas to maintain high B-IBI scores. In areas without formal land protection,

[23] Tacoma only owns 10% of the watershed, but they have agreements with other landowners to limit activities (Tacoma Public Utilities 2008)

forestry BMPs should be followed and enforced with special emphasis on maintaining sufficient intact riparian buffers around streams and wetlands.

Table 4. "Excellent" basins in partially protected forest land. All values are percentages.

Stream (WRIA)	2011 Land Cover (C-CAP)					Consolidated Zoning				Ownership			Protected Lands	Within SW Permit Area
	Urban WS	Urban 1km	Pasture/Hay WS	Natural WS	Natural WS 90	Resource Forest	Total Urban/Rural	Recreation	Resource Ag	Federal	State DNR	Private		
French Ck (5)	0.4	2.9	0.2	99.5	99.5	99.0	1.0	0.0	0.0	84.0	14.4	1.6	45.2	100
May Ck (7)	0.3	3.8	0.0	94.8	93.1	88.6	11.4	0.0	0.0	51.4	29.1	19.5	49.9	100
Raging R trib-2218 (7)	0.0	0.0	0.0	100	100	100	0.0	0.0	0.0	0.0	45.6	54.4	54.4	100
Issaquah Ck E Fork-928 (8)	1.2	4.9	0.0	98.7	99.1	89.4	10.6	0.0	0.0	0.0	88.8	11.2	65.6	100
Sunday Ck (9)	1.2	0.0	0.0	98.6	98.7	97.5	0.0	0.0	0.0	43.4	0.0	56.6	50.5	99.3
Canyon Ck (10)	0.9	0.1	0.0	96.6	93.6	100	0.0	0.0	0.0	56.6	13.0	30.3	40.0	100
Carbon R (10)	0.3	0.1	0.0	97.6	97.3	100	0.0	0.0	0.0	81.3	0.0	18.7	60.0	100
Hamma Hamma R (16)	0.1	0.1	0.0	89.7	97.2	81.7	0.0	18.3	0.0	100	0.0	0.0	68.6	0.0

3.5.1.3 Forest Harvest – Vulnerable

The remaining 37 forested basins have little protected land (generally less than 2%[24]) and are vulnerable to potential forest harvest activities (Table 5). Land ownership is almost exclusively private or state DNR (private plus DNR ownership is less than 100% at only three basins: Youngs 99.6%, Raging-2220 93.2% and Canyon 86.1%). These lands are actively managed for forestry and evidence of recent forest harvest is visible from 2013 orthophotos within all 37 basins.

Land protection actions (purchasing or conservation easements) are recommended for the unprotected areas to maintain high B-IBI scores. If formal land protection is not feasible, forestry BMPs should be followed and enforced with special emphasis on maintaining sufficient intact riparian buffers around streams and wetlands. Two basins have additional land use considerations that should be mitigated to maintain "excellent" B-IBI. Newaukum N Fork has 44% pasture and 22% urban in the 1 km contributing basin immediately upstream of the sampling location. Deep Creek has 16.5% urban in the 1 km basin. Therefore agricultural BMPs such as fencing livestock away from the creek and establishing intact riparian buffers should be followed in the Newaukum basin. Stormwater retrofits and BMPs should be incentivized and implemented in downstream areas of both Newaukum N. Fork and Deep Creek.

[24] Three basins have approximately 14% protected lands: Canyon, Benson and Raging River-2220).

Table 5. "Excellent" basins in vulnerable forest land. All values are percentages.

Stream (WRIA)	2011 Land Cover (C-CAP)					Consolidated Zoning				Ownership			Protected Lands	Within SW Permit Area
	Urban WS	Urban 1km	Pasture/Hay WS	Natural WS	Natural WS 90	Resource Forest	Total Urban/Rural	Recreation	Resource Ag	Federal	State DNR	Private		
Austin Ck (1)	1.6	6.0	0.0	98.4	98.6	95.5	4.5	0.0	0.0	0.0	95.7	4.3	0.0	0.9
Racehorse Ck (1)	0.3	1.1	0.0	99.7	99.7	100	0.0	0.0	0.0	0.0	100	0.0	0.0	0.0
Benson Ck (5)	0.0	0.0	0.0	100	100	98.7	1.3	0.0	0.0	16.3	83.5	0.2	14.1	100
Rock Ck (5)	0.9	1.4	0.0	96.5	98.5	81.5	18.5	0.0	0.0	0.0	61.9	38.1	0.0	72.6
Stillaguamish N Fork trib (5)	0.6	0.0	0.0	96.7	99.9	99.2	0.8	0.0	0.0	0.0	12.4	87.6	0.0	98.6
Beaver Ck (7)	1.8	0.1	0.0	90.9	90.6	99.9	0.0	0.0	0.0	0.0	0.8	99.2	0.0	100
Crandall Ck (7)	0.3	0.2	0.0	98.5	97.3	100	0.0	0.0	0.0	0.0	47.0	53.0	0.0	100
Griffin Ck (7)	0.3	0.0	0.0	96.6	96.4	99.2	0.8	0.0	0.0	0.0	13.2	86.8	0.0	100
Lewis Ck (7)	0.0	0.0	0.0	100	100	100	0.0	0.0	0.0	75.0	0.3	24.6	0.0	100
Olney Ck trib (7)	0.2	0.0	0.0	99.2	99.9	100	0.0	0.0	0.0	0.0	100	0.0	0.0	100
Peoples Ck (7)	2.3	8.6	0.4	97.2	97.4	100	0.0	0.0	0.0	0.0	54.6	45.4	0.0	100
Raging R -1893(7)	0.2	0.0	0.0	99.2	99.9	100	0.0	0.0	0.0	0.0	100	0.0	0.0	100
Raging R-2220 (7)	0.2	0.0	0.0	98.3	98.5	99.7	0.0	0.0	0.0	0.0	82.9	17.1	14.8	100
Raging R trib-1020 (7)	0.0	0.0	0.0	100	100	100	0.0	0.0	0.0	0.0	100	0.0	0.0	100
Raging R trib-2216 (7)	0.0	0.0	0.0	100	100	100	0.0	0.0	0.0	0.0	100	0.0	0.0	100
Snoqualmie Mid Fork trib (7)	0.1	0.1	0.0	99.9	99.7	100	0.0	0.0	0.0	0.0	65.2	34.8	0.0	100
Tate Ck (7)	1.5	1.6	0.0	88.5	91.1	99.6	0.0	0.0	0.0	0.0	0.0	100	0.0	100
Ten Ck (7)	2.7	3.7	0.0	97.2	96.8	98.9	0.0	0.0	0.0	0.0	11.7	88.3	0.0	100
Tokul Ck-350 (7)	1.2	2.7	0.0	95.3	94.9	99.0	0.8	0.0	0.0	0.0	10.6	89.4	1.4	100
Tokul Ck-901 (7)	1.7	0.4	0.0	96.3	95.2	100	0.0	0.0	0.0	0.0	30.0	70.0	0.0	100
Youngs Ck (7)	0.4	2.0	0.0	91.3	94.1	100	0.0	0.0	0.0	6.1	20.4	73.4	0.4	100
Holder Ck (8)	0.1	0.0	0.0	99.9	99.9	100	0.0	0.0	0.0	0.0	100	0.0	0.0	100
Holder Ck trib (8)	0.0	0.0	0.0	100	100	100	0.0	0.0	0.0	0.0	100	0.0	0.0	100
Coal Ck (9)	1.0	1.6	0.0	98.8	99.0	98.6	1.4	0.0	0.0	0.0	31.8	68.2	0.0	100
Deep Ck (9)	1.8	16.5	0.0	97.9	95.9	98.1	1.3	0.0	0.0	0.0	3.0	97.0	0.0	100
Newaukum Ck-259 (9)	1.3	6.5	2.1	95.6	97.3	87.5	12.5	0.0	0.0	0.0	30.8	69.2	0.0	100
Newaukum Ck-261 (9)	0.3	0.0	0.0	98.6	99.5	100	0.0	0.0	0.0	0.0	37.6	62.4	0.0	100
Newaukum Ck N Fork (9)	2.0	22.1	2.6	94.9	93.7	92.5	6.2	0.0	1.3	0.0	9.9	90.1	0.0	100
Boise Ck (10)	1.9	4.5	0.0	95.7	97.0	95.7	3.9	0.0	0.0	0.0	9.1	90.9	0.0	100
Ohop Ck N Fork (10)	1.2	0.2	0.0	97.3	97.1	99.8	0.2	0.0	0.0	0.0	0.0	100	0.0	100
Twentyfive Mile Ck (11)	2.1	1.0	0.0	97.8	98.6	100	0.0	0.0	0.0	0.0	0.0	100	0.0	100
McLane Ck (13)	0.4	0.0	0.0	99.2	99.8	83.6	16.4	0.0	0.0	0.0	83.6	16.4	0.0	0.0
Canyon Ck (18)	0.3	0.3	0.0	99.3	99.6	78.8	9.5	11.6	0.0	74.4	11.8	13.8	13.5	0.0
Tumwater Ck (18)	0.9	4.6	2.8	95.9	95.0	77.7	22.3	0.0	0.0	0.0	58.3	41.7	0.0	0.0
Boundary Ck (19)	0.3	0.0	0.0	99.7	100	99.9	0.0	0.1	0.0	29.9	54.8	15.3	0.0	0.0
Clallam R trib (19)	0.0	0.0	0.0	97.0	98.2	100	0.0	0.0	0.0	0.0	18.8	81.2	0.0	0.0
Deep Ck (19)	0.0	0.0	0.0	99.6	99.8	100	0.0	0.0	0.0	55.3	5.4	39.3	0.0	0.0

3.5.2 Higher-Than-Expected B-IBI

Studies have repeatedly confirmed that biotic integrity as measured by B-IBI decreases as watershed urbanization increases (Karr and Chu 1999, Morley and Karr 2002, Walsh et al. 2005, Roy et al. 2003, Booth and Jackson 1997) and various urbanization or impervious surface thresholds have been recommended for maintaining good stream health.

There are 19 basins with less than 70% resource forest zoning and more than 10% basin urbanization. These were classified in the higher-than-expected protection category because their B-IBI scores are higher than expected given the extent of urbanization. This category is further divided into two sub-categories, but for both, limited protection resources may be better utilized in other areas with lower current development and fewer future development pressures. Although they may rank highly for protection resources, there may be great value in studying these basins further. For instance, it could be very useful to know if there is something about where development has occurred within these basins that allows them to maintain "excellent" B-IBI scores while other basins with similar levels of development have not. Studying the development patterns and the extent and distribution of intact forested areas relative to stream corridors within these basins could help inform future BMPs and development actions and patterns.

3.5.2.1 Higher-than-expected tier 1

There are ten "excellent" basins where basin urbanization exceeds 20% based on 2011 land cover data (Table 6). The fact that these basins have "excellent" B-IBI is surprising given this extent of urbanization (e.g., Karr and Chu 1999, Morley and Karr 2002, Walsh et al. 2005, Roy et al. 2003, Booth and Jackson 1997). B-IBI scores are unlikely to be maintained without heavy investments in restoration actions to mitigate the already extensive development that has occurred in these basins. Recommended restoration actions rely extensively on stormwater retrofit projects in these already urbanized basins.

Two of these basins (Kackman and Taylor/Jem Creeks) also have extensive pasture in 18% and 11% of the area within the basin. For these two locations, agriculture BMPs would be necessary to maintain "excellent" B-IBI.

Projected future development is also an enormous challenge for the ability of these basins to maintain their "excellent" B-IBI scores. Only small portions of these basins (<11.5%) are currently protected lands. Nine of the ten basins have urban/rural combined zoning of at least 96% and the tenth basin (Nisqually River) has 87% intensively developed military and 13% rural character residential zoning.

If these basins are to maintain "excellent" B-IBI and achieve the PSP target, future development would have to be minimized by re-zoning, land protection through direct purchase, purchase of development rights, or conservation easements. Future development that does occur would have to follow strict stormwater BMPs to mitigate impacts to stream ecosystems. Nine of the basins fall entirely within the municipal stormwater permit boundaries and therefore future development is obligated to follow stormwater manual

guidelines. Only 12% of Clear is within the stormwater permit boundaries; the remaining military land is not required to follow stormwater manual guidelines for future development.

Table 6. Higher-than-expected tier 1 "excellent" basins. All values are percentages.

	2011 Land Cover (C-CAP)				Consolidated Zoning									
Stream (WRIA)	Urban WS	Pasture/Hay WS	Natural WS	Within UGA	Urban	Urban Character	Rural Character	Total Urban/Rural	Resource Forest	Resource Ag	Military	Resource Mineral	Within SW Permit Area	Protection 1 & 2
Kackman Ck (5)	22.6	18.3	49.4	0.0	5.1	0.0	94.8	99.9	0.0	0.1	0.0	0.0	100	0.0
Adair Ck (7)	37.8	0.0	55.8	71.3	0.0	72.2	27.8	100	0.0	0.0	0.0	0.0	100	0.0
Cottage Lake Ck (8)	29.3	0.2	56.3	18.5	6.2	1.5	91.3	99.1	0.0	0.0	0.0	0.0	100	0.0
Rutherford Ck (8)	34.1	0.1	55.0	30.3	0.0	30.7	69.2	100	0.0	0.0	0.0	0.0	100	0.0
Struve Ck (8)	30.0	0.0	56.1	3.6	0.0	3.7	96.0	99.7	0.0	0.0	0.0	0.0	100	0.0
Taylor/Jem Ck (8)	22.0	11.4	55.5	0.0	0.0	0.0	100	100	0.0	0.0	0.0	0.0	100	0.0
Trout Ck (8)	24.7	0.2	59.3	8.0	0.0	7.7	91.9	99.6	0.0	0.4	0.0	0.0	100	0.0
Olson Ck (9)	43.0	5.9	33.0	100	5.5	45.8	48.7	100	0.0	0.0	0.0	0.0	100	1.0
Soos Ck-268 (9)	39.1	3.9	38.4	53.7	4.6	41.6	49.7	95.9	0.0	0.0	0.0	0.9	100	0.0
Clear Ck (15)	35.4	0.2	55.4	0.0	0.0	0.0	12.7	12.7	0.0	0.0	87.3	0.0	12.5	0.0

3.5.2.2 Higher-than-expected tier 2

An additional nine basins have at least 10% basin urbanization which is still a very high threshold for achieving "excellent" B-IBI scores based on previous studies. Cristy Creek also has over 26% pasture and therefore agricultural BMPs are recommended (Table 7). Appropriate restoration of current conditions and mitigation of future development is likely more achievable than the tier 1 sites, but could still prove to be extremely challenging and resource intensive.

Future development is still a challenge; five of the nine basins have at least 80% urban and rural zoning, including four with over 10% of their area within the UGA boundary. One of these five (Soos Creek-1620) also has 7% resource mineral zoning so mining BMPs would also be necessary. The remaining three tier 2 basins have between 33 and 64% urban and rural zoning with the remaining portion being resource forest zoning (33-67%). In these three basins, forestry BMPs would be necessary. For all but one of these basins, 100% of the basin is within the stormwater permit area and almost 95% of the ninth is within the permit area. Therefore, future development would be required to follow stormwater manual guidelines. In addition, protection levels are higher (up to 57%) indicating that some of the zoned development or forestry may be less likely to occur.

Table 7. Higher-than-expected tier 2 "excellent" basins. All values are percentages.

Stream (WRIA)	2011 Land Cover (C-CAP)			Within UGA	Consolidated Zoning								Within SW Permit Area	Protection 1 & 2
	Urban WS	Pasture/Hay WS	Natural WS		Urban	Urban Character	Rural Character	Total Urban/Rural	Resource Forest	Resource Ag	Military	Resource Mineral		
Cougar Ck trib (5)	13.7	2.4	83.7	0.0	0.0	0.0	100	100	0.0	0.0	0.0	0.0	100	0.0
Tuck Ck (7)	18.4	0.1	76.1	0.0	0.0	0.0	99.6	99.6	0.0	0.0	0.0	0.0	100	0.0
Issaquah Ck-150 (8)	12.5	3.5	79.5	12.3	6.4	3.5	53.7	63.5	32.8	0.0	0.0	1.1	100	0.0
Issaquah Ck E Fork-934 (8)	12.5	0.0	86.7	0.0	10.5	0.0	22.7	33.2	66.8	0.0	0.0	0.0	100	0.0
McDonald Ck (8)	14.4	5.1	73.3	0.0	0.0	0.0	100	100	0.0	0.0	0.0	0.0	100	0.0
Rock Ck (8 L Cedar)	10.0	4.5	83.3	6.7	1.2	5.9	42.0	49.0	50.3	0.0	0.0	0.6	100	0.0
Cristy Ck (9)	14.5	26.3	49.9	0.0	0.1	0.0	89.3	89.4	0.0	10.6	0.0	0.0	100	0.0
Soos Ck-1620 (9)	16.1	3.3	67.1	41.8	7.0	33.1	41.4	81.4	11.0	0.0	0.0	7.3	100	0.0
Gorst Ck (15)	10.2	0.1	71.0	85.4	62.0	24.0	14.1	100	0.0	0.0	0.0	0.0	94.8	57.0

3.5.3 Development

Development basins have relatively low levels of current urbanization (less than 10% basin urbanization) but have combined urban, urban character, and rural character zoning exceeding 70% (Table 8 and 9). Fifteen basins meet these criteria.

Current land use in these basins ranges from 0 to 8.5% basin urbanization and natural lands comprise at least 76% of each basin. Agriculture is generally minimal (less than 3%) except in three basins (Stillaguamish-1247 20.1%, Bagley 14.7%, and Olalla 5.3%).

Protected lands are not common in these basins and development is likely to be predominantly rural character in nature. Three basins do have notable portions of protected land (70% of Seidel is in the Redmond Watershed Preserve; 57% of Canyon Creek is Grand Ridge Park and Mitchell Hill Connector Forest; 28% of Stavis Creek is in the DNR Stavis NRCA). Only three basins have less than 97% rural character zoning and two basins have small areas within a UGA boundary (Woods has 76% rural character, 24% resource forest, no area in an UGA; Chico has 72% rural character, 20% resource forest, 6% military, and 2.6% within an UGA; and Blackjack has 78% rural character, 13% active open space and recreation, and 8.5% within an UGA).

Future rural development will be a major challenge to maintain "excellent" B-IBI scores in these basins. Land protection strategies (outright purchase, conservation easements, purchasing development rights) should be considered where feasible and maintaining

intact riparian buffers throughout the basin's streams and wetlands is essential. Where development does occur it should adhere to strict stormwater BMPs.

Development basins are further subdivided based on whether they are inside or outside of the municipal stormwater permit area.

3.5.3.1 Development – Stormwater permit

The entire contributing area of seven basins falls entirely within the municipal stormwater permit area. Therefore, future development in these basins is required to adhere to stormwater manual requirements (Ecology 2014, King County 2009b). We assume that these requirements, if enforced, will help mitigate future development impacts though some impacts are still likely. In addition to stormwater BMPs, Agriculture BMPs will be necessary in Stillaguamish-1247 where there currently is 19% pasture and forestry BMPs will be necessary in Woods where 24% is zoned resource forestry (Table 8).

Table 8. Development "excellent" basins within stormwater permit area. All values are percentages.

	2011 Land Cover (C-CAP)				Consolidated Zoning									
Stream (WRIA)	Urban WS	Pasture/Hay WS	Natural WS	Within UGA	Urban	Urban Character	Rural Character	Total Urban/Rural	Resource Forest	Recreation	Resource Ag	Military	Within SW Permit Area	Protection 1 & 2
Stillaguamish N Fork trib-1247 (5)	3.3	19.0	76.7	0.0	0.0	0.0	97.5	97.5	2.5	0.0	0.0	0.0	100	0.0
Canyon Ck (7)	0.8	0.0	99.1	0.0	0.0	0.0	100	100	0.0	0.0	0.0	0.0	100	0.0
Creswell Ck (7)	3.8	0.0	96.2	0.0	0.0	0.0	100	100	0.0	0.0	0.0	0.0	100	0.0
French Ck (7)	2.7	0.2	93.4	0.0	0.0	0.0	100	100	0.0	0.0	0.0	0.0	100	0.0
Mud Ck (7)	0.0	0.0	100	0.0	0.0	0.0	100	100	0.0	0.0	0.0	0.0	100	0.0
Woods Ck W Fork (7)	2.9	1.4	94.0	0.0	0.0	0.0	75.8	75.9	24.1	0.0	0.0	0.0	100	0.0
Seidel Ck (8)	7.0	0.8	88.3	0.0	0.0	0.0	100	100	0.0	0.0	0.0	0.0	100	0.0

3.5.3.2 Development – No stormwater permit

Most of the area in eight development basins is outside the municipal stormwater permit area (less than 1.5% is inside the permit area except 18.4% in Blackjack; Table 9). This indicates that future development outside of UGAs may not be required to follow stormwater manual requirements (Ecology 2014, King County 2009b), although some

jurisdictions (e.g., Kitsap County[25]) are currently treating non-permitted areas as permitted and are adhering to stormwater manual requirements. While development in these basins may not be required to adhere to stormwater requirements, these BMPs should be encouraged, potentially incentivized, and implemented if the goal of maintaining "excellent" B-IBI scores is going to be achieved. In addition, forestry BMPs will be necessary in Chico and Bagley where 20% and 7% of the basin is zoned resource forestry.

Table 9. Development "excellent" basins outside stormwater permit area. All values are percentages.

	2011 Land Cover (C-CAP)				Consolidated Zoning									
Stream (WRIA)	Urban WS	Pasture/Hay WS	Natural WS	Within UGA	Urban	Urban Character	Rural Character	Total Urban/Rural	Resource Forest	Recreation	Resource Ag	Military	Within SW Permit Area	Protection 1 & 2
Blackjack Ck (15)	8.5	0.0	88.1	8.5	0.5	7.8	78.4	86.7	0.0	13.1	0.0	0.0	18.3	0.0
Boyce Ck (15)	2.5	0.0	93.9	0.0	0.0	0.0	100	100	0.0	0.0	0.0	0.0	0.0	0.0
Chico Ck (15)	3.5	0.1	93.3	2.6	0.1	0.0	71.6	71.7	19.5	0.5	0.0	6.4	1.3	0.0
Dewatto R (15)	0.7	0.0	95.8	0.0	0.0	0.0	98.5	98.5	1.2	0.0	0.0	0.0	0.0	0.0
Olalla Ck (15)	8.5	5.3	81.8	0.0	0.0	0.0	100	100	0.0	0.0	0.0	0.0	0.7	0.0
Stavis Ck (15)	3.4	0.0	96.0	0.0	0.0	0.0	100	100	0.0	0.0	0.0	0.0	0.0	0.0
Purdy Ck (16)	2.4	2.9	94.2	0.0	0.2	0.0	93.4	93.6	0.0	0.0	6.4	0.0	0.0	0.0
Bagley Ck (18)	5.6	14.7	77.9	0.0	0.1	0.0	93.0	93.2	6.8	0.0	0.0	0.0	0.0	0.0

3.5.4 Combination Zoning

Several basins do not fall into any of the previously described categories. These basins either have a diverse mix of zoning that will require a wide range of restoration or protection techniques to preserve "excellent" B-IBI or they have unique circumstances that are not commonly found in the other basins and therefore they are described individually. Those with a diverse mix of zoning are further divided based on the level of urbanization pressures.

3.5.4.1 Combination zoning – Urban influences

Six basins have a variety of zoning patterns: 0-19% active open space, 25-70% resource forest, 24-55% rural character, and 0-9% urban and urban character (Table 10). Therefore, in addition to land protection techniques, a mix of forestry and stormwater BMPs are likely

[25] Kitsap County policy is per personnel communication with Mindy Fohn of Kitsap County Surface Water Management. It was beyond the scope of this project to determine which jurisdictions are voluntarily adhering to stormwater guidelines, however there could be others following Kitsap's example.

essential in each of these basins. Agriculture BMPs will also be necessary in Issaquah-152 where 4% of the basin is pasture. The common element among these basins is that they all have urban stressors that may be the largest challenge to maintain "excellent" B-IBI. Three of these basins have at least 7% of their basin area within UGA boundaries: Dickerson 20%, Chuckanut 14%, Issaquah-152 7%. Four of the basins have current urban pressures in the local (1-km) basin or (90-m) buffer of more than 10% (Cherry 11% urban 1km, Mission 13% urban 1km and 10% urban 1km buffer, Issaquah E. Fork-159 22% urban 1km buffer, and Issaquah-152 90% urban 1km and 13% urban 1km buffer). Three of these basins are 100% within the stormwater permit area and two of the three have protected lands (Issaquah E. Fork-159, 59% protected in Grand and Preston Ridge Parks and Tiger Mountain NRCA, and Issaquah-152 29% protected in the Tiger Mountain and Tradition Plateau NRCAs; Cherry N. Fork has no protected land but is within the stormwater permit area).

Implementing stormwater BMPs in newly urbanizing areas and adding stormwater retrofits in existing urban areas are likely to be required in these basins to maintain "excellent" B-IBI.

Table 10. "Excellent" basins with combination zoning and urban influences. All values are percentages.

Stream (WRIA)	2011 Land Cover (C-CAP)					Within UGA	Consolidated Zoning						Within SW Permit Area	Protection 1 & 2
	Urban WS	Urban WS 90	Urban 1km	Pasture/Hay WS	Natural WS		Resource Forest	Urban	Urban Character	Rural Character	Total Urban/Rural	Recreation		
Chuckanut Ck (1)	5.4	6.1	9.2	0.0	93.7	14.3	56.8	0.6	8.6	24.2	33.4	9.8	13.9	0.0
Cherry Ck N Fork trib (7)	4.1	1.9	10.8	0.3	93.8	0.0	70.0	0.0	0.0	30.0	30.0	0.0	100	0.0
Issaquah Ck E Fork-159 (8)	5.7	7.7	6.9	0.0	92.8	0.0	51.1	3.4	0.0	45.4	48.8	0.0	100	0.0
Issaquah Ck-152 (8)	9.7	6.9	80.9	3.9	82.4	7.4	36.1	2.9	2.1	55.1	60.2	0.8	100	0.0
Dickerson Ck (15)	0.7	1.2	8.7	0.0	98.7	20.4	25.5	0.1	1.2	53.9	55.2	19.3	23.0	0.0
Mission Ck (15)	1.6	1.6	12.9	0.0	94.9	0.0	59.1	0.3	0.0	38.4	38.7	0.5	0.0	0.0

3.5.4.2 Combination zoning – Rural/forest mix

Two basins are primarily zoned for resource forest and rural character development, however no one zoning category exceeds 70%. Middle Green-249 is zoned about one third rural and two thirds resource forest (Table 11). Issaquah-935 is the opposite (two thirds rural and one third resource forest). Protected lands in the Tiger Mountain and Squak Mountain areas comprise 17% of Issaquah-935. Both basins are entirely within the stormwater permit area.

A combination of land protection, forestry, and permit-required stormwater BMPs will be necessary to maintain “excellent” B-IBI scores.

Table 11. “Excellent” basins with combination rural/forest zoning. All values are percentages.

Stream (WRIA)	2011 Land Cover (C-CAP) Urban WS	Urban WS 90	Urban 1km	Pasture/Hay WS	Natural WS	Within UGA	Consolidated Zoning Resource Forest	Urban	Urban Character	Rural Character	Total Urban/Rural	Recreation	Within SW Permit Area	Protection 1 & 2
Issaquah Ck-935 (8)	8.2	4.8	4.5	5.4	81.9	0.0	35.4	0.1	0.0	63.1	63.2	0.0	100	0.0
Mid Green trib-249 (9)	1.2	1.9	3.7	0.0	98.5	0.0	68.1	0.0	0.0	30.4	30.4	0.0	100	0.0

3.5.5 Unique – Consider Individually

The remaining six basins have very unique conditions that do not meet any of the previously discussed protection category criteria and must be considered individually. However, they are summarized together in Table 12 and discussed in the subsections below.

Table 12. “Excellent” basins with unique conditions for individual consideration. All values are percentages.

Category	Stream (WRIA)	2011 Land Cover (C-CAP) Urban WS	Pasture/Hay WS	Natural WS	Within UGA	Consolidated Zoning Urban Character	Rural Character	Resource Forest	Recreation	Resource Mineral	Within SW Permit Area	Protection 1 & 2
Forest - Protected	Siebert Ck (18)	0.0	0.0	100	0.0	0.0	0.0	0.0	100	0.0	0.0	100
Forest - Partial Protection	Carey Ck (8)	0.0	0.0	100	0.0	0.0	44.7	55.3	0.0	0.0	100	0.0
Forest - Partial Protection	Little R (18)	0.1	0.0	99.7	0.0	0.0	1.2	54.6	44.2	0.0	0.0	44.3
Mining	Covington Ck (9)	7.8	2.0	85.8	12.9	10.6	46.8	25.8	1.0	14.5	100	25.5
Mining	Mid Green trib-323 (9)	0.1	0.0	87.6	0.0	0.0	38.8	28.2	0.0	33.0	100	0.0
Forest - Vulnerable	Nisqually R (11)	0.3	0.0	97.8	0.0	No Zoning Information					0.0	0.0

3.5.5.1 Unique – Forest protected

Siebert Creek is zoned 100% active open space/recreation and is within Olympic National Park and is therefore entirely protected. This basin can be treated like the forest – protected category. It does not have resource forestry zoning, but it is currently in a

forested condition and is likely to stay that way. No actions are recommended to maintain "excellent" B-IBI.

3.5.5.2 Unique – Forest partial protection

Carey Creek is heavily forested and a large portion is protected (67% in the Cedar River Watershed Preserve and Taylor Mountain). This basin is zoned 55% resource forest and 45% rural character; however, all the rural character zoning is within Taylor Mountain area. Taylor Mountain is a working forest intended to demonstrate environmentally sound forest management that protect and restore ecological systems and the area provides passive recreational opportunities (King County 2003). Therefore, rural character development seems unlikely to occur despite the current zoning. This basin can be treated like the forest – partial protection category. No actions are recommended in the protected area, but forestry BMPs and a focus on maintaining intact riparian buffers are recommended in the remaining unprotected areas.

Little River is heavily forested and a large portion of this area is protected (44% in Olympic National Park). There is evidence of recent forest harvest in the national forest outside of national park boundaries. This basin is zoned 44% active open space and recreation and 55% resource forest. This basin can be treated like the forest – partial protection category. No actions are recommended in the protected area, but forestry BMPs and a focus on maintaining intact riparian buffers are recommended in the remaining unprotected areas.

3.5.5.3 Unique - Mining

Two of the remaining basins have significant basin area zoned as resource mining. Green Middle-323 is zoned 28% resource forest, 33% resource mining, and 39% rural character. Covington is zoned 15% resource mineral, 25% resource forest, 12% urban, and 45% rural character. The Covington mining is mostly abandoned coal mining[26] and there is evidence of recent forest harvest with 25% of the basin protected in the Black Diamond Natural Area. Both these basins will need the full suite of BMPs and land protection for all potential land uses to maintain "excellent" B-IBI.

3.5.5.4 Unique – Forest vulnerable

One basin was in the northern portion of Lewis County in the very southern portion of the Puget Sound Basin. However, the consolidated zoning layer omitted this small portion of Puget Sound and therefore zoning information is not readily available for this basin. The basin is entirely federally owned land within the Gifford Pinchot National Forest, but is not protected from resource extraction activities. Current land cover is 98% natural, dominated by forest. Recent forest harvest is visible in 2013 aerial photography. Zoning information should be identified, but it is assumed this area would be considered within

[26] Some coal mines in the Black Diamond area have recently been considered for re-opening (Hopperstad 2014).

the forest – vulnerable category. Forestry BMPs and a focus on maintaining intact riparian buffers are recommended.

3.6 Protection Summary

The 101 “excellent” basins currently are dominated by forested lands with minimal urban and rural development and infrequent agricultural or mining areas. However, the likely future conditions of these basins vary greatly and recommended protective actions vary based on existing conditions and anticipated future conditions (Figure 5). Some areas (forest – protected) are likely to maintain “excellent” B-IBI without any new actions. Other areas (forest – vulnerable) may be able to maintain “excellent” B-IBI if protective forestry BMPs are followed to minimize forest harvest impacts on stream ecosystems. Still other areas (development and combination zoning categories) are at risk of rural and urban development that could permanently change the character of these basins and will make maintaining “excellent” B-IBI extremely difficult.

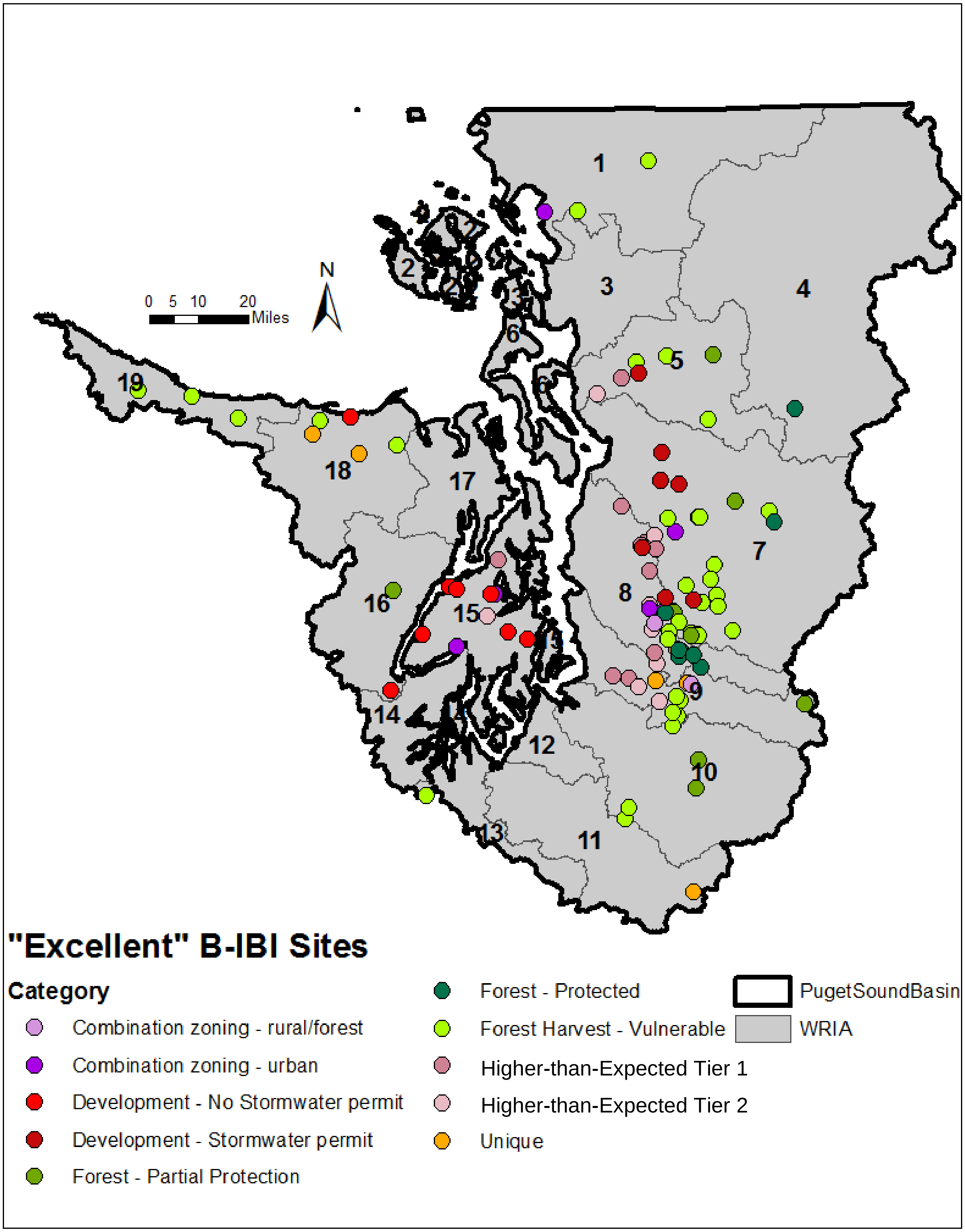

Figure 5. Distribution of protection categories for 101 basins with "excellent" B-IBI scores.

There were nine protection basins where no actions are recommended. The land within these areas is nearly entirely protected and therefore high B-IBI scores are expected to be

maintained without any intervention. However, for the remaining 92 basins land protection actions (land purchase, conservation easements, and purchase of development rights) are likely necessary along with a combination of BMPs to maintain “excellent” B-IBI scores. Forestry BMPs are recommended in 65 basins, stormwater BMPs in 46 basins, agriculture BMPs in 9 basins, and mining BMPs in 3 basins (Figure 6). Some of these BMPs are regulated and are required while others may be voluntary. Even in basins that have regulated BMPs for stormwater, forestry, and mining in place, work remains to ensure that regulations are sufficient and are working.

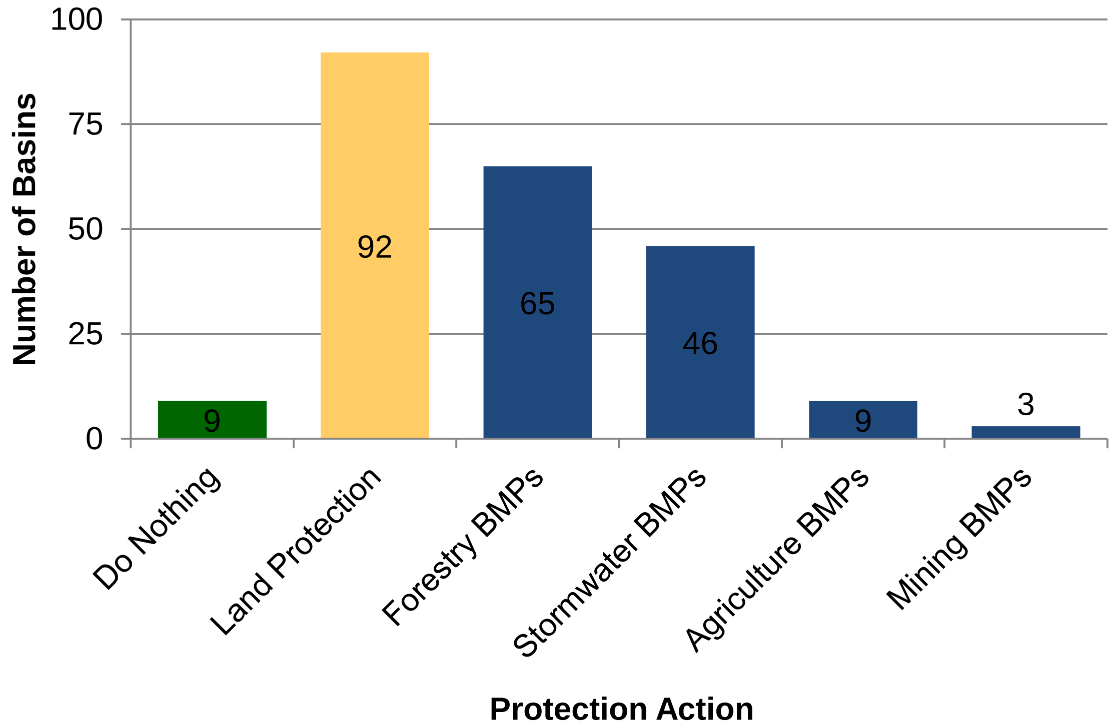

Figure 6. Summary of recommended actions in 101 protection basins intended to maintain “excellent” B-IBI scores.
BMPs are designated in blue.

4.0 RESTORATION BASINS

The second of the two 2020 B-IBI PSP ecosystem recovery targets is to restore 30 basins with "fair" B-IBI scores to "good" B-IBI scores. This section recaps how the top "fair" basins were selected and recommends applicable restoration and protection strategies.

4.1 "Fair" Site Selection and Filtering

Site selection of the top priority "fair" sites was discussed in detail in the July 2014 B-IBI Restoration Decision Framework and Site Identification Report (King County 2014c) and is summarized here. It should be noted that identifying basins for restoration based on B-IBI scores, and then using B-IBI scores as the metric to measure success, are relatively new approaches in restoration science. Without a standard procedure or road map to prioritize basins, we developed a novel decision framework that allowed us to select target basins from the more than 1000 basins that have scored "fair" in the last 15 years across Puget Sound. Because funds for restoration are limited and managers want to start where restoration efforts will have the greatest possible benefits, it was critical for us to develop this logical, transparent and updateable decision framework for selecting and prioritizing sites for restoration.

The restoration decision framework is based on widely available landscape data and simple calculations, and it consists of five criteria that were used to filter sites (Figure 7). These filtering criteria include median B-IBI score, ecoregion, sampling history, watershed area, and the Puget Sound Watershed Characterization water flow model. Rather than simply selecting basins that were nearly "good" and prioritizing those because they would be relatively easy to restore, the selection process was guided by the intent of the PSP target and identified sites with a median score of "fair". Restoring those basins may require more resources but the water quality and habitat improvements should likewise be substantial. The filters applied to those "fair" B-IBI ensure that sites selected for restoration activities (1) have minimal inherent variability in response to natural factors, (2) have reliable B-IBI condition categorization (e.g., good data quality/recent sampling history), (3) are a size that is tractable, i.e., a scale at which change can be tracked effectively, measured and related to local and watershed scale conditions, and (4) are considered hydrologically important without already being completely degraded. Applying the filters to the 1053 sites within Puget Sound, the number of sites under consideration was reduced to 59 (Figure 7). A single criterion (biological potential) was initially applied to order and prioritize the remaining 59 sites. Eight of these final 59 sites are located on four streams (2 sites per stream) and are located within 3 and 152 meters of each other. Any restoration actions proposed for this group of sites would be identical; therefore, these eight have been collapsed into four sites[27] reducing the total number of "fair" sites from 59 to 55. In

[27] The streams with nearly co-located sampling sites that are being collapsed are [site code (site ID)]: (1) Fifteenmile Creek - E1139 (306) and 08ISS4294 (153); (2) Tahlequah Creek – E2887 (354) and 65A (524); (3) Barker Creek – KCST-20 (865) and KCSSWM-001-Lower (1270); and (4) Stensland Creek – Stensland Middle (947) and WAM06600- 111639 (936).

addition, the total basin size for one "fair" basin was recalculated and found to exceed the 3,000 acre threshold, and therefore this site was also removed from further consideration[28]. The final count of "fair" sites that were identified in this process is 54.

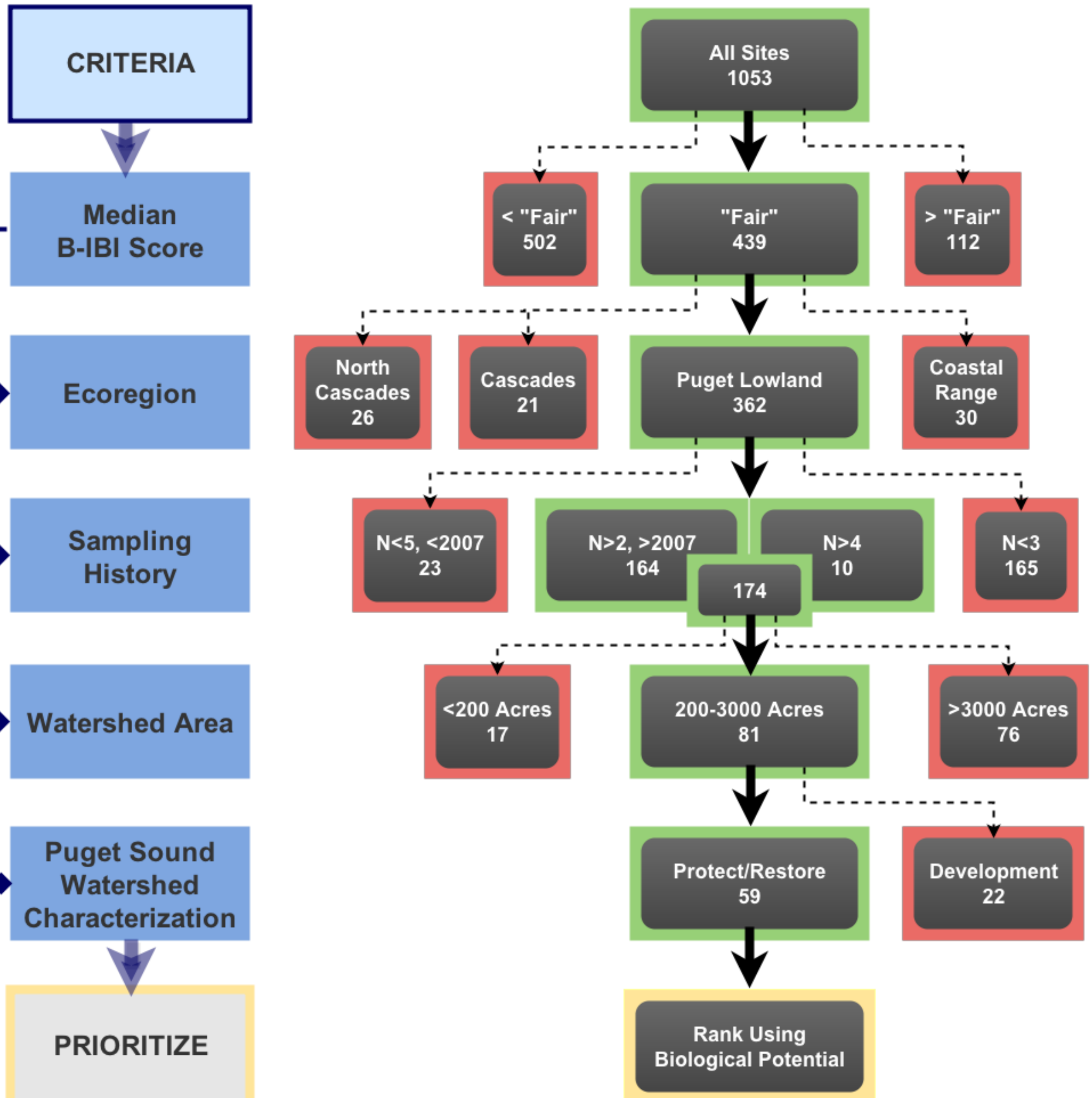

Figure 7. Conceptual diagram of the restoration decision framework. Criteria were applied in order and resulted in the reduction of sites from 1053 to 59 for further consideration (values indicate the number of sites).

[28] Site E633-CIP-1 (314) on Rock Creek was removed for having too large of a basin area once the basin delineation was corrected (5,066 acres). Neighboring sites on Rock Creek are included in the "excellent" basins being considered for protection strategies.

Instead of ranking and limiting our recommendations to 30 sites, we considered restoration actions for all 54 basins. If needed, ranking of these 54 sites can be done as site specific plans are developed and the feasibility and costs are considered. However, restoring any 30 of these would meet the PSP recovery target.

4.2 Historic and Current Stressors

For the "fair" sites, the overall objective was to identify possible restoration or management actions that would improve conditions within individual basins and result in B-IBI scores improving over time to "good." In contrast to the "excellent" sites, for which we assume historical conditions have been favorable, we assume the "fair" sites have been negatively affected by some stressor(s) and those stressors may still be present or ongoing.

There is rarely a single stressor or a "smoking gun" that has led to B-IBI scores of "fair"; degradation of whole communities is more typically due to a combination of stressors that have had cumulative impacts over time and can be difficult to measure or quantify (Karr 1991, Paul and Meyer 2001). Therefore, we considered a range of possible local or basin-scale stressors that may have led to the decline in B-IBI scores at a site, and from this inferred what actions could be taken to relieve or remove those stressors. For this project, assessments have been done based on best professional judgment, without individual site visits. We considered a variety of information (land cover data and photographs, etc.) and based on previous studies identified what may have impacted and what may currently be impacting the invertebrate community at each site (See Appendix K for descriptions of basins). We also solicited and received input from other scientists and local resource managers familiar with the basins to identify potentials stressors and potential restoration actions.

We appreciate that there are more rigorous and systematic approaches to identify stressors within a basin. Two examples include the Guidance for Stressor Identification of Biologically Impaired Aquatic Resources in Washington State (Ecology 2010[29]) and the Causal Analysis/Diagnosis Decision Information System, or CADDIS, developed by the Environmental Protection Agency[30]. The EPA has also developed tools for evaluating the recovery potential for US water bodies[31], and these resources were consulted throughout this project. Although these tools require more basin-specific information and time for analysis than we had, we recommend considering such approaches when developing more detailed restoration plans for individual basins. The broad scope and modest budget of this study required us to adopt the approach we describe here.

For each of the 54 "fair" basins, we considered the calculated percent land cover by category using the 2011 C-CAP data. We focused on land cover categories that have been shown to be correlated with B-IBI scores and would be most informative when assessing

[29] Washington stressor identification: https://fortress.wa.gov/ecy/publications/documents/1003036.pdf
[30] CADDIS: http://www.epa.gov/caddis/
[31] Recovery Potential Screening: Tools for Comparing Impaired Waters Restorability can be found at http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/recovery/index.cfm

what land uses may have affected B-IBI scores. These included percent urban, percent impervious surface, percent pasture, percent cultivated, and percent natural within the 90-m buffer. These categories were used to assess the extent native forest has been cleared for residential and commercial development and agriculture, and whether the buffer along the channel remains intact.

We also visually assessed land cover throughout each basin using 2006 and 2013 NAIP orthophotos in ArcMap. While the C-CAP data described the relative land cover by category, the photographs illustrated how the various land uses are distributed across each basin. We were particularly interested in the extent, condition and location of intact forest patches. For basins with areas zoned for forest harvest, the photos often revealed a history of clearcutting as seen by the patchwork of single-aged stands. Thus photographs were useful to identify basins that may have been impacted by previous logging, even if the current forest cover was quite extensive. Likewise, photographs were used to assess the density and distribution of agricultural, residential, and commercial development in the basin. For example in areas zoned for rural residential development, the extent of intact forest, and especially the width and age of forest near the creek channel, indicated how effective the forest may be in protecting the water quality and flow processes in the basin.

The PSWC models were also used to assess whether the degradation of water flow and water quality processes at the basin scale may impact macroinvertebrate communities. As described in Appendix B, each site was assigned a series of scores (of 1, 2, or 3) that reflected the likelihood that individual flow and water quality processes were degraded at the basin scale and could be limiting B-IBI scores. These scores were used as another line of evidence as we identified likely stressors within each basin.

In basins with residential developments, we used real estate information from online real estate databases (e.g., Zillow.com) and county assessor's reports to determine the typical age of homes and whether they were on public or private water and sewer systems. We assumed older developments (pre-1970s) had no stormwater controls required at the time of development, and therefore stressors arising from stormwater runoff and impervious surfaces had likely been impacting the creek for many decades. In basins with more recent development (post 1990), we assumed there may have been some level of stormwater controls required at the time of construction, though the number and types of stormwater controls installed and their effectiveness are uncertain. In basins with no public sewer system, we assumed that at least some failing septic systems may be contributing to water quality problems. Although it is uncertain how many failing septic systems it would take before excess nutrients and contaminants altered the invertebrate community, organic enrichment can lead to increases in periphyton and microbial production and which can result in drops in dissolved oxygen concentrations. These changes can alter the composition of invertebrate communities as sensitive taxa disappear (e.g., Friberg et al. 2010).

Insights gathered from local managers familiar with the B-IBI sites or the basins were also helpful in identifying possible stressors. Insights included observations and knowledge of stream reaches that have been impacted by a variety of stressors that would otherwise be

difficult to assess from available information. For example, through these discussions we heard about the recent expansion of mining activities in one basin and the effects of specific road projects that may have affected the nearby creek. These insights were also our only source of information about in-channel conditions including, for example, whether the substrate was embedded or there was a lack of large wood. (We note that there are additional habitat data available for some sites, but reviewing these sources was beyond the scope of this project; any such information should be considered when developing more detailed restoration plans).

Lastly, we considered any available information that would indicate the presence of factors that could affect B-IBI scores that may be independent of current stressors. These include natural habitat conditions that may limit the diversity of invertebrates and lead to lower than expected B-IBI scores. For example at one site, the dominant taxon for multiple years in a row was a caddisfly species that thrives in high energy environments like those present at the site (e.g., steep gradient, with large boulders). These conditions, while great for this caddisfly species, may be inhospitable for many other taxa that are present in more typical lowland streams. Taxa richness at a given site may also be limited by a lack of potential colonists. This may be especially true in basins that are not connected or do not have nearby source of diverse and sensitive taxa. The present conditions may be suitable for a variety of taxa that are not present only because they were extirpated in years past and have not been able to recolonize the basin (Brederveld et al. 2011, Harding et al. 1998). In these cases, available information regarding the natural history of the invertebrates and conditions at the sites was evaluated. To develop a more complete restoration plan for each basin, we would encourage managers to carefully consider any other natural limitations that may affect which taxa are present and absent and why.

4.3 Future Risk

As with the basins with "excellent" scores, it is important that strategies to improve B-IBI scores account for future conditions. If a basin is likely to be developed extensively in the future, restoration actions may not be able to compensate for the impacts of additional development. Understanding how future stressors may affect B-IBI scores will be useful when prioritizing basins for restoration and planning specific restoration actions.

To that end, we assessed the potential for additional stressors to affect invertebrate communities in the future and the likelihood they would undermine restoration efforts. We used a combination of sources including current zoning information (Department of Commerce 2015), recent photos (2013 NAIP photographs, GoogleMaps), property information (e.g., Zillow.com), and input from local resource managers. In several instances it was clear that areas zoned for urban development had not yet been developed, but that there were signs that construction was imminent. For example in some areas there were newly cleared parcels and roads that had been built since the last invertebrate sample had been collected. In others, large parcels with extensive forest were visible; however, information available on Zillow.com indicated that multiple large parcels were for sale and the listings emphasized that the parcels could be subdivided and developed.

Other potential future impacts, such as changes in precipitation and stream flows due to climate change or future risks such as exposure to emerging contaminants of concern, were not considered. Likewise, we did not consider how possible improvements could mitigate these future impacts. It is plausible that as new regulations are developed (e.g., improved stormwater treatment in re-developed areas) and protected second-growth forests mature, conditions may improve and may mitigate other future impacts. The effectiveness of those regulations and improvements will likely depend on how they are phased in across the region. We urge planners to consider as many future scenarios as possible when developing site-specific plans, even if that is simply including greater uncertainty in their projections.

4.4 Recommended Restoration Actions

The recommendations of restoration and management actions are based on our understanding of the ecological conditions and processes that are important to maintain diverse and sensitive aquatic macroinvertebrate communities. Unfortunately there are few studies that make that direct link between a specific management action and B-IBI score--and more effectiveness studies are needed (Miller et al. 2010).

Until more field-verified information on the effectiveness of actions are available, these recommendations stem from the impressions we developed regarding which potential stressors may have impacted each basin and the assumption that certain actions may alleviate or "fix" those stressors. For example, actions that improve water quality (e.g., treatment of stormwater, managing soil loss, limiting pesticide use) will likely improve habitat conditions for invertebrates that are intolerant of poor water quality. Likewise, invertebrate taxa that are sensitive to frequent scouring events would likely benefit from actions that are designed to restore hydrologic processes (e.g., flow controls, minimizing clear cutting, and extending buffers).

Restoration and ongoing management actions are both included here, despite there being some important distinctions between them. Restoration actions are intended to fix an identified problem, often with some initial large remedy (e.g., a project to add wood, stabilize banks, plant riparian buffer). Restoration actions may require maintenance, but it is often assumed that the stressor that impacted the system has been addressed. No restoration plan, for instance, would assume large boulders or woody debris would need to be added every few years in perpetuity. Management actions, on the other hand, may be needed continuously to minimize the effects of certain land uses on a stream, but there may not be any obvious physical activity. For restoration actions to be effective management actions may be necessary both initially and then perpetually in the future. An example of this would be restoring a basin that will continue to be managed for forest harvest. Restoration actions may be needed to restore in-channel habitat and riparian habitat, but forest BMPs will be needed to ensure that the effects of future logging do not negate restoration actions.

We developed a qualitative scoring system to indicate the likelihood that specific restoration or management actions would be needed and therefore helpful in restoring a

basin. For each basin, we used best professional judgment given the information that was described above to assign each action a score. An action received a "0" if it would not be applicable (e.g., mining BMPs in a basin with no mining), "1" if the action were unlikely to help, "2" if an action would possibly help, "3" if an action were likely to help, and a "4" if it were highly likely to help (e.g., stormwater BMPs in a basin with older but dense development and limited stormwater control structures). We also used zoning information and photos to assess how likely the basin was at risk for future degradation, and we gave each basin a score of 0-4 with "4" indicating the basin was highly likely to be at risk for future degradation. These scores illustrate a first, cursory step in identifying actions that may be needed in a basin and should not be interpreted as a quantitative measure of risk or benefit.

The actions that were considered for restoration are representative but not necessarily all-inclusive of those mentioned previously (Section 3.4). Assessing the potential need and likely benefit of actions was easier for some actions than for others. Because of this, we did not consider all possible agricultural, forest, mining, and stormwater BMPs, but rather focused on those that were most likely relevant in the Puget Sound and these basins. Likewise, our confidence in the recommendations varies by the action; for example, it is difficult to know from photos whether pesticide use should be limited but it can be obvious that a riparian buffer could be planted or widened. Similarly, the scores reflect, in part, how confident we were that an action would help address the need. We also acknowledge that some of the BMPs that are mentioned are being followed already as they are required under existing permits. We include these here, as well as additional actions, because often the required BMPs are the most important ones. They were established and required for a good reason: they are implemented to reduce the impacts of known stressors on stream habitat and water quality. By including them here we highlight that compliance and enforcement of those required BMPs are critical for the restoration and ongoing management of the basins.

A brief description of the restoration and management actions considered and our general conclusions are summarized below. Table 13 lists the actions considered and an example of the scores for a single basin. Table 14 includes the number of times each action scored 0, 1, 2, 3, and 4, and the average score across all 54 basins. Appendix L includes a table with all of the scores for each basin and a link[32] to all of the specific recommendations for the "fair" basins.

[32] http://your.kingcounty.gov/dnrp/library/2015/kcr2693/kcr2693-app.pdf

Table 13. An example of the restoration and management actions that would be recommended for a "fair" basin. Scores of 0-4 indicate the likelihood that an action would be needed and therefore helpful in restoring a basin, with 0 being not applicable and 4 being highly likely.

Restoration and Management Actions		Likelihood action would help restore the basin
In-stream	add wood	2
	add substrate	2
	enhance sinuosity	2
	replace culverts	2
	stabilize stream banks	2
Riparian	stabilize slopes	1
	plant vegetation, extend buffer	2
Agricultural BMPs	exclude livestock	0
	manage waste	0
	manage soil loss	0
Forest BMPs	road maintenance	2
	minimize clearcutting	4
	replant	3
Mining BMPs	mining BMPs	0
Stormwater BMPs	flow controls	3
	treatment	3
	maintain storage and treatment facilities	4
	street sweeping	2
Other Approaches and Actions	limit pesticide use	2
	outreach and education campaign	3
	create incentives to follow BMPs	3
	purchase and protect property	2
	seed invertebrates	3
Is the basin at risk of further degradation?		4

Table 14. The number of times that each action was given a 0, 1, 2, 3 or 4, and the average score for each action across all 54 "fair" basins. Scores of 0-4 indicate the likelihood that an action would be needed and therefore helpful in restoring a basin, with 0 being not applicable and 4 being highly likely.

Restoration and Management Actions		number of 0s	number of 1s	number of 2s	number of 3s	number of 4s	Average likelihood that action would help restore basins
In-stream	add wood	0	0	34	15	5	2.5
	add substrate	1	2	36	12	3	2.3
	enhance sinuosity	0	6	34	9	5	2.2
	replace culverts	0	5	37	10	2	2.2
	stabilize stream banks	0	6	39	8	1	2.1
Riparian	stabilize slopes	0	9	36	7	2	2.0
	plant vegetation, extend buffer	0	7	15	14	18	2.8
Agricultural BMPs	exclude livestock	26	5	9	6	8	1.4
	manage waste	28	6	11	4	5	1.1
	manage soil loss	35	6	8	3	2	0.7
Forest BMPs	road maintenance	37	0	10	4	3	0.8
	minimize clearcutting	36	0	0	2	16	1.3
	replant	40	4	4	3	3	0.6
Mining BMPs	mining BMPs	50	0	2	0	2	0.2
Stormwater BMPs	flow controls	3	2	4	17	28	3.2
	treatment	3	2	5	16	28	3.2
	maintain storage and treatment facilities	3	5	13	10	23	2.8
	street sweeping	5	26	13	7	3	1.6
Other Approaches and Actions	limit pesticide use	0	2	25	27	0	2.5
	outreach and education campaign	2	1	10	28	13	2.9
	create incentives to follow BMPs	0	1	17	29	7	2.8
	purchase and protect property	1	5	36	8	4	2.2
	seed invertebrates	1	6	17	25	5	2.5
Is the basin at risk of further degradation?		0	1	5	5	43	3.7

4.4.1 In-Stream Actions

In-stream actions are included that would increase the complexity and quality of benthic habitats, including stream banks, bottom substrate, and sinuosity. These are difficult to assess from landscape analysis and we largely relied on input from local managers regarding in-stream actions. For example, if staff familiar with the basin reported there

were in-stream problems (e.g., embedded substrate, unstable banks), in-stream actions were given "4s" as actions that would be highly likely to help restore the basin.

Overall, we suggest in-stream actions are "possibly" needed to help restore the 54 basins (average scores range from 2.1-2.5; Table 14). This weak recommendation reflects our uncertainty in the in-stream conditions for most of these basins. When we did have local knowledge of a site, it often suggested that in-stream restoration would be appropriate, but when we lacked local knowledge, we were less certain in-stream actions would be needed. Of the actions that were suggested to be "highly likely" to help restore basins, adding wood and enhancing channel sinuosity were recommended most often. More examples are given in the summaries for each site (Appendix L).

4.4.2 Riparian Actions

Riparian actions would aim to stabilize slopes and protect the many functions that the riparian area provides (e.g., treating and slowing down runoff; providing detritus, large wood and shade to the channel; providing habitat for adult insects). Photos and the percent of natural vegetation in the buffer were most useful in determining if these actions would be appropriate.

Overall, we suggest riparian actions are "possibly" or "likely" needed to help restore the 54 basins (average scores range from 2.1 – 2.8; Table 14). Although there are exceptions, most basins with greater than 95% natural vegetation in their 90-m buffers were given a score of "1" or "2," and would not likely benefit from additional stabilization or planting. Basins that were "highly likely" to benefit from riparian bank stabilization had on average 61% natural vegetation in their 90-m buffers. Likewise, basins that were "highly likely" to benefit from riparian planting or an extension of the existing buffer had on average 72% natural vegetation in their 90-m buffers, respectively. There were exceptions, such as basins that had nearly 99% natural vegetation in their 90-m buffer but were given a "4" for stabilizing slopes or planting. For these, photos often revealed the riparian vegetation was mostly grasses and shrubs, and tree planting was recommended.

4.4.3 Agricultural BMPs

Agricultural actions include BMPs that aim to limit the impacts of livestock and cultivation on nearby streams. These include excluding livestock, managing waste so that excess nutrients and pathogens do not contaminate streams, and reducing inputs of fine sediments from banks and fields. Photos, land use analysis and zoning were useful in assessing whether these actions would be needed. Additional actions may be needed in some basins, including limiting pesticide use and managing water withdrawals and drainage, but those are difficult to assess without visiting the site.

Overall, we suggest agricultural actions are "unlikely" needed to help restore most of the 54 basins (average scores range from 0.7 to 1.4; Table 14). This is largely because most basins have less than 1% of their area as pasture or cultivated land (median % pasture and % cultivated across the 54 basins are 0.1% and 0.0%, respectively). In basins with pasture

land and cultivation, excluding livestock from stream channels was most frequently recommended.

4.4.4 Forest Management BMPs

Forest actions include BMPs that aim to minimize the effects of forest harvest on stream channels. These include limiting the extent and frequency of harvest, leaving an intact buffer along streams and wetlands, replanting, and minimizing soil loss from harvested areas and roads. Photos, land use analysis and zoning were useful in assessing whether these actions would be appropriate.

For the 18 basins with at least some land managed for forest harvest, minimizing the extent and/or frequency of clearcutting was the most frequently recommended action (Table 14). However, for most of these basins (36 of 54), lands are not zoned or managed for forest harvest and therefore they received "0," or "not applicable" for all of the forest management actions. In these basins, where forests may be cleared for other land uses (e.g., residential development), the impacts of tree removal on streams should be minimized as much as possible.

4.4.5 Mining BMPs

Mining activity was present in only four of the 54 basins, but when present it was noted that some additional actions may be needed to minimize the effects of drainage and wash off from the mine on the stream. Mines are obvious in photos but the intensity of mining and the potential hazards are difficult to assess without visiting the site.

4.4.6 Stormwater BMPs

Stormwater BMPs aim to reduce the impacts of stormwater runoff on receiving waters. The installation of infrastructure designed to moderate flows and/or treat stormwater was recommended in most basins with at least some development because of the strong negative correlation between percent impervious surface and B-IBI scores. Almost all of the basins are zoned for some amount of rural residential development (51 of 54 basins), and typically over 75% of the area in each basin is zoned for either rural or urban residential (Appendix K). The extent of impervious surface in a basin is generally highly correlated with residential density and the density of roads serving those communities, and our suggestions for how likely stormwater BMPs would be helpful in a basin reflect the current amount of development in a basin. It is because of the extent of the impervious surface in many of the basins (Appendix K) that we suggest adding stormwater BMPs that help control stormwater flows are "likely" or "highly likely" to help restore 45 of the 54 basins.

Determining the precise number and type of stormwater BMPs needed to restore flow dynamics to conditions that would help elevate "fair" sites to "good" would require extensive modeling that was beyond the scope of this project. However, for local basins that have been studied intensively, model results indicate that stormwater retrofits and the installation of new stormwater BMPs may be especially helpful in areas that were developed prior to current regulations or are currently exempt from some of the more

stringent stormwater regulations (King County 2014e). In areas that likely have existing stormwater infrastructure, we recommended maintenance, and in areas with high-traffic roads near the stream, we also recommended street sweeping.

4.4.7 Other Approaches and Actions

Other approaches include a variety of non-structural actions that aim to limit the impacts of human activities on streams. These include some physical measures not in other categories (e.g. seeding macroinvertebrates), as well as strategies to persuade or incentivize individuals to change behavior (e.g. outreach, easements). Assessing whether these strategies would be applicable or effective in these basins was based on outreach to local mangers or, when lacking any specific information, it may be generally appropriate. The recommendation to seed invertebrates was based largely on whether there was a nearby source of diverse and sensitive taxa.

Overall, we suggest outreach and education campaigns would be "likely" or "highly likely" to help restore 41 of the 54 basins (Table 14). Likewise, creating incentives for landowners to follow BMPs may be "likely" or "highly likely" to help restore 36 of the 54 basins. Similar to the structural strategies identified above, we do not know the extent to which these strategies are effective, but they are increasingly being recognized as tools that should be incorporated in restoration plans[33].

Seeding invertebrates, or actively facilitating recolonization of invertebrates, may be "highly likely" to help in five basins, and "likely" to help in 25 basins. Because of the relatively low cost of this action, active recolonization should be considered before other actions are attempted in these basins.

4.5 Future Considerations for Restoration and Evaluating Restoration Effectiveness

In our review, most basins appeared to be highly likely to be at risk for further degradation based on anticipated development in the basin. As mentioned above, the restoration and management actions that are recommended now may not be sufficient if development proceeds as current land use analyses and zoning suggest it will. Although protecting land, through purchasing or easements, was highlighted as a strategy for "excellent" basins, protecting "fair" basins may also be appropriate to ensure restoration actions are successful.

The risk of further degradation highlights the need for evaluating the effectiveness of restoration. Just as it is critical for managers in the region to continue to try to identify stressors that impact specific basins, we need to carefully document the effectiveness of restoration actions as they are implemented. Over a century of literature has chronicled

[33] See the Recovery Potential Screening website for more information: http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/recovery/index.cfm

how various stressors can impact stream communities, but careful documentation of how active restoration can improve B-IBI scores is still needed.

It is also important to consider that some actions that are typically thought of as stream restoration activities may or may not benefit invertebrates or lead to improved B-IBI scores. For instance, actions that aim to improve fish habitat (Roni and Beechie 2013) may benefit invertebrates directly, indirectly or not at all. If they do affect both fish and invertebrates, they may not act via the same mechanism. For example, the addition of large boulders may provide needed shelter for fish but their benefit to insects may be that they provide critical oviposition sites. There are no established restoration actions that would target cold-water fish native to Puget Lowland streams that would adversely affect B-IBI scores.

One thing is clear: how to restore B-IBI scores is an emerging field; as more effectiveness studies are done, the restoration tool box should become more refined.

5.0 COST ESTIMATES FOR RESTORATION AND PROTECTION ACTIVITIES

This section provides information on costs associated with the strategies for (1) protecting streams with high B-IBI scores, and (2) improving B-IBI scores for 30 streams, that are outlined in the previous sections. It is important to note that for a variety of reasons, this analysis did not compile a total cost estimate for achieving the two targets, nor a cost estimate to protect or restore any individual basin (although as discussed below this could be a potential next step). Instead, what we provide here are cost estimates for the strategies, or protection and restoration actions, including: instream restoration and riparian planting, stormwater retrofits, agricultural best management practices and land conservation actions (e.g., purchase and easements). Cost figures are based on previous studies, experience, and in some cases best professional judgement, and unless otherwise indicated, are in current year (2015) dollars.

Two caveats to these cost estimates are warranted:

- The cost estimates are very rough and should be considered order-of -magnitude estimates. In many cases a range of costs are provided. The costs of implementing actions to achieve the target in any given basin are entirely site specific- they depend on the particular mix of actions appropriate to local conditions affecting B-IBI scores in each basin.
- Cost estimates for the strategies only include estimates of the physical measures (e.g., on the ground actions). They do not include other costs associated with implementation-such as implementation incentives (whether the action would be brought about by regulation, education or direct payment), how the costs would be paid for, and how measures would be administered. Thus they do not include how the costs would be distributed, for example between private parties and government agencies.

All proposed restoration activity cost estimates are derived from a variety of King County Department of Natural Resources and Parks projects. There may be significant variability even in these planning level cost estimates. Many factors influence the total cost of a restoration action including; location of restoration site, accessibility, jurisdiction or entity performing or managing the restoration, cost of materials, experience performing proposed restoration activity, etc.

5.1 Instream Restoration and Riparian Planting

Several different methods are used to improve instream habitat conditions for macroinvertebrates. Some include increasing hydrologic diversity, such as large wood placement. Other methods of large wood placement can be used to control sediment inputs to the stream or improve bank stabilization by anchoring wood to stream banks. Fine sediments are known to be undesirable to many macroinvertebrate taxa so importing

gravel can also be used to address biotic integrity (in conjunction with controlling the sediment source).

Cost estimates for instream restoration activities were compiled using King County restoration projects that have taken place over the last several years. The cost estimate table is broken down to include separate multipliers, for the different components of the construction and management (Table 15) of the proposed activities. These separate items include: cost of materials and construction, sediment controls, and water management; tax, contingency and construction management; project design; and inspection, monitoring and maintenance. The total cost estimate lower bounds are based on using the low end construction cost multiplied by the low end of the individual line items, while the upper end cost estimates are based on the high construction costs multiplied by the upper end of the individual line items. The total costs outlined in the table are all costs associated with 100 meters of restoration activity. Additional notes and construction assumptions are also included in the table.

Table 15. Instream restoration cost estimates per 100 meters of stream restored. TESC = Total Erosion and Sediment Control and CM&I = Construction Management and Inspection.

Restoration Action	Rough Estimate of Unit Construction Cost (Includes Mobilization, TESC, Water Management)	Tax, Contingency, CM&I (multiplier on construction cost)	Design (Multiplier on Construction cost)	Monitoring and Maintenance (Multiplier on Construction cost)	Estimated Total Cost	Assumptions
Large Wood Placement for Hydraulic Diversity	$20,000 - $30,000	1	0.25 - 1	0.05 - 0.2	$47,000 - $108,000	1 log w/rootwad
Bank Stabilization	$45,000 - $70,000	1	0.25 - 1	0.05 - 0.2	$105,000 - $252,000	1 log/5M, 1 shallow pile/3.3M
Establishing Spawning substrate (Import of Gravel)	$100,000 - $200,000	1	0.25 - 0.5	0.05 - 0.2	$236,000 - $720,000	Suitable conditions, but lacking gravel
Establishing Spawning Substrate	$20,000 - $30,000	1	0.25 - 1	0.05 - 0.2	$47,000 - $108,000	1 log w/rootwad

Riparian plantings are another restoration method commonly used in stream systems lacking vegetative cover along the banks. Table 16 outlines cost estimates for riparian planting. The cost table is based on restoring one acre that is devoid of native vegetation. The table includes three different vegetation types (deciduous, coniferous, shrubs), the quantity of each type and the spacing pattern used. The cost estimate includes 3 years of weed control as well as 2 years of watering the plantings.

Table 16. Riparian planting cost estimates based on restoring one acre. O.C. is "on center."

Plants	Quantity	Spacing	Cost	Assumptions
Conifers	680	8' O.C.	$2,100	
Deciduous trees	870	5' O.C.	$2,600	
Shrubs	870	5' O.C.	$2,600	
Planting labor	9 days		$12,000	
Mulch/weed fabric			$6,500	Labor and mulch
Weed control			$5,000	3 years
Watering			$5,000	2 years
Total			**$35,800**	

5.2 Stormwater Retrofits

Stormwater retrofits can reduce the negative impacts that rainfall on impervious surfaces can have on stream health. Stormwater retrofits generally apply to urbanized landscapes that were developed prior to significant stormwater BMP's.

Common stormwater treatments include several different types of facilities. Detention/retention ponds, bioswales, rain barrels (or cisterns) and bioretention facilities are all low impact development practices that increase the time of travel for stormwater to reach a receiving water through storage and infiltration, thereby mimicking a more natural hydrologic regime.

Between 2010 and 2013 King County (along with several partners and stakeholders) worked under an EPA grant on the Stormwater Retrofit Project for the Green River Watershed (WRIA 9). The project included development of cost estimates to construct the stormwater infrastructure necessary to return stream flows throughout WRIA 9 to conditions comparable to those found in a fully forested basin. The project used a model to calculate the optimum combination of treatment BMP's and quantities needed based on a cost/effectiveness curve. This model (SUSTAIN – System for Urban Stormwater Treatment and Analysis INtegration) included many different parameters associated with stormwater management. The model considered inputs such as: precipitation zone, soil type, land cover/land use, slope, land cost, and existing stormwater infrastructure. Additional information on the WRIA 9 stormwater retrofit project, including the final project report, can be found on the King County Green River Stormwater Retrofit website[34].

The SUSTAIN model used for the WRIA 9 retrofit analysis requires the input of numerous site-specific parameters, requires large computational time, and therefore was not feasible to incorporate into our scope of work given the time and resources available. However, we

[34] Green River Stormwater Retrofit website: http://www.kingcounty.gov/services/environment/watersheds/green-river/stormwater-retrofit-project.aspx

were able to utilize the WRIA 9 Retrofit cost estimates by binning them into 3 general land use categories. The residential, commercial, and agricultural cost estimates shown in Table 17 reflect the average of the different scenarios modeled for the WRIA 9 project. The scenarios included over 135 different combinations of land costs, precipitation zones, soil types, land use/ land cover and slope. The costs shown below reflect the average cost in 2013 dollars associated with retrofitting 100 acres of each of the three land use categories assuming that all of the facilities are built at one time. The capital costs include the costs for construction, design, and permitting. Several expenses that were addressed in the WRIA 9 project that may not be relevant here include the operation and maintenance cost associated with the management of the stormwater facilities as well as the inspection and enforcement of stormwater regulations as they apply to these particular facilities. The capital investment values in the table represent the cost of constructing all of the recommended facilities at one time.

Table 17. Stormwater retrofit cost estimates in 2013 dollars broken down by land use type. Costs are in millions of dollars to retrofit 100 acres of each land use. The total amount includes 30 years of operation, maintenance, inspection and enforcement (discount rate assumed at 5%).

	Land Use		
Type of Costs ($Million)	**Agriculture**	**Commercial**	**Residential**
Total Capital	5.70	13.95	9.00
Total O&M	3.35	3.27	4.35
Total I&E	6.28	5.96	8.25
Total	**15.33**	**23.18**	**21.60**

Assumptions could be made that an investment of this magnitude would be done over a number of years, not in one single project. Over time, as lands are redeveloped or new development occurs, current stormwater guidelines (King County 2009b, Ecology 2014) require stormwater mitigation if specific thresholds of development are exceeded. This in itself will offer a significant improvement to stormwater conveyance systems as new and redevelopment happens.

The project's use of the SUSTAIN model assumed that the redevelopment would happen over a 30 year time frame, with the capital investment portion representing the costs that would be associated with private new development and redevelopment combined with the portion being undertaken by the local government.

Additional line items include the operation and maintenance of the facilities (O&M) and the inspection and enforcement (I&E). These represent the cost of providing O&M and I&E for a 30-year planning horizon (with a 5% discount rate)[35].

[35] Note: assumptions were made by the WRIA 9 retrofit project team about the amount and cost of those activities over time which may not be relevant to the cost estimates associated for this project.

The result of the SUSTAIN modeling effort for WRIA 9 indicated that the cost of retrofitting 100 acres of residential land is approximately $9 million in capital investment, while retrofitting 100 acres of agricultural land and commercial land were approximately $5.7 million and $13.95 million, respectively. The total cost of the retrofits over the 30 year planning horizon is represented in the bottom row and is estimated at between $15.33 and $23.18 million dollars per 100 acres for the three land use types.

5.3 Agricultural BMPs

Several agriculture and livestock BMP's can provide water quality benefits. The exclusion of livestock from waterways or saturated lands can reduce the sediment, nutrient and bacteria load that reaches adjacent streams. Additional BMP's such as confinement areas, solid manure composting bins, pasture renovation, and grass filter strips all offer varying degrees of water quality improvements to waterways which receive their runoff. Table 17 shows the cost estimates for each of the mentioned BMP's. The cost tables were created based on the results of other King County projects performed by the Water and Land Resource Division (WLRD), Agriculture and Forestry Section.

Table 18. Cost estimates of agricultural BMPs.

BMP Type	Estimated cost	Units	Assumptions
Livestock exclusion fencing	$10-15	per linear foot	cost can vary based on the animals targeted , # of gates, and design
Solid manure handling (compost bins)	$500-1000	per large animal	
Confinement area	$500-1500	per large animal	
Pasture renovation/ grass filter strip	$300-500	per acre	includes: liming, tilling, seeding and equipment cost

Similar to exclusion fencing, livestock confinement areas can offer a water quality benefit associated with the reduction of fine sediments, nutrients, and bacteria from livestock holding areas. Solid manure handling facilities or compost bins are a method of containing and composting animal waste that keeps nutrients and bacteria from reaching the stream in wet weather. Pasture renovation or grass filter strips are used to provide a buffer of grass between the active agricultural land and the waterway. Grasses offer a high stem density, long growing cycle and the ability to take up nutrients in much the same way as a riparian buffer of native vegetation does.

5.4 Conservation Actions (Land Purchases and Easements)

Land purchases and conservation easements are both methods used by local governments to reduce or prevent development on parcels deemed important for ecological, flood, agriculture, or park purposes. Land purchases consist of the local government paying a fee to purchase the land from a seller. After the purchase, the land is owned by the agency that purchased it and they are responsible for the management of those lands. Conservation easements are a means to legally control the development of a parcel while the land still

remains in the hands of a private party or firm. Easement stipulations are generally handled on a case by case basis. Some may call for zero development of the land put into easements while other contracts may allow for limited development of the land. Generally speaking conservation easements are a cheaper alternative to outright land purchasing but they may not always be feasible.

Table 19 summarizes 3,014 acres of land purchases by King County since 2010 at a total price of over $140 million, and over 1,367 acres of land put into conservation easements at a total price of nearly $9 million. The land transactions in the table (435 parcels) represent a wide variety of land use types. Certain parcels were purchased (or put under an easement) for ecological protections while other were purchased for flood protection, park expansions or agricultural protections. The transaction values listed below may not be representative of all land values around Puget Sound. Parcels purchased or put under easements would be individually assessed for value before the transactions by the local jurisdiction. Different jurisdictions may also have different approaches to land conservation through purchase or easements and different prioritization schemes used to address those basins.

Table 19. Average cost estimates for 2010-2015 King County land purchases and conservation easements.

Action	Property Type	# of Parcels Purchased	Value	Acreage	Estimated $ per Acre
Land Purchases	City	3	$936,750	1	$900,000
	Ecological	140	$73,055,600	1421	$51,000
	Flood	116	$32,889,335	268	$123,000
	Parks	82	$32,335,700	1323	$24,000
	Stormwater	3	$953,366	1	$822,000
	Total	***344***	***$140,170,750***	***3014***	***$47,000***
Conservation Easements	Ecological	26	$3,402,000	338	$10,000
	Farmland	25	$1,293,000	589	$2,000
	Flood	9	$1,562,800	83	$19,000
	Parks	15	$77,000	1	$126,000
	TDR	16	$2,475,500	357	$7,000
	Total	***91***	***$8,810,300***	***1367***	***$6,000***

Transfer of Development Rights (TDR) are a type of conservation easement that allows landowners to separate the development rights from their property and sell them to a developer who will use them to increase density (above the zoning regulations) in an urban area. This process allows landowners to keep the rights to use their land, but restricts the property owner from developing the land which the TDR was purchased from. TDRs are a way to reduce development of sensitive areas while concentrating residential development to urbanized areas. Specific regulations apply to what lands can be used as a “sending site” and what lands are considered “receiving sites.” For the purposes of this project, TDR’s are summarized in Table 19 under Conservation Easements.

Table 19 displays the total price paid for each transaction type, as well as the average cost per acre for that property type since 2010. As the table shows, the average price per acre for purchasing land versus purchasing a conservation easement is drastically different. Since 2010, the 3,014 acres of land purchased by the county had an average value of $46,504 per acre while the average cost of purchasing a conservation easement is $6,443. In addition, there is generally some cost associated with the management of land that was purchased outright.

Basin wide cost estimates for purchasing land or putting conservation easements on land are not possible without direct contact with the landowner of the properties in question. Certain property owners may be agreeable to putting easements on their land while others may prefer to outright sell (or not sell) the desired property. Although conservation easements may appear cost effective, they may not always be feasible, as they are dependent on the landowner's desire to sell or provide an easement. In addition, public land ownership potentially provides more flexibility in regard to future management, for example making it easier to implement a restoration project or remove a structure on the property that may impair its ecological function.

5.5 Cost Estimate Summary

Before an accurate cost estimate to restore the biotic integrity of stream can be developed, significant basin-specific analysis must be done to determine the amount and type of restoration actions needed. This depends on size and existing conditions in the basin (e.g., stream length, amount of development requiring restoration) but it also depends upon the effectiveness of any specific action at improving a B-IBI score—information which, as described earlier, is not known at this time. The treatments recommended in this report are likely to be effective at improving B-IBI scores, but will need independent verification by local entities to determine their suitability and feasibility for any specific basin.

Some other points merit mention regarding the cost information presented here:

- All cost estimates reported in this project are based on in-house King County project experience. It should not be assumed that the detailed cost estimates can be evenly applicable to all areas of Puget Sound. An attempt was made to include a variety of projects, purchases and model results, but differences in material costs, management, construction, location, and land value all add significant variability to the estimates.
- Basin location has a strong influence on the cost of restoration or protection. Land values around Puget Sound are quite variable depending on location. King County rural land values may not be comparable to land values found in a more urbanized area around the region while desirable agricultural lands or forest parcels may not be comparable to rural land found in another region.
- Although financing (how to pay for these costs) is a separate question, opportunities for financing these restoration types also vary. Certain jurisdictions

offer matching funds for projects that improve water quality, such as exclusion fencing or riparian plantings. Joint projects such as this may shift the burden of project financing among multiple public and private parties. A similar scenario applies to stormwater retrofits with developers paying a portion of the capital cost as they redevelop existing areas (with current stormwater regulations).

- It may be efficient to consider implementing actions that both address B-IBI and other goals, such as improving water quality or recreation. Not all restoration types addressed above are equal in their ability to improve water quality and increase B-IBI scores. Some restoration types may require large capital investments (stormwater retrofits) but have the potential to significantly improve various aspects of water quality and water flow, while others may only address specific deficiencies locally (large wood placement or riparian plantings).
- It is worth noting that in most cases the cost of protecting lands (either through land purchase or conservation easements) is often much cheaper than restoring an already degraded stream basin. The upfront capital cost of land purchases (or easements) may be substantial but protecting a basin that is ecologically functional will most likely yield positive results into the future. Restoration efforts on the other hand can be time consuming, costly and may not always yield the desired ecological results (or to the desired magnitude).

5.5.1 Potential Next Steps

This section provided an overview of the various costs of particular protection and restoration actions that are likely to be needed to achieve the B-IBI restoration and protection targets. While beyond the resources available in this effort, there are several potential next steps that could be taken to provide more cost information to help implement the strategies:

- The development of cost estimates for individual basins, or an aggregate cost estimate for the two targets. This would require a basin by basin evaluation (or modeling) of the mix and level or extent to which the different strategies would be needed to protect or improve the B-IBI score- for example, the number of acres and location of land requiring protection, linear feet of riparian planting, extent of stormwater retrofits, etc. As indicated above, this requires site specific information and increased knowledge of the effectiveness of the recommended strategies at increasing B-IBI scores, which is not available from current science. Additional research about the level of treatment and extent necessary to achieve desired results should be undertaken. As additional research on the effectiveness of specific actions is undertaken it should include documentation of costs expended. This will allow for a comparison among different strategies, and the identification of the mix of strategies that are most cost-effective to implement.
- The identification and analysis of costs and effectiveness of different implementation incentives/approaches that will be needed to bring these changes about (e.g., a regulatory approach; an education campaign; a program that pays landowners to implement certain measures, etc.).

- The development of a funding strategy, i.e., how funds would be raised and distributed to implement the measures, programs, and policies; as well as the institutions (e.g., local or state governments, private parties) that might be required to ensure their adoption.

6.0 CONCLUSIONS AND NEXT STEPS

This document describes potential management, restoration, and conservation actions to meet PSPs ecosystem recovery targets for protecting and restoring stream basins using the Benthic Index of Biotic Integrity, or B-IBI, that characterizes the health of stream benthic macroinvertebrates. It also describes the process for identifying which actions may be appropriate for each basin, and the rough cost of these actions. These steps are only the beginning of what will ultimately have to be a multi-phased effort with broad buy-in and engagement if the restoration and protection targets are to be met.

We recognize that the actions and costs outlined in this report are a broad brush – the 30,000 foot view from above. Site visits and additional investigations (in particular, effectiveness studies) are needed to provide information necessary for detailed descriptions of individual site specific restoration and protection actions needed, and more detailed and basin-specific cost estimates.

In the Puget Sound region, much of the restoration work to date has focused on fish, and with salmon recovery as the final goal. Few, if any, projects have set out to target improvement of stream macroinvertebrate communities or biotic integrity as the end goal. However, B-IBI is a comprehensive target that integrates impacts of stormwater, water quality and stream flow, and is an indicator of habitat quality. The literature about what works and does not work to restore stream macroinvertebrate communities is somewhat inconclusive due to the lack of effectiveness monitoring. However, it appears a mix of actions will be necessary to restore habitat, water quality, and water flow and by extension biological communities (Walsh et al. 2015). Well-designed monitoring programs will be necessary to evaluate restoration successes and failures and to start to answer some of the many currently unanswered questions including which actions are successful and cost-effective. Pre- and post- project effectiveness monitoring will have to be comprehensive and carefully designed to inform how to adjust and adapt applied techniques to achieve the ambitious B-IBI targets to restore and protect Puget Sound stream basins.

We urge consideration of the following recommendations to move towards achieving the PSP restoration and protection targets. These recommendations are divided into three categories: (1) implementation and funding, (2) increasing the scientific knowledge base, and (3) adapting the B-IBI target.

6.1 Implementation and Funding

Implementation of the protection and restoration actions identified in this report is a logical next step towards restoring and protecting Puget Sound streams, but work towards achieving the B-IBI targets will require extensive funding. We recommend the following:

- Establish a process to build on this work by developing and funding the detailed planning and implementation of restoration and protection actions. It is unlikely that actions in all 101 protection basins and 54 restoration basins can be

implemented initially. A two-phased process is recommended in a few basins with the first phase for detailed planning including stressor identification that proposes the type and extent of specific actions and the more expensive second phase for implementation (with effectiveness monitoring, as described below). Information gathered from these pilot basins should lead the way for other basins. Selecting the initial basins could be based on their overlap with stormwater and/or salmon conservation priorities, or evaluating feasibility and likelihood of success.

- Continue the broad stakeholder support built by this and previous B-IBI projects and increasingly shift the focus to implementation. Stakeholders can provide expertise, seek funding, and develop and implement actions in their local areas based on the priorities most important to them.
- Develop statistically valid effectiveness monitoring guidelines for restoration efforts that will allow for adaptive management. All work must involve pre- and post-project monitoring so that we can learn from successes and failures and adapt techniques and actions accordingly. Monitoring intensity will have to be more extensive than one sample up and downstream of actions to be able to detect changes associated with implemented actions.
- In developing implementation plans, identify, evaluate, and consider a mix of appropriate implementation incentives. The actions recommended in this report focus primarily on physical measures such as stormwater retrofits, land protection, habitat restoration, and riparian plantings, and change in land use behavior. A strategic implementation plan will need to include incentives needed to initiate and implement these actions, as well as institutional capacity, funding, and public/political acceptance to carry them out. These implementation incentive measures and programs can be persuasive (e.g., education), positive (e.g., grants), or negative (e.g., regulatory programs).
- Implement (e.g., through education and enforcement) existing regulations and continue current BMP programs (for example, within stormwater permit areas and for forest harvest). Mandated BMPs are only effective and protective if implemented widely and consistently.
- Develop a comprehensive and integrated funding strategy to pay for the necessary actions, along with other actions to achieve other PSP vital sign targets. Development of the funding strategy is most appropriately led by a regional or state organization rather than by local agencies and should include establishment of appropriate institutional arrangements and capacity to support implementation.

6.2 Increasing the Scientific Knowledge Base

The basis for how to implement successful restoration and protection projects is constantly evolving and growing. It is important to push for new information and understand the regional implications in order to utilize limited resources most effectively. There are still several information gaps; we recommend the following:

- Continue experimenting with restoration and protection actions in order to build scientifically credible cause and effect relationships supporting BMP effectiveness. It is informative to understand what, where and why actions work, and to recognize what is attainable given natural and anthropogenic limiting factors and stressors.
- Look for and understand the applicability of related regional efforts and incorporate new information into project implementation as appropriate. For example, there are two directly relevant regional efforts, the Regional Stormwater Monitoring Program (RSMP, Ecology 2014) and Total Maximum Daily Load (TMDL) development for Squalicum and Soos Creeks (Plotnikoff and Blizard 2013), that should complement each other and inform our understanding of the effects of stressors on biological communities.
- Investigate the basins with higher-than-expected B-IBI scores and determine if there are any lessons to be learned from these basins. It would be helpful to know whether there is something about the pattern and intensity of development in these outlier basins that mitigates the typical impacts of development, or whether there are existing mitigating factors such as stormwater management or intact riparian buffers that are contributing to the higher-than-expected B-IBI scores.
- In basins with lower-than-expected B-IBI scores, seed streams with invertebrates and monitor their persistence to see if current conditions are actually better than current scores would indicate.
- Investigate current compliance rates of existing regulations such as stormwater manual guidelines, critical areas ordinance requirements such as maintaining riparian buffers, and forest practice rules. If noncompliance is found to exist, it would be useful to estimate the impact of full compliance on the stream B-IBI scores. This could inform the appropriate balance between new restoration project implementation and BMP implementation to achieve successful stream restoration and protection.
- Maintain funding for ongoing status and trends B-IBI monitoring and PSSB database activities. Evaluation of the effectiveness of recovery targets, and trends over time, cannot be done without data. Existing monitoring programs and the PSSB database are funded by a variety of sources, mostly local, and support for these is not guaranteed in perpetuity.

6.3 Adapting the B-IBI Target

This project is based on the existing PSP B-IBI target language. Suggestions for modifications to the target language and for ongoing assessment of the targets follow.

- Change the B-IBI target language so that it no longer references the 10-50 B-IBI score ranges. The B-IBI has been recalibrated and updated using extensive regional data to a continuous scale ranging from 0 to 100 (King County 2014a). The target should be modified to reflect this development and current best available science.
- Consider modifying the B-IBI target language so that restoration goals are not tied to specific condition categories. Currently the restoration goal is to restore 30

streams with "fair" B-IBI scores to "good". The exact line between some of these condition categories is blurry – B-IBI scores can vary from year to year. In addition, restoration efforts may be most effective if basins are targeted based on the likelihood of restoration success and level of impact on Puget Sound. There may be some streams with "poor" or "very poor" B-IBI scores that have obvious and addressable stressors. Restoration dollars are limited and looking for the locations where restoration can achieve the biggest ecological lift seems prudent to accelerate overall Puget Sound recovery.

- Model and predict B-IBI scores across all of Puget Sound streams. Candidate basins for restoration or protection currently have to be in locations with readily available B-IBI data stored in the PSSB. However, there are geographic gaps in the availability of monitoring data and these areas are currently ignored. It may be possible to evaluate existing B-IBI scores and landcover data to develop a watershed model for predicting B-IBI scores. This model could be applied to Puget Sound streams and likely would result in additional basins being added for protection or restoration where B-IBI data are currently lacking. This seems especially important for the protection target which aims to maintain high B-IBI scores in all applicable areas.
- Analyze and report on B-IBI data every 5 years. Hundreds of sampling locations are monitored annually across Puget Sound. These data should be organized and downloaded from the PSSB approximately every 5 years with protection basins identified based on "excellent" B-IBI scores and restoration basins identified through application of the restoration decision framework. New candidate stream basins for restoration and protection are likely to emerge through this process. In any event, this periodic comprehensive review will provide key information regarding the status and trends of stream ecological health throughout Puget Sound.

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APPENDICES

Appendix A: QA/QC of Basin Delineations

Appendix B: Puget Sound Watershed Characterization Results

Appendix C: Outreach Meeting Questions

Appendix D: PSSB Project Web Page

Appendix E: Strategies for Restoring and Protecting B-IBI Watersheds Stakeholder Workshop Agenda

Appendix F: B-IBI Biological Condition Categories

Appendix G: Sites Falling on Both the "Excellent" and "Fair" Lists

Appendix H: "Excellent" Site Filtration

Appendix I: 303(d) Impairment Listings in "Excellent" Basins

Appendix J: Washington State Forestry Ownership and Logging Intensity

Appendix K: Supporting Information Considered for B-IBI Restoration Basins

Appendix L: Restoration Strategies for Individual B-IBI Restoration Basins

Appendix A: QA/QC of Basin Delineations

Basins were initially delineated following an automated method. However, the automated method resulted in some delineation errors. Table A-1 summarizes the "fair" basins and Table A-2 summarizes the "excellent" basins that were corrected using manual delineation techniques.

Table A-1. Site information for 30 "fair" basins that had to be re-delineated. Sorted by WRIA and then unique PSSB site ID.

WRIA	ID	Site Code	Stream	Latitude	Longitude
5	500	CAR2B	Harvey Ck.	48.25214	-122.13922
7	283	E1076	Cherry Ck. Trib	47.74033	-121.90676
7	303	E1105	Harris Ck.	47.72195	-121.87679
7	342	E2153	Brockway Ck.	47.52951	-121.80248
7	346	E1031	Snoqualmie R. - S Fork Trib	47.46487	-121.75805
7	347	E1045	Boxley Ck. Trib	47.44589	-121.72874
7	496	CAR1A	Carpenter Ck. (Woods Ck.) Trib	48.01148	-121.95834
7	501	CAR3A	Little Pilchuck Ck. (Snohomish)	48.09226	-122.0453
7	520	05B	Cherry Ck.	47.74005	-121.94138
7	959	7-981	Swartz Lake Ck.	48.06831	-121.95393
7	962	7-279	Ricci Ck.	47.8212	-122.03921
8	314	E633-CIP-1	Rock Ck. (Lower Cedar)	47.37997	-122.0175
8	320	P325	May Ck. (Lake Washington)	47.50107	-122.10795
8	947	Stensland Middle	Stensland Ck.	47.68609	-122.08115
9	222	09COV1862	Rock Ck. Trib (Covington)	47.31721	-122.00522
9	242	09MID1374	O'Grady Ck.	47.2756	-122.08811
9	244	09MID1537	Crisp Ck.	47.28987	-122.05804
9	248	09MID1958	Icy Ck.	47.27889	-121.97857
9	260	09NEW2128	Newaukum Ck. - N Fork	47.23425	-121.93519
9	264	09SOO1022	Soosette Ck.	47.33264	-122.15626
9	273	VashJudd	Judd Ck.	47.40993	-122.47088
13	814	GreenThCo36th	Green Cove Ck.	47.08338	-122.95041
13	818	MissionThCoBethel	Mission Ck.	47.06368	-122.88465
15	86	BiBi-001 - Artondale Creek	Artondale Ck.	47.30006	-122.62228
15	873	KCSSWM-009	Boyce Ck.	47.60883	-122.9098
15	876	KCST-7	Gamble Ck.	47.77693	-122.59432
15	879	KCSSWM-011	Little Anderson Ck.	47.65573	-122.75502
15	880	KCSSWM-031	Little Boston	47.85565	-122.5716
15	884	KCST-16	Stavis Ck.	47.614	-122.87517
15	1292	KCSSWM-020	Big Scandia Ck.	47.7155	-122.6574

Table A-2. Site information for 56 "excellent" basins that had new or fixed delineations. Sorted by WRIA and then unique PSSB site ID.

WRIA	ID	Site Code	Stream	Latitude	Longitude	Task
1	970	BIO06600-AUST02	Austin Ck	48.7065	-122.343	Fix
5	1240	Benson	Benson Ck (Stillaguamish)	48.09107	-121.779	Fix
5	1820	16	Stillaguamish River - N Fork tributary	48.27834	-121.958	Fix
5	2045	fishtr	Cougar Ck Trib	48.16827	-122.261	New
5	2212	Kackman	Kackman Ck	48.21587	-122.154	New
7	322	N3872	Snoqualmie River - Middle Fork tributary (Lower)	47.47025	-121.687	Fix
7	373	cresup	Creswell Ck	47.9948	-121.981	Fix
7	384	frspada	French Ck (Snohomish)	47.9154	-121.991	Fix
7	520	05B	Cherry Ck	47.74005	-121.941	Fix
7	901	Tok_KC_Biosolids	Tokul Ck	47.66349	-121.76	Fix
7	905	TnU_KC_Biosolids	Ten Ck	47.57565	-121.753	Fix
7	906	Bvr_KC_Biosolids	Beaver Ck (Snoqualmie)	47.62307	-121.777	Fix
7	960	7-221	French Ck (Snohomish)	47.9154	-121.991	Fix
7	1869	BIO06600-YOUN02	Youngs Ck	47.80655	-121.825	New
7	1891	WAM06600-002335	Olney Ck tributary	47.9395	-121.724	New
7	1893	WAM06600-002867	Raging River	47.4981	-121.919	New
7	2216	07RGT022147	Raging River Tributary	47.45737	-121.836	New
7	2218	07RGT016851	Unnamed tributary of Raging River	47.45783	-121.866	New
7	2220	07RAG012515-2220	Raging River	47.46556	-121.865	New
7	2224	07RGT002867	Unnamed tributary of Raging River	47.49872	-121.919	New
8	116	08BEA3737	Seidel Ck	47.71879	-122.074	Fix
8	125	08CED4192	Rock Ck (Lower Cedar)	47.37475	-122.018	Fix
8	127	08CED4975	Hotel Ck (0342)	47.40985	-121.923	Fix
8	158	08ISS4735	Holder Ck tributary	47.44771	-121.965	Fix
8	159	08ISS4748	Issaquah Ck - E Fork	47.53173	-121.983	Fix
8	315	E633-CIP-2	Rock Ck (Lower Cedar)	47.37999	-122.017	Fix
8	316	E633-CIP-3	Rock Ck (Lower Cedar)	47.37987	-122.018	Fix
8	518	31I	Taylor Ck/Jem Ck (Lower Cedar)	47.40913	-122.025	Fix
8	934	WAM06600-108711	Issaquah Ck - E Fork	47.53042	-121.943	Fix
8	1087	WAM06600-027251	Rock Ck (Upper Cedar)	47.39922	-121.919	Fix
8	1089	WAM06600-083667	Hotel Ck (0342)	47.41416	-121.91	Fix
8	1906	WAM06600-007491	Taylor Ck	47.36588	-121.826	New
9	220	09COV1756	Covington Ck	47.32877	-122.022	Fix
9	226	09DEE2211	Deep Ck (Green River)	47.28753	-121.921	Fix
9	227	09DEE2266	Deep Ck (Green River)	47.28918	-121.908	Fix

WRIA	ID	Site Code	Stream	Latitude	Longitude	Task
9	246	09MID1744	Cristy Ck	47.27261	-122.021	Fix
9	247	09MID1817	Cristy Ck	47.26799	-122.01	Fix
9	257	09NEW2076	Newaukum Ck - N Fork	47.23594	-121.951	Fix
9	260	09NEW2128	Newaukum Ck - N Fork	47.23425	-121.935	Fix
9	261	09NEW2151	Newaukum Ck	47.22442	-121.931	Fix
9	285	E375	Coal Ck (Green River)	47.26873	-121.916	Fix
9	290	E365/366	Deep Ck (Green River)	47.28565	-121.924	Fix
9	1620	Soos Creek and SR 58 Crossing Kent-Black Diamond R	Soos Ck	47.3122	-122.097	Fix
9	1900	WAM06600-004206	Sunday Ck	47.25357	-121.383	New
9	1904	WAM06600-006574	Coal Ck	47.27612	-121.897	New
10	1887	WAM06600-002074	Ohop Ck North Fork	46.95743	-122.146	New
10	2228	BSE_21_GolfCrs	Boise Ck	47.19515	-121.953	New
13	817	McLaneThCoDNR	McLane Ck	46.99773	-123.01	Fix
15	882	KCST-9	Olalla Ck	47.45348	-122.574	Fix
15	1071	EPA06600-DEWA01	Dewatto River	47.46919	-123.026	Fix
15	1864	BIO06600-BOYC02	Boyce Ck	47.60896	-122.908	New
16	606	PurdSkokTrb2	Purdy Ck (Skokomish River)	47.3049	-123.16	Fix
18	1866	BIO06600-CANY02	Canyon Ck (Dungeness)	48.02311	-123.14	New
18	1868	BIO06600-TUMW02	Tumwater Ck	48.09074	-123.473	New
19	584	BoundaryMid_ECY_390	Boundary Ck	48.0967	-123.831	Fix
19	1895	WAM06600-002932	Clallam River tributary	48.1758	-124.267	New

Appendix B: Puget Sound Watershed Characterization Results

As mentioned in the body of the report (see section 2.2.4), the results of the Puget Sound Watershed Characterization (PSWC) water quality and water flow model runs helped inform the scale (e.g., reach or basin) of degradation of specific water flow and water quality possibly impacting macroinvertebrate communities. This information is mentioned in the individual-basin portfolio summaries for all restoration sites.

In an analysis similar to what was previously conducted to calculate a site's biological potential[36] (King County 2014c, Paul et al. 2009), the degradation index scores (ranging from 0-1) of individual[37] flow and water quality processes were plotted (e.g., surface storage, metals contamination) against the median B-IBI scores for all available sites. This analysis indicated that the distribution of each of the four water flow (water delivery, surface storage, recharge, and discharge) and four water quality (phosphorus, metals, nitrogen, and pathogens) processes was wedge-shaped.

The 90th percentile regression line was also calculated for all eight water quality and water flow processes to define the upper limit of expected B-IBI scores for a given level of degradation (Figure B-1). The regression line was used to distinguish between what would be considered "minimal degradation" and what would be "more than minimal degradation" at the basin scale. Minimal degradation was defined by the point at which the 90th percentile line crosses the lower limit of the "good" biological condition category (B-IBI=38). In the example shown in Figure B-1, it is ~0.25. Basins falling to the left of this threshold could be expected to have "good" B-IBI scores without any restoration of the process at the basin scale (i.e., the model output suggests that process is not degraded to the point at which it is the likely factor limiting B-IBI scores). Basins in this category were given a score of "1."

Basins falling to the right of the threshold (>0.25 in Figure B-1) are not likely to score "good" B-IBI without some significant restoration of the process being considered in the graph. The basins to the right of the threshold were further divided depending on whether they were above or below the 90th percentile line; those below were given a score of "2," while sites falling above the line were give a score of "3." These analyses were done for each of the 8 processes so that 8 scores were generated for each basin.

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[36] Biological potential is describes the upper limit of biological condition based on some stressor gradient, which in this project is basin urbanization. See Paul et al. 2009 for a full discussion of biological potential and King County 2014c to understand how it was used in the restoration decision framework.
[37] Water flow and quality processes were considered individually. However, these processes likely interact to influence basin conditions and expectations.

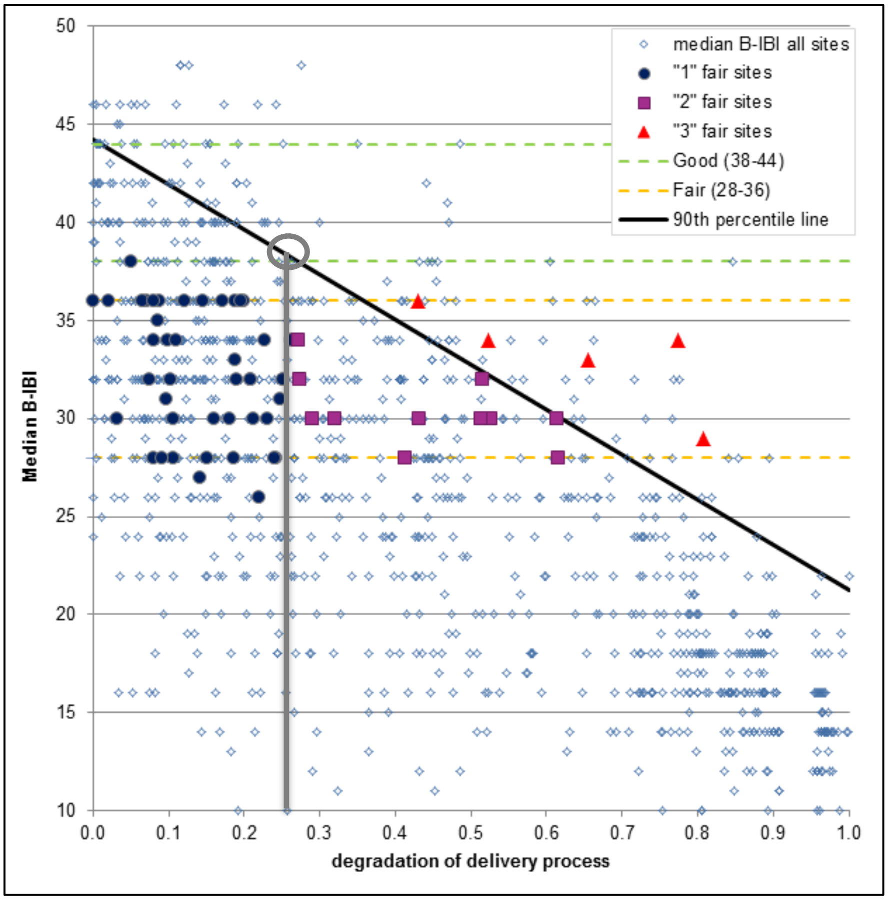


Figure B-1. An example of the distribution of B-IBI scores plotted against a PSWC water flow process (here it is water delivery).
Degradation represents the PSWC model results and 0 indicates no basin-scale degradation to the process of interest. The grey circle and vertical line indicates the "minimal degradation" point where the 90th percentile line crosses the lower limit of the "good" category (B-IBI = 38). In this example the minimal degradation is ~ 0.25.

When a flow or water quality parameter was minimally degraded (i.e., "1" sites), we assumed other conditions were limiting the B-IBI scores within the basin. When a flow or water quality parameter was moderately degraded but the B-IBI score was lower than the 90th percentile for that level of degradation (i.e., "2" sites), we assumed the degradation of that process may be basin-wide but if restored, B-IBI scores could improve. When a flow or water quality process was highly degraded and yet the B-IBI score was higher than the 90th percentile for that level of degradation (i.e., "3" sites), we assumed the degradation of that process was basin-wide and B-IBI scores were already higher than expected. Restoration actions could be implemented to reduce the degradation, but it would be unlikely that those actions could be extensive enough to result in much improvement in B-IBI scores and it would be especially difficult to improve B-IBI scores into the "good" range.

Appendix C: Outreach Meeting Questions

Ten small group meetings were conducted with regional stakeholders with expertise on "fair" and "excellent" basins of interest. The questions below were circulated prior to each meeting to help solicit feedback that could inform restoration or protection actions that could help achieve the PSP targets.

Questions pertaining to "fair" basins:

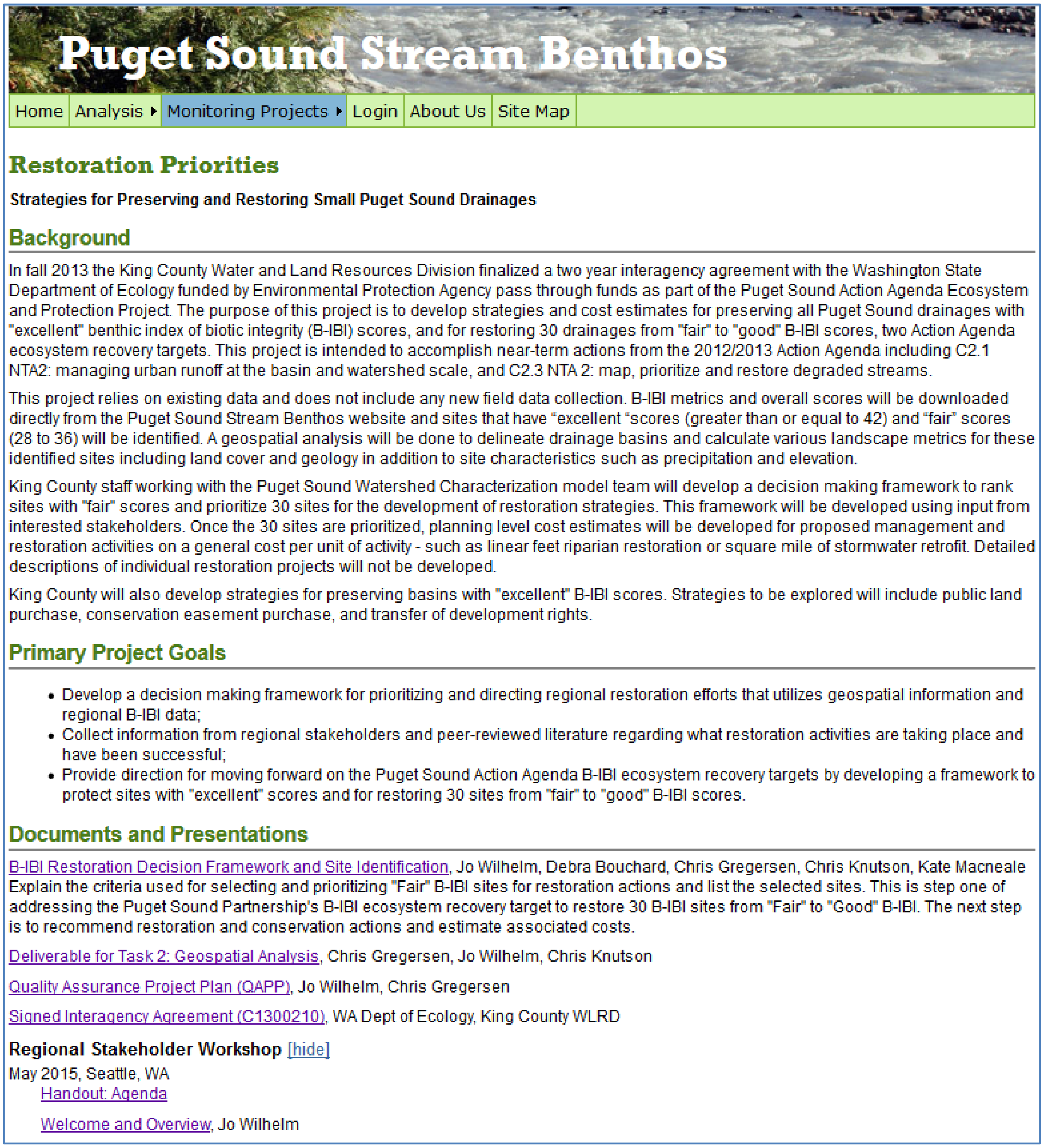
- What can you tell us about these basins?
- Do any of these basins fit into any salmon recovery or current stormwater retrofit priorities?
- Are you aware of any recent land use changes?
- Are there land use changes planned in the future that would facilitate or inhibit restoration activities?
- What are the limiting factors in these streams and watersheds?
- What actions do you think would help restore biology, habitat, and watershed processes? Where should these take place?
- Has any restoration taken place? Was it successful? What was done? Has there been effectiveness monitoring?
- Is any restoration scheduled or planned? Are there priority areas in the basin plans?
- Are there any other key players who we should talk to about these sites and basins?

Questions pertaining to "excellent" basins:

- Is there a risk of future changes in the watershed such as zoning, new developments, or other land use alterations?
- Do you have any recommendations how to best protect these sites and maintain high biotic integrity?

Appendix D: PSSB Project Web Page

Deliverables and presentations related to this project will be posted to the project web page on the Puget Sound Stream Benthos website (Figure D-1): http://pugetsoundstreambenthos.org/Projects/Restoration-Priorities-2014.aspx



Puget Sound Stream Benthos

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Restoration Priorities

Strategies for Preserving and Restoring Small Puget Sound Drainages

Background

In fall 2013 the King County Water and Land Resources Division finalized a two year interagency agreement with the Washington State Department of Ecology funded by Environmental Protection Agency pass through funds as part of the Puget Sound Action Agenda Ecosystem and Protection Project. The purpose of this project is to develop strategies and cost estimates for preserving all Puget Sound drainages with "excellent" benthic index of biotic integrity (B-IBI) scores, and for restoring 30 drainages from "fair" to "good" B-IBI scores, two Action Agenda ecosystem recovery targets. This project is intended to accomplish near-term actions from the 2012/2013 Action Agenda including C2.1 NTA2: managing urban runoff at the basin and watershed scale, and C2.3 NTA 2: map, prioritize and restore degraded streams.

This project relies on existing data and does not include any new field data collection. B-IBI metrics and overall scores will be downloaded directly from the Puget Sound Stream Benthos website and sites that have "excellent "scores (greater than or equal to 42) and "fair" scores (28 to 36) will be identified. A geospatial analysis will be done to delineate drainage basins and calculate various landscape metrics for these identified sites including land cover and geology in addition to site characteristics such as precipitation and elevation.

King County staff working with the Puget Sound Watershed Characterization model team will develop a decision making framework to rank sites with "fair" scores and prioritize 30 sites for the development of restoration strategies. This framework will be developed using input from interested stakeholders. Once the 30 sites are prioritized, planning level cost estimates will be developed for proposed management and restoration activities on a general cost per unit of activity - such as linear feet riparian restoration or square mile of stormwater retrofit. Detailed descriptions of individual restoration projects will not be developed.

King County will also develop strategies for preserving basins with "excellent" B-IBI scores. Strategies to be explored will include public land purchase, conservation easement purchase, and transfer of development rights.

Primary Project Goals

- Develop a decision making framework for prioritizing and directing regional restoration efforts that utilizes geospatial information and regional B-IBI data;
- Collect information from regional stakeholders and peer-reviewed literature regarding what restoration activities are taking place and have been successful;
- Provide direction for moving forward on the Puget Sound Action Agenda B-IBI ecosystem recovery targets by developing a framework to protect sites with "excellent" scores and for restoring 30 sites from "fair" to "good" B-IBI scores.

Documents and Presentations

B-IBI Restoration Decision Framework and Site Identification, Jo Wilhelm, Debra Bouchard, Chris Gregersen, Chris Knutson, Kate Macneale
Explain the criteria used for selecting and prioritizing "Fair" B-IBI sites for restoration actions and list the selected sites. This is step one of addressing the Puget Sound Partnership's B-IBI ecosystem recovery target to restore 30 B-IBI sites from "Fair" to "Good" B-IBI. The next step is to recommend restoration and conservation actions and estimate associated costs.

Deliverable for Task 2: Geospatial Analysis, Chris Gregersen, Jo Wilhelm, Chris Knutson

Quality Assurance Project Plan (QAPP), Jo Wilhelm, Chris Gregersen

Signed Interagency Agreement (C1300210), WA Dept of Ecology, King County WLRD

Regional Stakeholder Workshop [hide]
May 2015, Seattle, WA
Handout: Agenda

Welcome and Overview, Jo Wilhelm

Figure D-1. Screen Capture of the "Restoration Priorities" project page on the PSSB. Presentations and deliverables are available for download and this page will be routinely updated throughout the duration of this project.

Appendix E: Strategies for Restoring and Protecting B-IBI Watersheds Stakeholder Workshop Agenda

TUESDAY, MAY 12, 2015

12:30- 3:00 pm King Street Center in Seattle

201 S. Jackson St. 8th floor conference room

AGENDA

12:30 - 12:40	Welcome and Overview • introduce project team • B-IBI targets, grant objectives, and timeline	*Jo Wilhelm*
12:40 - 12:50	Regional Roundtable • introductions – one person from each agency	*Stakeholders*
12:50 - 1:05	Regional Context • PSP strategic initiatives • PSP implementation strategies • EPA funding mechanism	*Michael Rylko (EPA) and Todd Hass (PSP)*
1:05 - 1:20	Protecting Excellent Sites • site selection • strategies and examples	*Jo Wilhelm*
1:20 - 1:35	Restoring Fair Sites: Restoration Decision Framework • filtering criteria for site selection	*Chris Gregersen*
1:35 - 1:50	Break	
1:50 - 2:20	Restoring Fair Sites: Strategies for Restoration • considerations • examples • take home impressions	*Kate Macneale*
2:20 - 2:30	Cost Estimates for Restoration Strategies	*Chris Knutson*
2:30 - 2:35	Wrap Up and Setting up Group Exercise	*Jo Wilhelm*
2:35 - 3:00	Small Breakout Groups • groups organized geographically • time for feedback on specific basins and strategies	*Stakeholders*

Appendix F: B-IBI Biological Condition Categories

The B-IBI scoring system is a quantitative method for determining and comparing the biological condition of streams. The B-IBI is composed of 10 metrics and each individual metric is given a score of 1, 3, or 5, with higher numbers given to conditions representative of streams unaltered by anthropogenic influence. These metrics are then added together for the single, integrated overall B-IBI score ranging from 10 to 50 which fall in one of five biological condition classes (Table F-1).

Table F-1. Five classes of biological condition categories modified from Karr et al. (1986) by Morley (2000).

Biological Condition	Description	B-IBI Range
Excellent	Comparable to least disturbed reference condition; overall high taxa diversity, particularly of mayflies, stoneflies, caddis flies, long-lived, clinger, and intolerant taxa. Relative abundance of predators high.	46-50
Good	Slightly divergent from least disturbed condition; absence of some long-lived and intolerant taxa; slight decline in richness of mayflies, stoneflies, and caddis flies; proportion of tolerant taxa increases	38-44
Fair	Total taxa richness reduced – particularly intolerant, long-lived, stonefly, and clinger taxa; relative abundance of predators declines; proportion of tolerant taxa continues to increase	28-36
Poor	Overall taxa diversity depressed; proportion of predators greatly reduced as is long-lived taxa richness; few stoneflies or intolerant taxa present; dominance by three most abundant taxa often very high	18-26
Very Poor	Overall taxa diversity very low and dominated by a few highly tolerant taxa; mayfly, stonefly, caddis fly, clinger, long-lived, and intolerant taxa largely absent; relative abundance of predators very low	10-16

The PSP freshwater macroinvertebrate target specifies that 100 percent of Puget Sound lowland stream drainage areas monitored with baseline B-IBI scores of 42-46 or higher retain these “excellent” scores. Therefore, the term “excellent” for the purposes of this project extends from 42 to 50 and includes part of the B-IBI “good” condition class.

Appendix G: Sites Falling on Both the "Excellent" and "Fair" Lists

Of the 160 Puget Sound stream and river sampling locations that scored "excellent" B-IBI at least once, fifteen of these were also on the final list of 54 "fair" B-IBI sites. For the purposes of this project, these sites were omitted from the "excellent" list and were considered further as part of the "fair" restoration analysis. The record of the sampling and B-IBI scores for these fifteen sites are found in Table G-1.

Table G-1. B-IBI scores for fifteen sites omitted from the "excellent" list because they are on the final "fair" list.

Site Code (ID)	Stream (WRIA)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Median
CAR2B (500)	Harvey Ck. (5)										32	28	42					32
E1045 (347)	Boxley Ck. tributary (7)	22	28		36	36	40	32	36	46	38	46	32					36
E2153 (342)	Brockway Ck. (7)	14	28		30	28	38	30	22	46	38	34	38					30
05B (520)	Cherry Ck. (7)										40	28	46	36	36			36
E1076 (283)	Cherry Ck. tributary (7)	24	36	28	36	36	42	36	30	40	36	34	38					36
E1023 (348)	Clough Ck. (7)	20	36		38	44	28	40	30	40	38	32	34					36
E1191 (286)	Coal Ck. (7)						42	34	38	34	36	36	32					36
E1078 (282)	N. Fork Cherry Ck. (7)	16	20	34	34		32	36	36	46	42		32					34
E818 (332)	Raging River tributary (7)	22	30		34	32	40	28	40	42	42	40	36					36
08ISS3958 (151)	Cabin Ck. (8)				42	36		32	30	36	34	38	36	28			38	36
08ISS4724 (156)	Carey Ck. (8)					42			38	32	32	38	28	36	36	42	36	36
E1139 (306)	Fifteenmile Ck. (8)	22	26	36	38	30	34	40	36	38	42	32	32					35
09MID1958 (248)	Icy Ck. (9)				34	38		38	38	26	44	28	34	26	30	30	38	34
09NEW2128 (260)	N. Fork Newaukum (9)				30	32		36	26	46	38	38	32	30	36	44	36	36
KCSSWM-009 (873)	Boyce Ck. (15)		28	36	40	42	40	36						34				36

Appendix H: "Excellent" Site Filtration

Table H-1. B-IBI scores by year for 145 sites that scored "excellent" at least once. The 15 sites shown in Appendix G are excluded from this table. Filter type is explained in the text and in Figure 3. Blue bold font indicates an "excellent" score (>=42); red font indicates a "poor" or "very poor" score (<27). Sites are sorted by filter, then median B-IBI score, then site code.

Filter	ID	Stream (WRIA, Site Code)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	*Median*
Include: Median >= 42	1868	Tumwater Ck. (18, BIO06600-TUMW02)																	48		*48*
	2228	Boise Ck. (10, BSE_21_GolfCrs)																		48	*48*
	381	French Ck. (7, FCLU)																	48		*48*
	1030	Tumwater Ck. (18, WAM06600-001556)													50				46		*48*
	2220	Raging R. (7, 07RAG012515)																		46	*46*
	2224	Raging R. trib (7, 07RGT002867)																		46	*46*
	2216	Raging R. trib (7, 07RGT022147)																		46	*46*
	129	Webster Ck. 0341 (8, 08CED5046)						38			48	46	48	46	48	40	40	46	44	46	*46*
	1648	Nisqually R. (11, BIO06600-BIGC04)																46			*46*
	1866	Canyon Ck. (18, BIO06600-CANY02)																	46		*46*
	606	Purdy Ck. (16, PurdSkokTrb2)										46									*46*
	1887	Ohop Ck. N. Fork (10, WAM06600-002074)																	46		*46*
	1904	Coal Ck. (9, WAM06600-006574)																	46		*46*
	928	Issaquah Ck. E. Fork (8, WAM06600-074259)													46						*46*
	158	Holder Ck. trib (8, 08ISS4735)						38	42		48	46	46	46	44	40	40	48	40	46	*45*
	160	Issaquah Ck. E. Fork (8, 08ISS4884)						44	48		46	46	46	46	46	40	44	38	44	44	*45*
	517	Webster Ck. 0341 (8, 31Q)												44	46	40	48	44			*44*
	359	Barclay Ck. (7, BARCLAY)										42				44			46		*44*
	1647	Carbon R. (10, BIO06600-CAYA04)																44			*44*
	1869	Youngs Ck. (7, BIO06600-YOUN02)																	44		*44*
	585	Boundary Ck. (19, BoundaryRef_ECY_391)						44													*44*
	1464	Stavis Ck. (15, ENVVEST-36)				44															*44*
	2212	Kackman Ck. (5, Kackman)																		44	*44*
	322	Snoqualmie R. Mid Fork trib (7, N3872)								44	38	44	44	48	46	44					*44*
	1620	Soos Ck. (9, Soos Creek and SR 58 Crossing Kent-Black Diamond R)																44			*44*
	901	Tokul Ck. (7, Tok_KC_Biosolids)				44	44	40	44	40	46	42									*44*
	995	Crandall Ck. (7, WAM06600-000987)													44				44		*44*
	990	Canyon Ck. (10, WAM06600-001402)													46				42		*44*
	1891	Olney Ck. trib (7, WAM06600-002335)																	44		*44*
	1893	Raging R. (7, WAM06600-002867)																	44		*44*
	1895	Clallam R. trib (19, WAM06600-002932)																	44		*44*
	1900	Sunday Ck. (9, WAM06600-004206)																	44		*44*
	1906	Taylor Ck. (8, WAM06600-007491)																	44		*44*
	915	Webster Ck. (8, WAM06600-022259)													44	40	46	38	50		*44*
	932	Holder Ck. (8, WAM06600-098963)													44	40	46	44	42		*44*
	724	Siebert Ck. (18,Siebert WF 2.3)					46			42											*44*
	125	Rock Ck. (L. Cedar) (8, 08CED4192)						30	42		38	40	44	46	40	44	42	44	46	46	*43*
	906	Beaver Ck. (7, Bvr_KC_Biosolids)			40	38	40	46	48	42	44	44									*43*
	1086	Williams Ck. (8, WAM06600-015443)														36	42	44	48		*43*

Filter	ID	Stream (WRIA, Site Code)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Median
	2218	Raging R. trib (7, 07RGT016851)																		42	42
	127	Hotel Ck. (8, 08CED4975)						30	38		36	44	42	42		36	42	44	40	44	42
	518	Taylor Ck./Jem Ck. (8, 31I)												42	42	38	44	40			42
	589	Mission Ck. (15, BigMission_ECY_545)								42											42
	1864	Boyce Ck. (15, BIO06600-BOYC02)																	42		42
	1653	Sauk R. (4, BIO06600-SKUL77)																42			42
	584	Boundary Ck. (19, BoundaryMid_ECY_390)						42													42
	281	Cherry Ck. N. Fork trib (7, E1239)								34	30	34	44	44	46	42					42
	2045	Cougar Ck. trib (5, fishtr)											42								42
	1058	Lewis Ck. (7, Lewis648)														42					42
	903	Tate Ck. (7, Tat_KC_Biosolids)			32	44	40	42	48	42	40	48									42
	904	Ten Ck. (7, TnD_KC_Biosolids)				42	40	44	42	42	44	44									42
	1031	Twentyfive Mile Ck. (11, WAM06600-001418)													38				46		42
	1087	Rock Ck. (U. Cedar) (8, WAM06600-027251)														42	44	42	42		42
	1089	Hotel Ck. (8, WAM06600-083667)														38	40	44	46		42
	1088	Rock Ck. (U. Cedar) (8, WAM06600-086867)														36	40	46	44		42
	666	Deep Ck. (19,Deep 1.5)							42												42
Include: >=42 in '12, '13, or '14	261	Newaukum Ck. (9, 09NEW2151)						38	46		36	44	36	44	44	36	34	42	44	40	41
	1269	Dickerson Ck. (15, KCSSWM-008 - (Chico Trib														38		44			41
	459	Woods Ck. W. Fork (7, WOODS298)														40			42		41
	128	Rock Ck. (U. Cedar) (8, 08CED5032)						38	46			34	40	38	44	40	46	30	36	44	40
	226	Deep Ck. (9, 09DEE2211)						34			46	30	46	40	40	40		44	40	40	40
	228	Coal Ck. (9, 09DEE2294)						42	40		38	36	36	44	42	30	38	46	44	40	40
	249	Green R. Middle trib (9, 09MID2426)						40	40		40	44	30	40	34	34	28	34	42	40	40
	971	Chuckanut Ck. (1, EPA06600-CHUC01)														40			38	42	40
	1788	Dickerson Ck. (15, KCSSWM-046)																36	40	44	40
	1247	Stillaguamish R. N. Fork trib (5, stnftr115)											34				40			46	40
	1020	Raging R. trib (7, WAM06600-001251)													38				42		40
	1011	Mud Ck. (7, WAM06600-001415)													36				44		40
	912	Carey Ck. (8, WAM06600-006355)													40	46	32	40	46		40
	259	Newaukum Ck. (9, 09NEW2102)						34	38		48	40	44	38	40	30	42	38	42	38	39
	1060	May Ck. (7, MAY)														28			50		39
	246	Cristy Ck. (9, 09MID1744)						42	34		30	34	38	44	38	44	36	38	46	42	38
	257	Newaukum Ck. N. Fork (9, 09NEW2076)						42	40		30	34	38	40		28	34	42	44	26	38
	384	French Ck. (7, frspada)										34				38			42		38
	920	Issaquah Ck. E. Fork (8, WAM06600-039815)													34	38	32	38	42		38
	929	Cottage Lake Ck. (8, WAM06600-076119)													40	34	36	42	40	36	38
	118	Struve Ck. (8, 08BEA3826)						40	32		36	38	44	34	40	36	34	42	32	46	37
	152	Issaquah Ck. (8, 08ISS3962)									32	38	32	38	34	38	26	32	44	42	36
	268	Soos Ck. (9, 09SOO1134)						40	34		28	36	42	34	36	34	36	38	38	42	36
	412	Peoples Ck. (7, peoples)										36				34			42		36
	1235	Griffin Ck. (7, SEN06600-GRIF09)														32	36	42	36		36
	934	Issaquah Ck. E. Fork (8, WAM06600-108711)													32	36	36	42	38		36
	935	Issaquah Ck. (8, WAM06600-110035)													36	34	36	40	48		36
	1261	French Ck. (5, FrenchCr)															28			42	35
	147	Rutherford Ck. (8, 08EVA4077)						34						24		32	30	42	44	40	34
	155	High Point Ck. (8, 08ISS4573)						34	44		30	32	32	40	30	34	36	32	42	42	34

Filter	ID	Stream (WRIA, Site Code)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	*Median*
	116	Seidel Ck. (8, 08BEA3737)						30	32		30	34	32	38	38	38	32	42	36	32	*33*
	150	Issaquah Ck. (8, 08ISS3877)									22	34	30	32	36	28	24	38	42	38	*33*
	247	Cristy Ck. (9, 09MID1817)						38	36		34	36	36	30	32	30	32	26	42	30	*33*
	1285	Olalla Ck. (15, KCSSWM-041)														22		44			*33*
	239	Olson Ck. (9, 09LOW0751)						30	34		30	34	26	30	28	24	34	34	42	36	*32*
	482	Trout Ck. (8, TROUT)												24				30	34	46	*32*
	931	Issaquah Ck. E. Fork (8, WAM06600-082291)													32	38	30	32	46		*32*
	933	Issaquah Ck. (8, WAM06600-100519)													26	30	28	30	44		*30*
Include: >=42 >50 of time	1820	Stillaguamish R. N. Fork trib (5, 16)													40		42				*41*
	960	French Ck. (7, 7-221)													40	42					*41*
	69	Adair Ck. (7, ADR_UPD)	32		36	40	46					42	42		46	14					*41*
	1018	Racehorse Ck. (1, WAM06600-000672)													42				40		*41*
	970	Austin Ck. (1, BIO06600-AUST02)														42			38		*40*
	890	Dickerson Ck. (15, KCWQ-3)		44	44	36	38	34	34	44	42										*40*
	373	Creswell Ck. (7, cresup)										46				32					*39*
Include: Remaining	159	Issaquah Ck. E Fork (8, 08ISS4748)									40	44	36	42	36	42	40	40	34	40	*40*
	315	Rock Ck. (L. Cedar) (8, E633-CIP-2)							42			40	44	48	34	36	38				*40*
	316	Rock Ck. (L. Cedar) (8, E633-CIP-3)							34			30	38	46	42	40	40				*40*
	331	Canyon Ck. (7, E949)			22	30		46	22	44	36	40	44	42	44	34					*40*
	817	McLane Ck. (13, McLaneThCoDNR)						42	46	40	42	38	40	38							*40*
	227	Deep Ck. (9, 09DEE2266)						34	50		38										*38*
	285	Coal Ck. (9, E375)			20	34	40	38		38	44	44	32	42	44	38					*38*
	911	Carey Ck. (8, WAM06600-002259)													38	26	44	40	32		*38*
	220	Covington Ck. (9, 09COV1756)						30	36		38	36	38	42	40	34	44	28	34	40	*37*
	225	Coal Ck. (9, 09DEE2208)						32	36		36	38	38	42	44	32	24	28	38	40	*37*
	353	Tuck Ck. (7, P752)								36		38	34	42	38	36					*37*
	1236	Hamma Hamma R. (16, SEN06600-HAMM03)														36	42	34	38		*37*
	224	Deep Ck. (9, 09DEE2163)						38	38		32	30	42	42	36	34	36	40	32	28	*36*
	1240	Benson Ck. (5, Benson)											32				42			36	*36*
	305	McDonald Ck. (8, E1138)								36	26	46	46	36	36	30					*36*
	290	Deep Ck. (9, E365/366)								36	28	38	34	36	44	42					*36*
	1438	Blackjack Ck. (15, ENVVEST-7)				46		36	32												*36*
	905	Ten Ck. (7, TnU_KC_Biosolids)			36	38	34	42	36	30	36	46									*36*
	323	Green R. Middle trib (9, E2538)			24	28	30	38	32	36	34	30	42	42	44	36					*35*
	882	Olalla Ck. (15, KCST-9)				30	34	44	36	32	38										*35*
	579	Little R. (18, BIO06600-SLIT01)						34	34	44						32	32				*34*
	350	Tokul Ck. (7, E1017)			24		44	32	42	32	34	38	34	30	36	38					*34*
	1445	Clear Ck. (15, ENVVEST-14)				42		34	30												*34*
	1456	Gorst Ck. (15, ENVVEST-28)				44		30	34												*34*
	1071	Dewatto R. (15, EPA06600-DEWA01)														32	42	32	36		*34*
	1245	Rock Ck. (5, Rock)											42				34			34	*34*
	294	Issaquah Ck. E. Fork (8, E182)			22	32	40	28	34	26	30	30	44	42	34	38					*33*
	889	Chico Ck. (15, KCSSWM-002 - Mountaineers)		44	38	36	46	32	32	32	32					34			30		*33*
	646	Bagley Ck. (18,Bagley 0.7)			30	28	32	26			42		34								*31*

Filter	ID	Stream (WRIA, Site Code)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	*Median*
Exclude: >=25% "Poor", "V. Poor"	292	Issaquah Ck. E. Fork (8, E195)			22	46	42	26	38	26	30	32	40	40	36	36					*36*
	154	Issaquah Ck. trib 0203 (8, 08ISS4373)						24	34			40		42		26	34				*34*
	293	Issaquah Ck. E. Fork (8, E186)			24	34	44	32	30	24	38	34	40	42	26	34					*34*
	321	Snoqualmie R. Mid Fork trib (7, E1058)			20	22	44	38	16	22	30	34		46		36					*32*
	169	Many Springs Ck. (8, 08LAK3880)						30	38		30	44	24	28	32	24	24	40	34	32	*31*
	123	Cedar R. trib 0311 (8, 08CED2898)						18	24		20	26	46	24	26	24	28	28	26	26	*26*
	329	Newaukum Ck. (9, E519)								30	26	26	44	40	22	26					*26*
	900	Lynch Ck. (7, LyD_KC_Biosolids)			34	24		42	16	24	32	18									*24*
Exclude: <15% "Excellent"	812	Ellis Ck. (13, EllisThCoPriestPt)						38	44	38	36	36	36	38							*38*
	907	Griffin Ck. (7, GrD_KC_Biosolids)			34	38	36	44	38	30	36	38									*37*
	902	Griffin Ck. (7, GrU_KC_Biosolids)			34	40	34	44	36	34	28	36									*35*
	899	Lynch Ck. (7, LyU_KC_Biosolids)			34	38	34	42	40	20	36	32									*35*
	115	Bear Ck. (8, 08BEA3650)						30	34		30	32	34	34	30	36	42	34	32	36	*34*
	126	Walsh Lake Diversion (8, 08CED4479)						42	38		34	36	34	34	34						*34*
	192	Sammamish R. trib 0090 (8, 08SAM2862)						32	36		28	32	30	34	34	40	42	30	36	36	*34*

Table H-2. Same stream site groupings for "excellent" sites.

WRIA	Stream Group	Site ID	Site Code	Latitude	Longitude
7	French Creek 1	381	FCLU	47.9052	-122.00751
	French Creek 2	384	frspada	47.915396	-121.99073
		960	7-221	47.915396	-121.99073
	Ten Creek	904	TnD_KC_Biosolids	47.579993	-121.78236
		905	TnU_KC_Biosolids	47.575654	-121.75299
8	Carey Creek	911	WAM06600-002259	47.423196	-121.94844
		912	WAM06600-006355	47.420868	-121.9332
	High Point Creek	155	08ISS4573	47.531946	-121.97621
		931	WAM06600-082291	47.529744	-121.97755
	Hotel Creek	127	08CED4975	47.40985	-121.92331
		1089	WAM06600-083667	47.41416	-121.91041
	Issaquah Creek 1	150	08ISS3877	47.551207	-122.04688
	Issaquah Creek 2	152	08ISS3962	47.538939	-122.0426
		933	WAM06600-100519	47.536658	-122.04083
	Issaquah Creek E. Fork 1	159	08ISS4748	47.531728	-121.98346
		294	E182	47.532351	-121.98021
		920	WAM06600-039815	47.532713	-121.99379
	Issaquah Creek E. Fork 3	160	08ISS4884	47.525851	-121.94113
		928	WAM06600-074259	47.52609	-121.93997
	Issaquah Creek E. Fork 2	934	WAM06600-108711	47.530421	-121.94255
	Rock Creek (Lower Cedar)	125	08CED4192	47.374751	-122.01767
		315	E633-CIP-2	47.379986	-122.01726
		316	E633-CIP-3	47.379871	-122.01755
	Rock Creek (Upper Cedar)	128	08CED5032	47.415086	-121.88713
		1087	WAM06600-027251	47.39922	-121.91942
		1088	WAM06600-086867	47.43124	-121.8759
	Webster Creek	129	08CED5046	47.443557	-121.90239
		517	31Q	47.416394	-121.91938
		915	WAM06600-022259	47.423668	-121.91249
9	Coal Creek	1904	WAM06600-006574	47.276119	-121.89704
		228	09DEE2294	47.275939	-121.89478
		225	09DEE2208	47.269381	-121.91625
		285	E375	47.268727	-121.91552
	Cristy Creek	246	09MID1744	47.272614	-122.02107
		247	09MID1817	47.26799	-122.00974
	Deep Creek	224	09DEE2163	47.282302	-121.93269
		226	09DEE2211	47.287531	-121.92123
		227	09DEE2266	47.289178	-121.90794

WRIA	Stream Group	Site ID	Site Code	Latitude	Longitude
		290	E365/366	47.285648	-121.92367
	Newaukum Creek	259	09NEW2102	47.231078	-121.94603
		261	09NEW2151	47.224415	-121.93126
15	Dickerson Creek	890	KCWQ-3	47.581217	-122.72117
		1269	KCSSWM-008 - (Chico Trib)	47.5831	-122.7168
		1788	KCSSWM-046	47.586477	-122.7148
18	Tumwater Creek	1030	WAM06600-001556	48.090744	-123.47265
		1868	BIO06600-TUMW02	48.09074	-123.47264
19	Boundary Creek	584	BoundaryMid_ECY_390	48.0967	-123.8306
		585	BoundaryRef_ECY_391	48.0978	-123.8506
7	Olney Creek tributary	1891	07RGT002867	47.498716	-121.91917
		2224	WAM06600-002335	47.939504	-121.72428
15	Ollala Creek	1285	KCSSWM-041	47.4284	-122.568
		882	KCST-9	47.453483	-122.5742

Appendix I: 303(d) Impairment Listings in "Excellent" Basins

Table I-1. 303(d) impairment listings from 2008 for the "excellent" basins.

ID	Temp	DO	Fecal Coliform	pH	Total Phosphorus	Other Impairment Listings
118	X					
150		X				
152		X				
220	X					
246			X			
247			X			
268	X	X	X		X	Toxaphene, Total Chlordane, PCB, Hexachlorobenzene, Dieldrin, 2,3,7,8-TCDD
281					X	
381		X		X	X	
459		X				
584	X					
585	X					
646			X			Bioassessment
666	X					Fine sediment
724		X				
889		X	X			
890	X					
929	X					
971		X	X			
1071			X			
1269	X					
1285		X				
1445			X			
1620	X	X				PCB; 2,3,7,8-TCDD
1647				X		
1788	X					
1864		X	X			
2228	X			X		

Appendix J: Washington State Forestry Ownership and Logging Intensity

All Washington state timberlands are governed by the Washington Forest Practices Rules (222 WAC), which establish standards for forest practices such as harvest, thinning, road construction, fertilization, and chemical application. These rules are under constant review through the adaptive management program designed to protect public resources such as water quality and fish habitat.

Aside from standardized practices, variations that can occur between different timber harvest managers include harvest cycle period (age of timber at harvest), amount of land logged, intensity of logging (clear-cutting vs. thinning), chemical application, and forest certification. Certified forests are managed by an additional set of standards that demonstrate environmentally responsible, socially beneficial, and economically viable management. There are multiple certification choices available, which may be optional and separate from state laws.

To obtain a broad view of potential impacts of forestry type to B-IBI scores, we can compare total Washington state harvest by ownership group (DNR 2010, 2012a, 2012b, 2013, 2014) to the total area owned by each group (WFPA 2006, Table 3).

Table J-1. Average 2009-2013 timber harvest for 3 major timberland owners. Timber harvest is reported as the annual average percent (2009-2013) and the amount harvested in million board feet of lumber (MMFBM). Ownership is by percent of Washington State forest land and total acreage.

Owner	Timber Harvest		Ownership	
	%	MMFBM	%	Acres
USFS	3.7	0.100	34.8	7,700,000
DNR	22.1	0.600	10.0	2,200,000
Private	72.8	2.034	20.8	4,600,000

As Table 3 shows, logging intensity varies widely, with private lands being logged at a much higher intensity. This high intensity logging results in forests being in a cleared state for a longer time potentially posing greater risks to stream macroinvertebrate communities and consequently B-IBI scores. These data are for all of Washington State, but it is presumed that there are similar patterns in Puget Sound and in the selected "excellent" basins. USFS lands represent the least intensely logged area, with the lowest percentage of harvest even though it represents the largest area of forestry lands. Even though all forestry activity is subject to similar laws and regulations, based on these data, we can broadly assume that logging risk to B-IBI is greatest for privately owned commercial forest lands, and lowest for federally owned USFS lands.

Appendix K: Supporting Information Considered for B-IBI Restoration Basins

The following tables include site information about the 54 "fair" basins that were identified as the B-IBI restoration basins. A link to the basin-specific recommendations is provided in Appendix L.

Table K-1 The 54 "fair" B-IBI sites that characterize the restoration basins. IDs and site codes are used as identifiers in the Puget Sound Stream Benthos (PSSB) database.

WRIA	Stream	ID	Site Code	Latitude	Longitude
5	Harvey Ck.	500	CAR2B	48.25214	-122.13922
	Portage Ck.	502	CAR3C	48.17619	-122.121975
7	Cherry Ck. - N Fork	282	E1078	47.750501	-121.911981
	Cherry Ck. Trib	283	E1076	47.740329	-121.906761
	Coal Ck. (Snoqualmie R.)	286	E1191	47.526182	-121.837064
	Harris Ck.	303	E1105	47.721954	-121.876792
	Raging R. Trib	332	E818	47.503829	-121.904076
	Brockway Ck.	342	E2153	47.529513	-121.802481
	Snoqualmie R. - S Fork Trib	346	E1031	47.464867	-121.758054
	Boxley Ck. Trib	347	E1045	47.445891	-121.728739
	Clough Ck.	348	E1023	47.473741	-121.78624
	Carpenter Ck. (Woods Ck.) Trib	496	CAR1A	48.01148	-121.958336
	Little Pilchuck Ck. (Snohomish)	501	CAR3A	48.09226	-122.045304
	Cherry Ck.	520	05B	47.740049	-121.941377
	Swartz Lake Ck.	959	7-981	48.068309	-121.953934
	Ricci Ck.	962	7-279	47.821204	-122.039211
8	Cabin Ck.	151	08ISS3958	47.519491	-122.038574
	Carey Ck.	156	08ISS4724	47.426952	-121.97338
	Laughing Jacobs Ck.	168	08LAK3879	47.56535	-122.045569
	Fifteenmile Ck.	306	E1139	47.483739	-122.029482
	May Ck. (Lake Washington)	320	P325	47.501068	-122.107952
	Stensland Ck.	947	Stensland Middle	47.686092	-122.081153
9	Rock Ck. Trib (Covington)	222	09COV1862	47.317211	-122.00522
	O'Grady Ck.	242	09MID1374	47.275597	-122.088114
	Crisp Ck.	244	09MID1537	47.28987	-122.058042
	Icy Ck.	248	09MID1958	47.278886	-121.978571
	Newaukum Ck. - N Fork	260	09NEW2128	47.234245	-121.93519
	Soosette Ck.	264	09SOO1022	47.332643	-122.15626
	Christenson Ck.	272	VashChris	47.40277	-122.51693
	Judd Ck.	273	VashJudd	47.40993	-122.47088
	Tahlequah Ck.	354	E2887	47.334554	-122.508612
	Fisher Ck. (Vashon)	523	65B	47.383942	-122.481469

WRIA	Stream	ID	Site Code	Latitude	Longitude
10	Spiketon Ck.	1099	BiBi-033 - Spiketon Creek	47.14929	-122.02613
13	Green Cove Ck.	814	GreenThCo36th	47.083383	-122.950408
	Indian Ck. (Lower Deschutes)	815	IndianThCoWheeler	47.035544	-122.881733
	Mission Ck.	818	MissionThCoBethel	47.063684	-122.884651
15	Artondale Ck.	86	BiBi-001 - Artondale Creek	47.300062	-122.622276
	Carpenter Ck. (Kitsap)	867	KCSSWM-022 - Upper	47.810435	-122.521057
	Boyce Ck.	873	KCSSWM-009	47.608833	-122.9098
	Gamble Ck.	876	KCST-7	47.776933	-122.594317
	Little Anderson Ck.	879	KCSSWM-011	47.655733	-122.755017
	Little Boston	880	KCSSWM-031	47.85565	-122.5716
	Seabeck Ck.	883	KCST-17	47.627817	-122.8392
	Stavis Ck.	884	KCST-16	47.614	-122.875167
	Ray Nash Ck.	896	BiBi-025 - Ray Nash Creek	47.31866	-122.65909
	Purdy Ck. (Burley Lagoon)	908	BIBI-028 - Purdy Creek	47.38921	-122.6255
	Herron Ck.	1100	BiBi-034 - Herron Creek	47.271067	-122.805943
	Barker Ck.	1270	KCSSWM-001 - Lower	47.6378	-122.6701
	Mosher Ck.	1288	KCSSWM-012	47.6122	-122.6547
	Parish Ck.	1290	KCSSWM-018 - (Gorst Trib)	47.5284	-122.7142
	Anderson Ck. (Kitsap)	1291	KCSSWM-019	47.5262	-122.6819
	Big Scandia Ck.	1292	KCSSWM-020	47.7155	-122.6574
	Jump Off Ck.	1295	KCSSWM-030	47.8068	-122.6692
18	Bagley Ck.	647	BagleyClalCty4.6	48.064283	-123.324619

Table K-2 Annual and median B-IBI scores for the "restoration" basins. Initially, only data from 1999-2012 were available, and therefore only those were used for identifying the 54 target basins.

Stream	WRIA	B-IBI 1999	B-IBI 2000	B-IBI 2001	B-IBI 2002	B-IBI 2003	B-IBI 2004	B-IBI 2005	B-IBI 2006	B-IBI 2007	B-IBI 2008	B-IBI 2009	B-IBI 2010	B-IBI 2011	B-IBI 2012	B-IBI 2013	B-IBI 2014	B-IBI Median (1999-2012)
Harvey Ck.	5										32	28	42					32
Portage Ck.	5										34	32	36					34
Cherry Ck. - N Fork	7	16	20	34	34		32	36	36	46	42		32					34
Cherry Ck. Trib	7	24	36	28	36	36	42	36	30	40	36	34	38					36
Coal Ck. (Snoqualmie R.)	7						42	34	38	34	36	36	32					36
Harris Ck.	7		24	36	38	26	26	32	28	30	32		32					31
Raging R. Trib	7	22	30		34	32	40	28	40	42	42	40	36					36
Brockway Ck.	7	14	28		30	28	38	30	22	46	38	34	38					30
Snoqualmie R. - S Fork Trib	7	14	24	30	30	34	30	22	30	32	28	34	24					30
Boxley Ck. Trib	7	22	28		36	36	40	32	36	46	38	46	32					36
Clough Ck.	7	20	36		38	44	28	40	30	40	38	32	34					36
Carpenter Ck. (Woods Ck.) Trib	7										36	36	20					36
Little Pilchuck Ck. (Snohomish)	7										32	30	28					30
Cherry Ck.	7										40	28	46	36	36			36
Swartz Lake Ck.	7								32			34	20					32
Ricci Ck.	7								38			32	32					32
Cabin Ck.	8				42	36		32	30	36	34	38	36	28			38	36
Carey Ck.	8					42			38	32	32	38	28	36	36	42	36	36
Laughing Jacobs Ck.	8				28	28		28	28	30	22	32	30	30	28	28	30	28
Fifteenmile Ck.	8	22	26	36	38	30	34	40	36	38	42	32	32					35
May Ck. (Lake Washington)	8						32	34	36	40	36	36	30					36
Stensland Ck.	8											30	38	32	30	28		31
Rock Ck. Trib (Covington)	9				20			26	30	28	34	34	22	32		36	30	29
O'Grady Ck.	9				30	28		38	38	36	36	34	30	30	38	36	38	35
Crisp Ck.	9				34	30		34	30	26	24	30	20	20	26	22	26	28
Icy Ck.	9				34	38		38	38	26	44	28	34	26	30	30	38	34
Newaukum Ck. - N Fork	9				30	32		36	26	46	38	38	32	30	36	44	36	34
Soosette Ck.	9				28	36			32	30	40	38	32	34	36	36	28	34
Christenson Ck.	9							28	34	32	22	34	34	26	34	32	40	33
Judd Ck.	9							30	30	30		32	24	32	34			30
Tahlequah Ck.	9						22	24	32	34	32	28	24					28
Fisher Ck. (Vashon)	9										32	30	40	32	24			32

Stream	WRIA	B-IBI 1999	B-IBI 2000	B-IBI 2001	B-IBI 2002	B-IBI 2003	B-IBI 2004	B-IBI 2005	B-IBI 2006	B-IBI 2007	B-IBI 2008	B-IBI 2009	B-IBI 2010	B-IBI 2011	B-IBI 2012	B-IBI 2013	B-IBI 2014	B-IBI Median (1999-2012)
Spiketon Ck.	10			32			34						26			30		32
Green Cove Ck.	13				30	38	40	30	30	28	30							30
Indian Ck. (Lower Deschutes)	13					30	30	26	28	32	18							29
Mission Ck.	13					36	30	28	36	28	36							33
Artondale Ck.	15		30				32	26	32		26		30		28	28	28	30
Carpenter Ck. (Kitsap)	15			24	26	28	28	28	30				24	28		30		28
Boyce Ck.	15		28	36	40	42	40	36						34			42	36
Gamble Ck.	15		26	34	34	34	30											34
Little Anderson Ck.	15		28	40		26	34	32						34			36	33
Little Boston	15		34	36	24	32	32						26			24		32
Seabeck Ck.	15		40	30	22	36	26	22										28
Stavis Ck.	15		24	32	28	24	40											28
Ray Nash Ck.	15		24				34				26	34			28	28	30	28
Purdy Ck. (Burley Lagoon)	15			30				36				26		30		32		30
Herron Ck.	15												30	30	34	22		30
Barker Ck.	15												30	24	28	30	32	28
Mosher Ck.	15				38	26							30		30		24	30
Parish Ck.	15		36		30	32								32		28		32
Anderson Ck. (Kitsap)	15		28		34	34								24		26		31
Big Scandia Ck.	15		22		24								32		40		38	28
Jump Off Ck.	15		30		22									28		28		28
Bagley Ck.	18			28	30					26			30					29

Table K-3. Basin area for the "restoration" basins and percent land cover for select land cover categories.

Stream	WRIA	Basin area (acres)	Urban (% within 1 km)	Urban (% in entire basin)	Pasture (% within 1 km)	Pasture (% of entire basin)	Cultivated (% within 1 km)	Cultivated (% of entire basin)	Natural vegetation (% within 90-m buffer)	Impervious (% of entire basin in 2011)
Harvey Ck.	5	291.2	1.6	0.8	7.1	3.4	0.0	0.0	93.7	0.7
Portage Ck.	5	959.2	25.6	16.5	0.8	0.1	0.0	0.0	90.7	6.4
Cherry Ck. - N Fork	7	1124.9	16.6	5.7	0.0	0.0	0.0	0.0	98.1	1.9
Cherry Ck. Trib	7	584.4	7.9	8.0	0.0	0.0	0.0	0.0	89.5	2.6
Coal Ck. (Snoqualmie R.)	7	1949.1	15.7	16.4	0.5	0.0	0.0	0.0	86.3	9.1
Harris Ck.	7	770.0	2.4	1.5	0.0	0.0	0.0	0.0	98.6	1.0
Raging R. Trib	7	1595.2	6.3	7.9	0.0	0.2	0.0	0.0	97.0	4.3
Brockway Ck.	7	1171.2	0.0	0.3	0.4	0.0	0.0	0.0	99.9	0.4
Snoqualmie R. - S Fork Trib	7	826.3	3.5	8.1	0.0	0.1	0.0	0.0	94.3	4.2
Boxley Ck. Trib	7	398.3	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Clough Ck.	7	1382.1	9.6	3.8	0.0	0.0	0.0	0.0	95.3	0.4
Carpenter Ck. (Woods Ck.) Trib	7	382.1	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.7
Little Pilchuck Ck. (Snohomish)	7	1406.5	11.4	11.9	0.0	0.5	0.0	0.0	93.4	3.9
Cherry Ck.	7	860.1	3.4	6.6	0.0	0.2	0.0	0.0	98.1	2.1
Swartz Lake Ck.	7	1845.2	1.8	3.6	0.0	0.5	0.0	0.0	100.0	0.3
Ricci Ck.	7	1976.2	0.5	8.9	0.0	0.1	0.0	0.0	89.0	4.2
Cabin Ck.	8	369.8	13.0	5.6	0.0	0.0	0.0	0.0	95.8	2.0
Carey Ck.	8	2844.2	4.7	1.6	13.3	2.4	0.0	0.0	99.4	0.8
Laughing Jacobs Ck.	8	2869.8	51.6	45.7	0.0	0.0	0.0	0.0	53.5	22.2
Fifteenmile Ck.	8	2996.5	21.3	5.6	1.0	0.8	0.0	0.0	92.6	2.3
May Ck. (Lake Washington)	8	682.6	8.6	11.7	0.0	0.0	0.0	0.0	87.8	4.2
Stensland Ck.	8	400.1	16.2	28.7	24.9	7.1	11.0	3.0	52.3	12.7
Rock Ck. Trib (Covington)	9	1058.9	16.4	10.5	7.9	3.0	0.0	0.0	77.1	5.2
O'Grady Ck.	9	903.0	2.5	6.8	7.2	46.0	0.0	1.2	48.7	3.6
Crisp Ck.	9	1107.9	3.5	9.3	1.4	1.7	0.0	0.0	90.8	4.3
Icy Ck.	9	254.7	0.8	0.6	0.0	0.0	0.0	0.0	100.0	0.4
Newaukum Ck. - N Fork	9	1409.6	1.9	0.8	0.6	0.1	0.0	0.0	99.0	0.4
Soosette Ck.	9	2797.4	27.7	56.4	19.2	8.5	0.8	0.1	30.9	28.4
Christenson Ck.	9	500.8	0.2	2.7	7.1	25.4	0.0	0.0	100.0	1.7
Judd Ck.	9	2754.6	2.0	4.8	8.5	11.4	0.0	0.6	85.7	3.2
Tahlequah Ck.	9	984.1	3.3	4.9	0.2	0.0	0.2	0.0	99.3	2.4
Fisher Ck. (Vashon)	9	1242.5	2.8	2.9	4.9	25.5	0.0	0.0	80.6	2.0
Spiketon Ck.	10	920.9	9.7	5.1	23.7	16.0	1.3	0.7	86.4	2.2
Green Cove Ck.	13	1875.1	34.8	25.8	0.0	0.1	0.0	0.0	83.8	12.7
Indian Ck. (Lower Deschutes)	13	927.1	67.1	56.7	0.0	2.7	0.0	0.0	47.4	31.3
Mission Ck.	13	362.2	36.7	44.1	4.5	3.5	0.3	0.2	62.5	20.6

Stream	WRIA	Basin area (acres)	Urban (% within 1 km)	Urban (% in entire basin)	Pasture (% within 1 km)	Pasture (% of entire basin)	Cultivated (% within 1 km)	Cultivated (% of entire basin)	Natural vegetation (% within 90-m buffer)	Impervious (% of entire basin in 2011)
Artondale Ck.	15	1644.2	16.7	14.3	0.2	0.1	0.0	0.0	80.9	7.6
Carpenter Ck. (Kitsap)	15	564.9	3.8	6.2	0.2	0.2	0.0	0.0	86.9	3.0
Boyce Ck.	15	1006.6	0.6	2.4	0.0	0.0	0.0	0.0	96.3	1.3
Gamble Ck.	15	1483.4	9.2	10.2	0.2	3.5	0.0	0.2	82.0	4.1
Little Anderson Ck.	15	2176.2	0.6	17.3	0.0	0.1	0.0	0.0	91.4	6.1
Little Boston	15	602.8	8.5	3.9	0.0	0.0	0.0	0.0	96.0	1.1
Seabeck Ck.	15	2946.1	7.8	6.5	0.4	0.1	0.0	0.0	95.4	2.5
Stavis Ck.	15	1931.5	0.0	2.9	0.0	0.0	0.0	0.0	97.8	1.4
Ray Nash Ck.	15	1391.5	7.3	13.5	1.4	2.6	0.4	0.2	77.5	6.9
Purdy Ck. (Burley Lagoon)	15	2314.2	25.4	8.4	0.0	0.4	0.0	0.0	90.3	4.4
Herron Ck.	15	642.9	2.0	2.7	0.0	0.0	0.0	0.0	99.5	1.0
Barker Ck.	15	2512.6	38.9	33.4	0.1	0.9	0.0	0.0	62.1	16.4
Mosher Ck.	15	1051.9	26.8	51.4	0.1	0.0	0.0	0.0	53.2	25.1
Parish Ck.	15	1128.9	16.3	13.2	0.0	0.2	0.0	0.0	88.8	5.4
Anderson Ck. (Kitsap)	15	1221.8	3.2	15.8	0.0	0.3	0.0	0.0	80.6	7.6
Big Scandia Ck.	15	1750.0	11.2	14.6	0.9	0.2	0.0	0.0	82.0	6.6
Jump Off Ck.	15	830.9	51.1	28.4	0.0	0.5	0.0	0.0	71.1	13.5
Bagley Ck.	18	1481.8	4.8	2.9	0.0	0.0	0.0	0.0	96.0	0.6

Table K-4. Percent of area for each "restoration" basin zoned for select land uses.

Stream	WRIA	Urban (%)	Urban Residential (%)	Rural Residential (%)	Resource Agriculture (%)	Resource Forest (%)	Resource Mineral (%)	Military (%)	Tribal (%)	Active Open Space and Recreation (%)	Natural Preservation and Conservation (%)
Harvey Ck.	5	0.0	0.0	22.8	0.0	62.5	14.8	0.0	0.0	0.0	0.0
Portage Ck.	5	3.2	4.5	92.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cherry Ck. - N Fork	7	0.0	0.0	58.5	0.0	41.5	0.0	0.0	0.0	0.0	0.0
Cherry Ck. Trib	7	0.0	0.0	93.5	0.0	6.5	0.0	0.0	0.0	0.0	0.0
Coal Ck. (Snoqualmie R.)	7	33.5	10.1	26.5	0.0	29.4	0.0	0.0	0.0	0.5	0.0
Harris Ck.	7	0.0	0.0	25.9	0.0	74.1	0.0	0.0	0.0	0.0	0.0
Raging R. Trib	7	1.8	0.0	57.1	0.0	41.0	0.0	0.0	0.0	0.0	0.0
Brockway Ck.	7	0.0	0.0	44.4	0.0	55.6	0.0	0.0	0.0	0.0	0.0
Snoqualmie R. - S Fork Trib	7	0.0	3.2	96.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boxley Ck. Trib	7	0.0	0.0	14.2	0.0	85.5	0.0	0.0	0.0	0.0	0.0
Clough Ck.	7	0.0	0.0	51.0	0.0	49.0	0.0	0.0	0.0	0.0	0.0
Carpenter Ck. (Woods Ck.) Trib	7	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Little Pilchuck Ck. (Snohomish)	7	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cherry Ck.	7	0.7	15.3	84.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swartz Lake Ck.	7	0.0	0.0	56.9	0.0	37.8	5.3	0.0	0.0	0.0	0.0
Ricci Ck.	7	0.0	1.9	98.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cabin Ck.	8	2.9	20.3	74.6	0.0	0.0	0.0	0.0	0.0	2.2	0.0
Carey Ck.	8	0.0	0.0	56.8	0.0	43.2	0.0	0.0	0.0	0.0	0.0
Laughing Jacobs Ck.	8	3.0	93.1	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fifteenmile Ck.	8	0.2	0.0	30.6	0.0	69.3	0.0	0.0	0.0	0.0	0.0
May Ck. (Lake Washington)	8	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stensland Ck.	8	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rock Ck. Trib (Covington)	9	1.6	28.8	9.9	0.0	24.6	35.0	0.0	0.0	0.0	0.0
O'Grady Ck.	9	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Crisp Ck.	9	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Icy Ck.	9	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Newaukum Ck. - N Fork	9	0.0	0.0	2.0	0.0	97.9	0.0	0.0	0.0	0.0	0.0
Soosette Ck.	9	8.5	62.3	29.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Christenson Ck.	9	0.0	0.0	82.4	17.6	0.0	0.0	0.0	0.0	0.0	0.0
Judd Ck.	9	3.9	1.7	94.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tahlequah Ck.	9	0.0	0.0	99.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fisher Ck. (Vashon)	9	0.0	0.0	95.2	4.7	0.0	0.0	0.0	0.0	0.0	0.0
Spiketon Ck.	10	3.1	49.6	23.6	5.7	18.0	0.0	0.0	0.0	0.0	0.0
Green Cove Ck.	13	0.1	38.8	61.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indian Ck. (Lower Deschutes)	13	34.1	65.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mission Ck.	13	12.3	87.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Stream	WRIA	Urban (%)	Urban Residential (%)	Rural Residential (%)	Resource Agriculture (%)	Resource Forest (%)	Resource Mineral (%)	Military (%)	Tribal (%)	Active Open Space and Recreation (%)	Natural Preservation and Conservation (%)
Artondale Ck.	15	0.0	44.5	52.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0
Carpenter Ck. (Kitsap)	15	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boyce Ck.	15	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gamble Ck.	15	4.8	0.0	95.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Little Anderson Ck.	15	11.7	12.3	68.9	0.0	0.0	0.0	0.0	0.0	7.1	0.0
Little Boston	15	6.5	0.0	50.3	0.0	0.0	0.0	0.0	43.2	0.0	0.0
Seabeck Ck.	15	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stavis Ck.	15	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ray Nash Ck.	15	0.0	50.9	47.8	1.3	0.0	0.0	0.0	0.0	0.0	0.0
Purdy Ck. (Burley Lagoon)	15	0.1	16.8	82.2	0.8	0.0	0.0	0.0	0.0	0.1	0.0
Herron Ck.	15	0.0	32.8	63.1	0.0	0.0	0.0	0.0	0.0	4.1	0.0
Barker Ck.	15	3.1	39.2	51.3	0.0	0.0	0.0	0.0	0.0	4.6	0.0
Mosher Ck.	15	19.0	79.5	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Parish Ck.	15	7.4	3.1	89.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anderson Ck. (Kitsap)	15	2.4	83.7	6.6	0.0	0.0	0.0	0.0	0.0	0.0	4.0
Big Scandia Ck.	15	0.6	0.5	90.5	0.0	0.0	0.0	8.4	0.0	0.0	0.0
Jump Off Ck.	15	8.5	0.0	91.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bagley Ck.	18	0.0	0.0	78.8	0.0	21.2	0.0	0.0	0.0	0.0	0.0

Table K-5. Puget Sound Watershed Characterization (PSWC) values for flow and water quality parameters for "restoration" basins. See Appendix B for details.

Stream	WRIA	Percent (%) of basin under stormwater permit	PSWC Stormwater Retrofit Target Watershed	PSWC	Flow Parameters					Water Quality Parameters				
					Delivery	Surface Storage	Recharge	Discharge	Average	Phosphorus	Metals	Nitrogen	Pathogens	Average
Harvey Ck.	5	100.0	0	P2R	1	1	1	1	1.0	1	1	1	1	1.0
Portage Ck.	5	100.0	1	P3R	1	1	1	1	1.0	1	1	1	1	1.0
Cherry Ck. - N Fork	7	100.0	0	P2	1	1	1	1	1.0	1	1	1	1	1.0
Cherry Ck. Trib	7	100.0	1	P2R	1	1	1	2	1.3	1	1	1	1	1.0
Coal Ck. (Snoqualmie R.)	7	100.0	0	P2R	1	1	1	1	1.0	2	1	1	1	1.3
Harris Ck.	7	100.0	0	P1	1	1	1	1	1.0	1	1	1	1	1.0
Raging R. Trib	7	100.0	0	P1R	1	1	2	1	1.3	1	1	1	1	1.0
Brockway Ck.	7	100.0	0	P3	1	1	1	1	1.0	1	1	1	1	1.0
Snoqualmie R. - S Fork Trib	7	100.0	1	P1R	1	1	2	1	1.3	1	1	1	1	1.0
Boxley Ck. Trib	7	100.0	0	P1	1	1	1	1	1.0	1	1	1	1	1.0
Clough Ck.	7	100.0	1	P1	1	1	1	1	1.0	1	1	1	1	1.0
Carpenter Ck. (Woods Ck.) Trib	7	100.0	0	C1	1	1	1	1	1.0	1	1	1	1	1.0
Little Pilchuck Ck. (Snohomish)	7	100.0	0	P1R	1	1	1	1	1.0	1	1	1	1	1.0
Cherry Ck.	7	100.0	1	C1	1	1	1	1	1.0	1	1	1	1	1.0
Swartz Lake Ck.	7	100.0	1	P1	1	1	1	1	1.0	1	1	1	1	1.0
Ricci Ck.	7	100.0	0	P2R	1	1	1	2	1.3	1	1	1	1	1.0
Cabin Ck.	8	100.0	1	P3	1	1	1	1	1.0	1	1	1	1	1.0
Carey Ck.	8	100.0	0	P3	1	1	1	1	1.0	1	1	1	1	1.0
Laughing Jacobs Ck.	8	100.0	1	R2	2	2	2	2	2.0	2	2	2	2	2.0
Fifteenmile Ck.	8	100.0	0	P1	1	1	1	2	1.3	1	1	1	1	1.0
May Ck. (Lake Washington)	8	100.0	1	P2	1	1	1	1	1.0	1	1	1	1	1.0
Stensland Ck.	8	100.0	1	R2	2	1	2	1	1.5	2	2	2	2	2.0
Rock Ck. Trib (Covington)	9	100.0	1	R3	2	1	1	1	1.3	2	1	2	1	1.5
O'Grady Ck.	9	100.0	0	R2	3	3	1	2	2.3	2	2	3	1	2.0
Crisp Ck.	9	100.0	1	P1R	1	1	1	1	1.0	1	1	1	1	1.0
Icy Ck.	9	100.0	1	P3	1	1	1	1	1.0	1	1	1	1	1.0
Newaukum Ck. - N Fork	9	100.0	0	P1	1	1	1	1	1.0	1	1	1	1	1.0
Soosette Ck.	9	100.0	1	R2	3	3	3	2	2.8	3	3	3	3	3.0
Christenson Ck.	9	100.0	0	C2	1	1	1	2	1.3	1	1	1	1	1.0
Judd Ck.	9	100.0	0	P3R	1	1	1	1	1.0	1	1	1	1	1.0

Stream	WRIA	Percent (%) of basin under stormwater permit	PSWC Stormwater Retrofit Target Watershed	PSWC	Flow Parameters					Water Quality Parameters				
					Delivery	Surface Storage	Recharge	Discharge	Average	Phosphorus	Metals	Nitrogen	Pathogens	Average
Tahlequah Ck.	9	100.0	0	C1	1	1	1	2	1.3	1	1	1	1	1.0
Fisher Ck. (Vashon)	9	100.0	0	C2	1	1	1	1	1.0	1	1	1	1	1.0
Spiketon Ck.	10	100.0	1	R1	1	2	1	1	1.3	1	1	2	1	1.3
Green Cove Ck.	13	100.0	1	R1	2	1	2	2	1.8	2	2	2	2	2.0
Indian Ck. (Lower Deschutes)	13	100.0	0	R	3	2	3	2	2.5	3	3	3	3	3.0
Mission Ck.	13	100.0	1	R	3	2	3	1	2.3	3	3	3	3	3.0
Artondale Ck.	15	100.0	0	R3	1	1	1	2	1.3	1	1	1	1	1.0
Carpenter Ck. (Kitsap)	15	0.0	1	P3R	1	1	1	1	1.0	1	1	1	1	1.0
Boyce Ck.	15	0.0	0	P1	1	1	1	1	1.0	1	1	1	1	1.0
Gamble Ck.	15	0.0	0	R3	2	2	1	2	1.8	1	1	1	1	1.0
Little Anderson Ck.	15	37.1	0	C2	1	1	2	1	1.3	1	2	1	2	1.5
Little Boston	15	0.0	0	P1	1	1	1	1	1.0	1	1	1	1	1.0
Seabeck Ck.	15	0.0	0	P2R	1	1	1	1	1.0	1	1	1	1	1.0
Stavis Ck.	15	0.0	0	P2	1	1	1	1	1.0	1	1	1	1	1.0
Ray Nash Ck.	15	100.0	0	R3	1	2	1	2	1.5	1	1	1	1	1.0
Purdy Ck. (Burley Lagoon)	15	37.3	0	P2R	1	1	1	2	1.3	1	1	1	1	1.0
Herron Ck.	15	100.0	0	P3	1	1	1	1	1.0	1	1	1	1	1.0
Barker Ck.	15	100.0	1	R	2	2	2	2	2.0	2	2	2	2	2.0
Mosher Ck.	15	100.0	0	R2	2	2	2	2	2.0	2	2	2	2	2.0
Parish Ck.	15	39.2	1	P3R	1	1	1	1	1.0	1	1	1	1	1.0
Anderson Ck. (Kitsap)	15	100.0	0	P3R	1	1	1	1	1.0	1	1	1	1	1.0
Big Scandia Ck.	15	90.0	0	R3	2	2	1	2	1.8	1	1	1	1	1.0
Jump Off Ck.	15	36.1	0	R	2	2	2	2	2.0	1	1	1	1	1.0
Bagley Ck.	18	0.0	0	C2	2	1	1	1	1.3	1	1	1	1	1.0

Table K-6. The Intrinsic Potential fish score (sum of IP for Chinook, coho and steelhead; see Section 2.3.1 for details), resulting fish rank, and 303(d) class 5 listings for the "restoration" basins.

Stream	WRIA	Fish Score	Fish Rank	303(d) class 5 listings
Harvey Ck.	5	0.0		
Portage Ck.	5	1.5	1	
Cherry Ck. - N Fork	7	1.0	33	
Cherry Ck. Trib	7	1.2	20	
Coal Ck. (Snoqualmie R.)	7	0.8	42	
Harris Ck.	7	1.4	3	
Raging R. Trib	7	1.3	8	
Brockway Ck.	7	0.9	37	
Snoqualmie R. - S Fork Trib	7	0.0		
Boxley Ck. Trib	7	0.0		
Clough Ck.	7	0.0		
Carpenter Ck. (Woods Ck.) Trib	7	0.2	49	
Little Pilchuck Ck. (Snohomish)	7	1.2	16	
Cherry Ck.	7	1.4	6	
Swartz Lake Ck.	7	1.1	31	
Ricci Ck.	7	1.3	10	
Cabin Ck.	8	0.0	50	
Carey Ck.	8	0.6	45	
Laughing Jacobs Ck.	8	1.4	5	DO, FC
Fifteenmile Ck.	8	1.2	17	
May Ck. (Lake Washington)	8	0.6	44	
Stensland Ck.	8	1.1	24	
Rock Ck. Trib (Covington)	9	1.2	18	
O'Grady Ck.	9	1.1	26	
Crisp Ck.	9	1.2	13	
Icy Ck.	9	0.8	39	
Newaukum Ck. - N Fork	9	0.4	47	
Soosette Ck.	9	1.4	4	DO, FC
Christenson Ck.	9	0.5	46	
Judd Ck.	9	1.1	28	
Tahlequah Ck.	9	0.3	48	
Fisher Ck. (Vashon)	9	0.8	40	
Spiketon Ck.	10	1.3	11	
Green Cove Ck.	13	1.0	35	
Indian Ck. (Lower Deschutes)	13	1.4	7	FC
Mission Ck.	13	1.5	2	FC

Stream	WRIA	Fish Score	Fish Rank	303(d) class 5 listings
Artondale Ck.	15	1.1	27	
Carpenter Ck. (Kitsap)	15	0.0		
Boyce Ck.	15	1.2	14	DO, FC
Gamble Ck.	15	1.2	19	Temp
Little Anderson Ck.	15	0.9	38	
Little Boston	15	1.1	23	
Seabeck Ck.	15	0.9	36	DO
Stavis Ck.	15	1.0	32	
Ray Nash Ck.	15	1.1	25	
Purdy Ck. (Burley Lagoon)	15	1.1	22	DO
Herron Ck.	15	1.1	29	
Barker Ck.	15	1.2	21	DO, FC
Mosher Ck.	15	1.3	9	
Parish Ck.	15	1.1	30	FC
Anderson Ck. (Kitsap)	15	1.0	34	
Big Scandia Ck.	15	1.2	15	DO, FC
Jump Off Ck.	15	1.2	12	DO
Bagley Ck.	18	0.8	41	

Appendix L: Restoration Strategies for Individual B-IBI Restoration Basins

Individual basins were assessed and given scores indicating how likely specific restoration and management actions would be helpful in restoring the basin. A table of the scores for each is included here. In addition, a narrative summary of the recommended restoration actions and site-specific information for each restoration site is included in a separate report that can be accessed here: http://your.kingcounty.gov/dnrp/library/2015/kcr2693/kcr2693-rpt.pdf

Table L-1. Restoration and management actions and the initial estimate of the likelihood that each could help restore each basin. See section 4.4 for details.

		In-stream Actions					Riparian Actions		Agricultural BMPs			Forest Management BMPs			Mining BMPs	Stormwater BMPs				Other Approaches and Actions					
Stream	**WRIA**	add large wood	add coarse substrate	enhance sinuosity	replace culverts	stabilize stream banks	stabilize slopes	plant vegetation, extend buffer	exclude livestock	manage livestock waste	prevent soil loss	road maintenance	minimize clearcutting	replant	mining BMPs	flow control	treatment	maintain storage and treatment facilities	street sweeping	limit pesticide use	outreach and education campaign	create incentives to follow BMPs	purchase and protect property	seed invertebrates	**Is the basin at risk of further degradation?**
Harvey Ck.	5	2	2	2	2	2	2	4	4	4	2	4	4	3	2	3	3	2	1	3	4	3	3	3	4
Portage Ck.	5	2	2	2	2	2	2	3	1	1	1	0	0	0	0	4	4	4	3	3	3	3	3	3	4
Cherry Ck. - N Fork	7	2	2	1	1	1	2	3	4	0	0	0	4	0	0	3	3	2	1	3	4	4	2	2	4
Cherry Ck. Trib	7	2	2	2	2	2	2	3	0	0	0	2	3	0	0	4	4	2	1	2	4	4	2	2	2
Coal Ck. (Snoqualmie R.)	7	2	2	2	2	2	2	4	0	0	0	2	4	1	0	4	4	4	4	3	4	4	2	2	4
Harris Ck.	7	3	3	3	2	2	1	2	0	0	0	3	4	4	0	2	2	1	1	2	3	3	2	2	4
Raging R. Trib	7	2	2	2	2	2	2	2	0	0	0	2	4	3	0	4	4	4	1	3	4	3	2	2	4
Brockway Ck.	7	2	2	1	1	1	1	2	0	0	0	4	4	4	0	3	3	3	1	3	3	3	3	2	4
Snoqualmie R. - S Fork Trib	7	2	2	2	2	2	2	2	0	0	0	0	0	0	0	4	4	4	2	3	4	3	2	3	4
Boxley Ck. Trib	7	3	3	2	1	1	1	1	0	0	0	3	4	0	0	1	1	1	1	3	4	4	4	2	4
Clough Ck.	7	3	3	3	3	3	2	2	0	0	0	2	4	2	0	3	3	2	1	2	3	3	3	2	3
Carpenter Ck. (Woods Ck.) Trib	7	2	2	2	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	2	0	2	2	4	4
Little Pilchuck Ck. (Snohomish)	7	2	2	2	2	2	2	3	0	0	0	0	0	0	0	4	4	4	1	2	3	3	3	3	4
Cherry Ck.	7	2	2	2	2	2	2	3	3	2	2	0	0	0	0	3	3	2	2	2	3	2	2	2	4
Swartz Lake Ck.	7	2	2	2	2	2	2	2	1	1	1	2	4	1	4	4	4	4	1	2	2	2	2	3	4
Ricci Ck.	7	3	1	1	2	2	2	4	4	4	2	0	0	0	0	3	3	2	1	3	4	4	2	3	3
Cabin Ck.	8	2	2	4	2	2	2	2	0	0	0	0	0	0	0	3	3	2	1	1	2	2	1	1	4
Carey Ck.	8	2	2	4	2	2	2	4	2	2	1	2	3	1	0	3	2	1	1	2	2	2	2	0	4
Laughing Jacobs Ck.	8	4	4	4	4	2	3	4	2	2	1	0	0	0	0	4	4	4	3	3	3	2	2	2	4
Fifteenmile Ck.	8	3	3	3	3	3	2	4	2	2	0	4	4	0	0	4	4	4	1	3	4	4	2	1	4
May Ck. (Lake Washington)	8	2	2	2	2	2	2	2	0	0	0	0	0	0	0	4	4	4	1	3	4	3	1	3	4
Stensland Ck.	8	2	2	2	2	2	2	4	3	2	2	0	0	0	0	4	4	4	2	3	3	3	2	3	3
Rock Ck. Trib (Covington)	9	2	2	2	2	2	2	2	2	1	0	3	4	2	4	3	3	3	1	2	3	2	2	2	4
O'Grady Ck.	9	2	1	3	2	2	3	4	3	3	3	0	0	0	0	2	2	2	2	3	3	3	0	3	2

		In-stream Actions					Riparian Actions		Agricultural BMPs			Forest Management BMPs			Mining BMPs	Stormwater BMPs				Other Approaches and Actions					
Stream	**WRIA**	add large wood	add coarse substrate	enhance sinuosity	replace culverts	stabilize stream banks	stabilize slopes	plant vegetation, extend buffer	exclude livestock	manage livestock waste	prevent soil loss	road maintenance	minimize clearcutting	replant	mining BMPs	flow control	treatment	maintain storage and treatment facilities	street sweeping	limit pesticide use	outreach and education campaign	create incentives to follow BMPs	purchase and protect property	seed invertebrates	**Is the basin at risk of further degradation?**
Crisp Ck.	9	4	4	4	4	4	4	4	0	0	0	3	4	1	0	4	4	3	1	3	3	3	4	2	4
Icy Ck.	9	3	0	2	2	1	1	1	0	0	0	0	0	0	0	3	3	3	0	1	1	1	4	2	4
Newaukum Ck. - N Fork	9	4	2	4	2	3	3	3	0	0	0	2	4	4	0	0	0	0	0	2	0	2	2	1	4
Soosette Ck.	9	3	3	3	3	3	4	4	3	3	2	0	0	0	0	3	3	3	3	2	3	3	1	1	1
Christenson Ck.	9	3	3	1	1	1	1	1	2	2	0	0	0	0	0	0	0	0	0	3	3	3	2	4	3
Judd Ck.	9	3	3	2	3	3	2	4	3	2	2	0	0	0	0	4	4	3	1	3	3	3	2	3	2
Tahlequah Ck.	9	3	3	3	2	2	2	1	2	0	0	0	0	0	0	3	3	2	2	2	2	2	2	4	4
Fisher Ck. (Vashon)	9	4	4	3	2	3	3	3	4	3	3	0	0	0	0	2	2	2	1	2	3	3	2	4	4
Spiketon Ck.	10	2	2	2	2	2	2	3	3	3	2	2	4	2	0	4	4	4	1	3	3	3	2	3	4
Green Cove Ck.	13	2	2	2	2	2	2	3	2	2	0	0	0	0	0	4	4	4	2	3	3	3	2	3	4
Indian Ck. (Lower Deschutes)	13	3	3	3	3	3	3	4	0	0	0	0	0	0	0	4	4	4	4	3	3	3	2	1	4
Mission Ck.	13	2	2	2	3	2	2	3	0	0	0	0	0	0	0	4	4	4	4	2	2	2	1	3	4
Artondale Ck.	15	2	2	2	2	2	2	3	1	1	0	0	0	0	0	4	4	4	2	3	3	3	2	3	4
Carpenter Ck. (Kitsap)	15	2	2	2	3	2	2	4	4	4	4	0	0	0	0	4	4	3	2	2	3	4	2	3	4
Boyce Ck.	15	2	2	2	2	2	2	2	0	0	0	0	0	0	0	3	3	2	2	2	2	2	3	1	4
Gamble Ck.	15	2	2	2	2	2	2	4	4	2	2	0	0	0	0	4	4	4	1	3	4	3	2	2	4
Little Anderson Ck.	15	2	2	2	2	2	2	2	1	1	0	0	0	0	2	4	4	4	3	3	4	3	4	3	4
Little Boston	15	2	2	2	2	2	2	2	0	0	0	2	4	2	0	1	1	1	1	2	2	2	1	3	2
Seabeck Ck.	15	2	2	1	2	2	2	2	0	0	0	0	0	0	0	3	3	3	2	2	2	2	2	3	4
Stavis Ck.	15	3	2	1	1	1	1	1	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	4
Ray Nash Ck.	15	2	2	2	2	2	2	4	2	2	1	0	0	0	0	4	4	4	1	3	3	2	3	3	4
Purdy Ck. (Burley Lagoon)	15	2	2	2	2	2	2	2	4	4	4	0	0	0	0	3	3	1	0	3	3	2	2	3	4
Herron Ck.	15	2	2	2	2	2	1	1	0	0	0	0	0	0	0	4	4	3	1	2	3	3	2	3	4
Barker Ck.	15	3	3	2	3	2	3	4	0	0	0	0	0	0	0	4	4	4	3	2	3	3	2	3	4
Mosher Ck.	15	2	2	2	2	2	2	4	1	1	1	0	0	0	0	4	4	4	1	2	2	2	2	3	4
Parish Ck.	15	3	3	3	3	3	3	3	2	2	0	0	0	0	0	4	4	2	1	2	3	3	3	2	4
Anderson Ck. (Kitsap)	15	2	2	2	2	2	2	3	0	0	0	0	0	0	0	4	4	4	3	3	3	3	2	2	4
Big Scandia Ck.	15	2	2	2	2	2	2	3	4	4	3	0	0	0	0	3	3	3	2	3	4	3	2	3	4
Jump Off Ck.	15	3	3	2	3	2	2	4	0	0	0	0	0	0	0	4	4	4	3	2	3	3	2	4	3
Bagley Ck.	18	4	2	2	2	2	1	2	0	0	0	2	4	3	0	3	3	4	2	2	3	3	2	3	2