Toward a Natural Resources Asset Management Plan for Kitsap County
Workshop Agenda

Date: September 20, 2021, 1:00-3:30 pm PT
Goals: Share and discuss the final level of services (LOS) for shoreline, riparian and forest assets. Discuss project next steps, including concepts for assessing desired LOS and implementation of the asset management system.

1:00 PM	**Welcome and Introductions –** Dana Stefan and Elizabeth McManus and (Ross Strategic, Facilitators)

1:10 PM	**Final Level of Service Assessment-** Ryan Huffman (Kitsap County) Charlotte Dohrn (WEC), Matthew Medina (Kitsap County),
	• Provide an overview of changes and updated results of evaluating levels of service for shoreline, stream, and forest natural assets.
	    ○ Management unit overview and Q&A
	    ○ Level of service assessment overview and Q&A
	• Share feedback on approach and identify any remaining necessary and "wish list" revisions
	    ○ Initial reactions and comments on final assessment?
	    ○ Does the current approach align with project goals and meet core team's expectations?
	    ○ What are the necessary items to start with vs what are the nice-to-have items that may be incorporated at a later stage or may need further exploration?
	
	Materials:
	• *Summary document on development of levels of services for all assets*
	• *Web map with levels of services for all assets*

2:15 PM	**Break**
2:30 PM	**Updates from partners** - Paul McCollum (Port Gamble S'Klallam Tribe), Sam Phillips (Port Gamble S'Klallam Tribe), Tom Ostrom (Suquamish Tribe), Kitsap County • Updates from Port Gamble S'Klallam Tribe • Updates from Suquamish Tribe • Updates from Kitsap County (WSPER presentation, Kitsap Commissioner Work-study Presentation)
2:45 PM	**Discussion on next steps for development and ongoing implementation of the natural resource asset management program -** Core Team • Discussion questions TBD • Setting desired levels of services: what sources of information should we consider to ensure we set feasible desired levels of services and in line with the Kitsap County's overall direction? • How can we lay groundwork now for ongoing implementation of KNRAMP beyond the grant term? • Is there interest/need for public and stakeholder engagement?

	Materials: • *Possible summary document on desired level of service options and implementation strategies*
3:20 PM	**Wrap-up and Next Steps**
3:30 PM	**Adjourn**

Possible discussion topics/questions for second conversation (prioritizing effort through the end of the year):

- Defining desired level of service
    - What information should we gather and what process should we use to set desired level of service?
        - Core team internal process
        - Broader partner and stakeholder input (ex. Larger stakeholder group, LIOs, Collaboration w/ universities)
        - Draw from existing plans/frameworks (e.g., PSP, Steelhead Recovery Plan, other?)
        - Public input
    - Additional questions/examples of decisions to make:
        - What scale makes the most sense for setting desired level of service? Management unit, watershed, urban units and rural units, larger regions (e.g., North Kitsap)?
        - Should we define desired level of service generally, or should it involve setting targets for specific attributes? For example, “high” LOS for unurbanized stream units, vs. a specific % forest cover target or goal to increase forest cover.
        - Do we need a future scenarios analysis in order to determine DLOS? Is there past projects that could supplement that work?
        - Do DLOS also focus on human wellbeing measures (physical health, social wellbeing, cultural wellbeing, governance, economic wellbeing, etc.)?
- How can we lay groundwork now for ongoing implementation of KNRAMP beyond the grant term?
    - What guidance, documentation, etc. can we develop that will support the ongoing implementation and use of KNRAMP and integration into existing county processes?
    - How can we collaborate with other entities that are currently or will be working on setting ecosystem targets for Kitsap County?
- WEC’s work includes public and stakeholder engagement. Is there core team interest and support for any of the following this fall:
    - Reconvening the larger stakeholder group from initial scoping interviews and early workshops to vet LOS assessment, discuss DLOS targets, and/or identify programmatic and policy interventions?
    - Convening focus groups with specific community members to gather insights about public perceptions of ecosystem services and environmental priorities?
    - Testing a survey of some kind?
    - More specific collaboration with resource managers, leadership, and/or members of both Tribes?
    - Etc.?

Kitsap Natural Resource Asset Management Program

Level of Service Assessment Summary

I. Overview

A. Background

The Kitsap Natural Resource Asset Management (KNRAM) Program is a new approach for managing natural resources in the county. The goal of the program is to develop and implement a framework that centers ecosystem services; enables the county to monitor the condition of streams, forests, and shorelines; and guides decision-making. Ecosystem services – or the benefits that nature provides – are at the core of the natural resource asset management program. Across the Puget Sound basin, declining ecosystem health outpaces efforts to recover and protect natural resources like salmon and the habitat that supports them. Kitsap County and other local governments need systems for proactive, forward-looking management of natural resource assets and the benefits they provide.

The KNRAM system uses a 'level of service' framework to incorporate ecosystem services into decision-making. For example, just as a road could have a high or low service rating, a stream that is clean and providing quality habitat for fish is providing a higher level of service than a stream that is contaminated or degraded. Natural resource asset management provides a useful framework for assessing current conditions, setting targets, and tracking progress. This document summarizes the approach to-date for assessing the level of service of shoreline, stream, and forest natural assets.

B. Approach and Framework

Figure 1 below outlines the structural model of the KNRAM system, illustrating how natural assets, ecosystem services, attribute data, and condition ratings are linked to provide information about current condition and levels of service for natural assets in the county. In addition to the terms defined in Figure 1, key definitions are listed below.

- **Level of service (LOS):** A ranked metric that provides information about the condition of a natural asset and the ecosystem services the asset provides. LOS metrics are defined by an index of attribute condition ratings. The concept of levels of service is adapted from asset management approaches often used to manage capital facilities.
- **Desired LOS:** A goal for the future level of service for a natural asset level.
- **Management units (MUs):** The spatial foundation of the KNRAM system that provides the spatial container for analysis and results.

The following steps summarize the approach that the Core Team has taken to assess LOS for natural resource assets in Kitsap County.

- **Identify natural assets:** The Core Team identified shorelines, streams, forests as the three natural asset types that KNRAMP would initially focus on; the system could be expanded at a later date to include wetlands, open space, groundwater, or other natural systems.
- **Identify ecosystem services:** For each natural asset type, the Core Team and a wider group of partners discussed and identified important ecosystem services or benefits that assets provide. The Core Team held a workshop in June 2020 to discuss priority ecosystem services. The current

iteration of the KNRAM system focuses on a subset of ecosystem services. Ecosystem services provide the overarching framing for the LOS assessment, noting that relationships between asset condition and service delivery are generalized, some services are more directly addressed by the system than others.

- **Identify and prioritize attributes and indicators:** The Core Team then identified many possible attributes of natural assets that may be drivers of attribute condition or characterize condition. Potential attributes were assessed for their relevance, applicability, and data availability to prioritize a short list of potential attributes and associated indicators.
- **Compile attribute data**: We identified spatial data for each attribute, drawing from higher resolution sources whenever possible, and focusing on data that is routinely updated to allow for tracking of asset conditions.
- **Develop management units:** We drew from existing data (e.g., drift cell delineations, catchment delineations) with modifications to establish the spatial framework for shoreline, stream, and forest assets.
- **Assess asset condition:** For each attribute, we developed and applied a condition rating scale to standardize assessment of asset conditions at the management unit scale.
- **Calculate overall level of service**: We then aggregated condition ratings at the management unit scale using a simple index of condition ratings (average condition rating). The LOS metric provides a snapshot of the current level of service – based on included attributes – of shoreline, stream, and forest assets across the landscape.

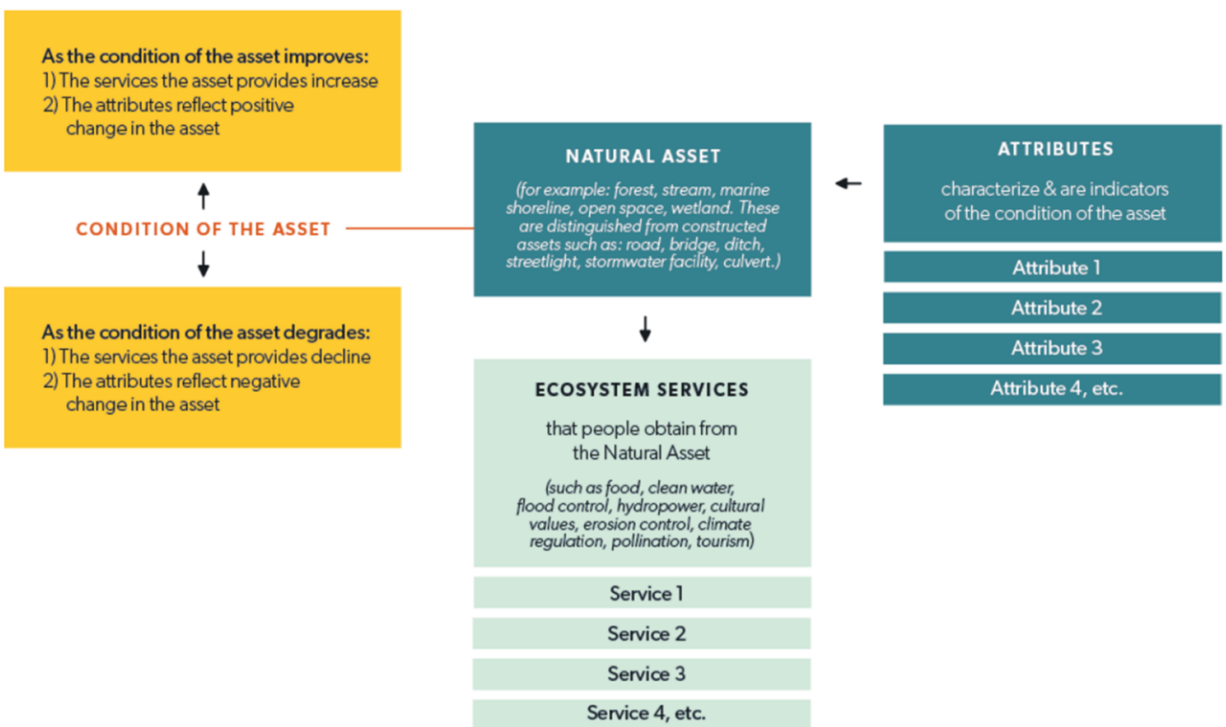


Figure 1. Structural model of the KNRAM system, showing the relationships between system elements and how asset condition provides information about the level of service an asset is providing.

II. Marine Shorelines

A. Asset Inventory

Kitsap County has about 254 miles of marine shoreline. The shoreline spans the western central basin of Puget Sound, Hood Canal, and many large and small bays and inlets. Shoretypes present in Kitsap County include feeder bluffs, transport zones, accretion shoreforms, areas of no appreciable drift, and pocket beaches. The condition of nearshore ecosystems in Kitsap County range widely, from relatively unmodified natural shorelines to highly developed urban and industrial areas. Juvenile salmon utilize estuarine and nearshore habitat, shorelines also support forage fish spawning which are the foundation of marine food webs in Puget Sound. Based on analysis conducted in 2017, about 48% of Kitsap County shorelines are armored, including about 40% of feeder bluffs (MacLennan et al. 2017).

B. Shoreline Ecosystem Services

Marine shorelines in Kitsap County provide many benefits, or ecosystem services. Participants in a June 2020 workshop agreed on the high importance of several shoreline ecosystem services, described below. The KNRAM system tracks attributes that are directly and indirectly linked to these services. Participants also discussed many other important ecosystem services of shorelines.

- **Forage fish**: Forage fish support the marine food web, including salmon, may be important for cultural harvest.
- **Habitat:** marine vegetation, such as eelgrass and kelp, are important nearshore habitat types that support species and ecosystem health.
- **Sediment supply:** Feeder bluffs supply sediment to replenish beaches and maintain habitat quality; shoreline sediment processes are affected by shoreline armor.
- **Shellfish**: The ability/availability to grow and harvest shellfish safely for sustenance, commercial, and cultural use; dependent on adequate water quality.
- **Climate resilience**: Shorelines can be managed to be more resilient to sea level rise and erosion.

C. Level of Service Assessment

1. Management Units

Marine shoreline management units (MUs) are based on recent drift cell delineations from Coastal Geologic's Beach Strategies Project/Nearshore Geospatial Framework. We made some minor modifications to generate marine shoreline MUs for KNRAMP, including splitting some of the longest drift cells at logical breaks to provide more resolution. Marine shoreline MUs include both an onshore and aquatic portion; onshore areas encompass the DNR ShoreZone shoreline to 200m onshore, aquatic subunits extend from the shoreline to 10m depth waterward.

Marine shoreline management unit summary:

- Number of units: 200
- Average length: 1.26 mi.
- Length range: 0.02 mi. to 7.63 mi.
- Average area: 90.52 acres
- Area range: 0.08 acres to 541.16 acres
- Largest unit: Sinclair Inlet (M_176)
- Smallest unit: Battle Point, Bainbridge (M_27)

2. Attributes and Condition Ratings

The KNRAM system uses three primary attributes to assess the condition of marine shoreline natural assets, described in Table 1.

Table 1. The attributes, indicators, and condition rating scales used to assess shoreline condition for each MU.

Attribute	Indicator	Condition Rating				
		0	1	2	3	4
M1. Shoreline armor	% armor in MU	>75%	51-75%	26-50%	1-25%	<1%
M2. Riparian vegetation	% forest cover in MU	<40%	41%-55%	56%-70%	71%-85%	>85%
M3. Water quality	SGA classification status in MU	Prohibited	Prohibited & cond./appr.	Conditional	Conditional & appr.	Approved

M1. Shoreline armor: Armoring has direct and indirect effects on numerous ecosystem functions, goods, and services (Dethier et al. 2017). Shoreline armoring negatively impacts physical processes, causing structural changes that result in functional responses, such as decreased habitat for fish and invertebrates and degraded migratory habitat for salmon (MacLennan et al. 2020). Studies throughout Puget Sound have documented local and landscape-scale impacts of shoreline armoring. Beaches with armor typically become steeper and narrower over time, coarse gravels replace finer sediment, and fewer logs, seagrass, and organic debris are found. At the drift cell scale, impacts of armor are likely cumulative causing beaches to become steeper, narrower, and have courser sediments that are less preferable for forage fish spawning. At a local scale, armored beaches have fewer logs, seagrass, algae, organic debris, and fewer invertebrates. Loss of shallow water habitat disrupts juvenile salmon migration and feeding (Dethier et al. 2016). Feeder bluffs supply sediment to the shoreline in Puget Sound; armoring feeder bluffs leads to habitat loss and degradation (Ramirez 2018). Condition rating is based on the unique value of unarmored shorelines and cumulative impact of armor, without specific thresholds. *Linked ecosystem services*: forage fish, habitat, sediment supply, and climate resilience.

M2. Riparian vegetation: The condition of marine riparian habitat influences important processes including sediment input, bank stability and erosion, shading and temperature regulation, nutrient fluxes, and inputs of terrestrial invertebrates (Hall 2019). Marine riparian buffers play an important role in filtering nonpoint source pollution and protecting water quality (Brennan 2004). Research has shown that juvenile chum and chinook salmon associate with vegetation characteristic of mature forests (e.g., cedar trees, mosses), and other studies have found increased surf smelt egg mortality on unshaded beaches (Pentilla 2001). Historically, mature marine riparian communities were likely evergreen forests, with understory species, and other tree species found in areas of high disturbance or specific local conditions (Brennan 2007). Condition rating is based on a general 40% threshold for forest condition (e.g., Arroyo-Rodriguez et al. 2020, Leahy 2017), with even breaks above this threshold. *Linked ecosystem services:* Forage fish, sediment supply, shellfish.

M3. Water quality: The status of shellfish growing areas provides information about water quality and pollution in the nearshore environment. Fecal coliform is the bacterial indicator used to measure water quality for shellfish growing areas. Fecal coliform must remain below a geometric mean value of 14 colony forming units (CFU) or most probable number (MPN) per 100 mL, and less than 10% of all samples exceed 43 CFU or MPN per 100 mL to meet the water quality standard (WAC, 2021). The DOH conducts regular “sanitary surveys” of the shoreline and nearshore environment, including identifying possible pollution sources, sampling marine waters to determine fecal coliform bacteria levels, and analyzing how tides, currents and precipitation events may affect the distribution of pollutants. Water samples are collected throughout the year and classification status is modified if conditions change. Waters can be classified as prohibited, restricted, conditional, or approved. We adapted the classification status ratings to the MUs by using area weighting if MUs contain polygons with different classifications. Condition rating is based on an existing standard adapted to the KNRAM system and rating scale. *Linked ecosystem services:* Shellfish

3. Level of Service Assessment Results

The overall LOS metric for each marine shoreline MU is calculated by taking the mean of the condition ratings for M1, M2, M3. The maximum possible score is 4, and the minimum possible score is 0. The LOS score reflects the generalized condition of shoreline assets. In this approach, we assume that degraded condition (low scores) corresponds with a low level of service and reduced ecosystem services.

Results map: LOS assessment results for shoreline natural assets can be viewed here.

Table 2. Summary of Marine Shoreline LOS Results

LOS Assessment	# of MUs (200 total)	Location Trends
High (3-4)	27	Hood Canal, Blake Island, scattered other locations
Medium (2-3)	59	North Kitsap, North Bainbridge, scattered other locations
Low (1-2)	46	Port Orchard Pass, Manchester, other scattered locations
Very Low (0-1)	68	Dyes Inlet, Liberty Bay, Sinclair Inlet, Winslow, Kingston

4. Additional Attribute Information

Eelgrass, forage fish, feeder bluffs: The Core Team has identified a number of attributes where information about presence and location is available, but there is not adequate data or it is not straightforward to rate the condition of attributes on a scale as shown in M1-M3. These attributes – eelgrass, forage fish habitat, and unarmored feeder bluffs – are included in the KNRAM system but not represented in the LOS metrics. These attributes provide important ecosystem services where they are present; absences may be “natural” (e.g., unsuitable substrate for eelgrass) or caused by anthropogenic impacts. Bluffs, eelgrass, and forage fish were all identified as valued ecosystem components of the nearshore environment by the Puget Sound Nearshore Ecosystem Restoration Project (PSNERP). Eelgrass beds provide structured habitat, support the food web, and providing nursery grounds and shelter during migration for salmon and other species (Mumford 2007). Feeder bluff erosion is the primary source of sediment for Puget Sound Beaches, creating shallow water habitat utilized by juvenile salmon and other species (Johannessen and MacLennan 2007). Forage fish, including sand lance, surf smelt, and herring are a critical prey species supporting the food web in Puget Sound; forage fish rely on the nearshore to spawn (Penttila 2007).

5. Data Sources

- Coastal Geologic Beach Strategies Phase 2 Analysis, available here.
- WDFW High Resolution Change Detection (HRCD) 2017 tree cover
- Washington Department of Health Shellfish Growing Area Classification Status, available here.

- DNR eelgrass monitoring available here; WDFW forage fish spawning survey data available here; locations of unarmored bluffs from Coastal Geologic, available here.

III. Streams

A. Asset Inventory

Kitsap County has approximately 980 miles of streams. The hydrology of the Kitsap Peninsula is unique compared to other regions in the state - it characterized by primarily small, rainfall-dominated, lowland streams. The Kitsap Peninsula includes over 580 streams that drain into Puget Sound and Hood Canal; most streams on the Kitsap Peninsula have surface drainage areas of less than one square mile, and few exceed 10 square miles (WRIA 15, 2021). Kitsap County contains 17 full and partial sub-watersheds (NHD HUC12 units). The Big Beef Creek sub-watershed contains the most stream miles, while Bainbridge Island contains the least. Streams in Kitsap County support ESA-listed salmonids, other resident fish species, and other wildlife.

B. Stream Ecosystem Services

Participants in a June 2020 workshop agreed on the high importance of several stream ecosystem services, described below. The KNRAM system tracks attributes that are directly and indirectly linked to these services. Hydrologic condition of streams (e.g., groundwater-surface water, flow regulation) are addressed only generally by including riparian forest cover. Participants also discussed many other important ecosystem services of streams, including water supply, recreation, and others.

- **Key species presence and productivity:** the presence and abundance of key species such as salmon for harvest, cultural use, or for prey for species like orcas now and in the future.
- **Connectivity between ground and surface water:** groundwater supports stream baseflows year-round, and aquifer reserves are important to preserve.
- **Flow regulation**: streams transport water, sediment, and large woody debris; healthy riparian areas assimilation of stormwater, wastewater and other water flows and pollutants associated with those.
- **Habitat and other species**: Sediment substrate, large woody debris, cool water are important habitat for salmon; stream and riparian areas support other species including indicators like invertebrates.

C. Level of Service Assessment

1. Management Units

MUs for streams and riparian areas are developed using National Hydrography Data (NHD) flowlines, a riparian buffer, and divided laterally using modified catchment boundaries from the USGS's NHDPlus HR dataset. In the latest guidance regarding riparian management zones (RMZ), the RMZ is defined by the distance of one 200-year Site Potential Tree Height (SPTH), measured from the edge of the channel migration zone (CMZ) or edge of the active channel (Windrope et al., 2020). In Kitsap County, the 200-year SPTH of a Douglas fir ranges from 144 feet – 231 feet. Based on an analysis conducted by WDFW, using Natural Resource Conservation Services and NHD data, the stream length-weighted 200-year SPTH is 204 feet (Windrope et al., 2018). The stream MUs units in the KNRAM system use a standard width of 204 feet, though SPTH varies (link). We used NHD flowlines, which do not include a spatial delineation of the channel migration zone or active channel. The 204-foot buffer that creates the management unit polygon is applied directly from the mapped flowline.

The stream polygons are divided at the boundaries of modified catchments adapted from NHDPlus HR. Using NHDPlus HR has limitations. Other jurisdictions are working on creating HUC 14-16 units using LiDAR based hydrography and stream modification (piping, ditching, etc.) data to delineate accurate unit boundaries. We do not anticipate updates to this dataset from USGS and it will likely become outdated 1-5 years. In addition, the NHDPlus HR data differs from the data currently used in County operations.

Stream management unit summary:

- Number of units: 833
- Mean area: 53 acres
- Area range: 0.10 to 984 acres
- Largest unit: Big Beef Creek (S_33)
- Smallest unit: Shoreline south of Kingston (S_382)

2. Attributes and Condition Ratings

The KNRAM system uses four primary attributes to assess the condition of stream natural assets, described in Table 3.

Table 3. The attributes, indicators, and condition rating scales used to assess stream condition for each MU.

Attribute	Indicator	Condition Rating				
		0	1	2	3	4
S1. Riparian vegetation	% forest cover in MU	<40%	41%-55%	56%-70%	71%-85%	>85%
S2. Biological condition (B-IBI)	Aggregated B-IBI score for stream	≤20	21-40	41-60	61-80	81-100
S3. Water Quality	Performance of stream against bacteria standard	Fails standard	NA	Meets first, fails second	NA	Meets standard
S4. Fish passage	Barrier presence/ absence in MU	NA	Yes	NA	NA	No

S1. Riparian vegetation: Riparian ecosystems are fundamentally important for clean water, salmon populations, and climate resilient watersheds. Riparian forests stabilize stream banks, shade streams and banks, remove pollutants, and contribute nutrients and woody debris. In western Washington, old, structurally complex, conifer-dominant forests are the desired future condition of riparian ecosystems and guidance recommends managers work to protect and restore these conditions (Windrope et al., 2020). An analysis of historical riparian forest condition in the Hood Canal and the Strait of Juan de Fuca found that old, structurally diverse conifer forests characterized stream ravines, and over half of historic conifer sites in bottomlands shifted to other stand compositions over the historical period (Labbe et al., 2013). Loss of forest cover and fragmentation contributes to salmon population decline in the Pacific Northwest (Andrew et al., 2011). Older forests support fish habitat by contributing more woody debris and transpiring less water, which is important where dry season flows are low (Quinn et al., 2020; WRIA 15, 2021). Condition rating is based on a general 40% threshold for forests, with even breaks above this threshold. *Linked ecosystem services:* Key species presence and productivity, habitat and other species, connectivity between ground and surface water, flow regulation

S2. Biological condition (B-IBI): The Benthic Index of Biotic Integrity (B-IBI) is a quantitative method for assessing the biological condition of streams, based on the abundance and type of macroinvertebrate species present at a site. Monitoring B-IBI provides an assessment of stream condition based on the characteristics of biota sampled, which reflect the influence different land uses and activities (e.g., agriculture, urban development, recreation, forestry, etc.) have on a watershed. These activities and disturbances can influence the flow regimes, habitat, chemical introduction, energy cycles, and invasive taxa, and therefore stream health. Low B-IBI scores and degraded salmon habitat may be correlated at the site scale; for example, one study found that Coho and chum salmon did not use stream reaches for spawning with low B-IBI scores (Plotnikoff and Polayes, 1999). The Puget Sound Stream Benthos project which reports B-IBI as an index developed and calibrated for the Puget Sound Lowlands that measures pollution tolerance/intolerance of taxa, taxonomic composition, and population attributes (Puget Sound Stream Benthos, n.d.). We downloaded B-IBI scores since 2015, and averaged and aggregated for each stream system in Kitsap County. Condition rating is from the Puget Sound Stream Benthos. *Linked ecosystem services:* Key species presence and productivity, habitat and other species.

S3. Water quality: E. Coli is an indicator of bacteria that originate from point source (sewer overflows and effluent discharge) and non-point pollutions sources (stormwater runoff). The presence of E. Coli is known to cause illness, therefore monitoring bacteria is essential to mitigate human health risk from recreation swimming, shellfish consumption and drinking water (Kitsap Public Health District, 2015). Stream monitoring is typically conducted at stream mouths to assess cumulative impacts for stream water quality of the basin, with some monitoring occurring above stream mouths to isolate reaches with elevated pollution risk. Monthly monitoring provides continuous long-term water quality results for Kitsap County. Data is gathered from 69 streams across Kitsap County and streams are rated for each water year. Condition rating is adapted to the KNRAM system from KPH's standard. *Linked ecosystem services:* Water supply, recreation

S4. Fish passage: Development can drive hydrologic changes, such as channel morphology, streambed material, nutrients, and stream flow, which effects the habitat suitability for aquatic species. Roads and other forms of development often result in the creation of barriers to fish passage, such as culverts. For example, one of the greatest concerns is the increased stream flow velocity through a culvert and culvert length which contribute to preventing fish from accessing upstream reaches (Thurman and Horner-Devine, 2007). Maintaining habitat connectivity is critical to allow ESA-listed salmon to access reaches that provide spawning and rearing habitat. Among the types of human constructed fish passage barriers identified in Kitsap County are culverts, dams, diversions, and others. Kitsap County has approximately 1,277 fish passage barriers constructed. Condition rating is based on the presence of barriers in the MU. *Linked ecosystem services:* Key species presence and abundance.

3. Level of Service Assessment Results

The methods for calculating LOS metrics for stream MUs are the same as shorelines above.

Results map: LOS assessment results for stream natural assets can be viewed here.

Table 4. Summary of Stream LOS Results

LOS Assessment	# of MUs (833 total)	Location Trends

High (3-4)	411	Away from population centers, scattered
Medium (2-3)	272	Throughout
Low (1-2)	134	Throughout
Very Low (0-1)	16	Dyes Inlet, other scattered locations

4. Additional Attribute Information

Fish presence: The presence and abundance of salmon is a priority ecosystem service in Kitsap County. The current assessment of stream LOS does not capture many site-scale attributes of salmon habitat quality, including spawning gravels, large woody debris, overhanging vegetation, pools, and others. The assessment also does not capture how productive stream systems or segments are in terms of their contributions to salmon abundance. As some additional information for use in applying the KNRAM system, we included fish usage from WDFW's Statewide Integrated Fish Distribution database. Each MU includes a list of species observed to use that unit (e.g., spawning, rearing, presence).

5. Data Sources

- WDFW High Resolution Change Detection (HRCD) 2017 tree cover
- Puget Sound Stream Benthos, 2015-present
- Kitsap Public Health 2020 monitoring data
- WDFW Fish Passage database

IV. Forests

A. Asset Inventory

Kitsap County is approximately 400 square miles, of which 40% is classified as forested (NLCD 2019). The Kitsap Peninsula is located in the Puget Trough ecoregion, which was historically dominated by extensive conifer forests. Much of this region is classified as the Western Hemlock Zone vegetation zone. Prior to industrial logging, forests within the Kitsap Peninsula were typical of Pacific Coastal forests, known for supporting massive trees and high productivity. Kitsap County itself owns over 6500 acres of forest land, of which 60% is comprised of forest stands that are dense, second and third growth Douglas fir plantations. Restoration of many areas is needed to improve the ecological condition and ecosystem services. County-owned forest lands are managed under the county's Integrated Forest Stewardship Policy, which describes desired future conditions that protect water resources, provide connected wildlife habitat, protect endangered species and habitat, demonstrate a diversity of age, densities, and ecotypes, enhance recreational opportunities, and other objectives (Kitsap County 2012). In addition to county-owned forest lands, forestlands on the Kitsap Peninsula are owned by small forest landowners, private/Tribal industrial owners, Washington Department of Natural Resources (DNR), other state agencies, the US federal government, local government, and private conservation entities – all of which contribute to the provisioning of forest ecosystem services in the County. Kitsap County has a policy of managing forests at a landscape scale, including partnering with other landowners to achieve forest stewardship goals (Kitsap County 2012).

B. Forest Ecosystem Services

Participants in a June 2020 workshop agreed on the high importance of several forest ecosystem service categories, described below. The KNRAM system tracks attributes that are directly and indirectly linked to these services. Participants also discussed many other important ecosystem services of streams.

- **Wildlife habitat**: Contiguous habitat for animals to live and migrate.

- **Water regulation:** Forests support infiltration for ground water supplies and base flows for salmon and other species, retain water on the landscape to protect landscapes and people from flooding, and collecting and filtering rainfall to release it slowly into streams and rivers so streams are clean and safe.
- **Climate resilience**: Forests store and sequestering carbon and provide habitat to support species as they adapt to climate change.

C. Level of Service Assessment

1. Management Units

MUs for upland forests are modified catchments from USGS's NHDPlus HR dataset (see above).

Upland forest management unit summary:

- Number of units: 1234
- Mean area: 212 acres
- Area range: 0.10 to 5463 acres
- Largest unit: Big Beef Creek watershed (F_398)
- Smallest unit: Shoreline south of Kingston (F_811)

2. Attributes and Condition Ratings

The KNRAM system uses two primary attributes to assess the condition of forest natural assets, described in Table 5.

Table 5. The attributes, indicators, and condition rating scales used to assess forest condition for each MU.

Attribute	Indicator	Condition Rating				
		0	1	2	3	4
F1. Forest cover	% forest cover in MU	<40%	41%-55%	56%-70%	71%-85%	>85%
F2. Succession class	% late succession in MU	<1%	1-25%	26-50%	51-75%	>75%

F1. Forest cover: Healthy forests support clean air, clean water, climate resilience, and healthy habitat for salmon, birds, large mammals, and other animals. Temperate forests, like those in Kitsap County, provide habitat for many "species of greatest conservation need" (SGCN) in Washington (SWAP 2015). Forests play a critical role in the water cycle by capturing, storing, and transferring water, regulating flow and discharge and supporting infiltration (Smith 2011). Forests support climate resilience by providing shade and lowering temperature and capturing and storing carbon. Harvest, clearing for development, roads, and other land use types have reduced the extent and changed the composition of forests in Kitsap County. Intact and undisturbed forest are critical to support salmon habitat; research has linked loss of forest cover and fragmentation to salmon population decline in the Pacific Northwest (Andrew et al., 2011). Attribute F1 uses percent forest cover in the management unit as an indicator to provide basic information about how forested an area is. Using a measure such as percent canopy cover does not provide information about habitat connectivity, forest structure/composition, or forest condition, which influence the ecosystem service provisioning. However, tracking percent forest cover helps assess generally if some forest ecosystem services are being provided or not, and also track forest conversion and restoration activities. Condition rating is based on a general 40% threshold for forests, with even breaks above this threshold. *Linked ecosystem services:* wildlife habitat, water regulation, climate resilience.

F2. Succession class: Late successional forests are characterized by higher biodiversity and complexity and provide important habitat for species dependent on these structures. Succession class data characterizes current vegetation conditions with respect to the vegetation species composition, cover, and height ranges of the successional states that are expected occur in the region. Mid-aged, high-density forests are overrepresented in western Washington relative to historical conditions. Late successional stage, older forests generally have higher biodiversity which supports diverse ecosystem services, compared to younger, more homogenous forests (DellaSalla 2015). Older, structurally complex forests provide unique habitat for birds and other wildlife. Older forests in some cases use less water than younger forest stands (Moore 2004), which may help protect in-stream flows, particularly as climate change accelerates. Older, larger trees may be more resilient to climate driven disturbance, including drought and fire. The data used to assess F2 comes from the USGS LANDFIRE project, which has developed extensive models of the biophysical setting of North American forests, which allow them to assess succession class in the context of that biophysical setting. The condition rating applied here uses the percentage of late development forests in the management unit. For the biophysical setting most common on the Kitsap Peninsula, class "E" are areas where the model predicts mature, old-growth forest stands dominated by large individuals of Douglas-fir and western hemlock, with advanced regeneration of western hemlock, and understories of shrubs including salal and others (USGS, n.d.). Condition rating scale includes a category for units with no late stage forest, with even breaks inferring increasing benefits as late succession forest percent increases: *Linked ecosystem services:* wildlife habitat, water regulation, climate resilience.

3. Level of Service Assessment Results

The methods for calculating LOS metrics for stream MUs are the same as streams and shorelines above.

Results map: LOS assessment results for stream natural assets can be viewed here.

Table 6. Summary of Stream LOS Results

LOS Assessment	# of MUs (1234)	Location Trends
High (3-4)	34	South Kitsap, Hood Canal shoreline, scattered other locations
Medium (2-3)	225	Throughout
Low (1-2)	505	Throughout
Very Low (0-1)	470	Concentrated in more urban areas, some shoreline areas

4. Additional Attribute Information

Pest and disease, urbanization: In addition to the attributes described above, we have included pest and disease occurrence and percent urbanized for each management unit. Pest and disease occurrence is available from aerial surveys and may be useful in assessing drivers of cover decline and determining management interventions. Disturbance, including pest and disease, is a natural process; therefore it is difficult to determine if pest and disease observations are symptoms of declining forest health or within the range of normal disturbance. Level of urbanization may be a useful attribute for planning processes, as urban areas may have different LOS targets for forests than rural and wilderness areas.

5. Data Sources

- WDFW High Resolution Change Detection (HRCD) 2017 tree cover

- [USGS LANDFIRE 2016]
- [DNR/Forest Service Forest Health Aerial Survey Data]

VI. References

Andrew, M.E. and Wulder, M.A. 2011. Idiosyncratic responses of Pacific salmon species to land cover, fragmentation, and scale, Ecography, 34: 780-797., 2011

Leahy, I. 2017. Why We No Longer Recommend a 40 Percent Urban Tree Canopy Goal. Accessed from: https://www.americanforests.org/blog/no-longer-recommend-40-percent-urban-tree-canopy-goal/

Arroyo-Rodriguez, V. et al. 2020. Designing optimal human-modified landscapes for forest biodiversity conservation. Ecology Letters, 23: 1404-1420. Doi: 10.1111/ele.13535

Brennan, J.S. 2007. Marine Riparian Vegetation Communities of Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-02. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington. https://wdfw.wa.gov/sites/default/files/publications/02192/wdfw02192.pdf

Brennan, J.S., Culverwell, H. (2004). Marine Riparian: An Assessment of Riparian Functions in Marine Ecosystems. Washington Sea Grant Program Copyright 2005, UW Board of Regents Seattle, WA. Retrieved from: here.

Dethier, M.N., J. D. Toft, and H. Shipman. (2017). Shoreline Armoring in an Inland Sea: Science-Based Recommendations for Policy Implementation. Conserv. Let. 10:626-633.

Dethier, M.N., Raymond, W. W., McBride, A., Toft, J. D., Cordell, J., Ogston, A., Heerhartz, S. M., Berry, H. (2016). Mulitscale impacts of armoring on Salish Sea shorelines: evidence for threshold and cumulative effects. Estuarine, Coastal and Shelf Science, 175. DOI: 10.1016/j.ecss.2016.03.033

Hall, J., Ross, K., Arterburn, D., Krall, M., Roni, P. (2019). Draft Appendix E: Protocol Recommendations for Evaluating Marine Riparian Habitat in Puget Sound, A Protocol For Reporting Marine Riparian Common Indicators. Report prepared for The Puget Sound Partnership, Tacoma.

Johannessen, J. and A. MacLennan. 2007. Beaches and Bluffs of Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-04. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington. https://wdfw.wa.gov/sites/default/files/publications/02216/wdfw02216.pdf

Kitsap Public Health District. 2015. Water Quality Monitoring Plan Streams, Lakes and Marine Waters. Kitsap Public Health District Water Pollution Identification & Correction Program.

Labbe, T., Adams, A., and Conrad, R. 2013. Historical Condition and Change in Riparian Vegetation, Hood Canal and Eastern Strait of Juan de Fuca, Washington. Northwest Science, Vol. 87, No. 1.

MacLennan, A., Coastal Geologic Services. (2020). Beach Strategies for Puget Sound, Phase 2 Summary Report. Prepared for the Estuary and Salmon Restoration Program of the Washington Department of Fish and Wildlife. Bellingham, Washington. 79 pp. Retrieved from: https://salishsearestoration.org/images/7/71/CGS_ESRP_BeachStrategies_Phase2Report_Sept2020_revised.pdf

MacLennan, A., Rishel, B., Johannessen, J., Lubeck, A., Øde, L. (2017). Beach Strategies Phase 1 Summary Report Identifying Target Beaches to Restore and Protect Estray and Salmon Restoration Program Learning Project#14-2308. Coastal Geologic Services, Inc. Prepared for Washington Department of Fish

and Wildlife. Retrieved from:
https://coastalgeo.com/publications/cgs_esrp_beachstrategies_summaryreport_20171025-1/

Morley, S.A. and J.R. Karr. 2002. Assessing and Restoring the Health of Urban Streams in the Puget Sound Basin. Conservation Biology. Abstract here:
https://conbio.onlinelibrary.wiley.com/doi/abs/10.1046/j.1523-1739.2002.01067.x

Mumford, T.F. 2007. Kelp and Eelgrass in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-05. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.
https://wdfw.wa.gov/sites/default/files/publications/02195/wdfw02195.pdf

NOAA, n.d. How to Use Land Cover Data as an Indicator of Water Quality: Description of Data and Derivatives Used. Coastal Change Analysis Program. Available here:
https://coast.noaa.gov/data/digitalcoast/pdf/water-quality-indicator.pdf#page=4

Northwest Indian Fisheries Commission (NWIFC). 2020. 2020 Puget Sound Regional Report. Available here: https://nwifc.org/publications/state-of-our-watersheds/

Penttila, D. 2007. Marine Forage Fishes in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-03. Published by Seattle District, U.W. Army Corps of Engineers, Seattle, Washington.
https://wdfw.wa.gov/sites/default/files/publications/02193/wdfw02193.pdf

Penttila, Dan. 2001. Effects of Shading Upland Vegetation on Egg Survival for Summer-spawning Surf Smelt on Upper Intertidal Beaches in Puget Sound. Washington Department of Fish and Wildlife.

Plotnikoff, R. and J. Polayes. 1999. The Relationship Between Stream Macroinvertebrates and Salmon in the Quilceda/Allen Drainage. Washington Department of Ecology. Available here:
https://apps.ecology.wa.gov/publications/documents/99311.pdf

Puget Sound Stream Benthos. N.d. About the Benthic Index of Biotic Integrity. Available here:
https://pugetsoundstreambenthos.org/About-BIBI.aspx

Quinn, T., G.F. Wilhere, and K.L. Krueger, technical editors. 2020. Riparian Ecosystems, Volume 1: Science Synthesis and Management Implications. Habitat Program, Washington Department of Fish and Wildlife, Olympia. Available here:
https://wdfw.wa.gov/sites/default/files/publications/01987/wdfw01987.pdf

Ramirez, M. (2018). Shoreline Armoring in Puget Sound Reporting on the Chinook Salmon Recovery Common Indicators. Puget Sound Partnership. Retrieved from:
https://pspwa.app.box.com/s/ufkel8ymfjwn1ikk0uhvbg01zbkihkr7

Schueler, T. et al. 2009. Is Impervious Cover Still Important? Review of Recent Research. Journal of Hydrologic Engineering. Vol. 14: 4. Abstract here:
https://ascelibrary.org/doi/pdf/10.1061/%28ASCE%291084-0699%282009%2914%3A4%28309%29

Thurman, D.R., Horner-Devine, A.R., 2007. Hydrodynamic Regimes and Structures in Sloped Weird Baffled Culverts and Their Influence on Juvenile Salmon Passage. Available here:
https://www.wsdot.wa.gov/research/reports/fullreports/687.1.pdf

Washington State Legistlature. (2021). Washington Administrative Code (WAC) Title 173 Department of Ecology Chapter: 173,201A, Section 210. WAC 173-201A-210:

Washington. Retrieved from: https://pspwa.app.box.com/s/xlhyteow83ftv10a06h1zaezel0o7s4m

Windrope. A., Quinn, T., Folkerts, K., Rentz, T. 2018. Riparian Ecosystems, Volume 2: Management Recommendations – Public Review Draft. A Priority Habitat and Species Document of the Washington Department of Fish and Wildlife. Available here: http://www.seattle.gov/light/skagit/Relicensing/cs/groups/secure/@scl.skagit.team/documents/document/cm9k/ntcx/~edisp/prod571195.pdf

Windrope. A., Quinn, T., Folkerts, K., Rentz, T. 2020. Riparian Ecosystems, Volume 2: Management Recommendations. A Priority Habitat and Species Document of the Washington Department of Fish and Wildlife. Available here: https://wdfw.wa.gov/sites/default/files/publications/01988/wdfw01988.pdf

WRIA 15. 2021. Watershed Restoration and Enhancement Draft Plan. Department of Ecology. Available here: https://www.ezview.wa.gov/Portals/_1962/images/WREC/WRIA15/Final%20Plan/WRIA15FinalDraftREVISED1Mar2021.pdf

Marine Shorelines Workshop: Definitions of Attributes

The table below provides detailed information of the attributes that are found in the KNRAMP – Prelimary Shoreline Level of Service Results.

Attribute Name	Alias	Description
DCName	Drift Cell Name	Drift Cells located in Kitsap County
DCType	Drift Cell Type	Types include left-to-right, right-to-left, and no appreciable drift (NAD)
ArmrPct	% Drift Cell Armored	Calculated by Coastal Geologic; the percentage of the drift cell that is armored
SdSrcAP	% Sediment Source Armored of Drift Cell	Calculated by Coastal Geologic; the percentage of feeder bluffs in the drift cell that are armored
M1_CR	Marine Attribute 1 (M1) Condition Rating	Condition rating is based on the percent of shoreline armor in the drift cell, and assigned as outlined in the Shoreline LOS Concepts document.
Perc_For	% Forest Cover	The percentage of 30m cells within the onshore drift cell that are classified as deciduous, evergreen, or mixed forest types
M2_CR	Marine Attribute 2 (M2) Condition Rating	Condition rating is based on the percent forested cover, and assigned as outlined in the Shoreline LOS Concepts document.
AreaID_Acr	Shellfish Growing Area Sub-Area ID	Unique record ID for each DOH Shellfish Commercial Growing Area ID sub-area
CLASS	Conditional Class for Shellfish Growing Area	DOH Shellfish Growing Area Classification Status, assessed at the drift cell scale

M3_CR	Marine Attribute 3 (M3) Condition Rating	Condition rating is based on the classification status. Method for calculating condition rating is outlined in the Shoreline LOS Concepts document.
fb_pres	Unarmored Feeder Bluff Presence	
lnc_prs	Sand Lance Presence	
smlt_prs	Smelt Presence	
hrrng_p	Herring Presence	
elgrss_	Eelgrass Presence	
sum_prs	Sum of Presence Attributes	(lnc_prs + smlt_prs + hrrng_p + elgrss_)
LOS_cond	Level of Service of M1-M3	LOS Method 1 Arithmetic Mean: (M1_CR +M2_CR +M3_CR)/3 LOS Method 2 - Geometric Mean: $((M1\_CR*M2\_CR*M3\_CR)^{(1/3)}$
LOS_all	Combined Level of Service Score	(LOS_cond + sum_prs)

LOS	Level of Service	Qualitative description of the LOS, categorized as described in the Shoreline LOS Concepts document.

Stream & Riparian Workshop: Level of Service Concepts

This document summarizes the preliminary approach for assessing baseline level of service (LOS) for streams and riparian areas in Kitsap County.

Level of service definition: A ranked metric usually used for capital facilities to define the kind and level of service that is required for meeting the needs of residents at current and projected demand. LOS metrics can guide Kitsap County's investments in activities, such as restoration, monitoring, and maintenance of natural assets.

The sections below include an overview of riparian management units, a description of each attribute that is currently included in assessing LOS, and a description of how attribute condition ratings are combined to calculate an overall LOS for each management unit. The approach described here is a starting point, we expect to revise many aspects of these methods based on feedback during the workshop and future updates.

Kitsap County Streams and Riparian Management Units

Kitsap County has approximately 980 miles of streams. The hydrology of the Kitsap Peninsula is unique compared to other regions in the state - it characterized by primarily small, rainfall-dominated, lowland streams. The Kitsap Peninsula includes over 580 streams that drain into Puget Sound and Hood Canal; most streams on the Kitsap Peninsula have surface drainage areas of less than one square mile, and few exceed 10 square miles (WRIA 15, 2021). Kitsap County contains 17 full and partial sub-watersheds (NHD HUC12 units). The table below shows the approximate number of stream miles within each sub-watershed; note that all 10 sub-watersheds that are only partially contained within Kitsap County are grouped together. The Big Beef Creek sub-watershed contains the most stream miles, while Bainbridge Island contains the least.

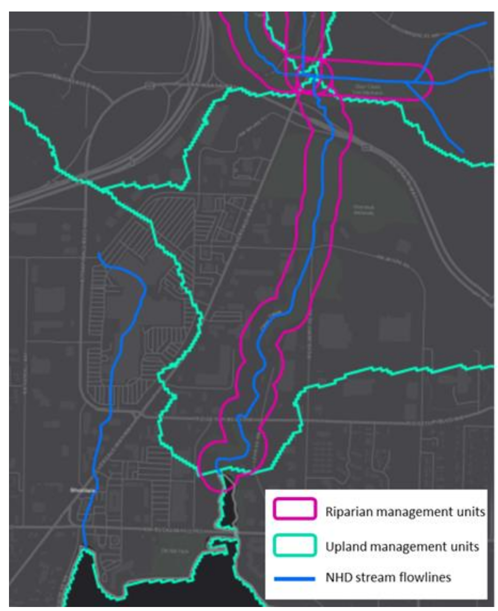
Sub-watershed (NHD HUC12)	Stream miles - perennial	Stream miles - intermittent	Stream miles - total
1. Big Valley-Puget Sound	42	88	130
2. Port Gamble-Hood Canal	30	81	111
3. Bainbridge Island	8	35	43
4. Barker Creek-Dyes Inlet	27	52	79
5. Chico Creek-Sinclair Inlet	19	33	52
6. Blackjack Creek-Port Orchard	42	52	94
7. Big Beef Creek-Hood Canal	78	72	150
Additional sub-watersheds partially within Kitsap County (n=10)	126	190	316

Management units are the spatial foundation of the asset management system and provide the spatial "container" for analysis and results. We developed temporary management unit polygons for streams and riparian areas using National Hydrography Data (NHD) flowlines and a riparian buffer (Figure 1 below). In the latest guidance regarding riparian management zones (RMZ), the RMZ is defined by the distance of one 200-year Site Potential Tree Height (SPTH), measured from the edge of the channel migration zone (CMZ) or edge of the active channel (Windrope et al., 2020). In Kitsap County, the 200 year SPTH of a Douglas fir ranges from 144 feet – 231 feet. Based on an analysis conducted by WDFW, using Natural Resource Conservation Services and NHD data, the stream length-weighted 200 year SPTH is 204 feet (Windrope et al., 2018). The temporary management units we used in assessing LOS for stream and riparian areas in Kitsap County currently use the standard width of 204 feet, though this could be updated to reflect the variable widths in WDFW's SPTH Map Tool (link).

The hydrography data we used is represented as a single flowline, and does not include a spatial delineation of the channel migration zone or active channel. The 204-foot buffer that creates the management unit polygon is applied directly from the mapped flowline. Further processing of county wide LiDAR data or visible surface water data available from WDFW could provide a mapped layer of channel migration zones or active channels. Management unit polygons are divided laterally at the boundaries of catchments or catchment groups (Figure 1). Some of the preliminary management units include several smaller branching tributaries that fall within the same catchment group.

For simplicity in this preliminary analysis, we generated management units only for the larger tributaries and the main stem of streams (stream order 2 and above). We will need to decide if we want to include management units for all streams, only perennial streams, larger order streams, or use other criteria. Additionally, due to the riparian buffering technique, management units currently overlap. Some riparian management units extend slightly beyond the boundaries of Kitsap County; we will need to decide to keep stream and catchment segments intact, or cut at the county boundary.

Using the NHD High Resolution Plus(NHDHR Plus), developed by USGS, does have limitations. Other jurisdictions are working on creating HUC 14-16 units using LiDAR based hydrography and stream modification (piping, ditching, etc.) data to delineate accurate unit boundaries.



- Not expecting updates from USGS and likely to become outdated 1-5 years
- This data differs from the data currently used in County operations
-

Temporary riparian management units:

- Number of units: 598
- Estimated Average length: 0.624 mi.
- Length range: 0.001 mi. to 3.228 mi.
- Mean area: 0.054 sq. mi.
- Area range: 0.005 sq. mi. to 0.243 sq. Mi.

Figure 1 (right). Temporary riparian management units shown in pink, with the full hydrography shown in blue. The green upland units are used to break the riparian units laterally. Note the overlapping buffers in this version where tributaries join the main stem.

Attributes Included in Stream and Riparian Level of Service Analysis

The analysis of riparian LOS uses five attributes to provide information about the condition of streams and riparian areas and the ecosystem services they provided. This is slightly different from the list discussed during the March 2021 workshop. The following sections include a brief overview of the science, ecosystem services linked to the attribute, condition ratings, and considerations for each attribute. The five stream and riparian attributes included in this analysis are:

- S1: Riparian vegetation
- S2: Imperviousness
- S3: Biological condition
- S4: Water quality
- S5: Fish passage

S1. Riparian vegetation

Indicator: % forest cover and tree height in the riparian management unit

Proposed condition rating:

Condition rating	0	1	2	3	4
% forest cover & tree height	<30%	30% -59%	60%-89%	≥90%	≥90% and average height >100ft
Description	Low forest cover	Low-moderate forest cover	Moderate-high forest cover	High forest cover	High forest cover, mature forest

Science summary: Healthy riparian ecosystems are fundamentally important for clean water, healthy salmon populations, and climate resilient watersheds. Fully functioning riparian ecosystems stabilize stream banks, shade streams and banks, remove pollutants, and contribute nutrients and woody debris. Loss of forest cover and fragmentation contributes to salmon population decline in the Pacific Northwest (Andrew et al., 2011). In western Washington, old, structurally complex, conifer-dominant forests are the desired future condition of riparian ecosystems and the latest guidance recommends managers work to protect and restore these conditions (Windrope et al., 2020). An analysis of historical riparian forest condition in the Hood Canal and Eastern Strait of Juan de Fuca areas, found that old, structurally diverse conifer forests characterized stream ravines, and over half of historic conifer sites in bottomlands shifted to other stand compositions over the historical period (Labbe et al., 2013). Older forests with larger trees provide more large wood to streams than smaller trees, which creates fish habitat (Quinn et al., 2020). Older forests transpire less water than young, rapidly growing stands; maintaining older forests can increase dry-season low flows (WRIA 15, 2021). The proposed condition rating for riparian vegetation includes both a measure of forest cover, as well as the modeled height of the canopy to represent the benefits of older, mature riparian forests.

Linked ecosystem services: Key species presence and productivity, other species, habitat, climate resilience, connectivity, connectivity between ground and surface water, flood regulation

Notes and considerations:

- Alternative condition rating scales could be considered. For example, at the watershed scale, watersheds that are over 65% forested have been found to protect a stream's biological community, and 40% forested is recommended by some as a goal for urban watersheds (NOAA, n.d.).
- Percent cover in the 204-foot riparian buffer is an imperfect estimate of riparian forest condition. Fully forested buffers are important for supporting functional stream and riparian ecosystems, though forests closer to the stream may have more direct impact. For example, a management unit with 60% forest cover that is located continuously along the stream is likely in better condition than a unit with 60% cover where the trees are patchy or absent along the stream.
- Cover and height metrics do not capture other important forest characteristics, like stand composition and species diversity.
- Where management units overlap lakes, the shoreline, or for larger streams where there may be surface water not covered by riparian vegetation; % riparian estimates for the whole unit may be inaccurate.
- Previous work under this project considered tree cover and tree height as separate attributes. This could be considered if preferred by the group and supported by the literature/recommendations.

Data source: Washington Department of Fish and Wildlife (WDFW) High Resolution Change Detection (HRCD) 2017 tree cover

S2. Imperviousness (DROPPED)

Indicator: % imperviousness in the sub-watershed (HUC 12)

Proposed condition rating:

Condition rating	0	1	2	3	4
% impervious	61-100%	26% -60%	11%-25%	6-10%	≤5%
Description	High impervious cover; poor stream quality	Moderate-high impervious cover; poor-fair stream quality	Moderate impervious cover; fair stream quality	Low-moderate impervious cover; fair to good stream quality	Low impervious cover; excellent stream quality

Science summary:

Impervious surface cover disrupts the process of surface water filtering into the ground and can contribute to higher storm water runoff, greater sediment quantities, and increased pollutant loads in streams. Relationships between impervious surface area and impacts to streams are well quantified. Schueler et al. (2009) modeled stream quality as a function of watershed impervious cover, finding that the health of sensitive streams can be impacted by as little as 5-10% of impervious surface area, with greater impairments expected above 25% (NOAA, n.d.). Urban land cover types are associated with decreased biological condition (Morley and Karr, 2002), and minimizing imperious surfaces is a key strategy for protecting salmon habitat (NWIFC, 2020).

Linked ecosystem services: Key species presence and productivity, other species, habitat, climate resilience, connectivity, connectivity between ground and surface water, flood regulation, water supply

Notes and considerations:

- This attribute is assessed at the sub-watershed scale and the condition rating is applied to all riparian management units within that watershed. The impervious cover model used to specify the condition rating scale is described at the watershed scale, and 30m resolution impervious cover data is likely more accurate at the watershed scale than at the management unit scale. However, we should consider if including watershed-scale metrics is appropriate for this analysis and the goals of the asset management system.
- Impervious cover is likely highly correlated with S1 and S3. We should consider if including this variable is value-adding from an analysis or management perspective.
- Impervious cover is derived based on coefficients associated with different land cover classifications, and may not capture the nuance of interventions like replacing pavement with more permeable options or other interventions.

Data source: NOAA C-CAP 30m derived impervious surface land cover – 2015-2017

S3. Biological condition

Indicator: Average aggregated B-IBI score for stream

Proposed condition rating:

Condition rating	0	1	2	3	4
B-IBI Score	≤20	21-40	41-60	61-80	81-100
Description	Very poor – low diversity	Poor – diversity depressed	Fair – taxa richness reduced	Good – Slightly disturbed	Excellent – comparable to reference conditions

Science summary:

The Benthic Index of Biotic Integrity (B-IBI) is a quantitative method for assessing the biological condition of streams, based on the abundance and type of macroinvertebrate species present at a site. Monitoring B-IBI provides an assessment of stream condition based on the characteristics of biota sampled, which reflect the influence different land uses and activities (e.g., agriculture, urban development, recreation, forestry, etc.) have on a watershed. These activities and disturbances can influence the flow regimes, habitat, chemical introduction, energy cycles, and invasive taxa, and therefore stream health. Low B-IBI scores and degraded salmon habitat may be correlated at the site scale; for example, one study found that Coho and chum salmon did not use stream reaches for spawning with low B-IBI scores (Plotnikoff and Polayes, 1999). To assess LOS, we used data from the Puget Sound Stream Benthos project, which reports B-IBI as an index developed and calibrated for the Puget Sound Lowlands that measures pollution tolerance/intolerance of taxa, taxonomic composition, and population attributes (Puget Sound Stream Benthos, n.d.). We downloaded B-IBI scores since 2015, aggregated for each stream network in Kitsap County for a total of 37 ratings. For streams with more than one year of data since 2015, we used an average to apply the condition rating.

Linked ecosystem services: Key species presence and productivity, other species, habitat

Notes and considerations:

- Data can be aggregated and summarized numerous ways when downloaded, may need to better understand the best way to access and represent these data at the site scale and consider how many years of data to include. Data appear patchy for any given year.
- Though sampling frequency and locations are variable, some streams have several sampling locations; incorporating how B-IBI varies along the stream would provide a more complete picture of stream health. Updated methods are needed to represent several sites along a stream network and determine how far up and down stream to apply condition ratings.
- B-IBI is likely correlated with other attributes.

Data source: Puget Sound Stream Benthos, 2015-present

S4. Water quality

Indicator: Fecal coliform bacteria water quality standard

Proposed condition rating:

Condition rating	0	1	2	3	4
Fecal coliform bacteria counts	Annual GMV >100 FC/100ML; >10% samples >200 FC/100 ML	NA	Annual GMV <100 FC/100ML; >10% samples >200 FC/100 ML	NA	Annual GMV <100 FC/100ML; <10% samples >200 FC/100 ML
Description	Fails both parts of the standard; high bacteria levels		Meets first standard and fails second; periodic high bacteria		Meets both parts of the standard; low bacteria levels

Science summary:

E. Coli is a reliable fecal bacteria indicator of bacteria presence that originate from point source (sewer overflows and effluent discharge) and non-point pollutions sources (stormwater runoff). The presence of E. Coli is known to cause illness, therefor monitoring bacteria is essential to mitigate human health risk from recreation swimming, shellfish consumption and drinking water (Kitsap Public Health District, 2015). Stream monitoring is typically conducted at stream mouths to assess cumulative impacts for stream water quality of the basin, with some monitoring occurring above stream mouths to isolate reaches with elevated pollution risk. Monthly monitoring provides continuous long-term water quality results for Kitsap County. Data is gathered from 69 streams across Kitsap County. Kitsap Public Health District changed the biologic metric used to indicate water quality from Fecal Coliform to E. Coli in the water year (Oct – Sept) 2020 - 2021. For the purpose of this preliminary analysis, we used data indicating whether stream samples met a two tiered water quality standard for the 2019 – 2020 water year. Water years 2020 –2021 and beyond will use E. Coli as the primary bacterial metrics used to assess water quality.

Linked ecosystem services: Recreation, other species, water supply

Notes and considerations:

- Kitsap Public Health District regularly monitors only 69 major creeks in Kitsap County. As a result, many smaller creeks/streams in Kitsap County do not have sampling data.
- In 2021, the fecal coliform standard was updated and streams will now be monitored for E. Coli bacteria. Condition ratings will need to be updated to reflect the new standard and new monitoring data.
- We used partial data from Kitsap Public Health to assess water quality and include this attribute in the LOS score. We approximated the locations of some monitoring locations based on the hydrography data we used for management units.

Data source: Kitsap Public Health 2020 monitoring data

S5. Fish passage

Indicator: Fish passage barrier presence

Proposed condition rating:

Condition rating	0	1	2	3	4
Presence of barrier in upland management unit	NA	Yes	NA	NA	No
Description		Barrier present in unit			No barriers present in unit

Science summary:

Development can drive hydrologic changes, such as channel morphology, streambed material, nutrients, and stream flow, which effects the habitat suitability for aquatic species. Roads and other forms of development often result in the creation of barriers to fish passage, such as culverts. For example, one of the greatest concerns is the increased stream flow velocity through a culvert and culvert length which contribute to preventing fish from accessing upstream reaches (Thurman and Horner-Devine, 2007). Maintaining hydrologic connectivity is critical to allow ESA listed salmon to access reaches that provide spawning and rearing habitat. Among the types of human constructed fish passage barriers identified in Kitsap County are culverts, dams, diversions, and others. Recently, fish passage barriers were inventoried in Kitsap County with data maintained in a statewide database. A fish passage barrier inventory provides basic information about the location, type of barrier, a reasoning for being a barrier, and potential species present. The inventory excludes information habitat extent and other metrics used to generate a prioritization values. Kitsap County has approximately 1,277 fish passage barriers constructed.

Linked ecosystem services: Key species presence and productivity, other species, habitat, connectivity

Notes and considerations:

- Existing fish passage barrier prioritization indexes are not suitable to use in a condition rating. Alternatively, certain variables used in the prioritization index could be repurposed for a condition rating but we currently do not have access to that data. The preliminary method only accounts for the presence or absence of a barrier.
- The current method does not incorporate information on extent of barrier, species blocked, habitat available upstream or habitat quality, or presence of barriers above and below in the stream network; methods need refining.

Data source:

- WDFW Fish Passage database

Calculating LOS

The overall LOS for each riparian management unit is calculated by taking an average of the condition ratings for S1, S2, S3, S4, S5. For riparian attributes, the maximum possible score is 4, and the minimum possible score is 0. The LOS score reflects the condition of stream and riparian assets. In this approach, we assume that degraded condition (low scores) corresponds with a low level of service and reduced ecosystem services. In addition to the numerical LOS score (i.e., the mean of the condition ratings across attributes), we assign a qualitative LOS rating according to the table below. Given the preliminary nature of the riparian and stream LOS assessment and the revisions needed to both the management units and attributes analyses, we have not included alternative methods for calculating LOS (e.g., geometric mean) at this time.

Qualitative LOS	Overall LOS Score (max4)
Very Low	0-1
Low	≥1-2
Medium	≥2-3
High	≥3-4

References

Andrew, M.E. and Wulder, M.A. 2011. Idiosyncratic responses of Pacific salmon species to land cover, fragmentation, and scale, Ecography, 34: 780-797., 2011

Kitsap Public Health District. 2015. Water Quality Monitoring Plan Streams, Lakes and Marine Waters. Kitsap Public Health District Water Pollution Identification & Correction Program.

Labbe, T., Adams, A., and Conrad, R. 2013. Historical Condition and Change in Riparian Vegetation, Hood Canal and Eastern Strait of Juan de Fuca, Washington. Northwest Science, Vol. 87, No. 1.

Morley, S.A. and J.R. Karr. 2002. Assessing and Restoring the Health of Urban Streams in the Puget Sound Basin. Conservation Biology. Abstract here: https://conbio.onlinelibrary.wiley.com/doi/abs/10.1046/j.1523-1739.2002.01067.x

NOAA, n.d. How to Use Land Cover Data as an Indicator of Water Quality: Description of Data and Derivatives Used. Coastal Change Analysis Program. Available here: https://coast.noaa.gov/data/digitalcoast/pdf/water-quality-indicator.pdf#page=4

Northwest Indian Fisheries Commission (NWIFC). 2020. 2020 Puget Sound Regional Report. Available here: https://nwifc.org/publications/state-of-our-watersheds/

Plotnikoff, R. and J. Polayes. 1999. The Relationship Between Stream Macroinvertebrates and Salmon in the Quilceda/Allen Drainage. Washington Department of Ecology. Available here: https://apps.ecology.wa.gov/publications/documents/99311.pdf

Puget Sound Stream Benthos. N.d. About the Benthic Index of Biotic Integrity. Available here: https://pugetsoundstreambenthos.org/About-BIBI.aspx

Quinn, T., G.F. Wilhere, and K.L. Krueger, technical editors. 2020. Riparian Ecosystems, Volume 1: Science Synthesis and Management Implications. Habitat Program, Washington Department of Fish and Wildlife, Olympia. Available here: https://wdfw.wa.gov/sites/default/files/publications/01987/wdfw01987.pdf

Schueler, T. et al. 2009. Is Impervious Cover Still Important? Review of Recent Research. Journal of Hydrologic Engineering. Vol. 14: 4. Abstract here: https://ascelibrary.org/doi/pdf/10.1061/%28ASCE%291084-0699%282009%2914%3A4%28309%29

Thurman, D.R., Horner-Devine, A.R., 2007. Hydrodynamic Regimes and Structures in Sloped Weird Baffled Culverts and Their Influence on Juvenile Salmon Passage. Available here: https://www.wsdot.wa.gov/research/reports/fullreports/687.1.pdf

Windrope. A., Quinn, T., Folkerts, K., Rentz, T. 2018. Riparian Ecosystems, Volume 2: Management Recommendations – Public Review Draft. A Priority Habitat and Species Document of the Washington Department of Fish and Wildlife. Available here: http://www.seattle.gov/light/skagit/Relicensing/cs/groups/secure/@scl.skagit.team/documents/document/cm9k/ntcx/~edisp/prod571195.pdf

Windrope. A., Quinn, T., Folkerts, K., Rentz, T. 2020. Riparian Ecosystems, Volume 2: Management Recommendations. A Priority Habitat and Species Document of the Washington Department of Fish and Wildlife. Available here: https://wdfw.wa.gov/sites/default/files/publications/01988/wdfw01988.pdf

WRIA 15. 2021. Watershed Restoration and Enhancement Draft Plan. Department of Ecology. Available here:
https://www.ezview.wa.gov/Portals/_1962/images/WREC/WRIA15/Final%20Plan/WRIA15FinalDraftREVISED1Mar2021.pdf