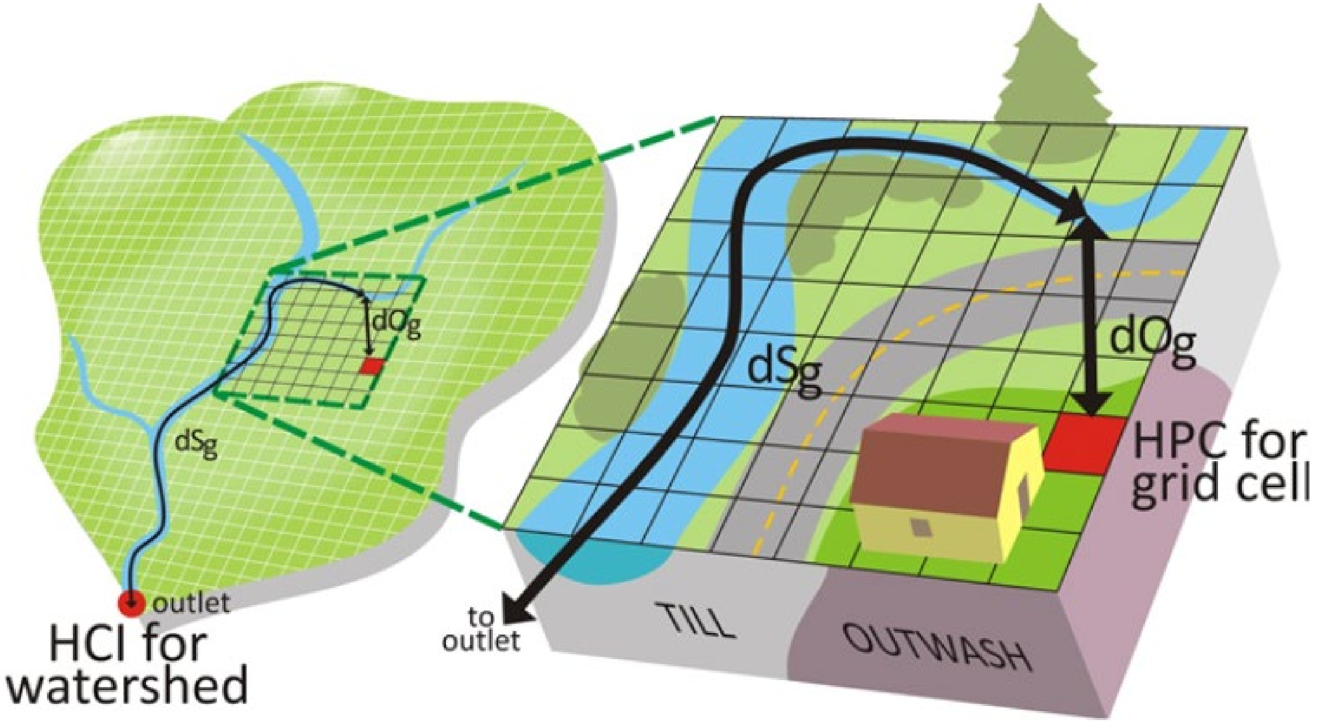
Phase 2 Development of a Hydrologic Condition Index for the Puget Sound Basin

Salish Sea Ecosystem Conference

April 27th, 2022



DEPARTMENT OF ECOLOGY State of Washington

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Shorelands and Environmental Assistance Program

Topics we'll cover today

- Phase 1 Hydrologic Condition Index (HCI) outcomes (Volume 4)
- Phase 2 HCI approach
- How HCI fits into existing and emerging decision-support frameworks

Project supported by:

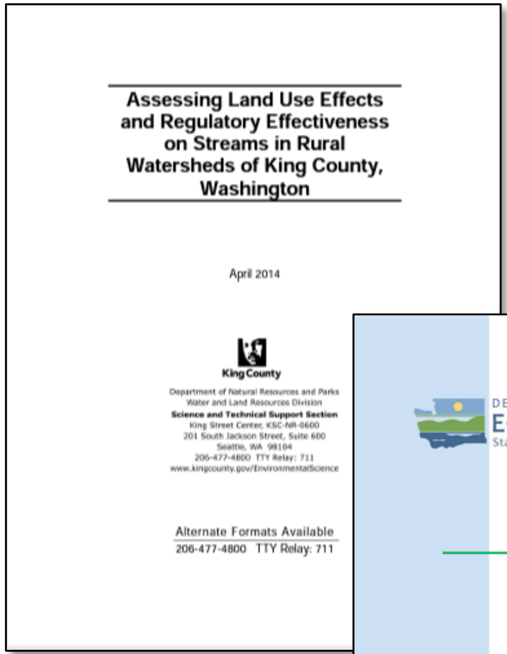
Environmental Science Associates

Clear Creek Solutions

Hydrologic Condition Index (HCI)

Background

- Conceptualized initially by Lucchetti et al. 2014 to assess CAO effectiveness
  - Building on concept that High-pulse-counts ("flashiness") correlate with stream biology
- Stanley et al. 2019 (Volume 4 of the PSWC):
  - Evaluated different methods for calculating HCI
  - Validated HCI with stream gage data
  - Initial proof of concept for "alternative futures" applications
  - Initial concepts on how to integrate HCI with existing PSWC indices and other stream data
  - Recommendations for phase 2 development


Assessing Land Use Effects and Regulatory Effectiveness on Streams in Rural Watersheds of King County, Washington

April 2014

King County

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Water and Land Resources Division
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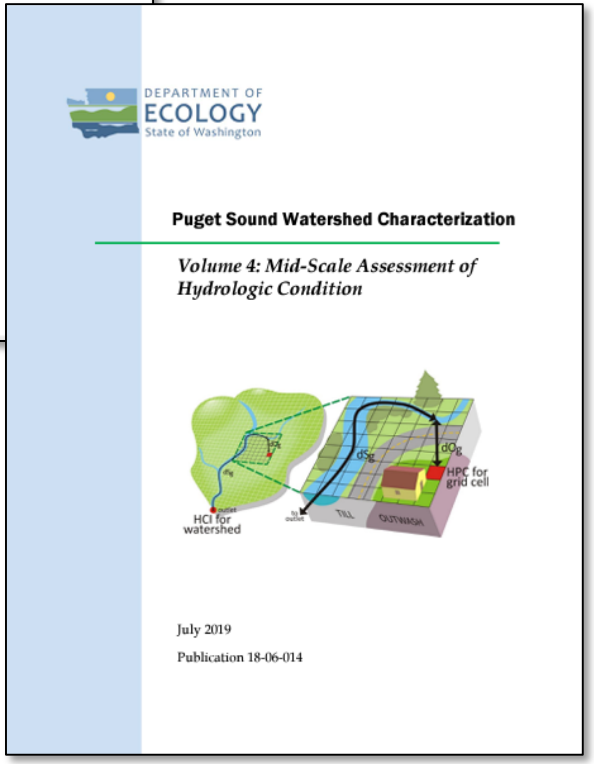
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Puget Sound Watershed Characterization

Volume 4: Mid-Scale Assessment of Hydrologic Condition

July 2019

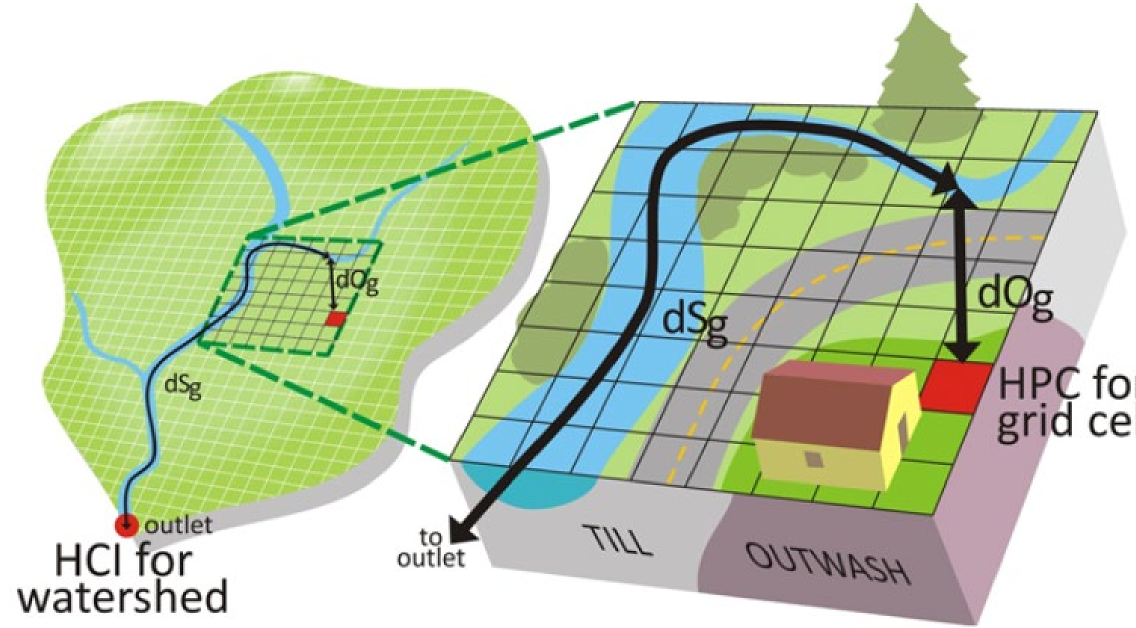
Publication 18-06-014

Hydrologic Condition Index (HCI)

Calculate the Index:

- Overlay grid on a watershed
- Each grid cell – shortest distance to stream (dOg), distance from stream intersection to outlet (dSg)
- Land cover and surficial geology combination for each grid cell has a $HPC_{coefficient}$ derived from HSPF hydrologic modeling
- Assess current condition relative to worst possible (all paved)

→ 0-1 index where **higher values are correlated with relatively more High-Pulse Counts** at the outlet

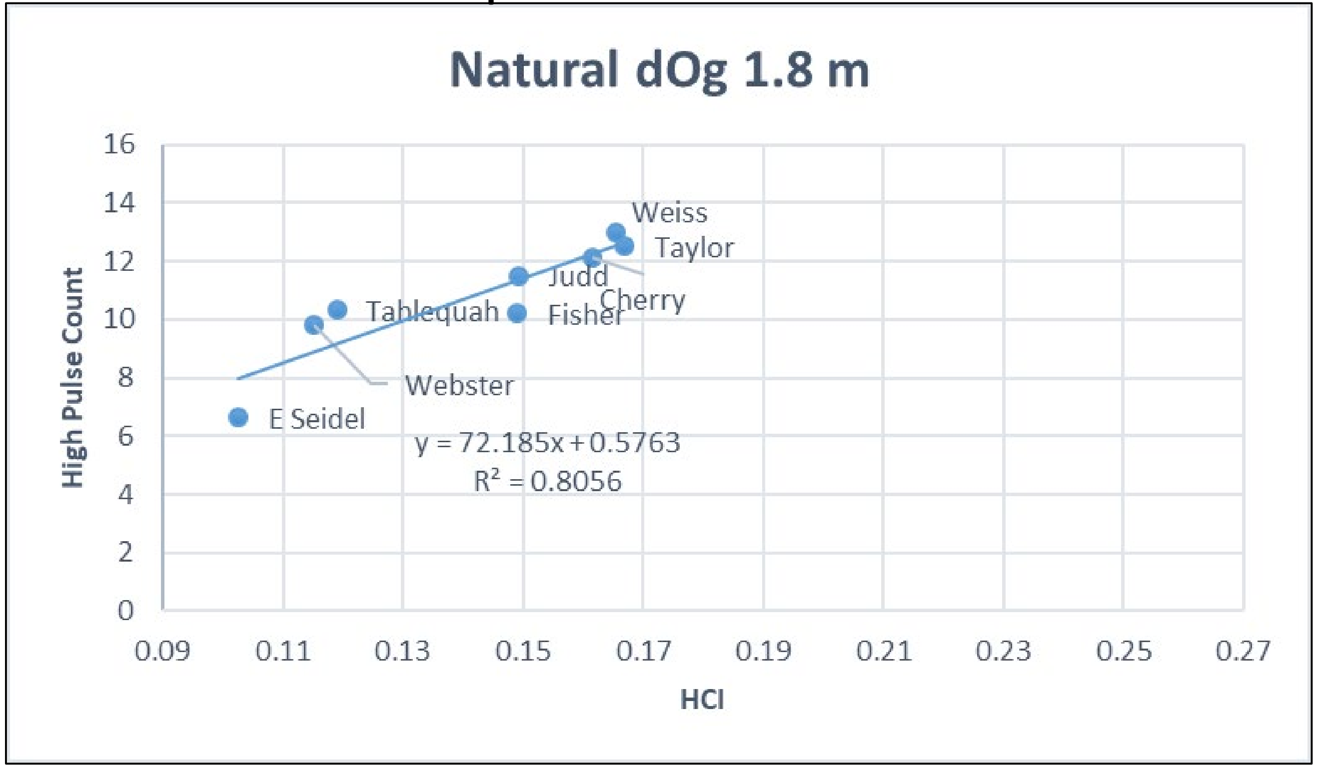


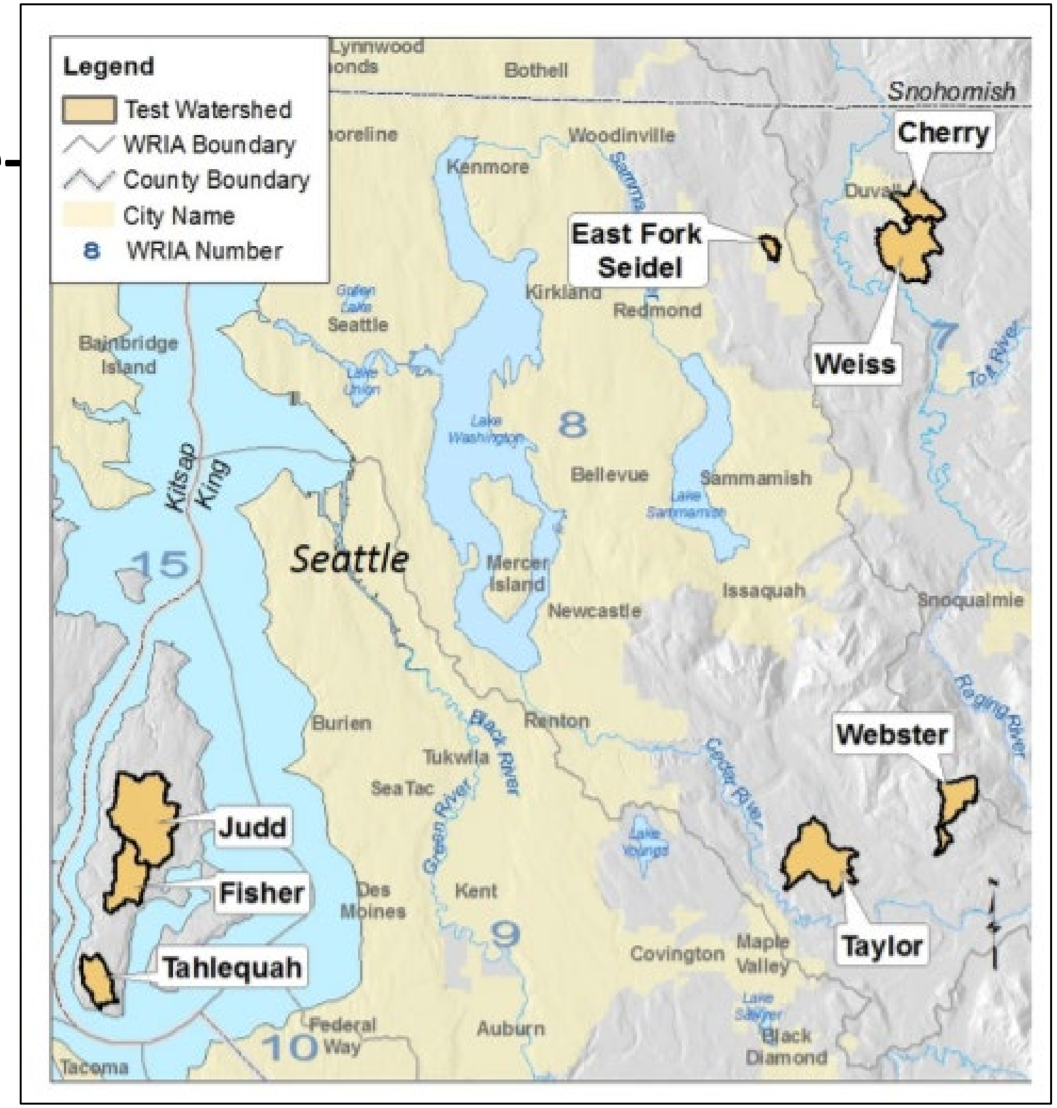
Calculation of Hydrologic Condition Index for a Watershed	This index uses **three components** to characterize each grid cell in a watershed: land cover type, geology, and distance to a stream.
Step 1. Calculate the High Pulse Count value for each grid cell (HPCg). Multiplying the average coefficient for the dominant land cover-geology combination of the grid cell, BY the inverse distance from that grid cell to the stream **(dOg)** and down to the watershed outlet **(dSg).**	$HPCg = HPC_{coeff} \left[\frac{1}{dOg + dSg} \right]$
Step 2. Calculate the Hydrologic Condition Value (HCVs) for the watershed. Sum all the HPC grid cell values within the watershed.	$HCVs = \sum_{g=1}^{n} HPCg$
Step 3. Calculate the Hydrologic Condition Index (HCI) for the watershed. Divide the hydrologic condition value BY the worst case HCV when the watershed is 100% paved.	$HCI = \left[\frac{HCVs}{HCVs\ worst} \right]$

HCI & High Pulse Counts

Index validation and methods comparison-

- HCI correlates well with **gage measured High-Pulse-Counts** or "stream flashiness" in 8 test basins
- Better than % impervious





Hydrologic Condition Index Phase 2

Major tasks:

- **Calibrate $HPC_{coefficients}$** for areas outside of Central Puget Sound → Ultimately allow for Puget Sound-wide application
- **Refine HCI Condition Categories →** validating with stream gage data and response variables such as B-IBI
  - Describe "uncertainty"
- **Local Application Use Case Pilots**

HCI Phase 2 - **Calibrate $HPC_{coefficients}$**

Watershed selection criteria:

1. Existing calibrated HSPF model available
2. Geographic spread North-Sound Puget Sound
3. Level of development (low – moderate)

Ultimately generate a library of $HPC_{coefficients}$ to draw from for local applications depending on scenario

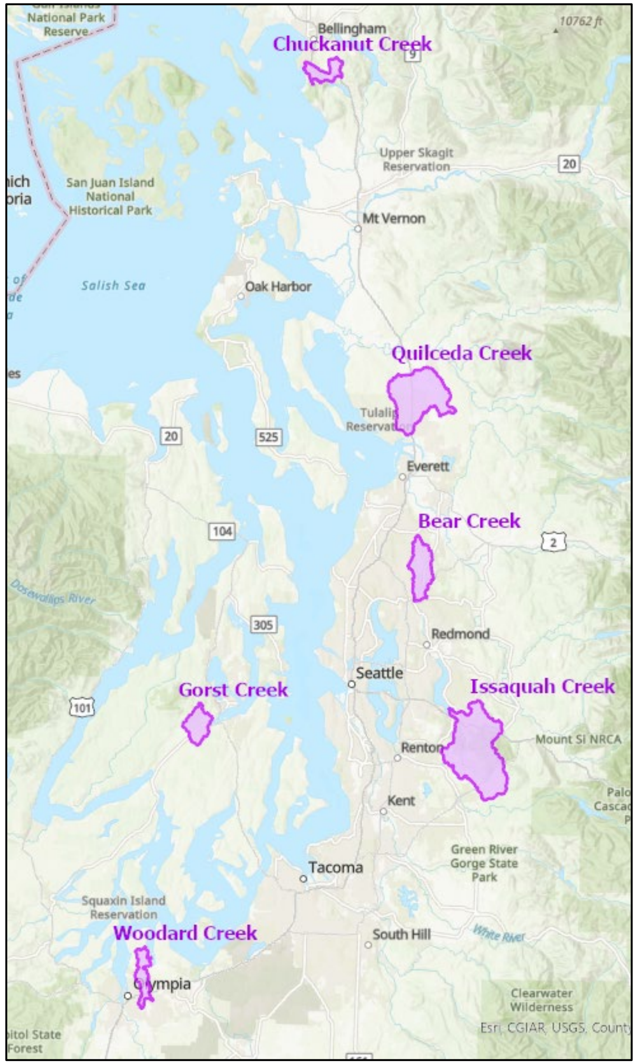
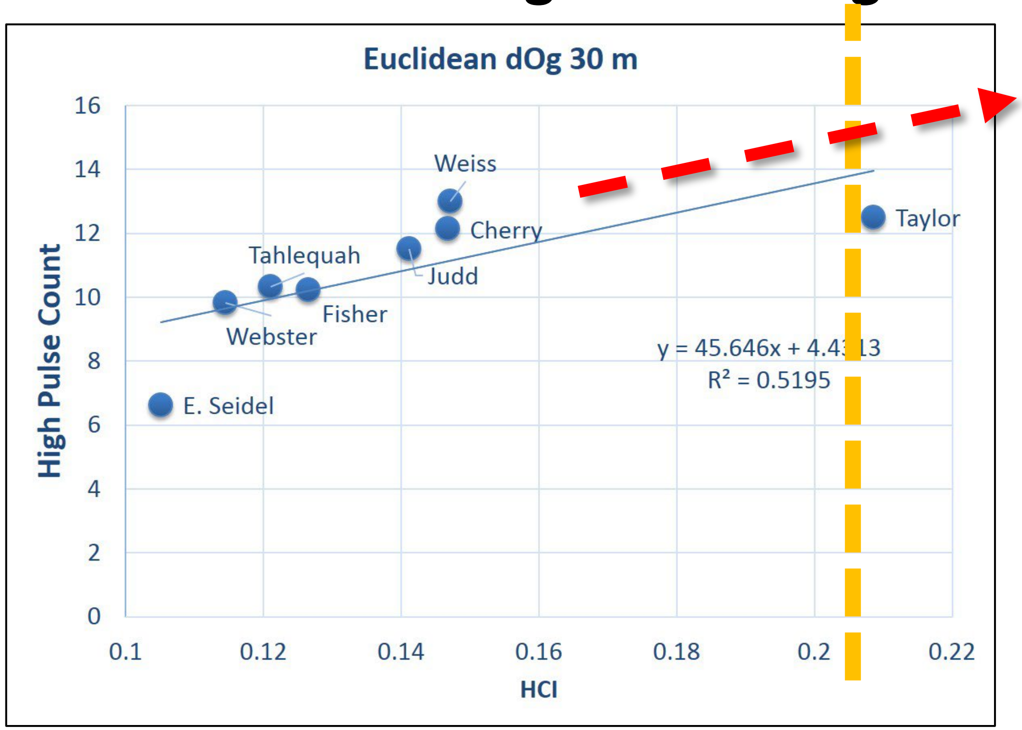


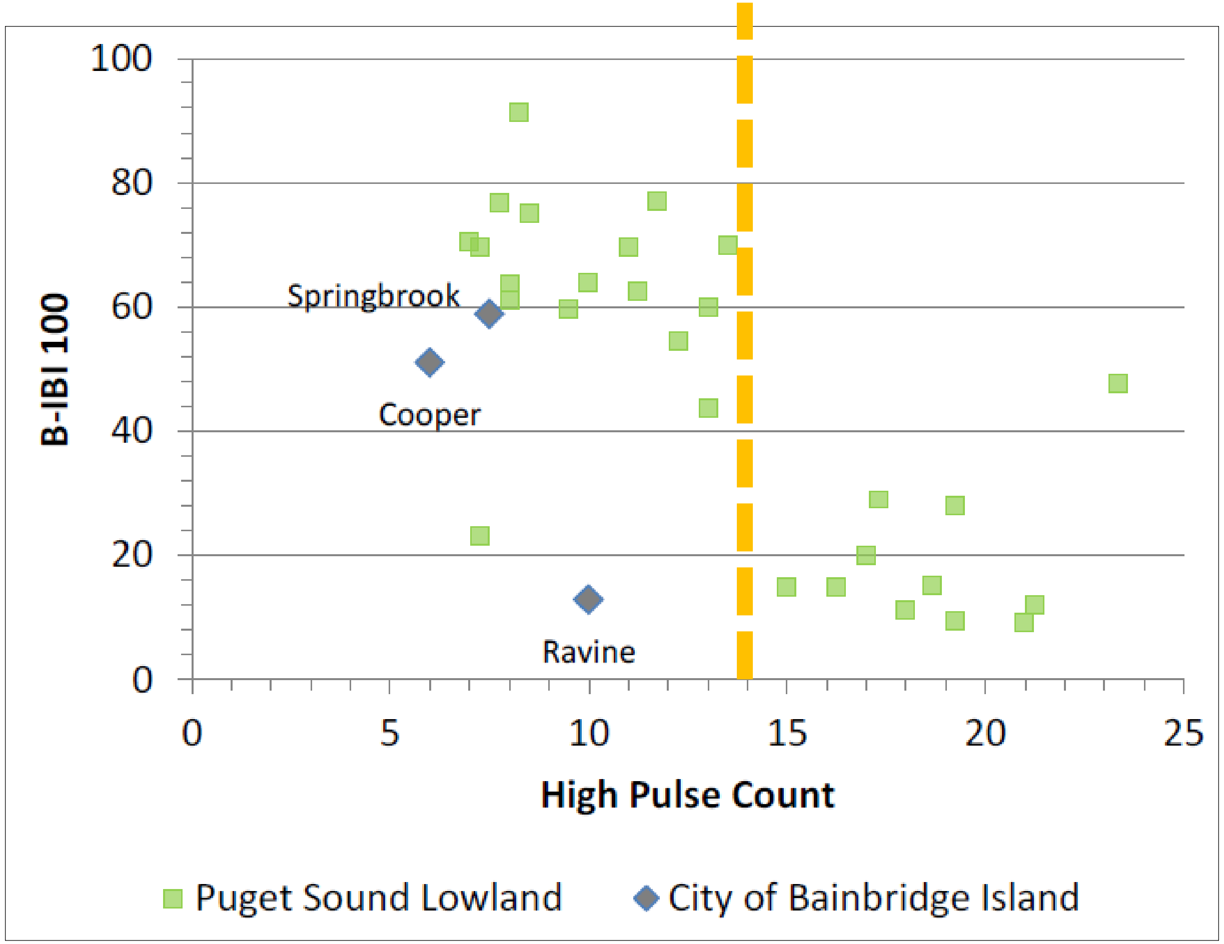
Table – Phase 1 High-Pulse-Count$_{coefficients}$ for Till surficial geology derived from five King County Watersheds (Lucchetti et al. 2014) with HSPF models which ran 61-years of climate data to generate average yearly HPCs for given combinations of land cover on surficial geology. Outwash values not displayed.

Land Cover on Till	Hamm Creek (set 1)	Miller Creek (set 2)	Des Moines Creek (set 3)	Newaukum Creek (set 4)	Duwamish Creek (set 5)	HPC AVG
forest	2.393443	2.672131	3.655738	4.606557	7.04918	4.07541
shrub	2.639344	3.311475	4.47541	6.016393	7.081967	4.704918
pasture	2.803279	4.032787	4.622951	6.590164	7.606557	5.131148
wetland	2.901639	4.868852	4.540984	7.52459	8.245902	5.616393
clear cut	3.819672	5.032787	5.360656	8.606557	8.803279	6.32459
grass	5.672131	5.213115	6.032787	9.983607	8.47541	7.07541
bare	5.114754	8.52459	7.901639	10.508197	11.459016	8.701639
building	30.508197	34.803279	33.491803	29.622951	31.836066	32.052459
pavement	26.540984	36.885246	36.508197	34.032787	35.737705	33.940984
open water	27.934426	38.163934	38.131148	36.655738	37.786885	35.734426
unpaved road	33.983607	37.180328	36.901639	34.754098	36.672131	35.898361
paved road	34.360656	37.655738	37.344262	35.180328	37.213115	36.35082

HCI Phase 2 – **Refine HCI Condition Categories**

Phase 1 Extrapolates the relationship between HPC and B-IBI to the HCI to establish thresholds of likely stream condition → **Phase 2 expand sample of watersheds to higher HCI range**.





Plot of measured high pulse counts and Benthic Index of Biotic Integrity (B-IBI) survey points. A high pulse count of approximately 14 to 15 provides an approximate, useful discrimination between good (60-80), fair (40-60), and poor (<40) B-IBI scores. B-IBI data from **DeGasperi & Gregersen (2015).**

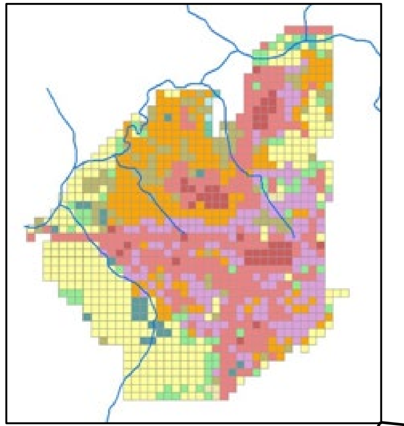
HCI Phase 2 – **Local Application Use Cases**

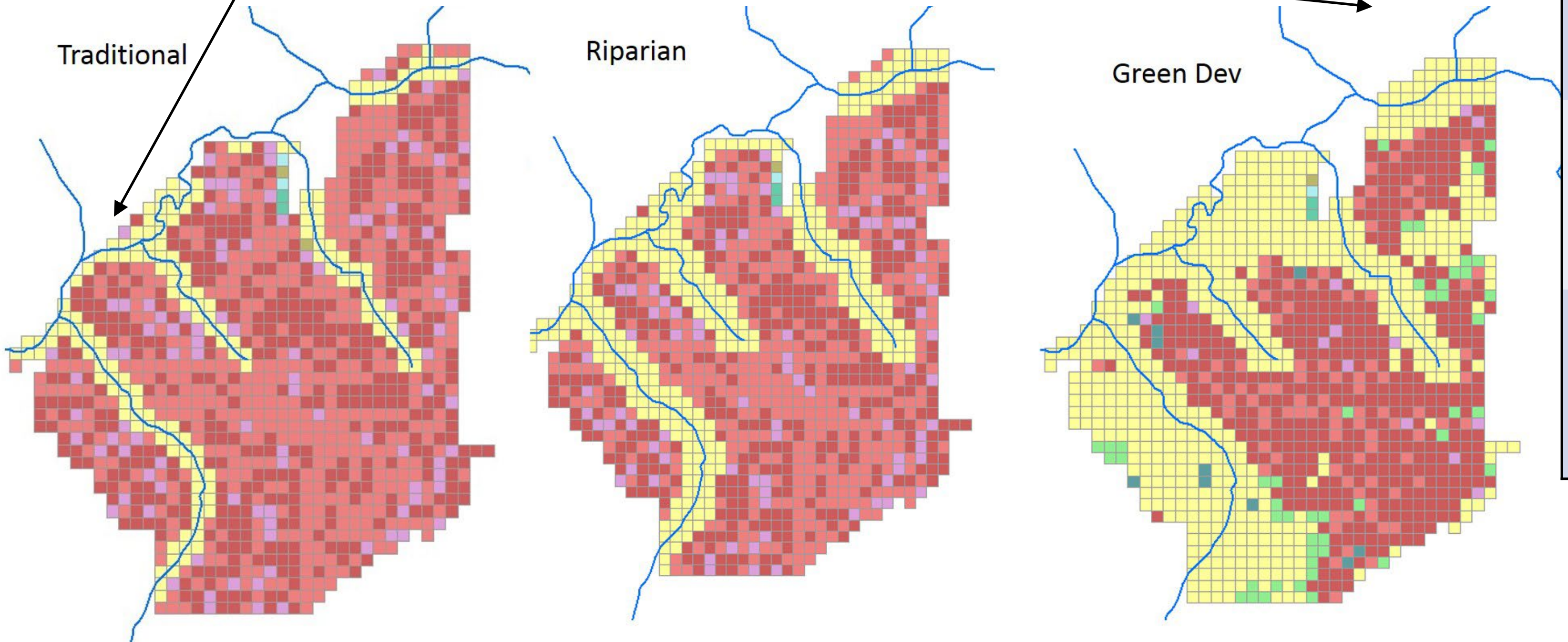
- HCI provides a metric (“ruler”) by which to evaluate current condition relative to potential “worst” – **status and trends application**
- HCI may be useful in evaluating hydrologic **implications of future land cover changes** and decisions related to:
  - Land use designations and zoning under GMA
    - CAO evaluations
    - Buildable Lands Programs
  - Stormwater planning (e.g. Stormwater Management Action Plans)
    - Condition Assessment
    - Retrofit or stormwater mitigation planning

A **planning-Level** tool for rapid assessment and scenario evaluation

Local Applications – **Buildout Scenarios**
Coarse-Scale

Current Condition





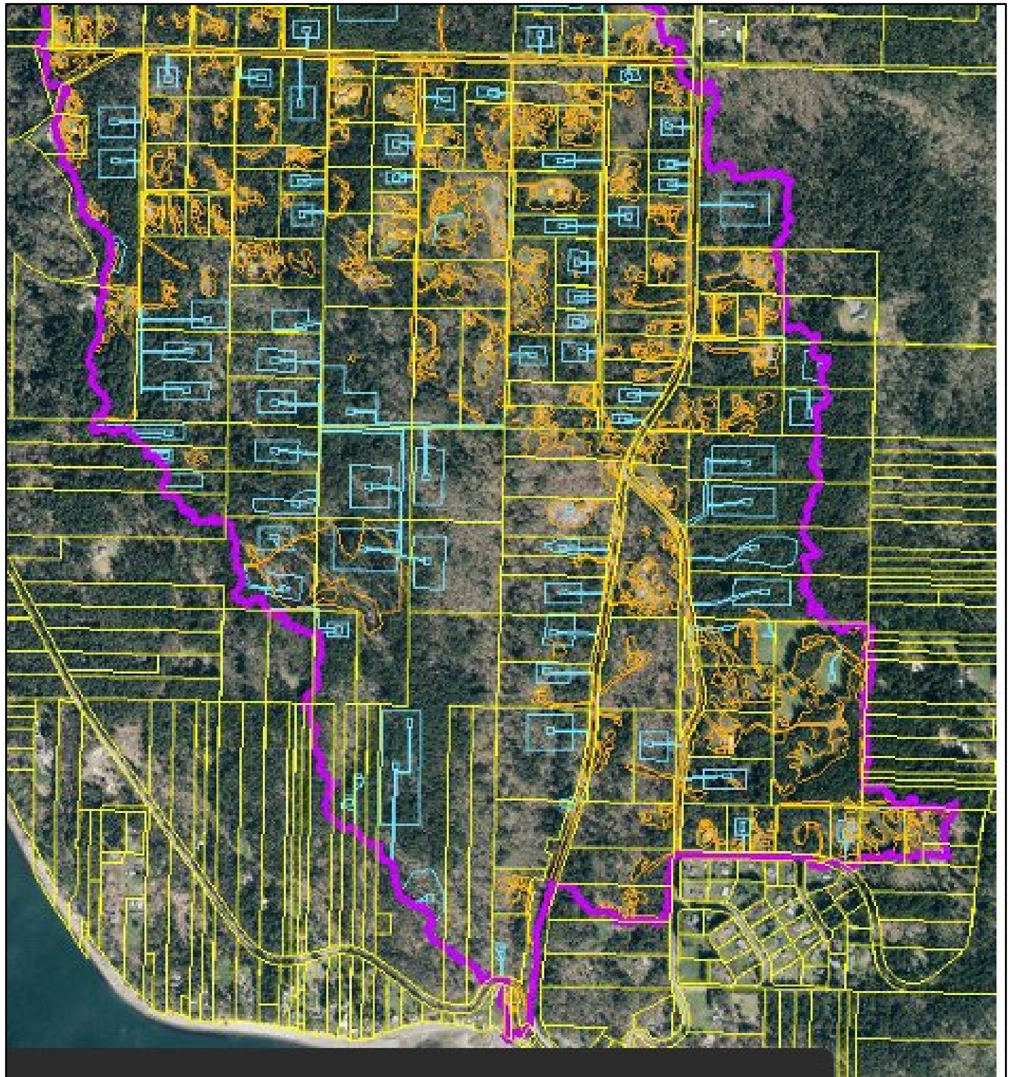
Future Buildout Scenario	**Potential Development Units**	**Hydrologic Condition Rating**
Traditional Scenario	1058 Units	HCI = 0.6 Poor Condition
Increased Riparian Buffer Scenario	923 Units	HCI = 0.44 Poor Condition
Green Developme nt Scenario	2122 Units	HCI = 0.23 Moderate to Good Condition

Story Map

Local Applications – **Buildout Scenarios** Finer-Scale

- Will generally require **higher resolution land cover** and **flow-path** layers
- Account for **Critical Areas** to some degree
- Account for **LID and/or stormwater mitigation** requirements
- Generalized templates for **typical development or redevelopment** in zoning categories

Image from Lucchetti et al. 2014



Pilot Opportunity!

- Looking for **3 pilot use cases** with local governments:
  - Stormwater Planning
  - Land Use Planning (GMA/SMA)
  - Restoration Planning
  - Status and Trends metric
  - Other?

- Consultant team and Ecology will produce a report which illustrates how the HCI can be integrated into an **existing planning framework**.

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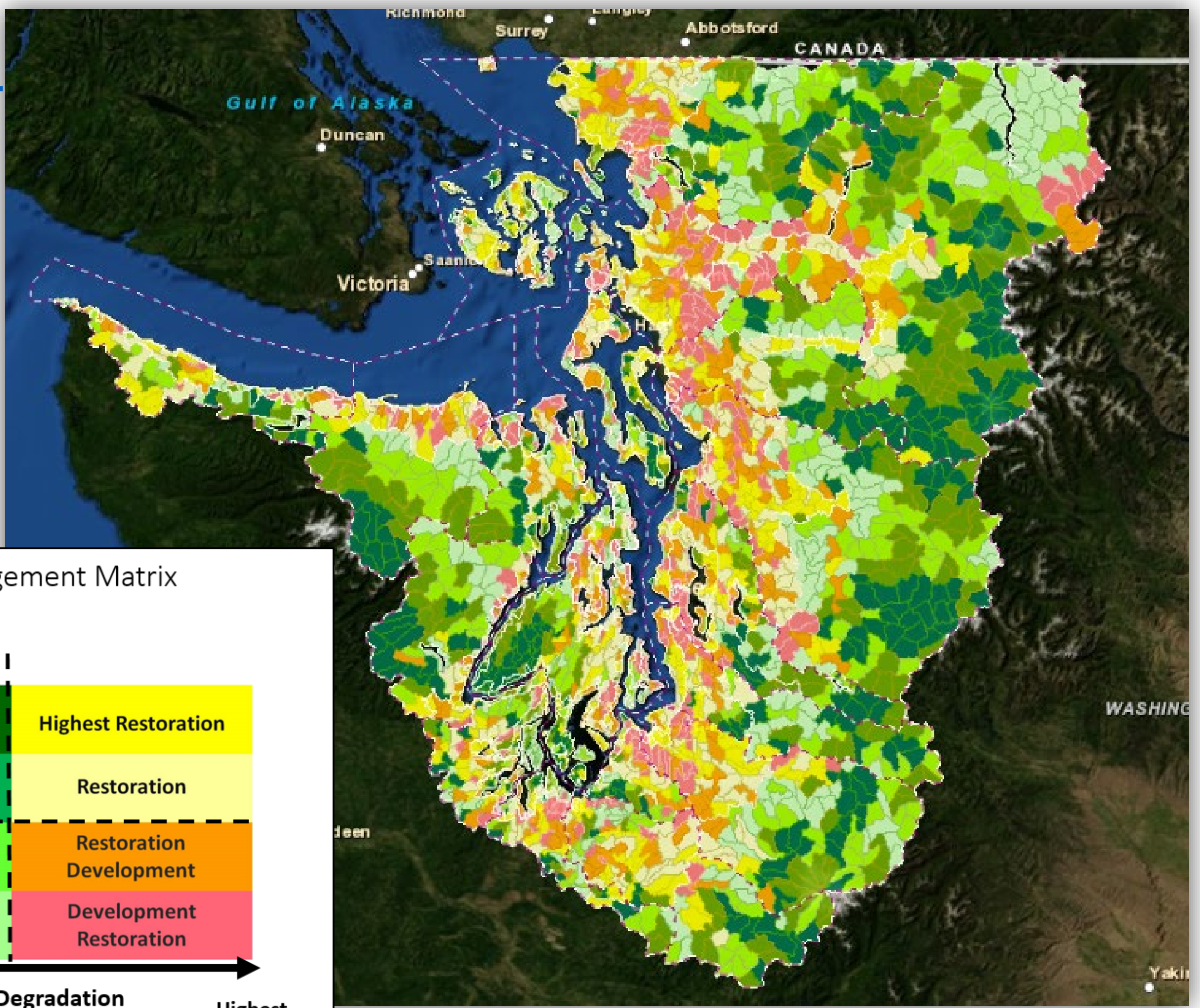
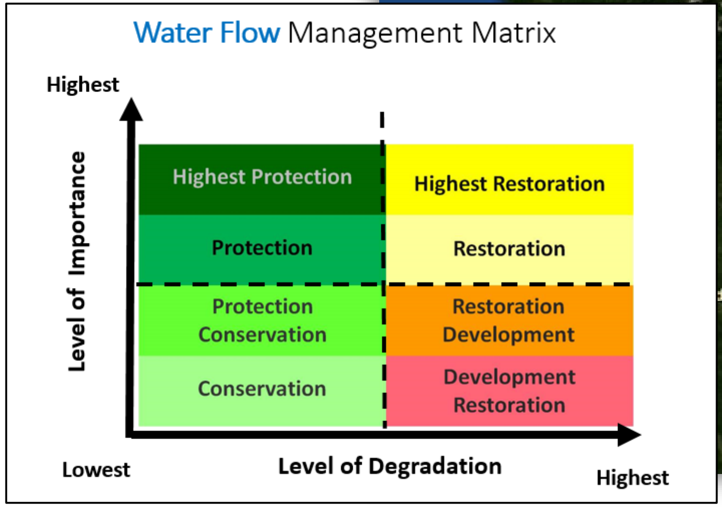
Integrating the HCI into the PSWC Framework

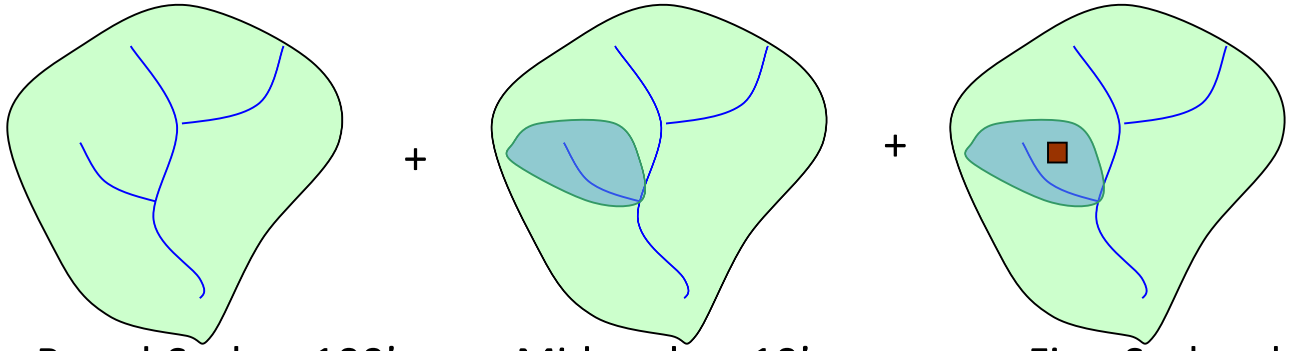
- Existing Broad-scale indices (Volumes 1 and 2) compare areas for their contribution and/or level of degradation for:
  - Water Flow Processes
  - Water Quality Processes
  - Terrestrial Habitats
  - Freshwater Habitats
  - Marine Shoreline Habitats





Integrating the HCI into the PSWC Framework

Scale:



+ + = Integrated result

Broad-Scale – 100's of sq. miles

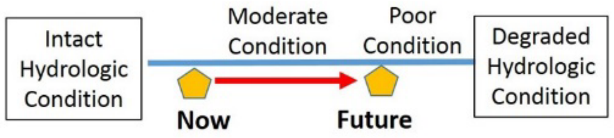
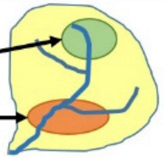
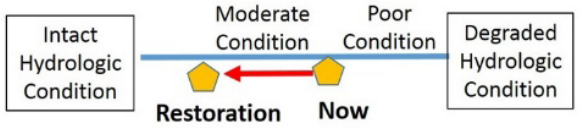
Mid-scale – 10's of sq. miles

Fine-Scale – less than 1 sq. mile

Application :	**Land use and stormwater planning** - Type, & location of new development, prioritization of restoration and protection actions.	**Project Design** of Restoration and Mitigation
What to Use:	Assessments of **watershed processes** such as those found in Puget Sound Characterization.	**Predictive** hydrologic models, water quality, species & habitat monitoring data etc.
Type of Data & Information:	**Coarse scale** data on land cover/land use, geology, precipitation, topography, & hydrology.	**Site specific data** on biological, physical and chemical conditions
What it tells you:	The **most important areas contributing to processes** such as movement of water, sediment, nutrients & general level of watershed integrity.	**Quantifies**: hydrologic flows, limiting water quality factors, habitat structure & functions

Integrating the HCI into PSWC Framework

- HCI can be used as a **“mid-scale”** part of the integration framework
- Complement the **Broad-scale** indices
- Narrower **indicator of stream function** than existing indices
- Allow for **alternative future scenarios** evaluation to communicate implications of future land cover change

Steps	Use Tool	Examples
① What is the predominate Watershed Management Category for your watershed?	Broad scale results and local information.	Protection? Restoration? Development? 
② Determine risk from future buildout. Good, moderate, or poor hydrologic condition?	HCI score for existing and full buildout.	
③ Integrate results from step 1 and 2.	Solution templates.	• For “Protection” areas and HCI < 0.21, use protection actions • For “Restoration” areas and HCI > 0.21 & < 0.44, use restoration actions. • For “Development” areas and HCI > 0.44, use LID.
④ Which areas will help maintain a healthy hydrologic condition?	HCI scores, land cover, geology, and proposed actions.	Identify areas that could improve Hydrologic condition through restoration actions or green development actions. 
⑤ Design future development alternatives and rerun HCI.	HCI score for proposed development.	

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[Puget Sound Watershed Characterization Website]

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Works Cited

- Cassin, J., R. Fuerstenberg, L. Tear, K. Whiting, D. St John, B. Murray, J. Burkey. 2005. Development of Hydrological and Biological Indicators of Flow Alteration in Puget Sound Lowland Streams. King County Water and Land Resources Division. Seattle, Washington.
- DeGasperi, Curtis, and C. Chris Gregersen. 2015. Stream Benthos and Hydrologic Data Evaluation for the City of Bainbridge Island.
- Lucchetti, G.*, J. Burkey, C. Gregersen, L. Fore, C. Knutson, J. Latterell, P. McCombs, R. Timm, J. Vanderhoof, and J. Wilhelm. 2014. Assessing land use effects and regulatory effectiveness on streams in rural watersheds of King County, Washington. Prepared by Water and Land Resources Division. Seattle, Washington.
- Stanley, S., B. McMillan, C. Hume, S. Grigsby. 2019. Puget Sound Watershed Characterization: Volume 4: Mid-Scale Assessment of Hydrologic Condition. Washington State Department of Ecology. Publication #18-06-014. Olympia, WA.