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Dictionary of Metrics for Physical Habitat

Definitions and Calculations
Used for Watershed Health Monitoring and Related Studies

by

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Abstract

Over the past decade, study of natural resource conditions has shifted from observations at scattered, hand-selected sites to much more intensive, statistically robust approaches, such as GRTS\(^1\) probability sampling. Observations resulting from such sampling are formulated as summaries called *metrics*. Metrics are related to variables: a variable is what we study; a metric is how we describe it.

Watershed Health Monitoring Web\(^2\) (WHMWeb) is part of a new tool, built by the Washington Department of Ecology, that translates statistically robust regional assessments of watershed conditions into metrics diagnostic of watershed health. The core of this tool is a metric calculation engine. WHMWeb is an interface from which users (1) can access a list of sites that have been surveyed and (2) call the associated metrics. Metrics are displayed in an ASP.Net web page, behind which is a SQL Server database. Metrics are updated daily, with an overnight refresh.

Metrics reporting from WHMWeb are specific to fresh flowing surface waters (and environs) of the state of Washington, as represented on the National Hydrography Dataset (NHD), and meeting the population definition used for watershed health monitoring and related studies. Various study designs are used, some probabilistic, such as GRTS, and some not. The emphasis is water quality and physical habitat for stream-associated organisms.

This dictionary defines physical habitat metrics reporting from WHMWeb and describes their calculations. It is intended as a reference, as a list of available metrics, and to promote transparency and confidence in use of results reported by WHMWeb. Observations, from which metrics are derived, also report from WHMWeb.

Conversely, this metric dictionary is not intended as (1) an exhaustive source of metric formulations, (2) a user guide for querying the WHMWeb interface, or (3) a description of observations.

Approximately 265 metrics report from WHMWeb as of December 2016.

---

1 Generalized random tessellation stratified.
2 Watershed Health Monitoring


Acknowledgements

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Dictionary of Metrics

Watershed Health Monitoring Web (WHMWeb)\(^3\) is part of a metric calculation engine. To date, procedures for calculating approximately 265 metrics are available to WHMWeb. A dictionary of these metrics follows.

The dictionary is organized hierarchically. The highest level of organization is categories, in which closely related metrics are grouped. Category names are organized alphabetically. Within categories, metrics are ordered by other characteristics. Typically the ordering is from simple to complex, thus taking into account dependencies rather than alphabetical relationship. Some categories contain only a single group or a single metric. Diagrammatic relationships are included for a few complex, higher-level diagnostic metrics to illustrate their dependencies.

Additionally, the structure of this dictionary is modular. Each group of metrics can stand alone. Provided for each metric is thus a long descriptive name, a definition, a short name reported by WHMWeb (i.e., WHM export ID), and a calculation. Readers can trace each metric through steps in the definition and calculation by following the parenthetical notations in each sub-group. Any dependencies are identified for the reader, as are key technical references. A modular structure adds some length to the dictionary but simplifies a potential future integration of the dictionary with WHMWeb.

Also, throughout the dictionary is reference to the term *data collection event* (DCE). DCEs combine study location IDs with dates of visitation. Thus, all site visitation IDs, even those which are repeat visits, are unique. All data within WHMWeb are ordinated to DCEs. All calculations described in the dictionary apply at the scale of individual DCEs.

Calculations for most of these metrics are modeled after those developed by the Environmental Monitoring and Assessment Program (EMAP), a research project of the U.S. Environmental Protection Agency (EPA). These calculations are currently used in EPA’s National Aquatic Resources Surveys (NARS). Methods for collecting the underlying data also are mostly modeled on federal sources: those of EMAP, particularly the Western Pilot; those of NARS, particularly Peck et al. (2005, 2006); and those of the National Marine Fisheries Service’s Integrated Status and Effectiveness Monitoring Program (ISEMP)\(^4\). For further detail about data underlying the metrics, see the associated quality assurance monitoring plan (Cusimano et al., 2006) and protocols, one for wadeable streams (Merritt, 2009) and one for wide streams and rivers (Merritt, 2010). Where reported, the sample form of the standard deviation (SD) equation is used to estimate population SDs.

\(^3\) Watershed Health Monitoring

\(^4\) Integrated Status and Effectiveness Monitoring Program (ISEMP)
http://www.nwfsc.noaa.gov/research/divisions/cb/mathbio/isemp.cfm
There are, however, important modifications and additions to some field methods and metrics. These changes are based on National Oceanic and Atmospheric Administration 2004-2005 methods for the Integrated Status and Effectiveness Monitoring Program (Hillman, 2004) or Moberg (2006, 2007). These include:

- Referencing the bankfull channel rather than the wetted channel for
  - Riparian observations
  - Substrate transects
  - Defining site length
- Using 11 stations per transect for observing substrate particles.
- Defining habitat unit criteria methods.
- Assessing bank instability.
- Assigning large wood size categories for eastern Washington.
- Using 100 thalweg increments for all sizes of streams.
- Calculating residual pool depths (PoolUnitDepth) based on the difference between maximum depth and crest depth of field-identified pool habitat units.\(^5\)

A few metric calculations which are still being resolved, such as other measures of bank extent and quality, will be described in a future update of the dictionary.

Note that the calculations described are not fully generalized, but instead refer back to (1) the underlying SQL Server database where the observations are housed and (2) procedures which calculate the metrics. The term `is.null` occurs in the calculations, for example, because null values are allowed in some value fields within the database tables. Procedures test for null values, as needed, when counting observations. Transparency of calculations is key to interpreting metrics, so effort is made to convey how the calculations actually work.

Lastly, included are metrics specific to 12 high-level indicators identified previously by the Washington Forum on Salmon Recovery and Watershed Health. These high-level indicators collectively account for over 100 metrics:

- Wetted width
- Bankfull width
- Channel gradient
- Percent pools
- Residual pool depth
- Pool maximum depth
- Pool crest depth
- Large woody debris frequency
- Large woody debris volume
- Percent fine sediment
- Canopy cover
- Vegetation structure

\(^5\) This supplements rather than replaces the EPA residual pool metric, ResidualPoolArea100.
In interpreting these and other metrics described by the dictionary, readers seeking inferences to particular locations are encouraged to review GRTS probability sampling theory.

Data-collection methods to which the dictionary applies were updated in 2017. Updated methods are not yet offered as citeable documents, so they are temporarily acknowledged here. For copies of the updated methods or earlier methods (Merritt, 2009; Merritt, 2010), contact G. Merritt: gmer461@ecy.wa.gov.

EAP073 Collection of Freshwater Benthic Macroinvertebrates in Streams and Rivers
EAP095 Collecting Water Samples
EAP105 GIS-Based Verification, Layout, and Data Collection (Wide Protocol)
EAP106 Verification and Layout of Sites (Narrow Protocol)
EAP107 Measuring Transect Coordinates with a Global Positioning System (GPS)
EAP108 Collecting In Situ Water Quality
EAP109 Estimating Stream Discharge (Narrow Protocol)
EAP110 Sample Sediment for Chemistry
EAP111 Periphyton Sampling, Processing and Identification in Wadeable Streams
EAP112 Assessing Bank Erosion Vulnerability
EAP113 Measuring Channel Dimensions
EAP114 Estimating Substrate Sizes and Embeddedness at Major Transects
EAP115 Measuring Riparian Cover Using a Convex Densiometer
EAP116 Estimating Fish Cover
EAP117 Assessing Riparian Vegetation Structure
EAP118 Visual Assessment of Human Influence
EAP119 Thalweg Profiling
EAP120 Quantifying Habitat Units
EAP121 Counting Large Woody Debris
EAP122 Measuring Stream Slope (Narrow Protocol)
EAP123 Measuring Compass Bearings (Narrow Protocol)
EAP124 Vertebrate Assemblage Sampling
EAP125 Managing Electronic Data Form Functionality using a Mobile Data-Collection Device
### Metric Category: Bank Quality

<table>
<thead>
<tr>
<th>Reported</th>
<th>WHM export ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank instability ratings, count</td>
<td>N BankInstab</td>
</tr>
<tr>
<td>Bank instability rating, average</td>
<td>X BankInstab</td>
</tr>
</tbody>
</table>
METRIC CATEGORY: Bank Quality

Group: Bank instability
Scope: All non-null observations per DCE, entire site reach
Reported: Bank instability ratings, count (i)
Bank instability rating, average (ii)

Definition: (i) count, of bank instability observations associated with the main channel (channel 0) as observed at the ends of each channel-spanning transect. Unit = observations of instability.
(ii) average, of bank instability observations associated with the main channel (channel 0), as rated at the ends of each channel-spanning transect. Unit = percent.

WHM export ID: (i) N_BankInstab
(ii) X_BankInstab

Observation type: Visual assessment
Allowed observation values: \( \geq 0 \) to \( \leq 100 \)
Data collection schema: Plots at ends of 11 evenly-spaced cross-channel transects, transects perpendicular to channel. Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE): 22; 1 observation per bank X 11 transects
Minimum reporting qualifiers: Survey at least 77% complete (17 plots rated)
Reporting years (to date): 2009-2017

Calculation:
(i) \( \text{count(Bank instability observations)} \neq \text{null} \)
(ii) \( \frac{\Sigma((\text{Bank instability ratings, left bank and right bank}))}{N_{\text{BankInstab}}} \)

\(^1\) X_BankInstab was experimental during 2009 – 2012. New, different bank quality metrics are planned for 2013 onward to incorporate discussion of status of Puget Sound tributaries (see below).

Dependencies: Sufficient bank instability observations collected
Assumptions: Observations sufficient to accurately characterize bank instability.
Source: We did not reference other sources for method of metric calculation. The field method was derived from Moberg (2007):
Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
## Metric Category: Bed Stability

<table>
<thead>
<tr>
<th>Reported</th>
<th>WHM export ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of lithic substrates sized, count</td>
<td>N Lith</td>
</tr>
</tbody>
</table>

Proportion of lithic substrates sized as

| Smooth bedrock (4000-8000 mm) | PPN Lith RS |
| Rough bedrock (4000-8000 mm)  | PPN Lith RR  |
| Hardpan (4000-8000 mm)        | PPN Lith HP  |
| Large boulders (1000-4000 mm) | PPN Lith XB  |
| Small boulders (250-1000 mm)  | PPN Lith SB  |
| Cobble (64-250 mm)            | PPN Lith CB  |
| Coarse gravel (16-64 mm)      | PPN Lith GC  |
| Fine gravel (2-16 mm)         | PPN Lith GF  |
| Sand (0.06-2 mm)              | PPN Lith SA  |
| Fines (0.001-0.06 mm)         | PPN Lith FN  |

\[ \log_{10} \text{geometric mean substrate diameter} \quad D_{gm}\log_{10} \]

Geometric mean substrate diameter \( D_{gm} \)

Relative bed stability \( RBS \)

\[ \log_{10} \text{relative bed stability} \quad LRBS \]

Diagrammatic hierarchical relationship of \( D_{gm} \) and LRBS to dependencies which also report from WHMWeb:

\[
\begin{array}{c|c|c|c|c|}
| D_{gm} & LRBS & RBS \\
| \hline
| D_{gm}\log_{10} & | & | \\
| \hline
| PPN Lith RS & X Slope & | \\
| PPN Lith RR & D_{gm} & | \\
| PPN Lith HP & X TWD & | \\
| PPN Lith XB & RP100 & | \\
| PPN Lith SB & X BFH & | \\
| PPN Lith CB & LWDVMS & | \\
| PPN Lith GC & | & | \\
| PPN Lith GF & | & | \\
| PPN Lith SA & | & | \\
| PPN Lith FN & | & | \\
\end{array}
\]
METRIC CATEGORY: **Bed Stability**

Groups: Geometric mean substrate size
Scope: All non-null observations per DCE, entire site reach
Reported: Substrate particle diameter observations, as

Number of lithic substrates sized, count (i)

Definition:  
 (i) count, of lithic substrate particle diameter observations, as observed, bank-to-bank, along channel-spanning transects, associated with the main channel (channel 0). Unit = observations of particle diameter.

WHM export ID:  
(i) N_Lith

Observation type: Count
Allowed metric values: ≥ 0 to ≤ 100
Data collection schema: Cross-channel transects, bank to bank, where transects are perpendicular to stream current and equidistant along the site reach. Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE), narrow protocol: 231, 11 observations X 21 transects
wide protocol: 121, 11 observations X 11 transects
Minimum reporting qualifiers: Observations at least 70% complete
Reporting years (to date): 2009-2017

Calculation:

(i) for all substrate particle diameter observations, 
{where Substrate_Type_Code <> is.null},

(count (Substrate_Type_Code) <> is.null))

Dependencies: Number of substrate observations within acceptable range.

Assumptions: Observations sufficient to accurately characterize substrate particle diameter as observed along the site reach.


1 if N Lith = 0 then procedure bypasses calculation of PPN Lith* & Dgm. Filter accounts for substrate of 100% pavement. Pavement is classified as non-lithic.
**METRIC CATEGORY: Bed Stability**

Groups: Geometric mean particle size  
Scope: All non-null observations per DCE, entire site reach  
Reported: Proportion lithic substrate, for particle-diameter categories observed, as

- Smooth bedrock (RS), (i)  
- Rough bedrock (RR), (ii)  
- Hardpan (HP), (iii)  
- Large boulders (XB), (iv)  
- Small boulders (SB), (v)  
- Cobble (CB), (vi)  
- Coarse gravel (GC), (vii)  
- Fine gravel (GF), (viii)  
- Sand (SA), (ix)  
- Fines (FN), (x)

Categorical diameter ranges:

- (i ) 4000- 8000 mm (vi ) 64-250 mm  
- (ii ) 4000-8000 mm (vii) 16-64 mm  
- (iii) 4000-8000 mm (viii) 2-16 mm  
- (iv) 1000-4000 mm (ix ) 0.06-2 mm  
- (v ) 250-1000 mm (x ) silt, clay, non-gritty, 0.001 – 0.06 mm

**Definition:** For substrate particle-diameter categories (i - x):

- narrow protocol; direct observation of lithic substrates present:
  
(i - x) areal proportion, of channel bed, along the site reach, composed of the specified particle diameter category, as observed, bank-to-bank, at channel-spanning transects, associated with the main channel (channel 0). A result of 1.0 indicates that the channel bed, as observed along the site reach, was composed of a single substrate particle diameter category. Unit = unitless.

- wide protocol; lithic substrate particle diameters present generally indirectly inferred from probing with poles or rods due to deeper water:

(i - x) areal proportion, of channel bed, along the site reach, dominated by the specified lithic particle diameter category, as observed, bank-to-bank, at channel-spanning transects, associated with the main channel (channel 0). A result of 1.0 indicates that the channel bed, as observed along the site reach, was dominated by a single substrate particle diameter category. Unit = unitless.

**WHM export ID:**

(i ) PPN_Lith_RS  
(ii ) PPN_Lith_RR  
(iii) PPN_Lith_HP  
(iv) PPN_Lith_XB  
(v ) PPN_Lith_SB  
(vi ) PPN_Lith_CB  
(vii) PPN_Lith_GC  
(viii) PPN_Lith_GF  
(ix ) PPN_Lith_SA  
(x ) PPN_Lith_FN
Observation type: Categorical rating
Allowed metric values: ≥ 0 to ≤ 100
Data collection schema: Cross-channel transects, bank to bank, where transects are perpendicular to stream current and equidistant along the site reach. Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE), narrow protocol: 231, 11 observations X 21 transects
wide protocol: 121, 11 observations X 11 transects
Minimum reporting qualifiers: narrow protocol: Observations at least 70% complete
wide protocol: All 11 transect required
Reporting years (to date): 2009-2017

Calculation:

\[(i - ix) \text{ for each unique substrate particle diameter category,}
\{\text{where Substrate\_Type\_Code} <> \text{is.null}\},
\{\text{where Substrate\_Type\_Code} = i\}\]

\[(\text{count (Substrate\_Type\_Code) <> is.null)}) / (N\_Lith)\]

where, \(N\_Lith = \text{count of particle diameter observations.}\)

Dependencies: \(N\_Lith\) within acceptable range.

Assumptions: Diameter ranges sufficient to accurately characterize substrate particle diameter as observed along the site reach.


Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: **Bed Stability**

Groups: Geometric mean particle diameter
Scope: All non-null observations per DCE, entire site reach

Reported: As observed, for all lithic substrate particle-diameter categories combined,

Log$_{10}$ of geometric mean bed substrate diameter (i)
Geometric mean bed substrate diameter (ii)

See URL below for definitions of categorical particle-diameter ranges

Definition: These two metrics build on calculations for proportions of lithic substrates.

(i) an exponent, determined from a logarithmic average diameter of each lithic substrate category, and from the proportion of each lithic category observed along the site reach, bank-to-bank, at channel-spanning transects, associated with the main channel (channel 0). Unit = log 10 millimeters.

(ii) the geometric central tendency of lithic substrate particle diameter, as a function of the exponent, (i). Unit = millimeters.

WHM export ID: (i) $D_{gm}$Log$_{10}$
(ii) $D_{gm}$

Observation type: Categorical rating
Allowed metric values: $\geq 0$ to $\leq 100$
Data collection schema: 21 cross-channel transects, bank to bank, where transects are perpendicular to stream current and equidistant along the site reach. Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE), narrow protocol: 231, 11 observations X 21 transects
wide protocol: 121, 11 observations X 11 transects
Minimum reporting qualifiers: Observations at least 70% complete
Reporting years (to date): 2009-2017

Calculation:

(i) for proportion of each unique proportion of lithic substrate diameter class, $a$ to $x$
{where Substrate_Type_Code <> is.null}, use

(Proportion_Lithic_Substrate) * (Log$_{10}$_Class_Mean_Diameter) = $Y$

resulting in, for diameter classes $a$ to $x$, $Y_a$, ..., $Y_x$

where,
<table>
<thead>
<tr>
<th>Substrate Type</th>
<th>Code</th>
<th>Log$_{10}$ Class Mean Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smooth bedrock</td>
<td>RS</td>
<td>3.752574989</td>
</tr>
<tr>
<td>Rough bedrock</td>
<td>RR</td>
<td>3.752574989</td>
</tr>
<tr>
<td>Hardpan</td>
<td>HP</td>
<td>3.752574989</td>
</tr>
<tr>
<td>Large boulders</td>
<td>XB</td>
<td>3.301029996</td>
</tr>
<tr>
<td>Small boulders</td>
<td>SB</td>
<td>2.698970004</td>
</tr>
<tr>
<td>Cobble</td>
<td>CB</td>
<td>2.102059991</td>
</tr>
<tr>
<td>Coarse gravel</td>
<td>GC</td>
<td>1.505149978</td>
</tr>
<tr>
<td>Fine gravel</td>
<td>GF</td>
<td>0.752574989</td>
</tr>
<tr>
<td>Sand</td>
<td>SA</td>
<td>-0.460409377</td>
</tr>
<tr>
<td>Fines</td>
<td>FN</td>
<td>-2.110924375</td>
</tr>
</tbody>
</table>

\[
\sum (Y_a + \ldots + Y_x) = i = D_{gm}\log_{10}
\]

See below for definitions of proportions of lithic substrates.

(ii) base 10 to the \( i \)th power, or \( 10^i \)

Dependencies: Proportions of lithic substrates within acceptable ranges.

Assumptions: Diameter ranges sufficiently narrow to accurately characterize substrate particle diameter as observed along the site reach.

See Faustini and Kaufmann (2007) for discussion of \( D_{gm} \) vs. \( D_{50} \).


Link to definitions: proportions of lithic substrates.
METRIC CATEGORY: **Bed Stability**

Groups: Relative bed stability  
Scope: All non-null observations per DCE, entire site reach  
Reported: As observed, for all lithic substrate particle-diameter categories combined, the index

Relative bed stability (i)  
Log$_{10}$ of relative bed stability (ii)

See below for definitions of categorical particle-diameter ranges

Definition:  This metrics builds on calculations for proportions of lithic substrates, which are combined, along with several dependencies, through a set of equations into,

(i ) an index, of the influence of human disturbance on stream sediments, as “the ratio of bed surface geometric mean particle diameter ($D_{gm}$) divided by estimated critical diameter ($D_{cbf}$) at bankfull flow, based on a modified Shield’s criterion for incipient motion” (Kaufmann et al., 2008). Stream sediments move frequently if the observed average lithic particle size of a stream bed is smaller than that which the evaluated stream is capable of moving. The degree of this instability of the stream bed is assessed by RBS (Kaufmann et al., 2008). We calculate the form of RBS presented by Kaufman et al. (2008), which takes into account a reduction in bed-shear stress resulting from channel-form roughness. For ease of cross-comparison with other studies, we calculate the index for a water temperature of 20 °C. Unit = none, dimensionless ratio.

(ii) (i) above, as Log$_{10}$RBS. Unit = none, dimensionless.

These definitions are identical to those of Kaufmann et al. (2008) and Kaufmann et al. (2009).

WHM export ID: (i ) RBS  
(ii) LRBS

Observation type: Measurements and categorical ratings
Allowed metric values: -6 to +2  
Expected typical range: -5 to +1  
Data collection schema: Cross-channel transects, bank to bank, where transects are perpendicular to stream current and equidistant along the site reach. Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE), narrow protocol: 231, 11 observations X 21 transects  
wide protocol: 121, 11 observations X 11 transects
Minimum reporting qualifiers,
narrow protocol: Observations at least 70% complete
wide protocol: All 11 transects required
if wadeable: All 11 transects required
Reporting years (to date): 2009-2017

Calculation:

(i ) determination of relative stability of a stream bed,

where, the constants,

\( \rho = 988.2 \text{ kg m}^{-3}, \text{ mass density of freshwater at 20 } ^\circ \text{C} \)
\( \rho_{\text{sed}} = 2650 \text{ kg m}^{-3}, \text{ average density of silicate minerals} \)
\( \nu = 1.004\times10^{-6} \text{ m}^2 \text{s}^{-1}, \text{ kinematic viscosity of water at 20 } ^\circ \text{C} \)
\( g = 9.81 \text{ m s}^{-2}, \text{ gravitational acceleration} \)

and where, the dependencies,

EPA notation          our equivalent
\( S = \) slope of reach water surface, m m\(^{-1}\),  X Slope
\( d_{\text{th}} = \) mean thalweg depth, m  X TWdepth
\( d_{\text{th-bf}} = \) mean (thalweg depth + bankfull height above water surface), m
\( d_{\text{h}} = \) hydraulic mean depth
---- approximated as \( 0.65(d_{\text{th}}) \)
\( d_{\text{h-bf}} = \) hydraulic mean depth at bankfull
---- approximated as \( 0.65(d_{\text{th-bf}}) \)
\( d_{\text{res}} = \) mean thalweg residual depth, m  X ResPoolArea100
\( Wd = \) wood volume per bankfull channel  LWD VolumeMSq
planform area (i.e., wood depth), m\(^3\) m\(^{-2}\)
\( D_{\text{gm}} = \) geometric mean bed surface particle diameter, from systematic pebble counts, m

\( ^{1}: d_{\text{th-bf}} = \) approximation of \( R_{\text{bf}} \) in determining RBS at bankfull (personal communication, P. Kaufmann 5/2013)

are defined elsewhere in our metric dictionary. See links to below.

then,

a) calculate hydraulic radius at bankfull, approximated as

\[
R_{\text{bf}} = 0.65d_{\text{th-bf}}
\]

b) calculate total hydraulic resistance, as
\[ C_t = 1.21d_{res}^{1.08}(d_{res} + Wd)^{0.638}d_{th}^{-3.32}, \quad \text{where} \]
\[ \text{if } C_t < C_p, \ C_t = C_p, \text{else } C_t \]
c) calculate particle hydraulic resistance, as
\[ C_p = \frac{1}{8}\{2.03 \log_{10}(12.2d_h/D_{gm})\}^{-2}, \quad \text{where} \]
\[ \text{if } C_p < 0.002, \text{else } 0.002 \]
d) calculate particle Reynolds number at bankfull, as
\[ Re_p = \frac{(gR_\text{bf}S)^{0.5}D_{gm}}{v} \]
e) calculate Shields number, from particle Reynolds number at bankfull flow, as
\[ \theta = 0.04Re_p^{-0.24}, \quad \text{if } Re_p \leq 26 \]
\[ \theta = 0.5\{0.22Re_p^{-0.6} + 0.06(10^{-7.7Re_p^{-0.6}})\}, \quad \text{if } Re_p > 26 \]
f) calculate RBS at bankfull flow, as
a ratio comparing observed mean bed particle diameter to the diameter of particles that can be mobilized at bankfull flow,
\[ RBS = D_{gm} / D_{\text{critical\_bankfull}} \]
\[ = D_{gm} / (0.604R_\text{bf}S/\theta) \]
\[ = 1.66\theta D_{gm} / (R_\text{bf}S) \]
\[ \text{or } 1.66\theta D_{gm} / \{R_\text{bf}(C_p/C_t)^{1/3}S\} \]
where \((C_p/C_t)^{1/3}\) is an adjustment applied to bankfull shear stress to account for channel-form roughness
g) calculate LRBS at bankfull flow, as
\[ LRBS = \log_{10}(RBS) \]

Dependencies: As listed above.

Assumptions: Observations sufficient to accurately characterize substrate particle diameter as observed along the site reach.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Links to definitions,
  Proportions of Lithic Substrates
  X Slope
  X TWDepth
  ResPoolArea
  LWDVolumeMSq
  D2em
## Metric Category: Channel Dimensions

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Residual pool depths, count \( N \) ResPoolArea
Vertical residual pool area, total \( \text{ResPoolArea} \)
Standardized vertical residual pool area, total \( \text{ResPoolArea100} \)

Diagrammatic hierarchical relationship of \( \text{ResPoolArea100} \) to dependencies which also report from WHMWeb:

```
ResPoolArea100
       |   
       |   ___________
       |   ResPoolArea
       |   |   Site Length
       |   |   X Slope
       |   |   N TWStations
       |   |   X TWDepth
       |   |   SD TWDepth
```
**METRIC CATEGORY:** Channel Dimensions

**Group:** Slope  
**Scope:** All non-null observations per DCE, entire site reach  
**Reported:** Slope of study reach, average (i)

**Definition:** (i) average, elevational change between upstream and downstream ends of a site reach along the main channel (channel 0), as observed during a DCE. Unit = percent.

**WHM export ID:** (i ) X_Slope

**Observation type:** Measurement  
**Allowed values:** > 0  
**Data collection schema:** Length of site reach  
Site reach length is variable, 150 - 2000 m.

**Maximum observations (DCE):** 1  
**Minimum reporting qualifiers:** 1  
**Reporting years (to date):** 2009-2017

**Calculation:**  
(i ) Usually determined at site by field staff.

**Dependencies:** None.

**Assumptions:** In cases where X_Slope is determined from digital imagery, elevation data is sufficiently accurate.

**Sources:** Kaufmann et al., 1999; Peck et al., 2005, 2006.

**Further documentation:** [https://fortress.wa.gov/ecy/publications/summarypages/1203029.html](https://fortress.wa.gov/ecy/publications/summarypages/1203029.html)
METRIC CATEGORY: Channel Dimensions

Group: Channel width
Scope: All non-null observations per DCE, entire site reach

Reported: Bankfull width, count (i)
Bankfull width, average (ii)
Bankfull width, standard deviation (iii)

Definition: (i) count, of bankfull width observations associated with the main channel (channel 0), at each channel spanning transect. Unit = observations of bankfull width.

(ii) average, of bankfull width observations, as the horizontal distance between bankfull margins (often present as scour lines), bank-to-bank and perpendicular to stream current, associated with the main channel (channel 0), at each channel-spanning transect. Unit = meters.

(iii) standard deviation, of bankfull width observations associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = meters.

WHM export ID: (i) N_BFWidth
(ii) X_BFWidth
(iii) SD_BFWidth

Observation type: Measurement
Allowed values: > 0
Data collection schema: Cross-channel transects, perpendicular to channel.
Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE), narrow protocol: 21; 1 bankfull width observation X 21 transects
wide protocol: 11; 1 bankfull width observation X 11 transects

Minimum reporting qualifiers,
Narrow protocol: 11 observations
Wide protocol: Observations at least 80% complete

Reporting years (to date): 2009-2017

Calculation:
(i) count(BFWidth) <> is.null
(ii) ( Σ (BFWidth)) / N_BFWidth
(iii) ( Σ ((BFWidth – X_BFWidth)^2)/(N_BFWidth-1))^1/2

Dependencies: N_BFWidth must be known to calculate X_BFWidth and SD_BFWidth.
Assumptions: Observations sufficient to accurately characterize bankfull width of site reach.
Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.
Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY:  Channel Dimensions

Group:  Channel width
Scope:  All non-null observations per DCE, entire site reach

Reported:  Wetted width, count (i)
           Wetted width, average (ii)
           Wetted width, standard deviation (iii)

Definition:  (i) count, of wetted width observations associated with the main channel (channel 0), as observed at each channel-spanning transect. Unit = observations of wetted width.

           (ii) average, of wetted width measurements, as the horizontal distances between wetted margins (i.e., shorelines), bank-to-bank and perpendicular to stream current, associated with the main channel (channel 0), at each channel-spanning transect. Unit = meters.

           (iii) standard deviation, of wetted width measurements associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = meters.

WHM export ID:  (i ) N_WetWidth
                (ii ) X_WetWidth
                (iii) SD_WetWidth

Observation type:  Measurement
Allowed values:  > 0
Data collection schema:  Evenly-spaced, cross-channel transects, perpendicular to channel. Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE), narrow protocol:  21; 1 wetted width observation X 21 transects
          wide protocol:  11; 1 wetted width observation X 11 transects
Minimum reporting qualifiers:  Observations at least 80% complete
Reporting years (to date):  2009-2017

Calculation:
   (i ) count(WWidth) <> is.null
   (ii ) ( Σ (WWidth)) / N_WetWidth
   (iii) ( Σ ((WWidth – X_WetWidth)^2)/(N_WetWidth-1))^1/2

Dependencies:  N_WetWidth must be known to calculate X_WetWidth and SD_WetWidth
Assumptions:  Observations sufficient to accurately characterize wetted width of site reach.
Sources:  Kaufmann et al., 1999; Peck et al., 2005, 2006.
Further documentation:  https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: Channel Dimensions

Groups: Site length
Scope: All non-null observations per DCE, entire site reach

Reported: Length of site reach, distance (i)
          Thalweg increment, distance (ii)

Definition: (i) length, as 20 initial bankfull widths, the upper and lower ends of the site reach determined by centering, on the sample point, a distance equal to 20 initial bankfull widths, along the sinuous watercourse of the main channel (channel 0). Unit = meters.

          (ii) increment, between thalweg stations associated with the main channel (channel 0) where each increment of the main channel (channel 0) = 1/100 of total length of the site reach. Unit = meters.

WHM export ID:   (i ) Site_Length
                (ii) TWIncrement¹

¹ included due to role in calculation of several other metrics.

Observation type: Measurement
Allowed values,
                  (i ) 150 – 2000
                  (ii) 1.5 – 20

Data collection schema:
                  (i ) Observations of bankfull width.
                  (ii) Site reach. Length of site reach is variable, 150 - 2000 m.

Maximum observations (DCE),
                  (i ) 5
                  (ii) 1, as length of site reach

Minimum reporting qualifiers: Observations complete

Reporting years (to date): 2009-2017

Calculation:
                  (i) to lay out the site reach, let

                      Initial_BFWidth = (width₁ +…..+ width₅) / 5, then

                      Initial_BFWidth X 20, rounded to nearest m,

                  except if

                      (i) < 150, then (i) = 150
                      (i) > 2000, then (i) = 2000,
where the site reach is centered on coordinates from a Generalized Random Tessellation Stratified probability sample draw,

and where, Initial_BFWidth = a bankfull width observation used only to lay out the site reach.

(ii) Site-Length / 100

except if

(i) < 150, then 1.5
(ii) > 2000, then 20

Dependencies: Site Length is 20 times the average five pre-sampling estimates of the bankfull width of the water body being sampled. The exception is extremes (i.e., < 7.5 m wide or > 100 m wide). See further documentation for handling of extremes.

Assumptions: Site coordinates and bankfull marks interpreted correctly.


Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: Channel Dimensions

Group: Channel depth
Scope: All non-null observations per DCE, entire site reach

Reported: Thalweg depth, count (i)
           Thalweg depth, average (ii)
           Thalweg depth, standard deviation (iii)

Definition: (i) count, of thalweg depth observations associated with the main channel (channel 0), where each increment of the main channel (channel 0) = 1/100 of total length of the site reach. Unit = observations of thalweg depth.

(ii) average, of thalweg depth observations, as the vertical distance between the channel bed and water surface elevation, perpendicular to the water surface and at the deepest cross-channel point, at each channel increment associated with the main channel (channel 0). Unit = centimeters.

(iii) standard deviation, of thalweg depth observations associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = centimeters.

WHM export ID: (i ) N_TWDepth
               (ii ) X_TWDepth
               (iii) SD_TWDepth

Observation type: Measurement
Allowed values: ≥ 0
Data collection schema: 100 equally-spaced thalweg stations along the length of the site reach beginning at the downstream end of the reach. Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE): 100 thalweg stations per site reach, 1 observation per station

Minimum reporting qualifiers: Observations 100% complete

Reporting years (to date): 2009-2017

Calculation:
   (i ) count(TWDepth) <> is.null
   (ii ) ( Σ (TWDepth)) / N_TWDepth
   (iii) ( Σ ((TWDepth – X_TWDepth)^2)/(N_TWDepth-1))^1/2

Dependencies: N_TWDepth must be known to calculate X_TWDepth and SD_TWDepth.
Assumptions: Observations sufficient to accurately characterize thalweg of site reach.
Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: **Channel Dimensions**

**Group:** Channel depth  
**Scope:** All non-null observations per DCE, entire site reach  
**Reported:** Bankfull height, count (i)  
Bankfull height, average (ii)  
Bankfull height, standard deviation (iii)  

**Definition:**  
(i) count, as the number of transects associated with the main channel (channel 0), where bankfull height was recorded for at least one bank, as observed at the ends of each channel-spanning transect, left bank to right bank, where each transect is perpendicular to stream current. Unit = observations of bankfull height.  
(ii) average, overall, of bankfull height observations per transect, as the vertical distances, water surface-to-high-water mark, as observed at the ends of each channel-spanning transect, associated with the main channel (channel 0). Unit = centimeters.  
(iii) standard deviation, of average bankfull height observations per transect associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = centimeters.  

**WHM export ID:**  
(i ) N_BFHeight  
(ii ) X_BFHeight  
(iii) SD_BFHeight  

**Observation type:** Measurement  
**Allowed metric values:** ≥ 0  
**Data collection schema:** Evenly-spaced, cross-channel transects, equidistant and perpendicular to channel. Site reach length is variable, 150 - 2000 m.  

**Maximum observations (DCE), narrow protocol:** 22; 1 observation X 2 banks X 11 transects  
**Maximum observations (DCE), wide protocol:** 11, 1 observation X 1 bank X 11 transects  
**Minimum reporting qualifiers:** Observations at least 80% complete  
**Reporting years (to date):** 2009-2017  

**Calculation:**  
(i ) count(transects) where, for each transect, 
left_BF_Height + right_BF_Height <> is.null  
(ii ) if left_BF_Height and right_BF_Height,  
average(left_BF_Height + right_BF_Height) = BFH  
else if left_BF_Height or right_BF_Height,
\[ (*_{BF\_Height}) = BF\_Height, \text{ where } * = \text{left or right} \]
\[ \text{average}(BF\_Height) = BFH \]
\[ \text{else exclude transect from average} \]
\[ \left( \sum (BFH) \right) / N_{BFHeight} \]

(iii) \[ \left( \sum (BFH - X_{BFHeight})^2 / (N_{BFHeight} - 1) \right)^{1/2} \]

where BFH = average bankfull height per transect

Dependencies: None

Assumptions: Bankfull stage has been correctly identified. Measurement from bankfull stage to water surface is plumb.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY:  Channel Dimensions

Group:  Channel cross section
Scope:  All non-null observations per DCE, entire site reach

Reported:  Bankfull depth, count (i)
Bankfull depth, average (ii)
Bankfull depth, standard deviation (iii)

Definition:  
(i)  count, of paired bankfull height and thalweg depth observations associated with the main channel (channel 0), as observed at each channel-spanning transect. Unit = pairs of bankfull height and thalweg depth.

(ii) average, of bankfull depths, as the vertical distances between the bankfull mark and the water surface plus the thalweg depth, associated with the main channel (channel 0), as observed for each channel-spanning transect. Unit = centimeters.

(iii) standard deviation, of bankfull depths associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = centimeters.

WHM export ID:  (i )  N_BFDepth
(ii )  X_BFDepth
(iii)  SD_BFDepth

Observation type:  Measurement
Allowed metric values:  ≥ 0
Data collection schema:  11 cross-channel transects, equally-spaced and perpendicular to channel. Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE), narrow:  30; (1 bankfull height X 2 banks) + 1 thalweg depth per transect X 10 transects
wide:  20; (1 bankfull height X 1 bank) + 1 thalweg depth per transect X 10 transects

Minimum reporting qualifiers:  Observations at least 80% complete
Reporting years (to date):  2009-2017

Calculation:

(i )  count(transects) where, for each transect,
   {left_BF_Height + right_BF_Height <> is.null} and TW_Depth <> is.null
(ii )  if left_BF_Height <> is.null and right_BF_Height <> is.null,
   (average(left_BF_Height + right_BF_Height) + TW_Depth) = BF_Depth
   if left_BF_Height or right_BF_Height,
\((*_\text{BF\_Height} + \text{TW\_Depth}) = \text{BF\_Depth}\), where * = left or right

else exclude transect from average

\((\sum (\text{BF\_Depth})) / \text{N\_BFDepth}\)

(iii) \((\sum ((\text{BF\_Depth} - \text{X\_BFDepth})^2) / (\text{N\_BFDepth} - 1))^{1/2}\)

where, \(\text{TW\_Depth}\) = an observation of thalweg depth.

Dependencies: Paired bankfull height and thalweg depth per transect were recorded.

Assumptions: Equivalent to direct measurement of maximum depth at winter bankfull condition.

Source: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
**METRIC CATEGORY:** Channel Dimensions

**Group:** Channel cross section  
**Scope:** All non-null observations per DCE, entire site reach  
**Reported:** Wetted cross-sectional area, count (i)  
Wetted cross-sectional area, average (ii)  
Wetted cross-sectional area, standard deviation (iii)  

**Definition:**  
(i) count, of paired wetted width and thalweg depth observations associated with the main channel (channel 0), as observed at each channel-spanning transect. Unit = observations of paired wetted width and thalweg depth.  
(ii) average, of wetted cross-sectional areas, approximated by a rectangle with Side A of horizontal distance between wetted shorelines, bank-to-bank and perpendicular to stream current, and Side B of thalweg depth, at each channel-spanning transect associated with the main channel (channel 0). Unit = square meters.  
(iii) standard deviation, of wetted cross-sectional area estimates associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = square meters.

**WHM export ID:**  
(i ) N_Wet_WxD  
(ii ) X_Wet_WxD  
(iii) SD_Wet_WxD  

**Observation type:** Measurement  
**Allowed metric values:** ≥ 0  
**Data collection schema:** Cross-channel transects, equidistant and perpendicular to channel. Site reach length is variable, 150 - 2000 m.  
**Maximum observations (DCE), narrow protocol:** 21; (1 wetted width + 1 thalweg depth) X 21 transects  
**Maximum observations (DCE), wide protocol:** 11; (1 wetted width + 1 thalweg depth) X 11 transects  
**Minimum reporting qualifiers:** Observations at least 80% complete  
**Reporting years (to date):** 2009-2017  

**Calculation:**  
(i ) count(transects) where, for each transect, WWidth and TW_Depth <> is.null  
(ii ) if, for each transect, WWidth and TW_Depth <> is.null then WWidth X TW_Depth = Wet_WxD  
else exclude transect from average
\[
\frac{\sum (\text{Wet}_W \times \text{D})}{N_{\text{Wet}_W \times \text{D}}}
\]

(iii) \[
\left( \frac{\sum ((\text{Wet}_W \times \text{D} - \text{X}_{\text{Wet}_W \times \text{D}})^2)/(N_{\text{Wet}_W \times \text{D}} - 1))^{1/2}}{\text{TW}_\text{Depth} = \text{an observation of depth.}}
\text{WetWidth} = \text{an observation of wetted width.}
\]

Dependencies: Complete pairs of wetted widths and thalweg depths.

Assumptions: Observations sufficient to accurately characterize cross-sectional area of site reach.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

METRIC CATEGORY: **Channel Dimensions**

**Group:** Channel cross section  
**Scope:** All non-null observations per DCE, entire site reach

**Reported:**  
Bankfull cross-sectional area, count (i)  
Bankfull cross-sectional area, average (ii)  
Bankfull cross-sectional area, standard deviation (iii)

**Definition:**  
(i) count, of bankfull width observations associated with the main channel (channel 0), as observed at each channel-spanning transect. Unit = observations of bankfull width.

(ii) average, of bankfull cross-sectional areas, approximated by a rectangle with Side A of horizontal distance between bankfull shorelines, bank-to-bank and perpendicular to stream current, and Side B of bankfull depth, at each channel-spanning transect associated with the main channel (channel 0). Unit = square meters.

(iii) standard deviation, of bankfull cross-sectional area estimates associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = square meters.

**WHM export ID:**  
(i ) N_BF_WxD  
(ii ) X_BF_WxD  
(iii) SD_BF_WxD

**Observation type:** Measurement  
**Allowed values:** > 0  
**Data collection schema:** Cross-channel transects, equidistant and perpendicular to channel. Site reach length is variable, 150 - 2000 m.

**Maximum observations (DCE):** 11; (1 bankfull width + 1 bankfull height) X 11 transects  
**Minimum reporting qualifiers:** Observations at least 80% complete  
**Reporting years (to date):** 2009-2017

**Calculation:**  
(i ) count(transsects) where, for each transect,  
Bankfull width <> is.null  
TW_Depth <> is.null  
BF_Height <> is.null

(ii ) if, for each transect,  
{Bankfull width <> is.null  
BF_Height <> is.null  
TW_Depth <> is.null},  
(Bankfull width) X (BF_Height + TW_Depth) = BF_WxD

deresis
\[
\frac{\sum(BF_{WxD})}{N_{BF_{WxD}}}
\]

(iii) \[\left( \sum (BF_{WxD} - X_{BF_{WxD}})^2/(N_{BF_{WxD}} - 1) \right)^{1/2}\]

where, \(TW\_Depth\) = observations of thalweg depth
\(BF\_Height\) = observations of bankfull height
\(BF\_Width\) = observations of bankfull width

Dependencies: Paired bankfull widths, bankfull heights, and thalweg depths

Assumptions: Observations sufficient to accurately characterize cross-sectional area of site reach.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: Channel Dimensions

Groups: Residual pool area
Scope: All non-null observations per DCE, entire site reach

Reported: Residual pool areas, count (i)
Vertical residual pool area, total (ii)
Standardized vertical residual pool area, total (iii)

Definition: (i) count, of individual depth-to-residual surface estimates, as calculated from the Stack equation, one estimate per thalweg station, for all observations associated with the main channel (channel 0). Unit = observations of depth-to-residual surface.

(ii) summation, of vertical cross sectional area of each residual pool intersected by the thalweg profile, as observed along the site reach, where incremental cross-sectional areas are approximated by a rectangle with Side A of depth of the residual pool, as adjusted to the local datum, and Side B of thalweg increment. Unit = square meters.

(iii) average, as for (ii), except standardized to per 100 meter of site reach. Unit = square meters.

WHM export ID: (i) N_ResPoolDepth
(ii) ResPoolArea
(iii) ResPoolArea100

Observation type: Count
Derived from Site_Length, X_Slope, N_TWStations

Allowed metric values:
(i) 100
(ii) $\geq 0$
(iii) $\geq 0$

Data collection schema: 100 thalweg stations, equidistant along the site reach, where the distance between stations is 1 / 100th of the site reach length. Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE): 100 thalweg stations per site reach, 1 observation per station

Minimum reporting qualifiers: Observations 100% complete
Reporting years (to date): 2009-2017

Calculation:

(i) for each thalweg station,
{where (Thalweg_Depth) $\neq$ is.null}
use length of reach = Site_Length
use count of thalweg stations = N_TWStations
use \( \text{TWIncrement} = \frac{\text{Site Length}}{\text{N_TWStations}} \)

use slope of reach = \( X_{\text{Slope}} \)

use average thalweg depth = \( X_{\text{TWDepth}} \)

use standard deviation thalweg depth = \( SD_{\text{TWDepth}} \)

use \( A = (X_{\text{TWDepth}} - SD_{\text{TWDepth}}) \)

apply Stack equation (1988) to estimate distance to residual surface from local datum as,

a) if,

first thalweg observation for reach, then first distance to residual surface, \( D\text{TRS} \),
as minimum of

\( (A + (0.12 + 0.25(X_{\text{Slope}})) \cdot \text{TWIncrement}) \) OR (first Thalweg\_Depth)

then depth of residual pool, \( DRP \), for first thalweg station, if any, as,

first \( \text{Thalweg\_Depth} - D\text{TRS} \)

then vertical cross-sectional area for first thalweg increment, as

\( ((DRP/100) \cdot \text{TWIncrement} = \text{Individual\_ResPoolArea}) \)

b) else,

distance to residual surface, \( D\text{TRS} \), as

for \( n \) thalweg depths,

\( ((n - ith \text{ Thalweg\_Depth}) + (0.12 + 0.25(X_{\text{Slope}})) \cdot \text{TWIncrement}), \) OR

first \( \text{Thalweg\_Depth} \)

then depth of residual pool, \( DRP \), for first thalweg station, if any, as,

first \( \text{Thalweg\_Depth} - D\text{TRS} \)

then vertical cross-sectional area for first thalweg increment, as

\( ((DRP/100) \cdot \text{TWIncrement} = \text{Individual\_ResPoolArea}) \)

repeat for each thalweg observation

c) count (all(Individual\_ResPoolArea)) \( <> \) is.null

(ii ) for all thalweg observations

\( \sum (\text{Individual\_ResPoolArea}) = \text{ResPoolArea} \)

(iii) \( \frac{\text{ResPoolArea}}{(\text{Site\_Length} / 100)} \)

Dependencies: \( \text{Site\_Length, X\_Slope, N\_TWStations, X\_TWDepth, SD\_TWDepth} \).

Assumptions: Reach slope was determined with sufficient accuracy. Results are sensitive to slope.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006; Stack, 1988

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
### Metric Category: Fish Cover

<table>
<thead>
<tr>
<th>Reported</th>
<th>WHM export ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of fish cover type observations, count</td>
<td>N_FishCover</td>
</tr>
<tr>
<td>Average cover, of type</td>
<td></td>
</tr>
<tr>
<td>Artificial structures</td>
<td>XFC_Artificial</td>
</tr>
<tr>
<td>Boulders</td>
<td>XFC_Boulder</td>
</tr>
<tr>
<td>Brush / woody debris, &lt; 0.3 m diameter</td>
<td>XFC_Brush</td>
</tr>
<tr>
<td>Bryophytes</td>
<td>XFC_Bryophytes</td>
</tr>
<tr>
<td>Algae</td>
<td>XFC_Algae</td>
</tr>
<tr>
<td>Live trees or roots</td>
<td>XFC_TreesRoots</td>
</tr>
<tr>
<td>Macrophytes</td>
<td>XFC_Macrophytes</td>
</tr>
<tr>
<td>Overhanging vegetation</td>
<td>XFC_OvHgVeg</td>
</tr>
<tr>
<td>Undercut</td>
<td>XFC_Undercut</td>
</tr>
<tr>
<td>Woody debris &gt; 0.3 m diameter</td>
<td>XFC_LWD</td>
</tr>
<tr>
<td>Proportion cover, of type</td>
<td></td>
</tr>
<tr>
<td>Artificial structures</td>
<td>PFC_Artificial</td>
</tr>
<tr>
<td>Boulders</td>
<td>PFC_Boulder</td>
</tr>
<tr>
<td>Brush / woody debris, &lt; 0.3 m diameter</td>
<td>PFC_Bush</td>
</tr>
<tr>
<td>Bryophytes</td>
<td>PFC_Bryophytes</td>
</tr>
<tr>
<td>Algae</td>
<td>PFC_Algae</td>
</tr>
<tr>
<td>Live trees or roots</td>
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</tr>
<tr>
<td>Overhanging vegetation</td>
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</tr>
<tr>
<td>Undercut</td>
<td>PFC_Undercut</td>
</tr>
<tr>
<td>Woody debris, &gt; 0.3 m</td>
<td>PFC_LWD</td>
</tr>
<tr>
<td>Average cover, combined types,</td>
<td></td>
</tr>
<tr>
<td>Non-aquatic vegetation types</td>
<td>XFC_NoAqVeg</td>
</tr>
<tr>
<td>Natural cover types</td>
<td>XFC_Natural</td>
</tr>
<tr>
<td>Persistent types</td>
<td>XFC_Persistent</td>
</tr>
<tr>
<td>Proportion cover, combined types,</td>
<td></td>
</tr>
<tr>
<td>Non-aquatic vegetation types</td>
<td>PFC_NoAqVeg</td>
</tr>
<tr>
<td>Natural cover types</td>
<td>PFC_Natural</td>
</tr>
<tr>
<td>Persistent types</td>
<td>PFC_Persistent</td>
</tr>
</tbody>
</table>
METRIC CATEGORY: **Fish Cover**

Groups: Mean fish cover  
Scope: All non-null observations per DCE, entire site reach  
Reported: Number of fish cover observations by type, count (i)  

Definition: \( (i) \) count, of transects\(^1\) where any type of fish-cover observation occurred, for all channel-spanning transects associated with the main channel (channel 0). Unit = observations of fish cover.

\(^1\) though plots are of interest, plots are defined by the transect ID, and the relationship of fish cover evaluation plots to transects is 1:1.

WHM export ID: (i) N_FishCover

Observation type: Count

Allowed metric values: \( \geq 0 \) to \( \leq 11 \)

Data collection schema, 11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with 1 plot per transect. Site reach length is variable, 150 - 2000 m.

- **narrow protocol:** Plot covers 10 m of wetted channel, extending 5 m upstream and 5 m downstream of each transect.
- **wide protocol:** Plots cover 20 m of littoral zone, extending 10 m upstream and 10 m downstream of each transect.

Maximum plot count (DCE): 11, 1 plot X 11 transects

Minimum reporting qualifiers: Observations at least 63% complete (7 of 11 transects rated)

Reporting years (to date): 2009-2017

Calculation:

\( (i) \) for each transect, where fish cover type ratings are stored as Fish_Cover_Percent

\[ \text{if any Fish\_Cover\_Percent} \neq \text{is.null,} \]  
\[ \text{count(unique(Transect\_Code))} \]

Dependencies: A given plot evaluated for at least one type of fish cover.

Assumptions: Observations sufficient to accurately characterize fish cover types observed.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

**METRIC CATEGORY:** Fish Cover

**Groups:** Mean fish cover

**Scope:** All non-null observations per DCE, entire site reach

**Reported:** Fish cover types observed, as

- Artificial structures, average (i)
- Boulders, average (ii)
- Brush / woody debris, average (iii)
- Bryophytes, average (iv)
- Algae, average (v)
- Live trees or roots, average (vi)
- Macrophytes, average (vii)
- Overhanging vegetation, ≤ 1 m of water surface, average (viii)
- Undercut, average (ix)
- Woody debris > 0.3 m diameter, average (x)

**Definition:** For fish cover types (i-x):

(i-x) average, of fish cover ratings per plot, for a given fish-cover type, associated with the main channel (channel 0), as observed, at channel-spanning transects. Unit = percent.

**WHM export ID:**

(i ) XFC_Artifical
(ii ) XFC_Boulder
(iii ) XFC_Brush
(iv ) XFC_Bryophytes
(v ) XFC_Algae
(vi ) XFC_TreesRoots
(vii ) XFC_Macrophytes
(viii ) XFC_OvHgVeg
(ix ) XFC_Undercut
(x ) XFC_LWD

**Observation type:** Categorical rating

**Allowed values:** ≥ 0 to ≤ 87.5

**Data collection schema:**

11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with 1 plot per transect. Site reach length is variable, 150 - 2000 m.

**narrow protocol:** Plot covers 10 m of wetted channel, extending 5 m upstream and 5 m downstream of each transect.

**wide protocol:** Plots cover 20 m of littoral zone, extending 10 m upstream and 10 m downstream of each transect.

**Maximum observations (DCE):** 11 per cover type, 1 observation X 11 transects

**Minimum reporting qualifiers:** Observations at least 63% complete (7 of 11 plots rated)

**Reporting years (to date):** 2009-2017
Calculation:

\[(i-ix)\] for a given fish cover type, e.g., Artificial structures
where fish cover type ratings are stored as Fish_Cover_Percent

\[
\frac{\sum (\text{Fish}_\text{Cover}_\text{Percent})}{N_{\text{FishCover}}}
\]

where, \(N_{\text{FishCover}} = \) count of observations of fish cover

Dependencies: \(N_{\text{FishCover}}\) within acceptable range.

Assumptions: Observations sufficient to accurately characterize fish cover types observed.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
**METRIC CATEGORY:** Fish Cover

**Groups:** Proportion fish cover  
**Scope:** All non-null observations per DCE, entire site reach  
**Reported:** Fish-cover types observed, as

<table>
<thead>
<tr>
<th>Artificial structures, proportion (i)</th>
<th>Live trees or roots, proportion (vi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulders, proportion (ii)</td>
<td>Macrophytes, proportion (vii)</td>
</tr>
<tr>
<td>Brush / woody debris, &lt; 0.3 m diameter, proportion (iii)</td>
<td>Overhanging vegetation, ≤ 1 m of water surface, proportion (viii)</td>
</tr>
<tr>
<td>Bryophytes, proportion (iv)</td>
<td>Undercut, proportion (ix)</td>
</tr>
<tr>
<td>Algae, proportion (v)</td>
<td>Woody debris, &gt; 0.3 m diameter, proportion (x)</td>
</tr>
</tbody>
</table>

**Definition:** For fish cover types (i-x):

(i-x) proportion, of plots containing a given fish-cover type to total plots evaluated, as observed, bank-to-bank, at channel-spanning transects associated with the main channel (channel 0). A value of 1 indicates a fish cover type was observed on all plots. Unit = unitless.

**WHM export ID:**

| (i ) PFC_Artificial | (vi ) PFC_TreesRoots |
| (ii ) PFC_Boulder | (vii ) PFC_Macrophytes |
| (iii ) PFC_Brush | (viii ) PFC_OvHgVeg |
| (iv ) PFC_Bryophytes | (ix ) PFC_Undercut |
| (v ) PFC_Algae | (x ) PFC_LWD |

**Observation type:** Count  
**Allowed metric values:** ≥ 0 to ≤ 1  
**Data collection schema,**  
11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with 1 plot per transect. Site reach length is variable, 150 - 2000 m.

* narrow protocol: Plot covers 10 m of wetted channel, extending 5 m upstream and 5 m downstream of each transect.  
* wide protocol: Plots cover 20 m of littoral zone, extending 10 m upstream and 10 m downstream of each transect.

**Maximum observations (DCE):** 11 per cover type, 1 observation X 11 transects  
**Minimum reporting qualifiers:** Observations at least 63% complete (7 of 11 plots rated)

**Reporting years (to date):** 2009-2017  
**Calculation:**

(i-x) for a given fish cover type, e.g., Artificial structures where fish cover type ratings are stored as Fish_Cover_Percent
(count (where (Fish_Cover_Percent) <> is.null)) / N_FishCover

where, N_FishCover = count of fish cover observations.

Dependencies: N_FishCover within acceptable range.

Assumptions: Observations sufficient to accurately characterize fish cover types observed.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: **Fish Cover**

Groups: Mean fish cover
Scope: All non-null observations per DCE, entire site reach
Reported: Combined fish cover types observed, as

- Non-aquatic vegetation types, average (i)
- Natural cover types, average (ii)
- Persistent types, average (iii)

Definition: For combined fish cover types (i-iii):

(i) average, as sum of all means of individual fish cover type, except for Aquatic Vegetation types (Macrophytes or Bryophytes or Filamentous Algae), as observed, bank-to-bank, at channel-spanning transects associated with the main channel (channel 0). Value may exceed 100% because seven metrics are summed. Unit = percent.

(ii) same as for (i), except limited to natural fish cover types (all types except Artificial Structures). Value may exceed 100% because nine metrics are summed. Unit = percent.

(iii) same as for (i), except limited to persistent fish cover types (Artificial Structures or Boulders or Live Trees and Roots or Large Wood or Undercut Banks). Value may exceed 100% because five metrics are summed. Unit = percent.

Categorical % average cover ratings assigned:

- 0: if 0% of water surface
- 5: if 1-10% of water surface
- 25: if 11-40% of water surface
- 57.5: if 41-75% of water surface
- 87.5: if >75% of water surface

WHM export ID:

- (i) XFC_NoAqVeg
- (ii) XFC_Natural
- (iii) XFC_Persistent

Observation type: Categorical ratings
Allowed metric values:

- (i) \( \geq 0 \) to \( \leq 612.5 \)
- (ii) \( \geq 0 \) to \( \leq 787.5 \)
- (iii) \( \geq 0 \) to \( \leq 437.5 \)

Data collection schema, narrow protocol:

11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with 1 plot per transect. Site reach length is variable, 150 - 2000 m.

Plot covers 10 m of wetted channel, extending 5 m upstream and 5 m downstream of each transect.
wide protocol: Plots cover 20 m of littoral zone, extending 10 m upstream and 10 m downstream of each transect.

Maximum observations (DCE): 11 per cover type, 1 observation per transect X 11 transects

Minimum reporting qualifiers: Observations at least 63% complete (7 of 11 plots rated)

Reporting years (to date): 2009-2017

Calculation:

(i-iii) for the means of specified individual fish cover types, XFC_*, such as XFC_NoAqVeg,

$\sum (XFC_* < > \text{is.null})$

See below for definitions of means of individual fish cover types.

Dependencies: N_FishCover within acceptable range.

Assumptions: Observations sufficient to accurately characterize fish cover types observed.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Link to definitions, individual fish cover types
METRIC CATEGORY: Fish Cover

Groups: Proportion fish cover
Scope: All non-null observations per DCE, entire site reach
Reported: Combined fish cover types observed, as

- Non-aquatic vegetation types, proportion (i)
- Natural cover types, proportion (ii)
- Persistent types, proportion (iii)

Definition: For combined fish-cover types (i-iii):

(i) proportion, as ratio of the number of FishCover rating plots where any cover type except Aquatic Vegetation (i.e., Macrophytes or Bryophytes or Filamentous Algae) was observed, to total plots evaluated, as observed, bank-to-bank, at channel-spanning transects associated with the main channel (channel 0). A value of 1 indicates a fish cover type other than Aquatic Vegetation was observed on all plots. Unit = unitless.

(ii) same as for (i), except limited to natural FishCover types (i.e., all types except Artificial Structures). A value of 1 indicates a fish cover type other than Artificial Structures was observed on all plots. Unit = unitless.

(iii) same as for (i), except limited to persistent FishCover types (i.e., Artificial Structures or Boulders or Live Trees and Roots or Large Wood or Undercut Banks). A value of 1 indicates these fish cover types were observed on all plots. Unit = unitless.

WHM export ID: (i ) PFC_NoAqVeg
(ii ) PFC_Natural
(iii ) PFC_Persistent

Observation type: Count
Allowed metric values: ≥0 to ≤1
Data collection schema, 11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with 1 plot per transect. Site reach length is variable, 150 - 2000 m.

narrow protocol: Plot covers 10 m of wetted channel, extending 5 m upstream and 5 m downstream of each transect.
wide protocol: Plots cover 20 m of littoral zone, extending 10 m upstream and 10 m downstream of each transect.

Maximum observations (DCE): 11 per DCE, 1 observation per transect X 11 transects
Minimum reporting qualifiers: Observations at least 63% complete (7 of 11 plots rated)
Reporting years (to date): 2009-2017
Calculation:

\[(i-iii)\quad \text{for plots where any of the specified fish cover types are observed,}\]

where fish cover type ratings are stored as \text{Fish\_Cover\_Percent},
count each plot once, as

\[
\frac{\text{count (where (Fish\_Cover\_Percent) <> is.null))}}{N\_FishCover}
\]

where, \text{N\_FishCover} = \text{count of fish cover observations}.

Dependencies: \text{N\_FishCover} within acceptable range.

Assumptions: Observations sufficient to accurately characterize fish cover types observed.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summariespages/1203029.html
**Metric Category: Habitat Unit Dimensions**

<table>
<thead>
<tr>
<th>Reported</th>
<th>WHM export ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pool crest depth, count</td>
<td>N_PoolCrestDepth</td>
</tr>
<tr>
<td>Pool crest depth, average</td>
<td>X_PoolCrestDepth</td>
</tr>
<tr>
<td>Pool maximum depth, count</td>
<td>N_PoolMaxDepth</td>
</tr>
<tr>
<td>Pool maximum depth, average</td>
<td>X_PoolMaxDepth</td>
</tr>
<tr>
<td>Pool unit depth, count</td>
<td>N_PoolUnitDepth</td>
</tr>
<tr>
<td>Pool unit depth, average</td>
<td>X_PoolUnitDepth</td>
</tr>
<tr>
<td>Pool unit depth, std.dev.</td>
<td>SD_PoolUnitDepth</td>
</tr>
</tbody>
</table>
METRIC CATEGORY: **Habitat Unit Dimensions**

**Group:** Residual pool depth  
**Scope:** All non-null observations per DCE, entire site reach, all detected pools

**Reported:**  
- Pool crest depth, average (i)  
- Pool maximum depth, average (ii)  
- Pool unit depth, count (iii)  
- Pool unit depth, average (iv)  
- Pool unit depth, standard deviation (v)

**Definition:** Description of pool characteristics for each detected pool along the site reach, surveyed using stream profile consisting of 100 thalweg observations stations, as

(i) count, of pool crest depth observations associated with the main channel (channel 0), one per pool. Unit = observations of pool crest depth.

(ii) count, of pool maximum depth observations associated with the main channel (channel 0), one per pool. Unit = observations of maximum pool depth.

(iii) average, of depth observations associated with the main channel (channel 0), one per pool, as the distance, water surface-to-crest of substrate

   a) at the downstream rim of each scour pool or plunge pool,  
   b) at the upstream shallow point of each dammed pool.  
   Unit = cm.

(iv) same as for (iii), except substituting pool maximum depth for pool crest depth. Unit = cm.

(v) count, of differences, pool maximum depth minus pool crest depth, for all pairs of depth observations, one pair per pool. Unit = unitless.

(vi) average, of differences, pool maximum depth minus pool crest depth, for all pairs of depth observations, one pair per pool associated with the main channel (channel 0). Unit = cm.

(vii) standard deviation, of differences, pool maximum depth minus pool crest depth, associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = cm.

**WHM export ID:**  
(i) N_PoolCrestDepth  
(ii) N_PoolMaxDepth  
(iii) X_PoolCrestDepth  
(iv) X_PoolMaxDepth  
(v) N_PoolUnitDepth  
(vi) X_PoolUnitDepth  
(vii) SD_PoolUnitDepth

**Observation type:** measurement

**Allowed observation values:** $\geq 0$
Data collection schema: reach of main channel, divided into habitat units. Number and length of habitat units is variable. Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE) no limit, typically < 20
Minimum reporting qualifiers: habitat unit survey 100% complete. No missing or out-of-sequence habitat units.

Reporting years (to date): 2009-2017

Calculation:
(i) for all pools observed, count(PoolCrestDepth observations) as N_PoolCrestDepth
(ii) for all pools observed, count(PoolCrestDepth observations) as N_PoolMaxDepth
(iii) (Σ(PoolCrestDepth)) / N_PoolCrestDepth
(iv) (Σ(PoolMaxDepth)) / N_PoolMaxDepth
(v) (count(pairs(PoolCrestDepth and PoolMaxDepth)))
(vi) (Σ(paired(PoolMaxDepth - PoolCrestDepth))) / N_PoolUnitDepth

( Σ ((PoolMaxDepth -PoolCrestDepth)) – X_PoolUnitDepth)^2) / (N_PoolUnitDepth-1))^1/2

Dependencies: Pool count > 1 to calculate SD_PoolUnitDepth.

Assumptions: Observations sufficient to accurately characterize residual pool characteristics.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
**Metric Category: Habitat Unit Extent**

<table>
<thead>
<tr>
<th>Reported</th>
<th>WHM export ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative length of site reach as</td>
<td></td>
</tr>
<tr>
<td>Dry channel</td>
<td>PCT_Dry</td>
</tr>
<tr>
<td>Wetted channel</td>
<td>PCT_Wet</td>
</tr>
<tr>
<td>Fast turbulent</td>
<td>PCT_FastT</td>
</tr>
<tr>
<td>Fast non-turbulent</td>
<td>PCT_FastNT</td>
</tr>
<tr>
<td>Fast (turbulent + non-turbulent)</td>
<td>PCT_Fast</td>
</tr>
<tr>
<td>Plunge pool</td>
<td>PCT_PoolPlunge</td>
</tr>
<tr>
<td>Scour pool</td>
<td>PCT_PoolScour</td>
</tr>
<tr>
<td>Dammed pool</td>
<td>PCT_PoolDammed</td>
</tr>
<tr>
<td>Pools, all types combined,</td>
<td>PCT_Pool</td>
</tr>
<tr>
<td>(plunge + scour + dammed)</td>
<td></td>
</tr>
</tbody>
</table>
METRIC CATEGORY: Habitat Unit Extent

Groups: Dry, Wet, Fast, Pool
Scope: All non-null observations per DCE, entire site reach

Reported: Channel habitat types observed, as relative lengths of:

- Dry channel (i)
- Wetted channel (ii)
- Fast turbulent (iii)
- Fast non-turbulent (iv)
- Fast (turbulent + non-turbulent) (v)
- Plunge pool (vi)
- Scour pool (vii)
- Dammed pool (viii)
- Pool (plunge + scour + dammed) (ix)

Definition: For habitat types (i-ix):

(i-ix) percent, of thalweg stations, associated with a given habitat type, where each increment of the main channel (channel 0) is assigned a habitat type code, and each increment = 1/100 of total length of the site reach. Unit = percent.

Fast, turbulent water includes falls, rapids, riffles, and chutes.

Fast, non-turbulent water includes sheets and runs.

WHM export ID: (i) PCT_Dry (vi) PCT_PoolPlunge
(ii) PCT_Wet (vii) PCT_PoolScour
(iii) PCT_FastT (viii) PCT_PoolDammed
(iv) PCT_FastNT (ix) PCT_Pool
(v) PCT_Fast

Observation type: Category assigned from visual survey
Allowed values: Habitat type codes
Data collection schema: 100 equally-spaced thalweg profile stations, at the end of each increment of the main channel one code assigned per station. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE) 100 thalweg stations per site reach, 1 observation per station
Minimum reporting qualifiers: Observations 100% complete
Reporting years (to date): 2009-2017

Calculation:

(i-ix) For each Habitat Type, e.g., Dry channel

\[
\text{count (stations of Habitat Type)} / \text{count (N_TW Depth)} \times 100
\]

Note: thalweg depths are counted instead of stations as an observation could be omitted.
where, $N_{TWDepth} = \text{count of thalweg depth observations}$

Dependencies: $N_{TWDepth}$ must be known to calculate percent site length as habitat type.

Assumptions: Observations sufficient to accurately characterize Habitat unit descriptions are accurate.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

**Metric Category: Large Woody Debris**

Metrics for large woody debris (LWD) generally follow the approach of Kaufmann et al. (1999), which provides a more compact description of these metrics. Here, the approach is to document each metric reported, and its calculation, either as a count or as a volume. Metrics for individual LWD size classes and those which combine LWD size classes are handled separately.

<table>
<thead>
<tr>
<th>Reported</th>
<th>WHM export ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjustment, counts, protocol = wide</td>
<td>note to users</td>
</tr>
<tr>
<td>Count, pieces, each Diameter x Length class</td>
<td></td>
</tr>
<tr>
<td>Diameter class 1 x Length class 1</td>
<td>LWDPiecesD1L1</td>
</tr>
<tr>
<td>Diameter class 1 x Length class 2</td>
<td>LWDPiecesD1L2</td>
</tr>
<tr>
<td>Diameter class 1 x Length class 3</td>
<td>LWDPiecesD1L3</td>
</tr>
<tr>
<td>Diameter class 2 x Length class 1</td>
<td>LWD_piecesD2L1</td>
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<td>Diameter class 2 x Length class 2</td>
<td>LWD PiecesD2L2</td>
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<tr>
<td>Diameter class 2 x Length class 3</td>
<td>LWDPiecesD2L3</td>
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<tr>
<td>Diameter class 3 x Length class 1</td>
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<td>Diameter class 3 x Length class 2</td>
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<tr>
<td>Diameter class 4 x Length class 3</td>
<td>LWDPiecesD4L3</td>
</tr>
<tr>
<td>Count, pieces, two or more Diameter X Length classes combined</td>
<td></td>
</tr>
<tr>
<td>All large wood, Size classes 1 to 5</td>
<td>LWDPieces</td>
</tr>
<tr>
<td>All large wood, Size classes 2 to 5</td>
<td>LWDPiecesStoX</td>
</tr>
<tr>
<td>All large wood, Size classes 3 to 5</td>
<td>LWDPiecesMtoX</td>
</tr>
<tr>
<td>All large wood, Size classes 4 to 5</td>
<td>LWDPiecesLtoX</td>
</tr>
<tr>
<td>Normalized count, pieces per 100 m,</td>
<td></td>
</tr>
<tr>
<td>Diameter class 1 x Length class 1 per 100m</td>
<td>LWDPieces100mD1L1</td>
</tr>
<tr>
<td>Diameter class 1 x Length class 2 per 100m</td>
<td>LWDPieces100mD1L2</td>
</tr>
<tr>
<td>Diameter class 1 x Length class 3 per 100m</td>
<td>LWDPieces100mD1L3</td>
</tr>
<tr>
<td>Diameter class 2 x Length class 1 per 100m</td>
<td>LWDPieces100mD2L1</td>
</tr>
<tr>
<td>Diameter class 2 x Length class 2 per 100m</td>
<td>LWDPieces100mD2L2</td>
</tr>
<tr>
<td>Diameter class 2 x Length class 3 per 100m</td>
<td>LWDPieces100mD2L3</td>
</tr>
<tr>
<td>Diameter class 3 x Length class 1 per 100m</td>
<td>LWDPieces100mD3L1</td>
</tr>
<tr>
<td>Diameter class 3 x Length class 2 per 100m</td>
<td>LWDPieces100mD3L2</td>
</tr>
<tr>
<td>Diameter class 3 x Length class 3 per 100m</td>
<td>LWDPieces100mD3L3</td>
</tr>
<tr>
<td>Diameter class 4 x Length class 1 per 100m</td>
<td>LWDPieces100mD4L1</td>
</tr>
<tr>
<td>Diameter class 4 x Length class 2 per 100m</td>
<td>LWDPieces100mD4L2</td>
</tr>
<tr>
<td>Diameter class 4 x Length class 3 per 100m</td>
<td>LWDPieces100mD4L3</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>--------------------</td>
</tr>
</tbody>
</table>

Normalized count, pieces per 100m, two or more size classes combined

- All large wood, Size classes 1 to 5 per 100 m: LWDPieces100m
- All large wood, Size classes 2 to 5 per 100 m: LWDPieces100mStoX
- All large wood, Size classes 3 to 5 per 100 m: LWDPieces100mMtoX
- All large wood, Size classes 4 to 5 per 100 m: LWD_pieces100mLtoX

Normalized count, pieces per square meter

<table>
<thead>
<tr>
<th>Diameter class 1 x Length class 1 per m²</th>
<th>LWDPiecesMSqD1L1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter class 1 x Length class 2 per m²</td>
<td>LWDPiecesMSqD1L2</td>
</tr>
<tr>
<td>Diameter class 1 x Length class 3 per m²</td>
<td>LWDPiecesMSqD1L3</td>
</tr>
<tr>
<td>Diameter class 2 x Length class 1 per m²</td>
<td>LWDPiecesMSqD2L1</td>
</tr>
<tr>
<td>Diameter class 2 x Length class 2 per m²</td>
<td>LWDPiecesMSqD2L2</td>
</tr>
<tr>
<td>Diameter class 2 x Length class 3 per m²</td>
<td>LWD_piecesMSqD2L3</td>
</tr>
<tr>
<td>Diameter class 3 x Length class 1 per m²</td>
<td>LWDPiecesMSqD3L1</td>
</tr>
<tr>
<td>Diameter class 3 x Length class 2 per m²</td>
<td>LWD_piecesMSqD3L2</td>
</tr>
<tr>
<td>Diameter class 3 x Length class 3 per m²</td>
<td>LWD_piecesMSqD3L3</td>
</tr>
<tr>
<td>Diameter class 4 x Length class 1 per m²</td>
<td>LWDPiecesMSqD4L1</td>
</tr>
<tr>
<td>Diameter class 4 x Length class 2 per m²</td>
<td>LWD_piecesMSqD4L2</td>
</tr>
<tr>
<td>Diameter class 4 x Length class 3 per m²</td>
<td>LWD_piecesMSqD4L3</td>
</tr>
</tbody>
</table>

Normalized count, pieces per square meter, two or more size classes combined

- All large wood, Size classes 1 to 5 per m² (i): LWD_piecesMSq
- All large wood, Size classes 2 to 5 per m² (ii): LWD_piecesMSqStoX
- All large wood, Size classes 3 to 5 per m² (iii): LWD_piecesMSqMtoX
- All large wood, Size classes 4 to 5 per m² (iv): LWD_piecesMSqLtoX

Volume per site, each size class

<table>
<thead>
<tr>
<th>Diameter class 1 x Length class 1 (i)</th>
<th>LWDVolumeD1L1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter class 1 x Length class 2 (ii)</td>
<td>LWDVolumeD1L2</td>
</tr>
<tr>
<td>Diameter class 1 x Length class 3 (iii)</td>
<td>LWDVolumeD1L3</td>
</tr>
<tr>
<td>Diameter class 2 x Length class 1 (iv)</td>
<td>LWDVolumeD2L1</td>
</tr>
<tr>
<td>Diameter class 2 x Length class 2 (v)</td>
<td>LWDVolumeD2L2</td>
</tr>
<tr>
<td>Diameter class 2 x Length class 3 (vi)</td>
<td>LWDVolumeD2L3</td>
</tr>
<tr>
<td>Diameter class 3 x Length class 1 (vii)</td>
<td>LWDVolumeD3L1</td>
</tr>
<tr>
<td>Diameter class 3 x Length class 2 (viii)</td>
<td>LWDVolumeD3L2</td>
</tr>
<tr>
<td>Diameter class 3 x Length class 3 (ix)</td>
<td>LWDVolumeD3L3</td>
</tr>
<tr>
<td>Diameter class 4 x Length class 1 (x)</td>
<td>LWDVolumeD4L1</td>
</tr>
<tr>
<td>Diameter class 4 x Length class 2 (xi)</td>
<td>LWDVolumeD4L2</td>
</tr>
<tr>
<td>Diameter class 4 x Length class 3 (xii)</td>
<td>LWDVolumeD4L3</td>
</tr>
</tbody>
</table>

Volume per site, two or more size classes combined

- All large wood, Size classes 1 to 5 (i): LWDVolume
<table>
<thead>
<tr>
<th>Description</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>All large wood, Size classes 2 to 5 (ii)</td>
<td>LWDVolumeStoX</td>
</tr>
<tr>
<td>All large wood, Size classes 3 to 5 (iii)</td>
<td>LWDVolumeMtoX</td>
</tr>
<tr>
<td>All large wood, Size classes 4 to 5 (iv)</td>
<td>LWDVolumeLtoX</td>
</tr>
</tbody>
</table>

Normalized volume, per 100m, each size class

| Diameter class 1 x Length class 1 per 100m | LWDVolume100mD1L1 |
| Diameter class 1 x Length class 2 per 100m | LWDVolume100mD1L2 |
| Diameter class 1 x Length class 3 per 100m | LWDVolume100mD1L3 |
| Diameter class 2 x Length class 1 per 100m | LWDVolume100mD2L1 |
| Diameter class 2 x Length class 2 per 100m | LWDVolume100mD2L2 |
| Diameter class 2 x Length class 3 per 100m | LWDVolume100mD2L3 |
| Diameter class 3 x Length class 1 per 100m | LWDVolume100mD3L1 |
| Diameter class 3 x Length class 2 per 100m | LWDVolume100mD3L2 |
| Diameter class 3 x Length class 3 per 100m | LWDVolume100mD3L3 |
| Diameter class 4 x Length class 1 per 100m | LWDVolume100mD4L1 |
| Diameter class 4 x Length class 2 per 100m | LWDVolume100mD4L2 |
| Diameter class 4 x Length class 3 per 100m | LWDVolume100mD4L3 |

Normalized volume, per 100m, size classes combined

| All large wood, Size classes 1 to 5 per 100 m | LWDVolume100m |
| All large wood, Size classes 2 to 5 per 100 m | LWDVolume100mStoX |
| All large wood, Size classes 3 to 5 per 100 m | LWDVolume100mMtoX |
| All large wood, Size classes 4 to 5 per 100 m | LWDVolume100mLtoX |

Normalized volume, per square meter, each size class

| Diameter class 1 x Length class 1 per m² | LWDVolumeMSqD1L1 |
| Diameter class 1 x Length class 2 per m² | LWDVolumeMSqD1L2 |
| Diameter class 1 x Length class 3 per m² | LWDVolumeMSqD1L3 |
| Diameter class 2 x Length class 1 per m² | LWDVolumeMSqD2L1 |
| Diameter class 2 x Length class 2 per m² | LWDVolumeMSqD2L2 |
| Diameter class 2 x Length class 3 per m² | LWDVolumeMSqD2L3 |
| Diameter class 3 x Length class 1 per m² | LWDVolumeMSqD3L1 |
| Diameter class 3 x Length class 2 per m² | LWDVolumeMSqD3L2 |
| Diameter class 3 x Length class 3 per m² | LWDVolumeMSqD3L3 |
| Diameter class 4 x Length class 1 per m² | LWDVolumeMSqD4L1 |
| Diameter class 4 x Length class 2 per m² | LWDVolumeMSqD4L2 |
| Diameter class 4 x Length class 3 per m² | LWDVolumeMSqD4L3 |

Normalized volume, per square meter, size classes combined

| All large wood, Size classes 1 to 5 per m² | LWDVolumeMSq |
| All large wood, Size classes 2 to 5 per m² | LWDVolumeMSqStoX |
| All large wood, Size classes 3 to 5 per m² | LWDVolumeMSqMtoX |
| All large wood, Size classes 4 to 5 per m² | LWDVolumeMSqLtoX |
METRIC CATEGORY: Large Woody Debris

Adjustments are applied to LWD tallies when wide rivers are inventoried.

Group: Adjustment to counts, inventory of LWD for wide rivers
Scope: Protocol = wide, all non-null observations per DCE

There are three adjustments. In the first, counts of LWD tallied while surveying a single stream bank are scaled up to approximate a tally of both stream banks. In the second, the 200 m subsample of surveyed study reach is scaled to the full length of study reach. In the third, counts of LWD tallied during the survey are scaled to account for incomplete sub-sampling, if any.

if protocol = wide, then

   adjust for surveying a single bank, as

   \(( \Sigma (LWD\_Count)) \times 2 = X\)

   adjust for sub-sampling and incomplete sub-sampling, as

   \(X \times \left[ \frac{(Number\ of\ transects\ observed \times 0.1 \times Site\_Length)}{(Number\ of\ transects\ observed \times 0.1 \times 200)} \right],\)

   which reduces to

   \(X \times \left[ \frac{Site\_Length}{200} \right]\)

See LWD, Pieces per Site for an example of these adjustments in use.
**METRIC CATEGORY:** Large Woody Debris

**Group:** Pieces per Site  
**Scope:** All non-null observations per DCE, entire site reach  
**Reported:** Count, of large woody debris, as

- Diameter class 1 x Length class 1 (i)  
- Diameter class 1 x Length class 2 (ii)  
- Diameter class 1 x Length class 3 (iii)  
- Diameter class 2 x Length class 1 (iv)  
- Diameter class 2 x Length class 2 (v)  
- Diameter class 2 x Length class 3 (vi)  
- Diameter class 3 x Length class 1 (vii)  
- Diameter class 3 x Length class 2 (viii)  
- Diameter class 3 x Length class 3 (ix)  
- Diameter class 4 x Length class 1 (x)  
- Diameter class 4 x Length class 2 (xi)  
- Diameter class 4 x Length class 3 (xii)  

where: categorical diameter class, categorical length class,

**Western Washington**
- D1 = 10-30 cm  
- D2 = > 30-60 cm  
- D3 = > 60-80 cm  
- D4 = > 80 cm  
- L1 = 2-5 m  
- L2 = > 5-15 m  
- L3 = > 15 m

**Eastern Washington**
- D1 = 10-15 cm  
- D2 = > 15-30 cm  
- D3 = > 30-60 cm  
- D4 = > 60 cm  
- L1 = 1-3 m  
- L2 = > 3-6 m  
- L3 = > 6 m

**Definition:** For each individual (Diameter x Length class) of large wood, (i–xii) count, of large woody debris of a given (Diameter x Length) class, either as intersecting or contained within the bankfull zone of the main channel (channel 0), as visually observed along the length of site reach. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm. Unit = count per site.

**WHM export ID:**

- (i) LWDPiecesD1L1  
- (ii) LWDPiecesD1L2  
- (iii) LWDPiecesD1L3  
- (iv) LWDPiecesD2L1  
- (v) LWDPiecesD2L2  
- (vi) LWDPiecesD2L3  
- (vii) LWDPiecesD3L1  
- (viii) LWDPiecesD3L2  
- (ix) LWDPiecesD3L3  
- (x) LWDPiecesD4L1  
- (xi) LWDPiecesD4L2  
- (xii) LWDPiecesD4L3

**Observation type:** Count  
**Allowed metric values:** ≥ 0  
**Data collection schema,
narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.

wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).

Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017

1 Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

\[(i - xii) \text{ for each unique (Diameter x Length) class,} \]
\[\{ \text{where LWD\_Count} <> \text{is.null} \}\]
\[\left( \sum \text{LWD\_Count} \right) \]

then, if protocol = wide,

adjust for surveying a single bank, as

\[\left( \sum \text{LWD\_Count} \right) \times 2 = X \]

adjust for sub-sampling, 200 m of channel, as

\[X \times \left( \frac{\text{Number of transects observed} \times 0.1 \times \text{Site\_Length}}{\text{Number of transects observed} \times 0.1 \times 200} \right) \]

which reduces to

\[X \times \left[ \frac{\text{Site\_Length}}{200} \right] \]

where Site\_Length = total length of the site reach surveyed.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.
Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.


**METRIC CATEGORY:** Large Woody Debris

**Group:** Pieces per Site  
**Scope:** All non-null observations per DCE, entire site reach

**Reported:** Count, of large woody debris, two or more size classes combined, as

- All large wood, Size classes 1 to 5 (i )
- All large wood, Size classes 2 to 5 (ii )
- All large wood, Size classes 3 to 5 (iii)
- All large wood, Size classes 4 to 5 (iv)

**Definition:** For each case of combined size classes of large wood, (i - iv)

(i – iv) count, of large woody debris of specified size classes, either as intersecting or contained within the bankfull zone of the main channel (channel 0), as visually observed along the length of site reach. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is $\geq 10$ cm. Unit = count per site.

where

Size-class 1 = D1L1  
Size-class 2 = D1L2, D2L1, D3L1  
Size-class 3 = D1L3, D2L2, D4L1  
Size-class 4 = D2L3, D3L2, D3L3, D4L2  
Size-class 5 = D4L3

See below for individual (Diameter x Length) class definitions

**WHM export ID:**  
(i ) LWDPieces  
(ii ) LWDPiecesStoX  
(iii) LWDPiecesMtoX  
(iv) LWDPiecesLtoX

**Observation type:** Count  
**Allowed metric values:** $\geq 0$

**Data collection schema,**

**narrow protocol:** Length of site reach, sub-divided into 10 equal-length sections.

**wide protocol:** Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).
Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017

Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

(i - iv) for each unique size class, a to x
{where LWD_Count <> is.null},

( Σ (LWD_Count)), as = Y_a, …., Y_x

then  Σ ( Y_a+ ....+ Y_x )

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel.
See first entry, LWD category.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume there are minimal numbers of pieces of LWD mid-channel (i.e., between left and right littoral zones). We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.


Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
**METRIC CATEGORY:** Large Woody Debris

**Group:** Pieces per 100 m  
**Scope:** All non-null observations per DCE, entire site reach  
**Reported:** Normalized count, of large woody debris, as

- Diameter class 1 x Length class 1 per 100m (i)  
- Diameter class 1 x Length class 2 per 100m (ii)  
- Diameter class 1 x Length class 3 per 100m (iii)  
- Diameter class 2 x Length class 1 per 100m (iv)  
- Diameter class 2 x Length class 2 per 100m (v)  
- Diameter class 2 x Length class 3 per 100m (vi)  
- Diameter class 3 x Length class 1 per 100m (vii)  
- Diameter class 3 x Length class 2 per 100m (viii)  
- Diameter class 3 x Length class 3 per 100m (ix)  
- Diameter class 4 x Length class 1 per 100m (x)  
- Diameter class 4 x Length class 2 per 100m (xi)  
- Diameter class 4 x Length class 3 per 100m (xii)  

where:  
- **categorical diameter class,**  
- **categorical length class,**

**Western Washington**

- $D_1 = 10-30$ cm  
- $D_2 = > 30-60$ cm  
- $D_3 = > 60-80$ cm  
- $D_4 = > 80$ cm  
- $L_1 = 2-5$ m  
- $L_2 = > 5-15$ m  
- $L_3 = > 15$ m  
- $L_4 = > 20$ m  

**Eastern Washington**

- $D_1 = 10-15$ cm  
- $D_2 = > 15-30$ cm  
- $D_3 = > 30-60$ cm  
- $D_4 = > 60$ cm  
- $L_1 = 1-3$ m  
- $L_2 = > 3-6$ m  
- $L_3 = > 6$ m  
- $L_4 = > 10$ m  

**Definition:** For each individual (Diameter x Length) class of large wood, (i-xii),

(i-xii) normalized count, of large woody debris of a given (Diameter x Length) class, either as intersecting or contained within the bankfull zone of the main channel (channel 0), per 100 m of channel, as visually observed along the length of site reach. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is $\geq 10$ cm. Unit = count per 100m.

**WHM export ID:**  
(i) LWDPieces100mD1L1  
(ii) LWDPieces100mD1L2  
(iii) LWDPieces100mD1L3  
(iv) LWDPieces100mD2L1  
(v) LWDPieces100mD2L2  
(vi) LWDPieces100mD2L3  
(vii) LWDPieces100mD3L1  
(viii) LWDPieces100mD3L2  
(ix) LWDPieces100mD3L3  
(x) LWDPieces100mD4L1  
(xi) LWDPieces100mD4L2  
(xii) LWDPieces100mD4L3

**Observation type:** Count  
**Allowed metric values:** $\geq 0$
Data collection schema,

narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.

wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).

Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017

Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

(i - xii) for each unique (Diameter x Length) class,
{where (LWD_Count) <> is.null}

\[
\left( \sum (LWD\_Count) \times 100 \right) / (Site\_Length)
\]

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel. See first entry, LWD category.

where, Site\_Length = total length of site reach surveyed.

See below for definitions of individual (Diameter x Length) classes.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Link to definitions, Individual LWD Diameter x Length classes
**METRIC CATEGORY:** Large Woody Debris

**Group:** Pieces per 100 m  
**Scope:** All non-null observations per DCE, entire site reach

**Reported:** Normalized count, large woody debris, size classes combined, as

- All large wood, Size classes 1 to 5 per 100 m (i )
- All large wood, Size classes 2 to 5 per 100 m (ii )
- All large wood, Size classes 3 to 5 per 100 m (iii)
- All large wood, Size classes 4 to 5 per 100 m (iv)

**Definition:** For each case of combined size classes of large wood, (i - iv)

(i – iv) normalized count, of large woody debris of specified size classes, either as intersecting or contained within the bankfull zone of the main channel (channel 0), per 100 m of channel, as visually observed along the length of site reach surveyed. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm.  
Unit = count per 100 m.

where

Size-class 1 = D1L1  
Size-class 2 = D1L2, D2L1, D3L1  
Size-class 3 = D1L3, D2L2, D4L1  
Size-class 4 = D2L3, D3L2, D3L3, D4L2  
Size-class 5 = D4L3

See below for individual (Diameter x Length) class definitions.

**WHM export ID:**

- (i ) LWDPieces100m
- (ii ) LWDPieces100mStoX
- (iii) LWDPieces100mMtoX
- (iv) LWDPieces100mLtoX

**Observation type:** Count  
**Allowed metric values:** ≥ 0

**Data collection schema,**

- narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.
- wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).
Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017

Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

(i - iv) for each unique size class, a to x
{where LWD_Count <> is.null},

( Σ (LWD_Count)), as = Y_a, ..., Y_x

then ( Σ ( Y_a + ... + Y_x ) * 100) / (Site_Length)

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel.
See first entry, LWD category.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.


Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: **Large Woody Debris**

Group: Pieces per square meter  
Scope: All non-null observations per DCE, entire site reach

Reported: Normalized count, as large woody debris encountered of,

<table>
<thead>
<tr>
<th>Diameter class 1 x Length class 1 per m²</th>
<th>Diameter class 3 x Length class 1 per m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>(vii)</td>
</tr>
<tr>
<td>Diameter class 1 x Length class 2 per m²</td>
<td>Diameter class 3 x Length class 2 per m²</td>
</tr>
<tr>
<td>(ii)</td>
<td>(viii)</td>
</tr>
<tr>
<td>Diameter class 1 x Length class 3 per m²</td>
<td>Diameter class 3 x Length class 3 per m²</td>
</tr>
<tr>
<td>(iii)</td>
<td>(ix)</td>
</tr>
<tr>
<td>Diameter class 2 x Length class 1 per m²</td>
<td>Diameter class 4 x Length class 1 per m²</td>
</tr>
<tr>
<td>(iv)</td>
<td>(x)</td>
</tr>
<tr>
<td>Diameter class 2 x Length class 2 per m²</td>
<td>Diameter class 4 x Length class 2 per m²</td>
</tr>
<tr>
<td>(v)</td>
<td>(xi)</td>
</tr>
<tr>
<td>Diameter class 2 x Length class 3 per m²</td>
<td>Diameter class 4 x Length class 3 per m²</td>
</tr>
<tr>
<td>(vi)</td>
<td>(xii)</td>
</tr>
</tbody>
</table>

where: categorical diameter class, categorical length class,

Western Washington

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1 = 10-30 cm</td>
<td>L1 = 2-5 m</td>
</tr>
<tr>
<td>D2 = &gt; 30-60 cm</td>
<td>L2 = &gt; 5-15 m</td>
</tr>
<tr>
<td>D3 = &gt; 60-80 cm</td>
<td>L3 = &gt; 15 m</td>
</tr>
<tr>
<td>D4 = &gt; 80 cm</td>
<td></td>
</tr>
</tbody>
</table>

Eastern Washington

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1 = 10-15 cm</td>
<td>L1 = 1-3 m</td>
</tr>
<tr>
<td>D2 = &gt; 15-30 cm</td>
<td>L2 = &gt; 3-6 m</td>
</tr>
<tr>
<td>D3 = &gt; 30-60 cm</td>
<td>L3 = &gt; 6 m</td>
</tr>
<tr>
<td>D4 = &gt; 60 cm</td>
<td></td>
</tr>
</tbody>
</table>

Definition: For each individual (Diameter x Length) class of large wood, (i–xii),

(i–xii) normalized count, of large woody debris of a given (Diameter x Length) class per square meter of estimated bankfull-channel surface area of the site reach, either as intersecting or contained within the bankfull zone of the main channel (channel 0), as visually observed along the length of site reach surveyed. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm. 

Unit = count per square meter.

WHM export ID:  

(i ) LWDPiecesMSqD1L1l (vii) LWDPiecesMSqD3L1l (ii ) LWDPiecesMSqD1L2l (viii) LWDPiecesMSqD3L2l (iii) LWDPiecesMSqD1L3l (ix) LWDPiecesMSqD3L3l (iv) LWDPiecesMSqD2L1l (x) LWDPiecesMSqD4L1l (v) LWDPiecesMSqD2L2l (xi) LWDPiecesMSqD4L2l (vi) LWDPiecesMSqD2L3l (xii) LWDPiecesMSqD4L3l
Observation type: Count
Allowed metric values: $\geq 0$

Data collection schema,

narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.
wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).

Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: $\geq 80\%$ of site reach surveyed
Reporting years (to date): 2009-2017

1 Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

$$(i - xii) \text{ for each unique Diameter x Length class,}$$

$${\text{where (LWD_Count) } \neq \text{null}}$$

$$(\sum \text{ (LWD_Count)}) / (\text{Site Length} \times \text{X_BFWidth})$$

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel.

See first entry, LWD category.

where, Site Length = total length of site reach surveyed

X_BFWidth = average bankfull width

See below for definitions of individual (Diameter x Length) classes.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Link to definitions, individual LWD Diameter x Length classes
METRIC CATEGORY: **Large Woody Debris**

**Group:** Pieces per square meter  
**Scope:** All non-null observations per DCE, entire site reach  
**Reported:** Combined normalized count, two or more size classes, as large woody debris of,  

- All large wood, Size classes 1 to 5 per m² (i)  
- All large wood, Size classes 2 to 5 per m² (ii)  
- All large wood, Size classes 3 to 5 per m² (iii)  
- All large wood, Size classes 4 to 5 per m² (iv)  

**Definition:** For each case of combined size classes of large wood, (i - iv)

(i – iv) normalized count, of large woody debris of specified size classes per square meter of estimated bankfull-channel surface area of the site reach, either as intersecting or contained within the bankfull zone of the main channel (channel 0), as observed along the length of site reach surveyed. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm. Unit = count per square meter.

where

- Size-class 1 = D1L1  
- Size-class 2 = D1L2, D2L1, D3L1  
- Size-class 3 = D1L3, D2L2, D4L1  
- Size-class 4 = D2L3, D3L2, D3L3, D4L2  
- Size-class 5 = D4L3  

See below for individual (Diameter x Length) class definitions

**WHM export ID:**  
(i ) LWDPiecesMSq  
(ii ) LWDPiecesMSqStoX  
(iii) LWDPiecesMSqMtoX  
(iv) LWDPiecesMSqLtoX

**Observation type:** Count  
**Allowed metric values:** ≥ 0

**Data collection schema,**  
**narrow protocol:** Length of site reach, sub-divided into 10 equal-length sections.  
**wide protocol:** Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).
Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017\(^1\)

\(^1\) Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

\[
(i - iv) \text{ for each unique size class, } a \text{ to } x \\
\{\text{where LWD_Count <> is.null}\},
\]

\[
(\Sigma (\text{LWD_Count})) \text{ as } Y_a, \ldots, Y_x
\]

then \[
\Sigma (Y_a + \ldots + Y_x) / (\text{Site_Length} * X_{BFWidth})
\]

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel. See first entry, LWD category.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.


METRIC CATEGORY: Large Woody Debris

Group: Volume per Site
Scope: All non-null observations per DCE, entire site reach

Reported: Volume, of large woody debris of

Diameter class 1 x Length class 1 (i) Diameter class 3 x Length class 1 (vii)
Diameter class 1 x Length class 2 (ii) Diameter class 3 x Length class 2 (viii)
Diameter class 1 x Length class 3 (iii) Diameter class 3 x Length class 3 (ix)
Diameter class 2 x Length class 1 (iv) Diameter class 4 x Length class 1 (x)
Diameter class 2 x Length class 2 (v) Diameter class 4 x Length class 2 (xi)
Diameter class 2 x Length class 3 (vi) Diameter class 4 x Length class 3 (xii)

where: categorical diameter class, categorical length class,

Western Washington
D1 = 10-30 cm
D2 = > 30-60 cm
D3 = > 60-80 cm
D4 = > 80 cm
L1 = 2-5 m
L2 = > 5-15 m
L3 = > 15 m

Eastern Washington
D1 = 10-15 cm
D2 = > 15-30 cm
D3 = > 30-60 cm
D4 = > 60 cm
L1 = 1-3 m
L2 = > 3-6 m
L3 = > 6 m

Definition: For each individual (Diameter x Length class) of large wood, (i–xii)
(i–xii) volume, as large woody debris of a given unique (Diameter x Length) class, either as intersecting or contained within the bankfull zone of the main channel (channel 0), as visually observed along the length of site reach. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm. Unit = cubic meters per site.

WHM export ID: (i) LWDVolumeD1L1 (vii) LWDVolumeD3L1
(ii) LWDVolumeD1L2 (viii) LWDVolumeD3L2
(iii) LWDVolumeD1L3 (ix) LWDVolumeD3L3
(iv) LWDVolumeD2L1 (x) LWDVolumeD4L1
(v) LWDVolumeD2L2 (xi) LWDVolumeD4L2
(vi) LWDVolumeD2L3 (xii) LWDVolumeD4L3

Observation type: Count
Allowed metric values: ≥ 0
Data collection schema,
narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.

wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).

Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017

Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

(i - xii) for each unique Diameter x Length class,
{where (LWD_Count) <> is.null}

(Σ (LWD_Count)) * Volume_factor / (Site_Length * X_BFWidth), using volume factor as,

Western Washington

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Length</th>
<th>Volume_factor</th>
</tr>
</thead>
</table>
| (i)      | 0.065  | 1.047
| (ii)     | 0.182  | 2.909
| (iii)    | 0.436  | 6.981
| (iv)     | 0.377  | 3.393
| (v)      | 1.047  | 9.425
| (vi)     | 2.513  | 22.619

Eastern Washington

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Length</th>
<th>Volume_factor</th>
</tr>
</thead>
</table>
| (i)      | 0.018  | 0.209
| (ii)     | 0.043  | 0.503
| (iii)    | 0.096  | 1.131
| (iv)     | 0.052  | 0.838
| (v)      | 0.126  | 2.011
| (vi)     | 0.283  | 4.524

where, Site_Length = total length of site reach surveyed.
X_BFWidth = average bankfull width.
Volume_factor = average volume of a single piece of LWD of the unique Diameter X Length class, as, for (i-xii)²,

² Source (see Robison):

\[
\text{Volume} = \pi \times \left[ 0.5 \times (\text{minDiam} + (\text{maxDiam} + \text{minDiam})/3) \right]^2 \times \left[ (\text{minLength} + (\text{maxLength} – \text{minLength})/3) \right]^{3/2}
\]

Upper limits: 

<table>
<thead>
<tr>
<th>Region</th>
<th>Length</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Washington</td>
<td>30 m</td>
<td>2 m</td>
</tr>
<tr>
<td>Eastern Washington</td>
<td>15 m</td>
<td>1.2 m</td>
</tr>
</tbody>
</table>

³ applies also to Kaufman et al., 1999 replacing,

\[
\text{Volume} = \pi \times \left[ \frac{4}{3} \times \left( \text{minDiam}/2 \right) \right] \times \left[ \frac{4}{3} \times \text{minLength} \right]
\]

See definitions of individual (Diameter x Length) classes elsewhere in this section.

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel.

See first entry, LWD category.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.


Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: Large Woody Debris

Group: Volume per Site
Scope: All non-null observations per DCE, entire site reach
Reported: Volume, of large woody debris, two or more size classes combined, as

- All large wood, Size classes 1 to 5 (i)
- All large wood, Size classes 2 to 5 (ii)
- All large wood, Size classes 3 to 5 (iii)
- All large wood, Size classes 4 to 5 (iv)

Definition: For each case of combined size classes of large wood, (i - iv)

(i – iv) volume, of large woody debris of specified size classes, either as intersecting or contained within the bankfull zone of the main channel (channel 0), as visually observed along the length of site reach. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm. Unit = cubic meters per site.

where

- Size-class 1 = D1L1
- Size-class 2 = D1L2, D2L1, D3L1
- Size-class 3 = D1L3, D2L2, D4L1
- Size-class 4 = D2L3, D3L2, D3L3, D4L2
- Size-class 5 = D4L3

See below for individual (Diameter x Length) class definitions

WHM export ID: (i ) LWDVolume (ii ) LWDVolumeStoX (iii) LWDVolumeMtoX (iv) LWDVolumeLtoX

Observation type: Count
Allowed metric values: ≥ 0
Data collection schema,

narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.

wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).
Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017

Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

\[
(i - xii) \text{ for each unique Diameter x Length class,} \\
\{\text{where (LWD_Count) <> is.null}\}
\]

\[
(\Sigma (LWD\_Count)) \times \text{Volume\_factor} / (\text{Site\_Length} \times \text{X\_BFWidth})
\]

using volume factor as,

Western Washington

<table>
<thead>
<tr>
<th>Diameter x Length Class</th>
<th>Volume_factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) 0.065</td>
<td>1.047</td>
</tr>
<tr>
<td>(ii) 0.182</td>
<td>2.909</td>
</tr>
<tr>
<td>(iii) 0.436</td>
<td>6.981</td>
</tr>
<tr>
<td>(iv) 0.377</td>
<td>3.393</td>
</tr>
<tr>
<td>(v) 1.047</td>
<td>9.425</td>
</tr>
<tr>
<td>(vi) 2.513</td>
<td>22.619</td>
</tr>
</tbody>
</table>

Eastern Washington

<table>
<thead>
<tr>
<th>Diameter x Length Class</th>
<th>Volume_factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) 0.018</td>
<td>0.209</td>
</tr>
<tr>
<td>(ii) 0.043</td>
<td>0.503</td>
</tr>
<tr>
<td>(iii) 0.096</td>
<td>1.131</td>
</tr>
<tr>
<td>(iv) 0.052</td>
<td>0.838</td>
</tr>
<tr>
<td>(v) 0.126</td>
<td>2.011</td>
</tr>
<tr>
<td>(vi) 0.283</td>
<td>4.524</td>
</tr>
</tbody>
</table>

where, Site\_Length = total length of site reach surveyed.
X\_BFWidth = average bankfull width.
Volume\_factor = average volume of a single piece of LWD of the unique Diameter X Length class, as, for (i-xii)²,

² Source (see Robison):

\[
\text{Volume} = \pi \times [0.5\times(\minDiam+(\maxDiam+\minDiam)/3)]^2\times[\minLength+(\maxLength-\minLength)/3]
\]
Upper limits: Length Diameter

Western Washington: 30 m 2 m
Eastern Washington: 15 m 1.2 m

3 applies also to Kaufman et al., 1999 replacing,

\[
\text{Volume} = \pi \times \left[ \frac{4}{3} \times (\text{minDiam}/2)^2 \right] \times \left[ \frac{4}{3} \times \text{minLength} \right]
\]

See definitions of individual (Diameter x Length) classes elsewhere in this section.

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel.
See first entry, LWD category.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.


Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: Large Woody Debris

Group: Volume per 100 m
Scope: All non-null observations per DCE, entire site reach

Reported: Normalized volume, as large woody debris of

Diameter class 1 x Length class 1 per 100m (i)
Diameter class 1 x Length class 2 per 100m (ii)
Diameter class 1 x Length class 3 per 100m (iii)
Diameter class 2 x Length class 1 per 100m (iv)
Diameter class 2 x Length class 2 per 100m (v)
Diameter class 2 x Length class 3 per 100m (vi)
Diameter class 3 x Length class 1 per 100m (vii)
Diameter class 3 x Length class 2 per 100m (viii)
Diameter class 3 x Length class 3 per 100m (ix)
Diameter class 4 x Length class 1 per 100m (x)
Diameter class 4 x Length class 2 per 100m (xi)
Diameter class 4 x Length class 3 per 100m (xii)

where: categorical diameter class, categorical length class,

Western Washington
D1 = 10-30 cm L1 = 2-5 m
D2 = > 30-60 cm L2 = > 5-15 m
D3 = > 60-80 cm L3 = > 15 m
D4 = > 80 cm

Eastern Washington
D1 = 10-15 cm L1 = 1-3 m
D2 = > 15-30 cm L2 = > 3-6 m
D3 = > 30-60 cm L3 = > 6 m
D4 = > 60 cm

Definition: For each individual (Diameter x Length) class of large wood, (i-xii),

(i-xii) normalized volume, of large woody debris of a given unique (Diameter x Length) class, either as intersecting or contained within the bankfull zone of the main channel (channel 0), per 100 m of channel, as visually observed along the length of site reach. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm. Unit = cubic meters per 100 m.

WHM export ID: (i ) LWDVolume100mD1L1 (vii ) LWDVolume100mD3L1
(ii ) LWDVolume100mD1L2 (viii) LWDVolume100mD3L2
(iii) LWDVolume100mD1L3 (ix ) LWDVolume100mD3L3
(iv) LWDVolume100mD2L1 (x ) LWDVolume100mD4L1
(v ) LWDVolume100mD2L2 (xi ) LWDVolume100mD4L2
(vi) LWDVolume100mD2L3 (xii) LWDVolume100mD4L3

Observation type: Count
Allowed metric values: ≥ 0
Data collection schema,

narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.

wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).

Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit

Minimum reporting qualifiers: ≥ 80% of site reach surveyed

Reporting years (to date): 2009-2017

1 Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

\[(i - xii)\] for each unique Diameter x Length class,
{where (LWD_Count) <> is.null}

\[\left(\sum (LWD\_Count)\right) \times \text{Volume\_factor} \div (\text{Site\_Length} \times X\_BFWidth),\]

using volume factor as,

Western Washington

\[
\begin{align*}
(i) & \ 0.065 & (vii) & \ 1.047 \\
(ii) & \ 0.182 & (viii) & \ 2.909 \\
(iii) & \ 0.436 & (ix) & \ 6.981 \\
(iv) & \ 0.377 & (x) & \ 3.393 \\
(v) & \ 1.047 & (xi) & \ 9.425 \\
(vi) & \ 2.513 & (xii) & \ 22.619
\end{align*}
\]

Eastern Washington

\[
\begin{align*}
(i) & \ 0.018 & (vii) & \ 0.209 \\
(ii) & \ 0.043 & (viii) & \ 0.503 \\
(iii) & \ 0.096 & (ix) & \ 1.131 \\
(iv) & \ 0.052 & (x) & \ 0.838 \\
(v) & \ 0.126 & (xi) & \ 2.011 \\
(vi) & \ 0.283 & (xii) & \ 4.524
\end{align*}
\]

where, Site\_Length = total length of site reach surveyed.
X_BFWidth = average bankfull width.
Volume_factor = average volume of a single piece of LWD of the unique Diameter X Length class, as, for (i-xii)²,

² Source (see Robison):

$$\text{Volume} = \pi \times \left[ \frac{1}{2} \times (\text{minDiam} + \frac{\text{maxDiam} + \text{minDiam}}{3}) \right]^2 \times \left[ \frac{1}{3} \times (\text{minLength} + (\text{maxLength} - \text{minLength})/3) \right]$$

Upper limits: Length Diameter

Western Washington: 30 m 2 m
Eastern Washington: 15 m 1.2 m

³ applies also to Kaufman et al., 1999 replacing,

$$\text{Volume} = \pi \times \left[ \frac{4}{3} \times \left( \frac{\text{minDiam}}{2} \right)^2 \right] \times \left[ \frac{4}{3} \times \text{minLength} \right]$$

See definitions of individual ( Diameter x Length ) classes elsewhere in this section.

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel.
See first entry, LWD category.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.


Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Link to definitions, individual LWD Diameter x Length classes
METRIC CATEGORY: Large Woody Debris

Group: Volume per 100 m
Scope: All non-null observations per DCE, entire site reach

Reported: Normalized volume, large woody debris, size classes combined, as

All large wood, Size classes 1 to 5 per 100 m (i )
All large wood, Size classes 2 to 5 per 100 m (ii )
All large wood, Size classes 3 to 5 per 100 m (iii)
All large wood, Size classes 4 to 5 per 100 m (iv)

Definition: For each case of combined size classes of large wood, (i - iv)

(i – iv) normalized volume, of large woody debris of specified size classes, either
as intersecting or contained within the bankfull zone of the main channel
(channel 0), per 100 m of channel, as visually observed along the length of
site reach. Any pieces of dead trees of minimum dimensions are counted,
including coarse roots and large limbs if not attached to a bole. Length
minima are 2 m, Western Washington, and 1 m, Eastern Washington.
Diameter minimum in all cases is ≥ 10 cm. Unit = cubic meters per
100 m.

where

Size-class 1 = D1L1
Size-class 2 = D1L2, D2L1, D3L1
Size-class 3 = D1L3, D2L2, D4L1
Size-class 4 = D2L3, D3L2, D3L3, D4L2
Size-class 5 = D4L3

See below for individual (Diameter x Length) class definitions.

WHM export ID: (i ) LWDVolume100m
(ii ) LWDVolume100mStoX
(iii) LWDVolume100mMtoX
(iv) LWDVolume100mLtoX

Observation type: Count
Allowed metric values: ≥ 0
Data collection schema,
narrow protocol: Length of site reach, sub-divided into 10 equal-length
sections.
wide protocol: Length of site reach is sub-sampled by observing 10 littoral
– bankfull plots (each 20 meters long), on a single bank,
one plot each at 10 of eleven transects. No observations are
taken at the last transect (transect K).
Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017

Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

\[
(i - xii) \quad \text{for each unique Diameter x Length class,}\n\{\text{where (LWD_Count) <> is.null}\}
\]

\[
(\Sigma (LWD\_Count)) \ast \text{Volume\_factor} / (\text{Site\_Length} \ast X\_BFWidth),
\]

using volume factor as,

Western Washington

\[
\begin{align*}
(i) & \quad 0.065 & (vii) & \quad 1.047 \\
(ii) & \quad 0.182 & (viii) & \quad 2.909 \\
(iii) & \quad 0.436 & (ix) & \quad 6.981 \\
(iv) & \quad 0.377 & (x) & \quad 3.393 \\
(v) & \quad 1.047 & (xi) & \quad 9.425 \\
(vi) & \quad 2.513 & (xii) & \quad 22.619
\end{align*}
\]

Eastern Washington

\[
\begin{align*}
(i) & \quad 0.018 & (vii) & \quad 0.209 \\
(ii) & \quad 0.043 & (viii) & \quad 0.503 \\
(iii) & \quad 0.096 & (ix) & \quad 1.131 \\
(iv) & \quad 0.052 & (x) & \quad 0.838 \\
(v) & \quad 0.126 & (xi) & \quad 2.011 \\
(vi) & \quad 0.283 & (xii) & \quad 4.524
\end{align*}
\]

where, Site\_Length = total length of site reach surveyed.

\[
X\_BFWidth = \text{average bankfull width.}
\]

\[
\text{Volume\_factor = average volume of a single piece of LWD of the unique Diameter X Length class, as, for (i-xii)}^2,
\]

\[
2 \text{ Source (see Robison):}
\]

\[
\text{Volume} = \pi \ast [0.5\ast(\text{minDiam}+(\text{maxDiam}+\text{minDiam})/3)]^2\ast[\text{minLength}+(\text{maxLength} - \text{minLength})/3] \]

\[
3
\]
Upper limits:     Length    Diameter
Western Washington:    30 m    2 m
Eastern Washington:   15 m    1.2 m

3 applies also to Kaufman et al., 1999 replacing,

\[
Volume = \pi \times \left( \frac{4}{3} \times \left( \frac{\text{minDiam}}{2} \right)^2 \right) \times \left( \frac{4}{3} \times \text{minLength} \right)
\]

See definitions of individual ( Diameter x Length ) classes elsewhere in this section.

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel.
See first entry, LWD category.

Dependencies:  Large woody debris survey was completed.  Counts were adjusted when the wide protocol was used.

Assumptions:  LWD diameter and length categories are sufficiently detailed to characterize channel conditions.  For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris.  We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.


Further documentation:  https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: Large Woody Debris

Group: Volume per square meter
Scope: All non-null observations per DCE, entire site reach

Reported: Normalized volume, as large woody debris of,

Diameter class 1 x Length class 1 per m² (i) Diameter class 3 x Length class 1 per m² (vii)
Diameter class 1 x Length class 2 per m² (ii) Diameter class 3 x Length class 2 per m² (viii)
Diameter class 1 x Length class 3 per m² (iii) Diameter class 3 x Length class 3 per m² (ix)
Diameter class 2 x Length class 1 per m² (iv) Diameter class 4 x Length class 1 per m² (x)
Diameter class 2 x Length class 2 per m² (v) Diameter class 4 x Length class 2 per m² (xi)
Diameter class 2 x Length class 3 per m² (vi) Diameter class 4 x Length class 3 per m² (xii)

where: categorical diameter class, categorical length class,

Western Washington
D1 = 10-30 cm  D2 = > 30-60 cm  D3 = > 60-80 cm  D4 = > 80 cm
L1 = 2-5 m  L2 = > 5-15 m  L3 = > 15 m

Eastern Washington
D1 = 10-15 cm  D2 = > 15-30 cm  D3 = > 30-60 cm  D4 = > 60 cm
L1 = 1-3 m  L2 = > 3-6 m  L3 = > 6 m

Definition: For each individual (Diameter x Length) class of large wood, (i-xii),

(i–xii) normalized volume, of large woody debris of a given unique (Diameter x Length) class per square meter of estimated bankfull-channel surface area of the site reach, either as intersecting or contained within the bankfull zone of the main channel (channel 0), as visually observed along the length of site reach. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm. Unit = cubic meters per square meter.

WHM export ID:

(i ) LWDVolumeMSqD1L1 (vii ) LWDVolumeMSqD3L1
(ii ) LWDVolumeMSqD1L2 (viii) LWDVolumeMSqD3L2
(iii) LWDVolumeMSqD1L3 (ix ) LWDVolumeMSqD3L3
(iv) LWDVolumeMSqD2L1 (x ) LWDVolumeMSqD4L1
(v ) LWDVolumeMSqD2L2 (xi ) LWDVolumeMSqD4L2
(vi) LWDVolumeMSqD2L3 (xii) LWDVolumeMSqD4L3
Observation type: Count
Allowed metric values: \( \geq 0 \)
Data collection schema,
\begin{align*}
\text{narrow protocol:} & \quad \text{Length of site reach, sub-divided into 10 equal-length sections.} \\
\text{wide protocol:} & \quad \text{Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).}
\end{align*}

Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: \( \geq 80\% \) of site reach surveyed
Reporting years (to date): 2009-2017

\begin{itemize}
\item Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.
\end{itemize}

Calculation:
\[
(i - xii) \quad \text{for each unique Diameter x Length class,} \\
\{ \text{where (LWD_Count) \( \neq \) is.null} \}
\]
\[
\left( \Sigma \text{ (LWD_Count)} \right) \times \text{Volume_factor} / (\text{Site_Length} \times \text{X_BFWidth}),
\]
using volume factor as,
\begin{align*}
\text{Western Washington} & \\
(i) & : 0.065 & (vii) & : 1.047 \\
(ii) & : 0.182 & (viii) & : 2.909 \\
(iii) & : 0.436 & (ix) & : 6.981 \\
(iv) & : 0.377 & (x) & : 3.393 \\
(v) & : 1.047 & (xi) & : 9.425 \\
(vi) & : 2.513 & (xii) & : 22.619 \\
\text{Eastern Washington} & \\
(i) & : 0.018 & (vii) & : 0.209 \\
(ii) & : 0.043 & (viii) & : 0.503 \\
(iii) & : 0.096 & (ix) & : 1.131 \\
(iv) & : 0.052 & (x) & : 0.838 \\
(v) & : 0.126 & (xi) & : 2.011 \\
(vi) & : 0.283 & (xii) & : 4.524
\end{align*}
where, Site Length = total length of site reach surveyed.  
X_BFWidth = average bankfull width.
Volume_factor = average volume of a single piece of LWD of the unique Diameter X Length class, as, for (i-xii)$^2$,

2 Source (see Robison):

$$\text{Volume} = \pi \times [0.5 \times (\text{minDiam} + (\text{maxDiam} + \text{minDiam})/3)]^2 \times [\text{minLength} + (\text{maxLength} - \text{minLength})/3]$$

Upper limits: Length Diameter

<table>
<thead>
<tr>
<th></th>
<th>Length</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Washington:</td>
<td>30 m</td>
<td>2 m</td>
</tr>
<tr>
<td>Eastern Washington:</td>
<td>15 m</td>
<td>1.2 m</td>
</tr>
</tbody>
</table>

$^3$ applies also to Kaufman et al., 1999 replacing,

$$\text{Volume} = \pi \times [4/3 \times (\text{minDiam}/2)^2] \times [4/3 \times \text{minLength}]$$

See definitions of individual (Diameter x Length) classes elsewhere in this section.

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel. See first entry, LWD category.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.


Link to definitions, [individual LWD Diameter x Length classes](https://fortress.wa.gov/ecy/publications/summarypages/1203029.html)
METRIC CATEGORY: Large Woody Debris

Group: Volume per square meter
Scope: All non-null observations per DCE, entire site reach

Reported: Combined normalized volume, two or more size classes, as large woody debris of,

All large wood, Size classes 1 to 5 per m² (i )
All large wood, Size classes 2 to 5 per m² (ii )
All large wood, Size classes 3 to 5 per m² (iii)
All large wood, Size classes 4 to 5 per m² (iv)

Definition: For each case of combined size classes of large wood, (i - iv)

(i – iv) normalized volume, of large woody debris of specified size classes per square meter of estimated bankfull-channel surface area of the site reach, either as intersecting or contained within the bankfull zone of the main channel (channel 0), as observed along the length of site reach. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm. Unit = cubic meters per square meter.

where

Size-class 1 = D1L1
Size-class 2 = D1L2, D2L1, D3L1
Size-class 3 = D1L3, D2L2, D4L1
Size-class 4 = D2L3, D3L2, D3L3, D4L2
Size-class 5 = D4L3

See URL below for individual (Diameter x Length) class definitions

WHM export ID: (i ) LWDVolumeMSq
(ii ) LWDVolumeMSqStoX
(iii) LWDVolumeMSqMtoX
(iv) LWDVolumeMSqLtoX

Observation type: Count
Allowed metric values: ≥ 0
Data collection schema,
narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.
wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).
Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017

Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

\[(i - xii) \quad \text{for each unique Diameter x Length class,}\]
\[\{\text{where (LWD_Count) } <> \text{ is.null}\}\]

\[(\sum \text{ (LWD_Count)}) \times \text{Volume_factor} / (\text{Site_Length} \times \text{X_BFWidth}),\]
using volume factor as,

Western Washington

| (i) | 0.065 | (vii) | 1.047 |
| (ii) | 0.182 | (viii) | 2.909 |
| (iii) | 0.436 | (ix) | 6.981 |
| (iv) | 0.377 | (x) | 3.393 |
| (v) | 1.047 | (xi) | 9.425 |
| (vi) | 2.513 | (xii) | 22.619 |

Eastern Washington

| (i) | 0.018 | (vii) | 0.209 |
| (ii) | 0.043 | (viii) | 0.503 |
| (iii) | 0.096 | (ix) | 1.131 |
| (iv) | 0.052 | (x) | 0.838 |
| (v) | 0.126 | (xi) | 2.011 |
| (vi) | 0.283 | (xii) | 4.524 |

where, Site_Length = total length of site reach surveyed.
X_BFWidth = average bankfull width.
Volume_factor =average volume of a single piece of LWD of the unique Diameter X Length class, as, for (i-xii)^2,

\[\text{Volume} = \pi \times [0.5*(\minDiam+(\maxDiam+\minDiam)/3)]^2*[(\minLength+(\maxLength-\minLength)/3) ^2]\]
Upper limits: Length Diameter
Western Washington: 30 m 2 m
Eastern Washington: 15 m 1.2 m

3 applies also to Kaufman et al., 1999 replacing,

\[ \text{Volume} = \pi \times \left[ \frac{4}{3} \times \left( \frac{\text{minDiam}}{2} \right)^2 \right] \times \left[ \frac{4}{3} \times \text{minLength} \right] \]

See definitions of individual (Diameter x Length) classes elsewhere in this section.

Note: if protocol = wide,

adjust counts, upsampling to both banks and length of surveyed channel.
See first entry, LWD category.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.


Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
**Metric Category: Riparian Cover**

<table>
<thead>
<tr>
<th>Reported</th>
<th>WHM export ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Densiometer readings at bank(s), count</td>
<td>N_DensioBank</td>
</tr>
<tr>
<td>Densiometer readings at channel center, count</td>
<td>N_DensioCenter</td>
</tr>
<tr>
<td>Densiometer readings at bank(s), average</td>
<td>X_DensioBank</td>
</tr>
<tr>
<td>Densiometer readings at channel center, average</td>
<td>X_DensioCenter</td>
</tr>
</tbody>
</table>
METRIC CATEGORY: Riparian Cover

Group: Cover density
Scope: All non-null observations per DCE, entire site reach

Reported: Densiometer readings at bank(s), count (i)
Densiometer readings at channel center, count (ii)
Densiometer readings at bank(s), average (iii)
Densiometer readings at channel center, average (iv)

Definition: (i) count, of densiometer readings, left bank or right bank, as one reading per bank, at the point where each cross-channel transect intersects the bankfull margin, for all observations associated with the main channel (channel 0). Unit = observations by densiometer.

(ii) count, of densiometer readings, channel center, as four reading per transect (Center left, Center right, Center upstream, Center downstream), at each cross-channel transect, for all observations associated with the main channel (channel 0). Unit = observations by densiometer.

Each reading is a tally of shaded grid-line intersections. Tallies range from 0 (no intersections shaded) to 17 (all intersections shaded). These tallies are what is averaged.

(iii) average, of readings of shaded (i.e., non-sky) densiometer grid-line intersections, as observed where the bankfull margins intersect each transect, for all observations associated with the main channel (channel 0). Unit = percent.

(iv) average, of readings of shaded (i.e., non-sky) densiometer grid-line intersections, as observed at the center of the bankfull channel, for all observations associated with the main channel (channel 0). Unit = percent.

WHM export ID: (i ) N_DensioBank
(ii ) N_DensioCenter
(iii) X_DensioBank
(iv) X_DensioCenter

Observation type, (i, ii): Count, of plots
(iii, iv): Count (as tallies of grid-cell intersections)

Allowed metric values,
(i ): ≥ 0 to ≤ 22
(ii ): ≥ 0 to ≤ 44
(iii, iv) : ≥ 0 to ≤ 100

Data collection schema: 11 cross-channel transects, equidistant and perpendicular to stream current. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE),
(i, iii):
  narrow protocol: 22; 1 reading per bank X 2 banks X 11 transects
  wide protocol: 11, 1 reading X 11 transects (one bank only)
(ii, iv):
  narrow protocol, only: 44; 4 readings per transect center X 11 transects
Minimum reporting qualifiers: Observations at least 80% complete
Reporting years (to date): 2009-2017

Calculation:

(i ) if, for each transect,
{Position = Bank and Value <> is.null}
count(Value) = N_DensiBank

(ii ) if, for each transect,
{Position = Center and Value <> is.null}
count(Value) = N_DensiCenter

(iii) if, for each transect,
{Position = Bank and Value <> is.null}
else exclude transect from average
∑ ((Count_Densiometer_Cells)/17 X 100 )

(iv ) if, for each transect,
{Position = Center and Value <> is.null}
else exclude transect from average
∑ ((Count_Densiometer_Cells)/17 X 100 )

Dependencies: Number of densiometer readings within acceptable range.

Assumptions: Observations sufficient to accurately characterize cross-sectional area of site reach.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
## Metric Category: Riparian Disturbance

<table>
<thead>
<tr>
<th>Reported</th>
<th>WHM export ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human influence plots, count</td>
<td>N_HumanInfluence</td>
</tr>
</tbody>
</table>

Proximity weighted presence, each disturbance type
- Buildings: PWP_Bldg
- Landfills or trash: PWP_Trash
- Logging: PWP_Log
- Mining: PWP_Mine
- Park or lawn: PWP_Lawn
- Pasture, rangeland, or hayfield: PWP_Range
- Paved road or railroad: PWP_Pave
- Unpaved road or motor trail: PWP_Unpav
- Human foot path: PWP_Path
- Clearing or lot: PWP_Clear
- Pipes, in or out: PWP_Pipe
- Row crops: PWP_Crop
- Wall, dike, or revetment: PWP_Dike

Proximity weighted presence, combined human influence types
- All: PWP_All
- Agricultural: PWP_Ag

Percent disturbance, by proximity to channel
- At bank, all human-influence types: PCT_BankAny
- At bank, agricultural human-influence types: PCT_BankAg
- Close to bank, all human influence types: PCT_CloseAny
- Close to bank, all human influence types: PCT_CloseAg
METRIC CATEGORY: **Riparian Disturbance**

Group: Riparian Disturbance  
Scope: All non-null observations per DCE, entire site reach  
Reported: Human influence plots, count (i)  

Definition: (i) count, of human influence observations associated with the main channel (channel 0), at each channel spanning transect. Unit = observations of human influence.  

WHM export ID: (i) N_HumanInfluence  
Observation type: Count  
Allowed values: > 0  
Data collection schema: Plots at ends of 11 evenly-spaced cross-channel transects, transects perpendicular to channel. Site reach length is variable, 150 - 2000 m.  
Maximum observations (DCE): 22; 1 observation per bank X 11 transects  
Minimum reporting qualifiers: Planned observations at least 80% complete  
Reporting years (to date): 2009-2017  
Calculation:  
(i) count(Human Influence rating) <> is.null  
Dependencies: None  
Assumptions: Observations sufficient to calculate weighted proximity scores for human influence types associated with the site reach.  
Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.  
Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: Riparian Disturbance

Group: Proximity weighted presence
Scope: All non-null observations per DCE, left and right banks, entire site reach
Reported: Proximity-weighted presence of human influence types:

- Buildings (i)
- Landfills or trash (ii)
- Logging (iii)
- Mining (iv)
- Park or lawn (v)
- Pasture, rangeland, or hayfield (vi)
- Paved road or railroad (vii)
- Unpaved road or motor trail (viii)
- Human foot path (ix)
- Clearing or lot (x)
- Pipes, in or out (xi)
- Row crops (xii)
- Wall, dike, or revetment (xiii)

Definition: All human influence types (i-xiii) have the same general definition:

(i-xiii) average, of categorical weights assigned to all rated plots for the proximity to the stream channel of a given human-influence type, as observed during a visual search of the region surrounding each cross-channel transect.

Unit = unitless

categorical weights assigned:

- 1.5 At least partially inside the bankfull-channel margins
- 1 Present 0-10 m from bankfull channel margin
- 0.66 Present >10-30 m from bankfull channel margin
- 0 Not present or > 30 m from bankfull channel margin

WHM export ID:

(i ) PWP_Bldg (viii) PWP_Unpav
(ii ) PWP_Trash (ix ) PWP_Path
(iii ) PWP_Log (x  ) PWP_Clear
(iv ) PWP_Mine (xi ) PWP_Pipe
(v ) PWP_Lawn (xii ) PWP_Crop
(vi ) PWP_Range (xiii) PWP_Dike
(vii) PWP_Pave

Observation type: Categorical weight assigned from visual estimate
Allowed values: ≥ 0 to ≤ 1.5

Data collection schema,
for weights < 1.5: 10 m X 10 m plots centered at ends of 11 evenly-spaced cross-channel transects, transects perpendicular to channel.
for weight = 1.5: Region in the channel surrounding the transects, 5 m upstream, 5 m downstream.
Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE): 22 per metric; 1 observation per bank X 11 transects
Minimum reporting qualifiers: Observations at least 80% complete
Reporting years (to date): 2009-2017

Calculation:

\[(i-xii) \text{ for a given disturbance type,} \]

\[\frac{\left( \sum \text{ (Left bank proximity score)} + \sum \text{ (Right bank proximity score)} \right)}{\text{N_HumanInfluence}}\]

where, \text{N_HumanInfluence} = \text{count of human influence observations.}

Dependencies: \text{N_HumanInfluence} must be known to calculate proximity weighted presence.

Assumptions: Observations sufficient to accurately characterize each rated human influence type.


Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: Riparian Disturbance

Group: Proximity weighted presence
Scope: All non-null observations per DCE, left and right banks, entire site reach

Reported: Proximity-weighted presence of human influence types:
- All (i)
- Agricultural (ii)

Definition:
(i) average, of all categorical proximity weights assigned to all rated plots for the proximity to the stream channel of all 13 human-influence types, as observed during a visual search of the plots. Unit = unitless.

(ii) same as for (i), except limited to agricultural human influence types (pasture/rangeland/hayfield, and row crops).

categorical weights assigned:

<table>
<thead>
<tr>
<th>Weight</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>At least partially within the bankfull channel margins</td>
</tr>
<tr>
<td>1</td>
<td>Present 0-10 m from bankfull channel margin</td>
</tr>
<tr>
<td>0.66</td>
<td>Present &gt;10-30 m from bankfull channel margin</td>
</tr>
<tr>
<td>0</td>
<td>Not present or &gt; 30 m from bankfull channel margin</td>
</tr>
</tbody>
</table>

WHM export ID:
- (i) PWP_All
- (ii) PWP_Ag

Observation type: Categorical weight assigned from visual estimate of proximity.

Allowed observation values,
- (i) minimum: 0
- (i) maximum: 19.5
- (ii) minimum: 0
- (ii) maximum: 3

Data collection schema,
- for weights < 1.5: 10 m X 10 m plots centered at ends of 11 evenly-spaced cross-channel transects, perpendicular to channel.
- for weight = 1.5: Region in the channel surrounding the transects, 5 m upstream, 5 m downstream.
- Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE): 22 per metric; 1 observation per bank X 11 transects
Minimum reporting qualifiers: observations at least 80% complete
Reporting years (to date): 2009-2017
Calculation:

(i) for all human influence types combined,
\[ \frac{\Sigma (\text{Left bank proximity score}) + \Sigma (\text{Right bank proximity score})}{N_{\text{HumanInfluence}}} \]

(ii) same as for (i), except only for agricultural human influence types

where, \(N_{\text{HumanInfluence}}\) = count of human influence observations.

Dependencies: \(N_{\text{HumanInfluence}}\) is the devisor for estimating proximity-weighted-presence.

Assumptions: Observations sufficient to accurately characterize each rated human influence type.


**METRIC CATEGORY:** Riparian Disturbance

**Group:** Percent disturbance

**Scope:** All non-null observations per DCE, left and right banks, entire site reach

**Reported:** Percent disturbance by extent of channel:

- At bank, all human-influence types (i)
- At bank, agricultural human-influence types (ii)
- Close to bank, all human influence types (iii)
- Close to bank, all human influence types (iv)

**Definition:**

(i) percent, of all rated plots where any human-influence type, as detected during a visual search of the plots, was observed up to 30 m from the bankfull channel margin. Unit = percent.

(ii) same as for (i), except limited to agricultural human influence types (pasture/ rangeland/ hayfield, and row crops). Unit = percent.

(iii) percent, of all rated plots where any human-influence type, as detected during a visual search of the plots, was observed up to 10 m from the bankfull channel margin. Unit = percent.

(iv) same as for (iii), except limited to agricultural human influence types (pasture or rangeland or hayfield and row crops). Unit = percent.

**WHM export ID:**

(i) PCT_BankAny

(ii) PCT_BankAg

(iii) PCT_CloseAny

(iv) PCT_CloseAg

**Observation type:** Categorical weight assigned from visual estimate of proximity

**Allowed observation values:** 

≥ 0 to ≤ 1.5

**Data collection schema,**

- narrow protocol: Plots are 10 m long.
- wide protocol: Plots are 20 m long.

**Maximum observations (DCE):** 22 per metric; 1 observation per bank X 11 transects

**Minimum reporting qualifiers:** Surveys at least 77% complete

**Reporting years (to date):** 2009-2017

**Calculation:**

(i) for any plot where any human influence proximity score = 1.5

\[
\left( \frac{\text{count(Left bank plots) + count(Right bank plots)}}{\text{N HumanInfluence}} \right) \times 100
\]

(ii) same as for (i), except only those plots with agricultural human influence types
(iii) same as for (i), except where any human influence proximity score \( \geq 1 \)

(iv) same as for (ii), except only those plots with agricultural human influence types

where, \( N_{\text{HumanInfluence}} = \text{count of human influence observations} \).

Dependencies: \( N_{\text{HumanInfluence}} \) and proximity scores for human influence types.

Assumptions: Observations sufficient to accurately characterize each rated human influence type.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
### Metric Category: Riparian Vegetation Structure

<table>
<thead>
<tr>
<th>Reported</th>
<th>WHM export ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers of riparian vegetation plots, by vegetation layer</td>
<td></td>
</tr>
<tr>
<td>Overstory, count</td>
<td>N_Canopy</td>
</tr>
<tr>
<td>Understory, count</td>
<td>N_Understory</td>
</tr>
<tr>
<td>Ground-covering, count</td>
<td>N_Ground</td>
</tr>
</tbody>
</table>

| Ratio of presence of riparian vegetation, per layer, to total observations | |
| Overstory, ratio | PPN_Canopy |
| Understory, ratio | PPN_Understory |
| Ground-covering, ratio | PPN_Ground |

| Ratio of presence of riparian vegetation, layers combined, to total observations | |
| (Overstory or Understory) | PPN_RipVegAboveGnd |
| (Overstory or Understory or Ground-covering) | PPN_CanUnderstoryGnd |

| Ratio, presence of a specific riparian vegetation type to total observations | |
| Coniferous overstory | PPN_CanConif |
| Deciduous overstory | PPN_CanDecid |
| Broadleaf overstory | PPN_CanBrdlf |
| Mixed overstory types | PPN_CanMixed |
| Coniferous understory | PPN_UnderstoryConif |
| Deciduous understory | PPN_UnderstoryDecid |
| Broadleaf understory | PPN_UnderstoryBrdlf |
| Mixed understory | PPN_UnderstoryMixed |

| Index, as percent of plot, each vegetation type | |
| Large overstory trees | IDX_CanopyLG |
| Small overstory trees | IDX_CanopyST |
| Large + small trees | IDX_UnderstoryHerb |
| Herbaceous understory | IDX_UnderstoryWood |
| Woody understory | IDX_GroundHerb |
| Herbaceous + woody understory | IDX_GroundWood |
| Herbaceous ground-cover | IDX_GroundBare |
| Woody ground cover | IDX_Canopy |
| Herbaceous+woody ground cover | IDX_Understory |
| Bare soil and litter | IDX_Ground |

| Index, as percent of plot, vegetation types combined | |

---

Page 104
(Large + small overstory trees) +
   (Woody + herbaceous understory)
   (Large + small overstory trees) +
   (Woody + herbaceous understory) +
   (Woody + herbaceous ground cover)
   (Large + small overstory trees) + (Woody understory)
   (Large + small overstory trees) +
   (Woody understory) +
   (Woody ground cover)

IDX_CanUnderstory
IDX_CanUnderstoryGnd
IDX_CanUnderstoryWood
IDX_CanUnderstoryWoodGndWood
**METRIC CATEGORY:** Riparian Vegetation Structure

**Groups:** Extent of site reach  
**Scope:** All non-null observations per DCE, entire site reach  
**Reported:** Riparian vegetation plots, by vegetation layer, as

- Overstory, count (i)  
- Understory, count (ii)  
- Groundcover count (iii)

where:  
- Overstory is canopy and stems of trees > 5 m in height  
- Understory is canopy and stems of trees > 0.5 to ≤ 5 m in height

**Definition:**

- (i) count, of plots where the presence of overstory vegetation was evaluated. Plots occur at the ends of each channel-spanning transect, for all transects associated with the main channel (channel 0). Unit = observations of overstory.
- (ii) same as for (i), except limited to understory vegetation  
- (iii) same as for (i), except limited to ground-covering vegetation

**WHM export ID:**  
(i) N_Canopy  
(ii) N_Understory  
(iii) N_Ground

**Observation type:** Count  
**Allowed metric values:** ≥ 0 to ≤ 22  
**Data collection schema,**  
11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with a vegetation plot at each end of each transect. Site reach length is variable, 150 - 2000 m.

- **narrow protocol:** Each plot is 10 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.  
- **wide protocol:** Each plot is 20 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.

**Maximum observations (DCE):** 22, 1 observation per bank X 2 banks X 11 transects  
**Minimum reporting qualifiers:** Observations at least 80% complete (18 of 22 plots rated)  
**Reporting years (to date):** 2009-2017

**Calculation:**

(i) if, for each transect,  
{Vegetation_Layer = Canopy}
\{\text{any}(\text{Left Bank} \text{ Cover score}) \not\equiv \text{is.null}\}\]
\begin{align*}
\text{count(Left Bank plots)} &= \text{N}_{\text{Left Bank}} \\
\text{if, for each transect,} & \\
\{\text{Vegetation Layer} = \text{Canopy}\} & \\
\{\text{any}(\text{Right Bank} \text{ Cover score}) \not\equiv \text{is.null}\} & \\
\text{count(Right Bank plots)} &= \text{N}_{\text{Right Bank}}
\end{align*}

\text{N}_{\text{Left Bank} \text{ Veg}} + \text{N}_{\text{Right Bank} \text{ Veg}} = \text{N}_{\text{Canopy}}

(ii) same as for (i) except \text{Vegetation Layer} = \text{Understory}

(iii) same as for (i) except \text{Vegetation Layer} = \text{Ground Cover}

Dependencies: Counts of rated plots within acceptable range.

Assumptions: Observations sufficient to accurately characterize vegetation layers observed.


Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: Riparian Vegetation Structure

Groups: Extent of site reach
Scope: All non-null observations per DCE, entire site reach
Reported: Observed presence of riparian vegetation, from a single vegetation layer, as

Overstory, proportion (i)
Understory, proportion (ii)
Groundcover proportion (iii)

where: overstory is canopy and stems of trees > 5 m in height
        understory is canopy and stems of trees > 0.5 to ≤ 5 m in height

Definition: (i ) proportion, as observed plots containing overstory vegetation to total plots evaluated. Plots occur at the ends of each channel-spanning transect, for all transects associated with the main channel (channel 0). A value of 1 indicates overstory (i.e., canopy) was observed on all plots. Unit = unitless.

(ii ) same as for (i), except limited to understory (i.e., mid-layer) vegetation

(iii) same as for (i), except limited to ground-covering vegetation

WHM export ID: (i   )  PPN_Canopy
                (ii  )  PPN_Understory
                (iii )  PPN_Ground

Observation type: Count
Allowed metric values: ≥ 0 to ≤ 1
Data collection schema, 11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with a vegetation plot at each end of each transect. Site reach length is variable, 150 - 2000 m.

narrow protocol: Each plot is 10 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.

wide protocol: Each plot is 20 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.

Maximum observations (DCE): 22, 1 observation per bank X 2 banks X 11 transects
Minimum reporting qualifiers: Observations at least 80% complete (18 of 22 plots rated)
Reporting years (to date): 2009-2017

Calculation:
  (i  ) if, for each transect,
    {Vegetation_Layer = Canopy}
    {any(Left_Bank_Cover score) <> 0 and <> is.null}
count(Left Bank plots) = N_LeftBank_Veg

if, for each transect,
   \{Vegetation\_Layer = Canopy\}
   \{Vegetation\_Description \neq \text{Bare}\}
   \{\text{any(Right\_Bank\_Cover score) \neq 0 and } \neq \text{is.null}\}

   count(Right Bank plots) = N_RightBank_Veg

\[N_{\text{LeftBank\_Veg}} + N_{\text{RightBank\_Veg}} = N_{\text{VegetationObserved}}\]

\[\frac{N_{\text{VegetationObserved}}}{N_{\text{Canopy}}} = \text{PPN\_Canopy}\]

(ii) same as for (i) except Vegetation\_Layer = Understory

(iii) same as for (i) except Vegetation\_Layer = Ground Cover

where, \(N_{\text{Canopy}}\) = count of total overstory vegetation observations

and, similarly,
\[N_{\text{Understory}} = \text{count of total understory vegetation observations}\]
\[N_{\text{Ground}} = \text{count of total ground covering vegetation observations.}\]

Dependencies: Counts of rated plots within acceptable range.

Assumptions: Observations sufficient to accurately characterize vegetation layers observed.


Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: **Riparian Vegetation Structure**

Groups: Extent of site reach  
Scope: All non-null observations per DCE, entire site reach  
Reported: Observed presence of riparian vegetation, overall, from one or more layers, as

(Overstory or Understory), proportion (i)
(Overstory or Understory or Ground-covering), proportion (ii)

where: overstory is canopy and stems of trees > 5 m in height  
understory is canopy and stems of trees > 0.5 to ≤ 5 m in height

Definition: (i) ratio, as plots containing either overstory or understory vegetation, or both, to total plots evaluated. Plots occur at the ends of each channel-spanning transect, for all transects associated with the main channel (channel 0). A value of 1 indicates overstory or understory was detected on all observed plots. Unit = unitless.

(ii) same as for (i), except considers presence of overstory or understory or ground-covering vegetation.

WHM export ID:  (i) PPN_RipVegAboveGnd  
(ii) PPN_CanUnderstoryGnd

Observation type: Count  
Allowed values: ≥ 0 to ≤ 1  
Data collection schema: 11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with a vegetation plot at each end of each transect. Site reach length is variable, 150 - 2000 m.

narrow protocol: Each plot is 10 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.

wide protocol: Each plot is 20 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.

Maximum observations (DCE): 22, 1 observation per bank X 2 banks X 11 transects
Minimum reporting qualifiers: Observations at least 63% complete (7 of 11 plots rated)
Reporting years (to date): 2009-2017

Calculation:

(i) if, for each transect,

\{Vegetation_Description <> Bare\}  
\{Vegetation_Layer = Canopy\} or  
\{Vegetation_Layer = Understory\}  
and, for both Canopy and Understory,
\{each(Left\_Bank\_Cover\ score) \<> 0 \text{ and } \<> \text{is.null}\} \\
\text{count(Left Bank plots) = N\_LeftBank\_Veg}

\text{if, for each transect,} \\
\{Vegetation\_Description \<> \text{Bare}\} \\
\{Vegetation\_Layer = \text{Canopy}\} \text{ or} \\
\{Vegetation\_Layer = \text{Understory}\} \\
\text{and, for both Canopy and Understory,} \\
\{each(Right\_Bank\_Cover\ score) \<> 0 \text{ and } \<> \text{is.null}\} \\
\text{count(Right Bank plots) = N\_RightBank\_Veg}

\text{N\_LeftBank\_Veg + N\_RightBank\_Veg = N\_VegetationObserved}

\text{if, for each transect,} \\
\{Vegetation\_Description \<> \text{Bare}\} \\
\{Vegetation\_Layer = \text{Canopy}\} \text{ or} \\
\{Vegetation\_Layer = \text{Understory}\} \\
\{any(Left\_Bank\_Cover\ score) \<> \text{is.null}\} \\
\text{count(Left Bank plots) = N\_LeftBank}

\text{if, for each transect,} \\
\{Vegetation\_Description \<> \text{Bare}\} \\
\{Vegetation\_Layer = \text{Canopy}\} \text{ or} \\
\{Vegetation\_Layer = \text{Understory}\} \\
\{any(Right\_Bank\_Cover\ score) \<> \text{is.null}\} \\
\text{count(Right Bank plots) = N\_RightBank}

\text{N\_LeftBank\_Veg + N\_RightBank\_Veg = N\_Plots}

\text{N\_VegetationObserved / N\_Plots = PPN\_\_*}

\text{where PPN\_\_* = PPN\_RipVegAboveGnd}

\text{(ii) same as for (i) except Vegetation\_Layer = Canopy or Understory or Ground Cover}

\text{Dependencies: Counts of rated plots within acceptable range.}

\text{Assumptions: Observations sufficient to accurately characterize vegetation layers observed.}

\text{Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.}

\text{Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html}
METRIC CATEGORY: **Riparian Vegetation Structure**

Groups: Extent of site reach  
Scope: All non-null observations per DCE, entire site reach  
Reported: Observed presence of riparian vegetation, as

- Coniferous overstory, proportion (i)  
- Deciduous overstory, proportion (ii)  
- Broadleaf overstory, proportion (iii)  
- Mixed overstory types, ratio (iv)  

- Coniferous understory, proportion (v)  
- Deciduous understory, proportion (vi)  
- Broadleaf understory, ratio (vii)  
- Mixed understory, ratio (viii)  

where: overstory is canopy and stems of trees > 5 m in height  
understory is canopy and stems of trees > 0.5 to 5 m in height

**Definition:**

(i-iv) proportion, as observed plots containing a specific type of overstory vegetation to total plots evaluated. Plots occur at the ends of each channel-spanning transect, for all transects associated with the main channel (channel 0). A value of 1 indicates the specific type of overstory (i.e., canopy) was observed on all plots. Unit = unitless.

(v-viii) proportion, as observed plots containing a specific type of understory vegetation to total plots evaluated. Plots occur at the ends of each channel-spanning transect, for all transects associated with the main channel (channel 0). A value of 1 indicates the specific type of understory (i.e., mid-layer) was observed on all plots. Unit = unitless.

**WHM export ID:**

<table>
<thead>
<tr>
<th>Proportion</th>
<th>Export ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) CanOver</td>
<td>PPN_CanConif</td>
</tr>
<tr>
<td>(ii) DecOver</td>
<td>PPN_CanDecid</td>
</tr>
<tr>
<td>(iii) BrdOver</td>
<td>PPN_CanBrdlf</td>
</tr>
<tr>
<td>(iv) MixOver</td>
<td>PPN_CanMixed</td>
</tr>
<tr>
<td>(v) CanUner</td>
<td>PPN_UnderstoryConif</td>
</tr>
<tr>
<td>(vi) DecUner</td>
<td>PPN_UnderstoryDecid</td>
</tr>
<tr>
<td>(vii) BrdUner</td>
<td>PPN_UnderstoryBrdlf</td>
</tr>
<tr>
<td>(viii) MixUner</td>
<td>PPN_UnderstoryMixed</td>
</tr>
</tbody>
</table>

where Can = canopy and Und = understory.

**Observation type:** Count  
**Allowed metric values:** ≥ 0 to ≤ 1  
**Data collection schema:** 11 cross-channel transects, perpendicular to stream current and equi-distant along the site reach, with a vegetation plot at each end of each transect. Site reach length is variable, 150 - 2000 m.  
**narrow protocol:** Each plot is 10 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.
wide protocol: Each plot is 20 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.

Maximum observations (DCE): 22, 1 observation x 2 banks x 11 transects
Minimum reporting qualifiers: Observations at least 68% complete (15 of 22 plots rated)
Reporting years (to date): 2009-2017

Calculation:

where Vegetation_Type = * ---> Coniferous
Deciduous
Broadleaf Evergreen
Mixed (at least 10% of type)

(i-iv) if, for each transect,
{Vegetation_Layer = Canopy}
{any(Left_Bank_Vegetation_Type) = *}
count(Left Bank plots) = N_LeftBank_Veg

if, for each transect,
{Vegetation_Layer = Canopy}
{any(Right_Bank_Cover_Type) = *}
count(Right Bank plots) = N_RightBank_Veg

N_LeftBank_Veg + N_RightBank_Veg = N_VegetationObserved

N_VegetationObserved / N_Canopy = PPN_CanConif

(v-viii) if, for each transect,
{Vegetation_Layer = Understory}
{any(Left_Bank_Vegetation_Type) = *}
count(Left Bank plots) = N_LeftBank_Veg

if, for each transect,
{Vegetation_Layer = Understory}
{any(Right_Bank_Cover_Type) = *}
count(Right Bank plots) = N_RightBank_Veg

N_LeftBank_Veg + N_RightBank_Veg = N_VegetationObserved

N_VegetationObserved / N_Canopy = PPN_CanConif

then repeat for each combination of vegetation layer and vegetation type, (ii) to (viii).

where, N_Canopy = count of total overstory vegetation observations
and, similarly,
N_Understory = count of total understory vegetation observations
N_Ground = count of total ground-covering vegetation observations.
Dependencies: Counts of rated plots within acceptable range.

Assumptions: Observations sufficient to accurately characterize vegetation layers observed.


Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: **Riparian Vegetation Structure**

Groups: Percent of plot index  
Scope: All non-null observations per DCE, entire site reach  
Reported: Observed percentage of riparian vegetative cover, from a single vegetation layer, as

- Large overstory trees, index (i)  
- Small overstory trees, index (ii)  
- Herbaceous understory, index (iii)  
- Woody understory, index (iv)  
- Herbaceous ground-cover, index (vii)  

- Woody ground cover, index (viii)  
- Bare soil and litter, index (x)  
- Large + small trees, index (iii)  
- Herbaceous + woody understory, index (vi)  
- Herbaceous+woody ground cover, index (ix)  

Definition: For each category of vegetative cover (i – x),

\[(i - x)\] average, of plot-level vegetative cover ratings, to total number of vegetation plots evaluated. Plots occur at the ends of each channel-spanning transect, for all transects associated with the main channel (channel 0). Unit = percent.

categorical % average cover ratings  
assigned:  
0: if 0% plot area  
5: if 1 -10% plot area  
25: if 11-40% plot area  
57.5: if 41-75% plot area  
87.5: if > 75% plot area

WHM export ID:  
(i ) IDX_CanopyLT  
(ii ) IDX_CanopyST  
(iii ) IDX_UnderstoryHerb  
(iv ) IDX_UnderstoryWood  
(v ) IDX_GroundHerb  
(vi ) IDX_GroundWood  
(vii ) IDX_GroundBare  
(viii ) IDX_Canopy  
(ix ) IDX_Understory  
(x ) IDX_Ground

where overstory = Canopy

Observation type: Count, categorical rating  
Allowed metric values:  
(i - vii): \(\geq 0\) to \(\leq 87.5\)  
(viii – x): \(\geq 0\) to \(\leq 115\)  

Data collection schema, narrow protocol: Each plot is 10 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.
wide protocol: Each plot is 20 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.

Maximum observations (DCE): 22, 1 observation per bank X 2 banks X 11 transects
Minimum reporting qualifiers: Observations at least 68% complete (15 of 22 plots rated)
Reporting years (to date): 2009-2017

Calculation:
(i - vii) if, for each transect,
{Vegetation_Layer = Canopy} and
{Vegetation_Description = Big Trees}
{any(Left_Bank_Cover score) <> 0 and <> is.null}
\[ \sum (\text{Left Bank plots}) = T_{\text{LeftBank IDX}} \]

if, for each transect,
{Vegetation_Layer = Canopy} and
{Vegetation_Description = Big Trees}
{any(Right_Bank_Cover score) <> 0 and <> is.null}
\[ \sum (\text{Right Bank plots}) = T_{\text{RightBank IDX}} \]

\[ T_{\text{LeftBank IDX}} + T_{\text{RightBank IDX}} = T_{\text{VegObserved IDX}} \]

if, for each transect,
{Vegetation_Layer = Canopy} and
{Vegetation_Description = Big Trees}
{any(Left_Bank_Cover score) <> is.null}
\[ \text{count(Left Bank plots)} = N_{\text{LeftBank IDX}} \]

if, for each transect,
{Vegetation_Layer = Canopy} and
{Vegetation_Description = Big Trees}
{any(Right_Bank_Cover score) <> is.null}
\[ \text{count(Right Bank plots)} = N_{\text{RightBank IDX}} \]

\[ N_{\text{LeftBank IDX}} + N_{\text{RightBank IDX}} = N_{\text{Plots IDX}} \]

\[ T_{\text{VegObserved IDX}} / N_{\text{Plots IDX}} = \text{IDX CanopyLT} \]

then repeat for each combination of vegetation layer and vegetation type, (ii) to (vii).

(viii) \[ \text{IDX CanopyLT} + \text{IDX CanopyST}, \text{for plots rating both small and large trees} \]
(ix) \[ \text{IDX UnderstoryWood} + \text{IDX UnderstoryHerb} \]
(x) \[ \text{IDX GroundWood} + \text{IDX GroundHerb} \]

Dependencies: Counts of rated plots within acceptable range.
Assumptions: Observations sufficient to accurately characterize vegetation layers observed.
Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: Riparian Vegetation Structure

Groups: Percent of plot index
Scope: All non-null observations per DCE, entire site reach

Reported: Sums of indices of riparian vegetative cover, multiple vegetation layers, as

(Large + small overstory trees) + (woody + herbaceous understory), index (i)
(Large + small overstory trees) +
(Woody + herbaceous understory) +
(Woody + herbaceous ground cover), index (ii)
(Large + small overstory trees) + (woody understory), index (iii)
(Large + small overstory trees) +
(Woody understory) +
(Woody ground cover), index (iv)

Definition: For categories of vegetative cover (i – iv),

(i – iv) index, as sum of site averages, of vegetative cover ratings per plot. Plots occur as observed in the riparian or upslope area at the ends of each channel-spanning transect, for all transects associated with the main channel (channel 0). Unit = percent.

categorical % cover ratings assigned:

0: if 0% plot area
5: if 1 - 10% plot area
25: if 11-40% plot area
57.5: if 41-75% plot area
87.5: if > 75% plot area

WHM export ID: (i ) IDX_CanUnderstory
(ii ) IDX_CanUnderstoryGnd
(iii ) IDX_CanUnderstoryWood
(iv ) IDX_CanUnderstoryWoodGndWood

where overstory = Canopy or Can, ground cover = Gnd

Observation type: Count, categorical rating

Allowed metric values:

(i ) \( \geq 0 \text{ to } \leq 230 \)
(ii ) \( \geq 0 \text{ to } \leq 345 \)
(iii) \( \geq 0 \text{ to } \leq 202.5 \)
(iv) \( \geq 0 \text{ to } \leq 290 \)

Data collection schema, 11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with a vegetation plot at each end of each transect. Site reach length is variable, 150 - 2000 m.
narrow protocol: Each plot is 10 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.

wide protocol: Each plot is 20 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.

Maximum observations (DCE): 22, 1 observation per bank X 2 banks X 11 transects
Minimum reporting qualifiers: Observations at least 68% complete (15 of 22 plots rated)
Reporting years (to date): 2009-2017

Calculation:

(i ) $IDX_{Canopy} + IDX_{Understory}$
(ii ) $IDX_{Canopy} + IDX_{Understory} + IDX_{Ground}$
(iii) $IDX_{Canopy} + IDX_{UnderstoryWood}$
(iv) $IDX_{Canopy} + IDX_{UnderstoryWood} + IDX_{GroundWood}$

See below for definition of single vegetation-layer metrics,

$IDX_{Canopy}$, $IDX_{Understory}$, $IDX_{Ground}$, $IDX_{UnderstoryWood}$, $IDX_{GroundWood}$

Dependencies: Counts of rated plots within acceptable range.

Assumptions: Observations sufficient to accurately characterize vegetation layers observed.


Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Link to definitions, single vegetation-layer metrics (IDX)
**Metric Category: Side Channel Quantity**

<table>
<thead>
<tr>
<th>Reported</th>
<th>WHM export ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum occurrence of side channels</td>
<td>SC_Max</td>
</tr>
<tr>
<td>Longitudinal extent of side channels</td>
<td>PPN_SideChannel</td>
</tr>
</tbody>
</table>


METRIC CATEGORY: Side Channel Quantity

Group: Side Channels
Scope: All non-null observations per DCE, entire site reach
Reported: Maximum occurrence of side channels, count (i)
Longitudinal extent of side channels, proportion (ii)

Definition: (i) maximum of counts, along thalweg transects perpendicular to the main channel, as extended from each thalweg station, of the number of side channels intersected. Only the first three side channels per thalweg station are counted. A count of three means at least three side-channels were observed. Unit = dimensionless.

(ii) proportion, as the count of thalweg stations where at which at least one side channel was observed, to the count of total thalweg stations rated. Observations are along the thalweg transects perpendicular to the main channel (channel 0). A value of 1 means that side channels were observed at all thalweg stations. Unit = dimensionless.

WHM export ID: (i) SCMax
(ii) PPN_SideChannel

Observation type: Visual assessment
Allowed values: 0, 1, 2, 3
Data collection schema: Observations along thalweg transects perpendicular to the main channel of the site reach at each of 100 equidistant thalweg stations. Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE): 100
Minimum reporting qualifiers: Observations 100% complete. Habitat unit survey 100% complete. No missing or out-of-sequence habitat units.
Reporting years (to date): 2009-2017

Calculation
(i ) for the number of observations, a to x, as counts of side channels \( Y_a \) to \( Y_x \)
\[ \text{Max}(Y_a, \ldots Y_x) \]

(ii ) for the number of observations, a to x, as counts of side channels \( Y_a \) to \( Y_x \)
1) where \( Y_a, \ldots Y_x > 0 \), count of observations \( Y_a, \ldots Y_x = C \)
2) count of all observations \( Y_a, \ldots Y_x = D \)
3) \( C / D \)
Dependencies: All 100 thalweg stations must be visited and rated.

Assumptions: Side channels are detectable through topography and brush.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
Metric Category: Sinuosity

<table>
<thead>
<tr>
<th>Reported</th>
<th>WHM export ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinuosity of site reach, index</td>
<td>Sinuosity</td>
</tr>
</tbody>
</table>
METRIC CATEGORY: Sinuosity

Group: Sinuosity
Scope: All non-null observations per DCE, entire site reach

Reported: Sinuosity of site reach, index (i)

Definition: (i) index, of deviation from the straight-line, point-to-point distance between the upper and lower ends of the site reach, as the ratio of shortest direct point-to-point aerial transit path to overall length of sinuous watercourse as estimated by the sum of site-level reach sub-segment lengths. Unit = dimensionless.

Reported for protocol = narrow only.

WHM export ID: (i) Sinuosity

Observation type: Derived from bearing readings
Allowed values: ≥ 1
Data collection schema: Observations parallel to thalweg of the site reach sufficient to characterize reach. Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE), narrow protocol: 30
wide protocol: not reported
Minimum reporting qualifiers, narrow protocol: 20
wide protocol: not reported
Reporting years (to date): 2009-2017

Calculation:

(i) where protocol = narrow, and bearing <> is.null,


\[
((\Sigma \text{Northing})^2 + (\Sigma \text{Easting})^2)^{0.5} / \Sigma \text{Segment length},
\]

where Northing and Easting are the sine and cosine decompositions of bearing readings.

Dependencies: Lengths and bearings of site reach segments must be known.

Assumptions: Observations sufficient to accurately characterize sinuosity of site reach.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
**Metric Category: Substrate**

<table>
<thead>
<tr>
<th>Reported</th>
<th>WHM export ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire reach</td>
<td></td>
</tr>
<tr>
<td>Embeddedness, count</td>
<td>N_Emb</td>
</tr>
<tr>
<td>Embeddedness, average</td>
<td>X_Emb</td>
</tr>
<tr>
<td>Embeddedness, std. dev.</td>
<td>SD_Emb</td>
</tr>
<tr>
<td>Mid-channel</td>
<td></td>
</tr>
<tr>
<td>Embeddedness, mid-channel, count</td>
<td>N_EmbCenter</td>
</tr>
<tr>
<td>Embeddedness, mid-channel, average</td>
<td>X_EmbCenter</td>
</tr>
<tr>
<td>Embeddedness, mid-channel, std. dev.</td>
<td>SD_EmbCenter</td>
</tr>
<tr>
<td>Number of all substrates observed, count</td>
<td>N_Substrate</td>
</tr>
<tr>
<td>Percent substrate, each diameter category</td>
<td></td>
</tr>
<tr>
<td>Smooth bedrock</td>
<td>PCT_BedrockS</td>
</tr>
<tr>
<td>Rough bedrock</td>
<td>PCT_BedrockR</td>
</tr>
<tr>
<td>Pavement (i.e., concrete)</td>
<td>PCT_Pavement</td>
</tr>
<tr>
<td>Large boulders</td>
<td>PCT_BoulderL</td>
</tr>
<tr>
<td>Small boulders</td>
<td>PCT_BoulderS</td>
</tr>
<tr>
<td>Cobble</td>
<td>PCT_Cobble</td>
</tr>
<tr>
<td>Coarse gravel</td>
<td>PCT_GravelC</td>
</tr>
<tr>
<td>Fine gravel</td>
<td>PCT_GravelF</td>
</tr>
<tr>
<td>Sand</td>
<td>PCT_Sand</td>
</tr>
<tr>
<td>Fines</td>
<td>PCT_Fines</td>
</tr>
<tr>
<td>Hardpan</td>
<td>PCT_Hardpan</td>
</tr>
<tr>
<td>Wood</td>
<td>PCT_Wood</td>
</tr>
<tr>
<td>Other</td>
<td>PCT_Other</td>
</tr>
<tr>
<td>Percent substrate, diameter categories combined</td>
<td></td>
</tr>
<tr>
<td>Bedrock, Smooth or rough</td>
<td>PCT_Bedrock</td>
</tr>
<tr>
<td>Coarse gravel and larger</td>
<td>PCT_GravelCx</td>
</tr>
<tr>
<td>Fine gravel and smaller</td>
<td>PCT_GravelFb</td>
</tr>
<tr>
<td>Sands and fines</td>
<td>PCT_SandFines</td>
</tr>
<tr>
<td>Boulder, large and small</td>
<td>PCT_Boulder</td>
</tr>
</tbody>
</table>
METRIC CATEGORY: **Substrate**

Group: Embeddedness  
Scope: All non-null observations per DCE, entire site reach  
Reported: Embeddedness, count (i)  
Embeddedness, average (ii)  
Embeddedness, standard deviation (iii)  

Definition: (i) count, as all embeddedness observations for all channel-spanning transects associated with the main channel (channel 0). Unit = observations of embeddedness.  
(ii) average, of all embeddedness observations associated with the main channel (channel 0), bank to bank, for all channel-spanning transects, where transects are perpendicular to stream current. Unit = percent.  
(iii) standard deviation, of all embeddedness observations associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = percent.  

WHM export ID:  
(i) N_Embed  
(ii) X_Embed  
(iii) SD_Embed  

Observation type: Visual numeric ratings  
Allowed values, precision: 0 – 100  
Data collection schema, narrow protocol: 11 equidistant observation stations, bank to bank, per transect.  
wide protocol: Work at one side of the channel. Observe at dry stations. Estimate an average for the littoral plot.  
Maximum observations (DCE): 121; 11 observations X 11 transects  
Minimum reporting qualifiers, narrow protocol: observations at least 80% complete (97 of 121)  
wide protocol: 22 (at least two observations per transect)  
Reporting years (to date): 2009-2017  

Calculation:  
(i) count(Embeddedness rating) <> is.null  
(ii) ( Σ (Embeddedness rating)) / N_Embed  
(iii) ( Σ ((Embeddedness rating – X_Embed)^2)/(N_Embed-1))^1/2  

Dependencies: N Embed must be known to calculate X_Embed and SD_Embed
Assumptions: Observations sufficient to accurately characterize bed character of site reach.


Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: Substrate

Group: Embeddedness
Scope: Non-null mid-active channel observations per DCE, entire site reach
      Narrow protocol data only.
Reported: Embeddedness, mid-active channel, count (i)
          Embeddedness, mid-active channel, average (ii)
          Embeddedness, mid-active channel, standard deviation (iii)

Definition: (i) count, of embeddedness observations at three stations (mid-channel, 1/10th
            of channel width left of mid-channel, 1/10th of channel width right of mid-
            channel) for all channel-spanning transects associated with the main channel
            (channel 0). Unit = mid-channel observations of embeddedness.
(ii) average, of embeddedness observations at three stations (mid-channel, left of
     mid-channel, right of mid-channel), for all channel-spanning transects
     associated with the main channel (channel 0). Unit = percent.
(iii) standard deviation, of all non-null, mid-channel embeddedness observations
     associated with the main channel (channel 0), as an estimate of dispersion
     from the sample average. Unit = percent.

WHM export ID: (i) N_EmbedCenter
               (ii) X_EmbedCenter
               (iii) SD_EmbedCenter

Observation type: Visual numeric ratings
Allowed values, precision: 0 – 100
Data collection schema: 11 evenly-spaced cross-channel transects, perpendicular to
                        channel, equidistant mid-channel observations.
                        Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE): 33; 3 observations X 11 transects
Minimum reporting qualifiers: Observations at least 80% complete
Reporting years (to date): 2009-2017

Calculation:
(i) count(mid-channel(Embeddedness ratings)) <> is.null
(ii) ( Σ (mid-channel(Embeddedness rating)) / N_EmbedCenter
(iii) ( Σ ((mid-channel(Embeddedness rating)) – X_EmbedCenter)^2) /
      (N_EmbedCenter-1))^1/2

Dependencies: N_EmbedCenter must be known to calculate X_EmbedCenter and
               SD_EmbedCenter
Assumptions: Observations sufficient to accurately characterize center-of-channel character of
             site reach.
Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
METRIC CATEGORY: **Substrate**

Groups: Percent substrate by size
Scope: All non-null observations per DCE, entire site reach
Reported: Substrate particle observations, as

Number of all substrates sized, count (i)

Definition: (i) count, of total substrate observations, lithic and non-lithic, as observed, bank-to-bank, along channel-spanning transects, associated with the main channel (channel 0). Unit = observations of substrate.

WHM export ID: (i) N_Substrate

Observation type: Count
Allowed metric values: \[0 \leq N_{Substrate} \leq 231\]
Data collection schema:
- narrow protocol: 21 cross-channel transects, bank to bank, where transects are perpendicular to stream current and equidistant along the site reach.
- wide protocol: 11 cross-channel transects, variable number of stations (2 to 11 per transect).

Maximum observations (DCE),
- narrow protocol: 231, 11 observations X 21 transects
- wide protocol: 121, 11 observations X 11 transects

Minimum reporting qualifiers,
- narrow protocol: Observations at least 70% complete (15 of 21 transects rated)
- wide protocol: 22 (2 observations X 11 transects)

Reporting years (to date): 2009-2017

Calculation:
\[
(i) \text{ for all substrate observations, lithic and non-lithic, where } \text{Substrate Type Code} \neq \text{null}, \\
\text{(count (Substrate Type Code) }\neq \text{null})
\]

Dependencies: Number of substrate observations within acceptable range.

Assumptions: Observations sufficient to accurately characterize substrate particle diameter as observed along the site reach.


METRIC CATEGORY: **Substrate**

Groups: Percent substrate by size
Scope: All non-null observations per DCE, entire site reach
Reported: Percent substrate of particle diameter categories observed, as

- Smooth bedrock (RS), (i)
- Rough bedrock (RR), (ii)
- Hardpan (HP), (iii)
- Pavement (i.e., concrete), (RC) (iv)
- Large boulders (XB), (v)
- Small boulders (SB), (vi)
- Cobble (CB), (vii)
- Coarse gravel (GC), (viii)
- Fine gravel (GF), (ix)
- Sand (SA), (x)
- Fines (FN), (xi)
- Wood (WD), (xii)
- Other (OT), (xiii)

*C is now only recorded if pavement is of size > 4000 mm. If <4000 mm then concrete is classified as Other (OT).*

Categorical diameter ranges:

<table>
<thead>
<tr>
<th>Category</th>
<th>Diameter Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>&gt;4000 mm</td>
</tr>
<tr>
<td>(ii)</td>
<td>&gt;4000 mm</td>
</tr>
<tr>
<td>(iii)</td>
<td>&gt;4000 mm</td>
</tr>
<tr>
<td>(iv) Pavement</td>
<td>&gt;250-1000 mm</td>
</tr>
<tr>
<td>(v)</td>
<td>&gt;250-4000 mm</td>
</tr>
<tr>
<td>(vi)</td>
<td>&gt;250-1000 mm</td>
</tr>
<tr>
<td>(vii)</td>
<td>&gt;64-250 mm</td>
</tr>
<tr>
<td>(viii)</td>
<td>&gt;16-64 mm</td>
</tr>
<tr>
<td>(ix)</td>
<td>&gt;2-16 mm</td>
</tr>
<tr>
<td>(x)</td>
<td>0.06-2 mm</td>
</tr>
<tr>
<td>(xi) Fines</td>
<td>&gt;0.061-0.06 mm</td>
</tr>
<tr>
<td>(xii) Wood</td>
<td>all sizes</td>
</tr>
<tr>
<td>(xiii) Other</td>
<td>not as above</td>
</tr>
</tbody>
</table>

Definition: For substrate particle diameter categories (i-xiii):

(i-xiii) ratio, adjusted to percent, as observations of the given substrate size category to total substrate observations, as observed, bank-to-bank, at channel-spanning transects, associated with the main channel (channel 0). A value of 100 indicates that the channel bed, as observed along the site reach, was dominated by a single substrate particle diameter category. Unit = percent.

WHM export ID:

- (i) PCT_BedrockS
- (ii) PCT_BedrockR
- (iii) PCT_Hardpan
- (iv) PCT_Pavement
- (v) PCT_BoulderL
- (vi) PCT_BoulderS
- (vii) PCT_Cobble
- (viii) PCT_GravelC
- (ix) PCT_GravelF
- (x) PCT_Sand
- (xi) PCT_Fines
- (xii) PCT_Wood
- (xiii) PCT_Other

Observation type: Categorical rating
Allowed metric values: ≥ 0 to ≤ 100
Data collection schema,
narrow protocol: 21 cross-channel transects, bank to bank, where transects are perpendicular to stream current and equidistant along the site reach.
wide protocol: 11 cross-channel transects, variable number of stations (2 to 11 per transect).

Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE),
narrow protocol: 231, 11 observations X 21 transects
wide protocol: 121, 11 observations X 11 transects

Minimum reporting qualifiers,
narrow protocol: Observations at least 70% complete (15 of 21 transects rated)
wide protocol: 22 (2 observations X 11 transects)

Reporting years (to date): 2009-2017

Calculation:

(i-xiii) for each unique substrate particle diameter category,
   {where Substrate_Type_Code <> is.null},
   {where Substrate_Type_Code = i}

   ((count(Substrate_Type_Code) = i <> is.null)) / count(Substrate_Type_Code)*100
or, ( (count(Substrate_Type_Code) = i <> is.null)) / (N_Substrate)*100

Dependencies: N Substrate within acceptable range.

Assumptions: Observations sufficient to accurately characterize substrate particle diameter as observed along the site reach.


Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html
**METRIC CATEGORY:** Substrate

*Groups:* Percent substrate by size  
*Scope:* All non-null observations per DCE, entire site reach  
*Reported:* Combined percent, two or more particle diameter categories, of substrates as

- Bedrock, smooth or rough (i)
- Coarse gravel and larger (ii)
- Fine gravel and smaller (iii)
- Sands and fines (iv)
- Boulder, large and small (v)

See below for definitions of combined substrate particle-diameter categories.

*Definition:* For each case of combined particle-diameter categories of substrate, (i - v)

(i - v) ratio, adjusted to percent, of channel bed, along the site reach, dominated by the specified particle-diameter categories, as observed, bank-to-bank, at channel-spanning transects, associated with the main channel (channel 0).

Unit = percent.

Combined particle diameter categories (see pg 128 for further detail):

(i ) BedrockS, BedrockR  
(ii ) BedrockS, BedrockR, Hardpan, BoulderL, BoulderS, Cobble, GravelC  
(iii ) GravelF, Sand, Fines  
(iv ) Sand, Fines  
(v ) BoulderL, BoulderS

*WHM export ID:*  
(i ) PCT_Bedrock  
(ii ) PCT_GravelCx  
(iii ) PCT_GravelFb  
(iv ) PCT_SandFines  
(v ) PCT_Boulder

*Observation type:* Categorical rating  
*Allowed metric values:* ≥ 0 to ≤ 100  
*Data collection schema,*  
**narrow protocol:** 21 cross-channel transects, bank to bank, where transects are perpendicular to stream current and equidistant along the site reach.  
**wide protocol:** 11 cross-channel transects, variable number of stations (2 to 11 per transect). Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE),
narrow protocol: 231, 11 observations X 11 transects
wide protocol: 121, 11 observations X 21 transects
Minimum reporting qualifiers,
narrow protocol: Observations at least 70% complete (15 of 21 transects rated)
wide protocol: 22 (2 observations X 11 transects)
Reporting years (to date): 2009-2017

Calculation:

(i - v) for each unique substrate particle diameter category, a to x
{where Substrate_Type_Code <> is.null},

(count (Substrate_Type_Code)) as = Yₐ, …., Yₓ

then  Σ ( Yₐ + ….+ Yₓ ) / (count(Substrate_Type_Code) * 100

Dependencies: none.

Assumptions: Observations sufficient to accurately characterize substrate particle diameter as observed along the site reach.


Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Link to definitions, substrate particle diameters
References

https://fortress.wa.gov/ecy/publications/summarypages/0603203.html


Note: The above protocol is out-of-date. Updated standard operating procedures will be available in 2018 here: https://ecology.wa.gov/Research-Data/Monitoring-assessment/River-stream-monitoring/Habitat-monitoring/Habitat-monitoring-methods and from glenn.merritt@ecy.wa.gov


Note: The above protocol is out-of-date. Updated standard operating procedures will be available in 2018 here: https://ecology.wa.gov/Research-Data/Monitoring-assessment/River-stream-monitoring/Habitat-monitoring/Habitat-monitoring-methods and from glenn.merritt@ecy.wa.gov


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Appendix A. Alphabetical List of Metrics Reporting from WHMWeb

This list relates WHM export IDs (i.e., metric name) to metric categories.

<table>
<thead>
<tr>
<th>Metric Name</th>
<th>unit</th>
<th>Metric Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_{gm}$</td>
<td>millimeter</td>
<td>BedStability</td>
</tr>
<tr>
<td>$D_{gmLog_{10}}$</td>
<td>millimeter, $\log_{10}$</td>
<td>BedStability</td>
</tr>
<tr>
<td>IDX Canopy</td>
<td>percent</td>
<td>RiparianVegetationStructure</td>
</tr>
<tr>
<td>IDX CanopyLT</td>
<td>percent</td>
<td>RiparianVegetationStructure</td>
</tr>
<tr>
<td>IDX CanopyST</td>
<td>percent</td>
<td>RiparianVegetationStructure</td>
</tr>
<tr>
<td>IDX CanUnderstory</td>
<td>percent</td>
<td>RiparianVegetationStructure</td>
</tr>
<tr>
<td>IDX CanUnderstoryGnd</td>
<td>percent</td>
<td>RiparianVegetationStructure</td>
</tr>
<tr>
<td>IDX CanUnderstoryWood</td>
<td>percent</td>
<td>RiparianVegetationStructure</td>
</tr>
<tr>
<td>IDX CanUnderstoryWoodGndWood</td>
<td>percent</td>
<td>RiparianVegetationStructure</td>
</tr>
<tr>
<td>IDX Ground</td>
<td>percent</td>
<td>RiparianVegetationStructure</td>
</tr>
<tr>
<td>IDX GroundBare</td>
<td>percent</td>
<td>RiparianVegetationStructure</td>
</tr>
<tr>
<td>IDX GroundHerb</td>
<td>percent</td>
<td>RiparianVegetationStructure</td>
</tr>
<tr>
<td>IDX GroundWood</td>
<td>percent</td>
<td>RiparianVegetationStructure</td>
</tr>
<tr>
<td>IDX Understory</td>
<td>percent</td>
<td>RiparianVegetationStructure</td>
</tr>
<tr>
<td>IDX UnderstoryHerb</td>
<td>percent</td>
<td>RiparianVegetationStructure</td>
</tr>
<tr>
<td>IDX UnderstoryWood</td>
<td>percent</td>
<td>RiparianVegetationStructure</td>
</tr>
<tr>
<td>LRBGS</td>
<td>dimensionless index</td>
<td>BedStability</td>
</tr>
<tr>
<td>LWDPieces</td>
<td>count per site</td>
<td>LargeWoodyDebris</td>
</tr>
<tr>
<td>LWDPieces100m</td>
<td>count per 100 meters</td>
<td>LargeWoodyDebris</td>
</tr>
<tr>
<td>LWDPieces100mD1L1</td>
<td>count per 100 meters</td>
<td>LargeWoodyDebris</td>
</tr>
<tr>
<td>LWDPieces100mD1L2</td>
<td>count per 100 meters</td>
<td>LargeWoodyDebris</td>
</tr>
<tr>
<td>LWDPieces100mD1L3</td>
<td>count per 100 meters</td>
<td>LargeWoodyDebris</td>
</tr>
<tr>
<td>LWDPieces100mD2L1</td>
<td>count per 100 meters</td>
<td>LargeWoodyDebris</td>
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<tr>
<td>LWDPieces100mD2L2</td>
<td>count per 100 meters</td>
<td>LargeWoodyDebris</td>
</tr>
<tr>
<td>LWDPieces100mD2L3</td>
<td>count per 100 meters</td>
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<tr>
<td>LWDPieces100mD3L1</td>
<td>count per 100 meters</td>
<td>LargeWoodyDebris</td>
</tr>
<tr>
<td>LWDPieces100mD3L2</td>
<td>count per 100 meters</td>
<td>LargeWoodyDebris</td>
</tr>
<tr>
<td>LWDPieces100mD3L3</td>
<td>count per 100 meters</td>
<td>LargeWoodyDebris</td>
</tr>
<tr>
<td>LWDPieces100mD4L1</td>
<td>count per 100 meters</td>
<td>LargeWoodyDebris</td>
</tr>
<tr>
<td>LWDPieces100mD4L2</td>
<td>count per 100 meters</td>
<td>LargeWoodyDebris</td>
</tr>
<tr>
<td>LWDPieces100mD4L3</td>
<td>count per 100 meters</td>
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</tr>
<tr>
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</tr>
<tr>
<td>LWDPieces100mMtoX</td>
<td>count per 100 meters</td>
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</tr>
<tr>
<td>LWDPieces100mStoX</td>
<td>count per 100 meters</td>
<td>LargeWoodyDebris</td>
</tr>
<tr>
<td>LWDPiecesD1L1</td>
<td>count per site</td>
<td>LargeWoodyDebris</td>
</tr>
<tr>
<td>LWDPiecesD1L2</td>
<td>count per site</td>
<td>LargeWoodyDebris</td>
</tr>
<tr>
<td>Metric Name</td>
<td>unit</td>
<td>Metric Category</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>LWDPiecesD1L3</td>
<td>count per site</td>
<td>LargeWoodyDebris</td>
</tr>
<tr>
<td>LWDPiecesD2L1</td>
<td>count per site</td>
<td>LargeWoodyDebris</td>
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<tr>
<td>LWDPiecesD2L2</td>
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<tr>
<td>LWDPiecesD2L3</td>
<td>count per site</td>
<td>LargeWoodyDebris</td>
</tr>
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Appendix B. Glossary

**Allowed metric values:** Range of values which a metric can assume, given the data collection schema. Metrics assuming values outside this range should be reviewed for errors.

**ASP.Net:** Framework supporting development of dynamic web pages, developed initially by Microsoft ®.

**Assumptions:** Conditions under which the resultant metric is expected to be reasonable.

**Calculation:** Generalized steps in the calculation of each metric.

**Data collection event (DCE):** An identification code associated with each observation. It identifies the site visited and the date of the visit. DCEs are unique. A single site visited twice in the same year would result in two unique DCEs.

**Data collection schema:** Key details about how observations underlying the metrics were collected, such as whether transects were bank to bank and perpendicular to the channel, or evenly spaced along the study reach.

**Definition:** What the metric actual represents, as a characteristic of the channel or riparian area where observations occurred, and the associated reporting unit, if any.

** Dependencies:** Metrics used to calculate other metrics. The latter are typically of higher level or more derived. For a dependent metric to report, the dependencies must be calculable.

**Group:** Second-highest hierarchical organizational level of the dictionary, describing clusters of related metrics within the metric categories considered.

**Hardpan:** Hardened or cemented sand & fines that are estimated to act as a lithic particle of ≥4000 mm diameter.

**Littoral zone:** An operational definition for WHMWeb, as, for streams and rivers, the area near the wetted margin of the channel.

**Maximum observations (DCE):** Upper limit on the number of observations possible, per DCE (see Data collection event, above), as well as how the limit is derived. Separate limits are given for wide and narrow protocols, if different.

**Metric category:** Highest hierarchical organizational level of the dictionary, identifying the broadest general groupings of metrics considered.

**Minimum reporting qualifiers:** Tests of completeness of observations underlying the metrics, for a given DCE.

**Narrow protocol:** Sampling approach for sites that are narrower than 25 meters bankfull width.
**Observation type:** Informs users of the dictionary of what the observations underlying the metric of interest actually are, such as counts.

**Reported:** Long descriptive name and type (e.g., count, average) of the metric reported. Reported IDs are analogous to WHM export IDs, the latter being more compact and not always identifying the metric type. Both reported IDs and WHM metric IDs play roles in defining metrics in the database. WHM export IDs are what reports from WHMWeb, see below.

**Reporting years:** Years of sampling, to date, for which metrics will be available. The goal is to load sample data through 2012 into the calculation engine by November 2013.

**Riparian:** Relating to the banks along a natural course of water.

**Riparian plot:** For WHMWeb, a survey area, centered on a transect and extending 10 m back horizontally from the bankfull margin of the main channel.

**Site:** Entire survey reach for a given data collection event, including any stations along the reach where observations or sample collection occurred. Maximum site length is 2000 meters. Minimum site length is 150 meters.

**SQL Server:** A database server implementing structured query language (SQL).

**Station:** Location within a site where observations or sample collection occurred. For example, each depth measurement along the site thalweg profile occurs at a different station.

**WHM export ID:** Compact name unique to each metric and analogous to reported IDs (see reporting, above). WHM export IDs are the metric identifiers exporting from the WHMWeb metric calculation engine. Both reported IDs and WHM export IDs play roles in defining metrics in the database, but WHM export IDs are generally what users of WHMWeb will seek.

**Surface waters of the state:** Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

**Units:** As used in the dictionary refers generally to proportions, percentages, and SI units associated with metrics reporting from WHMWeb. The exceptions are counts, which are often various types of observations.

**Wide protocol:** Sampling approach for sites associated with flowing water bodies wider than 25 meters bankfull width, or too deep or too swift to wade.

**Units of Measurement**

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<th>Description</th>
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<td>kilogram, a unit of mass equal to 1,000 grams</td>
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