

# **SKAGIT COUNTY SALMON HABITAT MONITORING PROGRAM QUALITY ASSURANCE PROJECT PLAN**

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## **INTRODUCTION**

Skagit County will conduct a survey of physical channel and in-stream habitat conditions to document, quantify, and track salmon habitat conditions in the Skagit Watershed. To accomplish this end, the County will use Environmental Monitoring and Assessment Program (EMAP) protocols and procedures to select a representative set of sampling locations (stream reaches) where habitat conditions will be measured. The objectives of this effort are to establish a baseline of current general physical habitat conditions in WRIs 3 & 4, analyze trends in salmon habitat conditions over time, determine whether habitat conditions are stable, improving or degrading in areas regulated under Skagit County Code 14.24.120, Ongoing Agriculture, and provide a means to differentiate between trends in salmon habitat conditions in lands within agricultural and rural resource zones versus other lands under Skagit County jurisdiction. This effort is in response to Skagit County Resolution #R20030210, which specifies actions the County will take to ensure that Skagit County Code 14.24.120, Ongoing Agriculture, is adequately protecting critical areas on agricultural lands.

## **PROJECT ORGANIZATION AND RESPONSIBILITY**

### **Personnel**

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## **SCHEDULE**

### **Year 1**

March 2004

- Begin work on rights of entry (ROE) for proposed 1st year monitoring sites.
- Begin preliminary site survey to establish problem sites, unusual circumstances, etc.

April 2004

- Field training with Washington State Department of Ecology
- Continue to pursue ROEs
- Continue preliminary site surveys

May – September 2004

- Initiate and complete 1<sup>st</sup> year Baseline Study encompassing 60 sampling sites (study period ends October 1, 2004)
- Continue to pursue ROEs
- Ongoing data entry

October - December 2004

- Review data, establish baseline habitat conditions, and draft report

December 2004

- Release Baseline Survey Report

### **Years 2-5**

March 2005, 2006, 2007, 2008 respectively

- Begin work on rights of entry (ROE) for proposed 2<sup>nd</sup> – 5<sup>th</sup> year monitoring sites.

June-August 2005, 2006, 2007, 2008 respectively

- Initiate and complete 2<sup>nd</sup> – 5<sup>th</sup> year Baseline Study encompassing 10 sampling sites per year (study period ends on October 1 of each year).
- Ongoing data entry

October 2005, 2006, 2007, 2008 respectively

- Review data and analyze habitat trends

December 2005, 2006, 2007, 2008 respectively

- Issue 2<sup>nd</sup> – 5<sup>th</sup> year Habitat Survey Report

### **Year 6-10**

Repeat procedures from years 1-5 with year 6 being a 60 site sampling year.

## **BACKGROUND AND PROJECT DESCRIPTION**

Skagit County staff proposes to use EMAP physical habitat survey protocols to conduct the salmon habitat survey for portions of Skagit County. Reaches will be randomly selected using EMAP site selection protocols. An overview of EMAP is provided below in the next section of this proposal.

A minimum of 60 stream reaches will be randomly selected for inclusion in the 2004 sampling regime. In 2005-2008, 10 randomly selected reaches per year will be surveyed to provide information to be used for trend analyses. In 2009 another randomly selected 60 reaches will be surveyed and the five-year data collection cycle will begin again. To estimate precision, ten percent (10%) of the reaches surveyed will be resurveyed by two independent crews each year (e.g. 6 repeat sites in years 1 & 6; 2 repeat sites in years 2-5).

All sampling will be conducted only on streams that are or have the potential to be salmonid-bearing and are wadeable. Salmonid-bearing status is based on SHIAPP (Salmon and Steelhead Analysis Inventory and Analysis Program) data. Sites selected will be equally divided between those in Agriculture-Natural Resource Land (Ag-NRL) and Rural Resource-Natural Resource Land (RRC-NRL) zoned lands (as defined by the Skagit County Comprehensive Plan) and other lands within County jurisdiction. After initial reconnaissance of selected sites, only those deemed to be safely accessible and with landowner permission for access will become part of the sample.

Details regarding the sampling site selection process can be found in Appendix A, *Skagit Basin Streams Survey Design*.

### **EMAP OVERVIEW:**

The Environmental Monitoring and Assessment Program (EMAP) is a research program to develop the tools necessary to monitor and assess the status and trends of national ecological resources. EMAP's goal is to develop the methodologies for translating environmental monitoring data from multiple spatial and temporal scales into assessments of current ecological condition and forecasts of future risks to our natural resources.

EMAP aims to advance the science of ecological monitoring and ecological risk assessment, guide national monitoring with improved scientific understanding of ecosystem integrity and dynamics, and demonstrate multi-agency monitoring through large regional projects. EMAP identifies and utilizes appropriate indicators to monitor the condition of ecological resources.

## **Study Area**

The study area encompasses those areas of WRIAs 3 & 4 under direct jurisdiction of Skagit County government. Areas specifically excluded from the study area include National Park and Forest lands, incorporated municipalities, and those portions of WRIAs 1 & 5 that fall within Skagit County's political jurisdiction.

Survey reaches will be equally divided between those in Agriculture-Natural Resource Land (Ag-NRL) and Rural Resource-Natural Resource Land (RRc-NRL) zoned lands (as defined by the Skagit County Comprehensive Plan), and other lands within County jurisdiction. Sampling will be limited to wadeable streams that are or have the potential to be salmonid-bearing.

## **Objectives**

1. Establish a statistically valid baseline of the current general physical habitat conditions in WRIAs 3 & 4 during the first year of the project.
2. Conduct additional habitat conditions monitoring in future years to be used to analyze trends in salmon habitat conditions over time.
3. Determine whether habitat conditions are improving or degrading in areas regulated under Skagit County Code 14.24.120, Ongoing Agriculture.
4. Provide a means to differentiate between trends in salmon habitat conditions in Ag-NRL and RRc-NRL zoned lands versus other lands under Skagit County jurisdiction.

## **MONITORING PARAMETERS AND PROTOCOLS**

The parameters and protocols to be used for Skagit County's Salmon Habitat Survey stem from the Environmental Protection Agency's *Surface Waters Western Pilot Study: Field Operations Manual for Wadeable Streams – Environmental Monitoring and Assessment Program*.

[<http://www.epa.gov/emap/html/pubs/docs/groupdocs/surfwatr/field/ewwsm01.html>]

A survey reach is defined as a stream reach with a minimum length of 40 times its low flow wetted width. Measurement points are systematically identified to represent the entire reach. Stream depth and wetted width are measured at tightly spaced intervals, whereas channel cross-section profiles, substrate, bank characteristics and riparian vegetation structure are measured at larger spacings. Large Woody Debris (LWD) is tallied along the full length of the survey reach, and discharge is measured at one location. The tightly spaced depth and width measures allow calculation of indices of channel structural complexity, objective classification of channel units such as pools, and quantification of residual pool depth, pool volume, and total stream volume.

## Types of Measurements

- **Stream Discharge** – Discharge (flow) is a measure of the amount of water flowing in a watercourse. Stream discharge is equal to the product of the mean current velocity and vertical cross sectional area of flowing water.
- **Thalweg Profile** – A longitudinal survey of depth, habitat class, presence of soft/small sediment deposits, and off-channel habitat along a stream's centerline between the two ends of the sampling reach. "Thalweg" refers to the flow path of the deepest water in a stream channel.
- **Large Woody Debris Tally** – A visual survey allowing for quantitative estimates of the number, size, total volume and distribution of wood within the stream reach. LWD is defined here as woody material with a small end diameter of at least 10 cm (4 in.) and a length of at least 1.5 m (5 ft.).
- **Channel and Riparian Characterization** – Measurements and/or visual estimates of channel dimensions, substrate, fish cover, bank characteristics, riparian vegetation structure, presence of large (legacy) riparian trees, non-native (alien) riparian plants, and evidence of human disturbances. In addition, measurements of the stream slope and compass bearing between stations are obtained, providing information necessary for calculating reach gradient, residual pool volume, and channel sinuosity.
- **Assessment of Channel Constraint, Debris Torrents, and Major Floods** – An overall assessment of the above mentioned characteristics for the whole reach including identifying features causing channel constraint, and estimating the percentage of constrained channel margin for the whole reach and the ratio of bankfull/valley width.

## Variables Calculated from the Field Data

Habitat metrics will be calculated from field data according to procedures described in Kaufmann and others, (1999). The metric list in Appendix B is a subset of the EMAP habitat variables and only includes those most often used by EMAP.

## Monitoring Protocols

### Stream Discharge:

- In medium and large streams measure water depth and velocity at 15 to 20 equally spaced intervals across one carefully chosen channel cross-section.
- In very small streams with a flow of less than one (1) cubic foot per second (cfs), stream velocities will be visually recorded to the nearest 0.5 or 1 cfs. Measurements above 1 cfs will be recorded with a flow meter.

### **Thalweg Profile:**

- Measure maximum depth, classify habitat and pool-forming features, check presence of backwaters, side channels and deposits of soft, small sediment at 10-15 equally spaced intervals between each of 11 channel cross-section transects (100 or 150 individual measurements along entire reach).
- Measure wetted width and evaluate substrate size classes at 11 regular channel cross-section transects and midway between them (21 width measurements and substrate cross-sections).

### **Large Woody Debris Tally:**

- Between each of the channel cross sections, tally large woody debris numbers within and above the bankfull channel according to length and diameter classes (10 separate tallies).

### **Channel and Riparian Characterization:**

- At 11 cross-section transects (21 for substrate size) placed at equal intervals along reach length:
  - Measure: channel cross section dimensions, bank height, bank undercut distance, bank angle, slope and compass bearing (backsight), and riparian canopy density (densiometer).
  - Visually Estimate: substrate size class and embeddedness; aerial cover class and type (e.g., woody trees) of riparian vegetation in Canopy, Mid-Layer and Ground Cover; aerial cover class of fish concealment features, aquatic macrophytes and filamentous algae.
  - Observe & Record: Presence and proximity of human disturbances and large trees; presence of alien plants

### **Assessment of Channel Constraint, Debris Torrents, and Major Floods:**

- After completing Thalweg and Transect measurements and observations, identify features causing channel constraint, estimate the percentage of constrained channel margin for the whole reach, and estimate the ratio of bankfull/valley width. Check evidence of recent major floods and debris torrent scour or deposition.

## **QUALITY CONTROL PROCEDURES**

### **Field QC Procedures**

Field instruments will be tested and calibrated prior to each sampling event and operated as per the manufacturers' instructions. Suspect readings from field meters will result in the examination of probes, recalibration if necessary, and/or repeated measurement.



Before leaving a sample reach, the team leader will review all of the data forms for accuracy, completeness, and legibility. When reviewing field data forms, the team leader will ensure that all required data forms for the reach have been completed and confirm that the site identification code, the year, the visit number, and the date of the visit are correct on all forms. On each form, all information will be verified to ensure it has been recorded accurately, is legible, and that any flags are explained in the comments section. The crew will also verify that the recorded data makes logical sense. After reviewing each form, the team leader will initial the upper right corner of each page of the form.

### **Corrective Procedures**

Corrective procedures related to the survey program will take place as they are warranted. The team leader will be responsible for corrective actions regarding field data collection and documentation. These actions may include additional data collection, field equipment training, equipment checks, calibrations standard verification, and recalibration in the field. Office activities may include correction of the database, meetings with monitoring team members, instrument repair, and revision of procedures. In addition, personnel with the Environmental Protection Agency (EPA) and/or the Washington State Department of Ecology (ECY) may be contacted to assist in resolving outstanding technical issues.

### **Data Quality Objectives**

The goal of this program is to generate sufficient reliable data to detect trends in salmon habitat conditions in Ag-NRL and RRc-NRL zoned lands under Skagit County jurisdiction and compare those trends, if any, to those zoned lands under Skagit County jurisdiction outside of Ag-NRL and RRc-NRL .

#### Bias

Bias will be minimized by use of standardized procedures by a trained staff. Surveys will be conducted according to written procedures and instruments will be calibrated and operated according to manufacturer's instructions.

Some forms of bias are unavoidable due to temporal and spatial considerations. In such cases, staff will be aware of the source of bias and substitute consistency for lack of bias in order to preserve data comparability over time.

#### Precision

Precision will be estimated at two levels. The first level consists of estimates of precision (or uncertainty) with which the overall habitat condition of the Skagit County stream reaches are estimated. This uncertainty is estimated from the specific design applied to the selection of reaches and the spatial structure of the habitat indicators. Data will be summarized as a frequency distribution of metric scores; the uncertainty of this description will be approximately +/- 12% with a sample size of 60 sites; precision will likely be better if the habitat characteristics are spatially correlated. The USEPA's

EMAP program will assist in calculating the survey precision after the first year's data have been compiled.

The second level of precision will be estimated by revisiting a subset of sites in the same year and compared with that published in Kaufmann, et al. (Kaufmann, P.R., P. Levine, E.G. Robison, C. Seeliger, and D.V. Peck. 1999. Quantifying Physical Habitat in Wadeable Streams. EPA/620/R-99/003. U.S. Environmental Protection Agency, Washington, D.C.), who have summarized an expected precision for many of these habitat metrics. This level of precision depends not only on measurement precision but on variation in metrics within the interval chosen as the seasonal survey window.

**Measurement Data Quality Objectives**

Measurement data quality objectives (measurement DQOs or MQOs) for the Skagit County Salmon Habitat Monitoring Program are given in Table 1. The MQOs given in Table 1 represent the maximum allowable criteria for statistical control purposes. Precision is determined from results of revisits by a different crew (field measurements) and by duplicate measurements by the same individual on a different day or by a different individual (map-based measurements).

The completeness objectives are established for each measurement *per site type* (e.g., EMAP sites, revisit sites). Failure to achieve the minimum requirements for a particular site type results in regional population estimates having wider confidence intervals. Failure to achieve requirements for repeat and annual site revisits reduces the precision of estimates of index period and annual variance components, and may impact the representativeness of these estimates because of possible bias in the set of measurements obtained.

**TABLE 1. MEASUREMENT DATA QUALITY OBJECTIVES: PHYSICAL HABITAT INDICATOR**

Variable or Measurement	Precision	Accuracy	Completeness
Field Measurements and Observations	±10%	NA	100%
Map-Based Measurements	±10%	NA	100%

NA = not applicable

**DATA ASSESSMENT PROCEDURES**

**QA/QC Process**

The Project Manager will review field data and notes to validated field techniques, calculate precisions, account for bias, and verify completeness. In addition, the reports will be reviewed and summarized annually during the project.

## **Data Entry and Review**

Data will be entered into the Skagit County Salmon Habitat Monitoring Database. After entry in the database, printouts will be compared with field sheets to detect and correct data entry errors. For analysis, data will be exported to spreadsheets and reviewed to focus on parameters of interest. Trends will be tracked and analyzed using graphical formats and other tools as deemed appropriate. Because all of the field analyses are standard procedures major problems with quality control are not expected. Nevertheless, data reports will be reviewed regularly by the Project Manager.

## **Statistics**

Statistical summaries will include frequency distributions for each of the major habitat attributes of interest along with the uncertainty estimates associated with these frequency distributions. For some habitat metrics, “criteria” that evaluate whether habitat is in good/poor condition will be used to evaluate what proportion of the stream network is in poor habitat condition (along with an estimated uncertainty associated with this proportion). The approximate uncertainty with which these proportions can be estimated with sample sizes of 60 sites is approximately +/- 12%. For example, the survey might suggest that 30% +/- 12% of the stream network has excess fine sediment. Frequency distributions between the two classes of stream types will be compared to determine whether the distributions differ and whether one class is in poorer condition than the other. At each five-year interval, these frequency distributions will be compared to assess whether a five-year change is detectable, and the magnitude of detectability. Over time, consistent change (trend) will be tracked. Because the sensitivity of both change detection and trend detection depend on spatial and temporal variation across the Skagit County stream network, they cannot be determined until data have been collected from this network. Research conducted in the EMAP program indicates that 1 – 2% trends in some key habitat features are detectable in 10 - 20 years with 80% likelihood if such trends actually occur.

## **DELIVERABLES**

1. Map of all reaches surveyed
2. Report detailing initial survey effort and associated baseline information
3. Annual reports to assist with establishing salmon habitat trend analysis and adaptive management considerations pertaining to Skagit County Code 14.24.120, Ongoing Agriculture, as outlined in Skagit County Resolution #R20030210.
4. Five-year reports detailing trends in habitat conditions in Ag-NRL and RRC-NRL zoned lands under Skagit County jurisdiction and a comparison of those trends, if any, to those zoned lands under Skagit County jurisdiction outside of Ag-NRL and RRC-NRL. The five-year reports will also be used to assist with adaptive management considerations as described above.

## **REFERENCES**

1. Peck, D.V., J.M. Lazorchak, and D.J. Klemm (editors). Unpublished draft.

*Environmental Monitoring and Assessment Program -Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams.* EPA/XXX/X-XX/XXXX. U.S. Environmental Protection Agency, Washington, D.C.

<http://www.epa.gov/emap/html/pubs/docs/groupdocs/surfwatr/field/ewwsm01.html>

2. Kaufmann, P.R, P. Levine, E.G. Robison, C. Seeliger, and D.V. Peck. 1999. *Quantifying Physical Habitat in Wadeable Streams.* EPA/620/R-99/003. U.S. Environmental Protection Agency, Washington, D.C.  
<http://www.epa.gov/emap/html/pubs/docs/groupdocs/surfwatr/field/phyhab.html>
3. Paulsen, S. (project leader), *Environmental Monitoring And Assessment Program: Integrated Quality Assurance Project Plan For Surface Waters Research Activities* U.S. Environmental Protection Agency Office, Washington, D.C.  
[http://www.epa.gov/owow/monitoring/rfp/qapp\\_97final.pdf](http://www.epa.gov/owow/monitoring/rfp/qapp_97final.pdf)

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# **APPENDIX A: SKAGIT BASIN STREAMS SURVEY DESIGN**

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# Skagit Basin Streams Survey Design

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## Description of Sample Design

**Objectives:** Skagit County is proposing conduct a survey of physical channel and in-stream habitat conditions to document, quantify, and track salmon habitat conditions in the Skagit Watershed. To accomplish this end, the County will use the Environmental Monitoring and Assessment Program (EMAP) protocols and procedures to select a representative set of sampling locations where habitat conditions will be measured. The objectives of this effort are to establish a baseline of current general physical habitat conditions in WRIs 3 & 4, analyze trends in salmon habitat conditions over time, determine whether habitat conditions are improving or degrading in areas regulated under Skagit County Code 14.24.120, Ongoing Agriculture, and provide a means to differentiate between trends in salmon habitat conditions in lands within agricultural and rural resource zones versus other lands under Skagit County jurisdiction.

Specific objectives are:

1. Establish a statistically valid baseline of the current general physical habitat conditions in WRIs 3 & 4 during the first year of the project.
2. Conduct additional habitat conditions monitoring in future years to be used to analyze trends in salmon habitat conditions over time.
3. Determine whether habitat conditions are improving or degrading in areas regulated under Skagit County Code 14.24.120, Ongoing Agriculture.
4. Provide a means to differentiate between trends in salmon habitat conditions in Ag-NRL and RRC-NRL zoned lands versus other lands under Skagit County jurisdiction, as defined by the Skagit County Comprehensive Plan.

**Target Population:** Target population consists of all wadeable streams within Skagit County that are in areas affected by Skagit County Code 14.24.120, Ongoing Agriculture (Ag-NRL and RRc-NRL zoned lands) and those outside of those zoning designations but still under County jurisdiction. These are further restricted to only those streams listed on the SHIAPP database as having salmon or the potential to have salmon. No survey work will occur outside of areas regulated by Skagit County (e.g. no sampling will occur in National Forest lands).

**Sample Frame:** Josh Greenberg, Skagit County GIS, provided the GIS coverage. Attribute INOUT is used to define two subpopulations of interest (those in Ag CAO and those outside those zoning designations). Those stream segments that are not coded as IN or OUT are excluded from the sample frame.

**Survey Design:** A Generalized Random Tessellation Stratified (GRTS) survey design for a linear stream resource was used. The GRTS design includes reverse hierarchical ordering of the selected sites.

**Stratification:** Two strata: those streams that are within the Ag CAO zoning designation and those streams which are outside the Ag CAO Zoning designation. Equal number of sites in each stratum.

**Multi-Density Categories:** None

**Panels:** Six panels. Panels “One” to “Five” will be visited once every five years with panel “One” being visited in year 1, panel “Two” in year 6, panel “Three” in year 11, etc. Panel “Annual” will have annual visits to the sites.

**Sample Size:** 220 stream sites: 40 each in panels “One” to “Five” and 20 in panel “Annual”. In each case expected number of sites in Ag CAO and outside Ag CAO should be equal.

**Oversample:** 100% over sample.

**Site Use:** The base design has 220 sites allocated to 6 panels. These sites are identified by panel name in the variable “Panel”. If it is necessary for a site in any panel to be replaced, then the lowest ordered SiteID that is part of the oversample of sites (identified by “OverSamp” in variable “Panel”) must be used. Subsequent replacement sites continue to be used in the same way.

### **Sample Frame Summary**

The total stream length in the GIS coverage is 794.907 km. The total stream length in the sampling frame that is in Skagit County study is 781.539 km with 243.258 km in the Ag CAO zoning designation and 538.281 km outside the Ag CAO zoning designation.

## Site Selection Summary

	Annual	Panel-1	Panel-2	Panel-3	Panel-4	Panel-5	OverSamp
IN	10	20	20	20	20	20	110
OUT	10	20	20	20	20	20	110

As noted above under the heading **Panel**, Panels “One” to “Five” will be visited once every five years with panel “One” being visited in year 1, panel “Two” in year 6, panel “Three” in year 11, etc. Panel “Annual” will have annual visits to the sites.

### Description of Sample Design Output:

To achieve an expected sample size of sites in the target population, an appropriate sample size was selected for the study area. A Base set of sites and an Oversample of sites are included in the output. The oversample sites should be added, as needed, in numerical SiteID order. Oversample sites are identified in the “panel” data column as Oversamp. Note that sites may be used in order beginning at the first SiteID number and continuing until desired sample size is reached.

A map of the stream network and the selected sites is given in the associated .pdf file labeled *SkagitDesign*.

The tab-delimited, ASCII file (SkagitSites.tab) has the following variable definitions:

Variable Name	Description
SiteID	Unique site identification (character)
arcid	Internal identification number
x	Albers x-coordinate
y	Albers y-coordinate
LonDD	Longitude, decimal degrees
LatDD	Latitude, decimal degrees
mdcaty	Multi-density categories used for unequal probability selection
weight	Weight (in meters), inverse of inclusion probability, to be used in statistical analyses
stratum	Strata used in the survey design
panel	Identifies base sample by panel name and Oversample by OverSamp
auxiliary variables	Remaining columns are from the sample frame provided

Albers projection used

Spheroid: Clarke1866

Center longitude (decimal degrees): -96

Origin latitude (decimal degrees): 23

Standard parallel 1 (decimal degrees): 29.5

Standard parallel 2 (decimal degrees): 45.5



For further information about the design, contact  
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**APPENDIX B: LIST OF EMAP  
HABITAT VARIABLES**

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Habitat metrics will be calculated from field data according to procedures described in Kaufmann and others, 1999). The metric list below is a subset of the EMAP habitat variables and only includes those most often used by EMAP.

#	Variable	Type	Len	Label
1	SITE ID	Char	15	Site ID
2	YEAR	Num	8	Year of visit
3	VISIT NO	Num	8	Number identifying which visit this is
4	SAMPLED	Char	30	Sample status (PHab)
5	XBKA	Num	8	Bank Angle--mean (degrees)
6	XUN	Num	8	Undercut Distance--Mean (m)
7	XBKF-W	Num	8	Bankfull Width--Mean (m)
8	XBKF H	Num	8	Bankfull Height-Mean (m)
9	XINC H	Num	8	Channel Incision Ht.-Mean (m)
10	XPCM-	Num	8	Riparian Canopy & Middle Layer Present (Fraction of reach)
11	XPCMG	Num	8	Riparian 3-Layers Present (Fraction of reach)
12	XCL	Num	8	Riparian Canopy > 0.3m DBH (Cover)
13	X GB	Num	8	Riparian Ground Layer Barren (Cover)
14	XC -	Num	8	Riparian Vegetation Canopy cover
15	XG-	Num	8	Riparian Vegetation Ground Layer Cover
16	XCMW	Num	8	Riparian Vegetation Canopy+Middle Layer (Woody Cover)
17	XCMGW	Num	8	Riparian Vegetation Canopy+Mid+Ground (Woody Cover)
18	PCAN C	Num	8	Riparian Canopy Coniferous (Fraction of reach)
19	XCDENBK	Num	8	Mean Bank Canopy Density (%)
20	XCDENMID	Num	8	Mean Mid-channel Canopy Density (%)
21	XEMBED	Num	8	Mean Embeddedness--Channel+Margin (%)
22	XFC ALG	Num	8	Fish Cover -Filamentous Algae (Areal Prop)
23	XFC-AQM	Num	8	Fish Cover-Aqautic Macrophytes (Areal Prop)
24	XFC-LWD	Num	8	Fish Cover-Large Woody Debris (Areal Prop)
25	XFC-BRS	Num	8	Fish Cover-Brush & Small Woody Debris (Areal Prop)
26	XFC-OHV	Num	8	Fish Cover-Overhanging Vegetation (Areal Prop)
27	XFC-UCB	Num	8	Fish Cover-Undercut Banks (Areal Prop)
28	XFC-RCK	Num	8	Fish Cover-Boulders (Areal Prop)
29	XFC-HUM	Num	8	Fish Cover-Artificial Structures (Areal Prop)
30	XFC-ALL	Num	8	Fish Cover-All Types (Sum Areal Prop)
31	XFC-NAT	Num	8	Fish Cover-Natural Types (Sum Areal Prop)
32	XFC-BIG	Num	8	Fish Cover-Large Woody Debris, Rock, Undercut Banks or Human Structures (Sum Area Prop)

#	Variable	Type	Len	Label
33	W1-HALL	Num	8	Riparian Disturbance--Sum of All Types (Proximity Weighted Presence)
34	W1-HNOAG	Num	8	Riparian Disturbance--Sum of Non-Agricultural Types (Proximity Weighted Presence)
35	W1 HAG	Num	8	Riparian Disturbance--Sum Agricultural Types (Proximity Weighted Presence)
36	W1H-WALL	Num	8	Riparian Disturbance--Wall/Bank Revetment (Proximity Weighted Presence)
37	W1H PIPE	Num	8	Riparian Disturbance--Pipes inflent/effluent (Proximity Weighted Presence)
38	LSUB DMM	Num	8	Substrate-Mean Log 10 (Diameter Class in mm)
39	LTEST	Num	8	Log 10 [Erodible Substrate Diameter (mm)]-Fast estimate
40	LRBS-TST	Num	8	Log 10 [Relative Bed Stability] -Fast estimate
41	LDMB BW5	Num	8	Log 10 [Erodible Substrate Diameter (mm)]-Est. 2
42	LRBS-BW5	Num	8	Log 10 [Relative Bed Stability]-Est. 2
43	REACHLEN	Num	8	Length of sample reach (m)
44	X SLOPE	Num	8	Channel Slope—field-measured reach mean (%)
45	X DEPTH	Num	8	Thalweg Mean Depth (cm)
46	RPGT75	Num	8	Residual Pools >75cm deep (number/reach)
47	RPGT100	Num	8	Residual Pools >100cm deep (number/reach)
48	RPMXDEP	Num	8	Maximum residual depth in reach (cm)
49	RPXAREA	Num	8	Mean vertical profile area of Residual Pools (m2/pool)
50	RP100	Num	8	Mean Residual Depth (m~/100m)
51	LSUBD SD	Num	8	Substrate-Standard Deviation Log 10 (Diameter Class mm)
52	PCT-FN	Num	8	Substrate Fines --Silt/Clay/Muck (%)
53	PCT-SA	Num	8	Substrate Sand --.06-2 mm (%)
54	PCT-HP	Num	8	Substrate Hardpan--(%)
55	PCT-RC	Num	8	Substrate Concrete (%)
56	PCT-SAFN	Num	8	Substrate Sand & Fines --<2 mm (%)
57	PCT-SFGF	Num	8	Substrate <= Fine Gravel <=16 mm) (%)
58	PCT-BIGR	Num	8	Substrate >- Coarse Gravel (>16 mm) (%)
59	PCT BDRK	Num	8	Substrate Bedrock (%)
60	PCT-ORG	Num	8	Substrate Wood or Detritus --(%)
61	VIW MSQ	Num	8	Large Woody Debris Volume in Bankful Channel (m3/m2-all sizes)
62	V4W MSQ	Num	8	Large Woody Debris Volume in Bankful Channel (m3/m2-L,X)
63	V1TM100	Num	8	Large Woody Debris Volume in or above Bankful Channel (#/100m-all sizes)

#	Variable	Type	Len	Label
64	V4TM100	Num	8	Large Woody Debris Volume in or above Bankful Channel (#/100m-L,X)
65	SINU	Num	8	Channel Sinuosity (m/m)
66	SDDEPTH	Num	8	Standard Deviation of Thalweg Depth (cm)
67	XWIDTH	Num	8	Wetted Width--Mean (m)
68	XWXD	Num	8	Mean Product of Width x Depth (m2)
69	XWD RAT	Num	8	Mean Ratio of Width/Depth (m/m)
70	SDWXD	Num	8	Standard Deviation of (Width x Depth) (m2)
71	PCT-FA	Num	8	Falls (% of reach)
72	PCT-FAST	Num	8	Fast Water Habitat (% riffle & faster)
73	PCT=SLOW	Num	8	Slow Water Habitat (% Glide & Pool)
74	PCT-POOL	Num	8	Pools --All Types (% of reach)
75	PCT-DRS	Num	8	Dry Channel or Subsurface Flow (%)
76	PCT-SIDE	Num	8	Side channel presence (% of reach)

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