NATURAL RESOURCES

Status and Trends Monitoring of Riparian and Aquatic Habitat in the Olympic Experimental State Forest

2013 Establishment Report: Field Installations and Development of Monitoring Protocols

April 2014

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Peter Goldmark - Commissioner of Public Lands

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Acknowledgements

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Acronyms and Abbreviations

7-DAD MAX – 7 Day Average Daily Maximum Temperature

DEM – Digital Elevation Model

DNR – Washington Department of Natural Resources

DOE – Washington State Department of Ecology

EPA – Environmental Protection Agency

GIS – Geographic Information Systems

GPS – Global Positioning System

LED – Light-Emitting Diode

LEW – Left Edge of Water

LPU – Landscape Planning Unit

LWD – Large Woody Debris

OESF – Olympic Experimental State Forest

ONP – Olympic National Park

PNW – USDA Forest Service Pacific Northwest Research Station

PVC – Polyvinyl Chloride

REW– Right Edge of Water

RP – Reference Point

TFW – Timber Fish and Wildlife

Executive Summary

The purpose of the status and trends monitoring of riparian and aquatic habitat in the Olympic Experimental State Forest (OESF) is to document changes over time of both riparian and in-stream conditions in basins managed for timber, wildlife habitat and other ecosystem values by Washington State Department of Natural Resources (DNR). The management of aquatic resources on the OESF is based on the working hypothesis that the natural processes of ecological succession and disturbance will continue to improve habitat conditions in managed forests. These assumptions have been quantified through time as habitat projections used in the development of the OESF Forest Land Plan (DNR 2013). Information from this monitoring will allow testing these assumptions and will reduce key uncertainties about ecological relationships between in-stream, riparian, and upland areas.

When integrated with information on management activities in the OESF, the results from this project will help make inferences about management effects on habitat (effectiveness monitoring required by the state trust lands Habitat Conservation Plan (DNR 1997)) and will characterize baseline habitat conditions for future study of fish response in managed landscapes (validation monitoring required by the state trust lands Habitat Conservation Plan (DNR 1997)).

This report covers the project's second year (November 1, 2012 – October 31, 2013). The project's study plan (Minkova et al. 2012) and the first-year establishment report (Minkova and Vorwerk 2012) are available on the DNR website at
http://www.dnr.wa.gov/ResearchScience/Topics/TrustLandsHCP/Pages/lm_hcp_oesf_main.aspx.

Five main goals were accomplished during the reporting period: 1) re-allocation of sample basins; 2) development of monitoring protocols; 3) refinement of field procedures; 4) installation of monitoring equipment; and 5) beginning of protocol implementation.

Reallocation of sample basins
The sample of 50 basins selected for monitoring in the OESF in 2012 was reviewed by a statistician from USDA Forest Service Pacific Northwest Research Station (PNW) for representativeness and bias. Based on the reviewer's recommendation and the field reconnaissance information from 2012, the allocation of sample basins was revised to better characterize the underrepresented northern part of the study area. Ten sample basins from the southern portion of the OESF were relocated to the north, which included delineating and permanently marking the new sample reaches, and moving the water and air temperature data loggers that were installed the previous year.

Development of monitoring protocols
Monitoring protocols for eight habitat attributes (stream temperature, in-stream large wood, stream shade, channel morphology, coarse channel substrate, stream discharge, habitat units, and channel and valley classification) were developed and peer-reviewed in May 2013. The remaining two protocols identified in the study plan (microclimate and riparian vegetation) are under development.

Refinement of field procedures
The project team refined the field procedures for the eight peer-reviewed protocols and trained the field crews in July 2013. The main changes included repositioning of some water temperature data loggers, changing the recording intervals of the water and air data loggers, and reducing the number of cross sections per sample reach.

Installation of monitoring equipment
Fourteen of the 50 OESF sample basins were selected for monitoring stream discharge. Stream gage stations were installed in these basins including a staff gage, a continuously recording water-level gage with air and water pressure transducers, and a benchmark. Discharge measurements were initiated and will continue throughout 2014 in order to build rating curves (relationships between stage and discharge). In the future, these rating curves will be used to obtain information on stream discharge by measuring only the water level.
Ten basins were selected for monitoring microclimate in the riparian areas. Eight of these basins also have stream gage stations. Two transects, each containing 5 air temperature and humidity data loggers, were installed in each selected basin and the continuously recording sensors were launched in September 2013.

Field sampling
Field sampling of physical stream habitat attributes was completed in 10 basins. This included stream gradient, confinement, sinuosity, in-stream large wood, habitat units, channel and valley classification, bankfull width, bankfull depth, coarse substrate, and shade.

Data management
Data management in 2013 consisted of organizing the field reconnaissance database, processing of GPS points in ArcGIS, developing MS Access databases for the hydrology and stream temperature data and entering the other field data into Excel spreadsheets. DNR funding for a data specialist was secured and the position is expected to be filled in 2014.

Collaboration, funding, and outreach
The monitoring work was conducted by DNR in collaboration with PNW. The 2013 project team included eight researchers, four scientific technicians, and one intern from the Evergreen State College.

The second year of this project was funded by DNR, with in-kind contributions of equipment and staff time by PNW.

The project team gave several presentations to external parties with the purpose of introducing the project, reporting on the accomplished work, and soliciting interest from potential research collaborators. Project updates are posted on the DNR website at
http://www.dnr.wa.gov/ResearchScience/Topics/TrustLandsHCP/Pages/lm_hcp_oesf_main.aspx

Next year, the project team will continue to explore opportunities for partnerships with other organizations, will finalize and publish all monitoring protocols, will continue the field sampling, will explore available operational records and remote sensing data for characterization of management and natural disturbances in the sample basins, and will start data analyses.

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Introduction

DNR has identified status and trends monitoring of riparian and aquatic habitat in the Olympic Experimental State Forest (OESF) as a high priority project. This project will provide empirical data on current and future in-stream and riparian conditions, with the goal of reducing key uncertainties around the integration of habitat conservation and revenue production. The information will be used to assess the habitat projections used in the OESF Forest Land Plan (DNR 2013) and to test assumptions about ecological relationships between in-stream, riparian, and upland conditions, thus improving DNR's forest management planning. When integrated with information on management activities in the OESF, the results from this project will help make inferences about management effects on habitat (effectiveness monitoring required by the state trust lands Habitat Conservation Plan (DNR 1997)) and will characterize baseline habitat conditions for future study of fish response in managed landscapes (validation monitoring required by the state trust lands Habitat Conservation Plan (DNR 1997)).

DNR developed a draft study plan for this project in 2011, contracted external peer-review later that year, and published the project's study plan in 2012 (Minkova et al. 2012). DNR provided project funding for the period 2012-2015 and is expected to continue to fund the project in the long-term (at least 10 years). The USDA Forest Service Pacific Northwest Research Station (PNW) joined as a research collaborator in the summer of 2012 contributing scientific expertise, funding, and field staff. The first year of implementation included identification of sample basins, delineation and permanent marking of sample reaches, and initial field characterization of the sample sites. These activities are described in the 2012 establishment report (Minkova and Vorwerk 2013).

This establishment report covers the period November 1, 2012 – October 31, 2013. Five main goals were accomplished during the project's second year: 1) re-allocation of sample basins; 2) development of monitoring protocols; 3) refinement of field procedures; 4) installation of monitoring equipment; and 5) beginning of protocol implementation.

Reallocation of Sample Basins

After GIS and field reconnaissance of the sample basins that were identified in the study plan, the project team delineated and marked 50 sample reaches in the OESF and 4 reference reaches in the Olympic National Park in 2012 (Minkova et al. 2012; Minkova and Vorwerk 2013). In May 2013, the research team consulted statistician to assess the validity of the study's spatial design. Specifically, the team was seeking answers to the following questions:

1. Is the process of identifying the sampling frame statistically sound and consistent with the stated objectives and monitoring questions?

2. Is it acceptable to use a hydrological basin around Type 3 streams[1] as a sample unit to characterize the riparian and aquatic conditions across the OESF?
3. Is it acceptable to have the aquatic and riparian status of the Type 3 basin characterized by the most downstream section of the Type 3 stream and the adjacent riparian area?
4. Can we reduce the number of sample basins down from 50?
5. Is the allocation of sampling units statistically sound?

Statistical review at the start of a project is important to ensure that data are sufficient to draw the conclusions needed. Dr. Ashley Steel, a statistician at PNW, reviewed the sampling design in June 2013 and provided several recommendations in order to increase the scope of inference and to avoid potential bias in the allocation of the sample basins.

Following the review recommendations, the team modified the selection of sample basins (the process is described in Appendix 1). This required the following adjustments in the field:

- Ten new basins were added in 2013 and 10 basins from the 2012 set were decommissioned. The change ensures a better characterization of the previously underrepresented northern part of the OESF and increases the scope of inference by including in the sampling frame the full range of basin sizes, the braided stream reaches, and stream reaches without pools;
- All newly selected basins were visited, described, and marked according to the 2012 field procedure;
- Five basins (489, 604, 649, 659, and 663) were excluded upon field visits either because the stream was not type 3 for the entire duration of the sample reach or the channel was dry (no surface flow for 200 m above the basin outlet). They were replaced with basins that were next in a randomly generated list of basins based on a stratification scheme recommended by the statistician.
- All temperature data loggers, flagging, tags, and plastic caps were removed from the decommissioned basins. Reference Point rebars, nails in trees, and paint were removed whenever possible.

➢ *2013 Accomplishment:* **Ten new basins were added to the sample in 2013 and 10 basins from the 2012 set were decommissioned (refer to Appendix1).**

The final set of monitored basins in the OESF is presented in Figure 1.

[1] The smallest fish bearing stream as identified through biological criterion (fish presence) or through physical criteria (a stream ≥ 2 ft (0.7 m) wide and ≤16% gradient for basins up to 50 ac (20 ha) or with a gradient between 16% and 20% for basins larger than 50 ac (20 ha)). Type 3 streams can be considered loosely equivalent to Strahler's 3rd order streams.

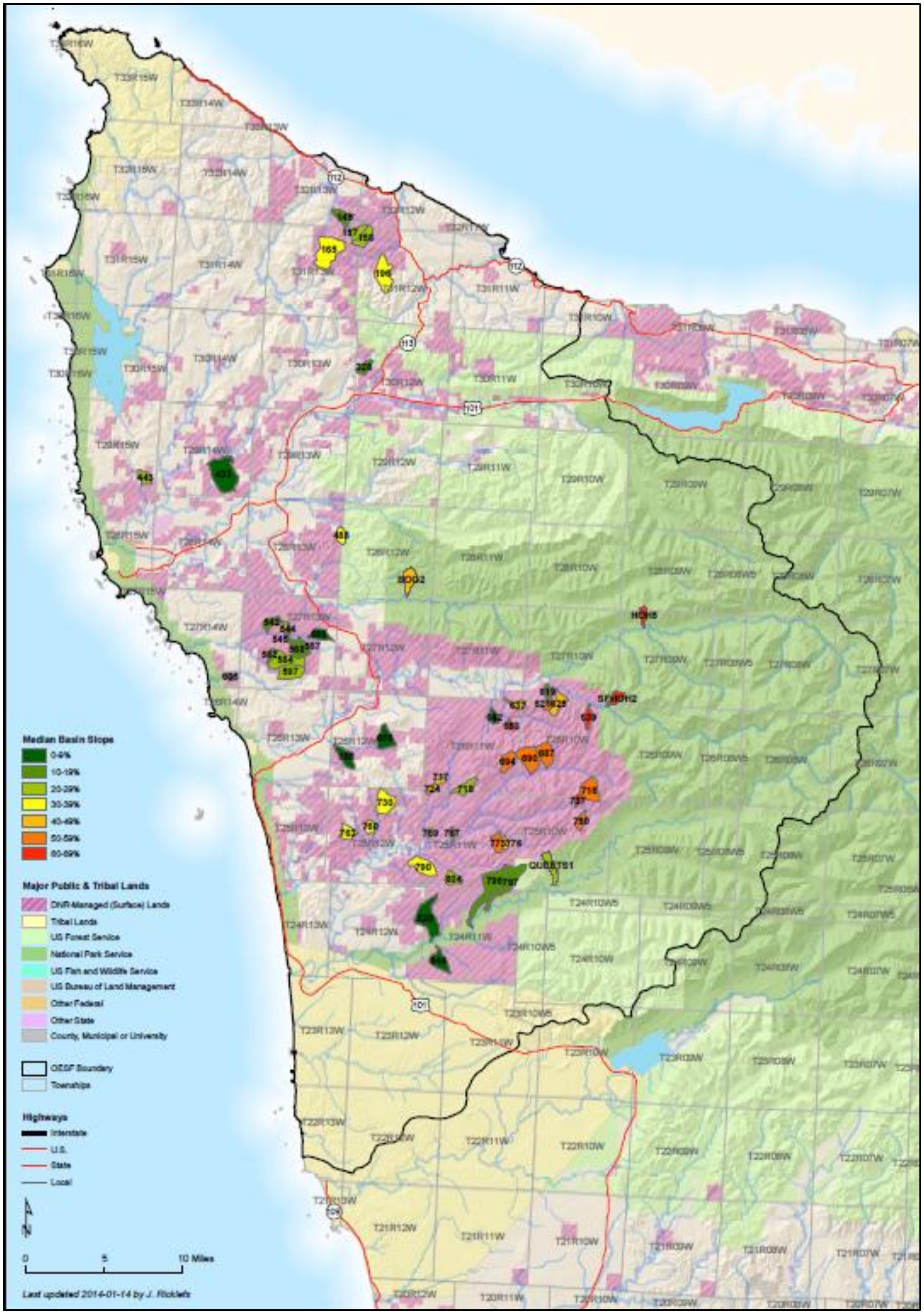


Figure 1. Map of the study area with 50 sample basins located in the OESF and 4 reference basins located in the Olympic National Park.

Development and Review of Monitoring Protocols

The DNR/PNW research team held three meetings in March and April 2013 to determine what monitoring protocols were needed to meet the objectives of the project. The discussed topics included selection of metrics and indicators, available information sources, sampling procedures, field techniques, labor intensity, equipment cost, sharing of data between agencies, time constraints, and dependencies between the protocols. The group agreed on a common template and each researcher was assigned protocols to develop.

By May 2013, eight draft protocols were developed. Two monitoring protocols remain to be developed: riparian microclimate and riparian vegetation. Refer to Table 1 for the protocols' status.

Table 1. Status of the monitoring protocols

#	Protocol Title	Author*	Status
1	Stream Temperature	Alex Foster	draft was peer reviewed; the final is under development, expected publication in May 2014
2	In-Stream Large Wood	Alex Foster	draft was peer reviewed; the final is under development, expected publication in May 2014
3	Stream Shade	Jeff Ricklefs	draft was peer reviewed; the final is under development, expected publication in May 2014
4	Stream Discharge	Jeff Ricklefs (draft), Rachel LovellFord (final)	draft was peer reviewed; the final is under development with major additions on field procedures and data management, expected publication in May 2014
5	Coarse Channel Substrate	Scott Horton	draft was peer reviewed; the final is under development, expected publication in May 2014
6	Stream Habitat Units	Teodora Minkova	draft was peer reviewed; the final is under development, expected publication in May 2014
7	Classification of Valleys and Channel Reaches	Teodora Minkova	draft was peer reviewed; the final is under development, expected publication in May 2014
8	Stream Morphology	Teodora Minkova	draft was peer reviewed; the final is under development, expected publication in May 2014
9	Riparian Microclimate	Richard Bigley	under development, draft expected in spring 2014
10	Riparian Vegetation	Richard Bigley	under development, draft expected in spring 2014

*Refer to Table 4 for the authors' affiliation and role in this project

The drafts of the protocols were reviewed by PNW statistician Dr. Ashley Steel and PNW fish biologist Dr. Rebecca Flitcroft. The protocols' reviews focused on three major questions:

1. Are the selected monitoring indicators, metrics, and measurements suitable to characterize the status and trends of riparian and aquatic habitat across the OESF?
2. Are the field procedures described in the protocols appropriate to collect data for calculation of the identified metrics?
3. Is the sampling frequency appropriate for our monitoring questions and limited budget?

The research team met with the reviewers to discuss the review findings and recommendations for improvement. To continue the discussion using field examples, a field tour with the reviewers took place in August 2013.

- *2013 Accomplishment:* **Eight of the ten monitoring protocols identified in the study plan were developed and peer reviewed.**

Refinement of Field Procedures

In June and July 2013, the DNR/PNW research team refined the field procedures described in the draft monitoring protocols. The recommendations from the protocols' peer reviews, several field tests, and additional literature reviews were taken into consideration. The more significant changes are listed below.

Number of cross sections: The number of cross sections within a sample reach was lowered from 11 to 6 to reduce the fine-scale measurements, such as repeated measurements of stream width. According to the protocol's review, the original sampling intensity was unnecessarily high to accurately calculate the stream morphology mean and median metrics for long-term comparisons.

Substrate sampling intensity: The research team decided that the number of sampled coarse substrate particles, which will be taken at the 6 cross sections, should not be reduced from the original protocol because of the expected high variability in substrate particle size. Therefore, substrate particles will be collected at 21 stations across each of the 6 cross sections instead of at 10 stations across the originally envisioned 11 cross sections.

Procedure for measuring channel gradient: The channel gradient, which is measured through differences in elevation between cross sections, will be sampled with an auto level and stadia rod. An alternative method of sampling with laser rangefinder and stadia rod was rejected because the appropriate mount and other hardware for the laser rangefinder were not readily available.
Procedure for measuring channel depth: Two methods for measuring the channel depth were selected. For streams narrower than 5 m at bankfull, the channel depth will be measured directly

with a stadia rod. For streams wider than 5 m at bankfull (where the tape stretched between the bankfull stages on the opposite banks is expected to sag), the channel depth will be measured with an auto level and stadia rod.

Procedure for measuring in-stream large wood: The field procedure for sampling in-stream large wood was modified from the Timber Fish and Wildlife (TFW) protocol (Schuett-Hames 1999) to better meet the objectives of our study and the layout of the sample reaches. The exact position of each LWD piece relative to the start of the sample reach will not be recorded; the position relative to each channel cross section will be recorded instead. Further modifications of the field procedure were considered (e.g. not measuring the logs' dimensions but classifying them as small, medium, or large). These modifications follow the reviewer's recommendation to reduce the sampling intensity at the sample reach level. The project research team decided to not implement them at this stage and to revisit the topic after analyzing the first set of large woody debris data.

Location and recording interval of water temperature data loggers: The continuously recording stream temperature data loggers were examined for physical changes or damage from the winter flows and repositioned as needed. Many were moved out of plunge pools where turbulence during high flows can be extreme. The recording intervals of stream temperature data loggers and the nearby air data loggers were changed from 80 min to 60 min for easier calculation of daily metrics and for consistency with other regional protocols.

Procedure for measuring peak flow: The method for detecting annual peak flow with Velcro strips was tested in 2012 in 8 basins (Minkova and Vorwerk 2013). The check of the sampling stations in spring deemed this method impractical and inaccurate. The installations were removed and the research team decided to install gage stations instead.

Procedures for measuring stream discharge: The field procedures for taking stream discharge measurements will follow the USGS protocol (Turnipseed et al. 2010) with some modifications due to the site physical limitations (e.g. very small streams) and budgetary restrictions. Elements of the protocol that differ are: less stable benchmarks and cheaper gages.

In addition to already developed protocols, the research team decided to establish a permanent station to take photos of each sample reach over the monitoring period. The value of this qualitative information is mainly in visually illustrating the seasonal dynamics and long-term changes in the monitored attributes.

Procedures for classifying channel types and habitat units: To reduce the observer's error in classifying habitat units and channel types and to speed up the identification process, the team developed a field guide, which included: photos, channel schematics, and stream types' comparison table (refer to Appendix 5)

- *2013 Accomplishment:* **Field procedures were refined for 8 of the 10 monitoring protocols identified in the study plan.**

Field Training

After the field procedures were refined, the scientific technicians were trained how to implement the eight peer-reviewed monitoring protocols. It is known that the differences in field measurements introduced by different observers can be considerable (Roper et. al 2010). To reduce the error introduced by different field crews and to increase the consistency of measurements across sample sites, each of the two field crews was assigned protocols to implement for the duration of the field season.

One field crew of two technicians was trained to implement the protocols on stream morphology, stream shade, coarse channel substrate, in-stream large wood, habitat units, and channel and valley classification. This field crew also installed the cross sections and the permanent photo stations. The same crew was tasked with recording the elevation of the reference point with a resource grade GPS unit and collecting GPS points at the beginning and the end of the sample reach for calculating the sinuosity.

A second field crew was trained in assessing the sample reach suitability for installing a stream gage, installing gage stations, taking stream flow measurements and downloading water level data. Later in the season, the same crew was trained in installing microclimate transects and installing the microclimate data loggers.

At the end of the field season, all scientific technicians and two of the researchers were trained in taking stream flow measurements and downloading water level data. This was done to ensure that there is enough qualified staff to collect hydrology data though the winter season.

To further ensure consistency in the data collection, one technician in each team was designated to make “the final call” on sometimes subjective determinations such as habitat unit type and location of the bankfull stage.

- *2013 Accomplishment:* **Four scientific technicians were trained to implement eight aquatic monitoring protocols.**

Implementation of Monitoring Protocols

Layout of the sample reaches

Most permanent field installations for the study have been placed in the sample reaches in 2012 and 2013. The layout of a sample reach is illustrated in Figure 2. The protocols for in-stream large wood, habitat units, and valley and channel type classification, which require continuous survey along the sample reach, are not depicted in Figure 2.

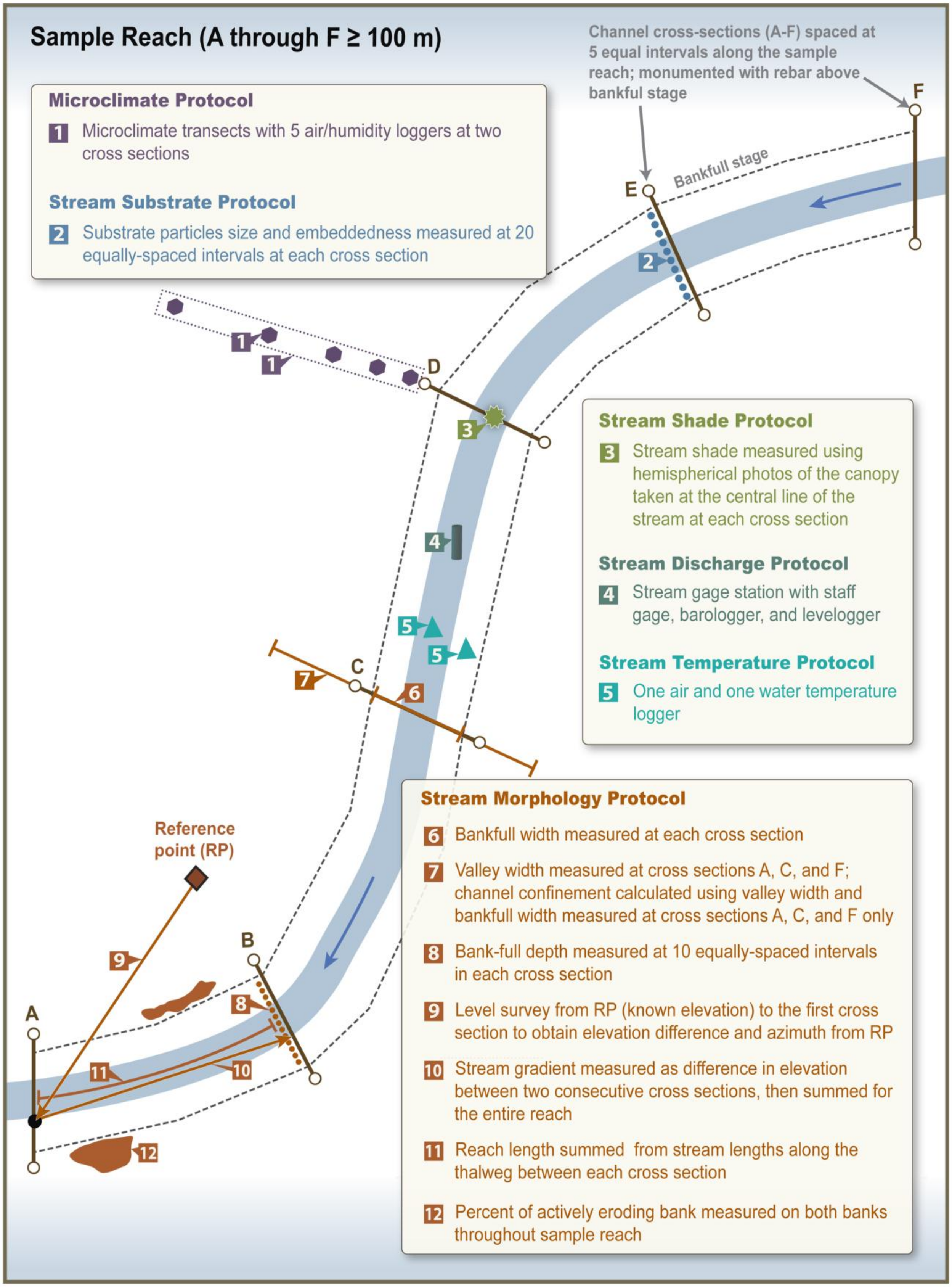


Figure 2. Layout of a sample reach

The field work completed during the reporting period is described in the sections below. Refer to Appendix 2 for the list of protocols accomplished in each basin. Details of all field procedures can be found in the monitoring protocols (Minkova and Foster (Eds.) in prep.). Refer to Appendix 4 for field data forms used for each protocol.

ESTABLISHMENT OF PERMANENT CROSS SECTIONS

The start of each sample reach was marked during the 2012 field reconnaissance. This point was identified to be the closest to the outlet of the Type 3 basin but above the 100-year floodplain of the main stream into which the sample stream drains. Refer to the project's establishment report (Minkova and Vorwerk 2013) for details of the field procedures. The length of the sample reach was determined as 20 times the bankfull width at the beginning of the reach or at least 100 meters. The length of the sample reach was measured along the thalweg using a meter tape. Six cross sections were identified at five equally spaced intervals along the sample reach. The cross sections were permanently marked with rebar installed on both banks slightly above the bankfull stage and labeled A-F (Figures 3 and 4)

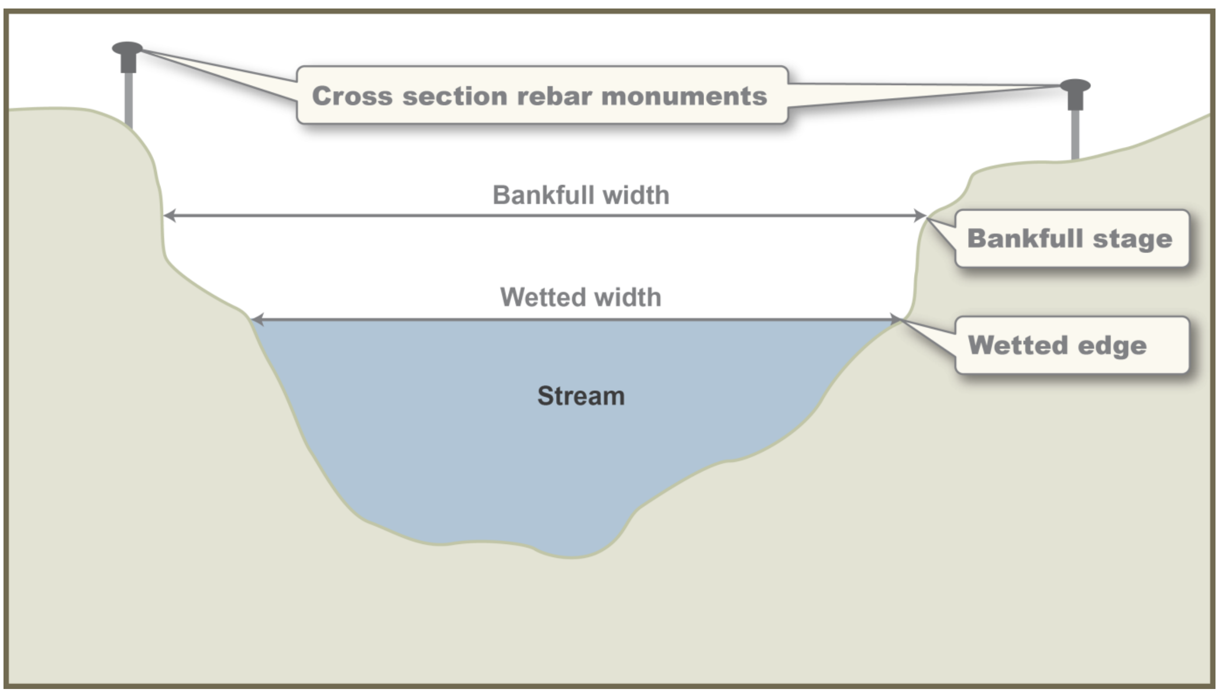


Figure 3. Elements of a stream cross section.

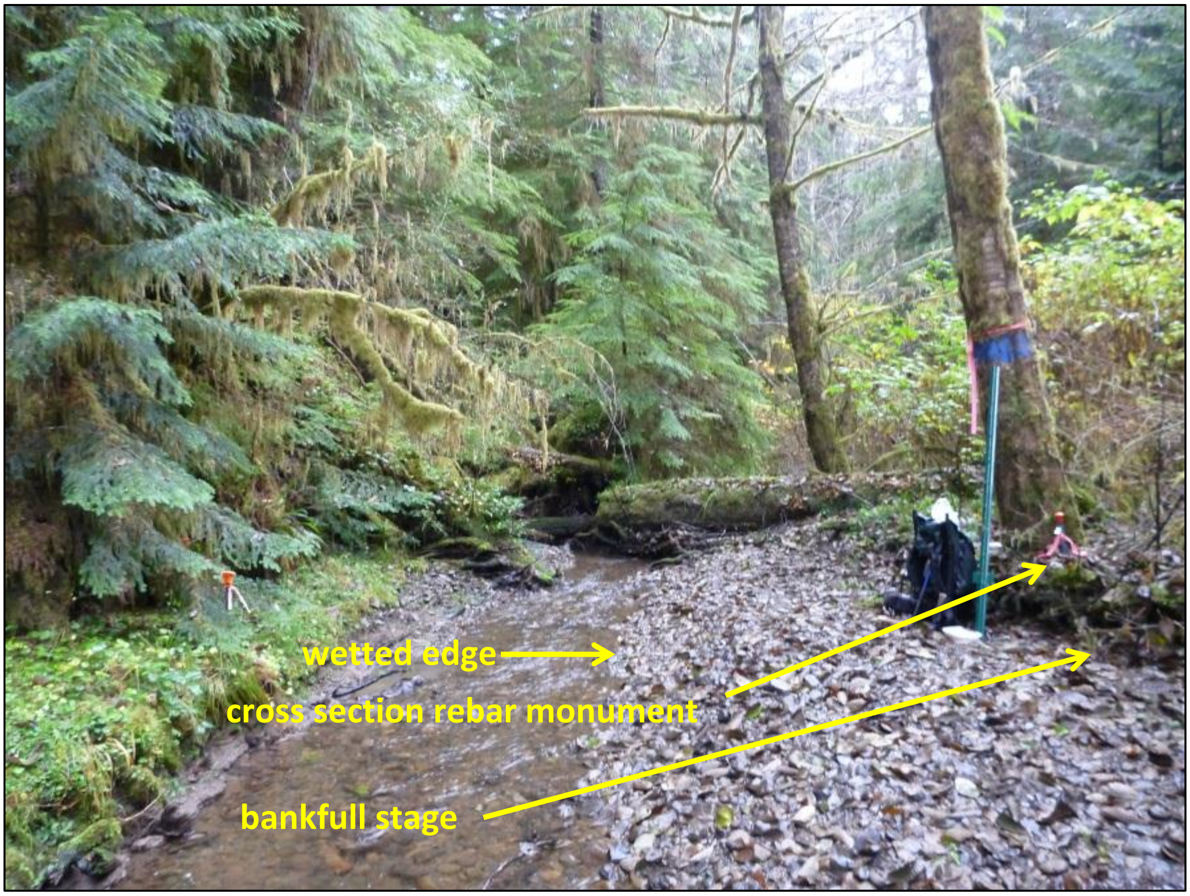


Figure 4. Example of a cross section.

Occasionally logjams, severe undercuts, or other obstructions covered the stream channel making it impossible to establish a cross section and make accurate bankfull measurements. In all cases, the obstruction was small and blocked only one cross section, so the cross section was moved to the nearest suitable location and a comment was made in the field form. Care was taken not to move the cross section more than 4 meters upstream or downstream.

> ➢ *2013 Accomplishment:* **Cross sections have been installed in 26 basins (refer to Appendix 2).**

ELEVATION MEASUREMENT OF REFERENCE POINTS

Reference point coordinates and elevations (x, y, and z data) were recorded using a resource grade GPS (Trimble Pro XT, Trimble Pro XH, or Trimble Juno). A new ArcPad layer was created to record the data and the antennae's height above the ground, which was programmed into the GPS unit. The elevation of the ground at the reference point was then recorded by standing directly over the top of the reference point rebar (Figure 5). Each collected point was averaged for at least 50-300 points, depending on satellite availability. All GPS data was differentially corrected back at the office using Trimble Pathfinder Office.

The reference point elevation will be used to characterize the sample reaches in general terms (e.g. determining what elevation zone they are in). The reference point will be used as a benchmark for all vertical measurements of attributes within the sample reach. However, for these relations the reference point can be assigned a value of 0, the actual elevation is not needed. The calculation of other points within the sample reach relative to the reference point will be done by differential leveling using an auto level and stadia rod (see the section Channel Gradient below).

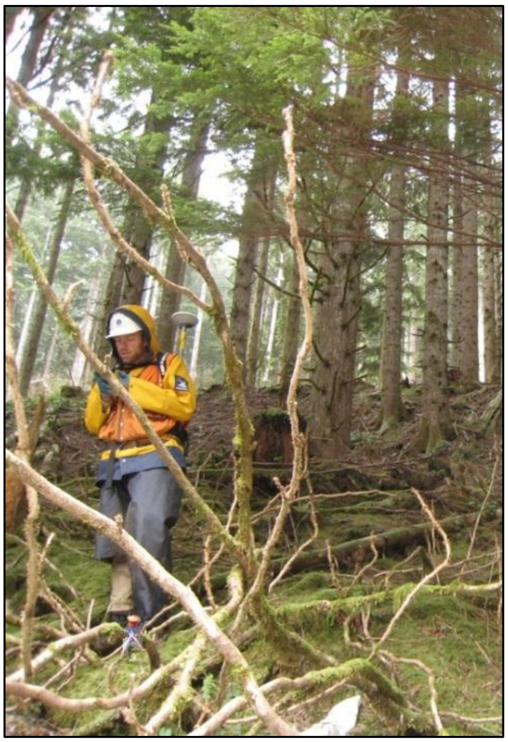


Figure 5. Using a GPS unit to measure reference point elevation.

- *2013 Accomplishment:* **Reference Point elevation data has been collected in 44 basins (refer to Appendix 2).**

CHANNEL MORPHOLOGY

The channel morphology protocol (Minkova and Foster (Eds.) in prep.) includes several elements: gradient, sinuosity, width and depth. The protocol implementation for each element is described in a separate section below.

CHANNEL GRADIENT

The channel gradient for a sample reach will be calculated from the differences in elevation between the 6 cross sections along the sample reach. The gradient of the sample reach is calculated as total rise (vertical change) divided by total run (horizontal distance). This method was chosen because it is more precise than measuring the gradient with a clinometer and thus better suites the objective of this study - detecting change in channel gradient over time. The field measurements were done with an auto level, tripod, and stadia rod (Figure 6) following the protocol of Harrelson et al. (1994).

A compass was used to take an azimuth reading between cross sections. These azimuth measurements will be used to produce a plan view map of the sample reach.

The channel gradient and a longitudinal profile (graphic presentation of elevation vs. distance) of the sample reaches will be calculated in the office.

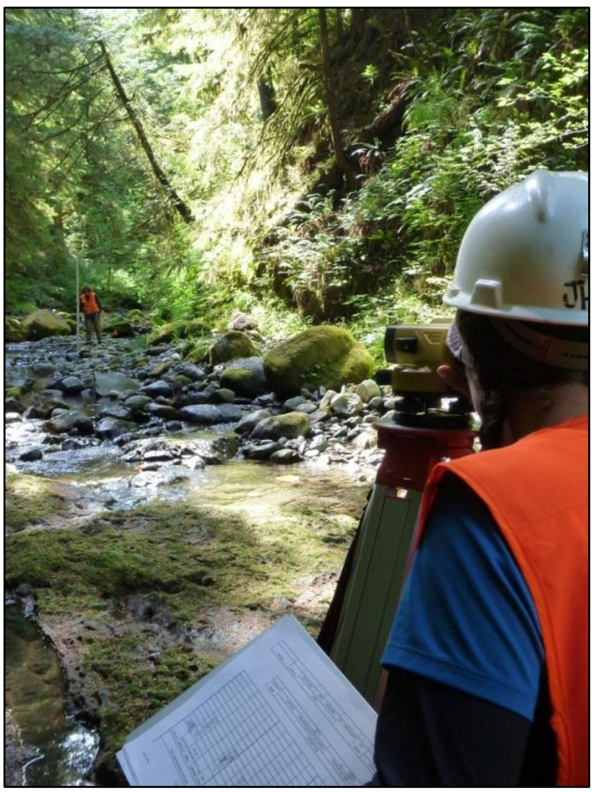


Figure 6. Using an auto level and stadia rod to measure stream gradient.

➢ *2013 Accomplishment:*	**Elevation differences have been measured in 10 basins (refer to Appendix 2). The channel gradients were calculated and the longitudinal profiles were created for the 10 sample reaches.**

CHANNEL SINUOSITY

Channel sinuosity is defined as the ratio of sample reach length measured along the thalweg to the straight line distance between the beginning and the end of the sample reach. Aerial photography is typically used to determine large scale channel pattern, and may record temporal changes at a location. However, field measurements are necessary for small streams in forested areas.

The length of the sample reach was measured along the thalweg using a meter tape. The straight line distance will be measured in the office with ArcGIS using GPS coordinates of the beginning and the end of the sample reach.

➢ *2013 Accomplishment:* **The field measurements for calculating channel sinuosity have been completed for 17 basins (refer to Appendix 2).**

CHANNEL WIDTH AND DEPTH

Bankfull width is the horizontal distance between the bankfull stage (water level at bankfull discharge) on the left and right banks of a stream measured directly across the channel (Figure 2). The procedure for determining the bankfull stage was described in the 2012 establishment report (Minkova and Vorwerk 2013). The bankfull width and wetted width were measured at each cross section using a meter tape stretched between two chaining pins.

The channel depth was measured at ten equally spaced intervals (eleven stations) across the bankfull stage at each cross section (Figure 7). For streams narrower than 5 m at bankfull, the channel depth was measured directly with a stadia rod. For streams wider than 5 m at bankfull (where the tape stretched between the bankfull stages on the opposite banks is expected to sag), the channel depth was measured with an auto level and stadia rod.

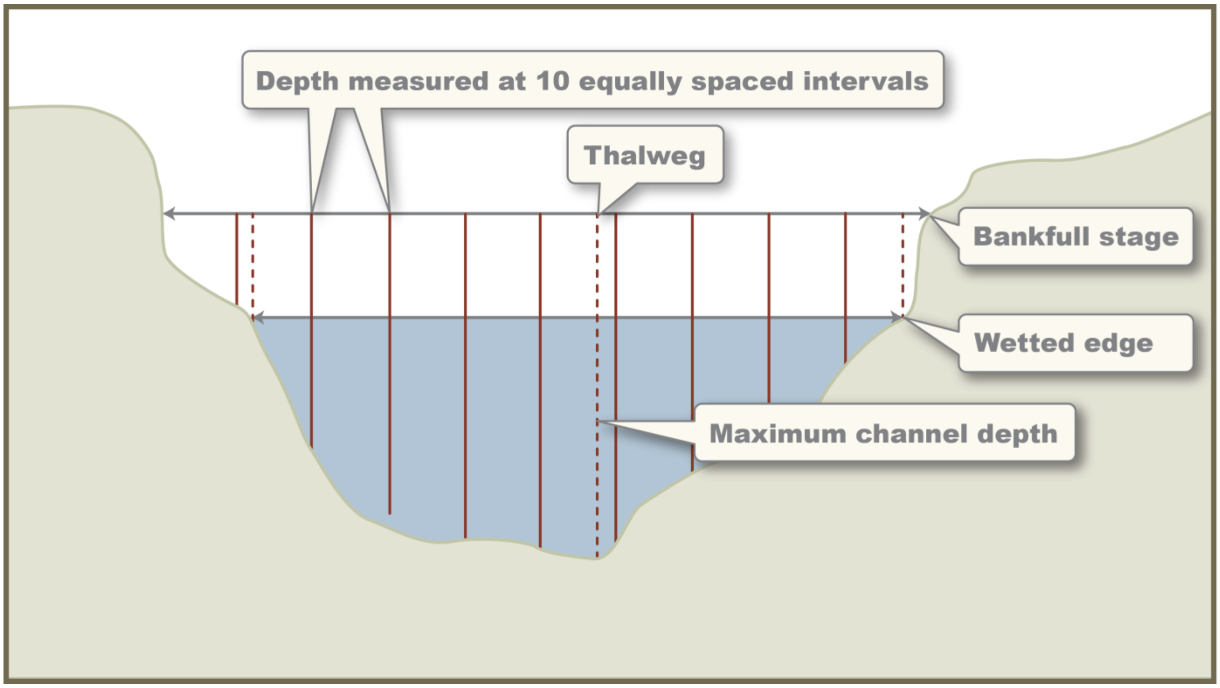


Figure 7. Depth measurements collected at a cross section. The solid vertical lines represent the established equally-spaced measurement stations. The dotted lines represent additional measurements taken at the thalweg and the wetted edges of a stream if different from the established stations.

- *2013 Accomplishment:* **Channel width and depth measurements have been completed in 10 basins (refer to Appendix 2).**

CHANNEL COARSE SUBSTRATE

The objective of this protocol is to document changes in spawning habitat overtime. Twenty substrate particles were sampled at 20 equally spaced intervals (21 stations) across each of the 6 cross sections (Figure 8) for a total of 126 particles measured at each sample reach.

Moving along the meter tape stretched across the stream for measuring the channel width, a stadia rod was placed vertically at each station. The particle located immediately below the bottom of the rod was selected. To standardize measurements among different surveyors, the size of each substrate particle was measured using a gravelometer (Figure 9) for particles up to 310 mm. For larger particles, a stadia rod was used to estimate/measure particle size.

The fraction of particle volume that is embedded in sand or finer sediments on the stream bed was estimated for each particle in classes of 10%. By definition, sand and fines are 100% embedded while bedrock is 0% embedded.

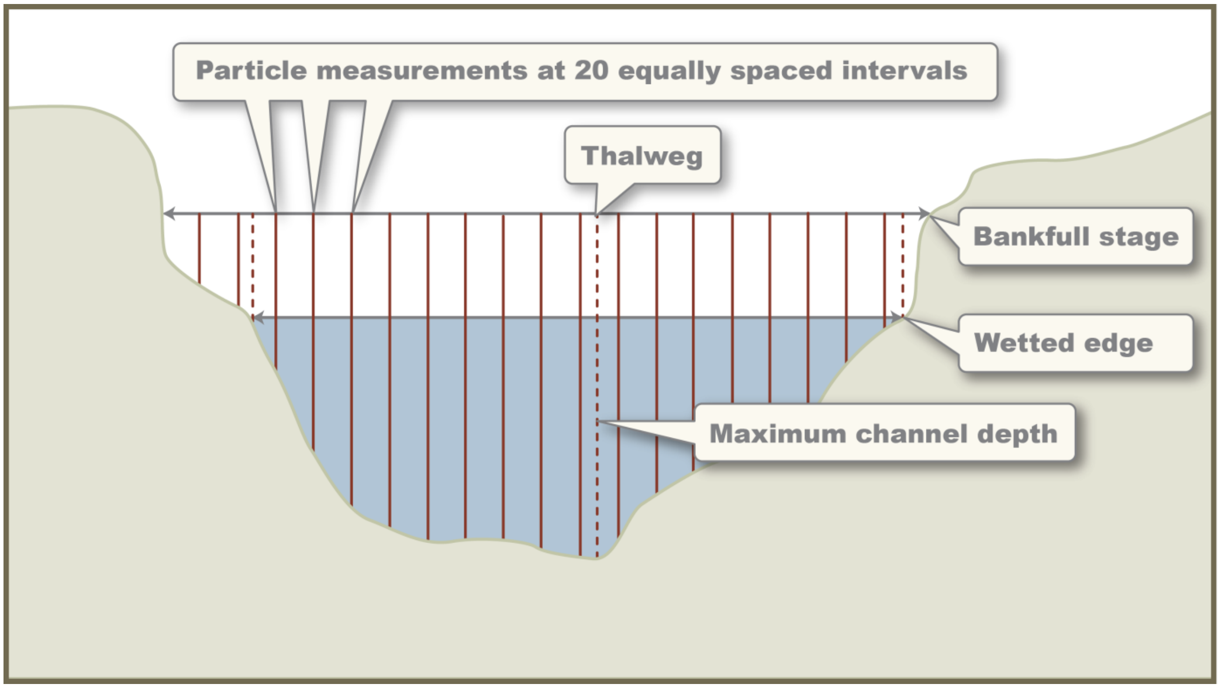


Figure 8. Coarse substrate measurement stations at a cross section.

Figure 9. Sampling channel course substrate using a stadia rod and gravelometer.

➢ *2013 Accomplishment:* **Course substrate protocol has been completed in 10 basins (refer to Appendix 2).**

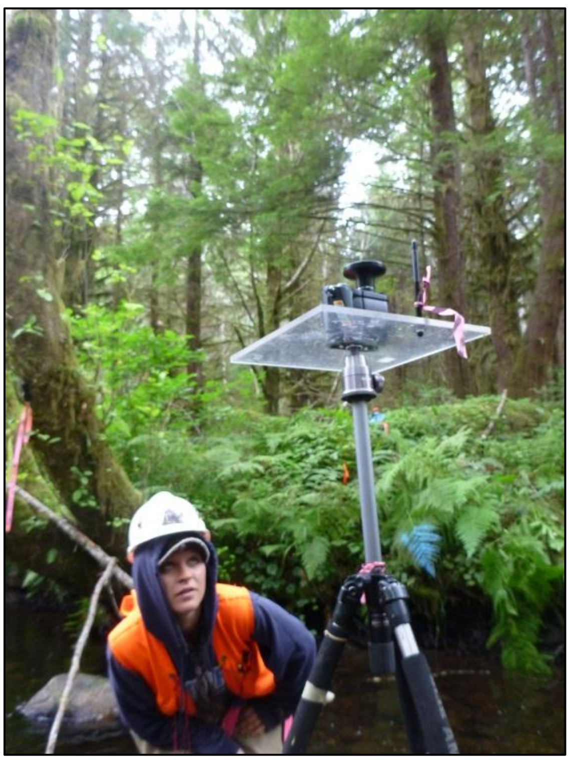
STREAM SHADE

The objective of this protocol is to document over-stream shade, to help with the interpretation of stream temperature data and to test assumptions about the relationship between the characteristics of the adjacent riparian forest, stream shade and stream temperature. Hemispherical canopy photos were taken at each cross section for a total of six photos per sample reach. The camera tripod was set up at the middle of the bankfull channel at each cross section (Figure 10).

Canopy closure is highly variable spatially and changes seasonally, which requires consistent timing and location of the photos. To reduce seasonal variability in the photographs between years, the exact location of the photos were recorded. Future photos will be taken within 2 calendar weeks of the initial year's photo at a given location.

A digital camera with fish-eye lens was attached to a cover plate on a tripod at 1.4 m above the stream bed (Figure 10a). The camera was aligned to face true (also known as geodetic) north and leveled horizontally.

The images (Figure 10 b) will be analyzed in the office to determine the percent shade.



a

b

Figure 10. Taking canopy photo (a) and example of a hemispherical photograph of the canopy (b).

➢ *2013 Accomplishment:* **Stream shade protocol has been completed in 9 basins (refer to Appendix 2).**

In-stream large wood

The objective of this protocol is to document changes in the amount and distribution of in-stream large woody debris. Our working hypothesis for recovery of habitat quality is controlled largely by the inputs of wood to the streams overtime. Wood surveys employed the Level II procedure described in Schuett-Hames (1999) with modifications described in the section Refinement of Field Procedures (above). The field procedure involved measuring and describing the functionality of every piece of qualifying wood or wood jam along the sample reach starting at cross section A.

A qualifying piece of wood had a minimum length of 2 meters and a minimum diameter of 10 cm at the mid-section of its length. Each qualifying piece received a unique number that also showed its position relative to the nearest downstream cross section. The piece dimensions were taken with calipers and measurement tape and its position relative to the bankfull stage and wetted channel was recorded. The piece was qualified as deciduous, coniferous, or unknown and its stability and pool forming or sediment storing function was estimated. The orientation and decay class were also noted in the field form (refer to Appendix 3).

Large wood jams are in-channel or channel spanning structures formed by accumulations of 10 or more qualifying logs and root wads. A qualifying piece of the jam needed to extend at least 0.1 meter into (or above) the bankfull channel to qualify as a jam. For each wood jam, the total number of logs per size class were counted.

- *2013 Accomplishment:* **The protocol for in-stream large wood has been completed in 10 basins (refer to Appendix 2).**

Classification of habitat units

The objective of this protocol is to document changes in in-stream habitat units over time. Channel geomorphic units, also called channel units, habitat types, or habitat units, are relatively homogenous areas of the channel that differ in depth, velocity and substrata characteristics from adjoining areas (Bisson et al. 2006). Channel unit classification is useful for decribing habitat in streams and for understanding the relationships between habitat changes and aquatic organisms.

The classification system described in Bisson et al. (2006) was used to identify and distinguish habitat units using a three-tier classification for fast water units and a modified two-tier classification for slow water units (scour and dammed pools) with the addition of backwater pools (Figure 11).To minimize the subjectivity in classifying a habitat unit, the research team developed a field guide, which included photos, channel schematics, and a stream types comparison table (refer to Appendix 5).

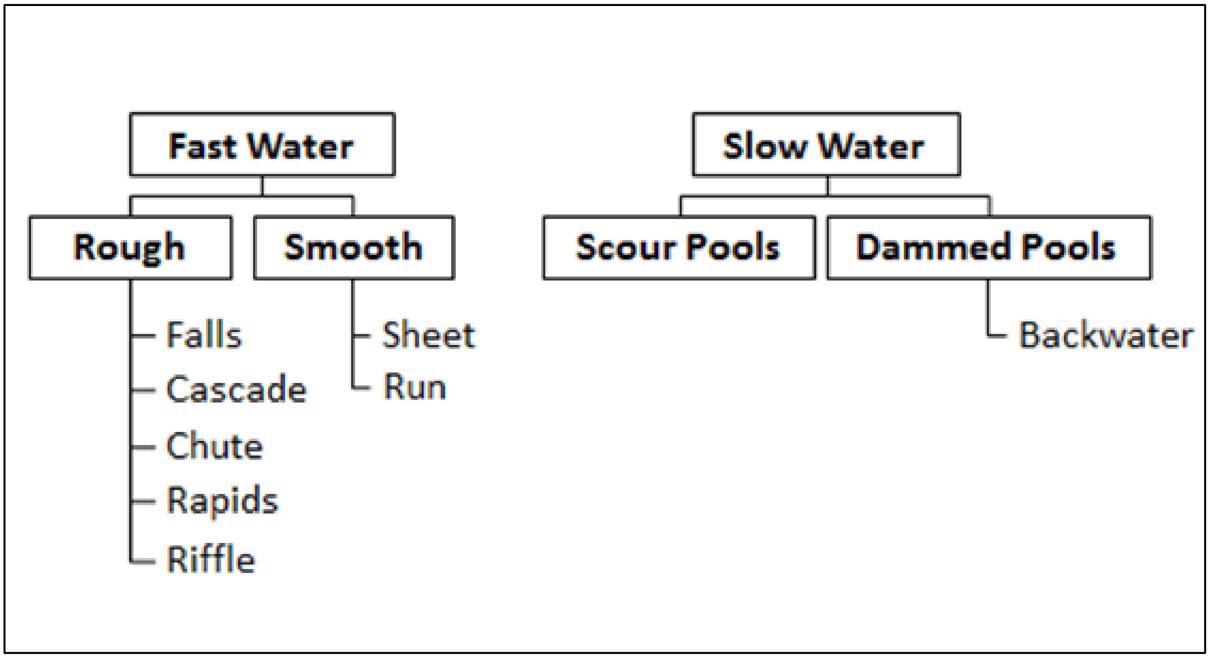


Figure 11. Classification of habitat units, modified from Bisson et al. (2006).

The habitat units were identified along the length of each sample reach starting at cross section A. In general, an area was counted as a separate unit if (1) its overall physical characteristics were clearly different from those of adjacent units, and (2) its size was significant relative to the size of the wetted channel.

A meter stick and/or measurement tape was used to collect the length and 3 to 5 width measurements for each habitat unit. The maximum pool depth and the pool tail crest depth were also measured and the residual pool depth calculated in the office.

➢ *2013 Accomplishment:* **Classification and measurement of habitat units have been completed in 10 basins (refer to Appendix 2).**

Classification of Valley and Channel Types

The objective of this protocol is to classify sample reaches and to help interpret stream discharge and coarse substrate data. We adopted the Valley and Channel Types classification system of Montgomery and Buffington (1993) (Figure 12). The system uses information on the nature of the valley fill, sediment transport process, channel transport capacity, and sediment supply, to identify three valley segment types: colluvial, bedrock, and alluvial. All sample reaches in our study area were in alluvial valleys.

Channel reaches consist of repeating sequences of specific types of channel units (e.g. pool-riffle sequences) and specific ranges of channel characteristics (slope, confinement, sediment size, width to depth ratio), which distinguish them from the adjoining reaches. Following the classification of Montgomery and Buffington (1993), six channel types were recognized: cascade, step-pool, plane-bed, pool-riffle, regime (dune-ripple), and braided (Figure 12).

The channel type was usually determined after the classification of habitat units and channel morphology measurements that help define diagnostic reach characteristics for the classification. In addition, to reduce the subjectivity and to speed up the classification process, a field guide with photos and schematic references has been developed (refer to Appendix 5).

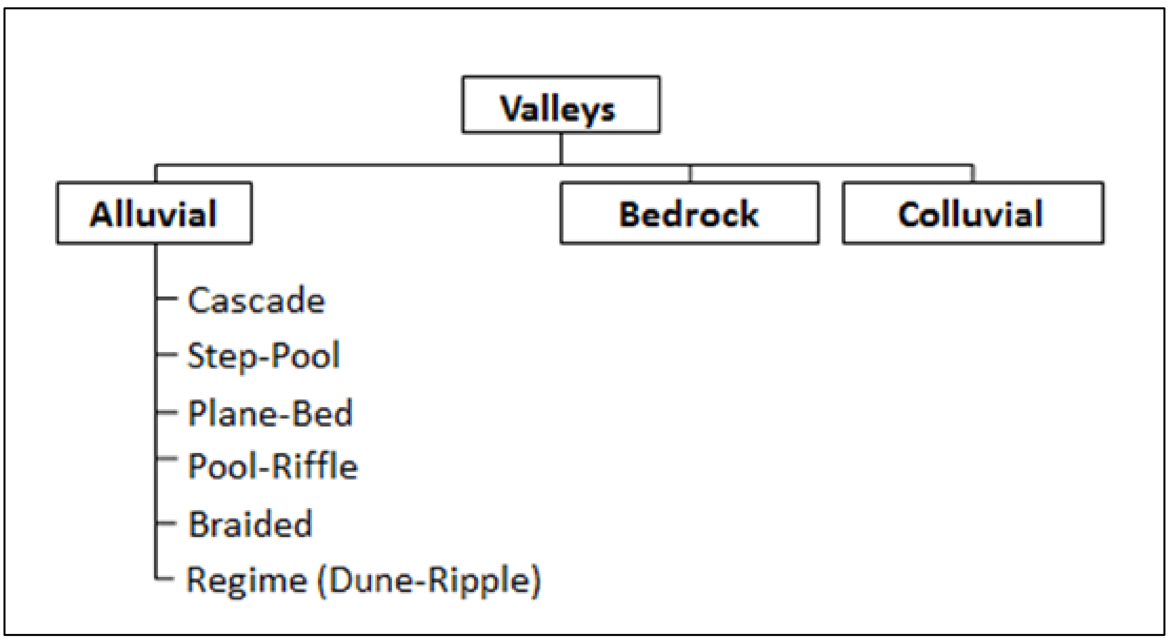


Figure 12. Classification of channel types, modified from Montgomery and Buffington (1993).

- *2013 Accomplishment:* **Classification of valley and channel types has been completed in 4 basins (refer to Appendix 2).**

ACTIVE EROSION

The metric “percent actively eroding bank” was used to quantify the amount of bank erosion occurring in the sample reach. One or more of the following characteristics were used to classify a bank as actively eroding: 1) exposed soils and inorganic material; 2) evidence of tension cracks; 3) active sloughing, or superficial vegetation that does not contribute to bank stability. A classifying eroding patch is above the bankfull line and with minimum dimensions of 2 m in length and 0.5 m in height. A stadia rod or a meter stick was used to measure erosion height and a meter tape was used to measure the length along the bank (Figure 13). If evident, the cause of erosion, such as a road, was noted. Photographs were taken to document each instance of recorded active erosion. The metric “percent actively eroding bank” will be calculated in the office using the raw field data.

Figure 13. Field crew measuring active erosion in basin 489.

- *2013 Accomplishment:* **The active erosion protocol has been completed in 10 basins (refer to Appendix 2).**

STREAM TEMPERATURE

The objective of this protocol is to document changes of water temperature over time. A stream temperature data logger and an air temperature data logger were installed in all sample reaches in 2012 (Minkova and Vorwerk 2013). The data loggers recorded temperature data continuously throughout the year at intervals of 80 minutes.

All sample reaches were visited during the 2013 field season. Three (or 6%) of the stream temperature data loggers were lost over the winter (basins 158, 625, and 750). The most likely reason for their disappearance was their location in plunge pools where the winter flows were turbulent and their tethers were severed. To reduce future losses of data loggers, some of the nylon tethers were shortened and many stream temperature data loggers were moved to calmer, more protected areas. The data loggers were inspected for physical damages and minor repairs were made.

Data from stream and air temperature data loggers were downloaded from all basins. For 18 sample basins in the OESF and one reference basin in the Queets drainage of the Olympic National Park, the stream temperature data covered an entire year (10/01/2012 - 10/01/2013). From this data, the 7-day daily average maximum temperature (7-DAD MAX) was calculated. This metric is used by the Environmental Protection Agency (EPA) and by the Washington State Department of Ecology (DOE) to set water temperature criteria for various aquatic life-use categories (per WAC 173-201A-200 in WADOE 2006). For the sample reaches in this project, the applicable category is core summer salmonid habitat with threshold value of 16°C (60.8°F).

The water temperature of the 18 OESF sample reaches was below the EPA threshold value (Figure 14). Multiple factors may contribute to the higher water temperature in the reference basin (i.e. southern aspect, flat topography in the Queets river flood plain, low elevation, and extensive 2008 blowdown upstream). Further data analyses are in process.

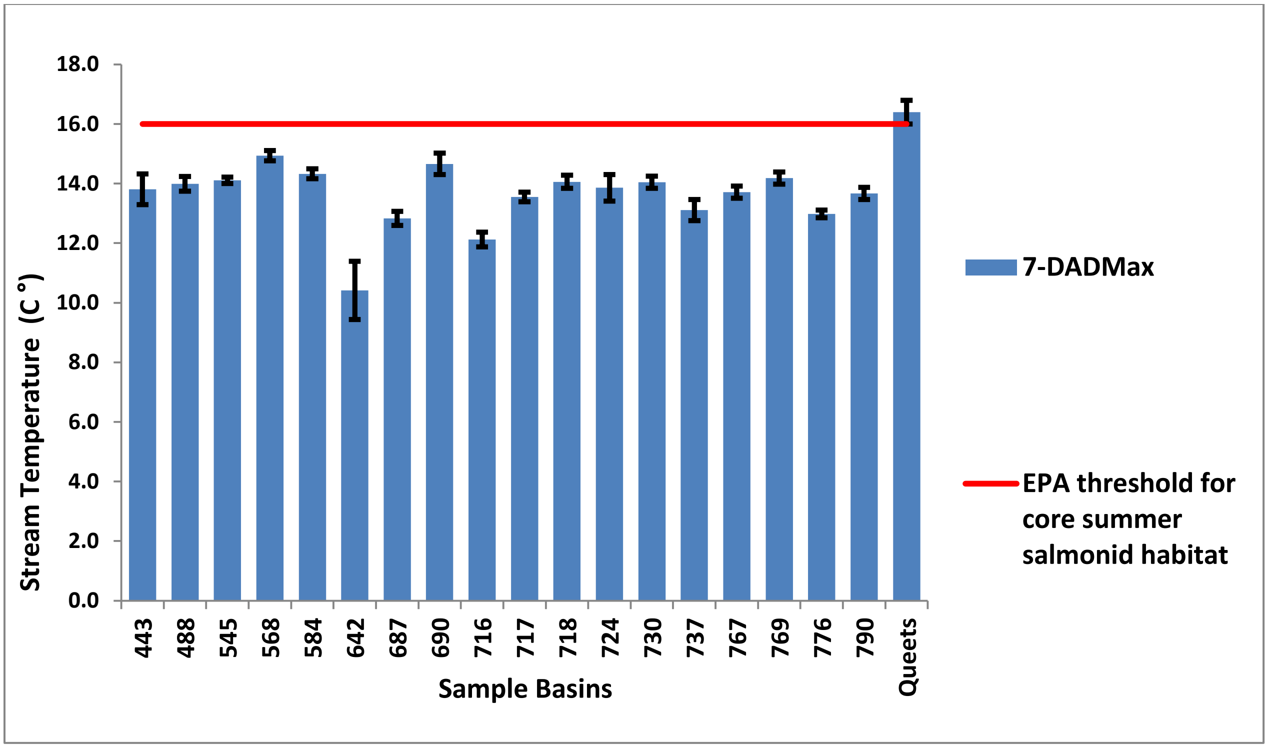


Figure 14. Seven-day daily average maximum temperature in 18 OESF basins and one reference sample basin compared to the regulatory threshold for water temperature in core summer salmonid habitat. The error bars represent one standard deviation.

Following the recommendation of the statistician, the recording interval of temperature data loggers was changed from 80 to 60 minutes. This was done to collect more data points for analysis and to be consistent with other local projects and collaborators.

- *2013 Accomplishment:* **Temperature data was downloaded from all 54 basins (refer to Appendix 2). The recording interval has been changed in 38 basins, the remaining data loggers will be switched to 60-min intervals in 2014.**

Stream Discharge

The stream discharge, also called streamflow or channel runoff, is the volume of water that moves over a designated point in a fixed period of time. It is a function of the cross sectional area of the wetted channel and the velocity of the water moving through that cross section. The stream discharge is a major element of the water cycle, a channel forming factor, and an important habitat attribute.

The stream discharge protocol developed for this project calls for producing an annual hydrograph which involves building a rating curve (a relationship between the stage of the water and the streamflow) and then calculating continuous discharge records using continuous water height recorder data. Water height data are obtained using a continuously recording water-level gage and a staff gage at each measurement site. Discharge measurements are taken at the same site at a variety of flow levels. The discharge measurements will then be combined with the staff gage readings to construct a rating curve. Once the rating curve is constructed, a hydrograph showing discharge over time can be constructed using the continuous recording water-level gage data and the rating curve.

Stratification and allocation of gaged basins

A subset of 14 basins out of the 50 sample basins in the OESF was selected for installing gage stations. This number was determined after considering the minimum number of basins necessary to represent the full range of hydrologic conditions within the project's sample frame and the maximum number of gages that a single crew can visit repeatedly throughout the year to take multiple discharge measurements for constructing rating curves.

The 50 sample basins in the OESF were stratified by basin area, dominant winter precipitation zone as related to elevation, and landscape planning units[2] (LPUs) (Figure 15).
The grouping of the LPUs roughly aligns with precipitation regimes, with northern LPUs characterized by lower rainfall intensity than the southern ones (Figure 15a).

- Landscape Planning Zones
  - N: North
  - S: South
- Precipitation Zone
  - R: rain-dominated (< 300m)
  - RST: rain-on-snow-transition (300-750m)
  - S: snow-dominated (>750m)
- Basin Area
  - 0-150 acres
  - 151-450 acres
  - 451– 1350 acres
  - 1351 – 4050 acres

These two variables are used to define the hydro regions 1-6.

Basin area bins are then represented within each hydro region. Sites are randomly selected.

Figure 15. Stratification plan for selecting stream gage basins

First, the LPUs and precipitation zones criteria divided the OESF in 6 hydro regions. The northern snow dominated hydro region was not represented by any of the 50 sample basins and was dropped from further analysis. The number of available sample basins in each of the remaining five hydro regions ranged from 2 to 26 (Table 2).

[2] Landscape Planning Units are DNR administrative planning areas with size range of 17,276 ac to 55,203 acres. There are 11 LPUs in the OESF: Clallam, Dickey, Sekiu, and Sol Duc LPUs were considered "North"; all other LPUs were considered "South".

Table 2. Hydro regions of the OESF as determined by geography (north -N or south -S) and the dominant winter precipitation type.

Hydro Region	Geographic Zone	Precipitation Zone and Elevation	Number of available sample basins
A	N	Rain (<300 m)	6
B	N	Rain-on-Snow (300-750 m)	2
C	S	Rain (<300 m)	26
D	S	Rain-on-Snow (300-750 m)	9
E	S	Snow (>750 m)	7

Next, the sample basins in each hydro region were allocated to 4 basin area bins (Table 3).
If there was more than one basin represented in a basin area bin within a hydro region, then a list of basins was randomly generated and the first basin was selected

One to four basins were selected randomly per hydro region based on the distribution of basin size within each region (Table 3). This stratification resulted in 12 basins. Finally, the largest and smallest of the 50 sample basins were added for a total of 14 basins identified for stream discharge monitoring.

Table 3. Distribution of gage basins across strata.

Distribution of Proposed Gages Across Strata		**Area Bins**				**Total Number of Gages in Each Hydro Region**
		0-150 acres	151-450 acres	451-1350 acres	1351-4050 acres	
Hydro Region	A		x	x	x	3
	B			x		1
	C	x	x	x	x	4
	D	x	x			2
	E		x	x		2
Total Number of Gages in Each Area Bin		2	4	4	2	12 + 2 end points

Field reconnaissance

Each of the 14 basins identified for discharge monitoring was visited in the field to check the suitability for installing a gaging station. On-the-ground suitability was evaluated following the criteria outlined in Rantz (1982). Four main factors were used: 1) the total flow is confined to one channel at all stages, and minimal flow bypasses the site as subsurface flow, 2) the gage site is far enough upstream from the confluence with another stream or from tidal effect to avoid any variable influence the other stream or tide may have on the stage at the gage site, 3) a satisfactory cross section for measuring discharge at all stages is available within reasonable proximity of the gage site, 4) the gage can be permanently installed within a cross section and will not be shifted by high flows or debris.

Accessibility throughout the year was another factor for excluding basins. This included observations whether the stream was wadeable when discharge is at the high water mark and whether the road to the basin is drivable in the winter.

If a basin did not meet the criteria for installation and access, the next basin on the randomly generated list in the hydro region was investigated. The location of the 14 gage basins selected for discharge monitoring is presented on Figure 16b.

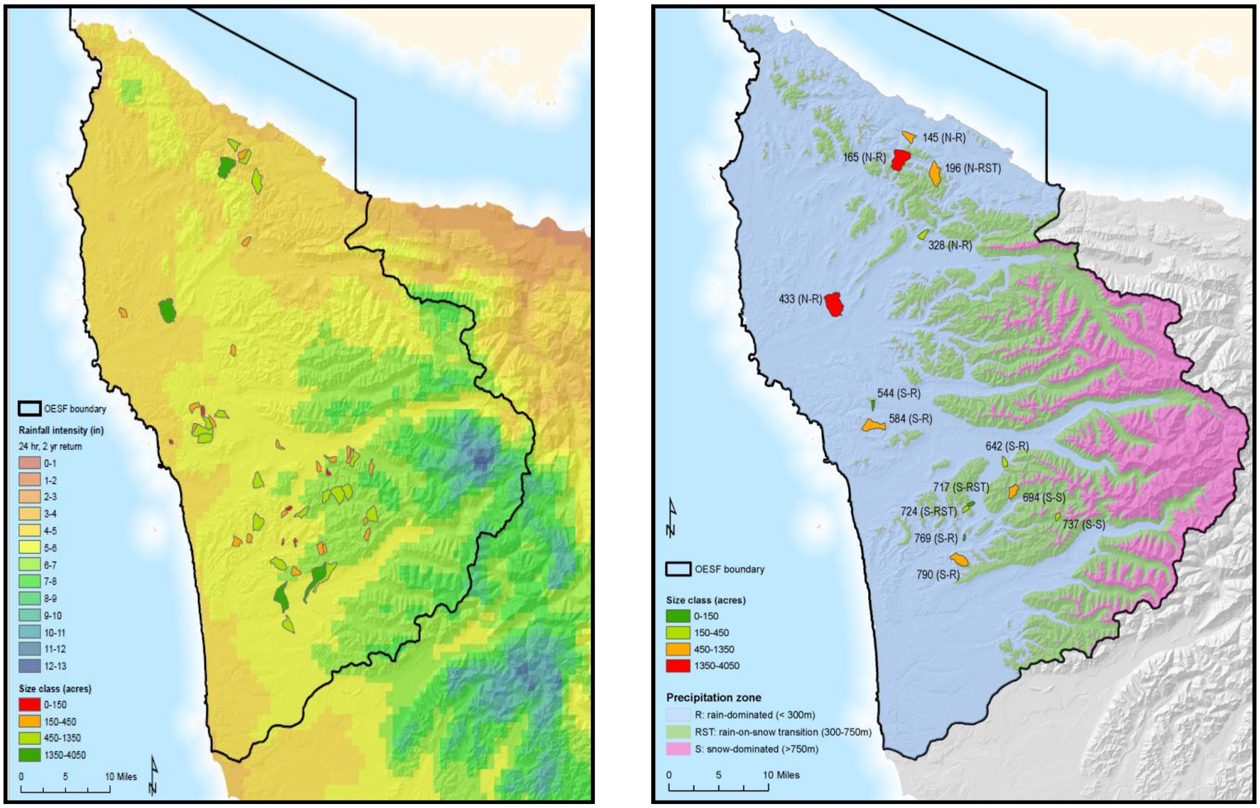


Figure 16. Stratification for stream gages: a) the 50 sample basins categorized by size and rainfall intensity; b) the 14 sample basins selected for discharge monitoring classified by precipitation zone, rainfall intensity, and size.

Field equipment

Pressure transducers (Figure 17a) were used for recording the water level: the data is downloaded in the field via the direct read cable without the instruments being removed from their housings (Figure 17b).

A magnetic flow meter (Figure 17c) was used for measuring water discharge.

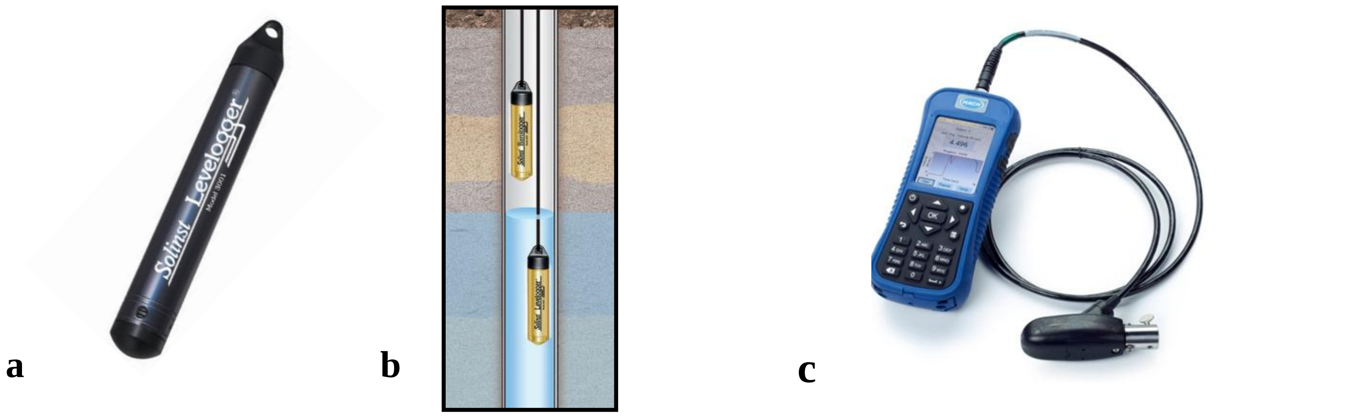


Figure 17. Field instruments used in the steam discharge protocol: a) Solinst© LT Levelogger Edge water level sensor; b) gage housing with suspended levelogger and barologger; c) Hach© FH950 Flow Meter.

Installation of gage stations

Three general gage designs were used for the recording water-level gages: overbank (Figure 18a), in-bank (Figure 18b), or vertical (Figure 18c). Vertical installations required a stable anchoring point directly beside or overhanging the stream. Overbank installations follow the contours of the bank and were utilized in situations where it was not feasible to install an in-bank gage and the main anchoring point was located away from the stream bank. In-bank installations were used when it was possible to dig a trench into the bank of the stream that was at the same depth as the stream thalweg. The data form in Appendix 3 shows the information recorded for each design.

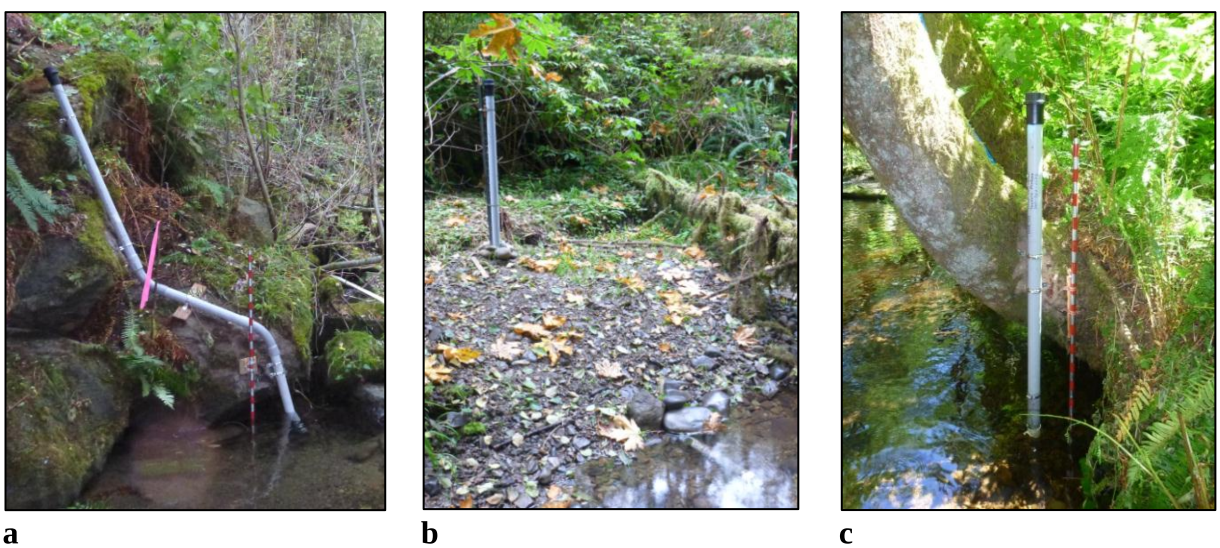


Figure 18. Stream gage designs: a) over-bank housing in basin 694; b) in-bank housing in basin 145; c) vertical housing in basin 433

The basic features of a gage include: 1) housing constructed from PVC pipe, which functions as a stilling well for the levelogger pressure transducer and protects it from damage; 2) perforated section at the base of the housing that provides the main water intake; 3) vent hole above the 100 year flood mark (which together with the intake section allows for equilibrium of the free water surface within the housing; and 4) well cap with attached direct read cable (Figure 19).

Each gage was fabricated off site and was brought to the gaging location in sections and reassembled on site. The gage housing was anchored to the stream bank and other available anchors such as tree trunks using variety of hardware including rebar, All-Thread and epoxy, two-hole straps, and concrete anchor screws. The methods for anchoring the housing varied depending on the site characteristics.

A staff gage, made of 1 inch galvanized conduit, was installed at each site as close to the recording gage as possible (Figure 17 and Figure 18 a,c). A water level measurement is taken on the staff gage each time a discharge measurement is taken and each time the continuously recording barologger and levelogger are downloaded. The water level measurements on the staff gage are used to create the rating curve. They also verify that the recording gage is taking accurate measurements. The difference between the barometrically compensated recording gage measurement and the staff gage measurement should be consistent.

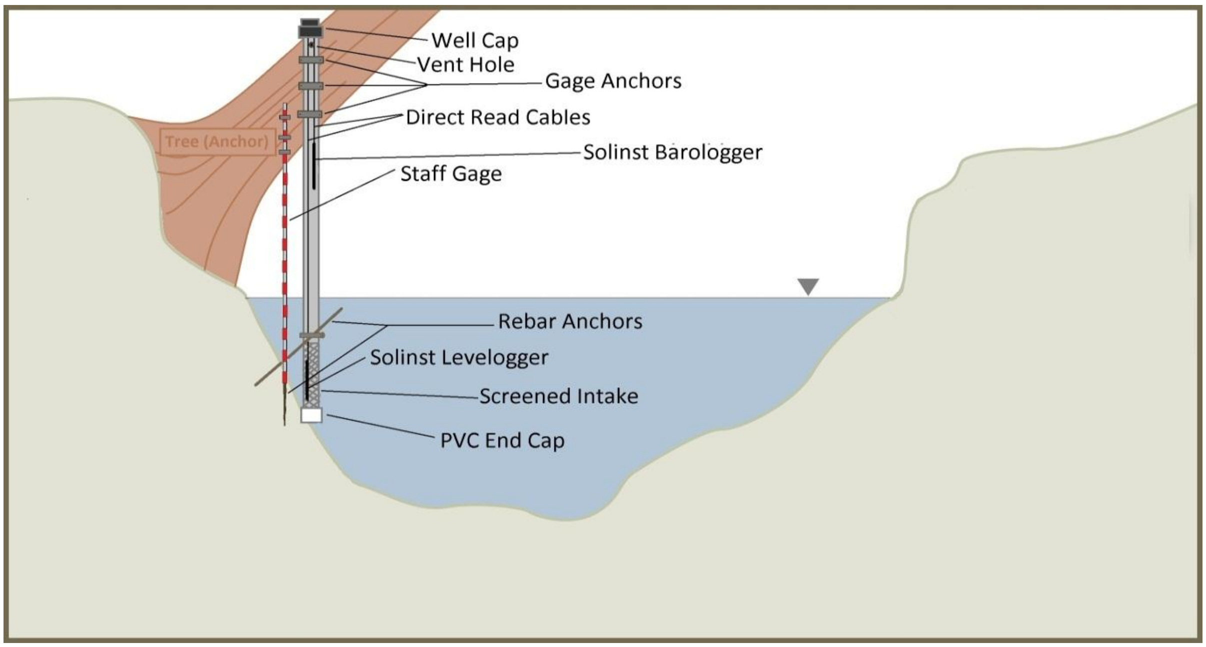


Figure 19. Schematic layout of steam gage station including staff gage and continuously recording water-level gage.

An Installation Worksheet (refer to Appendix 4) was completed for each gage station including: 1) a site plan with gage station layout and description of stream features affecting cross section stability; 2) detailed schematic of the planned gage housing and description of required parts and installation equipment; 3) sample reach metrics such as gradient, bankfull width and Manning's coefficients of the stream bed roughness; 4) final design of the built gage station with exact measurements and description of the anchoring methods; 5) notes on the data loggers setup; and 6) list of photos taken of the gage construction process and the completed installation.

Data loggers calibration and programming

All sensors were checked for accuracy before deployment by submerging them in a bucket of water for 24 hours and recording at one hour intervals. Loggers will be checked for accuracy annually and will be returned to the manufacturer for recalibration if necessary.

Both the levelogger and barologger were programed to record every 15 minutes. The actual water level will be calculated in office using the barometric compensation of the water level measurement.

For the first year of stream discharge monitoring, the gage stations will be visited 8-12 times at different flow levels. At each visit, the water level transducers will be downloaded; staff gage stage will be recorded, a photo and notes on the condition of the gage station and the stability of the cross section will be taken. All information is recorded in the Stream Gage Download Form (refer to Appendix 4).

➢ *2013 Accomplishment:* **Stream gages have been installed in all 14 basins selected for discharge monitoring (refer to Appendix 2). The pressure transducers started recording in November of 2013.**

Cross section stability survey

The accuracy of a rating curve relies on the stream cross section at the gage to remain stable. If the changes in the stream bed introduce more than 10% change in the calculated cross sectional area, the rating curve needs to be adjusted or reestablished (Turnipseed and Sauer 2010). Cross sections were identified within 2 m of the installed gage stations and were permanently marked using 2-ft rebar monuments. A baseline cross section stability survey was conducted at the beginning of the discharge recording period. The cross section stability survey will be repeated when changes to the cross section are visually observed, when the recording gage is disturbed, or in the case of unresolved gage reading differences

Measuring water discharge

Stream discharge measurements are taken on all 14 gaged streams. The goal for the first year is to take at least 8 measurements per stream at different flows in order to construct a rating curve that accurately predicts discharge at all possible water levels. After a reliable rating curve has been created at the end of the year, discharge measurements will still need to be taken regularly, although less frequently, to update and verify that the rating curve is representative of the stream.

A velocity area discharge measurement method was used for this project and described here. A suitable cross section is first selected near the gage station. A tape is stretched across the cross section and 15-30 stations are identified along the tape. Water depth measurements are taken at each station and water velocity is calculated at each station using the flow meter. After all measurements are completed, the flow meter (Figure 17c) calculates the total discharge at the cross section.

The discharge measurement is qualitatively ranked as excellent, good, fair or poor by the person performing the measurement. The factors considered in this assessment include the quality of the cross section, the uniformity of the velocity, the equipment used, the percent total discharge measured at each station, and the change in flow height from the start to end of the discharge measurement.

The time and staff gage measurement are taken at the beginning and end of every discharge measurement.All data are recorded in the Stream Discharge Field Sheet (refer to Appendix. 4).

PHOTO STATION

Permanent points (photo stations) were established in the sample reaches to take photos of the stream. The photos will be used to visualize the changes over time and to make qualitative comparisons between different water flows, seasons, and years.

In all gaging basins, photo stations were set up to include the gage in the photo. Targets were typically drawn on the recording gage or on plastic orange mushroom caps that were put on the staff gage. In the basins without gages, targets we drawn on the plastic orange mushroom cap of one of the cross section monuments. In some basins, an additional rebar was driven into the ground and it's plastic orange mushroom cap was the target.

A T-bar fence post was driven into the ground near the start of the sample reach with a good view of the target. Pictures were taken with a digital camera positioned on top of the T-bar. A 9-grid display was selected on the screen of the camera, with the center grid centered on the identified target. The photo number was recorded in the field form (refer to Appendix 4).

- *2013 Accomplishment:* **Photo stations have been installed in 26 basins (refer to Appendix 2).**

MICROCLIMATE

Microclimate monitoring protocol is being developed in 2013. It includes long-term monitoring of air temperature and relative humidity with 2-channel data loggers on transects extending from the stream to 60 m into the adjacent riparian forest. The objective of the monitoring is to document the gradient of temperature and humidity occurring with the current landforms and vegetation, and document any changes over time.

Stratification and allocation of microclimate basins

Ten basins of the 50 basins in the OESF are monitored for microclimate. The number of monitored basins was limited by cost and staff capacity to maintain the installations.

The selection of basins followed the same stratification used for identifying the basins for stream discharge monitoring (see the section Stream Discharge above). The stratification method was designed to capture the full range of hydrologic conditions within the 50 sample basins. The basins were stratified geographically by precipitation zone and size. Within each strata, the basins were randomly selected. If during the field reconnaissance the installation of the monitoring sites was determined unsafe, the next basin in the randomly generated list for the same strata was selected.

The final list of basins monitored for microclimate is presented in Table 4. There is 80% overlap of microclimate basins with the basins monitored for stream discharge.

Table 4. Distribution of basins selected for microclimate monitoring. Basins numbered in bold are also monitored for stream discharge.

Hydro region	Basin size classes			
	0-150 m	150-450 m	450-1350m	1350-4050m
1	_	157	**145**	**433**
2	_	**196**	_	_
3	545	**642**	**790**	_
4	_	**724**	_	_
5	_	**737**	**694**	_

Installation of microclimate transects

Two sampling transects on opposite banks of the stream were established in each sample reach identified for microclimate monitoring. Their start point was selected randomly from the six established cross sections. If slopes or terrain were unsafe to for installation, transects were moved to the next randomly selected cross section. Starting about 3m from the bankfull stage, to help ensure support posts were not damaged by winter flows, permanent sampling stations were established at 0, 10, 20, 40 and 60 m horizontal distance along transect perpendicular to the stream (Figure 20). Long-term vegetation monitoring and microclimate share a common transect. Future analysis for microclimate gradients will include information on vegetation condition and dynamics.

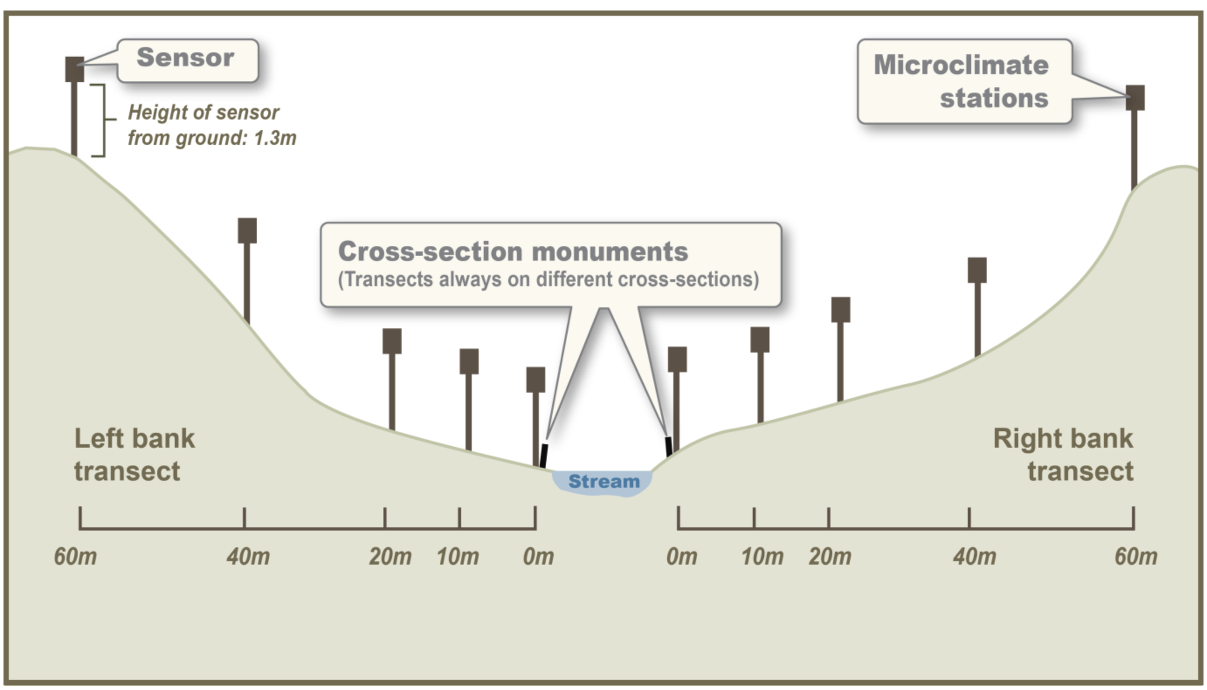
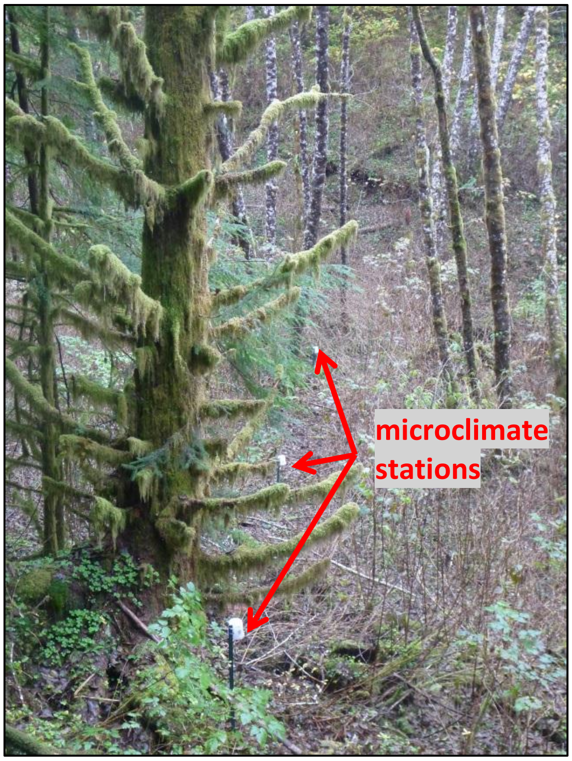


Figure 20. Schematic layout of microclimate sampling transects.



a

b

Figure 21. Microclimate transect (a) and microclimate data logger and shade housing (b).

A T-bar fence post was driven into the ground at each station and a prefabricated housing consisting of plastic bucket and removable sensor was attached to each post at 1.3 m height above ground (Figure 21 a and b).

➢ *2013 Accomplishment:* **Microclimate transects and data loggers have been installed in all 10 basins identified for microclimate monitoring (refer to Appendix 2).**

Field equipment calibration and post-deployment check

Two channel data loggers Onset© (model U23-001) are being used to record temperature and relative humidity. Initial launching and test calibration was performed per Onset manual by placing loggers in a constant temperature and humidity condition. All loggers met manufactures specifications of temperature and humidity variation.

A post deployment data check was conducted after two months in-situ. Data was downloaded from 2 basins (#157 and #196) to test field download and analysis procedures. On the 4 examined transects, the ANOVA with post-hoc comparisons (Tukey's procedure) showed no statistically significant difference in temperature between distances from the stream ($p=0.93$ in basin #196, $p=0.63$ in basin #157). Relative humidity decreased with distance from the stream at both basins ($p<0.0001$ in both basins). At basin 196 the relative humidity of the 0, 10, and 20 m distances were higher than at 40 and 60 m distances ($p<0.05$). At basin 157 the relative humidity was highest at 0 m, lower at 10 and 20 m, and lowest at 40 and 60 m ($p<0.05$).

RIPARIAN VEGETATION

We anticipate the protocol for monitoring riparian vegetation to be completed in the spring of 2014 and field establishment to be initiated in the summer of 2014. The protocol was field tested on two basins in the summer of 2013 to determine the feasibility of fixed area plot establishment given the terrain and understory condition.

The objective of the sampling is to document the condition and change in vegetation in the forest bordering the 54 sample reaches every 3 or 4 years. We intend to establish large fixed area permanent plots along two transects on opposite banks of the sample reach. The vegetation sampling areas will be superimposed on microclimate monitoring transects on the 10 sites in which microclimate monitoring occurs. Repeated hemispherical canopy photos will be taken at several locations within each plot. Overstory trees will be permanently tagged to follow individual tree growth and fate. Understory composition and cover will be sampled on nested fixed-area permanent plots.

As repeated LiDAR data become available for the study areas, overstory height, canopy complexity, and stream associated gap size and frequency will be documented using analysis with Fusion (McGaughey 2009).

Data Management

Field Data Forms were developed for all field procedures (refer to Appendix 4).

MS Access database for hydrology data was developed by Rachel LovellFord in October 2013. The database is currently being tested and finalized. The designated data steward is Ellis Cropper, DNR Forest Resources Division.

In October 2013, several members of the project team completed a two-day training on hydrology data management led by Rachel LovellFord (Figure 22). The training covered organization of the Access database, data entry procedures, quality control of the hydrology data, and reporting.

MS Access database for stream temperature data was developed by Alex Foster. Annual copies are stored at DNR, Forest Resources Division. The designated data steward is Alex Foster, PNW Olympia Forestry Sciences Laboratory.

The field reconnaissance data and the monitoring data on stream morphology, shade, channel substrate, microclimate, large woody debris, and habitat units are stored in MS Excel at DNR Forest Resources Division together with the original hard copies of all field forms. The designated data steward is Teodora Minkova, DNR Forest Resources Division.

All spatial data, collected primarily with Garmin and Trimble GPS units, are stored as shapefiles at DNR. The designated data steward is Mitchell Vorwerk, DNR Forest Resources Division.

The quality assurance, quality control and data management procedures for collected field data are described in each monitoring protocol (Minkova and Foster (Eds.) in prep.).

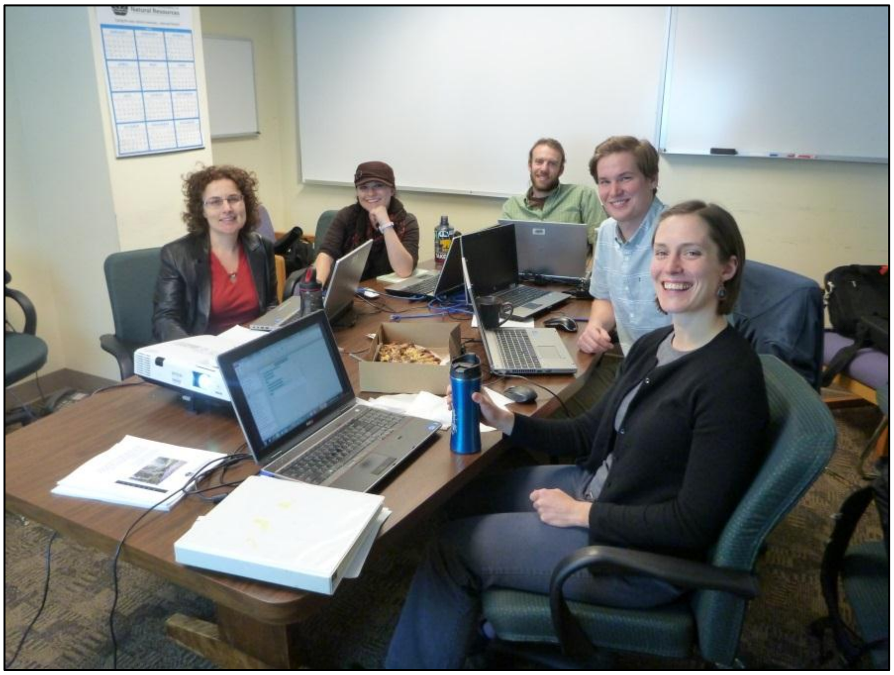


Figure 22. Data management training at DNR, Olympia, WA.

DATA SHARING

Numerous riparian and aquatic monitoring projects are currently conducted in the Pacific Northwest. It is well-recognized that data consistency and data sharing between these projects will increase the efficiency, lower the costs, and provide opportunities for larger-scale assessments and greater statistical power (Roper et al. 2010).

All stream temperature data collected as part of this project are shared with the national network for stream temperature monitoring maintained by Forest Service Rocky Mountain Research Station http://www.fs.fed.us/rm/boise/AWAE/projects/stream_temperature.shtml (Figure 23). The OESF sample basins were included in the network in January 2013.

DNR intends to share the stream discharge data from all gaged basins on a centralized server which provides open access to long-term meteorological and streamflow records from a national collection of research sites. The server CLIMDB/HYDRODB http://www.fsl.orst.edu/climhy/climdb/ is maintained by US Forest Service and Long Term Ecological Research (LTER) Network.

The project team is exploring opportunities for data sharing with the local Indian Tribes, specifically Quileute, Quinault, and Hoh (see the section Communication and Outreach below).

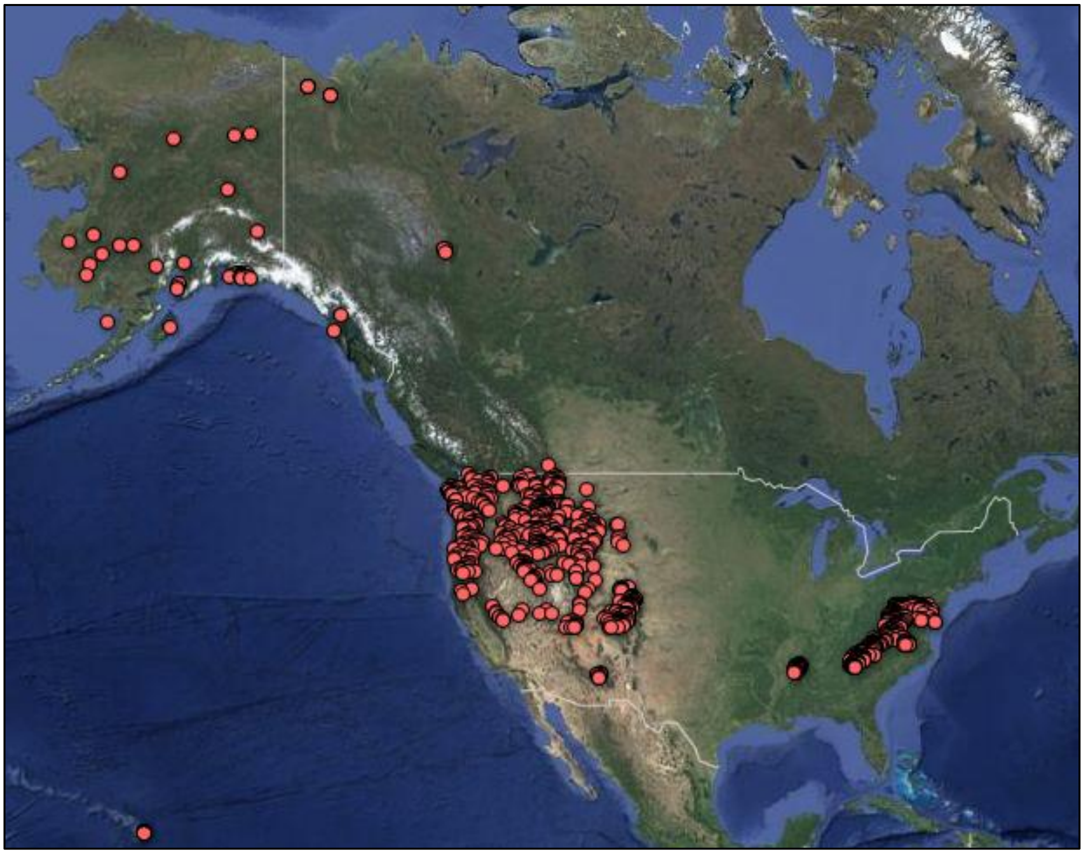


Figure 23. Full-year stream temperature data collected at nearly 3,200 sites in the US and Canada, including the OESF sample basins, is shared in a network maintained by the US Forest Service.

Budget

This report covers the period November 1, 2012 to October 31, 2013, which falls in two DNR fiscal years: FY2013 (July 1, 2012 - June 30, 2013) and FY 2014 (July 1, 2013 - June 30, 2014).The FY 2013 funding of $145, 000 was used for purchasing field equipment (microclimate data loggers, auto level, etc.), for a contract with PNW RS to review monitoring protocols and study sampling design, and for scientific technicians (including their travel, lodging expenses, and personal gear).

For FY 2014, DNR provided $145,000 for this project. During the reporting period, the funding was used primarily for scientific technicians (including travel, lodging expenses, and personal gear) and for additional field equipment (flow meter, leveloggers, barologgers). The remaining funds from this installment will be used for field work in the 2014 field season, expected to start in May 2014.

For FY 2015, DNR will fund the same amount of approximately $145,000.
During the reported period, PNW contributed in-kind through scientific expertise for developing the field protocols and refining the field procedures and through field work estimated at about 640 hours.

Project Staff

The project team for 2013 consisted of a research team, four technicians, and one college intern. The staff members and their primary roles in the project for the reported period are listed in Table 5.

Table 5. Project team and their primary roles during the reported period.

Name	**Affiliation**	**Project position**	**Primary role in 2013**
Teodora Minkova	OESF Research and Monitoring Manager, DNR	Principal Investigator, Project Manager	Preparation of 2012 establishment report, development of field protocols, coordination of peer reviews, planning and overseeing field work, training and supervising scientific technicians, project management (budget, hiring, and coordination), outreach and communication, data management.
Peter Bisson	Emeritus Scientist, PNW	Principal Investigator	Scientific consultation on field protocols and field procedures
Alex Foster	Ecologist, PNW	Researcher	Development of field protocols, refining field procedures, training field technicians, field work, data management
Shannon Claeson	Ecologist, PNW	Researcher	Consultation on field protocols and field procedures
Jeffrey Ricklefs	Environmental Analyst, DNR	Researcher	GIS support, development of field protocols, refinement of field procedures
Richard Bigley	Silviculturist, DNR	Researcher	Development of field protocols, refinement of field procedures
Scott Horton	Olympic Region Wildlife Biologist, DNR	Researcher	Development of field protocols, refinement of field procedures
Rachel LovellFord	Scientific Technician, DNR	Hydrology scientific technician	Development of hydrology protocols, planning and installation of gage stations, refinement of field procedures, development of Access database for hydrology data, training of field staff
Mitchell Vorwerk	Scientific Technician, DNR	Scientific technician	Field work, GIS support, preparation of 2012 establishment report
Ellis Cropper	Scientific Technician, DNR	Scientific technician	Field work, including planning and installation of gages and microclimate transects; management of hydrology data
Jessica Hanawalt	Scientific Technician, DNR	Scientific technician	Field work, data management
Julian Sammons	The Evergreen State College	Intern	Field work

In FY 2014, DNR provided funding for two positions with the OESF Research and Monitoring Program: data manager and fish biologist who will work on this project part time. DNR is in the process of developing position descriptions and intends to advertise and fill these positions in the spring of 2014.

Communication and Outreach

The project team held several presentations and meetings within DNR and with external parties with two main purposes: 1) update and accountability; and 2) soliciting interest from potential research collaborators.

DNR
The project was presented to DNR Forest Resources Division and to DNR Olympic Region in November 2012. The main purpose was to inform DNR managers and staff about this new project, to discuss overlap with and interest from other DNR programs and projects, to explain the relevance to management needs, and to solicit logistic support for the next field season.

Stakeholders
The study was introduced to the Olympic Forest Coalition on 11/27/2012 and to the American Forest Resource Council and the City of Forks on 03/11/2013.

Indian Tribes
As part of the outreach for the OESF Forest Land Plan, the project was presented to Quinault Nation in June 2013 and to Quileute and Makah tribes in July 2013. DNR will continue to update the local tribes on the progress of the project and will explore opportunities for data sharing and collaboration in the field sampling.

Current and Potential Research Partners
A meeting with PNW managers took place in January 2013 to explore additional opportunities for collaboration between DNR and PNW on this project. A field tour with PNW reviewers of the field protocols took place in August 2013. In addition to discussing their recommendations, the group discussed future collaboration for analysis of stream temperature data and fish monitoring.

The project is scheduled to be presented at two research seminars: one at University of Washington in January 2014 and one at Oregon State University in March 2014. The purpose is to stimulate interest and invite research collaborators.

Updates on the project are regularly posted on the DNR website. The study plan, 2012 establishment report, project status, and recent presentations are available at
http://www.dnr.wa.gov/ResearchScience/Topics/TrustLandsHCP/Pages/lm_hcp_oesf_main.aspx

Next Steps

Starting in November 2013, until the start of the next field season in May 2014, the project team will focus on the following:

- Entering and verifying the field data from the 2013 field season;
- Downloading and cleaning the GPS data and creating maps;
- Repeated field visits to the 14 gage sites (about 1 per month) to measure water velocity, water levels, and to download data from continuously recording leveloggers and barologgers;
- Finalizing the hydrology Access database and managing hydrology data;
- Midseason download and check of the continuously recording microclimate data loggers;
- Preparing the 2013 establishment report;
- Finalizing and publishing field protocols;
- Exploring available remote sensing data (LidAR, aerial photos, satellite imagery) for characterization of habitat attributes at the sample reach and in the entire sample basin;
- Exploring available operational records and remote sensing data for characterization of management and natural disturbances in the sample basins;
- Communication with potential research partners and monitoring collaborators.

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Appendix 1. Modified Basin Selection Process

The basin selection process described in the study plan (Minkova et al. 2012) and the 2012 establishment report (Minkova and Vorwerk 2013) was reviewed for statistical validity by Dr. Ashley Steel, PNW RS in June 2013. Following her recommendations, the spatial sampling design was modified in the summer of 2013 and follows the steps described below.

The sample frame (n=243 basins) was determined by sequentially applying the following criteria:

Step	Criterion	Number of basins (n)
1	Type-3 basin located within the OESF planning area	848
2	Basin contains DNR lands	601
3	True (vs. composite) basin	451
4	≥ 50% DNR ownership within the basin	243

Next, each basin was assigned a zone ("North" or "South") based on its location within an administrative designation known as a Landscape Planning Unit (LPU). The Clallam, Dickey, Sekiu, and Sol Duc LPUs were considered "North"; all other LPUs were considered "South". Basins that spanned LPU boundaries were assigned to the LPU that contained the largest proportion of the basin area.

All basins in the sample frame (n = 243) were also assigned a gradient class based on their median percent slope. Median percent slope was calculated using a 10 m DEM (Digital Elevation Model). Gradient classes were grouped in increments of 10% slope (0-9%, 10-19%, 20-29%, etc.)

The total area in each zone by gradient class (e.g., North zone, 0-9% median slope) was tallied, and the number of sample basins selected from each zone by gradient class was based on the proportion of the total area of the sample frame it represented (Table A1-1). All land within each basin regardless of ownership was included in this tally. For example, 3.74% of the total area of the sample frame was located in the "North zone, 0-9% median slope" class. Therefore, 3.74% of the sample (rounded to 2 out of 50) should come from that class.

All basins within the sample frame (n = 243) were assigned a random number using the Excel *rand()* function. Basins were sorted in ascending order by their random number within each zone x gradient class and the first basins on the list were selected. These basins were then remotely examined (visual inspection in a GIS) sequentially to determine if they were suitable for sampling. Basins were considered unsuitable for sampling from remote inspection if:

- Their outlet and lowermost reach was not located on public land (DNR, USFS, NPS);
- Basins were improperly delineated in the DNR hydrological dataset.

Basins were then visited in the field to determine if they were suitable for sampling. The filed crew was given the following criteria for excluding a basin from the sample:

- Year-round access to the sample reach was impractical or not possible (no basins were excluded based on this criterion);

- Sample reach was considered unsafe (for example, unstable log jams were present) (one basin was excluded based on this criterion);
- Stream was not Type 3 for the entire duration of the sample reach(one basin was excluded based on this criterion);
- Stream reach was dry (no surface flow) for more than 200 m from the basin outlet (two basins were excluded based on this criterion);
- Presence of man-made structures influencing the stream flow within or immediately below and above the sample reach (e.g. culverts potentially constraining the flow) (no basins were excluded based on this criterion);
- A tributary of significant size (approx. 10 % or more of the basin flow) enters the stream below the lowest possible starting point of the reach (one basin was excluded based on this criterion).

The final list of selected sample basins in the OESF is presented in Figure A1-1.

Table A1-1. Spatial allocation of sampling units

CUT A - in OESF	PASS		
CUT B – has DNR land	PASS		
CUT C - TRUE basin	PASS		
CUT D – has >50% DNR land	PASS		
Zone x gradient	**proportion of TOTAL_AC**		
North zone		x 50 sample basins	# Basins to sample
0-9	3.74%	1.87	2
10-19	3.05%	1.52	2
20-29	5.83%	2.91	3
30-39	4.45%	2.22	2
40-49	1.00%	0.50	0
50-59	0.09%	0.04	0
N Total	**18.17%**	9.08	9
South zone			
0-9	10.95%	5.47	5
10-19	17.17%	8.58	9
20-29	12.59%	6.29	6
30-39	11.18%	5.58	6
40-49	9.47%	4.73	5
50-59	13.15%	6.57	7
60-69	6.79%	3.39	3
70-79	0.53%	0.26	0
S Total	**81.83%**	40.91	41
Grand Total	**100.00%**		

Appendix 2. Completed Field Protocols in 2013 Field Season

Basin #	Establish-ment of Permanent Cross Sections	Elevation Measure-ment Reference Points	Channel Gradient	Channel Width and Depth	Channel Coarse Sub-strate	Stream Shade	Channel Sinuosity	In-stream Large Wood	Classifi-cation of Habitat Units	Channel and Valley Types	Active Erosion	Stream Tempe-rature	Stream Discharge	Photo Station	Micro-climate
145	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
157	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓
158		✓										✓			
165	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
196	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
328	✓	✓					✓					✓	✓	✓	
433	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
443	✓	✓					✓					✓		✓	
488		✓										✓			
542		✓										✓			
544	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	
545	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
550	✓	✓					✓					✓		✓	
567		✓										✓			
568	✓	✓										✓		✓	
582	✓											✓		✓	
584	✓											✓	✓	✓	
597		✓										✓			
605		✓										✓			
619		✓										✓			
621		✓										✓			
625		✓										✓			
637		✓										✓			
639		✓										✓			

Appendix 2. Completed Field Protocols in 2013 Field Season (continued)

Basin #	Establish-ment of Permanent Cross Sections	Elevation Measure-ment Reference Points	Channel Gradient	Channel Width and Depth	Channel Coarse Sub-strate	Stream Shade	Channel Sinuosity	In-stream Large Wood	Classifi-cation of Habitat Units	Channel and Valley Types	Active Erosion	Stream Tempe-rature	Stream Discharge	Photo Station	Micro-climate
642	✓	✓					✓					✓	✓	✓	✓
653												✓			
658												✓			
687	✓	✓					✓					✓		✓	
688	✓	✓										✓		✓	
690	✓	✓										✓		✓	
694	✓	✓										✓	✓	✓	✓
716	✓	✓										✓		✓	
717	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	
718		✓										✓			
724	✓	✓					✓					✓	✓	✓	✓
730												✓			
737	✓	✓					✓					✓	✓	✓	✓
750		✓										✓			
760	✓											✓		✓	
763		✓										✓			
767		✓										✓			
769	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	
773		✓										✓			
776	✓	✓										✓		✓	
790	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
796		✓										✓			
797		✓										✓			
804		✓										✓			
820		✓										✓			
844		✓										✓			

Appendix 2. Completed Field Protocols in 2013 Field Season (continued)

Basin #	Establish-ment of Permanent Cross Sections	Elevation Measure-ment Reference Points	Channel Gradient	Channel Width and Depth	Channel Coarse Sub-strate	Stream Shade	Channel Sinuosity	In-stream Large Wood	Classifi-cation of Habitat Units	Channel and Valley Types	Active Erosion	Stream Tempe-rature	Stream Discharge	Photo Station	Micro-climate
BOG2		✓										✓			
HOH5		✓										✓			
QUEETS1												✓			
SFHOH2												✓			
TOTALS	**26**	**44**	**10**	**10**	**10**	**9**	**17**	**10**	**10**	**4**	**10**	**54**	**14**	**26**	**10**

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Appendix 3. Equipment for Installing Sampling Stations and Implementing Field Protocols

Installation of cross sections
2-ft rebars, orange mushroom rebar caps, flagging, aluminum tags, wire
Hammer
50-meter tape

Installation of the permanent photo point and taking photos
T-style fence posts
Fence post driver
Hammer
Flagging, aluminum tags, wire, paint, permanent marker and orange mushroom rebar caps
Panasonic Lumix DMC-TS20 digital camera

Stream Temperature Protocol
Onset Tidbit© v2 temperature loggers
HOBO© Waterproof Shuttle
Data management software: Hoboware©

For the installation: PVC housing, nylon zip ties, brick, copper wire, nylon cord, lag screw, drill kit, hammer, aluminum nails, tags and wire, blue flagging, blue paint

Stream Morphology Protocol
Topcon Auto level, tripod
Stadia rod
Chaining pins
Spring clamps
50-meter tape
Compass
Chalk

Recording elevation of the reference point and end points of the sample reach
Resource grade Trimble Recon unit (Trimble Pro XT, Trimble Pro XH, and Trimble Juno)
Garmin GPSmap62s

Stream Shade Protocol
Digital Camera Nikon CoolPix 4500
Tripod
FC-E8 fisheye lens
Plexiglass mounting plate
LED pen
Extra batteries and extra memory card
Stadia rod
Chaining pins
Spring clamps

50-meter tape
Compass

In-Stream Large Wood Protocol

Log calipers
50 meter tape
Meter stick
Chalk

Stream Discharge Protocol

Solinst leveloader 3001 Gold with cables
Solinst barologger Edge M1.5 F5
Direct read cable assembly 5 ft
3001 well cap 2” (Qty 16)
Solinst levelogger Edge 3001 LT M5 F15
Direct read USB package
FH950 Hach velocity meter with 5’ cable
Top setting wading rod (metric)

Software for programming data loggers, and for downloading and managing field data: Solinst

Coarse Substrate Protocol

50 meter tape
Chaining pins
Spring clamps
Stadia rod
Gravelometer, metric

Habitat Units Protocol

50 or 100 meter tape
Meter stick or stadia rod
Habitat Unit Field Guide

Classification of Valley Segments and Channel Reaches Protocol

50 or 100 meter tape
Meter stick or stadia rod

Riparian Microclimate Protocol

HOBO Pri v2 Temp/RH data loggers
HOBO waterproof shuttle

Data management software: HOBOware PRO v.3.x

Riparian Vegetation

To be determined when the protocol is developed and launched in 2014.

Appendix 4. Field Data Forms

Field Form for Stream Morphology, Substrate, Shade

Olympic Experimental State Forest – Riparian Status and Trends Monitoring

Page 1 of 8

STREAM MORPHOLOGY, SUBSTRATE, SHADE

FIELD FORM 1. version 1

Site description

Basin #	Basin size (ac):	RP elevation (m):		
Date:	Survey start time:	Weather: heavy rain, light rain, cloudy, sunny, foggy, windy		
Field crew:				
Remarks on site condition: (e.g. recent disturbance, lost RP, management activity)				
Tributaries: yes no	Stream side: LB RB	Location relative to a x-section:		
Photo point location:	Photo point marked with:	Target:	Picture #:	Camera #:
LEW GPS coordinates:	GPS unit: Garmin, Juno, backpack	LEW distance and azimuth from RP:		
BFW at 0 m:	BFW at 2 m upstream:	BFW at 4 m upstream:	Average start BFW (m):	
Reach length (m):	Interval between x-sections (m):			
Monument LB: yes no	Monument RB: yes no			

Sketches:

Cross-section A

X-section depths and substrate

Cross-section A interval (BFW/10) (cm):

String method (for BFW< 5m)			Substrate					Auto level method (for BFW >5m)				
Station (cm)	Bankfull depth (cm)	Remarks	Particle 1		Particle 2		Remarks	Station (cm)	Backsight BS (+) (cm)	Height Instrument HI (cm)	Foresight FS (-) (cm)	Elevation
			Size (mm)	Embededness (%)	Size (mm)	Embededness (%)						

Shade

Photo station A				
Distance and AZ from LB monument	Distance and AZ from RB monument	Offset (m and AZ)	Picture #	Time

Width of 100-year floodplain (m):

Method: tape, laser range finder, autolevel, …..

Cross-section B

X-section depths and substrate

BFW (m): Cross-section B interval (BFW/10) (cm):

String method (for BFW< 5m)			Substrate					Auto level method (for BFW >5m)				
Station (cm)	Bankfull depth (cm)	Remarks	Particle 1		Particle 2		Remarks	Station (cm)	Backsight BS (+) (cm)	Height Instrument HI (cm)	Foresight FS (-) (cm)	Remarks
			Size	Embededn	Size (mm)	Embeded						

Shade

Photo station B				
Distance and AZ from LB monument	Distance and AZ from RB monument	Offset (m and AZ)	Picture #	Time

Erosion A → B

Location:		Length (m)	Estimted height (m)	Cause			Picture #	Remarks
LB	RB			slope failure	road	other (specify)		

Cross-section C

X-section depths and substrate

BFW (m):

Cross-section C interval (BFW/10) (cm):

String method (for BFW< 5m)			Substrate					Auto level method (for BFW >5m)				
Station (cm)	Bankfull depth (cm)	Remarks	Particle 1		Particle 2		Remarks	Station (cm)	Backsight BS (+) (cm)	Height Instrument HI (cm)	Foresight FS (-) (cm)	Remarks
			Size	Embededn	Size (mm)	Embeded						

Shade

Photo station C				
Distance and AZ from LB monument	Distance and AZ from RB monument	Offset (m and AZ)	Picture #	Time

Erosion B → C

Location:		Length (m)	Estimted height (m)	Cause			Picture #	Remarks
LB	RB			slope failure	road	other (specify)		

Width of 100-year floodplain (m):

Method: tape, laser range finder, autolevel, …..

Cross-section D

X-section depths and substrate

BFW (m): Cross-section D interval (BFW/10) (cm):

String method (for BFW< 5m)			Substrate					Auto level method (for BFW >5m)				
Station (cm)	Bankfull depth (cm)	Remarks	Particle 1		Particle 2		Remarks	Station (cm)	Backsight BS (+) (cm)	Height Instrument HI (cm)	Foresight FS (-) (cm)	Remarks
			Size	Embededn	Size (mm)	Embeded						

Shade

Photo station D				
Distance and AZ from LB monument	Distance and AZ from RB monument	Offset (m and AZ)	Picture #	Time

Erosion C → D

Location:		Length (m)	Estimted height (m)	Cause			Picture #	Remarks
LB	RB			slope failure	road	other (specify)		

X-section depths and substrate

BFW (m): Cross-section E interval (BFW/10) (cm):

String method (for BFW< 5m)			Substrate					Auto level method (for BFW >5m)				
Station (cm)	Bankfull depth (cm)	Remarks	Particle 1		Particle 2		Remarks	Station (cm)	Backsight BS (+) (cm)	Height Instrument HI (cm)	Foresight FS (-) (cm)	Remarks
			Size	Embededn	Size (mm)	Embeded						

Shade

Photo station E				
Distance and AZ from LB monument	Distance and AZ from RB monument	Offset (m and AZ)	Picture #	Time

Erosion D → E

Location:		Length (m)	Estimted height (m)	Cause			Picture #	Remarks
LB	RB			slope failure	road	other (specify)		

Cross-section F

X-section depths and substrate

BFW (m): Cross-section F interval (BFW/10) (cm):

String method (for BFW< 5m)			Substrate					Auto level method (for BFW >5m)				
Station (cm)	Bankfull depth (cm)	Remarks	Particle 1		Particle 2		Remarks	Station (cm)	Backsight BS (+) (cm)	Height Instrument HI (cm)	Foresight FS (-) (cm)	Remarks
			Size	Embededn	Size (mm)	Embeded						

Shade

Photo station F				
Distance and AZ from LB monument	Distance and AZ from RB monument	Offset (m and AZ)	Picture #	Time

Erosion E → F

Location:		Length (m)	Estimted height (m)	Cause			Picture #	Remarks
LB	RB			slope failure	road	other (specify)		

Width of 100-year floodplain (m): **Method: tape, laser range finder, autolevel, …..**

LEW GPS coordinates: **GPS unit: Garmin, Juno, backpack**

Taken at: LEW REW

Reach Longitudinal Profile

Auto Level					Azimuth (taken at lower station)	Laser Range Finder				Remarks
X-section	Backsight * BS (+)	Height Instrument	Foresight FS (-) (cm)	Elevation		X-section				
A										
B										
C										
D										
E										
F										

* When the assumed RP elevation is "0", BS = HI

HI = known elevation + BS

Unknown Elevation = HI-FS

Average Widths (m)

	A	B	C	D	E	F	Average
Bankfull							
Wetted							

Reach Confinement

Average BFW (6 x-sections)	Average FPW (x-sections A, C, F)	Confinement ratio	Confinement category		
			confined	unconfined	moderately confined

Confined: FPW ≤ 2 BFW (ratio 1.0-1.4)

Unconfined: FPW ≥ 4 BFW (ratio 2.2+)

Moderately confined: FPW ≥2 BFW and ≤4 BFW (ratio 1.4-2.2)

Olympic Experimental State Forest – Riparian Status and Trends Monitoring

FIELD FORM 2. version 1

HABITAT UNITS, IN-STREAM LARGE WOOD
VALLEY AND CHANNEL CLASSIFICATION

Basin #: Date: Field crew:

Average wetted width from the 6 x-sections (see Form 1):

SP - scour pool DP - dammed pool BP - backwater pool RF- riffle RN - run RP - rapid CA - cascade SH - sheet F - falls SF- subsurface flow

Habitat Unit	Length (m)	Widths (m)					Pool Depths (**cm**)		Remarks	Picture # / Camera #
		1	2	3	4	5	Max	Tail Crest		

Habitat units - continued

SP - scour pool DP - dammed pool BP - backwater pool RF- riffle RN - run RP - rapid CA - cascade SH - sheet F - falls SF- subsurface flow

Habitat Unit	Length (m)	Widths (m)					Pool Depths (**cm**)		Remarks	Picture # / Camera #
		1	2	3	4	5	Max	Tail Crest		

Valley segment type: alluvial, colluvial, bedrock

Channel type: cascade, step-pool, plane-bed, pool-riffle, braided, regime

FIELD FORM FOR IN-STREAM LARGE WOOD

LWD - Individual Pieces

Minimum pool surface area

Mean BFW (m)	Min pool size (m^2)
>0 to <2.5	0.5
≥2.5 to < 5	1.0
≥5 to <10	2.0
≥10 to <15	3.0

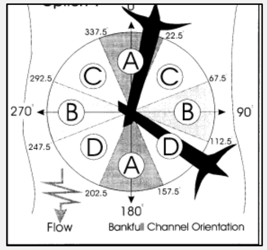
Channel orientation

A- paralel

B - perpendicular

C- downstream

D - upstream



Piece decay class

Class	1	2	3	4	5
Bark	Intact	Intact	Trace	Absent	Absent
Twigs < 3 cm	Present	Absent	Absent	Absent	Absent
Texture	Intact	Intact to soft	Hard, large pcs	Small, soft pieces	Soft, powdery
Shape	Round	Round	Round	Round ot oval	Irregular
Color of wood	Original	Original	Original to faded	Faded	Faded

Piece #	DWN X-section	Piece Categ. (L-R)	Piece Dia (cm)	Piece length (m)				Species Categ. (C-D-U)	Piece Stability				Pool Forming (Y-N)	Channel Orient	Piece Decay Class	Sediment Storage (Y-N)	Remarks
				Zone 1	Zone 2	Zone 3	Zone 4		R	B	P	Unstable					

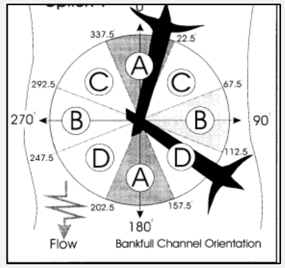
LWD - Individual Pieces (continued)

Minimum pool surface area

Mean BFW (m)	Min pool size (m^2)
>0 to <2.5	0.5
≥2.5 to < 5	1.0
≥5 to <10	2.0
≥10 to <15	3.0

Channel orientation

A- paralel
B - perpendicular
C- downstream
D - upstream



Piece decay class

Class	1	2	3	4	5
Bark	Intact	Intact	Trace	Absent	Absent
Twigs < 3 cm	Present	Absent	Absent	Absent	Absent
Texture	Intact	Intact to soft	Hard, large pcs	Small, soft pieces	Soft, powdery
Shape	Round	Round	Round	Round ot oval	Irregular
Color of wood	Original	Original	Original to faded	Faded	Faded

Piece #	DWN X-section	Piece Categ. (L-R)	Piece Dia (cm)	Piece length (m)				Species Categ. (C-D-U)	Piece Stability				Pool Forming (Y-N)	Channel Orient	Piece Decay Class	Sediment Storage (Y-N)	Remarks
				Zone 1	Zone 2	Zone 3	Zone 4		R	B	P	Unstable					

LWD - Logjams

Jam #	DWN X-section	Lowest zone (1-3)	Pool Forming (Y-N)	Rtwd dia ≥ 20 cm	Small Log ≥10 to ≤20 cm	Medium Log ≥20 cm to ≤50 cm	Large Log dia ≥50 cm	Log Total	Percent logs per zone *			Remarks
									Zone 1	Zone 2	Zone 3	
Tally Totals									%	%	%	
Tally Totals									%	%	%	
Tally Totals									%	%	%	
Tally Totals									%	%	%	
Tally Totals									%	%	%	
Tally Totals									%	%	%	
Tally Totals									%	%	%	
Tally Totals									%	%	%	
Tally Totals									%	%	%	
Tally Totals									%	%	%	

* Count the log in the lower zone if at least 10 cm are within that zone

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Field Form for Microclimate Installations

Micro Climate Field Sheet

Date:		**Site #:**		**Crew:**		
			Logger Start Date/Time:			
Transect #1						
Crossection:		**Streamside:**	Right	**Recording Interval:**		2hr
Distance(m):	**Serial #:**	**Logger Name:**		**Height(m):**	**Bearing(degrees):**	
0						
10						
20						
40						
60						
Transect #2						
Crossection:		**Streamside:**	Left	**Recording Interval:**		2hr
Distance(m):	**Serial #:**	**Logger Name:**		**Height(m):**	**Bearing(degrees):**	
0						
10						
20						
40						
60						

Camera #: **Photos #:**

General Notes:

Stream Gage Installation Field Forms

Stream Gage Installation Field Sheet

Date/Time (PDT or PST):	**Basin #:**	**Crew:**
	Camera #:	**GPS #**
Site Access different from main site accesss?		

Installation: Plan

tie flagging at location of planned install

Install Type: **vertical** **along bank** **in-bank** **other /combo:**

Draw Gaging Equiptment Layout (w/ stream section control, significant structures, etc. *Birdseye View*):

Draw Detailed Installation Plan(w/ estimated measurements, *Elevation View*)**:**

Installation: Site

Describe Stream Characteristics (Significant Structures, Strength of Flow, Section Controls, etc.)**:**

Bankfull Width:	**Length of Straight:**	**Gradient of Straight:**

Manning's n at cross section: * see roughness guide	channel bed	right bank		left bank		Notes:

Bank Compostion (Clay, Loose Gravel, Dirt, Bedrock, etc.):

Stream Gage Installation Field Forms (continued)

Installation: Final Design and Location of Recording Gage

Date/Time (PDT or PST) (if different from Plan date and time):			
Distance and Bearing from RP:			
GPS of Stream Gage:	**N:**	**W:**	**Point #:**

DO NOT GLUE HOUSING UNTIL RECORDING GAGES HAVE BEEN INSTALLED

Detailed Schematic of Gage Housing (Exact Measurement of sections, Degrees of Angles, etc, *Elevation View*)**:**

Installation: Anchoring for Recording and Staff Gages

Decribe Type of Anchor (Tree, Rebar, poured concrete, etc.):

Tree Species:		**DBH:**	

Describe Anchor Connection and Materials Used(Directly to tree, Bracket, plummers tape, etc):

Describe Staff Gage Anchor (If different):

Tree Species:		**DBH:**	

Describe Staff Gage Anchor Connection and Materials Used(Directly to tree, Bracket, plummers tape, etc):

Is staff gage stable?:	Yes	No	**Is staff gage level from all directions?:**	Yes	No
Depth of water on Staff Gage:			**Time of Staff Gage Reading:**		

Installation: Recording Gage Instrument Setup

Label With Teodora Minkova's Contact Information: 360-902-1175, DNR Riparian Monitoring, and Site Number

Levellogger Serial number:	**Barologger Serial number:**
Start Date/ Time:	Start Date/ Time:
Water Level (cm; Levelogger):	Atmospheric Pressure (kPa, Barologger):
Time of Water Level Reading:	Time of Atmospheric Reading:
Levellogger Sampling Interval:	Barologger Sampling Interval:
Averaging? Y or N; sec:	Averaging? Y or N; sec:

Length from Tip of Sensor to Well Cap Top:	**Barologger:**	**Length of PVC** (Used for Wrap)**:**
	Levellogger:	

Describe marking used to show if gage has shifted over time:

Stream Gage Installation Field Forms (continued)

Installation: Photos

Upstream Photo:	Downstream Photo:
Construction Photo(s):	
Final Recording Gage Photo(s):	Final Staff Gage Photo(s):
Final Recording Gage Anchor Photo(s):	Final Staff Gage Anchor Photo(s):

General Notes:

Base Values of Manning's n (modified from United States Geological Survey Water-supply Paper 2339)

Bed Material	Median Size of Bed Material (mm)	Straight Uniform Channel[1]	Smooth Channel (minimum value)[2]
Sand	0.2	**0.012**	--
	0.3	0.017	--
	0.4	0.02	--
	0.5	0.022	--
	0.6	0.023	--
	0.8	0.025	--
	1	0.026	--
Rock Cut	--	--	0.025
Firm Soil	--	0.025 to 0.032	0.02
Coarse Sand	1 to 2	0.026 to 0.035	--
Fine Gravel	--	--	0.024
Gravel	2 to 64	0.028 to 0.035	--
Coarse Gravel	--	--	0.026
Cobble	64 to 256	0.030 to 0.050	--
Boulder	>256	0.040 to 0.070	--

1 Benson and Dalrymple-No data.
2 For indicated material; Chow (1959)

Manning's n for Channels (Chow, 1959).

Type of Channel and Description	Minimum	Normal	Maximum
Natural streams - minor streams (top width at floodstage < 100 ft)			
1. Main Channels			
a. clean, straight, full stage, no rifts or deep pools	0.025	0.03	0.033
b. same as above, but more stones and weeds	0.03	0.035	0.04
c. clean, winding, some pools and shoals	0.033	0.04	0.045
d. same as above, but some weeds and stones	0.035	0.045	0.05
e. same as above, lower stages, more ineffective slopes and sections	0.04	0.048	0.055
f. same as "d" with more stones	0.045	0.05	0.06
g. sluggish reaches, weedy, deep pools	0.05	0.07	0.08
h. very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.1	0.15
2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
a. bottom: gravels, cobbles, and few boulders	0.03	0.04	0.05
b. bottom: cobbles with large boulders	0.04	0.05	0.07
3. Floodplains			
a. Pasture, no brush			
1.short grass	0.025	0.03	0.035
2. high grass	0.03	0.035	0.05
b. Cultivated areas			
1. no crop	0.02	0.03	0.04
2. mature row crops	0.025	0.035	0.045
3. mature field crops	0.03	0.04	0.05
c. Brush			
1. scattered brush, heavy weeds	0.035	0.05	0.07
2. light brush and trees, in winter	0.035	0.05	0.06
3. light brush and trees, in summer	0.04	0.06	0.08
4. medium to dense brush, in winter	0.045	0.07	0.11
5. medium to dense brush, in summer	0.07	0.1	0.16
d. Trees			
1. dense willows, summer, straight	0.11	0.15	0.2
2. cleared land with tree stumps, no sprouts	0.03	0.04	0.05
3. same as above, but with heavy growth of sprouts	0.05	0.06	0.08
4. heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.08	0.1	0.12
5. same as 4. with flood stage reaching branches	0.1	0.12	0.16

Stream Discharge Field Form

Stream Discharge Field Sheet-MMB							
Date:			Site:		Crew:		
Start Time (PST or PDT):					Start Staff Gage Level (closest 0.001 m):		
End Time (PST or PDT):					End Staff Gage Level (closest 0.001 m):		
Instrument Serial Number:					Weather: Sunny Cloudy Drizzle Rain Windy		
Calibration Check (0 m/s)?							
Camera #:			Photos: Upstream		Downstream	Other	
Station #	**Distance Along Tape (m)**	**Distance from Left Edge of Water**	**Depth of Water (cm)**	**Method**	**Velocity 1**	**Velocity 2**	**Notes**
		Estimate to the closest 0.01 m	*Estimate to the closest 1 cm*		*20 or 40 second averaging*	*20 or 40 second averaging*	*Right bank, left bank, stone affecting flow, roughness factor, etc.*
0				0.2 / 0.6 / 0.8			
1				0.2 / 0.6 / 0.8			
2				0.2 / 0.6 / 0.8			
3				0.2 / 0.6 / 0.8			
4				0.2 / 0.6 / 0.8			
5				0.2 / 0.6 / 0.8			
6				0.2 / 0.6 / 0.8			
7				0.2 / 0.6 / 0.8			
8				0.2 / 0.6 / 0.8			
9				0.2 / 0.6 / 0.8			
10				0.2 / 0.6 / 0.8			
11				0.2 / 0.6 / 0.8			
12				0.2 / 0.6 / 0.8			
13				0.2 / 0.6 / 0.8			
14				0.2 / 0.6 / 0.8			
15				0.2 / 0.6 / 0.8			
16				0.2 / 0.6 / 0.8			
17				0.2 / 0.6 / 0.8			
18				0.2 / 0.6 / 0.8			
19				0.2 / 0.6 / 0.8			
20				0.2 / 0.6 / 0.8			
21				0.2 / 0.6 / 0.8			
22				0.2 / 0.6 / 0.8			
23				0.2 / 0.6 / 0.8			
24				0.2 / 0.6 / 0.8			
25				0.2 / 0.6 / 0.8			
26				0.2 / 0.6 / 0.8			
27				0.2 / 0.6 / 0.8			
28				0.2 / 0.6 / 0.8			
29				0.2 / 0.6 / 0.8			
30				0.2 / 0.6 / 0.8			

Discharge Measurement Rating: Excellent (2%) Good (5%) Fair (8%) Poor (>8%)

* Consider the quality of the cross-section, the uniformity of the velocity, equipment and method used, Spacing of each station and % discharge at each station, change in flow height and other factors such as weather.

Comments on Control/ General Notes:

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Stream Gage Download Form

<table>
<tr><th colspan="4">Stream Gage Download Form</th></tr>
<tr><td colspan="3">Site ID:</td><td>Date:</td></tr>
<tr><td colspan="3">Crew:</td><td>Time (PST or PDT):</td></tr>
<tr><td colspan="4">Download Equipment: Leveloader or Laptop: ____________________</td></tr>
<tr><td colspan="2">Camera Number:</td><td colspan="2">Photo Point Picture:</td></tr>
<tr><th colspan="4">Levelogger</th></tr>
<tr><td colspan="4">SN:</td></tr>
<tr><td colspan="2">Real-time depth (m):</td><td colspan="2">Real-time Temperature (C):</td></tr>
<tr><td colspan="4">Real-time battery:</td></tr>
<tr><td>Restart gage?</td><td>Time Interval:</td><td colspan="2">Restart date and time:</td></tr>
<tr><th colspan="4">Barologger</th></tr>
<tr><td colspan="4">SN:</td></tr>
<tr><td colspan="2">Real-time atmospheric pressure(kPa):</td><td colspan="2">Real-time Temperature (C):</td></tr>
<tr><td colspan="4">Real-time battery:</td></tr>
<tr><td>Restart gage?</td><td>Time Interval:</td><td colspan="2">Restart date and time:</td></tr>
<tr><th colspan="4">Staff Gage</th></tr>
<tr><td colspan="4">Staff Gage Depth (m; nearest 0.001):</td></tr>
<tr><th colspan="4">Office Processing</th></tr>
<tr><td colspan="2">Enter date of data entry and initials</td><td colspan="2">Download File Name</td></tr>
<tr><td colspan="2">Barologger:</td><td colspan="2"></td></tr>
<tr><td colspan="2">Levelogger:</td><td colspan="2"></td></tr>
<tr><td colspan="2">Compensated Levelogger:</td><td colspan="2"></td></tr>
<tr><td colspan="4">Notes/ Any problems with data/loggers/gage housing and plan for fixing:</td></tr>
</table>

Cross Section Stability Form

Olympic Experimental State Forest – Riparian Status and Trends Monitoring

Page 1 of 3

GAGE STATION AND CROSS SECTION STABILITY SURVEY

FIELD FORM 3. version 3

Gage Station description

Basin #

Field crew:

Date:

Survey start time:

Survey end time:

Weather: heavy rain, light rain, cloudy, sunny, foggy, windy, snow, snowing

Remarks on site condition (e.g. recent disturbance, lost RP, management activity):

Photo point marked with:

Monument LB: yes no

Start of Survey Staff Gage Reading (m):

Photo target:

Monument RB: yes no

End of Survey Staff Gage Reading (m):

Picture #:

Camera #:

Gage x-section location (LB monument) from 2 points:

1) Nearest x-section's LB monument:

X-section #:

Distance (m):

Azimuth:

2) Backsite Location:

LBF X-section # or RP:

Distance (m)

Azmuth:

Notes/sketches:

Cross-section at Gage Station (+/- 2 feet upstream or downstream)(GXS)

BFW (m): Cross-section A interval (BFW/10) (cm): Width of 100-year floodplain (m):

X-section Depths

Station (cm)	Foresight FS (-) (cm)	n = Manning's coefficient	*Backsight (cm)	Backsight to (known Elevation)	Remarks/notes:

Flood Plane Slope Measurements

Dist. to Monument	Foresight	n= Manning's	Backsight	Backsight to	Remarks/ Notes

Gage Instrument Position

Point	*Backsight (cm)	Backsight to (Known Elevation)	Foresight FS (-) (cm)	Reference:
RGT				Top of the recording gage sensor housing
RGB				Bottom point of the recording gage sensor housing (describe in notes & w/ photo)
SGT				Top of the staff gage (if the staff gage is permanently installed)
SGB				The bottom of the staff gage or from fixed point used for unfixed staff gage

* When the assumed RP elevation is "0", BS = HI

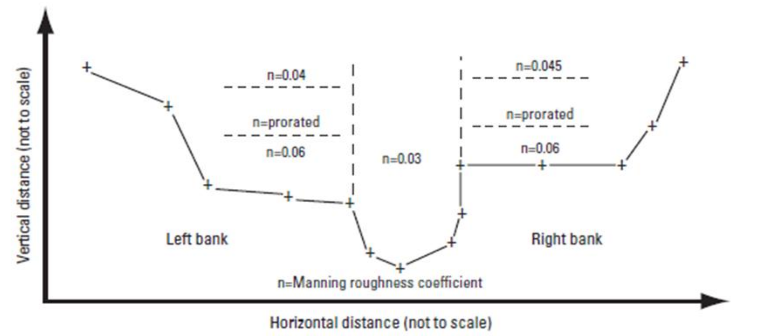
HI = known elevation + BS

Key

LBF	Left Bankfull	**RBF**	Right Bankfull
LEW	Left Edge Wetted	**REW**	Right Edge Wetted
LM	Left Monument	**RM**	Right Monument
***LFP**	Left Flood Plane	***RFP**	Right Flood Plane
TH	Thalweg	*FP is measured in slope distance unless otherwise noted	

Cross Section Stability Form (continued)

Cross section sketch with Manning's Coefficient; label significant points and banks.



STREAM TEMPERATURE DOWNLOAD FORM

OESF Monitoring Project Continuous Temperature Survey Form (Adapted from WADOE 2013)

Site ID#: ________ **Sampler(s):** ________________________

Interval Frequency ________

Water Temperature Logger

Serial# ________________

Water Depth ______ cm Deployment Depth ______ cm

Height (Abv Bottom) ______ cm Retrieval Depth ______ cm

Air Temperature Logger

Serial# ________________

Height (Abv Stream) cm ______

Date	Time	Water Temp	Air Temp	Weather/ Comments

Describe Air Temperature Logger Location:

Describe Water Temperature Logger Location:

Sketch 1 square = 1 m^2 Also take a picture

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Appendix 5. Field Guide on Channel Types & Habitat Units

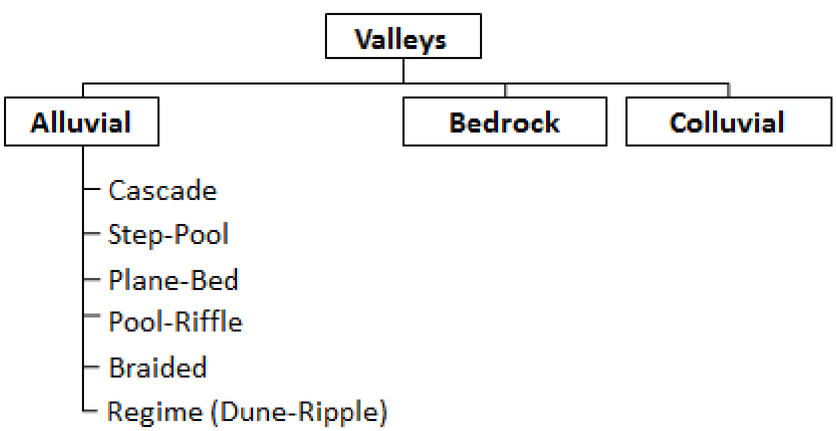
Field Guide for Identifying Channel Types and Habitat Units

Riparian Status and Trends Monitoring
in the Olympic Experimental State Forest

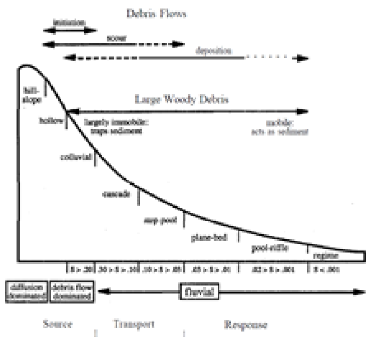
Prepared by: Mitchell Vorwerk and Teodora Minkova
Washington Department of Natural Resources

May 2013

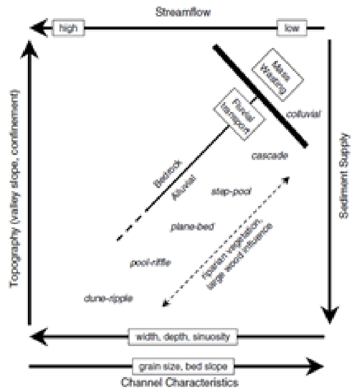
Channel Types



Channel Type Gradients



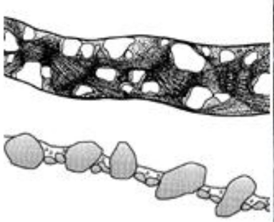
Idealized long profile from hilltops downslope through the channel network showing general distribution of channel types and controls on channel processes (Montgomery and Buffington 1993).



Influence of watershed conditions, sediment supply, & channel characteristics on reach morphology (Buffington and Montgomery 2013).

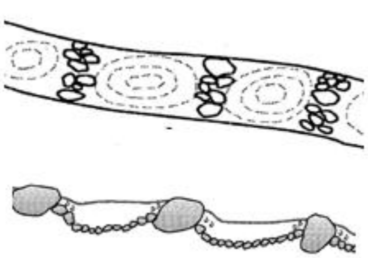
Cascade

- **Predominant bed material**: boulder
- **Bedform pattern**: chaotic
- **Dominant roughness elements**: boulders, banks
- **Dominant sediment sources**: fluvial, hillslope, debris flows
- **Typical slope**: >7.5 %
- **Typical confinement**: strongly confined
- **Pool spacing** : <1 channel widths



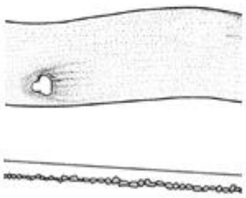
Step-Pool

- **Predominant bed material**: cobble/boulder
- **Bedform pattern**: vertically oscillatory
- **Dominant roughness elements**: bedforms (steps, pools) boulders, large wood, banks
- **Dominant sediment sources**: fluvial, hillslope, debris flows
- **Typical slope**: 3.0-7.5 %
- **Typical confinement**: moderately confined
- **Pool spacing** : 1-4 channel widths



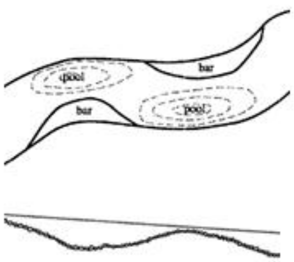
Plane-Bed

- **Predominant bed material**: gravel/cobble
- **Bedform pattern**: none
- **Dominant roughness elements**: boulders and cobbles, banks
- **Dominant sediment sources**: fluvial, bank erosion, debris flows
- **Typical slope**: 1.5-3.0 %
- **Typical confinement**: variable
- **Pool spacing** : none



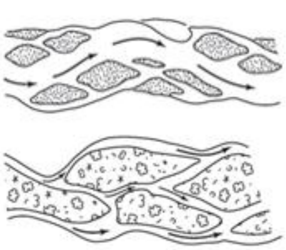
Pool-Riffle

- **Predominant bed material**: gravel
- **Bedform pattern**: laterally oscillatory
- **Dominant roughness elements**: bedforms (bars, pools) boulders and cobbles, large wood, sinuosity, banks
- **Dominant sediment sources**: fluvial, bank erosion, inactive channels, debris flows
- **Typical slope**: <1.5 %
- **Typical confinement**: unconfined
- **Pool spacing** : 5-7 channel widths



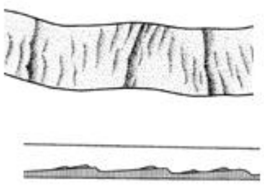
Braided

- **Predominant bed material**: variable (sand to boulder)
- **Bedform pattern**: laterally oscillatory
- **Dominant roughness elements**: bedforms (bars, pools), boulders and cobbles
- **Dominant sediment sources**: fluvial, bank erosion, debris flows, glaciers
- **Typical slope**: <2.5 %
- **Typical confinement**: variable
- **Pool spacing** : variable



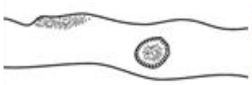
Regime (Dune-ripple)

- **Predominant bed material**: sand
- **Bedform pattern**: multilayered
- **Dominant roughness elements**: sinuosity, bedforms (dunes, ripples, bars) banks, large wood
- **Dominant sediment sources**: fluvial, bank erosion, inactive channels
- **Typical slope**: <0.1%
- **Typical confinement**: unconfined
- **Pool spacing** : 5-7 channel widths



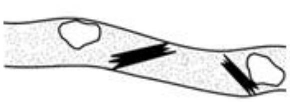
Bedrock

- **Predominant bed material**: bedrock
- **Bedform pattern**: variable
- **Dominant roughness elements**: streambed, banks
- **Dominant sediment sources**: fluvial, hillslope, debris flows
- **Typical slope**: variable
- **Typical confinement**: strongly confined
- **Pool spacing** : variable

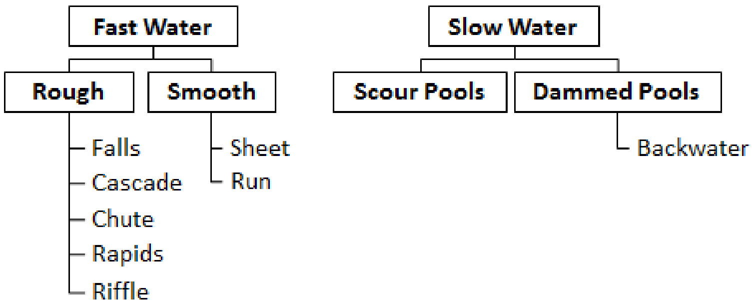


Colluvial

- **Predominant bed material**: variable
- **Bedform pattern**: variable
- **Dominant roughness elements**: banks, boulders, large wood
- **Dominant sediment sources**: hillslope, debrisflows
- **Typical slope**: >20.0%
- **Typical confinement**: Strongly confined
- **Pool spacing** : variable



Habitat Units



Falls

Vertical drops of water and are commonly found in bedrock, cascade, and step-pool stream reaches.

Cascade

Channel units that consist of a highly turbulent series of short falls and small scour basins, frequently characterized by very large sediment sizes and a stepped longitudinal profile. They are prominent features of bedrock and cascade reaches.

Chute

Units that are typically narrow, steep slots in bedrock. They are common in bedrock reaches and also occur in cascade and step-pool reaches.

Rapids

Moderately steep channel units with coarse substrata, but unlike cascades possess a somewhat planar (vs. stepped) longitudinal profile. Rapids are the dominant fast water channel unit of plane-bed stream reaches.

Riffles

The most common type of rough fast water in low gradient (<3%) alluvial channels and may be found in plane-bed, pool-riffle, dune-ripple, and braided reaches. The particle size of riffles tends to be somewhat finer than that of the other rough fast water units, since riffles are shallower than rapids and generally have lower tractive force to mobilize the stream bed.

Sheet

Sheet channel units are in many watersheds but may be common in valley segments dominated by bedrock. Sheets occur where shallow water flows uniformly over smooth bedrock of variable gradient; they may be found in bedrock, cascade, or step-pool reaches, but they are generally highly isolated as true sheet flow is highly rare in stream systems.

Runs

Fast water units of shallow gradient, typically with substrata ranging in size from sand to cobbles. They are characteristically deeper than riffles and because of their smaller substrata have little if any supercritical flow, giving them a smooth appearance. Runs are common in pool-riffle, dune-ripple, and braided stream reaches, usually in mid- and higher-order channels.

Scour Pools

Created by scour that forms a depression in the streambed. They can be created when discharge is sufficient to mobilize the substrata at a particular site.

Dammed Pools

Created by the impoundment of water upstream from an obstruction to flow. Unlike scour pools, they can be formed under any flow condition. Due to their characteristically low current velocities, dammed pools often have more surface fines than scour pools and fill with sediment at a much more rapid rate. However, some types of dammed pools tend to possess more structure and cover for aquatic organisms than scour pools because of the complex arrangement of material forming the dam.

Backwater Pools

A type of dammed pools that occur along the bank of the main stream at a downstream end of an upstream disconnected floodplain channel. Backwater pools often appear as a diverticulum from the main stream and possess water flowing slowly. Pool-riffle, regime (dune-ripple), and braided reaches are most likely to possess this type of channel unit.

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Photos:

Buffington and Montgomery (2013), Montgomery and Buffington (1997), and Washington Department of Natural Resources.

Text:

Modified from Montgomery and Buffington (1993).

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