

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

2014 Progress Report

May 2015



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Acknowledgements

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Photo Credits

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Acronyms and Abbreviations

7-DADMax – 7 Day Average Daily Maximum Temperature

BFW – Bankfull width

DNR – Washington Department of Natural Resources

DOE – Washington Department of Ecology

EPA – Environmental Protection Agency

FPW – Floodplain width

GIS – Geographic Information Systems

GPS – Global Positioning System

HCP – Habitat Conservation Plan

LiDAR – Light Detection and Ranging (a remote sensing method)

NOAA – National Oceanic and Atmospheric Administration

OESF – Olympic Experimental State Forest

ONP – Olympic National Park

PNW – USDA Forest Service Pacific Northwest Research Station

TFW – Timber, Fish, and Wildlife

USGS – United States Geological Survey

Executive Summary

The purpose of status and trends monitoring of riparian and aquatic habitat in the Olympic Experimental State Forest (OESF) is to document changes to riparian and in-stream conditions in basins managed by Washington State Department of Natural Resources (DNR) for timber, fish, and wildlife habitat and other ecosystem values. The central working hypothesis for riparian management in the OESF is that the natural processes of ecological succession and disturbance will continue to improve habitat conditions in managed forests (DNR 2013). It is assumed that current stream protection in the form of riparian buffers allows these processes to proceed.

DNR projects gradual improvement of riparian and aquatic conditions towards increased habitat complexity as afforded by natural disturbances (DNR 1997, DNR 2013). Monitoring information will allow testing this projection and will help reduce key uncertainties about ecological relationships between in-stream, riparian, and upland areas. Monitoring data will be used to characterize baseline habitat conditions for future study of fish response in managed landscapes, thus contributing to the validation monitoring required by the state trust lands Habitat Conservation Plan (DNR 1997).

Monitoring is conducted in 50 basins of small fish-bearing streams across the OESF and in four reference (unmanaged) basins in the Olympic National Park (ONP). Ten aquatic and riparian indicators such as stream temperature, stream flow, channel morphology, and riparian vegetation are sampled at a stream reach level at the outlet of each basin. The basins are monitored remotely or through operational records for management activities (timber harvest and road construction) and natural disturbances (wind throw and landslides).

This report covers the project's third year (November 1, 2013 – December 31, 2014). The project's study plan (Minkova et al. 2012) and the two establishment reports (Minkova and Vorwerk 2013; Minkova and Vorwerk 2014) are available on the [DNR website](#).

The main accomplishments for the third year are: completing a full set of monitoring protocols in 32 sample reaches; completing riparian vegetation sampling in 10 sample reaches; completing the planned number of discharge measurements at all 14 gage stations; downloading data from continuously recording filed sensors for water level, stream temperature, and riparian microclimate; developing relational databases and data management procedures for all monitoring data, and finalizing four monitoring protocols.

Data analyses are presented for 2014 stream temperature data, and preliminary data summaries are presented for the sample reaches measured through 2014.

The third year of this project was funded by DNR with in-kind contributions of equipment and staff time by the USDA Forest Service Pacific Northwest Research Station (PNW). The project team gave several presentations and field tours to external parties with the purpose of soliciting interest from potential research collaborators.

Project updates are posted on the [DNR website](#).

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Introduction

The status and trends monitoring of riparian and aquatic habitat quantifies changes over time of riparian and in-stream conditions in basins managed for timber, fish and wildlife habitat, and other ecosystem values in the Olympic Experimental State Forest (OESF). Washington State Department of Natural Resources (DNR) has identified this project as a high priority because it will provide empirical data to reduce key uncertainties around the integration of habitat conservation and revenue production. The project results will be used to assess the habitat projections 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 monitoring data will help make inferences about how management choices affect habitat, thus contributing to the effectiveness monitoring and adaptive management required by the state trust lands Habitat Conservation Plan (DNR 1997). The monitoring data will also be used to characterize baseline habitat conditions for future study of fish response in managed landscapes thus contributing to the validation monitoring required by the state trust lands Habitat Conservation Plan (DNR 1997).

DNR published a peer-reviewed study plan (Minkova et al. 2012) and has been funding the project implementation since 2012. 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 50 sample reaches in the OESF, and initial field characterization of the sample sites. These activities are described in the 2012 establishment report (Minkova and Vorwerk 2013). The second year included reallocation of some sample basins, development of monitoring protocols, refinement of field procedures, installation of monitoring equipment, and beginning of protocol implementation (Minkova and Vorwerk 2014). The plan for the third year included implementing all field protocols in the monitored basins, downloading data from continuously recording field sensors, and managing field data. The project is expected to continue long-term with the first five-year trend report expected in 2018 and the second 10-year trend report expected in 2023.

This annual progress report covers the period November 1, 2013 to December 31, 2014. The fieldwork and analyses completed during the reporting period are described in the following five sections. Refer to Appendix 1 for the list of field protocols completed in each basin. The rest of the report describes data management procedures, outreach and communication activities, and project staff and budget for the reporting period.

Study Area and Study Design

The OESF includes 110,000 hectares (270,000 acres) of state trust lands on the Olympic Peninsula in Washington State. It ranges in elevation from 150 m to 1,050 m (500–3,500 ft) and is characterized by steep erodible terrain. The climate is strongly influenced by the Pacific Ocean and the area receives heavy precipitation, ranging from 203 cm to 355 cm (80–140 in) per year with the majority of it falling as rain in the winter. The dense network of streams exceeds 4,000 km (2,500 mi) with abundant small and headwater streams.

The Sitka spruce vegetation zone dominates along the coast, while a majority of the OESF forest falls within the western hemlock zone with western red cedar found in the wetter areas. The Pacific silver fir zone extends higher in elevation. Douglas fir is a seral component in all zones; red alder is a seral component in lower elevations. The entire area is characterized by a very high tree-growth rate. Old growth forest, which once dominated the landscape, is still present on parts of the OESF. About half of the OESF is dominated by young (0-50 year-old) stands.

Wind is the most prevalent natural disturbance regime in the OESF, where moist conditions generally limit fire spread. Soil erosion, landslides, and debris flows are typical disturbances in stream valleys.

Riparian areas in the OESF provide habitat for diversity of fish including nine resident anadromous salmonid species: sockeye salmon, pink salmon, chum salmon, Chinook salmon, Coho salmon, steelhead trout, cutthroat trout, bull trout, and mountain whitefish.

DNR manages state trust lands in the OESF for revenue production (mainly from timber harvest) and ecological values (primarily habitat conservation) through an approach called integrated management. This experimental approach differs from the more common approach of dividing a forested area in large blocks that are managed for a single purpose by blending active management (such as tree planting, thinning, and stand-replacement harvest) with habitat conservation (such as provision for spotted owl habitat) across the landscape. The current sustainable harvest level for the OESF is 576 million board feet per decade (DNR 2007). The OESF conservation objectives, described in the Habitat Conservation Plan (DNR 1997), focus on restoring levels of habitat capable of supporting viable salmonid populations, spotted owls, and marbled murrelets.

Fifty Type 3 watersheds¹ (basins around the smallest fish-bearing streams) are selected for monitoring in the OESF (Figure 1). They are selected to be representative of the ecological conditions and management history across the forest. Four reference basins are monitored in the adjacent Olympic National Park (ONP). Their allocation is dictated by their ecological similarity to the OESF basins and the availability of access.

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 $\leq 16\%$ 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.

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

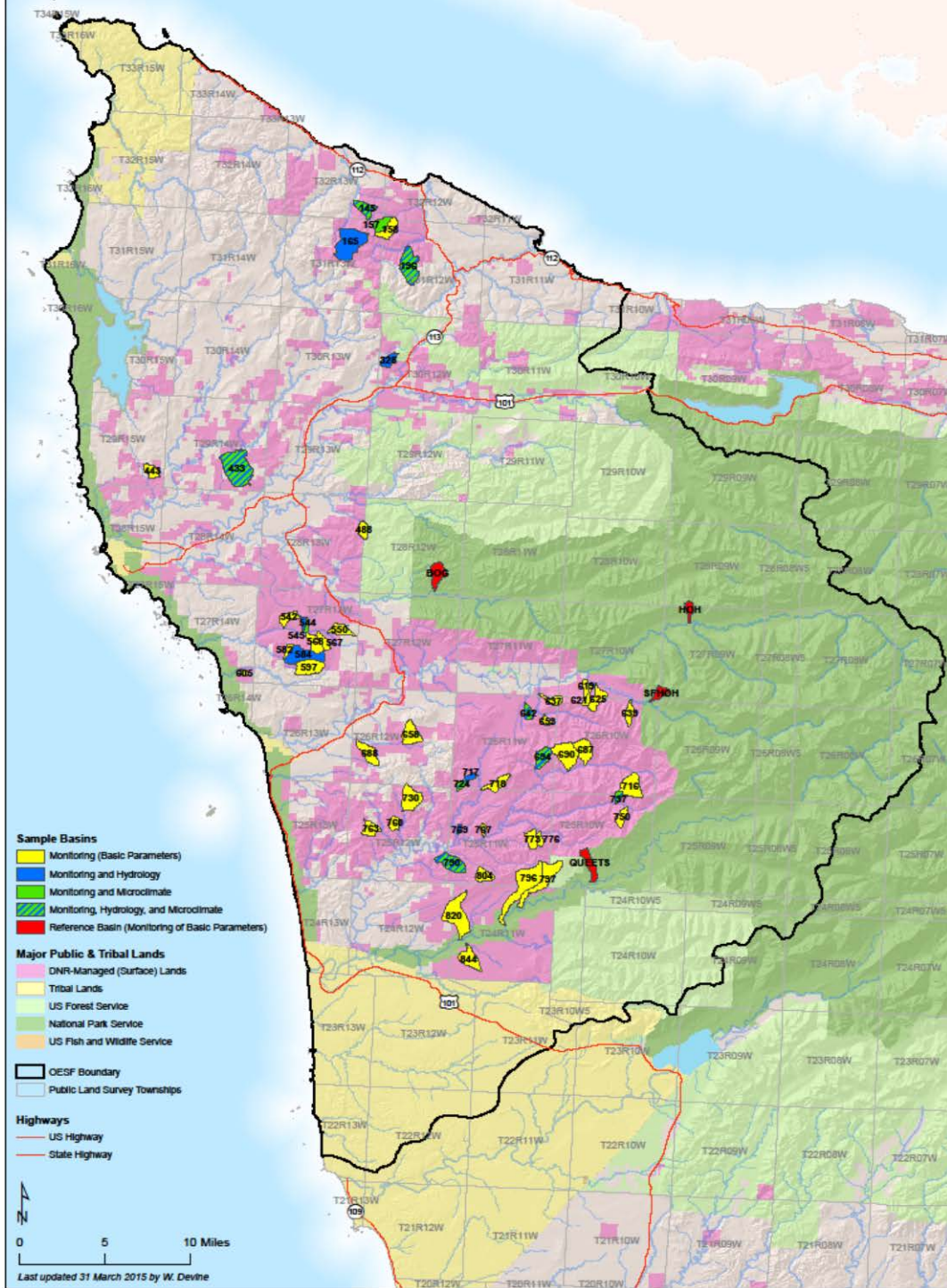


Figure 1. Map of the study area with 50 sample basins located in the OESF and four reference basins located in the ONP.

The aquatic and riparian conditions of each basin are characterized at the most downstream section of the Type 3 stream and the adjacent riparian area (Figure 2).

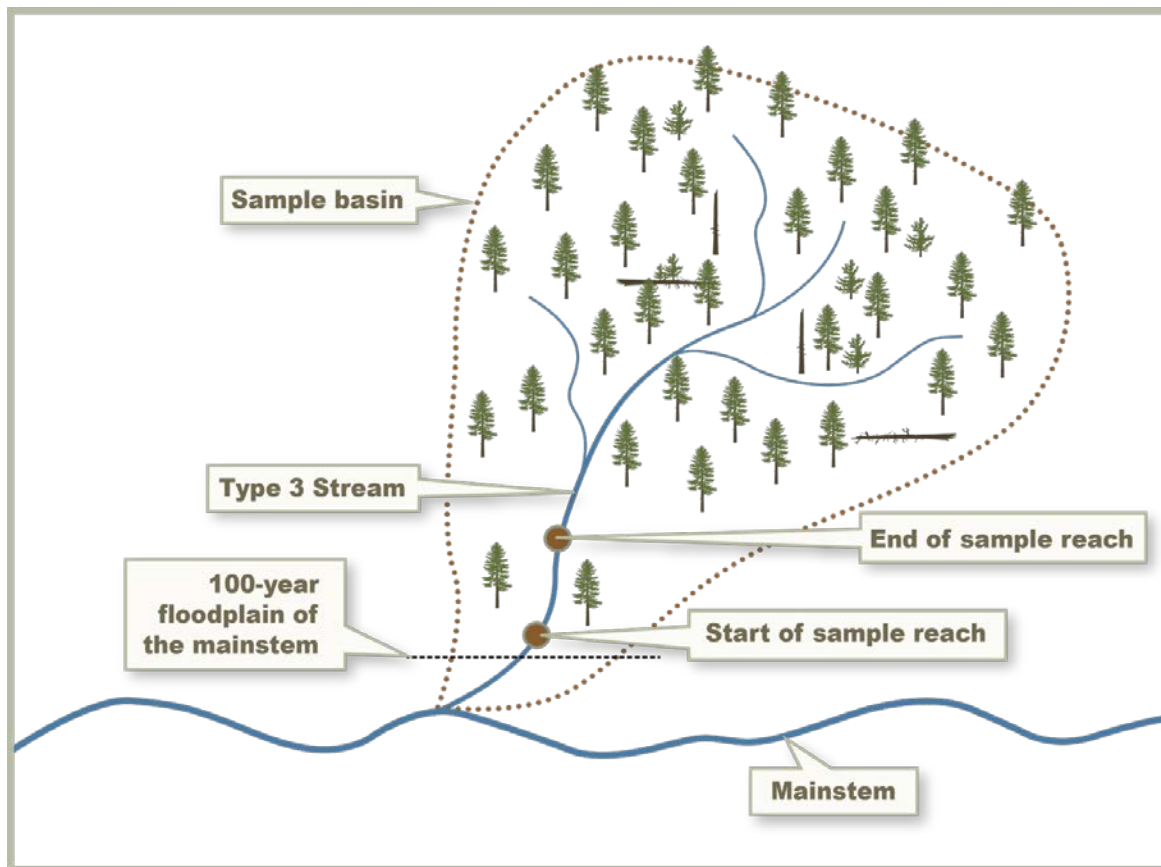


Figure 2. Schematic of a monitored basin with a sample reach.

Nine aquatic and riparian indicators are sampled at the reach level: 1) in-channel large woody debris, 2) channel morphology (including gradient, confinement, depth, and width), 3) water temperature, 4) stream discharge, 5) habitat units (such as pools), 6) channel substrate, 7) stream shade, 8) riparian microclimate, and 9) riparian forest vegetation. The layout of a sample reach is illustrated in Figure 3.

The study plan identifies watershed-level “stressors” such as land management (timber harvest, road management, and road use) and natural disturbances (including windthrow and landslides) to be monitored in each of the 50 monitored basins (Minkova et al. 2012). Data for these basin-wide changes will be collected retrospectively and prospectively using operational records, remote-sensing tools, and some field sampling. They will then be linked to the reach-level data using analytical approaches such as regression and model-based inference.

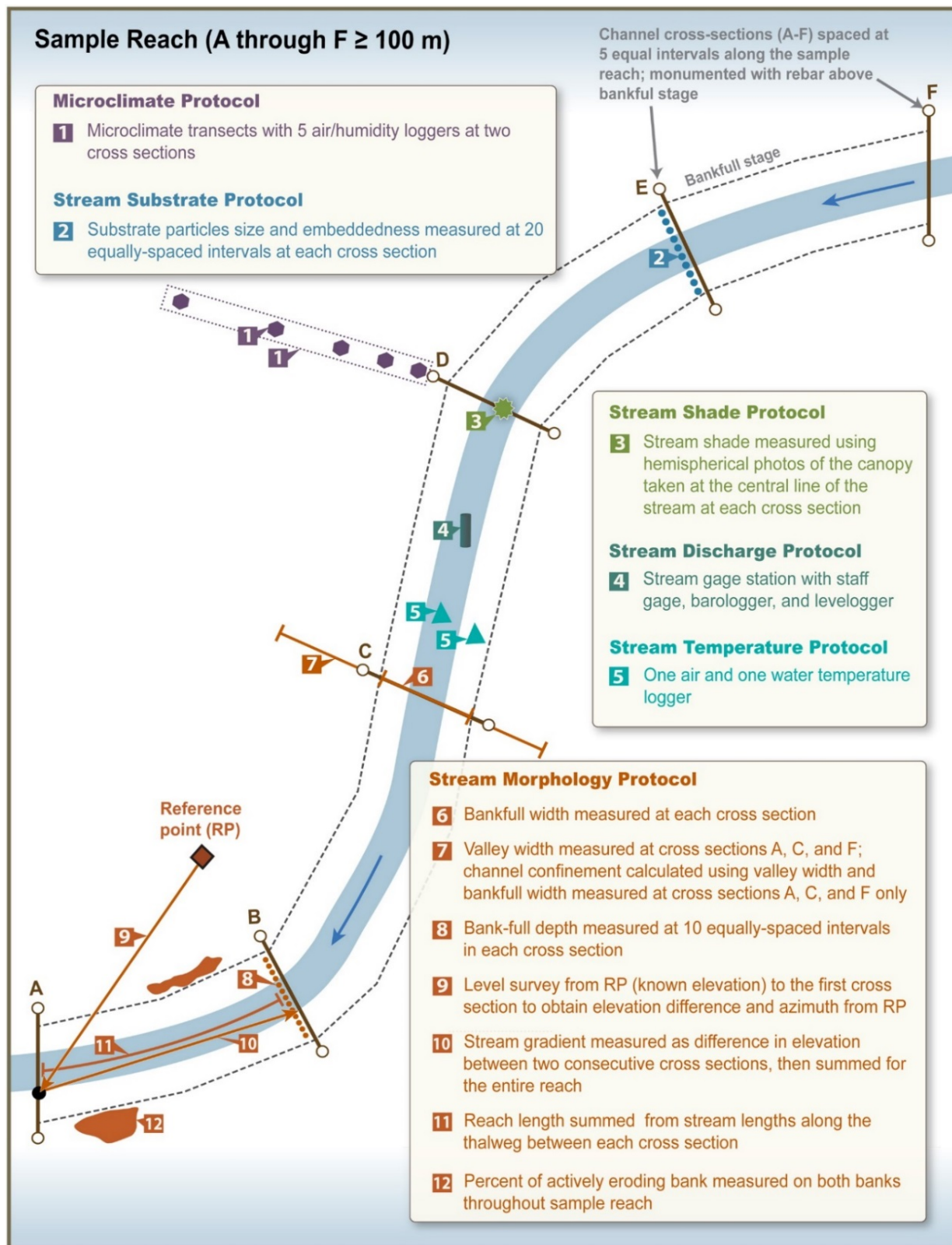


Figure 3. Layout of a sample reach. The protocols for in-stream large wood, habitat units, and valley and channel type classification, which require continuous survey along the sample reach, and the protocol for sampling riparian vegetation are not depicted.

Implementation of Stream Temperature Protocol and 2014 Data Summary

Stream temperature is a key indicator for determining the health of a stream system. Temperature changes can affect the productivity, mortality, and life histories of all aquatic life forms.

TASK 1.0 STREAM TEMPERATURE LOGGING

Stream and air temperature loggers (Onset Tidbit® v2 thermistors) were installed in each of the 54 sample reaches in 2012 (n=88) and 2013 (n=22). The loggers record temperature data throughout the year at an interval of 60 minutes. The data are downloaded at least annually and the field installations are maintained as needed.

The seven-day daily average maximum temperature (7-DADMax) is calculated yearly. This metric is used by the Environmental Protection Agency (EPA) and 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). Aquatic biota including salmonids can respond not only to daily maximum temperatures, but also to daily maximum fluctuation and cumulative temperature exposure. However, DNR uses the 7-DADMax because it is a standard metric commonly used by regulatory agencies in Washington. Additional temperature metrics will be analyzed in the future.

Three aquatic-life use categories are applicable to the sample reaches in this project (Table 1). The categories are designated based on the presence of, or the intent to provide protection for, the key uses listed in the table. The temperatures represent the regulatory maximum threshold for the time period specified.

Table 1. Stream temperature criteria (WADOE 2006) applicable to the sample reaches in this project.

Aquatic Life Temperature Criteria			Monitoring Basins
Category	Highest 7-DADMax (°C)	Time Period	
Core summer salmonid habitat	16	June 15–September 15	145, 157, 158, 165, 196, 328, 433, 443, 488, 542, 544, 545, 550, 567, 568, 582, 584, 597, 605, 637, 642, 653, 658, 688, 690, 796, 797, 820, 844, Bogachiel, Queets
Char spawning and rearing	12	All year	619, 621, 625, 639, 687, 694, 716, 737, 750, Hoh, South Fork Hoh
Char spawning and rearing	12	June 15–September 15	717, 718, 724, 730, 760, 763, 767, 769, 773, 776, 790, 804

Progress

All sample reaches were visited during the 2014 field season. Data were downloaded using optical shuttle and the installations were inspected for physical damages. The attachments of several installations were changed from tar-coated, nylon-braided cord to a PVC cover attached with epoxy to a boulder in the water. In the future, all sites with suitable boulders will be switched to an epoxy attachment. Three (6%) of the stream temperature data loggers were lost over the winter, probably due to high-energy stream flows. This occurred in basins 157, 158, and 687. These loggers were replaced.

Figure 4 shows the currently available stream temperature data expressed as the number of basins monitored for stream temperature, beginning in August 2012 when the first data loggers were installed.

All temperature data were checked for quality (refer to Data Management section on page 30 for more details on quality-control procedures) and the rejected data points were excluded from further analyses. This reduced the number of data points collected to date from 1,319,218 to 1,278,754—a three percent reduction. The most common reason for rejection was suspected dewatering of the stream logger.

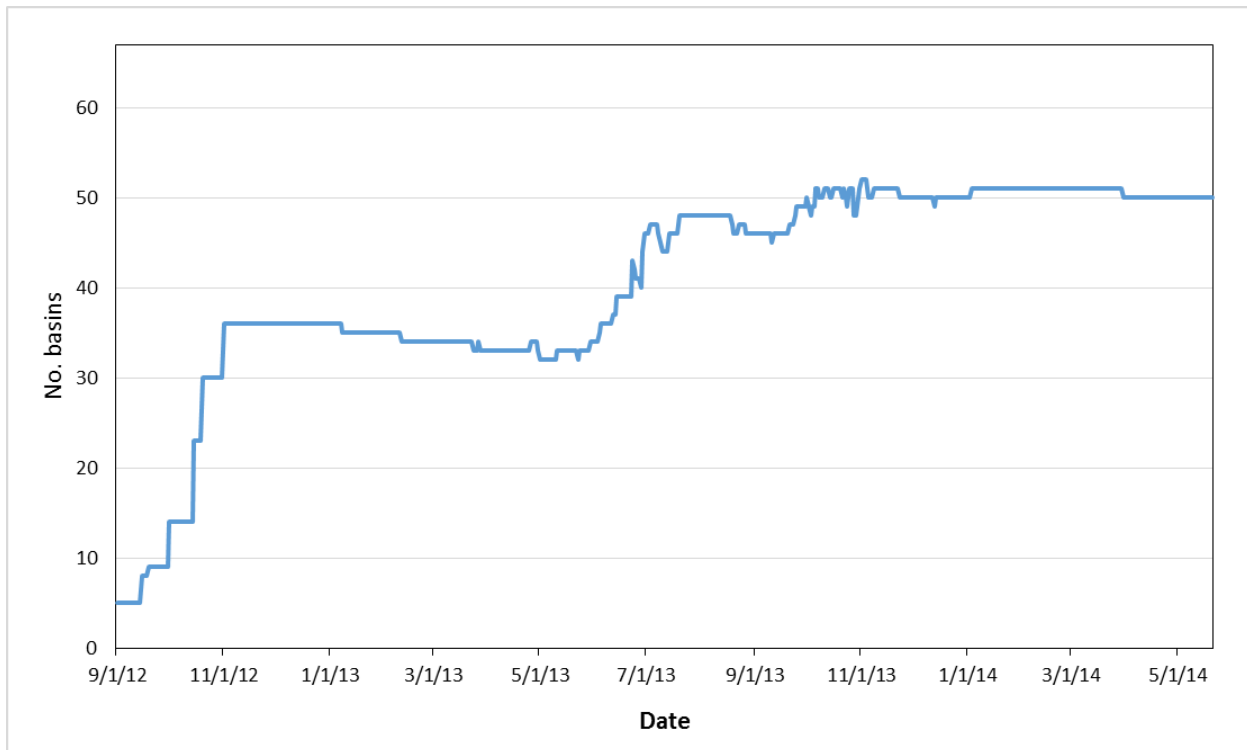


Figure 4. Available stream temperature data set. The step increases in the number of basins monitored for stream temperature reflect periods of installation of data loggers. Small fluctuations in sample size indicate portions of data that were rejected during the quality control process, often because loggers had become dewatered or buried in sediment.

Forty stream temperature metrics were calculated for each basin and water year. Stream temperature metrics included: annual and seasonal temperature means, minima and maxima, and

cumulative degree days. An abbreviated version of the stream temperature metrics calculated for 2014 water year is presented in Appendix 2.

The 16 °C core summer habitat (15 June–15 September) criterion applies to 31 reaches in DNR’s study area. Data for 2014 were available for 24 of these 31 reaches (Figure 5). Of the 24 basins, 20 (83%) had a summer 7-DADMax temperature below the DOE criterion. Three basins, including one ONP reference basin, exceeded the criterion by 0.1 °C, which is within the DOE-approved 0.3 margin of error. One reach (in basin #196) exceeded the habitat criterion by 0.6°C.

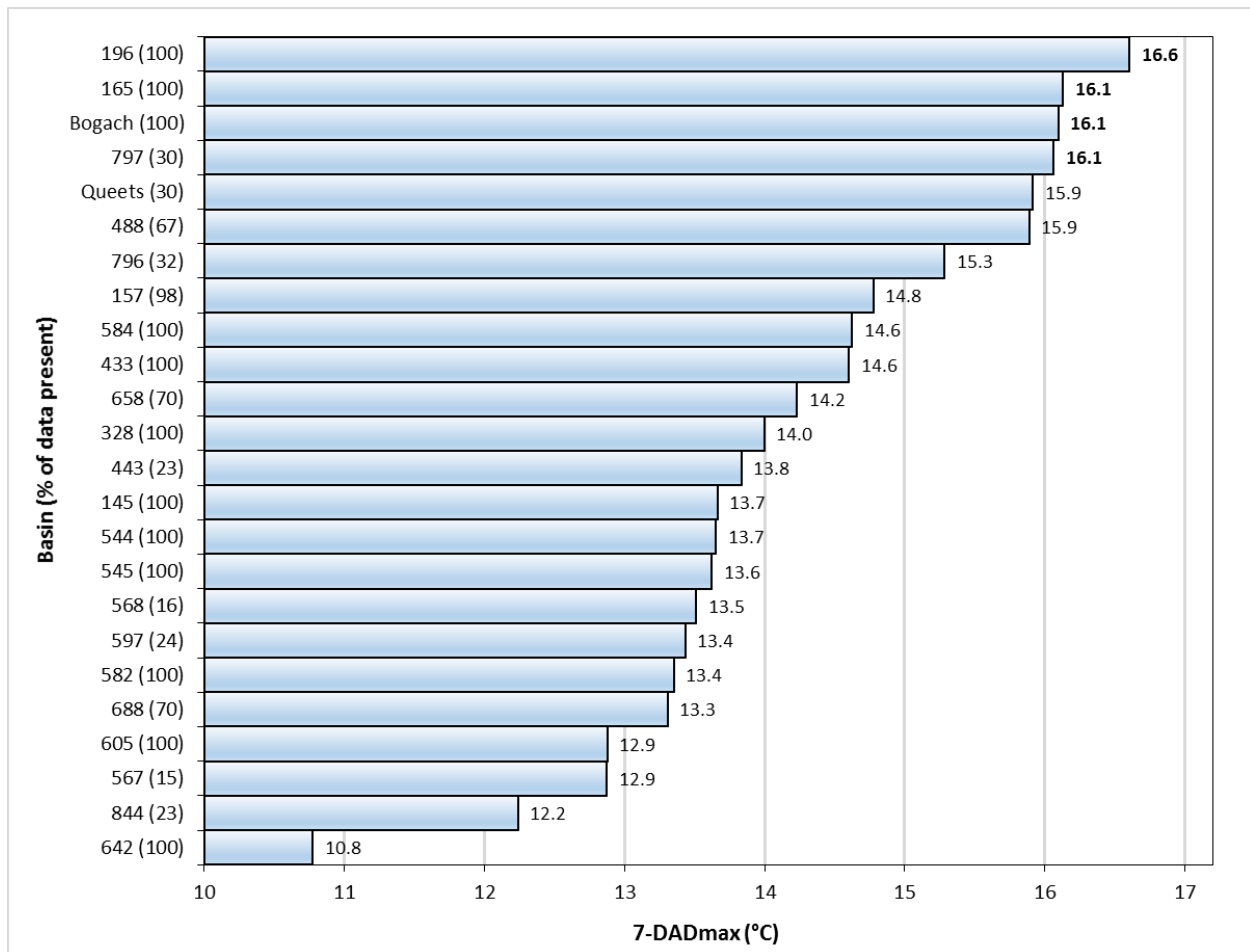


Figure 5. The 2014 7-DADMax stream temperature for basins with a 16 °C core summer (15 June 15–15 September) habitat criterion. The percentage of summer data used in the calculation appears in parentheses beside the basin number; a value less than 100 percent indicates that some data were rejected during the quality-control process or that the logger was last downloaded before the end of the time period.

The 12°C (all-year) char spawning and rearing habitat criterion applies to 11 reaches in the study area. Five reaches (46%) had a 7-DADMax temperature below the DOE criterion. Six basins (54%) exceeded the threshold by more than the DOE-approved 0.3 margin of error. Two of these basins were reference basins in the ONP (Figure 6).

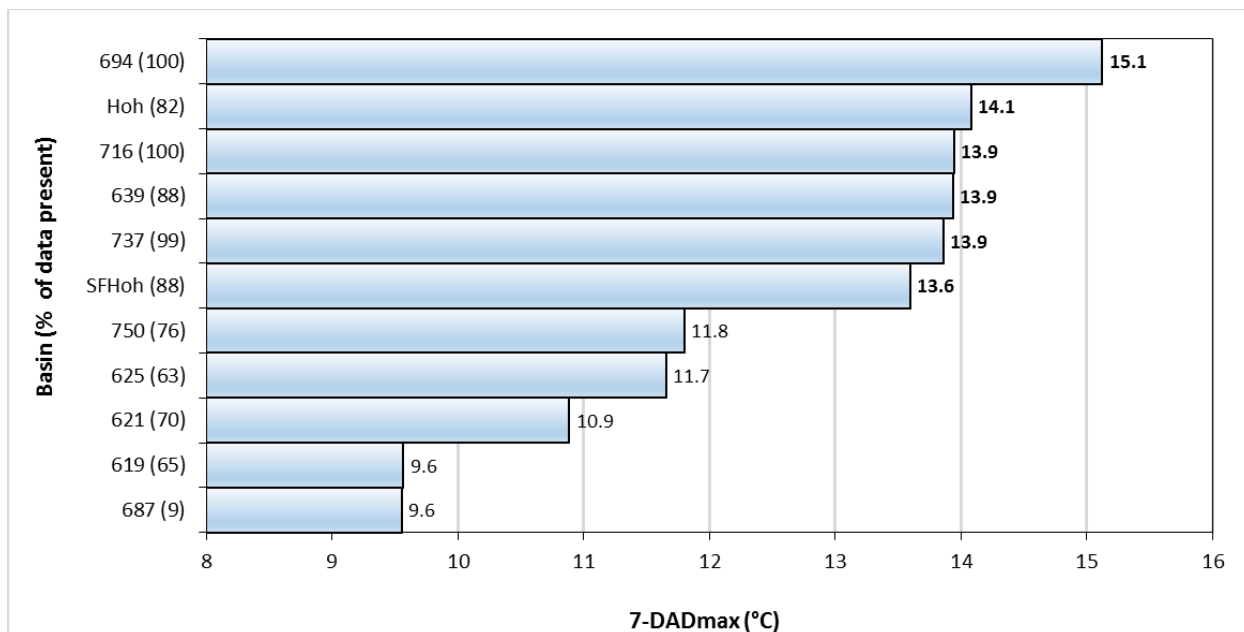


Figure 6. The 2014 7-DADMax stream temperature for basins with a 12 °C (all-year) char spawning and rearing habitat criterion. The percentage of water year 2014 data used in the calculation appears in brackets beside the basin number; a value less than 100 percent indicates that some data were rejected during the quality-control process or that the logger was last downloaded before the end of water year 2014.

The 12°C char spawning and rearing habitat (15 June–15 September) criterion applies to 12 sample reaches in our study area. All of them had 7-DAD MAX temperatures exceeding the threshold by more than the DOE-approved 0.3 margin of error (Figure 7).

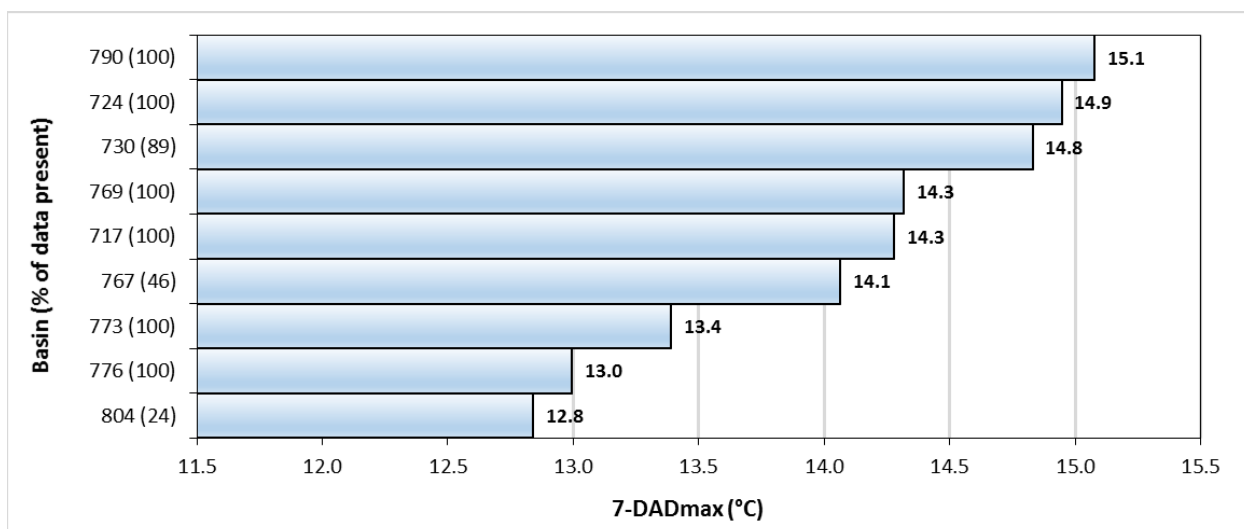


Figure 7. The 2014 7-DADMax stream temperature for basins with a 12 °C core summer (15 June 15–15 September) habitat criterion. The percentage of summer data used in the calculation appears in brackets beside the basin number; a value less than 100 percent indicates that some data were rejected during the quality-control process or that the logger was last downloaded before the time period.

Multiple factors may contribute to the higher water temperature in some of the sample reaches, including natural climatic or landscape attributes (such as southern aspect and flat topography) as well as management activities such as timber harvest that reduce shade either upstream or within the sample reach. It is important to note that one of the four reference reaches in the ONP exceeded the applicable stream temperature criteria.

DOE (2006) recognizes that portions of many water bodies cannot meet the assigned criteria due to the natural conditions of the water body. When a water body does not meet its assigned criteria due to natural climatic or landscape attributes, the natural conditions constitute the water quality criteria. In these cases, human actions, considered cumulatively, may not cause the 7-DADMax temperature of that water body to increase more than 0.3°C (0.54°F).

Further analyses are needed to assess the possible causes for higher temperature and the inter-annual variability of the 7-DADMax metric. It will be important to assess whether, and in which streams, the warmer water temperature arises from natural conditions. Assessment of the forest cover, past management history, and the ongoing harvest and road management across the sample basins will start in the fall of 2015.

Implementation of Stream Survey Monitoring Protocols and Preliminary Data Summaries

The stream survey monitoring protocols include site establishment, channel morphology, coarse substrate, stream shade, in-stream large wood, habitat units, and classification of valley segment and stream type. The field procedures are described and illustrated in the 2013 establishment report (Minkova and Vorwerk 2014). The stream survey monitoring protocols were completed in 10 of 54 monitored basins in 2013.

TASK 2.0: ESTABLISHMENT OF PERMANENT CROSS SECTIONS

Long-term monitoring requires repeated visits to the sample sites often by different crews and at large time intervals. Establishment of permanent cross sections along the sample reach ensures consistency of data collection and helps find elements within the reach.

The length of each reach was determined as 20 times the bankfull width at the beginning of the reach, or at least 100 meters. Six cross sections were identified at five equally spaced intervals along the sample reach (Figure 3). The cross sections were permanently marked with rebar installed on both banks slightly above the bankfull stage and labeled A–F.

Progress

Permanently marked cross sections were established in 18 basins in 2014, thus completing installation of all 50 sample reaches in the OESF. Reach lengths ranged from 100 to 205 meters (Figure 8).

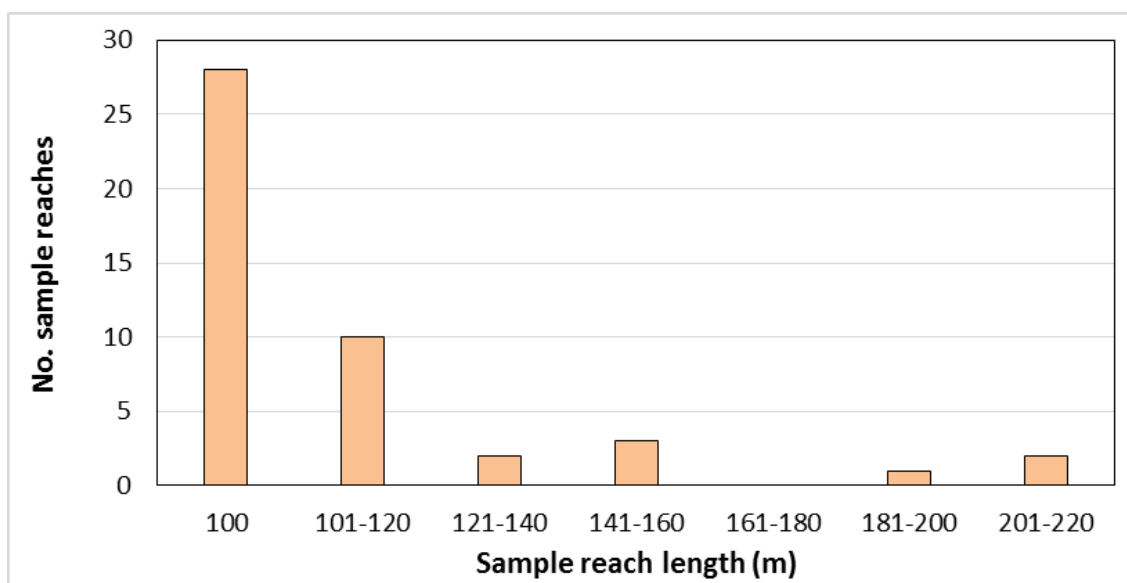


Figure 8. Distribution of sample reach lengths for the 50 sample reaches established in the OESF.

TASK 3.0: 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). Each collected point was averaged for at least 50–300 points, depending on satellite availability. All GPS data was differentially corrected using Trimble Pathfinder Office.

Progress

The reference point coordinates and elevation were recorded for 47 sample reaches in the OESF and two of the four reference reaches in the ONP. The data are currently being processed.

Channel Morphology

Channel morphology reflects stream-reach and watershed-level ecological processes and provides basis for interpreting the potential responses of the stream to perturbations such as sediment delivery and peak flows (Montgomery and Buffington 1993). Channel morphology influences the distribution and abundance of aquatic plants and animals by governing the characteristics of water flow and the capacity of streams to store sediment and transform organic matter (Bisson et al. 2006).

The channel morphology protocol (Minkova and Foster in prep.) includes several elements: channel gradient, sinuosity, width and depth, and active erosion.

TASK 4.0: CHANNEL GRADIENT MEASUREMENT

The channel gradient over the length of the reach is calculated from the differences in elevation between six cross sections along the reach. Field measurements were taken with an auto level, tripod, and stadia rod following the protocol of Harrelson et al. (1994). In addition, a compass was used to take an azimuth reading between cross sections in order to map the reach.

Progress

The channel gradient measurements were taken in 32 reaches (60%) in 2014. The slope for all sample reaches ranged from 1.3 to 13.8 percent (Figure 9).

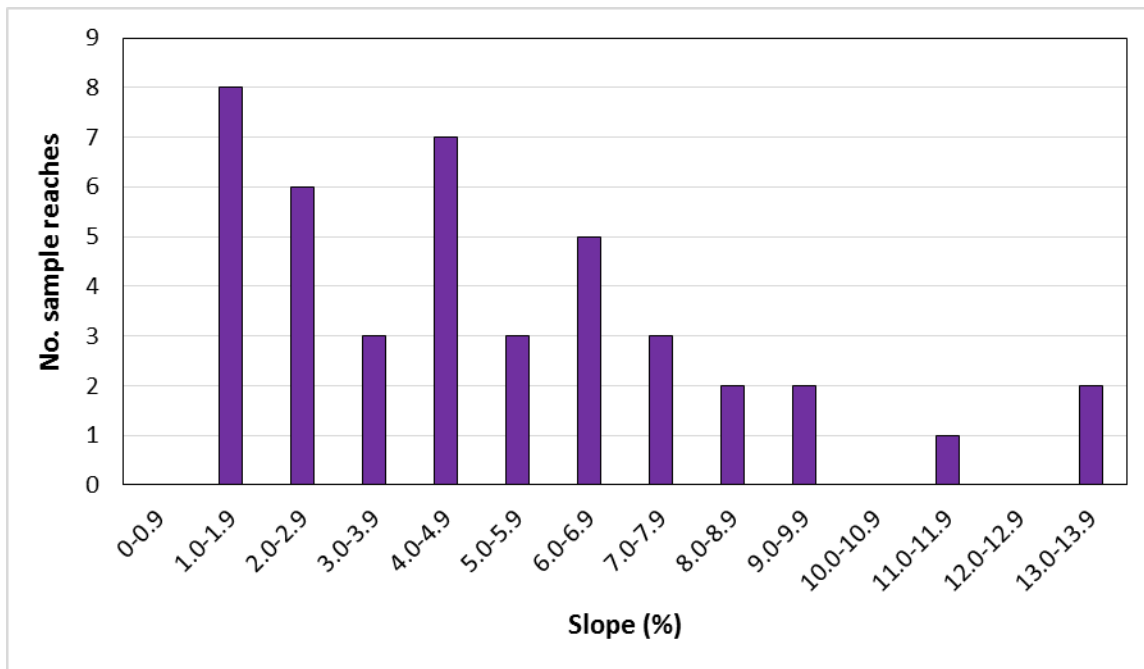


Figure 9. Distribution of the channel gradient (percent slope) for the 42 sample reaches measured through 2014.

TASK 4.1: 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. 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 end of the sample reach.

Progress

Channel sinuosity data were collected for the four reference reaches in the ONP and all OESF reaches remaining from the 2013 field season. The data will be processed in 2015.

TASK 4.2 CHANNEL WIDTH AND DEPTH

The bankfull and wetted widths are measured at each of the six cross sections per reach. The bankfull width is calculated as the average of the six cross-sectional bankfull widths. Channel depth is measured at ten equally spaced intervals (eleven stations) across the bankfull stage of each cross section. Width-to-depth ratios were calculated by dividing the cross-section wetted width by the mean depth of 11 stations along the cross section and then averaging the ratios for all six cross sections.

Progress

In 2014, channel width and depth were measured at 32 sample reaches. Bankfull width ranged from 1.9 to 9.9 meters and averaged 4.8 meters. (Figure 10).

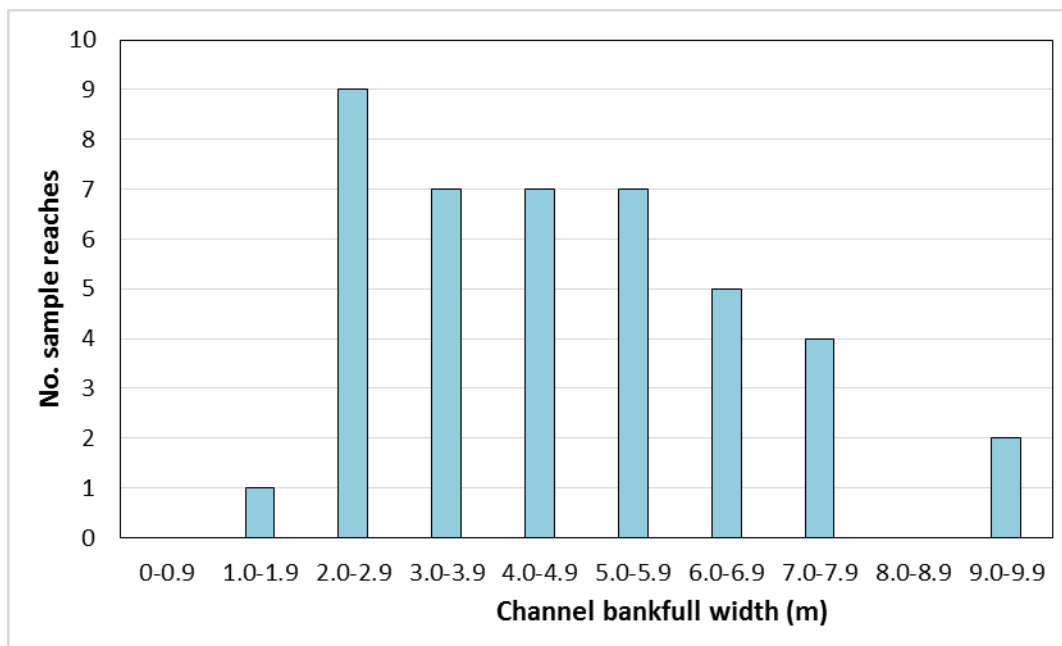


Figure 10. The distribution of mean channel bankfull widths for the 42 sample reaches measured through 2014.

Wetted width-to-depth ratios ranged from 18 to 71 with an average of 41 (Figure 11). Further analysis of bankfull width, width-to-depth ratios, and their importance to stream health will be explored in 2015.

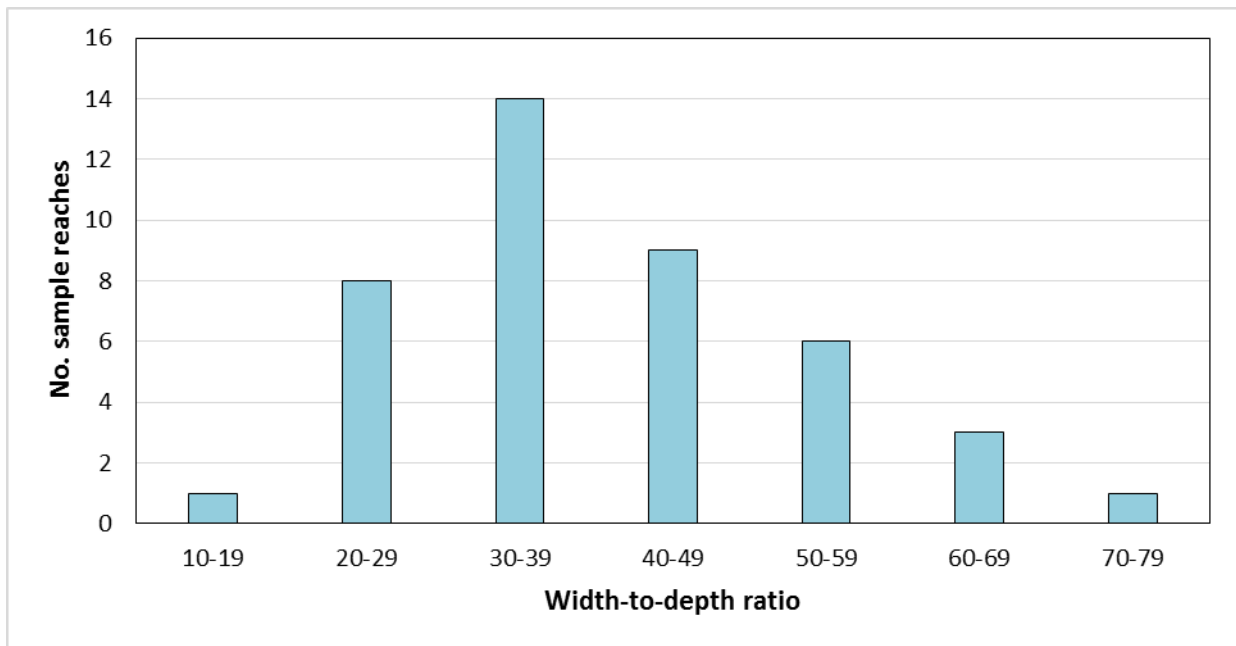


Figure 11. The distribution of wetted width-to-depth ratios for the 42 sample reaches measured through 2014.

TASK 4.3 CHANNEL CONFINEMENT

Channel confinement is defined as the ratio of 100-year floodplain width (FPW) to bankfull width (BFW). These measurements are taken at three cross-sections in each sample reach, and are averaged for the reach. Channels can then be classified into 3 confinement classes: confined ($FPW \leq 2 BFW$), moderately confined ($FPW > 2 BFW$ and $\leq 4 BFW$), and unconfined ($FPW > 4 BFW$).

Progress

Channel confinement was measured for 32 sample reaches in 2014. All of the reaches were either confined (28) or moderately confined (14), and no reaches were unconfined (Figure 12). Further analysis of channel confinement and its importance to stream health may be explored in 2015.

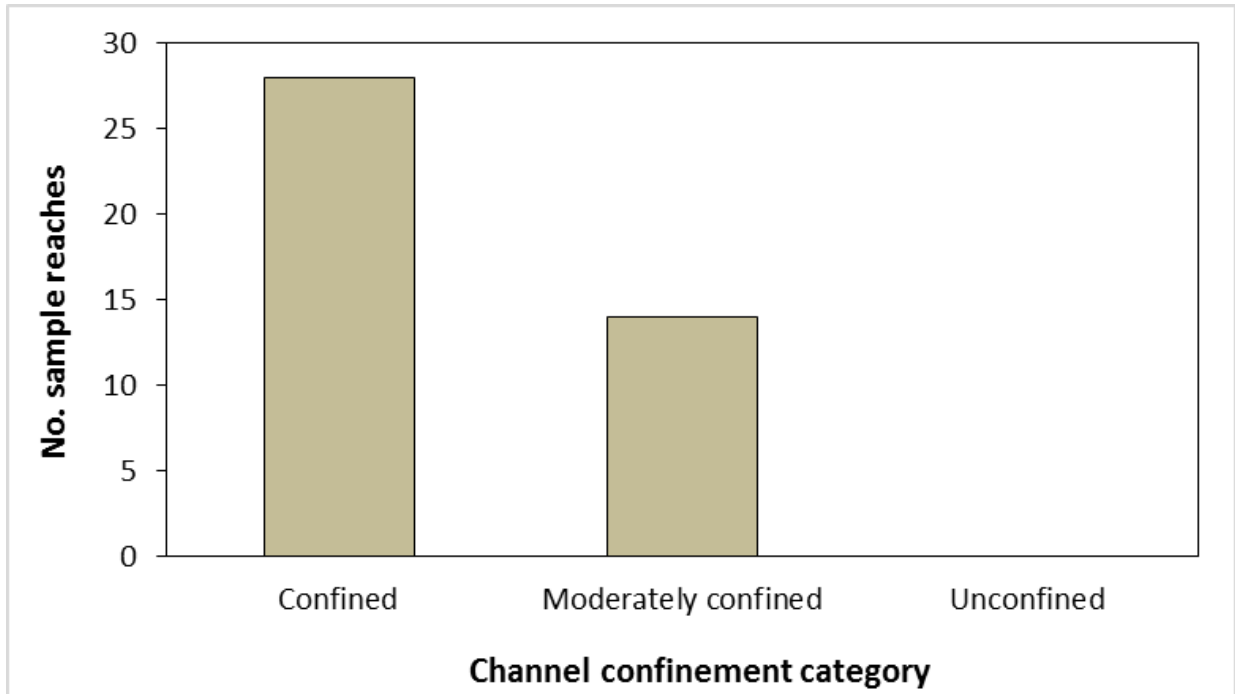


Figure 12. Sample reach channel confinement for the 42 sample reaches measured through 2014.

TASK 4.4 ACTIVE EROSION

Actively eroding patches were measured on both banks of the stream above the bankfull line. If evident, the cause of erosion (road failure, uprooted tree, etc.) was noted. Stream bank distance that is eroding was recorded along both sides of the active channel between cross sections and summed together for a reach total. The amount of erosion is presented as “percent eroding bank” by calculating the percentage of actively eroding stream bank along both banks of the two-times-reach length.

Progress

Thirty-one reaches were sampled for active erosion in 2014. Twenty-five of the 41 sites sampled to date had less than 10% erosion (Figure 13). Further analysis of active erosion and its importance to stream health may be explored in 2015.

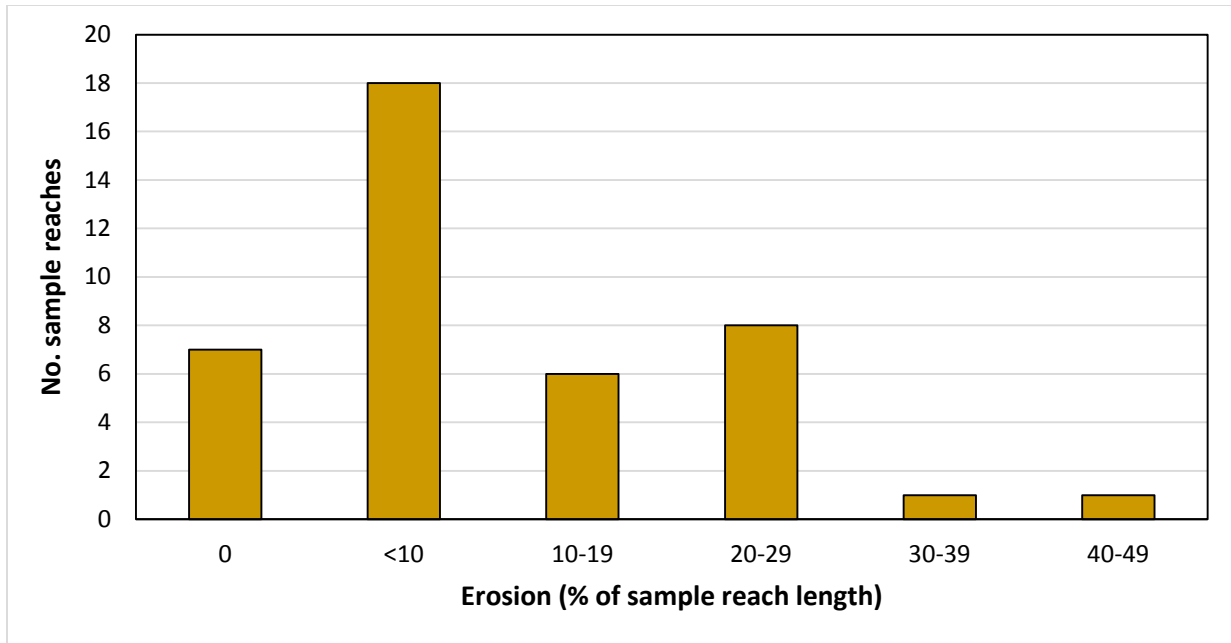


Figure 13. Active erosion, expressed as a percentage of each sample reach’s total length for both banks, for the 41 reaches for which erosion was surveyed through 2014.

TASK 5.0 CHANNEL COARSE SUBSTRATE

Channel substrate controls species composition of macroinvertebrate, periphyton, and fish assemblages in streams (Cummins 1974). It influences the hydraulic roughness and consequently the range of water velocities in a stream channel. It also influences the size range of interstices that provide living space and cover for macroinvertebrates, amphibians, and fish. The substrate size, composition, and stability can be limiting factors in anadromous salmonid spawning and rearing habitats.

Twenty one substrate particles are sampled at 20 equally spaced intervals across each of the 6 cross sections for a total of 126 particles measured at each sample reach. The size of each substrate particle is measured using a gravelometer and the fraction of particle volume that is embedded in sand or finer sediments on the stream bed was visually estimated in classes of 10%.

Progress

Channel coarse substrate was sampled in 32 sample reaches in 2014. The data have been entered, and they may be analyzed in 2015.

TASK 6.0 STREAM SHADE

Stream shade is one of the primary factors influencing stream temperature. Hemispherical canopy photos are taken at each cross section for a total of six photos per sample reach. A fish eye camera is set up on a tripod at the middle of the bankfull channel at each cross section. To reduce seasonal variability in the photographs between years, the exact location of the photos is recorded, so future photos can be taken within two calendar weeks of the initial year’s photo at a

given location. The sampling period for this protocol is shorter as it requires the presence of full foliage in deciduous trees and plants, which for the OESF typically is between June 1 and September 20.

Progress

Hemispherical canopy photos were taken in 29 sample reaches in 2014. The data will be processed in 2015.

TASK 7.0 IN-STREAM LARGE WOOD

Large woody debris is an important habitat component for fish and other aquatic organisms. Large wood pieces trap and retain sediment, change the shape and steepness of streams, change water velocity, release nutrients slowly as they decompose, and provide cover from predators (Bisson et al 1987, Cummins 1974).

Wood surveys employ a slightly modified Level II procedure described by Schuett-Hames (1999). The field protocol involves measuring and describing the functionality of every piece of qualifying wood or wood jam along the sample reach starting at cross section A.

Progress

In-stream large wood was sampled in 30 sample reaches in 2014. All Data have been entered and proofed. The density of large wood ranged from eight to 159 pieces per 100 m and peaked around 20 to 39 pieces (Figure 14). Further analysis of in-stream large wood and its importance to stream health and fish habitat may be explored in 2015.

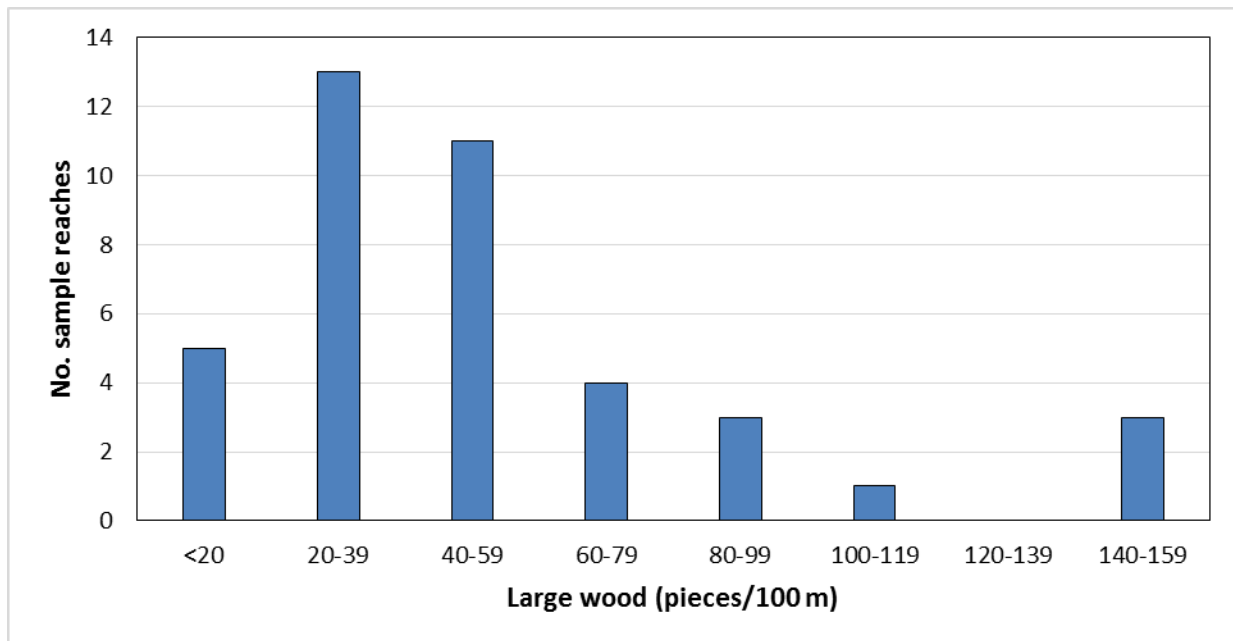


Figure 14. Number of pieces of large wood, expressed per 100 meters of reach length, for the 40 sample reaches surveyed through 2014.

TASK 8.0 HABITAT UNITS

Channel units, also called habitat types or habitat units, exert a powerful influence on the distribution and abundance of aquatic plants and animals by governing the characteristics of water flow and the capacity of streams to store sediment and transform organic matter (Bisson et al. 2006).

Habitat units are identified using the classification system described in Bisson et al. (2006) with an abbreviated two-tier classification for slow water units (scour and dammed pools) and the addition of backwater pools. To reduce the subjectivity and to speed up the classification, the field crew used a field guide developed in-house (Minkova and Vorwerk 2015). The habitat unit dimensions are measured using a stadia rod and a meter tape.

Progress

Habitat units were classified and measured on 31 sample reaches in 2014. All data have been manually entered and proofed. The most complex streams had between 24-28 habitat units per 100 meters, while the simplest streams had between 4 to 8 units (Figure 15). Reaches ranged between 0 to 16 pools per 100 meters with an average of 6 (Figure 16). Further analysis of habitat complexity, pool frequency, and their importance to stream health and fish habitat may be explored in 2015.

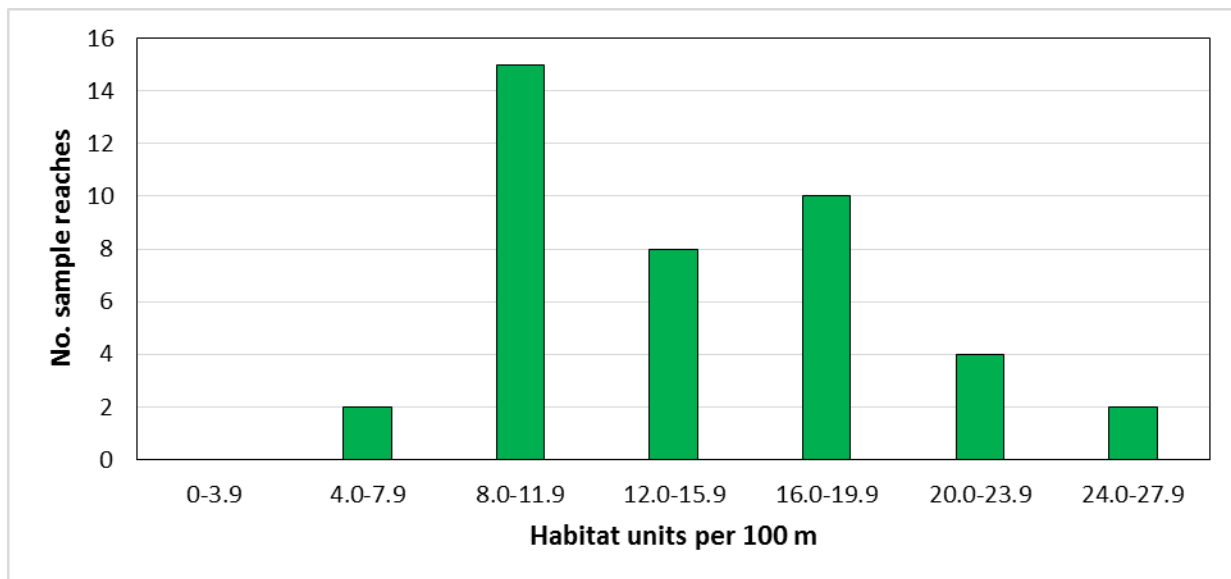


Figure 15. Number of habitat units, expressed per 100 meters of reach length, for the 41 sample reaches surveyed through 2014.

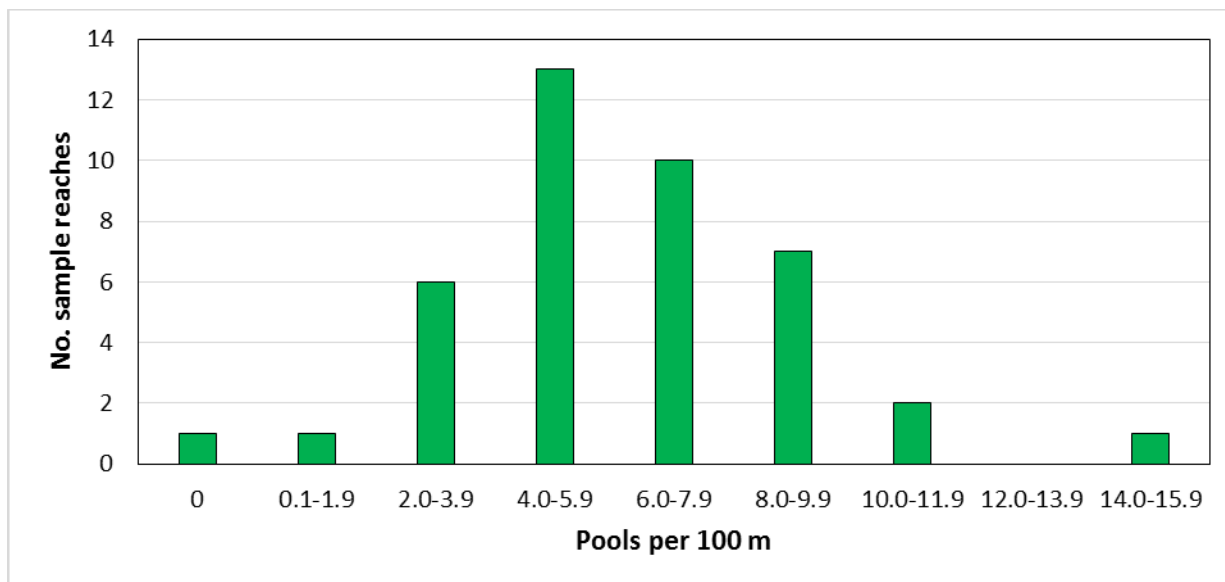


Figure 16. Frequency of pool habitat units, expressed as pools per 100 meters of reach length, for the 41 sample reaches surveyed through 2014.

TASK 9.0 CLASSIFICATION OF VALLEY AND CHANNEL TYPES

Valley and channel classification provides a foundation for interpreting channel morphology, assessing channel condition, and predicting responses to natural and anthropogenic disturbances (Montgomery and Buffington 1993).

The field protocol follows the Valley and Channel Types classification system of Montgomery and Buffington (1993), which 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. DNR follows the Montgomery and Buffington (1993) channel type classification to distinguish six channel types: cascade, step-pool, plane-bed, pool-riffle, regime (dune-ripple), and braided.

Progress

Thirty-three sample reaches were assessed for valley type, and thirty-one sample reaches were assessed for channel type in 2014. Thirty-two of the channels are in the alluvial valley type, and one is in a colluvial valley type. To reduce the subjectivity and to speed up the classification, the field crew used a field guide developed in-house in 2014 (Minkova and Vorwerk 2015). Step-pool and pool-riffle were the dominant channel types found on the OESF (Figure 17). Further analysis of valley and channel types and their importance to stream health may be conducted in 2015.

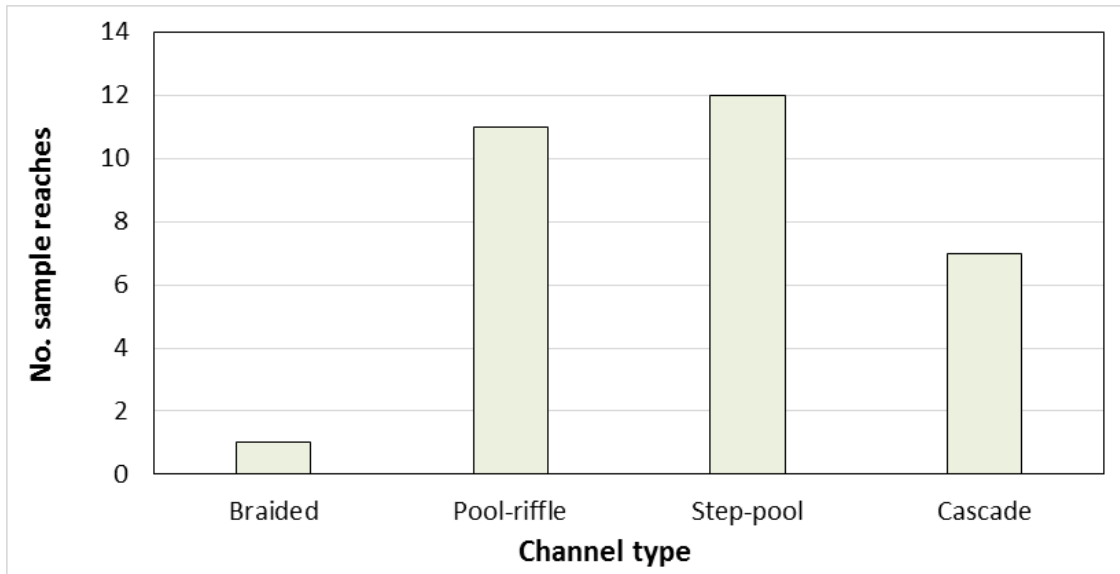


Figure 17. Number of sample reaches per channel type for the 31 sample reaches surveyed in 2014.

Implementation of Hydrology Monitoring Protocol and Preliminary Summary

Stream flow, or discharge, is an important determinant of water quality and aquatic habitat conditions. The amount and timing of water flow affects channel morphology, concentrations of chemical elements such as dissolved oxygen, and distribution of habitat elements such as in-stream large wood. The life histories of many aquatic species are dependent on natural seasonal changes in stream flow.

For this project, stream flow is measured through permanent gage stations, consisting of pressure transducers continuously recording water height, and a staff gage. The stations were installed in 14 reaches in 2013. In addition to the permanent installations, the stream discharge is measured in the field repeatedly throughout the year in the 14 reaches. These data will be used to produce annual hydrographs (a graph showing the rate of flow versus time past). The work will involve 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.

This is the most time consuming and technically sophisticated monitoring protocol in the project as it requires frequent field visits to capture variety of water levels, use of complex electronic equipment, instrument downloads in the field, and recording variety of gage station data and metadata at each visit.

TASK 10.0 DISCHARGE MEASUREMENTS

Stream discharge, or streamflow, is the volume of water that moves over a designated point in a fixed period of time. Discharge measurements are taken using Hach FH950[®] Flow Meters at a variety of flow levels following field procedures adapted from Butkus (2007) and Pleus (1999). A staff gage reading is taken before and after the discharge measurement. It will be used later to develop a relationship between the water level and discharge data (or rating curve). Changes in the channel form are noted at each visit because they affect the quality of the rating curve.

Progress

A total of 120 discharge measurements (an average of nine per gage station) were taken in 2014. Usually all 14 gaged sites were visited within a week (during one field trip to the OESF) and therefore the field trip typically captured similar flow conditions. Stream discharge ranged from 1 to 115 cubic meters/minute during the winter and spring and 0 to 1.8 cubic meters/minute in summer/fall. These seasonal differences in stream discharge are illustrated in the two graphs in Figure 18.

All stream discharge data and metadata were transferred to a Microsoft Access[®] database.

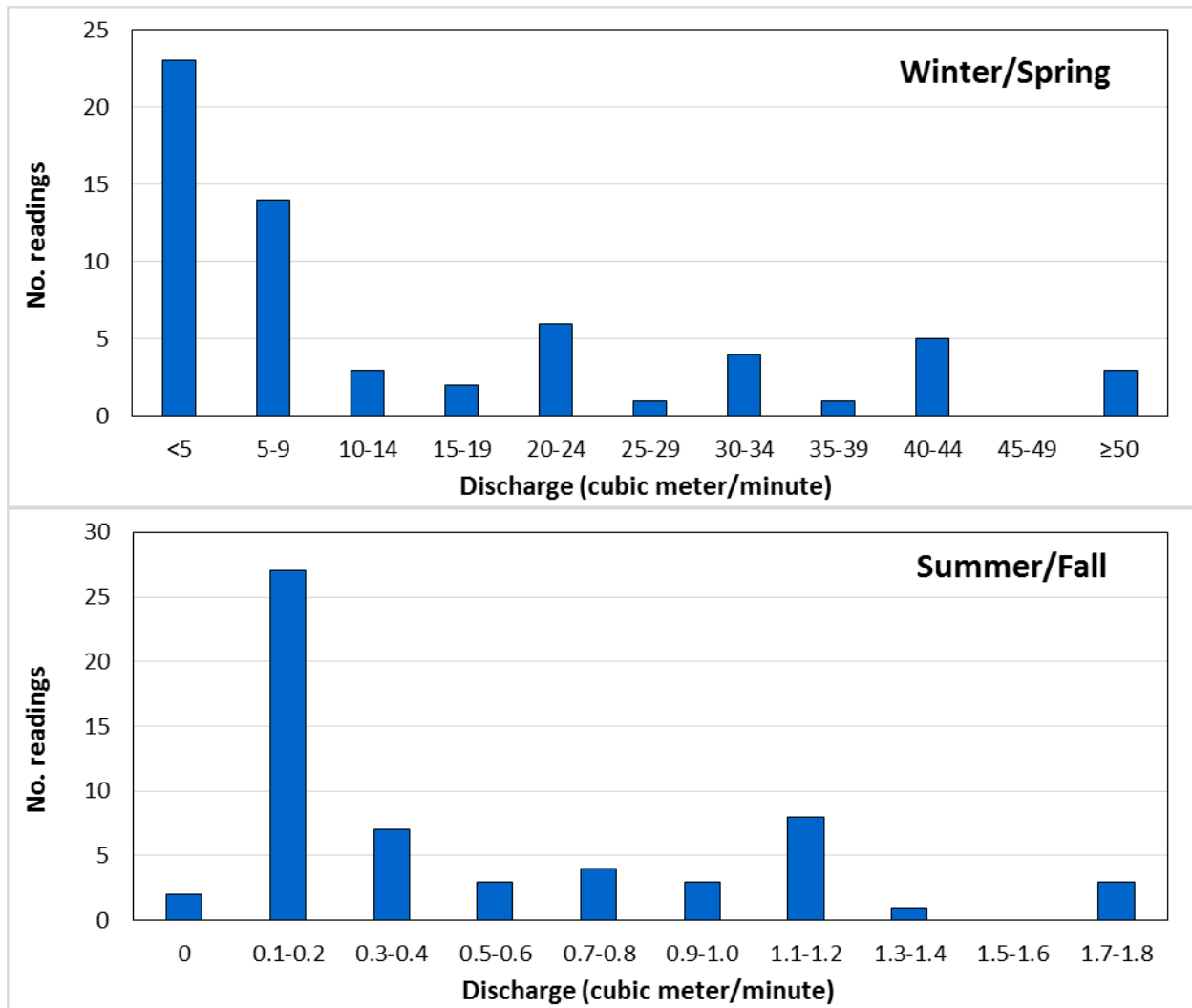


Figure 18. Distribution of all stream discharge readings from 14 sample reaches in 2014. Winter/Spring and Summer/Fall are graphed separately owing to the difference in magnitude of the discharge readings.

TASK 10.1 DATA DOWNLOAD FROM RECORDING GAGES

Water height is recorded every 15 minutes by two pressure transducers, one for water and one for barometric pressure. The actual water level is calculated using the barometric compensation of the water level measurement. The data are downloaded using a shuttle device. A measurement from the nearby staff gage is taken at each download.

Progress

The recording gages were downloaded during each visit at which a discharge measurement was taken—an average of nine times per gage station between December 2013 and January 2014. The recording gages were inspected for structural damage at each visit. The scheduled annual maintenance of the recording gages took place in October and November 2014. All gage intake sections were cleaned, and two damaged intake sections were replaced. The original staff gages,

made in house of metal conduit, were found to corrode quickly, and the measurement scale was difficult to read. In December 2014, they were replaced with USGS staff gages made of iron and finished with porcelain enamel. The elevation of the new staff gages was recorded relative to the site reference point.

All data and metadata, including instrument maintenance and calibration information, were transferred to an Access database. An example of the recorded hydrology data from one gage station for one year is presented in Figure 19. Data quality control, adjustments, and analyses will be conducted in 2015.

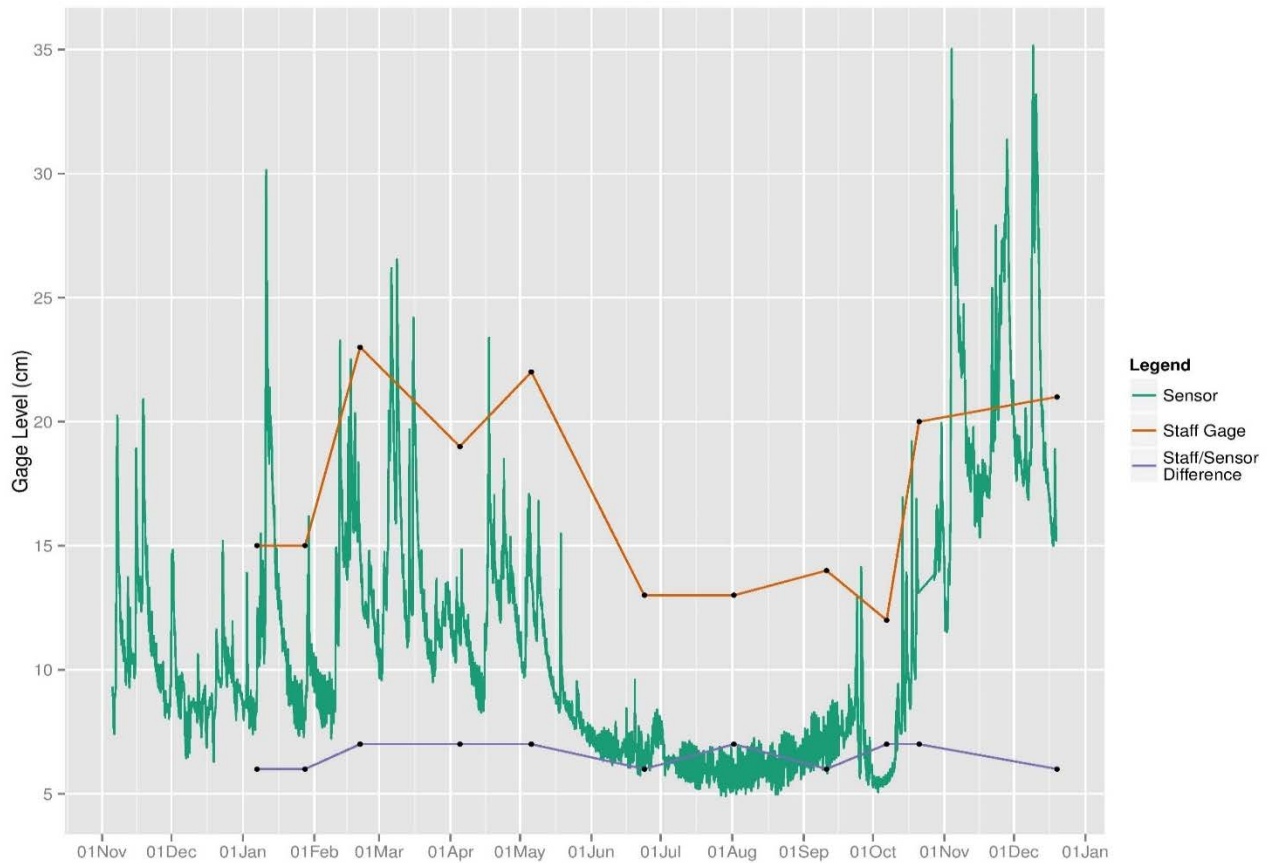


Figure 19. An example of raw, unadjusted data produced from a recording gage (green line) and staff gage readings (yellow line). Data shown are from November 2013 to December 2014 in basin 717. Graphs such as this one are used during the data quality-control process to evaluate the consistency of the relationship between recording gage and staff gage readings over time (blue line).

TASK 10.2 CROSS SECTION STABILITY SURVEYS

Task 10.2

In order to track the stability of the gages and cross-sections over time, it is important to perform elevation surveys of the water level sensor and staff gage as well as the cross-section itself

multiple times over the life of the gaging station. The field techniques described by Kenney (2010) were implemented.

Progress

The first cross-section and instrument stability survey of all 14 gage sites was performed in December, 2013. A second survey of all sites was done in July, 2014. All data and metadata were transferred to an Access database. The data will be analyzed in 2015.

TASK 10.3 INSTRUMENTS CALIBRATION

Task 10.3

The stream discharge field protocol requires annual calibration check of pressure transducers and stream flow meter.

Progress

All pressure transducers were removed from the field in November 2014 for visual inspection and calibration check in the office. The water level transducers were placed in a large cooler with known water depth to record every 15 min for 24 hours. The barometric pressure transducers were placed on top of the cooler recording at the same intervals. The recorded data were compared between the sensors and with the known water level. No serious damages or biofouling was noted. During the 24-hour office calibration, all sensors performed according to manufacturer specifications. Based on these results and consultation with the manufacturer, and the significant risk of not returning the sensors at the exactly same height in the streams, we decided not to remove them in the future unless the downloaded data show problems. All sensors were returned in the reaches in November making sure they were placed back at the same elevation (hanging from the same cable length).

The Hach FH950® Flow Meter was sent to the vendor for calibration after the end of the field season. Given the vendor's recommendations, our consultation with other users, the high cost of calibration, and the overall good performance of the instrument, we decided to calibrate the instrument every five years unless problems are noticed. The stream discharge field protocols will be updated with this new information.

Implementation of Riparian Microclimate Monitoring Protocol

Many riparian-associated plant and animal species require moist, cool, relatively stable conditions for their reproduction and survival.

TASK 11.0 RIPARIAN MICROCLIMATE MONITORING

The riparian microclimate is monitored in ten sample basins in the OESF through two sampling transects on opposite banks of the sample reach extending from the stream to 60 m into the adjacent riparian forest. Each transect consists of five data loggers housed in a plastic bucket mounted on a T-bar fence post approximately a 1.5 m above ground. Air temperature and relative humidity are recorded every 2 hours throughout the year with 2-channel HOBO® Pro v2 data loggers. The data are downloaded at least annually.

Progress

All sample reaches were visited twice during the 2014 field season and data were downloaded using an optical shuttle. No loggers were lost and only minor damages to the housing were observed, likely caused by animals.

All data and metadata were transferred to an Access database. Summary of the microclimate data records for the entire sampling period are presented in Table 2. The data will be processed in 2015.

Table 2. Number of microclimate temperature and relative humidity records per month. Note that the data from late 2014 will be downloaded in 2015.

Year	Month	Temperature Records (no.)	Relative Humidity Records (no.)
2013	September	7,488	7,488
2013	October	15,062	15,062
2013	November	34,918	34,918
2013	December	36,084	36,084
2014	January	36,126	36,126
2014	February	33,095	33,095
2014	March	36,084	36,084
2014	April	34,920	34,920
2014	May	36,084	36,084
2014	June	35,147	35,147
2014	July	36,404	36,404
2014	August	34,299	34,299
2014	September	34,952	34,952
2014	October	10,856	10,856
TOTAL		421,519	421,519

Implementation of Riparian Vegetation Monitoring Protocol

Stream-adjacent vegetation provides shade, controls riparian microclimate, supplies large wood and leaf litter to the stream, and stabilizes stream banks.

TASK 12.0 RIPARIAN VEGETATION MONITORING

Riparian vegetation is sampled in fixed area permanent plots along two transects on opposite banks of the sample reach extending 60 m away from the stream (Figure 20). The overstory vegetation (tree species and diameters) is sampled in 18 ha (44 ac) rectangular plots. Percent cover of forbs, ferns, low shrubs, and tall shrubs by species are visually determined on 1 m × 1 m plots. The canopy dynamics is sampled through hemispherical canopy photos taken at 0, 10, 20, 40 and 60 m distances from the stream.

Riparian vegetation is scheduled to be measured near all reaches in the summer every three to five years. However, the fieldwork may be partially substituted with remote sensing as new data becomes available. For example, overstory height, canopy complexity, and stream associated gap size and frequency will be documented through repeated light detection and ranging (LiDAR) data using analysis with the program Fusion (McGaughey 2009).

Progress

Riparian vegetation was sampled in the ten microclimate basins in 2014. The data will be processed in 2015.

Sample Reach (A through F ≥ 100 m)

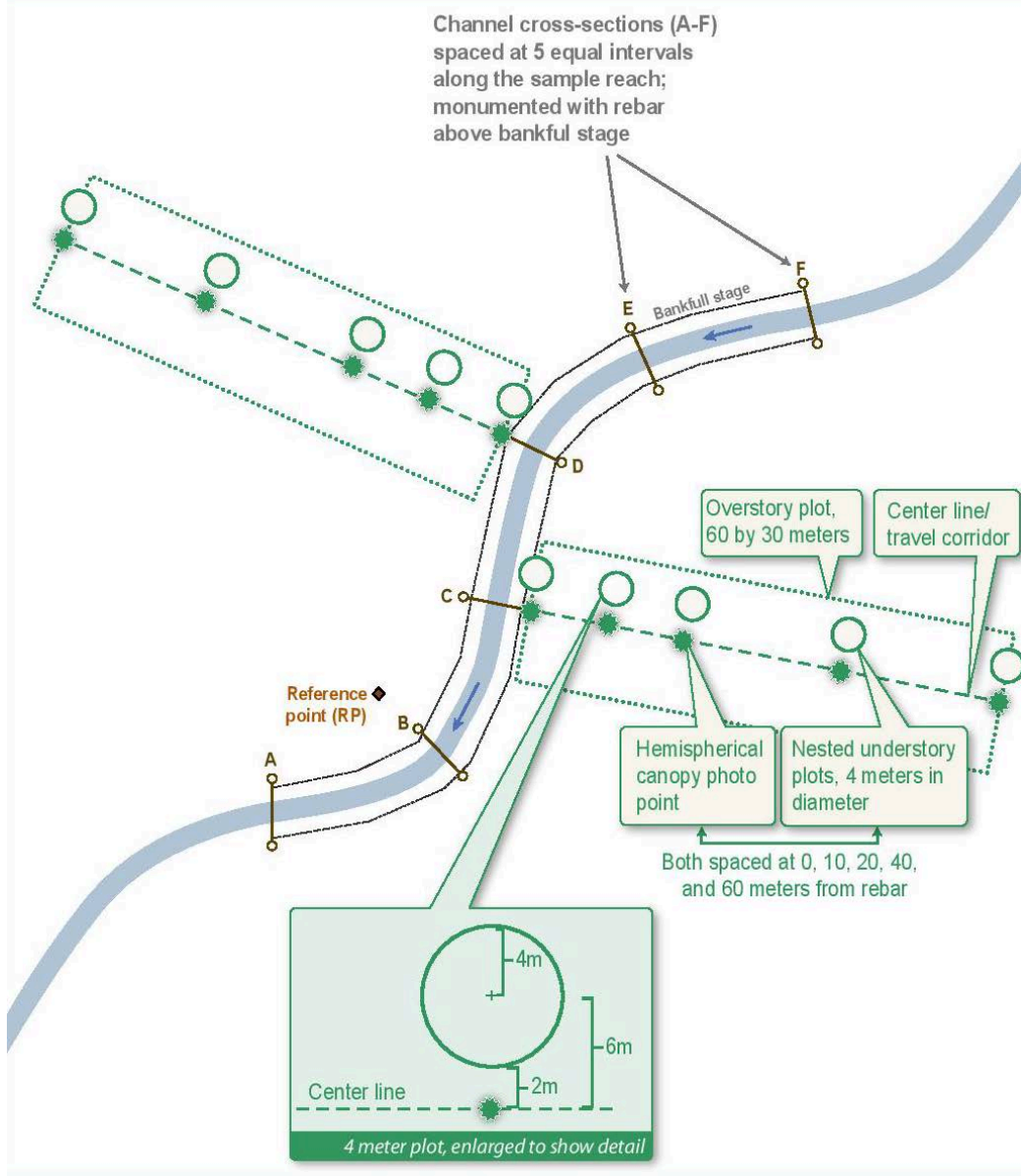


Figure 20. Schematic layout of riparian vegetation sampling plots

Finalizing Monitoring Protocols

TASK 13.0 FINALIZING 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 2013. The remaining two protocols identified in the study plan (microclimate and riparian vegetation) were under development in 2013 and were not peer reviewed. All protocols need to be finalized, formatted, and organized into a compendium.

Progress

In 2014, the project team finalized four monitoring protocols (site establishment, stream temperature, stream discharge field protocol, and hydrology data management) based on comments from reviewers. Drafts of the microclimate and riparian vegetation protocols were completed in 2014. One of the reasons for the delay in publishing the compendium of monitoring protocols was the further development and enhancement of the data management sections in all of the protocols. The new additions to the protocols are being developed by the newly hired OESF data manager. All protocols will be completed and published in the compendium in 2015.

The field guide on channel types and habitat units (Minkova and Vorwerk, in press), which was drafted in 2013, has been finalized and submitted for print.

Data Management

This monitoring project accumulates large amount of data that differ in type (such as stream temperature, riparian vegetation, habitat units) and in sampling frequency (for example, stream temperature sensors recording every hour whereas stream morphology data is expected to be collected every five years). The complexity and amount of monitoring data, combined with the project's longevity and the DNR's reporting commitments, requires a disciplined and efficient data management process.

During 2014, significant progress was made in the area of project data management, including development of six new relational databases, population of the new databases with all data collected through 2014, and development of data management protocols that include data quality-control procedures.

The new databases and data management processes developed in 2014 will greatly improve the efficiency of data management and the accessibility of data in 2015 and beyond. Additionally, 2014 was the final year in which data and metadata were collected on paper field forms. Beginning with the 2015 field season, data will be collected electronically using a ruggedized field data recorder.

TASK 14.0 DATABASE DEVELOPMENT

Develop databases for all monitoring protocols and populate them with the collected data and metadata.

Progress

DNR developed six relational databases in 2014 (Table 3). Each of these databases was designed for a specific monitoring protocol. The primary purpose of these databases is to store and manage all data and metadata associated with each component of the project. The databases have features to facilitate importing and exporting data, and they produce various data summaries including reports to assist fieldwork planning. For functions beyond the scope of a database, such as statistical analyses and graphing, the databases are designed to export data in the appropriate formats.

Table 3. Six relational databases developed in 2014.

Database	Data stored and managed	Additional database features
Stream Temperature	Stream temperature data and accompanying air temperature data collected hourly by a total of 108 data loggers, metadata, manually collected quality control data	Interactive quality control procedures, data formatting for graphing, processes for importing logger data
Microclimate	Air temperature and relative humidity data collected by 100 data loggers at a two-hour intervals, metadata	Interactive quality-control procedures, data formatting for graphing, processes for importing logger data
Stream Geomorphology	Descriptive data and metadata for each of the 54 sample reaches, stream cross-section depth profile and substrate data, erosion data, channel gradient data	Quality-control reports
Hemispherical Photography	Metadata, filenames, and file locations for all hemispherical photos taken in the 54 sample reaches	
Habitat units and Large Wood	Habitat unit survey data and large wood and debris jams data for the 54 sample reaches, metadata	
Hydrology	For 14 of the sample reaches: data from continuously recording steam gages, staff gage data, stream discharge data; gage elevation stability data, field maintenance data, metadata	Processes for importing gage and discharge datafiles, data formatting for graphing, management of sensor calibration data, quality-control reports

The databases were developed using Microsoft Access. Microsoft Access was selected over other proprietary database formats for four main reasons: (1) Access has the functionality and flexibility needed to create all the types of databases required for this project, (2) Access is widely used and will be supported for the foreseeable future, (3) Access is already available on all DNR computers and thus all project personnel will be able to use the databases without additional software purchases, and (4) using a single database format rather than multiple databases with specialized formats will reduce the need to train database users. Examples of database structures for manually collected data and continuously recorded data loggers are shown in Appendices 3 and 4 respectively.

Each of the new databases was populated with all data and metadata collected through the end of 2014. In cases where data were already stored electronically in tables, the data were imported directly to the new database, after which they were evaluated according to quality-control protocols. In other cases, data were still in a raw format (i.e., a proprietary data logger file format); these data were extracted and imported to the appropriate database following the appropriate data-management protocols. Table 4 contains a summary of the formats of data added to the six new databases.

Table 4. Sources of data and metadata added to the databases developed in 2014.

Database	Data Currently Stored in Database	Source of Data	Source of Metadata
Stream Temperature	All data and metadata through 31 December 2014	Majority of data were imported from an earlier database table; additional data were imported from raw data logger files	Excel spreadsheet records
Microclimate	All data and metadata through 31 December 2014	Imported from raw data logger files	Excel spreadsheet records
Stream Geomorphology	All data and metadata through 31 December 2014	Paper field forms; entered manually into database	Paper field forms; entered manually into database
Hemispherical Photography	All data and metadata through 31 December 2014	Paper field forms; entered manually into database	Paper field forms; entered manually into database
Habitat and Large Wood	All data and metadata through 31 December 2014	Paper field forms; entered manually into database	Paper field forms; entered manually into database
Hydrology	All data and metadata through 31 December 2014	Majority of data were imported from an earlier database; additional data were imported from raw data logger files	Most metadata were imported from an earlier database; additional metadata were entered manually

TASK 15.0 DATA MANAGEMENT PROTOCOLS

DNR is in the process of developing data management procedures for each monitoring protocol and including them as a section of the written protocols.

Progress

Data management protocols were drafted in association with each of the six new databases. After these protocols are finalized, they will be incorporated as a separate section in each respective monitoring protocol (Minkova and Foster in. prep). The data management protocols cover all aspects of post-collection data management, metadata management, processes for archiving raw data in its native format, and quality-control procedures, which are described in the next section. Progress toward developing data management protocols is summarized in Table 5.

Table 5. Status of data management protocols initiated in 2014.

Database	Data Management Protocol Status
Stream Temperature	Completed final draft
Microclimate	Revised draft completed
Stream Geomorphology	Initial draft completed
Hemispherical Photography	Initial draft completed
Habitat and Large Wood	Initial draft completed
Hydrology	Initial draft completed

Data management protocols define the procedures for handling data and metadata collected using field forms, data recorders, (e.g., discharge measurements collected using a flow meter) or data loggers (e.g., stream-temperature and water-level recording gages). Although the details of these protocols are unique to each dataset, all protocols contain the following information:

- **Data flow:** a step-by-step procedure covering all of the processes between the time data are collected and their long-term storage in a database. A separate process is described for each type of data (e.g., metadata, data collected on paper forms, and data collected electronically).
- **Data quality control:** a description of the specific quality-control procedures that have been developed for each dataset.
- **Database description:** a description of the database structure and all of the database tables that are used to store data and metadata.
- **Database products:** a description of the various data summaries produced by the database as well as metadata reports that are used to plan fieldwork.
- **Raw data archives:** a description of where and how data in its native, unprocessed format is to be stored.
- **Photographs:** procedures for labeling and storing digital photographs.

TASK 16.0 DATA QUALITY-CONTROL PROCEDURES

DNR is developing data quality-control (DQC) procedures for all monitoring protocols and implementing them on the collected data.

Progress

DQC procedures were created for all data collected for this project and appear in the data management protocols. The DQC procedures apply specifically to data that have already been collected; thus, they are separate from the quality-assurance and quality-control procedures used prior to and during field data collection (e.g., protocols for correctly installing field instruments and for consistently taking measurements).

Because the types of data and sources of potential error differ by dataset, DQC procedures are unique to each database and to the different types of data within each database. However, the DQC steps can be generalized as the following phases:

- **Field form transcription verification (for data collected on paper field forms and manually entered in the database):** A person (other than the one who initially entered the data) verifies the data by comparing the entered data to the values on the field sheets. This is done to identify any data-entry errors or handwriting misinterpretations.
- **Automated DQC checks:** Data are assessed using automated queries that identify extreme values, missing records, and other anomalies. All records identified as potentially erroneous are automatically flagged for closer inspection.
- **Review of flagged data:** All records flagged as potentially erroneous during the automated checks are examined individually in the context of neighboring data records. Records confirmed to be erroneous are then flagged to be excluded from all data analyses.
- **Data plots for visual DQC check (primarily used for time series data):** Data plots are specifically designed to reveal visible data irregularities that were not identified through the automated quality-control checks. This is a vital component of the DQC process because the human eye is able to detect irregular patterns in the data not detected by automated queries.

We implemented a data quality level identifier to label data records based on the level of DQC that they have thus far passed. Because it is more efficient to perform DQC procedures on large batches of data, this data quality identifier is useful for tracking the quality level of individual records until enough have been collected to perform large-batch DQC procedures. Data quality levels are 0 (raw data), 1 (provisional data), and 2 (published data) (Table 6). Current data quality levels for data collected through 2014 are shown in table 7.

Table 6. Data quality levels developed for data collected on the OESF.

Data Quality Level	Description
0: Raw	Unprocessed data. No QC checks have been applied, and no flagging has been added. These data are archived as raw data files or scanned field forms.
1: Provisional	Data have been imported to a database. Checks for completeness (e.g., data gaps within or between datafiles) as well as automated QC checks have been performed, and data have been flagged if any quality checks are not passed.
2: Published	All QC checks, both automated and manual, have been completed, and any potential problems in the data have been evaluated and resolved. All metadata is verified as complete and accurate. Data at this quality level are unlikely to change in the future.

Table 7. Current data quality levels for data collected through 2014 on the OESF.

Database	Data quality level
Stream Temperature	Level 2: Published
Microclimate	Level 1: Provisional
Stream Geomorphology	Level 1: Provisional
Hemispherical Photography	Level 1: Provisional
Habitat and Large Wood	Level 1: Provisional
Hydrology	Level 0: Raw Data

TASK 17.0 DATA SHARING

Monitoring data is shared online through DNR’s website and/or through regional and national online data centers.

Progress

All stream temperature data collected as part of this project are shared with the national network for stream temperature monitoring maintained by the [Forest Service’s Rocky Mountain Research Station](http://www.fs.fed.us/rm/boise/AWAE/projects/stream_temperature.shtml) (http://www.fs.fed.us/rm/boise/AWAE/projects/stream_temperature.shtml).

Precipitation and air temperature data from the three NOAA stations on the western Olympic Peninsula and stream discharge data from five USGS stations on major rivers on the western Olympic Peninsula are transformed and supplied to a [web harvester maintained by PNW](http://www.fsl.orst.edu/climhy/) (<http://www.fsl.orst.edu/climhy/>).

Project Staff and Budget

The project team for 2014 consisted of a principle investigator, three researchers, a data management specialist, two technicians, and volunteers from Washington Conservation Corps. The staff members and their primary roles in the project for the reported period are listed in Table 8.

Table 8. Project team and their primary roles during the reported period.

Name	Affiliation	Project Position	Primary role in 2014
Teodora Minkova	OESF Research and Monitoring Manager, DNR	Principal Investigator, Project Manager	Planning and overseeing fieldwork, training and supervising scientific technicians, project management (budget, hiring, and coordination), data management, outreach and communication, preparation of 2014 establishment report, finalizing all monitoring protocols
Alex Foster	Ecologist, PNW	Researcher	Scientific consultation, reporting, protocol development, review
Richard Bigley	Silviculturist, DNR	Researcher	Development of riparian monitoring protocol, training and supervision of WCC volunteers, fieldwork
Kyle Martens	Fish Biologist, DNR	Researcher	Scientific consultation, fieldwork
Warren Devine	Data Management Specialist, DNR	Data Manager	Designed and populated Access databases for all monitoring protocols, developed and implemented quality-control procedures for the stream monitoring data, revised hydrology data management protocol
Mitchell Vorwerk	Scientific Technician, DNR	Scientific Technician	Implementation of all field monitoring protocols, GIS support, data management, preparation of 2013 establishment report, finalizing of stream morphology and shade monitoring protocols
Ellis Cropper	Scientific Technician, DNR	Scientific Technician	Implementation of hydrology monitoring protocol, management of hydrology data, finalizing hydrology field monitoring protocol, implementation of other field monitoring protocols
Jacqueline Winter	Evergreen State College	Intern	Fieldwork
Andy Berger, Krystle Keese, Michele Borerck, Mary Bond		Field Volunteer	Field sampling of riparian vegetation

This report covers the period November 1, 2013 to December 31, 2014, which falls in two DNR fiscal years: FY2014 (July 1, 2013–June 30, 2014) and FY 2015 (July 1, 2014–June 30, 2015).

DNR provided funding for 22 staff months for scientific technicians; paid for lodging and travel expenses for the technical and research staff; and funded the purchase of necessary field equipment, supplies, and field gear.

DNR provided funding for two new permanent full-time positions with the OESF Research and Monitoring Program who work on this project part time—a data manager was hired in July 2014 and a fish biologist was hired in December 2014.

During the reported period, PNW contributed in-kind support through scientific expertise for finalizing two field protocols and through fieldwork estimated at about 640 hours.

Riparian vegetation sampling was conducted with assistance from four volunteers.

Communication and Outreach

Within DNR

The project was presented to DNR Olympic Region in March 2014 as part of annual update on OESF Research and Monitoring Program.

A field tour was organized for managers from Olympic Region and Forest Resources Division in the fall of 2013. The main purpose was to demonstrate the field installations and methods, explain the relevance to management needs, and discuss logistical support for the next field season.

Research Partners

A field tour was organized for the University of Washington school of Environmental and Forestry Studies and the Director of Olympic Natural Resource Center in June 2014. The research partnership and educational opportunities were discussed.

A group of PNW researchers and managers from Olympic National Forest and Forest Service Region 6 visited project installations in August 2014 to discuss potential collaboration and data sharing.

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

Students

One intern from The Evergreen State College conducted fieldwork on the project and prepared a class project on individual monitoring components.

A one-day field visit was organized for a National Geographic Student Expedition (Figure 21). Twelve high-school students were given an overview of ecological monitoring on state lands and had opportunities to take field measurements and learn about riparian and aquatic habitat indicators.



Figure 21. National Geographic Student Expedition on a field tour in the OESF.

Website

A project website is maintained and updates on the project are regularly posted. The study plan, 2012 and 2013 establishment reports, project status, and recent presentations are available at http://www.dnr.wa.gov/ResearchScience/Topics/TrustLandsHCP/Pages/lm_hcp_oesf_main.aspx.

Next Steps

From January 2015 until the start of the next field season in May 2015, the project team will focus on the following:

- Finalizing Access databases and managing all collected data and metadata
- Finalizing and implementing quality control procedures for stream survey data, microclimate, hydrology, and riparian vegetation data
- Analyzing available stream temperature data
- Field visits to the 14 gage sites to measure water velocity and water levels and to download data from continuously recording levelloggers and barologgers
- Communication with potential research partners and monitoring collaborators

The main tasks for the 2015 field season:

- Downloading stream, microclimate and hydrology data from field data loggers
- Conducting field visits to the 14 gage sites to measure water velocity and water levels and to download data from continuously recording levelloggers and barologgers
- Developing rating curves for the gaged streams
- Finishing stream survey monitoring protocols in the OESF and in the ONP
- Repeating stream shade measurements in the 10 basins sampled in 2012

Other near-term project tasks:

- Finalizing and publishing all field protocols
- Exploring available remote sensing data (LiDAR, aerial photos, satellite imagery) for characterization of habitat attributes at the sample reaches and in entire sample basins
- Exploring available operational records and remote sensing data for characterization of management and natural disturbances in the sample basins

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Appendix 1. Completed Field Protocols

<i>Basin #</i>	<i>Permanent Cross Sections</i>	<i>Elevation Measurement Reference Points</i>	<i>Channel Gradient</i>	<i>Channel Width and Depth</i>	<i>Channel Coarse Substrate</i>	<i>Channel Azimuths</i>	<i>Stream Shade</i>	<i>Channel Sinuosity</i>	<i>In-stream Large Wood</i>	<i>Classification of Habitat Units</i>	<i>Channel and Valley Types</i>	<i>Active Erosion</i>	<i>Stream Temperature</i>	<i>Stream Discharge</i>	<i>Photo Station</i>	<i>Micro-climate</i>
145	2013	2013	2013	2013	2013	2013	2013	2013	2013	2013		2013	2013	2013	2013	2013
157	2013	2013	2013	2013	2013	2013	2013	2013	2013	2013		2013	2013		2013	2013
158	2014		2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2013		2014	
165	2013	2014	2013	2013	2013	2013	2013	2013	2013	2013		2013	2013	2013	2013	
196	2013	2013	2013	2013	2013	2013	2013	2013	2013	2013		2013	2013	2013	2013	2013
328	2013	2013	2014	2014	2014	2014	2014	2013	2014	2014	2014	2014	2013	2013	2013	
433	2013	2013	2013	2013	2013	2013	2013	2013	2013	2013		2013	2013	2013	2013	2013
443	2013		2014	2014	2014	2014	2014	2013	2014	2014	2014	2014	2013		2013	
488	2014	2013	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2013		2014	
542	2014	2013	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2013		2014	
544	2013		2013	2013	2013	2013	2013	2013	2013	2013		2013	2013	2013	2013	
545	2013	2013	2013	2013	2013	2013	2013	2013	2013	2013		2013	2013		2013	2013
550	2013	2013	2014	2014	2014	2014	2014	2013	2014	2014	2014	2014	2013		2013	
567	2014	2013	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2013		2014	
568	2013	2013	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2013		2013	
582	2013	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2013		2013	
584	2013		2014	2014	2014	2014		2014	2014	2014	2014	2014	2013	2013	2013	
597	2014	2013	2014	2014	2014	2014		2014	2014	2014	2014	2014	2013		2014	
605	2014	2013	2014	2014	2014	2014		2014					2013		2014	
619	2014	2013											2013		2014	
621	2014	2013	2014	2014	2014	2014	2014		2014	2014	2014	2014	2013		2014	
625	2014	2013	2014	2014	2014	2014	2014		2014	2014	2014	2014	2013		2014	
637	2014	2013	2014	2014	2014	2014	2014		2014	2014	2014	2014	2013		2014	
639		2013											2013			
642	2013	2013	2014	2014	2014	2014		2013	2014	2014	2014	2014	2013	2013	2013	2013
653	2014		2014	2014	2014	2014	2014		2014	2014	2014	2014	2013		2014	
658													2013			
687	2013	2013						2013					2013		2013	

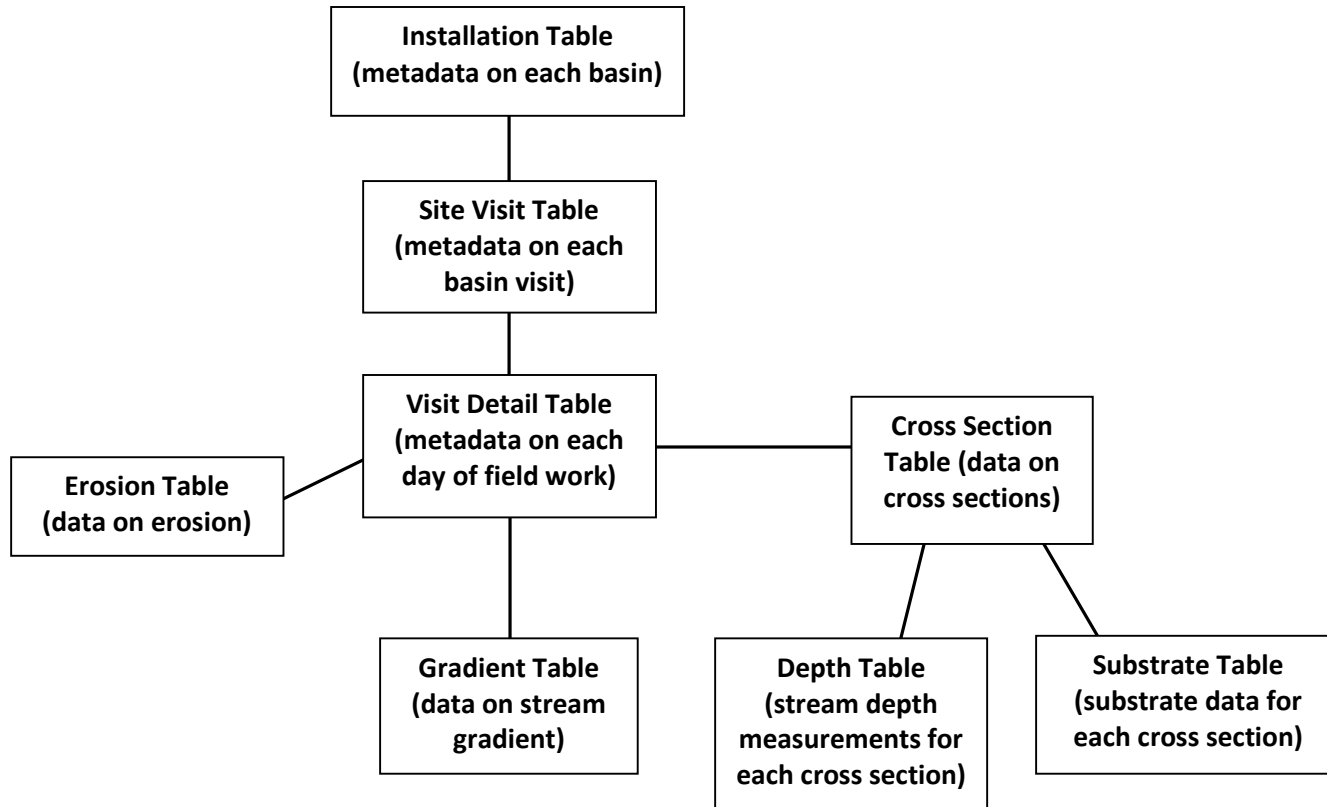
<i>Basin #</i>	<i>Permanent Cross Sections</i>	<i>Elevation Measurement Reference Points</i>	<i>Channel Gradient</i>	<i>Channel Width and Depth</i>	<i>Channel Coarse Substrate</i>	<i>Channel Azimuths</i>	<i>Stream Shade</i>	<i>Channel Sinuosity</i>	<i>In-stream Large Wood</i>	<i>Classification of Habitat Units</i>	<i>Channel and Valley Types</i>	<i>Active Erosion</i>	<i>Stream Temperature</i>	<i>Stream Discharge</i>	<i>Photo Station</i>	<i>Micro-climate</i>
688	2013	2013											2013		2013	
690	2013	2013	2014	2014	2014		2014	2014	2014		2014	2014	2013		2013	
694	2013	2013	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2013	2013	2013	2013
716	2013	2013											2013		2013	
717	2013	2013	2013	2013	2013	2013	2013	2013	2013	2013		2013	2013	2013	2013	
718	2014	2013	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2013		2014	
724	2013	2013	2014	2014	2014	2014	2014	2013	2014	2014	2014	2014	2013	2013	2013	2013
730	2014		2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2013		2014	
737	2013	2013	2014	2014	2014	2014	2014	2013	2014	2014	2014	2014	2013	2013	2013	2013
750		2013											2013			
760	2013	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2013		2013	
763	2014	2013	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2013		2014	
767	2014	2013	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2013		2014	
769	2013	2013	2013	2013	2013			2013	2013	2013		2013	2013	2013	2013	
773	2014	2013	2014	2014	2014	2014		2014	2014	2014	2014	2014	2013		2014	
776	2013	2013	2014	2014	2014	2014		2014	2014	2014	2014	2014	2013		2013	
790	2013	2013	2013	2013	2013	2013	2013	2013	2013	2013		2013	2013	2013	2013	2013
796	2014	2013	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2013		2014	
797	2014	2013	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2013		2014	
804	2014	2013	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2013		2014	
820		2013											2013			
844	2014	2013	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2013		2014	
BOG		2013											2013			
HOH		2013											2013			
QUEETS		2014											2013			
SFHOH													2013			
2013 Total	26	42	10	10	10	9	9	17	10	10	0	10	54	14	26	10
2014 Total	20	4	32	32	32	31	26	22	31	30	31	31	0	0	20	0
TOTAL	46	46	42	42	42	40	35	39	41	40	31	41	54	14	46	10

Appendix 2. Stream Temperature Metrics per Basin and Year²

Basin	Water Year 2014 Temperature Parameters (°C)				Mean Temperatures for 2014 (°C)			Daily Temperatures Ranges (2014)			Cumulative Degree Days (Jan.-Mar.)	Day of Water Year (2014)		No. days with temp. <4 °C
	Mean	Max.	Min.	7-DADmax	Winter	Spring	Summer	Winter	Spring	Summer		Max. Temp.	Min. Temp.	
145	8.8	13.7	0.7	13.7	5.8	8.9	12.5	0.6	0.6	0.5	533	318	130	18
165	9.1	16.4	0.2	16.1	5.8	9.2	13.6	0.7	1.4	1.8	527	308	130	20
196	9.6	16.9		16.6	5.5	9.2	13.8	0.9	1.6	2.3		284		
328	8.9	14.2	1.5	14.0	6	8.6	12.6	0.7	1	0.9	544	322	130	14
433	9.1	15	0.9	14.6	5.9	9.5	13.1	0.7	1.1	1.2	543	285	69	23
488	8.5		0.8		6.2	8.8		0.7	1.5		561		130	20
544	9.1	13.7	0.8	13.7	6.7	8.9	12.6	0.5	0.4	0.3	609	316	69	15
545	9	13.7	1.2	13.6	6.5	8.9	12.6	0.6	0.6	0.4	586	319	69	17
582	8.7	14.1	0.7	13.4	6.2	8.7	12.2	0.7	0.5	0.5	564	359	69	19
584	8.9	14.8	0.2	14.6	5.9	8.8	13	0.7	0.9	1	535	315	69	22
605	8.8	13.2	1.8	12.9	6.3	8.9	11.9	0.6	0.5	0.5	573	361	130	15
639	8		1.8		5.8	8.1		0.7	1.2		531		130	19
642	7.8	12.9	2.5	11.4	6	8.1	9.6	0.6	0.9	1.1	552	361	133	13
694	8.8	15.7	1.8	15.1	6.1	8.4	12.9	0.7	1.5	1.4	557	308	130	17
716	7.7	14.2	1.2	13.9	5	7.3	11.6	0.6	1.1	1.2	457	286	69	36
717	8.9	14.9	1.9	14.3	6.3	8.7	12.4	0.8	1.3	1.4	576	331	69	15
724	9.1	15.2	1.7	14.9	6.5	8.8	13	0.7	1.2	1.4	587	315	69	16
730	8.8		1.3		6.4	8.9	13.1	0.8	1.3	1.5	582		69	17
737	8.1	14.3	1.3	13.9	5.5	7.6	12.1	0.9	1.4	1	497	308	130	22
767	8.5		2.4		6.8	9		0.8	1		624		69	12
769	9.1	14.5	1	14.3	6.3	9	13.1	0.8	1	0.9	580	315	69	21
773	8.6	13.7	2.5	13.4	6.1	8.2	12.1	0.5	0.8	0.8	555	323	131	14
776	8.5	13.2	2.5	13.0	6.1	8.1	12	0.4	0.3	0.4	560	323	69	9
790	9.1	15.5	1.6	15.1	6.4	9	13	0.8	1.2	1.5	589	321	69	18
Bogachiel	9.5	16.3	1.4	16.1	6.1	9.2	14.5	0.6	1	0.8	560	323	130	18
Hoh	7.5		1.3		5.8	7.7		0.7	1		526		69	19
Queets			0.9		6.1	9.1		0.9	1.5		562		130	21
S.F. Hoh	7.8		1.2		5.7	7.9		0.6	0.9		515		69	20

² This is an abbreviated version of the full table of stream temperature metrics that were calculated: it shows 14 of the 40 metrics for a subset of the basins. Empty cells indicate that greater than 20 percent of the data for that time period were missing, and so the metric was not calculated. The blue-shaded bars represent the relative magnitude of the cell's value relative to the other data in that column.

Appendix 3. Structure of the Stream Geomorphology Database



Appendix 4. Structure of the Hydrology Database

