Washington State

Cooperative Monitoring, Evaluation, and Research Committee

(CMER)

Final Report

TYPE N STREAM DEMARCATION STUDY PHASE I: PILOT RESULTS

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For the

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EXECUTIVE SUMMARY

Non-fish bearing (Type N) streams are divided into seasonal (Type Ns) and perennial (Type Np) portions. Because forest practice regulations differ substantially between Np and Ns segments, an accurate estimate of the Np/Ns break is desirable.

The Type N Demarcation Study is intended to gather data to "refine the demarcation of perennial and seasonal Type N streams," a task identified in Schedule L-1 of the Forest & Fish Report (FFR). The pilot phase (phase 1) of this study was designed to:

- Test the adequacy and replicability of the pilot field protocol for identifying the Np/Ns break
- Estimate the size and variability of basin areas and other parameters
- Evaluate the potential for using basin and channel attributes to determine the Np/Ns break in the field

This information was collected for use in the larger statewide study envisioned to follow.

Ten cooperators (seven tribal, one state agency, and two timber industry) collected field data at a total of 224 Type N streams. Fifteen study areas were chosen by cooperators and included nine located on the Westside (one partially within the Coastal spruce zone) and six on the Eastside of the Cascade Crest. Within each study area, sites were selected either randomly or to revisit sites from past surveys. Data were collected during summer low flow conditions in 2001. At each study stream, field surveys documented the flow categories in each segment of 30 meters (~100 feet) or shorter. At each segment break channel width, depth, gradient, substrate, and associated features were recorded. The field data were subsequently analyzed to determine the location of three hydrologic transition points:

- Ch – the channel head
- Pd – the highest observed perennial water (may be continuous or discontinuous, flowing or standing). Pd is the regulatory Np/Ns break.
- Pc – the upper end of continuous perennial flow.

For consistency the basin area upstream from each Pd, Pc and Ch was delineated and determined on USGS topographic maps by a single technician within the ArcView GIS framework.

The statistical analysis summarized the field data, determined basin areas and variance, and alternative indicators of the Np/Ns break. All data distributions follow a lognormal distribution and appropriate transformations were used for statistical testing.

The key results of the pilot study are:

1. The pilot protocol is adequate for collecting observed field conditions associated with perennial flow. Adjustments and additions are necessary for

the Phase 2 effort; the most important are the inclusion of the channel head in all future surveys, random selection of study areas and survey routes, closer oversight of field parties, and more consistent QA/QC.

2. Observed basin areas are smaller than the FFR default basin areas. Median observed basin areas above the Np/Ns break (Pd) for the Eastside, Westside, and Coastal FFR default regions are 36, 7, and 2 acres, which are less than 15 percent of the FFR default basin area, and the average observed basin areas are 118, 24, and 8 acres, which are less than 61 percent of the FFR default basin areas. Comparison of observed basin areas to default basin areas is complicated by uncertainty over the whether the default values represent averages, medians, or some uncalculated and negotiated value.
3. Considerable variability was observed among basin areas. Observed basin areas differ significantly between FFR default regions. Average annual precipitation classes appear to provide a better means of stratification than either present default regions or ecoregions.
4. No channel characteristics were found to be reliable field indicators of the Np/Ns break. However, either the channel head or the distance downstream from channel head appear to be suitable field indicators and distance down slope from the basin divide may be a suitable map-based indicator.
5. The sample size required to estimate the average basin area with a 90% confidence interval and 10% precision depends on the stratification criteria. Assuming three cells (e.g. Eastside, Westside, Coastal) within the strata (e.g. FFR default regions or precipitation classes), the present FFR default regions and proposed precipitation class default regions require a minimum sample of 300 sites whereas, the use of distance downstream from divide to Pd as an alternative default criterion, requires a minimum sample of 30 sites.

If a statewide demarcation study with similar research objectives is pursued, insights from the 2001 pilot study support the following:

1. Utilize a field protocol similar to that used in 2001 with minor changes to include the channel head, debris-flow categories, and valley width.
2. In determining the survey route, randomly select the tributaries to be followed.
3. Stratify by average annual precipitation categories that would extend across the state.
4. Provide “equal probability” sampling from the population of N streams within each stratum.
5. Assess the adequacy of using other metrics as default criteria, e.g., channel head, seasonal stream length, or distance from divide.
6. Select a sample size that will provide the desired precision level.
7. Provide closer oversight of the field parties to insure consistent application of the protocol.

Expansion or modification of the scope of future studies beyond the demarcation focus of the pilot phase (e.g. in-channel habitat and functions) is feasible but will likely require additional changes to sampling approaches and field protocols.

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SECTION 1. INTRODUCTION TO REPORT

This document presents the results and recommendations of the Type N Stream Demarcation Pilot Study conducted by the Np Technical Group for the Cooperative Monitoring, Evaluation, and Research Committee (CMER) of Timber, Fish, and Wildlife (TFW). It is the first phase of a planned two-phase demarcation study to collect data to "refine the demarcation between perennial and seasonal Type N streams" (Forest & Fish Report, Schedule L-1). This phase of the study was designed to test the field protocol for use in the second data-collection phase and to obtain sufficient basin area data to estimate the sample size required for the second phase. The need for the second phase will be determined by the TFW Policy Committee (Policy).

This report has been reviewed and revised twice. The first review was by a CMER committee that revised the original report in mid-2003. The CMER report was submitted to Policy and Policy requested CMER to submit the report to the Scientific Review Committee (SRC) for review. The SRC returned three reviews (Appendix J) in September 2004. The CMER report was revised following SRC recommendations as outlined in the CMER-approved Action Plan (Appendix K) in December, 2004, resulting in the present version 7.5

The pilot study began as an effort to develop a field protocol and to test its adequacy while collecting sufficient data on basin area variability to determine a sample size for the following phase of the study. During the development of the scope of work for the pilot study, a set of hypotheses was developed to explore the ramifications of the data. The relative importance of the two aspects of the pilot study changed during the testing of these hypotheses as the large discrepancy between default basin areas and observed basin areas became apparent. Preliminary findings indicated the observed basin areas were significantly smaller than anticipated.

STUDY BACKGROUND

Forests and Fish

The Forests and Fish Report (FFR) establishes a water typing system that identifies headwater streams, which do not contain fish habitat, as “Type N” waters (**Table 1)**. Type N waters are further subdivided into two categories:

- Perennial (“Np”) segments that do not go dry (including “spatially intermittent” channels that contain short alternating wet and dry reaches); and
- Seasonal (“Ns”) segments that go dry “in a year of normal rainfall” and are located upstream of the perennial reaches.

Table 1: FFR stream types

Type	Description
S	All waters within their ordinary high water marks inventoried as “Shorelines of the state.”
F	All segments of natural water within bankfull widths containing habitat used by fish at any life stage and at any time of year.
N	All water that are not S or F that are either perennial or connected by an above ground channel to waters connected to F or S streams.
Np	Perennial: Type N waters that do not go dry at any time during “a year with normal rainfall.”
Ns	Seasonal: Type N water that goes dry during “ a year with normal rainfall.”

These definitions (**Appendix A**) are in Chapter 222-16-030(3) and (4) in the Washington Administrative Codes (WAC). The FFR definition is unclear about the flow conditions necessary to qualify as an “Np” stream, e.g. continuous or discontinuous bodies of water, flowing or standing, open or piped channels.

The distinction between Type Np and Ns streams is important to rule implementation. Type Np streams are believed to provide habitat necessary to support the long-term viability of state-protected amphibians and water conditions that support harvestable levels of salmonids in downstream Type F (fish-bearing) streams (Gomi and others, 2002; Meyer and Wallace, 2001; May and Gresswell, 2003). For these reasons, the riparian areas along Type Np streams are given specific protections during forest practices (logging, road maintenance) that are not required for Type Ns streams.

Identifying the change from seasonal (Ns) to perennial (Np) waters, the Np/Ns break, is difficult except during the late summer-early fall, low-flow season. The following quote from the FFR Appendix B, 2 (iii) describes the anticipated problem of field identification and provides for an interim solution.

"*Making the determination [of the initiation point of perennial Type N waters] will require a better understanding of the natural variability of the spatially intermittent component of perennial streams. Factors such as stream associated amphibian habitat, sediment deposition patterns, channel morphology, water flow, non-migrating seeps or springs, and position in the basin will be observed in preparing a protocol for perennial stream identification. In those cases where non-migrating seeps or springs as the point of initiation of perennial flow cannot be firmly identified with simple, non-technical observations: (A) on the Westside, Type N waters will be "perennial streams" if they have a basin size in excess of the following minimums: 13 acres in the coastal zone … and 52 acres on the rest of the Westside; and (B) on the Eastside, Type N waters will be "perennial streams" if they have a basin size in excess of 300 acres*."

The extent to which field identification vs. basin area defaults are used as the regulatory water typing method is unknown.

The basin area defaults were developed from limited, unpublished field data collected by volunteers during the Forest and Fish negotiations in 1998. Some of the pre-2001 studies are summarized in **Appendix B** (Pre-2001 Studies) and their results presented in **Table 2**. Of the data discussed during the 1998 rule negotiations, only the Kapowsin data were documented. Therefore, the default basin area does not reflect the numbers in **Table 2**. The FFR authors recognized the scientific uncertainty underlying the selected default basin areas by placing this study in Schedule L-1 of the FFR.

Table 2: **Previous Studies**. Results of pre-2001 field studies to assess default basin areas. Of these only the preliminary Kapowsin data were available during the 1998 FFR negotiations. See summary report in **Appendix B**.

Study Area	Basin Areas (acres)	
	Average	Median
Kapowsin	41	17
SW Washington	20	13
Mid-Columbia	90	32
Chelan	68	39
Stillman Basin	11	10
Skagit	23	17

CMER, which is responsible for assessing the effectiveness of the rules, identified this issue as a top priority for adaptive management efforts and approved funding the project in fiscal year 2001. The Upslope Processes Scientific Advisory Group

(UPSAG) is responsible for managing the project and established the *ad hoc* "Np Technical Group" in June 2001 to manage the process and provide technical guidance.

Study Development

The Np Technical Group developed a pilot study protocol (Perennial Stream Survey Field Sample Protocol, version 1.21) to guide data collection during the August to October 2001 field season. The ten CMER cooperators listed in **Table 3** collected field data using the pilot study protocol from a total of 234 surveys in 224 headwater basins in both Eastside (300 acres) and Westside (52 acres) FFR default basin regions (**Figure 1**). The Coastal FFR default region (13 acres) was not specifically targeted during the pilot study but one Westside study area

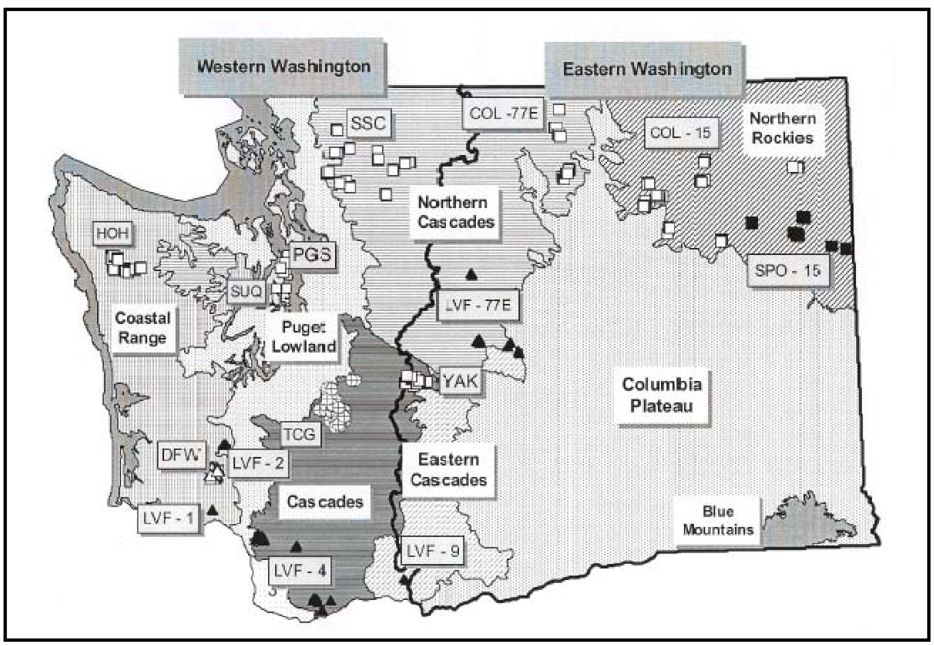


Figure 1: Location of study areas and USEPA Level III Ecoregions in Washington. The 15 study areas are identified by cooperator code (Table 3) and by ecoregion number. The heavy north-south line is the Cascade crest; it divides the state into Eastern Washington (Eastside) and Western Washington (Westside) FFR default regions. The Coastal spruce zone FFR default region is not shown but occurs as a band along the Pacific coast.

Table 3. **Cooperators providing field data** for the 2001 Type N Demarcation Study by name and code. The surveys provided by each cooperator are classified by location, survey type, and information provided. The total sample size available for different analyses varies with survey type, provided information, and basin delineation. Terms and procedures are described in the text. *The HOH study area includes both the Coastal and Westside default regions and in some analyses are included in both regions.

Cooperator	Study Areas		Survey Type					Surveys including Transition Points			Surveys for which Basin Areas were Delineated		
	FFR Default Region	Eco-region	Total	Initial	Repeat (Surveys / Sites)	Single Thread	Total Tributary (Surveys / /Sites)	Pc	Pd	Ch	Pc	Pd	Ch
Colville Confederated Tribes (COL)	E	15	7	7		7		7	6	0	6	5	0
	E	77E	6	6		6		5	6	3	5	6	3
Department of Fish and Wildlife (DFW)	W	1	42	34	8/3	29	5/2	31	37	37	18	23	24
Hoh Tribe (HOH)	C*	1	22	22		22		19	22	18	17	19	12
Longview Fibre Co. (LVF)	E	77E	15	15		15		14	15	11	10	12	9
	E	9	2	2		2		2	2	0	2	2	0
	W	1	2	2		2		2	2	0	2	2	0
	W	2	4	4		4		4	4	3	4	4	3
	W	4	16	16		16		16	16	9	16	16	10
Port Gamble S'Klallam Tribe (PGS)	W	2	4	4		4		4	4	3	1	1	0
Spokane Tribe (SPO)	E	15	6	6		6		5	6	0	4	6	0
Skagit System Cooperative (SSC)	W	77W	27	26	1/1	21	5/2	26	26	25	21	23	22
Suquamish Tribe (SUQ)	W	2	7	6	1/1	6		6	6	3	6	6	1
The Campbell Group (TCG)	W	4	61	61		61		54	61	28	50	57	20
Yakama Nation (YAK)	E	4	13	13		13		13	13	12	13	12	12
TOTAL	**3**	**7**	**234**	**224**	**10/5**	**214**	**10/4**	**208**	**226**	**152**	**175**	**194**	**116**

includes the boundary with the Coastal default region and was placed in that region to estimate its parameters. Coordinated training and quality control/assurance (QA/QC) programs were implemented on a limited basis because of time constraints.

An analytical protocol was developed during the fall and winter of 2001 and collation and analysis of the field data began in February 2002. The purpose of the analytical phase was to evaluate the 2001 pilot study protocol and the 2001 field data.

PILOT STUDY PURPOSE

The dual purposes of the pilot study are (a) to test a field protocol for collecting data on the initiation of perennial flow and (b) to collect sufficient data to assess basin area variability for use in the design of a statewide data collection effort envisioned to follow this pilot study. The objectives that achieve these purposes are listed in **Table 4.**

Table 4: **Objectives** of the Type N Stream Demarcation Study: pilot Phase.

1. Develop pilot field and analytical protocols for the collection and analysis of field observations.

2. To assess the:

- Adequacy and replicability of the pilot protocol.
- Variability of basin areas and other parameters.
- Basin and channel attributes that are potentially useful in defining the Np/Ns break.
- Refine protocols for the statewide study.

ASSUMPTIONS AND DEFINITIONS

A few key definitions and assumptions are necessary to assess Type N flow regimes and basin areas. Type N portions of streams are found above the uppermost extent of fish habitat, as defined in WAC 222-16-030(2) for Type F waters, and extend upstream to the channel head (**Figure 2**). As such, they are usually the smallest streams with few or no tributaries.

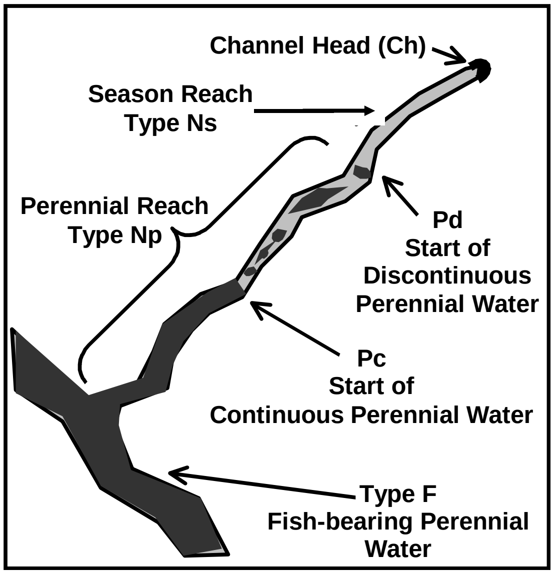


Figure 2: FFR water types and hydrologic points. The FFR water types are based on the distribution of fish habitat (Table 1). The hydrologic points define the limits of the seasonal and perennial water types.

Definitions

Hydrologic Points

The demarcation study includes three key hydrologic points that break flow conditions within a headwater stream (**Figure 2**):

Ch: The channel head is the highest observed point of channel incision or scour that separates unmodified forest floor from the channel. Ch marks the headward extent of flowing surface water with sufficient energy to erode a channel into surficial materials (Horton, 1945; Dunne, 1980). The pilot phase did not require cooperators to collect Ch data and it is important to this study because only surveys that reached Ch are assured to have properly identified the true Np/Ns break.

Pd: The highest observed point of perennial water (may be continuous or spatially intermittent [discontinuous], flowing or standing). The Pd is also the lowermost point of the continuously dry, seasonal (Type Ns) channel downstream from the channel head. Pd marks the headward extent of seepage in sufficient quantities to maintain storage in alluvium, dry season evapotranspiration, and small disconnected bodies surface water (Clement, 2003).

Pc: The highest observed point of continuous perennial water (may be flowing or standing). Pc was verified by a downstream survey to either the junction with Type F waters, or 200 meters whichever came first. Pc marks the headward extent of sufficient groundwater recharge to the channel to maintain continuous surface flow.

Channel Terms

The hydrologic points divide the channel into three reaches including one or more segments (**Figure 2**).

Reach: A portion of the channel having similar hydrologic characteristics. The reaches used in this report include:

Seasonal: The headward portion of the channel that goes dry during years of normal rainfall. It occurs between hydrologic points Ch and Pd.

Discontinuous Perennial: The headward portion of the channel that contains small (~5 cm) to large bodies of standing or flowing water throughout the year. It occurs between hydrologic points Pd and Pc and is Type Np waters.

Continuous Perennial: The portion of the channel that contains a mostly continuous body of flowing or standing water. It may contain dry segments as long as five meters (~16 feet) and occurs downstream of hydrologic point Pc and is Type Np waters.

Segment: A portion of the channel with similar flow characteristics identified during the pilot survey for purposes of description. Segment breaks occur at a change in flow characteristics or every 30 meters (98 feet) whichever is less.

Drainage Basin Terms

Drainage Basin: The drainage basin is the area that contributes water to a selected portion of a stream network (**Figure 3**). The term may refer to either surface water (watershed) or to subsurface water (soil and/or ground water). It is separated from adjacent drainage basins by the stream divide. Two drainage basin areas are referred to in this study: the *default basin area*, which is specified in the FFR (see quote on page 3) for a state default region and the *observed basin area,* which is the area delineated and measured on topographic maps in association with one or more study streams based on data provided by this study.

Stream Divide (Divide): The line of highest elevation on the land surface between adjacent drainage basins that separates surface water flowing toward one stream from that flowing toward the adjacent stream.

Subsurface Divide: The line of highest elevation on the top of the saturated zone between adjacent subsurface drainage basins that separates soil and/or groundwater flowing toward one stream from that flowing toward the adjacent stream (**Figure 3**). It may or may not coincide with the stream divide. Perennial waters require sufficient subsurface storage capacity to deliver water to streams for the duration of the dry season (Asano and others, 2002; Smakhtin, 2001).

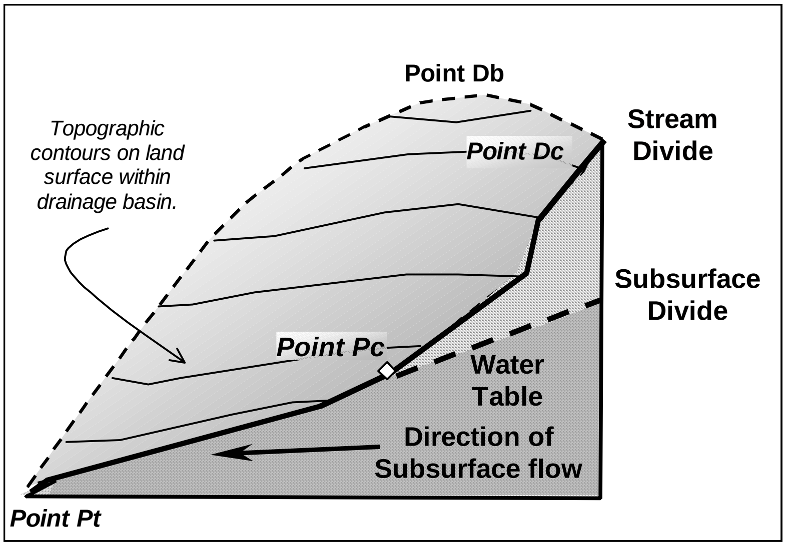


Figure 3: Block diagram showing the assumed relationship between surface and subsurface drainage basins. The subsurface divides are assumed to coincide with the surface divide with the subsurface water discharging to the stream to maintain perennial flow. The water table is shown intersecting the channel bed at Pc (the beginning of continuous perennial flow) but it may intersect the channel bed farther upstream at Pd (beginning of discontinuous perennial flow), which is not shown.

Data Stratification

The survey data from 224 sites (**Table 3**) were pooled into three progressively larger groups for analysis. The fundamental grouping for analysis was the study area and for assessing FFR default values the grouping was the default region. Ecoregions were a convenient grouping for study areas to assess spatial variability.

- **Site**: the location of an initial stream survey. A site may contain one or more (if surveys were repeated) surveys. A site includes the area encompassing the survey route, the downstream extension of the surveyed stream to its confluence with a larger tributary, and the delineated basin areas. A total of 224 sites have one or more surveys.
- **Study Area**: A study area consists of randomly distributed sites provided by one cooperator and located within one ecoregion. This distinction is necessary because three cooperators provided survey data from sites in more than one ecoregion (Longview Fibre Corporation - LVF, Colville – COL - and Spokane Tribes - SPO) and the number of surveys within a study area is variable. The distribution of the 15 study areas appear in **Figure 1**. Study

areas were randomly sampled and their summary statistics should be representative for the study area. For this reason study areas were used to test for variation within and between ecoregions and FFR default regions using ANOVA.

- **Ecoregions**: Washington is divided into eight level III ecoregions by the EPA (**Figure 1**). Level III ecoregions are based on the analysis of the patterns and the composition of the vegetation, wildlife, and physical phenomena (geology, topography, climate, soils, land use, and hydrology) that affect or reflect differences in ecosystem quality and integrity (Omernik 1987, 1995). Study areas are located in seven of the eight ecoregions.
- **FFR default regions:** FFR divides the state into three default regions for which default basin areas are specified (**Figure 1**). Study areas occur in the 300-acre (Eastside) default basin region and the 52-acre (Westside) default basin area. No study area occurs exclusively in the 13-acre default region (Coastal). However, the HOH study area in Ecoregion 1 encompasses both the Westside and Coastal default regions (three study sites) and for the purposes of this study the HOH data are included in both the Westside and Coastal default regions.

Watershed Attributes

Watershed attributes are topographic variables that further describe the observed drainage basin and are measured from topographic maps and DEMs using ArcView. These variables are included as parts of the search for channel or basin attributes that are potentially useful in defining the Np/Ns break. They are measured, in meters, from the Np/Ns break (Pd) as shown in **Figure 4** and are defined as follows:

- <u>Divide Distance</u> is the map distance measured perpendicular to the topographic contours along the valley axis between point Pd and the divide at the point where the valley trace intersects it (point “Dc” in **Figure 4**) and referred to as Pd-distance.
- <u>Basin Width</u> is the average width of the drainage basin as estimated by dividing the observed Pd-area by the Pd-distance and is referred to as Pd-width (the half width estimates the average length of hillslopes in basin);
- <u>Basin Relief</u> is the height of point Dc above point Pd and is referred to as Pd-relief.

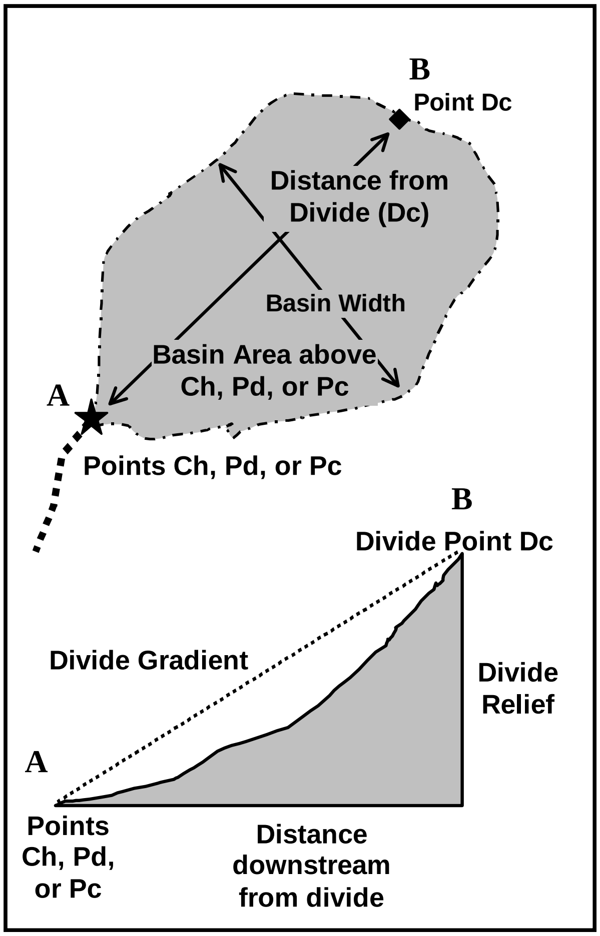


Figure 4: Watershed variables. Variables used to estimate the size of the subsurface reservoir maintaining perennial flow.

- Divide Gradient is the ratio of Pd-relief to Pd-distance and is referred to as Pd-gradient.

Assumptions

Drainage Basin Assumption

An implicit assumption underlying the use of basin area defaults in the FFR rules and this study is that for any perennial stream the subsurface divide and stream divide coincide. The drainage basin assumption allows the use of topographically defined default drainage basin areas to estimate the location of the Np/Ns break, which is probably controlled by discharge of subsurface water to the channel. Numerous studies have shown that drainage basin area is an important hydrologic control on perennial flow although other factors must also be considered (Smakhtin, 2001).

The drainage basin assumption may be reasonable for drainage basins located near primary drainage divides from which the land slopes away in both directions toward major streams. In these locations, the potential for subsurface inflow under the divide is probably low. However, the drainage basin assumption may not apply to all drainage basins (Freer and others, 1997). For instance, drainage basins located lower in the landscape where the potential for groundwater inflow along a variety of routes from areas higher than the secondary divides is possible (Winter, 1999). These relationships are shown schematically in **Figure 5**.

Where subsurface inflow to channels occurs at springs and seeps the location of points Pd and Pc are controlled by these features and their seasonal migration

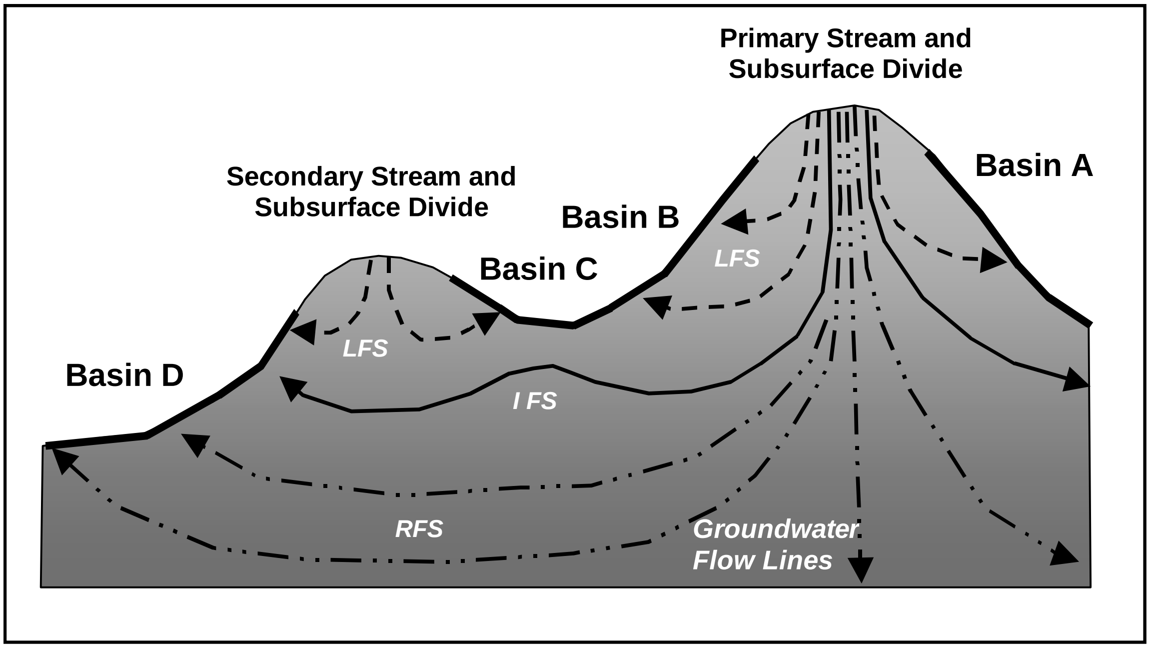


Figure 5: Groundwater flow regimens. A large dissected upland between two major rivers may support a complex groundwater flow system consisting of local flow systems (LFS) between hillslope and adjacent tributary stream [Basins B and C]; the intermediate flow systems (IFS) that may extend under local divides to discharge into a distant tributary stream [Basin D]; and the regional flow system (RFS) that extends from the major divide to the major stream [Basin D] and passes under local and intermediate divides.

inhibited. Some of these springs and seeps may be discharging groundwater that has flowed under the surface divide from upslope drainage basins.

Basin Delineation Assumptions

Two assumptions are necessary to determine and outline the boundaries of drainage basins on a topographic map – the topographic assumption (**Figure 6a**) and the symmetric basin assumption (**Figure 6b**). To the extent that these assumptions do not apply to the surveys within a study area, the statistical variability in basin areas and distances downstream increase for that study area.

The topographic assumption is that the topographic map accurately displays the location of stream channel and drainage divides in the vicinity of the study site. This assumption is necessary when using USGS topographic maps and digital elevation models (DEMs) as base maps on which to locate points and delineate basin divides.

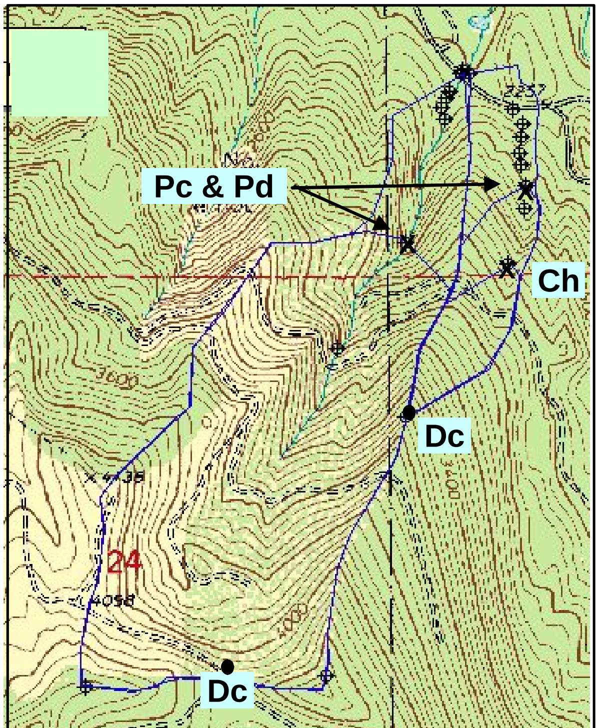


Figure 6A. Symmetric basin assumption. The stream divides for these study sites is drawn perpendicular to the topographic contours and symmetric to stream at points Pc, Pd, and Ch. The cooperator (TCG) provided a series of GPS points along the survey route that include Pd and Pc for both basins and Ch in one basin only. In the strongly defined topography of the Kapowsin tree farm, divides are easily and accurately delineated from topographic data. In lower relief areas, divide delineation becomes more difficult as illustrated in Figure 6B. Abbreviations defined in text.

The topographic assumption may not be valid for small streams that are unconfined, in valleys of low relief, and/or under a dense forest canopy (Meyer and Wallace, 2001). When the relief is too low to cause an undulation in the forest canopy, either the channel location and/or divides may not appear on the topographic map or their location, continuity, or configuration may be inaccurate. An example of this problem for a small, shallow valley on extensive side slopes of the Skagit River Valley is shown in **Figure 6b**.

The symmetric basin assumption is that the drainage divides above points Ch, Pd, or Pc extends upslope perpendicular to the contour lines on both sides of the valley as shown in **Figure 6a**.

The symmetric-basin assumption is not valid when the stream heads in a valley-side seep or spring. In this case, the drainage basin extends toward the divide on only one side of the valley.

Year of Normal Rainfall

Perennial Type N streams are defined in FFR as those that "do not go dry in a year of normal rainfall," though no definition of "normal rainfall" is provided. The precipitation for the 2001 water year (October 2000 through September 2001) can only be approximated for the study areas because of the lack of area meteorological stations. Based on the closest meteorological stations the 2001 water year precipitation is estimated to be around 85 inches for study sites in the Coastal region, 30 to 40 inches for most sites in the Westside and 8 to 15 inches for most sites on the Eastside. Westside and Eastside study areas located in the

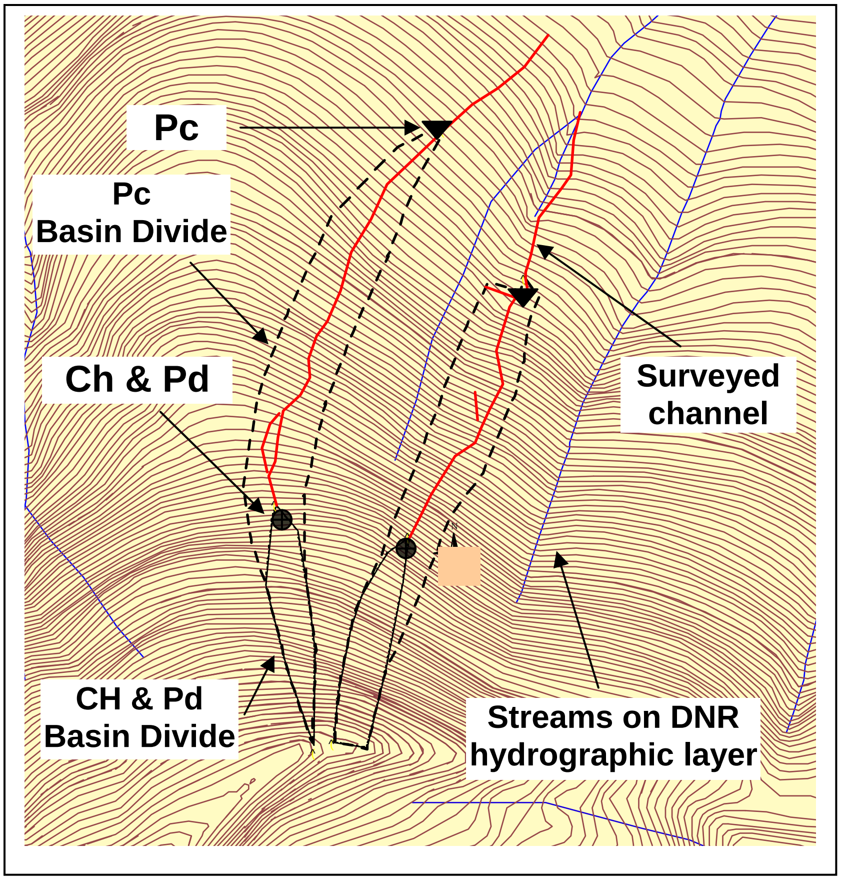


Figure 6b. Survey sites showing the discordance between surveyed streams and topographic contours on USGS 10-meter DEM. The surveyed streams follow lie in shallow valleys that do not appear beneath the dense forest cover. The hydrographic layer produced by the Washington Department of Natural Resources from aerial photographs and used for regulatory purposes shows a similar discordance to the topographic contours. (SSC sites 83W & 83A)

Cascade Range received more precipitation, around 50 to 60 inches. The pilot-study data must be evaluated with respect to "a year of normal rainfall" and interpreted accordingly. The analysis of the 2001 water year, which is presented in the Results section, indicates that the water year was unusually dry but that the summer months on the Westside were unusually wet.

Temporal Variability

The pilot study is confined to the 2001 field season and most basins were surveyed only once during 2001. As such, the data presented here are a snap shot in a continuum of seasonal and annual changes in stream discharge. This continuous variation in discharge can be assessed by investigating intra-annual and inter-annual variations in the surveyed basins.

Intra-annual variations describe the change in discharge in the headwater basins during the course of one year in response to seasonal variations in precipitation. Intra-annual (or seasonal) variations can be assessed by repeated surveys of the drainage basin from the end of one rainy season to the beginning of the next. The pilot protocol did not require cooperators to conduct repeat surveys although three cooperators (SUQ, SSC and DFW) conducted two or more repeat surveys in five basins. This sample is too small for analysis but it can be used to illustrate the temporal variability in Pc or Pd location.

Inter-annual variations describe the between year variations that result from variations in annual precipitation. Stream discharge regimens should differ between drought and wet years. These variations gave rise to the concern that the default drainage basin areas may not reflect conditions during a "year of normal rainfall." Inter-annual variations require repeat surveys of the same basin conducted at the same time of successive years. Inter-annual monitoring was not possible during a one-year project.

SECTION 2. METHODS

Field Data

Field data were collected following procedures (**Table 5**) in the pilot study protocol (**Appendix C**). Training and field assistance services were provided to tribal cooperators, other cooperators if requested, through the Northwest Indian Fisheries Commission (NWIFC). These services were designed to reduce potential variability in data collection and to identify the parts of the protocol producing the most problems. Time constraints precluded comprehensive protocol training for all cooperators.

Task	Procedure	Discussion
Sample Site Selection	Identify Type F/N breaks within study area; number breaks and select using a random number generator	Study sites are limited to lands managed under Forest Practice Rules. Other options to randomly select stream segments are available.
Identifying Survey Starting Point	Select a point on the sample stream with continuous perennial flow to mouth or where at least 200 m of continuous flow is visible. Select an easily identifiable point, such as a culvert, and survey upstream from this point.	Survey may be conducted in an upstream or downstream direction. Upstream is preferred direction.
Survey route (Selecting Tributaries)	In the Main Thread Survey, select the tributary with either the highest flow category or the highest channel category (see definitions in Appendix B). When tributaries are identical, flip a coin to select right or left tributary and alternate tributaries in further cases.	Two survey types possible – Main Thread and Total Tributary. In main thread only one channel is followed to head, In Total Tributary all tributaries upstream from the Type F/N break are surveyed.
Channel Segment Identification	New channel segments begin at changes in flow category, confluence with a tributary, or 30 meters, which ever is shortest.	At each change in channel segment, data on segment length and channel geometry and characteristics are recorded for the segment just surveyed. Features to be recorder are listed in Appendix B.
End Point Determination	Survey ends after 200 m of dry channel or the channel head are encountered.	Surveys were not required to continue to the channel head or to record the channel head if it was encountered.
QA/QC	Repeat surveys at different times, or with different crews, and by continuing to head of channel	Three survey components tested: 200 m distance, flow changes within sample period, and between crew variability

Table 5: Summary of the 2001 pilot protocol. The complete protocol appears in Appendix C.

Study Site Selection

Cooperators were free to choose one or more study areas according to their own selection criteria. Within each study area, the sites were randomly selected using the following procedure; the streams are numbered at one of the following locations:

1. Confluence between Type F and Type N streams
2. Intersection between streams and section boundaries

3. Confluence of second order streams
4. Previous stream surveys

Then, streams were selected using a random number generator. A few study sites were selected as being representative of the area and some were revisited basins from previous studies.

Survey and Segment Description

The intent of the survey was to identify points Pd and Pc and to describe the channel reach between them. To meet this intent, procedures were specified in the pilot study protocol for determining the survey type, direction, and route as well as for assuring the inclusion of the highest perennial water (point Pd) and the highest continuous perennial flow (point Pc). Each is covered here.

Two types of surveys are specified in the pilot study protocol – the Main Thread and the Total Tributary. The main thread survey was the project norm (**Table 3**) but each field party was encouraged to include one or more total tributary surveys. In the main thread survey, only one channel is surveyed whereas, in the total tributary survey, all non-dry tributaries are surveyed upstream from point Pc. The method for selecting tributaries to be included in the survey route depends on the survey direction.

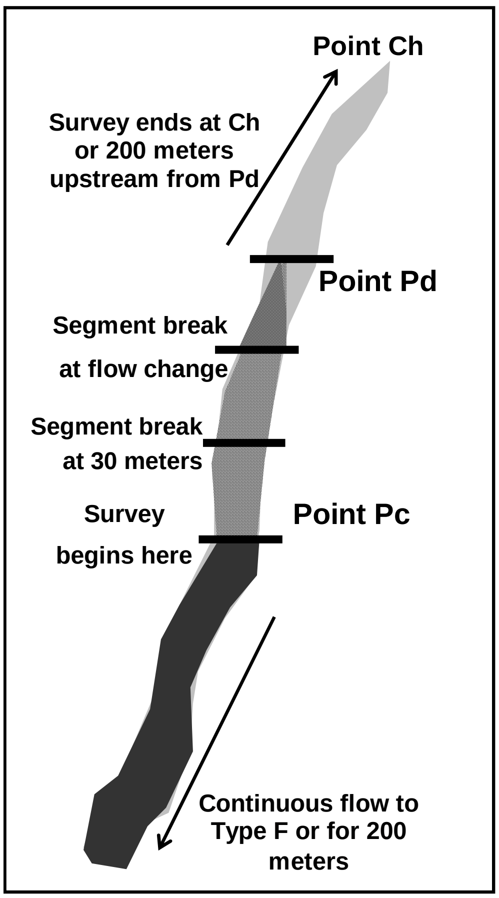


Figure 7: Survey reference points. Type N stream showing the requirements for survey end points and segment breaks at 30 meters or change in flow category.

The route followed by the field parties could be either in an upstream or downstream direction. Each direction had a different protocol for selecting tributaries to include in the survey. In the upstream survey, the channel with the higher flow category (see **Table 6** for flow categories) was to be followed; if two tributaries had similar flow categories, the choice was to be made by coin toss. Upstream from the first coin toss the selection of similar-flow tributaries is to alternate between right and left. The downstream selection method simply follows channels downstream to Pc. Some downstream surveys chose the initial channel head using the upstream selection method.

To assure inclusion of the highest perennial water (Pd) and the start of continuous perennial flow (Pc), the survey was to extend 200 meters (565 feet) upstream from the highest observed point of perennial water (Pd), which could be either spatially discontinuous or continuous flow, and 200 meters (565 feet) downstream from the highest point of continuous perennial flow (Pc) (**Figure 7**). The stream channel within the survey was subdivided into a series of segments for data collection and analysis. Segments were 30 meters long (~100 feet) unless a change in flow category (**Table 6**) reduced that length.

Table 6: **Segment Data**. Descriptive data required for each segment in a survey. Data are to be recorded at a segment break for the segment just completed.

Flow Category	
Flowing Water (FW)	Dry (D)
Standing Water (SW)	Unknown (U)
Flowing Pocket Water (FP)	Obscure (O)
Standing Pocket Water (SW)	
Channel Category	
Defined Channel (DC)	Piped Channel (PC)
Poorly Defined Channel (PDC)	No Channel (NC)
Modified Channel (MC)	
Channel Geometry	
Bankfull Width (BFW)	Upstream Gradient (%)
Bankfull Depth (BFD)	Downstream Gradient (%)
	Mean Segment Gradient (%)
Dominant Substrate	
Fine-grained [silt/muck/mud] (F)	Cobble (C)
Sand (S)	Boulder (B)
Gravel (G)	Bedrock (R)
Associated Features	
See Table 7	
Tributary Changes	
Record Flow and Channel categories	

Segment Observations

At each segment break, the field observations were recorded on the field data sheets (**Appendix C**). The geomorphic and hydrologic data collected for each segment are listed in **Tables 6** and **7** and described in **Appendix D**. Detailed

Table 7: Associated Features. List of features that could occur at flow-change segment breaks and be a potential cause of the flow change.

Spring (SP)	Gradient Break (GB)
Seep (SE)	Debris Slide (DS)
Wetland (WT)	Substrate Change (SC)
Wet Site (WS)	Road Crossing (RC)
Beaver Pond (BP)	Road Drainage Input (RD)
Perennial Tributary Junction (PJ)	Diversion (DI)
	Other (OT)

segment data were collected to (1) search for possible field indicators of the Np/Ns break and to aid in the identification of Pd using the field records.

Segment data were collected using reconnaissance-level procedures that would be similar to those used by practicing foresters searching for Pd:

- Bankfull width and depth were measured at one or two representative channel cross sections within a segment using a fiberglass tape, stadia rod or other common measuring devise.
- Segment gradient was measured at the segment break by upstream and downstream shots using a clinometer or by laser rangefinder from one segment break to the next.
- Dominant substrate was visually estimated for the segment.
- Geomorphic features that could affect the segment hydrology were visually identified at segment breaks created by changes in flow category (**Table 7**) and recorded where present.

Data Submission

To insure uniform and consistent data entry, the field data were recorded, collated, and submitted on 2001 Data Entry Forms (**Appendix E**) following the definitions in the 2001 Data Dictionary (**Appendix D**)). All submitted data were included in the pilot analysis. Data from incomplete surveys were included to the extent that their applicability could be determined.

GIS Data

The topographic and environmental data listed in **Table 8** were extracted for each study site from GIS layers using ArcInfo and ArcView. GIS data were provided by:

- Cooperators -- point locations and some basin area delineations;

- The Washington Department of Natural Resources-- Data layers listed **Table 8**
- CMER staff geomorphologist – located additional points and delineated most stream divides in the ArcView format.

Table 8: GIS data layers used to describe site characteristics.

GIS Layer	Description
USGS Topographic Maps	Scanned and georeferenced 1:24,000 topographic quadrangles; served as base maps for locating field points and measuring areas and distances.
DEM Data	Digital elevation models of the topographic maps at a 10-meter resolution. Used to determine elevation of points.
EPA Ecoregions	EPA Level III Ecoregions; used as a stratum for classifying site locations.
PRISM Precipitation Layer	Estimated average annual precipitation at points within survey sites.
DNR Stream Layer	Streams digitized from USGS topographic maps and aerial photographs and identified by a unique number.
DNR Soils Layer	Forest soil map interpreted for texture and used to categorize sites.
DNR Geology Layer	Digitized geology map of state at 1:100,000 that was interpreted for lithology and used to categorize sites.

GIS Procedures

The GIS portion of the analysis occurred in four steps:

1. ***Point Plotting***: Coordinates for Pd, Pc, and Ch were provided by cooperators and transformed to UTM coordinate system by Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP) and plotted on the GIS topographic base maps (**Figure 6**). These point locations were adjusted as necessary to align them with the channel or valley floor shown on the map. The locations of the adjusted GIS points were compared to those on hard copy maps provided by the cooperator whenever possible. Seventeen of the 224 surveys were omitted when they could not be located by the given coordinates and no topographic map was provided by the cooperator (**Table 3**);

2. ***Basin Area Delineation*****:** Drainage basins were manually delineated by identifying their stream divides on topographic maps. The stream divides were defined by lines drawn perpendicular to the elevation contours and through the highest elevations, as shown in **Figure 6b**. In 12 of the 207sites either Pd or the drainage divide was not apparent on the topographic map and no basin area could be delineated (**Table 3**). Once the drainage divides were delineated, point Dc (the point where the stream trace intersects the divide) was located and added to the point data set. Manual delineation was used after attempts at delineation by GIS algorithms failed.

3. ***GIS Measurements***: The areas of the delineated drainage basin were determined using the "ReturnArea" function in ArcView. Distances between points Dc and Pd were determined by drawing a line perpendicular to contours and along the valley floor between these points. The lengths were calculated using the "ReturnLength" function in ArcView;

4. ***Union with other GIS Coverages*****:** Elevation, precipitation, and ecoregion information was extracted for Pd and Dc using the DEM, PRISM precipitation, and USEPA Ecoregion GIS layers. These data were transferred to the database for statistical analysis. The other GIS layers in **Table 8** were not used because: (1) The DNR hydrography layer was too inaccurate (see **Figure 6b**); (2) the soils and geology layers would be useful to analyze the underlying causes of basin area variability, which was considered beyond the scope of this initial phase.

Protocol Assessment

An important purpose of the pilot study protocol was to assess the adequacy and replicability of the pilot protocol. Replicability was to be assessed by having different parties survey the same stream and the variability arising from the application of its procedures and definitions was assessed by reviewing field training, assistance and replicate surveys as well as questionnaire responses from cooperators (**Appendices F and G**). Protocol compliance was also tested through statistical analysis of segment lengths, survey beginning and ending criteria, and success at recording requested data.

Qualitative data that could be used to assess the replicability and overall adequacy of the protocol included reports from tribal training, field assistance, and quality control surveys, a formal cooperator questionnaire (**Appendix G**), and information from review of data-entry materials. This qualitative analysis results in a list of recommendations.

Quantitative assessment of field data consistency and capture success was determined by means of statistical analysis. More specifically,

- “Consistency” estimates the degree to which the field parties could implement protocol requirements for segment length and survey initiation and ending.
- “Capture success” estimates the degree to which field parties could observe or, measure, and record the required field data in **Tables 6** and **7**.

The capture and consistency measures were calculated by the ratio of number of sites meeting the protocol requirement to the number of sampled sites. Whenever the ratio exceeds 90 percent, the consistency/capture is judged to be high. A rate less than 90 percent may indicate that a change in protocol, variable selection or definition, or training should be considered.

Data Analysis

This report emphasizes Pd because it is the hydrologic transition between Type Np and Ns water as defined in FFR and WAC 222-16-030(3). Pc and Ch data were obtained in the field to assure the capture of Pd and are presented only as necessary in tables, figures, appendices and text.

Several statistical routines were used. The statistical routines in Excel were used to calculate summary statistics, determine some correlations, and perform some ANOVAs. Routines in SAS, and SPSS were used to assess the channel and basin area data by analysis of variance (ANOVA), least squares regression, analysis of covariance, and Student’s t-test. Summary statistics were calculated from the observed data pooled by study areas and pooled by FFR default region. A log transformation was used to normalize skewed distributions for statistical analyses. Because this is a pilot study seeking potential differences, comparisons are considered significantly different at the 90% level.

Although the survey areas were not selected according to a stratified sampling plan, the individual sites were grouped into study areas by ecoregion and default region strata to assess regional variability in the data. These groupings are referred to as “strata”. The HOH study area includes sites from the Coastal and Westside FFR default regions. Because no other study areas lay within the Coastal FFR default region, the HOH study area is assigned to the Coastal FFR default region with the understanding that it may not be truly representative of that region (The HOH study area is also retained within the Westside FFR default region to more fully describe the variation within that region.) The variability of Pd-area was assessed by ANOVA to determine the degree to which the differences between Pd-areas within a study area are less than the differences between study areas when grouped by state, default region, or ecoregions.

Measure of Central Tendency

The measures of central tendency are the average and median of the data distribution and both are used in this study. In a skewed distribution, such as occurs in the pilot study, the median is the appropriate statistical measure of central tendency because it is less affected by extreme values (Haan, 1977). Skewed data are generally transformed such that the resulting distribution is approximately normal.

Since the pilot study data are approximately log normally distributed, a logarithmic transformation was applied before statistical computations (e.g. sample size, confidence intervals, and correlation testing) were performed. The log-averages, when transformed back into the original arithmetic values, correspond to medians (Evans et al., 1993). Thus, the results of these statistical analyses apply to the observed median values. Transformation also facilitates interpretation of customary descriptive statistical metrics, such as standard deviation, which lose their intuitive significance when applied to skewed data. Although the median is the most appropriate measure of central tendency in this study, the average is included in the text and tables. The uncertainty of which measure of central tendency the default basin areas represent requires that both measures be included.

Sample Size

The sample size required to estimate the log-transformed average of the observed basin areas in each FFR default region was based on the 90% confidence interval for the log-transformed average and several levels of precision. The approximate 90% confidence interval for the log-transformed average, which becomes the median when back-transformed, is estimated using a normal Z-statistic by:

$$\boldsymbol{Mean} \pm \frac{\boldsymbol{Standard\ Deviation}}{\sqrt{\boldsymbol{n}}} \bullet 1.65$$

This provides a method to estimate sample sizes needed to achieve desired precision levels defined by the relative size of the confidence interval by;

$$\boldsymbol{n} = \boldsymbol{CV}^2 \frac{1.65^2}{\boldsymbol{r}^2}$$

where ***r*** is the relative size of the confidence interval (i.e.

$\left(\frac{\boldsymbol{Standard\ Deviation}}{\sqrt{\boldsymbol{n}}} \bullet 1.65\right) = \boldsymbol{r} \ \boldsymbol{*Mean}\}$

and ***CV*** is the coefficient of variation of the population

$(\frac{\boldsymbol{Standard\ Deviation}}{Mean} *100)$.

The sample-size equation has two inputs – the desired confidence interval of the transformed data (preliminary value of ±10%) and the coefficient of variation (estimated from the variability of available data). See **Appendix H** for further information on sample size.

Sample size was estimated from the pooled data for each FFR default regions because the sample data were distributed throughout the default regions. We assumed that the C.V. from the pooled data is most likely to approximate the maximum variance of the population under study, and therefore will produce a sample size sufficient to estimate the average of the true distributions. Because of this assumption, the estimated sample size should be considered as the minimum required in case the true variance was underestimated.

Alternative Field and Default Criteria

Alternate field and default criteria were sought at three different scales – channel, reach, and basin – to define the Np/Ns break. At the channel scale they were sought by comparing the values of channel characteristics at the Np/Ns break to those at other segment breaks. A potential field criteria for the Np/Ns break was considered to be a physical variable that occurred more frequently at the Np/Ns break than at other flow-category segment break (i.e. a segment break occurring at a change in flow category rather than the 30-meter length limit) or a change in the magnitude of a channel characteristic (e.g. channel depth or substrate) at the Np/Ns break that was different from the change that occurred at other flow-category segment breaks. At the reach scale, they were sought by comparing the location of the Np/Ns break to the channel head, and at the basin scale, they were sought by reference to the watershed variables in **Figure 4**. At the latter scales, a statistically consistent distance or height was sought.

Year of Normal Rainfall

Because "year of normal rainfall" is part of the FFR definition for seasonal and perennial flow, we evaluated the degree to which 2001 was "a year of normal rainfall." We assessed the degree to which 2001 was normal by analyzing annual and monthly precipitation during the field season and the preceding water year (October 2000 – September 2001) at NOAA long-term weather stations close to study areas, which were available through the Western Regional Climate Center. Monthly totals with more than three daily values missing were eliminated in most cases, as were water years with one or more incomplete months.

Annual and monthly precipitation values for the Water Year (WY) 2001 were compared to the quartiles of the long-term data. The following terms were applied to each quartile:

- First quartile (0-25th percentile): Unusually Dry
- Second quartile (25 – 50th percentile): Moderately Dry
- Third quartile (50 - 75th percentile): Moderately Wet
- Fourth quartile (75 - 100th percentile): Unusually Wet

The range contained within the second and third quartiles are interpreted as being "normal". This definition places half of all monthly and annual precipitation totals within the normal range. The quartile approach is useful for evaluating seasonal trends within the annual totals. Because the FFR is explicit in the use of rainfall to define normalcy, other variables, such as stream discharge, were not considered. In addition, we are not aware of forested headwater streams with active long-term gaging stations to allow analysis of stream discharge during the study.

Intra-Annual Variations

Three cooperators conducted one or more repeat surveys during the summer of 2001. The data on the changes in position of Pd and the size and abundance of different flow categories (**Table 6**) in the reach between Ch and Pc was summarized by:

1. Plotting the location of Pd downstream from Ch during each survey. This plot of distance downstream vs. time maps the seasonal migration of Pd.
2. Coding the flow categories in **Table 6** and then averaging the length-weighted flow categories by survey date. The plot of average flow category by survey date maps the changes in the wetness of the channel above Pc. The codes are:

Flow Category	Code
Flowing Water	10
Standing Water	5
Flowing Pocket Water	7
Standing Pocket Water	3
Dry	0
Unknown/Obscure	----

Inference Capabilities

Because cooperators chose study areas for their convenience, the study areas are not randomly distributed within either ecoregions or the FFR default region “strata”. For this reason, statistical inferences based on pooled or combined data sets in these “strata” should be assessed using professional judgment.

Location of the channel head was not required by the protocol and thus was not captured in many surveys. Without its capture, the highest occurrence of perennial water may have been missed and the identified Pd in these surveys would thus be located downstream from the true Pd. This problem is believed to be concentrated in three study areas: TCG on the Westside and the SPO and COL in ecoregion 15 on the Eastside.

SECTION 3. RESULTS

Protocol Assessment

The pilot protocol (**Table 5** and **Appendix C**) was assessed for its adequacy and replicability and for the adequacy of the 200-meter survey beginning and ending criterion. The quantitative assessment is presented first and qualitative assessment second.

Quantitative Assessment

The quantitative assessment determines the degree to which the channel variables (**Table 6**) and associated features (**Table 7**) could be observed or measured and were recorded. The results are presented in **Table 9** for segment lengths and in **Table 10** for channel attributes and associated features. The quantitative assessment does not include replicability for which no quantitative data are available.

The pilot protocol specified both a minimum and maximum length for segments. Segment length should not exceed 30 meters and should not be less than the length specified for the flow category -- flowing water (FW), standing water (SW) and dry (D) segments requires a minimum of 5 meters; pocket water requires a minimum of 0.1 m if located between FW or SW. As shown in **Table 9**, the 75th quartile is 27.4 m of all segment lengths, which is within protocol limits. Few segments do not meet the length constraints -- 8 percent of the segments exceed the maximum length of 30 m and 10 percent or less of the segments with flowing water, standing water or dry are shorter than the minimum of 5 m.

Table 9. Segment Lengths. Segments are defined by changes in flow category but are not to exceed 30 meters or to be less than 5 meters (except for flowing or standing pocket water, which may be as short as 0.1 meter).

Statistic	Segment Length (m)			Short Segments by Flow Category (m)		
	All	Long (>30 m)	Short (<5 m)	Flowing	Standing Water	Dry
Number	3473	266	543	337	23	183
Median	11.3	31.1	2.5	2.8	1.1	2.1
Minimum	0.1	30.1	0.1	0.1	0.2	0.1
Maximum	389.4	389.4	5.0	5.0	3.7	4.9
1st Qtile	6.5	30.5	1.2	1.5	0.5	1.1
3rd Qtile	27.4	45.2	3.7	3.9	2.7	3.3
Percent of Sample	100%	8%	16%	10%	1%	5%

Table 10: Capture Rates. The percentage of field parties that recorded requested information at each segment break. The requested observations are listed in Tables 6 and 7.

Feature	Number Observed	Percent Captured by Field Parties
Segment Distance	3,611	100
Flow Category	3,565	99
Channel Category	3,559	99
Bankfull Width	2,723	75
Bankfull Depth	2,692	75
Upstream Gradient	2,255	62
Downstream Gradient	2,220	61
Segment Gradient	1,874	52
Dominant Substrate	3,183	88
Associated Feature #1	873	24
Associated Feature #2	57	2

Field notes indicate that segments exceeding the maximum length (30 meters) had steep gradients, waterfalls, slash, or impenetrable vegetation that resulted in the field parties not being able to access the channel for measurement. The compliance rate of greater than 92% for the maximum segment length indicates that compliance with maximum segment limits is high as are the compliance rates for the minimum segment length with flowing (90%), standing water (99%), and dry segments (95%).

The protocol clearly states the procedures and criteria for identifying the upstream extent of a survey. It requires that the survey continue upstream 200 meters (656 feet) beyond the last perennial water (Pd) or to the channel head (Ch) whichever came first. Field parties were not required to survey to the channel head or to record its presence if observed. For these reasons Ch was recorded in only 29 (13%) of the 224 complete surveys. In an additional 123 (55%) surveys, Ch was identified from descriptions in the field data sheets by the change in channel category to “no channel.” The channel head was neither recorded nor identifiable from field data in 72 surveys (34%) for a compliance rate of 66%. Many (47 %) surveys on the Eastside missed the channel head. Field records indicate that 152 of 224 surveys or 68 percent extended to the channel head and another 11 surveys or five percent extended a median distance of 165 meters from Pd (on the Eastside the protocol was interpreted to mean 200 m beyond Pc). The remaining 61 surveys or 26 percent did not continue pass the field identified Pd and the compliance rate for terminating the upper end of the survey is low at 74 percent.

The field parties could not consistently obtain the channel characteristics required by the pilot protocol. The capture rates for the channel variables listed in **Tables 6** and **7** range from low to very high. **Table 10** compares the number of identified segments (3,513) with the number of segments including a record for the requested field parameter. A high (>90 % success) capture rate occurs for segment length and for flow and channel categories. Lower capture rates (<75 %) occurred for bankfull width and depth, and gradient. Dominant substrate was captured 88 % of the time. Gradient is difficult to assess because some survey parties measured upstream and downstream gradient from each segment junction (clinometer method), and some parties recorded gradient between segment junctions (laser range finder).

Associate features have a low capture rate. The cause for this capture rate is difficult to assess for two reasons:

1. No option was provided to the field party to enter "Not present" when the features were actively sought but not found
2. Field crews were encouraged *not* to identify Pd in the field so as not to bias their observations, which likely limited the search for these features at Pd.

Qualitative Assessment

A protocol specification for each cooperator was two replicate surveys per study area by two different field parties. This requirement was not met. The short duration of the 2001 field season (and most cooperators only had one crew available) placed the cooperators in the position of either including additional study sites or replicating surveys. Every cooperator chose the latter option. The independent contractor (report in **Appendix F**) visited the tribal cooperators at least once for training and assistance purposes. The provision of consistent training and field assistance was believed adequate to promote consistency between these cooperators.

In late September quality control surveys were conducted with three tribes. The independent contractor surveyed a length of channel with the field crew (**Appendix F**). These replicate surveys identified several potential problems with replicability:

1. Interpretation of side channels
2. Identification of flowing vs. standing pocket water
3. Consensus of the minimum length of a segment defined by dry and standing pocket water.
4. The use of consistent 30 m segment lengths rather than flow-defined segment lengths
5. Identification of channel category in wetlands
6. Definition of channel category in channels with degraded banks

The QA/QC report and responses to the questionnaire (**Appendices F** and **G**) raised the following substantive issues about the adequacy of the pilot field protocol to fully capture and describe the Type N stream characteristics:

- Spatially intermittent flow categories should be combined, particularly the “Flowing Pocket Water” and “Standing Pocket Water” flow categories because they are difficult to distinguish
- Treatment of Piped Channel and Obscure Channel requires clarification.
- Bankfull width and depth are difficult to determine in the field because of indistinct channel edges.
- Gradients are oftentimes difficult to measure because vegetation obscures the channel and valley floor.
- Riparian vegetation should be substituted for upland vegetation in the site description.
- The minimum segment length should be specified for modified channels
- A standard for assessing dominant substrate is required to reduce subjectivity
- The distinction between seeps and streams requires clarification.
- The notation for standing water bodies within the survey, that is, what is the notation that be used when a pond occurs downstream from the channel head?

Data collation and analysis indicated the field protocol/data dictionary should emphasize the search for piped channels. Piped channels are channels that run under the substrate or forest debris. Flow is typically heard and occasionally visible through small holes in the substrate. Piped channels were encountered in 52 study sites on the Westside. Important hydrologic transitions were located within these channels --Pd occurred within a piped channel at 18 (35%) of these sites and Ch occurred within piped-channels at 9 (17%) of these sites. Identification of piped channels was not required by the protocol but was available as a channel category when observed.

The FFR does not include piped channels as a category of typed waters. Appendix B in the FFR indicates that Type N channels must be connected to Type F or S channels by ‘above ground channels’ but it does not place similar constraints on the Np/Ns break (Pd) or channel head. If in some future FFR revision, piped channels are defined as macropores and not part of stream channel Pd and Ch would be placed at the last expression of the open channel and be interpreted as a channel-head spring.

Some cooperators encountered segments that were scoured to bedrock by recent debris flows and lacked both an alluvial/colluvial valley fill and channel. These segments were designated “poorly defined channels” because of the lack of a more appropriate category. The addition of the channel categories – “debris-flow scoured” and “debris flow deposits” -- would facilitate the identification of these segment types and provide information on the distribution of valleys affected by debris-flows. The variation in alluvial thickness in debris-flow dominated reaches probably influences the position of Pd within them. As alluvium/colluvium fills the hollow, Pd should move down stream because the elevation of the channel will likely exceed the elevation of the water table resulting in subsurface flow rather than surface flow.

Although these difficulties likely contributed to some inconsistency between crews in the description of channel characteristics, they were not thought to significantly compromise the study's objectives – testing the protocol and determining variability in Pd-area.

Potential Bias

A SRC reviewer noted that the upstream selection method introduce a bias toward baseflow dominated tributaries by preferring the "wetter" channel to its head. Only 85 surveys of the 128 surveys using the upstream protocol selected tributaries and of those 49 were based on difference in flow category and are thus biased. The basin areas estimated from the 42 biased surveys and those estimated by the 152 non-biased surveys are shown below and are statistically similar at $p = 0.05$. The complete bias analysis is included as **Appendix L**.

Statistic	Eastside	Westside	Coastal
	Biased		
Count	11	26	5
Median	11.5	11.3	3.2
1st Quartile	2.6	4.3	3.1
3rd Quartile	278.2	27.7	4.9
	Unbiased		
Count	32	108	12
Median	38.4	6.9	1.6
1st Quartile	14.0	3.6	0.7
3rd Quartile	67.5	20	4.0

Table 11. Study area descriptions including both hydrologic and watershed variables. In this table all units are in acres and feet. Elsewhere in the text, distances are reported in meters.

Study Area Descriptors					Pd Variables			Watershed variables			
Default Area	Ecoregion	Coop	Sites	Statistic	Pd-area (acres)	Pd-Dist.(ft)	Ch - Pd Dist. (ft)	Av. An. Ppt (in)	Elev. (ft)	Divide Relief (ft)	Divide Gradient
Eastside (300 acres)	Cascades (4)	YAK	13	Median	13	1,150	11	61	4,460	396	104%
				1-Qtile	3	863	0	59	3,966	155	70%
				3-Qtile	43	1,349	40	63	4,532	449	129%
	Eastern Cascades (9)	LVF	2	Median	46	2,691	ND	54	444	215	35%
				1-Qtile	37	2,358		54	413		
				3-Qtile	55	3,025		55	475		
	Northern Rockies (15)	COL	6	Median	229	4,644	ND	20	4,054	373	28%
				1-Qtile	176	3,817		16	2,371	320	18%
				3-Qtile	793	6,156		23	4,441	410	30%
		SPO	6	Median	105	3,226	ND	15	2,328	104	6%
				1-Qtile	47	2,305					
				3-Qtile	302	4,134					
	Northern Cascades (77E)	COL	5	Median	39	1,943	180	24	4,715	516	90%
				1-Qtile	30	1,553		21	4,086	379	79%
				3-Qtile	54	2,014		29	5,952	646	98%
		LVF	12	Median	9	1,109	3	35	3,883	429	41%
				1-Qtile	4	753	1	33	804	85	29%
				3-Qtile	21	1,841	8	57	4,108	500	150%
Westside (52 acres)	Coast Range (1)	DFW	34	Median	5	892	14	90	1,320	322	117%
				1-Qtile	4	654	1	81	1,064	226	104%
				3-Qtile	8	1,142	1	98	1,739	465	144%
		LVF	3	Median	8	889	14	69	1,017	231	84%
				1-Qtile	5	677		69	958	184	83%
				3-Qtile	8	1,066		73	1,233	272	85%
	Puget Lowland (2)	LVF	4	Median	12	1,629	1	30	1,973	392	19%
				1-Qtile	7	1,246		25	1,240	216	
				3-Qtile	70	2,553		37	3,010	531	
		PGS	4	Median	16	689	ND	37			
		SUQ	6	Median	8	846	0	54	325		
				1-Qtile	4	845	0	49	290		
				3-Qtile	25	2,057	0	61	379		
	Cascades (4)	LVF	15	Median	6	981	27	85	1,520	298	80%
				1-Qtile	4	877	10	66	1,317	198	65%
				3-Qtile	16	1,314	52	88	1,957	326	82%
		TCG	61	Median	19	1,347	29	71	2,361	286	86%
				1-Qtile	4	769	14	67	1,759	158	43%
				3-Qtile	44	2,508	29	77	3,040	730	120%
	Northern Cascades (77 West)	SSC	25	Median	5	1,014	0	74	1,631	453	158%
				1-Qtile	3	774	0	71	1,405	299	135%
				3-Qtile	11	1,679	24	77	2,164	972	187%
Coast (13 acres)	Coast Range (1)	HOH	22	Median	3	636	1	125	1,119	241	168%
				1-Qtile	1	387	1	125	723	149	95%
				3-Qtile	5	807	6	125	1,271	331	192%

Study Areas

The watershed characteristics of the 15 study areas in **Figure 1** are summarized here and in **Table 11** to provide a context for the basin descriptions to follow.

Average Annual Precipitation: The long-term (PRISM) average annual precipitation for a study area ranges from 375 mm (15 inches) on the Eastside to 3,125 mm (125 inches) on the Westside (**Figure 8**).

Elevation: The median elevation of study areas range from 100 meters (~300 feet) in the Puget Lowlands (ecoregion 2) to 1,400 meters (~4,700 feet) in the Northern Cascades (ecoregion 77E) and Northern Rockies (ecoregion 15) with the higher median elevations on the Eastside.

Divide Relief: Divide relief is generally between 70 and 200 meters (~210 and ~600 feet) and is greatest (>200 meters) in the Northern Rockies (ecoregion 15)

Divide Gradient: Median divide gradient ranges from a low of 19% in ecoregion 2 (Puget Lowland) to 168% in ecoregion 1 (Coastal Range) with the steepest gradients in the Coastal Ranges and Northern Cascades (<158%).

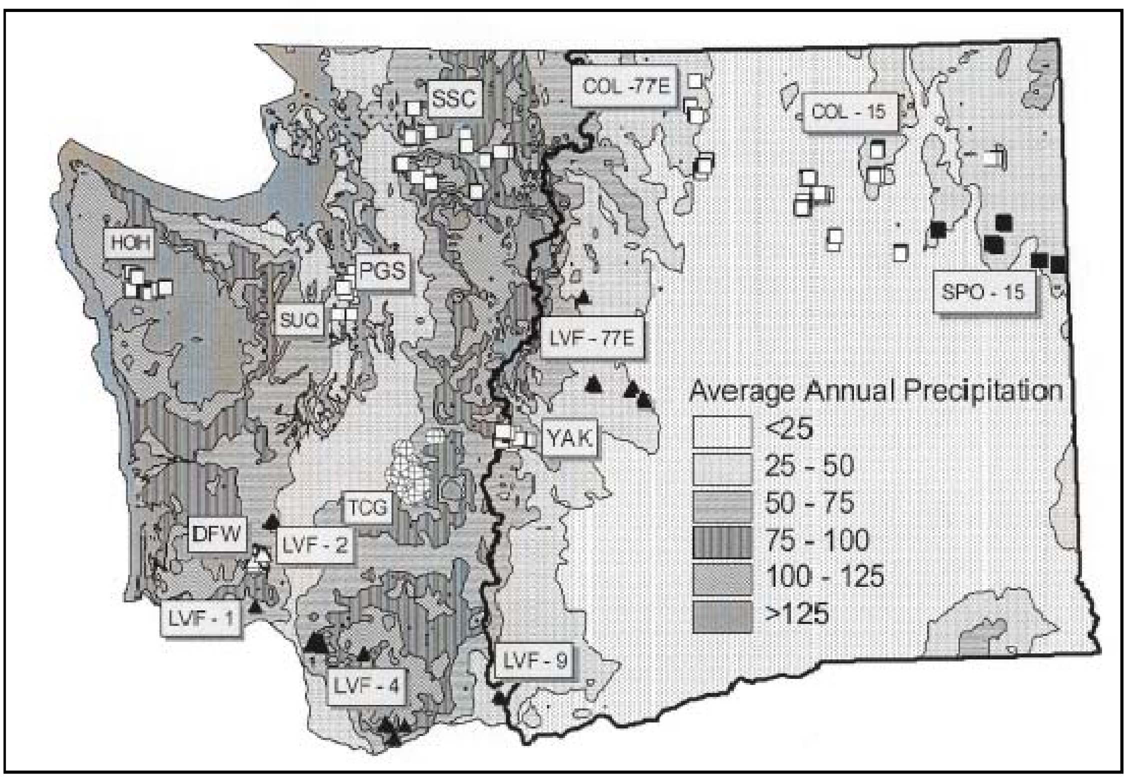


Figure 8: Average Annual Precipitation Classes. The distribution of study areas relative to average annual precipitation classes developed from PRISM data. A heavy north-south line shows the Cascade crest. It divides the state into Eastside and Westside FFR default regions. Note that sites occur in all precipitation classes and that some precipitation classes appear on both sides of the Cascade crest.

Year of Normal Rainfall

Precipitation data from the closest long-term meteorological station to each study area are presented in **Table 12**. Key observations are:

- The 2001 water year was "unusually dry" for all stations;
- The water year shortfall resulted from four consecutive "unusually dry" winter months (Nov-Feb);
- A return to moderately to unusually wet conditions occurred in March or April and continued through August or September;
- On the Eastside the moderately to unusually wet months alternate with moderately to unusually dry months;
- July was moderately dry at most stations.

Detailed interpretation of **Table 12** is deferred to the Discussion section.

Table 12. Year of Normal Precipitation. Precipitation data for the water year 2001 summarized by the meteorological station closest to each study area. The monthly and annual data are compared to the long-term record for the station and assigned to the appropriate quartile of the precipitation distribution.

Precipitation Station	2000			2001									
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Coastal													
Forks (HOH)	*9.8*	***6.3***	***10.1***	***13.6***	***3.8***	*9.6*	9.4	6.4	3.6	*1.2*	**7.6**	4.7	***86.1***
Westside													
Bremerton (Suq)	4.7	***4.0***	*6.2*	***4.4***	***2.3***	**4.9**	*2.9*	*2.8*	**3.0**	**1.7**	**3.7**	*0.6*	***41.9***
Doty (DFW)	*3.8*	***3.5***	***2.2***	***3.4***	***2.4***	***3.7****	3.9	2.8	2.7	*0.5*	**1.5**	*0.9*	***31.4***
Skamania (LVF)	7.0	***5.6***	***6.0***	***4.7***	***3.4***	*8.1*	7.1	4.4	**5.6**	*1.1*	2.0	***1.5***	***56.5***
Longmire (TCG)	*7.5*	***6.0***	***4.9***	***5.3***	***4.2***	*6.7*	6.1	4.9	**6.3**	*1.4*	1.4	*1.2*	***56.1***
Sedro Woolley (SSC)	4.3	***2.4***	***3.6***	5.0	***1.8***	4.3	**4.3**	*2.6*	5.0	*1.0*	2.0	*1.6*	***37.9***
Eastside													
Leavenworth (LVF)	*1.2*	***1.5***	*2.3*	***1.6***	***1.5***	2.1	***0.6***	***0.8***	1.2	**0.0**	**0.6**	0.2	***13.6***
Republic (COL)	*0.9*	***0.9***	*1.1*	***0.6***	***0.4***	1.7	***0.6***	***0.7***	1.8	*0.9*	***0.2***	0.9	***10.7***
Stampede Pass (YAK)	*4.0*	***5.8***	***5.6***	***5.6***	***4.0***	7.7	6.2	*4.2*	4.4	*1.4*	1.4	***1.2***	***51.5***
Winthrop (COL)	1.0	*1.2*	*1.2*	***0.5***	***0.7***	1.0	*0.4*	***0.1***	*0.8*	*0.6*	*0.3*	0.5	***8.3***

Category Codes

Bold underlined italics = Unusually Dry	< 25th percentile of long term record
Italics = Moderately Dry	25th to 50th percentile of long term record
Regular = Moderately Wet	50th to 75th percentile of long term record
Bold Regular = Unusually Wet	> 75th percentile of long term record

Basin Area Variability

A total of 109 basin areas (Ch, Pd, and Pc) were determined for Eastside sites and 385 (Ch, Pd, and Pc) were obtained for Westside sites. The summary statistics for observed Pd-areas by FFR default region are included in **Table 13** and the distribution of Pd-area by default regions is shown in **Figure 9**. The average observed Pd-areas for the three FFR default regions (Coastal, Westside, and Eastside, respectively) are 8, 22, and 118 acres and the median observed Pd-areas are 2, 6, and 36 acres. The observed values are considerably smaller than the FFR default basin areas of 13, 52, and 300 acres.

Table 13: Basin Areas above Pd. Descriptive statistics of basin areas above Pd (Np/Ns break) by FFR default region.

Statistics	**Eastside** (300 acres)	**Westside** (52 acres)	**Coastal** (13 acres)
Sample Size	43	152	18
Average (acres)	118	22	8
Median (acres)	36	6	2
Minimum (acres)	0.4	0.1	.3
Maximum (acres)	1,224	260	85
1st Quartile (acres)	9	3	1
3rd Quartile (acres)	68	22	5
Coefficient of Variation	206	191	249

The distribution of Pd-area in the different default regions is similar (**Figure 9**). The distribution peaks around 3 acres with a long tail toward larger basin areas. The differences in the distributions appear to lie in the frequency and size of the larger basins within each default region.

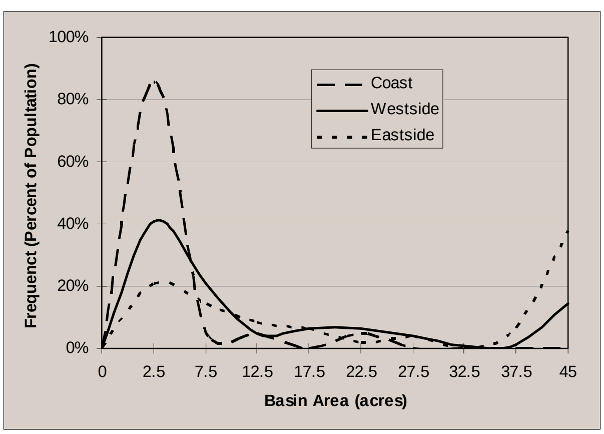
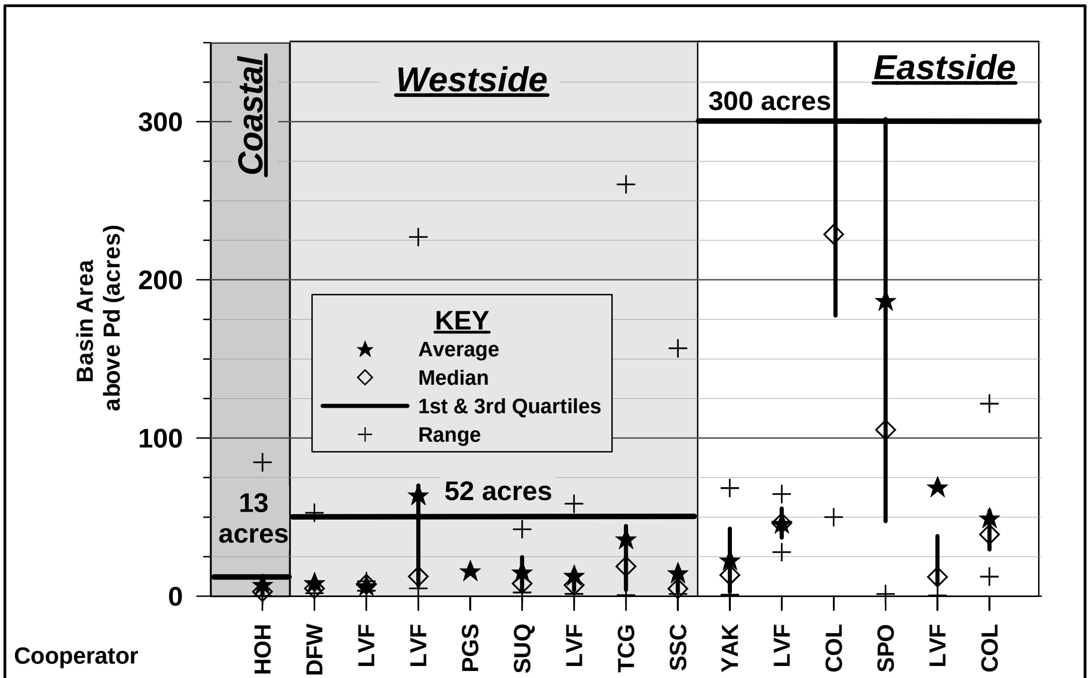


Figure 9. Basin Area Distribution. Distribution of Pd-area by FFR default region. The basin area frequency curve for each default region peaks around 3 acres. The differences in the median basin area between regions likely result from differences in the tails of the distribution - those beyond 10 acres - that differ for each default region.

Pd-areas differ between study areas within the state, between default region, and within some ecoregions (**Table 11, Figures 9** and **10**). In **Figure 10** the average and median of Pd-area are shown as points (star and diamond, respectively), the central 50 percent of the data as defined by the first and third quartiles is a solid line, and crosses bracket the range. The distributions in **Figure 10** indicate that:

- The FFR default basin area is larger than 75% quartile of the observed Pd-areas in 13 of the 15 study areas



Cooperator	HOH	DFW	LVF	LVF	PGS	SUQ	LVF	TCG	SSC	YAK	LVF	COL	SPO	LVF	COL
Number of Sites	22	34	3	4	1	6	15	61	25	13	2	6	6	13	5
Ecoregion	1	1	1	2	2	2	4	4	77W	4	9	15	15	77E	77E
Average Area (acres)	8	9	7	64	16	15	13	36	15	23	46	494	187	69	50
Median Area (acres)	3	5	8	12		8	7	19	5	13	46	229	105	12	39

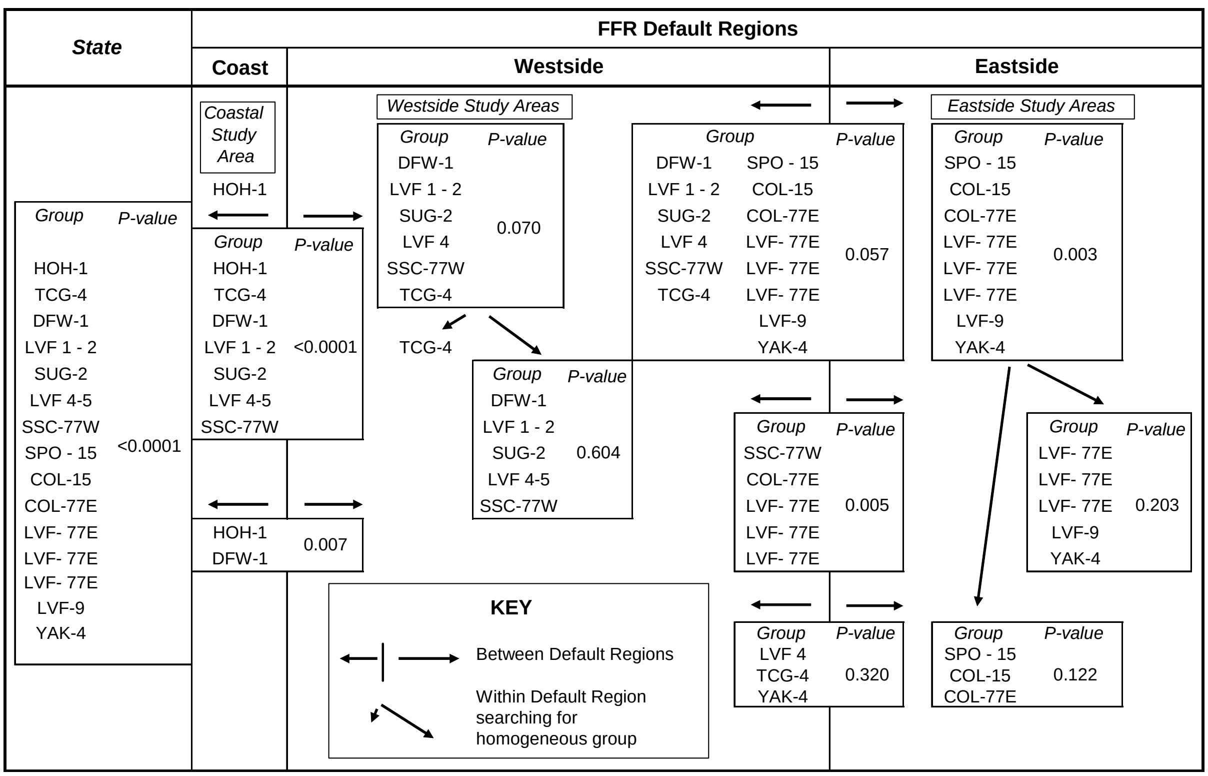
Figure 10: Basin areas above Pd by study area. Study areas are identified by cooperator (Table 3) and ecoregion (Figure 1). The heavy horizontal line in each FFR default region defines the default basin area for that region. The average and median values for each study do not coincide because of the skewed, lognormal distribution of the basin areas. Surveys in COL-15, SPO-15, and TCG did not reach the channel head and the basin areas may be biased toward larger areas in these study areas. The COL-15 distribution is truncated

- Within each FFR default region, the data distribution for each study area as defined by the 1st and 3rd quartiles overlaps that of the others in 13 of the 15 study areas
- The study areas in ecoregions 4 and 77, which straddle the Cascade crest thereby including both Eastside and Westside default regions, may have similar distributions of Pd-area.

These observations were tested by ANOVA. **Table 14** shows the groupings and probability (*p*) of the null hypothesis – no significance difference --- for each grouping. Significant differences ($p < 0.0001$) exist between study areas when grouped by the state as a whole. When the state grouping is disaggregated into default regions, significant differences remain between the study areas in the Eastside ($p = 0.003$) and Westside ($p = 0.07$) groupings. When these default- region groupings are subdivided into two groups based on average log Pd-area, the differences within them become non-significant (0.1 >

p < 0.6). These smaller default-region groupings indicate that on the Westside, the average log Pd-area in TCG-4 is significantly different from the average log Pd-area in the other Westside study areas, and on the Eastside the average log Pd-area in SPO and COL study areas are significantly different than the average log Pd-area in the LVF and Yak study areas. Pd-areas in the SPO, COL, and TCG study area are larger than those in the other study areas in the default region (**Table 11**). As noted elsewhere, the surveys in the SPO, COL, and TCG study areas captured fewer channel heads (**Table 3**), which could lead to misidentification of Pd and larger Pd-areas.

Table 14: Results of ANOVA between study areas grouped by ecoregion and FFR default region. Each box contains a study-area grouping and the probability of significant difference within the group. Study area names are composed of the cooperator (Letters) and the ecoregion number. Groupings crossing a default-region boundary as indicated by the horizontal arrows compare study areas in both default regions to determine differences between them. Groupings within a default region compare study areas within that default region. When significant differences exist in a within-region grouping it is divided into two internally homogeneous groupings as indicated by the diagonal arrows.



Significant differences in log Pd-area occur between some study areas within the same ecoregion. The HOH-1 study area and the DFW-1 study lie on opposite sides of ecoregion 1 (**Figure 1**) and their average log Pd-areas are significantly different (*p* = 0.007). Within ecoregion differences also exist for ecoregion 77, which is divided into 77-E and 77-W (for east or west of the Cascade crest). The significant difference in average log Pd-area between the HOH-1 and DFW-1 indicates the placement of the HOH-1 study area into the Coastal default region is reasonable

The average log Pd-areas for study areas within some ecoregions are not significantly different. Within ecoregion 4 (p = 0.320), in which YAK-4 lies east of the Cascade crest and LVF-4 and TCG-4 lie west of the Cascade crest, the average log Pd-areas are not different at p = 0.254. The larger Pd-areas in TCG-4 appear to be more similar to YAK-4 on the Eastside than to the Pd-areas in the other Westside study areas.

Sample Size

The sample size required to estimate the observed median basin areas described in **Table 13** at the 90% confidence interval changes with the precision selected. With a 10% precision, it is estimated as 84 and 99 for the Eastside, and Westside, default regions respectively (the Hoh study area is excluded from Coastal FFR, for the sample size analysis). If the precision is decreased to 15%, the sample sizes become 38, and 45 or about half of the size estimated with 10% precision. Sample size requirements are more fully developed in the Discussion section.

Field Indicators of the Np/Ns Break

The search for a definitive field indicator for the Np/Ns break was unsuccessful, with the exception of the channel head. Changes in flow category accounted for 2,361 segment breaks. However only 117 (5%) of these were actual Pd locations and only 57 (44%) of these had associated features recorded. In **Figure 11** the frequency of associated features at Pd segment breaks are compared with their frequency at other flow-change segment breaks. The most frequently noted features were "springs", "seeps", and "wetlands", which occurred at over 70 percent of the Pd and

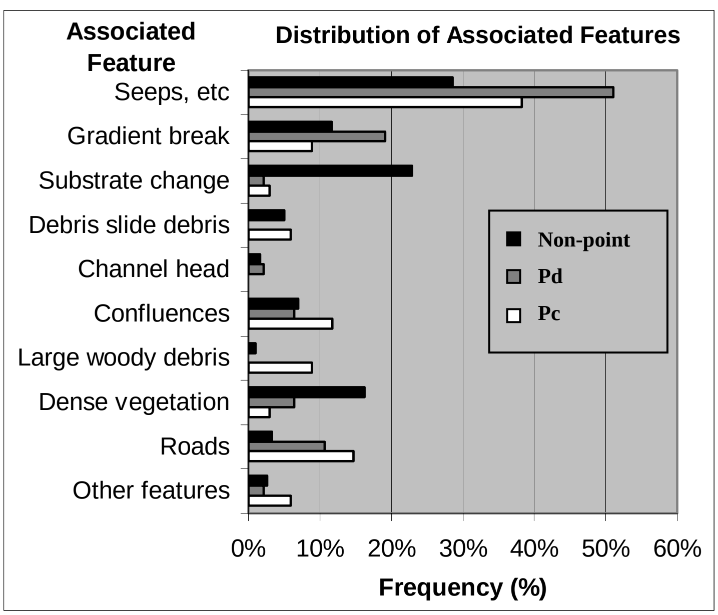


Figure 11: Histogram of associated points at flow-generated segment breaks. The histogram compares the frequency at which associated features occur at segment breaks defined by a change in flow category.

Pp breaks, and are the only FFR criteria for identifying the Np/Ns break. Roads are the only other associated features that are more frequent at Pd and Pp than at other flow-category breaks. Because springs, seeps, and roads are commonly found elsewhere they show little potential to conclusively identify Pd outside the dry season. Likewise, none of the other associated features appear to be definitive field indicators of the Np/Ns break.

Changes in channel variables at Pd were determined by comparing the segment upstream of Pd to the segment downstream. The variables included in this analysis were:
a) Substrate
b) Bankfull width
c) Bankfull depth
d) Segment gradient
The upstream/downstream values of these variables were not significantly different at $\alpha = 0.10$ and therefore are not suitable field predictors of Pd.

Other Indicators of the Np/Ns Break

Because the search for field indicators of Pd did not provide channel-scale predictors, other possible candidates were sought at the reach- and site-scales. These indicators include the channel head (Ch), seasonal reach length (Ch – Pd), and distance from the divide (Pd-distance).

Potential site-scale indicators of the Np/Ns break are the channel head (Ch) and length of the seasonal reach. The channel head lies close to the Pd. As shown in **Table 15**, the average length of the seasonal reach (Ch – Pd) is less than 35 meters (115 feet) and the corresponding median length is less than 17 meters (54 feet). In place of other indicators, placement of the Np/Ns break (Pd) at the channel head would result in a median error of less than 10 meters (30 feet) in the Eastside, 21 meters (63 feet) in the Westside, and 2 meters (6 feet) in the Coastal default region. This error is much less than that associated with the present FFR default basin areas.

Another indicator is the length of the seasonal reach (Ch – Pd). As shown in **Table 15** the average length of the seasonal reach is similar for the Eastside and Westside regions – 21 to 24 meters (67 to 79 feet) with springs/seeps included and around 29 to 35 meters (93 to 112 feet) with them excluded. It is lower in the Coastal region with an average length of 4 meters (13 feet) with springs/seeps and 5 meters (16 feet) without them. The presence of channel head springs/seeps in the sample affects its coefficient of variation (C.V.). When channel head springs and seeps are included the C.V.s are between 136 % and 353% and generally exceed those of default basin areas (182% to 249%). When channel head springs/seeps are excluded, the C.V.s decrease to between 118 % and 210 % and are less than those for default basin areas.

Table 15: Length of seasonal reach (Ch – Pd). Descriptive statistics for the length of the seasonal reach (meters) with reaches beginning at channel head (Ch) springs and seeps included (left) and excluded (right) from the sample

Statistic	Channel Head Springs and Seeps Included			No Channel Head Springs and Seeps		
	Eastside (300 acres)	Westside (52 acres)	Coastal (13 acres)	Eastside (300 acres)	Westside (52 acres)	Coastal (13 acres)
Sample Size	23	126	18	16	92	15
Average	24	21	4	35	29	5
Median	6	10	2	10	17	2
Minimum	0	0	0	1	1	1
Maximum	180	225	22	180	225	22
1st Qtile	0	0	1	5	7	1
3rd Qtile	22	27	6	37	37	8
Coefficient of Variation	187	353	136	147	210	118
Channel head springs or seeps	7 (30%)	34 (27%)	3 (17%)	0	0	0

Site-scale candidates for an alternate indicator for Pd were sought through the correlation of observed basin areas with the site-scale topographic parameters in **Figure 4**. In this analysis, the data were pooled at the state level to provide data sets that ranged between 105 and 162 pairs. Log Pd-distance is the only meaningful correlation at $r^2 = 0.75$ **(Table 16**) and its relationship to the observed Pd-area was explored.

Table 16: Basin area correlation with site variables to determine which site variables covary with basin area. Correlations expressed as r^2 between Pd basin area and site variables. All r^2 are significant at $\alpha = 0.1$ but only those correlations with $r^2 > 0.50$ are considered meaningful.

Variable	Log Pd Basin area	Sample Size
Log Ppt	-0.25	162
Db Elevation	0.13	124
Dc Elevation	0.12	150
Pd Elevation	0.08	157
Basin Relief	0.27	120
Divide Relief	0.19	146
Log Dc - Pd	0.77	125
Log Divide Gradient	-0.16	105

The summary of Pd distances by FFR default region (**Table 17)** indicates the average Pd-distances are short being 245 meters (804 feet) in the Coastal region, 431 meters (1,379 feet) in the Westside, and 780 meters (2,558 feet) in the Eastside.

Table 17: Distance from divide to Pd. Descriptive statistics for distance from divide (Dc) to Pd by FFR default regions.

Statistic	Eastside (300 acres)	Westside (52 acres)	Coastal (13 acres)
Sample Size	38	117	18
Average (m)	780	431	245
Median (m)	538	333	212
Minimum (m)	44	39	39
Maximum (m)	2,933	1,534	1,065
1st Qtile (m)	327	214	132
3rd Qtile (m)	1,038	544	248
Coefficient of Variation	94	74	90

Corresponding median Pd-distances are 538 meters (1,765 feet), 333 meters (1,065 feet) and 212 meters (695 feet) in the Eastside, Westside and Coastal regions, respectively. Their C.V.s are less than 95 %, which makes Pd-distance significantly less variable than observed Pd-area (C.V.> 182%).

Pd-distance is strongly related to observed Pd-area (**Figure 12).** Regressions of Pd-distance upon observed Pd-area are significant (**Appendix** I) for (1) sites within a study area, (2) study areas within a FFR default region, and (3) default regions within the state. Analyses of covariance of the interaction of study areas indicate no significant differences (p>0.2). The state regression in **Figure 12** thus expresses the relationship between observed Pd- area and Pd-distance at all study areas across all ecoregions.

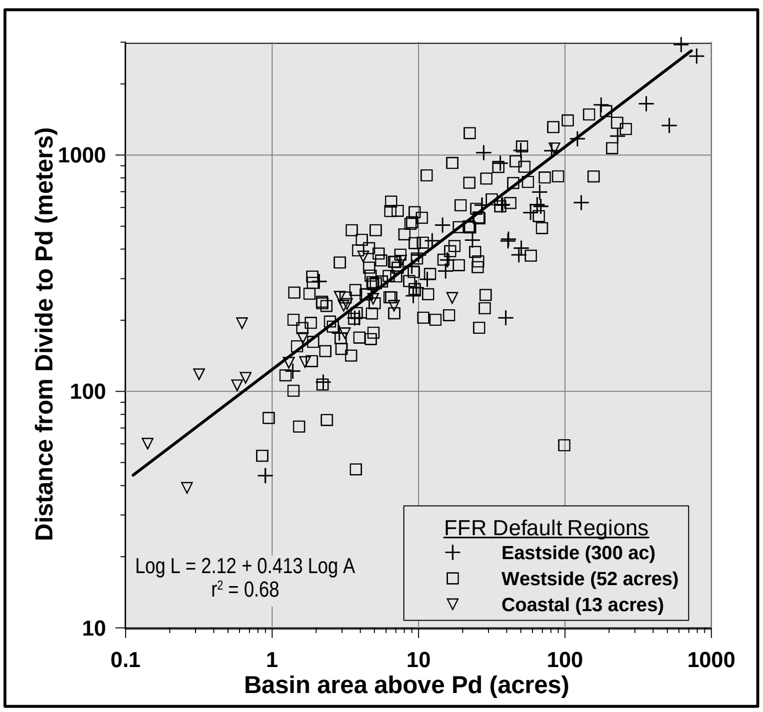


Figure 12: Distance from divide vs. Basin area. Scatter diagram showing the relationship between distance from divide to Pd and basin area above Pd. Regression equation for all data is highly significant.

Alternative Stratification Schemes for FFR Defaults

We tested three alternative hypotheses for establishing

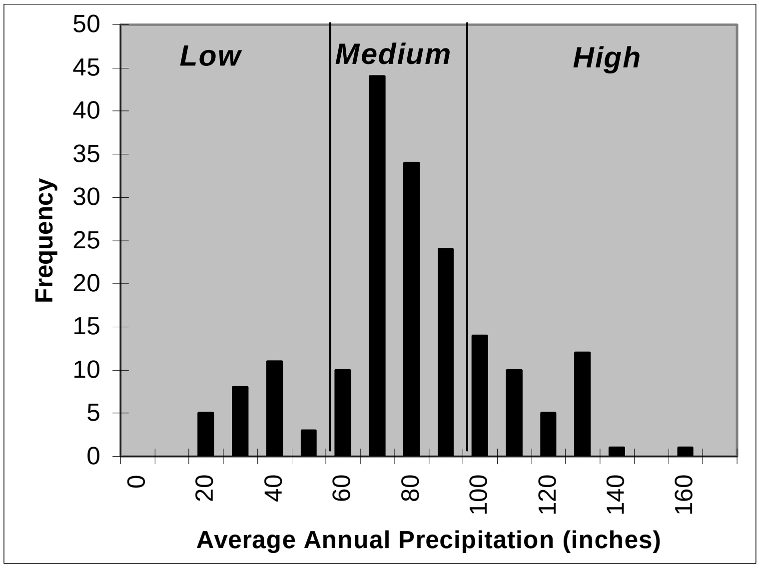


Figure 13: Histogram of Average Annual Precipitation. The frequency of precipitation values occurring at Pd in 218 study sites in the state. The precipitation classes used in the analysis are labeled Low through High.

FFR default regions based on a single physical attribute – average annual precipitation, elevation, and relief. Because Pd-areas were not significantly different when grouped into three classes based on elevation or relief, these two attributes were eliminated as potential criteria. Precipitation classes have significantly different Pd-areas and slightly lower C.V.s.

The distribution of the average annual precipitation in Washington is shown in **Figure 8**, which is based upon PRISM model data. These data were used to determine the precipitation distribution at Pd (**Figure 13)**, which was divided into three classes for a preliminary analysis of basin areas:

- Low (<30 to 60 inches, <750 to1,500 mm)
- Medium (60 to 100 inches, 1,500 – 2,500 mm)
- High (100 to 160 inches, 2,500 to 4,000 mm)

Table 18 presents the median and average observed Pd-areas for the three precipitation classes. With increasing average annual precipitation, the average Pd-areas decrease from 122 acres to 10 acres, and median Pd-areas decrease from 27 acres to 3 acres. ANOVA indicates that the Pd-areas in the different precipitation classes are significantly different. The C.V.s for the three-precipitation classes ranges from 163% to 281% and are similar to the C.V.s for default regions (182% to 249%).

Average annual precipitation may be an appropriate tool for determining default regions because Pd-areas vary inversely with average annual precipitation as shown in **Figure 14**. ANOVA indicates it is highly significant ($\alpha < 0.001$) although the explanatory power is not great with an $r^2 = 0.20$. The large variability around this trend indicates the importance of other contributing factors.

Table 18: Basin area above Pd by precipitation class. Class boundaries selected to divide precipitation range into approximately equal cells. Total number of sites in "Included sites by FFR default region" exceeds number used to develop statistics because not all included sites had basin area data.

Statistic	Average Annual Precipitation Class		
	<30 - 60 In (<7750 - 1,500 mm)	**60 - 100 in** 1,500 mm - 2,500 mm)	**100 - 160 in** (>2,500 mm)
Number of Sites	49	127	31
Average	54.6	38.0	3.6
Median	18.9	6.8	1.8
Minimum	0.4	0.7	0.3
Maximum	515.6	793.1	20.6
1st Qtile	6.8	3.5	1.2
3rd Qtile	58.3	22.4	3.5
COV	175.8	281.1	129.6
Sites by Default Region			
Coastal	0	0	21
Westside	16	124	10
Eastside	33	12	1

Table 19. Distance from divide by Precipitation Class. Distance between point Dc on the drainage divide and point Pd.

Statistic	Average Annual Precipitation Class		
	<30 - 60 In (<7750 - 1,500 mm)	**60 - 100 in** 1,500 mm - 2,500 mm)	**100 - 160 in** (>2,500 mm)
Number of Sites	41	120	30
Average	737	429	251
Median	581	339	230
Minimum	47	44	39
Maximum	2,933	1,534	1,065
1st Qtile	284	215	132
3rd Qtile	1,043	543	257
COV	86	71	89

Average annual precipitation classes also separate distance from divide to Pd into discrete classes with a low variance (**Table 19**). The precipitation classes indicate that distance from divide to Pd decreases from and average of 737 meters (2,417 feet) in drier areas to 251 meters (823 feet) in wetter areas and the median distances decrease from 581 meters (1,906 feet) in drier areas to 230 meters (754 feet) in wetter areas (the Eastside statistics are biased by the inclusion of sites wherein the channel head was not captured by the survey).

Intra-annual Variability

Figures 15 and **16** depict the changes in flow categories and the location of Pd and Pc in the five sites with multiple surveys during the summer of 2001. Both figures include the storm of August 21 – 22. The relative amount of perennial water between Ch and Pc is shown in **Figure 15**. No consistent pattern of drying is evident except that the August storm appears to have increased the degree of wetness within the channels.

Figure 16 shows the relative change in the distances between the channel head (Ch) and Pd and Pc. Both Pd and Pc appear to migrate downstream during the summer with Pc beginning its migration earlier than Pd. The August 21 – 22 storm does not appear to have affected the migration pattern of Pd and Pc.

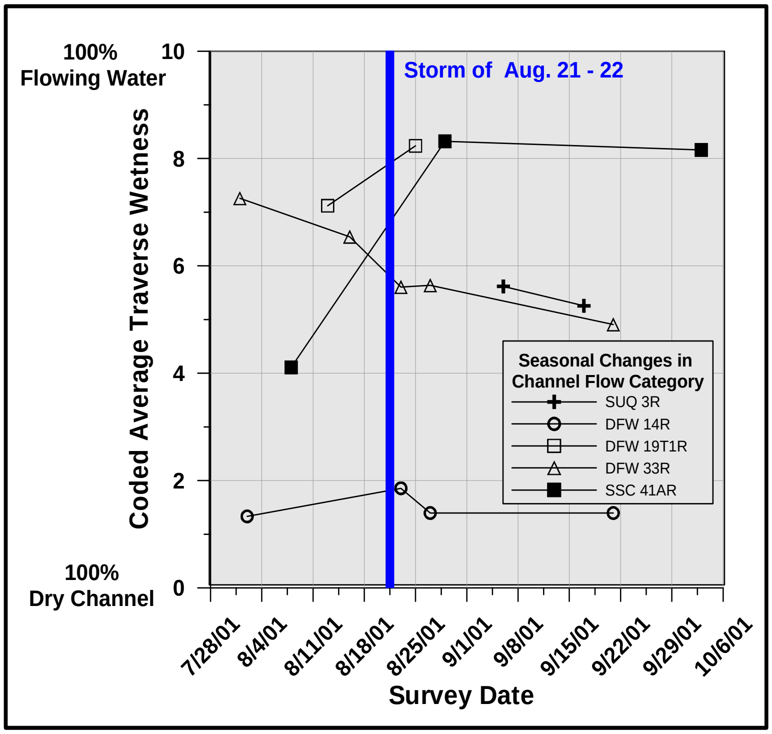


Figure 15: Coded Dryness of repeated surveys downstream from Ch showing intra-annual (seasonal) variation in the amount of perennial water in Type Np channels.

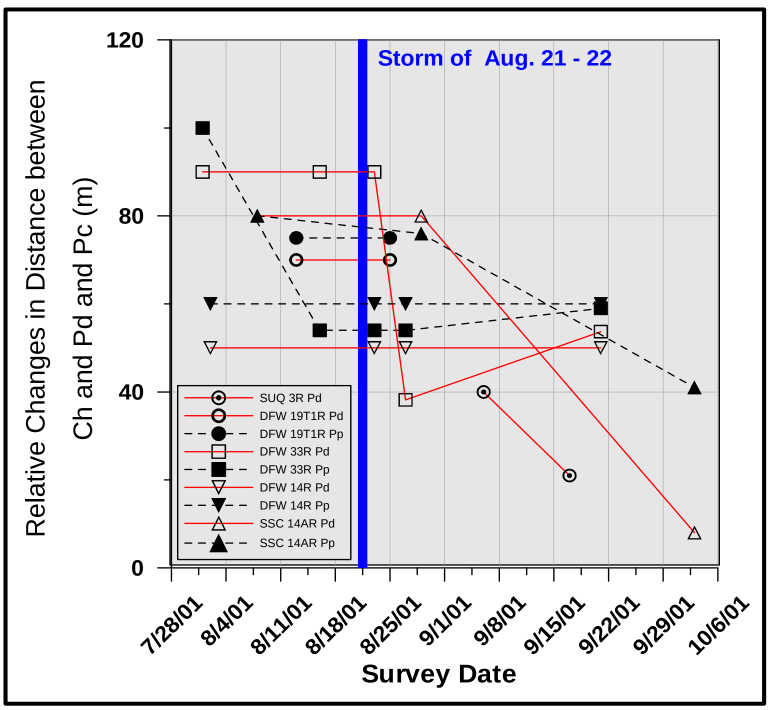


Figure 16: Changes in the position of Pd and Pc relative to Ch. The vertical scale is arbitrary and should be read as change since previous survey. No change produces a horizontal line and upstream migration a downward sloping line.

SECTION 4. DISCUSSION

Protocol

One of the dual purposes of the pilot study was to determine the adequacy and replicability of the pilot protocol. Replicability testing was only partially realized because most cooperators failed to conduct replicate surveys and the independent contractor conduct three replicate surveys. The result is that the replicability of the pilot protocol can not be fully and quantitatively assessed. The available information indicates that the observed field crews behaved differently. The identified problems are not deficiencies of the protocol but of management because segment break requirements are clearly specified in the protocol.

However, if the test of the pilot protocol is “Did it provide the necessary information?” The answer is that the field protocol is generally adequate but requires some modifications. The parameters included in the pilot study proved to be adequate to address the critical concerns of identifying and locating Pd, determining the variability of basin areas, and identifying possible alternative default criteria. Some additions and deletions are recommended to either streamline data collection or to provide the additional data required for new hypotheses recommended for testing. New parameters recommended for inclusion in the protocol are channel head, valley width, debris-flow scour, and debris-flow sediments. Recommended for deletion are bankfull channel width and depth.

The channel head (Point Ch) is an important hydrologic feature as it marks the beginning of channelized stream flow and usually can be identified during most seasons. Inclusion of Ch was not required by the pilot survey because the emphasis was on point Pd. Numerous surveys that did not reach the channel head may have missed isolated wet channels segments upstream of the previously identified Pd and thereby increased the average basin areas and distances from divide (Dc – Pd) and from the channel head (Ch – Pd). Because the channel head appears to vary in shape and degree of definition (Dietrich and Dunne, 1993; Roth and La Barbera, 1997), there should also be a certainty assessment (e.g. “definite”, “certain within a few channel widths”, “gradational over X distance”, “uncertain”).

The importance of valley width is uncertain. It may be an important control on the expression of surface flow (Kasahara and others, 2003; Storey and others, 2003) because it along with sediment depth and permeability controls the quantity of subsurface flow through the alluvial fill within the valley. Zellweger and others (1989) found that subsurface flow through alluvium could amount to about 25 percent of the surface flow and that aggradation of coarse sediment can increase the proportion of subsurface flow. Its inclusion in the study would allow the more complete analysis of the controls on Pd and the observed variability in basin area and distance downstream.

The addition of two channel categories would facilitate the assessment of debris-flow impacts. The additional channel categories are:

- "Debris-flow scoured" valleys containing little to no sediment on the valley floor because of recent debris-flow activity. The lack of sediment inhibits the development of a channel and perennial flow may occur further up stream because of the low storage within the valley. As colluvium and alluvium accumulate on the valley floor, perennial flow may begin farther down stream.
- "Debris-flow sediments" a valley floor containing debris-flow sediments. When the sediments are of sufficient thickness or high permeability surface water may disappear as underflow becomes dominant.

These channel categories will identify debris-flow prone valleys and allow the assessment of their uniqueness and potential impact on the location of the Np/Ns break. It is anticipated that debris-flows may affect a large proportion of the valleys in mountainous areas (Dunne, 1998; Montgomery, 1999; Whiting and Bradley, 1993).

The field parties recommended that bankfull channel width and depth be removed. Bankfull channel width and depth are difficult to measure because in many cases the channel edge is often indistinct in small streams. Because of this problem, the recorded channel widths and depths maybe inaccurate. Bankfull width and depth are more indicative of peakflow discharge rather than lowflows.

Several changes to the protocol would refine the data collected or streamline data collection. Field parties indicated that substrate was difficult to assess for a segment based on flow category. Allowing segment breaks at substrate changes could reduce the substrate identification problem and allow a fuller assessment of the association between substrate and Pd. The field parties also emphasized the large amount of time consumed by recording segment information at segment lengths of 30 meters (98 feet) or less and encouraged the increase in segment length to 100 meters (328 feet). This increase appears reasonable if both changes in flow and substrate categories are criteria for forced segment breaks.

Future surveys should emphasize the site and channel conditions occurring at Pd. Although the field protocol includes lists of possible indicators, the lists may not be sufficiently inclusive and an open-ended description may identify additional indicators.

Often the field coordinates for points do not plot on a recognizable drainage way on the USGS 7.5 minute topographic maps (Meyer and Wallace, 2001). The field party has the best understanding of the relationship of the survey to the topography and topographic map. Therefore they are in the best position to make any changes, such as moving a point to fit map, or plotting the drainage that does not appear on the map.

Year of Normal Rainfall

Different conclusions are possible from the 2001 precipitation data depending on the interval and area analyzed – the 2001 water year for the state or the summer of 2001 for the state default regions. At the state and annual scale, the WY 2001 had an unusually dry winter followed by a variable summer (average to wet on Westside, dry on the Eastside) that produced an unusually dry water year (**Table 12**). Based on the quartile definitions adopted here, 2001 was not "a year of normal rainfall." Rather 2001 was a year of less than normal rainfall that could be expected to produce longer dry reaches within headwater streams and move Pd downstream. Based on this annual assessment, we could anticipate Pd-areas to be larger than normal and the length of the seasonal reach to be longer than normal.

However, the seasonal variations in precipitation may be more important than the annual amount of precipitation. If so, the moderately wet summer months may compensate for the winter drought by providing sporadic recharge to the subsurface reservoir that maintains perennial flow and thereby decreases the Pd-area and shortens the length of seasonal reach.

At the seasonal level, regional differences appear. Summer conditions differed between the Eastside and Westside that could lead to different summer flow regimes. The monthly precipitation on the cooler Westside was typically two to three times larger than that on the hotter Eastside (**Table 12**). It is likely that more of the summer precipitation was lost to evapotranspiration on the Eastside than on the Westside. Consequently, little to no recharge to the soil reservoir would occur on the Eastside and some recharge to the reservoir could occur on the Westside. Based on this reasoning, it is likely that during the summer of 2001 the Eastside had unusually dry flow conditions while the Westside had normal flow conditions.

The “year of normal rainfall” raises two issues that are perhaps more important than the particulars of the 2001 water year. These are:

1. The FFR definition of “normal” is defined as annual, which precludes the use of seasonal precipitation data; seasonal precipitation may have a stronger control on the location of Pd
2. Precipitation is highly variable, so normalcy should be determined regionally.

The analysis presented here indicates that normalcy should be defined on a seasonal basis and for region smaller in area than the state.

Basin Areas

The observed Pd-areas are less than the FFR default basin areas. As shown in **Figure 9**, the FFR default basin areas are larger than the 75th percentile of the basin area distribution in most study areas. When the data are pooled by FFR default area, the average observed Pd-area in each default region (Coast, Westside, and Eastside, respectively) is 8 acres, 22 acres and 118 acres, which is only 61%, 42% and 39 % of the FFR default basin area. Likewise, the median observed Pd-area is 2 acres, 6 acres, and 36 acres, which are only 15%, 13 %, and 11.5% of the default basin areas (**Table 13**).

The observed Pd-areas in this study do not differ from those reported by other studies. Basin area studies conducted by CMER participants prior to 2001 (**Table 2, Appendix B**) report average basin areas ranging from 11 to 138 acres and median basin areas ranging from 10 to 40 acres. These studies used different protocols to collect the data and different definitions for point “Pd” from those in pilot study, so the similarity of their result to those of the pilot study is striking. This similarity indicates that

1. Differences in the definition of the Np/Ns break (point Pd) do not produce large changes in basin areas, and
2. Most available studies indicate that a smaller basin area is required to maintain perennial flow in headwater stream than envisioned by the default basin areas in the FFR.

The results of a study of perennial flow in Puget Lowland streams indicate larger drainage basin areas (Konrad, 2001). The study included 59 basins throughout Puget Lowland (ecoregion 2) that were surveyed in August 1998 and 1999. This study used stream-gaging records and basin areas above the stream gages to calculate the basin area required to maintain perennial flow at Pc. Streams with recorded surface flow during late summer were designated perennial and those without flow were designated ephemeral (seasonal) and a logistics equation used to estimate the probability of perennial flow with different basin areas. This approach indicated that a 50% probability existed for perennial flow where the drainage basin was less than 1.2 km^2 (296 acres).

Basin Area Variability

The observed Pd-areas differed significantly between FFR default regions and between some ecoregions (**Figure 9, Table 14**). The observed geographic variation in Pd-area may have resulted from inconsistency between cooperators in data collection. As shown in **Table 14**, Pd-areas for the different study areas did not differ statistically when specific study areas were removed from the grouping. On the Eastside, the separation of the COL and SPO study areas from YAK and LVF study areas resulted in two groups with no statistical differences in Pd-area. On the Westside, the removal of the TCG study area from the Westside group resulted in a grouping of statistically similar Pd-areas. As noted earlier, many surveys by the SPO, COL, and TGC did not capture the channel head, which means the actual Pd may lie farther upstream of the Pd identified in these surveys. Misidentification of Pd could produce larger Pd-areas. The median Pd-area in TCG is 19 acres compared to 5 to 15 acres for the other Westside study areas and Pd-area in the COL and SPO study areas are 229 and 105 acres compared to 12 to 46 acres for the other Eastside study areas. The conclusion that these differences may result from observer differences is clouded for TCG-4, which is not statistically different from the other study areas in ecoregion 4 (YAK-4 and LVF-4), and these similarities may be pointing to an unique situation in ecoregion 4. These relationships highlight the importance of capturing the channel head in future surveys because of the close relationship between perennial water and the channel head shown in **Table 15**

Part of the variability in Pd-area may result in part from differences in precipitation as shown by the precipitation analysis (**Table 18**). Castro and Jackson (2001) reached a similar conclusion in their analysis of bankfull discharges in the Pacific Northwest. They determined that although ecoregions included the statistically most significant spatial factors controlling bankfull discharges, climate regionalization was also significantly related to bankfull discharge. The authors attributed this duality to the climate-adapted vegetation associations in each ecoregion that controlled runoff conditions.

The watershed variables used in the pilot study do not appear to control perennial flow. As shown in **Table 16**, Pd-area is not related to elevation or relief. The Puget Lowland study (Konrad, 2001) also found that perennial flow was related only to basin area and not to four other physiographic variables or degree of urban development. They compared perennial flow to basin area, valley slope, valley relief, basin shape, and surficial geology. Perennial flow was related only to basin area and the contact between outwash and till. The study did not determine the changes in the extent of perennial flow that may have occurred during the initial clearing of the forests.

Precipitation Classes Defining Alternate Default Regions

Precipitation may be a more appropriate criterion for identifying FFR default regions. The precipitation classes in **Table 18**, which includes data from all FFR default regions, indicate the inherent heterogeneity of FFR geographically-based default regions. For instance, the less than 60-inch precipitation class includes 33 sites from the Eastside and 13 sites from the Westside. The precipitation class boundaries used in this analysis may not be the most appropriate, and if precipitation is used as the basis for default regions, further study to determine the most appropriate boundaries are recommended.

Alternative Indicators

The phase 1 search for alternative field indicators for the Np/Ns break was partially successful. The existence of a unique and consistent change in some channel feature was not found but the consistent proximity of the channel head to the Np/Ns break makes it an attractive alternate. The lack of unique changes in channel geometry at Pd indicates that either a consistent and unique change in channel geometry does not occur at Pd, or the 2001 protocol was not capable of detecting such a change that indeed was present. The 2001 protocol was capable of identifying several alternatives with lower variability than the present default basin areas.

The channel head may the best alternative field indicator for the Np/Ns break. It has three advantages: (1) It can be identified in the field during most seasons, (2) It does not migrate seasonally, (3) It lies close to the field-identified Pd (**Table 15**), and (4) Its use requires no measurements. A potential disadvantage is that the channel head probably can not be located on maps or aerial photographs without field data. Theoretical and empirical relationships exist for predicting the location of channel heads at the landscape scale (Montgomery and Dietrich, 1989), but the application of these relationships to predict channel head locations in Washington state have been unsuccessful (Jaeger, 2004).

The length of the seasonal reach also can be used in the field to identify the Np/Ns break. Once the channel head is identified, the location of the Np/Ns break in the channel can be determined using its median length (**Table 15**). Seasonal reach length can be used to reduce the discrepancy in distance between Pd and Ch at the expense of measuring a specified distance and placing a monument to mark the regulatory Np/Ns break.

Pd-distance is the third alternative indicator. As shown in **Figure 11**, it is strongly related to basin area (Montgomery and Dietrich, 1992) and as shown in **Table 17**, it has a much lower coefficient of variation (74% to 94%) than default basin areas (182% to 249%). Pd-distance has the advantage of being readily measured on a map and could be the basis for computer-generated default maps within the GIS environment. Pd-distance has two disadvantages; (1) it may be difficult to measure in the field and (2) it may change seasonally as Pd migrates up and down stream.

Sample Size and Design

The skewed distributions encountered in the pilot study skews the confidence interval about the average in the arithmetic data. The confidence intervals are symmetrical in the log-transformed data used to estimate the required sample size, but when back transformed, the confidence interval becomes skewed with a long tail toward larger values (**Appendix H, Figure 1**).

The sample design for the phase 2 statewide study should include:

1. Sample size,
2. Sample distribution, and
3. Stratification.

In order to assure a representative estimate of Pd across the selected strata (e.g. FFR default region or precipitation class), the sites should be selected with equal probability from the FFR lands within each stratum. Moreover, the estimated sample sizes should be considered minimum values so that statistical power will be adequate if actual variance was underestimated.

The estimated sample size depends on the stratification criterion. In **Table 20** sample sizes are listed for two stratification criteria – FFR default regions and precipitation classes -- and for two possible default criteria – basin area above Pd and Distance from divide to Pd. The estimated sample sizes are similar for both FFR default regions and precipitation classes because coefficients of variation for basin areas and for distance from divide do not change significantly. The large difference in sample sizes between potential default criteria -- basin areas and distance from divide -- results from the low CV and large median for the observed distance from divide.

Table 20: Estimated sample sizes. Sample size required to estimate the observed average basin area with a 10 percent confidence interval of different precisions. Average and CV (coefficient of variation) are estimated from the lognormal transformation of the observed data. Precision is the size of the 90% confidence interval as a percentage of the average. Dashes in the precision columns indicate estimated sample sizes less than one.

Default Variable	Stratum			Sample size for a Precision of				
	Cell	Average*	CV*	5%	10%	15%	20%	25%
Basin Areas	***FFR Default Region***							
	Eastside	27	56	329	84	38	22	15
	Westside	6	70	532	134	61	35	23
	Precipitation Class							
	<60”	29	54	329	84	38	22	15
	60” – 100”	9	59	391	99	45	26	18
	100 - 150”	3	137	1,974	532	238	134	87
Distance from Divide to Pd	***FFR Default Region***							
	Eastside	540	14	26	8	--	--	--
	Westside	431	12	26	8	--	--	--
						--	--	--
	Precipitation Class							
	<60”	525	14	26	8	--	--	--
	60” – 100”	341	12	13	9	--	--	--
	100 – 150”	201	13	26	8	--	--	--

Intra-Annual Variations

The limited data presented in **Figures 14** and **15** indicate that each surveyed stream behaved differently in response to seasonal precipitation trends. The large summer storm in August appears to have increased seepage to the channel and thereby increased its ‘wetness” but the storm did not appear to affect the migration pattern of either Pd or Pc. The lack of a consistent pattern may indicate that local conditions are more important that meteorological conditions in controlling the migration of Pd and Pc.

Replicate surveys using a larger sample were conducted in 2002 in the Stillman Basin by DFW. These surveys indicated that both Pd and Pc moved downstream during the August and September of 2002. Pd was more stable, with most points moving less than 10 meters. (Mark Hunter, pers. comm.)

SECTION 5. POTENTIAL STUDIES

In addition to the proposed statewide Np demarcation study outlined in the previous sections, the pilot study raised several related technical questions that could be addressed by either future studies or the proposed statewide study. These questions with an explanation follow.

1. ***Does the first appearance of perennial water in the channel (point Pd) change position relative to the channel head (point Ch) during the summer dry season?***

This question asks if low flow observations collected during one part of the summer dry season is representative of low flow conditions during other parts of the summer dry season. The limited intra-annual variation data collected in this study were not analyzed. Other studies (Mark Hunter and others, 2003) indicate no consistent pattern in the behavior of Pd during the summer. At some sites, the position of Pd was stable throughout the summer dry season, whereas, at other sites, downstream migration of Pd began at different times in August.

The issue of seasonal instability would be addressed by repeated surveys of representative streams beginning with wet conditions during the spring runoff and continuing through the entire summer dry season until wetter conditions return following the winter rains.

2. ***Does categorizing default criteria by annual precipitation classes predict point Pd with less variability than do the existing 13, 52, and 300-acre default area?***

Areas with similar amounts of annual precipitation occur both east and west of the Cascade crest. The analyses in the pilot study indicated that precipitation contributes to the observed variability in basin areas but the observed variability using precipitation classes was almost as large as that using FFR default regions. A study is recommended to determine the source and validity of this variability. A study with a sampling design that controlled for precipitation classes has would have two advantages:

1. It could reduce the observed variability, and
2. It would be based on a single physical attribute, one that has been shown to be a regional control of variability in basin areas and distances from divide.

The precipitation issue is complicated by our incomplete understanding of its control on perennial flow (i.e. is the annual or seasonal precipitation the primary control on Pd?). FFR refers to a “year of normal rainfall” but alternative measures of precipitation (e.g. summer averages, difference between spring & summer, etc) may offer more effective predictors as these measures may be more hydrologically significant to perennial expression.

3. ***Is the distance between the channel head (point Ch) or divide and the first downstream appearance of perennial water (Pd) a better predictor of this point than default basin area?***

The FFR requires the identification of simple, non-technical field indicator of the Np/Ns break, here identified as Pd. In most areas during snow-free conditions, the channel head can be identified by trained technicians and a default distance measured downstream from it. Moreover, the divide can be recognized on most topographic maps and the distance from the divide to channel marked off. The consistency of these distances can be evaluated by determining the location of both the channel head and Pd during future surveys.

Several cooperators noted that low relief valleys were sometimes incorrectly mapped or did not appear on the topographic map. The inaccuracy of the topographic base maps may limit the use of the divide as a default criterion (if so, the same limitation exists for default basin areas).

4. ***Do headwater streams susceptible to debris flows have different physical characteristics that affect the location of Pd and Pc?***

The pilot survey did not request information on debris-flow activity except to note where debris-flow sediments caused a change in flow category. At least one cooperator (HOH) noted that channels were poorly defined in debris-flow scoured valleys because of the lack of sediment (Dunne, 1998). The location and behavior of Pd and Pc should be different in these valleys (Gomi, 2002).

Several classification of headwater streams that appear in the literature (Montgomery, 1999; Whiting and Bradley, 1993), emphasize the distinction between debris-flow and fluvial dominated valleys. Future studies should include debris-flow prone valleys to determine if they constitute a unique subset.

5. ***What is the function of piped channels in the Np stream network?***

This question is important because piped channels are not presently being considered as "typed waters". In 2001, piped channels were surveyed as part of the Np stream network with Ch, Pd and occasionally Pc being located within them. The literature on piped channels and macropores is growing. Piped channels are extremely important conduits of storm flow with the shallow pipes on hillslopes intercepting soil throughflow and conducting it a quickflow to the channel (Jones, 1997; Pearce and others, 1986; Ward, 1984). The subsurface erosion associated with pipe enlargement is main mechanism leading to gully formation [channel head extension] in an area where 70 percent of the stormflow is through piped channels (Swanson and others (1989). Ziemer (1992) noted that the larger pipes in the Caspar Creek Watershed in California maintained summer low flows in drainage basins around one hectare in size. Ground and soil levels in bedrock hollows may be controlled by the depth of macropores and piped channels (Montgomery and Dietrich, 1995) and thus serve an important slope stability function. Piped channels respond quickly to forest harvest, but the biological functions of piped channels have not been assessed.

Future studies could focus on the identification and functions of piped channels to assess their importance to FFR rules and their inclusion in the channel system during the assessment of the Np/Ns break

SECTION 6. SUMMARY

The pilot study confirmed that the pilot protocol was adequate to consistently collect channel data that could be used to identify the Np/Ns break (Pd). The protocol would be improved by requiring the continuous survey of the channel to the channel head.

The pilot study provides some useful insights on the character of headwater streams and default basin areas:

1. ***Perennial water is commonly located near the channel head***. The proximity of the channel head and Pd indicates that: 1) the channel head is a good indicator of the beginning of perennial flow (the Np/Ns break), and 2) the length of seasonal channel is very small relative to the length of perennial channels. This proximity produces a small basin area for Pd and requires the protocol to include the channel head in the survey.

2. ***Channel attributes do not change at Pd***. Changes in channel attributes, such as substrate or width, do not occur at the change from seasonal to perennial water (Pd) in any greater frequency than at other flow break within the stream. It is unlikely that physical attributes can be used to identify the Np/Ns break.

3. ***Observed basin areas for Pd are smaller than FFR default basin areas***: The results indicate that average observed basin areas are around 50% of the default basin areas and the median observed basin areas are less than 15% of the default basin areas. These results are similar to those from earlier studies in Washington.

4. ***The basin areas above Pd vary spatially across the state***. This variation is indicated by the differences between basin areas in different FFR default regions. The preliminary analysis of this spatial variability indicates that precipitation is a stronger control on Pd location than default region.

5. ***Distance from divide to Pd is less variable than basin area***. Although distance from divide to Pd is a function of the basin area above Pd, it is less variable as measured by the coefficient of variation. Its lower variability and greater ease of delineation than basin area makes it an attractive alternative indicator and potential default criterion.

6. ***Sample sizes required depend on the attribute of Pd that is being characterized -- basin area or distance from divide***. Sample sizes are the same for FFR default regions and precipitation classes but differ significantly between variable being measured. Sample sizes required to estimate distance from divide are only 10% of those for basin area.

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Appendix A

Passages Defining Type N Waters

FFR Appendix B, B.1(e)(iii):

> ***"'Type N waters' include all segments of natural waters within the bankfull widths of defined channels that are not Type S or F waters and which are either perennial streams (as defined below) or are physically connected by an above-ground channel system to downstream waters such that water or sediment initially delivered to such waters will eventually be delivered to a Type S or F water. Type N waters include two subcategories of waters: seasonal and perennial streams. As used in this Report, 'perennial streams' include all Type N waters which do not go dry at any time during a year of normal rainfall. In many cases, field practitioners and scientists do not have the experience necessary to make a field determination of the initiation point of perennial Type N waters. Making the determination will require a better understanding of the natural variability of the spatially intermittent component of perennial streams. Factors such as stream associated amphibian habitat, sediment deposition patterns, channel morphology, water flow, non-migrating seeps or springs, and position in the basin will be observed in preparing a protocol for perennial stream identification. In those cases where non-migrating seeps or springs as the point of initiation of perennial flow cannot be firmly identified with simple, non-technical observations: (A) on the Westside, Type N waters will be 'perennial streams' if they have a basin size in excess of the following minimums: 13 acres in the coastal zone (which corresponds to the sitka spruce zone defined in Franklin and Dyrness 1973) and 52 acres on the rest of the Westside; and (B) on the Eastside, Type N waters will be 'perennial streams' if they have a basin size in excess of 300 acres. The basin size thresholds identified in the preceding sentence, may, at the request of any author and subject to adequate funding and prioritization, be subject to review through adaptive management."***[1]

WAC 222-16-030(3) and 222-16-031(4) specify:

"Type Np Water"; "Type 4 Water" means all segments of natural waters within the bankfull width of defined channels that are perennial nonfish habitat streams. Perennial streams are waters that do not go dry any time of a year of normal rainfall. However, for the purpose of water typing, <u>Type 4 Waters include the intermittent dry portions of the perennial channel below the uppermost point of perennial flow</u>. If the uppermost point of perennial flow cannot be identified with simple, nontechnical observations (see board manual, section 23), then Type 4 Waters begin at a point along the channel where the contributing basin area is:

(a) ***At least 13 acres in the Western Washington coastal zone (which corresponds to the sitka spruce zone defined in Franklin and Dyrness 1973);***
(b) ***At least 52 acres in other locations in Western Washington;***
(c) ***At least 300 acres in Eastern Washington.***

Summary of results from pre-2001 perennial flow transition studies

Introduction

Prior to the 2001 CMER pilot study, several TFW cooperators conducted independent field studies of the distribution of perennial and seasonal headwater streams (Table 1). All of the studies were conducted during the summer low flow seasons of 1998 or 2000, in part, to evaluate proposed regulatory guidelines that differentiate non-fish-bearing headwater streams on the basis of the seasonal flow regime (i.e. perennial vs. seasonal). However, each study was designed more-or-less independently and utilized slightly different field methods.

Table 1. Summary of available Washington perennial stream studies from 1998 and 2000.

Study sponsor	Contact person	Study area (location)	Year visited	Total sites (#)	Regulatory default region	Average annual precip. (inches)
Champion Timberlands	Mike Liquori[1]	Kapowsin (W. central Cascades)	1998	86	Western WA	35-95"
Longview Fibre	Jim MacCracken[2]	SW Washington	1998	68	Western WA	48-112"
		Mid-Columbia (Col. Gorge)	1998	32	Western & Eastern WA	32-114"
		Chelan (E. Cascades)	1998	38	Eastern WA	18-60"
Wash. Dept. Fish. & Wild.	Mark Hunter[3]	Stillman Basin (Willapa Hills)	2000	10	Western WA	60-110"
Skagit System Cooperative	Curt Veldhuisen[4]	Skagit River area (NW. Cascades)	2000	43	Western WA	62-116"
Contact information (email, phone): 1 – mliquori@campbellgroup.com, (206) 817-2137 2 - jmac@longfibre.com, (360) 575-5109 3 - HUNTEMAH@dfw.wa.gov, (360) 902-2542 4 – cveldhuisen@skagitcoop.org, (360) 854-7050						

The results of these pre-2001 studies are relevant to the subsequent CMER study for two reasons. First, preliminary data from several of these studies (i.e. Kapowsin and undocumented Weyerhaeuser studies) supported the development of the default basin area acreage values established in the Forest and Fish Report (Mike Liquori, personal communication). Secondly, the field experience and findings generated from these studies provided important background information for the ongoing CMER effort.

The purpose of this appendix is to summarize available results of pre-2001 studies for the convenience of readers of the 2001 pilot report. This appendix summarizes results from the four studies that were provided to the Np Technical Group in response to email requests within the CMER community. Each of these studies is documented more thoroughly in unpublished reports cited in the Reference section of this appendix. Readers interested in additional details on the individual studies should consult the original reports and/or authors (contact information supplied at the bottom of Table 1). This appendix provides minimal interpretation or synthesis of these study results, due mainly to the differences in field methods among various component studies.

Overview of Study Methods

All pre-2001 studies were done prior to the development of standard protocols (i.e. Np Survey Working Group, 2001). In fact, during this period there was considerable uncertainty regarding what field conditions would constitute a Type Ns/Np break. Original reports should be consulted for additional details.

<u>Study Areas and Site Selection:</u> Four of the six study areas are within the western Washington (non-coastal) regulatory default area (Table 1). Average annual precipitation for these sites ranges from around 40 to 120 inches. Longview Fibre's Chelan study area and portions of the Columbia Gorge study are located in the eastern Cascade regulatory region and receive 24-60 inches of precipitation (Table 1). Both studies are within 50 miles of the Cascade Crest, however. None of the pre-2001 studies include areas in the eastern interior or the coastal spruce zone. Individual study areas were bounded on the basis of either land ownership (i.e. Champion and Longview Fibre studies) or watershed boundaries (i.e. WDFW and SSC studies). Site selection approaches varied between studies, and incorporated considerations including accessibility, spatial representation, randomization, and/or proximity to pre-existing study sites.

<u>Field Survey Methods:</u> Field data collection methods varied considerably among the pre-2001 studies, though certain generalities can be made. All field surveys occurred during the late summer/early fall dry season. Most surveyors walked along small channels until they identified a point where the channel was wet downstream and dry upstream. Because the field definitions and terms for such points differed between studies (Table 2) they are referred to generically in this report as "flow transition points". Many investigators (i.e. Longview Fibre and Skagit studies) walked an additional several hundred feet up and downstream from potential flow transition points to verify that the flow status had changed for a substantial length. Most studies characterized, to some extent, channel conditions (e.g. gradient, substrate, channel width) at flow transition points, though most reports provide minimal documentation. Studies varied considerably in their consideration of so-called "spatial intermittent" segments, in which multiple flow transition points occurred along a single stream during field surveys. Only the Kapowsin study (Liquori 2001) differentiated between flow transition points at the upstream end of spatially continuous vs. discontinuous (or "spatially intermittent") reaches. From available documentation, it is not clear how any of the pre-2001 transition points compare with the flow transition points identified using the 2001 pilot method (Np Survey Working Group 2001).

<u>Point Location and Basin Area Determination</u>: Field identified flow transition points were mapped onto topographic maps or aerial photographs with assistance from hand compass, hip chain and/or hypsometer (AKA "laser range-finder") information. Many of the pre-2001 sites were revisited during the 2001 UPSAG pilot project, and documented using the standard method (Np Survey Working Group 2001). Contributing basin areas for flow transition points were determined using GIS or visual interpretation of surface topography shown on maps, DEMs or stereo air photography.

<u>Revisits to Evaluate Year-to-Year Differences</u>: Many (111) of the flow transition points evaluated in 1998 and 2000 were revisited during the 2001 pilot surveys. The resulting 2001 data was inspected to determine whether the previously-identified flow transition point was in a similar or different location. The field criteria from the initial visit were recreated as closely as possible in 2001, so that apparent differences would indicate year-to-year changes in flow conditions rather than differences in field methods.

Summary of Results and Discussion

Basin Areas: The pre-2001 studies included nearly 300 streams statewide (Table 2). Reports generally focus on the distribution of basin areas for flow transition points, with the exception of the Kapowsin study (Liquori 2001). The range of basin areas was variable within and between individual study areas (Table 2). For instance, standard deviations were larger than means for most studies where reported. The range of means and medians for the various studies was considerably narrower, especially the medians. Given that the distributions of basin areas for each study area were strongly skewed, medians appear to be the better statistic to describe the central tendency. Large-basin outliers were found in each study area except for the Stillman basin (Table 2).

Table 2. Summary of basin areas for perennial flow transition points

Study Area	Term for flow transition point	Number of sites	Basin area statistics (acres) Median	Mean	Min.-max	Standard deviation
Kapowsin	"Perennial initiation point[1]"	86	40	138	2 - 4207	472
	"Spatially intermittent initiation point"	34[2]	17	41	2 - 346	67
SW Washington	"Point of origin"	78	13	20	3 - 126	NR[3]
Mid-Columbia	"Point of origin"	32	32	90	1 - 624	NR[3]
Chelan	"Point of origin"	38	39	68	4 - 259	NR[3]
Stillman basin	"End of finger water"	10	10	11	8 - 15	2
Skagit	"Low flow initiation point"	43	17	23	1 - 136	256

1 – Perennial initiation points must be spatial continuous to downstream waters
2 – All spatially intermittent initiation points are located upstream of "perennial initiation points"

Year-to-year variation: Locations of flow transition points differed between years at the majority (84%) of sites (Table 3). Among sites that differed from the initial visit, most (66%) were located upstream, though some were found downstream as well. The prevalence of transition points upstream presumably reflects greater summer precipitation in summer 2001 (despite the very dry winter) relative to the summer of the initial visit (Table 3). It has been hypothesized that the modest proportion (16%) of transition points found in similar locations in both years, reflects the local influence of springs or other stationary groundwater release points (Liquori 2001).

Table 3. Summary of year-to-year location of flow transition points

Study Area	Point	Years visited	Relative location of 2001 point (#): upstream	similar	downstream	Difference in summer precip.
SW Wash.	PO	1998 & 2001	36	0	13	2001 wetter
Mid-Columbia	PO	1998 & 2001	9	3	3	2001 wetter
Chelan	PO	1998 & 2001	6	6	4	2001 wetter
Stillman	EOFW	2000 & 2001	3	4	1	2001 drier (for year)
Skagit	LFIP	2000 & 2001	12	5	6	2001 wetter
All areas	various	'98/'00 & '01	66 (60%)	18 (16%)	27 (24%)	Mostly wetter

References

Hunter, M., T. Quinn and D. Dugger. 2001. PIP Studies in the Stillman Basin, 2001. Draft report dated 12-1-01. Washington Department of Fisheries and Wildlife, Olympia, WA.

Hunter, Mark. 2002. Unpublished WDFW headwater stream field data from 2000. Washington Department of Fisheries and Wildlife, Olympia, WA.

Liquori, M. 2001. Observations on the location of perennial and intermittent stream initiation points in forested headwater streams. Unpublished report prepared by the Campbell Group for the CMER Np working group.

MacCracken, J. and W. Boyd. Spatial and temporal variation in stream origins on Longview Fibre Company timberlands in Washington. Unpublished report by Longview Fibre Company, Longview WA.

Np Survey Working Group. 2001. Perennial stream survey field sample protocol (version 1.21). Field protocol developed by sub-group of the Cooperative Monitoring Evaluation and Research Committee, Olympia WA.

Veldhuisen, C. 2000. Preliminary results and recommendations from the Northwest Cascades Type 4/5 stream study. Unpublished report by Skagit System Cooperative, Sedro Woolley, WA.

Appendix C

Perennial Stream Survey

Field Sample Protocol (version 1.21)

1.0 Introduction

This field sample protocol was developed to provide a consistent repeatable method to evaluate the locations in stream systems where continuous perennial flow and where spatially intermittent perennial flow are found and to develop a program to test whether the 12 (Sitka spruce zone), 52 (western WA), and 300-acre (eastern WA) basin area threshold relationships are correct. The protocol is intended to ensure that data collected in the summer of 2001 by various parties is comparable, that data collected in those programs is quantitative and repeatable, that data will be useful in addressing regulatory issues regarding perennial flow, and that site selection meets minimum requirements for random site selection. Ultimately,

The developers of this protocol recognize that additional work needs to be done to:

a) Develop a systematic statewide site selection process, including identification of an appropriate site stratification approach for sampling in year 2002.
b) Identify specific hypotheses to be tested and the specific data analysis methods to be used to address those hypotheses.
c) Attain a scientific review of the overall study plan and to fine tune the study protocol for a statewide sampling effort in 2002.

This protocol was developed and released in recognition that data would be collected by many parties in the summer of 2001, regardless of whether a protocol was available. Field data collected in compliance with this pilot protocol in 2001 will be considered to be comparable and thus potentially suitable for adaptive management purposes. Such data is expected to provide useful insight into a) problems with the protocol, b) appropriate sample sizes for the statewide study, and c) variables affecting identified relationships that might be useful in planning for data stratification. Individual cooperators may choose to collect additional information not described here, so long as the additional effort required is not supported by CMER funding. Efforts conducted in 2001 are primarily intended as a pilot effort for the larger statewide program projected for 2002.

1.2 Objective

The primary objective of the protocol is to generate data to support adaptive management related to water typing in headwater streams, particularly related to identification of perennial/nonperennial breaks. Please note that this protocol is specifically not to be used as an operational protocol for harvest unit application or water typing.

2.0 Overview

This protocol was developed to guide the collection of quantitative, repeatable data in the field. It is intended to document physical hydrologic breaks, regardless of whether fish are present or absent.

A method is provided to guide random selection of streams where the data is to be collected. Once randomly selected streams have been identified, the field crew will proceed to a site that is easily found again (bridge, confluence of tribs, etc) that is near or within the stream segments to be surveyed. Several types of flow have been defined. The field crews will work upstream, measuring the distance at which the character of flow per the definitions changes. Several ancillary variables are recorded at each change in flow category, which may be useful in defining field criteria for identifying these sites off-season, may be used in developing relationships that predict the locations of interest, and/or may be used to guide site stratification.

No procedure is provided for interpretation of data because it has not been determined yet.

3.0 Definitions

Definition of Flow Categories .

NOTE: Flow going under organic cover, such as logs, trees, stumps, and soil- or vegetation-covered root mats does not represent a break in flow class, except for circumstances defined by "Obscured" or "Unknown" below. As a rule of thumb, imagine the stream without its organic cover, when describing its flow definition.

Flowing Water (FW): Any segment of channel upstream of the point of continuous flow that is greater than five meters in length, where water exposed at surface shows any signs of flow. The width of the flowing water is not a defining criterion.

Standing Water (SW): Larger pools or areas of standing water (regardless of depth but not saturated ground), greater than five meters in length. TEST: If dry dust or small pine needles placed anywhere on the surface of the pool move without the aid of wind, it is flowing water, not standing water. Width is not a defining criterion.

Flowing Pocket Water (FP): Pools of water, in which flow is visible in at least some parts of the pool, separated by less than five meters of dry channel bed. Any unit of continuous surface water greater than a 10 cm by 10 cm square qualifies as a pocket. In those situations where both the upstream and downstream segment has 'Flowing water', 'Standing water' or 'Dry ' for over 5 meters, the FP unit can be as short as 0.1 meters.

Standing Pocket Water (SP): Pools of water, in which there is no discernable flow, separated by less than five meters of "Dry" flow (see below for definition). Any unit of continuous surface water greater than a 10 cm by 10 cm square qualifies as a pocket. In those situations where both the upstream and downstream segment is 'Flowing water', 'Standing water' or 'Dry ' for over 5 meters, the FP unit can be as short as 0.1 meters.

Dry (D): The streambed or area between or above defined channels shows no area of surface water greater than a 10 cm by 10 cm square for a minimum of five meters. This includes dry, moist and saturated substrates.

Unknown (U): Areas which could not be accessed (i.e., you did not walk the channel). For example, this may be a result of landowner restrictions, current operations such as timber harvest or blasting, steep inaccessible terrain, etc. Describe the situation in the notes. Estimate length and gradient of segment.

Obscured (O): Segments longer than 5 m that could not be typed because visibility is obscured by slash, debris, or dense vegetation. In cases where you can hear the stream flowing or can see it flowing through breaks in cover, record as F not O. If you cannot see or hear the stream, record as O. If the channel does not re-emerge at the end of the obscured segment, end the survey and describe the situation in the notes. Record the end distance and gradient of segment.

Please use your best judgment to identify the flow category. If it does not seem to fit any of the above categories, describe the situation in your notes, consult with your team leader and make your best estimation of a flow category.

Definitions of Channel Categories:

Defined Channel (DC): A stream channel defined by sharp incision into the substrate where water and mineral sediment are (or have been) transported in concentrated flows and vegetation and organic detritus is generally absent. Channels form as a result of downslope hydraulic (water-powered) scour into mineral substrate. For purposes of this survey, the low flow sections of the streambed must be mostly mineral substrate, comprised of sand, gravel, cobble, boulders, or bedrock. The boundary between the defined channel and surrounding riparian area is clear and usually abrupt. Woody debris or root mats suspended over the stream are not part of the streambed.

Poorly Defined Channel (PDC)– This is a stream channel with evidence of scour or deposition via past or present flowing water, but is poorly defined. Substrate material may include organic detritus, fine sediment deposits, or live vegetation, often in a patchy distribution. The boundary between the stream and riparian area is difficult to identify or patchy.

Modified channel (MC): All channels in culverts and following road ditch lines are in this category. Other circumstances, such as recent forest practices or dirt bike activity, that make it difficult to classify natural channel type should be classified as modified channel. The details must be recorded in the notes.

Piped Channel (PC): Channels conveying flowing water in a tube(s) or pipe(s) in the soil. Often, no expressed channel is defined at the surface. Pipes can often be observed through "holes" or "windows" that partially expose the channel. Piping DOES NOT include places where water simply disappears into the substrate (see Dry). Generally associated with established vegetation (i.e. tree or other roots), small channels covered by canopy litter, macropores in the soil, or lava tubes.

No Channel (NC): An area or swale with no observable evidence of scour or erosion that defines it's boundary with riparian or upslope areas.

Other Definitions

General Channel Width: Where a floodplain is present, the edge of the bank is characterized by 1) a berm or other break in slope from the floodplain down to the streambed; 2) a change in vegetation from trees, and perennial vegetation (brush) to bare surfaces and annual or water tolerant vegetation, and; 3) a change in substrate from fines or organic cover to sand, gravel, boulders or bedrock. For purposes of this survey, take a representative measurement of this width.

General Channel Depth. Channel Depth is the average distance from the bankfull width water surface elevation to the substrate. For purposes of this survey, take the average of three readings at ¼, ½ and ¾ intervals across the channel.

Stream Bed Substrate: F =silt/muck/mud, less than 0.625 mm grain size including organic component; **S** = sand, material 0.625 to 2 mm grain size with no organic component, **G** = gravel 2.0 to 64.0 mm (i.e., rocks smaller than a baseball), **C** = cobble 64.0 to 256.0 mm (i.e., rocks larger than a baseball and smaller than basketball), **B** = boulder > 256.0 mm (i.e., rocks larger than a basketball), **R** = bedrock.

Wetland: (WE): Wetlands are typically low gradient, and may have, deep organic muck, and wetland vegetation such as cattails or skunk cabbage. They may or may not have surface water visible or a discernable channel.

Seep (SE): Seeps are areas adjacent to the channel where water, which slowly oozes from the ground, does not form a Defined or Undefined Channel (defined above). These areas may have wetland vegetation and fine to coarse substrates.

4.0 Protocol Details

4.1 Sample Site Selection:

Site selection must be random within the area of interest, and three alternative methods have been identified. The methods below choose which streams will be included. The protocols will further direct them to the appropriate starting point for each chosen stream. It is important to define the area from which random selection will be made. This boundary defines the area that inferences can be made from your data assuming that the selection from the population of potential study sites (type 4 streams) is random. In other words, if you plan to pick streams at random from an area comprised of three WAUs, then you must initially specify the names and locations of those WAUs.

Option 1: GIS or hand mapped random selection of intersections between Type 3 and 4 streams. Using a GIS system or a water type map, identify and number all Type 3/ 4 breaks within the area of interest. Using a computerized random number generator, a random number generator on a hand held calculator, or random number tables available in statistical texts, select sites to be sampled.

Option 2: Using the same procedures in Option 1, randomly select points at where streams intersect section boundaries. From the intersections selected, identify the closest type 3/4 break. This will represent the stream to be sampled.

Option 3: If a DNR stream type map is not available, randomly select locations where two, second order streams come together. Follow the procedures described in Option 1 for the random selection.

Option 4 (2001 only): Revisit sites that have been visited during perennial flow surveys in prior years. These sites should be surveyed using this protocol and subject to all QA/QC requirements.

The area within which sites can be selected will be restricted to lands managed under Forest Practices Rules or other lands with similar site conditions. The intention of this restriction is to avoid spending time sampling site conditions that are rare or absent on FFR lands (e.g. agricultural or high alpine areas).

Once the first 50 field sites have been identified, sub-samples for QA/QC and optional Total Tributary surveys (more description provided later in the report) should be selected randomly. The QA/QC sub-sample requires at least 10 sites, or 10% once more than 100 sites are chosen. If the optional Total Tributary survey will be undertaken, randomly identify the 50% of all sites (can overlap with QA/QC sites) for this.

If a site is encountered that was randomly selected and cannot be sampled (e.g. access denied), move to the next type 3/4 break that can be sampled to the east. If this site cannot be sampled, then move to the next site south. Make sure to document situations where the pre-selected site could not be sampled, the reason it could not be sampled, and the process used to determine the next accessible site.

4.2 Equipment and Materials

1:24,000 scale (or larger) maps or air photos of the sample area
Flagging

Permanent marker
Hip chain or hypsometer
Field forms on rite-in-the-rain paper
Pencils
Watch
Compass
Clinometer
GPS with good resolution (±3meters) (Optional)
Tape measure or graduated rod
Spare batteries for hypsometers
Gloves
Coin

4.3 Sample period

The intent of the surveys is to identify the end of continuous and spatially intermittent perennial flow during the dry period. Hence, surveys are to be conducted during the dry season in summer. This is defined as August 1 through September 30. The field season can be extended if weather data suggests that the dry period lasted longer. For instance, field sampling can continue until fall rains begin, provided that documentation of weather conditions are provided with the data set. Whenever rain falls continuously for more than a 24-hour period, discontinue sampling for at least 2 days after rains cease. The suspension of surveys due to rainfall from sudden summer thunder storms will depend on the frequency or duration of the storms. Crews will need to use their judgment and record weather and precipitation conditions. Include flow observations such as measured increase in water elevation (mark a stick), presence of overland flow, or length of time a dry channel flows if at all.

4.4 Procedures

4.4.1. Starting Point along Stream:

The surveys may be conducted in either an upstream or downstream direction. Either way, the starting location is based on the mapped type ¾ break location. Although most of the subsequent guidance is oriented toward the upstream approach, most can be applied to the downstream method using common sense.

4.4.1.1 Upstream Method

The upstream method begins on a point along the stream where the surveyor is confident that continuous perennial flow to the mouth of the tributary is present. Go to the Type 3/4 break selected in the site selection process. If the stream flow at this location is clearly continuous to the mouth, start the survey at a location downstream that is readily map-able (e.g. road crossing, junction of two tributaries that are shown on a map, GPS point). If the stream does not have continuous flow, move downstream to a point where the field crew is confident that flow is continuous to the mouth. Then start the survey at a location downstream that is readily map-able (e.g. road crossing, junction of two tributaries, GPS point). If you do not know if flow is continuous to the mouth from your stating point, then you should assume it is continuous if you document that flow is continuous for 200 m downstream of that point.

4.4.1.2 Downstream Method

Starting from the initial ¾ break, the headwater tributary where the downstream survey begins is chosen using a map of the stream network. On the map, follow the stream upstream to each mapped tributary (assume all are flowing), then choose which tributary to follow using a coin toss. As you move up the selected branch, repeat this process at each subsequent tributary junction until you reach a first-order channel. This channel will be the site where the survey will begin. The field survey should begin at the channel head and proceed downstream.

4.4.1.3 General Notes

Use ample flagging to mark the start point. If in an area with abundant cattle or elk, make sure to leave flagging as high as possible. Mark the flagging with the site number, date (mm/dd/yy) and START using permanent indelible marker. Record GPS position. This protocol may require starting in an unusual situation. Since this is a pilot protocol, we expect that unanticipated situations will arise. Please do not be tempted to diverge from the above selection protocol**.** It is necessary that selection criteria are consistent to assure that planned statistical techniques are valid. In these cases, please continue to collect and report the data following the protocol as best as possible. You may document why it was a "weird" site. During analysis, a determination about suitability of each site will be made based on the description, and possible modification to future protocol may be necessary.

4.4.2 Selecting the Tributaries to Follow Along the Survey

There are two types of surveys: a Main Thread Survey and a Total Tributary Survey. The total tributary survey is a voluntary component of this pilot study. If you choose to do both types of surveys, each survey type should be conducted at one-half of the study sites in your sample population chosen at random. In a Main Thread survey you will make a decision at each tributary junction that will eventually lead you upstream to **one** headwater point in a stream network. In the Total Tributary Survey you will end up surveying the channel length to the headwaters of **all** tributaries in a stream network that occur upstream of the point where stream flow changes from F to another flow category.

Main Thread Survey

We are interested in two fundamental pieces of information about each stream segment: flow and channel category. We may have flow but no channel or a channel with no flow, or a combination of conditions. The selection criteria for which tributary to follow at a junction will be based on flow categories described below.

As you move along the stream, you may encounter junctions between two channels. If you are uncertain of the distinction between channel, seep and wetland, review the definitions carefully.

If you encounter a dry tributary junction, record the distance and flow type of this tributary on the data form. Note the location on a map and distance from the starting point of the junction and then continue moving on up the wet stream. It may be necessary to confirm the flow category of the tributary junction by walking at least 15 meters upstream.

If you encounter two tributaries with the same flow type for the first time, flip a coin. If 'heads', the survey proceeds up the right tributary. If "tails", the survey proceeds up the left tributary. Record results of the coin toss in the NOTES on the bank of Form b. The relative size of the two tributaries has no bearing on the decision. Only the flow type and coin toss. For subsequent tributaries where both streams have the same flow category, alternate the previous direction (e.g. if the coin flip said go Left at the first tributary, go RIGHT at the second). Continue to alternate directions until the survey is complete.

If a junction of two streams with different flow categories is encountered, follow the tributary with the "higher" flow category. Flow categories in descending order are:

Flowing water
Standing water
Flowing Pocket Water
Standing Pocket Water
Dry

In all cases, record the distance, flow type, and channel type of each tributary on the data form. Note the location of the stream that was not followed on your map. Where side channels (i.e. sections where channel diverges into two or more sub-channels, then recombines below) are encountered, follow the larger branch.

Total Tributary Survey

Start the survey in a flowing (F) stream as described for the Main Thread Survey. Proceed up- or downstream using the same tributary decision process for the junction of two streams that are flowing. If you encounter a junction of a flowing stream and a stream with a lower flow category, continue up the flowing stream, but record the distance and flow type for the stream that was not followed as described above. Continue this process until you pass the point where flow changes to a lesser category. Upstream of this point every tributary that you encounter that is not dry will be surveyed up to the point where the stream is dry. If you encounter a dry tributary, record the distance and flow type on the data form and continue surveying in the wet tributary

Assign a tributary number to all tributaries that are surveyed (not dry tribs) starting with the main thread, which should be tributary number one (see Figure 2). Assign a tributary number at each junction that is upstream of the main thread flow change.

4.4.3 Measurements

Two data forms are provided at the end of this document. Form A provides overall summary information and is discussed under Section 5.0. Form B is used to record field data.

Prior to starting data collection, fill out the header information on Form B. This information includes:

- Organization (e.g. name of tribe, company, agency collecting the data)
- Site number
- Township, section, and range of starting point
- Topo quad name
- Surveyors name(s)
- Stream name or name of nearest named tributary downstream
- Date
- Landowner(s)
- WAU
- Description of starting point (e.g. bridge at Mile Post X.X on road Y).
- Vegetation category that applies to the majority of the watershed above each tributary selected (None, sparse, moderate, dense, clear cut, partial cut, mature, … – use the watershed analysis, hydrology module definitions)
- Precipitation for the 2 days previous to the survey (qualitative or from nearby weather station)
- Survey type (circle either Main Thread or Total Tributary)
- Tributary number (use only when doing Total Tributary Survey)
- Name of study area from which random samples were drawn.

Start measurements at the starting point and walk upstream 30 meters, until the flow category changes, or until you reach a tributary junction, whichever is less. **In cases where you encounter a modified channel, start a new segment at the beginning and end of the Modified Channel.** Record the distance from the starting point, the flow category, and other information listed on Form B. Data to record include

- Segment Number (number each segment continuously from the start point)
- Distance from start point (meters, measured on the slope. Note that this measure will be translated into horizontal distances by using mapped gradient information.
- GPS location (optional)
- Flow Category (see above definitions)
- General Channel Width (meters)*
- General Channel Depth (meters)*
  * if at a flow change, take channel measurement 10 meters downstream of break.
- Channel gradient in percent: take measurements looking upstream and downstream. This should represent the 30 m segment . Dominant substrate (silt/muck/mud = F , sand = S , gravel = G, cobble = C, boulders = B, bedrock = R) – call should represent the majority of the overall condition of segment below the point recorded.

- Dominant channel type. Record the dominant channel category for that segment (i.e., channel category that makes up highest percentage in a segment): Defined channel = DC, Poorly Defined Channel = PDC, Modified channel = MC, Piped Channel (PC), or Covered Channel (CC), No Channel (NC),
- Feature (if any) associated with flow category changes. These may include
  - Spring
  - Seep
  - Intersection with perennial stream
  - Wetland
  - Beaver pond (active or breached)
  - Gradient break (change of at least 10 degree)
  - Evidence of debris slide (deposition, scour, etc.)
  - Road crossing
  - Visible road drainage Inputs
  - Water intake or diversion
  - “wet-site” vegetation patches (e.g. devil’s club, willow, etc.)
  - Significant change in substrate characteristics
  - Other items potentially affecting the change in flow category
- Trib Flow and Channel Categories (for tributaries that are not surveyed as main thread)

Continue moving along the channel recording information at tributary junctions, changes in flow and category and, where distances between changes are greater than 30 m, every 30 m within a flow category. Distances are to be cumulative. In other words, all distances recorded are to be the distance from the starting point. Record whether the following features are present at each change from any category to dry as you move upstream:

At each change in flow category, attempt to locate the change on the topographic maps. This may be done using GPS and/or orienteering methods. You may only be able to locate some changes due to scale (100 feet equals 0.05 inch on a 7.5’ topo sheet) or lack of orienting features. Keep in mind that these headwater streams may not be present on topographic maps. Hence, crews may have to map the stream as they travel along it. We encourage use of multiple orienteering tools (compass, orientation to mapped features) to locate sites on the maps. Protected aerial photographs are often a better tool for locating features that can then be transferred to a map, but care should be taken because of the scale differences.

Along the way, make notes on the back of Form B regarding location of major seeps, spring, lakes, emergent wetlands, etc. Also note whether fish, tadpoles or other amphibians are observed casually during the survey. Record the distance along the channel that the note refers to. If unusual situations are encountered, make a sketch in the space provided on the back of Form B.

When a site is complete, make sure to fill in the page numbers and the total pages on the bottom of each form.

4.4.4. Determining the end point

The survey will end once 200 meters of continuous dry (or flowing for downstream surveys) channel has been observed or the channel ends (see definition of channel). At the end point, flag the site with flagging marked END. Also mark the site number and date (mm/dd/yy) on flagging.

If piping continues upslope >200 meters beyond the last window, the survey ends 200 meters upstream point from the last window.

4.4.5 Unusual situations

If, during the survey, a manmade water diversion (other than roads, skid trails) or a spring development or other manmade structure that is diverting water from the stream, stop the survey of the stream and move on to a new site (see directions for selecting alternative sites when the pre-selected random site cannot be sampled). Drainage modifications from forest roads, skid trails, and landings are not considered unusual and should be surveyed according to the protocol: please note on data forms where these features exist and how they interact with the stream. In any situation that is somewhat "odd" (including stream segments designated as unknown), provide a sketch map of the site, which will help to clarify the situation to others.

4.4.5 QA/QC

A sub-sampling of sites should have been selected to test the: a) adequacy of the 200 meter distance used to determine a stream is dry or has continuous perennial flow, b) changes in flow within the defined sample period, and c) variability between field crews.

We are in the process of developing a QA/QC program for this work. Certain parts of this program will be implemented this year, including the "Test of the 200-meter distance" and the Documentation of changes in flow within the sample period". The process to test variability between crews is voluntary in 2001. We encourage you to collect data on between crew variability, but do not require it. Information on between crew variability is important and, when collected, will be used in the 2002 study design.

Test of 200-meter distance. The validity of the 200-meter distance will be checked in a subset of the sites. At least 10 sites or 10 percent of the total number of sites surveyed (which ever is more, to be chosen randomly) will be sampled to the top of the Defined, Undefined Channel, wet or dry (also referred to as the channel initiation or channel head).

Documentation of changes in flow within the sample period. Ten percent of the sample sites will be revisited at least 3 times during the defined sample period (minimum of one week between visits) to document any changes in flow observed over this time.

Between crew variability. If you choose to do this part of the QA/QC program this year, you should collect data at ten percent of the sample sites by a second, preferably independent, crew.

This information should be collected within one week of the original survey and will be used to test the between-crew variability. Obviously survey routes must be identical when testing for between crew variability. Therefore the second crew will need information on which stream and tributaries were surveyed, and the survey stating point. The second crew should not have any additional data (flow, channel, etc.) from the first crew that may compromise their independence.

The random subset of streams for which one element of the QA/QC program is designed will work for other elements of the QA/QC program. For example, the streams randomly picked to do the test of 200-meter distance can be the same streams that are used to determine changes in flow within the sample period.

5.0 Reporting

Data from various sources will be compiled. Prior to submitting data, fill out Form A. Header information on Form A includes the following information:

Organization submitting information
Contact Name
Contact Phone Number
Address
Contact e-mail
Date data is submitted
Total number of pages of data forms (Form B) submitted

Form A also includes a listing of the data submitted. For each site sampled, list the site number, and the date the site was surveyed. It also includes columns for upslope vegetation and data source. Upslope vegetation refers to the overall forest conditions upslope of the sample site. For data collected on the west side of the Cascades, indicate what portion of the upslope forest is 1-15 years, 15-35 years, and >35 years old. For data collected on the eastside, indicate what portion of the upslope forest is sparse, moderate, and mature using the WDNR watershed analysis hydrologic assessment classifications. The source of this data also needs to be described. This information is optional.

Data will be submitted to Darin Cramer, WDNR at:

Darin Cramer
Forest Practices Division
Dept. of Natural Resources
Phone: (360) 902-1088
Fax: (360) 902-1428
darin.cramer@wadnr.gov

Data submittals must be accompanied with Form A and copies of all sheets of Form B. Digital data is also accepted (and encouraged). Please fill out header information on each page to prevent confusion.

6.0 Training

To be developed.

Form A: Summary Information

Organization:	**Contact Name:**	**Address:**
Date Submitted:	**Contact Phone Number:**	
Number of Pages of Data Sheets Submitted:		**E-mail:**

Site Number	Survey Date	Basin Vegetation category	Data Source (for vegetation)	Site selection method (random or revisit of pre-existing site)

Page__________ of ____________

Form B: Perennial Stream Survey Field Measurements
Note: Record all Measurements in metric units

WAU:	**Stream Name:**	**T/R/S**	**Topoquad name:**
Organization:	**Description of start point (GPS optional):**		**Landowner:**
Site Number:	**Date:**	**Recorder(s):**	
Precipitation (in mm) for the 2 days prior to survey		**Survey type: Main thread or Total Tributary Tributary Number:**	

Segment Number	Distance from Start (m)	GPS coordinates (optional)	Flow Category	Channel Category	Channel Bankfull Width	Channel Bankfull Depth	Upstream gradient (%)	Down-stream gradient (%)	Dominant Substrate	Associated Feature at flow change	Flow categories of side trib not on main thread	Channel categories of side trib not on main thread	Notes (see also back page)

Codes for Flow Categories: **FW** = Flowing Water, **SW** = Standing Water, **FP** = Flowing Pocket Water, **SP** = Standing Pocket Water, **D** = Dry, **U** = Unknown, **O** = Obscured.
Codes for Channel Categories: **DC** = Defined Channel, **PDC** = Poorly Defined Channel, **MC** = Modified Channel, **PC** = Piped Channel, **NC** = No Channel
[Codes for Associated Features: **SP** = Spring, **SE** = Seep, **PT** = Perennial Tributary, **WT** = Wetland, **BP** = Beaver Pond, **GB** = Gradient Break, **DS** = Debris Slide, **RC** = Road Crossing, **RD** = Road Drainage Input,

Page _________ of ____________

DI = Diversion, **WS** = Wet Site, **SU** = Substrate Change, **OT** = Other (describe in notes)]

Back of Form B

NOTES

SKETCH

UPSAG/Np Technical Group
Perennial Stream Survey: 2001 Pilot Project Data Dictionary

This data dictionary is designed to provide definitions of the column headers on the formatted spreadsheets (Excel) for standard project data entry and incorporation in a proposed GIS database. Two data entry forms are provided including "Header and Basin Point Data" and "Channel Reach Data." The dictionary is formatted as two tables. Data entry spreadsheet files will be sent separately.

The "Field Name" column on each table corresponds to column headings listed on the spreadsheet forms used for data entry. Field names in **bold** type are key database fields and must be repeated exactly on different spreadsheets where indicated. Underlined row titles identify database fields that are essential for calculations and cannot be left blank or the calculations will not run.

The "Data Types" column identifies the limitations for each field name's information. If data is not entered consistent with the data type limitations, the database or calculation may not function correctly. The following provides definitions for the data types found on the spreadsheets:

- "char" = character - data can be either letters or numerals. The number following "char" describes how many digits or letters should be in the field. For example, "char 2" means that two letters are required whereas "char 1-20" means that any combination of numbers and characters up to 20 maximum can be entered. Do not include punctuation or other symbols.
- "dec" = decimal – data must be numerals with one period or decimal point included. Numbers after the "dec" indicate the range of numbers and decimals expected. For example, "dec 1,2" means one whole number followed by two decimal places (e.g., 3.43). Another example is "dec 1-4,1" which means that up to four whole numbers can be entered, but with only one decimal place (e.g., 1000.9).
- "int" = integer - data entered must be whole numbers only. , e.g., "3200" feet in elevation or reference point "16".
- "note" = extended notes - data can be either letters or numerals or punctuation or other symbols (e.g., !, @, #, etc.).
- "date" = numeric date - data must be entered in the form of mm/dd/yyyy (e.g., 09/07/2001).

The "Req" column identifies whether the field is required to be filled by either field data or a default code for missing data points. A shaded "Y" means that it is required and an "N" means that it is not required and leaving blank is appropriate where no field data has been collected.

The "Description" column provides definitions for each field name and clarifies requirements.

Please refer to the dictionary as you enter data from survey sheets. The spreadsheet entry program will accept whatever you enter, so you cannot count on the computer to notify you of incorrectly entered data. Also, do not enter spaces, dashes or any other extraneous marks unless requested or you are in a "note" field. Quality Control: It is required that whoever enters the data into the spreadsheet cross check the finished entered data with the original field forms to ensure accuracy. Check for errors or missing data.

Table 1. Perennial Stream Survey – Header and Basin Point Data

Field Name	Data Type	Req	Description
GIS ID	char 1-8	Y	Key field. Leave blank – will be filled in automatically at GIS entry stage.
Coop Code ID	char 3	Y	Key field. Cooperator code identification: A three-letter code to identify the individual participants contributing data. Use only one of the following codes (all caps required): **TCG** = The Campbell Group; **DFW** = Washington Department of Fish and Wildlife; **COL** = Colville Tribe; **HOH** = Hoh Tribe; **PGS** = Port Gamble S'Klallam Tribe; **SPO** = Spokane Tribe; **SSC** = Skagit System Cooperative; **SUQ** = Suquamish Tribe; **TUL** = Tulalip Tribe; **YAK** = Yakama Nation; **LF = Longview Fiber**, or other unique and consistently applied three-letter code.
SITE/PSS #	char 1-6	Y	Key field. Site or Perennial Stream Survey identification number: A unique multi-character identifier (numbers and letters okay) used to identify the specific stream site surveyed (e.g., "**162**"). Where repeat or total tributary surveys use the same site numbers or are otherwise repeated, add a letter or number code to make unique (e.g., "**162A**", "**162B**", and "**162C**").
Survey Date	date mm/dd/yyyy	Y	Key field. Survey date: Two integer month, two integer day, and four integer year identify date data was collected in the field (e.g., "**09/07/2001**").
Lead Contact – First Name	char 1-20	Y	First Name of Lead Contact: identifies first name of lead survey contact responsible for collection and management of field data.
Lead Contact – Last Name	char 1-20	Y	Last Name of Lead Contact: identifies last name of lead survey contact responsible for collection and management of field data.
Lead Contact - Affiliation	char 1-40	Y	Affiliation of Lead Contact: identifies the group, company, agency, tribe, or other entity to which the data belongs.
WAU Name	char 1-40	N	Official Watershed Analysis Unit name as defined by WADNR
WAU #	char 6	N	Official Watershed Analysis Unit six character number as defined by WADNR.
Basin Veg Cat	int 1	N	Basin vegetative category: identifies dominant upslope forest seral stage of basin surveyed. Use only one of the following: Westside – **1** = 1 to 15 years; **2** = 16 to 35 years; **3** = greater than 35 years; or Eastside – **4** = sparse; **5** = moderate; **6** = mature.
Basin Veg Cat Source	char 1-40	N	Identifies source for basin vegetation category information.

Stream Name	char 1-20	N	Stream name as identified in the WDF WRIA Stream Catalog or on a USGS 7.5 minute Topographic map – otherwise leave blank.
2-Day Prior Precip (mm)	int 1-4	Y	Record actual or estimated amount of precipitation in millimeters (mm) that fell on survey reach in the 2 days immediately prior to conducting the survey. No precipitation is recorded as "0" and a trace is recorded as "1."
Type Survey (M/T/R)	char 1	Y	Type of survey conducted: Use only one of the following - **M** = Main Thread Survey; **T** = Total Tributary Survey; **R** = Repeat Survey (Intra-annual study).
Site Selection Method (R/P)	char 1	Y	Identifies whether the survey was conducted on a randomly selected new or pre-selected resurvey of pre-2001 sites. Use only one of the following: **R** = randomly selected site; or **P** = previously selected site (resurvey) – includes same season repeat surveys.
Reg Default Basin Area (13/52/300)	int 2-3	Y	Regulatory Default Basin Area: Record which default basin area survey was conducted in per WAC 222-16-031(4). The three choices include: **13** = Western Washington Coastal Zone locations; **52** = other Western Washington locations; and **300** = Eastern Washington locations.
Survey Direction (UP/DN)	char 2	Y	Direction of survey data collection: Determined by segment numbering sequence. Use only one of the following – **UP** = Data collected (segment numbers increase) in the upstream direction; or **DN** = Data collected (segment numbers decrease) in the downstream direction.
Segment # @ Pp	Int 1-3	Y	Segment number at **Pp** Point (a.k.a. "PIP"): Point below which flow (FW or SW categories) is continuous to downstream end of survey reach. Above this point, flow may be either spatially intermittent (discontinuous) or channel is dry to channel head.
Pp Long (deg min sec)	char 9	N	Pp Point: longitude coordinate using degrees, minutes, and seconds (e.g., "127 46 22" – 9 characters including spaces).
Pp Lat (deg min sec)	char 8	N	Pp Point: latitude coordinates using degrees, minutes, and seconds (e.g., "43 46 22" – 8 characters including spaces).
Calc 1 Pp Basin Area (acres)	int 1-4	N	Calculated Pp Point Basin Area in acres: if conducted by participant, record the calculated basin area rounded to nearest acre (1-9999).
Calc 1 Pp Basin Area Method	char 1-40	N	Calculated Pp Point Basin Area Method: Identifies the method used to calculate basin area such as DNR stereo aerial photographs, field identification, etc.
Segment # @ Pd	Int 1-3	Y	Segment number at **Pd** Point (a.k.a. "SIIP"): Point below which is spatially intermittent (discontinuous – FP, SP) or continuous (FW or SW categories) to Pp or downstream end of survey reach. Above this point, channel must be dry to channel head. Duplicate Pp data if Pd point coincides in same

			location.
Pd Long (deg min sec)	char 9	N	Pd Point: longitude coordinate using degrees, minutes, and seconds (e.g., "127 46 22" – 9 characters including spaces).
Pd Lat (deg min sec)	char 8	N	Pd Point: latitude coordinates using degrees, minutes, and seconds (e.g., "43 46 22" – 8 characters including spaces).
Calc 1 Pd Basin Area (acres)	int 1-4	N	Calculated Pd Point Basin Area in acres: if conducted by participant, record the calculated basin area rounded to nearest acre (1-9999).
Calc 1 Pd Basin Area Method	char 1-40	N	Calculated Pd Point Basin Area Method: Identifies the method used to calculate basin area such as DNR stereo aerial photographs, field identification, etc.
Segment # @ Ph	int 1-3	N	Segment number at **Ph** Point (a.k.a. "Channel Head"): Leave blank if not collected. Point immediately below which there is some category of channel other than "NC" or No Channel. Channel may be dry or have either spatially or continuous flow categories to Pd, Pp or downstream end of survey reach. Above this point, there is no channel to basin edge. Duplicate Pp or Pd data if Ph point coincides in same location.
Ph Long (deg min sec)	char 9	N	Ph Point: longitude coordinate using degrees, minutes, and seconds (e.g., "127 46 22" – 9 characters including spaces).
Ph Lat (deg min sec)	char 8	N	Ph Point: latitude coordinates using degrees, minutes, and seconds (e.g., "43 46 22" – 8 characters including spaces).
General Notes	note 1-500	N	**PN (non flowing spatially intermittent water. Where should this go?)** Provides space to record further information regarding the Np/Ns break point up to 500 spaces long (including spaces and punctuation).
Driving Directions	note 1-500	N	Provides space to record driving directions for accessing survey site and landowner contact information.

Table 2. Perennial Stream Survey – Channel Reach Data

Field Name	Data Type	Req	Description
GIS ID	char 1-8	Y	Key field. Leave blank – will be filled in automatically at GIS entry stage.
Coop Code ID	char 3	Y	Key field. Cooperator code identification: A three-letter code to identify the individual participants contributing data. Use only one of the following codes (all caps required): **TCG** = The Campbell Group; **DFW** = Washington Department of Fish and Wildlife; **COL** = Colville Tribe; **HOH** = Hoh Tribe; **PGS** = Port Gamble S'Klallam Tribe; **SPO** = Spokane Tribe; **SSC** = Skagit System Cooperative; **SUQ** = Suquamish Tribe; **TUL** = Tulalip Tribe; **YAK** = Yakama Nation; **LF = Longview Fiber**.
SITE/PSS #	char 1-6	Y	Key field. Site or Perennial Stream Survey identification number: A unique multi-character identifier (numbers and letters okay) used to identify the specific stream site surveyed (e.g., "**162**"). Where repeat or total tributary surveys use the same site numbers or are otherwise repeated, add a letter or number code to make unique (e.g., "**162A**", "**162B**", and "**162C**").
Survey Date	date mm/dd/yyyy	Y	Key field. Survey date: Two integer month, two integer day, and four integer year identify date data was collected in the field (e.g., "**09/07/2001**").
Segment #	int 1-3	Y	Key field. Identifies the unique segment number from the start to the end of the survey. The starting segment number can be a "0" or any other number up to "999." It is acceptable to fill in a missing starting segment number that has no other segment data attached if you conducted your survey that way.
Seg Data Direction (UP/DN)	char 2	Y	Segment Data Direction: identifies whether channel data represents segment conditions upstream or downstream of the segment number. Use only one of the following two codes: **UP** = Upstream; or **DN** = downstream.
Seg Long (deg min sec)	char 9	N	Identifies the longitude of segment break location if collected - record coordinates using degrees, minutes, and seconds (e.g., "127 46 22" – 9 characters including spaces).
Seg Lat (deg min sec)	char 8	N	Identifies the latitude of segment break location if collected – record coordinates using degrees, minutes, and seconds (e.g., "43 46 22" – 8 characters including spaces).
Distance from Start (m)	dec 1-4,1	Y	Identifies the total distance of that segment break from the start of the survey – recorded to the nearest 0.1 meters. The distance to the starting segment number should always be "0.0".

Flow Cat	char 1-2	Y	Flow category: identifies dominant segment flow condition using only one of the following seven codes: **FW** = Flowing Water; **SW** = Standing Water; **FP** = Flowing Pocket Water; **SP** = Standing Pocket Water; **D** = Dry (no flow); **U** = Unknown; or **O** = Obscured.
Chan Cat	char 1-3	Y	Channel category: identifies the dominant segment channel category using only one of the following five codes: **DC** = Defined Channel; **PDC** = Poorly Defined Channel; **MC** = Modified Channel; **PC** = Piped Channel; or **NC** = No Channel.
BFW (m)	dec 1-2,1	N	Bankfull width: identifies the segment's mean bankfull width – recorded to the nearest 0.1 meters.
BFD (m)	dec 1,2	N	Bankfull depth: identifies the segment's mean bankfull width – recorded to the nearest 0.01 meters.
UP Grad (%)	int 1-3	N	Upstream Percent Gradient: identifies the segment gradient of the channel in the upstream direction – recorded to the nearest whole percent (e.g., "3" or "52" or "100")
DN Grad (%)	int 1-3	N	Downstream Percent Gradient: identifies the segment gradient of the channel in the downstream direction –record to nearest whole percent (e.g., "3" or "52" or "100")
Mean Seg Grad (%)	int 1-3	N	Mean Segment Percent Gradient: identifies the calculated or single mean segment gradient of the channel (regardless of direction) – record to nearest whole percent (e.g., "3" or "52" or "100")
Dom Sub	char 1	N	Dominant Substrate: identifies the segment's dominant stream bed substrate using only one of the following six codes: **F** = Silt/muck/mud (< 0.625mm); **S** = Sand (0.625-2.0mm); **G** = Gravel (2.0-64.0mm); **C** = Cobble (64.0-256.0mm); **B** = Boulder (> 256mm); or **R** = Bedrock.
Assoc Feat 1	char 2	N	Associate Feature 1: identifies primary factor associated with Np/Ns point break using one of the following codes: **SP** = Spring; **SE** = Seep; **PS** = intersection with Perennial Stream Tributary Channel flow; **WE** = Wetland; **BP** = Beaver Pond; **GB** = Gradient Break; **DS** = evidence of Debris Slide; **RC** = Road Crossing; **RD** = visible Road Drainage inputs; *WI* = Water Intake or diversion; **WS** = Wet Site vegetation patches; **SC** = significant change in Substrate Characteristics; **OT** = Other items potentially affecting the change in flow category. NEW – **CH** = Channel Head if survey conducted to this point. **RS = roots; WD = woody debris**
Assoc Feat 2	char 2	N	Associate Feature 2: Other associated feature factor recorded using one of the codes listed above. If none, leave blank.
Assoc Feat 3	char 2	N	Associate Feature 3: Other associated feature factor recorded using one of the codes listed above. If none, leave

			blank.
Assoc Feat 4	char 2	N	Associate Feature 4: Other associated feature factor recorded using one of the codes listed above. If none, leave blank.
Assoc Feat 5	char 2	N	Associate Feature 5: Other associated feature factor recorded using one of the codes listed above. If none, leave blank.
Tributary Change	char 1	N	Identifies segment breaks where tributary survey changes were made. Record "**Y**" (Yes) where the segment number corresponded to either a random (same flow category) or required (higher flow category) selection of alternate tributary. Record "**N**" (No) in all other cases.
Trib Flow Cat	char 1-2	N	Tributary Flow Category: identifies non-survey tributary's flow category – use only one of the seven "Flow Cat" codes listed above. Leave blank otherwise. This occurs where a tributary junction causes a segment break due to either a change in a flow category or change in which tributary the survey continues.
Trib Chan Cat	char 1-3	N	Tributary Channel Category: identifies non-survey tributary's channel category – use only one of the five "Chan Cat" codes listed above. Leave blank otherwise. This occurs where a tributary junction causes a segment break due to either a change in a flow category or change in which tributary the survey continues.
Notes	note 1-500	N	Provides space to record greater quantities of information up to 500 spaces long (including spaces and punctuation).

UPSAG Np Technical Group
Perennial Stream Survey (PSS) Project: 2001 Pilot Phase

Guidelines for Standard Data Entry and Data Transfer

The following guidelines are provided to help participants with consistent data entry, assembly and completion of related maps and other materials, and transfer of 2001 PSS project information to the project manager (Bob Palmquist) for analysis. This sheet provides guidelines on how to assemble the data and materials required by the 2001 Scope of Work document (PSS SOW.rtf) that has recently been completed and approved by UPSAG. The guidelines are organized into four tasks. Examples of data entry and completed maps are provided as noted. Refer data entry questions or requests for hardcopies of files to either Allen Pleus or Bob Palmquist at the contact information provided below. Requested data must be received by February 15, 2002 to be included in this analysis.

Task 1: Complete PSS "Protocol Application" Checklist/Questionnaire
The PSS "Protocol Application" checklist/questionnaire (PSS 2001 checklist.rtf) is provided to help the project manager interpret participant data and help in analysis of variability in its field application." It is recommend that this task be completed first to help participants identify variations in field data collection that may affect data entry. The file may be printed and completed, or completed electronically and renamed.

Task 2: Complete Data Entry
Perennial Stream Survey data will be entered on the two standard formatted Excel spreadsheet workbook pages and following the instructions provided in the data dictionary that have been provided. The dictionary will provide guidance on entering new data, modifying data to meet the standard format where needed, and adding data collected on PSS (version 1.21) Forms A and B. Caution: the format of data entry will not always follow that found on the field forms.

Step 1 – Assemble and organized field data by survey site.

Step 2 - Print out data dictionary file (PSS 2001 data dict.rtf) and review with spreadsheet example file (PSS 2001 entry example.xls)

Step 3 – Open data entry spreadsheet (PSS 2001 entry95.xls) and "Save As" using your three letter "Coop Code ID" and "2001" (e.g., "DFW 2001.xls; HOH 2001.xls; TCG 2001.xls; etc.")

Step 4 – Enter all data in this one file as instructed in data dictionary and save often. Any data revisions made to accommodate the standard format requirements should also be made back on original field forms and related materials for consistency.

Step 5 – Quality control: error check entered data after each site with original field forms.

Task 3: Complete Survey Site Maps

Prepare a GIS data layer and/or one photocopy of a USGS 7.5 minute map for each survey site showing the following locations and labels:

a) "**Pp**" – Point location on stream of uppermost extent of continuous "Flowing Water" flow category (a.k.a. "PIP") (refer to SOW Table 1 for definition)
b) "**Pd**" – Point location on stream of uppermost extent of spatially intermittent flow (a.k.a. "SIIP") (refer to SOW Table 1 for definition)
c) "**Ph**" – Point location on stream of channel head if known (refer to SOW Table 1 for definition)
d) "**Ss**" - Point location on stream of survey reach start (corresponds to where crew began collecting minimum required reach data: distance, flow category, and channel category)
e) "**Se**" – Point location on stream of survey reach end
f) Additional map information:
    i. Data contact name and data affiliation
    ii. USGS map name with Township, Range, and Section numbers of site
    iii. SITE/PSS number as recorded on data entry spreadsheet

Task 4: Send Data, Maps, and Other Related Materials

Send electronic and/or hard copies of completed PSS information to Bob Palmquist (project manager) at contact address listed below.

1. Cover letter identifying your project participation, list of SITE/PSS numbers for which data entry has been completed, and list of enclosed/attached information to help the project manager keep the information organized
2. Completed "Protocol Application" checklist/questionnaire
3. Electronic and/or hardcopies of PSS site maps or GIS file(s) identifying survey site location information
4. Electronic file of PSS survey data organized by standard format
5. Hardcopies of original field data forms, field maps, and other relevant survey information

Contact Information

Bob Palmquist

(253) 857-8016
meandering@harbornet.com

Allen Pleus
NWIFC
6730 Martin Way E.
Olympia, WA 98516
(360) 438-1181 x 354
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UPSAG/Np Technical Group: Perennial Stream Survey						**Appendix E**
Header and Basin Point Data			(Version 1-11-02)			
GIS ID	Coop Code ID	SITE/PSS #	Survey Date	Lead Contact - First Name	Lead Contact - Last Name	Lead Contact - Affiliation
KEY 1 (char 1-8)	KEY 2 (char 3)	KEY 3 (char 1-6)	KEY 4 (date mm/dd/yyyy)	(char 1-20)	(char 1-20)	(char 1-40)
Refer to Data Dictionary for appropriate data entry information						
WAU Name	WAU #	Basin Veg Cat (1-6)	Basin Veg Cat Source	Stream Name	2-Day Prior Precip (mm)	Type Survey (M/T/R)
(char 0-40)	(char 6)	(int 0-1)	(char 0-40)	(char 0-20)	(int 0-4)	(char 1)
	Shaded columns are required fields - do not leave blank					
Type	Underlined text uses specific coded data only - if not shaded, its not required					
Site Selection Method (R/P)	Reg Default Basin Area (13/52/300)	Survey Direction (UP/DN)	Segment # @ Pp	Pp Long (deg min sec)	Pp Lat (deg min sec)	Calc 1 Pp Basin Area (acres)
(char 1)	(int 2-3)	(char 2)	(int 1-3)	(char 9)	(char 8)	(int 1-4)
Calc 1 Pp Basin Area Method	Segment # @ Pd	Pd Long (deg min sec)	Pd Lat (deg min sec)	Calc 1 Pd Basin Area (acres)	Calc 1 Pd Basin Area Method	Segment # @ Ph
(char 1-40)	(int 1-3)	(char 9)	(char 8)	(int 1-4)	(char 1-40)	(int 1-3)
Ph Long (deg min sec)	Ph Lat (deg min sec)	General Notes	Driving Directions			
(char 9)	(char 8)	(note 1-500)	(note 1-500)			

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Channel Reach Data				(Version 1-11-02)			
GIS ID	Coop Code ID	SITE/PSS #	Survey Date	Segment #	Seg Data Direction (UP/DN)	Seg Long (deg min sec)	Seg Lat (deg min sec)
KEY 1 (char 1-8)	KEY 2 (char 3)	KEY 3 (char 1-6)	KEY 4 (date mm/dd/yyyy)	KEY 5 (int 1-3)	(char 2)	(char 9)	(char 8)
Refer to Data Dictionary for appropriate data entry information							
							Type
Distance from Start (m)	Flow Cat	Chan Cat	BFW (m)	BFD (m)	UP Grad (%)	DN Grad (%)	Mean Seg Grad (%)
(dec 1-4,1)	(char 1-2)	(char 1-3)	(dec 1-2, 1)	(dec 1,2)	(int 1-3)	(int 1-3)	(int 1-3)
Shaded columns are required fields - do not leave blank							
Underlined text uses specific coded data only - if not shaded, its not required							
Dom Sub	Assoc Feat 1	Assoc Feat 2	Assoc Feat 3	Assoc Feat 4	Assoc Feat 5	Tributary Change (Y/N)	Trib Flow Cat
(char 1)	(char 2)	(char 2)	(char 2)	(char 2)	(char 2)	(char 1)	(char 1-2)

UPSAG Perennial Stream Survey
DRAFT 2001 Quality Control Replicate Survey Method

The Perennial Stream Survey protocols, Section 4.4.5 (version 1.21), recommend conducting independent replicate surveys to document "between crew" variability on stream sites collected during the 2001 field season as part of an overall quality assurance project plan[1]. Quality control (QC) replicate surveys are a necessary part of the plan to provide essential variability information needed to guide study design development for the 2002 field season. This document provides rationale and guidelines for conducting QC replicate surveys for this study.

Background on TFW QC Replicate Surveys

The primary goal of the Timber/Fish/Wildlife (TFW) Monitoring Program was to provide survey methods that reliably detect changes in stream channel conditions and characteristics over time (Pleus 1994). That is, changes detected in stream channel parameters between surveys represent actual changes and are not the result of differences associated with crew application of the methods.

The replicate survey is a process developed to examine crew variability associated with the application of a standard stream survey. The testing hypothesis of the replicate survey is that variability is not significant between two independent crews (C_1 and C_2) when identifying and measuring stream channel conditions using the same established survey methods. Stated as a formula, H_0: $C_1 = C_2$; where the results of C_2 (QC crew) are considered the baseline from which C_1 (field crew) variability is determined. The assumption for this test is that the field crew has been trained in the method, but has an unknown competency, and is compared to the QC crew that represents the most thorough knowledge and consistency in application of the method. This is necessary where the survey method has not been statistically tested to determine baseline variability.

Same day replicate surveys were initiated in 1993 to increase the resolution in analysis of variability on clearly identified locations and to facilitate discussions of found variability factors with the original crew while it was still fresh in their minds. The bias introduced by crews knowing they were being tested (on their "best behavior") was judged to be less a factor than the variability caused by day-to-day changes in stream low-flow discharge,

[1] The terms quality assurance and quality control are defined according to the USEPA (1995) as follows:

Quality Assurance (QA) – "an integrated system of activities involving quality planning, quality control, quality assessment, quality reporting and quality improvement to ensure that a product or service meets defined standards of quality with a stated level of confidence."

Quality Control (QC) – "the overall system of technical activities whereby the purpose is to measure and control the quality of a procedure or service so that it meets the needs of users. The aim is to provide quality data that is satisfactory, adequate, dependable, and economical. One example of a quality control element for biological sampling is taking replicate samples to ensure consistency among and within sampling crews."

differences in start and stop points, and ability of field crews to recall what caused specific variability. Using the assumption that crews always collect data to the best of their abilities/training/support, analysis of TFW replicate survey data collected between 1993 and 1999 provided abundant and useful variability information (Pleus 1995; 1998 unpublished).

Recommended Changes to Version 1.21 Replicate Survey Protocols

Due to the late season start and other concerns/limitations, QC sites will be pre-selected, QC crews will be taken to the survey site by the field crew to be tested, and QC crews will replicate field crew surveys the same day. The objective of the QC crew is to determine whether the field crew applied the methods according to the version 1.21 protocol. The primary focus of the field crews this pilot season is to collect data on as many sites as possible before the fall rain begins. It is important to facilitate this by allowing the crews to collect relevant data on the day of the QC replicate survey. QC crews will strive to conduct replicate surveys on up to 10% of the study sites, within limitations of time, weather, and funding. Participating Tribes will utilize the services of a trained consultant as the QC crew to provide a consistent baseline of comparison.

The ability of various field crews to adequately provide explicit driving and survey access directions is a separate variability question of concern for any survey and should not be added on to this survey. The location of many of these sites is remote and already requires a large time commitment just to get there. Providing a complete set of access directions would take additional time and be problematic. Therefore, there is no justification for spending additional time and money to test this aspect of the survey.

Variability Types

Between crew variability is a compilation of crew, method, and background components (Pleus 1995). The reason is that each component requires a different solution to rectify. Crew variability is defined as variability associated with crew deviation from established standard methods. Examples of crew variability are bias and improper method training. Method variability is defined as variability associated with proper application of methods. Examples of method variability include protocols that can be broadly interpreted and parameters using inaccurate measurement techniques. Background variability is defined as variability associated with physical channel complexity. Examples include measurement obstructions caused by heavily brushed streams or methods not applicable with highly disturbed channels.

QC Replicate Survey Method

The scope of the replicability survey will focus on the main thread survey and the area of stream encompassed by the 200 meter continuous flow downstream and dry channel upstream criteria. It will look for discrepancies and causes in variability related to:

- Flow category changes and locations;
- Same flow category random selection process;
- Tributary junction flow/channel categories and locations;
- Feature associated with flow category changes;
- Mean segment dominant channel type category;
- Mean segment bankfull width;
- Mean segment bankfull depth;
- Mean segment gradient;
- Mean segment dominant substrate; and
- Field form/site location documentation review

The method for the QC replicate survey is as follows:

1. Establish starting point of survey

2. Participant field crew conducts survey as normal using standard Form B and waits at survey end until QC crew finishes their survey.

3. QC crew starts their survey as normal using standard Form B after the field crew is out of sight/sound and maintains this buffer, stopping if necessary to let the field crew keep well ahead. The QC crew will vary from standard protocols as follows
   a. QC crew will have a variety of colored flagging so that it does not match the field crew flagging when used. It is important that the QC crew ignores the evidence of the previous field crew such as hip chain line, flagging, footprints, etc.
   b. Every third segment (random start) collect intensive data on bankfull width, bankfull depth, flow category, channel category, gradient (elevation gain from last/nearest segment break or transect), and dominant substrate on Form PIP QC 1.1 (Appendix A). Randomly select the starting segment number (1, 2, or 3 using a single die, three scraps of paper, or other random method). The bankfull width line is used as the transect for collecting all other information related to conditions immediately under it. Segments that are 15 meters or less in length will have transects established every 2.5 meters. Segments greater than 15 meters will have transects established every 5.0 meters. For example, a 30 meter segment would have transects at 5.0, 10.0, 15.0, 20.0, and 25.0 meter intervals. Measurements are not take at segment breaks.
   c. Note identification and location differences in field crew flagging in the notes section.

4. After both crews have finished, the QC crew will complete Form PIP QC 1.2 (Appendix B). This form provides an important format for identifying discrepancies

between surveys, especially lumping and splitting issues. This information is best determined and discussed with both crews re-walking stream. The QC crew will document the type and cause of discrepancies. Any QC crew errors will be noted and not counted against field crew

5. Participant crews will provide copies of their field forms to QC crew in a timely manner for review and comment on their completeness of header information, legibility/completeness of data, flow category random selection process, and any other of importance.

Within one month, participant crews will provide copies of maps that identify the location of the uppermost flow and their calculated basin area [*Darin Cramer, DNR?*]. Included with the maps will be a description of rationale/methods used to determine the mapped location and the method used to calculate the basin area.

Data Analysis

Replicate surveys will be analyzed [*Need to identify lead*] to estimate the field variability for the following attributes:

1. Identification of the uppermost point of spatially intermittent flow
2. Application of the segmenting protocols
3. Measurement of cumulative distance
4. Identification of flow categories
5. Identification of channel categories
6. Random selection of same flow tributaries
7. Measurement of mean segment bankfull width
8. Measurement of mean segment bankfull depth
9. Measurement of mean segment gradient
10. Identification of mean segment dominant substrate category
11. Identification of flow category change features
12. Identification of tributary junctions, flow and channel categories

In addition to analysis of field data, variability will be estimated for:

1. Form A and B legibility, completeness, and errors
2. Mapping the location of the uppermost point of spatially intermittent flow [How to test?]
3. Calculating the basin area of the mapped point correctly

Replicate Survey Report

A post-season report will be generated [Need to identify lead] that includes a summary of the replicate survey findings with copies of the replicate survey forms and relevant information attached as appendixes. The report will include results of data analysis and technical recommendations for changes to the Perennial Stream Survey protocol for the

2002 field season. To provide the best analysis, CMER should make available the study design rationale for each parameter for which data was collected. This report will be submitted to CMER and distributed to survey participants and interested parties.

References

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Pleus, A.E. 1998. Draft Timber/Fish/Wildlife Monitoring Program Report: Variability associated with bankfull width, bankfull depth, and canopy closure measurements. Unpublished. Northwest Indian Fisheries Commission. Olympia, Washington.

USEPA, 1995. Generic quality assurance project plan guidance for programs using community level biological assessment in wadable streams and rivers. Office of Water (4503F). EPA 841-B-95-004. July.

Appendixes

Appendix A: Form PIP QC 1.1 – Intensive Segment Measurements Copy Master & Completed Example

Appendix B: Form PIP QC 1.2 – Matched Segments Copy Master & Completed Example

Appendix F

2001 Perennial Stream Survey
Training, Field Assistance, and Quality Control Reports

Centralized Service Provided to Tribal Cooperators
Through the
Northwest Indian Fisheries Commission

Contract Services Provided By
Ecological Landscape Services, Longview

2001 Training Reports

Note: Several tribes that participated in the trainings did not subsequently collect data.

August 27: Skagit System Cooperative
Report not available

August 30: Port Gamble S'Klallam, Skokomish, and Suquamish Tribes
September 5: Colville, Spokane, and Kalispel Tribes
September 6: Yakama Nation
The following is a summary from the training visits on the above dates.

Comments/questions with survey protocol:
- Need to clarify where to take representative measures (e.g. bankfull width, depth, dominant substrate, and gradient) in each segment. The Colville survey crew measured anywhere along the segment that appeared to be representative; whereas the Yakima survey crew more or less measured the representative portion of the stream at each segment break.
- May be inherent bias in the starting point with the upstream survey method.
- Why are there two measures for gradient – upstream and downstream?
- Need to clarify channel width definition.
- Is it necessary to take average of 3 readings for channel depth measurement?
- Need to define some of the associated features, such as spring, wet site, and wetland.
- Need to differentiate between channel categories – are some naturally or artificially defined? For instance, is livestock damage to stream bank categorized as a PCD or MC? (The manual seems to suggest an MC in this situation, but it isn't clear.)

Useful tips for survey crews:
- May be helpful to investigate the basin before beginning the survey.
- Essential to start survey from an easily mappable spot such as a road crossing, bridge, confluence of tributary, etc. Need to mark start point as permanently as possible – flagging, aluminum tree tags, GPS location, compass bearing work well. Starting/ending points must be marked on a topography map. Distance and bearing from a mappable spot to start/end point should be recorded.
- Aerial photos are very helpful to gauge length of wetlands, dry channels, and other features encountered in the field.
- Note on data form whether survey is upstream or downstream.
- Consider doing a downstream survey by noting tributaries and flow changes as move upstream, and starting survey 200 m above the perennial initiation point (if channelized). Then work downstream to record measurements at each segment.
- Document what is observed on the surface for the dominant substrate of each segment. Note a secondary substrate in the notes section if recorder is uncomfortable with identifying only one, dominant substrate. Additionally, the recorder may

document additional information in the notes section that may be useful to the tribe, but not analyzed by CEMR.

- Base left bank and right bank directions on downstream direction, but coin toss for tributaries based on upstream direction.
- Need to document results of coin toss and tributary chosen in notes section.
- Measure bankfull width to the nearest 0.5 m, depth to the nearest 0.1 m, and gradient to the nearest 1%.
- For gradient, both people should be at the same place in the reach, e.g. both in the channel or both on the bank. Alternatively, a flag tied at eye level can be used to measure gradient.
- Document upon which bank the associated feature occurs in the notes column.
- Draw sketch of perennial initiation point on back of data form. Sketch should include direction of stream and other important features.
- Note if observe any fish or amphibians during the survey at the appropriate distance along the channel.

September 10: Hoh Tribe
The tribal crew (Jill Silver and Mike Haggerty) performed an upstream survey on Rock Creek. Mike and Jill noted that many of their streams are a Type 2/Type 4 break and thought that it would be more accurate to base the stream randomization on nonfish-bearing versus fish-bearing streams, rather than only Type 3/Type 4 streams. They would prefer the nonfish-bearing versus fish-bearing method of selecting streams.

The crew was precise in collecting segment data. Flow and channel categories, dominant substrate, bankfull width, and bankfull depth were well defined and fairly easy to assess in Rock Creek. Mike and Gerry used a hip chain for segment length and a stadia and meter tape for measuring width and depth. Gradient was more difficult because of the stream's steepness; the crew was concerned about gradient accuracy and spent much time measuring gradient. Rock Creek had extensive areas of dry channel, >> 5 m in length, with continuous flow upstream and downstream of the dry areas. The crew was concerned about the value of collecting data on large areas of dry channel.

Additional questions and notes raised by the crew:

- Should wood be added as a dominant substrate? Rock Creek had much large, downed woody debris in the stream channel.
- When considered an associated feature, it is okay to define seeps as flowing water or dry in the flow category column?
- Is it appropriate to include dry islands within the bankfull width measurement, or should these areas be subtracted out of the width?
- What is the definition of a covered channel? It is on the bottom of the data form B, but is not defined in the protocol.
- What is the scientific basis for 200 m of continuous flow downstream of the starting point? Both Jill and Mike felt that 200 m continuous flow is long for a Type 4 stream in their area.

- For a downstream survey, the tributaries are assumed to be flowing and are randomly selected *ahead* of time based on the mapped tributaries. Although the crew didn't perform a downstream survey, we were trying to determine what you would do if an unmapped side tributary of the same flow category was encountered during a downstream survey. We decided that the unmapped side tributaries should be ignored in terms of selecting a tributary (because the tribs are pre-selected), but noted in the data sheet.

September 27: Tulalip Tribe
Report not available

2001 Field Assistance Reports

September 13: Suquamish Tribe
Both streams (tributary to Lost Creek, Site Number 10 and tributary to Wildcat Creek) were difficult to access because of dense vegetation and lack of nearby roads. The streams themselves had dense vegetation that obscured the channel, making it challenging for the crew to accurately measure variables. Consequently, bankfull width and depth may not be as accurate as less brushy streams. The tribal crew (Dawn Pucci and Allison O'Sullivan) measured segment length with a meter tape to avoid leaving hip chain string in streams; width and depth were measured with the same meter tape. One measurement was taken for the average depth.

Both streams were dry most of their entire length and only had short segments near the mouth that flowed. Additionally, the gradient of the flowing segments were low and few to no side tributaries or side channels were encountered along the surveyed length.

Neither stream had 200 m of continuous flow to the mouth, but flow was observed from the mouth into the Type 3 stream. At the Lost Creek Tributary, a short segment of dry channel (slightly > 5 m) near the mouth interrupted a segment of flowing water, which was flowing from the PIP. Is the survey invalid where the flow is not continuous to the mouth, but the water clearly empties into a Type 3 stream?

Additional questions and notes raised by the crew:

- Dawn and Allison noted that 200 m of continuous flow is long for streams in their area.
- Is it necessary to collect data on the 200 m of dry channel *above* the PIP? Or can this 200 m of dry channel simply be documented in data form B.

September 14: Skagit System Cooperative (SSC)
The upper reaches of the stream had alternating piped channels, side channels, and seeps that made it difficult to determine the PIP. Larry Peterson (SSC crew) was an expert in using his "best professional judgment" in the tricky situations. Additionally, he has good

knowledge of the streams and associated features. Because SSC is performing the stream surveys solo, gradient measures may be less accurate if a flag is not tied downstream at eye level (Larry was estimating without a flag). Larry used a hip chain for the segment length and a logging tape for the width and depth. One measurement was taken for the average depth.

Additional questions and notes raised:

- For an upstream survey, is it necessary to collect data for the 200 m of continuous flow downstream of the start point? Larry has been collecting these data.
- How to deal with a dis-tributary? The protocol doesn't specify anything.

September 19: Hoh Tribe

The Hoh Tribe crew (Jill Silver and Mike Haggerty) and trainers spent much time verifying the location of the stream (Unnamed tribs to Dry Creek - #322 and #323) we were surveying because the Forest Practices Base Map differed from what was present on the ground. Mike thinks that the most important parts of the survey is to accurately locate the perennial initiation point and to make certain that the stream you're surveying is the one you've randomly chosen.

Mike has completed about seven surveys to date. He uses a meter tape with a large eye bolt on the end to secure on one bank for measuring bankfull width, and a second measuring tape for depth. Gradient is measured by tying flags at eye level. Mike has been measuring the variables at increments favorable to measuring gradient, e.g. typically less than 30 m even if no flow change. The data can be adjusted later for the 30 m increments specified in the protocol. Additionally, Mike has found it easier to measure distance, flow category, channel category, and gradient working upstream. On his way back downstream, he then gathers the bankfull width, depth, and dominant substrate.

The second tributary surveyed was problematic because it was actually a confluence of three Type 4 streams. We used a hat and three pieces of paper to randomly select which tributary to survey. Additionally, beaver activity has created extensive ponding and obscured most of the channel. We located the start point and measured distance to the end point, but no other data were collected because the channel was nearly impossible to locate and extended into a ponded wetland area that covered approximately three acres. Jill and Mike stated that large wetland areas, such as the one we encountered, were typical for the Hoh and therefore we shouldn't consider it an unusual situation and merely abandon the survey.

Additional questions and notes raised by the crew:

- Would it be possible to organize a training workshop for PIP surveys this winter? Two training sessions - one for east side, one for west side - would be useful.
- It is highly important to provide detailed driving directions to each site.
- Mike suggested that NWIFC develop a standard spreadsheet with look-up tables for distances so all the data are entered in the same format.

- The bankfull width definition doesn't work for the Hoh because organic matter, such as mosses, is common within the active channel.
- The last part of the pocket water definition states that "In those situations where both the upstream and downstream segment has 'Flowing water, 'Standing water, or 'Dry' for over 5 meters, the FP or SP unit can be as short as 0.1 meters." Does the flow category have to be the same both upstream and downstream?
- Does the field crew map the basin area for the PIP in the field?
- How is a channel affected by beaver activity categorized and surveyed?

September 24: Suquamish Tribe
The tribal crew (Dawn Pucci and Alison O'Sullivan) determined that the randomly selected stream (unknown stream near Point No Point) was not suitable for the perennial stream survey because the upper reaches of the stream flow through private areas with agricultural use, mainly livestock grazing. According to the protocol, land adjacent to the stream must be subject to Forest Practices. The land adjacent to the subject stream was not currently subject to Forest Practices.

The section of the stream that flowed through the agricultural area was ditched along what appeared to be property boundaries. The dense vegetation along the ditched portions made it difficult to determine flow category. The flow categories would have not been as accurate to assess as a more open stream. Dawn learned from a landowner that the stream flow upstream of the ditched section was regulated by the water district. We were unsure of how this would affect the stream survey (and this is something that the protocol should address).

The stream crossed many private properties and Dawn and Alison had to take much time asking permission to survey from the landowners. The landowners generally were receptive about the stream survey and had many questions. At least one was concerned about how his property rights would be affected. Two of the landowners, including the one concerned about property rights, made plans to accompany Dawn and Alison on a future stream survey.

2001 Quality Control Survey Reports

September 25: Hoh Tribe
The tribal crew (Mike Haggerty and Jill Silver) performed and upstream survey on an unnamed left bank tributary to Dry Creek (#325). The QC crew (Allen Pleus - NWIFC, Mara McGrath and Steffanie Taylor - ELS) performed replicate survey on nearly 100 meters of stream surveyed by the field crew. We opted to end the QC portion of the survey at 100 meters because of time constraints and the need to compare and discuss matched segments with the field crew.

The QC crew used a metal stadia and meter tape firmly secured with pins for measuring bankfull width and depth. The stadia was also used for upstream gradient and elevation gain. All variables were collected at each segment moving upstream. In contrast, the field crew used a meter tape with an eye bolt at the end and a second "seamstress" meter tape for measuring bankfull width and depth. Upstream and downstream gradient were measured by aiming, at eye level, at the other person. The field crew measured segment length, gradient, flow category, channel category, and other variables moving upstream. Bankfull width and depth were measured moving downstream.

Most segments between the field crew and the QC crew were matched. We noted discrepancies in interpreting side channels, and defining flowing water versus flowing pocket water. Additionally, the QC crew overlooked a > 5 m section of dry channel.

Additional questions and notes raised by the crews:

- What is the difference between a seep and a stream? Jill noted that they are sometimes difficult to distinguish in the field.
- How to measure bankfull width and depth if channel is a MC because of a culvert? The QC crew measured the culvert width; depth and substrate were n/a. This should be added to the protocol.
- Need to clarify definitions for FP and SP. They can be difficult to distinguish in the field.
- The QC crew encountered a segment that ended 1 m less than a 30 m segment break because of a change in flow category. The protocol doesn't specify if you should "round-up" to the next segment, e.g. 30 m, or stop precisely where the flow category changes, e.g. 29.5 m. In this situation, the QC crew decided to round-up to the next segment break.
- When flowing water is audible beneath a channel covered with organic debris, the protocol specifies to record the flow category as FW. However, when the flow category is FP both upstream and downstream of the covered section, shouldn't this section be recorded as FP and not FW?
- The protocol doesn't specify how to record the bankfull width, depth, substrate, and other variables for a PC or O channel.
- The QC crew only measured the upstream gradient. Are two gradient measures necessary?
- Need to establish a standard for assessing the dominant substrate. The current method is subjective.
- In an MC, can the segment be less than 5 m? This is not clearly stated in the protocol.

September 26: Yakama Nation

The tribal crew (Jim Matthews and Elroy Shavehead) performed an upstream survey on an unnamed right bank tributary to the west fork of Bear Creek. The QC crew performed replicate survey on approximately 1000 feet of stream surveyed by the field crew. We opted to end the QC portion of the survey at 1000 feet because of time constraints and the need to compare and discuss matched segments with the field crew. The lack of time to compare the two surveys seems to be a problem. The QC replicate survey takes longer and therefore, holds up the field crew. We will need to decide how to perform the replicate survey (or a portion of the survey) and still have enough time to discuss the matched segments.

Both crews collected variables moving upstream. All measurements were made in English units. The QC crew used a PVC rod in tenths and measuring tape in tenths for measuring bankfull width and depth. The PVC rod was also used for upstream gradient and elevation gain. The field crew used a logging tape in inches and measuring tape in tenths for measuring bankfull width and depth. Upstream and downstream gradient were measured by aiming at a flag tied at eye level.

The QC crew noted three major differences with the field crew:

1. The field crew measured segments at standard, 100-foot intervals, regardless of flow change. The variables at flow category changes outside of the 100-foot intervals were not measured.
2. A difference in defining the minimum length required for flow categories. For example, the field crew split out several D and SP segments. The QC crew lumped these segments into FW because they did not meet the minimum length criterion specified in the protocol. It appeared that the field crew might be recording any change in flow category, regardless of the length as specified in the protocol, or that there was a discrepancy in measuring distance between the two crews.
3. Need to clarify how to categorize wetlands. The field crew categorized a wetland area as D and NC, whereas the QC crew categorized the wetland area as WE. Neither crew measured bankfull width or depth of the wetland area.

Additional questions and notes raised by the crews:

- The field crews need to make copies of any maps or photos for the QC crew. Ideally, the QC crew would have these in advance of the replicate survey.
- Field crews should recon the streams for the replicate survey in advance to make certain of suitability for surveying.
- What is the flow category of bedrock that is dripping/sheeting with water? Is this considered FW?
- For the intensive QC survey, is the flow categorized as what is present directly beneath the bankfull width line (even if it differs from the rest of the segment)? How do you categorize the flow when two different flow categories are present beneath the bankfull width line, e.g. a section of FW and a small section of D?
- Jim has questions about calculating the basin area—is it based on the end point of FW or can it be any other flow category such as SP or FP?

October 2: Colville Confederated Tribes

The field crew (Ruby Peone, Eric Krausz, Jim Priest) performed a downstream survey on Rock Creek 01 (tributary to Loup Loup Creek). They located the perennial initiation point and worked downstream until the stream entered into a lake. They then investigated upstream of the pip and noted two wetlands connected by a dry channel segment. Both the field crew and QC crew made measurements in metric. The field crew used a hip chain for segment length, and PVC rod for width and depth. The QC crew also used a hip chain for segment length, but used a metric tape for width and PVC rod for depth. The QC crew used the PVC rod for gradient and elevation gain. The QC crew failed to note how the field crew measured gradient.

The field crew surveyed the stream at standard 30 m intervals, whereas the QC crew broke segments at changes in flow category (no side tributaries were present). The field crew noted changes in flow category in the notes section, but did not consider a change in flow category a segment break unless it corresponded to a 30 m interval. Consequently, we found it difficult to compare the field crew data and the QC crew data on the matched segments form. Our discrepancies appeared to be most pronounced in determining segment breaks, determining channel category, and measuring bankfull width. The field crew categorized most of the stream a DC - "defined channel," whereas the QC crew categorized most of the stream a PDC - "poorly defined channel" because of the livestock damage. Bankfull width was difficult to measure because of extensive cow damage to the sides of the stream and the varying widths of the stream.
Additional questions and comments raised by the field crew:

- The field crew thought it would be more efficient to document that 200 m of dry channel is present above a pip, but not collect segment data.
- How should you deal with a stream that flows into a lake? Can you assume that flow is continuous to the mouth? The stream we surveyed entered into a lake approximately 200 m downstream of the pip. However, flow was not continuous into the lake.
- Eric thinks it is illogical to label the start point as 200 m upstream of the pip if a dry channel is present. He suggested labeling the pip as the start point and labeling segments above with a D for "dry"plus a number and segments below with F for "flow" plus a number to more accurately indicate the starting point of the survey.
- Jim would like all the tribes involved in the survey to have input on the final protocol.
- How do you deal with a wetland that is present above a pip? In Rock Creek 01, two wetlands were located above the pip, with a short dry channel connecting the two wetlands.
- Eric had a stream from an earlier survey that apparently originated in a lake. A dry channel was present above the lake and flowing water was present below the lake. Do you assume that the pip is located in the lake? Or is this an unacceptable stream to survey?

UPSAG Np Technical Group
Perennial Stream Survey (PSS) Project: 2001 Pilot Phase

Protocol Application Questionnaire

The PSS Protocol Application Questionnaire is designed to provide the PSS project manager with valuable information on how individual participants applied the PSS protocol version 1.21. This information is critical for interpreting participant data for analysis and assessment of variations in application. No response to a question will be interpreted as crews followed protocol and had no problems in its meaning or application. Please return completed questionnaire (electronic or printed and filled out) with the 2001 data package. Please provide the following contact information:
Name: ______________________________
Affiliation: ______________________________
Phone: ______________________________
Email: ______________________________

1. Identify any 2001 survey sites that you question whether they should be used for analysis of the pilot study and why.

2. Identify any 2001 survey sites that you believe can be used as reference sites of least management/human disturbance regimes.

3. Place a check mark in front of any of the Definitions (section 3.0) protocols that the field crew had problems with, never used, or knowingly applied differently and why.

__ Flowing Water
__ Standing Water
__ Flowing Pocket Water
__ Standing Pocket Water
__ Dry
__ Unknown
__ Obscured

__ Defined Channel
__ Poorly Defined Channel
__ Modified Channel
__ Piped Channel
__ No Channel

__ General Channel Width
__ General Channel Depth
__ Stream Bed Substrate
__ Wetland
__ Seep

4. Identify any problems or differences applied in use of the Sample Site Selection (section 4.1) protocols.

5. Identify any Equipment and Materials (section 4.2) used or not used that you believe biased results and how.

6. Identify any Sample Period (section 4.3) protocol problems or differences that were applied and why.

7. Identify any Upstream Method (section 4.4.1.1) protocol problems or differences that were applied and why.

8. Identify any Downstream Method (section 4.4.1.2) protocol problems or differences that were applied and why.

9. Identify any Main Thread Survey (section 4.4.2) protocol problems or differences that were applied and why.

10. Identify any Total Tributary Survey (section 4.4.2) protocol problems or differences that were applied and why.

11. Identify any Measurements (section 4.4.3) protocol problems or differences that were applied and why.

12. Identify any Determining the End Point (section 4.4.4) protocol problems or differences that were applied and why.

13. Identify if and how you applied the Unusual Situations (section 4.4.5) protocols and why.

14. Identify which sites you applied the QA/QC Test of the 200-meter Distance (section 4.4.6) protocols and results.

15. Identify which sites you applied the QA/QC test of documenting flow changes within the sample period (section 4.4.6) protocol.

16. Based on your experience, what physical channel or upslope characteristics would you use to identify the Type Np/Ns Water break during higher flow periods:
    a. Between "dry channel" and "spatially intermittent flowing water?"

    b. Between "spatially intermittent flowing water" and continuous flowing water?"

17. Identify any protocols that you believe cause variability in crew application either due to accuracy, precision, or bias.

18. What independent analysis have you done to date on your data that you think is important for analysis of 2001 data?

19. What physical parameters (e.g. substrate, bankfull width, etc) did you not collect data on and/or you believe could be deleted from the list and why?

20. Based on your analysis and/or experience, what are some critical elements/issues to consider for the 2002 study design?

You are welcome to add any other thoughts or insights to this questionnaire on the back of this sheet or separate page. Thank you for your assistance in completing this information.

UPSAG Np Technical Group

SUMMARY OF RESPONSES

Perennial Stream Survey (PSS) Project: 2001 Pilot Phase

Compiled 4/26/02, RCP

RESPONSES

Received	No Response
Colville/Spokane (COL)	
Longview Fiber (LVF)	
Port Gamble S'Klallam (PGS)	Campbell Group
Skagit System Cooperative (SSC)	HOH (HOH)
Suquamish (SUQ)	
Depart Fish & Wildlife (WDFW) – additional comments only - attached	
Yakama Nation (YAK)	

21. Place a check mark in front of any of the Definitions (section 3.0) protocols that the field crew had problems with, never used, or knowingly applied differently and why.

__ Flowing Water	__ Defined Channel	Yak General Channel Width
__NU (SSC) Standing Water	_ Poorly Defined Channel	SSC Yak General Channel Depth
LVF__ Flowing Pocket Water	_PGS_ Modified Channel	_Yak_ Stream Bed Substrate
LVF__ Standing Pocket Water	_Col_ Piped Channel	__ Wetland
__ Dry	__ No Channel	__PGS Seep
__ Unknown		
__ Obscured		

COL used mc for pc because there was a pipe or culvert
SSC – need to clarify that less than 5m of dry do not disrupt FW; 10 cm pocket too small – difficult to distinguish flow in 10 cm; substrate should include culvert and modified
YAK used uniform 30 m intervals as breaks were too time consuming

22. Identify any problems or differences applied in use of the Sample Site Selection (section 4.1) protocols.

SUQ – sites discarded because of urbanization/access

23. Identify any Equipment and Materials (section 4.2) used or not used that you believe biased results and how.

PGS – used abney level
SUQ – Use tape rather than surveyor's rod for measuring BFD
YAK used altimeter, compass, and USGS map for location

24. Identify any Sample Period (section 4.3) protocol problems or differences that were applied and why.

COL - should sample in early spring to account for base flow and fish presence
SSC - need longer time after ppt and not allow crew judgment to enter

25. Identify any Upstream Method (section 4.4.1.1) protocol problems or differences that were applied and why.

COL – redundant to locate PIP and then measure 200 m downstream to begin survey

26. Identify any Downstream Method (section 4.4.1.2) protocol problems or differences that were applied and why.

PGS – DNR hydro layer does not show Np streams in their watershed – difficult to apply method
SSC – problem with identifying PH
SUQ – faster than upstream because of ease of access

27. Identify any Main Thread Survey (section 4.4.2) protocol problems or differences that were applied and why.

SSC – problem with distributaries that don't reconnect
YAK recommends that when coin flip is used that both tribs are looked over and the one with the longest stretch of flowing water be followed.

28. Identify any Total Tributary Survey (section 4.4.2) protocol problems or differences that were applied and why.

29. Identify any Measurements (section 4.4.3) protocol problems or differences that were applied and why.

CO L – standardize measure units (0.1 or 0.01 m for rounding?), seg. Breaks should only be selected if they result in a change of flow category, veget. Categories are too broad and for upland not riparian vegetation

PGS - 30 m length too short – used 100 m default length; only one gradient measurement per segment usually near upstream end

SSC – need to better ID "Upstream/Downstream"; better guidance on choosing "features assoc with flow change"; more detail on sketches

SUQ – BFW/BFD

30. Identify any Determining the End Point (section 4.4.4) protocol problems or differences that were applied and why.

SSC – 200 m is too far to look above Ph and too short too insure a continuously flowing or dry channel
SUQ – 200 m excessive; ended survey at top of flow even if the channel continued
YAK 200 m may not be sufficient - they encountered water beyond 200 m of dry channel.

31. Identify if and how you applied the Unusual Situations (section 4.4.5) protocols and why.

SSC – sites with road influence – how to evaluate affects.

32. Identify which sites you applied the QA/QC Test of the 200-meter Distance (section 4.4.6) protocols and results.

33. Identify which sites you applied the QA/QC test of documenting flow changes within the sample period (section 4.4.6) protocol.

34. Based on your experience, what physical channel or upslope characteristics would you use to identify the Type Np/Ns Water break during higher flow periods:
    a. Between "dry channel" and "spatially intermittent flowing water?"

    LVF – can't be done
    SSC – perhaps average distance downstream from Ph
    SUQ – wetlands/saturated ground

    YAK – discontinuous flow oftentimes emerged at abrupt gradient break; also mesic or hydric plant communities and mossy rocks

    b. Between "spatially intermittent flowing water" and continuous flowing water?"

    LVF – can't be done

SSC – don't know all observed features were variable between sites
SUQ – defined channel
YAK – no distinction

35. Identify any protocols that you believe cause variability in crew application either due to accuracy, precision, or bias.

COL – clearer guidelines for identification. Seg breaks, measure BFW/BFD, and flow cat.
PGS – their inexpensive abney level could not measure accurately in the 1 – 4% range
SSC – small minimum lengths for flow cat., obscure flow/channel conditions; locating Ph
YAK – substrate size determination: distinction between pdc and nc

36. What independent analysis have you done to date on your data that you think is important for analysis of 2001 data?

PGS - compared PIP to geol. – close assoc with till/outwash contact
SCC – Ph to Np break

37. What physical parameters (e.g. substrate, bankfull width, etc) did you not collect data on and/or you believe could be deleted from the list and why?

LVF – substrate, BFW/BFD, probably not useful
SSC – all collected but longer default length would streamline survey
YAK – substrate and BFD difficult to measure and probably provide little useful info

38. Based on your analysis and/or experience, what are some critical elements/issues to consider for the 2002 study design?

COL – 2-day short course prior to field season; location of sites prior to field season.
LVF – survey should start at fixed physical point and confined to measuring distance and gradient to Pp, Pd, and Ph; better define these points to cleared ID. 200 m length excessive on west side, OK on east.
PGS – simplify – lengthen default dist. To 100 m; begin closer to PIP; eliminate some variables; greater use of other sources prior to survey (geol maps, etc)
SUQ – protocols too time-consuming – reduced sample size
YAK – channel seeps (SIIP)

You are welcome to add any other thoughts or insights to this questionnaire on the back of this sheet or separate page. Thank you for your assistance in completing this information.

Col –see attached sheet.

Comments on

<u>2001 Np Pilot Field Protocol</u>

Robert Palmquist

My comments take two forms: those related to my experience processing the data and those of geomorphologist considering potential influences on perennial flow.

Data Processing Experience

1. **Point Numbering and Segment descriptions**: For consistency in the interpretation of data – the traverse should begin at point #0. The description of the segment between #0 and #1 should be associated with point #1
2. **End Verification**: The survey information should state that the traverse extended 200 m beyond each end. This is best accomplished on an upstream traverse by point #0 being 200 m before the Pp and the last point being 200m beyond the Pd or just beyond the Ph. The Ph should be included in every survey.
3. **Associated Features**: Features relating to changes in flow regimen should be noted particularly such features as woody debris, debris flow sediment, bedrock (till) outcrops, hydric or mesic vegetation, and changes in valley width or valley floor width, along with those features presently included. The class OT should not exist – lets determine what could be included.
4. **Map Location**: The coordinates for points Pp, Pd, and Ph should be given in consistent units. I recommend that these points be located on a USGS topographic map (particularly the georeferenced topos available for GIS), so that they agree with the hydro layer and reduce interpretation by the GIS technician. Coordinates should be entered as either decimal degrees or northings and eastings (state plane).
5. **Entry protocol**: The data entry sheet should contain no letters or symbols in the numeric columns (this includes ", ', --, NA, no data, etc). All site-data should be entered sequentially on the same sheet and the sites numbered sequentially with the site numbering protocol being HOH1, HOH2, PGS1, PGS2, etc.

Perennial Flow Controls

Perennial flow is maintained by factors outside of the stream channel. As many of these environmental factors should be noted in the field as possible to facilitate the identification of field criteria. In addition to the factors presently requested, I recommend:

1. Valley floor width – the width of the level valley floor between the more steeply sloping valley sides (an estimate of quantity of possible subsurface flow).
2. Distance to outcrops and outcrops in channel bed – again an estimate of potential subsurface flow.
3. Valley relief (Inner gorge relief) – too small to measure from topographic maps but an indicator of potential soil water inflow to stream.
4. Riparian vegetation – a measure of degree of long term soil saturation and potential for perennial flow

Sample Sizes Required To Achieve Desired Precision Goals Within A Stratum.

Marianna Alexandersdottir
NWIFC

Evaluation of sample sizes required to achieve project objectives is only one part of a sample design. But assuming random sampling, the data gathered already can be used to provide some guidelines as to sample size requirements within a stratum. In this evaluation two strata are discussed, a stratum for the 52 acre default area region and a stratum within the 300 acre default area region. These strata could be ecoregions, the entire default area region or some other geographically defined areas.

The data analysis suggested that the basin area measurements have a distribution skewed to the left, with a longer right tail. A log-transformation appears to normalize the data and the median is a better estimator of the center of the distribution than the mean of the basin areas. The mean of the log-transformed data provides an estimate of the median when transformed back to the original scale.

The estimation of the mean of the log-transformed data with a 90% confidence interval (CI) also provides an estimated confidence interval on the original scale by transforming the mean and lower and upper bounds back to the original scale. The 90% CI of the log-transformed data will be symmetrical (the distance to the lower and upper bounds are equal), but when transformed back to the original scale the 90% CI will no longer be symmetrical, but will be wider on the upper end of the range (Figure 1, Table 1). In addition the size of the confidence interval on the original scale is larger that at the log-transformed scale, where the relative size is the distance to the lower or upper bound divided by the estimated median. A 90% CI with a relative size of ±10% for the log-transformed mean will translate to a confidence interval that ranges 32% of the estimated median to the lower bound and 48% to the upper bound (Table 1).

Table 1. Relative size of 90% confidence intervals at the log-transformed and original scales.

Relative Size of 90% CI for log-transformed data	Original Scale		
	Estimated median	Size for lower bound	Size for upper bound
5%	50	18%	22%
10%	50	32%	48%
15%	50	44%	80%
20%	50	54%	119%
25%	50	62%	166%
5%	300	25%	33%
10%	300	43%	77%
15%	300	57%	135%
20%	300	68%	213%
25%	300	76%	316%

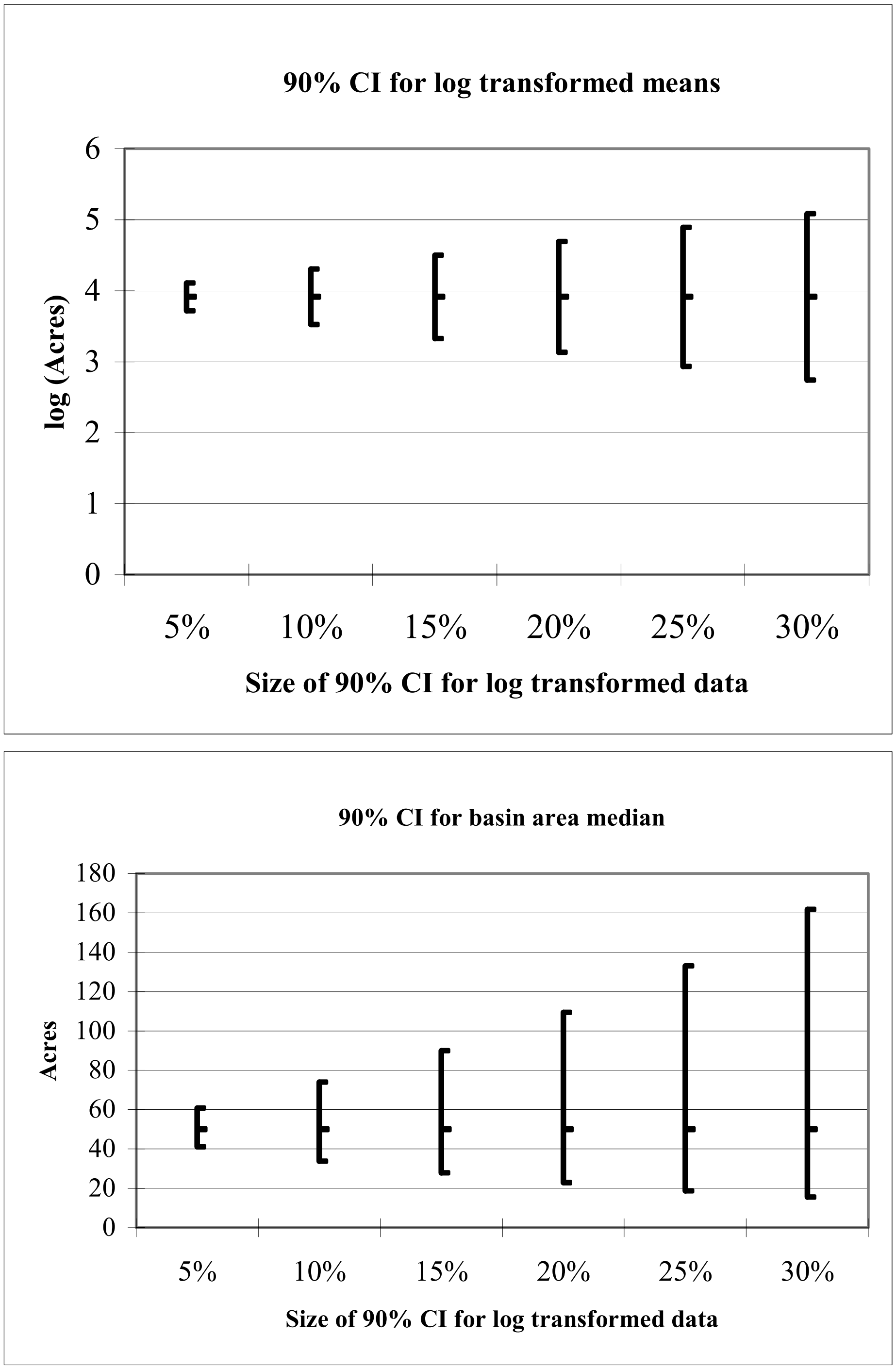


Figure 1. **90% Confidence intervals for log-transformed means and median in original scale relative to the size of the 90% CI of the log transformed mean. The CI for the log-transformed mean are symmetrical (upper graph), but the CI are not symmetrical when transformed back to the original scale (lower graph).**

1 Evaluation of Sample Sizes

The approximate 90% confidence interval for the log-transformed mean is estimated using a normal Z-statistic by:

$$\boldsymbol{Mean} \pm \frac{\boldsymbol{Standard\ Deviation}}{\sqrt{\boldsymbol{n}}} \bullet 1.65$$

This provides a method to estimate sample sizes needed to achieve desired precision levels defined by the relative size of the confidence interval by;

$$\boldsymbol{n} = \boldsymbol{CV}^2 \frac{1.65^2}{\boldsymbol{r}^2}$$

where ***r*** is the relative size of the confidence interval (i.e. $\left(\frac{\boldsymbol{Standard\ Deviation}}{\sqrt{\boldsymbol{n}}} \bullet 1.65\right) = \boldsymbol{r} * \boldsymbol{Mean}\}$

and ***CV*** is the coefficient of variation of the population ($\frac{\boldsymbol{Standard\ Deviation}}{Mean}$ *100).

1.1 Sample sizes

In order to evaluate sample sizes required to achieve the desired precision, three pieces of information are required:

1. The expected estimate of basin area. Here, we have used 52 and 300 acres, default basin areas used for the Westside and Eastside regions.
2. The expected variance, or CV, of the basin areas. Here, we have used the CVs estimated in sampling already accomplished (Table 2).
3. A measure of desired precision for the "new" estimate. Here, we have used the relative size of the 90% confidence interval as a measure of the precision.

A three step procedure is used:

1. It is necessary to decide what precision is desired for the estimates on the original scale, i.e., the median of the measured basin areas.
2. Once this is decided, the precision (or size of 90% CI) required for the log-transformed mean estimation can be determined using the graphs in Table 1.
3. Finally, given the expected basin areas (52 and 300 acres) and the expected CVs then Table 3 can be used to find the sample size required to achieve the desired precision, given the estimate and variances expected.

Table 2. Estimated Mean, Standard Deviation , coefficient of variation (CV)[1] and number of sites sampled for log transformed data by cooperator, ecoregion and default area stratum.

		log Pp				log Pd			
Ecoregion	Coop	Mean	Std. Dev.	CV	N	Mean	Std. Dev.	CV	N
300 Acre Stratum									
15	COL	5.5961	1.0835	19.4%	6	5.6605	1.2727	22.5%	5
15	SPO	4.9777	2.2261	44.7%	5	4.2188	2.1351	50.6%	6
Ecoregion average				32.0%				36.5%	
15 combined		5.3150	1.6351	30.8%	11	4.8742	1.8692	38.3%	11
77 East	COL	3.6600	0.8538	23.3%	5	3.6687	0.7628	20.8%	6
77 East	LVF	3.8102	1.7107	44.9%	11	2.6510	1.7949	67.7%	12
Ecoregion average				34.1%				44.2%	
77 E combined		3.7632	1.4665	39.0%	16	2.9902	1.5809	52.9%	18
9	LVF	4.1682			1	3.7466	0.5962		2
Stratum average				34.6%				45.2%	
300 Acre Stratum combined		4.3873	1.6638	37.9%	28	3.7075	1.8441	49.7%	31
50 Acre Stratum									
1	DFW	3.1447	1.1012	35.0%	18	1.8641	0.7685	41.2%	23
1	HOH	1.1742	1.6005	136.3%	17	0.8148	1.5426	189.3%	19
1	LVF	1.6541	0.6874	35.0%	3	1.8361	0.5177	28.2%	3
Ecoregion average				68.8%				86.2%	
1 combined		2.1700	1.6161	74.5%	38	1.4192	1.2466	87.8%	45
2	LVF	5.1472	2.2063	42.9%	4	2.9642	1.7260	58.2%	4
2	PGS	3.0350			1	2.7850			1
2	SUQ	2.4366	1.1922	48.9%	6	2.1772	1.2031	55.3%	6
Ecoregion average				45.9%				56.7%	
2 combined		3.4767	1.9889	57.2%	11	2.5186	1.3319	52.9%	11
4	LVF	2.3716	1.0344	43.6%	17	2.0214	1.1143	55.1%	17
4	TCG	2.8268	1.5526	54.9%	50	2.5991	1.5424	59.3%	57
4	YAK	3.7205	1.2394	33.3%	13	2.4093	1.4034	58.2%	13
Ecoregion average				44.0%				57.6%	
4 combined		2.8753	1.4556	50.6%	80	2.4578	1.4512	59.0%	87
77 West	SSC	2.2985	1.0290	44.8%	23	1.2832	0.7368	57.4%	18
Stratum average				56.8%				64.3%	
50 Acre Stratum combined		2.6552	1.5226	57.3%	152	2.0404	1.4182	69.5%	161

[1] $CV = \frac{\textbf{Standard Deviation}}{Mean} * 100$

1.1.1 An example.

We are using 50 and 300 acres as our expected estimate and Table 2 shows the CVs estimated for the samples taken in the previous sample. The pooled CV for log Pd in the 300-acre default is about 50% and for the 52-acre default, it is about 70%.

It is desired to have a 90% confidence interval that does not range more than 50% on either side for an estimated median of 50 acres and 300 acres.

Looking at Table 1 we would require a 90% confidence interval for the log-transformed data of no larger than ±10% for the 50 acre estimate and 5% for the 300 acre estimate to achieve this precision goal.

Using a relative size of the 90% CI of ±10% for the log-transformed mean, and a CV of 50% a sample size per stratum of 68 is required and a CV of 70% results in a sample size requirement of 133 (Table 3). With these sample sizes Table 1 indicates that the median for the 300-acre default will be about +77%, -43% and for the 52-acre default it will +48%, - 32%. If this is not sufficient for the 300 acre region, then sample sizes would have to be increased to 534 sites to achieve a 90% CI of ±5% for the log-transformed mean, which would translate to a 90% CI ranging from –25% to +33% around an estimate of 300 acres (Table 1).

Table 3. Sample sizes required to estimate 90% CI of mean of log-transformed basin areas for a given relative size and CV of the transformed data.

CV of log-transformed mean Basin Area	Relative Size of 90% CI of log-transformed mean Basin Area				
	5%	10%	15%	20%	25%
5%	3	1	0	0	0
10%	11	3	1	1	0
15%	25	6	3	2	1
20%	44	11	5	3	2
25%	68	17	8	4	3
30%	98	25	11	6	4
35%	133	33	15	8	5
40%	174	44	19	11	7
45%	221	55	25	14	9
50%	*272*	*68*	*30*	*17*	*11*
55%	329	82	37	21	13
60%	392	98	44	25	16
65%	460	115	51	29	18
70%	*534*	*133*	*59*	*33*	*21*
75%	613	153	68	38	25
80%	697	174	77	44	28
85%	787	197	87	49	31
90%	882	221	98	55	35
95%	983	246	109	61	39
100%	1,089	272	121	68	44

Basin Area to Stream Points vs. Distance from Divide to Stream Point

Marianna Alexandersdottir
NWIFC
March 17, 2002

This analysis is intended to evaluate the relationship of basin areas to the stream distance from the divide to the point on the stream characterizing the basin area, i.e. the point of discontinuous water (P_d) and of continuous flowing water (P_p).

Distribution of distances.

The distribution of the distances, like that of the basin areas, is skewed to the right, as shown in Figure 1 below. The data are more normally distributed when transformed using the natural logarithm as also shown in Figure 1 below. The QQ plots show that the log transformed data depart slightly at the tails from a natural distribution, but not severely. For the purposes of this analysis the log-transformed data are used. The mean and median distances, with standard errors for the mean are shown in Table 1 for the data on the original scale and for the log-transformed data. The 90% confidence interval for each cooperator is shown in Figure 2.

Relationship between distance to stream points P_d and P_p and basin areas

Linear regressions on the log-transformed data were used to evaluate the relationship between the basin areas measured to the point in the stream where discontinuous water started (P_d) and to where continuous flowing or perennial water was detected (P_p). The data were collected by cooperating agencies and are grouped within two major regions, the Westside where the default basin area is 52 acres and the Eastside where the default basin area is 300 acres. Regressions were done for each cooperator separately (Table 2).

In order to determine whether there were any differences among the datasets collected by the cooperating agencies Analysis of Covariance was used to test the hypotheses that there was no difference in the slope and intercepts of the regressions (Table 2). The model is as follows:

$$\ln(Px) = \ln(Ax) + Cooperator + \ln(Ax) \bullet Cooperator$$

where $\ln(P_x)$ is the log-transformed distance to a stream point and $\ln(A_x)$ is the log-transformed basin area defined by that point. If there is a significant interaction term this indicates there are differences in the slopes, while a significant main effect for cooperator indicates differences in the intercepts for the separate regressions.

For the basin area measured to P_d neither term was significant (Cooperator or interaction) in either region (Table 3), while these were both significant in the 300 acre default area region for the area measured to point P_p. This result indicates that the regressions are coincident for the P_d distance in both regions, but only in the regions with 52 acre defaults for the P_p distance (Table 3). The sample sizes are smallest for the cooperators in the eastside (300 acre) region and some points are very influential in the regressions (Figure 3), which may be resulting in this significant difference among cooperators. When cooperators are combined and regressions compared between regions (52 vs 300 acre default), no significant difference was found (Table 3, Figure 4).

The relationship on the original scale between distance to a stream point and basin area is a power function,

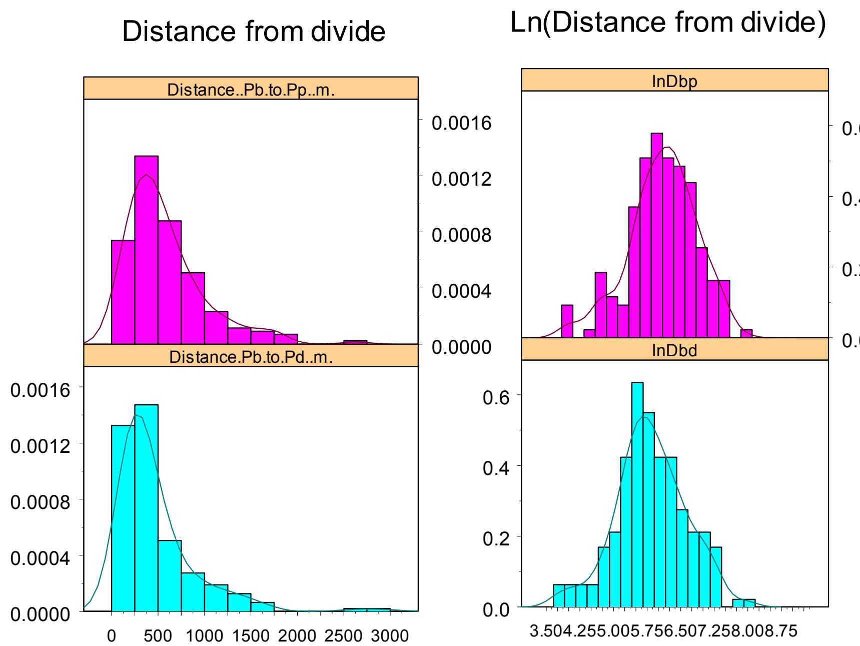
$$\textit{Distance to } P_x = \alpha A_x^b$$

where α is the exponential of the intercept of the regression and b is the slope of the regression (Figure 5). This function shows the decreasing rate at which the distance to the point of discontinuous water lengthens with increasing basin size.

Regressions of the log-transformed distance to P_d as a function of basin area A_d for each region separately and combining all data, were significant with R^2s ranging from 66-85%, and an R^2 of 70% for the statewide data (Table 4). Figure 6 shows the resulting regression with 90% prediction intervals.

Similar relationships exist for distance to perennial water P_p with basin area in the 52 and 300 acre regions and for all data combined (Table 4). But given the small sample sizes and differences between cooperators in the 300 acre default region, this relationship should be used with caution. In order to better define the relationship for P_p additional data collection would be necessary.

A. Distributions of distances and distances transformed using natural logarithm.



B. QQ plots for data on original scale and log-transformed data.

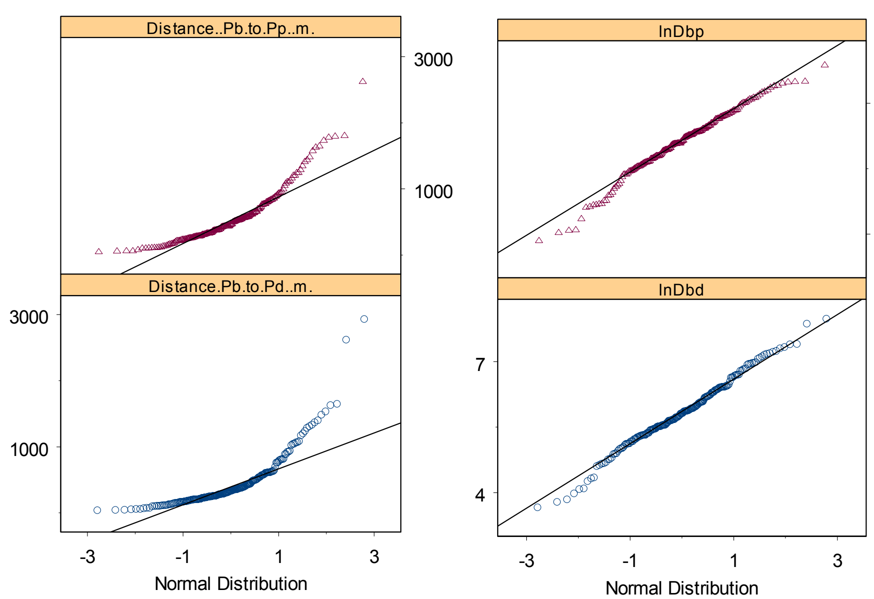
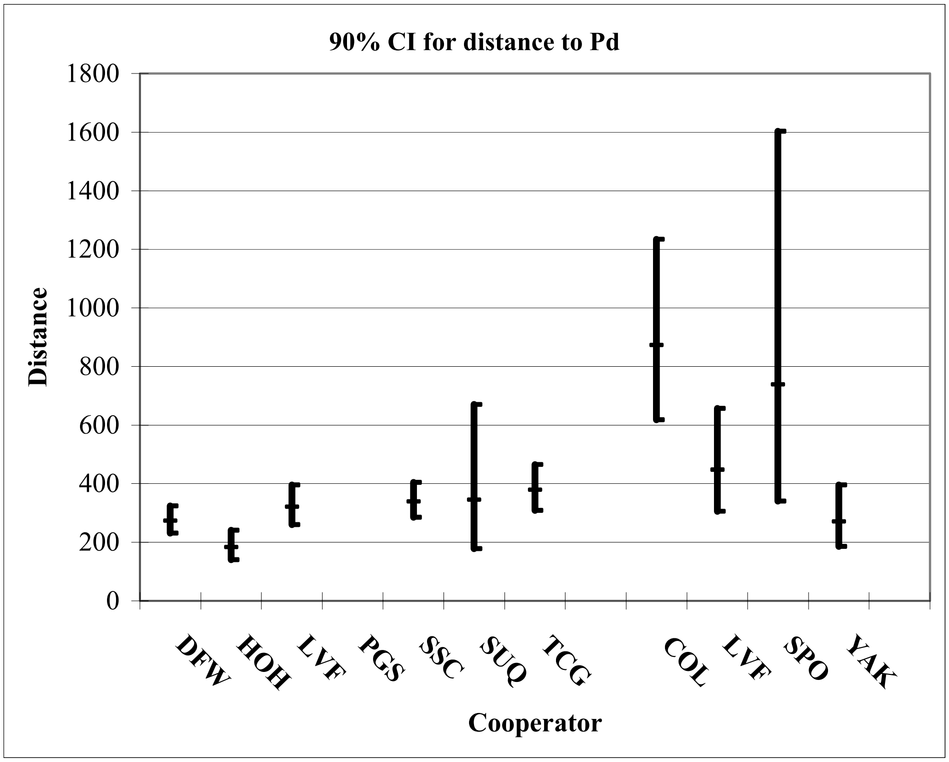


Figure 1. **Distribution (A) and QQ plots (B) of measurements of distance from divide to points (P_d and P_p) defining basin areas.**

Table 1. Statistics for distances to Pd and Pp by cooperator and region (default basin areas).

Region	Cooperator	Original Scale				Log-Transformed			
		N	Mean	Median	SE	N	Mean	Median	SE
Distance to Pd									
52	DFW	22	306.4	272.0	36.4	22	5.6132	5.6038	0.0978
	HOH	21	229.1	194.0	45.9	20	5.2134	5.3530	0.1559
	LVF	22	376.6	299.0	54.9	22	5.7707	5.7008	0.1222
	PGS	1	210.0	210.0		1	5.3471	5.3471	
	SSC	23	383.0	309.0	43.0	23	5.8282	5.7333	0.1013
	SUQ	5	417.2	258.0	124.5	5	5.8442	5.5530	0.3114
	TCG	55	530.6	395.0	54.1	55	5.9379	5.9793	0.1224
52		149	403.5	293.0	25.8	148	5.7427	5.7020	0.0609
300	COL	10	1,034.4	830.0	215.9	10	6.7728	6.6864	0.1886
	LVF	13	633.3	360.0	203.3	13	6.1049	5.8861	0.2142
	SPO	6	949.8	983.5	218.5	6	6.6049	6.8893	0.3843
	YAK	12	323.4	350.5	44.8	12	5.6030	5.8563	0.2102
300		41	686.8	441.0	97.5	41	6.1941	6.0890	0.1336
Distance to Pp									
52	DFW	17	650.5	561.0	87.0	17	6.3642	6.3288	0.1160
	HOH	18	311.8	244.0	56.2	18	5.5207	5.4980	0.1608
	LVF	22	433.6	351.5	63.9	22	5.8934	5.8594	0.1283
	PGS	1	214.0	214.0		1	5.3658	5.3658	
	SSC	23	649.5	577.0	78.4	23	6.3354	6.3578	0.1119
	SUQ	5	495.2	430.0	123.2	5	6.0733	6.0648	0.2602
	TCG	49	550.6	395.0	64.0	49	5.9415	5.9793	0.1347
52		135	524.6	422.0	33.0	135	5.9985	6.0450	0.0662
300	COL	9	1,110.3	1,106.0	229.9	9	6.8578	7.0085	0.1939
	LVF	12	571.6	507.5	70.7	12	6.2699	6.2297	0.1187
	SPO	5	1,114.4	1,163.0	243.2	5	6.8751	7.0588	0.2949
	YAK	12	562.7	513.0	86.0	12	6.1821	6.2404	0.1798
300		38	767.8	592.5	81.1	38	6.4610	6.3837	0.1006



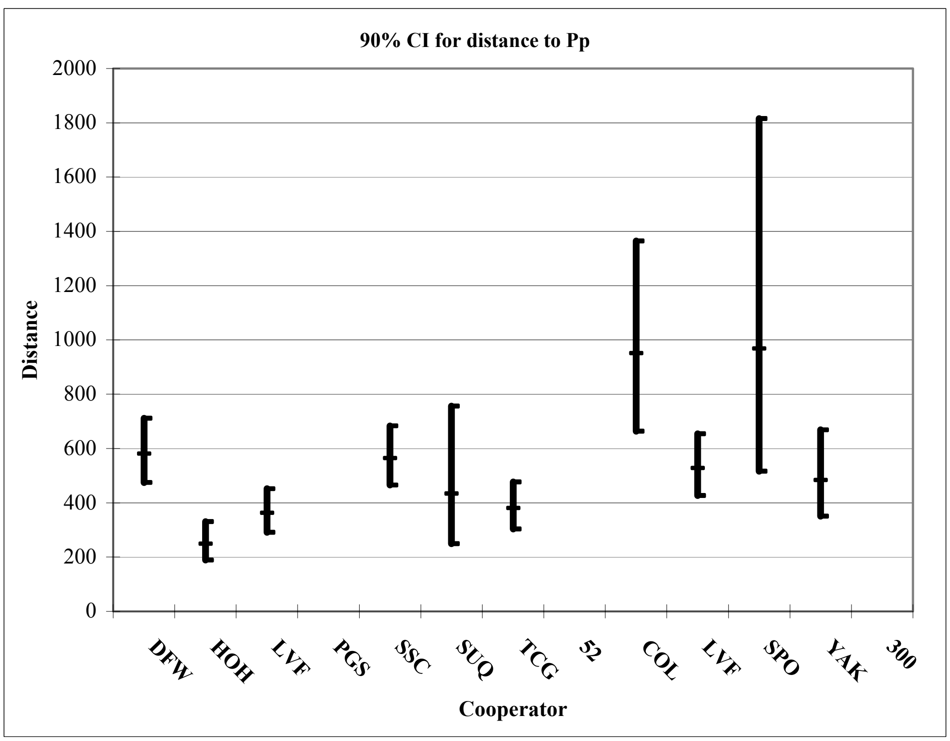


Figure 2. 90% confidence intervals for distance to discontinuous (P_d) and perennial water (P_p) by cooperator.

Table 2. Results of regressions of log-transformed distance to stream points P_d and P_p on log-transformed basin areas to those points.

Default Basin Area	Cooperator		ln(Distance to Pd)=f(Ad)				ln(Distance to Pp)=f(Ap)			
			Intercept	Slope	df	R^2	Intercept	Slope	df	R^2
52	DFW	Estimate	4.82	0.44	20	52.7%	5.22	0.36	15	72.6%
		SE	0.17	0.09			0.18	0.06		
		Lower 95% CI	4.46	0.25			4.83	0.25		
		Upper 95% CI	5.18	0.63			5.61	0.48		
		t-statistic	27.73	4.94			28.43	6.58		
		p-value	0.0000	0.0001			0.0000	0.0000		
	HOH	Estimate	4.90	0.41	16	79.7%	4.99	0.42	15	87.5%
		SE	0.09	0.05			0.08	0.04		
		Lower 95% CI	4.71	0.31			4.83	0.34		
		Upper 95% CI	5.08	0.52			5.15	0.50		
		t-statistic	56.47	8.23			65.64	10.64		
		p-value	0.0000	0.0000			0.0000	0.0000		
	LVF	Estimate	5.01	0.37	20	60.2%	5.11	0.29	20	64.9%
		SE	0.15	0.06			0.15	0.05		
		Lower 95% CI	4.69	0.23			4.80	0.19		
		Upper 95% CI	5.33	0.50			5.41	0.38		
		t-statistic	32.64	5.72			34.93	6.31		
		p-value	0.0000	0.0000			0.0000	0.0000		
	PGS	Estimate	5.35	-			5.37	-		
		SE								
		Lower 95% CI								
		Upper 95% CI								
		t-statistic								
		p-value								
	SSC	Estimate	5.40	0.32	15	27.7%	5.36	0.41	17	53.5%
		SE	0.20	0.12			0.24	0.09		
		Lower 95% CI	4.97	0.06			4.86	0.23		
		Upper 95% CI	5.84	0.57			5.86	0.60		
		t-statistic	26.52	2.67			22.65	4.66		
		p-value	0.0000	0.0174			0.0000	0.0002		
	SUQ	Estimate	4.58	0.53	3	82.4%	4.80	0.47	3	81.2%
		SE	0.31	0.12			0.32	0.11		
		Lower 95% CI	3.59	0.15			3.78	0.12		
		Upper 95% CI	5.58	0.91			5.81	0.83		
		t-statistic	14.70	4.45			15.04	4.27		

Table 2. Results of regressions of log-transformed distance to stream points P_d and P_p on log-transformed basin areas to those points.

Default Basin Area	Cooperator		ln(Distance to Pd)=f(Ad)				ln(Distance to Pp)=f(Ap)			
			Intercept	Slope	df	R^2	Intercept	Slope	df	R^2
		p-value	0.0007	0.0211			0.0006	0.0236		
	TCG	Estimate	4.68	0.47	53	62.0%	4.65	0.46	47	56.4%
		SE	0.15	0.05			0.18	0.06		
		Lower 95% CI	4.38	0.37			4.28	0.34		
		Upper 95% CI	4.99	0.58			5.03	0.57		
		t-statistic	30.67	9.44			25.17	7.94		
		p-value	0.0000	0.0000			0.0000	0.0000		
300	COL	Estimate	4.82	0.45	8	81.7%	4.86	0.44	7	90.6%
		SE	0.31	0.07			0.23	0.05		
		Lower 95% CI	4.10	0.29			4.31	0.33		
		Upper 95% CI	5.55	0.61			5.41	0.56		
		t-statistic	15.32	6.42			20.90	8.86		
		p-value	0.0000	0.0002			0.0000	0.0000		
	LVF	Estimate	4.63	0.51	11	89.4%	5.64	0.16	9	13.9%
		SE	0.16	0.05			0.42	0.10		
		Lower 95% CI	4.27	0.40			4.70	(0.06)		
		Upper 95% CI	4.98	0.62			6.58	0.38		
		t-statistic	28.58	10.12			13.57	1.62		
		p-value	0.0000	0.0000			0.0000	0.1400		
	SPO	Estimate	4.88	0.41	4	83.1%	5.31	0.29	2	77.2%
		SE	0.38	0.08			0.49	0.09		
		Lower 95% CI	3.83	0.18			3.21	(0.08)		
		Upper 95% CI	5.92	0.63			7.41	0.65		
		t-statistic	12.97	5.05			10.88	3.34		
		p-value	0.0002	0.0072			0.0083	0.0790		
	YAK	Estimate	4.58	0.42	10	70.3%	4.32	0.49	10	91.9%
		SE	0.23	0.08			0.17	0.04		
		Lower 95% CI	4.08	0.24			3.93	0.39		
		Upper 95% CI	5.09	0.61			4.71	0.58		
		t-statistic	20.15	5.20			24.88	11.23		
		p-value	0.0000	0.0004			0.0000	0.0000		

Table 3. Results for Analysis of Covariance testing the hypothesis of equal intercepts and slopes among cooperators within default basin areas and among default basin areas for cooperators combined.

Source	df	SS	F	p-value
Distance to Pd				
52 Acre Default Basin Area, compare cooperators				
Ln (Basin Area)	1	16.32	81.08	0.0000
Cooperator	5	1.77	1.76	0.1256
Interaction	5	0.55	0.54	0.7444
Error	127	25.56		
300 Acre Default Basin Area, compare cooperators				
Ln (Basin Area)	1	15.91	154.85	0.0000
Cooperator	3	0.09	0.29	0.8324
Interaction	3	0.13	0.44	0.7279
Error	33	3.39		
Combined data, compare basin areas				
Ln (Basin Area)	1	63.44	337.47	0.0000
Default Basin Area	1	0.55	2.91	0.0899
Interaction	1	0.27	1.44	0.2315
Error	177	33.28		
Distance to Pp				
52 Acre Default Basin Area, compare cooperators				
Ln (Basin Area)	1	16.82	77.96	0.0000
Cooperator	5	1.74	1.61	0.1627
Interaction	5	1.21	1.12	0.3528
Error	117	25.25		
300 Acre Default Basin Area, compare cooperators				
Ln (Basin Area)	1	7.34	93.41	0.0000
Cooperator	3	0.92	3.90	0.0190
Interaction	3	1.08	4.57	0.0100
Error	28	2.20		
Combined data, compare basin areas				
Ln (Basin Area)	1	32.40	140.90	0.0000
Default Basin Area	1	0.01	0.05	0.8202
Interaction	1	0.05	0.21	0.6490
Error	162	37.25		

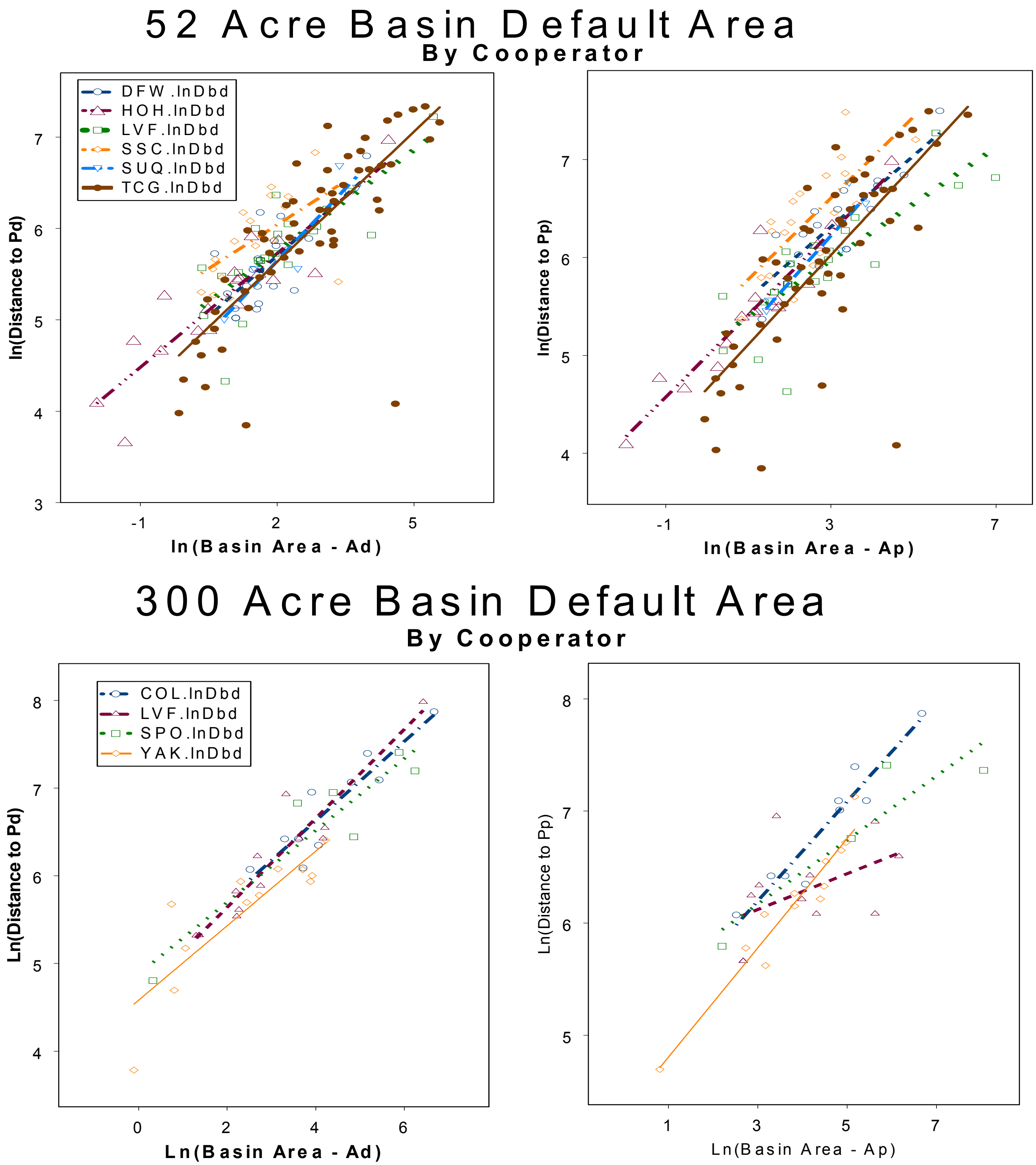
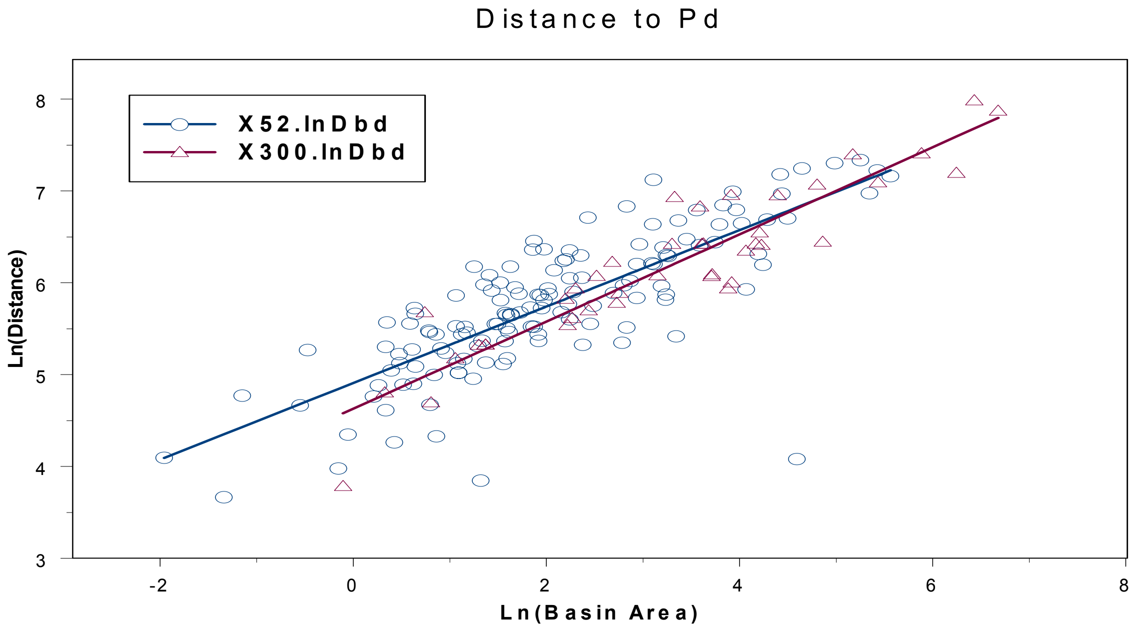


Figure 3. **Scatter plot of basin area and distance from divide to Pd and Pp for regions with default basin areas 52 and 300 default basin area showing scatter for each cooperator separately. Both measurements are log-transformed.**

Table 4. Estimates of intercept and slope of regression for region wide and statewide combined data.

	Estimate	SE	t-statistic	p-value	R2
Distance to P_d					
52 acre					
Intercept	4.889	0.072	67.50	0.00000	63.4%
Slope	0.424	0.029	14.50	0.00000	
300 acre					
Intercept	4.652	0.116	39.82	0.00000	85.5%
Slope	0.461	0.032	14.15	0.00000	
combined					
Intercept	4.863	0.062	78.87	0.00000	69.9%
Slope	0.424	0.022	19.02	0.00000	
Distance to P_p					
52 acre					
Intercept	4.954	0.086	56.97	0.00000	60.2%
Slope	0.391	0.029	13.49	0.00000	
300 acre					
Intercept	4.928	0.192	26.65	0.00000	67.4%
Slope	0.362	0.043	8.38	0.00000	
combined					
Intercept	4.980	0.076	65.61	0.00000	63.6%
Slope	0.370	0.022	16.52	0.00000	



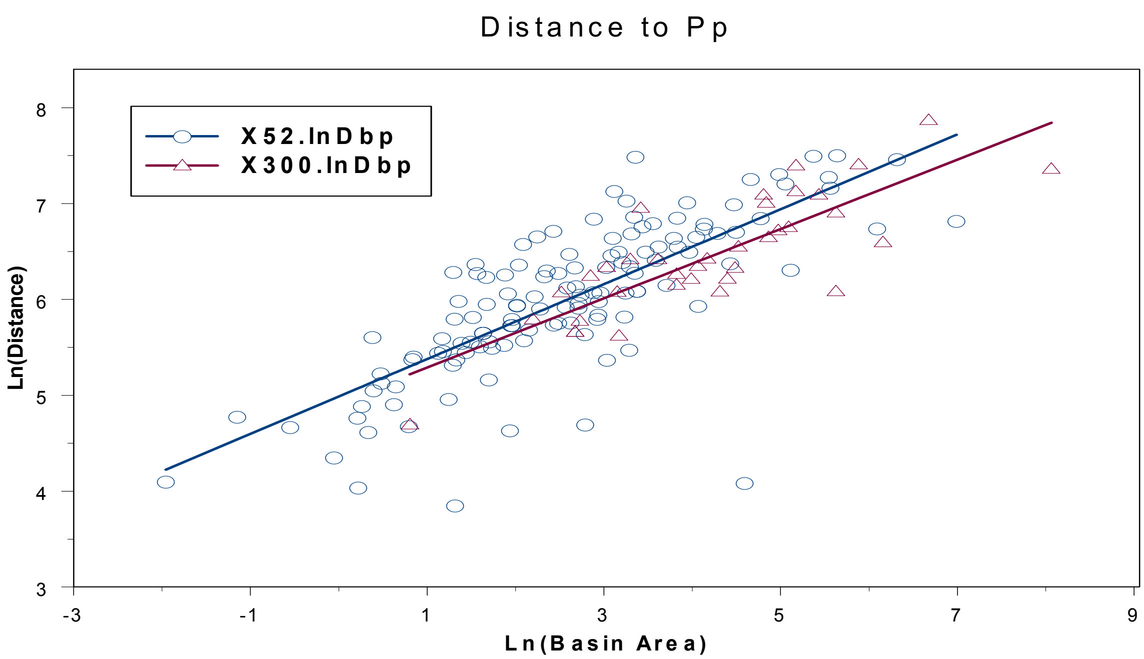
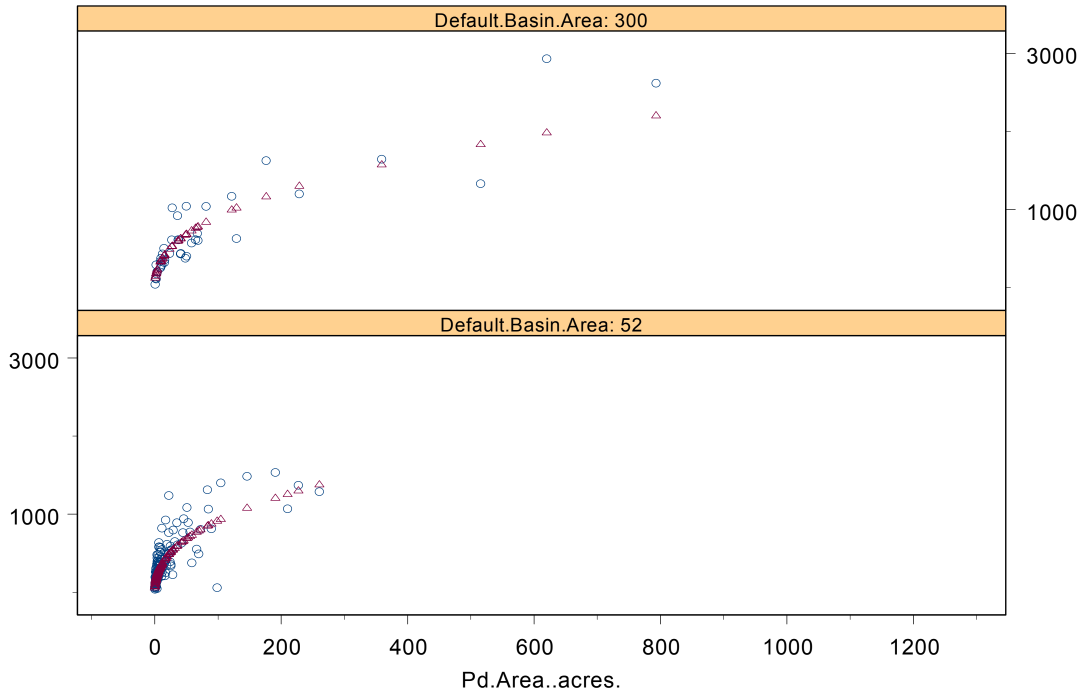


Figure 4. Scatter plot of basin area and distance for distance to Pd and Pp showing basin areas separately. Both measurements are log-transformed.



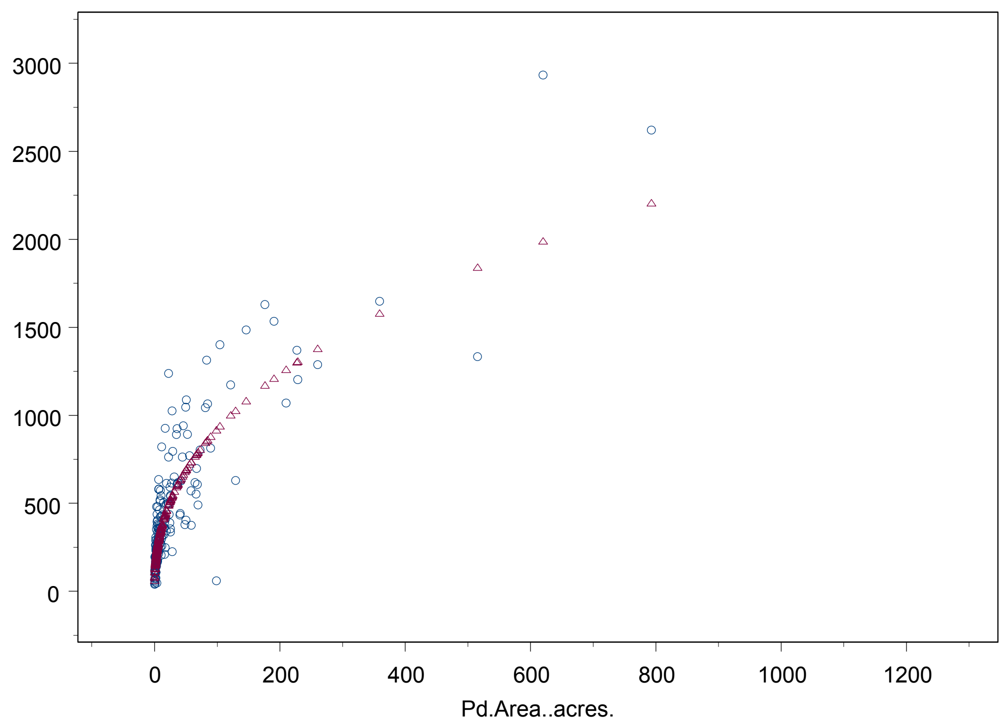
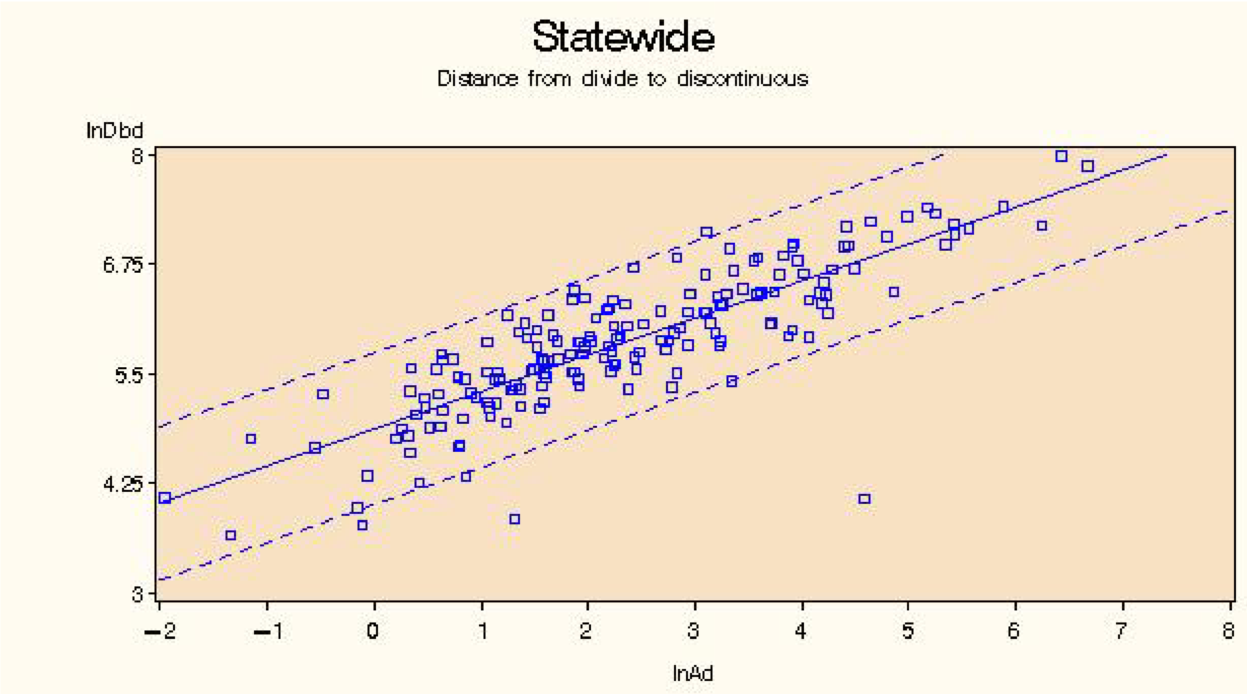


Figure 5. **Estimated relationship (estimated = Δ, observed data = o) between distance from divide to points P_d and basin areas (A_d) on the original scale by region and statewide.**



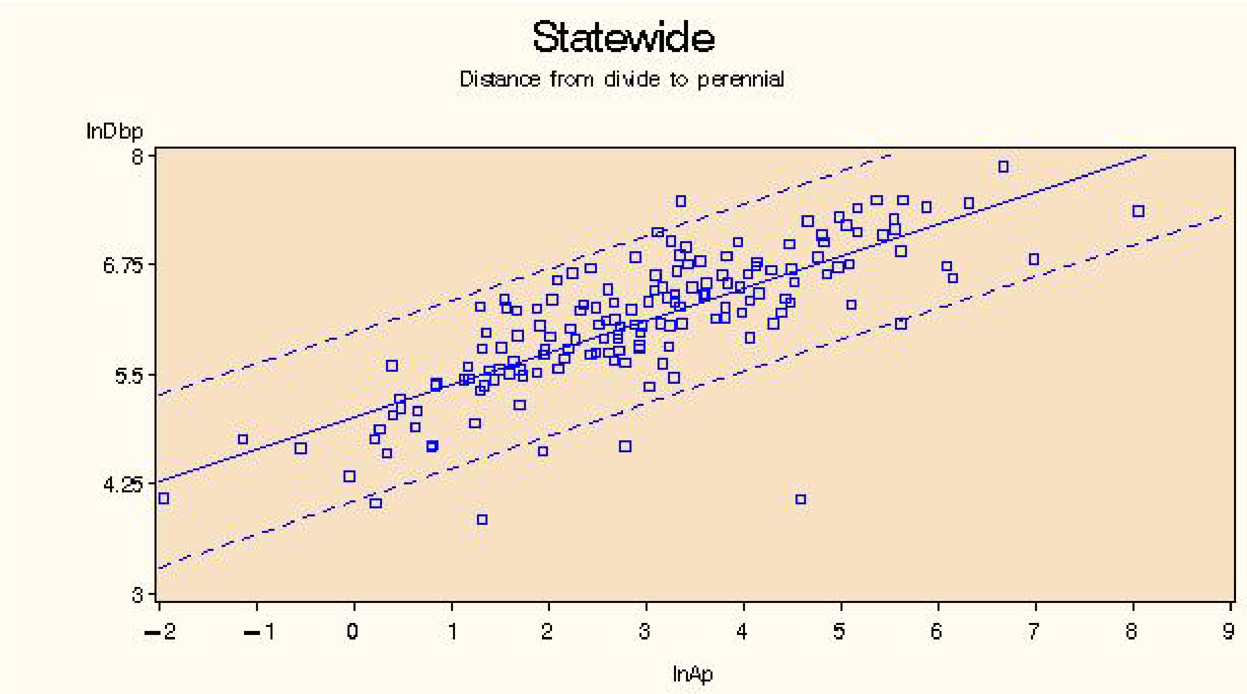


Figure 6. Relationship between distance from divide to points P_d and P_p and basin areas (A_d and A_p) for log-transformed data with prediction intervals.

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August 13, 2004

Professor Daniel Vogt
Managing Editor, CMER Reviews
College of Forest Resources Box 352100
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Seattle, WA 98195-2100

Dear Dan:

RE: "Type n stream demarcation study phase I: Pilot results" by Palmquist et al

Enclosed are three reviews of this report, and associated appendices. Reviewer A feels that while the report makes a good effort at testing a protocol for assessing perennial-seasonal streamflow partitioning in headwater streams, the approach is overly simplistic and provides "an extremely blunt tool that may not be addressing the larger management objective." In particular, the reviewer feels that the primary downfall of the report is the adequacy of the pilot protocol, which is not addressed. Furthermore, the reviewer feels that searching for a single explanatory variable to explain the demarcation (which the authors have shown is closely related to the channel head) is likely to be insufficient. The reviewer also questions whether the delineation between ephemeral and perennial stream will ensure the ecological functioning of these system. The reviewer argues that it is essential that the transition point be identified based on factors that are relatively insensitive to interseasonal and interannual climate variations.

Reviewer B feels that while the report is interesting and informative, it needs to be rewritten to address grammatical and organizational problems. The reviewer feels that the close coincidence between the channel head and the observed demarcation may be a result of bias in the experimental design, specifically the protocol of following the higher flow category at stream junctions. The reviewer also feels that the field protocol was inadequate, specifically because the 44% capture rate of the listed attributes was insufficient to support a thorough study. The reviewer also notes problems associated with the use of the very dry 2001 water year. The claim that the 2001 water year produced near-normal flow conditions west of the Cascades is not supported by observations; in fact flows over most of the PNW (both east and west of the Cascades) were well below normal in 2001. With respect to organization and grammar, the reviewer feels that readability needs to be improved, and notes awkward sentence structures, ambiguous and inconsistent definitions, and a pervasive practice of using variables before they are defined. The reviewer includes a lengthy, and more detailed, evaluation of the specifics of the report that need to be addressed.

Reviewer C feels that the report is “well organized and clearly presented and accomplishes the stated goals”. The reviewer feels that there are some problems with the statistical analysis, and is concerned that not all of the comments of the sampling teams have been addressed in the revised protocol. The reviewer includes several pages of specific comments.

Overall, the reviewers have clearly read the report and appendices carefully, and have uncovered what I believe are some fundamental deficiencies. The report clearly will need major revisions before it can be accepted in final form. To assure that the comments are adequately addressed, I suggest that the authors be asked to provide a summary of changes made in response to each of the reviewer comments along with the final report.

Sincerely

Dennis P. Lettenmaier

7/31/2004

Reviewer Comments to the manuscript:
Type N Stream Demarcation Study Phase 1: Pilot Results

The authors make a good effort to prepare and report on a protocol for assessing the spatial domain of perennial and seasonal streamflow in headwater streams. Unfortunately the authors attempt an overly simplistic approach that provides an extremely blunt tool that may not be addressing the larger management object. Major revisions are also needed to improve the clarity of the report and remedy analytical errors.

The primary downfall of the report is the adequacy of the pilot protocol in meeting the functional objectives of headwater stream management is not addressed or discussed. The primary question should have been: is the objective of using a subjective estimate of spatially continuous vs. discontinuous wet channel segments adequate for achieving the overall goals of the program. Instead the authors focus on compliance estimates and limited statistical descriptors of a few attributes associated with the subjective delineation of seasonal stream reaches.

Because the observed presence / absence of surface flow can be highly variable within a season and among water years, using a distinguishing characteristic that does not vary on short time scales should be the desired criteria. The authors clearly state that the channel head is typically located in very close proximity to the field observed Np/Ns transition and is less subjective in its identification. In addition to having temporal stability the channel head also denotes a change in process domains that is better aligned with the broader goals for headwater stream management.

Although the authors do not state it is an explicit objective of the study they appear to be searching for a refined estimate of the single threshold value for delineating the Np/Ns transition that is currently being used by FFR. This impression is based on the amount of time spent discussing the variation in drainage areas above the transition point for seasonal reaches encountered in the field. Given the broad range of natural variability in drainage areas for channel heads it is highly unlikely that a single threshold value will appropriately delineate the transition within reasonable limits (even if stratified by default region, ecoregion, or precipitation class). Instead, an understanding of the underlying mechanisms that drive the spatial variation should be explored. For example, multivariate analysis that incorporates variables such as precipitation, geology, basin elevation, ecoregion, the occurrence of spring-fed systems, etc. should be explored. At the very least the authors should search for a slope-dependant source area for channel heads or the seasonal transition point (see Montgomery and Foufoula-Georgiou 1993). Seeking a single explanatory variable is insufficient and considerable effort is needed in developing a more sophisticated analysis.

In additional to analytical limitations, the study appears to be incomplete. For example, the author's attempt to assess 'between crew' variability was not analyzed (Appendix F and text inserted into the report states that a lead investigator has still not been identified), inter-annual variation in determining the extent of the seasonal reach was not analyzed (pg. 44), and training and analytical protocols were intentionally left blank in the appendix. All of these aspects of the study are important for evaluating the adequacy of the approach and should be completed before the report is considered a final product.

The writing suffers from redundancy and inconsistent or vague terminology. A major re-write is needed to make the document clear and concise. It is evident that the authors did not pay sufficient attention to detail while writing the report. Numerous analytical and typographic errors occur throughout the text and it is apparent that the document was not thoroughly evaluated prior to submission.

Objectives:

If the general management objectives for heat / water temperature, large wood / organic inputs, sediment, and hydrology are the basis for this study, I question whether the delineation between perennial and seasonal flow in headwater streams will adequately ensure the structure and function of these systems. Perennial flow may be associated with amphibian and invertebrate habitat and downstream thermal loading during the summer dry season but issues related to sediment and wood delivery are not accounted for. Neither are seasonal dynamics of water, organic matter, and invertebrates. Wipfli and Gregovich (2002) clearly demonstrates that headwater streams are an important contributor to downstream food webs throughout the year. May and Gresswell (2003, 2004) also found that headwater streams store large volumes of sediment, the majority of which is trapped behind in-stream wood. These and other functional roles of headwater streams are discussed in Gomi et al. 2003.

Reviewer's Recommendation:

Because the variance in the field-determined transition point between perennial and seasonal reaches (Pd) can be extremely large within a season and among years it seems logical to use an approach that is not dependant upon short-term climate conditions. The authors make a strong point that the location of the channel head (Ch) is typically in close proximity to Pd (< 30m) so it seems logical to use the channel head as an objective and repeatable demarcation of the seasonal reach (if can be reliability located in the field and on high-resolution DEMs). Using the channel head would also provide a process-based approach instead of an arbitrary distinction between perennial and seasonal flow. An analysis of the slope-dependant source area for channel heads and how it varies with annual precipitation may account for a large portion of the observed variation and provide a meaningful indicator that is tailored to site characteristics.

The authors also seek an alternative, field-based indicator (such as changes in channel width, gradient, or substrate, etc) to aid determining the transition point (Pd). It is doubtful that these indicators will be useful for defining the transition point because the processes that shape the channel occur during high flow periods, which do not distinguish between seasonal and perennial reaches.

Definitions:

- Abbreviations are commonly used before they have been defined, making for a difficult reading of the document. This is especially problematic in the interpretation of Figures 5a and

5b. The abbreviations 'Dc' and 'Db' are not defined until two pages later. The caption for Figure 5b is also the only place in the document where 'Pt' is defined. This information belongs in the body of the text.

• Pg. 7 distinguishes between a 'stream divide' and a 'subsurface divide'. It is unclear how the subsurface divide is identified or used. The discussion simply refers to a 'divide' in the generic sense and does not distinguish between stream and subsurface. If the subsurface divide is not used it does not need to be discussed in the terminology section. It is also unclear if this variable can be meaningfully identified from limited topographic data.

• Why are the variables Dc and Db not included in the definitions section? It seems out of place to introduce them as late as page 11.

Topographic Assumptions:

• The authors should become familiar with the following citations:

Dietrich, W.E., and Montgomery, D.R. 1998. Hillslopes, channels and landscape scale. In: Sposito, G. (Ed.), Scale Dependence and Scale Invariance in Hydrology. Cambridge University Press, New York, pp. 30-60.

Montgomery, D.R., and Foufoula-Georgiou, E. 1993. Channel network source representation using digital elevation models. Water Resources Research 29(12): 3925-3934.

Bankfull Width and Depth:

• No hypotheses were developed for why bankfull channel dimensions would be a useful indicator of the transition from perennial to seasonal flow. Bankful dimensions form during high flow periods, not during low flow conditions. In addition, the concept of bankfull or channel forming flows was developed for larger alluvial rivers and may not be meaningful when applied to small colluvial channels. Given this limitation and the expressed difficulty in identifying these channel features in the field, this portion of the protocol should be omitted.

GIS Data

• Why were GIS layers for soils and geology acquired but not used? It seems very logical that the underlying geology (combined with precipitation) may explain a large portion of the variation in drainage basin areas at the transition point.

• Why were standard algorithms for determining drainage area and distances from DEMs not used? 10m resolution DEMs are of much higher quality than scanned in quad maps and are a much more appropriate tool.

• Why was a stream layer developed from low resolution topographic maps and subjective interpretation of air photos when standard algorithms for creating high quality stream layers are commonly used in coastal Oregon and California (see unpublished report on programs for DEM analysis by Dan Miller at Earth Systems Institute in Seattle).

Protocol Assessment:

• The authors stated that they met their objectives by reviewing field training, providing assistance and conducting replicate surveys. However, the training section of the appendix was intentionally left blank and an analysis of the replicate surveys was not presented. Again, the document is incomplete.

• Compliance with segment break distances is not a good indicator of adequacy or repeatability of the protocol. It is only a simple measure of the field personnel's ability to follow directions. A better question is: did the protocols provide the necessary information to delineate the Np/Ns transition in an objective and repeatable manner, and did the analysis help explain some of the variation in the observed results.

• The issue of repeatability of the protocol cannot be addressed because the analysis of replicate surveys was not presented. Because so many subjective classifications were used it is doubtful that the protocol achieved a desirably level of repeatability.

• The major downfall of the protocol (as discussed by the authors on page 23) is the inadequacy of the protocol to identify the channel head as the appropriate end point for the upper extent of the field survey. It is also odd that the authors report a compliance rate for identifying channel heads when it was not included in the protocol.

Analysis Issues:

• The stated objectives were to develop and test the pilot protocol for the purpose of water typing. A data collection protocol was devised and tested for compliance. Unfortunately the analytical process that should accompany this data collection effort is substantially lacking. The appendix clearly states that no foresight was given to planning the analysis (pg. C_2 'No procedure is provided for interpretation of data because it has not yet been determined.'). This is a major downfall of the study. No field data should have been collected until this vital component of the study design had been completed. Without an adequate study design the ability of the study to meet the desired objectives is extremely compromised. The authors need to employ the help of a statistician to develop more sophisticated analyses (a simple, single variable correlation is insufficient).

• Median values of log-transformed data are not equivalent to the geometric mean, they are only an approximation. The geometric mean should be reported in all cases (instead of the median), and the average value of highly skewed, non-transformed data is irrelevant and erroneous and should not be reported.

• How were the standard deviations of the log-transformed data calculated (e.g., Table 12 and 14)? The +/- values should not be equivalent because the back-transformation will be result in asymmetrical values around the geometric mean.

• The sample size reported in various tables and throughout the text is inconsistent. If specific streams were omitted from the dataset used in different analyses then the criteria for removal should be clearly stated. If this is not the case it appears that the authors were sloppy in their analysis and <u>all</u> summary statistics should be re-evaluated. Examples of this inconsistency:

Pg i	n = 218 streams
Pg 23	n = 213 streams
Table 12	n = 213 streams
Table 14	n = 173 streams
Figure 12	n = 218 streams
Table 15	n = 211 streams

• If a few extreme outlier values are causing a large portion of the variation than the analysis should be preformed with and without these outliers. If there are a few extreme outliers it would be instructive to investigate these areas and attempt to understand why the drainage areas are so variable. The reader will have much more information to critically evaluate the results if box-and-whisker plots were used to display the data because they graphically display outlier values and the distribution of the data.

• How is it possible to get a drainage area of zero for the basin area of Pd (table 12)?

• Excel is not a statistical software package (pg. 18) and contains numerous and well documented calculation errors. All statistics should be analyzed with an appropriate software package.

• Good discussion of the inference capabilities of the study design.

Discussion of Recommended Changes to the Pilot Protocol:

• Recommended inclusions in the revised protocol include four parameters: (1) channel head location, (2) valley width, (3) debris flow scour, and (4) debris flow sediments.

(1) Using the <u>channel head</u> as the primary indicator for the upper extent of the perennial stream network is highly advantageous to using the subjective estimate of channel segments that are wet to varying degrees to identify Pd. The authors state 'Numerous surveys that did not reach the channel head may have missed isolated wet channel(s) segments upstream of the previously identified Pd and thereby increased the average basin area and distance from divide…' Based on this potential source of error, combined with the variation within and among years, it is not logical to base the transition point on the field identification of spatially discontinuous wet segments. Therefore, using the channel head is more appropriate because it is typically located in close proximity to Pd, the field identification of this parameter is less subject to error and ambiguity, and it bases the demarcation on a parameter that is process-based and not dependant upon short-term climatic conditions.

(2) If no hypotheses can be proposed for why <u>valley width</u> should vary with the Np/Ns transition, then it does not seem useful to advocate measuring this parameter.

(3 and 4) Including information on <u>debris flow scour and deposition</u> will be useful. As the author's point out, scour and deposition can alter surface to subsurface flow paths. Channels that have recently been scoured to bedrock have a greater expression of surface flow. In contrast, depositional areas are subject to the loss of surface flow into the subsurface due to thick accumulations of highly porous substrate. Large log jams that store sediment and landslide deposits result in a similar phenomenon. However, debris flow deposits are quickly re-vegetated and may be difficult for field personnel to identify.

Although the documentation of debris flow scour and deposition zones may provide some insight into variation in the Np/Ns transition, it is unclear what the authors will do with this information. Will data from channels that recently experienced a debris flow be omitted? Will the Np/Ns transition be artificially adjusted?

The term 'debris flow sediments' on pg. 36 is vague and should be changed to 'debris flow deposits'.

• Recommended deletions from the revised protocols are bankfull width and depth. The reviewer concurs with this recommendation. Because bankfull width and depth is formed during high flows (which do not recognize the dry season pattern of surface flow) it is not expected to be a good field indicator for the transition point to perennial flow. Bankfull channel dimensions are also difficult to identify in colluvial channels because the concept was derived for larger, alluvial channels.

• A recommendation was made to increase the standard segment length from 30m to 100m. This appears reasonable for a maximum segment length.

Discussion: Year of Normal Rainfall

• The unusually dry water year that occurred during the pilot study is problematic. Because the Np/Ns transition may be highly dependant upon short-term climatic conditions, results from this study should not be used to set numeric standards for the Np/Ns transition. This source of among year variation can be reduced if the channel head is used as a repeatable identifier of the perennial channel domain.

Discussion: Basin Areas

• The authors provide little discussion of the alternative explanations for why the basin areas reported in this study differ from those used to set the FFR standards. Possible explanations include: differences in water year conditions, differences in methods used to identify the point Pd, and spatial variation.

• The authors need to go further in an investigation of the variation in basin areas reported in their study. Simple, single factor correlations are not sufficient (as the broad scatter in Figure 13 illustrates). Multivariate analysis should be used to explore the combined influences of geology, precipitation, elevation, spring-fed systems, etc.

Discussion: Alternative Indicators

• The authors discuss three alternative indicators for identifying the Np/Ns transition. (1) Distance from divide may have less variation than drainage area and requires a considerably smaller sample size (Table 18) but it is still subject to very high levels of within and among year variation in available water (driven by short-term climatic conditions) and therefore it does not provide the best alternative. (2) This reviewer recommends that identifying the channel head as the start of the perennial reach is the most appropriate indicator. Instead of spending a lot of extra effort and subjective estimation to delineate the short seasonal reach between the channel head and the perennial reach (Ch – Pd), the channel head provides an objective identifier that is not subject to short-term climate variations, does not require subjective estimation of spatially discontinuous wet channels, is more repeatable, and provides a process-based delineation for headwater streams. In addition, the seasonal reach below the channel head that was identified in the field was very short (typically 20 – 30m) so the extra effort in delineating the area does not appear warranted. (3) The author's recommend that precipitation classes could also be used to separate distance form divide to Pd into groups that have lower variance. A better place to start would be to analyze the slope-dependant source area for channel heads and then assess how the slope-area relationship changed with increasing levels of precipitation.

Potential Studies:

(1) Seasonal variation in Pd: This question is extremely relevant to the adequacy of the pilot study approach for delineating perennial streams. The authors could have addressed the question (to a limited extent) if they had analyzed the data collected on intra-annual variation. This topic warrants further investigation. If inter-annual variation is large or unpredictable than further evidence for use of the channel head as the potential upstream extent of Pd will be gained.

(2) Categorizing the default criteria by annual precipitation. It is unclear why a single variable is sought. The scatter in Figure 13 already indicates this is insufficient. A multivariate approach is clearly needed.

(3) Distance from channel head or distance from divide to the appearance of perennial flow. It is unclear why the extra effort in delineating this short reach is warranted when the channel head provides a more appropriate and less variable indicator.

(4) Influence of debris flows. Because the time-since-debris flow is a first-order control on the volume of sediment stored in the channel (May and Gresswell 2003) it is logical to presume that the expression of surface water will vary systematically with time. Because the field crews will only be able to recognize recent debris flow activity it is unlikely that the variation associated with debris flow history will be resolved. Because channels identified in the field as having debris flow activity are limited to recent events it should be explicitly recognized that this identifier cannot delineate channels that are prone to debris flows from those that are not. The authors also recognize the important distinction of channels formed by fluvial vs. debris flow processes; however, given the small size of the streams they are working in the distinction is not between fluvially formed valleys it is between different processes that operate within colluvial valleys.

(5) Piped channels. The authors recognize the importance of soil piping in structuring the timing and spatial distribution of water routing in some forested catchments. Unfortunately soil pipes are difficult to identify in the field and occur on hillslopes as well as channels so their incorporation into the protocol may be difficult. If the authors can devise a novel way of addressing this issue it would be beneficial.

Summary

Good summary of the primary results. The authors acknowledge the usefulness of the channel head in delineating Pd, the difficulty in identifying channel attributes that change at the field identified transition, and other spatial and temporal variability.

Organizational Issues:

- Too many acronyms and abbreviations are used. If they remain in the document they should all be listed in the definitions section so the reader can easily refer to them instead of searching the entire document.

- Results belong in the Results section and should not be presented for the firs time in the Discussion section (e.g., Figure 13 and Tables 16 and 17).
- Numerous typo's are present in the document, suggesting that the authors did not review the final document in adequate detail.
- The text relies too heavily on material presented in the Appendix and is not a stand alone document.
- All units of measure should be reported consistently. For example, lengths are commonly reported in metric units (and occasionally in both English and metric units) but basin area is only reported in acres (km^2 would be more appropriate).
- The text suffers from redundancy and needs to be made more succinct.
- Remove the inserts from 'track changes' editing that are present in the margins of the document and the appendix.

Figures

- Tables and figures are generally well organized but contain many typographical errors.
- Figure 5a caption refers to Pd twice. Should one be Pc? The resolution of the DEM should also be documented in the caption.
- Figure 6. The variable 'Db' is not illustrated and appears to be the same as Dc. Please clarify.
- Unfortunately Figure 8 does not follow the tendency of being well organized and is in dire need of reformatting. A standard box-and-whisker plot (although not available in Excel is common in more sophisticated graphical software packages such as Sigma Plot) is the more appropriate format to represent the data. This format will appropriately display the median, quartiles, and outlier values. The average value of this highly skewed data is meaningless and should be removed. The figure is also too crowded. Each of the three regions could be plotted separately and the legend key could be moved to the edge (instead of cluttering the center of the figure).
- Figure 9 contains categories of 'associated features' that are not consistent with the protocols listed in the appendix (C_10). Also, the category 'non-point' was added to the legend but the reader has not been informed what this refers to. Does this refer to the 'Pp' abbreviation that also remains undefined in the paragraph following this figure? What is 'debris slide debris'? A deposit? A typo?
- Figure 10 caption. Avoid subjective descriptors such as 'highly significant' and report the actual value of the statistical test.
- Figure 13. Scaling of x- and y-axis is odd. Why is '30' omitted on the x-axis? Why no intermediate values or tick marks for values between 100 and 200? It also appears that the font size and alignment are not consistent within the values reported for each axis. It is unnecessary to report intermediate values on the y-axis because the tick marks are clearly indicated and it only adds clutter. Also remove the grid lines from the plot area.

Tables

- Table 6 caption: Change 'data are to be recorded' from the future tense to the past tense.

- Table 12 headings. ‘Eastside’ header has a different font, orientation, and highlighting than the other header categories. This should be fixed.
- Table 13. This table is confusing. The caption indicates that r^2 values should be reported here but the only data is ‘log Pd basin area’ (which is not intuitive and should be back-transformed to provide meaning for the reader) and sample size. The caption also states that statistical values were calculated but they do not appear to be reported.

References

- Citations used in the text were limited and did not always refer to the most relevant primary literature.
- Formatting of the reference section is inconsistent.
- Several references are cited in the text but do not appear in the reference section (e.g., Horton 1945 (pg. 6), Ward 1984 (pg. 46), and Ziemer 1992 (pg. 46)).
- Two references are listed in the reference section but do not appear in the text (e.g., Montgomery et al. 2002, Oxtobee and Novakowski (2002).

Appendixes

Appendix F

- The authors provide a good write up of the potential sources of error and crew variation. Unfortunately they do not present or analyze the data that was collected to address these concerns. Based on the highly subjective nature of most of the field protocols, it is vital to determine how broadly interpreted the subjective estimates were and how this effects the repeatability of the protocol.
- The replicate survey design was flawed because the crews knew when and where they were being evaluated. Instead, replicate surveys should have been randomly selected and blind. It is well known that field crews will act on their best behavior when they know they are being evaluated. In addition, flagging from the previous crew should have been removed prior to the replicate survey. It is not reasonable to assume that a crew would 'ignore the evidence' of the previous survey.
- The text should be written in past tense. For example, statements of 'will be' should be changed to 'were' if the work has already been completed.

Appendix H

- The author of this section provided a good discussion of the difficulty in working with skewed data and the evaluation of adequate sample sizes.
- Values presented in the tables have too many significant figures to be meaningful and should be adjusted.

Appendix I

- This section contains numerous figures and tables but almost no discussion of them.
- Page I_2 states that alpha is the 'exponential' when it is the 'exponent' in the power function relationship.
- Figure 1. X-axis is illegible and the y-axis has an odd switch of orientation. A brief discussion of a QQ plot is also warranted.
- Values presented in the tables have too many significant figures to be meaningful and should be adjusted.
- The variable Pp is defined in this section for the first time but is not used in the main body of the text (except inadvertently on page 30, where it remains undefined). The Pp term appears to be equivalent to Pc. Consistent terminology should be used throughout the text and the appendixes.

Misc. Comments on Appendixes

- Pg. B_3, Table 2, footnote symbol '2' should be placed in the second column. Footnote symbol '3' is absent from the footer.
- Pg. C_5, Option 3. The determination of stream-order is highly dependant upon the resolution of the topographic data and/or stream layer that is used. What was the criteria and was it consistently used among cooperators? This should be explicitly stated in the report.

- Pg. C_13. Why is this section blank?
- Pg. D_6. The ‘associated features’ listed in this table do not correspond to those listed on page C_10 or Figure 9 (in the main body of the text). Please strive for consistency.
- Remove ‘track change’ inserts from the margins.

Review Sheet
For

Type N Stream Demarcation Study Phase I: Pilot results

Summary:

Overall the study is interesting, informative and pertinent to identifying field protocols and data collection requirements necessary to quantify/predict the transition point between seasonal and perennial waters ("Pd") in a stream network. Figures and tables are generally well placed and instructive. Most of the statistical analysis seems robust, accurate, and appropriate for answering the hypothesis. However, the report needs to be re-written to tighten the language, definitions, use of variables, grammar, and better define the overall purpose of the study. The following paragraphs are this reviewer's areas of concern with the technical components of the study. Following this summary are the general comments and the specific comments sections. This critique is meant to be constructive and hopefully beneficial for future analysis or additional pilot studies.

A major finding in the report is that the FRR default Pd basin areas (i.e., the FRR assumed drainage area necessary to initiate perennial "flow" or point Pd on a stream segment) is much larger than those delineated ("observed") from the field located Pd. An interesting additional finding is that perennial water occurred very close (within 30 meters) to the channel head in most of the surveyed streams. This last discovery is remarkable, especially for surveys located in the drier eastern side of the state. The methodology used in the surveys, however, might have inadvertently biased the study towards these results. In the "Main Thread" survey, investigators followed the "higher flow" category at tributary junctions. Thus, unless the survey was started on a first order stream, the investigators simply followed the stream network up tributaries with the highest sub-surface flow (or base flow) component and away from tributaries with little or no sub-surface flow (i.e., more runoff driven tributaries). In essence the survey was biased towards the major source of baseflow for the surveyed stream network. In addition, by ignoring dry channels in the "Total Tributary" study, the investigation disregards tributaries with only seasonal channels. In this case, the default FRR Pd basin area would have been lower than the observed Pd basin area for the dry channel (which would be either undefined or need an alternate definition as perhaps the entire drainage area of the dry channel). This omission would also tend to bias the result towards smaller observed Pd basin areas. Again, unless most surveys were started on first order tributaries, this survey method is of concern for the collected data and analysis.

The overall field protocol for performing the survey and collecting the associated basin, flow, and channel attributes was not fully "adequate" for acquiring data associated with the Pd break as claimed in the study. The capture rate of all the listed attributes (only 44% of the time were associated features recorded at the occurrence of Pd) was insufficient for a thorough analysis of the attributes relation to the occurrence of perennial flow.

The analysis in this study was insufficient to quantify if the seasonal variation in precipitation for water-year 2001 amounted to “normal” precipitation. The authors theorized that precipitation during the 2001 water year produced near normal flow conditions west of the Cascades and dry flow conditions east of the Cascades. A hydrologic analysis of discharge from nearby gaged streams needs to be included to more thoroughly identify flow conditions on the surveyed streams during the field season. In water-year 2001, most of the Pacific Northwest experience moderate to extreme drought conditions. It is doubtful that western Washington streams experienced normal flow conditions during the summer fall season.

The potential migration of Pd in a channel with varying water-year precipitation types needs to be addressed. Since the perennial reach in most cases is sustained by local groundwater, it follows that Pd might change with annual recharge. Regions need to be established, based on similar hydrologic conditions (i.e., flow generation type, precipitation, geology, soils, and vegetation), where Pd is stable and where Pd migrates. Repeated yearly surveys on a sub-set of the study areas could be used to address this issue.

The protocol modifications listed in the study seem warranted. Other modifications are needed to increase the capture rate of the other attributes mentioned in the study and remove any potential sampling bias (i.e., survey method). The selection of tributaries to survey in both methods (“Main Thread and Total Tributary”) needs to be addressed with the aim of using more random techniques and including dry channels. What would be an appropriate definition of “basin area” for dry channels would need to be addressed.

Even with the concerns, findings, and recommendations listed above, the study is an important step in identifying perennial and seasonal type streams and identifying field protocols that will lead to the success of future studies. The researches should be commended for this effort.

General Comments:

The readability of the document needs to be improved. Many of the sub-sections have awkward sentence structures, are ambiguous, and used inconsistent definitions. Variables are sometimes used prior to their definition or not defined at all.

As an example, a stated purpose of the pilot study is "to test field protocol for collecting <u>water-typing data</u> for the initiation of perennial flow". This is a vague statement. What is "water-typing" data? "Stream types" are listed as perennial and seasonal earlier in the document, but in the context of the above stated purpose, substituting the definition of "stream types" for "water-types" does not make sense and the overall purpose is unclear. A less ambiguous description would include a better explanation of "water-typing data" such as the collection of catchment, flow, and channel attributes that coincide with the initiation of perennial flow.

The variable "Dc" and "Db" are used in several figures prior to their definition. The term "basin area" is used loosely throughout the paper. Sometimes it references the default or FRR basin area which is the assumed drainage area (defined by FRR) necessary to initiate the perennial "flow" point in the stream network. Other times it is in reference to the drainage area above a specified point of flow type (e.g., Pd) in the stream network observed in the field. At most locations in the document there is no descriptor associated with the "basin area" and the reader is left to decipher what area the author is referencing (e.g., default FRR or observed Pc, Pd, Ch).

As previously mentioned the purpose as well as the objectives of the study are vague and need refinement. For example, a listed objective (Page 5, Table 4) is "to asses the adequacy and replicability of the pilot protocol." Replicability was not examined in the study, so why is it listed as an objective. "Adequacy of the pilot protocol" is a vague objective. Likewise, the first objective listed in Table 4.0 is too general. In addition the objectives are almost identical to the purposes, so why are they differentiated? A more thoroughly defined study objective will better inform readers on what to look for in subsequent sections of the report. Typically the objectives follow the reported findings in the summary and the pilot design stated in the executive summary. One of the objectives that wasn't stated, was to test weather the default basin area thresholds are correct or reasonable. This seems like a major finding.

It would be prudent to have a clearer definition of regulatory flow conditions necessary to qualify a stream as perennial before embarking on this or future studies. If the regulatory definition differs from the technical definition used in this or future studies, the value of these studies could be limited. Specifically if piped channels are not defined as part of the stream network, then the basin area would increase as Pd would be move downstream. This study, however, may have been instrumental in bringing this problem to light.

The analysis of normal water–year precipitation should include hydrologic analysis of flow conditions from nearby stream gages. These gages would be an indicator of the aggregated effect of antecedent precipitation and soil-moisture (i.e., water table) conditions on perennial flow in the nearby surveyed streams. If stream discharge in the dry season of a gaged stream is near normal, than the perennial flow conditions of the nearby surveyed streams should also be near normal. Care should be taken to make sure that the gaged streams are hydrologically similar to the surveyed streams (e.g., similar geology, soils, vegetation, and general hydrologic processes).

The fact that the channel head is a better indication of Pd than default basin area is interesting and worthy of more discussion. Could this be related to the fact that the cooperators always followed the higher flow category at tributary junctions thus increasing the likelihood of finding channels with higher contributions of baseflow? In other words, the method of selecting a tributary on the basis of higher flow category (Main Thread Survey) may have biased stream surveys towards tributaries and segments that have more springs and seeps (or a higher sub-surface flow component), and away from tributaries with more ephemeral (runoff) characteristics. This may be why most of the surveyed stream segments had extremely short seasonal channels, and that perennial flow was generally found within 30 meters of the channel heads. A statistical analysis that compares the means of the distance between channel head and Pd based on the type of survey (Main Thread or Total Tributary) may partially address this concern. However, there appears to be similar problems with the "Total Tributary" survey in that it ignores all ephemeral tributaries.

Based on the results of this study, the definition of perennial streams appears to include the stream network to the channel head (within 25 meters). That is, there is less error in defining the Pd point at the channel head than defining Pd by default basin area. If the above stated concerns with methodology is addressed it appears that finding the channel head is the best method of defining Pd.

The Alternative Indicators part of the discussion section is confusing and doesn't follow the results and methods section. Specifically the text dealing with identifying the Pd break needs clarification. The authors state that the Pd is identified by the *occurrence of non-migrating seeps and springs*, yet the parameter "Ch-Pd' is listed both with and without the presence of seeps and springs. If Pd is found by the presence of seeps and springs, how can there by any data for "Ch-Pd" without seeps and springs?

The executive summary states the pilot protocol is adequate for collecting observed field conditions associated with perennial flow. The executive summary also states that no physical channel characteristics were found to be reliable field indicators of the Pd break. The poor capture rate of 8 of the 11 "features" associated with segment breaks in addition to that fact that only 44% of Pd breaks had "associated features" recorded does not lend credence to a thorough analysis and these conclusions. In addition, the replicability of the study needs to be addressed, before by having different cooperators repeat the surveys from other cooperators. This could be a source of observed Pd basin area variability.

The potential studies section is well thought out and should be followed. The influence of varying water-year precipitation on the location of Pd should be investigated by repeating a sub-set of the surveyed sites over multiple years that having varying amounts of water-year precipitation (e.g., moderately wet, drought, etc.). One would expect that Pd would migrate lower in the stream-network following drought years and migrate higher in the network in response to wet years. The use of multiple linear regressions along with Pd basin parameters (soils, geology, precipitation, area, etc) to predict the location of Pd (e.g., distance from Ch or Dc to Pd) should also be investigated.

Specific Comments

Executive Summary:

Page i, 2nd paragraph bullets, 2nd bullet–
This is an ambiguous sentence. What are “basin area” and “other parameters” referencing? (e.g., stream segment, Ch, Pd, Pc?).

Page i, 2nd paragraph bullets
Shouldn’t verification of the FRR default basin areas necessary for perennial flow also be listed as a design criterion for the study?

Page ii, 2nd paragraph–
“Observed basin areas” is in reference to Pd, Pc, or Ch? Be consistent in terminology. “FRR default basin areas” needs to indicate that this is the drainage area necessary for the initiation of perennial flow (or the perennial stream segment) assumed or assigned by FRR.

Page ii, 4th paragraph, 2nd set of bullets.
The analysis of Ch and Pc locations was not given in this report.

Page ii, 3rd paragraph–
This shouldn’t be a surprise sense precipitation drives soil-moisture, sub-surface flow and hence streamflow.

Page ii, 4th paragraph–
Would not the assumption that Ch represents the Np/Ns also be an acceptable criterion? This seems to be as good of an indicator as drainage area.

Section 1: Introduction to Report

Page 1, 2nd paragraph.
The sentence structure and wording for this paragraph make it difficult to comprehend. The first sentence mentions the study “began as an effort to develop a field protocol…”. What was the purpose of the field protocol? It is not stated specifically. The third sentence mentions that “two aspects” of the pilot study changed. Describe the aspects. Describe the change.

Study Background

Page 1, 2nd paragraph, 2nd sentence
The FRR definition of perennial streams (Appendix A) is clear that intermittent streams can be classified as perennial so there should be no ambiguity about “discontinuous bodies of water” mentioned in the 2nd sentence.

Page 2, 2nd paragraph.
Even in the summer there will probably be changes to the Np/Ns break depending on water year precipitation and the local hydrology of the basin.

Page 3, 1st paragraph.
The 1st paragraph should reference the Np/Ns break somewhere.

Pilot Study Purpose

Page 4, 1st paragraph
What is "water-typing" data?

Assumptions and Definitions

Page 5, Table 4
Bullet #1: This statement is too generic to indicate what the objective is about.
Bullet #2: Again, these statements are very generic. The author mentions "basin areas"? Which ones? Pd basin area? Ch basin area? What type of "other parameters?" Flow parameters? Channel parameters? Catchment parameters? "Parameters" is too generic a descriptor. Isn't testing the validity of the default FRR basin areas to observed basin areas for Pd an objective?

Definitions
Page 6, 1st paragraph ("Ch").
How can the "Ch" parameter be listed in the executive summary as a key hydrologic transition point for analysis of the collected field data, and not be a data requirement for field collection?

Page 6, 2nd paragraph ("Pd")
The "Pd" location should vary with seasonal and annual precipitation.

Page 7, 2nd paragraph ("Segment")
What are "flow characteristics?" Are they listed in Table 6.0 flow categories?

Page 7, 3nd paragraph ("Drainage Basin")
These terms are also used in the report and should be included in this definition: "Basin Area" or "Drainage Area". The definition is the area contributing water upslope from a specified point.

Page 7, Figure 3
Dc, Db, and Pt are not defined in the figure or adjacent text.

Assumptions.
Page 9, 2nd paragraph.
This is a confusing paragraph. Seeps and springs can migrate up and down a channel in response to the seasonal (and annual) fluctuation of the local water table (as previously shown in Figure 3), especially in headwater catchments. How else does sub-surface water get to the stream network at the hillslope scale? Does the author mean "visible"

seeps and springs? Aside from discrete springs, seepage from the soil-matrix in the stream network is what sustains perennial streams during the dry season. The "control" classification is not mentioned in the results and discussion sections.

Basin Delineation Assumptions.
Page 9, Figure 5a.
Again Dc, Db, and the (basin boundary?) lines are not described in the Figure. The possible impact of the assumptions on the results should be discussed in the "Discussion" section. Was data collected on streams that violated these assumptions not used?

Year of Normal Rainfall
Page 10
The Washington State Climatologist can give information on what constitutes "normal" rainfall. Usually it means a moving 30-year average (e.g., 1961-90 or 1971-00). Discharge records for small stream near the study site can provide insight if the stream discharge is close to normal during the summer. This is probably the best aggregated signal of stream response to antecedent precipitation and soil moisture conditions. The 2001 water year was considered a drought year in most of the Pacific Northwest.

Potential Controls on Basin Areas

Page 11
This description seems incomplete in general and inconsistent between the aquifer properties and potential surrogates. The first sentence should mention the upland soils matrix along with sub-surface storage capacity. A description of the size of the local aquifer draining to the stream would also work. In addition, it is not only the storage capacity of the draining soils, but the other hydrologic soil properties such as infiltration rates, permeability, porosity, and hydraulic vertical and horizontal conductivity that dictate weather a steam will be perennial. Only two of these properties are mentioned. Two extreme examples are a drainage area comprised of either pumice or clay. Both have high capacities to store water (porous), but both would likely drain to seasonal streams for different reasons.

Two of the surrogates listed pertain to the volume (capacity) property. One of the surrogates listed relates to the energy gradient driving subsurface flow which is not listed as one of the three properties used to estimate reservoir conditions. The last surrogate would relate to the last two other reservoir properties (porosity, permeability), but was not examined in this study. This omission should be included as a possible source of observed basin area variability in the discussion.

Section 2: Methods

Field Data

Page 13, Table 5.

What constitutes a change in "flow category"? The categories listed in Table 6.0? If so table 6.0 should be given earlier in the report.

For the "Task"of "Selecting Tributaries". In the "Main Thread" survey, doesn't selecting the highest "flow category" for tributaries always lead to only stream segments with higher amounts of sub-surface flow? This would bias the study towards smaller contributing areas necessary for perennial flow, by leading the investigator up tributaries that contain springs/seeps. Was there any difference in observed Pd basin areas between the two survey types?

Survey and Segment Description

Page 14, 1st paragraph.

What was the rationale for the 200 meter extension criteria above and below Pd and Pc respectively?

GIS Data

Page 16, Table 8.0

Upslope (or catchment) vegetation characteristics might be helpful in future analysis. How was the soils and geology information used?

GIS Procedures

Page 17, bullet #1

How much adjustment was needed? How many sites had to be adjusted? Could this be a source of area variability cited in the results?

Page 17, bullet#2

A 10 meter DEM used in conjunction with the auto-delineation features in Arc/Info would probably be more consistent. Finally Dc and Db are described.

Data Analysis

Page 19, 1st paragraph

Does default region strata refer to the FRR defined basin areas for Pd?

Page 19, 3rd bullet.

It should be always stated that the FRR default basin area is in reference to the basin area required for perennial flow.

Alternative Field and Default Criteria

Page 21

The 1st sentence is confusing. What is the "alternative field and default criteria" in reference too?

Year of Normal Rainfall

Page 21, 1st sentence, 1st paragraph.
If the data was collect prior to October of 2001, then the 1st sentence should refer to the 2001 water year precipitation, not the preceding water year precipitation.

Page 21, 2nd paragraph
Since the FRR report refers to "normal" rainfall, the precipitation classification should be made to include a "average" category.

Section 3: Results

Protocol Assessment

Page 23, 1st paragraph.
The repeatability of finding Pd between cooperators and in relation to previous studies should be examined.

Quantitative Assessment.

Page 23, 3rd sentence.
The number of segments exceeding 31 meters is quoted as 133 in this paragraph, but 131 in Table 9.0.

Page 23, 2nd paragraph
How does a compliance rate of 96% of surveyed segments less than 30 meters signify that segment breaks were correctly identified? It may mean that the criteria for maximum segment lengths of 30 meters were correctly followed, but it is not necessarily an indicator that other criteria for segment breaks were followed correctly.

Qualitative Assessment

Page 24, 1st paragraph
"….cooperators in the position of either including additional study sites or replicating surveys. Ever cooperator chose the latter option." This is incorrect. The latter option is that cooperators replicated surveys. The cooperators chose additional surveys.
Page 24, 2nd paragraph, 5th bullet
Why should upland vegetation be replaced by riparian vegetation? What purpose is there for collecting this data?

Page 24, 3rd paragraph
How can you locate that Pd transition or Ch point within a piped channel? This could be a source of Pd drainage area variability in the analysis.

Year of Normal Rainfall.

Page 26, last paragraph
The 2001 water year was considered a drought in Washington and Oregon. Even if the summer was relatively wet, the effects of the dry winter months would still effect antecedent soil moisture conditions, the local water table and hence the location of Pd.

Page 27, Table 11.
An additional table showing an analysis of 2001 summer and early fall discharge at nearby headwater gage streams compared to long term average discharge for the same streams (1961-90 or 1971-00) would help in the understanding of the aggregated water year precipitation and soil moisture effects on stream flow in the headwater stream network.

Basin Area Variability

Page 27, 1st paragraph
Why wasn't the analysis for basin areas above Ch and Pc reported? The analysis of these transition points was mentioned in the executive summary?

Page 28, 2nd paragraph.
The observed basin areas are in reference to point Pd. This descriptor for the type of basin area should always be included when discussing this variable.

Page 28, 2nd paragraph, 2nd bullet
The FRR default basin area is in reference to point Pd.

Page 28, 2nd paragraph, 2nd bullet
Do ecoregions 4 and 77 have similar precipitation zones?

Page 28, 3rd paragraph, 1st bullet
The "basin areas" between FRR default regions are in reference to point Pd.

Sample Size

Page 29, 1st paragraph, 2nd sentence
The Costal FRR is excluded from this sentence, but the next sentence mentions the results for three default regions. (?)

Field Indicators of the Np/Ns Break

Page 30, 1st paragraph
The paragraph mentions the "Pp" break, which is not defined in the study. Is this the same as "Pc"? If FRR only uses "springs", "seeps", and "wetlands" to identify Pd breaks, why did the pilot study use different indicators to identify breaks? Np/Ns break means the same as Pd breaks, but their use is alternated in the paragraph, which makes it more difficult to comprehend. Figure 9 is difficult to interpret. What is a "Non-point" flow-generated segment break?

Other Indicators of the Np/Ns Break

Page 31, Table 13
The basin area should be specified as the Pd basin area.

Page 31, 1st paragraph, 1st sentence.
What does "…field indicators of Pd did not provide channel–scale predictors…" mean? What are "channel-scale predictors"? Does this mean the field channel and flow parameters were unable to indicate the Pd break?

Page 31, 1st paragraph, last sentence
The R^2 value in the text is 0.75, while the figure shows an R^2 value of 0.68.

Alternative Stratification Schemes for FRR Defaults
Always include a descriptor (e.g., Pd, Pc, Ch, observed, default) for "Basin areas". Why not include a regression analysis on the continuous Pd site precipitation data analysis and Pd basin area? OK. PERFORMED IN DISCUSSION.

Section 4: Discussion:

Protocol

Page 35, 1st paragraph, 1st sentence
The field protocol is adequate for what? Be specific.

Page 35, 1st paragraph, 2nd sentence
What are the initial questions?

Year of Normal Rainfall

Page 37, 1st and 2nd paragraph
Including a streamflow assessment of "normal water year precipitation" would provide some insight on the aggregate effect of varying seasonal rainfall amounts. Instead of alluding that the west side probably had "normal" flow conditions and the east side had "dry" flow conditions, do an analysis on nearby gages to ascertain what flow conditions in the regions were like.

Basin Areas

Page 38, last paragraph, 1st sentence
The author needs to specific what the cited study is being compared too.

Precipitation Classes Defining Alternate Default Regions.

Page 39
This is a very important part of the study and should be included in the results/analysis section. Figure 13 demonstrates that perhaps GIS information on soils/geology above Pd should be included in the next study, as stated on the next page.

Alternative Indicators

Page 40, 1st paragraph, 1st sentence
The first sentence is confusing. There are other field indicators of Pd listed in the study aside from non-migrating seeps and springs. If this sentence is true, why is there data for

"Ch-Pd" without seeps and springs included? What about changes in flow categories such as pools of standing water and wetlands? The authors merely indicate that Pd is the change from ephemeral to perennial streams. This doesn't only coincide with the presence of seeps and springs. In the results section only 70% of Pd and Pc breaks were associated with seeps and springs.

Page 40, 1st paragraph, 3rd sentence
The third sentence references a consistent and unique change was not present at Pd? Unique change of what? Channel parameters? Flow parameters?

Page 41,
The fact that the channel head is a better indication of Pd than default basin area is interesting and worthy of more discussion. This probably should be included in the executive summary along with speculation on why the perennial reaches were so close to the channel heads in most surveys. Is this due to biases in the stream surveys towards tributaries with "higher flow" categories?

Section 4. Potential Studies

Page 44, Item#1
The annual variation of the Pd location based on water year precipitation needs to be addressed and may be of higher importance than changes during the dry season. Inclusion of hydrologic response and flow conditions from nearby streams would be a good surrogate for flow conditions in the headwater catchments.

Page 44, Item#2
Why not include a multiple linear regression analysis with basin area and precipitation as variables to predict Ch-Pd? In reference to the controls on Pd being seasonal or yearly precipitation it will depend on the geology/soils and mechanism of flow generation (i.e., groundwater flow paths to the stream network).

Review of: Type N Stream Demarcation Study, Phase 1: Pilot Results, Final Report

General:

This report presents a draft sampling protocol to be used for field surveys with the aim of identifying the dividing point between seasonal and perennial non-fish bearing streams in the State of Washington. The report describes a pilot study used to evaluate the sampling protocol and to evaluate the level of additional sampling necessary for a more definitive statewide study. In general, the report is well-organized and clearly presented and accomplishes the stated goals. My primary editorial concerns are with regards to discrepancies in terminology in different sections of the report and a couple of the appendices that are not presented as clearly as the rest of the report. Scientifically, I have a few suggestions for the statistical analysis and concern that not all of the comments of the sampling teams were adequately addressed by the revised protocol. In addition, I think the section describing potential controls on basin areas could use a little more thoughtful discussion on hydrologic controls. All of these concerns are described in more detail below. A listing of editorial comments follows.

Specific Comments:

1. ES, 2nd paragraph. Determining the required sample size for future studies should be listed as one of the design goals.
2. ES, Key Result 3. Stratification by ecoregion was not adequately tested, see comment 27.
3. ES, Key Result 5. If precision is being used to refer to the length of the confidence interval, it is actually equal to 20% of the mean, see comment 12. It should be explicitly stated that "10% precision" is with respect to the mean.
4. Section 1, Topographic assumption, general. Does the topographic assumption imply that the topography reflects a zone of convergence for a given sample location, or that the map actually contains a blue line? The blue line is implied by the text ("…topographic map accurately displays the location of stream channel…"), however I imagine that a large number of the sample locations will be upstream of the blue lines on 7.5 minute quads.
5. Section 1, Potential controls on basin area. Figure 6 illustrates "Distance from Divide" and "Distance downstream from divide", while the 5th bullet defines "Distance" and the 6th bullet refers to "Pd distance". The terminology must be consistent.
6. Section 1, Potential controls on basin area, 7th bullet. I think it would be clearer if "Relief" was composed of "basin relief" and "channel relief". The text does not state how the relief variables are calculated, i.e. difference in elevation between points Db and Pd?
7. Section 2, Segment observations, 1st bullet. What is a representative cross section.
8. Section 2, Table 8. What is the source of the 10 meter digital elevation data. Why was the DEM not used for basin delineation?
9. Section 2, GIS Procedures, Point Plotting: This step appears to be a limiting factor in the analysis so more detail is warranted. How were the coordinates determined by cooperators? If using handheld GPS, is the coordinate system specified? Datum? Differential correction performed? How many points were moved, average distance moved, etc.? Is the problem great enough that much more stringent requirements should be incorporated into the protocol, such as requiring GPS coordinates? GPS are relatively cheap, and can be rented on a daily basis, it may be a worthwhile requirement.
10. Section 2, GIS Procedures, Basin Area Delineation: Hand delineation is certainly preferred in some cases where the expert has knowledge of the stream system in question.

However, it is somewhat subjective and not easily reproducible. Has there been any comparison between the hand delineations and those determined automatically using GIS?

11. Section 3, Protocol Assessment and Appendix F. Please explain the difference between tribal training, field assistance and quality control surveys.
12. Section 3, Sample size. The "relative size of the confidence interval", r, needs to be defined more explicitly in the text; I think this definition is misleading. As currently presented, r is equal to the "half-length" of the confidence interval as a percentage of the mean. (The length of the confidence interval, L = 2*1.65*st. dev./n^.5, so r*mean = L/2). The first sentence of the 3rd paragraph should be clarified as follows: "The sample-size equation has two inputs - the desired confidence interval length (or precision) of the transformed data (preliminary value of +- 10% of the mean) and the coefficient of variation (estimated from the variability of available data)."
13. Section 3, Year of Normal Rainfall, 1st paragraph, last sentence. No monthly totals or water years are excluded from Table 11, so it is unclear why these screening criteria are mentioned. I presume they apply to the calculation of the quartiles of the long-term data, but this is not actually mentioned.
14. Section 3, Quantitative assessment, 2nd paragraph, general. The number of surveys (29 with Ch, 112 with inferred Ch, 73 without Ch), does not add up to 213. The last sentence refers to a "compliance rate" of 66%, but it was not required to extend the survey to the channel head, so there can be no compliance. The compliance rate should indicate what percentage of surveys extended for 200 m above Pd, which was not provided.
15. Section 3, Table 10. Why do the number of observations for the first three features exceed the number of identified segments (3,513)? How is the percent captured for these features less than 100%? If more flow categories were recorded than identified segments, doesn't that imply a lack of compliance with segment break criteria? Is assessment of associated features valid as a measure of compliance if "no feature" is a valid response? The procedure for gradient measurement must be clarified.
16. Section 3, Qualitative Assessment. Appendix C indicates that the replicate surveys should be performed on ten sample sites or 10%, whichever is greater. This section indicates two replicate surveys per cooperator. It is also not clear what is involved in visits by the independent contractor to "validate protocol implementation" and "conduct replicate surveys". How was protocol implementation validated?
17. Section 3, Qualitative Assessment, 3rd sentence. Should this be the former option?
18. Section 3, Study Areas. Provide a reference and brief description of the PRISM precipitation product.
19. Section 3, Year of Normal Rainfall. Indicate for each station the number of years of long-term record used for the computation of normal quartiles.
20. Section 3, Basin Area Variability, third bullet. I have a problem with the assertion that the study areas in regions 4 and 77 have similar distributions. The statistics of regions 77E and 77W appear different in Figure 8, and according to the subsequent bullets were significantly different from one another according to the ANOVA analysis.
21. Section 3, Figure 8, general. This figure is difficult to interpret and could be improved. Data should be shown as box plots and the key should be moved from the middle of the plot area.
22. Section 3, Basin Area Variability, ANOVA analysis. There is no description of the ANOVA analysis in the Methods section or appendices which would help in interpretation. It appears that five different analyses were performed, with treatments of

FFR default region or study area. I am concerned about the appropriateness of ANOVA given that the selection of study areas within FFR default regions was not random and the ANOVA indicates that the study areas are significantly different from one another. Possibly this could be addressed by a blocking design, but I'm not positive of the implications. Since blocking would simply serve to minimize the estimate of within-treatment variance and the analysis already indicates that basin areas are significantly different between default regions I think it is arguable that blocking is irrelevant for such purposes, but at the very least the design of the statistical experiment and possible problems and implications should be discussed.

23. Section 3, Sample Size. The sample sizes mentioned in this section are not consistent with the values given in Appendix H. In addition, Appendix H should be referenced in the text. The first sentence is misleading, because according to Appendix H, the observed basin areas were not used to estimate the confidence interval length for the sample size analysis. It is unclear why three sample sizes are listed for the 15% precision when the text states that the Coastal FFR was excluded from the sample size analysis.
24. Section 3, Field Indicators of the Np/Ns Break. Shouldn't there be a segment break for all Pd locations due to a flow category change? If this only happened in 117/213 (55%), doesn't that indicate a problem with following the protocol?
25. Section 3, Field Indicators of the Np/Ns Break. How was the significance of the upstream/downstream variables assessed? Was the mean of all downstream data compared to the mean of all upstream data? It might be more appropriate to analyze the paired differences.
26. Section 3, Table 13. What are the values listed in the Table 13? The caption indicates r^2 values, but the value for Log Dc-Pd does not match the text.
27. Section 3, Alternative Stratification Schemes. Which measures of elevation or relief were used? It seems to me based on Figure 8 that stratification by ecoregion (or ecoregion groups) would be possible, was this explored? (This comment also applies to Section 4, Basin Area Variability).
28. Section 4, Year of Normal Rainfall. The discussion of differences in summer precipitation between the eastside and the westside and using summer versus annual precipitation to determine a normal year highlights the fact that this measure does not take into account differences in regional hydrology. One leaves with the feeling that this issue is not resolved and there is still the potential for substantial discrepancy in the interpretation of future stream surveys. The length of the necessary precipitation window for analysis will depend on the amount of memory in the system. Stream discharge may provide a better indicator of “normal” conditions for a region since it will take into account this memory. A similar quartile analysis could be done for the nearest USGS gauge with drainage area below some maximum threshold, for example.
29. Section 4, Precipitation Classes Define Alternate Default Regions. I have a problem with the first sentence of the second paragraph. Are there references to support the statement that precipitation is the dominant statewide control on basin area variability? The analyses presented in this report are not sufficient to support this statement because other potential statewide controls on basin area variability (such as climate, air temperature, soil type, soil depth, vegetation, average watershed slope, ecoregions, etc.) have not been analyzed.
30. Section 4, Alternative Indicators, last paragraph. The last sentence is unclear. The header to Table 17 implies that sites without identified channel heads were not included in the statistics, while the text indicates that they were. A short explanation as to why inclusion may bias the statistics is warranted.

31. Section 4, Sample Size and Design, last paragraph. I think the second sentence should say that the CV does not change much between FFR Default Region stratification and Precipitation Class stratification. The CV does change between basin area and distance to divide.
32. Section 4, Table 18, header. Is precision a percentage of the average or the log-transformed average?
33. Section 4, Table 18. The values in Table 18 are similar to those in Appendix H, Table 3, but I'm not convinced that they are entirely consistent (in particular, the sample sizes listed for a CV of 70% differ slightly).
34. Section 5, first paragraph. It was not clear on first reading that a statewide demarcation study was proposed in Section 4. The only sub-section that refers to further sampling was the last section on sample sizes and this section was not definitive on recommendations or strategy. If a proposed statewide study is a firm conclusion of this work, it should be presented much more prominently.
35. Section 5, question 1. I think I related question raised by this study is the time scale of point Pd variability with respect to precipitation. What is an appropriate time scale of precipitation to use to establish consistency between surveys (if one exists)?
36. Appendix C, Section 4.1. Study site selection is not consistent between the Methods Section in the main report and the Appendix. The report refers to intersections of Type N and F streams, as defined by the FFR, while the appendix refers to Type 3 and 4 streams, which are not defined in the text. At least one cooperator (Appendix F) indicated they would prefer to use the Type N/F boundary for stream selection.
37. Appendix C, Section 4.4.2, Main Thread Survey. Typo in 4th paragraph, 3rd sentence.
38. Appendix C, Section 4.4.2, Total Tributary Survey, 2nd paragraph. A Figure 2 is not provided in the Appendix. Figure 2 in the main document is not relevant. The demarcation point for the initiation of tributary surveying is unclear. Is the "main thread flow change" the same as Point Pc?
39. Appendix C, Section 4.4.3, 1st paragraph following bullets. The last sentence is incomplete.
40. Appendix D, general. The text throughout refers to point "Pp" or PIP, I believe this should be Pc. Also refers to "Ph", should be "Ch"? The "General Notes" row contains an editorial comment.
41. Appendix E, Task 3. Text refers to Pp and Ph, rather than Pc and Ch. Unkown reference to "SOW Table 1".
42. Appendix F, QC Replicate Survey Method. Point no. 4 refers to Form PIP QC 1.2 in Appendix B. Neither the Appendix nor the Form was included.
43. Appendix F, Ecological Land Services portion. This section is confusing because there is no explanation given either in the Appendix or in the main text regarding the role of the independent contractor in Training, Field Assistance and Quality Control. (There are numerous references to QA/QC in the main text and in the sampling protocol, but they are sometimes contradictory and misleading since it is not always clear when they are describing proposed activities versus what actually took place for the pilot study.) A short introduction describing the involvement of the independent contractor in each of the activities would be useful. In addition, the text refers to the PIP, rather than Pc or Pd.
44. Appendix H, 3rd paragraph, 4th sentence. "…the relative size is the distance to the lower or upper bound…" distance from where?

45. Appendix H, general. The term "log-transformed mean" is used numerous times. This should be the "mean of the log-transformed data".
46. Appendix H, Table 1. Header should state "Size relative to the median" or something similar.
47. Appendix H, Section 1. See comment 12, definition of r should be more specific.
48. Appendix H, Section 1.1.1, 2nd paragraph. This sentence should read "It is desired to have a 90% confidence interval that does not range more than 50% of the median on the original scale on either side for an estimated median of 50 and 300 acres.
49. Appendix H, 4th paragraph. This text is very confusing with many percentages presented without reference to actual size. I think it would be more useful to give the confidence intervals in this example in terms of actual areas, not percentages. e.g. for the 2nd sentence: "With these sample sizes Table 1 indicates that the confidence interval for the 300-acre default will be between 129 and 531acres…"
50. Appendix H, Table 2. The table uses Pp instead of Pc. Too many significant digits provided for mean and standard deviation.
51. Appendix I, general and Figure 1. Text refers to point Pp, not Pc.
52. Appendix I, Distribution of distances. Define standard error. Why is cooperator 'PGS' missing data.
53. Appendix I, Relationship between distance…, 3rd paragraph. Text should indicate how significance is determined (i.e. p value < 0.1, etc.).
54. Appendix I, Figure 5. It would be clearer if the estimated relationship were shown as a line.

Editorial Comments:

1. TOC. The Appendices should be listed in the Table of Contents.
2. Section 1, Drainage Basin Assumptions, 2nd paragraph, 4th sentence. Grammatical error.
3. Section 1, Figure 3. The perspective of the Figure makes it difficult to interpret. Points Pt, Db and Dc are not defined, are they used?
4. Section 1, Figure 5a. Caption should read Ch, Pd and Pc. Dc and Db still not defined for both Figure 5a and 5b.
5. Section 2, Table 5, Survey Route. Text should refer to the definitions in Appendix C, not Appendix B.
6. Section 2, GIS Data, 3rd bullet should read: "Data layers listed *in* Table 8;".
7. Section 3, Alternative Field and Default Criteria, 1st paragraph. Second sentence should read: "…flow-category segment break*s*…".
8. Section 3, Qualitative Assessment, 2nd to last paragraph. Typo in the last sentence.
9. Section 3, Field Indicators of the Np/Ns Break. The text in this section refers to point Pp, rather than Pc.
10. Section 3, Field Indicators of the Np/Ns Break, 3rd paragraph. There is a parenthesis missing in the second sentence.
11. Section 3, Figure 11. Typo in the figure caption and the precipitation units are not given. The classes shown in Figure 11 should mirror those in Figure 12. (There can be more classes, but they should break on the same boundaries, i.e. 60 and 100 inches).
12. Section 4, Protocol. Typo in 3rd sentence of 2nd paragraph ("channels segments").
13. Section 4, Protocol, 3rd paragraph. Typo in the 2nd sentence.

14. Section 4, Alternative Indicators, last paragraph. There is a typo in the second sentence.
15. Section 4, Potential Studies. This should be Section 5.
16. Section 5, question 2. There is a typo in the fourth sentence.
17. Section 5, question 5. There are several typographical and grammatical errors in this paragraph. Please review.
18. Appendix A. Delete Word editing comments.
19. Appendix B, Table 2. Typo in the first footnote. The third footnote is missing.

Appendix K
"Type N Stream Demarcation Study Phase I: Pilot Results"
DRAFT UPSAG Proposed Actions
Resulting from SRC Review Comments

This table summarizes the proposed actions arising from the comments and recommendations embedded in the SRC reviews. The SRC comments are a distillation of the general and specific concerns raised by the three reviewers. The response table addresses the individual comments by individual reviewers and that table should be referred to for the action to be taken on specific comments. Items in this table are numbered for convenience in referencing and do not represent a ranking.

SRC Comment	Proposed Action	Rationale
1. The report needs to be rewritten to address grammatical and organizational problems.	Editorial issues will addressed as will requested clarifications	The report should be as clearly written and professional as possible. It may require the input of a technical editor.
2. The study does not address functions and larger management issues and is simplistic in search for a single variable to explain basin-area variability. It is "… an extremely blunt tool that may not be addressing the larger management objectives."	**NO ACTION**	The comments address issues that lie outside the scope of Type N Demarcation Study.
3. The protocol for determining the route of the upstream surveys is biased toward groundwater-dominated tributaries and should lead to the selection of the wettest headwater reach with the smallest basin area and shortest seasonal reach.	The protocol for Phase II will be revised as recommended by the reviewer to require the random selection of all tributaries. The pilot study results do not require changing because of bias. This potential bias will be noted in any revisions to the report and, if option 4 of the Action Plan is selected, will lead to the removal of potential bias from the Results.	The Phase I protocol could lead to a bias toward wetter streams and this potential for bias should not present in the Phase II protocol. Re - analysis of the pilot study data did not detect a difference between the basins with non-randomly selected tributaries and those without tributaries or with randomly-selected tributaries (See Analysis of Bias Report – available from bpalmquist@nwifc.org).
4. The protocol analysis is not adequate.	The protocol analysis will expand	Testing of the pilot protocol was a major

The protocol analysis does not address all issues raised by field parties and does not explain the reasons why some variables were not captured by all field crews.	upon these issues and some components will be re-analyzed to assess their adequacy.	objective of the pilot study. Some of the SRC concerns can be resolved by clarifying the method and analysis and others require additional consideration.
5. Inter-annual and intra-annual variations in the location of Np/Ns break are not adequately addressed by the study.	**Undetermined** The Phase II study design could include a component for a multi-year study to address these variations. If Option 4 of the Finalization Plan is selected, data collected by others will be included in Final Report.	The extent to which the Np/Ns break migrates with water availability is an unknown factor with any default criterion based on a potentially moveable point and should be addressed to assess its inherent error. Alternatively, the selection of a fixed point, such as the channel head, would eliminate the need for these studies.
6. The pilot study does not adequately address the degree to which water-year 2001 was a year of normal streamflow.	**Undetermined** The report does address "**rainfall**" which was the attribute specified in FFR. There are insufficient stream gage data from very small watersheds to assess whether 2001 was a year of normal **streamflow** in the study streams. .	The pilot study raises the issues underlying the determination of the normalcy of any water year. The analysis indicated the need for better definitions. The objectives of the pilot study do not require an extensive analysis of the normalcy of water year 2001 but the second, state-wide phase of the study will require this analysis. Policy guidance should be sought in more-fully defining this concept. If option #4 Action Plan is selected, additional analysis of this issue will be performed after Policy direction.
7. The statistical analysis has some problems – use of statistical routines in Excel and the use of ANOVA to test for differences between non-randomly distributed study areas within ecoregions.	**NO ACTION**	No critical findings are based on Excel-derived statistics or on the results from ANOVA. According to our statisticians, the statistical routines in Excel are adequate for simple summary statistics, and for correlation, regression, and ANOVA when used for exploratory purposes. In the Phase II study, we will consistently use accepted statistical packages. We understand that study areas are not randomly distributed and that ANOVA assumes

		such as random distribution. The results of the ANOVA analyses should be assessed using professional judgment. We will clarify the pilot report to emphasize this need.