



DEPARTMENT OF
ECOLOGY
State of Washington

Standard Operating Procedure EAP105, Version 1.1

GIS-Based Verification, Layout, and Data Collection (Wide Protocol)

July 2019
Publication 19-03-220
[Approved March 2, 2017]

Purpose of this Document

The Washington State Department of Ecology develops Standard Operating Procedures (SOPs) to document agency practices related to sampling, field and laboratory analysis, and other aspects of the agency's technical operations.

Publication Information

This SOP is available on the Department of Ecology's website at <https://fortress.wa.gov/ecy/publications/SummaryPages/1903220.html>.

Ecology's Activity Tracker Code for this SOP is 18-031.

Recommended citation:

Hartman, C. 2019. Standard Operating Procedure EAP105, Version 1.1: GIS-Based Verification, Layout, and Data Collection (Wide Protocol). Publication 19-03-220. Washington State Department of Ecology, Olympia. [Approved March 2, 2017.]
<https://fortress.wa.gov/ecy/publications/SummaryPages/1903220.html>.

Contact Information

For more information contact:

Publications Coordinator
Environmental Assessment Program
P.O. Box 47600, Olympia, WA 98504-7600
Phone: (360) 407-6764

Washington State Department of Ecology – <https://ecology.wa.gov>

- Headquarters, Olympia 360-407-6000
- Northwest Regional Office, Bellevue 425-649-7000
- Southwest Regional Office, Olympia 360-407-6300
- Central Regional Office, Union Gap 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

Any use of product or firm names in this publication is for descriptive purposes only and does not imply endorsement by the author or the Department of Ecology.

To request ADA accommodation for disabilities, or printed materials in a format for the visually impaired, call the Ecology ADA Coordinator at 360-407-6831 or visit <https://ecology.wa.gov/accessibility>. People with impaired hearing may call Washington Relay Service at 711. People with speech disability may call TTY at 877-833-6341.

Title – Standard Operating Procedure EAP105, Version 1.1: GIS-Based Verification, Layout, and Data Collection (Wide Protocol)

Author – Chris Hartman

Date – 01/08/2016

Reviewers – George Onwumere, Glenn Merritt, and Meghan Rosewood-Thurman

Date – 03/02/2017

QA Approval – William R. Kammin, Ecology Quality Assurance Officer

Approval Date – 03/02/2017

SIGNATURES AVAILABLE UPON REQUEST

Please note that the Washington State Department of Ecology's Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Ecology use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. Distribution of these SOPs does not constitute an endorsement of a particular procedure or method.

Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by the Department of Ecology.

Although Ecology follows the SOP in most instances, there may be instances in which the Ecology uses an alternative methodology, procedure, or process.

SOP Revision History

Revision Date	Revision History	Summary of changes	Sections	Reviser(s)
12/27/16	1.1	Added footers, edited name, references	All	Meghan Rosewood-Thurman
12/29/16	1.1	General edits	All	Meghan Rosewood-Thurman
1/10/17	1.1	Revised method for calculating bearing. Removed figure.	6.1.1.5, 6.2.2	Jenny Wolfe
1/19/2017	1.1	Refined definitions 3.2 (candidate sites) 3.5 (GIS), 3.6 (GPS) 3.9 (Major Transect) 3.10 (Narrow Protocol) 3.11 (NHD), 3.12 (NHDPlus) 3.13 (Protocol), 3.14 (QAMP) 3.16 (site), 3.17 (SITE ID) 3.20 (Strahler order (Figure)) 3.22 (Thalweg Station) 3.24 (WHM Sampling Frame) Added definition: 3.23 (WHM) Added references: 10.16 (Merritt, 2017 (EAP106)) 10.20 (Nat. Geo. Soc., 2017a (GIS)) 10.21 ((Nat. Geo. Soc., 2017b (GPS)) Edited references: 10.22 Office of the... 2010) 10.26 (US Geo Survey, 2017a) 10.27 (US Geo Survey, 2017b)	3.0, 10.0	Glenn Merritt
1/20/2017	1.1	Removed “for Sites Sampled” 3.16 edited “Site” definition 4.5 new link to EPA 2012, Leopold 6.1.2.7 erased nonsense line 10.9 new link to EPA 2012 10.13 Revised Janisch cite/Title 10.15 new link to Leopold video	Title 3.0 4.0 6.0 10.0	Glenn Merritt
2/13/17	1.1	Added Reviewers	Signature Page	Meghan Rosewood-Thurman
2/15/17	1.1	Footer Changed	All	Meghan Rosewood-Thurman
3/2/17	1.1	Edited tables and text	6.1.1.6 and 6.1.1.7	Meghan Rosewood-Thurman
7/19/19	1.1	Edited, formatted for publication	all	Ponzetti

1.0 Purpose and Scope

- 1.1 This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for GIS-based procedures associated with Watershed Health Monitoring (WHM) program sites sampled with the Wide Protocol. This SOP covers site verification and layout, as well as slope and bearing measurements.
- 1.2 This SOP is also used for related projects in EAP, such as Ambient Bioassessment Monitoring, Sentinel Site Monitoring, or other special projects that need comparable data.

2.0 Applicability

- 2.1 The verification and layout procedures described in this SOP should be followed prior to performing a data collection event (DCE) at a site that meets the criteria for Wide Protocol.
- 2.2 The slope and bearing calculation procedures described in this SOP should be followed after a DCE has been conducted with the Wide Protocol.

3.0 Definitions

- 3.1 Bankfull stage: This stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in streambank slope, perennial vegetation limit, rock discoloration, and root-hair exposure (Endreny, 2003).
- 3.2 Candidate sites: Lists of candidate sites are generated during winter months after evaluating larger lists (e.g., the Washington Master Sample). WHM staff narrow the larger lists using map-based target criteria to locate landowner contact information and then request access permission.
- 3.3 DCE: *Data Collection Event*. This is a sampling event for a given protocol. Data for a DCE are indexed using a DCE code that includes the site ID followed by the year, month, day, and the time (military) that the sampling event began, as follows: WAM06600-000222-DCE-YYYY-MMDD-HH:MM. DCEs are each intended to be completed within a single day. They consume 4 to 6 hours, on average.
- 3.4 EIM: The Environmental Information Management System (EIM) is the Department of Ecology's main database for environmental monitoring data. EIM contains records on physical, chemical, and biological analyses and measurements. Supplementary information about the data (metadata) is also stored, including information about environmental studies, monitoring locations, and data quality. The “search by map” feature enables plotting coordinates over orthophotographic imagery.
- 3.5 GIS: A geographic information system (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth’s surface (National Geographic Society, 2017a).
- 3.6 GPS: A global positioning system (GPS) is a network of satellites and receiving devices used to determine the location of something on Earth (National Geographic Society, 2017b). The WHM crew references the GPS to identify coordinates using a hand-held receiver or an on-board receiver within the data recording tablet.

- 3.7 Index station: The point location mapped by the site coordinates. It is sometimes called "X." This is normally located at major transect F. However, it may occur at any elevation in the stream between transects A and K.
- 3.8 Major transect: One of 11 equidistant transects across the length of a site. These transects run perpendicular to the thalweg and are labeled as follows: A (farthest downstream), B, C, D, E, F, G, H, I, J, and K (farthest upstream).
- 3.9 Minor transect: One of 10 equidistant transects across the length of a site that is sampled using the Narrow Protocol. Each minor transect is located midway between major transects. Minor transects are A5, B5, C5, D5, E5, F5, G5, H5, I5, and J5.
- 3.10 Narrow Protocol: The set of Watershed Health Monitoring SOPs that describe data collection at wadeable sites with an average bankfull width of less than 25 m at the index station.
- 3.11 NHD: The 1:24,000-scale National Hydrography Dataset is used to portray surface water on the National Map. The NHD represents the drainage network. (U.S. Geological Survey, 2017b). NHD is the hydrography standard for Washington State (Office of the Chief Information Officer, 2010).
- 3.12 NHDPlus: NHDPlus is a geospatial hydrologic framework data set envisioned by the U.S Environmental Protection Agency (Horizon Systems Corporation, 2015). First released in 2006 as the NHDPlusV1, it has consisted of multiple components, one of which has been the 2006 version of the 1:100,000-scale National Hydrography Dataset (NHD). The Watershed Health Monitoring program for the Department of Ecology uses NHDPlus to make Strahler order assignments because Strahler order was not an available attribute of our other hydrography when the project began.
- 3.13 Protocol: A collection of SOPs used to accomplish a DCE. Watershed Health Monitoring uses two protocols: The *Narrow Protocol* is used for sampling wadeable streams that are less than 25 m average bankfull width. The *Wide Protocol* is used for rivers or streams that are wider than 25 m average bankfull width or too deep to wade.
- 3.14 QAMP: Quality Assurance Monitoring Plan. The QAMP for WHM is Cusimano et al. (2006). An updated version is in early stages of development.

Reach Type: See Table 1 and Figure 1.

Table 1. Reach types (from Montgomery and Buffington, 1993, 1997, 1998).

<p>Bedrock reach: A <i>Reach Type</i> choice on the <i>Site Verification</i> form. This is where the streambed lacks fill material, except for temporary storage spots. Bedrock channels generally are confined by valley walls (Montgomery and Buffington, 1998).</p>
<p>Braided reach: A <i>Stream Type</i> choice on the <i>Site Verification</i> form. Braided reaches are characterized by wide channels containing series of bars. They have a high supply of sediment. They have mobile bed forms. They lack valley confinement and are characterized erodible banks (Montgomery and Buffington, 1993).</p>
<p>Cascade reach: A <i>Reach Type</i> choice on the <i>Site Verification</i> form. Cascade reaches occur on steep slopes where energy is high. They are characterized by disorganized cobbles and boulders and by confined valley walls (Montgomery and Buffington, 1998).</p>
<p>Colluvial reach: A <i>Reach Type</i> choice on the <i>Site Verification</i> form. This is a portion of the stream network that is typically in headwaters and typically consists of intermittent or ephemeral flow. In colluvial valleys, expect long-term accumulation of sediment, punctuated by periodic catastrophic erosion (Montgomery and Buffington, 1998). Colluvial material is of mixed sizes.</p>
<p>Plane-bed reach: A <i>Reach Type</i> choice on the <i>Site Verification</i> form. A plane-bed reach is characterized by a relatively featureless gravel/cobble bed. There is an absence of tumbling flow, but may include glides, riffles, or rapids. They lack lateral flow. Bed surfaces are often armored (Montgomery and Buffington, 1998).</p>
<p>Pool-riffle reach: A <i>Reach Type</i> choice on the <i>Site Verification</i> form. A pool riffle reach is typically unconfined, with a laterally oscillating sequence of bars, pools, and riffles. There is local sediment accumulation in discrete bars (Montgomery and Buffington, 1998).</p>
<p>Regime reach: A <i>Reach Type</i> choice on the <i>Site Verification</i> form. In a regime reach, mobile bed forms provide the primary flow resistance. A regime reach is typically a low-gradient sand bedded channel. Low slope, frequency and presence of ripples or dunes throughout the channel bed distinguish a regime channel from a pool-riffle channel (Montgomery and Buffington, 1993).</p>
<p>Step-pool reaches: These consist of coarse materials that are organized into discrete series of steps separating pools containing finer materials. They consist of alternating turbulent flow over steps and tranquil flow in pools (Montgomery and Buffington, 1998).</p>

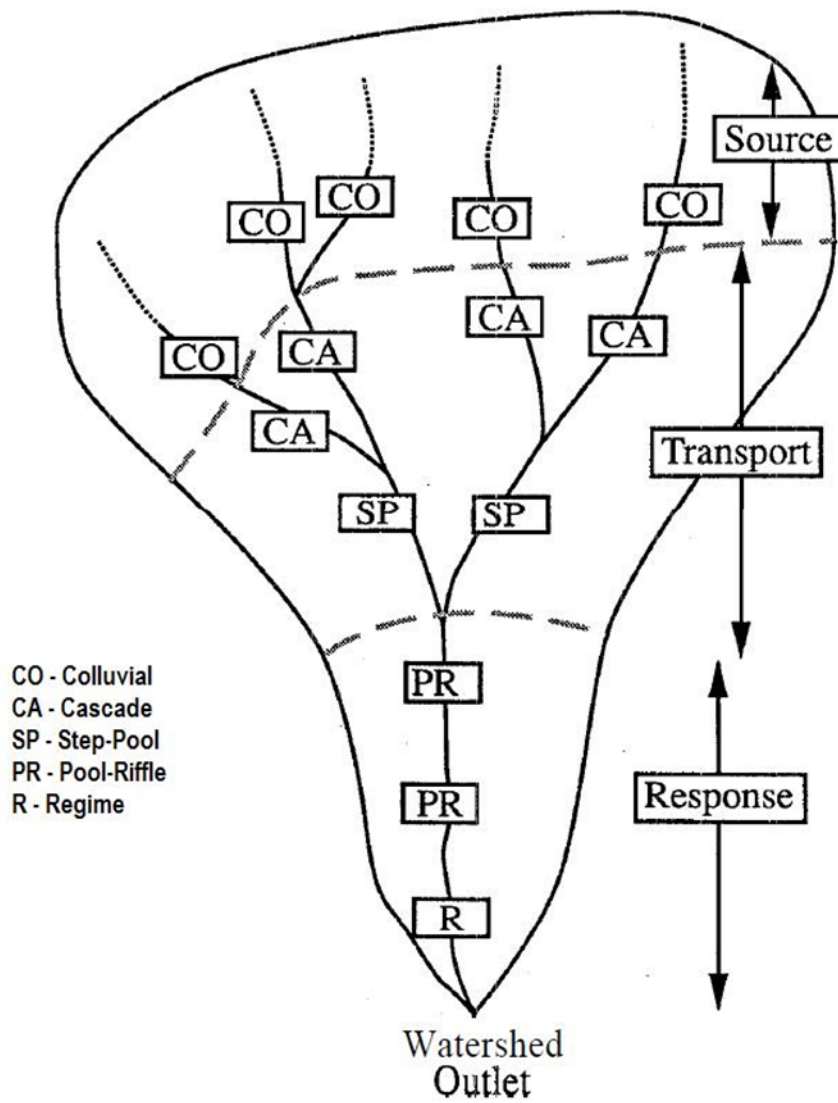


Figure 1. Idealized reach type positions (aerial view) within a watershed [modified from Figure 22 of Montgomery and Buffington (1993)].

3.16

Site: A site is defined by the coordinates provided to a sampling crew and the boundaries established by the protocol's site layout method (this SOP, EAP105 [Hartman, 2019] for the Wide Protocol; SOP EAP106 [Merritt, 2018] for the Narrow Protocol). Typically, a site is centered on the index station and equal in length to 20 times the average of 5 bankfull width measurements. Sites cannot be longer than 2 km nor shorter than 150 m. Narrow Protocol sites range from 150 m to 500 m long. Wide Protocol sites are up to 2 km long. The most downstream end of a site coincides with major transect A; the most upstream end coincides with major transect K.

- 3.17 SITE ID: Identity code for the proposed sampling site.
The Format is WAM06600 - # # # # #
- Random sites from the Washington Master Sample have a *WAM06600*- prefix.
 - Statewide sentinel sites have a *SEN06600*- prefix.
 - Ambient Bioassessment Sites have a *BIO06600*- prefix.
- 3.18 Station: Any location within the site where an observation is made or part of a sample is collected.
- 3.19 STR: Status and Trends Regions (STRs) are based on Salmon Recovery Regions (SRRs) that were described by the Governor’s Salmon Recovery Office (JNRC, 1999). Membership is as follows:
- Puget STR _____ Puget Sound & Hood Canal/Puget Sound SRRs
 - Coastal STR _____ Coastal SRR
 - Lower Columbia STR ___ Lower Columbia SRR
 - Mid-Columbia STR ___ Mid-Columbia SRR
 - Upper Columbia STR ___ Upper Columbia SRR
 - Snake STR _____ Snake SRR
 - Northeast Wash. STR ___ Northeast Washington SRR
 - Unlisted STR _____ No SRR identified

3.20

Strahler order: Strahler (1957) described a system of naming sizes of streams based on their position in the watershed. 1st order streams are headwaters. 2nd order streams are where two 1st order streams converge. A 3rd order stream is where two 2nd order streams converge, etc. For WHM, we use the Strahler order assignments provided by NHDPlus. We assign Strahler order of 0 to small headwater streams that are not depicted by the NHDPlus network. See Figure 2.

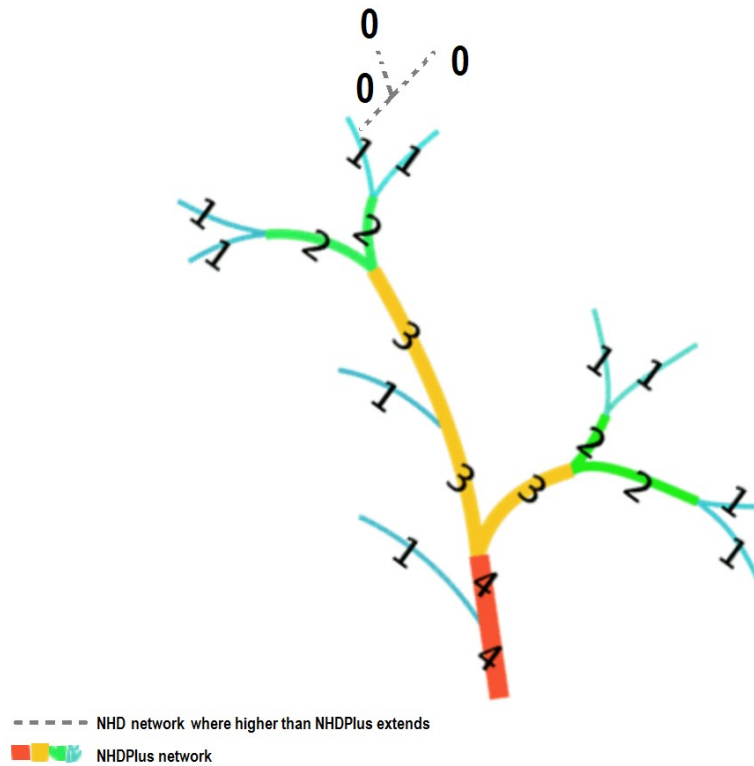


Figure 2. Strahler-order (modified from U.S. Geological Survey, 2017a).

3.21

Thalweg: Path of a stream that follows the deepest part of the channel (Armantrout, 1998). For WHM, we emphasize Armantrout’s use of the word “path” because the thalweg longitudinal profile excludes (sometimes deeper) side pools that are not part of the dominant flow path.

3.22 Thalweg station: One of 100 equidistant measurement locations in the thalweg, across the length of a site. For example, the thalweg stations at/above each major transect are named as follows:

- A0, A1, A2, A3, A4, A5, A6, A7, A8, A9,
- B0, B1, B2, B3, B4, B5, B6, B7, B8, B9,
- C0, C1, C2, C3, C4, C5, C6, C7, C8, C9,
- ...
- J0, J1, J2, J3, J4, J5, J6, J7, J8, J9, and
- K0.

3.23 WHM: Watershed Health Monitoring, a status and trends monitoring program within the Environmental Assessment Program at the Washington State Department of Ecology.

3.24 WHM Sampling Frame: This is the 1:24,000-scale hydrography from which the Master Sample Points were selected. It is described in [Ecology \(2015a\)](#).

3.25 Wide Protocol: The set of WHM SOPs that describes the sample and data collection at non-wadeable sites or sites wider than 25 m bankfull width. It is an abbreviated version of the Narrow Protocol and is usually accomplished by use of rafts.

4.0 Personnel Qualifications/Responsibilities

4.1 This SOP pertains to all Environmental Assessment Program field staff collecting and entering data for WHM.

4.2 All field staff must comply with the requirements of the EAP Safety Manual (Ecology, 2019).

4.3 All field staff must have completed the annual WHM field training and be familiar with both WHM protocols: *Narrow Protocol* and *Wide Protocol*. The training includes sampling goals and objectives as defined in the QAMP.

4.4 Field staff must be annually trained to minimize the spread of invasive species. See SOP EAP070 (Parsons et al., 2018).

- 4.5 Field staff should know how to identify bankfull stage. Below are some useful resources:
- [Hydrologic Processes: Bankfull Discharge](#) (EPA, 2012)
 - [Identifying Bankfull Channel Edge Part 1](#) (Grizzel, 2008a)
 - [Identifying Bankfull Channel Edge Part 2](#) (Grizzel, 2008b)
 - [A Guide for Field Identification of Bankfull Stage in the Western United States](#) (Leopold et al., 1995)
 - Fluvial Geomorphology Module, UCAR COMET Program and NOAA River Forecast Center (Endreny, 2003)
- 4.6 Field staff should have access to and familiarity with ArcMap.

5.0 Equipment, Reagents, and Supplies

- 5.1 GPS receiver
- 5.2 Maps
- 5.3 Tablet (charged) with WHM e-forms.
- 5.4 Measuring devices (measuring rod, 50-m tape, laser rangefinder)
- 5.5 Flagging and permanent marker
- 5.6 Wading/rafting gear (pre-cleaned of organisms)
- 5.7 Paper (waterproof) version of field data forms with number 2 pencil and clipboard
- 5.8 Paper (waterproof) site diagram form
- 5.9 Digital camera
- 5.10 Computer with access to ArcMap

6.0 Summary of Procedure

- 6.1 Prior to the field season, review the candidate sampling sites on GIS and determine which of them will be sampled with the wide protocol, either by raft or on foot while wading. Use GIS to determine the location of major transects for each site. After the sites have been sampled use the pre-season site layout information to calculate slope and bearing.
- 6.1.1 Pre-Season Site Layout and Verification
- 6.1.1.1 Start a new ArcMap project and add the necessary layers. At a minimum you will need the following
- Washington Master Sample
 - Current aerial photography
 - USGS topographic map
 - NHD flowline layer.
- 6.1.1.2 Recall that the wide protocol is employed when the average bankfull width at the master sample coordinates is 25 m or greater. Using the measurement tools available in ArcMap, do an overview of the candidate sites and determine which (if any) would be sampled with the wide protocol. For every site in this subset of the candidate list determine the site length and also the location of every major transect.
- 6.1.1.3 Estimate bankfull stage on an aerial photo and measure bankfull width (whole meters) at five locations near X:
- The Index Station (X)
 - One bankfull width upstream from X
 - Two bankfull widths upstream of X
 - One bankfull width downstream from X
 - Two bankfull widths downstream of X
- 6.1.1.4 Take the average of these 5 bankfull width estimates and multiply by 20 to get the site length. Divide site length by 10 to get the segment length (the distance between major transects).
- 6.1.1.5 Determine the latitude and longitude (decimal degrees) of every major transect for sites that will be sampled with the wide protocol. Create a point feature class that represents the thalweg location at these transects.
- 6.1.1.5.1 This process will require you to create and edit spatial data. Start by creating a File Geodatabase where you want to house your data. Within this File Geodatabase create a point feature class called “Wide_Transects.”

6.1.1.5.2 When you create this feature class, add a field called “TransectID.” This field will correspond to the master sample site ID and to the transect that each point represents (3298A, 3298B, 3298C, etc.). When you are finished, every site should have 11 transects associated with it.

6.1.1.5.3 Add the newly created “Wide_Transects” feature class to your ArcMap project.

6.1.1.5.4 Choose a site to start with and zoom to the master sample coordinates. Be aware that the master sample coordinates may not correspond with the real-world morphology of the river. The master sample coordinates may be associated with a mapped side channel of the river or may simply be inaccurate due to mapping error (Figure 3).

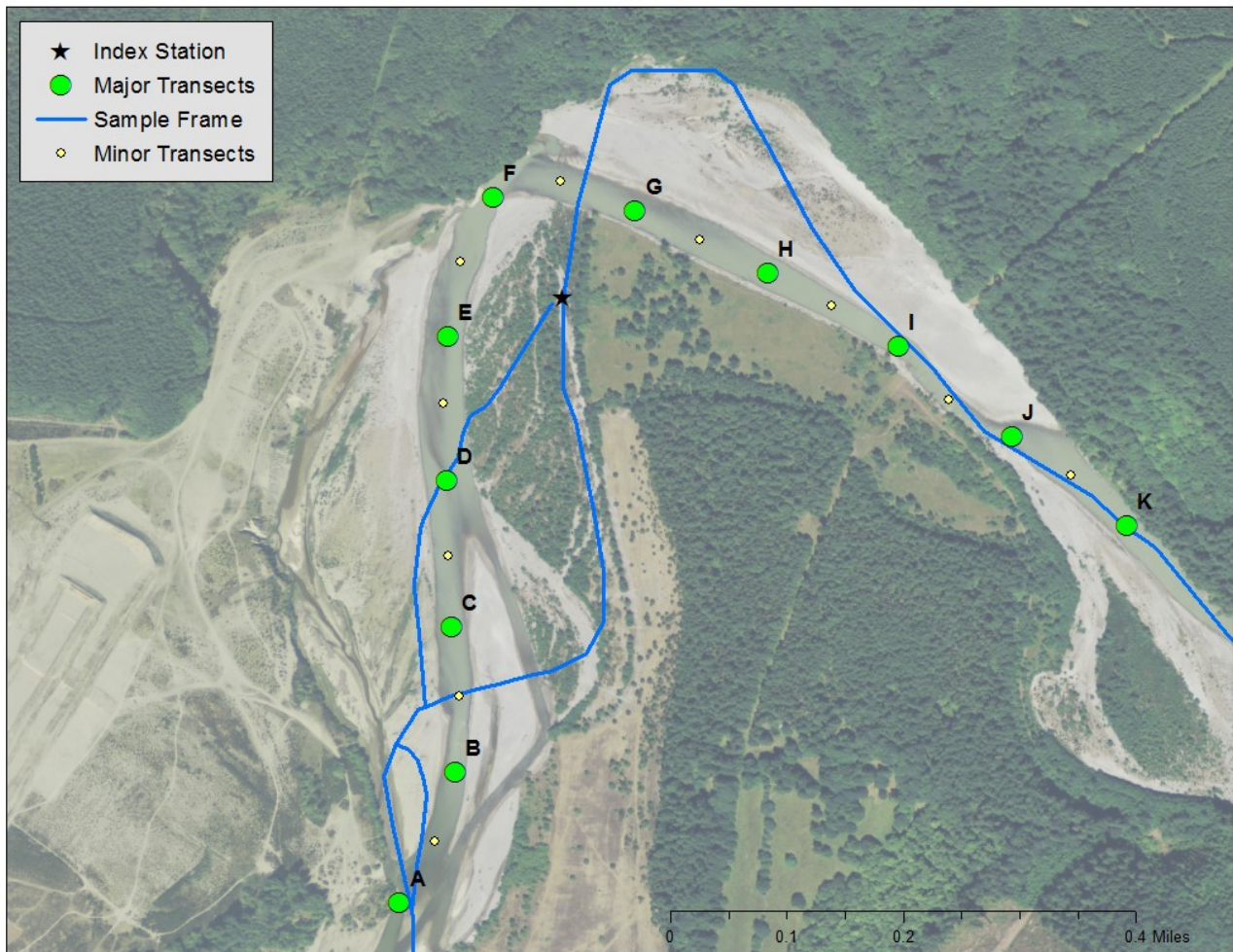


Figure 3. The mapped watercourse (blue line) may differ from the true path of the watercourse. Estimate the real-world position of the index station and transect locations relative to the mapped watercourse on the most current aerial imagery available to you.

- 6.1.1.5.5 Create a point feature that corresponds with the thalweg at the index station. If the thalweg is not evident from aerial imagery, put the point in the center of the wetted channel. After you have created this new feature populate the “TransectID” attributes. Label this transect F.
- 6.1.1.5.6 Using the measurement tools in ArcMap, approximate the thalweg locations of all the downstream transects (A–E) and all the upstream transects (G–K). When you are finished, your map should look like Figure 4. Be sure to update the “TransectID” attributes as you go. It is important to use a naming convention that indicates both the site ID and transect location (3298A, 3298B, etc.). This will be useful when the coordinates are loaded onto a GPS unit.



Figure 4. Wide protocol site layout showing the estimated locations of all 11 major transects.

6.1.1.5.7 All the sites on the candidate list should meet the WHM target criteria based on a GIS assessment. However, once you have created locations for every transect, verify that the site still meets all the target criteria. The site should be:

- Non-federal and non-tribal.
- Perennial, with observable flow during the sample period, across most of the site.
- Of a size class and sampling sequence meeting the criteria for the study.
- Represented by the sample frame and corresponding NHD.
- Of consistent NHD reach and Strahler order from top to bottom.
- In a natural channel (pre-dating humans).

6.1.1.5.8 Once you have created locations for each transect for all the sites that will be sampled with the wide protocol, use the “calculate geometry” tool in GIS to calculate latitude and longitude fields in decimal degrees.

6.1.1.6 The wide protocol is an abbreviated version of the narrow protocol, and many measurements are only made on one predetermined bank. During the pre-season site layout process identify which bank will be sampled. This is based on whether the site ID is an even or odd number according to the Table 2.

Table 2: Use this table to determine which bank to sample at each transect.

EVEN # SITE ID		ODD # SITE ID	
Transect	Bank	Transect	Bank
A	Right	A	Left
B	Right	B	Left
C	Right	C	Left
D	Left	D	Right
E	Left	E	Right
F	Right	F	Left
G	Right	G	Left
H	Left	H	Right
I	Left	I	Right
J	Right	J	Left
K	Right	K	Left

6.1.1.7

Load the latitude and longitude coordinates from the “Transects” feature class into a GPS that you’ll take with you into the field. Compile all of this GIS-derived data into a table and make it available to the field crews who will sample the site. Include all of the information contained in Table 3.

Table 3: GIS-derived site layout information to be made available to field crews.

Site ID: WAM06600-001047			
Stream Name: Snoqualmie River			
GIS Average Bankfull Width: 70 m			
GIS Site Length: 1400 m			
	Latitude	Longitude	Bank to Sample
Index Station	47.59189	-121.92261	
A	47.59565	-121.91513	left
B	47.59489	-121.91663	left
C	47.59390	-121.91784	left
D	47.59305	-121.91929	right
E	47.59272	-121.92114	right
F	47.59197	-121.92271	left
G	47.59079	-121.92335	left
H	47.59021	-121.92169	right
I	47.58951	-121.92005	right
J	47.58833	-121.91954	left
K	47.58705	-121.91939	left
Put In			
Take Out			
Comments: Need to recon			

- 6.1.2 Sampling Wide Sites from a Raft
 - 6.1.2.1 Be sure to research potential put-in and take-out locations well before sampling sites via raft. An initial search can be done on GIS or an online mapping program, but these locations should always be assessed in the field as well.
 - 6.1.2.2 You will not typically need permission from private landowners to access or float large rivers. Most large rivers have publically accessible access points, and navigable waterways are a state-owned resource. The Washington State Department of Natural Resources has produced a useful document that explains the boundaries of state-owned aquatic lands (DNR, 2015). If public access points are unavailable, inconvenient, or unsafe, consider asking for permission from private landowners.
 - 6.1.2.3 On the day of sampling, prior to launching rafts, leave a shuttle vehicle at the take-out location. During this trip, examine the GPS receiver to verify that the site coordinates are contained within this stretch of the river.
 - 6.1.2.4 Estimate the safety status of the river through field reconnaissance and online research. The crew must be unanimous in their opinion. Find the latest river stage and hazard data (e.g., <https://www.americanwhitewater.org/>), and read pertinent guidebooks.
 - 6.1.2.5 Using GPS for navigation, float to each transect of the site, arriving at transect K first. Keep in mind that the coordinates gathered during the pre-season GIS exercise correspond to the thalweg and not the bank that is to be sampled; however, sampling will be conducted at the predetermined bank. Align the sampling area with the predetermined coordinates as much as possible. Safety comes first, so switch banks if the predetermined one is unsafe to sample.
 - 6.1.2.6 Once you reach transect K verify that the site meets all the target criteria listed in section 6.1.1.5.7.
 - 6.1.2.7 Establish the Data Collection Event.
 - 6.1.2.7.1 Turn on the Tablet (see SOP EAP125 [Janisch, 2017]).
 - 6.1.2.7.2 Click the button for Create a New Data Collection Event (Figure 5).

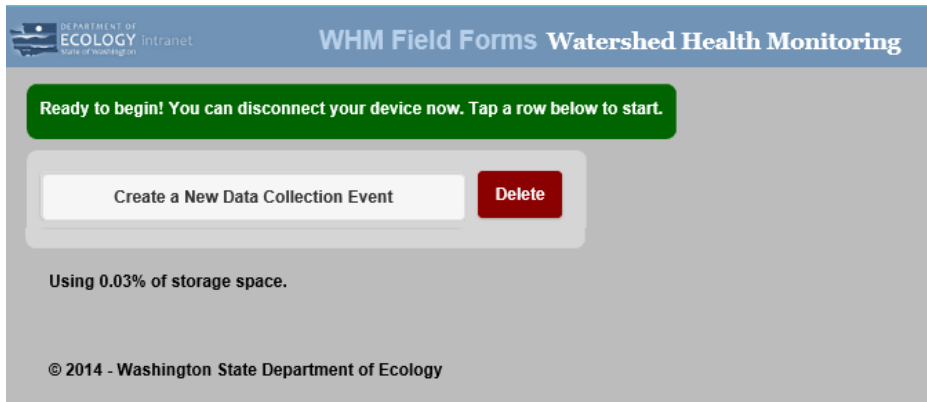


Figure 5. The Create a New Data Collection Event page.

6.1.2.7.3 Find the correct SITE ID on the Create DCE page (Figure 6).

6.1.2.7.4 Click the Create DCE! Button (Figure 6).

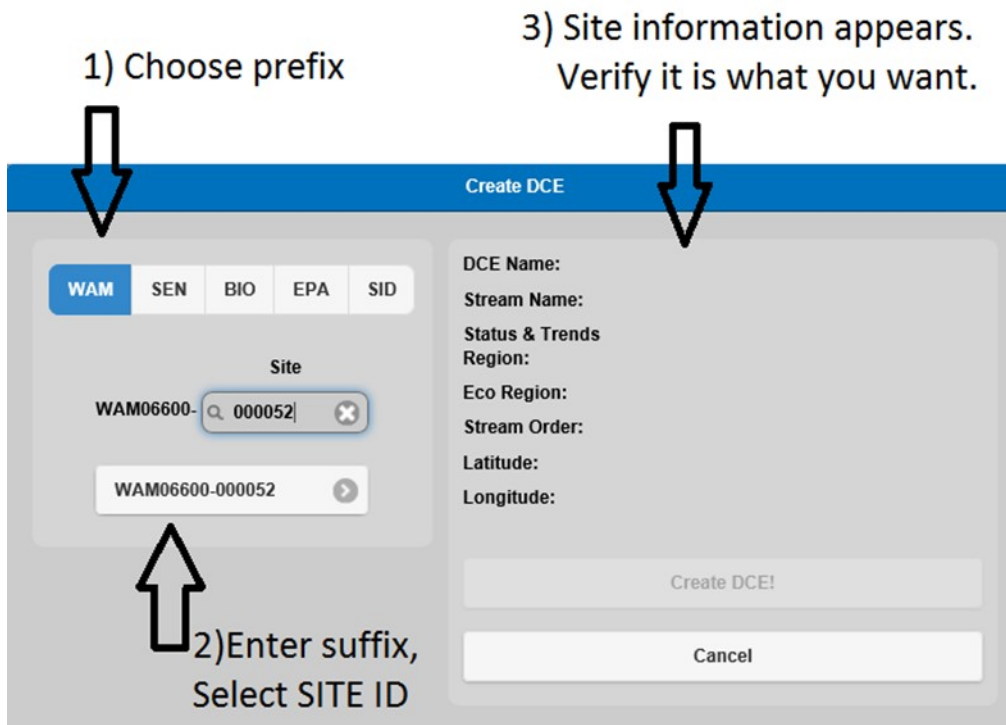


Figure 6. The Create DCE Screen.

- 6.1.2.7.5 Use the Navigation page (Figure 7) to open the Site Verification page (Figure 8).
- 6.1.2.7.6 Enter crew information, including staff names, their organization(s), and the tasks of the DCE that each person will be performing during the day.
- 6.1.2.7.7 Record that you are using the Wide Protocol.
- 6.1.2.7.8 Choose a Reach Type; use the Cheat Sheet or glossary to this SOP for help.
- 6.1.2.7.9 The “Site Length Calculator” at the bottom of the Site Verification Page is intended for sites sampled with the Narrow Protocol. The average bankfull width and site length for sites sampled with the Wide Protocol are predetermined from the pre-season GIS exercise. Input the average bankfull width into each of the 5 “BF Width” fields and identify which transect corresponds with the index station.

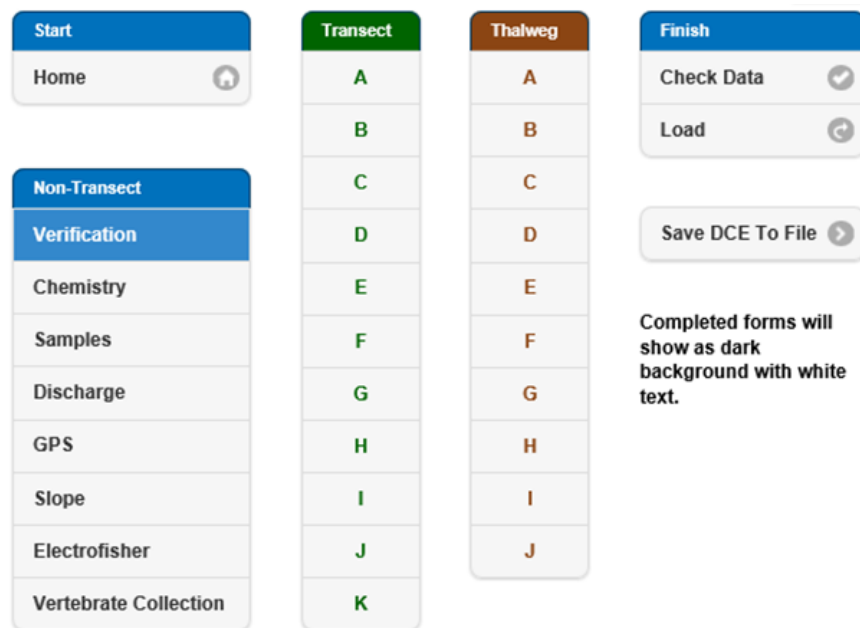


Figure 7. The Navigation page.

The screenshot shows the 'Site Verification' page with the following data:

Organization	Crew Member	Collected				
Ecology	Cassidy, Butch	Habitat	Water	Sediment	Invertebrates	Fish
Ecology	Kid, Sundance	Habitat	Water	Sediment	Invertebrates	Fish
Ecology	Curie, Marie	Habitat	Water	Sediment	Invertebrates	Fish
Ecology	Blackwell, Liz	Habitat	Water	Sediment	Invertebrates	Fish

BF Width 1 (m)	BF Width 2 (m)	BF Width 3 (m)	BF Width 4 (m)	BF Width 5 (m)	Stream Order
5	6	4	4	5	1

Site Length (m): 150 m Distance to K (m): 75 m Distance to A (m): 75 m Calculate Site Length Index Station: F0

Note: Site Length Calculator

Figure 8. The Site Verification page.

- 6.1.3 Sampling Wide Sites While Wading
 - 6.1.3.1 Obtain all necessary access permission before walking to, in, or around wide rivers.
 - 6.1.3.2 Be extra cautious when working in and around large rivers. As when rafting wide sites, estimate the safety status of the river through field reconnaissance and online research. The crew must be unanimous in their opinion. Find the latest river stage and hazard data (e.g. www.americanwhitewater.org), and read pertinent guidebooks.
 - 6.1.3.3 Using GPS for navigation, walk to each transect of the site. Keep in mind that the coordinates gathered during the preseason GIS exercise correspond to the thalweg; however, sampling will be conducted at the predetermined bank. Align the sampling area with the predetermined coordinates as much as possible. Safety comes first, so switch banks if the predetermined one is unsafe to sample.
 - 6.1.3.4 Once you reached the site verify that the site meets all the target criteria listed in section 6.1.1.5.7.
 - 6.1.3.5 Establish the Data Collection Event on the tablet and begin data collection.
 - 6.1.3.5.1 Follow the steps outlined in sections 6.1.2.7.1 thru 6.1.2.7.9.

6.2 Post Field Season GIS Procedures

6.2.1 Calculating Slope

6.2.1.1 For sites sampled with the Wide Protocol, slope is not measured in the field during the DCE, but instead measured on GIS after the DCE has been completed (Ohio EPA, 2006).

6.2.1.2 Start a new ArcMap project and add the necessary layers. You will need the following:

- Washington Master Sample.
- Current aerial imagery.
- Digitized elevation contours or USGS topographic map.

6.2.1.3 With the aerial photo on display, zoom to the site of interest. Follow the stream course downstream until it crosses an elevation contour and mark this location. Now repeat this process going upstream from the site of interest.

6.2.1.4 Measure the stream distance from the upstream to the downstream contour. If this distance is greater than 1 mile, proceed to the next step. If the distance is less than 1 mile, extend the length by one contour line downstream and one upstream until the total length is greater than 1 mile.

6.2.1.5 Determine the contour interval on the map and calculate the total change in elevation over the distance measured. Calculate percent slope using the equation pictured in Figure 9.

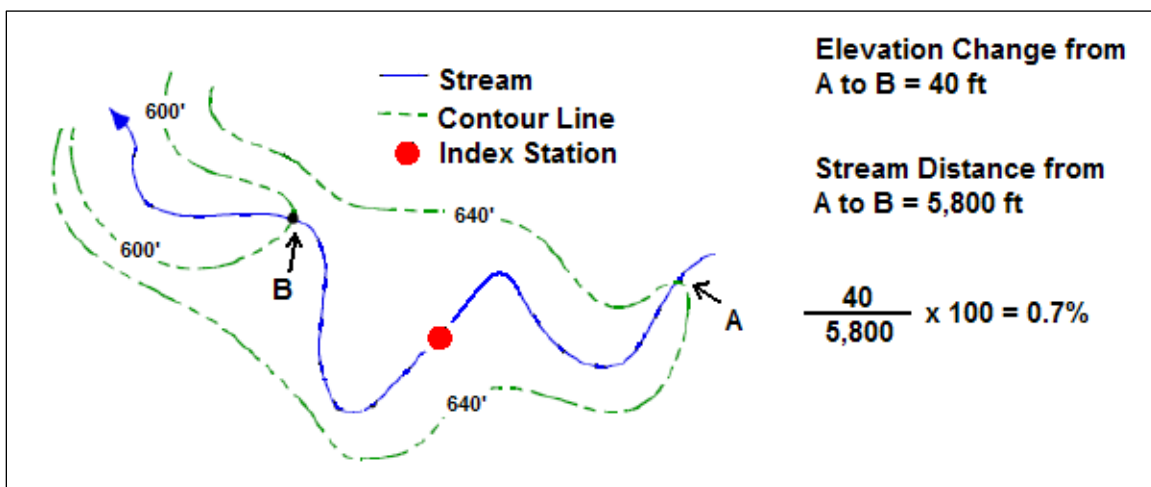


Figure 9. GIS procedure for measuring percent slope for WHM sites sampled with the Wide Protocol.

6.2.1.6

Once you have calculated slope, input this value onto the *Slope* form with a comment in the notes section that states that slope was calculated with GIS (Figure 10). Leave all other fields blank or set to their default value.

The screenshot shows a web form titled "Slope" with a header "WAM06600-WEST03-DCE-2015-1214-09:42". The form is divided into several sections:

- Equipment Used:** A dropdown menu with "Laser" selected.
- Value Units:** A dropdown menu with "degrees" selected.
- Reach Length (m):** An empty text input field.
- Slope (%):** A text input field containing the value "0.07".
- Calculate:** A green button.
- Table:** A table with two columns: "Value (degrees)" and "Increment Length (m)". It contains 11 rows, numbered 1 to 11, each with two empty input fields. Below the table is an "Add Row" button.
- Note:** A text input field containing the text "Calculated with GIS".

Figure 10. Example of a completed slope form.

- 6.2.2 Calculating Bearing
- 6.2.2.1 Bearing is not measured in the field for sites sampled with the Wide Protocol. Instead bearing is measured with GIS after the DCE has been completed.
- 6.2.2.2 This process will require you to create and edit spatial data. Within the File Geodatabase created in step 6.1.1.5.1., create a new line feature class called “Wide_BearingSegments.”
- 6.2.2.3 The line features represent the direction of flow between each major and minor transect and will be used to approximate bearing angle from one transect to the next. When you create this feature class, add a field called “UpstreamTransect.” “UpstreamTransect” refers to the upstream transect associated with each line segment (A5, B, B5, etc.). Each site will have 20 separate lines associated with it and each line should have only two vertices.
- 6.2.2.4 Start a new ArcMap project and add the necessary layers. You will need the following:
- Washington Master Sample.
 - Current aerial imagery.
 - Point feature class named “Wide_Transects.”
 - Line feature class named “Wide_BearingSegments.”
- 6.2.2.5 Add minor transects to “Wide_Transects” feature class.
- 6.2.2.5.1 The Wide_Transects feature class only depicts the locations of major transects. However, in order to calculate bearing both major and minor transects are needed. Follow the steps outlined in section 6.1.1.5 and create point locations for minor transects A5, B5, C5, D5, E5, F5, G5, H5, I5, and J5. Each site should now have a total of 21 transects: 10 minor and 11 major.
- 6.2.2.6 Add line features to “Wide_BearingSegments” and populate layer attributes.
- 6.2.2.6.1 Start by creating a line that extends from K0 to J5. This line should only have two vertices, and each vertex should be “snapped” to a transect.
- 6.2.2.6.2 Once you have created this line populate the “UpstreamTransect” attributes for this line. Repeat this process for every stream segment. When you are finished there should be 20 line segments for each DCE (Figure 11).
- Note: It is important to start at K0 and work downstream to A0 for each site.

6.2.2.7 Calculate the compass bearing for each individual line in “Wide_BearingSegments.”

6.2.2.7.1 Use the Linear Directional Mean tool to calculate the compass bearing for each segment in the “Wide_BearingSegments” layer. This tool is found within the “Measuring Geographic Distributions” subset of the “Spatial Statistics” toolbox. Figure 12 shows an example of the settings you should use with this tool. The Linear Directional Mean tool will “identify the general (mean) direction and mean length for a set of vectors.” With the optional “Case Field” set to “UpstreamTransect,” the output for this tool provides the compass direction for every bearing segment.



Figure 11. An example showing the 20 bearing segments that will be used to calculate bearing in GIS.

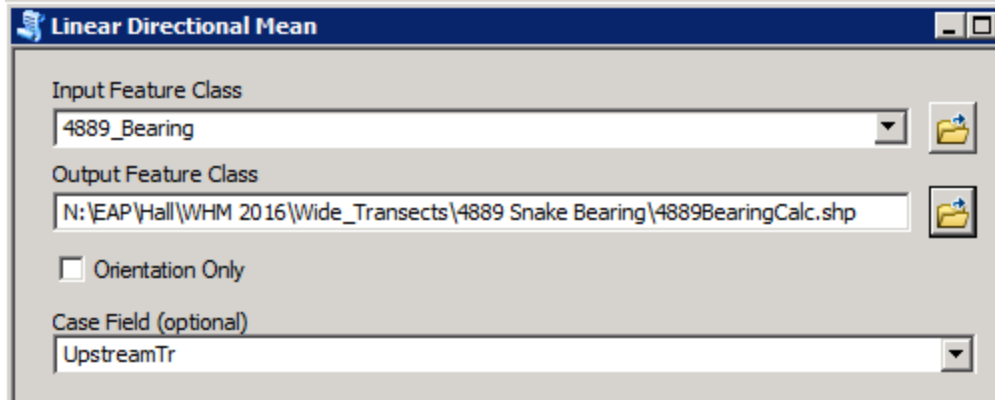


Figure 12. An example of the settings used with the Linear Directional Mean tool to calculate bearing. Input and Output Feature Class will be named differently; however, Case Field should be set to UpstreamTr.

6.2.2.7.2 Once you complete this procedure, review the output to certify that the results are as expected. Figure 13 shows the spatial and tabular data created by the Linear Directional Mean tool. Be sure that all bearing direction vectors are pointed downstream and that the bearing values make sense.

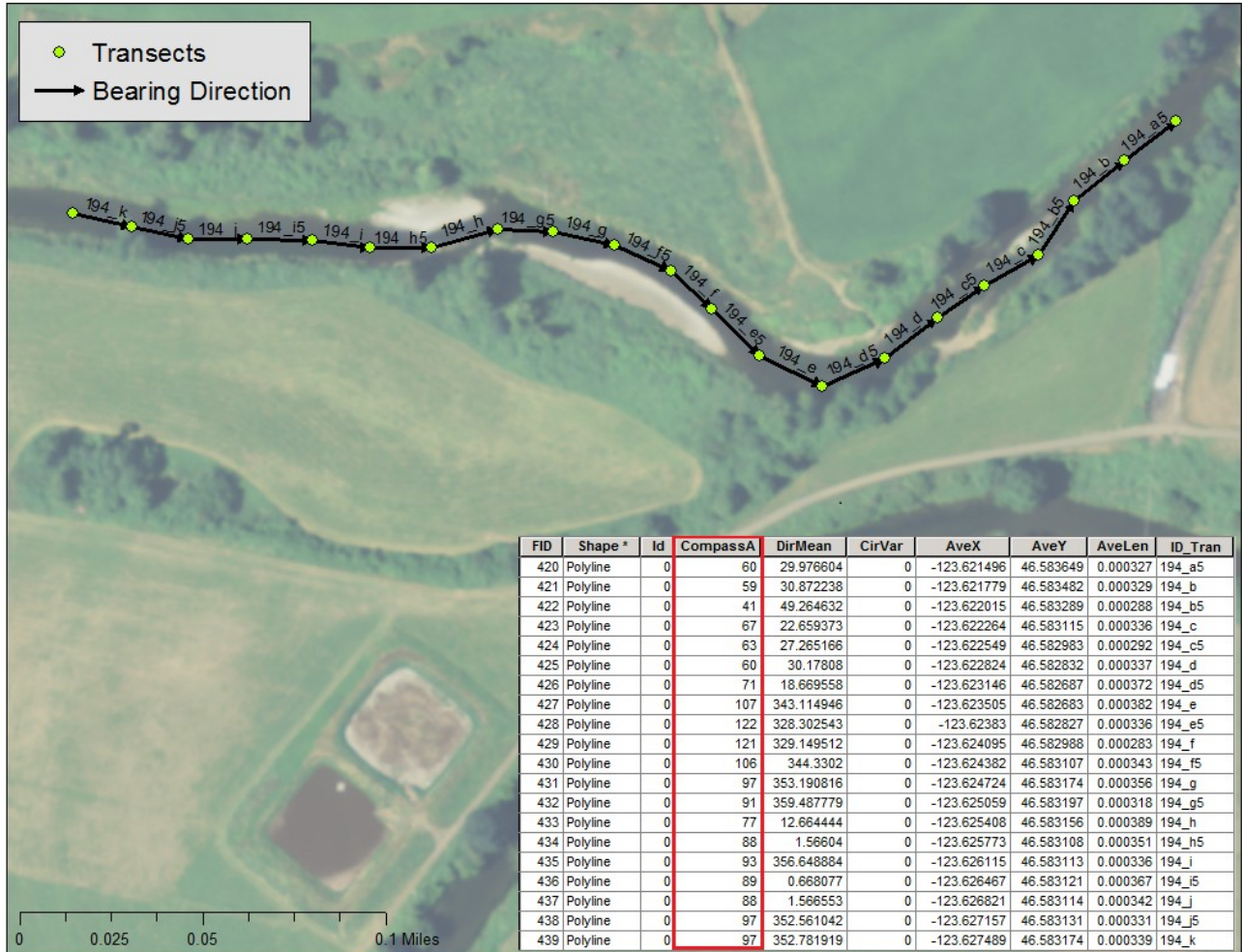


Figure 13. Tabular and spatial output from the Linear Directional Mean tool. Notice that all the “Bearing Direction” vectors point downstream. The CompassA field of the tabular output shows the compass direction for each segment of each site. A quick overview of the results suggests that the tool worked as expected for the site pictured.

7.0 Records Management

7.1 Refer to SOP EAP125 (Janisch, 2017).

7.2 During the course of each DCE, draw a site diagram using paper and pencil (Figure 14). Email a digital photograph of the site diagram to the project coordinator when submitting the electronic data forms for the DCE.

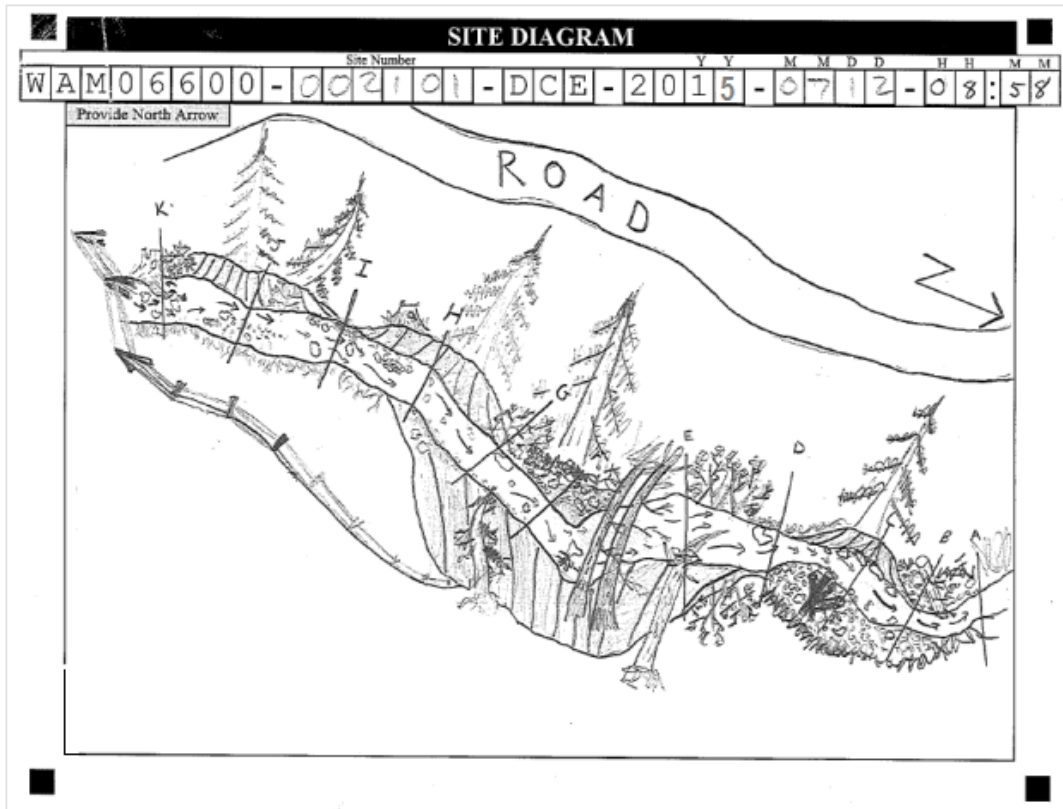


Figure 14. An example of a site diagram, drawn using paper and pencil.

8.0 Quality Control and Quality Assurance

- 8.1 PROJECT QA/QC is discussed in the Quality Assurance Monitoring Plan (Cusimano et al., 2006), which is in the process of being updated.
- 8.2 SAMPLING PRECISION: Repeat the sampling for 10% of all sites per year per Status and Trends Region. Timing of replicates should be several weeks or more following initial samples (as far apart in time as possible but within the same index period).
- 8.3 SAMPLING ACCURACY: Persons using this SOP must either attend the annual training event (June), or be trained by someone who did.
- 8.4 REPRESENTATIVENESS: Sample sites are randomly chosen using a Generalized Random Tessellation Stratified (GRTS) design. Samples must be collected from within the site boundaries (between transects A and K).
 - 8.4.1 Site verification should be finalized on the same day that all other data are collected for the DCE.
 - 8.4.2 Each random sample site must always correspond with a stream on the sample frame represented by the statistically derived coordinates for X.
 - 8.4.3 Field measurements assign an index station (X) on the stream that best represents (is closest to) the given coordinates, as measured by GPS. The sample site must always envelope the X (i.e., X must always be situated between Transects A and K).
 - 8.4.4 The stream represented on the frame must also correspond in geometry with a single NHD reach.

9.0 Safety

- 9.1 All field staff must comply with the requirements of the EA Safety Manual (Ecology, 2019).

10.0 References

- 10.1 Armantrout, N.B., compiler. 1998. Glossary of Aquatic Habitat Inventory Terminology. American Fisheries Society, Bethesda, Maryland.
- 10.2 Cusimano, R., G. Merritt, R. Plotnikoff, C. Wiseman, C. Smith, and WDFW. 2006. Status and Trends Monitoring for Watershed Health and Salmon Recovery: Quality Assurance Monitoring Plan. Washington State Department of Ecology, Olympia. <https://fortress.wa.gov/ecy/publications/documents/0603203.pdf>.
- 10.3 DNR. 2015. Boundaries of State-Owned Aquatic Lands. Washington State Department of Natural Resources, Olympia. http://file.dnr.wa.gov/publications/aqr_aquatic_land_boundaries.pdf.
- 10.4 Ecology. 2019. Environmental Assessment Program Safety Manual. Washington State Department of Ecology, Olympia.

- 10.5 Ecology 2015a. Washington Master Sample. Washington State Department of Ecology, Olympia, WA. [Internet page, accessed March 9, 2015].
<https://ecology.wa.gov/Research-Data/Data-resources/Geographic-Information-Systems-GIS/Data#m>.
- 10.6 Ecology. 2015b. Sampling Schedules for Watershed Health Monitoring. Washington State Department of Ecology, Olympia, WA. [Internet page, accessed March 9, 2015].
<https://ecology.wa.gov/Research-Data/Monitoring-assessment/River-stream-monitoring/Habitat-monitoring/Watershed-health/Sampling-schedules>.
- 10.7 Ecology. 2015c. EIM STREAM Map Search (Status and Trends Map). Washington State Department of Ecology, Olympia, WA. [Internet page, accessed March 9, 2015].
<https://fortress.wa.gov/ecy/eimreporting/Map/Map.aspx?MapType=STREAM>
- 10.8 Endreny, T.A. 2003. Fluvial Geomorphology Module, UCAR COMET Program and NOAA River Forecast Center, Syracuse, NY.
<https://www.therrc.co.uk/publications/fluvial-geomorphology-module>.
- 10.9 EPA [U.S. Environmental Protection Agency]. 2012. Hydrologic Processes: Bankfull Discharge (In Watershed Assessment of River Stability & Sediment Supply [WARSSS]). Internet page [last updated 3/6/2012].
<https://web.archive.org/web/20121030031039/http://water.epa.gov/scitech/datait/tools/warsss/bankfull.cfm>.
- 10.10 Grizzel, J. 2008a. Identifying Bankfull Channel Edge, Part 1. Video, 1 min. 52 sec. Washington State Department of Natural Resources, Forest Practices Board, Olympia.
www.dnr.wa.gov/Publications/fp_bfw_video_pt1.wmv.
- 10.11 Grizzel, J. 2008b. Identifying Bankfull Channel Edge, Part 2. Video, 9 min., 6 sec. Washington State Department of Natural Resources, Forest Practices Board, Olympia.
www.dnr.wa.gov/Publications/fp_bfw_video_pt2.wmv.
- 10.12 Horizon Systems Corporation. 2015. NHDPlus Website.
www.horizon-systems.com/NHDPlus/index.php.
- 10.13 Janisch, J. 2017. Watershed Health Monitoring: Standard Operating Procedures for Managing Electronic Data Forms with a Mobile Data-Collection Device. SOP EAP125. Washington State Department of Ecology, Environmental Assessment Program, Olympia.
- 10.14 JNRC. 1999. Statewide Strategy to Recover Salmon – Extinction is Not an Option, Chapter III: A Road Map to Recovery. Governor’s Salmon Recovery Office, Olympia, WA. www.digitalarchives.wa.gov/governorlocke/gsro/strategy/summary/roadmap.htm.
- 10.15 Leopold, L.B., W.W. Emmett, H.L. Silvey, and D. L. Rosgen. 1995. A Guide for Field Identification of Bankfull Stage in the Western United States. Online video, 31 min., closed captioned). Stream Systems Technology Center USDA, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.
www.fs.fed.us/biology/nsaec/assets/BankfullStageWestern/BankfullStageWesternUS1995.html.

- 10.16 Merritt, G. 2018. Standard Operating Procedure EAP106, Version 1.8: Standard Operating Procedures for Verification and Layout of Sites (Narrow Protocol). Publication 18-03-226. Washington State Department of Ecology, Environmental Assessment Program, Olympia. <https://fortress.wa.gov/ecy/publications/SummaryPages/1803226.html>.
- 10.17 Montgomery, D.R., and J.M. Buffington. 1993. Channel Classification, Prediction of Channel Response and Assessment of Channel Condition, Washington State. TFW-SH10-93-002. www.krisweb.com/biblio/gen_wadnr_montgomeryetal_1993_tfwsh1093002.pdf.
- 10.18 Montgomery, D.R. and J.M. Buffington. 1997. Channel-reach morphology in mountain drainage basins. *Geological Society of America Bulletin* 109(5): 596–611. http://stream.fs.fed.us/fishxing/fplibrary/Montgomery_1997_Channel-reach_morphology_in_mountain.pdf.
- 10.19 Montgomery, D.R., and J.M. Buffington, 1998. Channel processes, classification, and response. Pp. 13–42 in R. Naiman and R. Bilby (editors), *River Ecology and Management*, Springer-Verlag, New York. www.fs.fed.us/rm/boise/publications/watershed/rmrs_1998_montomeryr001.pdf.
- 10.20 National Geographic Society. 2017a. Collection: GIS. [Internet page, accessed January 19, 2017]. www.nationalgeographic.org/topics/gis/.
- 10.21 National Geographic Society. 2017b. Encyclopedic Entry: GPS. [Internet page, accessed January 19, 2017]. www.nationalgeographic.org/encyclopedia/gps/.
- 10.22 Office of the Chief Information Officer. 2010. Washington State. Policy 161.03 version 1: Hydrography Data Standard, adopted Dec. 21, 2010. <https://ocio.wa.gov/policies/>.
- 10.23 Ohio EPA. 2006. Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI). Ohio EPA Division of Surface Water.
- 10.24 Parsons, J., D. Hallock, K. Seiders, B. Ward, C. Coffin, E. Newell, C. Deligeannis, and K. Welch. 2018. Standard Operating Procedure EAP070, Version 2.2: Minimize the Spread of Invasive Species. Publication 18-03-201. Washington State Department of Ecology, Olympia. <https://fortress.wa.gov/ecy/publications/documents/1803201.pdf>.
- 10.25 Strahler, A.N. 1957. Quantitative analysis of watershed geomorphology. *Transactions of the American Geophysical Union* 38: 913–920.
- 10.26 U.S. Geological Survey. 2017a. Introduction to the NHD, Feature Attribution, Stream Order. [Internet page, accessed January 19, 2017]. https://usgs-mrs.cr.usgs.gov/NHDHelp/WebHelp/nhd_help_portal.html
- 10.27 U.S. Geological Survey. 2017b. Hydrography: The National Hydrography Dataset, Watershed Boundary Dataset. [Internet page accessed January 19, 2017] <http://nhd.usgs.gov/>.