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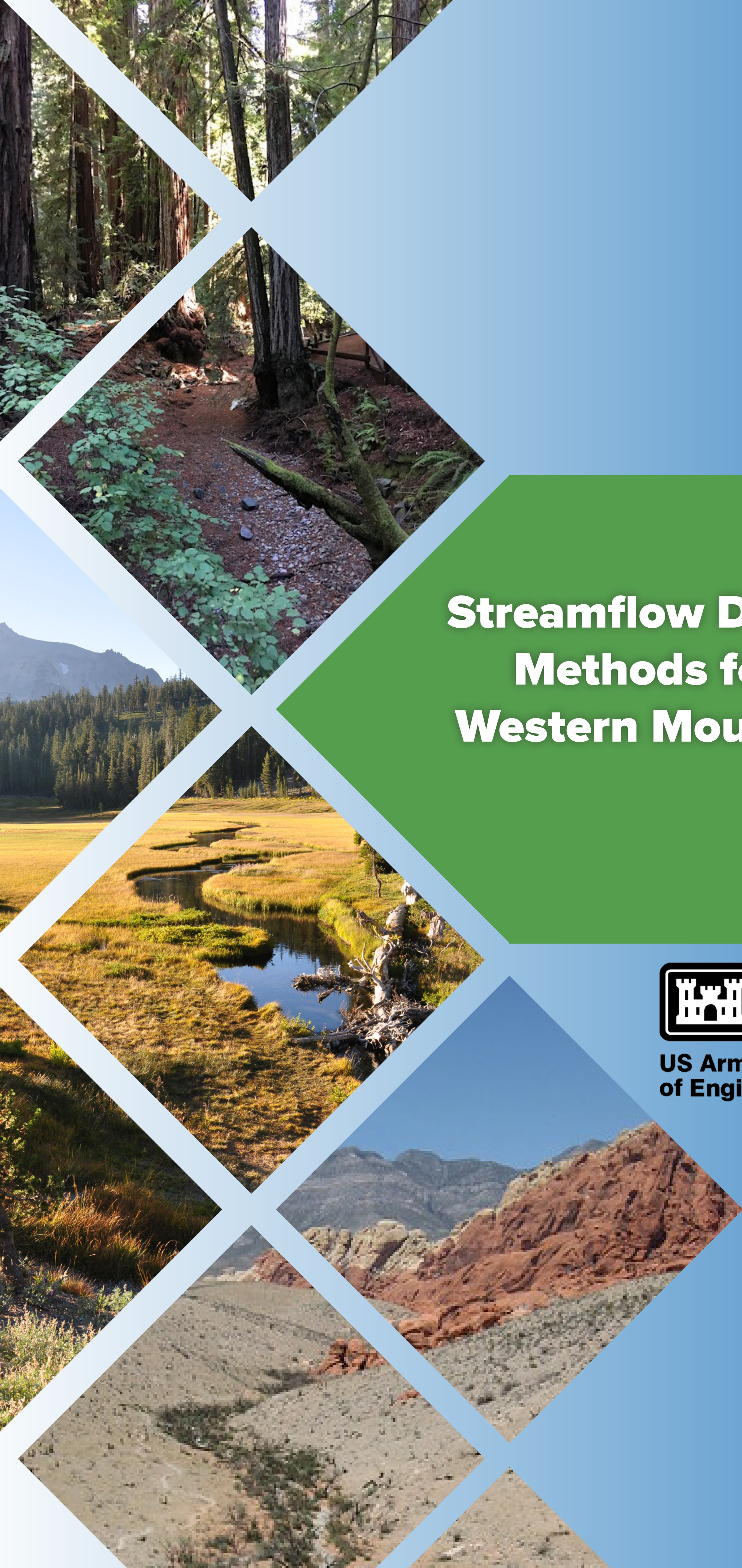

Streamflow Duration Assessment Methods for the Arid West and Western Mountains of the United States of America

US Army Corps of Engineers

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ENGINEER RESEARCH & DEVELOPMENT CENTER

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Streamflow Duration Assessment Methods for the Arid West and Western Mountains of the United States

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Section 1: Introduction and Background

Streams exhibit a diverse range of hydrologic regimes, and the hydrologic regime strongly influences the physical, chemical, and biological characteristics of active stream channels and adjacent riparian areas. Thus, information describing a stream's hydrologic regime is useful to support resource management and regulatory decisions. One important aspect of the hydrologic regime is streamflow duration—the length of time that a stream sustains surface flow. However, hydrologic data to determine flow duration has not been collected for most stream reaches nationwide. Although maps, hydrologic models, and other data resources exist (e.g., the National Hydrography Dataset, McKay et al. 2014), these may exclude small headwater streams and unnamed second- or third-order tributaries, and limitations on accuracy and spatial or temporal resolution may reduce their utility for many management applications (Hall et al. 1998, Nadeau and Rains 2007, Fritz et al. 2013). Therefore, rapid, field-based methods are needed to determine flow duration class at the reach scale (defined in Section 2: Overview of the AW and WM SDAMs and the Assessment Process) in the absence of long-term hydrologic data (Fritz et al. 2020).

These methods are intended to classify stream reaches into one of three streamflow duration classes[1]:

> *Ephemeral reaches* are channels that flow only in direct response to precipitation. Water typically flows only during and/or shortly after large precipitation events, the streambed is always above the water table, and stormwater runoff is the primary water source.
>
> *Intermittent reaches* are channels that contain sustained flowing water for only part of the year, typically during the wet season, where the streambed may be below the water table and/or where the snowmelt from surrounding uplands provides sustained flow. The flow may vary greatly with stormwater runoff.
>
> *Perennial reaches* are channels that contain flowing water continuously during a year of normal rainfall, often with the streambed located below the water table for most of the year. Groundwater typically supplies the baseflow for perennial reaches, but the baseflow may also be supplemented by stormwater runoff and/or snowmelt.

Example photographs and hydrographs of stream reaches in each class are shown in Figure 1.

[1] The definitions used for development of this manual are consistent with the definitions used to develop the SDAMs for the Pacific Northwest, the Great Plains, Northeast, and Southeast.

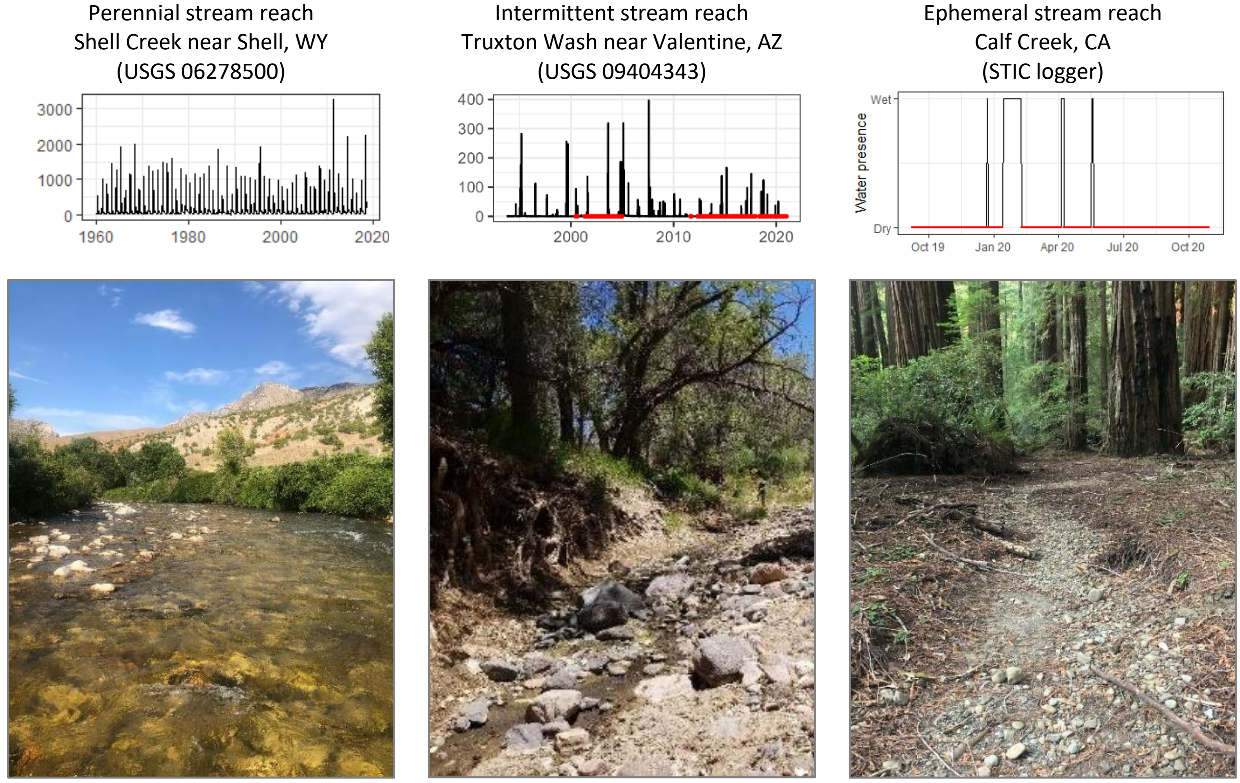


Figure 1. Examples of western stream reaches in each streamflow duration class. The left and center plots show hydrographs from USGS stream gages; units are in cubic feet per second. The right plot shows the presence of water inferred from a Stream Temperature, Intermittency, and Conductivity (STIC) logger, which measures positive raw intensity values when water is present. In all plots, red dots indicate dry conditions. Image credits: Lex Cobarrubias (left), Matthew Robinson (center), and Mason London (right).

These classes describe the typical patterns exhibited by a stream reach over multiple years, although observed patterns in a single year may vary due to extreme and transient climatic events (e.g., severe droughts). Although flow duration classes are not strictly defined by their sources of flow (e.g., storm runoff, groundwater, snowmelt), the duration is often related to the relative importance of different flow sources to stream reaches and the stability of their contributions. Perennial reaches have year-round surface flow in the absence of drought conditions. Intermittent reaches have one or more periods of extended surface flow in most years, where the flow is sustained by sources other than surface runoff in direct response to precipitation, such as groundwater, melting snowpack, irrigation, reservoir operations, or wastewater discharges. Ephemeral reaches have a surface flow for short periods and only in direct response to precipitation.

This manual describes the final Streamflow Duration Assessment Methods (SDAMs) intended to distinguish flow duration classes of stream reaches in the Arid West (AW) and Western Mountains (WM). These regions are defined by the Arid West and Western Mountains, Valleys and Coast regional supplements to the U.S. Army Corps of Engineers wetland delineation manual (U.S. Army Corps of Engineers 2008, 2010), excluding portions of the AW and WM regions that overlap with the states of Washington, Oregon, and Idaho, which are covered by the SDAM for the Pacific Northwest described in Nadeau et al. (2015). These regions are largely based on vegetation type and precipitation levels.

Throughout this manual, the term “The West” refers to the combined AW and WM regions, but not the Pacific Northwest.

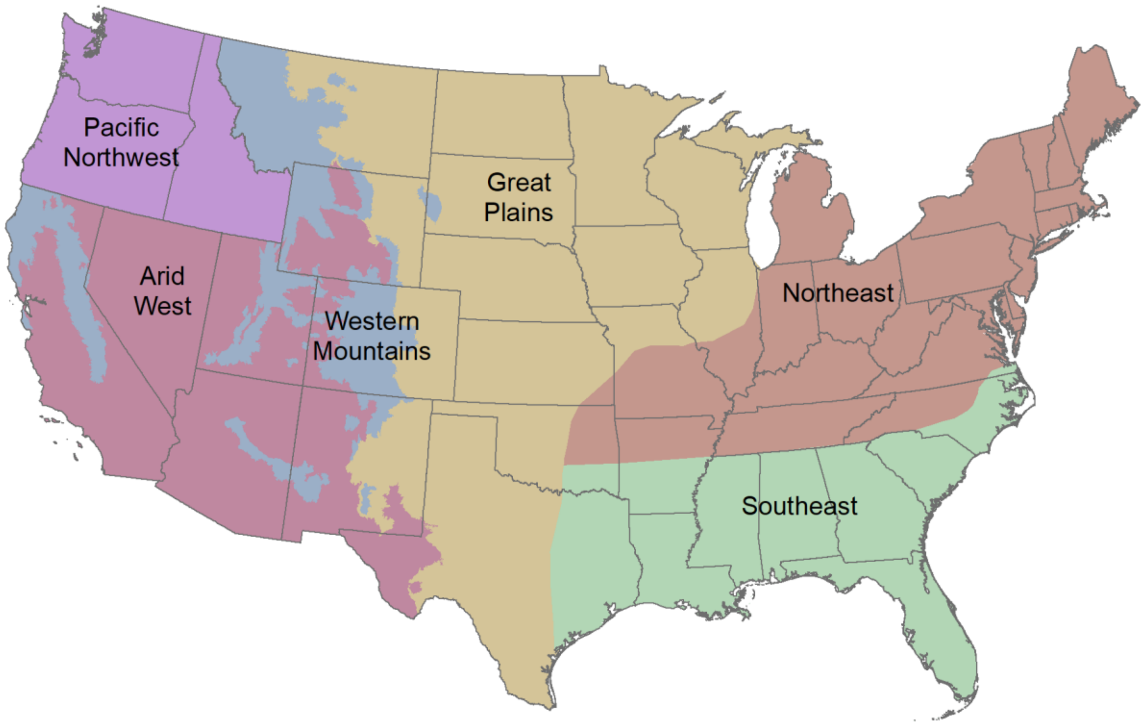


Figure 2. Map of flow duration study regions. “The West” refers to the combined Arid West and Western Mountain regions, but not the Pacific Northwest region.

The AW and WM SDAMs are based on biological and geomorphological indicators. Biological indicators, known to respond to gradients of streamflow duration (Fritz et al. 2020), have notable advantages for assessing natural resources. The primary advantage of these indicators is the ability to reflect long-term environmental conditions (e.g., Karr et al. 1986, Rosenberg and Resh 1993) making them well suited for assessing streamflow duration because some species reflect the aggregate hydrologic conditions a stream has experienced over multiple years. As a result, relatively rapid field observations of biological indicators made at a single point in time can provide long-term insights into streamflow duration and other hydrological characteristics of a stream reach. Geomorphological indicators can also be rapidly measured and provide information about the hydrologic drivers of streamflow duration. For example, wide channels in areas with low precipitation are associated with shorter durations of streamflow; in wetter areas, narrow channels are typically associated with headwaters where the contributing catchments may be too small to generate long-duration flows.

1.1 The SDAMs for the AW and WM

This manual describes two methods that use a small number of indicators to predict the streamflow duration class of wadeable stream reaches in the AW and WM. All indicators are measured during a single field visit. Beta SDAMs for the two regions were released in 2021 (see Mazor et al. 2021a and Mazor et al. 2021b). After additional data collection, analysis, and user feedback, these final SDAMs were developed, reflecting somewhat different indicators from the beta methods. For more information on the development of these SDAMs or SDAMs for other U.S. regions, please refer to the U.S. Environmental Protection Agency's (EPA) SDAM website.

The AW and WM SDAMs assign reaches to one of six possible classifications: ephemeral, intermittent, perennial, at least intermittent, less than perennial, and needs more information. An at least intermittent classification occurs when an intermittent or perennial classification cannot be made with high confidence, but an ephemeral classification can be ruled out. A less than perennial classification is the opposite; an ephemeral or intermittent classification cannot be made with high confidence, but a perennial classification can be ruled out. If no class can be determined with confidence, the stream is classified as needs more information.

Because the AW and WM SDAMs share many indicators in common, and because many practitioners work in both regions, the two methods are presented in a combined manual. When assessing reaches near the boundary between regions or in areas more closely matching the characteristics of a different SDAM region, practitioners are encouraged to measure all indicators required for both methods, although some indicators may only be used for one method.

Indicators of the AW and WM SDAMs

Biological indicators

- Prevalence of rooted upland plants in the streambed
- Differences in vegetation
- Shading (WM only)
- Algal cover (AW only)
- Abundance of Ephemeroptera, Plecoptera, and Trichoptera (WM only)
- Abundance of perennial indicator taxa
- Number of hydrophytic plant species

Geomorphological indicators

- Bankfull channel width
- Slope
- Riffle-pool sequence
- Particle size or stream substrate sorting (WM only)

The AW and WM methods were developed using a machine learning model known as random forest. Random forest models are increasingly common in the environmental sciences because of their superior performance in handling complex relationships among indicators used to predict classifications (Cutler et al. 2007). In some cases, a random forest model can be simplified into a decision tree or table (e.g., Nadeau et al. 2015, Mazor et al. 2021c); however, that was not possible for the AW or WM models. To obtain a flow classification for an individual assessment reach, there is an open-access, user-friendly web application for entering indicator data and running the region-specific random forest model. No data entered into the web application are visible to or stored by the EPA or any other agency.

1.2 Intended use and limitations

The AW and WM SDAMs are intended to support field classification of streamflow duration at the reach scale in streams with defined channels (having a bed and banks) in the AW and WM regions. Use of the SDAMs may inform a range of activities where information on streamflow duration is useful, including jurisdictional determinations under the Clean Water Act; however, the classification resulting from use of an SDAM is not in itself a jurisdictional determination. SDAMs are not mandatory for completing a Clean Water Act jurisdictional determination, nor are they intended to supersede more direct measures of streamflow duration (e.g., long-term records from stream gages). Other sources of information, such as aerial imagery, reach photographs, traditional ecological knowledge, and local expertise, can supplement the SDAMs when classifying streamflow duration (Fritz et al. 2020).

Although the AW and WM SDAMs are intended for use in both natural and altered stream systems, some alterations may complicate the interpretation of field-measured indicators or potentially lead to incorrect conclusions. For example, streams managed as flood control channels may undergo frequent maintenance to remove some or all vegetation in the channel and along the banks of the assessment reach. Although some biological indicators recover quickly from these disturbances, the results from assessments conducted shortly after such disturbances may be misleading. In addition, these types of channels may not display channel features that result from natural geomorphic processes, such as a typical riffle-pool sequence.

1.3 Development of the AW and WM SDAMs

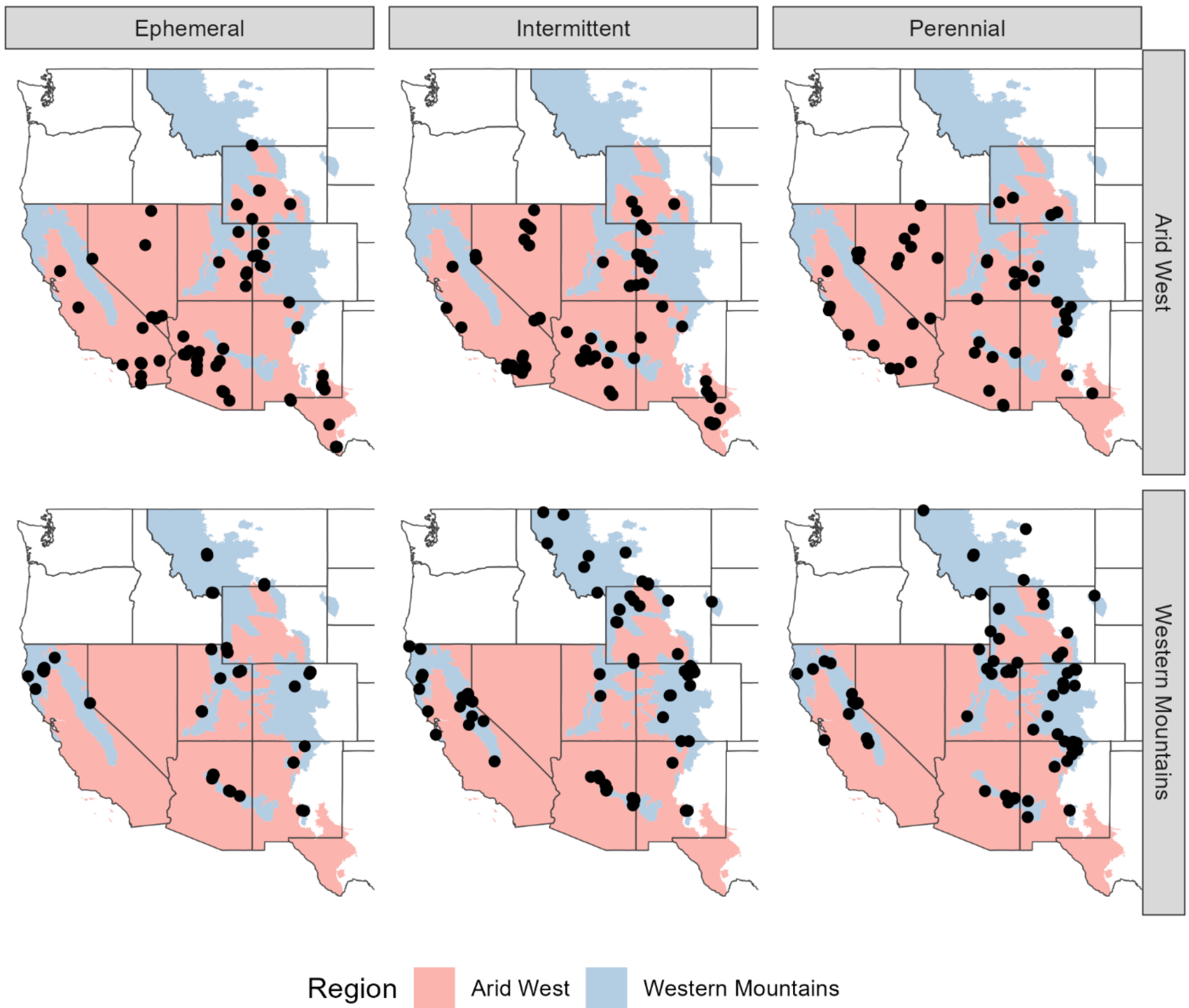


Figure 3. Locations of ephemeral, intermittent, and perennial stream reaches used to develop the AW and WM SDAMs.

These methods resulted from a multi-year study conducted in 194 locations in the AW region and 201 locations in WM region following the process described in Fritz et al. (2020). Of these, data from 387 sites (or reaches) where flow class could be determined from direct hydrologic data were used to develop the SDAMs (Figure 3). Streamflow duration class was directly determined from continuous (hourly interval) data loggers deployed at 209 study reaches during the data collection period. Streamflow duration classes were determined at an additional 101 study reaches from U.S. Geological Survey (USGS) gages. Multiple sources of hydrologic data (e.g., non-USGS stream gage data, published studies, consultation with local experts) were used to classify the remaining reaches (80) for which data from continuous loggers were not available. Four AW reaches and one WM reach were rejected from the study because streamflow duration class could not be determined. Data from three reaches in the AW (one intermittent and two perennial) were also excluded because data collection was incomplete. Thus, 187 reaches in the AW and 200 in the WM were used to develop the SDAMs; reaches were distributed across flow duration classes as shown in Table 1.

Table 1. Number of reaches in each flow duration class and region used to develop the AW and WM SDAMs.

Flow duration class	Arid West	Western Mountains
Ephemeral	68	56
Intermittent	71	78
Perennial	48	66
Total	187	200

Development of the SDAMs followed the process steps below (Fritz et al. 2020):

Preparation

- Conducted literature reviews (McCune and Mazor 2019, Mazor and McCune 2021):
  - Identified existing SDAMs, focusing on those originating in the AW or WM or developed using a similar approach (see Nadeau 2015; New Mexico Environmental Department (NMED) 2020).
  - Identified 27 potential field biological, hydrological, and geomorphological characteristics related to streamflow duration for evaluation in the AW and WM.
- Identified candidate study reaches with known streamflow duration class, representing diverse environmental settings throughout the region.

Data Collection: Beta Method Development

- Collected field data at 238 study reaches, visited up to 3 times each.

Data Analysis

- Evaluated 95 candidate indicators from the field data and geospatial indicators for their ability to discriminate among streamflow duration classes. Geospatial indicators included climatic measures that characterize hydrologic drivers of streamflow duration (e.g., long-term precipitation and temperature) and are straightforward to calculate.
- Calibrated a classification model using a machine learning algorithm (i.e., random forest).
- Refined and simplified the beta method for rapid and consistent application.

Evaluation / Beta Implementation

- Published a beta method, data analysis report, and data used to develop the method.
- Trained EPA and Corps staff on the beta method.
- Collected public comment and agency experience using the beta method for more than a year.
- Collected additional data at 152 additional study reaches and revisited a subset of the study reaches from beta method development efforts. Half the study reaches were visited at least 3 times, up to a maximum of 10 visits at a reach. A total of 387 study reaches were used across the AW and WM.

Re-Analysis and Evaluation

- Evaluated 97 candidate indicators from the field data and geospatial indicators for their ability to discriminate among streamflow duration classes. Geospatial indicators included climatic measures that characterize hydrologic drivers of streamflow duration (e.g., long-term precipitation and temperature) and are straightforward to calculate.
- Calibrated a classification model using a machine learning algorithm (i.e., random forest).
- Refined and simplified the final method for rapid and consistent application in light of the agency experience and public comments received on the beta method.

Implementation

- Publish User Manual, data analysis report, and data used to develop the method.
- Publish web application and code.
- Publish training materials to support implementation.
- Train EPA and Corps staff on the method and how to train others.

Eighty percent of sites in the development data set were used for method calibration, while twenty percent were withheld to provide an independent test of method performance.[2] Based on this withheld subset, the final methods correctly classified 64% of AW reaches and 69% of WM among three classes (*perennial* vs. *intermittent* vs. *ephemeral*). Accuracy was much higher for differentiating *ephemeral* from *at least intermittent* reaches (82% for the AW and 84% for the WM), as well as for differentiating *perennial* from *less than perennial* reaches (83% for the AW and 84% for the WM). Generally, misclassifications between intermittent and perennial reaches were more common than misclassifications between ephemeral and intermittent reaches. The ability of the AW and WM SDAMs to discriminate *ephemeral* more accurately and consistently from *at least intermittent* reaches is consistent with previous studies evaluating streamflow duration indicators and assessment methods (Fritz et al. 2008, 2013, Nadeau et al. 2015, Mazor et al. 2021).

[2] Note, Table 1 above includes all sites used in method development, those used to calibrate the model and the subset of sites withheld for determining accuracy.

Section 2: Overview of the AW and WM SDAMs and the Assessment Process

2.1 Considerations for assessing streamflow duration and interpreting indicators

2.1.1 Clean Water Act jurisdiction

Regulatory agencies evaluate aquatic resources based on current regulations, guidance, and policy. The AW and WM SDAMs do not incorporate that broad scope of analysis. Rather, the methods provide information that may support timely jurisdictional decisions because they help determine streamflow duration as ephemeral, intermittent, or perennial in the absence of hydrologic data.

2.1.2 Scales of assessment

The AW and WM SDAMs apply to an assessment reach, the length of which scales with the mean bankfull channel width. Regardless of channel width, reaches must be a minimum of 40 m and no longer than 200 m. The minimum reach-length of 40 m ensures that a sufficient area has been assessed to evaluate indicators. Quantification and observations of indicators are restricted to the bankfull channel and within one-half bankfull channel width from the top of each bank. However, ancillary information from outside the assessment reach (such as surrounding land use) is also recorded.

2.1.3 Spatial variability

Indicators of streamflow duration (and other biological, hydrologic, and geomorphic characteristics of streams) vary in their strength of expression within and among reaches in a stream system. The main natural drivers of spatial variation are generally the physiographic province (e.g., geology and soils) and climate (e.g., seasonal patterns of precipitation, snowmelt, and evapotranspiration). For example, certain indicators, such as riparian vegetation, may be more strongly expressed in a floodplain with deep alluvial soils than they would be in a reach underlain by shallow bedrock, even if both reaches have a similar duration of flow. Therefore, understanding the sources of spatial variability in streamflow indicators will help ensure that assessments are conducted within relatively homogenous reaches.

Common sources of variation within a stream system that may affect the expression of indicators include:

- Natural longitudinal changes in channel gradient, valley width, and size (e.g., going from a confined canyon to an alluvial fan, or going from wide to narrow valley).
- Other natural sources of variation, such as bedrock material (limestones, sandstones, shales, conglomerates, and lignite) or water source (runoff, springs, summer rains, and groundwater).
- Drought or unusually high precipitation.
- Transitions in land use with different water use patterns (e.g., from commercial forest to pasture, from pasture to cultivated farmland, or cultivated farmland to an urban setting), or changes in management practices (e.g., intensification of grazing).
- Stream management and manipulation, such as diversions, water importation, dam operations, and habitat modification (e.g., streambed armoring).

2.1.4 Temporal variability

Temporal variability in indicators may affect streamflow duration assessment in two ways: interannual (e.g., year-to-year) variability and intra-annual (e.g., seasonal) variability. These methods were developed to be robust to both types of temporal variability and is intended to classify streams based on their long-term patterns in either flowing or dry conditions. However, both long-term sources of temporal variability (such as El Niño-related climatic cycles) and short-term sources (such as scouring storms before sampling) may influence the ability to measure or interpret indicators at the time of assessment. Timing of management practices, such as dam operations, channel clearing, or groundwater pumping, may also affect the flow duration assessment.

Some indicators are highly responsive to temporal variability. For example, the AW is known to experience high intensity, short-lived flood events. After these scouring events, aquatic macroinvertebrates may be displaced from a stream reach. In contrast, rooted hydrophytic plants, if present, will likely remain. Similarly, greater numbers of aquatic macroinvertebrates may be able to colonize an ephemeral to intermittent reach during wet years, depending on the presence of upstream or downstream refugia; however, changes in flow regimes may take several years to result in changes to vegetation in the riparian corridor. For example, willows with well-established root systems are likely to survive in an intermittent reach experiencing severe drought, even when flow in a single year is insufficient to support aquatic macroinvertebrates in greater numbers or at all.

2.1.5 Ditches and modified natural streams

Assessment of streamflow duration is sometimes needed in canals, ditches, and modified natural streams that are primarily used to convey water. These systems tend to have altered flow regimes compared to natural systems with similar drainage areas (Carlson et al. 2019), and the AW and WM SDAMs may determine if these flow regimes support indicators consistent with different streamflow duration classes. Thus, the SDAMs may be applied to these systems when streamflow duration information is needed.

Geomorphological indicators (specifically, bankfull channel width and riffle-pool sequence) may be difficult to assess in straightened or heavily modified systems. Indicator measurements should be based on present-day conditions, not historic conditions. Assessors should note if the channel geomorphology reflects natural processes or if it reflects the effects of management activities.

2.1.6 Other disturbances

Assessors should be alert for natural or human-induced disturbances that either alter streamflow duration directly or modify the ability to measure indicators. Streamflow duration can be directly affected by groundwater withdrawals, flow diversions, urbanization and stormwater management, septic inflows, agricultural and irrigation practices, effluent dominance, or other activities. In the method development data set, disturbed reaches were identified as those in urban or agricultural settings or those with notable impacts from grazing, mining, or other human activities; the two SDAMs had slightly lower accuracy in assessing disturbed reaches compared to undisturbed reaches for identification of ephemeral, intermittent and perennial flow, but almost no difference when assessing ephemeral versus at least intermittent flow.

Streamflow duration indicators can also be affected by disturbances that may not substantially affect streamflow duration (for instance, grading, grazing, recent fire, riparian vegetation management, and bank stabilization); in extreme cases, these disturbances may eliminate specific indicators (e.g., absence of aquatic macroinvertebrates in channels that have undergone recent grading activity). Groundwater pumping, impoundments, and diversions can affect both vegetation and geomorphological indicators (e.g., Friedman et al. 1997). Some long-term alterations or disturbances (e.g., impoundments) can make streamflow duration class more predictable by reducing year-to-year variation in flow duration and/or indicators. Discussion of how specific indicators are affected by disturbance is provided in Section 3: Data Collection. Assessors should describe disturbances in the "Notes on disturbances or difficult site conditions" section of the field form.

2.1.7 Multi-threaded systems

Assessors should identify the lateral extent of the active channel, based on the outer limits of ordinary high-water mark (OHWM), and apply the method to that area. That is, do not perform separate assessments on each of the main and secondary channels within a multi-threaded system. Some indicators may be more apparent in the main channel versus the secondary channels; note these differences on the field form. Upland islands within the OHWM should not be included within the assessment.

Section 3: Data Collection

3.1 Conduct desktop reconnaissance

Before an assessment, desktop reconnaissance helps ensure a successful assessment of a stream. During desktop reconnaissance, assessors evaluate reach accessibility and set expectations for conditions that may affect field sampling. In addition, assessors can begin to compile additional data that may inform determination of streamflow duration, such as location of nearby stream gages.

Desktop Reconnaissance for:

- Access, permissions and permits;
- Reach placement;
- Watershed and site context; and
- Flora and fauna lists.

This stage of the evaluation is crucial for determining reach access. The reach or project area should be plotted on a map to determine access routes and whether landowner permissions are required. Safety concerns or hazards that may affect sampling should be identified, such as road closures, controlled burns, or hunting seasons. These access constraints are sometimes the most challenging aspect of environmental field activities, and desktop reconnaissance can reduce these difficulties. Also, assessors can determine if inaccessible portions of the reach (e.g., those on adjacent private property) have consistent geomorphology or other attributes, compared with accessible portions.

Desktop reconnaissance can also help identify features that may affect assessment reach placement or determine the number of assessment reaches required for a project. Look for natural and artificial features that may affect streamflow duration at the reach—particularly those that may not be evident during the field visit, or that are on inaccessible land outside the assessment area. These features include sharp transitions in geomorphology, upstream dams or reservoirs, springs, storm drains and major tributaries. It may be possible to see bedrock outcrops or other features that modify streamflow duration in sparsely vegetated areas.

A preliminary assessment of adjacent landuse may be ascertained during desktop reconnaissance. This preliminary assessment should be verified during the field visit.

Evaluating watershed characteristics during desktop reconnaissance can produce useful information that will help assessors anticipate field conditions or provide contextual data to help interpret results. The USGS StreamStats tool, as well as the EPA's WATERS GeoViewer, provide convenient online access to watershed information for most assessment reaches in the United States, such as drainage area, soils, land use or impervious cover in the catchment, or modeled bankfull channel dimensions and discharge.

Assessors should consider consulting local experts and agencies to gain further insights about reach conditions and request additional available data. For example, state agencies may have records on water quality sampling indicating times when the reach was sampled and when it was dry. Local experts may have information about changes in the reach's streamflow.

Local or regional flora lists of species known to grow in the vicinity of an assessment reach may be available to assist with plant identification and helpful for determining a plant's hydrophytic status. Nearby public land managers (such as U.S. Forest Service or the National Park Service) should be consulted to see if they have lists of common riparian plants in the vicinity of the assessment reach. Several online databases can generate regionally appropriate flora lists and/or assist with identification (Table 2). Consult the appropriate list for your location (see further discussion under 3.8.5 Number of hydrophytic plant species.

Table 2. Examples of online resources for generating local flora lists.

Resource	Geographic coverage
National Wetlands Plant List	United States and territories
The Biota of North America Program (BONAP) Vascular Flora Taxonomic Data Center	United States and territories
USDA Plants Database	United States and territories
Lady Bird Johnson Wildflower Center	Continental U.S. (native species only)
SEINet	Arizona, New Mexico, and Colorado
Calflora	California
Arizona Native Plant Society	Arizona and adjacent desert regions
Rocky Mountain Herbarium	Montana, Wyoming, Colorado, Utah, Arizona, and New Mexico
California Native Plant Society	California

Desktop reconnaissance also helps determine if permits are required to collect aquatic macroinvertebrates. Threatened and endangered species may be expected in the area, and stream assessment activities may require additional permits from appropriate federal, Tribal and state agencies. Additional information on threatened or endangered species may be found on the U.S. Fish and Wildlife Service's Environmental Conservation Online System, as well as at state resource agencies and natural heritage programs.

3.2 Prepare sampling gear

The following gear is suggested for completion of the AW and WM SDAMs.

- This manual and field forms (paper or digital).
- Convex spherical densiometer, prepared as described in 3.8.4 Shading (WM only).
- Clipboard, pencils, permanent markers, field notebook.
- Flagging tape.
- Clinometer or laser range finder with slope and stadia rod.
- Maps and aerial photographs (1:250 scale if possible).
- Global Positioning System (GPS) – used to identify the downstream boundary of the reach assessed. A smartphone that includes a GPS may be a suitable substitute.
- Tape measures – for measuring bankfull channel width and reach length.

- Kick-net or small net and tray – used to sample aquatic macroinvertebrates.
- Hand lens or field scope – to assist with plant and aquatic macroinvertebrate identification.
- Featherweight forceps and/or dropper for sorting macroinvertebrates
- Digital camera (or smartphone with camera), plus charger. Ideally, use a camera that automatically records metadata, such as time, date, directionality, and location, as part of the EXIF data associated with the photograph.
- Shovel, soil auger, rock hammer, hand trowel, pick or other digging tools to facilitate hydrological observations of subsurface flow.
- Aquatic macroinvertebrate field guides (e.g., *A Guide to Common Freshwater Invertebrates of North America* Voshell 2002).
- Vials filled with 70% ethanol and sealable plastic bags for collection of biological specimens, with sample labels printed on waterproof paper.
- Bags or plant press for collecting plant vouchers.
- Hydrophytic plant identification guides (e.g., *Trees and Shrubs of California*, Stuart and Sawyer 2001; *Western Wetland Flora: An Introduction to the Wetland and Aquatic Plants of the Western United States,* Chadde 2019).
- The U.S. Army Corps of Engineers list of wetland plants for sites to be visited.
- Boots or waders.
- First-aid kit, sunscreen, insect repellant, and appropriate clothing.

Ensure that all equipment is functional before each assessment visit and has been cleaned off-site between assessment visits to prevent the spread of invasive species. Sampling gear that comes into contact with the water (such as nets and boots or waders) should be properly decontaminated to prevent the spread of aquatic invasive species. California's Surface Water Ambient Monitoring Program provides up-to-date information on gear decontamination methods, such as scrubbing, drying, freezing, or treating with pesticides and herbicides. Stop Aquatic Hitchhikers, an initiative of Aquatic Nuisance Species Task Force sponsored by USFWS also provides resources and links.

3.3 Order of operations for completing the AW and WM SDAM field assessments

After completing the in-office activities described above, the following general workflow is recommended for efficiency in the field:

1. Walk Assessment Reach (avoid walking in channel)

- Confirm assessment reach placement in the field (3.5.1).
- Measure the bankfull channel width at 3 locations and calculate average to determine assessment reach length and identify reach boundaries (3.5.2). Record average bankfull channel width in Step 2.
- Record coordinates of downstream reach boundary from center of channel and photograph reach.
- Begin to note expression and strength of indicators (except bankfull width and aquatic macroinvertebrate indicators).
- Take photographs at middle and upstream end of reach.
- Start sketching assessment reach on field form.

2. Record General Reach Information on Field Form (3.7.1)

3. Evaluate Indicators (3.8)

- Collect aquatic macroinvertebrates from reach, starting from downstream end.
- Measure slope.
- Sort and identify aquatic macroinvertebrates. If two practitioners are available, one should proceed with other measurements while the other conducts this step.
- Measure other indicators:
  - Measure percent shading at top, middle and bottom of reach.
  - Identify hydrophytic vegetation taxa and determine presence/absence of upland plants in the channel.
  - Assess live or dead algal cover on the streambed (AW only).
  - Assess the degree to which the riparian corridor has different or more vigorous vegetation than surrounding uplands.
  - Assess the expression and degree of riffle-pool sequence.
  - Assess the degree of substrate sorting and/or difference of channel substrate material from surrounding uplands (WM only).
- Complete sketch of the assessment reach on the field form.

4. Review Field Form for Completeness

5. Enter Data into Web Application (in office)

3.4 Timing of sampling

Ideally, application of the AW and WM SDAMs should occur during the growing season when many aquatic macroinvertebrates are most active, hydrophytes are readily identifiable, and differences in vegetation or growth vigor in the riparian corridor are easier to discern. In many parts of the West, the optimal time of sampling is typically between April and June, when biological indicators are most readily apparent in less-than-perennial reaches. Assessments may be made during other times of the year, but there is an increased likelihood of specific indicators being dormant or difficult to observe at the time of assessment, especially in higher elevations of the WM, where the presence of snow and channel ice during the colder months may also be a factor. However, most of the indicators included in the methods persist well beyond a single growing season (e.g., hydrophytic vegetation) or are not dependent on it (e.g., geomorphological indicators), reducing the sensitivity of the methods to the timing of sampling.

These protocols may be used in flowing streams as well as in dry or drying streams. However, care should be taken to avoid sampling during flooding conditions and assessors should wait at least one week after large storm events that impact vegetation and sediment in the active stream channel before collecting data to allow aquatic macroinvertebrates and other biological indicators to recover (Grimm and Fisher 1989; Hax and Golladay 1998; Fritz and Dodds 2004) and water level and clarity to stabilize and enable clear observation of physical features. In general, aquatic macroinvertebrate abundance is suppressed during and shortly after major channel-scouring events, potentially leading to inaccurate assessments. Recent rainfall can interfere with measurements (e.g., by washing away aquatic macroinvertebrates). Assessors should note recent rainfall events on the field form and consider the timing of field evaluations to assess each indicator's applicability. Field evaluations should not be completed within one week of significant rainfall that results in surface runoff. Local weather data and drought information should be reviewed before assessing a reach or interpreting indicators. Evaluating antecedent precipitation data from nearby weather stations after each sampling event helps to determine if storms may have affected data collection and informs interpretation of SDAMs data. The Antecedent Precipitation Tool (APT; U.S. Army Corps of Engineers 2023) can also be helpful for evaluating recent precipitation conditions at a site relative to the 30-year average.

3.5 Assessment reach considerations

3.5.1 Reach placement

Stream assessments should begin by walking the channel's length, to the extent feasible, from the target downstream end to the top of the assessment reach. This initial review of the reach allows the assessor to examine the channel's overall form, landscape, parent material, and variation within these attributes as they develop or disappear upstream and downstream. This helps determine whether adjustments to assessment reach boundaries are needed, or whether multiple assessment reaches are needed to adequately characterize streamflow duration throughout the project area where information is needed. Walking alongside, rather than in, the channel is recommended for the initial review to avoid unnecessary disturbance to the stream. Walking alongside the channel also allows the assessor to observe the surrounding landscape's characteristics, such as land use and sources of flow (e.g., stormwater pipes, springs, seeps, and upstream tributaries).

The assessor should document the areas along the stream channel where various sources (e.g., stormflow, tributaries, or groundwater) or sinks of water (alluvial fans, abrupt changes in bed slope, etc.) may cause abrupt changes in flow duration. When practical, assessment reaches should have relatively uniform channel morphology. When evaluating the reach's homogeneity, focus on permanent features that control streamflow duration (such as valley gradient and width), rather than on the presence or absence of surface water. Project areas that include confluences with large tributaries, significant changes in geologic confinement, or other features that may affect flow duration may require separate assessments above and below the feature.

For some applications, reach placement is dictated by project requirements. For example, a small project area may be fully covered by a single assessment reach. In these cases, assessment reaches may contain diverse segments with different streamflow duration classes (e.g., a primarily perennial reach with a short intermittent portion where the flow goes subsurface). In these cases, the portions of the reach with long-duration flows will likely have a greater influence on the outcome than the portions with short-duration flows, depending on each portion's relative size.

Natural features, such as bedrock outcrops or valley confinements, and non-natural features like culverts or road crossings may alter hydrologic characteristics in their immediate vicinity. For example, culverts may create plunge pools, and drainage from roadways is often directed to roadside ditches that enter the stream near crossings, leading to a potential increase in indicators of long streamflow duration. Specific applications may require that these areas be included in the assessment, even though they are atypical of the larger assessment reach. For other applications, the area of influence may be avoided by moving the reach at least 10 m up- or downstream.

3.5.2 Reach length

An assessment reach should have a length equal to ***40 bankfull channel-widths,*** with a minimum length of 40 m and a maximum of 200 m. An assessment reach should not be less than 40 m in length to ensure that sufficient area is assessed to observe and appropriately measure indicators. Assessments based on reaches shorter than 40 m may not detect all indicators and could provide inaccurate classifications.

Bankfull channel width is averaged from measurements at three locations: at the bottom of the reach, 15 m upstream, and 30 m upstream from the bottom of the reach, or at three locations that are representative of the reach as a whole. See 3.7.1 General reach information and 3.8.1 Bankfull channel width for more guidance on measuring bankfull channel width. Width measurements are made at bankfull elevation, perpendicular to the thalweg (i.e., the deepest point within the channel that generally has the greatest portion of flow); how to find bankfull elevation is discussed in 3.7 Conducting assessments and completing the field form. In multi-thread systems, the bankfull width is measured for the entire active channel, based on the outer limits of the OHWM. Reach length is measured along the thalweg. If access constraints require a shorter assessment reach than needed, the actual assessed reach-length should be noted on the field form along with an explanation for why a shortened reach was necessary.

Note that bankfull channel width is also an indicator of streamflow duration, as described below in 3.8.1 Bankfull channel width.

3.5.3 How many assessment reaches are needed?

The outcome of an assessment applies to the assessed reach and may also apply to adjacent reaches some distance upstream or downstream if the same conditions are present. The factors affecting spatial variability of streamflow duration indicators (described above) dictate how far from an assessment reach a classification applies. More than one assessment may be necessary for a large or heterogenous project area, and multiple assessments are usually preferable to a single assessment. In areas that include the confluence of large tributaries, road crossings, or other features that may alter the hydrology, multiple assessment reaches may be required (e.g., one above and one below the feature).

3.6 Photo-documentation

Photographs can provide strong evidence to support conclusions resulting from application of the AW and WM SDAMs, and extensive photo-documentation is recommended. Taking several photos of the reach condition and any disturbances or modifications relevant to making a final streamflow duration classification is strongly recommended. Specifically, the following photos should be taken as part of every assessment:

- A photograph from the top (upstream) end of the reach, looking downstream.
- Two photographs from the middle of the reach, one looking upstream and one looking downstream.
- A photograph from the bottom (downstream) end of the reach, looking upstream.

Photographs that illustrate the following are also strongly recommended:

- Hydrophytic plant identifications, showing diagnostic features and extent within the reach.
- Extent of rooted upland plants in channel.
- Typical riffle-pool sequence, if present.
- Particle size and/or stream substrate sorting.
- Disturbed or unusual conditions that may affect the measurement or interpretation of indicators.

3.7 Conducting assessments and completing the field form

3.7.1 General reach information

After walking the reach and determining the appropriate boundaries for the assessment area, record on the field form the project name, reach code or identifier, waterway name, assessor(s) name(s), and the date of the assessment visit. These data provide essential context for understanding the assessment but are not indicators for determining streamflow duration class.

<u>Coordinates</u>

Record the coordinates of the downstream end of the reach from the center of the channel.

<u>Weather conditions</u>

Note current weather conditions (e.g., rain and intensity, sun, clouds, snow). If known, note precipitation within the previous week on the datasheet, and consider delaying sampling, if possible. If rescheduling is not possible, note whether the streambed is recently scoured, and if turbidity is likely to affect the measurement of indicators.

<u>Surrounding land use</u>

A preliminary assessment of surrounding land use should be conducted during desktop reconnaissance (see 3.1 Conduct desktop reconnaissance). Once at the site, verify whether the preliminary assessment is correct, making sure to note evidence of human activities that may not be evident in or have occurred since the aerial imagery.

Indicate the dominant land-use around the reach within a 100-m buffer. Check up to two of the following:

- Urban/industrial/residential (buildings, pavement, or other anthropogenically hardened surfaces).
- Agricultural (e.g., farmland, crops, vineyard, pasture).
- Developed open space (e.g., golf course, sports fields).
- Forested.
- Other natural.
- Other (describe).

<u>Bankfull channel width</u>
Measure bankfull channel width values (to nearest 0.1 m) at 0, 15, and 30 m above the downstream end of the reach or at three locations spread out over approximately one-third of the expected reach length and record values on the field form (Figure 4 and Figure 5). Note, this approach replicates how the data used to develop these SDAMs were collected at study reaches across the West. Widths should be measured perpendicular to the thalweg. In multi-threaded systems, width measurements should span all channels within the OHWM. Calculate the average width.

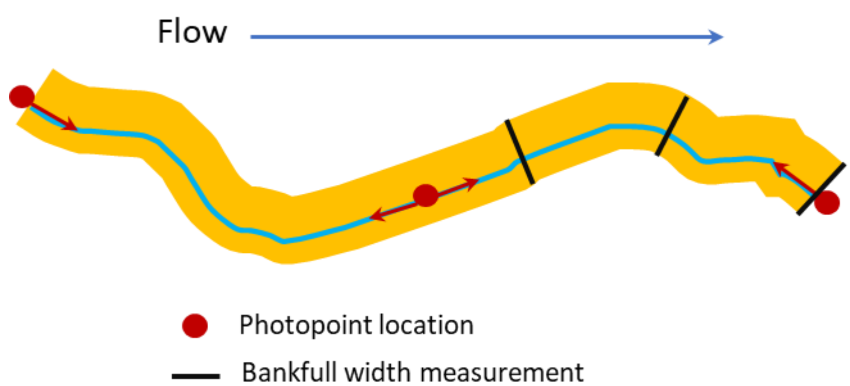


Figure 4. Bankfull measurement and photopoint locations. Bankfull is represented by the yellow area and the blue line represents the thalweg of the channel. Bankfull width should be measured at three locations that are representative of the expected reach length.

Figure 5. Measuring bankfull width. Image credit: James Treacy

The bankfull width[3] is the portion of the channel that contains the bankfull discharge, which is a flow event that occurs frequently (typically every 1.01 to 5 years; David and Hamill 2024), but that does not include larger flood events. The bankfull discharge has an important role in forming the physical dimensions of the channel. For many stream channels, the bankfull elevation (from where bankfull width is measured) can be identified in the field by an obvious slope break that differentiates the channel from a relatively flat floodplain terrace higher than the channel, or a transition from exposed stream sediments or more water and scour tolerant vegetation (e.g., willows) to terrestrial and intolerant vegetation (David et al. 2022). In locations without vegetation, moss growth on rocks along the banks can be an indicator of bankfull height as can breaks in bank slope or changes in substrate composition.

Certain indicators of bankfull height may be more or less evident in different stream types, so assessors should evaluate multiple bankfull indicators when measuring bankfull channel width. The bankfull width should be measured in a straight section of the stream (e.g., riffle, run, or glide if present) that is representative of the study reach. Pools and bends in the stream or areas where the stream width is affected by the deposition of rocks, debris, fallen trees, or other unusual constrictions or expansions should be avoided. In the field, it may often be possible to determine the bankfull channel width using bankfull indicators on only one bank of the stream. This point can be used as a reference to determine the bankfull elevation on the opposite bank by creating a level line across the stream from the identified bankfull elevation perpendicular to the stream flow.

[3] Resources for bankfull identification are found on the SDAM training materials site.

In larger systems (e.g., drainage area > 0.5 square miles), it may be helpful to compare field measurements to bankfull channel dimensions derived from regional curves relating bankfull dimensions to watershed characteristics. These models may be derived at large regional scales (e.g., StreamStats; U.S. Geological Survey 2024) or a local scale (e.g., Texas: Asquith et al. 2020 Wyoming: Foster (2012)). Bieger et al. (2015) provide regional curves for several regions of the continental United States. If observed bankfull dimensions are substantially different from estimated bankfull dimensions derived from regional curves (e.g., more than twice the maximum or less than half the minimum estimates), it may be helpful to re-evaluate bankfull indicators that were used to establish bankfull channel height. Regional curve estimates for bankfull dimensions of small channels (small drainage areas) may be extrapolated outside the range used to develop relationships so such estimates have unknown errors (bias) associated with them and should be used with caution if at all.

Note that bankfull channel width is also an indicator of streamflow duration, as described below in 3.8.1 Bankfull channel width.

Describe reach length and boundaries

Record the reach length in meters as described in 3.5.2 Reach length. Record observations about the reach on the field form, such as changes in land use, disturbances, or natural changes in stream characteristics that occur immediately up or downstream. If the reach is less than 200 m and shorter than 40 times the average bankfull channel width, explain why a shorter reach length was appropriate. For example: “The downstream end is 30 m upstream of a culvert under a road. The upstream end is close to a conspicuous dead tree just past a large meander, near a fence marking a private property boundary. The reach length was shortened to 150 m to avoid neighboring private property.”

Photo-documentation of reach

Record the photo ID or number, or check the designated part of the field form for required photographs taken from the bottom (facing upstream), middle (facing upstream and downstream) and top (facing downstream) of the reach (see Figure 4).

Disturbed or difficult conditions

Note any disturbances or unusual conditions that may create challenges for assessing flow duration. Common situations include practices that alter hydrologic regimes, such as diversions, culverts, discharges of effluent or runoff, and drought. Note circumstances that may limit the growth of hydrophytes and/or affect stream geomorphology, such as channelization, or vegetation removal that may affect the measurement or interpretation of several indicators Figure 6. Also note if the stream appears recently restored, for example, stream armoring with large substrate or wood additions and recently planted vegetation in the riparian zone.

Figure 6. Examples of difficult conditions that may interfere with the observation or interpretation of indicators. Left: As the Arroyo Trabuco progresses through the city of San Juan Capistrano in California, its banks have been hardened and the natural riparian vegetation has been removed (although there is still aquatic vegetation apparent in the channel itself). The removal of in-stream and riparian zone habitat and addition of urban non-point source discharges may also impact the abundance of aquatic macroinvertebrates and hardened banks may obscure identification of bankfull elevation. Right: An unnamed creek near Vacaville, California, has been straightened and channelized, affecting naturally occurring stream pattern (e.g., riffle-pool sequence). Image credits: Raphael Mazor (left) and the California Department of Fish and Wildlife's Aquatic Bioassessment Lab (right).

Observed hydrology

Surface flow

Visually estimate or use a tape measure to determine the percentage of the reach length that has flowing surface water or subsurface flow. The reach sketch should indicate where surface flow is evident and where dry portions occur.

Subsurface flow

If the reach has discontinuous surface flow, investigate the dry portions to see if subsurface flow is evident. Examine below the streambed by turning over cobbles and digging with a trowel. Resurfacing flow downstream may be considered evidence of subsurface flow (Figure 7). Other evidence of subsurface flow includes:

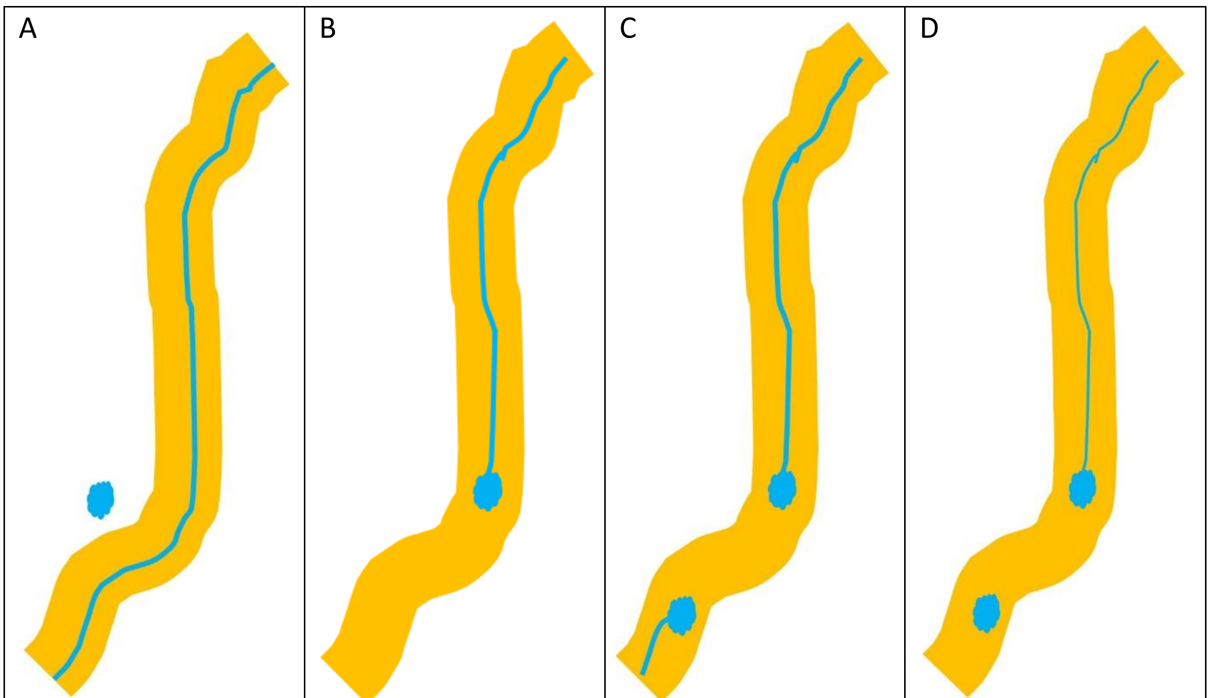
- Flowing surface water disappears into alluvial deposits and reappears downstream. This scenario is common when a large, recent alluvium deposit created by a downed log or other grade-control structure creates a sharp transition in the channel gradient or in valley confinement.
- Water flows out of the streambed (alluvium) and into isolated pools.
- Water flows below the streambed and may be observed by moving streambed rocks or digging a small hole in the streambed.
- Shallow subsurface water can be heard moving in the channel, particularly in steep channels with coarse substrates.

Record the percent of the reach length with subsurface and surface flow (combined). That is, the percent of reach length with subsurface flow should be greater than or equal to the percent of reach length with surface flow (Figure 7).

The reach sketch should indicate where subsurface flow is evident.

Number of isolated pools

If the reach is dry or has discontinuous surface flow, look for isolated pools within the channel that provide aquatic habitat. If there is continuous surface flow throughout the reach, enter 0 (zero) isolated pools. The reach sketch should indicate the location of pools in the channel or on the floodplain (Figure 7). However, only isolated pools within the channel are counted, including isolated pools within secondary channels that are part of the active channel and within the OHWM. Pools connected to flowing surface water and isolated pools on the floodplain do not count. Dry pools (i.e., pools that contain no standing water at the time of assessment) do not count.



100% surface flow **100%** surface + subsurface flow **0** isolated pools	**70%** surface flow **70%** surface + subsurface flow **0** isolated pools	**80%** surface flow **100%** surface + subsurface flow **0** isolated pools	**70%** surface flow **70%** surface + subsurface flow **1** isolated pool

Figure 7. Examples of estimating surface and subsurface flow, and isolated pools. Orange represents the dry channel and blue represents surface water in the channels. White represents the floodplain outside the channel. The pool in A does not count because it is outside the channel, whereas the pools in B and C do not count because they are connected to flowing surface water. In contrast, the lower pool in D counts because it is isolated from any flowing surface water and is within the channel.

3.7.2 *Assessment reach sketch*

Sketch the assessment reach on the field form indicating important features, such as access points, important geomorphological features, the extent of dry or aquatic habitats, riffles, pools, etc. Note locations where photographs are taken and where channel measurements are made.

3.8 How to measure indicators of streamflow duration

Eight indicators are required for the AW SDAM, and ten indicators are required for the WM SDAM; seven indicators are shared by both methods. All required indicators must be measured to obtain a classification.

Biological indicators

- Prevalence of rooted upland plants in the streambed
- Differences in vegetation
- Shading (WM only)
- Algal cover (AW only)
- Aquatic macroinvertebrate indicators
    - Abundance of perennial indicator taxa
    - Abundance of Ephemeroptera, Plecoptera, and Trichoptera (WM only)
- Number of hydrophytic plant species

Geomorphological indicators

- Bankfull channel width
- Slope
- Riffle-pool sequence
- Particle size or stream substrate sorting (WM only)

Most indicators are positive indicators of streamflow duration; that is, a greater abundance or score of these indicators is generally associated with longer duration flows (Dodds et al. 2004, Burk and Kennedy 2013, Bigelow et al. 2020). For example, hydrophytic riparian corridor vegetation and a stronger riffle-pool sequence are both associated with perennial reaches. Percent shading is typically slightly higher at intermittent reaches than at ephemeral or perennial reaches. Slope and bankfull channel width have a less straightforward relationship with streamflow duration, and these indicators serve to modify the interpretation of other indicators. Although larger bankfull widths and lower-gradient slopes are often associated with longer flow duration, large, low-gradient ephemeral reaches are also common, particularly in the AW. Rooted upland plants are negative indicators of streamflow duration, as the prevalence of upland plants on the streambed is lower at reaches with greater flow duration.

These indicators are based on what is observed at the time of assessment, not on what would be predicted to occur if the channel were wet or in the absence of disturbances or modifications. Disturbances and modifications (e.g., vegetation management, channel hardening, diversions) should be described in the “Notes” section of the datasheet and are considered when drawing conclusions.

Common ways that disturbances can interfere with indicator measurement are described within each indicator description, where applicable. The indicators are presented in the order they appear on the field forms, also reflecting the recommended order of operations for efficiency in the field.

3.8.1 Bankfull channel width

Bankfull channel width is generally associated with streamflow duration, as wider channels tend to reflect longer-lasting flows. However, this pattern is sometimes reversed in more arid regions and in regions overlying alluvial geology, particularly in the AW. Bankfull channel width is measured (to the nearest 0.1 m) at three locations during the initial layout of the assessment reach and then averaged, as described in 3.5 Assessment reach considerations (see Figure 4 and Figure 5). In multi-threaded channels, the width of the entire active channel is measured, based on the outer limits of the OHWM. Wohl et al. (2016) describe the active channel as the portion of the valley bottom distinguished by one or more of the following characteristics:

- Channels defined by erosional and depositional features created by river processes (as opposed to upland processes, such as sheet flow or debris flow).
- The upper elevation limit at which water is contained within a channel.
- Portions of a channel generally without trunks of mature woody vegetation.

3.8.2 Aquatic macroinvertebrate indicators

The WM SDAM has two indicators based on aquatic macroinvertebrates, and one of these indicators is also used in the AW SDAM. Both indicators are measured from the same sample collection effort described below.

Sample Collection Instructions

Aquatic macroinvertebrates are assessed within the defined reach. A kick-net or D-frame net is used to collect specimens. Assessors begin sampling at the most downstream point in the assessment reach and proceed to sample in the upstream direction. Where there is rapidly flowing water, the net is placed perpendicular against the streambed while the substrate is disturbed upstream of the net for a minimum of one minute. This disturbance will dislodge and suspend aquatic macroinvertebrates such that they are carried by the stream flow into the net. For slower flowing or standing water areas, jab the net under banks, overhanging terrestrial and aquatic vegetation, leaf packs, and in log jams or other woody material to dislodge and capture aquatic macroinvertebrates and the leaves or other light materials they may be clinging to. Samples should be collected from **at least six** distinct locations representing the different habitats occurring in the reach. Without releasing aquatic macroinvertebrates, strain the net contents to remove fine sediments that would interfere with observing them. Empty contents of the net into a white tray with fresh stream water for determining abundance of individuals present.

Searching is complete when:

- **At least six different locations within the reach have been sampled** across the range of habitat types **and** a minimum of **15 minutes** of effort expended (not including specimen identification time), **or**
- **All available habitat in the assessment reach has been completely searched** in less than 15 minutes. A search in dry stream channels with little bed or bank development and low habitat diversity may be completed in less than 15 minutes.

During the 15-minute sampling period, search the full range of habitats present, including: water under overhanging banks or roots, in pools and riffles, accumulations of leaf packs, woody debris, and coarse inorganic particles (i.e., pick up rocks and loose gravel). If a reach contains both dry and wet areas, focus on searching the wet habitats, as these are the most likely places to encounter aquatic macroinvertebrates, but do not ignore dry areas.

Dry channels: Focus the search on areas serving as refuge such as any remaining pools or areas of moist substrate for living aquatic macroinvertebrates and under cobbles and other larger bed materials for evidence such as caddisfly casings (Figure 8) and snail shells. Exuviae of emergent mayflies or stoneflies may be observed on dry cobbles or stream-side vegetation (Figure 8). In summary, sampling methodology consistent with the Xerces Society's recommendations on using aquatic macroinvertebrates as indicators of streamflow duration (Blackburn and Mazzacano 2012) as developed for the Pacific Northwest SDAM (Nadeau 2015) is recommended. Take care, especially in dry channels, to only collect aquatic species and life stages. Field guides (e.g., Voshell 2002) and identification keys (e.g., Merritt et al. 2019) are recommended for both experienced and novice practitioners.

When searching dry channels (or dry portions of partially wet channels), be sure to avoid counting terrestrial macroinvertebrates in the streambed. Figure 9 depicts some taxa (especially snails) that may be found near stream channels in the West, though this list is certainly not exhaustive. If you are unsure whether the macroinvertebrates you encounter are aquatic or terrestrial, collecting a voucher specimen and identifying it in a lab setting or consulting an entomologist is recommended.

Taxonomic identification: Analysis of samples can occur streamside with live specimens. Alternatively, samples may be preserved in 70% ethanol for off-site analysis and identified with an appropriate guide (e.g., Merritt et al. 2019) or sent to a professional lab. For SDAM development, all insects and mollusks were identified to the family level, while other organisms were identified to the order or class level. However, for the AW and WM SDAMs, family-level identifications are only necessary for four insect orders: Ephemeroptera, Plecoptera, Trichoptera, and Coleoptera. Non-insects and insects in other orders are not used as indicators in either SDAM. Appendix B presents more information on family-level identification for this indicator. Photos (if feasible) should be taken of any taxon in question to allow further identification to be made off-site, if necessary. If the identification is uncertain, then describe any distinguishing features that were observed in the notes.


Figure 8. Examples of evidence of aquatic macroinvertebrates in dry channels. Left: Caddisfly cases may persist under large cobbles or boulders well after the cessation of flow. Right: Stonefly (Plecoptera) exuvia. Exuviae are left behind when aquatic nymphs or pupae emerge from the stream and go through a final molt to metamorphose to winged adults. Image credits: Raphael Mazor.


Figure 9. Examples of terrestrial macroinvertebrates you may find in a dry channel. Left: larva of soldier flies (Stratiomyidae). Right: garden snail (*Cornu aspersum*).

3.8.2.1 Abundance of Ephemeroptera, Plecoptera, and Trichoptera (WM only)

This indicator is based on the abundance of aquatic macroinvertebrates in the orders of mayflies, stoneflies, and caddisflies (i.e., Ephemeroptera, Plecoptera, and Trichoptera, or EPT). EPT are widespread insects in perennial and intermittent streams but are not typically found in ephemeral streams. Indicate on the field form how many mayflies, stoneflies, or caddisflies are encountered in the reach in the macroinvertebrate sample. Living aquatic lifestages (e.g., larvae or pupae) and non-living material (e.g., caddis cases, shed exuviae) all count towards this indicator. Photos are included in Appendix B. This indicator counts the number of individuals found, which may come from the same or different orders, such that no one family counts for more than 11 individuals in the total. For example, observing 25 Heptageniidae (flathead mayflies) only counts for 11 individuals in the total number of individuals of EPT taxa. There is also a box for indicating that no aquatic macroinvertebrates were observed in the assessment reach.

The abundance of EPT taxa may be recorded in these categories:

- 0 EPT individuals observed
- 1 to 4 EPT individuals observed
- 5 to 9 EPT individuals observed
- 10 to 19 EPT individuals observed
- 20 or more EPT individuals observed

3.8.2.2 Abundance of perennial indicator taxa

This aquatic macroinvertebrate indicator is used in both the AW and WM SDAMs. This indicator is based on the abundance of aquatic macroinvertebrate families that were identified as perennial indicator taxa in data from across the western United States. These taxa are more commonly found in perennial reaches, although they may also occur in intermittent or ephemeral reaches (typically at lower abundance).

Eleven families were identified as indicators of perennial flows in the West (Table 3). Indicator species analysis determines if ≥2 sets of samples (e.g., samples from perennial vs. intermittent vs. ephemeral reaches) differ in relative abundances and occurrence frequencies of different taxa (DeCaceres and Legendre 2009). All but one of these families are in the Orders of Ephemeroptera, Plecoptera, and Trichoptera. Living material (e.g., live larvae or pupae) and non-living material (e.g., caddis cases, shed exuviae) all count towards this indicator. This indicator counts the number of individuals found, which may come from the same or different families, such that no one family counts for more than 11 individuals in the total. For example, observing 25 Perlidae (common stoneflies) only counts for 11 individuals in the total number of individuals of perennial indicator taxa. There is also a box for indicating that no aquatic macroinvertebrates were observed in the assessment reach.

Table 3. Perennial indicator families for the AW and WM SDAMs.

Order	Family
Ephemeroptera (mayflies)	Ephemerellidae (spiny crawler mayflies) Heptageniidae (flathead mayflies) Leptohyphidae (little stout crawler mayflies) Leptophlebiidae (prong-gilled mayflies)
Plecoptera (stoneflies)	Chloroperlidae (green stoneflies) Perlidae (common stoneflies)
Trichoptera (caddisflies)	Brachycentridae (humpless casemaker caddisflies) Glossosomatidae (saddle casemaker caddisflies) Hydropsychidae (common net-spinner caddisflies) Rhyacophilidae (free-living caddisflies)
Coleoptera (beetles)	Elmidae (riffle beetles)

The abundance of perennial indicator taxa may be recorded in these categories:

- No perennial indicator taxa detected
- 1 to 4 perennial indicator individuals
- 5 to 9 perennial indicator individuals
- 10 to 19 perennial indicator individuals
- 20 or more perennial indicator individuals

3.8.3 Slope

Slope has an indirect relationship with streamflow duration and can help modify the interpretation of other indicators measured as part of the SDAM. Reaches with very high slopes are often ephemeral headwaters, and lower slopes are typical of perennial mainstem reaches. However, these patterns can be reversed, particularly in the AW, where headwaters often have longer flow durations than lower portions of the watershed.

Slope is measured as the percent slope between the upper and lower extent of the assessment reach. This task requires a two-person team (Figure 10). One person stands at bankfull elevation at the downstream end of the reach, and a second person stands within eyesight at the opposite end of the reach, also at bankfull elevation. This measurement requires direct line-of-sight between the lower and upper ends of the reach. If direct line-of-sight from the bottom to top of the reach is not possible, the slope of the longest representative portion of the reach should be 'line-of-sight' evaluated. If multiple slope measurements are needed, the average slope of the assessment reach should be recorded (note, calculation of the average slope would need to be weighted by the channel distance represented by each slope measurement). Slope should be recorded to the nearest half-percent. Some low-gradient streams may have slopes that are indistinguishable from zero using this method.

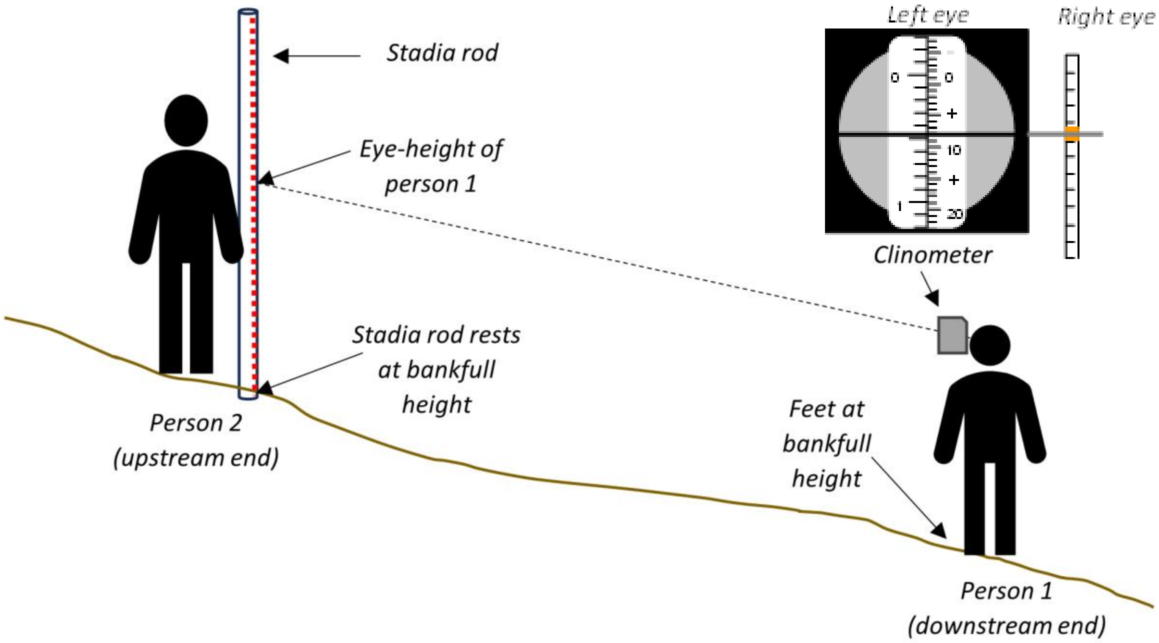


Figure 10. Schematic illustration of slope measurement using a clinometer.

3.8.4 Shading (WM only)

Data used to develop the WM SDAM indicated that intermittent reaches tended to have higher levels of shading than ephemeral or perennial reaches. Ephemeral reaches may have insufficient flow to support extensive riparian forests that provide shade, whereas some perennial reaches may be too wide for streamside vegetation to affect sun exposure in the middle of the channel. Although this pattern was also evident with data collected for the AW SDAM, the best predictive model for the AW SDAM did not include this indicator.

Using a convex spherical densiometer, stream shading is estimated in terms of the percent cover of objects (e.g., vegetation, buildings, canyon walls, etc.) that have the potential to block sunlight. The method used in the WM SDAM uses the Strickler (1959) modification of a densiometer to correct for over-estimation of stream shading that occurs with unmodified readings. Taping off (Figure 11) the lower left and right portions of the mirror emphasizes overhead structures over foreground structures (the main source of bias in stream shading measurements).

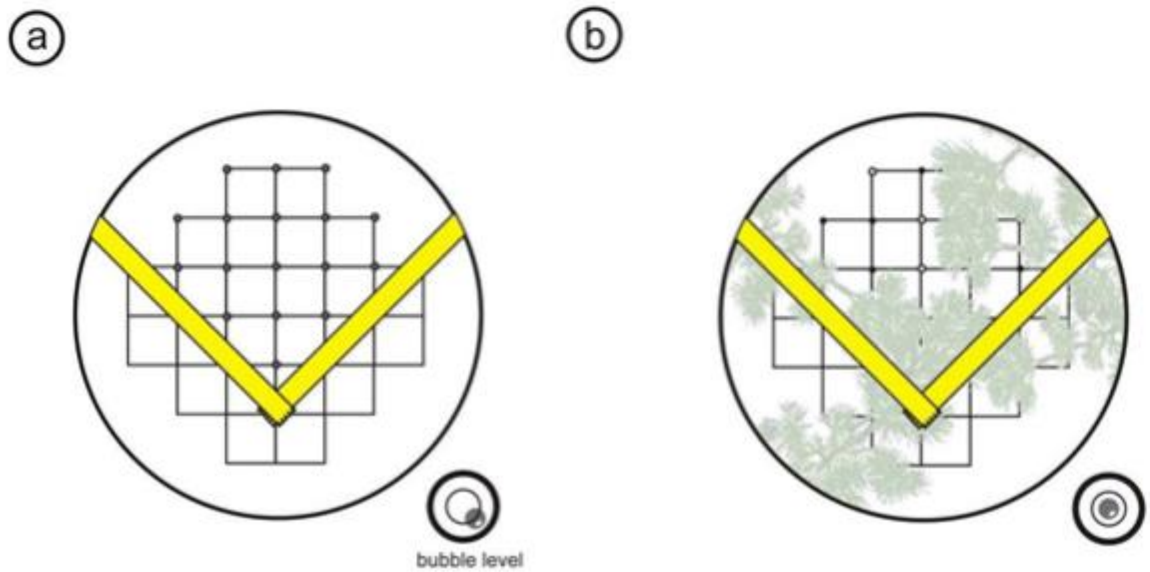


Figure 11. Representation of the mirrored surface of a convex spherical densiometer showing the position for taping the mirror and the intersection points used for the densiometer reading. The score for the hypothetical condition (b) is 9 out of 17 possible covered intersection points within the "V" formed by the two pieces of tape.

The densiometer is read by counting the number of line intersections on the mirror that are obscured by overhanging vegetation or other features that prevent sunlight from reaching the stream. If measurements are being taken when leaves of deciduous woody vegetation are not fully expressed, count all grid intersections that lie within the branches of the woody vegetation. So rather than looking at individual tree leaves, look at the "zone of influence" of vegetative cover (Nadeau et al. 2020).

All densiometer readings should be taken at 0.3 m above the water surface (or dry streambed surface) and with the bubble on the densiometer leveled. The densiometer should be held just far enough from the squatting observer's body so that his/her forehead is just barely obscured by the intersection of the two pieces of tape, when the densiometer is oriented so that the "V" of the tape is closest to the observer's face.

Take and record four readings from the center of each of three transects: a) facing upstream, b) facing downstream, c) facing the left bank, d) facing the right bank. Each recording should be an integer value ranging from 0 to 17. The observer should revolve around the densiometer (i.e., the densiometer pivots around a point) over the center point of the transect (as opposed to the densiometer revolving around the observer). Read and record densiometer readings at the top, middle, and bottom of the reach, for a total of 12 readings (four readings at each of three transects). The indicator is then recorded as the percent of points covered by shade-casting objects, total points covered divided by 204 and multiplied by 100.

3.8.5 Number of hydrophytic plant species

For the AW and WM SDAMs, hydrophytes are defined as those with a Facultative Wetland (FACW) or Obligate (OBL) wetland indicator status in the regional National Wetland Plant Lists (NWPL, U.S. Army Corps of Engineers 2020). The two western NWPL regions (i.e., the Arid West and Western Mountains, Valleys and Coasts) are identical to the SDAM regions (AW and WM, respectively). Indicator status for certain species may differ between regions; therefore, it is important to consult the correct list when determining indicator status. For example, California corn lily (*Veratrum californicum*), a common, widespread herb often found growing in wetlands and riparian zones, is FACW in the AW but only Facultative (FAC) in the WM. Conversely, mule fat (*Baccharis salicifolia*) is rated FAC in the AW but FACW in the WM.

Hydrophytic plant species that exhibit an odd or unusual distribution pattern in the assessment reach should not be considered among the number of hydrophytic plant species present. Examples of odd or unusual distribution patterns are described below:

- Isolated individuals, or small patches covering only a small portion of the total assessment area (e.g., < 2%) and only found in one location (as opposed to plants sparsely distributed throughout the reach). Hyperlocal hydrologic conditions may support the growth of hydrophytes in an otherwise unsuitable stream reach. In more arid regions, this can occur at road crossings, where road runoff increases water availability to vegetation (Figure 12).
- Long-lived species exclusively represented by seedlings or plants less than one-year old. A large flood may promote the growth of hydrophytes in streams that are normally too dry to sustain them (Figure 13).
- Old specimens clearly in decline. This scenario may be a sign of major long-term reductions in water availability due to changes in water use practices or to extreme and/or persistent drought (Figure 14).

These species may be recorded on the field form, along with notes explaining the unusual distribution patterns observed, but should not be among the number of hydrophyte species entered for this SDAM indicator.

Figure 12. Local conditions that support growth of hydrophytes. In Ridgecrest, California, a culvert at an ephemeral stream crossing disrupts the movement of water, sustaining the growth of hydrophytes in the immediate vicinity. Photo credit: Cara Clark.

Figure 13. Long-lived species only represented by young specimens. Red alders (*Alnus rubra*), while abundant at Mission Creek in the Mojave Desert, were only observed as seedlings. Photo credit: Raphael Mazor.

Figure 14. Water-stressed riparian trees near Oro Grande on the Mojave River. Reproduced from Lines (1999).

For this indicator, identify hydrophytic plant species growing within the channel or up to one half-channel width from the channel of the assessment reach that do not have unusual or odd distribution patterns. Hydrophytes growing at greater distances from the channel may be supported by local water sources not related to streamflow in the assessment reach. Once six taxa are identified, counting can stop; however, where the user may not be confident in all identifications, more species should be assessed, if possible.

In general, focusing on the most dominant species in the reach is efficient. Take photos of each plant species, focusing on diagnostic features and photos that illustrate the abundance and environmental context where the species grows. Where practical, voucher material (e.g., flowers, leaves, etc.) may be collected and preserved (e.g., in a plant press) for later identification.

If the site is devoid of vegetation, check the box marked “No vegetation within reach.”

Common questions about identifying hydrophytes

Are FACW and OBL plants equally important?
Yes. For this method, OBL and FACW plants are equally important indicators of streamflow duration.

Do Facultative (FAC) or Facultative Upland (FACU) status plants count?
No. Although some applications of the NWPL treat FAC or FACU plants as hydrophytes, they do not count towards this indicator for the AW or WM SDAM. For instance, some important, high-profile riparian species are FAC in some or all of the NWPL regions applicable to the West, such as American sycamore (*Platanus occidentalis*; AW), eastern cottonwood (*Populus deltoides*; AW and WM regions), desert willow (*Chilopsis linearis*, AW and WM regions), and mule fat (*Baccharis salicifolia*, AW region). This exclusion in no way lessens the ecological importance or conservation value of these plants, but rather it indicates their relative tolerance for drier conditions than FACW or OBL species.

What if a species is not included in the NWPL?
If a plant is not included in the NWPL, assume that it is not a hydrophyte unless environmental context strongly indicates otherwise. (See “What if I can’t confidently identify a dominant plant?” below.)

Is genus-level identification sufficient?
It depends on the genus. Consult the NWPL. Some genera contain high levels of diversity (e.g., *Carex*), while others are dominated by wetland species (e.g., *Ludwigia*). For instance, across the AW and WM, nearly all willow (*Salix*) species are hydrophytes (although there are a few exceptions), so genus-level identifications of willows are usually acceptable. Post-sampling confirmation based on photos or collected specimens is recommended.

What if I can’t confidently identify a dominant plant?
It may be acceptable to use environmental context and cues to determine that a plant is a hydrophyte, even if taxonomic identifications cannot be made. Examples include submerged or emergent hydrophytes, or plants observed to grow exclusively in saturated soil and absent from adjacent uplands (Figure 15). Post-sampling confirmation based on photos or collected specimens is strongly recommended. Photo documentation should convey this context. Photo confirmation is particularly important if the only hydrophytes observed in an assessment cannot be identified on-site. Photos can also be used when consulting plant identification applications that use image recognition (e.g., Seek, iNaturalist).

What if a hydrophytic plant species covers <2% of the assessment area (channel width plus ½ channel width on both sides of the channel x reach length) or is represented only by seedlings and/or dead/dying individuals?
Do not consider the species among the number of hydrophyte plant species present in the reach. The species with such distributions can be photographed and noted for additional information on the reach.

Figure 15. Examples of plants determined to be hydrophytes based on context. Left: An emergent hydrophyte growing within the channel. Right: Sedges and cattails growing exclusively in the streamside zone absent from adjacent uplands.

3.8.6 Prevalence of rooted upland plants in the streambed (AW and WM)

Few plants can tolerate the conditions they would experience on the streambed of a reach with relatively long flow durations. Prolonged inundation, soil saturation, and sheer stress create an inhospitable environment for most upland plants, preventing their establishment or perseverance. Thus, the prevalence of upland plants in the streambed indicates that flows have insufficient frequency, duration, or severity to limit these species (Figure 16).

For this indicator, upland plants are those with Facultative (FAC), Facultative upland plants (FACU) and Upland (UPL) species on the most recent regionally appropriate National Wetland Plant List (Lichvar et al. 2016). Species not listed in the NWPL (No Indicator; NI) are also considered upland plants.

When assessing this indicator, the focus should be on plants rooted on the entire streambed, including the thalweg. Upland plants growing on any part of the bank or on upland islands within the OHWM should not be considered. A user will indicate the prevalence of upland plants growing in the streambed along the entire reach and identify them on the field form. This indicator is scored as shown in Table 4. Note that a ***lower*** score indicates ***greater*** prevalence of rooted upland plants in the streambed.

This indicator is derived from the New Mexico Hydrology Protocol (NMED 2020). As with other indicators derived from the New Mexico Hydrology Protocol, “moderate” scores (i.e., 2) are intended as an approximate midpoint between the extremes of “poor” and “strong”. Half scores (i.e., 0.5, 1.5, and 2.5), mid-way between the scores shown in Table 4 are appropriate to allow the assessor the flexibility to characterize this indicator more continuously.

Figure 16. Example of an ephemeral stream with rooted upland vegetation growing in the channel. Where vegetation is growing within the streambed of Agua Chinon in southern California, it is dominated by mule fat (*Baccharis salicifolia*) which is rated FAC on the National Wetland Plant List for the Arid West region. Chaparral yuccas (*Hesperoyucca whipplei*), which is not listed in the NWPL, also grows on the streambed.

Table 4. Scoring guidance for the Rooted Upland Plants indicator.

Score	Evidence of perennial flows	Guidance
0	Poor	Rooted upland plants are prevalent within the streambed/thalweg.
1	Weak	Rooted upland plants are consistently dispersed throughout the streambed/thalweg.
2	Moderate	There are a few rooted upland plants present within the streambed/thalweg.
3	Strong	Rooted upland plants are absent from the streambed/thalweg.

3.8.7 Algal cover (AW only)

Visually estimate the extent of algal cover on the streambed (from the toe of one bank to the toe of the other) over the entire assessment reach. Algal cover is based on the entirety of the streambed and is not restricted to the wetted channel. In braided systems, estimate algae cover as a percent of the streambed of the entire active channel. Diagrams in Figure 17 can help visualize increasing levels of algal cover.

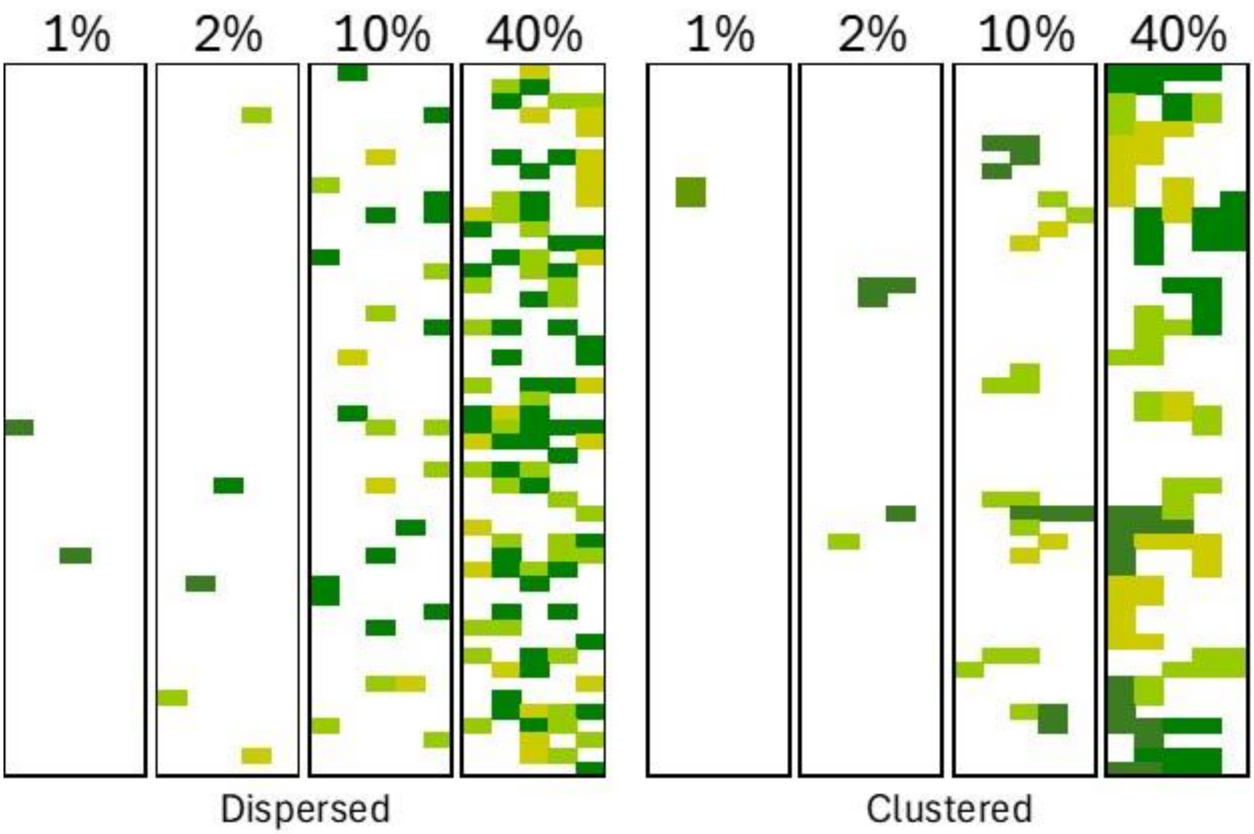


Figure 17. Visual guides to assist estimates of algal cover on a streambed. The left side shows a relatively dispersed distribution, whereas the right side shows a more clustered distribution.

Algae are visible as a pigmented mass or film, or sometimes hair-like growths on submerged surfaces of rocks, logs, plants, and any other structures within the channel, and may form mats that cover portions of the streambed. Microscopic algae associated with biofilm can be felt as a slippery film on substrates, but growth must be extensive enough to be visible to the naked eye to be counted. Periphyton growth is influenced by chemical disturbances such as increased nutrient (nitrogen or phosphorus) inputs and physical disturbances such as increased sunlight to the stream from riparian zone disturbances – observations of these should be noted on the field form under Surrounding Land Use and Disturbed or difficult conditions, respectively. All macroscopic algal forms (filamentous algae, mats, periphyton, macroalgal clumps, or microalgae growing as a visible biofilm or mat) count, whether living, dead, or dying. Estimates should fall into one of the following categories:

- Not detected
- ≤2% cover
- 2 to 10% cover
- 10 to 40% cover
- >40% cover

Figure 18 shows examples of reaches with high and low algal cover in both flowing and dry conditions.

Figure 18. Examples of low (i.e., ≤2%; left) and high (i.e., >40%; right) algal cover in flowing (top) and dry (bottom) reaches.

Live algal mats typically have a dull to bright green color. In contrast, dead algal mats are typically dull brown under wet conditions or powdery white when desiccated. Include both live and dead algal mats in the overall estimate of extent. Note that it is possible to observe dead algae mats submerged under water if a stream has only recently started to flow.

In some circumstances, it may be possible to determine if an algal mat originated locally, or if it washed in from an upstream location. Sloughed algal mats tend to collect in snags or on top of boulders and rest unevenly on the streambed, or may be attached to overhanging branches. In contrast, mats with a local origin are often found in pools, depressions, or areas of flow accumulation. In some cases, algal mats may wash in from upstream and continue to grow if local conditions are favorable. Indicate on the field form if evidence suggests that algal mats *strictly* have an upstream origin. If ***all*** algae within the reach was deposited from upstream reaches, the AW SDAM treats this circumstance as though there are no algae within the reach.

3.8.8 Differences in vegetation

Stream reaches with longer streamflow durations tend to support a distinct riparian vegetation community that includes more hydrophytic species compared to surrounding uplands. Even stream reaches of shorter duration may enable upland species in the riparian corridor to grow more vigorously in and or near the channel than in surrounding uplands. It is important to note in the context of this indicator, an ‘upland’ species does not have the same definition as in 3.8.5 Number of hydrophytic plant species or 3.8.6 Prevalence of rooted upland plants in the streambed *(AW and WM)*. For this indicator, an ‘upland’ species is not defined by its NWPL indicator status, but rather by its location relative to the channel. For example, cottonwoods (*Populus deltoides*, which are FAC and would be considered ‘upland’ plants for other indicators) found only in the riparian corridor along the length of the assessment reach, but not in the uplands outside of the riparian corridor, would receive a strong score for this indicator (see Table 5. Scoring guidance for the Differences in Vegetation indicator.).

When assessing this indicator, consider the entire length of the reach, and choose the score from Table 5 that best characterizes the predominant condition; photos that demonstrate the scoring guidance are shown in Figure 19. High levels of distinctness in either composition or vigor results in a higher score. In settings where upland vegetation cannot be assessed due to development in the surrounding area, consider the upland vegetation growing in comparable areas outside the reach. In settings where the riparian corridor has been eliminated due to wildfire or management activities (e.g., channel clearing, mowing), the preferred option is to conduct the assessment after the vegetation has recovered. When a delay is not an option and the riparian corridor is devoid of vegetation, a score of zero is appropriate.

This indicator is derived from the New Mexico Hydrology Protocol (NMED 2020). As with other indicators derived from the New Mexico Hydrology Protocol, “moderate” scores (i.e., 2) are intended as an approximate midpoint between the extremes of “poor” and “strong”. Half scores (i.e., 0.5, 1.5, and 2.5), midway between the scores shown in Table 5 are appropriate to allow the assessor flexibility to characterize this indicator more continuously.

Table 5. Scoring guidance for the Differences in Vegetation indicator.

Score	Evidence of perennial flows	Guidance
0	Poor	No compositional or density differences in vegetation are present between the banks and the adjacent uplands.
1	Weak	Vegetation growing along the reach may occur in greater densities or grow more vigorously than vegetation in the adjacent uplands, but there are no dramatic compositional differences between the two.
2	Moderate	A distinct riparian vegetation corridor exists along part of the reach. Riparian vegetation is interspersed with upland vegetation along the length of the reach.
3	Strong	Dramatic compositional differences in vegetation are present between the banks and the adjacent uplands. A distinct riparian vegetation corridor exists along the entire reach – riparian, aquatic, or wetland species dominate the length of the reach.

A. Score: 0

B. Score: 1

C. Score: 2

D. Score: 3

Figure 19. Example photos of reaches that attained different scores for the Differences in Vegetation indicator. A: The vegetation along the reach is non-hydrophytic and similar in composition and vigor to surrounding uplands (Score: 0). B: Although the plant community composition is similar, the riparian vegetation is growing with more vigor (Score: 1). C: The riparian corridor is a mix of upland (e.g., *Populus deltoides*) and hydrophytic (e.g., *Populus angustifolia*) vegetation. These and other hydrophytic species are absent from the surrounding uplands (Score 2). (D) The streambanks are dominated by hydrophytes (e.g., *Alnus viridis*, *Salix sp*., *Phalaris arundinacea*) that are absent in adjacent uplands (Score 3).

3.8.9 Riffle-pool sequence

A riffle is a zone with a relatively high channel slope gradient, shallow water, and high flow velocity and turbulence. In smaller streams, riffles are defined as areas of a distinct change in gradient where flowing water can be observed. The bottom substrate material in riffles contains the largest particles that are moved by bankfull flow (bedload). A pool is a zone with relatively low channel slope gradient and deep water that moves at a low velocity and with minimal turbulence. Fine textured sediments generally dominate the bottom substrate material in pools. A repeating sequence of riffles and pools can be readily observed in most perennial systems, though the form of this sequence can differ based on gradient and bed material (riffle-run or ripple-pool in low gradient and sand bed systems, or step-pool in higher gradient systems). Riffle-run (or ripple-run) sequences in low gradient systems are often created by in-channel woody structures such as roots and woody debris. No matter the form, these features can be observed even in dry channels by closely examining their local profile and patterns of sediment deposition (at least for streams with coarser bed material). Score the indicator using the guidance in Table 6.

This indicator is derived from the New Mexico Hydrology Protocol (NMED 2020). As with other indicators derived from the New Mexico Hydrology Protocol, “moderate” scores (i.e., 2) are intended as an approximate midpoint between the extremes of “poor” and “strong”. Photos that demonstrate the scoring guidance are shown in Figure 20. Half scores (i.e., 0.5, 1.5, and 2.5), midway between the scores shown in Table 6 are appropriate to allow the assessor flexibility to characterize this indicator more continuously.

Table 6. Scoring guidance for the Riffle-Pool Sequence indicator.

Score	Evidence of perennial flows	Guidance
0	Poor	No riffle-pool sequences observed.
1	Weak	Mostly has areas of pools or of riffles.
2	Moderate	Represented by a less frequent number of riffles and pools. Distinguishing the transition between riffles and pools is difficult to observe.
3	Strong	Demonstrated by a frequent number of structural transitions (e.g. riffles followed by pools) along the entire reach. There is an obvious transition between riffles and pools.

A. Score: 0

B. Score: 1

C. Score 2

D. Score 3

Figure 20. Examples illustrating scoring levels for the Riffle-Pool Sequence indicator. A: No structural definition is apparent throughout the reach. Score is 0. B: The reach is largely comprised of pools and transitions to other structures infrequent or not distinct. Score is 1. C: More structural definition is apparent, but distinctions are subtle. Score is 2. D. A sequence of structures is present throughout the reach and transitions between them are obvious. Score is 3.

3.8.10 Particle size or stream substrate sorting (WM only)

Well-developed streams that have eroded through the soil profile often have substrate materials dominated by larger sediment sizes, such as coarse sand, gravel, and cobble, relative to floodplain sediments and adjacent soils. Finding similar sediment sizes in the stream bed and the adjacent stream side area may indicate that stream channel-forming processes have not been consistent enough to cut into the soil profile as typically seen in intermittent and perennial streams. The bed in ephemeral channels can be soil, having the same or similar texture as areas adjacent to the channel, and can have differentiated soil horizons.

This indicator can be evaluated in two ways:

1) In channel versus outside channel: Determine if the sediment texture on the bed of the channel is similar to sediment texture adjacent to the channel (e.g., on banks or adjacent floodplain). If

this is the case, then there is evidence that erosive forces have not been active enough to down cut the channel and support an intermittent or perennial system. Stormflow runoff resulting from human development can form incised ephemeral or intermittent channels; however, these channels often show little to no coarsening of the substrate.

2) Substrate sorting: Look at the particle size distribution on the channel bed, are there substrate differences between the bedforms identified in the Riffle-Pool Sequence indicator? For lower gradient channels dominated by sand substrate, the user may need to identify sorting across coarse versus fine sand.

Regardless of the approach used to assess channel sediments (e.g., pebble count, sand-gauge reference card), evaluate an area adjacent to but not in the channel for comparison purposes. Avoid adjacent areas with dense vegetation or recent soil disturbance.

Score the indicator using the guidance in Table 7. Photos that demonstrate the scoring guidance are shown in Figure 21.

This indicator is derived from the New Mexico Hydrology Protocol (NMED 2020). As with other indicators derived from the New Mexico Hydrology Protocol, “moderate” scores (i.e., 1.5) are intended as an approximate midpoint between the extremes of “poor” and “strong”. Half scores (i.e., 0.75 and 2.25), midway between the scores shown in Table 7 are appropriate to allow the assessor flexibility to characterize this indicator more continuously.

Table 7. Scoring guidance for Particle Size/Streambed Sorting indicator.

Score	Evidence of perennial flows	Guidance
0	Poor	Particle sizes in the channel are similar or comparable to particle sizes in areas close to but not in the channel. Substrate sorting is not readily observed in the channel.
1.5	Moderate	Particle sizes in the channel are moderately similar to particle sizes in areas close to but not in the channel. Various sized substrates are present in the channel and are represented by a higher ratio of larger particles (gravel/cobble).
3	Strong	Particle sizes in the channel are noticeably different from particle sizes in areas close to but not in the channel. There is a clear distribution of various sized substrates in the channel with finer particles accumulating in the pools and larger particles accumulating in the riffles/runs.

A. Score: 0

B. Score: 1.5

C. Score: 3

Figure 21. Examples illustrating scoring levels for the Particle Size/Stream Substrate Sorting indicator. Top- left photo (A): Dry channel in New Mexico where the in-channel particle size of material is similar to surrounding uplands (score of 0). Top-right photo (B): This Wyoming stream shows signs of increased sorting in the middle of the channel, with larger particles than surrounding uplands (score of 1.5). Lower left photo (C): Many particles in this Arizona channel are much larger compared to surrounding uplands and a high level of sorting can be seen in the middle of the photo (score of 3).

3.9 Additional notes and photographs

After assessing and recording all the indicators described above, provide any additional notes about the assessment, and include photographs in the photo log.

Section 4: Data Interpretation and Using the Web Application

The AW and WM SDAMs rely on random forest models to make classifications; therefore, the EPA has developed a free, open-access web application that runs the model for each assessment reach and is required to obtain a flow classification. This application allows assessors to input data from an assessment and obtain a classification. In addition, users have the option to produce a PDF report, which may be included as documentation of SDAM results.

The web application walks users through three steps in analyzing data from an SDAM. First, the user selects the desired regional SDAM (either by entering coordinates, clicking on a map, or selecting from a drop-down list). The coordinates field of the web application uses decimal degrees format of the World Geodetic System of 1984 (WGS84) datum. Then, the user enters field data on each indicator required for the selected SDAM. At this point, the user can run the model and obtain the resulting classification. The third step, report production, is optional. Users may enter additional information about the assessment (such as date of the site visit, notes, and photos of indicators) and produce a PDF report. No data entered into the web application is stored or submitted to the EPA or other agencies. A link at the top of the web application goes to Supporting Materials including User Manuals, Field Forms, Training Videos and more.

4.1 Outcomes of SDAM classification

As described in 1.1 The SDAMs for the AW and WM, application of the SDAMs can result in one of six possible classifications:

- Ephemeral
- Intermittent
- Perennial
- At least intermittent
- Less than perennial
- Needs more information

The first three streamflow duration classifications correspond to the three classes of stream reaches used to calibrate the AW and WM SDAMs. These outcomes occur when the pattern of observed indicators closely matches patterns in the calibration data measured at reaches directly determined to have perennial, intermittent, or ephemeral flow durations, and thus a classification can be assigned with high confidence.

In some cases, the pattern of indicators is associated with multiple classes, and the AW and WM SDAM models cannot assign an unambiguous classification with high confidence. However, the models may be able to rule out an ephemeral classification with high confidence or a perennial classification with high confidence. In the former case, the outcome is at least intermittent, meaning that there is a high likelihood that the stream is either perennial or intermittent, but not ephemeral. In the latter case, the outcome is less than perennial, meaning that there is a high likelihood that the stream is either intermittent or ephemeral, but not perennial. In both cases the two classes (i.e., perennial vs.

intermittent and intermittent vs. ephemeral) cannot be distinguished with confidence. In some instances, this information may be sufficient for management decisions, although additional assessment may be warranted. Two outcomes—at least intermittent and less than perennial—were rare in the AW and WM SDAM development data sets; at least intermittent occurred at 1.9% of assessments in both regions and less than perennial occurred at 2.6% of assessments in the WM and 1.2% of the AW. The needs more information outcome is possible and generally occurs when no classification can be made with confidence, but this did not occur in the development data sets for either region.

4.2 Applications of the SDAMs outside their intended areas

The AW and WM SDAM are intended only for application to the regions shown in Figure 2. The online web application allows the user to apply the protocol to reaches outside these regions (e.g., the AW SDAM may be applied to a site in an adjacent region, such as the Great Plains). However, classifications resulting from these applications are for informational purposes only; the Great Plains and Pacific Northwest SDAMs had substantially worse accuracy when applied to the development data sets for the AW and WM regions compared to when the regionally appropriate SDAM was used.

4.3 What to do when a more specific classification is needed

If the application of the AW or WM SDAM results in need more information, it means that no classification can be made with confidence. If an assessment's outcome is ambiguous about the specific flow duration class (i.e., less than perennial or at least intermittent), it may help to examine other lines of evidence or conduct additional evaluations as described below in approximate order of increasing effort.

When a more specific classification is needed:

- Review historical aerial imagery
- Conduct additional assessments at the same reach
- Conduct assessments at similar nearby reaches
- Conduct reach visits during regionally appropriate wet and dry seasons
- Collect hydrologic data

4.3.1 Review historical aerial imagery

In many parts of the West (particularly the AW), sequences of aerial imagery can provide information about streamflow duration. Google Earth's time slider and USGS Earth Explorer offer a convenient method of reviewing historical imagery, particularly for areas where trees do not obscure channels (however, Google Earth time slider may not have accurate image dates). If surface water is observed in all interpretable images across multiple years (especially during dry seasons), this may provide evidence that the reach is likely perennial. If surface water is never observed, even when other nearby intermittent streams show water, the consistent absence of surface water may provide evidence that the reach is likely ephemeral (particularly if images are captured during the wet season or after major storm events). If surface water is

Considerations for aerial imagery

- Accurate dates of images
- Changes in reach or watershed conditions since image was taken
- Seasonal and recent climatic conditions for each image

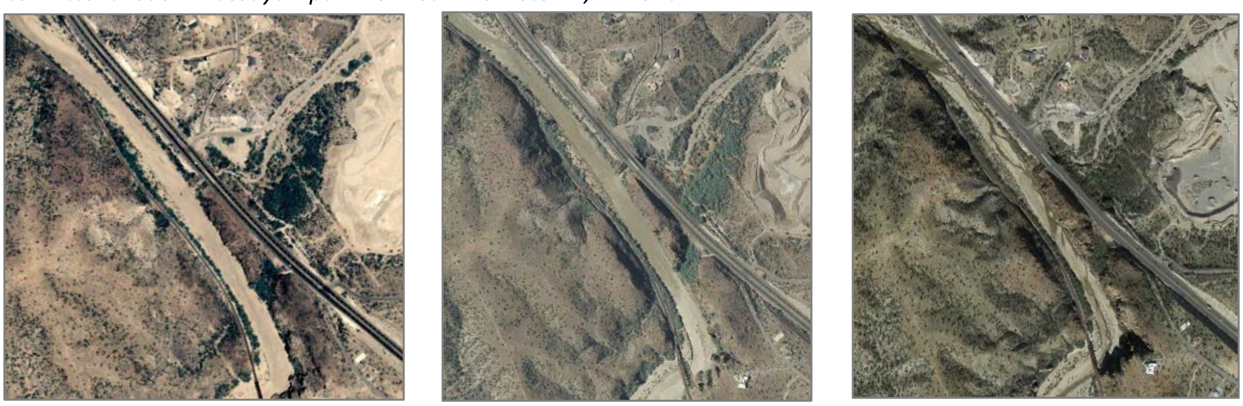
present in some images and dry in others, the stream may be intermittent. The evidence for perennial flow is strong if the images with surface water occur in the dry season and do not coincide with recent storm events. It is also important that users consider whether conditions as reflected by historical imagery are congruent with current conditions. For example, due to groundwater withdrawals, a stream that once flowed perennially may now have ephemeral flow; therefore, images from 15-20+ years ago might not be indicative of current flow conditions.

Any time that discrete observations of flow or no flow are used to inform a determination of flow duration class, such observations should be evaluated in the context of relatively normal climatic conditions. Doing so ensures that flow duration class is not determined based on observations of flow or no flow during abnormally wet or abnormally dry periods. The Antecedent Precipitation Tool (U.S. Army Corps of Engineers 2023) is a useful tool to determine if climate conditions are 'normal' for a locale (see 3.4 Timing of sampling). However, aerial images may not have high enough temporal resolution to confidently classify streams as ephemeral or perennial without additional data. See examples in Figure 22.

Perennial site: Jemez River near Zia Pueblo, New Mexico.

11/2015: Flowing 4/2017: Flowing 2/2018: Flowing

Intermittent reach: Hassayampa River near Morristown, Arizona.



6/2007: Dry 9/2007: Flowing 12/2014: Flowing

Reach on unnamed wash near Las Vegas, Nevada.

4/2007: Dry 6/2012: Dry 3/2014: Dry

Figure 22. Examples of using aerial imagery to support streamflow duration classification. Images were taken from Google Earth using the time slider.

4.3.2 Conduct additional assessments at the same reach

Some indicators may be difficult to detect or interpret due to short-term disturbances, floods, severe drought, or other conditions that affect the sampling event’s validity. A repeat application of the SDAM, even a few weeks later when effects from the disturbance have abated, may be sufficient to provide a determination. Similarly, conducting an additional evaluation during a different season may improve the ability to identify vegetation and collect aquatic macroinvertebrates, leading to a more conclusive assessment.

4.3.3 Conduct assessments at nearby reaches

Indicators may provide more conclusive results at reaches upstream from the assessment reach or downstream from the assessment reach, and if those locations represent similar conditions may be useful for interpreting ambiguous results. For example, there should be no significant discharges, diversions, or confluences between the new and original assessment locations, and they should have similar geomorphology. See 3.5 Assessment reach considerations for additional information.

4.3.4 Conduct reach revisits during regionally appropriate wet and dry seasons

A single, well-timed assessment may provide sufficient hydrologic evidence about streamflow duration. As with observations from aerial imagery, any time onsite observations of flow or absence of flow are used to inform a determination of flow duration class, such observations should be evaluated in the context of normal climatic conditions. Doing so ensures that flow duration class is not determined based on hydrologic observations of flow that occurred during abnormally wet or abnormally dry periods. The previously mentioned APT can provide this information.

4.3.5 Collect hydrologic data

Properly deployed loggers, stream gauges, or wildlife cameras can provide direct evidence about streamflow duration at ambiguous assessment reaches. It may be possible to distinguish intermittent from ephemeral streams in just a single season with these tools, assuming typical precipitation.

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Appendix A. Glossary of Terms

Term	Definition
Abdomen	The terminal section of an arthropod body.
Active channel	A portion of the valley bottom that can be distinguished based on the three primary criteria of (i) channels defined by erosional and depositional forms created by river processes, (ii) the upper elevation limit at which water is contained within a channel, and (iii) portions of a channel without mature woody vegetation. Braided systems have multiple threads and channel bars that are all part of the active channel.
Alluvial	Refers to natural, channelized runoff from terrestrial terrain, and the material borne or deposited by such runoff.
Assessment reach	The length of reach, ranging from 40 m to 200 m, where SDAM indicators are measured.
Aquatic macroinvertebrates	Invertebrate organisms that require aquatic environments for parts or all of their life cycle and are visible without the use of a microscope (i.e., > 0.5 mm body length). Includes bottom dwelling or benthic macroinvertebrates.
Bank	The side of an active channel, typically associated with a steeper side gradient than the adjacent streambed, floodplain, or valley bottom.
Bankfull elevation	The elevation associated with a shift in the hydraulic geometry of the channel and the transition point between the channel and the floodplain. In unconstrained settings this is the height of the water in the channel just when it begins to flow onto the floodplain.
Bankfull width	Width of the stream channel at bankfull elevation.
Braided system	A stream with a wide, relatively horizontal channel bed over which during low flows, water forms an interlacing pattern of splitting into numerous small conveyances that coalesce a short system downstream. Same as multi-threaded system.
Canal	An artificial or formerly natural waterway used to convey water between locations, possibly in both directions. Same as ditch.
Catchment	An area of land, bounded by a drainage divide, which drains to a channel or waterbody. Synonymous with watershed.
Channel	A feature in fluvial systems consisting of a streambed and its opposing banks which confines and conveys surface water flow. A braided system consists of multiple channels, which may include inactive or abandoned channels.
Confinement	The degree to which levees, terraces, hillsides, or canyon walls prevent the lateral migration of a fluvial channel.
Culvert	A drain or covered channel that crosses under a road, pathway, or railway.
Ditch	An artificial or formerly natural waterway used to convey water between locations, possibly in both directions. Same as canal.

Dorsal	Upper surface of abdomen, or back when viewed from above.
Ephemeral	Channels that flow only in direct response to precipitation. Water typically flows at the surface only during and/or shortly after large precipitation events, the streambed is always above the water table, and stormwater runoff is the primary water source.
Exuviae	The shed exoskeletons of arthropods typically left behind when an aquatic larva or nymph becomes a winged adult. Singular: exuvium.
FAC	Facultative plants. They are equally likely to occur in wetlands and non-wetlands.
FACU	Facultative upland plants. They usually occur in non-wetlands but are occasionally found in wetlands.
FACW	Facultative wetland plants. They usually occur in wetlands but may occur in non-wetlands.
Floodplain	The bench or broad flat area of a fluvial channel that corresponds to the height of bankfull flow. It is a relatively flat depositional area that is periodically flooded (as evidenced by deposits of fine sediment, wrack lines, vertical zonation of plant communities, etc.).
Groundwater	Water found underground in soil, pores, or crevices in rocks.
Head	The anterior-most section of an arthropod body, where mouthparts, eyes, and other sensory organs are located. The head is typically (but not always) distinct from the rest of the body.
Hydrophyte	Plants that are adapted to inundated conditions found in wetlands and riparian areas.
Hyporheic	The saturated zone under a river or stream, including the substrate and water-filled spaces between the particles.
Indicator	For the AW and WM SDAMs, indicators are rapid, generally field-based measurements that are used to predict streamflow duration class.
Instar	A phase between two periods of molting in arthropods (i.e., insects).
Intermittent	Channels that contain sustained flowing surface water for only part of the year, typically during the wet season, where the streambed may be below the water table and/or where the snowmelt from surrounding uplands provides sustained flow. The flow may vary greatly with stormwater runoff.
Larva	An immature stage of an insect or other invertebrates. Several insects have aquatic larval stages, such as mayflies, stoneflies, and caddisflies. Immature salamanders are sometimes also described as larvae. Plural: larvae.
Low-flow channel	In braided systems, the main channel with the lowest thalweg elevation. In intermittent or ephemeral reaches, the low-flow channel typically retains flow longer than other channels.

Multi-threaded system	A stream with a wide, relatively horizontal channel bed over which during low flows, water forms an interlacing pattern of splitting into numerous small conveyances that coalesce a short system downstream. Same as braided system.
NI	Plants that have no assigned wetland indicator (e.g., FACW, FACU) in a specific National Wetland Plant List region.
OBL	Obligate wetland plants. They almost always occur in wetlands.
Ordinary high-water mark (OHWM)	The line on the shore established by the fluctuations of water and indicated by physical characteristics, such as a clear natural line impressed on the bank, shelving, changes in the character of the soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas. See 33 CFR 328.3. An OHWM is required to establish lateral extent of U.S. Army Corps of Engineers jurisdiction in non-tidal streams. See 33 CFR 328.4.
Perennial	Channels that contain flowing surface water continuously during a year of normal rainfall, often with the streambed located below the water table for most of the year. Groundwater typically supplies the baseflow for perennial reaches, but the baseflow may also be supplemented by stormwater runoff and/or snowmelt.
Pool	A depression in a channel where water velocity is slow and suspended particles tend to deposit. Pools typically retain surface water longer than other portions of intermittent or ephemeral streams.
Proleg	Leg-like extensions on the abdomen (never the thorax) of some insect larvae. Typically, prolegs are unsegmented.
Pupa	An immature stage of insect orders with complete metamorphosis, occurring between the larval and adult stage. Pupal stages are typically immobile.
Reach	A length of stream that generally has consistent geomorphological and biological characteristics.
Riffle	A shallow portion of a channel where water velocity and turbulence are high, typically with coarse substrate (cobble and gravels). Riffles typically dry out earlier than other portions of intermittent or ephemeral streams, and harbor higher abundance and diversity of aquatic macroinvertebrates.
Riparian	A transitional area between the channel and adjacent upland ecosystems.
Rooted upland plants	Plants rooted in the streambed that have wetland indicator statuses of FAC, FACU, UPL, and NI.
Runoff	Surface flow of water caused by precipitation or irrigation over saturated or impervious surfaces.
Sclerotized	Hardened, as in the tough plates covering various body parts in some arthropods.

Scour	Concentrated erosive action of flowing water in streams that removes and carries material away from the bed or banks. Algal and invertebrate abundance is typically depressed after scouring events.
Secondary channel	A subsidiary channel that branches from the main channel and trend parallel or subparallel to the main channel before rejoining it downstream.
Streambed	The bottom of a stream channel between the banks over which water and sediment are transported during periods of flow.
Thalweg	The line along the deepest flowpath within the channel.
Thorax	The middle section of an arthropod body where legs and wing pads (if present) are attached.
Tributary	A stream that conveys water and sediment to a larger waterbody downstream.
UPL	Upland plants. They almost always occur in non-wetlands.
Uplands	Any portion of a drainage basin outside the river corridor.
Valley width	The portion of the valley within which the fluvial channel is able to migrate without cutting into hill slopes, terraces, or artificial structures.
Ventral	Underside of abdomen, or belly when viewed from below.
Watershed	An area of land, bounded by a drainage divide, which drains to a channel or waterbody. Synonymous with catchment.

Appendix B. Guide to Aquatic Invertebrate Orders and Families in the Western United States

For the AW and WM SDAMs, assessors need to identify perennial indicator taxa to the family in the field. They also need to be able to distinguish these families from other invertebrate taxa that may appear similar but are not used as indicators in the SDAMs. This appendix will help assessors recognize these taxa and how to distinguish them from other aquatic macroinvertebrates.

Available online resources that have informed this appendix include:

- Macroinvertebrates.org, an online reference for identification of aquatic insects of eastern North America. Although this website is focused on the East, it covers all the orders and families of aquatic macroinvertebrates used as indicators in the AW and WM SDAMs.
- NAAMDRC: North America Macroinvertebrate Digital Reference Collection , maintained by the U.S. Geological Survey (Walters et al. 2017).

Ephemeroptera (mayfly) larvae

Mayflies have plate-like gills along the dorsal side of their abdomen, which typically ends with three cerci, or “tails” (some species appear to have only two cerci, and cerci may break off during sampling). Legs always end in a single tarsal claw (never two claws). Mayflies have an aquatic larval stage that goes through direct metamorphosis into a short-lived terrestrial adult stage. There is no pupal stage.

Perennial indicator Ephemeroptera families

Ephemerellidae (spiny crawler mayflies)

This family is distinguished from other mayflies by the lack of gills in the second abdominal segment. Overall, ephemerellid mayflies have a flattened appearance (but not nearly so flattened as the Heptageniidae). A live larvae feeling threatened may be observed to assume "scorpion" posture, raising its caudal filaments above its head and wielding them like swords. This specimen is in the genus *Serratella*.

Heptageniidae (flathead mayflies)

Heptageniidae have a flattened appearance, and cling to the undersides of cobbles in fast-flowing water. Still, they have the single tarsal claws, abdominal gills, and three cerci typical of mayflies. This specimen is *Rhithrogena.*

Leptohyphidae (little stout crawler mayflies)

Leptohyphidae have a pair of enlarged, hardened (i.e., sclerotized) abdominal gills that can cover the smaller, translucent abdominal gills. The family typically has three cerci, but the right one has broken off in this specimen. This specimen is a species of *Tricorythodes.*

Caenidae have similar enlarged gills on abdominal segment two that cover the more anterior gills ("operculate" or "semioperculate" gills). However, in Leptohyphidae, these operculate gills are roughly triangular or oval, whereas in Caenidae, these gills are square-shaped.

Leptophlebiidae (prong-gilled mayflies)

Prong-gilled mayflies have distinctive gills that either appear as thin, forked filaments, oval double-layered gills, or small tufts.

Other common Ephemeroptera families

Baetidae (small minnow mayflies)

Baetidae have a streamlined appearance and appears to swim like a minnow. The abdominal gills and three cerci (tails) are conspicuous in this photo. Wingpads are usually visible. This specimen is *Baetis.*

Caenidae (square-gilled mayflies)

Like Leptohyphidae, Caenidae have enlarged operculate gills that cover other gills on the abdomen. However, in Caenidae, these gills are square-shaped, whereas in Leptohyphidae, the gills are triangular or oval. This specimen is in the genus *Caenis.*

Ephemeridae (burrowing mayflies)

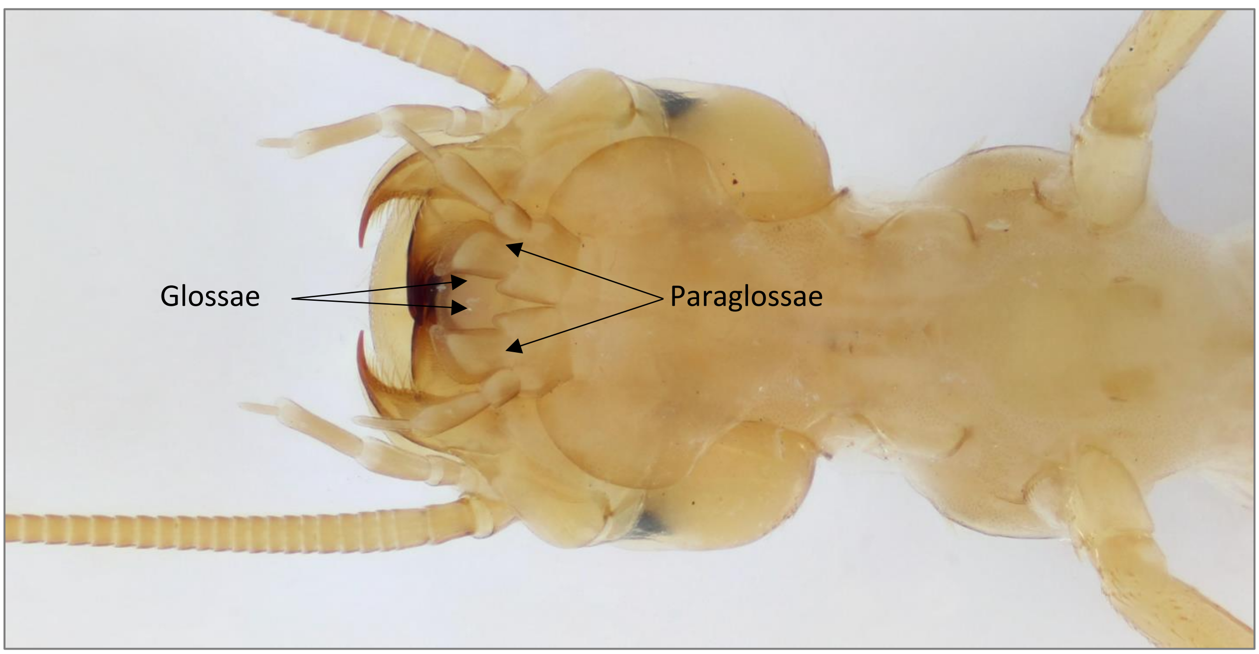
Ephemeridae prefer to burrow in soft, silty sediments. Although this family is more common in lakes, it may be found in pools and slow-moving portions of rivers. The long feathery gills and single tarsal claws make this recognizable as a mayfly. This specimen is *Hexagenia limbata.*

Plecoptera (stonefly) larvae

Stoneflies have tuft-like gills on the thorax (not along the abdomen), two (not one) tarsal claw at the end of each leg, and always has two (never three) cerci, making them easily distinguished from mayflies. Stoneflies have an aquatic larval stage that goes through direct metamorphosis into a short-lived terrestrial adult stage. There is no pupal stage.

Perennial indicator Plecoptera families

Chloroperlidae (green stoneflies)



Like a few other families of stoneflies, green stoneflies lack gills and have a plain, unpatterned thorax. Wingpads are parallel to the mainline of the body. Cerci are relatively short (less than three-quarters of the length of the abdomen). The hind-legs should reach the tip of the abdomen when extended. This specimen is in the genus *Alloperla.*

The mouthparts provide an important diagnostic feature of this family: the glossae are much shorter than the paraglossae.

Chloroperlidae are most likely to be confused with other smaller, unpatterned stoneflies that lack gills:

- Leuctridae have mouthparts with glossae nearly equal in size to the paraglossae, giving the appearance of three notches on the lower lip, and the hind wingpads are usually much longer than they are wide. If the hind legs are extended, they do not reach the tip of the abdomen.
- Capniidae have a similar arrangement of mouthparts as Leuctridae. The cerci are usually the same length as the abdomen. If the hind legs are extended, they do not reach the tip of the abdomen. In top-view, the margin of the abdomen appears like a zigzag.

Perlidae (common stoneflies)

Perlidae (common stoneflies) are large and conspicuous, often with ornate patterns on the head and thorax. Wingpads are usually visible. Perlidae have gills on the thorax. This specimen is *Claasenia sabulosa.*

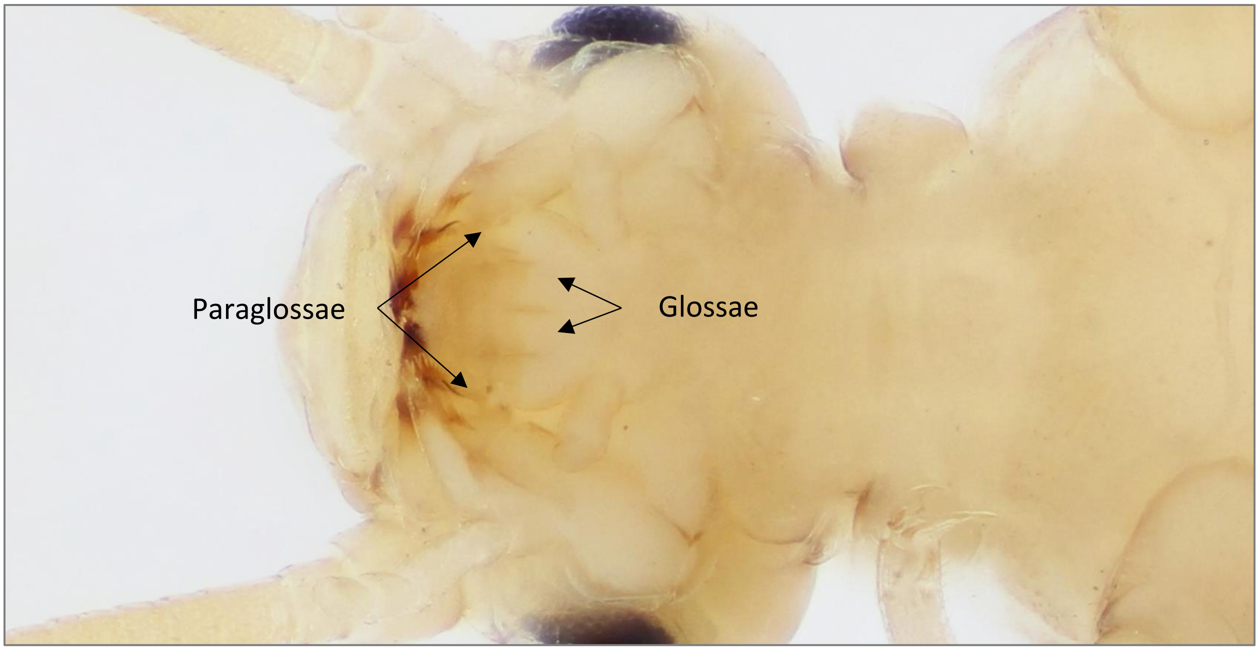
Perlodidae look similar but lack gills and have a different arrangement of mouthparts.

Other common Plecoptera families

Leuctridae (roll-winged stoneflies)

Leuctridae resemble Chloroperlidae, in that they lack gills and have an unpatterned thorax. However, the cerci are typically as long as the abdomen. Leuctridae have mouthparts with glossae nearly equal in size to the paraglossae, giving the appearance of three notches on the lower lip, and the hind wingpads are usually much longer than they are wide (similar to Capniidae; see image below). If the hind legs are extended, they do not reach the tip of the abdomen. This specimen is in the genus *Leuctra.*

Capniidae (small winter stoneflies)

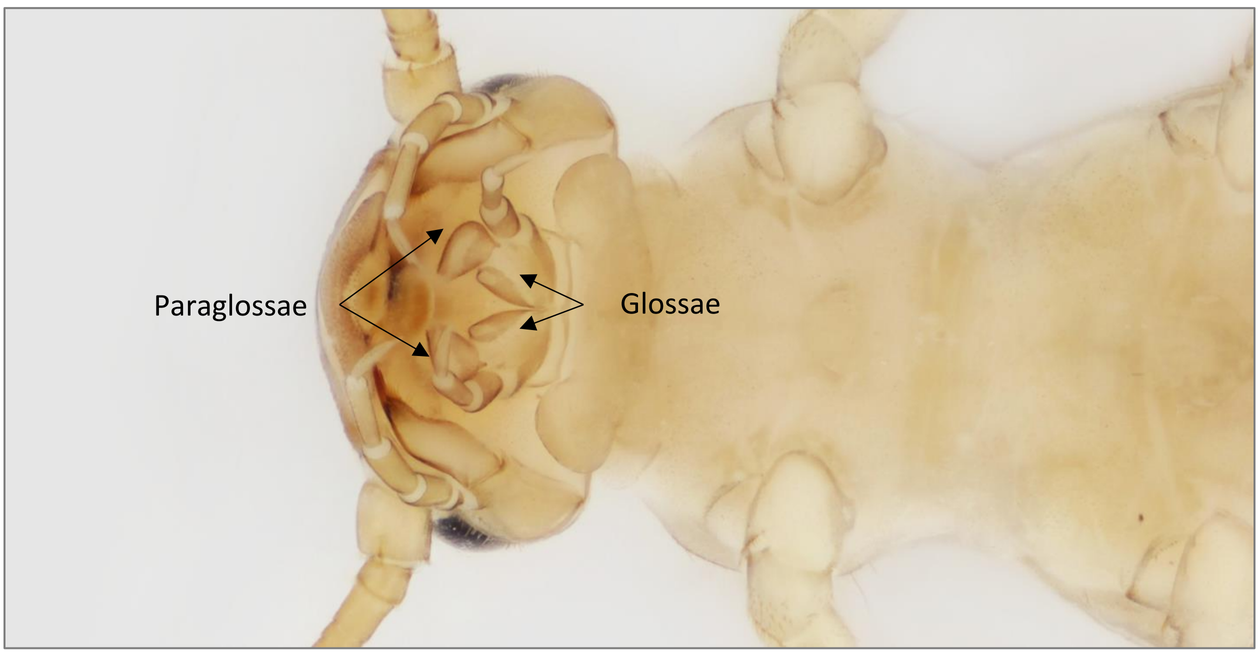


Capniidae (small winter stoneflies). Capniidae resemble Chloroperlidae, but they have a different arrangement of mouthparts (with glossae and paraglossae about the same length, as in Leuctridae). The cerci are usually the same length as the abdomen. If the hind legs are extended, they do not reach the tip of the abdomen. In top-view, the margin of the abdomen appears like a zigzag. This specimen is in the genus *Allocapnia.*

Nemouridae (spring stoneflies)

Nemouridae are relatively small, and this family contains species that are well adapted to intermittent streams in the West. This specimen is a species of *Soyedina.*

Perlodidae (springflies)



Perlodidae are large and have conspicuous patterns which make them similar to Perlidae. However, they lack gills on the thorax. Examination of the mouthparts will show that the glossae are much shorter than the paraglossae. This specimen is in the genus *Isoperla.*

Peltoperlidae (roach-like stoneflies)

Even moreso than other stonefly families, Peltoperlidae have a roach-like appearance. This specimen is a species of *Sierraperla.*

Trichoptera (caddisfly) larvae and pupae

Caddisfly larvae have filamentous gills on the ventral side of the abdomen (as opposed to the plate-like gills on the dorsal side of the abdomen, as seen with mayflies). Their abdomen ends in two anal prolegs, each with a sclerotized hook, rather than long tail-like cerci. No wingpads are visible, but the thorax is usually dark and hardened (i.e., sclerotized) on the top, with the abdomen being completely membranous. Caddisfly larvae are generally C-shaped (less evident in this pudgy specimen).

Many caddisfly larvae build portable cases out of pebbles, sand, or organic matter. Some families live in fixed retreats. A few families are free-living and build neither cases nor retreats. However, all caddisflies build cases for their aquatic pupal stage, from which they emerge as short-lived terrestrial adults.

Perennial indicator Trichoptera families

Brachycentridae (humpless casemakers)

Unlike most other caddisflies Brachycentridae lack a hump on abdominal segment one. The mesonotum (i.e., the second thoracic segment) is sclerotized, whereas the metanotum (i.e., the third thoracic segment) is mostly membranous. The distinctive case is made of plant material arranged in parallel layers, either as a tapered cylinder or a four-sided “log cabin” tube. This specimen is in the genus *Brachycentrus.*

Glossosomatidae (saddle casemakers)

The mesonotum and metanotum of Glossosomatidae are both membranous, and each are adorned with three pairs of setae (hairs). There is a small sclerite on the ninth abdominal segment. The unique case has a dome made of stones, with a ventral strap made of fine sand. The case has openings on both the anterior and posterior ends. This specimen is in the genus *Glossosoma.*

Hydropsychidae (common netspinners)

Hydropsychidae (net-spinner caddisflies). This group lives within nets in fixed locations out of silk, pebbles, and other materials. These nets are usually located in fast-flowing areas and on large, stable particles (such as large cobbles and boulders). Like a spider in a web, they wander about the retreat to catch prey that gets caught in the net. Turning over a boulder typically destroys these nets, but the larvae may be found crawling among the remains of the net.

Rhyacophilidae (free-living caddisflies)

Rhyacophilidae (free-roaming caddisflies). This family is usually found wandering freely on the undersides of boulders and cobbles, actively hunting for prey. Abdominal gills are present, but not evident in this photo. Notice the long anal prolegs, which have large sclerotized claws. Some species of this family have a striking blue-green coloration, which may fade when preserved in alcohol.

Other common Trichoptera families

Limnephilidae (northern casemakers)

Limnephilids are a large group of roaming caddisflies that build cases out of diverse materials, such as pebbles, sand, leaf segments, and twigs. This specimen is a mature *Dicosmoecus gilvepes*.

Lepidostomatidae (scaley-mouthed caddisflies)

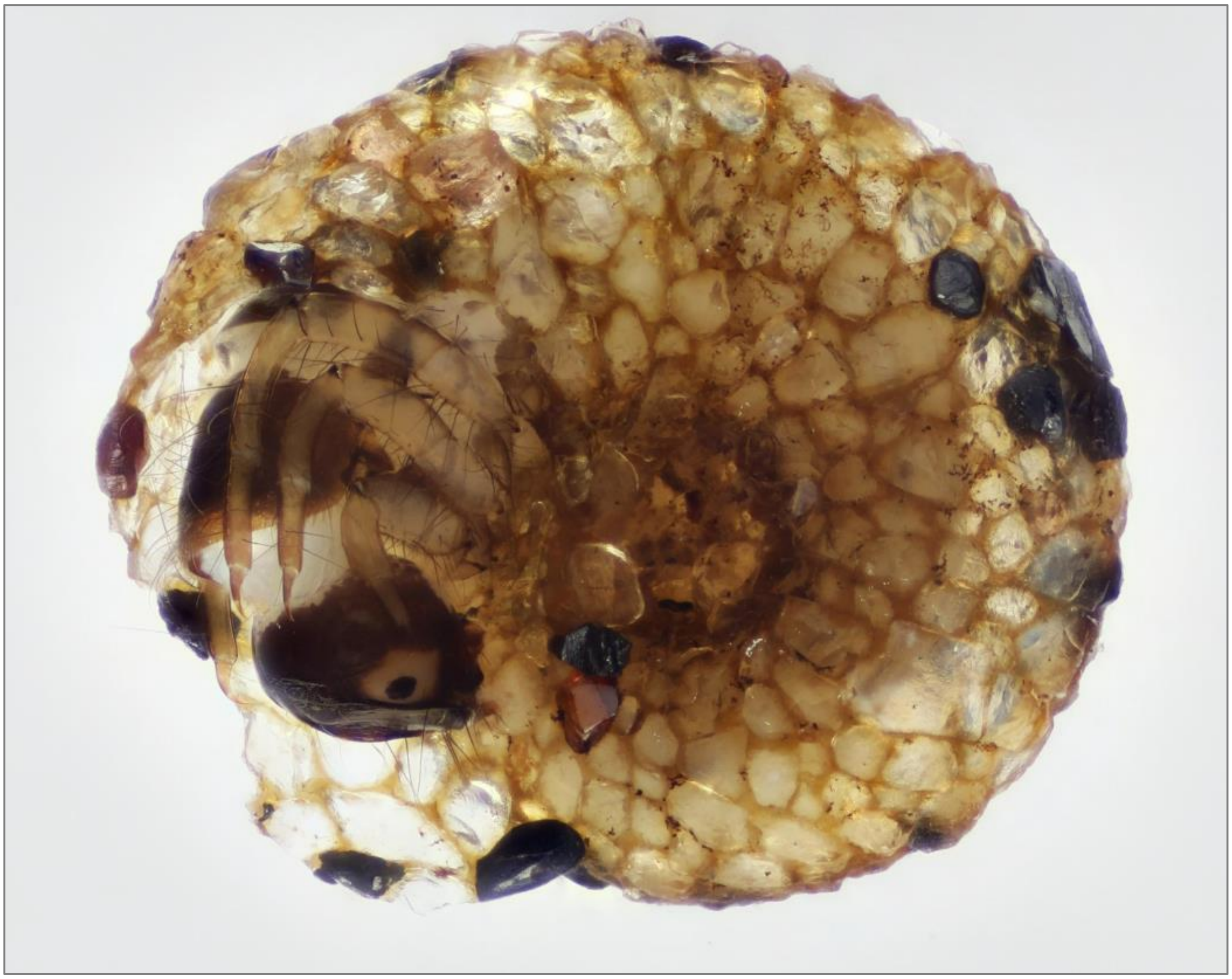
Lepidostomatidae. This specimen (*Lepidostoma* species) builds its case out of leaf segments and silk.

Lepidostomatidae. This specimen (*Lepidostoma* species) has a case made of twigs.

Hydroptilidae (microcaddisflies)

These are small caddisflies (2-4 mm long) that build purse-like cases out of sand grains. They may be very abundant, but hard to see due to their size. This specimen is a species of *Hydroptila.*

Helicopsychidae (snail casemaker caddisflies)



Helicopsychidae (snail case-makers) are unusual in that they build spiral-shaped, snail-like cases. This specimen is *Helicopsyche.*

Coleoptera (beetle) larvae and adults

Adult beetles are among the most recognizable insects due to their conspicuous hardened forewings (elytra). The larvae can be identified by their eye spots, the absence of lateral gills (in most families), and the legs, which typically have 4 or 5 segments.

Perennial indicator Coleoptera families

Elmidae (riffle beetles)

Elmidae (riffle beetles). These small insect larvae have a completely sclerotized body, unlike caddisflies which only have the thorax sclerotized. Also, there are no gills along the abdomen, as in the caddisflies. Instead, the gills are found at the tip of the abdomen (where the caddisfly's two anal prolegs with hooks would be found), within a covered chamber (the lid is called an operculum). This image shows a *Stenelmis* larva.

The C-shaped larvae may be confused with the larvae of caddisflies. However, elmid larvae are completely sclerotized, whereas caddisfly larvae have at most only a few sclerotized abdominal segments (and sometimes none). Furthermore, Elmidae lack the anal hooks that characterize caddisfly larvae.

The larvae may also resemble those of the non-biting midges (Diptera: Chironomidae, described below). Elmid larvae always have three pairs of true (segmented) legs, whereas Chironomidae have unsegmented prolegs. Additionally, chironomid larvae lack the sclerotization of Elmidae.

Adult riffle beetles are small (~2-4 mm) and typically have distinctive stripes of indentations along their elytra. Their legs end in 5-segmented tarsi, which end in large claws. They typically have thread-like antennae. This image shows *Stenelmis*.

Adult elmid beetles may be confused for other diminutive aquatic beetles, such as some of the smaller species of Dytiscidae. However, dytiscids have hairs adapted for swimming on their legs, which are absent from elmids.

Other common Coleoptera families

Dytiscidae (predaceous diving beetles)

Dytiscidae (diving beetles). Larvae of this group lack the gills and tarsal claws that characterize mayflies and stoneflies. Their thorax is not as strongly sclerotized as with caddisflies; conversely, caddisfly larvae never have sclerotized abdomens, unlike most beetle larvae. Adults are usually much larger than Elmidae. Dytiscid adults have hairs on their legs that help them swim. This specimen is a species of *Agabus.*

Haliplidae (crawling water beetles)

Both adults and larvae of this beetle family are considered aquatic. Larvae usually have legs with 4-5 segments and a single tarsal claw. Instead of compound eyes, the larvae have eye spots. Lateral gills are usually absent and mature (last instar) larvae have long dorsal projections from thoracic and abdominal segments. Generally, beetle larvae can look superficially like caddisfly larvae (see below); however, their bodies usually show a greater degree of sclerotization (including the abdomen), and they usually have prominent chewing and/or piercing mouthparts, though Haliplid larvae have less prominent mouthparts compared to other beetle families (e.g., Gyrinidae, Dytiscidae, and Hydrophilidae). Haliplid adults swim slowly and clumsily by moving their legs alternately (rather than in unison like predaceous diving beetles) and are usually found crawling among vegetation rather than swimming. Adults usually also have highly patterned (splotchy) elytra (hardened forewings). In addition, Haliplid adults have expanded hind coaxae (first segment of last leg), which have been expanded into a broad, flat plate on the ventral surface, covering the first 2 or 3 abdominal segments and most of the hind femora (third segment of last leg).

Other Insect Orders

Assessors need to recognize other aquatic insect orders and differentiate them from the EPT orders shown above. A few commonly encountered insects are shown here. These organisms contribute to the total count of aquatic macroinvertebrates but are not counted towards the EPT indicator.

Diptera: Chironomidae (non-biting midges)

Superficially, the larvae of this family of true flies resemble those of Trichoptera, thanks to the C-shaped body and the posterior prolegs that resemble hooks. Furthermore, several species are found in tubes of silk lined with silt and muck, which can resemble a caddis case. While generally smaller, the sizes of the two groups can overlap considerably. Chironomidae are best distinguished from caddisflies by the lack of abdominal gills, the soft thorax, and the lack of true legs (i.e., three pairs of sclerotized, jointed legs). Some chironomids have bright red bodies, thanks to hemoglobin pigment, which helps them survive in low-oxygen conditions.

Diptera: Culicidae (mosquitos)

Culicidae (mosquito larvae) hang at the water surface and breathe air through a tube at the tip of the abdomen. When disturbed, they "wriggle" and swim away from the surface (leading to the common name "wrigglers"). Photo credit is the Missouri Department of Conservation.

Megaloptera: Corydalidae (hellgrammites, dobsonflies)

This large, centipede-like insect larva has distinctive lateral filaments along the sides of the abdomen. They lack the C-shaped bodies of caddisflies, and the lateral filaments contrast with the gills on the ventral side of the abdomens of caddisflies. Although most species are associated with perennial streams, some species in California and Arizona persist in intermittent streams by building a chamber in sandy substrate beneath boulders, where they wait out the dry season; as a result, they are among the first invertebrates to be observed after the onset of flow.

Other invertebrates

Margaritiferidae and Unionidae (freshwater mussels)

Anodonta californiensis (California floater) is a freshwater mussel found in streams throughout the West. Most freshwater mussels are imperiled and should not be collected or disturbed during assessments.

Appendix C. Field Forms

Appendix C1: Combined field form for the AW and WM SDAMs

Arid West and Western Mountains SDAMs

General site information

Project name or number:		**Region** □ Arid West □ Western Mountains
Site code or identifier:	**Assessor(s):**	
Waterway name:		**Visit date:**
Current weather conditions (check one): □ Storm/heavy rain □ Steady rain □ Intermittent rain □ Snowing □ Cloudy (___ % cover) □ Clear/sunny	Notes on current or recent weather conditions (e.g., precipitation in prior week):	**Coordinates at downstream end (decimal degrees):** Lat (N): Long (E): Datum:
Surrounding land-use within 100 m (check one or two): □ Urban/industrial/residential □ Agricultural (farmland, crops, vineyards, pasture) □ Developed open-space (e.g., golf course) □ Forested □ Other natural □ Other: ___________________________________	**Describe reach boundaries:**	
Mean bankfull channel width (m):_________ (Indicator 1) ______ _______ _______	**Reach length (m):** 40x width min 40 m max 200 m	**Site photographs**: Enter photo ID or check if completed. Top down: _________ Mid down: __________ Mid up: ___________ Bottom up: __________
Disturbed or difficult conditions (check all that apply): □ Recent flood or debris flow □ Stream modifications (e.g., channelization) □ Diversions □ Discharges Notes on disturbances or difficult site conditions:	□ Drought □ Vegetation removal/limitations □ Other (explain in notes) □ None	
Observed hydrology: ______ % of reach with surface flow ______ % of reach with sub-surface or surface flow ______ # of isolated pools	Comments on observed hydrology:	

Site sketch:

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1. Mean bankfull channel width (m) (AW and WM) (nearest 0.1 m, copy from first page of field form)

Notes about mean bankfull channel width:

Aquatic macroinvertebrate indicators

Collect aquatic macroinvertebrates from at least 6 locations in the assessment reach, searching all suitable habitats on the streambed (including dry habitats, if present).

Aquatic macroinvertebrate indicators are used in both the AW and WM SDAMs.

2. Aquatic macroinvertebrates: Abundance of Ephemeroptera, Plecoptera, and Trichoptera (WM only)

Determine total abundance of individuals in the orders of Ephemeroptera, Plecoptera, and Trichoptera (EPT), such that no one family counts for more than 11 individuals in the total:

Mark the appropriate box for the number of EPT individuals observed.

☐ No EPT detected
☐ 1 to 4 EPT individuals
☐ 5 to 9 EPT individuals
☐ 10 to 19 EPT individuals
☐ 20 or more EPT individuals

Check if applicable: ☐ No aquatic macroinvertebrates in assessment area

Notes on abundance of EPT indicator:

3. Aquatic macroinvertebrates: Abundance of perennial indicator taxa (AW and WM)

Determine total abundance of individuals in perennial indicator families listed below, such that no one family counts for more than 11 individuals in the total.

Ephemeroptera	Plecoptera	Trichoptera	Coleoptera
Ephemerellidae (spiny crawler mayflies)	Chloroperlidae (green stoneflies)	Brachycentridae (humpless casemakers)	Elmidae (riffle beetles)
Heptageniidae (flathead mayflies)	Perlidae (common stoneflies)	Glossosomatidae (saddle casemakers)	
Leptohyphyidae (little stout crawler mayflies)		Hydropsychidae (common netspinners)	
Leptophlebiidae (prong-gilled mayflies)		Rhyacophilidae (free-living caddisflies)	

Mark the appropriate box for the number of perennial indicator individuals observed.

☐ No perennial indicator taxa detected
☐ 1 to 4 perennial indicator individuals
☐ 5 to 9 perennial indicator individuals
☐ 10 to 19 perennial indicator individuals
☐ 20 or more perennial indicator individuals

Check if applicable: ☐ No aquatic macroinvertebrates in assessment area

Notes on perennial indicator taxa:

4. Slope (AW and WM)

Using a clinometer or other device, record the slope as a percent, up to the nearest half-percent.

Notes about slope:

5. Shading (WM only)

At the center of three transects, use a convex spherical densiometer to record the number of points covered by trees, canyon walls, buildings, or other structures that provide shade (up to 17 points per location). Calculate percent shading as the percentage of points covered by such structures (total points covered divided by 204).

Percent shading: ___________

	Downstream transect	*Middle transect*	*Upstream transect*	
Facing upstream	/17	/17	/17	
Facing right bank	/17	/17	/17	Total number of points covered:
Facing downstream	/17	/17	/17	____ / 204 * 100%
Facing left bank	/17	/17	/17	

Notes on shading:

6. Number of hydrophytic plant species (AW and WM)

Record up to 6 hydrophytic plant species (FACW or OBL in the appropriate regional wetland plant list, depending on location) within the assessment area: **within the channel or up to one half-channel width outside the channel**. Explain in notes if species has an odd distribution (e.g., one individual or small patch, long-lived species solely represented by seedlings, or long-lived species solely represented by specimens in decline), or if there is uncertainty about the identification. Enter photo ID or check if photos are taken.

____________ Number of hydrophytic plant species identified from the assessment reach without odd distribution. Enter zero if none were found.

Check if applicable: ☐ No vegetation in assessment area

Species	**Odd distribution?**	**Notes**	**Photo ID**

Notes on hydrophytic vegetation:

7. Prevalence of rooted upland plants in the streambed (AW and WM)

____ **(0-3)** *Half-scores (0.5, 1.5, and 2.5) are allowed.*	Evaluate the prevalence of rooted upland plants (i.e., plants rated as FAC, FACU, UPL, or not listed in the regionally appropriate National Wetland Plant List) in the streambed. 0 (Poor) Rooted upland plants are *prevalent* within the streambed/thalweg. 1 (Weak) Rooted upland plants are *consistently dispersed* throughout the streambed/thalweg. 2 (Moderate) There are *a few* rooted upland plants present within the streambed/thalweg. 3 (Strong) Rooted upland plants are *absent* from the streambed/thalweg.

Upland Species	**Notes**	**Photo ID**

Notes on rooted upland plants:

8. Algal cover (AW only)

Mark the appropriate percent of the streambed covered by live or dead algae on the streambed.

☐ Not detected ☐ 10 to 40% cover
☐ ≤2% cover ☐ >40% cover
☐ 2 to 10% cover ☐ Check here if algae *exclusively* appears to have been deposited from an upstream source, and *no* local growth is evident.

Notes on algal cover on the streambed:

9. Differences in vegetation (AW and WM)

____ **(0-3)** *Half-scores (0.5, 1.5, 2.5) are allowed.*	Compare the composition and density of plants growing on the banks and riparian areas to plants in the adjacent uplands. For this indicator, an upland species is not defined by its wetland indicator status, but rather by its location relative to the channel. 0. (Poor) No compositional or density differences in vegetation are present between the banks and the adjacent uplands. 1. (Weak) Vegetation growing along the reach may occur in greater densities or grow more vigorously than vegetation in the adjacent uplands, but there are no dramatic compositional differences between the two. 2. (Moderate) A distinct riparian corridor exists along part of the reach. Riparian vegetation is interspersed with upland vegetation along the length of the reach. 3. (Strong) Dramatic compositional differences in vegetation are present between the banks and the adjacent uplands. A distinct riparian vegetation corridor exists along the entire reach. Riparian, aquatic, or wetland species dominate the length of the reach.

Notes on differences in vegetation:

10. Riffle-pool sequence (AW and WM)

____ (0-3) *Half-scores (0.5, 1.5, 2.5) are allowed.*	Evaluate the prevalence of riffles, pools, and other microhabitats in the streambed. 0 (Poor) No riffle-pool sequences observed. 1 (Weak) Mostly has areas of pools or riffles. 2 (Moderate) Represented by a less frequent number of riffles and pools. Distinguishing the transition between riffles and pools is difficult to observe. 3 (Strong) Demonstrated by a frequent number of structural transitions (e.g., riffles followed by pools) along the entire reach. There is an obvious transition between riffles and pools.
Notes about riffle-pool sequence:	

11. Particle size or stream substrate sorting (WM only)

____ (0-3) *Half scores (0.75, 2.25) are allowed.*	Evaluate the extent of substrate sorting. Compare substrate on the channel bed to the banks and adjacent floodplain. Look for sorting within the channel bed (e.g., along bars and islands). 0 (Poor) Particle sizes in the channel are similar or comparable to particle sizes in areas close to but not in the channel. Substrate sorting is not readily observed in the channel. 1.5 (Moderate) Particle sizes in the channel are moderately similar to particle sizes in areas close to but not in the channel. Various sized substrates are present in the channel and are represented by a higher ratio of larger particles (gravel/cobble; coarse sand in low-gradient streams). 3 (Strong) Particle sizes in the channel are noticeably different from particle sizes in areas close to but not in the channel. There is a clear distribution of various sized substrates in the channel with finer particles accumulating in the pools, and larger particles accumulating in the riffles/runs
Notes about substrate sorting:	

Photo log

Indicate if any other photographs taken during the assessment:

Photo ID	Description

Additional notes about the assessment:

Model classification:

☐ Ephemeral

☐ At least intermittent

☐ Intermittent

☐ Less than perennial

☐ Perennial

☐ Needs more information

Appendix C2: Field form for the AW SDAM

Arid West Streamflow Duration Assessment Method

General site information

Project name or number:			
Site code or identifier:	**Assessor(s):**		
Waterway name:		**Visit date:**	
Current weather conditions (check one): □ Storm/heavy rain □ Steady rain □ Intermittent rain □ Snowing □ Cloudy (___ % cover) □ Clear/sunny	Notes on current or recent weather conditions (e.g., precipitation in prior week):	**Coordinates at downstream end (decimal degrees):** Lat (N): Long (E): Datum:	
Surrounding land-use within 100 m (check one or two): □ Urban/industrial/residential □ Agricultural (farmland, crops, vineyards, pasture) □ Developed open-space (e.g., golf course) □ Forested □ Other natural □ Other: ___________________________________	**Describe reach boundaries:**		
Mean bankfull channel width (m): _________ (Indicator 1) ______ _______ _______	**Reach length (m):** 40x width min 40 m max 200 m	**Site photographs**: Enter photo ID or check if completed. Top down: _________ Mid down: __________ Mid up: ___________ Bottom up: __________	
Disturbed or difficult conditions (check all that apply): □ Recent flood or debris flow □ Stream modifications (e.g., channelization) □ Diversions □ Discharges Notes on disturbances or difficult site conditions:	□ Drought □ Vegetation removal/limitations □ Other (explain in notes) □ None		
Observed hydrology: ______ % of reach with surface flow ______ % of reach with sub-surface or surface flow ______ # of isolated pools	Comments on observed hydrology:		

Site sketch:

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1. Mean bankfull channel width (m) (nearest 0.1 m, copy from first page of field form)

Notes about mean bankfull channel width:

2. Aquatic macroinvertebrates: Abundance of perennial indicator taxa

Collect aquatic macroinvertebrates from at least 6 locations in the assessment reach, searching all suitable habitats on the streambed (including dry habitats, if present). Determine total abundance of individuals in perennial indicator families listed below, such that no one family counts for more than 11 individuals in the total.

Ephemeroptera	**Plecoptera**	**Trichoptera**	**Coleoptera**
Ephemerellidae (spiny crawler mayflies)	Chloroperlidae (green stoneflies)	Brachycentridae (humpless casemakers)	Elmidae (riffle beetles)
Heptageniidae (flathead mayflies)	Perlidae (common stoneflies)	Glossosomatidae (saddle casemakers)	
Leptohyphyidae (little stout crawler mayflies)		Hydropsychidae (common netspinners)	
Leptophlebiidae (prong-gilled mayflies)		Rhyacophilidae (free-living caddisflies)	

Mark the appropriate box for the number of perennial indicator individuals observed.

☐ No perennial indicator taxa detected
☐ 1 to 4 perennial indicator individuals
☐ 5 to 9 perennial indicator individuals
☐ 10 to 19 perennial indicator individuals
☐ 20 or more perennial indicator individuals

Check if applicable: ☐ No aquatic macroinvertebrates in assessment area

Notes on perennial indicator taxa:

3. Slope

Using a clinometer or other device, record the slope as a percent, up to the nearest half-percent.

Notes about slope:

4. Number of hydrophytic plant species

Record up to 6 hydrophytic plant species (FACW or OBL in the appropriate regional wetland plant list, depending on location) within the assessment area: **within the channel or up to one half-channel width outside the channel**. Explain in notes if species has an odd distribution (e.g., one individual or small patch, long-lived species solely represented by seedlings, or long-lived species solely represented by specimens in decline), or if there is uncertainty about the identification. Enter photo ID or check if photos are taken.

____________ Number of hydrophytic plant species identified from the assessment reach without odd distribution. Enter zero if none were found.

Check if applicable: ☐ No vegetation in assessment area

Species	**Odd distribution?**	**Notes**	**Photo ID**

Notes on hydrophytic vegetation:

5. Prevalence of rooted upland plants in the streambed

____ (0-3) *Half-scores (0.5, 1.5, and 2.5) are allowed.*	Evaluate the prevalence of rooted upland plants (i.e., plants rated as FAC, FACU, UPL, NI, or not listed in the regionally appropriate National Wetland Plant List) in the streambed. 0 (Poor) Rooted upland plants are *prevalent* within the streambed/thalweg. 1 (Weak) Rooted upland plants are *consistently dispersed* throughout the streambed/thalweg. 2 (Moderate) There are *a few* rooted upland plants present within the streambed/thalweg. 3 (Strong) Rooted upland plants are *absent* from the streambed/thalweg.

Upland Species	**Notes**	**Photo ID**

Notes on rooted upland plants:

6. Algal cover

Mark the appropriate box for the percent of the streambed covered by live or dead algae on the streambed.

☐ Not detected
☐ ≤2% cover
☐ 2 to 10% cover
☐ 10 to 40% cover
☐ >40% cover
☐ Check here if algae *exclusively* appears to have been deposited from an upstream source, and *no* local growth is evident.

Notes on algal cover on the streambed:

7. Differences in vegetation

____ (0-3) *Half-scores (0.5, 1.5, 2.5) are allowed.*	Compare the composition and density of plants growing on the banks and riparian areas to plants in the adjacent uplands. For this indicator, an upland species is not defined by its wetland indicator status, but rather by its location relative to the channel. 0 (Poor) No compositional or density differences in vegetation are present between the banks and the adjacent uplands. 1 (Weak) Vegetation growing along the reach may occur in greater densities or grow more vigorously than vegetation in the adjacent uplands, but there are no dramatic compositional differences between the two. 2 (Moderate) A distinct riparian corridor exists along part of the reach. Riparian vegetation is interspersed with upland vegetation along the length of the reach. 3 (Strong) Dramatic compositional differences in vegetation are present between the banks and the adjacent uplands. A distinct riparian vegetation corridor exists along the entire reach. Riparian, aquatic, or wetland species dominate the length of the reach.
Notes on differences in vegetation:	

8. Riffle-pool sequence

____ (0-3) *Half-scores (0.5, 1.5, 2.5) are allowed.*	Evaluate the prevalence of riffles, pools, and other microhabitats in the streambed. 0 (Poor) No riffle-pool sequences observed. 1 (Weak) Mostly has areas of pools or riffles. 2 (Moderate) Represented by a less frequent number of riffles and pools. Distinguishing the transition between riffles and pools is difficult to observe. 3 (Strong) Demonstrated by a frequent number of structural transitions (e.g., riffles followed by pools) along the entire reach. There is an obvious transition between riffles and pools.
Notes about riffle-pool sequence:	

Photo log

Indicate if any other photographs taken during the assessment:

Photo ID	**Description**

Additional notes about the assessment:

Model classification:

☐ Ephemeral

☐ At least intermittent

☐ Intermittent

☐ Less than perennial

☐ Perennial

☐ Needs more information

Appendix C3: Field form for the WM SDAM

Western Mountains Streamflow Duration Assessment Method

General site information

<table>
<tr><td colspan="4">Project name or number:</td></tr>
<tr><td colspan="2">Site code or identifier:</td><td colspan="2">Assessor(s):</td></tr>
<tr><td colspan="3">Waterway name:</td><td>Visit date:</td></tr>
<tr><td colspan="2">Current weather conditions (check one):
□ Storm/heavy rain
□ Steady rain
□ Intermittent rain
□ Snowing
□ Cloudy (___ % cover)
□ Clear/sunny</td><td>Notes on current or recent weather conditions (e.g., precipitation in prior week):</td><td>Coordinates at downstream end (decimal degrees):

Lat (N):

Long (E):

Datum:</td></tr>
<tr><td colspan="2">Surrounding land-use within 100 m (check one or two):
□ Urban/industrial/residential
□ Agricultural (farmland, crops, vineyards, pasture)
□ Developed open-space (e.g., golf course)
□ Forested
□ Other natural
□ Other: ____________________________________</td><td colspan="2">Describe reach boundaries:</td></tr>
<tr><td>Mean bankfull channel width (m): _________
(Indicator 1)

______ _______ _______</td><td>Reach length (m):
40x width
min 40 m
max 200 m</td><td colspan="2">Site photographs:
Enter photo ID or check if completed.

Top down: _________ Mid down: __________

Mid up: ___________ Bottom up: __________</td></tr>
<tr><td colspan="4">Disturbed or difficult conditions (check all that apply):
□ Recent flood or debris flow
□ Stream modifications (e.g., channelization)
□ Diversions
□ Discharges
□ Drought
□ Vegetation removal/limitations
□ Other (explain in notes)
□ None
Notes on disturbances or difficult site conditions:</td></tr>
<tr><td colspan="2">Observed hydrology:

______ % of reach with surface flow

______ % of reach with sub-surface or surface flow

______ # of isolated pools</td><td colspan="2">Comments on observed hydrology:</td></tr>
</table>

Site sketch:

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1. Mean bankfull channel width (m) (nearest 0.1 m, copy from first page of field form)

Notes about mean bankfull channel width:

Aquatic macroinvertebrate indicators

Collect aquatic macroinvertebrates from at least 6 locations in the assessment reach, searching all suitable habitats on the streambed (including dry habitats, if present).

2. Aquatic macroinvertebrates: Abundance of Ephemeroptera, Plecoptera, and Trichoptera

Determine total abundance of individuals in the orders of Ephemeroptera, Plecoptera, and Trichoptera (EPT), such that no one family counts for more than 11 individuals in the total.

Mark the appropriate box for the number of EPT individuals observed.

☐ No EPT detected
☐ 1 to 4 EPT individuals
☐ 5 to 9 EPT individuals
☐ 10 to 19 EPT individuals
☐ 20 or more EPT individuals

Check if applicable: ☐ No aquatic macroinvertebrates in assessment area

Notes on abundance of EPT indicator:

3. Aquatic macroinvertebrates: Abundance of perennial indicator taxa

Determine total abundance of individuals in perennial indicator families listed below, such that no one family counts for more than 11 individuals in the total.

Ephemeroptera	**Plecoptera**	**Trichoptera**	**Coleoptera**
Ephemerellidae (spiny crawler mayflies)	Chloroperlidae (green stoneflies)	Brachycentridae (humpless casemakers)	Elmidae (riffle beetles)
Heptageniidae (flathead mayflies)	Perlidae (common stoneflies)	Glossosomatidae (saddle casemakers)	
Leptohyphyidae (little stout crawler mayflies)		Hydropsychidae (common netspinners)	
Leptophlebiidae (prong-gilled mayflies)		Rhyacophilidae (free-living caddisflies)	

Mark the appropriate box for the number of perennial indicator individuals observed.

☐ No perennial indicator taxa detected
☐ 1 to 4 perennial indicator individuals
☐ 5 to 9 perennial indicator individuals
☐ 10 to 19 perennial indicator individuals
☐ 20 or more perennial indicator individuals

Check if applicable: ☐ No aquatic macroinvertebrates in assessment area

Notes on perennial indicator taxa:

4. Slope

Using a clinometer or other device, record the slope as a percent, up to the nearest half-percent.

Notes about slope:

5. Shading

At the center of three transects, use a convex spherical densiometer to record the number of points covered by trees, canyon walls, buildings, or other structures that provide shade (up to 17 points per location). Calculate percent shading as the percentage of points covered by such structures (total points covered divided by 204).

Percent shading: ___________

	Downstream transect	*Middle transect*	*Upstream transect*
Facing upstream	/17	/17	/17
Facing right bank	/17	/17	/17
Facing downstream	/17	/17	/17
Facing left bank	/17	/17	/17

Total number of points covered:

____ / 204 * 100%

Notes on shading:

6. Number of hydrophytic plant species

Record up to 6 hydrophytic plant species (FACW or OBL in the appropriate regional wetland plant list, depending on location) within the assessment area: **within the channel or up to one half-channel width outside the channel**. Explain in notes if species has an odd distribution (e.g., one individual or small patch, long-lived species solely represented by seedlings, or long-lived species solely represented by specimens in decline), or if there is uncertainty about the identification. Enter photo ID or check if photos are taken.

_____________ Number of hydrophytic plant species identified from the assessment reach without odd distribution. Enter zero if none were found.

Check if applicable: ☐ No vegetation in assessment area

Species	**Odd distribution?**	**Notes**	**Photo ID**

Notes on hydrophytic vegetation:

7. Prevalence of rooted upland plants in the streambed

____ **(0-3)** *Half-scores (0.5, 1.5, and 2.5) are allowed.*	Evaluate the prevalence of rooted upland plants (i.e., plants rated as FAC, FACU, UPL, or not listed in the regionally appropriate National Wetland Plant List) in the streambed. 0 (Poor) Rooted upland plants are *prevalent* within the streambed/thalweg. 1 (Weak) Rooted upland plants are *consistently dispersed* throughout the streambed/thalweg. 2 (Moderate) There are *a few* rooted upland plants present within the streambed/thalweg. 3 (Strong) Rooted upland plants are *absent* from the streambed/thalweg.

Upland Species	**Notes**	**Photo ID**

Notes on rooted upland plants:

8. Differences in vegetation

____ (0-3) *Half-scores (0.5, 1.5, 2.5) are allowed.*	Compare the composition and density of plants growing on the banks and riparian areas to plants in the adjacent uplands. For this indicator, an upland species is not defined by its wetland indicator status, but rather by its location relative to the channel. 0 (Poor) No compositional or density differences in vegetation are present between the banks and the adjacent uplands. 1 (Weak) Vegetation growing along the reach may occur in greater densities or grow more vigorously than vegetation in the adjacent uplands, but there are no dramatic compositional differences between the two. 2 (Moderate) A distinct riparian corridor exists along part of the reach. Riparian vegetation is interspersed with upland vegetation along the length of the reach. 3 (Strong) Dramatic compositional differences in vegetation are present between the banks and the adjacent uplands. A distinct riparian vegetation corridor exists along the entire reach. Riparian, aquatic, or wetland species dominate the length of the reach.
Notes on differences in vegetation:	

9. Riffle-pool sequence

____ (0-3) *Half-scores (0.5, 1.5, 2.5) are allowed.*	Evaluate the prevalence of riffles, pools, and other microhabitats in the streambed. 0 (Poor) No riffle-pool sequences observed. 1 (Weak) Mostly has areas of pools or riffles. 2 (Moderate) Represented by a less frequent number of riffles and pools. Distinguishing the transition between riffles and pools is difficult to observe. 3 (Strong) Demonstrated by a frequent number of structural transitions (e.g., riffles followed by pools) along the entire reach. There is an obvious transition between riffles and pools.
Notes about riffle-pool sequence:	

10. Particle size or stream substrate sorting

____ (0-3) *Half scores (0.75, 2.25) are allowed.*	Evaluate the extent of substrate sorting. Compare substrate on the channel bed to the banks and adjacent floodplain. Look for sorting within the channel bed (e.g., along bars and islands). 0 (Poor) Particle sizes in the channel are similar or comparable to particle sizes in areas close to but not in the channel. Substrate sorting is not readily observed in the channel. 1.5 (Moderate) Particle sizes in the channel are moderately similar to particle sizes in areas close to but not in the channel. Various sized substrates are present in the channel and are represented by a higher ratio of larger particles (gravel/cobble; coarse sand in low-gradient streams). 3 (Strong) Particle sizes in the channel are noticeably different from particle sizes in areas close to but not in the channel. There is a clear distribution of various sized substrates in the channel with finer particles accumulating in the pools, and larger particles accumulating in the riffles/runs.
Notes about substrate sorting:	

Photo log

Indicate if any other photographs taken during the assessment:

Photo ID	Description

Additional notes about the assessment:

Model classification:

☐ Ephemeral

☐ At least intermittent

☐ Intermittent

☐ Less than perennial

☐ Perennial

☐ Needs more information