User Manual for Beta Streamflow Duration Assessment Methods for the Northeast and Southeast of the United States

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November 2023

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Center: Black-eyed susan (*Rudbeckia hirta*), courtesy of Amy James

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Section 1: Introduction and Background

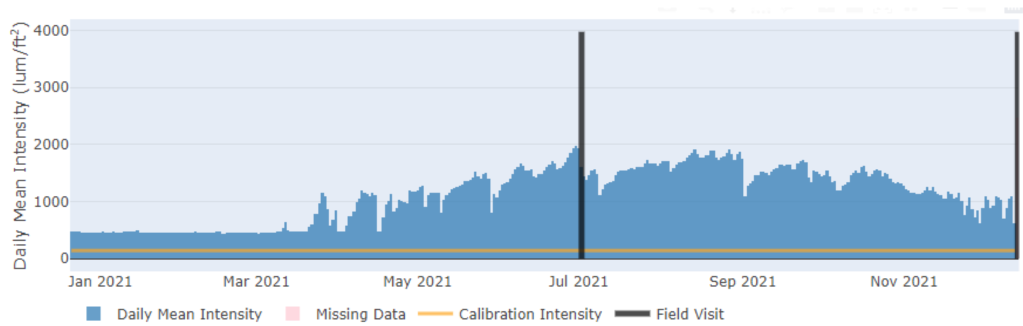
Streams exhibit a diverse range of hydrologic regimes, and the hydrologic regime strongly influences the physical, chemical, and biological characteristics of active stream channels and their adjacent riparian areas. Thus, information describing a stream's hydrologic regime is useful to support resource management decisions, including Clean Water Act Section 404 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), they 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 (Fritz et al. 2013, Hall et al. 1998, Nadeau and Rains 2007). Therefore, there is a need for rapid, field-based methods to determine flow duration class at the reach scale (defined in Section 2) in the absence of long-term hydrologic data (Fritz et al. 2020).

This streamflow duration assessment method (SDAM) is intended to classify stream reaches into one of three streamflow duration classes[1]:

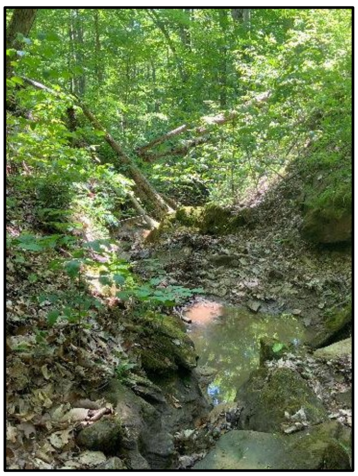
> *Perennial reaches* are channels that contain flowing water continuously during a year of normal rainfall, often with the streambed located below the water table for most of the year. Groundwater typically supplies the baseflow for perennial reaches, but the baseflow may also be supplemented by stormwater runoff and/or snowmelt.
>
> *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.
>
> *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.

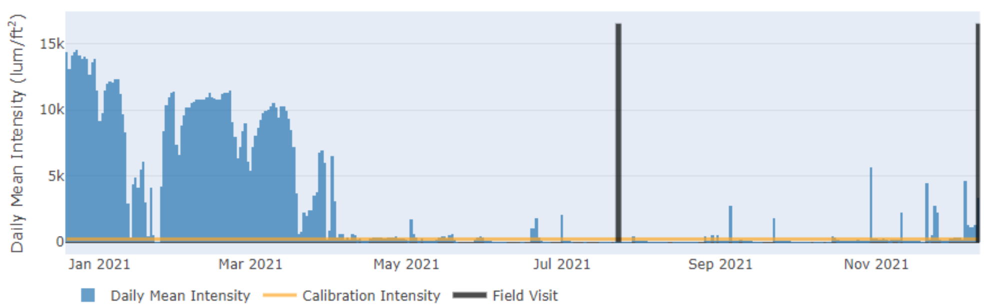
Example photographs and hydrographs of stream reaches in each class are shown in Figure 1.

[1] The definitions used for development of this manual are consistent with the definitions used to develop the SDAM for the Pacific Northwest and the beta SDAMs for the Arid West, Western Mountains, and Great Plains.

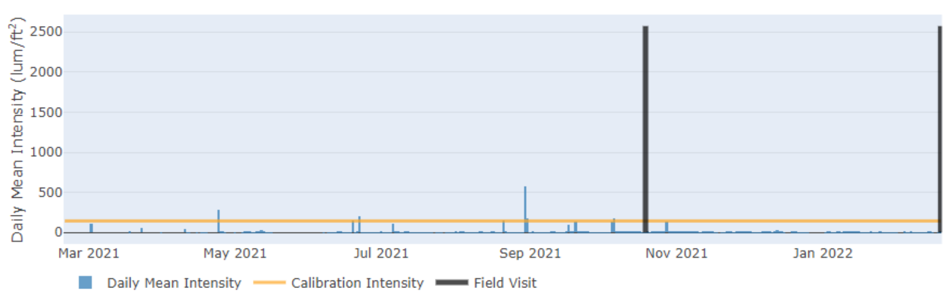


Perennial stream reach
Tributary to Scituate Reservoir, Scituate, Rhode Island





Intermittent stream reach
Tributary to Asher Run, Adams County, Ohio



Ephemeral stream reach
Tributary to Blue Creek, Blackwater State Forest, Florida

Figure 1. Streams of different flow classes. Photos of stream reaches in each streamflow duration class are shown at left, with corresponding visualizations of daily flowing vs. dry periods of these reaches on the right and their flow classification. Daily flowing vs. dry observations are derived from Stream Temperature, Intermittency, and Conductivity (STIC) loggers deployed in the channel thalweg in erosional or riffle habitat in each study reach (Chapin et al. 2014, Kelso et al. 2023). For these loggers, the presence of flowing surface water is inferred from raw intensity values that are higher than logger-specific intensity values calibrated to distilled water (yellow lines). Blue areas above the yellow lines denote flowing periods and black bars denote field visits when logger data was downloaded, and indicator data was collected.

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 primary sources of flow (e.g., storm runoff, groundwater, and 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 typically have year-round surface flow in the absence of drought conditions. Intermittent reaches have one or more periods of flow sustained by sources other than surface runoff in direct response to precipitation, including groundwater and melting snowpack but also 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 beta SDAMs that are intended to distinguish flow duration classes of stream reaches in the Northeast and Southeast regions of the United States (or NE and SE) as defined in *Synthesizing the Scientific Foundation for Ordinary High-Water Mark Delineation in Fluvial Systems* (Wohl et al. 2016), which is based largely on vegetation type and precipitation levels. In the Northeast, snowmelt contributes at least some flow to streams and rivers during the year while the Southeast is dominated by rainfall runoff other than snowmelt, including tropical storms and hurricanes (Figure 2).

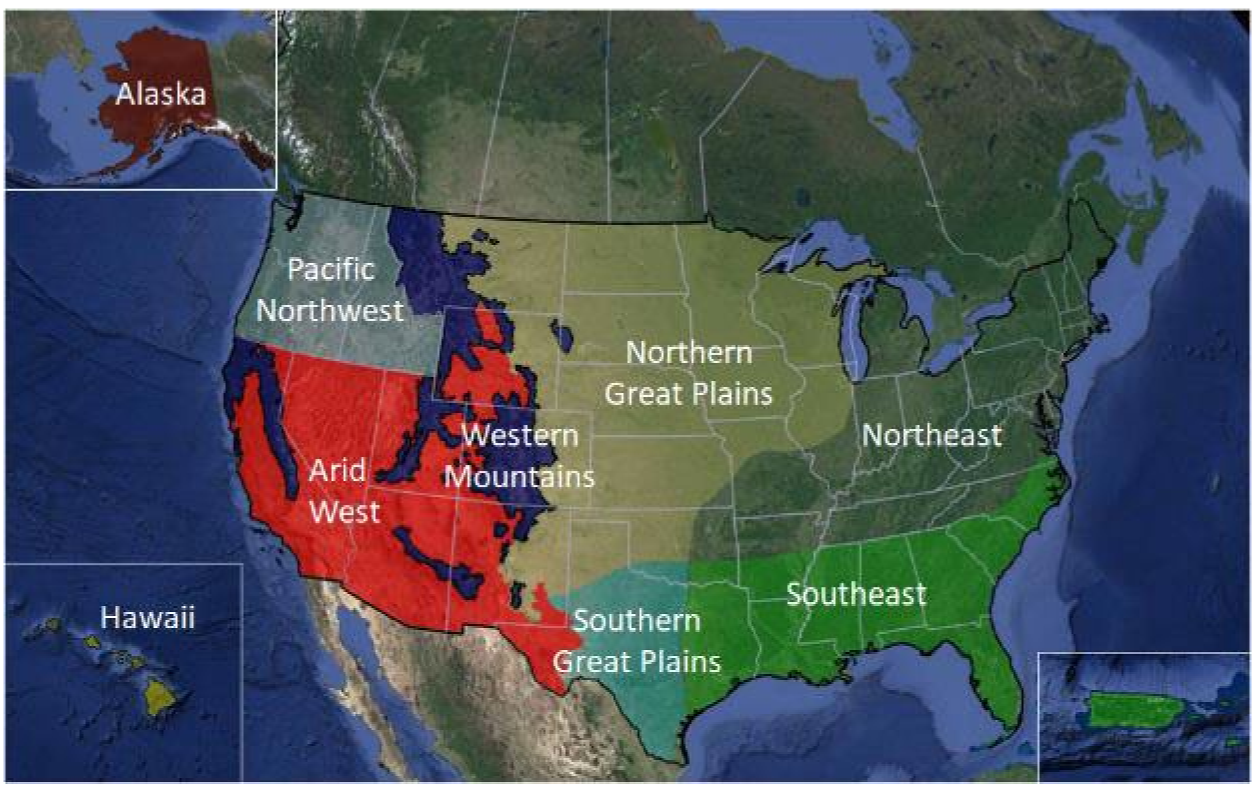


Figure 2. Map of flow duration study regions, showing the Northeast and Southeast. Note, U.S. territories in the Caribbean Sea (Puerto Rico and the U.S. Virgin Islands, inset) are not covered by the SE beta method.

Based on data analysis, distinct beta SDAMs for the NE and SE provide higher classification accuracy than a single stratified method, though certain indicators are used in both methods. The beta SDAMs for the NE and SE are based on biological and geomorphological indicators measured in the field, as well as geospatial indicators determined using desktop methods. Biological indicators, known to respond to gradients of streamflow duration (Fritz et al. 2020), have notable advantages for assessing natural resources. The primary advantage is their ability to reflect long-term environmental conditions (e.g., Karr et al. 1986, Rosenberg and Resh 1993). This characteristic makes them well suited for assessing streamflow duration because some species reflect the aggregate hydrologic conditions that 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.

The beta methods for the Northeast and Southeast

This manual describes protocols that use a small number of indicators to predict the streamflow duration class of stream reaches in the NE and SE. All indicators except two are measured during a single field visit. The methods are available as beta versions for a one-year preliminary implementation period to allow the user community to provide feedback before final SDAMs for the NE and SE are produced. For more information on the development of the beta SDAMs for the NE and SE, please see the NE and SE Data Analysis Supplement at (https://www.epa.gov/system/files/documents/2023-04/Development-of-Beta-SDAM-NE-and-SE-April-2023.pdf). For more information on the development of SDAMs for other U.S. regions, please refer to EPA's SDAM website: https://www.epa.gov/streamflow-duration-assessment.

The beta SDAMs for the NE and SE assign reaches to one of six possible classifications: *ephemeral, intermittent, perennial, at least intermittent, less than perennial,* and *needs more information*. The *less than perennial* classification occurs when an *intermittent* or *ephemeral* classification cannot be made with high confidence, but a *perennial* classification can be ruled out. The *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. Lastly, the needs more information classification occurs when no individual classification is supported more than another. The protocol uses 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. For more information on how random forest models were used to develop the beta SDAMs, see Gross et al. 2023. We have developed an open-access, user-friendly web application (https://ecosystemplanningrestoration.shinyapps.io/beta_sdam_nese/) for entering SDAM indicator data and running the developed random forest model to obtain the classification for individual assessment reaches. The beta SDAMs for the NE and SE are based on the indicators listed in Table 1.

Table 1. Indicators of the beta SDAMs for the Northeast and Southeast.

Type of Indicator	Northeast Indicators	Southeast Indicators
Biological	Benthic Macroinvertebrate Index (BMI) Score Percent Shading Upland Rooted Plants	BMI Score Total Benthic Macroinvertebrate Abundance Upland Rooted Plants
Geomorphological	Bankfull Channel Width Natural Valley Channel Slope	Bankfull Channel Width Particle Size of Stream Substrate
Geospatial	Drainage Area Average Precipitation (August-October)	Drainage Area Average Precipitation (May-July)

Intended use and limitations

The beta SDAMs for the NE and SE are intended to support field classification of streamflow duration at the reach scale in streams with defined channels (i.e., having a bed and banks) in their respective regions. Use of these beta SDAMs can inform a range of activities where information on streamflow duration is useful, including jurisdictional determinations under the Clean Water Act; however, the beta SDAMs for the NE and SE are not in themselves a jurisdictional determination. The methods are not 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 beta SDAMs for the NE and SE when classifying streamflow duration (Fritz et al. 2020).

Although the beta SDAMs for the NE and SE 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 can be misleading.

Poor water quality in streams can affect biological indicators; for example, streams in watersheds dominated by agricultural or urban uses may have lower benthic macroinvertebrate species richness and/or abundance (e.g., Moore and Palmer 2005, Roy et al. 2003, and Stone et al. 2005). Consequently, the beta SDAMs for the NE and SE may fail to identify perennial reaches as *perennial* in situations where water quality has been severely degraded by nutrients, sediment, or other stressors such that benthic macroinvertebrate communities are reduced in number and/or taxa richness.

Development of the beta SDAMs for the Northeast and Southeast

These methods resulted from a multi-year study conducted in 388 total study reaches across the NE region (202) and SE region (186, including 23 in the U. S. Caribbean territories of Puerto Rico and the U.S. Virgin Islands) following the process described in Fritz et al. (2020). Of these, data from 336 study reaches where streamflow duration class could be determined from direct hydrologic data were used to develop the beta SDAMs for the NE and SE (Figure 3). We did not include the U. S. Caribbean study reaches in developing the beta SDAM for the SE because 1) the candidate indicators were distinct from those measured at other SE study reaches, and 2) preliminary models developed including U.S. Caribbean study reaches had lower classification accuracy than those that did not include the U. S. Caribbean reaches (Gross et al. 2023). At this time, we do not have a large enough dataset to develop a U. S. Caribbean-specific beta SDAM.

Of the 336 study reaches included in the development of the beta SDAMs for the NE and SE, 71 were ephemeral, 150 were intermittent, and 115 were perennial (Table 2).

Table 2. Distribution of streamflow duration classes across the NE and SE study reaches.

Stream Class	Northeast	Southeast
Ephemeral	37	34
Intermittent	85	65
Perennial	66	49

Streamflow duration class was directly determined using continuous (hourly interval) hydrological data from loggers deployed at the study reaches (200) and/or from active USGS stream gages (22). Multiple sources of hydrologic data (e.g., inactive USGS stream gage data, published studies, consultation with local experts) were used to classify the remaining study reaches (117), for which continuous hydrological data were not available. Development of the beta SDAMs for the NE and SE followed the process steps below (Fritz et al. 2020):

- Conducted a literature review (James et al. 2022a) with two goals:
  - Identified existing SDAMs, focusing on those originating in the NE/SE or developed using a similar approach (see NCDWQ 2010; Nadeau 2015).
  - Identified (40) potential biological, hydrological, and geomorphological field indicators of streamflow duration for evaluation in the NE and SE.
- Identified candidate study reaches with known streamflow duration class, representing diverse environmental settings throughout each region.
- Collected field indicator data at study reaches.
- Evaluated 97 candidate metrics from the field data and geospatial metrics for their ability to discriminate among streamflow duration classes. Geospatial metrics included climatic measures that characterize hydrologic drivers of streamflow duration (e.g., long-term precipitation and temperature) as well as metrics like drainage area and stream order.

- Calibrated a classification model(s) using a machine learning algorithm (i.e., random forest).
- Created separate methods for the NE and SE to produce greater accuracy.
- Refined and simplified the final beta methods for rapid and consistent application.

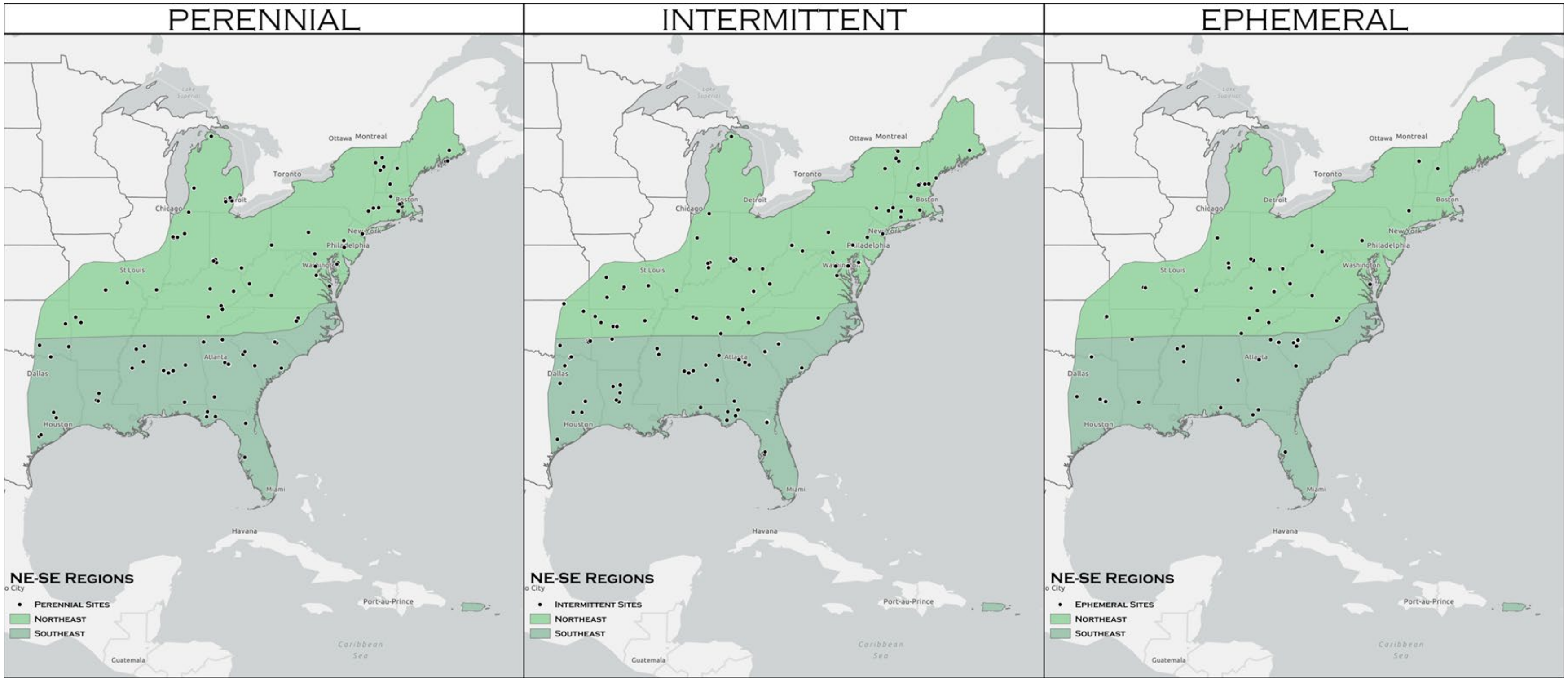


Figure 3. Locations of ephemeral, intermittent, and perennial stream reaches used to calibrate the beta SDAMs for the NE and SE (Note, due to map scale some dots represent more than one site).

The final beta method for the NE correctly classified 73% of site visits among three classes (*perennial* vs. *intermittent* vs. *ephemeral*), while 90% of site visits were classified correctly between two classes (*ephemeral* vs. *at least intermittent*). The final beta method for the SE correctly classified 73% of site visits among the three classes, with 90% of site visits classified correctly between the two classes. Generally, misclassifications among intermittent and perennial reaches were more common than misclassifications among ephemeral and intermittent reaches for both methods. The ability of the beta SDAMs for the NE and SE 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).

How the beta SDAMs for the NE and SE differ from other regional SDAMs

The beta SDAMs for the NE and SE are the fifth and sixth regional methods resulting from an EPA-led effort to develop SDAMs for nationwide coverage of the United States (Figure 4). The first was developed for the Pacific Northwest (PNW; Nadeau et al. 2015) and finalized in 2015 (Nadeau 2015). The second, third, and fourth methods for the Arid West (AW; Mazor et al. 2021a), the Western Mountains (WM; Mazor et al. 2021b), and Great Plains (GP; James et al. 2022b), respectively, were made available as beta versions for a preliminary implementation period while the EPA and its partners continue an expanded data collection effort to inform the refinement of the final SDAMs for these regions (anticipated in 2023). The six SDAMs differ in several respects, due in part to resources and time available to gather data for their development, but the differences are primarily to optimize performance of each region's data-driven SDAM. Differences between the SDAMs are summarized in Table 3.

Table 3. General differences and similarities among regional SDAMs developed by the EPA.

	Northeast-Southeast (beta) (2023)	Great Plains (beta) (Sept 2022)	Western Mountains (beta) (Dec 2021)	Arid West (beta) (March 2021)	Pacific Northwest (Nov 2015)
Collection of data used to develop the method	Blend of instrumented and single-visit reaches, similar to the Western Mountains and Great Plains	Blend of instrumented and single-visit reaches, similar to the Western Mountains and NE and SE	Blend of single-visit reaches (where streamflow duration was already well characterized) and instrumented reaches (where continuous hydrologic data was generated to classify streamflow duration).	Single-visit reaches alone. Minimal collection of new hydrologic data.	Extensive collection of hydrologic data.
Types of indicators	Biological, geomorphological, and climatic	Biological, geomorphological, and regional location	Biological, geomorphological, and climatic	Biological	Biological and geomorphological
Single indicators?	None	None	Fish	Fish Algal cover ≥10%	Fish Aquatic life stages of snakes or amphibians
Type of tool	Random forest model	Random forest model	Random forest model	Classification table (simplified from random forest model)	Decision tree (simplified from random forest model)
Stratification	Region	None (strata used as indicator)	Snow-influence	None	None
Classifications*	P, I, E, LTP, ALI, and NMI	P, I, E, LTP, ALI, and NMI	P, I, E, LTP, ALI, and NMI	P, I, E, LTP, and ALI	P, I, E, and ALI
Aquatic invertebrate identification	Required; Abundance and how many different taxa (based on Family, Order, or Class level depending on taxon).	Required at Family level for Ephemeroptera, Plecoptera, and Trichoptera only	Required at Family level for some aquatic insects and mollusks	Required at Order level for Ephemeroptera, Plecoptera, and Trichoptera	Required at Family level for some aquatic insects and mollusks
Hydrophytic plant identification	Upland plants only (FAC, FACU, or UPL)	Required	None	Required	Required
Field time required	Up to 2 hours	Up to 2 hours	Up to 2 hours	Up to 2 hours	Up to 2 hours

*P=Perennial, I=Intermittent, E=Ephemeral, LTP=Less Than Perennial, ALI=At Least Intermittent, and NMI=Needs More Information.

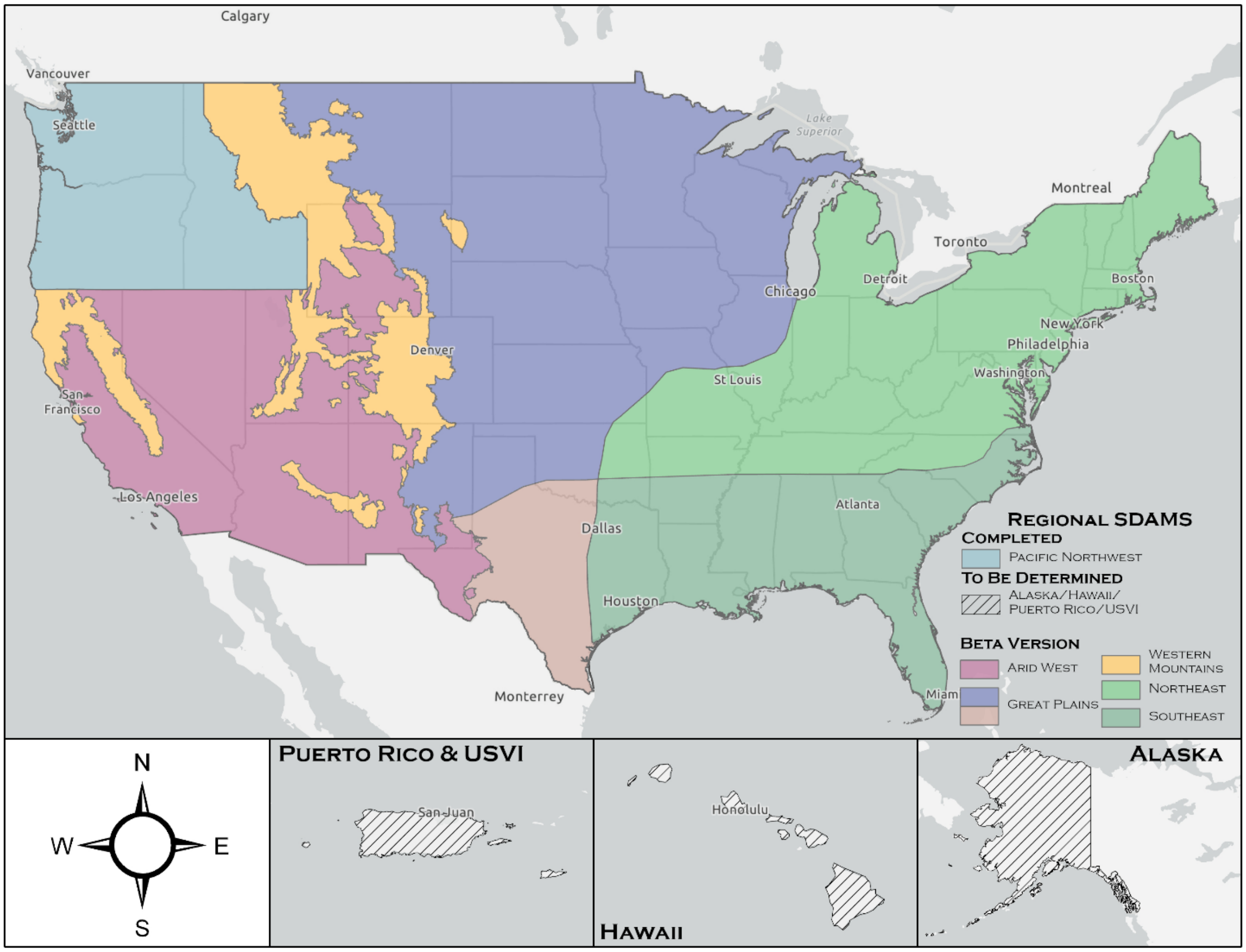


Figure 4. Status of the development of regional SDAMs at the time of this manual's publication.

Section 2: Overview of the Beta SDAMs for the NE and SE and the Assessment Process

Considerations for assessing streamflow duration and interpreting indicators

Scales of assessment

The field protocols associated with the beta SDAMs for the NE and SE apply to an assessment reach, the length of which scales with the mean bankfull channel width. Regardless of channel width, SDAM assessment reaches are required to be a minimum of 40 meters and no longer than 200 meters in length. The minimum reach-length of 40 meters is necessary to ensure that a sufficient area has been assessed to observe indicators. Quantification and observations of SDAM indicators are restricted to the bankfull channel and within one-half bankfull channel width from the top of each bank along the assessment reach. However, ancillary information from outside the assessment reach (such as surrounding land use) should also be recorded.

Clean Water Act Jurisdictional Determinations

Regulatory agencies evaluate aquatic resources for jurisdiction under the Clean Water Act based on current regulations, guidance, and policy. The beta SDAMs for the NE and SE do not incorporate that broad scope of analysis. Rather, the beta SDAMs provide information that can be used to support a timely jurisdictional decision because they aid in determining streamflow duration class.

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 regional spatial variation are generally the physiographic province (e.g., geology and soils) and climate (e.g., seasonal patterns of precipitation, snowmelt, and evapotranspiration). The drivers of reach-scale spatial variability in flow duration within a stream system include changes in physiographic province and climate as well as changes in surrounding land and water uses and local geology. Understanding these sources of spatial variability in streamflow duration and indicators will help ensure that assessments are conducted within relatively homogenous reaches.

Common sources of variation in flow duration within a stream system include:

- Changes in catchment size and volume of flow. Increasing catchment size and changing volume of flow can lead to changes in streamflow duration. As streams gain or lose streamflow, the expression of indicators will also change.
- Changes in channel gradient and valley width affect physical processes and may directly or indirectly affect streamflow duration and the expression of indicators. These changes can be sharp or gradual. For example, sharp transitions in valley gradient or width (e.g.,

going from a confined canyon to an alluvial fan) can be associated with changes in streamflow duration.

- Changes in stream size. Streams develop different channel dimensions due to differences in flow magnitude, sediment loads, landscape position, land-use history, and other factors.
- Changes in bedrock material (e.g., limestones, sandstones, shales, conglomerates, and lignite), water source (runoff, springs, summer rains, and groundwater), and localized climate extremes (e.g., drought or unusually high precipitation events) should also be noted by the user.
- Transitions in land use or water use (e.g., from commercial forest to pasture, from pasture to cultivated farmland, or cultivated farmland to urbanization), or changes in management practices (e.g., intensification of grazing or change in irrigation method) that affects streamflow duration and the expression of indicators.
- Stream management and manipulation, such as diversions, water importation, dam operations, and habitat modification (e.g., streambed armoring), can also influence streamflow duration and the biological, hydrological, and physical characteristics of streams.

Temporal variability

Streamflow is subject to interannual (e.g., year-to-year), intra-annual (e.g., seasonal), and episodic (e.g., storm-driven) variability. This method was developed to be robust to interannual and intra-annual variability and is intended to classify streams based on their long-term patterns in either flowing or dry conditions. However, in addition to seasonal variability, both long-term sources of temporal variability (such as El Niño-related climatic cycles) and short-term sources (such as scouring storms before sampling) can influence measurements taken at the time of assessment. Timing of management practices, such as dam operations, channel clearing, or groundwater pumping, can also affect the flow duration assessment results.

Certain indicators are more sensitive to temporal variability than others. For example, after a scouring flood event aquatic invertebrates may be displaced from a stream reach. In contrast, rooted upland plants, if present, will likely remain. Similarly, longer-lived benthic 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 stream channel or the riparian corridor.

Ditches and modified natural streams

Assessment of streamflow duration is sometimes needed in canals, ditches, and modified natural streams that are primarily for efficient conveyance of water. These systems tend to have altered flow regimes compared to natural systems with similar drainage areas (e.g., Buchanan et al. 2013), and the beta SDAMs for the NE and SE can help to determine if these flow regimes support indicators consistent with different streamflow duration classes. Thus, the beta methods may be applied to these types of systems when streamflow duration information is needed.

Geomorphological indicators (e.g., bankfull channel width and slope; sometimes drainage area if ditching is extensive) 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 the degrees to which channel geomorphology reflects natural processes or if it reflects the effects of management activities.

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 this study, the beta SDAMs for the NE and SE classified disturbed reaches with similar accuracy as undisturbed reaches (Gross et al. 2023).

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 invertebrates in channels that have undergone recent grading activity). Logging, mining, and impoundments can affect both vegetation and geomorphological indicators (e.g., Choi et al. 2012, Jaeger 2015). 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 below in the section on data collection. Assessors should describe disturbances in the “Notes on disturbances or difficult assessment reach conditions” section of the field form.

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 channel 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 assessment form.

Section 3: Data Collection

Order of operations in completing assessments for the beta SDAMs for the NE and SE

The following general workflow is recommended for efficiency in the field; if a step needs to be completed for one beta SDAM and not the other, it is noted as such in the text:

> **Two Methods**
>
> The beta SDAM for the NE and beta SDAM for the SE are separate SDAMs that share four indicators. See Gross et al. 2023 for explanation of how the indicators for each method were selected.

In the office:

1. Conduct desktop reconnaissance.
    a. Confirm location in NE or SE with reach latitude/longitude (if needed).
    b. Perform preliminary assessment of drainage area; based on exact location of reach in the field, this calculation may need to be adjusted later.
    c. Determine if placement of assessment reach will need to be adjusted to avoid changes in stream order/tributaries (and account for major disturbances if project constraints allow). Placement may need to be adjusted in the field, depending on conditions on the ground.
    d. Download and have available appropriate USACE wetland plant lists and benthic macroinvertebrate field guides and/or identification apps.
    e. Check for potential influences on water quality that may affect benthic macroinvertebrate indicators (e.g., 303d lists, NPDES permit discharge locations, etc.).
2. Prepare sampling gear.

On-site:

3. Walk the assessment reach, avoiding being in the channel, where possible, such that substrate is not disturbed prior to benthic macroinvertebrate collection.
    a. Confirm assessment reach placement avoids changes in stream order, channel morphology, major disturbances, proximity to incoming tributaries, etc.
    b. Record the bankfull channel width at three locations and calculate the average to determine the assessment reach length (40 x bankfull width (m); minimum assessment reach length: 40 m; maximum: 200 m).
    c. Identify the reach boundaries.
    d. Determine channel slope using a clinometer with a two-person team (one person at bottom of reach, one at the top of reach; NE only)
    e. Record the coordinates of the downstream boundary of the assessment reach from the center of the channel and photograph the assessment reach. Collect densiometer readings (NE only). Begin to note any upland rooted plants in the reach (both regions), degree of valley development (NE only),

and differences in channel substrate material as compared to surrounding uplands (SE only).

   f. Continue taking photographs (for both regions) and collecting densiometer readings (NE only) at the middle and top of the assessment reach, continue noting the degree of indicator expression along the reach.
   g. Start sketching the assessment reach on the field form.
4. Record general assessment reach information on the field form (see: Appendix C).
5. Evaluate the remaining indicators:
   a. Collect benthic macroinvertebrates from reach—determine total abundance and up to 5 different taxa.
   b. Score degree of difference in channel substrate material as compared to surrounding uplands (SE only).
   c. Score upland plants growing in the channel based on their prevalence and distribution.
   d. Score presence of natural valley (NE only).
   e. Complete sketch of the assessment reach on the field form.
6. Review the field form for completeness.

In the office:

7. Confirm drainage area determination was accurately calculated (e.g., field observations confirm point used was at the downstream end of the assessment reach).
8. Enter data into the web application to get average seasonal total precipitation and a flow duration classification: (https://ecosystemplanningrestoration.shinyapps.io/beta_sdam_nese/).

If more than one user is conducting the field assessment, it may be efficient for one person to collect, identify, and count benthic macroinvertebrates while the other is completing the remaining on-site tasks in steps 3-5.

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 could 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.

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 potential hazards 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 determine assessment reach placement or the number of assessment reaches required for a project. Look for natural and artificial features that can affect streamflow duration at the reach—particularly those that may not be evident during the field visit, or 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.

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 USEPA WATERS GeoViewer, provide convenient online access to watershed information for most assessment reaches in the United States, such as soils, land use or impervious cover in the catchment, or modeled bankfull discharge (StreamStats is also used to measure drainage area, where available.)

- USGS StreamStats: https://streamstats.usgs.gov/ss/
- USEPA WATERS GeoViewer: https://www.epa.gov/waterdata/waters-geoviewer

Assessors should consider consulting local experts and agencies to gain additional insights about reach conditions and see if additional data are available. 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 duration.

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, which can be helpful for determining whether a plant is considered an 'upland' plant (see 4. Absence of Rooted Upland Plants indicator, below). Several online databases can generate regionally appropriate flora lists and/or assist with identification (Table 4). Note that there are four National Wetland Plant List (NWPL) regions that overlap with the area covered by the beta SDAM NE and three that overlap with the area covered by the beta SDAM SE; consult the appropriate list for your location.

Table 4. Examples of online resources for generating local flora lists.

Resource	Geographic coverage
NWPL Mapper Tool https://wetland-plants.usace.army.mil/nwpl_static/v34/mapper/mapper.html	United States and territories
USDA Plants Database https://plants.usda.gov/home	United States and territories
Lady Bird Johnson Wildflower Center https://www.wildflower.org/collections/	Continental U.S. (native species only)
Atlas of Florida Plants https://florida.plantatlas.usf.edu/	Florida (species lists by county)
Tennessee-Kentucky Plant Atlas https://tennessee-kentucky.plantatlas.usf.edu/	Tennessee and Kentucky (species lists by county)

Desktop reconnaissance also helps determine if permits are required to collect aquatic invertebrates. If threatened and endangered species are expected in the area, stream assessment activities may require additional permits from appropriate federal and state agencies.

Prepare sampling gear

The following gear is suggested for completion of the beta SDAMs for the NE and SE; if a piece of equipment is required for one method only, it is indicated as such. Ensure that all equipment is functional before each assessment visit. Also ensure that all equipment has been cleaned off-site between assessment visits to prevent the spread of invasive species.

- This manual and copies of paper field forms on write in the rain paper.
- Clipboard/pencils/permanent markers.
- Field notebook.
- 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 (or Global Navigation Satellite System) may be a suitable substitute.
- Tape measures – for measuring bankfull channel width and reach length in meters.
- Clinometer – for measuring slope (NE Only).
- Kick-net, small net, white tray, forceps, and squirt bottle – used to sample aquatic macroinvertebrates.
- Hand lens – to assist with macroinvertebrate and plant identification.
- Digital camera (or smartphone with camera) and charger. Ideally, use a digital camera that automatically records metadata, such as time, date, directionality, and location, as part of the EXIF (Exchangeable Image File Format) data associated with the photograph.
- Shovel, soil auger, rock hammer, hand trowel, pick, or other digging tools - to facilitate hydrological observations of subsurface flow.

- Sand-gauge card (SE only).
- Convex spherical densiometer, taped to restrict assessment to the forward-facing 17 grid intersections (NE only; see the Percent Shading indicator for information on how to prepare the densiometer).
- Appropriate regional plant field guides and/or web applications (e.g., iNaturalist)
- Benthic macroinvertebrate field guides (e.g., *A Guide to Common Freshwater Invertebrates of North America*, Voshell 2002) and/or web applications (e.g., PocketMacros[2]).
- Vials filled with 70% ethanol and sealable plastic bags - for collection of biological specimens with sample labels printed on waterproof paper.
- The U.S. Army Corps of Engineers List of wetland plants - for assessment reaches to be visited http://wetland-plants.usace.army.mil/.
- First-aid kit, sunscreen, insect repellant, and appropriate clothing.

Additional resources for benthic macroinvertebrate and plant identification can be found in the associated web application under "Additional Resources" (https://ecosystemplanningrestoration.shinyapps.io/beta_sdam_nese/).

Timing of sampling

Ideally, application of the beta SDAMs for the NE and SE should occur during the growing season when many benthic macroinvertebrates are most active and are readily identifiable. 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 or identify at the time of assessment, especially in the NE, 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 method persist well beyond a single growing season (e.g., rooted upland plants) or are not dependent on it (e.g., geomorphological indicators), reducing the sensitivity of the method to the timing of sampling.

The protocol 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 benthic macroinvertebrates and other biological indicators to recover (e.g., Angradi 1997; McCord et al. 2009; Smith et al. 2019). In general, benthic 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 benthic macroinvertebrates). Assessors should note recent rainfall events (generally, within a week) 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

[2] https://www.macroinvertebrates.org/app/download

sampling event helps to determine if storms may have affected data collection and informs data interpretation. The Antecedent Precipitation Tool (APT; U.S. Army Corps of Engineers 2020a) can also be helpful for evaluating recent precipitation conditions at an assessment reach relative to the 30 year average https://www.epa.gov/wotus/antecedent-precipitation-tool-apt.

Assessment reach size, selection, and placement

An assessment reach should have a length equal to ***40 bankfull channel-widths****,* with a minimum of 40 m (to ensure that sufficient area is assessed to observe indicators) and a maximum length of 200 m. Bankfull channel width is averaged from measurements at three locations representative of the assessment reach. 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 the conducting assessments and completing the field form section. 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.

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 can 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 can be avoided by moving the reach at least 10 m up- or downstream.

Walking the assessment reach

Stream assessments should begin by first 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 investigation can 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. <u>Walking alongside, rather than in, the channel is recommended for the initial review to avoid unnecessary disturbance to the stream.</u> Walking alongside the channel also allows the assessor to observe characteristics of the surrounding landscape, such as land use and sources of flow (e.g., stormwater pipes, springs, seeps, and upstream tributaries).

Once the walk is complete, the assessor can document the areas along the stream channel where various sources (e.g., stormflow, tributaries, or groundwater) or sinks (e.g., alluvial fans, abrupt changes in bed slope, etc.) of water 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 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. Regardless of whether the assessment reach is shifted, shortened, or multiple reaches are assessed, an assessment reach should not be less than 40 m in length to ensure that indicators are measured appropriately. Assessments based on reaches shorter than 40 m may not detect indicators that would be recorded by assessments with the recommended size and may thus provide inaccurate classifications.

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 up- or down-stream 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).

Photo-documentation

Photographs can provide strong evidence to support conclusions resulting from the application of the beta SDAMs for the NE and SE, 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:

- Extent of upland rooted plants in channel.
- Particle size in the streambed vs. uplands (SE only).
- Disturbed or unusual conditions that may affect the measurement or interpretation of indicators.

Conducting assessments and completing the field form

General reach information

After walking the reach and determining the appropriate boundaries for the assessment area, enter the project name, reach code or identifier, waterway name, assessor 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.

Coordinates

Record the latitude and longitude in the center of the channel on the downstream end of the assessment reach. Record in units of decimal-degrees, and note the datum used. Sub-meter accuracy should be prioritized to find the downstream coordinates, as this point will be used to determine drainage area, an indicator in both regions. If the assessment reach is near a tributary confluence, note if the assessment reach is the tributary reach (smaller of the two streams joining), the upstream mainstem reach (larger of the 2 streams joining), or the downstream mainstem reach formed by the joining of the two streams. Not all streams are represented on maps and online resources. While in the field, note the surrounding topography and nearby features (e.g., roads, buildings) to confirm the geographical accuracy against maps and aerial imagery.

Weather conditions

Note current weather conditions. If known, note precipitation within the previous week on the field form and if possible, consider delaying sampling. If rescheduling is not possible, note whether the streambed is recently scoured and if turbidity is likely to affect the measurement of indicators.

Surrounding land use

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

- Urban/industrial/residential (e.g., 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).

Bankfull channel width

Record the 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 (Figure 5). Note, this replicates how the data used to develop this beta SDAM was collected at study reaches across the NE and SE. Widths should be measured perpendicular to the thalweg. In braided systems, width measurements should span all channels within the OHWM. Calculate the average width.

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

The bankfull width[3,4] is the portion of the channel that contains the bankfull discharge, which is a flow event that occurs frequently (typically every 1 to 2 years), 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 this 'line' as can breaks in bank slope or changes in substrate composition.

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[3] See this recent technical bulletin for further description and illustration of how to find bankfull width: https://dirtandgravel.psu.edu/wp-content/uploads/2022/06/TB_Bankfull-1.pdf.

[4] See also: https://dec.vermont.gov/sites/dec/files/wsm/rivers/docs/rv_identification_of_bankfull_stage.pdf

Certain indicators 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.

Note that bankfull channel width is also an indicator of streamflow duration, as described below under 5. Bankfull Channel Width, below.

Reach length

Record the reach length (m), which should be 40 times the average bankfull channel width, but no less than 40 m and no more than 200 m, and measured along the thalweg (i.e., along the deepest points within the channel) with a tape measure. In multi-thread systems, measure reach-length along the thalweg of the deepest channel. If circumstances require a shorter reach length, enter the assessed reach's actual length. Justification for an assessment reach length shorter than 40 m should be provided in "Describe reach boundaries" on the field form.

Describe reach boundaries

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 used. 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 private property."

Photo-documentation of reach

Record the photo ID 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.

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 affect stream geomorphology, such as channelization, or vegetation removal that may affect the presence of bankfull indicators or the percent shading indicator in the NE (Figure 6). Also note if the stream appears recently restored, for example, placement of large substrate or wood 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: This stream reach in the North Carolina Piedmont is heavily impacted by cattle through input of nutrients as well as trampling, which may affect abundance and richness of benthic macroinvertebrate and obscure identification of bankfull elevation. Image credit: EPR. Right: This stream in a park in South Bend, Indiana is surrounded by urban land uses; the addition of urban non-point source discharges may also impact aquatic invertebrate communities.

Observed hydrology

Surface flow

Visually estimate or use the tape measure to determine the percentage of the reach length that has flowing surface water. 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. Flow resurfacing downstream may be considered evidence of subsurface flow (Figure 7). Other evidence of subsurface flow includes:

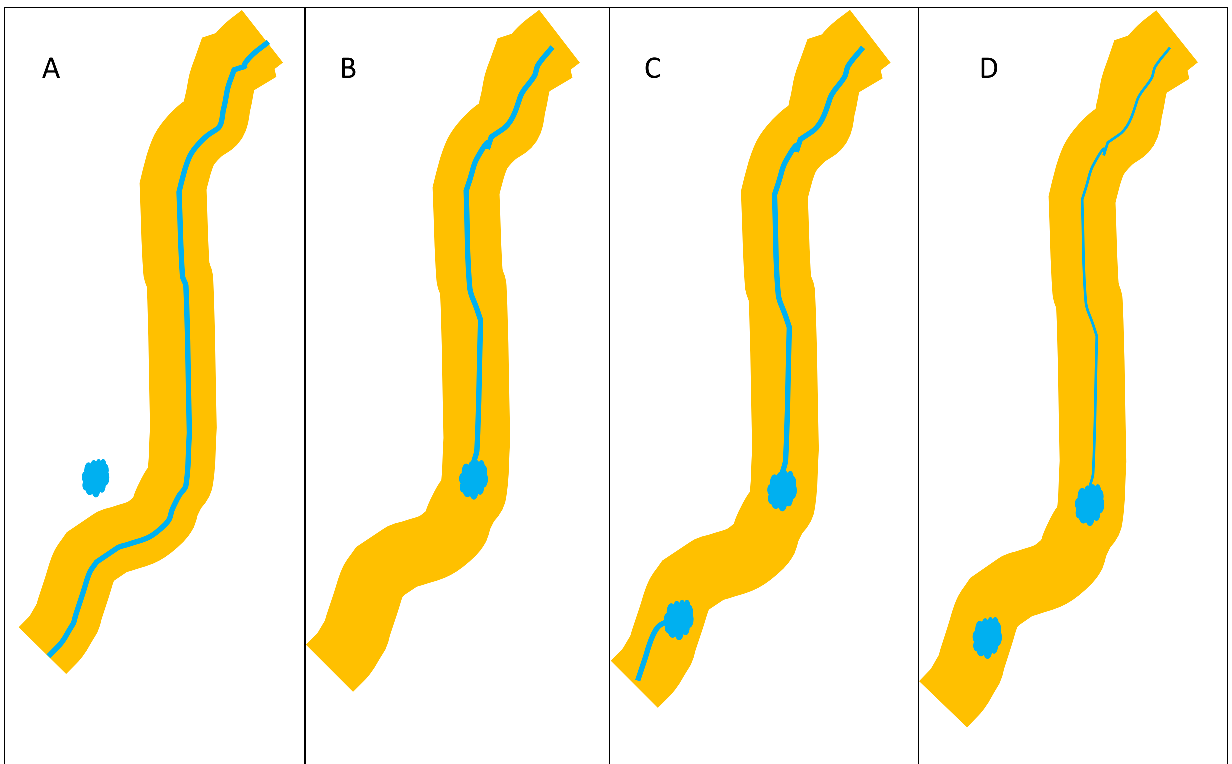
- Flowing surface water disappears into alluvial deposits and reappears downstream. This is scenario is common when a large, recent alluvium deposit created by a downed log or other grade-control structure creates a sharp transition in the channel gradient or in valley confinement.
- Water flows out 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). Note, 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 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, blue represents surface water in the channels, and blue circles represent pools. 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.

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, and other features. Note locations where photographs are taken and where channel measurements are made.

How to measure indicators of streamflow duration

Assessments are based on measurement of indicators of streamflow duration for each method, seven in the SE and eight in the NE. While some indicators overlap, others are unique to each method as indicated below:

Biological indicators

- Benthic macroinvertebrate (BMI) score (NE and SE)
- Total benthic macroinvertebrate abundance (SE only)
- Percent shading (NE only)
- Absence of rooted upland plants in the streambed (NE and SE)

Geomorphological indicators

- Bankfull channel width (NE and SE)
- Natural valley (NE only)
- Channel slope (NE only)
- Drainage area (NE and SE)
- Particle size of stream substrate (SE only)

Climatic indicator

- Average precipitation (NE and SE, but using different month ranges, see indicator below)

BMI score and total abundance, natural valley, drainage area, bankfull width, and particle size/stream substrate sorting are positive indicators of streamflow duration. That is, a greater abundance, strength, or size of these indicators is generally associated with longer duration flows (e.g., Delucchi 1988, Fritz et al. 2008, Smith et al. 2017). For example, higher benthic macroinvertebrate abundance is associated with perennial reaches. The relationship between streamflow duration and bankfull channel width is less straightforward. In general, in the NE and SE, wider channels are more likely to be perennial and positioned lower in the watershed than narrower non-perennial channels (e.g., Fritz et al. 2008, OH EPA 2020, Svec et al. 2005). Rooted upland plants are a negative indicator of streamflow duration. Greater abundance or expression of rooted upland plants in the assessment reach is associated with shorter flow duration classes. For consistency with the other indicators in terms of its relationship to evidence of perennial flow, the scoring for the rooted upland plants indicator is reversed by characterizing its rarity or absence. Climatic indicators, like precipitation, have been shown to be highly correlated with flow duration and the timing of drying (Hammond et al. 2021). The average precipitation across certain months may be fundamental to whether and/or when drying will occur in NE and SE streams.

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 field form and are considered when drawing conclusions. Within each indicator description, common ways that disturbances can interfere with indicator measurement are described.

1. BMI score (NE and SE)

This indicator scores the total abundance and richness of all aquatic benthic macroinvertebrates. Richness is based on family-level identification for aquatic insects and mollusks, order-level for crustaceans and mites, and class or phylum for all other non-insects. When enumerating this indicator, living material (e.g., live larvae or pupae) and non-living material (e.g., caddisfly cases, shed exuviae) are equally considered.

Benthic macroinvertebrates are assessed within the defined reach. A kick-net or D-frame net is used to collect and a hand lens is used to identify specimens for richness measures. Smaller streams may require a small aquarium net or sieve. Assessors begin sampling at the most downstream point in the assessment reach and proceed to sample in the upstream direction. The net is placed perpendicular against the streambed while the substrate is disturbed upstream of the net for a minimum of one minute. Jab the net under banks, overhanging terrestrial and aquatic vegetation, leaf packs, and in log jams or other woody material. Samples should be collected from **at least six** distinct locations representing the different habitats occurring in the reach. Empty contents of the net into a white tray with fresh water for determining abundance and richness of individuals present. Collecting voucher specimens for later confirmation of identification in a lab is suggested but not required.

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 picking and 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 (pick up rocks and loose gravel).

Dry channels: Focus the search on areas serving as refuge, such as any remaining pools or areas of moist substrate for living macroinvertebrates, and under cobbles and other larger bed materials for caddisfly casings (Figure 8). Exuviae of emergent mayflies or stoneflies may be observed on dry cobbles or stream-side vegetation (Figure 8). Additional explanation can be found in the Xerces Society's recommendations for using aquatic macroinvertebrates as indicators of streamflow duration (Mazzacano and Black 2008), as developed for the SDAM PNW (Nadeau 2015).

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 benthic macroinvertebrates. However, do not ignore dry areas.

Figure 8. Examples of evidence of aquatic benthic macroinvertebrates in dry channels. Left: Caddisfly cases may persist under large cobbles or boulders well after the cessation of flow. Right: A stonefly (Plecoptera) exuviae left on a rock surface after the aquatic nymph emerged from the stream and completed its final molt to the winged adult stage. Image credits: Raphael Mazor.

Scoring for this indicator is as shown in Table 5. Though not required, identified taxa contributing to richness should be indicated on the field form. A guide to taxa commonly encountered during field data collection for the beta SDAM NE and SE effort can be found in Appendix B.

Table 5. Scoring guidance for the BMI indicator.

Score	Evidence of perennial flows	Guidance
0.0	Absent	Total abundance of benthic macroinvertebrates is zero.
1.0	Weak	Total abundance is 1 to 3.
2.0	Moderate	Total abundance is ≥4.
3.0	Strong	Total abundance is ≥10 AND richness ≥3, OR Total abundance < 10 AND richness ≥5.

2. Total Benthic Macroinvertebrate abundance (SE only)

For this indicator, follow sampling guidance for BMI score. Scoring for this indicator is based on total number of individuals, or abundance, for all aquatic benthic macroinvertebrates (insects and non-insects) only, as shown in Table 6.

Table 6. Scoring guidance for the benthic macroinvertebrate abundance indicator.

Score	Evidence of perennial flows	Guidance
0.0	Absent	Total abundance of benthic macroinvertebrates is zero
1.0	Weak	Total abundance is ≥1 and ≤10
2.0	Moderate	Total abundance is ≥11 and ≤32
3.0	Strong	Total abundance is ≥33

3. Percent shading (NE only)

Using a convex spherical densiometer, stream shading is estimated in terms of percent cover of objects (e.g., vegetation and buildings) that block sunlight. The method described uses the Strickler (1959) modification of a densiometer to correct for over-estimation of stream shading that occurs with unmodified readings. As shown in Figure 9, taping off the lower left and right portions of the mirror emphasizes overhead structures over foreground structures (the main source of bias in stream shading measurements).

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. Consider the “zone of influence” of vegetative cover expected during the growing season (Nadeau et al. 2018).

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 oriented such that the “V” of the tape is closest to the observer’s face and held just far enough from the squatting observer's body such that their forehead is just barely obscured by the intersection of the two pieces of tape.

Take and record four readings (integer values ranging 0 to 17) from the center of the channel at three locations in the reach (upstream, middle, and downstream): a) facing upstream, b) facing downstream, c) facing the left bank, d) facing the right bank. The observer and the densiometer should revolve together over the center point of the transect to keep the "V" oriented as described above.

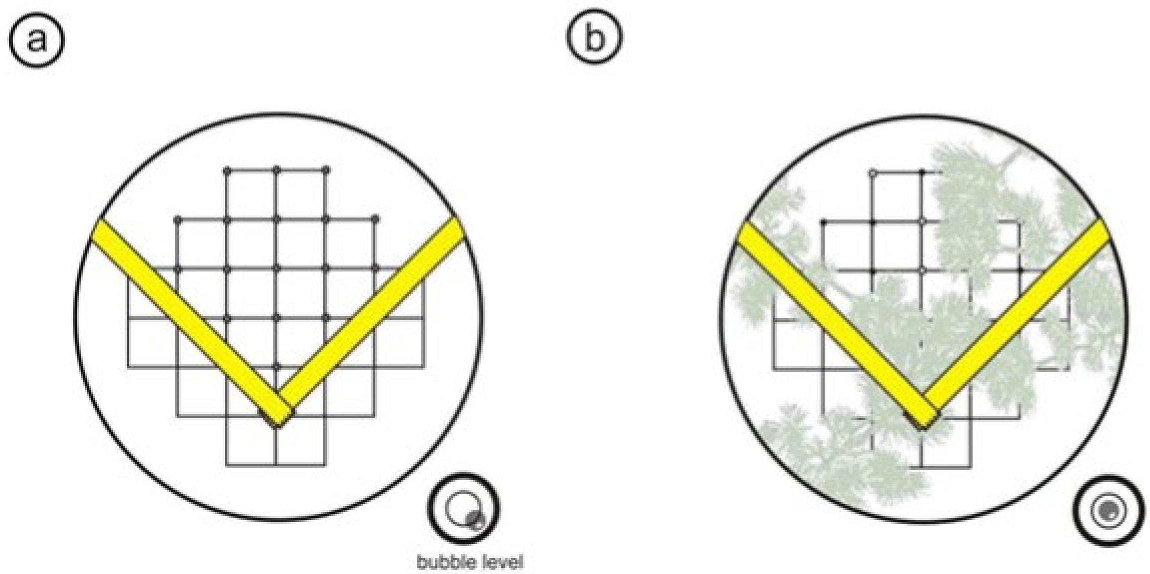


Figure 9. Representation of the mirrored surface of a convex spherical densiometer showing the position for taping the mirror and the intersection points used for the densiometer reading. The score for the hypothetical condition (b) is 9 out of 17 possible covered intersection points within the "V" formed by the two pieces of tape (figure from Ode et al. 2016).

4. Absence of rooted upland plants in streambed (NE and SE)

Upland plant species are usually unable to establish in streams having longer streamflow duration, as prolonged soil saturation provides less than ideal growth conditions for these species. Surface flow can limit plant establishment by displacing seeds or otherwise preventing germination and growth. Therefore, reaches where rooted upland plants cover much of the streambed may indicate ephemeral or intermittent flow. For both the beta SDAM NE and SE, upland plants are those with FAC, FACU, and Upland (UPL) indicators on the most recent National Wetland Plant List[5] (NWPL) or species with No Indicator (NI). **NOTE**: while some applications of the NWPL treat FAC plants as hydrophytes, they do not count as hydrophytes for purposes of the NE and SE beta SDAMs. For instance, some well-known riparian species are FAC in the NWPL regions applicable to the NE and SE, such as Eastern cottonwood (*Populus*

[5] https://cwbi-app.sec.usace.army.mil/nwpl_static/v34/home/home.html

deltoides; all applicable NWPL regions) and box elder (*Acer negundo*; all applicable NWPL regions).

The NE region encompasses parts of four different NWPL regions: Atlantic and Gulf Coastal Plain (AGCP), Eastern Mountains and Piedmont (EMP), Midwest (MW), and North-central Northeast (NCNE) (Figure 10). The SE region encompasses parts of three different NWPL regions: AGCP, EMP, and the Great Plains (GP) (Figure 10). Indicator status for certain species may differ between regions; therefore, it is important to consult the correct list when determining indicator status. For example, stinging nettle (*Urtica dioica*), a common, widespread herb often found growing in riparian areas, is FACW in the MW but FAC in the GP and NCNE.

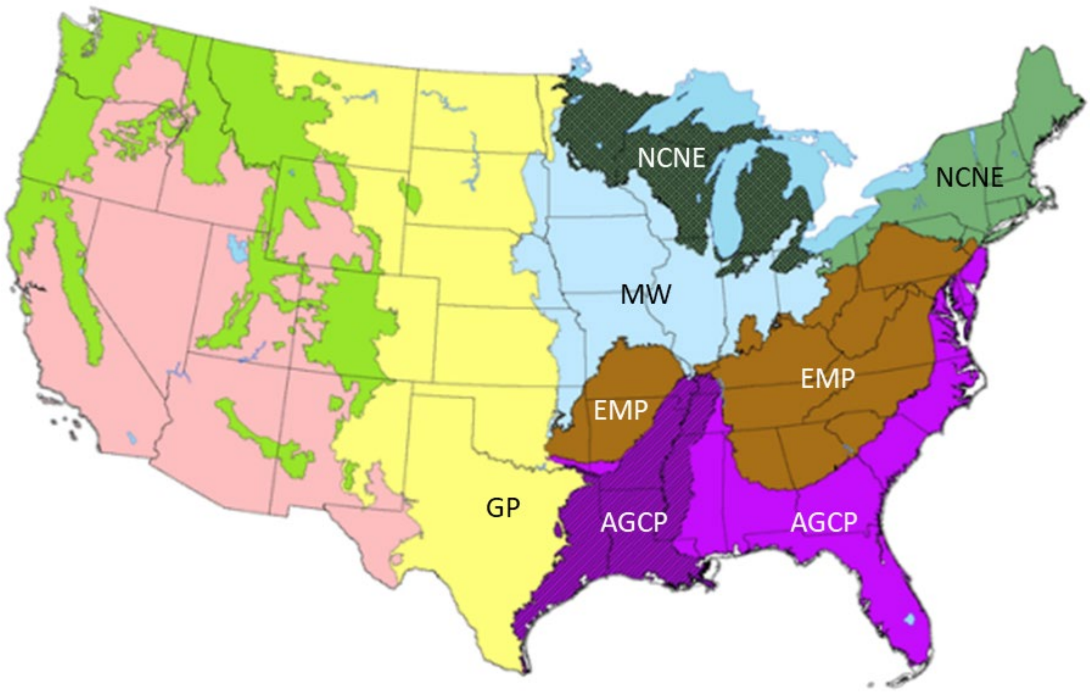


Figure 10. National Wetland Plant List (NWPL) regions that overlap with the NE and SE regional beta SDAMs.

What if I can't confidently identify a plant?

It may be acceptable to use environmental context and cues to determine that a plant is a non-hydrophyte, even if taxonomic identifications cannot be made. If a plant is growing exclusively in the channel and is absent from adjacent uplands, that may indicate the plant is a hydrophyte and should not be considered for this indicator. Also, if a genus-level identification can be made, some genera are dominated by either upland species (e.g., *Acer*) or hydrophytic species (e.g., *Ludwigia*). Post-sampling confirmation based on photos or collected specimens is strongly recommended. Photos can also be used when consulting plant identification applications that use image recognition (e.g., Seek, iNaturalist).

When assessing this indicator, the focus should be on plants rooted in the streambed; plants growing on any part of the bank should not be considered (Figure 11). Evaluate the entire length of the reach for this indicator and choose the score from Table 7 that best characterizes the predominant condition in the reach. Note that a higher score is given for the absence of rooted upland plants in the streambed.

Table 7. Scoring guidance for the Absence of Rooted Upland Plants indicator.

Score	Evidence of perennial flows	Guidance
0.0	Absent	Rooted upland plants are prevalent within the streambed (greater than 75%).
1.0	Weak	Rooted upland plants are consistently dispersed throughout the streambed (20 – 75%).
2.0	Moderate	Few rooted upland plants are present within the streambed (less than 20%).
3.0	Strong	Rooted upland plants are absent within the streambed.

*Figure 11. Example of an ephemeral stream with rooted upland vegetation growing in the channel. Japanese stiltgrass (*Microstegium vimineum*), which is FAC in the Eastern Mountains and Piedmont NWPL region, is prevalent within the streambed of this tributary to Kirk Springs Hollow in Oklahoma.*

5. Bankfull channel width (NE and SE)

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. 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 above in the conducting assessments and completing the field form section. In multi-threaded channels, the width of the entire active channel is measured for this indicator, based on the outer limits of the OHWM. Wohl et al. (2016) described 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. (Note, this is not always true in southeast Coastal Plain, where trunks of mature woody vegetation often occur in the active channel, e.g., see Robertson 2005 and Shankman 1993).

6. Natural valley (NE only)

This indicator addresses the degree of valley development due to water as an erosional agent. In the continuum of a single valley, the degree of development of that valley usually increases in the downstream direction. When observing the local topography in the field, does the land slope towards the channel thereby indicating a “draw” or valley? In other words, does the land have slopes that seem to drain to or indicate a natural valley? It is important to note that unconfined valleys may have very wide floodplains and may not be as obvious as with a confined V- or U- shaped valley (see Figure 13 for an unconfined valley example). Consulting a topographic map may also be helpful for contextual landscape clues (e.g., is the feature located in a contour crenulation).

Assess the presence of a well-developed valley at the location of the reach being evaluated using the scoring guidance in Table 8; photos that demonstrate the scoring guidance are shown in Figure 12 and 13. Intermediary scoring (i.e., 0.25, 0.75) of the ordinal scores shown in Table 8 are appropriate to allow the accessor flexibility to characterize this indicator more continuously.

Table 8. Scoring guidance for the Natural Valley indicator.

Score	Evidence of perennial flows	Guidance
0	Absent	No indication of surrounding land sloping to the valley bottom or stream. Channel located on side slope indicative of an artificial channel or stream relocation/manipulation.
0.5	Weak	Subtle valley indicated by some of the surrounding land sloping downward to the valley bottom or stream.
1.0	Moderate	Defined valley indicated by most of the surrounding land sloping downward to the valley bottom or stream.
1.5	Strong	Well defined valley indicated by all surrounding land sloping downward to the valley bottom or stream.

0

1

0.5

1.5

Figure 12. Examples illustrating different levels of scoring for the natural valley indicator. Scores are shown next to each photo. For the 'absent' score (0), while the channel banks are well-defined, the land on either side does not naturally slope towards the stream, indicating the channel may have been created and/or artificially deepened. The 'strong' example is of a V-shaped valley.

Figure 13.Stream with a strong natural valley indicator in an unconfined valley.

7. Channel slope (NE only)

Channel slope is measured as percent slope (to the nearest 0.5 percent) between the lower and upper extent of the assessment reach. This is most easily accomplished by a two-person team, with one individual standing at bankfull elevation at the downstream extent of the reach and, using a clinometer, sighting a location at eye-level at the upper extent of the reach (Figure 14) (e.g., if team members are of the same height, one individual standing at bankfull elevation at the lower end of the reach would 'sight' the eyes of the crew member standing at bankfull elevation at the upper end of the reach). 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, or several measurements can be averaged (e.g., if 60% of the reach length has a-1% slope, 20% a 3% slope, and 20% a 5% slope, the average channel slope is 2.2% [1*0.6 + 3*0.2 +5*0.2 = 2.2]).

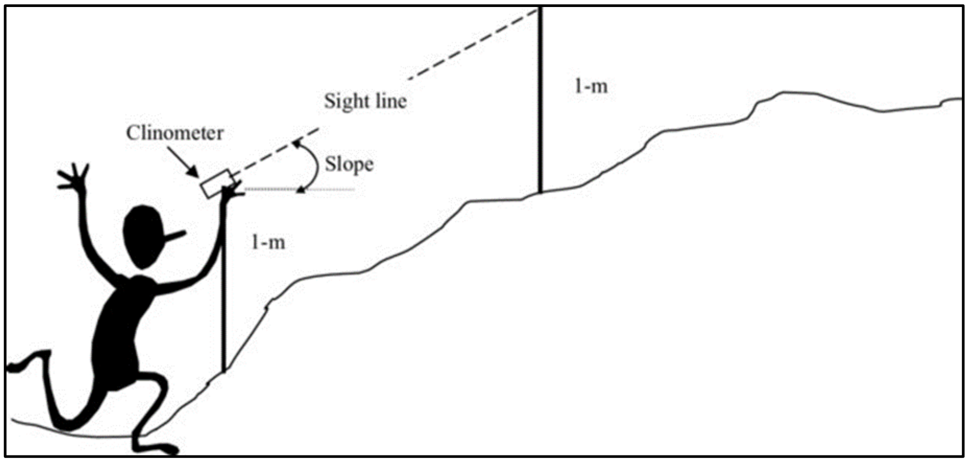


Figure 14. Measurement of slope using a clinometer.

This measurement is not necessarily the same as the 'average water-surface slope' which is often evaluated as part of stream ecological assessments including EPA's Environmental Monitoring and Assessment Program (EMAP) (Peck et al. 2006).

8. Particle size of stream substrate (SE only)

Well-developed channels 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 finer textured floodplain sediments and adjacent soils. Similar sediment sizes in the stream bed and the adjacent streamside area may indicate that stream forming processes have not been consistent enough to cut into the soil profile typical of an intermittent or perennial stream. For instance, the bed of intermittent or perennial streams is often comprised of coarser sediment relative to the bank area or floodplain due to consistent stream-forming flows that have transported finer particles downstream as the channel has eroded downward.

Evaluate whether the distribution of sediment size in the stream substrate is relatively coarser than the adjacent floodplain or streamside area to determine if downcutting has penetrated through the soil profile.

Score the indicator using the guidance in Table 9; photos that demonstrate the scoring guidance are shown in Figure 15. Intermediary scoring (i.e., 0.5, 1.5) of the ordinal scores shown in Table 9 is appropriate to allow the assessor flexibility to characterize this indicator more continuously.

Table 9. Scoring guidance for Particle Size of Stream Substrate indicator.

Score	Evidence of perennial flows	Guidance
0.0	Absent	The channel is poorly developed, very little to no coarse sediment is present. There is no difference between particle size in the stream substrate and adjacent land.
1.0	Weak	The channel is poorly developed through the soil profile. Some coarse sediment is present in the streambed but is discontinuous. Particle size differs little between the stream substrate and adjacent land.
2.0	Moderate	There is a well-developed channel, but it is not deeply incised through the soil profile. Some coarse sediment is present in the streambed in a continuous layer. Particle size differs somewhat between the stream substrate and adjacent land.
3.0	Strong	The channel is well-developed through the soil profile with relatively coarse streambed sediments compared to the riparian zone soils: coarse sand, gravel, or cobbles in the piedmont; cobbles or boulders in the Mountains; and medium or coarse sand in the coastal plain. Particle size differs greatly between the stream substrate and adjacent land.

Figure 15. Examples illustrating different levels of scoring for the particle size of stream substrate indicator. Scores are shown next to each photo.

9. Drainage area (NE and SE)

Drainage area is rapidly calculated using one of two existing web tools, USGS StreamStats or the National Map viewer. The National Map viewer is used only when a StreamStats calculation cannot be made due to regional unavailability or a restricted boundary, or when the channel is not mapped by the National Hydrography Dataset (NHD). States in which StreamStats is currently not available include, but are not limited to: Florida, Louisiana, Michigan, and Texas. See instructions below on how to calculate drainage area using these tools.

Instructions to calculate drainage area using StreamStats:

1. Refer to field notes and sketches made during the reach assessment that identify features such as roads, confluences, and topographic relief (see [Conducting assessments and completing the field form]() section). This will help confirm the reach location when calculating drainage area.
2. Go to https://streamstats.usgs.gov/ss/.
3. In the Search for a place box, enter latitude and longitude (longitude should be a negative value) coordinates in decimal degrees separated by a comma and space, press enter, and select the appropriate state that pops up on the left-hand panel.
4. Click the Delineate button in blue on the left-hand panel; the Delineate button will then turn red. On the map, the red circle represents the assessment reach. Click on a blue water pixel within the circle, and the basin will be delineated.
    a. Before selecting the blue pixel, observe geographical features on the web map and compare with field notes for coordinate selection.
        i. On StreamStats and the National Map viewer, different base maps are available for viewing imagery. If the coordinate location does not fall directly on one of the blue water pixels, but its location can be traced perpendicular to a pixel, then using that pixel is acceptable. This should be given careful consideration because selecting a pixel on a larger, downstream segment or parallel segment draining an adjacent catchment would likely produce an inaccurate drainage area. Not all channels observed in the field may be represented as blue pixels in StreamStats or as blue lines on the National Map layer. In this case, it is best to refer to field observations of surrounding features and compare with the web map. If the coordinate point does not correspond to a pixel on StreamStats, the National Map viewer should be used.
        ii. Conditions that complicate drainage area calculations include locations near tributary junctions where three potentially different stream channels (upstream mainstem, tributary, and mainstem) connect at a single point, and where the coordinate location is between two parallel stream channels. In both cases, use field notes, assessment reach sketches, and features on base map layers like roads and topographic relief to select the appropriate pixel for the assessment reach.

   b. If the red circle does not touch a water pixel or does not border one, then clicking on the red circle may produce an inaccurate delineation (this is especially true with changes in elevation). In this case, use the National Map viewer instead.
5. The Basin will be delineated in yellow (Figure 16). Click Continue on the left-hand panel. Scroll down to Basin Characteristics and check DRNAREA and then click Continue at the bottom. If the DRNAREA option does not show up (as has been observed in Montana, for example), use the National Map viewer instead.
6. Select Open Report to see the area measurement.

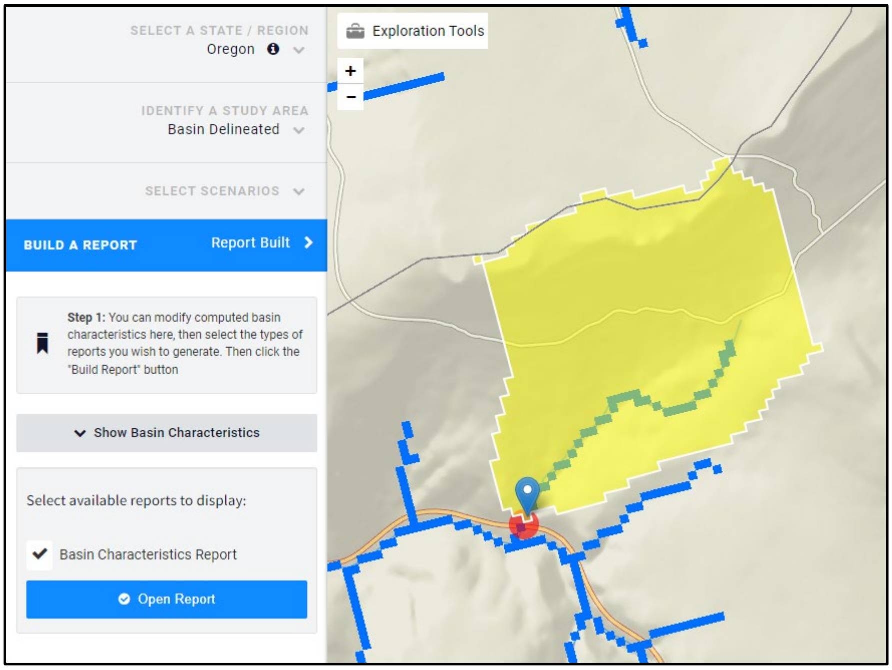


Figure 16. Calculating drainage area using StreamStats.

Instructions to calculate drainage area using the National Map viewer:

10. Go to https://apps.nationalmap.gov/viewer/.
11. On the green toolbar at the top, click on the second button from the left, Basemap Gallery. Select USGS National Map.
12. Click on the button to its right, Layer List. Check NHD Plus High-Resolution Dataset and Watershed Boundary Dataset. The pink lines represent catchment boundaries for NHD Plus.
13. In the white search bar on the right-hand side of the toolbar, enter the latitude coordinate, a comma and space, and then the longitude coordinate (which should be a negative value). Coordinates should be in decimal degrees. Press enter and a black circle will appear on the map.
14. Zoom out to see the surrounding topographic contour lines to delineate the basin.
15. On the toolbar, select the button with a ruler, the Measurement tool. Click the leftmost Area button with Sq Miles as the unit.

16. Start at the black circle and begin to draw by left clicking and dragging the mouse.
17. Where possible, trace the NHD Plus Catchment boundary; otherwise, use the contour lines for the delineation. Concave curvature (contour lines bending away) represents the valley containing the channels whereas convex curvature (bending toward) represents the ridge.
18. Open the Measurement tool window to see the area measurement. If < 0.01 sq miles, redo the delineation in hectares and divide that value by 259 to obtain it in square miles (Figure 17).

Figure 17. Calculating drainage area using the National Map.

10. Average Precipitation (NE and SE)

This indicator is calculated using the 30-year average precipitation from the PRISM (Parameter elevation Regression on Independent Slopes Model Climate Group[6]) statistical mapping system from August, September, and October for the NE and May, June, and July for the SE. This will be automatically calculated by the beta SDAM NE and SE web application based on the coordinates entered.

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.

[6] http://www.prismclimate.org

Section 4: Data Interpretation and using the web application

Because the beta SDAMs for the NE and SE rely on a random forest model to make classifications, we have developed a free, open-access web application (https://ecosystemplanningrestoration.shinyapps.io/beta_sdam_nese/) that allows assessors to input data from assessments and obtain a classification. In addition, users have the option to produce a PDF report in a standardized format, which may then be included in any documentation that requires incorporation of SDAM results.

The web application provides three tabs. The first tab provides background information about the beta methods. The second tab is where users can enter geographic coordinates or select the region (Northeast or Southeast), as well as enter field data needed to obtain a classification and additional information (such as assessment date) and photographs needed to produce a standard report. Note, the application will time out and data and additional information entry will have to restart if a report is not generated within 60 minutes. The third tab provides links to additional resources. Classifications may be obtained without producing a report. No data submitted to the web application are stored or submitted to the EPA or other agencies.

Outcomes of classification using the beta SDAMs for the NE and SE

Application of the beta SDAMs for the NE and SE 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 streams used to calibrate both beta SDAMs (i.e., perennial, intermittent, or ephemeral streams). These outcomes occur when the pattern of observed indicators closely matches patterns in the calibration data, and thus a classification can be assigned with high confidence.

In rare cases, the pattern of indicators is associated with multiple classes, and the beta SDAM models cannot assign a single classification with high confidence. However, the beta SDAM models may be able to rule out an ephemeral classification with high confidence. In this case, the outcome is *at least intermittent*, meaning that there is a high likelihood that the stream is either perennial or intermittent. Similarly, the beta SDAM models may be able to rule out a perennial classification with high confidence. In this case, the outcome is less than perennial, meaning that there is high likelihood that the stream is either ephemeral or intermittent. In these two circumstances, however, a single class cannot be distinguished with confidence. In some cases, this information may be sufficient for management decisions, although additional assessment may be warranted. In rare cases, the beta SDAM model cannot predict any individual classification with high confidence, and the needs more information result is returned. The perennial, intermittent, and ephemeral outcome was most common (94% and 95% of the NE and SE site visits respectively).

Applications of the Beta SDAMs for the NE and SE outside the intended area

The beta SDAMs for the NE and SE are intended only for application to their respective regions shown in Figure 4. The online web application allows the user to apply the protocol to reaches outside the NE and SE; however, classifications resulting from these applications are for informational purposes only. For example, it may be helpful to assess reaches near regional boundaries. Reports generated from such applications are accompanied by warnings.

What to do if more information about streamflow duration is desired?

The beta SDAMs for the NE and SE will result in one a *perennial, intermittent,* or *ephemeral* classification most of the time. There may be cases when additional information is desired. For example, conditions at the time of assessment may have complicated the evaluation and scoring of some indicators. It may help to examine other lines of evidence or conduct additional evaluations.

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 beta SDAM NE or SE, 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 aquatic invertebrates, leading to more conclusive assessments.

Conduct evaluations at nearby reaches

Indicators may provide more conclusive results at reaches up- or downstream from the assessment reach, as long as those locations represent similar conditions. 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 the assessment reach size, selection, and placement section for guidance.

Review historical aerial imagery

In much of the NE and SE, forest cover often prevents the ability of sequences of aerial imagery to provide information about streamflow duration. In settings where forest cover is absent or less dense, as well as certain areas along the western margins of the NE and SE regions (e.g., Texas and Oklahoma), the use of Google Earth's time slider and USGS Earth Explorer (https://earthexplorer.usgs.gov/) offer a convenient method of reviewing historical imagery (however, dates indicated by Google Earth time slider may be approximate or not accurate). 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 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 in the past 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 APT (U.S. Army Corps of Engineers 2020a) is a useful tool to determine if climate conditions are 'normal' for a locale (see timing of sampling section). 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 18.

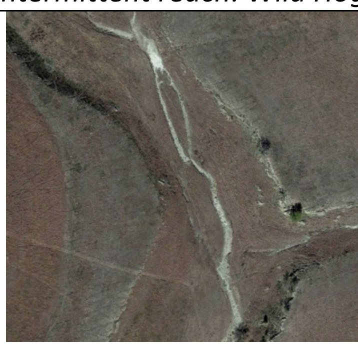
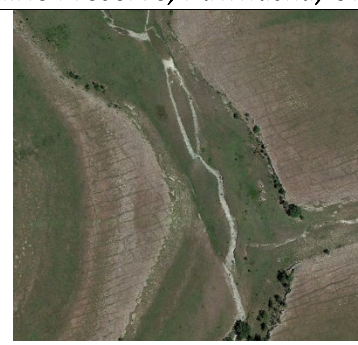
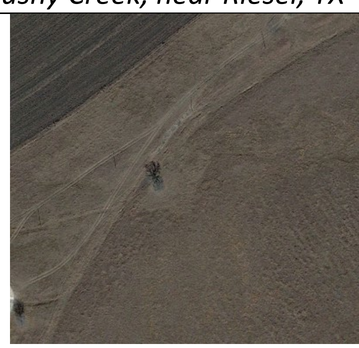
<table>
<tr><td colspan="3">Perennial reach: Tackett Creek, Claiborne County TN</td></tr>
<tr><td>
4/2008: Flowing</td><td>
4/2013: Flowing</td><td>
11/2020: Flowing</td></tr>
<tr><td colspan="3">Intermittent reach: Wild Hog Creek, Joseph Williams Tallgrass Prairie Preserve, Pawhuska, OK</td></tr>
<tr><td>
10/2011: Dry</td><td>
4/2013: Flowing</td><td>
7/2022: Isolated Pools</td></tr>
<tr><td colspan="3">Ephemeral reach: Tributary to Brushy Creek, near Riesel, TX</td></tr>
<tr><td>
12/2009: Isolated Pools</td><td>
12/2012: Dry</td><td>
5/2021: Isolated Pools</td></tr>
</table>

Figure 18. Examples of using aerial imagery to support streamflow duration classification. Images were taken from Google Earth using the time slider.

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.

Collect additional hydrologic data

Properly deployed loggers, stream gages, 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 (or sections, if segmented) of an arthropod body.
Abundance	The total number of individuals present in a sample (versus richness, which is the total number of taxa).
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 beta SDAM indicators are measured.
Bank	The side of an active channel, typically associated with a steeper side gradient than the adjacent channel bed, 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
Benthic macroinvertebrates	Invertebrate organisms usually found on, in, or near the bottom of waterbodies (*benthos*, “the depths”) and visible without the use of a microscope (i.e., > 0.5 mm body length). For this application, exceptions to the benthic rule include mosquitos and water striders.
Braided system	A stream with a wide, relatively horizontal channel bed over which during low flows, water forms an interlacing pattern of numerous, splitting channels that coalesce a short distance downstream. Same as multi-threaded system.
Canal	An artificial or formerly natural waterway used to convey water between locations, possibly in both directions. Sometimes used interchangeably with ditch.
Catchment	An area of land, bounded by a drainage divide, which drains to a channel or waterbody outlet. Sometimes used interchangeably with drainage area or watershed.
Cerci	The tail-like filaments at the posterior end of some arthropod’s abdomens. Singular: cercus.
Channel	A feature in fluvial systems consisting of a bed and its opposing banks which confines and conveys surface water flow. A braided or multi-threaded system consists of multiple channels, including active and inactive or abandoned channels.

Channel Slope	Percent upward inclination of the channel from the bottom to the top of the assessment reach measured at the bankfull elevation.
Confinement	The degree to which levees, terraces, hillsides, canyon walls, and other natural or artificial structures prevent the lateral migration of a fluvial channel.
Contour Crenulation	Contours on a topographic map that suggest the presence of a stream channel; crenulations are curves or notches in the contour that point upslope.
Culvert	A drain or covered channel that crosses under a road, pathway, or railway.
Ditch	An artificial or formerly natural waterway designed to convey water between locations, possibly in both directions. Sometimes used interchangeably with canal.
Dorsal	Upper surface of abdomen, or back when viewed from above.
Drainage area	An area of land, bounded by a drainage divide, which drains to a channel or waterbody. Often used interchangeably with catchment or watershed.
Ephemeral	Ephemeral streams are 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 exoskeleton and other materials left behind when an invertebrate molts.
FAC	Facultative plants. They are equally likely to occur in wetlands and non-wetlands. They are treated as 'upland' plants for this application.
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 adjacent to 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.
Hydrophyte	Plants that are adapted to inundated conditions found in wetlands and riparian areas.
Hyporheic flow	Water from a stream or river channel that enters sub-surface materials of the streambed and bank and then returns to the stream or river.
Hyporheic zone	The saturated zone adjacent to under a river or stream, including the substrate and water-filled spaces between the particles, in which hyporheic flow occurs.

Indicator	A measurement of environmental conditions. For the beta SDAM, indicators are rapid, generally field based measurements that are used to predict streamflow duration class.
Intermittent	Intermittent reaches are 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	The immature stage of an insect or other invertebrates. Some insects, such as mayflies, stoneflies, and caddisflies, have aquatic larval stages and terrestrial adult stages. Plural: larvae.
Metamorphosis	The process of transformation from immature to adult form through a series of distinct life stages. The term may apply to the transformation from larval to adult insects, as well as to amphibians (e.g., the transformation from tadpoles to adult frogs).
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.
Nymph	The larval form of insects that undergo partial metamorphosis (i.e., groups that lack a pupal stage and molt directly from larval to adult stage). Mayflies and stoneflies are examples of aquatic insects that have larvae known as nymphs.
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 USACE jurisdiction in non-tidal streams. See 33 CFR 328.3(c)(4).
Perennial	Perennial reaches are 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. Caddisflies are an example of an aquatic insect order with a pupal stage. Plural: pupae.
Reach	A length of stream that generally has consistent geomorphological and biological characteristics.
Richness	The total number of different taxa in a sample (versus abundance, which is the total number of individuals). For example, family level richness is the number of different families found in a sample.
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 invertebrates.
Riparian area	A transitional area between the channel and adjacent terrestrial 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 cuticle, as in the tough plates covering various body parts of 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 runs parallel or subparallel to the main channel before rejoining it downstream.
Streambed	The bottom of a stream channel between the banks that is inundated during baseflow conditions.
Thalweg	The line along the deepest flowpath within the channel.
Thorax	In most arthropods, the middle section of the body where legs and wings or 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 that is not a wetland, stream channel, lake, or part of another aquatic resource.
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	The under surface of the abdomen; from below.

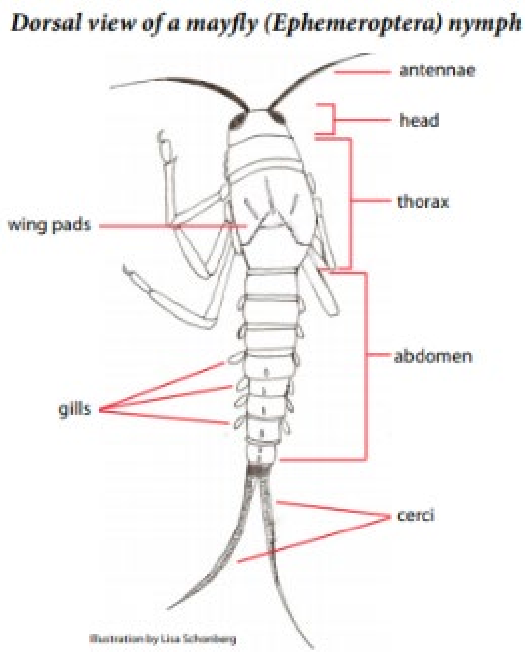
Watershed	An area of land, bounded by a drainage divide, which drains to a channel or waterbody. Often used interchangeably with catchment or drainage area.

Appendix B. Guide to Commonly Found Benthic Macroinvertebrates in the NE and SE

To determine richness for the BMI indicator, assessors must distinguish aquatic insects and mollusks to the family level, crustaceans and mites to the order level, and all other non-insects to the class or phylum level. For convenience, we provide a guide to common taxa encountered during field data collection at SDAM study sites for the NE and SE.

All photographs are from the Macroinvertebrates.org website, an online reference for identification of aquatic insects of eastern North America, unless otherwise noted.

General insect anatomy

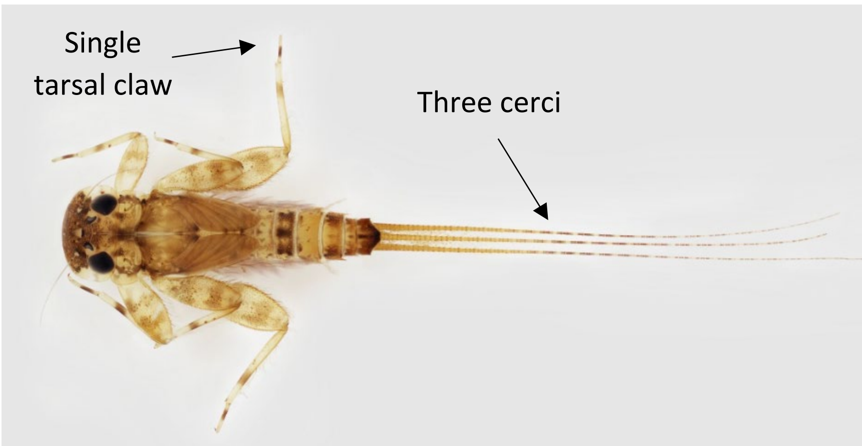


Appendices

Insect Orders and Families

Ephemeroptera (mayflies)

Mayfly larvae have abdominal gills and generally three cerci (tails), though some species have two. A single tarsal claw is present and wing pads are usually visible. Adult mayflies are short-lived and terrestrial but may be found in large breeding swarms near waterbodies. Identification to family level is needed for richness.



Heptageniidae (flat-headed mayflies). Heptageniid mayflies often have a flattened appearance, and cling to the undersides of cobbles in fast-flowing water. Heptageniid mayflies were among the most common and abundant taxa encountered during data collection.

Baetidae (small minnow mayflies). This family has a streamlined appearance and swimming motion similar to a minnow. This specimen is *Baetis.* In some species of *Baetis*, only two cerci are evident. Baetid mayflies were the second most encountered mayfly during NE and SE data collection. Image credit: California Department of Fish and Wildlife (CADFW).

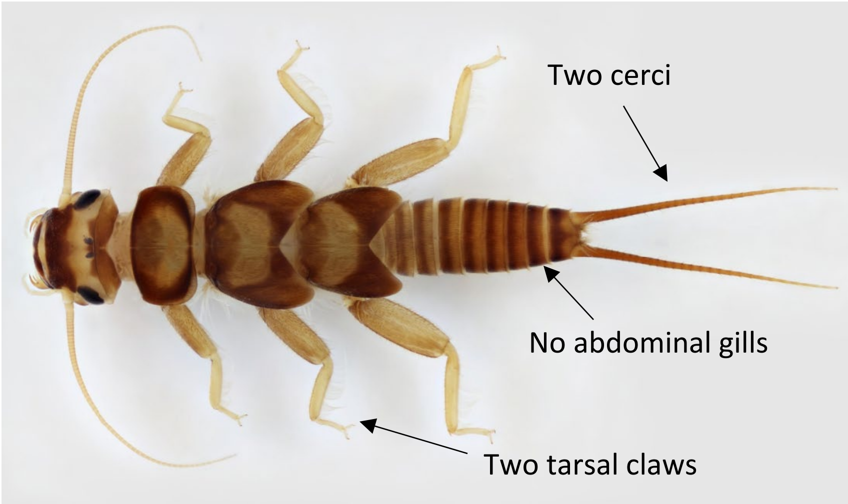
Leptophlebiidae (prong-gilled mayflies). This family of mayflies prefers gravel-bottomed streams and is often found in woody debris or among roots protruding from the bank. They are flat bodied and tend to cling to substrate. Their gills often have long forked prongs, giving this family its common name. Image credit: James Treacy.

Ephemerellidae (spiny crawler mayflies). This family tends to be found in riffles and at the margins of flowing water and swim with a ‘floppy’ motion. Gills have a ‘spine’ type shape and are absent from abdominal segment two (just below wing pads).

Ameletidae (comb-mouthed minnow mayflies). Often found in cold, fast-flowing mountain streams. Similar streamlined shape to Baetidae, but antennae are much shorter. Family represented by one genus, *Ameletus*.

Plecoptera (stoneflies)

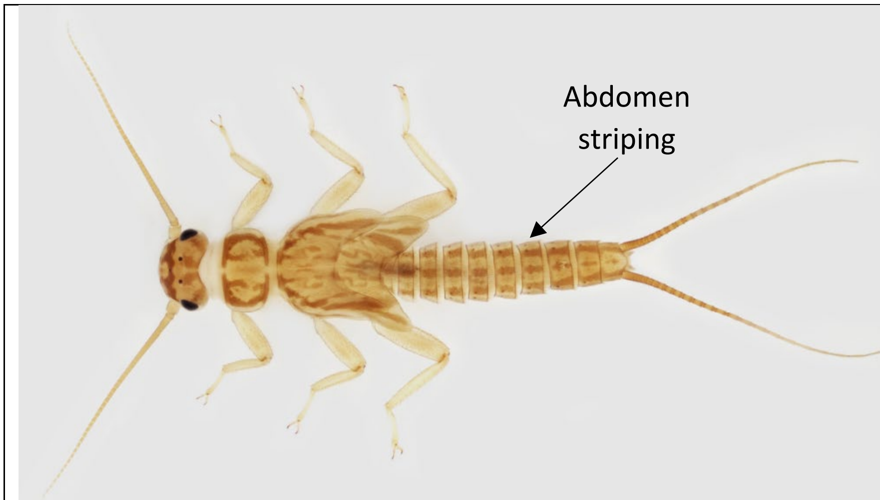
Stonefly larvae usually have tuft-like gills on the thorax (and sometimes also on the first few abdominal segments), two (not one) tarsal claws at the end of each leg, and always have two (never three) cerci, making them easily distinguishable from mayflies. Wing pads are usually visible. There is no pupal stage. All stonefly larvae are aquatic, and adults are terrestrial.



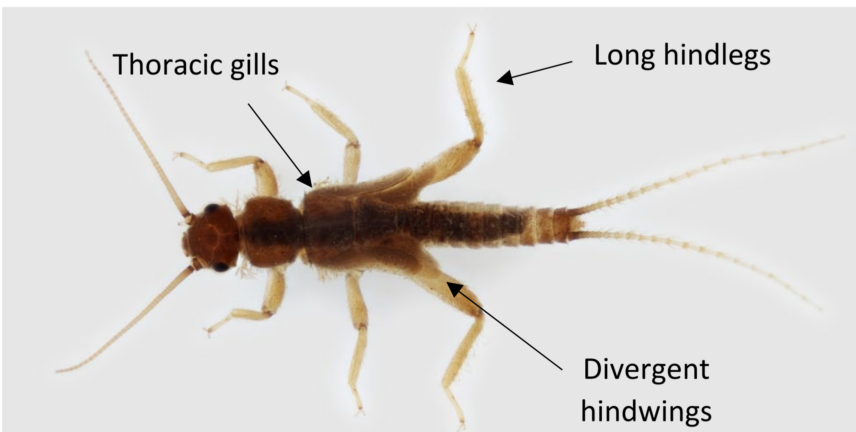
Perlidae (common stoneflies). The Perlidae family is large and conspicuous, often with ornate patterns on the head and thorax. This family has gills on the thorax (not abdomen). Perlids were the most common and abundant stoneflies identified during field sampling to develop the beta SDAM NE and SE outside winter and early spring.

Capniidae (small winter stoneflies). Members of this family have long, slender bodies with no thoracic or abdominal gills. Capniids were the most common and abundant stonefly collected during winter and early spring surveys.

Leuctridae (rolled winged stoneflies). Very similar in appearance to Capniid stoneflies; also have no thoracic or abdominal gills.



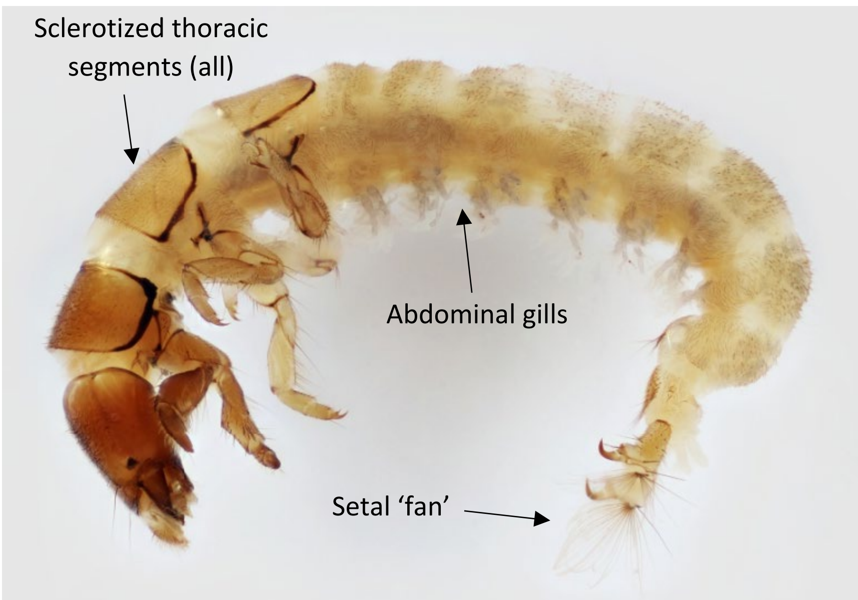
Perlodidae (stripetails). Members of this family have a patterned head and thorax and often longitudinal black-and-yellow striping on the abdomen. However, unlike the Perlids, no abdominal or thoracic gills are present.



Nemouridae (nemourid stoneflies). This family is relatively small and is distinguished from other stonefly families by hindwings that diverge conspicuously from the boxy axis, and long hindlegs that can extend to the tip of the abdomen.

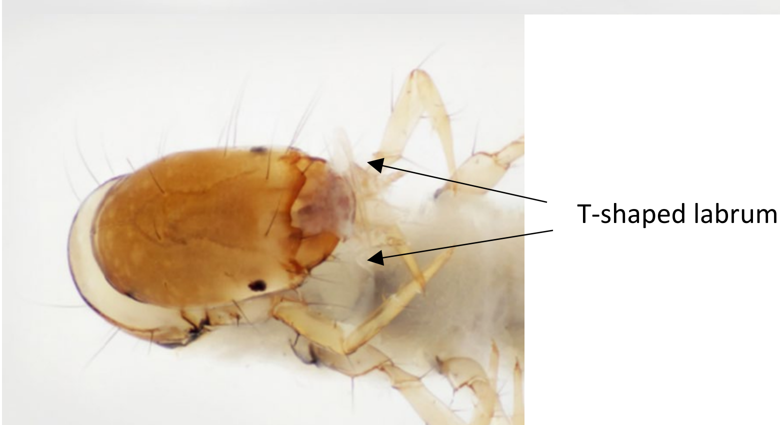
Trichoptera (caddisflies)

Caddisflies are closely related to moths and butterflies. Unlike mayflies and stoneflies, they have a pupal stage and undergo complete metamorphosis. Many taxa build conspicuous cases or retreats that may persist in dry streams. Some have filamentous gills on the ventral side (underside) of the abdomen (as opposed to the plate-like gills on the dorsal side (back) 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 wing pads 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. All larvae and pupal stages are aquatic, and all adults are terrestrial.



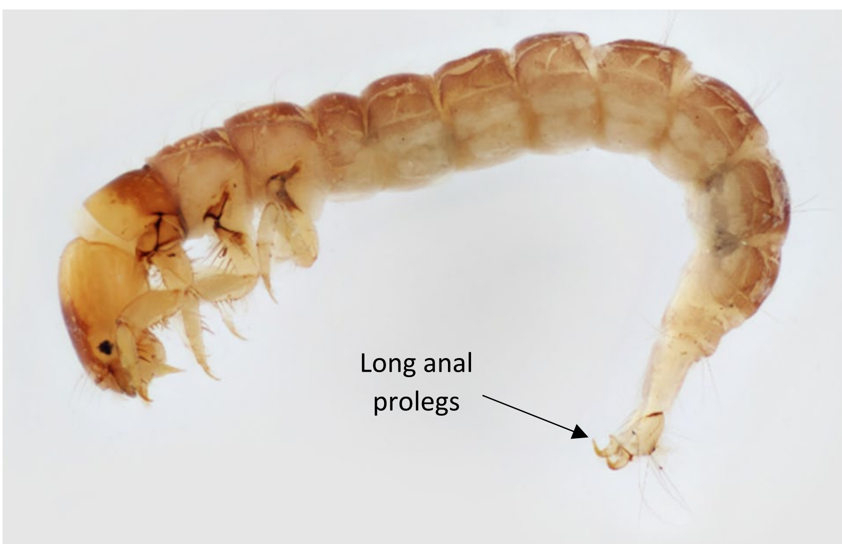
Hydropsychidae (net-spinner caddisflies). This group lives within nets made out of silk, pebbles, and other materials. All thoracic segments are sclerotized and a setal ‘fan’ is present on the prolegs. Hydropsychids were the most common caddisfly (and one of the most common families overall) collected during field sampling to develop the beta SDAM NE and SE.

Limnephilidae (northern case-makers). Limnephilids are a large group of roaming caddisflies that build cases out of diverse materials, such as pebbles, sand, leaf segments, and twigs.



Philopotamidae (finger-net caddisflies). Like hydropsychid caddisflies, members of this family build a net retreat but are often found roaming free. It is distinguished from other families of caddisflies by its T-shaped labrum (extendable mouthpart).

Lepidostomatidae (scaly mouth caddisflies). Members of this group are most commonly found in mountainous regions in small streams or the edges of large rivers. Cases are of various materials and shapes, though a four-sided case constructed of square pieces of leaves is most commonly found. The lepidostomatids are the only trichopteran family with very small antennae situated directly next to the eyes.



Polycentropodidae (trumpet-net, tube maker caddisflies). Members of this family do not utilize a case; instead, they construct a tubular silken net. Only the first thoracic segment is sclerotized; the anal prolegs are long and freely moveable.

Rhyacophilidae (free-roaming caddisflies). This family is usually found wandering freely on the undersides of boulders and cobbles, actively hunting for prey. Notice the long anal prolegs, which have large, sclerotized claws. Members of this family often have well defined segments, giving them a beaded appearance. Some species have a striking blue-green coloration, which may fade when preserved in alcohol. Image credit: CADFW.

Coleoptera (beetles)

The order Coleoptera can include both aquatic larvae and adults, unlike most of the insect orders covered in this Appendix. All adult beetles have hardened forewings known as elytra, though no wingpads are visible on larvae. Larvae have diverse morphology, typically with eyespots present but compound eyes absent, legs with four to five segments, and no lateral gills on the abdomen or thorax (if gills are present, they are often at the tip of abdomen). Beetle larvae can also look superficially like caddisfly larvae; however, their bodies usually show a greater degree of sclerotization (including the abdomen), and they usually have prominent chewing and/or piercing mouthparts.

Dytiscidae (diving beetles). Larvae have less sclerotization than other beetles, but generally have some hardening of the abdomen (in contrast to caddisflies). Dytiscidae were the most common and abundant beetle family collected during field sampling to develop the beta SDAM NE and SE.

Elmidae (riffle beetles). Elmid beetle larvae have a completely sclerotized body and tufted gills at the tip of the abdomen. Adult elmids are typically very small (1 to 8 mm). They frequently have rows of indentations along the elytra, relatively long legs ending in proportionally long claws, and thread-like antennae.

Psephenidae (water pennies). The larvae of this family are fully aquatic; however, adults are terrestrial and rarely observed as they are relatively short lived. Larvae are round and flat, often found clinging like suction cups to cobbles in fast-flowing streams; their legs are only visible from the ventral side. Their unusual shape makes them unmistakable for any other aquatic insect larvae.

Gyrinidae (whirligig beetles). The larvae of this family have lateral, abdominal gills, unlike most of the larvae of aquatic Coleopteran families. Larvae also have four hooks on the last abdominal segment. Adults have compound eyes on the dorsal and ventral surface, giving them a four-eyed appearance. Adult beetles often zip around in swirling motions along the surface of the water, giving them their common name.

Hydrophilidae (water scavenger beetles). The larvae of some genera are easily recognized by lateral filaments along the abdomen (not gills; *Berosus* (left), though most taxa do not have these filaments (e.g., *Tropisternus*, below)

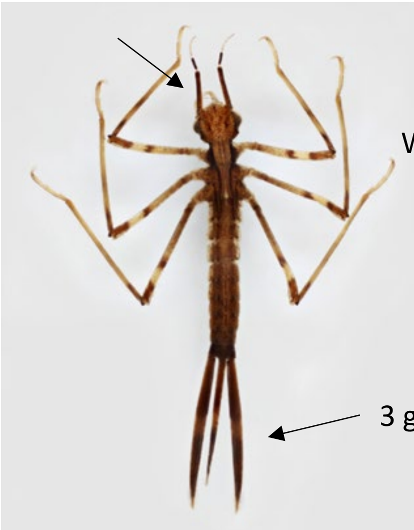
Odonata (dragonflies and damselflies)

Dragonflies and damselflies have large, predatory aquatic larvae. They have a conspicuous labial mask held under the head (see below), which extends to capture prey nearby. Larvae of dragonflies tend to have stout, robust bodies (round or elongated) and abdomens that end with 5 stiff points. In contrast, larvae of damselflies have abdomens that end in three paddle-like gills. Both have wing pads that are evident in mature specimens and neither have external gills along the length of their abdomens, unlike mayflies and caddisflies.

Labial mask

Gomphidae (clubtail dragonflies). This family is distinguished by its short, four-segmented antennae, the third of which is much larger than all the other segments (the final segment may be very small). The labial mask is relatively flat.

Cordulegastridae (spiketail dragonflies). This family has hairy abdomens that taper at the midpoint. The labral mask has spoon-like palps that cover the face on the ventral side.



Calopterygidae (broad-winged damselflies; left): Calopterygidae can be distinguished from other damselflies by the long first antennal segment (indicated with an arrow).

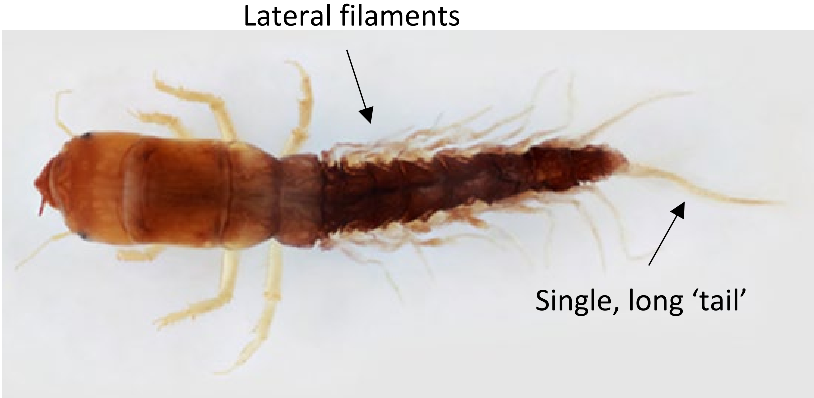
Coenagrionidae (narrow-winged damselflies; right)

Megaloptera (dobsonflies, alderflies)

Megaloptera have long-lived aquatic larvae and terrestrial adults. Larvae can be quite large and imposing. The order is distinguished by the presence of lateral filaments on the abdomen. Mouthparts have large pinchers, and each leg is tipped with small two-parted pinchers.

Corydalidae (dobsonflies). Also called hellgrammites. Large and centipede-like. Lack C-shaped bodies of caddisflies and have lateral filaments instead of gills along the abdomen. Image credit: CADFW.

Lateral filaments



Sialidae (alderflies). Usually much smaller than dobsonflies. Also distinguished from Corydalidae by the abdomen ending in a single 'tail', rather than in two prolegs.

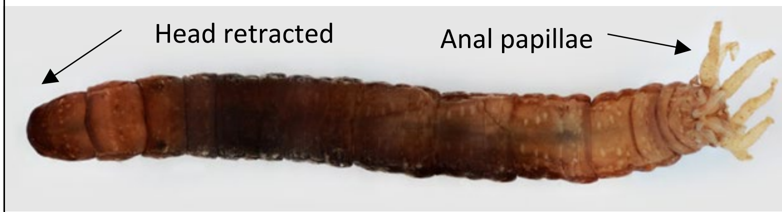
Diptera (true flies)

Dipterans are a diverse group of insects, of which some have an aquatic larval and/or pupal stage. Aquatic dipteran larvae are soft-bodied and legless (although they may have prolegs). Some families have conspicuous head capsules (e.g., Simuliidae, Chironomidae).

Chironomidae (non-biting midges). Chironomidae are among the most numerous and widespread aquatic invertebrates in waterbodies. Some species have hemoglobin pigments to help them extract oxygen from hypoxic water, giving them a blood-red appearance. They have a distinct head capsule, a c-shaped body, and prolegs on the thorax and abdomen (no segmented legs like caddisflies). **This family was the most common and abundant of all taxa collected during field sampling to develop the beta SDAM NE and SE, for all sampling periods.**

Dixidae (meniscus midges). Similar to Chironomids but have addition of flat lobes fringed with hair on the last abdominal segment.

Simuliidae (black flies). The base of the abdomen in this family is swollen, giving them a “bowling pin” appearance. Have two labral fans they use to filter particles from the stream.



Tipulidae (crane flies). Larvae of this family are sometimes the largest aquatic insects encountered in a stream (aside from dobsonflies). They are legless, appear to be headless (the head is withdrawn into the body), and sometimes have conspicuous anal papillae at the end of the abdomen.

Culicidae (mosquitos). Mosquito larvae hang at the water surface and breath air through a tube at the tip of the abdomen. When disturbed, they "wriggle" and swim away from the surface. Image credit: MO Department of Conservation.

Hemiptera (true bugs)

Hemipterans have partially hardened, partially membranous forewings (hemelytra), unlike beetles, and piercing mouthparts. They do not undergo complete metamorphosis, and juvenile stages generally resemble adults. While aquatic families of this order are included as taxa in the BMI score, they are not found along the bottom of the streambed ('benthic'). Instead, they are usually found striding, skating, or rowing across the water surface.

Veliidae (small water striders). They have stouter bodies and shorter legs than water striders in family Gerridae (see below). Most common and abundant hemipteran family collected during field sampling to develop the beta SDAM NE and SE.

Gerridae (large water striders or skaters).

Corixidae (water boatmen). These insects have oar-like front-legs, which they use to paddle through the water.

Mollusk Families (mussels, clams, and snails)

The freshwater mussels are represented by the families **Margaritiferidae** and **Unionidae**. The **Unionidae** are much better represented in the East. Both families include many endangered and protected species and should not be disturbed or collected during assessments. Freshwater mussels are distinguished by their large size, with individuals often reaching several inches in length. Different shell sizes and shapes of *Elliptio complanata* (Eastern elliptio) are shown, this is a common Unionid species found in most of the Eastern coastal states. Image credit: M. Marchand.

Corbiculidae (Asian clam). Asian clams are introduced non-native species that have become widespread in many areas of the U.S. In contrast to mussels, freshwater clams have a more symmetrical shape and a sturdier shell. They rarely reach more than an inch in diameter. Image credit: John Joseph Giacinto.

Physidae (bladder snails). Physidae are among the most common snails in streams. They are left-handed, meaning that the opening is on the left side if the spire is pointed away from you, and typically have fewer, wider whorls than other snails.

Planorbidae (ramshorn snails). Ramshorn snails have a flattened, disc-like appearance, and lack a conspicuous spire that many other snails have.

Crustacean Orders (crayfish, amphipods, and isopods)

Decapoda (crayfish). Crayfish are familiar occupants of streams; however, many species are vulnerable or critically imperiled, particularly in the southeastern states where diversity is highest. For this reason, they should not be collected during assessments. Image credit: NC Wildlife Resources Commission.

Amphipoda (amphipods, also known as scuds or side-swimmers). Amphipods resemble shrimp in form and are usually compressed laterally. They do not have a carapace (the hard covering of the thorax common in other crustacea), and most or all thoracic segments are distinct and bear leglike appendages. Image credit: Scott Bauer.

<table>
<tr>
<td></td>
<td>Isopoda (isopods). Unlike amphipods, isopods are usually flattened dorsoventrally (top to bottom). Isopods are many-segmented, with head, thorax, and abdomen not immediately distinct, and have seven pairs of legs. Some looks similar to terrestrial isopods, like pillbugs (aka roly-polies)</td>
</tr>
</table>

Appendix C. Field Forms

Beta Streamflow Duration Assessment Method – Northeast 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 previous 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 4)	**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 ☐ Drought ☐ Vegetation removal/limitations ☐ Other (explain in notes) ☐ None	Notes on disturbances or difficult site conditions:			
Observed hydrology: ______ % of reach with surface flow ______ % of reach with sub-surface or surface flow ______ # of isolated pools	Comments on observed hydrology:			

Site sketch:

1. BMI Score

Collect aquatic invertebrates from at least 6 locations in the assessment reach.

____ **BMI score (0-3)**	Scoring guidance: 0: (Absent) Total abundance of benthic macroinvertebrates is zero. 1: (Weak) Total abundance is 1 to 3. 2: (Moderate) Total abundance ≥4 3: (Strong) Total abundance ≥10 and richness ≥3 OR Total abundance < 10 and richness ≥5 *Note: Richness is based on family-level identification for aquatic insects and mollusks, order-level for crustaceans and mites, and class or phylum for all other non-insects.*
Taxa/Notes:	

2. Percent Shading

Densiometer readings Record # points covered (out of 17)		
Upper	Middle	Lower
_____ Upstream _____ Left _____ Right _____ Downstream	_____ Upstream _____ Left _____ Right _____ Downstream	_____ Upstream _____ Left _____ Right _____ Downstream
Sum of all readings: ______ Percent Shading = Sum of readings/204 x 100: ______ %		

3. Absence of Rooted Upland Plants in Streambed

____ **Absence of Rooted Upland Plants in Streambed score (0-3)**	Scoring guidance: 0: Rooted upland plants are prevalent within the streambed (greater than 75%). 1: Rooted upland plants are consistently dispersed throughout the streambed (20 – 75%). 2: Few rooted upland plants are present within the streambed (less than 20%). 3: Rooted upland plants are absent within the streambed. *Note: 'Upland' plants include those with UPL, FACU and FAC indicators as well as those with No Indicator (NI)* *Recommended photos (record in photolog, below):* *1) channel vegetation, and* *2) upland vegetation*
Notes:	

4. Bankfull channel width (copy from first page of field form)

5. Natural Valley

____ **Natural Valley score (0-1.5)** Half-scores are allowed	Scoring guidance: 0: (Absent) No indication of surrounding land sloping to the valley bottom or stream. Channel located on side slope indicative of an artificial channel or stream relocation/manipulation. 0.5: (Weak) Subtle valley indicated by some of the surrounding land sloping downward to the valley bottom or stream. 1: (Moderate) Defined valley indicated by most of the surrounding land sloping downward to the valley bottom or stream. 1.5: (Strong) Well defined valley indicated by all surrounding land sloping downward to the valley bottom or stream.
Notes:	

6. Channel Slope (to nearest 0.5 percent)

________%

If multiple sights are needed to cover the entire reach, record each and calculate a weighted average to get channel slope:

1) ________% slope _________% of reach

2) ________% slope _________% of reach

3) ________% slope _________% of reach

4) ________% slope _________% of reach

7. Drainage Area (in square miles, to nearest tenth)

8. Average Precipitation (August, September, October)

PRISM 30-year average precipitation _____________

Photo log

Indicate if any other photographs taken during the assessment:

Photo ID	Description

Additional notes about the assessment:

Model Classification:

☐ Ephemeral ☐ Perennial ☐ At least intermittent

☐ Intermittent ☐ Less than perennial ☐ Needs more information

Beta Streamflow Duration Assessment Method – Southeast **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 previous 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 4)</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="2">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</td><td colspan="2">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:

1. BMI Score

Collect aquatic invertebrates from at least 6 locations in the assessment reach; use sample for BMI score and total benthic macroinvertebrate abundance score (see indicator #2).

____ **BMI score (0-3)**	Scoring guidance: 0: (Absent) Total abundance of benthic macroinvertebrates is zero. 1: (Weak) Total abundance is 1 to 3. 2: (Moderate) Total abundance ≥4 3: (Strong) Total abundance ≥10 and richness ≥3 OR Total abundance < 10 and richness ≥5 *Note: Richness is based on family-level identification for aquatic insects and mollusks, order-level for crustaceans and mites, and class or phylum for all other non-insects.*
Taxa/Notes:	

2. Total Benthic Macroinvertebrate Abundance

____ **Total Benthic Macroinvertebrate Abundance score (0-3)**	Scoring guidance: 0: (Absent) Total abundance of benthic macroinvertebrates is zero 1: (Weak) Total abundance is ≥1 and ≤10 2: (Moderate) Total abundance ≥11 and ≤32 3: (Strong) Total abundance ≥33
Notes:	

3. Absence of Rooted Upland Plants in Streambed

____ **Absence of Rooted Upland Plants in Streambed score (0-3)**	Scoring guidance: 0: Rooted upland plants are prevalent within the streambed (greater than 75%). 1: Rooted upland plants are consistently dispersed throughout the streambed (20 – 75%). 2: Few rooted upland plants are present within the streambed (less than 20%). 3: Rooted upland plants are absent within the streambed. *Note: 'Upland' plants include those with UPL, FACU and FAC indicators as well as those with No Indicator (NI)* *Recommended photos (record in photolog, below):* *1) channel vegetation, and* *2) upland vegetation*
Notes:	

4. Bankfull channel width (copy from first page of field form)

5. Particle Size of Stream Substrate

____ **Particle Size or Stream Substrate Sorting score (0-3)** Half-scores are allowed	Scoring guidance: 0: (Absent) The channel is poorly developed, very little to no coarse sediment is present. There is no difference between particle size in the stream substrate and adjacent land. 1: (Weak) The channel is poorly developed through the soil profile. Some coarse sediment is present in the streambed but is discontinuous. Particle size differs little between the stream substrate and adjacent land. 2: (Moderate) There is a well-developed channel, but it is not deeply incised through the soil profile. Some coarse sediment is present in the streambed in a continuous layer. Particle size differs somewhat between the stream substrate and adjacent land. 3: (Strong) The channel is well-developed through the soil profile with relatively coarse streambed sediments compared to the riparian zone soils: coarse sand, gravel, or cobbles in the piedmont; cobbles or boulders in the mountains, and medium or coarse sand in the coastal plain. Particle size differs greatly between the stream substrate and adjacent land.
Notes:	

6. Drainage Area (in square miles, to nearest tenth)

7. Average Precipitation (May, June, July)

PRISM 30-year average precipitation ______________

Photo log

Indicate if any other photographs taken during the assessment:

Photo ID	Description

Additional notes about the assessment:

Model Classification:

- ☐ Ephemeral
- ☐ Intermittent
- ☐ Perennial
- ☐ Less than perennial
- ☐ At least intermittent
- ☐ Needs More Information