**DWR-NR-G-03-Hydrologic Determinations – 04012020**
**Guidance for Making Hydrologic Determinations**

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**Tennessee Department of Environment and Conservation**

Division of Water Resources

# Guidance for Making Hydrologic Determinations

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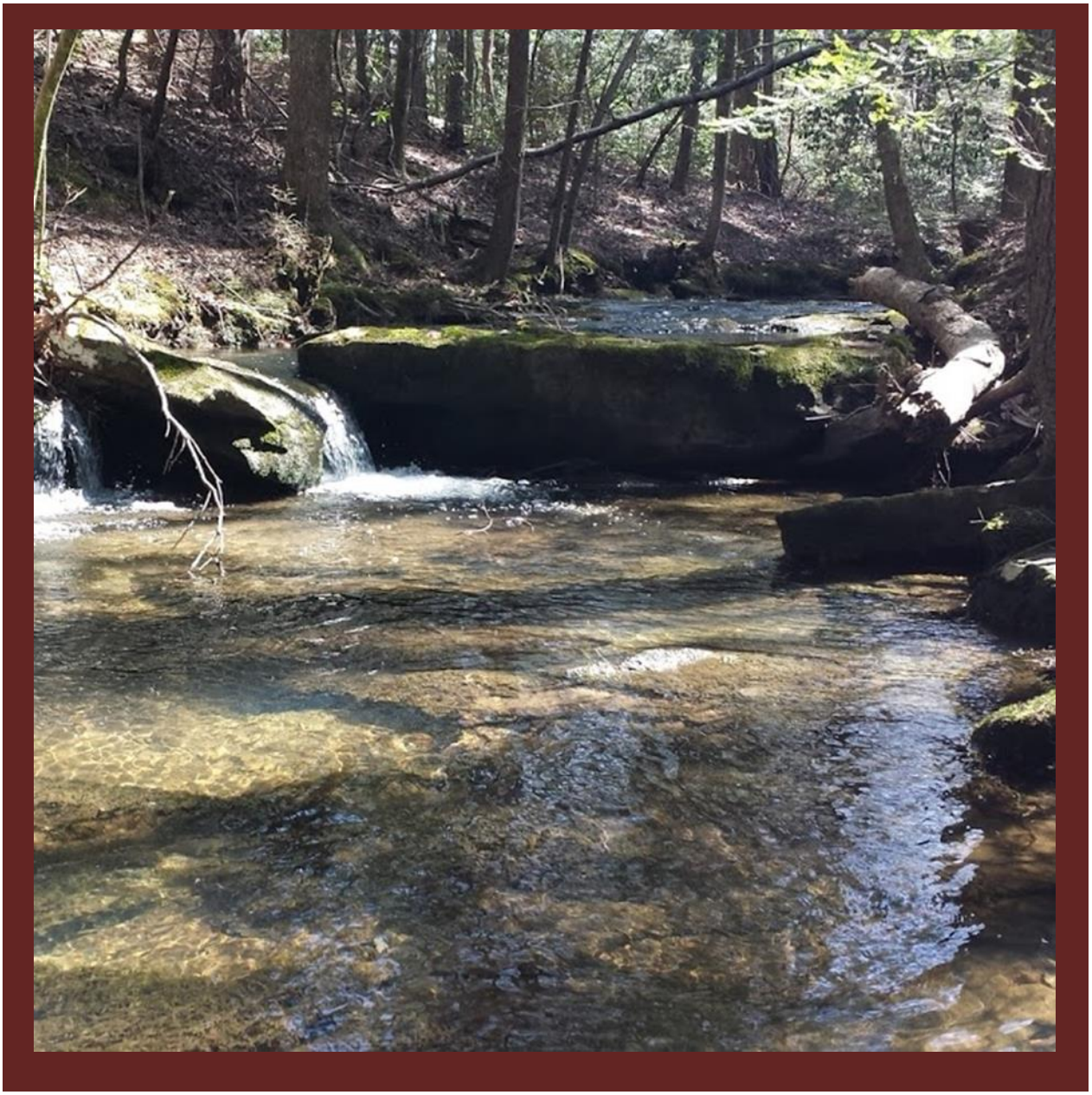

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# Introduction

Purpose of this Manual

The purpose of this manual is to provide guidance on how to consistently and accurately determine the jurisdictional status of water features in Tennessee, utilizing scientifically based principles and applicable State and Federal rules and regulations. This manual outlines the regulations, legal definitions, and general concepts involved in hydrologic determinations (HDs). This guidance is intended as a supplement to the standard operating procedures for making stream and wet weather conveyance (WWC) determinations (hydrologic determinations), as found in Rule 0400-4-03 as provided for in Public Chapter 464 of 2009. Those making hydrological determinations for TDEC jurisdictional purposes must familiarize themselves with Rule and Guidance.

The bulk of this document will outline the specific standard procedures utilized by TDEC to perform hydrologic determinations for permitting purposes. These procedures are based on the relationships between the underlying disciplines of biology, geology, geomorphology, meteorology, and hydrology that are involved in creating, maintaining, and identifying hydrologic features. The manual will provide guidance in applying the standard procedure, including specific instructions, examples, and definitions.

Limitations.

It should be noted this manual is specifically designed to address the jurisdictional status of linear watercourses, not other hydrologic features such as wetlands or isolated ponds, although these features may be mentioned as they relate to HDs. It should also be noted that this manual is designed to determine hydrologic status for DWR permitting purposes, and not for the applicability of federal regulations, local ordinances, real-estate appraisals, or other uses.

Acknowledgements.

The basic design of this manual and many of the specific parameters utilized in these standard HD procedures are based upon concepts and methodologies originally developed and revised by the North Carolina Division of Water Quality since 1997, and currently adopted whole or in part by many other agencies. In particular, the scoring index and much of the guidance language concerning the Secondary Field Indicators included in this document is taken directly from the *North Carolina Division of Water Quality Identification Methods for the Origins of Intermittent and Perennial Streams, Version 3.1*, and the *Methodology for Identification of Intermittent and Perennial Streams and Their Origins*

*Version 4.11.* We are grateful for their previous work and assistance in the development of this manual.

This manual has also greatly benefitted from the work over the last several years of the many DWR personnel involved in field investigations permitting, and policy issues associated with hydrologic determinations. Additional input from other agencies (especially the Tennessee Department of Transportation), outside experts, and advocacy groups have also helped guide and improve this document.

**History of DWR Hydrologic Determinations.**

The Division's need to characterize the hydrologic status of watercourses has its roots in the early days of establishing the National Pollution Discharge Elimination System (NPDES) program in Tennessee in the late 1970's. Whether a watercourse flowed perennially, intermittently, or only carried storm runoff was important in making regulatory decisions involving point source effluent discharges into Waters of the State.

An early guidance document outlined the various regulatory definitions involved (many of which remain very similar today), briefly described characteristics of the various stream types that may be observed, and provided some guidance on how to make a determinant decision. The focus of this document was on wasteload allocations and discharge locations, and as such, is no longer wholly applicable, but is interesting to note that it too described physical, hydrological, and biological indicators of flow permanence.

With the development of the Aquatic Resource Alteration Permit program in the 1980's, the need to accurately and consistently characterize watercourses became even more important. In 1994, an updated version of WWC determination guidance was produced by the DWR Chattanooga Environmental Field Office. It featured expanded sections on benthic macroinvertebrates and hydrophytic vegetation, and provided a specific flow chart/dichotomous key for making stream determinations. As stated in its introduction, however, it was tailored for southeastern Tennessee streams, and was intended as a general guidance document that would help inform staff and the regulated community.

In the early to mid-2000's two factors arose to put even more weight on the stream determination process. The EPA began promulgating stormwater regulations, including the development of the local Municipal Separate Storm Sewer System (MS4) programs. One aspect of these programs involved the establishment of local stream buffer ordinances, many of which were tied to the State's definitions and determination procedures. In addition, the State's Construction Stormwater permit also required stream buffers in more limited situations (such as sediment-impaired streams). These new regulations, which were directly tied to hydrologic status (as were ARAP permits),

combined with unprecedented population growth and land development around the state, made hydrologic determinations more frequent, of larger scale and consequence, and occasionally more controversial.

Responding to these factors, in 2006 the Division updated its internal HD procedures in an effort to produce more consistent and clear documentation of determinations across all field offices. . An updated dichotomous key outlining the basic decision-making processes and a standardized HD field data sheet was created, partially based on procedures North Carolina and others had been using. This too utilized an expanded suite of physical (geomorphological), hydrological, and biological indicators, updated to reflect the current scientific understanding of stream processes. Although internal training and seminars were conducted with Division staff on standard HD procedures, and how to use the updated forms, a larger written SOP or guidance document was not produced.

In 2009, the General Assembly enacted Public Chapter 464. This new law largely codifies the regulatory treatment of wet weather conveyances. A definition of "wet weather conveyance" was added to the Water Quality Control Act (see next section). It differed from the previous definition that had been a part of TDEC regulations, in that it was more specific about the aquatic life that may qualify a water course as a stream, although it left essentially unchanged the other three elements of the definition. This HD Guidance document is one part of the standard operating procedure that Section 4 of P. Ch 464 directed the department to develop.

## Submission of Hydrologic Determinations

The submission of hydrologic determinations to the Department is typically done in response to a permitting or other regulatory need and should meet the minimal guidelines of required information as required under statute and rule. Public Chapter 464 and Rule 0400-40-17 specify that submissions of hydrologic determination reports may be either standard submissions or submissions seeking treatment under Statute §69-3-108(r). These minimal requirements for both types of submissions are specified in the following documents: ***Hydrologic Determination Report Submittal Checklist: Standard Submittal*** and ***Hydrologic Determination Report Submittal Checklist; Requesting Treatment under Statute §69-3-108(r)***. These documents may be downloaded from the https://www.tnhdt.org/ website at the resources page at https://www.tnhdt.org/page.asp?Title=PDFs.

**Hydrologic Determination Report Submittal Checklist** TDEC Reviewer: _____

**Standard Submittal**

Waterlog HD #_____ Project name: _____ County: _____
Other Tracking #_____

_____ 1. Name, address, and phone number of the current property owner(s).

_____ 2. Name, affiliation, and certification identification number of the QHP or QHP IT submitting the report.

_____ 3. QHP or QHP IT status verified.

_____ 4. The identification of the starting and ending points along a watercourse of the areas determined to be a wet weather conveyance.

_____ 5. A vicinity map, including the property boundaries or hydrologic determination review area (if different than property boundary). On linear projects, start and terminus points are required. The map should clearly indicate the specific locations of all hydrologic features identified in the report.

_____ 6. Specific latitude/longitude coordinates (decimal degrees) either included on the map or in the body of the hydrologic determination report.

_____ 7. Color photographs of each of the hydrologic features to potentially be altered or otherwise identified in the report; including the date each photograph was taken, latitude and longitude, in decimal degrees of each photograph location and indicate the location and direction of each photographic view on the site map or plan. These photographs must be representative of the overall reach of water feature evaluated. At a minimum, include a photograph of the area to potentially be altered, immediately up channel of the area to potentially be altered, and immediately down channel.

_____ 8. TDEC Hydrologic Determination Field Data Sheets, completed in conformance with the current TDEC-DWR Guidance for Making Hydrologic Determinations. At least one data sheet must be submitted for each watercourse to potentially be altered or identified.

_____ 9. Any previous assessments of hydrologic features on site known to the submitter. (See : http://tdeconline.tn.gov/dwr/ )
Previous HD's submitted or found during TDEC review:
_____
_____

_____ 10. Evidence HD was conducted under normal weather conditions.

_____ 11. List any other information submitted with report(e.g. NRCS Soil Maps, precipitation data, site plan etc.):
_____
_____
_____

EFO administrative required information:
_____ 1. Property owner(s) granted written permission to access land/site.

_____ 2. Is there a site, associated with this HD? If yes, then associate HD to site within Waterlog.

_____ 3. Verified HD was conducted under normal weather conditions.

Report Received: ___/___/___ Assigned date: ___/___/___ Application Complete: ___/___/___

Deficiency Letter Sent: _____ Date: ___/___/___ Field Verified: _____ Date:___/___/___
List of Report Deficiencies: Final Determination Notification Date:___/___/___
_____
_____

All Required Info Received: ___/___/___
MS4: _____ MS4 Contact Date: ___/___/___

**Hydrologic Determination Report Submittal Checklist** TDEC Reviewer: _____

**Requesting treatment under Statute §69-3-108(r)**

Waterlog HD #_____ Project name: _____ County: _____
Other Tracking #_____

Submitted by: _____ QHP #_____

Per Rule 0400-40-17-.04 Requirements for Wet Weather Conveyance Determination Reports:
(1) A report regarding a wet weather conveyance determination submitted to the department by a person certified as a Qualified Hydrologic Professional (QHP) seeking to qualify for the treatment provided in §69-3-108(r) shall so state in bold print on the first page of the document and shall be sent to the appropriate field office of the department accompanied by the following documentation.

_____ 1. Statement seeking treatment under §69-3-108(r) on first page of document.

_____ 2. Name, address, and phone number of the current property owner(s).

_____ 3. The person or applicant requesting the hydrologic determinations (if different from the owner).

_____ 4. Name, affiliation, and certification identification number of the QHP submitting the report.

_____ 5. Certified QHP status verified.

_____ 6. A statement, signed by the certified QHP attesting that all submitted information is true, accurate and complete.

_____ 7. An explanation of the purpose and context of the hydrologic determination report, including any proposed alterations if known to wet weather conveyances, streams, wetlands, or other aquatic resources.

_____ 8. The identification of the starting and ending points along a watercourse of the areas determined to be a wet weather conveyance; such areas may not be larger than what is currently proposed to be altered by the proponent of project.

_____ 9. A vicinity map, including the property boundaries or hydrologic determination review area (if different than property boundary). On linear projects, start and terminus points are required. The map should clearly indicate the specific locations of all hydrologic features that are subjects of the provisions of §69-3-108(r) identified in the report.

_____ 10. Specific latitude/longitude coordinates (decimal degrees) either included on the map or in the body of the hydrologic determination report.

_____ 11. Color photographs of each of the hydrologic features to potentially be altered or otherwise identified in the report; including the date each photograph was taken, latitude and longitude, in decimal degrees of each photograph location and indicate the location and direction of each photographic view on the site map or plan. These photographs must be representative of the overall reach of water feature evaluated. At a minimum, include a photograph of the area to potentially be altered, immediately up channel of the area to potentially be altered, and immediately down channel.

_____ 12. TDEC Hydrologic Determination Field Data Sheets, completed in conformance with the current TDEC-DWR Guidance for Making Hydrologic Determinations. At least one data sheet must be submitted for each watercourse to potentially be altered or identified.

_____ 13. Any previous assessments of hydrologic features on site known to the submitter. (See : http://tdeconline.tn.gov/dwr/ )
Previous HD's submitted or found during TDEC review:
_____
_____

_____ 14. Evidence HD was conducted under normal weather conditions.

_____ 15. Any other information used in making the hydrologic determinations included in the report. Examples include NRCS Soil Maps, local geological data, recent and seasonal precipitation gauge records, benthic surveys, etc.
If yes please describe:
_____
_____

Per Rule 0400-40-17-.04 *Recommended but not required* information for Wet Weather Conveyance Determination Reports
_____ 16. Can include one or more of the following:
_____ Site development plans
_____ Close-contour maps
_____ Aerial photo with overlay of property boundary
_____ Municipal jurisdiction of project site
_____ Type of sewage/septic system proposed.
_____ Other: _____

**Figure 1. Checklists for Hydrologic Determination Submissions**
Checklists of required information for a hydrologic determination submission may be seen and downloaded from: https://www.tnhdt.org/page.asp?Title=PDFs or seen in Appendix B.

Division's processing deadlines only apply to complete submissions, therefore, the submission of incomplete information can result in delays.

The Division recommends that all wetland and other non-linear water features be included in submissions in order to allow for more efficient and timelier site review. Applicants are also encouraged to submit HDs separately from (preferably in advance of) any associated ARAP applications or CGP Notices of Intent.

# Definitions

Although there are many scientific terms and definitions associated with stream hydrology and the various related sciences, the TDEC standard procedures for hydrologic determinations focus on jurisdictional status as based upon the key regulatory definitions provided below.

"Ground water" means water beneath the surface of the ground within the zone of saturation, whether or not flowing through known and definite channels. [Rule 0400-40-03-.05(9)]

"Ground water table" means the upper surface of the zone of saturation by ground water. [Rule 0400-40-03-.05(9)]

"Interflow" means the runoff infiltrating into the surface soil and moving toward streams as shallow, perched water above the main ground-water level. [Rule 0400-40-03-.05(9)]

"Multiple populations" means two or more individuals, from each of two or more distinct taxa, in the context of obligate lotic aquatic organisms. [Rule 0400-40-03-.05(9)]

"Normal weather conditions" means those within one standard deviation of the cumulative monthly precipitation means for at least the three months prior to the hydrologic determination investigation, based on a 30-year average computed at the end of each decade. Precipitation data shall come from National Oceanographic and Atmospheric Agency's National Climatic Data Center, Natural Resources Conservation Service's National Water and Climate Center, or other well-established weather station. [Rule 0400-04-03-.05(9)]

"Obligate lotic aquatic organisms" means organisms that require flowing water for all or almost all of the aquatic phase of their life cycles. [Rule 0400-40-03-.05(9)]

"Perched water" or "perched water table" means water that accumulates above an aquitard that limits downward migration where there is an unsaturated interval below it, between the aquitard and the zone of saturation. [Rule 0400-40-03-.07(2)]

"Process Discharge" means a discharge from a non-natural source that does not include stormwater runoff and is not otherwise waters of the State. [Rule 0400-40-03-.05(9)]

"Stream" means a surface water that is not a wet weather conveyance. [Rule 0400-4-3-.04(20)]

"Watercourse" means a manmade or natural hydrologic feature with a defined linear channel which discretely conveys flowing water, as opposed to sheet-flow. [Rule 0400-40-03-.05(9)]

"Waters of the State" means any and all water, public or private, on or beneath the surface of the ground, that are contained within, flow through, or border upon Tennessee or any portion thereof, except those bodies of water confined to and retained within the

limits of private property in single ownership that do not combine or effect a junction with natural surface or underground waters [T. C. A. § 69-3-103]

"Wet Weather Conveyances" are man-made or natural watercourses, including natural watercourses that have been modified by channelization: that flow only in direct response to precipitation runoff in their immediate locality; whose channels are at all times above the ground water table; that are not suitable for drinking water supplies; and in which hydrological and biological analyses indicate that, under normal weather conditions, due to naturally occurring ephemeral or low flow there is not sufficient water to support fish, or multiple populations of obligate lotic aquatic organisms whose life cycle includes an aquatic phase of at least two months. [Rule 0400-40-03-.05(9)]

## General Concepts

As stated earlier, the basic concepts and procedures involved in HDs are based on 1) the scientific fields that inform our understanding of the natural processes that create, maintain, and shape surface water features, as well as 2) the applicable regulatory language and definitions involved in jurisdictional status. For linear watercourses, the core DWR jurisdictional distinction is "stream" vs. "wet weather conveyance". The standard procedures involved in HDs are geared toward determining if a watercourse fits the WWC definition or not. The most robust distinction within the WWC definition, and most commonly used during the HD process is: "Does the channel carry flow for extended periods of time, or only in direct response to rainfall?" Other distinctions provided in the WWC definition must also be considered, but duration of flow is one of the most useful characteristics in making HDs because it generates abundant and accurate physical and ecological indicators that will be available during field evaluations, including the type of biological support described within the WWC definition.

The definition of a "stream" is an inverse one – that is, all watercourses that are <u>not</u> WWCs are streams. The definition of a WWC has 4 characteristics and all must be met to be considered a WWC. If any one of the characteristics is not met, the watercourse must be considered a stream.

This Guidance is intended to establish a standard framework for all professionals involved in making HDs in Tennessee. Professional experience in performing HDs in general, and specific knowledge of the nature of regional watercourses and watersheds, are critical in assuring that accurate determinations are made. This is one reason for the education and experience requirements for Certified Hydrological Professionals as outlined in section 5 of P. Ch. 464. Site-specific factors such as anthropogenic alterations, watershed topography

and underlying geology, recent/seasonal precipitation in the local area, and anomalous features can and should inform an investigator's interpretation of observed indicators at a given site on a given date. It is vital that the investigator consistently use and follow the standard HD guidance to evaluate all available field indicators and to thoroughly document all evidence and any additional sources of information used during the determination process. However, the Field Assessment Form is a tool, and not intended to blindly override an assessor's best professional judgement, especially in the presence of compelling additional evidence.

## General Hydrologic Determination Guidance

- In most cases, if the jurisdictional status of a water feature is in question, a field evaluation will need to be conducted. Due to the nature of the DWR regulatory program, this evaluation may be restricted to a single field investigation, and may be conducted under inopportune climate conditions. It is important to note that the jurisdictional status of a watercourse is based upon its hydrologic regime during a typical year, even if the HD evaluation has to be conducted during an atypical year. Even perennial streams can go dry during an unusually dry year.
- Prior to conducting a field evaluation, the investigator should always review the recent precipitation patterns for the local area, and the longer-term seasonal precipitation trends. Looking at local weather conditions over the one week, one month, and three-month intervals prior to the field investigation date is recommended. (also see "Determining Normal Weather Conditions" section below)
- The investigator should always consider other available information such as historic land-use, regional geology and soil types, or previous HDs near the site.
- Because the presence of direct storm runoff can hamper evaluation of hydrologic and geomorphic indicators, HDs should not be conducted if a one-inch precipitation event in 24 hours has occurred in the area of investigation within the previous 48 hours as specified in Rule. The Division can deem any HD conducted within 48 hours of such an event as incomplete or invalid.
- Watercourses vary seasonally based on annual cycles of precipitation and evapotranspiration rates, and in some cases, ground water table elevations. Therefore, some available field indicators and their relative importance in making an HD will also vary by season. For example, ecological indicators will play a much larger role in intermittent systems during the wet winter/spring months, than when the watercourse may be dry in the summer. The presence of in-stream flow

in a typical August may have different HD implications than flow observed in March.

- Watercourses vary along their lengths, with headwaters often transitioning from WWC to intermittent to perennial streams along a continuum, with no single distinct transition points. Many streams originate as perennial springs, with little to no upstream channel of any sort. Other watercourses may exhibit sinking or losing reaches, or the channels simply disappear altogether.
- Because of longitudinal variability, Hydrologic Determinations should not be made on a single point without first looking up-channel and down-channel for indicators available along the watercourse. When possible, several hundred feet of channel should be evaluated before making a determination. The Hydrologic Determination is a reach-based procedure, and this concept is especially important when evaluating and scoring secondary indicators. It is especially vital to investigate a significant distance upstream when establishing stream origination points, or when the site in question has been previously altered from recent activities or historical land-use practices.
- Watercourses vary across physiographic provinces due primarily to the climate and the underlying geology, soils, and relief. For example, in the mountains of East Tennessee the in-channel structure may be rocks and boulders arranged in a step-pool configuration, the Highland Rim may have riffle-run-pool with cobble substrate, while low relief West Tennessee streams exhibit long sandy runs and woody debris grade controls.
- The HD standard procedures described in this manual have been designed to work across the various stream types found in Tennessee, however; experience and knowledge of the local geographic area and stream systems will increase the investigator's ability to accurately perform HDs.
- Useful equipment for HD field evaluations include: HD guidance manual, HD Field Data Sheets, field book, GPS to determine Lat/Long coordinates, USGS topo map, camera, small net & tray for capturing aquatic organisms, soil auger & Munsell soil color guide to determine presence of hydric soils.

The field investigative process relies on the underlying scientific principle that watercourses carrying surface flow for extended periods of time are more likely to develop certain physical, hydrological, or ecological characteristics that are absent or diminished in watercourses that carry flow only in direct response to precipitation. These characteristics are considered indicators that a watercourse may be jurisdictional. Some indicators are considered definitive and can be used to determine a watercourse is a stream in all but the most anomalous situations (see "Primary Field Indicators" section below).

## Determining Normal Weather Conditions

The investigator must decide if the determination is being conducted under normal weather conditions. Normal weather conditions will be based on a 30-year average of precipitation data computed at the end of each decade. If conditions are wetter or drier than normal the investigator must take this into consideration in making a hydrologic determination. In addition, the applicability of certain field indicators (such as the absence of water during the late winter/early spring) is dependent on the observation being made under normal conditions.

There are a variety of on-line resources that can aid in evaluating recent and seasonal precipitation in a given locality. Average monthly means for 30-year precipitation data can be found at National Oceanic and Atmospheric Association (NOAA) Climatic Data Center at (https://www.ncdc.noaa.gov/cdo-web/datatools/normals, or the NRCS National Water and Climate Center (http://www.wcc.nrcs.usda.gov/climate/wetlands.html).

Recent local precipitation data can be found at the NOAA site above, the National Weather Service (http://water.weather.gov/precip), the CoCoRahs network (http://www.cocorahs.org/Maps/ViewMap.aspx?state=TN), or other well established weather station. The National Climatic Data Center is a good resource featuring the Palmer Hydrologic Drought index which analyzes climate conditions in relation to reservoir and ground water levels (https://www.drought.gov/drought/data-maps-tools/current-conditions ). Another good resource for evaluating recent and seasonal precipitation data can be found at the National Weather Service's Advanced Hydrologic Prediction Service (http://water.weather.gov/precip), where the user can review previous rainfall statewide for various time intervals. Using the "percent departure from normal" feature for the last 90 days is an example of a good method of screening for seasonal normal conditions.

Investigators can check the nearest USGS on-line gauge (http://waterdata.usgs.gov/tn/nwis/current?type=flow) for comparison to long-term median flows, and to get an idea of whether flows in the general area are rising or falling from previous rain events.

If the investigator believes the HD is being conducted during weather/climate conditions that are significantly drier or wetter than normal for the previous three-month period, the following procedure should be used to document whether or not the HD is being conducted under normal weather conditions:

1) Obtain the local monthly precipitation mean and standard deviation for the previous three months from the NOAA Research Physical Sciences Division : (http://www.esrl.noaa.gov/psd/cgi-bin/data/usstation/city.pl?state=TN&lane=scroll&itypea=1&submit=Submit&.cgifields=itypea)

A. Select nearest City (weather station)
B. Select Variable = "precipitation"
C. Type of Climatology = "monthly"
D. Type of Input = "mean" or "standard deviation"
E. Year Range: First Year = "1981" ; Last Year = "2010"
F. Submit.
G. For each of the previous three months, divide the resulting plot values by 100 to get each month's standard deviation in number of inches. (Hitting "Get File" link at bottom will provide the actual numeric values for the plotted points).

(Note: Snowfall amounts are already converted to liquid-equivalents and included in the daily and monthly precipitation columns on NOAA/NWS tables.)

2) Calculate the observed monthly precipitation totals at the closest established weather station for the previous three months.

3) Use Table 1 below to determine if current Weather Conditions are Normal (methodology is a modified version from the NRCS Engineering Field Handbook)

A. Record the Normal Monthly Mean in inches
B. Subtract the local monthly standard deviation from the mean, record total in "DRY" column. Add the local monthly standard deviation to the mean, record total in "WET" column.
C. Record the actual recorded rainfall total for each month, and compare to the previous three columns to determine the Condition Category for each month. For example, if the actual total of rainfall for a given month is greater than the value in the "WET" column, the condition category for that month is "WET".
D. Assign a Condition Value for each month (see scale in center-right of table). Multiply the Condition Value with the Month's Weighted Value, and record product in the far-right column. Note: Weather conditions in more recent months are weighed more heavily.
E. Add the final Product Values for the three months together to produce an overall Sum. Compare this Sum with the scale at the center-left of the table, to determine

if the previous three months' precipitation is considered Normal Weather Conditions.

**Table 1. Normal Weather Conditions – Nashville, TN March 2019**

| | | | Long-term rainfall records | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Month** | **Standard Deviation** | **Minus One Std. Dev. (DRY)** | **Normal (Mean inches)** | **Plus One Std. Dev. (WET)** | **Actual Rainfall** | **Condition (elevated, low, average)** | **Condition value** | **Month weight value** | **Product of previous two columns** |
| **1st prior month*** | February | 1.97 | 1.83 | 3.80 | 5.77 | 13.47 | Elevated | 3 | x 3 | 9 |
| **2nd prior month*** | January | 2.34 | 1.71 | 4.05 | 6.39 | 4.54 | Average | 2 | x 2 | 4 |
| **3rd prior month*** | December | 2.68 | 1.57 | 4.25 | 6.94 | 5.41 | Average | 2 | x 1 | 2 |
| | | | | | | | | | Sum = | **15** |

Note:

| **If sum is:** | |
|---|---|
| 6-9 | then prior period has been abnormally dry |
| 10-14 | then prior period has been normal (average) |
| 15-18 | Then prior period has been abnormally wet |

| **Condition value:** | |
|---|---|
| Low = | 1 |
| Average = | 2 |
| Elevated = | 3 |

Conclusions: A total of **15** indicates the weather conditions (precipitation) were wetter than normal range for the three months prior to March 2019 for Nashville, TN.

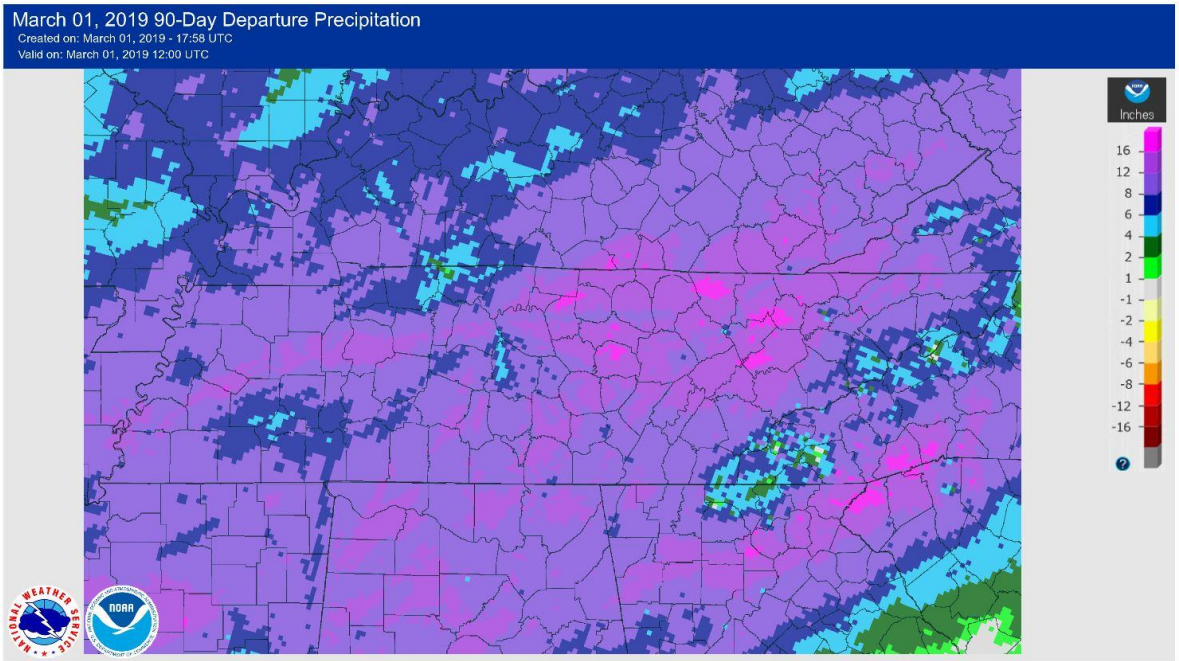


**Figure 2. Departure From Normal Precipitation**
As seen on the National Weather Service Advanced Hydrologic Prediction Service website: (https://water.weather.gov/precip/)

The above figure depicts the departure from normal precipitation measured in total inches for the 90 days prior to March 1, 2019. The image depicts that precipitation totals were between eight and twelve inches above normal for most of Tennessee during this time period. This data provides a quick assessment of weather conditions over the past 90 days. Given the data presented in the map above, any assessments occurring during this time frame should use the normal weather calculations procedure described above, as weather conditions are likely outside of the normal range. The data presented here does not cover the full method for documenting normal weather conditions, but can be used as a quick reference to determine if the full calculation method is needed. This and any additional relevant information should be included in the Notes section of the field data sheet.

# Hydrologic Determination Field Data Sheet & Methodology

The standard TDEC HD field investigation methodology and documentation format are reflected in the Hydrologic Determination Field Data Sheet (Appendix A). In addition to available field indicators necessary to make an accurate HD, any other evidence utilized in making a determination should always be documented, either on this form or as an addendum.

Where the purpose of the HD SOP (Rules and Guidance) is to consistently and accurately determine the jurisdictional status of watercourses based upon the four elements of the Wet Weather Conveyance definition, the Field Sheet provides the standardized format for recording the data generated from the application of the SOP.

Header Information.

The top portion of the form allows for a concise recording of basic information regarding the HD, especially the field investigation. The header is not designed to be comprehensive, and expansion of some of this information will often be necessary in another format (written report or map).

- Qualified Hydrologic Professionals should include their TDEC certification ID number in the "Assessor" box.
- The "Named Waterbody" refers to the closest downstream confluence from the evaluated watercourse with a named stream (since most HDs will occur on WWCs and unnamed headwater tributaries).
- The "Lat/Long" box is simply for a single reference coordinate for tracking purposes – additional coordinates recorded elsewhere may be necessary to fully document the HD reach. Please record latitude and longitude in decimal degrees (dd.dddd, -dd.dddd).
- "Watershed Size" is the size of the basin draining to the evaluated reach or origin point.
- The source(s) of the information for determining recent and seasonal precipitation should be documented. Use of "abnormally wet" or "abnormally dry" categories should only be used to designate conditions outside the range considered Normal Weather Conditions (see earlier section on evaluation of Normal Weather Conditions)
- The source(s) of information used in evaluating the site's soil and geology should also be documented

## Primary Field Indicators

The indicators included on the Field Sheet are broken into two categories – primary and secondary. Primary indicators are individual or combinations of field characteristics that under normal circumstances and in the absence of any directly contradictory evidence are considered to be definitive for jurisdictional determination purposes. Primary indicators are typically very conclusive evidence and allow for an immediate HD endpoint to be reached, without further evaluation of secondary indicators.

1. "*Hydrologic feature exists solely due to a process discharge*": Watercourses in which flow is solely a result of process or wastewater discharge or other non-natural sources shall not be regulated as streams even though they may exhibit characteristics of a stream rather than a wet weather conveyance. Seepage from an impoundment or other relatively permanent hydrologic alteration, such as stormwater discharges from flood detention basins, is not considered a process discharge.

2. "*Defined bed and bank absent, vegetation dominated by upland and FACU species*": A watercourse that has no distinct demarcation of bed or banks, and has essentially the same terrestrial, non-hydrophytic vegetation as the surrounding land, such as a simple grassy swale. These characteristics throughout the evaluated reach indicate a lack of sustained flow sufficient to create and maintain a distinct channel, or support the requisite type of aquatic life, and therefore merit wet weather conveyance status.

**Figure 3. Examples of Grassy Swales**
Grassy swales indicate that there has not been enough concentrated flow in the drainway to incise a channel through the soil profile.

3. "*Watercourse dry anytime during February through April 15th, under normal precipitation / ground water conditions*" : In an average hydrologic year in Tennessee, if a watercourse carries flow

for an extended period of time (as opposed to only in direct response to rainfall), the flow will normally occur within this time period. This is due to the combination and interactions of the annual cycles of precipitation, evapotranspiration rates, and ground water levels. Although a watercourse does not have to flow continuously over this entire time frame, or throughout its entire length to be a stream (see "Commonly Encountered Variants" section), the absence of water throughout the channel during this period will be considered primary evidence of WWC status, unless there is compelling conflicting data, or severe recent alterations (such as a stream that has been impounded, or highly inundated by sediment releases which preclude the normal volume of flow).

As mentioned earlier, for purposes of this indicator, "Normal precipitation/ground water conditions" will be based on a 30-year average computed at the end of each decade. Precipitation data can be obtained from NOAA's National Climatic Data Center, NRCS National Water and Climate Center, or other well-established weather station. See *Determining "Normal Weather Conditions*" section for more details.

4. "*Daily flow and precipitation records showing feature only flows in direct response to rainfall*": If a watercourse only flows in direct response to rainfall, and does not carry flow for an extended period of time in an average year (and meets the other conditions of the WWC definition), it is a wet weather conveyance. Evidence that a feature only flows in direct response from rainfall may include data from installed water-level recorders or continuously gauged in-stream weirs, matched against local meteorological data. The period of record for the data required for this primary indicator needs to be substantial, encompassing multiple seasons of the year, including at least some of the wetter months (December through May), and fact-specific to the watercourse in question (not generalizations or models involving large geographic regions). Use of this primary indicator is predicated on the observations being made under normal weather conditions (see *Determining "Normal Weather Conditions"* section above).

5. "*Presence of multiple populations of obligate lotic organisms with ≥ 2 months aquatic phase* " : The presence of certain types and numbers of aquatic organisms are considered primary indicators of extended periods of flow, and their absence over a normal year is one of the four defining elements of a WWC. The organisms must require a flowing water habitat (lotic), not be able to survive for extended periods in a still-water, low-oxygen habitat (lentic), and must have an aquatic phase that requires at least two months to complete. A list of primary indicator taxa that meet these conditions is provided in Table 2 below.

In order for this primary indicator to be affirmatively determinant, more than one individual (and preferably many individuals) of at least two qualifying taxa must be found in the evaluated reach. Unhatched eggs or any other stage of a taxon's life cycle that could be found in a WWC or lentic habitat (such as a deceased winged adult) should not be considered as a primary indicator. The specific taxa found should be noted on the Field Data Sheet. Representative individuals of the taxa

used to make this determination should be collected for ID confirmation, and kept for at least 90 days.

Note: All aquatic life observed should be noted, even if they do not qualify as primary indicators. These organisms may also become a component in the Secondary Field Indicator Evaluation (see following section).

There are conditions in which a stream may be dry for a period of weeks or even months, but supports at least two taxa of obligate lotic aquatic organisms or fish at other times during a year. In such conditions, an investigator could appropriately determine that there is sufficient water on an annual basis to support such populations even though there were not any present on a particular date. In addition, manmade pollution or other water quality issues may preclude support of these organisms. Therefore, the absence of obligate lotic aquatic organisms at the time of the investigation cannot be the sole basis for a determination that a watercourse meets the fourth element of the WWC definition.

**Table 2. TDEC Stream Primary Indicator Taxa List October 2010**

*Indigenous members of the benthic macroinvertebrate taxa groups listed below are obligate lotic aquatic organisms and thus are primary indicators that a watercourse is a stream when two or more specimens of two or more taxa are documented., per* TDEC Rule 1200-4-3-.05(9)(b)4(ii).

**Molluscs:**

Gastropoda (snails): Pleuroceridae, Viviparidae, Valvatidae

Bivalvia (mussels): Unionidae

**Insects:**

Coleoptera (beetles): Dryopidae, Elmidae, Psephenidae, Ptilodactylidae, Staphylinidae

Diptera (true flies): Athericidae, Blephariceridae, Chironomidae (except: Chironomini or red midges), Empididae, Ptychopteridae, Tanyderidae, and some Tipulidae (*Antocha, Rhabdomastix, Dicranota, Hexatoma, Limnophila, Tipula*)

Ephemeroptera (mayflies): all members, except: Siphlonuridae, and some Ephemeridae (*Hexagenia*)

Megaloptera (hellgrammites and alderflies): all members, except: *Chauliodes*

Odonata (dragonflies and damselflies): Aeshnidae, Calopterygidae, Cordulegastridae, Gomphidae, some Coenagrionidae (*Argia, Chromagrion, Amphiagrion*), some Libellulidae (*Perithemis*) and some Corduliidae (*Epitheca, Helocordulia, Neurocordulia*)

Plecoptera (stoneflies): all members

Trichoptera (caddisflies): all members, except : Molannidae, some Leptoceridae (*Nectopsyche, Triaenodes*), and some Limnephilidae (*Ironoquia, Limnephilus, Hesperophylax*)

**Worms:**

Oligochaetes: Branchiobdellidae, Lumbriculidae, Sparganophilidae, some Tubificidae (subfamily Naidinae, *Ilyodrilus, Rhyacodrilus, Varichaetadrilus*), and some Lumbricidae (*Eiseniella tetraedra* only).

6. "*Presence of fish (except Gambusia)*": Watercourses that provide habitat for fish are considered streams, as the WWC definition specifically indicates. The mosquitofish (*Gambusia*) is the only indigenous fish that is considered transient enough to rapidly move into a WWC when carrying stormflow, and is not a primary indicator.

Fluctuating water levels of intermittent streams provide unstable and stressful habitat conditions for fish communities. When looking for fish, all available habitats should be observed, including pools, riffles, root clumps, and other obstructions (to greatly reduce surface glare, the use of polarized sunglasses is recommended). In small streams, the majority of species usually inhabit pools and runs. Fish should be easily observed within a minute or two. Also, fish will seek cover once alerted to your presence, so be sure to look for them slightly ahead of where you are walking. Check several areas along the sampling reach, especially underneath undercut banks.

Western Mosquitofish (Gambusia affins) - Male

Western Mosquitofish (Gambusia affins) - Female

Eastern Mosquitofish (Gambusia holbrooki) – Male and Female

**Figure 4. Various Mosquitofish (*Gambusia* ssp.)**
Both western and eastern mosquitofish (*Gambusia ssp.)* have been introduced into Tennessee as a mosquito-control agent.

On rare occasions a single or a few primary fish can become stranded in a puddle in a WWC left behind by flooding into fields or washed down from a pond higher in the watershed. Assessors should be aware of this possibility if the fish observed are in isolated puddles in an otherwise dry channel.

Blackspotted Topminnow (Fundulus olivaceus)

Blackstripe Topminnow (Fundulus notatus)

**Figure 5. Topminnows (*Fundulus* ssp.)**
This genus, though similar in appearance to *Gambusia*, should not be confused with it.

7. "*Presence of naturally occurring ground water table connections*": This primary indicator is designed for watercourses exhibiting clear connection with the ground water table, thereby disqualifying them from WWC status. To use this indicator, it is especially important for the field investigation to be temporally removed from recent precipitation events. Baseflow in a stream can result from a variety of hydrogeologic scenarios, in addition to contact with the ground water table. The observed emergence of water from the ground is not necessarily water from the ground water table and should not be considered as conclusive for the purpose of this primary indicator. Further investigation into factors including those listed below is necessary to determine the source of the emergent water.

Since larger streams and rivers are frequently in contact with the ground water table, the investigator should review topographic maps to determine if the watercourse is within the floodplain of, or within twenty feet in elevation of a larger stream or river known to carry perennial flow. Flow in such a watercourse should not alone be considered conclusive evidence of a ground water table connection, but is contributing evidence to be considered in the determination.

Since the presence of wetlands often indicates a shallow depth to the ground water table, the investigator should search for the presence of wetlands in the immediate vicinity of the watercourse both on desktop resources and in the field. The presence of wetlands in the vicinity of the

watercourse being examined should not alone be considered conclusive evidence of a ground water table connection, but is contributing evidence to be considered in the determination.

The investigator should review United States Department of Agriculture (USDA) soil surveys. The USDA soil descriptions often contain information on depth to water table. For watercourses whose channels are at a depth that indicates contact with the ground water table for the soil type in which they are formed, the investigator can conclude that the watercourse is in contact with the water table, absent contradicting field information.

The investigator should review site geological characteristics affecting the elevation of the ground water table with respect to the elevation of the channel, including the presence of karst bedrock features, erodibility of watershed soils, thicknesses of regolith and channel alluvium, depth to bedrock or laterally persistent silt or clay horizons, land-use disturbances, and other watershed conditions controlling or contributing to the presence or absence of channel baseflow

If data are available from water wells within one mile of and in similar landscape position to a watercourse under investigation, and if the surface elevation of standing water in the well is at or above the elevation of the bottom of the channel of the watercourse, then the investigator can conclude that the watercourse is in contact with the ground water table.

The presence of historic non-natural structures such as spring boxes may be an indicator of a connection with a ground water table (as well as usage as a drinking water source, see primary indicator #9).

8. "*Flowing water in channel and 7 days since last precipitation >0.1" in local watershed*" : As stated earlier, one of the most important attributes of a WWC is that it carries flow <u>only</u> in direct response to rainfall. The vast majority of WWCs will generally cease to flow within 48 hours of almost all rain events, except some of the largest events. This is especially true in urbanized, impervious areas, or other areas with low infiltration rates, such as mowed lawns. If instream surface flow is observed within the evaluated reach, and it has been at least seven days since the last rainfall event, or significant snowmelt in the upstream watershed, the observed flow will not be considered a direct storm response, and therefore the feature is a stream. Precipitation records from a local, established gauge should be used and documented.

**Figure 6. Springbox**
Springboxes are a good indicator that a constant discharge of groundwater is present.

9. "*Evidence watercourse has been used as a supply of drinking water*: The investigator should note spring boxes, water pipes to carry water from the watercourse to a residence, or other observable evidence the watercourse has been used as a household water supply upstream of or within the segment being evaluated. If sustained hydrology is present and the investigator finds evidence the feature was historically or is currently utilized for drinking water supply, the investigator can conclude that the watercourse is a stream, absent contradicting information.

# Secondary Field Indicator Evaluation

If none of the primary indicators are present at the time of the investigation, the investigator must evaluate the aggregate evidence provided by secondary indicators along the watercourse in question in order to make a determination. This process is based on the principle that over the long-term, the longer the duration of continuous flow in a channel, the stronger the corresponding observed field indicators are likely to be.

The scoring methodology for the Secondary Indicator Evaluation is adapted from the *NC DWQ Identification Methods for the Origins of Intermittent and Perennial streams, Version 3.1*, and the subsequent update of this protocol, *Version 4.11*. All stream systems are characterized by interactions among hydrologic, geomorphic (physical), and biological processes, and attributes of these three processes are used to produce a numeric score. Scores less than 19.0 indicate the channel carries only stormflow ephemerally, and is therefore a wet weather conveyance, whereas scores 19.0 or greater indicate that the channel is at least an intermittent stream.

Determination of jurisdictional status is accomplished by evaluating 28 different attributes of the watercourse and assigning a numeric score to each attribute (indicator). The back page of the Hydrologic Determination Field Data Sheet (Appendix A) is used to record the score for each of the secondary indicators and determine the total numeric score for the channel under investigation.

<u>Scoring and Descriptions of secondary indicators</u>

<u>Scoring</u>

Scores should reflect the persistence of water, with higher scores indicating intermittent and perennial streams. A four–tiered weighted scale used for evaluating and scoring each indicator addresses the natural variability of stream channels. The scores, “Absent”, “Weak”, “Moderate”, and “Strong” are applied to sets of geomorphic, hydrologic and biological indicators. The score given to an indicator reflects the evaluator’s observations of the average degree of development of the indicator along the channel being evaluated. Sample reaches should include all of the channel accessible to the investigator that is applicable to the project goals; it is preferable that reaches scored be at least 200 feet long if possible. These scoring categories are intended to allow the evaluator to make a more precise description in assessing variable features or attributes than simple “presence/absence”. In addition, the small increments in scoring between gradations will help reduce the range in scores between different evaluators. The score ranges were developed in order to better assess the often gradual and variable transitions of streams from ephemeral to intermittent.

“Moderate” scores are intended as an approximate qualitative midpoint between the two extremes of “Absent” and “Strong.” The remaining qualitative description of” Weak” represents gradations

that will often be observed in the field. In some situations it is appropriate to rate an individual secondary indicator as falling between two categories, with a correspondingly averaged score. For example, if the *Continuous Bed and Bank* indicator is rated as falling between "Strong" and "Moderate", it would score 2.5 points for this indicator.

General Definitions of Absent, Weak, Moderate, and Strong are provided in Table 3. These definitions are intended as guidelines and the evaluator must select the most appropriate category based upon experience and observations of the stream under review, its watershed, and physiographic region. All secondary indicators have individual descriptions of each scoring category, but this general guide is helpful in considering the effort/time required to locate a particular indicator.

**Table 3. General Guide to Scoring Categories for Secondary Indicators**

| Category | Description |
|---|---|
| Absent | The characteristic is not observed |
| Weak | The characteristic is present but you have to search intensely (i.e., ten or more minutes) to find and evaluate it |
| Moderate | The characteristic is present and observable with mild (i.e., one or two minutes) searching and evaluation |
| Strong | Easily observable throughout the reach and quickly evaluated |

Since many channels do not contain flow during the determination, some of the secondary indicators will require the investigator to envision how water would flow through the channel during wetter times, including the location of the thalweg. This is important in evaluating in-channel structure (3), braided channels (7), leaf litter in channel (16), fibrous roots in channel (20), and rooted plants in channel (21).

## A. Geomorphic Indicators

### 1. Continuous Bed and Bank

*Throughout the length of the stream, is the channel clearly defined by having discernable banks and a streambed?*

The bed of a stream or river or creek is the physical confine of the normal low water flow (baseflow). The lateral constraints (channel margins) during all but flood stage are known as the stream banks. In fact, a flood occurs when a stream overflows its banks and partly or completely fills its flood plain. As a general rule, the bed is that part of the channel below the "normal" water line, and the banks are that part above the water line; however, because water flow varies, this differentiation is subject to local interpretation. In a stream the bed is usually kept clear of terrestrial vegetation, whereas the

banks are subjected to water flow only during unusual or infrequent high water stages, and therefore can support vegetation much of the time. This indicator will lessen and may diminish or become fragmented upstream as the stream transitions into a WWC.

Note: Highly erodible soils such as in West Tennessee, or impervious, flashy systems may develop oversized, well-defined channel margins, but often lack a clear demarcation between the bed and bank, especially in terms of substrate differentiation.

*Strong* – There are continuous bed and banks present throughout nearly all the length of the stream channel. There is clear demarcation between bed and bank, and between bank and riparian corridor.

*Moderate* – The majority of the stream has a continuous bed and banks. However, occasionally there are obvious interruptions in the channel margins, or areas with less demarcation between the bed and banks.

*Weak* – The majority of the stream has obvious interruptions in the continuity of the channel margins and demarcation between the bed and bank. However, there is still some representation of channel morphology.

*Absent* – There is little or no ability to distinguish between the bed, the banks, and upland.

**Figure 7. Example of Ill-Defined Bed and Bank**
Weak - Note the lack of a well-defined bed and bank as well as poor incision through the soil profile.

## 2. Sinuosity

*Is the stream channel sinuous throughout the reach being evaluated?*

Sinuosity is a measure of a stream's "crookedness." Specifically, it is the total stream length measured along the stream thalweg (deepest part of the channel) divided by the valley length (Figure 4). The higher the number, the greater the sinuosity. Sinuosity is related to slope gradient along the channel. Natural undisturbed streams with steep channel slope gradients have lower sinuosities, and streams with low channel slope gradients typically have higher sinuosities.

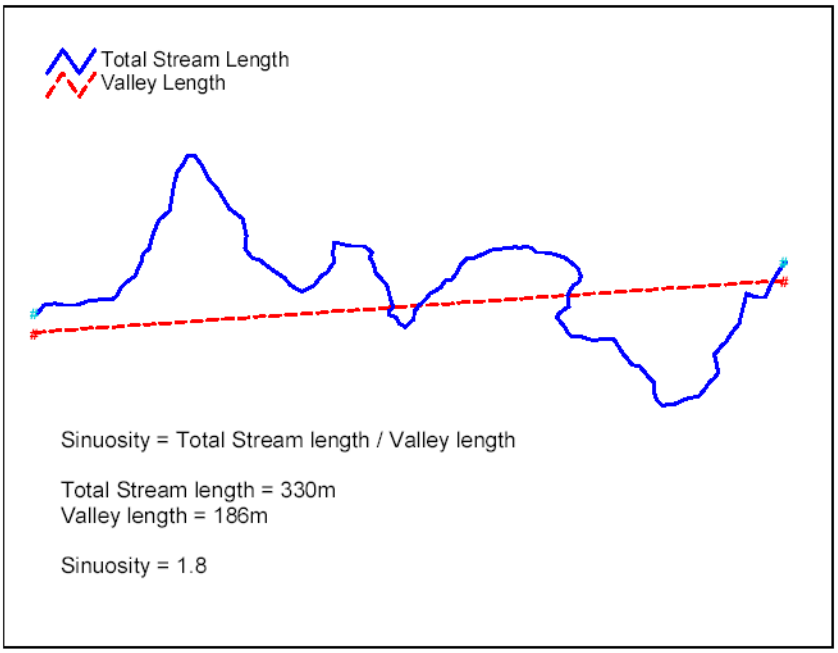


**Figure 8. Stream Sinuosity**
Note that sinuosity is calculated from the total stream length/total valley length.

Sinuosity is the result of the stream naturally dissipating its flow forces. Intermittent streams don't have as constant of a flow regime, and as a result generally exhibit a significantly less sinuous channel than farther downstream in the perennial stream. WWC's that carry flow only in direct response to rainfall will have even less sinuosity. While scoring, take into consideration the size of the stream and the size and grade of its watershed, which may also influence the stream wavelength.

As with some of the other secondary indicators (such as #s 5 and 7), in cases of severe channel incision and/or channelization, channel evolution may be re-establishing a new morphology within the older channel. Sinuosity of the newly developing thalweg within the older channel should be evaluated in these cases. Sinuosity should be visually estimated or

measured in the field. Sinuosities of small headwater streams approximated from maps or aerial photos are usually not of sufficient accuracy. Examples are provided in Figure 10.

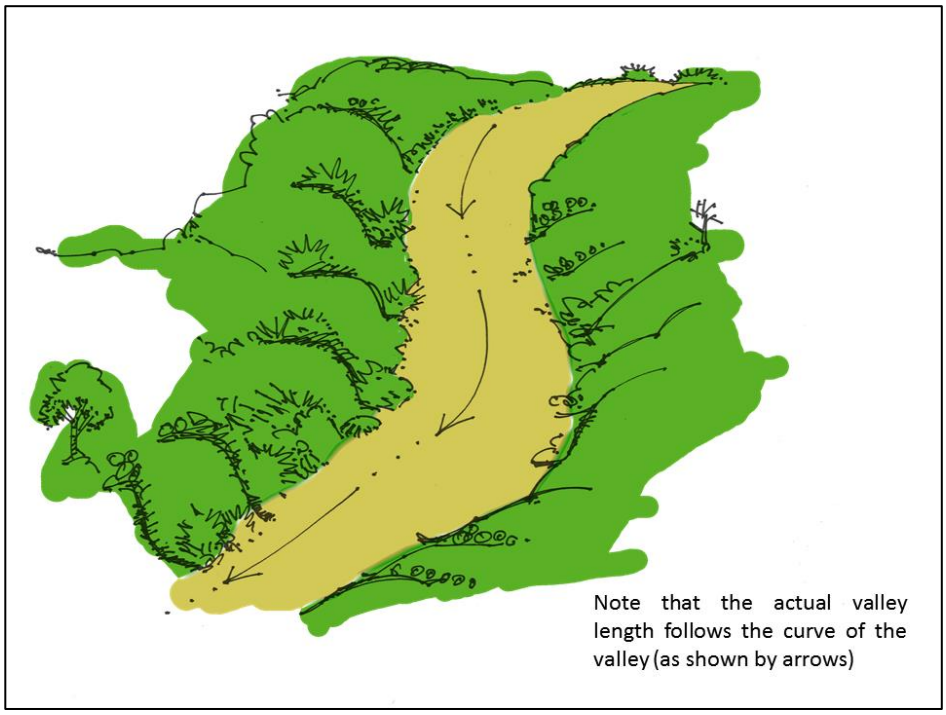


**Figure 9. Valley Length Is Based on Curvature**
The full length of the valley (including curvature) is to be used to determine sinuosity.

*Strong* – Ratio > 1.4. Stream has numerous, closely spaced bends, very few straight sections.

*Moderate* – 1.2 < Ratio < 1.4. Stream has good sinuosity with some straight sections.

*Weak* – 1.0 < Ratio < 1.2. Stream has very few bends and mostly straight sections.

*Absent* – Ratio = 1.0. Stream is completely straight with no bends.

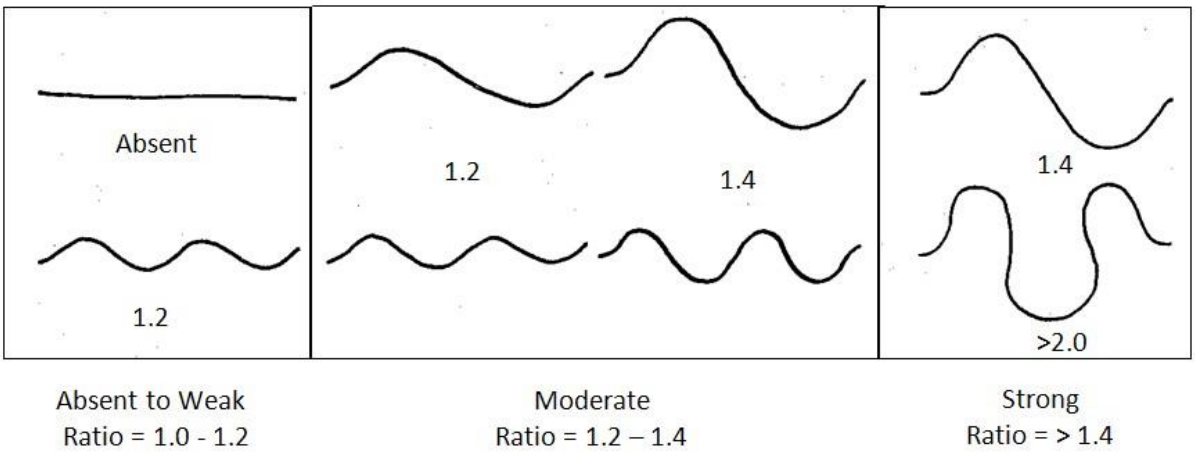


**Figure 10. Examples of Stream Sinuosity**

### 3. In-channel Structure -- Riffle-Pool Sequences

*Is there a regular sequence of riffles and pools or other erosion/deposition structural features in the channel indicative of frequent high flows?*

A repeating sequence of riffle/pool features (riffle/run in lower-gradient streams, ripple/pool in sand bed streams, or step/pool in higher gradient streams where slope > 2-4%) can be observed readily in perennial streams at baseflow. This morphological feature is almost always present to some degree in higher gradient streams frequently found in the interior plateau and mountain regions of the state. Riffle-run (or ripple-run) sequences in low gradient streams, such as those in West Tennessee may be less frequent, and are often created by in-channel woody structure such as roots and woody debris. These features may be quite subtle in streams where the available substrata are all very fine material.

A riffle is a zone with relatively high channel slope gradient, shallow water, and high flow velocity and turbulence. In smaller streams, riffles are defined as areas of a distinct change in gradient where flowing water can be readily observed. The bottom substrate material in riffles usually consists of the coarser particle sizes that are present in the stream. A pool is a zone with relatively low channel slope gradient, deeper water, and low velocity and turbulence. Fine textured sediments generally dominate the bottom substrate material in pools. Along the stream reach, take notice of the spacing and frequency of the riffles and pools or other types of in-stream structures. When present, all of these characteristics can be observed even in a dry stream bed by closely examining the local profile of the channel.

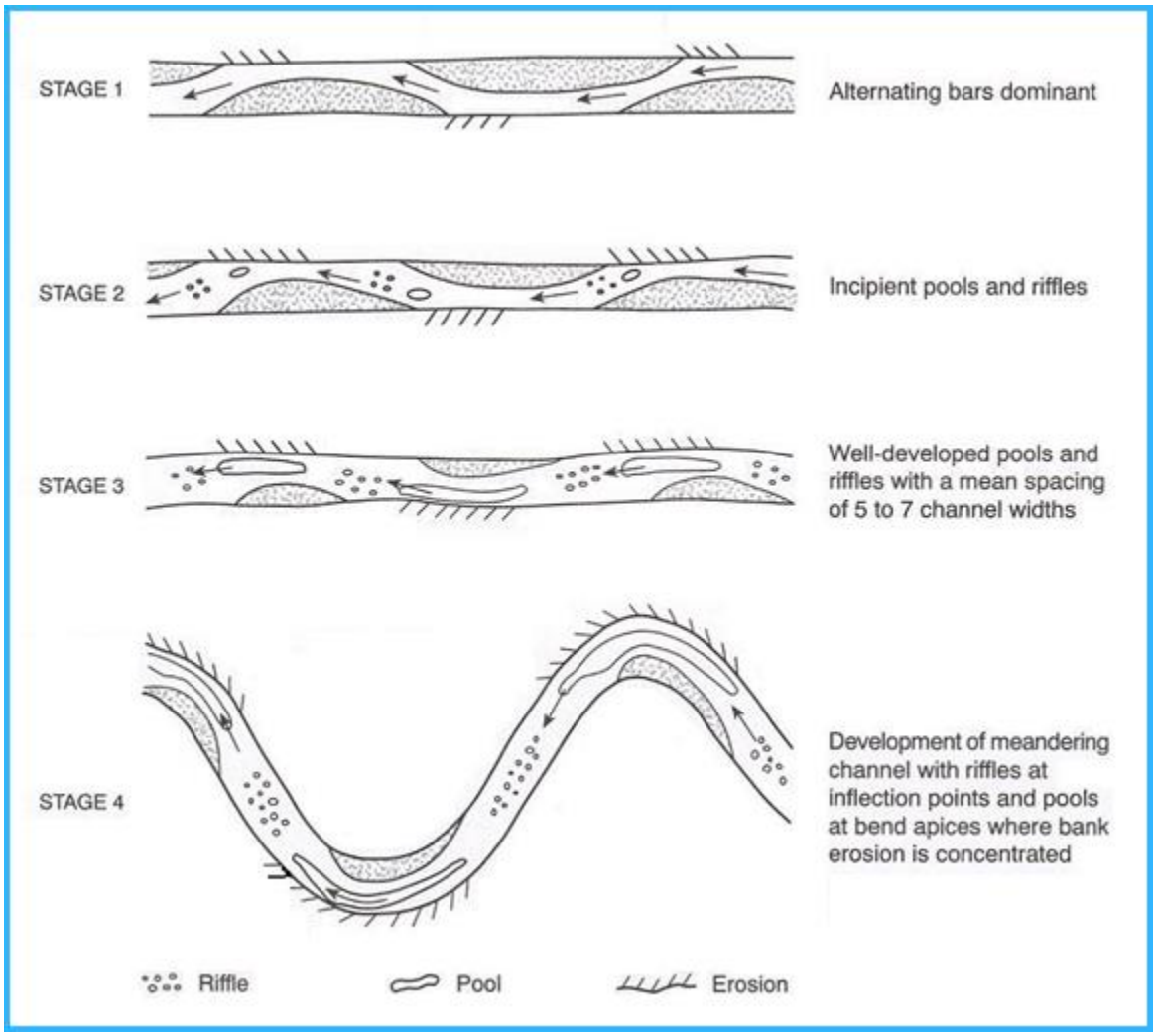


**Figure 11. Bar and Bend Development**
The formation of riffles and pools in a sequence is often related to the formation of bars and meanders within a stream channel.

*Strong* – Demonstrated by an even and frequent number of riffles followed by pools (every 5 -7 channel widths or more frequent) along the entire reach. There is an obvious transition between riffles and pools.

*Moderate* – Represented by a less frequent number of riffles and pools (every 10-14 channel widths). Distinguishing the transition between riffles and pools may be more difficult.

*Weak* – Channels show occasional hydraulic diversity, but mostly exhibit long reaches of uniform hydraulics.

*Absent* – There is no sequence exhibited.

## 4. Soil Texture and Stream Substrate Sorting

*Has channel erosional downcutting penetrated through the soil profile such that the texture of the bottom substrate is relatively coarser than that of the soil in the adjacent floodplain? Is there evidence of sorting of the bottom substrate materials, indicative of frequent high flows?*

This indicator can be examined in two ways. The first is to determine if the overall soil texture in the bottom of the stream channel is similar to the soil texture outside the channel. If this is the case, then there is evidence that erosive forces from continuous flow regimes have not been active enough to downcut the channel and support an intermittent or perennial stream. Soils in the bed of wet weather conveyances typically have the same or comparable soil texture as areas close to but not in the channel. The bottom substrate of intermittent or perennial streams often has accumulations of coarse sand and larger particles.

Note that unnaturally accelerated stormflow discharges resulting from land development may produce deep, well-developed ephemeral or even intermittent channels but which may have little or no coarse bottom materials indicative of upstream erosion and downstream transport.

The second way this indicator can be examined is to look at the distribution of the soil particles in the substrate in the stream channel. Is there an even distribution of various sized substrates throughout the reach or does partitioning or sorting occur? In West Tennessee one may need to look for size variations among sand grains – for instance, coarse versus fine sand. The occurrence of depositional features will be more infrequent in more highly intermittent streams. Perennial streams, on the other hand, tend to exhibit correspondingly larger depositional features, with cobble/gravel/boulders being localized in riffles and runs, and with accumulations of fine sediments settling out in pools.

Note, the usefulness of this indicator may vary among physiographic provinces. For instance, in the Southeastern Plain or Mississippi Valley, the variability in the size of soil particles is less than in middle Tennessee and the mountains. In addition, the degree of incision and distribution of particles may be difficult to distinguish in bedrock bottom streams, common to areas such as the Nashville Basin.

Sorting of material that has clearly been washed into the channel (road gravel, soil stockpiles, etc.) should be scored lower than natural bedload.

**Table 4. Standard USDA Particle Sizes**

| | Diameter | |
|---|---|---|
| Description | millimeters (mm) | inches (in.) |
| silt | .02-.05 | .00008-.02 |
| fine sand | 0.1-0.25 | .004-.01 |
| medium sand | 0.25-0.5 | .01-.02 |
| coarse/very coarse sand | 0.5-2.0 | .02-.08 |
| pebbles (gravel) | 2-75 | .08-3.0 |
| cobbles | 75-250 | 3.0-9.8 |
| stones | 250-600 | 9.8-23.6 |
| boulders | > 600 | > 23.6 |

*Strong* – The channel has cut down (incised) through the soil profile, resulting in relatively coarse-textured bottom sediments compared to riparian zone soils: coarse sand, gravel, or cobbles in middle Tennessee; gravel, cobbles, stones, or boulders in the mountain regions, and medium or coarse sand in the western part of the state. There is a clear sorting of the various sized substrates across bars and benches. Depositional features are present, finer particles are absent or accumulate in pools, and larger particles are located in the riffles/runs.

*Moderate* – The channel may not be completely eroded through the soil profile. Coarse-textured bottom sediments are present in contrast to the surrounding soil texture but there is relatively little sorting of fine material from coarser materials. Small depositional features are present; small pools are accumulating some sediment, indicating downstream transport.

*Weak* – The channel has cut down only partway through the soil profile. A small amount of coarse textured bottom sediments may be present, but bottom substrate has more similarity to the surrounding soil textures. Substrate sorting is not readily observed. There may be some small depositional features present on the downstream side of obstructions (large rocks, etc.).

*Absent* – The channel has incised very little through the soil profile, very little to no coarse textured bottom sediments are present, and substrate sorting is absent. There are few to no depositional features, and bottom substrate is nearly identical to the surrounding textures of soils.

**Figure 12. Weak Substrate Sorting**
Note that substrate material in channel has very little coarse-textured material and is similar in appearance to the material on the side of the channel.

**Figure 13. Strong Substrate Sorting**
Smaller cobble, gravel, coarse sand, and sand may be seen in this photo. Note that the material has segregated out according to size from left to right.

## 5. Active Floodplain

*Is there an active floodplain at the bankfull* elevation or is there evidence of channel incision with a relic floodplain (the channel has been cut off from its floodplain) above the current bankfull elevation?*

Floodplains are relatively flat areas usually located outside of or adjacent to the stream bank that accumulate organic matter and inorganic alluvium deposited during flooding. In many cases there should be evidence of a floodplain if the stream is of moderate to low gradient and has perennial flow. Floodplains will generally not be present in small channels or moderate to higher gradient streams. An active floodplain (at current bankfull elevation) shows characteristics such as surface scour, drift lines, development of side channels, and sediment deposited on the banks or surrounding plants, which may also be flattened by flowing water.

> * "Bankfull": Experience has shown that this term may cause confusion among persons making stream geomorphology observations. Dunne and Leopold (1978) define "bankfull" as follows: "The bankfull stage corresponds to the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels." Bankfull flows are the primary channel-forming flows, and have an average recurrence interval of 1.5 years. It is sometimes tricky to identify where the bankfull elevation is on a channel, if the channel is incised, in transition to a successive geomorphic stream type, or does not have a well-developed floodplain. *Often "top-of-bank" is confused with the elevation of the bankfull stage*. There are a variety of visual indicators available in the field such as the top of the highest depositional features (point & central bars), a vegetation line on the banks, or a breakpoint in the slope or particle size of the bank (Rosgen 1996).

In cases of severe channel incision (down cutting) and subsequent over-widening due to channel evolution, the stream's new floodplain may be restricted to within the oversized channel and the previous but now disconnected (relic) floodplain will be harder to see (outside of the channel). In these instances look for indicators along the sides and within the incised channel (see Figure 8 below).

In low-gradient, smaller-order intermittent and perennial steams, floodplains may not be continuous, but rather may be present in some locations and absent in others, especially if also incised. In medium to high-gradient wet weather conveyances and intermittent streams, fans of alluvial material may spread out in areas where channel bed and bank lose definition. These features are more representative of weak bed and bank development than overbank flooding and deposition in a true floodplain. However, these features may score points under the following metric as weak depositional bars or benches.

*Strong* – The area displays all of the aforementioned characteristics. The floodplain consists of coarse- to fine-textured alluvium and is relatively wide and continuous on one or both sides of the channel

*Moderate* – Most of the characteristics are apparent. The floodplain is not continuous on one or both sides of the channel

*Weak* – The floodplain is not obvious, however some of the indicators are present. Small, infrequent segments of floodplain are present.

*Absent* – The characteristics are not present.

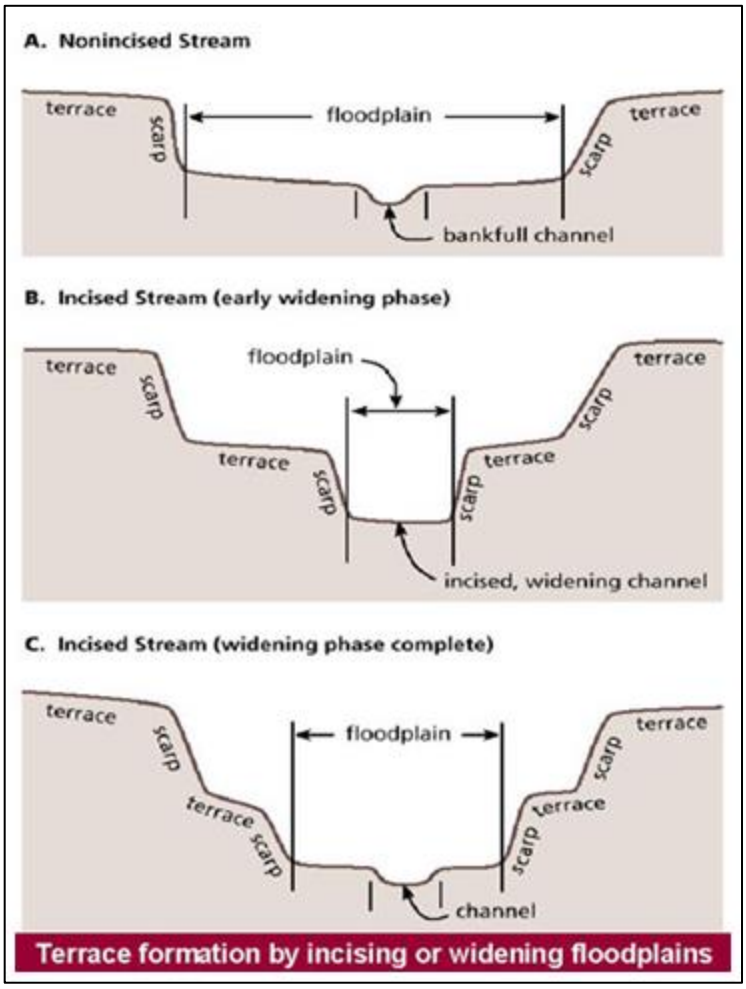


**Figure 14. Floodplains and Channel Evolution**

## 6. Depositional Bars or Benches

*Are there well-developed depositional benches or bars, the top of which is approximately at bankfull elevation?*

When a stream channel conveys continuous flow the forces of channel scouring and deposition create certain distinct physical erosional and depositional features which can be readily observed. One of these features includes scoured areas along the bank above which the streambanks are much less eroded and below which little or no vegetation is present. Another feature is accumulations of sand or silt creating a bar or "bench" which may or may not be covered with vegetation. The aforementioned "scour line" should be fairly continuous along the length of the stream's banks and should be seen at roughly the same elevation as the top of any sediment bars (above which the stream bank slope begins to increase dramatically).

Bars are sediment storage areas in streams located along the margins or the middle of the stream. Point bars are located on the inside of bends in meandering streams, alternate bars are located along the sides of streams and are typical of streams with low sinuosity (see Figure 11). Medial or midpoint bars are typical of streams that lack the capacity to transport their sediment load.

Bankfull benches are located along the margins of the stream and are usually associated with deposition and scour resulting from bankfull flows in incised streams. Over time, the scour from bankfull flow and/or the deposition of sediment from receding bankfull flows accumulate, resulting in a bench on one or both of the stream margins. The presence of a bankfull bench is an indicator that the stream experiences bankfull flows and subsequent sediment transport and deposition usually associated with longer periods of sustained flow.

The presence of depositional bars or benches implies that the channel experiences a relatively continuous hydrologic regime and is in dynamic equilibrium with the shaping forces of its water/sediment load. The flow regime, soils and grade determine the bankfull width and morphology of the conveyance channel. The more obvious and continuous these deposition features are throughout the reach, the higher the score should be. Depositional features are often absent on very small channels. Sometimes there may be depositional features along the side of the channel, the tops of which are significantly below bankfull elevation. These features should not receive as many points as well-developed bankfull benches, but should receive some points.

In the case of channels that may be bedload limited (due to upstream impoundments, for example) score according to this guidance, but note on the field sheet that the lack of bars may be due to a bedload-limiting factor other than natural erosive processes.

*Strong* – Well-developed depositional bars or benches and bankfull scour areas are obvious throughout the sample reach.

*Moderate* – Some indications of depositional bars and benches and bankfull scour areas are present throughout most of the reach.

Weak – Indications of depositional bars or benches or bankfull scour areas are infrequent along sampling reach.

*Absent* – Indications of bankfull scour and depositional bars or benches are completely lacking.

**Figure 15. Bankfull Bench and Related Features**

## 7. Braided Channel

*Is there a reach with multiple channels present in a low gradient area of sedimentation?*

Braided channels occur in shallow, low gradient areas where abundant sediment has a tendency to build up across the watercourse creating a braided pattern of channels and an extensive floodplain. Are there two or more small channels that cross or "braid" over one another? This usually occurs in areas where the land flattens significantly and where there is abundant sediment supply in a wide streambed with shallow water flow. Braided channels should normally carry baseflow (when present), as opposed to high-flow "cut-off" channels that would only carry flow during large storm events. Note that braiding can occur *within* a channelized, hard-armored, or over-widened channel.

*Strong* – The watercourse displays a braided appearance with many crossings creating many "islands".

*Moderate* – The watercourse displays a braided pattern; however, it does not cross many times and only has a few "islands".

*Weak* – The braided pattern is present but the watercourse only crosses one or two times creating only one or two "islands".

*Absent* – The gradient is too high such that the water is flowing too quickly in order to create

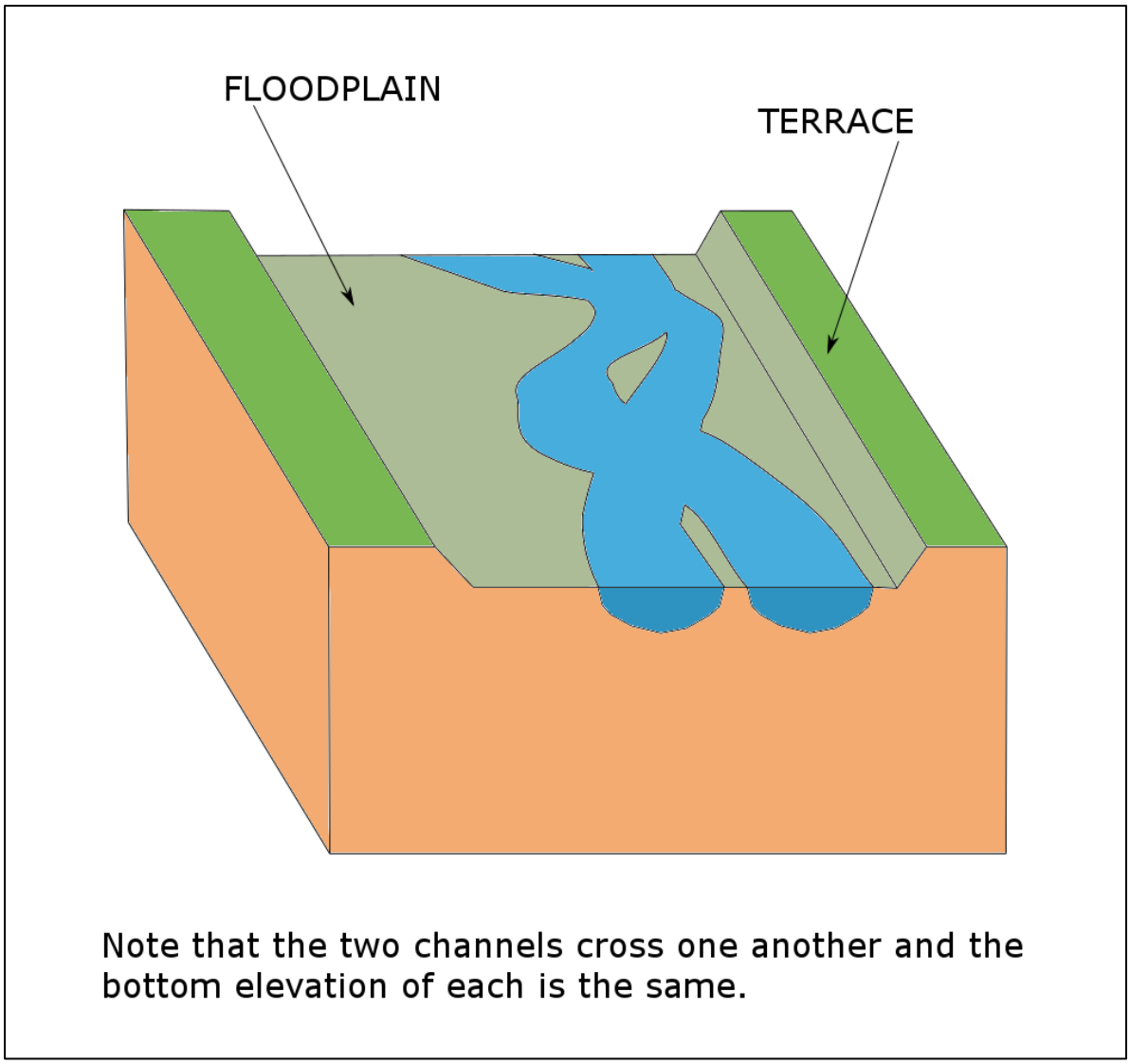


**Figure 16. Braided Channel**
Braided channels will intersect one another and have the same bottom elevation. This will differ from "cutoff" channels that that will typically have a higher bottom elevation than the main channel.

## 8. Recent Alluvial Deposits

*Are there fresh deposits of inorganic alluvial materials that have been transported and deposited on bars or benches in the stream channel or on the floodplain by recent high flows?*

Alluvium may be deposited as sand, silt, various sized cobble, and gravel. Observe whether or not there is any fresh deposition or accumulation of these substrates within the stream channel (sand and point bars) or floodplain left from the last two to three large rain events. The amount of alluvium deposited will indicate whether continuously flowing water is constantly pushing substrate downstream. Keep in mind that eroding stream channels destabilized by increased stormwater runoff from drains/outfalls may appear to score higher than undisturbed channels for this indicator.

Freshly deposited alluvium may be distinguished from older deposits by color (usually lighter), level of consolidation (newer deposits are usually looser, less compacted), and absence of colonizing vegetation.

*Strong* – Large amounts of freshly deposited sand, silt, cobble, and/or gravel alluvium is easily observed on bars and benches, or even outside the channel. New point or medial bars may be forming.

*Moderate* - Freshly deposited sand, silt, cobble, and/or gravel observed in the reach with mild searching, present within the stream channel only.

*Weak* – Small amounts of freshly deposited sand, silt, and/or small cobble present within the channel or on bars and benches.

*Absent* – There are no recent deposits of transported bedload present and no indication of overbank deposition within the floodplain.

**Figure 17. Alluvial Deposition**
Note the deposition of alluvial material below the weak grade control. It may be noted that the deposited material has not weathered or been colonized by plants.

## 9. Natural Levees

*Are well developed natural levees present on the active or relic floodplain?*

Levees develop at the top of the bank adjacent to the stream when sand is deposited by overbank vertical accretion relatively parallel to the top of the bank from flood flows. These result from the deposition of heavier particles immediately adjacent to the channel as flood waters leave the channel. Natural levees are broad low ridges that may be covered by vegetation or remain as bare areas. Scoring is based on the presence and length of the levee through the stream reach.

It may be necessary to distinguish between natural levees and spoil piles. Spoil piles are created when a stream is ditched, when a ditch is created, or when sediment is removed from a stream. When natural levees are present, they will occur along both stream banks in generally equal heights. However, spoil piles most often occur along only one stream bank. There may be times when it is difficult to distinguish between natural levees and spoil piles, and in these cases this must be noted on the field scoring sheet.

*Strong* – Natural levees are clearly observed on both sides of the channel throughout the reach.

*Moderate* – Natural levees are observed in portions of the reach, or may not be continuous on both banks.

*Weak* – some evidence of natural levees can be found in the reach with intensive searching.

*Absent* – No evidence of natural levees.

## 10. Headcut

*Is there a headcut at the upstream end of the reach being evaluated? Is there water present at the base of this headcut? Is there more than one headcut within the reach being evaluated?*

A headcut is an abrupt vertical drop in the bed of a stream channel that is an active erosional feature. It often resembles a small intermittent waterfall (or a miniature cliff) and may have a deep pool at the base resulting from the scour produced during high flows. Intermittent or perennial streams sometimes begin at a headcut in higher-gradient streams. Headcuts are transient structures of the stream and often exhibit relatively rapid upstream movement during periods of high flows. Ground water seepage may also be present from the face or base of a headcut.

In many cases over time the elevation of the streambed at an active headcut has downcut to a point where it intersects subsurface water, and that intersection can provide the baseflow for a stream. Since headcuts usually migrate upstream, this process may often essentially move the stream origin upstream over time. Although headcuts are commonly found at stream origins, especially in urban streams, this is not always the case.

While a headcut may exist in more ephemeral streams by way of the same mechanics, large headcuts with the presence of water at the toe, or multiple headcuts throughout a reach in most cases are more indicative a stream and should be scored higher. An exception to this would be in West Tennessee, where due to the extreme erodibility of loess soils, headcuts more commonly occur in wet weather conveyances than in other regions of the state. Therefore, scoring for West Tennessee streams may be given less weight in this category.

Care should be taken to not misinterpret (or "double-count") the in-channel step-pool morphological structures commonly found in high-gradient streams.

*Strong* – A large head cut with water present at the base is located in the upstream end of the reach being evaluated, or frequent medium headcuts are located throughout the reach.

*Moderate* – A large headcut, or several small to medium headcuts are located throughout the reach.

*Weak* – Only one or two minor headcuts are located throughout the reach.

*Absent* – No headcuts are apparent in the evaluated reach.

**Figure 18. Examples of Headcuts**
Left photo shows a medium headcut with standing water at the base of the headcut, lateral seeping of water into the channel, and the presence of iron-oxidizing bacteria above the headcut. Right photo shows a large headcut with standing water at the base of the headcut.

## 11. Grade Control Point

*Is there a grade control point within the reach being evaluated?*

A grade control point is a structural feature in the channel that separates an abrupt change in grade of the streambed or a point where erosional downcutting has been stopped by an obstruction. Grade controls may be caused by bedrock outcrops (nick points), large stones or large roots which extend across the channel, or accumulations of large woody debris. Pipes, or other man-made structures (especially perched culverts) may also serve as grade control points, but should only be counted if they are clearly controlling an active headcut. Headcuts often separate an abrupt change in grade of the stream bed. Where headcuts are usually active, unstable features, grade control points

are more stable, static features.

*Strong* –Exposed bedrock shelves, boulder and cobble clusters or several large wood jams or roots are present throughout the reach and appear to be acting as relatively permanent grade controls.

*Moderate* – A few boulder and cobble clusters, and/or large wood and roots are present in the channel and appear to be acting as grade control, but only with moderate longevity, or multiple smaller root controls throughout the reach.

*Weak* – No bedrock or large boulder clusters, few roots or wood are present, but some may be acting as short-term grade control. If the only grade controls present are artificial, then score no higher than 'Weak'.

*Absent* – No grade control structures are in the stream.

**Figure 19. Examples of Grade Controls**
Grade controls can be of different sizes, different types of materials (eg., rocks, roots, etc.), and of different lengths of longevity. Top left photo shows a moderate grade control composed of woody debris. Bottom left photo shows a weak grade control composed of a root(s) across the channel. The right photo shows several grade controls (weak to weak+) composed of roots across the channel as well as various pools below them. Additionally, recent alluvial deposition may be seen in this photo.

## 12. Natural Valley or Drainageway

*Is there a well-developed stream valley at the location of the reach being evaluated?*

A valley is an extended depression in the Earth's surface that is usually bounded by uplands, hills or mountains and is commonly occupied by a river or stream. Valley formation and maintenance results from the gradual erosion by water. The frequency and magnitude of water flowing over the land surface over time, in conjunction with the erodibility of underlying rock and soil material, determine the degree of valley formation.

When looking at the local topography in the field (or on a U.S. Geological Survey map),

does the land slope towards the channel, or are the mapped contour lines fairly close together and v-shaped or u-shaped thereby indicating a "draw" or valley? In other words, does the land have slopes that seem to drain to or indicate the channel lies within a natural valley or drainage way?

*Strong* – Surrounding land contours slope steeply toward the channel in a natural v- or u-shaped valley and the direction of flow is readily apparent. USGS map clearly indicates a topographic valley.

*Moderate* – Surrounding land contours slope toward the channel and the direction of flow is apparent, but the v- or u-shaped valley is less readily apparent. The contours or drainage area may be artificially altered.

*Weak* – Surrounding land contours are indistinct and may be artificial. The gradient of the reach is such that the direction of flow may not be immediately apparent. USGS map indicates little to no contour lines indicative of a natural valley in the area around the reach.

*Absent* – Channel is incised into an otherwise flat or convex land surface, where the surrounding area does not obviously drain toward the channel and the direction of flow may not be easily observed. USGS map does not indicate a valley or drainageway.

## 13. Second (or greater) Order Channel

*Is the channel reach being evaluated second order or greater?*

Determine the order of the reach being evaluated in accordance with the Strahler Stream Order method (Strahler 1952). The higher the channel order, the more likely the watercourse is to carry extended periods of flow. Indications of stream order may be found using watercourses shown on either the most recent version of the 1:24,000 USGS topographic map or Natural Resource Conservation Service (NRCS) county soil survey. Only clearly defined intermittent or perennial stream channels as depicted on these maps should be used by the field evaluator to determine that the channel being evaluated is second order or greater.

It can be difficult to evaluate stream order on channels where historic alterations have altered the watershed, such as piping of first-order tributaries. A review of historic data such as the County Soil Survey or older editions of topo maps may be utilized to determine order. Assessors are encouraged to field verify order where the maps indicate significant physical alterations have occurred.

*Strong* – Two or more first (or higher) order channels indicated on a USGS

topographic map and a NRCS Soil Survey map combine and drain into the watercourse above the evaluated reach.

*Moderate* – Two or more first (or higher) order channels as depicted only on a USGS topographic map combine and drain into the watercourse above the evaluated reach.

*Weak* – Two or more (or higher) first order channels as depicted only on an NRCS Soil Survey map combine and drain into the watercourse above the evaluated reach.

*Absent* – Drainage above the evaluated reach is unmapped or consists only of a single first order channel or WWC.

## B. Hydrologic Indicators

### 14. Subsurface Flow/Discharge into channel

*Are there indicators of a subsurface discharge into the channel, indicating the potential for significant periods of sustained non-storm (baseflow) discharge to the stream?*

This secondary indicator differs from the primary indicator which evaluated contact with the ground water table (as defined in Rule 0400-4-3-.04(7)). This secondary indicator can be thought of as evaluating other types of subsurface discharges (or "ground water" with a little "g") arising from sources such as the slow migration of unsaturated drainage from the soil moisture zone above the water table, perched water tables, or karst conduits.

*Seeps and Springs*: The presence of water discharging (i.e. seeps or springs) from the bank, both above or below the elevation of the channel bottom may indicate a relatively reliable source of baseflow to a stream. Seeps have water dripping or slowly flowing out from the ground or from the side of a hill or incised stream bank. Springs may be quite pronounced, or may simply look "mushy" or very wet, with black decomposing leaf litter nearby in small depressions or natural drainage ways. Springs and seeps often are present at grade controls and headcuts. The presence of this indicator suggests that the stream is being recharged by a consistent water source, except during a period of drought.

Even when there is no visible discharge above the channel bottom, there may likely be slow subsurface discharge into and flow within the hyporheic zone. The hyporheic zone is the accumulation of coarse textured sediments in the bottom of the channel that may be up to 2-3 feet deep in small streams. *A functioning part of the stream, the hyporheic zone is the site of much ground water discharge to the stream, and biological and chemical activity associated with aquatic functions of the stream.*

In-stream flow that is maintained for extended periods of time from some of these types of subsurface sources, such as a perched water table, is considered to be more than a "direct response to precipitation runoff in [the watercourse's] immediate locality". In other instances, such as in areas with a highly karst geology, observed seeps into a watercourse may be not be able to sustain extended periods of flow, and may be considered a more direct response to rainfall.

In the field, ground water can often be detected by measuring a distinct temperature difference from the surface flow, or even analyzing a chemical difference, such as conductivity. Besides direct observations and measurements of ground water connections, indirect indicators such as the presence of iron-fixing bacteria (iron flocculant), or in West Tennessee, plumes or deposits of very fine grained, white sand in the bed of the channel, are also important pieces of evidence.

Seasonal high ground water levels are commonly found in West Tennessee within areas with low relief. Indicators of a perched water or the ground water table can also be observed by digging a bore hole in the adjacent floodplain approximately two feet away from the streambed. The presence of water standing in the hole above the elevation of the channel bottom after waiting for at least 30 minutes (longer for clayey soils) indicates the presence of a water table. The presence of hydric soil indicators above the elevation of the channel bottom in floodplain soils adjacent to the channel indicates the presence of a seasonal ground water source that can provide a significant period of base flow. The presence of hydric soils should be determined in accordance with methods in the:

"*Corps of Engineers Wetlands Delineation Manual*" and appropriate regional supplement (https://www.usace.army.mil/Missions/Civil-Works/Regulatory-Program-and-Permits/reg_supp/) or "*Field Indicators of Hydric Soils in the United States*" (www.nrcs.usda.gov). Note: Also see Secondary Indicator #19.

Score this category based on the abundance of these features observed within the reach.

*Note: Score lower if area is highly karst. Assessors are strongly discouraged from conducting HDs within 48 hours of significant rainfall.*

Strong – Visible springs, seeps or other indicators of subsurface discharge are readily observable in more than one location within the reach.

Moderate – Visible springs, seeps or other indicators of subsurface discharge are present, but are either difficult to locate, or present in only one location within the reach.

Weak – Water is standing in pools at multiple places in the reach and the hyporheic zone is saturated, but there may not be visible flow above the channel bottom. Visible

subsurface discharges such as seeps or springs are not present. Other indicators of subsurface discharge may be present, but require considerable time to locate.

*Absent* – Little to no water in the channel. No springs or seeps present and no other indications of any type of subsurface input.

**Figure 20. Examples of Seeps (subsurface discharge)**
Seeps may typically be seen below head cuts, beginning of a channel incision, or at the margins of a channel.

## 15. Water in Channel and > 48 Hours Since Last Significant Rainfall

It is necessary to discern between direct stormwater inflow (resulting from significant precipitation within the past 48 hours) and baseflow. As described previously in the Guidance, flow observations preferably should be taken at least 48 hours after the last significant rainfall or snowmelt. Local weather data and drought information should be reviewed before evaluating flow conditions. Perennial streams will have water in their channels year-round in the absence of drought conditions. If a stream exhibits flowing water (baseflow) in the height of the dry season (mid-summer through early fall in a normal year), then it probably conveys water perennially. On the other hand, a stream that does not exhibit flow during the seasonal periods of increased rainfall and lower temperatures would indicate a more intermittent or ephemeral watercourse.

*Baseflow Presence*: Under normal conditions, water flowing in the channel more than 48

hours after significant rainfall is often evidence of subsurface discharge or source of sustained flow, from saturated soils or a perched water table adjacent to the stream.

For the purposes of this secondary indicator, the presence of flowing water should be scored higher than a watercourse with areas of standing water only. Flow is more readily observed in the riffles and very shallow, higher-velocity areas of the stream. Dropping a floating object on the water surface will aid in determining if flow is present. Flow is often very hard to discern in small, shallow, very low gradient streams.

Intermittent streams will not always have water in them depending on the time of investigation. A good rule of thumb for differentiating intermittent streams from WWCs is if they have non-storm related water anywhere in them during dry (drought) conditions or during the growing/dry season. Look for water in pool areas or in holes in the streambed. The presence or type of plants and fauna as well as the dampness of the soil in the channel (look under rocks) are also good indications of the sustained presence of water during the growing and dry seasons.

Significant precipitation in this context is defined as enough precipitation in the local watershed to potentially generate enough runoff to the channel to affect the assessor's ability to accurately score this indicator. The volume and intensity of rainfall deemed significant will be influenced by impervious land cover, antecedent soil moisture, temperature, and other variables.

Note: Assessors are strongly discouraged from conducting HDs less than 48 hours after a significant rain event. Any HD conducted within 48 hours of such an event such that the scoring outcome is significantly affected will be considered provisional, and may be deemed incomplete by the Division.

*Strong* – Flow is highly evident throughout the reach. Moving water is easily seen in riffles and runs.

*Moderate* – Moving water is easily seen in riffle areas but not as evident throughout the evaluated reach. Some isolated areas may appear as standing pools, but there is generally water present throughout nearly all the thalweg (some may be within the hyporheic zone).

*Weak* – Isolated standing pools, or "wet" hyporheic zones only, no flow is discernable.

*Absent* – Dry channel without standing pools.

## 16. Leaf litter in channel (January-September)

*Are leaves accumulating in the streambed?*

Perennial streams (with deciduous riparian vegetation) should continuously transport plant material through the channel. Leaves and lighter debris are typically present throughout the length of wet weather conveyances, whereas little to no leaves are present along the active channel of streams with constant or near-constant flow. Accumulations of organic debris, including leaves, on the upstream side of obstructions ("leaf packs") are not considered to be leaf litter. This is an "inverse" hydrologic indicator in which strong evidence receives fewer points than absent.

*Cautions*: This indicator may be hindered during active leaf-fall in autumn between rain events; assessors should be cautious about scoring during such periods if no significant runoff events have occurred since the leaves fell. Consideration should also be taken after recent and heavy rain events, especially within urbanized, flashy systems, where already sparse leaf litter often gets washed away in all types of channels. Green leaves blown into a channel as a result of a violent storm should be disregarded. Caution should also be taken in low-gradient, woodland streams where flow velocities even during storm events remain low, and leaf densities are high. In this scenario, the presence of shredding activity by aquatic fauna may be used as a surrogate, with little to no leaf shredding scoring in the Moderate or Strong categories, and more widespread shredding activity scoring in the Weak or Absent categories.

*Strong* – Abundant amount of leaf litter is present throughout the length of the stream. Greater than 80% of the active channel is covered with leaves and the thalweg substrate is not visible.

*Moderate* – Leaf litter is present throughout most of the stream's reach. Between 25% and 80% of the active channel bottom is covered with leaves and only portions of the thalweg are visible.

*Weak* – Leaf litter outside of pools is present but most leaves are accumulated in pools. Between 5% and 25% of the streambed is covered with leaves and most of the thalweg is visible.

*Absent* – Leaf litter is not present in the fast-moving areas of the reach but there may be some present in the pools. Less than 5% of the active channel bottom is covered with leaves. The thalweg is swept clear of leaf litter and the substrate is continuously visible throughout the assessment reach

## 17. Sediment on Plants or Debris

*Is fine sediment deposited on plants or organic debris in the channel or on the active floodplain?*

The transportation and processing of sediment is a main function of streams. Therefore, evidence of sediment on plants or other organic debris in a channel may be an important indicator of the persistence of flow. Note that sediment production in stable, vegetated watersheds is considerably less than in disturbed watersheds. Are plants in the channel, on the channel margins, or in the floodplain covered with sediment? Look for silt/sand accumulating in thin layers on organic debris or rooted aquatic vegetation in the runs (disregard the bottoms of pools). Be aware of upstream land-disturbing construction activities, which may contribute greater amounts of sediments to the channel, and can confound this indicator. Record these types of activities on the data sheet if these confounding factors are present.

In urban or developed areas where natural organic materials are less common, non-natural materials such as trash, plastics, etc. may be used as surrogates, as long as it is clear to the assessor that the materials have been part of the flow dynamics of the channel (not blown into the channel by the wind or tossed in as litter).

**Figure 21. Sediment on Leaves**
Sediment from a high flow event has dropped out of suspension onto leaf material at the edge of the channel.

*Strong* – Sediment found readily coating plants and organic debris within the channel AND along the channel margins throughout much of the watercourse.

*Moderate* – A dusting of sediment consistently found on plants or organic debris scattered along the channel margins, although not very prevalent on debris within much of the channel.

*Weak* – Sediment is isolated in small amounts on organic debris within the reach.

*Absent* – No sediment is present on plants or debris.

## 18. Organic Drift Piles and Drift Lines (Wrack lines)

*Are there accumulations of organic debris in piles or lines in the channel or on the active floodplain?*

Organic drift is defined as twigs, sticks, logs, leaves, trash, plastics, and any other floating materials that may be piled up on the upstream side of obstructions in the channel, on the bank, in overhanging branches, and/or in the floodplain. Large amounts of tightly packed leaves behind obstructions in the channel are indicative of continual downstream transport of materials during extended periods of flow. Organic drift in overhanging branches or on the flood plain occurs when previously transported material is deposited during high flows. (Parallel lines of debris along the bank margins are also commonly referred to as "wrack lines."). WWCs usually exhibit fewer or no drift lines within their channels unless downstream of a stormdrain or extensive urban runoff. The magnitude of the accumulation of drift may be influenced by watershed characteristics and sources of debris. For example, streams in watersheds dominated by herbaceous vegetation may not exhibit strong drift lines.

*Strong* – Large Drift piles are prevalent along the upstream side of most of the obstructions within the channel and parallel linear wrack lines are evident along the margin, demarking an obvious 'high water mark' at multiple locations.

*Moderate* – Moderate-sized organic drift piles are present along the upstream side of many of the obstructions within the channel; sporadic patches of wrack lines may be found along the channel margins.

*Weak* – Small drift piles are present but rare within the channel, little to no wrack lines evident.

*Absent* – No drift piles or lines are present.

**Figure 22. Wrack Line**
Leaves and other organic material have been deposited in a long line parallel to the channel during a high flow event.

## 19. Hydric Soils (Evidence of Seasonal High Water Table)

*Are there hydric soils (evidence of seasonal high water table) present at or below channel bed elevation, or well developed hydric indicators in the hyporheic zone?*

Hydric soils are defined as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part of the soil (Federal Register, July 13, 1994). Nearly all hydric soils exhibit characteristic morphologies that result from repeated periods of saturation or inundation, or both, producing extended periods of soil reduction. Soils immediately below the channel bed or along the bank often develop hydric features if they seasonally contact the ground water table, or persistent subsurface water discharge is present. Thus, the presence of well-developed hydric soil indicators in soils at the base of the bank or strongly reduced hyporheic zone materials provides strong evidence of extended annual periods of base flow.

Differing periods of inundation or saturation will produce soil color variation in soils with silts and clays that have iron and manganese oxides. When the soil is unsaturated and aerobic, chemically oxidizing conditions in the soil produce oxidized forms of iron and manganese which precipitate and coat soil particles, producing brown, yellow, and red colors. When the

soil is saturated and anaerobic, chemically reducing conditions in the soil water produce reduced forms of iron and manganese that are colorless ions in solution. Gray or neutral low chroma soil colors result. In sandy soils with very low clay content, long periods of saturation result in accumulation of organic matter that coats the sand grains and produces dark, low chroma colors.

In soils with frequent, long periods of saturation the oxidation/reduction reactions of iron and manganese may also produce color variations called redoximorphic features (formerly called mottles). The degree of development of redoximorphic features is indicative of the frequency and duration of periods of soil saturation. Weakly developed redoximorphic features in the soil at the toe of the bank above the channel bed are common in intermittent streams, and may indicate the level of a seasonal high water table. Strongly developed redoximorphic features are common in the soils at the toe of banks and in the streambed sediments of more perennial streams. Wet weather conveyances have oxidized soils in the bed and bank. Types of redoximorphic features are: (1) depleted matrix – matrix color has chroma ≤ 2; (2) depletions – zones of low chroma (≤ 2) within a matrix of higher chroma; (3) concentrations - soft masses or pore linings; zones of accumulation of oxidized iron and manganese, bright yellow, orange, or red colors (Figure 13).

Use a Dutch auger, Oakfield probe, or similar device to obtain 6 to 8-inch cores in the toe of the bank in a shallow zone of the channel, or at the base of a headcut and examine the soil core for hydric indicators such as redoximorphic features and low chroma. If the channel is dry at the time of investigation, look for hydric features several inches below the stream bed. *Note that non-soil such as relatively young alluvial accumulations of coarse sand, gravel, and cobble in the stream bank or hyporheic zone will not have redoximorphic features or other hydric soil indicators*. The soil samples should be representative of the major channel bed/bank soil type observed throughout the sample reach. If necessary, use the Munsell Color Charts book to determine the chroma of the soil matrix. The soil matrix is defined as the dominant soil constituent (>50%). Low chroma values (≤2) indicate continual saturation, while brightly colored soils or mottles (> 2) indicate shorter periods of wetting, typical of intermittent or WWC channel bed soils or upland soils. Soil hue, value, and chroma values should be included in HD submittals where soils are examined.

Note: Scoring of this metric should be made based upon the prevalence of hydric soil indicators throughout the reach, not at a single location. More recent alluvial deposits and certain other areas will not have sufficient time for reduction of the soil to occur and will not display hydric soil characteristics. In general, the scorer is trying to determine if there are indications of a seasonal high-water table and is making a YES or NO determination. However, in cases where hydric soils or redoximorphic indicators are found at a single location in the reach, assessors can score in-between (0.75).

YES – In the soil just above, at, or below channel bed elevation, the presence of hydric soil indicators is found.

NO - In the soil just above, at, or below channel bed elevation, the presence of hydric soil indicators is not found.

Upland Soil | Hydric soil depicting gleying | Hydric soil with redox concentrations

**Figure 23. Hydric and Non-Hydric Soils**

## C. Biological Indicators

### 20. Fibrous Roots

*Are fibrous roots present near the surface of the hyporheic zone in the thalweg of the watercourse?*

Fibrous roots are non-woody, small diameter (< 0.25 in), shallow wide spreading roots that often form dense masses in the top few inches of the soil. Roots in these root masses consist of many roots with generally equal diameters. Fibrous roots of plants are those which function in water and nutrient uptake. Since oxygen is needed for respiration, fibrous roots are intolerant of water (unless they are roots of water tolerant plants, see note below). Thus, in areas of stream bottom substrates where water is persistent, fibrous roots may be infrequent or even absent. Observe the channel thalweg and determine if very small (fibrous) roots are present within the top couple of inches of the soil substrate. This is an "inverse" hydrologic indicator in which strong evidence receives fewer points than absent.

*Considerations to Note*:

1) During an extended growing season, or unusually dry periods, fast growing fibrous roots that would not be present during normal flow conditions may grow across the bottom of a stream.

2) This indicator is only applicable if the substrate would be suitable for root development in the absence of water. In urban or otherwise "flashy" streams, or recently "ditched"/channelized systems, a rapidly eroding wet weather conveyance may down-cut below the active root zone or to a hardpan, and not have fibrous root growths normally indicative of the actual flow regime. In addition, watercourses that have been concreted, or whose substrate is wholly inorganic (such as constantly shifting sand) may also produce an erroneous evaluation of this indicator. ***If the channel substrate is not suitable for fibrous root colonization for reasons other than hydrology, this indicator should be noted as "Not Applicable"***.

3) This indicator refers to the network of fine underground fibrous roots of upland riparian plant communities like that found in forest topsoil rather than the roots of individual aquatic plants that may be growing in the channel, or adventitious root wads from hydrophilic riparian trees growing out into the water column, or along the toe of the bed/bank junction.

4) In natural bedrock channels, assessors should search for fibrous roots in the cracks and fissures where soil and other substrates collect, rather than on the bedrock plates themselves. Bedrock that is swept completely clear of soil and other debris is a useful indicator of sustained flows, therefore "Not Applicable" can be misleading and result in inaccurate scoring.

*Strong* – A strong network of fibrous roots is present throughout most of the thalweg and surrounding channel margins.

*Moderate* – Occasional patches of fibrous roots are present along the thalweg and channel margins.

*Weak* – Very few fibrous roots are present anywhere in the channel.

*Absent* – No fibrous roots are present.

**Figure 24. Fibrous Roots**
Note that these roots have been exposed at the surface. Fibrous roots may not always be exposed but may be noted by cutting through the soil profile with a blade or other sharp implement.

## 21. Rooted Plants in Channel

*Are rooted terrestrial plants growing in or near the thalweg area of the watercourse?*

This indicator relates flow to the absence of rooted plants, since flow will often act as a deterrent to plant establishment by removing seeds or preventing aeration to roots. This is an "inverse" hydrologic indicator in which strong evidence receives fewer points than absent. Focus should be on the presence of non-hydrophytic plants in the bed or thalweg of the channel (FAC or drier; see Secondary Indicator No. 28 – Wetland Plants in Channel). Plants growing on any part of the bank of the channel, or on depositional benches that extend above bankfull level, should not be considered. In most cases, rooted upland plants present in the channel indicate ephemeral or intermittent flow. Note, there can be exceptions to this attribute. For example, rooted plants can be found in shaded perennial streams with

moderate flow but in most cases these plants will be water tolerant (FACW or better).

The number and distribution of any rooted plants growing in the channel should be compared to the number and distribution of the rooted plants typical of the surrounding land use. In other words, a wet weather conveyance running through an open fallow field dominated by herbaceous vegetation would normally have much greater number of rooted plants growing within its channel than would a WWC running through a fully canopied mature forest setting that has very few understory plants anywhere.

As with the previous indicator (fibrous roots), this indicator is only applicable if the substrate would be suitable for plant colonization. In urban or otherwise "flashy" channels, or recently "ditched"/channelized systems, a rapidly eroding wet weather conveyance may down-cut below the active root zone or to a hardpan, and not have the rooted plants normally indicative of the actual flow regime. In addition, watercourses that have been concreted, or whose substrate is wholly inorganic (such as constantly shifting sand) may also produce an erroneous evaluation of this indicator. ***If the channel substrate is not suitable for plant colonization for reasons other than hydrology, this indicator should be noted as "Not Applicable"***.

*Strong* – Rooted, non-hydrophytic plants consistently present along the bed of watercourse. Nearly each pace while walking the length of the channel bed contains one or more non-hydrophytic plant.

*Moderate* – Moderate numbers of non-hydrophytic rooted plants easily observed along the channel bed. Every second or third pace walking the channel bed contains one or more non-hydrophytic plant.

*Weak* – A few non-hydrophytic rooted plants scattered within reach, spaced many paces apart.

*Absent* – Non-hydrophytic rooted plants absent in the channel bed.

**Figure 25. Rooted Plants in Channel**

## 22. Crayfish

Most species of crayfish are associated with aquatic or wet environments such as streams and wetlands. A small net can be used to examine small pools, under rocks, under logs, sticks or within leaf packs in the stream for crayfish. Crayfish associated with small holes or "chimneys" (roughly cylindrical chimneys) on the muddy streambank or floodplain may be indicators of wet soils (wetlands) rather than streams. The presence of crayfish holes or chimneys alone should not contribute any points for this indicator (score as 'absent'); only the presence of actual crayfish within the channel thalweg should be counted.

*Strong* – multiple crayfish found in the stream channel with minimal effort.

*Moderate* – A few crayfish found in the stream channel after some effort.

*Weak* – One or two crayfish found in the channel with intensive searching.

*Absent* – No crayfish observed.

## 23. Bivalves

Bivalves (mollusks with two shells, Class Bivalvia) include clams or mussels, and are often highly dependent on water presence for survival. To find mollusks, one should examine various habitats: hard substrates such as sticks and rocks, silty areas of the stream bed, leaves and stems of aquatic vegetation, and within leaf-litter. Also, look for empty shells washed up on the bank. Some bivalves (e.g., Fingernail clams; Figure 15) can be pea-sized or smaller, so careful examination may be required to find them in the silty substrates they often prefer. Since clams require a fairly constant aquatic environment in order to survive, the search for bivalves can be conducted while looking for other benthic macroinvertebrates. A small net may be useful. *Note*: Presence of Unionid mussels may be a Primary Indicator of stream status.

**Figure 26. Fingernail Clams**

*Strong* – Multiple bivalves found in the reach with minimal effort, or one or more Unionid mussels or relic Unionid shells.

*Moderate* – A few bivalves located in the reach with mild effort, as other benthics are collected. No Unionid mussels or shells observed.

*Weak* – One or two live non-Unionid bivalves observed after intensive searching (10 or more minutes), or a few relic non-Unionid shells found.

*Absent* – No bivalves observed.

## 24. Amphibians

Amphibians such as salamanders, frogs, and toads require water, or at least moist conditions, for egg laying and larval development. Many salamander species' immature, gilled larvae require aquatic environments until they transform to adults. All frogs and toads lay their eggs in fresh water and tadpoles (the larval form of toads and frogs) require water for development.

Older (>1 year old) salamander larvae can be a very good indicator of relatively permanent waters, and other studies (such as Johnson et al. 2009), indicate that the presence of any salamander larvae, regardless of age, suggests at least intermittent flow. The tadpoles of many species of frogs and toads require 2-3 months before final metamorphosis to adult occurs. However, the very large tadpoles of the American Bullfrog (*Rana catesbeiana*), River Frog (*Rana heckscheri*), and Carpenter Frog (*Rana virgatipes*) require a year or more before metamorphosis to adults. When large specimens of these species are found, it is a strong indicator of the presence of water over several seasons.

Salamanders and tadpoles can be found under rocks, on streambanks and on the bottom of the stream channel. They may also appear in the benthic sample. Frogs will alert you of their presence by jumping into the water for cover, usually following an audible "squeak". Frogs and tadpoles typically inhabit the shallow, slower moving waters of the pools and near the sides of the bank. Amphibian eggs, also included as part of this indicator, can be located on the bottom of rocks and in or on other submerged debris. They are usually observed in gelatinous clumps or strings of eggs.

Because many adult frogs, toads, and salamanders are primarily terrestrial, lesser weight should be given to their presence than amphibian eggs and larvae. Frequency and ease of detection, as well as the presence of multiple amphibian species should be considerations in scoring.

**Figure 27. Salamander and Salamander Eggs**
Amphibians such as the Spring Salamander (*Gyrinophilus porphyriticus*) on the left require moist conditions. The presence of amphibian eggs, such as the eggs from the Streamside Salamander (*Ambystoma barbouri*) shown on the right, should typically be given more weight than adults.

*Strong* – amphibians observed at multiple locations in the reach with little effort, including amphibian larvae or egg masses.

*Moderate* – amphibians observed at more than one location in the reach but some effort is required to evaluate. If only adults are found in the riparian areas, score lower.

*Weak* – With intensive searching (10 or more minutes), some adult amphibians can be found in the reach, or indirect evidence such as frog calls, squeaks, or splashes.

*Absent* – No evidence of amphibians

## 25. Benthic Macroinvertebrates

The larval stages of many aquatic insects and other classes of aquatic invertebrates are well-established indicators of flow duration and stream status because a continuous aquatic habitat of some duration is required for these organisms to mature. Examine rocks and sticks in the stream, and use a small net and sample a variety of other habitats including under overhanging banks, root wads, accumulations of organic debris (e.g. leaves), and the bottom substrate. Note both the quantity as well as the diversity of your macroinvertebrate sample on the field form when scoring. While this secondary indicator category applies to any type of benthic macroinvertebrate, it should be noted that some taxa are considered definitive stream indicators. Details on specific macroinvertebrate taxa that are considered

primary indicators of stream status can be found in Table 2. Note that only taxa used as primary indicators must be collected and preserved, as described in Primary Indicator #5.

*Strong* – Many individuals within several different taxa are easily observed at more than one location in the reach, or individuals of one or more primary indicator taxa are observed

*Moderate* – With some effort, a few individuals from several different taxa, or many individuals from a few different taxa are observed at more than one location in the reach

*Weak* – With intensive searching, a few individuals of taxa that are not primary indicators are observed, or evidence of the past presence of benthic macroinvertebrates are observed (e.g. relic caddisfly cases, shed larval skins, etc)

*Absent* – No evidence of aquatic organisms observed

Note: winged adult beetles or hemipterans, or transitory fast-developing larvae such as mosquitos should not be counted.

Caddisfly: *Diplectrona ssp.*

Stonefly: *Eccoptera ssp.*

**Figure 28. Benthic Macroinvertebrates**

## 26. Presence of Filamentous Algae and Periphyton

These forms of algae are aquatic and are attached to streambed substrate. They may be visible as a pigmented mass or film, or sometimes as hairlike (filamentous) growths on submerged surfaces of rocks, logs, plants and any other structure within the stream channel. These life forms require an aquatic environment to persist. Benthic algal abundance is strongly influenced by the amount of sunlight reaching the stream, relative rate of stream discharge, availability of

appropriate substrates, and level of nutrient enrichment. It may also be influenced by human activities such as increased nutrient (nitrogen or phosphorus) inputs, increased sunlight to the stream from riparian removal, or increased disturbance to the substrate through channelization, dredging, or increased frequency and magnitude of high-flow events (flashiness).

Periphyton is often not visible to the naked eye. However, the film or coating of periphyton, consisting of microscopic algae and diatoms, which is common to most aquatic substrates can be readily detected by rubbing rock or leaf substrates with the fingertips. A slick or slimy coating of variable thickness can indicate the presence of periphyton even when it is not visible. In contrast, substrate from the bottom of a wet weather conveyance channel should feel rough or 'clean' to the touch, even when (storm) flow is present.

Algal growth should not be confused with mosses, which do not have the slick or 'slimy' feel common to algae. Filamentous algae should be scored more strongly than periphyton coatings.

*Strong* – Filamentous algae and periphyton observed at multiple locations in the reach, or heavy periphyton growth observed consistently throughout the reach.

*Moderate* – Sparse filamentous algae observed at more than one location in the reach or periphyton detected consistently at multiple locations in the reach.

*Weak* – With intensive searching, some examples of periphyton can be found at more than one location in the reach. Filamentous algae not found or only at one location. OR clear evidence of dried algae can be seen on dry substrates

*Absent* – No evidence of algae

## 27. Iron Oxidizing Bacteria

*In slow moving (or stagnant) areas of the stream, are there clumps of "fluffy" rust-red material in the water? Additionally, on the sides of the bank (or in the streambed) are there red or rust colored stains (usually an "oily sheen" or "oily scum" will accompany these areas) on the soil surface?*

These features are often (although not exclusively) associated with iron-oxidizing bacteria and the emergence of subsurface flow. Iron oxidizing bacteria derive energy by converting iron in the ferrous form ($Fe^{2+}$) to the ferric form ($Fe^{3+}$), which then combines with oxygen to produce iron oxide, essentially rust. Since the reaction is dependent on oxygen presence it is more likely to be found in areas of the wetted channel where oxygen-poor ground water is

just reaching the surface. Iron oxidizing bacteria can be detected in these areas by looking for the iron oxide waste product, often appearing as a rusty red or orange material in “fluffy” clumps or as a stain within the wetted channel, or as an oily sheen on the water’s surface. This indicates that the stream is being recharged from a subsurface water source, and these features are most commonly seen at seeps or springs.

Filmy deposits on the surface or banks of a stream are often associated with the greasy "rainbow" appearance of iron oxidizing bacteria. This is a naturally occurring phenomenon where there is iron in the ground water. However, a sudden or unusual occurrence may indicate a petroleum product release from an underground fuel storage tank. One way to differentiate iron-oxidizing bacteria from oil releases is to trail a small stick or leaf through the film. If the film breaks up into small islands or clusters, it is most likely bacterial in origin. However, if the film swirls together, it is most likely a petroleum discharge.

**Figure 29. Iron Oxidizing Bacteria**

*Strong* – Iron Oxidizing bacteria or orange iron staining easily observed throughout the reach.

*Moderate* – Iron Oxidizing bacteria or staining is observed at more than one location in the reach.

*Weak* – Iron Oxidizing bacteria or iron staining observed at one location only in the reach, with some searching.

*Absent* – No Iron oxidizing bacteria or staining observed.

## 28. Wetland Plants in Streambed

The U.S. Army Corp of Engineers wetland delineation procedure utilizes a plant species classification system upon which soil moisture regimes can be inferred (Table 6). This same system can be used to infer the duration of soil saturation in stream channels. Small, low gradient, low velocity intermittent and perennial streams with adequate sunlight will often have OBL and FACW plants or submerged aquatic vegetation growing within the stream channel. All wetland plant designations are defined by *the most current version of the U.S. Army Corps of Engineers National Wetland Plant List*. Information can be found on-line at:

http://wetland-plants.usace.army.mil/nwpl_static/v33/home/home.html

**Table 5. Indicator Categories of Wetland Plants.**

| Code | Wetland Type | Comment |
|---|---|---|
| OBL | Obligate Wetland | Occurs almost always (estimated probability 99%) under natural conditions in wetlands. |
| FACW | Facultative Wetland | Usually occurs in wetlands (estimated probability 67%-99%), but occasionally found in non-wetlands. |
| FAC | Facultative | Equally likely to occur in wetlands or non-wetlands (estimated probability 34%-66%). |
| FACU | Facultative Upland | Usually occurs in non-wetlands (estimated probability 67%-99%), but occasionally found on wetlands (estimated probability 1%-33%). |
| UPL | Obligate Upland | Occurs in wetlands in another region, but occurs almost always (estimated probability 99%) under natural conditions in non-wetlands in the regions specified. If a species does not occur in wetlands in any region, it is not on the National List. |

*Strong* – OBL or FACW plants present throughout much of the channel within the evaluated reach.

*Moderate* – Some OBL plants present, or FACW scattered throughout the reach.

*Weak* – No OBL plants and only a few FACW scattered along reach

*Absent* – No plant species FACW or wetter observed within channel

Curly Knotweed (*Persicaria lapithifolial)*

Cattail (*Typha latifolia*) and Broadleaf Arrowhead (*Sagittaria latifolia*)

Water Cress (*Nasturtium officinale)*

Black Willow ( *Salix nigra*)

**Figure 30. Hydrophytic Vegetation**

Other examples of hydrophytic vegetation and their indicator status may be seen online at: http://wetland-plants.usace.army.mil/nwpl_static/v33/home/home.html or https://dev.tnky.plantatlas.usf.edu/ .

## Commonly Encountered HD Variants - General Policy Guidelines

Given the wide range of stream types, physiographic regions, land uses, and natural diversity found across Tennessee, it would be impossible to create detailed written policy that would cover every possible site-specific scenario that may be encountered when making hydrologic determinations. This is especially true when encountering the wide array of possible human disturbances, both recent and historical. However, certain confounding issues are more commonly encountered, and require more frequent jurisdictional interpretation. The following list is designed to provide guidelines of how, *in general*, these commonly encountered variants fit within the department's regulatory framework. Since in nature, exceptions exist for every rule, each site must be evaluated independently and in the context of any proposed activity.

It is imperative that, other than the few exceptions provided for with this guidance, the investigator score each of the primary and secondary indicators as they currently appear in the field. Interpretation of the scoring of certain indicators, especially in disturbed systems, will often be warranted, but this interpretation should be made in narrative form, and should be targeted at explaining why a particular primary indicator, or overall secondary indicator scoring might be inaccurate for a specific evaluated reach. In other words, the evaluator should not adjust the scoring of an indicator, but rather explain why that score may be artificially high or low in the comment field.

<u>As an example</u>: A recent unpermitted alteration has channelized a watercourse into a straight ditch. This will directly affect the *Sinuosity* indicator (among others), but the indicator should be scored as Absent (straight), and the evaluator then documents why the scoring of this indicator, and thus the total score of secondary indicators, may be artificially low (See also the *Effects of Urbanization / Impervious Surfaces* section below). ***The ultimate determination of the hydrologic status should not be held hostage to the Form (it is a tool), and therefore there should be no temptation to make the scores "come out right" by modifying individual criteria, indicators, or scoring ranges.***

<u>Sinking / Losing Stream Reaches</u>: Natural conditions, or historic alterations and land use, often result in some portion of a stream to lose sustained surface flow, or even cause the channel to disappear altogether. Examples of this would include a stream leaving a forested area and disappearing in a historically drained or tiled field, karst geology producing sinks and swallets, hyporheic flows, including excessive aggradation of bedload "soaking up" surface flow, unrestricted livestock access "disappearing" creek channels and flow, or simply stream reaches whose lithography creates small-scale migration of surface flow to ground water.

In general, if the surface flow has receded, but water remains present within or just below the channel substrate and is following the same basic course until it resurfaces, the reach is usually considered a contiguous part of the stream. If the physical characteristics of the stream channel

remain essentially the same (well-defined bed, bank, substrate), but surface flow drops off for a short distance, the losing reach is usually considered a contiguous part of the stream.

If the channel loses surface flow and significantly loses channel definition for a long distance, the jurisdictional stream status is usually ended or at least broken through this area. If the stream flow obviously drops deep into a well-defined sinkhole or swallet, such as in a karst area, leaving a long reach of channel that will never sustain baseflow (only stormflow), this portion of the watercourse may be broken out as a WWC. If the flow disappears and channel integrity "peters out" and remains ill-defined over a long distance before reforming downstream (such as running through a large livestock pasture), the lost reach may be broken out as a WWC.

Stream Origins / Transition Breakpoints: In many regulatory situations, it is necessary not only to determine the jurisdictional status of a watercourse, but also to delineate a fixed stream origin point, or distinct breakpoints between the WWC and stream portions of a watercourse. Because in reality most stream hydrology operates on a continuum, without "bright-line" demarcations, determining these points may be difficult. In some situations there is a distinct and dramatic change in stream characteristics at a defined point (such as emergence of a large feeder spring). In other cases the investigator will observe within a channel a point upstream that is clearly a WWC and a point downstream that is clearly a stream, and have to choose the most appropriate location to break the two. Relatively permanent, easily identifiable natural features tend to make the best breakpoints, both from a scientific and regulatory aspect.

Some examples of good breakpoints would include: convergence of side hollows or other significant drainages, large headcuts, very large riparian trees (also can indicate some minor source of subsurface flow input), or man-made structures such as spring boxes or rock walls. A common breakpoint used in west Tennessee relies on soil survey information indicating the depth to the seasonal high water table as compared to the depth of the bed of the channel. A breakpoint may be made between the area where soil information indicates that the bed of the channel would not intercept a deep water table with the point where the bed of the channel would likely intercept the shallower seasonal water table.

Wetland-Stream Interconnection: The jurisdictional interface between wetlands and streams can be one of the more difficult variants to deal with from a regulatory aspect, due to the naturally occurring continuum between the two types of water features, and the myriad variations of overlap between the two encountered in the field.

Common scenarios include: streams with marginal wetlands contained within a larger "top-of-bank" channel; adjacent wetlands that may be "perched" above a narrow stream channel; wetland fringes around impounded stream segments; or wetland areas interwoven with ill-defined braided stream channels.

These systems will generally have to be evaluated on a case-by-case basis to determine what portions of an overlapping system should be regulated as a wetland, and which as a stream. Some factors that may inform the determination include the vertical and horizontal proximity of hydrologic features, the degree of "co-mingling" of the two hydrology types, or the hydrologic functionality of a feature (i.e. is it functioning more like a wetland, or more as a linear watercourse?).

The jurisdictional status of such a feature is particularly important if mitigation is involved, and in general the Division tries to avoid "doubling up" by requiring both stream and wetland mitigation for a single feature. Mitigation in such circumstances may be combined, and will also be influenced by the specific nature of the proposed alteration activity, and the specific nature of the hydrologic feature.

Impoundments / Ponds: Although there are a wide-range of scenarios involving ponds and impoundments that are encountered in the field, a basic rule-of-thumb is that if there is a jurisdictional stream leading into or out of the pond, the pond is considered an impounded portion of the stream and is subject to the same regulations. If there is a clear connection to a ground water source that feeds the pond, it is usually subject to regulation either as a stream or a wetland depending on its specific nature (see previous section). In middle and east Tennessee a significant ground water connection usually takes the form of a spring, which may be difficult to detect when under water. In west Tennessee, a simple excavated basin often intercepts the ground water table, and is therefore a regulated feature.

If the pond has no jurisdictional stream feeding or issuing from it, there is no connection to ground water, AND the pond is in single ownership, the feature may not be Waters of the State. This scenario is commonly referred to as an "isolated farm pond", and generally entails a simple excavation and berm across a draw that is fed solely by surface storm-flow. Man-made hydrologically isolated farm ponds or active detention basins that have over time acquired more wetland characteristics are also not generally subject to TDEC regulation, although they may still fall under USCOE jurisdiction.

Historic & Recent Alterations: Recent human disturbances and historic land-uses and alterations are very commonly encountered variants that can present significant obstacles in the interpretation of observed field indicators, and the overall hydrologic determination of a water feature.

A high degree of recent disturbance, such as might be encountered in a complaint investigation, can disrupt the natural indicators so completely as to prevent the application of the normal HD process. In these cases the investigator must use whatever evidence may be currently remaining, and couple that with any historic information that may be available, such as USGS or NRCS maps, or aerial photographs. Appropriate comparable features, such as an undisturbed upstream or downstream segment, or an adjacent watercourse of similar size and location may also provide some indication

as to the jurisdictional status of the altered feature. In general, the hydrologic determination of such a watercourse should reflect conditions just prior to the recent impact.

In situations where the channel geomorphology and biology have been physically eliminated, the Division reserves the right to deem an HD submittal incomplete if available evidence such as less disturbed segments, comparable nearby watercourses, duration of flow, and possible connection to groundwater has not been adequately addressed.

Historic alterations attributable to either direct human actions (such as relocations to valley sides, channelized and tiled reaches), or to long-term land use practices (such as grazing livestock) can also significantly alter the field indicators that would normally be present in an undisturbed setting. Unrestricted livestock access in particular has a tendency to "disappear" streams over time, reducing them to ill-defined conveyances with sporadically spaced water-filled holes. It is important to recognize when a feature may have been historically altered, and to interpret the currently observable field indicators appropriately and with caution, especially if relying solely on the secondary indicators. Streams may have weaker geomorphic indicators in particular in these situations, even when the qualifying hydrology or biology is still present.

This is particularly important in some flatter portions of west TN, where most headwater channels have been historically channelized, leaving straightened 'ditches' with very limited natural geomorphology remaining. It can be difficult in these situations to distinguish channelized streams from WWCs or linear wetlands, especially in the drier times of the year when primary and secondary hydrologic indicators may not be as evident. Connection to the seasonal high groundwater table, nearby water well levels, and historic information such as County soil surveys and pre-channelization maps can be critical in making determinations where secondary indicators have been heavily altered and therefore less reliable. Assessors are encouraged to conduct HDs in these situations during wetter times of the year whenever possible, when groundwater levels are highest and most likely to intersect channel elevations.

However, even if the watercourse in question may have been a stream prior to human settlement, if the historic land-uses have altered the hydrology to the extent that the channel currently functions only as a wet weather conveyance (and will for the foreseeable future), in most cases it should be determined as a WWC for regulatory purposes (see "Sinking / Losing Reaches" section above for further guidance).

**Figure 31. Examples of Alterations**

Exposed Ground Water: One particular type of human disturbance that occasionally needs addressing is the exposing of ground water to the surface, through historic excavation or mining

activities. Over time, this exposed ground water (now surface flow) may develop jurisdictional stream characteristics and may be regulated as a stream. (Ground water that has only been *recently* exposed during ongoing construction activities must be protected through the use of appropriate EPSC measures, and its ultimate disposition should be coordinated through the DWR Natural Resources Section).

In certain situations where historic activities have resulted in the creation of a jurisdictional stream, the conversion of the current feature back to its pre-alteration hydrology may be considered a "restoration", such as channelized stream channel in West Tennessee being restored to the wetland condition that had been originally ditched and drained.

Effects of Urbanization / Impervious Surfaces: Watercourses in an urban environment can present a special challenge in making accurate hydrologic determinations. Some of the issues involved have been described above. But even where direct physical alterations have not been made to a watercourse, the change in hydrological regime that often occurs in an urbanized setting can have profound effects on a channel's characteristics.

The most common impact in an urbanized setting is the increase in stormwater runoff volumes the channel must carry, due to an increase in impervious surface cover within the watershed. Many studies have shown the direct correlations between the percent of impervious cover and the degree of channel destabilization, as well as the corresponding decline in ecological health.

Where the percent of impervious surface in the upstream watershed of a watercourse exceeds 10%, the investigator should take into account the potential for the following commonly observed responses (see Table 7 below). Responses to urban stormwater may manifest themselves in different ways, depending on the specific urban setting and soil types. Awareness of the potential for confounding observations in urban watercourses is especially important when evaluating the secondary indicators to make a determination, as some of these geomorphic and hydrologic responses may directly or indirectly affect several of these indicators. In these situations (>10% impervious watershed), the investigator may modify their interpretation of the overall score produced by evaluation of the secondary indicators if there is good evidence that the overall score has been unnaturally inflated or reduced due to effects of the urban setting. Care must be taken in making such interpretations, and the reasoning behind each modification must be clearly described.

**Table 6. Potential Effects of Urban Stormwater Runoff**

| | |
|---|---|
| Destablized banks / increased bank erosion | Steeper banks, channel widening |
| Loss of sinuosity, channel straightening | Downcutting, channel incision |
| Increased wrack lines due to increased debris | Changes in amount of available leaf litter |
| Increased soil deposits within channel bed | Loss of in-channel structure |
| Exaggerated head cutting | Loss of substrate sorting |

**Figure 32. Effect of Impervious Cover in the Upstream Watershed**

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# Appendix A: Hydrologic Determination Field Data Sheet

# Hydrologic Determination Field Data Sheet

Tennessee Division of Water Pollution Control, Version 1.5

| | |
|---|---|
| Named Waterbody: | Date/Time: |
| Assessors/Affiliation: | Project ID : |
| Site Name/Description: | |
| Site Location: | |
| HUC (12 digit): | Lat/Long: |
| Previous Rainfall (7-days) : | |
| Precipitation this Season vs. Normal : abnormally wet elevated average low abnormally dry unknown<br>Source of recent & seasonal precip data : | |
| Watershed Size : | County: |
| Soil Type(s) / Geology : | Source: |
| Surrounding Land Use : | |
| Degree of historical alteration to natural channel morphology & hydrology (circle one & describe fully in Notes) :<br>Severe Moderate Slight Absent | |

## Primary Field Indicators Observed

| Primary Indicators | NO | YES |
|---|---|---|
| 1. Hydrologic feature exists solely due to a process discharge | | WWC |
| 2. Defined bed and bank absent, vegetation composed of upland and FACU species | | WWC |
| 3. Watercourse dry anytime during February through April 15th, under normal precipitation / groundwater conditions | | WWC |
| 4. Daily flow and precipitation records showing feature only flows in direct response to rainfall | | WWC |
| 5. Presence of multiple populations of obligate lotic organisms with ≥ 2 month aquatic phase | | Stream |
| 6. Presence of fish (except *Gambusia*) | | Stream |
| 7. Presence of naturally occurring ground water table connection | | Stream |
| 8. Flowing water in channel and 7 days since last precip >0.1" in local watershed | | Stream |
| 9. Evidence watercourse has been used as a supply of drinking water | | Stream |

**NOTE: If any Primary Indicators 1-9 = "Yes", then no further investigation is necessary. However, assessors may choose to score secondary indicators as supporting evidence.**

In the absence of a primary indicator, or other definitive evidence, complete the secondary indicator table on page 2 of this sheet, and provide score below.

Guidance for the interpretation and scoring of both the primary & secondary indicators is provided in *TDEC-WPC Guidance For Making Hydrologic Determinations, Version 1.5*

**Overall Hydrologic Determination =**

**Secondary Indicator Score (if applicable) =**

**Justification / Notes :**

# Secondary Field Indicator Evaluation

| **A. Geomorphology** (Subtotal = ) | **Absent** | **Weak** | **Moderate** | **Strong** |
|---|---|---|---|---|
| 1. Continuous bed and bank | 0 | 1 | 2 | 3 |
| 2. Sinuous channel | 0 | 1 | 2 | 3 |
| 3. In-channel structure: riffle-pool sequences | 0 | 1 | 2 | 3 |
| 4. Sorting of soil textures or other substrate | 0 | 1 | 2 | 3 |
| 5. Active/relic floodplain | 0 | 0.5 | 1 | 1.5 |
| 6. Depositional bars or benches | 0 | 1 | 2 | 3 |
| 7. Braided channel | 0 | 1 | 2 | 3 |
| 8. Recent alluvial deposits | 0 | 0.5 | 1 | 1.5 |
| 9. Natural levees | 0 | 1 | 2 | 3 |
| 10. Headcuts | 0 | 1 | 2 | 3 |
| 11. Grade controls | 0 | 0.5 | 1 | 1.5 |
| 12. Natural valley or drainageway | 0 | 0.5 | 1 | 1.5 |
| 13. At least second order channel on existing USGS or NRCS map | No = 0 | | Yes = 3 | |

| **B. Hydrology** (Subtotal = ) | **Absent** | **Weak** | **Moderate** | **Strong** |
|---|---|---|---|---|
| 14. Subsurface flow/discharge into channel | 0 | 1 | 2 | 3 |
| 15. Water in channel and >48 hours since sig. rain | 0 | 1 | 2 | 3 |
| 16. Leaf litter in channel (January – September) | 1.5 | 1 | 0.5 | 0 |
| 17. Sediment on plants or on debris | 0 | 0.5 | 1 | 1.5 |
| 18. Organic debris lines or piles (wrack lines) | 0 | 0.5 | 1 | 1.5 |
| 19. Hydric soils in channel bed or sides of channel | No = 0 | | Yes = 1.5 | |

| **C. Biology** (Subtotal = ) | **Absent** | **Weak** | **Moderate** | **Strong** |
|---|---|---|---|---|
| 20. Fibrous roots in channel bed [1] | 3 | 2 | 1 | 0 |
| 21. Rooted plants in the thalweg [1] | 3 | 2 | 1 | 0 |
| 22. Crayfish in stream (exclude in floodplain) | 0 | 1 | 2 | 3 |
| 23. Bivalves/mussels | 0 | 1 | 2 | 3 |
| 24. Amphibians | 0 | 0.5 | 1 | 1.5 |
| 25. Macrobenthos (record type & abundance) | 0 | 1 | 2 | 3 |
| 26. Filamentous algae; periphyton | 0 | 1 | 2 | 3 |
| 27. Iron oxidizing bacteria/fungus | 0 | 0.5 | 1 | 1.5 |
| 28.Wetland plants in channel bed [2] | 0 | 0.5 | 1 | 1.5 |

[1] Focus is on the presence of terrestrial plants.

[2] Focus is on the presence of aquatic or wetland plants.

Total Points = _____

*Under Normal Conditions, Watercourse is a Wet Weather Conveyance if Secondary Indicator Score < 19 points*

**Notes :**

# Appendix B: Checklists

# Hydrologic Determination Report Submittal Checklist

TDEC Reviewer: _____

**Standard Submittal**

Waterlog HD #_____ Project name: _____ County: _____
Other Tracking #_____

_____ 1. Contact information of the current property owner(s).

_____ 2. Name, affiliation, and certification identification number of the QHP or QHP IT submitting the report.

_____ 3. QHP or QHP IT status verified.

_____ 4. The identification of the starting and ending points along a watercourse of the areas determined to be a wet weather conveyance.

_____ 5. A vicinity map, including the property boundaries or hydrologic determination review area (if different than property boundary). On linear projects, start and terminus points are required. The map should clearly indicate the specific locations of all hydrologic features identified in the report.

_____ 6. Specific latitude/longitude coordinates (decimal degrees) either included on the map or in the body of the hydrologic determination report.

_____ 7. Color photographs of each of the hydrologic features to potentially be altered or otherwise identified in the report; including the date each photograph was taken, latitude and longitude, in decimal degrees of each photograph location and indicate the location and direction of each photographic view on the site map or plan. These photographs must be representative of the overall reach of water feature evaluated. At a minimum, include a photograph of the area to potentially be altered, immediately up channel of the area to potentially be altered, and immediately down channel.

_____ 8. TDEC Hydrologic Determination Field Data Sheets, completed in conformance with the current TDEC-DWR Guidance for Making Hydrologic Determinations. At least one data sheet must be submitted for each watercourse to potentially be altered or identified.

_____ 9. Any previous assessments of hydrologic features on site known to the submitter. (See : http://tdeconline.tn.gov/dwr/ )
Previous HD's submitted or found during TDEC review:
_____
_____

_____ 10. Evidence HD was conducted under normal weather conditions.

_____ 11. List any other information submitted with report(e.g. NRCS Soil Maps, precipitation data, site plan etc.):
_____
_____
_____

EFO administrative required information:

_____ 1. Property owner(s) granted written permission to access land/site.

_____ 2. Is there a site, associated with this HD? If yes, then associate HD to site within Waterlog.

_____ 3. Verified HD was conducted under normal weather conditions.

Report Received: ____/____/____ Assigned date: ____/____/____ Application Complete: ____/____/____

Deficiency Letter Sent: _____ Date: ____/____/____ Field Verified: _____ Date:____/____/____

List of Report Deficiencies: Final Determination Notification Date:____/____/____

_____

_____

_____

All Required Info Received: ____/____/____

MS4: _____ MS4 Contact Date: ____/____/____

# Hydrologic Determination Report Submittal Checklist

TDEC Reviewer: _____

**Requesting treatment under Statute §69-3-108(r)**

Waterlog HD #_____ Project name: _____ County: _____
Other Tracking #_____

Submitted by: _____ QHP #_____

Per Rule 0400-40-17-.04 Requirements for Wet Weather Conveyance Determination Reports:
(1) A report regarding a wet weather conveyance determination submitted to the department by a person certified as a Qualified Hydrologic Professional (QHP) seeking to qualify for the treatment provided in §69-3-108(r) shall so state in bold print on the first page of the document and shall be sent to the appropriate field office of the department accompanied by the following documentation.

_____ 1. Statement seeking treatment under §69-3-108(r) on first page of document.

_____ 2. Contact information of the current property owner(s).

_____ 3. The person or applicant requesting the hydrologic determinations (if different from the owner).

_____ 4. Name, affiliation, and certification identification number of the QHP submitting the report.

_____ 5. Certified QHP status verified.

_____ 6. A statement, signed by the certified QHP attesting that all submitted information is true, accurate and complete.

_____ 7. An explanation of the purpose and context of the hydrologic determination report, including any proposed alterations if known to wet weather conveyances, streams, wetlands, or other aquatic resources.

_____ 8. The identification of the starting and ending points along a watercourse of the areas determined to be a wet weather conveyance; such areas may not be larger than what is currently proposed to be altered by the proponent of project.

_____ 9. A vicinity map, including the property boundaries or hydrologic determination review area (if different than property boundary). On linear projects, start and terminus points are required. The map should clearly indicate the specific locations of all hydrologic features that are subjects of the provisions of §69-3-108(r) identified in the report.

_____ 10. Specific latitude/longitude coordinates (decimal degrees) either included on the map or in the body of the hydrologic determination report.

_____ 11. Color photographs of each of the hydrologic features to potentially be altered or otherwise identified in the report; including the date each photograph was taken, latitude and longitude, in decimal degrees of each photograph location and indicate the location and direction of each photographic view on the site map or plan. These photographs must be representative of the overall reach of water feature evaluated. At a minimum, include a photograph of the area to potentially be altered, immediately up channel of the area to potentially be altered, and immediately down channel.

_____ 12. TDEC Hydrologic Determination Field Data Sheets, completed in conformance with the current TDEC-DWR Guidance for Making Hydrologic Determinations. At least one data sheet must be submitted for each watercourse to potentially be altered or identified.

_____ 13. Any previous assessments of hydrologic features on site known to the submitter. (See :http://tdeconline.tn.gov/dwr/ )
Previous HD's submitted or found during TDEC review:
_____
_____

_____ 14. Evidence HD was conducted under normal weather conditions.

_____ 15. Any other information used in making the hydrologic determinations included in the report. Examples include NRCS Soil Maps, local geological data, recent and seasonal precipitation gauge records, benthic surveys, etc.
If yes please describe:
_____
_____

Per Rule 0400-40-17-.04 *Recommended but not required* information for Wet Weather Conveyance Determination Reports

_____ 16. Can include one or more of the following:
- _____ Site development plans
- _____ Close-contour maps
- _____ Aerial photo with overlay of property boundary
- _____ Municipal jurisdiction of project site
- _____ Type of sewage/septic system proposed.
- _____ Other: _____

# Hydrologic Determination Report Submittal Checklist

TDEC Reviewer: _____

**Requesting treatment under Statute §69-3-108(r)**

Waterlog HD #_____ Project name: _____ County: _____
Other Tracking #_____

EFO administrative required information:

_____ 1. Property owner(s) granted written permission to access land/site.

_____ 2. Is there a site, associated with this HD? If yes, then associate HD to site within Waterlog.

_____ 3. Verified HD was conducted under normal weather conditions.

Report Received: ____/____/____ Assigned date: ____/____/____ Application Complete: ____/____/____

Deficiency Letter Sent: _____ Date: ____/____/____

SDQ Letter Sent: _____ Date:____/____/____

List of Report Deficiencies:

_____

_____

_____

Field Verified: _____ Date:____/____/____

Final Determination Notification Date:____/____/____

All Required Info Received: ____/____/____

MS4: _____ MS4 Contact Date: ____/____/____

# Appendix C: Figure Credits

## Figure Credits

**Figure 1. Checklists for Hydrologic Determination Submissions**
Illustration courtesy of Daugherty, Tracy, Department of Environment and Conservation, Division of Water Resources

**Figure 2. Departure from Normal Precipitation.**
Source: https://water.weather.gov/precip/

**Figure 3. Examples of Grassy Swale**
Source: Division of Water Resources.

**Figure 4. Various Mosquitofish (Gambusia ssp.)**
Top left and right photos courtesy of Bryant, Richard T. and Starnes, Wayne C. Fishes of Tennessee. The University of Tennessee Press / Knoxville. 1992. Right photo in public domain.

**Figure 5. Topminnows (Fundulus ssp.)**
Top photo courtesy of Gibbs , W. Keith. Tennessee Tech University. Cookeville, TN. Bottom photo courtesy of Bryant, Richard T. and Starnes, Wayne C. Fishes of Tennessee. The University of Tennessee Press / Knoxville. 1992.

**Figure 6. Springbox**
Photo courtesy of Dees, Jason. Tennessee Department of Environment and Conservation, Division of Water Resources.

**Figure 7. Example of ill-defined bed and bank**
Photo courtesy of Smith, Jimmy. Tennessee Department of Environment and Conservation, Division of Water Resources.

**Figure 8. Stream sinuosity**
Source: (FISRWIG 1998).

**Figure 9. Valley Length Is Based on Curvature**
Illustration courtesy of Daugherty, Tracy. Department of Environment and Conservation, Division of Water Resources.

**Figure 10. Examples of Stream Sinuosity**
Source: Division of Water Resources

**Figure 11. Bar and Bend Development**
Image courtesy of Scwartz, John. University of Tennessee. Physical Sciences of Streams. Electronic presentation for Hydrologic Determination Training.

**Figure 12. Weak Substrate Sorting**
Photo courtesy of Smith, Jimmy. Tennessee Department of Environment and Conservation, Division of Water Resources.

**Figure 13. Strong Substrate Sorting**
Photo courtesy of Kington, Sharon. Department of Environment and Conservation, Division of Water Resources.

**Figure 14. Floodplains and Channel Evolution**
Source: EPA

**Figure 15. Bankfull Bench and Related Features**
Image courtesy of USACE 2005

**Figure 16. Braided Channel**
Illustration courtesy of Daugherty, Tracy, Department of Environment and Conservation, Division of Water Resources.

**Figure 17. Alluvial Deposition**
Photo courtesy of Daugherty, Tracy, Department of Environment and Conservation, Division of Water Resources.

**Figure 18. Examples of Headcuts**
Photos courtesy of Daugherty, Tracy. Tennessee Department of Environment and Conservation, Division of Water Resources.

**Figure 19. Examples of Grade Controls**
Top left photo courtesy of Fritz, Amy. Tennessee Department of Environment and Conservation, Division of Water Resources. Bottom left and right photos courtesy of Daugherty, Tracy. Tennessee Department of Environment and Conservation, Division of Water Resources.

**Figure 20. Examples of Seeps (subsurface discharge)**
Left photo courtesy of Smith, Jimmy. Tennessee Department of Environment and Conservation, Division of Water Resources. Right photo courtesy of Daugherty, Tracy. Tennessee Department of Environment and Conservation, Division of Water Resources.

**Figure 21. Sediment on Leaves**
Photo in the public domain.

**Figure 22. Wrack Line**
Photo courtesy of Smith, Jimmy. Tennessee Department of Environment and Conservation.

**Figure 23. Hydric and Non-Hydric soils.**
Source: NCDWQ

**Figure 24. Fibrous Roots**
Photo courtesy of Daugherty, Tracy. Department of Environment and Conservation, Division of Waster Resources.

**Figure 25. Rooted Plants in Channel**
Source: NC DWQ

**Figure 26. Fingernail Clams**
Source: NC DWQ

**Figure 27. Salamander and Salamander Eggs**
Left photo courtesy: NC DWQ. Right photo courtesy of Elam, Caitlin, Tennessee Department of Environment and Conservation, Division of Natural Heritage.

**Figure 28. Benthic Macroinvertebrates**
Source: NC DWQ

**Figure 29. Iron Oxidizing Bacteria**
Source: NC DWQ

**Figure 30. Hydrophytic Vegetation**
Phtotos courtesy of Daugherty, Tracy. Tennessee Department of Environment and Conservation, Division of Water Pollution Control.

**Figure 31. Examples of Alterations**
Source: Division of Water Resources

**Figure 32. Effects of Impervious Cover in the Upstream Watershed.**
Image courtesy of the Center for Watershed Protection)

# Appendix D: Normal Weather Conditions Calculations Table

# Normal Weather Conditions Calculations Table

| | | | Long-term rainfall records | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Month** | **Standard Deviation** | **Minus One Std. Dev. (DRY)** | **Normal (Mean inches)** | **Plus One Std. Dev. (WET)** | **Actual Rainfall** | **Condition (elevated, low, average)** | **Condition value** | **Month weight value** | **Product of previous two columns** |
| **1st prior month*** | | | | | | | | | | |
| **2nd prior month*** | | | | | | | | | | |
| **3rd prior month*** | | | | | | | | | | |
| | | | | | | | | | Sum = | |

Note:

| **If sum is:** | |
|---|---|
| 6-9 | then prior period has been abnormally dry |
| 10-14 | then prior period has been normal (average) |
| 15-18 | Then prior period has been abnormally wet |

| **Condition value:** | |
|---|---|
| Low = | 1 |
| Average = | 2 |
| Elevated = | 3 |