

Tennessee Department of Environment and Conservation

Division of Water Pollution Control

**Standard Procedures for Identification of Wet Weather  
Conveyances and Streams**

**Version 1.0**

**September 2009**

**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. It will outline the regulations, legal definitions, and general concepts involved in hydrologic determinations (HDs), as well as the qualifications and reporting requirements of those making HDs.

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 underlying disciplines of biology, geology, geomorphology, precipitation, 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 that 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 WPC 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 the 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 *NC DWQ Identification Methods for the Origins of Intermittent and Perennial streams, Version 3.1*. 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 WPC personnel involved in field investigations and ground-truthing, 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 helped guide and improve this document.

#### History of WPC hydrologic determinations.

The Division's need to characterize the hydrologic status of watercourses has its roots in the early days of establishing the 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. This focus of this document was on wasteload allocations and discharge locations, and as such is no longer wholly applicable, but it 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 WPC Chattanooga 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. EPA began promulgating stormwater regulations, including the development of the local 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 rate of 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 once again updated its internal HD procedures in an effort to produce more consistent determinations, and documentation of those determinations across all the field offices state-wide. To this end, an updated dichotomous key was produced, 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. The definition below of “wet weather conveyance” was added to the Water Quality Control Act. It differs from the definition that had been in the regulations in that it is more specific about the aquatic life that indicates a water course is a stream, although it leaves unchanged the other three elements of the definition. Section 2 of P. Ch. 464 codifies the general permit for alterations of wet weather conveyances. This document is one part of the guidance that section 4 of P. Ch 464 directs the department to develop.

#### Definitions.

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

“Multiple populations” means two or more individuals, from each of two or more distinct taxa, in the context of obligate lotic aquatic organisms. [Rule 1200-4-3-.04]

"Obligate lotic aquatic organisms" means organisms that require flowing water for all or almost all of the aquatic phase of their life cycles. [Section 1 of P. Ch. 464 of the Acts of 2009 ]

“Perched water” or “perched water table” mean 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 1200-4-3-.07(2)]

"Stream" means a surface water that is not a wet weather conveyance. [Section 1 of P. Ch. 464 of the Acts of 2009 ]

“Watercourse” means a manmade or natural hydrologic feature with a defined linear channel which discretely conveys flowing water, as opposed to sheet-flow. [Section 1 of P. Ch. 464 of the Acts of 2009.]

“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 groundwater 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. [Section 1 of P. Ch. 464 of the Acts of 2009]

### General Concepts.

As stated earlier, the basic concepts and procedures involved in HDs are based on the scientific fields that inform our understanding of the natural processes that create, maintain, and shape surface water features, as well as the applicable regulatory language involved in jurisdictional status. For linear watercourses, the core WPC jurisdictional distinction is “stream” vs. “wet weather conveyance” (WWC). The standard procedures involved in HDs are geared toward determining if a watercourse fits the WWC definition or not. And 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 far more 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 not 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 document is intended to establish a standard framework for all professionals involved in making HDs in Tennessee. Nonetheless, professional experience in performing HDs in general, and specific knowledge of the nature of regional watercourses in particular, are critical to assure that accurate determinations are

made. This is one reason for the education and experience requirements pursuant to section 5 of P. Ch. 464. Site-specific factors such as anthropogenic alterations, recent / seasonal precipitation variables in the local area, or just simply 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 evaluate all available field indicators as accurately as possible, to consistently follow the standard HD procedures, and to thoroughly document any other evidence their final determination was based upon.

### **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 overall WPC regulatory program, this evaluation may be restricted to a single field investigation, and may be conducted under inopportune climate conditions, such as a drought year. 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, the longer-term seasonal precipitation trends, and any 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 within 48 hours of significant rain events in the local area.
- Watercourses vary seasonally based on generally consistent annual cycles of precipitation and evapotranspiration rates, and in some cases, groundwater levels. Therefore some of the available field indicators and their relative importance in making an HD will also vary depending upon the 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 instream 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 this longitudinal variability, Hydrologic Determinations should not be made on a single point without first looking upstream and downstream for indicators available along the watercourse. In general, several hundred feet of channel should be evaluated before making a determination. (Note : The scoring of many of the Secondary Indicators on the Hydrologic Determination Field Data Sheet is reach-based). 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.

- Watercourses vary across physiographic provinces, due primarily to 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 the 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 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 standard TDEC HD field investigation methodology and documentation format is provided in the Hydrologic Determination Field Data Sheet (Figure 1). In addition to all the available field characteristics necessary to make an accurate HD using this form, any other evidence utilized in making a determination should always be documented, either on this form or as an addendum.

**Hydrologic Determination Field Data Sheet**  
Tennessee Division of Water Pollution Control, Version 1.0

County:	Named Waterbody:	Date/Time:
Assessors/Affiliation:		Project ID :
Site Name/Description:		
Site Location:		
USGS quad:	HUC (12 digit):	Lat/Long:
Previous Rainfall (7-days) :		
Precipitation this Season vs. Normal :    very wet        wet        average        dry        drought unknown		
Watershed Size :		Photos: Y or N (circle) Number :
Soil Type(s) / Geology :		
Surrounding Land Use :		
Degree of historical alteration to natural channel morphology & hydrology (circle one & describe fully in Notes) : 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, dominated by upland vegetation / grass		WWC
3. Flow absent anytime during February through April, under normal precipitation / groundwater conditions		WWC
4. Substantial evidence that feature only flows in direct response to rainfall		WWC
5. Presence of lotic benthic organisms with ≥ 2 months aquatic phase		Stream
6. Presence of fish (use caution if only <i>Gambusia</i> is present)		Stream
7. Obvious presence of naturally occurring groundwater connections (springs)		Stream
8. Flowing water in channel and 7 days since last precipitation in local watershed		Stream

**NOTE : If any Primary Indicators 1-8 = "Yes", then STOP; determination is complete.**

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 Standard Procedures for the Identification of Wet Weather Conveyances and Streams, Version 1.0*

**Overall Hydrologic Determination =**

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

**Justification / Notes :**

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## Secondary Field Indicators

A. <b>Geomorphology</b> (Subtotal = )	<b>Absent</b>	<b>Weak</b>	<b>Moderate</b>	<b>Strong</b>
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	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Braided channel	0	1	2	3
8. Recent alluvial deposits	0	1	2	3
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. <b>Hydrology</b> (Subtotal = )	<b>Absent</b>	<b>Weak</b>	<b>Moderate</b>	<b>Strong</b>
14. Groundwater flow/discharge	0	1	2	3
15. Water in channel and >48 hours since 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 stream bed or sides of channel	No = 0		Yes = 1.5	

C. <b>Biology</b> (Subtotal = )	<b>Absent</b>	<b>Weak</b>	<b>Moderate</b>	<b>Strong</b>
20. Fibrous roots in channel <sup>1</sup>	3	2	1	0
21. Rooted plants in channel <sup>1</sup>	3	2	1	0
22. Crayfish in stream (exclude in floodplain)	0	0.5	1	1.5
23. Bivalves/mussels	0	1	2	3
24. Fish	0	0.5	1	1.5
25. Amphibians	0	0.5	1	1.5
26. Macroinvertebrates (record type & abundance)	0	0.5	1	1.5
27. Filamentous algae; periphyton	0	1	2	3
28. Iron oxidizing bacteria/fungus	0	0.5	1	1.5
29. Wetland plants in channel <sup>2</sup>	FAC = 0.5; FACW = 0.75; OBL = 1.5; SAV = 2.0; Other = 1			

<sup>1</sup> Focus is on the presence of upland plants.      <sup>2</sup> Focus is on the presence of aquatic or wetland plants.

Total Points = \_\_\_\_\_  
*Watercourse is a Wet Weather Conveyance if Secondary Indicator Score ≤ 18 points*

**Notes :**

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## **Hydrologic Determination Field Data Sheet & Methodology.**

Much of the field HD investigative process relies on the underlying scientific principle that, in general, watercourses that in a normal year carry surface flow for extended periods of time are more likely to develop certain physical, hydrological, or ecological characteristics than are WWCs that flow only in direct response to precipitation. Although a WWC may exhibit some degree of these indicators, in general, indicators will be stronger and more prevalent the more persistent the in-channel flow. Some specific combinations of indicators may rise to the level of being considered definitive in all but the most anomalous situations.

The Hydrologic Determination Field Data Sheet is based upon the various interdisciplinary sciences that underlie stream development, channel maintenance, and the relationship between hydrologic regime and stream ecology. The general format is a modification of existing concepts and protocols from other regulatory agencies, primarily the North Carolina Division of Water Quality.

### Header Information.

The top portion of the form allows for a concise recording of basic information regarding the field investigation. It is not designed to be comprehensive, and expansion of some of these categories may be necessary in another format (written report or map). Qualified Hydrologic Professionals should include their TDEC certification ID number. 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. “Watershed Size” is the size of the basin draining to the evaluated reach, or origin point.

### 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 end-point to be reached, without further evaluation of Secondary Indicators.

1. “Hydrologic feature exists solely due 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.

2. “Defined bed and bank absent, dominated by upland vegetation / grass” : 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, and therefore wet weather conveyance status.

[need photo example of grassy swale]

3. “Flow absent anytime during February through April, under normal precipitation / groundwater conditions” : In an average hydrologic year in Tennessee, if a watercourse will flow for an extended period of time (as opposed to only in direct response to rainfall), it will normally occur within this time period. This is due to the combination and interactions of the annual cycles of precipitation, evapotranspiration rates, and groundwater 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), given that HD investigations in many cases may be restricted to a single day the observation of an absence of flow 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 highly impaired by sediment releases which preclude the normal volume of flow).

For purposes of this indicator, “Normal precipitation/ groundwater conditions” will be based on a 30-year average computed at the end of each decade. Precipitation data can come from NOAA’s National Climatic Data Center, NRCS National Water and Climate Center, or other well established weather station. “Normal” will be considered within one standard deviation of the cumulative monthly means for at least the six months prior to the HD investigation.

4. “Substantial evidence that 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 may include data from installed water-level recorder or continuously gauged instream weirs, or data from previous HDs in the immediate vicinity.

5. “Presence of lotic benthic organisms with  $\geq 2$  months aquatic phase “ : The presence of certain types of aquatic organisms are considered primary indicators of extended periods of flow. 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 indicator taxa that meet these conditions is provided in Table 1 below.

In order for this primary indicator to be affirmatively determinant, more than one individual (and preferably many individuals) of at least two qualifying genera must be found in the evaluated reach. 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 come into play as Secondary Field Indicators (see following section)

## Table 1. TDEC Stream Primary Indicator Taxa List September 2009

*Indigenous members of the taxa groups listed below are considered Primary Indicators of jurisdictional Stream status in Tennessee, per TDEC Rule 1200-4-3-.05(9)(b)2.*

Gastropoda : Pleuroceridae, Viviparidae, Valvatidae

Bivalvia: Unionidae

Coleoptera : Dryopidae, Elmidae, Psephenidae, Ptilodactylidae, Staphylinidae

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

Ephemeroptera : all members, *except* : Siphonuridae, and some Ephemereidae (*Hexagenia*)

Megaloptera : all members, *except* : *Chauliodes*

Odonata : Aeshnidae, Calopterygidae, Cordulegastridae, Gomphidae, some Coenagrionidae (*Argia, Chormagion, Amhiagrion*), and some Corduliidae (*Epitheca, Helocordulia, Neurocordulia*)

Plecoptera : all members

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

Oligochaetes (lentic, >2mo ?) → suggest letting RDK decide)

6. “Presence of fish (use caution if only *Gambusia* is present)” : 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 may not be a primary indicator.

[insert picture of gambusia]

7. “Obvious presence of naturally occurring groundwater connections (springs)” : The category is designed for watercourses exhibiting clear surface connections with groundwater, and 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 a regional water table. Instream flow that is maintained for extended periods of time from other 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 the field, groundwater can often be detected by measuring a distinct temperature difference from the surface flow, or even analyzing a chemical difference, such as conductivity. The presence of historic man-made structures such as spring boxes is also a clue.

[insert picture of springbox emergence]

Besides direct observations and measurements of groundwater connections, indirect indicators such as the presence of iron-fixing bacteria (iron flocculant), the locations of likely groundwater/seasonal high water/water table connections within a given soil type (as described by the U.S. Department of Agriculture Soil Conservation Service in each individual County Soil Survey), 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 that are more fully described in the “Secondary Indicators” section.

8. “Flowing water in channel and 7 days since last precipitation in local watershed” : As stated earlier, one of the most important attributes of a WWC is that it carries flow only in direct response to rainfall. The vast majority of WWCs will cease to flow within 48 hours of even the largest rain 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 in the upstream watershed, the flow will not be considered a direct storm response, and the feature is a stream. Precipitation records from the local gauge used should be documented.

## Secondary Field Indicators.

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

This scoring methodology is adapted from the *NC DWQ Identification Methods for the Origins of Intermittent and Perennial streams, Version 3.1*, and has been field-tested on hundreds of watercourses. 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 ephemeraly, 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 29 different attributes of the watercourse and assigning a numeric score to each attribute. The back page of the Hydrologic Determination Field Data Sheet (Figure 1) is used to record the score for each of the secondary indicators and determine the total numeric score for the channel under investigation.

## Scoring and Descriptions of Secondary Indicators.

### Scoring.

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 attribute addresses the variability of stream channels. The scores, "Absent", "Weak", "Moderate", and "Strong" are applied to sets of geomorphic, hydrologic and biological attributes. The score given to an attribute reflects the evaluator's observations of the average degree of development of the attribute along a reach of the stream at least 100 ft long. These categories are intended to allow the evaluator flexibility in assessing variable features or attributes. 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.

General Definitions of Absent, Weak, Moderate and Strong are provided in Table 2. 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.

**Table 2. General guide to scoring categories**

<b>Category</b>	<b>Description</b>
Absent	The character is not observed
Weak	The character is present but you have to search intensely (i.e., ten or more minutes) to find it
Moderate	The character is present and observable with mild (i.e., one or two minutes) searching
Strong	The character is easily observable

## **A. Geomorphic Indicators**

### **1. Continuous Bed and Bank**

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

The bed of a stream or river or creek is the physical confine of the normal water flow. 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. Usually the bed is 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 becomes ephemeral.

*Strong* – There is a continuous bed and bank present throughout the length of the stream channel.

*Moderate* – The majority of the stream has a continuous bed and bank. However, there are obvious interruptions.

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

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

## 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 1). The greater the number, the higher the sinuosity. Sinuosity is related to slope gradient along the channel. Natural undisturbed streams with steep channel slope gradients have low sinuosities, and streams with low channel slope gradients typically have high sinuosities.

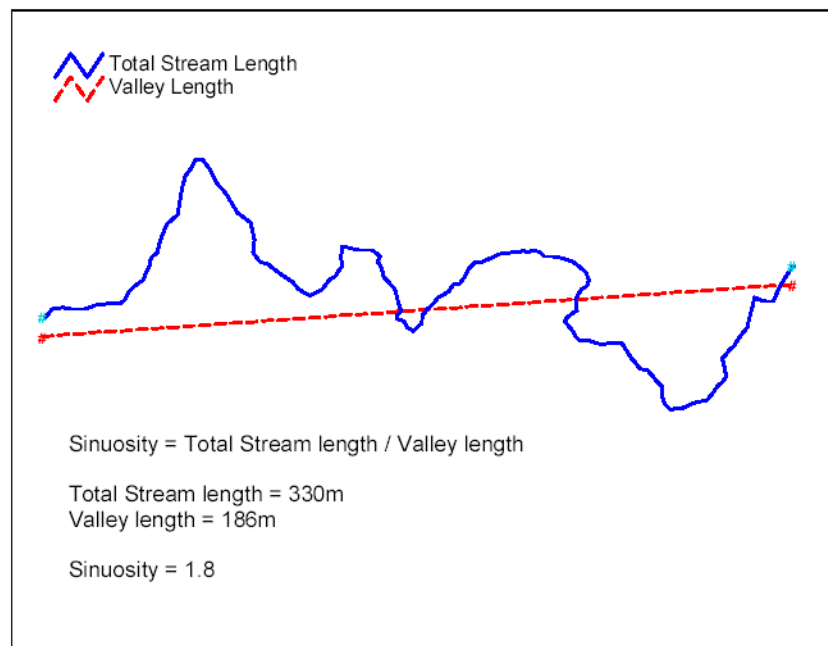


Figure 1. Stream sinuosity

Sinuosity is the result of the stream naturally dissipating its flow forces. Intermittent streams don't have a constant flow regime, and as a result generally exhibit a significantly less sinuous channel than farther downstream in the perennial stream. While ranking, take into consideration the size of the stream and its watershed, which may also influence the stream wavelength. 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 2.

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

*Moderate* –  $1.2 < \text{Ratio} < 1.4$ . Stream has good sinuosity with some straight sections.

*Weak* –  $1.0 < \text{Ratio} < 1.2$ . Stream has very few bends and mostly straight sections.

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

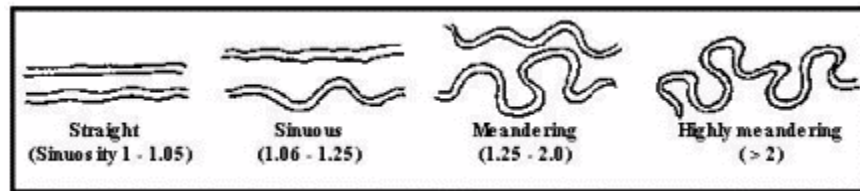


Figure 2. Examples of stream sinuosity

### 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 (riffle/run in lower-gradient streams, ripple/pool in sand bed streams, or step/pool in higher gradient streams) can be observed readily in perennial streams. This morphological feature is almost always present to some degree in higher gradient streams such as interior plateau and mountain streams. Riffle- run (or ripple-run) sequences in low gradient streams, such as those in West Tennessee are often created by in-channel woody structure such as roots and woody debris. When present, these characteristics can be observed even in a dry stream bed by closely examining the local profile of the channel.

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 observed. The bottom substrate material in riffles contains the largest sedimentary particles that are moved by bankfull flow (bedload). A pool is a zone with relatively low channel slope gradient, deep 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 instream structures. Riffles are more frequent in the mountain and interior plateau physiographic provinces than in the southeastern plain and Mississippi valley.

*Strong* – Demonstrated by an even and frequent number of riffles followed by pools along the entire reach. There is an obvious transition between riffles and pools.

*Moderate* – Represented by a less frequent number of riffles and pools. Distinguishing the transition between riffles and pools is difficult.

*Weak* – Streams show some flow but mostly have areas of pools or mostly

areas of riffles.

*Absent* – There is no sequence exhibited.

#### **4. Soil Texture or Stream Substrate Sorting**

*Has channel erosion down-cutting penetrated through the soil profile? Is the texture of the bottom substrate different (i.e. much 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 feature can be examined in two ways. The first is to determine if the 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 have not been active enough to down cut 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. Accelerated stormflow resulting from development may produce deep, well-developed ephemeral or even intermittent channels but which have little or no coarse bottom materials indicative of upstream erosion and downstream transport. The bottom substrate of intermittent or perennial streams often have accumulations of coarse sand and larger particles.

The second way this feature 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, however, the usefulness of this attribute 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.

Table 2. Standard USDA particle sizes

Description	Diameter	
	millimeters (mm)	inches (in.)
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* – There is a well-incised channel through the soil profile with relatively coarse-textured bottom sediments compared to riparian zone soils: coarse sand, gravel, or cobbles in the middle Tennessee; gravel, cobbles, stones, or boulders in the mountain regions, and medium or coarse sand in the west part of the state. There is a clear distribution of various sized substrates. Depositional features are present, finer particles are absent or accumulate in pools, and larger particles are located in the riffles/runs.

*Moderate* – There is a well-developed channel but it is not deeply incised through the soil profile. Some coarse-textured bottom sediments are present that indicates downstream transport. Relatively little sorting of fine material from coarser materials. Small depositional features are present; small pools are accumulating some sediment.

*Weak* – The channel is poorly developed, and incised only part way through the soil profile. Some coarse textured bottom sediments are present, but 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 is poorly developed, very little to no coarse textured bottom sediments are present, and substrate sorting is absent. There are few to no depositional features.

## 5. *Active/Relic Floodplain*

*Is there an active floodplain at the bankfull\* elevation or is there evidence of recent channel incision with a relic 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. An active floodplain (at current bankfull elevation) shows characteristics such as drift lines, sediment deposited on the banks or surrounding plants, which may also be flattened by flowing water. In cases of severe channel incision (down-cutting) the stream's new floodplain may be restricted to within the channel itself 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. Floodplains on smaller order, incised streams may not be continuous but rather may be present in some locations and absent in others. In many cases there should be evidence of a floodplain if the stream has perennial flow.

*Strong* – The area displays all of the aforementioned characteristics.

*Moderate* – Most of the characteristics are apparent.

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

*Absent* – The characteristics are not present.

\* “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).

## **6. Depositional Bars or Benches**

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

When a stream channel conveys continuous flow, the forces of channel scouring and deposition create certain distinct physical erosion and depositional features, which can be readily observed. One of these features includes scoured areas along the bank above which the stream banks 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 former 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 (where the stream bank slope begins to increase dramatically).

The presence of deposition bars or benches imply 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.

*Strong* – Depositional bars or benches are obvious throughout the sample reach.

*Moderate* – Indicators are present throughout most of the reach.

*Weak* – Indicators are infrequent along sampling reach.

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

## **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 stream creating a braided pattern of channels and an extensive floodplain. Are there two or more small stream 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.

*Strong* – The stream displays a braided appearance with many crossings creating many “islands”.

*Moderate* – The stream 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 stream 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 a braided channel.

## **8. Recent Alluvial Deposits**

*Are there fresh deposits of alluvial materials that have been transported and deposited on surfaces 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 recent deposition or accumulation of these substrates within the stream channel (sand and point bars) or floodplain. The amount of alluvium deposited will indicate whether water is constantly pushing substrate downstream. Keep in mind that eroding stream channels destabilized by increased stormwater runoff from drains/outfalls may score higher than undisturbed channels for this indicator.

*Strong* – Large amounts of sand, silt, cobble, and/or gravel alluvium present in the channel and in the floodplain.

*Moderate* – Large to moderate amount of sand, silt, cobble, and/or gravel mostly present in the stream channel.

*Weak* – Small amounts of sand, silt, and/or small cobble present within the channel.

*Absent* – There are no sand or point bars present within the stream channel and no indication of overbank deposition within the floodplain.

## **9. Natural Levees**

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

Levees develop on the bank top adjacent to the stream when sand is deposited 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.

## **10. Head Cut**

*Is there a head cut at the upstream end of the reach being evaluated? Are there one or more head cuts within the reach being evaluated?*

A head cut is an abrupt vertical drop in the bed of a stream channel that is an active erosion feature. It often resembles a small intermittent waterfall (or a miniature cliff) and will have a deep pool at the base resulting from the high energy, turbulent waterfall produced during high flows. Intermittent or perennial streams sometimes begin at a head cut in higher-gradient streams. Head cuts are transient structures of the stream and often exhibit relatively rapid upstream movement during periods of high erosion rates. Groundwater seepage may also be present from the face or base of a head cut.

## **11. Grade Control Point**

*Are there grade control points 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 stream bed or a point where erosion down-cutting 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 may also serve as grade control points. These structures separate an abrupt change in grade of the stream bed.

### **12. Natural Valley or Drainageway**

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

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 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 a natural valley or drainage way?

### **13. Second (or greater) Order Channel**

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

The higher the channel order, the more likely the stream is to be perennial. Stream order is best evaluated in the field, since headwater streams are poorly depicted on maps. However for the purposes of this manual, stream order may be evaluated 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. In those unusual instances where a clearly defined intermittent or perennial stream channel is not shown on either map, the field evaluator may decide that the channel is second order or greater and provide clear documented evidence.

It is often difficult to evaluate stream order on channels starting at a stormwater outfall. When based solely on field observations, these channels are considered 1st order. However, a review of historic data such as the County Soil Survey may indicate that the order is greater.

*YES* – One or more first order channels are draining into the stream above sampling reach.

*NO* – There are only first order channels above sampling reach.

## **B. Hydrologic Indicators**

### **14. Groundwater Flow/Discharge**

*Does the presence of baseflow, and indicators of groundwater presence and groundwater discharge indicate a significant period of groundwater discharge to the stream ?*

Baseflow Presence: Water flowing in the channel more than 48 hours after significant rainfall is evidence of groundwater discharge from saturated soils below the water table adjacent to the stream. Even when there is no visible

flow above the channel bottom, there may likely be slow groundwater discharge into and downstream flow in 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 ft deep in small streams. A functioning part of the stream, the hyporheic zone is the site of much groundwater discharge to the stream, downstream flow, and biological and chemical activity associated with aquatic functions of the stream.*

Groundwater Table: The presence of a seasonal high water table or groundwater discharge (i.e. seeps or springs) from the bank, both above the elevation of the channel bottom indicates a relatively reliable source of baseflow to a stream. Indicators of a current water table can 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 high water table 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” (1987 online ed., <http://www.wes.army.mil/el/wetlands/pdfs/wlman87.pdf>) or “Field Indicators of Hydric Soils in the United States (<http://soils.usda.gov/use/hydric/>).

Note that hydric soil indicators may be poorly developed at the seasonal high water table elevation in young, coarse textured, alluvial soil materials with low concentrations of clay, iron and manganese, or floodplain soils where moving water fails to become reduced.

Seasonal high water tables are commonly found in West Tennessee within areas with low relief. Seeps: Seeps have water dripping or slowly flowing out from the ground or from the side of a hill or incised stream bank. Springs: Look for “mushy” or very wet, and 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 groundwater source except during a period of drought. Score this category based on the abundance of these features observed within the reach.

**Strong** – Significant base flow is present. Spring, seep or groundwater table is readily observable throughout reach. \* Note that this category is essentially the same as the Primary Indicator

**Moderate** – Some base flow is present. Springs, seeps or groundwater table are present, but not abundant throughout reach.

**Weak** – Water is standing in pools and the hyporheic zone is saturated, but there is not visible flow above the channel bottom. Indicators of groundwater discharge are present, but require considerable time to

locate.

*Absent* – Little to no water in the channel. No springs or seeps present and no indication of a high groundwater table.

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

It is necessary to discern stormwater inflow (resulting from precipitation within the past 48 hours) and groundwater inputs. Flow observations preferably should be taken at least 48 hours after the last rainfall. 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 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 periods of increased rainfall would indicate an intermittent or ephemeral watercourse. 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 do not always have water in them. Look for water in pool areas or in holes in the streambed. Another good rule of thumb for differentiating ephemeral streams from intermittent ones is if they have water in them during dry (drought) conditions or during the growing season. 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 presence of water during the growing season.

*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 runs.

*Weak* – Flow is barely discernable in areas of greatest gradient change (i.e. riffles)

or floating object is necessary to observe flow.

*Absent* – Water present but there is no flow; dry channel with or without standing pools.

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

*Are leaves (freshly fallen or older leaves that may be “blackish” in color and/or partially decomposed) accumulating in the streambed?*

Perennial streams (with deciduous riparian vegetation) should continuously transport plant material through the channel. In non-perennial stream channels, there may be little

to no leaves present in the stronger flowing areas (riffles) with small accumulations on the upstream side of obstructions. This indicator may be hindered during investigations in autumn between rain events, and therefore is

most useful from January - September. This is a "inverse" hydrologic indicator in which strong evidence receives fewer points than absent.

*Strong* – Abundant amount of leaf litter is present throughout the length of the stream.

*Moderate* – Leaf litter is present throughout most of the stream's reach with some accumulation beginning on the upstream side of obstructions and in pools.

*Weak* – Leaf litter is present and is mostly located in small packs along the upstream side of obstructions and accumulated in pools.

*Absent* – Leaf litter is not present in the fast moving areas of the reach but there may be some present in the pools.

#### **17. Sediment on Plants or Debris**

*Is fine sediment deposited on plants or 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 debris in the stream 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 stream, on the streambank, or in the floodplain covered with sediment? Look for silt/sand accumulating in thin layers on debris or rooted aquatic vegetation in the runs and pools. Be aware of upstream land-disturbing construction activities, which may contribute greater amounts of sediments to the stream channel, and can confound this indicator. Note these activities on the data sheet if these confounding factors are present.

*Strong* – Sediment found readily on plants and debris within the stream channel, on the streambank, and within the floodplain throughout the length of the stream.

*Moderate* – Sediment found on plants or debris within the stream channel although not prevalent along the stream. Mostly accumulating in pools.

*Weak* – Sediment is isolated in small amounts along the stream.

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

#### **18. Organic Drift Lines (Wrack lines)**

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

Organic drift lines are defined as twigs, sticks, logs, leaves, trash, plastics, and any other floating materials piled up on the upstream side of

obstructions in the stream, on the streambank, in overhanging branches, and/or in the floodplain that indicate high stream flows. (These lines of debris are also commonly referred to as “wreck lines.”) Ephemeral streams 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 drift lines.

*Strong* – Large drift lines are prevalent along the upstream side of obstructions within the channel and the floodplain.

*Moderate* – Large drift lines are dispersed mostly within the stream channel.

*Weak* – Small drift lines are present within the stream channel.

*Absent* – No drift lines are present.

## **19. Hydric Soils**

*Are there hydric soils present at the toe of the bank or base of head cuts above the stream bottom 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, for more than a few days during the growing season that results in extended periods of soil reduction. 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.

Soils with sufficient periods of inundation or saturation and that contain significant amounts of clay or silt and significant amounts of iron and manganese will develop color features indicative of extended saturation and reduction. These features are commonly referred to as redoximorphic features and include mottling and gleying (low chroma). Soils immediately adjacent to the stream bed along the stream bank may have redoximorphic features if persistent groundwater discharge is present. Use a Dutch auger or Oakfield probe to obtain a 12 to 14-inch deep core and examine the soil pedon for mottles and low chroma. These features indicate that a seasonal water table is commonly present and that the channel is at least intermittent. Look for redoximorphic features several inches below the surface. Note that non-soil (i.e. relatively young) alluvial accumulations of coarse sand, gravel, and cobble in the stream bank or hyporheic zone, will not develop hydric soil indicators.

Mineral soils which are exposed to atmospheric oxygen in the soil profile will have some degree of oxidation occurring and as a result will have bright red, orange, or yellow matrix colors. Saturated soils, such as those found in the

streambeds of perennial streams, have limited or no contact with oxygen, will remain reduced and subsequently have a very dull color chroma or may be gleyed completely (dull gray hues or chroma throughout the soil ped. The soil sample should be representative of the major stream 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) or gleyed soils indicate continual saturation, while brightly colored soils or mottles (> 2) indicate only short periods of wetting, typical of intermittent or ephemeral streambed soils or upland soils. Table xx provides a key for scoring.

Table 3. Scoring redoximorphic features

<b>Redoximorphic feature</b>	<b>Score (see form)</b>
<i>Strong</i> - Gleyed soils	1.5
<i>Moderate</i> - Matrix chroma of 1	1.5
<i>Weak</i> - Matrix chroma of 2	1.5
<i>Absent</i> - Matrix chroma of 2.5 or greater.	0

## **C. Biological Indicators**

### **20. Fibrous Roots**

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

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 the root mass consist of many roots with generally equal diameters. Fibrous roots of woody 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. Thus, in areas of stream bottom substrates where water is persistent or frequent high energy flows disturb the bottom substrate, fibrous roots may be infrequent or even absent. A higher score is given for the absence of fibrous roots. Observe the bottom (or edge) of the stream and determine if very small (fibrous) roots are present. Note that during extended growing season, or dry periods, fast growing fibrous roots may grow across the bottom of a stream that would not be present during normal flow conditions. *Note that this indicator refers to fibrous roots of upland plants rather than aquatic plants that may be growing in the channel, or adventitious root wads from hydrophilic riparian trees.*

### **21. Rooted Plants in Streambed**

*Are rooted plants growing in the hyporheic zone in the thalweg area of the stream?*

This attribute 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 (see No. 20 Fibrous Roots above). A higher score is given for the absence of rooted plants. Focus should be on the presence of plants in the bed or thalweg of the stream and plants growing on any part of the bank of the stream should not be considered. Note, however, there will be exemptions to this attribute. For example, rooted plants can be found in shaded perennial streams with moderate flow but in all cases these plants will be water tolerant (OBL, FACW; see No. 29 – Wetland Plants in Streambed, page 27). Cases where rooted upland plants are present in the streambed may indicate ephemeral or intermittent flow.

## **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 in the muddy streambank or “chimneys” (roughly cylindrical chimneys) on the muddy bank or floodplain may be indicators of wet soils (wetlands) rather than streams.

## **23. Bivalves**

Examine the streambed or look for them where plants are growing in the streambed. Also, look for empty shells washed up on the bank. Some bivalves (e.g., Fingernail clams; Figure 8) can be pea-sized or smaller. 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.

## **24. Fish** \* Note that this category is essentially the same as the 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 along the stream. Check several areas along the stream sampling reach, especially underneath undercut banks. In most cases, fish are indicators of perennial streams, since fish will rarely inhabit an intermittent stream.

## **25. Amphibians**

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 an 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.

## **26. Benthic Macroinvertebrates**

The larval stages of many aquatic insects are good indicators of stream status because a continuous aquatic habitat is required for these species to mature. Use a small net and sample a variety of habitats including water under overhanging banks or roots, accumulations of organic debris (e.g. leaves) and the 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 xx above.

*Strong* – Many individuals within several different taxa are easily observed

*Moderate* – With a little effort, a few individuals from several different taxa, or many individuals from a few different taxa are observed

*Weak* – With intensive searching, a few individuals of taxa that are not Primary Indicators are observed

*Absent* – No aquatic organisms observed

## **27. Presence of Filamentous Algae and Periphyton**

These forms of algae are attached to the substrate. They are visible as a pigmented mass or film, or sometimes hairlike 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. Periphyton growth is influenced by chemical disturbances such as increased nutrient (nitrogen or phosphorus) inputs and physical disturbances such as increased sunlight to the stream from riparian zone disturbances.

## **28. Iron Oxidizing Bacteria/Fungus**

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 groundwater. Iron oxidizing bacteria/fungus in streams derives energy by oxidizing iron, originating from groundwater, in the ferrous form ( $\text{Fe}^{2+}$ ) to the ferric form ( $\text{Fe}^{3+}$ ). In large amounts, iron-oxidizing bacteria/fungus discolors the stream substrate giving it a red appearance. In small amounts, it can be observed as an oily sheen on the water’s surface. This indicates that the stream is being recharged from a groundwater 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 groundwater. 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.

## 29. 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 xx). 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 wetland plants or submerged aquatic vegetation growing in the stream bed. All wetland designations are defined by *National List of Plant Species That Occur in Wetlands: Southeast Region 2*. 1988. U.S. Fish and Wildlife Service. (<http://wetlands.fws.gov/plants.htm>) Submerged Aquatic Vegetation (SAV) grows completely underwater (for instance Coontail -- *Ceratophyllum demersum*)

**Table 4. 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.

## 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. However, certain confounding issues are more commonly encountered, and require more frequent jurisdictional interpretation. The following list is designed to provide general 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.

Sinking / Losing Stream Reaches : 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 groundwater.

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 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 breakpoints between the WWC and stream portions of a watercourse. Because in reality most stream hydrology operates on a continuum, not bright-lines, 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 an upstream reach that is clearly a WWC and a downstream reach 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 groundwater 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 (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 part of the stream and is subject to the same regulations. If there is a clear connection to a groundwater 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 groundwater 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 regional water table, and is therefore a regulated feature.

If the pond has no jurisdictional stream feeding or issuing from it, and there is no connection to groundwater, the feature is not considered to be Waters of the State, and is not regulated. 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 isolated farm ponds 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, and 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 pre-impact conditions.

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.

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).

Exposed Groundwater: One particular type of human disturbance that occasionally needs addressing is the exposing of groundwater to the surface, through historic excavation or mining activities. Over time, this exposed groundwater (now surface flow) may develop jurisdictional stream characteristics and may be regulated as a stream. (Groundwater 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 WPC 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.

### **Useful Resources / Citations**

[NC HD SOP manual](#)

[Leopold bankful quote citation](#)

[PC 464 link](#)

[Links to HD rules, QHP rules, \(ARAP rules ?\)](#)

[Precipitation web links, including : NOAA's National Climatic Data Center, NRCS National Water and Climate Center](#)

[NRCS soil map links](#)

[Benthic links, incl. Merritt & Cummins](#)