CHAPTER 9

PHYSICAL HABITAT OF AQUATIC SYSTEMS

Objective

This chapter describes the methods used by the TCEQ for the collection and assessment of physical-habitat data primarily in wadable freshwater streams. A stream is considered wadable if most of its channel is accessible by wading during normal flow conditions. Generally, these streams are third order or less. Pool areas or high-flow conditions may make the stream inaccessible to wading in certain places or at certain times; however, the stream will still be considered wadable when determining reach length. Method modification for use of these protocols in non-wadable rivers and streams is described at the end of this chapter.

In general, the TCEQ will use aquatic habitat data collected according to these methods, in conjunction with fish and benthic macroinvertebrate community surveys, to holistically evaluate the health of biological assemblages and to develop future indices of aquatic-life use for these waters. A physical habitat evaluation of a stream is an integral and required part of all biological assessment activities. One of the main functions of a habitat assessment is to characterize the aquatic-life potential of a stream. Aquatic habitat quality is an important factor affecting the integrity of fish and benthic macroinvertebrate communities. Characteristics of physical stream habitat such as the presence or absence of instream cover, substrate characteristics, and riparian integrity have important effects on both benthic macroinvertebrate and fish assemblages. Habitat characterization, therefore, is important in interpreting results and determining the cause of decreasing biotic integrity. The data-collection protocols outlined below must be followed.

Habitat-Assessment Forms

Habitat assessment is recorded using forms broken into three parts. Use the Stream Physical Characteristics Worksheet—Part I to record required data in the field. The worksheet is divided into two portions. The upper portion is for general observations made over the entire evaluated reach, while the lower, or boxed, portions are for measurements and observations made at specific transect locations. After field work is complete, summarize and average data from the worksheets to complete the Summary of Physical Characteristics of Water Body—Part II. Then score and calculate the Habitat Quality Index (HQI) using the Habitat Quality Index—Part III form based on the values summarized in Part II. Mark transect locations on a USGS topographic quadrangle map and attach it to the forms. For RWAs, also locate each existing or proposed discharge point on the map. See Appendix C for Part I, II, and III forms.

Requirements for Habitat Assessments

Aquatic-Life Monitoring, Aquatic-Life Assessments, and Use-Attainability Analyses

A habitat assessment is a required part of any biological monitoring event. For ALM, ALA, and UAA monitoring, the placement requirements for habitat reach are the same and are outlined in

Chapter 2. It is very important that the habitat-assessment reach covers the areas where fish and benthic macroinvertebrate samples are collected. Ensure the reach is not close to a bridge overpass. Occasionally a bridge crossing is strewn with riprap or other debris that forms the only riffle in the reach. Sampling from these artificial riffles is discouraged and should only be conducted after exhausting all other sampling efforts outlined in Chapter 5. Once the leaders of the crews sampling habitat, fish, and benthic macroinvertebrates have agreed where sampling will be conducted, the habitat crew marks the ends of the reach with bright survey flagging. Sampling from areas outside those boundaries is discouraged.

Habitat Assessment Requirements for UAA, ALA, and ALM during the Second Event in an Index Period

In any one year, most ALMs, ALAs, and UAAs will involve two sampling events within an index period. An HQI score must be part of every biological monitoring data set. A full habitat assessment must be conducted at the **first** biological monitoring event (within the index period) per year. Photographs must be included. A full habitat assessment must be conducted at the **second** biological monitoring event per year, unless conditions have demonstrably not changed appreciably since the first habitat assessment that year. The following evidence must be gathered to demonstrate similar conditions between events.

1. flow
2. wetted-channel width
3. photographs of reach
4. description of bank conditions in relation to first event
5. description of canopy conditions in relation to first event

If best professional judgment determines that conditions have not changed significantly based on these five pieces of evidence, then the HQI from the first event may be used in the second data set. The same lead field staff must assess habitat at both events. These allowances apply only to two habitat events within one index period.

Habitat-Assessment Requirements for RWAs

For new permit applications or for WWTPs that have not yet discharged, conduct the habitat assessment beginning at the proposed location of the WWTP outfall and proceed downstream. Once the transect measurements are completed, make general observations over the reach while returning to the point of the proposed outfall.

For amendments or renewals of existing WWTP permits, an assessment upstream of the WWTP outfall is required. Make transect measurements starting from a point approximately 30 m upstream of the outfall and continuing upstream. Once the transect measurements are completed, make general observations over the reach while returning to the discharge point.

See Figures B.8 and B.9 in Appendix B for examples of where to locate sites for RWAs in relation to existing or proposed WWTP outfalls.

Determining Reach Lengths and Placing Transects

After site selection, the next step in conducting a stream habitat assessment is to determine the length of stream to be evaluated, or the “stream reach.” Determine the stream reach by walking the stream for several hundred meters to locate the areas where biological collections will be made. Determine an average stream width during this initial reconnaissance by taking four to five width measurements at points along the stream channel that best represent the diversity of stream widths without biasing measurement toward very narrow or very wide sections of the channel. Take the width measurements and average them, then multiply that average by 40 and round to the nearest whole number using standard rounding rules. Forty times the average wetted stream width becomes the length of stream reach evaluated, with a minimum required reach length of 150 m. For most streams, this usually results in a reach length of approximately 200 to 300 m. The maximum reach length for wadable streams is 500 m. The calculated reach length is then divided into evenly spaced units depending on its length.

Once you have determined the reach length, locate the first transect far enough upstream from a bridge or road crossing so as not to influence the natural stream channel. Mark it with bright survey flagging and label it Transect “A” or “1.” This becomes the downstream end of the reach and biological sampling should not be conducted downstream of that point unless absolutely necessary. Then locate and flag subsequent transects upstream of the first transect and evenly spaced to cover the entire reach.

The placement of transects within the reach is as follows:

For streams 150–300 m, place five equidistant transects along the reach, and include the ends of the reach. Then divide the reach length by four. The distance between transects is no greater than 75 m. See Figure 9.1.

For streams 301–500 m, place six equidistant transects along the reach and include the ends of the reach. Then divide the reach length by five. The distance between transects is no greater than 100 m. See Figure 9.2.

For example, if the average stream width is 9.7 m, the average will be rounded to 10 m. Then $10 \times 40 = 400$ m, so 400 m is the reach length. Divide 400 by 5 (to include one transect at each end of the reach) to determine the transect spacing—in this case, $400/5 = 80$, so each transect will be 80 m apart.

The stream reach encompasses the biological and chemical collection areas and includes as many different geomorphic channel units as possible, e.g., riffles, runs, glides, and pools.

Transect Area

For transect measurements, left- and right-bank orientation is determined by the investigator facing downstream.

Place transect lines perpendicular to the stream channel at five to six evenly spaced intervals along the reach, as shown in Figure 9.3.

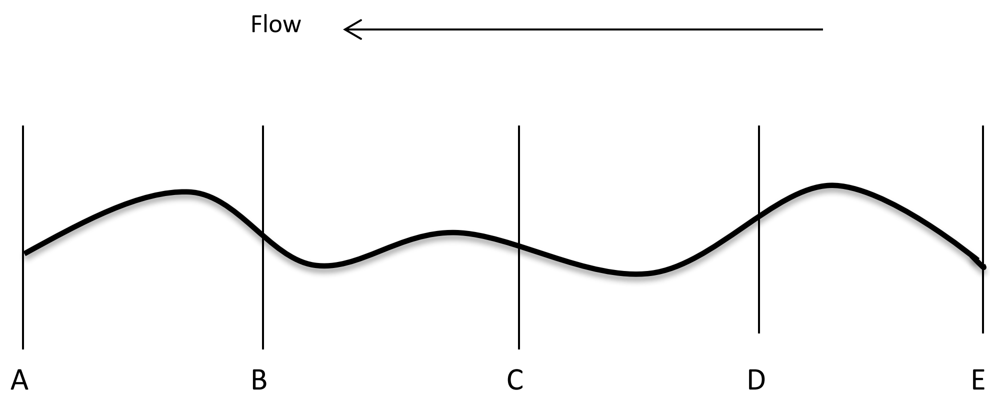

Figure 9.1. Transect placement for reach lengths of 150 to 300 m.

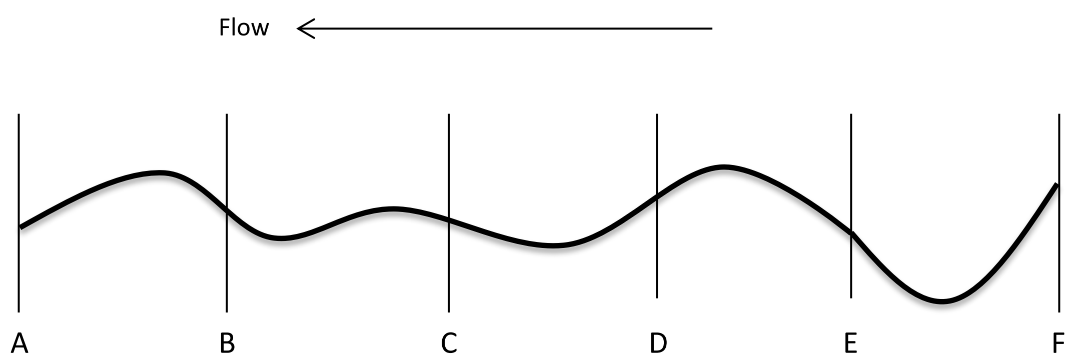

Figure 9.2. Transect placement for reach lengths of 301 to 500 m.

Measurements of some habitat attributes are made along the transect line and in the area 3 m on either side of the transect line defined as the transect area in Figure 9.3. Reach boundaries are included as transects. It is preferable to begin with the transect farthest downstream, as this allows biological sampling ahead of the habitat assessment, thereby minimizing disturbance to the biota. The distance between transects is uniform and must be measured with a measuring tape, hip chain, or range finder.

Low-Flow or Dry Conditions

A habitat assessment must accompany the collection of biological community samples in rivers and streams. If the stream is dry, do not conduct a habitat assessment. If the stream contains standing perennial pools in which aquatic life is found and sampled, conduct a habitat assessment as described in this document, with the following modifications.

Determine the reach length as stated above, using the channel width at base-flow conditions (as best as can be determined) as the wetted width. If the existing perennial pools cover most (> 50 percent) of the reach length, assess the habitat according to the procedures in this chapter. If a transect crosses a dry part of the channel, record any meaningful data from that transect, such as substrate characterization, bank angle under what appears to be normal base flow conditions,

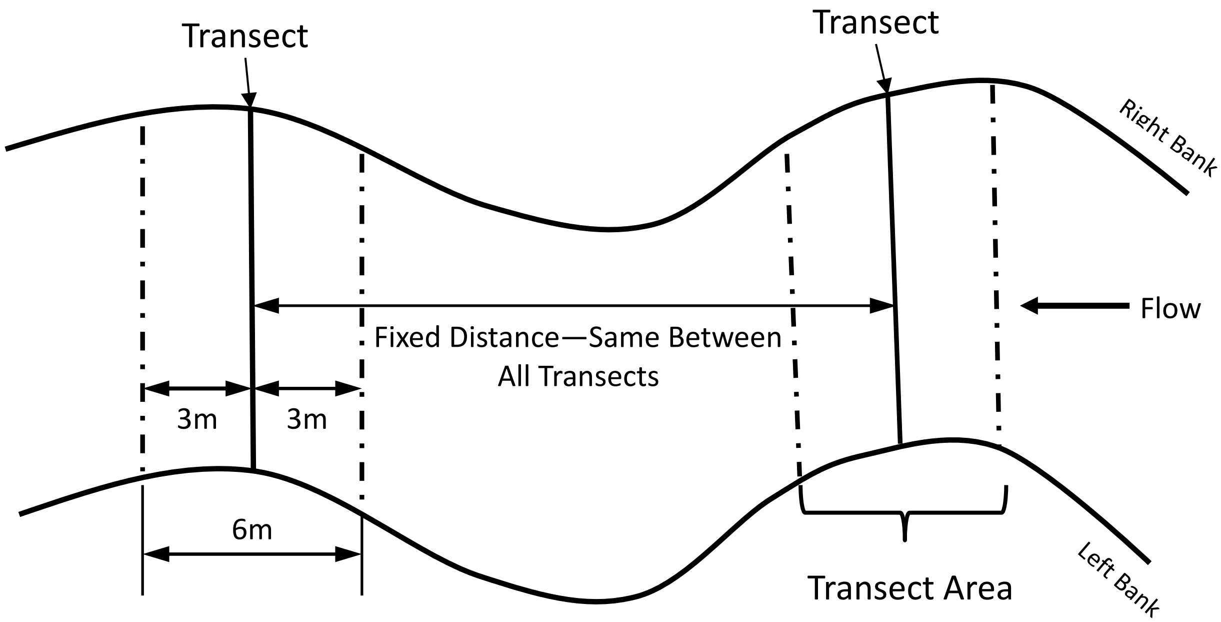

Figure 9.3. Transect area.

riparian information, etc. If the pools cover less than 50 percent of the reach length and are separated by exposed channel bed, place transects such that they best characterize the pools and available water.

Record the maximum pool length, depth, and width at each pool measured in the reach. Transect placement must still follow the minimum spacing requirements stated above; however, some transects may be spaced farther apart, depending on pool location. The overall objective is to characterize the pools where either benthic macroinvertebrates or fish are sampled and to assess the same number of transects that a typical reach of that length would have if there were water in the stream. Characterize only those pools in the reach that are at least 10 m in length and at least 0.4 m in depth.

Part I: Stream Physical Characteristics Worksheet

Use the Stream Physical Characteristics Worksheet to record primary, secondary, and tertiary attributes for each transect or for the entire reach. Record instream channel measurements (primary information), stream morphology (secondary information), and riparian environment (tertiary information) in the upper portion of the form for attributes describing the entire reach, and in the lower boxes for each transect.

Primary Attributes—Instream Channel Characteristics

Primary attributes of a stream's aquatic habitat are the in-channel aspects of habitat type, substrate quality, and food and cover availability for fish and benthic macroinvertebrates. Basically, primary attributes characterize the shelter and food quality for aquatic organisms.

Kaufmann and Robison (1998) provide the basis for many of the measurement protocols in this chapter.

Habitat Type (Geomorphic Units)

Identify the habitat type in the area where the transect falls. To be considered a discrete habitat type, the width of the geomorphic unit (riffle, run, glide, pool) must be greater than 50 percent of the width of the stream and the length of the geomorphic unit must be greater than or equal to the average stream width. If the transect falls in a transition area or on the border between two habitat types, identify both in the box marked "Habitat Type."

Riffle: A shallow portion of a stream extending across a stream bed characterized by relatively fast-moving turbulent water with a broken surface. The water column in a riffle is usually constricted and water velocity is high due to a change in surface gradient. The channel profile in a riffle is usually straight to convex.

Run: A relatively shallow portion of a stream characterized by relatively fast-moving, bank-to-bank, non-turbulent flow. A run is usually too deep to be considered a riffle, but the water velocity is too fast to be a glide. The channel profile under a run is usually a uniform flat plane.

Glide: A portion of a stream where the flow is slow moving and laminar, similar to that found in a shallow canal. Water surface gradient over a glide is nearly zero, so velocity is low, but flow is uniform across the channel without eddy development. A glide is too shallow to be a pool but the water velocity is too slow to be a run. The channel profile under a glide is usually a uniform flat plane.

Pool: A portion of a stream in which water velocity is low and the depth is greater than the riffle, run, or glide. Pools often contain eddies with varying directions of flow compared to riffles, runs, and glides where flow is almost exclusively downstream. The water surface gradient of pools is close to zero and their channel profile is usually concave.

Number of Riffles

Count the number of riffles in the entire habitat assessment reach, not just those that fall in transect areas. Riffles are considered discrete if they are separated by a run, glide, or pool that is at least as long as the average stream width. Otherwise, count one riffle.

Dominant Substrate Type

The channel substrate is the mineral or organic material that forms the bottom of the stream.

Substrate materials are usually classified by particle size. Identify the dominant substrate type that characterizes the stream bottom along and 3 m on either side of each transect according to the following guidelines.

- Bedrock: > 400 cm, size range—larger than a car
- Boulders: > 25 to 400 cm, size range—basketball to car
- Cobble: > 6 to 25 cm, size range—tennis ball to basketball
- Gravel: > 2 to 60 mm, size range—ladybug to tennis ball
- Sand: 0.06 to 2 mm, gritty between fingers

- Mud, clay, and silt: < 0.06 mm, not gritty between fingers

The size composition can be assessed visually or by obtaining one or more small samples by hand or grab. For situations where a thin layer of silt or organic material covers a dominant substrate type such as cobble or bedrock, ignore the overlying material. For areas where the overlying material is thick enough to alter the habitat for the types of organisms who would normally live there—i.e., all interstitial spaces are filled in, dense leaf pack, etc.—then use professional judgment to possibly call the overlying material the dominant substrate.

Percent Gravel or Larger

Estimate the percentage of the substrate that is > 2 mm in size along the transect, and 3 m on either side of it. The size composition can be assessed visually or by obtaining a small sample by hand.

Algae and Macrophytes

Determine if algae and macrophytes are present along and 3 m on either side of the transect. Visually estimate whether algae and macrophytes are abundant, common, rare, or absent. If only algae or only macrophytes are present, circle either "algae" or "macrophyte" on the form and estimate the abundance.

Instream Cover Types

Instream cover refers to physical structures that shelter fish and benthic macroinvertebrates. It includes, but is not limited to, logs, tree stumps, woody debris, root wads, leaf packs, gravel or larger substrates, boulders, artificial cover (for example: tires or cement slabs), undercut banks, macrophyte beds, and overhanging vegetation.

Percent Instream Cover

Visually estimate percentage instream cover along and 3 m on either side of the transect. This percentage represents an evaluation of the area of the stream bottom described above, as well as the water column and area immediately above the water surface along the stream banks. The cover must be at a depth suitable for use by aquatic organisms. For example, if leaf packs and logs are in 2 cm of water on a sand bar, they are not suitable for use by fish or most benthic macroinvertebrates and must not be counted.

Percent instream cover must be evaluated with a gradient of percentages from the lowest percentage, for bare bedrock or concrete, to the highest, for a highly heterogeneous mix of several categories, such as gravel, cobble, logs, macrophytes, and overhanging vegetation. Additional dimensions contribute to higher percentages, such as cover that extends from the substrate up though the water column and above the stream surface.

Secondary Attributes—Stream Morphology

Secondary attributes of a stream's aquatic habitat are characterized by the structure of the stream channel over the entire reach where the primary attributes are located. It is a broader look at the channel itself and the morphological characteristics that influence the quality of the primary attributes. Figure 9.4 depicts a typical stream channel with a well-developed stream pattern.

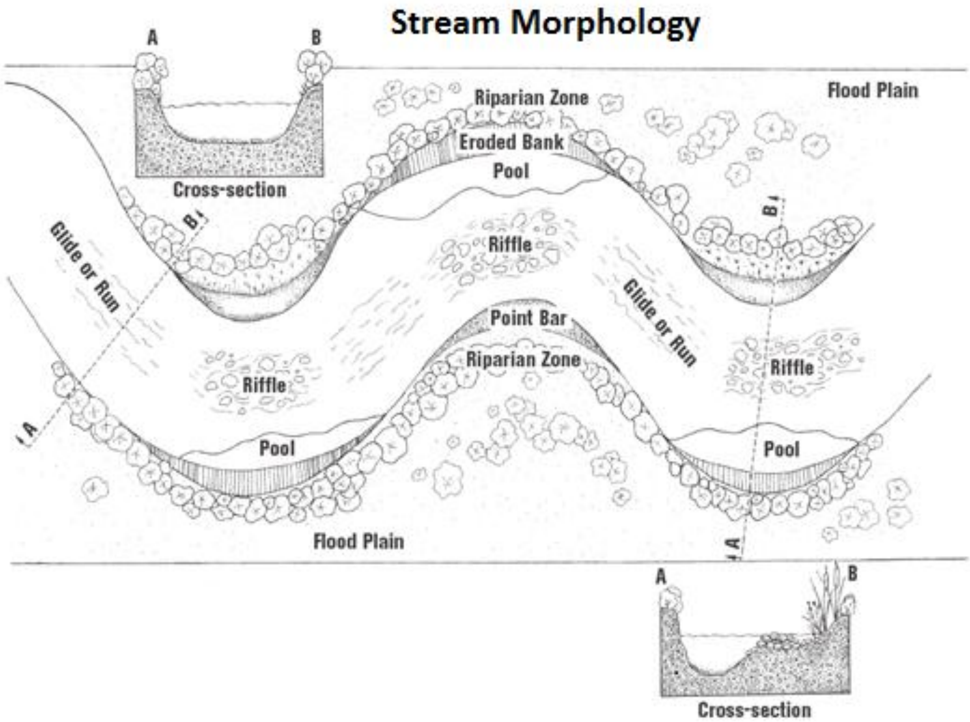

Figure 9.4. Stream morphology.

Stream Bends

Count the number of stream bends and determine their definition (well-defined, moderately defined, poorly defined). Figure 9.5 illustrates stream-bend classifications.

High sinuosity produces diverse habitat and fauna, and such a stream is better able to handle surges during storm fluctuations. The absorption of this energy by bends protects the stream from excessive erosion and flooding and shelters benthic macroinvertebrates and fish.

A well-defined bend will usually have a point bar at the inside and a cut bank on the outside of the bend with flow directed toward the cut-bank side. Eddy currents are usually present in these bends. Moderately defined stream bends have somewhat less sinuosity, and the bends and point bars are not as well developed.

Poorly defined bends have almost no sinuosity or are straight as in channelized streams. In some situations stream-bend development can be evaluated from topographical maps.

The speed of water flow depends on several factors, including the angle of the bed slope, the roughness of the bed, the depth of the water, and the type of geologic materials the stream flows through. For example, streams flowing through soft soils tend to meander more and have less velocity than streams flowing through hard erosion-resistant rock. Generally, if the stream meanders a great deal, the stream’s gradient is probably low.

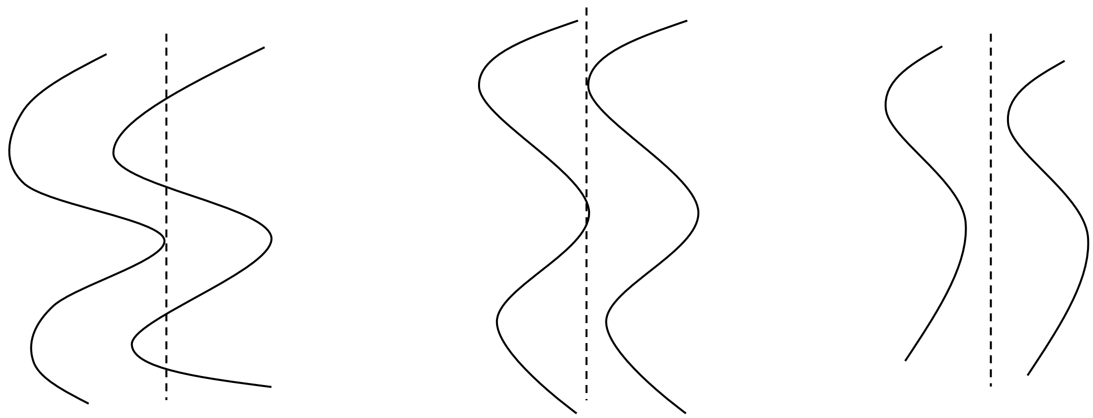

Figure 9.5. Stream bends.

Channel Obstructions or Modifications

Indicate observed channel obstructions such as fences, log jams, culverts, and low water bridges. Also indicate any channel modifications such as channelization, levees, concrete lining, or riprap within the reach; note whether these modifications are natural or artificial.

Water Level

The water level is the degree to which water covers the entire available channel substrate, from bank to bank. It is not to be confused with "flow severity" referred to in Volume 1 (RG-415) or measured discharge. Flow severity is a visual assessment of the amount of flowing water in the channel relative to base flow or normal flow conditions. Water level represents the percentage of substrate that is covered with water throughout the reach, or conversely, the percentage of substrate that is exposed in the channel. This attribute is a measure of how much of the potential habitat is available to aquatic organisms based on the amount of water in the channel at the time of assessment. When water does not cover much of the stream bed, the amount of substrate available for aquatic organisms is limited relative to times when water level is higher. For example, if the true channel is 20 m wide and water only fills 10 m of the channel, the channel flow status will be reported as "low," with water filling 25 to 75 percent of the available channel. This observation is especially useful for interpreting biological information under low-flow conditions.

Estimate the percentage of water in the available channel and the amount of substrate exposed as—

High: Water reaches the base of both banks. Very little (less than 5 percent), if any, of the channel substrate is exposed.

Moderate: Water fills more than 75 percent of the available channel, or less than 25 percent of channel substrate is exposed.

Low: Water fills 25 to 75 percent of the available channel and riffle substrates are mostly exposed.

Dry: Very little water in the channel—mostly present as standing pools—or the stream is dry.

Stream Width

Stream width is the horizontal distance along the transect line from water's edge to water's edge along the existing water surface. It is also referred to as the wetted width.

Measure the width of the water in the stream channel from water's edge to water's edge at a transect. The water's edge is the point where stream materials, such as rocks, are no longer surrounded by water. Record this width in meters.

Remember that stream width is only the wetted width, whereas channel flow status looks at the entire available channel, bank to bank.

Stream Depths at Points across the Transect

Stream depth is the vertical height of the water column from the existing water surface level to the channel bottom.

Measure the water depth in meters at 11 equally spaced points across each transect for wadable streams, beginning and ending with the depth at the water's edge. For streams less than 1.5 m wide or greater than 11 m wide, measure as many depths as will adequately profile the channel substrate. Also locate the *thalweg*, or deepest portion of the channel, and measure its depth. Indicate the thalweg depth as a separate depth measurement in the area labeled "Thalweg Depth" on Part I.

For non-wadable streams, measure the water depth at 11 or more equally spaced points across each transect. Locate and measure the depth of the thalweg as for wadable streams. In non-wadable streams, best professional judgment will be required to determine how many depth measurements to make; the number chosen must adequately profile the stream channel bottom at that transect. The number of depth measurements must increase as the stream bottom becomes more irregular.

Tertiary Attributes—The Riparian Environment

The riparian environment is defined as follows.

Riparian Zone

The *riparian zone* can be defined in many ways, but it is generally considered to be the area from the stream bank out onto the flood plain. The limit of the zone depends on many factors including plant community, soil moisture, and distance from the stream. It also depends on the limit of interaction between land and stream processes. The riparian zone is periodically inundated by floodwaters from the stream. Interaction with this terrestrial zone is vital for the health of the stream.

Natural Vegetative Buffer

Natural vegetative buffer refers to an area of either natural or native vegetation that buffers the water body from terrestrial runoff and human activities. In natural areas, it may be much wider than the riparian zone. In human-altered settings, the natural vegetative buffer limit is at the point of human influence in the riparian zone, such as a road, parking lot, pasture, or crop field. It is the width of this buffer that the TCEQ is most interested in measuring for qualifying potential stream disturbances.

Aesthetics

Circle the descriptor that most adequately describes the reach as a whole. Make only one selection.

Wilderness (1): The surrounding landscape has outstanding natural beauty. Usually wooded or unpastured areas typical of what would be found in a wilderness area such as in a national forest or preserve. There is no evidence of human alterations to landscape. Water clarity **may** be exceptional.

Natural area (2): Trees or native vegetation (or both) are common. Some development or human alteration to the landscape may be evident, but is usually minimal. Could include fields, pastures, or rural dwellings.

Common setting (3): The landscape and stream are fairly altered by humans, but the alteration is not offensive. Could include an urban park setting.

Offensive (4): The stream does not enhance the aesthetics of the landscape. It is littered with trash, highly developed, or a dumping area. Water **may** be discolored or very turbid.

Riparian Vegetation (Percent)

Indicate the percentage of riparian vegetation types on each bank located in the riparian zone. If no plants exist in the riparian zone, indicate this by recording 100 percent in “other.”

Bank Slope (Bank Angle)

Measure the slope of each bank at the transect with a clinometer and a survey rod or pole. Place one end of the survey rod at the water’s edge and lay it on the ground perpendicular to the stream channel along the bank and pointed toward the top of the first main terrace. Lay the clinometer on top of the survey rod and record the angle reading. Refer to Figure 9.6 for bank-angle measurements. The clinometer can only measure angles less than 90°.

During low-flow conditions, the water’s edge may recede from the true bank, revealing part of the stream bottom as the apparent bank. In these instances, measure the slope of this apparent bank from the water’s edge.

A *vertical bank* has a bank angle of 90°. If the vertical portion of the bank is ≥ 0.3 m, record only the vertical measurement. If the vertical portion of the bank is < 0.3 m, measure the vertical portion of the bank as well as the angle at the top of the vertical section and average the readings. Record the average as the bank angle.

A *gently sloping bank* has a bank angle of < 90° and can be read directly off the clinometer.

For banks greater than 90° (*undercut banks*), place a survey rod flush against the roof of the undercut bank and in as far as possible. Turn the clinometer over, take the reading, and subtract it from 180°.

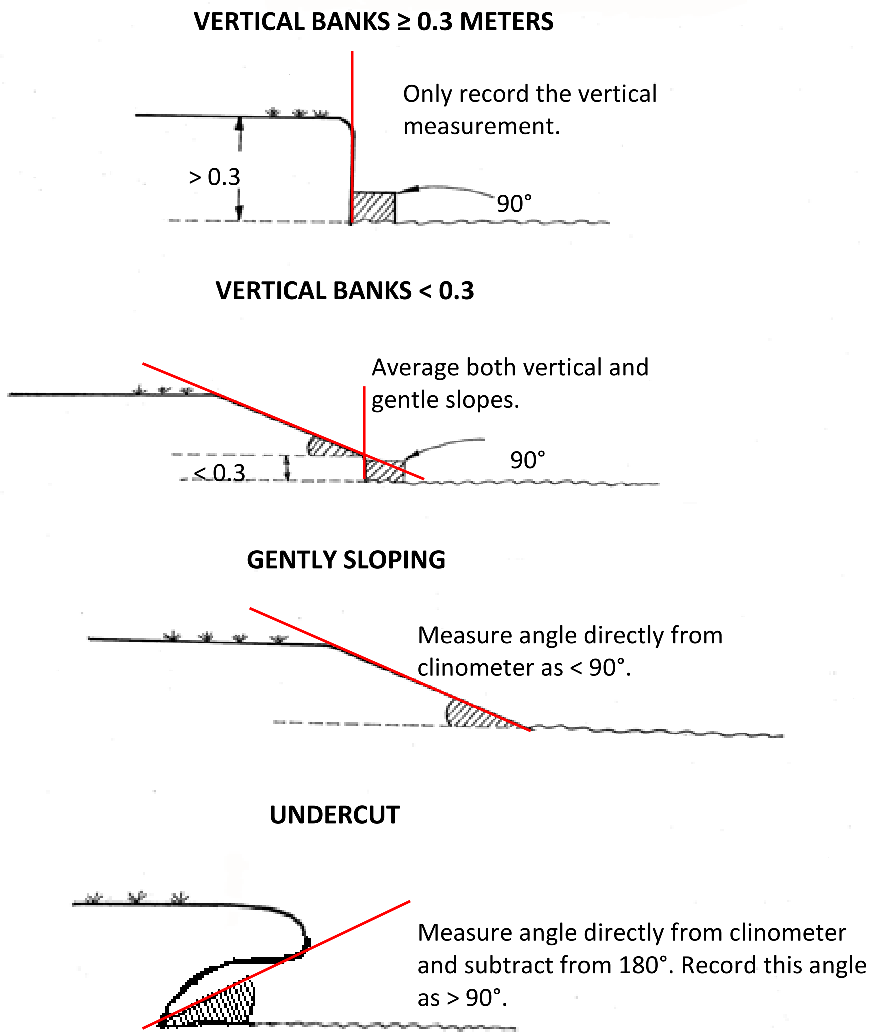

Figure 9.6. Bank-angle measurements.

If the bank is very irregular in shape or has many small, intermediate terraces, take several bank-angle readings at each elevation break and average the readings, or, if the irregularities are fairly small, lay the survey rod across the irregularities and take one average bank angle reading. Record the average as the bank angle.

Measure both left and right banks and record those angles separately.

Bank Erosion

Estimate the percentage of the areas of the stream bank that shows evidence of or potential for erosion. Assess each bank separately, up to the first terrace within the transect area—along and 3 m on either side of the transect. Record an estimate for each bank on the form. The range is as follows—

- 100 percent: totally bare, unconsolidated soil not stabilized by roots
- 0 percent: totally covered by thick vegetation or hard rock, such as a canyon wall

Tree Canopy

Tree canopy is the uppermost spreading, branching layer of stream-side trees that shades the water surface. Tree canopy is reported as percent cover and is measured with a densiometer. Tree canopy is an indicator measurement of stream corridor health and level of disturbance. The possible measurement range is from 0 percent (totally open canopy cover) to 100 percent (totally closed). See Figure 9.7. Measure the amount of tree canopy cover with a **convex** spherical densiometer along the transect line at mid-channel, once facing the left bank and once facing the right bank. Make two additional measurements along the transect line at the water's edge, once facing the left bank and once facing the right bank.

Use the following method for marking and reading a convex densiometer.

- With a black permanent fine-tipped marker, mark the densiometer, as shown in Figure 9.7, so that 17 grid intersections are located above the marked lines. Measure canopy cover by holding the densiometer level 0.3 m above the surface of the water.
- The observer's face must be kept from reflecting in the grids of the mirror. While concentrating on the 17 points of intersection, the observer then counts the number of intersections that are covered by reflected canopy cover. In this example, the densiometer reading would be 10.

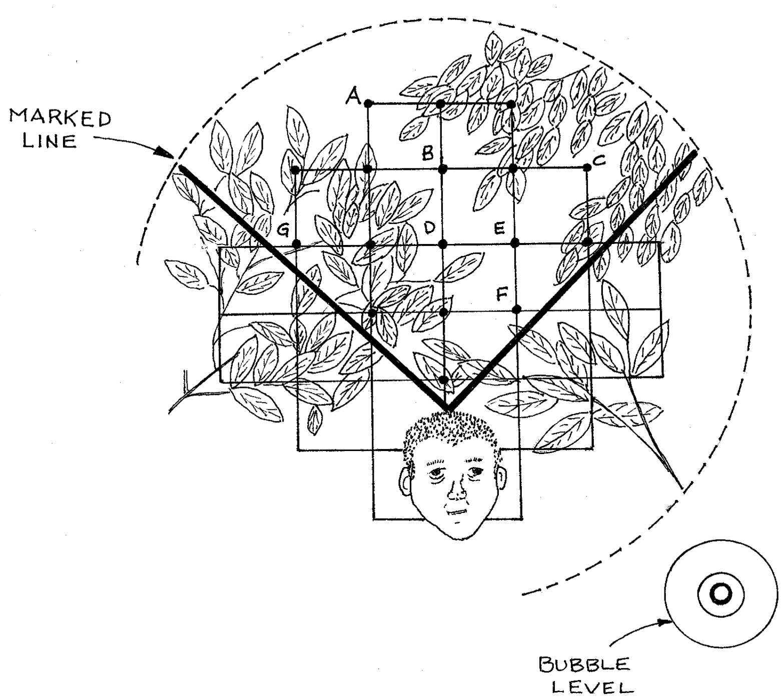

Figure 9.7. Convex spherical densiometer diagram. (From Mulvey et al., 1992.)

- Two densiometer readings are taken at midstream, one facing the left bank and one facing the right bank. Two additional readings are taken at the water's edge, one facing the left bank and one facing the right bank. The four readings are averaged and the percentage calculated. For example, if the average of the four densiometer readings is 9, the reported percent tree canopy would be:

  9 ÷ 17 = 0.53 or 53 percent

- Range: no trees, totally open = 0 percent
  large trees providing total shading = 100 percent

Dominant Types of Riparian Vegetation

Indicate the types of riparian vegetation observed within 3 m either side of the transect (oak trees, sunflowers, Bermuda grass) for each bank. Record this information for each bank separately. If a bank contains no riparian vegetation, indicate this by describing the conditions, such as a paved parking lot up to the edge of the stream bank.

Width of Natural Buffer Vegetation

Measure the width in meters of the natural vegetative buffer on each bank. This can be performed with a hip chain, a measuring tape, or an optical range finder. If the buffer is greater than 20 m, simply indicate "> 20 m" on the form.

General Observations

After finishing the transect measurements, complete the "general observation" portion of the worksheet. Count the number of riffles throughout the evaluated reach. Record the width and maximum depth, in meters, of the largest pool in the reach, if applicable. Also note the number and quality of bends in the reach.

At an appropriate location within the stream reach, measure streamflow. See Volume 1, Chapter 3, for details.

Photograph the stream reach from mid-channel, facing upstream and downstream. Ideally, take photographs at each transect from mid-channel facing the left bank, the right bank, upstream, and downstream.

Part II—Summary of Physical Characteristics of Water Body

Once the field worksheet (Part I) has been completed, summarize the measurements on the summary sheet (Part II) in preparation for calculating the habitat metrics. Use information from all transects and measurements in Part I, as well as from other sources, to complete this form. This summary is used primarily to calculate the habitat metrics but is also used in other areas of biological assessment, such as determining appropriate ALUs. The parameter codes for each habitat descriptor are listed in parentheses after each descriptor heading.

Streambed Slope

Using a USGS topographic map of the reach, measure the **change in elevation** between the first contour line crossing the stream upstream of the upstream reach boundary and the first contour line crossing the stream downstream of the downstream reach boundary. Convert to meters.

Divide this by the **length of the stream reach** in meters from Part I. Multiply by 1,000 to get m/km.

Example: 10 ft / 250 m = 3.048 m / 250 m × 1000 = 12.192 (1 ft = 0.3048 m)

For low-gradient streams or for short reach lengths, the reach may fall between two contour lines (see Figure 9.8). In these instances, determine the slope over the entire interval between the two contour lines that encompass the reach and assign that slope to the reach.

Drainage Area

Using GIS (or possibly either a USGS topographic map or a quarter-scale county highway map and a planimeter) determine the drainage area upstream of the furthest downstream transect. Record this area in square kilometers.

Stream Order

Using a USGS topographic map with a scale of 1 : 24,000, determine the stream-order classification. The smallest unbranched tributaries of a drainage basin (intermittent or perennial on the map) are designated *first-order streams*. Where two first-order streams join, a second-order stream is formed; where two second-order streams join, a third order stream is formed; and so on. Figure 9.9 depicts a typical stream-order pattern.

Length of Stream Evaluated

From Part I. Record it in meters.

Number of Lateral Transects Made

Record the number of transects measured in the stream reach. There will be anywhere from five to 11 transects, depending on the length of the reach.

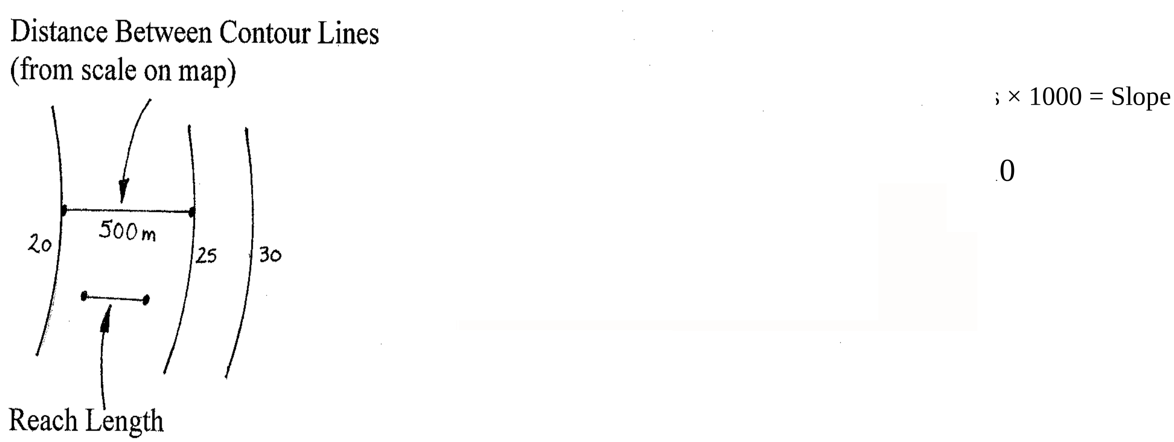

Figure 9.8. Streambed slope.

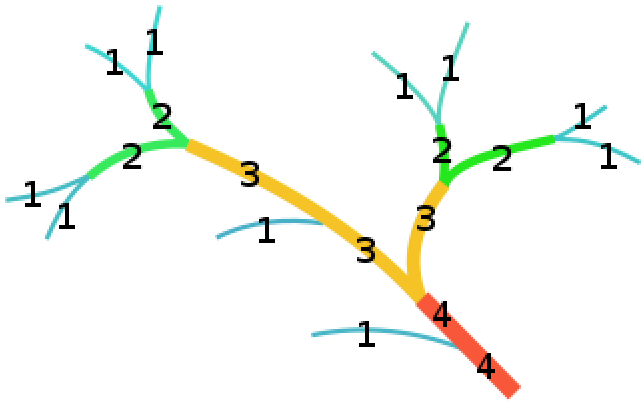

Figure 9.9. Stream order.

Average Stream Width

Average the stream width measurements from all transects. Record in meters.

Average Stream Depth

Average the individual stream depth measurements from all transects. For example, if there were five transects, with 10 depth measurements at each transect, calculate the average from all 50 individual depth measurements. Record it in meters.

Stream Discharge

Record the measured streamflow in the reach on the same day the transect measurements are made. It is preferable to measure flow in the field even if there is a USGS streamflow gauge nearby. Record in ft^3/sec.

Flow Measurement Method

Indicate the type of equipment used to measure flow.

Channel Flow Status

Record high, moderate, low, or no flow from Part I.

Maximum Pool Width

Record, in meters, the maximum width of the largest pool encountered in the reach. This is usually done when making general observations on the walk back after the last transect measurement.

Maximum Pool Depth

Record, in meters, the maximum depth of the largest pool encountered in the reach. This is usually done when making general observations on the walk back after the last transect measurement.

Total Number of Stream Bends

Record the sum of the following three sub-categories from Part I: well-defined, moderately defined, and poorly defined. These are usually tallied during the general observations. Additionally, record the number of bends in each bend category:

- well-defined bends
- moderately defined bends
- poorly defined bends

Total Number of Riffles

Record the number of riffles from Part I. These are usually tallied during general observations.

Dominant Substrate Type

Record the dominant substrate type from all transects in the reach. For example, if six transects were measured and four listed "sand" as the dominant substrate type and two listed "gravel" as the dominant substrate type, then "sand" would be recorded as the dominant type for the reach on Part II. If there is an even number of two types, use professional judgment to determine the most prevalent type.

Average Percent of Substrate Gravel-Sized or Larger

Average all percent gravel numbers recorded for each transect from Part I. Record as a percentage.

Average Percent Instream Cover

Average all percent instream cover numbers recorded for each transect from Part I. Record the average as a percentage.

Number of Instream Cover Types

Total the number of different types of instream cover such as macrophytes, gravel, snags, artificial, etc.

Average Percent Stream Bank Erosion Potential

Average the individual percent stream bank erosion determinations from all transects. For example, if five transects were made, and a left- and right-bank percent erosion was determined at each transect, the average is calculated from all 10 individual percent stream bank erosion numbers. Record the average as a percentage.

Average Stream-Bank Slope

Average the individual stream bank angle measurements from all transects. For example, if five transects were made, and a left and right bank-angle measurement was made at each transect, calculate the average from all 10 individual bank angle measurements. Record the average in degrees.

Average Width of Natural Buffer Vegetation

First, determine the minimum natural buffer vegetation width at each transect. Next, average the minimum widths for all transects in the reach.

Average Riparian Vegetation Percent Composition

Average the left and right bank determinations made in Part I for each category of vegetation type. For example, if the percent trees were 65 percent on the left bank and 40 percent on the right bank, record 52 percent for total percent trees. The total of all vegetation types equals 100 percent. Record average percent vegetation type as follows:

- average percent trees as riparian vegetation
- average percent shrubs as riparian vegetation
- average percent grasses as riparian vegetation
- average percent cultivated fields as riparian vegetation
- average percent other as riparian vegetation

Average Percent Tree Canopy Coverage

Average the individual percent tree canopy coverage measurements from all transects and record that value.

Overall Aesthetic Appraisal of the Stream

Record your assessment from Part I.

Part III—Habitat Quality Index

After completing the form summarizing physical characteristics of the water body (Part II), complete the HQI form (Part III) and calculate a total habitat score for the stream. Use the values from Part II and any field notes to score each metric. For example, if the average percent instream cover from Part II was 50 percent, the available instream cover metric would score a 3 as common. Once all metrics are scored individually, calculate the total score by adding all individual scores. The assigned habitat assessment category based on the HQI is as follows:

26–31	Exceptional
20–25	High
14–19	Intermediate
≤ 13	Limited

Assessing the Habitat of Non-Wadable Rivers and Streams

Streams are considered non-wadable if water depth in the stream channel prohibits wading and requires use of a flotation device (boat or tube) during normal flow conditions. Generally, these are streams of the fourth order or larger and are usually considered rivers. Riffle areas or low flow may render the stream accessible to wading in certain places or at certain times; however, the stream will still be considered non-wadable when determining reach length.

Determine the stream reach using GIS tools before heading into the field or by boating the stream for several kilometers to locate the areas where biological collections will be made. Determine an average stream width during this initial reconnaissance.

The reach length of a non-wadable stream should include one full meander of the stream channel, if possible, and two examples each of at least two types of geomorphic channel units.

The minimum reach length for a non-wadable stream is 500 m and the maximum length is 1 km. On some rivers, one full meander may be longer than 1 km. In other rivers, the channel may be dominated by only one geomorphic unit, such as a glide. In these cases, limit the reach length to 1 km with as many different types of geomorphic units represented as possible.

Non-Wadable Streams

For reach lengths of 500 m to 1 km, place six to 11 evenly spaced transects over the reach length and include the reach boundaries as transects. Select an appropriate number of transects no more than 100 m apart.

Assessing the Habitats of Lakes and Reservoirs

At this time guidance is limited on assessing the physical habitats of lakes and reservoirs for regulatory purposes. The HQI is designed for freshwater streams. Some of the HQI are not applicable to lakes and reservoirs. As habitat assessments become an important part of assessing biological integrity, a uniform approach to assessing the habitat of lakes and reservoirs will need to be developed.

Preliminary work has begun to determine what habitat attributes are important for reservoirs. Some of the attributes being studied include aquatic macrophyte coverage, shoreline habitat, human disturbance, and volumetric surveys. The EPA has a field operation manual for environmental monitoring and assessment for lakes (U.S. EPA 1997) and a guide to lake and reservoir bioassessment and biocriteria (U.S. EPA 1998) that provides guidance on how to conduct habitat assessment for Texas reservoirs.

Assessing the Habitat of Tidal Streams and Estuaries

There are no standardized guidelines for evaluating habitat in Texas tidal streams and estuaries. A recommended resource for habitat evaluation in larger (non-wadable) tidal streams is Section 6 of the EPA's EMAP protocol for non-wadable streams (U.S. EPA 2000).