Habitat Assessments associated with Bioassessments

ADEQ's Stream Ecosystem Monitoring field data sheets (FDS, Appendix A) provide ecological information needed to interpret macroinvertebrate bioassessments. These field forms provide for the collection of water chemistry and discharge data, field observations about the hydrology, biology and general condition of the stream reach, non-point source observations, a site sketch, photos, the ADEQ Habitat Assessment Index, Rosgen stream type classification, and riparian community assessment. The sum of all these data provide an ecological context in which to place the macro-invertebrate data. Causes and sources of biological impairment can be explained by the chemical physical, biological and land use information produced in this habitat assessment.

1. **Site information**

   The Stream Ecosystem Monitoring field data sheets (FDS) provides for the collection of locational information needed for data entry, mapping and general site information. Required information includes stream name and site description, date, time, Site code, field crew, program name, topographic map, latitude/longitude, ownership, elevation, watershed area, and predicted cross-sectional area of the channel. Optional information includes watershed name, HUC-reach number, upland vegetation formation, designated uses, site recommendations.

2. **Field measurements, observations & Sample collection information**

   a. Precipitation, cloud cover, air temperature, and field measurements of the water are recorded. There is room for 3 measurements of physicochemical parameters to allow for variations in measurements over space and time. Other information is also recorded, such as the water collection method, which samples were collected, and which analyses will be performed. There is a place for sample time and to check if a QC sample was collected.

   b. Bacteria values (E. coli)

   c. Stream habitat variables are selected as a decision matrix to inform the sampler when it is an appropriate time to sample.

   d. A discharge measurement is collected using one of three methods: USGS staff height, Marsh-McBirney method, and float method. There are other sampling methods which can be used for discharge, but these are the methods we most commonly employ (ADEQ, 1995; Harrelson, et al., 1994).

3. **Non-point source observations** - Sources of potential impairment must be identified as part of the bioassessment process. The non-point source codes used in the 305(b) water quality assessment process are presented for ease of use. Sources adjacent to the study reach as well as sources within the watershed are identified from visual observations in the field and from topographic maps or aerial photos.

4. **In-stream observations** - Narrative observations about the general stream condition can be

helpful in diagnosing potential problems. These observations consist of general appearance of the stream reach and streambank, water appearance and odor, presence of fish, especially sunfish and crayfish as well as hydrological information about flood or drought evidence, flow regime and water source. Biotic interactions by exotic species such as crayfish and sunfish are an important cause of impairment of the macro-invertebrate community and must be actively searched for in the field. Hydrological information is important for identifying flood or drought impacts, and ensuring that the stream is perennial prior to macroinvertebrate sample collection.

5. **Algae/macrophytes** - Observations about the percent cover by filamentous and diatomaceous algae and macrophytes can be very helpful for diagnosing nutrient problems and understanding the trophic structure of the macroinvertebrate community. Notes are collected on the percent cover of filamentous algae and macrophytes, the presence of floating algae mats and diatom cover, and the types of flora present in the study reach.
   a. Percent cover by filamentous algae is visually estimated for the whole study reach. Filamentous algae consists of green and blue-green algae that can form small tufts to large beards attached to substrates.
   b. Floating algae mats refers to clumps of green or blue green algae that detach because of the large quantity present in the stream due to nutrient enrichment. Sometimes floating mats will naturally occur in desert streams in summer or during drought conditions, when decaying late successional communities are present.
   c. Algal slime refers to the abundance of diatom cover on substrates. The diatom cover can be detected visually as a brown staining on cobbles and can be felt as a slippery coating of material on cobble.
   d. Macrophytes are generally found along the edge of water, but sometimes are found in shallow water or covering the stream bed (water grass). Percent cover of macrophytes within the wetted channel area is visually estimated for the study reach and is generally a low number unless there is nutrient enrichment.
   e. Identification of aquatic plants and algae species can be helpful in understanding nutrient cycling (eg. abundance of nitrogen fixing blue-green algae indicates that nutrients are bound up in vegetation and are not abundant in the water) and whether nuisance species of macrophytes are present. Hydrilla and Eurasian milfoil infest waterbodies and are difficult to eradicate. Identification guides are available. We currently use the following identification references:

      - How to Know the Freshwater Algae (Prescott, 1978)
      - U of Florida macrophyte key
      - Western Wetland Flora

6. **Site sketch** - A sketch of the stream reach provides a visual idea of the general habitat available to the macroinvertebrate community. The site sketch demonstrates the relative proportions of macro-habitats, such as riffle, run, and pool, as well as displaying micro-habitats

such as woody debris, leaf packs, macrophyte and algae beds, undercut banks and riparian vegetation. The sketch can also give clues to potential causes of impairment such as excess sediment in the form of side and mid-channel bars from cut banks or degraded tributaries. Be sure to scale the map to include the entire study reach, displaying floodplains, and terraces, features such as trees, rocks or flood debris. Also include the stream name, date, direction of stream flow, north arrow, cross-section pins, point bars, abandoned channels, and composite sample locations.

7. **Photo-documentation** - Photos are required to track changes in the channel over time and to demonstrate the substrate and channel conditions at the time of macroinvertebrate sampling. The camera and film type should be recorded in addition to the photo number corresponding the list of suggested photos to be taken. If there are cross-section benchmarks in the study reach, collect photos looking upstream, downstream and viewing each bank with the cross-section tape in view.

8. **Habitat Assessment Index** - While all the notes in the field data sheets are considered part of the broad level habitat assessment, ADEQ provides a specific substrate and bank habitat assessment. The habitat condition parameters were extracted from USEPA's visual based habitat assessment protocols described in the Rapid Bioassessment Protocols (Barbour et al., 1999) and USEPA's Environmental Monitoring and Assessment Protocols (Lazorchak et al., 1998).

   a. **Riffle habitat quality**

   Habitat quality within riffles is evaluated through a survey of the variety of natural structures within the stream reach, such as cobble, large rocks, woody debris, and undercut banks available for colonization by macroinvertebrates. A wide variety and abundance of submerged structures provides benthic macroinvertebrates with a large number of habitat niches, thus increasing community diversity. As the variety and abundance of cover decreases, the habitat structure becomes less complex, community diversity decreases, and the potential for community recovery after disturbance decreases.

   Complete the Segment habitat quality portion of the field form prior to conducting the habitat scoring. Walk a minimum distance of 100m or 25 times the bankfull width of the stream, identifying the relative abundance of each micro and macro-habitat. For warm water streams, give an optimal score if there are 2-3 habitats in the common to abundant categories, suboptimal if there are 2+ habitats with 1 abundant, marginal if there is sand common or abundant with 1 additional habitat, and poor if the habitat is dominated by abundant sand with possible algae or macrophytes present. For cold water streams, give an optimal score if there are 3+ habitats in the common to abundant categories, suboptimal if there are 2+ habitats with 1 abundant, marginal if there are 2+ habitats that are rare or common, and poor if the habitat is dominated by abundant sand with possible algae or macrophytes present.

b. Extent of riffle habitat

In addition to habitat quality, the quantity of the riffle habitat is also an important factor in the support of healthy biological communities in streams. Riffles should fill the width of the stream, extend twice the width in length, and contain an abundance of cobble to provide abundant habitat for maintenance of the macroinvertebrate community and support of the aquatic food web. Where cobble substrate is lacking, riffles are also lacking. In streams with excess sediment, riffles become homogenous sandy runs. Diverse macroinvertebrate communities cannot develop in sandy runs which lack interstitial spaces and which have constant bedload movement.

Complete the Riffle Geometry portion of the field form prior to conducting the habitat scoring. Mark the widths and lengths of 3 or more riffles in the study reach. Calculate the length to width ratios for each then calculate the average ratio. Use these data to score the Extent of Riffle Habitat.

c. Embeddedness in riffles

Embeddedness refers to the extent to which rocks (gravel, cobble, and boulders) and woody debris are covered or sunken into the silt, sand, or mud in stream riffles. Generally, as rocks become more embedded, the surface area available as habitat for macroinvertebrates decreases. Embeddedness is the result of an infusion of fine sediments from upland and stream bank erosion into stream substrates. Embeddedness is one of the best measures of excess bottom deposits that reduce interstitial spaces and available habitat for macroinvertebrates.

Complete the Embeddedness portion of the field form prior to conducting the habitat scoring. To calculate embeddedness, collect 100 measurements across multiple straight transects within the wetted width of riffle habitats where the macroinvertebrate sample was collected. Embeddedness measurements should be collected at the same time as the pebble count measurements for efficiency purposes. Collect particles at even increments across each transect. Measure particle embeddedness with a ruler or make a visual estimate of the percent that cobbles are embedded in the finer particles of the stream bottom. Begin and end transect at the edges of riffles. Count patches of gravel, sand, silt and clay as 100% embedded and bedrock and travertine as 0% embedded.

d. Sediment deposition

This parameter measures the amount of sediment that has accumulated on the stream bottom and in pools throughout the reach. This parameter is also an indicator of large-scale movement of sediment into a stream. Sediment deposition may cause the formation of side or mid-channel bars, enlargement of point bars, or may result in the filling of runs and pools. Usually sediment deposition is evident in areas that are obstructed by natural or manmade debris and in areas where stream flow decreases, such as bends. Large amounts of fine sediment deposition throughout the reach creates a homogenous, unstable, sandy substrate that is unsuitable for macroinvertebrate

colonization.

Complete the Depositional features and Riffle pebble count sections of the field form prior to conducting the habitat scoring. For the depositional features parameter, mark all categories that apply to the stream channel within the selected study reach. Keep in mind that A and B type streams generally don't have depositional features.

The riffle pebble count is a modified version of the Wolman pebble count (Leopold, et al. 1964). The purpose of the riffle pebble count is to evaluate whether a bimodal particle size distribution exists and to determine the amount of fine sediment in the substrate, affecting colonization space. The ADEQ riffle pebble count consists of measuring particles at equal increments across multiple straight transects within the wetted width of riffle habitats where the macroinvertebrates were collected to achieve an approximately 100 count of particles. Be sure to complete the last transect, even if 100 particles have already been collected.

Field staff should be familiar with Rosgen stream types (Rosgen, 1996) and be able to identify the stream type of the study reach (see following discussion of Stream Type Identification). The stream type is needed to evaluate whether excess sediment is present for that stream type and to determine whether the channel features are typical or not. There is more detailed discussion of bar features, bimodal particle size distribution, and excess sediment presented in each category of the sediment deposition parameter in the Habitat Assessment.

e. Bank stability

This habitat parameter evaluates stream bank stability within the active, bankfull channel and is an indicator of the source and amount of sediment contributing to sediment deposition in the stream. Stable, well vegetated banks with little erosion will maintain a stable geomorphic profile and adequate cobble habitat. Unstable banks are characterized by steep walls, unvegetated banks, exposed tree roots, and exposed soil. Unstable banks will erode during moderate flows, contributing large amounts of sediment to the stream bed.

This parameter is evaluated by visual estimation or measurement of the linear percent that each bank is eroding. Both bank scores are summed for the total bank stability score. A visual estimate of bank erosion for each bank can be determined from markings on the site sketch. To measure bank erosion, the length of eroding banks can be paced off or measured with a longitudinal profile tape, as a percentage of the total bank length. Any vertical bank (>45°) that is higher than bankfull is considered eroding. Bankfull height or depth is evaluated by field observation and through the use of the Arizona Regional Curves. See the following section on Stream Type Identification for more information.

f. **Habitat Assessment Index Scoring**

Scores for the five habitat parameters are summed for either a warm water or cold water index score. The habitat parameters are the same but the field assessment criteria are slightly different in the cold and warm water Habitat Assessment Indexes, allowing for the increased habitat diversity common in cold water streams. The five in-stream and bank habitat parameters are scored on a scale of 1 to 4, with higher scores indicating better condition. The habitat scores are summed for a total habitat score ranging from 5-20, with habitat improving with increasing scores. The Habitat Assessment Index score is then categorized as being good, impaired or very impaired, using the 25th percentile of ADEQ reference habitat assessment scores as the primary criterion and half of that value of 14 as the criterion for very impaired. The 25th percentile of reference method was selected because it is a conservative scoring criteria and allows for the natural variance among reference site scores. The range of values for each Habitat Assessment Category are shown in Table 1. The scoring criteria are the same for both the cold and warm water Habitat Assessment Indexes. If both the IBI score and Habitat Assessment Index score are impaired, then the biological impairment is determined to be associated with sediment and habitat impairment.

Table 1. Habitat Assessment Index categories for perennial, wadeable streams in Arizona.

Habitat Assessment Category	Good	Impaired	Very Impaired
Habitat Assessment Index Scores	15 - 20	8 - 14	0 - 7

9. **Rosgen Stream Type Identification**

a. Six stream types, letter codes A to G, were classified by Rosgen (1996). The stream type is determined from the following five variables: 1) entrenchment ratio, 2) bankfull width/depth ratio, 3) sinuosity, 4) slope, and 5) median particle size of the channel material. The following procedure describes methods for determining stream type without a rotating laser level, using the Arizona Regional Curves for cross-sectional area.

b. The Regional Curve is a series of regression lines on a log-log graph of watershed area vs. cross-sectional area of channels at bankfull (Moody and Odem, 1999). The curve is based on empirical data from 66 gaged and ungaged study sites, statewide and is a good broadscale tool for predicting the cross-sectional area and bankfull elevation you would expect to find at a study site of known watershed area. There are two regression lines; one for central and southern Arizona, and one for eastern Arizona and New Mexico. Apply the central and southern Arizona curve for streams in the Verde, Santa Cruz, San Pedro and middle/lower Gila Rivers. Apply the eastern Arizona and New Mexico curve to streams in the the upper Little Colorado River, upper Gila and Salt Rivers and their tributaries as well as streams in New Mexico.

c. To identify bankfull width and depth - Begin survey by walking the study reach, marking bankfull indicators with flag stakes for a stream reach length of 25 times bankfull width. This distance allows for study of two full meander lengths of the stream. Bankfull indicators include: top of point bars, a change in particle size, a slope break, a vegetation line, presence of a floodplain at the point of incipient flooding, undercut banks, or rock stains. At a representative riffle cross-section, run the measuring tape across the stream to the width identified as bankfull during the toothpick survey. Position the stadia rod in the thalweg, touching the measuring tape. Ensure that the tape is horizontal to the water surface. Determine maximum depth from the location where the tape touches the stadia rod.

d. To calculate cross-sectional area of the channel at bankfull elevation, the mean depth must be calculated. To do this, multiply the maximum depth by an appropriate correction factor; 0.4 for triangular shaped channels to 0.8 for rectangular shaped channels (Appendix B). Multiply the mean depth by bankfull width to calculate cross-sectional area. Compare this field calculated value with the regional curve value for that region (Appendix C). The field value should be similar, but not exactly matched, to the regional curve value. If not, look for and measure at a different bankfull value, or try to identify a reason why the area is different (such as a water diversion, impoundments in the watershed). ***Remember that the field observed bankfull indicators are more important than the regional curve value. Do not modify field measurements to fit the curves.***

e. To identify floodprone width, take a width measurement at 2 times the maximum bankfull depth, measured in the thalweg. The width measured at this elevation should be close to the correct floodprone width. Other field observations of floodplain indicators may be used as well. The field protocol for doing this is to maintain the stadia rod in the thalweg, then raise the tape to the Floodprone Depth and run the measuring tape out on both sides of the stream along the cross-section until earth is encountered. Ensure that the tape is horizontal to the water surface. The distance between the ends of the tape is Floodprone Width.

f. The five classification variables are calculated and Rosgen's classification chart used to identify the stream type.

- Entrenchment Ratio is calculated by dividing floodprone width by bankfull width.
- Bankfull width/depth ratio is calculated by dividing bankfull width by bankfull mean depth.
- Sinuosity can be calculated from an orthophotoquad or aerial photo.
- Slope can be calculated from a longitudinal profile of the stream bottom.
- The median particle size (D50) can be estimated from the riffle or reach pebble count cumulative percent data or from a graph of the cumulative percent by particle size class.
- Determine stream type by using Rosgen's classification chart and the classification variables calculated: Entrenchment Ratio, Bankfull Width/Depth

Ratio, sinuosity, slope, and median particle size. The classification chart can also be found in Applied River Morphology (Rosgen, 1996).

10. Riparian community assessment

a. **Vegetation cover** - Percent cover of different canopy layers of the riparian community is a semi-quantitative measure of riparian health. Record the percent cover of the overstory of riparian trees, the understory of shrubs, ground cover and barren ground within the floodprone width of the channel. Consider each vegetative layer separately with a score of 0-100 percent for each. Use the "Methods of measuring areal extent" provided on that page for visually estimating percent cover.

b. **Riparian associations and riparian species** - The riparian association indicates the broad biotic community or zone in which the site occurs. This is identified primarily by presence of riparian tree species and secondarily by elevation in which it occurs. Individual riparian species may also be listed or circled. Some riparian species identification guides include:

i.Shrubs and Trees of the southwest uplands (Elmore and Janish, 1976)
ii.Desert Plants: Riparian forest and scrubland community types of Arizona and New Mexico (Szaro, 1989)
iii.Trees of Arizona (Little, 1968; Brockman, 1968)
iv.Salicaceae: willow family key (Argus, 1995)
v.Willow quick ID guide (ADEQ)
vi.Riparian tree quick ID guide (ADEQ)

c. **Measuring Percent Canopy Density with the Spherical Densiometer**
Percent canopy density is measured with a Spherical Densiometer, manufactured by Forest Densiometers, Bartlesville, OK This procedure is discussed in "A New Instrument for Measuring Forest Overstory Density" by Paul E. Lemmon, 1957, Journal of Forestry 55(9)667-668. Measurements are taken at 3 cross-sections of the reach being assessed: 1) The uppermost end of the reach, 2) At mid-reach, and 3) The lowermost end of the reach. At each cross-section, four measurements are taken; 1) At right edge of water facing the right bank, 2) At mid-channel facing upstream, 3) At mid-channel facing downstream, and 4) At left edge of water facing the left bank. The field procedure is as follows:

i. At right edge of water while standing in the stream, facing the right bank, hold the instrument level 12 inches above the water surface and 12 inches from the edge of water. Your head should be just outside of the grid area and touching the top of the grid line. The bubble in the bubble level in the right corner should be centered. Black dots have been marked on the Densiometer at corners and grid intersections. Count the dots that are covered by vegetation and record that number on the field data sheet (Attachment A) in the appropriate location.

ii. Move to the center of the stream and face upstream. Hold the instrument level 12 inches above the water surface. Your head should be just outside of the

grid area and touching the top of the grid line. The bubble in the bubble level in the right corner should be centered. Black dots have been marked on the Densiometer at corners and grid intersections. Count the dots that are covered by vegetation and record that number on the field data sheet in the appropriate location.

iii. Repeat this procedure facing downstream at mid-channel.

iv. Repeat step 1 at the left bank except that you should face the left bank when taking the measurement.

v. Repeat steps 1 through 4 at mid-reach and again at the lower reach cross-section.

vi. On the field data sheet, sum the tallies for each column. Each column represents a cross-section. Sum the cross-section tallies and divide by 3 to obtain the mean number of points.

vii. If the stream order is less than 5, multiply the mean number of points by 1.5. This value is the percent canopy density. If the stream order is greater than or equal to 5, multiply the mean number of points by 0.75.

d. **Regeneration potential** - Observations of regeneration capacity aid in evaluating the health of the riparian community. A stressed community will exhibit reduced age class diversity, changes in percent cover, loss of species diversity and increased abundance of exotic species. To complete the regeneration potential table, record the presence of the 5 most common trees in 4 age classes; mature trees, young trees, saplings, and seedlings. The community is considered in best condition if tree species are abundant in 3 age classes. Use the scoring table given to evaluate riparian condition.

e. **Proper functioning condition (PFC) assessment** - This riparian condition assessment technique was adopted from the document "Process for assessing proper functioning condition"(BLM,1993). This is a visual based method used by professional biologists, hydrologists, and geomorphologists at the BLM to provide screening level assessments for riparian communities along stream reaches. ADEQ has developed Guidelines for completing the PFC checklist which aid staff in answering the 17 questions on the checklist. Several of the previous habitat measurements can be used to assist the evaluations, such as depositional features, pebble count, regeneration potential, and Rosgen stream type. If a "no" answer is given, a remark must also be given as to why. The number of yes and no answers on the checklist are used to summarize the overall condition into one of 6 categories: Proper functioning condition, Functional at risk/upward trend, Functional at risk/downward trend, Functional at risk/no apparent trend, Non-functional, and Unknown. There is no numeric scoring involved. Best professional judgement is used to determine the appropriate assessment category.

f. **Field observations** - Field observations can be helpful in identifying field conditions which may have affected the sample. Note hydrologic conditions, channel features, streambed structure, sedimentation issues, possible predators, comments on the riparian vegetation, or other notes about potential non-point sources, relocating the site, and any future recommendations for the study site.

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