# ADEQ
# BIOCRITERIA PROGRAM
# QUALITY ASSURANCE PROGRAM PLAN

## APPENDIX B:

Lawson, L.L., ed. 2005. Habitat Assessments Procedures, Section 3, Part C in *A Manual of Procedures for the Sampling of Surface Waters*. Arizona Department of Environmental Quality, TM05-01. Phoenix, AZ.

# SECTION 3

# PART C

# HABITAT ASSESSMENT PROCEDURES

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## 3.17 Habitat Assessments

The habitat assessment provides ecological information needed to interpret macroinvertebrate bioassessments. Habitat assessments are conducted by analyzing substrate, channel, riparian and other measures that are collected and recorded on ADEQ's Stream Ecosystem Monitoring (SEM) forms (Section 1.13.2) which are found at the end of this section. These field forms provide for the collection of water chemistry, 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 a riparian community assessment. The sum of all these data provide an ecological context in which to place the macroinvertebrate data. Causes and sources of biological impairment can be explained by the chemical physical, biological and land use information produced in the habitat assessment.

### 3.17.1 Site information

Page one of ADEQ's 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, and field crew. Optional information includes watershed name, HUC-reach number, upland vegetation formation, designated uses, and site recommendations.

### 3.17.2 Field measurements, Observations and Sample Collection Information

Precipitation, cloud cover, air temperature, and field measurements of the water should be recorded. There is space on the field data sheet for more than one measurement of physicochemical parameters to allow for variations in measurements over space and time. For sample collection information, record the water collection method, which samples were collected, which analyses will be performed, sample time and what kind of QC sample was collected, if any.

Bacteria analyses (*E. coli*) are recorded. The procedures for collection and analysis are found in Section 3.13.

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

A discharge measurement is recorded using one of four methods: flow meter method (Section 3.18.1), float method (Section 3.18.2), USGS staff height (Section 3.18.3), and volumetric method (Section 3.18.4). Other sampling methods can be found in Harrelson, et al., 1994.

### 3.17.2.1 Non-Point Source Observations

Sources of potential impairment must be identified as part of the bioassessment process. A list of non-point sources (Figure 1) as used in the 305(b) water quality assessment process are tabled. 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.

**Figure 1. Non-Point Source Codes.**

NON-POINT SOURCE CODES

Circle sources directly impacting the site, asterisk sources located in the watershed. Source Group is bolded, Category Code is italicized, and Sub-category Code is regular style font.

| Code | Source Category | Code | Source Category | Code | Source Category |
|---|---|---|---|---|---|
| **1000** | **Agriculture** *(Agriculture)* | 7350 | Upstream impoundment | 6600 | Hazardous waste storage/disposal |
| 1050 | Crop-related sources | 7400 | Flow regulation/Modification/Diversions | 8000 | Highway salt storage/use |
| 1100 | Non-irrigated crop production | 7550 | Habitat Modification | 8200 | Storage tank leaks |
| 1200 | Irrigated crop production | 7555 | Erosion materials from tributaries | 8250 | Underground storage tank leaks |
| 1300 | Specialty crop production | 7600 | Removal of riparian vegetation | 8275 | Above ground storage tank |
| 1350 | Grazing-related sources | 7700 | Streambank modification or destabilization | **0100** | **Wastewater** *(Industrial Point Source)* |
| 1400 | Pasture grazing - riparian and/or upland | 7750 | Highway/Road/Bridge-erosion or aggradation | 0110 | Major industrial point source |
| 1410 | Pasture grazing - riparian | 7800 | Drainage/Filling of wetlands | 0120 | Minor industrial point source |
| 1420 | Pasture grazing - upland | *7900* | *Marinas and recreational boating* | 0200 | Municipal point source |
| 1500 | Range grazing - riparian and/or upland | 7910 | Boating with in-water releases | 0210 | Major municipal point source |
| 1510 | Range grazing - riparian | 7920 | Boating with on-land releases | 0220 | Minor municipal point source |
| 1520 | Range grazing - upland | **5000** | **Mining** *(Resource extraction)* | 0230 | Package plants (small flows) |
| *1600* | *Intensive Animal feeding Operations* | 5075 | Active Mining operation | *0300* | *Other Wastewater* |
| 1620 | Concentrated Animal Feeding Operations point source/permitted) | 5100 | Surface Mining | 0400 | Combined system (sewage and stormwater) |
| 1640 | Confined animal feeding operations (non-point source | 5150 | Sand and gravel operations | 0500 | Collection system failure |
| *1700* | *Aquiculture/Fish Hatchery* | 5200 | Subsurface mining | 0900 | Sewage lagoons |
| **2000** | **Forestry** *(Silviculture)* | 5300 | Placer mining | 0975 | Reuse (Effluent to lakes, golf courses, artificial |
| 2100 | Harvesting, restoration (residue management) | 5400 | Dredge mining | 6500 | Septic systems |
| 2200 | Forest management (fertilization, pesticide use) | 5500 | Petroleum activities | 6700 | Septage disposal (e.g. from septic tank trucks) |
| 2300 | Logging roads | 5600 | Mill tailings | **8100** | **Other** (Atmospheric deposition) |
| 2500 | Clear cutting | 5650 | Mill or mine tailings | 8400 | Spills |
| 8610 | Wildfires or controlled burns | 5700 | Mine tailings | 8500 | Contaminated sediments |
| **3000** | **Hydro/Habitat Modification/Runoff** *(Construction)* | 5800 | Acid mine drainage | 8510 | |
| 3100 | Highway/Road/Bridge construction | 5900 | Abandoned mining operation | 8530 | |
| 3200 | Land development/Land clearing | 5950 | Inactive mining operation | 8540 | |
| *4000* | *Urban runoff/Stormwater sewers* | **8700** | **Recreation** (non-boating) | 8600 | |
| 4100 | Non-industrial (NPDES) stormwater runoff | 8710 | Golf courses | 8910 | |
| 4200 | Industrial (NPDES) stormwater runoff | 8720 | Camping/Campground recreation | Other Non-point Source Observations at the site or within the reach | |
| 4300 | Other urban runoff | 8730 | All terrain vehicles/Off road vehicles/Biking | | |
| 4400 | Illicit connections to stormwater sewers (dry weather flows) | **6000** | **Storage and Disposal** (Land disposal/Storage) | | |
| 4500 | Urban Highway/Road/Bridge runoff | 6100 | Sludge disposal/storage | | |
| *4600* | *Non-urban runoff/Erosion and sedimentation* | 6300 | Landfills | | |
| 8300 | Non-urban (highway/Road/Bridge Runoff/Maintenance) | 6350 | Inappropriate waste disposal/Wildcat dumping | | |
| *7000* | *Hydrological modifications* | 6400 | Industrial land treatment | | |

### 3.17.2.2 Reach Observations

Narrative observations about the general stream condition can be helpful in diagnosing potential problems. The 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 source of impairment of the macroinvertebrate community. Hydrological information is important for identifying flood or drought impacts, and ensuring that the stream is perennial prior to macroinvertebrate sample collection.

### 3.17.2.3 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.

- 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.
- Floating algae mats refers to detached clumps of green or blue green algae present in the stream. Large volumes of algae are usually an indication of nutrient enrichment. Sometimes floating mats will naturally occur in desert streams in summer or during drought conditions, when senescent communities develop.
- 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 rock surfaces.
- 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 is visually estimated for the study reach and is generally a low number unless there is nutrient enrichment.
- Identification of aquatic plants and algae species can be helpful in understanding nutrient cycling (e.g. 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)
    - University of Florida macrophyte key (Ramey, 1995)
    - Western Wetland Flora (Mohlenbrock et al., not dated)

### 3.17.2.4 Site sketch

A sketch of the stream reach provides a visual representation of the general habitat available to the macroinvertebrate community. The site sketch demonstrates the relative proportions of macro-habitats, such as riffles, runs, and pools. It should also display micro-habitats such as woody debris, leaf packs, macrophyte and algae beds, undercut banks, and riparian vegetation. The sketch can also present potential sources of impairment such as excess sediment in the form of side and mid-channel bars from cut banks or degraded tributaries. The map should be scaled to include the entire study reach, displaying floodplains, terraces, features such as trees, rocks or flood debris, the stream name, date, direction of stream flow, a north arrow, benchmarks, point bars, abandoned channels, and sample locations.

### 3.17.2.5 Photo Monitoring

Photos are required to track changes in the channel over time and to demonstrate the substrate and channel conditions at the time of sampling. See Section 3.17.11 for the photo monitoring procedure.

### 3.17.2.6 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 (eds.), 1998).

#### 3.17.2.6.1 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 habitat structure becomes less complex, the variety and abundance of cover decreases. Habitat loss leads to a decrease in community diversity, and the potential for community recovery lessens.

Complete the Habitat Assessment Field Data Sheet prior to conducting the habitat scoring. Walk a minimum distance of 100m or at least 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 sand is common or abundant with 1 additional habitat; 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; poor if the habitat is dominated by abundant sand with possible algae or macrophytes present.

#### 3.17.2.6.2 Extent of Riffle Habitat

In addition to habitat quality, the quantity of the riffle habitat is an important factor for the support of healthy biological stream communities. Good riffle habitat covers the width of the streambed, extends twice the width in riffle length, and is populated with an abundance of cobble. When present, these factors provide abundant habitat for maintenance of the macroinvertebrate community and support of the aquatic food web. Where cobble substrate is lacking, riffles may also be lacking. In streams with excess sediment, the interstitial spaces around the rocks fill with sand which converts the riffle to a sandy run. The lack of habitat in sandy runs prevent macroinvertebrate communities from developing.

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

#### 3.17.2.6.3 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. As rocks become more embedded, the surface area available as habitat for macroinvertebrates decrease. Embeddedness is the result of an infusion of fine sediments from upland and stream bank erosion into stream substrates. Embeddedness is one of the primary measures of excess bottom deposits.

Complete the Riffle Embeddedness portion of the field form prior to conducting the habitat scoring. Refer to the field data sheet for the Embeddedness calculation procedure. The sample transects should be traversed in the same location(s) as the macroinvertebrate samples. Collect particles at even increments across each transect. Visually estimate percent particle embeddedness. Begin and end transect at the edges of riffles. Count sand and fines as 100% embedded and bedrock, and hardpan as 0% embedded.

#### 3.17.2.6.4 Sediment Deposition

This parameter measures the amount of sediment that has accumulated on the stream bottom and in pools throughout the reach, and for 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 riffles and pools. Usually sediment deposition is evident in areas that are obstructed by natural or manmade debris and in areas where stream flow decrease, such as at 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 on 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 study reach of at least 25 times the bankfull width. Keep in mind that Rosgen A and B type streams are usually without 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. The ADEQ riffle pebble count consists of measuring particles at equal increments across multiple transects within the wetted width of riffle habitats where the macroinvertebrates were collected. The count objective is 100 particles. See Section 3.16.15 for pebble count procedures.

Field staff should be familiar with Rosgen stream types (Rosgen, 1996) and be able to identify the stream type of the study reach. The stream type is required to evaluate whether excess sediment is present for that stream type and to determine whether the channel features conform to the model for a stream type. There is additional discussion of bar features, bimodal particle size distribution, and excess sediment presented in each category of the sediment deposition parameter in Section 3.16.

#### 3.17.2.6.5 Bank Stability

The bank stability parameter evaluates 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, banks devoid of vegetation, exposed tree roots, and exposed soil. Unstable banks will erode during moderate flows, contributing large amounts of sediment to the stream bed.

Bank stability is evaluated by visual estimation or measurement of the percent of bank erosion for each bank. Both bank scores are summed for the total bank stability score. A visual estimate of bank erosion for each bank is determined from markings on the site sketch. To measure bank erosion, the length of eroding banks can be paced off or measured with a reel tape, as a percentage of the total bank length. Any bank height greater than bankfull height is considered to be eroding.

#### 3.17.2.6.6 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 6-24, 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 criterion. The $25^{th}$ 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 |

### 3.17.3 Rosgen Stream Type Identification

Six stream types, with associated 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
5) median particle size of the channel material.

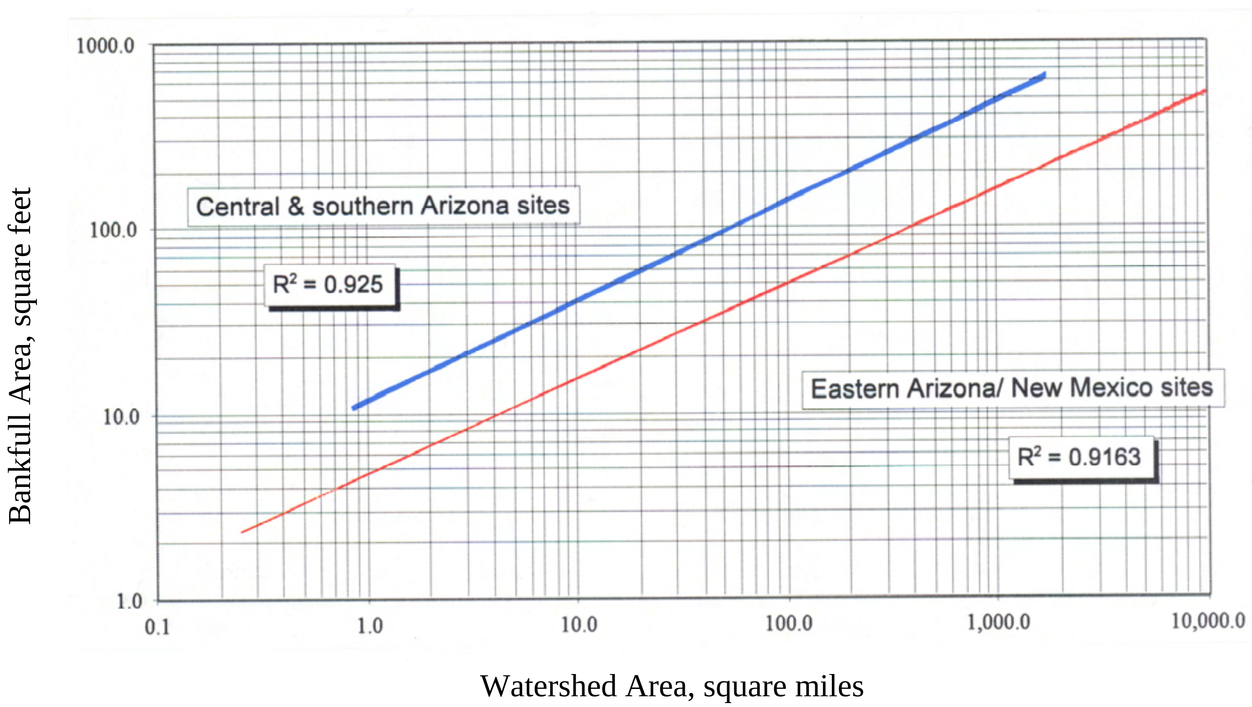
The following procedure describes methods for determining stream type without a rotating laser level, using the Arizona Regional Curves (Fig. 2) for determination of cross-sectional area.

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 gauged and ungaged statewide study sites, and is a good generic tool for predicting the cross-sectional area and bankfull elevation expected 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, and San Pedro and middle/lower Gila Rivers. Apply the eastern

Arizona and New Mexico curve to streams in the upper Little Colorado River, upper Gila and Salt Rivers and their tributaries.

1. Identifying bankfull width and depth - The first task is to make a “toothpick” survey by walking the study reach, marking bankfull indicators with flag stakes for a stream reach length of at least 25 times bankfull width. Bankfull indicators include: top of point bars, changes in particle size, slope breaks, vegetation lines, presence of a floodplain at the point of incipient flooding, undercut banks, or rock stains. Vegetation lines should be used with caution and are not good indicators at most elevations, but will sometimes confirm another indicator. At a representative riffle cross-section, run the measuring tape across the stream channel, and to the width identified as bankfull during the tooth-pick survey. Position the stadia or extendable rod in the thalweg against the measuring tape. Ensure that the height of the extended tape is horizontal to the channel or water surface. Determine maximum depth at the junction of the tape and the stadia rod.

**Figure 2. Regional Curves for Arizona and New Mexico.**




2. Cross-sectional area ($A_{bkf}$) of the channel at bankfull elevation can be derived from bankfull width ($W_{bkf}$) and mean depth ($\bar{d}_{bkf}$). Mean depth is calculated by multiplying the bankfull maximum depth ($D_{bkf}$) by the coefficient, 0.6. The product is then multiplied by $W_{bkf}$ to obtain cross-sectional area.

3. Compare this field calculated value against the appropriate regional curve value. The field value should be similar or close to the predicted value. The closeness is a best professional judgment. If the field value is very dissimilar from the predicted value,

there may be an explanation for the discrepancy. Typical explanations are an incorrect bankfull depth, a water diversion, or an impoundment in the watershed. If the issue cannot be resolved, use the field observed bankfull indicators to obtain cross-sectional area.

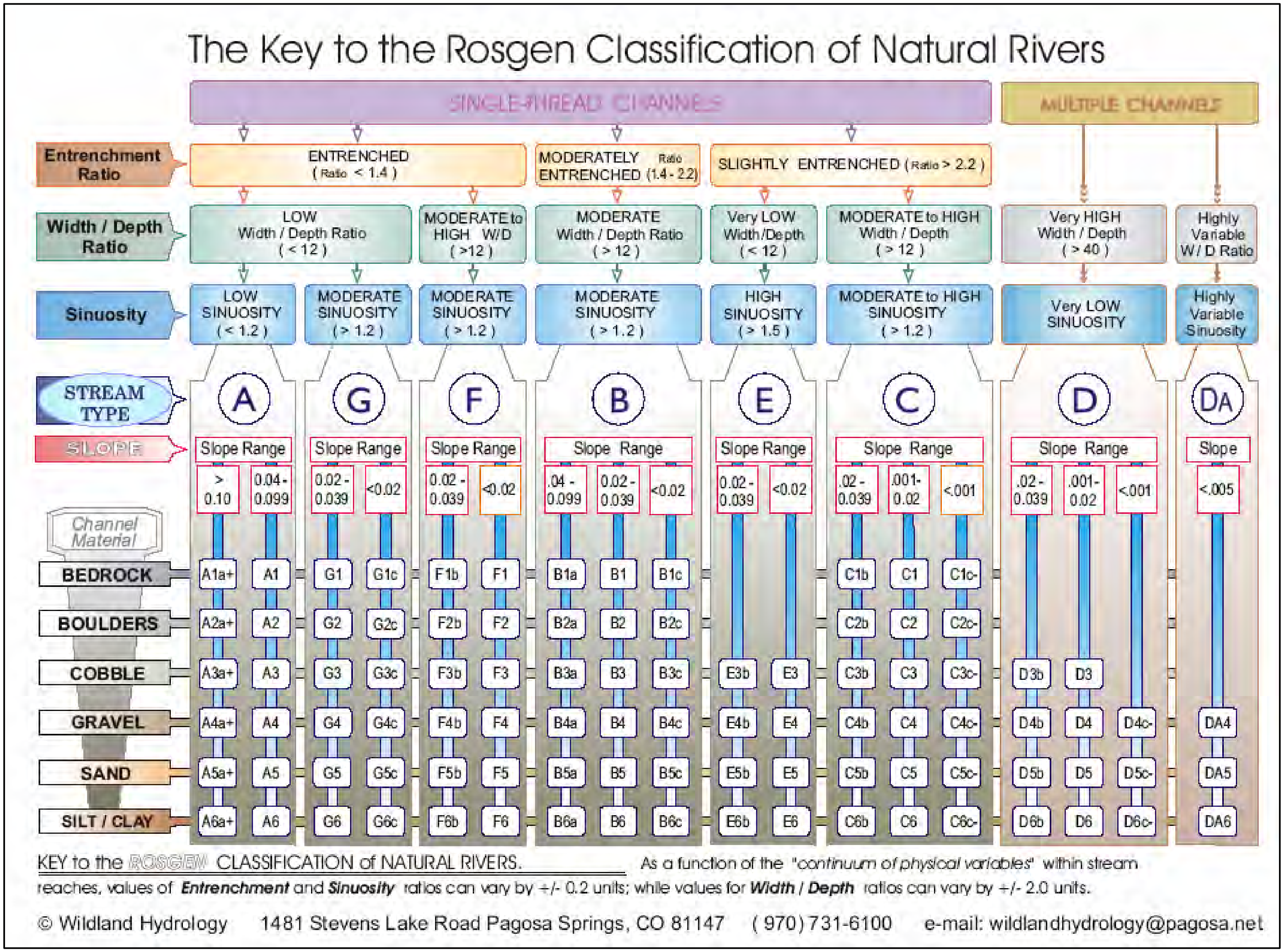
4. To identify floodprone width, take a width measurement at 2 times the maximum bankfull depth, measured in the thalweg. The width measured at this elevation should be close to the correct floodprone width. Other field observations of floodplain indicators may be used as well. The field protocol for doing this is to maintain the stadia or telescoping 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 or streambed if ephemeral. The distance between the two ends is the measured Floodprone Width.

5. The five classification variables are calculated and Rosgen's classification chart is 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 ($D_{bkf} = A_{bkf} / W_{bkf}$; where $D_{bkf}$ is bankfull mean depth, $A_{bkf}$ is bankfull area, and $W_{bkf}$ is bankfull width)
   - Sinuosity can be calculated from a topographical map for the study reach.
   - Slope can be calculated from a topographical map for the study reach,or if available, a longitudinal profile of the streambed
   - 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

6. Determine stream type by using Rosgen's classification chart (Figure 3) and the five classification variables. The classification chart can also be found on page 5-6 in Applied River Morphology (Rosgen, 1996).

**Figure 3. Rosgen stream type classification chart.**



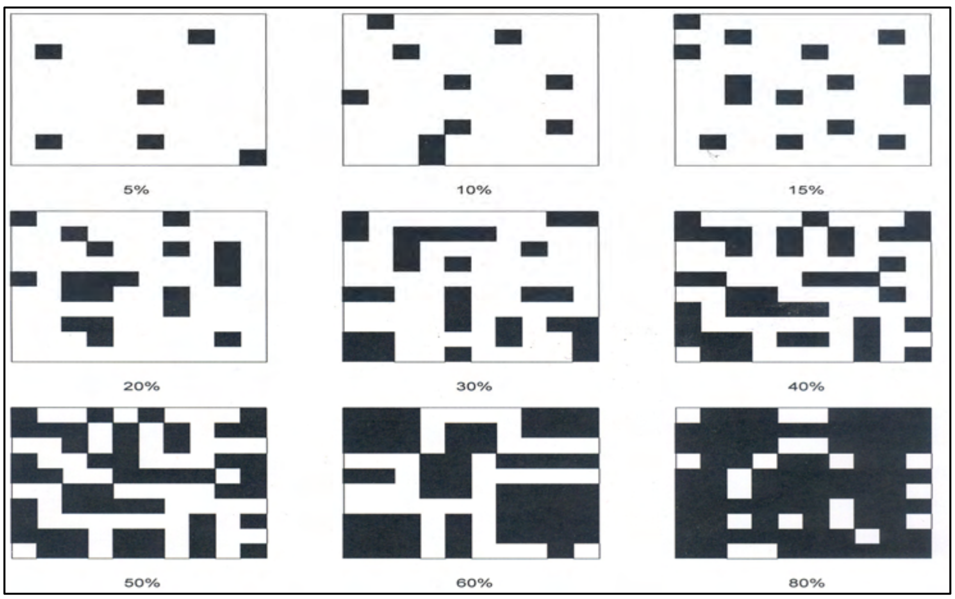
### 3.17.4 Riparian Community Assessment

The riparian community assessment is comprised of the estimate of vegetation cover and the observations of riparian associations and riparian species.

#### 3.17.4.1 Vegetation Cover

Estimating percent cover of different canopy layers of the riparian community is a semi-quantitative measure of riparian condition. Record the estimated percent cover of the overstory of riparian trees, the understory of shrubs, ground cover and barren ground. Consider each vegetative layer separately with a score of 0-100 percent for each. Use the "Methods of measuring areal extent" provided on the field data sheet for visually estimating percent cover (Figure 4).

**Figure 4. Figure used for estimating percent areal cover.**




#### 3.17.4.2 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 on the field data sheet page. Some riparian species identification guides include:

- ❖ Shrubs and Trees of the southwest uplands (Elmore and Janish, 1976)

- Desert Plants: Riparian forest and scrubland community types of Arizona and New Mexico (Szaro, 1989)
- Trees of Arizona (Little, 1968; Brockman, 1968)
- Salicaceae: willow family key (Argus, 1995)
- Willow quick ID guide (ADEQa)
- Riparian tree quick ID guide (ADEQb)

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### 3.17.5 Measuring Percent Canopy Density with the Spherical Densiometer

Percent canopy density is measured with a Spherical Densiometer, manufactured by Forest Densiometers, Bartlesville, OK   Section 3.17.10 details the procedure for measuring percent canopy density.

### 3.17.6 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 five most common trees in four age classes; mature trees, young trees, saplings, and seedlings.  The community is considered in best condition if tree species are abundant in three age classes.  Complete the assessment of riparian condition by filling out the scoring table (Table 2) given on the Stream Ecosystem Monitoring Field Data Sheets.

**Table 2. Regeneration Potential of Riparian Trees.**

| Regeneration Potential of Riparian Trees | | | | | |
|---|---|---|---|---|---|
| Species | | Mature Trees>16" @ 3 ft height | Young Trees~1 ¼" @ 3 ft. height | Saplings< 1 ¼" | Seedlings New growth |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |

| Age Classes of the Dominant Riparian Tree Species | | | | | | | |
|---|---|---|---|---|---|---|---|
| ☐ | Species abundant in 3 age classes | ☐ | Abundant in 2 age classes | ☐ | One age class present | ☐ | No regeneration evident, few mature trees present, no saplings or seedlings, or if present, they are heavily grazed |

### 3.17.7 Proper Functioning Condition (PFC) Assessment

Proper Functioning Condition (PFC) is a qualitative method for assessing the condition of riparian-wetland areas (Prichard et al,1993). The term PFC is used to describe both the assessment process, and a defined, on-the-ground condition of a riparian-wetland area.

The PFC assessment refers to a consistent approach for considering hydrology, vegetation, and erosion/deposition (soils) attributes and processes to assess the condition of riparian-wetland areas. A checklist is used for the PFC assessment which synthesizes information that is essential for determining the overall health of a riparian-wetland system. The on-the-ground condition termed PFC refers to how well the physical processes are functioning. PFC is a state of resiliency that will allow a riparian-wetland area to hold together during high-flow events with a high degree of reliability. This resiliency allows an area to produce desired values, such as fish habitat, bird habitat, or forage, over a period of time. Riparian-wetland areas that are not functioning properly cannot sustain these values.

PFC is a qualitative assessment based on quantitative science. The PFC assessment is intended to be performed by an interdisciplinary team with local, on-the-ground experience in the kind of quantitative sampling techniques that support the PFC checklist. These quantitative techniques are encouraged in conjunction with the PFC assessment for individual calibration, where answers are uncertain, or where experience is limited. PFC is also an appropriate starting point for determining and prioritizing the type and location of a quantitative inventory or monitoring.

The PFC form consists of a set of guidelines for filling out the checklist (Figure 5 and 6). The guidelines are from BLM training courses and training materials. The guidelines should accompany the checklist into the field and be referred to as the checklist is being filled out by the assessment team.

Several of the field data sheet habitat measurements should be used to assist the PFC evaluations, such as depositional features, pebble count, regeneration potential, and Rosgen stream type. If a “No” answer is given for any of the PFC items, a remark must be given that describes the condition. The number of yes and no answers on the checklist are used to summarize the overall condition into one of six 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 judgment is used to determine the appropriate assessment category.

### 3.17.8 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.

**Figure 5. Guidelines for Completing the PFC Checklist.**

GUIDELINES FOR COMPLETING THE PFC CHECKLIST

General guidance: If 75% or more of stream reach is PFC, classify entire reach as PFC. All "No" answers must have comments in notes section. Answers can go on the line between "Yes" and "No", but consider it a "No" and comment in notes section.

Q1. Instantaneous peak flows don't count. Inundation means to bankfull depth. Bankfull can be identified from top of the point bars, changes in vegetation, topographic break in slope, change in size of bank materials, evidence of an inundation feature such as small benches, exposed root hairs below an intact soil layer indicating exposure to erosive flow, and bank undercuts. "No" if channelization or entrenchment. "N/A" if a "V"-canyon without floodplain development.

Q2. Usually "N/A", but may be applicable at high altitude sites; also, consider the present environment (could they be present).

Q3. Based on the stream type expected & the regional curves, all three features must be present for a "YES". Use bankfull width, not wetted width. "NO" if straightness, excessive sediment, or entrenched channel.

Q4. Widening can mean encroaching on the channel as well as moving toward the terraces. The age of the vegetation in an indicator. "NO" if upland species encroaching on the floodplain or Kentucky bluegrass present. "YES" if recruitment of wetland/riparian species on new landforms. "N/A" if an A1 stream type.

Q5. Need to look at upland ground cover and erosion signs (e.g. plants on pedestals, debris dams around plants, rills, gullies). "NO" if side channel and mid-channel bars, gullies, fan shaped deposits from tributaries, braided channels, overloading of point bars, or cementing of streambed.

Q6. "YES" if 3 age classes (mature, young, saplings) present for a single species, or young and sapling classes if recruitment & replacement is occurring, or dense matting of herbaceous riparian/wetland plants. "NO" if individual plants. "N/A" if A1 Stream Type.

Q7. Maintenance means recruitment. Is it occurring? "YES" if several different species present (e.g. willows, rushes, sedges). It depends on the elevation and the potential natural community that might be present if all constraints are removed. In some environments, 2 species could be a "YES". Usually "NO" if 1 species present.

Q8. "YES" if sedges, rushes, willows, seep willows, alders, cottonwoods, etc. Don't consider quantity. Do you see any at all?

Q9. A high stream flow event is one that occurs once in 25-30 years. Q9 is similar to Q*, but you are now looking for quantity. "NO" if presence of upland species. "YES" if willows, alder, aspen, birch, cottonwood, sedge, rush, bulrush, and wetland grasses.

Q10. Are the plants healthy and dense? "NO" if yellow leaves, stunted plants, many dead stems and branches, a thin crown, infested with insects, diseased, or grazed down by browsers.

Q11. This is a quantity question. Use 80% cover as a guide. Look for riparian plants, herbaceous cover, salt cedar (tamarisk), seep willows, etc. "NO" if "NO" on Q9. If Q6-Q10 are "NO", this is probably a "NO".

Q12. "N/A" for meadows, desert streams, and probably intermediate elevation streams, or sedge/grass community streams. "YES" if fallen trees. For some locations consider living and dead trees and trees along banks out of the water.

Q13. "YES" if large boulders, roughness of the floodplain, large trees & dense vegetation along stream banks. "NO" if incision & no access of stream to floodplain.

Q14. "YES" if sedge/rush components. Consider potential, height and newness of the point bar. Sandy soils don't hold water well and there may be no potential for revegetation. A1 Stream Type is "N/A".

Q15. "NO" if straight channel, not confined geologically, and channel movement with every high flow event. "YES" if single channel, stable banks (especially on straight segments), & natural deposition.

Q16. "NO" if entrenchment, down cutting (some is natural), excessive aggradation, unstable vertical banks. "YES" if streambed is armored with large rock, bedrock, heavy gravel. Don't consider old down cutting. If a bedrock stream then "N/A".

Q17. "NO" if excessive sediment from side drainages, excessive aggradation, mid-channel bars, braiding, or unstable banks. "NO" if Q5 is "NO".

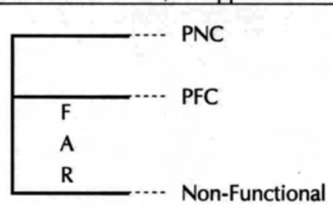
**Figure 6. PFC Field Worksheet.**

**Proper Functioning Condition Worksheet**

| Yes | No | N/A | Hydrologic |
|---|---|---|---|
| | | | 1) Flood plain inundated in "relatively frequent" events (1-3 years) |
| | | | 2) Active/stable beaver dams |
| | | (shaded) | 3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region) |
| | | | 4) Riparian zone is widening or has achieved potential extent. |
| | | | 5) Upland watershed not contributing to riparian degradation |
| | | | **Vegetative** |
| | | | 6) Diverse (3) age structure of vegetation (Recruitment for maintenance/recovery) |
| | | | 7) Diverse composition of vegetation (For maintenance/recovery) |
| | | | 8) Species present indicate maintenance of riparian soil moisture characteristics |
| | | | 9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events |
| | | | 10) Riparian plants exhibit high vigor |
| | | | 11) Adequate vegetative cover present to protect banks and dissipate energy during high flows |
| | | | 12) Plant communities in the riparian area are an adequate source of coarse and/or large woody debris |
| | | | **Erosion Deposition** |
| | | (shaded) | 13) Flood plain and channel characteristics (i.e., rocks, coarse and/or large woody debris) adequate to dissipate energy |
| | | | 14) Point bars are revegetating |
| | | (shaded) | 15) Lateral stream movement is associated with natural sinuosity |
| | | (shaded) | 16) System is vertically stable |
| | | (shaded) | 17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition) |

**Functional Rating**

| | | | |
|---|---|---|---|
| ☐ | Proper Functioning Condition | ☐ | Functional at risk, downward trend |
| ☐ | Functional at risk, upward trend | ☐ | Non-Functional |
| ☐ | Functional at risk, no apparent trend | ☐ | Unknown |




PFC Remarks

Use reverse side for additional comments.

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**Figure 7. Stream Ecosystem Monitoring Field Data Sheets.**

WQDB Site Number:________________

ADEQ Arizona Department of Environmental Quality

Stream Ecosystem Monitoring
Field Data Sheets

Site Code______________________________ Date________________ (MM/DD/YYYY) Water Sample Time ________

Site Name__________________________________________________________ Field Crew_________

GPS: Latitude______________________________ Longitude__________________________________

| Entered: | Approved: |
|---|---|

| Meter Results | | | | | |
|---|---|---|---|---|---|
| *E. coli* | | cfu/100 ml | TDS | | mg/L |
| Air Temp | | °C | Conductivity | | µmos/cm |
| Water Temp | | °C | pH | | SU |
| Dissolved Oxygen | | mg/L | Turbidity | Average = <br> Signal Avg. = | NTU |
| % D.O. | | % | | | |
| Deviations from SOP | | | | | |

| Field Calibrations – Hydrolab and Turbidity Meter | | | | |
|---|---|---|---|---|
| % D.O. → | Precal Reading = <br> Postcal reading = | Barometric Pressure: inches Hg = | X 25.4 = | mm Hg |
| Turbidity → | Standard = | Standard solution reading = | % Difference = | |

| Sample Collection Information | | | | |
|---|---|---|---|---|
| Sample Method | | Quality Control | | Bottle Label Identification |
| Equal Width Increment (EWI) | | Equipment Churn Blank | | |
| Modified EWI | | Sample Split | | |
| Equal Discharge Increment | | Sample Duplicate | | |
| Grab | | DI Blank | | |
| If Grab Sample - distance (1/4, 1/3, ½, etc.) from REW = ____________; | | | | Taken from – run ☐ pool ☐ riffle ☐ |
| DRY CHANNEL ☐ | | | | PONDED WATER – NO FLOW ☐ |

| Photo Reach Monitoring Log | | | | | | Prints ☐ Digital ☐ |
|---|---|---|---|---|---|---|
| Camera Make: | | Model: | | DEQ Name: | | |
| | Upstream looking downstream | Downstream looking upstream | | X-sec @ discharge location LDS | | |
| | Upstream RB cross-section | Downstream RB cross-section | | X-sec @ discharge location LUS | | |
| | Upstream LB cross-section | Downstream LB cross-section | | | | |
| | Upstream riffle substrate | Downstream riffle substrate | | | | |

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## Flow Measurements

Marsh-McBirney Flow Meter

Measurement from: riffle ☐ run ☐ pool ☐

| Station | Distance from Initial Pt., ft. | Width, ft. | Depth, ft. | Velocity, ft/s | Discharge, cfs |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |
| 11 | | | | | |
| 12 | | | | | |
| 13 | | | | | |
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| 15 | | | | | |
| 16 | | | | | |
| 17 | | | | | |
| 18 | | | | | |
| 19 | | | | | |
| 20 | | | | | |
| 21 | | | | | |
| 22 | | | | | |
| 23 | | | | | |
| 24 | | | | | |
| 25 | | | | | |
| 26 | | | | | |
| 27 | | | | | |
| 28 | | | | | |
| 29 | | | | | |
| 30 | | | | | |
| | Total Width | QC width | Average | Average | Total Q |
| | | | | | |

| From USGS Gage | |
|---|---|
| USGS Gage Height = | USGS Discharge = |

| Float Method Discharge Measurement | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Timed Measurements, seconds | | | | | | | | | | Avg. Time |
| | | | | | | | | | | |
| Width, ft | X | Depth, ft | X | Dist., ft | X | Velocity, fps | X | 0.85 | = | Discharge, cfs |

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| Albion Sample Documentation | | | | | |
|---|---|---|---|---|---|
| Metals | Composite ___ | ; Grab ___ | ; Blank ___ | ; Duplicate ___ | ; Split ___ |
| Hg | Composite ___ | ; Grab ___ | ; Blank ___ | ; Duplicate ___ | ; Split ___ |
| Deviations from 1669 protocol: | | One person only processing the complete sample ☐ | | | Re-used clean box ☐ |
| Delayed filtration/processing (not at site) ☐ | | | Processed without a clean box, exposed to ambient atmosphere ☐ | | |
| No gloves or insufficient clean supplies (e.g. filter clogging, no replacement available) ☐ | | | | | Other ☐ |
| Comments: | | | | | |

| *E. Coli* | | |
|---|---|---|
| Collection Time ___ | Distance (1/4, 1/3, ½, etc) from REW ___ | From run ☐; riffle ☐; pool ☐ |
| Incubation Period is 24 hours for membrane filter technique and 18 hours for colilert technique | | |
| Beginning Incubation Time ___ ; Enumeration Time ___ | | |

| Membrane Filter Results | | | | | |
|---|---|---|---|---|---|
| Dilution, ml | Number of colonies | Dilution Used in Calculation | Quality Control | | |
| | | ☐ | | Pass | Fail |
| | | ☐ | Equipment Blank | ☐ | ☐ |
| | | ☐ | Technique Blank | ☐ | ☐ |
| Calculated Colony Forming Units/100 ml ⇨ | | | Comments: | | |

| Colilert Results | | | |
|---|---|---|---|
| Sample Number | Number Large Wells Positive | Number Small Wells Positive | Most Probable Number form Table |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| Average Most Probable Number = | | cfu / 100 ml | |
| Comments | | | |

| Field Meter Documentation | | | |
|---|---|---|---|
| Meter Type | Model | Serial Number | DEQ Name |
| Hydrolab | | | |
| Turbidimeter | | | |
| Incubator | | | |
| Flow Meter | | | |
| Camera Make : | | | |
| Chlorine Colorimeter | | | |
| Laser Level | | | |

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| Field Conditions at Time of Visit | | | |
|---|---|---|---|
| Flood Evidence within Last Month | | | |
| 1. None ☐ | 2. Fresh debris line in channel above bankfull elevation ☐ | 3. Grasses laid over ☐ | |
| 4. Fresh debris line in bushes/trees ☐ | 5. Other ☐ | 6. Drought conditions prevailing ☐ | Flood width________ |
| 7. Recent flood event greater than baseflow but less than bankfull ☐ | 8. Riparian vegetation scoured away ☐ | | |
| Weather Conditions : | | | |
| Precipitation at sample time : None ☐; Light ☐; Moderate ☐; Heavy ☐; Cloud Cover (%) = | | | |
| Previous Precipitation (w/in 24 hrs.) : None ☐; Light ☐; Moderate ☐; Heavy ☐ | | | |

| Reach Observations | | | |
|---|---|---|---|
| General appearance in the channel (check all that apply) (GAS) | No refuse visible ☐; Small refuse visible ☐; Small volume refuse common ☐; large volume refuse (tires, carts) rare ☐; large volume refuse common ☐ | | |
| General appearance along the banks (check all that apply) (GAB) | No refuse visible ☐; Small refuse visible ☐; Small volume refuse common ☐; large volume refuse (tires, carts) rare ☐; large volume refuse common ☐ | | |
| Water Clarity (WAP) | Clear ☐; Milky ☐; Light brown ☐; Dark brown ☐; Oily sheen ☐; Greenish ☐; Other________ | | |
| Water odor (check all that apply) (WOD) | None ☐; Sewage ☐; Chlorine ☐; Fishy ☐; Rotten eggs ☐; Other________ | | |
| Appearance at water's edge (check one) (AWE) | No evidence of salt crusts ☐; White crusty deposits rare ☐; Numerous white crusty deposits ☐; banks covered with white crusty deposits ☐ | | |
| Fish presence | Absent ☐; | rare ☐; | Common ☐ |
| Crayfish presence | Absent ☐; | rare ☐; | Common ☐ |
| Sunfish presence | Absent ☐; | rare ☐; | Common ☐ |
| Leopard frog presence | Absent ☐; Number observed alive ______; Dead______ | | |
| Floating leaves or other organic mater (not algae) | Absent ☐; | rare ☐; | Common ☐ |
| Leaves or other organic matter on streambed | Absent ☐; | rare ☐; | Common ☐ |

| Organic Debris / Channel Blockages in Active Channel | | | |
|---|---|---|---|
| ☐ | 1. No organic debris or channel blockages | ☐ | 6. Extensive, large debris dams either continuous or influencing over 50% of channel area. Forces water onto flood plain even with moderate flows. Generally presents a fish migration blockage. |
| ☐ | 2. Infrequent debris, what's present consists of small, floatable organic debris. | ☐ | 7. Beaver dams. Few and/or infrequent. Spacing allows for normal stream/flow conditions between dams. |
| ☐ | 3. Moderate frequency, mixture of small to medium size debris affects less than 10% of active channel area. | ☐ | 8. Beaver dams - Frequent. Back water occurs between dams - stream flow velocities reduced between dams. |
| ☐ | 4. Numerous debris mixture of medium to large sizes - affecting up to 30% of the area of the active channel. | ☐ | 9 .Beaver dams - abandoned where numerous dams have filled in with sediment and are causing channel adjustments of lateral migration, evulsion, and degradation etc. |
| ☐ | 5. Debris dams of predominantly large material affecting <u>over</u> 30% to 50% the channel area and often occupying the total width of the active channel. | ☐ | 10. Man made structures - diversion dams, low dams, controlled by-pass channels, baffled bed configuration with gabions, etc. |

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| Flow Regime | |
|---|---|
| ☐ | Perennial stream channel. Surface water persists all year long |
| ☐ | Intermittent stream channel. One which flows only seasonally or occasionally. Surface source includes springs, snow melt, and flows that reappear along various locations of a reach, then run subterranean (interrupted) |
| ☐ | Subterranean stream channel. Flows parallel to and near the surface for various seasons |
| ☐ | Ephemeral stream channel. Flows only in response to precipitation |
| **Category** | |
| ☐ | Seasonal variation in stream flow dominated primarily by snowmelt runoff |
| ☐ | Seasonal variation in stream flow dominated primarily by stormflow runoff |
| ☐ | Uniform stage and associated stream flow due to spring fed conditions |
| ☐ | Regulated stream flow due to diversions, dam releases, dewatering, effluent dominated, etc. |
| ☐ | Altered flows due to development, such as urban streams, cut-over watersheds, vegetation conversions (e.g. forested to grassland) that changes flow response to precipitation events |

**Stream Type Identification**

Walk the reach and flag all likely bankfull indicators. Select the riffle with the best bankfull indicators to collect measurements. A measuring tape, stadia rod, and calculator are sufficient, although a laser level can also be used. Calculate the classification variables and use Rosgen stream type classification chart to identify stream type.

| | | Valley Type | | | | |
|---|---|---|---|---|---|---|
| Watershed Area: | | ☐ I | ☐ III | ☐ V | ☐ VII | ☐ IX |
| Predicted Cross-section Area: | | | | | | |
| Which regional curve used? | ☐ Central / Southern<br>☐ Eastern AZ / New Mexico | ☐ II | ☐ IV | ☐ VI | ☐ VIII | ☐ X |

**Measurements for Determining Stream Type**

| Measurement | Riffle Cross-section #1 | Riffle Cross-section #2 | | Bankfull Indicators Used |
|---|---|---|---|---|
| Bankfull Width | | | ☐ | Top of point bars |
| Bankfull Max. Depth | | | ☐ | Change in particle size |
| Correction Factor | | | ☐ | Slope break |
| Bankfull Mean Depth | | | ☐ | Vegetation line |
| Cross-sectional Area | | | ☐ | Rock stains |
| Floodprone Width (2x BKF max depth) | | | ☐ | Undercut banks |
| STREAM TYPE = | | | ☐ | Presence of a floodplain at the elevation of incipient flooding |

**Notes/Comments**

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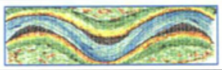
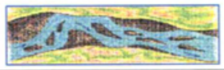
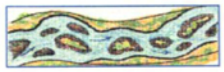
| Depositional Features | | | |
|---|---|---|---|
| Check off the feature that is most appropriate for the reach condition. | | | |
| ☐ 1. Point Bars |  |  | ☐ 5. Diagonal Bars |
| ☐ 2. Point Bars with Few Mid-Channel Bars |  |  | ☐ 6. Main Channel Branching with Numerous Mid-Bars and Islands |
| ☐ 3. Numerous Mid-Channel Bars |  |  | ☐ 7. Side Bars and Mid-Channel Bars with Length Exceeding 2 to 3 times Channel Width |
| ☐ 4. Side Bars |  |  | ☐ 8. Delta Bars<br>☐ 9. NO bars |
| Illustrations from D. Rosgen, 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, CO. | | | |

| Segment Habitat Quality | | | | |
|---|---|---|---|---|
| Segment length equals 2 meander lengths or 20-30 times bankfull width of the stream. Use a minimum 300-feet reach to identify habitat types for large streams or rivers. | | | | |
| Cobble | Absent ☐; | rare ☐; | Common ☐; | Abundant ☐ |
| Undercut banks | Absent ☐; | rare ☐; | Common ☐; | Abundant ☐ |
| Leaf packs | Absent ☐; | rare ☐; | Common ☐; | Abundant ☐ |
| Root masses | Absent ☐; | rare ☐; | Common ☐; | Abundant ☐ |
| Macrophyte beds | Absent ☐; | rare ☐; | Common ☐; | Abundant ☐ |
| Submerged logs / snares | Absent ☐; | rare ☐; | Common ☐; | Abundant ☐ |
| Sand dominated substrate | Absent ☐; | rare ☐; | Common ☐; | Abundant ☐ |
| Filamentous algae beds | Absent ☐; | rare ☐; | Common ☐; | Abundant ☐ |

| Reach Channel / Habitat Complexity | | |
|---|---|---|
| Reach length equals 2 meander lengths or 20-30 times bankfull width. Use minimum of 300 foot reach to identify habitat types for large streams | | |
| Habitat | Number of paces | Total |
| Pool | | |
| Riffle | | |
| Run | | |
| Riffle / Run Ratio = | | |

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| Site Sketch |
|---|
| Include location of riffles, pools, snags, submerged logs, undercut banks, areas of stable cobble habitat, type of bar formations, location and types of riparian vegetation, and areas with cut or eroding banks. Pace off length of eroding banks, length and width of riffles. |
| |

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## Decision Criteria for Sampling Macroinvertebrates

The target stream habitat for collecting macroinvertebrates must be wadeable, perennial, contain riffle or run habitat, must contain heterogenous substrates, and must be sampled during the spring index period. Spring index period is April - May for warm water streams and May - June for cold water streams. Use the following specific specific decision criteria to determine whether to collect a macroinvertebrate sample. Circle the action taken regarding whether a sample was collected. Where you have found the stream conditions to be inappropriate for macroinvertebrate sampling, record a comment indicating the rationale for not collecting.

| Parameter | Condition | Action to Take |
|---|---|---|
| Hydrologic Conditions | Baseflow conditions are occurring and it is approximately 4 or more weeks after a bankfull flow event. * | Collect macroinvertebrates |
| | A bankfull or greater magnitude flow event has occurred within 4 weeks of site visit. Or extreme high flow events have occurred resulting in deep scouring of the streambed and benthic community such that the macroinvertebrate community will not recover within the spring index period. | Do not collect macroinvertebrates |
| | Extended drought conditions have reduced flow from previously perennial condition to pools only or stagnant wetland habitat. | Do not collect macroinvertebrates |
| Substrate Type | A substrate consisting of a mixture of some of the following particle sizes is the target condition: boulder, cobble, gravel, sand, clay, silt, bedrock. | Collect macroinvertebrates |
| | Streams which have substrates dominated (consisting of >50% of that substrate type) by bedrock, travertine, or sand are considered non-target conditions. | Do not collect |
| Waterbody Type | The target waterbody type is a flowing stream with riffle or run (erosional) habitats present. | Collect macroinvertebrates |
| | We do not have methods developed for the following waterbody types and are not sampling them at this time: Effluent dependent streams, wetlands, ephemeral streams, lakes, seasonally intermittent streams. | Do not collect |

Comments: (Indicate rationale for not collecting macroinvertebrate sample, if different from the above descriptions)

* Identification of bankfull and high flow elevation in the field: Using known watershed area, use appropriate Regional Curve and field bankfull indicators to estimate bankfull elevation. Look for debris lines and other high flow markers as an indicator of the most recent high flow stage. This procedure is explained in more detail and a copy of the regional curves is provided in the ADEQ Habitat Assessment Procedures (2005)

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| Biological Sampling and Observations | | | |
|---|---|---|---|
| Types of Biological Samples and Sample Locations | | | |
| Macroinvertebrates | Riffle ☐ and riffle field split ☐; Pool ☐ and pool field split ☐; Edge ☐ and edge field split ☐ | | |
| Algae | Diatoms – riffle ☐/ pool ☐; artificial substrate ☐; filamentous riffle ☐; filamentous pool ☐; filamentous composite ☐ | | |
| Observations | | | |
| Filamentous Algae Covering Streambed throughout the reach | | 1) <1% 2) 1-25% 3) 26-50% 4) 51-75% 5) 76-100% | |
| Floating algae (detached clumps/mats) floating downstream | | 1) <1% 2) 1-25% 3) 26-50% 4) 51-75% 5) 76-100% | |
| Algal slime on rocks, wood, etc. (not filamentous) | | Absent ☐; rare-thin coating ☐; common thick coating ☐ | |
| Comments | | | |
| Macrophytes | | | |
| Macrophytes covering streambed throughout the reach | | 1) <1% 2) 1-25% 3) 26-50% 4) 51-75% 5) 76-100% | |
| Comments | | | |
| Identification of Algae (A) and Macrophytes (M) | | | |
| ☐ A | Cladophora (hairlike feel, long beards) | ☐ M | Watercress (Rorippa) |
| ☐ A | Spirogyra (slimy to touch, bright green) | ☐ M | Monkey flower ( Mimulus, yellow flower) |
| ☐ A | Nostoc (looks like jelly beans or round black to blue colored nodules) | ☐ M | Pondweed (Potomogeton, submerged water grass) |
| ☐ A | Blue-greens (blue-green to black in colo, e.g. Oscillatoria, Anabena) | ☐ M | Columbine (yellow fower) |
| ☐ M | Stoneworts (feels gritty, looks like a vascular plant, found in upwelling zones) | ☐ M | White water buttercup (Ranunculus, white flower) |
| ☐ M | Vaucheria (dark green felt-like mats) | ☐ M | Eurasian water milfoil (Myriophyllum) |
| ☐ M | Hydrodictyon (bright green, net forming algae) | ☐ M | Hydrilla |
| ☐ M | Praesiola (cold water algae, looks like sea lettuce) | | |

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| Riffle Pebble Count | | | | | |
|---|---|---|---|---|---|
| For transect method, tally 100-pebbles in riffle habitat only. Measure particles at equal increments across multiple transects within the wetted width of available riffle habitat throughout the reach. | | | | | |
| **Size Class** | **Size Range** | **Tally** | **Count** | **Percent** | **Cum. %** |
| Silt/Clay * | <0.062 | | | | |
| Sand ** | 0.063 – 2.0 | | | | |
| Very Fine Gravel | 3 – 4 | | | | |
| Fine Gravel | 5 – 8 | | | | |
| Medium Gravel | 9 – 16 | | | | |
| Coarse Gravel | 17 – 32 | | | | |
| Very Course Gravel | 33 – 64 | | | | |
| Small Cobble | 65 – 96 | | | | |
| Medium Cobble | 97 – 128 | | | | |
| Large Cobble | 129 – 180 | | | | |
| Very Large Cobble | 181 – 256 | | | | |
| Small Boulder | 257 – 512 | | | | |
| Medium Boulder | 513 – 1024 | | | | |
| Large Boulder | 1025 – 2048 | | | | |
| Very Large Boulder | 2049 – 4096 | | | | |
| Bedrock | >4097 | | | | |
| | Totals | | | | |

| Comments: | |
|---|---|
| | % fines <2 mm | |
| | # Size Classes | |
| | D15 | |
| | D50 | |
| Note: * Silt / clay particles feel slick when rubbing between thumb and forefinger.<br>** Sand Particles feel gritty when rubbing between thumb and forefinger. | D84 | |

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## Riffle Embeddedness

**Embeddedness** measurements are collected concurrently with particle sizes within wetted width of 3 riffle transects. Count sand & fines as 100% embedded, bedrock & travertine as 100% embedded and gravel from a gravel patch as 100% embedded. Embeddedness is taken as a visual estimate. Keep a tally of embeddedness counts within each embeddedness category. Sum the counts and calculate a percentage for each embeddedness category. Then calculate weighted percent embeddedness as indicated. Take a sum of the weighted percents and divide by 100 for an average embeddedness value.

| Embeddedness Category | Embeddedness Range (percent) | Tally | Count | Percent | Weighted Percent |
|---|---|---|---|---|---|
| Low | 0 - 33 | | | | (% embed * 17) |
| Moderate | 34 - 66 | | | | (% embed * 17) |
| High | 67 - 100 | | | | (% embed * 17) |
| | | | | Avg. % Embed | (sum weighted percents/100 |

## Riffle Geometry

| Riffle # | Length | Width | Length / Width ratio |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| | | Average length / width ratio | |

## Notes

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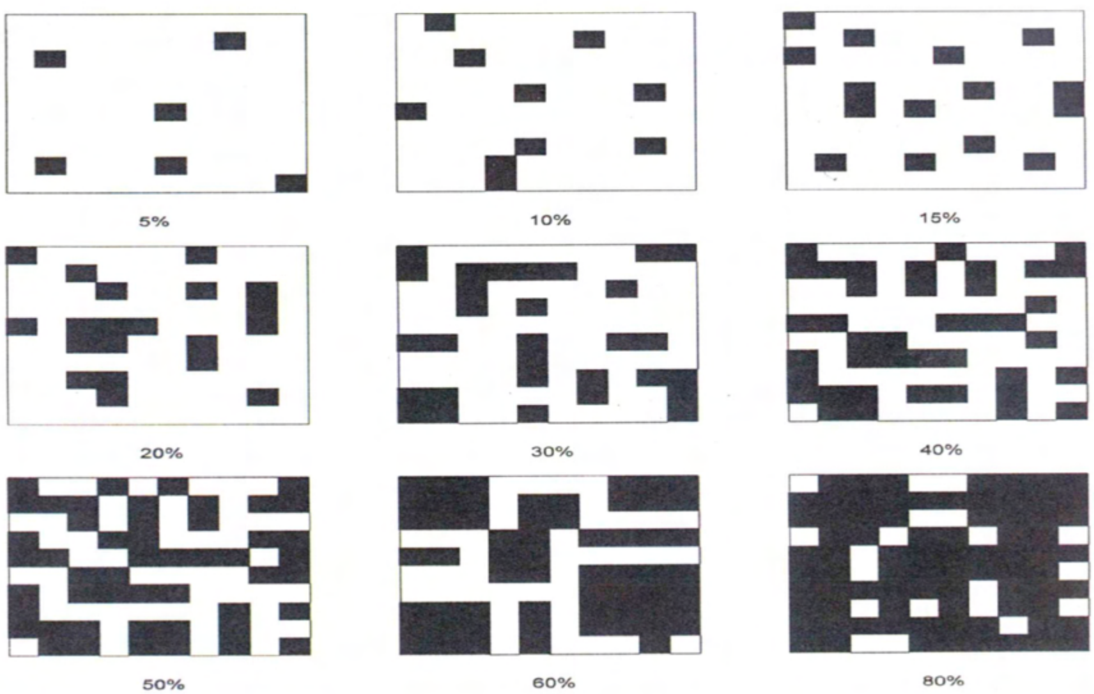
| Riparian Vegetation Cover | |
|---|---|
| Record the percent cover of each vegetation type within the floodplain. Consider each vegetative layer separetly with a score of 0 – 100% for each. The object is to identify what vegetation type is holding the banks and floodplain together. | |
| Riparian Vegetation Cover | Estimated Percent Cover |
| Canopy of riparian trees > 15 feet high | |
| Understory of woody shrubs, saplings, herbs, grasses and forbs – 1.5 to 15 feet high | |
| Ground cover of woody shrubs, seedlings, herbs, and forbs - < 1.5 feet high | |
| Barren or bare dirt | |




| Riparian Association | | | |
|---|---|---|---|
| Place a check beside the most appropriate association using the riparian species list and elevation. | | | |
| ☐ | Sonoran riparian deciduous forest<br>Cottonwood-Willow & Mesquite located at <3280′ elevation | ☐ | Montane riparian deciduous forest<br>mixed broadleaf species such as Big-tooth Maple; Narrowleaf Cottonwood; Box-elder; SW Choke Cherry; Arizona Alder; Pacific, Coyote, Red, or Bebb's Willow; located at 5740′ – 8200′ elevation |
| ☐ | Interior riparian deciduous forest<br>Cottonwood-Willow & mixed broadleaf species such as Sycamore, Ash, Walnut, Alder, Soapberrry, and Hackberry located at 3280′ – 5740′ elevation | ☐ | Actic – Boreal forest<br>Distinctive riparian communities are not present however there are some indicator species such as shrubby Scouler and Bebb's willows, Red Elderberry, Shrubby Cinquefoil, Goose-berry Currant, Raspberry, and Thin-leaf Alder located along streams of subalpine forests and meadows at >8200′. |

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## Riparian Species

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | Alder, Thinleaf | ☐ | Cinquefoil | ☐ | Hawthorn, River | ☐ | Tamarisk | ☐ | Willow, Peachleaf | ☐ | Equisetum |
| ☐ | Alder, Arizona | ☐ | Cottonwood, Fremont | ☐ | Maple, Big-tooth | ☐ | Walnut, Arizona | ☐ | Willow, Red | ☐ | Monkeyflower |
| ☐ | Ash, Lowell | ☐ | Cottonwood, Lanceleaf | ☐ | Maple, Rocky Mountain | ☐ | Willow, Arizona | ☐ | Willow, Scouler | ☐ | Phragmites |
| ☐ | Ash, velvet | ☐ | Cottonwood, Narrowleaf | ☐ | Mesquite | ☐ | Willow, Arroyo | ☐ | Willow, Seep | ☐ | Rushes |
| ☐ | Birch | ☐ | Elder, Blueberry | ☐ | Netleaf Hackberry | ☐ | Willow, Bebb | ☐ | Willow, Yewleaf | ☐ | Sedges |
| ☐ | Boxelder | ☐ | Elder, Mexican | ☐ | New Mexican Locust | ☐ | Willow, Bonpland | ☐ | Willow, Unknown | ☐ | Sacaton |
| ☐ | Buckthorn, Birchleaf | ☐ | Elderberry | ☐ | Raspberry | ☐ | Willow, Coyote | ☐ | Bamboo | ☐ | |
| ☐ | Buckthorn, California | ☐ | Elderberry, Desert | ☐ | Red-osier Dogwood | ☐ | Willow, Desert | ☐ | Carex | ☐ | |
| ☐ | Burro bush | ☐ | Gooseberry | ☐ | Soapberry | ☐ | Willow, Gooding | ☐ | Cattail | ☐ | |
| ☐ | Chokecherry | ☐ | Hawthorn, Cerro | ☐ | Sycamore, Arizona | ☐ | Willow, Pacific | ☐ | Deer Grass | ☐ | |

## Measuring Canopy Density

| | Number of Points Intercepted Along the Transect | | |
|---|---|---|---|
| Position | Upper Reach | Mid-Reach | Lower Reach |
| Right Edge Water | | | |
| Middle – Looking Upstream | | | |
| Middle – Looking Downstream | | | |
| Left Edge Water | | | |
| Sum | | | |

Mean Number of Points = Sum of the three columns__________ ÷ 3 =

| | | |
|---|---|---|
| If stream order <5 | Percent Canopy Density = Mean Number of Points * 1.5 = | % |
| If stream order >5 | Percent Canopy Density = Mean Number of Points * 0.75 = | % |

## Regeneration Potential of Riparian Trees

| | Species, in order of dominance | Mature Trees >16" @ 3 ft height | Young Trees ~1 ¼" @ 3 ft. height | Saplings < 1 ¼" | Seedlings New growth |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |

### Age Classes of Riparian Tree Species

(Classify according to species present, not just the dominant tree type of that plant association)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ☐ | Species abundant in 3 age classes | ☐ | Abundant in 2 age classes | ☐ | One age class present | ☐ | No regeneration evident, few mature trees present, no saplings or seedlings, or if present, they are heavily grazed |

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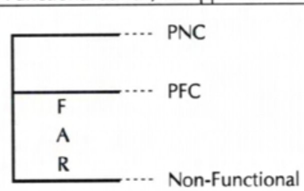
## Proper Functioning Condition Worksheet

| Yes | No | N/A | Hydrologic |
|---|---|---|---|
| | | | 1) Flood plain inundated in "relatively frequent" events (1-3 years) |
| | | | 2) Active/stable beaver dams |
| | | | 3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region) |
| | | | 4) Riparian zone is widening or has achieved potential extent. |
| | | | 5) Upland watershed not contributing to riparian degradation |
| | | | **Vegetative** |
| | | | 6) Diverse (3) age structure of vegetation (Recruitment for maintenance/recovery) |
| | | | 7) Diverse composition of vegetation (For maintenance/recovery) |
| | | | 8) Species present indicate maintenance of riparian soil moisture characteristics |
| | | | 9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events |
| | | | 10) Riparian plants exhibit high vigor |
| | | | 11) Adequate vegetative cover present to protect banks and dissipate energy during high flows |
| | | | 12) Plant communities in the riparian area are an adequate source of coarse and/or large woody debris |
| | | | **Erosion Deposition** |
| | | | 13) Flood plain and channel characteristics (i.e., rocks, coarse and/or large woody debris) adequate to dissipate energy |
| | | | 14) Point bars are revegetating |
| | | | 15) Lateral stream movement is associated with natural sinuosity |
| | | | 16) System is vertically stable |
| | | | 17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition) |

### Functional Rating

| | |
|---|---|
| ☐ Proper Functioning Condition | ☐ Functional at risk, downward trend |
| ☐ Functional at risk, upward trend | ☐ Non-Functional |
| ☐ Functional at risk, no apparent trend | ☐ Unknown |




PFC Remarks

Use reverse side for additional comments.

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## GUIDELINES FOR COMPLETING THE PFC CHECKLIST

General guidance: If 75% or more of stream reach is PFC, classify entire reach as PFC. All "No" answers must have comments in notes section. Answers can go on the line between "Yes" and "No", but consider it a "No" and comment in notes section.

Q1. Instantaneous peak flows don't count. Inundation means to bankfull depth. Bankfull can be identified from top of the point bars, changes in vegetation, topographic break in slope, change in size of bank materials, evidence of an inundation feature such as small benches, exposed root hairs below an intact soil layer indicating exposure to erosive flow, and bank undercuts. "No" if channelization or entrenchment. "N/A" if a "V"-canyon without floodplain development.

Q2. Usually "N/A", but may be applicable at high altitude sites; also, consider the present environment (could they be present).

Q3. Based on the stream type expected & the regional curves, all three features must be present for a "YES". Use bankfull width, not wetted width. "NO" if straightness, excessive sediment, or entrenched channel.

Q4. Widening can mean encroaching on the channel as well as moving toward the terraces. The age of the vegetation in an indicator. "NO" if upland species encroaching on the floodplain or Kentucky bluegrass present. "YES" if recruitment of wetland/riparian species on new landforms. "N/A" if an A1 stream type.

Q5. Need to look at upland ground cover and erosion signs (e.g. plants on pedestals, debris dams around plants, rills, gullies). "NO" if side channel and mid-channel bars, gullies, fan shaped deposits from tributaries, braided channels, overloading of point bars, or cementing of streambed.

Q6. "YES" if 3 age classes (mature, young, saplings) present for a single species, or young and sapling classes if recruitment & replacement is occurring, or dense matting of herbaceous riparian/wetland plants. "NO" if individual plants. "N/A" if A1 Stream Type.

Q7. Maintenance means recruitment. Is it occurring? "YES" if several different species present (e.g. willows, rushes, sedges). It depends on the elevation and the potential natural community that might be present if all constraints are removed. In some environments, 2 species could be a "YES". Usually "NO" if 1 species present.

Q8. "YES" if sedges, rushes, willows, seep willows, alders, cottonwoods, etc. Don't consider quantity. Do you see any at all?

Q9. A high stream flow event is one that occurs once in 25-30 years. Q9 is similar to Q*, but you are now looking for quantity. "NO" if presence of upland species. "YES" if willows, alder, aspen, birch, cottonwood, sedge, rush, bulrush, and wetland grasses.

Q10. Are the plants healthy and dense? "NO" if yellow leaves, stunted plants, many dead stems and branches, a thin crown, infested with insects, diseased, or grazed down by browsers.

Q11. This is a quantity question. Use 80% cover as a guide. Look for riparian plants, herbaceous cover, salt cedar (tamarisk), seep willows, etc. "NO" if "NO" on Q9. If Q6-Q10 are "NO", this is probably a "NO".

Q12. "N/A" for meadows, desert streams, and probably intermediate elevation streams, or sedge/grass community streams. "YES" if fallen trees. For some locations consider living and dead trees and trees along banks out of the water.

Q13. "YES" if large boulders, roughness of the floodplain, large trees & dense vegetation along stream banks. "NO" if incision & no access of stream to floodplain.

Q14. "YES" if sedge/rush components. Consider potential, height and newness of the point bar. Sandy soils don't hold water well and there may be no potential for revegetation. A1 Stream Type is "N/A".

Q15. "NO" if straight channel, not confined geologically, and channel movement with every high flow event. "YES" if single channel, stable banks (especially on straight segments), & natural deposition.

Q16. "NO" if entrenchment, down cutting (some is natural), excessive aggradation, unstable vertical banks. "YES" if streambed is armored with large rock, bedrock, heavy gravel. Don't consider old down cutting. If a bedrock stream then "N/A".

Q17. "NO" if excessive sediment from side drainages, excessive aggradation, mid-channel bars, braiding, or unstable banks. "NO" if Q5 is "NO".

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| PFC No Response Sheet – Comments and Notes |
| --- |
| |

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## Habitat Assessment Field Data Sheet

| Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|
| | Optimal | Sub-optimal | Marginal | Poor |
| Habitat Quality | Large variety of habitats available for colonization which may include cobble, undercut banks, snags, submerged logs, leaf packs, root masses, macrophyte beds or other organic material. | Moderate variety of habitats which may include cobble, leaf packs, root masses, macrophyte beds or other organic material. | Habitat has minimal variety, substrate dominated by one particle size, may have some cobble, macrophyte beds, or algae beds. | Homogeneous substrate dominated by sand, shallow with uniform velocity, no shade on riffles, may have extensive filamentous algae beds. |
| Score ⇨ | 4 | 3 | 2 | 1 |
| Extent of Riffle Habitat | Well developed riffle that is as wide as stream and its length extends 2x the wetted width of the stream. | Riffle is as wide as stream, but is less than 2x stream width; abundance of cobble; boulders and gravel are common. | Reduced riffle area does not extend across entire cross-section and is less than 2x width; gravel or large boulders and bedrock prevalent; cobble present. | Riffles virtually non-existent; sand, gravel, large boulders or bedrock prevalent; cobble lacking. |
| Score ⇨ | 4 | 3 | 2 | 1 |
| Embeddedness of Riffles | Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment (bedrock is 0% embedded). | Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment. | Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment. | Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment (sand is 100% embedded). |
| Score ⇨ | 4 | 3 | 2 | 1 |
| Sediment Depostion | Point bars in C type channel maintained, no mid-channel or side bars. No bimodal particle size distribution. No excess sediment in riffles and pools of A, B, or C type channels. | Point bars with few mid-channel bars or side bars in C type channels. No bimodal particle size distribution. Some filling in of pools in A, B, and C type channels. | Numerous mid-channel or diagonal bars in C type channels. Some loss of pool and riffle habitat in A, B, and C type channels. Bimodal distribution may be present with excess fines in the substrate. | Branched or braided C channel with numerous mid-channel bars and islands, some exceeding 2-3x channe width in length. Heavy deposites of finae material evident with bimodal particle distribution. Pools and riffles filled in, with run habitat dominating. |
| Score ⇨ | 4 | 3 | 2 | 1 |
| Bank Stability within the active bankfull channel (score each bank) | Banks stable; no evidence of erosion or bank failure; <5% of bank affected. | Banks moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion. | Banks moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods. | Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; 60-100% of bank has erosional scars. |
| Score____ Left Bank ⇨ | 2 | 1.5 | 2 | 0.5 |
| Score____ Right Bank ⇨ | 2 | 1.5 | 2 | .05 |

| Sum of Habitat Category Scores________ ⇨ | Rating Category | | |
|---|---|---|---|
| | 0 – 7 | 8 – 14 | 15 - 20 |
| | ☐ Very Impaired | ☐ Impaired | ☐ Good Condition |

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## NON-POINT SOURCE CODES

Circle sources directly impacting the site, asterisk sources located in the watershed. Source Group is bolded, Category Code is italicized, and Sub-category Code is regular style font.

| Code | Source Category | Code | Source Category | Code | Source Category |
|---|---|---|---|---|---|
| **1000** | **Agriculture** *(Agriculture)* | 7350 | Upstream impoundment | 6600 | Hazardous waste storage/disposal |
| 1050 | Crop-related sources | 7400 | Flow regulation/Modification/Diversions | 8000 | Highway salt storage/use |
| 1100 | Non-irrigated crop production | 7550 | Habitat Modification | 8200 | Storage tank leaks |
| 1200 | Irrigated crop production | 7555 | Erosion materials from tributaries | 8250 | Underground storage tank leaks |
| 1300 | Specialty crop production | 7600 | Removal of riparian vegetation | 8275 | Above ground storage tank |
| 1350 | Grazing-related sources | 7700 | Streambank modification or destabilization | **0100** | **Wastewater** *(Industrial Point Source)* |
| 1400 | Pasture grazing - riparian and/or upland | 7750 | Highway/Road/Bridge-erosion or aggradation | 0110 | Major industrial point source |
| 1410 | Pasture grazing - riparian | 7800 | Drainage/Filling of wetlands | 0120 | Minor industrial point source |
| 1420 | Pasture grazing - upland | *7900* | *Marinas and recreational boating* | 0200 | Municipal point source |
| 1500 | Range grazing - riparian and/or upland | 7910 | Boating with in-water releases | 0210 | Major municipal point source |
| 1510 | Range grazing - riparian | 7920 | Boating with on-land releases | 0220 | Minor municipal point source |
| 1520 | Range grazing - upland | **5000** | **Mining** *(Resource extraction)* | 0230 | Package plants (small flows) |
| *1600* | *Intensive Animal feeding Operations* | 5075 | Active Mining operation | *0300* | *Other Wastewater* |
| 1620 | Concentrated Animal Feeding Operations point source/permitted) | 5100 | Surface Mining | 0400 | Combined system (sewage and stormwater) |
| 1640 | Confined animal feeding operations (non-point source | 5150 | Sand and gravel operations | 0500 | Collection system failure |
| *1700* | *Aquiculture/Fish Hatchery* | 5200 | Subsurface mining | 0900 | Sewage lagoons |
| **2000** | **Forestry** *(Silviculture)* | 5300 | Placer mining | 0975 | Reuse (Effluent to lakes, golf courses, artificial |
| 2100 | Harvesting, restoration (residue management) | 5400 | Dredge mining | 6500 | Septic systems |
| 2200 | Forest management (fertilization, pesticide use) | 5500 | Petroleum activities | 6700 | Septage disposal (e.g. from septic tank trucks) |
| 2300 | Logging roads | 5600 | Mill tailings | **8100** | **Other** (Atmospheric deposition) |
| 2500 | Clear cutting | 5650 | Mill or mine tailings | 8400 | Spills |
| 8610 | Wildfires or controlled burns | 5700 | Mine tailings | 8500 | Contaminated sediments |
| **3000** | **Hydro/Habitat Modification/Runoff** *(Construction)* | 5800 | Acid mine drainage | 8510 | |
| 3100 | Highway/Road/Bridge construction | 5900 | Abandoned mining operation | 8530 | |
| 3200 | Land development/Land clearing | 5950 | Inactive mining operation | 8540 | |
| *4000* | *Urban runoff/Stormwater sewers* | **8700** | **Recreation** (non-boating) | 8600 | |
| 4100 | Non-industrial (NPDES) stormwater runoff | 8710 | Golf courses | 8910 | |
| 4200 | Industrial (NPDES) stormwater runoff | 8720 | Camping/Campground recreation | **Other Non-point Source Observations at the site or within the reach** | |
| 4300 | Other urban runoff | 8730 | All terrain vehicles/Off road vehicles/Biking | | |
| 4400 | Illicit connections to stormwater sewers (dry weather flows) | **6000** | **Storage and Disposal** (Land disposal/Storage) | | |
| 4500 | Urban Highway/Road/Bridge runoff | 6100 | Sludge disposal/storage | | |
| *4600* | *Non-urban runoff/Erosion and sedimentation* | 6300 | Landfills | | |
| 8300 | Non-urban (highway/Road/Bridge Runoff/Maintenance) | 6350 | Inappropriate waste disposal/Wildcat dumping | | |
| *7000* | *Hydrological modifications* | 6400 | Industrial land treatment | | |

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### 3.17.10 Measuring Percent Canopy Density With the Spherical Densiometer

The Spherical Densiometer optically identifies a series of points in the canopy above the sampling location. The observer records the number of shaded points.

Equipment Required: One modified Model C concave Spherical Densiometer, Field Data Sheets, and writing instrument.

#### 3.17.10.1 Measuring Percent Canopy for Streams Having a Strahler Stream Order of Less than Five

Within the stream reach being assessed, three cross-sections are visually established. Four measurements are taken at each cross-section.

The three cross-sections should represent the reach being evaluated. Typically, one cross-section is located at the uppermost end of the reach, one at mid-reach, and the last at 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.

1. At edge of water while standing in the stream, and facing the stream bank, hold the instrument level, away from the body, with the “V” pointing toward the observer. Position the densitometer twelve inches above the water surface, and twelve inches from the edge of water as shown in Figure 8.

   The observers head reflection should be touching the top of the uppermost grid line. Center the bubble level which is located in the right corner. The densiometer mirror is scribed with interconnecting squares. Count all line intersecting points (recording points) that are surrounded or covered by vegetation (line intercept points) and record that number on the field data sheet in the appropriate location (see example below).

2. Move to the center of the stream and face upstream. Hold the instrument level, 12 inches above the water surface. Repeat as above.

**Figure 8. Positioning the Densiometer at stream side.**

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

4. Repeat step 1 at the opposite bank.

5. Repeat steps 1 through 4 at the remaining two reach cross-sections.

6. 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 as shown on Table 3.

**Table 3. Example of a completed field form.**

| | **Number of points intercepted** | | | | |
|---|---|---|---|---|---|
| Along Transect | Upper Reach | Mid-Reach | Lower Reach | | |
| Right Edge Water | *7* | *10* | *17* | | |
| Middle - Looking Upstream | *1* | *2* | *0* | | |
| Middle - Looking Downstream | *3* | *2* | *0* | | |
| Left Edge Water | *11* | *9* | *15* | Grand Sum | Mean # of Points |
| SUM | *22* + | *23* + | *32* | = *77* | ÷ 3 = *26* |
| If stream order < 5, Percent Canopy Density = Mean # Points X 1.5 = ____*38*_____% | | | | | |
| If stream order ≥5, Percent Canopy Density = Mean # Points X 0.75 = __________% | | | | | |

7. If the Strahler stream order is less than 5, multiply the mean number of points by 1.5. This value is the percent canopy density.

### 3.17.10.2 Measuring Percent Canopy for Streams Having a Strahler Stream Order Equal to or Greater than Five

Use the same procedure described in Section 3.17.10.1, except eight readings are taken at each cross-section transect, since streams having a higher order number will be wider than those with a smaller order number. Take one reading at each bank and upstream and downstream readings at 1/4, 1/2, and 3/4 distances across the channel. Multiply the total recording points for all eight readings by 0.75. Then deduct one percent if the score is between 30 and 66. Deduct two percent for scores over 66. Make no deductions for scores below 30 (Cowley, 1992).

#### 3.17.10.2.1 Modifying the Model C Concave Spherical Densiometer

Place a narrow strips of black tape at a right angles forming a “V” as shown in Figure 9. This will provide 17 line intersect recording points. The modification improves the measurement of canopy closure (Platts et al, 1987). To facilitate the reading of the mirror surface in the field, place black dots at the intersections of all lines with a Sharpie.

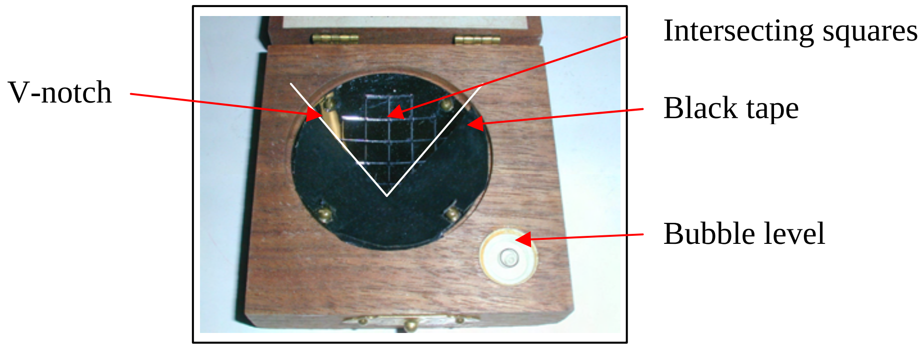



**Figure 9. Modified Spherical Densiometer.**

### 3.17.10.3 Literature Cited

Cowley, E.R. 1992. Protocols for classifying, monitoring, and evaluating stream/riparian vegetation on Idaho rangeland streams. Idaho Department of Health and Welfare, Div. Of Environmental Quality, Boise, Idaho.

Platts, W.S., C. Armour, G.D. Minshall, M. Bryant, J.L. Bufford, P. Cuplin, S. Jensen, G.W. Lienkaemper, G.W. Minshall, S.B. Monsen, R.L. Nelson, J.R. Sedell, and J.S. Tuhy. 1987. Methods for evaluating riparian habitats with applications to management. Gen. Tech. Report INT-221. U.S. Department of Agriculture, Forest Service, Intermountain Research Station. Ogden, Utah. 177 pp.

### 3.17.11 Photo Monitoring

The primary consideration in photo monitoring is the fulfilling of an objective. The objective may vary, depending on the reasons for establishing the site or the results expected over time. Determination of the objective will require some consideration. Generally speaking, monitoring implies the need to determine change. Ask yourself these questions when framing a shot: What will this picture demonstrate? What am I trying to show with this photo? Why is this photograph important? What is appealing about the shot? Does it capture a representative view of the site? (Hall, 2001).

Photos are taken at each visit to a FSN sampling site. Based on the desired objectives, the photo should provide a representative view of that site. The minimum number of photos is two: looking upstream from below the sample point and looking downstream from above the sample point. However, the taking of additional photos is encouraged. Document the sampling event, any changes from the last visit, outgrowths of filamentous algae on the stream bed, channel obstructions, man-made channel alterations or disturbances, floodplain debris, trash, sediment deposition features, point bars, bank erosion, head cuts, streambed particles, riparian community, wetlands community, bank particle composition, etc. The objective is to fully document the condition of the site and photos are ideal for this purpose.

Equipment Required: Either a digital camera or a 35 mm single lens reflex camera with color print film.

#### 3.17.11.1 Procedure

Photographic documentation of sample sites is an essential first step in photo monitoring. At the first visit to a sample site, establish permanent photo points for the upstream/downstream pictures. The preferred type of photo points is a distinctive landmark such as a large tree or boulder. If such a naturally occurring landmark is unavailable at a given site, photo points should be marked in an unobtrusive manner (e.g. small pieces of flagging or rock cairn). Photo points should be described in detail on the field form at the first visit to the site and then recorded in the site files as a permanent part of the file. Photos of the photo points are recommended. If the sample site is not easily found, take photographs of the route to the site. The photos should feature points easily recognized and any changes in direction en route to the site that will enable a new visitor to navigate to the site.

Photos should be taken to include the sample point with a person framed within the photo to show scale. If the stream channel has been altered since the last site visit, additional photos should be taken. Site alteration may include recent flood evidence, channel scour, sediment deposition, construction or man-made alterations in the floodplain or channel, or other biological or ecological changes that warrant documentation. All photos taken at a site should have the photo number recorded on the FSN Field Data Sheet form with the description of the photo (e.g. looking upstream, looking downstream).

Any photos taken at a site, whether print film or digital, should immediately be printed upon return to the office.

Print Film

On the back of each photograph, the scene should be fully identified with the site identification code, the date the photo was taken, and photo description (e.g. looking downstream, erosion along right bank, cottonwood-willow community), and any applicable notes. Photos should be placed in holders and placed into the respective site file.

Digital Photos

Digital photos should be printed on non-acidic picture quality paper. Color prints are preferable. It is suggested that the photos be inserted into a Word or Word Perfect document. Underneath each photo print the site description, site ID, photo description, and date of photograph. The file name attached to the digital photo should include the camera assigned number, site ID, photo description, and date. The suggested format for a digital file code is Camera Number (DSCN0134), Site ID (UGGLR205_38 ), Description Code (LDS ), and Date (10 May 04). The JPEG file extension is preferred. Common photo description codes include LDS (looking downstream), LUS (looking upstream), and XSEC (cross-section). Each site file should contain a compact disk containing all digital photographs.

### 3.17.11.2 Literature Cited

Hall, F. 2001. Photo point monitoring handbook: part A – field procedures. Gen. Tech. Rep. PNW-GTR-526. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

## 3.18 Measuring Flow

Stream discharge (Q) is the volume of water passing through a cross-sectional area per unit of time. As such, discharge is expressed in terms of volume per unit of time; examples might include cubic feet per second, gallons per minute, millions of gallons per day, cubic meters per second, etc. Different types of discharge measurement methods may require the use or application of different units of measurement. Flows measured by gauging a cross-section are typically reported in cubic feet per second; flows measured volumetrically are recorded in units of gallons per minute or gallons per second. All such measurements, however, are converted to their CFS (cubic feet per second) equivalent for data repository storage.

### 3.18.1 Instantaneous Discharge with Flow Meter

Instantaneous discharge with a flow meter is calculated as the velocity (V) in feet per second multiplied by cross-sectional area (A) in square feet. For metered measurements, cross-sectional area is determined by stringing a graduated tape (1/10 ft. increments) across the channel to measure distance at cross-section stations where depth and velocity are measured. Depth of water is measured with a top setting rod (Figure 10) having 1/10 foot increments. Area is depth multiplied by width in small increments (Harrelson et al., 1994). A Marsh-McBirney Flow Meter is used to measure velocity and depth at a pre-determined position in the channel. Select a location in the stream channel that will provide a representative measurement of the entire flow. Do not select a location with a split channel, on a meander, or one with an obstruction immediately upstream from the measurement location.

#### 3.18.1.1 Field Procedure

Equipment required: Marsh McBirney Model 2000 flow meter with sensor and cable, top-setting wading rod with one-tenth foot gradations, two tent pegs, a fiberglass measuring tape with one-tenth foot gradations, and an instantaneous discharge data sheet.

1. Extend the fiberglass tape across the channel from bank-to-bank and perpendicular to the flow. Each end of the tape should be tied to a tent peg firmly secured in the earth. If a bush or some other firmly anchored structure is available, it may also be used. After the tape has been tied to the tent pegs, the tape should be taut with as little sag as possible. If the channel is wide and the wind is blowing, tie strips of flagging on the tape to keep it from whipping.

2. Attach the meter sensor to the top-setting wading rod (Figure 10), place the sensor in the flow, turn the meter on, and check the reporting units. The meter should be set for reading flow in feet per second.

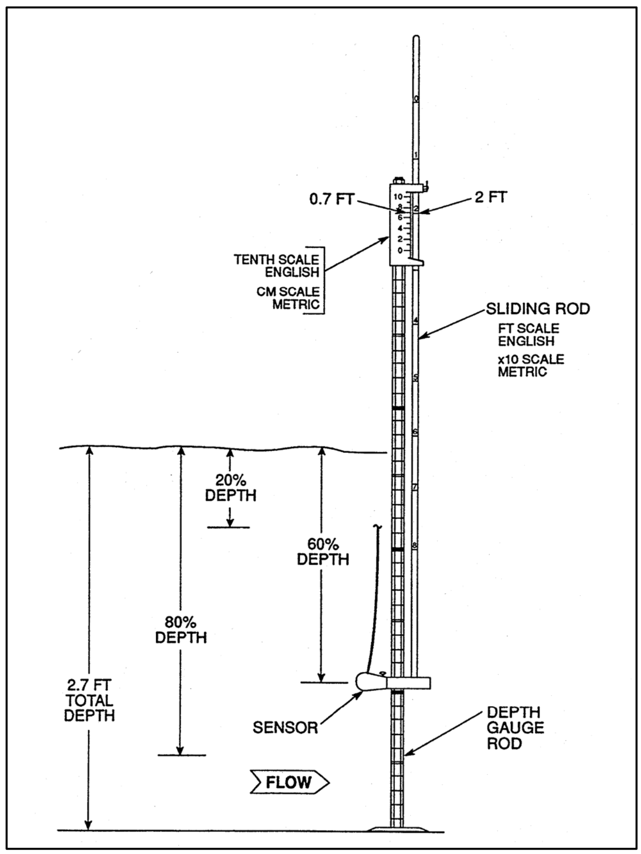
3. The meter can be set to average flows over a set period of time. To set the fixed point average, press the ⬆ and ⬇ keys simultaneously until the display shows the letters

Fixed Point Averaging (FPA). Press ⬆ or ⬇ keys until the FPA increment is set to 10 seconds. Wait until the display automatically switches back to velocity.

4. The observer taking the measurements should move to one edge of the channel, for example the right edge of water (REW), as determined by facing downstream. Position one eye directly above the tape at the exact location where the water and the bank interface, and call out the measurement to the Recorder, for example the reading is 0.8 feet. This figure should be recorded under DIST on the first line together with the abbreviation REW (right edge of water) (Table 4).

    - ❖ The convention of labeling banks relative to a downstream orientation is consistently applied to all bank determinations. There is no convention regarding which bank should serve as the beginning of the transect, as this may vary from site to site depending on access conditions. Neither is there any convention stating that the tape must have its lower end values starting from one or the other bank; calculation after the measurement is concluded proceeds in the same fashion whether values on the tape are increasing or decreasing. For this example, it is arbitrarily assigned that the measurement proceeds with increasing tape stations from the REW. Any of the three other permutations (decreasing from LEW, increasing from LEW, decreasing from REW) is also acceptable

**Figure 10. Top-setting wading rod.**



5. The observer should move to the LEW, and read the measurement off the tape at the water-bank interface and calculate the width of channel. Divide the width by 20 and round to the nearest whole number. USGS recommends that no more than 5% of the stream discharge be represented in each sub-sectional area of the cross-section; in practice, this usually equates to 20 to 25 measurements across the width of the stream. For example, if the channel is 58 feet wide, 58 ÷ 20 = 2.5; round up to 3.0. Take flow measurements every 3 feet.

   For narrow channels the minimum spacing is 0.3 feet.

6. For our example, to begin the process of measuring discharge, the observer moves to the nearest foot mark beyond 0.8 feet and inserts the top-setting wading rod into the flow. Therefore, the first measurement station on the tape is at 1.0 foot and is recorded under DIST.

7. Observer positions the wading rod vertically with the sensor pointed upstream into the flow. Determine the depth of water from the rod depth gauge to the nearest 10th of a foot. The exception to this would be if the water level is at the half way mark between 0.4 feet and 0.5 feet on the depth gauge (hexagonal rod); in this case the reading is 0.45 feet. If the water level is between 0.4 and 0.45 or between 0.45 and 0.5, round off to the nearest 1/10 foot increment. The depth measurement is recorded under DEPTH.

The one-point method, as described in Step #7, is used when the water depth is less than 2.5 feet. For depths of 2.5 feet or greater, the two-point method for measuring flow is used. Whereas the one-point method measures flow at 0.6D (Depth), the two-point method requires an average of flow measurements taken at 0.2D and 0.8D (Corbett, 1962). If the depth is 2 feet, the single-point method requires a measurement at 1.2 feet (2 ft. x 0.6). If the depth is 3 feet, the two-point method requires readings at 0.7 feet. (3.5 ft. X 0.2) and 2.8 feet (3.5 ft. X 0.8). Record the average of the two velocities for that station.

- ❖ The top-setting wading rod consists of two rods; round and hexagonal. The depth gauge rod (hexagonal shaped) is 4.5 feet long, and the round rod is the sliding rod, 3 inches longer than the depth gauge rod. The sliding rod has grooves spaced about every 4.75 inches apart. At the top of the hexagonal rod is a lever called the "sliding rod lock" (Figure 10). The top of the depth gauge rod is graduated into 10 divisions numbered in even numbers.

8. The movable scale on the sliding rod represents the foot value of the water depth; the stationary scale on the hexagonal rod represents tenths of a foot. Any depth value setting must incorporate both of these scales by setting the station depth’s value on the movable scale opposite the station depth’s tenths value on the stationary scale. For our example, this would entail aligning the zero mark on the sliding rod between four and five on the stationary scale to represent 0.45 feet.

**Table 4. Completed discharge measurement form.**

| INSTANTANEOUS DISCHARGE | | | | | | |
|---|---|---|---|---|---|---|
| # | DIST | WIDTH | DEPTH | VEL | Area | Q |
| 1 | 0.8 | 0.1 | 0 | REW | 0 | 0 |
| 2 | 1.0 | 1.6 | 0.45 | 0.22 | 0.72 | 0.16 |
| 3 | 4.0 | 3 | 0.59 | 0.33 | 1.77 | 0.58 |
| 4 | 7.0 | 3 | 0.98 | 0.56 | 2.94 | 1.65 |
| 5 | 10.0 | 3 | 1.21 | 0.89 | 3.63 | 3.23 |
| 6 | 13.0 | 3 | 1.53 | 1.25 | 4.59 | 5.74 |
| 7 | 16.0 | 3 | 1.65 | 1.66 | 4.95 | 8.22 |
| 8 | 19.0 | 3 | 1.48 | 2.11 | 4.44 | 9.34 |
| 9 | 22.0 | 3 | 1.5 | 2.46 | 4.50 | 11.07 |
| 10 | 25.0 | 3 | 1.5 | 2.35 | 4.50 | 10.58 |
| 11 | 28.0 | 3 | 1.53 | 2.56 | 4.59 | 11.75 |
| 12 | 31.0 | 3 | 1.53 | 2.54 | 4.59 | 11.66 |
| 13 | 34.0 | 3 | 1.65 | 2.12 | 4.59 | 10.49 |
| 14 | 37.0 | 3 | 1.68 | 2.29 | 5.04 | 11.54 |
| 15 | 40.0 | 3 | 1.78 | 2.37 | 5.34 | 12.66 |
| 16 | 43.0 | 3 | 1.67 | 2.18 | 5.01 | 10.92 |
| 17 | 46.0 | 3 | 1.23 | 2.56 | 3.69 | 9.45 |
| 18 | 49.0 | 3 | 1.04 | 1.89 | 3.12 | 5.90 |
| 19 | 52.0 | 3 | 0.85 | 1.01 | 2.55 | 2.58 |
| 20 | 55.0 | 3 | 0.3 | 0.89 | 0.90 | 0.80 |
| 21 | 58.0 | 1.5 | 0 | LEW | 0 | 0 |
| 22 | | | | | | |
| 23 | | | | | | |
| Total Dist. | | QC summed Total | Avg. Depth | Avg. Velocity | Total Area | Total Discharge |
| 57.2 | | 57.2 | 1.15 | 1.54 | 71.82 | 138 |

- The topmost groove on the sliding rod represents the depth distance from zero to one foot. The second groove represents the depth distance from 1 foot to 2 feet, and so on. If depth of water is less than or equal to 1 foot, use the topmost groove. If the depth is between 1 and 2 feet, use the second groove, etc.

9. With the sensor submerged, allow the sensor to stabilize, and then wait for the timing slide on the meter display to cycle one complete fixed point averaging cycle before reading the flow measurement. Make a mental note of the velocity reading. After the meter has cycled through a third cycle, record the reading if it is within 10% of the second reading. If the third reading is not within 10% of the second reading, continue to cycle through successive readings, comparing each one with the previous reading until two successive readings are within 10% of each other. The Recorder records the last observed reading under VEL on the field data sheet. If the readings are unstable and highly variable, take three successive readings and have the Recorder calculate the average.

10. In step 5, the measuring stations on the tape were determined to be at 3 foot intervals. After the first measurement at the one foot station on the tape, the next measurement is at the 4 foot station. Steps 7-9 are repeated until the left edge of water is reached.

11. At left edge of water, the Observer positions one eye directly above the tape at the exact location where the water and the ground interface. This distance is recorded under DIST and the abbreviation LEW next to it.

Refer to Section 5.13 for calculating discharge.

#### 3.18.1.2 Meter Error Messages

The displaying of errors alerts the user of possible problems with either the meter or the process. Errors can be displayed as messages or numerical codes. There are three error messages and five numerical codes.

- With the exception of Err 2, error codes freeze the display. Turn the unit OFF, and then back ON to clear the display. If the error message persists, return the meter to the manufacturer for maintenance.

Low Bat - Indicates low battery voltage. Replace the batteries with two D cells. This operation will require a screwdriver or coin to open the battery compartment.

Noise - Indicates electrical noise is present in the flow. The noise flag usually comes on for a few seconds right after the sensor is placed in the water. This is normal. If the noise level is too high to get accurate readings, the screen will blank out.

Con Lost - Indicates sensor electrodes are out of the water or have become coated with oil or grease. After a few minutes, the unit will turn itself OFF. If the electrodes are coated, clean the sensor with a mild soap and a soft cloth.

<u>Numbered Error Messages</u>

Error #1 - Problem with sensor drive circuit.  Check sensor disconnect.

Error #2 - Memory full error.  Memory must be cleared before another reading can be stored.

Error #3 - Incorrect zero adjust start sequence.  Reinitiate zero start sequence.

Error #4 - Zero offset is greater than the zero adjust range.  Repeat the zero adjust procedure.  If error is still displayed, unit needs servicing.

Error #5 - Electroconductivity lost or noises detected during zero adjust.  Usually caused by the sensor being out of the water.

### 3.18.1.3  Key Summary

The function keys can be operated as single key functions or two-key functions.

<u>One Key Function</u>

ON/C - Turns Unit ON.  Clears the display and restarts the meter.

OFF - Turns Unit OFF.

⬆ - Increments FPA (fixed point averaging), TC (Time Constant), and Memory Location.

⬇ - Decrements FPA, TC, and Memory Location.

RCL - Alternates between Recall and Real-Time Operating Modes.

STO - Stores Values in Memory.

<u>Two Key Function</u>

ON/C + OFF - Change Units, Turns Beeper ON/OFF.

⬆ + ⬇ - Alternates between FPA (fixed point averaging) and rC (Time Constant) Filtering.

ON/C + STO – Memory may be cleared from either the real-time or recall mode by pressing ON/C and STO simultaneously.

RCL + STO - Initiates zero adjust sequence.  Zero stability is ± 0.05 ft/sec.

### 3.18.2 Float Method

The float method is a simple means of estimating discharge.

Equipment Required: A measuring tape, a timer (i.e. digital watch), and 5-10 floats. For floats, use orange peel, a water-soaked block of wood, or other natural material that sinks at least halfway into the water, is visible from shore, not influenced by the wind, and is expendable and non-polluting.

#### 3.18.2.1 Float Method Procedure

1. Measure and mark two points along the length of the channel, at least two to three channel widths apart, at the channel cross-section.

2. Two observers are best. One tosses the float into the channel above the marker and calls out when it crosses the upstream point. Toss each float a different distance from the bank to obtain an average of velocities.

3. The downstream observer starts the timer, sighting across the stream from the lower point. When the float passes, stop the watch and record the time. Repeat the procedure 5 to 10 times. Determine the mean surface velocity. A coefficient of 0.85 is commonly used to convert the velocity of a surface float to mean velocity in the vertical (http://wwwrcamnl.wr.usgs.gov/sws/fieldmethods/).

4. Using the previously measured cross-sectional area, multiply velocity times area to find discharge (Q= VA). Record it on a data sheet with date, time, etc. If the cross-sectional area cannot be obtained because of unsafe wading conditions, record the velocity. If it is possible to return to the site under favorable conditions, measure the cross-sectional area and compute the estimated Q (Harrelson et al, 1994).

### 3.18.3 U.S.G.S. Staff Gage

At sites located near or next to a U.S.G.S. gauging station, a discharge measurement can be made by recording the time of day and the staff gauge height. On the U.S.G.S. web page http://waterdata.usgs.gov/nwis/ , find the appropriate gauging station and determine the discharge from the table provided and record on the field data sheet for that site.

### 3.18.4 Volumetric Measurement

The volumetric measurement of discharge is only applicable to small discharges, but it is the most accurate method of measuring such flows. In this method the hydrographer observes the time required to fill a container of known capacity, or the time required to partly fill a calibrated container to a known volume.

Volumetric measurements are usually made where the flow is concentrated in a narrow stream, or can be so concentrated, so that all the flow may be diverted into a container (Examples or possible locations include: V-notch weir, artificial control where all the flow is confined to a notch or to a narrow width of catenary-shaped weir crest, and a cross section of natural channel where a temporary earth dam can be built over a pipe of small diameter, through which the entire flow is diverted).

Volumetric measurements have also been made when no other type of measurement is feasible, as for example on small streams composed of a series of pools behind broad-crested weirs. At low flows the depth of water on the weir crest is too shallow to be measured by current meter, and the velocity in the pools is too slow for such measurement. Discharge is measured by taking timed samples of flow sufficient to fill a container of known volume held along the downstream face of a control.

### 3.18.5 Source Material

http://wwwrcamnl.wr.usgs.gov/sws/ fieldmethods/.

Corbett, D. M. 1962. Stream-gaging procedure. U.S. Geological Survey, Water-Supply Paper 888, Washington, DC.

Marsh-McBirney, Inc. 1990. MMI Model 2000 Flo-Mate Portable Water Flowmeter Instruction Manual. Frederick, MD.

### 3.18.6 Literature Cited

Harrelson, C.C., C.L. Rawlins, and J.P. Potyondy. 1994. Stream channel reference sites: an illustrated guide to field technique. U.S.D.A., Forest Service, Rocky Mountain Forest and Range Experiment Station. Gen. Tech. Rep. RM-245, Ft. Collins, CO.

## 3.19 Equipment and Personnel Decontamination Procedures

The purpose of this procedure is to provide a description of methods for preventing or reducing cross-contamination and description methods that will protect the health and safety of site personnel.

### 3.19.1 Field Equipment Decontamination

All reusable sampling equipment should be properly cleaned before going into the field. When sampling and field activities are completed, sampling equipment that has come in contact with contaminated or suspect water should be decontaminated before leaving the site. The purpose of the field decontamination procedures is to protect the field equipment from cross contamination. The field decontamination procedure should provide a quick method of removing most sample residues from the equipment.

#### 3.19.1.1 Sampling Equipment and Containers

Surface water with known or suspected contamination by biological organisms should be decontaminated with a mixture of bleach and water. A specified technique is not specified, but two suggestions for decontaminating equipment are presented.

- ❖ The bleach/water mixture is contained in a bucket. Equipment is placed into the bucket and thoroughly brushed with a long handle bottle brush and then rinsed with either tap or distilled water. For equipment that is too large to fit into the bucket, hold the piece over the bucket and proceed as described above. For churn splitters, pour some of the bleach/water mixture into the container and proceed as described above.
- ❖ A bleach/water mixture is contained in a spray can. The piece of equipment is held over a bucket while it is being sprayed with the mixture. The bucket collects the drippings from the equipment and disposed of properly. The decontaminated equipment is then rinsed with either tap or distilled water. The outside and inside surface of churn splitters is sprayed and rinsed with either tap or distilled water. The bleach/water residue is collected in the disposal bucket for later disposal.

### 3.19.2 Sampling Safety

Proper safety precautions must always be observed when sampling. In all cases, the person collecting a sample must be aware of the potential dangers from the material to be sampled and from the site location. Background site information should be obtained about the sample stream. This information will be helpful in deciding the extent of sampling safety precautions to be observed. If background information does not exist, use the best available precautions.

The following general safety rules and practices should be implemented whenever sampling:

1. The best way to simplify decontamination is to minimize contact with contaminants.

2. Each sample should be handled with care to minimize the risk of personal exposure.

3. If special handling of the sample is appropriate, such as safety glasses/goggles, hard hats, boots, gloves, and respirators, must be worn in areas where hazardous conditions are suspected. In addition, eye and hand protection should be worn when handling acidic, caustic (e.g. bleach), or other hazardous liquids (including preservative chemicals, such as formaldehyde).

**3.19.2.1 Sample Handling**

The portion of sample to be analyzed is transferred to the appropriate containers. It may be necessary to transfer the sample into two or more containers if multiple analyses will be requested and they require different preservatives.

Preservatives should be added to water samples as soon as practical after collection (in general, within 15 minutes). As each portion of sample is transferred to the various containers, it may be necessary to stir or agitate the samples so that suspended matter remains evenly distributed.

The receiving laboratory must be notified of preservatives used in the samples and the extent of the potentially hazardous material in the water sample.