Aquatic Biota Monitoring Plan

Prepared by the Coal Bed Natural Gas Interagency Working Group – Aquatic Task Group (ATG)

Purpose:

Monitoring of aquatic biota (fish, macro-invertebrates, herps) and their habitat is needed to assess impacts of CBNG surface water quality and quantity (flow) discharges into the Powder River Basin (PRB). This monitoring will be used to assess overall and site-specific biotic conditions for drainages listed in the Bureau of Land Management (BLM) Record of Decision (ROD) for Montana and Wyoming. This monitoring is not specific to any particular CBNG project or development.

Objectives:

- Establish baseline conditions for aquatic biota (fish, macro-invertebrate, amphibians) and their habitat in drainages with current or anticipated CBNG development.
- Evaluate the existing or potential effects of CBNG water discharges on aquatic life.

Scope:

The Rosebud Creek, Tongue River, Powder River, Belle Fourche River, and Cheyenne River watersheds have been identified as needing monitoring to assess effects on CBNG development on water quality and aquatic biota. The Tongue and Powder Rivers flow from Wyoming into Montana, the Belle Fourche River flows from Wyoming into South Dakota, the Cheyenne River flows from Wyoming into Nebraska, and Rosebud Creek is located completely in Montana. The potential for impacts due to CBNG development will be compared to baseline data over time to assess effects of CBNG development on aquatic life. Current biotic conditions will serve as the benchmark against which subsequent monitoring data will be compared to assess effects of CBNG discharges as development (and monitoring) progresses.

Methods:

Biological and aquatic habitat information will be collected at USGS monitoring stations and priority reaches in the drainages as outlined in Table 2 (spreadsheet). The frequency of these data collections, and the specific information collected and analyzed, will depend upon the specific station being considered, anticipated data needs, access for conducting surveys, and whether CBNG discharge water is present.

Specific plans and methods relative to aquatic habitat, fish, and macro-invertebrates are outlined in **Chapters 1, 2, and 3**, respectively. It is recommended that a monitoring plan also be developed for amphibians and aquatic dependent reptiles. The ATG recommends initiating an amphibian and aquatic reptiles (Herps) monitoring plan with a research project proposal: “Impacts to Amphibians and Reptiles in Relation to Effects from Coal

Bed Natural Gas Production", as outlined in the recommended research section of this plan.

We anticipate that most of the data recommended for collection under this plan will serve as baseline information due to the paucity of historical biotic data in many of these drainages. Where possible, study reaches and biotic data collected and analyzed will be associated with sites where water quality data are also being monitored and analyzed by the Water Task Group (WTG) to assess changes in water quality that may affect aquatic biota. Additional sites have been recommended where some previous data exist, or where the ATG identified the need to assess current conditions to provide adequate baseline data on the drainage biota and their habitats. Additional monitoring may be necessary (i.e., periphyton, over-night net sets for fish) pending results of initial sampling.

We envision this monitoring to be a dynamic process that annually will be evaluated to determine the sampling procedures, frequency and locations necessary to optimize comparisons of current conditions to baseline conditions in the respective drainages. For instance, most of the defined sampling sites may not directly capture the effects of a particular CBM discharge or initial data collections will indicate the need for modifying procedures. We anticipate adding (or reducing) sites and modifying procedures as groundwork and baseline data are collected. In addition, the ATG is recommending some contracted or graduate level research projects for consideration to determine direct impacts on aquatic biota.

Products:

Biological and habitat information will be tabulated, graphed, compared to historical conditions where data exists, compared to applicable water quality and quantity data reported from the WTG, compared to applicable state and federal biocriteria, and compared to predictions and precautions noted in the MT and WY CBNG EIS documents. A monitoring summary report will be prepared annually. Recommendations concerning changes in stations, parameters and frequency of sampling will be included in the annual report.

Responsibilities:

The collection of aquatic biota and habitat information will be a cooperative effort lead primarily by the respective BLM offices in MT and WY. Our initial recommendation calls for the hiring of GS-level personnel and technicians within the respective state BLM filed offices. These personnel will have responsibility for conducting surveys; obtaining pertinent data from other agencies and institutions; analyzing and compiling data, and comparing it to available historical or baseline data; coordination with and making recommendations to the ATG; and preparing and presenting annual reports. Certain aspects of the recommended data collection and research is recommended for outsourcing to academic institutions and/or private consultants that will aid in data collection or analyses.

Cost:

Estimated cost per station is summarized on the attached spreadsheets (Table 1). The total cost for conducting aquatic surveys in Wyoming and Montana is $217,530 annually ($108,765 per state). The total is based on 2 field crews of 3 summer technicians and one full time aquatic or fishery biologist. The total cost for three research proposals is $433,400 (one-time costs). Estimates are based on hiring additional GS-level personnel within the BLM to specifically conduct these surveys with appropriate funding and input from other agencies, as available. Portions of some monitoring or data analyses are recommended for outsourcing as defined in the specific monitoring plans. If monitoring surveys are contracted or assigned outside the BLM or state agencies, different cost estimates should be expected. Annual reporting will be coordinated by the BLM

Proposed Locations:

Drainages potentially affected by CBM development in Wyoming and Montana are listed with recommended survey sites within these drainages in Table 1.

(See exel table)

Chapter 1: Aquatic Task Group Monitoring Plan For Habitat:

Purpose:

Aquatic life habitat is an essential part of aquatic community assemblages and life histories. The condition and type of habitat can define species diversity, growth rates, and abundance. Monitoring aquatic habitat is crucial to assessing the potential effects of CBNG development on aquatic life. The monitoring will be used to assess differences between current habitat available and habitat available before, during and after CBNG development.

Objectives:

(1) Determine the current type of aquatic life habitat available. (2) Assess the negative and positive changes in aquatic habitat over time. (3) Determine if changes in aquatic habitat are caused by CBNG development. (4) Develop mitigation measures to minimize potential negative effects to aquatic life habitat.

Sampling locations:

Sampling locations for habitat monitoring will be listed in the ATG spreadsheet (Table 1). Additional sites may be established to further clarify data on aquatic life habitat relative to potential impacts due to CBNG development.

Sampling reach:

Aquatic life habitat monitoring will occur within a stream segment that is equal to two meander lengths, 20 bank full channel widths, or 500m, which ever is greater. On larger streams, such as the Tongue and Powder Rivers, this length may be changed to reflect the amount of habitat needed to achieve credible results.

Sampling periods/frequency:

The sampling period will consist of monitoring each site for habitat once a year.

Sampling methods:

Sampling methods are described in Appendices 1 and 2.

Equipment Needs:

(1) GPS unit, camera, film, densiometer, conductivity meter, Hach kit (or meters to measure units on form (Appendix 1), Turbidity meter, thermometer, 300’ measuring tape, stadia rod, transit with level, bank full pins, rebar to establish cross sections, spray paint, string, ruler, water velocity meter, flagging and waders.

Forms:

The required form and definitions are located in Appendices 1 and 2.

Project cost/station:

Refer to ATG spreadsheet (Table 1)

References:

Bramblett, R. G., T.R Johnson, A.V. Zale, & D. Heggem. 2003. Development of Biotic Indices for Prairie Streams in Montana Using Fish, Macroinvertebrate and Diatom Assemblages. Montana Cooperative Research Unit.

EPA. 1999. Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers. Second Edition. Washington DC.

Department of Aquatic, Watershed, and Earth Resources (AWER). 2003. BLM Buglab Stream Assessment Data Sheet. National Aquatic Monitoring Center. Utah State University.

Rosgen. Dave. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, CO.

US Department of Interior. 1998. A User Guide to Assessing Proper Functioning Condition and Supporting Science for Lotic Areas. TR 1737-15

US Forest Service. 1999. Stream Inventory Handbook Level I & II. Pacific Northwest Region 6. Version 9.9

Chapter 2: Aquatic Task Group Monitoring Plan for Fish

Purpose:

Native fish in the prairie streams of Montana and Wyoming have evolved in, and are uniquely adapted to the hydrologic conditions of these watersheds. Monitoring of fish and their associated habitat is needed to assess the potential impacts of CBNG water discharges to surface waters quality and quantity (flow) in drainages potentially affected by CBNG water discharges in Montana and Wyoming. This monitoring will be used to assess existing fish composition and distribution in the respective drainages. Data will be compared to historical or reference conditions over time to assess the occurring or potential impact due to CBNG development. This monitoring is not specific to any particular project.

Objectives:

Determine native and introduced fish species composition, distribution temporally and spatially within drainages affected, or potentially to be affected, by CBM development – within the permitted scope and regulations of the individual States where sampling is proposed.

Sampling locations:

Sampling locations for fish monitoring are listed in Table 1. Additional sites may be established in the future pending data collected at these initial sites and the need to further clarify data on fish relative to potential impacts due to CBNG development.

Sampling reach:

A total of 2 meander lengths, 20 bankfull channel widths, or 500 meters (whichever is greatest) will be used as the basic sampling reach. This will be consistent with monitoring protocol for habitat and invertebrates. For larger, main-stem channels, such as the Powder and Tongue, modification of the sampling reach may be needed to ensure that all habitat types (pools, riffles, runs, backwater, side channels) are sampled.

Sampling periods/frequency:

- 3 times within one year: pre-runoff (April/May); post-runoff (July/August); and late season (October/November).
- Repeat annually for 3 years to establish baseline condition

Sampling methods:

Protocols in use or proposed in WY and MT, or by EPA and USGS (i.e., EMAP and NAWQA) for prairie streams will be reviewed prior to recommending a standard sampling protocol for fish. These various methods share some common sampling procedures, although application to some of WY and MT's unique streams, such as the lower Powder and Tongue main-stems, might require some modification to collect representative samples. Initial recommendations are:

- Select minimum of 2 of each habitat type present (define) within reach for sampling.
- Determine fish species composition w/in each habitat type using suitable sampling techniques (electrofishing, seining).
- Overnight sampling (trap nets and minnow traps may be added to the sampling if active sampling (seining, electrofishing, etc.) techniques are not adequate to collect representatives of all species expected to be present.
- Collect representative sample (2) of each species within station for voucher specimens and identification verification (hybogs – sample of 20).

Equipment needs:

Suggested sampling equipment and supplies will be included when a standard protocol is adopted.

Forms:

Suggested forms will be included when a standard protocol is adopted.

Projected cost/station:

Estimated cost per station is included in Table 1.

References:

Wyoming WSA

Bramblett R.G., T.R. Johnson, A.V. Zale, and D. Heggem. 2003. Development of biotic integrity indices for prairie streams in Montana using fish, macroinvertebrate, and diatom assemblages. Montana Cooperative Fishery Research Unit, USGS, Montana State University, Bozeman, MT. 96p.

Lazorchak, J.M., D.J. Klemm, and D.V. Peck, eds. 1998. Environmental monitoring and assessment program-surface waters; field operations and methods for measuring the ecological condition of wadeable streams. EPA/620/R-94/004F. U.S. Environmental Protection Agency, Washington D.C.

Moulton, S.R., J.G. Kennen, R.M. Goldstein, and J.A. Hambrook. 2002. Revised protocols for sampling algal invertebrate and fish communities as part of the national water quality assessment program. U.S. Geological Survey open-file report 02-150, Reston, VA. 75p.

Quist, M.C., W. Hubert, F. Rafel. 2004. Warmwater Stream Assessment Manual. Prepared for Wyoming Game and Fish Dept., by U.S.G.S., University of Wyoming Cooperative Fish and Wildlife Research Unit of University of Wyoming, and Wyoming Game and Fish Dept., Cheyenne, WY., 182 p.

Chapter 3: Aquatic Task Group Monitoring Plan for Macroinvertebrates

Purpose/Rationale

The bioassessment is a relatively inexpensive method that can be used to detect stream water quality and biological changes related to changes in land use or introduction of point and non-point source (NPS) pollutants. Bioassessments have been used in Wyoming and throughout the U.S. to examine water quality changes related to a wide range of point discharge effluents, NPS pollutants, land use changes, toxics, and for baseline siting studies. When objectives allow, the bioassessment is a sound alternative to costly and complex water quality based monitoring programs.

Bioassessments using macroinvertebrates have several advantages for determination of stream water quality changes since they:

1. Respond quickly to changes in water quality and environmental conditions;
2. Are relatively easy to sample and analyze with a minimal number of personnel;
3. Reside in water during all or most of their life cycles and are thus full-time monitors of water quality;
4. Are relatively immobile and cannot avoid "events" or "pulses" of water pollutants often missed by conventional water sampling;
5. Are abundant in most streams and rivers; and
6. Serve as the primary food sources for stream fishes and thus reflect potential impact to the fishery.

Objective

Use measures of macroinvertebrate community composition and tolerance to assess impacts of CBNG development on aquatic life in the project area.

Sampling Locations

Sampling locations for macroinvertebrates monitoring are listed in Table 1. Initially, Table 1 sampling sites in Wyoming will be in the same general area as water quality sampling data are collected, as outlined by the Water Task Group. Additional sites may be established in the future pending data collected at these initial sites and the need to further clarify data on macroinvertebrates relative to potential impacts due to CBNG development.

Sampling Reach

The sampling reach should be consistent with the reach required for fish sampling and the habitat assessment. A reach that is twenty times the bankfull channel width is recommended.

Sampling Periods/Frequency

Sampling should be conducted annually at all sites during the summer/fall low flow period.

Sampling Methods

The sampling methods are based on a combination of Wyoming Department of Environmental Quality (WDEQ, 2001) and USGS National Water Quality Assessment (NAWQA) program methods (Moulton et al. 2002). The methods are only described briefly below. See the given references for specific guidance on sampling techniques.

A semi-quantitative sample (WDEQ 2001) is collected to provide a measure of relative abundance of the invertebrate taxa living in the shallowest, fastest flowing habitat in the reach. This habitat generally supports the faunistically richest invertebrate community and is typically represented by a coarse-grained riffle, but in the absence of a riffle it also may be a run or glide comprised of fine to coarse grained material. The sample consists of a series of eight discrete Surber samples that are collected from random locations in the targeted habitat. All Surber samples are combined into a single composited sample. Substrate composition and embeddedness are visually estimated, and current velocity is measured, at each Surber sample location and recorded on the field data sheet.

> WDEQ, 2001. Standard operating procedures for sample collection and analysis. Wyoming Department of Environmental Quality, Cheyenne, Wyoming.
>
> - see SOP for Macroinvertebrate Sampling
> - see SOP for Current Velocity, Measuring

A qualitative multi-habitat sample (QMH)(Moulton et al. 2002) is collected to document the invertebrate taxa that are present throughout the sampling reach. A discrete QMH collection is taken from each of the different instream habitats that are present in the reach. These discrete collections are then processed and combined into a single composited sample.

> Moulton, et al. 2002. Revised protocols for sampling algal, invertebrate, and fish communities as part of the National Water Quality Assessment Program. U.S. Geological Survey Open-File Report 02-150. Reston, VA. 75 p.

Equipment Needs

See WDEQ (2001) and Moulton et al. (2002).

Datasheets/Field Forms

Will be developed at a later date. Will incorporate fish and habitat protocols into the same form.

Projected cost per station

Estimated costs per station are included in Table 1.

APPENDIX 1: CBM Aquatic Habitat Monitoring Stream/River Survey Form

Stream/Site Name/State: Date:

Samplers/Organization: Weather:

Location: T N/S, R E/W, Section, Location in Section:

GPS coordinates (decimal degrees): Latitude: Longitude:

Landownership (Public y n) If private please provide landowner contact information:

General sight overview:
Comments: (i.e. beaver activity, archeology, natural features, prominent geology, etc.)

Photo (upstream) Photo (downstream)

Photos from center of study sight

Management Activities:	Rank	Description						
Instream Structures (i.e. culverts, bridges, stabilization)		Notes:						
Agriculture		Notes:						
Recreation		Notes:						
Mining		Notes:						
Roads		Notes:						
Stream Diversions		Notes:						
Urbanization		Notes:						
Livestock Grazing		Notes:						
Livestock Use Index:	Left Transect				Right Transect			
	Cow-old	Cow-new	Sheep-old	Sheep-new	Cow-old	Cow-new	Sheep-old	Sheep-new
Number of fecal droppings								

Riparian Assessment:

Riparian vegetative zone width (least buffered side):_________ feet

Dominant overstory: Dominant understory:

Are known invasive plant species present? Yes No If Yes, please list:

Is there evidence of plant recruitment for non-invasive trees/shrubs? Yes No

	Densiometer measurements (Number of points shaded of 96)			
Direction	Unit 1	Unit 2	Unit 3	Unit 4
Upstream				
Left Bank				
Right Bank				
Down Stream				

Vegetative cover of sample reach (circle one): ≥ 95%, 85–94%, 75–84%, ≤ 75%
Consumption of trees and shrubs by livestock (leader growth): ≥ 50%, 25–50%, 5–25%, 0–5%

Stream Banks:

% of streambank in sample reach with deep, binding root masses (circle one): ≥ 85%, 65–85%, 35–64%, ≤ 35%

Erosional deposition from surrounding slopes (circle one):
None, Some in specific limited locales, Obvious signs, Mass wasting

% bank with lateral cutting (circle one): ≥ 35%, 15–35%, 5–15%, ≤ 5%

Condition of Banks (✓check the most appropriate statement)
__ Banks stable; __ Banks moderately stable; __ Banks moderately unstable; __Banks unstable

Water Chemistry:

Site measures							
Conductivity µmhos/cm	P Alkalinity (ppm $CaC0_3$)	Total Alkalinity (ppm CaC03)	pH	Dissolved Oxygen	Turbidity (NTU's)	Air temp.	Water Temp.

Channel Morphology:

Cross section	1	2	3	4	5	6	7	8	9	10	Mean values
Bankful Width											
Bankful Depth											

Bankful area (from x-sections)											

Water Velocity: _____fps
Calculated discharge: ______ cfs
Width of flood prone area (2xBankful depth) = __________
Stream Slope (S_s) (ft/mile) = ___________
Valley slope (S_v) (ft/mile) = ___________

Valley Length (ft) = __________
Stream Length (ft) = __________
Sinuosity from Length (K_L) = __________

Meander Length (L) (ft) = __________
Width of stream belt (ft) = __________
Width/depth ratio = _______
Entrenchment ratio = _______
Pool:riffle ratio = ________
Residual pool depth = _________

Substrate and instream habitat:

Instream cover within study reach (✓check the most appropriate statement)
__ Greater than 50%, __ 30 to 50%, __ 10 to 30%, __ Less than 10%

Large woody debris:
Count all pieces of woody debris in study reach that measuring at least 6 inches in diameter and 10 feet in length.

Total count _______

Stream incisement (✓check the most appropriate statement)
__ No incisement, __ Old incisement, __ Deep incisement, new floodplain development, __ Deep incisement, active downcutting

Particle	MM	#@1	#@2	#@3	#@4	#@5	#@6	#@7	#@8	#@9	#@10
silt/clay	<0.062										
fine sand	0.062-0.125										
med. sand	0.25-0.5										
coarse sand	0.5-1.0										
very coarse sand	1.0-2.0										
very fine gravel	2.0-4.0										
fine gravel	4.0-6.0										
med-fine gravel	6.0-8.0										
med. gravel	8.0-12.0										
med-coarse gravel	12.0-16.0										
coarse gravel	16.0-24.0										
coarse gravel	24.0-32.0										
very coarse gravel	32.0-48.0										
very coarse gravel	48.0-64.0										
small cobble	64.0-96.0										
med. cobble	96.0-128.0										
large coble	128.0-192.0										
very large cobble	192.0-256.0										
small boulder	256.0-384.0										
med. boulder	384.0-512.0										
large boulder	512.0-1024.0										
very large boulder	1024.0-4096.0										
bedrock											

Major Grain Size (field):

ϕ15 ϕ34 ϕ50 ϕ84 ϕ95

Manning Roughness Coefficient _____

Elevations and (distance from) set benchmark						Stream bed elevations and (distance form) set benchmark												Elevations and (distance from) set benchmark				
Cross section Number	LBM	LT, LFP	LBF	LB	LEW													REW	RB	RBF	RT, RFP	RBM

LBM = Left Bench Mark
LT, LFP = Left Terrace/Floodplain
LBF = Left Bankfull
LB = Left Bank
LEW = Left Edge water

RBM = Right Bench Mark
RT, RFP = Right Terrace/Floodplain
RBF = Right Bankfull
RB = Right Bank
REW = Right Edge water

APPENDIX 2: CBNG Aquatic Habitat Monitoring Stream/River Protocol & Definitions

Header Information

Stream/Site Name: Record the full name of the stream. Include the river or creek designation. Write down the state and county. Assign a unique site ID number to each site sampled.
Samplers/Organization: Record the names of the people collecting data at that site. Record the name of the company or government organization (with district) that the work is being conducted for.
Date: Record as day, month, year. (e.g. 04 July 1998)
Weather: Describe the weather (i.e. – partly cloudy, drizzle, etc.)
Location: Record the Township, Range, and Section.
Location in the Section: Record the location in the Section (i.e. SW of SE)
GPS coordinates (decimal degrees): Record Latitude, Longitude, and elevation.
Landownership: Circle y or n to verify if the land is publicly owned. If not, please provide landowner contact information:

The information on the CBM Aquatic Habitat Monitoring Stream/River Survey Form should be taken within a stream segment that is equal to two meander lengths, 20 bankfull channel widths, or 500 m, which ever is greater (for larger rivers, such as the Tongue and Powder Rivers, stream segment length may be adjusted to achieve credible results). Establish the beginning and end of the stream segment and complete the form. The following text involves definitions and protocol for the parameters on the survey form.

General Sight Overview

Comments:

Use this space to elaborate on any of the attributes below. Note apparent watershed problems, special features or habitats, management problems, beaver activity, tributary information, natural features, prominent geology, biological information, etc.

Photos:

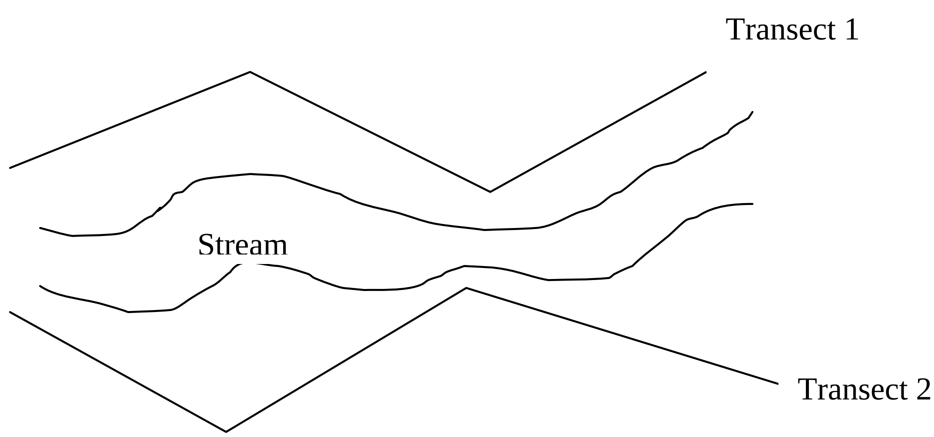
Include at least two photos from the center of the stream segment (one downstream and one upstream).

Management Activities:

Rank all of the management activities, as described on the data form that occur along the stream segment according to their relative impact on the stream system. A ranking of 1 represents the most significant impact. A ranking of 4 indicates no impact. Describe the impact in the comments.

Livestock Use Index:

We calculate a livestock use index by counting the number of cow and sheep droppings (feces) observed along two 75m, zigzag transects, 1 located on each side of the stream. Start each transect at the lower end of the study area. Each transect should zigzag 3 times over the 75m total length. Start at the streams' edge and locate a landmark ~ 25m away and angling at ~ 30-45o away from the stream. Walk directly toward the landmark and count all cattle and sheep droppings within 1m on either side of you (i.e., a 2m wide band). Keep counts for cattle and sheep separate. Keep counts of >new= and >old= droppings separate as well. New droppings cannot be turned over intact with a stick; old droppings can. Use a 25m tape or string to locate the end of the first 25m part of the transect. After completing the first 25m of the transect, locate another landmark ~ 25 meter away back toward the stream channel. Count droppings along this transect. The 3rd portion of the transect should angle away from the stream again. Repeat this procedure on the other side of the stream.



Riparian Assessment

Riparian Vegetative Zone Width:

Take a measurement of the representative riparian zone width within the reach. This area is defined from the bankfull mark to the point where there is a distinctive change in upland vegetation or hillslope. If there is no clear transition, consider the area within 10 - 15 m of the bank when answering riparian related questions.

Dominant Overstory: Enter the dominant overstory species of vegetation (should be a woody shrub species unless none are present) growing in the riparian zone. The task is to define from an overhead (i.e., bird's-eye) view which species occupies the most overstory area within the riparian zone along both banks of the measured habitat. It is the average of both bank's condition.

Dominant Understory: Enter the dominant understory species of vegetation (should be a woody shrub species unless none are present) growing in the riparian zone. The task is to define the dominant understory vegetation (based on percent area covered) on the site. This should be a woody shrub species unless none are present. A grass/forb/sedge delineation should not be used if a large number of understory woody shrub species are present, even though it may constitute a higher percentage of the riparian area.

Invasive plants: Indicate whether noxious weeds or other nonnative plant species are present on site. List these species.

Non-invasive plants: Indicate whether there is recruitment of all age classes of native plant species on site (i.e. Are there cottonwood saplings intermixed with older age classes?)

Densiometer:

Take four densiometer readings from the center of each of the four habitat units sampled for invertebrates. Readings should be taken facing upstream, downstream, bank left, and bank right. For each reading, place the densiometer near the surface of the stream and level it before taking a reading. Estimate shading by assigning 0 -4 points to each square on the densiometer grid and summing across grid squares. Points are assigned based on the percent of each square containing a shade object: 0 for no objects, 1 for 25% cover, 2 for 50% cover, 3 for 75% cover, and 4 for 100% cover.

Vegetative Cover: Estimate the % of the floodplain covered by mature perennial plants (tress, shrubs, or grass).

4 = > 95%
3 = 85 - 95%
2 = 75 - 85%.
1 = < 75%

Consumption of trees & shrubs by livestock (leader growth):

4 = 0 - 5%
3 = 5 - 25%
2 = 25 - 50%
1 = > 50%

Stream Banks

Percent of streambank with deep, binding root mass:

4 = > 85% of the bank with deep, binding root mass.
3 = 65 - 85% of the bank with deep, binding root mass.
2 = 35 - 64% of the bank with deep, binding root mass.
1 = < 35% of the bank with deep, binding root mass.

Erosional deposition into stream from surrounding hillslopes - Scan the hillsides on both sides of the stream for evidence of active erosion:

4 = No erosional deposition is apparent.
3 = Some signs of erosional deposition are apparent, but these areas are confined to specific, limited locales along the stream (e.g., gulleys, washes, slumps, roads).
2 = Obvious signs of erosional deposition from the hillslopes are apparent.
1 = Mass wasting is evident on hillslopes. Stream deposition is significant enough to cause obvious changes in stream flow (e.g., debris avalanche, torrent tracks).

Percent of stream with active lateral cutting:

4 = 5% or less of the streambank shows active lateral cutting.
3 = 5 - 15% of the streambank shows active lateral cutting.
2 = 15 - 35% of the streambank shows active lateral cutting.
1 = > 35% of the streambank shows active lateral cutting.

Condition of Stream Banks (Check the most appropriate statement)

__ Stream banks stable; no evidence of erosion or bank failure
___ Banks moderately stable; infrequent or small areas of erosion mostly healed over.
___ Banks moderately unstable; up to 60% of banks in the reach have areas of erosion.
___ Banks unstable, many eroded areas. "Raw" areas frequent along straight sections, bends and side slopes. 60-100% of stream banks have erosional scars.

Water Chemistry

Conductivity: Turn on the conductivity meter and place the probe into the main flow. When the reading stabilizes, record the conductivity as micro-Siemens per cm.
P Alkalinity: Use the test kit to determine the alkalinity of the water. Record the

value as ppm of $CaCO_3$.
Total Alkalinity: Use the test kit to determine the total alkalinity of the water. Record the value as ppm of $CaCO_3$.
pH: Use a test kit or meter to determine pH and record the value.
Dissolved Oxygen (DO): Use a test kit or meter to determine DO and record the value.
Turbidity (NTU's): Use a test kit or meter to determine turbidity and record the value.
Air Temperature: Place or hold the thermometer away from the direct sunlight and materials that conduct heat (metal, etc.) for 30 seconds. Read
and record the temperature.
Water Temperature: Place the thermometer into the main flow. After 1 minute, read and record the temperature.

Channel Morphology

Bankfull: A term used to describe streamflow which occurs on average once every 1.5 years. Flows of this magnitude transport the most sediment over time. Bankfull flows are the discharge for maintaining the present channel shape. In channel types possessing a well-developed floodplain (i.e. Rosgen streamtype C), Bankfull is the stage or streamflow that just overtops the channel's banks and begins to inundate the floodplain (Stream Inventory Handbook 1999)

Bankfull Indicators: The channel attributes created during bankfull flow and visible during low flow conditions. The best indicator of bankfull flow is the deposits of streambed material which remain after a bankfull event. The top of these depositional features closely approximates the height of bankfull flow. Other indicators of bankfull are the lower limit of perennial vegetation, a change in streambanks' slope, a change in the particle size of the streambank, undercut banks and the presence of stain lines or the lower extent of lichen colonization on the banks (Stream Inventory Handbook 1999).

Bankfull Stage: The water level elevation during a bankfull discharge. This elevation leaves a signature on the channel in the form of depositional areas and distinct streambank slopes. The line of permanent vegetation along a stream is often a close approximation of the bankfull stage (Stream and Inventory Handbook 1999).

Bankfull Width: This is the measured width (perpendicular crossection) of the stream at bankfull stage. Use bankfull indicators to determine where the bankfull stage is located. Complete ten cross-sections within the study stream segment.

Bankfull Depth: This is the mean depth of at bankfull stage taken every foot across the crossection from the bankfull stage. Complete ten crossections within the study segment.

Bankfull Area: The bankfull area is the bankfull width times the mean bankfull depth (bankfull width x mean bankfull depth.

Water velocity: Use a velocity meter or measure and mark off ten feet of stream and time how long it takes an orange to float through the ten feet of the stream. Divide ten feet by the number of seconds it takes the orange to float through the area. This number would result in water velocity (feet per second).

Calculated Discharge: Discharge is equal to the water velocity multiplied by the cross-sectional area.
Width of flood prone area: The flood prone area is equal to the measured width at two times the maximum bankfull depth (Rosgen 1996) (2 x maximum Bankfull depth)

Stream Slope: This is equal to the vertical distance divided by the linear distance.

Valley Slope: This is equal to the vertical distance divided by the linear distance from the headwaters to the mouth.

Valley Length: This is the length of a linear straight line from the beginning point of your stream segment to the ending point of your stream segment.

Stream Length: Length of the stream segment surveyed following the channel thalweg.

Sinuosity from Length: Channel sinuosity is the ratio of stream channel length to valley length (Rosgen 1996) (stream length divided by valley distance).

Meander Length: It is the length of the stream in each meander in your stream segment. This is measured by following the channel thalweg.

Width of stream belt: This is equal to the average width of the meanders within the stream segment.

Width/depth ratio: The width/depth ratio is the ratio of the bankfull surface width to the mean depth of the bankfull channel (Rosgen 1996) (bankfull width divided by the mean bankfull depth).

Entrenchment ratio: The entrenchment ratio is the ratio of the width of the flood-prone area to the surface width of the bankfull channel. The flood prone width is measured at the elevation that corresponds to twice the maximum depth of the bankfull channel as taken from the established bankfull stage (flood-prone area width divided by the bankfull channel width) (Rosgen 1996).

Pool (or Glide)/Riffle Ratio: Count and estimate the wetted length, width and average depth of each habitat unit (pool (or glide)/riffle) within the study reach (500m to 1000m).

A pool is defined as a portion of the stream which usually has reduced surface turbulence and has an average depth greater than riffles when viewed during low flow conditions. A pool may at times contain substantial surface turbulence at the upstream end, but always has a hydraulic control present across the full width of the channel at the downstream end.

A riffle is a portion of stream with increased water velocity. Streamflow during low flow discharge is intercepted partially or completely by submerged obstructions to produce relatively high surface turbulence. Stream channel gradient is greater in riffles than in pools. Riffles are an inclusive term for low gradient riffles, moderate gradient rapids, and high gradient cascades.

Residual Pool Depth: Within each pool habitat unit, measure the maximum pool depth and the depth at pool tail crest. Subtract the maximum pool depth from the depth at the pool tail crest. Record these numbers on the data sheet.

The pool tail crest is the maximum depth measured at the hydraulic control of a pool.

Substrate and Instream Habitat

Instream cover within study reach (check the most appropriate statement):

__ Greater than 50% mix of boulder, cobble, submerged logs, undercut banks or other stable habitat. Good habitat
___ 30 to 50% mix of boulder, cobble, submerged logs, undercut banks, or other stable habitat. Adequate habitat.
___ 10 to 30% mix of boulder, cobble, submerged logs, undercut banks, or other stable habitat. Less than desirable habitat.
___ Less than 10% mix of boulder, cobble, submerged logs, undercut banks, or other stable habitat. Habitat is lacking.

Large Woody Debris:

Count all pieces of LWD in the study reach (500m to 1000m) equivalent to a minimum of 6 inches in diameter (or larger) and a minimum of 10 feet in length (or larger) within the bankfull channel.

Stream Incisement:

4 = No incisement.
3 = Old incisement.
2 = Deep incisement with new floodplain development.
1 = Deep incisement with active downcutting.

Pebble Counts:

(1) Locate a Reach for sampling through two meander wave-lengths or cycles of a channel reach that is approximately 20 to 30 "channel widths" in length.

(2) Determine the percentage of the reach configured as riffles and pools (this should have been completed in your pool/riffle ratio.

(3) Adjust the pebble-count transects of sampling locations so that riffles and pools are sampled on a proportional basis, where the percentage of samples taken in riffles is equal to the percentage of channel reach length.

(4) A total of ten transects with 10 samples at each transect needs to be taken (100 samples altogether).

(5) Always begin a transect at the edge of the bankfull channel and end each transect at the opposite edge of the bankfull channel.

(6) For pebble counting accuracy, use a tape line with equally spaced intervals to assist in determining an appropriate location for selecting in-channel particles for measurements. These measurements should be taken at each interval without looking at the substrate.

(7) Refer to Figure.

Mannings Roughness Coefficient:

$$\bar{U} = \frac{1.49(R)^{2/3}(S)^{1/2}}{n}$$

$\bar{U}$ = mean velocity
R = Hydraulic radius (cross-sectional area/wetted perimeter)
S = Slope of stream
n = Manning's Roughness Coefficient.