CHANNEL MONITORING METHODOLOGY

Dave Rosgen
1481 Stevens Lake Road
Pagosa Springs, CO 81147

General Monitoring Concepts

The objective for this type of monitoring is to evaluate the physical character of the stream dimension, pattern, profile and bed material to determine whether the river is unstable. The stability of streams depends on the sediment supply and the river's ability to transport it. Any sustained imbalance results in either erosion or deposition. Changes in streamflow, width, velocity, depth, slope, roughness of channel materials, sediment volumes and sediment sizes induced by management treatments can directly affect the stability of streams. This in turn often results in deteriorated water quality, reduction in quality and diversity of fish habitat and land loss through erosional processes.

Monitoring can indicate what is the current stability of a stream by evaluating whether the stream is aggrading (building up bed elevation by deposition over time), degrading (down cutting due to bed scour) or laterally eroding and at what rate. These data are important to help direct restoration, mitigation and fish habitat enhancement projects. In order to recommend grade control structures in a channel it is important to know if the river has a grade control problem. As simple as this statement appears there are hundreds of grade control structures installed annually in North American without any understanding of the processes controlling the vertical stability of the river. To predict the potential impact of an activity on a river it is necessary to determine the current state or stability of the river . . . what is the river doing?

Another objective of monitoring is to determine the degree of departure from existing conditions or changes in stability due to management activities. Mitigation measures are often proposed to offset potential adverse consequences of channel instability. Monitoring can be effective at determining the effectiveness of such mitigation.

Often it is also necessary to isolate the effect of differences in climate, geology and morphology from management impacts on stream stability. Monitoring can be implemented by using one of the following three approaches:

1. **Comparison with a reference reach (Control)**

   A stream reach is measured for comparison purposes that is unaffected by management activities. The chosen reach has to be of the same stream type and *state (impaired condition?)* as the reach being monitored for management impacts. The reference reach acts as the control or represents the least disturbed condition. Reference and study reaches need to be in neighboring watersheds. The assumption for this design is that the same storms, snowmelt rate, etc., and resulting streamflow will be reflected in both the control and study reach (Figure 1).

2. <u>Above versus below impact area for the same stream type</u>

Reference reach(es) on the same stream upstream of the management activity are compared to study reach(es) below. Reference and study reaches need to be in close proximity and of the same stream type (Figure 2).

3. <u>Before versus after management activity</u>

This approach establishes a "baseline" or calibration of individual reach conditions prior to implementation of a potentially impacting activity (Figure 3). Ideally, the period of evaluation will span similar weather patterns (dry vs. wet years, unique storms, etc.).

<u>Field methods</u>

These specific monitoring methods are designed to evaluate channel stability and sediment supply that affects bed material size-frequencies, distribution, bank erosion, etc.

I. Channel Stability

A. Vertical Stability (aggradation/degradation)
Objective: To determine if the stream is either down cutting (degrading), filling (aggrading), or is stable. The rate, magnitude and direction of vertical change is determined.

B. Lateral Stability
Objective: To determine the rate of lateral migration through bank erosion.

C. Bed Material Size-frequency Distribution
Objective: To observe a shift in bed material size-frequency distribution.

II. Methods

A. Vertical Stability

<u>Monumented Cross Sections</u> – This method employs the use of permanently monumented cross-sections located on at least a riffle and pool segment of a reach (or step vs pool segment if a step/pool stream). This involves locating the benchmark for the cross-section on a stable site above the active channel. If the left or right side of the cross-section is located on an unstable slope, an elevation benchmark is set (it does not have to be tied into an absolute elevation but rather a relative elevation set at 100 feet). Holes are dug on high banks on opposite sides of the river. Each will hold a half of a bag of "Sacrete". Each is approximately the same level (figure 4). A 10 inch stove bolt is placed in the concrete before it sets up, flush with the concrete.

The profile of the stream cross-section is measured from the intercept of the rod with the "leveled" tapeline (Figure 4). A re-survey of the cross-section should be done annually and/or following storm flow/snowmelt runoff events. Any "high water" marks need to be marked and indicated on the cross-section. The cross-section needs to be plotted for each measurement and compared to previous cross-sections. These measurements must include the floodplain and terrain outside of the "active channel".

A vicinity map and detailed site map need to be prepared so that the monumented cross-section can be located in the future by others who may not have previously been to the site. An upstream and downstream photograph is also recommended for site documentation. Channel dimensions for stream classification need to be collected in order to document morphological comparisons and extrapolation (see attached field forms).

Use cross section plotting and computation program such as R2-CROSS-81, or a similar plotting program as an alternative to using level/tripod survey instruments.

1. Locate the permanent benchmark on both side of stream.
2. Stretch tape very tight with spring clamp and level tape.
3. Tape at same elevation as reference bolt on benchmark.
4. Read distance and elevation reading of rod intercept with tape.
5. Measure major features such as:
    a. left bench

b. left terrace/floodplain
c. left bankfull
d. left bank
e. left edge of water
f. differences in bed configurations across bed
g. thalweg
h. inner berm features
i. right edge of water
j. right bank
k. right bankfull
l. right terrace/floodplain
m. right bench mark

B. Lateral Stability

To determine the rate and magnitude of bank erosion, the installation of bank "pins" and/or bank profiles are installed in sites representative of the stream banks of the river. These should be stratified and installed on outside bends and straight reaches of banks with different erodibility conditions along stream segments of the same stream type. Erosion rates can be expressed in feet/year, cubic yards/year or total tons/stream reach. Monumented cross-sections, maps and photos of this site need to be *undertaken/implemented* as described in II. A above. Stream classification measurements need to be taken to provide for extrapolation and comparison purposes.

1. Bank pin installation

The erosion pin method involves the installation of 2 or 3 smooth rods (4-5 feet in length with a diameter of 0.3 to 0.5 inch), horizontally into the bank at each location. Periodically, or as a minimum before or after storm periods, the distance between the end of the rod and the bank face is measured (Figure 5). Bank pins need to be installed in the banks of the permanent cross-section. This not only provides a rate of lateral migration but indicates if *levels/dimensions* such as bankfull elevation are changing.

2. Bank profile procedure involves:

a. Installing a permanent cross-section over the bank profile site.
b. Installing a permanent toe pin (rod) (offset and directly) adjacent to the study bank (Figure 6).
c. Place survey rod vertically on toe pin.

d. Stabilize rod with either a tripod or a frame to attach to bank to hold rod “plumb”.
e. Measure horizontally with tape rule rom vertical rod to bank. Measure at frequent vertical intervals to describe bank dimensions and features.
f. Plot data to display profile for each survey.
g. Compare with previous annual surveys or following storms.
h. Compute mean erosion/deposition rate (Figure 7).

3. Bed material size-frequency distribution procedure:

a. Use transect to obtain existing and departures of a frequency of particle size distribution by measuring 100 particles from bed material at riffles, pools and special features of interest (spawning reds, fish habitat structures, etc.).
b. Imbeddedness (percent fines in bed features)
c. Freeze core sampling and other similar procedures

If a pebble-count method is used without a permanently established transect for resurvey, *then proportionally distributed samples should be taken by the frequency of riffle (steeper slope with coarser bed material sizes).* For example, if 80% of the channel is composed of riffles, then 80% of the cross-sections sampled should be in riffles. Permanent transects are preferred for monitoring at a higher level of detail to make replication easier and to reduce sample error.

4. Bar material

A bar sample is excavated from a location on the lower 1/3 (planview) of a Point Bar at an elevation midway between the thalweg and bankfull stage. A core sample is taken with a bottomless bucket at a depth equal to 2 times the largest size rock on the bar surface within the bucket sample. The sample is sieved (size distribution by weight) and plotted both on a cumulative percent distribution (on log/normal paper) and by percent by size. Record the first and second particle from the bar surface sample. This provides information on the size distribution of bedload at bankfull discharge. If the size distribution changes following a bankfull event, sediment supply interpretations can be made. Examples of comparisons of bar samples are described and shown on pages 7-7 and 7-8 of the

"Applied River Morphology" book, Rosgen, 1996). Figure 7-6 from the book is included for review.

The largest particle from the bar (Di) and the D_{50} of the cumulative plot of size distribution are used to calculate critical dimensionless shear stress values. This is then used to calculate the corresponding depth and slope associated with a given river reach.

$$T_{ci} = 0.0834\ (d_i/d_{50})^{-0.872}$$

where: T_{ci} = critical dimensionless shear stress\

$d_i = D_{50}$ of bed material *(from active bed of a riffle)*

$d_{50} = D_{50}$ of bar material (*or subpavement located on the riffle bed)*

where: T_{ci} = Critical dimensionless shear stress

d = mean depth of flow

S = water surface slope

D_i = largest particle in bar

(largest available to be moved at the bankfull stage)

1.65 = is the ratio of weight of sediment to weight of water.

If the bankfull depth is less than this equation would indicate, then the stream has the potential to aggrade. If the slope is too flat aggradation potential also exists. Conversely, if the depth and/or slope is greater than the above equation would indicate, then bed scour or potential degradation could occur.

Example Entrainment Computation

Stream:	West Fork San Juan
Drainage Area:	85.4 $miles^2$
Bankfull Discharge:	1150 cfs

Step 1: Calculate critical dimensionless shear stress

$$\tau^*_{ci} = 0.0834\left(D_{50} \Big/ \hat{D}_{50} \right)^{-0.872}$$

τ^*_{ci} : Critical Dimensionless Shear Stress

D_{50} = Bed material D50 (from riffle pebble count) = 70mm

$\hat{D}_{50}$ = Sub-surface D50 or Bar Sample D50 = 20mm

$$\tau^*_{ci} = 0.0834\left(\frac{70}{20} \right)^{-0.872}$$

$$\tau^*_{ci} = 0.028$$

Step 2: Calculate the mean bankfull depth required to move the largest particle from bar sample

$$\tau^*_{ci} = \frac{dS}{\gamma_s D_i} \quad \text{transformed to:}$$

$$d = \frac{\tau^*_{ci} \gamma_s D_i}{S}$$

d :	Mean bankfull depth at riffle (feet)	
τ^*_{ci} :	Critical Dimensionless Shear Stress =	0.028
S:	Bankfull water surface slope =	0.007 ft/ft
γ_s :	Submerged specific weight of sediment =	1.65
D_i :	Largest particle in Bar Sample 130mm* =	0.43 feet

**Verification: A 140mm particle was caught in bedload sampler during runoff*

$$d = \frac{(0.028)(1.65)(0.43)}{0.007}$$

$$d = 2.8 \text{ feet**}$$

***Verification: Existing bankfull depth at the USGS gage (from 9-207 forms): 2.6 feet*

Summary

This monitoring methodology is designed to help identify and evaluate the physical characteristics of existing and possible future conditions of the river. The relative stability of the bed, banks and materials of the river provides for very valuable interpretations and assessments. Upon implementation of a good monitoring plan you will discover that excellent data can be obtained in relatively few days each year. A well designed monitoring plan will identify the rate, magnitude, consequence and nature of change of the river characteristics before vs. after imposed change and/or above vs. below impacts. This monitoring effort can provide insight into:

1. Causes, rates, magnitude and direction of river adjustment:
2. Effectiveness of mitigation measures:
3. Accuracy of prediction methodologies and;
4. Development of effective mitigation/restoration measures.

Biological monitoring and water quality monitoring (physical, biological and chemical), all need to be studied and integrated by stream type for these physical characteristic assessments.

Only through monitoring can we truly understand the consequence of our actions in the watershed on the river system. We must know how the stream system responds for purposes of prevention, prediction and restoration. Hopefully it will help us be more effective at properly managing our lands and rivers for the future.

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