BAKER RIVER: FLOW, SEDIMENT TRANSPORT, AND BANK EROSION AT A MEANDER BEND

This lab will introduce you to some common field techniques and some general understanding of the geomorphic processes operating in a stream. This field project has two primary objectives: field and quantitative analysis of (1) basic flow hydraulics (Manning's n, bed shear stress, etc.); and (2) the interaction between flow, sediment transport, and channel form around a meander bend. Thus, the lab will focus initially (the first day) on how the channel affects the flow -- on the various factors that cause resistance to flow and the large number of approaches to determining the amount and cause of that resistance. This effort will concentrate initially on data collection in 3-4 cross sections. On the second day the lab will focus more on the interaction between the flow and channel form. There are three basic lines of evidence that you will want to pursue: (1) the distribution of sediment sizes as an indicator of differential sediment motion during channel-forming flows; (2) the behavior of the present flow (boundary shear stress, velocity, slope, etc.) to the various channel geometries imposed upon it; and (3) the spatial distribution of bank erosion processes and the rate of channel migration.

In addition, we will spend some time discussing the larger-scale morphology of the river floodplain and looking for evidence for the rates and styles of channel migration. Aerial photographs of the study reach will be available in the lab (1017) for your use to allow a longer-term assessment of channel migration rates and styles.

Equipment Required: field notebook, pencils, eraser, millimeter-scale protractor, clipboard, waders/hip boots, rain gear, warm clothes, and lunch.

FIELDWORK

Split into four groups. Each group will work as a team all day, and a spirit of cooperation within the group, between groups, and especially with the instructors will make the day much more tolerable. A certain amount of data will be shared with the entire class, as described below. However, everyone should hand in an individual report, map, and field notebook.

The exercise consists of three parts: (1) mapping the channel and banks, (2) mapping the spatial pattern of sediment grain-sizes (pebble counts), and (3) velocity measurements at selected cross-sections. We have a limited number of current meters and surveying equipment, so groups will need to rotate their use throughout the day.

There is sufficient field equipment for the following rotation to work smoothly (assuming all goes well). At any one time: 2 groups can be collecting hydraulic and roughness data at their assigned cross-section (2 current meters); 1 group can be completing their topographic surveys: cross-section and longitudinal profile; and 1 group can be completing their map and making observations on channel erosion/deposition processes. Try to pace yourself so that you can pass off field equipment when the next group is ready.

<u>Mapping of channel and banks</u>

Using the level, stadia rod, and tapes, survey in enough points to accurately tie down the important features of the channel. Be sure to include:

- A good overall map, including the spatial distribution of erosion/deposition processes & their magnitude
- A map of the thalweg (deepest part of the channel) and the trace of the high-velocity core (use surface floats if necessary - orange peels work well)
- A map of bed topographic features: bars, bedforms, etc
- Longitudinal profile of the channel bed, water surface, and (if possible) the bankfull surface. The water surface slope is particularly important, especially near the gaging cross-sections.
- Channel cross-sections at all gaging locations (these will be staked at the beginning of the day). The cross-sections should extend at least to bankfull width and show banks, bed, and water surface.
- Any other notable features (bank under cutting or slumps, bedforms, etc)
- A permanent marker, for "absolute" elevation control, which will be established at the beginning of the day.
- Use Chow's method to estimate Manning's n for this channel (page 5)

Once the map is surveyed in, mark on it the distribution of vegetation, sediment sizes, and anything else of interest. In particular, map in everything that affects the roughness of the channel.

<u>Distribution of Sediment Grainsizes (Pebble Counts)</u>

Pebble counts should be made at six localities, including the cross-sections where your group has gaged the stream flow. At the cross-section, measure 5-10 pebbles at each velocity station & average across the channel. Other sites might include the channel thalweg elsewhere or frequently inundated bars. Depending on the variability, 50-100 pebbles should be measured along their intermediate diameter and recorded to the nearest mm. Each person in the group should take their turn at doing a pebble count (best done in pairs). You will be given a quick tutorial in making pebble counts in the morning.

<u>Measurement of Flow Hydraulics: Stream Gaging</u>

Each group will do one cross-section. The velocity measurements will yield four separate data sets: (1) discharge and mean velocity for use in the Manning equation (or other hydraulic formulae), (2) vertical velocity profiles for determining shear stress and roughness assuming a logarithmic profile, (3) near-bank velocity profiles for determination of bank shear-stresses, and (4) information on the local flow patterns (i.e. cross-stream currents or helical flow). The following must be measured:

- a series of depth measurements (roughly 20 per section) (these should be made using the level, tape, and rod while your group is surveying)
- a series of mean velocity measurements (4/10 rule) (these will be integrated across the channel width to give an estimate of flow discharge)
- two or three vertical velocity profiles near the center of the channel
- at least one horizontal velocity profile near the outer bank wall
- a series of measurements of flow direction (at positions both across-stream and in the vertical) to characterize the flow pattern: this is best done with colored flagging tape attached to a pole

Each group will be responsible for supplying the data for their gaging sections to the class by the Thursday lab meeting. This should include for each gaging station: section #, hydraulic radius, maximum depth, width, discharge, mean velocity, surface slope, flow patterns (velocity directions) and average grain size. Remember that the flow will evolve as it makes its way through the channel bend: only your group has the information every group needs for a given part of the channel bend.

<u>DATA ANALYSIS</u>

1) Determine Manning's n at each gaging locality based on:

   a) direct calculation using R, S, and V

   b) average grain size (from graph by Leopold et al.)

   and compare these values with your estimates based on your mapping and the use of the chart from Chow. Comment on your findings.

2) Plot a longitudinal profile (bed elevation, water surface elevation, and bankfull elevation, all on one figure).

3) Plot your vertical velocity profiles on a semi-log plot and determine u_* and z_o.

   Compare this stress value with what you would calculate using the depth-slope product. Comment on you findings.

4) For each gaging location, estimate the bankfull discharge, based on Manning's n, cross-sectional area, and slope. Compare your estimate to the hydrograph data for the Baker River: what is the recurrence interval of a bankfull flow at this site?

5) Spend some time looking at the distribution of channel roughness, geometry, slope, and sediment size and see of there are any consistent relations.

6) Consider qualitatively and/or quantitatively what would happen if the vegetation on the banks were removed.

<u>To Hand In</u>:

Your report should follow the established guidelines. Turn in:

1. A field notebook complete for his/her group.
2. A detailed map that fills a 8-1/2 x 11" page, properly labelled, in ink.
3. Appendices with tabled data from all 4 cross-sections, pebble histograms and other graphics, calculations, other quantitative data.
   NOTE: Do not simply copy your field notebook into the appendices. Things like tables of pebbles, measurements, or "revs per second", etc. are <u>not</u> appropriate.
4. Discussion (up to 4 typed pages).

<u>Discussion</u>:

1. Provide a quantitative description of stream flow for the Baker River. Obviously this includes velocity, boundary shear stress, discharge, roughness, sediment size, and characteristics.
2. What is happening to the stream through the study area? Discuss the interaction of the hydraulic parameters with bank stability, bedforms, thalweg migration, sediment sources and storage, changes in channel slope, width, and depth. Are observed changes predictable? What parameters are the most important?

Reference to the following papers and/or your text may help guide your thinking, but insure that your discussion is well-tied to your field data, not just conclusions or observations by others:

- Dietrich and others, 1979, J. Geol., 87, 305-315
- Hooke, 1975, J. Geol., 83(5), 543-565.

Please remember that your discussion should be firmly based on your observations and measurements. Speculation may be appropriate if used with caution.

Chow's Method:

n is estimated from the formula
$n = (n_o + n_1 + n_2 + n_3 + n_4)n_5$

Material n_o	
earth	0.020
rock	0.025
fine gravel	0.024
coarse gravel	0.028
Degree of surface irregularity, n_1	
smooth	0.000
minor (e.g. only minor slumping)	0.005
moderate (e.g. moderate slumping)	0.010
severe (e.g. badly slumpted, or irregular rock surfaces)	0.020
Variation of channel cross section, n_2	
gradual	0.000
alternating occasionally	0.005
alternating frequently	0.010-0.015
Relative effect of obstructions (e.g. debris, roots, boulders), n_3	
negligible	0.000
minor	0.101-0.015
appreciable	0.020-0.030
severe	0.040-0.060
Vegetation, n_4	
none	0.000
low	0.005-0.010
medium	0.010-0.025
high	0.025-0.050
very high	0.050-0.100
Degree of meandering, m_5 (multiplier)	
minor (sinuosity <1.21)	1.00
appreciable (sinuosity 1.2-1.5)	1.15
severe (sinuosity > 1.5)	1.30