Does stream type matter?
If you're interested in hydraulic geometry, it does.
Use and Limitations of CEM

- Excellent tool for developing a management strategy for incised stream systems
- Indicates condition of floodplain attachment and potential for riparian restoration
- Indicates threshold changes in cost of physical treatment
- Sometimes base-grade has been manipulated by entities such as county road departments, municipalities, or others. Short-term alterations may confuse casual observer. (e.g. hard checks put by road departments)
- Enough history of perturbations have passed that there are no reference sites to build upon for stage I of the Schumm Model
- Some Stage Vs are natural
Use and Limitations Rosgen’s Classification System

**UPSIDE**
- System is morphometric based and results are reproducible
- Stratification into correct stream type leads to a more appropriate planning and design
- We can talk in common terms about stream types instead of a wordy complicated description
- System is Robust

**DOWNSIDE**
- Bankfull Indicators can be difficult to find
- Bankfull regional curves are recommended but they can be time consuming and data may be limiting
- Mis-use of system
- Validation process may be time consuming
How good are we at observation?

If you see sheep . . .

. . . you need glasses!
Streams operating outside of their range of natural physical variability long enough to induce an evolutionary channel change. For example, the combination of poor lateral stability (reduction of critical native plants as in Carex) and a significant flood event can easily drive a pool:riffle gravel bed stream into a state beyond a threshold, inducing a new stream form striking off a new channel evolutionary path. State and transition assessments really needs to consider this.
Stream Balance Equation
(Lane, 1955)

Load $\propto$ Energy

$Q_s \cdot D_{50} \propto Q_w \cdot S$

- $Q_w = $ Stream Flow
- $S = $ Stream Slope
- $Q_s = $ Sediment Load
- $D_{50} = $ Sediment Particle Size
Depth Velocity and Shear

\[ v = 1.486 \frac{r^{2/3} \times s^{1/2}}{n} \]

\[ r = \frac{A}{WP} \]

Why Floodplains?
As WP goes up,
R goes down,
As R goes down,
Velocity goes down
Bed shear is less
Depth Velocity and Shear

Related to Threshold

BHR 1.2 – 1.4

Depends on bank stratigraphy and near bank stress

Floodplain

\[ \tau \approx \frac{A}{WP} \times \gamma_w \times S \]

\[ \tau \approx d \times \gamma_w \times S \]
Bank Height Ratio – 1.3

WENAS Creek near Yakima, WA

Photo by W. Barry Southerland, 1998
Opposite Problems

Incised Stream – J-Bar - South Fork Asotin Creek

Braided and Aggraded Stream – Koch - Asotin Creek

Lane’s balance

\[ Q_s * d_{50} \sim S * Q \]
Why Bank Height ratio (BHR)?

BHR ~ 1.05

BHR > 1.2, early incision begins to show impacts

Wenas Stream near Yakima, average prec., 11 inches

Sanpoil Stream

Bankfull
Channel Succession

1. E → C → Gc → F → C → E

Channel Evolution Models

Schumm, Harvey, Watson (1984):

- **I** Stable Floodplain Q2 Terrace1
  - h < h_c
- **II** Incision Q10 (Headcutting)
  - h > h_c
- **III** Widening +Q10 (Bank Failure)
  - h > h_c
- **IV** Stabilizing Deposition +Q10
  - h = h_c
- **V** Stable Terrace2 Floodplain Q2 Terrace1
  - h < h_c

h = bank ht
h_c = critical bank ht.

Slide modified from Lyle Steffen
“Natural stream channel stability is achieved by allowing the river to develop a stable dimension, pattern, and profile such that, over time, the stream system neither aggrades or degrades (incision). For a stream to be stable it must be able to consistently transport its sediment load, both in size and type, associated with local deposition and scour.”

**Entiat Reference Reach**

Width Depth Ratio = 20

**Entiat Immediately Upstream**

Width Depth Ratio = 48
A Practical Approach to Assessing Stream Stability Using Geomorphic Reference Sites
Chapter 4

Entiat Reference Reach
Width Depth Ratio = 20

Entiat Immediately Upstream
Width Depth Ratio = 48
## Percent Departure from Reference Reach

**Percent departure from reference condition**

<table>
<thead>
<tr>
<th>Measured Feature</th>
<th>Reference Reach</th>
<th>Reach of Interest</th>
<th>Erosion Potential</th>
<th>Percent Departure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank Height Ratio</td>
<td>1.07</td>
<td>1.25</td>
<td>Moderate</td>
<td>17%</td>
</tr>
<tr>
<td>Root Density</td>
<td>70%</td>
<td>25%</td>
<td>High</td>
<td>64%</td>
</tr>
<tr>
<td>Root Matrix</td>
<td>.78</td>
<td>.30</td>
<td>High</td>
<td>62%</td>
</tr>
</tbody>
</table>
## Dimensionless Ratios

<table>
<thead>
<tr>
<th>Dimensionless ratios, C4 stream type on Cascade East slope in Glacial-Fluvial Valleys</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LONG. PROFILE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pool bankfull depth/Average bankfull depth, ft/ft</td>
<td>2.2</td>
<td>1.6-3.2</td>
</tr>
<tr>
<td>Riffle bankfull depth/Average bankfull depth, ft/ft</td>
<td>0.85</td>
<td>0.59-0.92</td>
</tr>
<tr>
<td>Run bankfull depth/Average bankfull depth, ft/ft</td>
<td>1.4</td>
<td>1.2-1.6</td>
</tr>
<tr>
<td>Glide bankfull depth/Average bankfull depth, ft/ft</td>
<td>1.2</td>
<td>1.1-1.5</td>
</tr>
</tbody>
</table>
Departure Analysis

Figure 5-15. Relationship of BHR ranges to corresponding stream stability ratings (Rosgen, 2001b).
Width Depth Ratio Departure Analysis

Figure 5-13. Stability ratings based on departure of width/depth ratio from reference condition (Rosgen, 2001b).
Departure Analysis Continued

Figure 5-12. Width/depth ratio stability descriptions.
J-Bar Ranch Case Study

J-Bar Ranch, Jake Schlee’s cattle winter feeding area, is located on the floodplain adjacent to the South Fork of Asotin Creek in the Blue Mountains of Washington. The South Fork is a 3rd order perennial stream and a tributary to the Main Stem of Asotin Creek. The South Fork of Asotin is an important summer steelhead habitat severely lacking in pool quantity and quality, Juvenile steelhead are abundant on the South Fork when pools are present. Streambank stability was a major concern. Temperature is also a concern.
Types of Alternatives

- Move channel back to previous flood channels and rip rap in place – most expensive - $45,000
- Centerline channel relative to valley, rock toes relative to the needed hydraulic geometry, pull back banks, bioengineer several vegetative layers, irrigate plant materials first three years. Est. $18,000
- Rebuild stream relative to similar current stable analog located in similar valley and stream types within the watershed. Re-establish pools, riffles, glides, and run. Address resting, hiding, and spawning for salmonids. Re-establish floodplain at lower elevation. Est. $20,000, Actual cost $15,000
- Keep channel as is: Threat to bridge downstream and winter feeding shed.
Incised Stream Description

1995

Photo by WBS, South Fork Asotin CK, 1995

3/97

Photo by WBS, South Fork Asotin CK, 1997
J-Bar Ranch Case Study

- Watershed size: 37 m², perennial stream
- BFQ (Channel forming Q): 75cfs
- CEM Stage: III with some II
- BHR 2.7
- 12 inches annual precipitation
- Important steelhead rearing area

Photo by WBS, South Fork Asotin CK
**Problems**

- No resting and hiding refugia for salmonids
- Highly unstable banks – excessive bank failure. **Establish riparian plant community**
- Poor low flow conditions for salmonids and poor bedform condition for macroinvertebrate population
- Temperature for salmonid habitat
- No diversity
- Aesthetically, not pleasing
- Winter feeding area w/ concentrated livestock

**Morphometry and Morphology**

- Water surface slope 2.7%
- K-before = 1.02 Incised
- MWR = 1.3
- Watershed size: 37 m², perennial stream
- (Channel forming Q): 75cfs (14.8 ft²)
- CEM Stage: III with some II
- BHR 2.7
- 12 inches annual precipitation
- Degraded Stream type: G3 & F3b
- D₅₀ = 68mm
- LPT (Dmax) = 190mm
Goal and Objective

- Transport bedload in a stable manner while maintaining local deposition and scour (bedload competence)
- Reduce streambank erosion
- Re-attach floodplain to provide water table for riparian plants
- Restore salmonid habitat (steelhead)
- Increase hyporeic zone
- Cost effectiveness
Alternatives generated in 1997 after planning process

- Move back to pre-channel and riprap – plane bed profile – $45,000
- Move back to center of small valley, rock the toes, lay back banks for planting facines, willow and cottonwood root stock – $24,000
- Reconstruct channel to natural channel characteristics but at a lower floodplain level – priority 3 or confined floodplain approach –
- $14,000 – Priority III – floodplain - confined
Meander Reconstruction
Rebuilding bankfull channel and floodplain w/i incised system
Bankfull channel and floodplains rebuilt.
Late fall 1997 before planting
Before and After

1997  G3

Six years and two large floods later

2002  B4

Pages 5-22 and 5-23 in SCRM
J- Bar – 2006 – 9 years later
Steelhead
1996 no redds
2002 three redds
2006 five redds
J-Bar Ranch
Before and after

9 years after priority
III Restoration
### Aquatic Habitat Response to Stream Type Change

<table>
<thead>
<tr>
<th>Variable</th>
<th>Stage II</th>
<th>Stage III</th>
<th>Priority I, II, or III restore floodplain and long profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instream Cover</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Overhead Cover</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Substrate Composition</td>
<td>↑</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Pool Quality</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Holding Cover Velocity</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Temperature</td>
<td>→</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Oxygen</td>
<td>→</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Macro Invertebrates</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Spawning Habitat</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Diversity</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Rearing</td>
<td>↓</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>IBI Score</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
</tr>
</tbody>
</table>
Opposite Problems

Incised Stream – J-Bar - South Fork Asotin Creek

Braided and Aggraded Stream – Koch - Asotin Creek

Lane’s balance $Q_S d_{50} \sim S * Q$

Lane’s balance $Q_S d_{50} \sim S * Q$
Example of Dimensionless Ratio and Regional Bankfull Discharge Based Design
Asotin Creek Red Counts

- No Redds Observed at Koch Project in 1997

(9.9 redds/km) unaltered to (17.6 redds/km) treated
Components of the system 2005, 7 years and three floods later

Constructed Log Jam

Deep pools with riffles, glides, and runs
What it is really all about?

“Protect the best, restore the rest”

Thank you for your attendance.
Any Questions?