

Evolution of Unstable Streams

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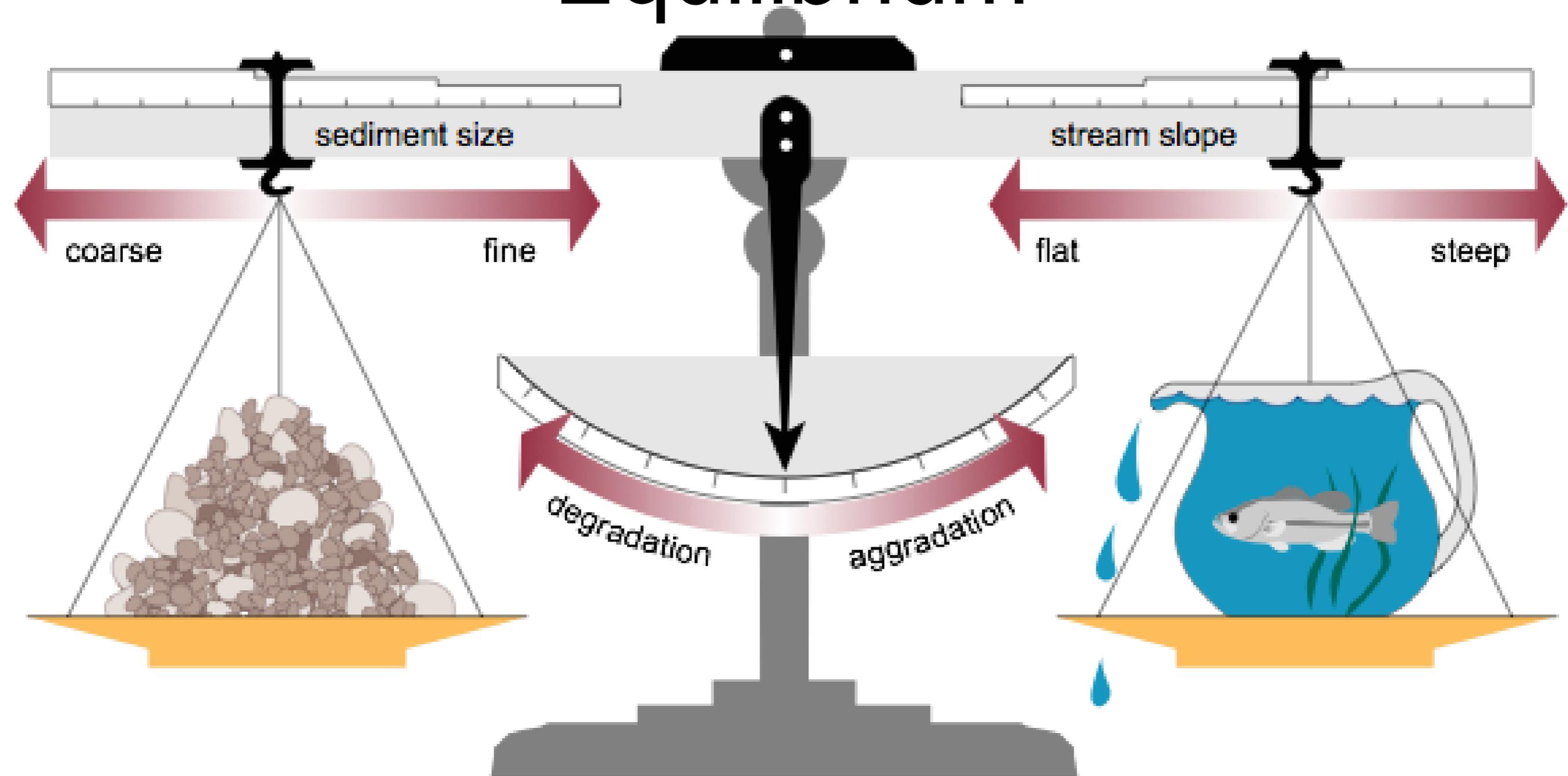


Unstable Stream Systems

- Wide spread in Mississippi due to various channelization works
- Much studied since the 1940s with special emphasis in the 1970s-1990s
- Evolution described by Conceptual Channel Evolution Models



Channel Morphological Equilibrium



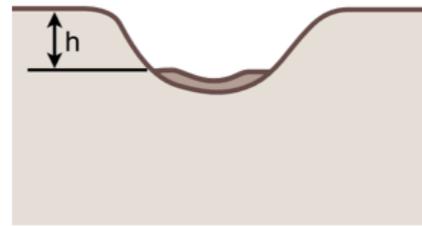
$$Q_s \cdot D_{50} \propto Q_w \cdot S$$

After Lane (1955)

Conceptual Channel Evolution

Model

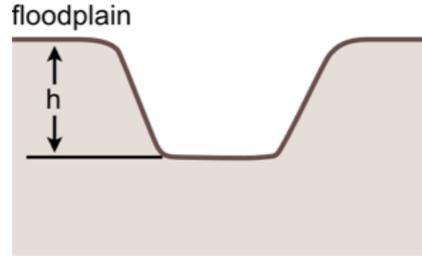
Stage I. Sinuous, Premodified
 $h < h_c$



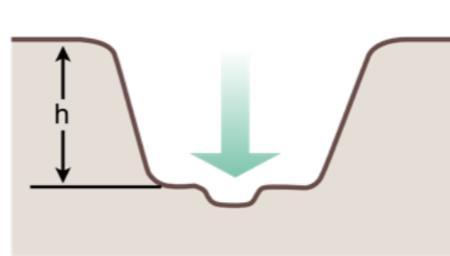
h_c = critical bank height

→ = direction of bank or bed movement

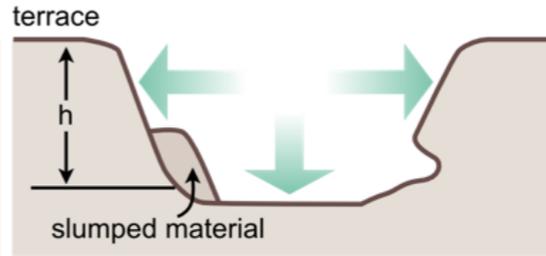
Stage II. Channelized
 $h < h_c$



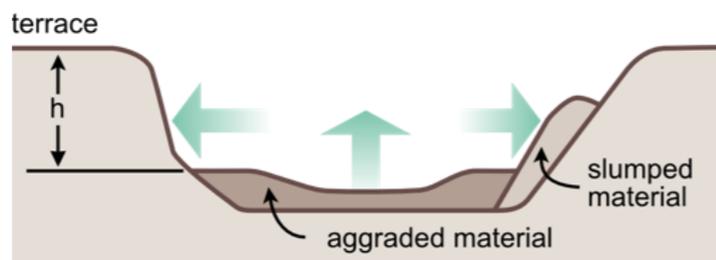
Stage III. Degradation
 $h < h_c$



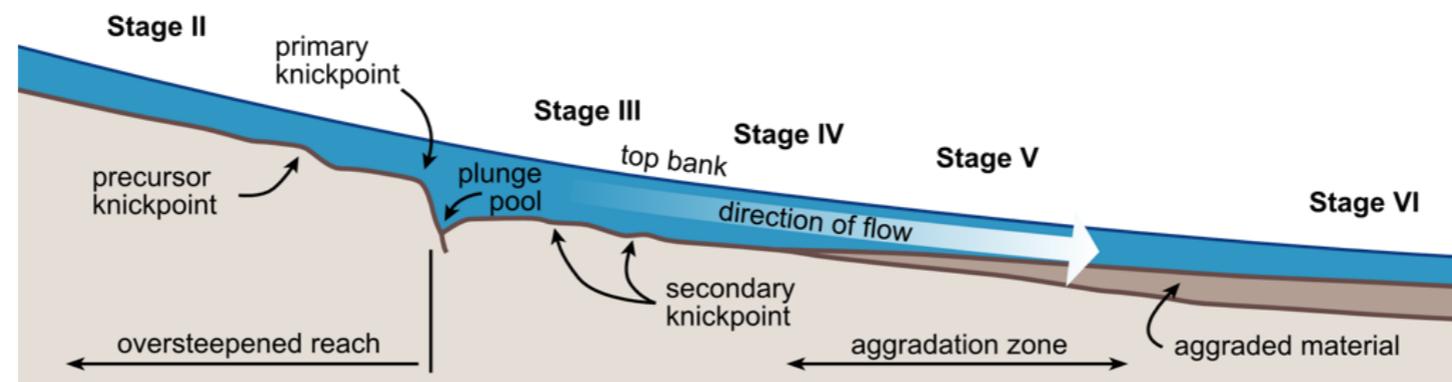
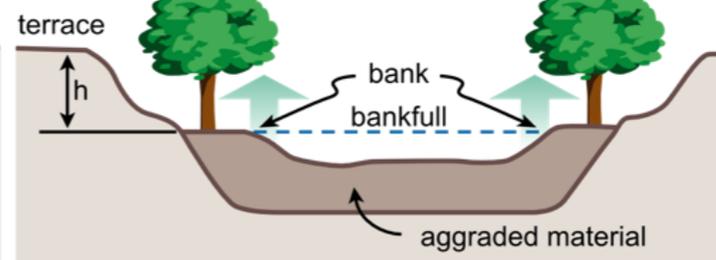
Stage IV. Degradation and Widening
 $h > h_c$



Stage V. Aggradation and Widening
 $h > h_c$



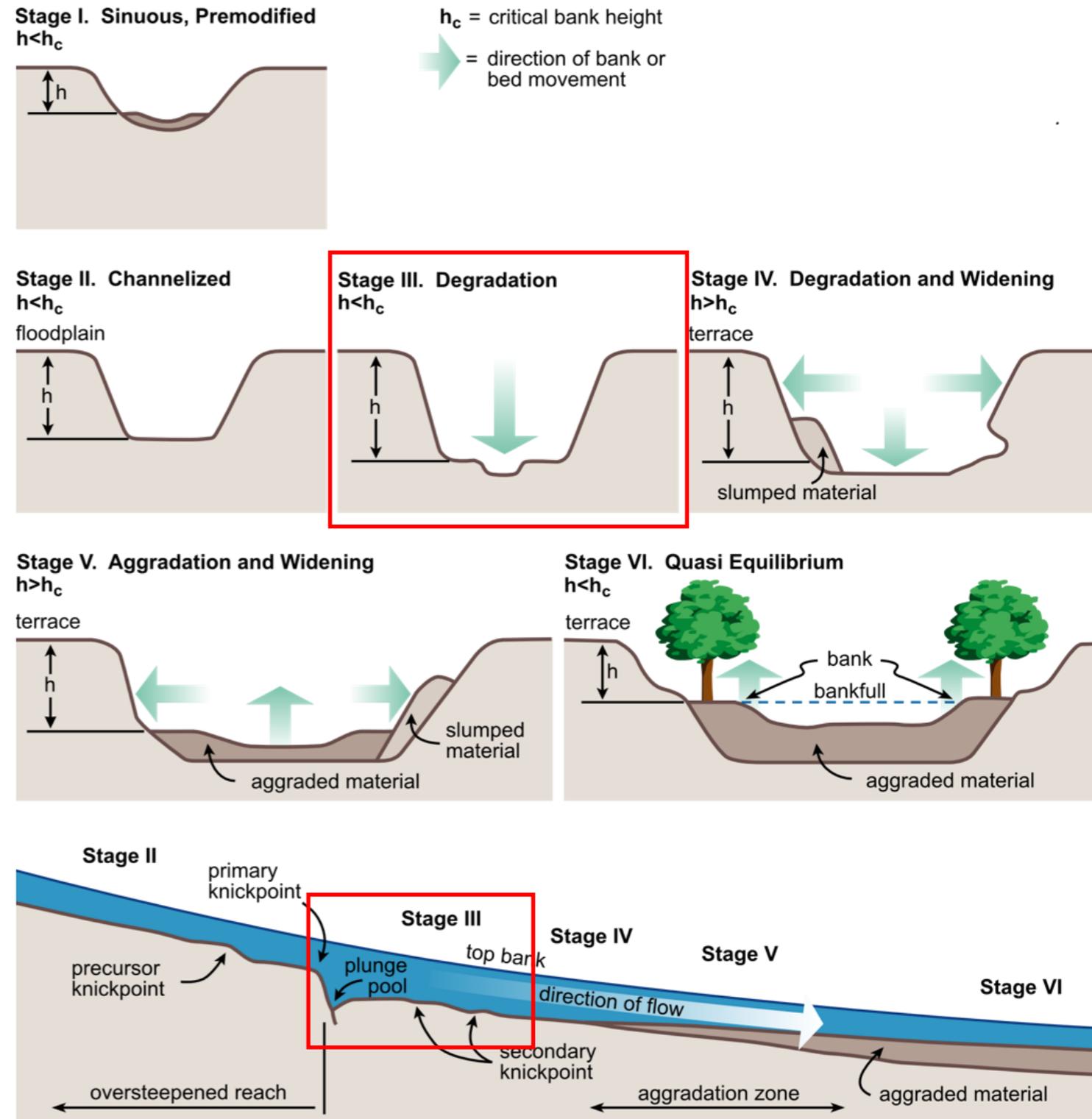
Stage VI. Quasi Equilibrium
 $h < h_c$



After Simon & Hupp (1986)

Channel Adjustment Processes

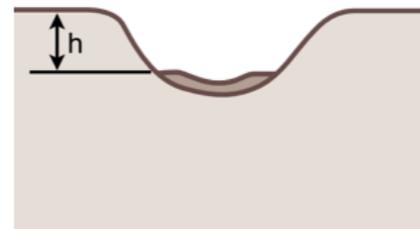
- Stage III
- Rapid incision caused by migrating knickpoints
- Bed material main source of sediment



Channel Adjustment Processes

- Stage IV
- Reduced bed erosion
- Bank mass failure
- Bank material main source of sediment

Stage I. Sinuous, Premodified
 $h < h_c$



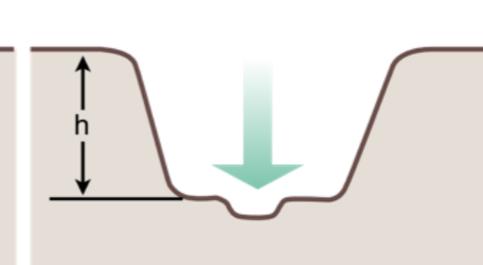
h_c = critical bank height

→ = direction of bank or bed movement

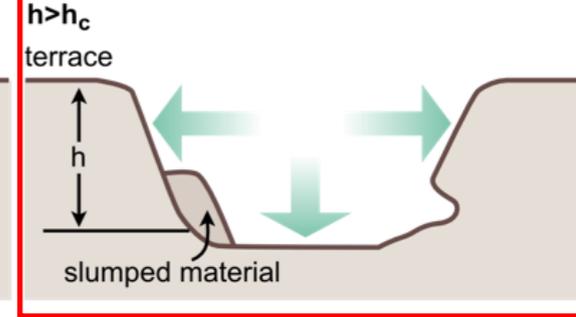
Stage II. Channelized
 $h < h_c$



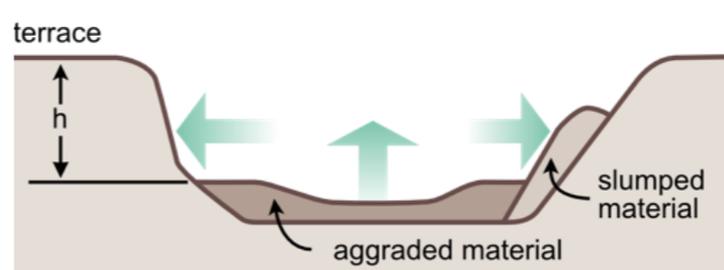
Stage III. Degradation
 $h < h_c$



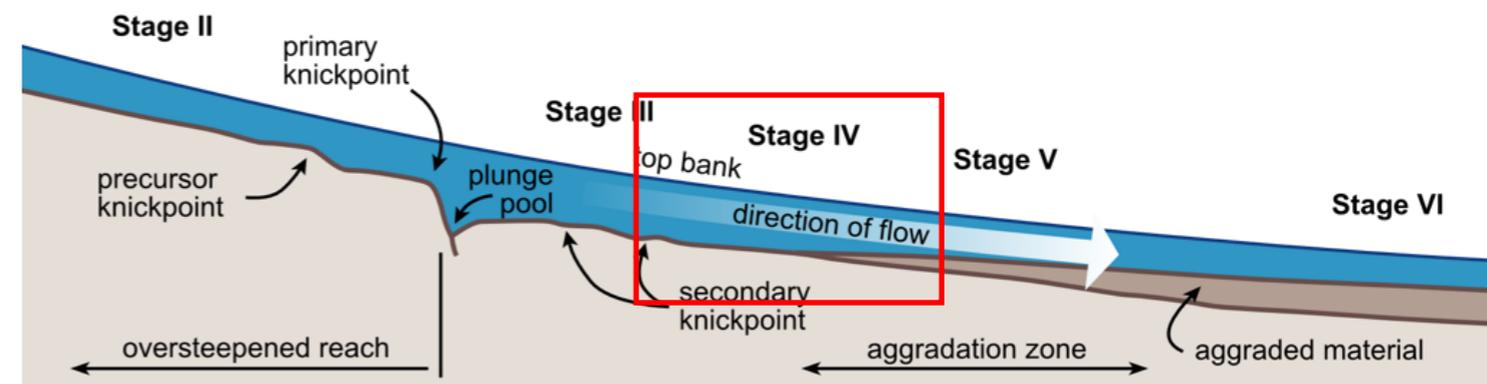
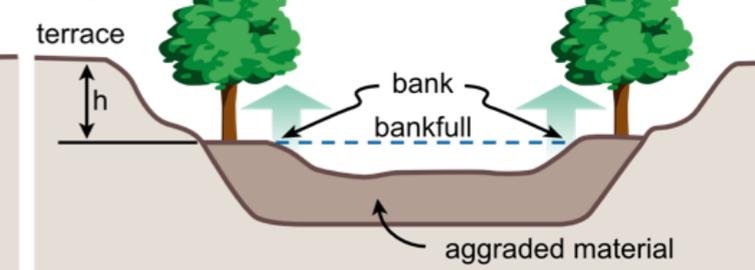
Stage IV. Degradation and Widening
 $h > h_c$



Stage V. Aggradation and Widening
 $h > h_c$



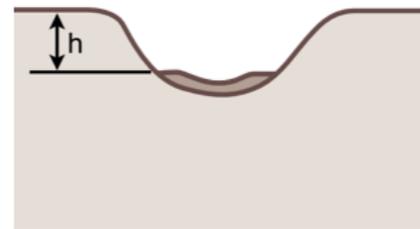
Stage VI. Quasi Equilibrium
 $h < h_c$



Channel Adjustment Processes

- Stage V
- Bed deposition
- Continued bank mass failure
- Bank material main source of sediment

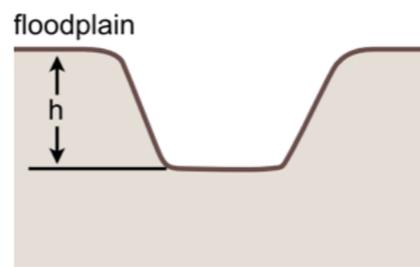
Stage I. Sinuous, Premodified
 $h < h_c$



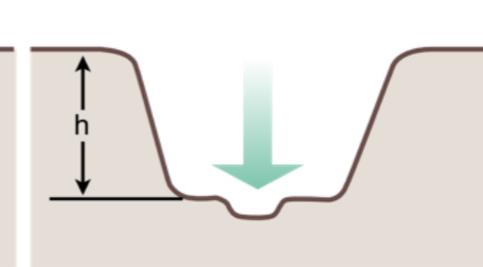
h_c = critical bank height

→ = direction of bank or bed movement

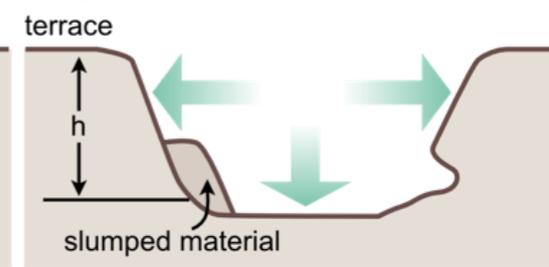
Stage II. Channelized
 $h < h_c$



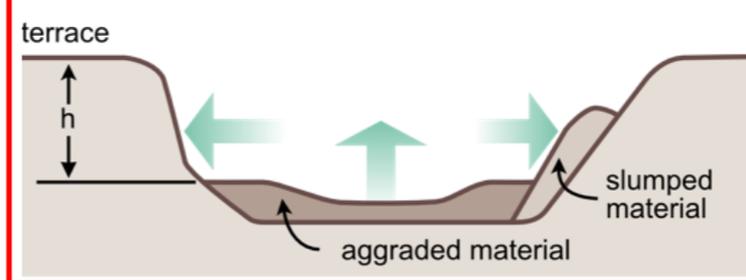
Stage III. Degradation
 $h < h_c$



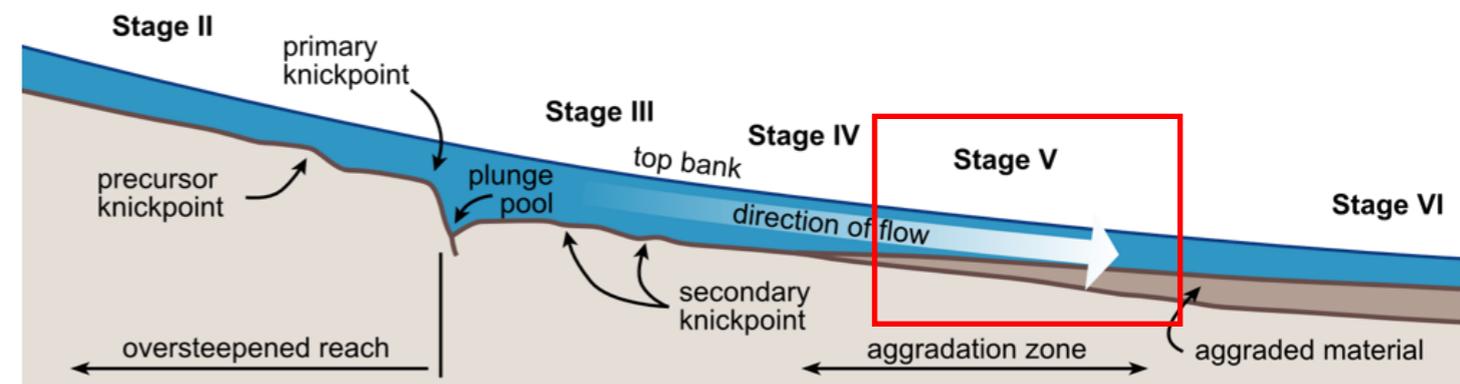
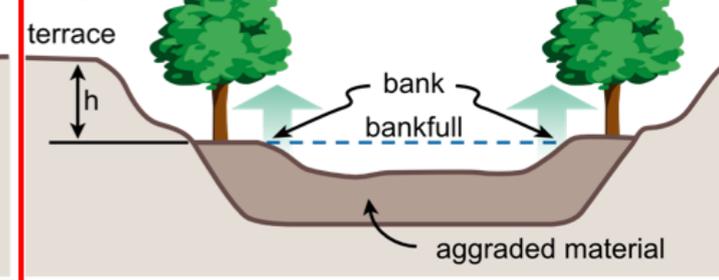
Stage IV. Degradation and Widening
 $h > h_c$



Stage V. Aggradation and Widening
 $h > h_c$



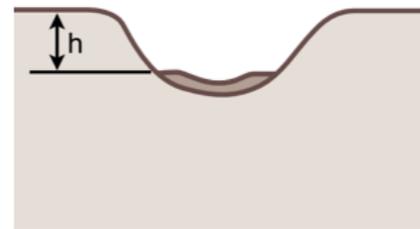
Stage VI. Quasi Equilibrium
 $h < h_c$



Channel Adjustment Processes

- Stage VI
- Long-term morphologic equilibrium
- Small amounts of erosion & deposition

Stage I. Sinuous, Premodified
 $h < h_c$

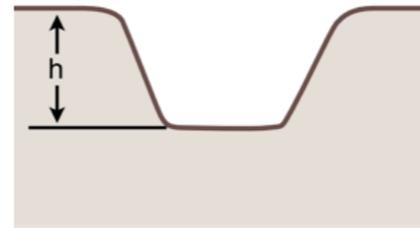


h_c = critical bank height

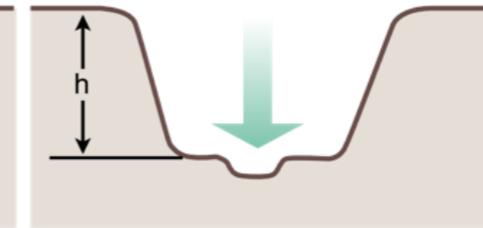
→ = direction of bank or bed movement

Stage II. Channelized
 $h < h_c$

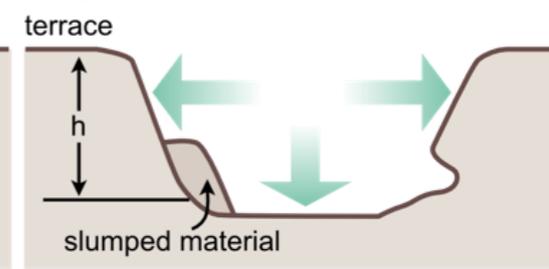
floodplain



Stage III. Degradation
 $h < h_c$

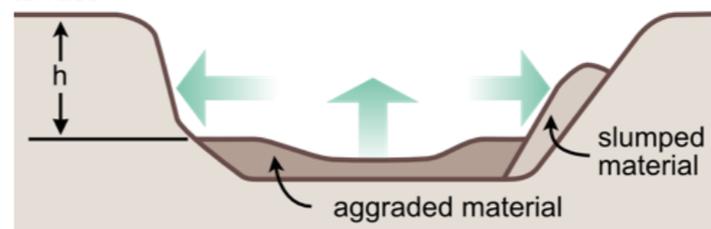


Stage IV. Degradation and Widening
 $h > h_c$



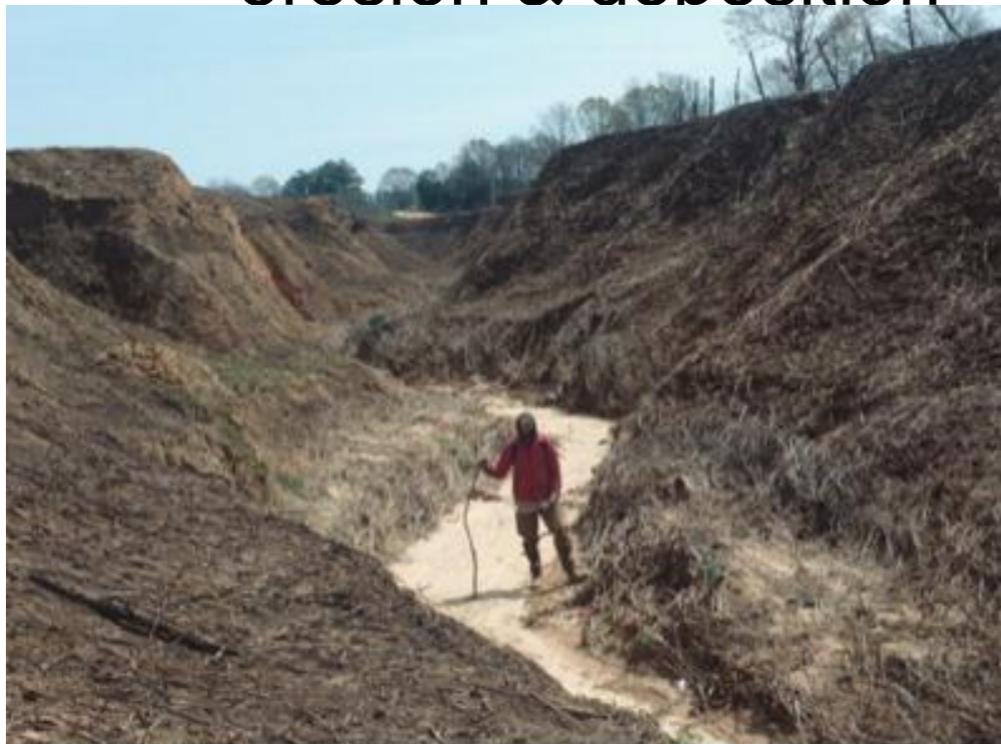
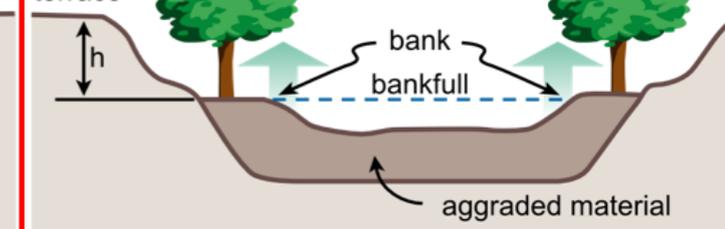
Stage V. Aggradation and Widening
 $h > h_c$

terrace

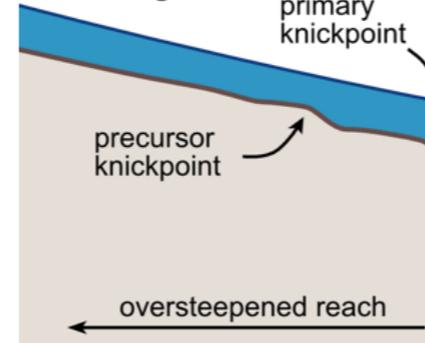


Stage VI. Quasi Equilibrium
 $h < h_c$

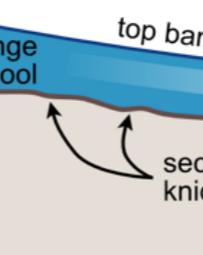
terrace



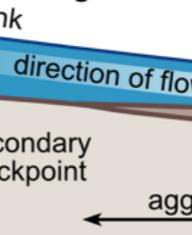
Stage II



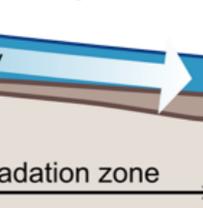
Stage III



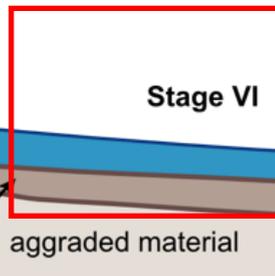
Stage IV



Stage V

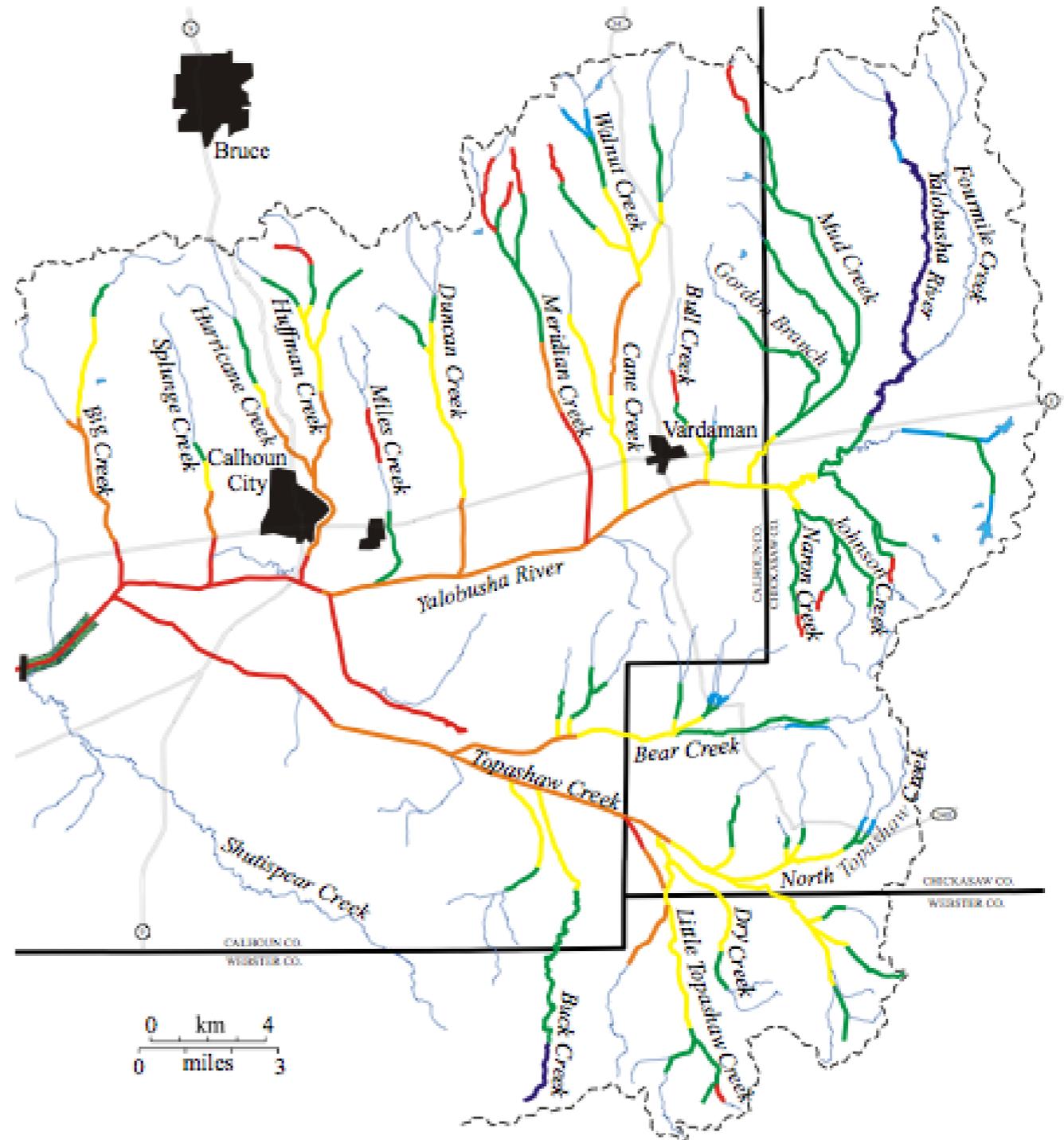


Stage VI



Use of CCEMs

- Assess the geomorphic state of the channel network
- Target stream stabilization
- **CANNOT** provide a quantitative analysis:
 - How much, where & when



NSL Tools (I)

- Rapid Geomorphic Assessments (RGA)s:
- Uses diagnostic criteria of channel form to infer dominant channel processes
- Enables assignment of stages of channel evolution

CHANNEL-STABILITY RANKING SCHEME

Station Name <i>Miss-Stockman Farm</i>		Station Description	
Date <i>10/24/09</i>	Time (24 hour) <i>9:55</i>	Crew <i>JB</i>	
Pictures (circle) <i>US DS cross section bankfull</i>		Samples	% PC %PS
Survey (circle) <i>Thalweg Bankfull Survey ref. point TBM</i>			

Water surface profile

- Primary bed material**

Bedrock	Boulders/Cobbles	Gravel	Sand	Silt/Clay
0	1	2	3	4
- Bed/bank protection**

Yes	No	(with)	1 bank	2 banks
0	1	2	3	4
- Degree of incision (Relative elevation of "normal" low water; floodplain / terrace @ 100%)**

0-10%	11-20%	21-30%	31-75%	76-100%
4	3	2	1	0
- Degree of constriction (Relative decrease in top-bank width from up to downstream)**

0-10%	11-20%	21-30%	31-75%	76-100%
0	1	2	3	4
- Stream bank erosion (Each bank)**

	None	Fluvial	Man made (ditches)
Left	0	1	2
Right	0	1	2
- Stream bank instability (Percent of each bank failing)**

	0-10%	11-20%	21-30%	31-75%	76-100%
Left	0	0.5	1	1.5	2
Right	0	0.5	1	1.5	2
- Established riparian woody-vegetative cover (Each bank)**

	0-10%	11-20%	21-30%	31-75%	76-100%
Left	0	1	2	3	4
Right	0	1	2	3	4
- Occurrence of bank accretion (Percent of each bank with fluvial deposition)**

	0-10%	11-20%	21-30%	31-75%	76-100%
Left	0	1	2	3	4
Right	0	1	2	3	4
- Stage of channel evolution**

I	II	III	IV	V	VI
0	1	2	3	4	5

Total Rank 20.5

- Condition of adjacent side slope (circle)** *None* Bedrock Boulders Gravel/SP Fluv
- Percent of slope (length) contributing sediment** Left Right
- Severity of side-slope erosion** None Low Moderate High

left side "natural" accretion on bank

Sub-total

2 *Cost for bottom bed area is a 5' bar all in middle of channel*

2 *Right bank has other planting road.*

3 *Very sandy channel*

0 *ASH 38.7 mm*

2 *with 11.6 mm*

1 *multiple years - 20*

1 *Walrus 11.7 mm*

1.5 *Shallow holes 2.2 mm*

0.5 *multiple years*

2 *ASH 15.7 mm*

2 *ASH 22.7 mm*

1 *20.7 mm*

1 *American Cuckoo 10*

2 *12*

16 *16*

3 *Shallow holes 2.2 mm*

5 *Walrus 11.7 mm*

1.5 *gullies 4.5 mm*

2 *2.2 mm*

1 *multiple years*

1 *multiple years*

1 *multiple years*

1 *Dominant = 4' flow*

ASH 2

ASH 2

NSL Tools (II)

- **Models**
 - *BSTEM* - Bank stability & toe erosion model
 - *RVR-Meander* - Toolbox for river meander assessment and design
 - *CONCEPTS* - Stream-riparian corridor evolution model

BSTEM - Bank Stability & Toe Erosion Model

- 2D wedge & cantilever failures
- Hydraulic toe erosion
- Bank protection
- Vegetation effects through RipRoot
- Bank material properties and vegetation assemblage

Input bank geometry and flow conditions
 Work through all 4 sections then hit the "Run Bank Geometry Macro" button.

1) Select EITHER Option A or Option B for Bank Profile and enter the data in the relevant box-cells in the alternative option are ignored in the simulation and may be left blank if desired.
 2) Enter bank material layer thicknesses (if bank is all one material it helps to divide it into several layers).
 3) If bank is submerged then select the appropriate channel flow elevation to include confining pressure and calculate erosion amount; otherwise set to an elevation below the bank toe.
 To ensure bank profile is correct you can view it by clicking the View Bank Geometry button.

Option A - Draw a detailed bank profile using the boxes below

Option A

Point	Station (m)	Elevation (m)	Top of toe?
A	0.00	5.00	<input type="checkbox"/>
B	5.14	5.00	<input type="checkbox"/>
C	5.25	4.58	<input type="checkbox"/>
D	6.37	4.37	<input type="checkbox"/>
E	6.49	4.05	<input type="checkbox"/>
F	6.60	3.74	<input type="checkbox"/>
G	6.72	3.42	<input type="checkbox"/>
H	6.83	3.10	<input type="checkbox"/>
I	6.85	2.78	<input type="checkbox"/>
J	6.95	2.47	<input type="checkbox"/>
K	9.15	2.16	<input type="checkbox"/>
L	9.29	1.84	<input type="checkbox"/>
M	9.41	1.52	<input type="checkbox"/>
N	9.52	1.21	<input type="checkbox"/>
O	9.64	0.89	<input type="checkbox"/>
P	9.75	0.57	<input type="checkbox"/>
Q	9.87	0.26	<input checked="" type="checkbox"/>
R	10.08	0.21	<input type="checkbox"/>
S	10.25	0.16	<input type="checkbox"/>
T	10.45	0.10	<input type="checkbox"/>
U	10.64	0.05	<input type="checkbox"/>
V	10.83	0.00	<input type="checkbox"/>
W	11.63	0.00	<input type="checkbox"/>

Shear emergence elev:
 Shear surface angle:

Option B - Enter a bank height and angle, the model will generate a bank profile

Option B

a) input bank height (m)
 b) input bank angle (°)
 c) input bank toe length (m)
 d) input bank toe angle (°)
 Input shear surface angle

Bank layer thickness (m)

Layer	Thickness (m)	Elevation of layer base (m)
Layer 1	<input type="text" value="1.00"/>	4.00
Layer 2	<input type="text" value="1.00"/>	3.00
Layer 3	<input type="text" value="1.00"/>	2.00
Layer 4	<input type="text" value="1.00"/>	1.00
Layer 5	<input type="text" value="1.00"/>	0.00

Parallel layers, starting from point B
 Bottom Layer

Channel parameters

Input reach length (m)
 Input reach slope (m/m)
 Input concentration (kg/kg)
 Input elevation of flow (m)
 Input duration of flow (hrs)

View Bank Geometry

Run Bank Geometry Macro

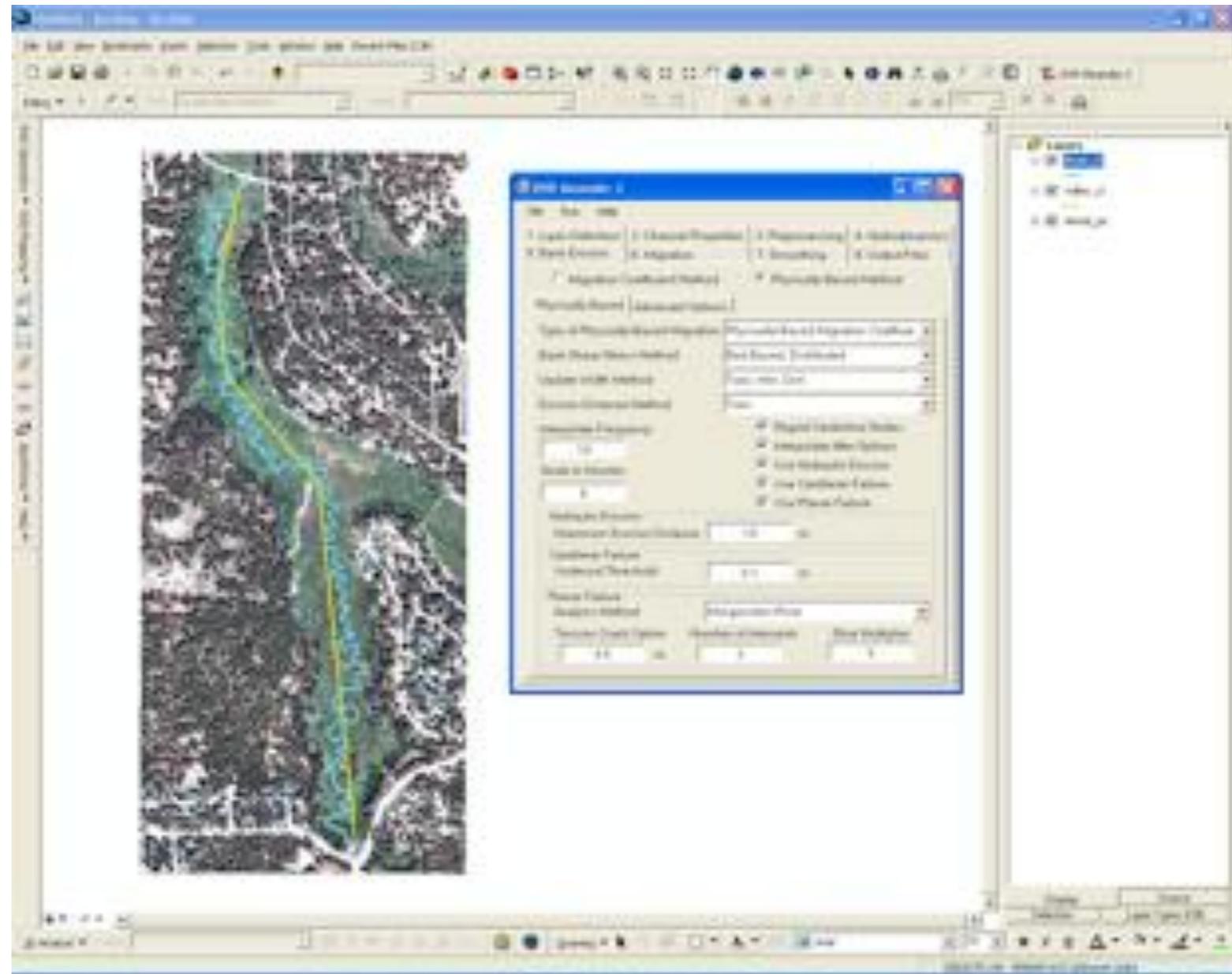
Definition of points used in bank profile

A - bank top: place beyond start of shear surface
 B - bank edge
 C-P - shear surface emergence (if no breaks of slope place as intermediary points)
 Q - top of bank toe
 R-U - breaks of slope on bank toe (if no breaks of slope then insert as intermediary points)
 V - base of bank toe
 W - end point (typically mid point of channel)

Notes:
 Bank profile may overhang. If the bank profile is fully populated, the shear surface emergence point should be anywhere between points B and Q. The shear surface emergence point must not be on a horizontal section; the elevation of this point must be unique or an error message will display.

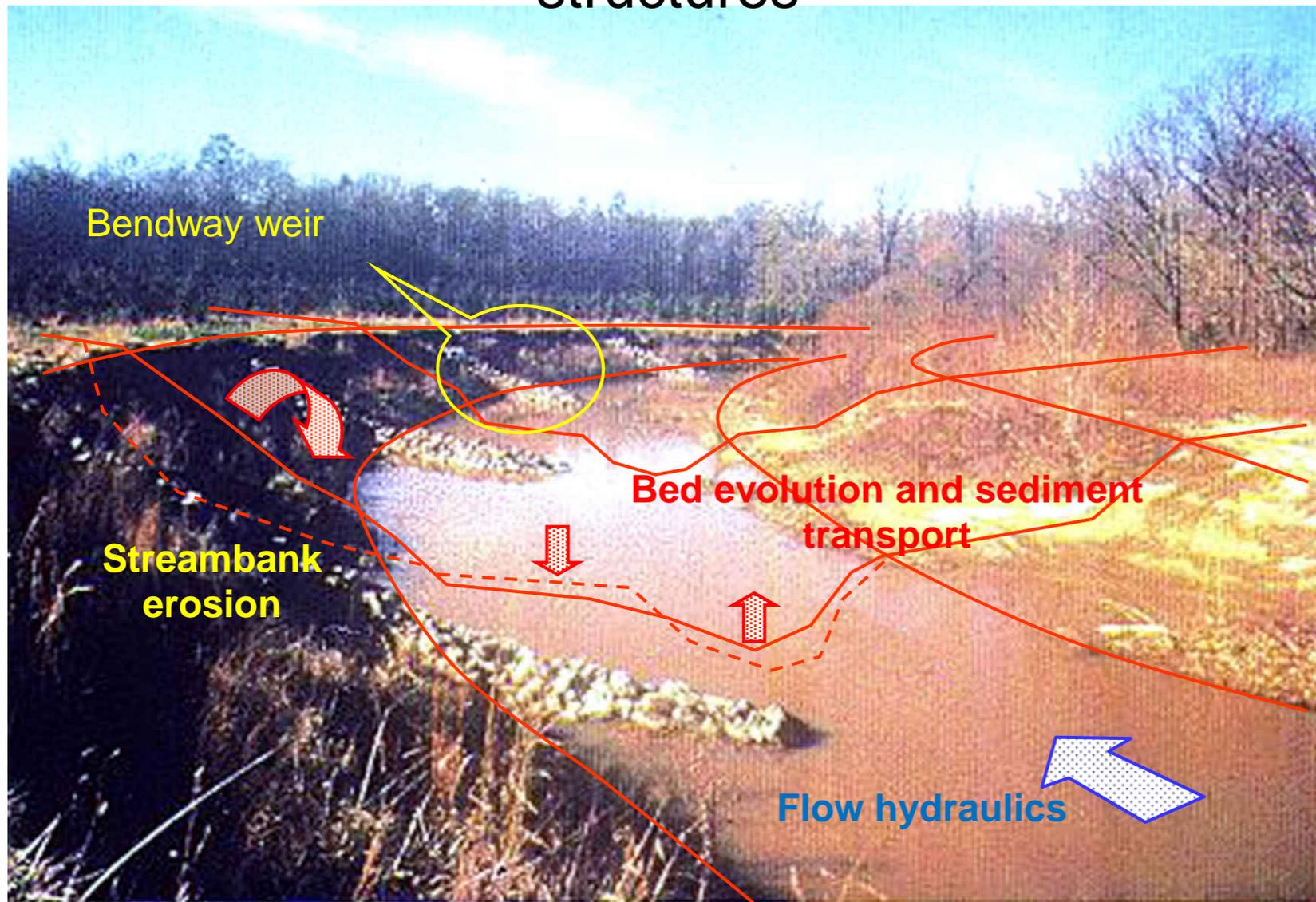
RVR Meander

- 2D model of meander hydrodynamics, bed evolution, and migration
- GIS based: ArcGIS 9.3 or 10
- Assess existing or design new meander planform
- Design discharge, valley slope, roughness, channel dimensions & bank



CONCEPTS – CONservational Channel Evolution and Pollutant Transport System.

CONCEPTS simulates long-term response of channels to loadings of water and sediments, and to instream structures



Input

- Channel geometry
- Bed & bank material properties
- Loadings of water and sediments

• Output

- Changes in channel geometry
- Time series of hydraulic variables and sediment yield

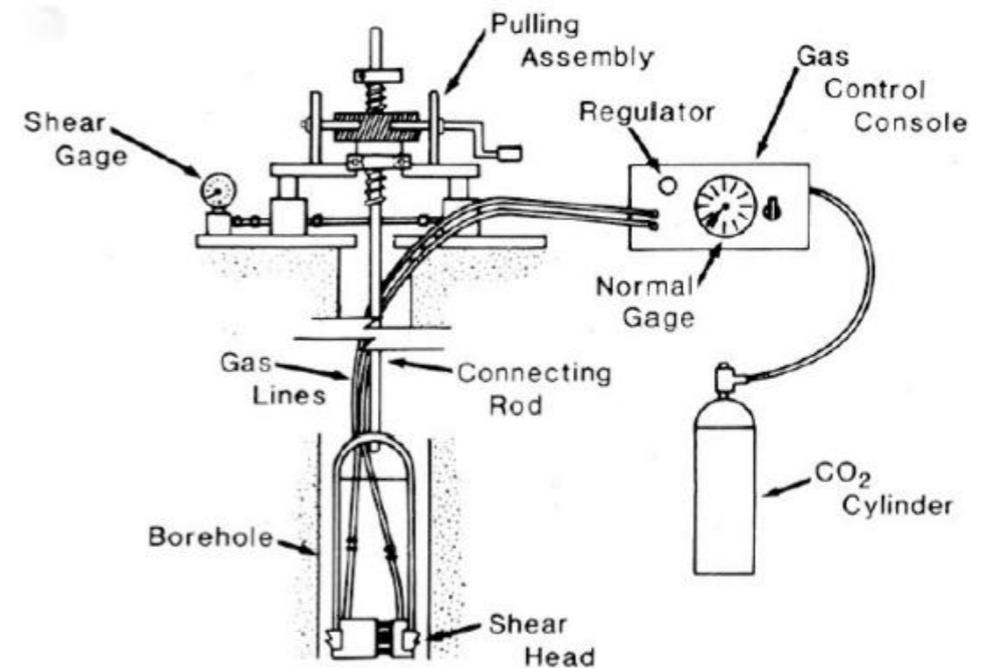
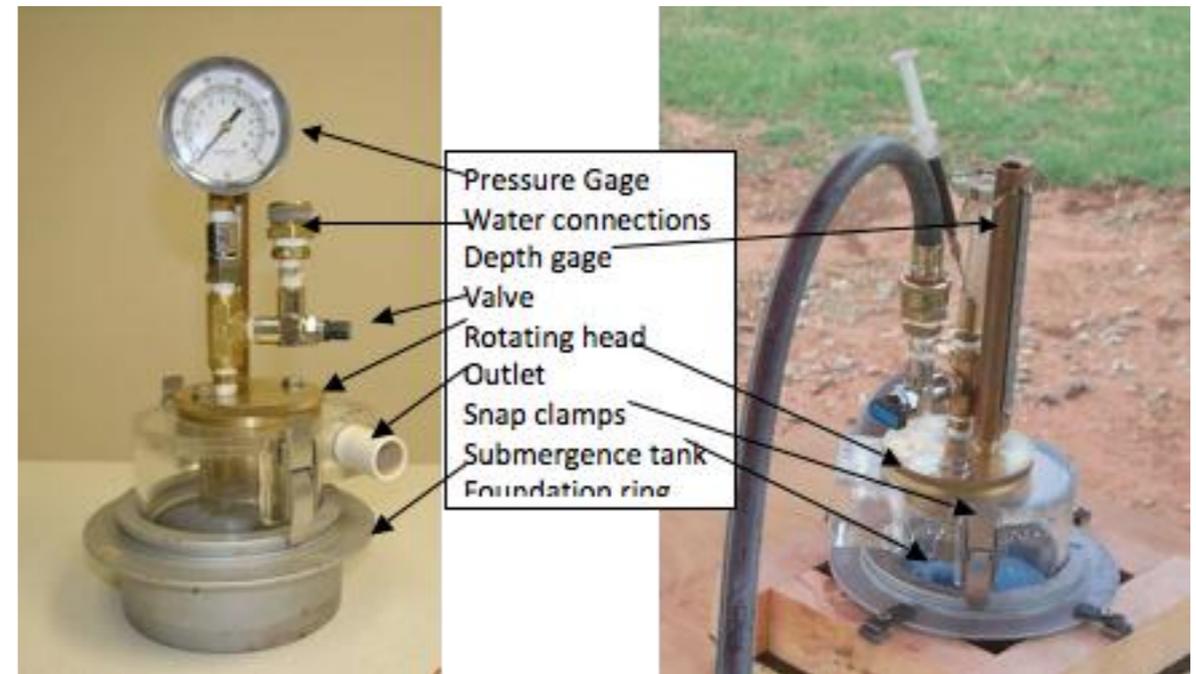
Stream Restoration/Stabilization

Assessment

- *BSTEM*
- Local impact of bank protection on bank erosion
- *RVR Meander*
- Reach scale impact of bank protection on channel planform
- *CONCEPTS*
- Reach scale impact of bed and bank protection on channel evolution and sediment transport

Quantifying Bank & Bed Material Resistance

- Grain size analysis
- Bulk density
- Soil erodibility
- Soil shear strength
- Soil water distribution





Thank You