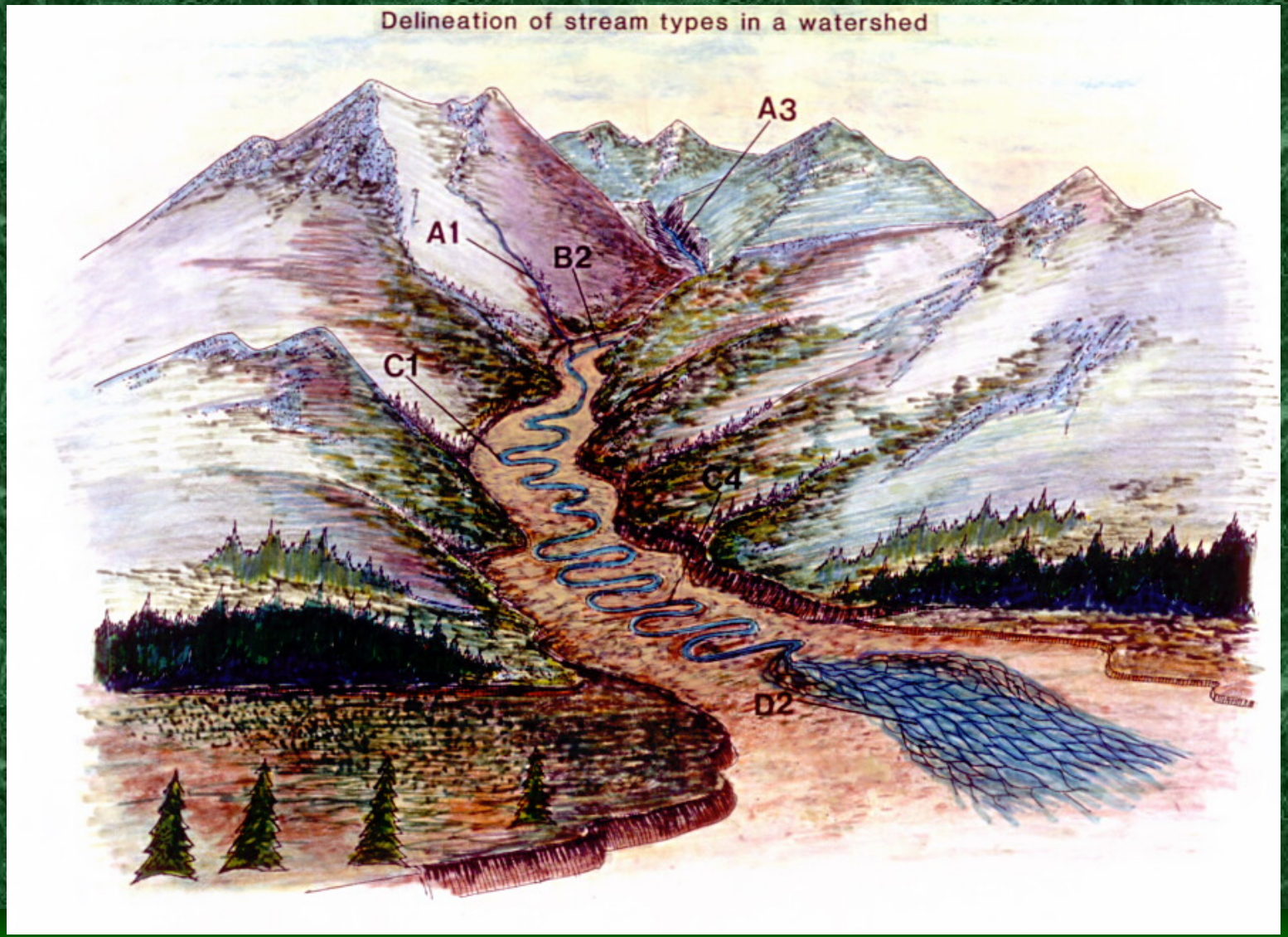
Geomorphic Stream Classification

"A Classification of Natural Rivers", Rosgen, D.L.

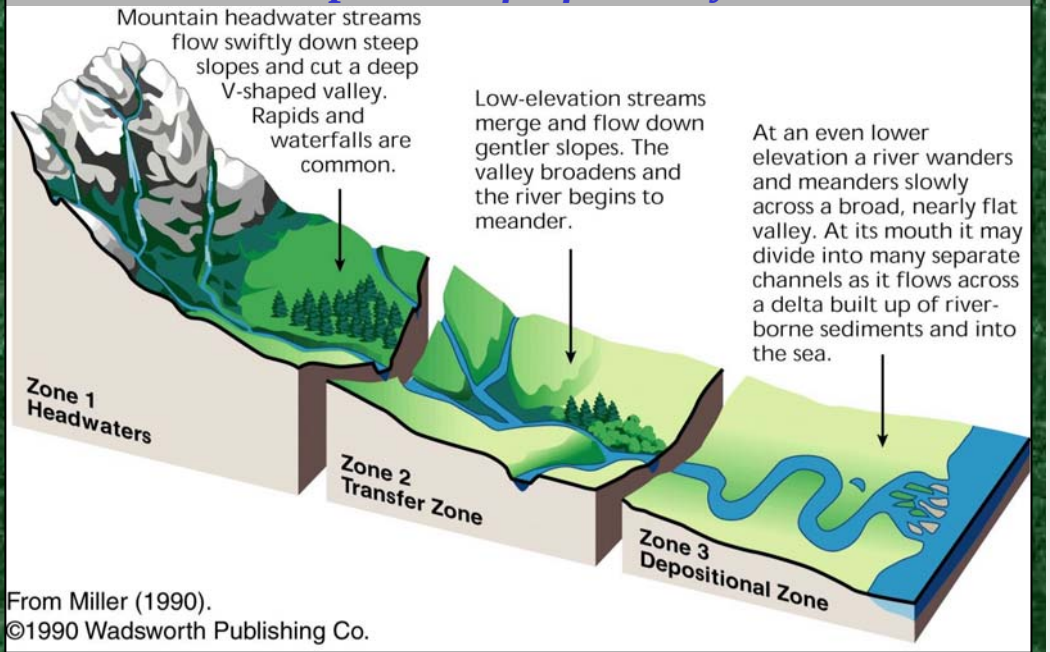


Why is Stream Classification Essential?

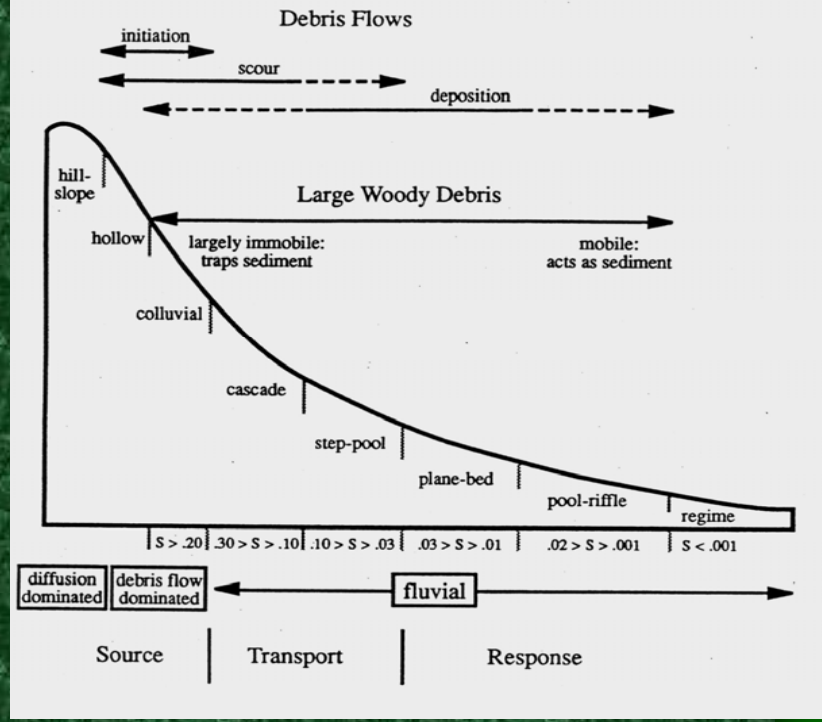
- Physical stream channel evolution
- Similar stream types manifest similar patterns
- Natural channel design
- Planning and management
- Riverine habitats, plants and animals are constrained by natural channel physics

Napeequa River

A stream is a portion of a fluvial system

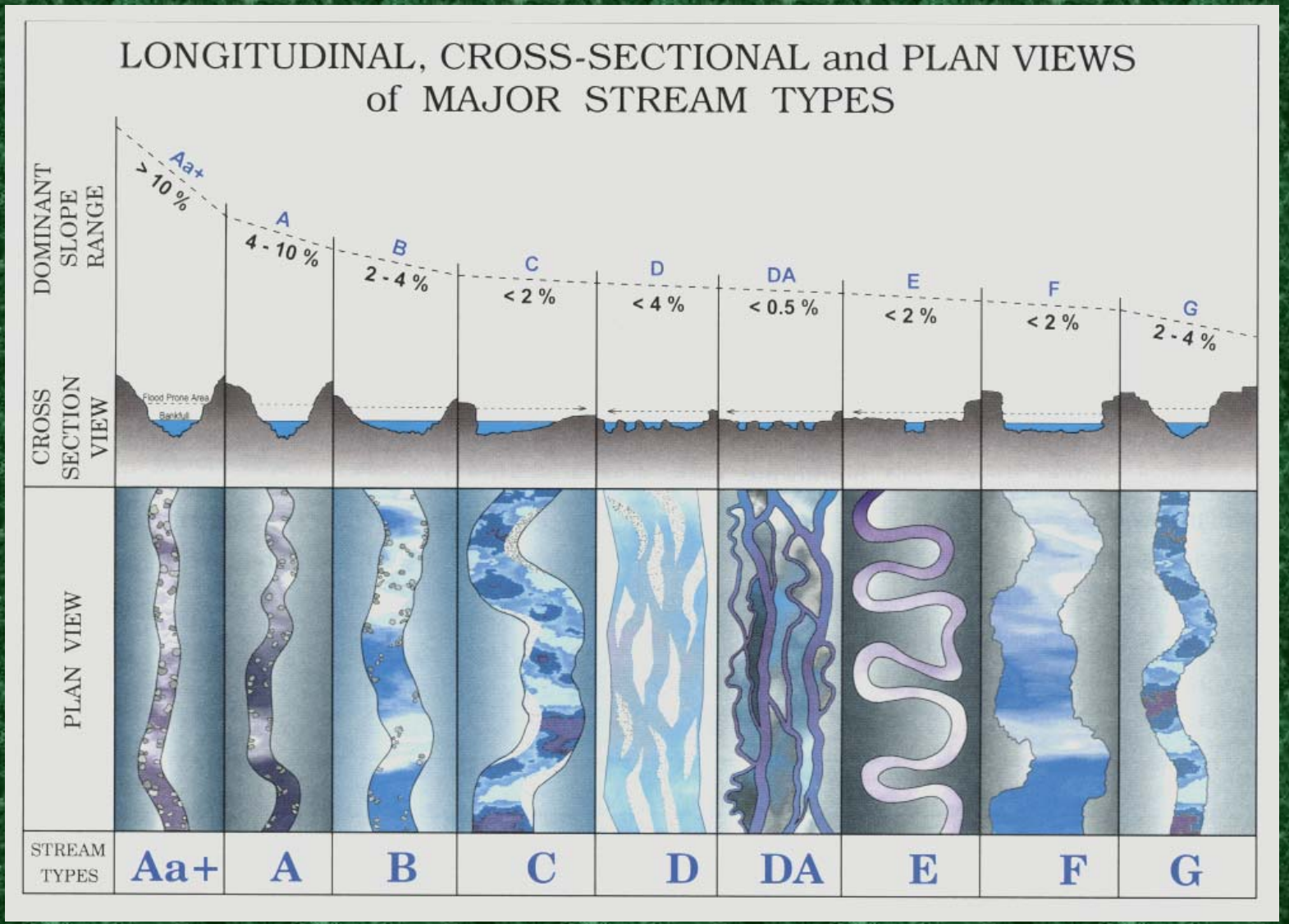


Stream Corridor Restoration: Principles, Processes, and Practices, 1998



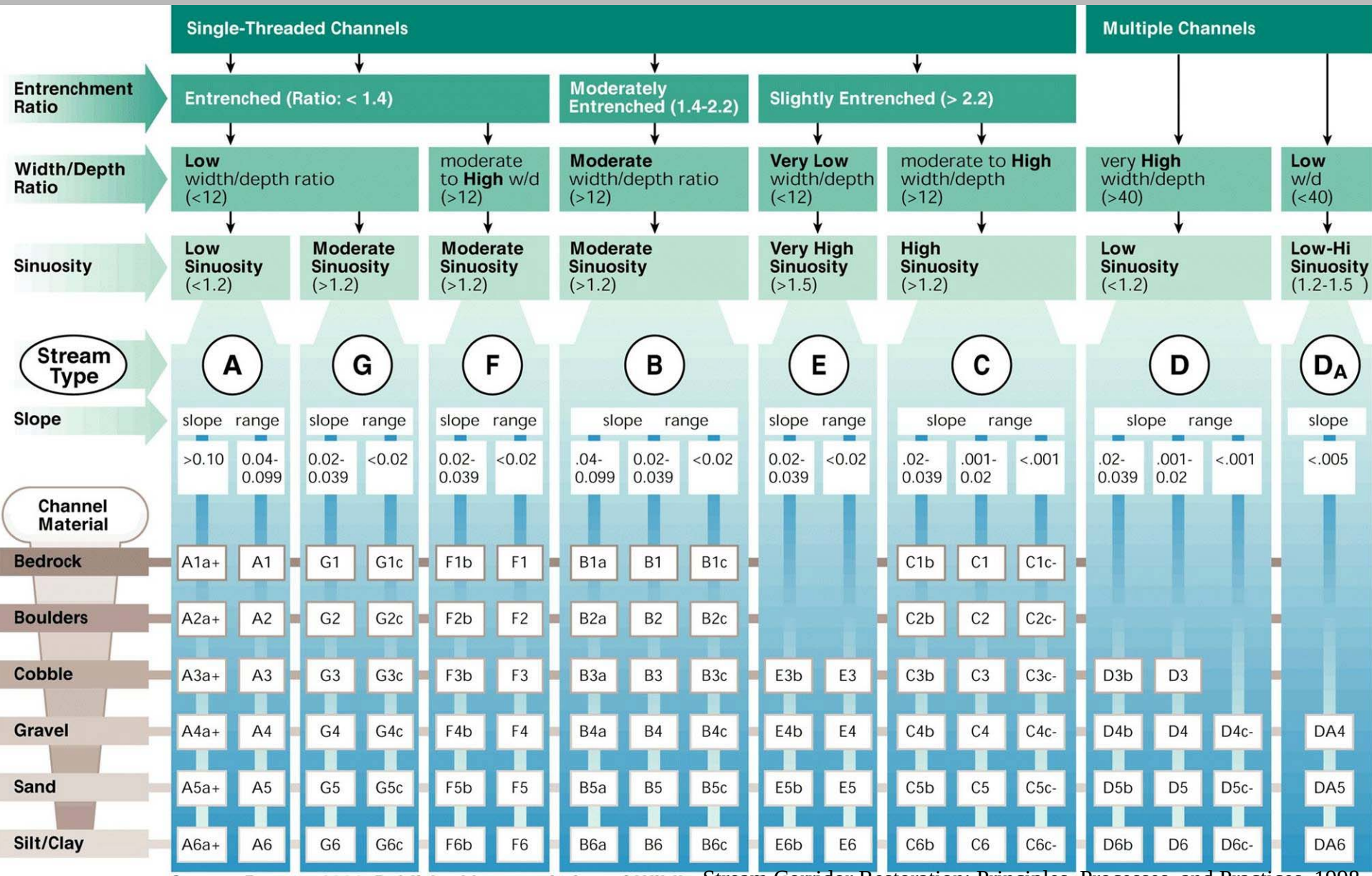
We need a greater resolution on the landscape based on morphometry. It must be reproducible and measurable. We can communicate about a relatively complex description in relatively simple terms.

Classification Level 1



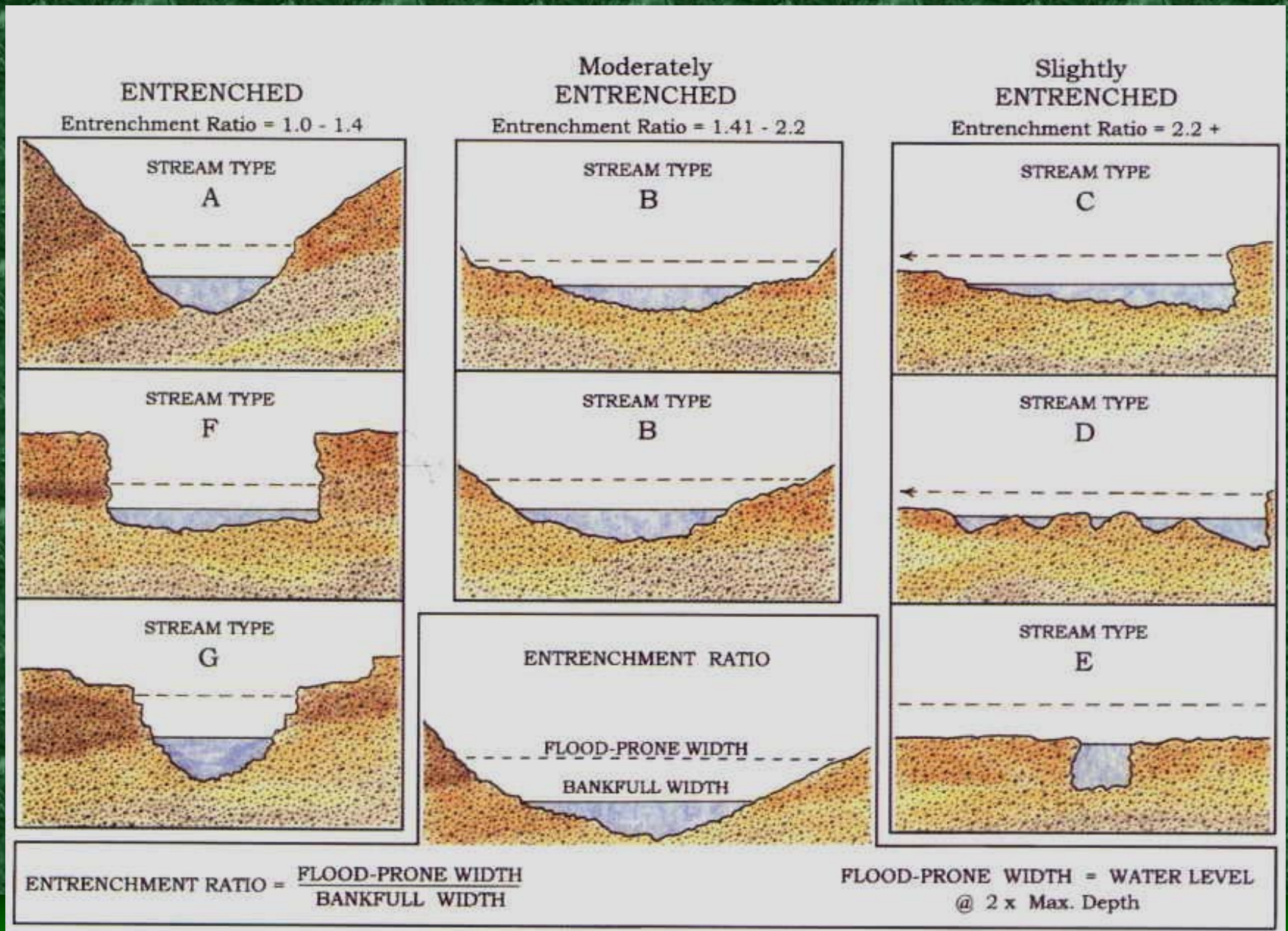
Rosgen (1994)

Classification Level II

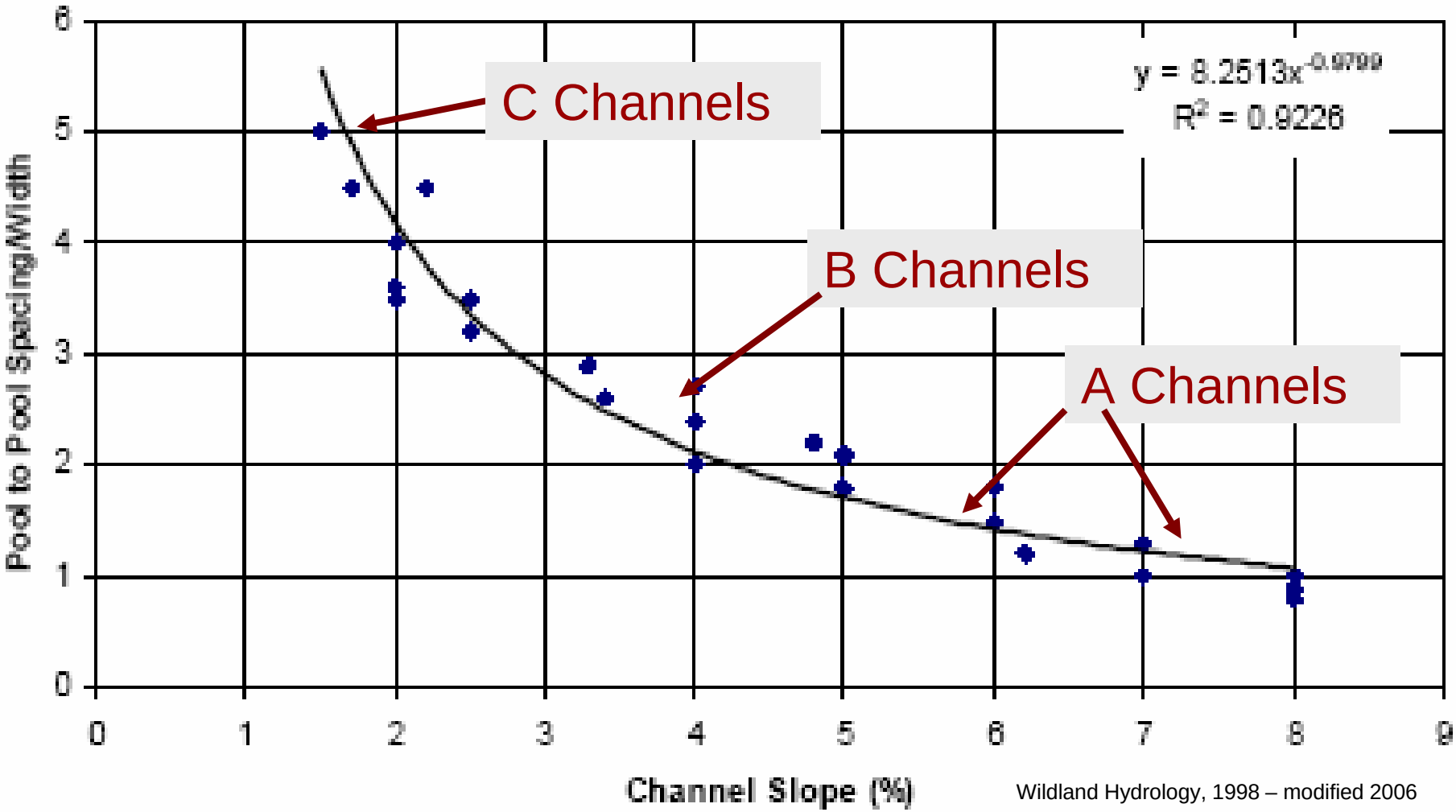


Stream Corridor Restoration: Principles, Processes, and Practices, 1998

Entrenchment Ratio

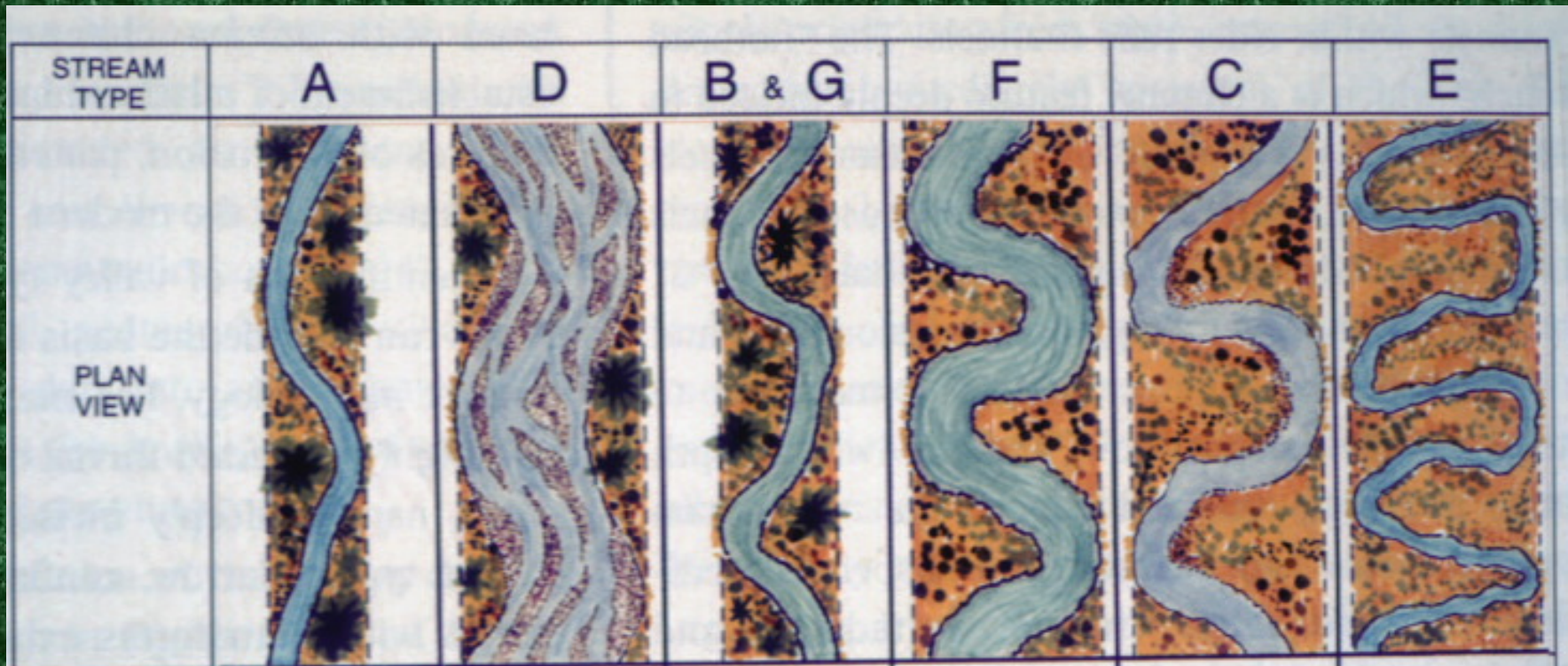


What are the dimensionless ratios for the stable form relative to the specific reach of interest?



Wildland Hydrology, 1998 – modified 2006

Distinct Morphology by Stream Type (i.e, meander belt width)

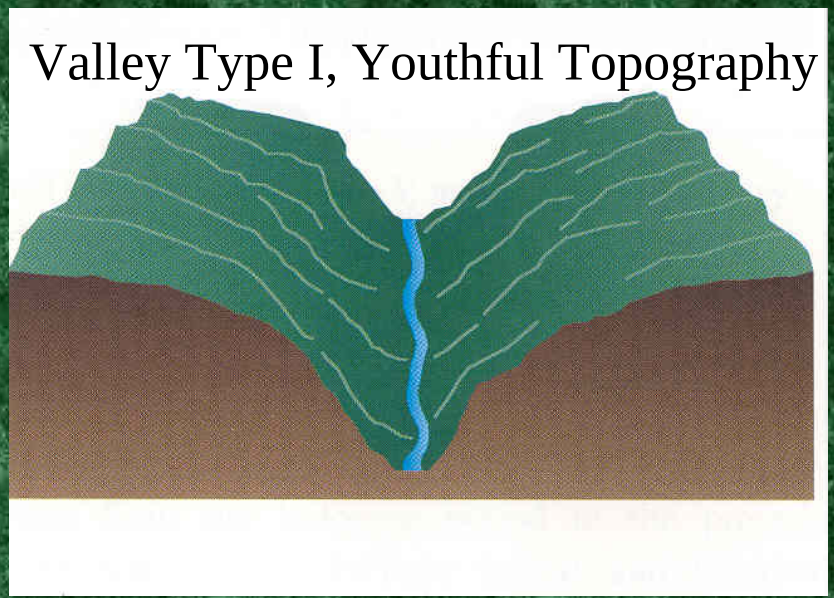


We need to answer these concerns

- Are we comparing apples to apples ?(94 basic geomorphic stream types.)
- Dimensions applied in stream design are not regionalized.
- Database and stream design dimensions are lacking.

A1a Morphology

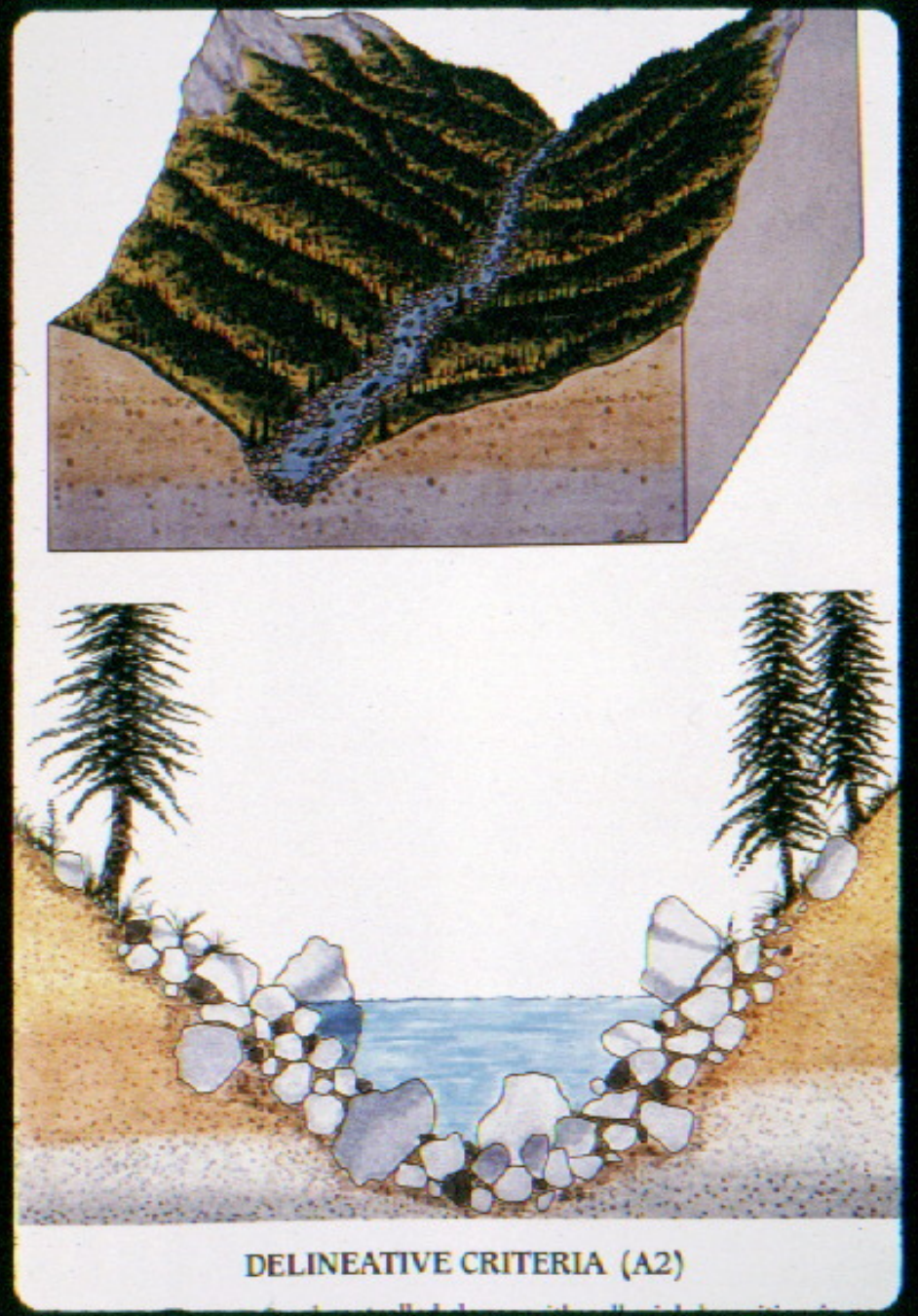
A1a Trib. to Uncampaghre



A2 - Yelm, WA

Valley Type I, Source

A2a on Mission Falls



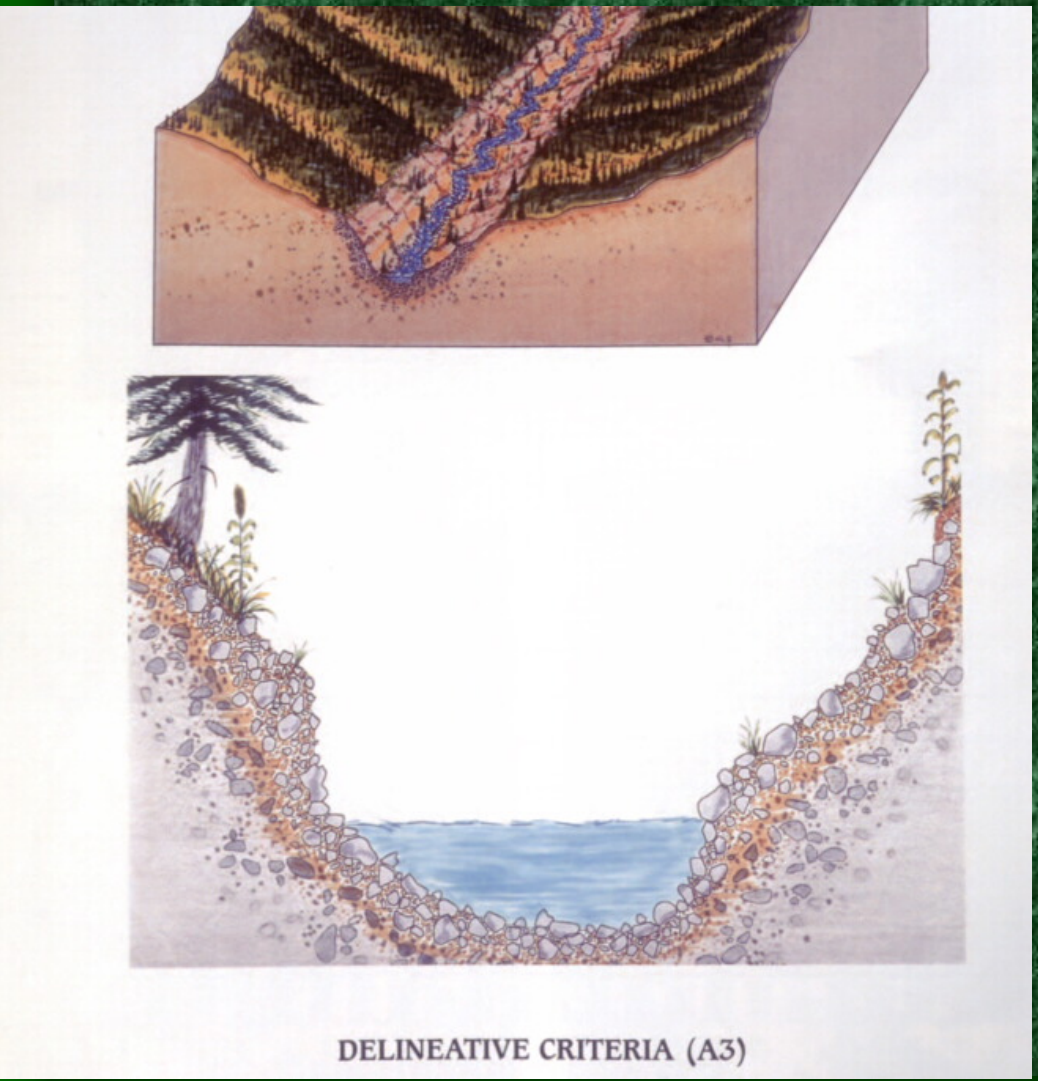
A3a Stream Morphology

A3a on Uncampaghre Headwaters

DELINEATIVE CRITERIA (A3)

Landform/soils:	Steep, narrow depositional slopes typical of glacial moraines and debris slid associated with unconsolidated, heterogeneous and non cohesive materials
Channel materials:	Predominantly cobble with a mixture of boulders, gravel and sand
Slope Range:	.04 - .10 (A3a+ > .10)
Entrenchment Ratio:	< 1.4
Width/depth Ratio:	< 12
Sinuosity:	< 1.2

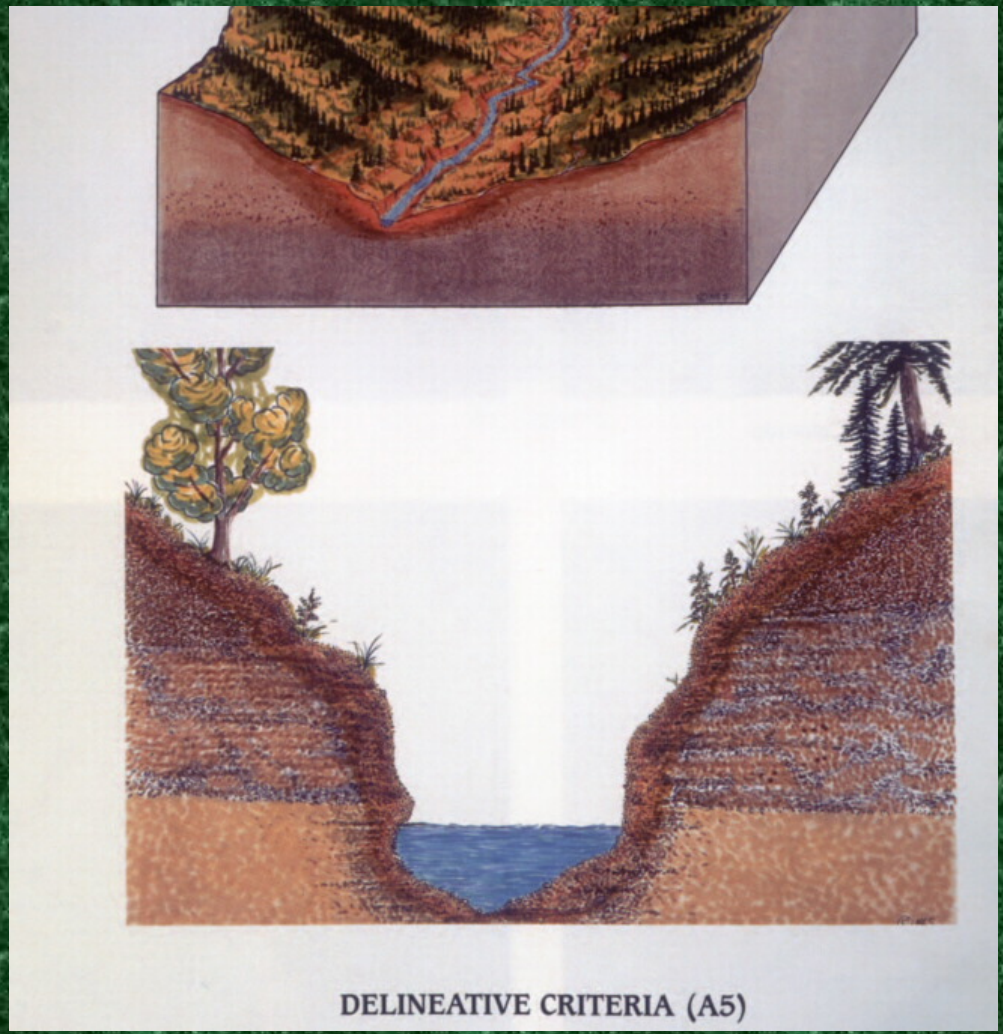
A3 less than 10% Slope



Cobble Bed, Highly Entrenched, Low Width to Depth Ratio, Low Sinuosity.

Sometimes miss-classified as a G stream type.

A5 Stream Type



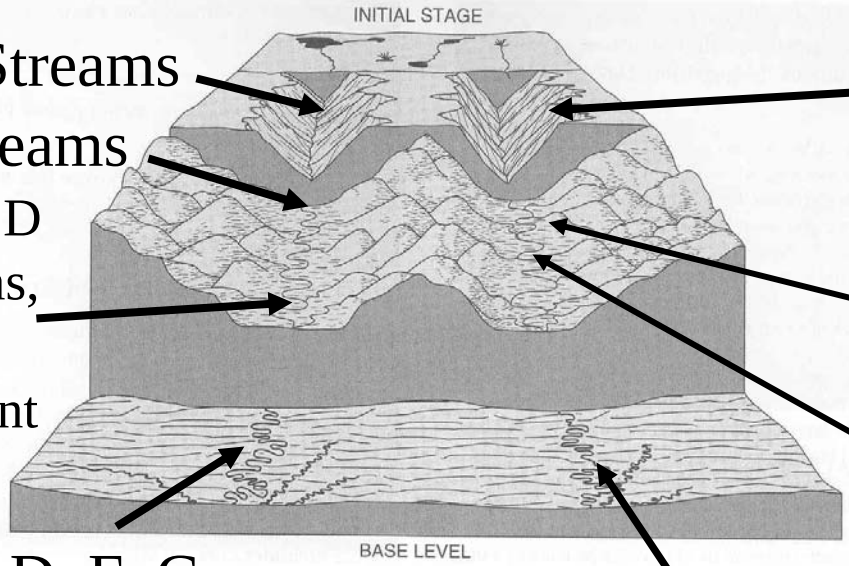
DELINEATIVE CRITERIA (A5)

Valley Types and Stream Classification

A Streams

B Streams

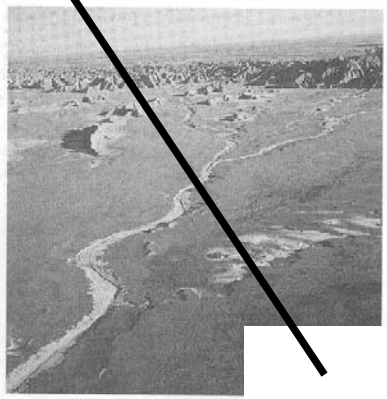
C and D streams, high gradient



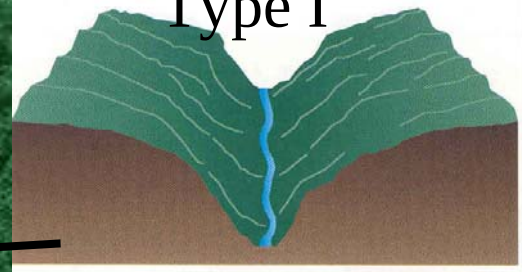
C, E, D, F, Gc


B.

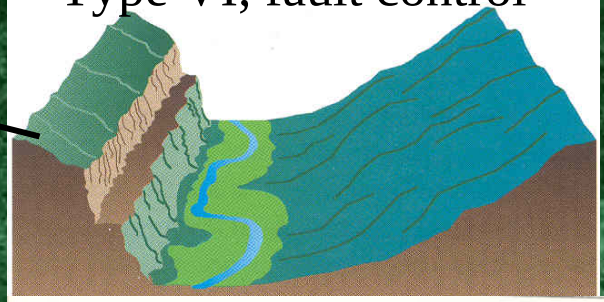

C.


D.

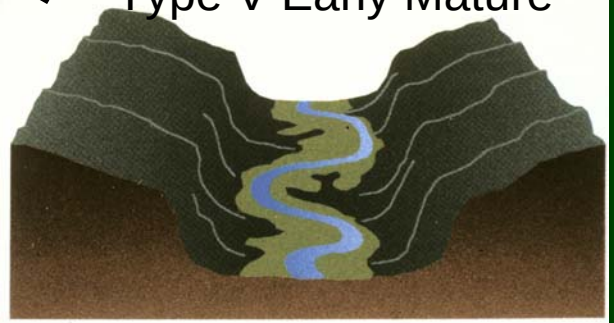
Type I



Type VI, fault control

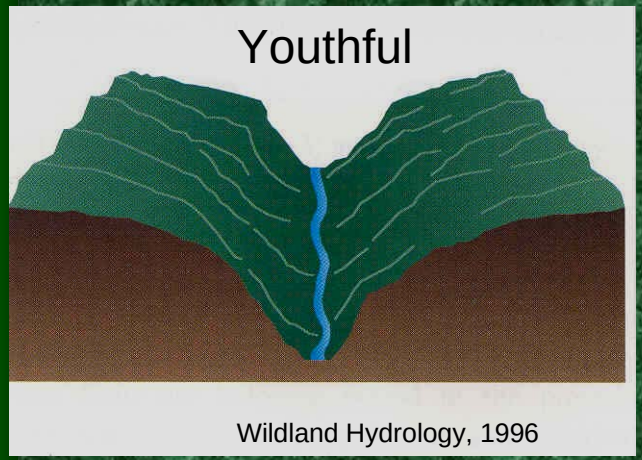


Type V Early Mature



Type VIII, Mature

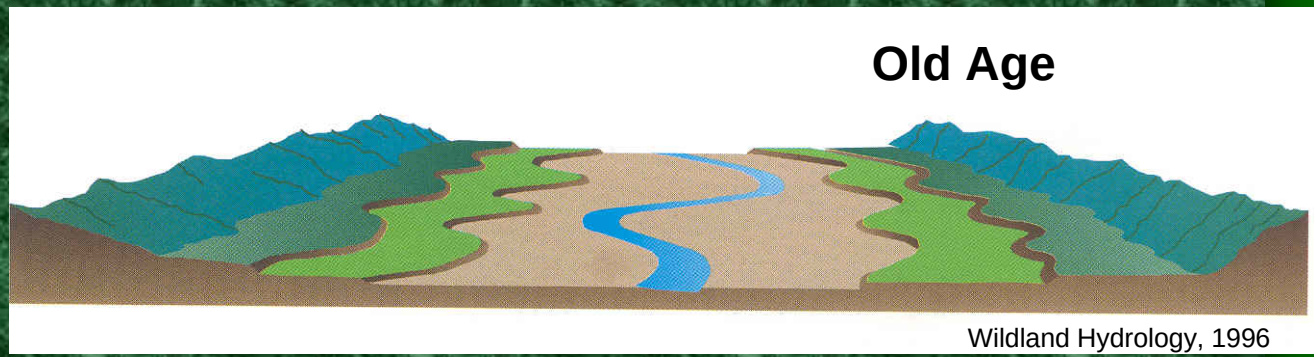
Geomorphic Valley Types



Wildland Hydrology, 1996

Wildland Hydrology, 1996

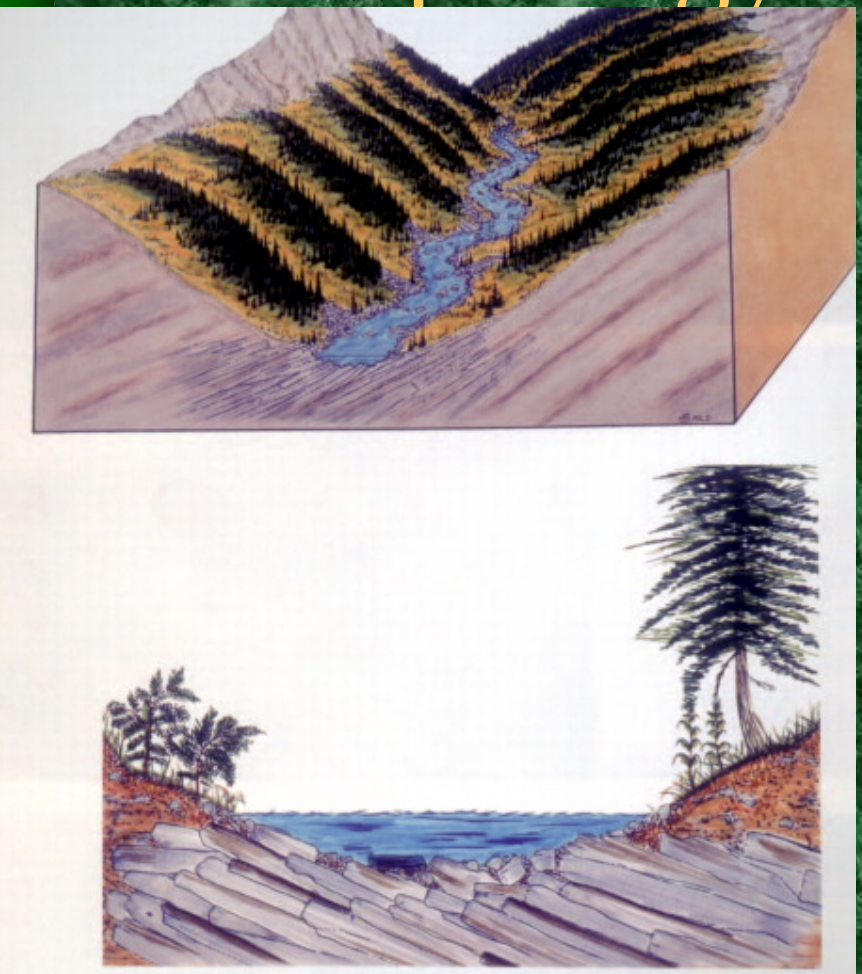
What do William Morris Davis (1899) and Dave Rosgen have in common?



Wildland Hydrology, 1996

Wildland Hydrology, 1996

B1 Morphology

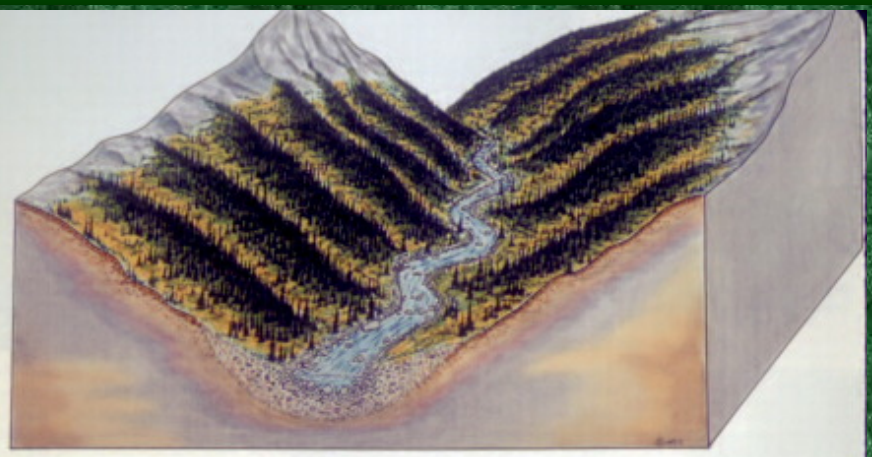


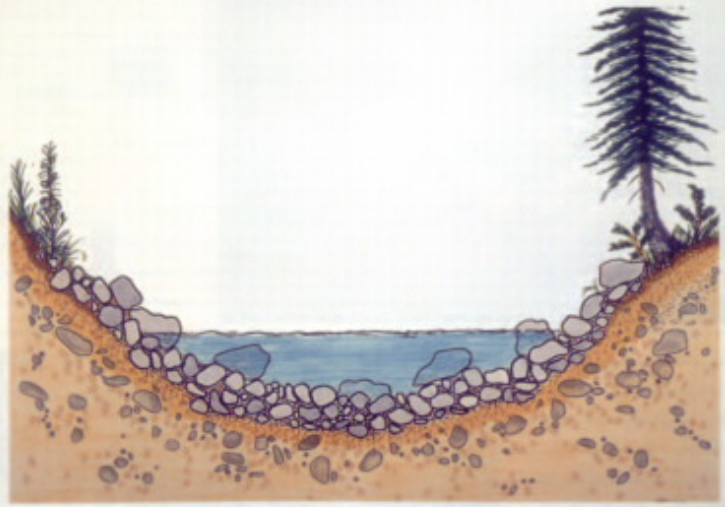
DELINEATIVE CRITERIA (B1)

Landform/soils:	Structural controlled narrow valleys with moderate side slopes.
Channel materials:	Bedrock bed with streambanks composed of boulders, cobble and grave
Slope Range: .02 - .04 (B1c < .02)	Entrenchment Ratio: 1.4 - 2.2
Width/depth Ratio: > 12	Sinuosity: > 1.2

B Morphology

- Single Threaded
- Entrenchment 1.4 – 2.2
- Width to depth Ratio > 12
- Sinuosity > 1.2
- Slope 2 to 4%
- B_a Slope range 4 to 10%
- B_c Slope less than 2%





DELINEATIVE CRITERIA (B2)

Landform/soils:	Structural controlled narrow valleys associated with colluvium or lag deposit narrow, moderate to gentle glaciated valleys.
Channel materials:	Boulders with smaller amounts of cobble, gravel and sand.
Slope Range: .02 - .04 (B2c < .02)	**Entrenchment Ratio:** 1.4 - 2.2
Width/depth Ratio: > 12	**Sinuosity:** > 1.2

B2 Morphology

B2c with a slope less than 2% (0.002ft/ft)

B2 Step:Pool Morphology

DELINEATIVE CRITERIA (B3)

Landform/soils:	Narrow, moderately steep colluvial valleys with gentle side slopes. Soils a colluvium and/or alluvium. Often in fault line valleys or on well vegetate alluvial fans.
Channel materials:	Predominantly cobble with lesser amounts of boulders, gravel and sand. Streambanks are stable due to coarse material.

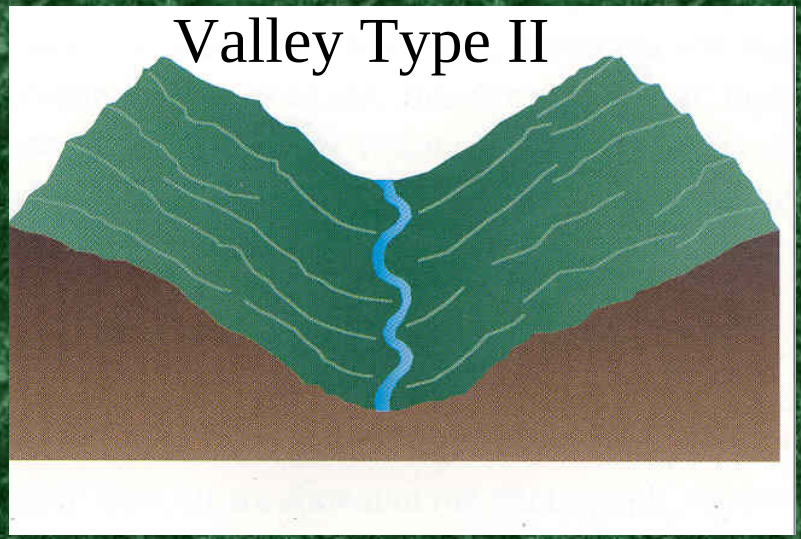
Slope Range: .02 - .04 (B3c, < .02) **Entrenchment Ratio:** 1.4 - 2.2

Width/depth Ratio: > 12 **Sinuosity:** > 1.2

B3 Morphology

Cobble Bed

B stream Type in Valley Type II Young Valleys



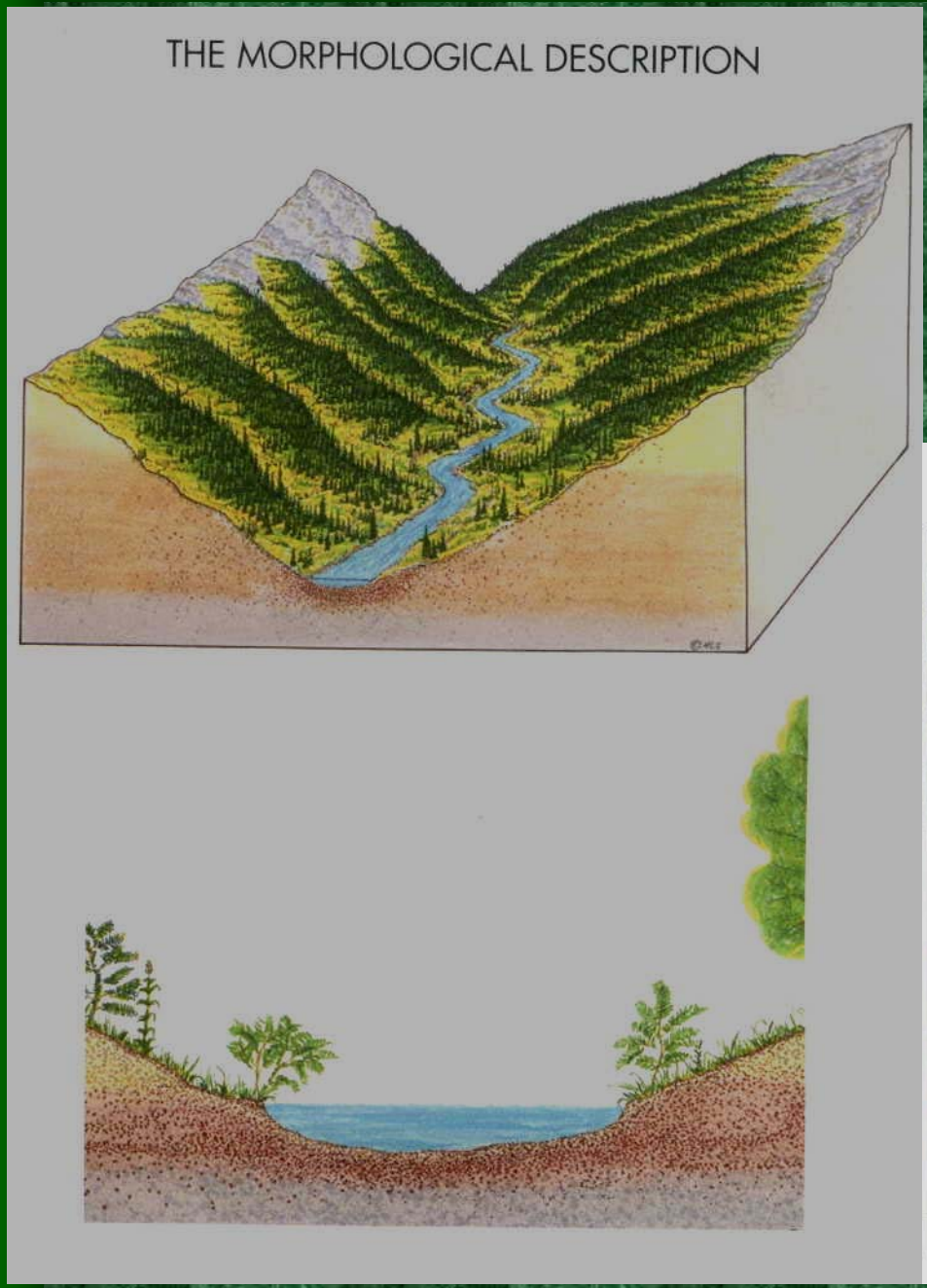
DELINEATIVE CRITERIA (B4)

Landform/soils:	Narrow, moderately steep colluvial valleys, occasionally on well vegetated stable alluvial fan, or in fault line valleys.
Channel materials:	Gravel dominated with lesser amounts of boulders, cobble and sand.
Slope Range: .02 - .04 (B4c < .02)	**Entrenchment Ratio:** 1.4 - 2.2
Width/depth Ratio: > 12	**Sinuosity:** > 1.2

B4
Slope 2-4%

B4c is very common
Slope < 2%

Often may have numerous cobbles present but D50 < 64mm



B5-Sand

Very Sensitive to Disturbance

B5 Stream Type

DELINEATIVE CRITERIA (B6)

Landform/soils:	Narrow, moderately steep valleys with gentle sloping sideslopes. Soils either residual, alluvial and/or colluvial.
Channel materials:	Silt/Clay with lesser amounts of sand.
Slope Range:	.02 - .04 (B5c, < .02)
Entrenchment Ratio:	1.4 - 2.2
Width/depth Ratio:	> 12
Sinuosity:	> 1.2

B6
Not very common but present in steep loess country

B6 forming on Palouse

Not Common

C Stream Type Morphology

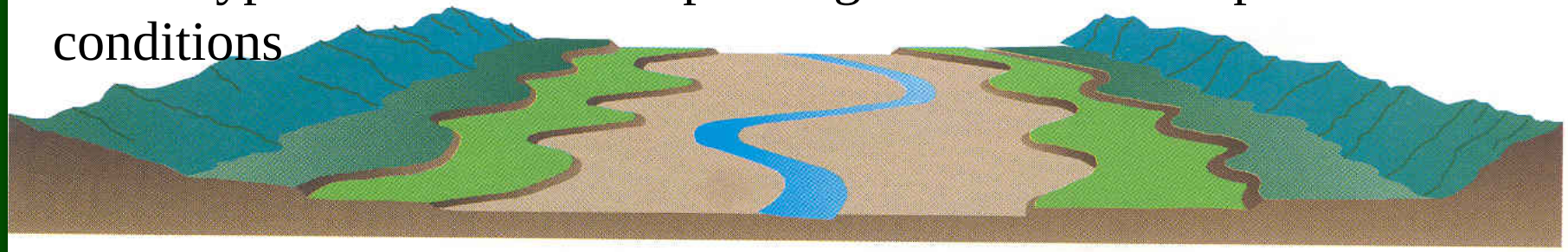
Classic Pool:Riffle Morphology

Well-Attached Floodplain

C3, C4, and C5 are some of the most common stream types

Valley Type VIII
Multiple Terraces

Common valleys for C type streams, sometime Es. However, D, F, and G types can be found depending on stream and riparian conditions



C Morphology

Single and thread channel

Entrenchment Ratio > 2.2

Width:Depth Ratio > 12

Sinuosity > 1.2

Slope, 0.01 to 2%

C_b slope 2-4%

C_c- slopes < 0.1%

C4

C Morphology Restored

DELINEATIVE CRITERIA (C1)

Landform/soils:	Broad, gentle gradient structural controlled alluvial valleys.
Channel materials:	Bedrock bed with alluvial banks (cobble, gravel and sand).
Slope Range: < .02 (C1c- .001)	**Entrenchment Ratio:** > 2.2
Width/depth Ratio: >12	**Sinuosity:** >1.2

C1
Bedrock control cobbles and boulders present

Not a common type

C4 Current Stable Analog-North Cascades

THE MORPHOLOGICAL DESCRIPTION

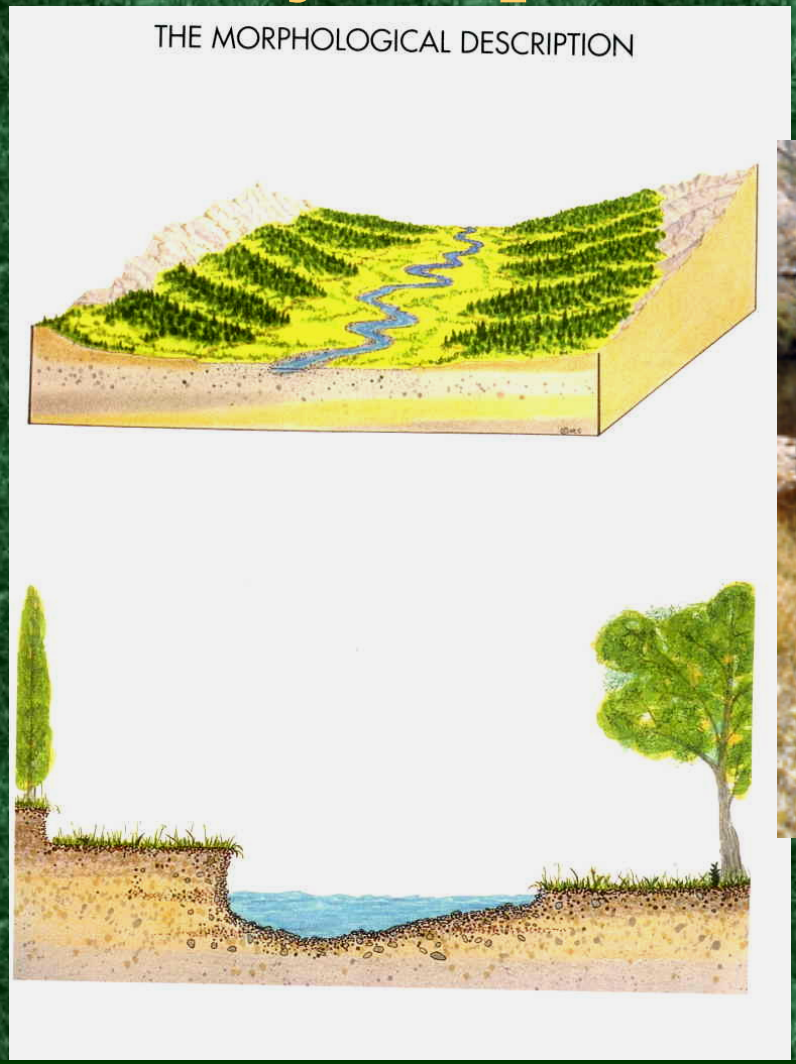
C4 - New Mexico

C4 - Colorado

C4 - Wisconsin

The C4 Stream Type is a Key Stream Type for Salmonids.

C4 Morphology, very common, very important on the landscape



C5 Sand Bed

DELINEATIVE CRITERIA (C5)

Landform/soils: Broad, gentle gradient alluvial valleys, river deltas, broad plains. Soils are depositional such as lacustrine, glacial outwash, eolian.

Channel materials: Predominantly sand bed and banks, with occasional gravel and silt/clay. Streambanks may contain finer particles than bed material.

Slope Range: < .02 (C5c- .001) **Entrenchment Ratio:** > 2.2

Width/depth Ratio: >12 **Sinuosity:** >1.4

DELINEATIVE CRITERIA (C6)

Landform/soils: Broad gentle valleys, plains, and deltas. Depositional soils (alluvium), associated with cohesive materials from riverine and lacustrine process. Often associated with tidal influence deltas, marshes and other wetland complexes.

Channel materials: Silt-clay predominates, however many of these C6 stream types are associated with a high organic component including peat.

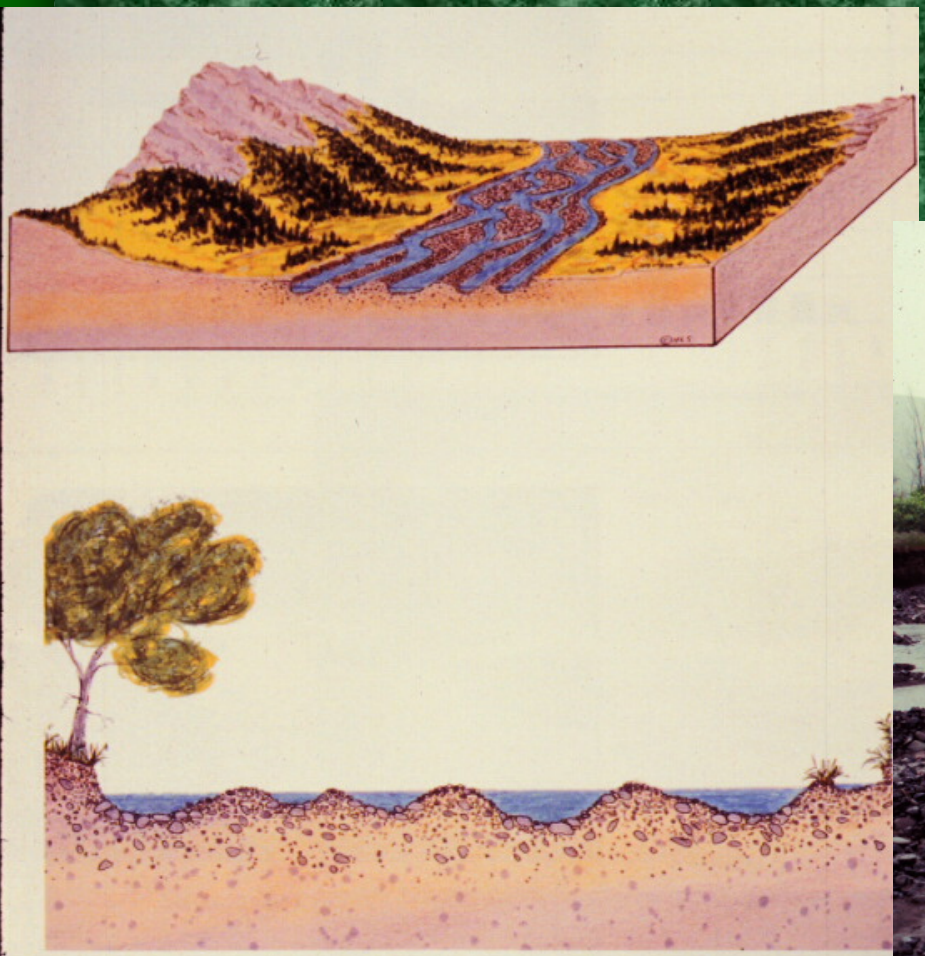
Slope Range: < .02 (C6c- .001) (.0001 more common) **Entrenchment Ratio:** > 2.2

Width/depth Ratio: >12 (generally lowest of C's) **Sinuosity:** >1.4

C6 Morphology

Usually very gentle slopes often associated with lacustrine valley development

D4 Braided



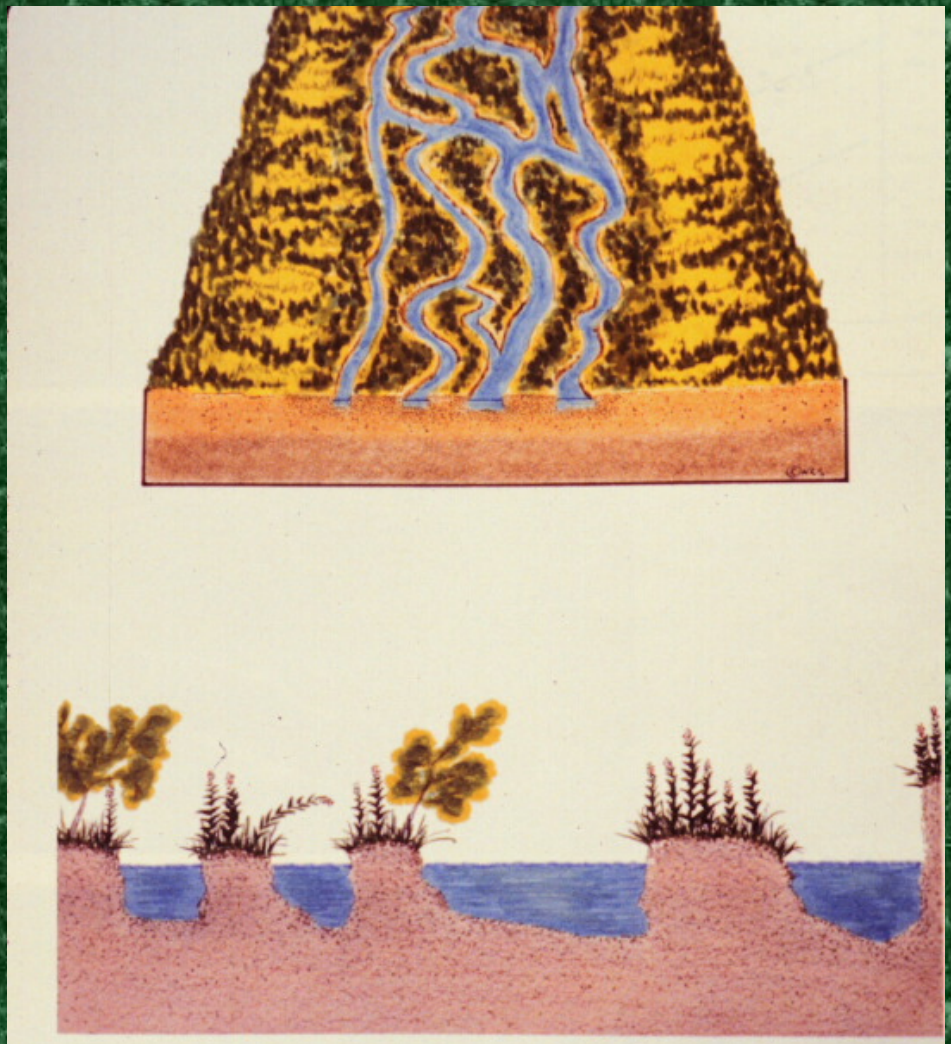
DELINEATIVE CRITERIA (D4)

Landform/soils: Moderately steep glacial valleys, alluvial fans, narrow fluvial mountain valleys and terraced valleys in coarse alluvium. Can occur in gravel splays, and coarse delta deposits.

Channel materials: Gravel bed with smaller quantities of cobble. Typical is a bi-modal distribution of sands. Stream bank materials generally finer than bed, actively eroding.

Slope Range: < .04 **Entrenchment Ratio:** N/A (not incised)

Width/depth Ratio: > 40 **Sinuosity:** Low, channel slope = valley slope



DELINEATIVE CRITERIA (DA4-DA6)

Landform/soils:	Broad gentle valleys and deltas. Wetland environments with stable islands often cohesive banks mixed with organic material. Depositional soils.
Channel materials:	The materials vary from gravel (DA4), sand (DA5), to silt/clay (DA6). Peat and other organic materials are very common with these streams.

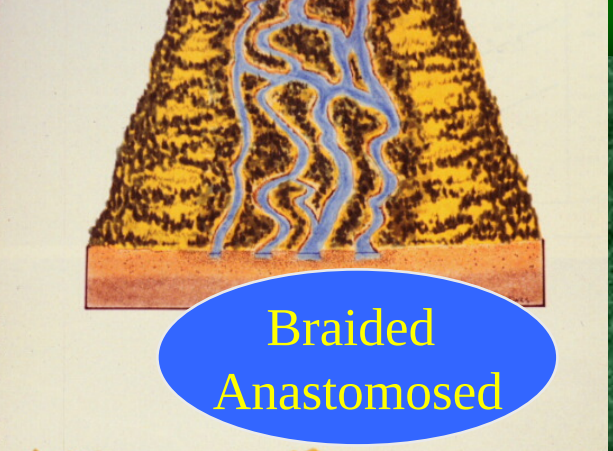
Slope Range: < .005 (average closer to .0001) **Entrenchment Ratio:** N/A (not incised)

Width/depth Ratio: Highly variable **Sinuosity:** Highly variable

Braided (DA_)
Anastomosed

Mature natural stable type braided stream with multiple low width to depth ratio channels, most highly biologically productive per linear stream distance. Often found in estuaries, lacustrine bed very flat valleys and outlets to lakes

Is your river an anastomosed braided system or in a highly perturbed braided condition?



Braided Anastomosed

DELINEATIVE CRITERIA (DA4-DA6)

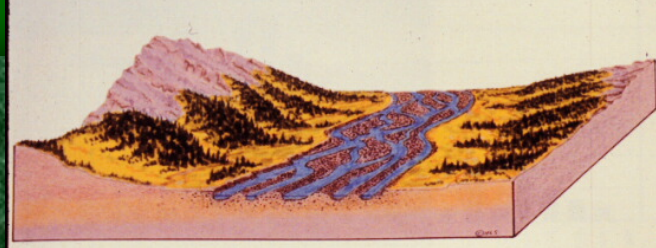
Landform/soils:	Broad gentle valleys and deltas. Wetland environments with stable island often cohesive banks mixed with organic material. Depositional soils.
Channel materials:	The materials vary from gravel (DA4), sand (DA5), to silt/clay (DA6). Peat and other organic materials are very common with these streams.

Slope Range: < .005 (average closer to .0001) Entrenchment Ratio: N/A (not incised)

Width/depth Ratio: Highly variable Sinuosity: Highly variable

Stehekin Anastomosed

June 21, 1927 - third of three.



Braided Aggraded

DELINEATIVE CRITERIA (D4)

Landform/soils:	Moderately steep glacial valleys, alluvial fans, narrow fluvial mountain valleys and terraced valleys in coarse alluvium. Can occur in gravel splays, and coarse delta deposits.
Channel materials:	Gravel bed with smaller quantities of cobble. Typical is a bi-modal distribution of sands. Stream bank materials generally finer than bed, actively eroding.

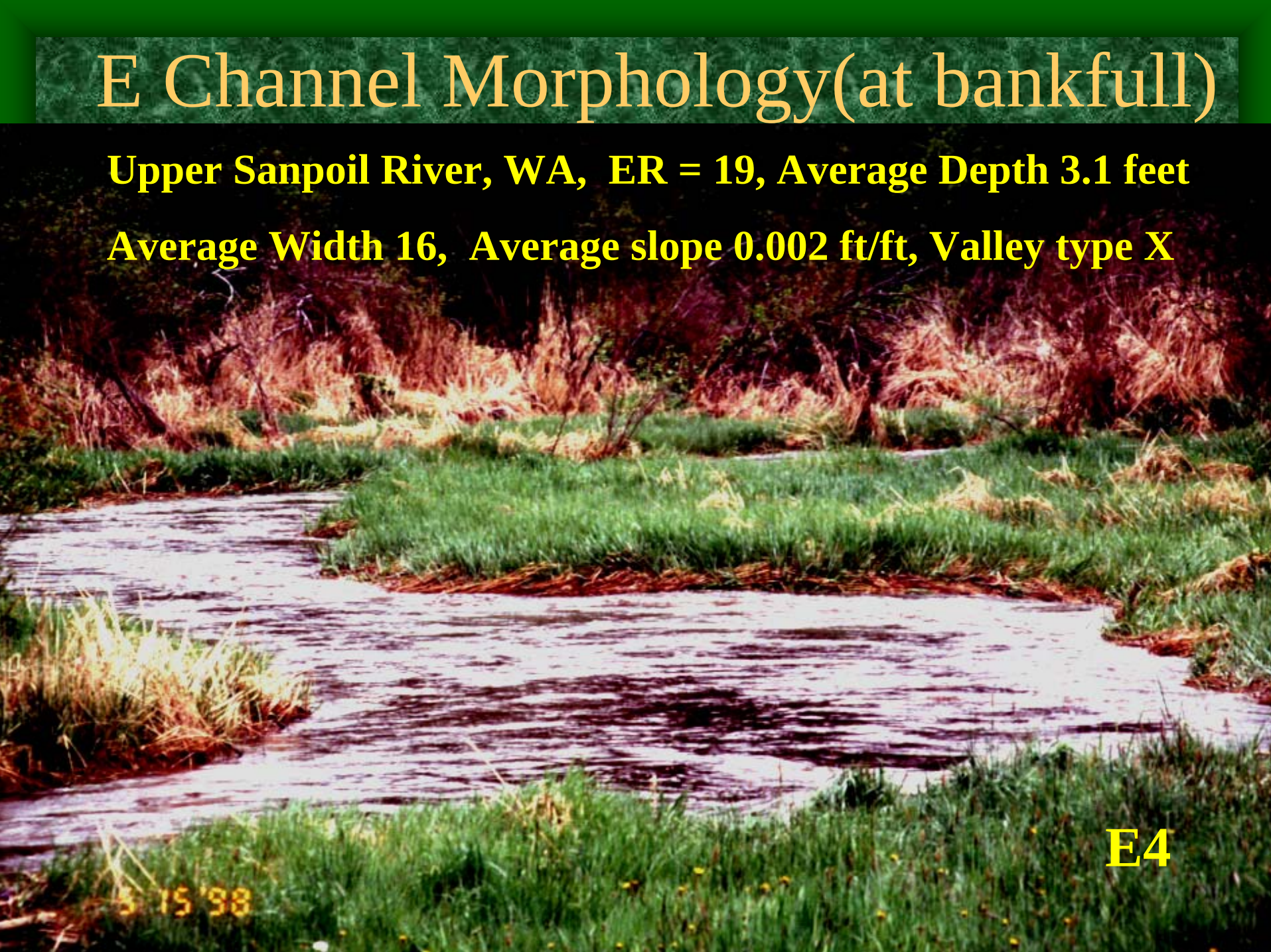
Slope Range: < .04 Entrenchment Ratio: N/A (not incised)

Width/depth Ratio: > 40 Sinuosity: Low, channel slope = valley slope

E Channel Morphology(at bankfull)

Upper Sanpoil River, WA, ER = 19, Average Depth 3.1 feet

Average Width 16, Average slope 0.002 ft/ft, Valley type X



E Channel Morphology

Single Thread channel

Entrenchment Ratio > 2.2

Width to Depth Ratio < 12

Sinuosity > 1.5

Slope < 2%

E_b, Slope ranges 2-4%, not common

Valley Type X: Often E or C

E4 Stream Type

DELINEATIVE CRITERIA (E3)

Landform/soils: Broad, gentle to moderately steep alluvial valleys.

Channel materials: Cobble dominated with fewer accumulations of gravel and sand. Stream bank have gravel/sand matrix mixed with dense root mats/organic material. Very stable.

Slope Range: < .02 (E3ₕ, .02-.04)

Entrenchment Ratio: > 2.2

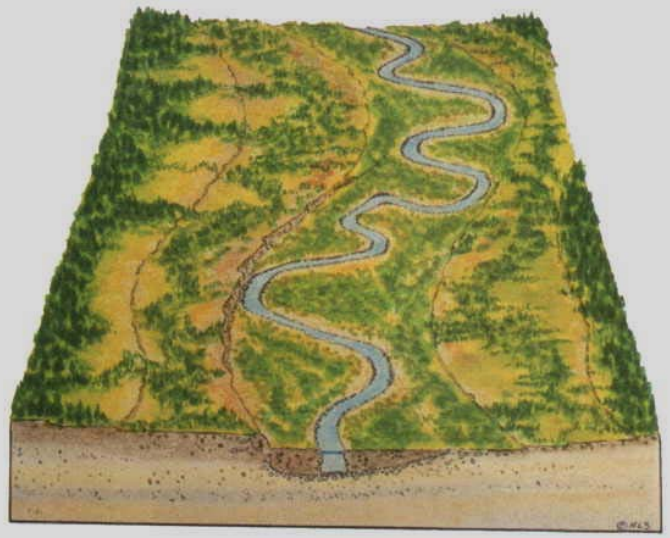
Width/depth Ratio: < 12

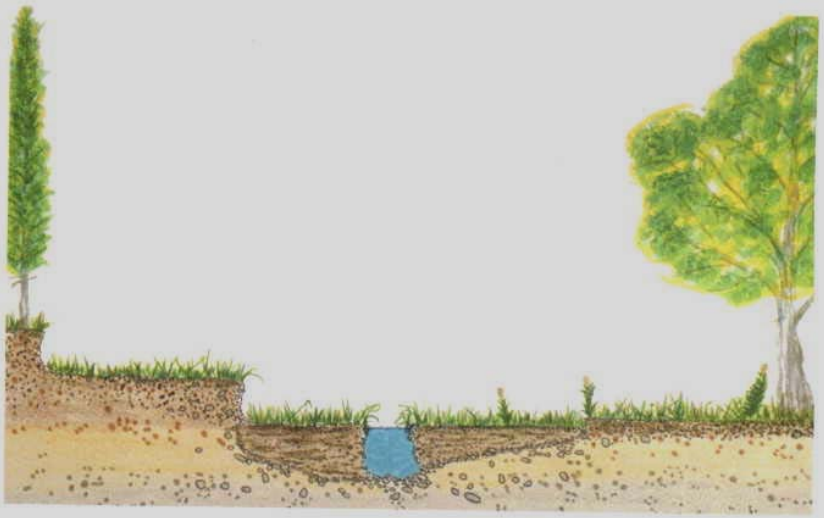
Sinuosity: > 1.5 (less if E3ₕ)

E3 Channels Not Common but present in high mountain meadows

E4 Stream Type

THE MORPHOLOGICAL DESCRIPTION





THE MORPHOLOGICAL DESCRIPTION

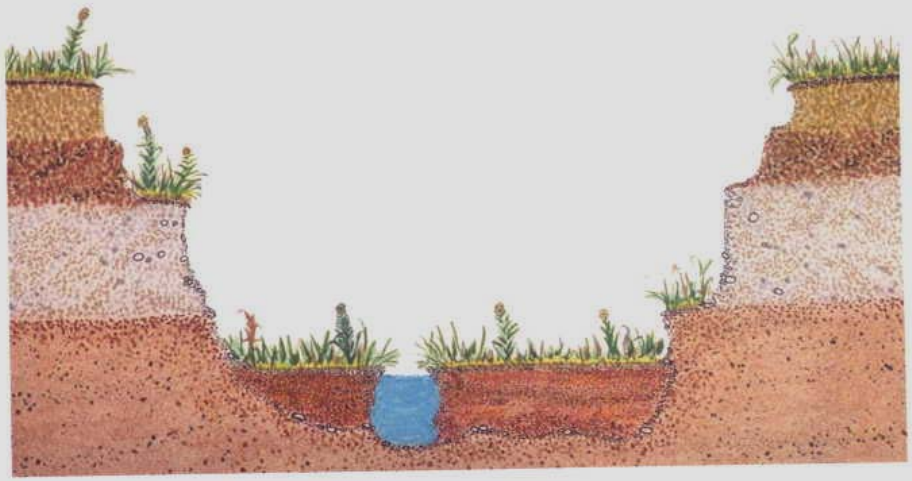
E5 - Colorado

E5 - Wisconsin

E5 - Colorado

E5, Sand Bed

THE MORPHOLOGICAL DESCRIPTION

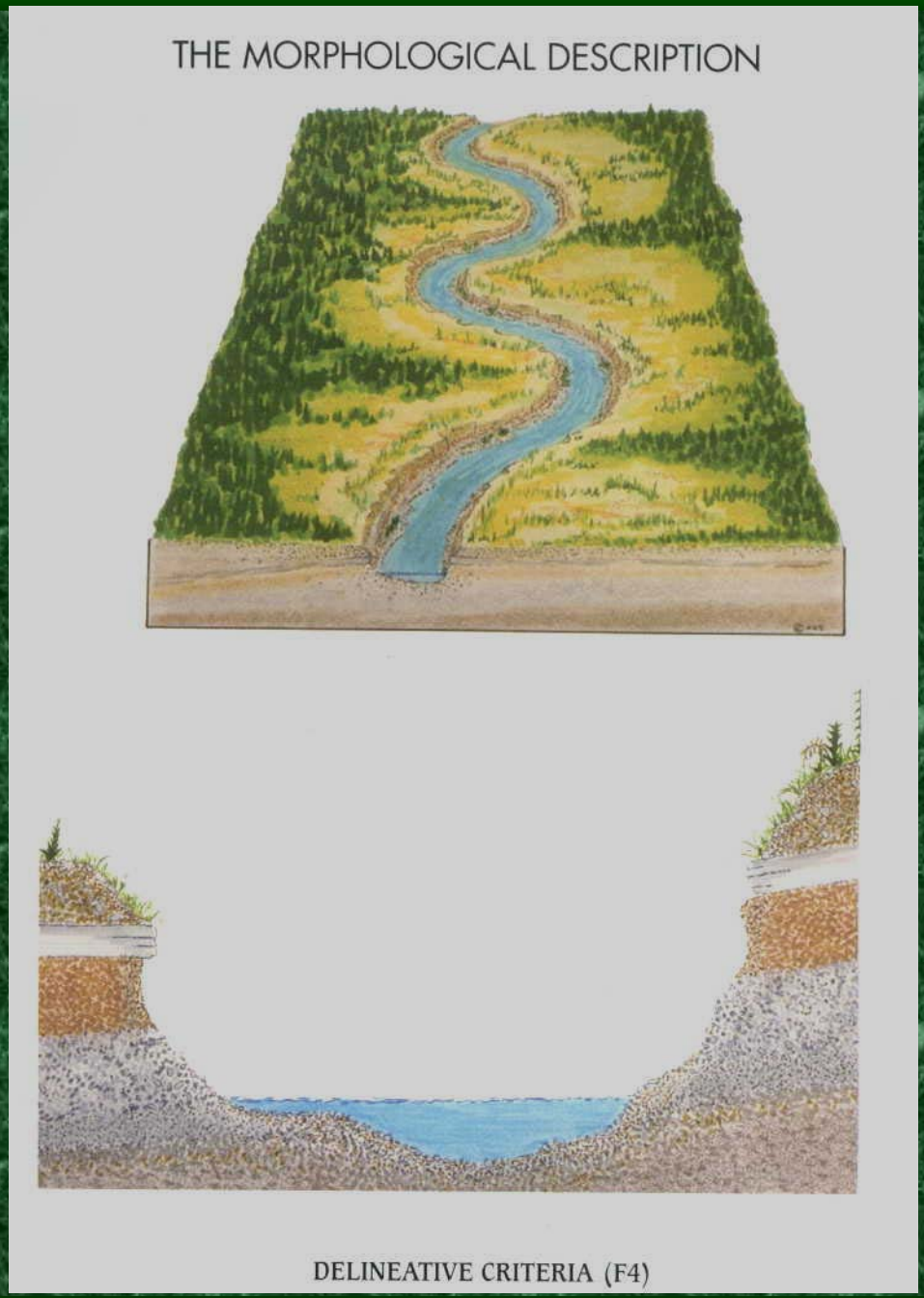


THE MORPHOLOGICAL DESCRIPTION

E5 - Colorado

E5 - Wisconsin

E5 - Colorado



F Channel Morphology

Highly Entrenched >1.4

High Width to Depth Ratio > 12

Sinuosity > 1.2

Slopes < 2.0% (0.02ft/ft)

F_b Slopes, 2 to 4%

THE MORPHOLOGICAL DESCRIPTION

F4 - Colorado

F4 - California

F4 - Texas

G Stream Types

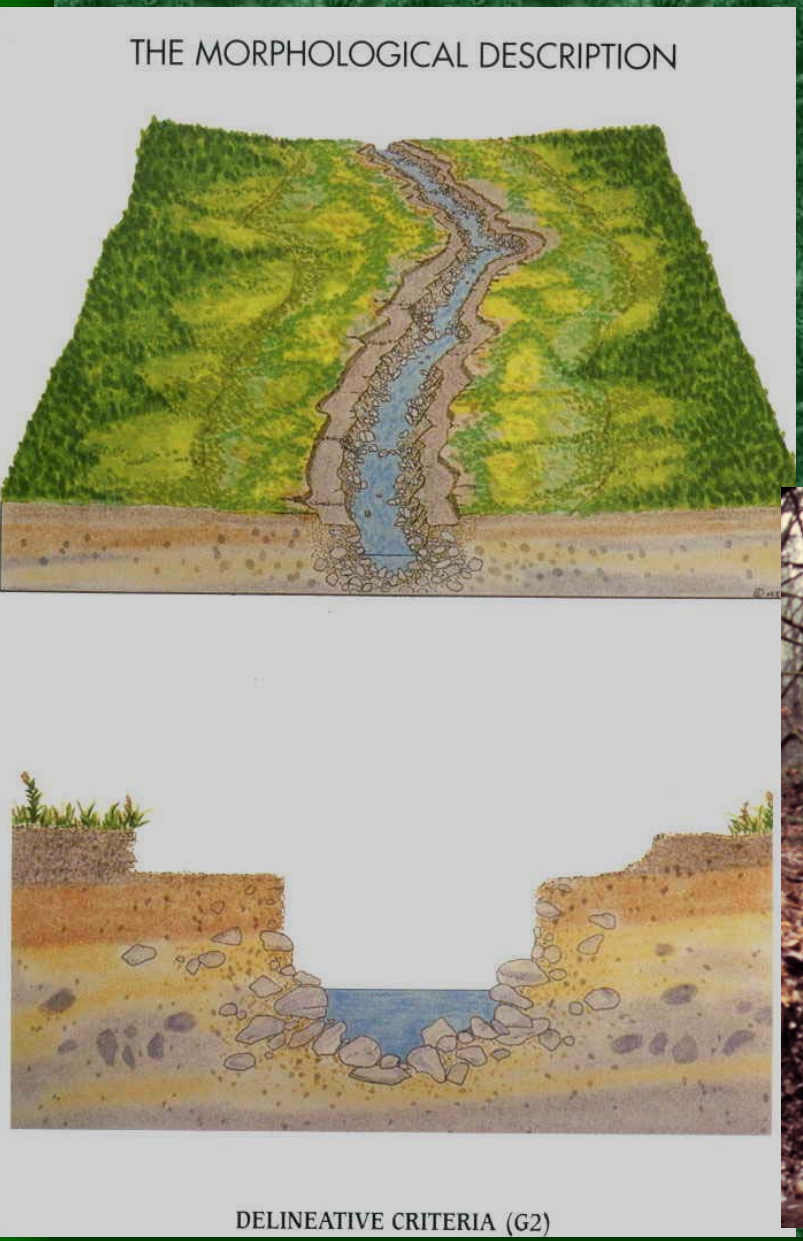
Entrenchment Ratio < 1.4

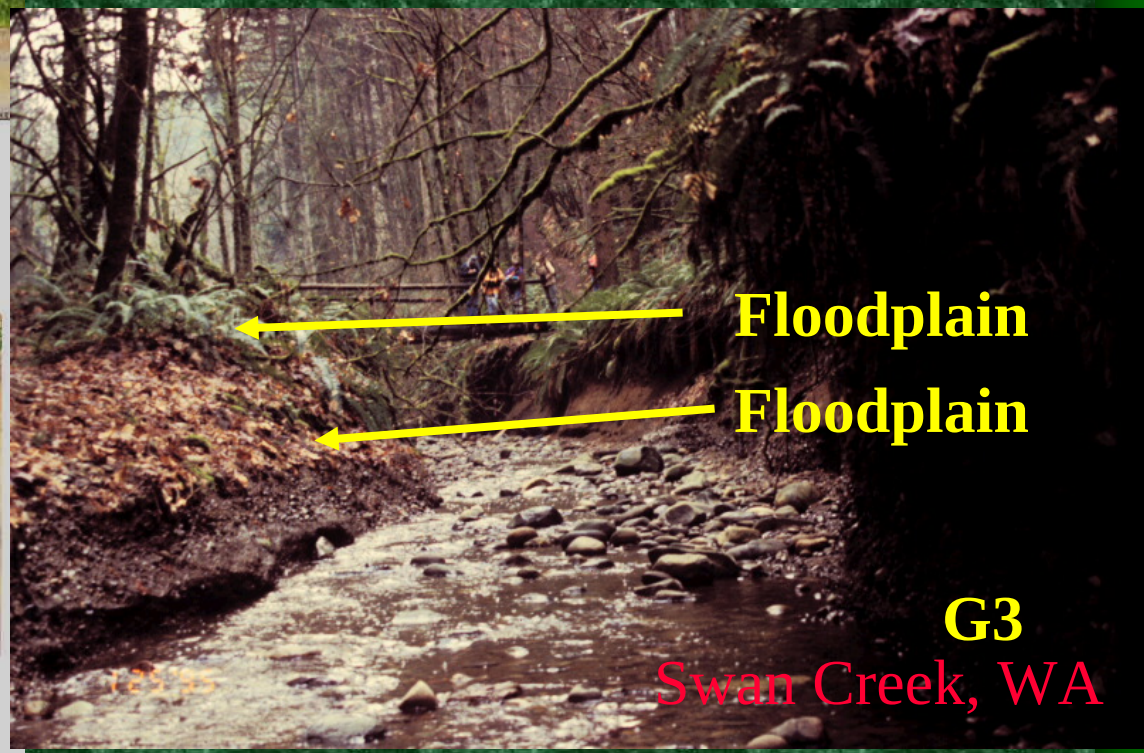
Width Depth Ratio < 12

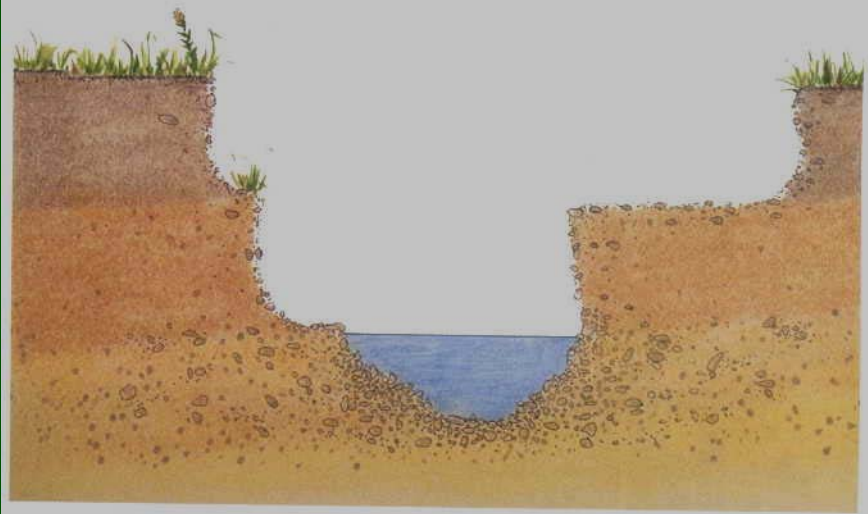
Sinuosity > 1.2

Slope, 2-4%

G_c Slopes < 2% Common on Ag. Landscape, Schumm Stage II, Rapid Channel adjustment







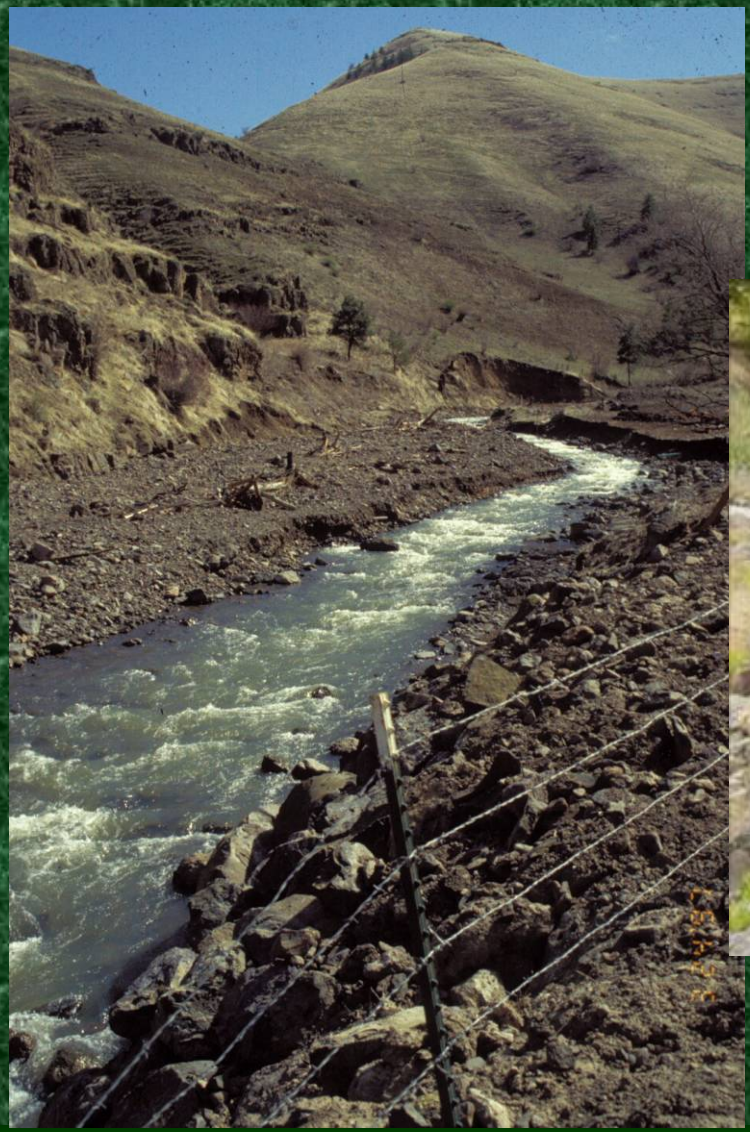
DELINEATIVE CRITERIA (G4)

G4 - Nevada

G4 - California

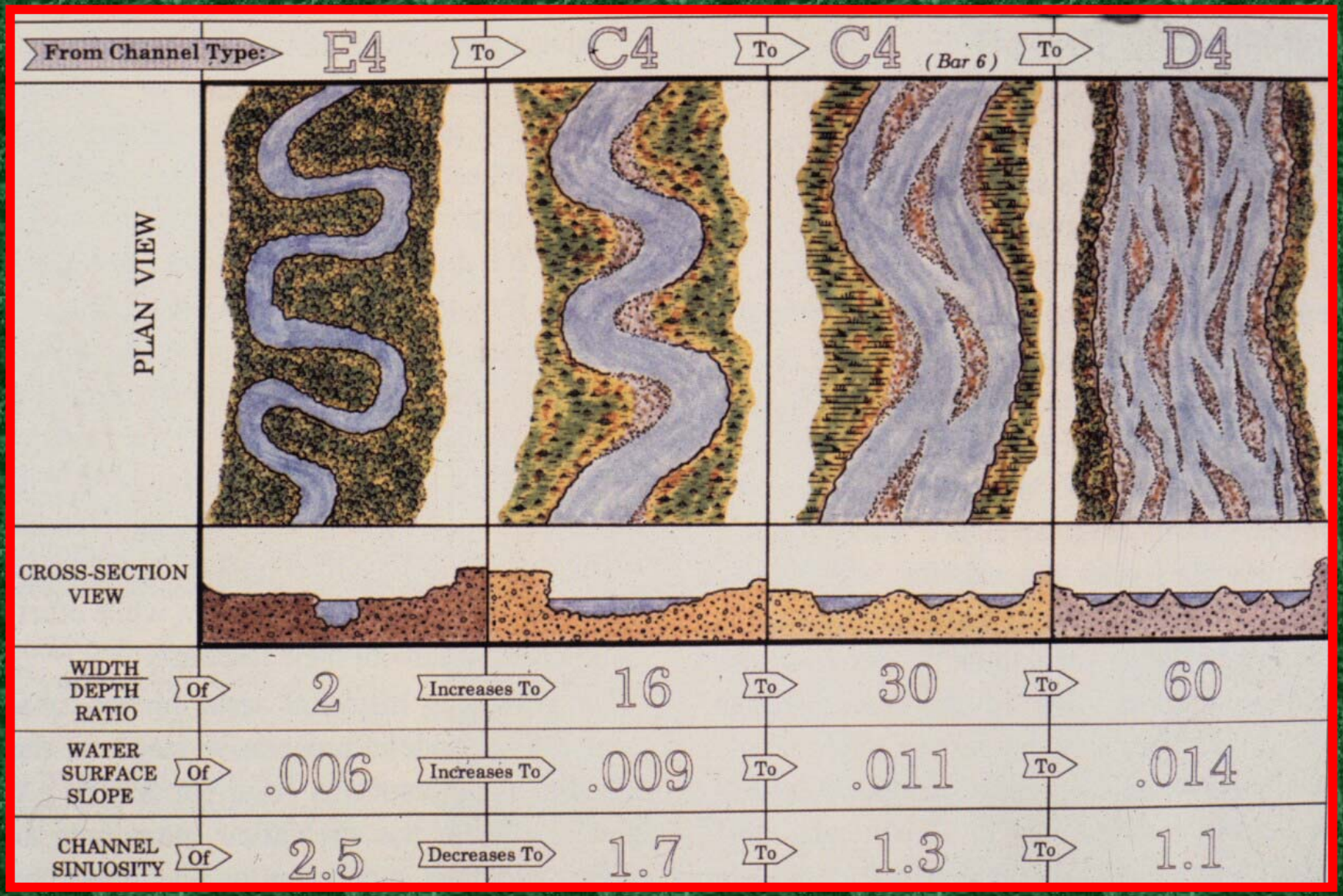
G4 - Maryland

Before and After



Six years and two large floods later

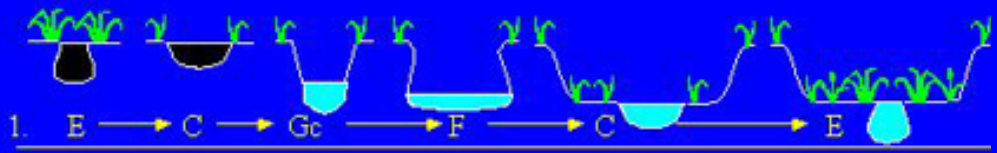
Channel Change Adjustments and Evolution



1997

Five years
Later

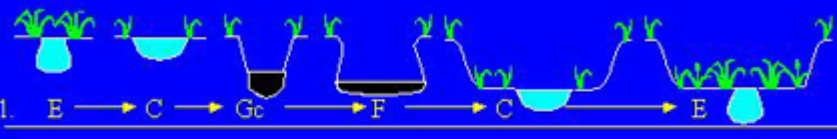
Channel Succession



E

E → C

Channel Succession



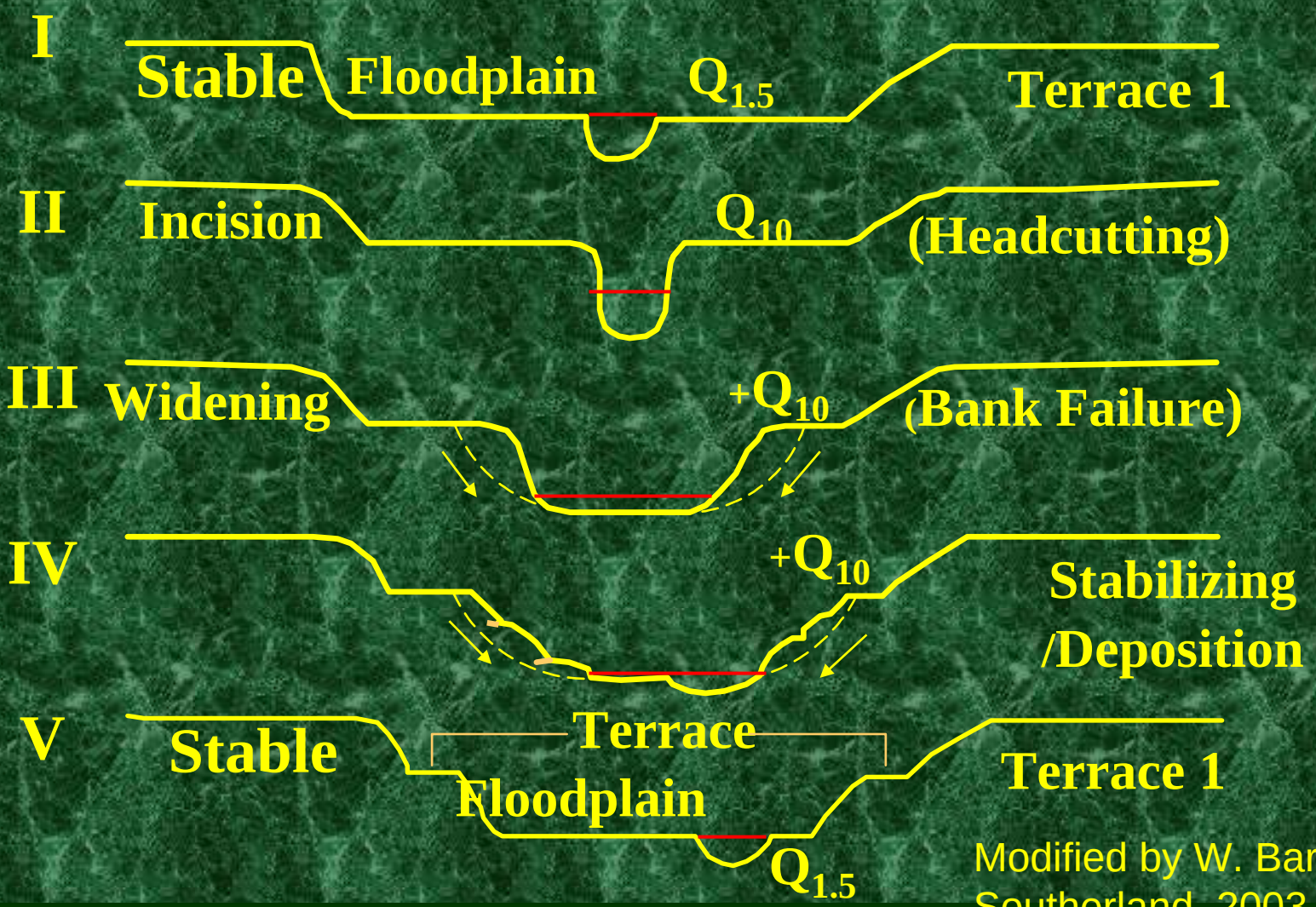
G_c

F

Channel Evolution Model

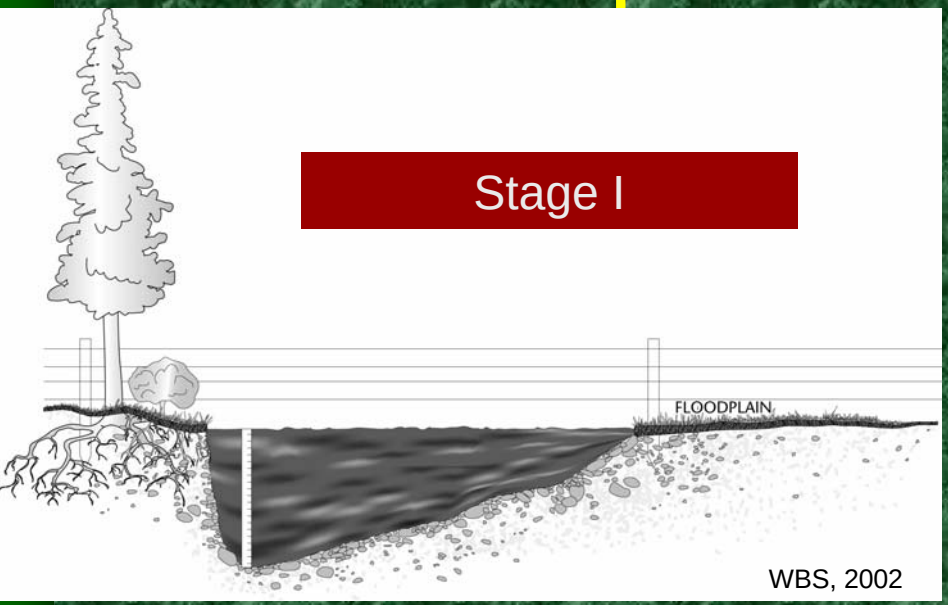
Schumm, Harvey, Watson (1984):

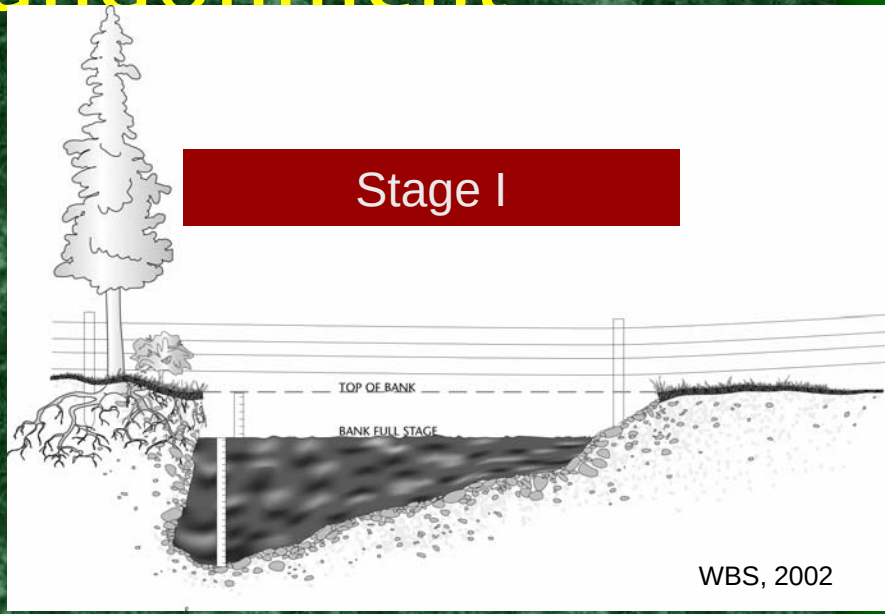
— = Bankfull Q



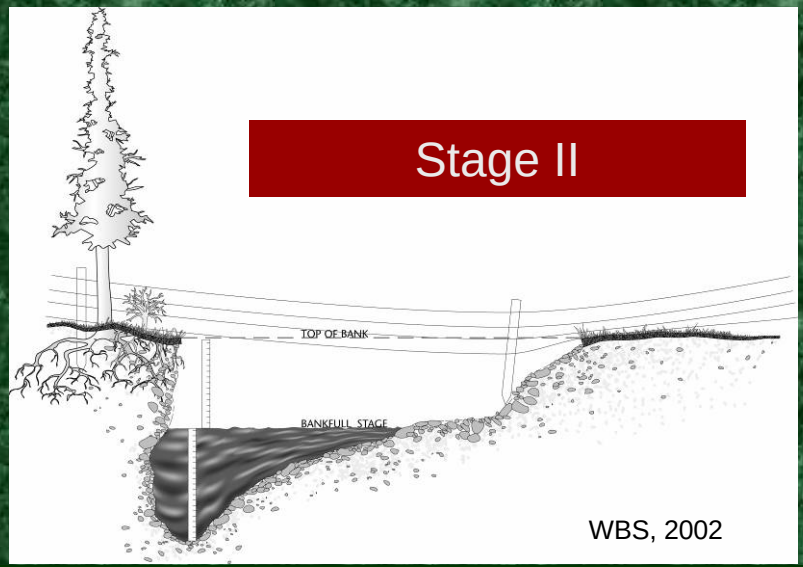
Modified by W. Barry Southerland, 2003

Floodplain Abandonment





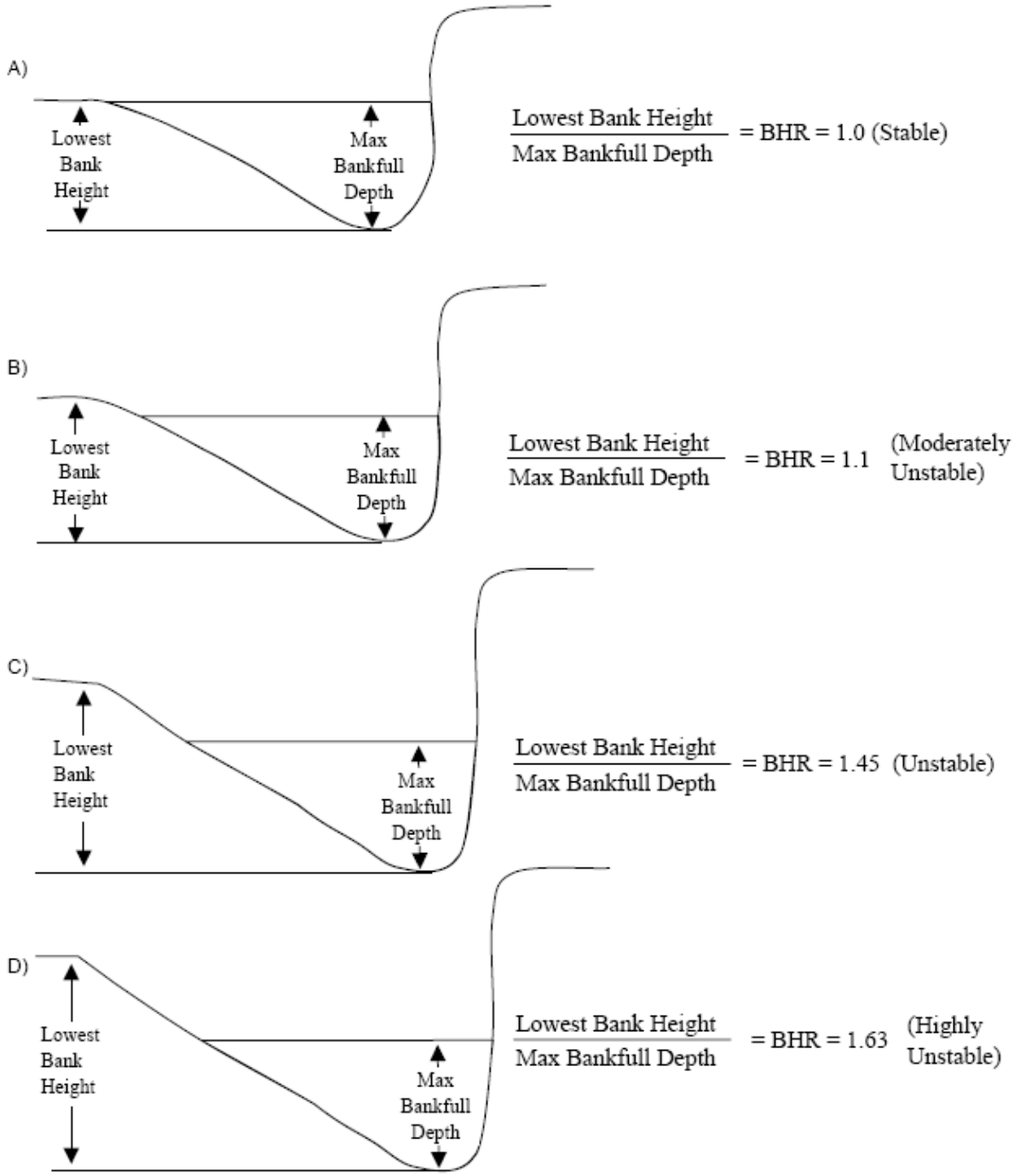
Schumm Channel Evolution Model and Bank Height Ratio (BHR)



BHR = Top of the Bank / Bankfull Height. This is a measure of the degree of incision

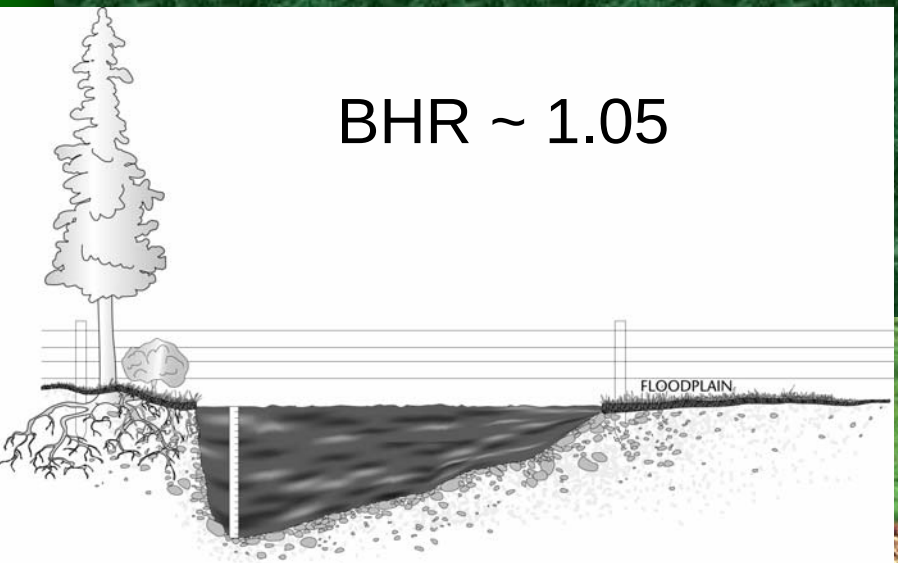
Bank height ratio

This variable is a field measurement that determines the degree of channel incision. It is calculated by dividing the maximum bankfull depth into the height of the lowest bank.

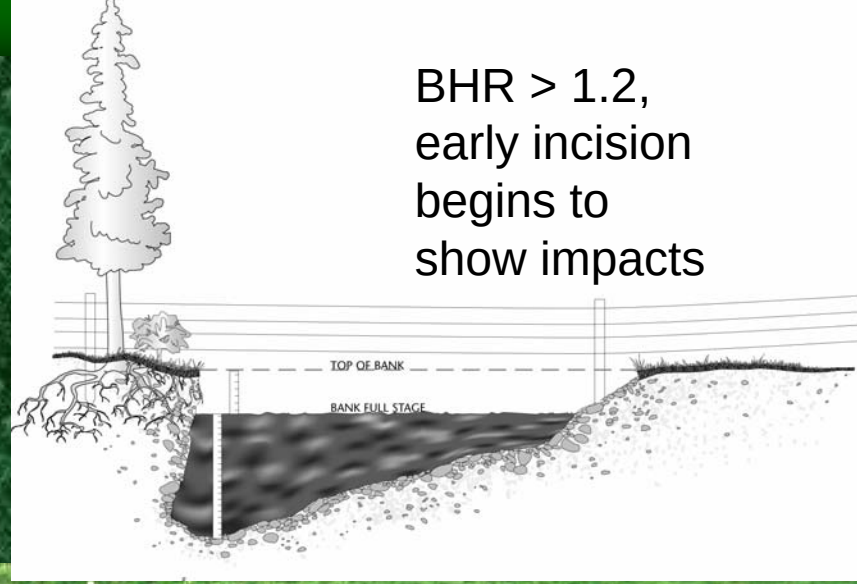


Why BHR?

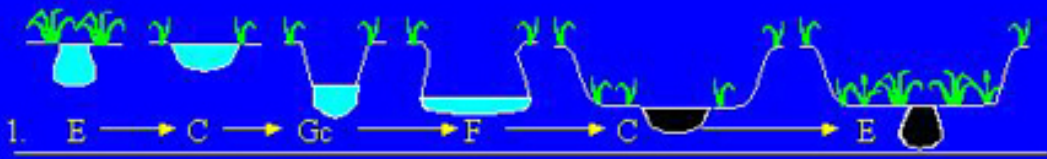
BHR ~ 1.05

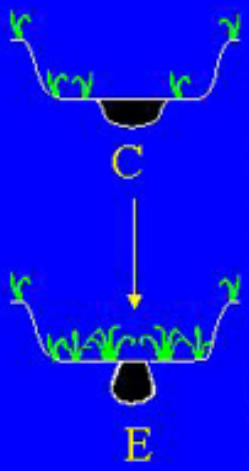


BHR > 1.2, early incision begins to show impacts



Channel Succession





Slight entrenchment but with meander confinement,

Schumm Stage V – E4 Channel

Aquatic Habitat Response to Stream Type Change

Variable	C→G	G →F	F →C	C →D
Instream Cover	↓	↓	↑	↓
Overhead Cover	↓	↓	↑	↓
Substrate Composition	↑	↓	↑	↓
Pool Quality	↓	↓	↑	↓
Holding Cover Velocity	↓	↓	↑	↓
Temperature	→	↑	↓	↑
Oxygen	→	↓	↑	↓
Macro Invertebrates	↓	↓	↑	↓
Spawning Habitat	↓	↓	↑	↓
Diversity	↓	↓	↑	↓
Rearing	↓	↑	↑	↑
IBI Score	↓	↓	↑	↓

Pot. Treat. Opt. Low Banks (<8 ft.) Low Grad. Rosgen Str. Typ. & Schumm CEM Stage

Schumm	Rosgen	Treatment Strategies	Typical Practices
I Stable	C and E for meandering streams	Maintain Watershed (W/S) Discharge (Qw), & Sediment (Qs) Maintain riparian	Spot Treat. Soil Bio. Stakes, fascines, Rooted stock Whole Plant

Pot. Treat. Options Low Banks (<8 ft.), Low Gradient, Rosgen Stream Type & Schumm CEM Stage

Schumm	Rosgen	Treatment Strategies	Typical Practices
Stage II Down-cutting and widening	F & Gc Type	Reduce W/S Qw & Qs. May need to raise the channel and reconnect floodplain, increase sinuosity (K) and improve riparian	Channel re-alignment and grade control. Use soil bioengineer-ing only with other stability practices

Pot. Treat. Options Low Banks (<8 ft.), Low Gradient, Rosgen Stream Type & Schumm CEM Stage

Schumm et al.	Rosgen	Treatment Strategies	Typical Practice
Early Stage III widening following downcut	F Type	Reduce W/S Qw. & Qs. May need to excavate (shape) a flood plain & banks for to obtain protection	Grading with long term toe protection Soil bioengineer-ing & whole plant transplants

Pot. Treat. Options Low Banks (<8 ft.), Low Gradient, Rosgen Stream Type & Schumm CEM Stage

Schumm et al.	Rosgen	Treatment Strategies	Typical Practice
Late Stage III of Widening	F & Bc	Maintain existing W/S, Qw & Qs. May need to grade for more flood plain and shape banks for toe protect. & riparian improvement	Grading w/ long term toe protection and needed soil bio. no independent soil bio.

Pot. Treat. Options Low Banks (<8 ft.), Low Gradient, Rosgen Stream Type & Schumm CEM Stage

Schumm et al.	Rosgen	Treatment Strategies	Typical Practice
Stage IV Deposition	F & Bc	Maintain existing W/S Qw & Qs; soil bio. to improve riparian	Minor grading and needed soil bioengineer-ing

Pot. Treat. Options Low Banks (<8 ft.), Low Gradient, Rosgen Stream Type & Schumm CEM Stage

Schumm et al.	Rosgen	Treatment Strategies	Typical Practice
Late Stage IV Deposition	C & E	Maintain existing W/S Qw & Qs; soil bioengine-ering to improve riparian	Minor grading and needed soil bioengineer-ing

Pot. Treat. Options Low Banks (<8 ft.), Low Gradient, Rosgen Stream Type & Schumm CEM Stage

Schumm et al.	Rosgen	Treatment Strategies	Typical Practice
Stage V	C & E	Maintain existing W/S Qw & Qs; Maintain riparian corridor; May need isolated soil bioengine-ering to improve riparian	Spot treatment w/ fascine, live stake w/ rooted stock or grasses

Streambank slope relative to structure

Thank you. Questions, please?