

Stream Classification

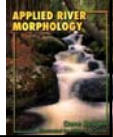
Why Classify Streams?

- Communication Tool
- Describe Existing Conditions & Trends
- Describe Restoration Goals
- Research Tool



Morphologic Stream Classification Systems

- Schumm (1977)
 - Alluvial channels
 - Meandering, straight, braided
 - Type related to channel stability & sediment transport
- Montgomery & Buffington (1993)
 - Alluvial, colluvial, bedrock channels
 - Channel response related to sediment inputs
 - 6 classes of alluvial channels: cascade, step-pool, plane-bed, riffle-pool, regime, and braided
- Rosgen (1994)
 - www.wildlandhydrology.com



Rosgen Classification of Natural Rivers

- Based on physical characteristics (empirical)
- Requires field measurements
- Requires bankfull dimensions



www.wildlandhydrology.com

What factors affect stream morphology?

- Width
- Depth
- Slope
- Velocity
- Discharge
- Flow resistance
- Sediment size
- Sediment load



Leopold et al (1964)

Rosgen Classification of Natural Rivers

- Dimension (cross-section)
- Pattern (plan form)
- Profile (bed form)
- Bed material (substrate)



Level 1 Rosgen Classification

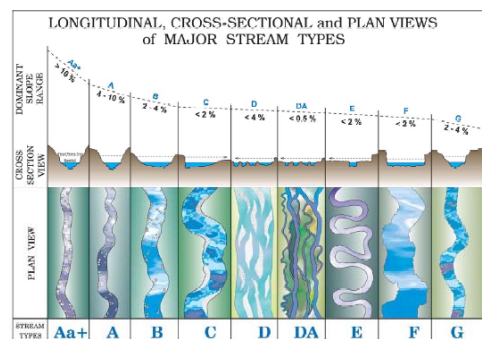
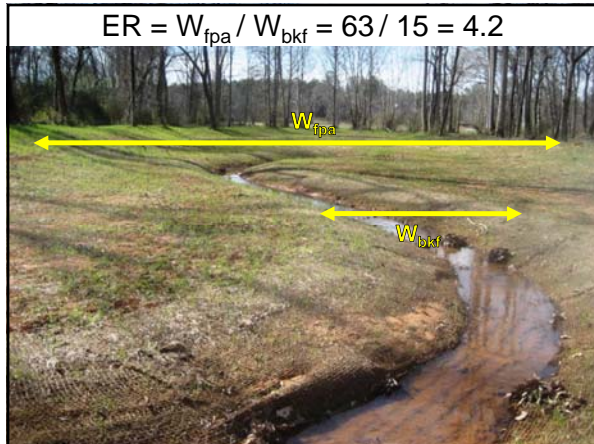
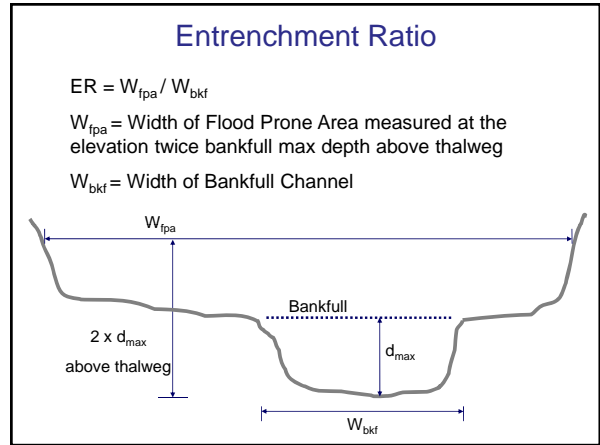
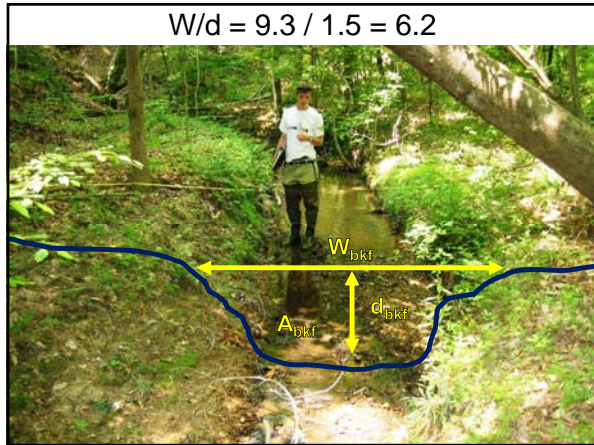
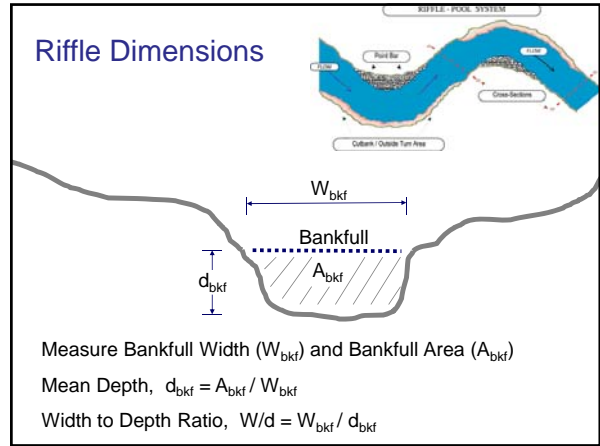
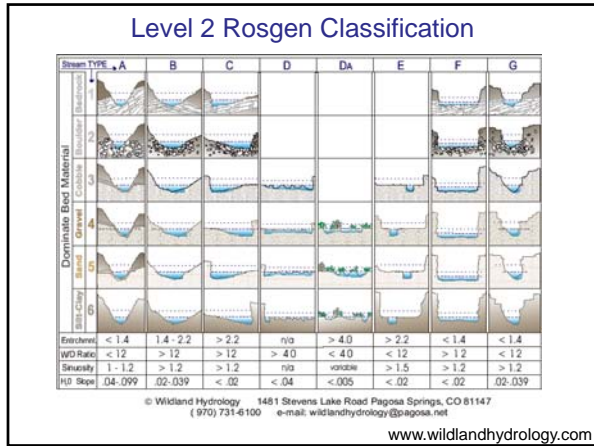


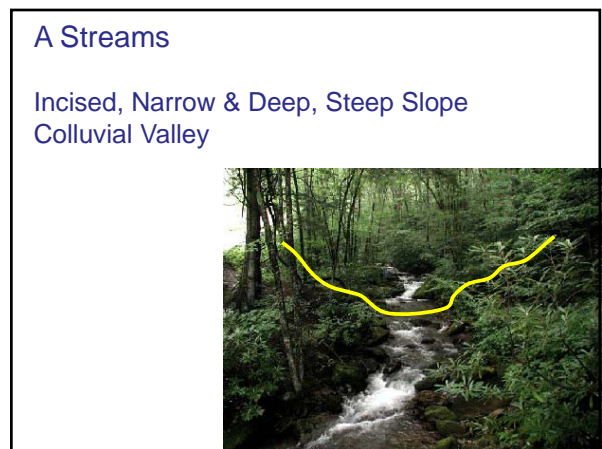
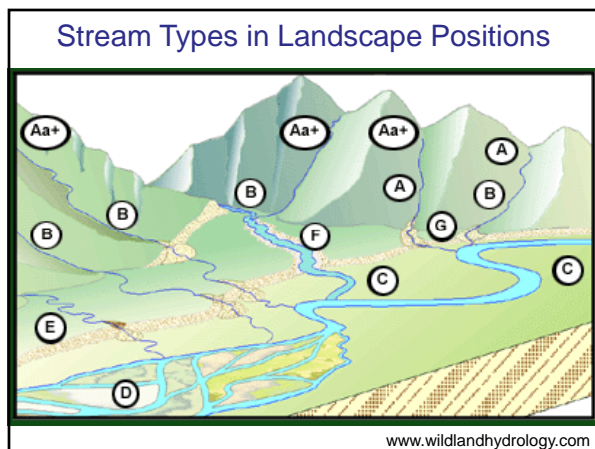
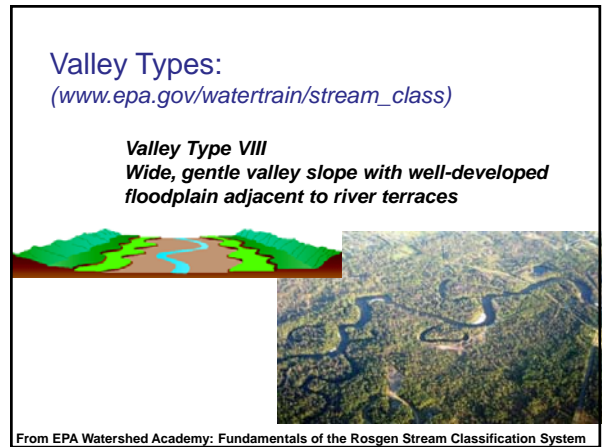
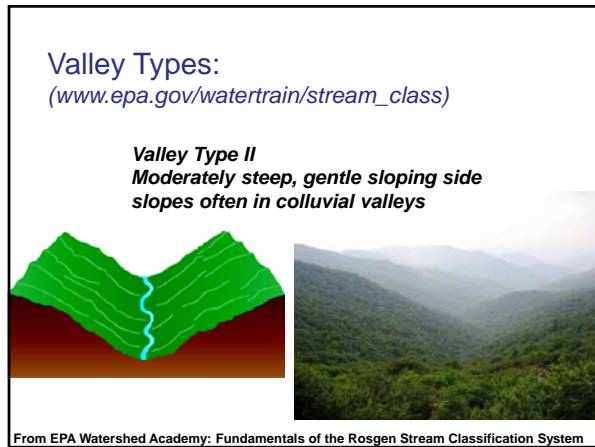
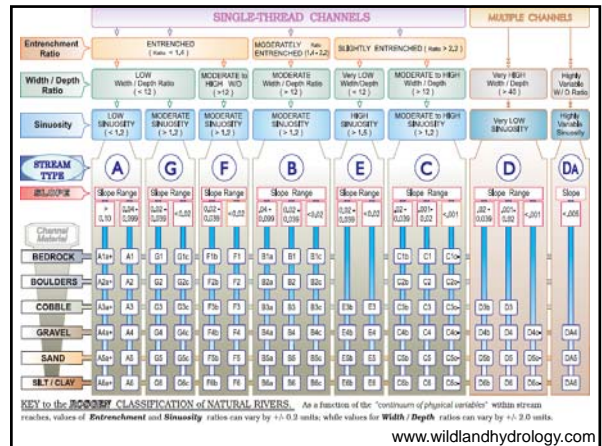
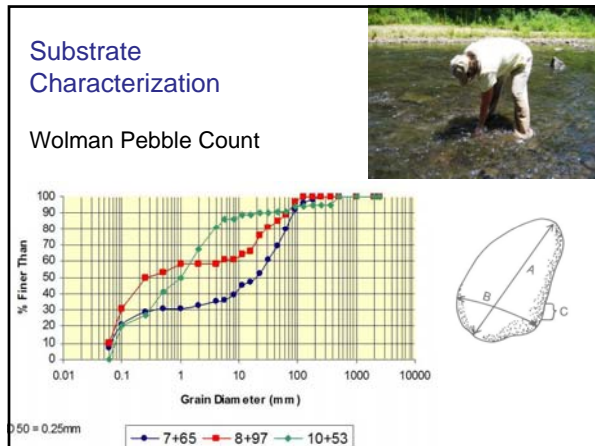
Figure 14. Broad level stream classification delineation showing longitudinal, cross-sectional, and plan views of major stream types. (From Rosgen, 1994) (Applied River Morphology, 1996, David L. Rosgen, Wildland Hydrology, www.wildlandhydrology.com)

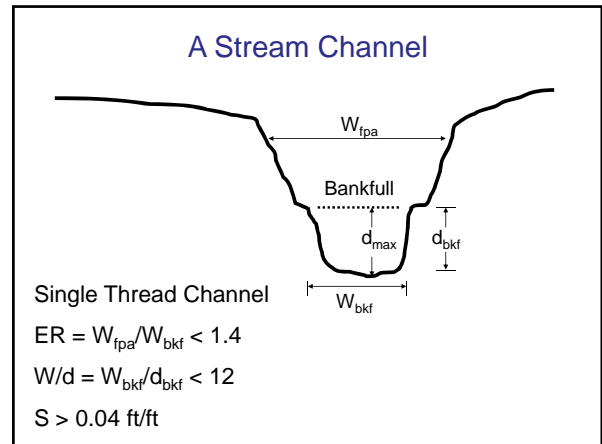
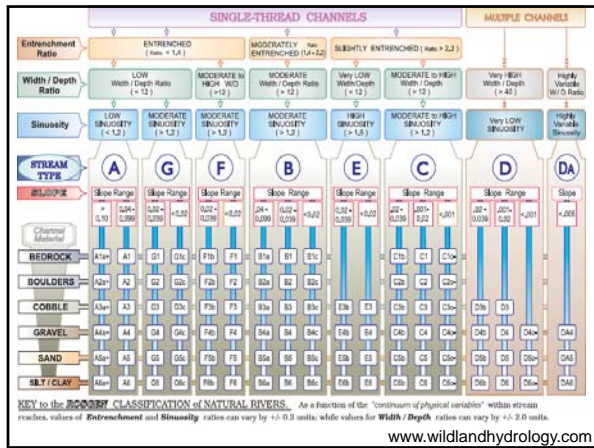
www.wildlandhydrology.com



Bed Material (Substrate)

- Silt/Clay: < 0.062 mm
- Sand: 0.062 – 2 mm
- Gravel: 2 – 64 mm
- Cobble: 64 – 256 mm
- Boulder: 256 – 2048 mm





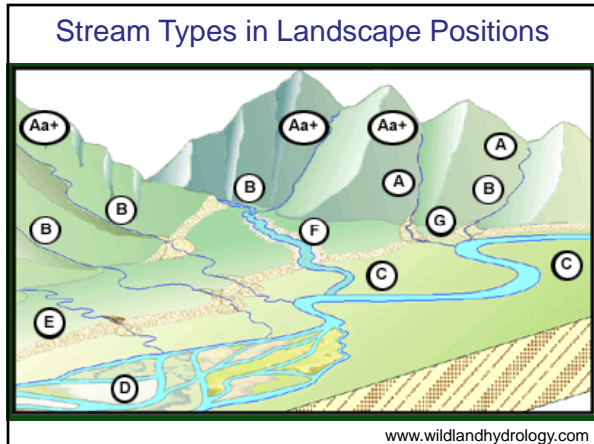


B Streams

Moderately Incised, Wide & Shallow,
Moderate Slope, Colluvial Valley

B Stream Channel

Single Thread Channel
 $ER = W_{fpa}/W_{bkf} = 1.4 - 2.2$
 $W/d = W_{bkf}/d_{bkf} > 12$
 $S = 0.02 - 0.04 \text{ ft/ft}$



Channel Material	SINGLE-THREAD CHANNELS										MULTIPLE CHANNELS		
	ENTRENCHED (max = 1.4)			MODERATELY ENTRENCHED (1.4-2.2)			SLIGHTLY ENTRENCHED (max = 2.2)				Very High Width / Depth (> 40)		High Width / Depth (> 12)
Entrenchment Ratio	ENTRENCHED (max = 1.4)			MODERATELY ENTRENCHED (1.4-2.2)			SLIGHTLY ENTRENCHED (max = 2.2)				Very High Width / Depth (> 40)		High Width / Depth (> 12)
Width / Depth Ratio	LOW Width / Depth Ratio (< 12)			MODERATE to HIGH Width / Depth Ratio (> 12)			MODERATE to HIGH Width / Depth Ratio (> 12)				Very LOW Width / Depth (< 12)		High Width / Depth (> 12)
Sinuosity	LOW SINUOSITY (< 1.2)			MODERATE SINUOSITY (> 1.2)			MODERATE SINUOSITY (> 1.2)				Very LOW SINUOSITY		High Width / Depth Sinuosity
STREAM TYPE	A, G, F			B, E			C, D				DA		
SLOPE	Slope Range: 0.01 - 0.03			Slope Range: 0.02 - 0.03			Slope Range: 0.02 - 0.03				Slope Range: 0.01 - 0.03		Slope Range: < 0.01
BEDROCK	A1+	A1	G1	F1	F1	B1	E1	C1	C1	D1	D1	DA	
BOULDERS	A2+	A2	G2	F2	F2	B2	B2	C2	C2	D2	D2	DA	
COBBLE	A3+	A3	G3	F3	F3	B3	B3	C3	C3	D3	D3	DA	
GRAVEL	A4+	A4	G4	F4	F4	B4	B4	C4	C4	D4	D4	DA	
SAND	A5+	A5	G5	F5	F5	B5	B5	C5	C5	D5	D5	DA	
SILT/CLAY	A6+	A6	G6	F6	F6	B6	B6	C6	C6	D6	D6	DA	

KEY to the BICHOBY CLASSIFICATION OF NATURAL RIVERS. An a function of the "continuum of physical variables" within stream reaches, values of Entrenchment and Sinuosity ratios can vary by +/- 0.5 units; while values for Width / Depth ratios can vary by +/- 2.0 units.

www.wildlandhydrology.com



B3 Western NC



B3 Western NC



B3 Western NC



B4 Tennessee



B3 Western NC



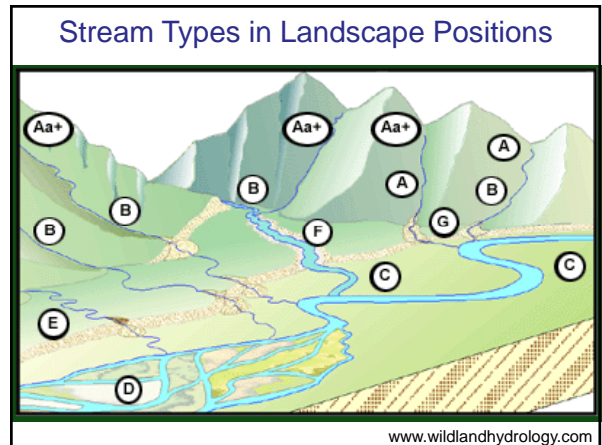
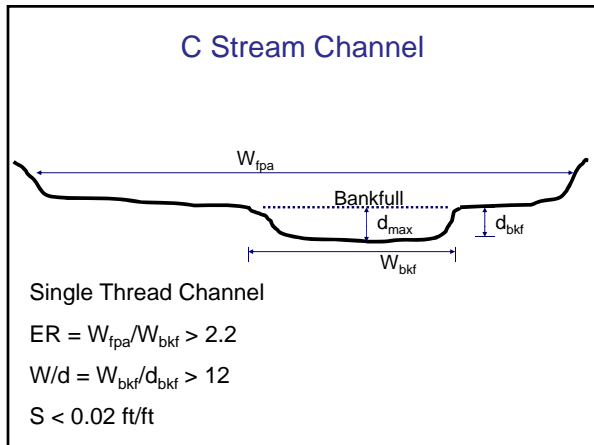
B4 Western NC



B4c Western NC

C Streams

Not Incised, Wide & Shallow, Low Slope Alluvial Valley



Channel Method	SINGLE-THREAD CHANNELS						MULTIPLE CHANNELS	
	ENTRENCHED (Rate = 1.4)		MODERATELY ENTRENCHED (1.4-2.2)		SLIGHTLY ENTRENCHED (Rate > 2.2)			
Entrenchment Ratio	ENTRENCHED (Rate = 1.4)		MODERATELY ENTRENCHED (1.4-2.2)		SLIGHTLY ENTRENCHED (Rate > 2.2)			
Width / Depth Ratio	LOW Width / Depth Ratio (< 12)		MODERATE to HIGH Width / Depth Ratio (> 12)		MODERATE to HIGH Width / Depth Ratio (> 12)		Very High Width / Depth Ratio (> 40)	
Sinuosity	LOW SINUOSITY (< 1.2)		MODERATE SINUOSITY (> 1.2)		MODERATE to HIGH SINUOSITY (> 1.2)		Very High SINUOSITY	
STREAM TYPE	A		G		F		B	
SLOPE	Slope Range: 1.00-1.50		Slope Range: 1.50-2.00		Slope Range: 2.00-3.00		Slope Range: 3.00-4.00	
BEDROCK	A1+	A1	G1	G2	F1	F2	B1	B2
BOULDERS	A2+	A2	G2	G3	F2	F3	B2	B3
COBBLES	A3+	A3	G3	G4	F3	F4	B3	B4
GRAVEL	A4+	A4	G4	G5	F4	F5	B4	B5
SAND	A5+	A5	G5	G6	F5	F6	B5	B6
SLT/CLAY	A6+	A6	G6	G7	F6	F7	B6	B7

KEY to the **RODNEY CLASSIFICATION OF NATURAL RIVERS**. As a function of the "continuum of physical variables" within stream reaches, values of **Entrenchment** and **Sinuosity** ratios can vary by +/- 0.3 units; while values for **Width / Depth** ratios can vary by +/- 2.0 units.

www.wildlandhydrology.com



C4 Western NC



C4 Western NC



C4 Washington



C4 New Zealand



C4 Western NC



C5 Alabama

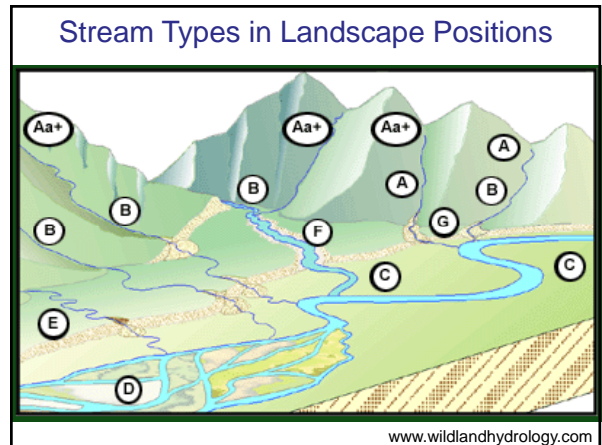
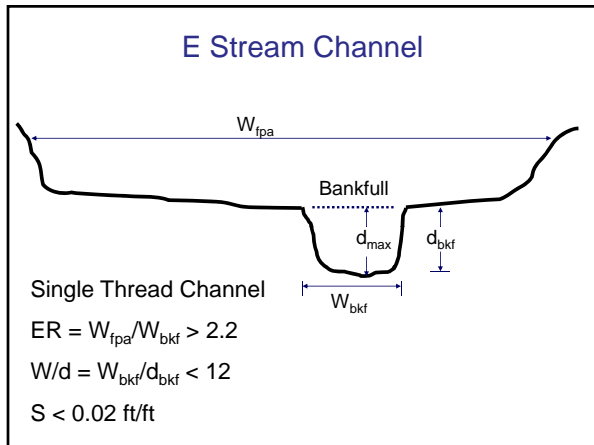


C4 Utah



E Streams

Not Incised, Narrow & Deep, Low Slope Alluvial Valley



Channel Method	SINGLE-THREAD CHANNELS						MULTIPLE CHANNELS	
	ENTRENCHED (Rate = 1.4)		MODERATELY ENTRENCHED (1.4-2.2)		SLIGHTLY ENTRENCHED (Rate > 2.2)			
Entrenchment Ratio	ENTRENCHED (Rate = 1.4)		MODERATELY ENTRENCHED (1.4-2.2)		SLIGHTLY ENTRENCHED (Rate > 2.2)			
Width / Depth Ratio	LOW Width / Depth Ratio (< 12)		MODERATE to HIGH Width / Depth Ratio (> 12)		MODERATE to HIGH Width / Depth Ratio (> 12)		Very High Width / Depth Ratio (> 40)	
Sinuosity	LOW SINUOSITY (< 1.2)		MODERATE SINUOSITY (> 1.2)		MODERATE to HIGH SINUOSITY (> 1.2)		Very Low SINUOSITY	
STREAM TYPE	A, G		F, B		E, C		D, DA	
SLOPE	Slope Range (m/m): 0.04-0.06, 0.06-0.08		Slope Range (m/m): 0.02-0.03, 0.03-0.04		Slope Range (m/m): 0.01-0.02, 0.02-0.03		Slope Range (m/m): 0.005-0.01, 0.01-0.02	
BEDROCK	A1+, A1	G1, G2	F1b, F1	B1a, B1, B1c	E1, E2	C1, C1c, C1w	D1, D1c, D1w	DA1
BOULDERS	A2+, A2	G2, G2c	F2b, F2	B2a, B2, B2c	E2, E2c	C2, C2c, C2w	D2, D2c, D2w	DA2
COBBLE	A3+, A3	G3, G3c	F3b, F3	B3a, B3, B3c	E3, E3c	C3, C3c, C3w	D3, D3c, D3w	DA3
GRAVEL	A4+, A4	G4, G4c	F4b, F4	B4a, B4, B4c	E4, E4c	C4, C4c, C4w	D4, D4c, D4w	DA4
SAND	A5+, A5	G5, G5c	F5b, F5	B5a, B5, B5c	E5, E5c	C5, C5c, C5w	D5, D5c, D5w	DA5
SLT / CLAY	A6+, A6	G6, G6c	F6b, F6	B6a, B6, B6c	E6, E6c	C6, C6c, C6w	D6, D6c, D6w	DA6

KEY to the BEDROCK CLASSIFICATION of NATURAL RIVERS. As a function of the "continuum of physical variables" within stream reaches, values of Entrenchment and Sinuosity ratios can vary by +/- 0.3 units, while values for Width / Depth ratios can vary by +/- 2.0 units.

www.wildlandhydrology.com





E4 Central NC



E4 Central NC



E4 Western NC



E4 Western NC

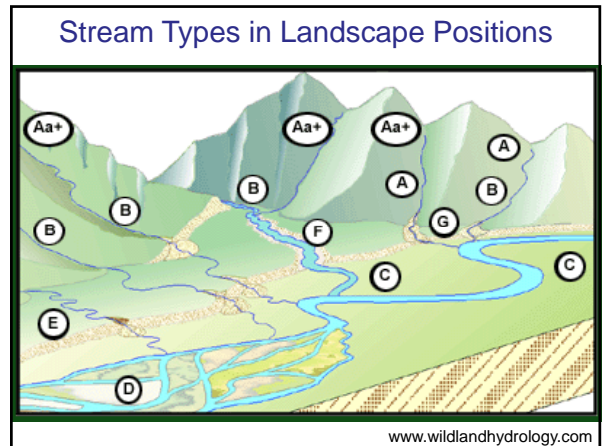
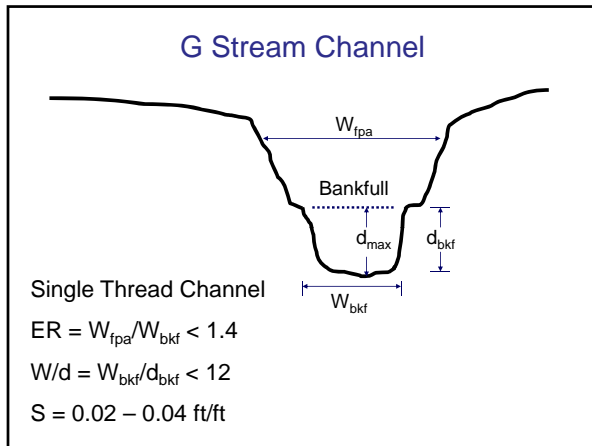


E4b Western NC



E4 Western NC





Channel Material	SINGLE-THREAD CHANNELS										MULTIPLE CHANNELS			
	ENTRENCHED (ER < 1.4)			MODERATELY ENTRENCHED (1.4-2.2)			SLIGHTLY ENTRENCHED (ER > 2.2)				MULTIPLE CHANNELS			
Width / Depth Ratio	LOW (< 12)			MODERATE IN HIGH W/D (> 12)			MODERATE W/D (< 12)			VERY LOW (< 12)		MODERATE TO HIGH (> 12)	VERY HIGH (> 40)	HIGHLY VARIABLE
Sinuosity	LOW (< 1.2)			MODERATE (> 1.2)			MODERATE (> 1.2)			HIGH (> 1.8)		MODERATE TO HIGH (> 1.2)	VERY LOW (< 1.2)	HIGHLY VARIABLE
Stream Type	A, G, F			B			E		C		D	DA		
Slope	0.10-0.99			0.02-0.99			0.02-0.99		0.01-0.99		0.01-0.99	0.01-0.99		
Bedrock	A1+, A1, S1			F1+, F1, S1			B1+, B1, S1		C1+, C1, S1		D1+, D1, S1	DA1+, DA1, S1		
Boulders	A2+, A2, S2			F2+, F2, S2			B2+, B2, S2		C2+, C2, S2		D2+, D2, S2	DA2+, DA2, S2		
Cobble	A3+, A3, S3			F3+, F3, S3			B3+, B3, S3		C3+, C3, S3		D3+, D3, S3	DA3+, DA3, S3		
Gravel	A4+, A4, S4			F4+, F4, S4			B4+, B4, S4		C4+, C4, S4		D4+, D4, S4	DA4+, DA4, S4		
Sand	A5+, A5, S5			F5+, F5, S5			B5+, B5, S5		C5+, C5, S5		D5+, D5, S5	DA5+, DA5, S5		
Silt/Clay	A6+, A6, S6			F6+, F6, S6			B6+, B6, S6		C6+, C6, S6		D6+, D6, S6	DA6+, DA6, S6		

KEY to the RECOVERY CLASSIFICATION of NATURAL RIVERS. An assessment of the "spectrum of physical variables" within stream reaches; values of Entrenchment and Sinuosity ratios can vary by +/- 0.2 units, while values for Width / Depth ratios can vary by +/- 2.0 units.

www.wildlandhydrology.com





**G5 Headcut
Georgia**



G4c Central NC



G4c Alabama



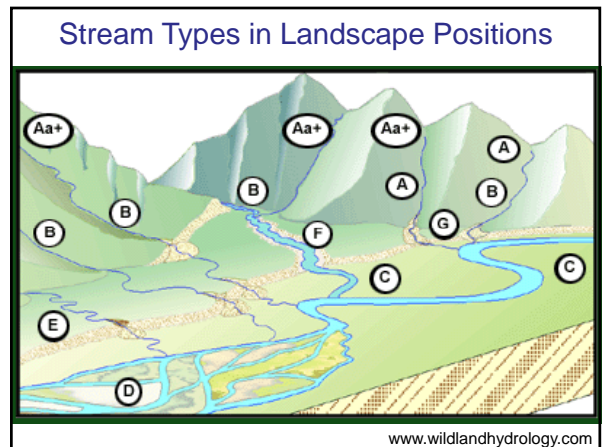
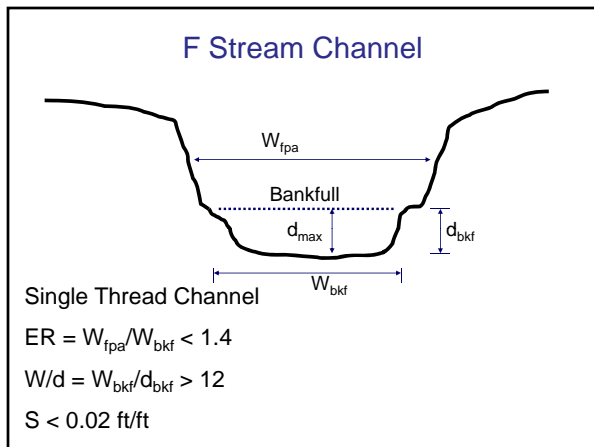
G4c Alabama

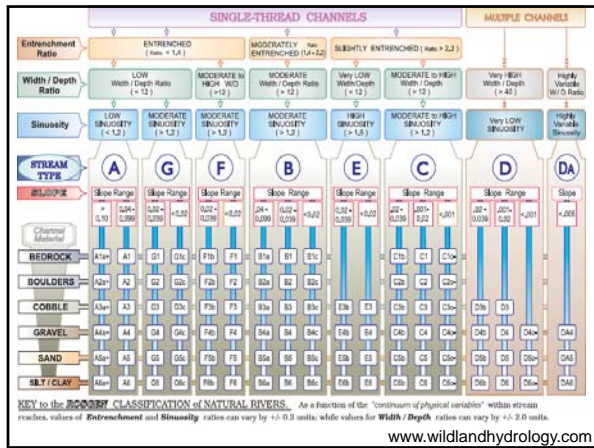


G5c Eastern NC



G5c Alabama







F4 Texas



F4 Texas



F4 Alabama



F5 Georgia



F5 South Carolina



Ugg Texas

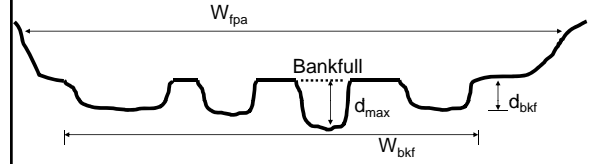
D & DA Streams

Multiple Channels, Wide & Shallow, Low Slope



D4 Virginia

D Stream Channel

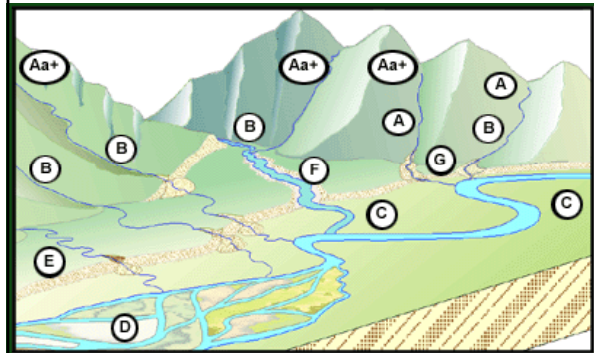


Multiple Thread Channel

$$ER = W_{fpa} / W_{bkf} > 2.2$$

$$W/d = W_{bkf} / d_{bkf} > 40$$

Stream Types in Landscape Positions



www.wildlandhydrology.com

Stream Type	SINGLE-THREAD CHANNELS						MULTIPLE CHANNELS		
	ENTRENCHED (max = 1.4)		MODERATELY ENTRENCHED (1.4-2.2)		SLIGHTLY ENTRENCHED (max = 2.3)		MULTIPLE CHANNELS		
Entrenchment Ratio	ENTRENCHED (max = 1.4)		MODERATELY ENTRENCHED (1.4-2.2)		SLIGHTLY ENTRENCHED (max = 2.3)		MULTIPLE CHANNELS		
Width / Depth Ratio	LOW Width/Depth Ratio (< 12)		MODERATE to HIGH Width/Depth Ratio (> 12)		MODERATE to HIGH Width/Depth Ratio (> 12)		Very High Width/Depth Ratio (> 40)		
Sinuosity	LOW SINUOSITY (< 1.2)		MODERATE SINUOSITY (> 1.2)		MODERATE to HIGH SINUOSITY (> 1.2)		Very Low Sinuosity		
Channel Material	A1H, A1L, A2H, A2L, A3H, A3L, A4H, A4L, A5H, A5L, A6H, A6L, A7H, A7L, A8H, A8L, A9H, A9L, A10H, A10L	B1H, B1L, B2H, B2L, B3H, B3L, B4H, B4L, B5H, B5L, B6H, B6L, B7H, B7L, B8H, B8L, B9H, B9L, B10H, B10L	C1H, C1L, C2H, C2L, C3H, C3L, C4H, C4L, C5H, C5L, C6H, C6L, C7H, C7L, C8H, C8L, C9H, C9L, C10H, C10L	D1H, D1L, D2H, D2L, D3H, D3L, D4H, D4L, D5H, D5L, D6H, D6L, D7H, D7L, D8H, D8L, D9H, D9L, D10H, D10L	E1H, E1L, E2H, E2L, E3H, E3L, E4H, E4L, E5H, E5L, E6H, E6L, E7H, E7L, E8H, E8L, E9H, E9L, E10H, E10L	F1H, F1L, F2H, F2L, F3H, F3L, F4H, F4L, F5H, F5L, F6H, F6L, F7H, F7L, F8H, F8L, F9H, F9L, F10H, F10L	G1H, G1L, G2H, G2L, G3H, G3L, G4H, G4L, G5H, G5L, G6H, G6L, G7H, G7L, G8H, G8L, G9H, G9L, G10H, G10L	H1H, H1L, H2H, H2L, H3H, H3L, H4H, H4L, H5H, H5L, H6H, H6L, H7H, H7L, H8H, H8L, H9H, H9L, H10H, H10L	I1H, I1L, I2H, I2L, I3H, I3L, I4H, I4L, I5H, I5L, I6H, I6L, I7H, I7L, I8H, I8L, I9H, I9L, I10H, I10L
Channel Slope	Slope Range: 0.01-0.05		Slope Range: 0.05-0.1		Slope Range: 0.1-0.2		Slope Range: 0.2-0.5		
Channel Bedrock	A1H, A1L, A2H, A2L, A3H, A3L, A4H, A4L, A5H, A5L, A6H, A6L, A7H, A7L, A8H, A8L, A9H, A9L, A10H, A10L		B1H, B1L, B2H, B2L, B3H, B3L, B4H, B4L, B5H, B5L, B6H, B6L, B7H, B7L, B8H, B8L, B9H, B9L, B10H, B10L		C1H, C1L, C2H, C2L, C3H, C3L, C4H, C4L, C5H, C5L, C6H, C6L, C7H, C7L, C8H, C8L, C9H, C9L, C10H, C10L		D1H, D1L, D2H, D2L, D3H, D3L, D4H, D4L, D5H, D5L, D6H, D6L, D7H, D7L, D8H, D8L, D9H, D9L, D10H, D10L		
Channel Boulders	A1H, A1L, A2H, A2L, A3H, A3L, A4H, A4L, A5H, A5L, A6H, A6L, A7H, A7L, A8H, A8L, A9H, A9L, A10H, A10L		B1H, B1L, B2H, B2L, B3H, B3L, B4H, B4L, B5H, B5L, B6H, B6L, B7H, B7L, B8H, B8L, B9H, B9L, B10H, B10L		C1H, C1L, C2H, C2L, C3H, C3L, C4H, C4L, C5H, C5L, C6H, C6L, C7H, C7L, C8H, C8L, C9H, C9L, C10H, C10L		D1H, D1L, D2H, D2L, D3H, D3L, D4H, D4L, D5H, D5L, D6H, D6L, D7H, D7L, D8H, D8L, D9H, D9L, D10H, D10L		
Channel Cobble	A1H, A1L, A2H, A2L, A3H, A3L, A4H, A4L, A5H, A5L, A6H, A6L, A7H, A7L, A8H, A8L, A9H, A9L, A10H, A10L		B1H, B1L, B2H, B2L, B3H, B3L, B4H, B4L, B5H, B5L, B6H, B6L, B7H, B7L, B8H, B8L, B9H, B9L, B10H, B10L		C1H, C1L, C2H, C2L, C3H, C3L, C4H, C4L, C5H, C5L, C6H, C6L, C7H, C7L, C8H, C8L, C9H, C9L, C10H, C10L		D1H, D1L, D2H, D2L, D3H, D3L, D4H, D4L, D5H, D5L, D6H, D6L, D7H, D7L, D8H, D8L, D9H, D9L, D10H, D10L		
Channel Gravel	A1H, A1L, A2H, A2L, A3H, A3L, A4H, A4L, A5H, A5L, A6H, A6L, A7H, A7L, A8H, A8L, A9H, A9L, A10H, A10L		B1H, B1L, B2H, B2L, B3H, B3L, B4H, B4L, B5H, B5L, B6H, B6L, B7H, B7L, B8H, B8L, B9H, B9L, B10H, B10L		C1H, C1L, C2H, C2L, C3H, C3L, C4H, C4L, C5H, C5L, C6H, C6L, C7H, C7L, C8H, C8L, C9H, C9L, C10H, C10L		D1H, D1L, D2H, D2L, D3H, D3L, D4H, D4L, D5H, D5L, D6H, D6L, D7H, D7L, D8H, D8L, D9H, D9L, D10H, D10L		
Channel Sand	A1H, A1L, A2H, A2L, A3H, A3L, A4H, A4L, A5H, A5L, A6H, A6L, A7H, A7L, A8H, A8L, A9H, A9L, A10H, A10L		B1H, B1L, B2H, B2L, B3H, B3L, B4H, B4L, B5H, B5L, B6H, B6L, B7H, B7L, B8H, B8L, B9H, B9L, B10H, B10L		C1H, C1L, C2H, C2L, C3H, C3L, C4H, C4L, C5H, C5L, C6H, C6L, C7H, C7L, C8H, C8L, C9H, C9L, C10H, C10L		D1H, D1L, D2H, D2L, D3H, D3L, D4H, D4L, D5H, D5L, D6H, D6L, D7H, D7L, D8H, D8L, D9H, D9L, D10H, D10L		
Channel Silt/Clay	A1H, A1L, A2H, A2L, A3H, A3L, A4H, A4L, A5H, A5L, A6H, A6L, A7H, A7L, A8H, A8L, A9H, A9L, A10H, A10L		B1H, B1L, B2H, B2L, B3H, B3L, B4H, B4L, B5H, B5L, B6H, B6L, B7H, B7L, B8H, B8L, B9H, B9L, B10H, B10L		C1H, C1L, C2H, C2L, C3H, C3L, C4H, C4L, C5H, C5L, C6H, C6L, C7H, C7L, C8H, C8L, C9H, C9L, C10H, C10L		D1H, D1L, D2H, D2L, D3H, D3L, D4H, D4L, D5H, D5L, D6H, D6L, D7H, D7L, D8H, D8L, D9H, D9L, D10H, D10L		

KEY to the BODENBY CLASSIFICATION of NATURAL RIVERS. As a function of the "continuum of physical variables" within stream reaches, values of Entrenchment and Sinuosity ratios can vary by ±0.2 units; while values for Width / Depth ratios can vary by ±0.5 units.

www.wildlandhydrology.com



D4 Georgia



D4 New Zealand



D4 Oregon



D4 Pennsylvania



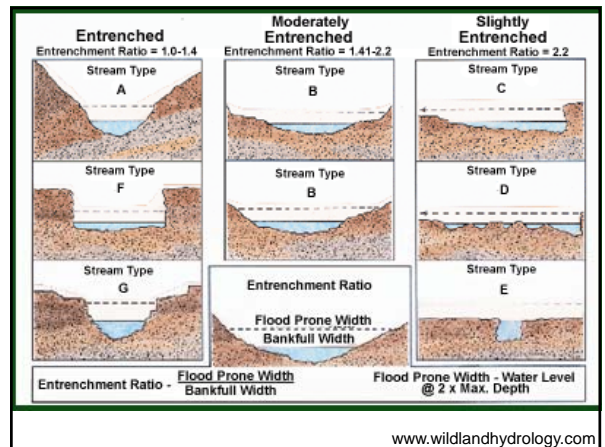
C4 -> D4 Western NC



C4 -> D4 Western NC



DA5 Florida





ER=11; W/d=16; S=0.004; D50=1 mm



ER=1.3; W/d=7; S=0.007; D50=1.5 mm



ER=2.2; W/d=14; S=0.024; D50=75 mm



ER=1.5; W/d=10; S=0.009; D50=2 mm



