

Erosion and Sedimentation

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Short Course
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Knowledge to Go Places

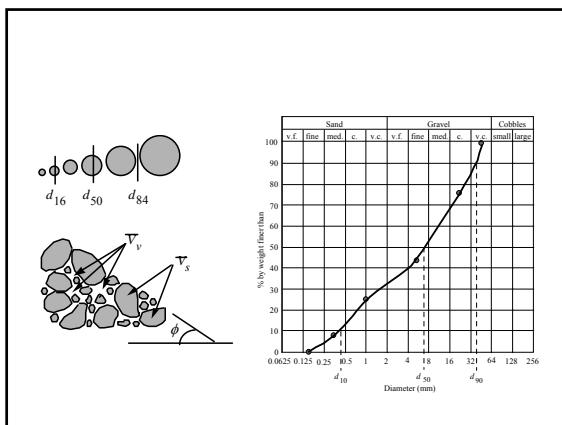
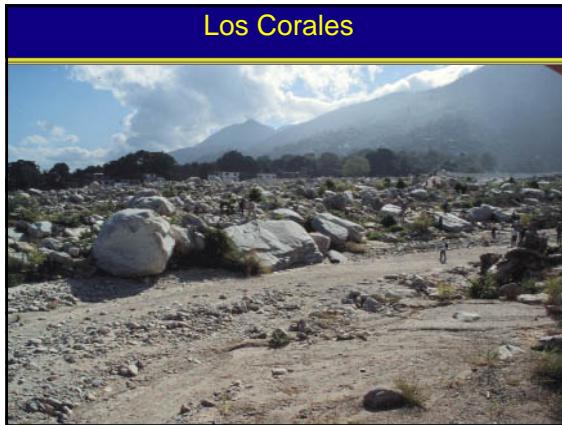
Objectives

Erosion and Sedimentation:

1. Sediment Properties and Fall Velocity;
2. Flow Properties;
3. Incipient Motion;
4. Riprap Design;
5. Bed Load and Suspended Load;
6. Flow in Bends.

1. Sediment Properties and Fall Velocity

Per Inch					
Millimeters	Microns	Inches	Tyler	U.S. Standard	
4000-2000	—	—	160-80	—	Very large boulders
2000-1000	—	—	80-40	—	Large boulders
1000-500	—	—	40-20	—	Medium boulders
500-250	—	—	20-10	—	Small boulders
250-130	—	—	10-5	—	Large cobbles
130-64	—	—	5-2.5	—	Small cobbles
64-32	—	—	2.5-1.3	—	Very coarse gravel
32-16	—	—	1.3-0.6	—	Coarse gravel
16-8	—	—	0.6-0.3	2-1	Medium gravel
8-4	—	—	0.3-0.15	5	Fine gravel
4-2	—	—	0.16-0.08	9	Very fine gravel
—	—	—	—	—	—
2-1	2.00-1.00	2000-1000	—	16	Very coarse sand
1-1/2	1.00-0.50	1000-400	—	32	Coarse sand
1/2-1/4	0.50-0.25	500-250	—	60	Medium sand
1/4-1/8	0.25-0.125	250-125	—	116	Fine sand
1/8-1/16	0.125-0.062	125-62	—	230	Very fine sand
—	—	—	—	—	—
1/16-1/32	0.062-0.031	62-31	—	—	Coarse silt
1/32-1/64	0.031-0.016	31-16	—	—	Medium silt
1/64-1/128	0.016-0.008	16-8	—	—	Fine silt
1/128-1/256	0.008-0.004	8-4	—	—	Very fine silt
—	—	—	—	—	—
1/256-1/512	0.004-0.0020	4-2	—	—	Coarse clay
1/512-1/1024	0.0020-0.0010	2-1	—	—	Medium clay
1/1024-1/2048	0.0010-0.0005	1-0.5	—	—	Fine clay
1/2048-1/4096	0.0005-0.0002	0.5-0.25	—	—	Very fine clay



The diagram shows a vertical column of blue water with a single orange sphere falling downwards. The height of the column is labeled h .

Fall Velocity

$\omega = \frac{g(G-1)d_s^2}{18v}$ Stokes Law → valid for silts & clays

$\omega = \sqrt{\frac{4}{3} \frac{g(G-1)d_s}{C_D}}$ valid for gravels, cobbles & boulders

$\omega = \frac{8v_m}{d_s} \left[\left(1 + \frac{d_s^3}{72} \right)^{0.5} - 1 \right]$

dimensionless particle diameter

$d_s = d_i \left[\frac{(G-1)g}{v_m^2} \right]^{\frac{1}{3}}$

2. Flow Properties

Logarithmic Velocity Profile

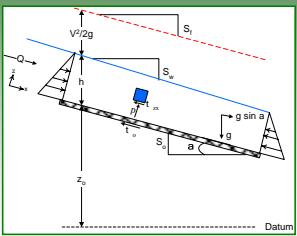
The figure consists of three parts:

- (a)** A cross-section of a channel showing a velocity profile. The channel has a "Valley wall" and a "Worn Area". Red lines indicate the profile across the channel width.
- (b)** A schematic diagram of a slope with depth d , slope S , and a "Maximum shear" layer near the bed. A velocity profile $V(z)$ is shown across the depth.
- (c)** A cross-section of a stream flowing over a bed, showing a velocity profile across the stream width.

Below the diagrams is the formula for the logarithmic velocity profile:

$$\frac{V_z}{U_*} = \frac{1}{K} \ln \frac{z}{z_0}$$

Open Channel Flow



- Pressure Distribution

$$\int dp = \rho g \int_z^h -gdz$$

$$p = \rho g(h-z)$$

- Shear Stress

$$\tau_{zx} = \rho g(h-z)S_f$$

$$\tau_o = \rho ghS_f$$

- Shear Velocity

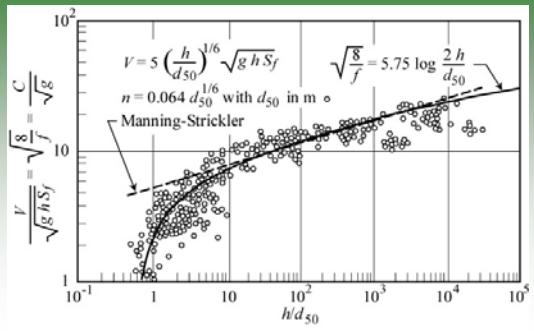
$$u_* = \sqrt{\frac{\tau_o}{\rho}} = \sqrt{ghS_f}$$

Example - Shear Velocity

$$u_* = \sqrt{ghS_f} = \sqrt{9.81 \frac{m}{s^2} * 9.9m * 0.0001312}$$

$$u_* = 0.113 \frac{m}{s}$$

Resistance to Flow



3. Incipient Motion

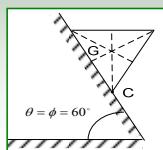
Incipient Motion

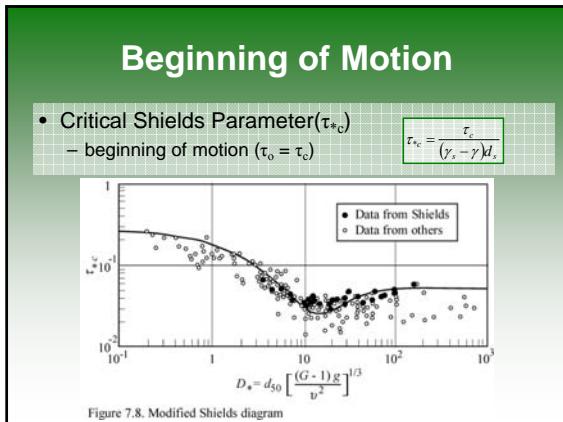
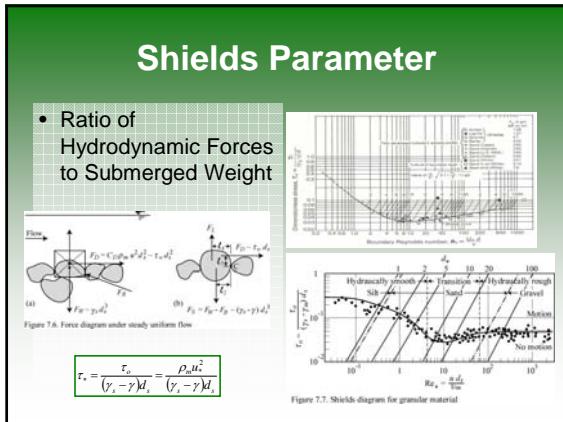
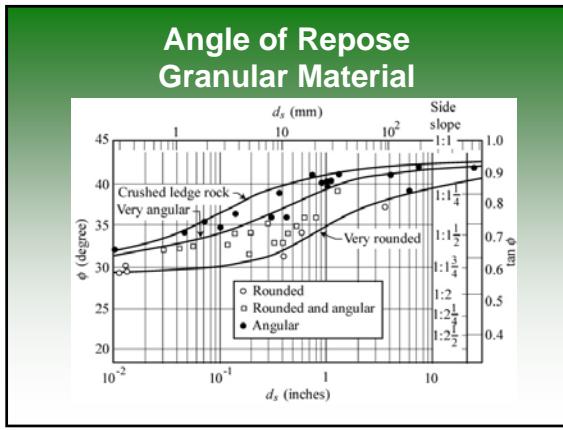


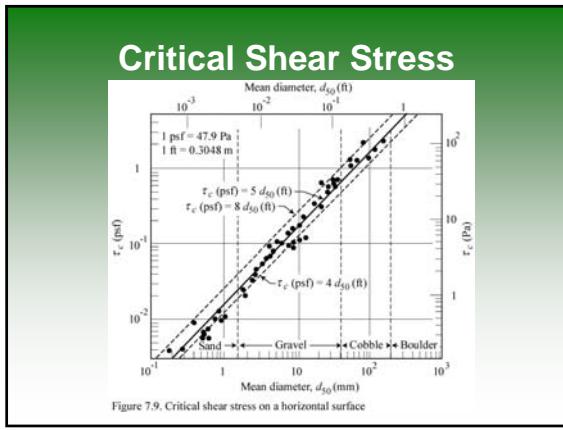
Angle of Repose Effects of Angularity

$$\phi = \frac{180^\circ}{3} = 60^\circ \quad \phi = \frac{180^\circ}{4} = 45^\circ \quad \phi = \frac{180^\circ}{5} = 36^\circ \quad \phi = \frac{180^\circ}{6} = 30^\circ \quad \phi = \frac{180^\circ}{\infty} = 0^\circ$$

Motion occurs when the center of gravity (G), is inline with the point of contact (C).





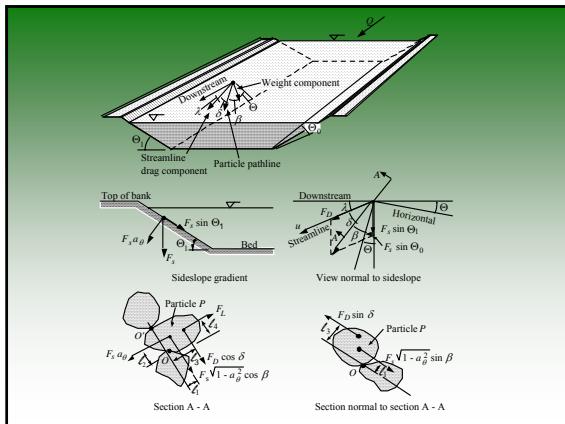


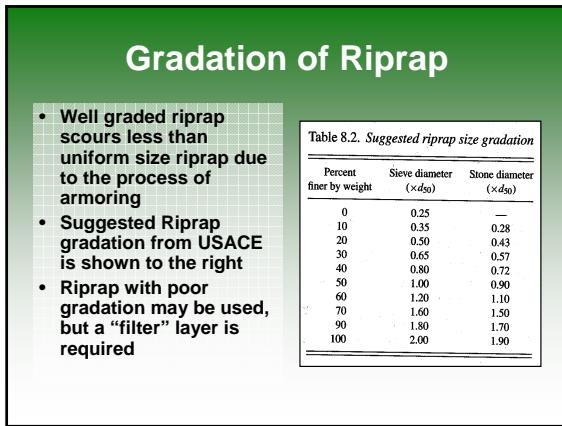
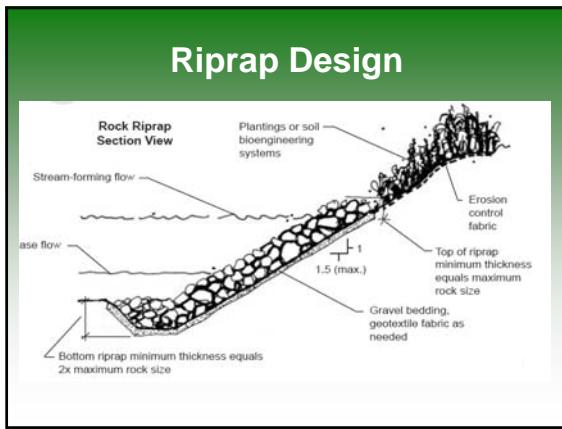
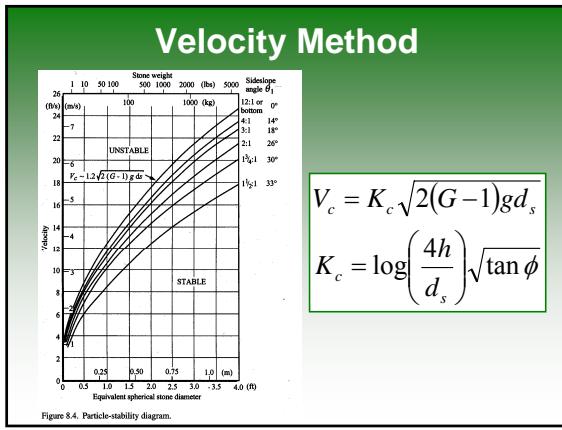
4. Riprap Design











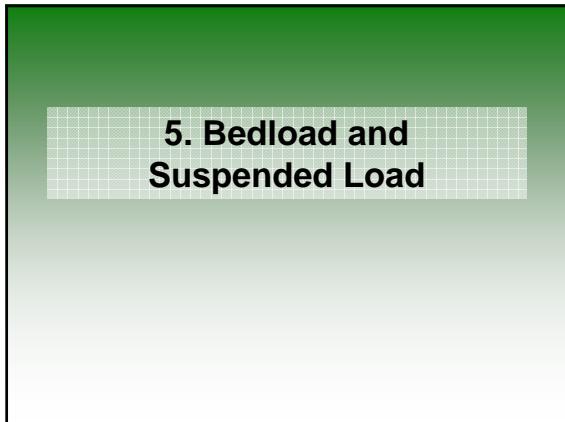
Gravel Filters

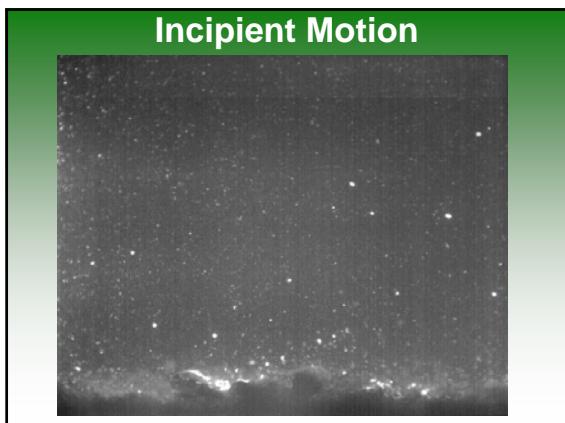
- Gravel filters should not be less than 15 to 23 cm
- ½ thickness of Riprap layer is a good guideline
- Suggested gravel filter gradation equations are shown to the right

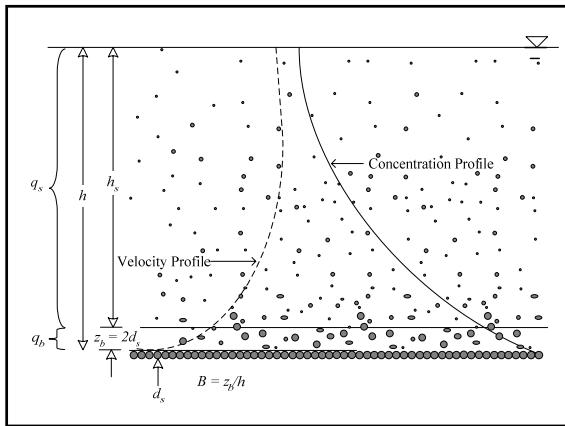
$$\frac{d_{50}(\text{filter})}{d_{50}(\text{bank})} < 40$$
$$5 < \frac{d_{15}(\text{filter})}{d_{15}(\text{bank})} < 40$$
$$\frac{d_{15}(\text{filter})}{d_{85}(\text{bank})} < 5$$





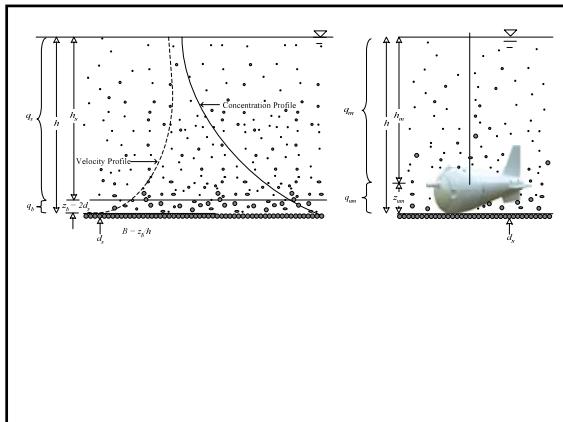
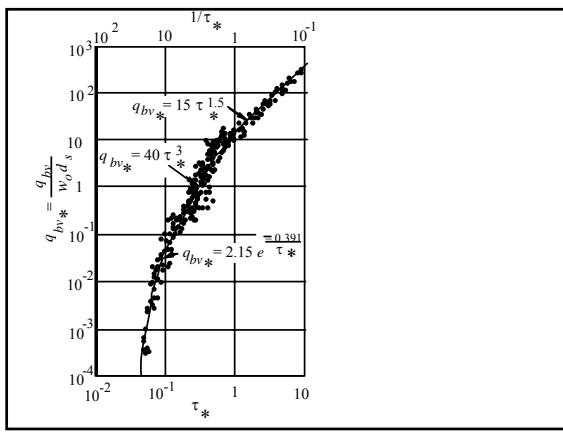




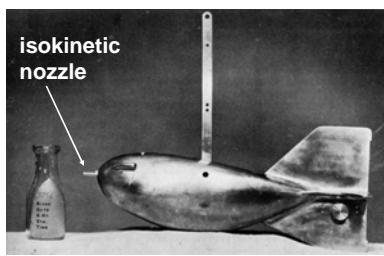


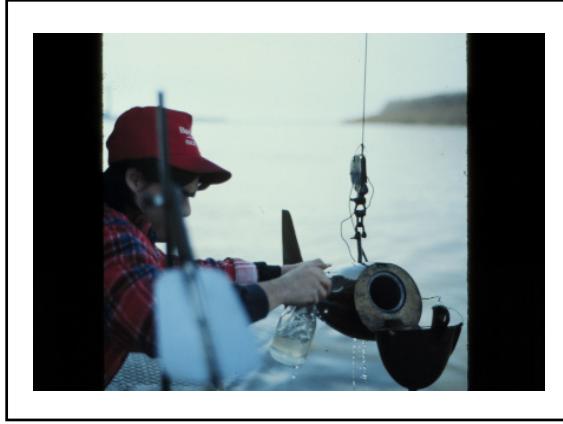




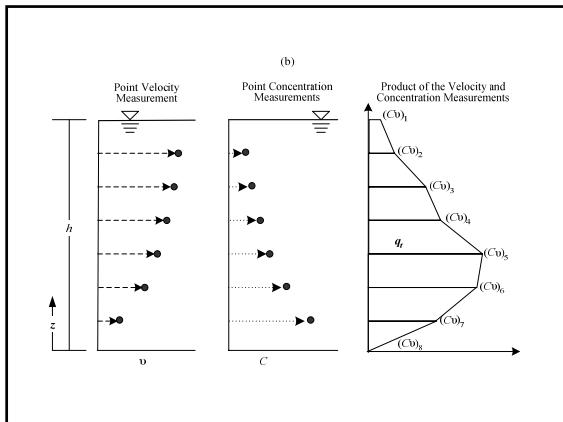


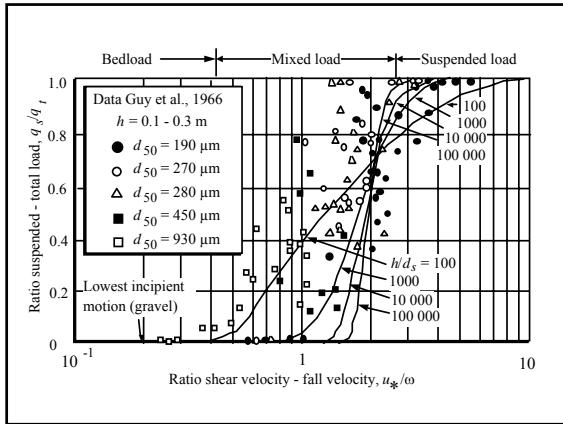
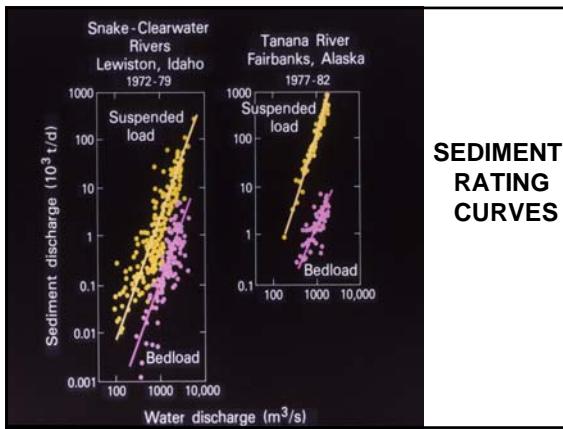
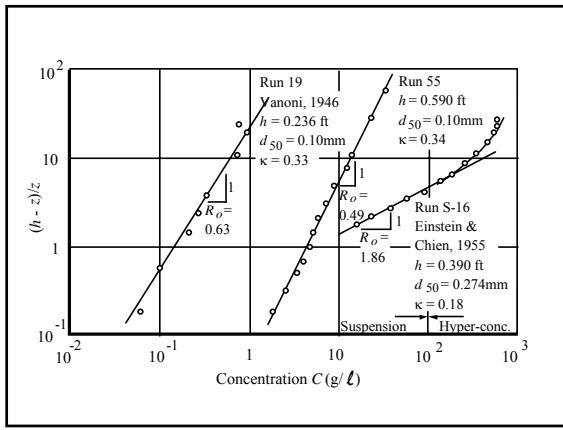
Isokinetic Depth-integrating Sampler





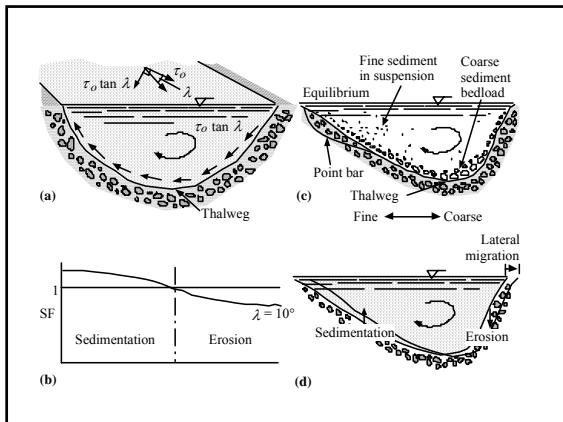




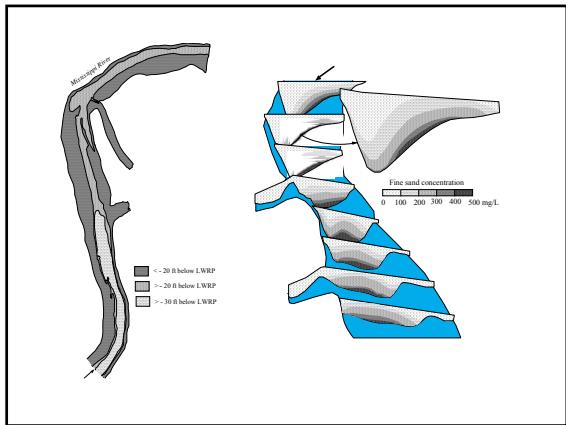


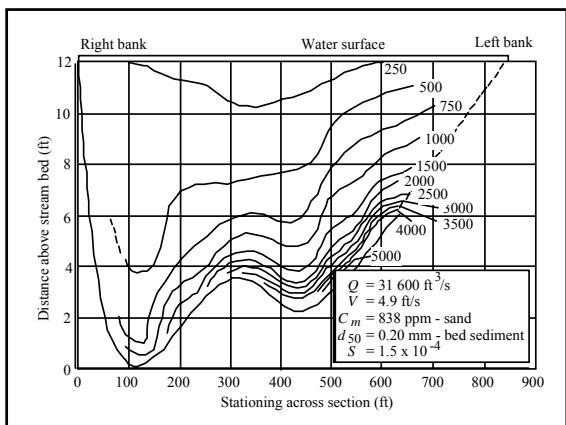


6. Flow in Bends

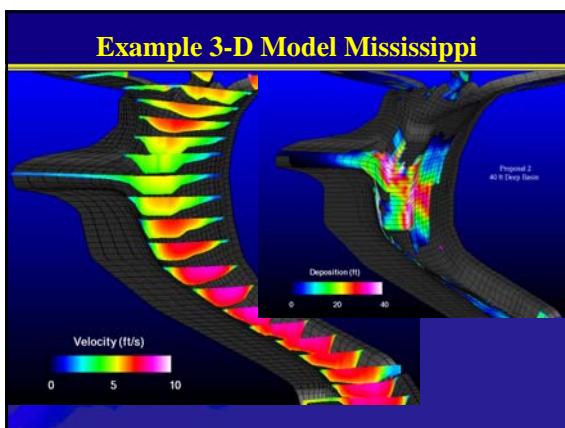


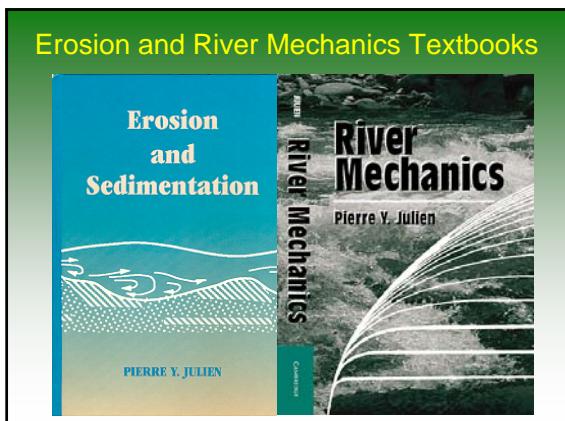












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