Stream Rehabilitation Concepts, Guidelines and Examples

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Wuhan 2005

Objectives

Part I - Stream restoration and rehabilitation:

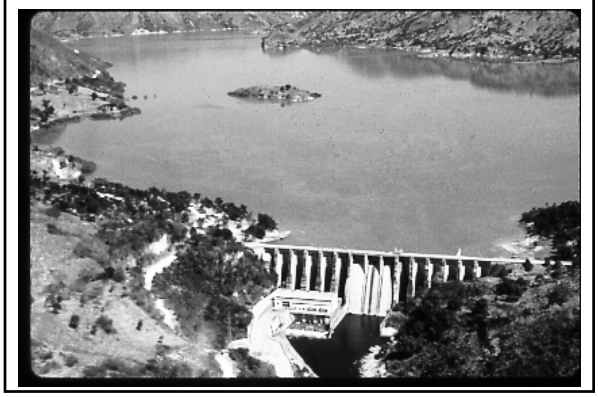
1. **Present and discuss important concepts, laws, criteria and guidelines**
2. **Present examples of stream rehabilitation**

Three Laws of Stream Restoration

#1 There is no cookbook approach to stream restoration projects.

Example Showing the Impact of Deforestation and Flood Control

Water Resources Development



Demographic Expansion

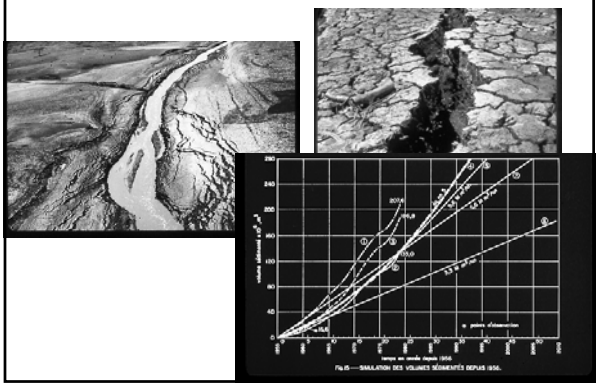
Lowland Slash and Burn

Subsistence Farming

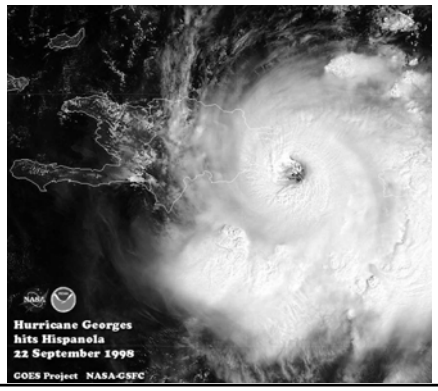
Farming Hilltops?

Watershed Deforestation

Peligre Dam (sedimentation)



Hurricane Impact



Emergency Spillway Operation

Flood Damages

Emergency Situation

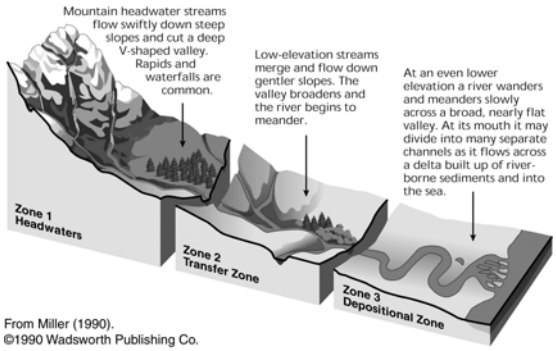
Citizens Blame their Government

Three Laws of Stream Restoration

#1 There is no cookbook approach to stream restoration projects.

#2 Solutions normally seek **equilibrium** conditions between water and sediment regime and stream ecology.

Concept of Equilibrium



From Miller (1990).
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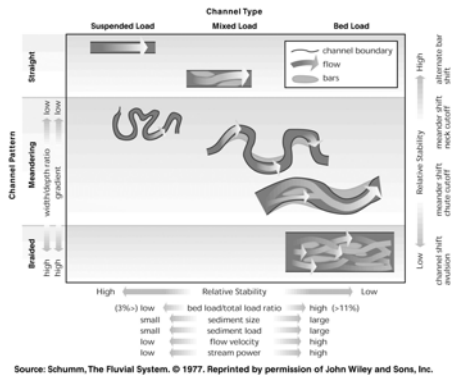

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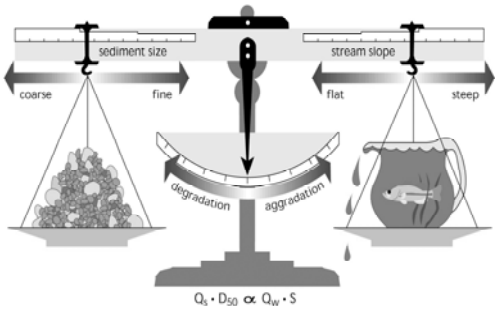
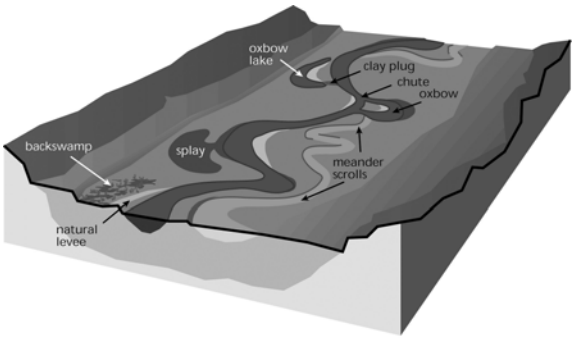
Concept of Equilibrium

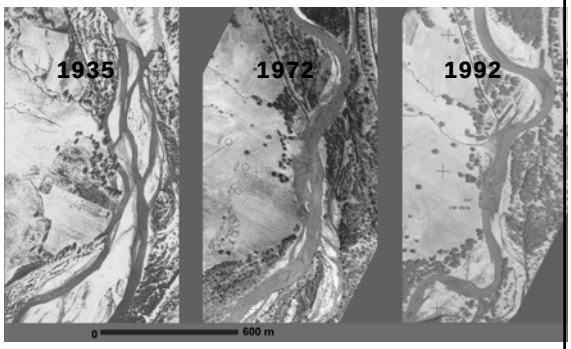


Time Scale

- Geological ~ 1,000,000 years
- Engineering ~ 100 years
- Aquatic life ~ 1 year



Hydraulic geometry of the Rio Grande



Impact on Aquatic Life

Debris Deposition

Restoration vs Rehabilitation

Restoration

•returning a resource to some former condition.

Rehabilitation

•maximize the potential beneficial uses of a resource to some reasonable and practical level.

Three Laws of Stream Restoration

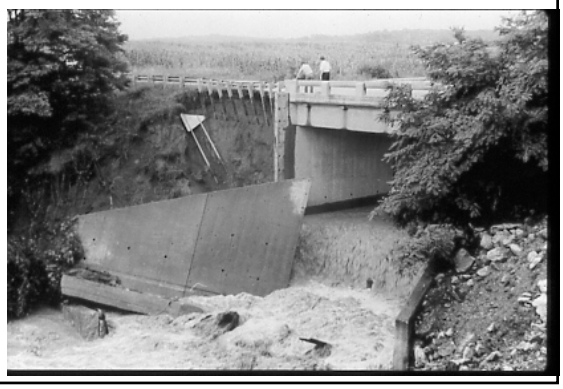
#1 There is no cookbook approach to stream restoration projects.

#2 Solutions normally require equilibrium conditions between sediment regime and stream ecology.

#3 Solutions need to be effective, environmentally acceptable and economical.

Effective

Effective



Effective

Effective

Environmentally Sound

Environmentally Sound

Environmentally Sound

Environmentally Sound

Environmentally Sound

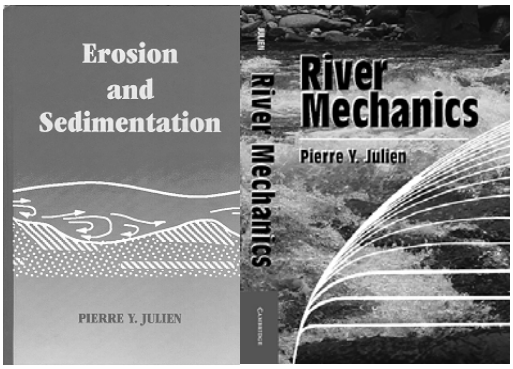
Economical

Economical

Economical

E, E and E!

Erosion and River Mechanics Textbooks



Objectives

Part II – Guidelines and Case Study

1. Guidelines for Stream Restoration Projects
2. Case-study on the Rio Grande

Stream Restoration Guidelines

1. **OBJECTIVES** - Clearly define the engineering and ecological objectives. Restoration vs rehabilitation.

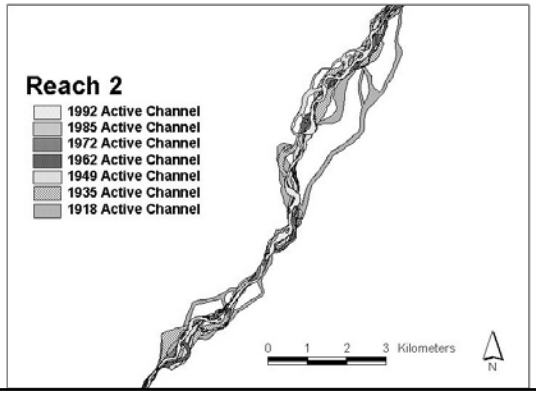
2. **PAST, PRESENT and FUTURE –** Consider present conditions in the perspective of past events and examine future changes.

Rio Grande Restoration– Santa Ana

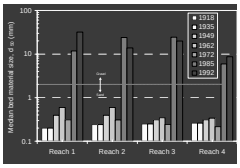
Project Goals

- **Protect Levee**
- **Create a Functioning Floodplain**
- **Improve Wildlife Habitat**

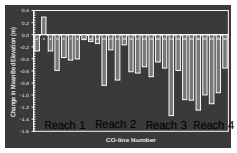
Changes in hydraulic geometry



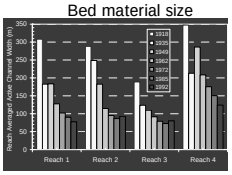
Hydraulic geometry of the Rio Grande



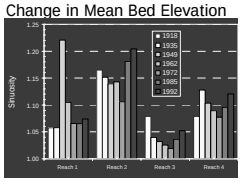
Bed material size



Change in Mean Bed Elevation



Active channel width



Sinuosity

Stream Restoration Guidelines

3. **UPPER WATERSHED** – Look at the geology, deforestation, land use changes, urbanization, climate and extreme events. Examine water and sediment supply, flood frequency curves, sediment mass curves sediment concentrations, water quality, etc.

4. **DOWNSTREAM REACH** – Look at possible changes in the downstream reach that may affect current conditions – like reservoirs, base level changes, headcutting, etc.

5. Woody Debris against Bridges

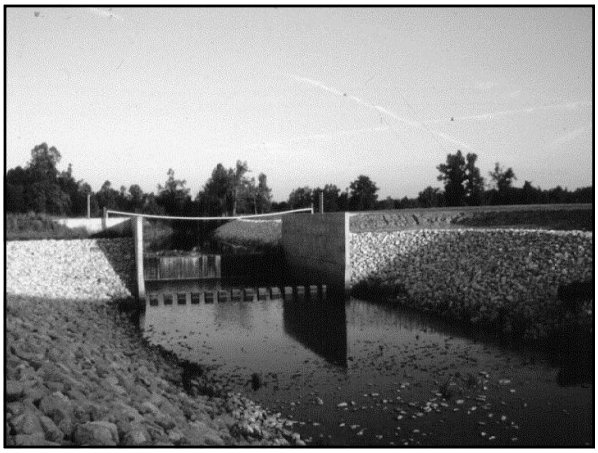
5. Woody Debris - Lower Mississippi River

Vertical Degradation

Headcutting

Headcutting

Bank Caving



Stream Restoration Guidelines

5. **CHANNEL GEOMETRY** – Determine equilibrium downstream hydraulic geometry in terms of width, depth, velocity, slope, discharge and morphology.

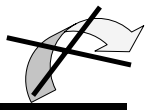
6. **AQUATIC HABITAT**– determine appropriate aquatic habitat conditions including low and high flow periods, pools, riffles, spawning grounds, shade, aeration, migration, etc.

Rio Grande Restoration– Floodplain restoration

Santa Ana Reach - Mid 80's

Santa Ana Reach – Mid 90's

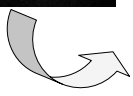
Rio Grande Restoration– Endangered Species



- **Bimodal sand/gravel bed**
- **Deep water h ~ 1.20 m**
- **Water velocities 1.4 m/s**

Restoration

- **Create wider channels**



- **Sandy/silty substrate**
- **Shallow water h < 0.4 m**
- **Water velocities**
  0.1 m/s < V < 0.5 m/s

Stream Restoration Guidelines

7. **EXAMINE ALTERNATIVES** – Identify several different stream rehabilitation schemes that would suit the engineering and environmental needs.

8. **DESIGN SELECTION –** examine the various alternatives and select the best possible alternative and proceed with the design. Solution must be effective, environmentally sound and economical.

River Realignment

- **Construct Bio-engineering Bankline**

Habitat Improvement

- **Sediment Storage Upstream from GRF**
- **Low Velocity Overbank Flows**
- **Planting and Natural Reseeding of Native Vegetation**

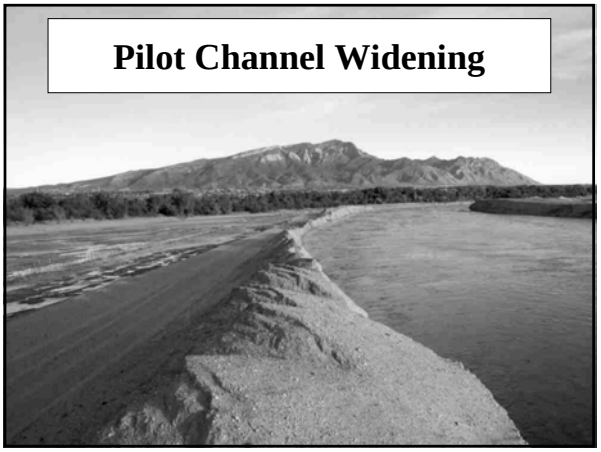
Stream Restoration Guidelines

9. **CONSTRUCTION** – Carefully plan the construction and consider the possible impact of possible extreme events during the construction period.

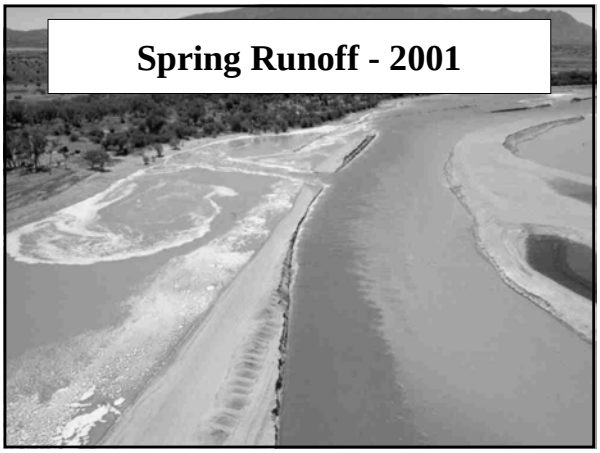
10. **MONITORING** – Things may not work as planned. A post-construction analysis and monitoring should be carried out until the objectives have been met.

Opening Pilot Channel

Pilot Channel Widening



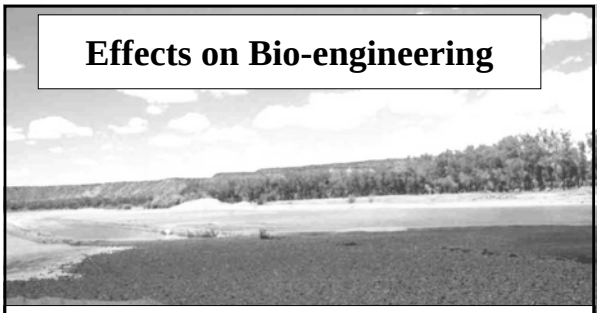
Spring Runoff - 2001



Post-Runoff Assessment

- More Gravel than Anticipated
- Mean Bed Elevation 2 ft Higher than Anticipated
- Pilot Channel 50-100 ft Narrower than Desired

Effects on Bio-engineering



- Most Willows in Fabric Encapsulated Soil (FES) Completely Submerged
- Sections of Bio-engineering Covered in Sediment

Rio Grande Conclusions

- Thoroughly study river mechanics and apply finding to the design process.
- Understand the evolution of the project and consider intermediate conditions.
- Be Flexible…Apply adaptive management techniques.

Stream Restoration Guidelines

1. Clearly define the **OBJECTIVES**
2. **PAST,** Present and **FUTURE**
3. Look at the **UPPER WATERSHED**
4. Look **DOWNSTREAM** for degradation
5. **EQUILIBRIUM** Hydraulic Geometry
6. Appropriate **AQUATIC HABITAT**
7. Examine various design **ALTERNATIVES**
8. **DESIGN** must be Effective, Environmentally sound and Economical
9. Plan **CONSTRUCTION** for the unexpected
10. Post-construction **MONITORING**

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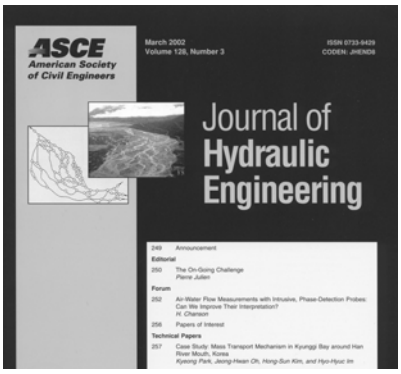

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THANK YOU for your Attention!