Objectives

Part I – Equilibrium and Bank Protection

1. Concept of Equilibrium, environmental river mechanics and bank protection
2. Provide Three basic laws for Stream Restoration

Three Laws of Stream Restoration

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

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.
• The system is dynamic

• A stable river is one in which, over a period of years, slope is delicately adjusted to provide just the velocity required to transport the available water & sediment supplied from the drainage basin.  
  (... after Mackin, 1948)
2. Bank Protection
Requirements of Bank Stabilization

- Effective
- Environmentally Sound
- Economical

(Listed in order of necessity)
Figure 7.10  Longitudinal Stone Fill Toe Protection Placed Adjacent to Bank With Tiebacks

Figure 7.3  Schematic Diagram of Windrow Revetment
Figure 7-5 Placement of Windrow Rock in Excavated Trench on Top Bank
Figure 8.2 Typical Impermeable Dikes
There is no cookbook approach to stream restoration projects.

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

Solutions need to be effective, environmentally acceptable and economical.

Three Laws of Stream Restoration

Erosion and River Mechanics Textbooks

NEW!!
www.cup.org
Objectives

**Part II** – River Dynamics and Response

1. Deforestation impact on rivers
2. The concept of time scales
3. Headcutting and degradation

Peligre Dam in Haiti (deforestation)
#1 Deforestation may impact river equilibrium for a very long time.
Time Scale

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

Jetty fields and vegetation of the Rio Grande
Jetty System (near Bernardo), USACE 1963

Bernardo Gage
River Dynamics

#1 Deforestation may impact river equilibrium for a very long time.

#2 Stream restoration/rehabilitation may be effective only after a long period of time.
Vertical Degradation

Headcutting
#1 Deforestation may impact river equilibrium for a very long time.

#2 Stream restoration/rehabilitation may be effective only after a long period of time

#3 Looking downstream may prevent headcutting and severe degradation problems

**River Dynamics**
Objectives

**Part III – Guidelines and Case Study**

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

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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.

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Rio Grande Restoration– Santa Ana

**Project Goals**

- Protect Levee
- Create a Functioning Floodplain
- Improve Wildlife Habitat
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.
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 $h \sim 1.20 \text{ m}$
- Water velocities $1.4 \text{ m/s}$

Restoration
- Create wider channels

- Sandy/silty substrate
- Shallow water $h < 0.4 \text{ m}$
- Water velocities $0.1 \text{ m/s} < V < 0.5 \text{ m/s}$
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.

**Gradient Restoration Facility**

- Raise Riverbed with GRF
River Realignment
- Construct Bio-engineering Bankline

Floodplain Maintenance
- Lower Terraces with Heavy Equipment

Floodplain Restoration
- Excavated Sediment Placed near Pilot Channel
Habitat Improvement

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

Pilot Channel – Pre-Watering

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

River Realignment
  • Divert River into 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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THANK YOU for your Attention!