Overview of Stream Restoration

Purdue Road School
March 10, 2010

One Team. Infinite Solutions

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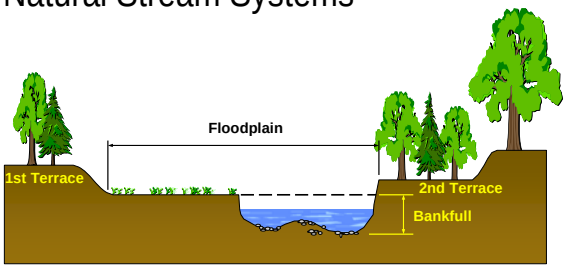
Fluvial Geomorphology

Branch of science concerned with influence of rivers and streams on the formation of the earth's surface

Governing Processes:

- **Erosion**
- **Sediment Transport**
- **Sediment Deposition**

Natural Stream Systems



Bankfull Discharge

- Controls Channel Form
- Corresponds to the Discharge at Which Channel Maintenance is Most Effective
- Recurrence Interval on Order of 1.2 to 1.6 Years
- Higher Recurrence Interval in Urban Watersheds

Bankfull Indicators

- Flat, Depositional Surface Adjacent to Active Channel
- Height of Depositional Features (Point Bars)
- Change in Vegetation
- Slope or Topographic Breaks or Changes Along the Bank
- Change in Particle Size of Bed Materials

Differences

CONCEPT	TRADITIONAL	GEOMORPHOLOGICAL
Time	Short-term	Long-term
Model	Theoretical	Field Measurement
Water	Clear	Sediment Laden
Spatial Scale	Reach	Watershed
Boundary	Rigid	Mobile
Maintenance	High	Sustainable
Design Flow	100 yr.	Bankfull Flow
Factor of Safety	Conservative	Balance of Forces

Stream Restoration Techniques

Natural Channel Design

Process by which new or re-constructed stream channels and their associated flood plain riparian systems are designed to be naturally functional, stable, healthy, productive and sustainable.

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Stream Restoration Techniques

Soil Bioengineering

The Use of Living and Non-Living Materials to Provide Soil Reinforcement and Prevent Erosion

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Effect of Straightening Streams

- Increased Slope
- Higher Shear Stresses
- Incision/Bedcutting
- High Streambanks
- Overwidening
- Headcutting Upstream

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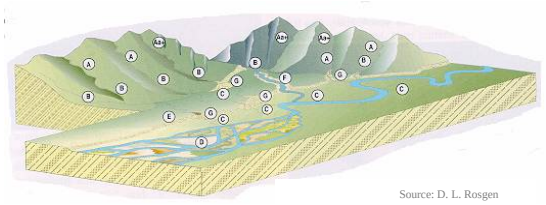
Rosgen Stream Classification



Source: D. L. Rosgen

Function of:

◆ Entrenchment ◆ Width/Depth Ratio ◆ Slope

◆ Sinuosity ◆ Number of channels ◆ Channel Materials

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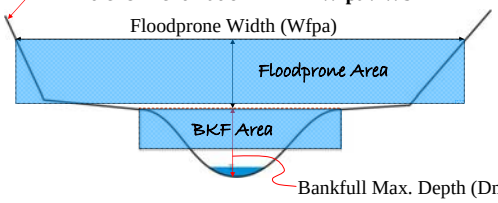
Rosgen Stream Classification System

Entrenchment Ratio (ER)

Idealized Natural River Cross Section

Entrenchment Ration = ER = Wfpa / Wbkf

Floodprone Width (Wfpa)



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Rosgen Stream Classification System

Entrenchment

The Vertical Containment of the Stream or the Degree of Incision in the Valley Floor

$$\text{Entrenchment Ratio} = \frac{\text{Width of Floodprone Area}}{\text{Width of Bankfull Channel}}$$

- Entrenched (Ratio < 1.4)
- Moderately Entrenched (1.4 - 2.2)
- Slightly Entrenched (Ratio > 2.2)

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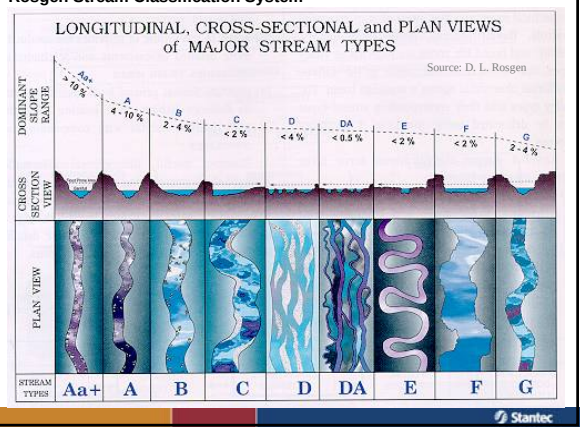
Rosgen Stream Classification System



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Rosgen Stream Classification System

Channel Materials

Based on the D_{50} of the Dominant Bed Material

1 - Bedrock	4 - Gravel
2 - Boulder	5 - Sand
3 - Cobble	6 - Silt/Clay

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Rosgen Stream Classification System

STREAM TYPE - C5

- Well Defined Floodplain
- Meandering Point-Bars
- Good Riffle/Pool Distribution
- Entrenchment Ratio: > 2.2
- W/D Ratio: > 12
- M/W Ratio: 4-20
- Sinuosity: > 1.2
- Slope: < 0.02

Source: D. L. Rosgen

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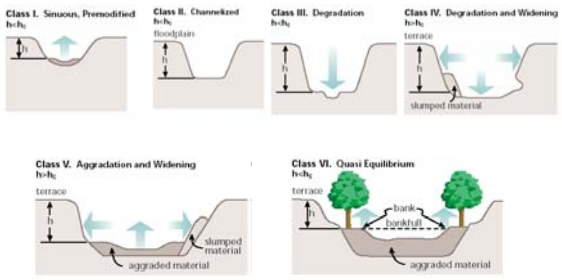
Stream Classification and Channel Evolution Models

Simon's Modification of Schumm's Model



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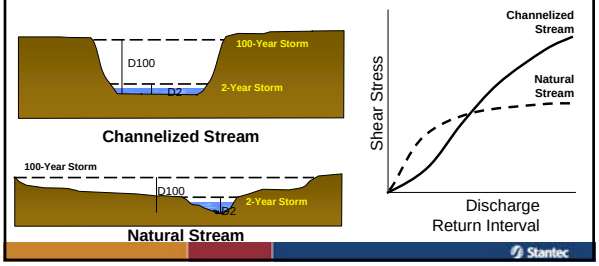
Stream Classification and Channel Evolution Models

Shear Stresses in Streams

Shear Stress = γ R S



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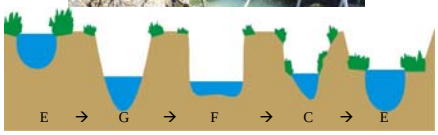
Stream Classification and Channel Evolution Models

Use of Rosgen's Classification System to Predict Channel Evolution



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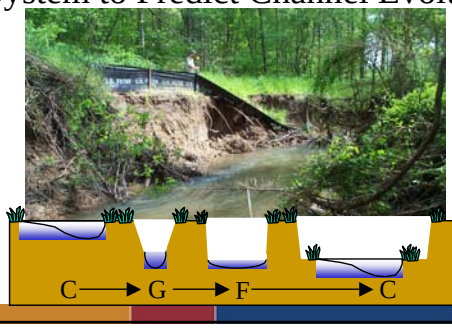

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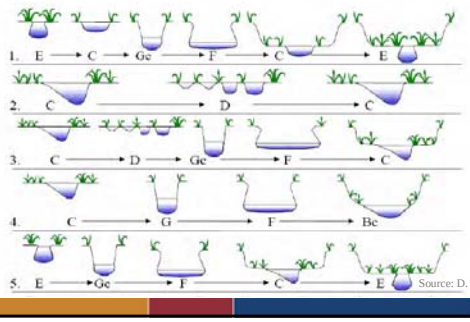

Source: D. L. Rosgen

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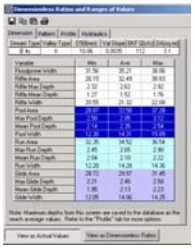
Stream Restoration Techniques

Reference Reach Approach

- Stable reference stream in same hydro-physiographical region
- Streams exist in dynamic state of equilibrium
- Requires a number of geomorphic measurements - range of dimensionless ratios
- Applies to streams where upper ranges of depositional particles begin to mobilize at bankfull
- In sand bed streams additional analytical analyses is necessary



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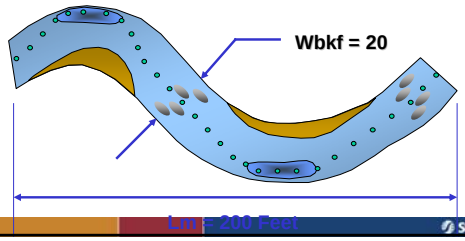
Stream Restoration Techniques

Dimensionless Ratios



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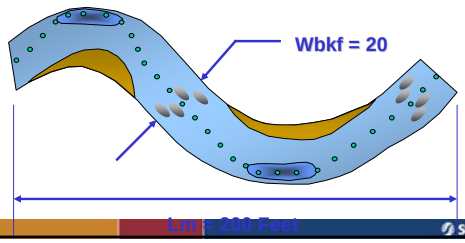
Stream Restoration Techniques

Dimensionless Ratios

Lm/Wbkf = 200/20=10



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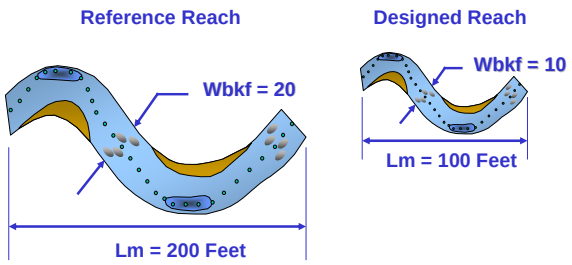
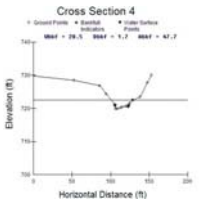
Dimensionless Ratios



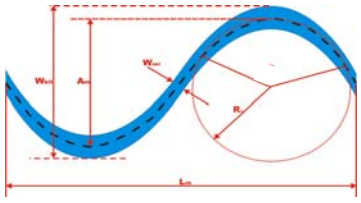
Primary Dimensionless Ratios – Cross Sectional Dimensions

- Pool
  - Pool Area/Riffle Bankfull Area
  - Max. Pool Depth/Mean Riffle Bankfull Depth
  - Mean Pool Depth/Mean Riffle Bankfull Depth
  - Pool Width/Riffle Bankfull Width
- Run
  - Run Area/Riffle Bankfull Area
  - Max. Run Depth/Mean Riffle Bankfull Depth
  - Mean Run Depth/Mean Riffle Bankfull Depth
  - Run Width/Riffle Bankfull Width
- Glide
  - Glide Area/Riffle Bankfull Area
  - Max. Glide Depth/Mean Riffle Bankfull Depth
  - Mean Glide Depth/Mean Riffle Bankfull Depth
  - Glide Width/Riffle Bankfull Width



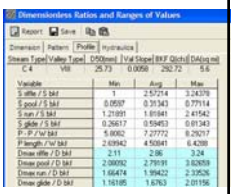
Primary Dimensionless Ratios – Pattern

- Meander Wavelength (Lm)/Riffle Bankfull Width (Wbkf)
- Radius of Curvature (Rc)/Riffle Bankfull Width (Wbkf)
- Beltwidth (Wblt)/Riffle Bankfull Width (Wbkf) = MWR
- MWR = Meander Width Ratio



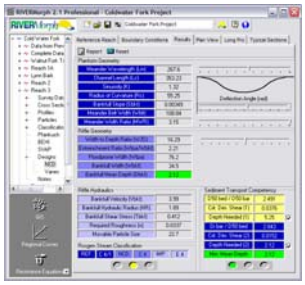
Primary Dimensionless Ratios – Profile

- Slope
  - Riffle Slope/Bankfull Slope
  - Pool Slope/Bankfull Slope
  - Run Slope/Bankfull Slope
  - Glide Slope/Bankfull Slope
- Pool Spacing
  - Pool to Pool Spacing/Riffle Bankfull Width
  - Pool Length/Riffle Bankfull Width
- Maximum Depths
  - Max. Riffle Depth/Mean Riffle Bankfull Depth
  - Max. Pool Depth/Mean Riffle Bankfull Depth
  - Max. Run Depth/Mean Riffle Bankfull Depth
  - Max. Glide Depth/Mean Riffle Bankfull Depth

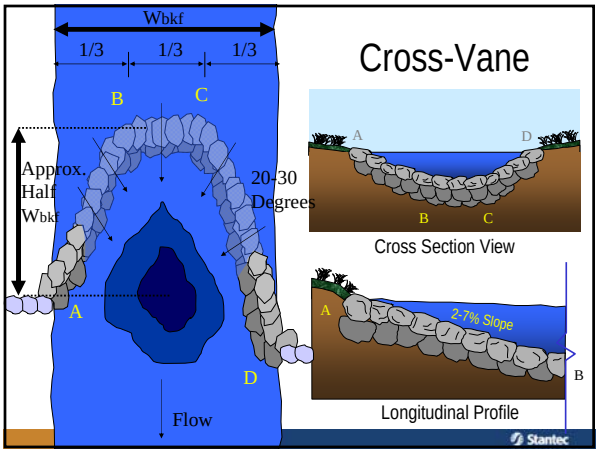


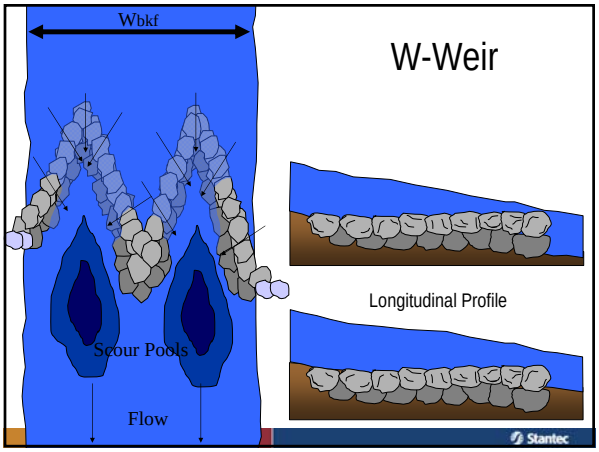
Reference Reach NCD Process

- Determine Site Constraints & Design Parameters
- Predict Stable Geometry Based on Reference Reach
- Check Sediment Transport Competency Equations
- Iterative Design Until Geometry and Calculated Depths Converge



Cross-Vane




Wbkf
W-Weir
Longitudinal Profile
Scour Pools
Flow
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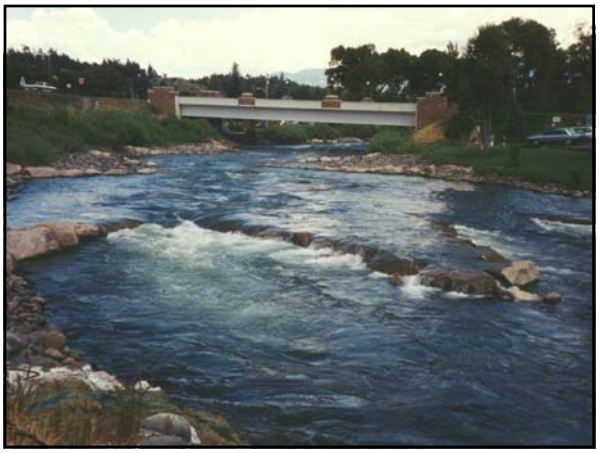
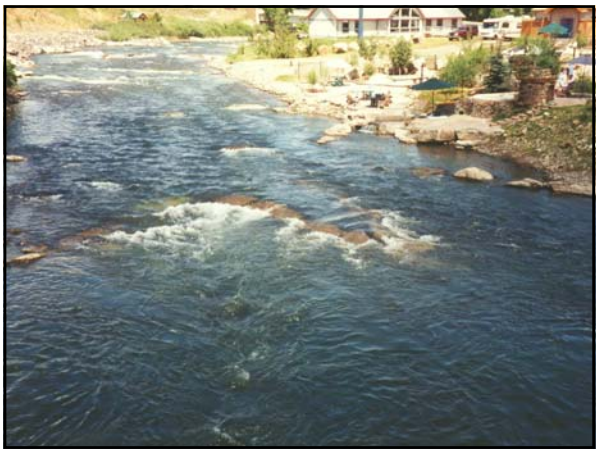
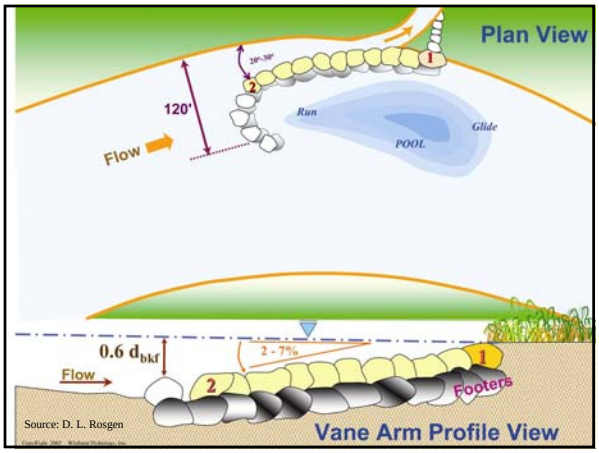
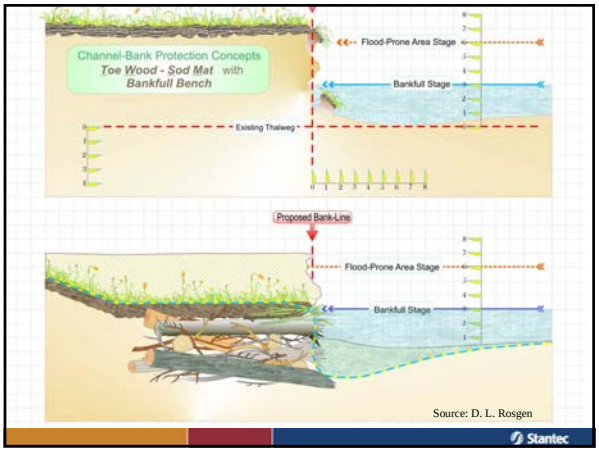





Plan View
120'
Flow
Run
Glide
POOL
0.6 d_{bkf}
2 - 7%
Flow
Footers
Source: D. L. Rosgen
Vane Arm Profile View

Rootwad - Log Vane - Combo

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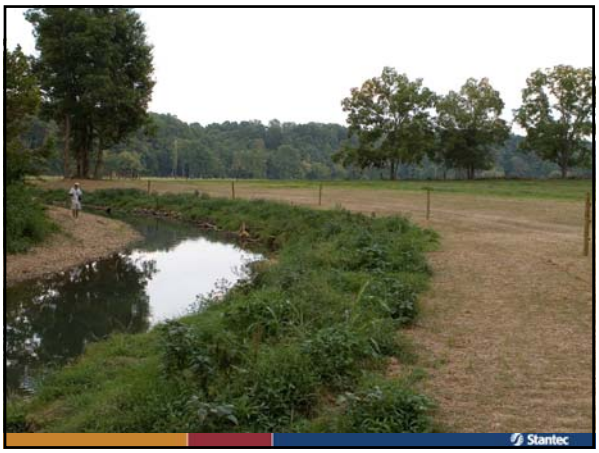
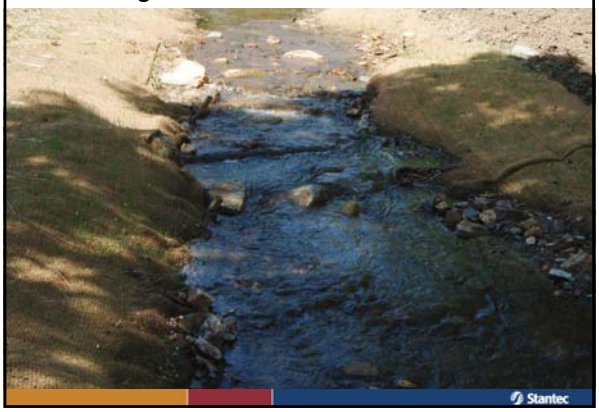
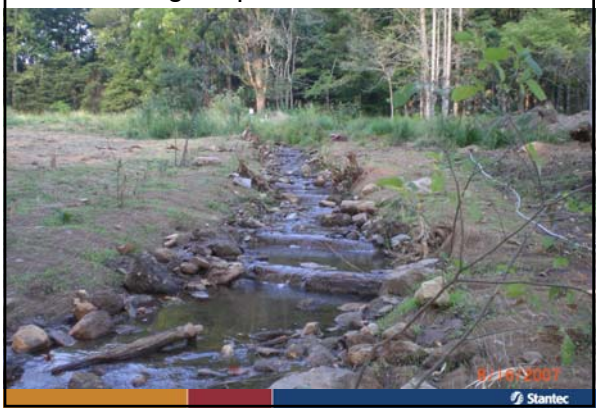


Rock Constructed Riffles w/ Pocket Pools

Log/Rock Constructed Riffles



Log Step Pool Structures

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