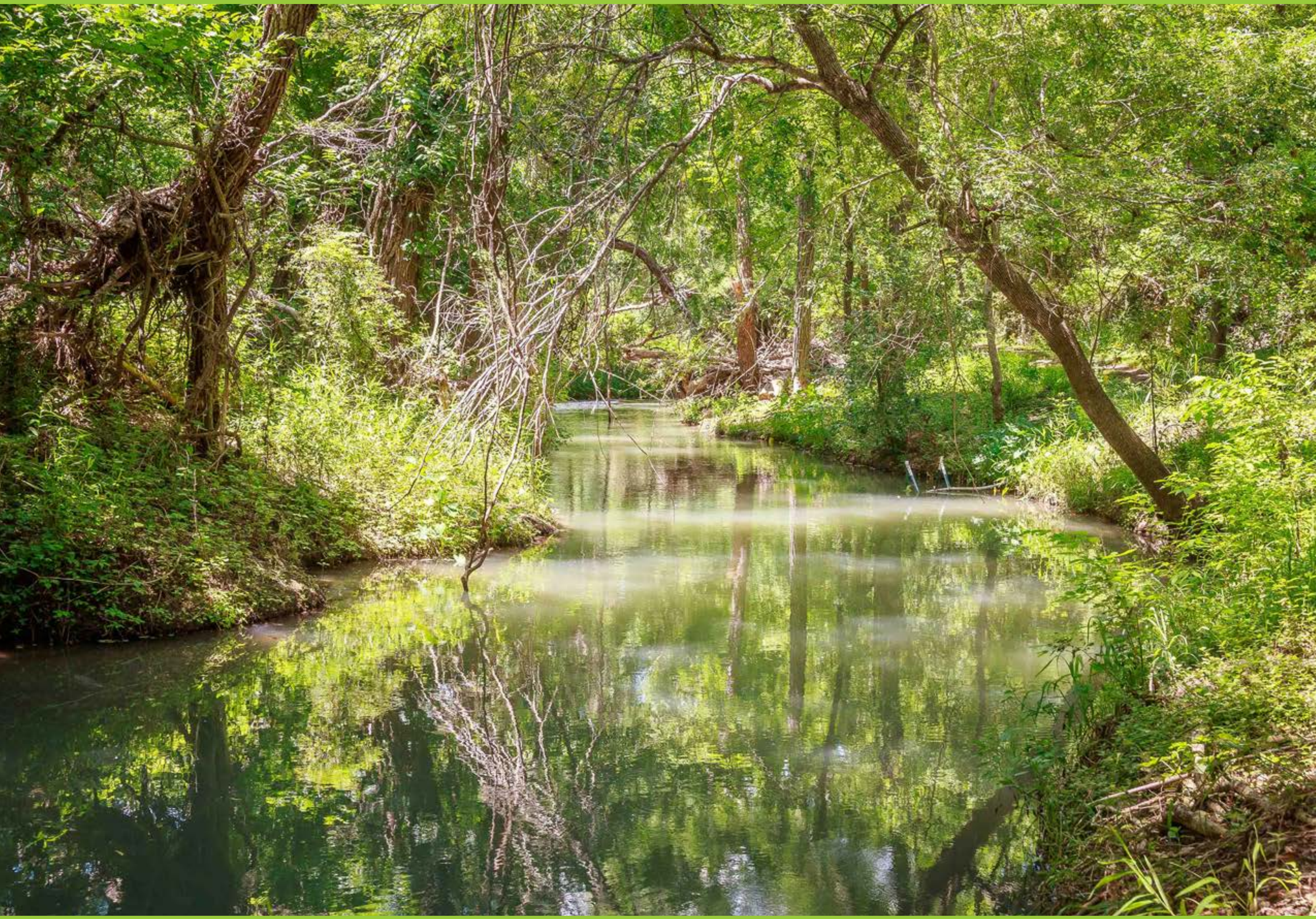
Urban Stream Processes and Restoration Program



Funding provided through a Clean Water Act Section 319(h) nonpoint source grant from the Texas Commission on Environmental Quality and U.S. Environmental Protection Agency.

Texas Water Resources Institute EM-127 September 2019

Local volunteers plant obligate plant species near the edge of the water on a portion of the Urban Stream Process and Restoration Program demonstration site at the Irma Lewis Seguin Outdoor Learning Center in the Geronimo Creek watershed in Seguin, Texas. Obligate species thrive in saturated soils and help prevent soil erosion along the bank. Photo by Clare Entwistle, Texas Water Resources Institute.

Table of Contents

Urban Riparian & Stream Restoration Program: Introduction to Stream Processes & Restoration

Clare Entwistle
Texas Water Resource Institute

State of the Nation's Rivers

- 55% of the river and stream miles in the United States are reported to be in poor condition due to streamside disturbance and poor riparian vegetation cover (USEPA 2013).
- Increases in human population along with industrial, commercial, and residential development place heavy demands on stream corridors.
- Riparian and stream degradation is a major threat to:
  - Water Quality
  - In-Stream Habitat
  - Terrestrial wildlife
  - Aquatic Species
  - Overall Stream Health

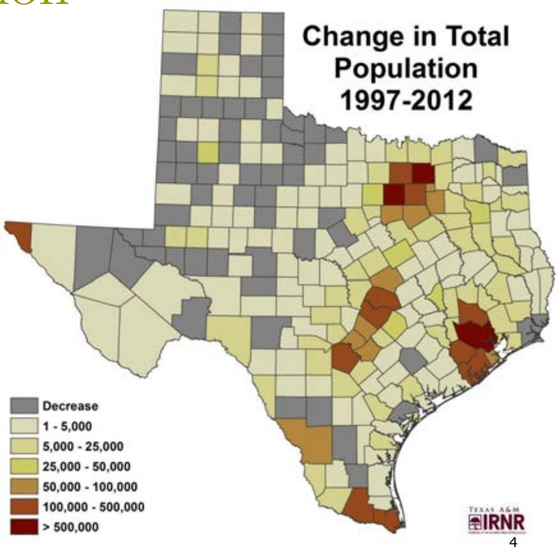
Unhealthy Watersheds

Most streams and rivers in Texas have been adversely affected by past natural and human activities resulting in:

- Increasingly damaging floods
- Lower base flows
- High sediment loads
- Reduced reservoir storage capacity
- Invasion of exotic species
- Loss of natural riparian habitats
- Degraded water quality

Texas Population

- 1997 – 19 Million
- 2012 – 26 Million
- 36% increase
- 500,000/year
- 65% of increase occurred within *Top Ten Highest Populated* Counties



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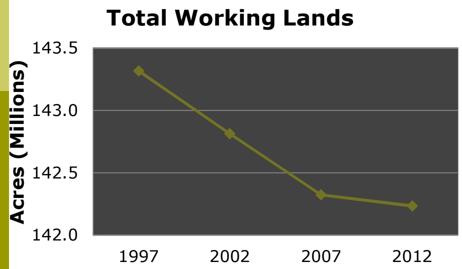
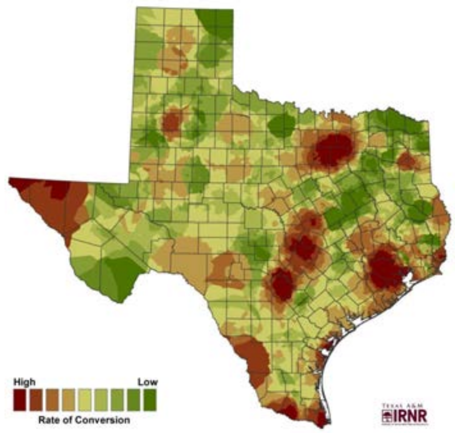
Loss of Rural Working Lands

- 1997 – 143.4 Million acres
- 2012 – 142.3 Million acres
- Loss 1.1 Million acres





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Floods

Erosion and Sedimentation Threatens Water Storage Capacity

- Stream erosion threatens land-use, property values and human safety.
- Texas Water Development Board (TWDB) predicts surface water in Texas will decline by 3 percent from 2020-2070 due to sedimentation, reducing reservoir storage.
- It is estimated that reservoirs will lose 104,000 acre-feet of water storage capacity due to sedimentation during that same time period, which is roughly equal to the amount of water for over 231,100 homes based on a family of four use in one year.

Management Strategies for Water Supply Reservoirs

- TWDB reported that dredging the sediment from reservoirs to increase water storage costs twice as much or more than constructing a new reservoir.
- Cities such as Austin, have found that improving creek and floodplain protection is needed to prevent unsustainable public expense to maintain drainage infrastructure.
- Focusing management efforts on quality land management to stabilize stream banks and riparian areas may be one of the most cost effective strategies for extending the life of the state’s water supply reservoirs.

Program Goals

- Promote healthy watersheds and improve water quality through the delivery of Urban Riparian and Stream Restoration training programs in priority watersheds and an Advanced 3-day Stream Restoration training.
- Restoration Demonstration Site to show the benefits of riparian restoration on bank erosion and total suspended solids levels within the creek.

Educational Trainings

- 15 one-day trainings and 1 advanced three-day training in year 3.
- Geared toward professionals interested in conducting restoration projects
- Help attendees understand urban stream functions
  - what the impacts of development on urban streams look like
  - recognize healthy and degraded stream systems
  - assess and classify a stream using the Bank Erosion Hazard Index (BEHI)
  - Comprehend what natural versus traditional restoration techniques

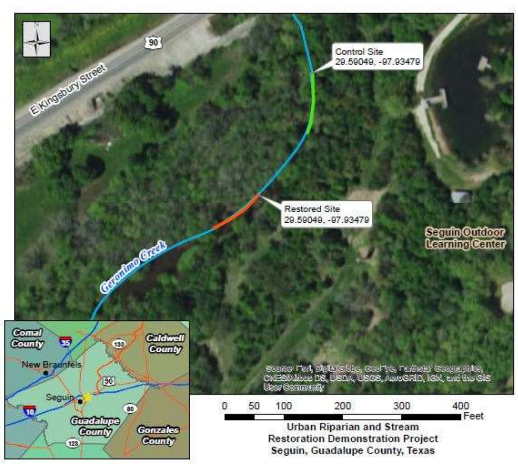
Training Outline

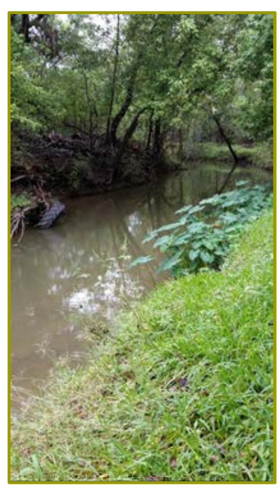
1. Hydrologic cycle
2. Introduction to stream morphology
   a) Bankfull discharge
   b) Stability
   c) Channel measurements
3. Stream classification
4. Stream instability
5. Stream restoration
6. Stabilization structures
7. Vegetation
8. Monitoring and evaluation

Restoration Demonstration Project

- The demonstration site is owned by the Irma Lewis Seguin Outdoor Learning Center and the Texas Water Resources Institute is coordinating with partners including the Guadalupe-Blanco River Authority and the Geronimo and Alligator Creeks Watershed Partnership.
- The Geronimo and Alligator Creek Watershed Protection Plan, as does most watershed plans, includes implementing riparian forest and herbaceous buffers to reduce pollutant loads in the watershed.
- The demonstration will implement restoration of riparian buffers using natural bank stabilization techniques and planting native vegetation on one of the two sites.
- Both sites will be monitored to demonstrate the difference in bank erosion rates and total suspended solids in the creek.

Restoration Demonstration Project





Properly Functioning Riparian Area

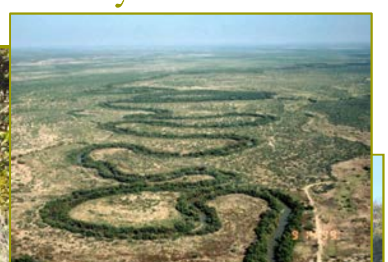
Adequate vegetation, landform or large woody material to:

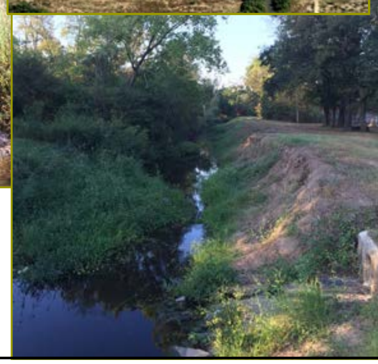
- Dissipate stream energy
- Stabilize banks
- Reduce erosion
- Trap sediment
- Build / enlarge floodplain
- Store water
- Floodwater retention
- Groundwater recharge
- Sustain baseflow

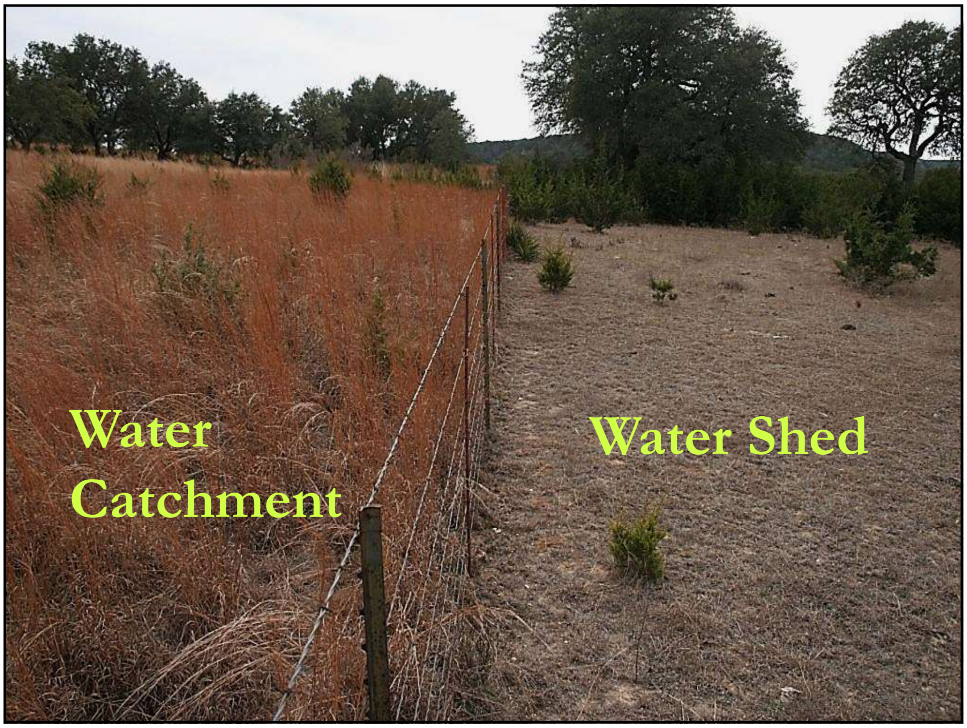
- Water quality
- Water quantity
- Forage
- Aquatic habitat
- Wildlife habitat
- Recreational value
- Aesthetic beauty

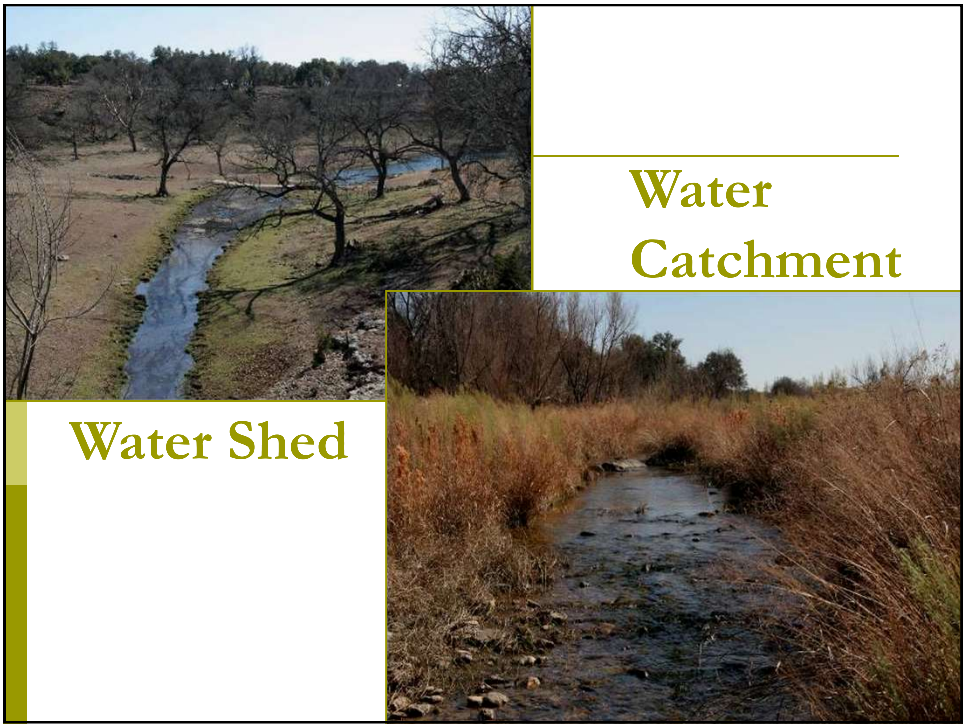
Physical Function → Values

Riparian Vegetation is Key






Water
Catchment
Water Shed


Water
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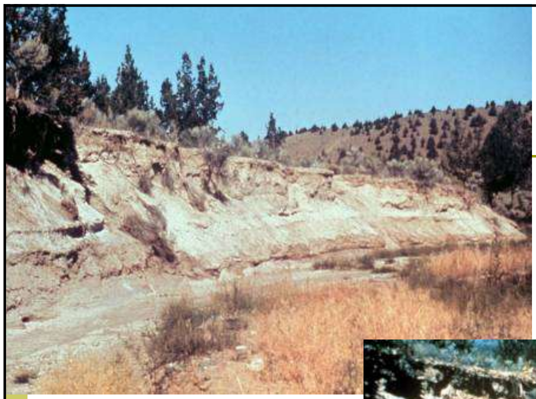


An Overlooked Opportunity

Catching the water

Storing the water in the land

Benefits of Healthy Riparian and Stream Systems

- Proper management, protection, and restoration of riparian areas decrease:
  - Bacteria, nutrients, sediment loading into stream
  - Lower in-stream temperature
  - Improve dissolved oxygen levels
  - Improve aquatic habitat
  - Improve macrobenthos and fish communities

Riparian Chain Reaction of Adequate Vegetation:

Protects banks from excess erosion

Dissipates energy and slows the velocity of floodwater

Sediment dropped

Sediment trapped and stabilized

Floodplain / riparian sponge is enlarged

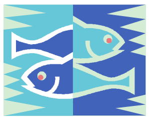
Increased groundwater recharge

Base-flow is sustained over time

Water Quality and Watershed Planning

- Texas has more than 191,000 miles of rivers and streams with riparian zones and floodplains that comprise corridors of great economic, social, cultural, and environmental value.
- The 2014 Texas Integrated report assessed 1,409 water bodies; of those 1,065 had sufficient data for evaluations with 7-10 yrs.
- 2014 303d List has **589** impaired water bodies on it (+21).
- Many WPP and TMDL Implementation projects are ongoing across the state to improve water quality in watersheds.
- Bacteria is the cause for over 43% of impairments followed by low dissolved oxygen (nutrients) for 16% and organics in fish tissue at 19%.

Designated Uses



Aquatic Life

- Protect aquatic species
- Dissolved Oxygen, Toxic Chemicals, Total Dissolved Solids

Recreation

- Estimates the relative risk of swimming and other water recreation activities
- Bacteria

Drinking Water

- Indicates if water is suitable as a source of drinking water
- Metals, Pesticides, Toxic Chemicals, Total Dissolved Solids, Nitrates

Fish Consumption

- Protect public from consuming fish that may be contaminated
- Metals, Pesticides, Other Toxic Chemicals

Surface Water Quality

Numeric

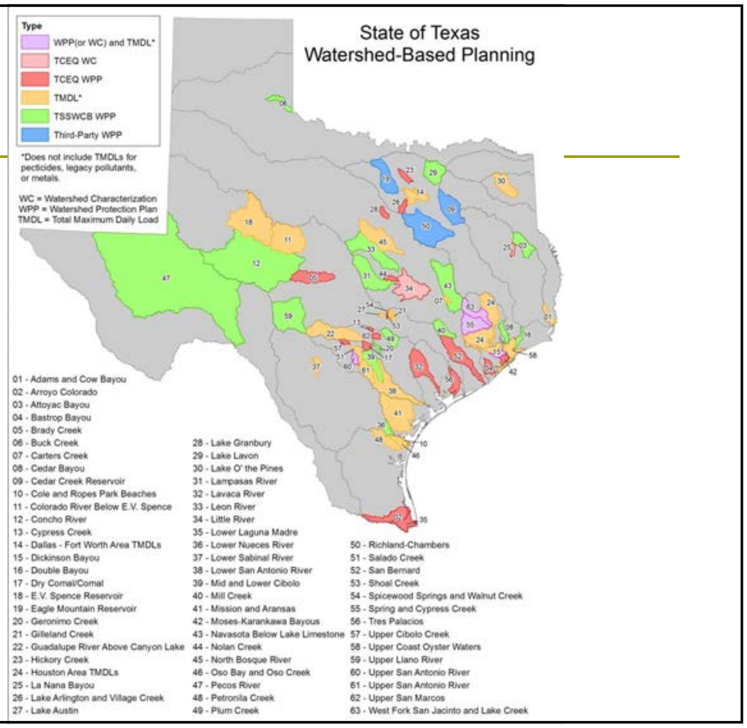
- High Aquatic Life Use
  - Dissolved Oxygen – 5.0 mg/L

  (4-5 stressed <3 can't survive)
  - pH – Optimum Range 6.5-9.0
  - Temperature – 90 F (32.2 C) common range 68-86 F
  - Total Dissolved Solids – *396 mg/L
  - Sulfate – *48 mg/L
  - Chloride - *70 mg/L

* Specific criteria for segment

Screening Criteria

- Nitrite and Nitrate Nitrogen – 1.95 mg/L
- Phosphorus – 0.69 mg/L
- Ammonia
- Chlorophyll *a* (algae)



Point Source Pollutant Sources

- Point Source
  - Permitted Discharges
    - Wastewater Treatment Plants
    - Industrial Facilities
    - Confined Animal Feeding Operation
- Stormwater Permit

Nonpoint Sources

- Urban
- Wildlife
- Feral Hogs
- Livestock
- Crops
- Onsite Septic Facilities

Why should we be concerned about the health of the stream and riparian areas?

- Cumulative impacts of natural and man induced disturbances in the drainage area.
- Management not only affects the individual landowner but everyone else downstream.
- They are critical acting as natural water "pipelines" that impact how much surface water and sediment is transported downstream, the quality of that water, as well as the sediment filling up our reservoirs.
- Stream and riparian systems are one of the most important resources found on private and public lands in Texas and they need to be managed and protected.

We need to build more support for resource stewardship through education and use an informed public to mitigate, protect and restore our stream systems.

Questions?

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Urban Riparian Restoration Program: Introduction to Stream Processes and Restoration

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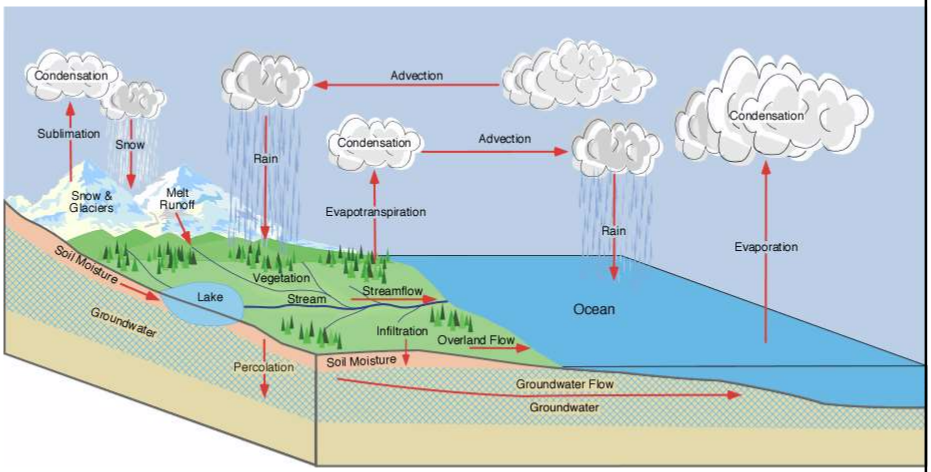
Texas A&M AgriLife Research and Extension Center at Dallas

Outline

1. Hydrologic cycle
2. Introduction to stream morphology
   1. Bankfull Discharge
   2. Stability
   3. Channel measurements
3. Stream Classification
4. Stream Instability
5. Stream Restoration
6. Stabilization structures
7. Vegetation
8. Monitoring and evaluation

Hydrologic Cycle

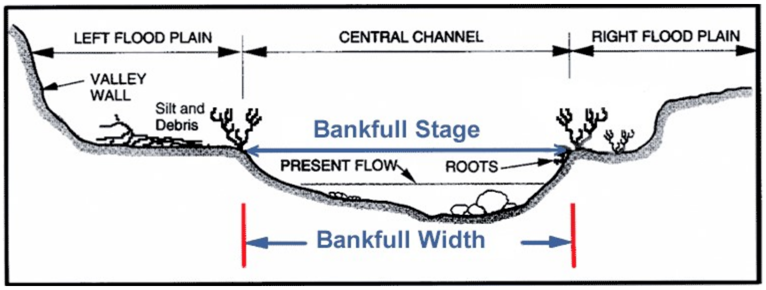


Stream Function

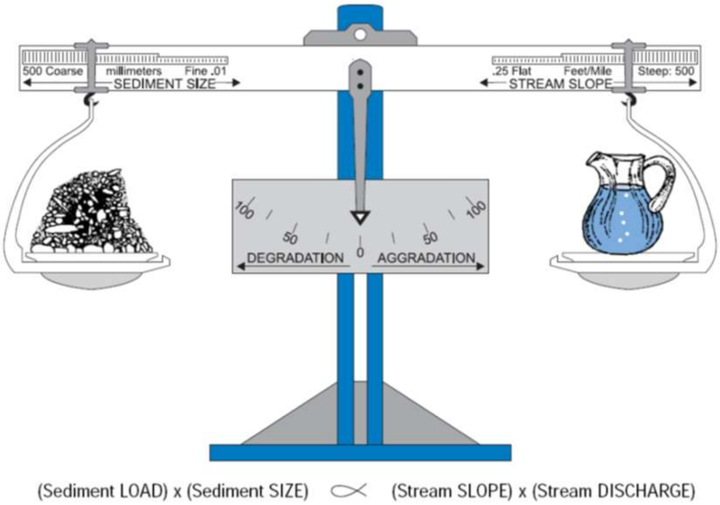
- Transporting water and sediments
- Habitat to aquatic organisms
- Trees and shrubs on banks provide food source and regulate temperatures
- Channel features such as pools, riffles and glides provide diversity
- Natural design important to maintain these features

Bankfull Discharge

- Most important process defining channel
- Effective (or dominant) discharge
- Transports majority of sediment load in stream
- Considered the insipient point of flooding



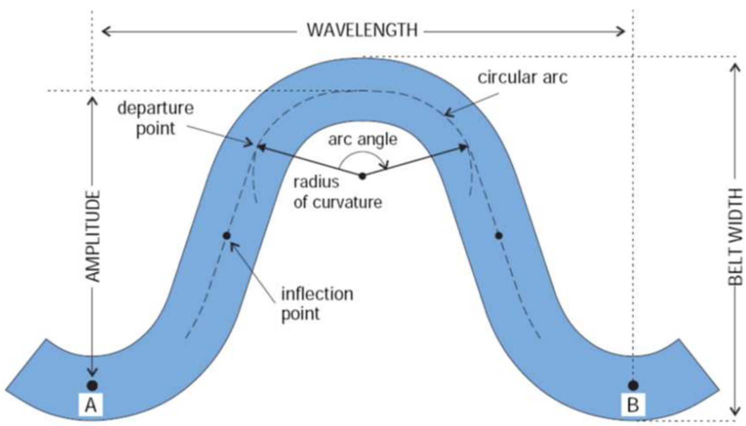
Natural Channel Stability



Channel Dimension and Characteristics

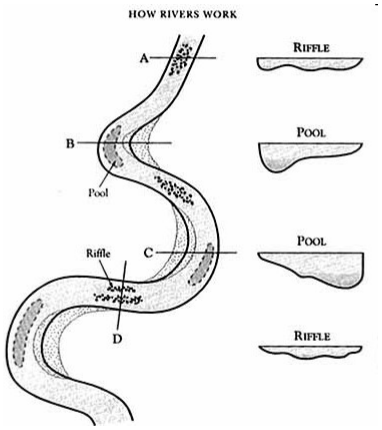
- It is the cross section of stream at bankfull measured at a stable riffle in stream
- Width of stream increases as you go downstream
- In arid regions, streams are wider due to lack of vegetation and erosion
- The mean depth of stream varies within stream depending on channel slope and riffle/pool spacing

Meander Geometry



Channel features

- Sequences of riffles and pools
- Riffles: larger rock particles, shallower, and steeper
- Pools: flat surfaces, deep
- Run: between riffles and pools
- Glide: between pools and riffles



Natural Stream Restoration

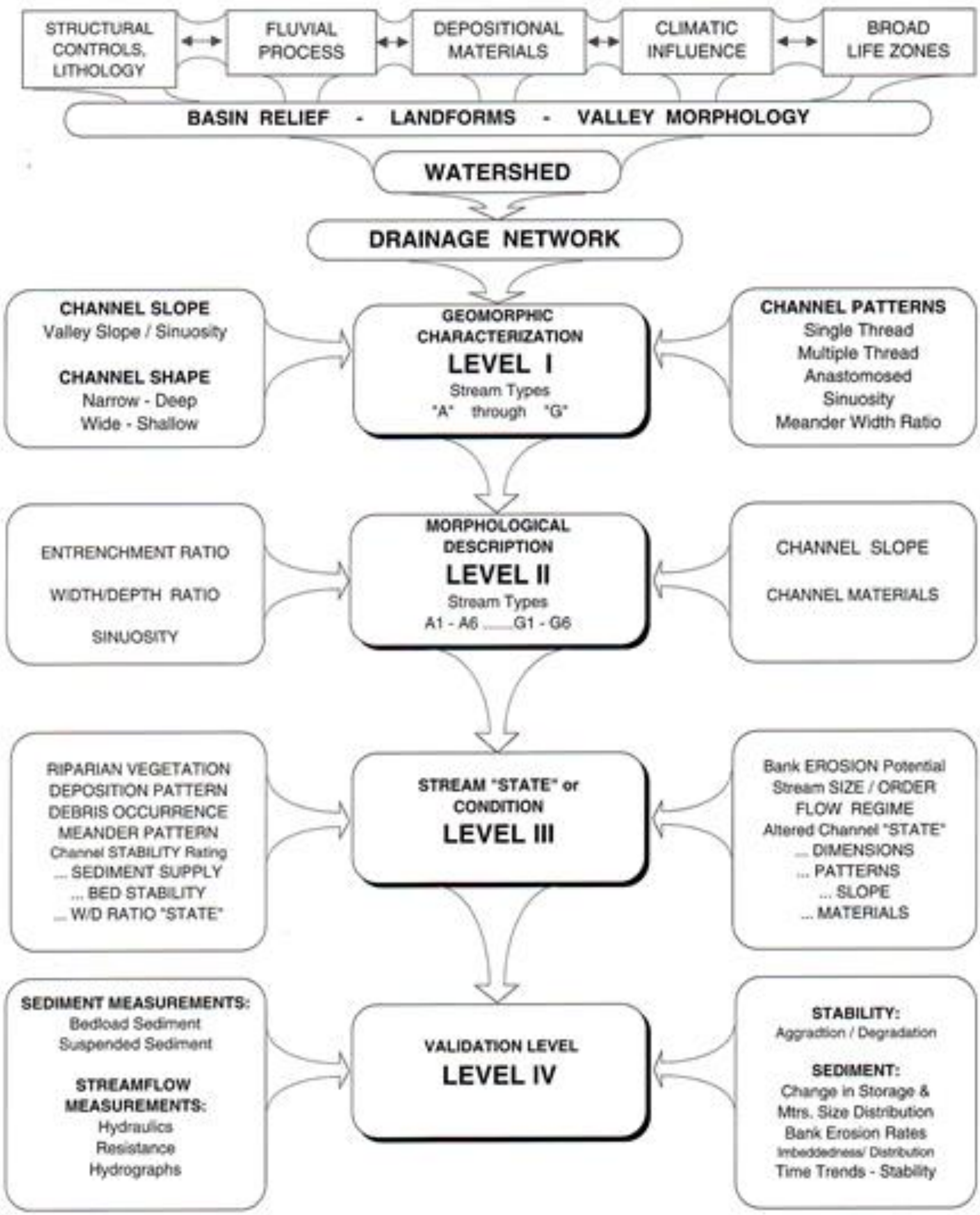
- Utilizes reference reach
- Includes bankfull and floodplain areas
- Restoration should result in water and sediment movement without degradation or aggradation
- Improves habitat and promotes diversity
- Promotes riparian vegetation

Stream Assessment

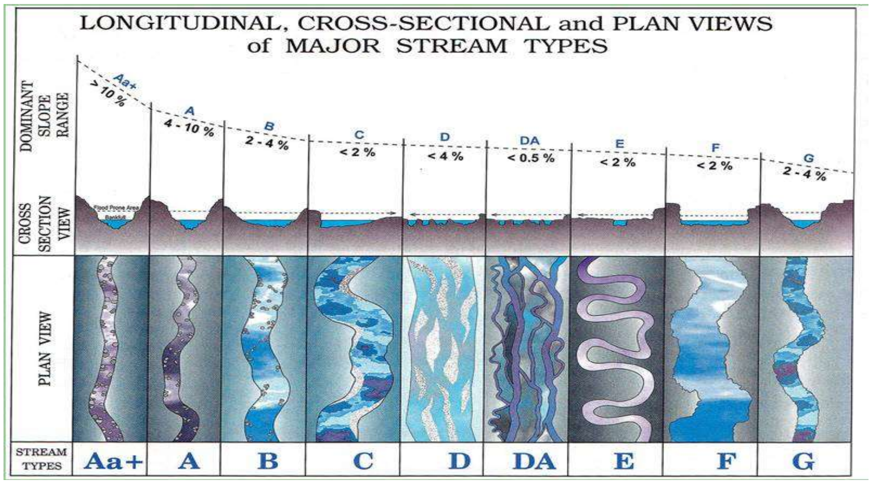
- Determine watershed drainage area (GIS)
- Determine land use (map or survey)
- Determine bankfull (field observation)
- Determine channel dimension (survey)
- Determine stream pattern: sinuosity, radius of curvature, belt width and meander wavelength (1:24000 maps)
- Channel profile

Stream Assessment

- Substrate Analysis
- Estimate bankfull discharge and velocity (Manning's equation)
- Assess riparian condition: topography of floodplain, constraints in urban settings, soil fertility, plant inventory


STRUCTURAL CONTROLS, LITHOLOGY
FLUVIAL PROCESS
DEPOSITIONAL MATERIALS
CLIMATIC INFLUENCE
BROAD LIFE ZONES
BASIN RELIEF - LANDFORMS - VALLEY MORPHOLOGY
WATERSHED
DRAINAGE NETWORK
CHANNEL SLOPE
Valley Slope / Sinuosity
CHANNEL SHAPE
Narrow - Deep
Wide - Shallow
GEOMORPHIC CHARACTERIZATION
LEVEL I
Stream Types
"A" through "G"
CHANNEL PATTERNS
Single Thread
Multiple Thread
Anastomosed
Sinuosity
Meander Width Ratio
ENTRENCHMENT RATIO
WIDTH/DEPTH RATIO
SINUOSITY
MORPHOLOGICAL DESCRIPTION
LEVEL II
Stream Types
A1 - A6 ......G1 - G6
CHANNEL SLOPE
CHANNEL MATERIALS
RIPARIAN VEGETATION
DEPOSITION PATTERN
DEBRIS OCCURRENCE
MEANDER PATTERN
Channel STABILITY Rating
... SEDIMENT SUPPLY
... BED STABILITY
... W/D RATIO "STATE"
STREAM "STATE" or CONDITION
LEVEL III
Bank EROSION Potential
Stream SIZE / ORDER
FLOW REGIME
Altered Channel "STATE"
... DIMENSIONS
... PATTERNS
... SLOPE
... MATERIALS
SEDIMENT MEASUREMENTS:
Bedload Sediment
Suspended Sediment
STREAMFLOW MEASUREMENTS:
Hydraulics
Resistance
Hydrographs
VALIDATION LEVEL
LEVEL IV
STABILITY:
Aggradation / Degradation
SEDIMENT:
Change in Storage &
Mtrs. Size Distribution
Bank Erosion Rates
Imbeddedness/ Distribution
Time Trends - Stability

Level I Assesment



Level II: Key terms

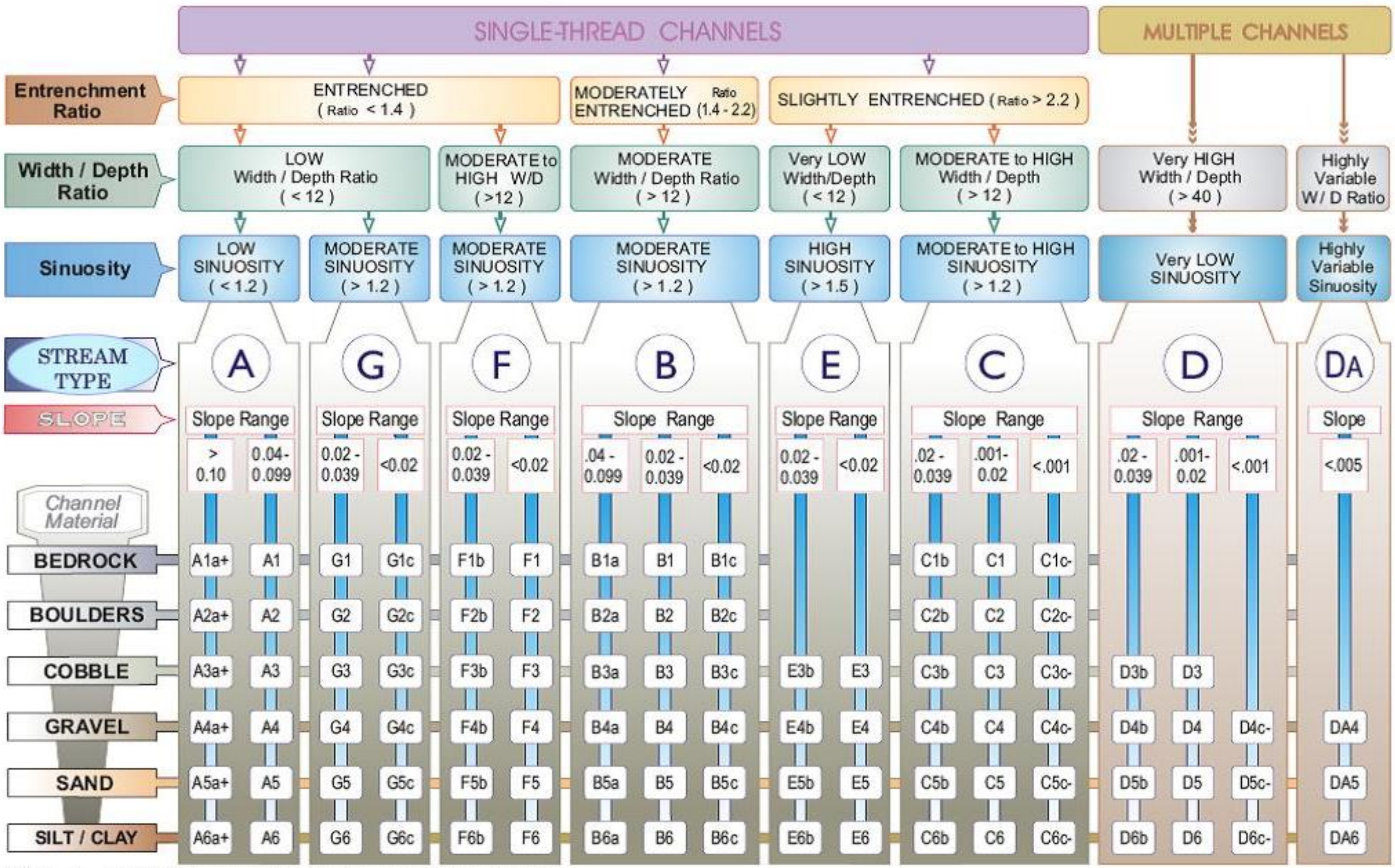
- <u>Entrenchment ratio:</u>

Width of the flood prone area/bankfull surface width

- <u>Sinuosity:</u>

Stream Length/Valley Length

The Key to the Rosgen Classification of Natural Rivers



KEY to the ROSGEN 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 +/- 2.0 units.

1481 Stevens Lake Road Pagosa Springs, CO 81147 (970) 731-6100 e-mail: wildlandhydrology@pagosa.net

Level III

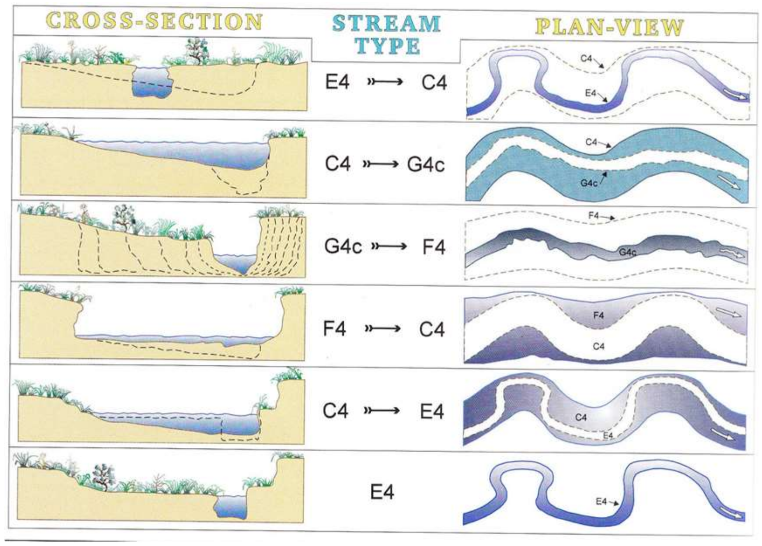
- Watershed scale instability
  - Channelization
  - Development
- Local (reach) instability
  - Outside bank of meander bend
  - Channel constrictions
- Channel stability assessment
  - Channel evolution
  - Streambank erosion

Watershed Scale Instability

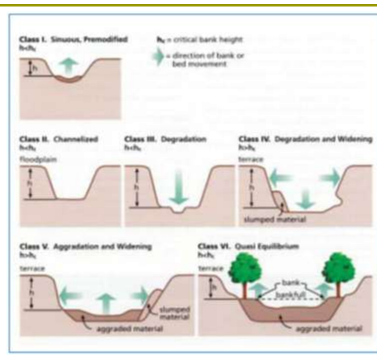
Local Scale: Outside Bend Erosion

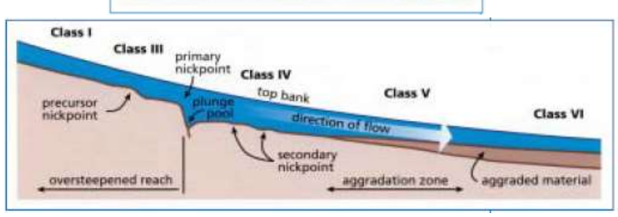
Local Scale: Channel Constrictions

Channel Evolution



Channel Evolution



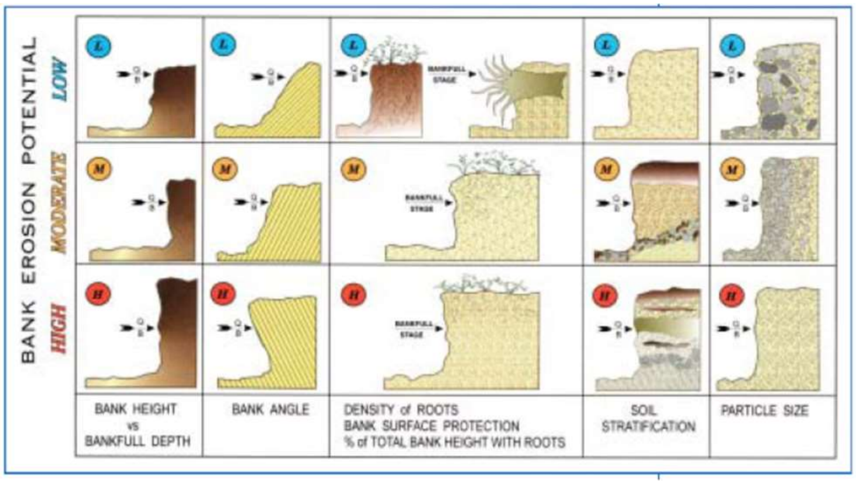


Degradation and Widening

Channel Evolution

Stream Evolution: F4 Channel

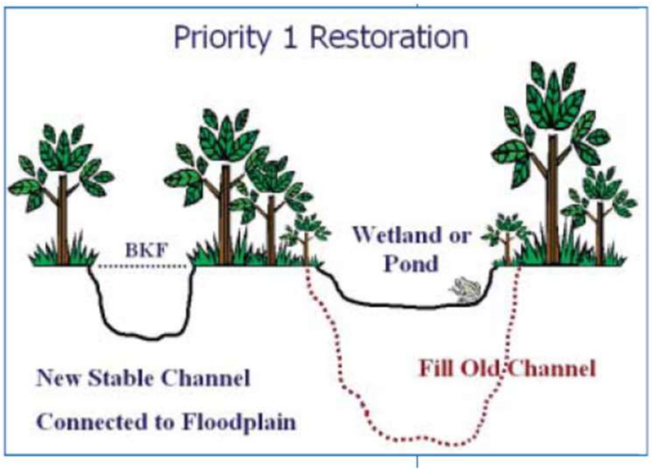
Bank Erodibility Factors



Erodibility

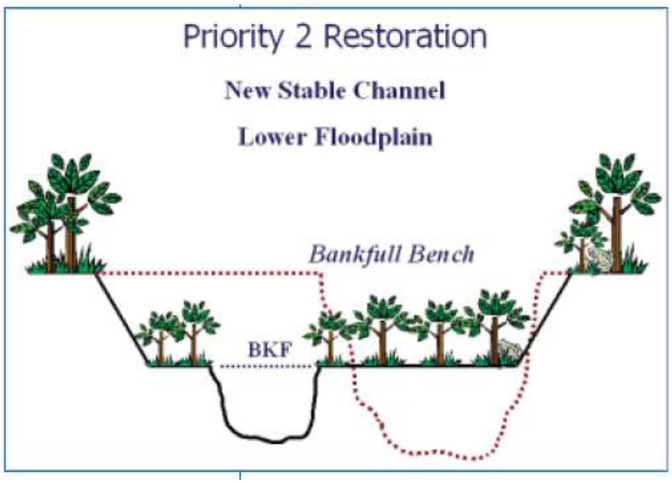
Stream Restoration Options

- I- Establish bankfull at historical floodplain elevation: E, C




Civitan Park Stream

II- Create new floodplain at present elevation: E, C



Priority 2

Before

After

III- Widen floodplain B, Bc

Priority 3

Before

After

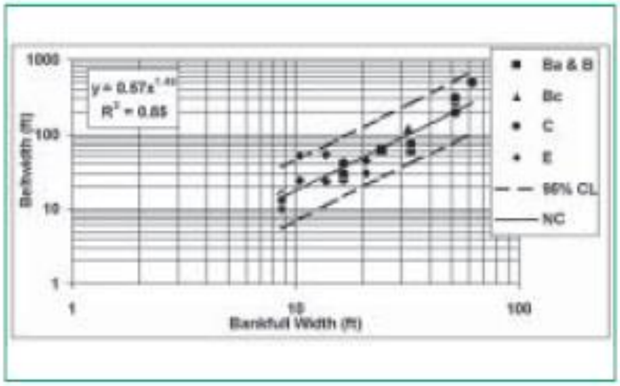


Figure 6.5

Belt width as a function of bankfull width
Clinton et al., 1999

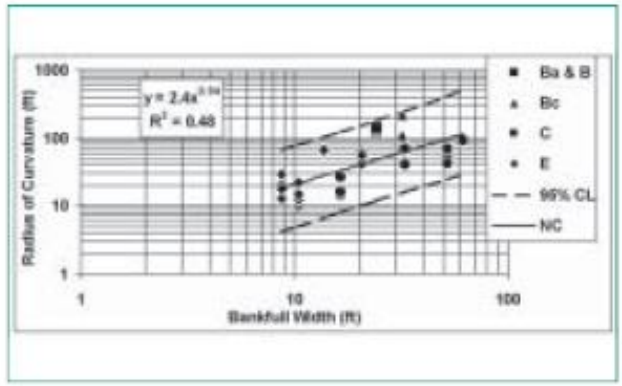


Figure 6.6

Radius of curvature as a function of bankfull width
Clinton et al., 1999

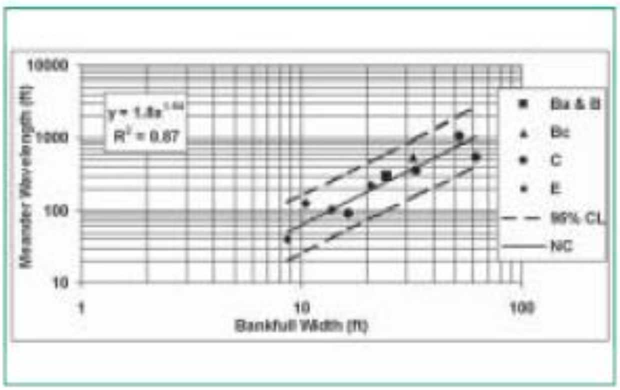


Figure 6.7

Meander wavelength as a function of bankfull width
Clinton et al., 1999

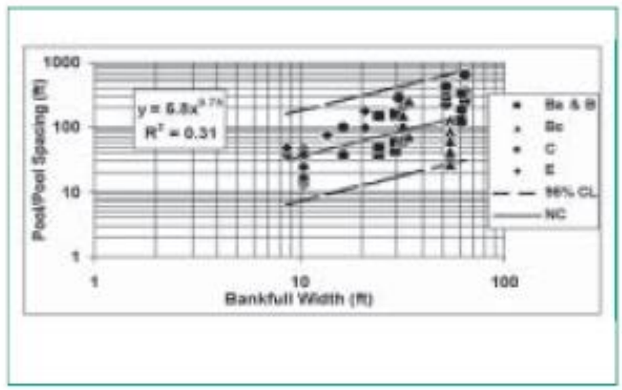


Figure 6.8

Pool-to-pool spacing as a function of bankfull width
Clinton et al., 1999

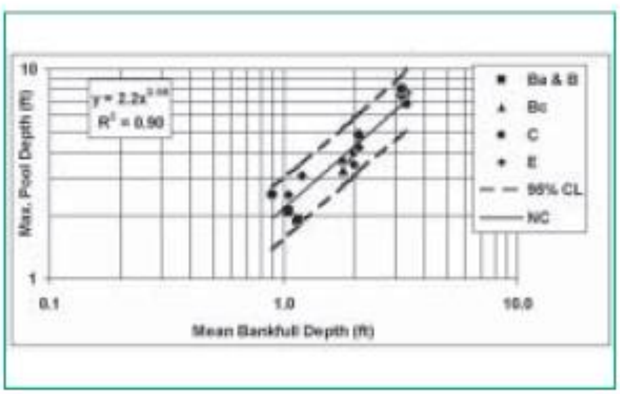


Figure 6.9

Max pool depth as a function of riffle mean bankfull depth
Clinton et al., 1999

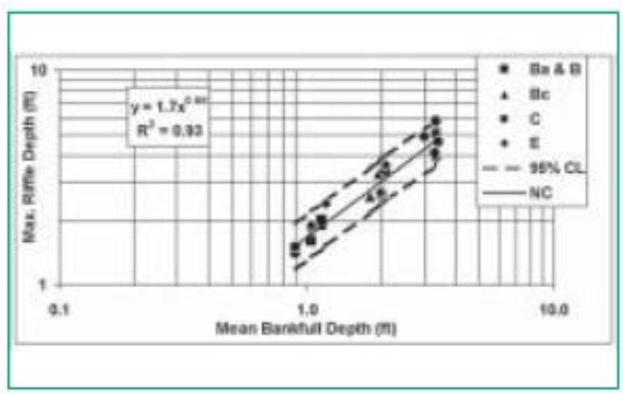


Figure 6.10

Max riffle depth as a function of mean bankfull depth
Clinton et al., 1999

IV- Stabilize Existing Streambanks in place

- Use in-stream structures
- Riprap?
- Gabions?
- Concrete?
- Bioengineering
- Study upstream and downstream impacts

Stream Stabilization?

Structures: Root Wad

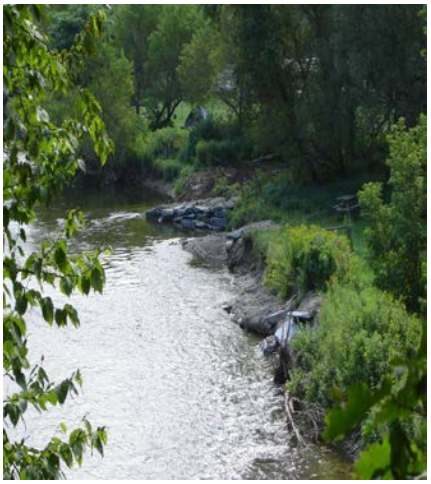
Figure 8.1

Root wad placed on outside of meander bend

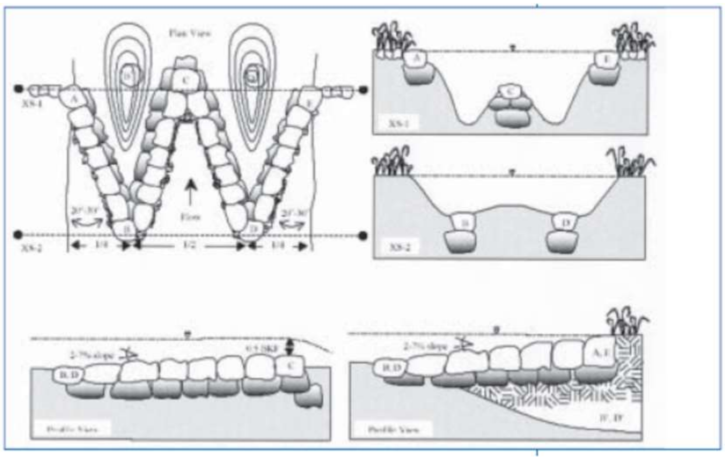
Figure 8.2

Track hoe with hydraulic thumb inserting root wad into streambank

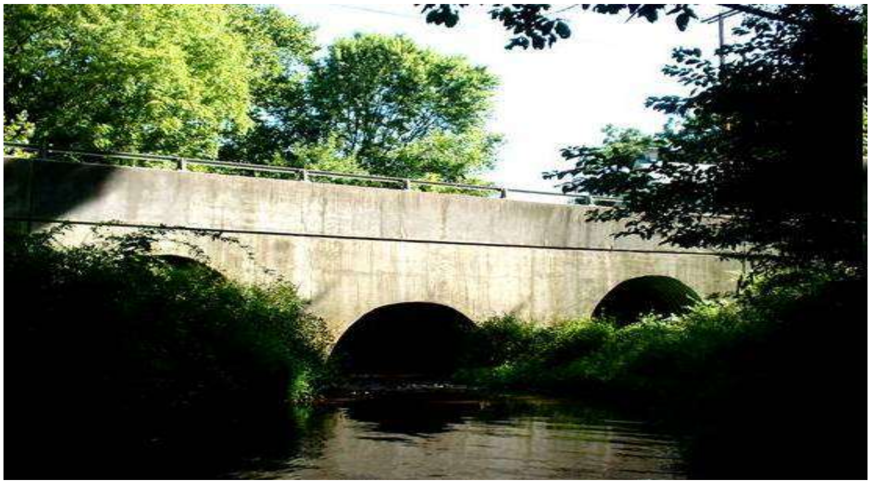
Structures: J-HookVanes



Structures: W-weir



Stream Crossings



Vegetation: Assessments are Needed Prior to Construction

- Determine if existing vegetation is a good template for revegetation
- Discover problematic issues to plan for before construction
- Identify special features to enhance or protect
- Gather ecological data for restoration planning

Soils

- Nutrients
- Compactedness
- Composition
- Plans for tilling, mulching, liming

AgriLIFE EXTENSION
Texas A&M System

Soil, Water and Forage Testing Laboratory
Department of Soil and Crop Sciences
Texas AgriLife Extension Service

D-494
S 11

SOIL SAMPLE INFORMATION FORM

Please submit this completed form and payment with samples. Mark each sample bag with your sample identification and ensure that it corresponds with the sample identification written on this form. *See sampling and mailing instructions on the back of this form.
(PLEASE DO NOT SEND CASH)

SUBMITTAL AND INVOICE INFORMATION: This information will be used for all official invoicing and communication.

Name ____________________
Address ____________________
City ____________ State ______ Zip ______

County where sampled ____________
Phone ____________

CLIENT NAME: Client name will only be included with information above on result reports.

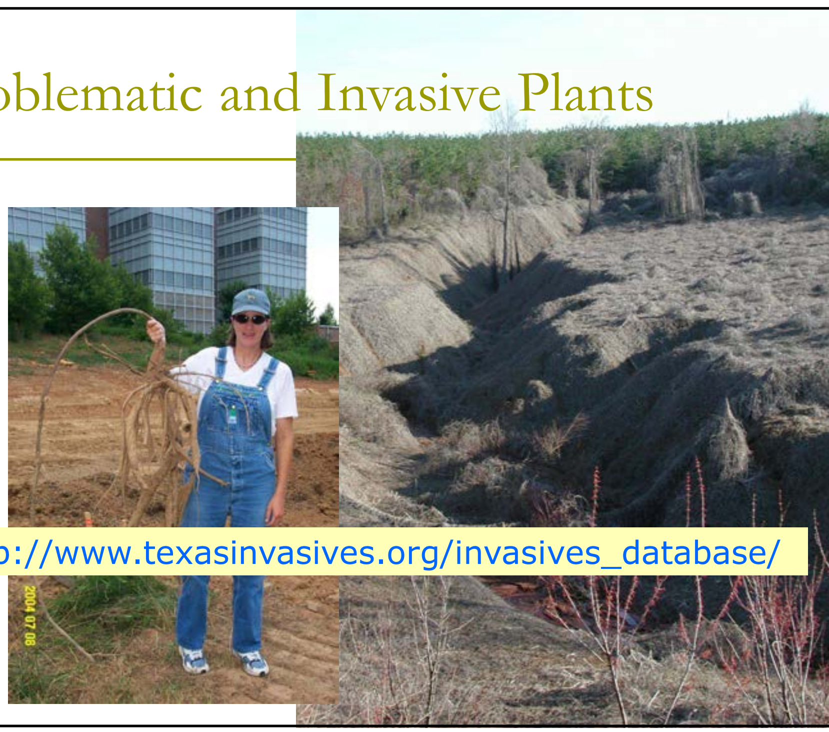
Name ____________________

Lab Use only

Payment (DO NOT SEND CASH)
☐ Check
☐ Money Order
☐ Credit Card – requires additional form*

Amount Paid $__________
Make Checks Payable to: **Soil Testing Laboratory**
*Credit card payment forms can be downloaded at http://soiltesting.tamu.edu

Problematic and Invasive Plants



http://www.texasinvasives.org/invasives_database/

Vegetation

- Salvage on-site vegetation
- Live staking (2-4 feet apart)
- Bare-root planting
- Container plant material
- Permanent seeding

Do Not Mow Streambanks

- Promotes bank stability
- Flood flow reduction
- Water quality
- Reduction of mosquito habitat
- Wildlife habitat

Evaluation and Monitoring

- Morphology
- Photo documentation
- Vegetation
- Bank stability
- Shading and temperature
- Fish and invertebrate data

Links and Resources

- USDA Stream Restoration Design: https://directives.sc.egov.usda.gov/viewerFS.aspx?id=3491
- Wildland Hydrology Resources: https://wildlandhydrology.com/resources/
- NC State University Dept. of Biological and Agricultural Engineering Extension Publications: https://www.bae.ncsu.edu/extension/extension-publications/
- Texas Stream Team at The Meadows Center for Water and the Environment: http://txstreamteam.rivers.txstate.edu/
- Invasives Database: http://www.texasinvasives.org/invasives_database/
- Texas A&M AgriLife Ecological Engineering Group: www.facebook.com/agrilifeecoeng/
- The Dallas Center’s Urban Ecological Engineering Program: http://dallas.tamu.edu/extension/engineering/

Texas A&M AgriLife Research | Extension

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Urban Riparian & Stream Restoration Program: Management & Photo Monitoring

Nathan Glavy
Texas Water Resource Institute

Hindrances to Healthy / Functional Riparian Areas:

- Farming too close to the bank
- Mowing, spraying close to the creek
- Manicured landscapes next to the creek
- *Chronic grazing concentrations in* creek areas
- Excessive deer, exotics, hogs in creek
- Burning in riparian area
- Removal of large dead wood
- Artificial manipulation of banks / sediment
- Excessive vehicle traffic in creek area
- Poorly designed road crossings / bridges
- Excessive recreational foot traffic
- Excessive alluvial pumping or other withdrawals

Visual Indicators of Stream Health Include:

http://texasriparian.org/wp-content/uploads/2013/02/Stream-Visual-Assessment-Protocol-2.pdf

- Channel condition
- Access to floodplain and hydrologic alteration
- Riparian zone
- Bank stability
- Water appearance
- Nutrient enrichment
- Barriers to fish movement
- Instream fish cover
- Pools
- Invertebrate habitat

Other factors if applicable include:

- Canopy cover
- Manure presence
- Salinity
- Riffle embeddedness
- Macroinvertebrates observed
- Fish species observed

Management and Stewardship

- The impacts of stream flow and water quality are cumulative as the water moves down the system.
- Management upstream can lead to positive or negative impacts downstream.
- As you assess the stream and riparian ecosystem, think about what may be hindering it.
- Has something caused a change in the water, sediment or vegetation?
- Management activities should protect healthy systems or allow recovery to return to a healthy functioning system.
- Land and Water Stewardship!

Access to Streams

- Restricting access to specific points along a stream should be a primary goal.
- This will eliminate most of the bank erosion caused by human traffic and wildlife.
- Develop access ramps or trails with hardened surfaces such as coarse gravel over geotextile and slopes of 6:1 or flatter.
  - Reduces amount of vehicles, boats, foot traffic along the banks by providing one main access point for recreators.
- Locating shade, salt, minerals, and winter feeding sites in portions of the pasture away from the stream will help reduce the time livestock spend at or adjacent to the water.

Managing Invasive Species

- Noxious and Invasive species include any species that has a serious potential to cause economical or ecological harm to agriculture, native plants, ecology and waterways.
- Invasives are affecting aquatic, riparian and upland areas throughout the state.
- The Texas Department of Agriculture currently lists 30 noxious weeds proliferating in Texas: giant salvinia, giant cane (*Arundo donax*), Chinese tallow tree are some of the most potent invaders.
- Feral hogs are estimated to cause an estimated $52 Million in damage annually in Texas and are increasing in numbers.
- Manage to reduce invasive species.

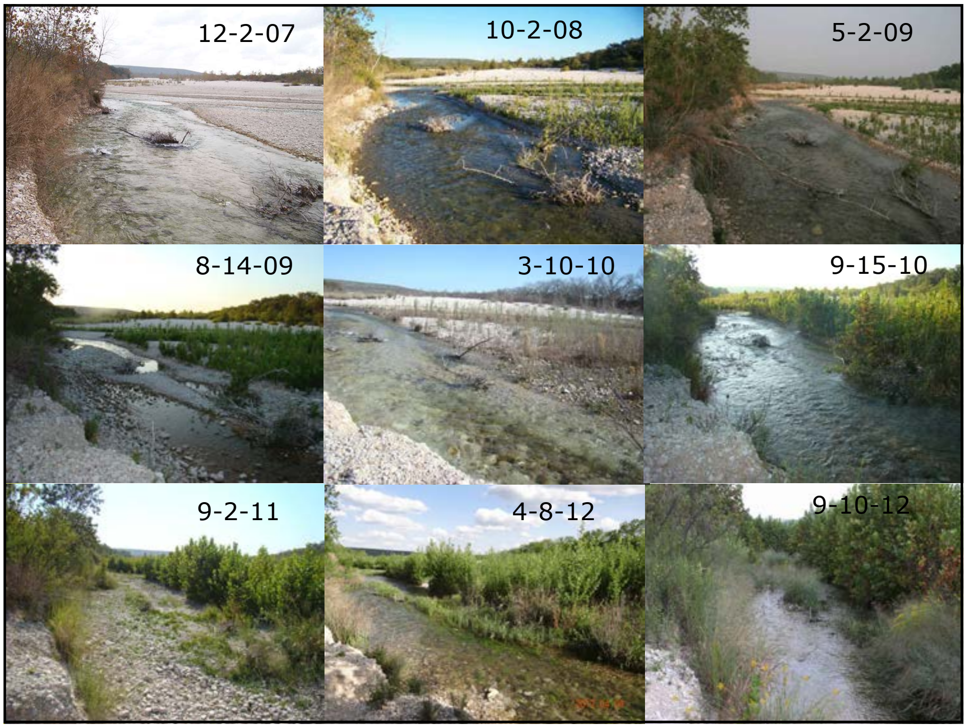
Austin Grow Zone

- Establish a "Grow Zone" along both banks of the creek, approximately 25 ft.
- Allow for passive/natural plant growth in entire buffer area.
- Monitor for changes over time and apply adaptive management approaches where necessary.
- Coordinate periodic trash removal, weed/invasive vegetation management, and native seeding/planting.
- Install educational and demarcation signage where appropriate.

Mowed | First Year Growth | 5 to 10 Years

Photo Monitoring

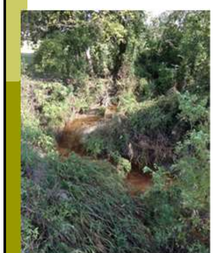
- Repeating photographs at set locations will allow better assessment of current conditions and changes over time.
- Location selection: critical sites along the stream where the force of moving water has the potential for detrimental impacts
  - A tributary or high runoff location
  - Where the stream changes course – point bar or bend
  - Sites that are easily accessible and representative

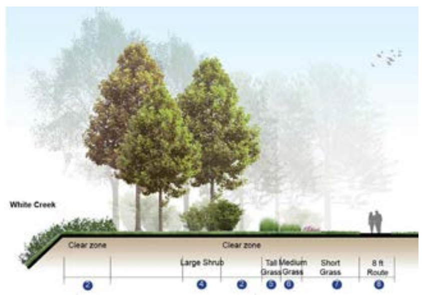


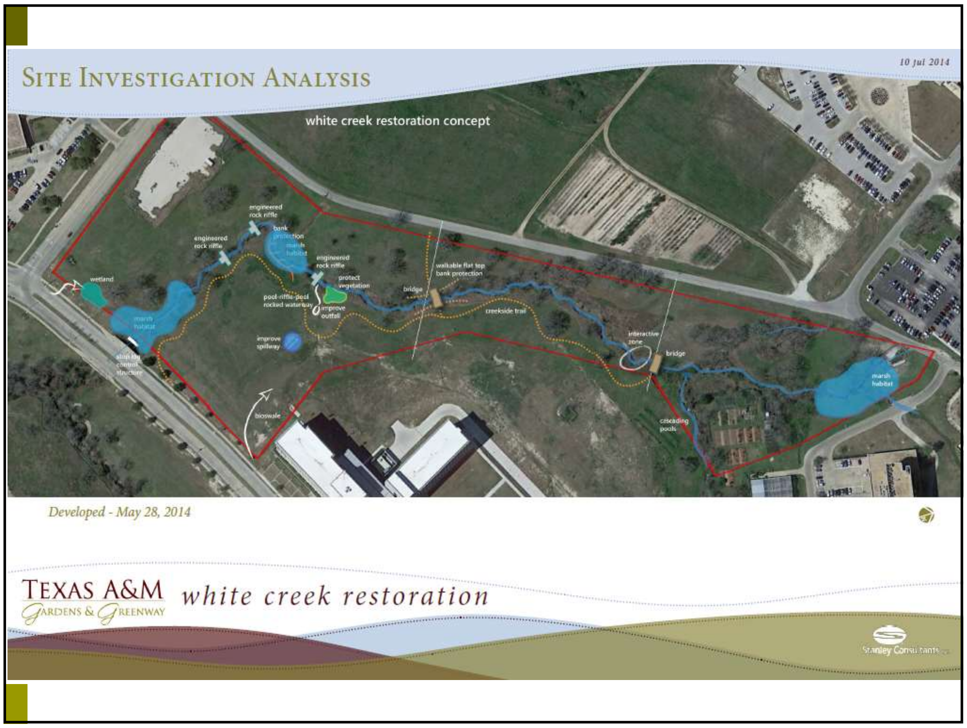
2015 May Flood and Post Flood

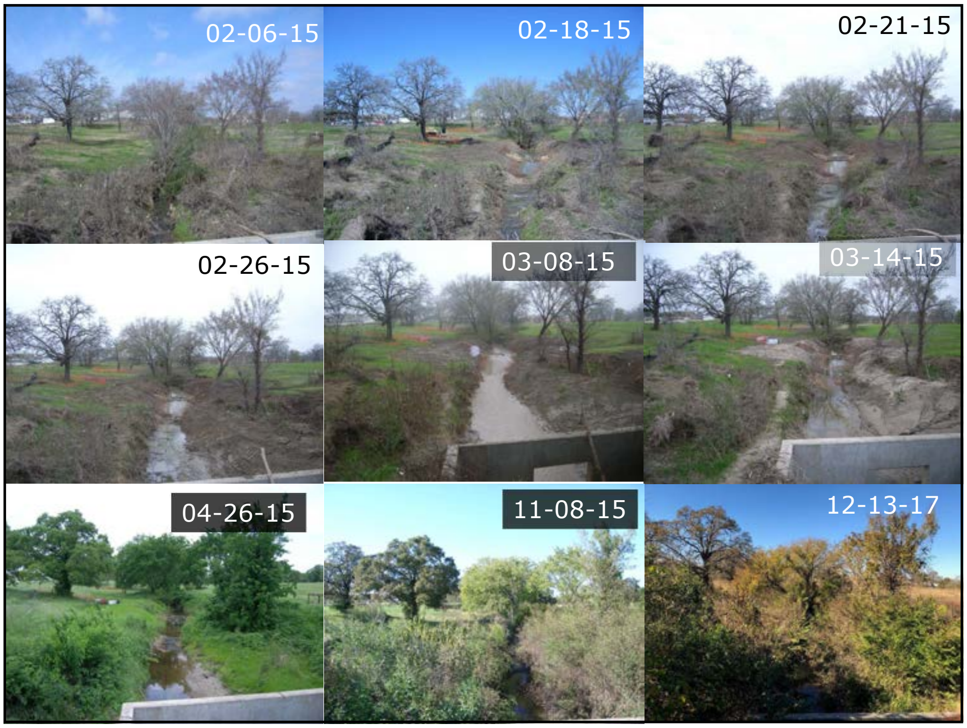
Texas A&M Gardens and Greenway

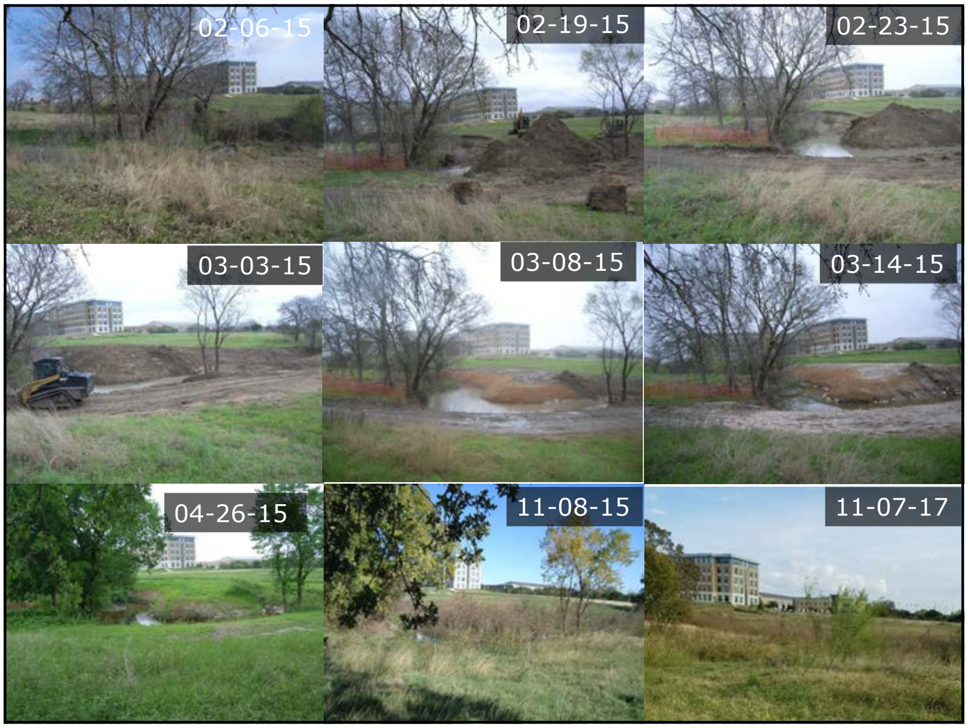
White Creek Stabilization






SITE INVESTIGATION ANALYSIS
10 Jul 2014
white creek restoration concept
wetland
engineered rock riffle
engineered rock riffle
bank protection
engineered rock riffle
protect vegetation
improve outfall
improve spillway
bridge
walkable flat top bank protection
creekside trail
interactive zone
bridge
marsh habitat
cascading pools
bioswale
Developed - May 28, 2014
TEXAS A&M GARDENS & GREENWAY
white creek restoration
Stanley Consultants


02-06-15
02-18-15
02-21-15
02-26-15
03-08-15
03-14-15
04-26-15
11-08-15
12-13-17

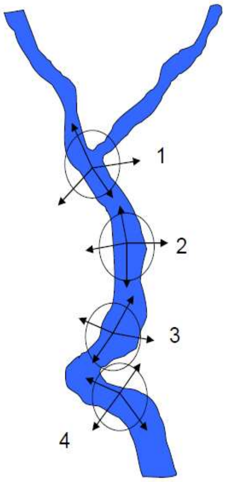


Permanent Photo Point Method

- Four photographs should be taken at each observation site:
  - 1) upstream showing the nearest bank , stream channel and opposite bank if possible,
  - 2) perpendicular to the stream of the opposite bank,
  - 3) perpendicular to the stream away on the bank where the observer is standing, and
  - 4) downstream showing the channel and both banks if possible.
- With a felt pen and a yellow paper pad (white is too bright), make a sign to include in the photo scene.
- Include some identification (stream name, range site, etc.) concerning the specific scene being photographed and the date.

Key Locations to Monitor

- Each location should be permanently marked for future evaluations using a steel stake or on-the-ground reference plus GPS coordinates if possible.
- Locate the permanent reference point a "safe" distance inland
- Make a map of the stream showing the location of each permanent marker and the monitoring point.



Physical location for monitoring stream-riparian areas should be located on either bank. Arrows show the direction of photographs.

Thank You!

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Pebble Count

Overview

The composition of the streambed and banks is an important facet of stream character. It influences channel form and hydraulics, erosion rates, sediment supply and other parameters. Each permanent reference site should include a basic characterization of bed and bank material.

The composition of the streambed (substrate) influences how streams behave. Steep mountain streams with beds of boulders and cobbles act differently than low-gradient streams with beds of sand or silt. This difference may be documented by a quantitative description of the bed material called a pebble count.

Pebble count consists of 3 parts: The first requires collecting samples a total of 100 pebbles from cross sections throughout the longitudinal reach of the stream. This count is used for stream classification. The second samples 100 pebbles at a single cross section. This is for cross-section analysis. The third also samples 100 pebbles at a riffle, but includes only the pebbles from the wetted perimeter (anywhere the water is in contact with the channel bed) at normal flow. This count is used to calculate entrainment and velocity. The third part will be undertaken in this workshop.

(Source: *Doll, B.A., G.L. Grabow, K.R. Hall, J. Halley, W.A. Harman, G.D. Jennings and D.E. Wise, 2003. Stream Restoration: A Natural Channel Design Handbook. NC Stream Restoration Institute, NC State University. 128 pp.*)

Pebble Count Instructions

Step 1. Collect 100 pebbles from a riffle cross section, zigzagging from the left water's edge to the right water's edge at normal flow.

Step 2. Measure the intermediate axis of each particle collected (Figure 1). Measure embedded particles or those too large to be moved in place by using the smaller of the two exposed axes. Call out measurements for the note-taker to tally by size class. Sample pebble count data sheets are in Table 1.

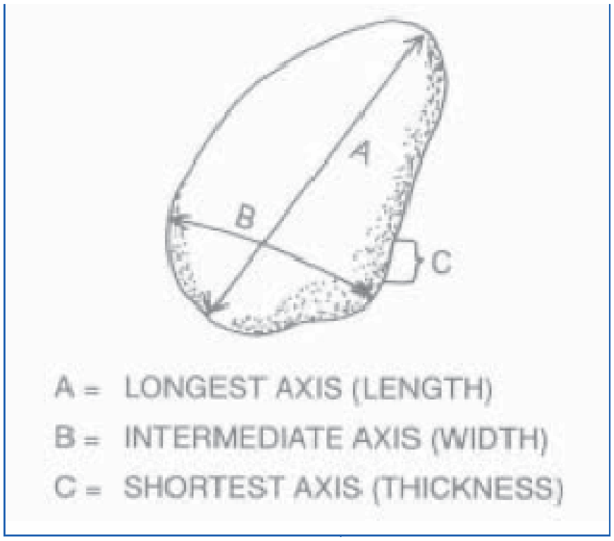


Figure 1. Axes of pebble.

Step 3. Take a step forward and collect a pebble moving across the channel in a direction perpendicular to the flow. Repeat the process, continuing to pick up particles until the requisite number of measurements is taken. The note-taker should keep count. Continue traversing the stream until all areas between the left and right edges of water are representatively sampled.
Step 4. After counts and tallies are complete, plot the data by size-class and frequency. Table 1 is an example of a pebble-count form. A sample pebble count plot is shown in Figure 2.
Step 5. For stream Classification, use the d_{50} value.

For more information refer to : Doll, B.A., G.L. Grabow, K.R. Hall, J. Halley, W.A. Harman, G.D. Jennings and D.E. Wise, 2003. Stream Restoration: A Natural Channel Design Handbook. NC Stream Restoration Institute, NC State University. 128 pp. Also available at: http://www.bae.ncsu.edu/programs/extension/wqg/srp/guidebook.html

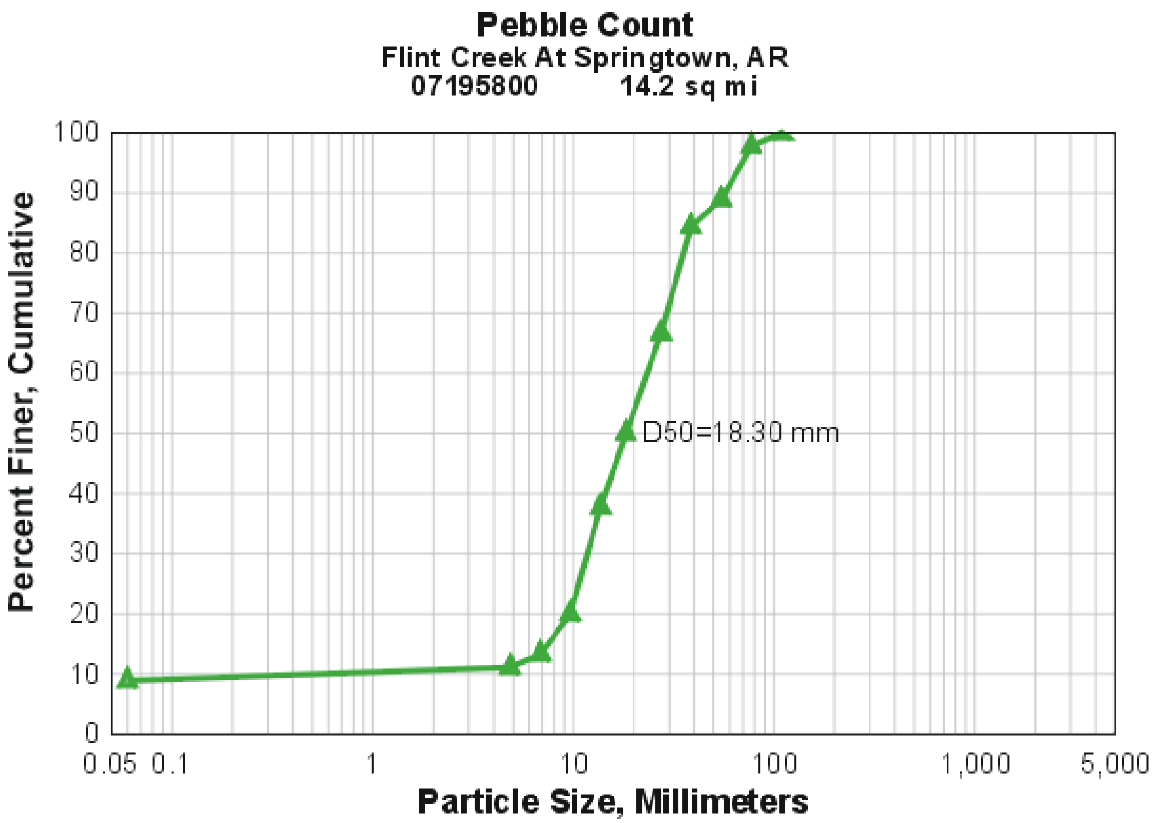


Figure 2. Example cumulative pebble count plot.

Pebble Count										Pebble Count			Pebble Count		
Site:		Date:								Date:			Date:		
Party:		Reach:								Reach:			Reach:		
INCHES	PARTICLE	MILLIMETERS		PARTICLE COUNT			TOTAL#	ITEM %	%CUM	TOTAL#	ITEM %	%CUM	TOTAL#	ITEM %	%CUM
	SILT/CLAY	< .062	S/C	1	2	3									
	Very Fine	.062 – .125	S												
	Fine	.125 – .25	A												
	Medium	.25 – .50	N												
	Coarse	.50 – 1.0	D												
.04 – .08	Very Coarse	1.0 – 2	S												
.08 – .16	Very Fine	2 – 4													
.16 – .24	Fine	4 – 6	G												
.24 – .31	Fine	6 – 8	R												
.31 – .47	Medium	8 – 12	A												
.47 – .63	Medium	12 – 16	V												
.63 – .94	Coarse	16 – 24	E												
.94 – 1.26	Coarse	24 – 32	L												
1.26 – 1.9	Very Coarse	32 – 48	S												
1.9 – 2.5	Very Coarse	48 – 64													
2.5 – 3.8	Small	64 – 96	C												
3.8 – 5.0	Small	96 – 128	O												
5.0 – 7.6	Large	128 – 192	B												
7.6 – 10	Large	192 – 256	L												
10 – 15	Small	256 – 384	B												
15 – 20	Small	384 – 512	L												
20 – 40	Medium	512 – 1024	D												
40 – 160	Lrg-Very Lrg	1024 – 4096	R												
	BEDROCK		BDRK												
					TOTALS										

Cross-Section Instructions

1. Set up the level at a location where the entire cross-section is visible (watch for obstacles such as trees). The instrument location should be above the highest point in the cross-section (Figure 1).
2. Measure the distance across the channel with a tape. Keep the tape stretched perpendicular to the flow during the entire exercise.
3. Determine the Bankfull maximum depth by measuring the distance between the deepest point and the Bankfull Stage (D_{MAX}).
4. Take a Backsight (BS) to a permanent feature so that you can use it later for cross checking your data. (You can use an assumed known elevation for the Benchmark e.g. 100 ft). Determine the height of instrument HI (Table 1).
5. Take rod readings to the major features of the stream channel (top of left bank, left bankfull, left edge of water, thalweg, right edge of water, right bankfull, and top of right bank) along the tape. Record both distance and rod reading. Left and right are always determined looking downstream. (Table 1).
6. Measure the width at an elevation 2 times the Maximum Bankfull Depth. This is known as the Flood Prone Width (W_{fpa})
7. Calculate bankfull cross sectional area and plot cross section(Table 2, Figure 2)
8. Calculate mean depth (D_{BKF}), Width/Depth ratio (W/D) and entrenchment ratio (ER) Use worksheet (last page in this handout)
9. Check Regional curves (available at http://www.wildlandhydrology.com/assets/Rosgen_Geomorphic_Channel_Design.pdf) to make sure cross sectional area,b ankfull width and depth are reasonable)

Figure 1. Cross section survey.

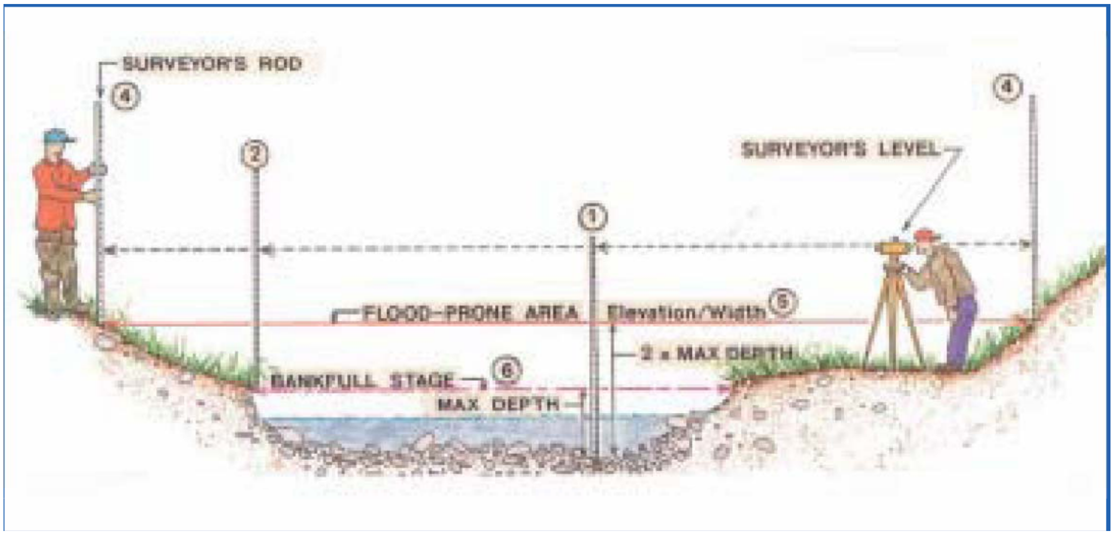


Table 1: Cross-Section Form (example)

*Instructions: Enter data only in gray cells

Site:

	Distance, Point, or	Back-Sight	Height of Instrument	Fore-Sight	
Station	**BS**	**HI**	**FS**	**Elevation**	**Notes, Comments, Remarks**
ft	ft	ft	ft	ft	
BM	5	105	----	100	Benchmark
0			8	97	LBF
2			8.25	96.75	
3			8.8	96.2	
6			9	96	
8			9.5	95.5	LEW
12			10	95	THL
16			9.95	95.05	REW
19			9.5	95.5	
21			9	96	
22			8.45	96.55	
25			8	97	RBF

BM=Benchmark
LBF=Left Bankfull
LEW=Left Edge Water
THL=Thalweg
REW=Right Edge Water
RBF=Right Bankfull

Unit helper

Field Measurement			able form
ft	in	in (fraction)	ft
1	0	0	1.000
ft	in	in (fraction)	ft
0	1	0	0.083
ft	in	in (fraction)	ft
0	0	1/8	0.010

Table 2: Cross-Sectional Area Calculation (example)

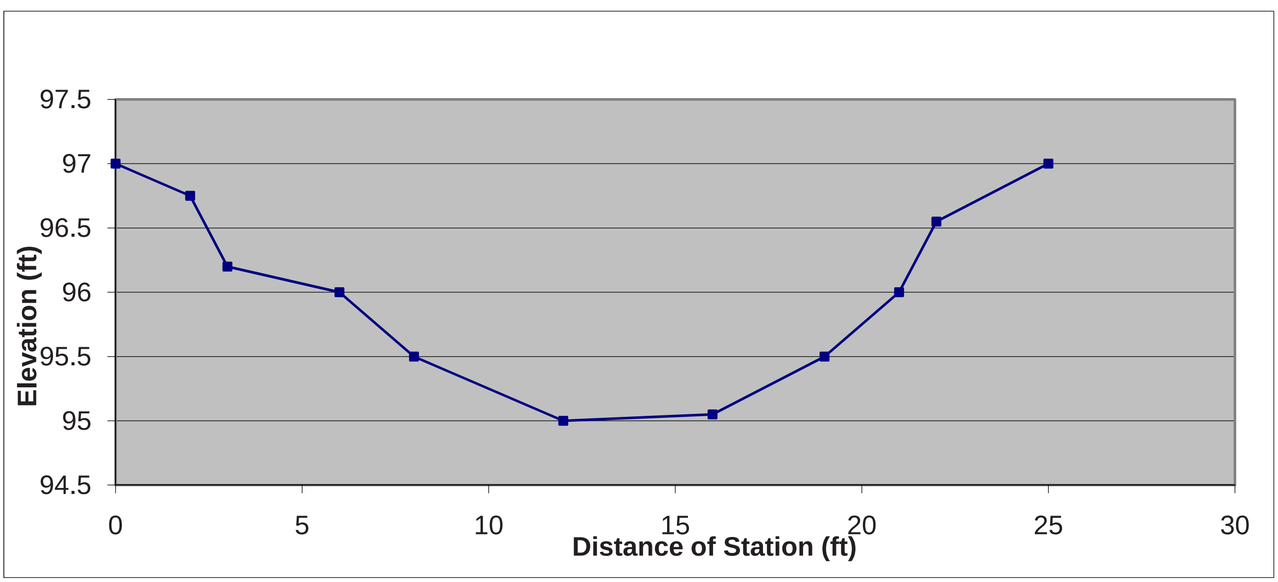
Station	Elevation	Depth	Cell Width	Average Cell Depth	Incremental Area
0	97	0	-----	-----	-----
2	96.75	0.25	2-0=2	(0+.25)/2=0.125	2x0.125=0.25
3	96.2	0.8	1	0.525	0.525
6	96	1	3	0.9	2.7
8	95.5	1.5	2	1.25	2.5
12	95	2	4	1.75	7
16	95.05	1.95	4	1.975	7.9
19	95.5	1.5	3	1.725	5.175
21	96	1	2	1.25	2.5
22	96.55	0.45	1	0.725	0.725
25	97	0	3	0.225	0.675
				Total Area (ft^2)	30.0

Key Morphological Parameters

Bankfull Area (ft^2)	Bankfull Width (ft)	Mean bankfull Depth (ft)	Width/Depth Ratio
30.0	25.0	1.2	20.9

Width of Flood Prone Area (ft)	Entrenchment Ratio
35.0	1.4

(measured value)



TEXAS A&M AGRILIFE EXTENSION

Stream processes and restoration
Dr. Fouad Jaber

Item	Distance, Point, or Station (ft)	Back-Sight BS (ft)	Height of Instrument HI (ft)	Fore-Sight FS (ft)	Elevation (ft)	Notes, Comments, Remarks
1	BM		100	----	100	Benchmark
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

BM=Benchmark
LBF=Left Bankfull
LEW=Left Edge Water
THL=Thalweg
REW=Right Edge Water
RBF=Right Bankfull

Unit helper

Field Measurement			Table form
ft	in	in (fraction)	ft
1	0	0	1.000
ft	in	in (fraction)	ft
0	1	0	0.083
ft	in	in (fraction)	ft
0	0	1/8	0.010

Stream Survey Data Sheet

Site:

Riffle Cross-Section:

Area at Bankfull, A_{bkf}	0.0	ft^2	Mean Depth at Bankfull, $D_{bkf}=A_{bkf}/W_{bkf}$	0.0	ft
Width at bankfull, W_{bkf}	0.0	ft	Entrenchment Ratio, ER= $Wfpa/W_{bkf}$	0.0	ft/ft
Width Flood Prone Area, W_{fpa}	0.0	ft	Width to Depth Ratio, $W/D=W_{bkf}/D_{bkf}$	0.0	ft/ft
Maximum Depth Bankfull, D_{max}	0.0	ft	Bank Height Ratio, $BHR=D_{TOB}/D_{max}$	0.0	ft/ft
Max Depth Top Low Bank, D_{TOB}	0.0	ft	Max Depth Ratio=D_{max}/D_{bkf}	0.0	ft/ft

Longitudinal Profile:

Length of Channel Thalweg		ft	Slope of Channel	0	ft/ft
Length of valley		ft	Sinuosity	0	ft/ft
Elevation Change		ft			

Pool Cross-Section:

Pool Area at Bankfull		ft^2	Pool Area Ratio		ft^2/ft^2
Pool Width at Bankfull		ft	Pool Width Ratio		ft/ft
Pool Max Depth Bankfull		ft	Pool Max Depth Ratio		ft/ft

Pattern survey

Meander Wavelength		ft	Meander Wavelength Ratio		ft/ft
Meander Belt Width		ft	Meander Width Ratio		ft/ft
Radius of Curvature		ft	Radius of Curvature Ratio		ft/ft

Pebble Count Results (reachwide):

Median Particle Size, d50	-	mm

More information about Texas Water Resources Institute's trainings can be found at:

twri.tamu.edu/urban-riparian

or

texasriparian.org