Principles of Wetlands Creation and Restoration in North Carolina

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BAE 495R: Applications of Ecological Engineering
Spring 2009

Wetlands must have

- USACE - Hydrophytic vegetation, hydric soils, and inundated/saturated to the surface (within 12 in) for 5-12.5 % of the growing season - 12-30 days
- http://www.saj.usace.army.mil/permit/documents/87manual.pdf
- Much debate
- Which is the most important component?
  - Hydrophytic Vegetation
  - Hydric Soils
  - Hydrology

True or False
Can you legally build on wetlands?

- Yes but you must obtain a permit that shows you have tried to
  - Avoid Impact
  - Minimize Impact
- Then you must compensate for impact in one of 3 ways
  - Rebuild a wetland yourself (**Permittee responsible mitigation**)
  - Buy one from a **mitigation bank** (a wetland area already enahnced or restored that has been set aside by a third party)
  - **In-Lieu Fee mitigation** - pay into a wetlands fund (i.e. NCDENR -NCEEP) for wetlands to be built later

Permitting

- Federal
  - Section 404 provisions of Clean Water Act (USACE oversees permitting)
- NC
  - To receive federal permit, must satisfy State requirements under Section 401 rules to protect water quality
  - Must adhere to CAMA regulations if in coastal counties
- There are exceptions
  - Nationwide 26 permit - smaller freshwater wetlands (1/3 acre – 1 acre) require only USACE notification
  - Ongoing farming, ranching, and forestry operations

Wetland Creation and Restoration

Wetland Restoration
(NRCS Code 657, 1998)

- "A rehabilitation of a drained or degraded wetland where the soils, hydrology, vegetative community, and biological habitat are returned to the natural condition to the extent practicable"

Wetland Creation (NRCS Code 658, 1998)

- "A wetland that has been created on a site location which historically was not a wetland
- or is a wetland, but the site will be converted to a wetland with a different hydrology, vegetation type, or function than naturally occurred at the site"

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Wetland Enhancement (NRCS Code 659, 1998)

- "The modification or rehabilitation of an existing or degraded wetland, where specific functions and/or values are modified for the purpose of meeting specific objectives.
- Some functions may remain unchanged while others may be degraded."

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Restore, Create or enhance?

- Compensation ratios
- Depends on distance from surface water
- Restore/create 2:1 – 4:1 near stream (150 ft)
- Enhancement or preservation ratios if allowed up to 10:1

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Steps for Restoration/Creation

- Define Restoration/Creation goals
- Permitting?
- Identify/survey reference community
- Design and/or design models
- Special considerations at this site and are they economically feasible?
- Construction sequencing plan
- Planting Plan
- Post construction monitoring Plan
- Identify Success criteria

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Wetland Restoration/Creation

- Must have a defined goal based on values of wetland mitigating for
- Examples
  - General Habitat
  - Waterfowl
  - Flood control/hydrologic dampening
  - Downstream water quality improvement

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New restorations should use a Reference based approach

- Locate 1 or more nearby "Natural" established wetland communities to help identify final restoration site and design criteria
- Gives info on target
  - Hydrology
  - Soil type
  - Vegetation type
  - Water quality levels

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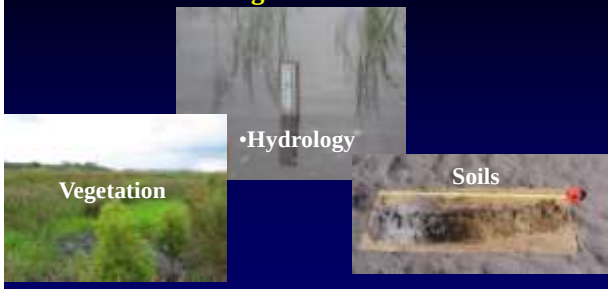
To achieve a successful wetland restoration, creation, or enhancement you must get the following criteria correct:



Which is the most important?

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Wetland Hydrology

- Hydrology is the primary driving force influencing wetland development, character, function(s) and persistence
- Wetland restoration success will require **getting the hydrology right**

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Wetland Hydrology

- Science of water as it relates to the origin, circulation, and distribution of water
- Hydrologic Cycle
- Water flows/moves from point of high potential (hydraulic head) to point of lower potential
- Water flows downhill

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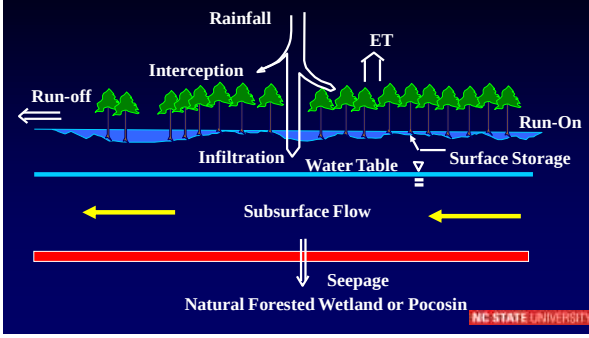
Surface Depressional Storage



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Example - Hydrologic Restoration of Prior Converted Wetlands

- Drained with ditches, subsurface drains
- Also crowned and smoothed
- Fertilizer/pesticide inputs

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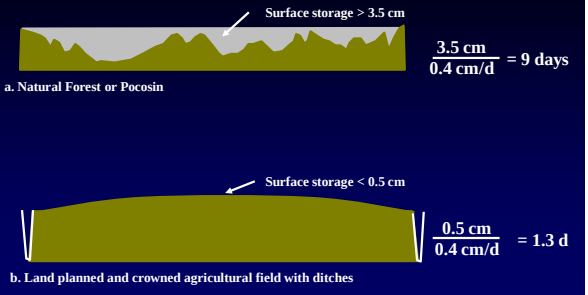
Natural wetlands have more surface storage and retain water inputs longer



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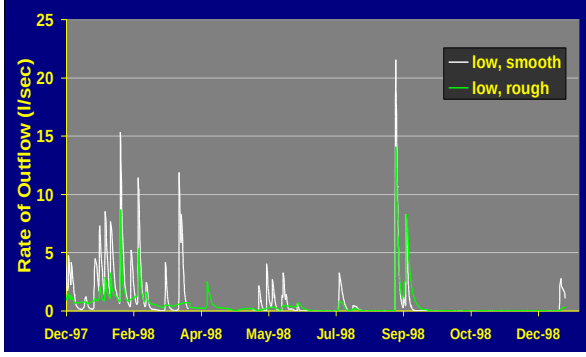
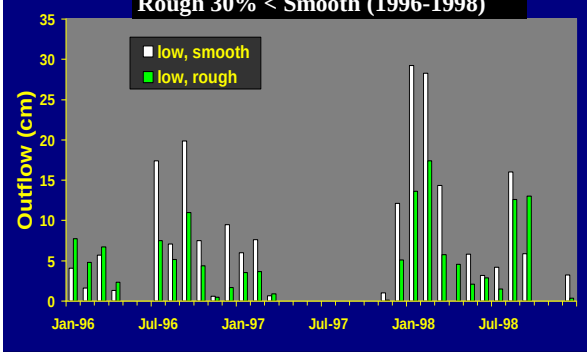
Influence of Surface Roughness on Outflow Rate

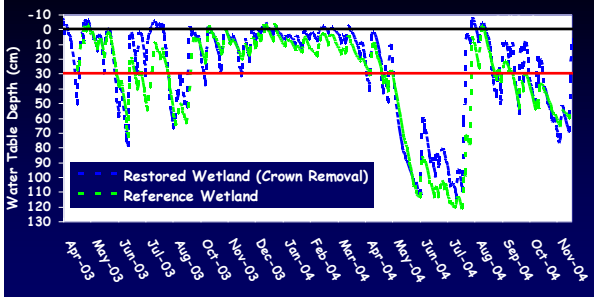


Influence of Surface Roughness on Total Outflow

Rough 30% < Smooth (1996-1998)



Must meet wetland criteria 1 out of 2 years



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Vegetation

- Provide soil stability
- Habitat
- Roots for microbial activity
- Evapotranspiration
- Unlimited supply of organic carbon that make wetlands pollutant sinks

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Vegetation selection

- Restoration sites are often planted to speed natural succession
- Must have a clear planting plan
- Can be expensive
- Results can vary
  - Natural seedbanks (enhancement (+) or competition (-))
  - Site preparation/maint. (herbicides/mowing)
  - Weather following planting
  - Source of the plants (viability)
  - Herbivory
  - Was the hydrology correct?

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Vegetation – Bottomland Hardwood/Swamp

Taxodium distichum (bald cypress)
Nyssa aquatica (water tupelo)
Chamaecyparis thyoides (Atlantic white cedar)
Nyssa sylvatica (swamp blackgum or tupelo)
Quercus lyrata (overcup oak)
Quercus michauxii (swamp chestnut oak)
Fraxinus pennsylvanica (green ash)
Quercus nigra (water oak)
Quercus pagoda (cherry bark oak)
Quercus laurifolia (laurel oak)
Persea palustris (swamp bay)
Pinus palustris (longleaf pine)

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Wetland hardwood trees

Tupelo

Cypress

Atlantic White Cedar

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Vegetation – Freshwater Marshes

Freshwater Marsh (salinity < 0.5 ppt)

Elevation	Species
Lowest elevation	*Schoenoplectus tabernaemontani* (soft stem bulrush)
	Schoenoplectus americanus (three square)
	Peltandra virginica (arrow arum)
Mid elevation	*Cladium jamaicense* (saw grass)
	Amsonia ciliata (soft rush)
High elevation	*Schoenoplectus cyperinus* (woolgrass)
Shrubs and trees	Same as brackish marsh with additional tree species such as
	Nyssa sylvatica (swamp blackgum or tupelo)
	Quercus lyrata (overcup oak)
	Quercus michauxii (swamp chestnut oak)
	Fraxinus pennsylvanica (green ash)

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Pickeralweed

Bulrush

Woolgrass and cattail

Cardinal Flower

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Vegetation – Brackish Marshes

Brackish Marsh (salinity 0.5 to 35 ppt)

Elevation	Species
Lowest elevation adjacent to stream	*Spartina alterniflora* (smooth cordgrass)
Mid elevation	*Juncus roemerianus* (Black needle rush)
	Spartina cynosuroides (big cordgrass)
High marsh	*Spartina patens* (saltmeadow cordgrass)
Occasional shrubs	*Myrica cerifera* (wax myrtle)
	Baccharis halimifolia (groundsel tree)
	Hibiscus moscheutos (rose mallow)
	Salsal minor (pickerel)
Trees	*Taxodium distichum* (bald cypress)
	Nyssa aquatica (water tupelo)
	Chamaecyparis thyoides (Atlantic white cedar)

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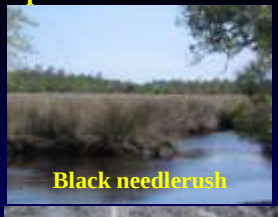
Salt marsh species

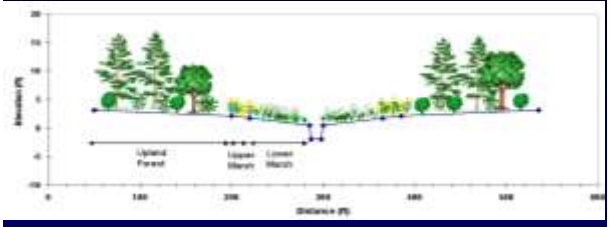
Smooth cordgrass



Black needlerush

Sawgrass

Salt meadow cordgrass



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Soils

- The importance of soils cannot be overlooked during design and construction
- Permeable layers will threaten hydrologic goals
- Excavation must be followed by redistribution of topsoil to ensure plant growth
- Soil type will affect equipment traffic
- Over time detrital mat will form

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Biological & Agricultural Engineering

CASE Study

North River Farms – Restoration of Multiple Wetland Communities

Drainage of Wetlands for Agriculture

- Prior converted wetlands drained with ditches typically spaced at 100 meters
- Fields crowned to improve surface runoff
- Poorly drained soils rich in organic matter – highly productive farmland

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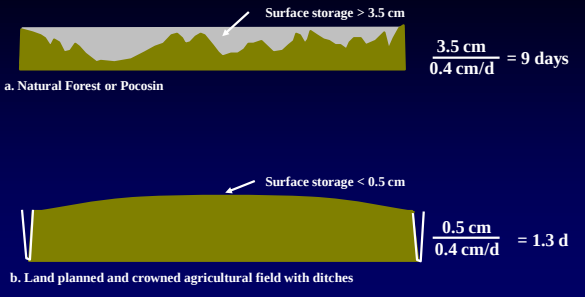
Natural wetlands have more surface storage and retain water inputs longer



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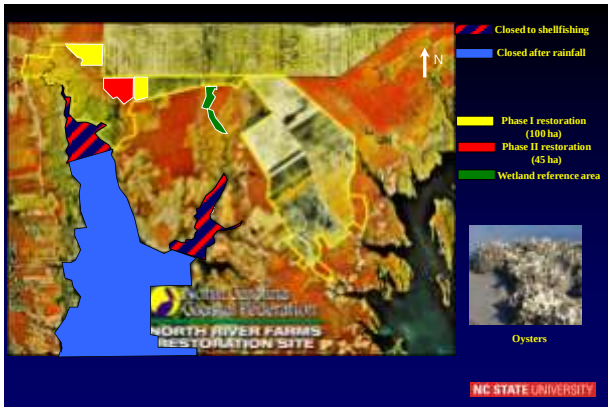

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NCSU-BAE Project goals

- Advance the science of wetland restoration
- Provide NC EEP with guidance for design and construction techniques
- Improve water quality of the North River estuary
- Restore habitat function of the farmland

Ecosystem Enhancement PROGRAM

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Restoration/Research Activities

- **NCSU Phase I** (250 ac. Non-riverine wet hardwood forest)
  - Design and Construction (2002-March 2003)
  - Monitoring
    - Post Construction (2003-Present)
    - Reference Wetland (2003-Present)
    - Phase II Background (2003-2005)
- **NCSU Phase II** (100 acre. – multiple communities)
  - Design and Permitting (2004)
  - Construction (Aug 2005 – July 2007)
  - Monitoring (June 2006-Present)

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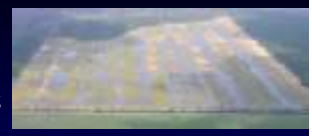
Phase I Construction – Non-Riverine Wet Hardwood Forest

- Jan 2003- March 2003



- Features
  - Multiple restoration techniques
  - Ditch plugs and land contouring
  - Berms to separate treatments
  - Simulated treefalls
  - Open water areas
  - Reference wetland identified

- Water control structures to control/measure outflow
- 85,000 trees planted (oaks, green ash, cypress, pine, Atlantic white cedar)

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February 5, 2003

May, 2003

Photo courtesy of Restoration Systems

June 3, 2003

May 2005

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Summer 2006

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What we have learned (or confirmed) about converting PC lands to Non-Riverine Wet Hardwood Forest

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1. Monitoring can be a "Bear"

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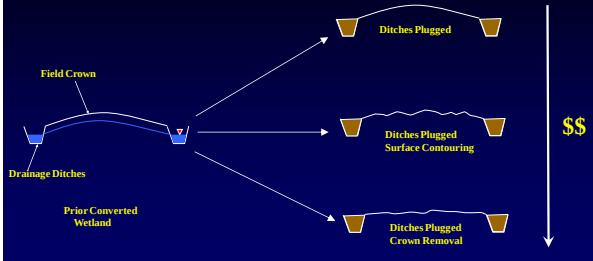
Wetland Restoration Techniques



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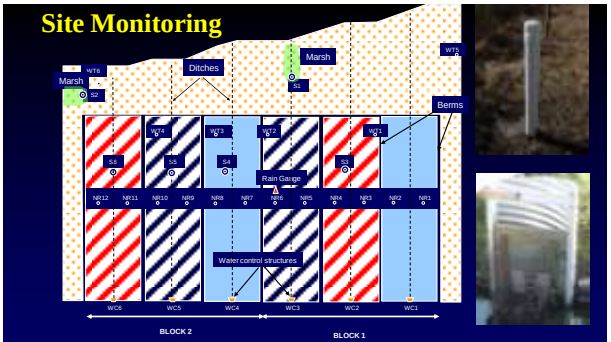
Site Monitoring



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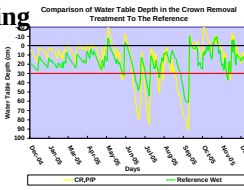
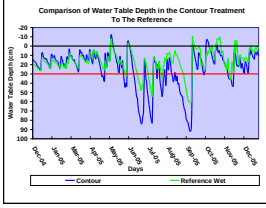
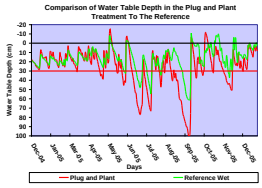
Site Monitoring





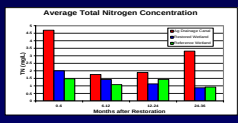


Wetland outflows

Ag canals

Water Quality Sampling Locations

Reference wetland



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2. Achieving appropriate Wetland Hydrology may not always require extensive earthmoving

- **CONTOURED** treatment appears closest to hydrology observed in the center of the **reference** wetland
- No real advantage observed by reducing the crown in this wet area
- May not be the case at locations further inland

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3. Replacing topsoil improves vegetation establishment

- In addition slowly establishing wetland hydrology will improve tree establishment and early growth

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4. Downstream Water quality can be improved

- Measurement of WQ show nutrient levels similar to reference wetland conditions
- Long term simulations (DRAINMOD) indicate that this wetland will reduce outflows by 30% compared to farmed conditions (reduced pollutant loads and freshwater slugs)

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Photo courtesy NCCF

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Phase II Innovation

- Unique site – multiple, complex communities interacting.
- Large scale marsh effort, tidal creek.
- Opportunity to expand limited knowledge on restoring these systems.

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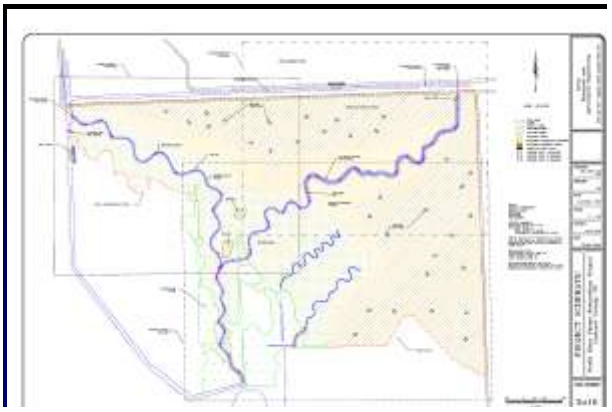
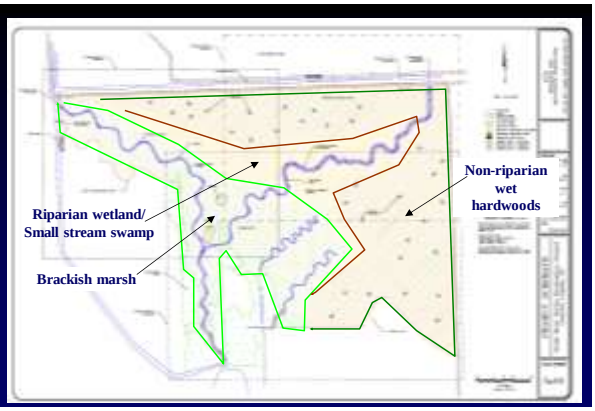
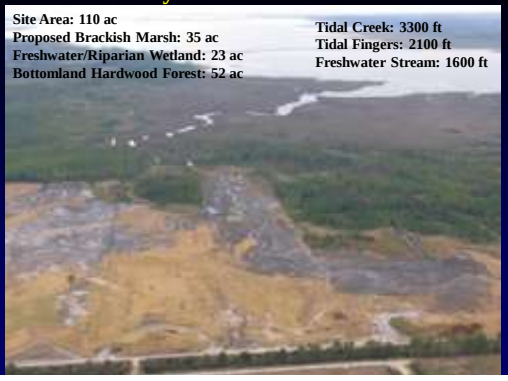




Site Plan Summary

Site Area: 110 ac
Proposed Brackish Marsh: 35 ac
Freshwater/Riparian Wetland: 23 ac
Bottomland Hardwood Forest: 52 ac

Tidal Creek: 3300 ft
Tidal Fingers: 2100 ft
Freshwater Stream: 1600 ft

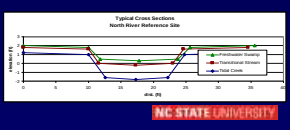


Background monitoring and Reference Site

Reference Site Survey

Stream Classification
North River Reference Site

Parameter	Freshwater Swamp MIN	Freshwater Swamp MAX	Transitional Stream MIN	Transitional Stream MAX	Tidal Creek MIN	Tidal Creek MAX
Drainage Area, DA (acres)	107	120	120	125	125	135
Stream Type (Rosgen)		C/E-C/c		C/c-E/c		E/c
Bankfull XSEC Area, Abkf (sq ft)	12.5	19.4	13.87	22.74	16.2	38.2
Bankfull Width, Wbkf (ft)	11.6	20.7	11.4	17.7	13.3	19.1
Bankfull Mean Depth, Dbkf (ft)	0.9	1.5	0.98	1.8	1.7	1.5
Width to Depth Ratio, W/D (ft/ft)	13.6	14.3	9.8	11.6	7.8	5.5
Width Floodprone Area, Wfpa (ft)	100.0	200.0	60	120	80	150
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	8.6	9.7	5.3	6.8	6.0	7.9
Sinuosity, K			1.3	1.3		1.2
Valley Slope, Sval (ft/ft)		0.0010		0.001		0.001
Channel Slope, Schan (ft/ft)		0.0013		0.0026		0.0042



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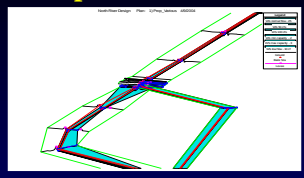
HEC-RAS Model Proposed Conditions



1. Pre-construction monitoring important.
2. Make sure design does not negatively impact upstream landowners!

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3. Construction – Experienced local contractors and proper equipment save time and $

4. Think Through Construction Sequencing

5. Provide construction oversight and insist on heavy resource commitment during dry periods

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6. Rough surfaces Good – smooth/packed BAD for surface water storage, habitat, and vegetation establishment

Evan's Creek, Spring 07

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7. Spend the $ and Effort for Root wads, grade control and matting

Structures, wood, bank blanket
Spring 2006

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8. Stockpile and replace topsoil and invest in planting marsh and riparian vegetation

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Tidal stream 2006

Tidal stream 2007

Upstream - 2008

Was planting worth the expense?

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9. Make sure that diverting water does not negatively affect upstream landowners

Low rock weir
diverts canal through marsh

10. Post construction monitoring a critical component at this stage in restoration science