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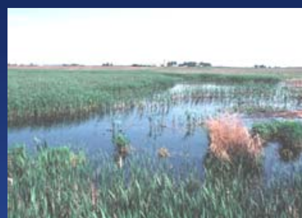
The Wetland Water Budget



Richard Weber
Wetland Hydraulic Engineer
Wetland Team
CNTSC, Fort Worth, Texas

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Objectives

- Understand Hydroperiod and Hydrologic Regime
- Awareness of the Water Budget Components
- List Data Sources
- Understand use of HGM Type for Water Budgeting
- Analyse wetland water budget QUALITATIVELY

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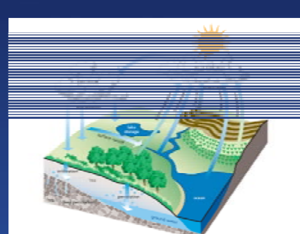
The Hydrologic Cycle

Wetlands are a transition zone between deep water and uplands



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The water budget analyzes the temporal and spatial changes of water in a wetland

- The wetland hydroperiod
  - Timing and duration of wetland conditions
- The wetland regime
  - Depth of inundation or degree of saturation

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Hydroperiod

- The period of time (on an average basis) that a site has wetland hydrology

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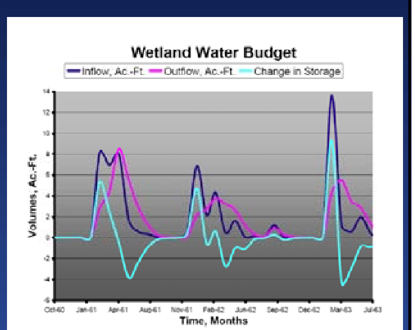
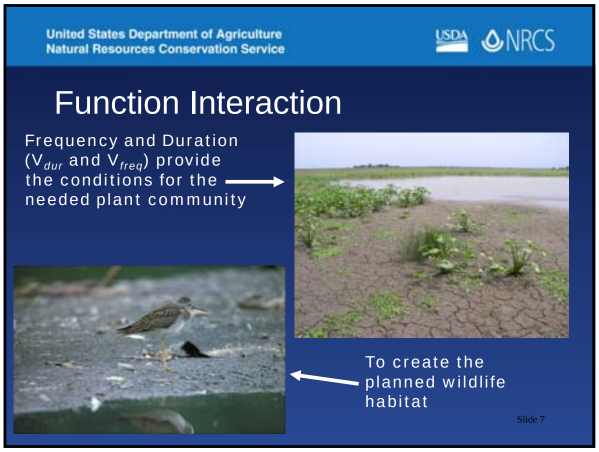
Hydroperiod Analysis

Hydroperiods are-

- Cyclic
- Repeatable

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Function Interaction
Frequency and Duration (V_{dur} and V_{freq}) provide the conditions for the needed plant community
To create the planned wildlife habitat
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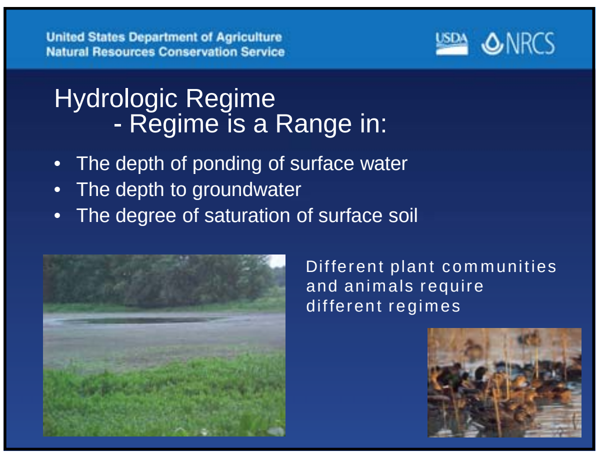
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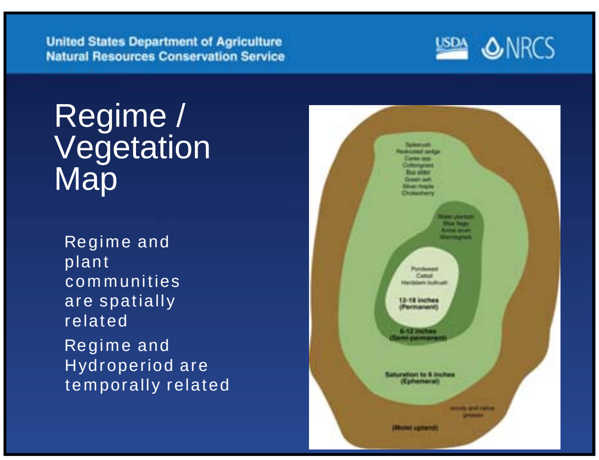
Hydrologic Regime
- Regime is a Range in:
• The depth of ponding of surface water
• The depth to groundwater
• The degree of saturation of surface soil
Different plant communities and animals require different regimes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Regime / Vegetation Map
Regime and plant communities are spatially related
Regime and Hydroperiod are temporally related
Pondweed
Cattail
Hardstem bulrush
12-18 inches (Permanent)
6-12 inches (Semi-permanent)
Saturation to 6 inches (Ephemeral)
(Moist upland)

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Diversity

- CREATE DIVERSITY
  - Deep Water AND Shallow Water
  - Long Hydroperiod AND Short Hydroperiod
  - Keep Slopes FLAT
  - Match vegetative establishment with hydroperiod and regime

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Water Budget Paramenters

- Precipitation – P
- Evaporation – E
- Transpiration – T
  - E and T MAY be considered together as ET
- Groundwater out – Go
- Groundwater in – Gi
- Surface Runoff in – Ri
- Surface Runoff out – Ro

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The Equation -

(P + Ri + Gi) – (Ro + Go + E + T) = **DS**

The good news is –

If you know your HGM type, you may be able to ignore several factors

The bad news is –

Some factors you DO need are hard to come by!

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HGM Wetland Types

- RIVERINE
- SLOPE
- ESTUARING FRINGE
- LACUSTRINE FRINGE
- MINERAL SOIL FLAT
- ORGANIC SOIL FLAT
- DEPRESSION

Landscape Position, Dominant Water Source, and Hydrodynamics

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The Time Step

- Daily
  - SPAW Model
  - Spreadsheet Tools
  - Requires actual daily climate data
- Weekly
  - Spreadsheet Tools
- Monthly
  - Simplified Water Budget Spreadsheet
  - Calculate by hand
  - Most commonly used time step

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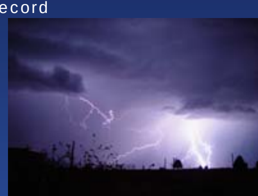
Precipitation – "P"

- WETS Tables
  - Monthly Time Step
- Climate Daily Data
  - Daily Data for Period of Record



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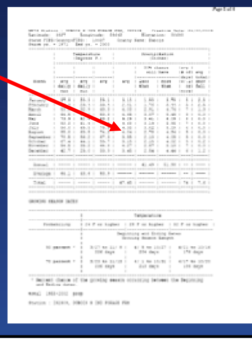
WETS Tables

Average Monthly Precipitation

Monthly Time Step -

Use with hand calculations or simplified spreadsheets

ftp://ftp.wcc.nrcs.usda.gov/support/climate/wetlands/



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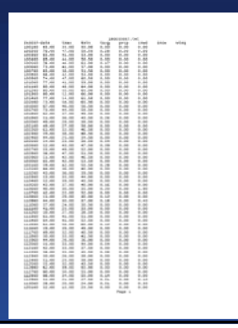
Daily Precipitation Data

Includes temperature and precipitation data from Oct. 1, 1960 to Sept. 30, 1998

-Large Text File
-Can be opened in EXCEL Spreadsheet

ftp://ftp.wcc.nrcs.usda.gov/support/climate/daily-data/in/



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Statistics

- Average is not 50% chance probability
- We can use daily data for 50% chance probability analysis, using spreadsheet tools.
- Average, Normal, and % Chance Probability are not the same things

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Surface Runoff in – "Ri"

- EFH – 2, TR – 55, and TR – 20 are "out the window"
- We're trying to match reality, not design a dam.
- We can use statistics with daily precipitation data to estimate runoff

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50% Chance Monthly Runoff

- Use Daily Data (Daily Time Step)
- Use Antecedent Runoff Conditions
- Use NRCS Runoff Curve Number Method

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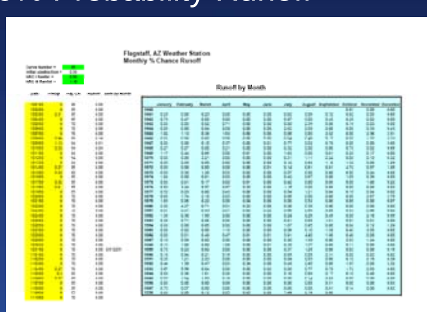
50% Probability Runoff



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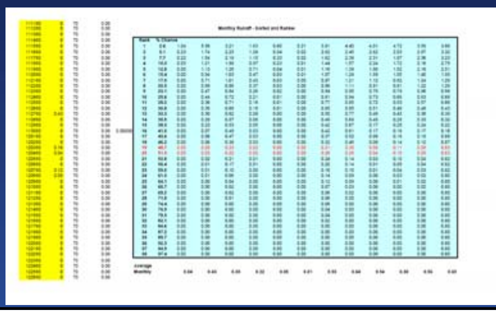
Spreadsheet (cont.)



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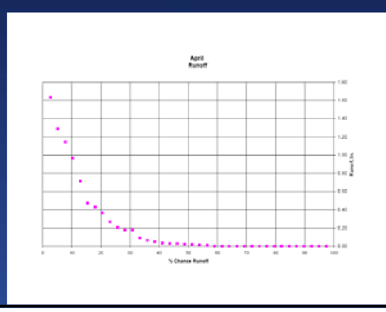
50% Chance April Runoff



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Surface Outflow (Ro)

- If outflow exists through the hydroperiod
  - Storm runoff inflows may be assumed to “pass through” the wetland
  - Ri = Ro, and both terms can be “crossed out” of the equation.
  - Base Inflow is due to groundwater (Gi).

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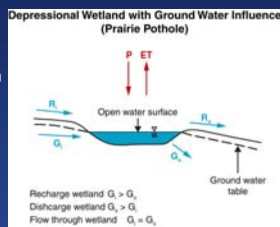
Groundwater – Gi and Go

- Movement can be horizontal and/or vertical
- Movement can be up and/or down
- We will refer to these movements as hydrodynamics
- A proper HGM classification, with knowledge of soils can assist with determining hydrodynamics



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Soil Hydrodynamics – General Statements

- Water moves through soil faster in the horizontal direction than the vertical
- Upward vertical movement is usually influenced by plants (in the root zone)
- The ability of the soil to store water is the critical factor in many, if not most wetlands (V_{por}).

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Boutwell Permeameter

Can measure both vertical and horizontal hydraulic conductivity

Commercially available, and can be made inexpensively

Requires two days to conduct test

Most appropriate for depressional wetlands where vertical downward movement is dominant

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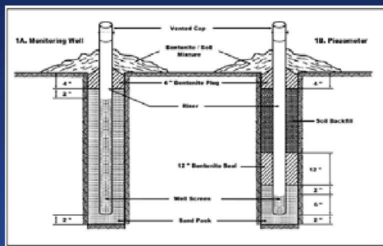
Monitoring Wells/Piezometers

- Inexpensive
- Easy to Install
- Monitoring wells provide water table information only
- Wells WITH piezometers can detect direction of movement and can provide estimates of RATE of water movement.



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Determine downward movement rate (seepage)

- Look it up
  - Web Soil Survey
- Measure it
  - Boutwell Permeameter
  - Amoozemeter
  - Static or Falling Head Permeameter
- Calculate it
  - Soil Mechanics Testing
  - Ag. Waste Management Field Handbook, Section 10D
  - MUUF and Rosetta
- Monitor it
  - Monitoring Wells
  - Piezometers

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Evaporation and Transpiration – E, T, and ET

- Often the most important water budget component
- Usually the hardest component to accurately measure

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Evapotranspiration

- No good data available for local plant communities.
- Most ET technology has been focused on water use for irrigation

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Evaporation

- Usually expressed as “Pan” or “Lake” evaporation
- Data available in NOAA NWS 33 and 34.
- Other readily available data is Lake evaporation found in the Ag. Waste Management program
- County level data, monthly time step
- Good data to use for wetlands with open water more than a foot deep.

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So what DO we know?

- Start with lake evaporation, and make monthly adjustment based on the following known factors
  - Non-green vegetation will reduce E due to reductions in water temp, solar radiation, and wind velocity
  - Growing vegetation will obviously add to consumptive use of water (add T to E).
  - Hydrologic Regime (depth of water or depth to saturation) has a significant effect on water use by plants
  - Very few plant communities will extract water at rates more than 1.5 times lake evaporation.
  - Look for local studies done by ARS, USGS or other agencies and adjust for your local site conditions.

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Storage (DS)

- Surface Storage (Inundation)
  - Stage Storage from Topography
- Soil Storage (Saturation)
  - Porosity (V_{por})
  - Available Water Capacity

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Surface Storage - Microtopography

- Surface Features no more than 6” above or below average ground surface
- Creates diversity in hydroperiod and regime
- Created by actions of soil, water, weather, and vegetation
- Often the most valuable physical features in a wetland

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Surface Storage - Microtopography

Created by Soils-

Gilgai Soil in Mississippi Bottomland Hardwood

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Surface Storage Microtopography

Created, (or maintained) by wind

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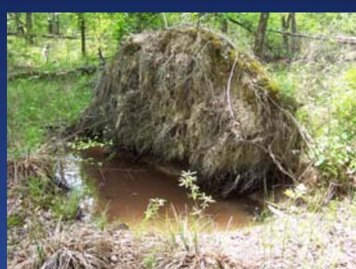
Surface Storage - Microtopography

Created by Weather Events –

“Wind throw”



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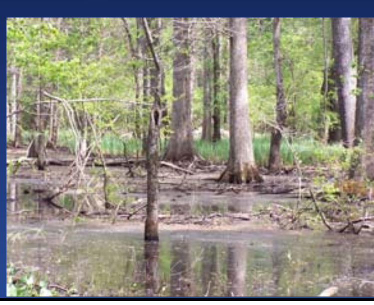
Surface Storage - Microtopography

Created by Flow-

Floodplain Scour in RIVERINE wetland



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Surface Storage - Microtopography

Plant Growth Characteristics

– Hummocks created by herbaceous vegetation

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Surface Storage - Macrotopography

RIVERINE HGM Types-

Oxbows, Scours, Splays

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Soil Storage – Irrigation Analogy

- Soil storage = water volume at saturation – water volume at an assumed percentage of depletion
- Can make assumptions based on Permanent Wilting Point values in Irrigation Guide
- Must assume a soil depth, which is assumed to be plant rooting depth, or depth to low permeability layer

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Soil Storage – Drainage Analogy

- Soil storage is taken as the drainable porosity between two different groundwater levels.
- Works well if groundwater monitoring data is available.

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Soil Storage – Soil Mechanics Analogy

- Assumes complete loss of water in soil between hydroperiods
- Storage is the total soil porosity
- Must still assume some rational depth of soil.

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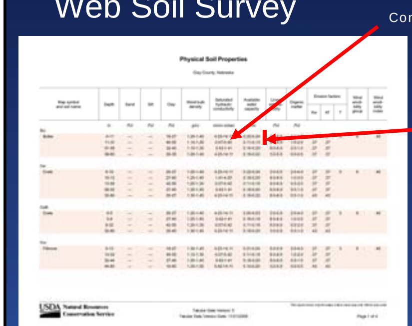
Web Soil Survey



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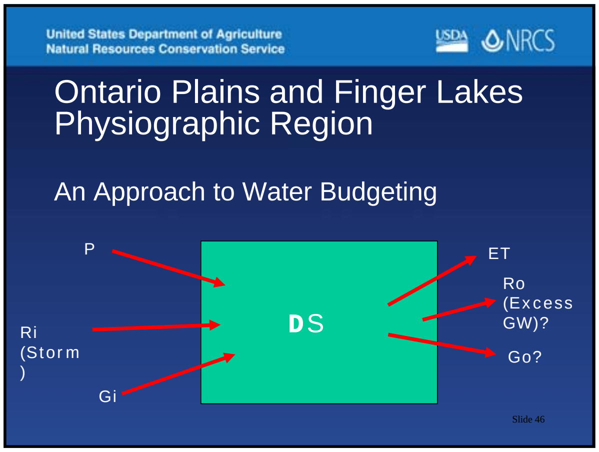
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Ontario Plains and Finger Lakes Physiographic Region
An Approach to Water Budgeting
P
Ri (Storm)
Gi
DS
ET
Ro (Excess GW)?
Go?
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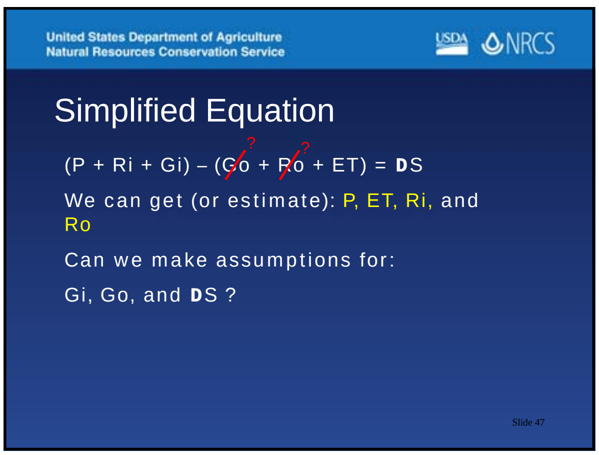
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Simplified Equation
(P + Ri + Gi) – (Go + Ro + ET) = DS
We can get (or estimate): P, ET, Ri, and Ro
Can we make assumptions for:
Gi, Go, and DS ?
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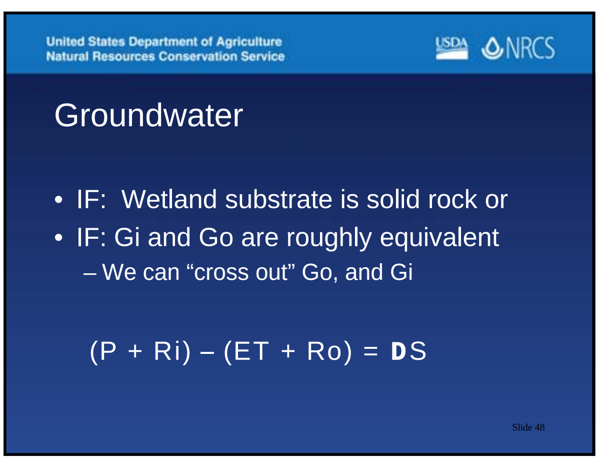
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Groundwater
• IF: Wetland substrate is solid rock or
• IF: Gi and Go are roughly equivalent
– We can "cross out" Go, and Gi
(P + Ri) – (ET + Ro) = DS
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Water Budget

- Hydrology Restorations CAN affect
  - ET
    - Change in vegetation
    - Change in regime or area
  - Ro and **D**S
    - Water control structures
    - Raise outlet grade

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Needed Information

- Measure Outflow
  - Average Velocity
  - Current Meters
  - Flumes, Weirs, Orifices
  - Hydraulics, using cross-section, Manning's "n" and slope
- Estimate E and ET
- Develop Stage-Storage Curve
  - Topography
- Develop Stage-Discharge Relationship
- Precipitation from WETS Tables

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Flow Measurement

Sharp-Crested Weir

$Q = CLH^{3/2}$

C = 3.1

L = Weir Length, ft.

H = water height over crest, ft.

Q is in cfs

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Depressional HGM Type with groundwater influence

- Surface runoff (Ri and Ro)
- Groundwater inflow and outflow (Go and Gi) Is Gi = Go?
- Direct Precipitation (P)
- ET

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Riverine HGM Types

- Dominated by stream hydrograph
  - Episaturation from surface flooding
  - Endosaturation from stream supported groundwater table

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Stream Hydrographs

Hydroperiod

Floodplain Evevaton?

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Riverine Wetlands

- Episaturation
  - Requires out of bank flows

Flood flows are perched on low-permeability floodplain soils

Typically found in low-gradient stream systems

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Riverine Wetlands - Endosaturation

Stream water surface supports high groundwater table.

Floodplain soils are coarse-grained, high permeability

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Manipulation of Hydrology, Ri (Watershed Conditions)

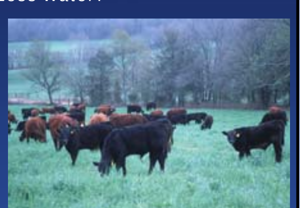
High Peak Discharges

High Sediment Load

More Water?

Low Peaks, Low Sediment

Less Water?



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Manipulation of Hydrology Ro and S

Water Control Structures

Change in DS, Ro.

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Manupilation of Hydrology, Go

- Ditch Plugs
  - Raise groundwater table, Gi = Go, increase regime
- Stream Channel Modification
  - Decrease channel capacity, increase stream water surface, Gi = Go, increase regime
- Compaction of Substrate
  - Reduce Go, increase inundation

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Manupilation of Hydrology, E and ET

Low ET

High ET

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