Water Table and Nutrient Fluctuations within the Floodplain of the Upper Cape Fear River

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NWQMC May 2, 2012
Floodplain Functions

- Floodwater storage
Floodplain Functions

- Floodwater storage
- Sediment storage
Floodplain Functions

- Floodwater storage
- Sediment storage
- Groundwater recharge

Modified from: Winter, TC and others (1998) USGS Circular 1139
Floodplain Functions

- Floodwater storage
- Sediment storage
- Groundwater recharge
- Water quality moderation
Floodplain Functions

- Floodwater storage
- Sediment storage
- Groundwater recharge
- Water quality moderation
- Habitat
Upper Cape Fear River Basin

North Carolina

Haw River Basin

Deep River Basin

Upper Cape Fear River Study Area
B. Everett Jordan Dam
Confluence Haw and Deep Rivers
Lockville Dam
Buckhorn Dam
Jordan Lake
Shearon Harris Lake
Reach Energy Reach
Bradley Road Reach
City of Lillington
Research Questions

- Is the upper Cape Fear River a “gaining stream” for the majority of the year?
- Are there spatial and seasonal differences in floodplain water quality?
- Does nutrient processing within the floodplains function as expected?
Discussion Topics

- Floodplains of two reaches investigated
- Measuring interaction
- Differences between groundwater and surface water
  - Hydrology
  - Water quality
- Answers to research questions
Floodplains of Two Reaches

- Morphology slightly different

Progress Energy Reach

- Rural
- No up-gradient agriculture
- Nearby area logged in 2002
- No facilities at boat ramp
Progress Energy Reach Soils

Mapped as Riverview silt loam

Particle size analysis
  • Mostly silt loam

% Carbon from cores
  • 0.3 to 1.2%
Progress Energy Piezometer Transect

- 6 piezometers
- 2 on the bank
- 3 beneath river bed
- 1 river stage
Bradley Road Reach

- Rural
- Up-gradient area logged in 1999
- Nearby subsistence farm last planted in 1989
- No septic facilities
Bradley Road Reach (BR) Soils

Mapped as Congaree loam

Particle size analysis
• Sandy loam to sand

% Carbon from core
• 0.3 to 3.2%
Bradley Road Piezometer Transect

- 6 piezometers
  - 3 on the bank
  - 2 beneath river bed
  - 1 river stage
- BR-1U destroyed

Destroyed Nov. 2009
Piezometers

- Jet pump installation
- 1.5 in diameter PVC
- 1 ft screen length
- Capped bottom
- Filter sand
- Bentonite seal
- Casing elevations surveyed to closest 0.01 ft
Measuring GW/SW Interaction

- 15-min hydraulic data
- Water level
- Dec 2009 to Nov 2010
Measuring GW/SW Interaction

- 15-min hydraulic data
- Water level
- Dec 2009 to Nov 2010
- QA 2X a month
Measuring GW/SW Interaction

- 15-min hydraulic data
- Water level
- Dec 2009 to Nov 2010
- QA 2X a month
- Precipitation data from State Climate Office of NC
- Discharge from USGS Lillington, NC gage
Water Quality Samples

- Attempted collection 2X a month from Dec. 2009 to Nov. 2010
- All 11 piezometers
- River grab sample at both sites
- Pumped 3 well volumes or until dry
Water Quality Samples

- Total N
- NO₃ - N
- NH₄ - N
- Organic N
- PO₄ - P
- DOC
- Cl
- Field Parameters
- River stage range about 6 ft
- Floodplain is well connected to river
- A few days when all piezometers were submerged
- Extended dry period during the summer
BR Reach Hydrology

- River stage range about 16 ft
- Floodplain well connected to river
- Several weeks when all piezometers were submerged
- Extended dry period during the summer
Hydraulic Gradients

PE Reach

- Gaining ~ 25%
- Losing ~ 45%
- Mixed ~ 30%
- Range 0.4 to -0.5 ft/ft

BR Reach

- Gaining ~ 30%
- Losing ~ 20%
- Mixed ~ 50%
- Range 0.07 to -0.13 ft/ft
- Periods of high flow to baseflow (2 seasons)
- Biased to lower river stages at BR transect
Flow Paths Comparisons

PE samples

BR samples
Riverbed Piezometers

Cape Fear River

Riverbank Piezometers

Red = High flow samples     Blue = Baseflow samples
Nitrate as N Distribution

- Generally little, with river more than floodplain
- PE baseflow and BR high flow statistically different

Red = High flow samples  Blue = Baseflow samples
Ammonium as N Distribution

- High, with floodplain containing more than river
- Several samples seasonally statistically differ

Red = High flow samples  Blue = Baseflow samples
Dissolved Organic Nitrogen Distribution

- Distribution differences between sites
- Samples statistically different at PE in riverbed

Red = High flow samples     Blue = Baseflow samples
**Dissolved Organic Carbon Distribution**

- Concentrations about 2X greater at BR than PE
- Samples statistically different at BR

Red = High flow samples  Blue = Baseflow samples
Is the upper Cape Fear River a “gaining stream” for the majority of the year?

- The two Cape Fear River floodplains investigated are hydraulically different
  - Floodplains are well connected
  - PE reach area has
    - small river stage range,
    - large groundwater level range, and
    - more frequently “losing” than “gaining”
  - BR reach area has
    - large river stage range,
    - smaller groundwater level range, and
    - more frequently “gaining” than “losing”
Are there spatial and seasonal differences in floodplain water quality?

- Yes there are spatial and seasonal differences in floodplain water quality
  - Ammonium and DOC increase with depth beneath river and distance up the floodplain
  - DON increases beneath the river at PE reach and into the floodplain at BR reach
  - Nitrate during baseflow at PE reach and high flow at BR reach statistically different
Does nutrient processing within the floodplains function as expected?

- Not exactly...
  - There is very little nitrate, which was expected.
  - But, there are very high concentrations of $\text{NH}_4^+$ beneath the river and within the floodplain.
  - DON and DOC concentrations are also elevated, suggesting that the source of nitrogen for the ammonium is organic rather than anthropogenic.
  - The lack of nitrate coupled with high $\text{NH}_4^+$, DON, and DOC under anoxic conditions suggest that N mineralization is occurring.
  - The floodplain is flushing $\text{NH}_4^+$ to the Cape Fear River during high flow events
Questions?

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Acknowledgements

- Committee
  - Dr. Deanna Osmond
  - Dr. Aziz Amoozegar
  - Dr. April James
- Progress Energy
- Taylor Family
- Wesley Childres
- Dr. Robarge & lab team
- USGS NC WSC
  - Curtis Weaver
  - Doug Harned
- Ethan McSwain
- Joe Bukowski
Interaction Between Groundwater and Surface Water

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Interaction Between Groundwater and Surface Water

River

River bottom

Direction of stream flow

Hyporheic zone

High oxygen

Low oxygen

NO_3

NH_4

Ferric iron

Ferrous iron

Groundwater

Commonly low in oxygen

Direction of groundwater flow

Water Quality Samples

Field Parameters

- Temperature
- Specific conductance
- pH
- Dissolved oxygen