Watershed Approach to Restoring Streams and Wetlands in the Urban Upper Sandy Creek Watershed

Joshua White, PG, CFM, EI

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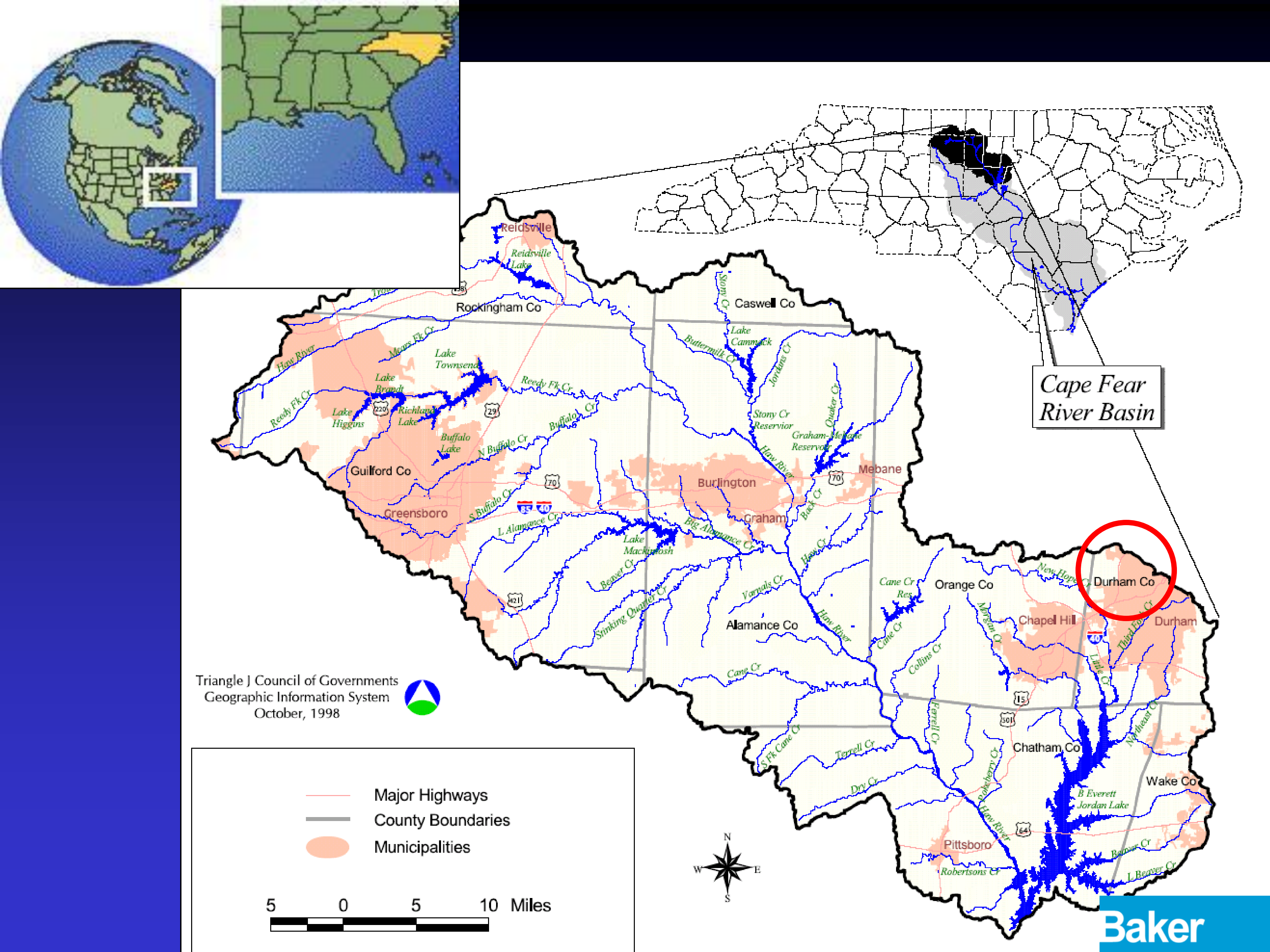
Mid-Atlantic Stream Restoration Conf. – NOV 2010


Cape Fear River Basin
Reidsville
Reidsville Lake
Rockingham Co
Caswell Co
Haw River
Mears Fk Cr
Lake Townsend
Lake Brandt
Reedy Fk Cr
Lake Higgins
Richland Lake
Buffalo Lake
N Buffalo Cr
Buffalo Cr
Guilford Co
Greensboro
S Buffalo Cr
L Alamance Cr
Lake Mackintosh
Big Alamance Cr
Burlington
Graham
Mebane
Stony Cr
Lake Cammack
Buttermilk Cr
Jordans Cr
Stony Cr Reservior
Quaker Cr
Graham-Mebane Reservoir
Back Cr
Haw Cr
Beaver Cr
Stinking Quarter Cr
Varnals Cr
Alamance Co
Cane Cr Res
Cane Cr
Orange Co
New Hope Cr
Durham Co
Durham
Chapel Hill
Morgan Cr
Third Fork Cr
Little Cr
Collins Cr
Terrell Cr
S Fk Cane Cr
Dry Cr
Ferrell Cr
Pokeberry Cr
Chatham Co
Northeast Cr
B Everett Jordan Lake
Wake Co
Pittsboro
Robertsons Cr
Beaver Cr
L Beaver Cr
Triangle J Council of Governments
Geographic Information System
October, 1998
Major Highways
County Boundaries
Municipalities
5 0 5 10 Miles
N
E
S
W

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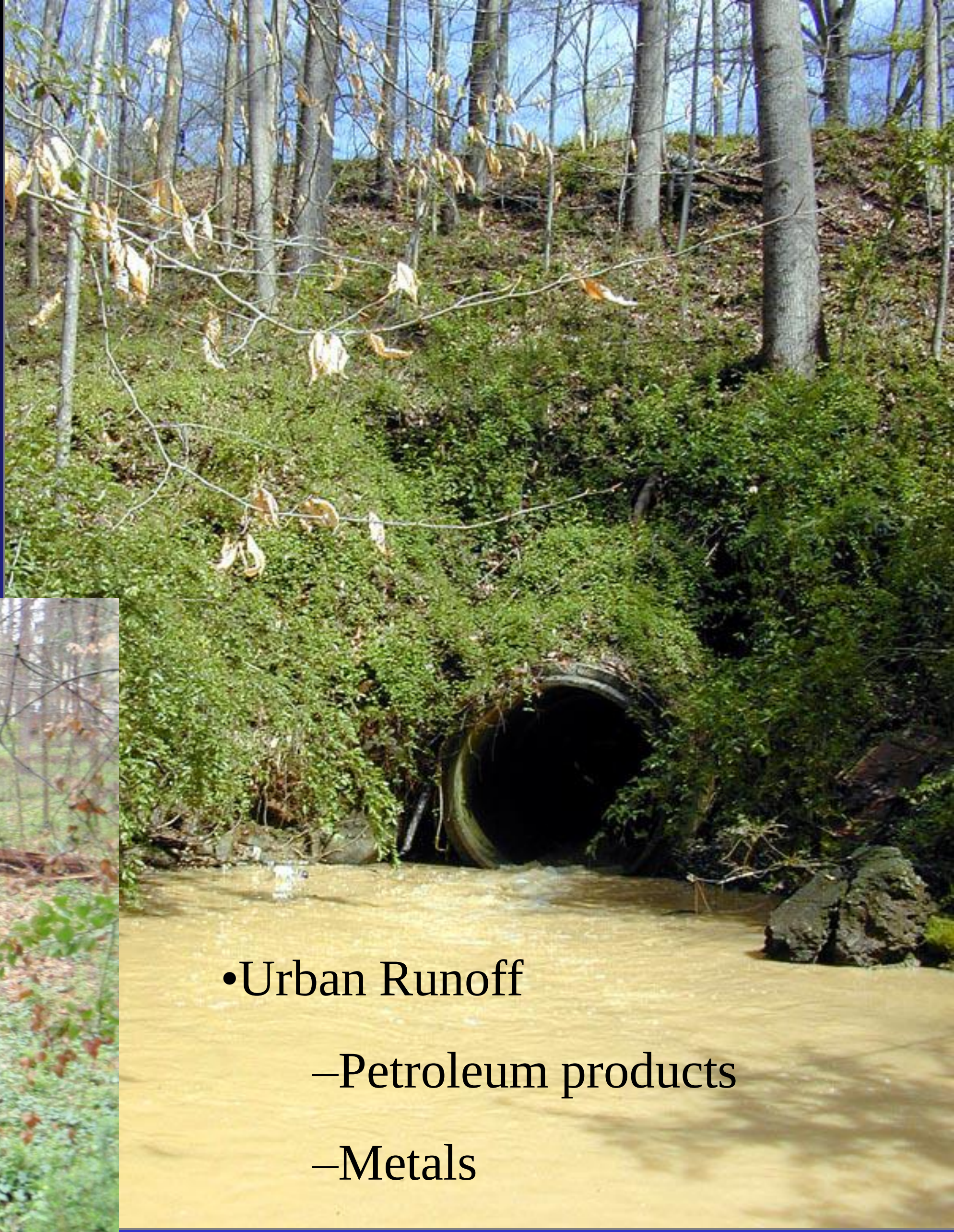
Nutrient Inputs

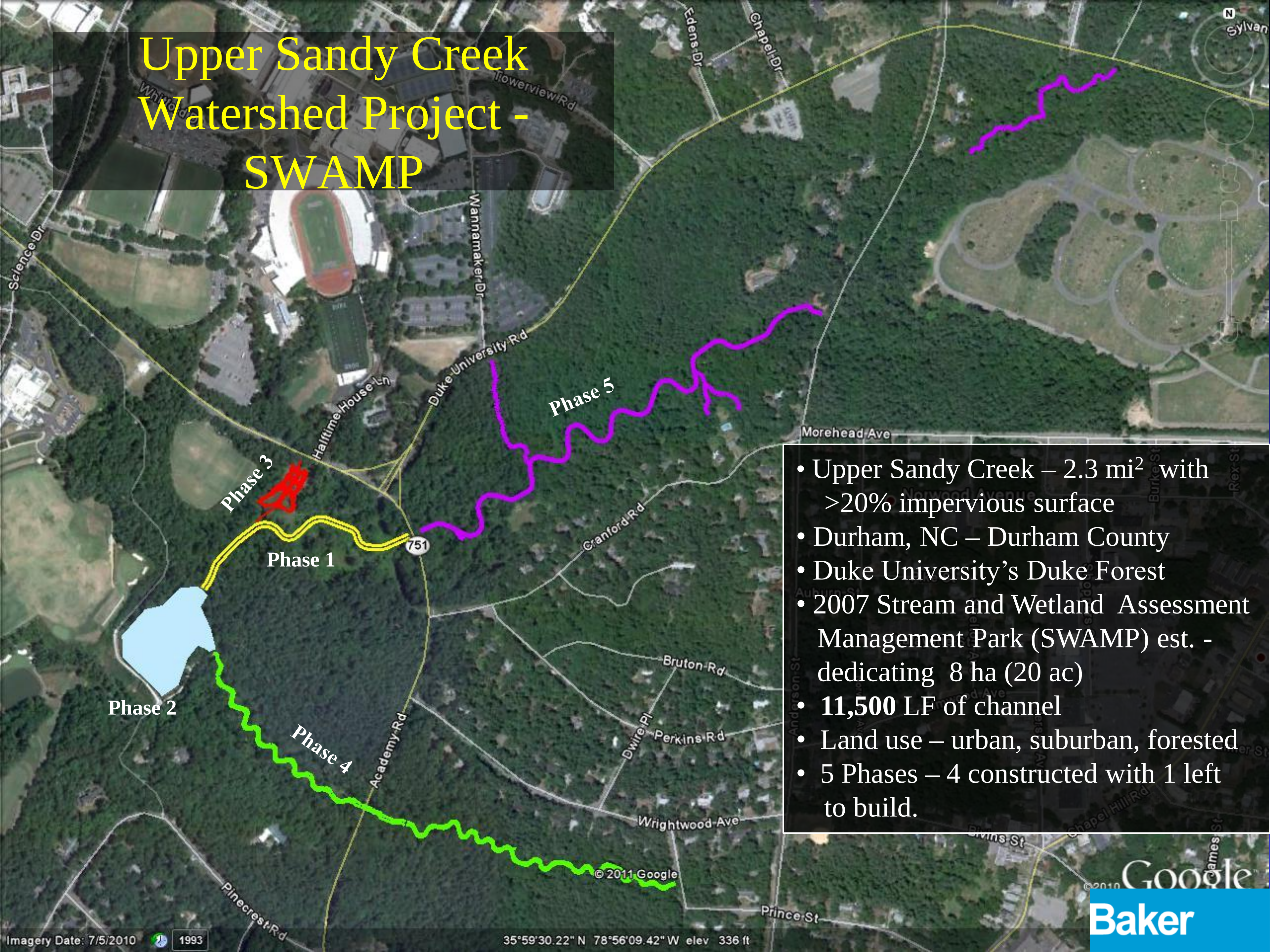
- Fertilizers
  - Playing fields
  - Residential Lawns
- Sewer Overflow



- Urban Runoff
  - Petroleum products
  - Metals

Upper Sandy Creek Watershed Project - SWAMP

- Upper Sandy Creek – 2.3 mi^2 with >20% impervious surface
- Durham, NC – Durham County
- Duke University's Duke Forest
- 2007 Stream and Wetland Assessment Management Park (SWAMP) est. - dedicating 8 ha (20 ac)
- **11,500** LF of channel
- Land use – urban, suburban, forested
- 5 Phases – 4 constructed with 1 left to build.



Upper Sandy Creek (SWAMP) Projects

- Funding Sources:
  - NC Clean Water Management Trust Fund (CWMTF)
  - Division of Water Resources (DWR)
  - Durham Soil and Water Conservation District
  - EPA 319 Program
  - National Science Foundation (NSF)
  - Duke Forest
  - USDA
  - NC Ecosystem Enhancement Program

- Partners:
  - Duke University Wetland Center -Faculty and Students
  - Durham Soil and Water Conservation District

- Designer/Contractor:
  - Michael Baker Engineering, Inc. (Baker)
  - River Works, Inc.

SWAMP
Ecological Goals of Restoration

- Restore connectivity between stream channel and abandoned riparian floodplain
- Increase stream function while reducing sediment, erosion, & shear stresses
- Create functioning wetland areas
- Mitigate impacts of runoff from urban development
- Implement strategies for non-native species management
- Improve habitat for wildlife
- Increase safety around the stream

Why is the integrated restoration of streams and wetlands critical to restoring ecosystem functions on the landscape?

- Degradation of both Streams and Wetlands
- Streams and Wetland Functions are Linked
- Current Conditions
  - Incised channel - >2 BHR
  - Fallen trees causing debris jams
  - Erosion and high shear stresses
  - Non-native species invasions
  - Loss of landscape diversity
  - Poor water quality

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Questions To Be Answered Through Monitoring

- Did the stream restoration result in hydrologic conditions to support adjacent wetland functions?
- Are hydrologic conditions conducive to wetland plant establishment and survival?
- What is the role of restored groundwater interactions on the biogeochemical functions of the system like denitrification?
- At what rate do wetland plant communities become established after restored wetland hydrology?
- Does stream and wetland restoration result in improved water quality (i.e. reduced TN, TP, and fecal coliform)?
- Does stream restoration and improved water quality improve stream habitat for macroinvertebrates?

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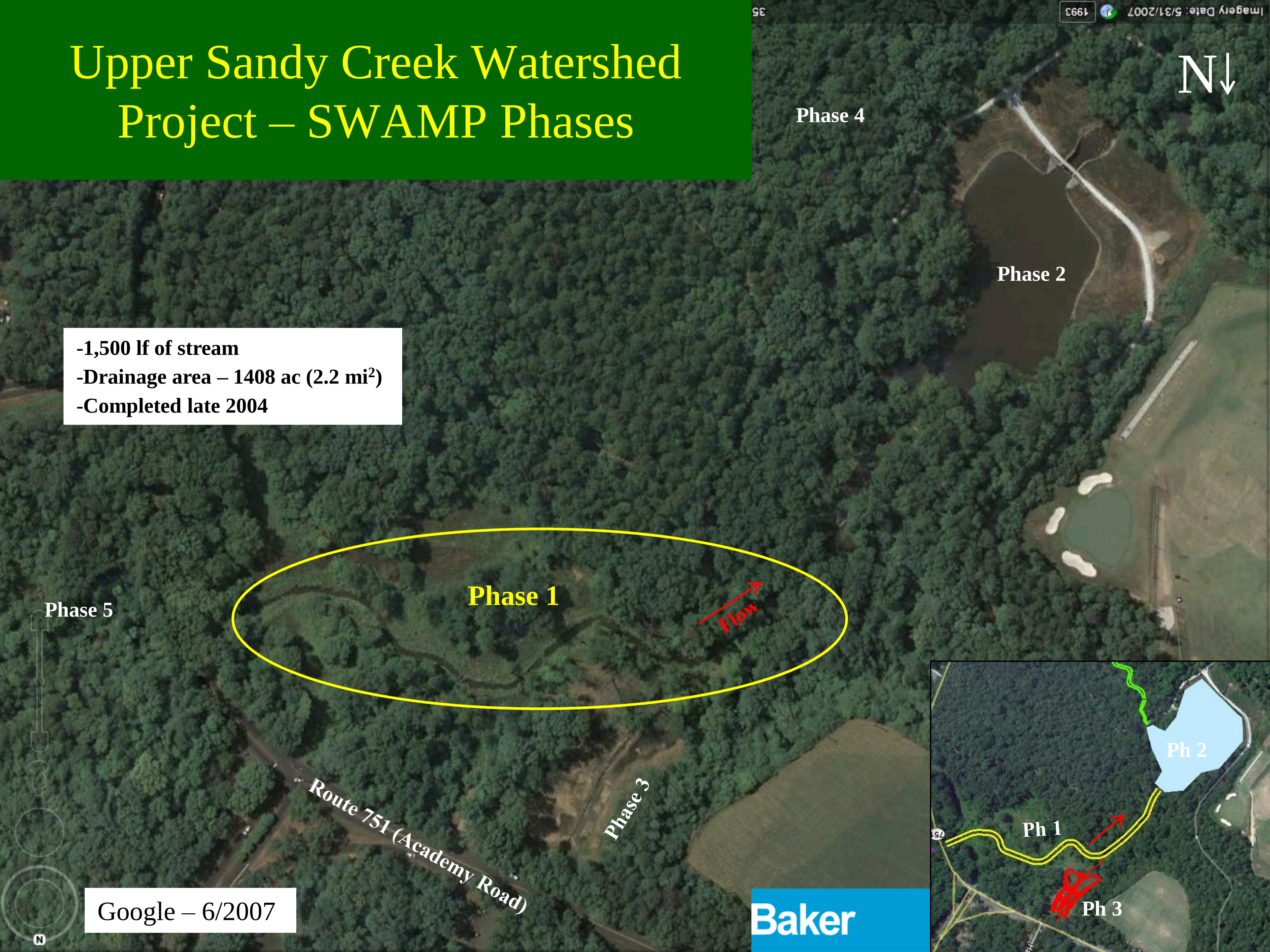
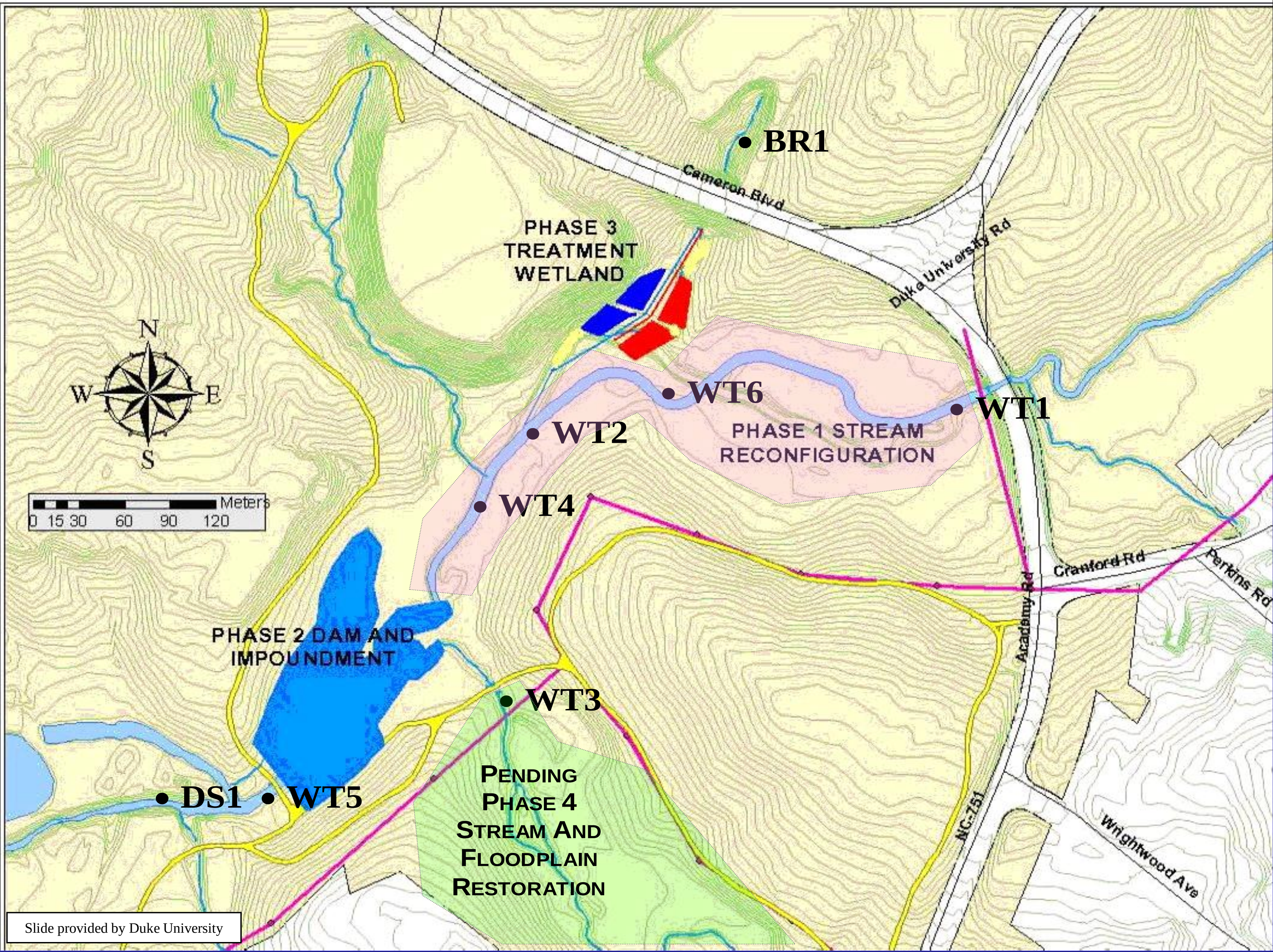
Upper Sandy Creek Watershed Project – SWAMP Phases

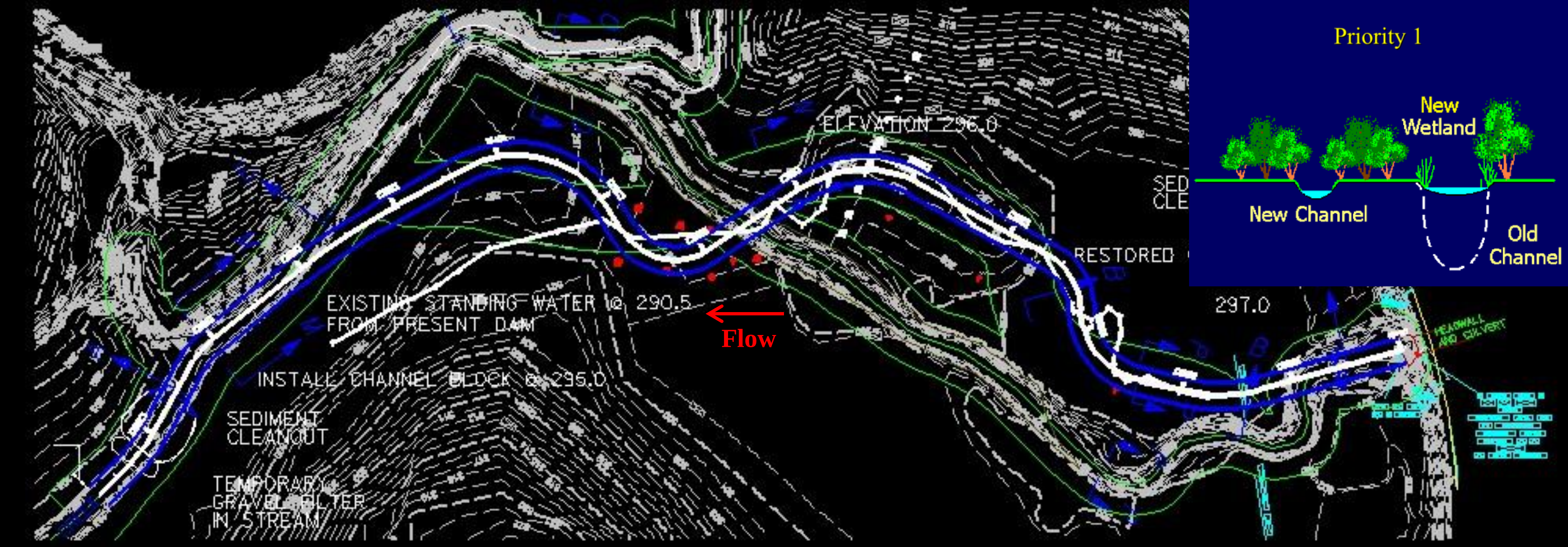
- -1,500 lf of stream
- -Drainage area – 1408 ac (2.2 mi^2)
- -Completed late 2004



Google – 6/2007



Slide provided by Duke University



Priority 1
New Wetland
New Channel
Old Channel
ELEVATION 296.0
RESTORED
297.0
EXISTING STANDING WATER @ 290.5
FROM PRESENT DAM
Flow
INSTALL CHANNEL BLOCK @ 295.0
SEDIMENT
CLEANOUT
TEMPORARY
GRAVEL FILTER
IN STREAM


June 2005

•Construction completed late 2004


June 2007


June 2010

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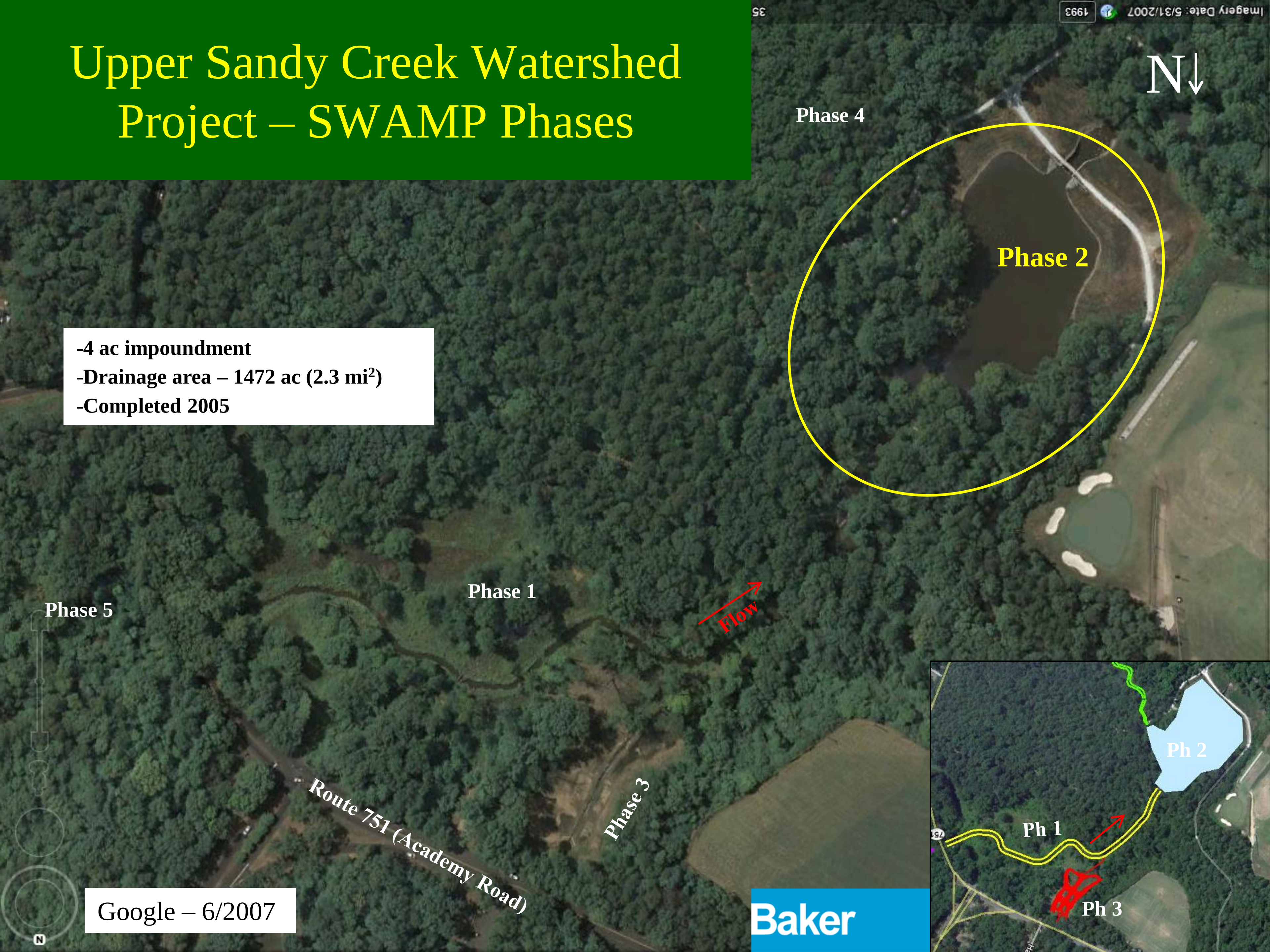
Upper Sandy Creek Watershed Project – SWAMP Phases

- -4 ac impoundment
- -Drainage area – 1472 ac (2.3 mi^2)
- -Completed 2005



Phase 2

Slide provided by Duke University

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June 2009
Slide provided by Duke University
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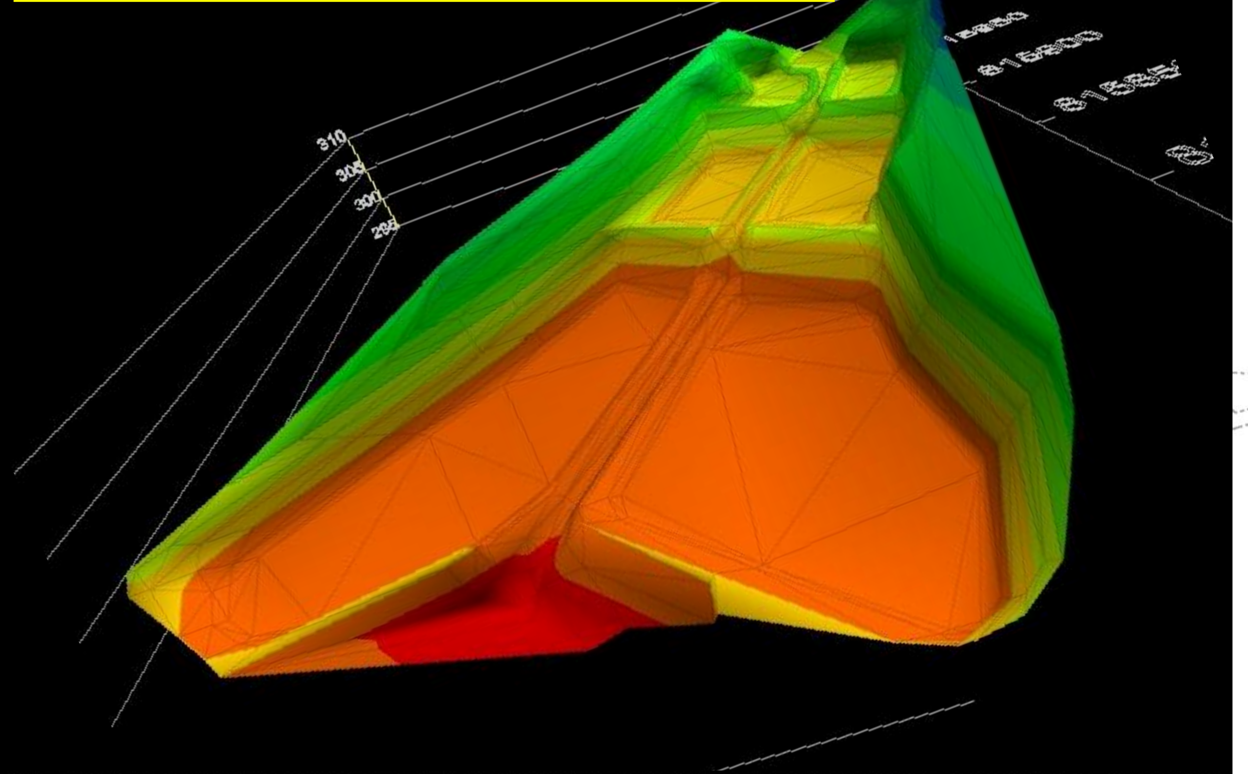
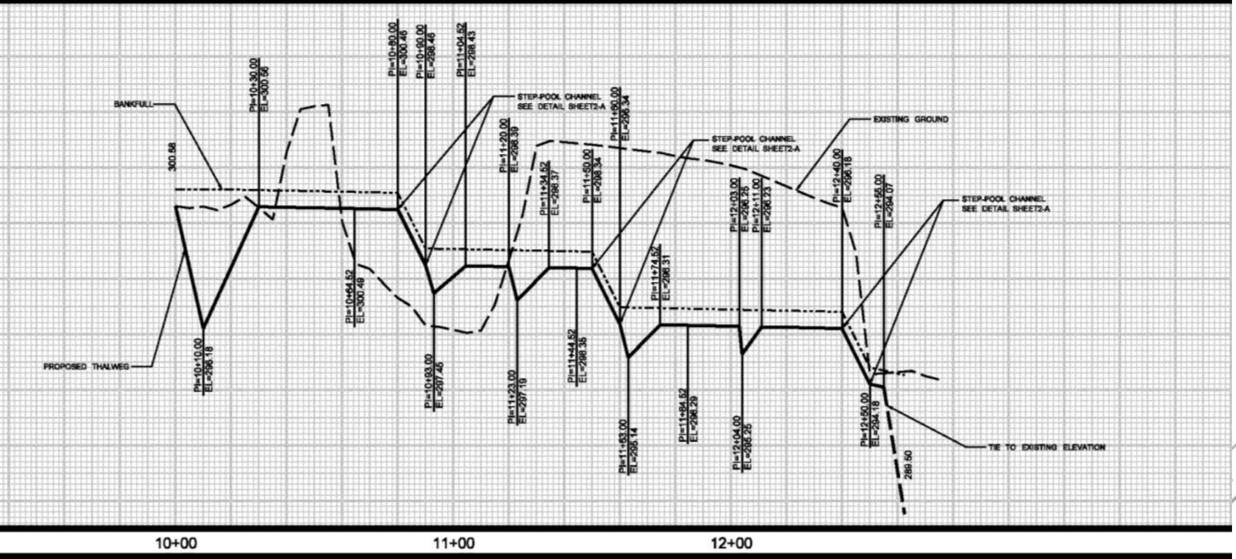
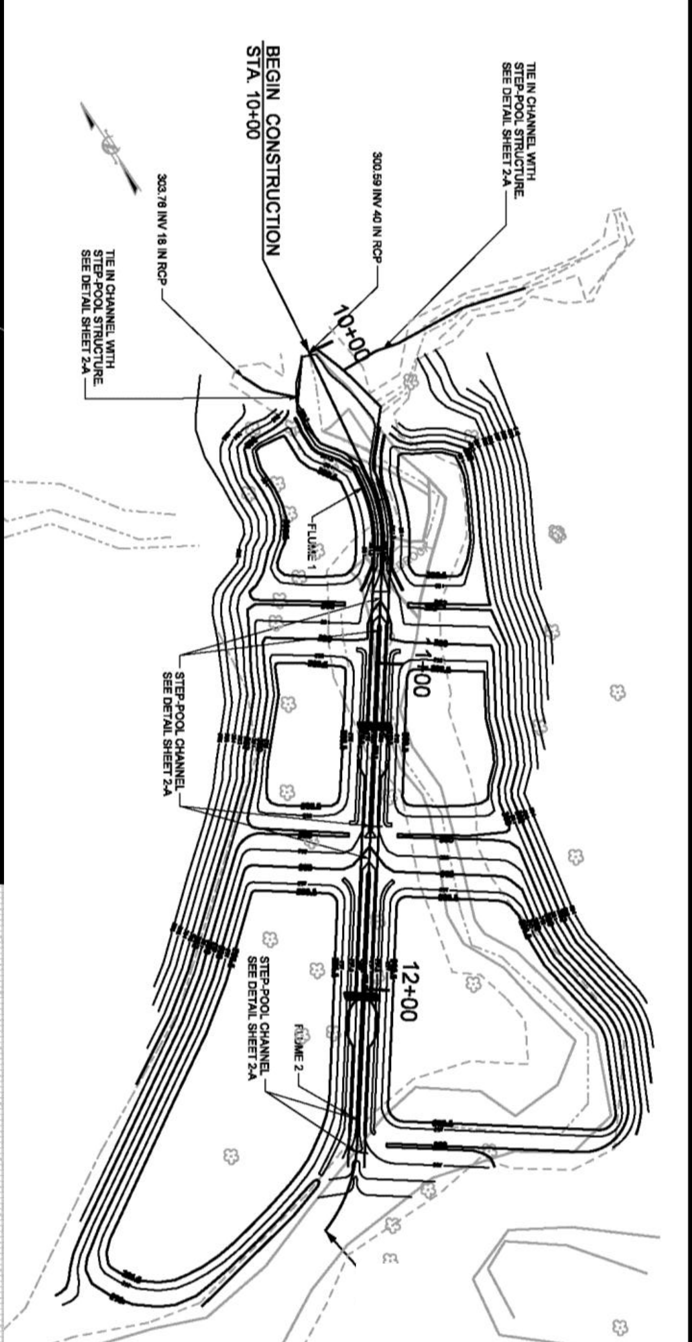
Upper Sandy Creek Watershed Project – SWAMP Phases

- Six offline wetland cells
- Drainage area – 58 ac (0.09 mi^2)
- Completed June 2006

Phase 3 – Offline Wetlands







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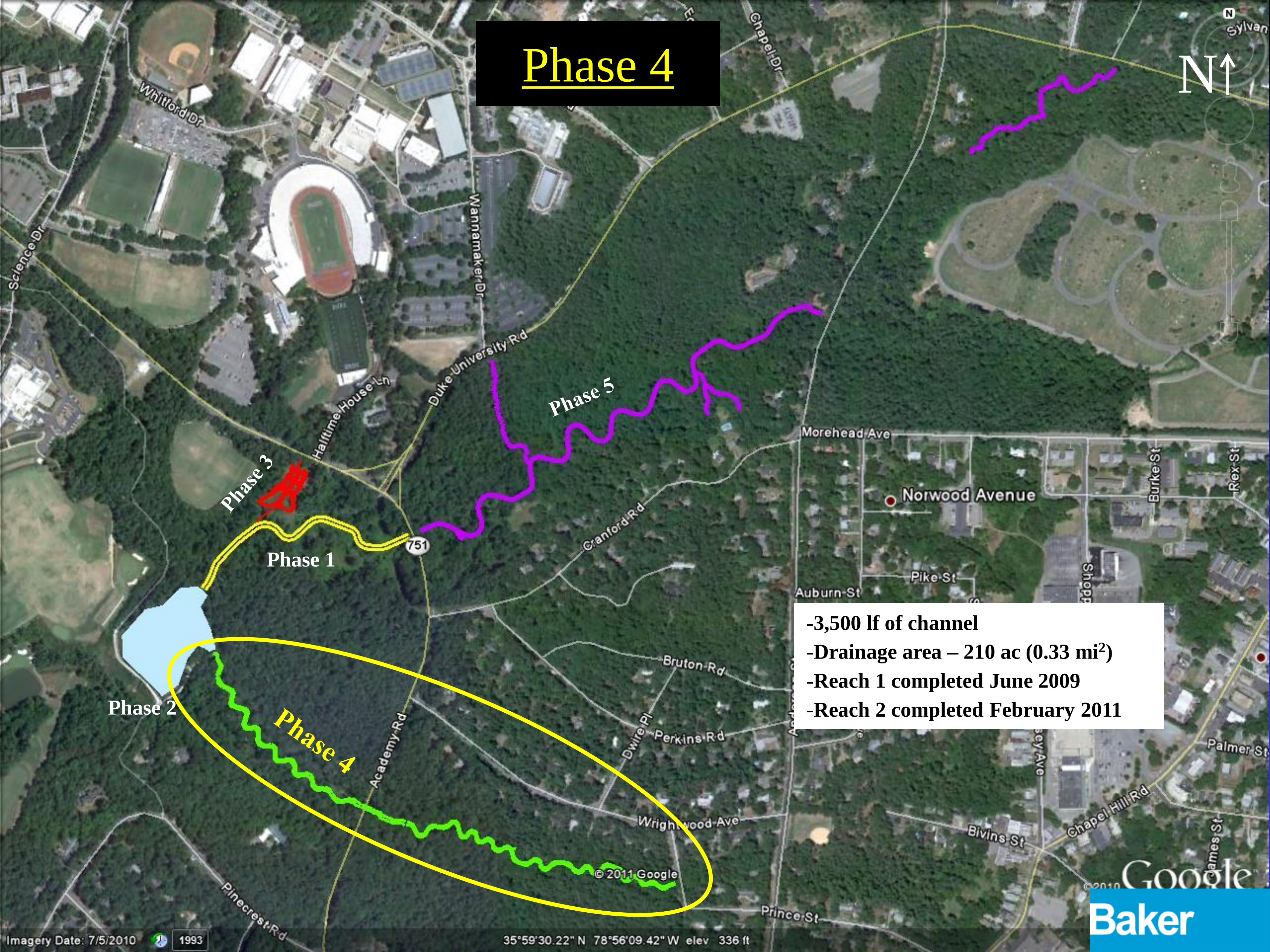
Phase 4



-3,500 lf of channel
-Drainage area – 210 ac (0.33 mi^2)
-Reach 1 completed June 2009
-Reach 2 completed February 2011


Culvert hanging
about 4 ft
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During storm event
Baker


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-Incised channel – lacking floodplain
-Lacking woody vegetation on the banks
-Fallen tree due to channel incision below rooting depth
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-Incised channel – lacking floodplain
-Lacking woody vegetation on the banks
-Invasives speceies

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-Constraint – old sewer line from 1940


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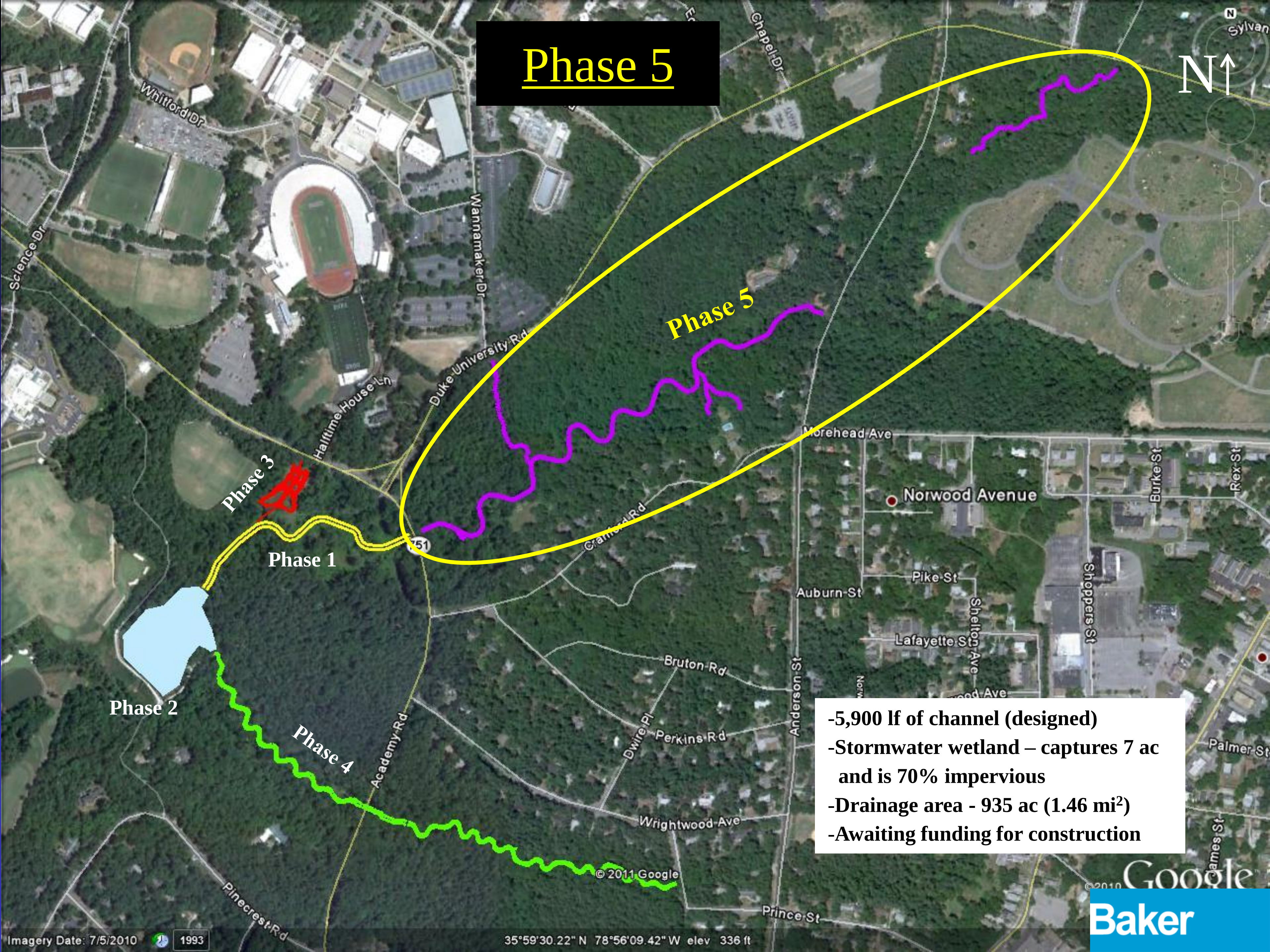
Phase 5



- 5,900 lf of channel (designed)
- Stormwater wetland – captures 7 ac and is 70% impervious
- Drainage area - 935 ac (1.46 mi^2)
- Awaiting funding for construction

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-Incised channel – lacking floodplain
-Lacking woody vegetation on the banks
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-Incised channel – lacking floodplain
-Large woody debris jam
-Invasive species on the banks
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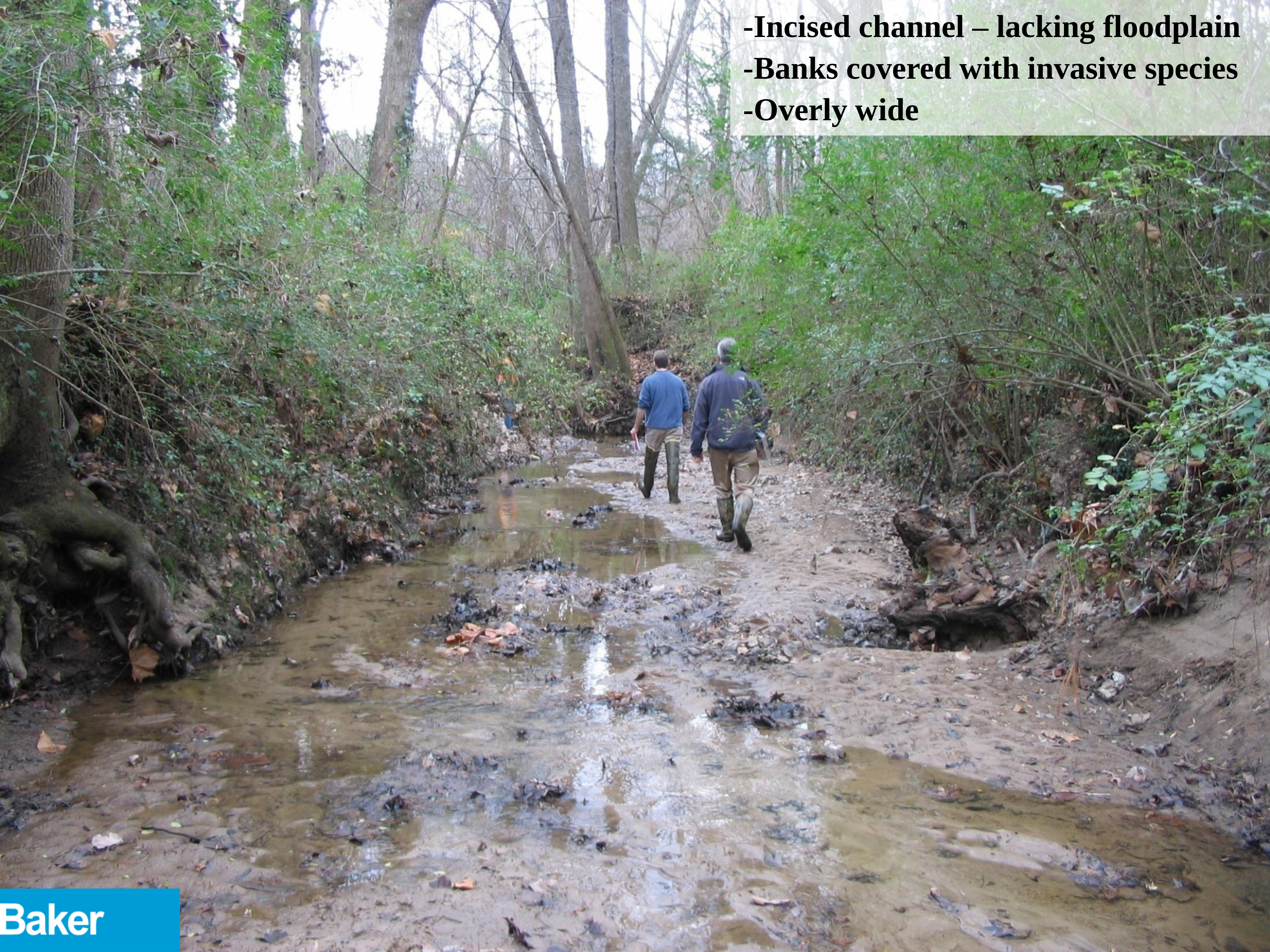
-Incised channel – lacking floodplain
-Lacking woody vegetation on the banks
-Fallen tree due to channel incision below rooting depth


-Incised channel – lacking floodplain
-Banks covered with invasive species
-Overly wide
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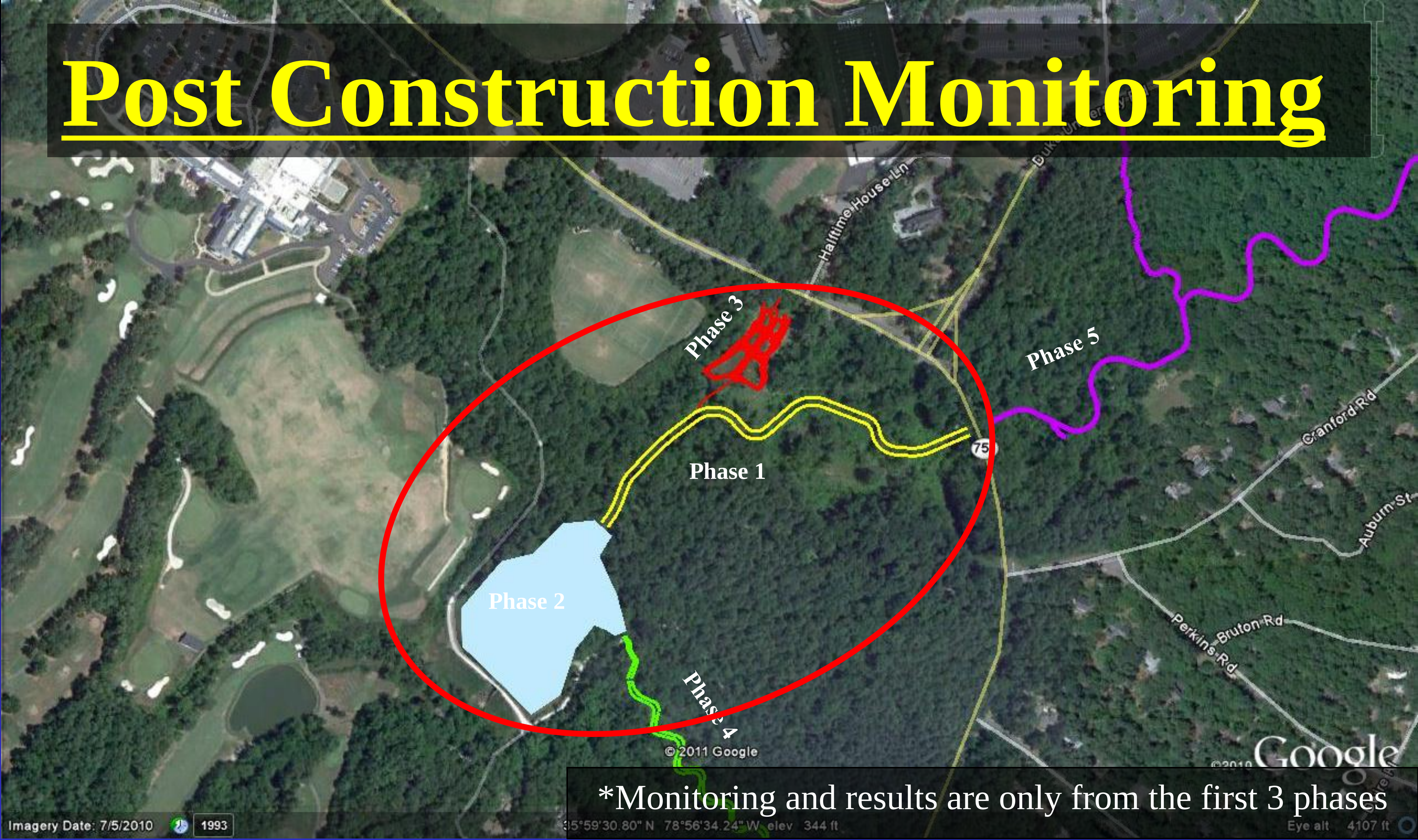
Post Construction Monitoring



*Monitoring and results are only from the first 3 phases

NICHOLAS SCHOOL OF THE ENVIRONMENT AND EARTH SCIENCES
DUKE UNIVERSITY

*All monitoring and results data were provided by Duke University Faculty and Students

See paper: Richardson, C.J., N. Flanagan, M.Ho, and J.Pahl, *Integrated stream and wetland restoration: A watershed approach to improved water quality on the landscape*, Ecological Engineering, vol. 37 (2011), pp. 25-39 .

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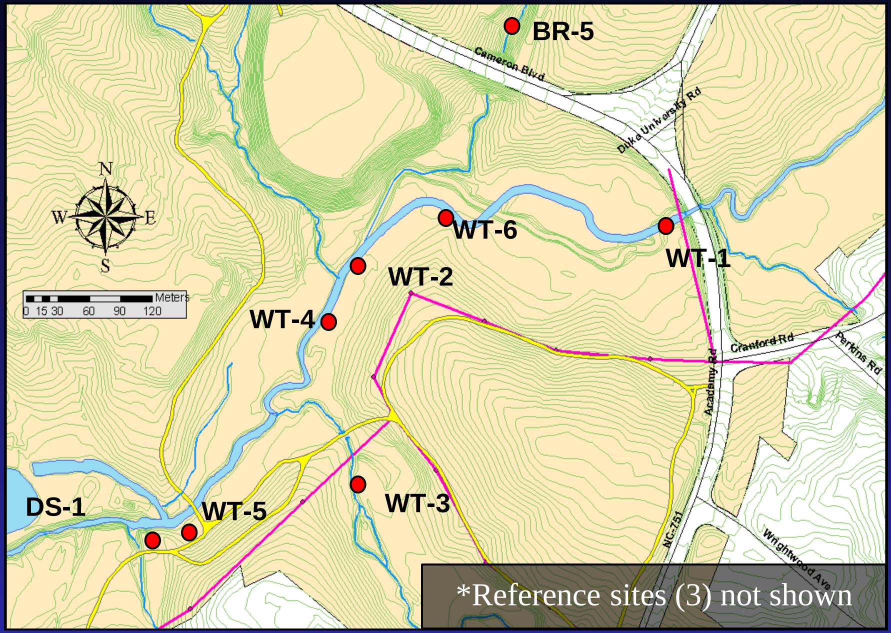
PARAMETERS MONITORED



- GROUNDWATER FUNCTIONS
- WETLAND PLANT COMMUNITTIES
- MACROINVERTEBRATES
- SEDIMENT RENTENTION
- WATER QUALITY
  - ELEVEN STATIONS
  - MONTHLY AMBIENT MONITORING
  - NSF WATER QUALITY INDEX PARAMETERS

    FECAL COLIFORMS, BOD, pH, dO_2, TEMPERATURE, TOTAL DISSOLVED SOLIDS, TURBIDITY, NO_3^{2-} + NO_2^-, PO_4^{3-} (SRP)

  - OTHER PARAMETERS

    FLOW VELOCITY, NH_4^+, TOTAL N, TOTAL P, TOTAL SOLIDS, ALKALINITY, (SPECIFIC) CONDUCTIVITY, Ca, Mg, K, Na
  - STORM MONITORING
    - ISCO hourly samples for TN, TP, NO_3-NO_2
  - HYDROLOGIC LOADING
    - Data loggers measure hydraulic head over compound weirs

RESULTS

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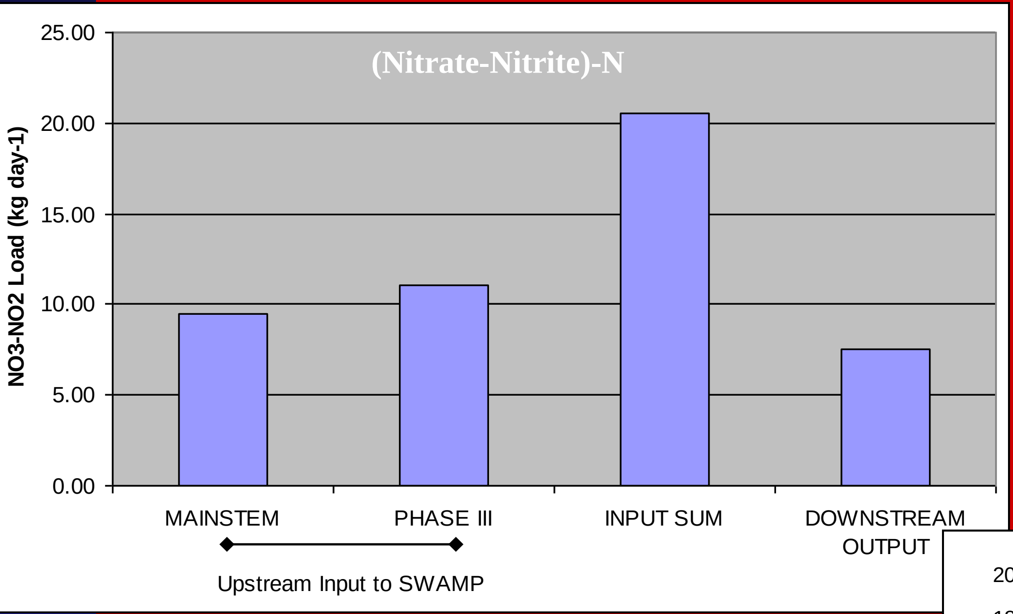
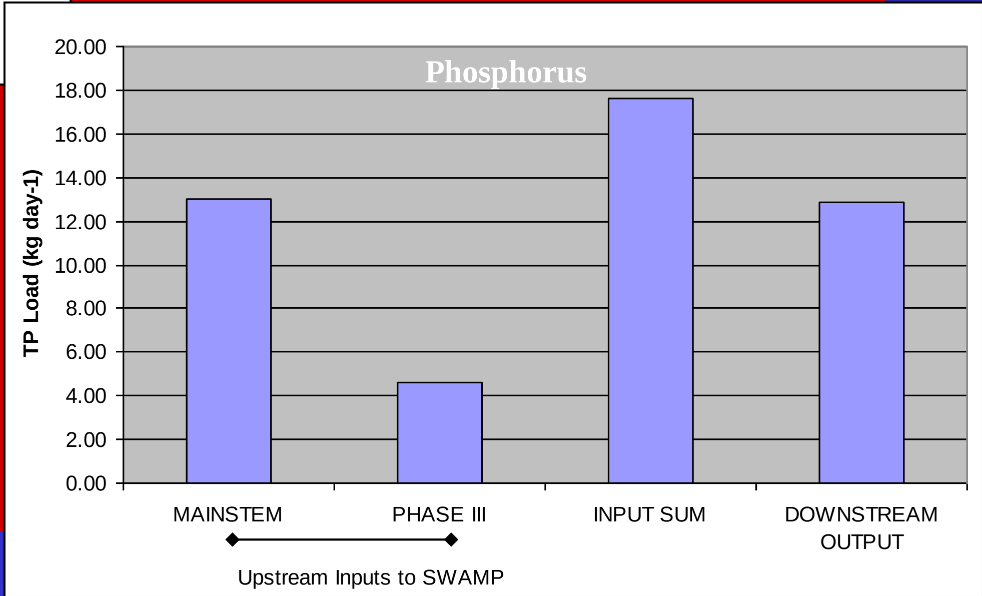
Results – Water Quality was Improved

- **Storm mass balance calculations indicate (NO3- NO2)-N loads were reduced by 64% and TP by 28%**



- **Estimates of 24 hr. total inflow and outflow differed by only 7%,**
  - **dilution could not explain load reductions**



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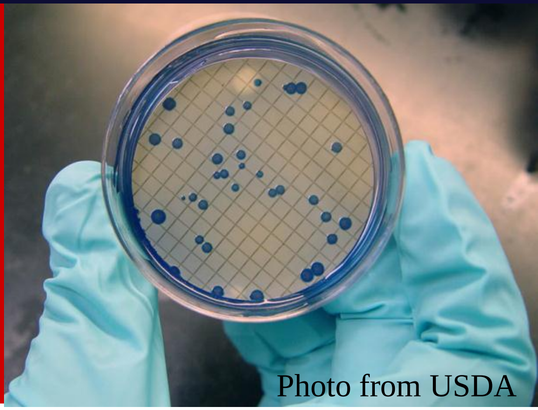
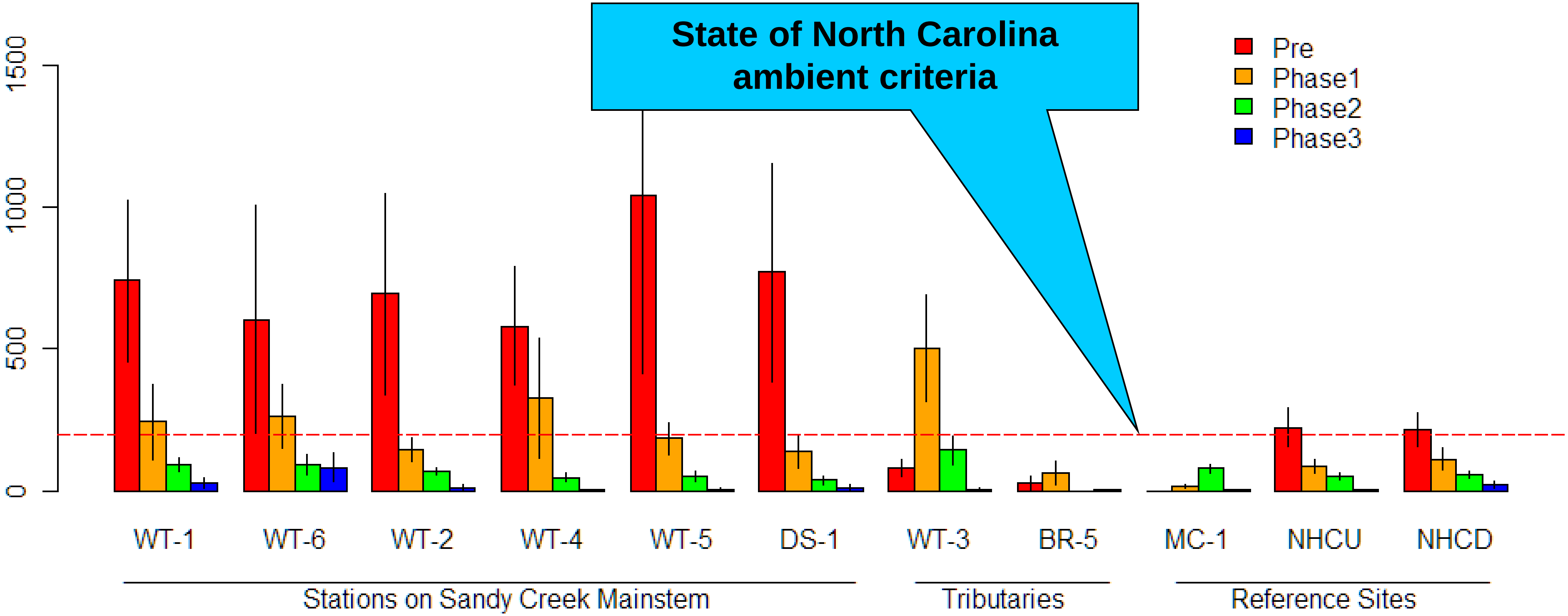
Results – Water Quality was Improved

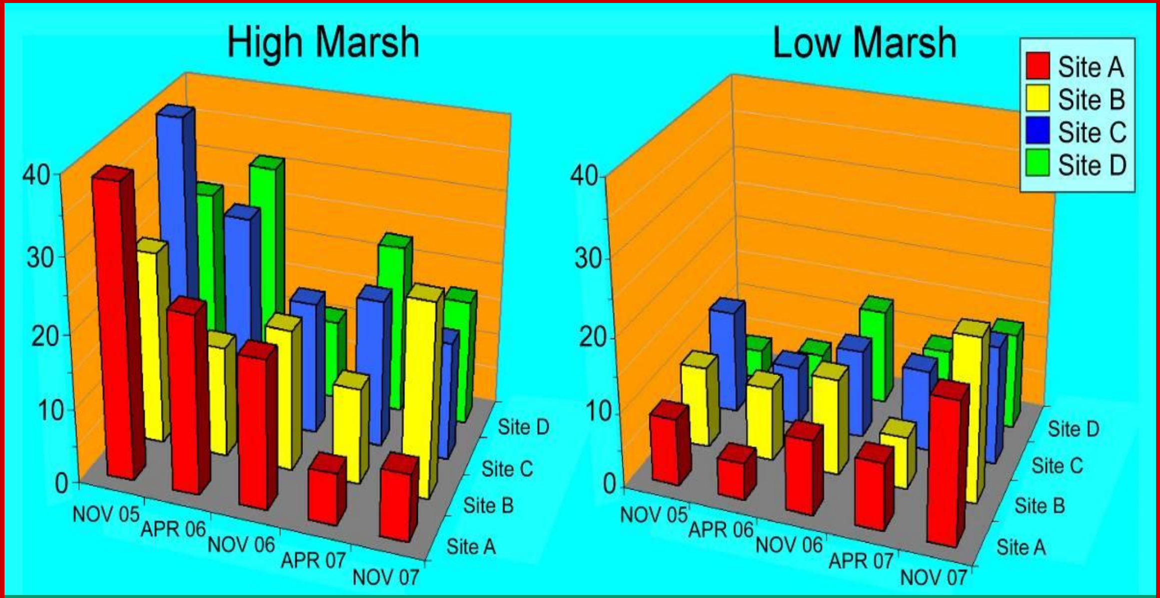
- **Significant decreases in fecal coliform counts were seen at the downstream project boundary during sampling periods**





Results – Wetland Plant Community was restored

- Wetland plant diversity increased in low marsh and decreased in high marsh
- Invasive *microstegium* did not invade low marsh benches



Fluctuation of plant species in High Marsh and Low Marsh through five semi-annual vegetation surveys.

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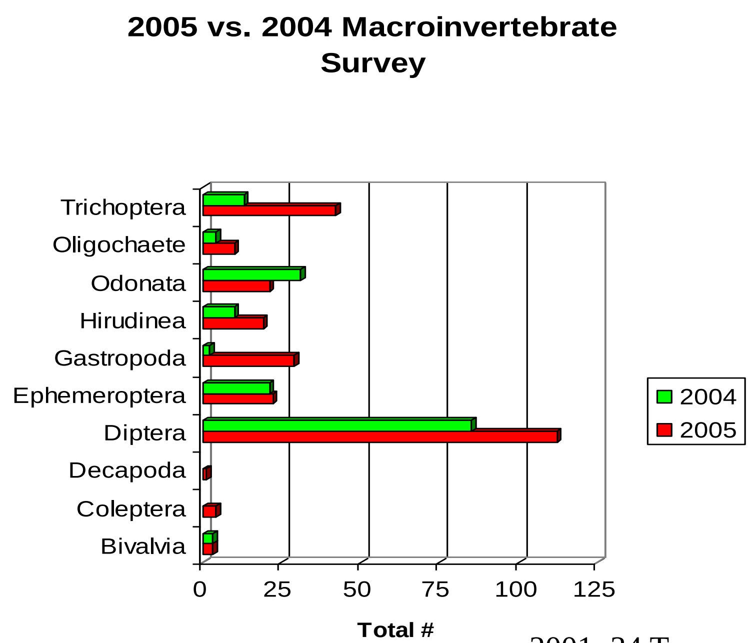
Results – **Stream Habitat Increased**

- Stream macroinvertebrate species increased 3x after restoration



(Roberts, 2005)

2001: 34 Taxa
2005: 89 Taxa

(Still, 2009)

	Gathering Collectors	Filtering Collectors	Predators	Shredders	Scrapers
WT-1	22	30	32	13	4
WT-A	9	34	31	22	8
WT-5	20	1	13	21	3
MC	41	22	29	8	10
PRE	6	4	23	5	4

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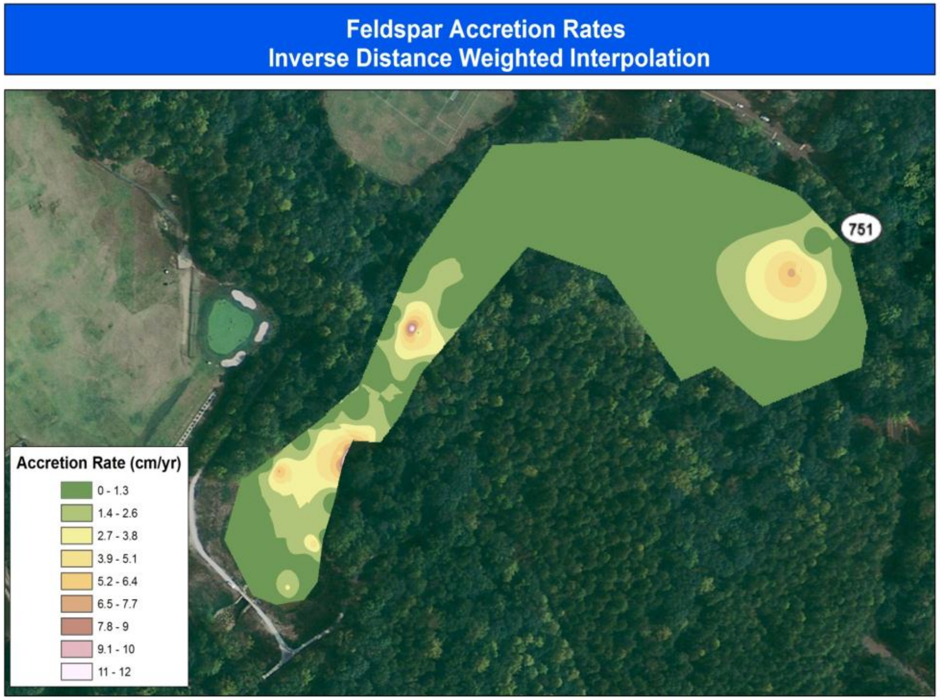
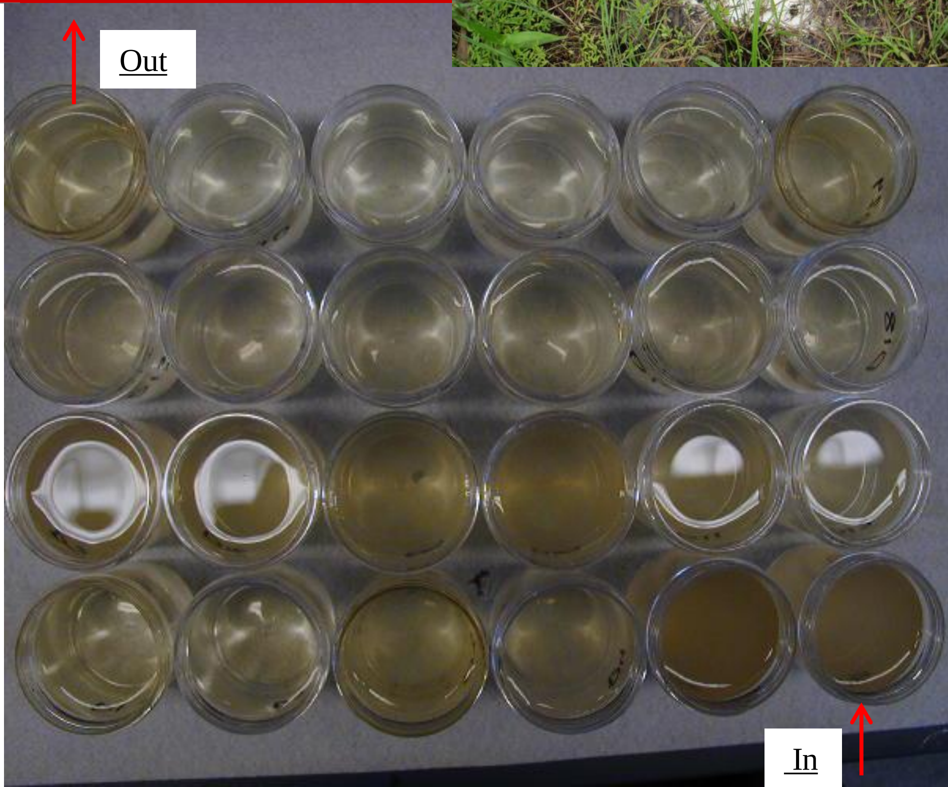
Results – Wetland Hydrology and Sediment Retention was Restored

- SWAMP removed 488 MT of sediment each year from Duke and Durham urban runoff
- Nearly 2,000 MT of sediment removed since 2006





Conclusions

- Reconnecting the channel with its original floodplain can restore the wetland functions and be conducive to wetland plant survival
- Reduction can occur in suspended solids, nutrients, and fecal coliform when properly integrating wetlands and streams
- Stream habitat for macroinvertebrates can improve with stream restoration and with improved water quality (i.e. reduced loads of TN, TP, fecal coliform, and suspended solids)

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Upper Sandy Creek - SWAMP Projects

Funded by

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USDA

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Continued Monitoring