Development of Nutrient TMDLs for the Raritan River Basin

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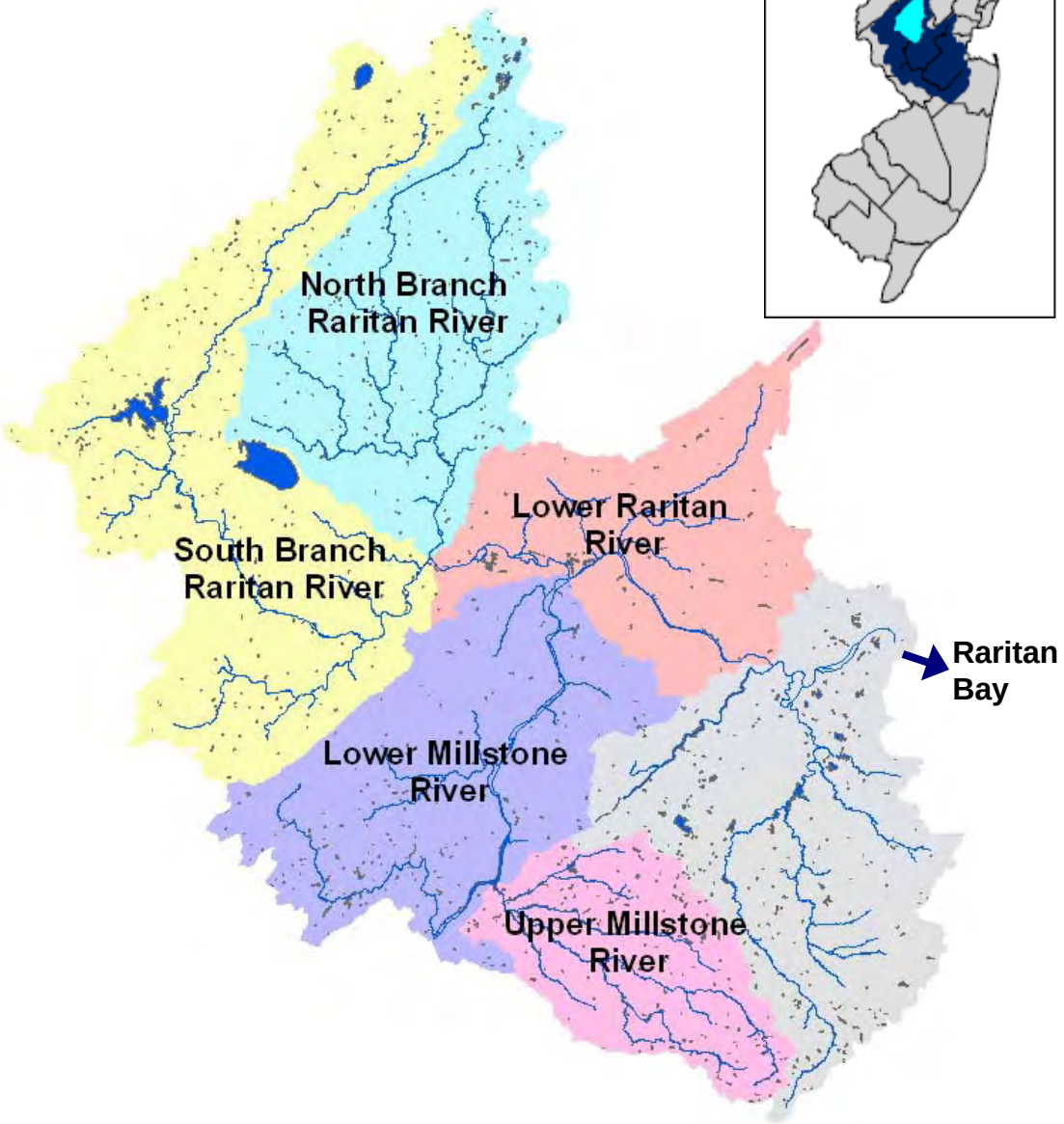
Outline

- Overview
  - Raritan River Basin
  - TMDL Study
- Sampling Program
- Watershed Model
  - Flow Models
  - Water Quality Models
- Conclusions

Raritan River Basin Overview

- Pollutant Sources
  - > 80 STPs (mostly very minor)
  - Highly varying land uses
  - Generally nonpoint source dominated
- Impairment Designations
  - Phosphorus, temperature, pH, TSS
- Key Issues
  - Where is phosphorus causing impairment?
  - What measures would solve the problem?
  - What is natural condition?
  - What are causes of other impairments?



Raritan River Basin TMDL Study

- Provide technical basis for NJDEP to develop TMDLs as necessary to address phosphorus and other conventional impairments in the Raritan River Basin
  - Identify nutrient impairments and critical locations
  - Develop, calibrate, and verify watershed models to relate nutrient sources to water quality targets at critical locations
- Complements Phosphorus Evaluation Studies
  - Beden Brook Nutrient Study 2000-2001
  - Lower Millstone / Mainstem Raritan 2003
  - South Branch Raritan River in Washington Township 2004
  - Matchaponix Brook at Pine Brook 2004

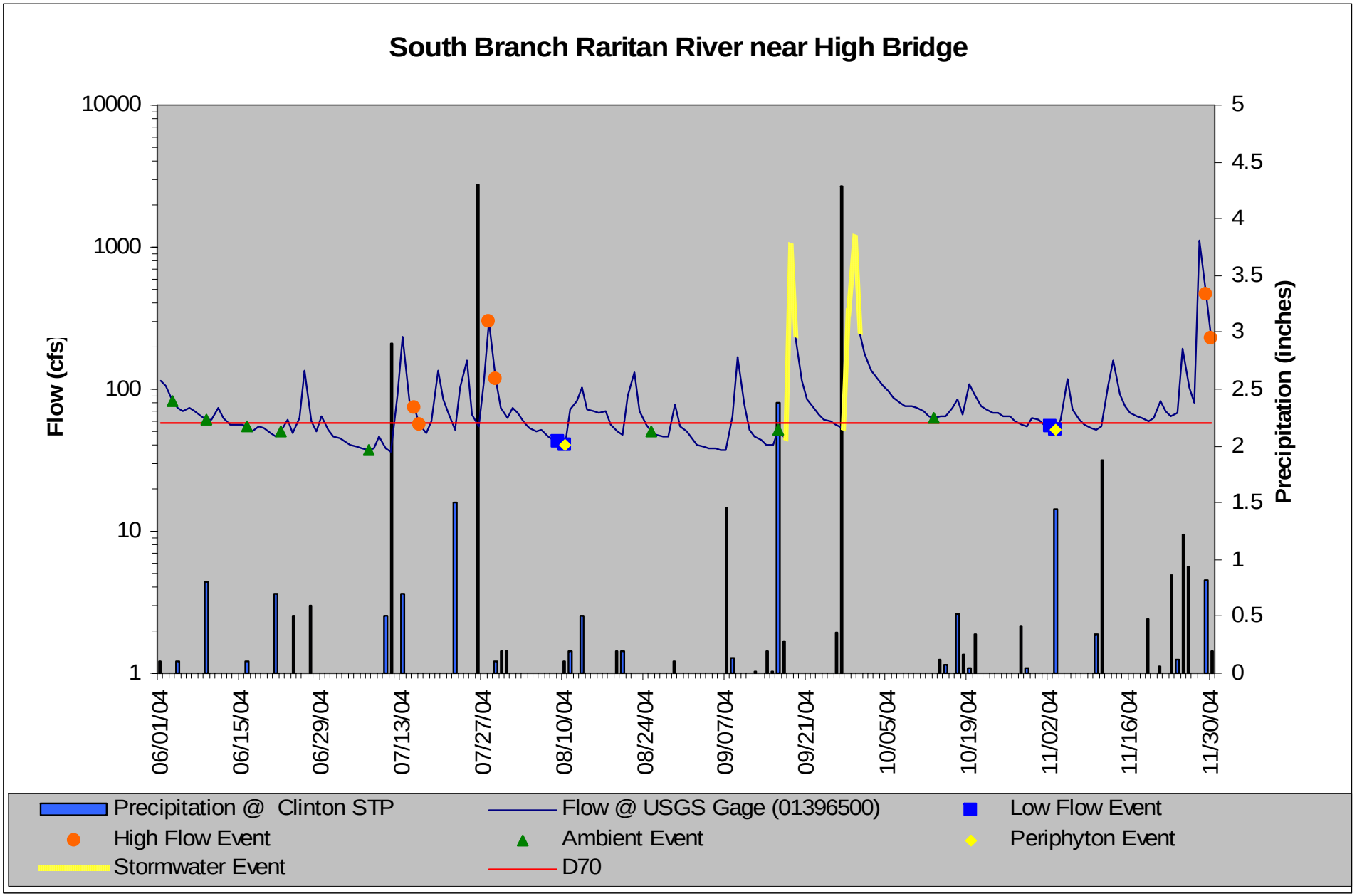
Monitoring Objectives and Networks

- Monitoring Objectives
  - Identify nutrient impairments and critical locations
  - Assess nature and cause of other conventional impairments
    - DO, pH, TSS, temperature
  - Develop, calibrate and verify watershed models
- Monitoring Networks
  - Streams and Lakes
    - 32 Stream Stations
    - 9 Lake Stations (Inlet, Inlake, and Outlet)
    - 6 Tributary Stations
    - 9 Baseflow Stations
  - 6 Stormwater Stations
  - 13 STP Stations

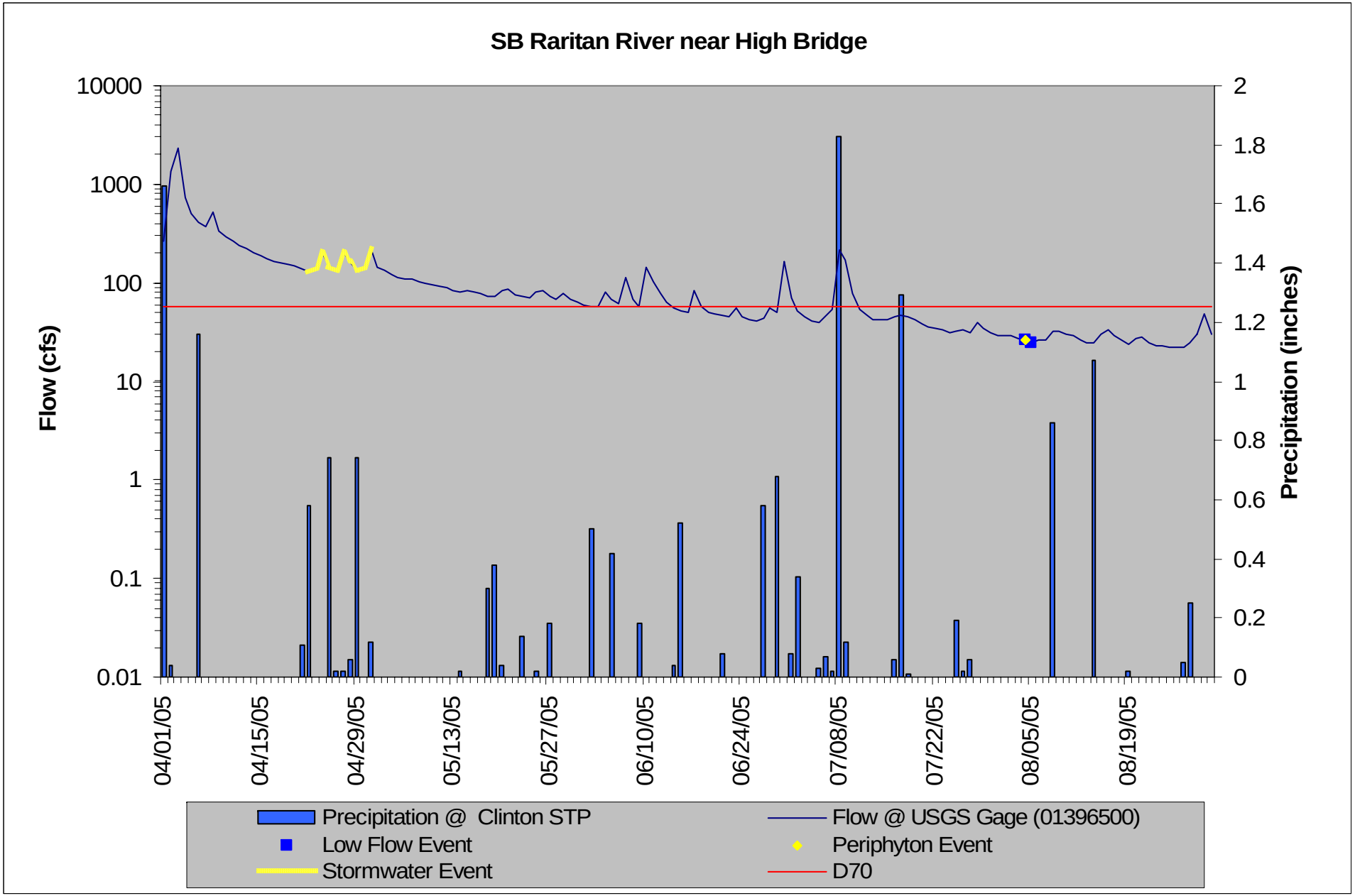
Monitoring Events and Parameters

- Monitoring Events
  - 3 Low-flow Events (2 days each) @ 77 stations (including 12 STPs)
  - 3 High-flow Events (2 days each) @ 69 stations (including 13 STPs)
  - 8 Ambient Events @ 41 stations
  - 3 Diurnal Events @ 41 stations
  - 3 Stormwater Events @ 6 stations
- Monitoring Parameters
  - In Situ
    - pH, temperature, dissolved oxygen, flow (stream and STP)
    - Diurnal meters @ 41 stream and lake locations
  - Laboratory
    - P-series, N-series, TDS, TSS, alkalinity, $CBOD_5$ (stream and STP)
    - Chlorophyll-a (phytoplankton and periphyton), iron, and turbidity (stream only)

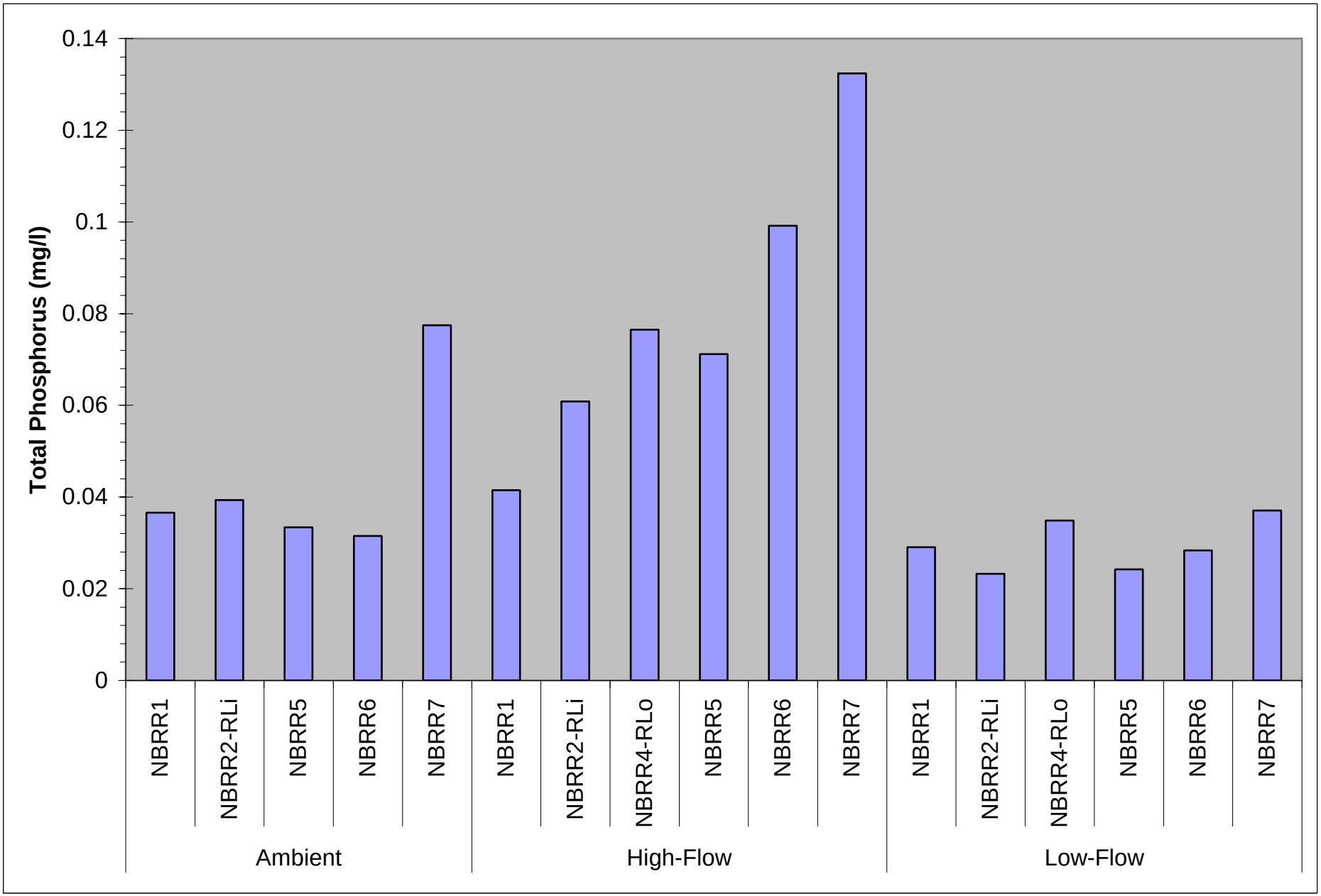
Flow and Precipitation Conditions During Sampling (2004)



Flow and Precipitation Conditions During Sampling (2005)



Average Phosphorus Concentrations in North Branch Raritan River

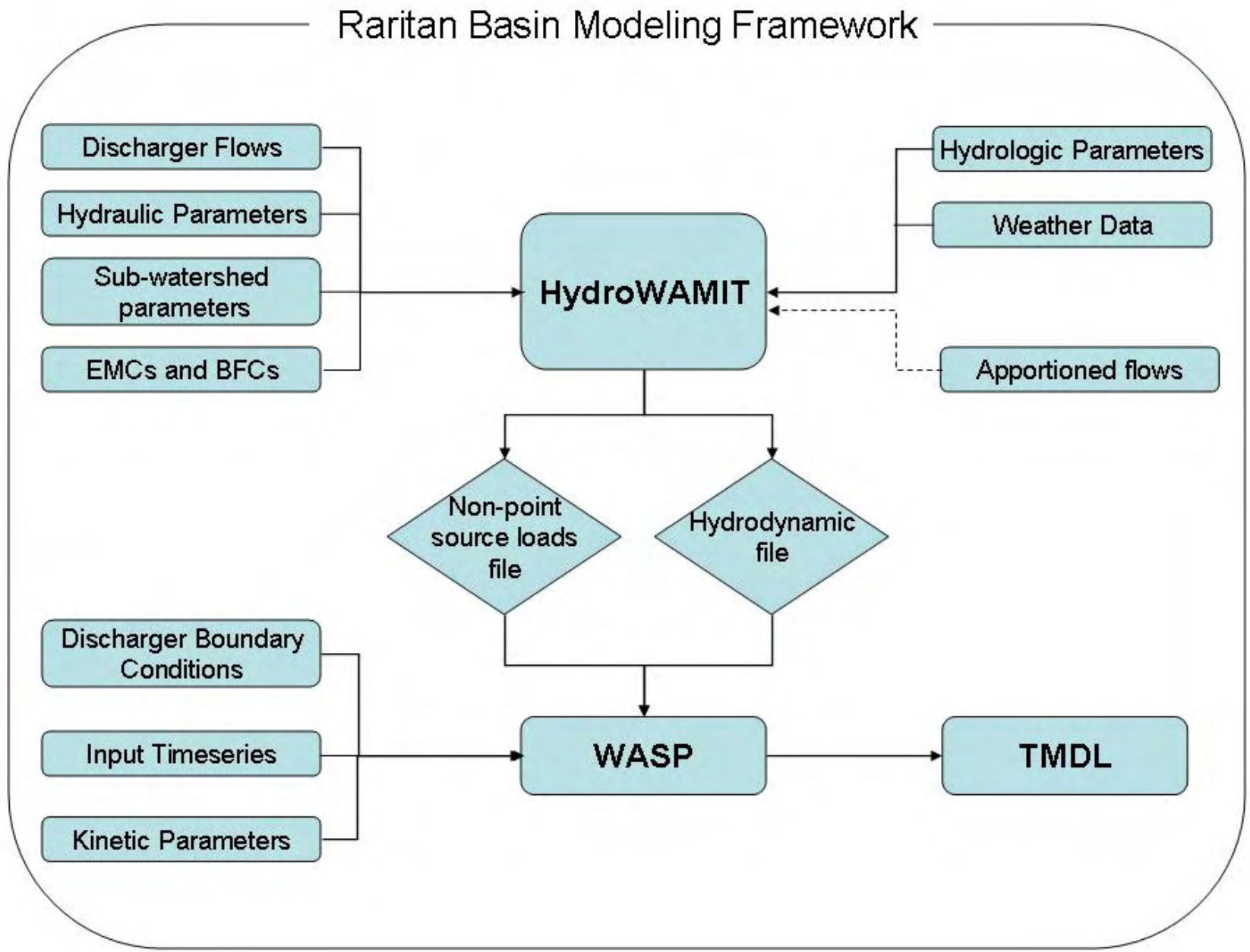


Watershed Model Purpose

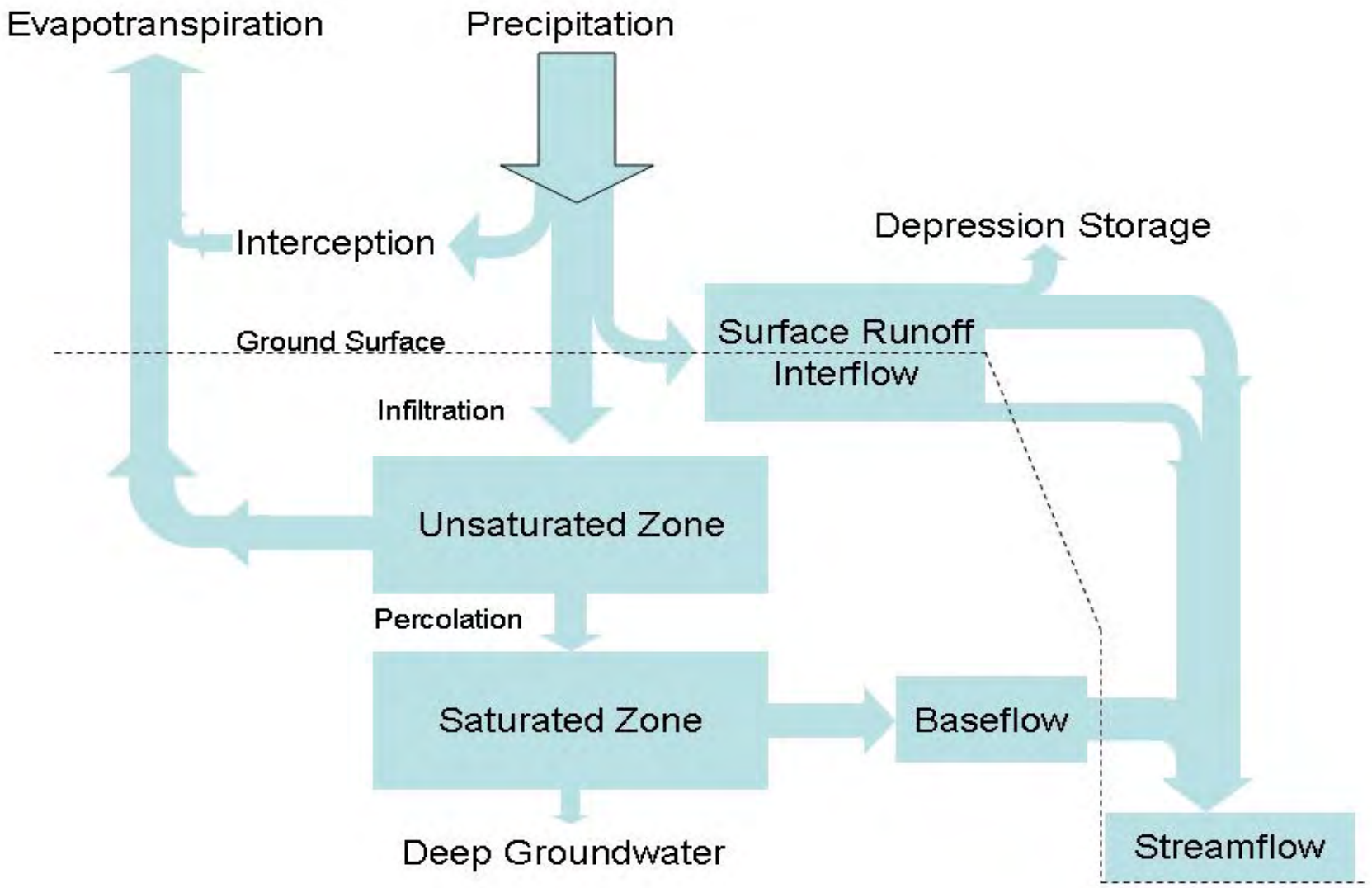
- Purpose
  - To relate point and nonpoint sources of nutrients to water quality impacts under a variety of conditions, including critical conditions
- Critical Water Quality Indicators
  - Dissolved oxygen
  - Phosphorus
  - Nitrogen components (ammonia and nitrate)

Watershed Model Overview

- Flow Model
  - Hydrologic Model (HydroWAMIT)
  - Five Basin Sub-models
- Water Quality Model
  - One-Dimensional dynamic simulation using WASP
  - Five Basin Sub-models
- Watershed Model Integration (HydroWAMIT)
  - Nonpoint source simulation
    - flow-weighted runoff EMCs
    - area-weighted baseflow concentrations
  - DA-FLOW and WASP integration


Raritan Basin Modeling Framework
Discharger Flows
Hydraulic Parameters
Sub-watershed parameters
EMCs and BFCs
HydroWAMIT
Hydrologic Parameters
Weather Data
Apportioned flows
Non-point source loads file
Hydrodynamic file
Discharger Boundary Conditions
Input Timeseries
Kinetic Parameters
WASP
TMDL

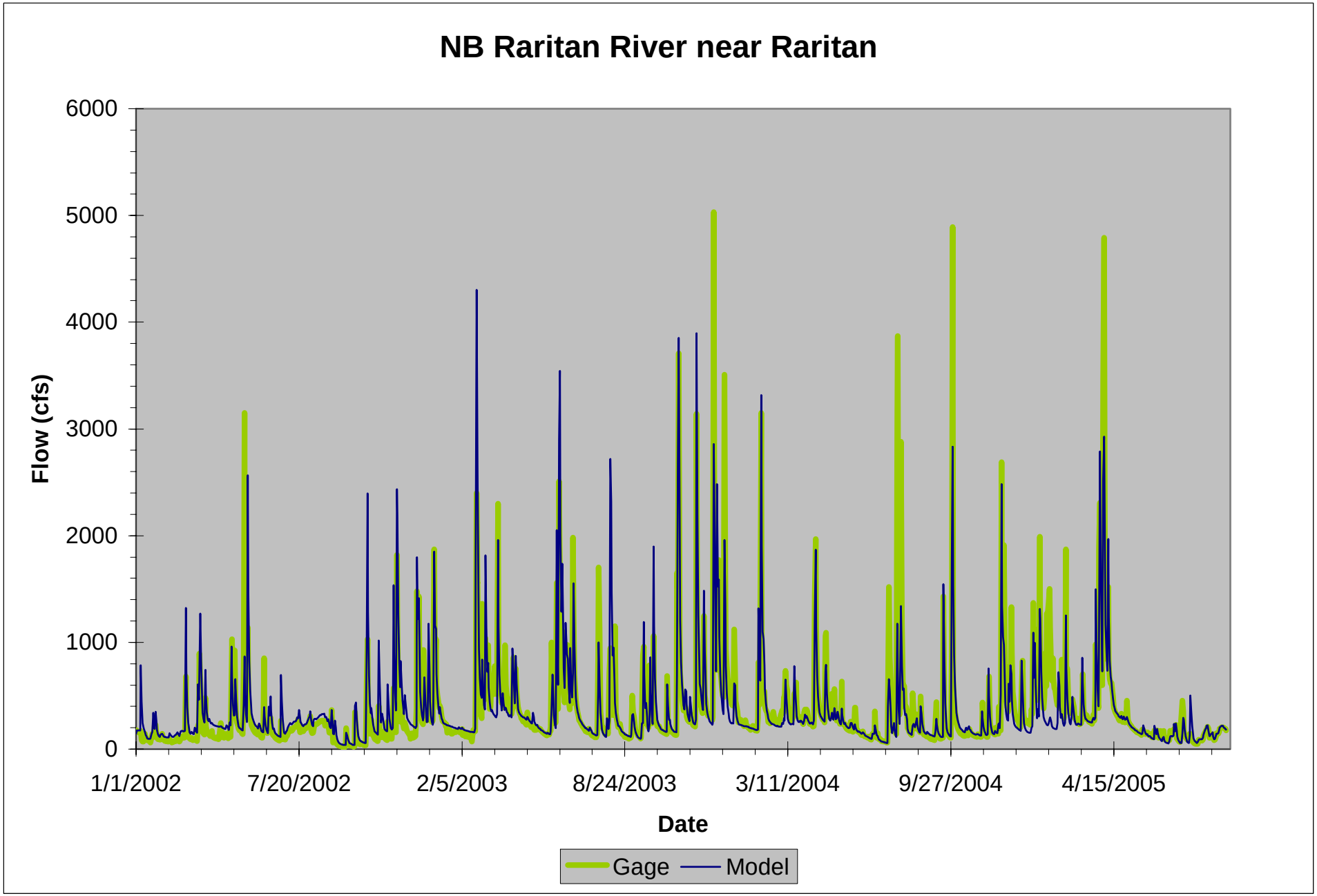
Conceptual Hydrologic Model



Main Features of Hydrologic Model

- Model is a hybrid of GWLF and HSPF
- Precipitation driven
- Daily time step and long term simulations
- Area of interest can be subdivided into multiple interconnected sub-watersheds
- The smallest hydrologic simulation unit is the land use type within each sub-watershed
- Surface runoff is calculated as a direct function of imperviousness, precipitation and available water in the unsaturated zone
- Allows changes in flow and pollutant loads due to changes in land use distribution and perviousness
- Flow routing routine is DAFLOW

Hydrologic Model Calibration Results



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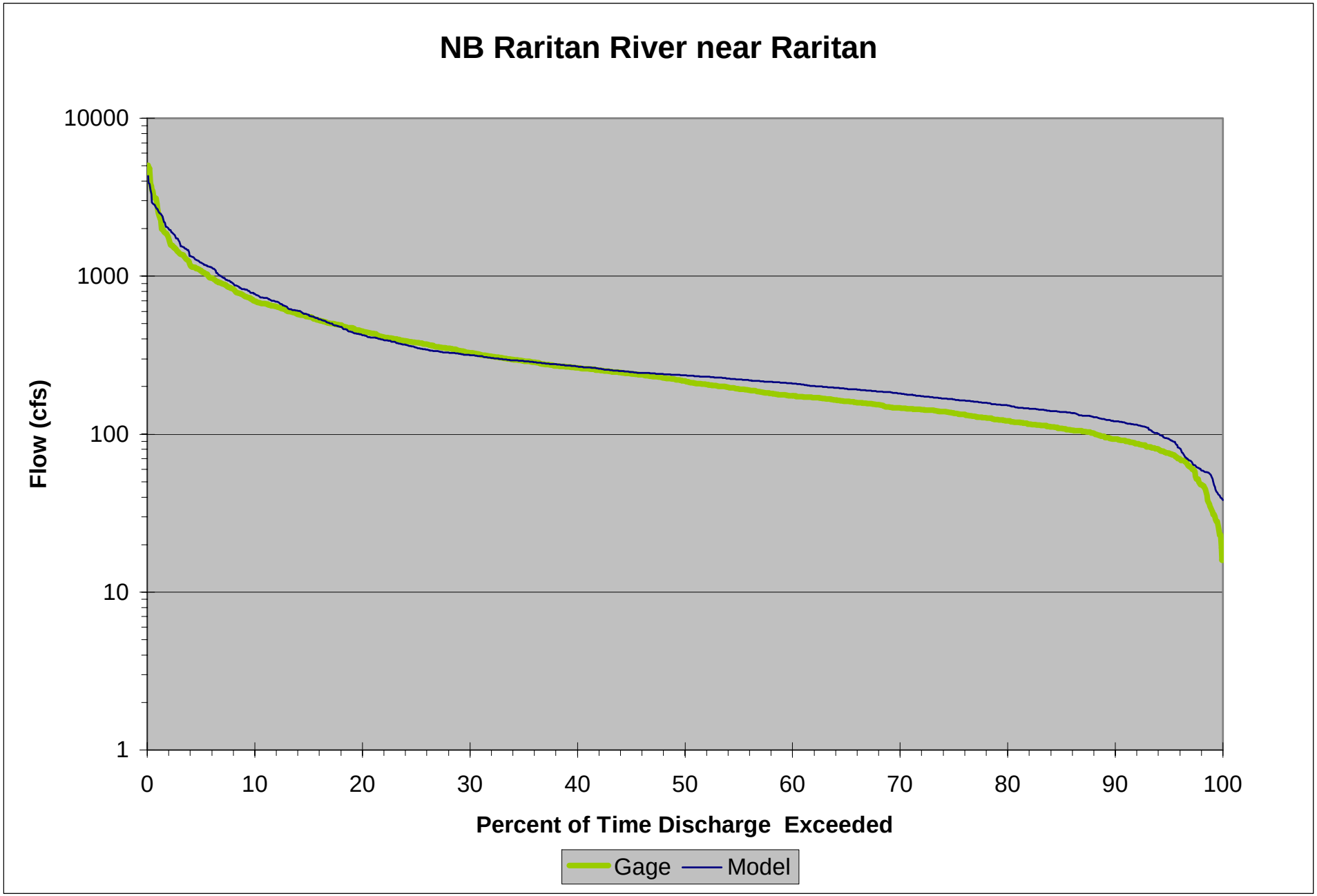
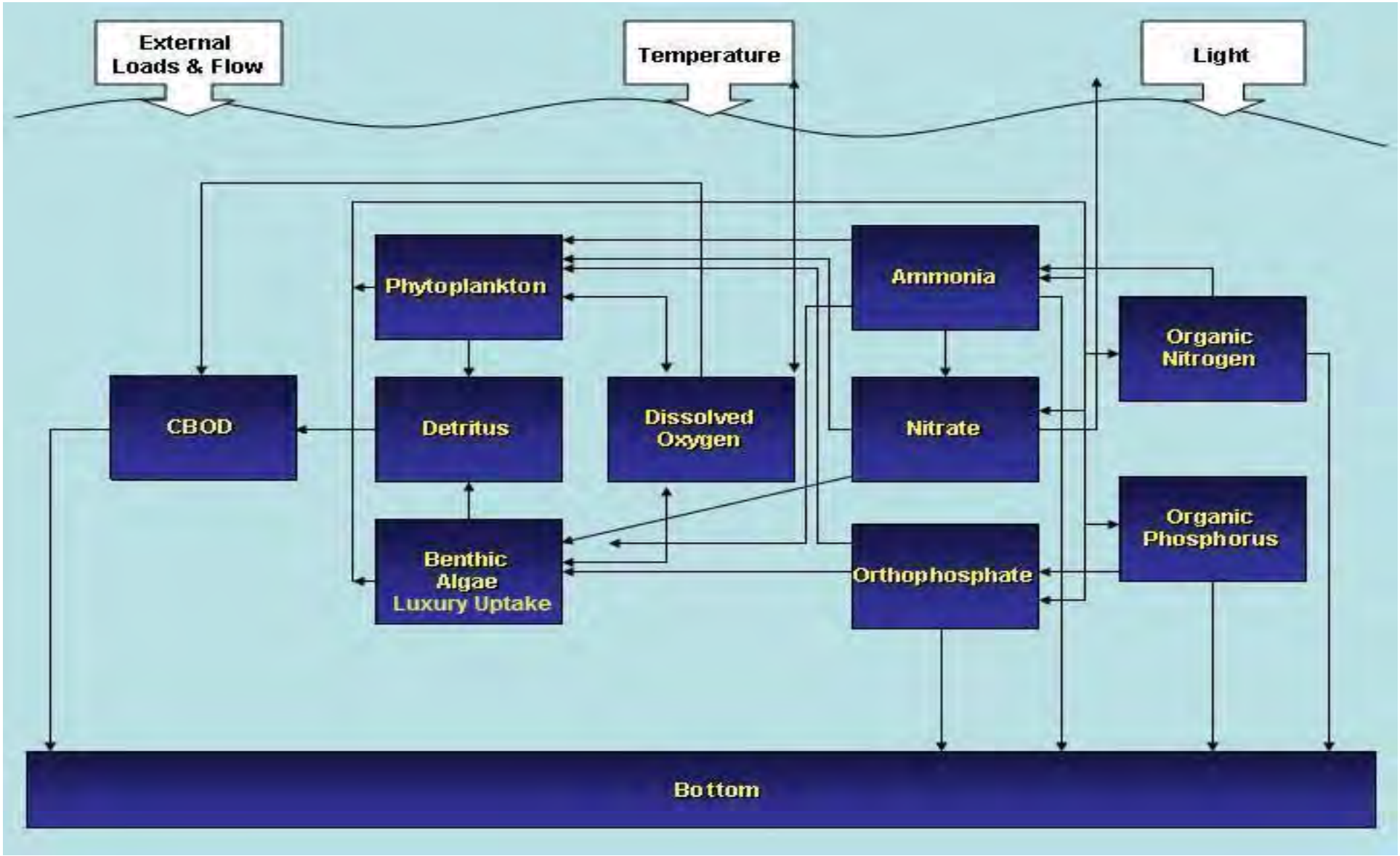


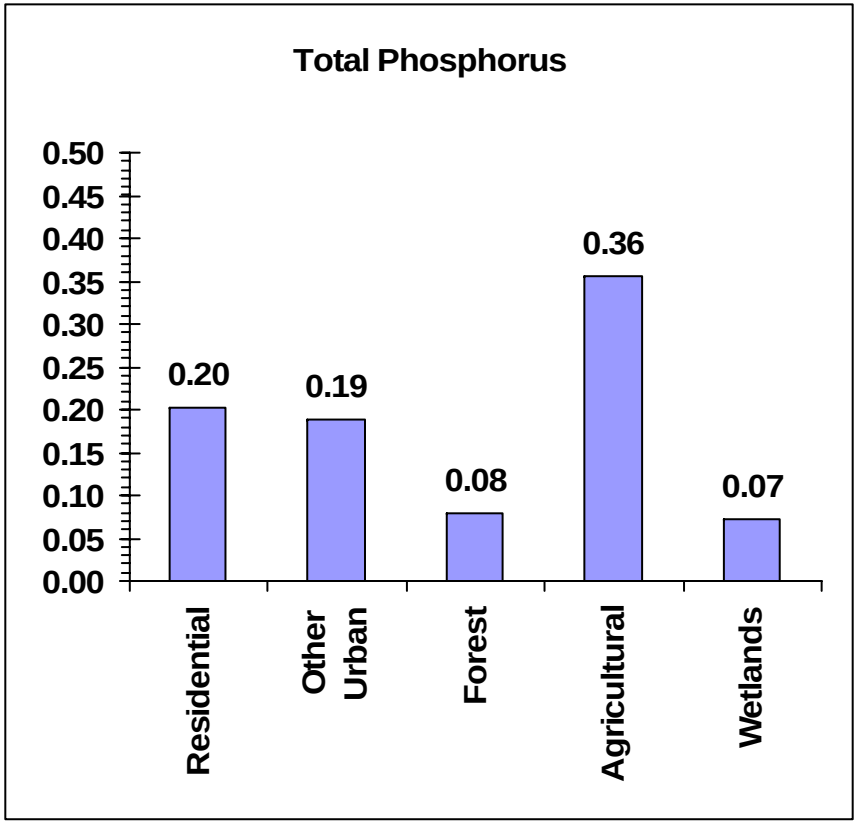
Water Quality Model: WASP 7.1

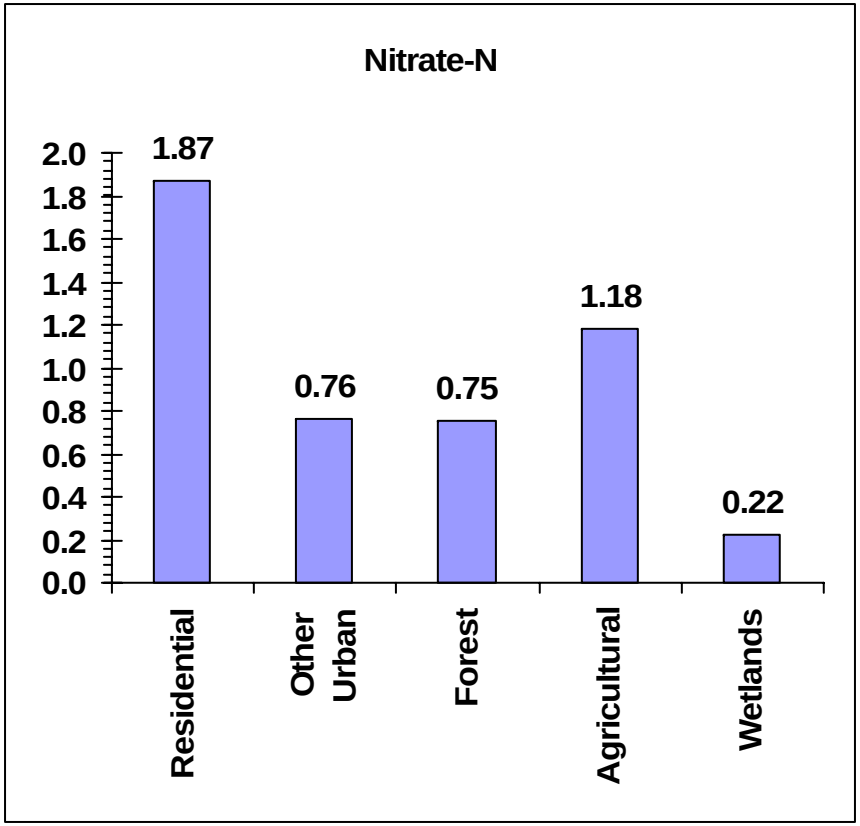


Nonpoint Source Load Calculations

- NPS loads are associated with the stormwater and tributary flows simulated by the hydrologic model.
- Stormwater loads are calculated by multiplying the flow from a given land use by the respective concentration
  - Stormwater concentrations are defined for each land use type and can vary according to sub-watershed
- Tributary loads are calculated by multiplying the sub-watershed tributary flow by the tributary concentrations
  - Tributary concentrations are defined for each sub-watershed according to land uses and can vary in time

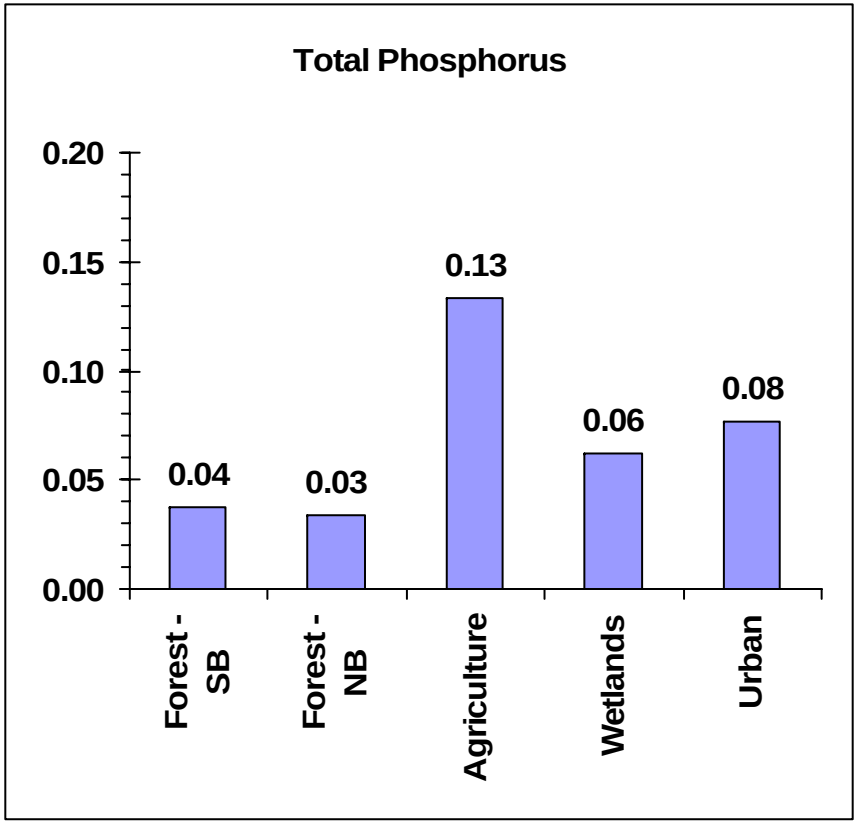
Stormwater Concentrations* (mg/l)

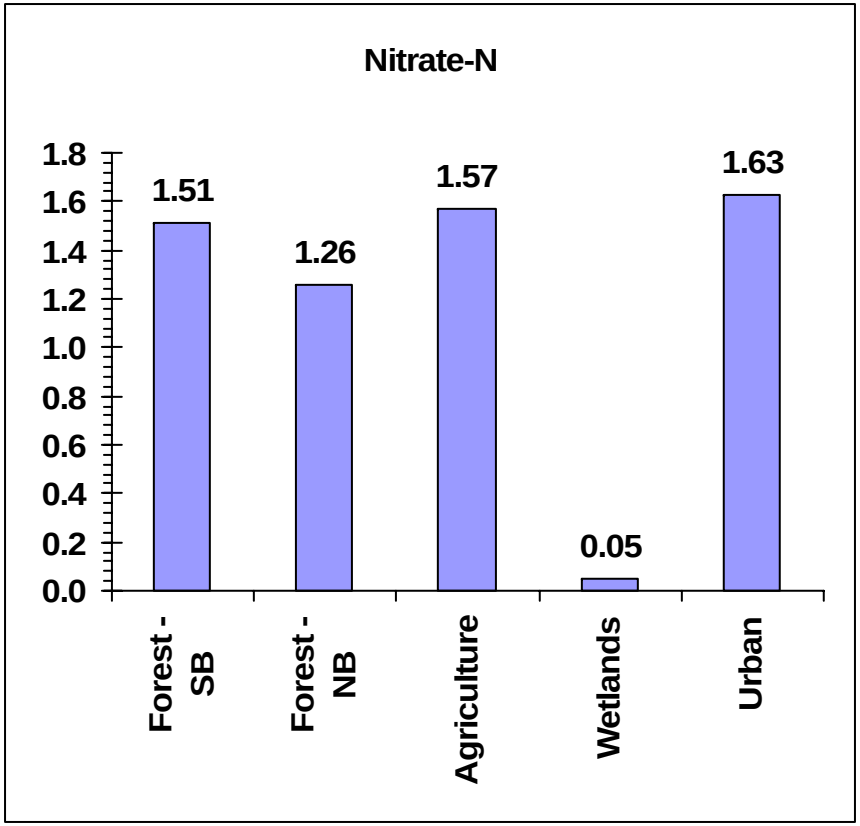




*Under review by NJDEP and New Jersey EcoComplex

Tributary Concentrations* (mg/l)





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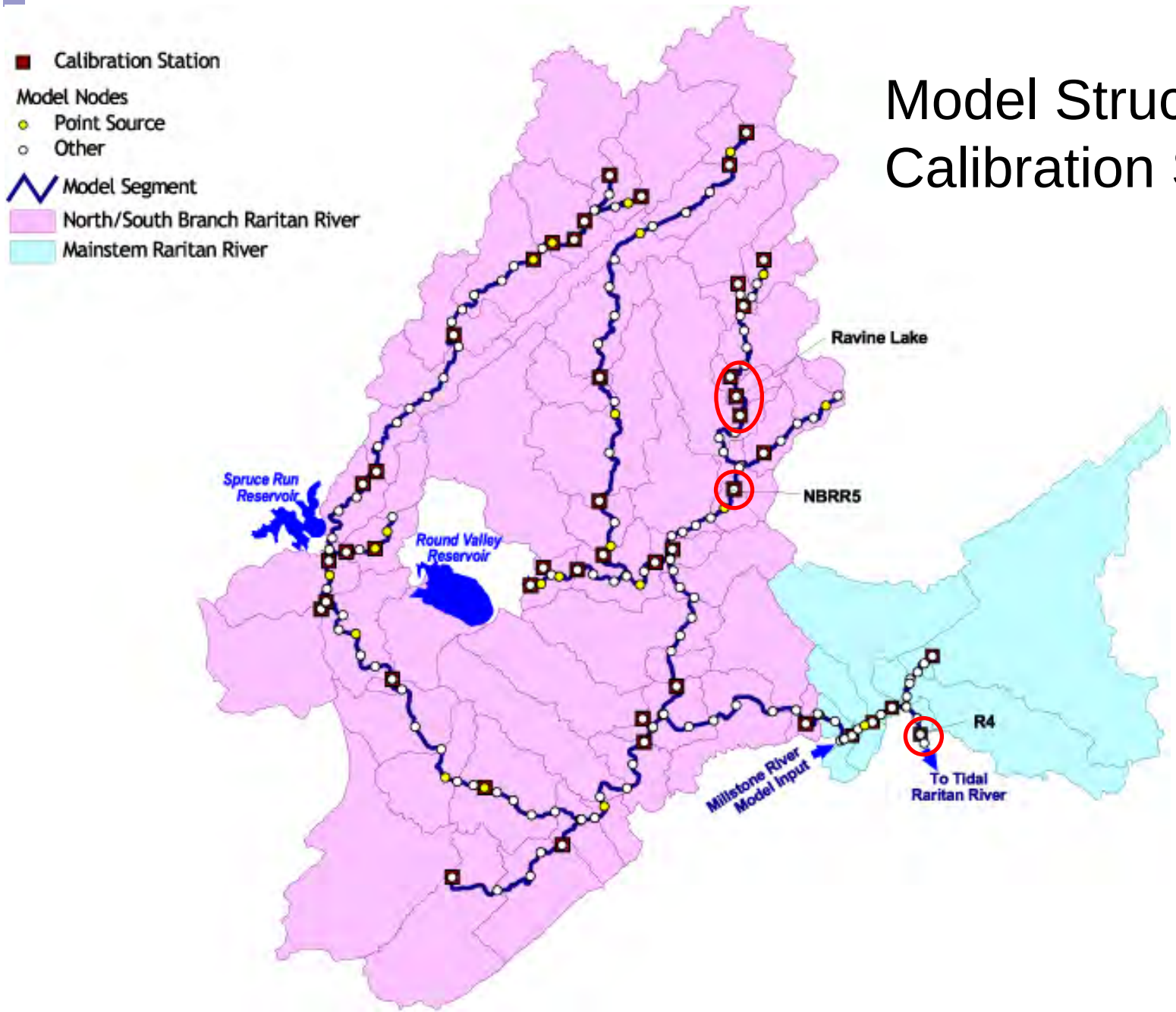
Model Structure and Calibration Stations



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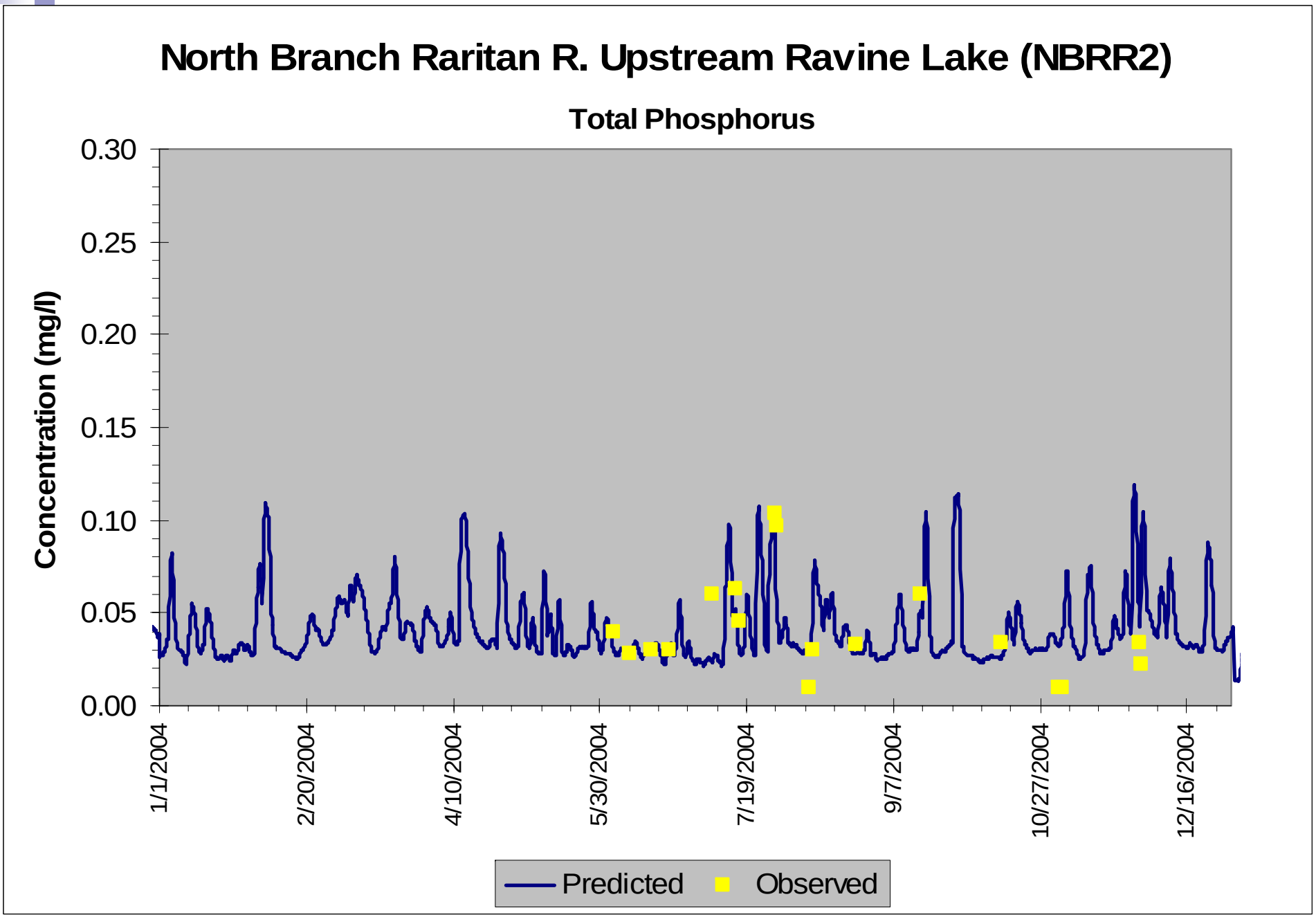

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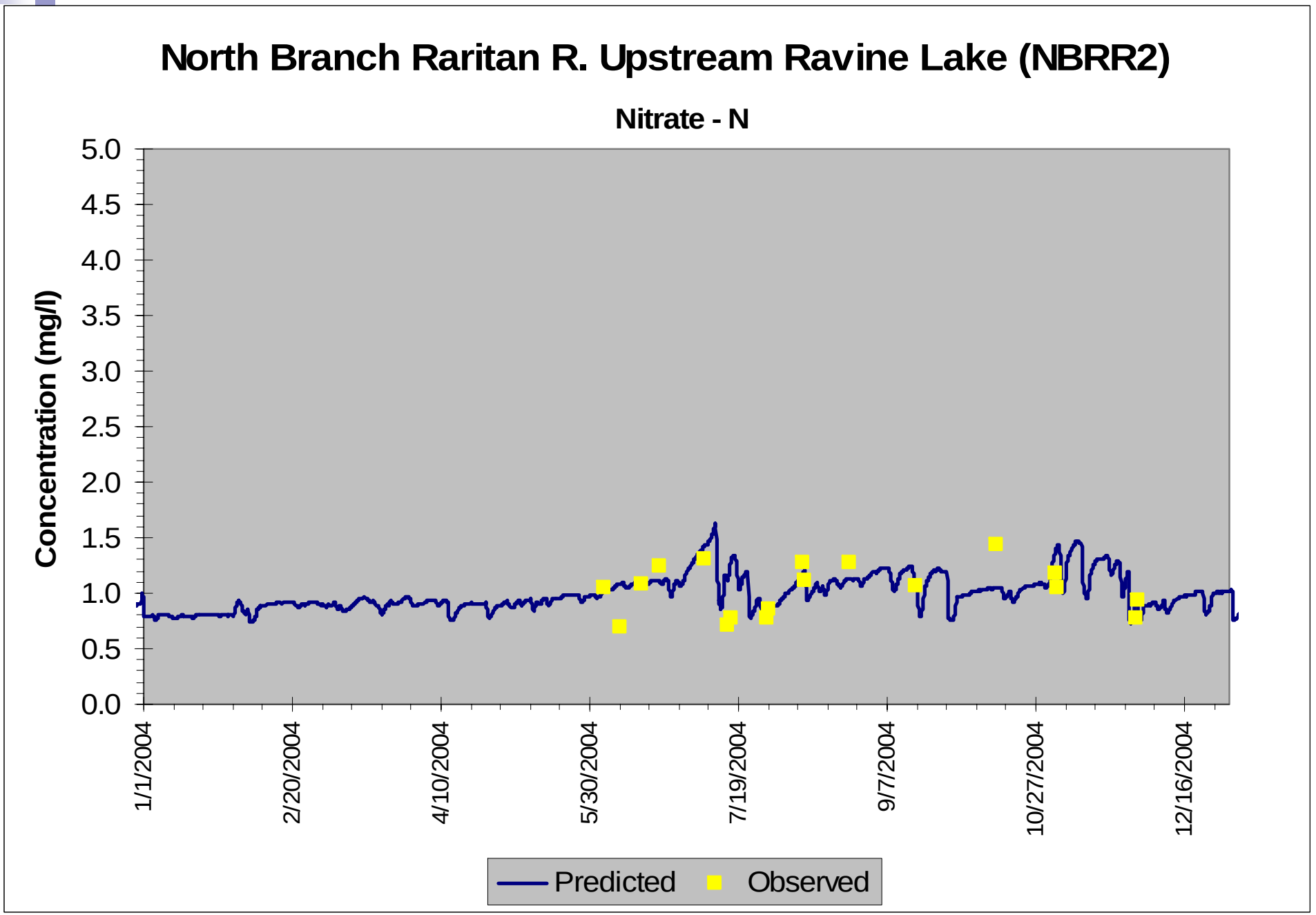

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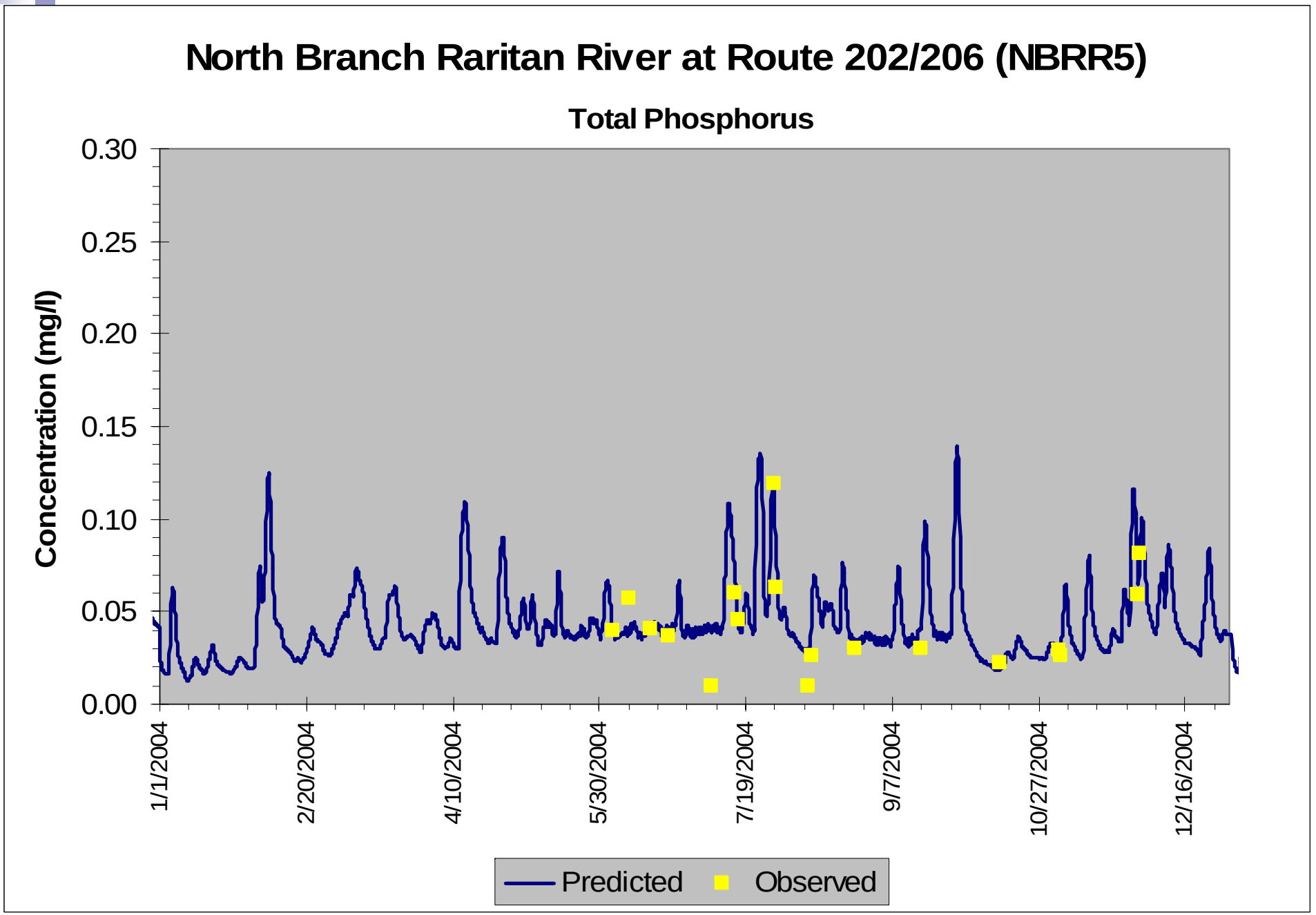

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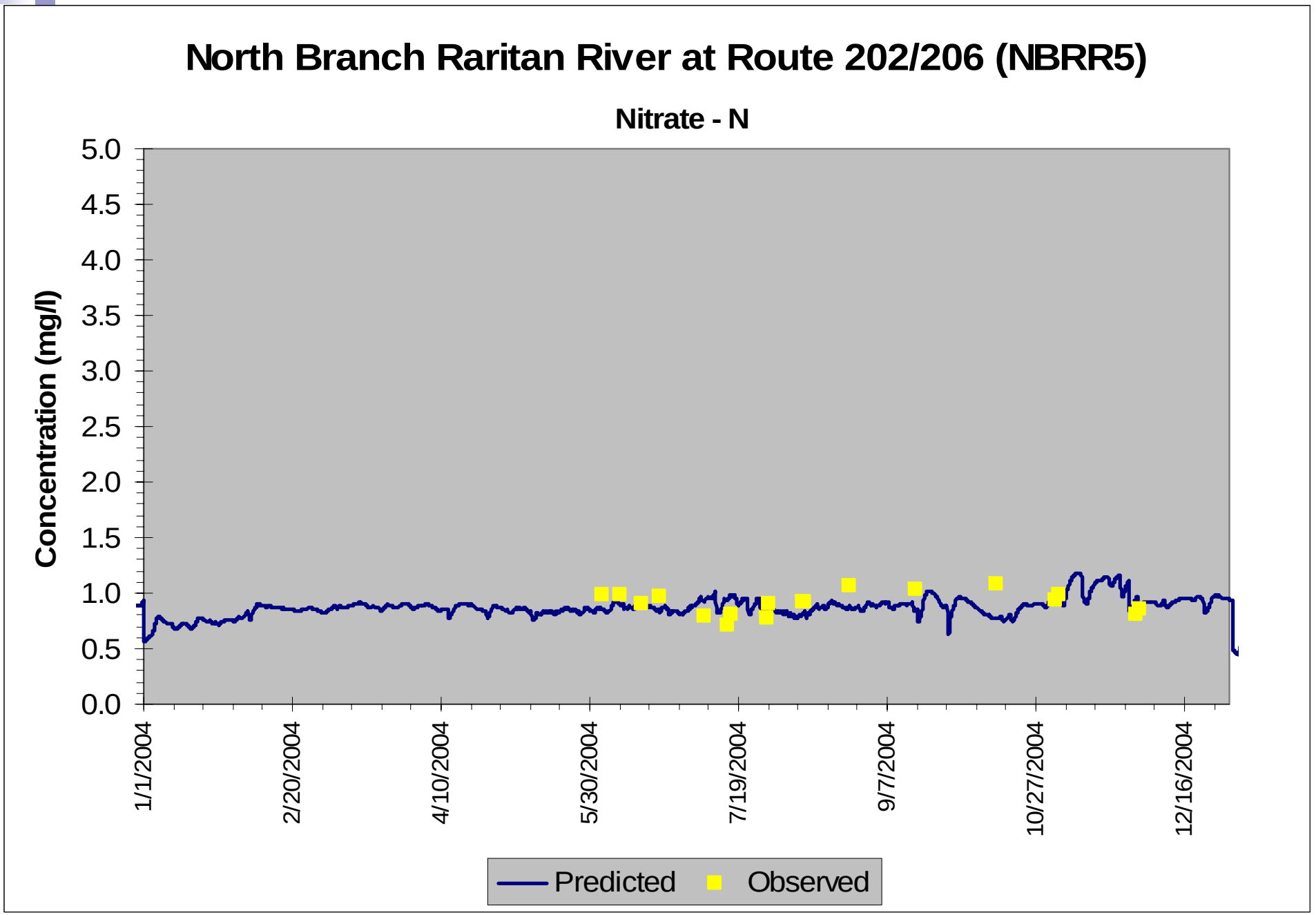

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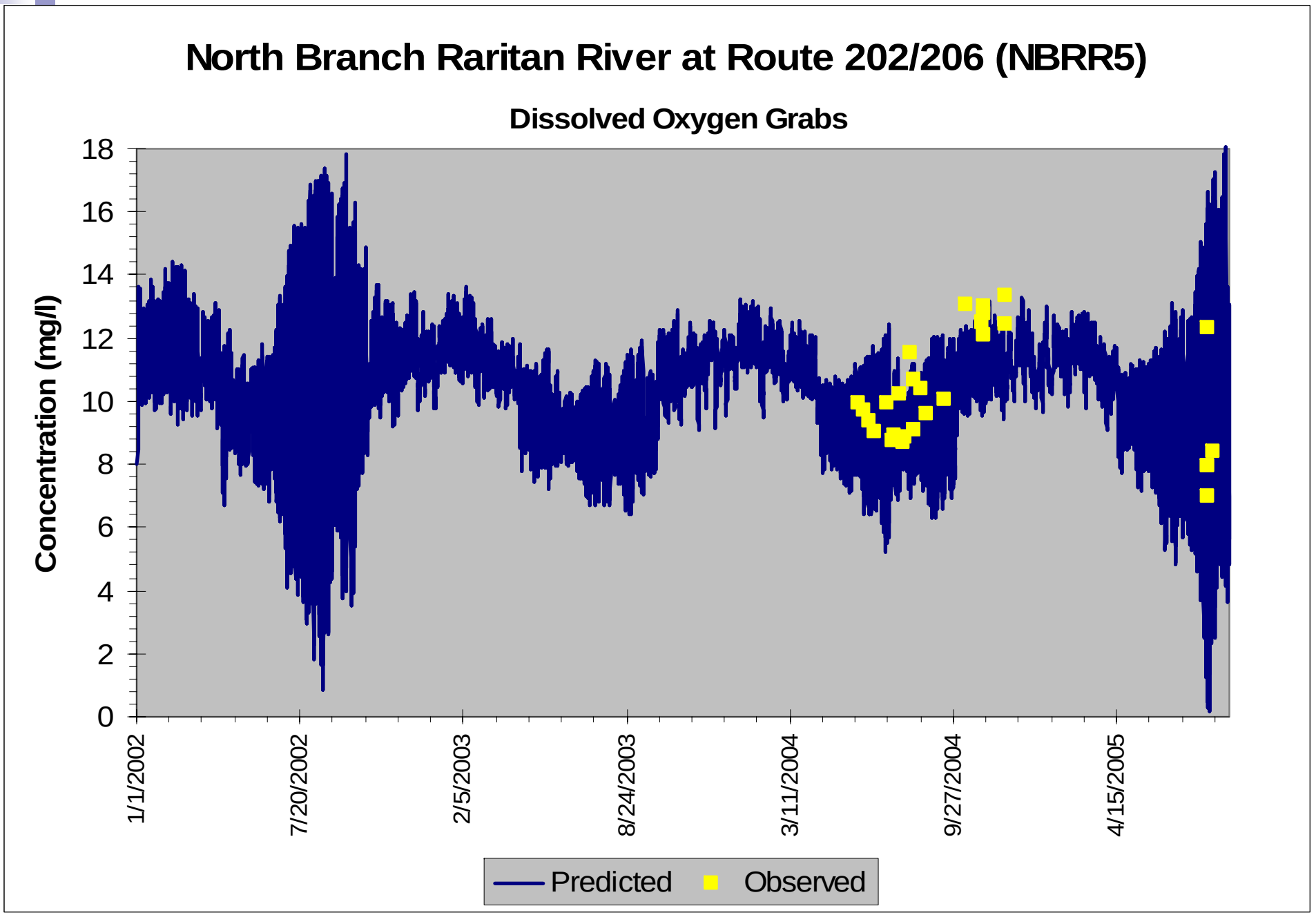

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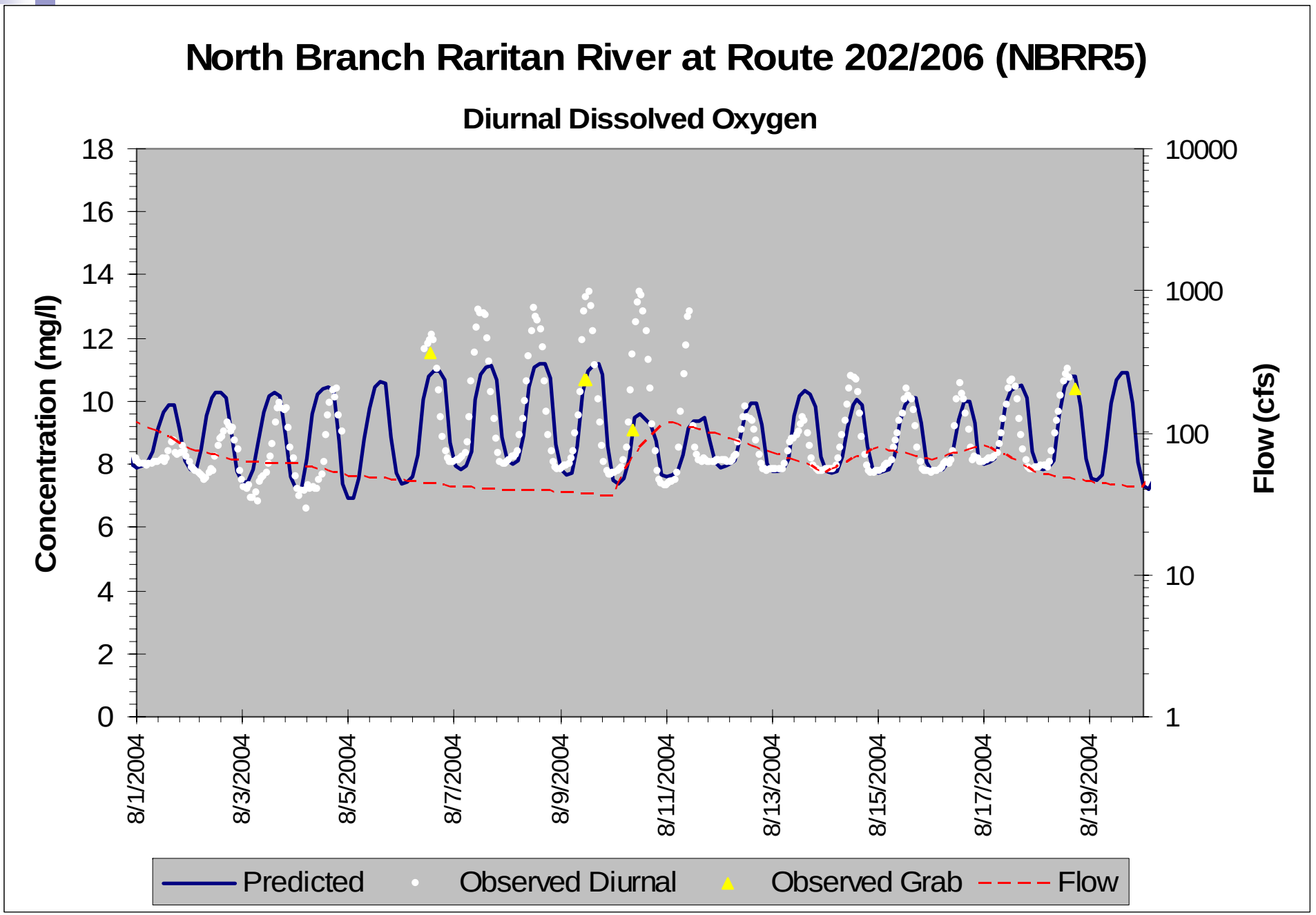

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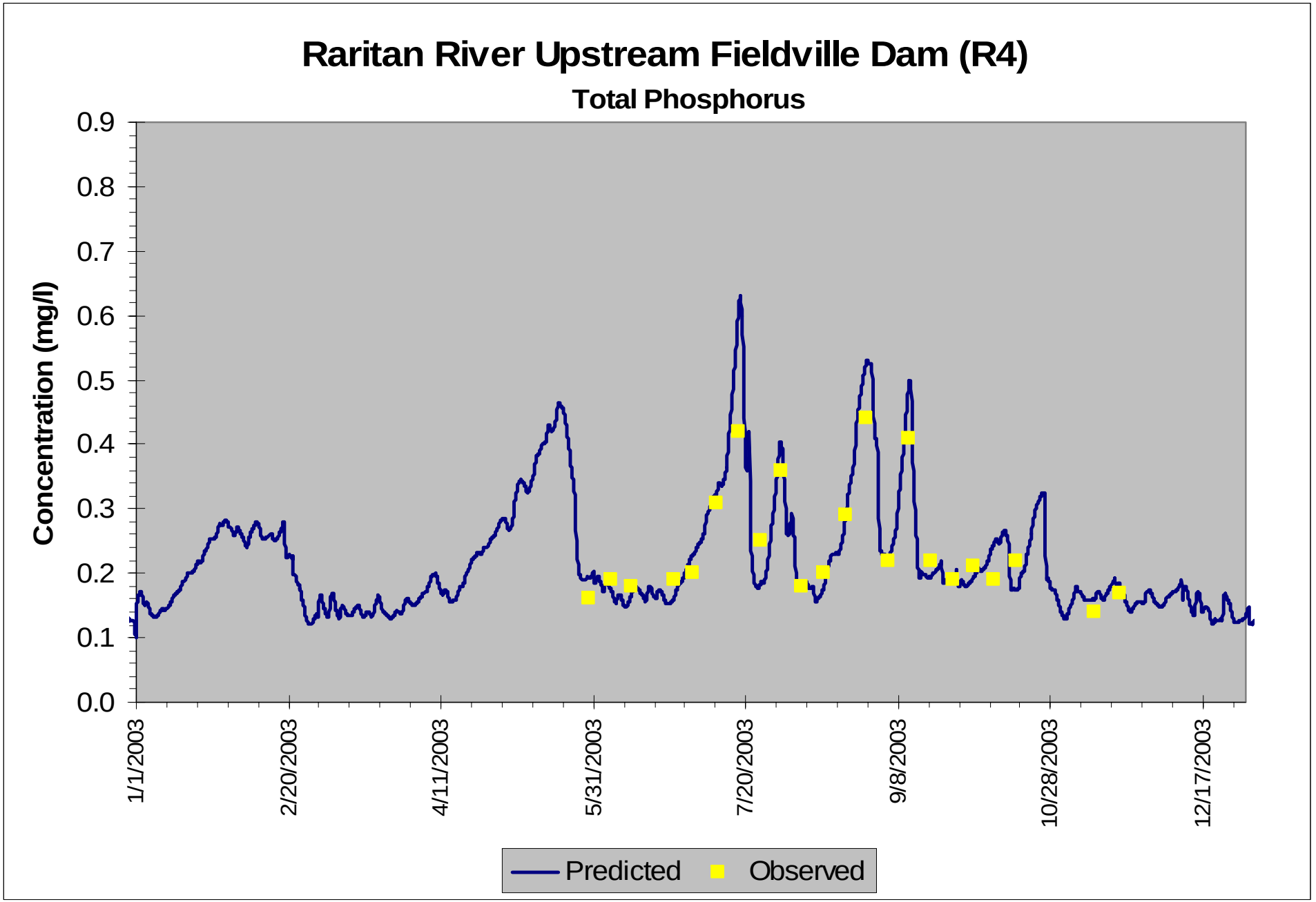

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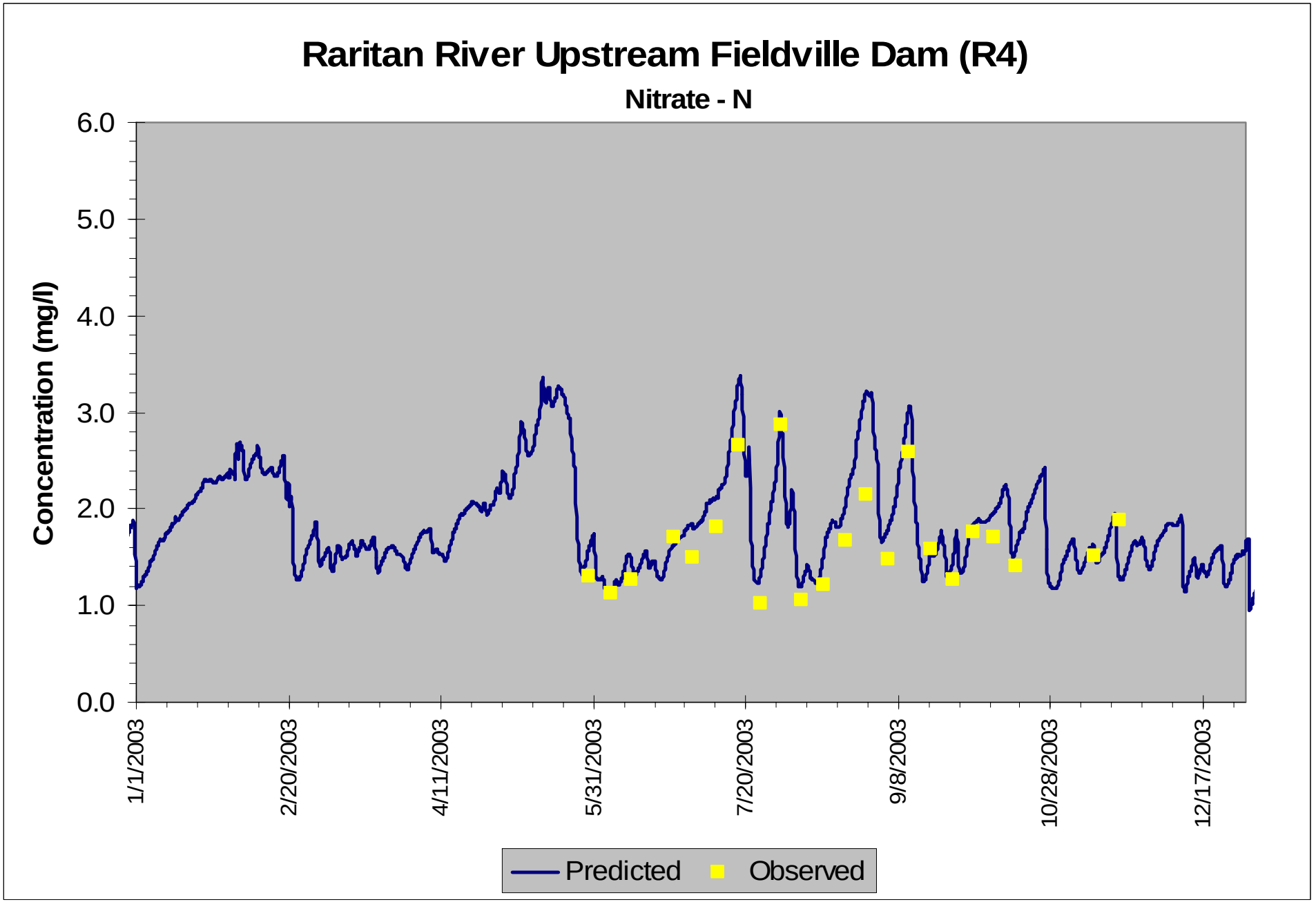

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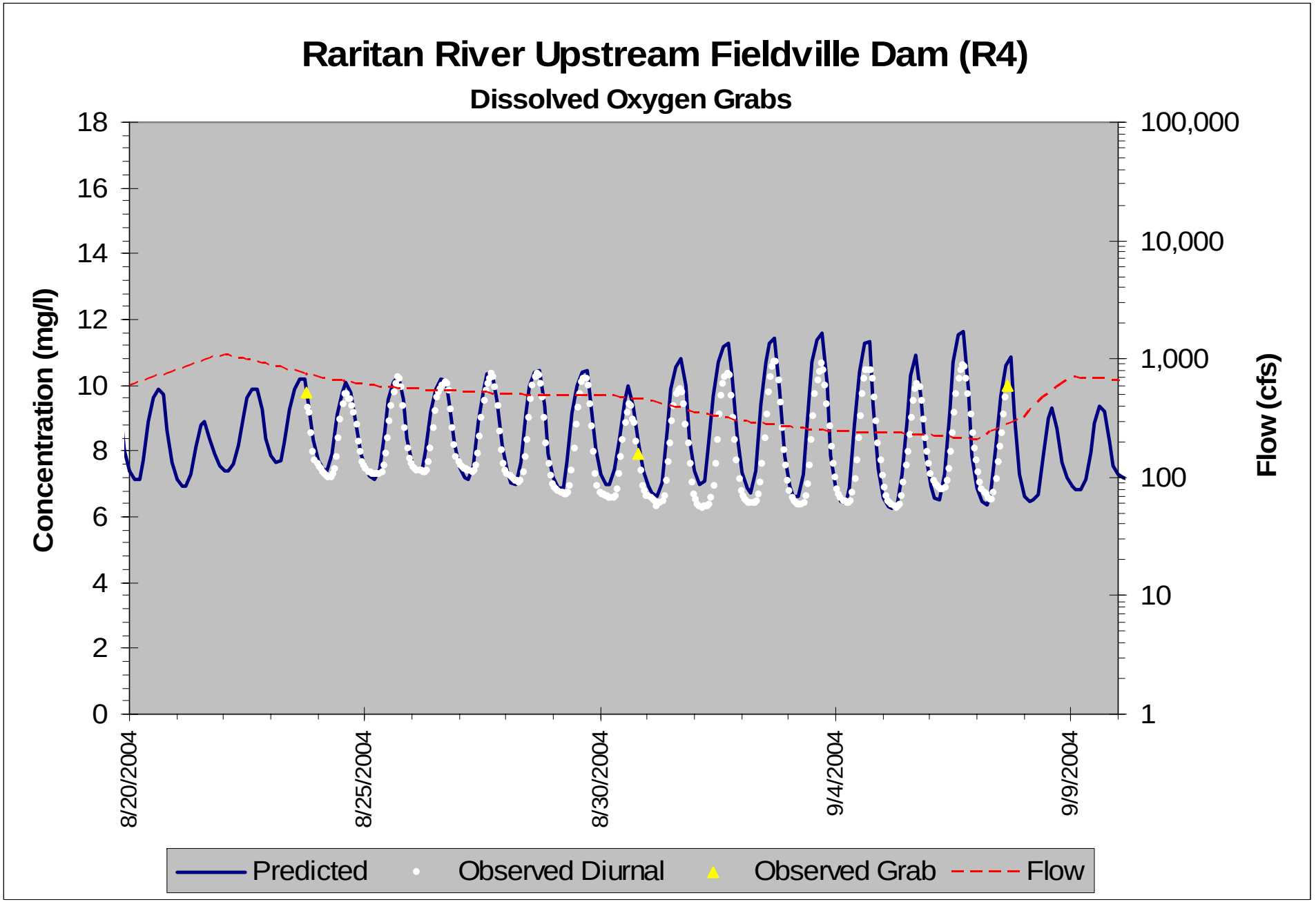

Conclusions

- State-of-the-art watershed model to relate nutrient sources to water quality impacts
  - Precipitation-based hydrologic model (HydroWAMIT)
  - Stormwater and tributary sources modeled by subwatershed
  - Hydraulic and water quality modeling through integration of DA-FLOW and WASP 7.1
  - Long term simulation from 2002 to 2005 that encompasses a wide range of weather and flow conditions
- Flow and water quality models calibrated and validated for nutrients, dissolved oxygen, and chlorophyll-a
- Impact of point and nonpoint source reductions on dissolved oxygen, phosphorus concentrations, and chlorophyll-a can be calculated
- Currently under review by New Jersey EcoComplex and NJDEP

Next Steps

- Investigate the impact of point and nonpoint source phosphorus reductions
  - dissolved oxygen
  - phosphorus concentrations
- Work with NJDEP to establish a combination of load and wasteload allocations
- NJDEP will use study as basis to propose TMDL

Acknowledgments

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- Project coordination and oversight provided by NJDEP Division of Watershed Management
- Academic review provided by Rutgers University's New Jersey EcoComplex
- Special thanks to the staff of TRC Omni for their tireless efforts in developing and calibrating the flow and water quality models for this project
  - Marcelo Cerucci, Ph.D.
  - Gopi Jaligama