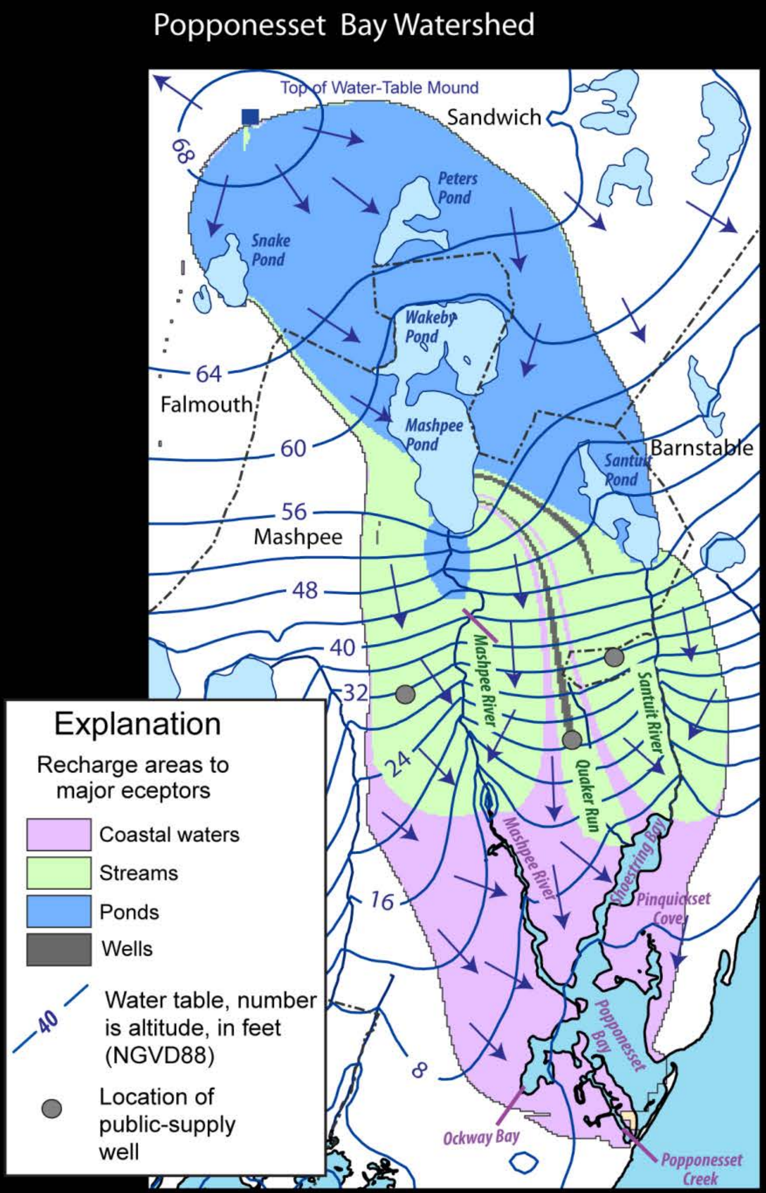
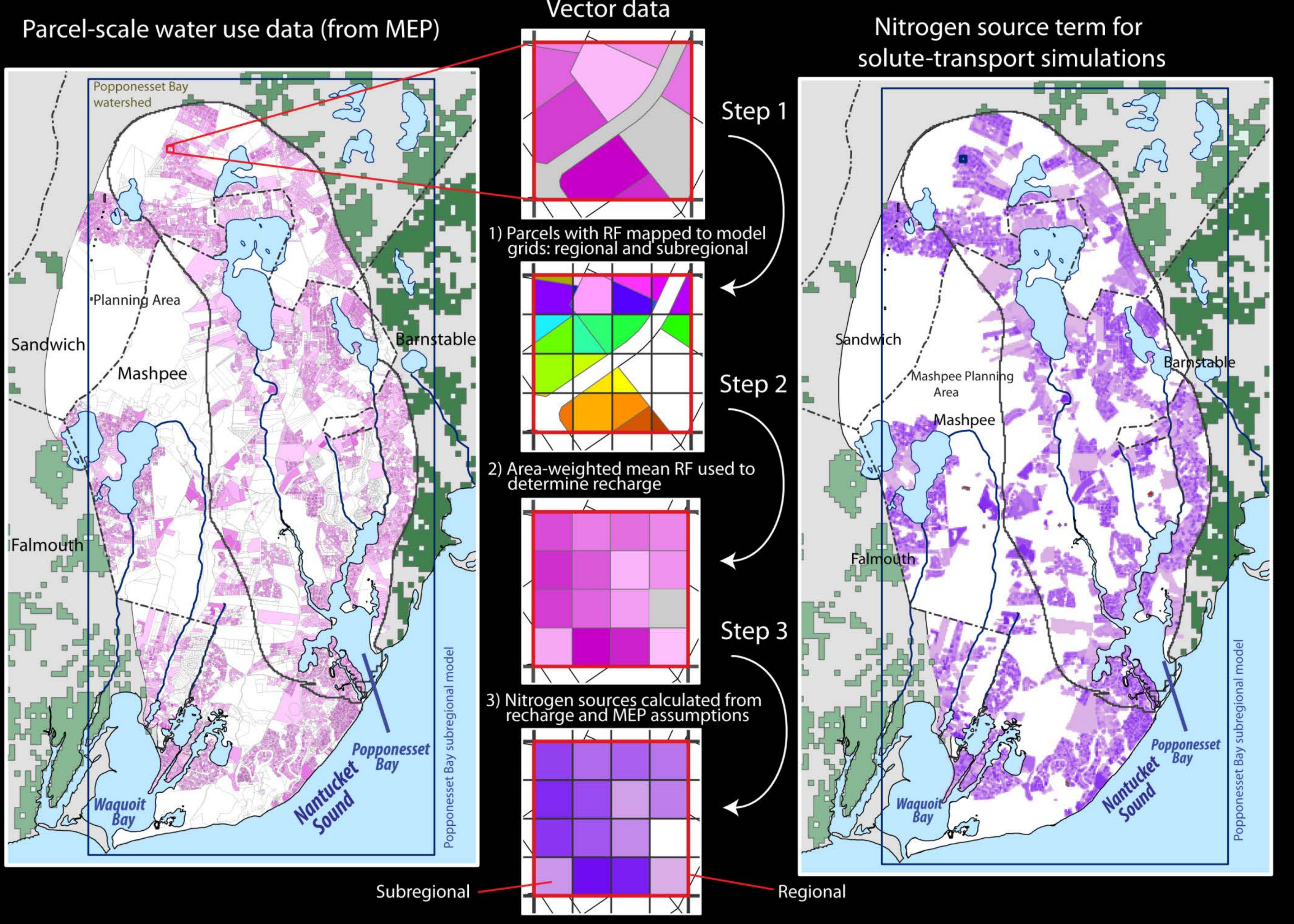
Popponesset Bay Watershed, Town of Mashpee



- About 20 mi^2
- About 100 acres of eel grass habitat in 1951; absent from estuary (1995-2001)
- Recharge to the groundwater system sole source of water
  - About 25 percent discharge to estuaries
  - About 33 percent discharge to streams
  - About 40 percent passes through a pond
- Total nitrogen load of about 80 Kg/day

Rasterization Process for Conversion of MEP Parcel-Scale Water Use Data



Assumptions regarding nitrogen transport:

- Consumptive loss of 10 percent
- Nitrogen loss prior to recharge of 25 percent (septic systems and unsaturated zone)
- Conservative transport through the aquifer
- No loss within estuarine sediments
- Numerical dispersion approximates real dispersion

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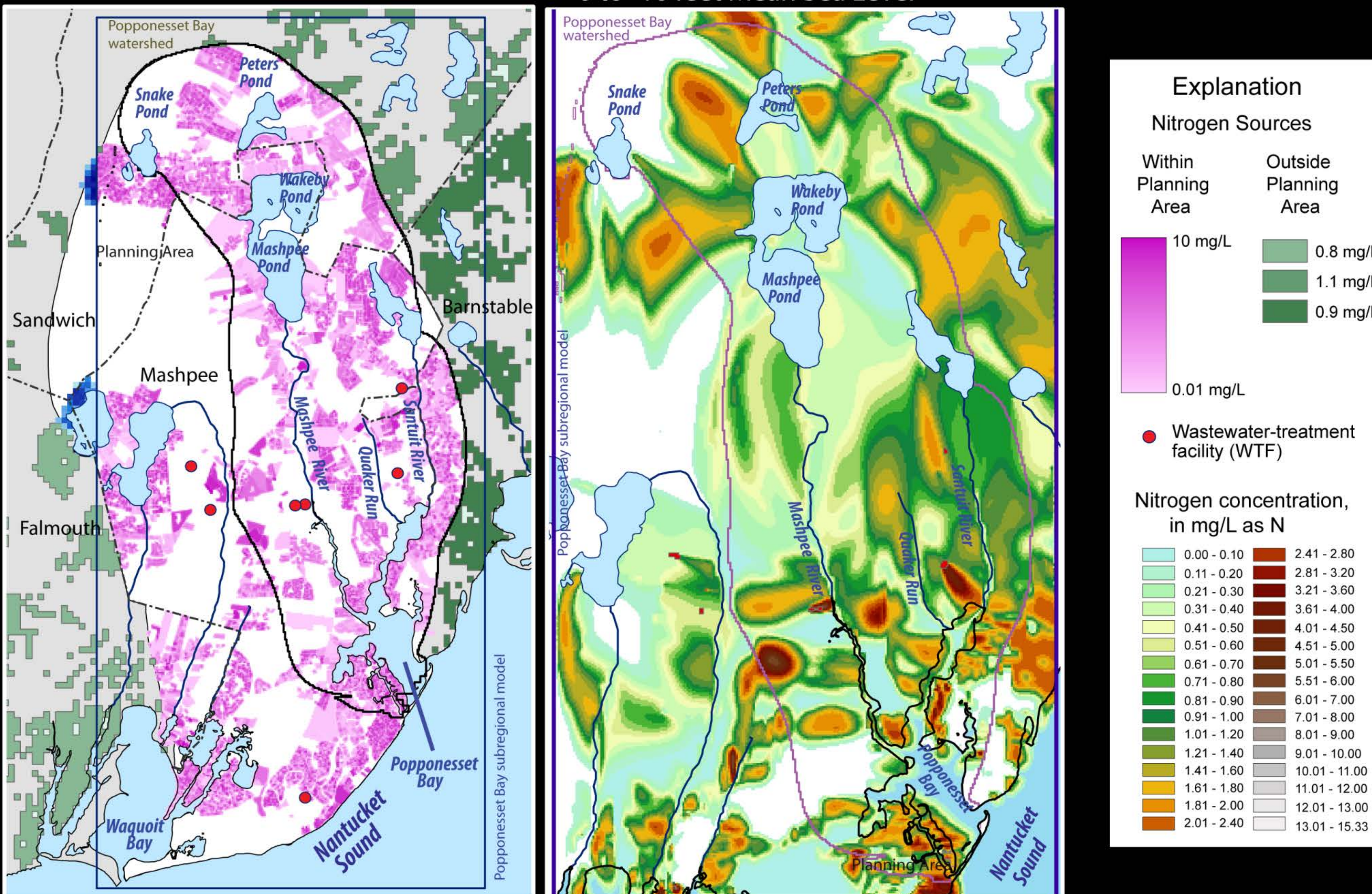
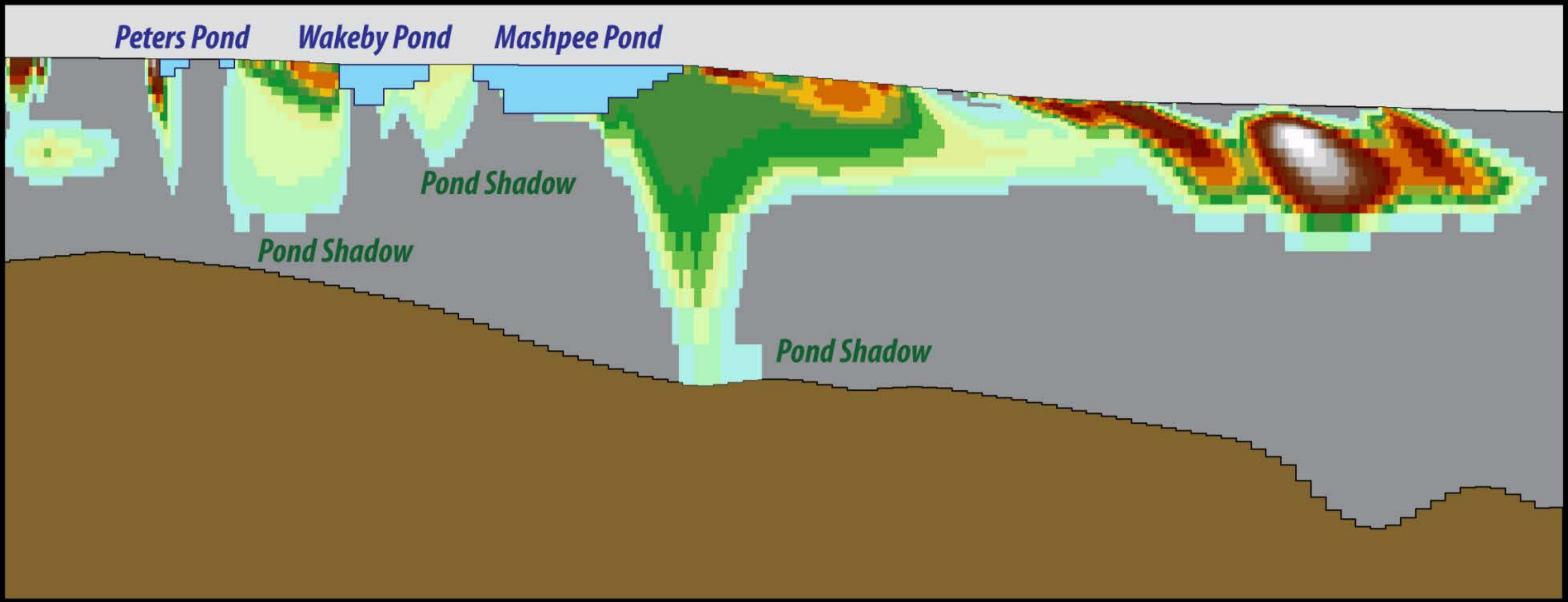
Nitrogen Sources and Simualted Nitrogen Concentrations after 30 Years of Transport

Nitrogen Sources for Current Conditions

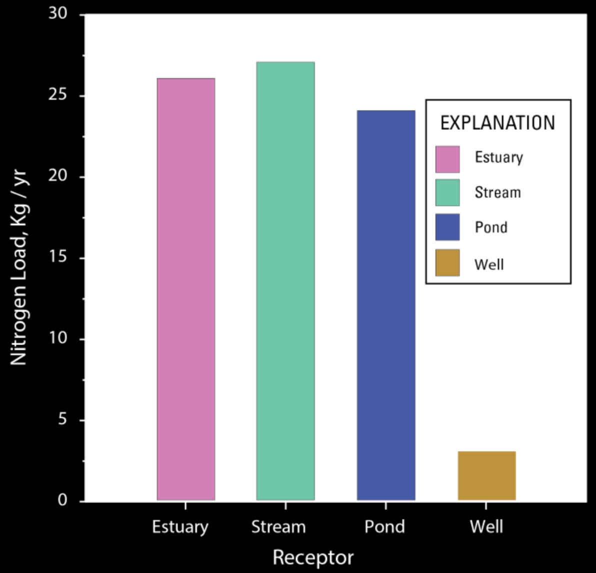
Simulated Nitrogen Concentrations,
0 to -10 feet Mean Sea Level

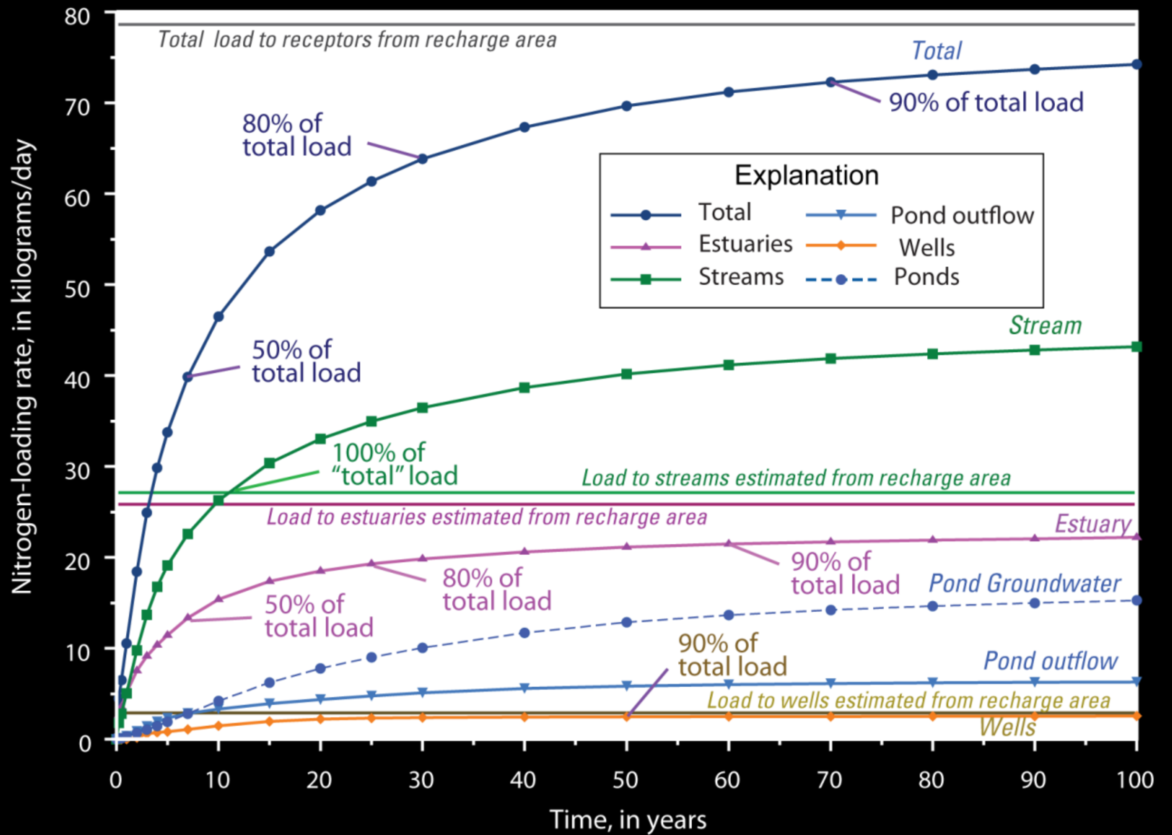


Nitrogen Concentrations, Central Popponesset Bay Watershed

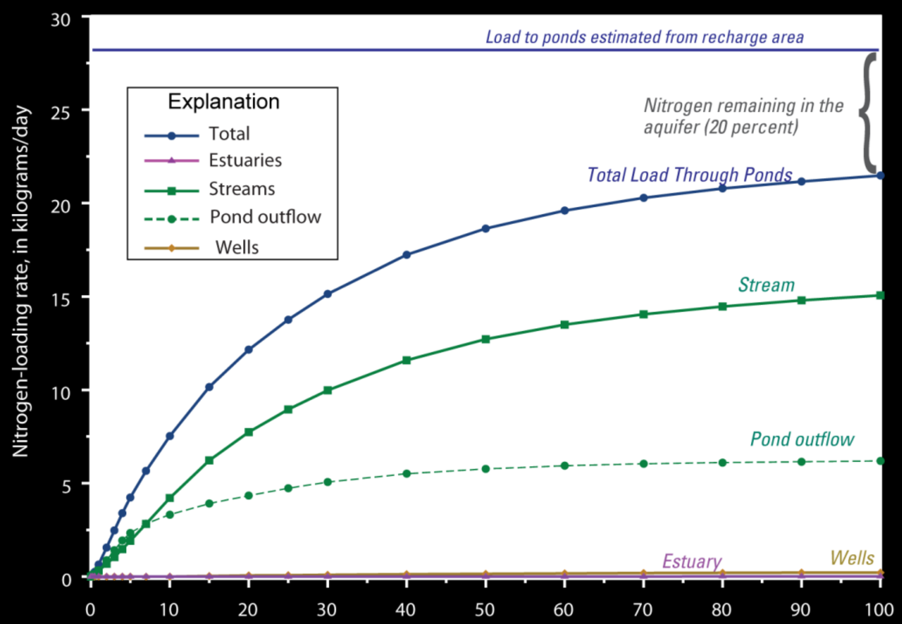


Comparison of Instantaneous and Time-Varying Nitrogen Loads

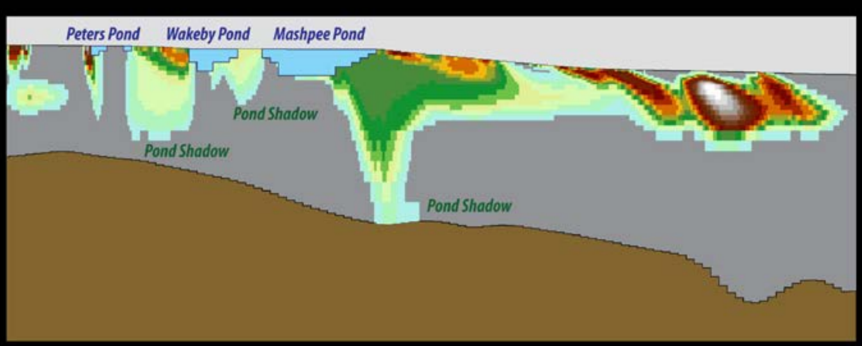


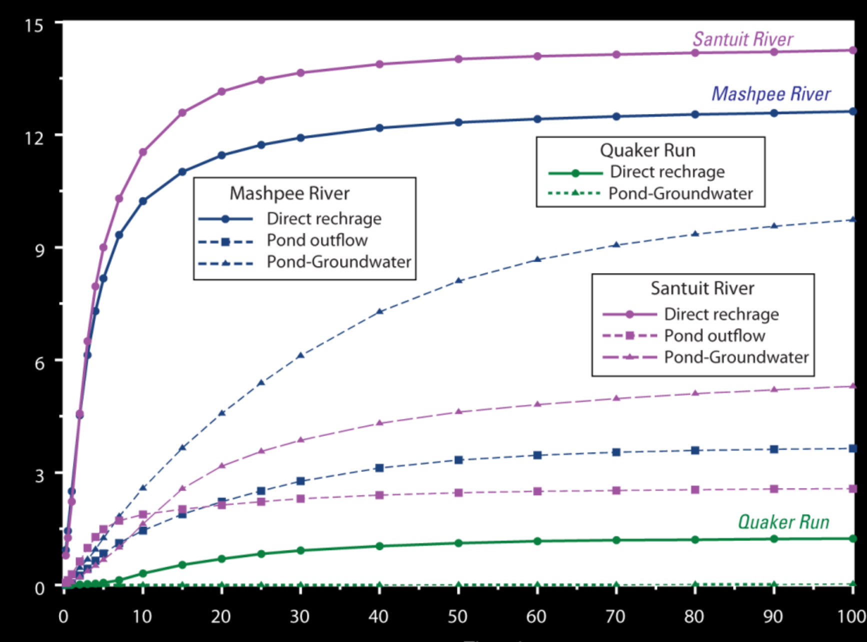


Complex Surface-Water Interactions, Ponds and Streams



- Groundwater flow through ponds can't be represented using delineated watersheds
- Additional attenuation can be accounted for by including these surface-water complexities





Evaluating Time-Varying Responses to Wastewater Management:

- Explicitly represents mass
- Accounts for changes in watershed boundaries in response to changing stresses
- Transport time fully integrated into simulation
- Ability to represent dispersion and attenuation
- Can simulate complex scenarios with linked management actions

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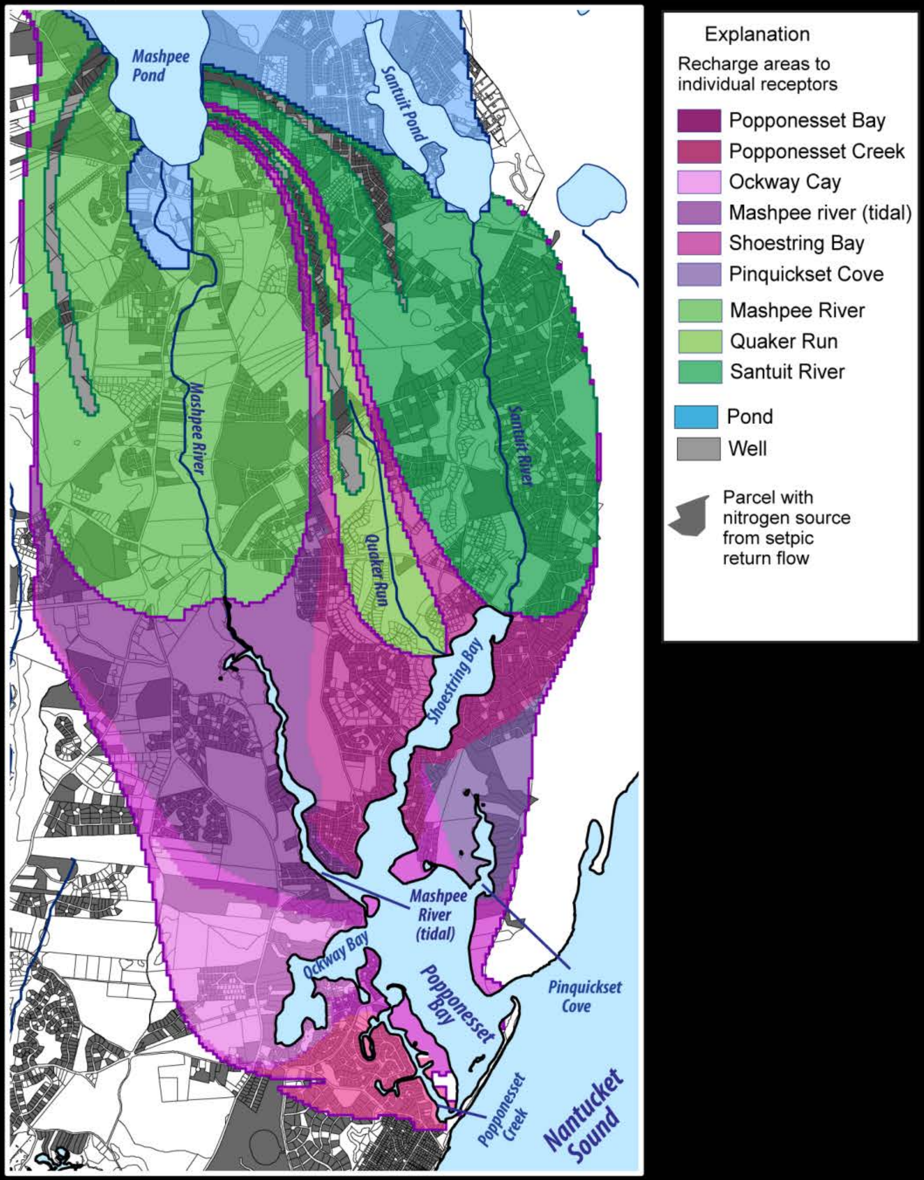
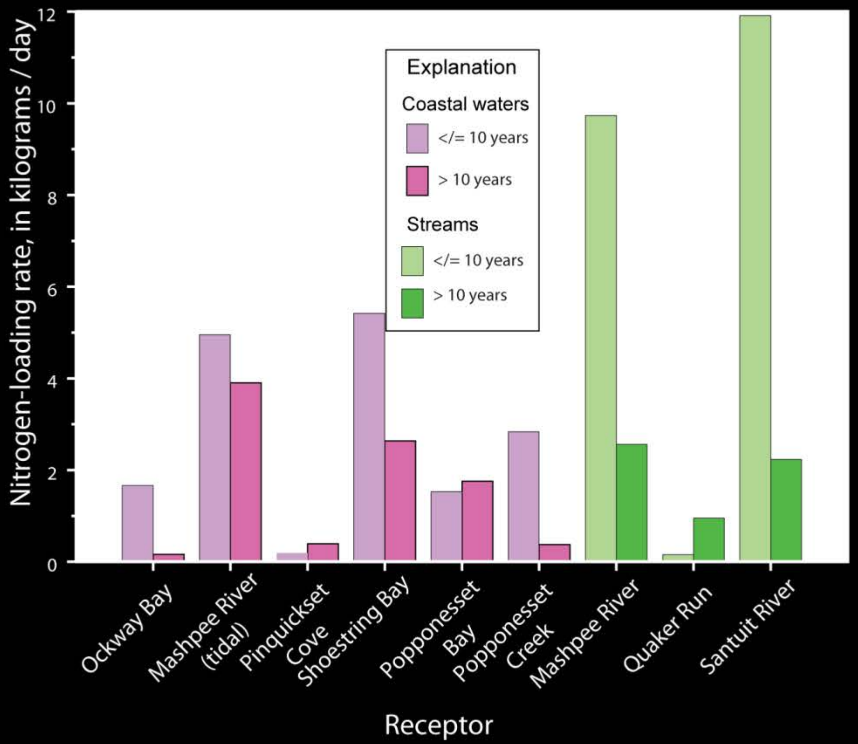
Recharge Areas to Streams and Estuaries and Estimated Current Nitrogen Loads

Recharge areas to streams and estuaries

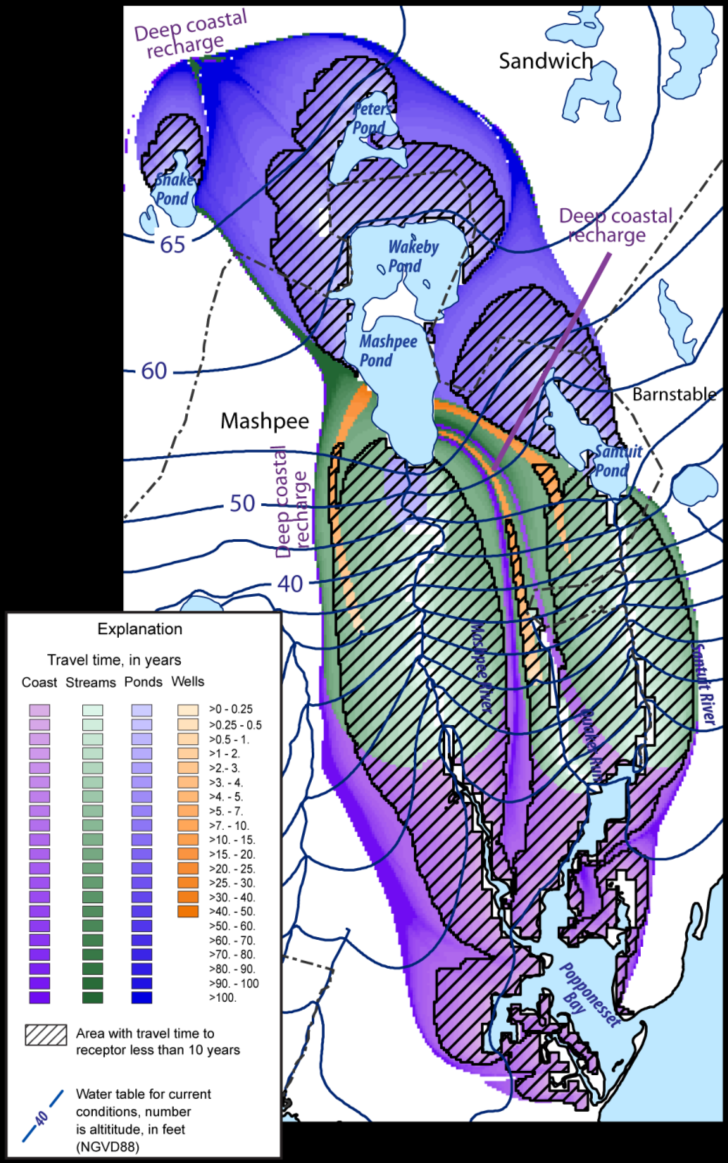


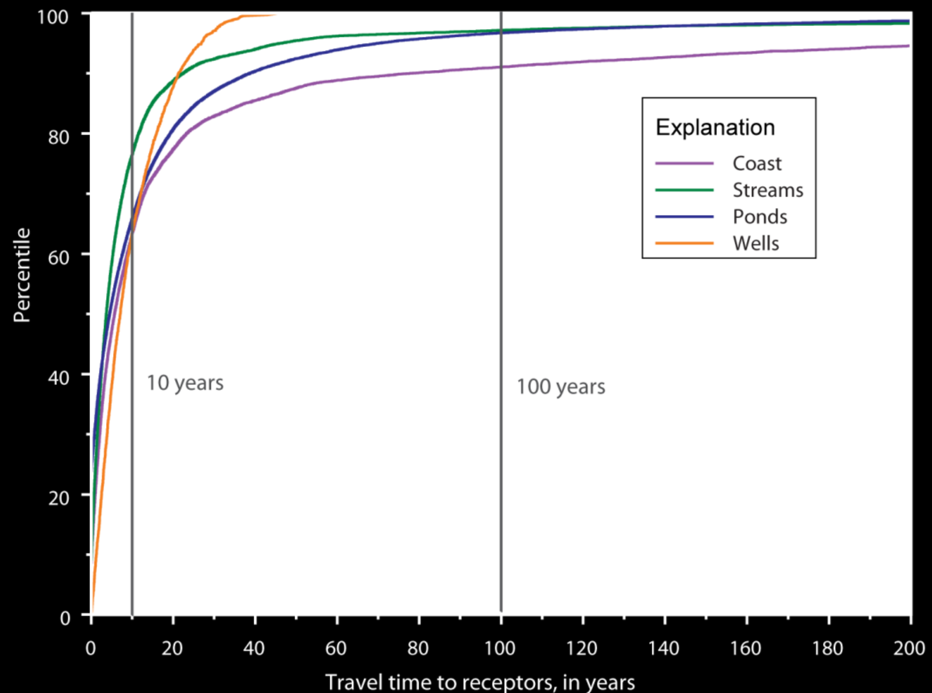
Nitrogen Loads Estimated by Summation of Sources Within Recharge Areas



Travel Times to Major Receptors, Popponesset Bay Watershed

Travel times, in years

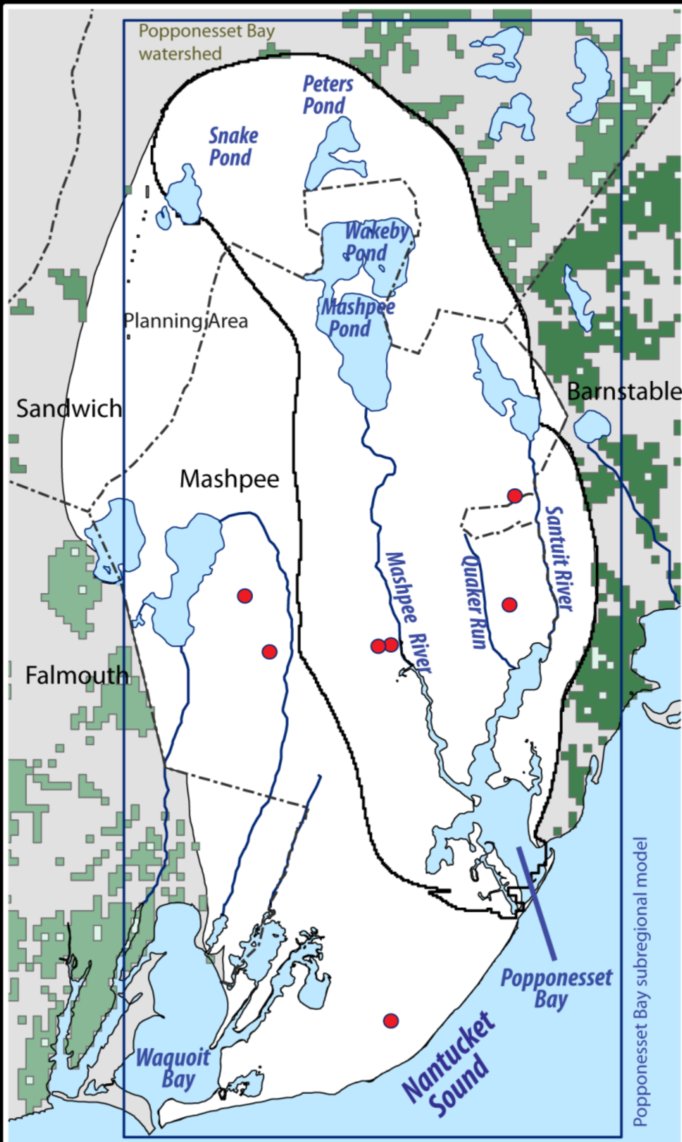




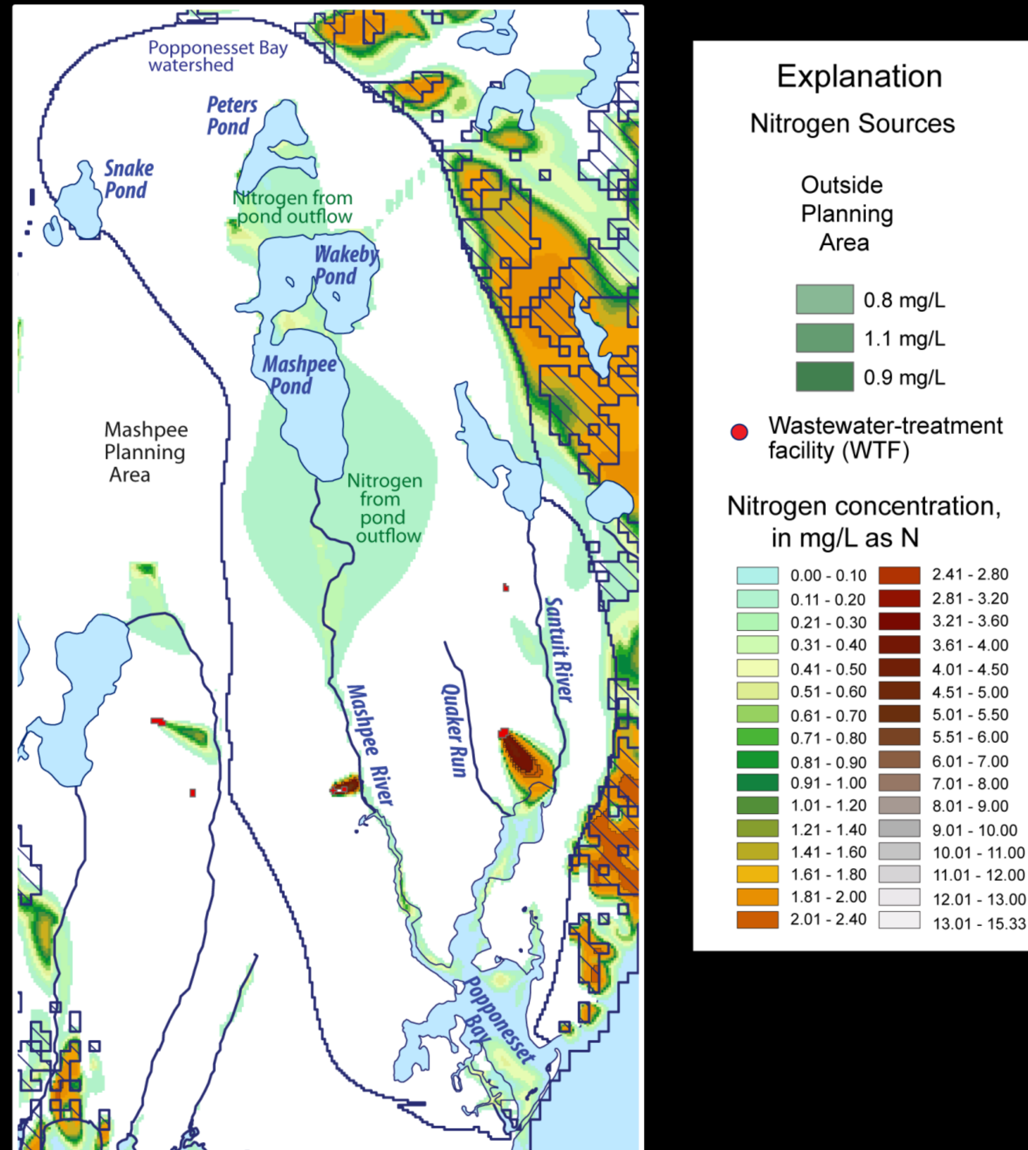
- Median travel times 4 to 6 years
- Transport primarily from advection
- Suggests rapid response in nitrogen loads

Nitrogen Sources and Simualted Nitrogen Concentrations after 30 Years of Transport

Nitrogen Sources for Full Sewering

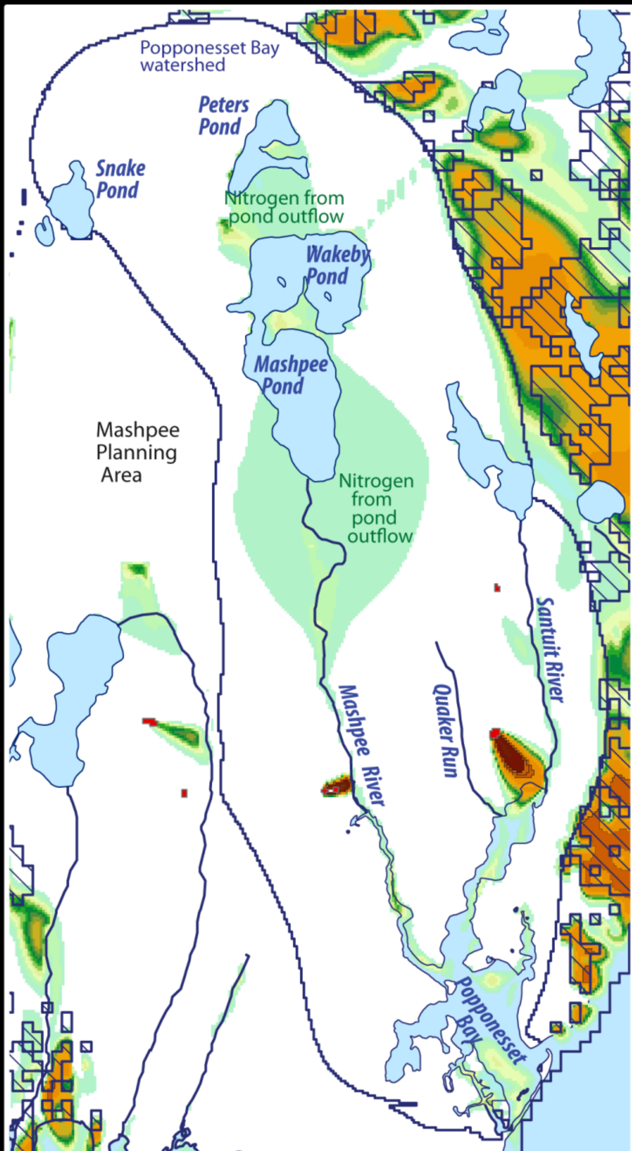


Simulated Nitrogen Concentrations, 0 to -10 feet Mean Sea Level

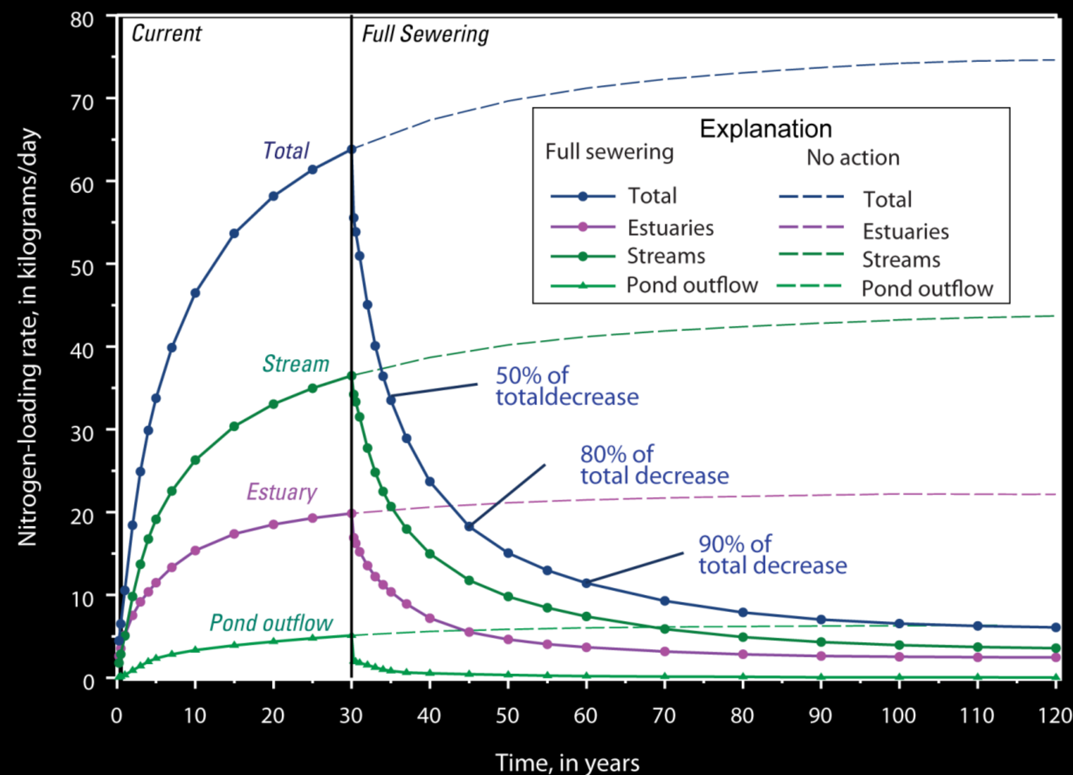


Response of Nitrogen Loads at Major Receptors to Full Sewering

Simulated Nitrogen Concentrations,
0 to -10 feet Mean Sea Level



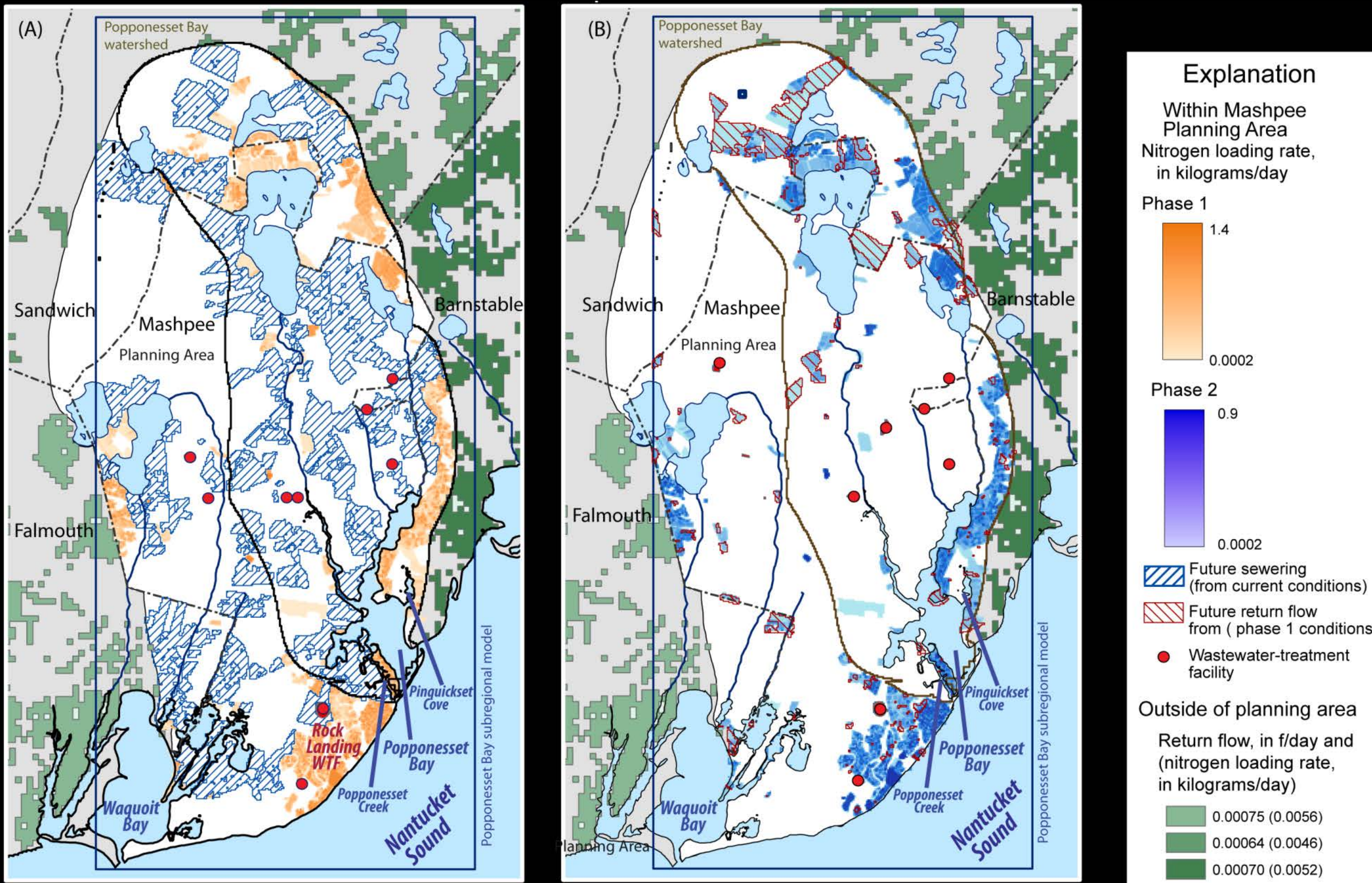
Response of nitrogen loads at major receptors to full sewering



Complex (Multi-Phase) Wastewater-Management Actions

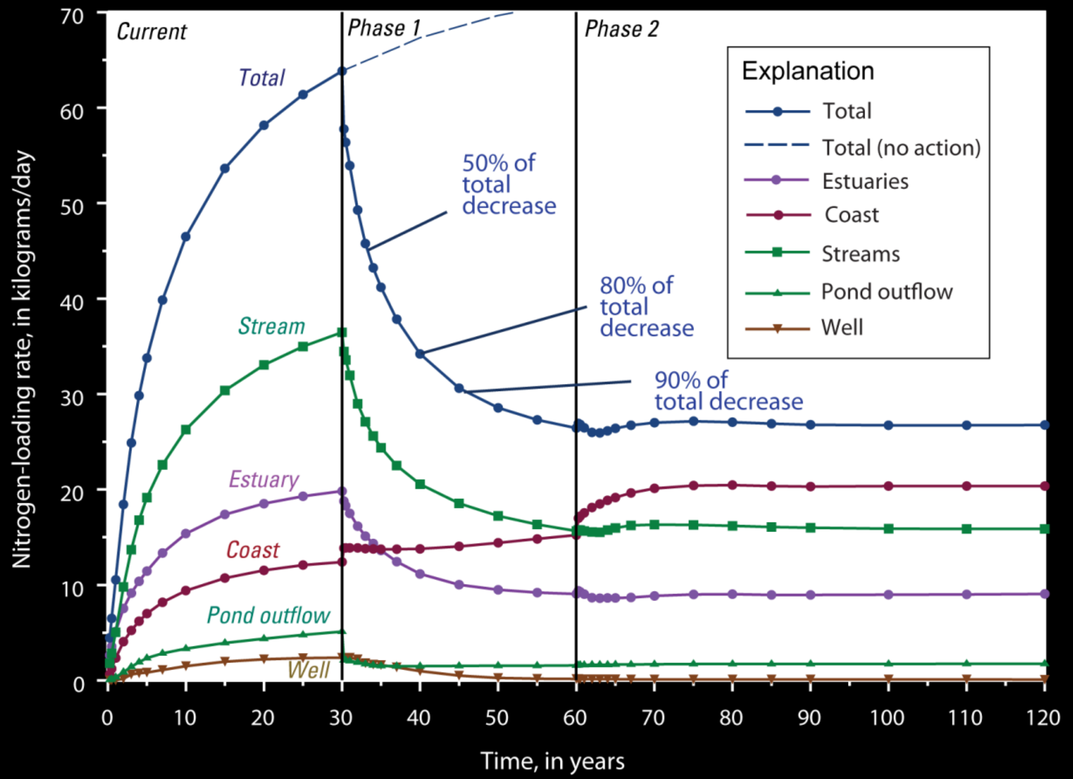
Phase 1: Partial sewering and Disposal at WTFs

Phase 2: Build-out development and additional sewering

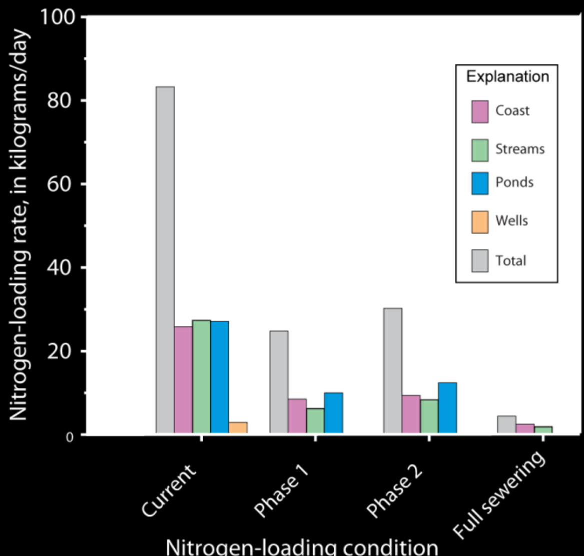


Response of Nitrogen Loads at Receptors to Two Phases of Wastewater Management

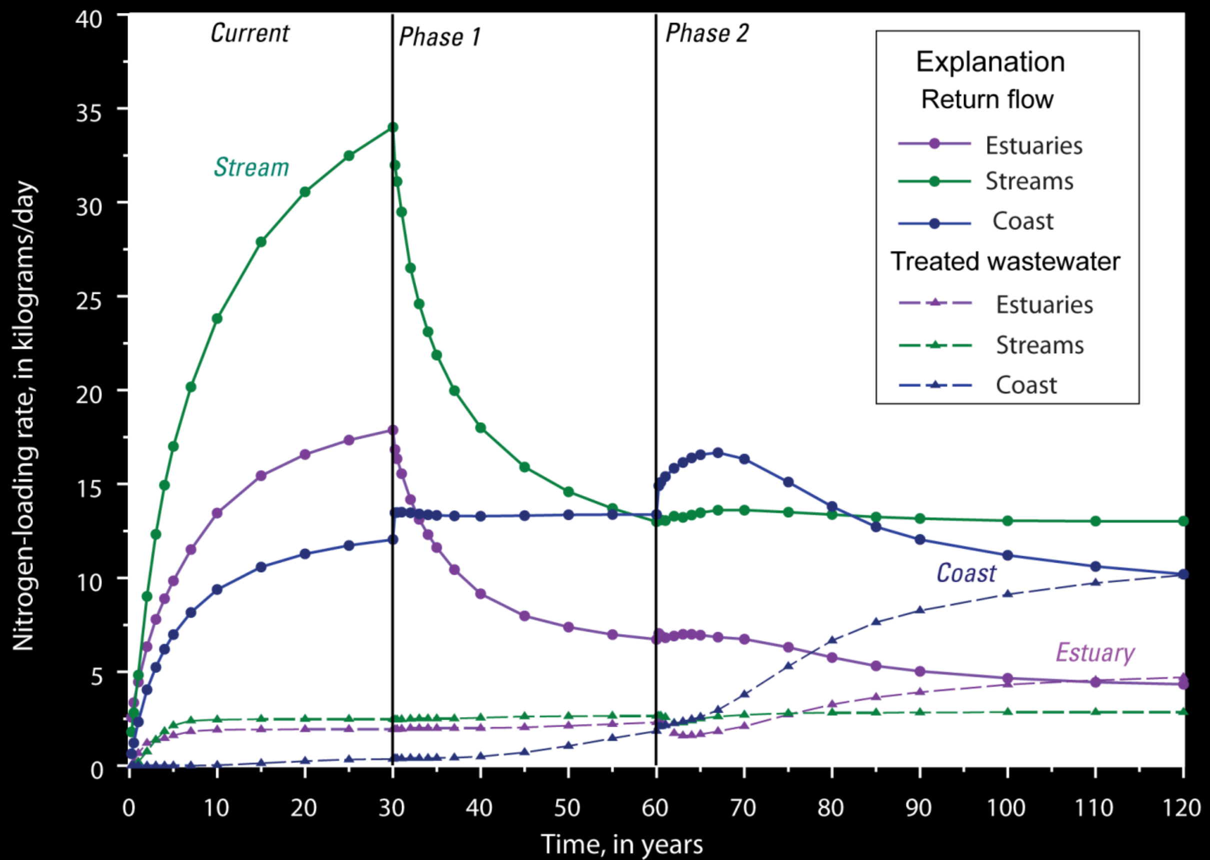
Response of nitrogen loads at major receptors to partial sewering and disposal at wastewater-treatment facilities



Total Loads Predicted From Recharge Areas

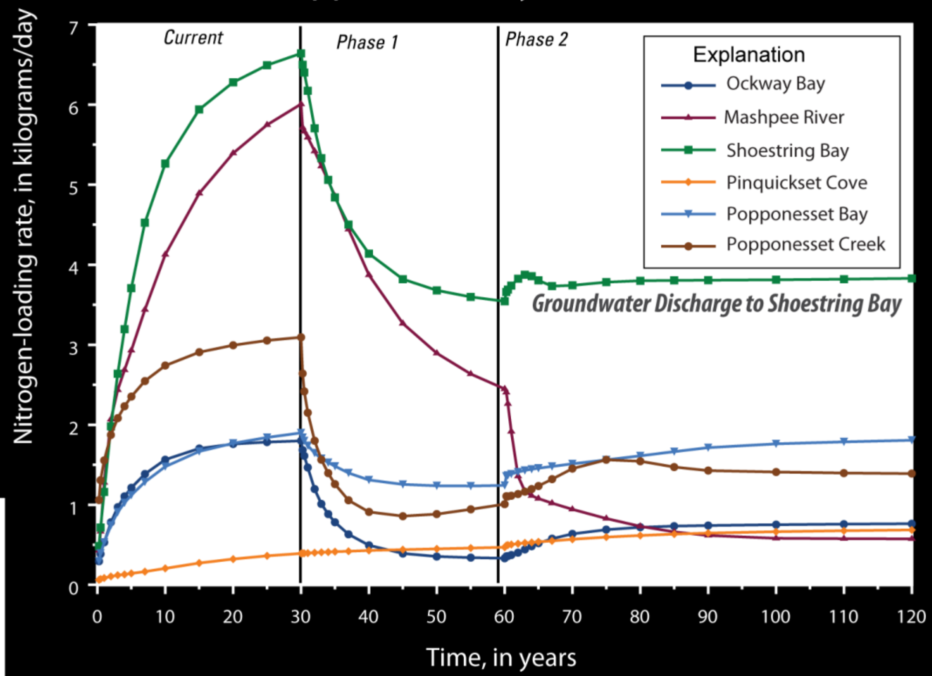


Response of Nitrogen Loads at Receptors to Two Phases of Wastewater Management: Return Flow and Wastewater Treatment

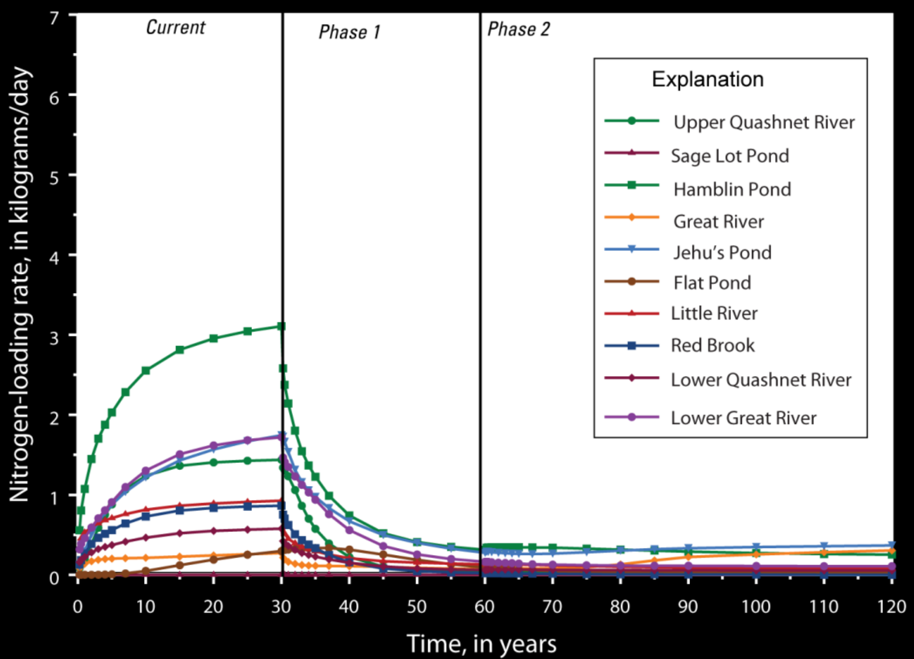


Response of Nitrogen Loads To Individual Estuaries to Wastewater Management : Direct Groundwater Discharge

Popponesset Bay Watershed

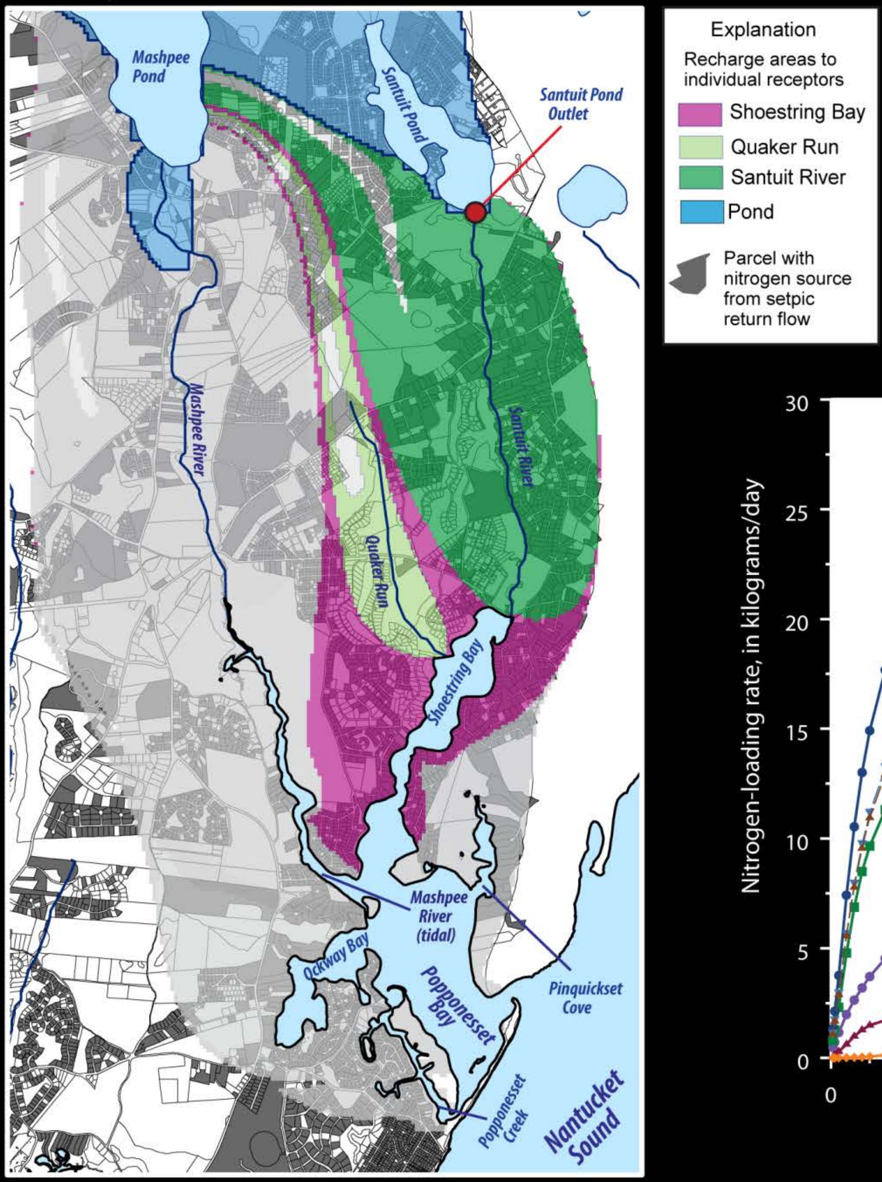


Eastern Waquoit Bay Watershed

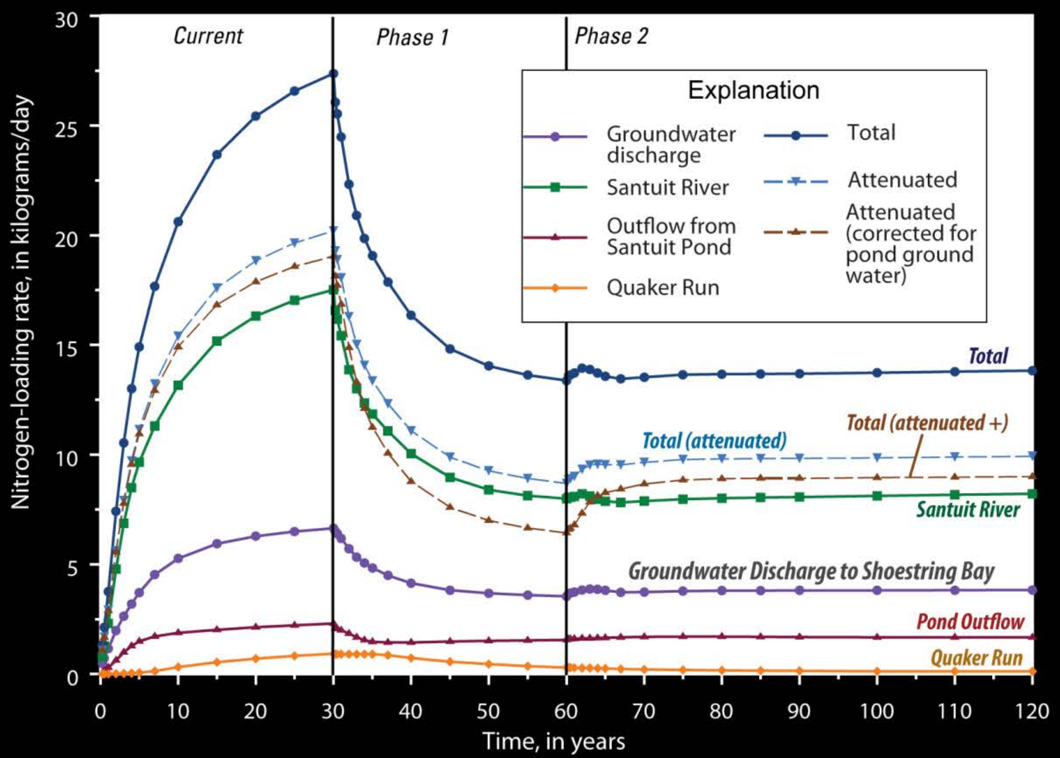


Response of Nitrogen Loads in the Shoestring Bay System

Recharge areas to Showstring Bay system



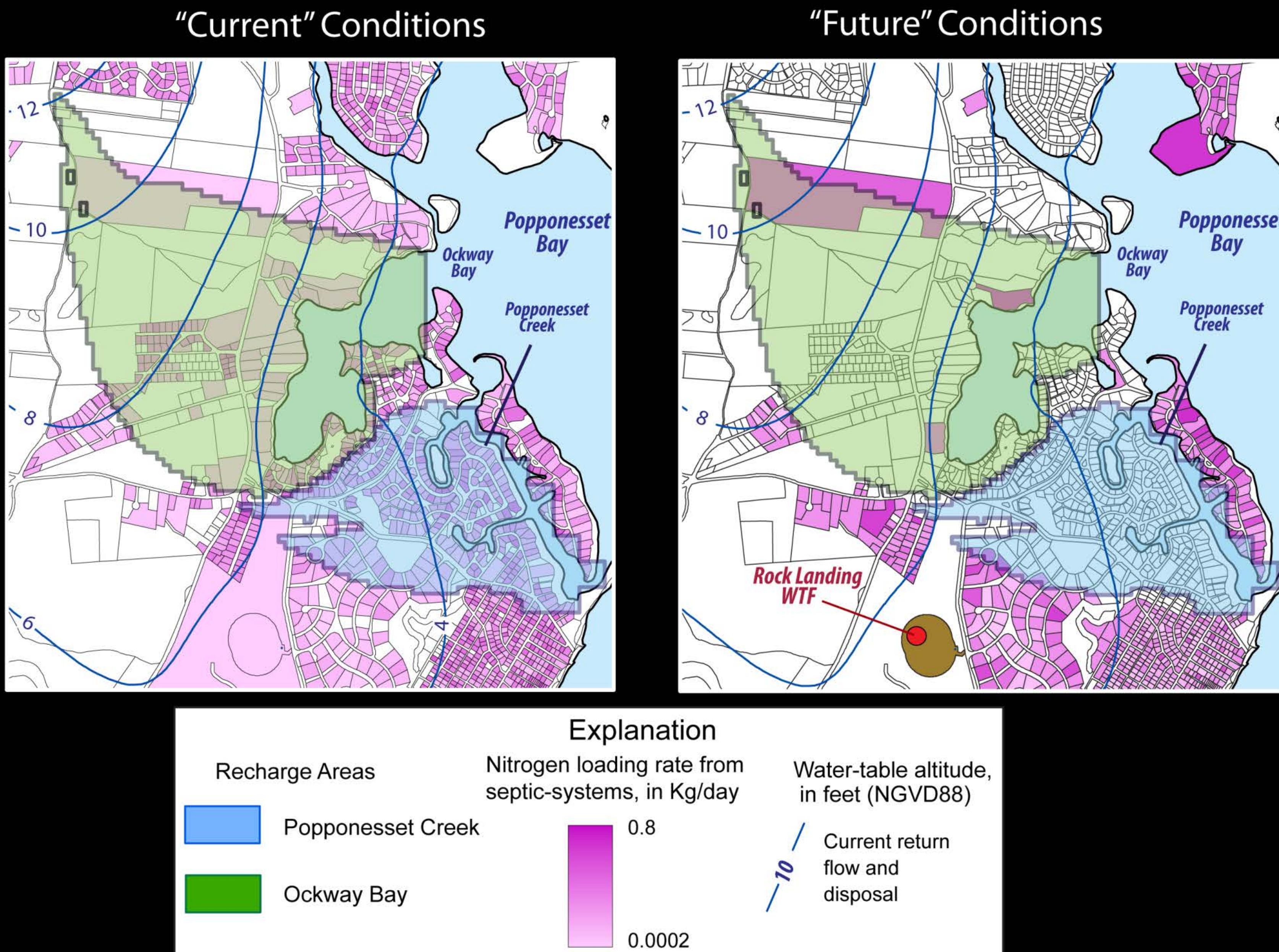
Response of nitrogen-load components



Accounting for Dynamic Watersheds:

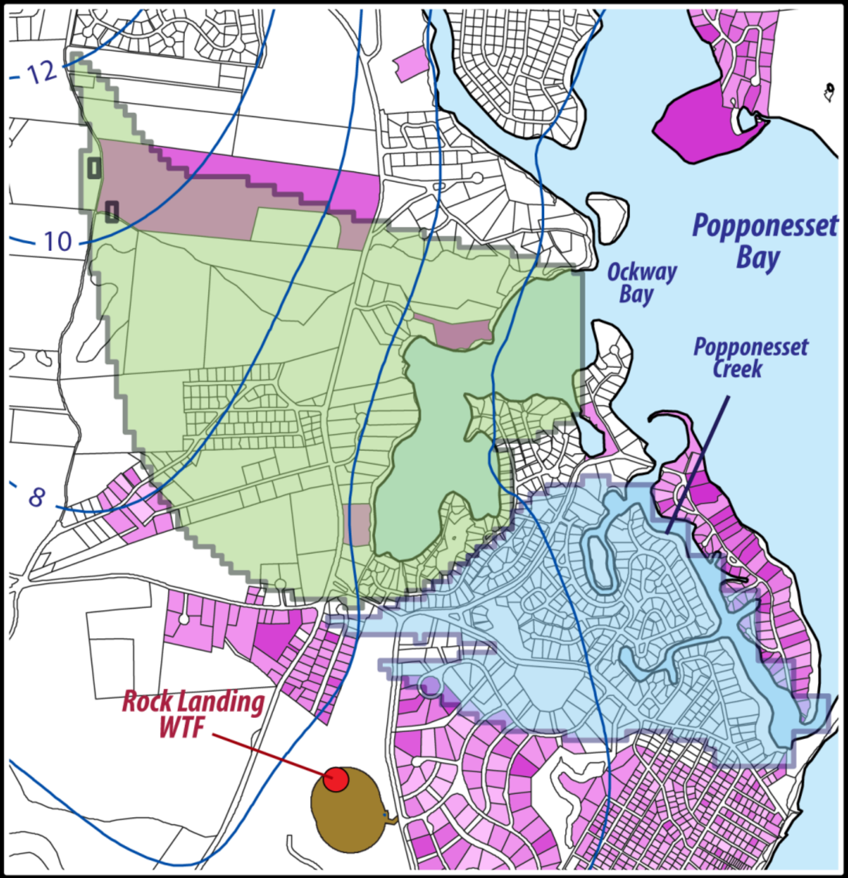
- MEP uses delineated watersheds for current conditions when evaluating future wastewater conditions
- Wastewater-managements actions (particularly centralized disposal) can change hydraulic gradients and recharge areas
- Inconsistencies between recharge areas and nitrogen sources can result in erroneous nitrogen-load estimates when evaluating TMDL compliance

Nitrogen Sources Within Recharge Areas to Ockway Bay and Popponesset Creek

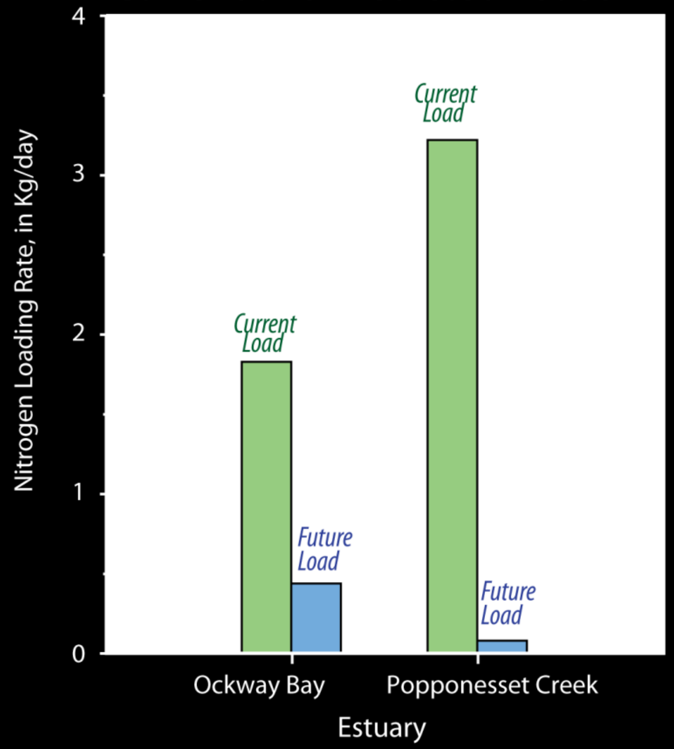


Nitrogen Sources and Loads Within Recharge Areas to Ockway Bay and Popponesset Creek

"Future" Conditions



Current and Predicted Loads



Explanation

Recharge Areas

Popponesset Creek

Ockway Bay

Nitrogen loading rate from septic-systems, in Kg/day

0.8

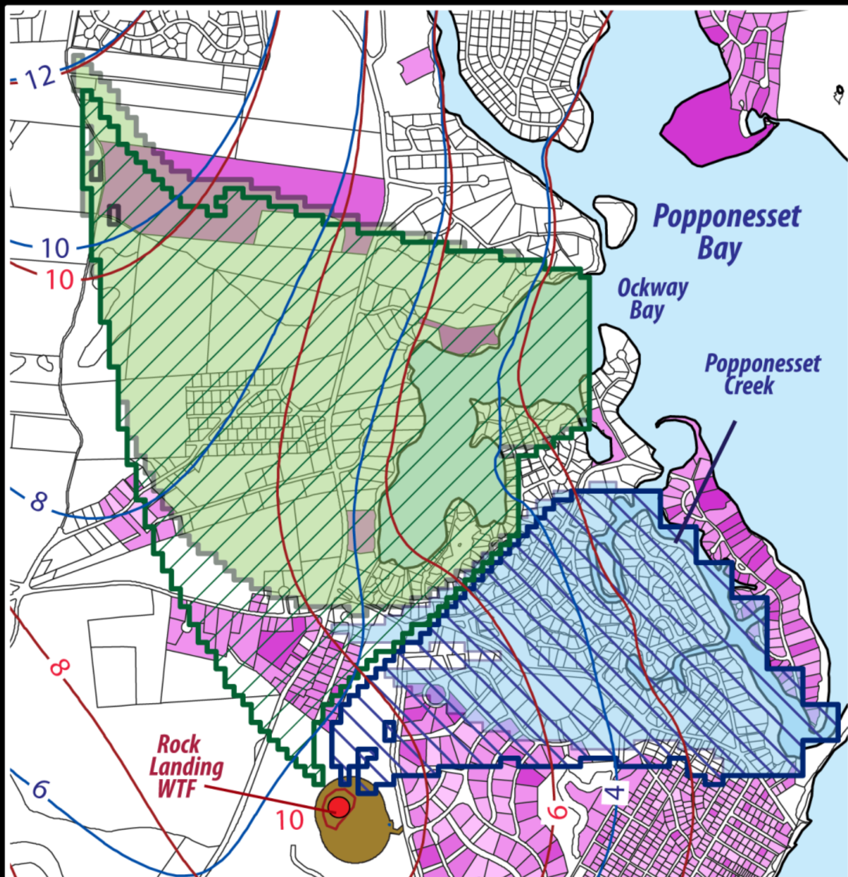
0.0002

Water-table altitude, in feet (NGVD88)

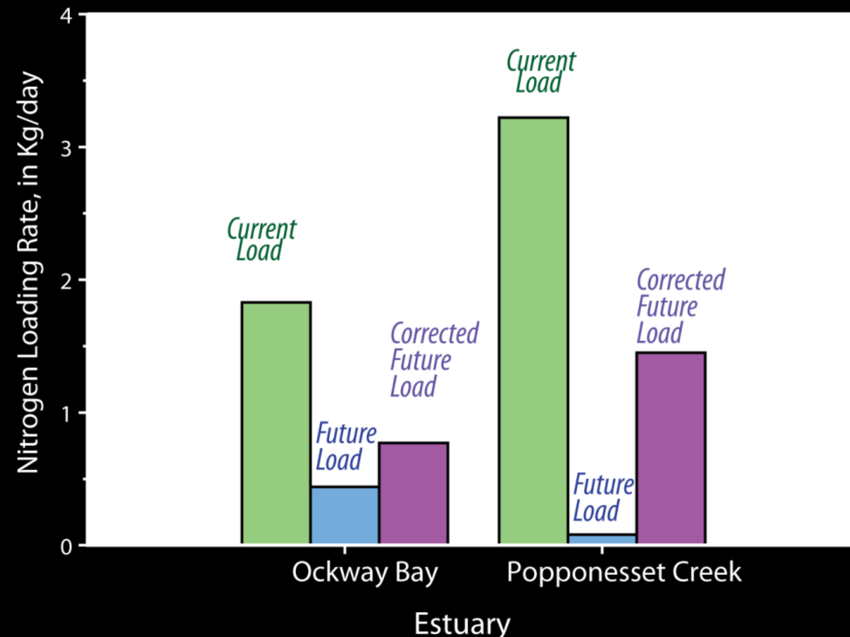
10 Current return flow and disposal

Recharge Areas and Nitrogen Loads to Ockway Bay and Popponesset Creek

Future Conditions



Current and Predicted Loads



Recharge area to Popponesset Creek

- Current hydrologic conditions
- Future hydrologic conditions (phase 2)

Recharge area to Ockway Bay

- Current hydrologic conditions
- Future hydrologic conditions (phase 2)

Nitrogen loading rate from septic-systems, in Kg/day

0.8

0.0002

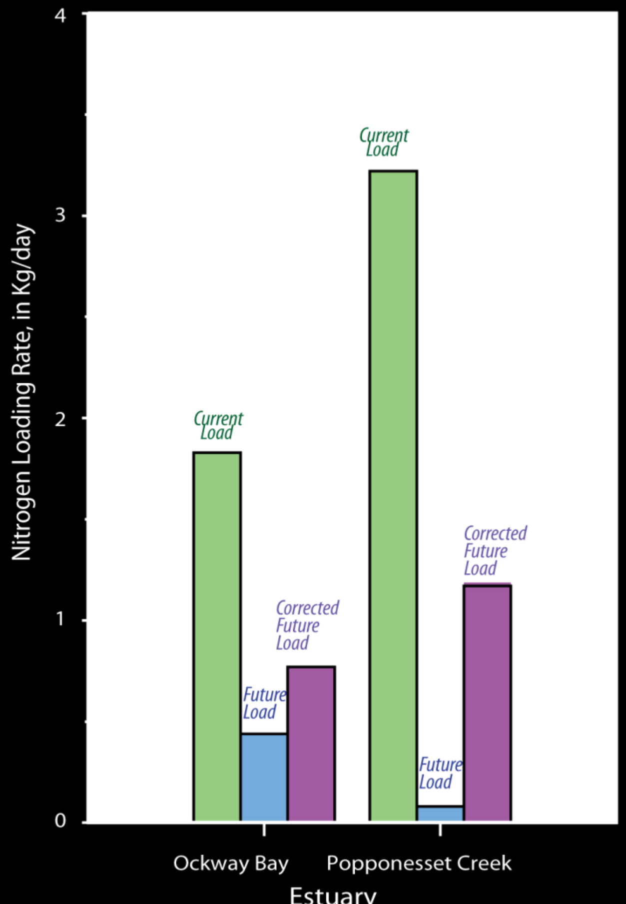
Water-table altitude, in feet (NGVD88)

10 Current return flow and disposal

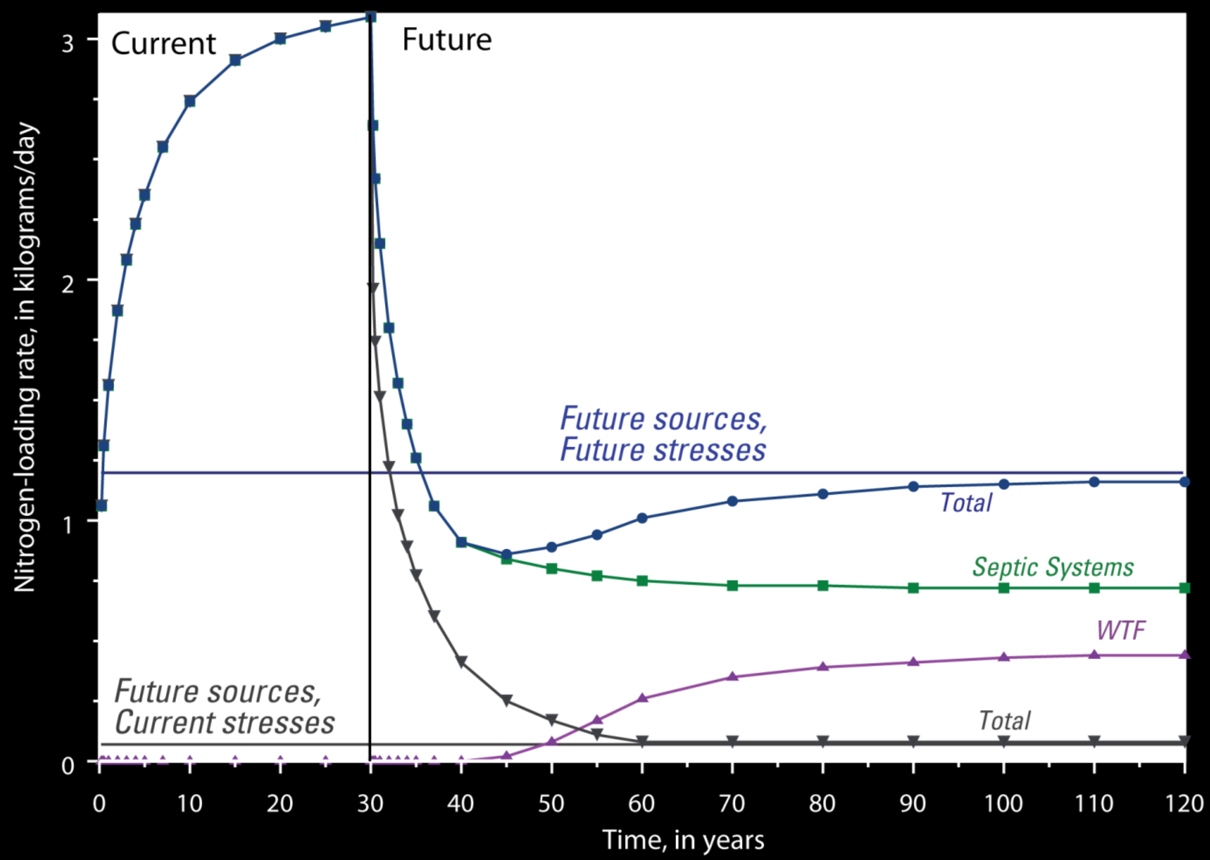
10 Wastewater-management, partial sewering and disposal (phase 2)

Nitrogen Load to Popponesset Creek in Response Wastewater Management

Current and Predicted Loads from recharge area



Predicted Loads Using Transport Model



Resources

MEP Reports:

http://www.oceanscience.net/estuaries

USGS Reports:

http://pubs.er.usgs.gov/publication/sim2857

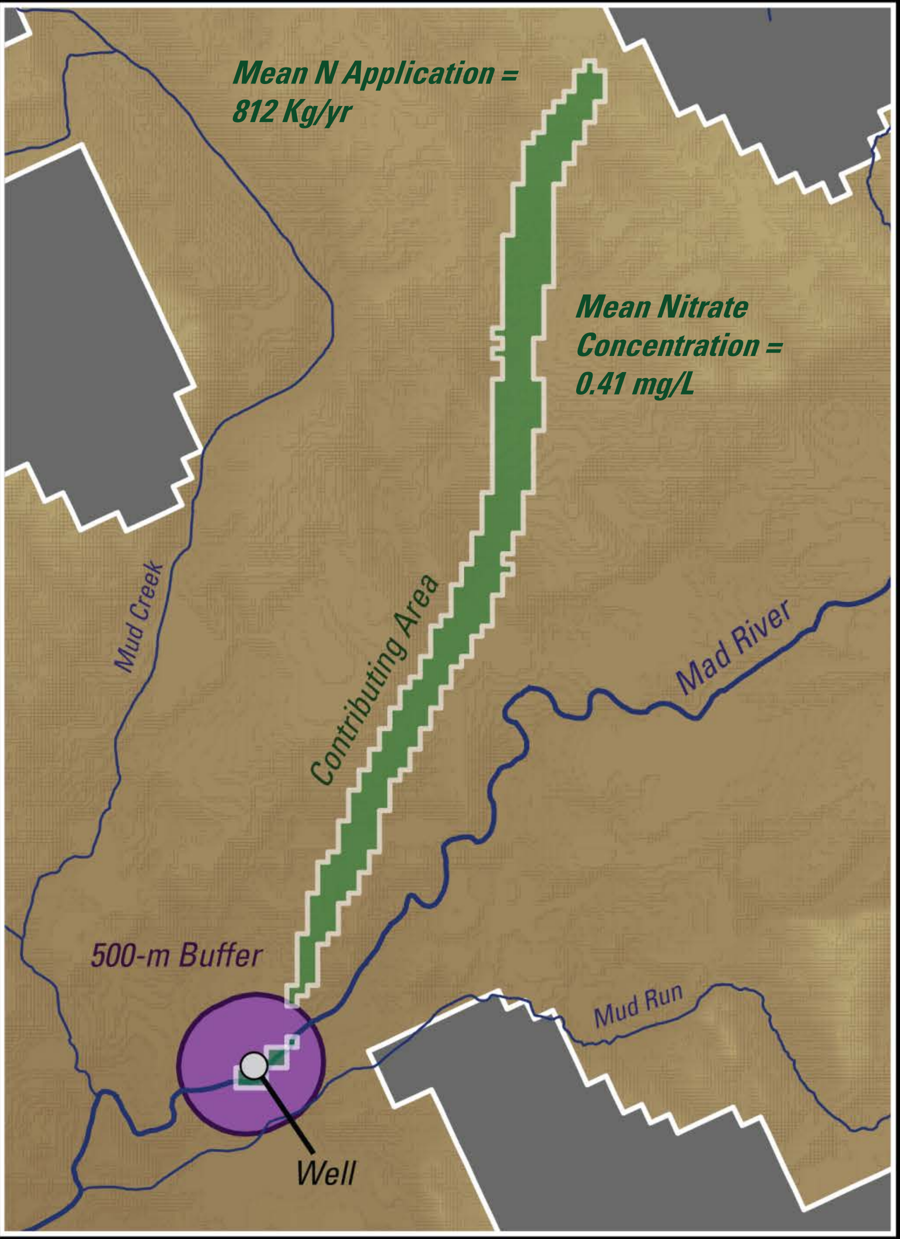
http://pubs.er.usgs.gov/publication/sir20135060

http://pubs.usgs.gov/sir/2007/5259/

Lessons Learned

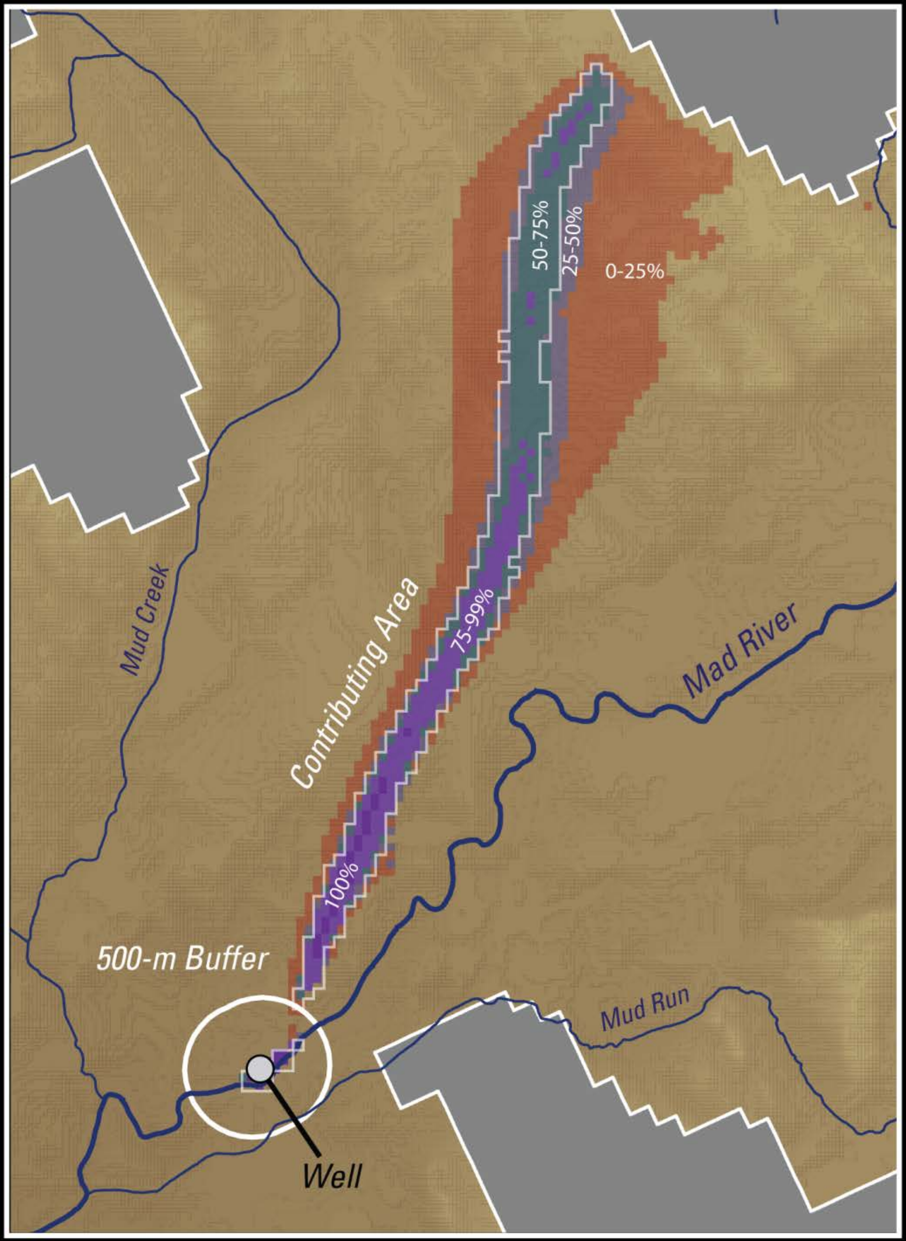
- Uncertainty in model predictions
- Potential underflow of nitrogen
- Nitrogen attenuation in estuarine sediments

Simulated Recharge Area to A Public Supply Well

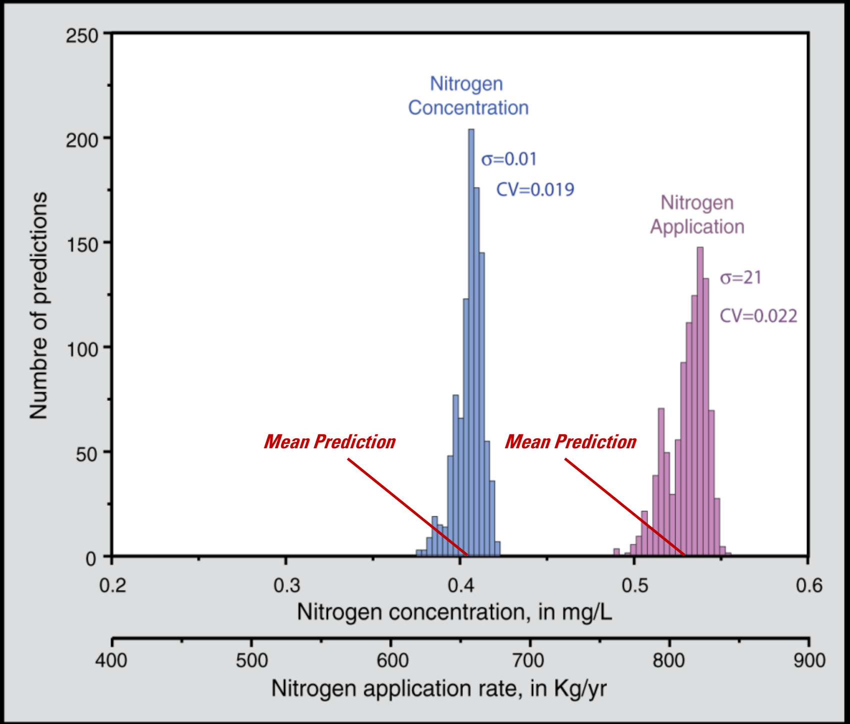


- Simulated recharge areas, and predicted characteristics, are sensitive to model parameters
- Model uncertainties can be estimated using standard methods if a model is inversely calibrated

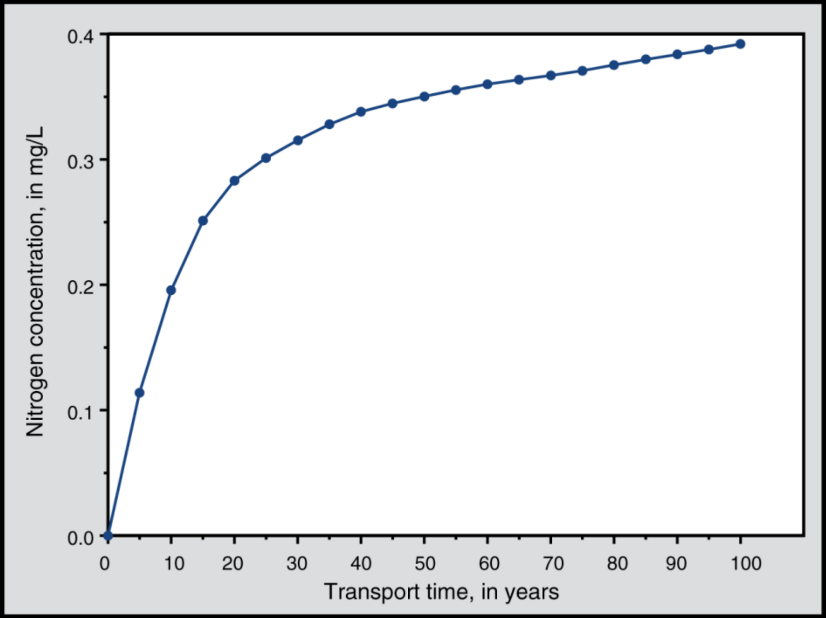
Probabilistic Recharge Areas and Prediction Uncertainties

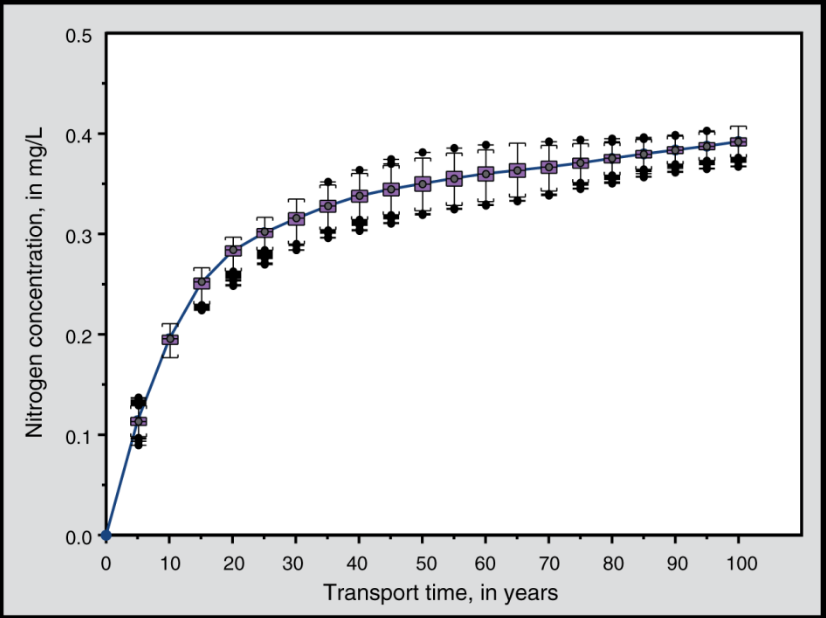


- Recharge areas can be represented as probabilities to account for model uncertainty (Monte Carlo analysis)
- Derived model predictions, like mean nitrogen load, can be expressed as a population of predictions



Uncertainties Also Can Be Estimated for Transport Simulations





Underflow

- The transport of nitrogen underneath an estuary to offshore receptors would mean lower nitrogen loads
- The amount of nitrogen underflow is a function of a given conceptual model
- Can it vary for shallow or deep interface positions

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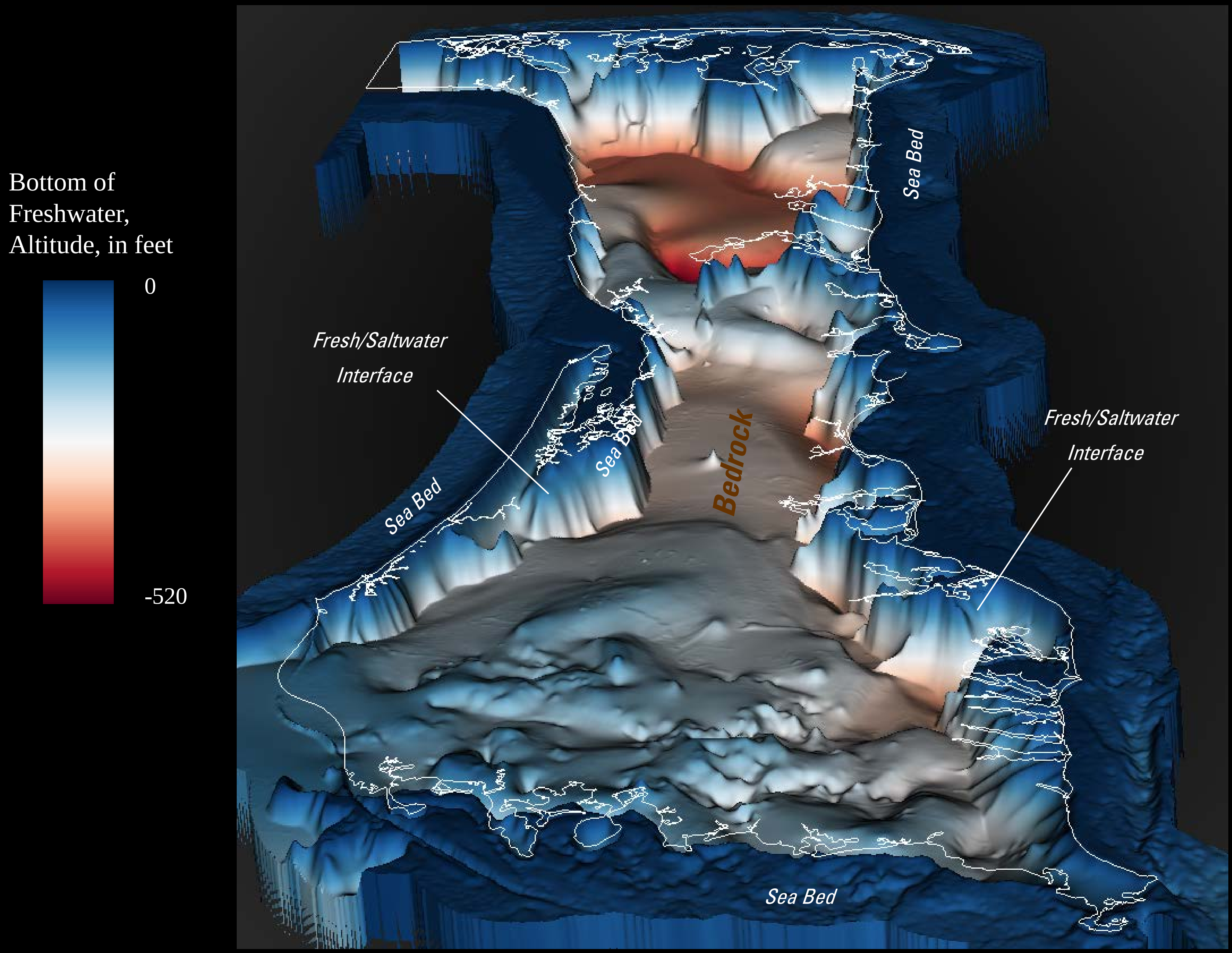
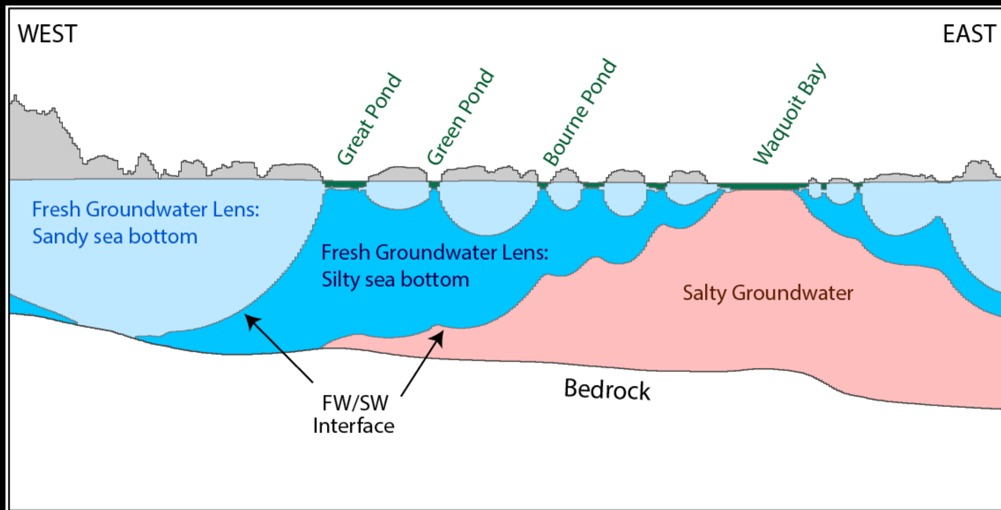
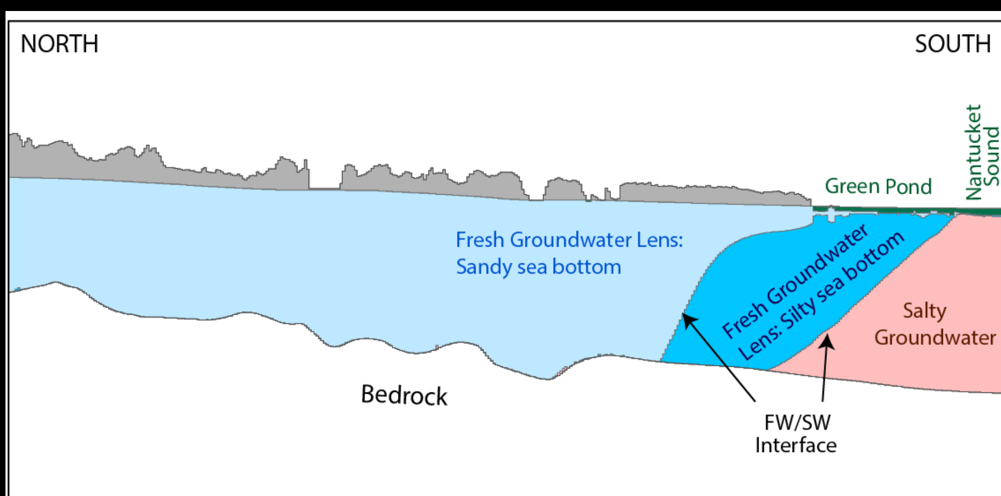
Bottom of freshwater, current (2011) sea level position



Alternative Conceptualizations of the Fresh/Saltwater Interface





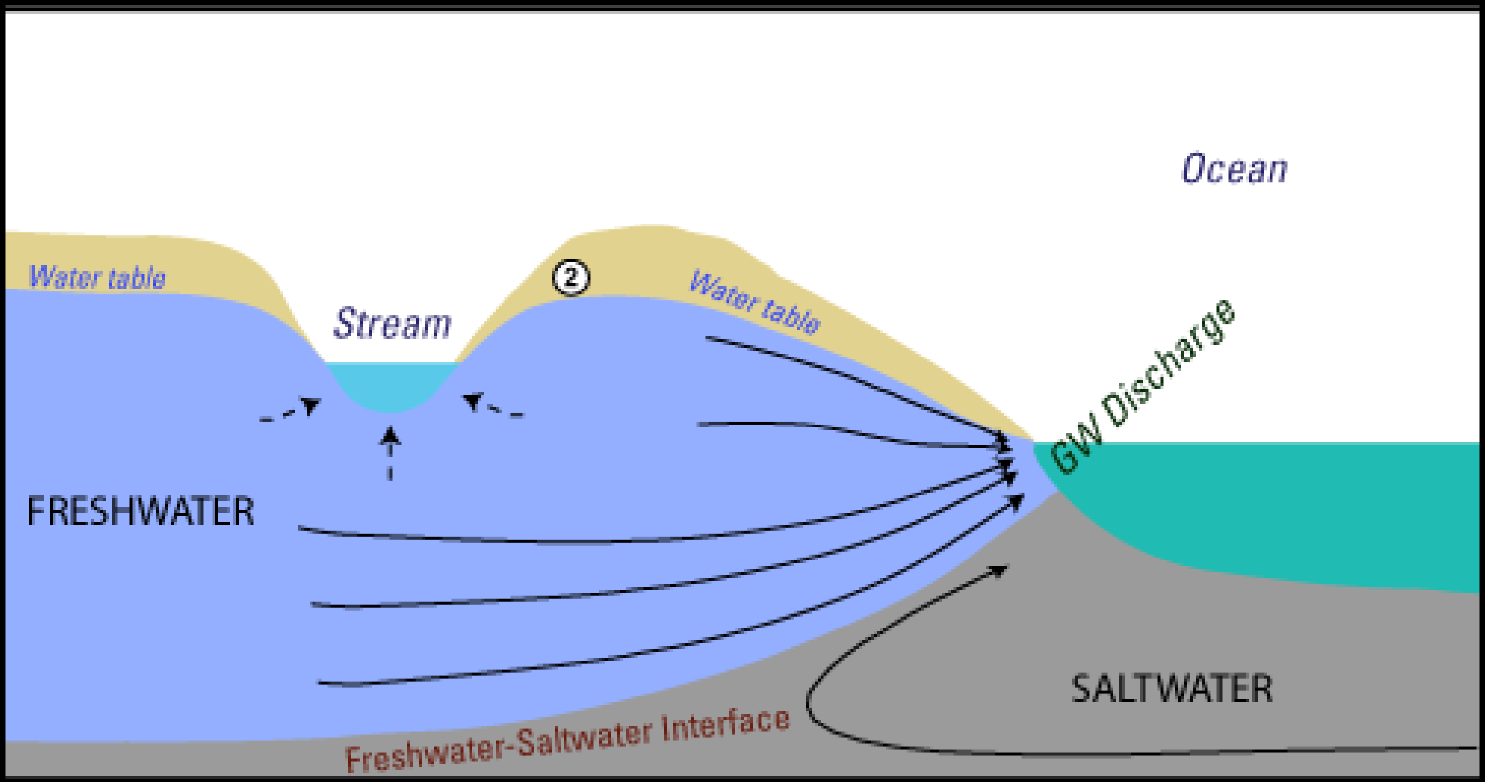
- The FW/SW interface a function of seabed leakance
- Deeper interfaces could allow for underflow of some of the nitrogen load
- GW flux at depth likely small and underflow may not be significant

Attenuation in Estuarine Sediments

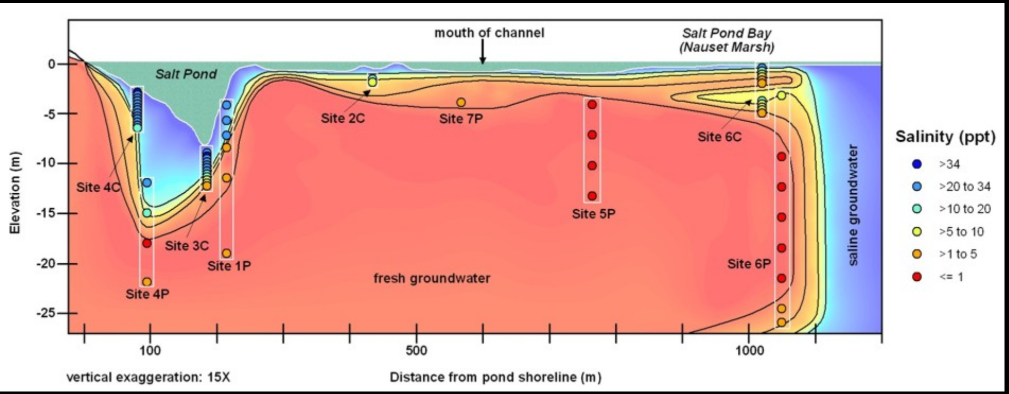
- Assumptions of conservative transport may be reasonable in oxic, carbon-poor aquifers
- But nitrogen could be attenuated in geochemical environments within estuarine sediments
- Denitrification has been documented in these settings

Conceptual Models of Groundwater Discharge near Estuaries

Simple model (conservative)

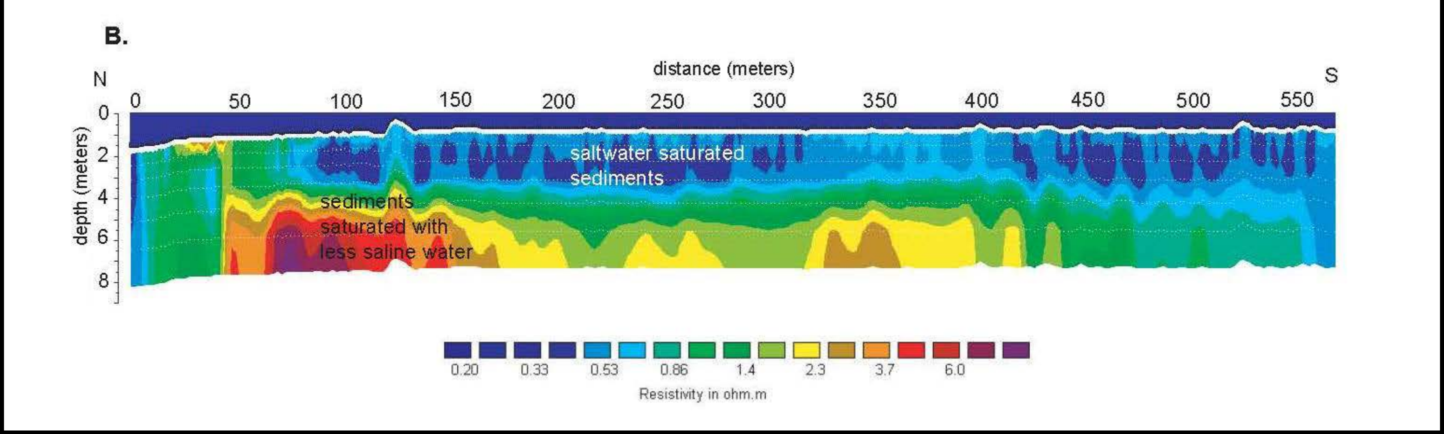


Conceptual Models of Groundwater Discharge near Estuaries



Nauset Marsh Estuary
fresh under salt

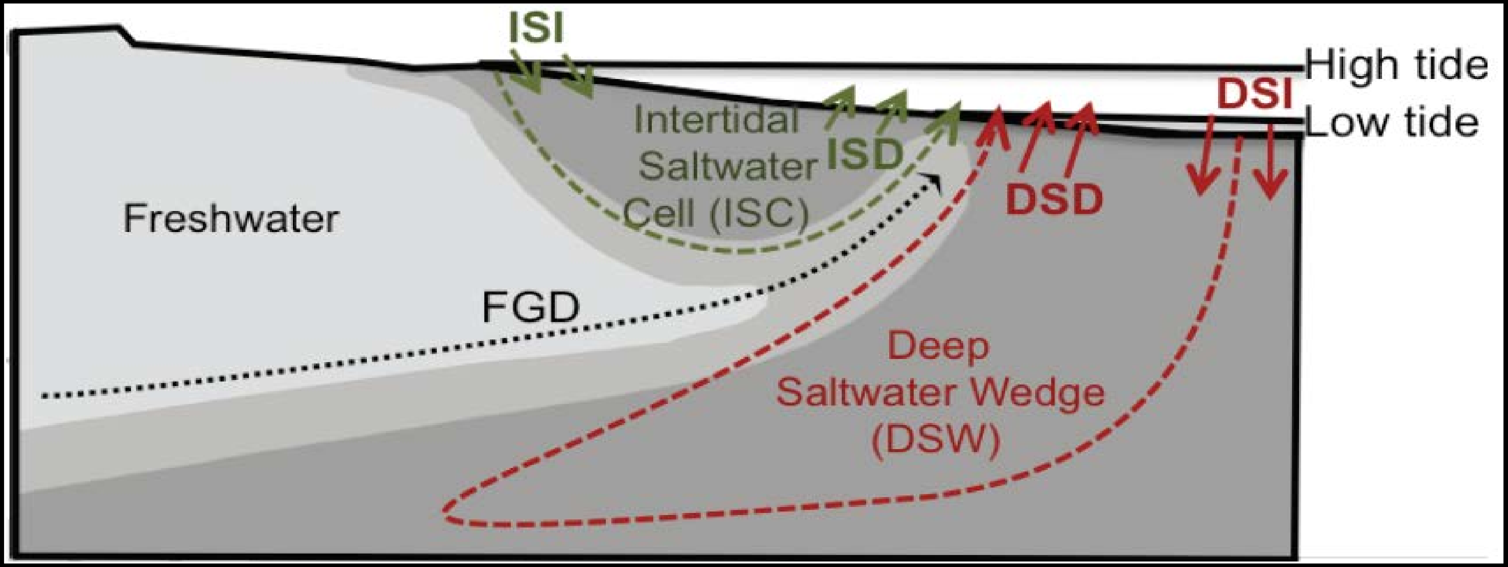
- Local interface likely more complex
- Variable redox conditions
- Complex GW discharge
- Simplifying assumptions of nitrogen discharge may not be valid



Waquoit
Bay fresh
under salt

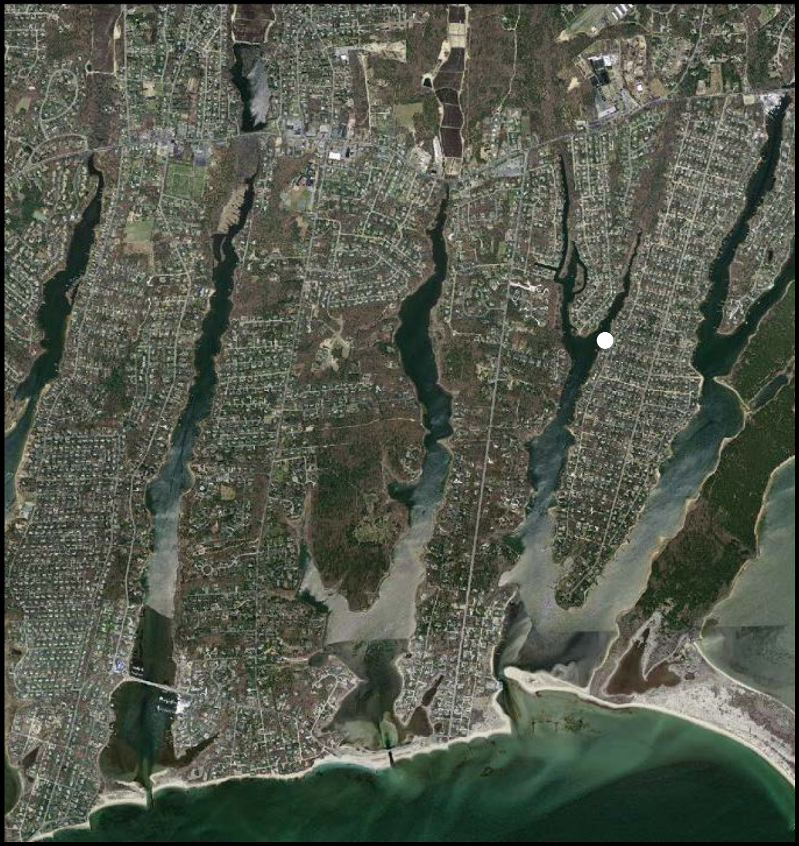
Conceptual Models of Groundwater Discharge near Estuaries

Complex model



Investigation of Potential Nitrogen Attenuation, Eel River, Falmouth

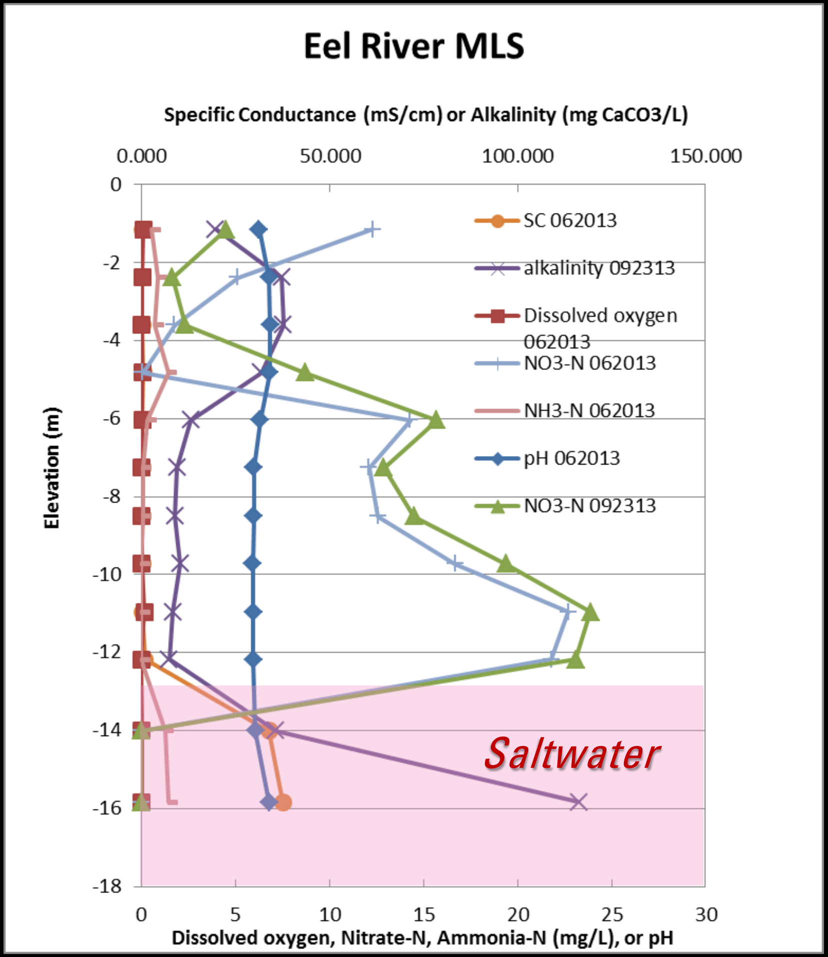
- In cooperation with the EPA
- Evaluating N attenuation using wells and multi-level samplers
- Data collection in and near the Eel River

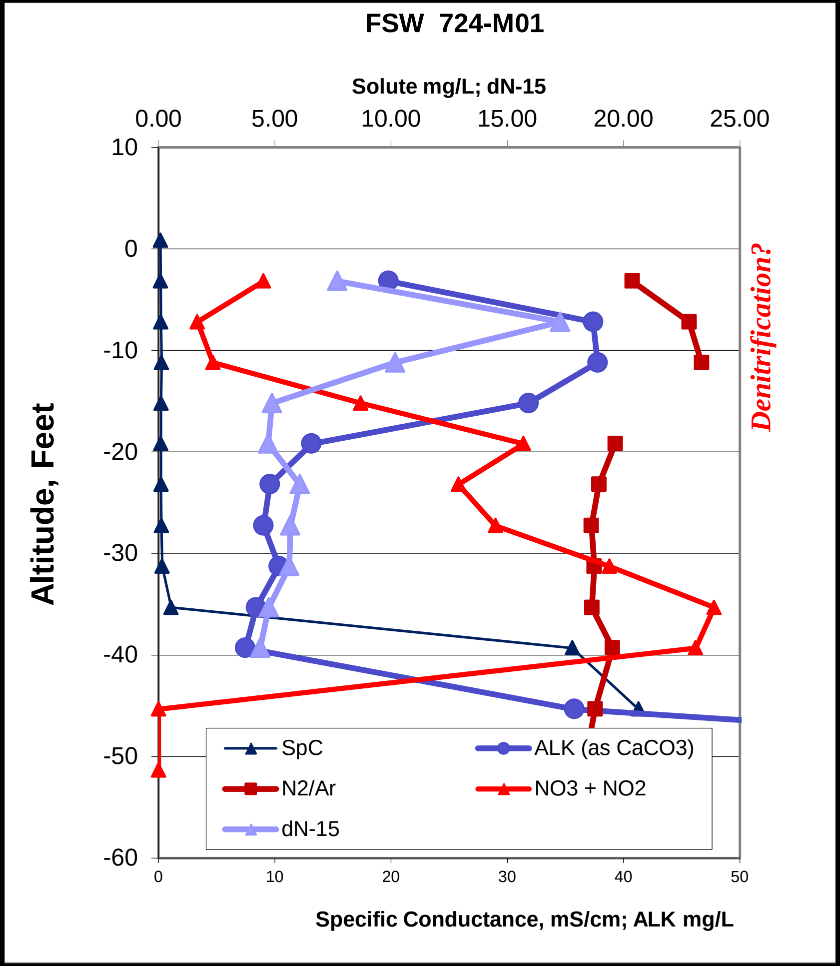


Gradient vectors for mean water levels from continuous loggers (8/20/13 - 9/16/13) for three triangles in the Seacoast Shores area

Investigation of Potential Nitrogen Attenuation, Eel River, Falmouth

Shoreline and Offshore Water Quality, Eel River

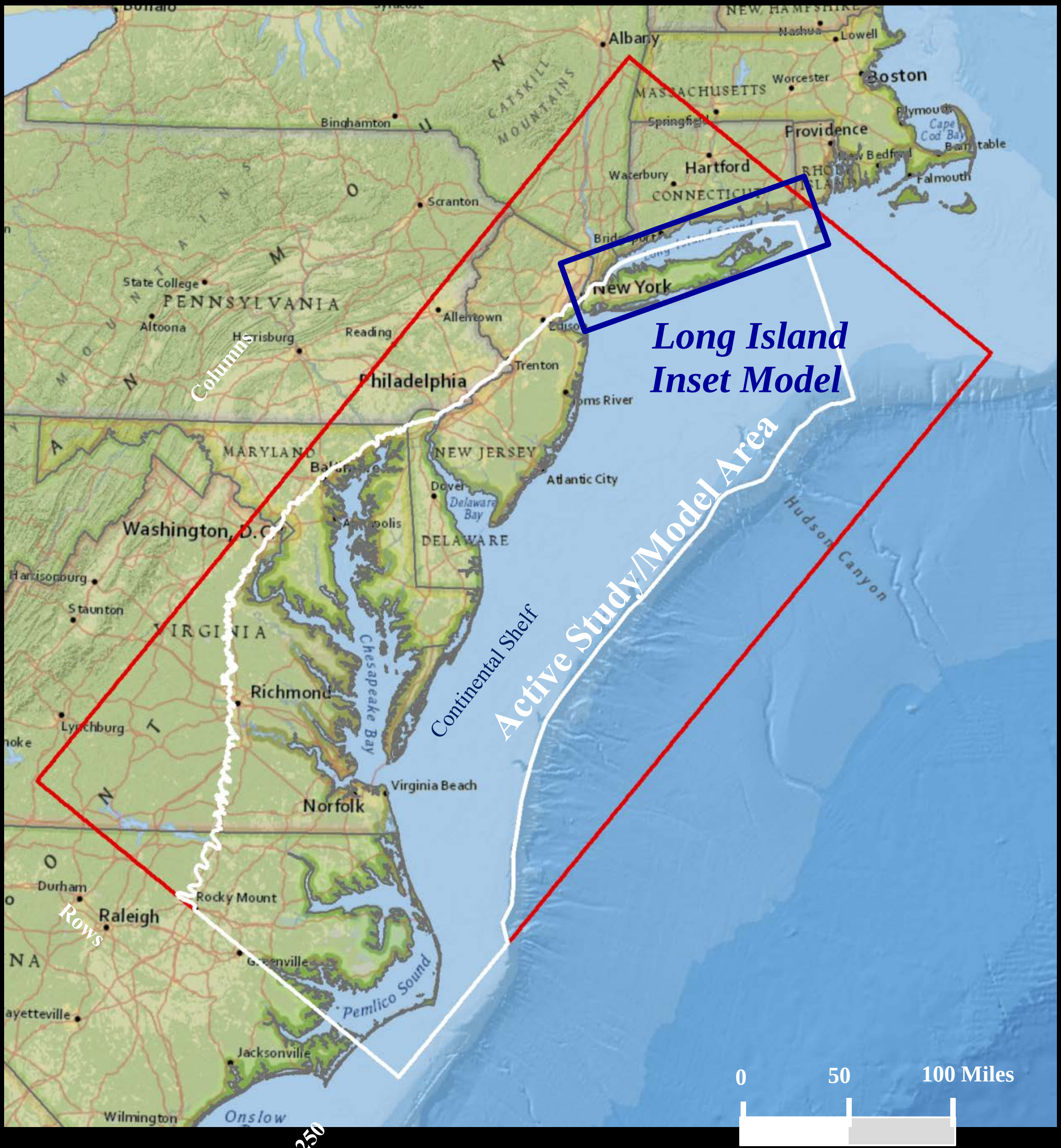




Application to Long Island GW System

- Different hydrography
- Longer travel times, instantaneous loads may be less valid
- Legacy land uses may be important
- Complex geology

NACP Regional Model and Long Island Inset Model



NACP Model:

Rows: 250

Columns: 500

Layers: 19

Horizontal Grid Spacing: 1 x 1 mile

Long Island Model:

Rows: 348

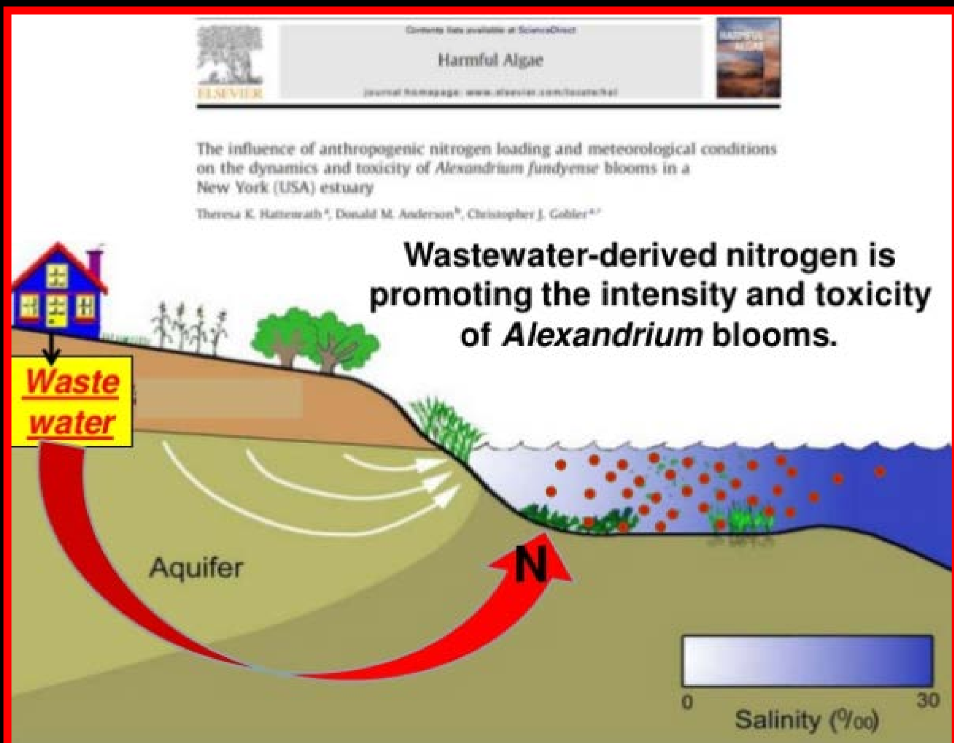
Columns: 1309

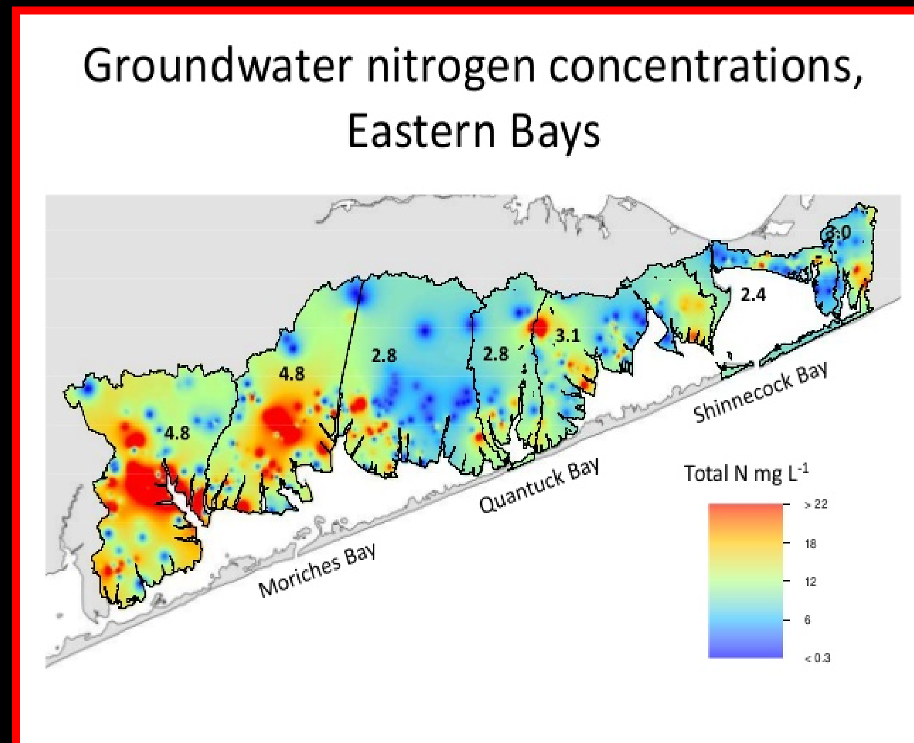
Layers: 24

Horizontal Grid Spacing: 500 x 500 feet

USGS-NYSDEC Cooperative Study

Comprehensive Delineation of Groundwater Recharge Areas, Travel Times, and Outflows to Long Island Streams and Estuaries





https://www.google.com/search?q=long+island+groundwater+pollution&biw=1235&bih=777&source=lnms&tbm=isch&sa=X&ved=0CAYQ_AUoAWoVChMIzdSGgKawxwIVBdOACh3t8QAX#imgrc=qwBlbt8n-XvpMM%3A

http://www.slideshare.net/Savethegreatsouthbay/gobler-water-worries-oct-2013-v2?related=1

Resources

MEP Reports:

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USGS Reports:

http://pubs.er.usgs.gov/publication/sim2857

http://pubs.er.usgs.gov/publication/sir20135060

http://pubs.usgs.gov/sir/2007/5259/