

USGS Studies in the Namskaket Marsh Area, Orleans, MA:

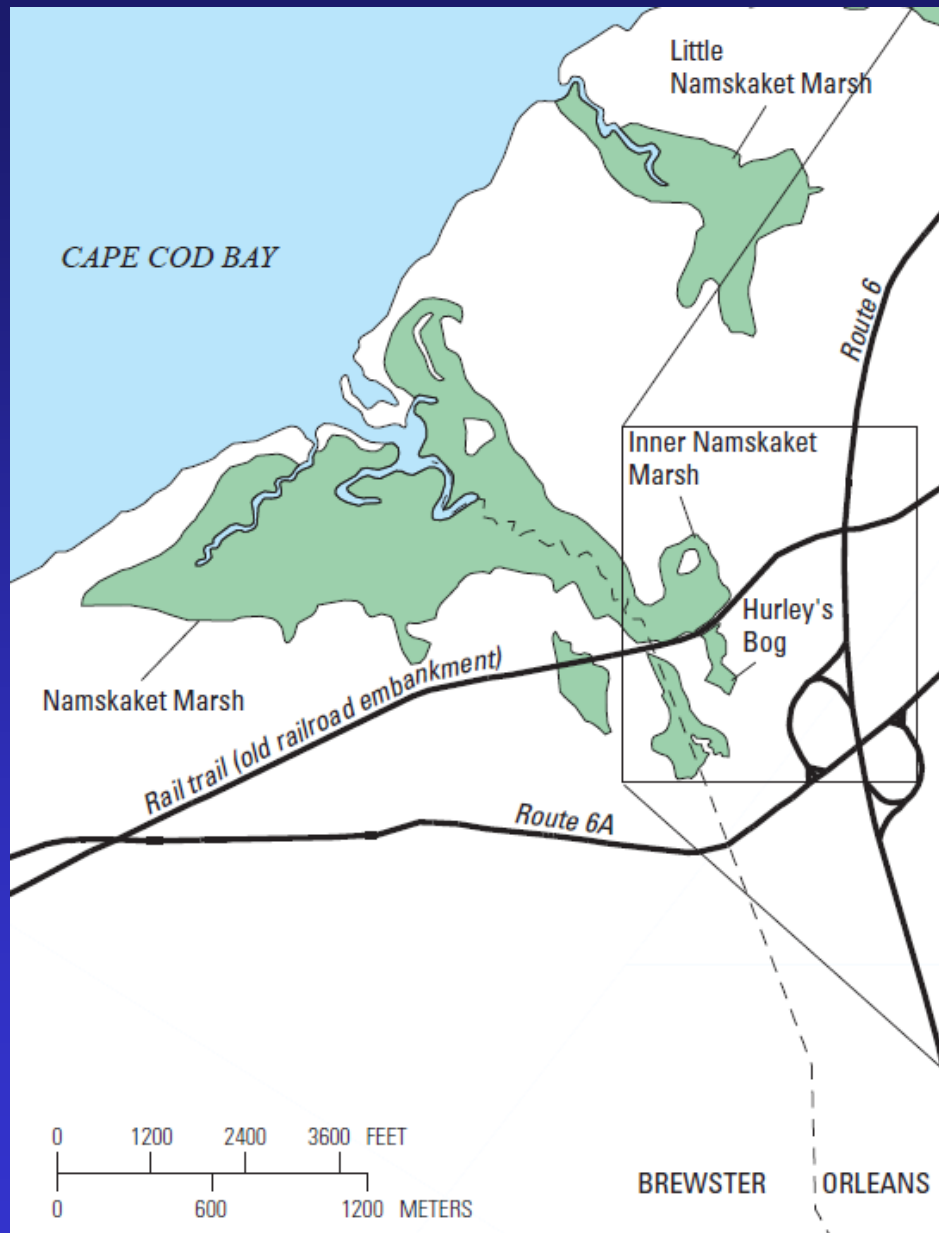
Summary of Major Findings

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U.S. Geological Survey

October 12, 2016



Location of study area, Orleans, MA



DeSimone
and others, 1998a

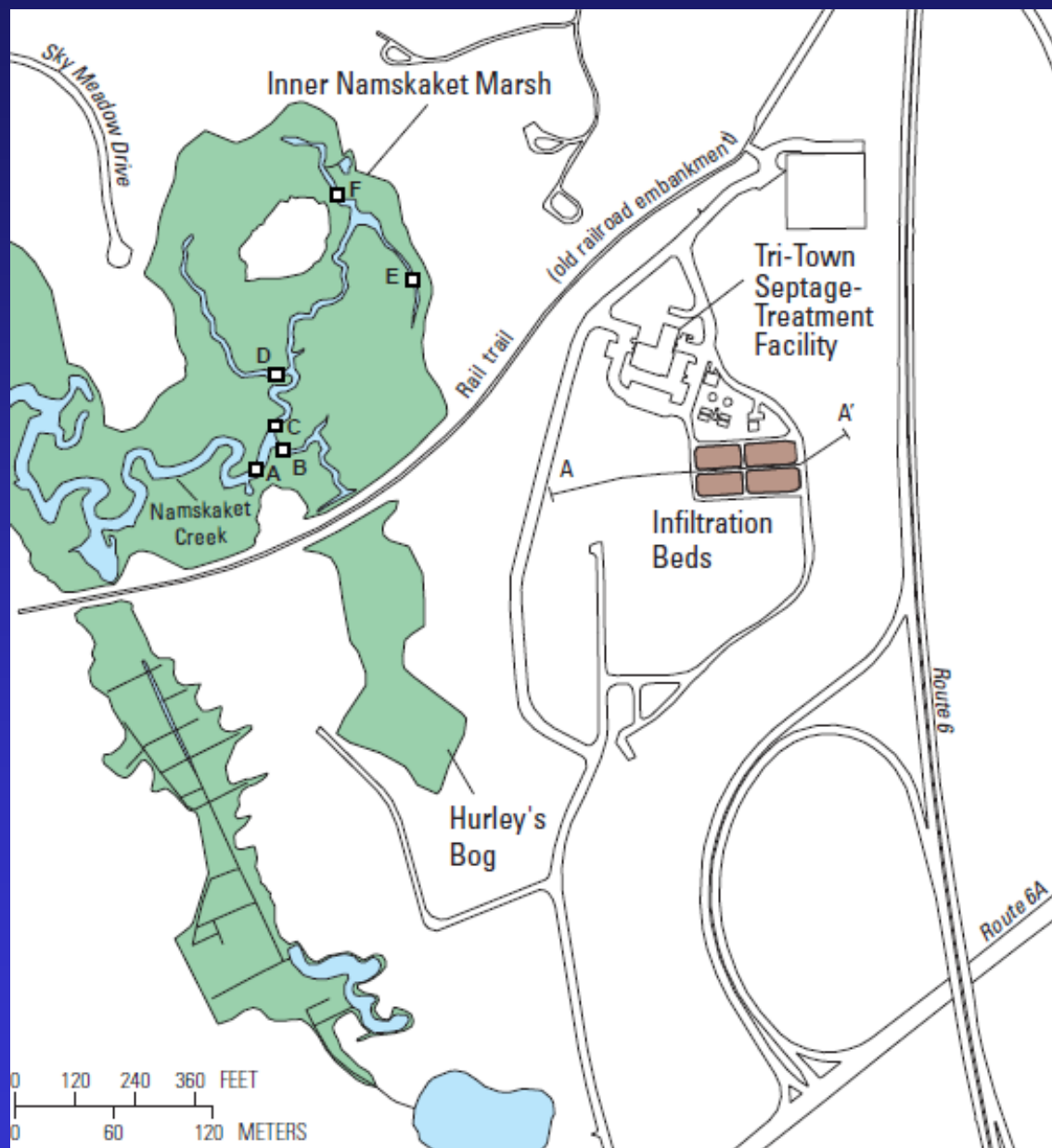
Topics: USGS Summary Report

- Geology and groundwater flow at facility site; development and movement of the nitrogen plume.
- Natural groundwater discharge zones, Namskaket Marsh (boundary zone and creek bottoms).
- Baseline marsh ecology, and relation to porewater salinity.
- Comparison between baseline (1994-96) and recent (2010-11) ebb-tide water quality, Namskaket Creek.

Geology and groundwater flow at site; development of the nitrogen plume.

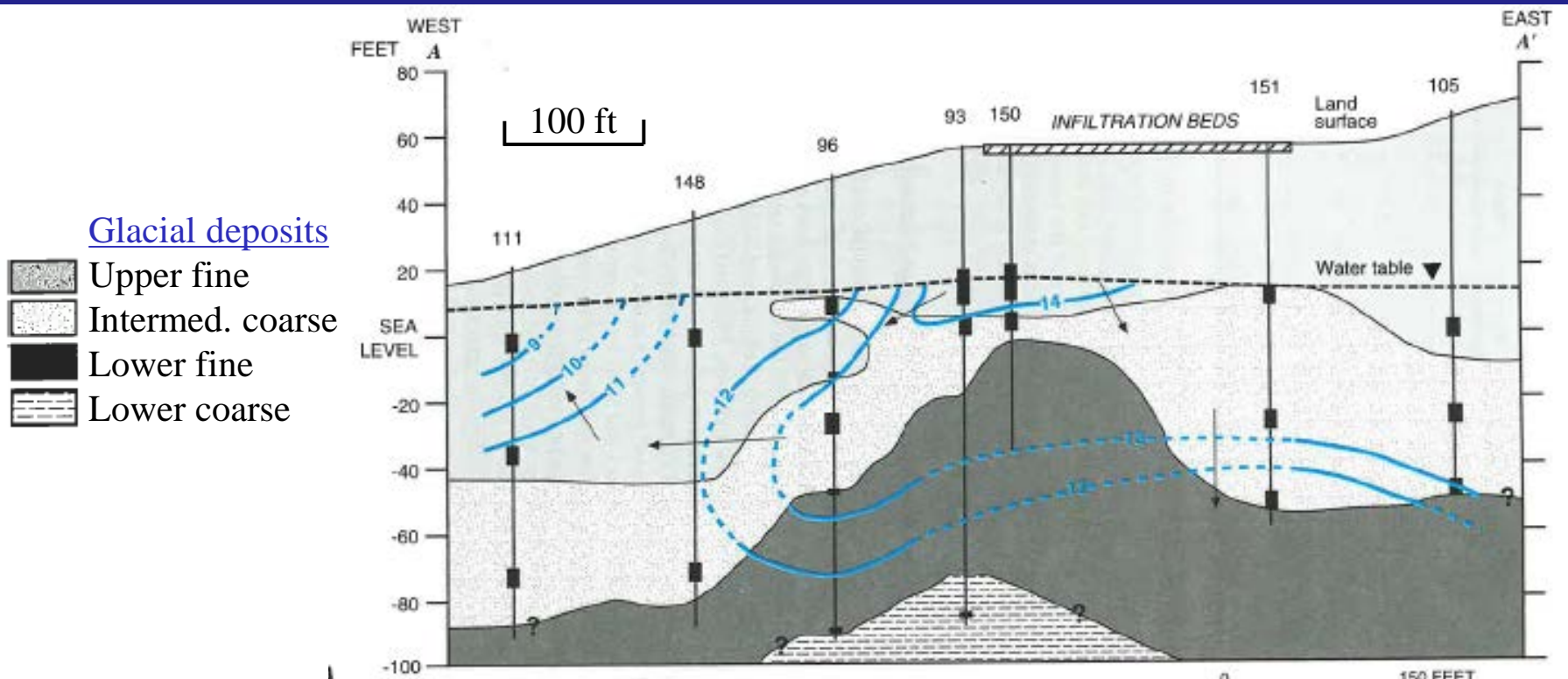
- Site geology is complex, underlain by medium to coarse sandy glacial deposits, with interbedded fine sand, silt, and clay, deposited during retreat of the Cape Cod Bay lobe of last ice sheet.
- Overall thickness of glacial deposits is 300-400 feet, underlain by granite bedrock.
- Groundwater flow and plume movement below facility site has mainly occurred through a medium-coarse sand layer of varying thickness, located ~ 30-70 ft below mean sea level.

Location of facility site, and A-A' section



DeSimone and others, 1998a

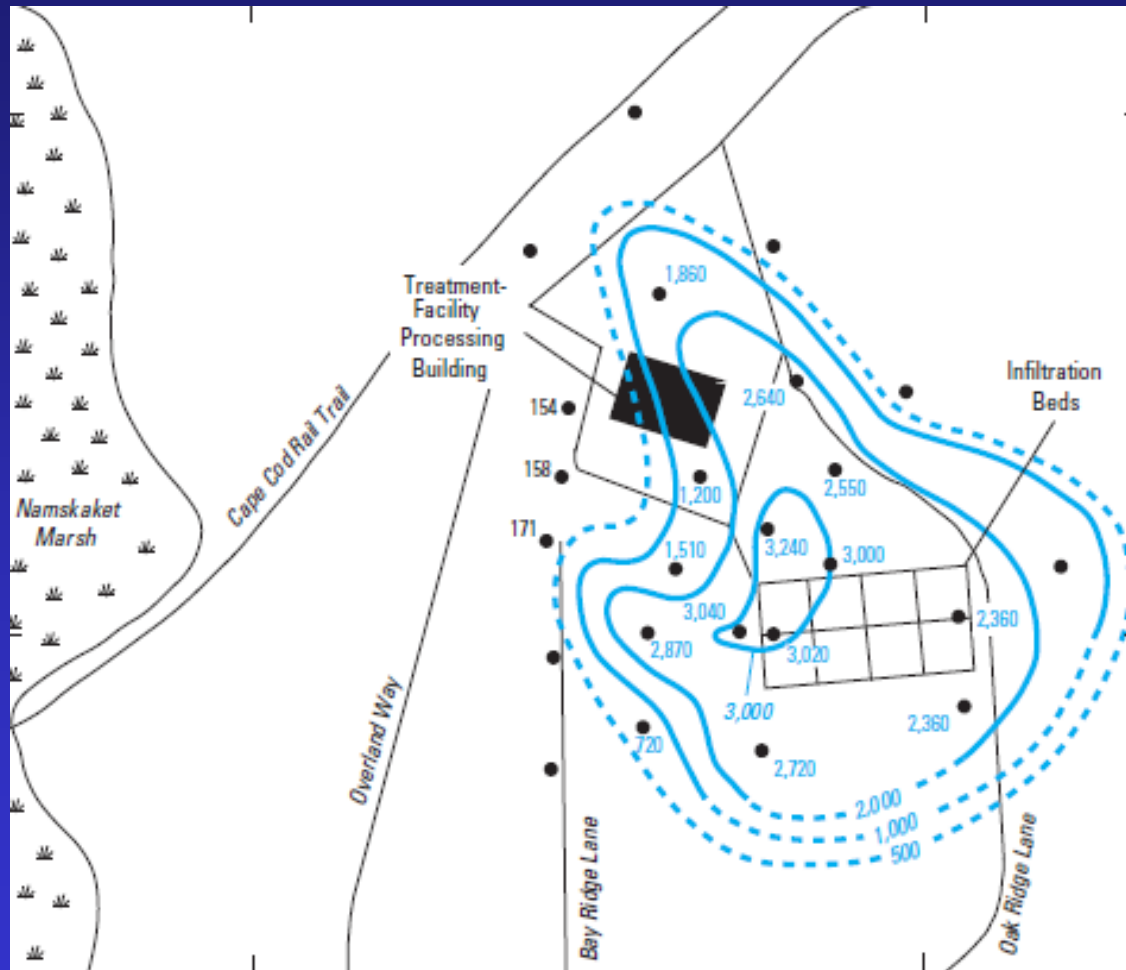
Cross section A-A', showing fine and coarse deposits, and groundwater flow directions below facility



DeSimone and others, 1996

Geology and groundwater flow at site; early development of the nitrogen plume

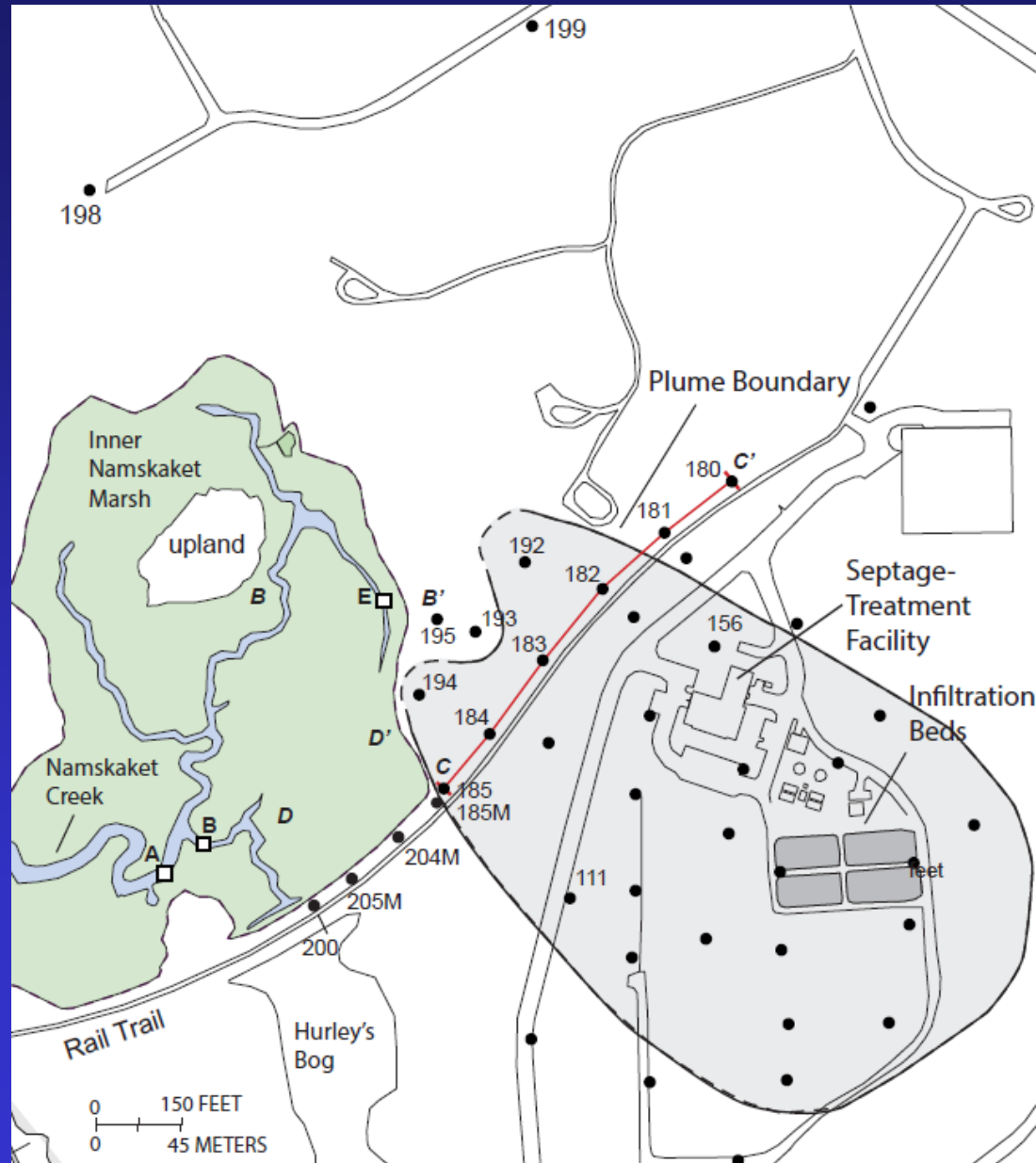
Contours of specific conductance (indicator of total dissolved solids)
Dec. 1992



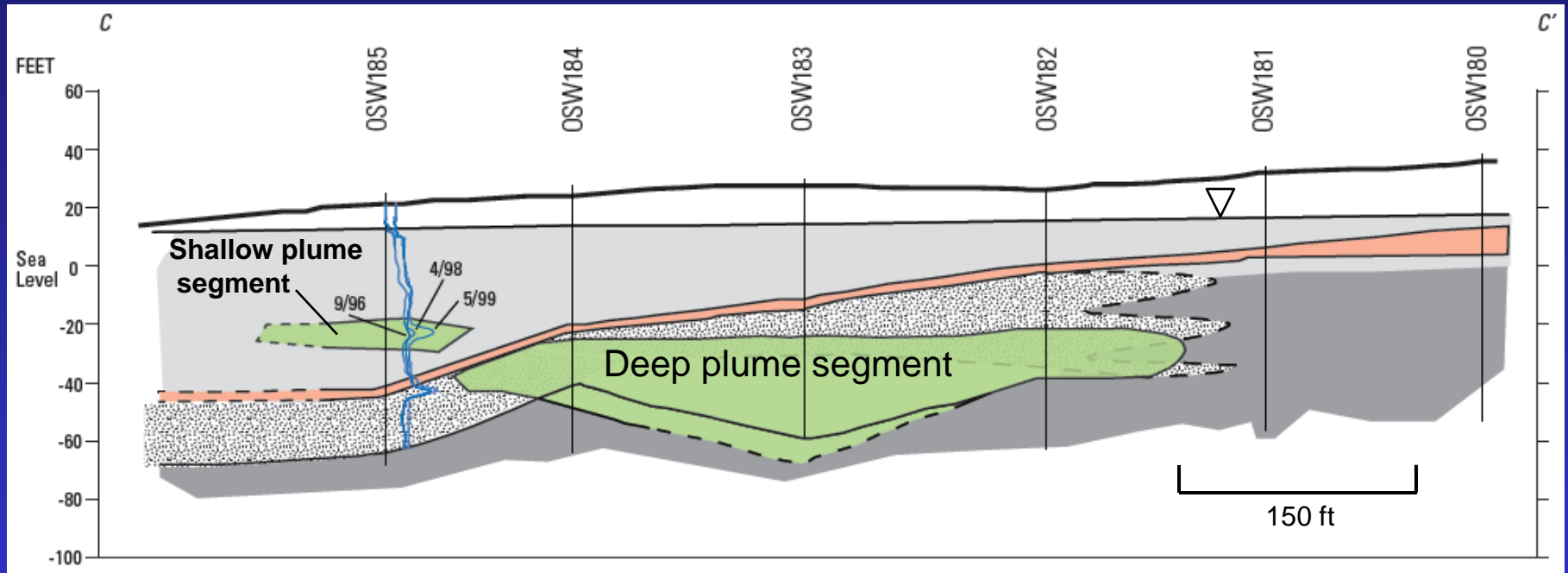
DeSimone and others, 1996

Continued development of deep plume segment (1994 -)

Plume extent,
May 1999
(gray area,
dashed where
uncertain)



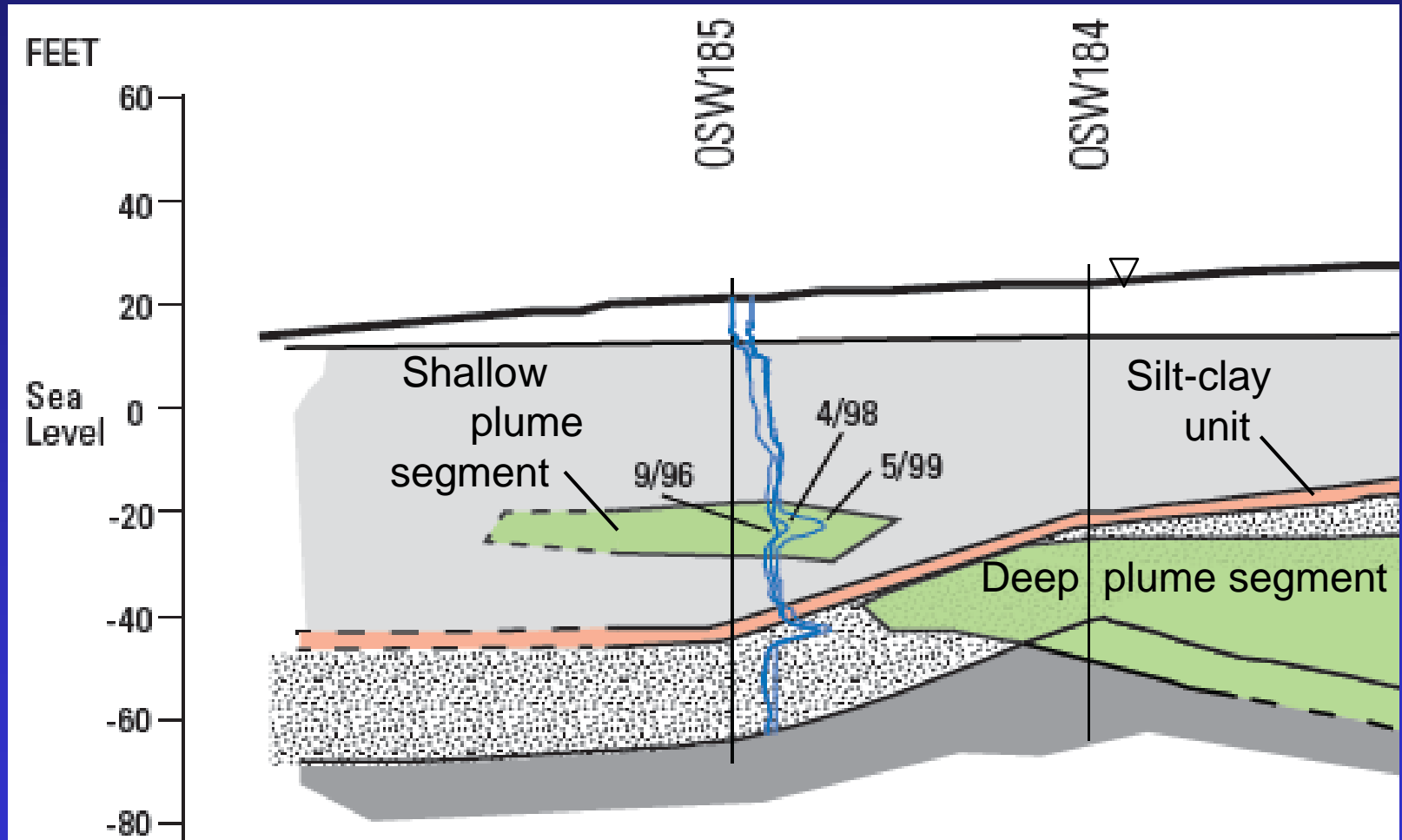
Rail Trail Cross Section C - C', May 1999, showing geology, plume segments and borehole EM logs at well 185 (flow direction into the page)



EM-logs measure the combined conductivity of sediment and groundwater at a radius of ~1 ft from PVC well.

EM-logs, well 185, show:

- location of silt-clay unit (no EM changes over time)
- location of shallow plume segment (EM changes over time)

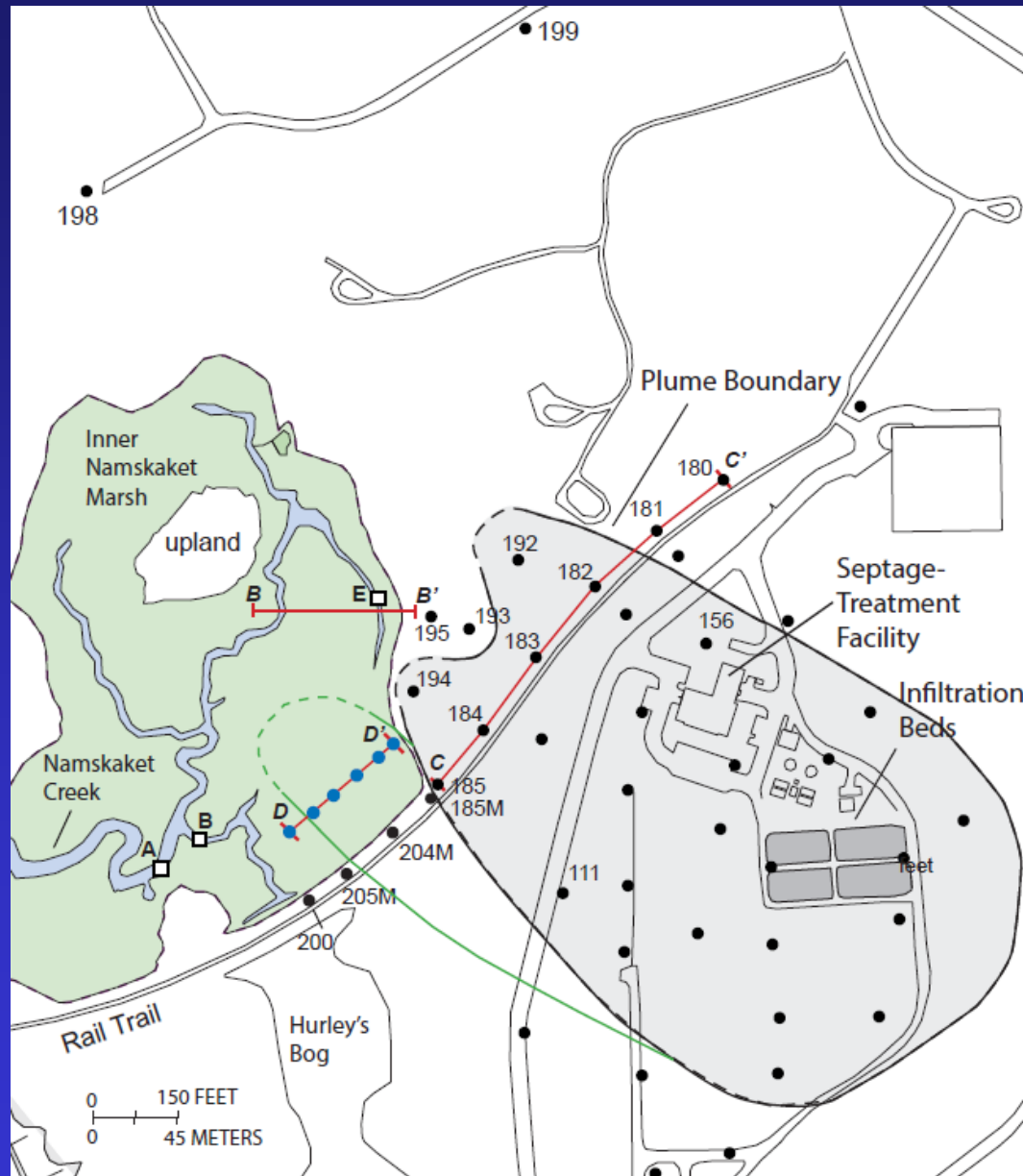


Shallow and deep plume segments (1999 -)

Shallow plume segment observed at rail trail and beneath marsh

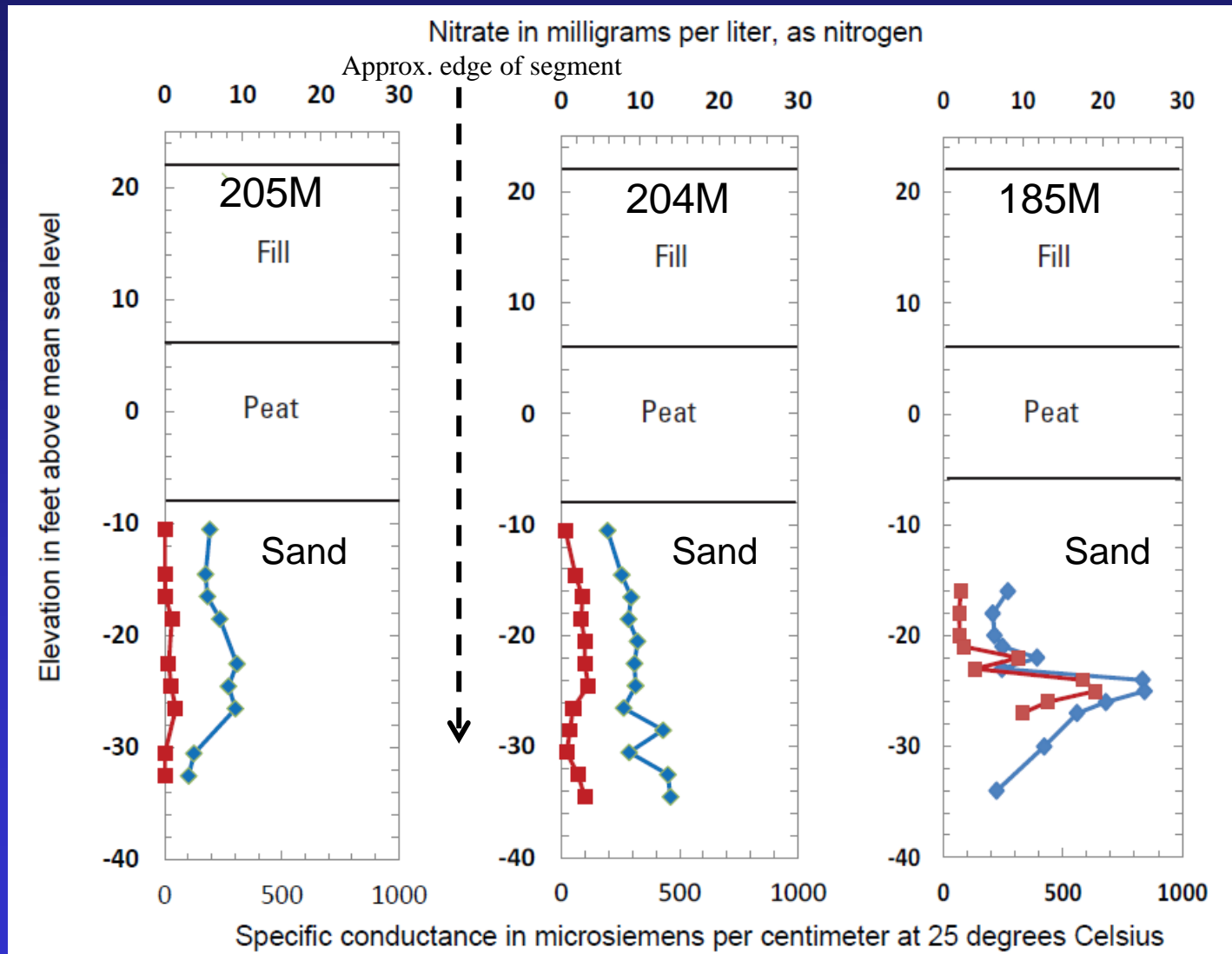
Evidence:

- EM-logs--well 185
- Multi-level GW samples--185M, 204M
- Sub-marsh well point samples, D-D' transect



Rail trail multi-level samplers, Oct. 2003–Jan. 2004

(flow direction into the page)

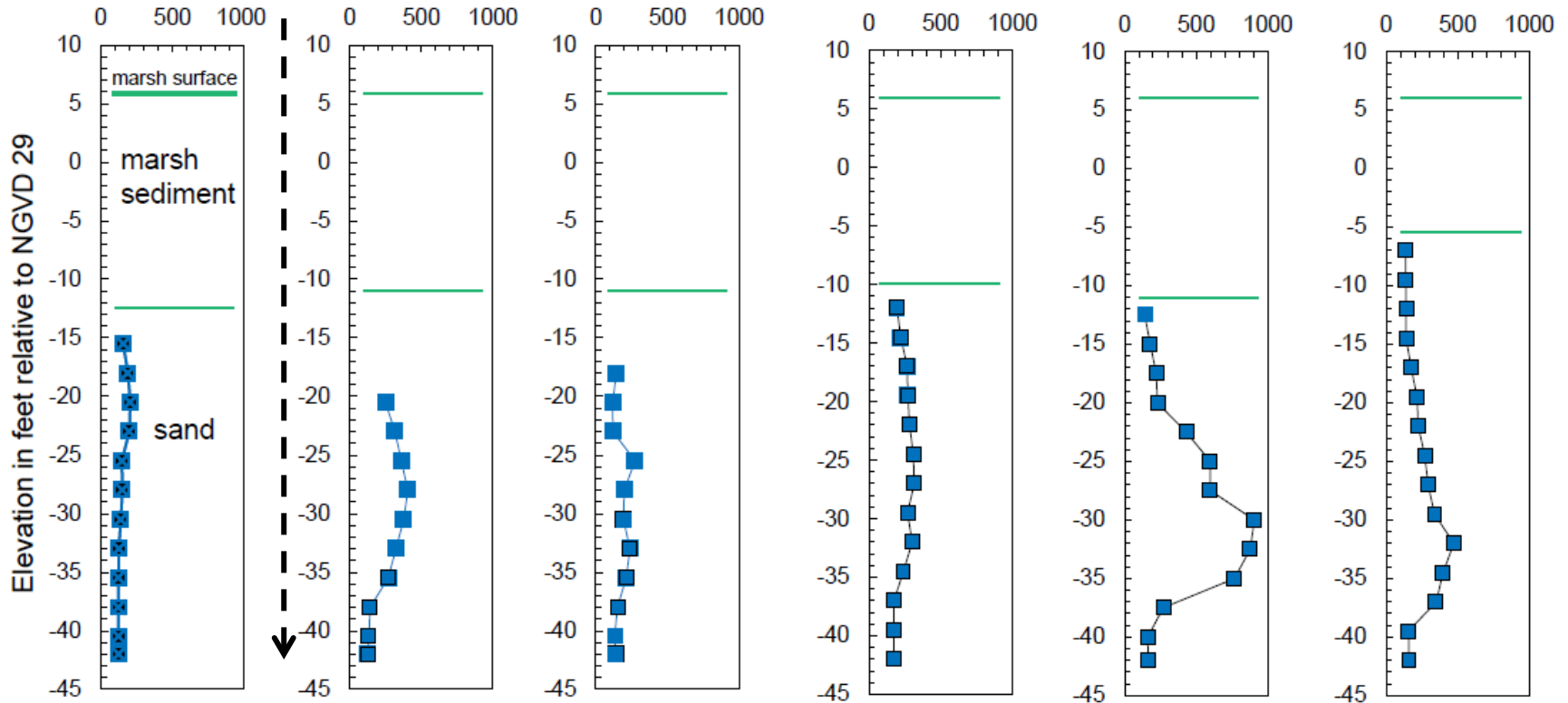


Sub-marsh well-point samples, D – D', Oct. 2003

(flow direction into page)

Specific Conductance in microsiemens per centimeter at 25 degrees Celsius

Approx. plume edge



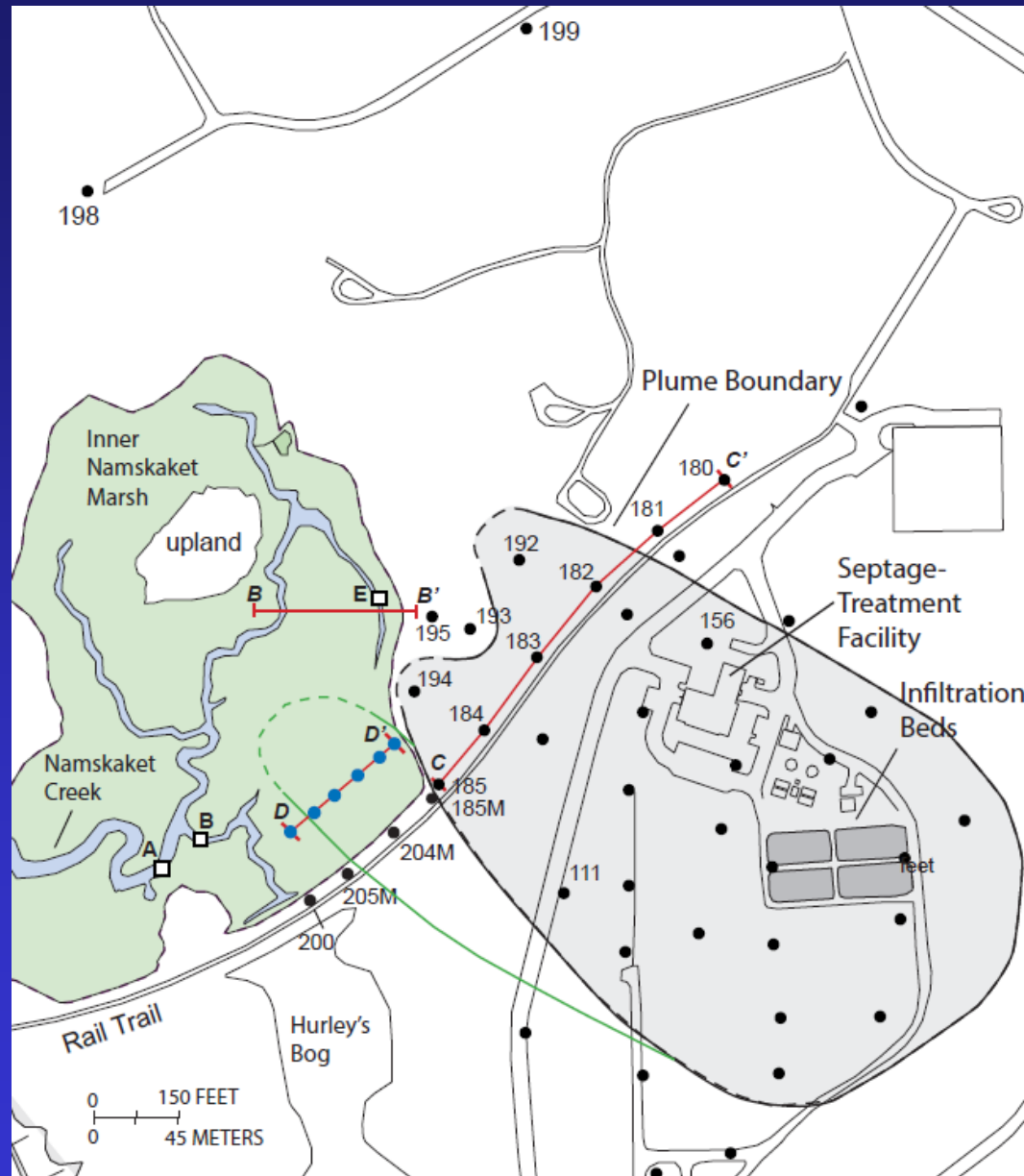
Potential natural groundwater discharge zones:

1. Boundary zone

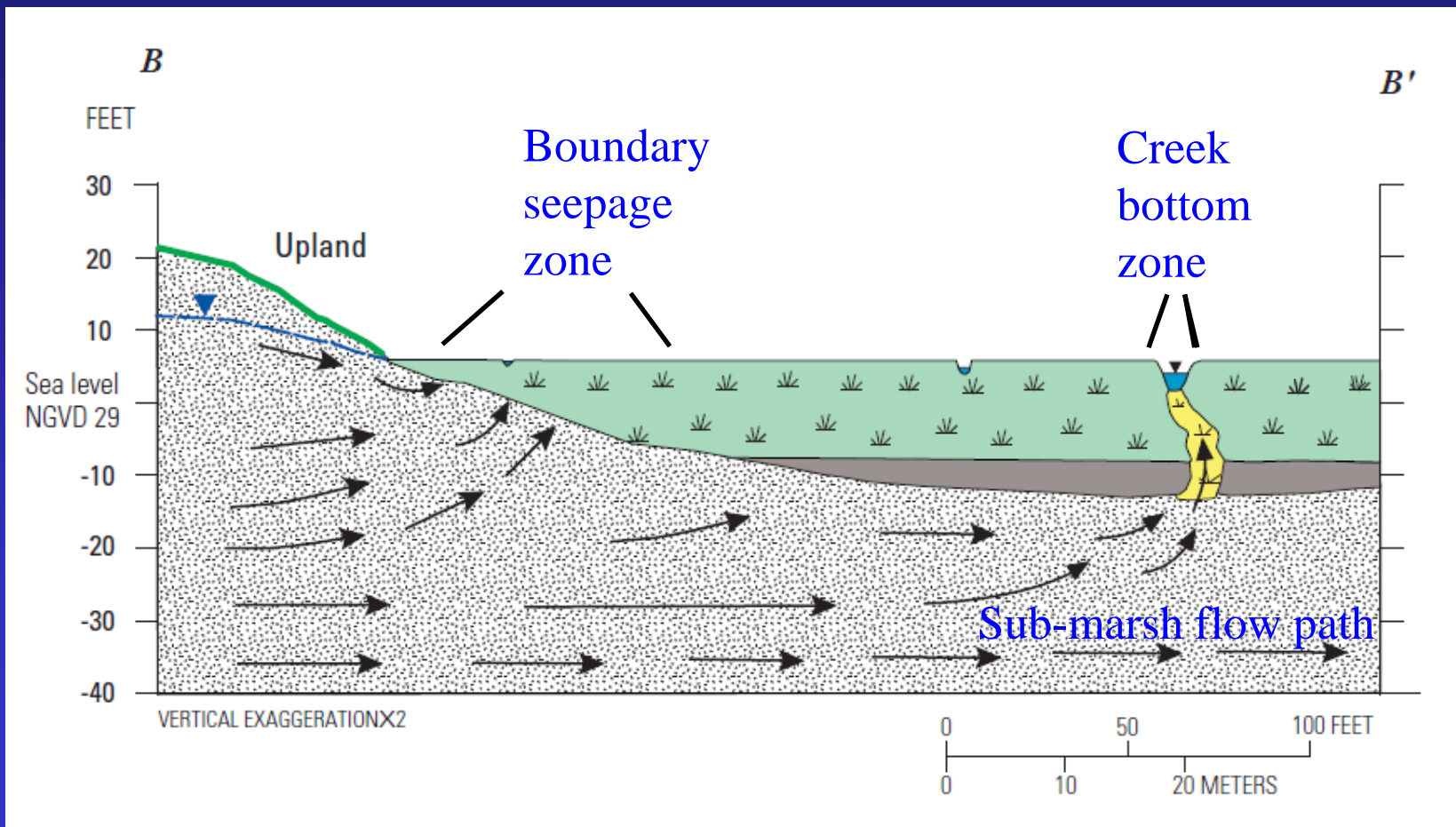
2. Creek bottom zone

3. Downgradient receptors

(section B' – B)



Observed natural groundwater discharge zones (boundary and creek-bottom zones).



Observed natural groundwater discharge zones— boundary and creek bottoms.

- Evidence:

- Standing, low-salinity water in boundary zone during dry periods and winter cold periods indicates gw discharge (DeSimone, 1998).

- Downstream gains in freshwater component of creek flow during ebb tide indicates gw discharge through creek bottoms.

(Weiskel, 1996).



Potential fates of shallow plume segment:

A function of the natural discharge zones/ flow paths.

1. Boundaries
2. Creek bottoms
3. Downgradient receptors

Continued monitoring of both plume segments was constrained by two factors:

1. Deep segment was moving away from areas accessible to drilling of monitoring wells.
2. Continued sub-marsh drilling (shallow segment) could have harmful effects on the marsh ecology.

Therefore, monitoring effort shifted to detailed re-sampling of creek system, to detect possible effects of plume segment(s) on creek nitrogen concentrations.

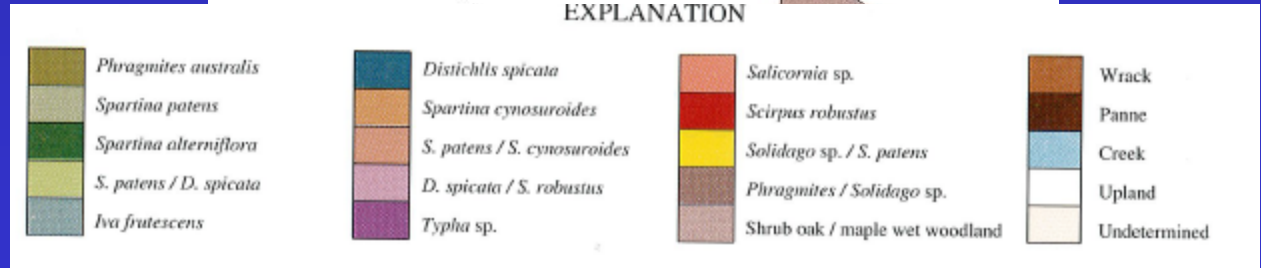
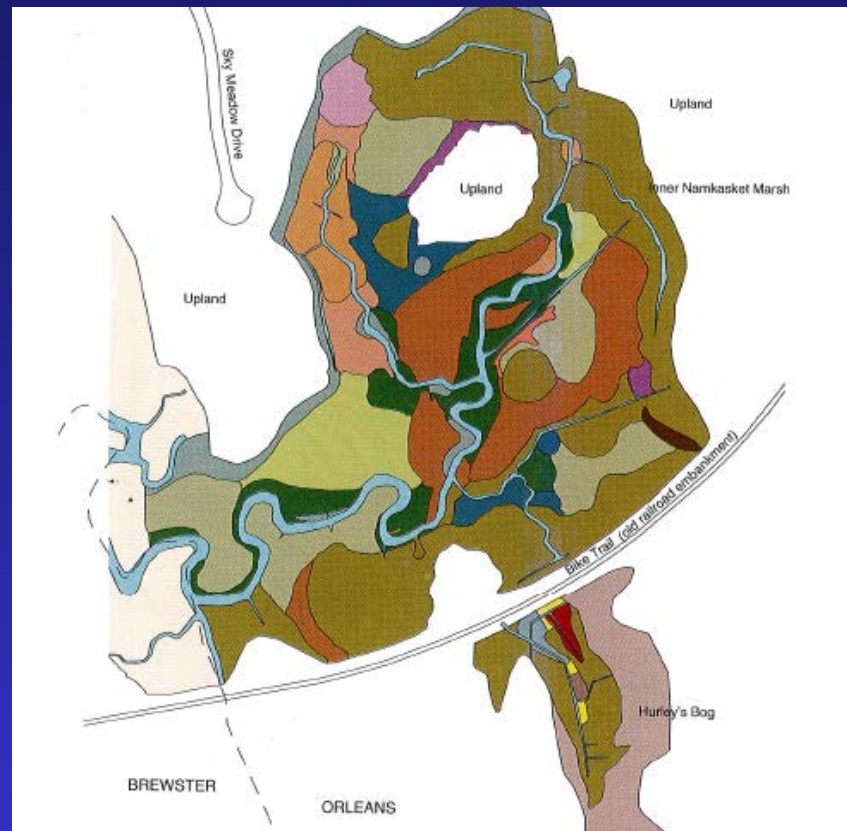
First– Let's review baseline marsh hydrology and ecology. Then the 2010-11 creek water quality will be compared to the 1990s baseline.

Baseline marsh ecology, and relation to porewater salinity

- Baseline distribution of marsh plants (1995): e.g., *Phragmites* (common reed), *Spartina patens* (salt marsh hay, *Spartina alterniflora* (cordgrass)
- Baseline marsh porewater salinity (1995)
- All results from DeSimone and others (1998).

Baseline marsh plant distribution, 1995

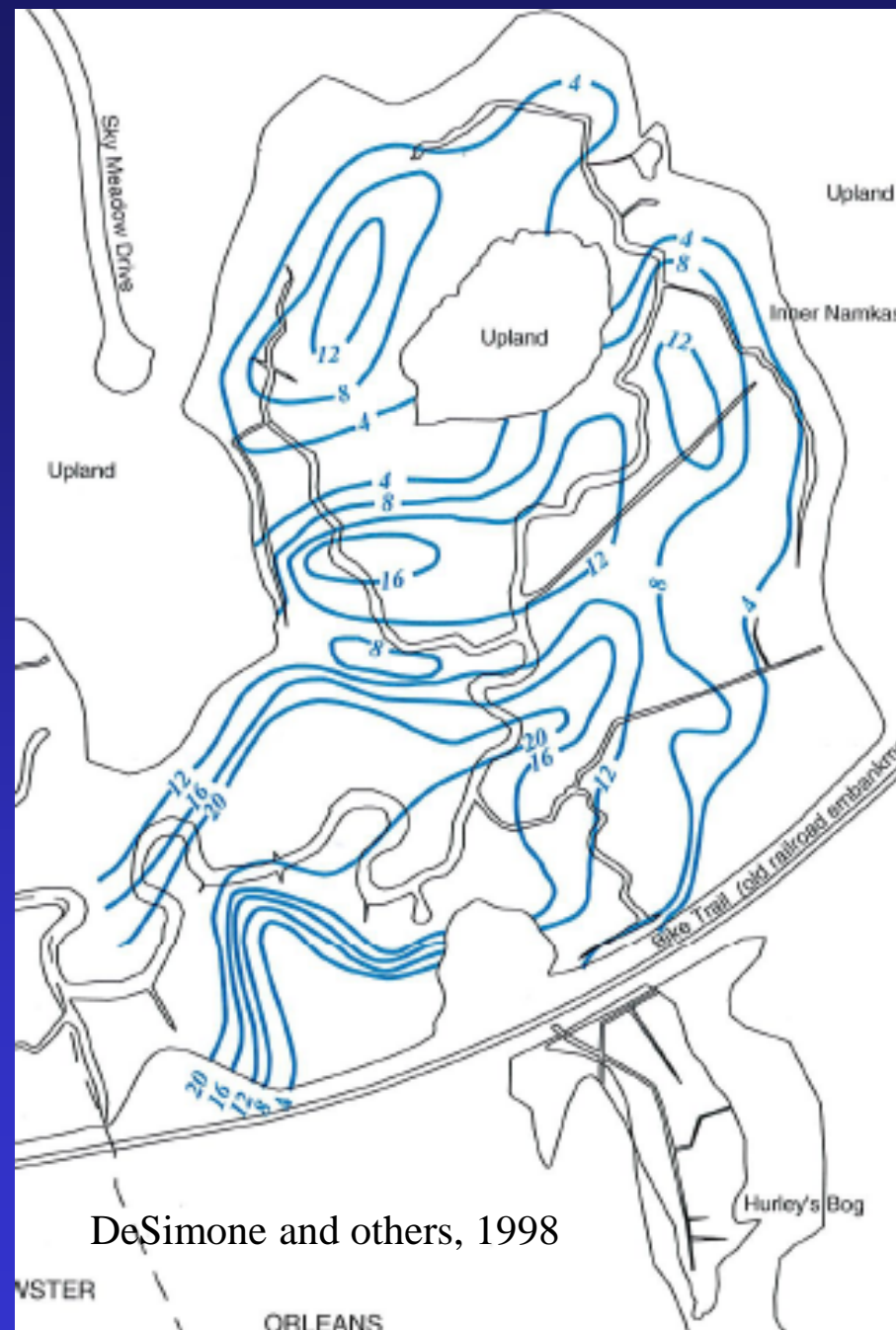
- Dominant species:
- *Phragmites australis*
- *Spartina patens*
- *Spartina alterniflora*
- plus wrack deposits



DeSimone and others, 1998

Baseline porewater salinity, 1995

- Inner Marsh has range of salinities, and plant species (~10 species, several plant associations).
- Areas of low salinity (0-4 ppt) correspond to large stands of *Phragmites*, under 1995 baseline conditions.
- Inner Marsh has substantial areas of plant debris (wreck), mostly dead *S. Alterniflora* stems, derived from main marsh during spring tides.



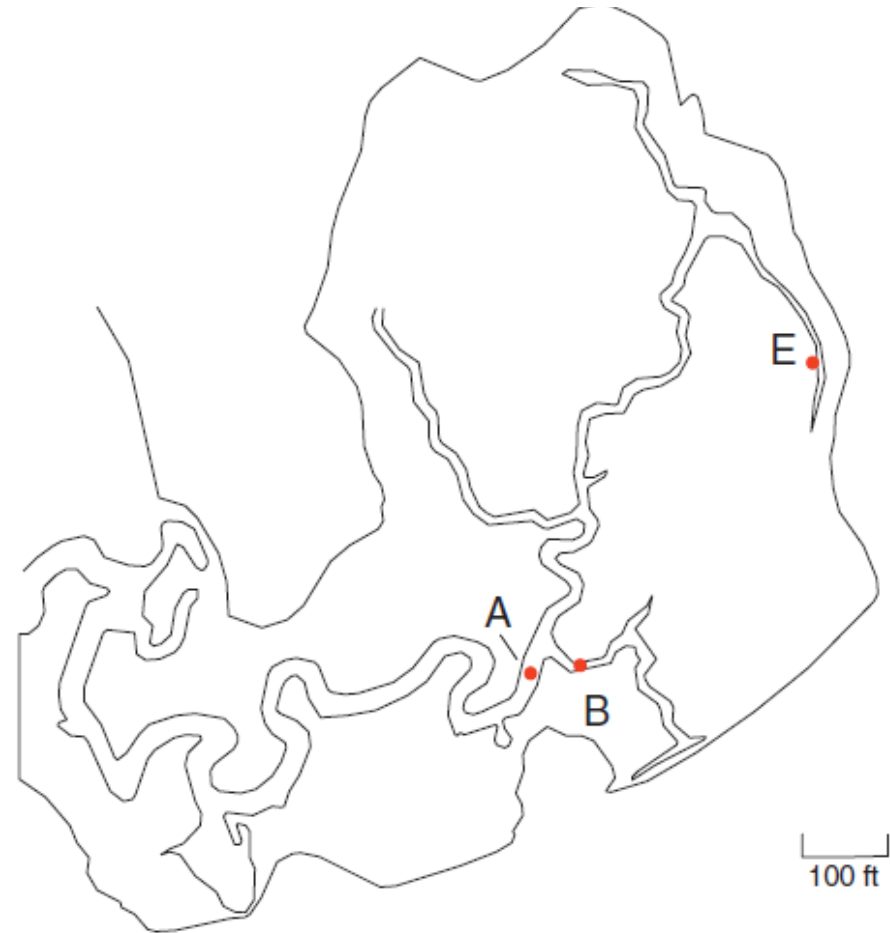
Comparison between baseline (1993-98) and recent (2010-11) ebb-tide water quality, Namskaket Creek

- Resumed biweekly sampling at baseline sites, under same tidal conditions as baseline, to compare nutrient concentrations and detect possible changes.

Detailed creek monitoring

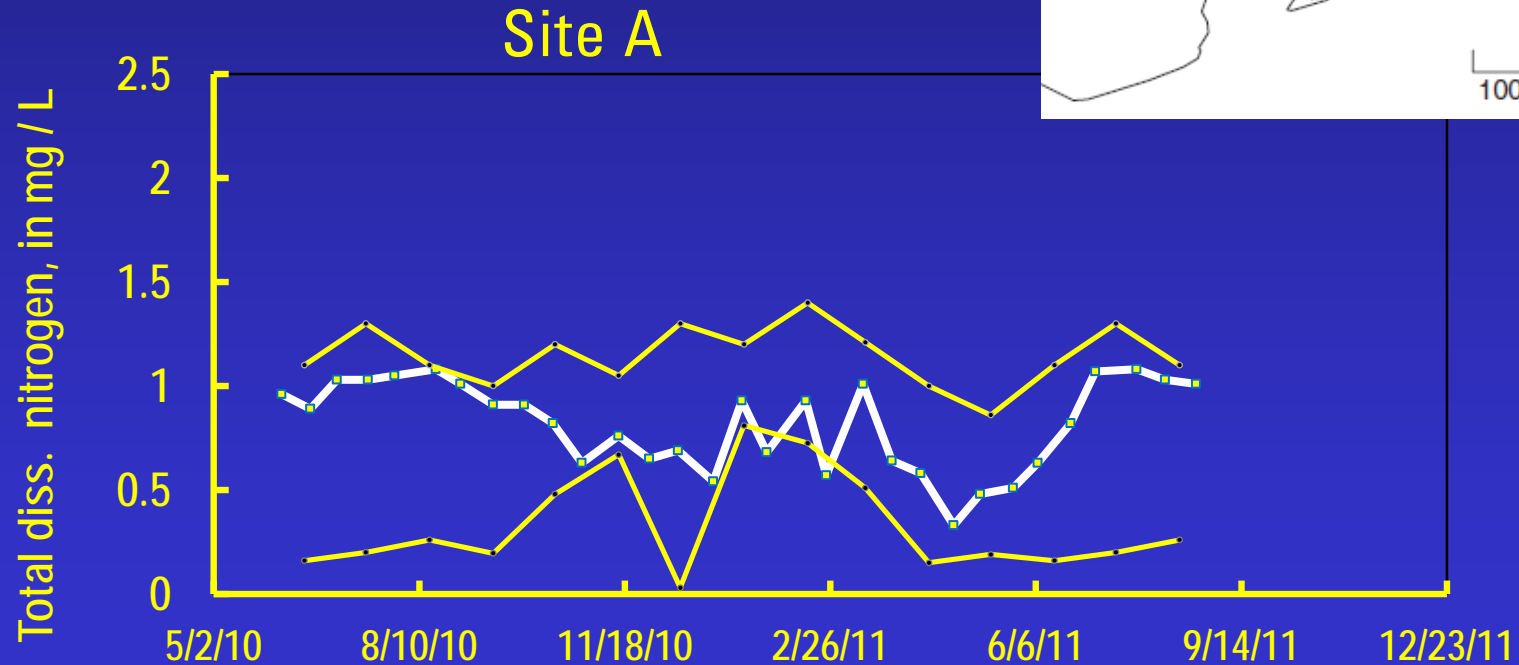
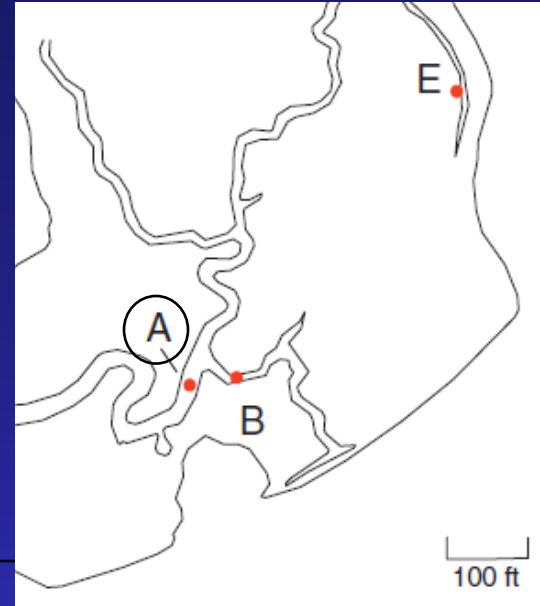
- To detect effects of possible plume discharge on creek-water quality
- Sampling biweekly during late ebb, under neap conditions, to maximize potential for detecting groundwater nitrogen during both baseline and recent sampling.
- **E**: Area of high GW inflow at boundary; **B**: Trib drains Hurley Bog; **A**: Integrator site for entire Inner Namskaket Marsh.

Ebb-tide creek sampling sites, 1993-98 baseline, and 2010-11



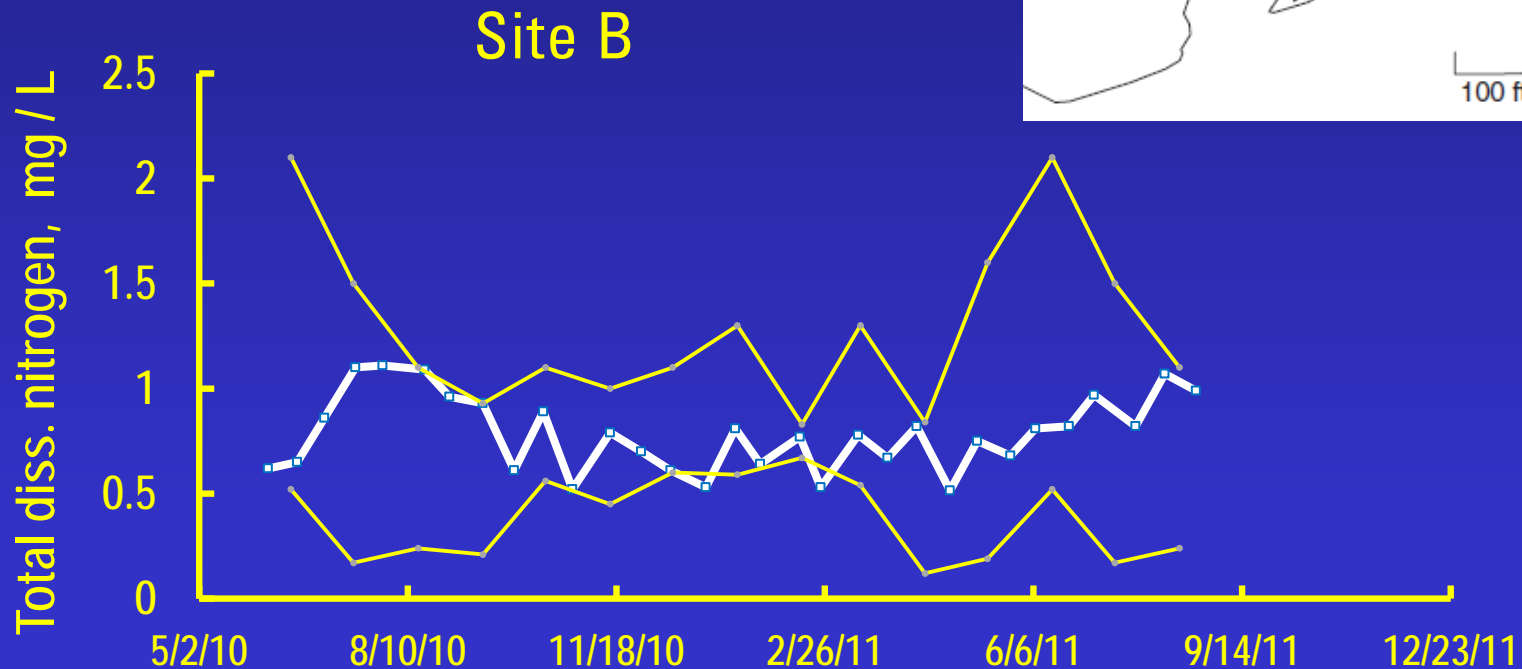
Detailed creek monitoring (seasonal variation)

- Comparison of recent sampling (white line) to mid-1990s sampling (monthly max and min lines, in yellow):



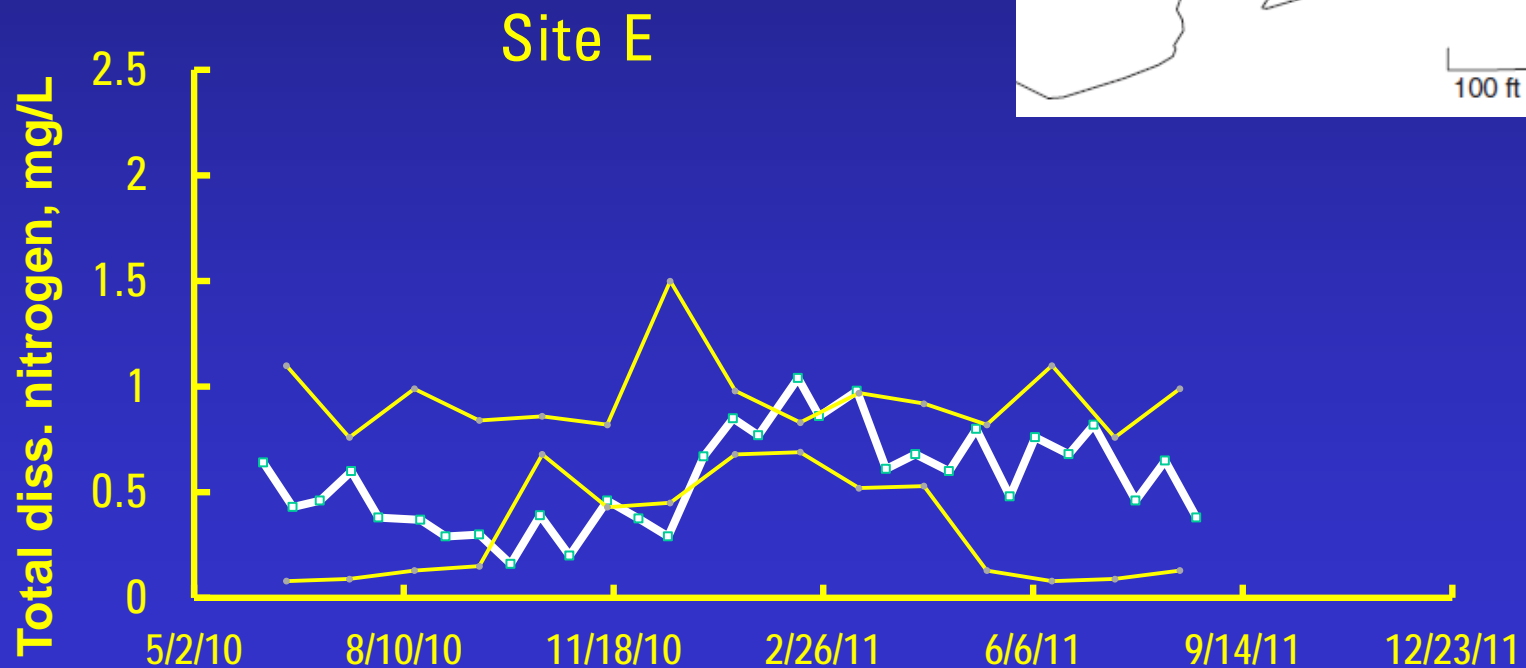
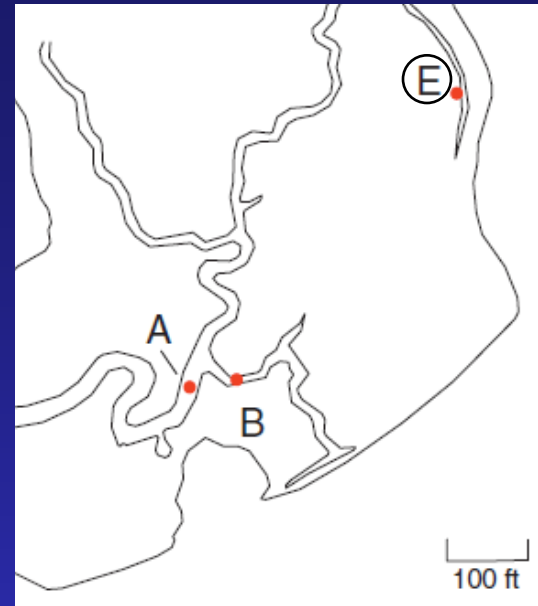
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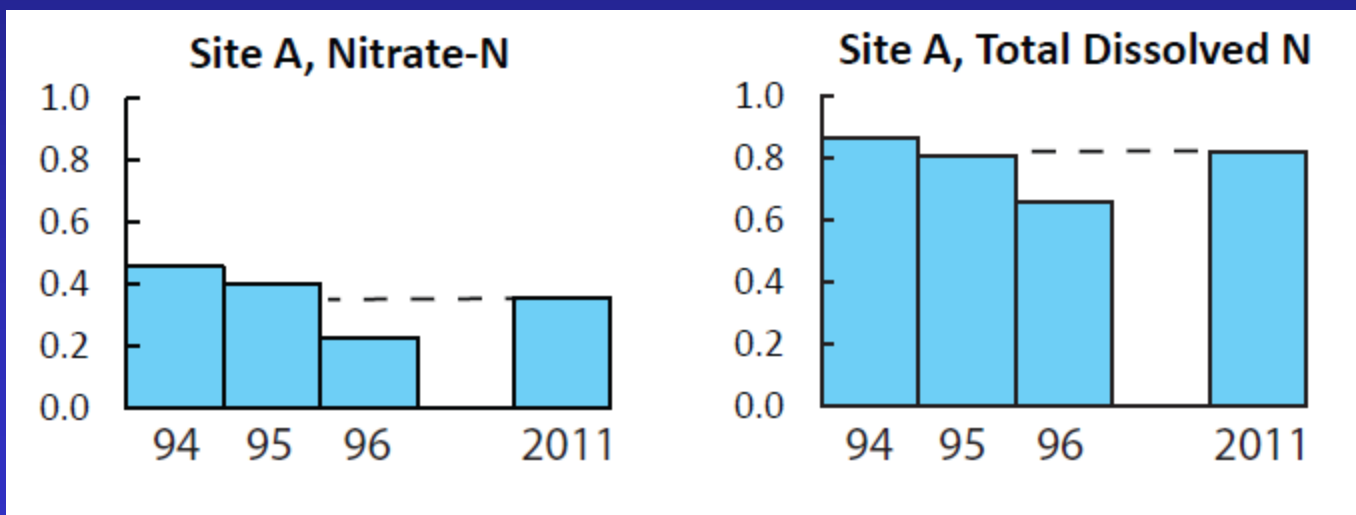
Detailed creek monitoring (seasonal variation)

- Comparison of recent sampling (white line) to mid-1990s sampling (monthly max and min lines, in yellow):



Detailed creek monitoring (annualized comparison)

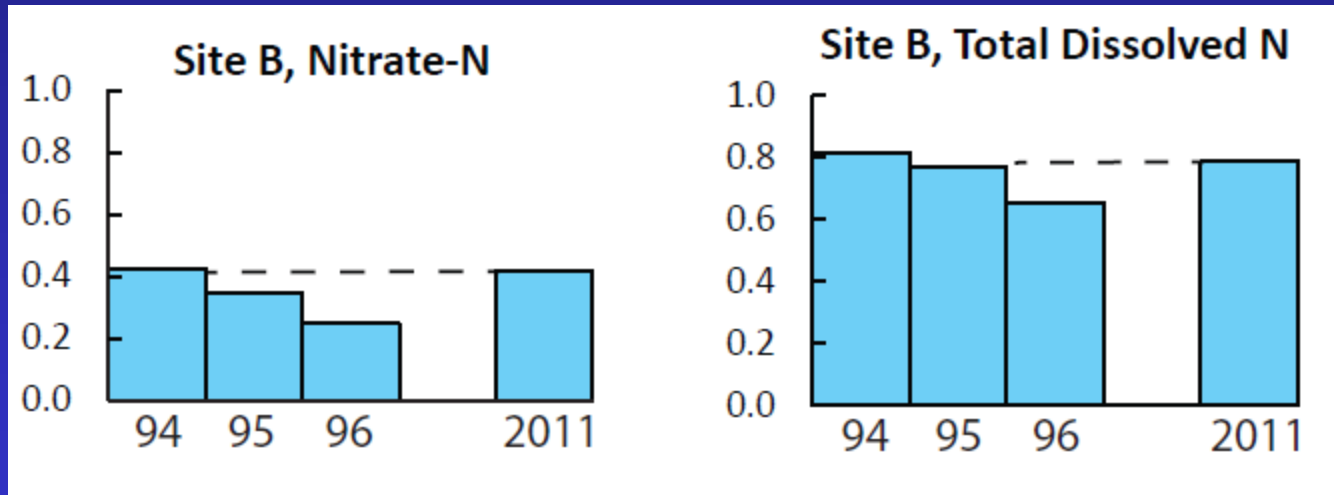
- Comparison of the median of the biweekly samples for 2011 to the medians of the biweekly samples for 1994, 95, and 96, respectively, in mg/L as nitrogen– Site A:



Detailed creek monitoring

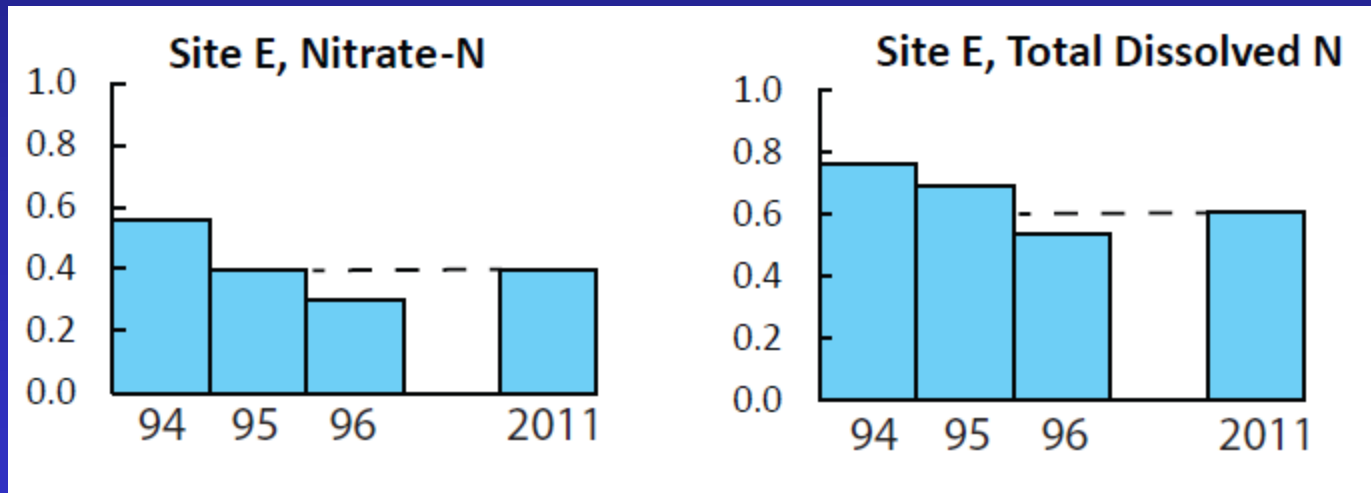
(annualized comparison)

- Comparison of the median of the biweekly samples for 2011 to the medians of the biweekly samples for 1994, 95, and 96, respectively, in mg/L as nitrogen– Site B



Detailed creek monitoring (annualized comparison)

- Comparison of the median of the biweekly samples for 2011 to the medians of the biweekly samples for 1994, 95, and 96, respectively, in mg/L as nitrogen– Site E:



Conclusions: Creek monitoring program

- No detectable increase in 2011 creek nitrogen concentrations, relative to 1994-96 baseline. Possible explanations:
- Natural nitrogen removal in marsh groundwater discharge zones is substantial, relative to N load.
- and/or, size of plume nitrogen load is low, relative to volumes of flood-tidal water and natural gw discharge
- and/or, plume segments are moving beneath inner marsh to downgradient areas.
- These findings pertain to the current N loading conditions, and may change under future loading conditions.

Ebb-tide creek sampling sites, 1994-96 baseline and 2010-11



Final report

Environmental conditions in the Namskaket Marsh Area, Orleans,
Massachusetts: A summary of studies by the U.S. Geological
Survey, 1989–2011

USGS Scientific Investigations Report 2016-5122

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*Prepared in cooperation with the Orleans, Brewster, and Eastham Groundwater
Protection District*

<https://pubs.er.usgs.gov/publication/sir20165122>