Strafford/Rockingham Permeable Reactive Barrier Demonstration Project

Lamprey River Symposium 2015
January 9, 2015

Danna B. Truslow, PG – Truslow Resource Consulting LLC / Rockingham County Conservation District
and
Mark Kelley, PE – Haley & Aldrich, Inc.

Funded in part with Clean Water Act Section 319 funds from the US Environmental Protection Agency

Project Purpose

- To install and test the effectiveness of Permeable Reactive Barriers in the Great Bay Watershed for nitrogen removal
- To develop shallow groundwater quality data adjacent to existing septic systems to determine septic system nitrogen contribution
- **To implement effective nitrogen removal solutions in the Great Bay Watershed as part of the watershed management plan.**

Project Partners

Lead Agencies – Rockingham County Conservation District and Strafford County Conservation District

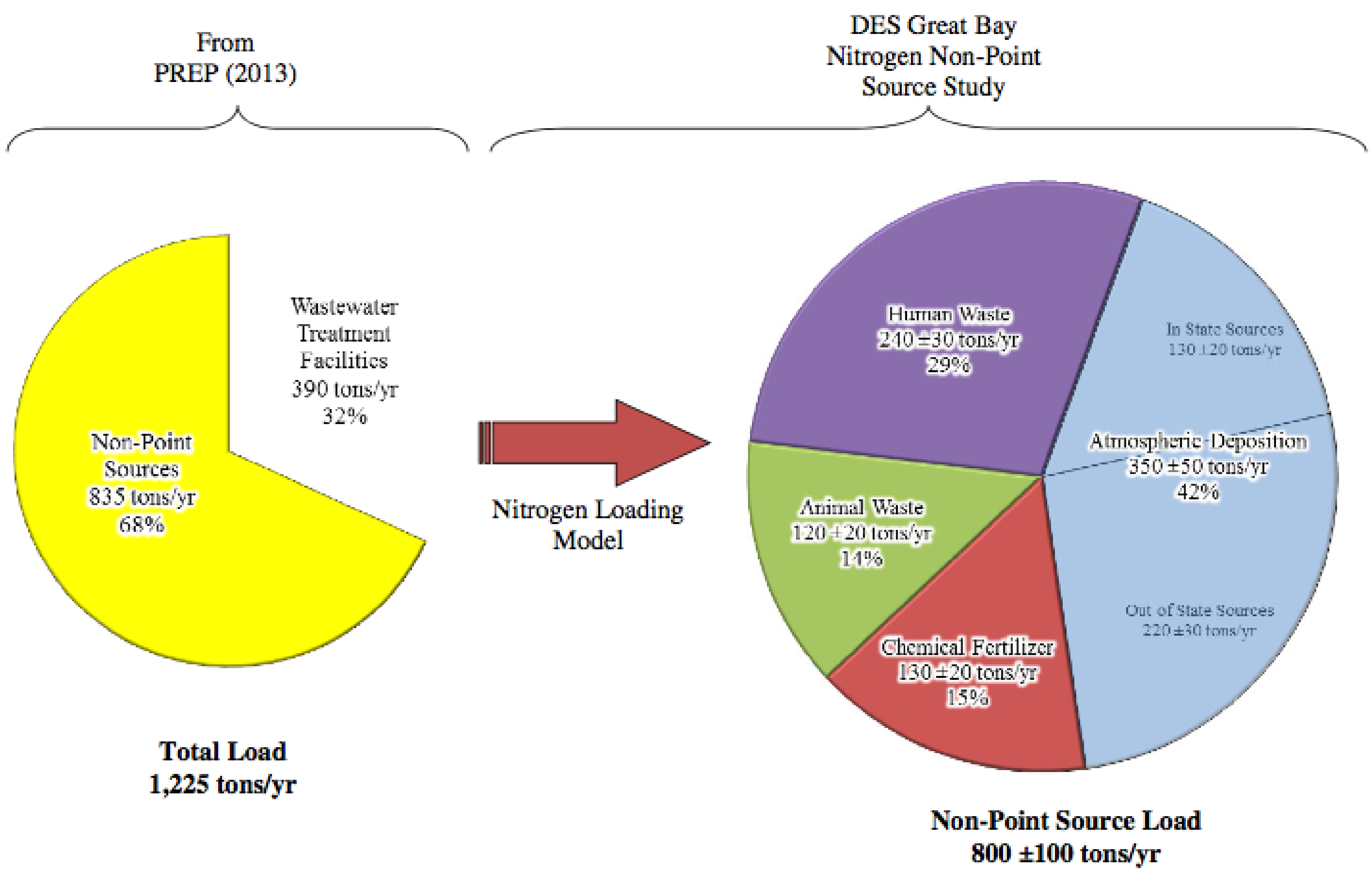
Haley & Aldrich Inc. – Permeable Reactive Barrier Design and Installation

Site Owners – Durham and Brentwood

Towns of Brentwood and Durham – PRB Construction Manpower, Equipment, and Materials

Absolute Resource Associates - Laboratory

Septic Load to Great Bay Watershed – 29% of Non Point Source Load



Source : Trowbridge, et. al., 2014. Great Bay Nitrogen Nonpoint Source Study

What are some measures that can be taken to reduce nitrogen loading from septic systems?

- Regularly maintain systems and pump septic tanks
- For new systems site properly and use nitrate-removing systems
- Control inorganic nitrogen migration from sources through *PRBs and other passive technologies*?

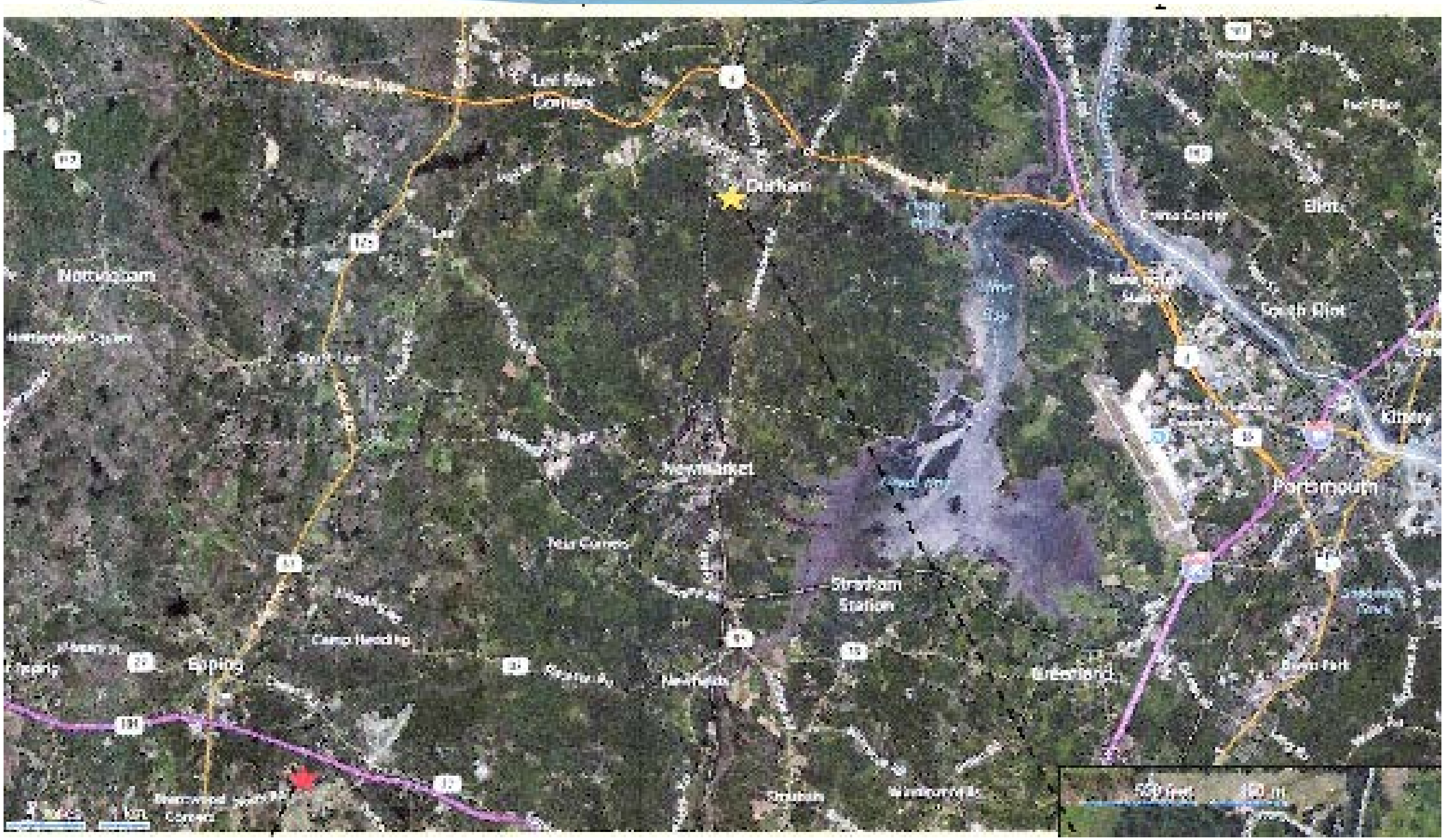
Project Tasks

- Well installation and hydraulic conductivity testing – 2014
- Pre- installation GW and SW design parameter sampling – 2014
- Pre-installation GW and SW baseline monitoring – Year 2014, 2015
- PRB design and installation – 2015
- Post installation monitoring – 2015 and 2016
- Evaluation of effectiveness – 2015 and 2016
- Outreach – 2015 and 2016

Criteria for Project Sites

- Active septic system
- Shallow groundwater
- Nearby surface water
- Sandy overburden underlain by restrictive silt/clay
- Willing landowner
- Accessible site for PRB installation

Project Locations – Durham and Brentwood, NH



Durham Site

- Near Chesley Brook tributary of Oyster River
- Failed septic close to house, new septic 2008
- Glaciomarine sand underlain by silt
- K = 2×10^{-4} to 9×10^{-3} cm/s
- Nitrate 6.2 mg/L at one field-side monitoring well,
- < 1 mg/L at other wells and SW
- Other Water Quality data available on handout

Groundwater Elevations (December 2014)

Legend

- Groundwater Elevation 0.5' Contours
- Hydrography
- Septic System Leach Fields

Rockingham County Conservation District
Strafford County Conservation District
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Durham, NH

NO3-N Concentrations (November 2014)

Legend

Hydrography

Septic System Leach Fields

Rockingham County Conservation District
Strafford County Conservation District
Permeable Reactive Barrier Demonstration Project
Durham, NH

NO3-N Concentrations (December 2014)

Legend

- Hydrography
- Septic System Leach Fields
- Roads
- Groundwater Monitoring Wells (MW)
  Surface Water (SW)

Rockingham County Conservation District
Strafford County Conservation District
Permeable Reactive Barrier Demonstration Project
Durham, NH

Brentwood Site

- Near Dudley Brook, tributary of Exeter River
- Failed bed area in community system
- New area installed in 2009
- Glaciomarine sand with underlying silt
- $K = 1.5 \times 10^{-4}$ to 3.6×10^{-4} cm/s
- Nitrate 12 to 42 mg/L at wells
- < 1 mg/L in SW
- Other Water Quality data available on handout

Groundwater Elevations (December 2014)

Legend

- Groundwater Elevation 2' Contours
- Hydrography
- Septic System Leach Fields
- Roads
- Monitoring Wells (MW)

Rockingham County Conservation District
Strafford County Conservation District
Permeable Reactive Barrier Demonstration Project
Brentwood, NH

NO3-N Concentrations (November 2014)

Legend

- NO3-N Concentration Contours (10 mg/L) - Nov. 2014
- Hydrography
- Septic System Leach Fields
- Roads
- Monitoring Wells (MW) Surface Water (SW)

Rockingham County Conservation District
Strafford County Conservation District
Permeable Reactive Barrier Demonstration Project
Brentwood, NH

NO3-N Concentrations (December 2014)

Legend

- NO3-N Concentration Contours (10mg/L) - Dec. 2014
- Hydrography
- Roads
- Septic System Leach Fields
- Monitoring Wells (MW) Surface Water (SW)

Rockingham County Conservation District
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Brentwood, NH

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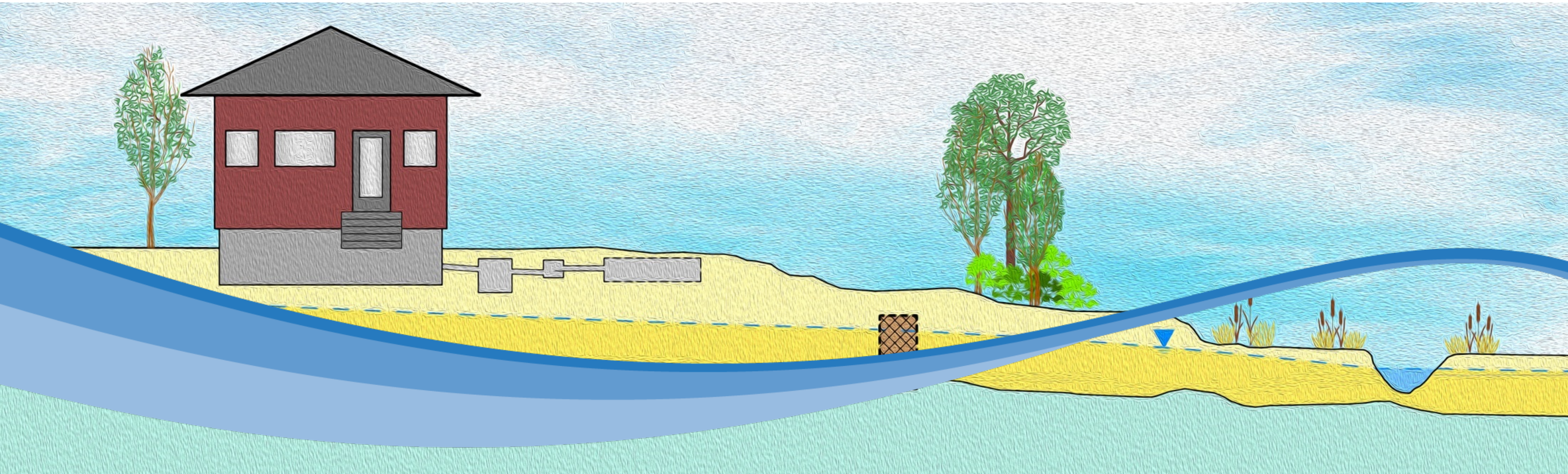
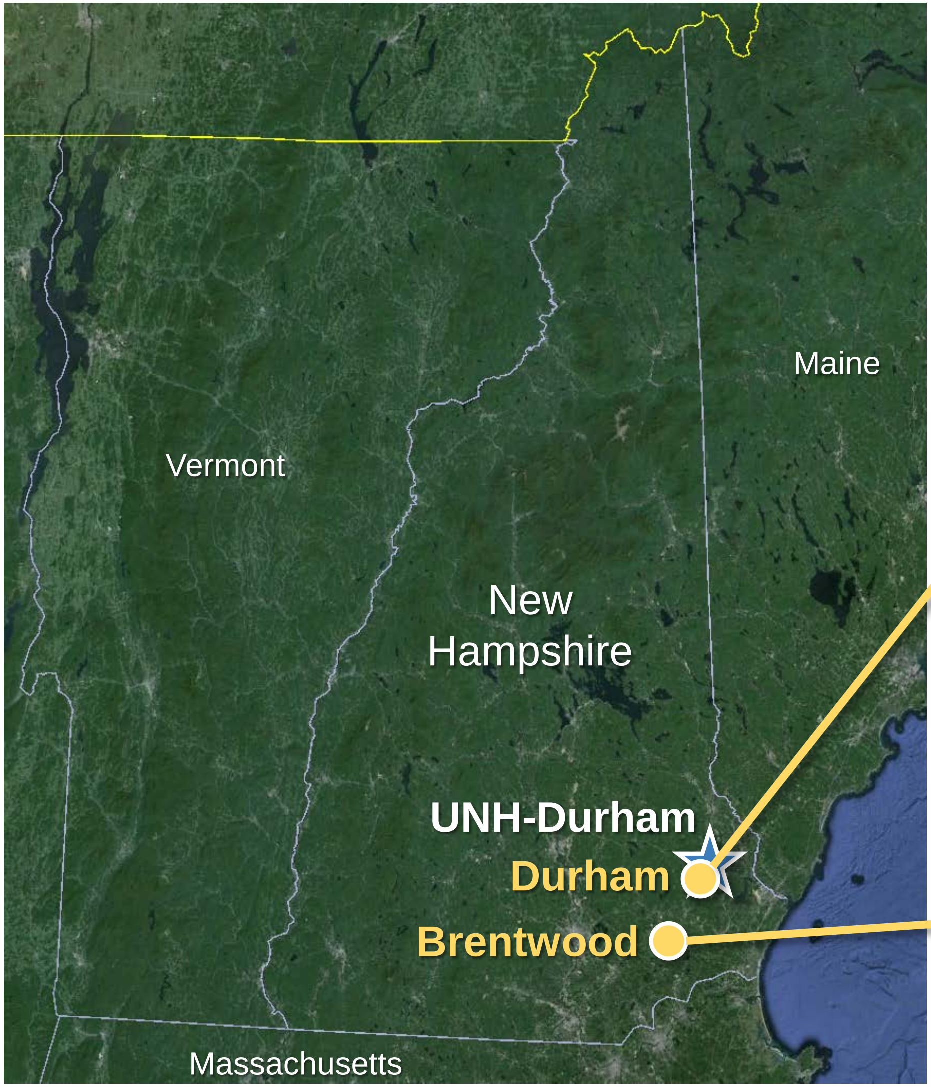
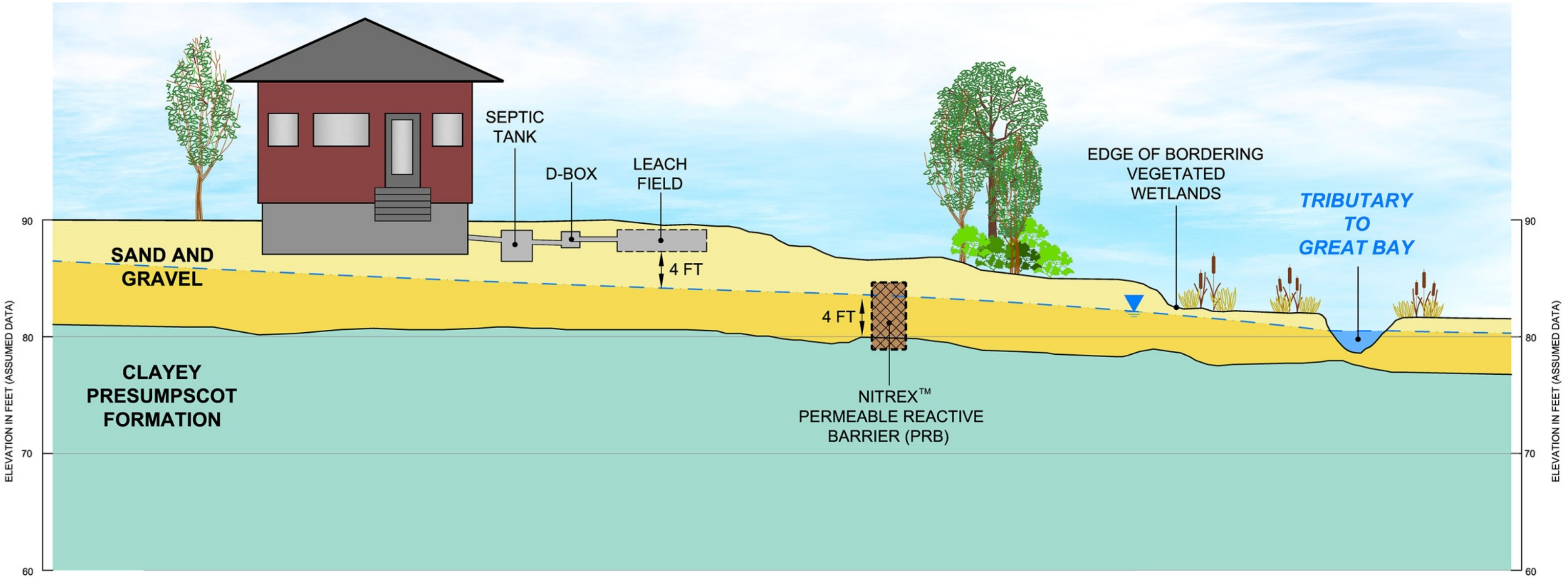


Site Locations



Permeable Reactive Barrier (PRB) Demonstration: Showing Nitrate Removal Using PRB



SITE DESIGNATION	LENGTH OF NITREX™ PRB	DEPTH OF NITREX™ PRB
RESIDENTIAL SYSTEM (600 GPD ±) DURHAM, NH	40 FT	6 FT
COMMUNITY SYSTEM (8,000 GPD ±) BRENTWOOD, NH	100 FT	8 FT

NOTES:

1. ASSUME DEPTH IS 1 FT INTO CLAY AND 1 FT ABOVE TYPICAL GROUNDWATER DEPTH.
2. TYPICAL NITREX PRB WIDTH TO BE 6 FT.

PRB Demonstrations Projects

- 2 PRBs installed in Waquoit Bay, Massachusetts in July 2005
- 2 PRBs proposed in Durham and Brentwood, New Hampshire
- Many additional site at University of Waterloo, Canada

Long-Term Performance of In Situ Reactive Barriers for Nitrate Remediation

by W.D. Robertson[a], D.W. Blowes[a], C.J. Ptacek[a], and J.A. Cherry[a]

Abstract

Nitrate is now recognized as a widespread ground water contaminant, which has led to increased efforts to control and mitigate its impacts. This study reports on the long-term performance of four pilot-scale field trials in which reactive porous barriers were used to provide passive in situ treatment of nitrate in ground water. At two of the sites (Killarney and Borden), the reactive barriers were installed as horizontal layers underneath septic system infiltration beds; at a third site (Long Point), a barrier was installed as a vertical wall intercepting a horizontally migrating septic system plume; and at the fourth site (North Campus), a barrier was installed as a containerized subsurface reactor treating farm field drainage water. The reactive media consisted of 15% to 100% by volume of waste cellulose solids (wood mulch, sawdust, leaf compost), which provided a carbon source for heterotrophic denitrification. The field trials have been in semicontinuous operation for six to seven years at hydraulic loading rates ranging from six to 2000 L/day. Trials have been successful in attenuating influent NO_3^- (or $NO_3^- + NH_4^+$ at Borden) concentrations averaging from 4.8 mg/L N at North Campus to 57 mg/L N at Killarney, by amounts averaging 80% at Killarney, 74% at Borden, 91% at Long Point, and 58% at North Campus. Nitrate consumption rates were temperature dependent and ranged from 0.7 to 32 mg L N/day, but did not deteriorate over the monitoring period. Furthermore, mass-balance calculations indicate that carbon consumption by heterotrophic denitrification has so far used only about 2% to 3% of the initial carbon mass in each case. Results suggest that such barriers should be capable of providing NO_3^- treatment for at least a decade or longer without carbon replenishment.

Reactive barriers have now been used to treat nitrate contamination from a variety of sources including septic systems, agricultural runoff, landfill leachate, and industrial operations. This demonstration of successful long-term operation should allow this technology to become more widely considered for nitrate remediation, particularly at sites where passive treatment requiring a minimum of maintenance is desired.

Wood Chip Bioreactors

- Low-cost carbon source for denitrification
- In-stream reactors and shallow subsurface reactive barriers are simple to install and maintain

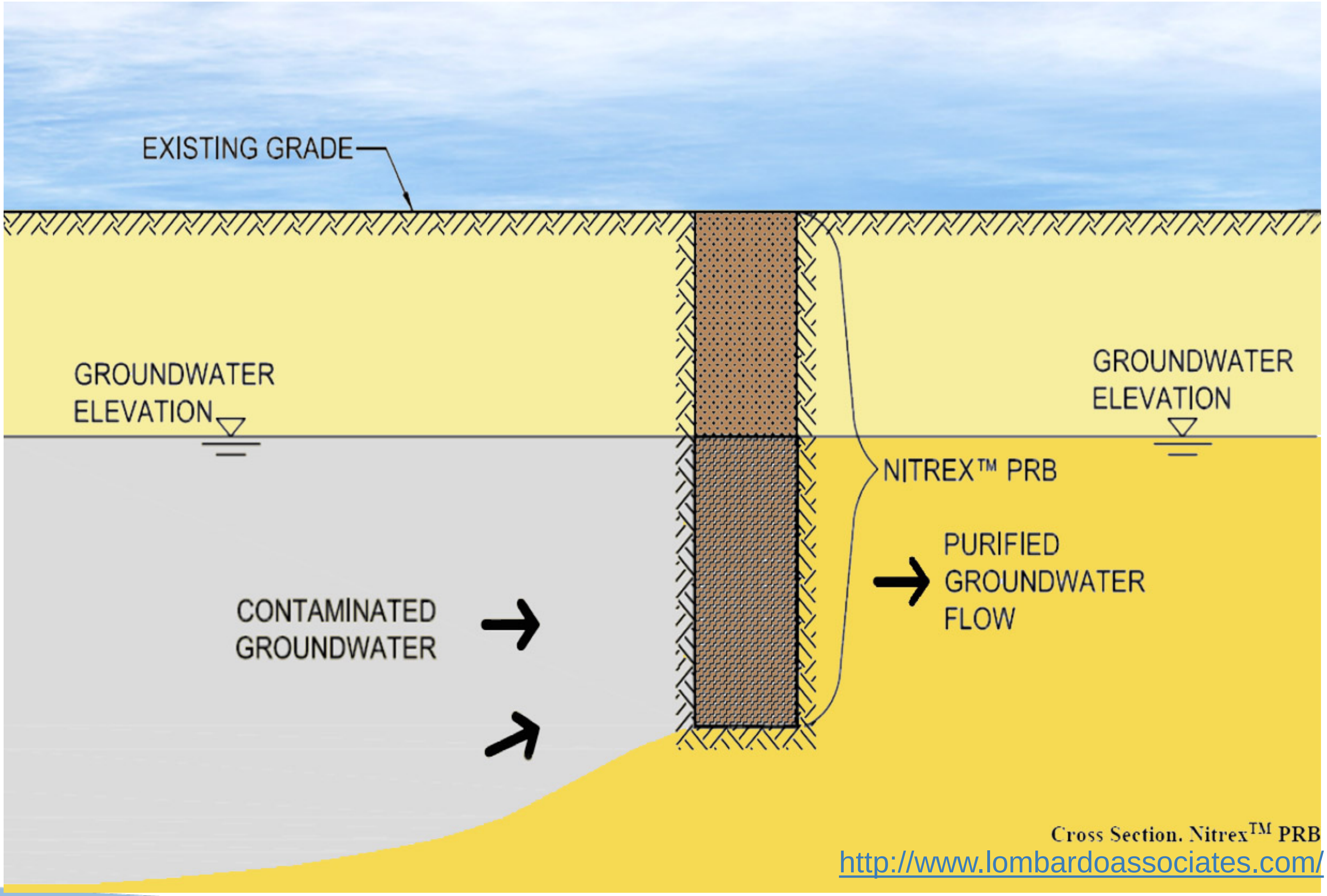
$$C + N0_3 \Rightarrow N^2$$

(Carbon + nitrate) ⇒ (nitrogen gas)

(Dr. Will Robertson, U. Waterloo, Canada)
wroberts@sciborg.uwaterloo.ca

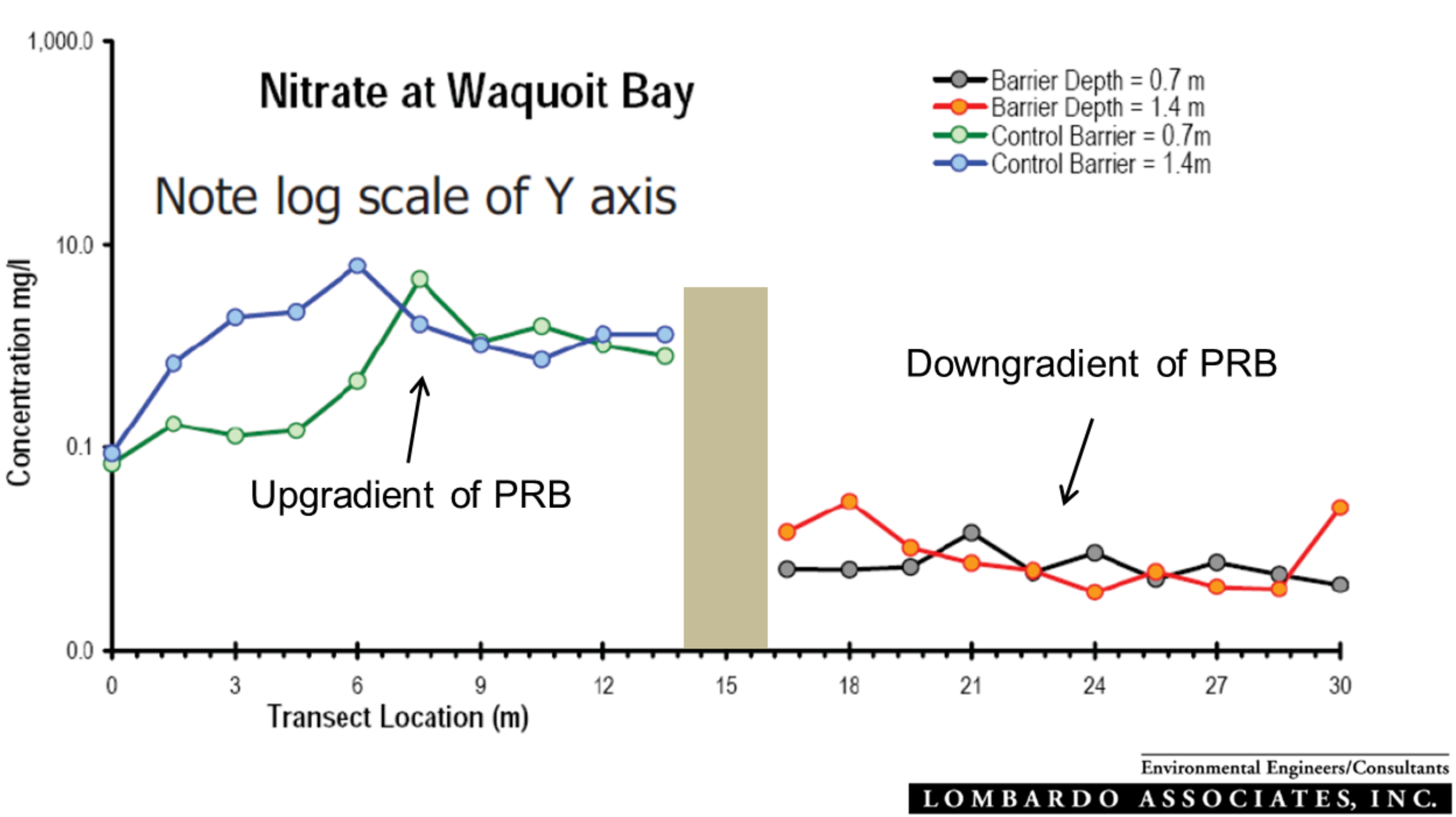
1, 2 and 8-yr-old woodchips

Bioreactor for Treating Nitrate in Shallow Groundwater



http://www.lombardoassociates.com/

Groundwater Quality at Waquoit Bay Data Collected by Woods Hole MBL



Design Challenges

Durham:

Low transmissivity (shallow groundwater with small saturated thickness) and fluctuating groundwater table

Brentwood:

Radial flow away from raised leaching fields – for demonstration of PRB a finite trench will be designed

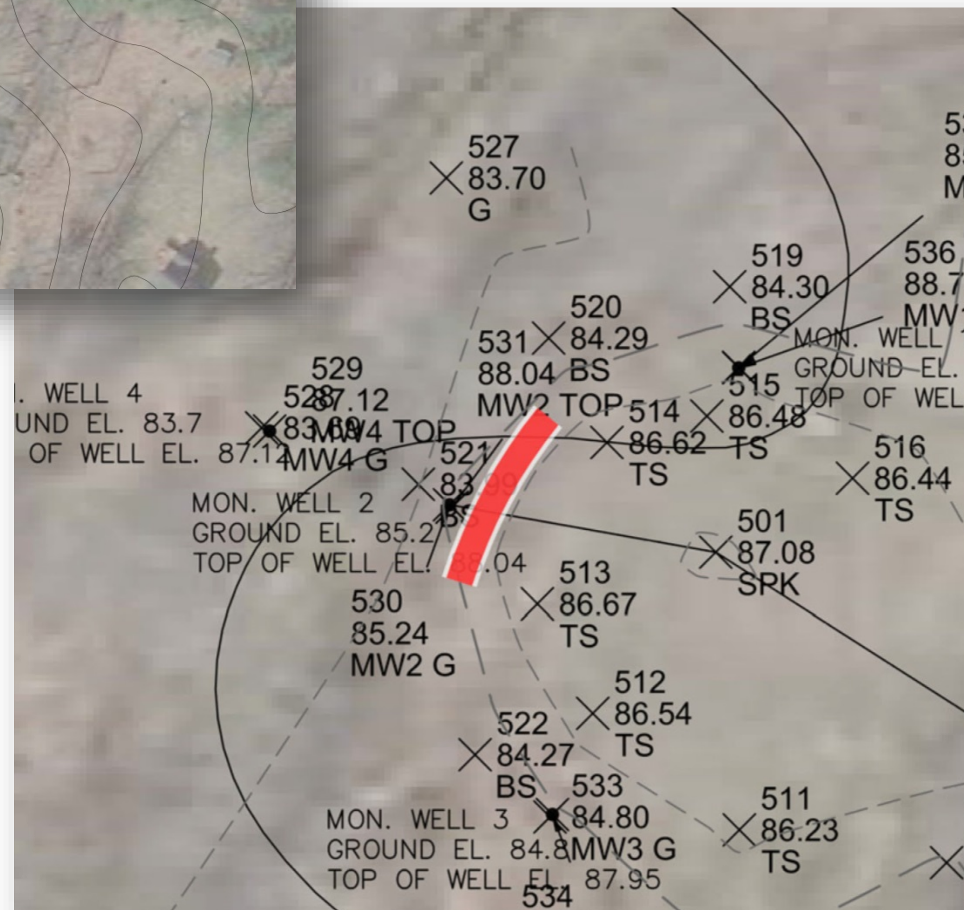
PRB Design Parameters

- **Understanding of Site Hydrogeology:**
  Groundwater velocity about 0.1 ft/day at both sites (Hydraulic conductivity is about 4 x 10-4 cm/sec)
- **PRB Residence time:**
  Function of removal goal: Published Values range from 0.7 to 32 mg/L N/day
- **Width and Depth of PRB:**
  Width is determined by specified PRB residence time, and depth by site specific geology

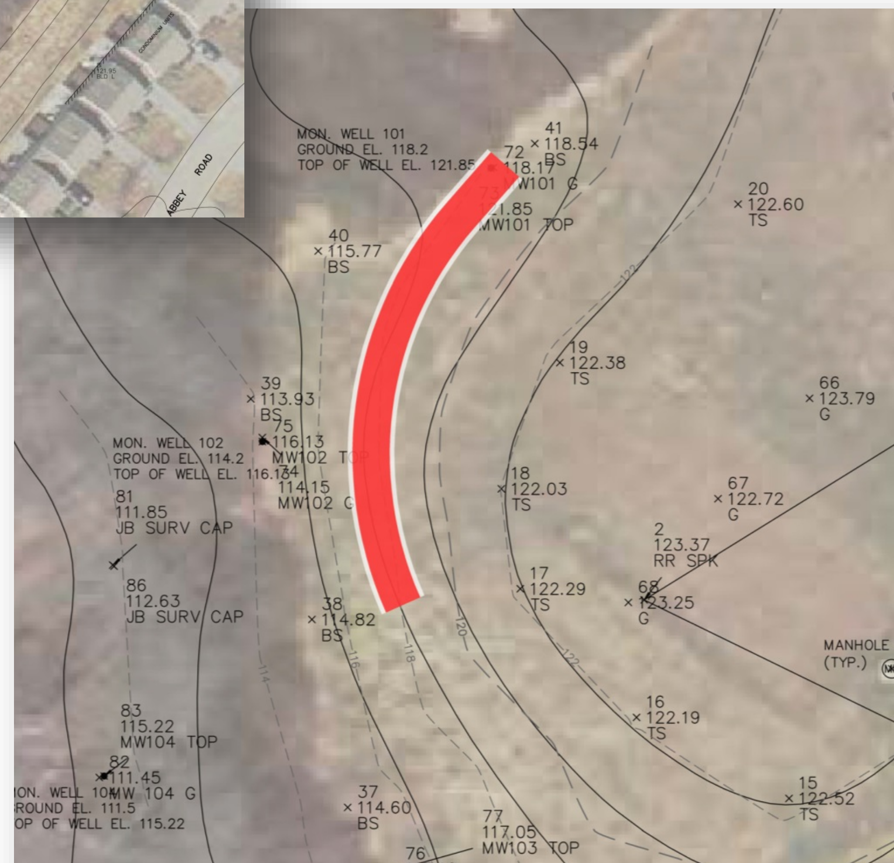
Conceptual PRB Designs

- **Design Parameter:** 2 mg/L N/day Removal
- **Residence time of 10 days:**
  PRB Hydraulic Conductivity will need to be about 1x10-3 cm/sec (GW velocity of 0.3 ft/day)
- **Width of PRB** = 3 to 4 ft.
- **Depth:** Durham = 5 ft.
  Brentwood = 8 ft.
- **Length:** Durham = 40 ft.
  Brentwood = 100 ft.

Durham
PRB = 40Ft x 3Ft x 6Ft (Deep)



Brentwood
PRB = 100Ft x 4Ft x 8Ft (Deep)



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Questions?

ROCKINGHAM COUNTY CONSERVATION DISTRICT

STRAFFORD COUNTY CONSERVATION DISTRICT

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

Truslow RESOURCE CONSULTING LLC

HALEY & ALDRICH