

Nitrogen Management on Cape Cod: Potential for Green Infrastructure

The Problem

The bays and estuarine environments of Cape Cod, Massachusetts, receive more nitrogen than what the waters can naturally assimilate. This excess load has led to eutrophication and degraded water habitats, resulting in the loss of eel grass beds and shellfish growing areas. Nitrogen loading to Cape Cod's watersheds must be reduced in order to restore ecological health.

The Approach

The Cape Cod Commission has developed the 208 Plan to mitigate this nitrogen loading using a variety of green infrastructure technologies. Although these green technologies have somewhat broad ranges of performance, they are significantly less expensive than traditional sewerage in most cases.

The Project Goals

Tufts University graduate students in the Water: Systems, Science, & Society (WSSS) program are designing a Green Infrastructure Guide to provide accessible opportunities (both online and in the field) for stakeholders and the public to learn about these technologies and the unique benefits they offer.

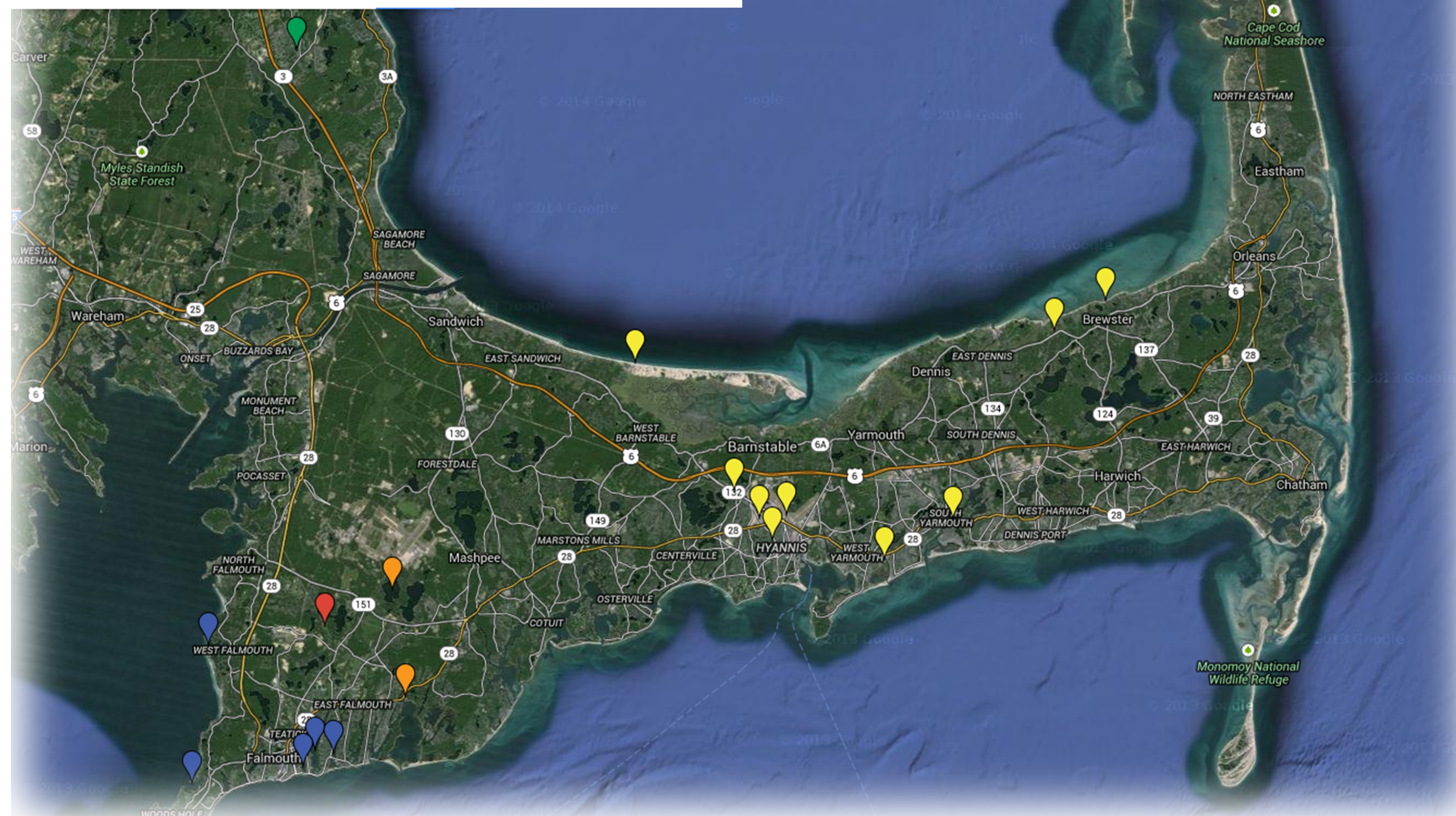
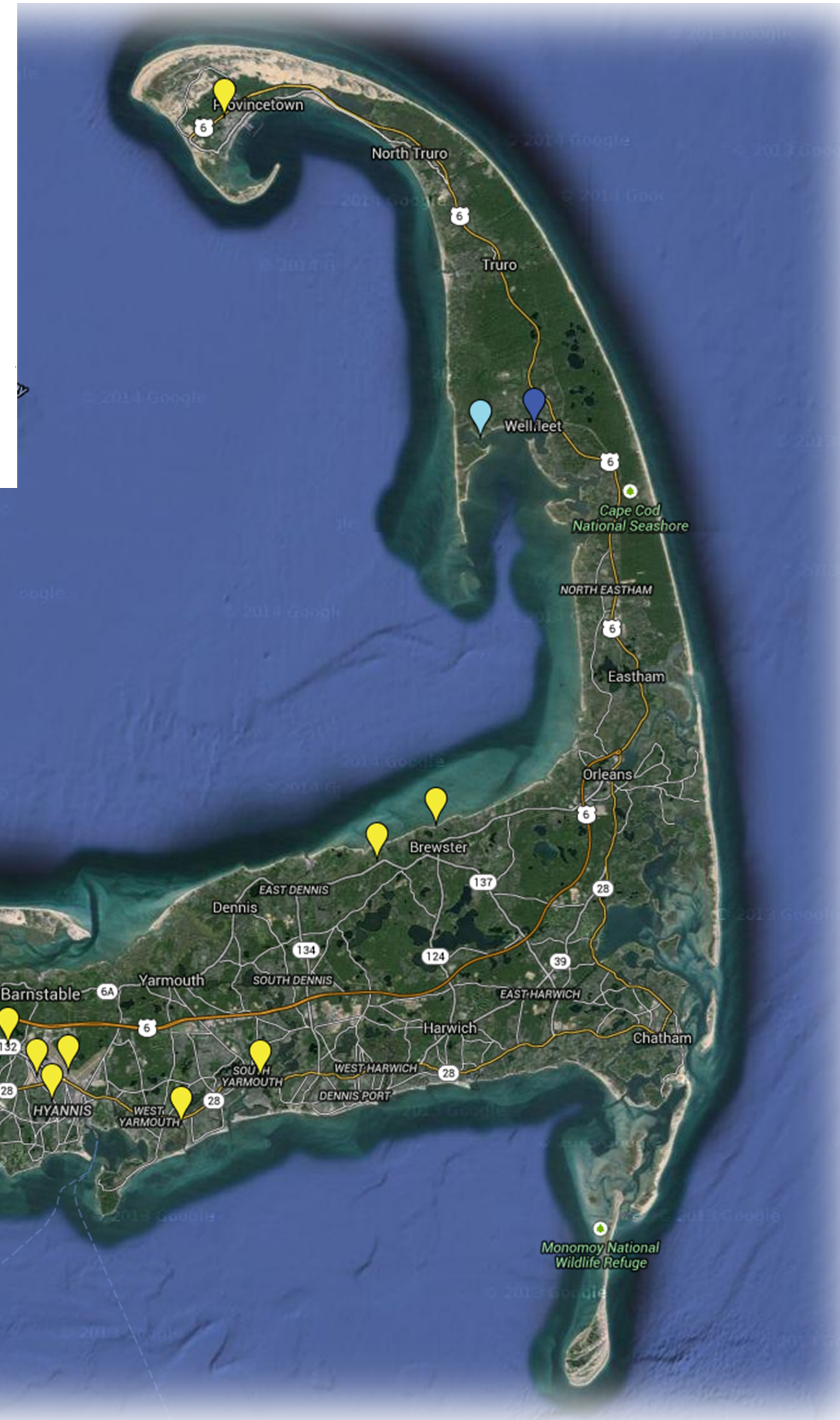
This Green Infrastructure Guide will provide state-of-the-art information about the technologies recommended in the 208 Plan – how they work, performance data, and costs – in addition to information that distinguish these green infrastructure technologies from conventional, hard or "grey" infrastructure solutions. It will also identify sites where technologies have been installed and can be viewed, proposed sites on Cape Cod, and local experts who can provide further information.

The Guide will be available in multiple formats, including a brochure and a website, and will contain multimedia explanations of each technology.



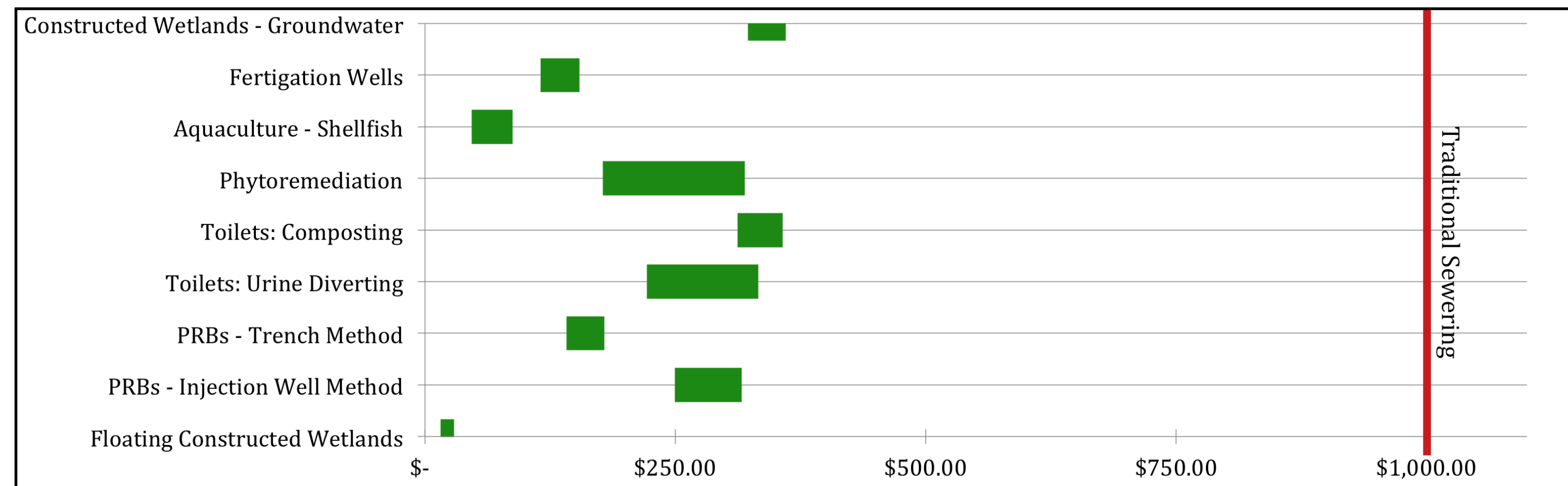
Green Infrastructure Sites on Cape Cod

- ◆ Pinehills Golf Club
- ◆ Wellfleet Oyster Farm
- ◆ Little Pond
- ◆ West Falmouth Harbor
- ◆ Green Pond
- ◆ Quissett Harbor
- ◆ The Green Center
- ◆ Ashumet Pond
- ◆ Waquoit Bay National Estuarine...
- ◆ Herring River Restoration Pr...
- ◆ Hyannis Wastewater Treatm...
- ◆ Cape Cod Museum Of Natur...
- ◆ Former Drive In Theater
- ◆ Barnstable Elementary School
- ◆ Barnstable Municipal Airport
- ◆ Bass River Park
- ◆ Sandy Neck Beach Park
- ◆ Breakwater Beach Park
- ◆ SHALLOW POND PROFESSI...
- ◆ 90 Shank Painter Rd
- ◆ Great Pond



Map of Cape Cod, Massachusetts, demonstrating sites of green infrastructure. Sites are color-coded by technology. The upper left corner lists some of the site names. Information compiled by students working on the project with help from experts on each technology in the cape.

Nitrogen Removal Cost-efficiency Estimates (\$/kg) of Green Infrastructure

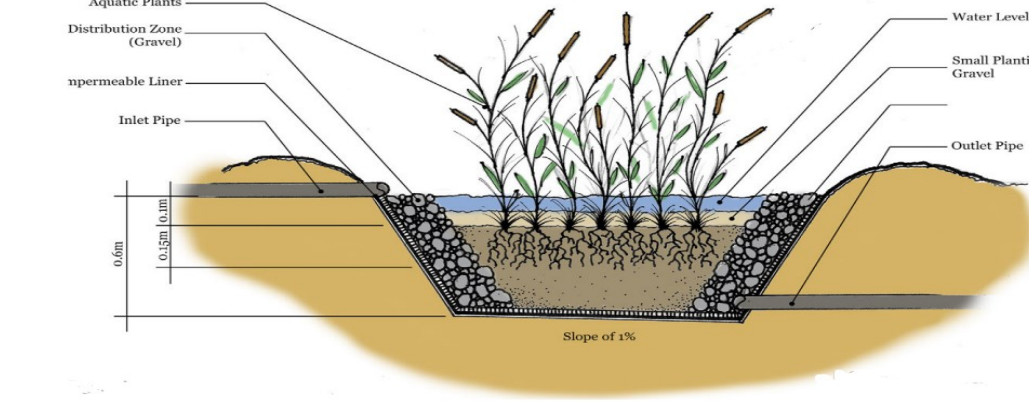


Graph compares the estimated range of cost for each technology per kilogram (\$/kg) of nitrogen removed, based upon reported variable performance data. The red line represents an estimate for the average cost of conventional sewerage derived from updated data from the 2010 "Comparison of Costs for Wastewater Management Systems Applicable to Cape Cod."

Floating & Constructed Wetlands

Floating and constructed wetlands are artificial wetlands created in coastal areas to remove contaminants from water

- ✓ **Benefits and Opportunities:**
 - ✓ Can remove up to 95% of Nitrogen
 - ✓ Provides natural habitat for both aquatic and terrestrial life
 - ✓ Are relatively quick and easy to construct
- ✓ **Potential Sites:**
 - ✓ Cranberry bogs
 - ✓ Public parks, and other public land
 - ✓ Along bays, ponds, and other bodies of water



Fertigation Wells

Fertigation wells capture nutrient-rich groundwater and redistributes it on turf and other lands as fertilizer

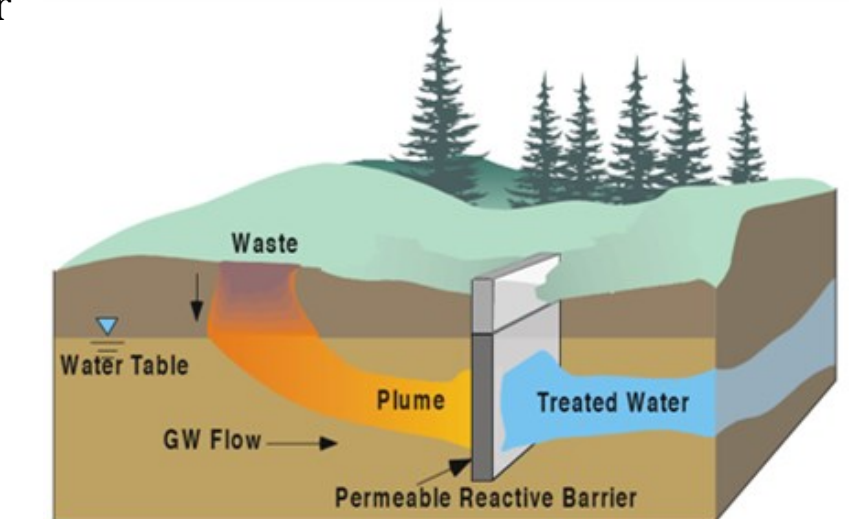
- ✓ **Benefits and Opportunities:**
 - ✓ Can remove up to 80% of Nitrogen
 - ✓ Reduces nutrient loads
 - ✓ Decreases fertilizer costs and applications to irrigated land
- ✓ **Potential Sites:**
 - ✓ Golf courses, and other recreational green spaces
 - ✓ Agricultural lands, like cranberry bogs
 - ✓ Lawns



Permeable Reactive Barriers (PRBs)

PRBs are walls that use carbon sources and microbes to remove nitrogen from contaminated groundwater

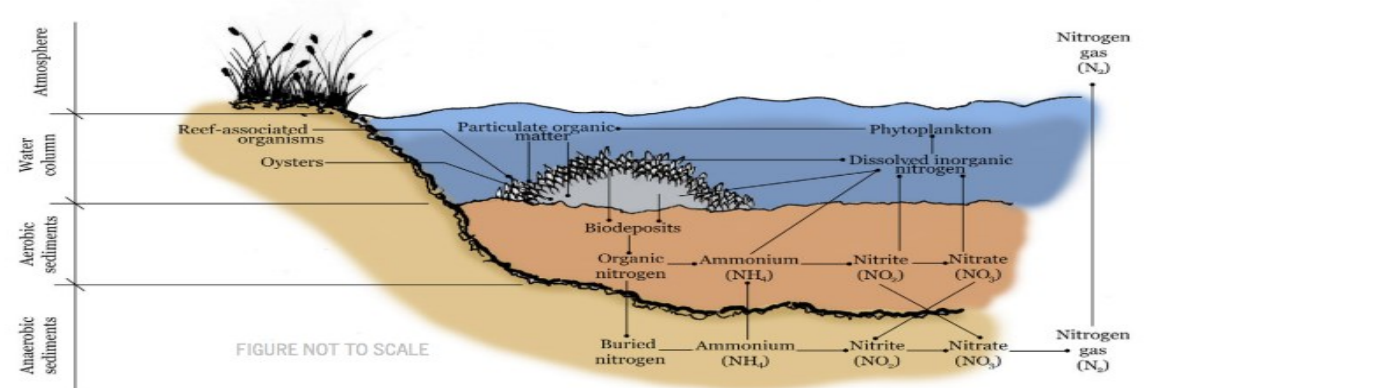
- ✓ **Benefits and Opportunities:**
 - ✓ Can remove up to 95% of Nitrogen
 - ✓ Low operation and maintenance costs
 - ✓ Relatively long lifespan – effective for up to 20 years
- ✓ **Potential Sites:**
 - ✓ Areas with high groundwater nitrogen concentration



Aquaculture: Shellfish

Aquaculture uses mature oysters and other shellfish to remove nitrogen from estuaries and incorporates it into the organism or processes it in the sediments.

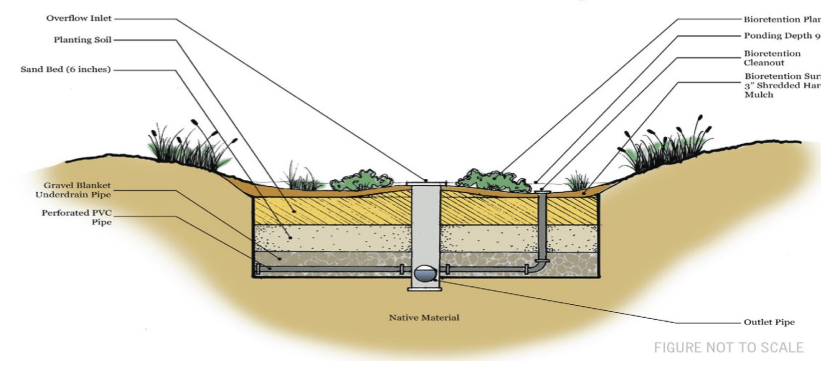
- ✓ **Benefits and Opportunities:**
 - ✓ One oyster can filter 20 to 30 gallons of water per day
 - ✓ Provide ecosystem benefits, like promotion of native eel grass
 - ✓ Improvement of local economy
- ✓ **Potential Sites:**
 - ✓ Coastal estuary communities with good water movement



Stormwater Bioretention

Stormwater bioretention uses a graded treatment area of grass buffers, sand, ponding area, mulch layer, and plants to filter water as it collects

- ✓ **Benefits and Opportunities:**
 - ✓ Can remove up to 75% of Nitrogen
 - ✓ Are easy to include in smaller areas, like parking lot islands
 - ✓ Can also control flooding, provide habitat, and act as a windbreak
- ✓ **Potential Sites:**
 - ✓ In parking areas of industrial and commercial properties
 - ✓ Along sidewalks
 - ✓ Residential areas, called 'rain gardens'



Phytoremediation

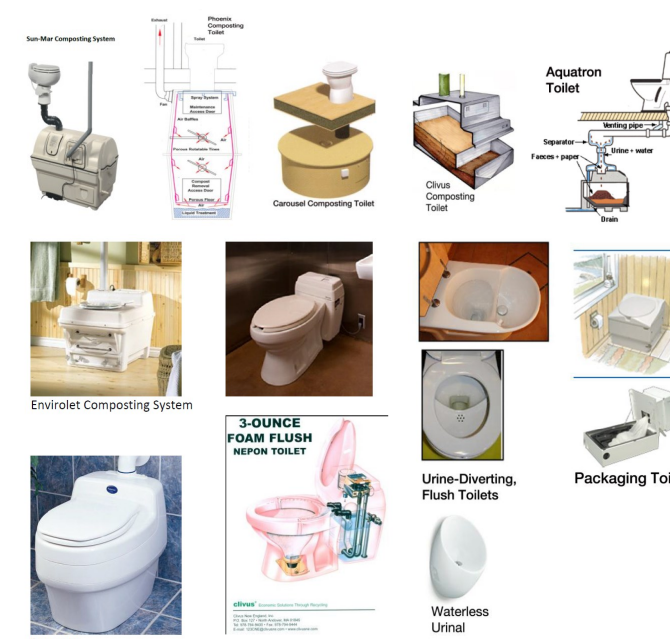
Phytoremediation uses microbes and plants in the root zone to intercept nitrogen-rich groundwater and filter it

- ✓ **Benefits and Opportunities:**
 - ✓ Can remove up to 90% of Nitrogen
 - ✓ Also reduces erosion and runoff by providing stability to soil
 - ✓ Aesthetically pleasing and self sufficient
- ✓ **Potential Sites:**
 - ✓ Public parks
 - ✓ Brownfields
 - ✓ Residential lawns



Eco-Toilets

The term "eco-toilet" broadly refers to any toilet designed to minimize contamination of clean water, such as urine diversion and composting toilets



- ✓ **Benefits and Opportunities:**
 - ✓ Can remove up to 80% of Nitrogen before it enters the watershed
 - ✓ Reduces water usage and costs
 - ✓ Urine can be processed to produce fertilizers
- ✓ **Potential Sites:**
 - ✓ Urinals
 - ✓ Public restrooms
 - ✓ Residential houses

An incentive program in the town of Falmouth provides up to \$5,000 in subsidies for home eco-toilet installation!