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Groundwater, Out of Sight, Out of Mind?

Florida Stormwater Association

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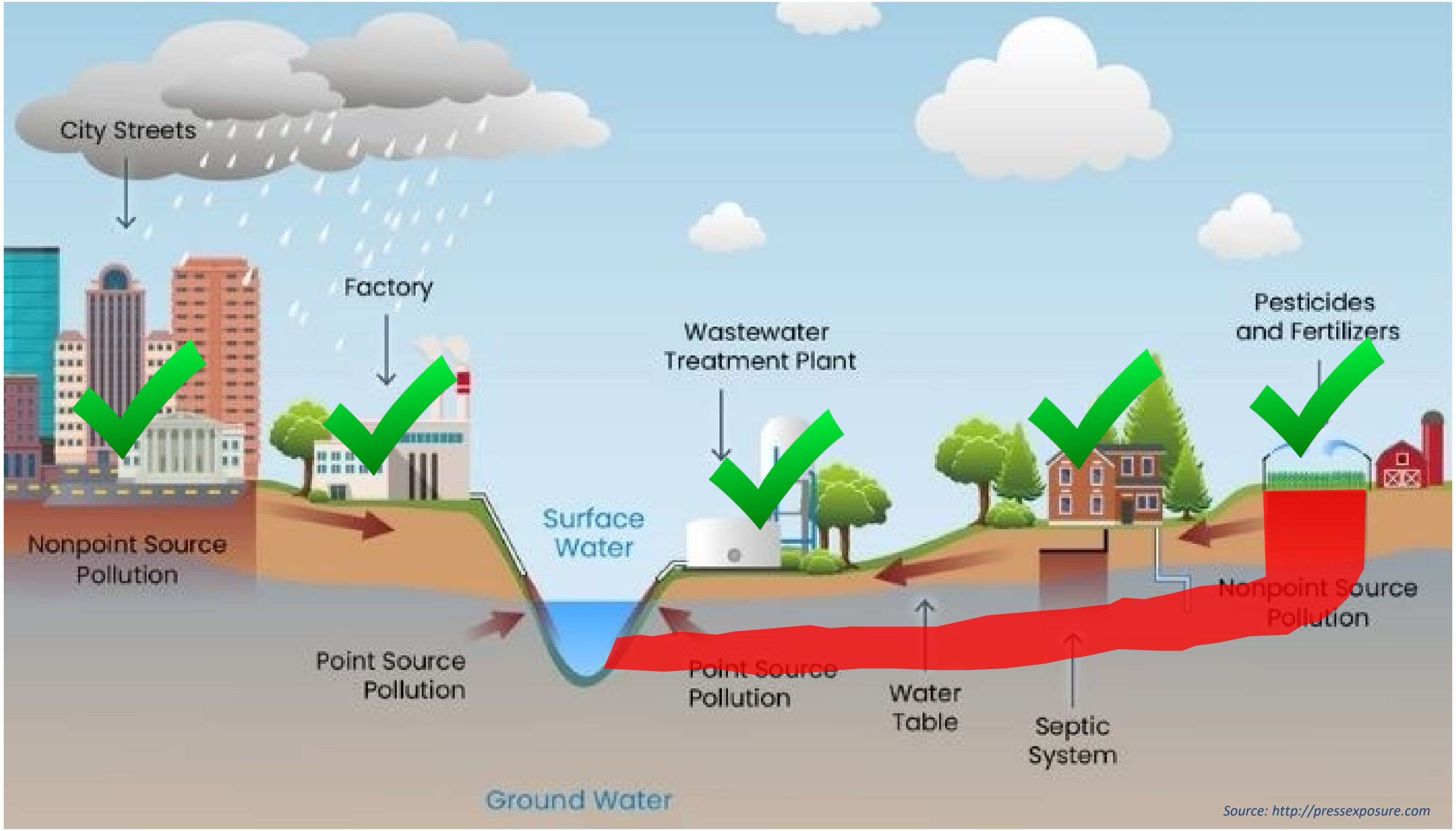
Presentation Outline

- What is the issue and who is affected?
- What is the role of groundwater in addressing our water quality compliance goals?
- How can we assess the nature and extent of nutrients in groundwater?
- What treatment techniques are available to address nutrient issues in groundwater?
- Case Studies

What is the Issue?



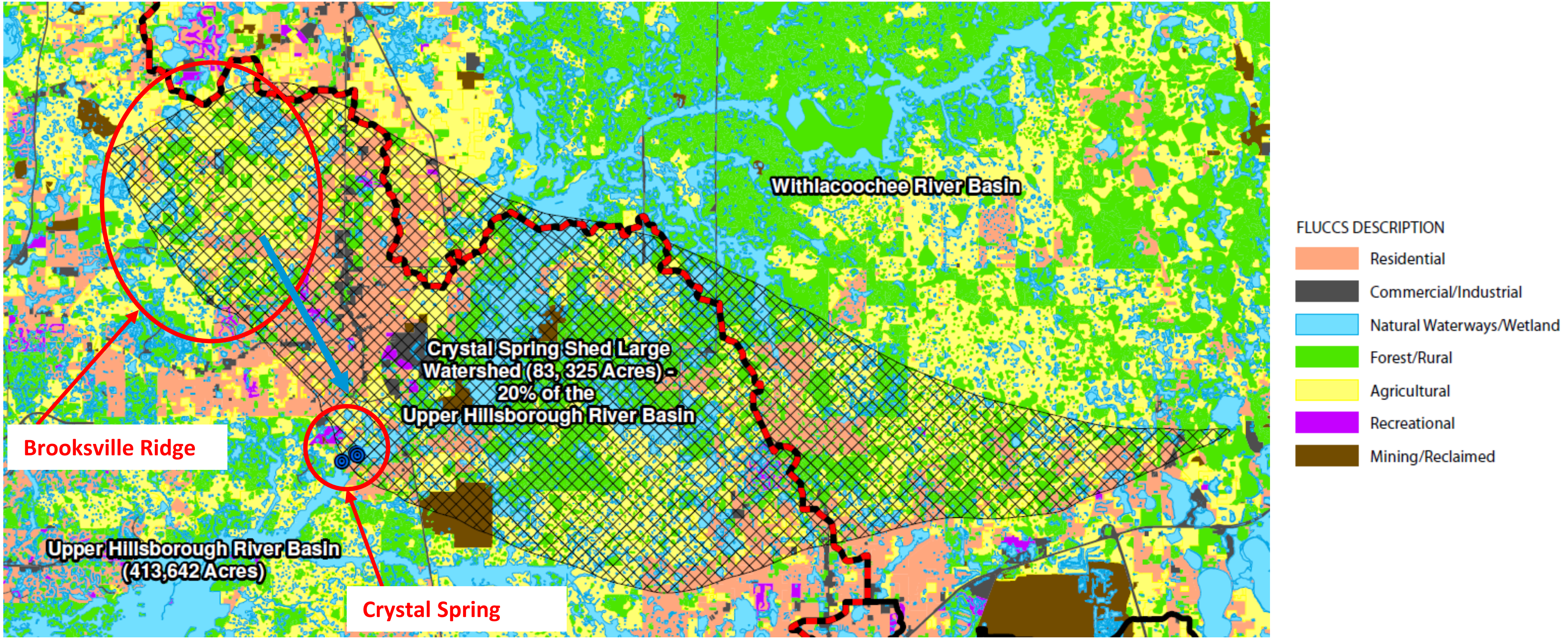
Source: http://pressexposure.com

Who is affected?

If your jurisdiction includes any of the land uses below and if you have water quality targets outlined in a Basin Management Action Plan (BMAP):

- Active and closed landfills
- Agricultural operation areas
- Biosolids application areas
- Wastewater effluent application/discharge areas
- Septic tanks
- Industrial/manufacturing (agrichemical, food/beverage, specialty chemical) facility discharge

Example of Continuing Groundwater Source



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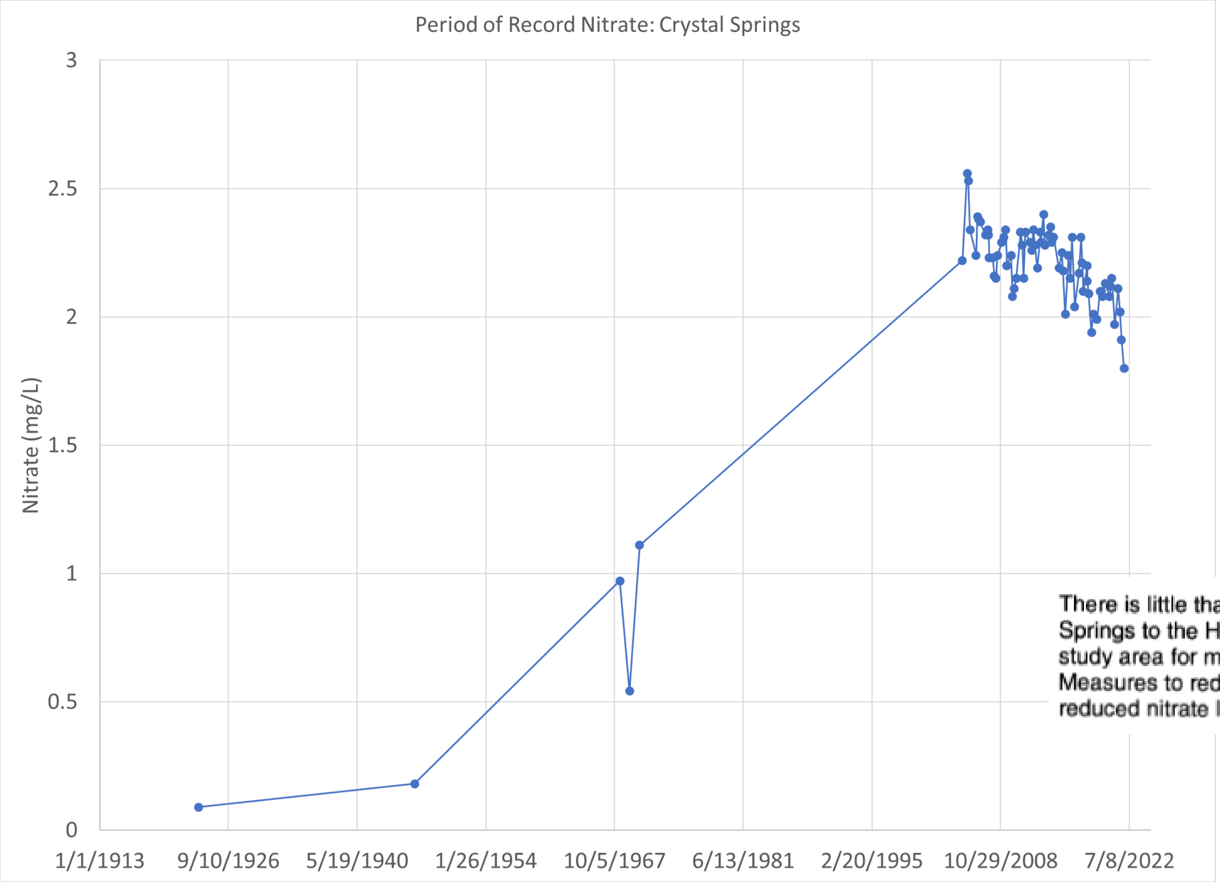


There is little that can be done to reduce present nitrogen loading from Crystal Springs to the Hillsborough River because nitrogen has been applied to the study area for many years and is now entrained in the ground-water flow system. Measures to reduce nitrate loading in the recharge area may not result in reduced nitrate levels in the springs for a decade or longer.

How can we assess the nature and extent of nutrients in groundwater?

Several technologies are used to evaluate groundwater flow patterns and nutrient concentrations.

- Groundwater profiling using several techniques based on lithology:
  - Unconsolidated soils (sands/silts clays): direct push technology (DPT) drilling methods
  - Consolidated/lithified rock (limestone): sonic drilling methods

DPT Drilling and Sampling

DPT drilling allows for:

- Ideal for unconsolidated conditions only
- Collection of continuous soil samples
- Collection of high-resolution grab groundwater quality samples
- Discrete sampling intervals can be selected based upon the lithology observed
- Permanent well install

Sonic Drilling and Sampling

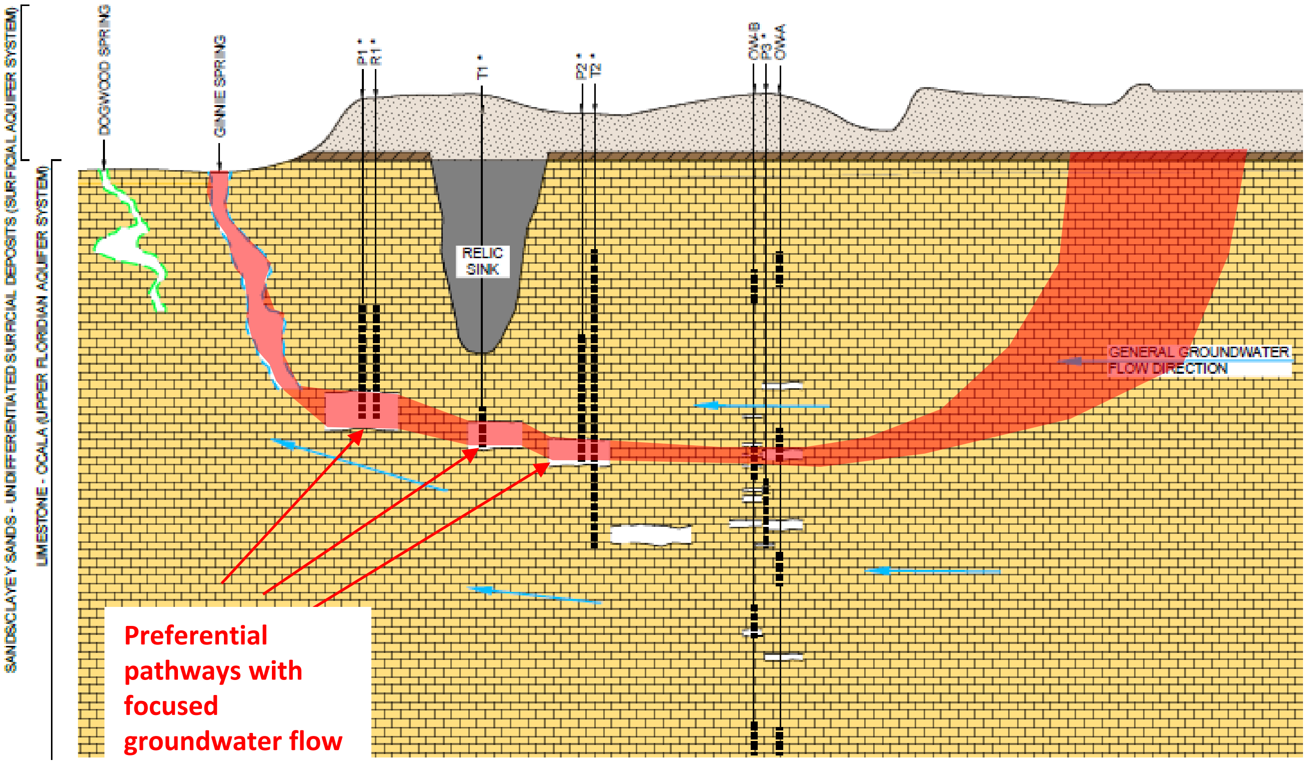
Sonic drilling allows for:

- Ideal for unconsolidated or lithified rock conditions
- Collection of continuous soil samples
- Pumping of discrete intervals to obtain water quality samples and to assess aquifer permeability
- Permanent well install in intervals of interest where aquifer permeability is high and elevated nutrient results are observed

Nutrient Groundwater Assessment

Objectives:

- Document the nature and extent of nutrients in groundwater;
- Identify level of heterogeneity present and locate primary flow paths; and
- Calculate the groundwater and nutrient flux



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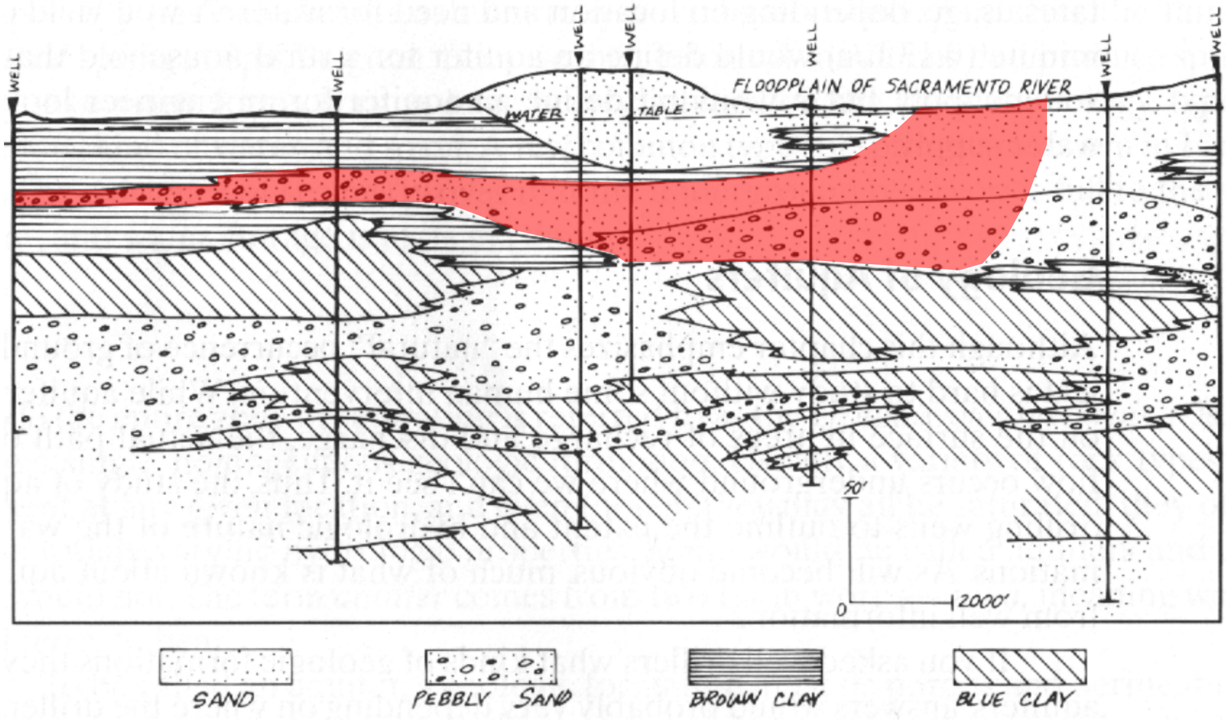


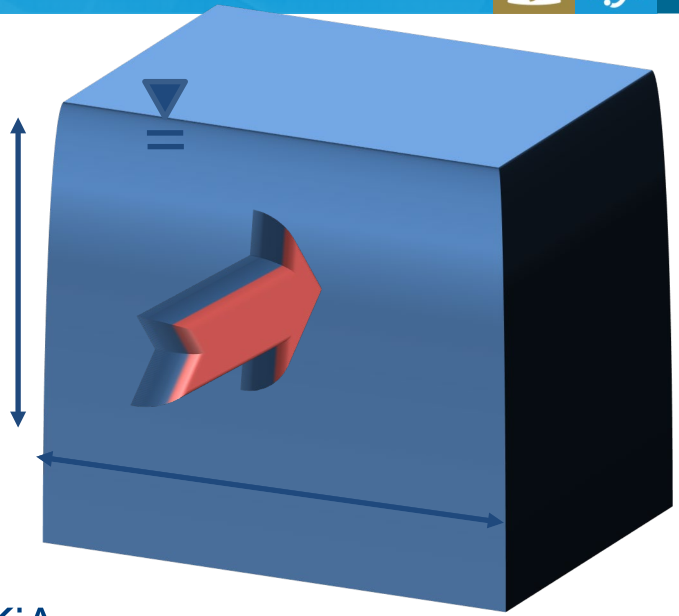
Groundwater and Nutrient Flux Calculation

Design Requirements

1. Define System Objective(s)
2. Conceptual Site Model
   - Target Contaminant Footprint
   - Lithology
   - Permeability
   - Groundwater Flow

Design Approach Options

1. Hand calculations (determine groundwater flux across a plane)
2. Groundwater modeling



Q = KiA

where:
Q = groundwater flux
K = hydraulic conductivity
I = hydraulic gradient
A = cross sectional area of aquifer

What are the available treatment options?

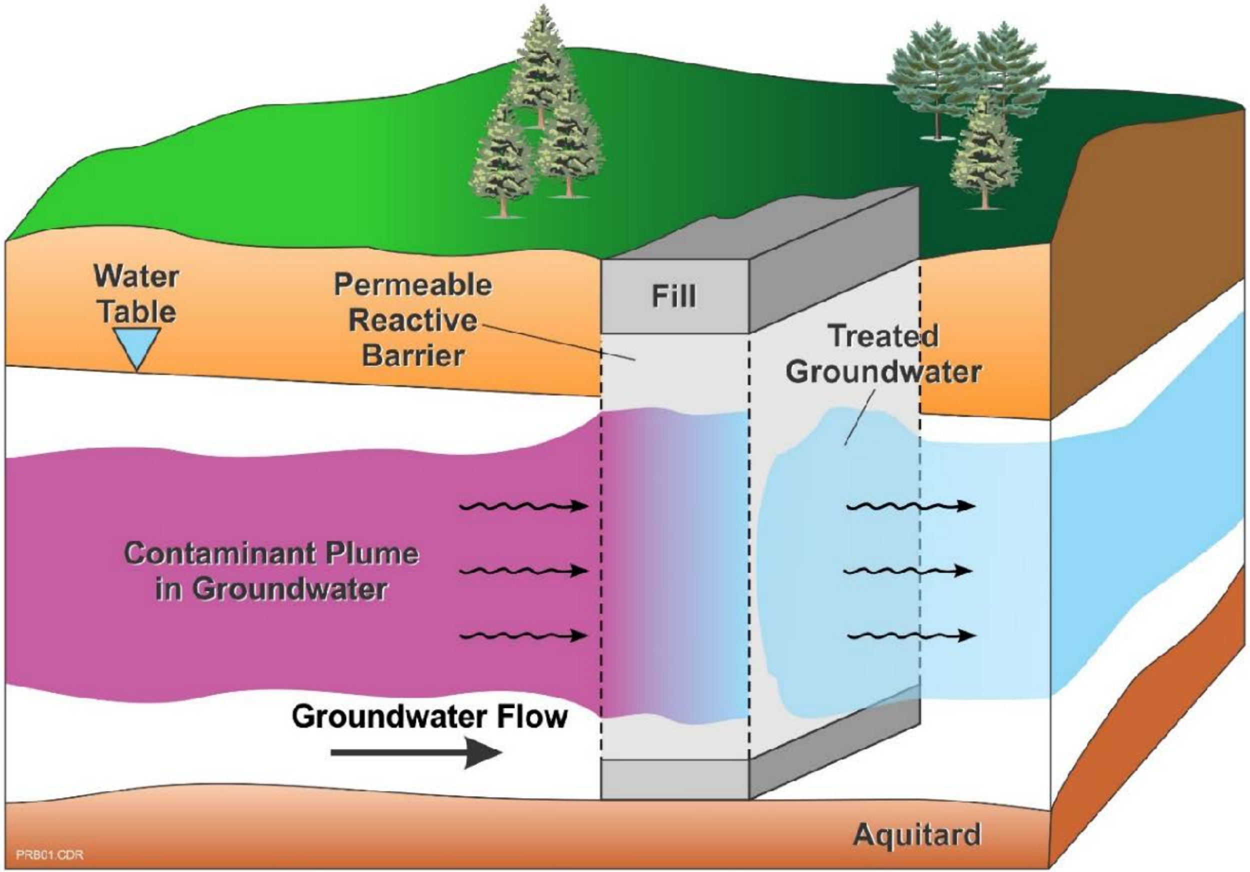
Objective is to treat nutrient pollution in groundwater with Best Management Practices (BMPs) prior to discharge into surface waterbodies.

If groundwater is not intercepted prior to surface water discharge the cost of treatment and the loss of beneficial use can be significant.

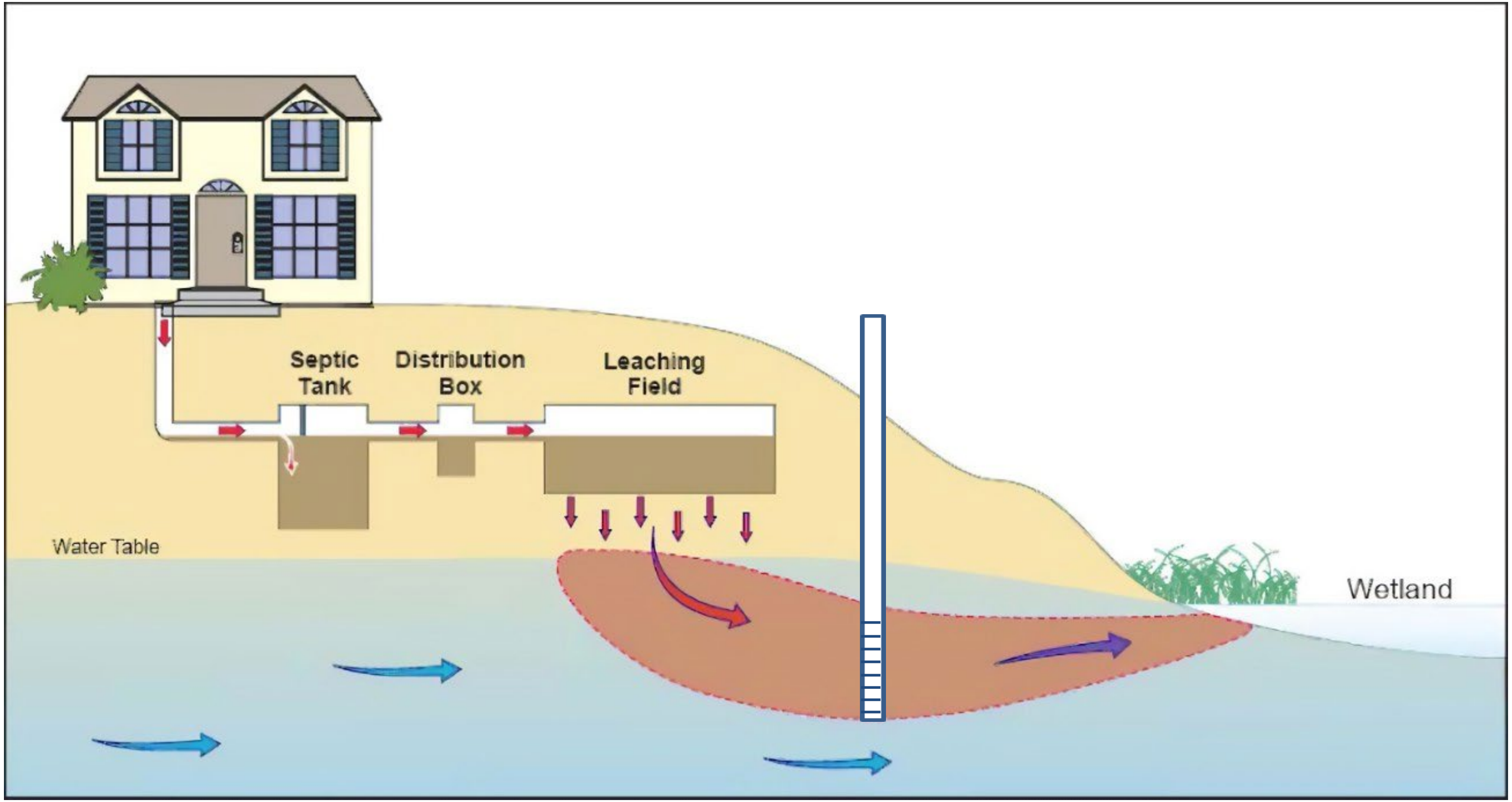
Completion of a feasibility study will identify suitable treatment option(s) which could include the approaches below:

- Permeable reactive barriers;
- Groundwater capture and treatment systems; and
- Phytotechnology including TreeWells®

Permeable Reactive Barriers

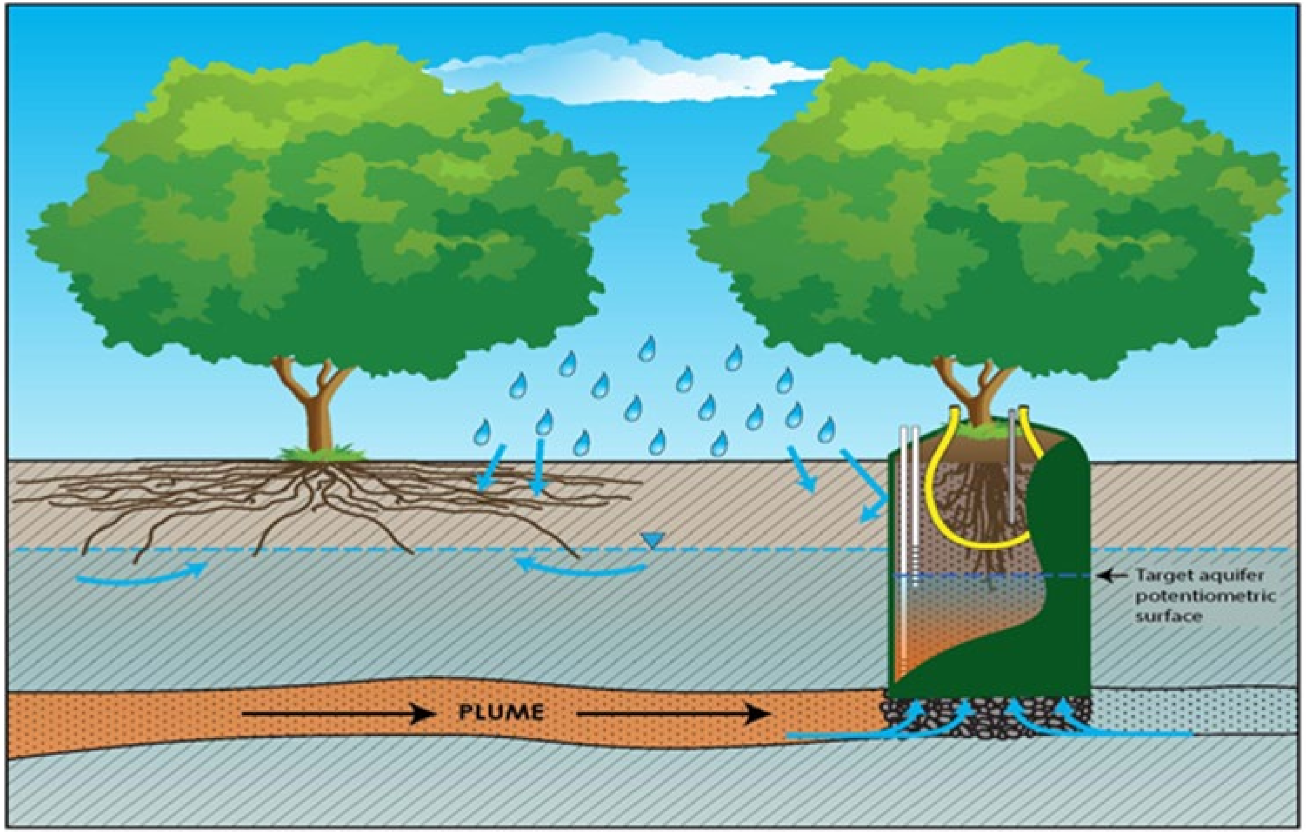


Groundwater Capture and Treatment Systems



Engineered Phytotechnology: The *TreeWell*® System

- Patented by Applied Natural Sciences (ANS)
- Geosyntec is licensed for the design and use of *TreeWell*® systems
- Flow rate for each tree expected between 40-50 GPD at full tree maturity



Key Mechanisms of Phytoremediation

Phytovolatilization
VOCs volatilize off leaf surface (1,4-Dioxane, TCE)

Phytoextraction
Uptake and removal of contaminants through the roots

Phytodegradation
In Planta degradation (TCE, TNT)

Phytosequestration
In Planta sequestration or accumulation (salts, metals/metalloids)

Rhizodegradation/Rhizofixation/Chelation
Microbial degradation in the rhizosphere (salts, metals, organic contaminants)

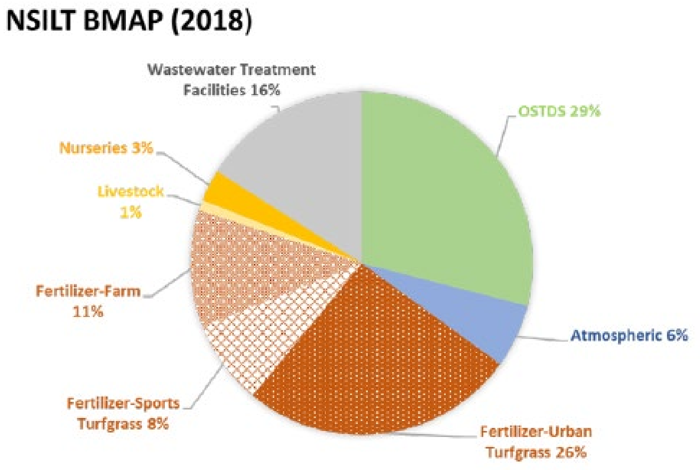
Chemical Reduction
Strongly reducing conditions (organic contaminants)

Phytohydraulics
Groundwater uptake

Typically a combination of these mechanisms at work concurrently

Case Study #1: Case Study #1: Nutrient Removal Groundwater Feasibility Study

- TN and TP water quality goals have been established for the Wekiva Spring BMAP and PFA
  - Current Wekiva Spring concentration ranging between approx. 0.75 and 1.5 mg/L NO3
  - Goal concentration of 0.238 mg/L NO3
- Stakeholders have goals for nutrient removal
- Orange County commissioned a feasibility study was conducted to identify project opportunities for nutrient removal
- Several groundwater projects were identified as opportunity for significant nutrient reduction



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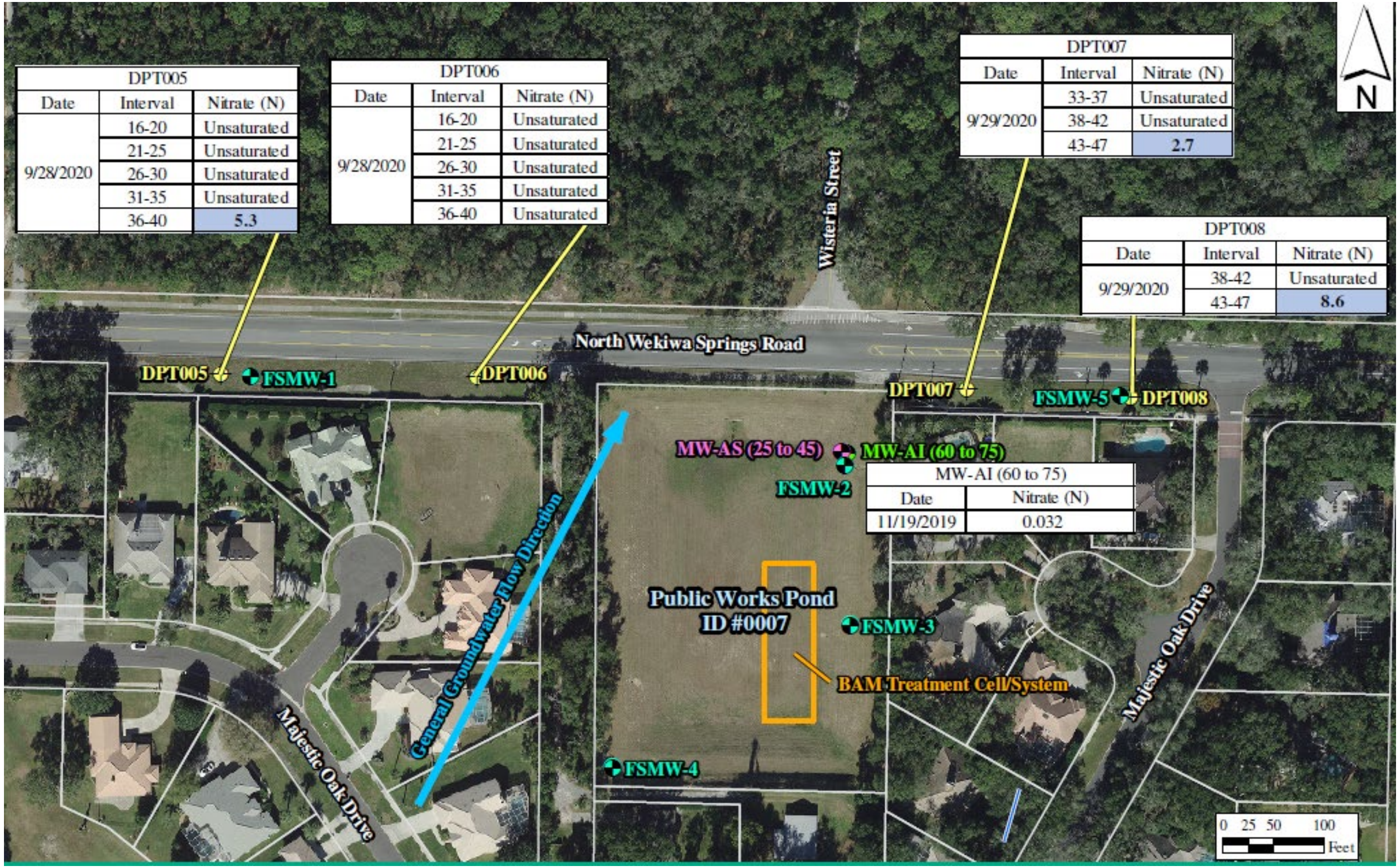

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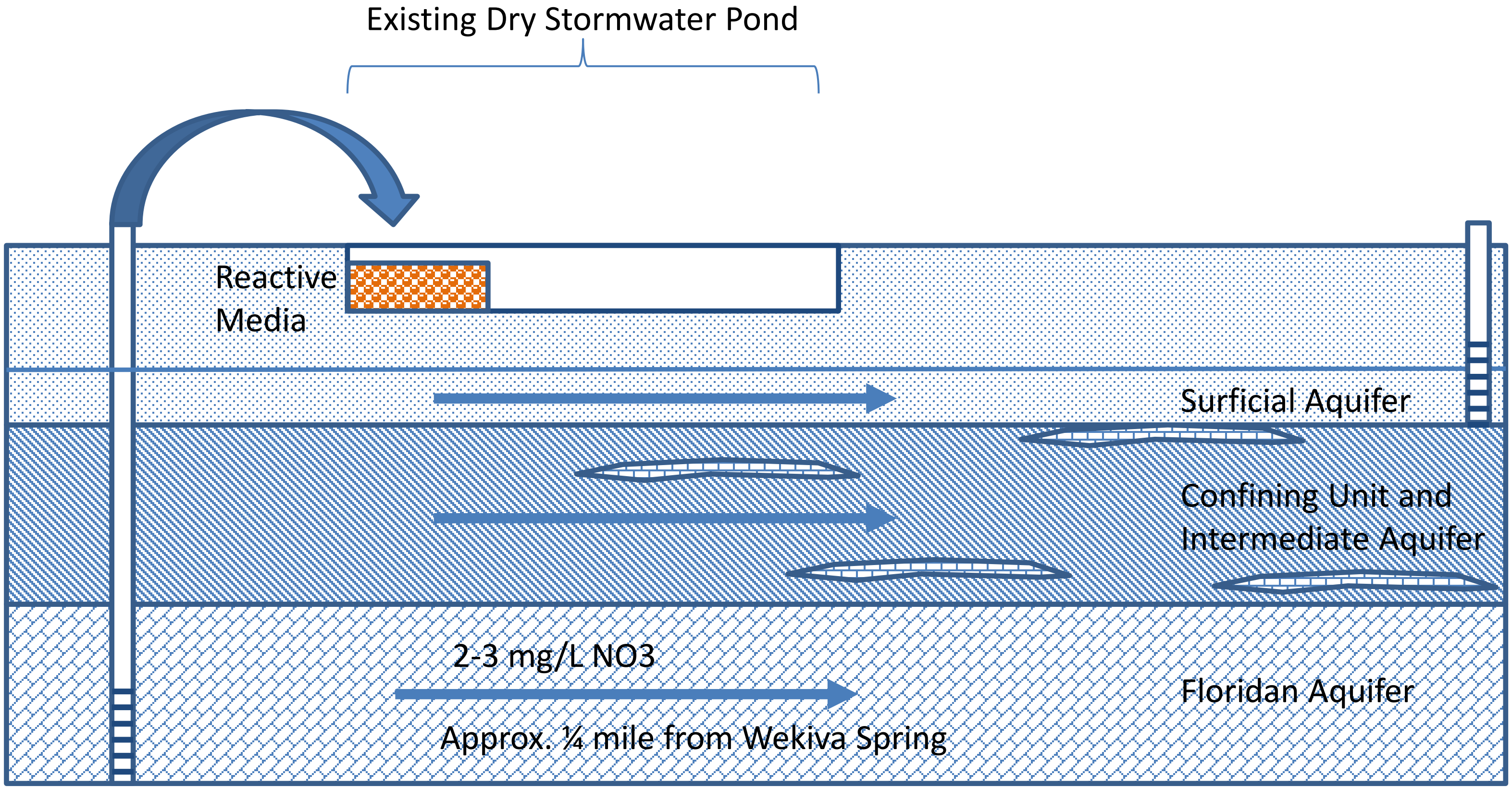
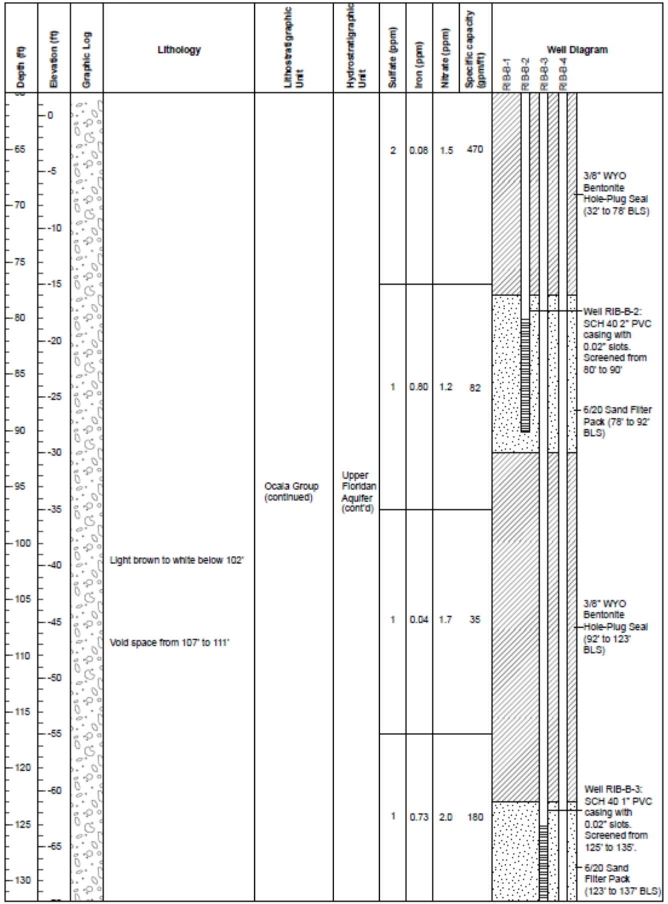


Case Study #1: Nutrient Removal Groundwater Feasibility Study

Site conditions indicated:

- Heterogenous conditions noted during drilling
- High permeability zones coincided with high nutrient zones
- High yield supply of elevated nitrate groundwater was confirmed
- Downgradient, background and side gradient monitoring well system was installed
- Pre-construction groundwater monitoring underway
- Permitting evaluation and feasibility for system is in progress
- Potential to remove up to approx. 1,000 lbs of nitrate on an average annual basis



Case Study #2: Engineered Phytotechnology Demonstration for Treatment of NOx

- City of Casselberry golf course permitted to receive 0.359 MGD of reclaimed water for irrigation with an average 6.6 mg/L NO3.
- Conditions of application per NPDES permit: surficial aquifer remains below 10 mg/L NO3
- Multiple loading sources (reclaimed water and golf course fertilizers)
- Aquifer characterization completed in 2017 using DPT methods and well installation
- Interval of elevated NO3 was identified between 15 and 24 ft below land surface and a flux of 90 GPD

Case Study #2: Engineered Phytotechnology Demonstration for Treatment of NOx

- 15 TreeWell® units were planted in 2018.
- The TreeWell® system incorporated the integration of Bold and Gold biosorption-active media (BAM) into the soil backfill at half of the locations
- Monitoring data indicate average NO3 attenuation of between 5 and 10 mg/L across planting area.
- BAM amended TreeWell® units encourage complete denitrification.
- This treatment technology offers a passive method that utilizes vegetation, specifically trees, to target groundwater with elevated nutrient concentrations.

Case Study #2: Engineered Phytotechnology Demonstration for Treatment of NOx

Basic Approach

- Borehole advanced to the horizon of interest
- Safety platform set
- Liner, aeration tubing other desired infrastructure are added
- Borehole is backfilled with topsoil and selected amendments
- Tree is then planted, and unit is finished

Case Study #2: Engineered Phytotechnology Demonstration for Treatment of NOx

Primary Benefits

- Substitute for other treatment technologies
- More effective than other treatment technologies in low permeability zones or thin aquifers
- “Active” treatment
- Low operation and maintenance costs

Secondary Benefits

- Aesthetic appeal to community
- “Enthusiastic” regulatory acceptance
- Defined as “Green and Sustainable” by USEPA

Case Study #2: Engineered Phytotechnology Demonstration for Treatment of NOx

Planting

Tree Height (ft)	Canopy (sq ft)
11.4	13.9

Year 1

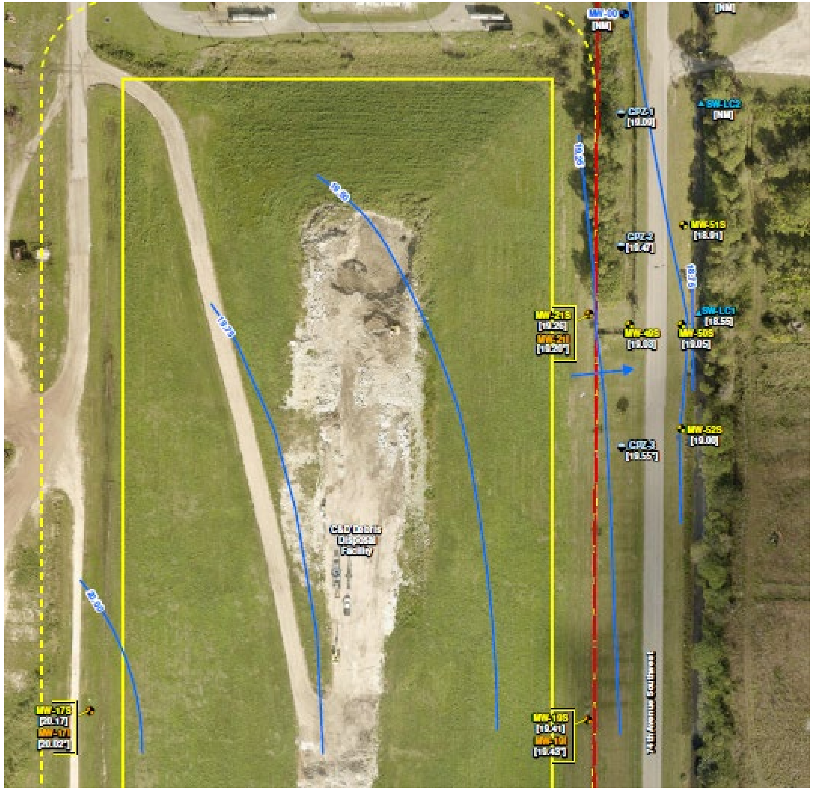
Tree Height (ft)	Canopy (sq ft)
16.6	42.4

Year 2

Tree Height (ft)	Canopy (sq ft)
19.2	56.6

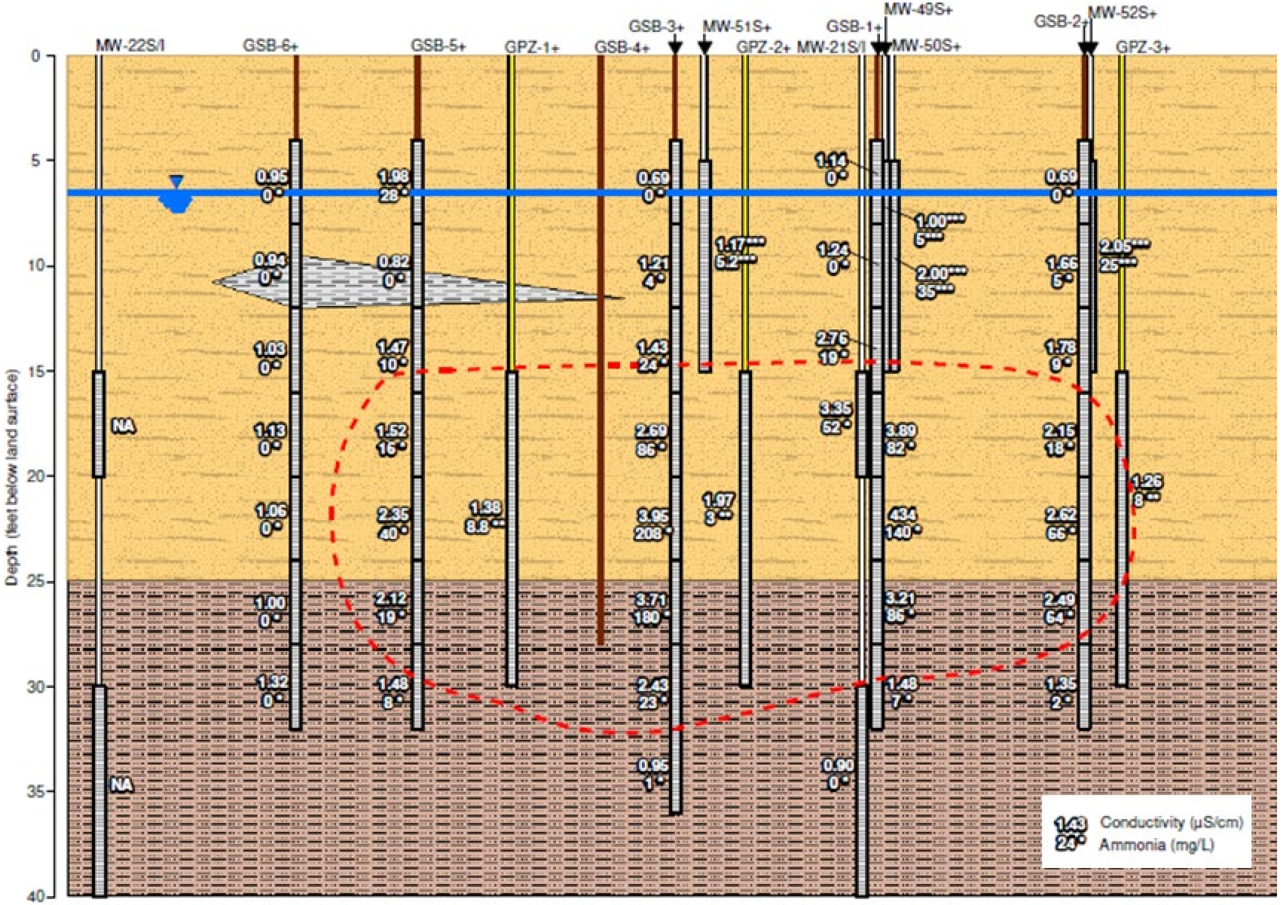
Case Study #3: Nutrient Flux Assessment and Remedial Design

- A landfill located adjacent to a canal was identified as a source of nutrient seepage to surface water
- A groundwater assessment was completed to evaluate the source of nutrient discharge.
- The assessment included:
  - groundwater profiling using DPT drilling methods,
  - field analysis of nutrients,
  - construction of permanent monitoring wells,
  - slug testing,
  - quarterly groundwater and surface water monitoring



Case Study #3: Nutrient Flux Assessment and Remedial Design

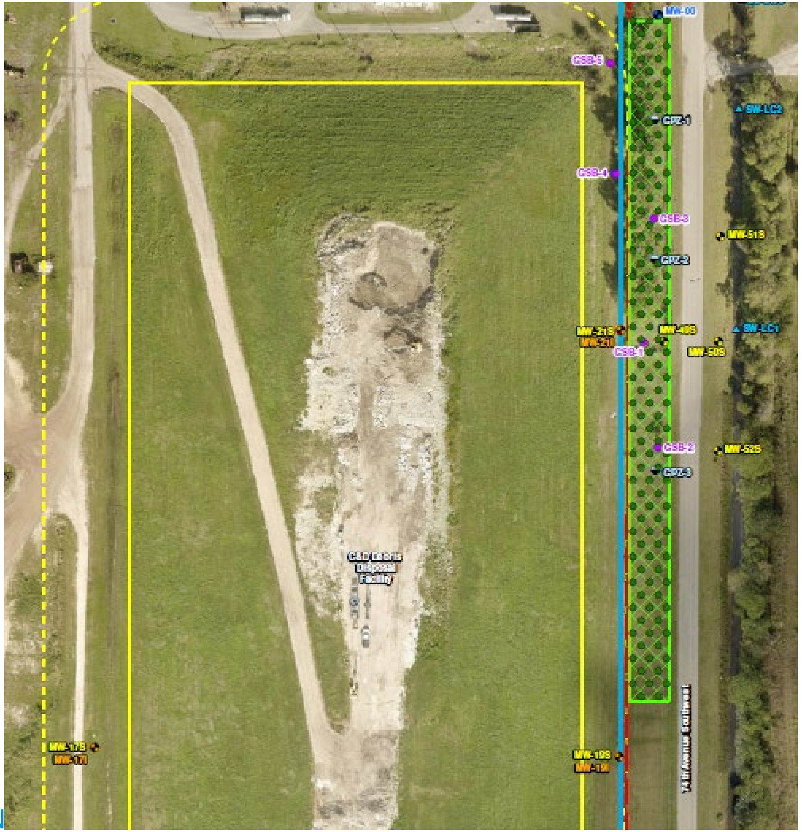
- Groundwater and nutrient flux rates to the neighboring canal were calculated.
- A profile of nutrient concentrations and seepage velocities was completed downgradient of the suspected source areas



Case Study #3: Nutrient Flux Assessment and Remedial Design

- Pre-design for a TreeWell® system consisting of 135 units has been completed
- Located between the landfill and the canal
- The system will be capable of intercepting at least 5,400 GPD
- Passive system would be installed in lieu of an active remediation system needing continual operation and maintenance

Groundwater Gradient	Hydraulic Conductivity	Groundwater Velocity (1)		Groundwater Flux Rate		
(ft/ft)	(ft/day)	(ft/day)	(ft/year)	(ft^3/day)	(gal/day)	
0.001	5.81	0.019	7.1	232	1,739	Minimum
0.002	9.05	0.060	22.0	724	5,415	Geomean
0.004	16.49	0.220	80.3	2,639	19,740	Maximum



Closing Thoughts

- Understand the importance of the lag of “legacy” groundwater pollutants when evaluating water quality goals
- Scope subsurface investigations assuming the subsurface is not uniform
- Implement high-resolution assessment to identify heterogeneity within aquifer systems in order to focus remedial efforts to high transmissivity zones
- Quantification of the groundwater/nutrient flux is required for a successful project
- Leverage state-of-the-art remediation techniques to address groundwater nutrient issues

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Questions??

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