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Groundwater Assessment and Treatment Approaches for Springs BMAPs

Mike Hardin, Ph.D., P.E., CFM – Geosyntec Consultants, Inc.

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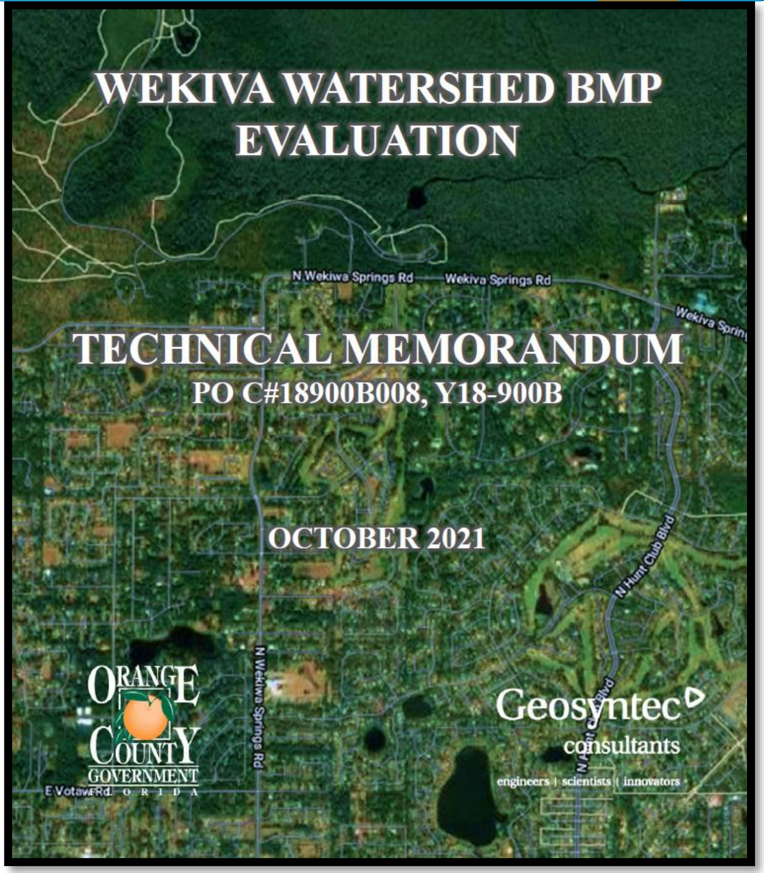
Presentation Outline

- Introduction
- Assessment of nutrients in groundwater
- Available treatment technologies
- Wekiva PFA case studies
- Closing thoughts



Introduction

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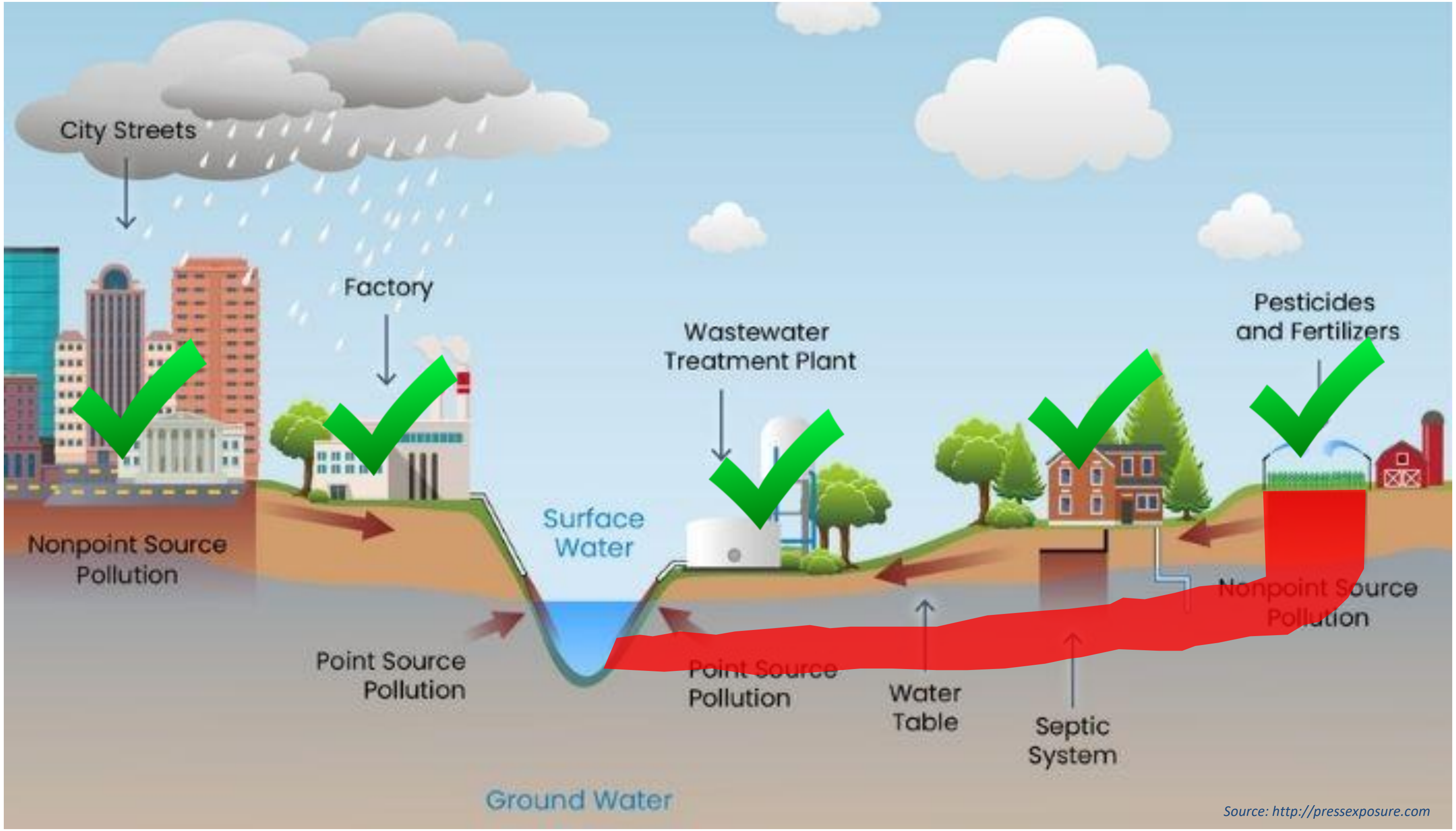
Introduction

- Springs BMAPs are a significant challenge
- Several sources contribute nutrients to springs
  - Septic sources
  - Wastewater RIBs
  - Stormwater infiltration areas (dry ponds)
  - Rainfall that infiltrates directly to the ground (UTF)
  - Fertilizer from Ag and recreation
- Some of these sources are very difficult to control, if not impossible

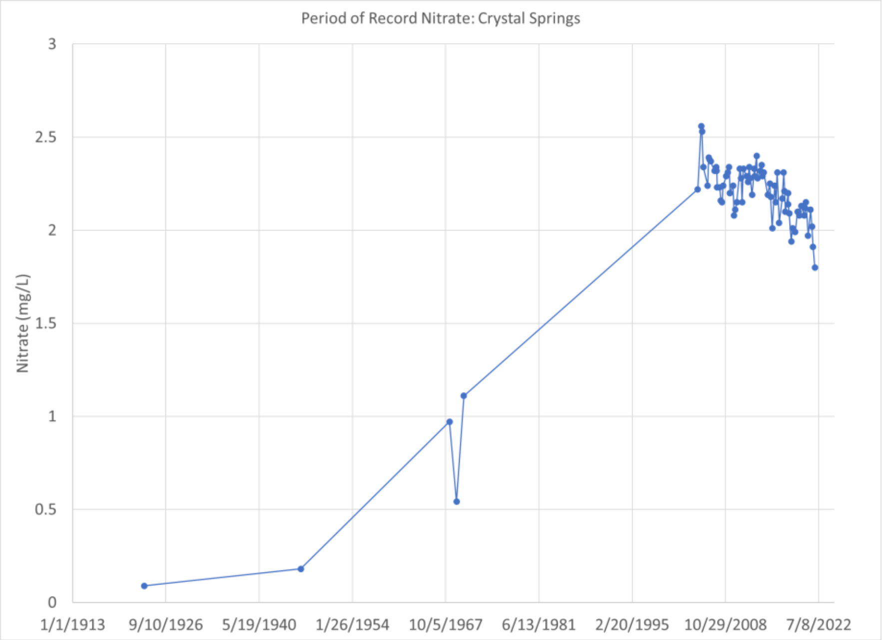
What is the Issue?



Source: http://pressexposure.com

Introduction

- Implementation of surface controls may take a long time to show up at the spring vent
  - Travel time can be significant, on the order of decades
  - Even if we implement all the surface controls, we may not see the results of this for a long time



Assessment of Nutrients in Groundwater

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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

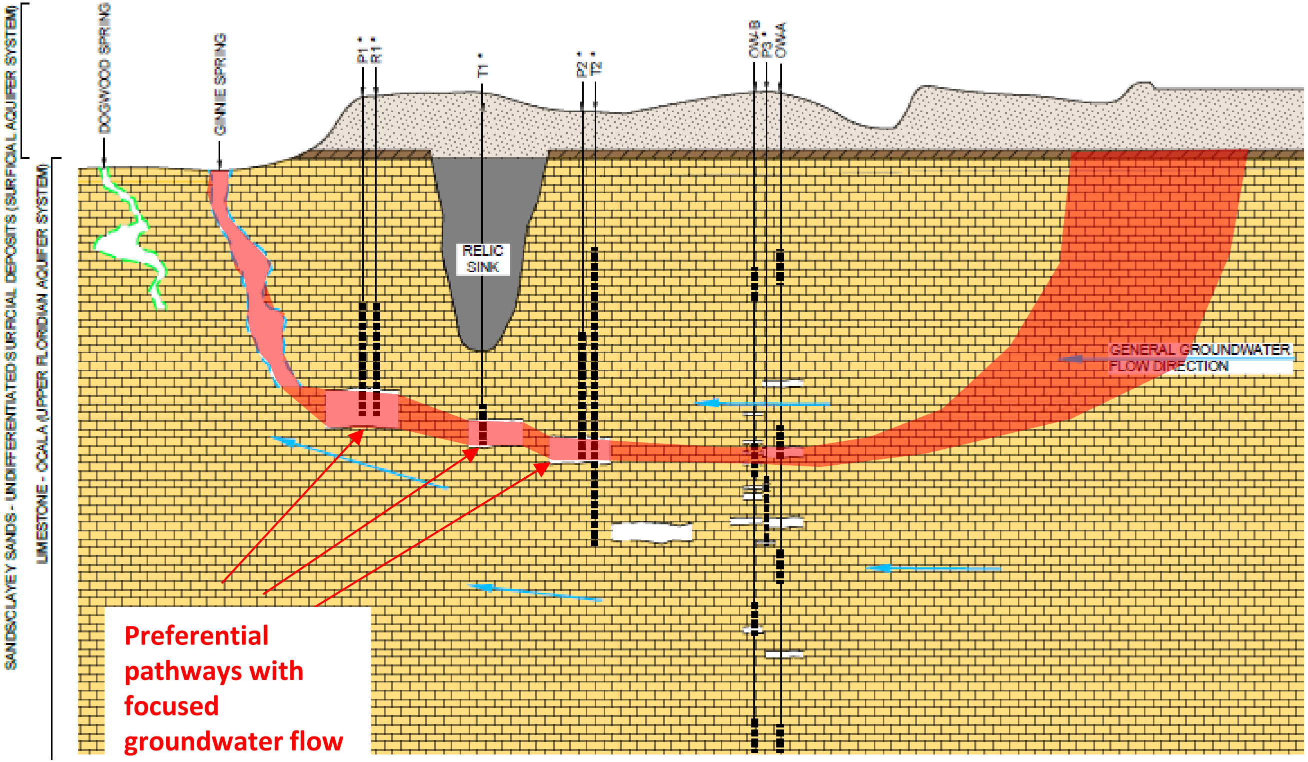
Sonic drilling allows for:

- 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



Groundwater and Nutrient Flux Calculation

<u>Design Requirements</u>

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

<u>Design Approach Options</u>

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

Available Treatment Technologies

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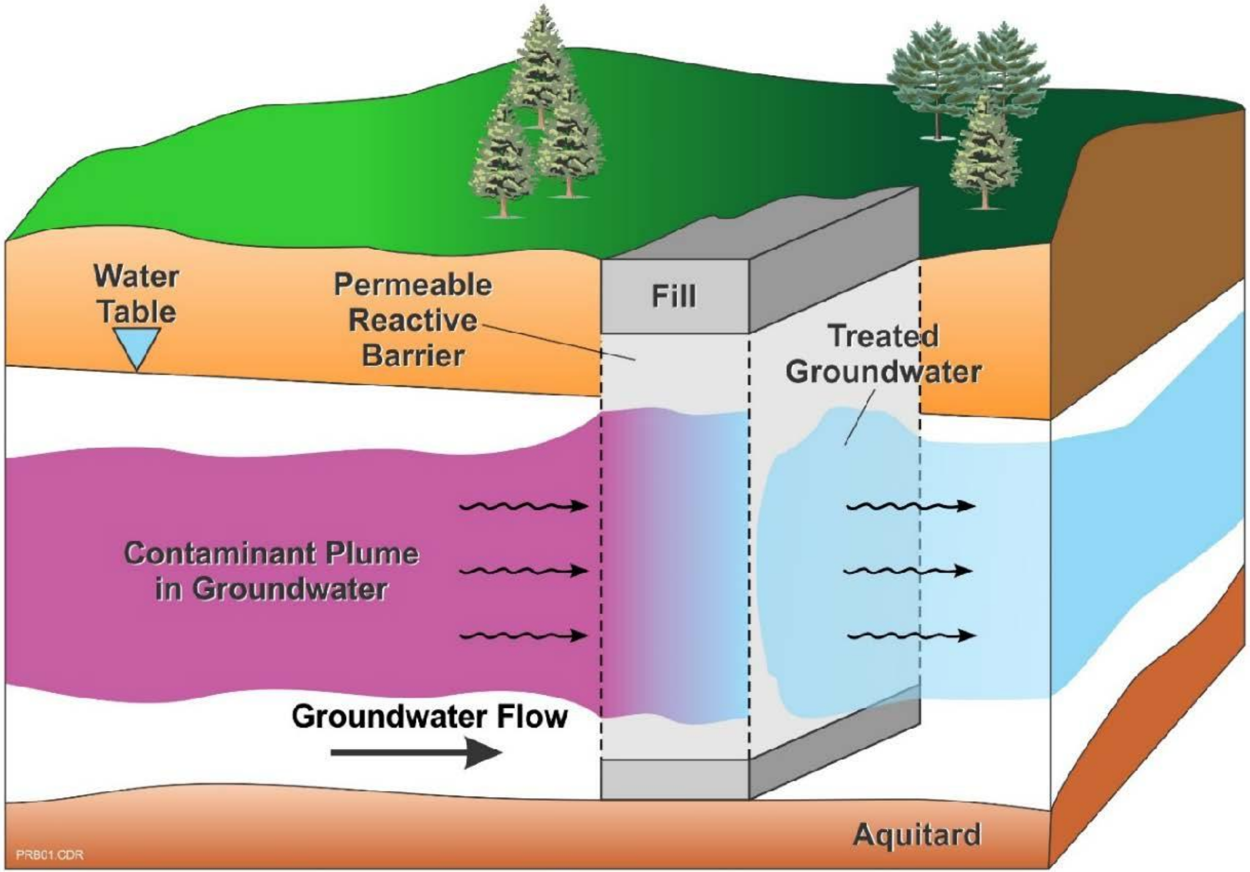
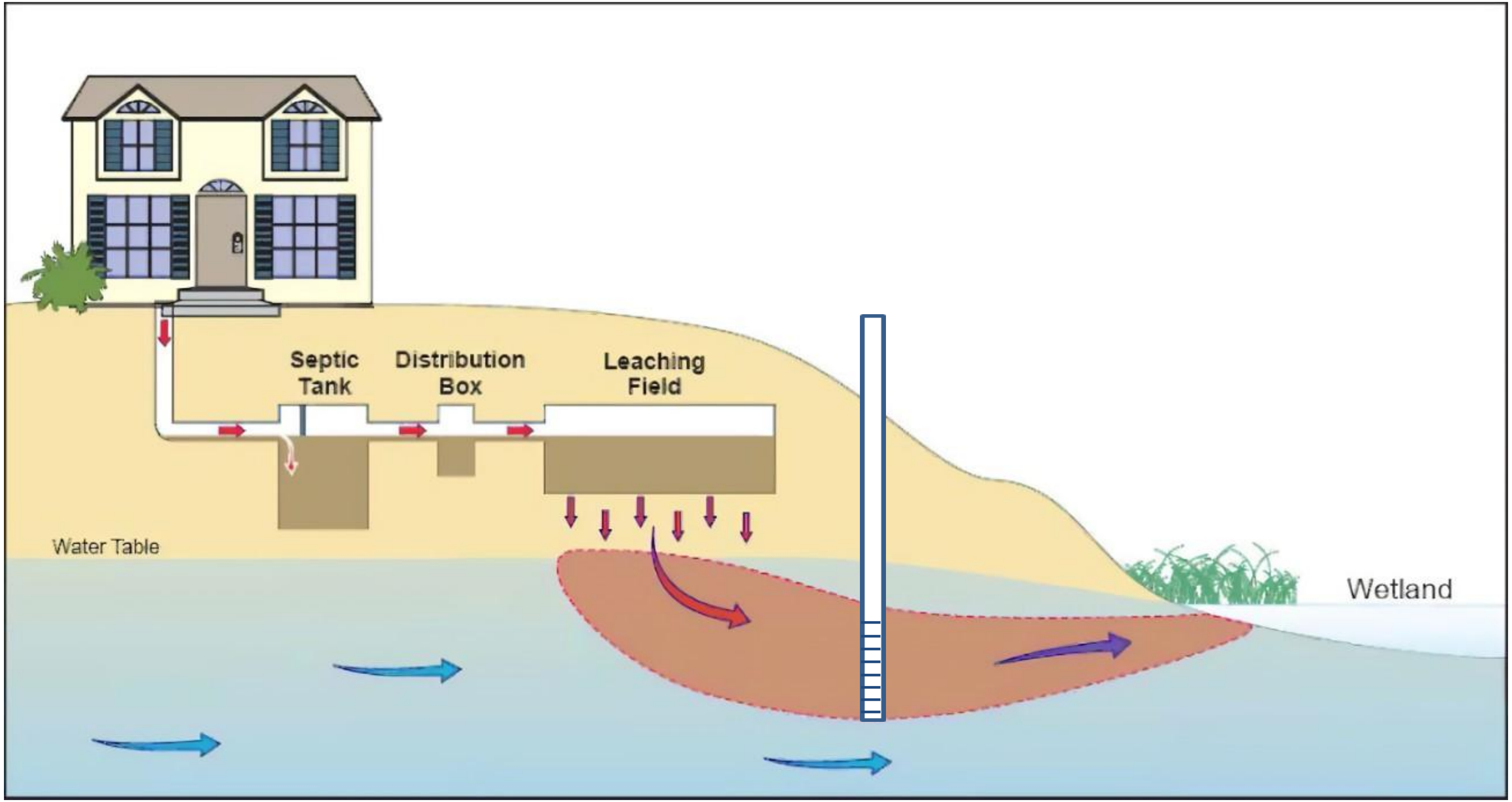
What are the available treatment technologies?

- Suitable treatment options could include the approaches below:
  - Permeable reactive barriers;
  - Groundwater capture and treatment systems; and
  - Phytotechnology including TreeWells®

Permeable Reactive Barriers

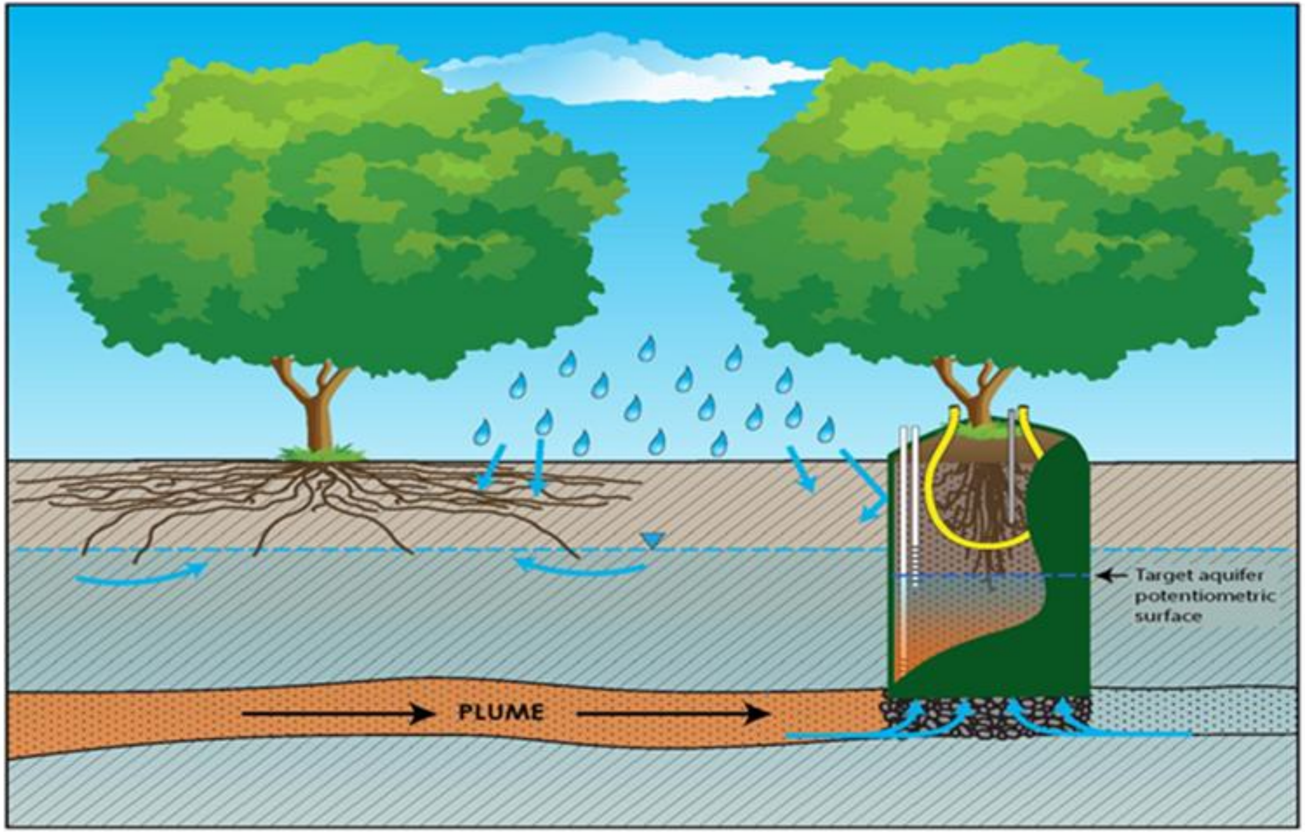


Groundwater Capture and Treatment Systems



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

Wekiva Springs PFA Case Studies

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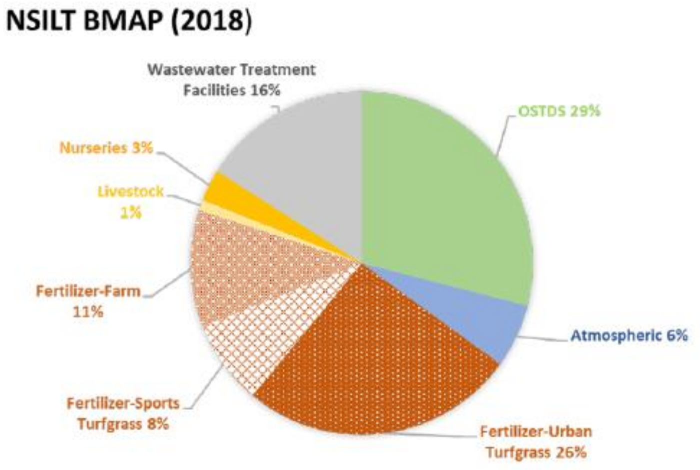
Orange County Government Florida

Environmental Protection Division

Wekiva PFA Case Studies

- 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



Wekiva PFA Case Studies – Well Monitoring Data

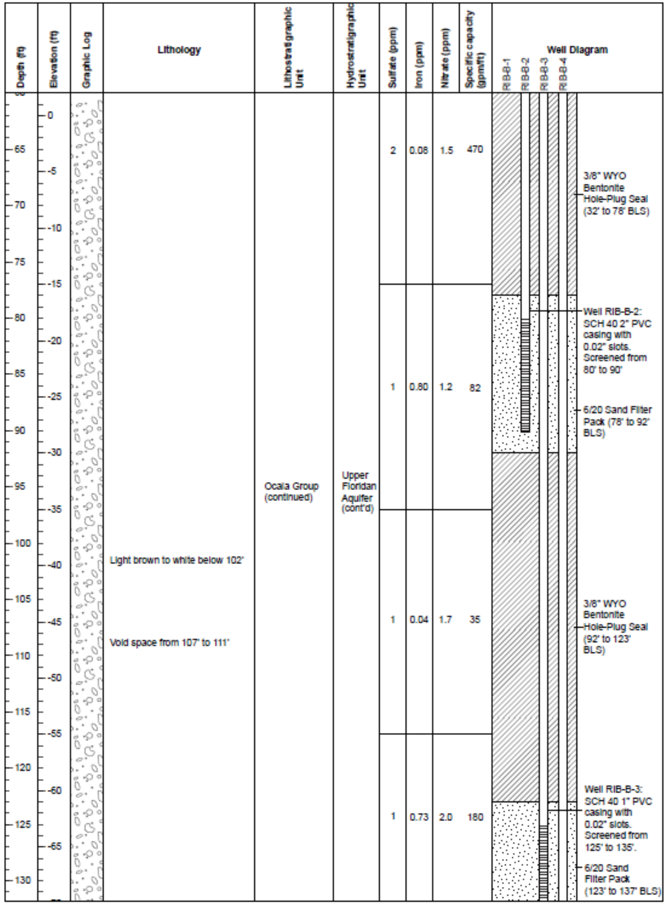
- County collecting data from 26 wells installed to different monitoring zones
  - Surficial Aquifer System (SAS) 25-40 ft BLS
  - Intermediate Aquifer System (IAS) 15-90 ft BLS
  - Upper Floridan Aquifer (UFA) 115-210 ft BLS
- Data evaluated for trend analysis
  - Time series plots to identify increasing or decreasing trends
  - Box plot seasonal comparisons
  - Comparisons to the median concentrations to identify elevated groundwater concentrations

Well ID	TN Trend	TP Trend
BW-02	Neutral	Decreasing
MW-01	Neutral	Decreasing
MW-02	Increasing	Neutral
MW-03	Decreasing	Decreasing
MW-04*	Decreasing	Neutral
MW-04R*	Neutral	Neutral
MW-06	Decreasing	Decreasing
MW-07	Decreasing	Decreasing
MW-11	Neutral	Neutral
MW-14	Decreasing	Decreasing
MW-15	Increasing	Decreasing
MW-17	Increasing	Decreasing
MW-20	Decreasing	Decreasing
MW-22	Decreasing	Decreasing
MW-AI	Decreasing	Increasing
MW-BS	Neutral	Neutral
MW-BU	Neutral	Neutral
MW-CI	Decreasing	Increasing
MW-CU	Increasing	Neutral
MW-DS	Decreasing	Neutral
MW-DU	Decreasing	Increasing
MW-EU	Increasing	Increasing
SW-01	Increasing	Increasing
XDEPFLD	Decreasing	Increasing
XDEPPBD	Increasing	Neutral
XDEPPBS	Neutral	Neutral

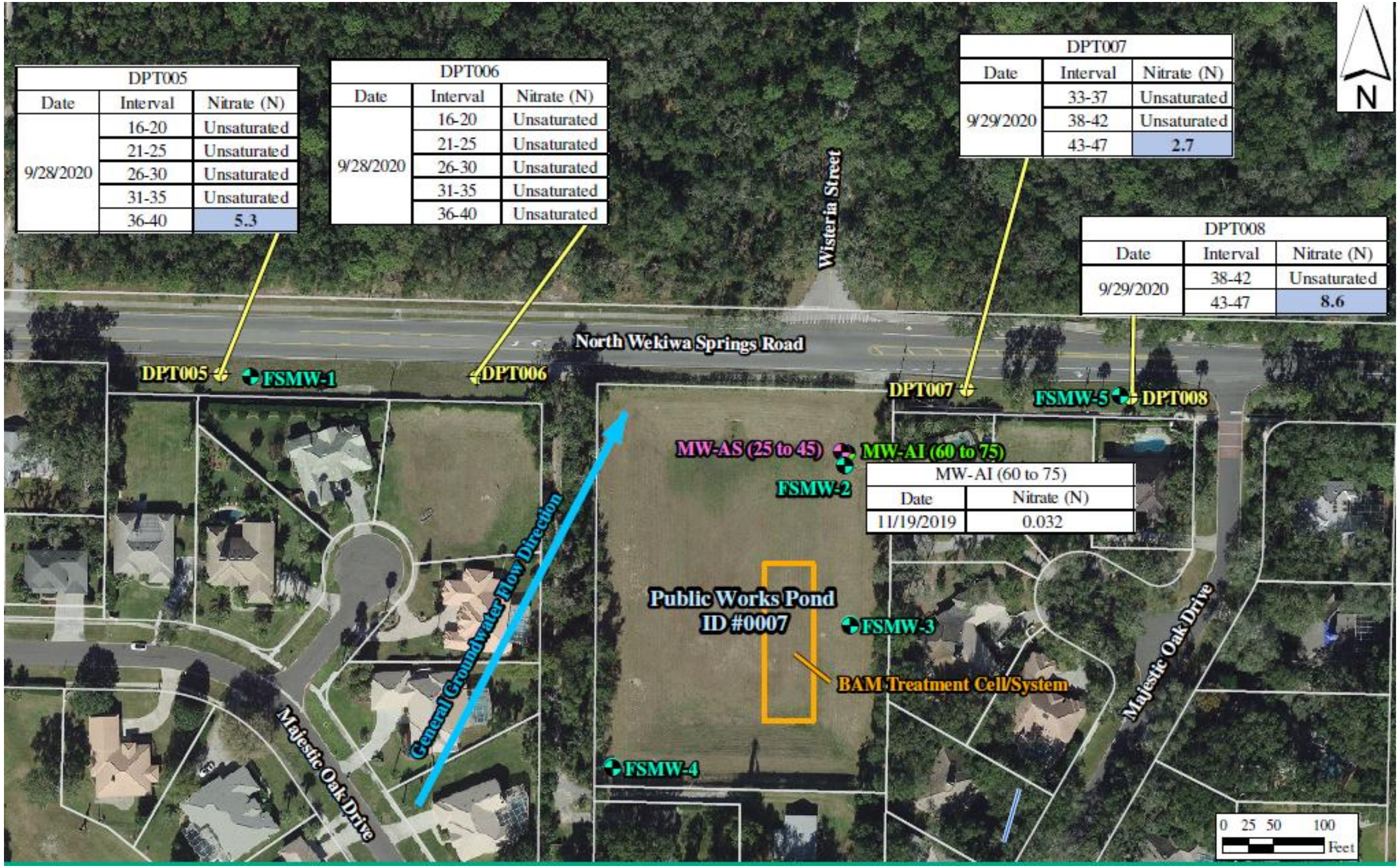
Well ID	Well Screen Aquifer Zone	Median TN (mg/L)	Minimum TN Concentration (mg/L)	Maximum TN Concentration (mg/L)
BW-02	SAS	0.66	0.17	1.59
MW-01	SAS	2.57	1.97	4.09
MW-02	IAS	1.31	0.26	4.04
MW-03	IAS	0.47	0.22	0.72
MW-04	SAS	12.30	7.56	14.80
MW-04R	SAS	9.29	8.59	11.79
MW-06	SAS	0.29	0.11	4.40
MW-07	SAS	1.93	0.39	7.83
MW-11	IAS	2.59	1.19	4.05
MW-14	SAS	0.14	0.01	2.07
MW-15	IAS	1.02	0.50	1.39
MW-17	SAS	0.49	0.01	12.64
MW-20	SAS	3.16	0.58	18.30
MW-22	IAS	2.43	0.76	8.32
MW-AI	IAS	0.11	0.01	0.52
MW-BS	SAS	1.38	0.98	15.40
MW-BU	UFA	1.46	0.96	15.00
MW-CI	IAS	0.27	0.01	1.40
MW-CU	UFA	1.01	0.27	4.50
MW-DS	SAS	2.06	1.59	2.90
MW-DU	UFA	0.09	0.02	1.10
MW-EU	UFA	0.54	0.05	1.00
SW-01	SAS	1.13	0.12	1.77
XDEPFLD	UFA	0.06	0.00	0.51
XDEPPBD	UFA	0.18	0.04	0.67
XDEPPBS	SAS	0.87	0.51	3.09

Wekiva PFA Case Studies – Site Lithology

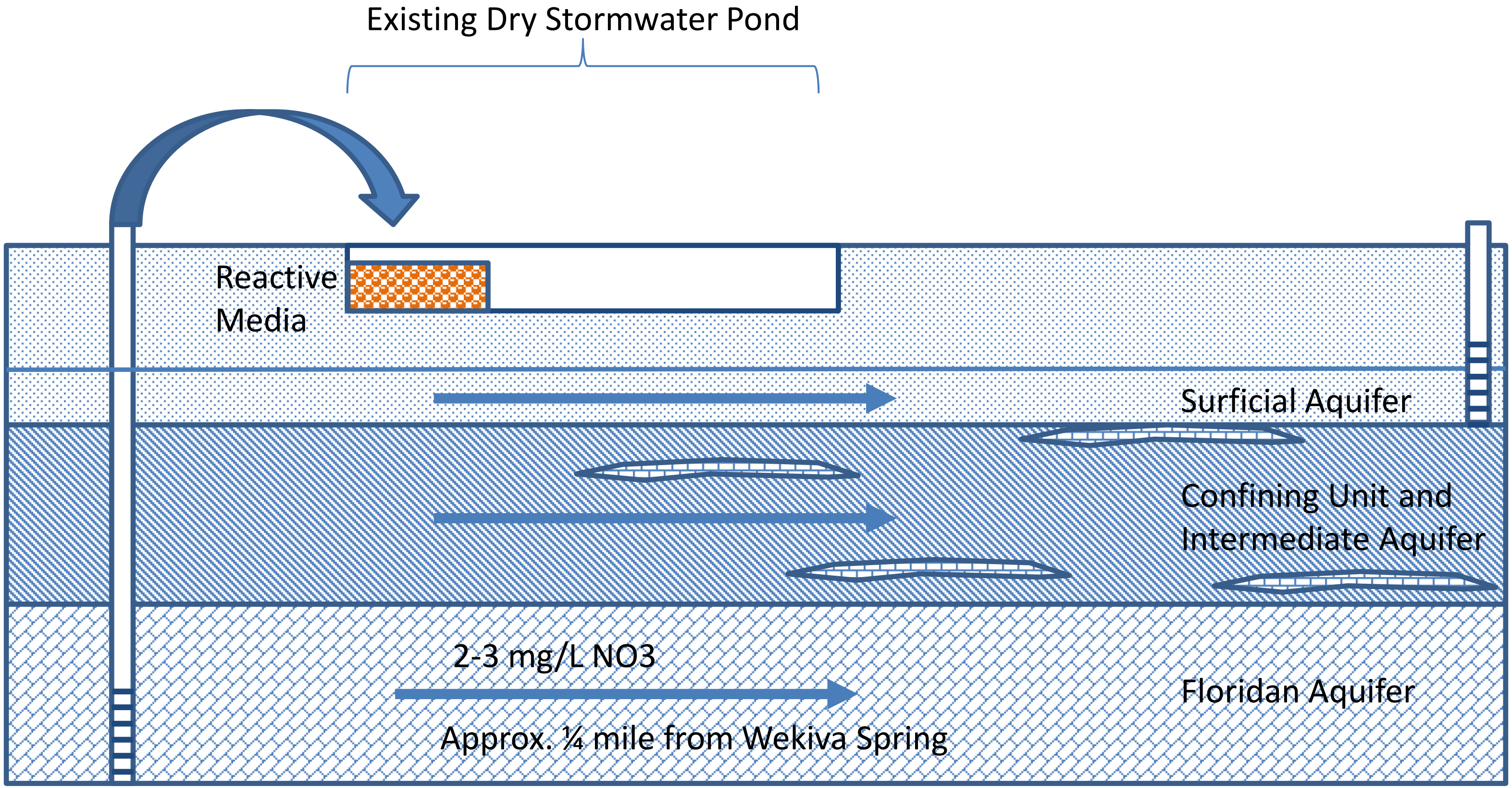
- Site conditions indicated:
  - Heterogenous conditions noted during drilling
  - **High permeability zones coincided with high nutrient zones**
  - **High yield supply of elevated nitrate groundwater was confirmed**
  - Downgradient, background and side gradient monitoring well system was installed
  - Pre-construction groundwater monitoring underway
  - Project design underway
  - Potential to remove up to approx. 1,000 lbs of nitrate on an average annual basis



Wekiva PFA Case Studies – Site Groundwater Investigation



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



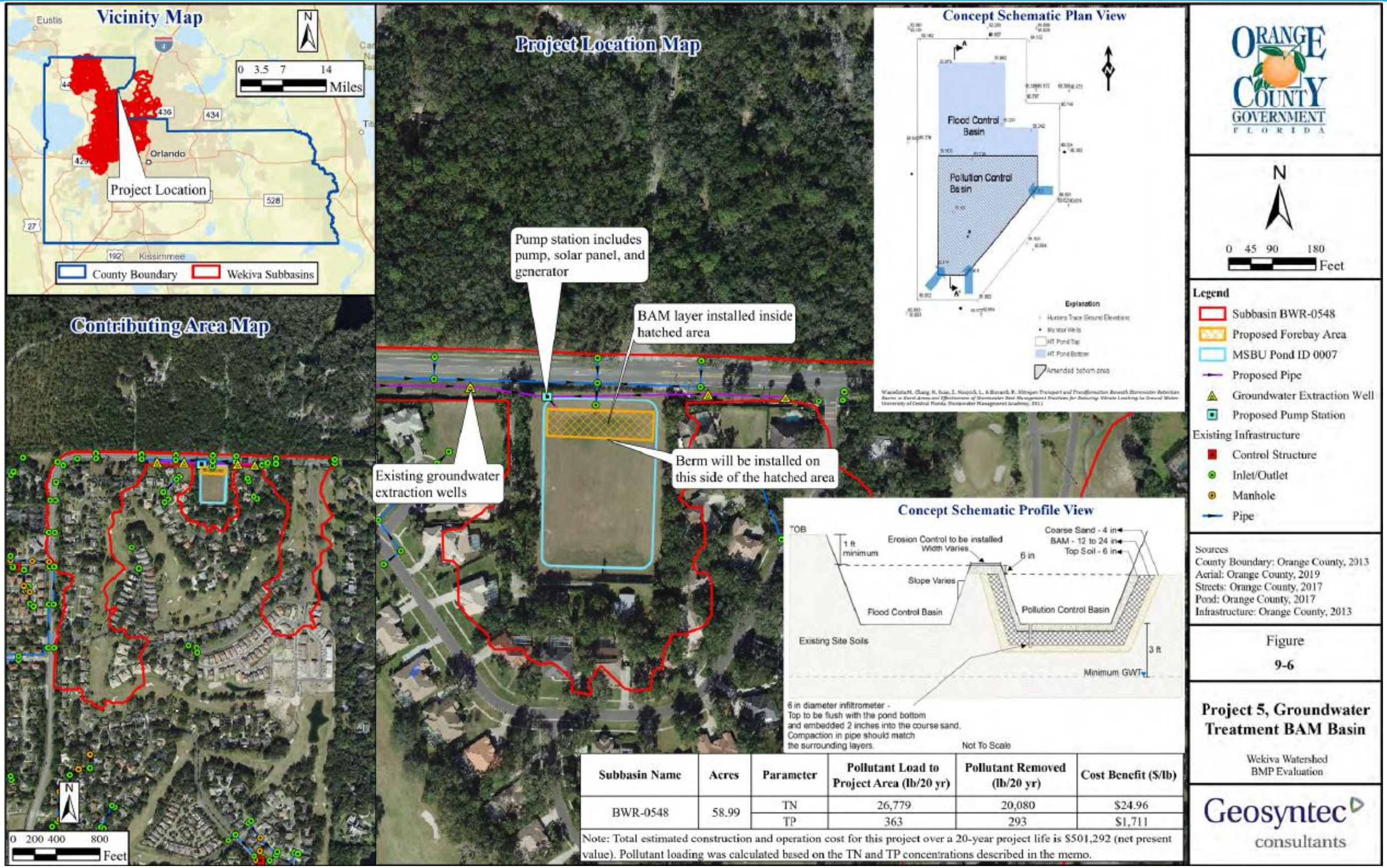
Project Identification and Prioritization

- Project 5 Groundwater Treatment BAM Basin
  - Utilizes portion of dry retention pond to create a treatment area with BAM
  - Pump water from aquifer to treatment area
  - System can operate during dry periods and have sensor to cut off when rainfall is received
  - Allows for near continuous treatment of groundwater

Subbasin Name	Acres	Parameter	Pollutant Load to Project Area (lb/20 yr)	Pollutant Removed (lb/20 yr)	Cost Benefit ($/lb)
BWR-0548	58.99	TN	26,779	20,080	$24.96
		TP	363	293	$1,711

Note: Total estimated construction and operation cost for this project over a 20-year project life is $501,292 (net present value). Pollutant loading was calculated based on the TN and TP concentrations described in the memo.

Project Identification and Prioritization



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Project Identification and Prioritization

- Project 1 Groundwater Treatment BAM Basin
  - Utilizes portion of dry retention pond to create a treatment area with BAM
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Subbasin Name	Acres	Parameter	Pollutant Load to Project Area (lb/20yr)	Pollutant Removed (lb/20yr)	Cost Benefit ($/lb)
BWR-0442	79.30	TN	9,104	6,828	$92
		TP	1,543	1,466	$429
Note: Total estimated construction and operation cost for this project over a 20-year project life is $628,416 (net prsent value). Pollutant load was calculated based on the groundwater TN TP concentrations described in the memo.					

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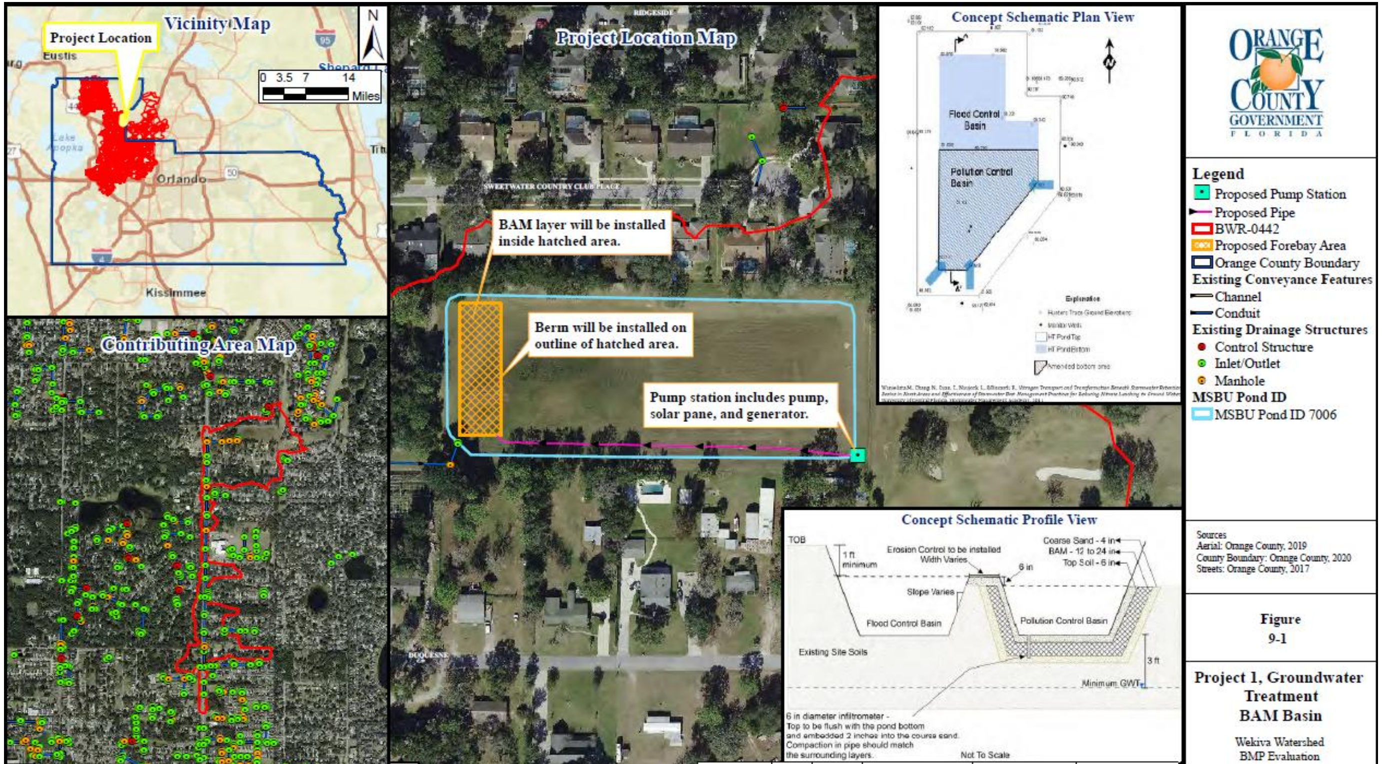

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Closing Thoughts

Closing Thoughts

- Treating groundwater from diffuse sources is very difficult
- Its important to understand the lag of "legacy" groundwater pollutants when evaluating water quality goals
- Perform subsurface investigations to use data driven approach to treatment
  - Wide monitoring network that covers a large area and located near potential sources of interest
  - Implement high-resolution assessment to identify heterogeneity within aquifer systems in order to focus remedial efforts to high transmissivity zones

Closing Thoughts

- Quantification of the groundwater/nutrient flux is required for a successful project
- Leverage state-of-the-art remediation techniques to address groundwater nutrient issues
- Leverage under-utilized space

Acknowledgements

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Questions?

Mike Hardin, PhD, PE, CFM
Geosyntec Consultants, Inc.
(321) 244-1464
mhardin@geosyntec.com