Orleans Water Quality Advisory Panel

Permeable Reactive Barrier (PRB) Stakeholder Workshop

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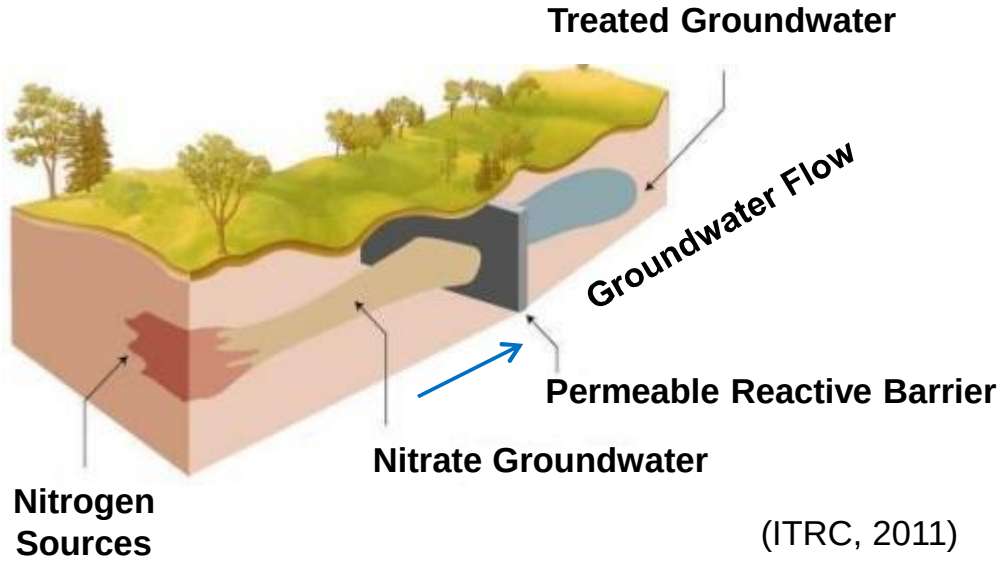
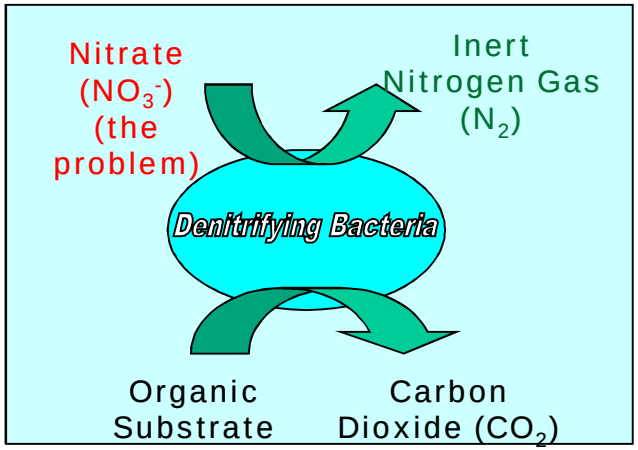
PRB Overview

- A PRB Consists of a Zone of Reactive Material Installed in the Path of a Dissolved Contaminant (e.g. nitrate) Plume



(ITRC, 2011)



- Denitrification - Biological Process by Bacteria Ubiquitous in the Environment
  - Nitrate converted to inert nitrogen gas (N_2)
  - Requires anoxic (low oxygen conditions)

Planning and Design-AECOM PRB Team Activities

- Technical Memo on Site Characterization for PRBs
  - Groundwater & soil investigation to support PRB planning
- Technical Memo for Preliminary Engineering Work Plan for PRBs
  - Includes results from groundwater & soil investigations
- Final Technical Memos available on Town website

PRB Planning and Design – Site Characterization

❖ Technical Memorandum on Site Characterization for PRBs

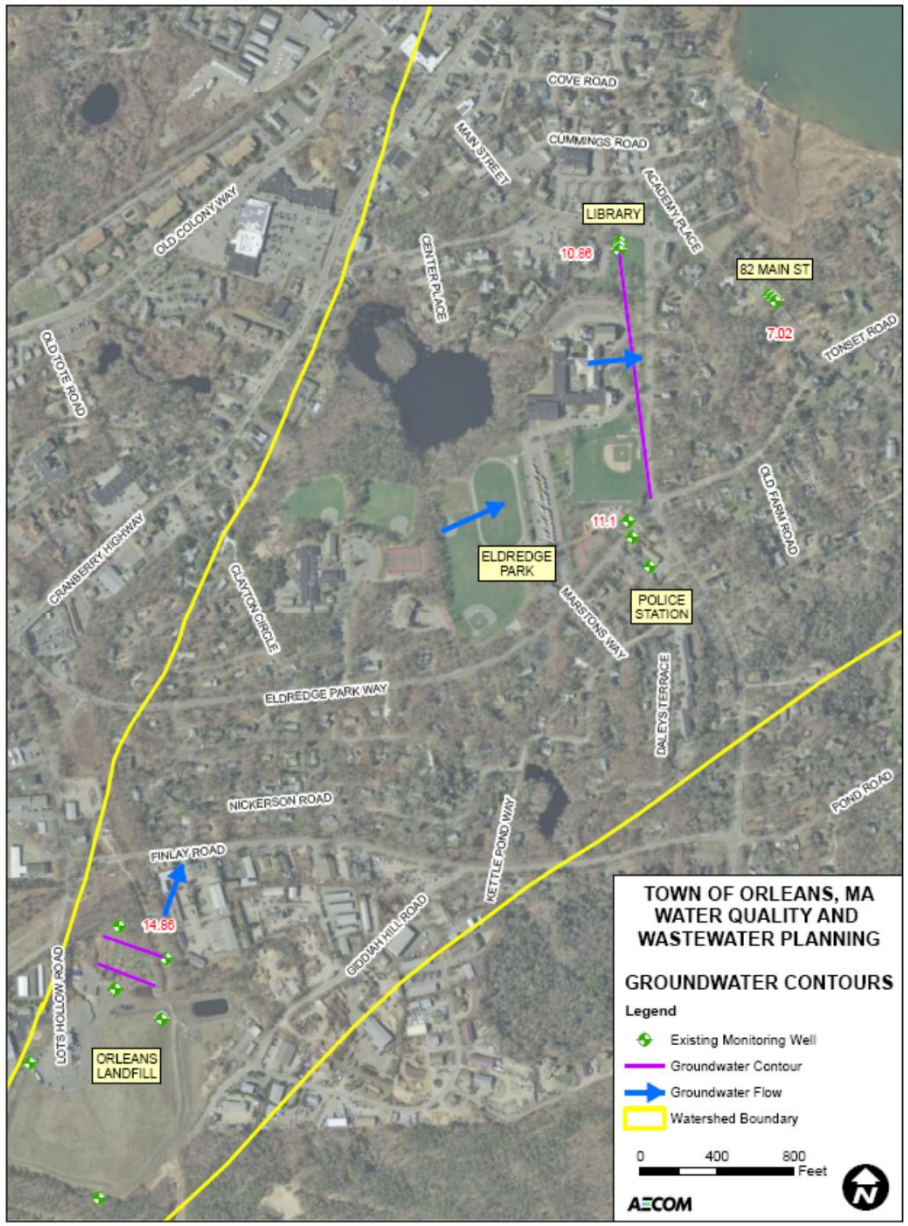
- Final memo submitted to Town in May 2016
- Evaluated sites using 4 major criteria (20 sub-criteria)
  - Site Suitability
  - Permitting
  - Project Evaluation
  - Other Considerations
- 8 sites in Orleans
  - A. Main Street/Tonset Road
  - B. Eldredge Parkway
  - C. Town Cove Gibson Road
  - D. Namequoit Road
  - E. Town Landfill
  - F. Paw Wah Pond
  - G. Rock Harbor Road Area
  - H. Lonnie's Pond
- **Top rated sites in red**

PRB Planning and Design – 2016 Field Investigations

- Collected soil & groundwater samples from highest 4 ranked locations
- New multi-depth wells installed
  - Snow Library
  - 82 Main Street
  - Gibson Road at Asas Landing
  - Town Landfill
- Sampled existing wells at Town Landfill and Eldredge Park
- Measured Parameters to Support PRB Site Selection and Design
  - Vertical Profile of Nitrate (and ammonia) Concentrations
  - Depth to Groundwater
  - Groundwater Flow Velocity
  - Soil Types
  - Other Groundwater Analytes of Interest

Results of Investigation

- Groundwater flow directions confirmed in areas of interest
- Initial view of nitrate/ammonia profile
- Better understanding of area hydrogeology
  - Aquifer material and groundwater flow velocity



Nitrate Concentrations in Groundwater

- Eldredge Park – up to ~21 mg/L (5 years historical data)
- Landfill – up to ~40 mg/L (10 years historical data)
- Library – maximum ~ 2 mg/L (one round of samples)
- Main Street near Town Cove maximum ~ 5 mg/L (one round of samples)
- Asas Landing < 1mg/L (one round of samples)

Preliminary estimate: Groundwater flow velocity is in the range of 1 to 5 feet/day so nitrate flux is high

PRB Planning and Design – Preliminary Design

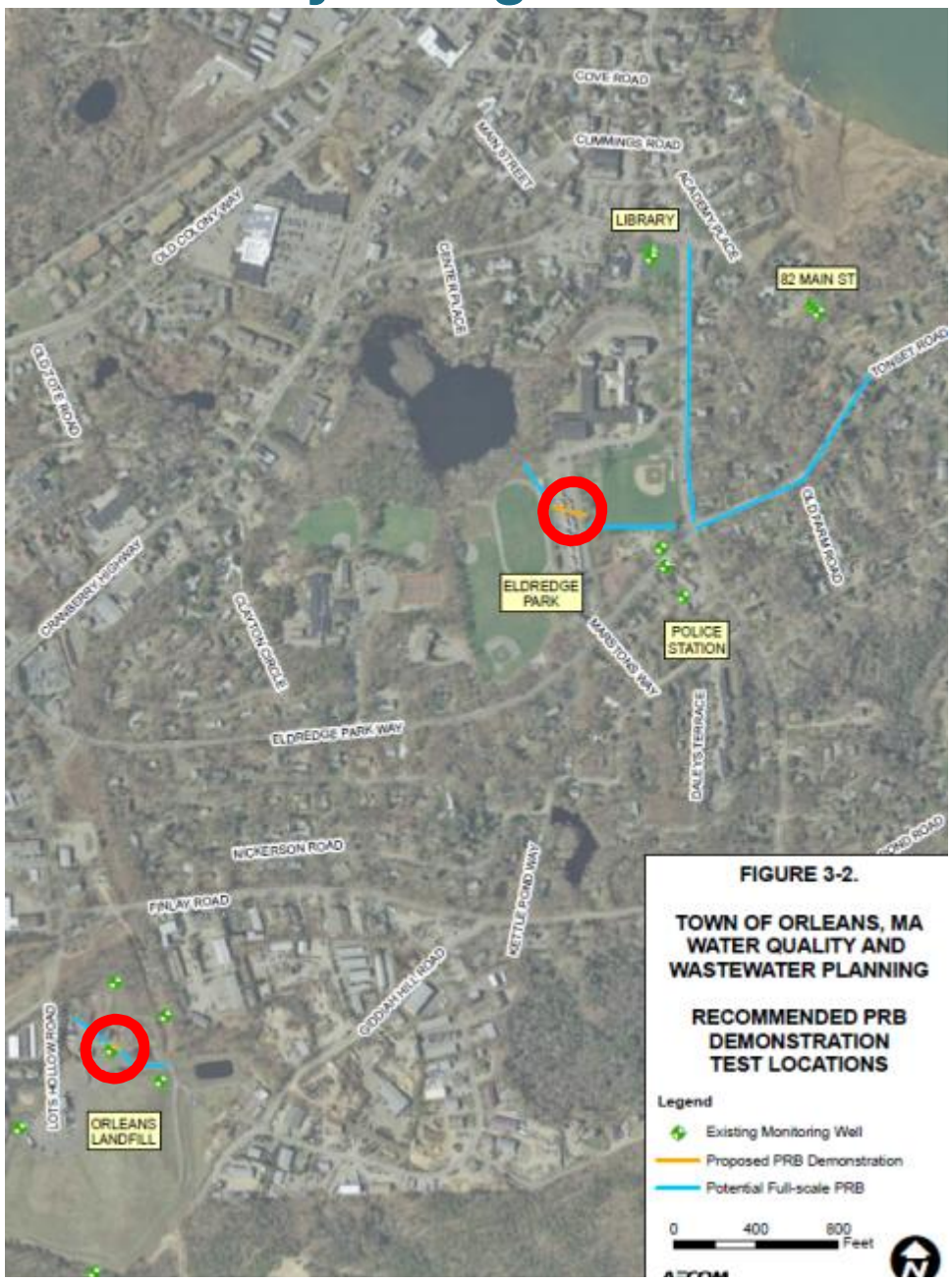
- Technical Memorandum on Preliminary Engineering Work Plan for PRBs
  - Memo finalized in May 2016
  - Preliminary Design for PRB Demonstration Tests
    - Process Description
    - Demonstration Test Objectives
    - Demonstration Test Sizing
    - Amendments and Application Methods
    - Treatment Dosages
    - Performance Monitoring

PRB Planning and Design – Preliminary Design

- Detailed Demonstration Tests
  1. Eldridge Park
  2. Town Landfill

- 50 to 200 feet long Demonstration Tests

- Assume treatment 40 feet below groundwater table



PRB Application Method – Injection

- Widely accepted groundwater treatment method and equipment readily available.
- Small equipment footprint
  - small drill rig
  - all pumps and mixing tanks contained to box truck/trailer
  - All points temporary
- Injection can generate a wider treatment zone than trench
- Application not limited by depth
- Shorter field construction time than trenching
- Injection can be performed under roadways
  - Hose ramps can be used to keep street open to traffic
  - Limited impact to traffic and abutters

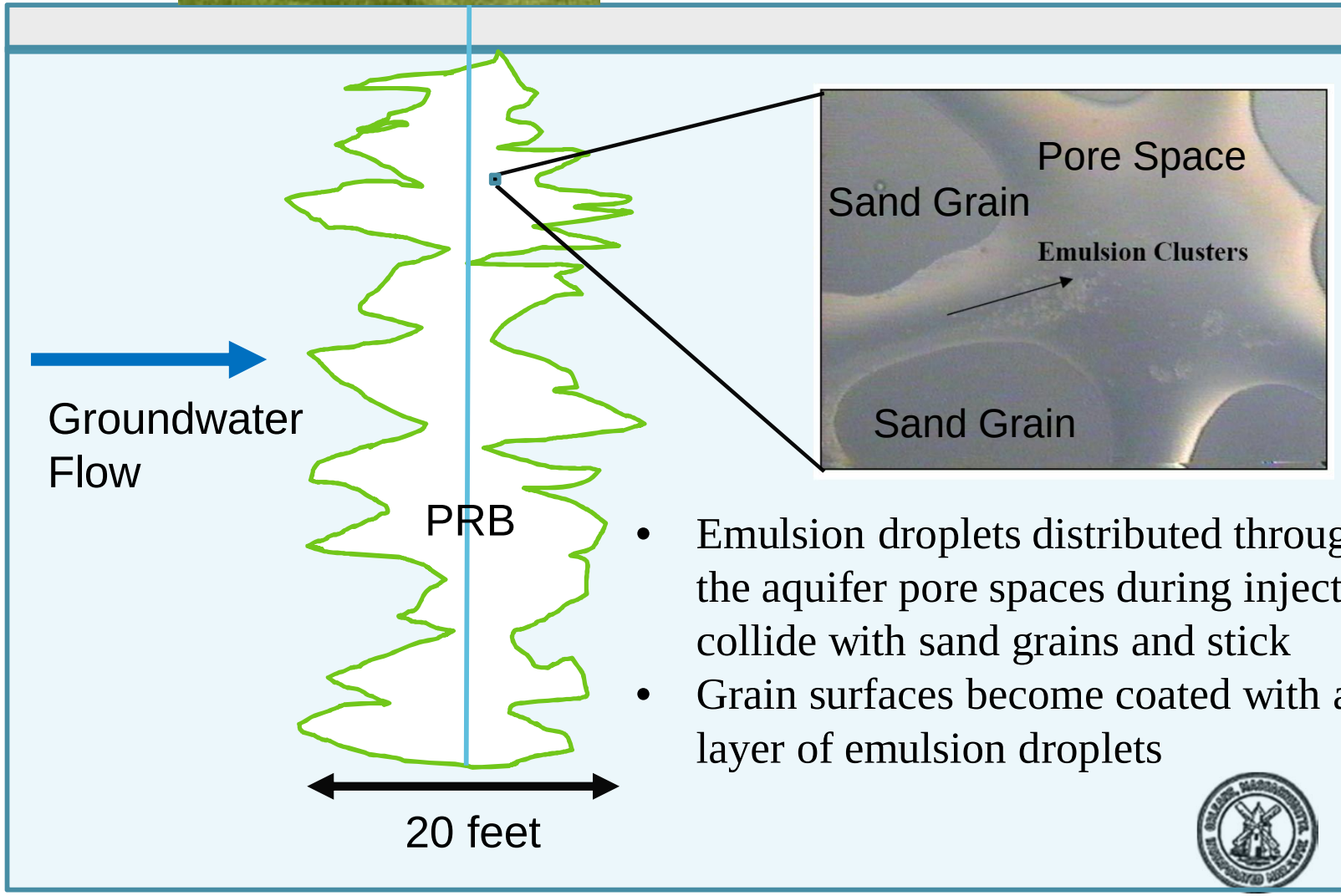
Site at end of an injection day

PRB Amendment – Emulsified Vegetable Oil

- Emulsified Vegetable Oil is a food-grade substrate made with soybean oil (oil-in-water emulsion with consistency similar to soy milk)
- Emulsion slowly releases dissolved organic carbon and provides a long term carbon source for denitrifying bacteria
- Emulsions are designed to be immobile once injected into groundwater
- AECOM experience at 10s of sites – emulsion never travels more than 100 feet (mostly less than 20 feet)
- Laboratory studies with Cape Cod sand used to develop an emulsion mixture that does not migrate (less than 3 feet in a column study)

Conceptual Cross Section of a Permeable Reactive Barrier (PRB)

Direct Injection Rig



- Emulsion droplets distributed through the aquifer pore spaces during injection collide with sand grains and stick
- Grain surfaces become coated with a layer of emulsion droplets

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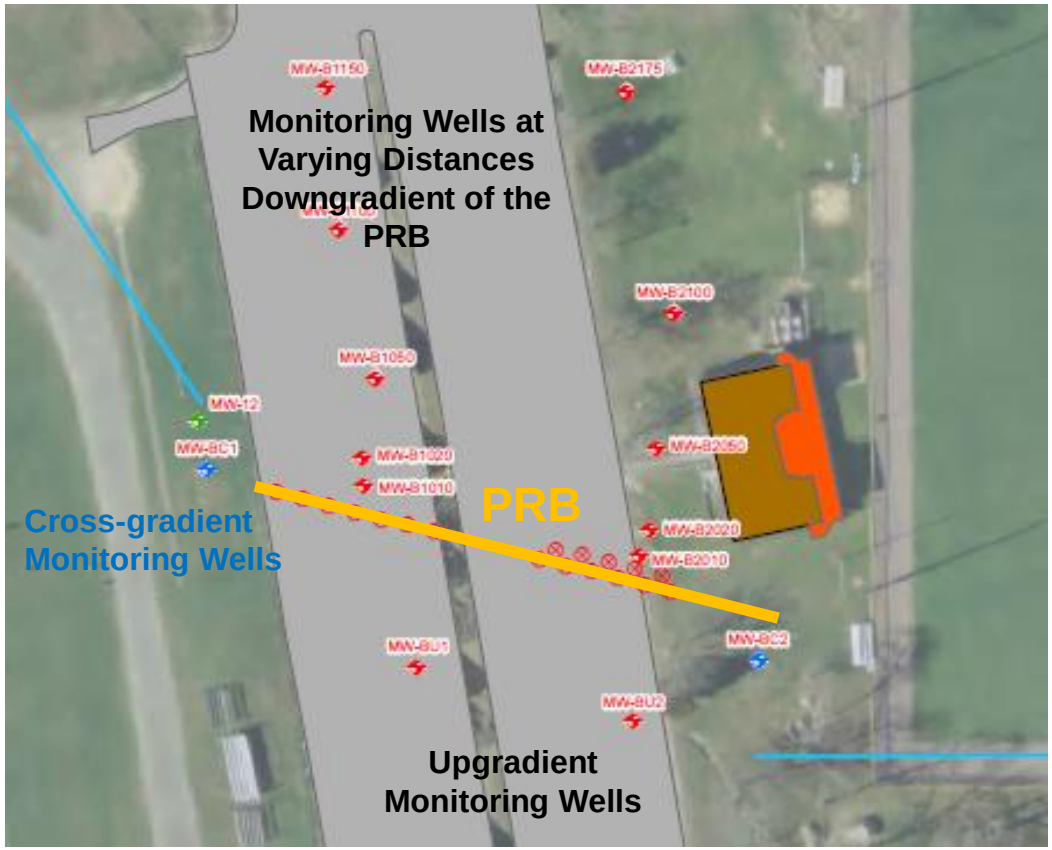
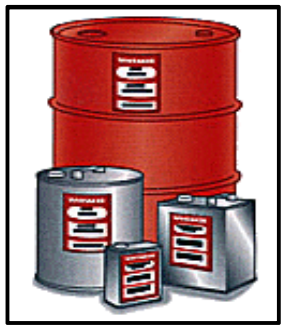
Eldredge Park PRB Demonstration Test Layout & Monitoring Overview

- 50 to 200 feet long Demonstration Test Emulsion Injection
- Upgradient and downgradient monitoring wells with quarterly sampling
- Monitoring Parameters
  - Total Nitrogen
  - Nitrate
  - Ammonia
  - Nitrite
  - Dissolved Metals
  - Sulfate
  - Dissolved Organic Carbon
  - Methane
  - Dissolved Oxygen
  - pH
  - Oxidation-Reduction Potential

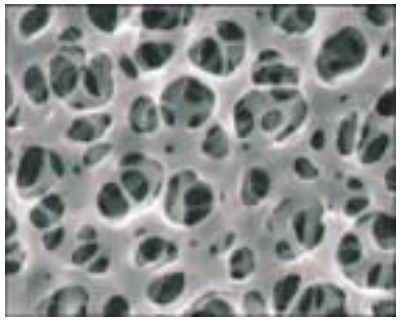


What is 1,4-Dioxane?

- **Solvent stabilizer** and acid corrosion inhibitor used to prevent decomposition of 1,1,1-trichloroethane
- Main or minor ingredient of many products
- Produced as by-product from polyester or nonionic detergent manufacturing process
- Unlikely to volatilize into soil vapor or sorb to soil particles = highly mobile



Solvent Stabilizer of 1,1,1-TCA



Main ingredient: Cellulose Acetate Membrane Production

Byproduct from detergent production

Dioxane-free detergent

1,4-Dioxane Assessment at Landfill

- 1,4-Dioxane detected at one well above GW-1 standard
  - 1.4-1.9 μg/L (MW-2D)
- AECOM PRB team to initiate Phase I assessment of 1,4-dioxane in groundwater at 5 additional locations (multiple depths per location)
- Analyses will also include nitrate and ammonia to further support extents of nitrogen sources
- Phase II 1,4-dioxane investigation to be determined based on Phase I results

- Potential for combined treatment with nitrogen to be evaluated

PRB Next Steps

- Complete Design for Demonstration Test #1 Eldredge Park – FY 2017
  - To be completed August 2016
- Implement Demonstration Test #1 Eldredge Park – FY 2017
  - Monitoring well installation – August/September 2016
  - Baseline groundwater sampling – September 2016
  - EVO Application – September/October 2016
- Town Landfill – FY 2017
  - Implement Groundwater Assessment
  - Identification and Evaluation of Alternatives for Nitrogen and 1,4-dioxane
  - Conceptual Design and Cost Estimate for the Recommended Alternative
- Town Landfill - FY 2018
  - Implement Demonstration Test #2 with Recommended Alternative
- Groundwater sampling for PRB Demonstrations – FY 2017–FY 2019

Town of Orleans Massachusetts

Thank You

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