Exhibitor Showcase

Case Study of Application of Organophilic Clay Materials for Adsorption of Petroleum along Bulkhead at Petroleum Storage Facility

November 2016

*** Unique stone-core design**

AquaBlok® Composite Particle System

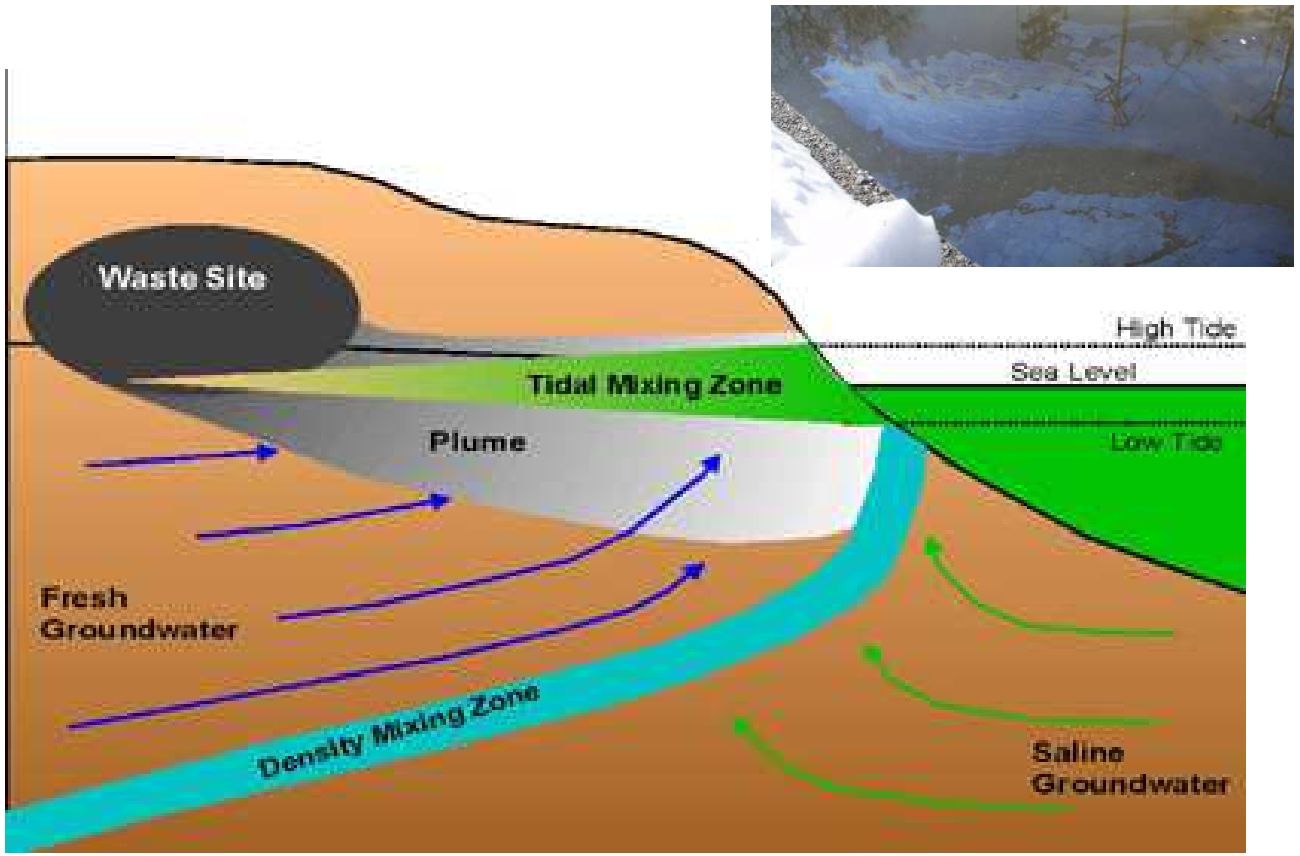
www.aquablok.com

Presentation Outline

- Problem Statement – Groundwater/Surface Water
- Introduction to AquaGate – Permeable Treatment
- Case Studies
- Summary/Questions

AquaBlok®
Composite Particle System

Problem - Ground Water to Surface Water Interaction



Examples:

- Sheen
- Dissolved Phase PAH (i.e. BTEX)
- Metals
- PCBs

AquaBlok Technology Platform

A Delivery Method for Uniform Placement of Small Quantities of High-Value Materials

- Uniform Distribution
- Flexible/Rapid Installation (Low Cost)
- Custom Blends for Targeted Designs
- Can Vary/Control Permeability
- Self-Compacting for Low Permeability
- Placement Through Standing Water
- Marine & Freshwater Blends
- Passive Adsorption/Treatment Media

powder coating

+

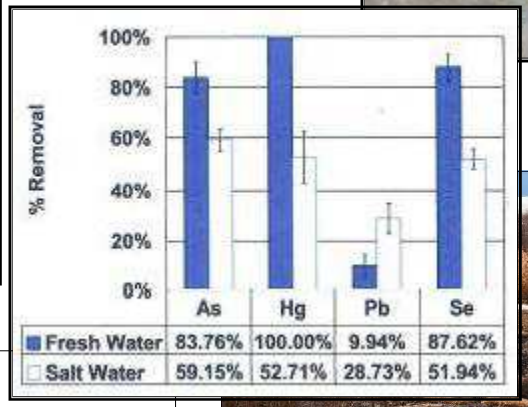
aggregate core

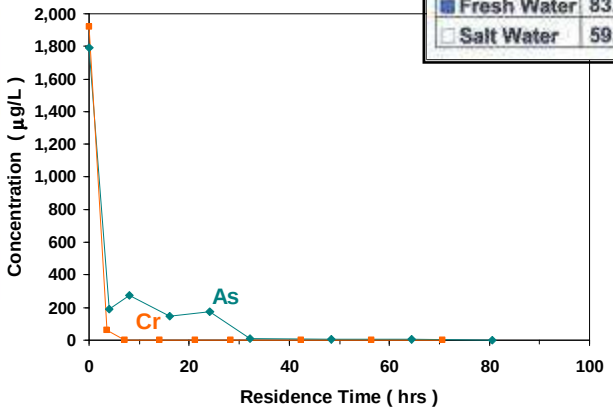
=

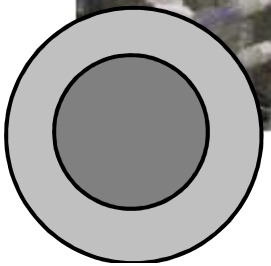
AquaBlok/AquaGate+
"composite particle"

Aquagate+ Permeable Materials for In-Situ Treatment & Remediation Applications


Refinery/PAH Sites







Range/Applications for Contaminated Water

Technologies Available – AquaGate+ Delivery

Contaminant	Treatment Materials
PAHs, Pesticides, BTEX, PCB's (Free Product / Dissolved Phase)	Activated Carbon, Provect-IRM[1], Organoclay, Rubber
Gasoline	Provect-OX[1], Oxygen Delivery, Nutrients
VOCs	Activated Carbon, Zero Valent Iron, Bimetallic
Metals, Ammonia (Arsenic, Chrome, Mercury, etc)	Sorbster[2], Zero Valent Iron, Provect-IRM[1], Zeolites, Ferric Sulfides, Organic Carbon,

[1] Provectus Product

[2] MAR Systems Product

AquaBlok® 800-688-2649

www.aquablokinfo.com

Adsorptive Material – Petroleum Based Contaminants

Aquagate+ **ORGANOCLAY**™

Aggregate: Nominal AASHTO #8 (1/4-3/8") or custom-sized to meet project-specific need * Limestone or non-calcareous substitute, as deemed project-appropriate

Binder: Cellulosic polymer

Permeability: 1 x 10^{-2} to 1 x 10^{-5} cm/sec

Dry Bulk Density: 65 – 85 lbs/ft^3

Moisture: 10 – 20% (maximum)

REMEDIATION TECHNOLOGIES
Technical Data

CETCO

ORGANOCLAY® P

ORGANIC ADSORPTION MEDIA (POWDER GRADE)

Product Description:

Organoclay® P is a proprietary powder adsorption media effective in removing oils, greases other non-aqueous phase liquids (NAPL) and other dissolved high molecular weight/low solubility organic contaminants.

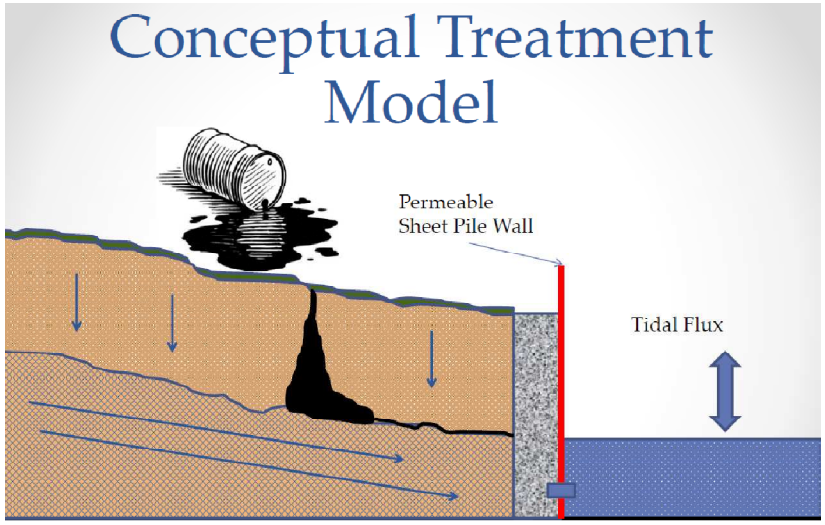
Characteristics:

- Hydrophobic; will not absorb water or swell when wetted
- Non-toxic to marine and benthic organisms
- High adsorption capacity of oils, greases and other NAPL
- Demonstrates noncompetitive sorption—can sorb multiple contaminants

Properties:

Property	Value	Test Method
Particle Size	70% Min. passing 200 mesh sieve	CETCO Test Method
Bulk Density	50-54 lbs/ft^3	CETCO Test Method
Oil Adsorption Capacity	0.5 lb/lb Min.	CETCO Test Method
Quaternary Amine Content	25% Min.	CETCO Test Method

Permeable Reactive Barrier (PRB)



Contaminated Groundwater Flow

AquaGate+ Organoclay PRB

Tidal Estuary

Lab Testing of AquaGate+ organoclay

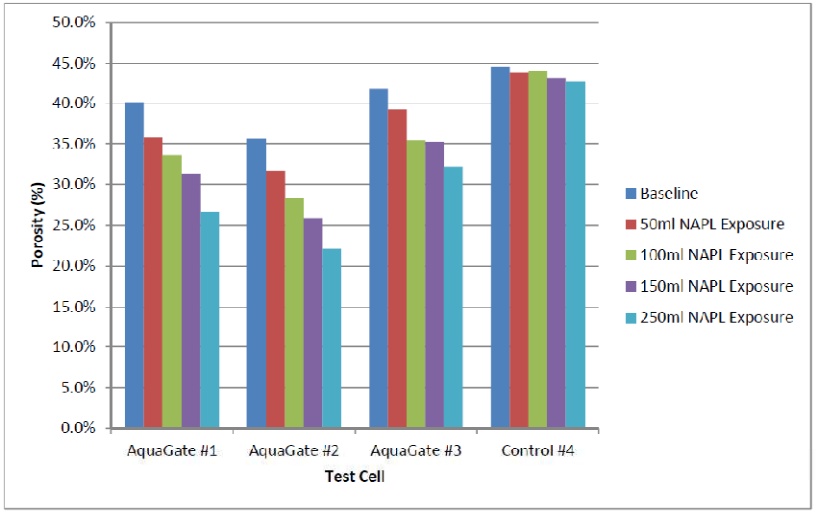


Figure 3.3 - LNAPL Influence on AquaGate Porosity

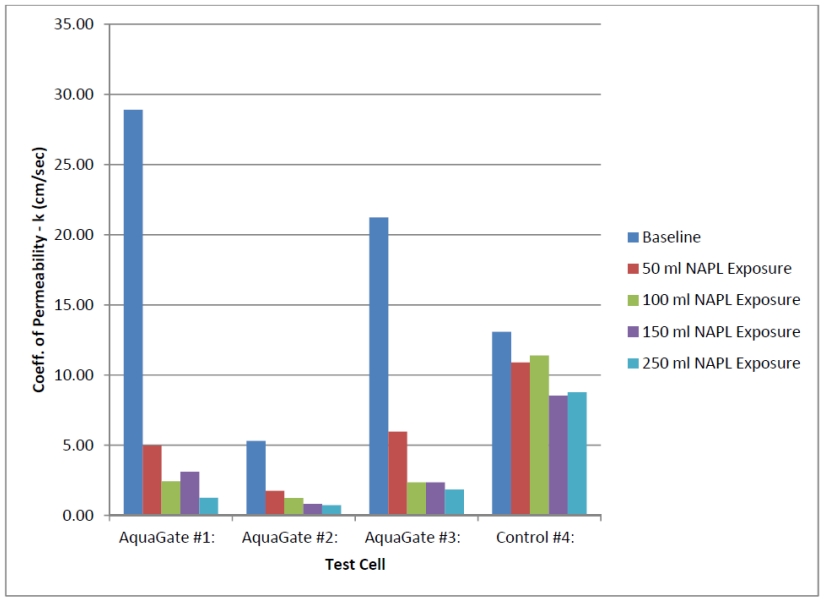
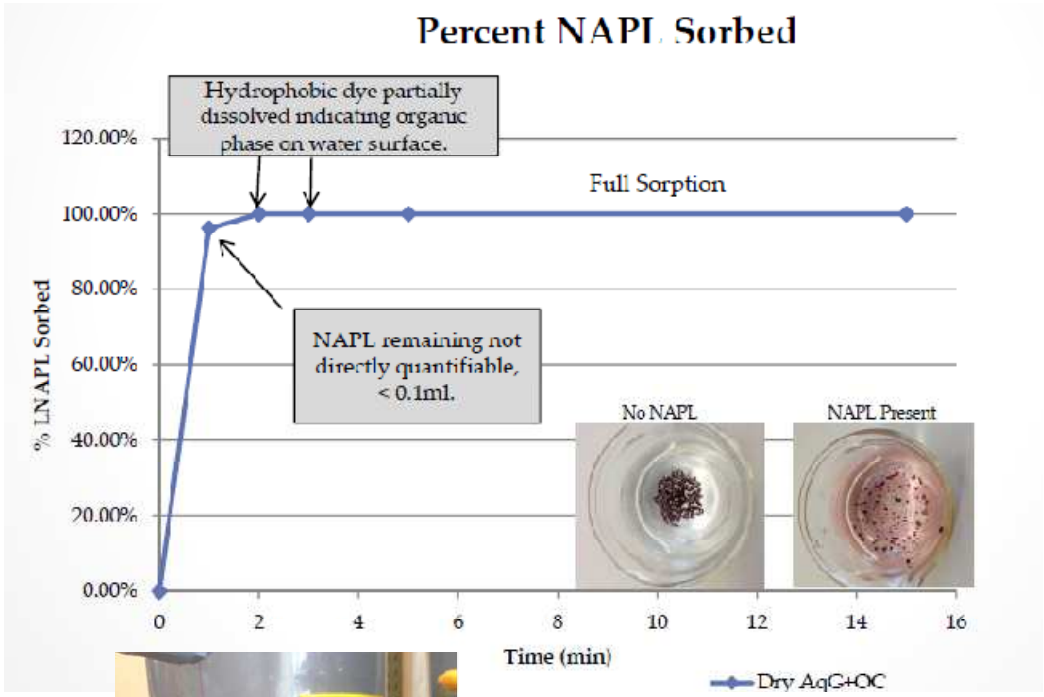


Figure 3.4 – Change in Permeability due to Increased LNAPL Exposure



(c) No breakthrough observed in AquaGate Cell profile

Example Model Output Results

Case	Media	For model (kg/m2/cm	Reactive layer Loading lb Oclay/cf	% Oclay by wt	thickness (cm)	Sand thickness (cm)	Log Koc	Initial Porewater conc(C0)(ug/L)	Surface sediment (0-10 cm) Average bulk concentration (Conc at 100 yrs	Conc at 200 yrs	Conc at 300 yrs	Conc at 400 yrs
Area A:												
Extent of removal ranges from approx 1 feet to potentially 6 feet of sediment to reach a target elevation of 573 feet												
Porewater concentrations range from 1.6 ug/L to 958.2 ug/L with a mean of 195.8 ug/L and a 95 UCL of 427.5 ug/L												
Koc index ranges from 3.7 to 5.0 with a mean of 4.3												
Active Layer Mix of Organoclay and granular media												
	Oclay	2.28	14.20	14%	7.6	30.5	4.3	427.5	24.75	281.05	439.28	482.73
	Oclay	1.52	9.47	9%	15.22	30.5	4.3	427.5	0.74	131.86	373.12	468.94
	Oclay	5.32	33.14	45%	7.6	30.5	4.3	427.5	0.02	15.03	103.24	230.87
	Oclay	**2.28**	**14.20**	**14%**	**15.22**	**30.5**	**4.3**	**427.5**	**< 0.01**	**14.47**	**142.16**	**317.19**
***	Oclay	3.8	23.67	27%	15.22	30.5	3.7	958.2	25.23	215.75	258.64	261.60
	AC	1.95	na	na	1	30.5	4.3	427.5	71.29	209.75	300.43	357.02
Area B:												
Extent of removal ranges from none to 1 feet of sediment to reach a target elevation of 573 feet												
Porewater concentrations range from < 1 ug/L to 119.9 ug/L with a mean of 23.76 ug/L and a 95 UCL of 41 ug/L												
Koc index ranges from 3.8 to 5.6 with a mean of 4.6												
Active Layer Mix of Organoclay and granular media												
	Oclay	0.76	4.73	4%	7.6	30.5	4.6	41	20.95	78.90	90.14	91.29
	Oclay	0.76	4.73	4%	15.22	30.5	4.6	41	0.11	23.04	67.93	86.38
	Oclay	**1.52**	**9.47**	**9%**	**7.6**	**30.5**	**4.6**	**41**	**0.67**	**26.21**	**62.56**	**81.30**
	Oclay	2.28	14.20	14%	7.6	30.5	4.6	41	0.02	5.63	28.73	54.64
	Oclay	2.28	14.20	14%	15.22	30.5	4.6	41	< 0.01	< 0.01	0.23	3.13
***	Oclay	3.8	23.67	27%	15.22	30.5	3.8	119.9	0.81	23.75	38.28	40.70
	AC	1.95	na	na	1	30.5	4.6	41	11.76	37.63	55.42	66.74

TETRA TECH

Post-Placement Active Material Properties Confirmation Testing & Analysis

Did the Reactive Material Placed Retain the Adsorptive Properties Assumed in the Design?

#1 Oil Sorption Capacity – Pre/Post Placement

Sample Description	Samples	Oil sorption capacity (%)
Raw Orgaoclay (Control)	1-1	71.70
	1-2	68.36
	1-3	68.61
	1-4	70.04
	1	average 69.68
As Manufactured Organoclay	2-1	65.82
	2-2	64.88
	2-3	63.44
	2-4	60.59
	2	average 63.68
Sample Buckets - (As-Placed Material Recovered from River Bottom)	3-1	62.86
	3-2	62.65
	3-3	61.40
	3-4	61.99
	3	average 62.22

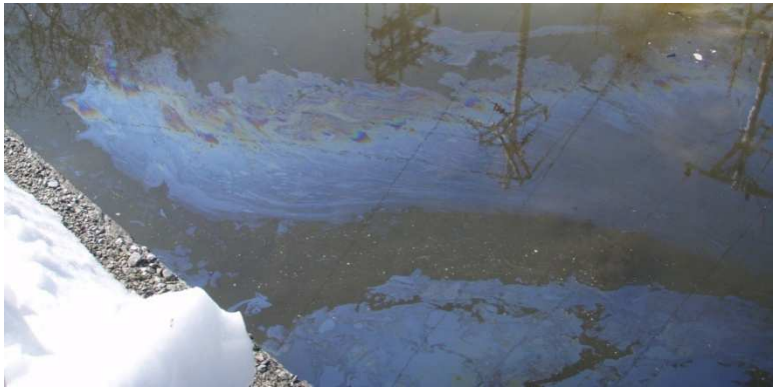
Oil Sorption Capacity (% dry wt.) for samples

Samples of material were sent to CETCO for testing utilizing Test Method: LP-Organoclay Powdered Sorption Oil Centrifuge-modified to 72 hours

Funnel & Gate Approach to Address Ground Water Impacts from MGP Site

Site Location: ***U.S. EPA Region 2***
Confidential Site – New York State

- **Setting/Purpose:** Canal/River (freshwater). MGP Site – PRB and low permeability barrier/cap over contaminated sediments. Site area was approximately 4,000 square feet.
- **Contaminant(s) of Concern:** Coal Tar associated with historic MGP site, including PAH (polynuclear aromatic hydrocarbons) and DNAPL (Dense Non-Aqueous Phase Liquids).
- **AquaBlok Cap Design/Site Area:** Multi-layer design comprised of a one inch basal layer AquaGate+ORGANOCLAY PRB covered with a hydrated layer (~6 inches in target thickness) of AquaBlok 3070FW. The cap was then armored with a two-inch layer of AASHTO #2 stone.
- **Method of AquaBlok Placement:** Shore-based excavator

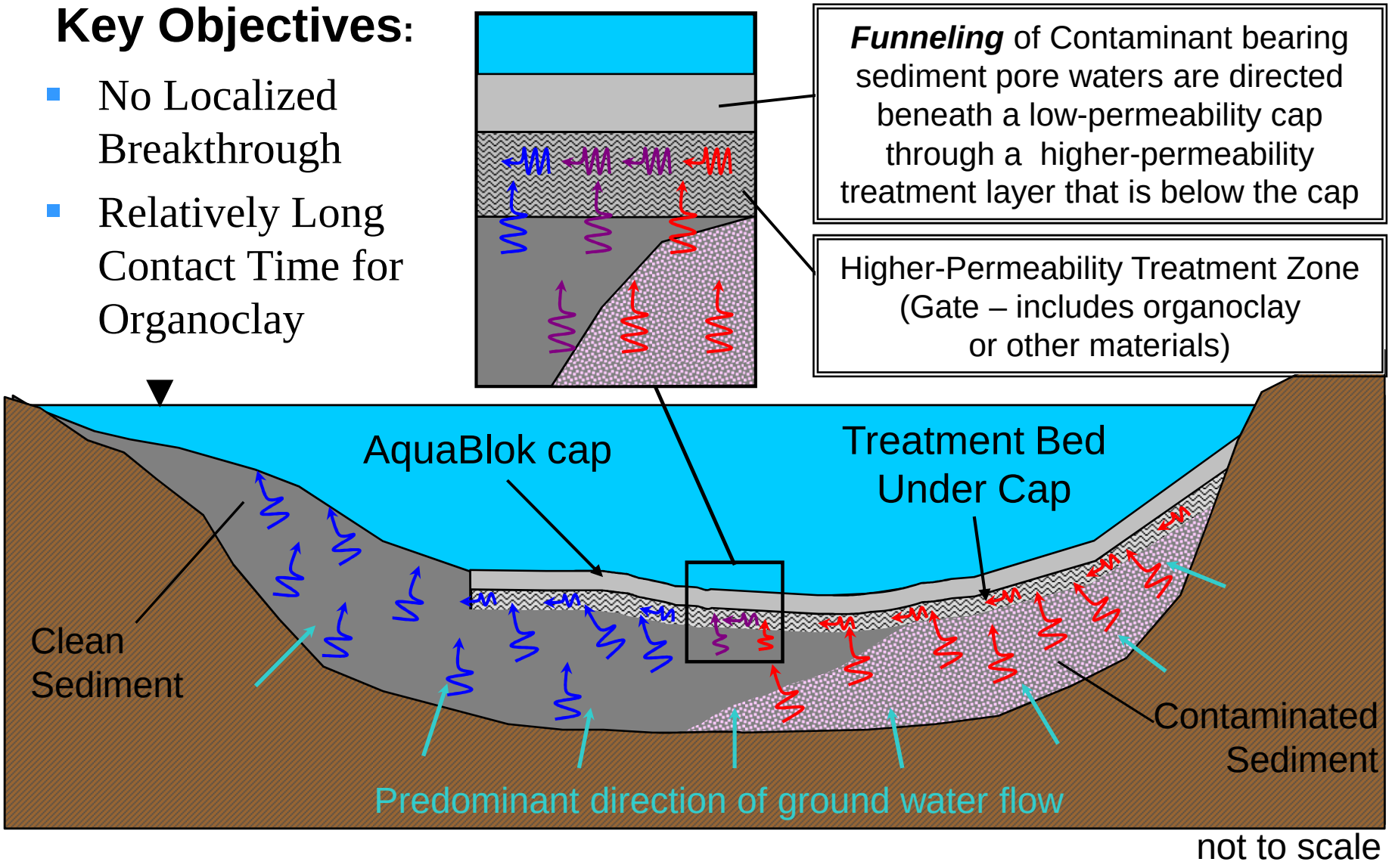


Example of Sheen

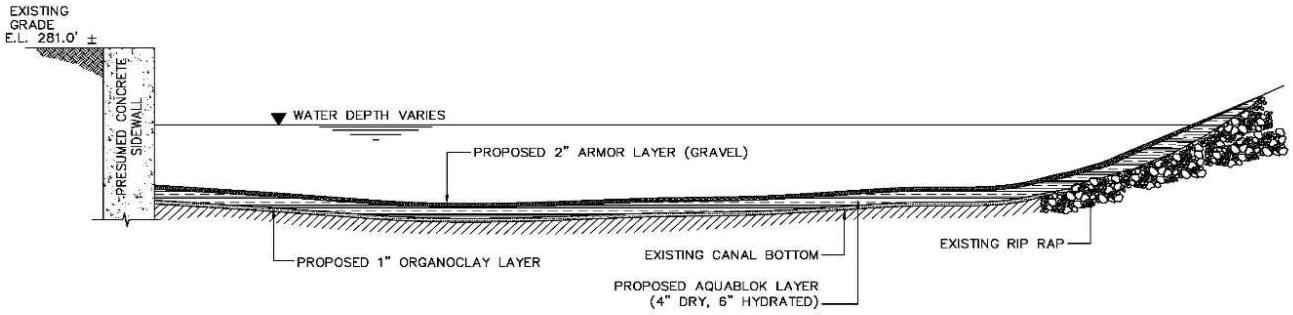
The Approach – Funnel & Gate

Key Objectives:

- No Localized Breakthrough
- Relatively Long Contact Time for Organoclay



Funnel & Gate Approach - Continued



PROPOSED SECTION A–A
SCALE 1/4"=1'–0"

Below and Right: View of AquaGate+Organoclay Being Applied & Close up View in Place

Funnel & Gate Approach - Continued

Placement of Low-Permeability Cover Layer & Armor Stone

Case Study of Funnel & Gate Approach - Continued

Completed Cap with Armor Stone - Right

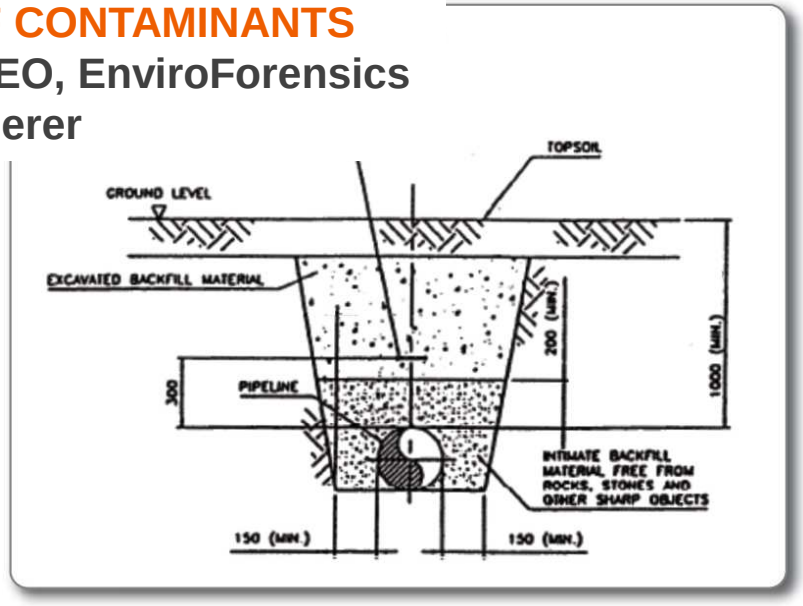
View of Completed Cap Following Spring – Water Levels Back to Normal Level - Left

Problem – Preferential Pathways

PREFERENTIAL PATHWAYS; UNDERGROUND PIPES AND UTILITY LINES CAN BE CONDUITS FOR THE MIGRATION OF CONTAMINANTS

Written by Stephen R. Henshaw, P.G., President & CEO, EnviroForensics

As seen in the March 2013 issue of Cleaner & Launderer



Typical Pipeline Construction

Preferential Flow Pathways:
Conduits for Groundwater Contamination

by Lisa Weatherford

Tuesday, February 18th, 2014

"New research by the U.S. Geological Survey USGS) concerning the vulnerability of our nation's underground drinking water supplies offers a better understanding of how contamination can occur and what we can do to stop it. Yesterday we reviewed three basic measures for drinking water analysis and today we will look at the importance of preferential flow pathways contribute to groundwater contamination."

Application Examples

Preferential Pathway - Flow Along Pipes

Setting / Purpose: Pipeline cap and Anti-Seep Collar. Objective was to cut off site contaminant pathways during excavation and installation of natural gas pipeline.

Key Benefits:

- Reduce potential impacts in Ecologically sensitive areas (River Crossings)
- Provide Seismic/Fatigue Dampening in Sensitive Areas

Installation Notes:

- Coffer Dam approach used to isolate pipe trench from surrounding soil
- Continuous measurement of AquaBlok performed to insure design thickness of cap

Handling/Installation Factors

Handling / Installation Advantages:

- Place directly through water column
- Self-compacts on bottom – hydration fills voids to create stable erosion resistant cap layer
- Conventional construction equipment used for placement
- Easy to confirm uniformity of installation (core samples)
- Handles like sand or gravel
- Can be manufactured on-site for significant cost savings

Summary – Q&A

Aquagate+

Permeable Treatment Material for Remediation Applications:

Permeable Treatment Material for Sediment Remediation Applications

- Provides Uniform Delivery of Small Quantities of a High Value Treatment Material
- Use of Powder Treatment Materials = Faster Adsorption Rates
- Creates Thicker (uniform) Layers with Less Material Usage
- Ability to Mix Treatment Materials with other Granular Capping Materials and Provide Uniform Delivery in a Single Lift - Less Risk of Material Separation Wide Range of Treatment Materials

- **Rapid Installation – Using Conventional Equipment**
- **Proven Full-Scale Production – On-Site Manufacturing**