An Innovative Air Sparging Approach for Treatment of BTEX and VOCs

Presenters:

Matt Ambrusch – Langan

Rob Gaupp – AWT

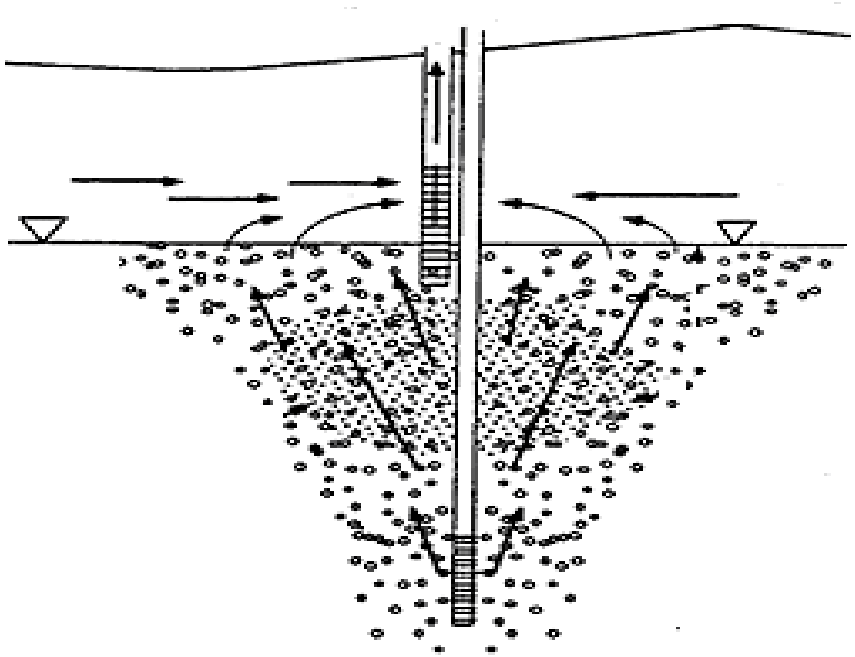
Project Team:

S. Ciambruschini, S. Abrams, O. Uppal, N. Najib and A. Quinn – Langan

T. Russo – AWT

Presentation Outline

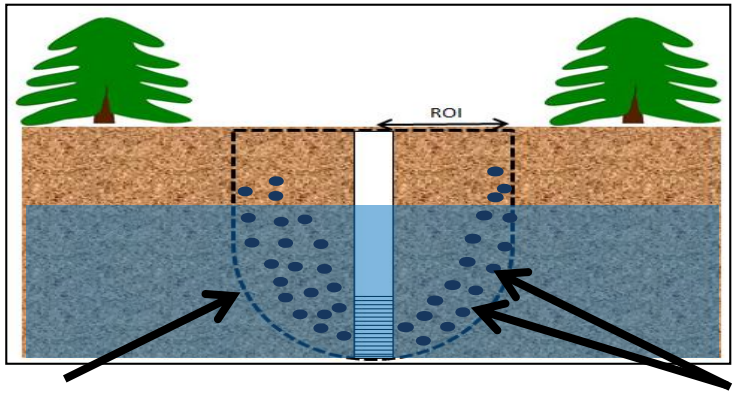
- What Really is Air Sparging?
- Site Background
- Pilot Test
- Pneumatic Modeling
- Results/Considerations
- Final Design
- Implementation



What Really Is Air Sparging

In order to **Design** and **Optimize**, you have to understand the fundamentals:

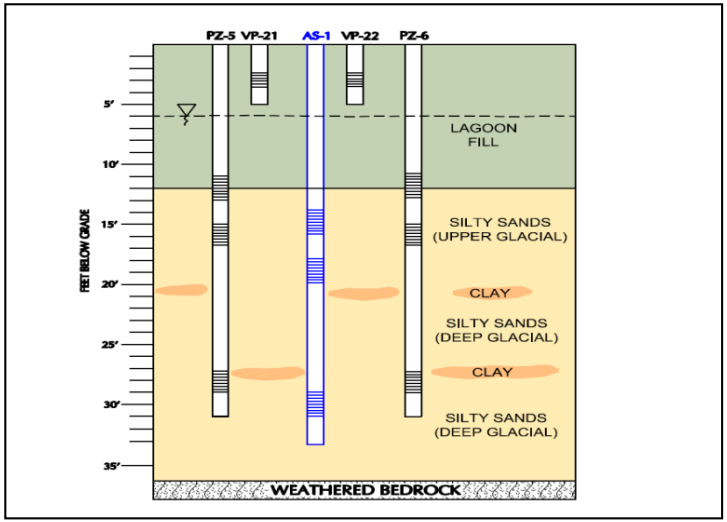
- Mass transfer from aqueous phase to vapor phase
  - Henry's Law
  - Vapor Pressure
- Design Variables
  - Contaminant(s) of Concern
  - Lithology
  - Groundwater Flow Rate
  - Air to Water Ratio
  - Temperature



Flow is Treatment, **NOT** Pressure

Site Background

- Former textile mill/pharmaceutical manufacturing plant
- Primary COCs :
  - Benzene up to 20,900 µg/L
  - Phenol up to 12,800 µg/L
  - Arsenic up to 31.2 µg/L
- Geology
  - Fill layer
  - Alluvium layer
  - Glacial Till layer
- Hydrogeology
  - Groundwater table ranges approximately 1.5 to 6.5 feet bgs

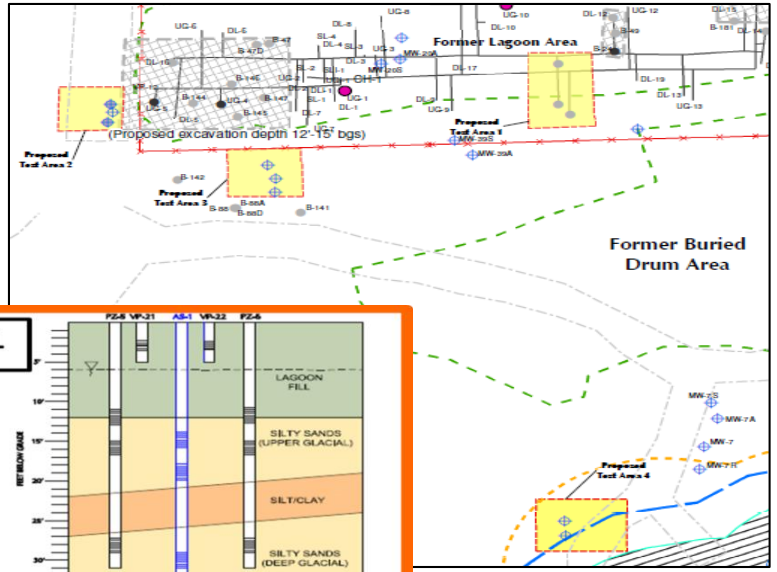


Lagoon Waste!

Pilot Test

Testing Methods

- Point Permeability
- Radius of Influence
- Helium Tracer
- Biorespiration



Parameters of Interest

- Air Flow Rate
- Pressure
- Vacuum
- Contaminant Mass Removal Rate
- Anisotropy – Vertical Profile of Pilot Test Network & Pressure Distribution

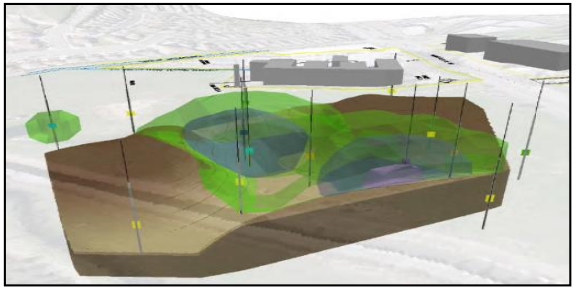
Vacuum – Flow Relationship!

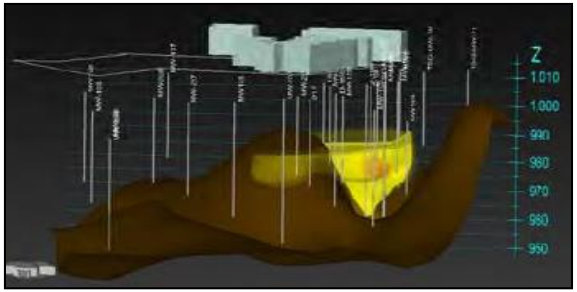
Pilot Test

Signs of air sparging on the ground surface above which active sparging is occurring…

Pneumatic Modeling – Why?

- Determine Existing Conditions
- Simulate Proposed Conditions
- Better Predict:
  - Air Flow in Complex Geologic Settings
  - System Performance
  - Compliance and Closure
- Cost-Effective and Reliable Remediation Systems
- **Saves Time and Money!**





Pneumatic Modeling – Air Stripping

Input Parameters:

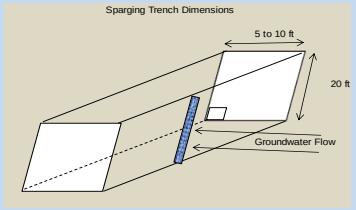
- Contaminant of Concern (i.e., Henry's Law Constant)
- Temperature
- Air Flow Rate
- Groundwater Flow Rate
- # of Air Sparge Rows

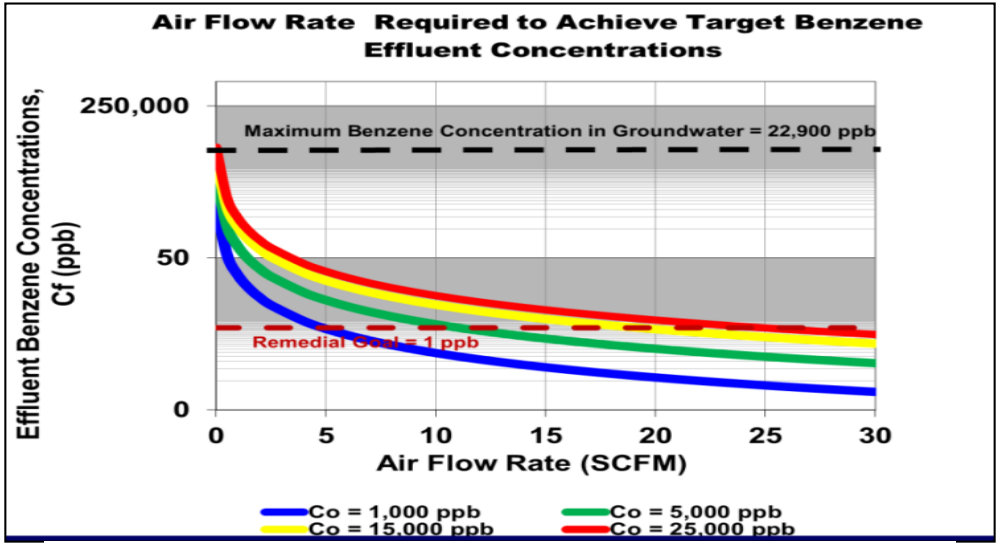
$$1-\frac{C_{L,e}}{C_{L,i}}=1-\left[1+\frac{Q_g}{Q_L}(Hc)\left(1-e^{-\phi}\right)\right]^{-1}$$

Where:
$C_{L,e}$ = COC concentration in reactor/trench effluent (ug/L),
$C_{L,i}$ = COC concentration in reactor/trench influent (ug/L),
Q_g = Gas or air flow rate (ft3/day),
Q_L = Liquid or groundwater flow rate per unit length (ft3/day),
Hc = Henry's law constant (unitless), and
φ = Saturation parameter

$$\phi=\frac{(K_La)_{COC}\cdot V}{H_C\cdot Q_g}$$

Where:
$K_{La|COC}$ = Mass transfer coefficient for COCs (1/day), and
V = Volume of reactor per unit length/porosity (ft3).





Air to Water Ratio is KEY

Pneumatic Modeling – Vapor Capture

Modeling Procedure

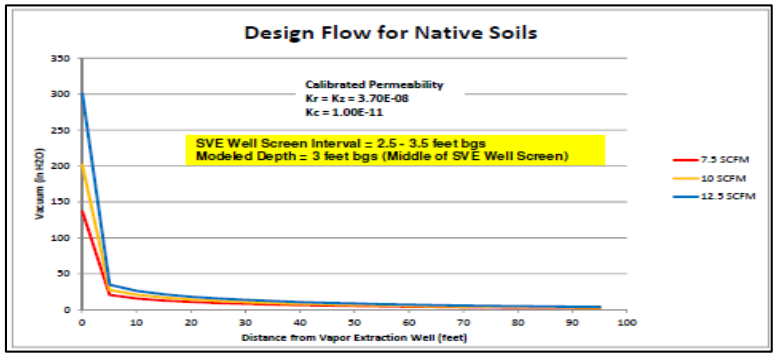
Step 1 – Conceptual Model

Step 2 – Input Pilot Test Data

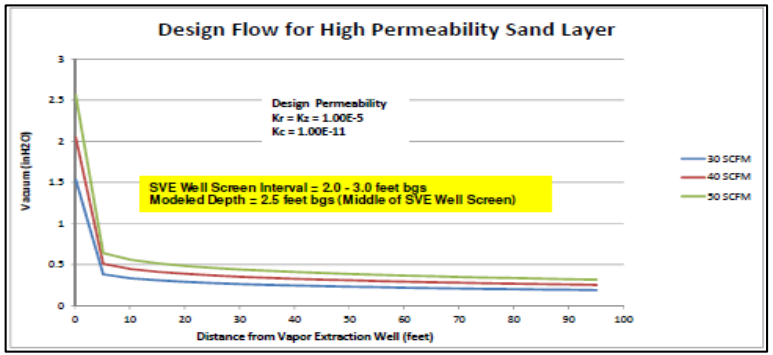
Step 3 – K_i Estimation in vertical and radial directions simulation

Step 4 – K_i Calibration

Step 5 – Predictive Modeling



VS



Native Soils **Engineered Fill**

Results/Considerations

In addition to determining the required injection and extraction flow rates and pressures/vacuums…

- Semi-Confining Layers
  - Pressure Buildup
  - Groundwater Mounding
  - Contaminant Migration
- Low Permeable Vadose Zone
- Shallow Water Table
- Leaky Confining Layer

Final Design - Components

Low Permeable Vadose Zone/Shallow Water Table

- Artificial Cap
- Horizontal Vapor Collection

Leaky Confining Layer

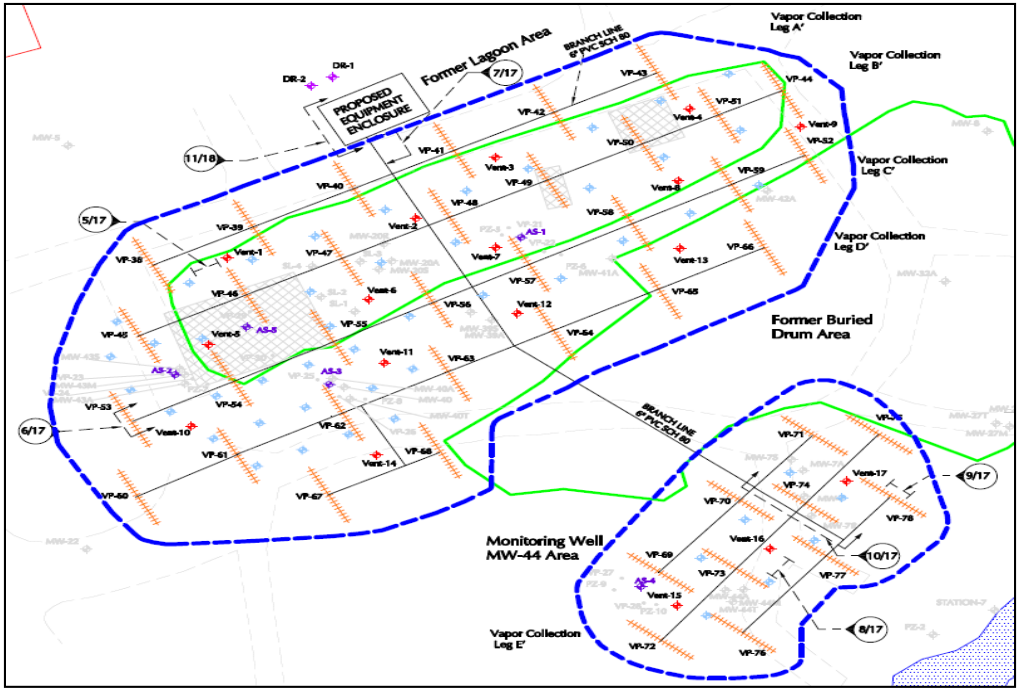
- Impermeable Membrane

Semi-Confining Layers

- Pulsing Strategy
- Chimney Wells

53 nested air sparge wells
(10-15 ft. ROI)

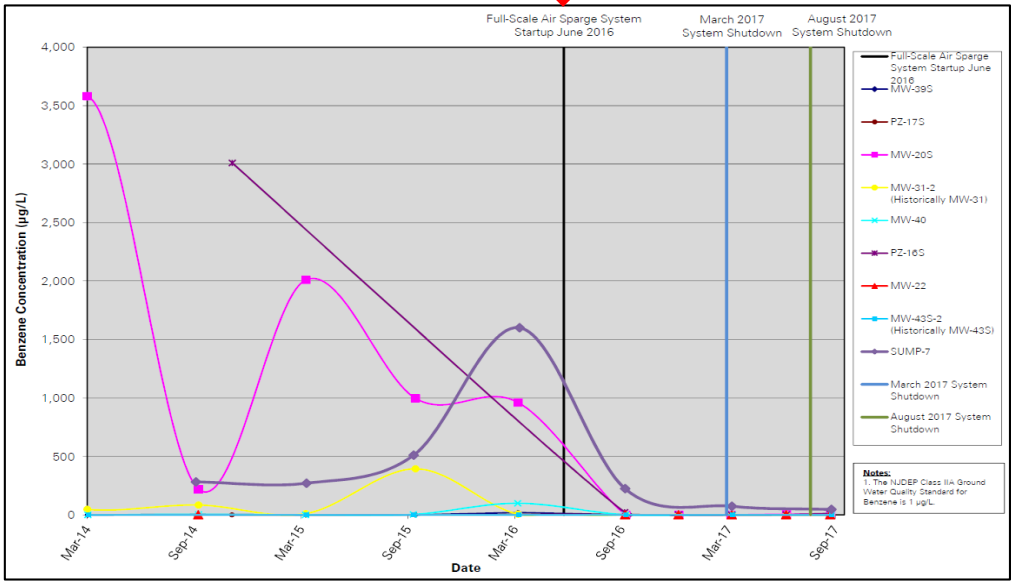
41 vapor collection wells
(15 ft. ROI)



Final Design – Initial Results

Initiated system operations June 2016…

- Mass removal **~ 62 pounds of VOCs** (based on vapor effluent)
- Some metals mobilization – oxidizing environment
- Drop in pH and increase in sulfate
  - Aerobic degradation – organic acids formation
  - Metal sulfides dissociate to metal and sulfide



Implementation

The design is only as good as the **implementation**:

- Water Management
- Instrumentation Integrity
- Well Construction
- Liner Installation

Questions?

Thank You