BASICS OF PETROLEUM REMEDIATION - 101

Geoff Schaefer, PE

October 29, 2009

MACTEC

REMEDIATION PROCESS

- Assessment
- Design
- Installation
- Operation
- Monitoring
- Closure

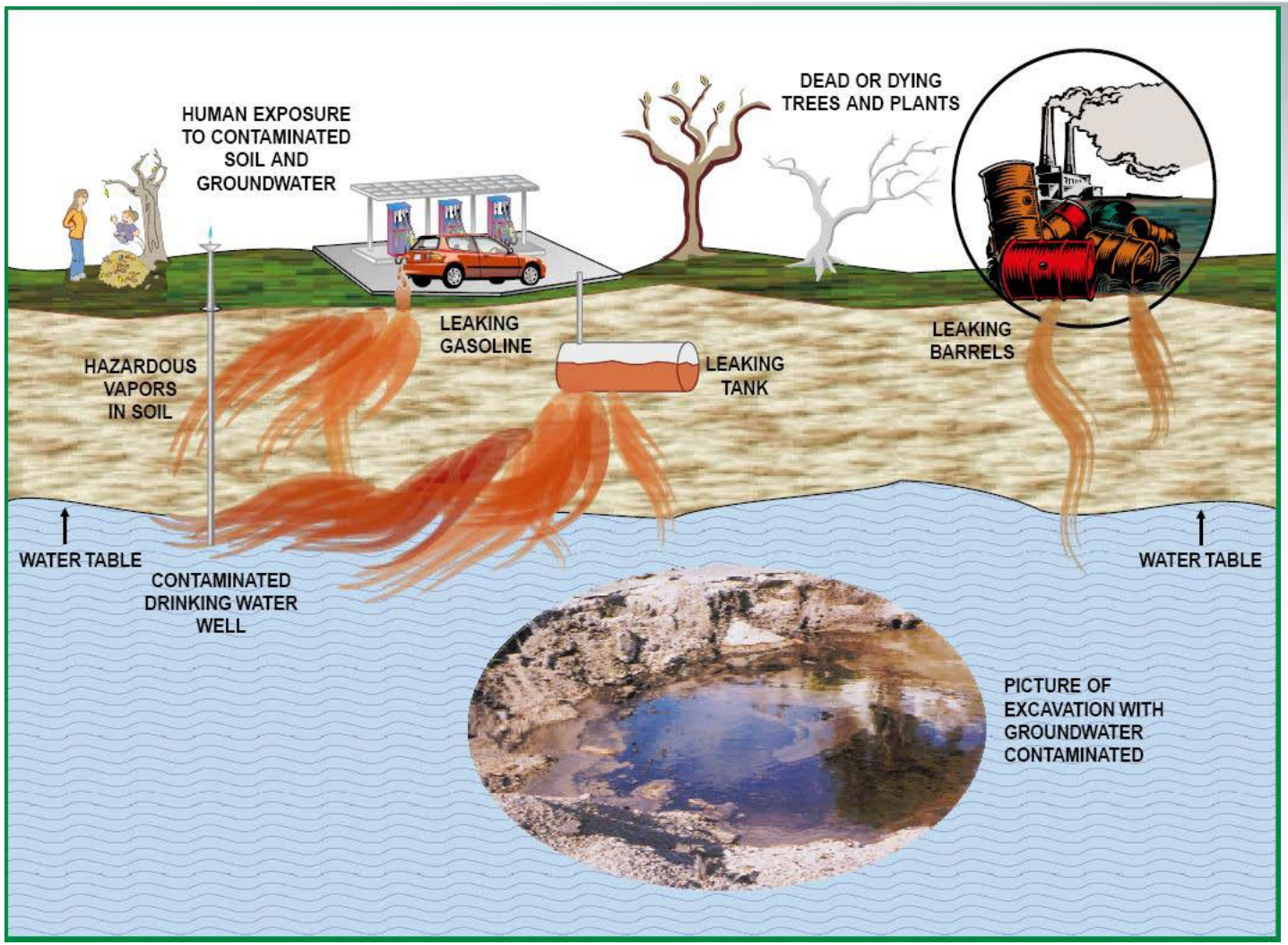
MACTEC

ASSESSMENT PROCESS

- Identify Sources
- Define Horizontal And Vertical Extent Of All Contamination
  - Free Product
  - Soil
  - Water (Groundwater And Surface Water)
  - Vapors
- Know The Regulations
- On Site Days To Weeks In Phases
- Total Duration Of Months To Years

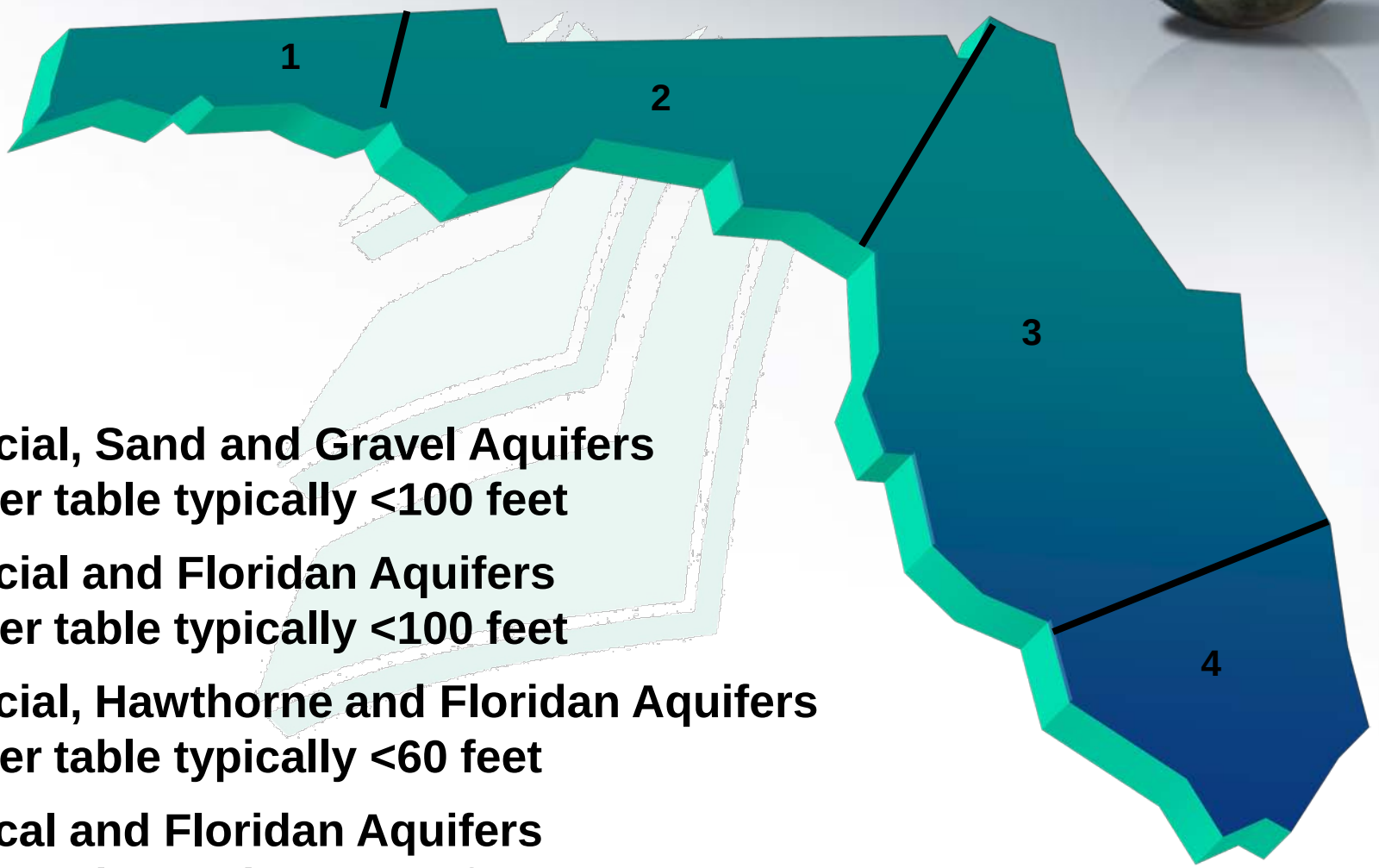
MACTEC

IDENTIFY SOURCES



MACTEC

FLORIDA'S UNIQUE HYDROGEOLOGY



1 – Surficial, Sand and Gravel Aquifers
Water table typically <100 feet

2 – Surficial and Floridan Aquifers
Water table typically <100 feet

3 – Surficial, Hawthorne and Floridan Aquifers
Water table typically <60 feet

4 – Surfical and Floridan Aquifers
Water table typically <15 feet

MACTEC

PRESUMPTIVE REMEDY ZONE 1

- Typical Cost $500K to $800K
- Conventional Excavation for Source Removal
- Large Dimensional Auger (LDA) Excavations for Source Removal
  - Clayey areas with deep water table
- Air Sparge (AS) – Soil Vapor Extraction (SVE)
- Multi-Phase Extraction when product present
- Biosparge
- Chemical & Biological Injections

MACTEC

PRESUMPTIVE REMEDY ZONE 2 & 3

- Typical Cost $500K to $1M
- LDA Excavations for Source Removal
  - Clayey areas with deep water table
- Conventional Excavations for Source Removal
  - Shallow water table and coastal areas
- AS – SVE and MPE when product present
- Horizontal Wells
- Chemical & Biological Injections
- Biosparge

MACTEC

PRESUMPTIVE REMEDY ZONE 4

- Typical Cost $400K
- Conventional Excavations for Source Removal
  - Shallow water table and coastal areas
- AS – SVE
- MPE when product present
- Biosparge
- Chemical & Biological Injections

MACTEC

DESIGN

- Pilot Testing
- Additional Sampling
- Incorporate Site Specific Considerations
  - Regulatory Requirements For Each Media
  - Active Systems
  - Passive Systems
  - System Location
- On Site Zero To A Few Days

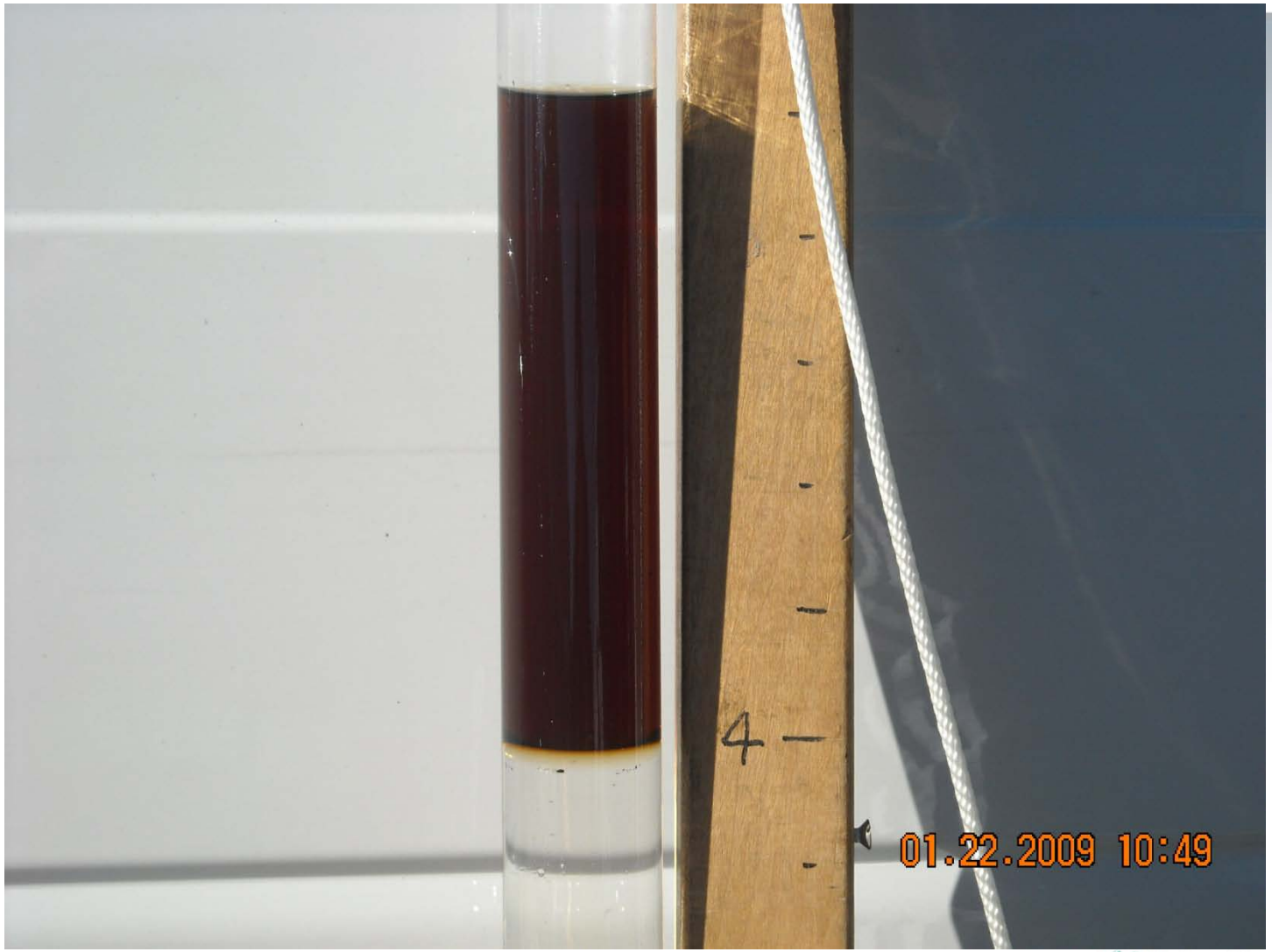
MACTEC

FREE PRODUCT REMEDIATION

- Bailer
- Sorbents
- Skimmers
- Vacuum Truck
- Multi-Phase Extraction

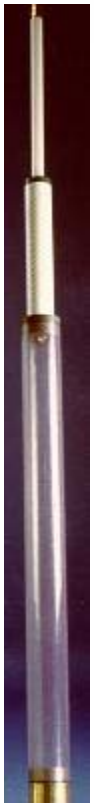
MACTEC

Bailer With Free Product



MACTEC

Sorbents And Passive Skimmer

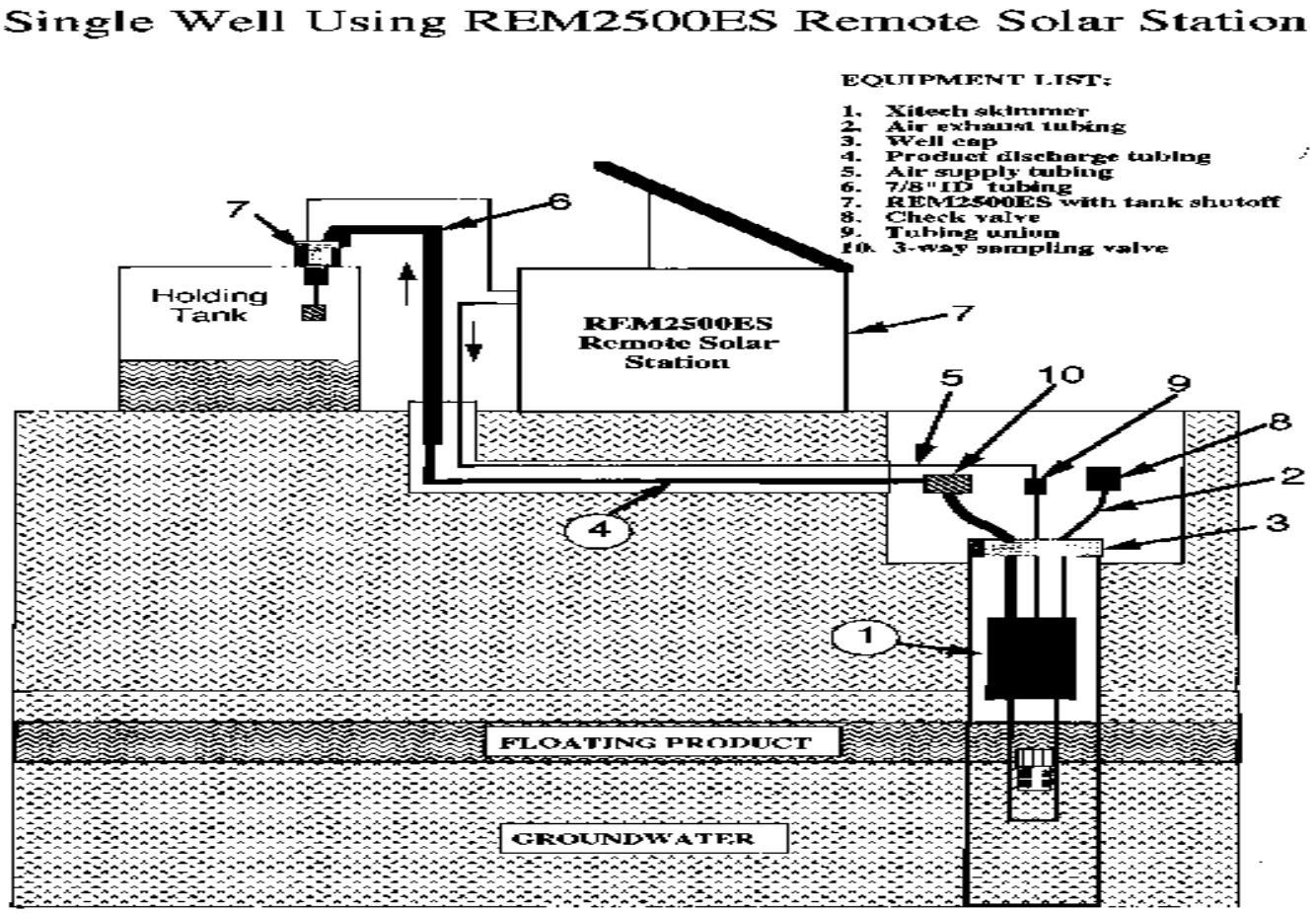


MACTEC

Solar Powered Skimmer

MACTEC

Solar Skimmer Schematic



MACTEC

Vacuum Truck

MACTEC

Soil Remediation

- Conventional Excavation
- Large Diameter Auger (LDA) Excavation
- Soil Vapor Extraction (SVE)

MACTEC

CONVENTIONAL EXCAVATION

MACTEC

SHEET PILING

MACTEC

SHEET PILING INSTALLED

MACTEC

LDA SUPPORT COLUMNS

MACTEC

LARGE DIAMETER AUGER

MACTEC

PORTABLE CONCRETE PLANT

MACTEC

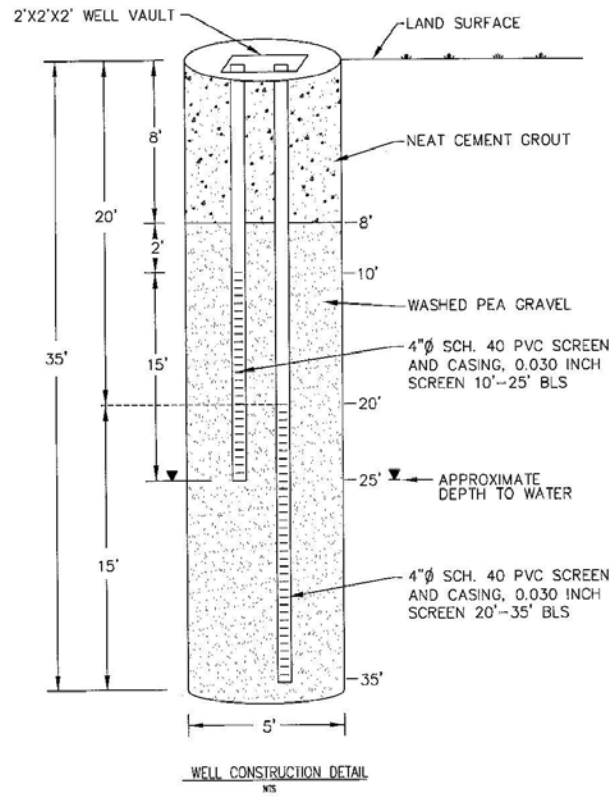
FILLING WITH FLOWABLE FILL

MACTEC

OVERLAPPING LDA HOLES

MACTEC

LDA BORING CONVERTED TO WELL



WELL CONSTRUCTION DETAIL
NTS

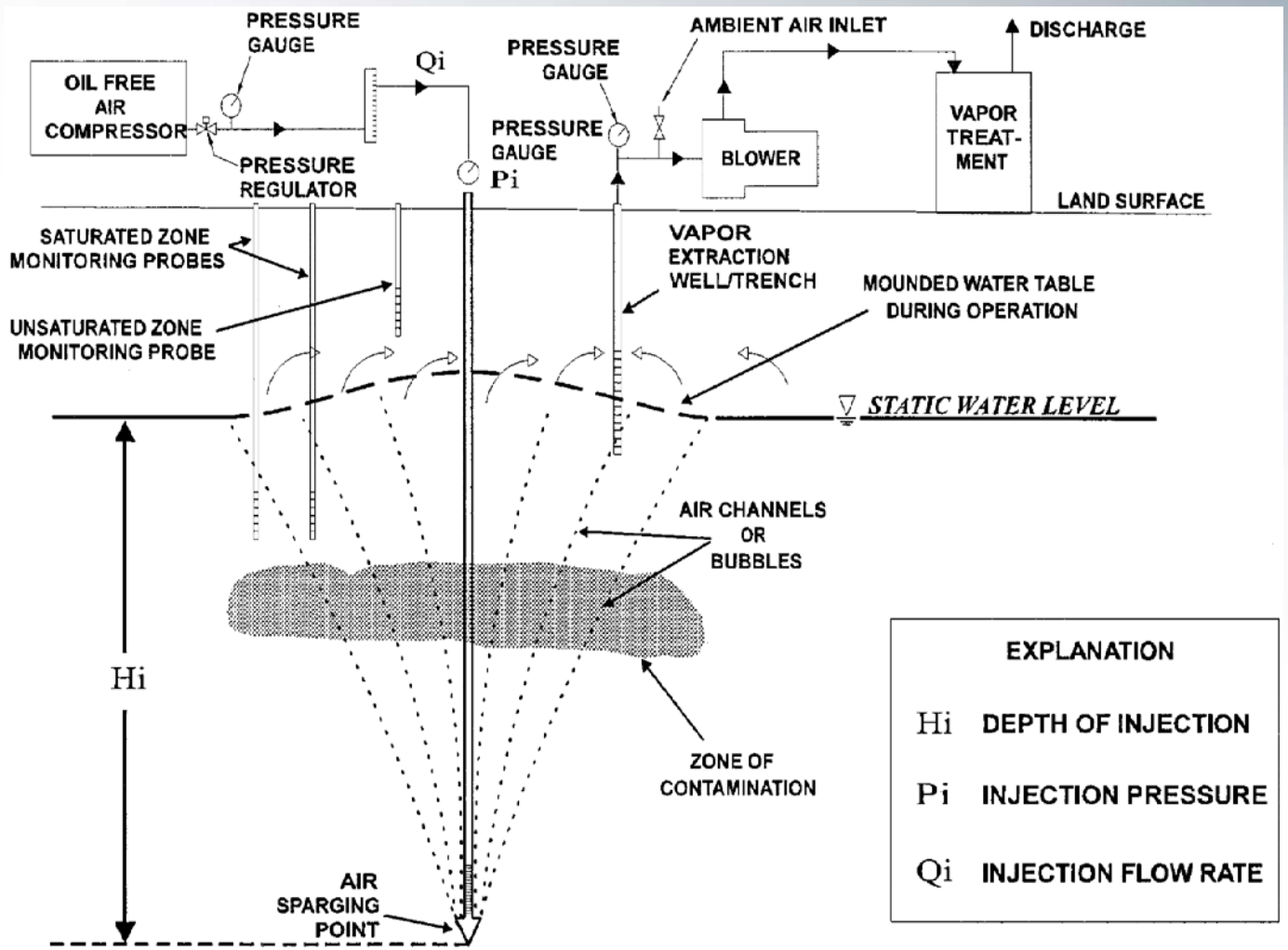
MACTEC

GROUNDWATER REMEDIATION

- Air Sparge and Vapor Extraction
- Groundwater Extraction
- Bioremediation
- Chemical Oxidation

MACTEC

AIR SPARGING AND SOIL VAPOR EXTRACTION SCHEMATIC



MACTEC

SVE SYSTEM

MACTEC

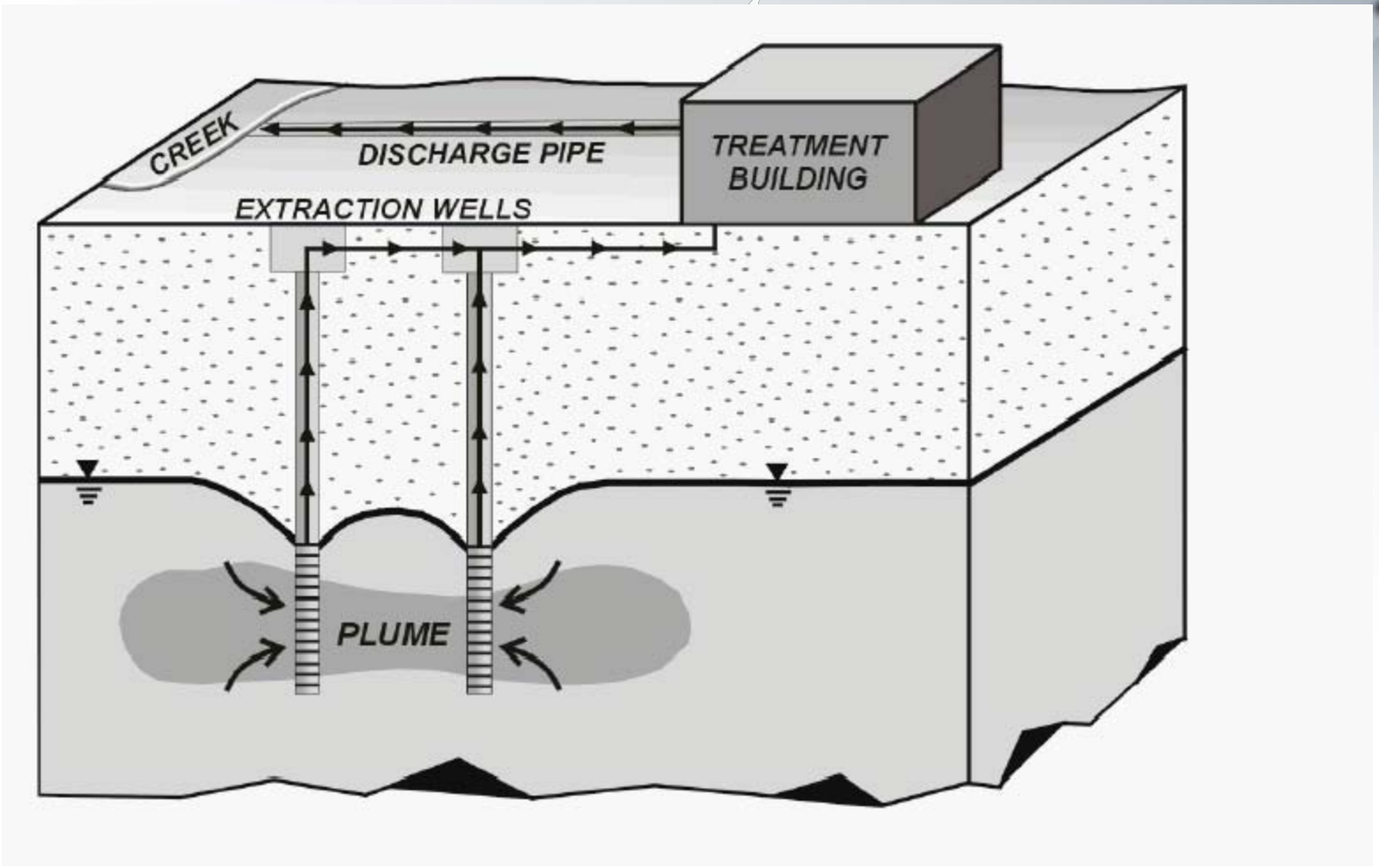
AIR SPARGE SYSTEM

MACTEC

TREATMENT SYSTEM TRAILER

MACTEC

GROUNDWATER EXTRACTION SCHEMATIC

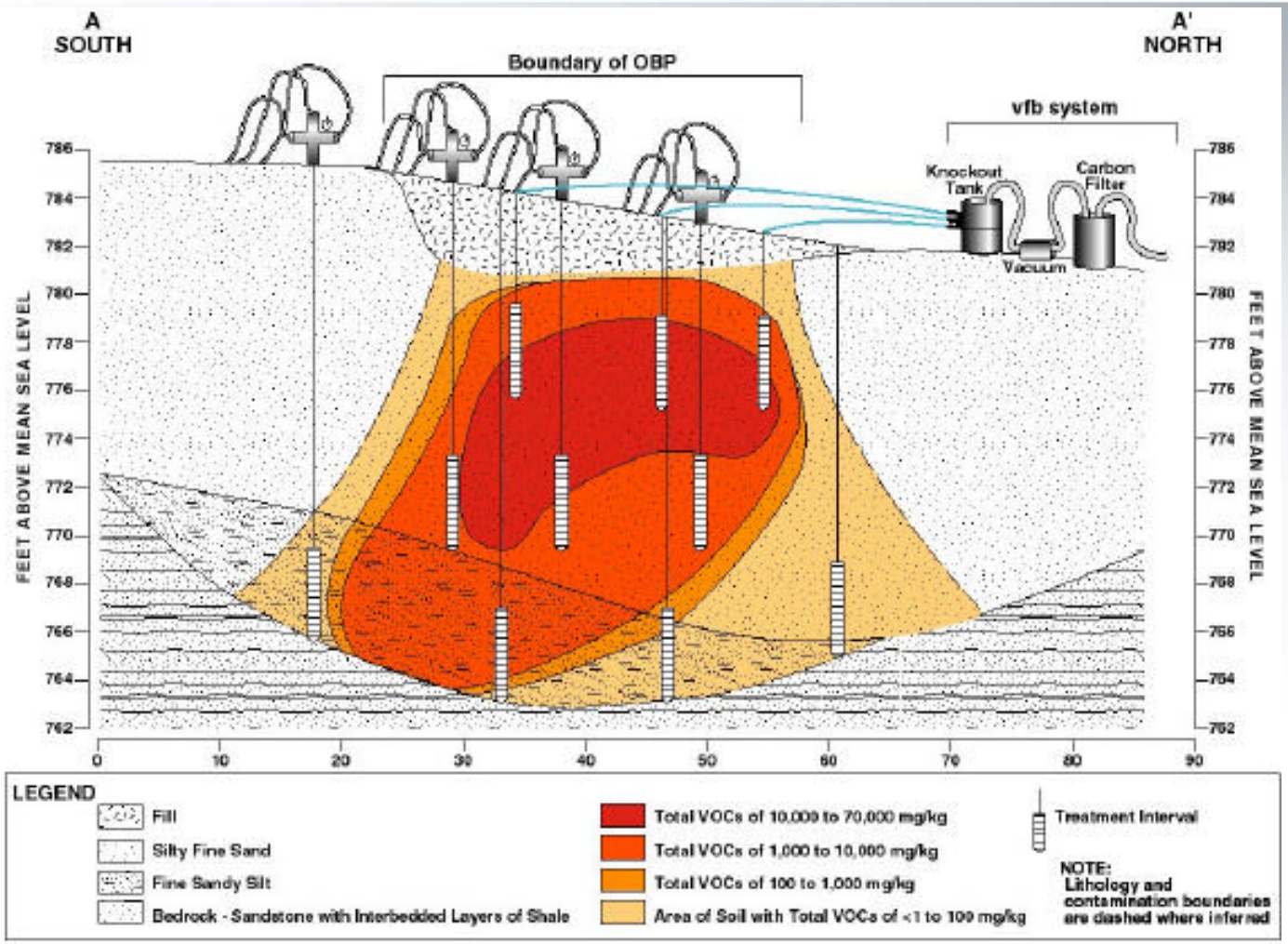


MACTEC

TREATMENT SYSTEM WITH TRAY STRIPPER

MACTEC

CHEMICAL OXIDATION OR BIOREMEDIATION SCHEMATIC



99P-1392

SCHEMATIC OF SOIL VADOSE ZONE INJECTION SYSTEM WITHIN THE OIL BURN PIT
LETTERKENNY army DEPOT

MACTEC

CHEMICAL INJECTION SYSTEM

MACTEC

IN-SITU CHEMICAL OXIDATION

- Hydrogen Peroxide/Fenton's Reagent
- Hydrogen Peroxide/Chelated Iron Catalyst
- Potassium or Sodium Permanganate
- Sodium Persulfate
- Ozone/Hydrogen Peroxide plus Ozone
- Calcium/Magnesium Peroxide

MACTEC

POTASSIUM PERMANGANATE

MACTEC

HYDROGEN PEROXIDE

MACTEC

OTHER CHEMICAL INJECTIONS/OXIDATION

- Sodium Persulfate
  - —Activated with heat or ferrous salts
  - —Relatively long lasting (hours to weeks)
- Ozone
  - —Gas generated on site
  - —Short life span (minutes to hours)
- Calcium Peroxide
  - —Works at neutral to basic pH
  - —Very long lasting (weeks to months)
  - —Encourages biological activity

MACTEC

BIO INJECTION SYSTEM

MACTEC

BIOREMEDIATION

- Aerobic vs. Anaerobic
- Biostimulation
  - Add nutrients, oxygen, etc. to stimulate existing microbes
  - Molasses, edible oil, lactate, magnesium peroxide
- Bioaugmentation
  - Add microbes, either natural or genetically engineered
  - Dehalococcoides, gene expression factor
- Natural Attenuation

MACTEC

MONITORING

- Typically Quarterly site visits to collect system and groundwater samples
- During remediation to evaluate progress
- One year post remediation to demonstrate target levels are achieved
- System Restart/Reinjection if concentrations rebound

MACTEC

CLOSURE

- Typically one to five years to achieve
- $20,000 to $5 million
- Closure with Conditions
- Clean Closure
- Regulatory Approval Order

MACTEC

MACTEC

Your Full Service Local Engineering Firm

Geoff Schaefer, PE

gdschaefer@mactec.com

850-656-1293

www.mactec.com

THANK YOU