KSC Remediation Program Briefing

Field Application of Enhanced Bioremediation at KSC

Presented to:

2007 RPM Conference

By:

KSC Remediation Team

June 2007
Pasadena, CA

Our Agenda for the next 30 minutes…

- General Site Information
- Remediation Program Update
- Decision Process Document
- Process Initiatives
- Bioremediation at KSC

Kennedy Space Center

- Location
  - KSC is located within the Cape Canaveral Barrier Island Complex
- Land Area
  - Covers 140,000 acres (6,000 for center operations); land cover mostly urban/developed & pine flatwoods
  - 92,000 acres part of the Merritt Island Wildlife Refuge
    - 310 species of birds, 25 mammals, 117 fishes, & 65 amphibians/reptiles
  - Wetlands represent ~¼ KSC property
  - Lithology is dominated by sand with varying amounts of organics, silt, & shell

Current Site Breakdown

Category	Number of Sites	Percentage of Total
No Further Action	116	58%
Corrective Measures Implementation	40	20%
Corrective Measures Study	6	3%
RCRA Facility Investigation	11	6%
Confirmation Sampling	14	7%
SWMU Assessment	11	6%
Petroleum	2	1%

KSC's Remediation Program

- RCRA Corrective Action Program
  - KSC program overseen by FDEP
  - TSCA decisions coordinated with EPA, Region 4
- KSC Remediation Team
  - Comprised of FDEP, NASA, & A&E consultants
  - Meets every six weeks to discuss site progress and make decisions on paths forward

Decision Documents

- KSC utilizes a Decision Process Document to:
  - Standardize approach for site characterization, risk assessment, etc.
  - Better define consultant requirements
  - Provide cost control for data collection & analysis, work plan preparation, report preparation, etc.
  - Provide consistency in submittals

- Four main documents:
  - Health & Safety Reference Manual (Rev 0, March 2003).
  - Environmental Setting Reference Manual (Rev 0, May 2003).
  - Sampling & Analysis Plan (Rev 2, Nov 2005).
  - Decision Process Document (Rev 1, June 2007).

Decision Documents

- Decision Process Document:
- Defines procedures and establishes process flow for:
  - Site characterization and remediation
  - Human health risk assessment
  - Ecological risk assessment
- Provides templates for standard submittals
- Describes data screening process and includes screening tables (“Appendix C”, April 2007)
- Contains Wildlife Exposure Factors & Toxicity Reference Values (TRVs)

Process Initiatives

- Background Screening Values
  - Developed for soil, groundwater, surface water, & sediments in 2000
  - Primarily for inorganic constituents as determined by soil type
- Reference Values
  - Swale soil, sediment, & surface water for general use & high-traffic areas
  - Values are for metals, PAHs, and pesticides
- Screening
  - Contaminants eliminated if concentrations within the 2x mean and/or if maximum value is within the range of background

Process Initiatives

- Preliminary Risk Evaluation
  - Implemented as an abbreviated form of human health risk assessment that uses default cleanup target levels for soil & groundwater

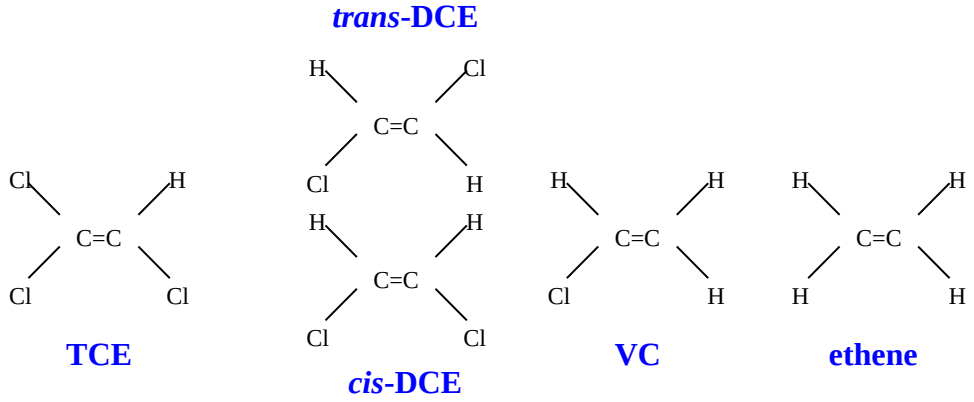
- Implemented fieldwork changes:
  - Analyze for probable site contaminants vs. RCRA Appendix IX (or CERCLA full scans or TAL/TCL).
  - Utilize Direct Push Technology for groundwater samples at 10, 25, & 35 feet bls during Confirmation Sampling/Site Investigation
  - Discontinue duplicate samples IAW FDEP standard procedures
  - Install ¾ -1 inch diameter, pre-packed microwells
    - Minimizes quantity of IDW generated

Process Initiatives

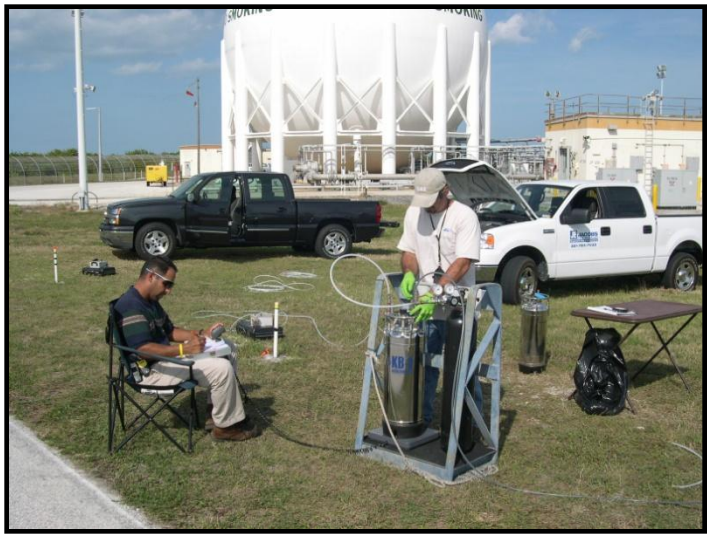
- Streamlined Steps 1-3 of the ecological risk assessment process
  - Conduct early site visit with FDEP to determine existence of viable ecological habitat prior to sampling & ecological screening
  - Developed alternate ecological screening levels with FDEP for receptors that represent assessment endpoints

Enhanced Bioremediation

- Definitions
  - Biostimulation: Adds nutrients & carbon sources to reduce VOC concentrations
  - Bioaugmentation: Adds microbes to the subsurface to reduce VOC concentrations
  - Reductive Dechlorination
    - *Dehalococcoides ethenogenes* only known organism to completely dechlorinate TCE



KSC Remediation

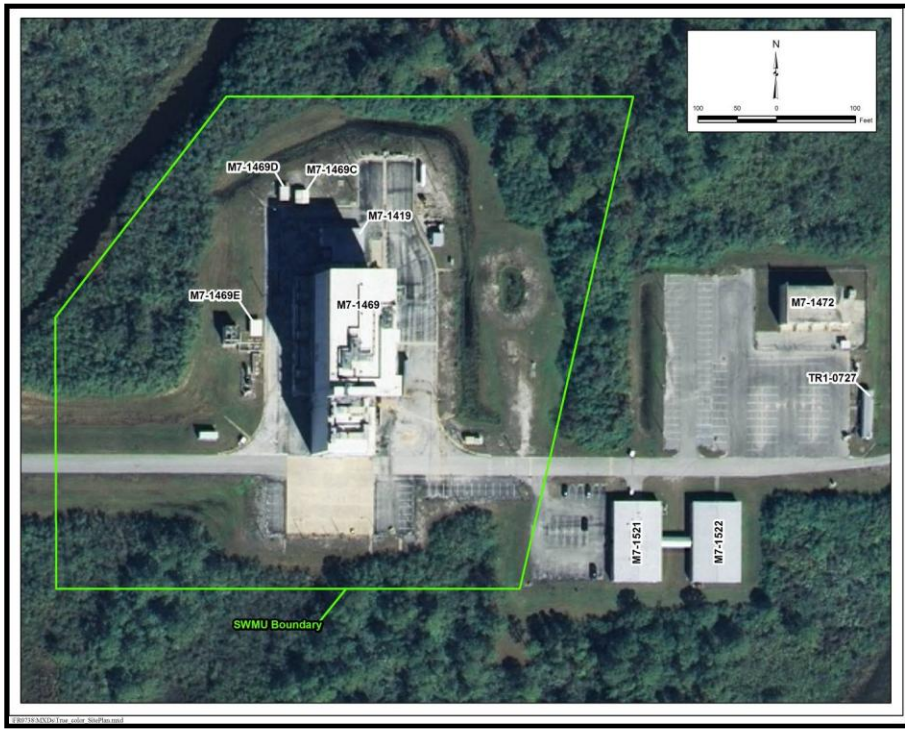


- Biostimulation
  - Vehicle Assembly Building (VAB) Area
- Bioaugmentation/Biostimulation
  - Launch Complex 39B (39B)
  - Vertical Processing Facility (VPF)
- Monitored Natural Attenuation
  - Selected remedy at over 20 sites

Vertical Processing Facility

- KSC Industrial Area: SE portion
- Plume location
  - Corresponds with former septic tank & drain field
- Source Area Assessment
  - Soil contamination footprint

    < 3,000 ft^2 & ~5 ft thick
  - Maximum Concentrations of TCE
    - Soil: 0.5 mg/kg
    - DPT groundwater: 8,750 µg/L
    - TCE MW: 754 µg/L



Vertical Processing Facility

- Remedial Action
  - Initially amended with ethyl lactate
- Problems
  - Sulfate reducers consumed electron donor
- Solution
  - Used emulsified soybean oil & augmented with KB-1

- Results/Lessons Learned
  - Sulfate reduction led to rapid dechlorination
  - Difficulties with dechlorination in areas with high sulfate concentrations (~1,000 mg/L)
  - Slow release electron donors have advantages at sites with elevated sulfate

Launch Complex 39B

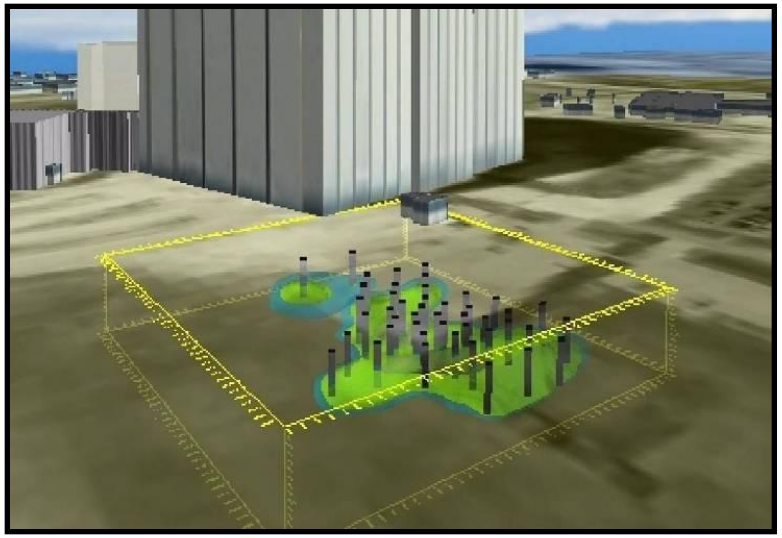
- Remedial Action
  - Ethyl lactate and augmented with KB-1
- Problems
  - Low pH
  - Discharge to adjacent wetland
- Solution
  - Low pH: Bicarbonate buffer
  - Discharge: Solar powered recirculation system
- Results/Lessons Learned
  - Bioremediation can be successfully implemented in low pH environment
  - Recirculation system was successful at preserving water quality in adjacent wetland

VAB Area

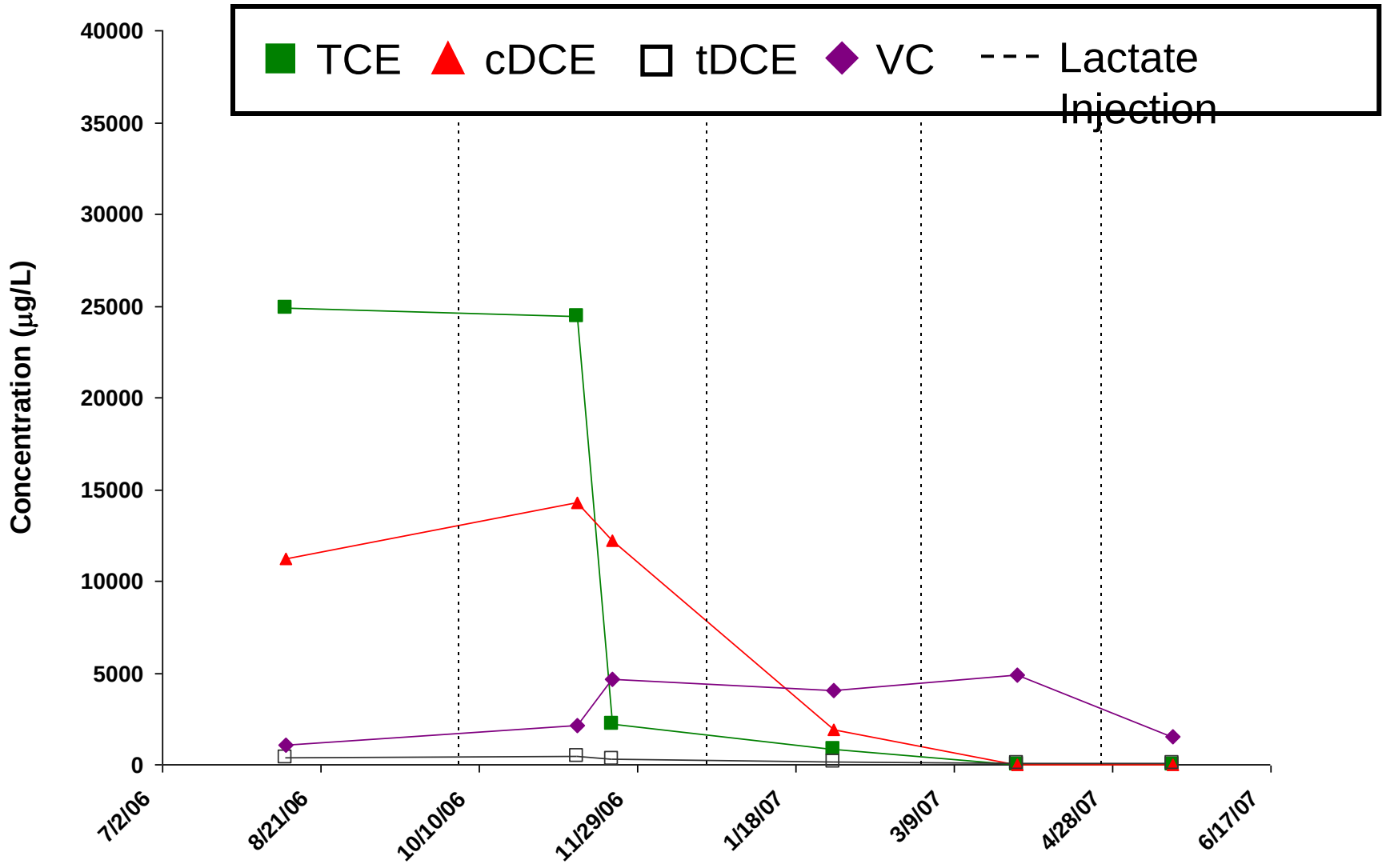
- Investigation Results
  - RFI/Pre-CMS identified TCE source zone beneath the parking lot northeast of VAB
    - Maximum TCE soil concentrations not indicative of DNAPL
    - Maximum concentrations in 40 to 48 ft BLS interval
  - CVOC ~115 acres

VAB Area Strategy

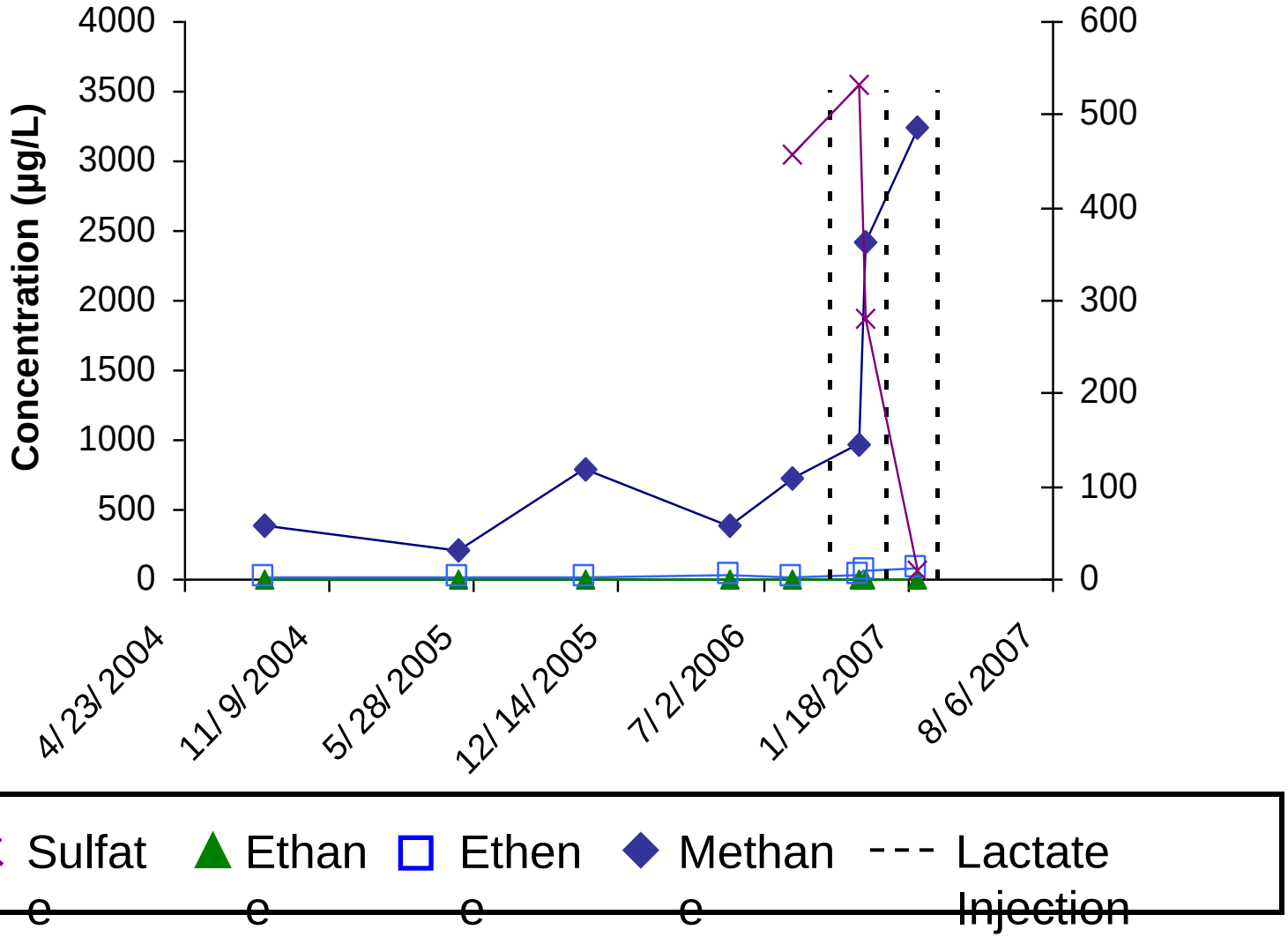
- CMS Strategy
  - Source Area: Biostimulation using ethyl lactate
  - VC Plume**:** Biosparge barrier to treat area above NADCs (NE of VAB)
  - Low concentration dissolved plume (primarily VC): MNA
- Enhanced Bioremediation using Biostimulation
  - Ethyl lactate as electron donor
  - Injection wells for delivery
- Performance Monitoring
  - CVOCs
  - Dissolved gases
  - Sulfate and Nitrate
  - Dehalococcoides & VC reductase



IW14D: VAB Area VOC Results



IW14D: VAB Area Dissolved Gases



Data Summary

	08/10/2006		01/30/2007		
Well ID	**TCE (µg/L)**	**TCE (µmol/L)**	**TCE (µg/L)**	**TCE (µmol/L)**	**% TCE Reduction**
MW-14D	24,900	190	819	6.2	96.7
SAMW-01	4,170	31.7	3,690	28.1	11.5
SAMW-02	12,700	96.7	7,940	60.4	37.5
SAMW-03	18,900	144	5,580	42.5	70.5

KSC Remediation Summary

- KSC Challenges
  - Stringent regulations protecting groundwater and surface water resources
  - Implementation under mission constraints
- Team Setting
  - NASA, FDEP, and A&Es
    - Provides expertise
    - Quick decision making
- Enhanced Bioremediation
  - Using lessons learned to maximize benefits of new treatment technology
  - A successful addition to the site remediation tool bag