# Mid-Valley Groundwater Feasibility Study

## APPENDIX P: Remedial Alternatives Cost Estimates

**Vendor Quotes and Information on Remedial Alternatives**

**November 2005**
**Draft Final Document**

## Table ES-1 Summary of Group 1 Alternatives Analysis

| Alternative | Description | Capital Cost | Discounted O&M | Total Present Worth |
|---|---|---|---|---|
| **RDX Contaminated Groundwater** | | | | |
| RDX-2 | MNA | **$54,000.00** | **$328,737.25** | **$382,737.25** |
| **TCE Contaminated Groundwater and Surface Water** | | | | |
| TCE-2 | MNA AND LTM | **$89,000.00** | **$541,545.35** | **$630,545.35** |
| TCE-3 | PRB TO PROTECT SURFACE WATER WITH MNA POLISHING AND LTM | **$2,916,309.31** | **$541,545.35** | **$3,457,854.66** |
| TCE-4 | BIOREACTIVE MAT TO PROTECT SURFACE WATER WITH MNA POLISHING AND LTM | **$1,268,661.60** | **$612,181.70** | **$1,880,843.30** |
| TCE-5 | IN SITU COMETABOLISM WITH MNA POLISHING AND LTM | **$20,637,810.38** | **$520,905.09** | **$21,158,715.46** |
| TCE-6 | IN SITU TREATMENT USING NANO-SCALE ZERO-VALENT IRON WITH MNA POLISHING AND LTM | **$2,691,758.95** | **$520,905.09** | **$3,212,664.04** |

**DETAILED CALCULATION**

**ALTERNATIVE RDX-2 - MNA**

Alternative RDX-2 would involve continuous implementation of ICs, in particular restrictions on groundwater use and implementation of a long-term groundwater monitoring program. Through the long term groundwater monitoring program the results would be evaluated for the applicability of MNA. It is assumed that ICs and the long-term groundwater monitoring would be performed for 40 years. The anticipated length of MNA will be reevaluated following review of the first two years (8 quarters) of groundwater sampling results, and development of site-specific attenuation rates.

## CAPITAL COSTS

### 1.0 Institutional Controls/Planning

**Land Use Restrictions:** A site-specific Land Use Control Implementation Plan (LUCIP) will need to be written in order to place restrictions on activities that can be performed in areas of the plumes at the Mid Valley Sites. These restrictions can be enforced through existing institutional controls and by restricting future land use. The land use restrictions will ensure that potential receptors are not exposed to contaminated groundwater from the Mid Valley plumes.

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| Paralegal | $150.00 /hr | 40 hrs | $6,000.00 |
| Lawyer | $200.00 /hr | 40 hrs | $8,000.00 |
| **Total Cost For the Land Use Control Implementation Plan:** | | | **$14,000.00** |

### 2.0 Planning, Permitting and Reporting

Permit equivalents required for this alternative will include drilling additional groundwater monitoring wells installed in the vicinity groundwater plume(s). Deliverables will include work plan, health and safety plan and a closure report. In addition, the substantive requirements for a Classification Exemption Area submittal will need to be made.

| Description | Unit Rate | Number of Units | Cost |
|---|---|---|---|
| Permit equivalents | $10,000 | Lump Sum | 10,000.00 |
| Work Plan | $5,000 | Lump Sum | 5,000.00 |
| Health and Safety Plan | $5,000 | Lump Sum | 5,000.00 |
| FSP, QAPP, and DQOs | $15,000 | Lump Sum | 15,000.00 |
| Closeout Report (Draft, Draft Final, Final) | $5,000 | Lump Sum | 5,000.00 |
| **Total Cost for Reporting** | | | **$40,000.00** |

**Summary of Institutional Control/Planning Costs**

| Description | Cost |
|---|---|
| Total Cost For Institutional Controls Plan Amendments: | $14,000.00 |
| Total Cost For Planning, Permitting, and Reporting | $40,000.00 |
| **Total Capital Cost for Institutional Controls:** | **$54,000.00** |

## OPERATION AND MAINTENANCE (O&M) COSTS

### 3.0 Long-Term Groundwater Monitoring

The long-term groundwater monitoring would be designed to evaluate the extent to which natural attenuation of the COCs is occurring, ensure that the plume characteristics are not changing in an unexpected manor, no new source areas are apparent, regulatory levels are being met, and the plume as a whole is acting as predicted.

The analytical program for the long-term groundwater monitoring program will consist of RDX and daughter products in addition to dissolved oxygen, ORP, nitrate, iron (II), sulfate, and methane. These parameters ensure monitoring of the plume for regulatory compliance as wells as monitoring for changing geochemical and oxidation reduction state. All quality control sample analysis (field duplicates, rinse blanks) are assumed to be 20% of the total number of samples collection (20% of analytical costs).

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

| | | |
|---|---|---|
| Field Sampler: | $50.00 | /hr/person |
| Number of People: | 2 | people |
| Hours worked per day: | 10 | hrs |
| Anticipated time to collect samples per location: | 1.5 | hrs |
| Number of Wells to Sample for the long-term monitoring: | 14 | wells |
| Monitoring Report per sampling event: | $3,000.00 | per event |

**DETAILED CALCULATION**

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| **COSTS PER SAMPLING EVENT** | | | |
| Labor for chemical sampling | $50.00 /hr/person | 21 hrs | $2,100.00 |
| *Chemical Analysis Cost* | | | |
| Explosives (Including RDX) | $155.00 | 17 samples | $2,635.00 |
| RDX Reductive Intermediates (MNX, DNX and TNX) | $155.00 | 17 samples | $2,635.00 |
| Hydrazine Semivolatiles | $200.00 | 17 samples | $3,400.00 |
| Dissolved Oxygen | $10.00 | 17 samples | $170.00 |
| Nitrate | $20.00 | 17 samples | $340.00 |
| alkalinity | $20.00 | 17 samples | $340.00 |
| Iron (II) | $29.00 | 17 samples | $493.00 |
| Sulfate | $20.00 | 17 samples | $340.00 |
| Methane | $110.00 | 17 samples | $1,870.00 |
| **TOTAL CHEMICAL ANALYSIS COST:** | | | **$12,223.00** |
| Monitoring Report Costs per Event | $3,000.00 per event | 1 event | $3,000.00 |
| **Total Sampling and Reporting Costs per Sampling Event** | | | **$17,323.00** |

**DESCRIPTION OF COSTS PER PHASE ADJUSTED TO PRESENT VALUE**

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Quarterly Sampling Costs for Year 1-2 (8 Quarters) | | $17,323.00 /event | 4 events | $69,292.00 |
| **Using a discount rate of** | **7%** | **for a period of** | **2 years** | **$125,281.19** |

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Annual Sample Costs for Year 3-7 (5 years annually) | | $17,323.00 /event | 1 events | $17,323.00 |
| **Using a discount rate of** | **7%** | **for a period of** | **5 years** | **$62,038.36** |

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Sampling Costs for Year 8-38 (30 years, once every five years) | | $17,323.00 /event | 1 events | $17,323.00 |
| **Using a discount rate of** | **7%** | **for a period of** | **30 years** | **$23,278.30** |

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Closure Sampling Costs Year 40 | | $17,323.00 /event | 1 events | $17,323.00 |
| **Using a discount rate of** | **7%** | **at end of** | **40 years** | **$1,156.84** |

**Total Discounted Sampling Cost:**

| | |
|---|---|
| **Years 1-2** | **$125,281.19** |
| **Years 3-7** | **$62,038.36** |
| **Years 8-38** | **$23,278.30** |
| **Year 40** | **$1,156.84** |
| **Total** | **$211,754.69** |

### 4.0 Well Abandonment and Maintenance

Since natural attenuation monitoring will occur over an anticipated period of 40 years, the groundwater monitoring wells will require maintenance to allow for accurate sampling of the aquifer. This will include inspections yearly with maintenance as needed.

| Description | Unit Rate | Number of units | Discounted Cost |
|---|---|---|---|
| Well inspection and maintenance | $2,000.00 /year | 40 years | $26,663.42 |
| Future Well abandonment | $1,150.00 /well | 14 wells | $1,075.16 |
| **Well Replacement**<br>Well replacement will be performed periodically as needed. For the purpose of this FS, the well replacement is assumed to occur every five years for the entire duration of the project. | | | |
| **Description** | **Unit Rate** | **Number of units** | **Discounted Cost** |
| Well replacement | $5,000.00 / 5 year | 40 years | $11,591.30 |
| **Total Discounted Well Abandonment and Maintenance Cost** | | | **$39,329.88** |

**Discount Rate = 7%**

### 5.0 5-Year Review

Five-year reviews will be performed to assess the effectiveness of the remedy. For the purpose of this FS, the duration for these activities is assumed to be 40 years.

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| 5-Year Review (including draft, draft final, and final reports) | | $15,000 | lump sum | $15,000.00 |
| **Using a discount rate of** | **7%** | **for a period of** | **40 years** | **$34,773.90** |

**Discounted O&M Cost:**

| | |
|---|---|
| **40-Year Sampling Cost** | **$211,754.69** |
| **Well Abandonment and Maintenance** | **$39,329.88** |
| **5-Year Reviews** | **$34,773.90** |
| **Total** | **$285,858.48** |

| | | |
|---|---|---|
| **TOTAL CAPITAL COST:** | | **$54,000.00** |
| **DISCOUNTED O&M COST:** | | **$285,858.48** |
| **Contingency of Scope:** | **5%** | **$14,292.92** |
| **Contingency of Bid:** | **10%** | **$28,585.85** |
| **TOTAL DISCOUNTED O&M COST:** | | **$328,737.25** |
| **TOTAL PRESENT WORTH VALUE:** | | **$382,737.25** |

## ALTERNATIVE TCE-2

## MNA AND LTM

Alternative TCE-2 would involve 1) MNA for the 241-3109 Plumes; and, 2) continuous implementation of ICs, in particular restrictions on groundwater use and implementation of a long-term groundwater monitoring program for the 3100/Shell Burial Area Plume, which has a continuing source that will be addressed in a subsequent FS. It is assumed that ICs and the long-term groundwater monitoring would be performed for 40 years. The anticipated length of MNA will be reevaluated following review of the first two years (8 quarters) of groundwater sampling results, and development of site-specific attenuation rates.

1) The costs are adopted from 2003 R.S. Means Site Work and Landscape Cost Book, previous work conducted by Shaw Environmental at PTA, and professional judgment.
2) The costs are adjusted with a location factor for Dover, New Jersey
3) The costs and duration of the construction activities are based on an 8-hour 5-day per week working schedule.
4) Works are to be conducted under a safety level D condition. However, a general health and safety markup of **10%** modification of safety level condition.
5) A UXO screening mark up of **40%** will be used for well installation and sampling activities.
6) Refer to **Figure 8-3** for the proposed locations

### CAPITAL COSTS

#### 1.0 Institutional Controls/Planning

**Land Use Restrictions:** A site-specific Land Use Control Implementation Plan (LUCIP) will need to be written in order to place restrictions on activities that can be performed in areas of the plumes at the Mid Valley Sites. These restrictions can be enforced through existing institutional controls and by restricting future land use. The land use restrictions will ensure that potential receptors are not exposed to contaminated groundwater from the Mid Valley plumes.

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| Paralegal | $150.00 /hr | 40 hrs | $6,000.00 |
| Lawyer | $200.00 /hr | 40 hrs | $8,000.00 |
| **Total Capital Cost For the Land Use Control Implementation Plan:** | | | **$14,000.00** |

#### 2.0 Planning, Permitting and Reporting

Permit equivalents required for this alternative will include drilling additional groundwater monitoring wells installed in the vicinity groundwater plume(s). Deliverables will include work plan, health and safety plan and a closure report. In addition, the substantive requirements for a Classification Exemption Area submittal will need to be made.

| Description | Unit Rate | Number of Units | Cost |
|---|---|---|---|
| Permit equivalents (including CEA) | $10,000 | Lump Sum | 10,000.00 |
| Design documents (drawings, specifications, design basis) - draft, draft final, and final | $15,000 | Lump Sum | 15,000.00 |
| Work Plan | $10,000 | Lump Sum | 10,000.00 |
| Health and Safety Plan | $10,000 | Lump Sum | 10,000.00 |
| FSP, QAPP, and DQOs | $15,000 | Lump Sum | 15,000.00 |
| Closeout Report (Draft, Draft Final, Final) | $15,000 | Lump Sum | 15,000.00 |
| **Total Cost for Reporting** | | | **$75,000.00** |

| Description | Cost |
|---|---|
| Total Cost For Institutional Controls Plan Amendments: | $14,000.00 |
| Total Cost For Planning, Permitting, and Reporting | $75,000.00 |
| **Total Capital Cost for Institutional Controls:** | **$89,000.00** |

#### 3.0 MNA Groundwater Monitoring (241-3109 Plumes)

The long-term groundwater monitoring would be designed to evaluate the extent to which natural attenuation of the COCs is occurring, ensure that the plume characteristics are not changing in an unexpected manor, no new source areas are apparent, regulatory levels are being met, and the plume as a whole is acting as predicted.

The analytical program for the long-term groundwater monitoring program will consist of TCE and daughter products in addition to dissolved oxygen, ORP, nitrate, iron (II), sulfate, and methane. These parameters ensure monitoring of the plume for regulatory compliance as well as monitoring for changing geochemical and oxidation reduction state. All quality control sample analysis (field duplicates, rinse blanks, trip blanks) are assumed to be 20% of the total number of samples collection (20% of analytical costs).

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

| | |
|---|---|
| Field Sampler: | $50.00 /hr/person |
| Number of People: | 2 people |
| Hours worked per day: | 10 hrs |
| Anticipated time to collect samples per location: | 1.5 hrs |
| Number of Wells to Sample for MNA: | 19 wells |
| Number of surface water sample locations: | 23 locations |
| Monitoring Report per sampling event: | $3,000.00 per event |

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| **COSTS PER SAMPLING EVENT** | | | |
| Labor for chemical sampling | $50.00 /hr/person | 63 hrs | $6,300.00 |
| *Chemical Analysis Cost* | | | |
| TCL VOCs (including TCE, DCE, and VC) | $180.00 | 51 samples | $9,180.00 |
| Dissolved Oxygen | $10.00 | 23 samples | $230.00 |
| Nitrate | $20.00 | 23 samples | $460.00 |
| alkalinity | $20.00 | 23 samples | $460.00 |
| Iron (II) | $29.00 | 23 samples | $667.00 |
| Sulfate | $20.00 | 23 samples | $460.00 |
| Methane | $110.00 | 23 samples | $2,530.00 |
| **TOTAL CHEMICAL ANALYSIS COST:** | | | **$13,987.00** |
| Monitoring Report Costs per Year | $3,000.00 per event | 1 event | $3,000.00 |
| **Total Sampling and Reporting Costs per Sampling Event** | | | **$23,287.00** |

## ALTERNATIVE TCE-2

## MNA AND LTM

**DESCRIPTION OF COSTS PER PHASE ADJUSTED TO PRESENT VALUE**

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Quarterly Sampling Costs for Years 1-2 (8 Quarters) | | $23,287.00 /event | 4 events | $93,148.00 |
| **Using a discount rate of** | **7%** | **for a period of** | **2 years** | **$168,413.28** |

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Annual Sample Costs for Year 3-7 (5 years annually) | | $23,287.00 /event | 1 events | $23,287.00 |
| **Using a discount rate of** | **7%** | **for a period of** | **5 years** | **$83,397.06** |

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Sampling Costs for Year 8-48 (40 years, once every five years) | | $23,287.00 /event | 1 events | $23,287.00 |
| **Using a discount rate of** | **7%** | **for a period of** | **40 years** | **$33,619.35** |

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Closure Sampling Costs Year 50 | | $23,287.00 /event | 1 events | $23,287.00 |
| **Using a discount rate of** | **7%** | **at end of** | **50 years** | **$790.54** |

**Total Discounted Sampling Cost:**

| | |
|---|---|
| **Years 1-2** | **$168,413.28** |
| **Years 3-7** | **$83,397.06** |
| **Years 8-48** | **$33,619.35** |
| **Year 50** | **$790.54** |
| **Total** | **$286,220.23** |

### 4.0 Long-term Groundwater Monitoring (3100/Shell Burial Area Plume)

The long-term groundwater monitoring would be used for the 3100/Shell Burial Area plume to determine whether subsequent actions were required to protect surface water and determine if MNA is applicable following completion of the source remediation, if it is required.

The analytical program for the long-term groundwater monitoring program will consist of TCL VOCs. All quality control sample analysis (field duplicates, rinse blanks, trip blanks) are assumed to be 20% of the total number of samples collection (20% of analytical costs).

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

| | |
|---|---|
| Field Sampler: | $50.00 /hr/person |
| Number of People: | 2 people |
| Hours worked per day: | 10 hrs |
| Anticipated time to collect samples per location: | 1.5 hrs |
| Number of Wells to Sample for the long-term monitoring: | 7 wells |
| Monitoring Report per sampling event: | $3,000.00 per event |

| **Description** | **Unit Rate** | **Number of units** | **Cost** |
|---|---|---|---|
| **COSTS PER SAMPLING EVENT** | | | |
| Labor for chemical sampling | $50.00 /hr/person | 11 hrs | $1,050.00 |
| *Chemical Analysis Cost* | | | |
| TCL VOCs (including TCE, DCE, and VC) | $180.00 | 9 samples | $1,620.00 |
| **TOTAL CHEMICAL ANALYSIS COST:** | | | **$1,620.00** |
| Monitoring Report Costs per Year | $3,000.00 per event | 1 event | $3,000.00 |
| **Total Sampling and Reporting Costs per Sampling Event** | | | **$5,670.00** |

**DESCRIPTION OF COSTS PER PHASE ADJUSTED TO PRESENT VALUE**

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Annual Sampling Costs for Years 1-25 | | $5,670.00 /event | 1 events | $5,670.00 |
| **Using a discount rate of** | **7%** | **for a period of** | **25 years** | **$66,075.82** |

**Total Discounted Sampling Cost:**

| | |
|---|---|
| **Years 1-25** | **$66,075.82** |
| **Total** | **$66,075.82** |

## ALTERNATIVE TCE-2

## MNA AND LTM

### 5.0 Well Construction, Abandonment, and Maintenance

Since the MNA monitoring will occur over an anticipated period of 50 years, the groundwater monitoring wells will require maintenance to allow for accurate sampling of the aquifer. This will include inspections yearly with maintenance as needed and the immediate installation of 5 new wells.

| Description | Unit Rate | Number of units | Discounted Cost |
|---|---|---|---|
| Well inspection and maintenance | $2,000.00 /year | 50 years | $27,601.49 |
| Future Well abandonment | $1,150.00 /well | 26 wells | $1,015.04 |
| New Monitoring Well installation (including 40% markup for UXO survey) | $8,400.00 /well | 5 wells | $42,000.00 |

**Well Replacement**

Well replacement will be performed periodically as needed. For the purpose of this FS, the well replacement is assumed to occur every five years for the entire duration of the project.

| Description | Unit Rate | Number of units | Discounted Cost |
|---|---|---|---|
| Well replacement | $5,000.00 / 5 year | 50 years | $11,999.11 |
| **Total Discounted Well Construction, Abandonment, and Maintenance Cost** | | | **$82,615.64** |

**Discount Rate = 7%**

### 6.0 5-Year Review

Five-year reviews will be performed to assess the effectiveness of the remedy. For the purpose of this FS, the duration for these activities is assumed to be 50 years.

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| 5-Year Review (including draft, draft final, and final reports) | $15,000 | each | $15,000.00 |
| **Using a discount rate of 7%** | **for a period of** | **50 years** | **$35,997.32** |

**Discounted O&M Cost:**

| | |
|---|---|
| **50-Year MNA Sampling Cost** | **$286,220.23** |
| **25-Year LTM Sampling Cost** | **$66,075.82** |
| **Well Construction, Abandonment, and Maintenance** | **$82,615.64** |
| **5-Year Reviews** | **$35,997.32** |
| **Total** | **$470,909.00** |

| | | |
|---|---|---|
| **TOTAL CAPITAL COST:** | | **$89,000.00** |
| **DISCOUNTED O&M COST:** | | **$470,909.00** |
| **Contingency of Scope:** | **5%** | **$23,545.45** |
| **Contingency of Bid:** | **10%** | **$47,090.90** |
| **TOTAL DISCOUNTED O&M COST:** | | **$541,545.35** |
| **TOTAL PRESENT WORTH VALUE:** | | **$630,545.35** |

## ALTERNATIVE TCE-3

## PRB TO PROTECT SURFACE WATER WITH MNA POLISHING AND LTM

Alternative TCE-3 would involve 1) installation of the PRB to protect surface water; 2) MNA polishing for the remainder of the 241-3109 Plumes; and, 3) continuous implementation of ICs, in particular restrictions on groundwater use and implementation of a long-term groundwater monitoring program for the 3100/Shell Burial Area Plume, which has a continuing source that will be addressed in a subsequent FS. It is assumed that ICs and the long-term groundwater monitoring would be performed for 40 years. The anticipated length of MNA will be reevaluated following review of the first two years (8 quarters) of groundwater sampling results, and development of site-specific attenuation rates.

1) The costs are adopted from 2003 R.S. Means Site Work and Landscape Cost Book, previous work conducted by Shaw Environmental at PTA, and professional judgment.
2) The costs are adjusted with a location factor for Dover, New Jersey
3) The costs and duration of the construction activities are based on an 8-hour 5-day per week working schedule.
4) Works are to be conducted under a safety level D condition. However, a general health and safety markup of **10%** modification of safety level condition.
5) A UXO screening mark up of **40%** will be used for remedy installation and sampling activities.
6) Refer to **Figure 8-3** for the proposed locations
7) Dimensions of the Wall Area (2 stretches of stream, directionally drilled with 2:1 slope to 10 ft bgs, 314 and 357 ft long, respectively):

| Area | PRB | | Surface Area |
|---|---|---|---|
| | Area (SF) | Thickness | Area (SF)* |
| **PRBs** | 30,061 | 0.5 | 33,067 |

* PRB area multiplied by 1.1 to account for unforseen changes due to complications in the field

## CAPITAL COSTS

### 1.0 Institutional Controls/Planning

**Land Use Restrictions:** A site-specific Land Use Control Implementation Plan (LUCIP) will need to be written in order to place restrictions on activities that can be performed in areas of the plumes at the Mid Valley Sites. These restrictions can be enforced through existing institutional controls and by restricting future land use. The land use restrictions will ensure that potential receptors are not exposed to contaminated groundwater from the Mid Valley plumes.

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| Paralegal | $150.00 /hr | 40 hrs | $6,000.00 |
| Lawyer | $200.00 /hr | 40 hrs | $8,000.00 |
| **Total Cost For the Land Use Control Implementation Plan:** | | | **$14,000.00** |

### 2.0 Planning, Permitting and Reporting

Permit equivalents required for this alternative will include drilling additional groundwater monitoring wells installed in the vicinity groundwater plume(s). Deliverables will include work plan, health and safety plan and a closure report. In addition, the substantive requirements for a Classification Exemption Area submittal will need to be made.

| Description | Unit Rate | Number of Units | Cost |
|---|---|---|---|
| Permit equivalents (including CEA) | $10,000 | Lump Sum | 10,000.00 |
| Design documents (drawings, specifications, design basis) - draft, draft final, and final | $15,000 | Lump Sum | 15,000.00 |
| Work Plan | $10,000 | Lump Sum | 10,000.00 |
| Health and Safety Plan | $10,000 | Lump Sum | 10,000.00 |
| FSP, QAPP, and DQOs | $15,000 | Lump Sum | 15,000.00 |
| Closeout Report (Draft, Draft Final, Final) | $15,000 | Lump Sum | 15,000.00 |
| **Total Cost for Reporting** | | | **$75,000.00** |

### 3.0 Site Preparations

**3.1 Clearing**

Under this alternative, areas for clearing are minimized because the installation of the PRB does not require the entire area to be cleared, only the areas along Robinson Run where the wall will be installed and accessways. For costing purposes, it is assumed only 10% of the total wall area would be cleared and that the natural material cleared shall be chipped and used elsewhere on site.

RS Means 2003 (17010106) $5,186.00 /acre
Area to be cleared and grubbed: 11,573 sf = 0.27 acres

This work will consist of the removal of all objectionable material, rubbish, debris, trees, stumps, brush, roots, rotten wood, and any other vegetation, from the limits of the work area and support facilities. The vegetative material cleared will be chipped.

| Description | Cost Code | Unit Rate | Number of units | Duration | Cost |
|---|---|---|---|---|---|
| Clear & grub, cut & chip light trees to 6" diameter | 17010106 | $5,186.00 /acre | 0.27 acres | 0.3 | $1,377.86 |
| Grub stumps and remove | 17010301 | $52.48 /EA | 25.00 EA | 0.5 | $1,312.00 |
| **Clearing Cost** | | | | | $2,689.86 |
| **UXO Screening Survey** | | **40%** | | | $1,075.95 |
| **Total Clearing Cost with H & S Markup of** | | **10%** | | | **$4,142.39** |

Estimated time required for Clearing = 1 days
MSF = 1,000 square feet

**3.2 Erosion Control (Silt Fence Construction and Maintenance):**

Prior to start of work, silt fence will be erected along the perimeter of the work areas adjacent to Robinson Run.
Silt fence will be maintained in an erect position and cleaned as required to ensure efficiency.

Required length of silt fence: 1,500 LF

## ALTERNATIVE TCE-3

## PRB TO PROTECT SURFACE WATER WITH MNA POLISHING AND LTM

| Description | Cost Code | Unit Rate | Number of units | Duration (days) | Cost |
|---|---|---|---|---|---|
| Silt fencing, vinyl, adverse conditions, 3' high | 18050206 | $2.02 /lf | 1,500 lf | 2 | $3,030.00 |
| **Additional H & S Markup of** | | **10%** | | | **$303.00** |
| **Additional Cost for UXO Screening at a Rate of:** | | **40%** | | | **$1,212.00** |
| **Total Erosion Control Cost** | | | | | **$4,545.00** |

Estimated time required for Erosion Control = 2 days

**3.3 Vehicle and Personnel Decontamination Area:**

The decontamination facility will be constructed using a geomembrane liner to contain liquids generated during the decontamination activities. The liner will be placed directly on the existing ground surface. Sand will be used to smooth existing terrain.

**Material and Installation costs for Decontamination Pad** **$5,000**
Cost based on past jobs with similar construction.

| | | |
|---|---|---|
| **Total Cost for Decon Area** | | **$5,000** |
| **Total Cost for Decon Area with H & S Markup of** | **10%** | **$5,500.00** |

Estimated time required for the construction of decon area = 2 days

**3.4 Layout and Construction Survey**

The purpose of a layout/construction survey is to assure that the proper amount of cover materials are in place. The work will consist of furnishing, placing, and maintaining the construction layout controls (stakes) necessary.

**Assumptions:**
1) Survey crew used to perform the construction layout survey will require a two person crew.

| Description | Cost Code | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Surveying Crew, 2 person survey | 99141201 | $810.27 /day | 2 days | $1,620.54 |
| **Total Cost for Survey Crew** | | | | **$1,620.54** |
| **Total Surveying Cost with H & S Markup of** | | **10%** | | **$1,782.59** |

Estimated Number of days required = 2 days

### 4.0 Construction of PRB

Construction of a PRB in four locations (on each side of two stretches of Robinson Run). Directionally drilled with 2:1 slope to 10 ft bgs. Total PRB length is 240 ft. PRBs installed to prevent surface discharge above ARARs.

| Description | Cost Code | Unit Rate | | Number of units | Cost |
|---|---|---|---|---|---|
| PRB Construction - including labor, mat'ls, drilling, hydrofracturing | Prof. Judgment | $30 | /SQ FT | 33,067 | $992,006.40 |
| Mob/Demob | Prof. Judgment | $30,000 | /lump sum | EACH | $30,000.00 |
| Cost of Iron (assume need 50 lbs/sq ft) | Prof. Judgment | $800 | /Ton | 827 | $661,337.60 |
| License Fee (15% of Construction and Iron Costs) | Prof. Judgment | $248,002 | /lump sum | EACH | $248,001.60 |
| Benchscale Testing | Prof. Judgment | $30,000 | /lump sum | EACH | $30,000.00 |
| **Total Cost for System Construction and Installation** | | | | | **$1,961,345.60** |
| **Total Cost for PRB Construction with H&S markup:** | | **10%** | | | **$2,157,480.16** |

**Estimated construction time for the PRB installation:** 4 months

### 5.0 Mobilization/Demobilization

Mobilization and demobilization consists of providing and removing all required equipment and materials to and from the Site. In addition, providing all required utilities is also included with mobilization. Mob and demob is included in the quote for the PRB installation. Mob and Demob costs for all additional activities are estimated at 10 percent of direct capital cost.

| | | |
|---|---|---|
| **Mobilization/Demobilization** | **10% of capital** | **$1,597** |

### 6.0 Construction and Technical Oversight

PRB implementation will require technical oversight during the planning and design stages and during the implementation.

| Estimated total construction time frame: | | | |
|---|---|---|---|
| | Site preparations: | 7 | days |
| | PRB Constr. | 88 | days |
| | Mob/Demob | 2 | days |

| Description | | Unit Rate | Number of units | | Cost |
|---|---|---|---|---|---|
| Data Review | | $3,000.00 | lump sum | | $3,000.00 |
| Site Visit and Meeting | | $5,000.00 | lump sum | | $5,000.00 |
| Field Engineer | ECHOS 99110402* | $2,116.00 /week | 20 | weeks | $42,320.00 |
| H&S Engineer | ECHOS 99110702* | $3,286.70 /week | 20 | weeks | $65,734.00 |
| Site Superintendent | ECHOS 99110202* | $3,220.00 /week | 20 | weeks | $64,400.00 |
| **Total Cost for Construction and Oversight** | | | | | **$180,500.00** |

*Bare cost from ECHOS was multiplied by 2.3 to account for overhead and profit

## ALTERNATIVE TCE-3

## PRB TO PROTECT SURFACE WATER WITH MNA POLISHING AND LTM

### 7.0 Travel and Per Diem

| | | |
|---|---|---|
| Construction time | 97 | days |
| Estimated total number of field laborers/crew: | 6 | |
| Estimated daily travel and per diem cost per crew: | $157.00 | per day |

| Item | Cost Code* | Unit Rate | Number of Units | Cost |
|---|---|---|---|---|
| Travel and per diem | Professional judgment | $157.00 per man/day | 582 man/days | $91,374.00 |
| **Total Cost For Travel and Perdiem** | | | | **$91,374.00** |

**SUMMARY OF CAPITAL COSTS:**

| | | |
|---|---|---|
| **1) Institutional Controls/Planning** | | **$14,000.00** |
| **2) Planning, Permittin, and Report Writing** | | **$75,000.00** |
| **3) Site Preparations** | | **$15,969.98** |
| **4) Construction of PRB and Monitoring Wells** | | **$2,157,480.16** |
| **5) Mobilization/Demobilization** | | **$1,597.00** |
| **6) Construction and Technical Oversight** | | **$180,500.00** |
| **7) Travel and Per Diem** | | **$91,374.00** |
| **Contingency of Scope** | **10%** | **$253,592.11** |
| **Contingency of Bid** | **5%** | **$126,796.06** |
| **TOTAL CAPITAL COST** | | **$2,916,309.31** |

## OPERATION AND MAINTENANCE (O&M) COSTS

### 8.0 MNA Groundwater Monitoring (241-3109 Plumes)

The long-term groundwater monitoring would be designed to evaluate the extent to which natural attenuation of the COCs is occurring, ensure that the plume characteristics are not changing in an unexpected manor, no new source areas are apparent, regulatory levels are being met, and the plume as a whole is acting as predicted.

The analytical program for the long-term groundwater monitoring program will consist of TCE and daughter products in addition to dissolved oxygen, ORP, nitrate, iron (II), sulfate, and methane. These parameters ensure monitoring of the plume for regulatory compliance as well as monitoring for changing geochemical and oxidation reduction state. All quality control sample analysis (field duplicates, rinse blanks, trip blanks) are assumed to be 20% of the total number of samples collection (20% of analytical costs).

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

| | | |
|---|---|---|
| Field Sampler: | $50.00 | /hr/person |
| Number of People: | 2 | people |
| Hours worked per day: | 10 | hrs |
| Anticipated time to collect samples per location: | 1.5 | hrs |
| Number of Wells to Sample for MNA: | 19 | wells |
| Number of surface water sample locations: | 23 | locations |
| Monitoring Report per sampling event: | $3,000.00 | per event |

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| **COSTS PER SAMPLING EVENT** | | | |
| Labor for chemical sampling | $50.00 /hr/person | 63 hrs | $6,300.00 |
| *Chemical Analysis Cost* | | | |
| TCL VOCs (including TCE, DCE, and VC) | $180.00 | 51 samples | $9,180.00 |
| Dissolved Oxygen | $10.00 | 23 samples | $230.00 |
| Nitrate | $20.00 | 23 samples | $460.00 |
| alkalinity | $20.00 | 23 samples | $460.00 |
| Iron (II) | $29.00 | 23 samples | $667.00 |
| Sulfate | $20.00 | 23 samples | $460.00 |
| Methane | $110.00 | 23 samples | $2,530.00 |
| **TOTAL CHEMICAL ANALYSIS COST:** | | | **$13,987.00** |
| Monitoring Report Costs per Year | $3,000.00 per event | 1 event | $3,000.00 |
| **Total Sampling and Reporting Costs per Sampling Event** | | | **$23,287.00** |

## ALTERNATIVE TCE-3

## PRB TO PROTECT SURFACE WATER WITH MNA POLISHING AND LTM

**DESCRIPTION OF COSTS PER PHASE ADJUSTED TO PRESENT VALUE**

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Quarterly Sampling Costs for Years 1-2 (8 Quarters) | | $23,287.00 /event | 4 events | $93,148.00 |
| **Using a discount rate of** | **7%** | **for a period of** | **2 years** | **$168,413.28** |

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Annual Sample Costs for Year 3-7 (5 years annually) | | $23,287.00 /event | 1 events | $23,287.00 |
| **Using a discount rate of** | **7%** | **for a period of** | **5 years** | **$83,397.06** |

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Sampling Costs for Year 8-48 (40 years, once every five years) | | $23,287.00 /event | 1 events | $23,287.00 |
| **Using a discount rate of** | **7%** | **for a period of** | **40 years** | **$33,619.35** |

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Closure Sampling Costs Year 50 | | $23,287.00 /event | 1 events | $23,287.00 |
| **Using a discount rate of** | **7%** | **at end of** | **50 years** | **$790.54** |

**Total Discounted Sampling Cost:**

| | |
|---|---|
| **Years 1-2** | **$168,413.28** |
| **Years 3-7** | **$83,397.06** |
| **Years 8-48** | **$33,619.35** |
| **Year 50** | **$790.54** |
| **Total** | **$286,220.23** |

### 9.0 Long-term Groundwater Monitoring (3100/Shell Burial Area Plume

The long-term groundwater monitoring would be used for the 3100/Shell Burial Area plume to determine whether subsequent actions were required to protect surface water and determine if MNA is applicable following completion of the source remediation, if it is required.

The analytical program for the long-term groundwater monitoring program will consist of TCL VOCs. All quality control sample analysis (field duplicates, rinse blanks, trip blanks) are assumed to be 20% of the total number of samples collection (20% of analytical costs).

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

| | |
|---|---|
| Field Sampler: | $50.00 /hr/person |
| Number of People: | 2 people |
| Hours worked per day: | 10 hrs |
| Anticipated time to collect samples per location: | 1.5 hrs |
| Number of Wells to Sample for the long-term monitoring: | 7 wells |
| Monitoring Report per sampling event: | $3,000.00 per event |

| **Description** | **Unit Rate** | **Number of units** | **Cost** |
|---|---|---|---|
| **COSTS PER SAMPLING EVENT** | | | |
| Labor for chemical sampling | $50.00 /hr/person | 11 hrs | $1,050.00 |
| *Chemical Analysis Cost* | | | |
| TCL VOCs (including TCE, DCE, and VC) | $180.00 | 9 samples | $1,620.00 |
| **TOTAL CHEMICAL ANALYSIS COST:** | | | **$1,620.00** |
| Monitoring Report Costs per Year | $3,000.00 per event | 1 event | $3,000.00 |
| **Total Sampling and Reporting Costs per Sampling Event** | | | **$5,670.00** |

**DESCRIPTION OF COSTS PER PHASE ADJUSTED TO PRESENT VALUE**

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Annual Sampling Costs for Years 1-25 | | $5,670.00 /event | 1 events | $5,670.00 |
| **Using a discount rate of** | **7%** | **for a period of** | **25 years** | **$66,075.82** |

**Total Discounted Sampling Cost:**

| | |
|---|---|
| **Years 1-25** | **$66,075.82** |
| **Total** | **$66,075.82** |

## ALTERNATIVE TCE-3

## PRB TO PROTECT SURFACE WATER WITH MNA POLISHING AND LTM

### 10.0 Well Construction, Abandonment, and Maintenance

Since the MNA monitoring will occur over an anticipated period of 50 years, the groundwater monitoring wells will require maintenance to allow for accurate sampling of the aquifer. This will include inspections yearly with maintenance as needed and the immediate installation of 5 new wells.

| Description | Unit Rate | Number of units | Discounted Cost |
|---|---|---|---|
| Well inspection and maintenance | $2,000.00 /year | 50 years | $27,601.49 |
| Future Well abandonment | $1,150.00 /well | 26 wells | $1,015.04 |
| New Monitoring Well installation (including 40% markup for UXO survey) | $8,400.00 /well | 5 wells | $42,000.00 |
| **Well Replacement** | | | |
| Well replacement will be performed periodically as needed. For the purpose of this FS, the well replacement is assumed to occur every five years for the entire duration of the project. | | | |
| **Description** | **Unit Rate** | **Number of units** | **Discounted Cost** |
| Well replacement | $5,000.00 / 5 year | 50 years | $11,999.11 |
| **Total Discounted Well Construction, Abandonment, and Maintenance Cost** | | | **$82,615.64** |

**Discount Rate = 7%**

### 11.0 5-Year Review

Five-year reviews will be performed to assess the effectiveness of the remedy. For the purpose of this FS, the duration for these activities is assumed to be 50 years.

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| 5-Year Review (including draft, draft final, and final reports) | $15,000 | each | $15,000.00 |
| **Using a discount rate of 7%** | **for a period of** | **50 years** | **$35,997.32** |

**Discounted O&M Cost:**

| | |
|---|---|
| **50-Year MNA Sampling Cost** | **$286,220.23** |
| **25-Year LTM Sampling Cost** | **$66,075.82** |
| **Well Construction, Abandonment, and Maintenance** | **$82,615.64** |
| **5-Year Reviews** | **$35,997.32** |
| **Total** | **$470,909.00** |

| | | |
|---|---|---|
| **TOTAL CAPITAL COST:** | | **$2,916,309.31** |
| **DISCOUNTED O&M COST:** | | **$470,909.00** |
| **Contingency of Scope:** | **5%** | **$23,545.45** |
| **Contingency of Bid:** | **10%** | **$47,090.90** |
| **TOTAL DISCOUNTED O&M COST:** | | **$541,545.35** |
| **TOTAL PRESENT WORTH VALUE:** | | **$3,457,854.66** |

## ALTERNATIVE TCE-4

## BIOREACTIVE MAT TO PROTECT SURFACE WATER WITH MNA POLISHING AND LTM

Alternative TCE-4 would involve 1) installation of a bioreactive mat to protect surface water; 2) MNA polishing for the remainder of the 241-3109 Plumes; and, 3) continuous implementation of ICs, in particular restrictions on groundwater use and implementation of a long-term groundwater monitoring program for the 3100/Shell Burial Area Plume, which has a continuing source that will be address in a subsequent FS. It is assumed that ICs and the long-term groundwater monitoring would be performed for 40 years. The anticipated length of MNA will be reevaluated following review of the first two years (8 quarters) of groundwater sampling results, and development of site-specific attenuation rates.

1) The costs are adopted from 2003 R.S. Means Site Work and Landscape Cost Book, previous work conducted by Shaw Environmental at PTA, and professional judgment.
2) The costs are adjusted with a location factor for Dover, New Jersey
3) The costs and duration of the construction activities are based on an 8-hour 5-day per week working schedule.
4) Works are to be conducted under a safety level D condition. However, a general health and safety markup of **10%** modification of safety level condition.
5) A UXO screening mark up of **40%** will be used for remedy installation and sampling activities.
6) Refer to **Figure 8-3** for the proposed locations
7) Dimensions of the Stream Treatment Area:

| Area | SW Discharge Area | | Surface Area |
|---|---|---|---|
| | Area (SF) | Thickness (FT) | Area (SF)* |
| $Mat_1$ | 523.3 | 1 | 575.7 |
| $Mat_2$ | 1249.5 | 1 | 1374.5 |
| **$Mat_T$** | 1,773 | 1 | 1,950 |

* Bioreactive mat area multiplied by 1.1 to account for unforseen changes due to complications in the field

## CAPITAL COSTS

### 1.0 Institutional Controls/Planning

**Land Use Restrictions:** A site-specific Land Use Control Implementation Plan (LUCIP) will need to be written in order to place restrictions on activities that can be performed in areas of the plumes at the Mid Valley Sites. These restrictions can be enforced through existing institutional controls and by restricting future land use. The land use restrictions will ensure that potential receptors are not exposed to contaminated groundwater from the Mid Valley plumes.

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| Paralegal | $150.00 /hr | 40 hrs | $6,000.00 |
| Lawyer | $200.00 /hr | 40 hrs | $8,000.00 |
| **Total Cost For the Land Use Control Implementation Plan:** | | | **$14,000.00** |

### 2.0 Planning, Permitting and Reporting

Permit equivalents required for this alternative will include drilling additional groundwater monitoring wells installed in the vicinity groundwater plume(s). Deliverables will include work plan, health and safety plan and a closure report. In addition, the substantive requirements for a Classification Exemption Area submittal will need to be made.

| Description | Unit Rate | Number of Units | Cost |
|---|---|---|---|
| Permit equivalents (including CEA) | $10,000 | Lump Sum | 10,000.00 |
| Design documents (drawings, specifications, design basis) - draft, draft final, and final | $15,000 | Lump Sum | 15,000.00 |
| Pilot Tests (Bioreactive Mat, ROI) | $100,000 | Lump Sum | 100,000.00 |
| Work Plan | $10,000 | Lump Sum | 10,000.00 |
| Health and Safety Plan | $10,000 | Lump Sum | 10,000.00 |
| FSP, QAPP, and DQOs | $15,000 | Lump Sum | 15,000.00 |
| Closeout Report (Draft, Draft Final, Final) | $15,000 | Lump Sum | 15,000.00 |
| **Total Cost for Reporting** | | | **$175,000.00** |

### 3.0 Site Preparations

**3.1 Clearing**

Under this alternative, areas for clearing are minimized because the installation of the bioreactive mat does not require the entire area to be cleared, only the areas along Robinson Run where the mat will be installed and accessways. For costing purposes, it is assumed only 35% of the total length of the mat area would be cleared (both sides of Robinson Run - assumed to be 8-ft wide for vevicle access) and that the natural material cleared shall be chipped and used elsewhere on site.

| | | | |
|---|---|---|---|
| RS Means 2003 (17010106) | | | $5,186.00 /acre |
| Area to be cleared and grubbed: | 3,758 sf | = | 0.1 acres |

## ALTERNATIVE TCE-4

## BIOREACTIVE MAT TO PROTECT SURFACE WATER WITH MNA POLISHING AND LTM

This work will consist of the removal of all objectionable material, rubbish, debris, trees, stumps, brush, roots, rotten wood, and any other vegetation, from the limits of the work area and support facilities. The vegetative material cleared will be chipped.

| Description | Cost Code | Unit Rate | Number of units | Duration | Cost |
|---|---|---|---|---|---|
| Clear & grub, cut & chip light trees to 6" diameter | 17010106 | $5,186.00 /acre | 0.1 acres | 0.1 | $518.60 |
| Grub stumps and remove | 17010301 | $52.48 /EA | 25.00 EA | 0.2 | $1,312.00 |
| **Clearing Cost** | | | | | $1,830.60 |
| **UXO Screening Survey** | | **40%** | | | $732.24 |
| **Total Clearing Cost with H & S Markup of** | | **10%** | | | **$2,819.12** |

Estimated time required for Clearing = 1 days
MSF = 1,000 square feet

**3.2 Stream Diversion:**
Prior to start of work, Robinson Run will be diverted and pumps will be used to prevent ponding within the construction area. Pumps are sized to handle twice the excpected flow requirement, and a backup pump (and piping) will be kept on hand for each operating pump.

| Description | Source | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Pumps, General Utility with Motor, 4"Dx5"S., 30 HP | 152005003100 | $11,500 lump sum | 2 EA | $23,000.00 |
| Pumps, General Utility with Motor, 2"Dx3"S., 15 HP | 152005002140 | $7,200.00 lump sum | 6 EA | $43,200.00 |
| Piping, HDPE Butt Fusion Joints, SDR 21, 40' Lengths, 4" Dia. | 025108500010 | $8.50 /LF | 3,440 LF | $29,240.00 |
| Diversion Materials | Prof. Judgement | $2,000.00 /site | 2 EA | $4,000.00 |
| Fuel for Pumps | Prof. Judgement | $3,000.00 /site | 2 EA | $6,000.00 |
| Field Engineer | 99110402* | $2,116.00 /wk | 25 WK | $53,323.20 |
| Laborer (Fire watch)*2 (8hr shifts) | 99110601* | $4,314.80 /wk | 25 WK | $108,732.96 |
| **Stream DIversion Cost** | | | | **$267,496.16** |
| **Additional H & S Markup of** | | **10%** | | **$5,332.32** |
| **Additional Cost for UXO Screening at a Rate of:** | | **40%** | | **$21,329.28** |
| **Total Stream Diversion Cost** | | | | **$294,157.76** |

*Bare cost from ECHOS was multiplied by 2.3 to account for overhead and profit

Estimated time required for Stream Diversion = 6 months

**3.3 Vehicle and Personnel Decontamination Area:**

The decontamination facility will be constructed using a geomembrane liner to contain liquids generated during the decontamination activities. The liner will be placed directly on the existing ground surface. Sand will be used to smooth existing terrain.

**Material and Installation costs for Decontamination Pad** **$5,000**
Cost based on past jobs with similar construction.

| | | |
|---|---|---|
| **Total Cost for Decon Area** | | **$5,000** |
| **Total Cost for Decon Area with H & S Markup of** | **10%** | **$5,500.00** |

Estimated time required for the construction of decon area = 2 days

**3.4 Layout and Construction Survey**
The purpose of a layout/construction survey is to assure that the proper amount of cover materials are in place. The work will consist of furnishing, placing, and maintaining the construction layout controls (stakes) necessary.

**Assumptions:**
1) Survey crew used to perform the construction layout survey will require a two person crew.

| Description | Cost Code | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Surveying Crew, 2 person survey | 99141201 | $810.27 /day | 2 days | $1,620.54 |
| **Total Cost for Survey Crew** | | | | **$1,620.54** |
| **Total Surveying Cost with H & S Markup of** | | **10%** | | **$1,782.59** |

Estimated Number of days required = 2 days

### 4.0 Installation of Bioreactive Mat and Installation of Monitoring Wells

Installation of bioreactive mat in two portions of Robinson Run. Total mat length is 120 ft. Bioractive mat installed to prevent surface discharge above ARARs.

| Description | Cost Code | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Bioreactive Mat Installation - including labor, mat'ls, drilling, mob./demob. | GeoSyntec Consultants Verbal Quote (Duane Graves) | $50 /SQ FT | 1,950 | $97,505.83 |
| Benchscale Testing | | $30,000 Lump Sum | Each | $30,000.00 |
| Oversight (USGS, Consultant) | Prof. Judgment | $109,186 Lump Sum | Each | $109,185.60 |
| **Total Cost for System Construction and Installation** | | | | **$236,691.43** |
| **Total Cost for Bioreactive Mat Construction and Installation of Monitoring Wells with H&S markup:** | | **10%** | | **$260,360.58** |

## ALTERNATIVE TCE-4

## BIOREACTIVE MAT TO PROTECT SURFACE WATER WITH MNA POLISHING AND LTM

**Estimated construction time for the Bioreactive Mat installation:** 6 months

### 5.0 Mobilization/Demobilization

Mobilization and demobilization consists of providing and removing all required equipment and materials to and from the Site. In addition, providing all required utilities is also included with mobilization. Mob and demob is included in the quote for the bioreactive mat construction. Mob and Demob costs for all additional activities are estimated at 10 percent of direct capital cost.

| | | |
|---|---|---|
| **Mobilization/Demobilization** | **10% of capital** | **$30,426** |

### 6.0 Construction and Technical Oversight

Bioreactive mat implementation will require technical oversight during the planning and design stages and during the implementation.

| | | | |
|---|---|---|---|
| Estimated total construction time frame: | Site preparations: | 5 | days |
| | Construction: | 132 | days |
| | Mob/Demob | 2 | days |

| Description | | Unit Rate | Number of units | | Cost |
|---|---|---|---|---|---|
| Data Review | | $1,000.00 | lump sum | | $1,000.00 |
| Site Visit and Meeting | | $5,000.00 | lump sum | | $5,000.00 |
| H&S Engineer | ECHOS 99110702* | $3,286.70 /week | 28 | weeks | $92,027.60 |
| Site Superintendent | ECHOS 99110202* | $3,220.00 /week | 28 | weeks | $90,160.00 |
| **Total Cost for Construction and Oversight** | | | | | **$188,200.00** |

*Bare cost from ECHOS was multiplied by 2.3 to account for overhead and profit

### 7.0 Travel and Per Diem

| | | |
|---|---|---|
| Construction time | 139 | days |
| Estimated total number of field laborers/crew: | 6 | |
| Estimated daily travel and per diem cost per crew: | $157.00 | per day |

| **Item** | **Cost Code*** | **Unit Rate** | **Number of Units** | | **Cost** |
|---|---|---|---|---|---|
| Travel and per diem | Professional Judgement | $157.00 per man/day | 834 | man/days | $130,938.00 |
| **Total Cost For Travel and Perdiem** | | | | | **$130,938.00** |

**SUMMARY OF CAPITAL COSTS:**

| | | |
|---|---|---|
| **1) Institutional Controls/Planning** | | **$14,000.00** |
| **2) Planning, Permittin, and Report Writing** | | **$175,000.00** |
| **3) Site Preparations** | | **$304,259.48** |
| **4) Installation of Bioreactive Mat and Construction of Monitoring Wells** | | **$260,360.58** |
| **5) Mobilization/Demobilization** | | **$30,425.95** |
| **6) Construction and Technical Oversight** | | **$188,200.00** |
| **7) Travel and Per Diem** | | **$130,938.00** |
| **Contingency of Scope** | **10%** | **$110,318.40** |
| **Contingency of Bid** | **5%** | **$55,159.20** |
| **TOTAL CAPITAL COST** | | **$1,268,661.60** |

## OPERATION AND MAINTENANCE (O&M) COSTS

### 8.0 MNA Groundwater Monitoring (241-3109 Plumes)

The long-term groundwater monitoring would be designed to evaluate the extent to which natural attenuation of the COCs is occurring, ensure that the plume characteristics are not changing in an unexpected manor, no new source areas are apparent, regulatory levels are being met, and the plume as a whole is acting as predicted.

The analytical program for the long-term groundwater monitoring program will consist of TCE and daughter products in addition to dissolved oxygen, ORP, nitrate, iron (II), sulfate, and methane. These parameters ensure monitoring of the plume for regulatory compliance as wells as monitoring for changing geochemical and oxidation reduction state. All quality control sample analysis (field duplicates, rinse blanks, trip blanks) are assumed to be 20% of the total number of samples collection (20% of analytical costs).

## ALTERNATIVE TCE-4

## BIOREACTIVE MAT TO PROTECT SURFACE WATER WITH MNA POLISHING AND LTM

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

| | |
|---|---|
| Field Sampler: | $50.00 /hr/person |
| Number of People: | 2 people |
| Hours worked per day: | 10 hrs |
| Anticipated time to collect samples per location: | 1.5 hrs |
| Number of Wells to Sample for MNA: | 19 wells |
| Number of surface water sample locations: | 23 locations |
| Monitoring Report per sampling event: | $3,000.00 per event |

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| **COSTS PER SAMPLING EVENT** | | | |
| Labor for chemical sampling | $50.00 /hr/person | 63 hrs | $6,300.00 |
| *Chemical Analysis Cost* | | | |
| TCL VOCs (including TCE, DCE, and VC) | $180.00 | 51 samples | $9,180.00 |
| Dissolved Oxygen | $10.00 | 23 samples | $230.00 |
| Nitrate | $20.00 | 23 samples | $460.00 |
| alkalinity | $20.00 | 23 samples | $460.00 |
| Iron (II) | $29.00 | 23 samples | $667.00 |
| Sulfate | $20.00 | 23 samples | $460.00 |
| Methane | $110.00 | 23 samples | $2,530.00 |
| **TOTAL CHEMICAL ANALYSIS COST:** | | | **$13,987.00** |
| Monitoring Report Costs per Year | $3,000.00 per event | 1 event | $3,000.00 |
| **Total Sampling and Reporting Costs per Sampling Event** | | | **$23,287.00** |

**DESCRIPTION OF COSTS PER PHASE ADJUSTED TO PRESENT VALUE**

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Quarterly Sampling Costs for Year 1-2 (8 Quarters) | | $23,287.00 /event | 4 events | $93,148.00 |
| **Using a discount rate of** | **7%** | **for a period of** | **2 years** | **$168,413.28** |

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Annual Sample Costs for Year 3-7 (5 years annually) | | $23,287.00 /event | 1 events | $23,287.00 |
| **Using a discount rate of** | **7%** | **for a period of** | **5 years** | **$83,397.06** |

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Sampling Costs for Year 8-48 (40 years, once every five years) | | $23,287.00 /event | 1 events | $23,287.00 |
| **Using a discount rate of** | **7%** | **for a period of** | **40 years** | **$33,619.35** |

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Closure Sampling Costs Year 50 | | $23,287.00 /event | 1 events | $23,287.00 |
| **Using a discount rate of** | **7%** | **at end of** | **50 years** | **$790.54** |

**Total Discounted Sampling Cost:**

| | |
|---|---|
| **Years 1-2** | **$168,413.28** |
| **Years 3-7** | **$83,397.06** |
| **Years 8-38** | **$33,619.35** |
| **Year 50** | **$790.54** |
| **Total** | **$286,220.23** |

### 9.0 Long-term Groundwater Monitoring (3100/Shell Burial Area Plume)

The long-term groundwater monitoring would be used for the 3100/Shell Burial Area plume to determine whether subsequent actions were required to protect surface water and determine if MNA is applicable following completion of the source remediation, if it is required.

The analytical program for the long-term groundwater monitoring program will consist of TCL VOCs. All quality control sample analysis (field duplicates, rinse blanks, trip blanks) are assumed to be 20% of the total number of samples collection (20% of analytical costs).

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

| | |
|---|---|
| Field Sampler: | $50.00 /hr/person |
| Number of People: | 2 people |
| Hours worked per day: | 10 hrs |
| Anticipated time to collect samples per location: | 1.5 hrs |
| Number of Wells to Sample for the long-term monitoring: | 7 wells |
| Monitoring Report per sampling event: | $3,000.00 per event |

## ALTERNATIVE TCE-4

## BIOREACTIVE MAT TO PROTECT SURFACE WATER WITH MNA POLISHING AND LTM

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| **COSTS PER SAMPLING EVENT** | | | |
| Labor for chemical sampling | $50.00 /hr/person | 11 hrs | $1,050.00 |
| *Chemical Analysis Cost* | | | |
| TCL VOCs (including TCE, DCE, and VC) | $180.00 | 9 samples | $1,620.00 |
| **TOTAL CHEMICAL ANALYSIS COST:** | | | **$1,620.00** |
| Monitoring Report Costs per Year | $3,000.00 per event | 1 event | $3,000.00 |
| **Total Sampling and Reporting Costs per Sampling Event** | | | **$5,670.00** |

**DESCRIPTION OF COSTS PER PHASE ADJUSTED TO PRESENT VALUE**

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| Annual Sampling Costs for Years 1-25 | $5,670.00 /event | 1 events | $5,670.00 |
| **Using a discount rate of 7%** | **for a period of** | **25 years** | **$66,075.82** |

**Total Discounted Sampling Cost:**

| | |
|---|---|
| **Years 1-25** | **$66,075.82** |
| **Total** | **$66,075.82** |

### 10.0 Well Construction, Abandonment, and Maintenance

Since the MNA monitoring will occur over an anticipated period of 50 years, the groundwater monitoring wells will require maintenance to allow for accurate sampling of the aquifer. This will include inspections yearly with maintenance as needed and the immediate installation of 5 new wells.

| Description | Unit Rate | Number of units | Discounted Cost |
|---|---|---|---|
| Well inspection and maintenance | $2,000.00 /year | 50 years | $27,601.49 |
| Future Well abandonment | $1,150.00 /well | 26 wells | $1,015.04 |
| New Monitoring Well installation (including 40% markup for UXO survey) | $8,400.00 /well | 5 wells | $42,000.00 |
| **Well Replacement** | | | |
| Well replacement will be performed periodically as needed. For the purpose of this FS, the well replacement is assumed to occur every five years for the entire duration of the project. | | | |
| **Description** | **Unit Rate** | **Number of units** | **Discounted Cost** |
| Well replacement | $5,000.00 / 5 year | 50 years | $11,999.11 |
| **Total Discounted Well Construction, Abandonment, and Maintenance Cost** | | | **$82,615.64** |

**Discount Rate = 7%**

### 11.0 5-Year Review

Five-year reviews will be performed to assess the effectiveness of the remedy. For the purpose of this FS, the duration for these activities is assumed to be 50 years.

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| 5-Year Review (including draft, draft final, and final reports) | $15,000 | lump sum | $15,000.00 |
| **Using a discount rate of 7%** | **for a period of** | **50 years** | **$35,997.32** |

**Discounted O&M Cost:**

| | |
|---|---|
| **50-Year MNA Sampling Cost** | **$286,220.23** |
| **25-Year LTM Sampling Cost** | **$66,075.82** |
| **Well Construction, Abandonment, and Maintenance** | **$82,615.64** |
| **5-Year Reviews** | **$35,997.32** |
| **Total** | **$470,909.00** |

| | | |
|---|---|---|
| **TOTAL CAPITAL COST:** | | **$1,268,661.60** |
| **DISCOUNTED O&M COST:** | | **$470,909.00** |
| ***Contingency of Scope:** | **10%** | **$47,090.90** |
| ***Contingency of Bid:** | **20%** | **$94,181.80** |
| **TOTAL DISCOUNTED O&M COST:** | | **$612,181.70** |
| * Contingency Factors are doulbled for this Alternative because the Technology is unproven on Full-Scale | | |
| **TOTAL PRESENT WORTH VALUE:** | | **$1,880,843.30** |

## ALTERNATIVE TCE-5

## IN SITU COMETABOLISM WITH MNA POLISHING AND LTM

Alternative TCE-5 would involve 1) injection of propane and oxygen to promote cometabolism of TCE followed by MNA polishing for the 241-3109 Plumes and, 2) continuous implementation of ICs, in particular restrictions on groundwater use and implementation of a long-term groundwater monitoring program for the 3100/Shell Burial Area Plume, which has a continuing source that will be address in a subsequent FS. It is assumed that ICs and the long-term groundwater monitoring would be performed for 40 years. The anticipated length of MNA will be reevaluated following review of the first two years (8 quarters) of groundwater sampling results, and development of site-specific attenuation rates.

### GENERAL ASSUMPTIONS

1) The costs are adopted from 2003 R.S. Means Site Work and Landscape Cost Book, previous work conducted by Shaw Environmental at PTA, and professional judgment.
2) The costs are adjusted with a location factor for Dover, New Jersey
3) The costs and duration of the construction activities are based on an 8-hour 5-day per week working schedule.
4) Works are to be conducted under a safety level D condition. However, a general health and safety markup of **10%** will be used to account for modification of safety level condition.
5) A UXO screening mark up of **40%** will be used for clearing and grubbing, excavation, and sampling activities.
6) Refer to **Figure 8-4** for the proposed locations and quantity of the construction components.
7) Dimensions of the TCE Plume where Concentrations Exceed 10 ppb:

| Area | GW Plume | Surface Area |
|---|---|---|
| | Area (SF) | Area (SF)* |
| **Plume** | 1,426,246 | 1,568,871 |

* Groundwater plume area multiplied by 1.1

## CAPITAL COSTS

### 1.0 Institutional Controls/Planning

Land Use Restrictions: A site-specific Land Use Control Implementation Plan (LUCIP) will need to be written in order to place restrictions on activities that can be performed in areas of the groundwater plumes at the Mid Valley Sites. These restrictions can be enforced through existing institutional controls and by restricting future land use. The land use restrictions will ensure that potential receptors are not exposed to contaminated groundwater from the Mid Valley plumes.

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| Paralegal | $150.00 /hr | 40 hrs | $6,000.00 |
| Lawyer | $200.00 /hr | 40 hrs | $8,000.00 |
| **Total Cost For the Land Use Control Implementation Plan:** | | | **$14,000.00** |

### 2.0 Planning, Permitting and Reporting

Permit equivalents required for this alternative will include drilling for injection wells and additional groundwater monitoring wells installed in the vicinity of two targeted areas of remediation. Deliverables will include a work plan, design drawings and specifications, a health and safety plan and a closure report. In addition, the substantive requirements for a Classification Exemption Area submittal will need to be made.

| Description | Unit Rate | Number of Units | Cost |
|---|---|---|---|
| Permit equivalents (including CEA) | $10,000 | Lump Sum | 10,000.00 |
| Design documents (drawings, specifications, design basis) - draft, draft final, and final | $15,000 | Lump Sum | 15,000.00 |
| Pilot Tests (Methane/Propane Injections, ROI) | $100,000 | Lump Sum | 100,000.00 |
| Work Plan | $10,000 | Lump Sum | 10,000.00 |
| Health and Safety Plan | $10,000 | Lump Sum | 10,000.00 |
| FSP, QAPP, and DQOs | $15,000 | Lump Sum | 15,000.00 |
| Closeout Report (Draft, Draft Final, Final) | $15,000 | Lump Sum | 15,000.00 |
| **Total Cost for Reporting** | | | **$175,000.00** |

**Summary of Institutional Control/Planning Costs**

| Description | Cost |
|---|---|
| Total Cost For Institutional Controls Plan Amendments: | $14,000.00 |
| Total Cost For Planning, Permitting, and Reporting | $175,000.00 |
| **Total Cost for Institutional Controls:** | **$189,000.00** |

## ALTERNATIVE TCE-5

## IN SITU COMETABOLISM WITH MNA POLISHING AND LTM

### 3.0 Site Preparations

**3.1 Clearing**

Under this alternative, areas for clearing are minimized because the propane/methane/oxygen injections do not require the entire plume area to be cleared, only the areas in the immediate vicinity of the injection points and accessways. Additionally, injection would target hot spots rather than the entire plume. For costing purposes, it is assumed that injection points would be installed in 100 rows of 25 points with an 8-ft wide path cleared for each row and an additional path cleared connenting the rows. The natural material cleared shall be chipped and used elsewhere on site.

| | | | |
|---|---|---|---|
| RS Means 2003 (17010106) | | | $5,186.00 /acre |
| Area to be cleared and grubbed: | 350,000 sf | = | 8.03 acres |

This work will consist of the removal of all objectionable material, rubbish, debris, trees, stumps, brush, roots, rotten wood, and any other vegetation, from the limits of the work area and support facilities. The vegetative material cleared will be chipped. Additionally, rocks shall be removed using a rock picker or backhoe and the existing surface of the work area shall be graded.

| Description | Cost Code | Unit Rate | Number of units | Duration | Cost |
|---|---|---|---|---|---|
| Clear & grub, cut & chip light trees to 6" diameter | 17010106 | $5,186.00 /acre | 8.03 acres | 8.0 | $41,668.96 |
| Grub stumps and remove | 17010301 | $52.48 /EA | 25 EA | 16.1 | $1,312.00 |
| **Clearing Cost** | | | | | $42,980.96 |
| **UXO Screening Survey** | | **40%** | | | $17,192.38 |
| **Total Clearing Cost with H & S Markup of** | | **10%** | | | **$66,190.68** |

Estimated time required for Clearing = 25 days
MSF = 1,000 square feet

**3.2 Erosion Control (Silt Fence Construction and Maintenance):**

Prior to start of work, silt fence will be erected along the perimeter of the work areas adjacent to Robinson Run.
Silt fence will be maintained in an erect position and cleaned as required to ensure efficiency.

Required length of silt fence: 7,500 LF

| Description | Cost Code | Unit Rate | Number of units | Duration (days) | Cost |
|---|---|---|---|---|---|
| Silt fencing, vinyl, adverse conditions, 3' high | 18050206 | $2.02 /lf | 7,500 lf | 7.9 | $15,150.00 |
| **Additional H & S Markup of** | | **10%** | | | **$1,515.00** |
| **Additional Cost for UXO Screening at a Rate of:** | | **40%** | | | **$6,060.00** |
| **Total Erosion Control Cost** | | | | | **$22,725.00** |

Estimated time required for Silt Fence Construction = 8 days

**3.3 Vehicle and Personnel Decontamination Area:**

The decontamination facility will be constructed using a geomembrane liner to contain liquids generated during the decontamination activities. The liner will be placed directly on the existing ground surface. Sand will be used to smooth existing terrain.

**Material and Installation costs for Decontamination Pad** **$5,000**
Cost based on past jobs with similar construction.

| | | |
|---|---|---|
| **Total Cost for Decon Area** | | **$5,000** |
| **Total Cost for Decon Area w/ H & S Markup of** | 10% | **$5,500.00** |

Estimated time required for the construction of decon area = 2 days

**3.4 Layout and Construction Survey**

The purpose of a layout/construction survey is to assure that the proper amount of cover materials are in place. The work will consist of furnishing, placing, and maintaining the construction layout controls (stakes) necessary.

**Assumptions:**

1) Survey crew used to perform the construction layout survey will require a two person crew.

| Description | Cost Code | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Surveying Crew, 2 person survey | 99141201 | $810.27 /day | 5 days | $4,051.35 |
| **Total Cost for Survey Crew** | | | | **$4,051.35** |
| **Total Surveying Cost with H & S Markup of** | | 10% | | **$4,456.49** |

Estimated Number of days required = 5 days

## ALTERNATIVE TCE-5

## IN SITU COMETABOLISM WITH MNA POLISHING AND LTM

### 4.0 Injections of Propane/Methane/Oxygen and Construction of Monitoring Wells

Injections of propane/methane/oxygen would involve: (1) installation of 2500 injection points (assuming an injection point spacing of 15 ft on center laterally and 30 ft on center in the assumed direction of groundwater flow) for all portions of the overburden plume where concentrations of TCE exceed 10 ppb; and (2) injection of approximately 2,187,500 lbs of propane/methane/oxygen. Injection wells would be installed to a depth of up to 75 fbg to target the plume "hot spots". Personnel required on-site for the first four weeks and 2 days/month thereafter for 29 months.

The initial stage would consist of installing approximately six injection and eleven monitoring points for completion of a pilot test. Construction of monitoring points would be identical to injection points to allow for the possible future inclusion in the injection well network. Injection of propane/methane/oxygen would be performed by site personnel and therefore would not require subsequent mobilization. Propane/methane requirement is based on required mass to achieve a concentration of 10 μg/L within the targeted region.

| Description | Cost Code | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Injection Well Installation | Prof Judgement | $5,000 /point | 2500 points | $12,500,000.00 |
| Propane/Methane/Oxygen | Prof Judgement | $1 /lb | 2,187,500 lbs | $2,187,500.00 |
| Labor | Prof Judgement | $1,864 /day | 78 days | $145,362.44 |
| **Total Cost for MW Installation and Propane/Methane/Oxygen Injection** | | | | **$14,832,862.44** |
| **Total Cost with H&S markup of:** | | **10%** | | **$16,316,148.68** |

**Estimated construction time for the injections:** 30 months

### 5.0 Mobilization/Demobilization

Mobilization and demobilization consists of providing and removing all required equipment and materials to and from the Site. In addition, providing all required utilities is also included with mobilization.

Mobilization is calculated as 10% of the direct capital costsn (Well installation and injected substrates are excluded).

| | | |
|---|---|---|
| **Mobilization/Demobilization** | **10% of capital** | **$9,887** |

### 6.0 Construction and Technical Oversight

Enhanced anaerobic degradation will require technical oversight during the planning and design stages and during the implementation.

| Estimated total construction time frame: | | | |
|---|---|---|---|
| | Site preparations: | 40 | days |
| | Injection: | 660 | days |
| | Mob/Demob: | 2 | days |

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Data Review | | $1,000.00 | lump sum | $1,000.00 |
| Site Visit and Meeting | | $5,000.00 | lump sum | $5,000.00 |
| Field Engineer | ECHOS 99110402* | $2,116.00 /week | 141 weeks | $298,356.00 |
| H&S Engineer | ECHOS 99110702* | $3,286.70 /week | 141 weeks | $463,424.70 |
| Site Superintendent | ECHOS 99110202* | $3,220.00 /week | 141 weeks | $454,020.00 |
| **Total Cost for Construction and Oversight** | | | | **$1,221,800.00** |

*Bare cost from ECHOS was multiplied by 2.3 to account for overhead and profit

### 7.0 Travel and Per Diem

| | |
|---|---|
| Construction time | 702 days |
| Estimated total number of field laborers/crew: | 6 |
| Estimated daily travel and per diem cost per crew: | $157.00 per day |

| **Item** | **Cost Code*** | **Unit Rate** | **Number of Units** | **Cost** |
|---|---|---|---|---|
| Travel and per diem | Professional Judgement | $157.00 per man/day | 702 man/days | $110,214.00 |
| **Total Cost For Travel and Perdiem** | | | | **$110,214.00** |

## ALTERNATIVE TCE-5

## IN SITU COMETABOLISM WITH MNA POLISHING AND LTM

**SUMMARY OF CAPITAL COSTS:**

| | | |
|---|---|---|
| **1) Land Use Restrictions & Institutional Controls** | | **$14,000.00** |
| **2) Permits and Reports Writing** | | **$175,000.00** |
| **3) Site Preparation** | | **$98,872.17** |
| **4) Installation of Injection Points and Propane/Methane/Oxygen Injection** | | **$16,316,148.68** |
| **5) Mobilization/Demobilization** | | **$9,887.22** |
| **6) Construction Oversight** | | **$1,221,800.00** |
| **7) Travel and Per Diem** | | **$110,214.00** |
| **Contingency of Scope** | **10%** | **$1,794,592.21** |
| **Contingency of Bid** | **5%** | **$897,296.10** |
| **TOTAL CAPITAL COST** | | **$20,637,810.38** |

### OPERATION AND MAINTENANCE COSTS

#### 8.0 MNA Groundwater Monitoring (241-3109 Plumes)

The MNA groundwater monitoring for the 241-3109 Plumes would be designed to monitor the system performance and ensure that the plume characteristics are not changing, no new source areas are apparent, regulatory levels are being met, and the plume as a whole is acting as predicted. Surface water would also be monitored for TCL VOCs, degradation products, and dissolved organic carbon to ensure that the remedial alternative does not negatively impact surface water bodies.

The analytical program for the MNA polishing will consist of all of the contaminants of concern in addition to dissolved oxygen, nitrate, iron (II), sulfate, and methane. These parameters ensure monitoring of the plume for regulatory compliance as wells as monitoring for changing geochemical and oxidation reduction state. All quality control sample analysis (field duplicates, rinse blanks, trip blanks) are assumed to be 20% of the total number of samples collection (20% of analytical costs).

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

| | | |
|---|---|---|
| Field Sampler: | $50.00 | /hr/person |
| Number of People: | 2 | people |
| Hours worked per day: | 10 | hrs |
| Anticipated time to collect samples per location: | 1.5 | hrs |
| Number of surface water sample locations: | 23 | locations |
| Number of Wells to Sample for the long-term monitoring program: | 19 | wells |
| Monitoring Report per sampling event: | $3,000.00 | per event |

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| **COSTS PER SAMPLING EVENT** | | | |
| Labor for chemical sampling | $50.00 /hr/person | 63 hrs | $6,300.00 |
| *Chemical Analysis Cost* | | | |
| TCL VOCs (including TCE, DCE, and VC) | $180.00 | 51 samples | $9,180.00 |
| Dissolved Oxygen | $10.00 | 23 samples | $230.00 |
| Nitrate | $20.00 | 23 samples | $460.00 |
| alkalinity | $20.00 | 23 samples | $460.00 |
| Iron (II) | $29.00 | 23 samples | $667.00 |
| Sulfate | $20.00 | 23 samples | $460.00 |
| Methane | $110.00 | 23 samples | $2,530.00 |
| **TOTAL CHEMICAL ANALYSIS COST:** | | | **$13,987.00** |
| Monitoring Report Costs per Year | $3,000.00 per event | 1 event | $3,000.00 |
| **Total Sampling and Reporting Costs per Sampling Event** | | | **$23,287.00** |

**DESCRIPTION OF COSTS PER PHASE ADJUSTED TO PRESENT VALUE**

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| Quarterly Sampling Costs for Year 1-2 (8 Quarters) | $23,287.00 /event | 4 events | $93,148.00 |
| **Using a discount rate of 7%** | **for a period of** | **2 years** | **$168,413.28** |

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| Annual Sample Costs for Year 3-7 (5 years annually) | $23,287.00 /event | 1 events | $23,287.00 |
| **Using a discount rate of 7%** | **for a period of** | **5 years** | **$83,397.06** |

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| Sampling Costs for Year 8-18 (10 years, once every five years) | $23,287.00 /event | 1 events | $23,287.00 |
| **Using a discount rate of 7%** | **for a period of** | **10 years** | **$17,711.77** |

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| Closure Sampling Costs Year 20 | $23,287.00 /event | 1 events | $23,287.00 |
| **Using a discount rate of 7%** | **at end of** | **20 years** | **$6,017.80** |

**Total Discounted Sampling Cost:**

| | |
|---|---|
| **Years 1-2** | **$168,413.28** |
| **Years 3-7** | **$83,397.06** |
| **Years 8-18** | **$17,711.77** |
| **Year 20** | **$6,017.80** |
| **Total** | **$275,539.92** |

#### 9.0 Long-term Groundwater Monitoring (3100/Shell Burial Area Plume)

## ALTERNATIVE TCE-5

## IN SITU COMETABOLISM WITH MNA POLISHING AND LTM

The long-term groundwater monitoring would be used for the 3100/Shell Burial Area plume to determine whether subsequent actions were required to protect surface water and determine if MNA is applicable following completion of the source remediation, if it is required.

The analytical program for the long-term groundwater monitoring program will consist of TCL VOCs. All quality control sample analysis (field duplicates, rinse blanks, trip blanks) are assumed to be 20% of the total number of samples collection (20% of analytical costs).

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

| | | |
|---|---|---|
| Field Sampler: | $50.00 | /hr/person |
| Number of People: | 2 | people |
| Hours worked per day: | 10 | hrs |
| Anticipated time to collect samples per location: | 1.5 | hrs |
| Number of Wells to Sample for the long-term monitoring: | 7 | wells |
| Monitoring Report per sampling event: | $3,000.00 | per event |

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| **COSTS PER SAMPLING EVENT** | | | |
| Labor for chemical sampling | $50.00 /hr/person | 11 hrs | $1,050.00 |
| *Chemical Analysis Cost* | | | |
| TCL VOCs (including TCE, DCE, and VC) | $180.00 | 9 samples | $1,620.00 |
| **TOTAL CHEMICAL ANALYSIS COST:** | | | **$1,620.00** |
| Monitoring Report Costs per Year | $3,000.00 per event | 1 event | $3,000.00 |
| **Total Sampling and Reporting Costs per Sampling Event** | | | **$5,670.00** |

**DESCRIPTION OF COSTS PER PHASE ADJUSTED TO PRESENT VALUE**

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Annual Sampling Costs for Years 1-25 | | $5,670.00 /event | 1 events | $5,670.00 |
| **Using a discount rate of** | **7%** | **for a period of** | **25 years** | **$66,075.82** |

**Total Discounted Sampling Cost:**

| | |
|---|---|
| **Years 1-25** | **$66,075.82** |
| **Total** | **$66,075.82** |

## ALTERNATIVE TCE-5

## IN SITU COMETABOLISM WITH MNA POLISHING AND LTM

### 10.0 Well Abandonment, Replacement, and Maintenance

Since the long term monitoring will occur over an anticipated period of 25 years, the groundwater monitoring wells will require maintenance to allow for accurate sampling of the aquifer. This will include inspections yearly with maintenance as needed and the immediate installation of 5 new wells.

| Description | Unit Rate | Number of units | Discounted Cost |
|---|---|---|---|
| Well inspection and maintenance | $2,000.00 /year | 25 years | $23,307.17 |
| Future Well abandonment | $1,150.00 /well | 26 wells | $5,509.05 |
| New Monitoring Well installation (including 40% markup for UXO survey) | $8,400.00 /well | 5 wells | $42,000.00 |

**Well Replacement**

Well replacement will be performed periodically as needed. For the purpose of this FS, the well replacement is assumed to occur every five years for the entire duration of the project.

| Description | Unit Rate | Number of units | Discounted Cost |
|---|---|---|---|
| Well replacement | $5,000.00 / 5 year | 25 years | $10,132.25 |
| **Total Discounted Well Construction, Abandonment, and Maintenance Cost** | | | **$80,948.47** |

**Discount Rate = 7%**

### 11.0 5-Year Review

Five-year reviews will be performed to assess the effectiveness of the remedy. For the purpose of this FS, the duration for these activities is assumed to be 25 years.

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| 5-Year Review (including draft, draft final, and final reports) | $15,000 | lump sum | $15,000.00 |
| **Using a discount rate of 7%** | **for a period of** | **25 years** | **$30,396.75** |

**Discounted O&M Cost:**

| | |
|---|---|
| **10-Year MNA Sampling Cost** | **$275,539.92** |
| **40-Year LTM Sampling Cost** | **$66,075.82** |
| **Well Abandonment, Replacement, and Maintenance** | **$80,948.47** |
| **5-Year Reviews** | **$30,396.75** |
| **Total** | **$452,960.94** |

| | | |
|---|---|---|
| **TOTAL CAPITAL COST:** | | **$20,637,810.38** |
| **DISCOUNTED O&M COST:** | | **$452,960.94** |
| **Contingency of Scope:** | **10%** | **$45,296.09** |
| **Contingency of Bid:** | **5%** | **$22,648.05** |
| **TOTAL DISCOUNTED O&M COST:** | | **$520,905.09** |
| **TOTAL PRESENT WORTH VALUE:** | | **$21,158,715.46** |

## ALTERNATIVE TCE-6

### IN SITU TREATMENT USING NANO-SCALE ZERO-VALENT IRON WITH MNA POLISHING AND LTM

Alternative TCE-6 would involve: 1) nano-scale zero valent iron (ZVI) injection for the in-situ treatment of the TCE plumes followed by MNA polishing for the 241-3109 Plumes and, 2) continuous implementation of ICs, in particular restrictions on groundwater use and implementation of a long-term groundwater monitoring program for the 3100/Shell Burial Area Plume, which has a continuing source that will be address in a subsequent FS. It is assumed that ICs and the long-term groundwater monitoring would be performed for 40 years. The anticipated length of MNA will be reevaluated following review of the first two years (8 quarters) of groundwater sampling results, and development of site-specific attenuation rates.

### GENERAL ASSUMPTIONS

1) The costs are adopted from 2003 R.S. Means Site Work and Landscape Cost Book, previous work conducted by Shaw Environmental at PTA, and professional judgment.

2) The costs are adjusted with a location factor for Dover, New Jersey

3) The costs and duration of the construction activities are based on an 8-hour 5-day per week working schedule.

4) Works are to be conducted under a safety level D condition. However, a general health and safety markup of **10%** will be used to account for modification of safety level condition.

5) A UXO screening mark up of **40%** will be used for clearing and grubbing, excavation, and sampling activities.

6) Refer to **Figure 8-4** for the proposed locations and quantity of the construction components

7) Dimensions of the TCE Plume where Concentrations Exceed 10 ppb:

| Area | GW Plume<br>Area (SF) | Surface Area<br>Area (SF)* |
|---|---|---|
| **Plume** | 1,426,246 | 1,568,871 |

* Groundwater plume area multiplied by 1.1

## CAPITAL COSTS

**1.0 Institutional Controls/Planning**

Land Use Restrictions: A site-specific Land Use Control Implementation Plan (LUCIP) will need to be written in order to place restrictions on activities that can be performed in areas of the groundwater plumes at the Mid Valley Sites. These restrictions can be enforced through existing institutional controls and by restricting future land use. The land use restrictions will ensure that potential receptors are not exposed to contaminated groundwater from the Mid Valley plumes.

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| Paralegal | $150.00 /hr | 40 hrs | $6,000.00 |
| Lawyer | $200.00 /hr | 40 hrs | $8,000.00 |
| **Total Cost For the Land Use Control Implementation Plan:** | | | **$14,000.00** |

**2.0 Planning, Permitting and Reporting**

Permit equivalents required for this alternative will include drilling for injection wells and additional groundwater monitoring wells installed in the vicinity of two targeted areas of remediation. Deliverables will include a work plan, design drawings and specifications, a health and safety plan and a closure report. In addition, the substantive requirements for a Classification Exemption Area submittal will need to be made.

| Description | Unit Rate | Number of Units | Cost |
|---|---|---|---|
| Permit equivalents (including CEA) | $10,000 | Lump Sum | 10,000.00 |
| Design documents (drawings, specifications, design basis) - draft, draft final, and final | $15,000 | Lump Sum | 15,000.00 |
| Pilot Tests (ZVI Injections, ROI) | $100,000 | Lump Sum | 100,000.00 |
| Work Plan | $10,000 | Lump Sum | 10,000.00 |
| Health and Safety Plan | $10,000 | Lump Sum | 10,000.00 |
| FSP, QAPP, and DQOs | $15,000 | Lump Sum | 15,000.00 |
| Closeout Report (Draft, Draft Final, Final) | $15,000 | Lump Sum | 15,000.00 |
| **Total Cost for Reporting** | | | **$175,000.00** |

**Summary of Institutional Control/Planning Costs**

| Description | Cost |
|---|---|
| Total Cost For Institutional Controls Plan Amendments: | $14,000.00 |
| Total Cost For Planning, Permitting, and Reporting | $175,000.00 |
| **Total Cost for Institutional Controls:** | **$189,000.00** |

**3.0 Site Preparations**

## ALTERNATIVE TCE-6

### IN SITU TREATMENT USING NANO-SCALE ZERO-VALENT IRON WITH MNA POLISHING AND LTM

**3.1 Clearing**

Under this alternative, areas for clearing are minimized because the ZVI injections do not require the entire plume area to be cleared, only the areas in the immediate vicinity of the injection points and accessways. Additionally, injection would target hot spots rather than the entire plume. For costing purposes, it is assumed that 180 injection points would be installed in two rows along the length of the plume. It is assumed that an 8-ft wide path would be cleared and that the natural material cleared shall be chipped and used elsewhere on site.

| | | | |
|---|---|---|---|
| RS Means 2003 (17010106) | | | $5,186.00 /acre |
| Area to be cleared and grubbed: | 56,000 sf | = | 1.29 acres |

This work will consist of the removal of all objectionable material, rubbish, debris, trees, stumps, brush, roots, rotten wood, and any other vegetation, from the limits of the work area and support facilities. The vegetative material cleared will be chipped. Additionally, rocks shall be removed using a rock picker or backhoe and the existing surface of the work area shall be graded.

| Description | Cost Code | Unit Rate | Number of units | Duration | Cost |
|---|---|---|---|---|---|
| Clear & grub, cut & chip light trees to 6" diameter | 17010106 | $5,186.00 /acre | 1.29 acres | 1.3 | $6,667.03 |
| Grub stumps and remove | 17010301 | $52.48 /EA | 25 EA | 2.6 | $1,312.00 |
| **Clearing Cost** | | | | | $7,979.03 |
| **UXO Screening Survey** | | **40%** | | | $3,191.61 |
| **Total Clearing Cost with H & S Markup of** | | **10%** | | | **$12,287.71** |

Estimated time required for Clearing = 4 days
MSF = 1,000 square feet

**3.2 Erosion Control (Silt Fence Construction and Maintenance):**

Prior to start of work, silt fence will be erected along the perimeter of the work areas.
Silt fence will be maintained in an erect position and cleaned as required to ensure efficiency.

Required length of silt fence: 7,500 LF

| Description | Cost Code | Unit Rate | Number of units | Duration (days) | Cost |
|---|---|---|---|---|---|
| Silt fencing, vinyl, adverse conditions, 3' high | 18050206 | $2.02 /lf | 7,500 lf | 8 | $15,150.00 |
| **Additional H & S Markup of** | | **10%** | | | **$1,515.00** |
| **Additional Cost for UXO Screening at a Rate of:** | | **40%** | | | **$6,060.00** |
| **Total Erosion Control Cost** | | | | | **$22,725.00** |

Estimated time required for Silt Fence Construction = 8 days

**3.3 Vehicle and Personnel Decontamination Area:**

The decontamination facility will be constructed using a geomembrane liner to contain liquids generated during the decontamination activities. The liner will be placed directly on the existing ground surface. Sand will be used to smooth existing terrain.

**Material and Installation costs for Decontamination Pad** **$5,000**
Cost based on past jobs with similar construction.

| | | |
|---|---|---|
| **Total Cost for Decon Area** | | **$5,000** |
| **Total Cost for Decon Area w/ H & S Markup of** | 10% | **$5,500.00** |

Estimated time required for the construction of decon area = 2 days

**3.4 Layout and Construction Survey**

The purpose of a layout/construction survey is to assure that the proper amount of cover materials are in place. The work will consist of furnishing, placing, and maintaining the construction layout controls (stakes) necessary.

**Assumptions:**

1) Survey crew used to perform the construction layout survey will require a two person crew.

| Description | Cost Code | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Surveying Crew, 2 person survey | 99141201 | $810.27 /day | 5 days | $4,051.35 |
| **Total Cost for Survey Crew** | | | | **$4,051.35** |
| **Total Surveying Cost with H & S Markup of** | | 10% | | **$4,456.49** |

Estimated Number of days required = 5 days

## ALTERNATIVE TCE-6

## IN SITU TREATMENT USING NANO-SCALE ZERO-VALENT IRON WITH MNA POLISHING AND LTM

### 4.0 Injections of ZVI and Construction of Injection/Monitoring Wells

Injections of ZVI would involve (1) installation of 180 injection points for all portions of the overburden plume where concentrations of TCE exceed 10 ppb; and (2) injection of approximately 7,500 pounds of nano-iron slurry into the subsurface in 241-3109 Plumes. ZVI injection points would be located to target elevated concentrations of TCE.

| Description | Cost Code | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Injection Well Installation | Prof Judgement | $6,000 /point | 180 points | $1,080,000.00 |
| Application of Nano-scale zero valent iron - including labor, mat'ls, drilling, mob./demob., benchscale study, and pilot test | Vendor Quote (Appendix O) | $678,000 | lumpsum | $678,000.00 |
| Oversight - Field Engineers (2) | 99110402* | $4,232.00 /wk | 4 WK | $17,774.40 |
| **Total Cost for System Construction and Installation** | | | | **$1,775,774.40** |
| **Total Cost for ZVI Injection and Installation of Monitoring Wells with H&S markup:** | | **10%** | | **$1,953,351.84** |

*Bare cost from ECHOS was multiplied by 2.3 to account for overhead and profit

**Estimated construction time for the ZVI injections/well installation:** 1 month

### 5.0 Mobilization/Demobilization

Mobilization and demobilization consists of providing and removing all required equipment and materials to and from the Site. In addition, providing all required utilities is also included with mobilization. Mob and demob is included in the quote for the application of nanoscale iron. Mob and Demob costs for all additional activities are estimated at 10 percent of direct capital cost (mob/demob are included in vendor quote).

| | | |
|---|---|---|
| **Mobilization/Demobilization** | **10% of capital** | **$4,497** |

### 6.0 Construction and Technical Oversight

ZVI and ORC will require technical oversight during the planning and design stages and during the implementation.

| Estimated total construction time frame: | | | |
|---|---|---|---|
| | Site preparations: | 19 | days |
| | ZVI Inject. | 30 | days |
| | Mob/Demob | 2 | days |

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Data Review | | $1,000.00 | lump sum | $1,000.00 |
| Site Visit and Meeting | | $5,000.00 | lump sum | $5,000.00 |
| Field Engineer | ECHOS 99110402* | $2,116.00 /week | 11 weeks | $23,276.00 |
| H&S Engineer | ECHOS 99110702* | $3,286.70 /week | 11 weeks | $36,153.70 |
| Site Superintendent | ECHOS 99110202* | $3,220.00 /week | 11 weeks | $35,420.00 |
| **Total Cost for Construction and Oversight** | | | | **$100,800.00** |

*Bare cost from ECHOS was multiplied by 2.3 to account for overhead and profit

### 7.0 Travel and Per Diem

| | |
|---|---|
| Construction time | 51 days |
| Estimated total number of field laborers/crew: | 6 |
| Estimated daily travel and per diem cost per crew: | $157.00 per day |

| Item | Cost Code* | Unit Rate | Number of Units | Cost |
|---|---|---|---|---|
| Travel and per diem | Professional judgment | $157.00 per man/day | 306 man/days | $48,042.00 |
| **Total Cost For Travel and Perdiem** | | | | **$48,042.00** |

**SUMMARY OF CAPITAL COSTS:**

| | | |
|---|---|---|
| **1) Land Use Restrictions & Institutional Controls** | | **$14,000.00** |
| **2) Permits and Reports Writing** | | **$175,000.00** |
| **3) Site Preparation** | | **$44,969.20** |
| **4) ZVI Injection** | | **$1,953,351.84** |
| **5) Mobilization/Demobilization** | | **$4,496.92** |
| **6) Construction Oversight** | | **$100,800.00** |
| **7) Travel and Per Diem** | | **$48,042.00** |
| **Contingency of Scope** | **10%** | **$234,066.00** |
| **Contingency of Bid** | **5%** | **$117,033.00** |
| **TOTAL CAPITAL COST** | | **$2,691,758.95** |

## ALTERNATIVE TCE-6

### IN SITU TREATMENT USING NANO-SCALE ZERO-VALENT IRON WITH MNA POLISHING AND LTM

### OPERATION AND MAINTENANCE COSTS

#### 8.0 MNA Groundwater Monitoring (241-3109 Plumes)

The MNA polishing groundwater and surface water monitoring would be designed to monitor the system performance and ensure that the plume characteristics are not changing, no new source areas are apparent, regulatory levels are being met, and the plume as a whole is acting as predicted.

The analytical program for the MNA polishing will consist of all of the contaminants of concern and daughter products in addition to dissolved oxygen, nitrate, iron (II), sulfate, and methane. These parameters ensure monitoring of the plume for regulatory compliance as wells as monitoring for changing geochemical and oxidation reduction state. All quality control sample analysis (field duplicates, rinse blanks, trip blanks) are assumed to be 20% of the total number of samples collected (20% of analytical costs).

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

| | |
|---|---|
| Field Sampler: | $50.00 /hr/person |
| Number of People: | 2 people |
| Hours worked per day: | 10 hrs |
| Anticipated time to collect samples per location: | 1.5 hrs |
| Number of surface water sample locations: | 23 locations |
| Number of Wells to Sample for the MNA monitoring program: | 19 wells |
| Monitoring Report per sampling event: | $3,000.00 per event |

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| **COSTS PER SAMPLING EVENT** | | | |
| Labor for chemical sampling | $50.00 /hr/person | 63 hrs | $6,300.00 |
| *Chemical Analysis Cost* | | | |
| TCL VOCs (including TCE, DCE, and VC) | $180.00 | 51 samples | $9,180.00 |
| Dissolved Oxygen | $10.00 | 23 samples | $230.00 |
| Nitrate | $20.00 | 23 samples | $460.00 |
| alkalinity | $20.00 | 23 samples | $460.00 |
| Iron (II) | $29.00 | 23 samples | $667.00 |
| Sulfate | $20.00 | 23 samples | $460.00 |
| Methane | $110.00 | 23 samples | $2,530.00 |
| **TOTAL COST:** | | | **$13,987.00** |
| Monitoring Report Costs per Year | $3,000.00 per event | 1 event | $3,000.00 |
| **Total Sampling and Reporting Costs per Sampling Event** | | | **$23,287.00** |

**DESCRIPTION OF COSTS PER PHASE**

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| Quarterly Sampling Costs for Year 1-2 (8 Quarters) | $23,287.00 /event | 4 events | $93,148.00 |
| **Using a discount rate of 7%** | **for a period of** | **2 years** | **$168,413.28** |

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| Annual Sample Costs for Year 3-7 (5 years annually) | $23,287.00 /event | 1 events | $23,287.00 |
| **Using a discount rate of 7%** | **for a period of** | **5 years** | **$83,397.06** |

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| Sampling Costs for Year 8-18 (10 years, once every | $23,287.00 /event | 1 events | $23,287.00 |
| **Using a discount rate of 7%** | **for a period of** | **10 years** | **$17,711.77** |

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| Closure Sampling Costs Year 20 | $23,287.00 /event | 1 events | $23,287.00 |
| **Using a discount rate of 7%** | **at end of** | **20 years** | **$6,017.80** |

**Total Discounted Sampling Cost:**

| | |
|---|---|
| **Years 1-2** | **$168,413.28** |
| **Years 3-7** | **$83,397.06** |
| **Years 8-18** | **$17,711.77** |
| **Year 20** | **$6,017.80** |
| **Total** | **$275,539.92** |

#### 9.0 Long-term Groundwater Monitoring (3100/Shell Burial Area Plume)

The long-term groundwater monitoring would be used for the 3100/Shell Burial Area plume to determine whether subsequent actions were required to protect surface water and determine if MNA is applicable following completion of the source remediation, if it is required.

The analytical program for the long-term groundwater monitoring program will consist of TCL VOCs. All quality control sample analysis (field duplicates, rinse blanks, trip blanks) are assumed to be 20% of the total number of samples collection (20% of analytical costs).

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

| | |
|---|---|
| Field Sampler: | $50.00 /hr/person |
| Number of People: | 2 people |
| Hours worked per day: | 10 hrs |
| Anticipated time to collect samples per location: | 1.5 hrs |
| Number of Wells to Sample for the long-term monitoring: | 7 wells |
| Monitoring Report per sampling event: | $3,000.00 per event |

| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| **COSTS PER SAMPLING EVENT** | | | |
| Labor for chemical sampling | $50.00 /hr/person | 11 hrs | $1,050.00 |
| *Chemical Analysis Cost* | | | |
| TCL VOCs (including TCE, DCE, and VC) | $180.00 | 9 samples | $1,620.00 |
| **TOTAL CHEMICAL ANALYSIS COST:** | | | **$1,620.00** |
| Monitoring Report Costs per Year | $3,000.00 per event | 1 event | $3,000.00 |
| **Total Sampling and Reporting Costs per Sampling Event** | | | **$5,670.00** |

## ALTERNATIVE TCE-6

### IN SITU TREATMENT USING NANO-SCALE ZERO-VALENT IRON WITH MNA POLISHING AND LTM

**DESCRIPTION OF COSTS PER PHASE ADJUSTED TO PRESENT VALUE**

| Description | | Unit Rate | Number of units | Cost |
|---|---|---|---|---|
| Annual Sampling Costs for Years 1-25 | | $5,670.00 /event | 1 events | $5,670.00 |
| **Using a discount rate of** | **7%** | **for a period of** | **25 years** | **$66,075.82** |

**Total Discounted Sampling Cost:**

| | |
|---|---|
| **Years 1-40** | **$66,075.82** |
| **Total** | **$66,075.82** |

### 10.0 Well Abandonment, Replacement, and Maintenance

Since the long term monitoring will occur over an anticipated period of 25 years, the groundwater monitoring wells will require maintenance to allow for accurate sampling of the aquifer. This will include inspections yearly with maintenance as needed and the immediate installation of 5 new wells.

| Description | Unit Rate | Number of units | Discounted Cost |
|---|---|---|---|
| Well inspection and maintenance | $2,000.00 /year | 25 years | $23,307.17 |
| Future Well abandonment | $1,150.00 /well | 26 wells | $5,509.05 |
| New Monitoring Well installation (including 40% markup for UXO survey) | $8,400.00 /well | 5 wells | $42,000.00 |

**Well Replacement**

Well replacement will be performed periodically as needed. For the purpose of this FS, the well replacement is assumed to occur every five years for the entire duration of the project.

| Description | Unit Rate | Number of units | Discounted Cost |
|---|---|---|---|
| Well replacement | $5,000.00 / 5 year | 25 years | $10,132.25 |
| **Total Discounted Well Construction, Abandonment, and Maintenance Cost** | | | **$80,948.47** |

**Discount Rate = 7%**

## ALTERNATIVE TCE-6

## IN SITU TREATMENT USING NANO-SCALE ZERO-VALENT IRON WITH MNA POLISHING AND LTM

### 11.0 5-Year Review

Five-year reviews will be performed to assess the effectiveness of the remedy. For the purpose of this FS, the duration for these activities is assumed to be 25 years.

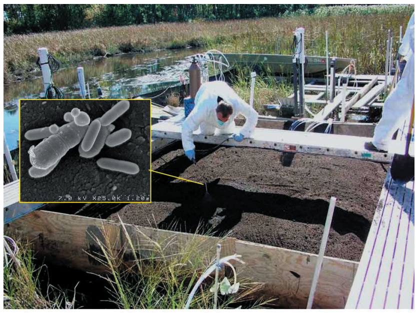
| Description | Unit Rate | Number of units | Cost |
|---|---|---|---|
| 5-Year Review (including draft, draft final, and final reports) | $15,000 | lump sum | $15,000.00 |
| **Using a discount rate of 7%** | **for a period of** | **25 years** | **$30,396.75** |

**Discounted O&M Cost:**

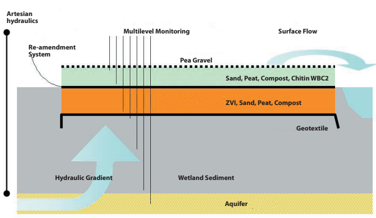
| | |
|---|---|
| **10-Year MNA Sampling Cost** | **$275,539.92** |
| **25-Year LTM Sampling Cost** | **$66,075.82** |
| **Well Abandonment, Replacement, and Maintenance** | **$80,948.47** |
| **5-Year Reviews** | **$30,396.75** |
| **Total** | **$452,960.94** |

| | | |
|---|---|---|
| **TOTAL CAPITAL COST:** | | **$2,691,758.95** |
| **DISCOUNTED O&M COST:** | | **$452,960.94** |
| **Contingency of Scope:** | **5%** | **$22,648.05** |
| **Contingency of Bid:** | **10%** | **$45,296.09** |
| **TOTAL DISCOUNTED O&M COST:** | | **$520,905.09** |
| **TOTAL PRESENT WORTH VALUE:** | | **$3,212,664.04** |

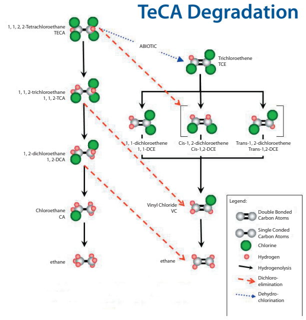
# USGS and GeoSyntec Consultants Collaborate on Development of New In Situ Bioremediation Technology



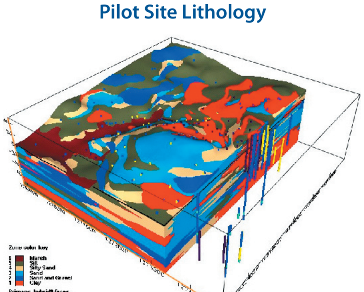
### Reactive Mat Design Concept




### TeCA Degradation



### Aberdeen Proving Ground Pilot Site Lithology



*(Courtesy of Weston Solutions)*

The United States Geological Survey (USGS), a bureau of the US Department of the Interior, and GeoSyntec Consultants signed a cooperative research and development agreement (CRADA) to collaborate on the further development of an in situ bioremediation technology application that combines bioaugmentation with an engineered mat to passively treat contaminated groundwater. The geotechnically engineered, horizontal, permeable, biologically reactive mat consists of several different media layers impregnated with naturally-occurring biological agents capable of degrading contaminants directly at the point of groundwater discharge to surface water.

This targeted exposure point treatment has been effectively pilot tested by USGS and GeoSyntec at the Edgewood Area of Aberdeen Proving Ground at an area where chlorinated solvents seep into a creek. By utilizing a dechlorination consortium of bacteria (WBC2), 1, 1, 2, 2-tetrachloroethane (TeCA) and several other chlorinated ethanes and ethenes were rapidly degraded.

This technology is expected to significantly contribute to the field of in situ remediation solutions, particularly for exposure point treatment in estuarine, riverine, wetland, and coastal environments. Plans are to further develop both the reactive mat delivery technology and the dechlorinating consortium for use with contaminants and other physiographic settings.

GeoSyntec, a leader in chlorinated solvent remediation, is an employee-owned, engineering consulting company with over 500 employees in North America, the United Kingdom, and Malaysia.

USGS is the nation's largest water, earth, and biological science and civilian mapping agency, which collects, monitors, analyzes, and provides scientific understanding about natural resource conditions, issues, and problems. The 10,000 scientists, technicians, and support staff of the USGS are located in offices in every state and in several foreign countries

Aberdeen Proving Ground in Maryland originated as a munitions testing site in 1917, and evolved to a R&D facility for energetics, projectiles, bombs, and ballistics. They are considered one of the US Army's leading test, evaluation, research, development, and training facilities.

A CRADA allows a government agency and private company to optimize resources, share technical expertise and intellectual property emerging from the effort, and speed the commercialization of federally developed technology.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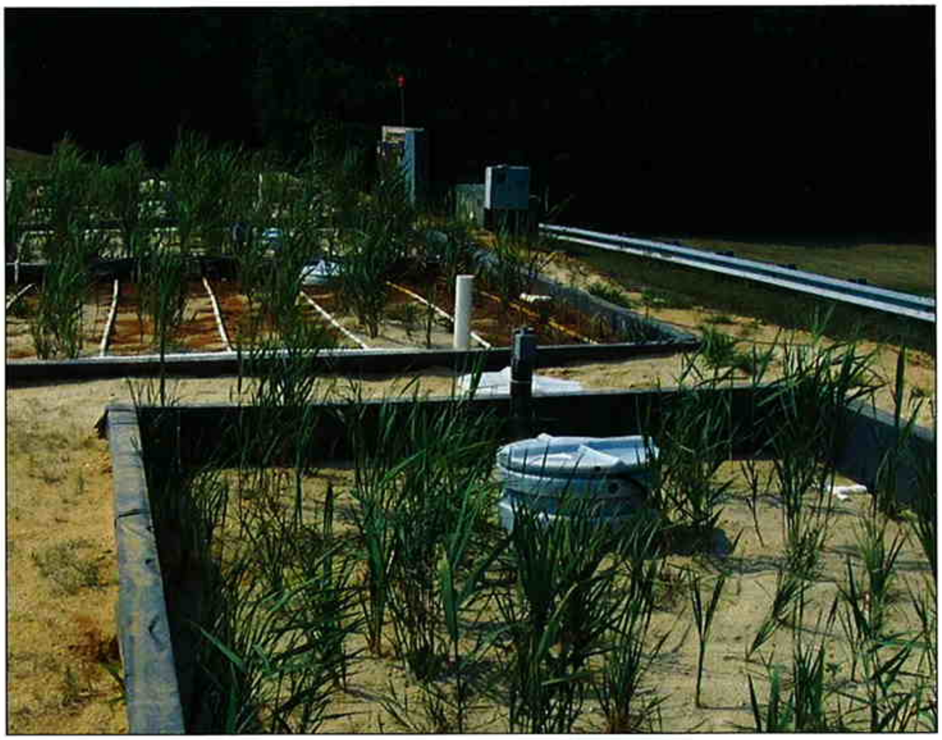
June/July 2005

# COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENT (CRADA) *~BRINGS TWO NEW BIOREMEDIATION TECHNOLOGIES TO THE MARKETPLACE*

*By Julie Beem*

The U.S Geological Survey and GeoSyntec Consultants have entered a Cooperative Research and Development Agreement (CRADA) for advancing the development of two technologies: Bioaugmentation in treating TeCA and Receptor-Focused Remediation.



### Bioaugmentation Using WBC-2

Chlorinated solvents are the most common groundwater contaminants in the United States, and of those, the most common are PERC (tetrachlorothene), the common dry cleaning fluid, and TCE (trichloroethene), the degreasing solvent. But a number of other chlorinated solvents have been used as well. For example, the Department of Defense developed and used a solvent mix known as DANC (degreasing agent non-corrosive) at some of its installations. DANC is composed of 90 percent 1,1,2,2-tetrachloroethane (TeCA), six percent TCE, and four percent other solvents. The Department of Defense also used TeCA in the clothing impregnating process at some installations. At some sites, TCE biodegrades naturally or by the addition of biodegradable organic carbon compounds. TeCA may also biodegrade naturally. In situations where biodegradation does not occur without human intervention, bioaugmentation can be beneficial. When bioaugmentation is needed, TCE has been shown to biodegrade under anaerobic conditions, and several commercially available microbial products are available to facilitate reductive dechlorination of TCE. But, until recently no naturally-occurring cultures were available with the capability to degrade TeCA.

TeCA is a contaminant found in groundwater at Aberdeen Proving Ground, Maryland. Dr. Michelle Lorah of the U. S. Geological Survey Maryland-Delaware-D.C. Water Science Center in Baltimore is a leading expert on the biodegradation of TeCA and other chlorinated solvents, especially in wetland environments. She and colleagues, Dr. Mary Voytek (with USGS' National Research Program) and Emily Majcher, P.E. (USGS Baltimore), have characterized the hydrology and microbiology of TeCA biodegradation in wetlands at Aberdeen Proving Ground, in cooperation with the U.S. Army Garrison's Directorate of Safety, Health, and the Environment Installation Restoration program.

Dr. Lorah and her USGS colleagues identified a naturally-occurring microbial consortium in wetland sediment that can completely biodegrade TeCA to ethene. Testing showed that this consortium of microorganisms reliably degraded TeCA and all its degradation products. But without a mechanism to propagate the culture, purify it, and produce large quantities, the discovery of this consortium was little more than a research novelty. Working collaboratively with GeoSyntec Consultants and its SiREM Laboratory, the USGS has been able to advance the consortium, known as WBC-2 from small laboratory quantities to a culture free from wetland sediment and with enough volume to support full-scale bioaugmentation programs for groundwater remediation.

### Receptor-Focused Remediation Using Reactive Mat Technology

Concurrent with the development of WBC-2 and wetlands investigations, Lorah and Majcher identified seeps as a potential source of contamination to Aberdeen wetlands. Seeps are small areas where groundwater escapes to the surface and flows into surface water at velocities that exceed the ambient groundwater flow in the wetlands by 100 times or more. The high groundwater flow velocity results in a very short contact time with the sediment. That short contact time appears to be inadequate for naturally-occurring microbes to biodegrade TeCA and other solvents dissolved in the groundwater.

The USGS and GeoSyntec are developing

remediation solutions for the efficient treatment of groundwater seep areas that target chlorinated solvents at the point of surface exposure. This technology, known as receptor-focused remediation, is easily adaptable for the treatment of a variety of chlorinated solvents such as TCE, PCE, carbon tetrachloride, chloroform, TeCA and its degradation products including 1,1,2-trichoroethane (1,1,2-TCA), cis and trans-1,2-dichloroethene (c and tDCE), 1,2-dichoroethane (1,2-DCA), and vinyl chloride (VC).

Several seep areas in the Aberdeen wetlands were identified, using thermal infrared imaging. Follow-up water sampling indicated that groundwater issuing from some of the seeps was highly contaminated with TeCA and other solvents. The solvent-impacted groundwater migrates to the wetlands and discharges through 10 to 15 feet of wetland sediment. Using traditional technologies for groundwater remediation of the aquifer appeared both difficult and costly, and may be technically impracticable. However, using the existing wetlands as a natural treatment system proved to be an effective approach for remediating groundwater before it reached sensitive ecological or human receptors. Lorah carefully documented that TeCA and other chlorinated solvents naturally attenuated in the wetland sediments with the notable exception of the seep areas. The USGS conceived a novel treatment concept to specifically remediate groundwater seeps at the point of water emergence from the ground and worked with GeoSyntec to field test the technology. Remediating contaminated water at the point of exposure substantially reduces ecological and human risk from surface water contact and provides a very practical alternative to in situ groundwater treatment.

The seep treatment process involved the design and placement of a horizontal biologically reactive mat that intercepted seep water and treated it during the short time the water contacted the mat material prior to surface discharge. The first reactive mat was designed by USGS with support from GeoSyntec. The mat contained a proprietary combination of geosynthetic fabric, composted organic matter, sand, pea gravel and other components to provide a matrix with a density and hydraulic conductivity suitable for stable placement on tidally flooded wetland sediment. Construction in a wetland presented a challenging combination of issues that were thoroughly evaluated to prevent geotechnical, hydraulic, and biological failure of the reactive mat.

To insure rapid and complete

biodegradation of chlorinated solvents including TeCA, the reactive mat was bioaugmented with WBC-2. The consortium had been cultured in 20-liter batches, shown to be free of human pathogens, and genetically and physiologically characterized. SiREM Laboratory prepared and delivered WBC-2 in anaerobic tanks to reduce its exposure to oxygen, and then the culture was applied to the mat during construction using a simple garden-style sprayer attached to the pressurized anaerobic tank. The culture was sprayed directly onto lifts of mat material and immediately covered with more mat material. Although reductive dechlorination requires anaerobic conditions, WBC-2 was found to be surprisingly tolerant to oxygen. WBC-2 will survive at least one hour of exposure to air with no loss of activity. This characteristic offers flexibility in culture delivery during construction.

Characterization of the seep area in preparation of the mat design required measurements of sediment compressive strength, shear strength, hydraulic conductivity, hydraulic head pressure, chemical composition of the groundwater, seep microbiology, and sediment geochemistry. The optimized design indicated a 22-inch thick mat with a hydraulic conductivity and density slightly less than that of the native seep area sediment. Based on seep area groundwater flow velocity, the mat retained water for ten to 14 days prior to discharge. The mat was bioaugmented with WBC-2 to assure solvents would be biodegraded rapidly and completely.

The first deployment of the reactive mat technology occurred in October 2004. Preliminary monitoring results indicate removal efficiencies approaching 100 percent, with several solvents entering the reactive mat at parts per million concentrations. Near the top surface of the mat, solvents and degradation products were either not detected or present in low parts per billion concentrations, in contrast to concentrations hundreds to thousands of times higher entering the bottom of the mat.

The technical advances made during the initial development and deployment of the reactive mat have general applicability to sites where contaminated groundwater seeps to the surface in wetland, riverine, estuarine, and coastal environments. Georgia contains approximately 7.7 million acres of wetland ranging from upland freshwater to coastal saltwater wetlands. Residential, commercial, and industrial developments often exist near wetlands and in some cases release harmful or hazardous materials to groundwater that make their way to the surface water in a nearby wetland. The influx of hazardous materials can cause quantifiable damage to wetland ecosystems and introduce hazardous substances into the food chain. Reactive mats provide a very focused method for treating groundwater at the point of surface water exposure. The degradation chemistry of the reactive mat can be specifically engineered using naturally-occurring microbes from the wetland or by introducing microbial cultures capable of degrading specific chemicals such as TeCA in the case of WBC-2. The reactive mat technology and WBC-2 provide environmental engineers with new tools for protecting Georgia's wetland, groundwater, and surface water resources.

To continue the development of the reactive mat technology and remediation applications of WBC-2, the USGS and GeoSyntec have entered into a CRADA. This CRADA represents an important step in the full commercialization of government-developed technology.

Dr. Duane Graves, GeoSyntec's principal investigator for the agreement explains, "The CRADA between Geosyntec and our USGS collaborators represents a truly exciting partnership, linking the inventors of the reactive mat and discoverers of WBC-2 with a firm that has consistently shown success in implementing new, innovative, and emerging technologies. We anticipate additional applications of the reactive mat that will allow us to work with Dr. Lorah and Ms. Majcher to further refine the design, construction details, and critical monitoring requirements of the reactive mat technology. Furthermore, our ability to mass produce WBC-2 for pilot and full-scale testing of bioaugmentation techniques for TeCA biodegradation makes this remediation technology a possibility for a wider range of sites.

Dr. Lorah expressed great satisfaction with the CRADA parternship between USGS and GeoSyntec indicating that it "provides a unique opportunity for USGS to further advance the understanding of bioremediation, microbiology, and hydrogeology of near surface environments through the broader use of these bioremediation technologies." She added, "I speak for our Science Center and project team when I say we are all genuinely excited for the opportunity to collaborate with GeoSyntec. It really is a win-win situation for both the public and private sectors." ❖

175
177



# ELECTRICALLY INDUCED REDOX BARRIERS FOR TREATMENT OF GROUNDWATER – PRELIMINARY RESULTS

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Co-Performers: Dave Gilbert; Matt Petersen

The concept of an electrically induced redox barrier ($e^-$barrier) is that of a permeable reactive barrier driven by low amperage, low voltage direct current. This is accomplished by installing closely spaced (planar) permeable electrodes transverse to flow through a targeted plume. Sequential oxidizing and reducing conditions are generated about the positive and negative electrodes, respectively.

An ESTCP-funded field demonstration $e^-$barrier was installed in August 2002 at F.E. Warren AFB. The barrier is approximately 2 m high and 10 m long (20 $m^2$). The base of the barrier is completed to a depth of ~5.5 m below grade. Prior to startup, the barrier was allowed to equilibrate with contaminants in the aquifer for 4 months. Conditions about the barrier are characterized using 36 multilevel sampling bundles that contain a total of 144 sampling points. A potential of 3 volts was applied in January 2003. Preliminary results indicate 60% of the TCE is removed across the barrier at this voltage. Dichloroethene (DCE) and vinyl chloride (VC) have not been detected above method limits in the vicinity of the barrier. Current density has remained stable during the first 4 months of the demonstration. This suggests that the scale management strategy (periodic changes in electrode polarity) is controlling scale formation. At 3 volts, power consumption is 1.5 watts $m^{-2}$ or 30 watts for the entire barrier. This equates to a power cost (assuming \$0.05/kwatt-hour) of \$0.0018 $m^{-2}$ $day^{-1}$ or \$0.036 $day^{-1}$ for the entire barrier. The potential applied to the barrier was increased to 6.5 volts in May 2003. Preliminary results indicate that 90-95% of the TCE is removed at this potential. Power density at 6.5 volts is 20.2 watts $m^{-2}$ for a total barrier power cost of \$0.48 $day^{-1}$. Current density has increased following the potential increase, suggesting that the scale management strategy is effective.

The overall plan for the field demonstration is to evaluate performance through winter 2004. Results, including methods of construction, performance and cost, will be documented in a comprehensive report scheduled for completion in July of 2004.

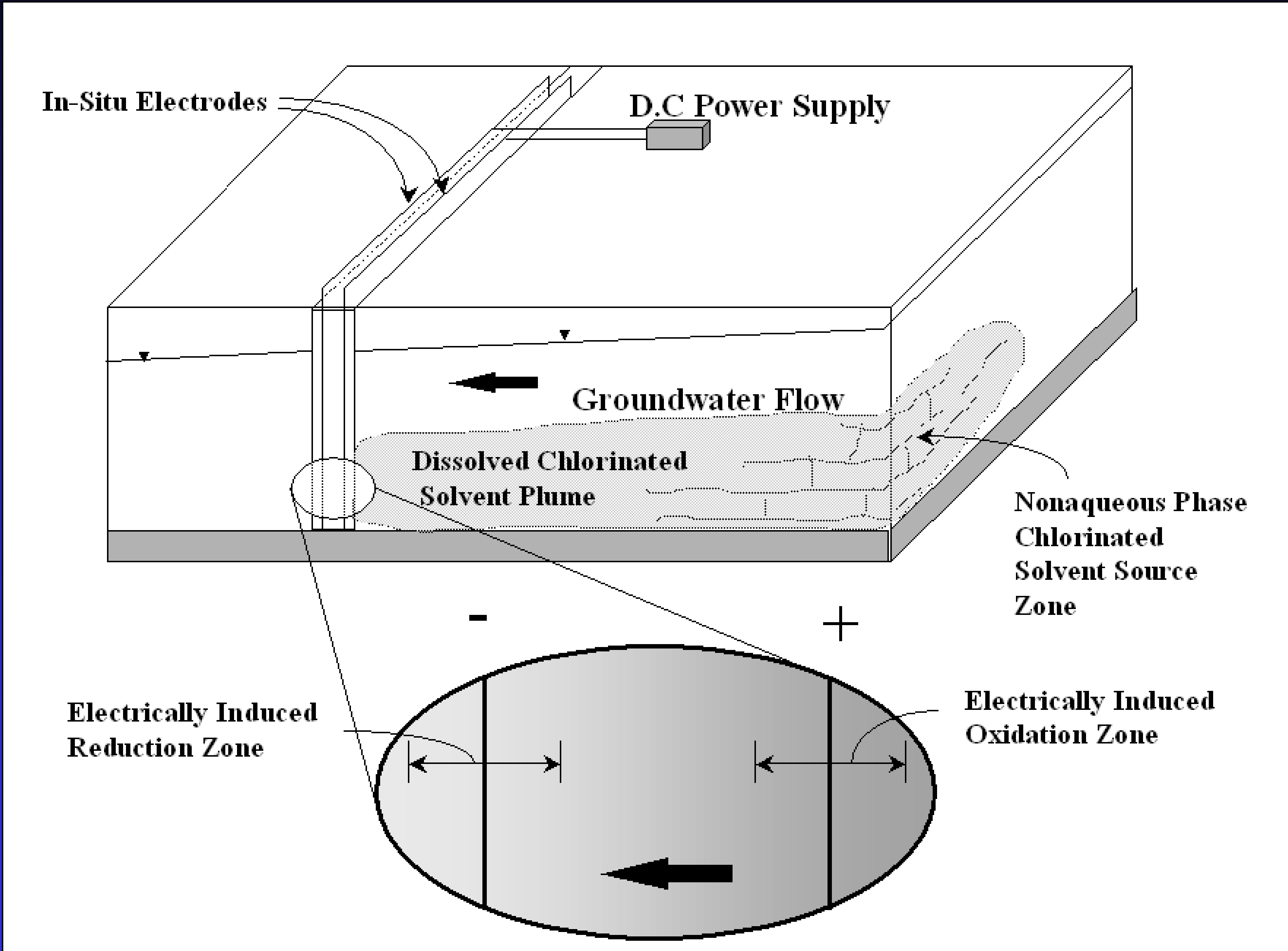
# Electrically Induced Redox Barriers (e-barriers)

Tom Sale • Dave Gilbert

Colorado State University

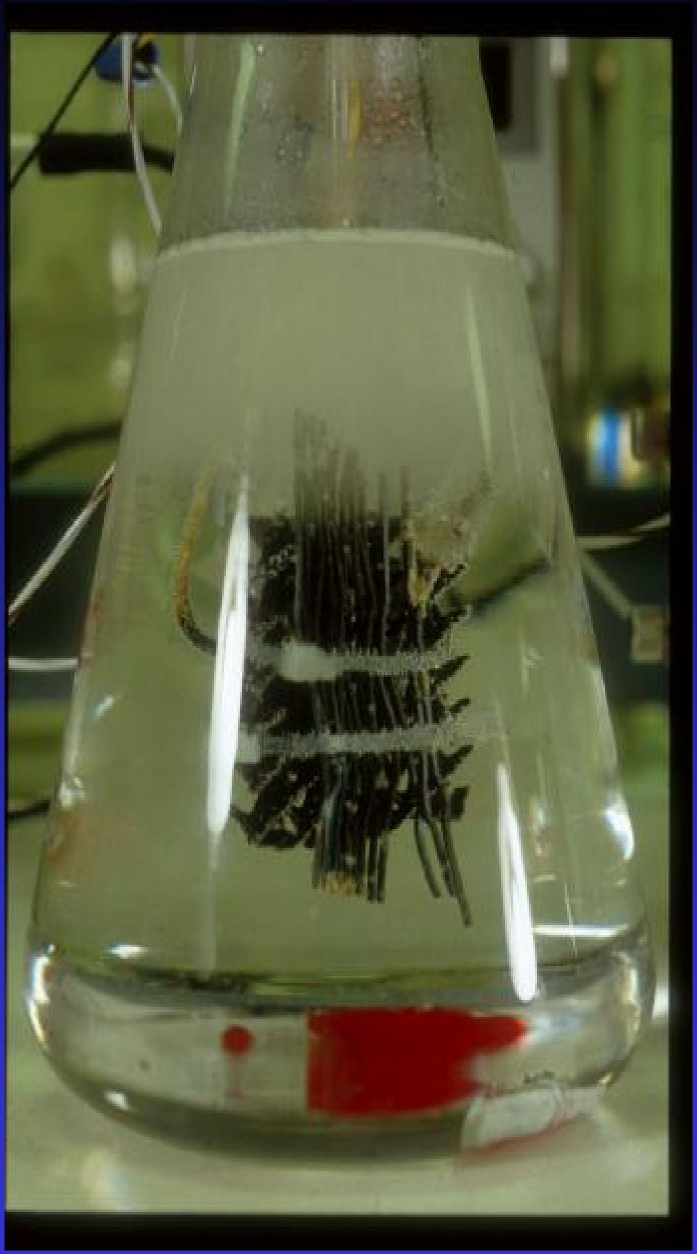
Fort Collins • Colorado

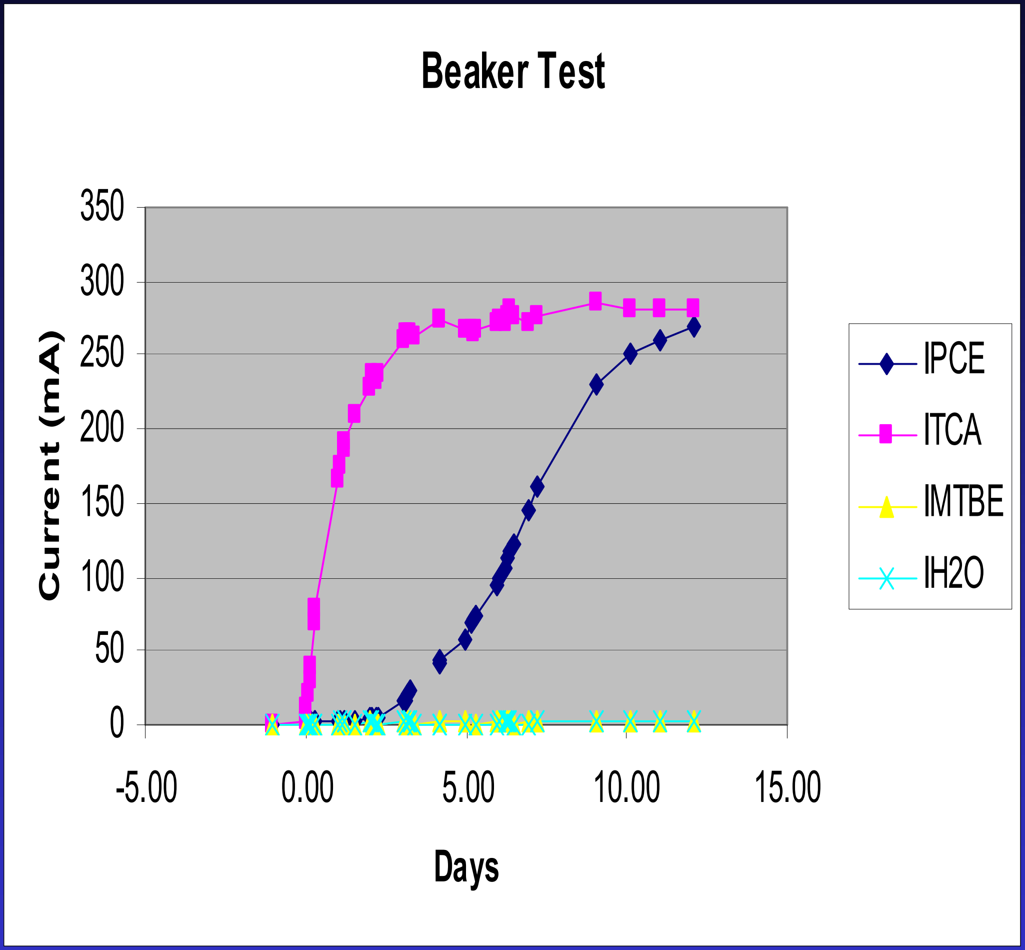
# e⁻barrier concept



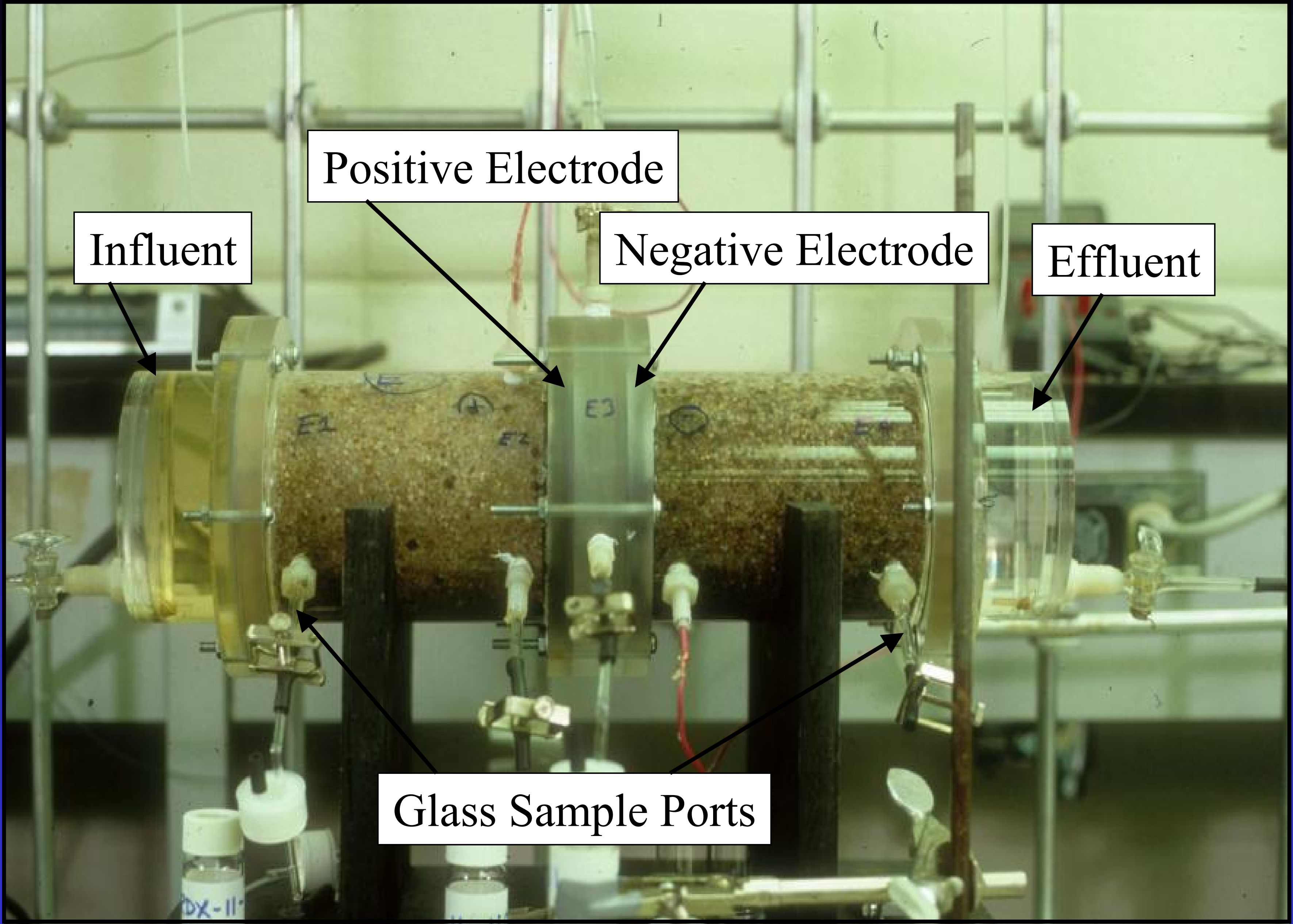
# Presentation

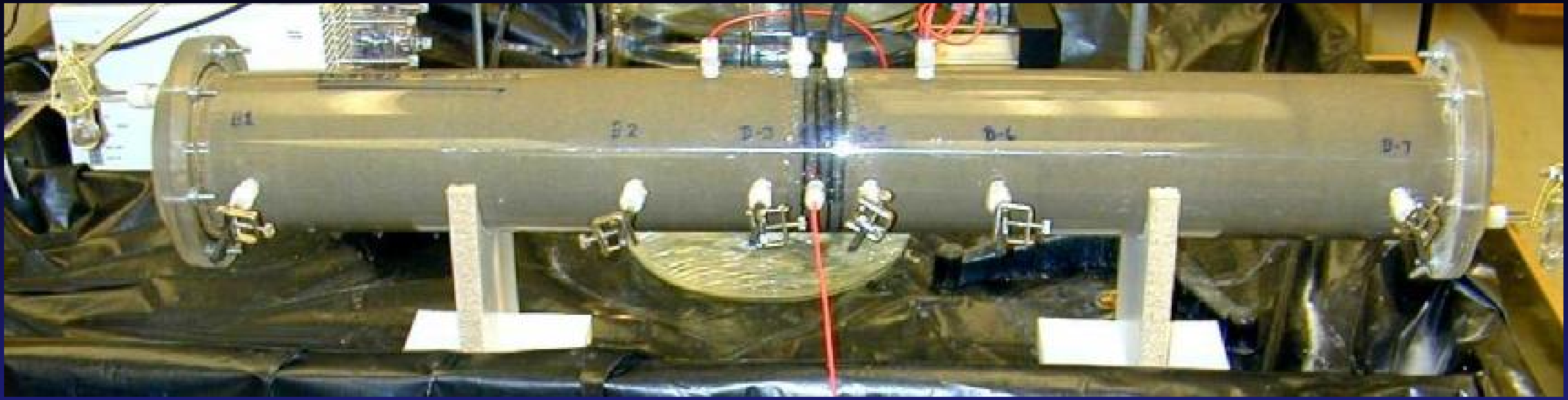
- Laboratory Studies
  - Chlorinated Solvents
  - Energetics
- Field Studies
  - CFB Borden, Ontario
  - F. E. Warren AFB, Cheyenne, Wyoming



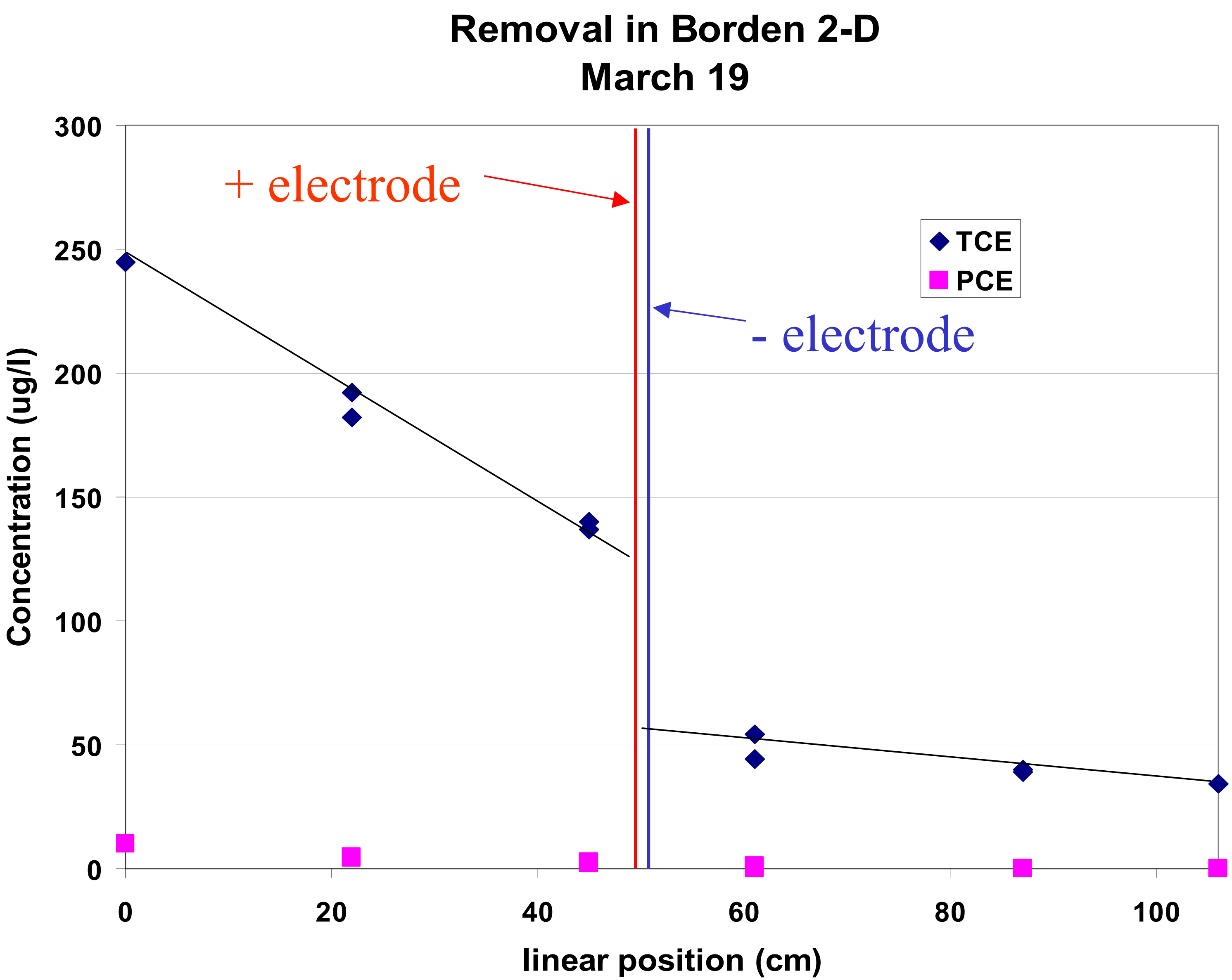

Beaker Test
Current (mA)
350
300
250
200
150
100
50
0
-5.00
0.00
5.00
10.00
15.00
Days
IPCE
ITCA
IMTBE
IH2O

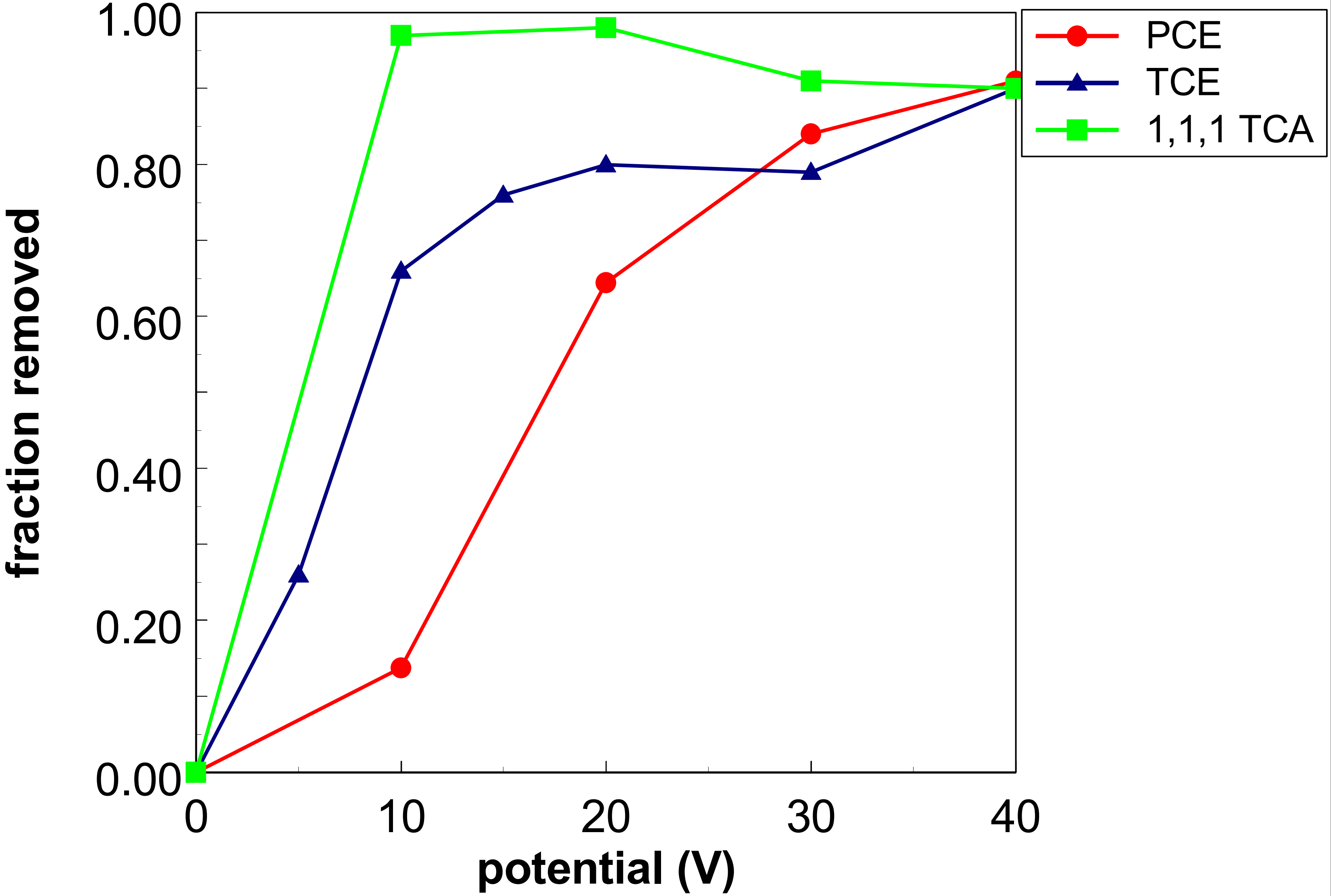

A-3
A-6
Redox VII
#2 41.53
87Ω


Positive Electrode
Influent
Negative Electrode
Effluent
Glass Sample Ports



Borden Column
and Tank Experiments


Removal in Borden 2-D
March 19
+ electrode
- electrode
TCE
PCE
Concentration (ug/l)
300
250
200
150
100
50
0
0
20
40
60
80
100
linear position (cm)



1.00
0.80
0.60
0.40
0.20
0.00
fraction removed
0
10
20
30
40
potential (V)
PCE
TCE
1,1,1 TCA

# Sequential Electrolytic Degradation of Energetic Compounds in Groundwater

Colorado State University

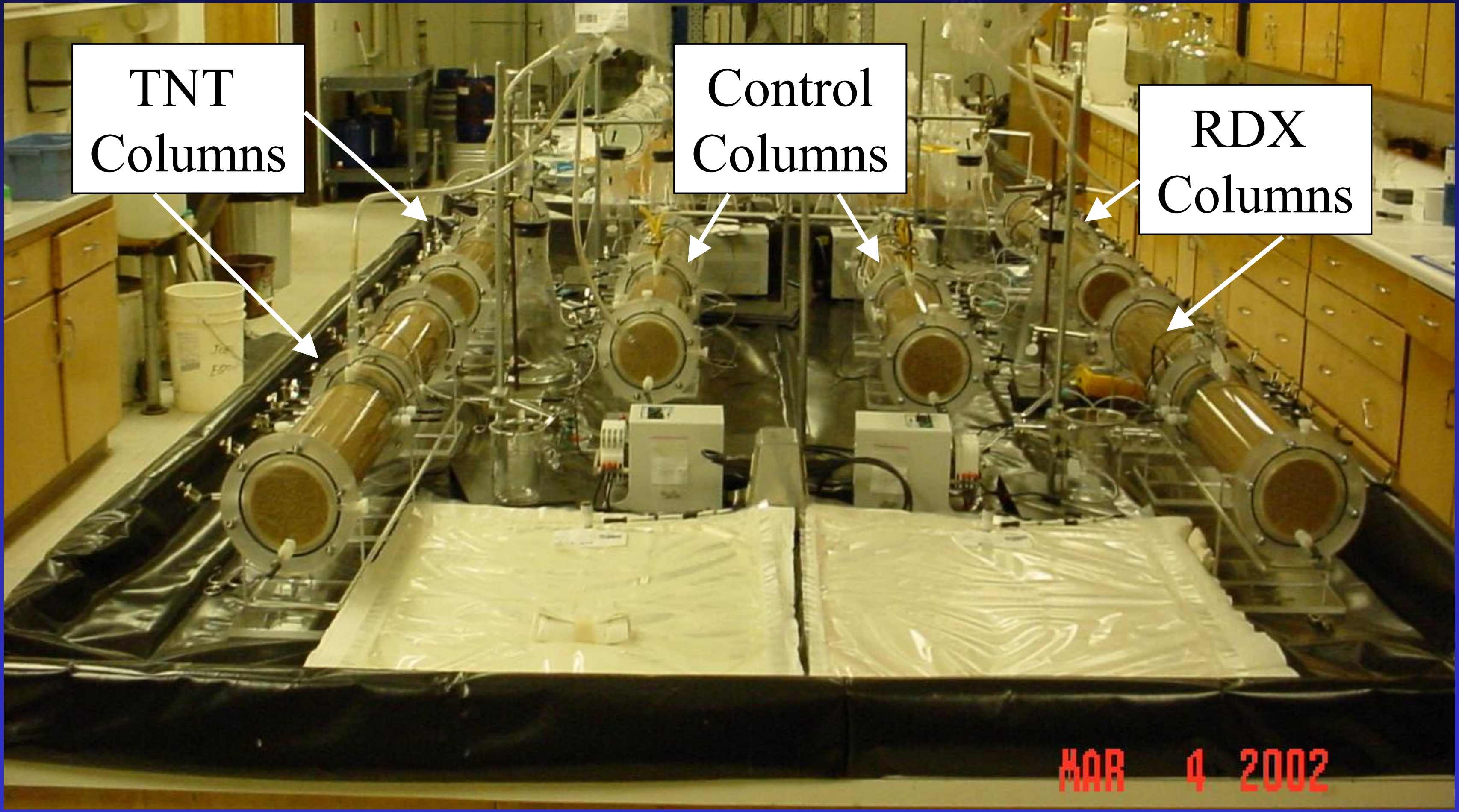
*Knowledge to Go Places*

DoD EPA DOE SERDP

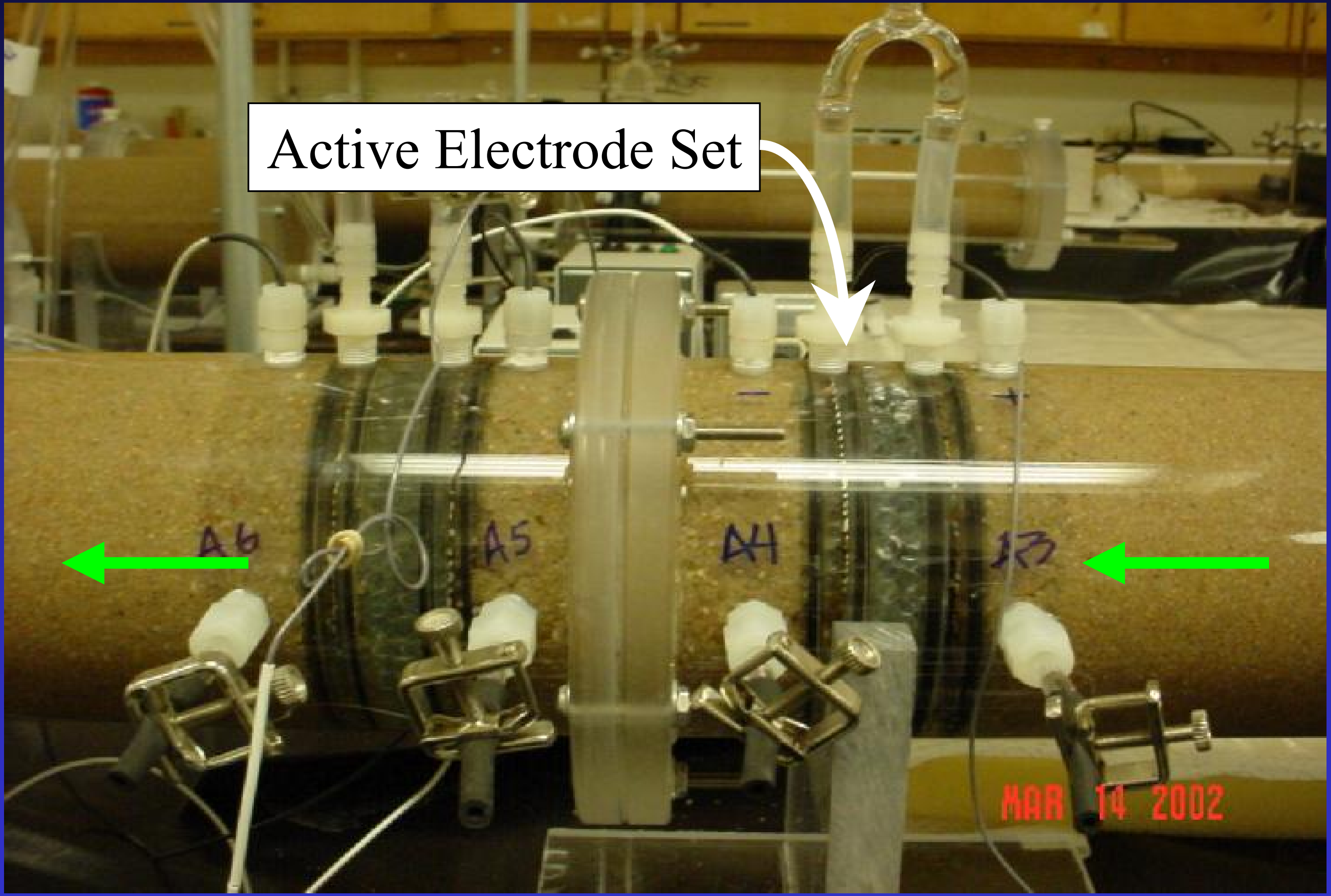
Strategic Environmental Research and Development Program

Improving Mission Readiness Through Environmental Research

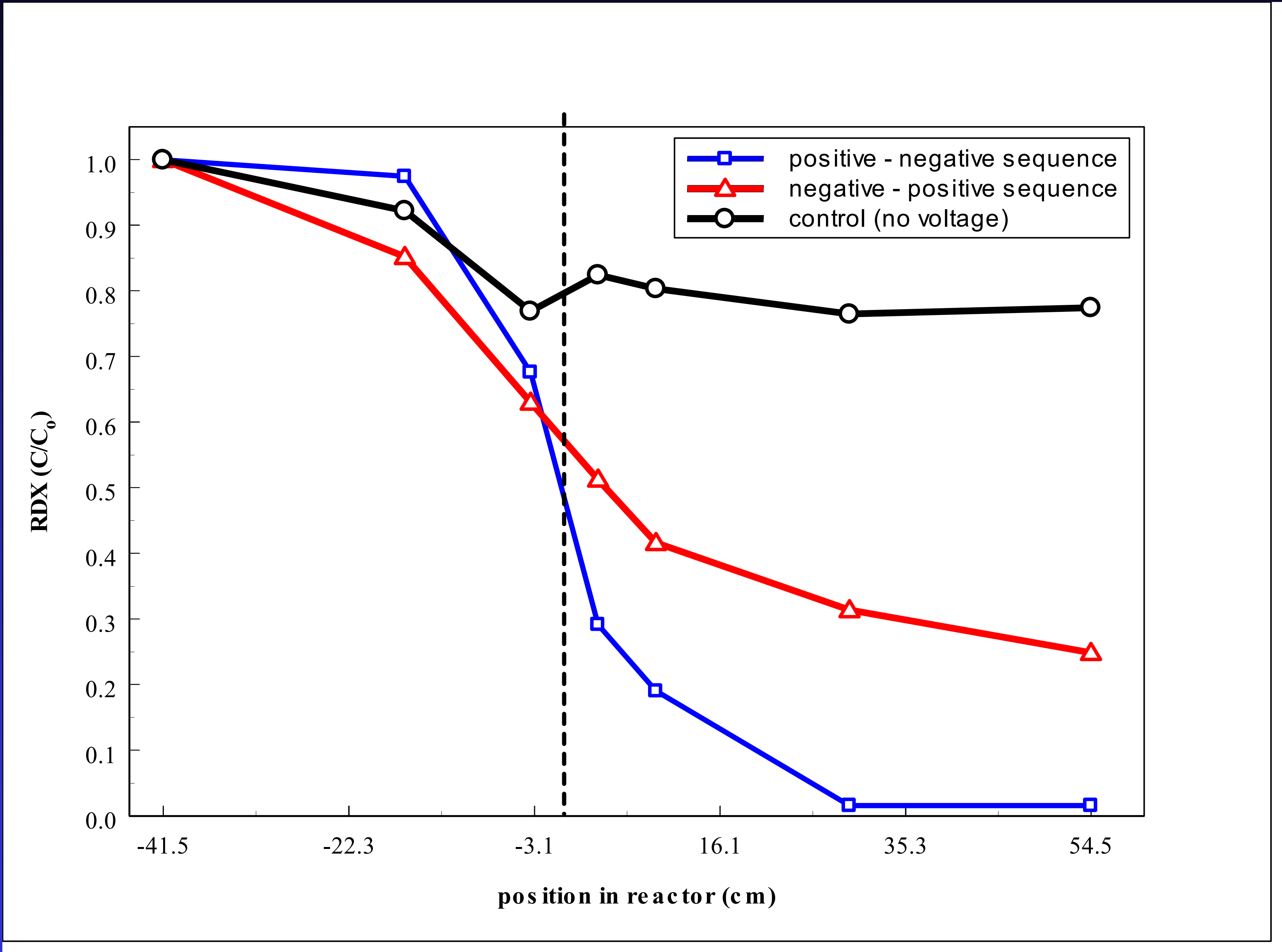
# Flow through reactors



# Electrode detail



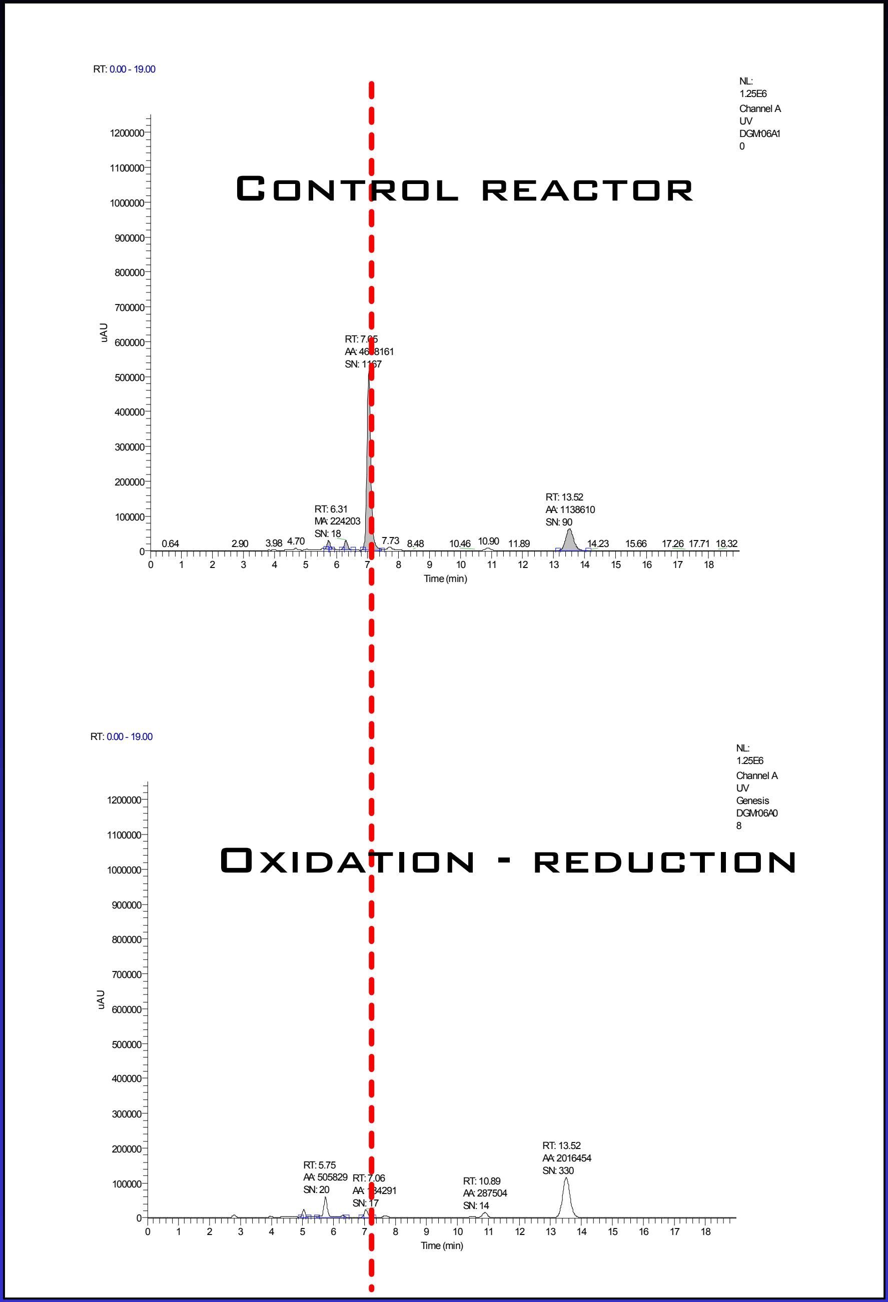
# RDX Results



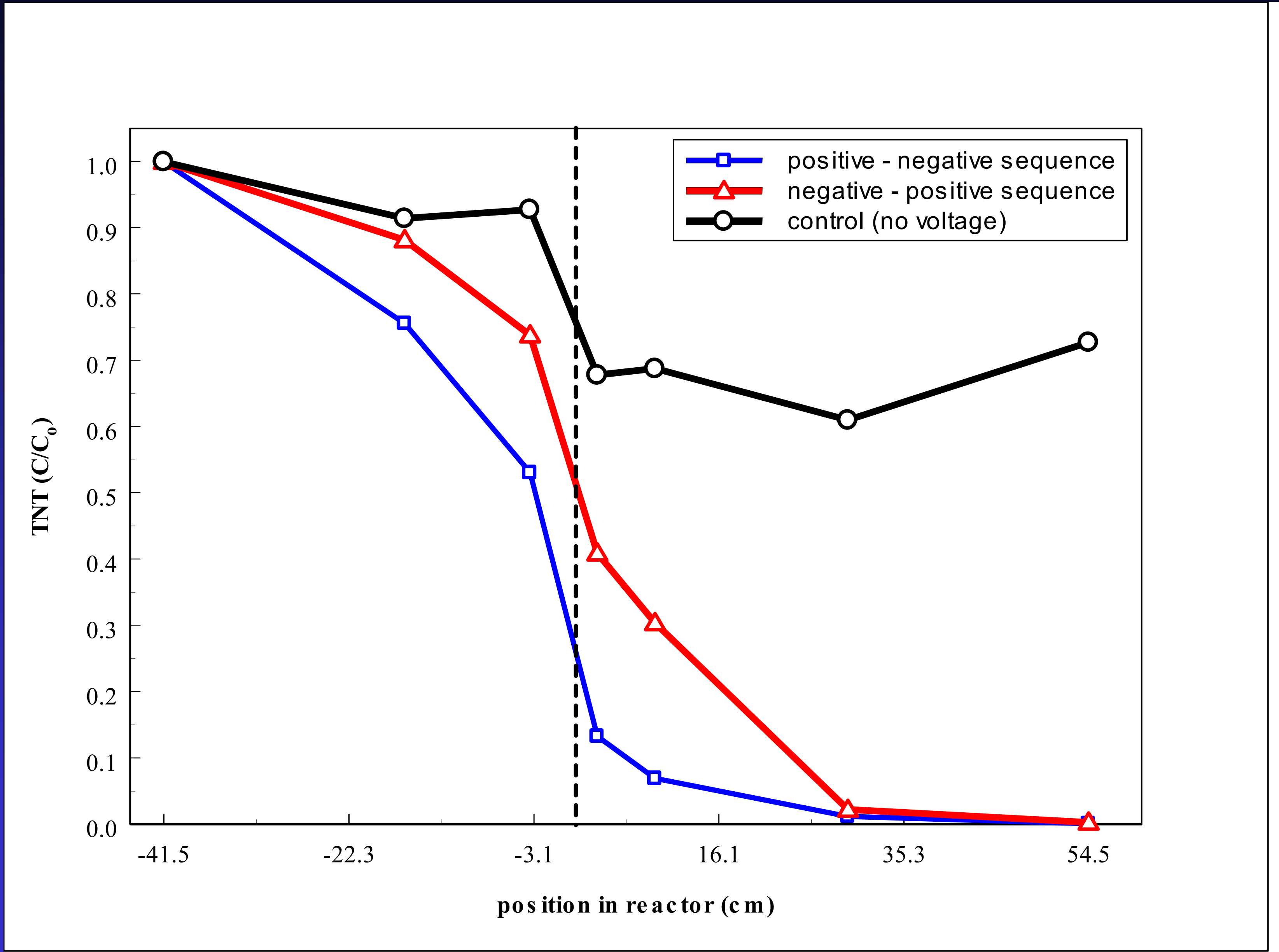
positive - negative sequence
negative - positive sequence
control (no voltage)
RDX (C/C0)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-41.5
-22.3
-3.1
16.1
35.3
54.5
position in reactor (cm)

# RDX Results

- minor peaks present also in control
- oxidation products transient



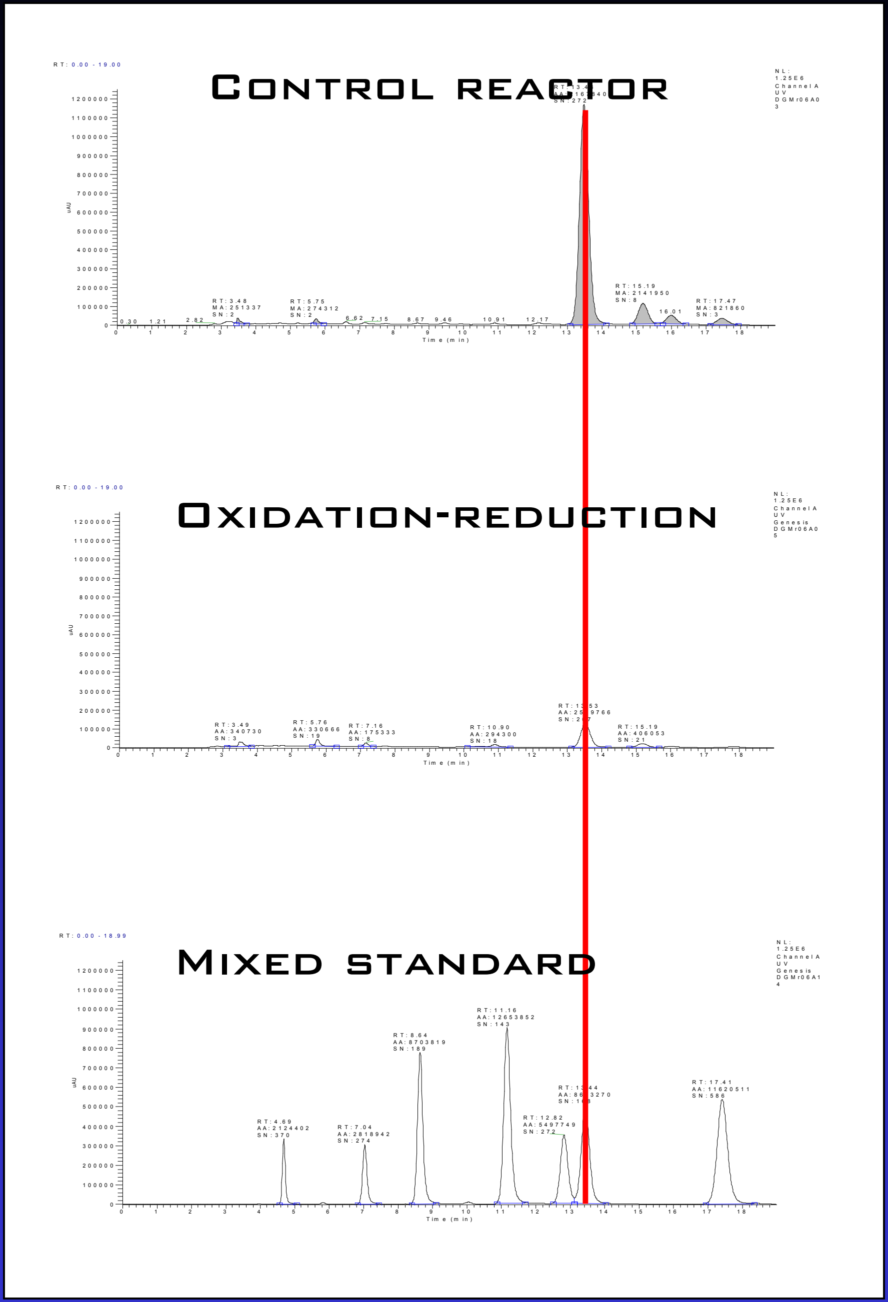
# TNT Results



positive - negative sequence
negative - positive sequence
control (no voltage)
TNT (C/C$_0$)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-41.5
-22.3
-3.1
16.1
35.3
54.5
position in reactor (cm)

# TNT Results

- common intermediate compounds absent
- minor peaks present also in control



# CFB Borden Field Experiment

Colorado State University

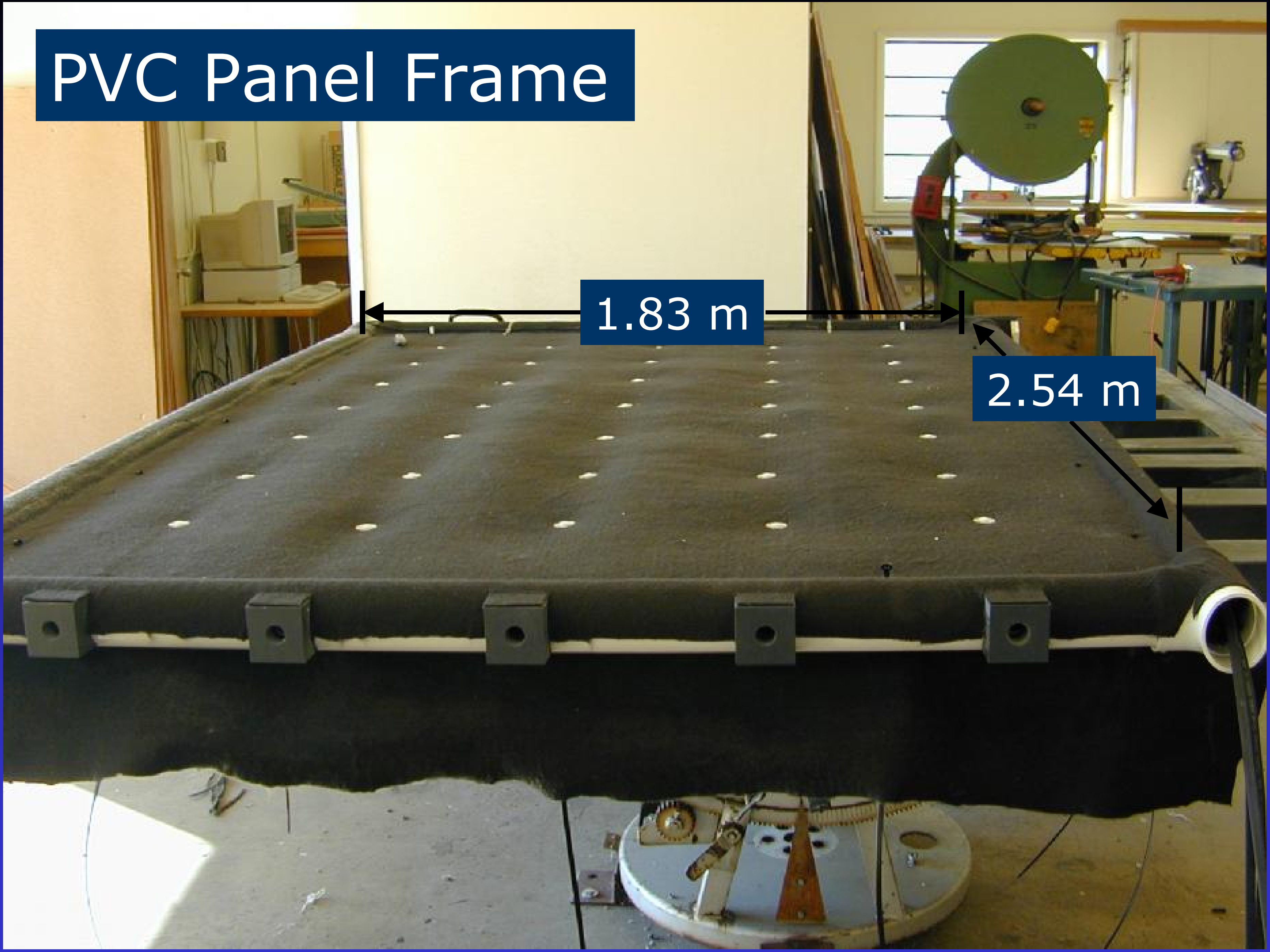
*Knowledge to Go Places*

University of Waterloo

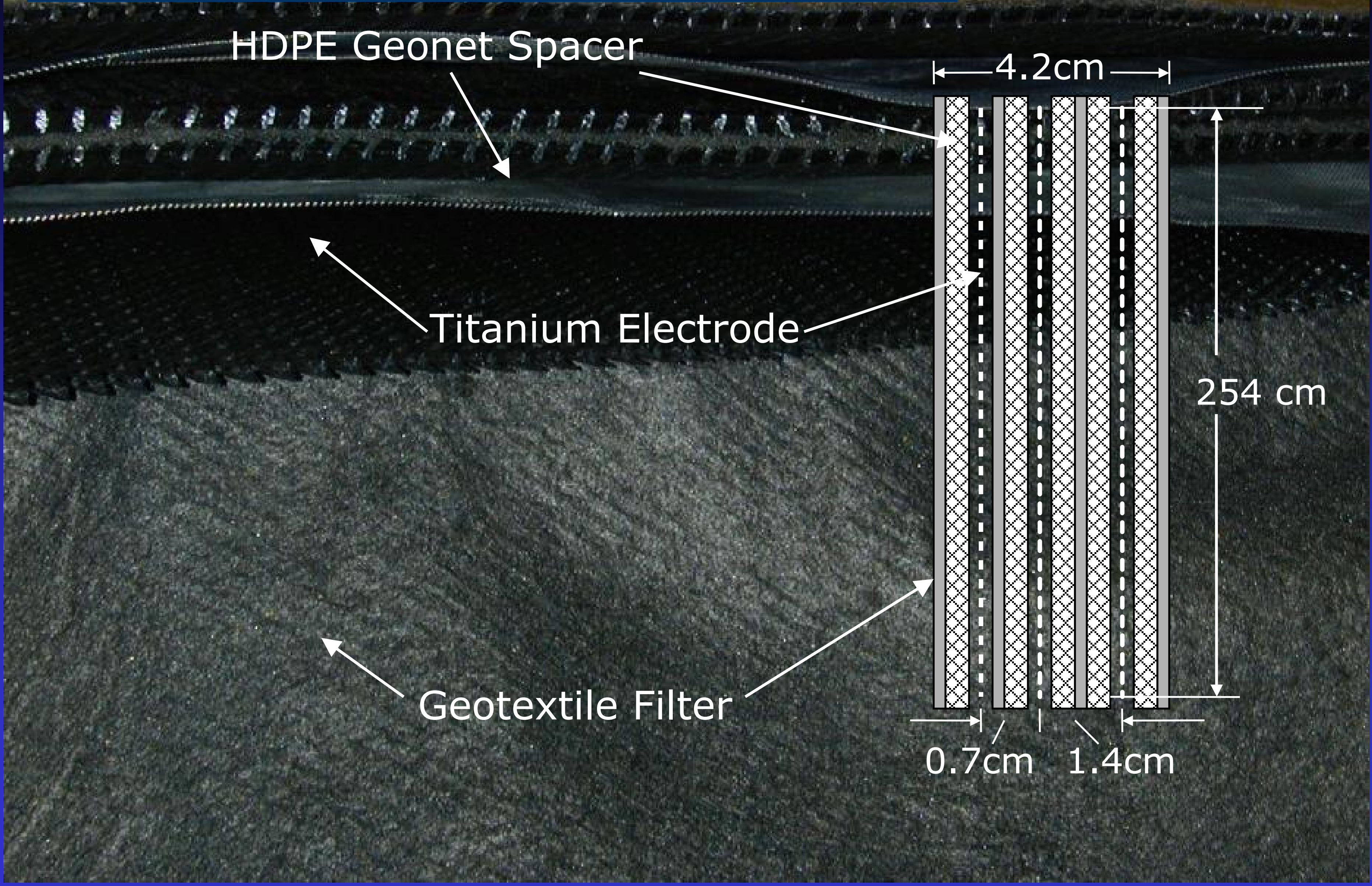
# Field Prototype Objectives

- Evaluate Scaling Lab to Field
  - Panel Fabrication/Construction
  - Installation
  - Performance
    - Electrical
    - pH and pe shifts
    - PCE-TCE depletion

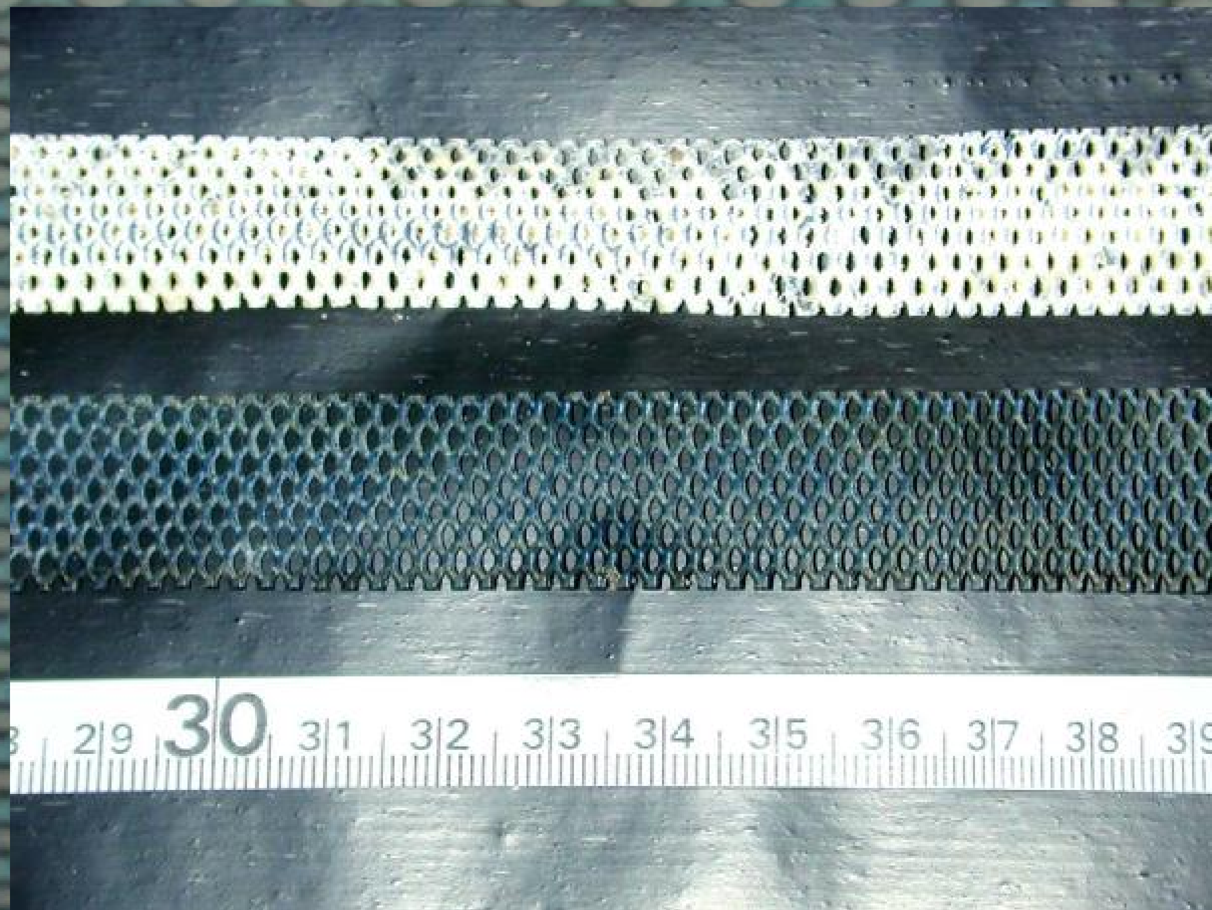
# PVC Panel Frame



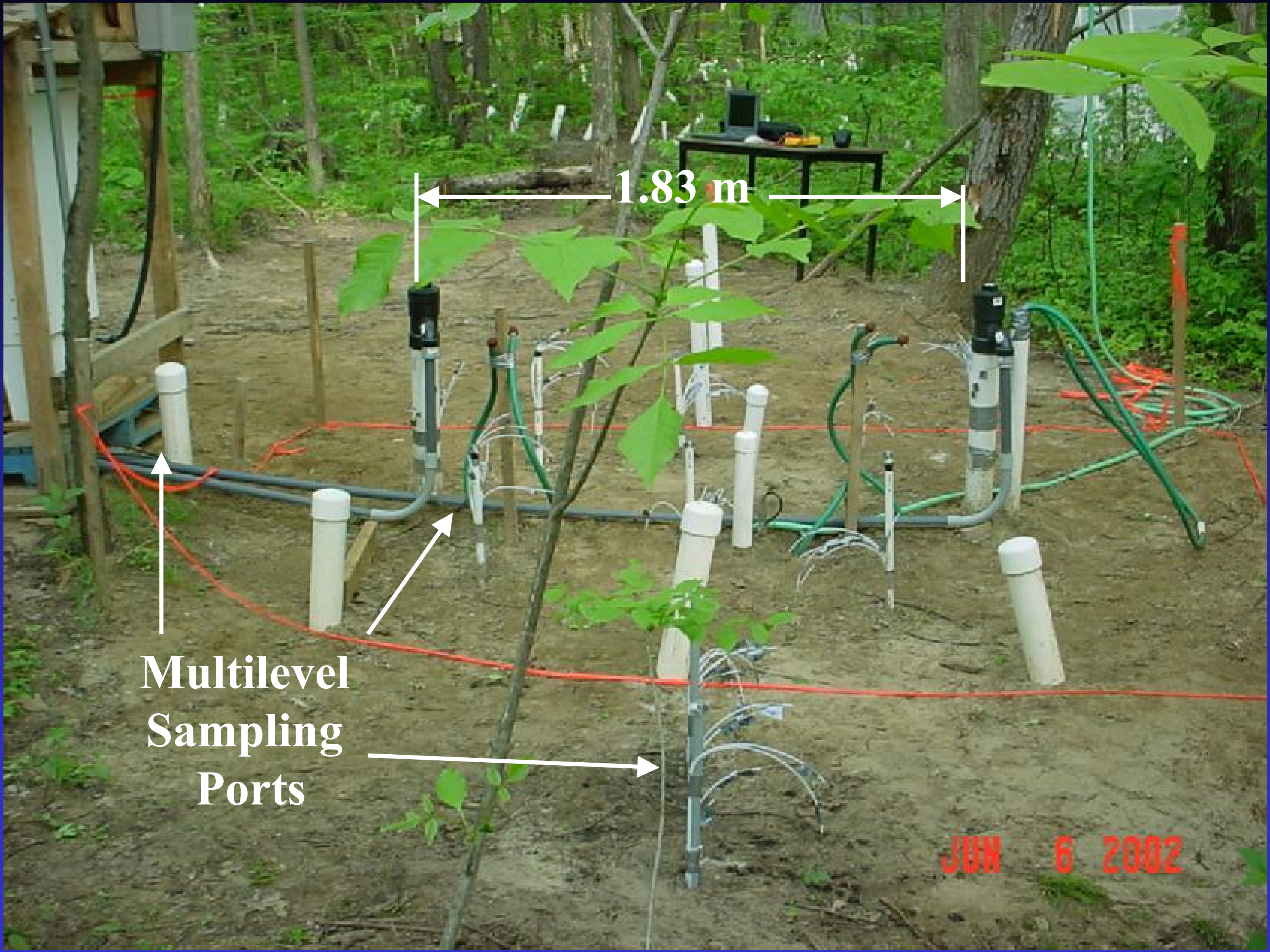
# Construction Materials



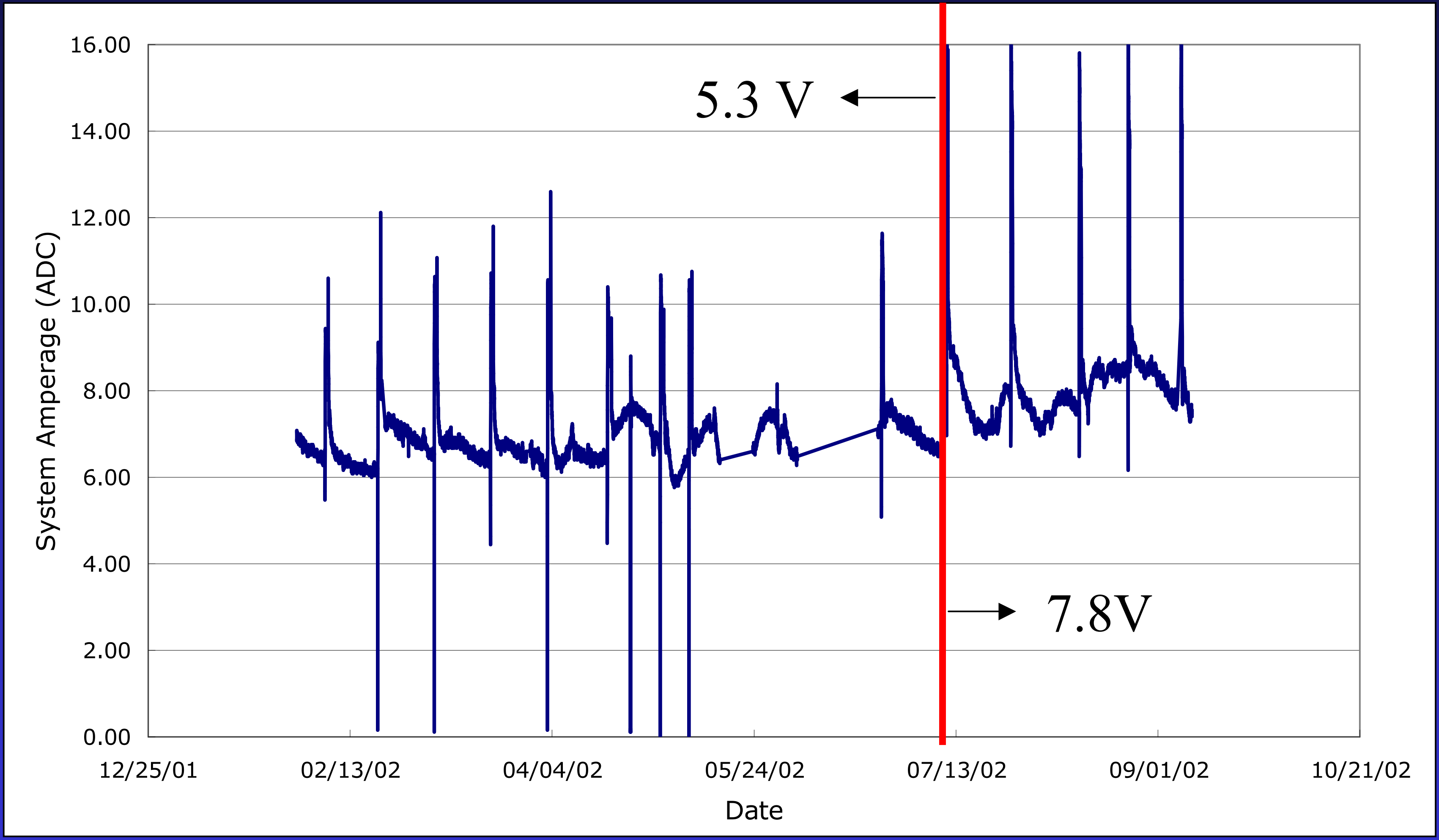
# Expanded titanium



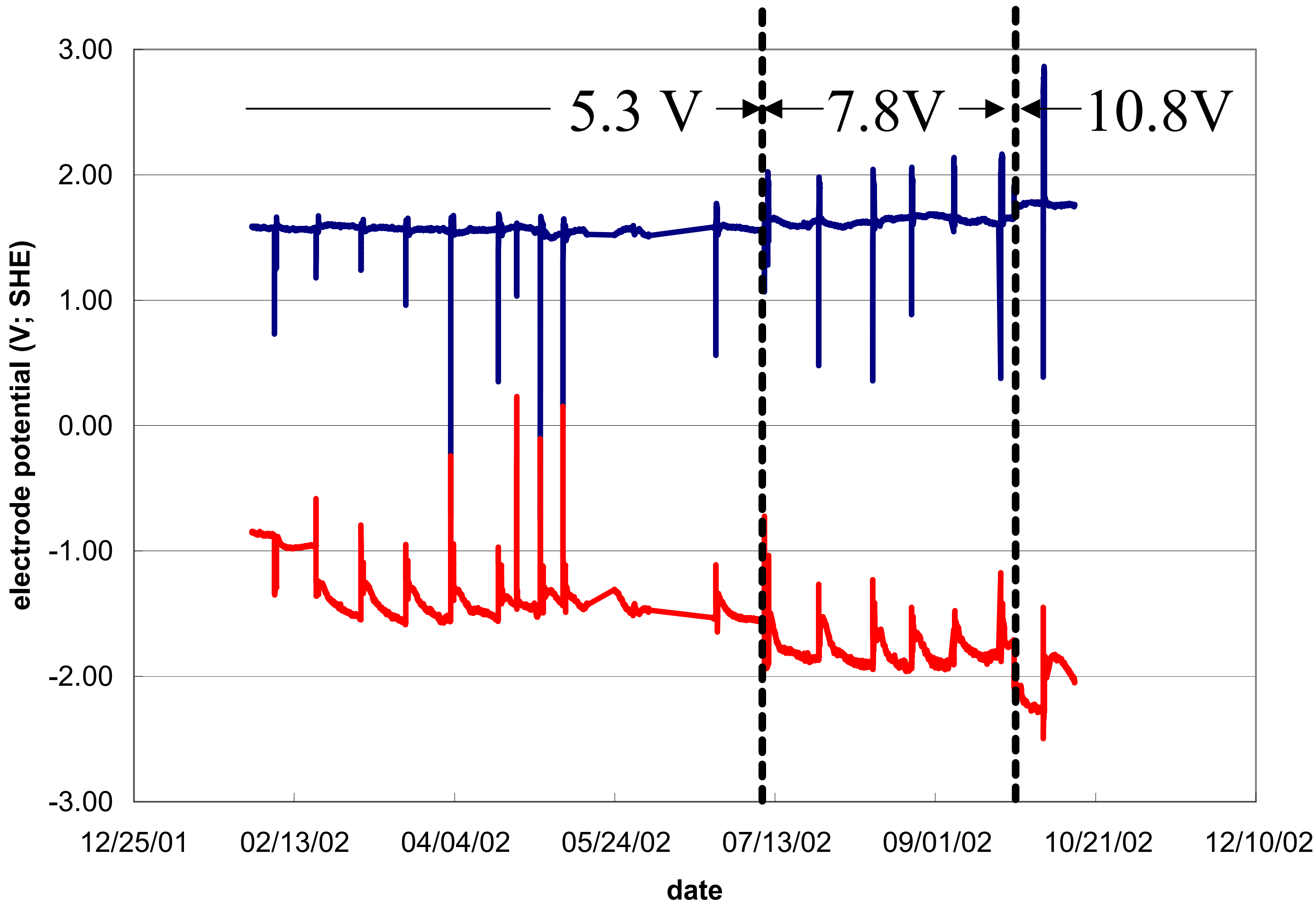
# Borden Field Prototype



1.83 m
Multilevel
Sampling
Ports
JUN 6 2002

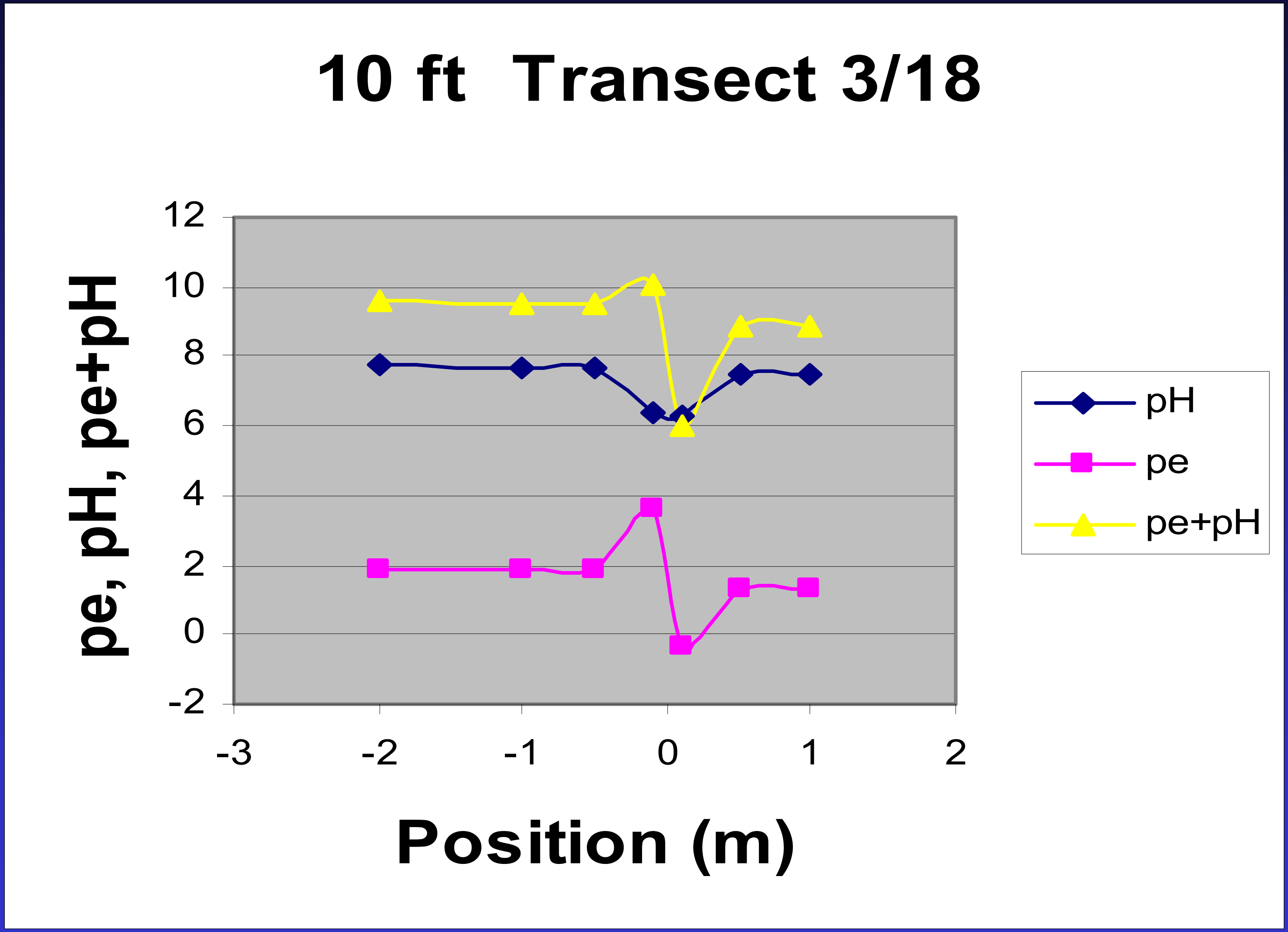
# Amperage vs. Time



# Reference Electrodes

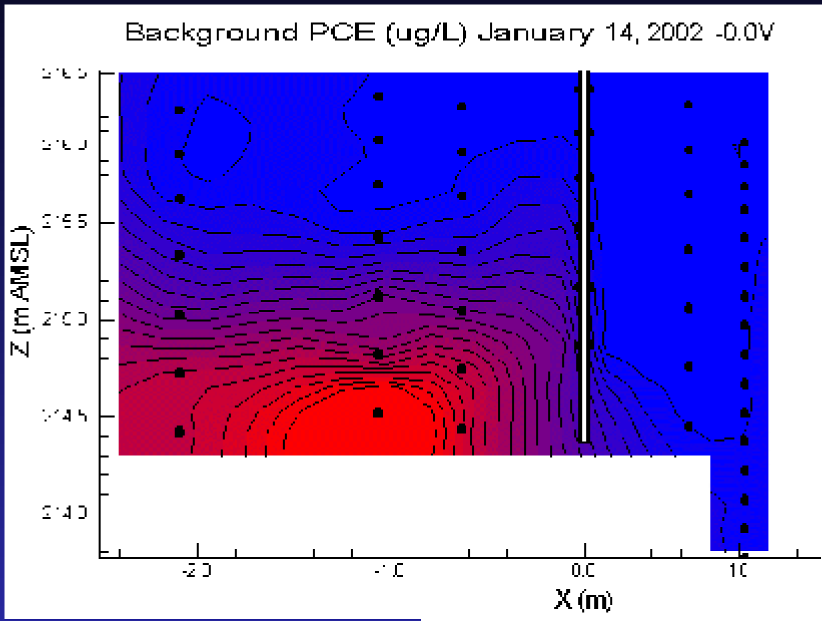


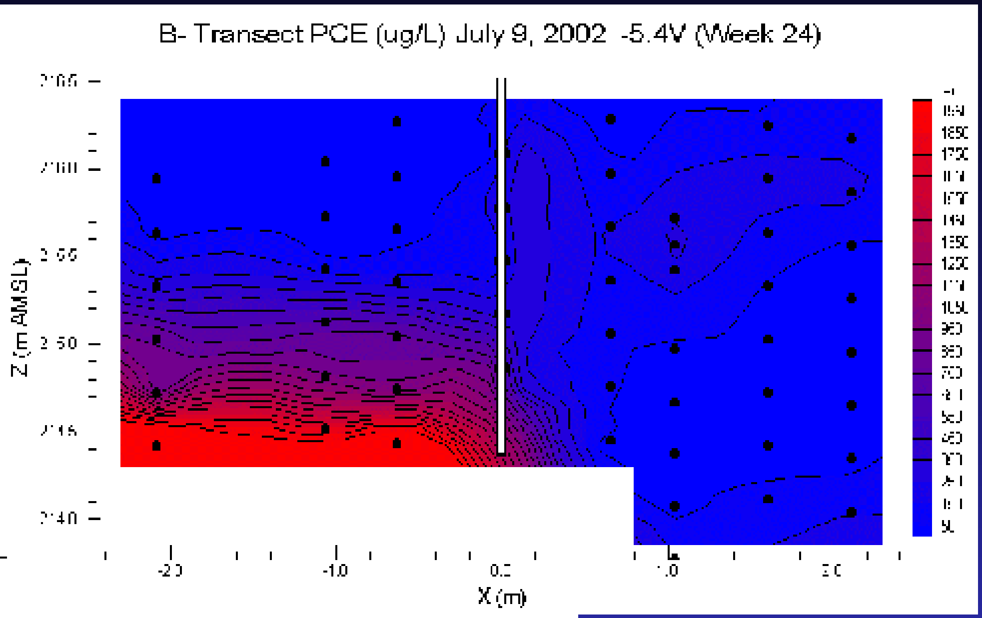
# pH and pe

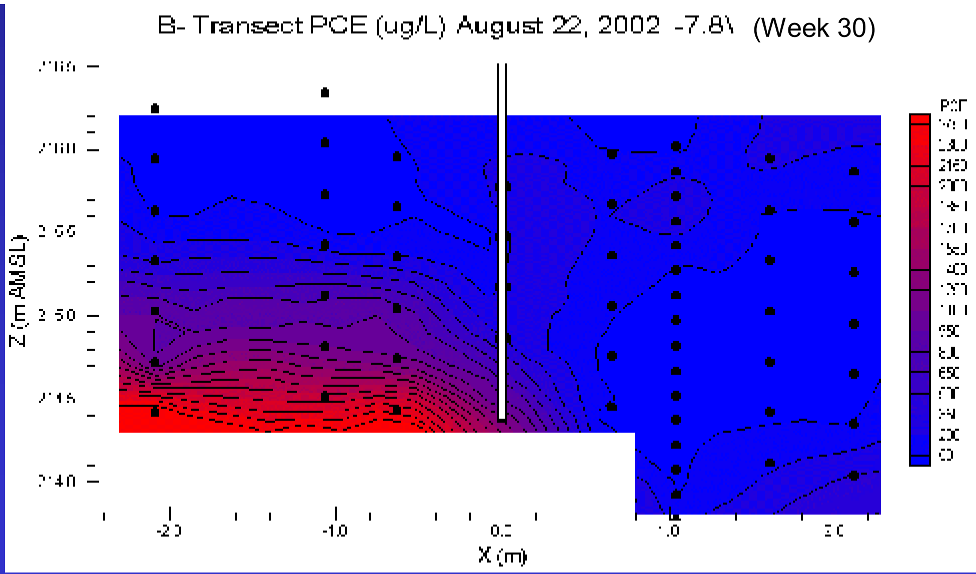


10 ft Transect 3/18
pe, pH, pe+pH
12
10
8
6
4
2
0
-2
-3
-2
-1
0
1
2
Position (m)
pH
pe
pe+pH

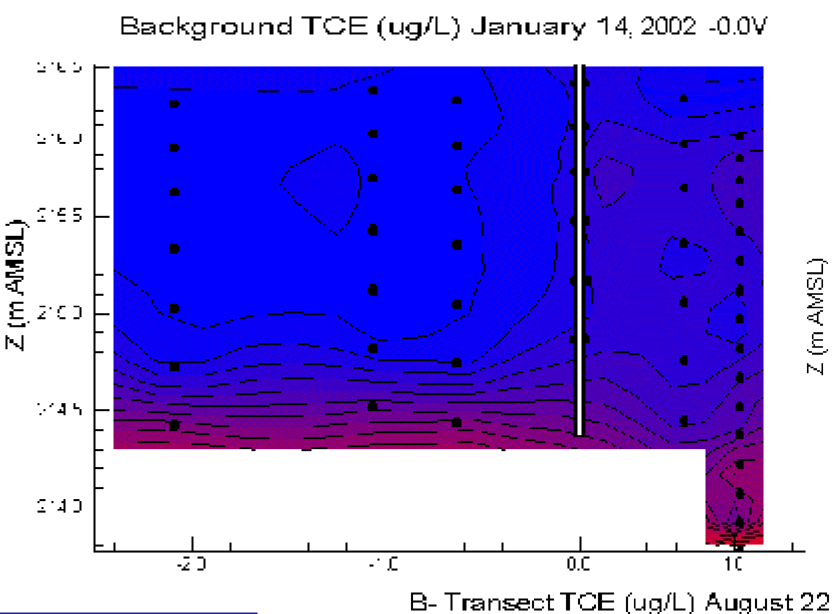
# Results - PCE

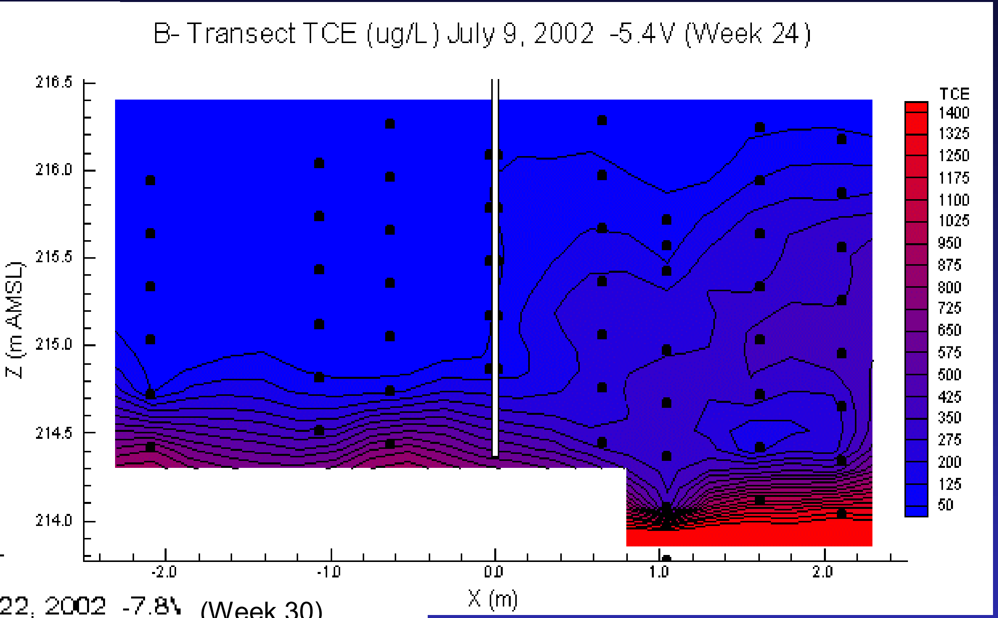

Background PCE (ug/L) January 14, 2002 -0.0V
Z (m AMSL)
X (m)

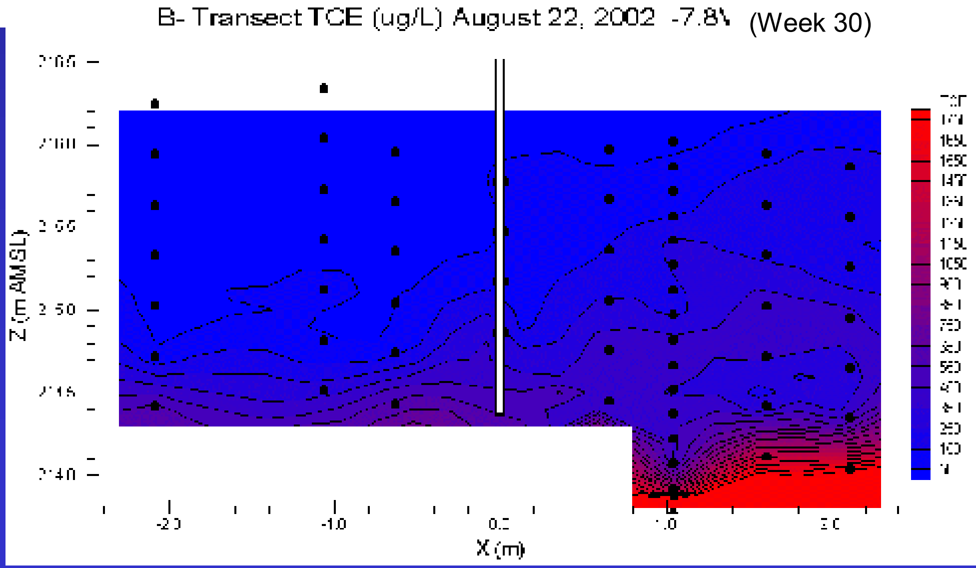

B- Transect PCE (ug/L) July 9, 2002 -5.4V (Week 24)
Z (m AMSL)
X (m)


B- Transect PCE (ug/L) August 22, 2002 -7.8\ (Week 30)
Z (m AMSL)
X (m)

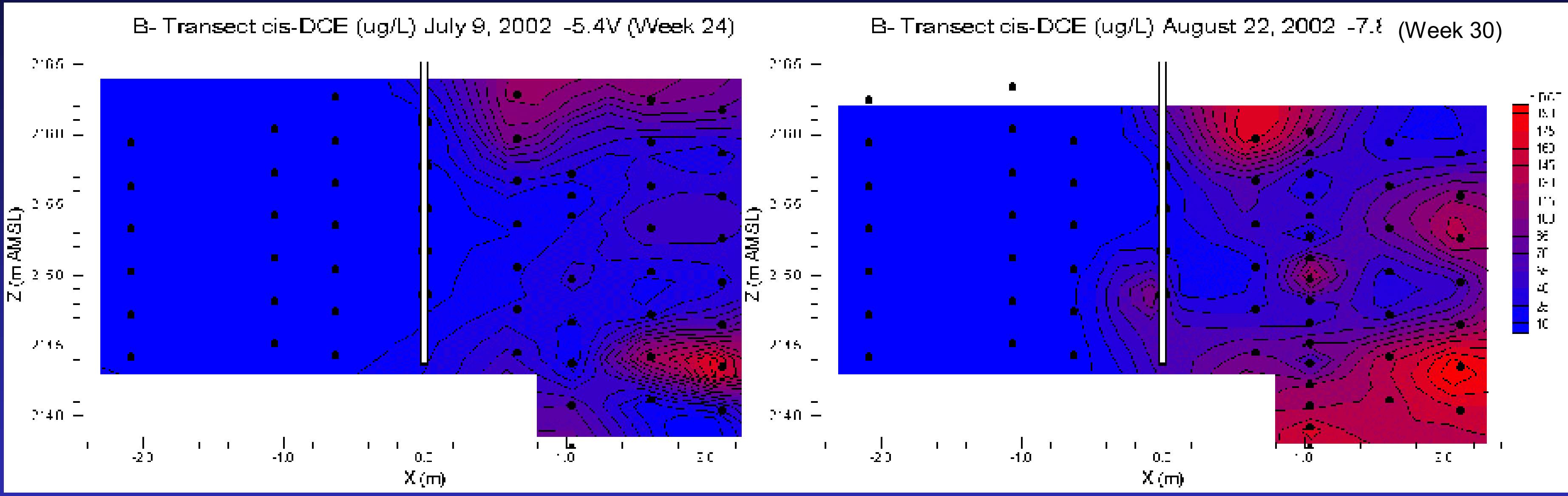
# Results - TCE


Background TCE (ug/L) January 14, 2002 -0.0V
Z (m AMSL)
0.0


B- Transect TCE (ug/L) July 9, 2002 -5.4V (Week 24)
Z (m AMSL)
X (m)
216.5
216.0
215.5
215.0
214.5
214.0
-2.0
-1.0
0.0
1.0
2.0
TCE
1400
1325
1250
1175
1100
1025
950
875
800
725
650
575
500
425
350
275
200
125
50


B- Transect TCE (ug/L) August 22, 2002 -7.8V (Week 30)
Z (m AMSL)
X (m)
-1.0

# Results - c-DCE



# CFB Borden
# Preliminary Conclusions

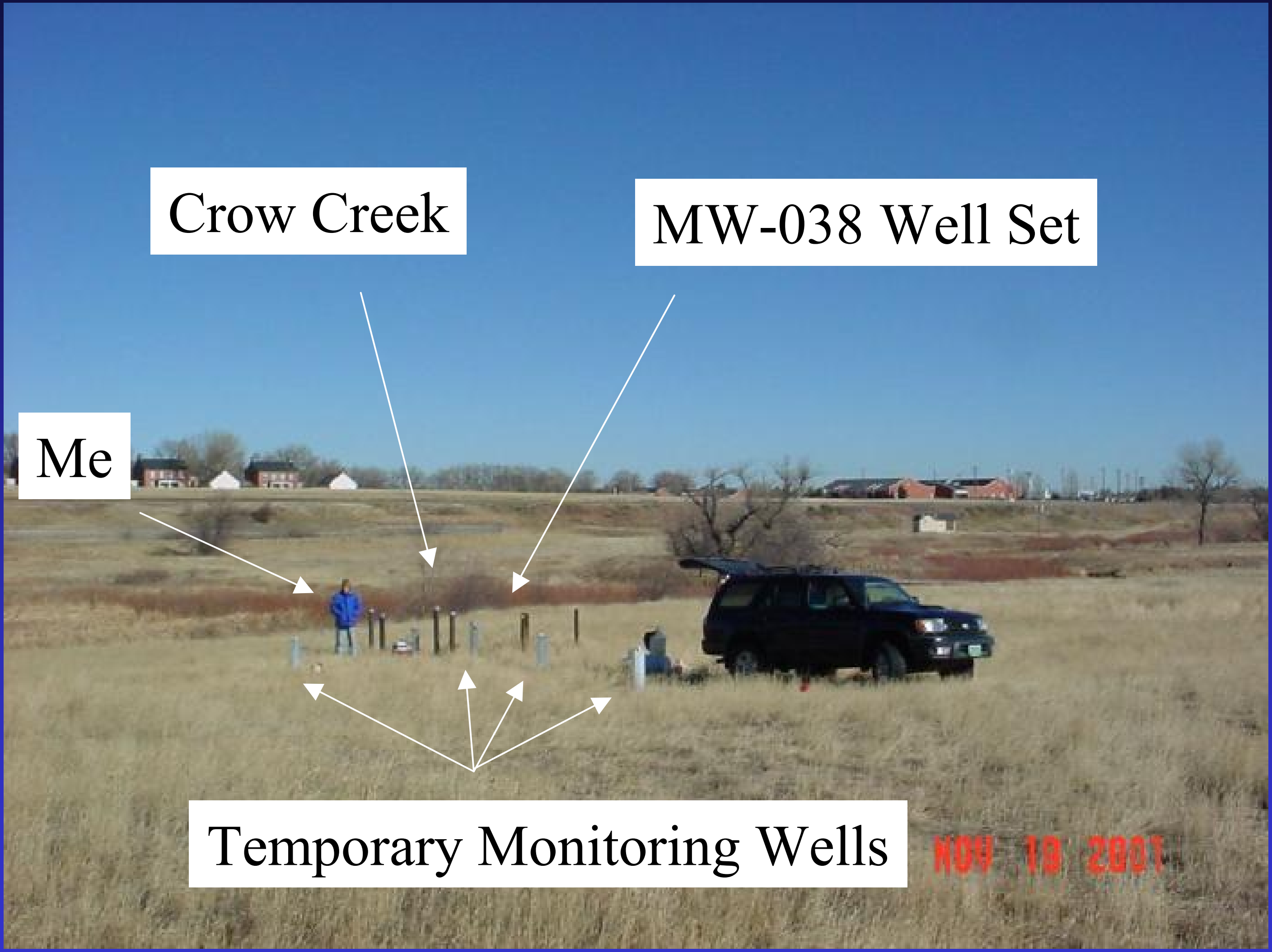
- Panel Construction – Worked, room for improvement
- Installations – Feasible, challenging
- Performance
  - Sustained amperage
  - Cost ~ \$0.01/day/$m^2$
  - pH, pe, Ref Potentials shifted
  - High level of PCE depletion sustained, generation of cis-DCE

# Electrically Induced Redox Barrier for Treatment of a Trichloroethylene Plume

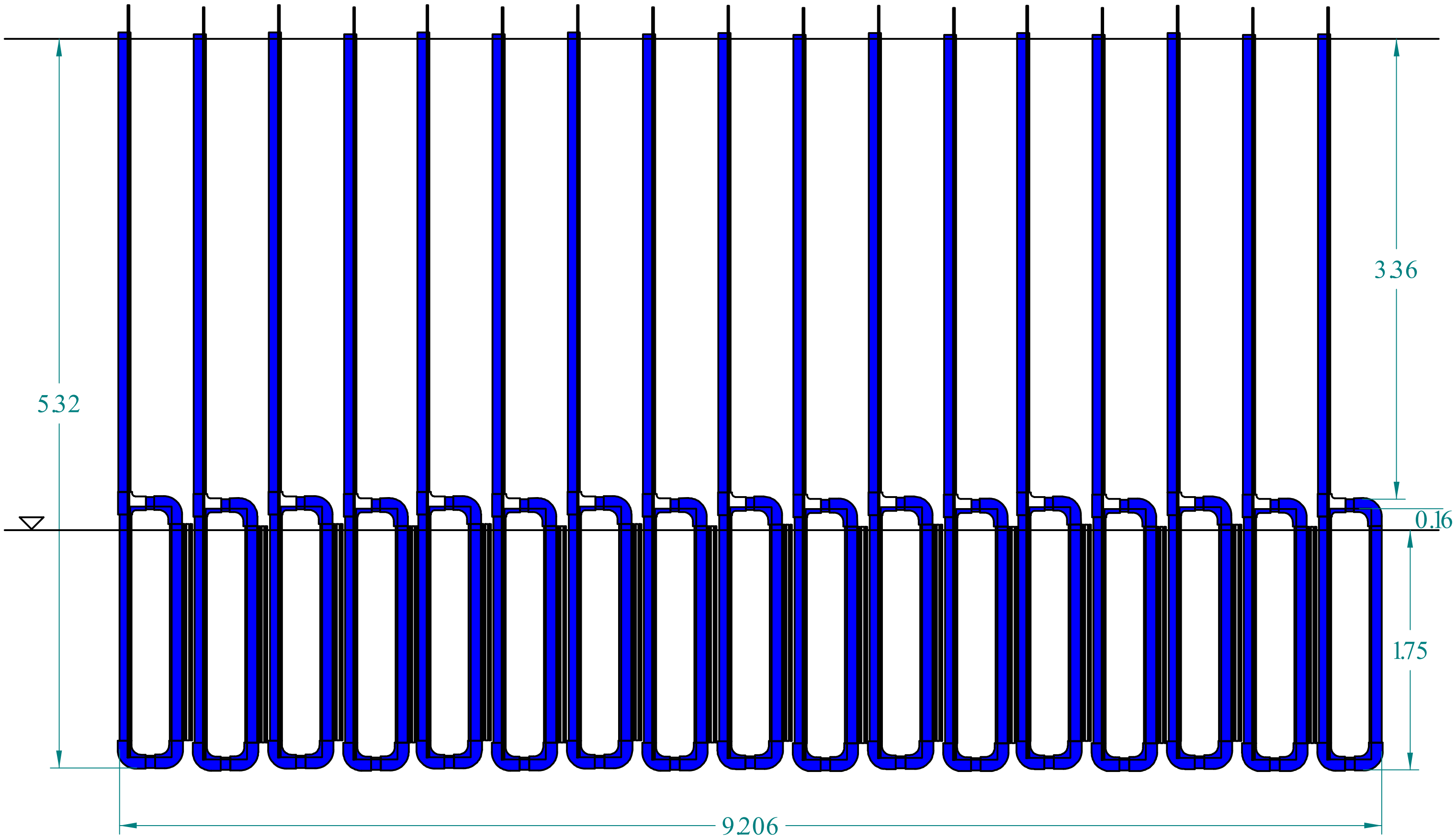
Colorado State University
Knowledge to Go Places

ESTCP
Environmental Security Technology Certification Program

# Field Demonstration Site

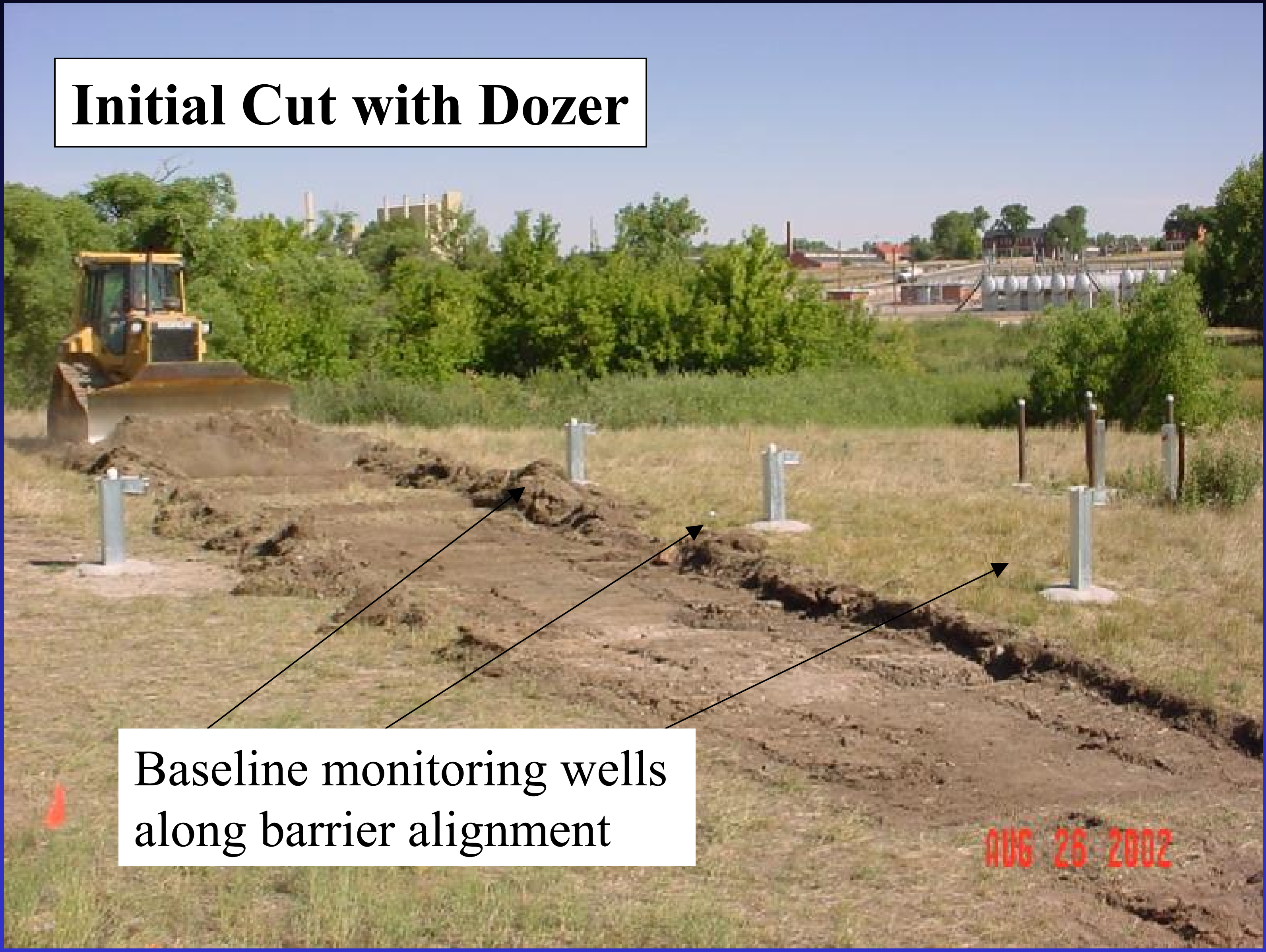


# Panel Design




(Dimensions in m)

# Initial Cut with Dozer



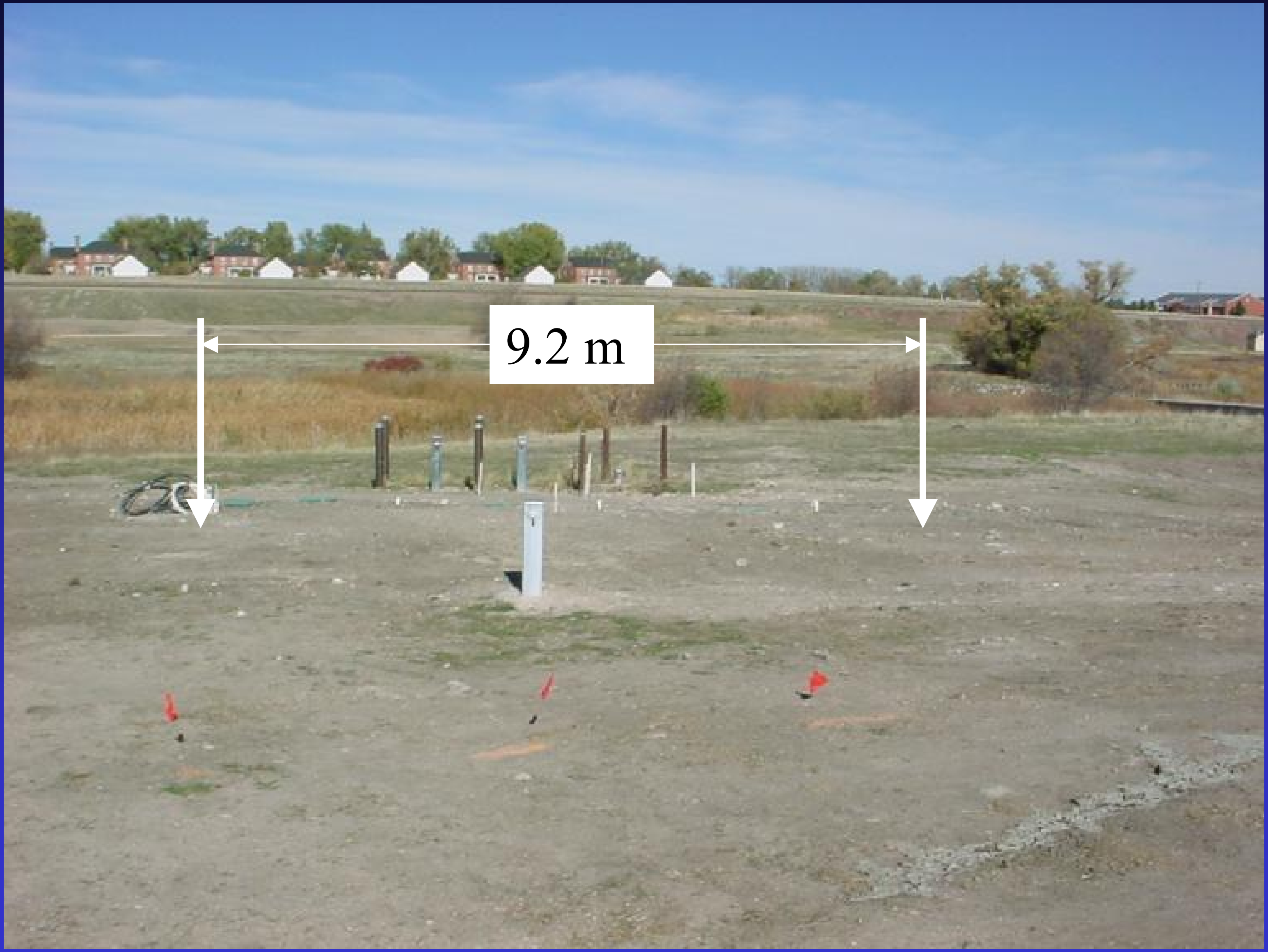
Initial Cut
With Excavator

# Set ½ Barrier in the Trench

# ½ of the Barrier Set

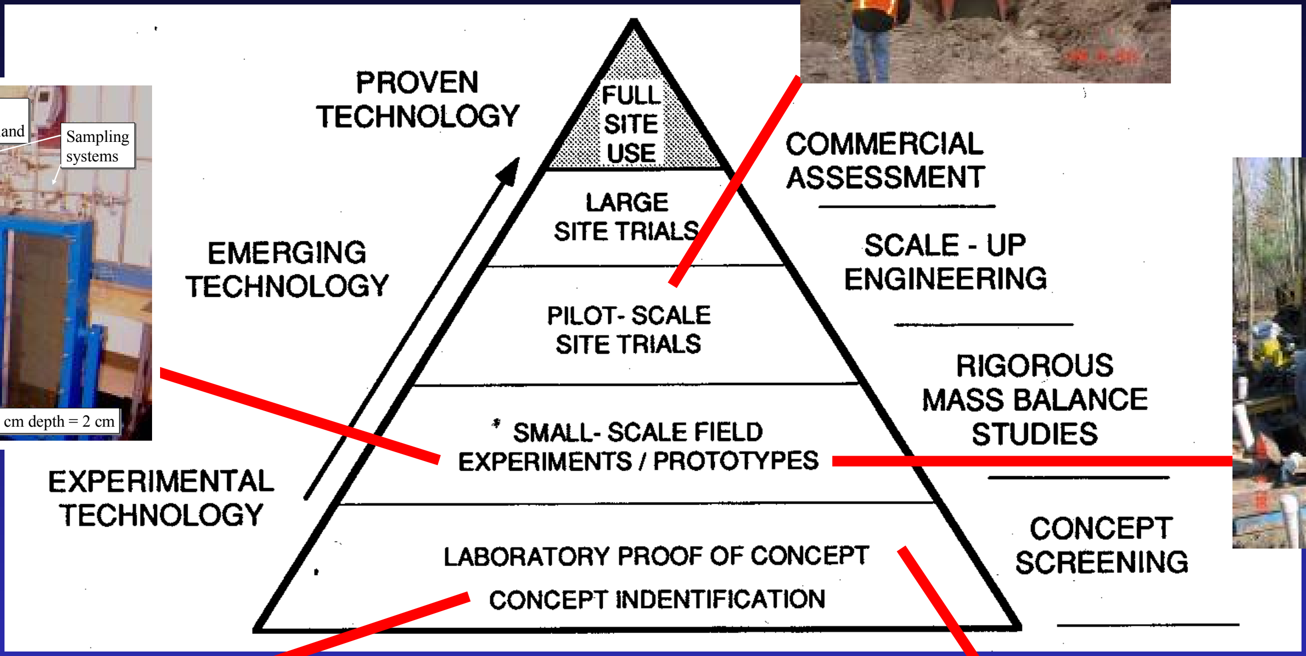

Well Sorted Medium Sand Backfill

# Finish Assembly at Grade

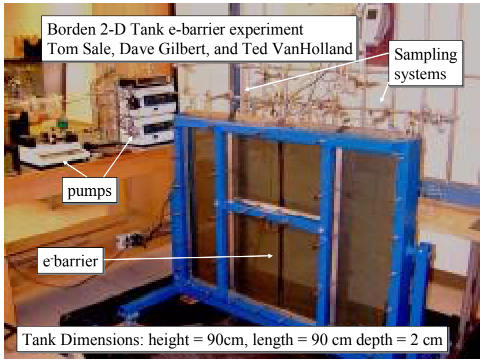


# Evolution
# Concept → Technology

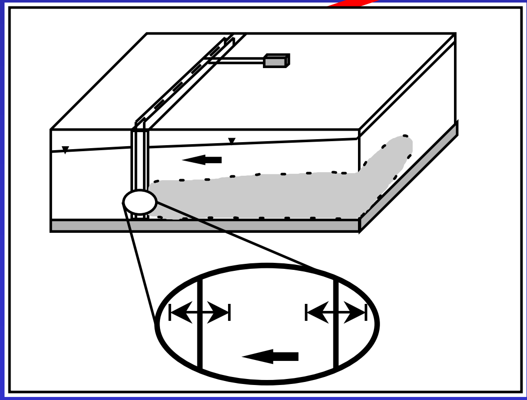
2002




2001




2000



1998

1999

# Acknowledgements - Funding

- University Solvents-in- Groundwater Research Consortium
- ESTCP
- SERDP
- United Technologies Corp.
- National Science Foundation

# Acknowledgements

- University of Waterloo - Bob Gillham, Beth Parker, John Cherry, Cory Repta, Matthew Ballaban, Greg Friday, Bob Ingleton, Paul Johnson
- CSU - Willard Lindsay, David McWhorter, Junior Garza, Bart Rust, Pete Romack, Jay Bryner, Ted VanHolland, Dawn Fairchild, Brian Cranmer, Don Dick

**PRELIMINARY PLANNING-LEVEL COST ESTIMATE**
**PTA Mid-Valley Area Site**
**July 7, 2005**

PARS proposes that the remediation of Picatinny Mid-Valley Area Site be conducted in 4 phases.

**Phase 1 – Data Review & Design**
This phase includes review and analysis of available information regarding the site. Following the review, PARS shall plan the NanoFe™ pilot test in a cost-effective manner.

Approximate total - $ 3,000

**Phase 2 – NanoFe™ Bench Scale Testing (Optional)**
It is assumed that Shaw Environmental will collect groundwater and/or soil samples from a contaminated site location for bench-scale testing. Bench-scale testing will consist of batch testing. The batch testing will focus on the ability of NanoFe™ to treat contaminated groundwater at the site. The NanoFe™ dose for the pilot test will be determined during this phase of testing. PARS will provide a report evaluating the results of the bench-scale testing.

Approximate total - $ 25,000

**Phase 3 – NanoFe™ Pilot Test**
PARS has assumed that the NanoFe™ Pilot Test will be conducted at the vicinity of 161MW-1. The area of the pilot plot will be approximately 1,000 $ft^2$ and the average impacted groundwater will be 45 ft thick.

It has also been assumed that Shaw Environmental will install and develop four downgradient monitoring wells. The existing wells at the pilot plot could be one of the downgradient monitoring wells. There will be one injection event, which will be performed by PARS and approximately five groundwater sampling events (including baseline sampling) and periodic field measurements of geochemical parameters, which will be performed by Shaw Environmental in accordance with guidance provided by PARS.

Laboratory analytical costs are assumed to be the responsibility of Shaw Environmental. All samples will be analyzed for VOCs, chloride, dissolved and total iron, ethane, ethene, and a suite of geochemical field measurements, which will include DO, pH, ORP, temperature, and specific conductance. PARS will provide a report evaluating the pilot test results.

Approximate total - $ 35,000

**PRELIMINARY PLANNING-LEVEL COST ESTIMATE**
**PTA Mid-Valley Area Site**
**July 7, 2005**

**Phase 4 – NanoFe™ Full Scale**

PARS has assumed that NanoFe™ technology will be utilized to treat the overburden plume in the 3109 area where the TCE concentration is higher than 10 ppb of the site. We assumed that the total treatment area is 1,212 000 $ft^2$ and the average impacted aquifer is 45 ft thick. A total of 7,500 lbs of NanoFe™ will be injected into 150 to 180 temporary injection points. There will be one injection event which will require two PARS injection teams working approximately 20 days on site. Costs for post-injection monitoring are not included. PARS will provide a report summarizing the remedial action process.

Approximate total - $615,000

**Based on the anticipated scope of work as described above, the estimated total cost for evaluating the effectiveness of NanoFe™ at this site is approximately $ 38,000 (or $63,000 if a bench testing is done). The subsequent full-scale remediation is estimated at $ 615,000 for treating the chlorinated solvents at the active treatment area of the site. PARS can provide sampling and analytical services at an additional charge.**