Fort Detrick Remedial Investigation/Feasibility Study

Bench Scale Peroxide/Permanganate Testing Summary of Results

Fort Detrick Restoration Advisory Board Meeting - July 11, 2001
Fort Detrick, Frederick, MD

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Bench Testing

Why Chemical Oxidation?

- **The number of potentially successful clean-up technologies are limited for Area B Groundwater due to two major Factors:**

  1) The contaminant sinks in the aquifer (hard to find)

  2) The aquifer contains solution features (groundwater flow erratic)

- **Chemical Oxidation has been successfully demonstrated at Letterkenny Army Depot where similar site conditions exist**

The Oxidants

- **Two oxidation processes were tested:**
  - **1) Sodium permanganate direct oxidation**
  - **2) GeoCleanse Process - Consisting of a hydrogen peroxide/iron mixture producing a highly oxidizing "Fenton's Reaction"**

Summary of the Two Oxidation Techniques

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PERMANGANATE PROCESS

Sodium permanganate ($KMnO_4$) in solution is allowed to contact the rock and aquifer directly. The chemical directly attacks organics.

SIMPLIFIED EXAMPLE OF A TYPICAL REACTION

Sodium Permanganate + Organic Contaminant (VOC) + Water → Carbon Dioxide + Manganese Oxide + Chloride Ions

GEOCLEANSE HYDROGEN PEROXIDE PROCESS

In the GeoCleanse Process hydrogen peroxide is mixed with an iron catalyst solution. This mixture reacts to form an intermediate extremely oxidizing environment.

SIMPLIFIED EXAMPLE OF A TYPICAL REACTION

Hydrogen Peroxide + Catalyst + Organic Contaminant (VOC) → Carbon Dioxide + Water + Chloride Ions

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Approach to Testing

- Rock core samples were acquired from the two major rock types in the contaminant zone (Cambrian Limestone and Triassic Conglomerate).

- Natural faces (fractures and partings) and cut surfaces were exposed to oxidant to determine whether there could be significant degradation of the aquifer and how much oxidant would be consumed during reaction with the rock.

- Faces were also exposed to a catalyst solution that is only used in the GeoCleanse process

- Water samples from well 24D (high level of contamination) were subject to each oxidation process at varying concentrations to assess oxidant consumption/efficiency at differing oxidant concentrations.

- Permanganate tests at other sites have shown the potential for oxidizing metals in the aquifer to more toxic species (e.g. Cr^{3+} to Cr^{6+}); therefore, metals testing was performed during rock/permanganate reaction tests to determine if the oxidant causes metals to oxidize to more toxic species.

Photos of Unreacted Rock Core

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Triassic Conglomerate before reaction showing cut face and natural face

Cut Face

Natural Face

Cambrian Limestone before reaction showing cut face and natural face

Natural Face

Cut Face

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Photos of Reacted Rock (Permanganate Test)

Triassic Conglomerate after reaction showing cut face and natural face staining

Natural Face

Cut Face

Cambrian Limestone after reaction showing cut face and natural face staining

Natural Face

Cut Face

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Permanganate Bench Testing

Test Results

Oxidant Consumption by the Rock

- **Little staining by permanganate or deterioration of bedrock materials observed**
- **Cut face reacted more than natural surfaces**
- **No permanganate consumed by exposure to natural face of Triassic conglomerate**
- **Amount of permanganate consumed was within acceptable limits based upon experience at other sites.**
- **Metals analysis of the permanganate solutions from the rock interaction tests revealed no oxidized species from the bedrock itself; however some Cr^{+6} was detected at low levels. This was due to chromium impurity in the permanganate.**

Oxidation Efficiency/Groundwater Tests

- **PCE and TCE were degraded to below detectable levels by permanganate in less than 8 hours.**

Peroxide Bench Testing Results

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Oxidant Consumption by the Rock (two tests types, one with catalyst, one with peroxide)

GeoCleanse Process Catalyst Interaction Test Results

- **The exposed surfaces (either natural fractures or the cut faces) were coated with an orange precipitate (most likely hydrous iron oxide).**
- **This precipitate is believed to isolate the exposed surfaces from further reaction.**

GeoCleanse Process Peroxide Interaction Test Results:

- **Some reaction between the peroxide and bedrock was exhibited (although minor) for both the Triassic conglomerate and the Frederick limestone, and in both cut faces and natural fracture faces.**
- **Most peroxide was degraded during the test.**

Oxidation Efficiency/Groundwater Tests

- **Contaminants were completely removed from the test groundwater under relatively mild conditions.**
- **pH levels, catalyst and peroxide concentrations used indicate that field achievable conditions are possible for a high level of contaminant destruction.**

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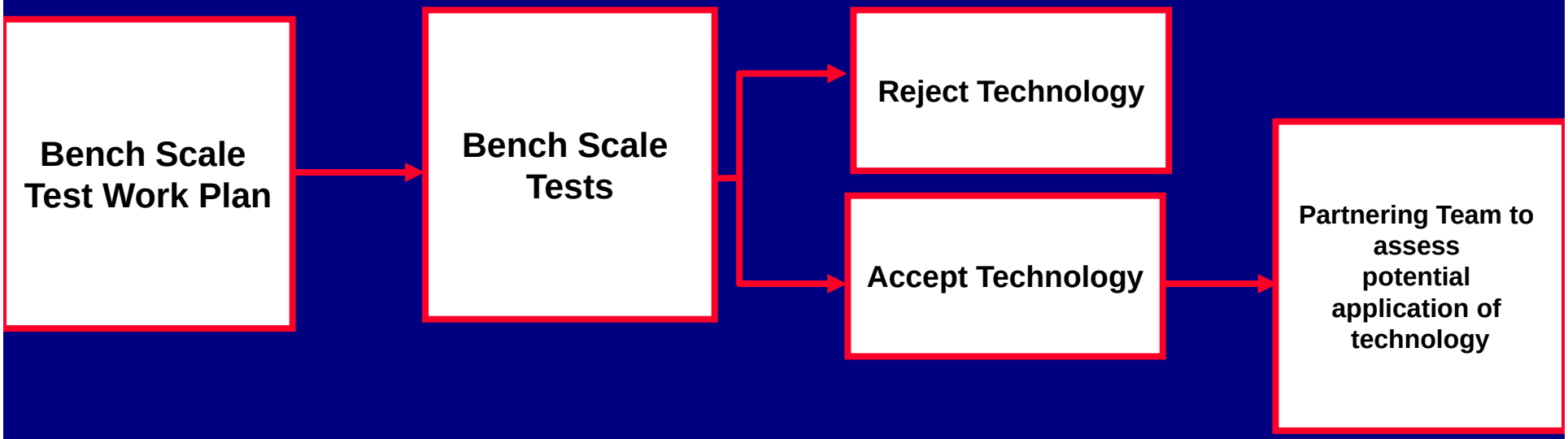
Area B Pilot Testing Activity Flow Chart