2023 ITRC Project Team Final Proposal

Proposed Project Title

Remediation of Contaminant Mass in Low Permeability and Heterogeneous Matrices

Proposal Contacts

List the contact information [name, organization, phone number(s), and email address] for each individual submitting this proposal.

Cynthia Frickle United States Environmental Protection Agency, Frickle.Cynthia@epa.gov, 703-603-8763
Elizabeth Cohen Arcadis, Libby.Cohen@arcadis.com
Elizabeth Rhine Bhate, erhine@bhate.com, 864.982.9890
Ted Tyler Cardno, Ted.Tyler@cardno-gs.com 805-564-4940
Tamzen Macbeth CDM Smith, macbethtw@cdmsmith.com 208.904.0238
Jaydeep Parikh ERM, Jaydeep.Parikh@ERM.com 484 913 0446
Chapman Ross FRx, cross@frx-inc.com 617.821.0686
Suzanne O'Hara Geosyntec, sohara@geosyntec.com
Richard Desrosiers GZA, richard.desrosiers@gza.com 860-858-3130
Yasemin Kunukcu TRC Companies, ykunukcu@trcsolutions.com 908.988.1729
Dan Bryant Woodard & Curran, jbryant@woodardcurran.com (609) 375-8026
David Scheer, Minnesota Pollution Control Agency, dave.scheer@state.mn.us, 651.332.3968

Abstract

Remediation of contaminated soil, sediment and groundwater often fails to achieve remedial objectives for sites with low-permeability geologic soil types (e.g. clay) or porous bedrock (e.g. sandstone). In these cases, contaminant mass diffusion and subsequent back-diffusion acts as a persistent, long-term source of contaminant mass flux. Remediation using *in situ* treatment relies on effective amendment distribution to treat contaminant-impacted soil and sediments, which is often difficult or impractical in low permeability matrices. Recent advances in technologies to characterize sites to improve the conceptual site model (CSM) and remediate low-permeability matrices can improve remedial outcomes. The Remediation of Contaminant Mass in Low Permeability and Heterogeneous Matrices (LPHM) team will produce a technical regulatory guidance document to introduce the problem, review physical and chemical properties of various contaminants of concern, including chlorinated ethenes and PFAS, that exacerbate contaminant storage in low permeability matrices, identify conditions that impede remedial actions, and provide strategies to effectively remediate contaminant mass stored in low permeability matrices. Appendices will provide fact sheets specific to enhanced characterization and remedial technologies for low permeability and heterogeneous matrices with case study example of sites where these enhanced technologies were successfully applied. The LPHM technical regulatory guidance document and associated training video modules, short courses and webinars will overview solutions with costs and benefits for improved characterization to establish realistic remedial objectives and select remedies that are designed to address these persistent contaminant sources resulting in more efficient remedy implementation and shortened timeframes to meet remedial objectives.

Problem Statement and Highlight the Importance to the States and to the Broader Environmental Community

Low permeability matrices (e.g., silt and clay) can store significant contaminant mass, and this mass can diffuse into adjacent permeable zones (termed 'back diffusion'), acting as a long-term source of contamination. Advances in high-resolution site characterization techniques have improved site conceptual models and advanced understanding of stratigraphic sequences, contaminant mass distribution and its relationship to storage mechanisms in the subsurface. This understanding highlights the role of contaminant storage of various contaminants and back-diffusion from low permeability matrices as a persistent, long-term, source of contaminant mass flux to aquifers. Many liquid amendment injection remedies just treat contaminant mass in high permeability zones and leave contaminant source mass in low permeability zones. **Containment technologies such as pump and treat or permeable reactive barriers are often selected to manage contaminant mass flux. Rather than operate and maintain these systems in perpetuity under the belief that contaminants in low permeability matrices cannot be effectively remediated, *in situ* technologies and strategies can be used to directly target source mass in these low-permeability zones.**

The fate and transport of industrial chemicals discharged to the subsurface are controlled by physical, chemical and biological processes coupled with the characteristics of the subsurface geologic matrix. Remediation of contaminant mass in low permeability and/or heterogeneous matrices is a challenge as it requires either direct contact with stored contaminant mass or enhancement of matrix back-diffusion. **Methods that improve remediation of contaminant mass in low permeability and heterogeneous zones include:**

- **High pressure injection**
- **Pulsing and other injection techniques for altering/controlling preferential flow**
- **Hydraulic or pneumatic fracturing for amendment distribution or permeability enhancement**
- **Electro kinetic-enhanced amendment distribution**
- **Recirculation/flushing (with or without amendments)**
- **Use of shear thinning fluids to enhance amendment distribution**
- **Soil mixing**
- **Thermal treatment**

Although there are numerous publications related to the general use of *in situ* remediation technologies (e.g. chemical oxidation, enhanced bioremediation and chemical reduction) **there is no comprehensive guidance for remediation practitioners, regulators, and other stakeholders that specifically addresses how to treat contaminant mass stored in low permeability and heterogeneous matrices.** This project would address key issues associated with implementing technologies to successfully distribute amendments into low permeability matrices or uniformly throughout heterogeneous matrices and enhance contaminant mass removal or destruction.

AUDIENCE: The intended audience of this project proposal include remediation staff from state and federal government, consultants, and academia. The guidance would also be useful to remediation managers, hydrogeologists, environmental engineers, and other environmental practitioners from state or federal government, consultants and academia working on projects that require remediation of contaminants in low permeability and/or heterogeneous matrices.

Project Deliverables

Document Products: Technical Regulatory Guidance Document

Listed below are the subjects proposed to be covered in the proposed **ITRC technical regulatory guidance document.**

- Section 1 - Introduction: The problem and the need; indefinite timeframe and significant costs of long-term mass flux control remedies; failed or inadequate performance of in situ applications.
- Section 2 - Background: Identify conditions that exacerbate diffusion of chemicals of concern in low permeability matrices. Identify Conceptual site models including contaminant mass distribution and resulting mass flux using high-resolution site characterization; contaminant mass residing in thicker low permeability layer versus thinner lenses within heterogeneous geology; benefits of targeting the identified mass laterally and vertically across the plume to design cost-effective remediation strategies and treatment trains.
- Section 3 – Traditional Treatment Technologies: Review of available in situ remedial methods and their key design and implementation parameters as pertaining to treating low permeability and/or heterogeneous matrices.
- Section 4 – Lessons Learned: Understanding and quantifying costs and missed opportunities due to extended remediation timeframes for remedies that do not address long-term sources in low permeability and/or heterogeneous matrices, lifecycle costs for site closure, and missed opportunities for site reuse/redevelopment.
- Section 5 – Enhancement Concepts: Conceptual discussion of general approaches for enhancing in situ remediation of contaminant mass in low permeability and/or heterogeneous matrices including modifying physical and/or chemical properties of amendments, enhancing the permeability of the low permeability zones, and increasing the rates of mass diffusion/transfer of contaminants from these zones.
- Section 6A – Available Enhancement Technologies: Approaches and best practices for applying available technologies to in situ remediation methods for treatment of contaminant mass in the low permeability and/or heterogeneous materials including ways to combine multiple technologies. Applicability for various geological and contaminant situations would be identified.
- Section 6B – Emerging Enhancement Technologies: Additional approaches being researched and technologies under development as part of federal and commercial programs.
- Section 6C – Summary of Enhancement Technologies: Summary matrix of available enhancement technologies, their key features, advantages and limitations. Would include factsheets on individual enhancement technologies.
- Section 7 – Case Studies: Example case studies for each of the enhancement technologies for in situ remediation including high pressure injection, hydraulic fracturing, pneumatic fracturing, shear thinning fluids, recirculation, electro kinetic enhanced amendment distribution, soil mixing, and thermal treatment.
- Section 8 – Cost Assessment: Cost information that a remediation professional could use to reasonably estimate the costs for implementing in-situ remedial technologies at a given site.

Training Products:

- Training Video Modules: The Team will determine what sections from the above list should become training video modules. Each module will be 10-15 minutes long and provide detailed information about the section. The Team expects to create 6-8 training modules.
- Training slides will be developed for conference short courses and workshops.
- Selected sections from those listed above will be used to develop 45-minute webinars.

State Team Leader

Which, if any, states have indicated an interest in leading the team and providing a Team Leader:

1. Jen Jevnisek, Minnesota Pollution Control Agency

Additional Information

Describe any additional information that might be relevant to this proposal. Additional information could include:

- *Similar work done by other organizations that could be leveraged.*
- *Identifying subject matter experts that would be interested in joining this project team:*
    - *Chuck Newell, GSI*
- *state contacts that might be interested in participating in the team:*
    - *Paula Panzino, Arizona Department of Environmental Quality*
    - *Charles Graff, Michigan Department of Environment, Great Lakes and Energy*