



2015 ITRC PROJECT PROPOSAL FORM
Remediation Projects Only

CHARACTERIZATION AND REMEDIATION OF CONTAMINATION IN
FRACTURED BEDROCK

PROPOSAL DATE: 15 March 2015

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Proposals Topical Area

- CHAR: Characterization and Remediation of Contaminants in Fractured Bedrock (Crystalline and Sedimentary) including detailing the fate and transport of contaminants in fractured bedrock
- CONT: Remediation of Contamination in Fractured Bedrock (focus on proven environmental technologies (physical/chemical/biological) to meet remedial action objectives).
- CONT: Characterization and Remediation in Fractured Rock: The document will include an interactive table to help regulators and other users in selection and evaluation of appropriate bedrock remedial and characterization tools

Proposal Summary

Problem Statement

After decades of contaminated site characterization and remediation, our understanding of the distribution, fate, and transport of contamination in the environment, and our remedial technologies have improved such that many sites are reaching remedial objectives. However, as the number of sites requiring remediation is being reduced, many of the remaining sites that require remediation are more challenging because the contamination is present in fractured and weathered crystalline and sedimentary bedrock.

The challenge of characterizing and conducting environmental remediation in fractured bedrock is attributable, in part, to the complexities of fate and transport characteristics in fractured media that

diverge from the better understood characteristics of fate and transport in unconsolidated porous media. Moreover, contaminants in fractured bedrock can and do present a threat to human health, the environment, or other societal interests down gradient from the contaminant source area(s). This is especially true in portions of the US where bedrock groundwater is a primary source of drinking (and process) water and demands are increasing.

Traditional site characterization (e.g. drilling numerous monitoring wells) and remedial technologies (e.g., pump and treat, soil vapor extraction, air sparging) based in part on past practices in unconsolidated media have often been applied to sites where contaminants are present in fractured bedrock. These attempts; however, are often met with significant difficulties (e.g., non-isotropic properties such as permeability and primary and secondary porosity) in meeting site cleanup objectives and goals.

In the past 10-15 years, significant research has been conducted on understanding fractured bedrock hydrogeology, characterizing contaminant flow and transport in fractured media, and on developing remedial strategies and technologies to address contamination present in fractured bedrock. With our increasing understanding of these issues, we have been seeing successes in the application of this knowledge, development of innovative technologies, and in application of more conventional technologies that now can better focus on the contaminated bedrock.

These advances however, are slow in being recognized by regulators and practitioners who are not familiar with the ongoing research into contamination in fractured bedrock. Sites where fractured bedrock is contaminated are often still considered too difficult to successfully remediate, and remedial activities are too often focused on containment and long term monitoring instead of addressing the contamination.

Technical, Knowledge, and/or Regulatory Barriers that will be addressed through the completion of the project

This project is necessary to provide guidance for regulators, the regulated community, and remediation practitioners. It will facilitate communication and planning, and aid in the selection of appropriate characterization techniques (e.g., geophysics, remote sensing, geologic mapping) and remedial technologies (e.g., nanotechnology such as nanoscale iron) or combinations of technologies to remediate common (e.g., chlorinated solvents, petroleum hydrocarbons, etc.) and emerging contaminants (e.g., 1,4-Dioxane, Perchlorate, N-Nitroso-dimethylamine and metals) in fractured or weathered crystalline and sedimentary bedrock.

Therefore, this project will fully meet the ITRC vision, purpose, and mission:

To develop information resources and help break down barriers to the acceptance and use of technically sound innovative solutions to environmental challenges through an active network of diverse professionals

The approach for the project: general process that will be used to implement the project

The proposed Fractured Bedrock Characterization and Remediation team will review the 2011 Integrated DNAPL Site Strategy document to identify major uncertainties with regard to developing characterization and remedial strategies for sites where contaminants occur in fractured bedrock.

The team will also perform a detailed review of documents prepared by the DNAPL Site Characterization team to understand the degree to which the fate and transport of DNAPL and associated dissolved phase contaminants in fractured bedrock has been addressed as part of the development of a larger discussion

of the fate and transport of common and emerging contaminants in fractured bedrock for the proposed document.

The team will perform a detailed literature review to help identify the advances in contaminated fractured bedrock site characterization and remediation. The team will rely on academics involved in this research who have agreed to work with the team (already identified) to help focus much of the literature review.

The team will additionally address the following issues for incorporation into a document:

- Collect and summarize fundamental background information regarding typical types of fractured bedrock that are encountered and issues of primary and secondary porosity.
- Collect and summarize developing characterization tools and strategies focused on fractured bedrock.
- Evaluate established and emerging contaminants and their varying fate and transport properties as they relate to the challenge of remediation in fractured bedrock.
- Evaluate case studies of successful predictive fate and transport modeling for established and emerging contaminants.
- Evaluate case studies of demonstrated successful application of conventional/innovative remediation technologies (e.g., nanotechnology) for application to fractured bedrock.
- Develop a fractured bedrock characterization tools table to help users select appropriate tools to help better define the contamination Fate and Transport CSM.
- Develop a fractured bedrock remediation technologies table to guide users to the most appropriate remediation technologies to address site conditions described in the CSM

The team will develop a Fractured Bedrock Characterization and Remediation Technical and Regulatory Document that provides objective guidance on the issues summarized above with emphasis on:

- Understanding the fate and transport of established and emerging contaminants in fractured bedrock to aid in development of conceptual site models within fractured bedrock settings.
- Evaluation of conventional and innovative characterization and remediation technologies, along with their benefits and shortcomings, for application to contaminants in fractured bedrock that will help regulators improve their knowledge and provide a basis for decision making when faced with major decisions regarding remediation.

The team will also develop an internet-based training module or a more innovative training module if appropriate.

Topics that the Fractured Bedrock Characterization and Remediation team will address include:

- Overview of the types of fractured and/or weathered bedrock typically encountered.
- Current state of the practice with regard to characterization of established and/or emerging contaminants in fractured bedrock.
- Understanding the role of primary and secondary porosity in the remediation of fractured bedrock.
- Predictive modeling for the fate and transport of established and/or emerging contaminants in fractured bedrock.
- Selection of traditional or innovative remedial techniques with proven effectiveness for addressing established and/or emerging contaminants in fractured bedrock.

- What managers should consider when reviewing/approving proposed remedies.
- The relative costs for remediation in fractured bedrock.

General Project Schedule

- 1) Begin work at 2015 ITRC kick-off meeting.
- 2) Conduct monthly conference calls to begin to scope document outline and strategy.
- 3) Meet with team in person at 2015 spring meeting to finalize strategy for developing the document.
- 4) Complete review of Integrated DNAPL Site Strategy and DNAPL Site Characterization documents and conduct extensive literature: July 2015.
- 5) Complete review and summation of established and emerging contaminants, successfully demonstrated conventional and emerging remediation technologies, and case studies for both fate and transport predictive modeling by October 2015.
- 6) Complete outline of Tech Reg January 2016.
- 7) Complete a rough first draft to discuss at 2016 spring meeting.
- 8) Revised Draft complete by August 2016.
- 9) Complete final draft Tech Reg and submit for External review by January 2017.
- 10) Final Web-based guidance and Training completed October 2017.

Proposed Personnel

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States

Arizona, Massachusetts, Maine, Vermont, Virginia, Minnesota, Florida (more are expected to join)

Federal Agencies:

US EPA Headquarters, Regional Offices, Office of Solid Waste and Emergency Response, Office of Superfund Remediation and Technology Innovation
US DOD remedial and research Programs, SERDP
USGS
DOE

Private Environmental Consultants

Arcadis	GSI Environmental, Inc.
Aquifer Solutions, Inc.	Geo-Cleanse International, Inc.
Battelle	JRW Bioremediation, LLC
Burns & McDonnell Engineering Co., Inc.	Kleinfelder Inc.
CDM Smith	Stone Environmental
Geosyntec Consultants, Inc.	(More Companies are expected to join)

Academia

University of Waterloo, University of Guelph, University of New Mexico, Yale University

The team is a forum in which academics can bring their research and network with practitioners from both the private and public sectors. The skill mix of Team Members required includes hydrogeology, engineering, computer modeling, site characterization, regulatory, geology, and chemistry, among other disciplines. As the fractured bedrock remediation issue is so common and wide spread, the team needs all of the above sectors involved.

Summary of Deliverables (primary project product(s))

- The team will begin work with the team leaders attending the 2015 Kick-off meeting. The team leaders will hold monthly conference calls with team members and meet in person the first time at the 2015 spring meeting. As per the direction of the Life Cycle Guidance, the team will start by assessing the advancements since publication of the Integrated DNAPL Site Strategy (ITRC IDSS-2012) and DNAPL Site Characterization documents as well as conducting a literature review for the purpose of understanding and summarizing major remaining uncertainties with regard to characterization and/or remediation of contaminated groundwater within fractured bedrock. The team will collect case studies that demonstrate successful characterization and successful application of conventional or innovative characterization and remedial technologies for contaminated groundwater in fractured bedrock. The team will prepare a formal ITRC technical regulatory document. Upon completion of the draft technical and regulatory document, the team will go through the formal ITRC review process. Concurrent with the development of the draft technical regulatory document, the team will begin development of Internet training. If the team determines that there may be an innovative training technique to supplement the Internet training, the team will consider a proposal to the Board to revise the training methodology.
- The final technical regulatory document and training should lead to a greater knowledge base for the regulator understanding the fate, transport and risks associated with established and emerging contaminants in fractured bedrock, should provide a basis for predictive modeling of contaminants from source areas in fractured bedrock, and should provide a framework for selecting the appropriate remedial technology to meet site specific remedial objectives and goals.

Targeted Users (who will use products generated by this project?)

The primary targeted users of this document and training will be state and federal personnel of regulatory programs that are tasked with characterizing and remediating state, superfund, RCRA and other sites that have contaminated bedrock. We also expect consultants to use the products as well as stakeholders and problem holders.