An Introduction to FRx

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In a broad sense, FRX develops and **installs** innovative methods for controlling and monitoring physical and chemical conditions in subsurface formations, with particular emphasis on environmental processes related to the remediation of contaminated soil, bedrock, and groundwater. The techniques have broad applications in the increasingly demanding market for effective remediation processes. In particular, we introduced and validated the innovative technique of **hydraulic fracturing**, which greatly accelerates remediation of contaminated sites, and are leaders in providing these capabilities as a service to environmental consultants and site owners.

The Technology

FRX utilizes hydraulic fracturing and related methods to access sub-surface **source zones** (hot spots) or intercept contaminant **plumes** in soil or bedrock for the purpose of **destroying** or **removing** the contaminants. The fracturing methods are in reality a delivery system that allows placement of modest quantities of beneficial solids at chosen in situ locations. The injected materials can be tailored strategically to effect or enhance various physical or chemical processes that result in remediation of the soil. For example, **sand-filled fractures improve in situ fluid** flow in low permeability media by altering the flux field, thereby **promoting recovery processes**, such as NAPL extraction or SVE, as well as remediation processes that depend upon **delivery of reagents** into targeted soils, such as ISCO or bio-stimulation. Alternatively, fracturing techniques can be used to **place reactive solids** into subsurface soil and rock. Examples of these materials include solid potassium **permanganate** or **iron** for chemical destruction of chlorinated solvents, activated carbon for adsorption of contaminants, inoculated porous solids to initiate bioremediation, **oxygen releasing** or **hydrogen releasing** compounds for chemical or biological enhancement, and electrically conductive materials as electrodes. Because we are providing a delivery technique, the examples mentioned must not be considered exhaustive, and materials yet to be invented may also be usable.

Likewise, the list of contaminants that can be targeted is unrestricted. **Contaminants** that may be treated include **petroleum hydrocarbons** such as gasoline, diesel, jet fuel and motor oils and chlorinated solvents such as trichloroethylene **(TCE)** and perchloroethylene **(PCE)**, as well as inorganic contaminants such as hexavalent chromium, copper, nitrates, arsenic and selenium and even radionuclides such as uranium and strontium.

Hydraulic fracturing is applicable to a wide variety of site conditions and contaminants. It can be applied at **depths of 5 to 150** feet or greater in either **saturated or unsaturated** soils. Fractures can be **created around and under most structures**. The technology appears viable for all but the smallest jobs. In general hydraulic fracturing has a strong cost advantage compared to other available remediation methods.

The Company

Lawrence Murdoch and William Slack founded FRX in 1994. The two principals synergistically interact to meet the challenges of managing FRX. Presently, Larry Murdoch performs as president and research director while Bill Slack serves as vice president with responsibilities for operations and finance. The company operations are based in Cincinnati, Ohio. Operations are based near Greenville, South Carolina, under the supervision of Douglas Knight.

Larry Murdoch is a nationally recognized authority on delivery and recovery of fluids from soils. He developed his expertise by leading technology development and demonstration programs with a hands-on, personal involvement in the mud and grime of field testing. He conceived and led the US EPA hydraulic fracturing research program during the 1980's and early 1990's. He has a Ph.D. in Geology, a M.S. in Environmental Science and a M.S. in Geology from the University of Cincinnati and a B.S. in Geology from Pennsylvania State University. Dr. Murdoch is registered as a Professional Geologist in Indiana. Presently he holds an appointment as Professor of Geology at Clemson University.

Bill Slack joined the hydraulic fracturing research team in 1990 after 12 years of service in petroleum production industry as an engineer and technical manager of hydraulic fracturing applications and porous media research. He has a Ph.D. and an M.S. in Chemical Engineering from Carnegie Mellon University and a B.S. in Chemical Engineering from Cornell University. He is registered as a Professional Engineer in Ohio and Kentucky. He presently oversees day-to-day operations of the company.

Doug Knight serves as manager of field operations. He selects and hires support labor and services and oversees the logistics of projects. He has recently been taking an increased role in business development. Doug has nearly fifteen years experience with environmental field work. He holds a B. S. in Geology from Clemson University.

In summary, FRX is uniquely positioned to function as a service provider for soil remediation technologies. It will continue to build upon its base of research and innovation by maintaining its links to the research community. This advantage will build upon its strong track record, extensive trade secrets, and strategic partnerships while utilizing its growing collection of specialty equipment in offering the highest caliber services in an expanding market niche.

Additional Statements of Qualification

The following pages present greater detail about FRx.

- Partial Customer List
- Partial Project List
- Bibliography
- Vitae of Principals and Key Personnel
- Corporate Information and Vender References