IN SITU DELIVERY OF ISCR REAGENTS: RELATIONSHIPS BETWEEN AMENDMENT PROPERTIES, INJECTION METHODOLOGY, AND DISTRIBUTION

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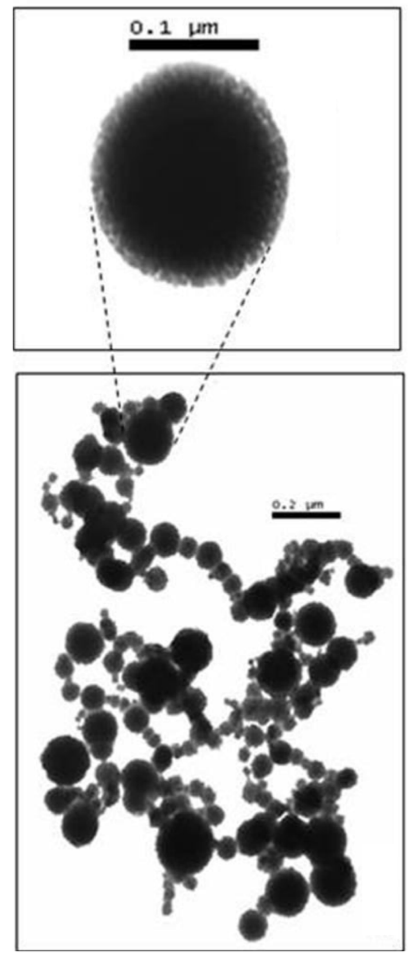
BACKGROUND

In-situ Chemical Reduction (ISCR) is a powerful technology for decontaminating soil and groundwater containing halogenated hydrocarbons, pesticides, hexavalent chromium, arsenic, and other toxic groundwater contaminants. Successful remediation outcomes are predicated on amendment reactivity, but equally important is the delivery method used to bring the amendments into contact with the targeted contaminants. Understanding and optimizing the relationships between material properties (particle size, viscosity), lithology, and amendment delivery method can improve performance and result in more rapid and complete in-situ remediation.

TYPES OF ZVI

Iron type: Soluble ferrous iron
Particle Size: Soluble



Iron type: Nanocrystalline (NZVI)
Particle Size: ~0.1 µm

Iron type: Colloidal
Particle Size: 1-3 µm

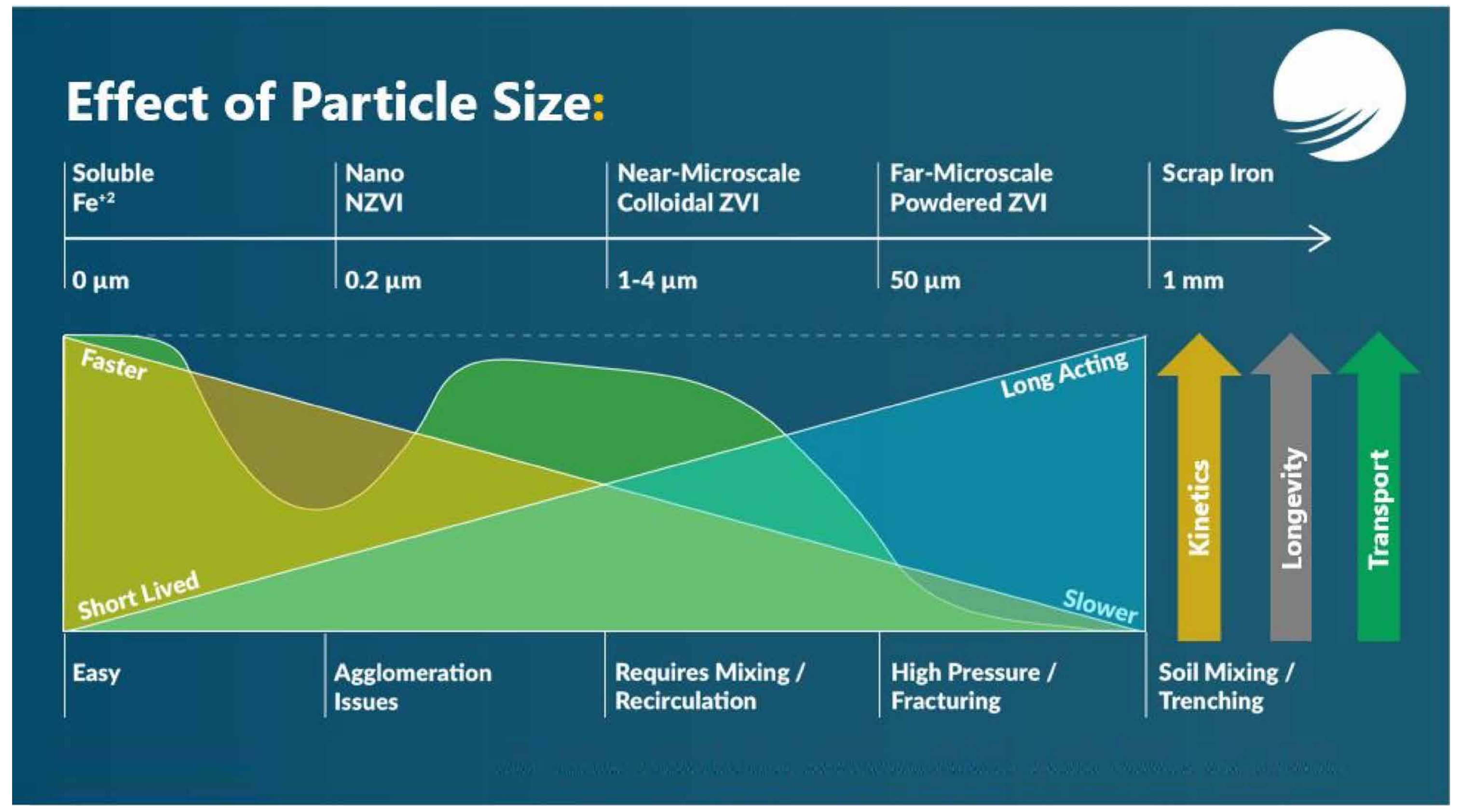
Iron type: Microscale
Particle Size: 10- 100 µm

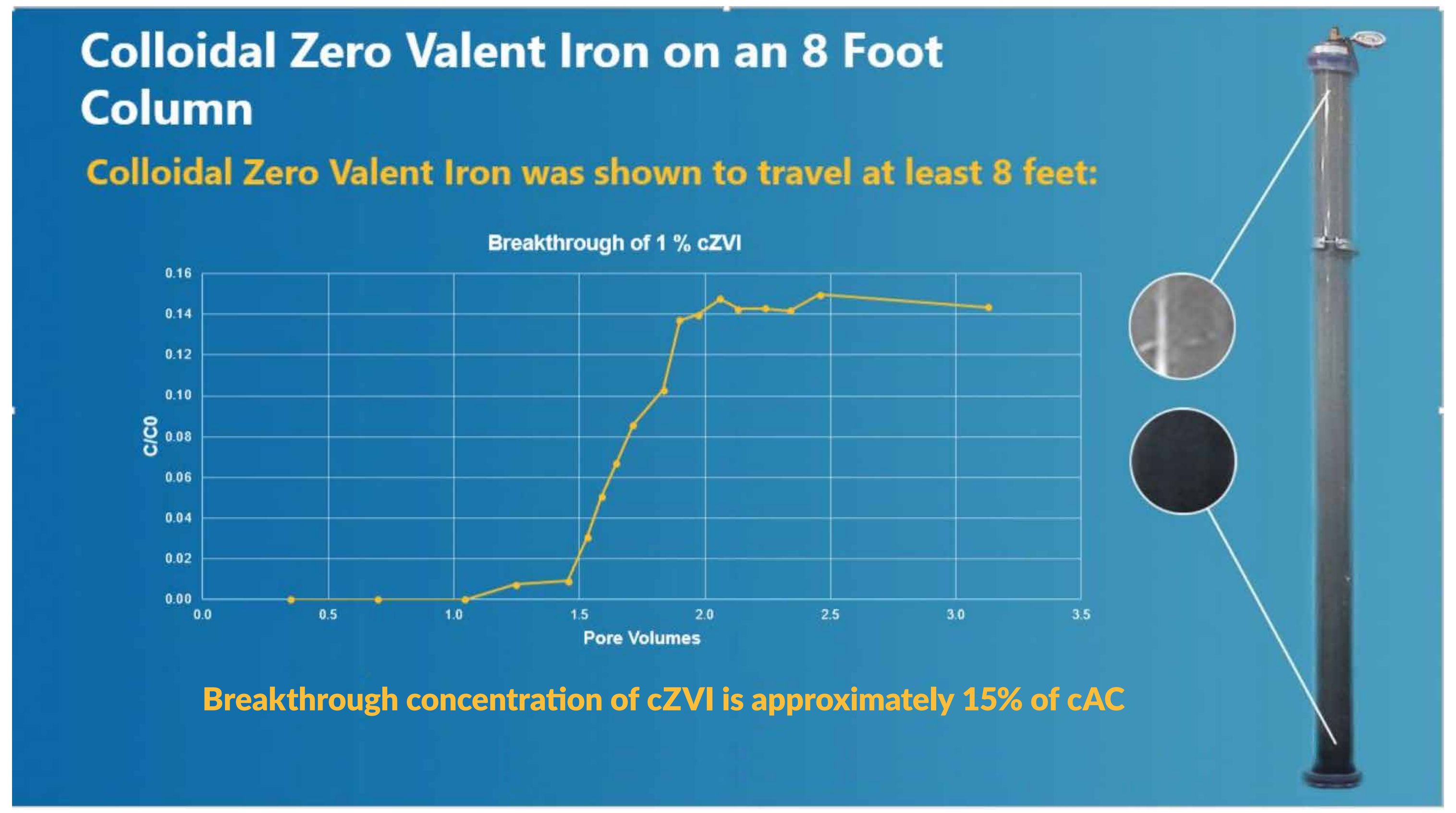
Iron type: Coarse
Particle Size: > 100 µm

HOW TO APPLY ZVI

The physical properties of remediation amendments vary considerably, and a remedial approach can be tailored to match site specifics including lithology, contaminant concentration, injection methods, etc. For example, ease of delivery generally decreases with increasing particle size and viscosity. Thus, water soluble and small particle size materials are typically the easiest to apply while viscous large particle size suspensions are the most difficult. Amendment persistence generally follows an opposite trend with larger particle size amendments exhibiting greater tenacity. In addition to evidence presented by prior experience, bench scale experiments are undertaken to show injection characteristics of a variety of large and small particle size materials. The theories we present are verified visually with a three-dimension transparent vessel into which injected various materials and observed their behavior.

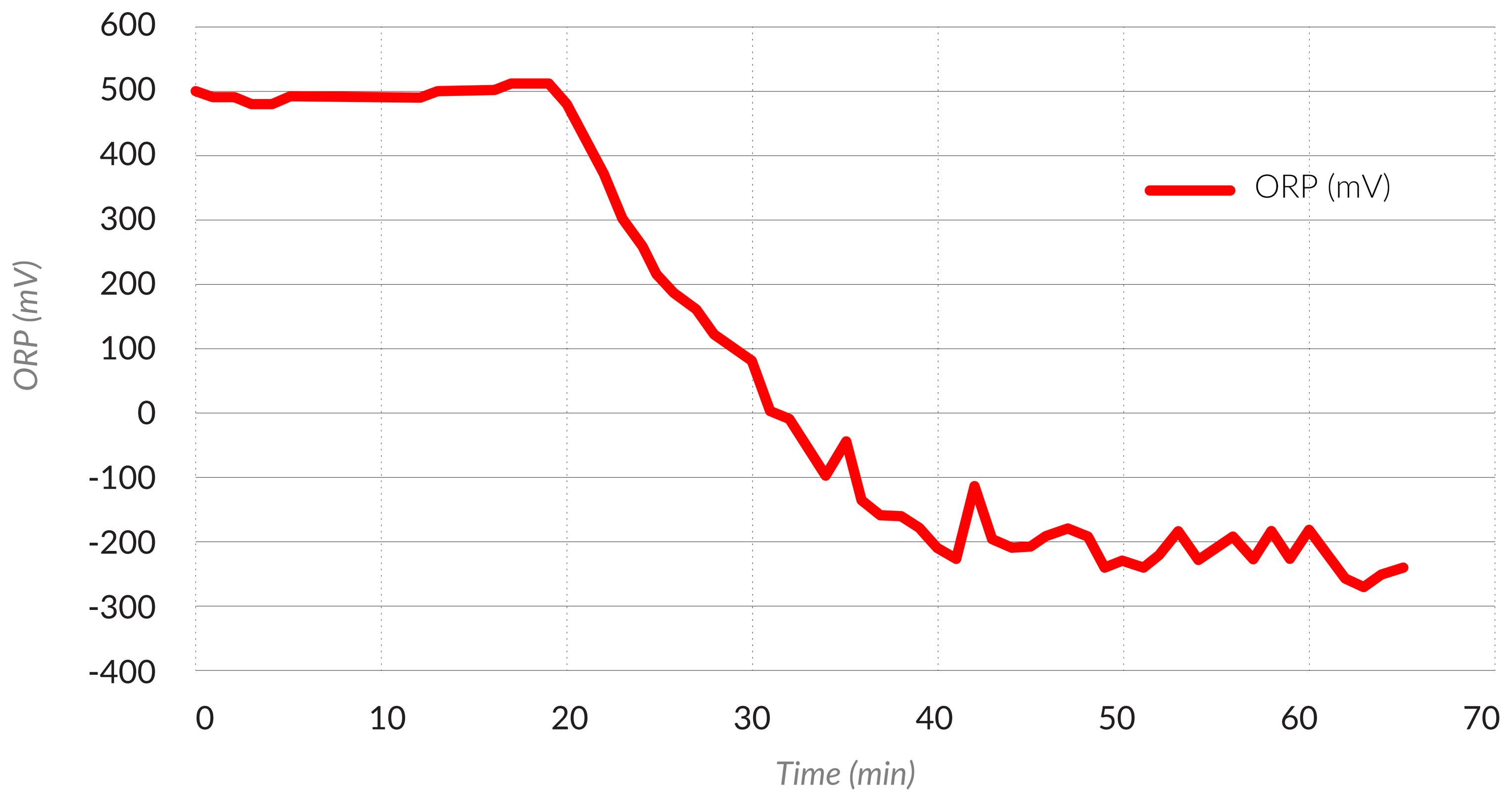
EFFECTS OF PARTICLE SIZE





RESULTS

A qualitative comparison of injectability is presented based on the model, under the pretense of 'best possible conditions' i.e. injection into sandy subsurface lithology. Variables influencing the performance of delivery of suspensions containing small particle size amendments are investigated including the use of dispersants, surfactants, and how the possibility of fluidization of sand and soil may influence radius of influence. This information is presented in terms of 'real world' applications and can be influential in choosing remediation materials based on a variety of site specifics and ultimately what can be expected in terms of performance and cost.



Graph- Low pressure injection (10-15 psi) delivers amendments with the best possible chance of even distribution. The above ORP data was from a down gradient monitoring well during low pressure injection. This indicates that it is unlikely that a fracture or preferential pathway reached the monitoring well; it was likely a true snapshot of subsurface conditions. This phenomena is observed countless times with soluble amendments, but it is much more difficult to transport zero valent iron the same way. Methods such as pulse-pumping application and adding small amounts of dispersants have beneficial in the field.

AquaZVI suspended in water (small particle size) compared to 40 micron commodity iron. 40 micron iron settles very quickly and does not suspend.

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