[Form 2 (to be reported to Committee on Countermeasures for Contaminated Water Treatment and to be disclosed to public)

Technology Information	
Area	6 (Select the number from "Areas of Technologies Requested")
Title	Electrical geophysical imaging methods for [1] characterizing permeability controlling groundwater flow, and [2] monitoring groundwater/saline water interactions
Submitted by	Lee Slater & Dimitrios Ntarlagiannis, Rutgers University

1. Overview of Technologies (features, specification, functions, owners, etc.)

Low frequency electrical geophysical methods, primarily electrical resistivity, induced polarization and spectral induced polarization can be used to non-invasively image and characterize hydrogeological structure controlling groundwater flow and contaminant transport. Permeability (a.ka. hydraulic conductivity) variations can now be quantitatively estimated non-invasively using induced polarization measurements coupled to recent petrophysics relations. Electrical resistivity imaging can be used to monitor groundwater/saline water interactions and provide almost real time information non-invasive information at high spatial resolution. Waterborne measurements can be used to rapidly delineate locations of submarine groundwater discharge and identify areas of focused exchange between groundwater and saline water. Recent advances permit autonomous 4D monitoring under large grids of electrodes.

The spectral induced polarization method is very sensitive to lithology, especially clay and silt layers, and provides the most reliable estimates of permeability (a.k.a. hydraulic conductivity) possible with non-invasive geophysical techniques. Unlike most geophysical measurements, two pieces of information on the subsurface properties are non-invasively obtained, from which permeability can be estimated using Kozeny-Carman like models. The method could be used to determine the hydrogeological structure in the vicinity of the plant and provide spatially extensive data that could be used to parameterize groundwater flow and transport models for the site.

Professor Lee Slater is an internationally recognized expert with these techniques and has extensively applied them to major groundwater contamination problems involving surface water-groundwater interactions. He has made fundamental contributions to the development of the induced polarization geophysical method for environmental investigations, particularly estimation of permeability structure.

2. Notes (Please provide following information if possible.)

- Technology readiness level (including cases of application, not limited to nuclear industry, time line for application)

Slater led a major geophysical investigation at the U.S. Department of Energy Hanford site that demonstrated the readiness of these methods for imaging hydrogeological structures and monitoring the exchange of surface water with groundwater. These measurements identified the spatial distribution of the hydrogeological units channeling uranium-contaminated groundwater to the Columbia River. Information was acquired both on land and offshore. Slater was also involved in continuous resistivity monitoring experiments that were deployed to non-invasively determine the exchange of surface water and groundwater inland of the Columbia River.

- Challenges

Geophysical methods provide non-invasive, indirect information over unique spatial scales. Hard geological information (e.g. from boreholes) should be used, where possible, to minimize uncertainty in the interpretation of the geophysical images of the subsurface in terms of hydraulic properties (e.g. permeability)

- Others (referential information on patent if any)

Johnson, T. C., Slater, L. D., Ntarlagiannis, D., Day-Lewis, F. D., & Elwaseif, M. (2012). Monitoring groundwater-surface water interaction using time-series and time-frequency analysis of transient three-dimensional electrical resistivity changes. *Water Resources Research*, *48*(7), n/a–n/a. doi:10.1029/2012WR011893

Johnson, Timothy C., Versteeg, R. J., Rockhold, M., Slater, L. D., Ntarlagiannis, D., Greenwood, W. J., & Zachara, J. (2012). Characterization of a contaminated wellfield using 3D electrical resistivity tomography implemented with geostatistical, discontinuous boundary, and known conductivity constraints. *GEOPHYSICS*, *77*(6), EN85–EN96. doi:10.1190/geo2012-0121.1

Mwakanyamale, K., Slater, L., Binley, A., & Ntarlagiannis, D. (2012). Lithologic imaging using complex conductivity: Lessons learned from the Hanford 300 Area. *GEOPHYSICS*, *77*(6), E397–E409. doi:10.1190/geo2011-0407.1

Slater, L. D., Ntarlagiannis, D., Day-Lewis, F. D., Mwakanyamale, K., Versteeg, R. J., Ward, A., … Lane, J. W. (2010). Use of electrical imaging and distributed temperature sensing methods to characterize surface water–groundwater exchange regulating uranium transport at the Hanford 300 Area, Washington. *Water Resources Research*, *46*(10), 1–13. doi:10.1029/2010WR009110