



Demonstration Bulletin

ElectroChemical Remediation Technologies (ECRTs)

Technology Description: The ElectroChemical Remediation Technologies (ECRTs) process was developed by P2-Soil Remediation, Inc. P-2 Soil Remediation, Inc. formed a partnership with Weiss Associates and ElectroPetroleum, Inc. to apply the technology to contaminated sites. The ECRTs process was evaluated for the treatment of marine sediments contaminated with mercury, PAHs, and phenolic compounds. The demonstration of the ECRTs was conducted at the Georgia Pacific, Inc. (G-P) Log Pond located along the Whatcom Waterway in Bellingham Bay, Bellingham, Washington. The G-P Log Pond pilot project consisted of a demonstration of ECRTs, which utilizes a DC/AC current passed between an electrode pair (anode and cathode) placed in sediment. Remediation of the sediment was to be accomplished by either the mineralization of organic contaminants through the ElectroChemicalGeoOxidation (ECGO) process, or by use of the Induced Complexation (IC) process to complex, mobilize, and remove metal contaminants plated to the electrodes. The pilot study was designed to assess and evaluate the ability of the ECRTs process to reduce concentrations of mercury, polycyclic aromatic hydrocarbons (PAHs), and phenolic compounds in a marine sediment.

The following information has been provided by the technology developer as descriptions of the ECGO and IC processes. The SITE program has not substantiated any claims made in these descriptions.

ElectroChemicalGeoOxidation—Using a low voltage, low amperage proprietary coupled DC/AC current, an induced polarization field is created within the sediment. The sediment acts as a capacitor, discharging and charging electricity resulting in redox reactions, which cause desorption of the contaminants from the sediments and mineralization of the organics in the matrix. Empirical evidence indicates that reaction rates are inversely proportional to grain size, such that ECRTs remediate faster in finer-grained materials typically found at contaminated sediment sites. The sediment-pore water system can be considered an electrochemical cell. In an electrochemical cell, reactions only occur at the electrodes and comprise anodic oxidation or cathodic reduction. However, in sediment, in addition to the local electrode reactions, redox reactions occur simultaneously at any and all interfaces within the sediment-water-contaminant system at the pore scale. The reaction partners for oxidations and reductions are simultaneously generated by water hydrolysis.

Empirical ECRTs field remediation data of rapid mineralization of organic contaminants including phenolic compounds and PAHs (and enhanced mobilization rates for metals) suggest that the secondary current released via

sediment electrical discharges provides the activation and dissociation energy for the ensuing redox reactions. Additionally, it is suspected that trace metals in the sediment may act as catalysts, reducing the activation energy required for the redox reactions. The quantification of these energy releases remains to be completed. Since the redox reactions are occurring at the pore scale, the ECRTs system pH is stabilized in the neutral range.

Induced Complexation—Metals remediation is achieved when redox reactions, created by the same low voltage/amperage current described above, desorb the contaminants from the sediment and create ionic metal complexes that are mobile. These mobile ions move readily to the electrodes, are electrically contained by the induced direct current, and are migrated to the electrodes where they are chemically deposited. Following treatment, the electrodes are removed and disposed, or the metals deposited onto the electrodes are recycled.

For this demonstration project, Weiss Associates, (Emeryville, CA) installed, operated, and maintained the ECRTs pilot test equipment at the Log Pond site. Installation of the pilot study infrastructure involved placing 9 anode (graphite) and 9 cathode (8 steel and 1 graphite plate) electrodes, in two rows, into the sediments. Each electrode row (e.g., anode sheet electrode line) was approximately 30 feet long. The distance between the anode and cathode sheet electrode lines was approximately 30 feet. Electricity was supplied, in parallel, to each individual electrode plate.

Demonstration Site Description: The G-P Log Pond is a marine embayment that served as a former log storage and handling area and receiving water for facility effluent and stormwater runoff. The ECRTs project area was designated as an approximately 50-foot (ft) by 50-ft area within a pre-characterized area of the G-P Log Pond known to contain elevated concentrations of mercury, phenolics, and PAHs. However, based on results from a preliminary survey, mercury was identified as the most ubiquitous and consistently elevated contaminant relative to Washington State Sediment Management Standards (SMS) Sediment Quality Standards (SQS) and Cleanup Screening Levels (CSL) which are used in Puget Sound to assess contaminated sediments under Washington State law.

The actual area for sample collection to evaluate the technology's effectiveness was a 20-ft by 30-ft zone within the electrode arrays. With the exception of the Port of Bellingham's Shipping Terminal dock on the Whatcom Waterway adjacent to the test plot, there were no structures within the project area. The mudline elevations within the test plot ranged from approximately -4 to -8 feet Mean Lower Low

Water (MLLW). Log Pond sediments with elevated chemical concentrations and woody debris measured approximately 5 to 6 ft thick between underlying native material and a cap of clean sand from regional maintenance dredging projects. The area was capped in late 2000 and early 2001 with clean capping material as part of a Model Toxics Control Act (MTCA) interim cleanup action. Cap thickness within the sediment treatment demonstration area ranged from 0.5 to 1 foot in thickness.

Demonstration Results: The SITE demonstration of the ECRTs system was conducted from August 2002 (Baseline Survey prior to installation) until March 2003 (Post-Demonstration Survey) in cooperation with the Washington State Department of Ecology (Ecology). The performance of the ECRTs process was evaluated by collecting sediment cores from within and adjacent to the electrode array and from 'reference' stations located within the log pond but beyond the influence of the ECRTs electrical field. Intermediate monitoring events were conducted in November 2002 and December 2002 during the active ECRTs demonstration period. A third monitoring event scheduled for February 2003 was canceled due to system operational concerns.

The primary technical objective of the demonstration was to determine whether there was a significant trend in the reduction of sediment mercury concentrations over the period of the demonstration. Reference area samples were collected for comparison to determine whether treatment differed from natural attenuation. The experimental design was based upon the presence of a significant mercury reduction from the baseline sampling event relative to the post-treatment sampling event. The primary objective is not associated with a percent reduction but instead the primary objective is to determine a statistically significant negative trend over time. Samples of the cap material and the underlying native material were used to evaluate potential migration of contaminants.

Sediment samples were collected from ten locations within the test plot, five from the extended zone of influence (adjacent to the test plot), and five remote reference locations. Samples were collected on four occasions including a baseline survey prior to the demonstration, two intermediate monitoring events, and the final post-demonstration event. Six samples were collected from each sediment core including three separate vertical composite samples from the contaminated horizon (i.e. top, mid, and bottom third of material between the cap and native material); one

composite over the length of the contaminated horizon (i.e. equivalent to compositing the three vertical samples together); one cap sample; and one native material sample. Select samples were either submitted for analysis of mercury, PAHs, phenolic, and sediment conventionals (organic carbon, total solids, and grain size distribution), or archived (frozen).

A statistical analysis of the sediment chemistry results indicate no significant trend in the reduction of sediment mercury concentrations over the period of the demonstration. In addition, there was no trend in the reduction of PAHs and phenolic compounds. Performance issues may be partially attributed to system operational problems encountered during the course of the demonstration. Electrical readings collected by the technology's sponsor indicated a steady degradation of system performance throughout the duration of the demonstration, resulting in an early shutdown of the system prior to completion of the planned test period. In addition, when the electrodes were removed from the test plot, it was evident that the connections between the electrical supply and anode plates had completely corroded to the point that a viable contact had not been maintained. A more detailed discussion of the technology and results are presented in two companion SITE documents: the Technology Capsule and the Innovative Technology Evaluation Report (ITER).

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