MEMO

Date **May 9, 2019**
To **Nevada Environmental Response Trust**
From **John Pekala, Scott Warner, and Chris Ritchie**
Copy to **Nevada Division of Environmental Protection**
United States Environmental Protection Agency
Subject **In-Situ Bioelectrochemical Laboratory-Scale Treatability Study Monthly Progress Report**

TASK PROGRESS UPDATE: MARCH 2019

At the direction of the Nevada Environmental Response Trust (NERT or Trust), Ramboll US Corporation (Ramboll) has prepared this memorandum which summarizes Ramboll's progress during March 2019 toward successfully implementing the In-Situ Bioelectrochemical Laboratory-Scale Treatability Study for the remediation of perchlorate in water.

TASK M24 – IN-SITU BIOELECTROCHEMICAL LABORATORY-SCALE TREATABILITY STUDY

- Task Leaders – Scott Warner / Chris Ritchie
- Current Status
  - Three experimental flow through soil columns were operated to assess perchlorate and competing electron acceptor (i.e. nitrate, nitrite, and chlorate) removal. Testing of these columns has been completed, bringing the first stage of column testing to a close. The columns were operated under the following electron donor conditions: 1) no electron donor to act as the control, 2) electrochemically-produced hydrogen and acetate to simulate a direct treatment and 3) hydrogen only to simulate an indirect treatment. Results are summarized below.
    - In the electrochemical treatment column (acetate and hydrogen as electron donors; the top panel in the Figure 1), despite variability in the perchlorate and chlorate removal, the results establish mixotrophic microbial metabolisms can be stimulated via electrochemical treatment.
    - In the indirect treatment column (hydrogen as the only electron donor; the middle panel in Figure 1), the results established that autohydrogenotrophic microbial metabolisms can be stimulated in the presence of hydrogen as an electron donor. This observation in the indirect treatment column is not only important for the potential application of electrochemical treatment, but also other technologies that utilize hydrogen as an electron donor (e.g., zero-valent iron).
    - Enhancement of electron acceptor consumption compared to the "No Treatment" control were only significant for nitrate and nitrite, not for chlorate and perchlorate

due to slow electron acceptor reduction kinetics and/or a low abundance of chlorate- and perchlorate-reducing bacteria.

- Further investigation related to the initial findings of low microbial DNA in the column soils was conducted. Three different DNA extraction kits were tested and the following protocol modifications were evaluated: cell lysis procedures, cell lysis chemistry, soil "washing", DNA pooling and concentration, DNA binding and purification, and DNA elution. At the completion of multiple tests, it was determined that the bacterial biomass in the soils in the columns is low. As a result, two species of *Dechloromonas* known to reduce perchlorate, namely *D. aromatica* and *D. agitata*, were cultured in preparation for bioaugmentation studies in both soil flow-through columns and additional batch microcosms.

- The original site soil flow-through columns were re-started with modifications to the electron acceptors in the influent. Specifically, the synthetic groundwater was re-formulated with a higher perchlorate concentration relative to other competing electron acceptors: perchlorate = 36 mg/L, chlorate = 1.6, nitrate = 1.5 mg/L, nitrite = 1.3 mg/L. The flow conditions will be similar to the first stage column investigations. In addition, the columns have been bioaugmented with two *Dechloromonas* species. Influent and effluent samples are currently being collected and monitored.

- As previously reported, an additional set of microcosms with different soils and with and without bioaugmentation have been initiated. For these microcosms, both electrolyzed groundwater (pH ~11, simulating "direct" electrochemical treatment) and non-electrolyzed groundwater (pH~8.5, simulating "indirect" electrochemical treatment) will be used with a high perchlorate/low nitrate concentration and have excess electron donors (either acetate and hydrogen, or hydrogen only). For each treatment, both native soil (though different soil samples than the first set of microcosms) and bioaugmented microcosms will be prepared. Additionally, a no electron donor control set of microcosms will be prepared. These microcosm tests will build on the microcosm results presented in the January 2019 update demonstrating biological perchlorate and chlorate reduction after a lag period. Specifically, the new microcosms will be used to better understand how conditions impact lag time and will inform column operation (e.g., the effect of competing electron acceptor concentrations and bioaugmentation) and future field testing (e.g., direct or indirect electrochemical treatment of groundwater). Sampling and monitoring are ongoing and will discussed in subsequent progress reports.

- Schedule and Progress Updates

  As discussed in the February 2019 update, bench-scale testing is expected to continue into June 2019. A bench-scale treatability study report is anticipated to be submitted in Q3 2019. A work plan addendum proposing a field test will be provided as an attachment provided that the data continue to support moving forward with a field test.

- Health and Safety
  - There were no safety incidents during March 2019.

ATTACHMENTS

Figure 1: Electron Acceptor Removal in Experimental Columns

In-Situ Bioelectrochemical Laboratory-Scale Treatability Study Progress Update

Nevada Environmental Response Trust Site
(Former Tronox LLC Site)
Henderson, Nevada

Nevada Environmental Response Trust (NERT) Representative Certification

I certify that this document and all attachments submitted to the Division were prepared at the request of, or under the direction or supervision of NERT. Based on my own involvement and/or my inquiry of the person or persons who manage the systems(s) or those directly responsible for gathering the information or preparing the document, or the immediate supervisor of such person(s), the information submitted and provided herein is, to the best of my knowledge and belief, true, accurate, and complete in all material respects.

Office of the Nevada Environmental Response Trust

Le Petomane XXVII, not individually, but solely in its representative capacity as the Nevada Environmental Response Trust Trustee

Not Individually, but Solely as President of the Trustee

Signature: Jay A Steinberg _____, not individually, but solely in his representative capacity as President of the Nevada Environmental Response Trust Trustee

Name: Jay A. Steinberg, not individually, but solely in his representative capacity as President of the Nevada Environmental Response Trust Trustee

Title: Solely as President and not individually

Company: Le Petomane XXVII, Inc., not individually, but solely in its representative capacity as the Nevada Environmental Response Trust Trustee

Date: 5/9/19

In-Situ Bioelectrochemical Laboratory-Scale Treatability Study Progress Update

Nevada Environmental Response Trust Site
(Former Tronox LLC Site)
Henderson, Nevada

Responsible Certified Environmental Manager (CEM) for this project

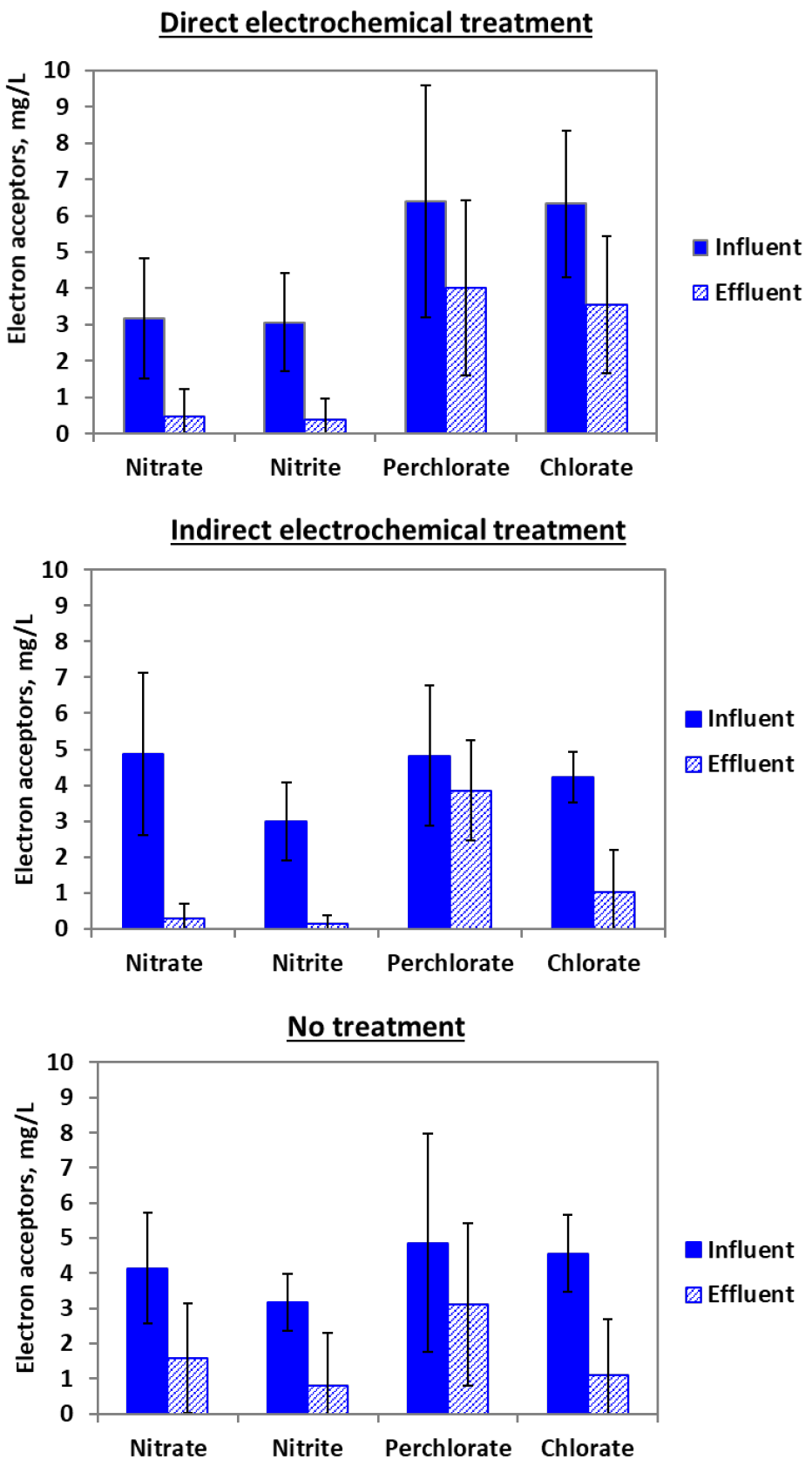
I hereby certify that I am responsible for the services described in this document and for the preparation of this document. The services described in this document have been prepared in a manner consistent with the current standards of the profession, and to the best of my knowledge, comply with all applicable federal, state, and local statutes, regulations, and ordinances. I hereby certify that all laboratory analytical data was generated by a laboratory certified by the NDEP for each constituent and media presented herein.

Description of Services Provided: Prepared In-Situ Bioelectrochemical Laboratory-Scale Treatability Study Progress Update, Nevada Environmental Response Trust Site, Henderson, Nevada

5/9/2019

John M. Pekala, PG
Principal
Certified Environmental Manager
Ramboll US Corporation
CEM Certificate Number: 2347
CEM Expiration Date: September 20, 2020

Date



RAMBOLL

Average influent and effluent electron acceptor concentrations from flow through soil columns. Each panel represents one of the three experimental columns.

Figure

1

Drafter: RZ | Date: 04/17/19 | Contract Number: 1690011200-052 | Approved: | Revised: