

TECHNICAL MEMORANDUM

To: Nevada Environmental Response Trust

Cc: Nevada Division of Environmental Protection
United States Environmental Protection Agency

From: Katie Hendrickson

Date: December 23, 2020

Subject: Hydrogen-Based Gas Permeable Membrane Pilot Study Monthly Progress Report

At the direction of the Nevada Environmental Response Trust (NERT or Trust), Tetra Tech, Inc. (Tetra Tech) has prepared this memorandum that summarizes Tetra Tech's progress made during November 2020 toward successfully implementing the Hydrogen-Based Gas Permeable Membrane Pilot Study.

Task Progress Update: November 2020

Task M26 – Hydrogen-Based Gas Permeable Membrane Pilot Study

- Current Status
 - Test Scenario #1, which involves treatment of the existing FBR influent obtained from the FBR equalization tank, began on August 31, 2020. Once the planned acclimation was completed, weekly steady state performance sample collection, as outlined in the Hydrogen-Based Gas Permeable Membrane Pilot Study System Operation Manual, started on September 14, 2020.
 - While initial observations of the performance of Scenario #1 were quite promising, the Pilot System demonstrated inconsistent performance. Sampling results demonstrated the Pilot System was capable of achieving significant perchlorate concentration reductions, including to less than 5 µg/L. However, effluent perchlorate concentrations were not consistently below the 18 µg/L treatment target limit throughout Test Scenario #1. Acknowledging that treatment of the NERT site water is a new application of the APT technology, this performance was not unexpected and adjustments were anticipated as part of the learning process to determine optimal operational parameters and maintenance requirements.
 - Performance assessment sample results for this reporting period, including analytical data and field parameters from the influent, effluent from each reactor, and final effluent are shown in Table 1. Performance results from Week 7 (collected on November 6, 2020) show a reduction in perchlorate concentration from 53,000 µg/L in the influent to 17 µg/L in the lag reactor and performance results from Week 8 (collected on November 19, 2020) show a reduction of 43,000 µg/L in influent to 0.39 µg/L in the lag reactor. Chlorate and nitrate concentrations in the final effluent were below detection limits in both Week 7 and Week 8 performance samples.

- On November 19, 2020, a progress status meeting was held with NDEP and the Trust to discuss the sample results to date and preliminary assessment of the Pilot System. Key points from the preliminary assessment include:
 - The Pilot System has been shown to meet the objective of reducing high concentrations of perchlorate to less than 18 µg/L. However, stable and sustainable treatment system operation and performance had not been demonstrated as part of Scenario Test #1 due to the factors further discussed below:
 - Evidence of sulfate reducing bacteria, which competes with the perchlorate reducing bacteria, was present in the Pilot System. Optimizing the hydrogen addition to each reactor and adding oxygen (air) to the lag reactor appears to control the growth of sulfate reducing bacteria and maintain the preferred ORP range, which improves Pilot System performance. Additionally, Pilot System performance was negatively impacted by the large amounts organic materials observed to be present in the influent water after ETI performed intensive multi-day pipeline pigging events in late October. ETI will be providing advance notification of pigging events or other maintenance that could impact the influent water quality from this point forward.
 - Temperature changes affect biological activity and the associated perchlorate reduction rate. Unlike the FBR system which treats water with temperature between approximately 70 and 80 degrees Fahrenheit, the influent water for the pilot test is held in two frac tanks prior to and during use and is influenced by ambient daytime and nighttime temperatures. Pilot system influent water temperatures dropped below 70 degrees Fahrenheit on multiple occasions in late October and November, which impeded biological activity and perchlorate reduction. Water heaters will be installed to maintain the influent water temperature above 70 degrees Fahrenheit consistent with the FBR influent water.
 - Biomass accumulation in the reactors, likely exacerbated by the growth of sulfate reducing bacteria and high organic loading as discussed above, reached an operational pressure benchmark indicating a cleaning was needed for optimal Pilot System performance.
- Based on discussions between Tetra Tech, NDEP and the Trust, it was concluded that a number of factors not directly related to or accounted for in the design of the Pilot System contributed to the inconsistent performance. Accordingly, it was decided the Pilot System should be cleaned and Test Scenario #1 would be extended (with the original test referred to as Scenario #1A and this extension referred to as Scenario #1B). The objective of Scenario #1B will be to demonstrate stable and sustainable performance by applying lessons learned from Scenario #1A. The Pilot System cleaning was performed November 20 through November 24, 2020. Pilot System operations for Scenario #1B with FBR influent water was started on November 24, 2020 and system acclimation is ongoing. It is currently anticipated that Scenario #1B will run for a minimum of 12 weeks to ensure sufficient data can be gathered. Additional Test Scenario #1B details will be provided in the December 2020 monthly progress report.
- Schedule and Progress Updates
 - Operation of the Pilot System under Scenario #1B using FBR influent water is anticipated to continue for a minimum of 12 weeks. Analytical results for additional performance sampling events will be presented in future monthly progress reports when data are available.

- Health and Safety
 - There were no health and safety incidents related to Task M26 during November 2020. Safety measures continue to be implemented to minimize potential exposure to COVID-19, including the use of face coverings, gloves, and hand sanitizer, as well as protocols for monitoring temperatures, minimizing the number of people on site at one time, and evaluating tasks to increase physical distance between personnel.

CERTIFICATION

Hydrogen-Based Gas Permeable Membrane Pilot Study Monthly Progress Report

**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

Signature: Jay A Steinberg <sup>Not Individually, but Solely
as President of the Trustee</sup>, 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

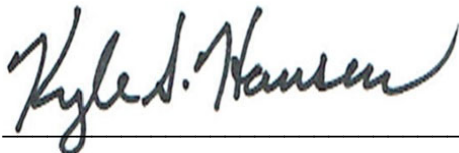
Company: Le Petomane XXVII, Inc., not individually, but solely in its representative capacity as the Nevada Environmental Response Trust Trustee

Date: 12/23/2020

CERTIFICATION

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 Hydrogen-Based Gas Permeable Pilot Study Monthly Progress Report.



Kyle Hansen, CEM
Field Operations Manager/Geologist
Tetra Tech, Inc.

December 23, 2020

Date

Nevada CEM Certificate Number: 2167
Nevada CEM Expiration Date: September 18, 2022

Tables

Table 1
Scenario 1 Performance Monitoring Data
Hydrogen-Gas Based Permeable Membrane Pilot Study

Week and Date	Influent Water									Biological Reactors																							
	Flow	T	pH	Perchlorate	Chlorate	Nitrate -N	TDS	TSS	TSS	Perchlorate (ppb)			Chlorate (ppb)			Nitrate (ppm)			TSS (ppm)			pH			T (°C)			ORP			Pressure (psig)		
	gpm	°C	s.u.	ppb	ppb	ppm	ppm	ppm		Lead	Middle	Lag	Lead	Middle	Lag	Lead	Middle	Lag	Lead	Middle	Lag	Lead	Middle	Lag	Lead	Middle	Lag	Lead	Middle	Lag	Lead	Middle	Lag
1 (9/15/20)	2.0	28.1	7.67	58,000	97,000	8.4	5,800	17	34,000	340	4.2	31,000	<100	90 J	0.29 J+	<0.014	0.13 J+	12	39	15	7.79	7.78	7.65	29.5	30.6	30.4	-102	-397	-406	12.8	5.7	8.8	
2 (9/21/20)	2.0	30.6	7.69	37,000	100,000	8.8	4,800	13	34,000	240	6.1	33,000	<100	<100	0.33	<0.014	<0.014	17	19	9.5	7.85	7.86	7.89	31.2	31.8	31.5	-80	-383	-373	13.3	5.8	8.1	
3 (9/30/20)	2.4	30.2	7.69	60,000	99,000	9.2	5,500	14	40,000	10,000	54	49,000	7,000	<10	1.8	0.093	<0.014	14	5.5	<5	7.83	7.83	7.49	29.8	30.5	30.4	-162	-116	-327	13.6	6.7	8.1	
4 (10/6/20)	2.4	27.7	7.60	73,000	120,000	9.9	5,000	<5	43,000	13,000	200	58,000	8,800	<100	2.0	0.078	<0.014	<5	<5	6.6	7.80	7.81	7.44	28.5	29.6	29.6	-93	-119	-163	14.6	9.0	8.5	
5 (10/14/20)	3.5	22.3	7.58	50,000	98,000	7.9	5,700	18 J	62,000	2,900	52	49,000	2,100	<10	0.059 J+	1.3 J+	<0.014	7.5	<5	6.0	7.80	7.81	7.80	20.9	22.2	20.8	-68	-471	-175	18.7	13.2	9.3	
6 (10/26/20)	2.0	17.7	7.66	65,000	120,000	NA	5,000	13	65,000	2,300	350 J-	15,000	250	350 J-	NA	NA	NA	5.0	12	12	8.18	7.80	7.84	18.8	19.4	19.4	-190	-394	-403	17.2	13.6	15.6	
7 (11/6/20)	2.0	22.4	7.65	53,000	94,000	8.3	6,000	6.5	9,500	140	17	1,300	<10	24 J	<0.014	<0.014	<0.014	18	14	9.0	7.24	7.24	7.24	25.1	26.3	26.3	-383	-462	-368	6.8	5.2	6.6	
8 (11/19/20)	1.6	20.8	7.76	43,000	54,000	8.5	5,100	15 J	4,200	98	0.39 J	5,000	30 J	19 J	<0.014	<0.014	<0.014	5.0	7.5	16	7.68	7.82	7.60	25.6	27.1	28.9	-443	-194	-390	26.6	17.0	21.2	

Week and Date	Post Reactor Tank Effluent						Treated Water Holding Tank				Cartridge Filter Effluent						
	Perchlorate	Chlorate	Nitrate - N	TSS	T	pH	TSS	T	pH	Turbidity	Perchlorate	Chlorate	Nitrate -N	TDS	TSS	T	pH
	ppb	ppb	ppm	ppm	°C	s.u.	ppm	°C	s.u.	NTU	ppb	ppb	ppm	ppm	ppm	°C	s.u.
1 (9/15/20)	4.7	70 J	<0.014	13	29.5	7.65	27	30.2	8.38	251	2.2	<100	<0.014	5,500	21	30.0	8.40
2 (9/21/20)	6.4	<100	<0.014	16	30.9	7.72	18	31.1	8.32	286	2.2	<40	<0.014	4,800	9.5	31.2	8.28
3 (9/30/20)	20	<10	<0.014	12	28.5	7.76	9.5	30.0	7.92	37.4	130	180	<0.014	5,200	5.0	30.2	7.83
4 (10/6/20)	89	<100	<0.014	6.1	27.7	7.55	12	28.7	7.76	42.1	73	<100	<0.014	4,700	<5	28.9	7.49
5 (10/14/20)	28	<10	<0.014	5.0	20.8	8.35	14	25.3	8.46	10.2	38	<10	<0.014	5,700	15	25.3	8.48
6 (10/26/20)	190	<10	NA	16	14.0	8.06	11	17.5	8.38	22.3	170	<10	NA	5,200	<5	17.8	8.42
7 (11/6/20)	10	<10	<0.014	16	25.5	7.84	14	25.7	8.16	309	16	<10	<0.014	5,800	5.5	25.6	8.13
8 (11/19/20)	0.71 J	<10	<0.014	20	25.8	8.15	20	26.5	8.29	83.5	0.59 J	<10	<0.014	4,900	26	26.6	8.28

NA = Not analyzed
 J = Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value.
 J+ = The result is an estimated quantity, but the result may be biased high.
 J- = The result is an estimated quantity, but the result may be biased low.