ARCADIS Design & Consultancy for natural and built assets

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Nevada Environmental Response Trust
35 E. Wacker Drive, Suite 690
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Subject:
Arcadis Comments on the Las Vegas Wash Bioremediation Pilot Study
Nevada Environmental Response Trust Site
Henderson, Nevada

Dear Mr. Loffman:

Arcadis U.S., Inc. (Arcadis) has prepared the enclosed technical memorandum (memo) at the request of the Nevada Environmental Response Trust (NERT). The memo summarizes technical comments and observations associated with Arcadis' review of the Las Vegas Wash Bioremediation Pilot Study Work Plan Addendum and the Las Vegas Wash Bioremediation Pilot Study Phase 2 Cost Estimate and Basis prepared by Tetra Tech, Inc. and dated August 2019.

Arcadis appreciates the opportunity to provide this review, as well as the opportunity to participate in the conference calls on February 21, April 9, April 15, and July 7, 2019 and the in-person meetings on April 2 and June 16, 2019 (which Arcadis attended via phone). If there are any questions or comments, please contact the undersigned.

Sincerely,

Jo Wang, PE, CEM (#2125)
Principal Environmental Engineer

Jeffrey McDonough, PE_{NJ}
Associate Vice President

Date:
September 24, 2019

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Our ref:
OH001193.0003

MEMO

ARCADIS Design & Consultancy for natural and built assets

To:

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From:

Jeffrey McDonough, Arcadis

Justin Provolt, Arcadis

Date:

September 24, 2019

Arcadis Project No.:

OH001193.0003

Subject:

Arcadis Comments on the Las Vegas Wash Bioremediation Pilot Study

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At the request of the Nevada Environmental Response Trust (NERT or the Trust), Arcadis U.S., Inc. (Arcadis) respectfully submits this technical memorandum (memo) summarizing technical comments and observations associated with the review of the Las Vegas Wash Bioremediation Pilot Study Work Plan Addendum (Work Plan Addendum) and the Las Vegas Wash Bioremediation Pilot Study Phase 2 Cost Estimate and Basis (Cost Basis). The documents were authored by Tetra Tech, Inc. (Tetra Tech) and dated August 2019. Overall, Arcadis finds the Work Plan and Cost Basis to be technically implementable at a reasonable cost for what is proposed. The technical comments provided herein are optimization measures that in Arcadis' opinion will increase the certainty of success of the proposed work, which can have overall cost ramifications.

It should be noted that Arcadis, Ramboll, Tetra Tech, and the Trust participated in structured conference calls on February 21, 2019, April 9, 2019, April 15, 2019, and July 7, 2019 and convened an in-person meeting on April 2, 2019 and June 16, 2019 (Arcadis participated via phone) to discuss the project objectives and goals as the overall study's scope continued to be refined. Through collaborative discussions and the April/June meetings, the scope of the Work Plan Addendum changed considerably since the initial version was shared with Arcadis. Therefore, Arcadis has minimal comments on the Work Plan Addendum and Cost Basis documents and agrees with the scope and cost details presented therein.

ARCADIS COMMENTS

General Comments:

1. Arcadis recognizes and appreciates the addition of Section 5.4.4 (Hydraulic Response), which serves to monitor the overall hydraulic influence of simultaneous injection and extraction. The most robust assessment of hydrogeological parameters possible during implementation of the Las Vegas Wash pilot study is strongly endorsed. Strategically positioning transducers and collecting relevant groundwater extraction data simultaneously with relevant injection data opportunistically provides data to inform other technologies to be evaluated in the feasibility study. Understanding how injection and extraction simultaneously influence the aquifer enables an evaluation of engineered hydraulic flushing of aquifer pore space, which can influence the overall lifecycle of an in situ remedial strategy.

2. Arcadis recognizes and appreciates the addition of Appendix I (Injection Well Spacing and Injection Volume Design Summary), which summarizes the calculations and hydraulic modeling used to estimate injection volumes. Effective porosity is a key parameter used to estimate injection volumes and is currently approximated by nuclear magnetic resonance data and experience. The only tool available to directly measure the dual-domain nature of porous media (i.e., the relationship of mobile to immobile pore space) is a tracer study. Developing a rationale to support the injection volumes (e.g., Appendix I) is a necessary first step; however, those injection volumes are then field verified (using a tracer) during the pilot study. The field verification is based on an observed tracer response at strategically placed dose response monitoring wells located at a targeted radius of influence from the injection well. The data quality objectives of the tracer study are carefully designed to ensure the test is implemented until the objectives have been accomplished. Tracer studies significantly optimize injection volumes by empirically verifying those injection volumes previously approximated through multiple lines of hydrogeological data.

Tracer Study Focused Comments:

1. Charcoal dye samplers by design are not sufficiently quantitative. They are only as quantitative as the sampling frequency with which they are collected. During injection, dose response should be analyzed via water samples collected from targeted monitoring wells over carefully specified cumulative injection volumes that are then normalized to a consistent injection concentration. Following injection, arrival times and cumulative mass distributions should be analyzed via water samples collected over carefully specified time increments based upon the anticipated groundwater movement. Charcoal dye samplers can be an effective way to manage unanticipated results, but if they are used to identify meaningful dose response, accurate downgradient arrival times, and other hydrogeological specific objectives they are generally insufficient. It is true that charcoal dye samples will continue to collect dye over time, and this is precisely why they are insufficiently quantitative to determine an injected volume to radial distribution relationship.

2. The Work Plan Addendum/Cost Basis document does not list a prescriptive tracer injection concentration. This is a potential pitfall. Throughout the course of the tracer injection, several injection solution samples should be collected to maintain consistency of a prescriptive tracer injection concentration (preferably 20 to 40 milligrams per liter [mg/L]). The importance of this is that tracer response will be normalized to the injection solution and is a critical design component of a successful tracer study.

3. As written, the Work Plan Addendum/Cost Basis assumes 6 months of monitoring for the tracer study. This can be a potential pitfall. Rather than specify a timeframe associated with observing tracer response downgradient, it is advisable to specify a total number of samples to be collected adaptively based on arrival/field observation. There is infinitely more value in a longer tracer study that yields meaningful results than a tracer study arbitrarily stopped too soon.

4. Setting the expectation that tracer may be observed in surface water is ill-advised (4th objective of Section 5.4.3). Monitoring for tracer arrival in surface water would be an ideal application of the charcoal filters, but the concentrations may be so low due to dilution that any response at all may be significantly muted. Given the distance of the injection well transects from the Las Vegas Wash, it should be explicitly stated that visual or analytically quantified dye arrival in the surface water may be unrealistic due to dilution (it is not recommended to be one of the objectives of the tracer study).

5. Ozark Underground Laboratory can analyze for multiple dyes in a single sample. It is recommended to report as many dyes as can be reported for a single fluorescent spectroscopic analysis given historical tracer use. If eosine and fluorescein are selected, please be aware that their spectroscopic peaks are similar and concentration differences may be required to further distinguish these dyes.

CONCLUSION

Arcadis appreciates the opportunity to review the Work Plan Addendum and the Cost Basis. The proposed Work Plan Addendum describes an *in situ* anaerobic treatment mechanism using a sparingly soluble carbon substrate to address elevated concentrations of perchlorate and chlorate. In addition, an important hydrogeological tracer study component has been added to quantitively evaluate the injected volume to radial distribution relationship, comparative transport and bulk groundwater velocities, and understand vertical connectivity of the alluvium and the Upper Muddy Creek formation. The proposed scope of work is appropriate, reasonably priced, and anticipated to be successful upon achieving uniform distribution of the carbon substrate and dye *in situ* to the extent practicable. The offered comments herein are optimization measures to increase the certainty of success. If there are questions or comments associated with this memo, the Trust is encouraged to contact Arcadis.