ARCADIS Design & Consultancy for natural and built assets

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Nevada Environmental Response Trust
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Subject:
Arcadis Comments on the Galleria Drive Bioremediation Treatability 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 Galleria Drive Bioremediation Treatability Study Work Plan Addendum dated January 7, 2019 and the Galleria Drive Bioremediation Treatability Study Phase 2 Cost Estimate and Basis dated January 15, 2019 prepared by Tetra Tech, Inc. and the Budgetary Proposal for Field Services Emulsified Vegetable Oil Injection – Galleria Drive prepared by Cascade Technical Services.

Arcadis appreciates the opportunity to provide this review, as well as the opportunity to participate in the February 12, 2019 teleconference with the greater NERT team. If there are any questions or comments, please contact the undersigned.

Date:
March 8, 2019

Contact:
Jo Wang

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Our ref:
OH001193.0003

Sincerely,

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

Jeffrey McDonough, PE_{NJ}
Associate Vice President

MEMO

ARCADIS Design & Consultancy for natural and built assets

To:

Nevada Environmental Response Trust

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From:

Jeffrey McDonough, Arcadis

Justin Provolt, Arcadis

Date:

March 8, 2019

Arcadis Project No.:

OH001193.0003

Subject:

Arcadis Comments on the Galleria Drive Bioremediation Treatability 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 Galleria Drive Bioremediation Treatability Study Work Plan Addendum (Work Plan), the Galleria Drive Bioremediation Treatability Study Phase 2 Cost Estimate and Basis (Cost Basis), and the Budgetary Proposal for Field Services Emulsified Vegetable Oil Injection – Galleria Drive (Proposal). The Work Plan and the Cost Basis were authored by Tetra Tech, Inc. (Tetra Tech), and the Proposal was authored by Cascade Technical Services (Cascade). 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.

Arcadis and Tetra Tech had a teleconference on February 12, 2019 to discuss these comments. Some resolutions were discussed during the teleconference and in subsequent correspondence. This memo provides technical comments along with Arcadis' understanding of noted resolutions where appropriate.

ARCADIS COMMENTS

***Comment* #1**: Given the anticipated low permeability of the Upper Muddy Creek formation (UCMf) and that the success of *in situ* bioremediation (ISB) is predicated on achieving uniform distribution of the injected carbon substrate to the extent possible, Arcadis recommends the installation of 4-inch-diameter injection

wells in a minimum of 8-inch-diameter boreholes rather than the recommended 2-inch-diameter injection wells. Arcadis has no objection to 2-inch-diameter monitoring wells.

Comment #2: Arcadis supports and recommends the planned concept of injection well screen discretization to no longer than 15 feet, which justifies the need for multiple injection wells at a single location. The current injection well installation scope specifies nested injection wells (i.e., colocation of the injection wells within the same borehole). For 2-inch-diameter injection wells, there is a cost savings associated with investigative-derived waste (IDW) with nested injection wells. If 4-inch-diameter injection wells are selected, the larger borehole required eliminates the IDW cost savings and nested injection wells are not recommended. Injection well clusters (i.e., separately drilled boreholes) are recommended for 4-inch-diameter injection wells.

Comment #3: The proposed injection well construction materials in the Work Plan are Schedule 40 polyvinyl chloride (PVC) with slotted screens. Arcadis recommends the use of stainless-steel, continuously wire-wrapped screens with a Schedule 80 PVC riser. Additionally, Arcadis recommends site-specific grain-size analysis to influence the filter-pack specification with at least 2 feet of choker sand overlain by neat cement grout as an injection well seal to the surface completion.

- The purpose for the continuously wire-wrapped screen specification is the increased open area to remove the flow constriction of the slotted screen. The capital cost ramifications of specifying stainless-steel well construction for the Galleria Road Treatability Test and then scaling up to full-scale implementation are understood; however, the anticipated diminished injection capacity is expected to result in larger increase in operation and maintenance (O&M) costs to complete the injections and may jeopardize overall remedy performance.

- The purpose of the stainless-steel material specification is to withstand the recommended >200 pounds per square inch (psi) jetting well development pressures.

- The purpose of Schedule 80 PVC is to withstand the heat of hydration associated with the neat cement grout seal. There have been field observations of long neat cement grout well seals deforming Schedule 40 PVC casing.

Given the comparatively extreme concentrations of total dissolved solids (TDS) and sulfate within the UMCf proximal to the proposed bioremediation treatability study, there is a high likelihood of biological and/or geochemical fouling following the first injection of carbon substrate. The open area of the continuously wire-wrapped screens and the materials of construction (i.e., stainless steel) to withstand aggressive well redevelopment are anticipated to facilitate the initial injection and accommodate future injections. Arcadis has no objection to using Schedule 40 PVC well construction with bentonite grout completion for monitoring wells.

Comment #4: The drilling method specified in the Work Plan and the Cost Basis is rotosonic. It is Arcadis' opinion that production wells (either extraction or injection) installed via vibratory methods without 100 percent (%) recovery of IDW may reduce the achievable production (either extraction or injection) of the well. Arcadis respectfully defers to Tetra Tech's historical drilling experience at the NERT site; however, the large permeability difference between the alluvium and the UMCf is noted and may influence the productivity of an injection well installed within the UMCf using rotosonic methodology without 100% IDW recovery.

Comment #5: The Work Plan and Cost Basis specify a sparingly soluble carbon substrate (emulsified vegetable oil; EVO) in the form of EOS Pro and recommend the separate field-addition of glycerin to increase the soluble carbon. Arcadis supports the addition of a soluble carbon component; however, Arcadis recommends revisiting the selection of EOS Pro in favor of EOS-LS (both similarly priced). The EOS-LS product maximizes the glycerin content in the solution delivered to the site by the vendor without compromising the emulsion. This would eliminate the need to add glycerin separately as an additional process component during field implementation and would still retain all the benefits of EOS Pro. The injection of a single reagent greatly reduces the complexity of the field implementation without sacrificing the designed intention of injecting both sparingly soluble and soluble carbon.

The Work Plan and Cost Basis recommend the addition of phosphorus as a nutrient and sodium sulfite as a dissolved oxygen scavenger. Arcadis does not recommend the addition of either phosphorus or sodium sulfite. Given the concerns for biological and geochemical fouling and because the University of Las Vegas laboratory studies specific to the Galleria Road Treatability Test in the UMCf demonstrated that phosphorus addition is not necessary to achieve perchlorate reduction regardless of depth and geochemistry, the addition of phosphorus seems unnecessary and increases the risk of biological and/or geochemical fouling of the aquifer. The field management of sodium sulfite requires increased health and safety measures and, considering the comparative dissolved oxygen in water versus the reducing equivalents in the injected carbon substrate, the addition of sodium sulfite does not seem to be justified.

Comment #6: The Proposal specifies batch mixing of the targeted carbon substrate injection concentration to facilitate the addition of glycerin, phosphorus, and sodium sulfite as well as manage mixing batches versus the anticipated injection flow rates. Arcadis recommends a continuous in-line mixing injection approach rather than large batch mixing of a carbon substrate. The addition of a soluble carbon (i.e., glycerin) to large dilute batches of carbon substrate in warm climates can result in biological fouling *ex situ*, which can increase the O&M costs of the injection. This can be exacerbated when low injection flow rates are anticipated, like those associated with the UMCf. The removal of phosphorus and sodium sulfite from the planned injection scope and the consideration of EOS-LS (a delivered solution of EVO and glycerin combined) will facilitate a large water storage tank with a centrifugal pump and a hydraulically driven dosing pump to achieve continuous in-line mixing and mitigate the potential for fouling.

Comment #7: The Work Plan specifies a flexible range of 1:4 to 1:20 carbon substrate to water ratio (i.e., 5% to 25% by volume) for an injection concentration for a small volume of the total injected volume followed by the balance of the planned injection volume as clean water for chasing purposes. In Arcadis' experience, this form of dosing is effective for purely soluble substrates where there is a risk of *ex situ* biofouling. Arcadis' opinion is that a 1:4 carbon substrate to water ratio may be more applicable in a more permeable material like the alluvium/paleochannel, but (with any degree of fouling and less effective injection well construction) in a lower permeable environment (i.e., UMCf) may drastically reduce delivery and result in insufficient injection volumes. Therefore, for a sparingly soluble form of carbon (i.e., EVO in the form of EOS Pro or EOS-LS), Arcadis recommends a consistent injection concentration throughout the entire injection event, typically on the order of 2% to 3% by volume (1:30 to 1:50 carbon substrate to water ratio), to achieve uniform distribution of the injected carbon substrate throughout the targeted treatment area to the extent possible. Arcadis is in favor of the flexible language in the Work Plan that indicates the ultimate carbon substrate to water ratio will be determined in the field during start-up of the Galleria Road Treatability Test based on initial step rate injection testing.

Comment #8: Arcadis recommends including an inert tracer (e.g., fluorescein dye) during the first injection of the Galleria Road Treatability Test. Arcadis also recommends including up to 1 year of post-injection

tracer monitoring to be conducted during the proposed performance monitoring. The purpose of the recommended tracer is to understand the potential for contaminant storage and migration within the UMCf. By using the tracer to determine site-specific transport and average groundwater flow velocities, we will have information to guide full-scale injection frequency and injection well transect spacing. Additionally, the tracer can be used as visual determination of achieving the radius of influence during the injection as the proposed well network for the Galleria Road Treatability Test includes both injection dose response wells and post-injection downgradient observation wells (Figure 5 of the Work Plan [not attached to this comment letter]).

The location of the Galleria Road Treatability Test is anticipated to be a sufficient distance from the Las Vegas Wash (LVW) with minimal chances of tracer entering the LVW. The inert tracer recommended is fluorescein dye at approximate concentration of 20 milligrams per liter (which represents a minimal cost at approximately $60 per pound). It is recommended the tracer be included during the first already planned injection event, but not during subsequent injection events. As part of the already proposed monitoring program, groundwater samples will be collected from upgradient, cross-gradient, and downgradient monitoring wells for analysis of the dye by Ozark Underground Laboratory. This would include the collection of groundwater samples from 24 monitoring wells during each of the already planned monthly groundwater sampling events, which would represent approximately $16,200 in additional laboratory charges.

Comment #9: More detail regarding multiple facets of the CASCADE Proposal are requested. Specifically, these include health and safety measures for implementing the injections, a process flow diagram, a process and instrumentation diagram, and more descriptive line items for the cost estimate. Arcadis understands that a future CASCADE Proposal will be submitted with more detail.

Comment #10: The costs provided in the CASCADE Proposal do not appear to reconcile. For example, each event is estimated at $116,840; however, if there are three events, this is a total cost of $350,520, which is less than $400,050 provided in the Cost Basis. Additionally, the 16 days proposed for the implementation in the Proposal appear to be on the low side given the anticipated lower permeability of the UMCf and the existing hydraulic data collected in support of the Work Plan. Arcadis understands that Tetra Tech applied an unspecified 15% increase to the CASCADE Proposal costs to accommodate unknown injection performance/productivity.

CLOSING COMMENTS

Arcadis appreciates the opportunity to review the Work Plan, the Cost Basis, and the Proposal as well as the February 12, 2019 teleconference to discuss these comments. The proposed Galleria Road Treatability Test Work Plan describes an *in situ* anaerobic treatment mechanism using a sparingly soluble carbon substrate to address elevated concentrations of perchlorate, chlorate, and hexavalent chromium. The proposed scope of work is appropriate, reasonably priced, and anticipated to be successful upon achieving uniform distribution of the carbon substrate *in situ* to the extent practicable. The offered comments herein are optimization measures to facilitate uniform distribution of the carbon substrate and increase the certainty of success. If there are questions or comments associated with this memo, the Trust is encouraged to contact Arcadis.