



October 8, 2019

## TECHNICAL MEMORANDUM

To: Brian Loffman, Steve Clough, Andrew Steinberg  
Nevada Environmental Response Trust

From: Alex Bowerman, Ramboll  
Chris Ritchie, Ramboll  
Scott Warner, Ramboll  
John Pekala, CEM#2347, Expires 9/20/2020, Ramboll

**Re: Treatability/Pilot Study Modification No. 9  
Nevada Environmental Response Trust Site  
Henderson, Nevada  
Ramboll Project No. 1690011200-046**

This Technical Memorandum recommends a modification to the scope of work for the ZVI-Enhanced Bioremediation Treatability Study at the Nevada Environmental Response Trust (NERT) Site (the "Site") located in Henderson, Nevada. The approved Galleria Drive ZVI Bioremediation Treatability Study Work Plan (the "Work Plan"<sup>1</sup>) dated September 29, 2017 described the rationale and implementation of a field treatability program along Galleria Drive (Figure 1) to evaluate the feasibility and effectiveness of implementing ZVI-enhanced bioremediation at the mid-plume Operable Unit (OU) boundary (i.e., the boundary between OU-2 and OU-3). NERT has been informed that the Galleria Drive field site will likely be sold to a real estate developer in the near future, thus reducing or potentially eliminating access for completing the field program. The scope of work identified in the Work Plan was to be implemented on parcel 179-06-101-003, owned by Basic Environmental Company (BEC) and identified on Figure 1 (hereafter referred to as the "Galleria Parcel"). Phase I site characterization activities of the Galleria Parcel as identified in the Work Plan were completed by Ramboll between April 2018 and February 2019.

Previous evaluations of ZVI technology for application at the Site have included bench-scale testing conducted in collaboration with the University of Nevada, Las Vegas (UNLV). As reported in the Trust's monthly progress reports, the bench-scale testing results to-date have provided valuable information demonstrating that the reduction of perchlorate, nitrate, and chlorate can be promoted under certain conditions. Data collected from the bench-scale testing and Phase I site characterization activities will be used to inform the ZVI field test design, the results of which will support remedy selection as part of the Remedial Investigation and Feasibility Study (RI/FS). This modification proposes to conduct site

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<sup>1</sup> Ramboll, 2017. Galleria Road Zero Valent Iron Treatability Study Work Plan, Nevada Environmental Response Trust Site, Henderson, Nevada. Ramboll Project No. 1690011200-046. September. Approved by NDEP on October 26, 2017.

characterization activities and additional limited bench-scale testing to address data gaps associated with a newly selected location for the treatability study, as further described below.

Resulting from dialogue between the Trust and BEC surrounding future development and potential sale of the Galleria Parcel, the Trust directed Ramboll to evaluate potential new locations to implement the treatability study, with minimal impact to the scope of the Work Plan. The evaluation, which included dialogue led by the Trust with input from Tetra Tech and Arcadis, determined that "Transect 1A", as identified in the Las Vegas Wash Bioremediation Pilot Test Work Plan (the "LVW Work Plan"),<sup>2</sup> is the most suitable location and is the subject of this Treatability Study Modification.

The Transect 1A area was characterized by Tetra Tech between March and July 2018 as part of the Phase 1 pre-design investigation activities identified in the LVW Work Plan. Subsequent to the investigation, the Trust revised the scope of the LVW Work Plan to exclude Transect 1A from Phase 2 of the pilot study. The results of the Phase 1 pre-design investigation and details surrounding the elimination of Transect 1A from Phase 2 of the pilot study will be reported under separate cover by Tetra Tech.

Acknowledging the above, Ramboll has reviewed all data and has identified a small number of data gaps necessary to be filled in advance of design and implementation of the Phase 2 field test of ZVI technology, which shall now be referred to as the Las Vegas Wash ZVI-Enhanced Bioremediation Treatability Study.

These data gaps include:

<b>Data Gap</b>	<b>Approach and Rationale</b>
Transect 1A groundwater velocities were estimated at one well location (LVWPS-MW107A/B/C) through single borehole dilution testing. Additional groundwater velocity measurements are necessary across the Transect 1A area.	Additional single-borehole dilution testing will be performed at 11 existing wells and three proposed new wells to fill the data gap. Groundwater velocities throughout Transect 1A will be used to design the ZVI reactive zone and associated performance monitoring network.
The saturated alluvium soil sample collected from 27.5 to 28 ft below ground surface (bgs) at LVWPS-MW102A/B contained perchlorate at 2.0 mg/kg, which is at least one order of magnitude higher than the samples collected from the underlying UMCf (<0.013 to 0.30 mg/kg); however, both existing wells at that location are screened within the UMCf.	A new groundwater monitoring well will be installed for chemical and hydraulic characterization of the saturated alluvium near existing wells LVWPS-MW102A and LVWPS-MW102AB. The new well will be screened from approximately 20-30 feet bgs.

<sup>2</sup> Tetra Tech, 2017. Las Vegas Wash Bioremediation Pilot Study Work Plan, Nevada Environmental Response Trust Site, Henderson, Nevada. September 22. Approved by NDEP on October 16, 2017.

<p>Shallow groundwater in the vicinity of LVWPS-MW102A/B requires further characterization.</p>	
<p>The shallowest saturated soil sample collected from the LVWPS-MW110 location (29 to 29.5 ft bgs) contained perchlorate at 2.7 mg/kg, which is at least one order of magnitude higher than all of the other samples collected from deeper intervals of that same boring (&lt;0.012 to 0.056 J mg/kg); however, the existing well is screened from approximately 48 to 68 ft bgs. The saturated alluvium in the vicinity of LVWPS-MW110 requires further characterization.</p>	<p>A new groundwater monitoring well will be installed for chemical and hydraulic characterization of the saturated alluvium near existing well LVWPS-MW110. The new well will be screened from approximately 20-30 feet bgs.</p>
<p>The saturated soil sample collected from 53.5 to 54 ft bgs within the UMCf at location LVW-MW104 contained perchlorate at 2.0 mg/kg, while the perchlorate concentrations in shallower samples at that location ranged from &lt;0.014 to 0.64 mg/kg; however, existing well LVWPS-MW104 is screened in the saturated alluvium (approximately 24 to 34 ft bgs). Groundwater within the UMCf in this area requires further characterization.</p>	<p>A new groundwater monitoring well will be installed for chemical and hydraulic characterization of the UMCf near existing well LVWPS-MW104. The new well will be screened from approximately 50-70 feet bgs.</p>
<p>Bench scale ZVI-enhanced bioremediation tests performed to date have been conducted using soil and groundwater collected from the originally-proposed Galleria Parcel. Soils and groundwater in the Transect 1A area may react differently.</p>	<p>Limited bench-scale testing is required to evaluate whether soils and groundwater collected from Transect 1A behave similarly to the Galleria Parcel. A streamlined microcosm testing program (discussed below) using soils and groundwater from Transect 1A will be used to augment existing data from Galleria Parcel bench-scale testing.</p>

**PROPOSED SCOPE OF WORK**

The following sections describe recommended technical activities to be performed to fill the above-mentioned data gaps in support of finalizing the Phase 2 design of the Las Vegas Wash ZVI-Enhanced Bioremediation Treatability Study which will be implemented at Transect 1A. All soil and groundwater sampling, monitoring well installations, monitoring well development, analytical testing, aquifer testing, etc. will be performed in a manner consistent with the methodologies presented in the NDEP-approved Phase 1 RI Field Sampling Plan<sup>3</sup>, Revision 1, dated July 18, 2014, and the approved Work Plan. Data

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<sup>3</sup> Environ, 2014. Phase 1 RI Field Sampling Plan, Revision 1. Nevada Environmental Response Trust Site, Henderson, Nevada. July. Approved by NDEP on August 1, 2014.

collected during this additional investigation along with the prior field investigation data from the Galleria Parcel will be presented in accordance with the Work Plan.

### New Monitoring Well Installation and Development

Three new four-inch diameter Schedule 40 PVC groundwater monitoring wells will be installed in the Transect 1A Study Area. Proposed locations are shown in Figure 2 and representative cross sections of the study area are presented in Figures 3 and 4. The new wells will be located adjacent to existing monitoring wells LVWPS-MW102A/B, LVWPS-MW104, and LVWPS-MW110, and installed with screened intervals of approximately 20 to 30, 50 to 70, and 20 to 30 ft bgs, respectively, as summarized in Table 1. Borings will be advanced to approximately 10 feet below the proposed depths listed above, and actual screen intervals may differ based on evaluation of lithology at the time of drilling. The proposed locations will allow for collecting additional cross-sectional information along alignments that are parallel and perpendicular to flow directions and thus will be critical for engineering the field pilot system.

Following installation, the new monitoring wells will be developed in accordance with procedures described in the Work Plan.

### Soil Sampling

Soil samples will be collected from selected depth intervals at each new monitoring well location to supplement existing data. The borehole advanced adjacent to the LVWPS-MW102A/B pair will be sampled at 10, 15, 20, and 25 feet bgs. A soil sample will be collected from 45 feet bgs at the new borehole advanced near existing well LVWPS-MW104, and samples will be collected from 35 and 40 feet bgs in the new borehole advanced near existing well LVWPS-MW110. Additional samples may be collected from selected intervals as needed based on visual observations of soil cores. Soil samples will be analyzed for perchlorate, chlorate, nitrate, total chromium, total organic carbon, and moisture content. Additional soil will be collected as needed to provide sediment necessary for inclusion into the limited bench scale testing described below.

### Aquifer Testing

Single well hydraulic tests consisting of "slug tests" will be performed on each of the newly installed wells.

Single-borehole dilution tests also will be performed at the three newly installed wells plus the existing wells listed below. The collection of area-wide groundwater velocity data from the more comprehensive set of wells will assist with both design and performance evaluation of the ZVI treatability study.

- LVWPS-MW102A
- LVWPS-MW104
- LVWPS-MW105
- LVWPS-MW108A
- LVWPS-MW108B
- LVWPS-MW109
- LVWPS-MW110
- LVWPS-MW111A



- LVWPS-MW111B
- LVWPS-MW112A
- LVWPS-MW112B

### Groundwater Monitoring

Following installation and development of new groundwater monitoring wells, a groundwater monitoring event will be performed to collect samples from all Transect 1A wells (24 wells total).

Groundwater samples will be analyzed for perchlorate, chlorate, chloride, sulfate, nitrate, metals [calcium, magnesium, potassium, sodium, and iron], bicarbonate, total dissolved solids, total organic carbon, dissolved organic carbon, iron [ferrous and ferric], and total chromium. Samples will also be analyzed for dissolved hydrogen using the bubble strip method, which will be described in an addendum to the existing Quality Assurance Project Plan (QAPP<sup>4</sup>) Revision 3, dated April 8, 2019.

### Bench-Scale Testing

Ramboll plans to collaborate with UNLV to conduct streamlined bench-scale testing to evaluate the performance of ZVI under conditions present at Transect 1A. While acknowledging the extensive examinations of ZVI conducted by UNLV in support of this treatability study, the intent of this streamlined additional testing is to quickly and efficiently gather data which will augment the information gained from the Galleria Parcel and provide design details for a subsequent field test. Specifically, the bench-scale testing will be performed to address the following focused objectives:

- Verify the efficacy of ZVI as a treatment matrix to promote the reduction of contaminants in groundwater within the UMCf and alluvium in Transect 1A;
- Evaluate the effects of guar and/or other potential carrier agents<sup>5</sup>, which may be replaced with ZVI as part of field implementation at Transect 1A; and
- Evaluate relative performance of ZVI with carbon and nutrient amendments (e.g., Vitamin B-12, diammonium phosphate, molybdate) to enhance perchlorate, chlorate, and nitrate reduction in Transect 1A groundwater.

Bench-scale testing will be performed using soil and groundwater collected during the field investigation activities described in previous sections of this Technical Memorandum. The collected soil and groundwater will be delivered to UNLV where they will be stored until bench-scale testing begins. Bench-scale testing will be consistent with the methodologies presented in the approved Work Plan and is anticipated to be limited to short-duration batch microcosm testing.

As mentioned above, Ramboll has determined that this additional laboratory effort is necessary and will collaborate with UNLV on the specifics of the limited microcosm experiments. However, due to the accelerated nature of this streamlined bench-scale

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<sup>4</sup> Ramboll. 2019. Quality Assurance Project Plan, Revision 3. Nevada Environmental Response Trust Site, Henderson, Nevada. April. Approved by NDEP on April 17, 2019.

<sup>5</sup> "Carrier agents" are often used to enhance the injection of ZVI into the subsurface. Frequently, biodegradable, food-grade guar gum is used to temporarily increase the viscosity of the injecting fluid to "carry" the ZVI particles further into the surrounding formation. The guar gum, being a simple organic compound, is readily degraded in the subsurface and can be used as an electron donor by perchlorate-reducing bacteria; therefore, this potential effect will be evaluated.

testing, in the event that UNLV is unable to perform the bench-scale testing due to timing or staffing, a qualified commercial laboratory (e.g., PRIMA Environmental of El Dorado Hills, California) may be utilized under the direction of Ramboll and with UNLV to satisfy the expedited timeline of the limited laboratory effort.

## **EVALUATION OF RESULTS**

The results of field investigations and preliminary results of the bench-scale testing activities proposed in this modification will be analyzed along with existing Transect 1A data and presented in the forthcoming Work Plan Addendum. The Work Plan Addendum will also include Trust recommendations for the Phase 2 approach for field testing of ZVI-enhanced bioremediation.

## **SCHEDULE**

Permitting, access, and planning activities for the field investigation can begin immediately following receipt of NDEP approval of this modification and are anticipated to take approximately four (4) weeks. Mobilization and field activities, as described herein, will take approximately 3-4 weeks to complete, and data validation will begin as soon as results are received from the laboratory. Bench-scale testing is anticipated to commence upon receipt of soil and groundwater samples from the field activities and is anticipated to take approximately 12 weeks. All data (initial investigation data and the additional field investigation data) will be evaluated and used in the preparation of the Work Plan Addendum. Bench-scale testing is anticipated to commence in fourth quarter 2019. It is anticipated that a Work Plan Addendum will be submitted to NDEP in late first quarter or early second quarter 2020.

Please contact us should you have any questions about the recommended additional investigation.

## **Attachments**

- Table 1      Planned Additional Investigation Locations
- Figure 1     Treatability Study Area Locations
- Figure 2     Proposed Additional Well Locations
- Figure 3     Schematic Subsurface Cross-Section A-A'
- Figure 4     Schematic Subsurface Cross-Section B-B'



**Treatability / Pilot Study  
Modification No. 9**

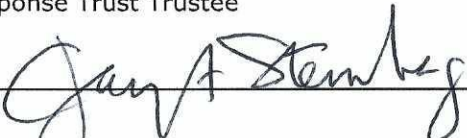
**Nevada Environmental Response Trust Site  
(Former Tronox LLC Site)  
Henderson, Nevada**

**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 system(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, Inc., not individually, but solely in its representative capacity as the Nevada Environmental Response Trust Trustee

**Signature:**  **Not Individually, but Solely  
as President of the 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:** 10/1/19



**Treatability/Pilot Study  
Modification No. 9**

**Nevada Environmental Response Trust  
(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 provided 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.

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**John M. Pekala, PG  
Principal**

October 8, 2019

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**Date**

Certified Environmental Manager  
Ramboll US Corporation  
CEM Certificate Number: 2347  
CEM Expiration Date: September 20, 2020

**TABLE 1. PLANNED ADDITIONAL INVESTIGATION LOCATIONS**  
**Treatability/Pilot Study Modification No. 9**  
**Nevada Environmental Response Trust Site; Henderson, Nevada**

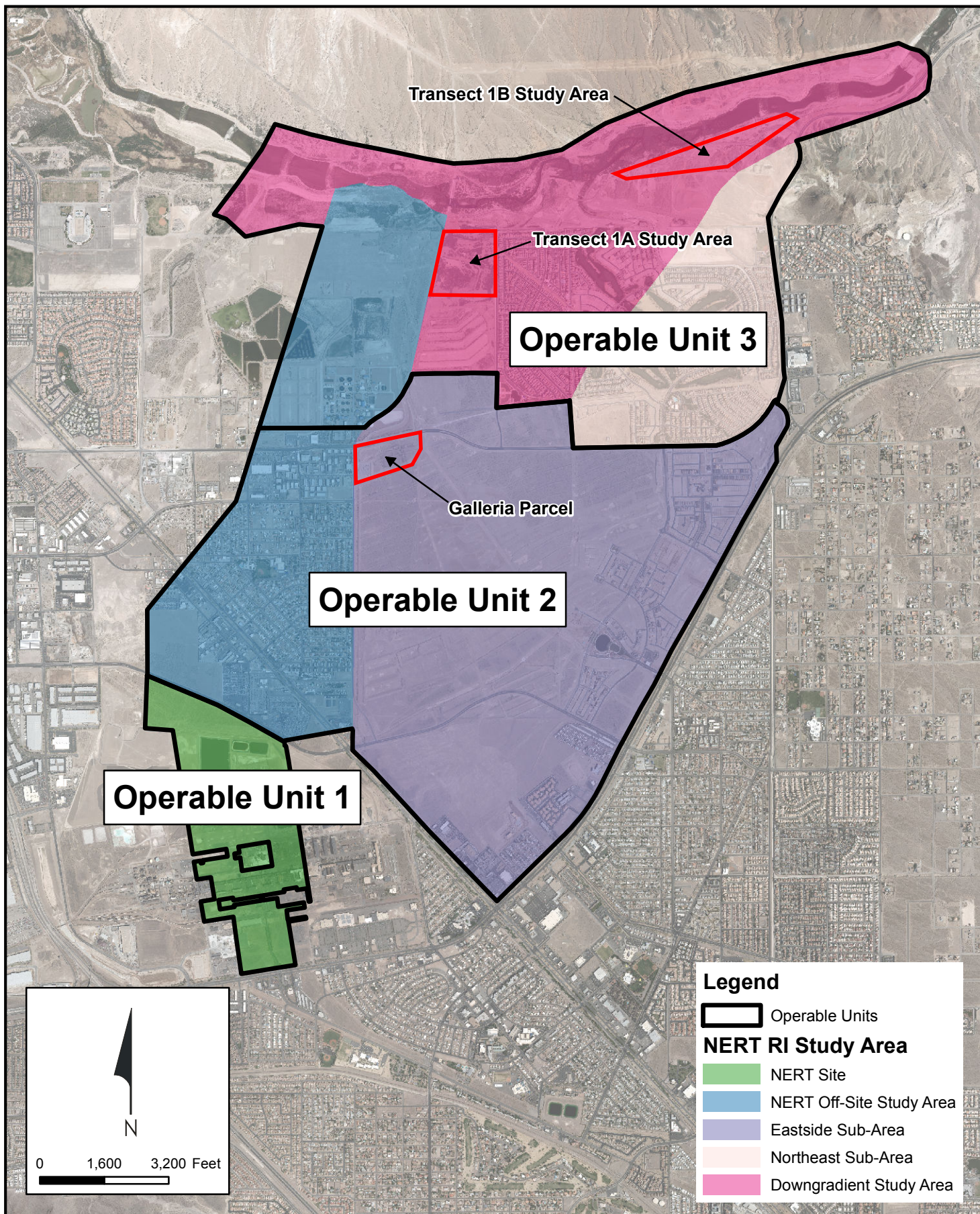
Planned Monitoring Well ID	LVW Transect 1A ZVI Treatability Study Area Location	Initial Planned Well Construction Details					
		Well Boring Total Depth (ft bgs)	Casing Diameter and Type	Screen Size (inches)	Screened Interval (ft bgs)	Sand Pack Interval (ft bgs)	Sand Pack Size
ZTS-MW113	Adjacent to Wells LVWPS-MW102A (screened 47-67 ft bgs) LVWPS-MW102B (screened 77-97 ft bgs)	40	4" PVC	0.01	20-30	18-30	No. 2/12
ZTS-MW114	Adjacent to Well LVWPS-MW104 (screened 24-34 ft bgs)	80	4" PVC	0.01	50-70	48-70	No. 2/12
ZTS-MW115	Adjacent to Well LVWPS-MW110 (screened 48-68 ft bgs)	40	4" PVC	0.01	20-30	18-30	No. 2/12

**Notes:**

See Figure 2 for planned additional investigation locations.

ft bgs: feet below ground surface





Figure



**Treatability Study Area Locations**  
 Nevada Environmental Response Trust Site  
 Henderson, Nevada



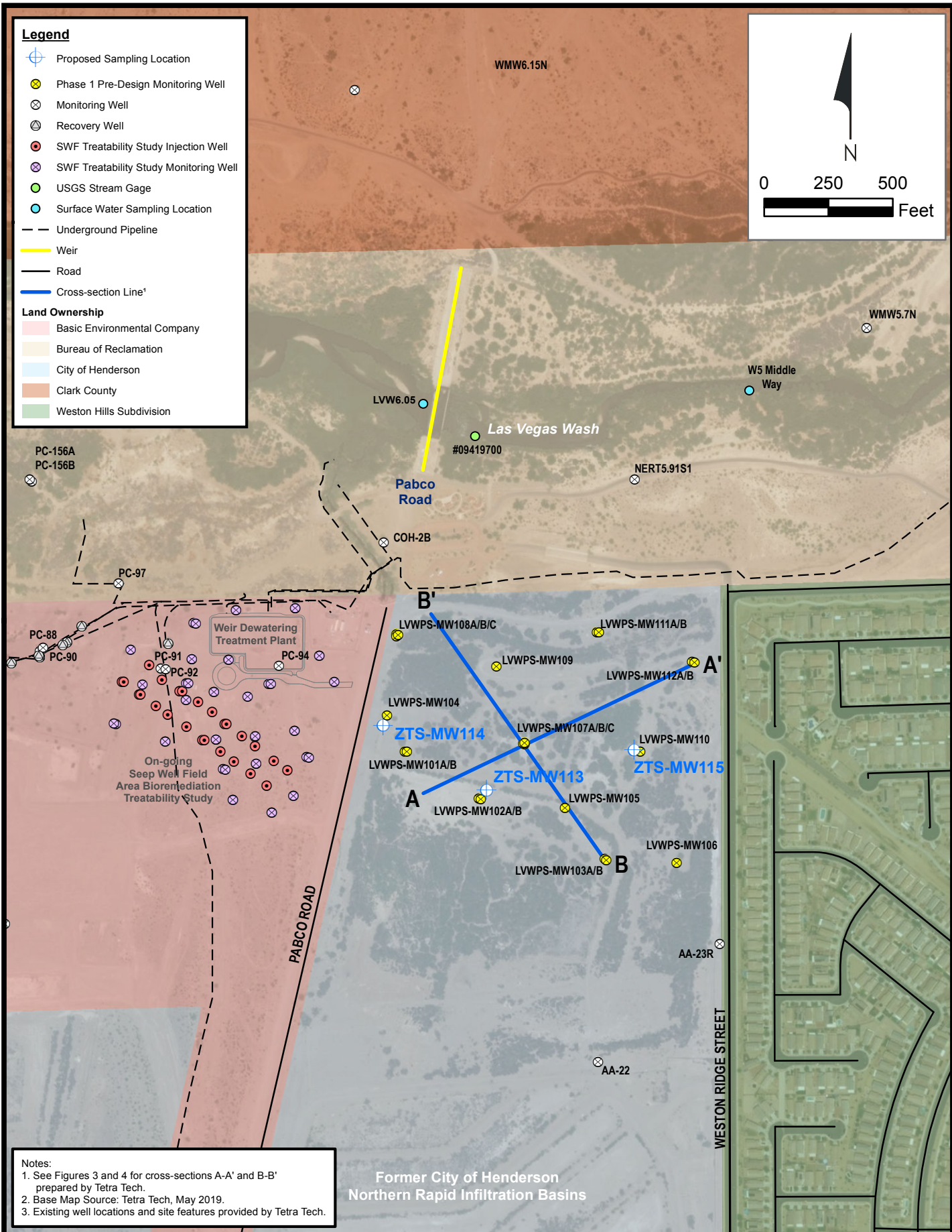
**Legend**

- Proposed Sampling Location
- Phase 1 Pre-Design Monitoring Well
- Monitoring Well
- Recovery Well
- SWF Treatability Study Injection Well
- SWF Treatability Study Monitoring Well
- USGS Stream Gage
- Surface Water Sampling Location
- Underground Pipeline
- Weir
- Road
- Cross-section Line

**Land Ownership**

- Basic Environmental Company
- Bureau of Reclamation
- City of Henderson
- Clark County
- Weston Hills Subdivision

0 250 500 Feet



**Notes:**  
 1. See Figures 3 and 4 for cross-sections A-A' and B-B' prepared by Tetra Tech.  
 2. Base Map Source: Tetra Tech, May 2019.  
 3. Existing well locations and site features provided by Tetra Tech.

Former City of Henderson  
 Northern Rapid Infiltration Basins

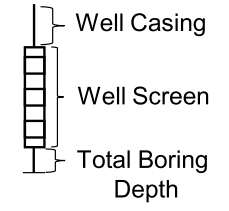
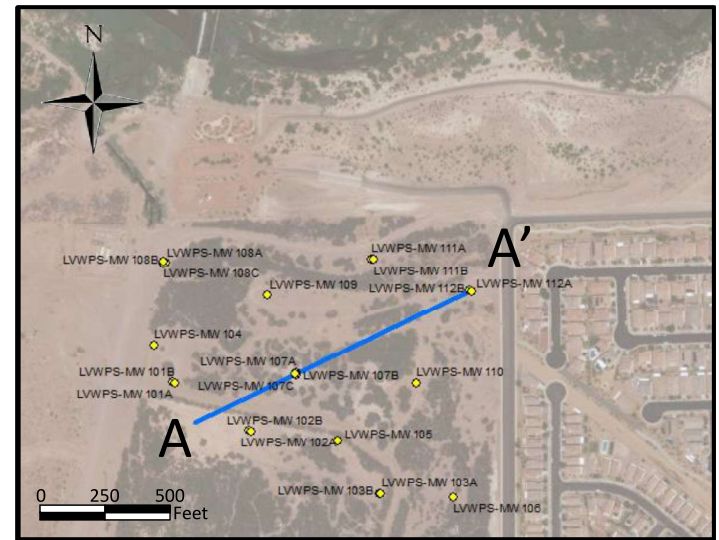
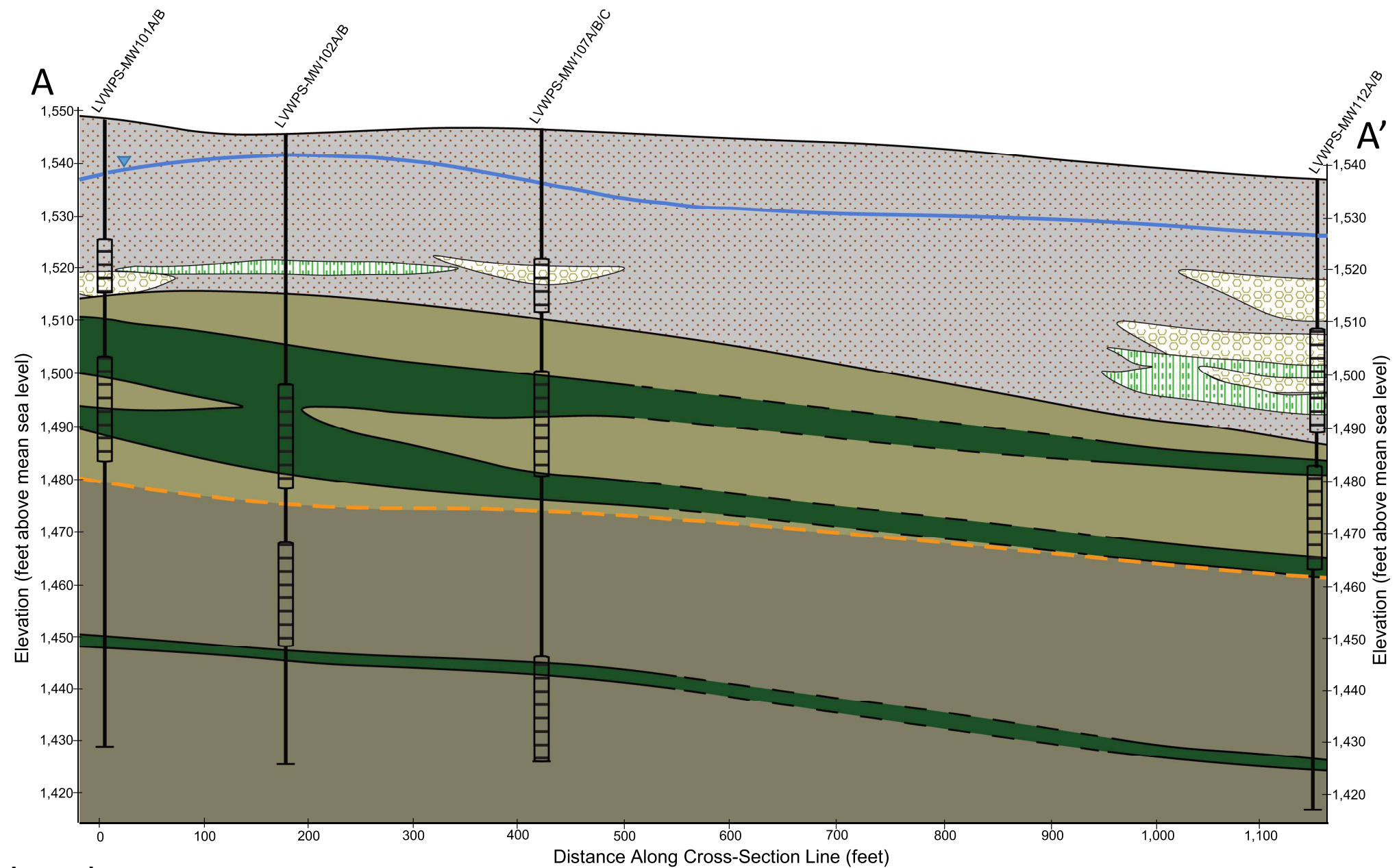


**Proposed Additional Well Locations**  
 Treatability/Pilot Study Modification No. 9 ZVI-Enhanced  
 Bioremediation Treatability Study

Figure  
**2**  
 169001 1200 - 046

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- Legend**
- |                                                                   |                                                                 |                                                             |                                 |             |
|-------------------------------------------------------------------|-----------------------------------------------------------------|-------------------------------------------------------------|---------------------------------|-------------|
| Alluvium – Sand                                                   | Alluvium – Sandy Silt and Silty Sand (>30% Silt)                | Upper Muddy Creek Formation – Silt and Sandy Silt with Clay | Inferred Contact                | Water Table |
| Alluvium – Gravel and Sand with Gravel Channel Fill (>30% Gravel) | Semi – Consolidated Upper Muddy Creek Formation – Silt and Clay | Upper Muddy Creek Formation – Organic – Rich Silt and Clay  | Depth to First Gypsum Encounter |             |

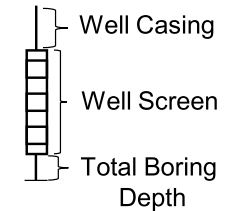
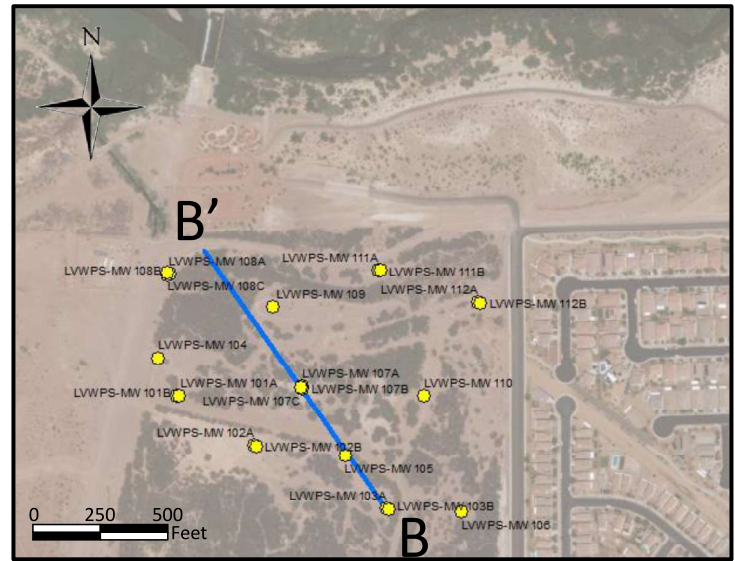
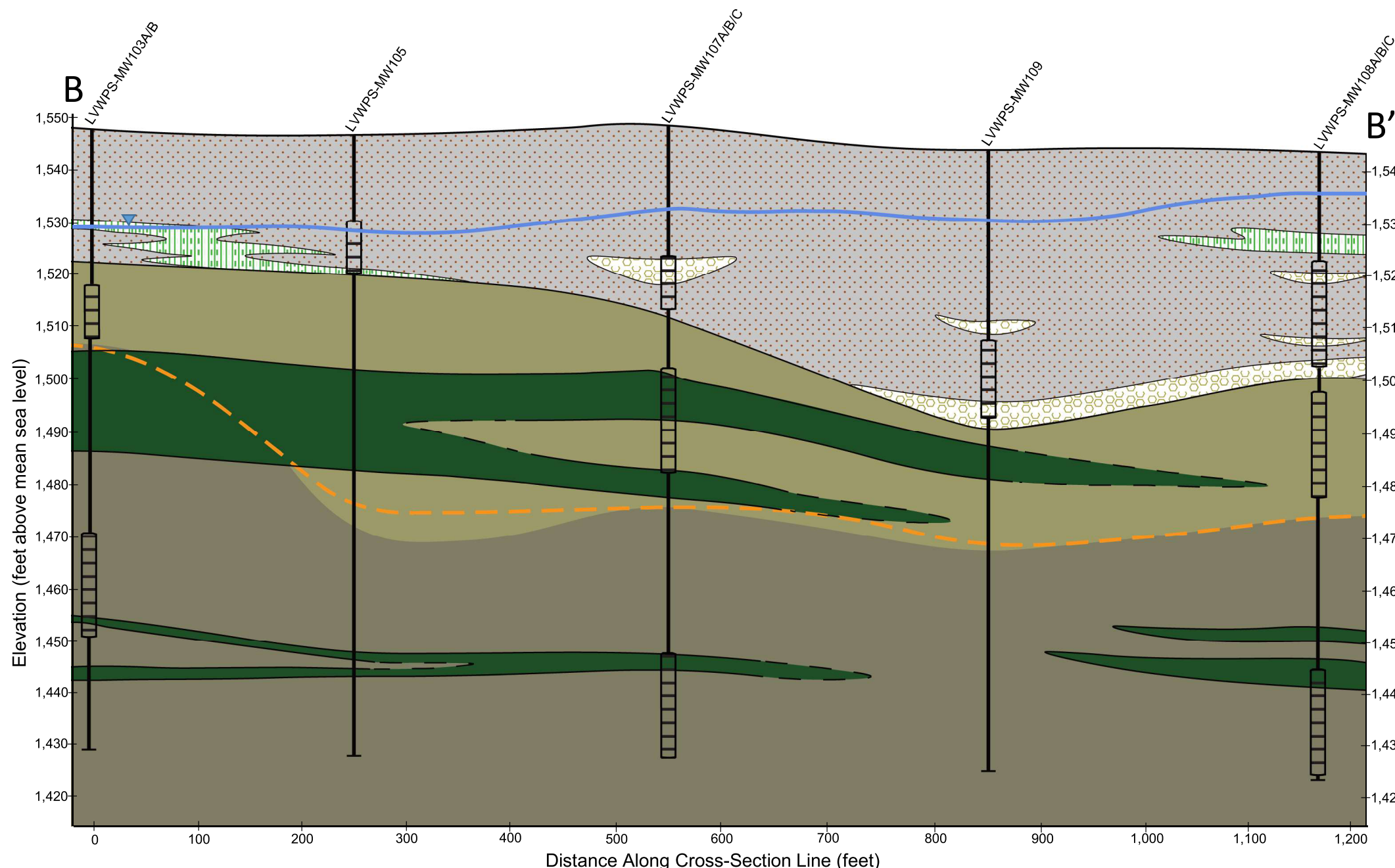
- Notes:
1. Water level depiction is based on water level measurements taken on July 9, 2018.
  2. Wells are projected onto section A-A' from a maximum distance of 170 feet.
  3. Each well was completed in a separate borehole; for simplicity, the clustered wells are shown as a single location with multiple screens on the cross-section.
  4. Semi-consolidated Upper Muddy Creek formation contact represents the depth of the first occurrence of more cemented and consolidated material. Degree of cementation and consolidation varies with depth.
  5. Cross-section prepared by Tetra Tech for inclusion in their forthcoming Las Vegas Wash Bioremediation Pilot Study Work Plan Addendum.



**Schematic Subsurface Cross-Section A-A'**

Nevada Environmental Response Trust Site; Henderson, Nevada





**Legend**

- |                                                                   |                                                                 |                                                             |                                 |             |
|-------------------------------------------------------------------|-----------------------------------------------------------------|-------------------------------------------------------------|---------------------------------|-------------|
| Alluvium – Sand                                                   | Alluvium – Sandy Silt and Silty Sand (>30% Silt)                | Upper Muddy Creek Formation – Silt and Sandy Silt with Clay | Inferred Contact                | Water Table |
| Alluvium – Gravel and Sand with Gravel Channel Fill (>30% Gravel) | Semi – Consolidated Upper Muddy Creek Formation – Silt and Clay | Upper Muddy Creek Formation – Organic – Rich Silt and Clay  | Depth to First Gypsum Encounter |             |

- Notes:
1. Water level depiction is based on water level measurements taken on July 9, 2018.
  2. Wells are projected onto section B-B' from a maximum distance of 155 feet.
  3. Each well was completed in a separate borehole; for simplicity, the clustered wells are shown as a single location with multiple screens on the cross-section.
  4. Semi-consolidated Upper Muddy Creek formation contact represents the depth of the first occurrence of more cemented and consolidated material. Degree of cementation and consolidation varies with depth.
  5. Cross-section prepared by Tetra Tech for inclusion in their forthcoming Las Vegas Wash Bioremediation Pilot Study Work Plan Addendum.



**Schematic Subsurface Cross-Section B-B'**

Nevada Environmental Response Trust Site; Henderson, Nevada

Drafter: RS      Date: 7/24/19      Project Number: 1690011200 - 046      Approved by:      Revised:

Figure

**4**