

TECHNICAL MEMORANDUM

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

From: Dan Pastor and Dana Grady, Tetra Tech

Date: August 17, 2018

Subject: Treatability/Pilot Study Modification No. 2 – Las Vegas Wash Bioremediation Pilot Study
Nevada Environmental Response Trust Site, Henderson, Nevada

This technical memorandum has been prepared on behalf of the Nevada Environmental Response Trust (NERT) to present Tetra Tech's recommended modification to the scope of work for Phase 1 activities associated with the Las Vegas Wash Bioremediation Pilot Study that are currently in progress. As presented in the Las Vegas Wash Bioremediation Pilot Study Work Plan (Work Plan) (Tetra Tech, 2018), a pilot study will be performed to demonstrate and evaluate the effectiveness of implementing in-situ bioremediation to reduce the perchlorate mass flux that is migrating into the Las Vegas Wash, which is the primary remedial action objective for OU-3. Based on recent estimates of perchlorate mass flux into the Las Vegas Wash, approximately 35.6 pounds per day (lbs/day) of perchlorate discharges to the Las Vegas Wash between the Pabco Rd weir and Homestead Weir. As a result, this pilot study is located within a high priority area with respect to evaluating remedial efforts to reduce the mass flux to the LVW. The locations of the pilot study are shown on Figure 1.

Phase 1 of the pilot study includes several pre-design field activities to collect appropriate area-specific data to be used to optimize the final pilot study design to best target the perchlorate mass flux entering the Las Vegas Wash. These pre-design field activities, which include the installation of soil borings/monitoring wells, groundwater and surface water sampling, and aquifer testing, began in March 2018 and are on-going. Results from these pre-design field activities have revealed the discovery of deep perchlorate contamination in both soil and groundwater. Additionally, lithologic logging indicates that a paleochannel identified near the Las Vegas Wash was significantly deeper than expected. Based on these recent discoveries, additional investigations are necessary to properly define the extent of contamination and develop a more thorough understanding of the geology within this high priority area.

1.0 PHASE 1 ACTIVITIES TO-DATE

During the on-going Phase 1 pre-design activities at both Transect 1A and Transect 1B, soil borings were advanced to a depth of 120 feet below ground surface (bgs), except where bedrock or consolidated Upper Muddy Creek formation (UMCf) was encountered shallower than 120 feet bgs. Monitoring wells were also installed at multiple intervals within the saturated alluvium and UMCf. Soil samples were generally collected on approximate 10-foot intervals from the top of the water table to the bottom of the boring and analyzed for perchlorate. Following the completion of well development, groundwater samples were collected from newly installed monitoring wells and analyzed for a variety of parameters (including perchlorate), in accordance with the Las Vegas Wash Bioremediation Pilot Study Work Plan (Tetra Tech, 2017).

Soil boring and well locations located immediately upgradient of the Las Vegas Wash in Transect 1B on Clark County property are shown on Figure 2. A draft cross-section of this area is provided in Figure 3. The cross-section presents the geology of the investigated area, including the approximate locations of two paleochannels as well as several faults that were identified with the limited available data. The geological information gathered to date appears to indicate that at least one of the paleochannels formed atop an area that shifted downward as a result of faulting; as a result, the paleochannel was significantly deeper than anticipated. Dashed lines on the cross-section identify areas where information is inferred, and further delineation is recommended. Note that cross-section A-A' presents lithologic information for existing monitoring wells located within a projected distance of 144 feet from the line of section; wells located farther from the line of section are not portrayed on Figure 3.

Preliminary unvalidated analytical results from the Transect 1B study area, located immediately upgradient of the Las Vegas Wash on Clark County property, indicate that both soil and groundwater contained perchlorate in many of the deepest samples collected from 120 feet bgs. Figures 4 and 5 present the perchlorate concentrations at depth (as interpolated by Earth Volumetric Studio) for soil and groundwater, respectively. As with Figure 3, the cross-section diagrams include information for existing monitoring wells located within a projected distance of 144 feet from the line of section; wells located farther from the line of section are not portrayed on Figures 4 and 5. The results presented in this Technical Memorandum are considered preliminary because data validation is currently in progress and the validated data are not yet available. However, at the direction of the Trust, this technical memorandum presenting preliminary information with recommendations for additional Phase 1 pre-design field work has been prepared to minimize the impact to the project schedule due to the high priority of this pilot study.

2.0 RECOMMENDATION

Based on these observed deep perchlorate detections and evidence of paleochannels, Tetra Tech recommends modifying the scope of work for the current Phase 1 activities associated with the Las Vegas Wash Bioremediation Pilot Study. Additional investigation is recommended to further delineate the vertical distribution of perchlorate contamination in the subsurface in both soil and groundwater and confirm details of this complex geologic/hydrogeologic setting. Four existing locations and six new locations are proposed for additional investigation. The following table presents a summary of each boring location presented in geographical order from west to east as identified on Figure 2.

Proposed Location	Justification	Total Depth; Soil Sampling Interval
Additional Investigation at Existing Locations		
LVWPS-MW204	Perchlorate concentrations in soil increased with depth at this location, with the highest soil perchlorate concentration of 10 milligrams per kilogram (mg/kg) detected at 120 feet bgs. Monitoring well LVWPS-MW204 is screened within the alluvium from 50 to 70 feet bgs. A deeper soil boring and additional monitoring wells (screened deeper than 70 feet bgs) are warranted at this location to delineate perchlorate contamination in both soil and groundwater.	250 ft; 10 ft intervals from 130 – 250 ft

Proposed Location	Justification	Total Depth; Soil Sampling Interval
LVWPS-MW209	<p>Similar to location LVWPS-210, neither UMCf nor bedrock were encountered within the 120-foot bgs boring. Only one well, screened from approximately 70 to 90 feet bgs, was installed in this vicinity during the Phase 1 pre-design investigation. The groundwater sample collected from LVWPS-MW209 indicated a perchlorate concentration of 4.1 mg/L, which is similar to the perchlorate concentration detected in groundwater collected from the same depth interval at LVWPS-MW210. As mentioned above, increasing perchlorate concentrations were detected in groundwater at the LVWPS-MW210 location to a depth of 120 feet bgs, and it is possible that a similar pattern may be present at LVWPS-MW209. Accordingly, additional investigation is recommended at this location to delineate the extent of the deep perchlorate contamination and define the bottom of the alluvial channel.</p>	250 ft; 10 ft intervals from 130 – 250 ft
LVWPS-MW210	<p>The highest perchlorate concentration detected in groundwater during Phase 1 activities was collected from the deepest well within the LVWPS-MW210 cluster (10.0 milligrams per liter [mg/L] at monitoring well LVWPS-MW210C, screened from 100-120 feet bgs). Additionally, the UMCf was not encountered at this location, indicating the presence of a deep alluvial channel; the depth of this channel is undefined. It is recommended that further delineation be performed to determine the extent of the deep perchlorate contamination and define the bottom of this alluvial channel.</p>	250 ft; 10 ft intervals from 130 – 250 ft
LVWPS-MW212	<p>Similar to LVWPS-MW210 and LVWPS-MW209, neither UMCf nor bedrock were encountered within the 120 feet bgs boring. LVWPS-MW212 is located upgradient of LVWPS-MW210C, the location of the groundwater sample with the highest perchlorate detection. Additionally, soil perchlorate concentrations at LVWPS-MW212 increased with depth, with the highest soil perchlorate detection of 4.4 mg/kg at 115 feet bgs. Furthermore, advancing a soil boring deeper than 120 ft bgs at LVWPS-MW212 may help delineate the geometry of the faulting associated with the deep alluvial channel adjacent to the bedrock outcrop. Additional investigation is recommended at this location to delineate soil and groundwater perchlorate contamination at depth as well as to further refine the hydrogeologic understanding.</p>	250 ft; 10 ft intervals from 130 – 250 ft

Newly Proposed Phase 1 Soil Boring and Monitoring Well Locations

LVWPS-MW217	<p>Because the highest soil perchlorate concentration of 10 mg/kg was detected at 120 feet bgs at location LVWPS-MW204, an additional location (LVWPS-MW217) is proposed to the east of LVWPS-MW204 to evaluate the spatial distribution of perchlorate contamination in the vicinity of LVWPS-MW204 and LVWPS-MW205. Data collected may provide additional information to delineate the geometry of the alluvial channel at LVWPS-MW205 (Figure 3).</p>	250 ft; 10 ft intervals from top of the water table to 250 ft
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Proposed Location	Justification	Total Depth; Soil Sampling Interval
LVWPS-MW218	A new location is proposed to the west of the highest perchlorate concentration detected in groundwater collected from the deepest well within the LVWPS-MW210 cluster. Data collected from this location will be used to evaluate the spatial distribution of perchlorate contamination in the vicinity of LVWPS-MW210 and geometry of the deep alluvial channel present within this vicinity.	250 ft; 10 ft intervals from top of the water table to 250 ft
LVWPS-MW220	New location LVWPS-MW220 is proposed west of LVWPS-MW209 to further evaluate the morphology of the deep alluvial channel encountered at LVWPS-MW209 and the depth of elevated perchlorate concentrations.	250 ft; 10 ft intervals from top of the water table to 250 ft
LVWPS-MW221	New location LVWPS-MW221 is proposed southwest of LVWPS-MW212 to further evaluate the spatial distribution of perchlorate contamination in the vicinity of LVWPS-MW212, where perchlorate concentrations increased with depth.	250 ft; 10 ft intervals from top of the water table to 250 ft
LVWPS-MW222	New location LVWPS-MW222 is proposed southeast of LVWPS-MW212 to further evaluate the spatial distribution of perchlorate contamination where perchlorate concentrations increased with depth. Furthermore, LVWPS-MW222 is adjacent to the bedrock outcrop and may provide valuable information to delineate the geometry of the faulting associated with the deep alluvial channel west of the bedrock outcrop.	250 ft; 10 ft intervals from top of the water table to 250 ft
LVWPS-MW219	A new location is proposed to the east of the highest perchlorate concentration detected in groundwater collected from the deepest well within the LVWPS-MW210 cluster. Data collected from this location will be used to evaluate the spatial distribution of perchlorate contamination in the vicinity of LVWPS-MW210 and the geometry of the deep alluvial channel in this vicinity.	250 ft; 10 ft intervals from top of the water table to 250 ft

As part of this proposed modification, the first soil boring at each location will be advanced to a depth of up to 250 feet bgs. If bedrock is encountered prior to reaching 250 feet bgs, then the boring will be advanced up to 15 feet into bedrock to evaluate its characteristics. If cemented or consolidated UMCf is encountered prior to reaching 250 feet bgs, the boring will be advanced to the shallower of 250 feet or up to 50 feet into the consolidated UMCf and then terminated.

During this additional investigation, soil samples will be collected on approximate 10-foot intervals from the top of the water table to the bottom of the boring and analyzed for perchlorate at each of the six new locations. At the four existing locations, soil samples will be collected starting at 130 feet bgs and will continue to be collected on approximate 10-foot intervals to 250-foot bgs, as soil samples were already collected during Phase 1 activities to a depth of 120 feet. Soil samples will be sent to Test America for perchlorate analysis on a 24-hour turnaround to provide as close to real-time data as possible that will be used to make field decisions thus allowing the field effort described herein to be completed within a single mobilization. Upon completion of the first boring (at either of the

existing or new locations), a monitoring well will be installed. It is anticipated that this well will be screened deeper than 120 feet bgs in a permeable interval identified from the lithology recorded for the first boring.

The quick turnaround soil perchlorate results from the newly installed deep boring will be used to decide the total number of monitoring wells (and associated screened intervals) to be installed at each location. Per the Work Plan, these monitoring wells will be used to evaluate the extent of groundwater perchlorate contamination within the pilot study area and collect data for key parameters to help optimize the design and effectiveness of this field pilot study. This scope of work proposes up to 3 additional monitoring wells constructed at each of the four existing and six new locations. The total well depth, slot size, filter pack, and length of the well screens will be determined in the field based on the soil analytical results and lithology encountered. The majority of the monitoring wells will be constructed using either 2-inch Schedule 40 or 80 polyvinyl chloride (PVC) casing (depending on depth) and screened with 2-inch diameter slotted PVC well screen. The deepest well at each location will be installed with 4-inch diameter Schedule 80 PVC casing and screened with 4-inch diameter slotted PVC well screen to allow for the use of higher-resolution nuclear magnetic resonance (NMR) logging in characterizing the deeper sediments. All monitoring wells will be installed, developed, and sampled in accordance with the approved Las Vegas Wash Bioremediation Pilot Study Work Plan (Tetra Tech, 2017) and approved Field Sampling Plan, Revision 1 (ENVIRON, 2014b).

Following completion of well development, groundwater sampling will be performed in all new and existing wells at each of the ten locations described in this modification (namely, LVWPS-MW204, LVWPS-MW209, LVWPS-MW210, LVWPS-MW212, LVWPS-MW217, LVWPS-MW218, LVWPS-MW219, LVWPS-MW220, LVWPS-MW221, and LVWPS-MW222). Groundwater samples will be collected from all new monitoring wells and analyzed in accordance with the approved Las Vegas Wash Bioremediation Pilot Study Work Plan (Tetra Tech, 2017). Existing monitoring wells at these locations (LVWPS-MW204, LVWPS-MW209, LVWPS-MW210A/B/C, and LVWPS-MW212A/B) will also be sampled and analyzed for perchlorate and chlorate. The full suite of parameters listed in the Work Plan are not required in these existing wells since these analyses were performed as part of the recent Phase 1 activities.

In addition to groundwater sampling, aquifer testing consisting of slug testing, borehole dilution testing, and NMR logging will be performed in accordance with the approved Las Vegas Wash Bioremediation Pilot Study Work Plan (Tetra Tech, 2018). Specifically, slug testing will be performed on all newly installed monitoring wells. Borehole dilution testing will be performed at up six locations based on the lithology encountered during drilling. Finally, NMR logging will be performed on the deepest well at each of the ten locations.

3.0 REFERENCES

ENVIRON. (2014b). *Field Sampling Plan, Revision 1, Nevada Environmental Response Trust Site, Henderson, Nevada*. July 18, 2014.

Tetra Tech, Inc. (2017). *Las Vegas Wash Bioremediation Pilot Study Work Plan, Nevada Environmental Response Trust Site, Henderson, Nevada*. September 22, 2017.

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: Prepare Treatability/Pilot Study Modification No. 2 – Las Vegas Wash Bioremediation Pilot Study



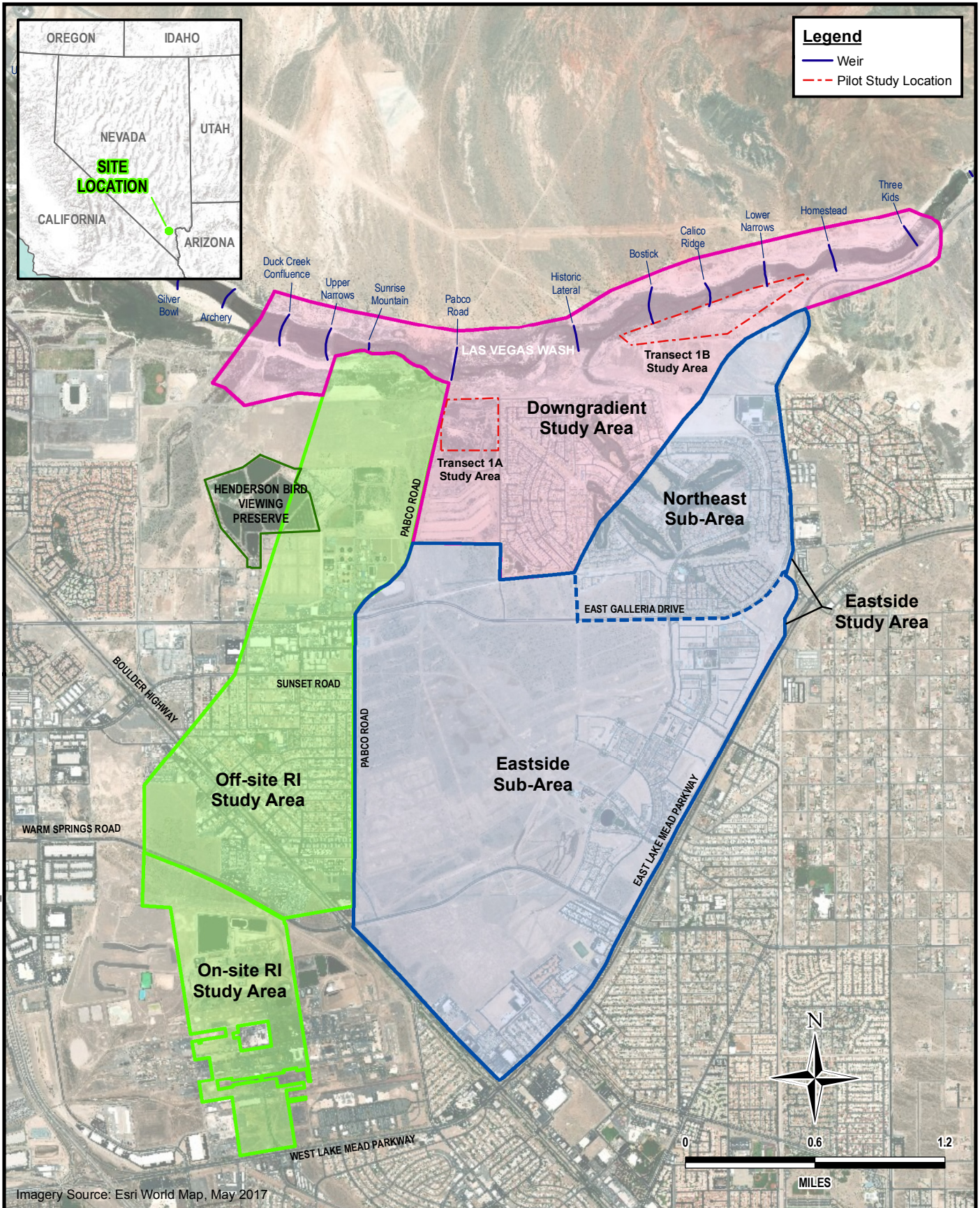
Kyle Hansen, CEM
Field Operations Manager/Geologist
Tetra Tech, Inc.

August 17, 2018

Date

Nevada CEM Certificate Number: 2167
Nevada CEM Expiration Date: September 18, 2020

Figures



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TETRA TECH

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NEVADA ENVIRONMENTAL RESPONSE TRUST

TREATABILITY/PILOT STUDY MODIFICATION NO. 2 -
LAS VEGAS WASH BIOREMEDIATION PILOT STUDY

PILOT STUDY LOCATION

Project No.: 117-7502018

Date: AUGUST 17, 2018

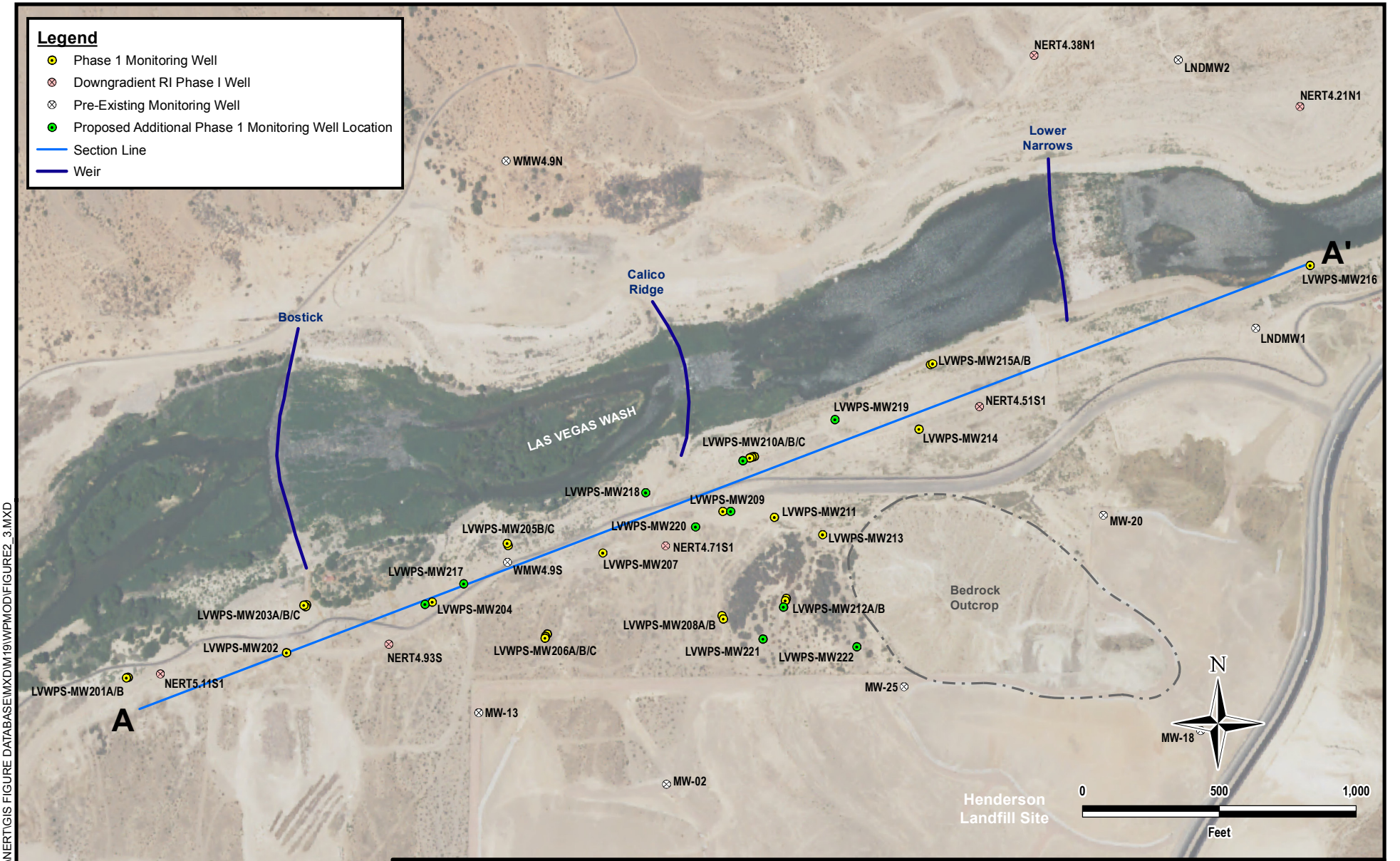
Designed By: SRA

Figure No.

1

Legend

- Phase 1 Monitoring Well
- ⊗ Downgradient RI Phase I Well
- ⊗ Pre-Existing Monitoring Well
- Proposed Additional Phase 1 Monitoring Well Location
- Section Line
- Weir



\\TTS\00FS\PROJECTS\NERTGIS\FIGURE DATABASE\MXDM\19\WPMOD\FIGURE2_3.MXD

Imagery Source: Esri World Map, May 2017

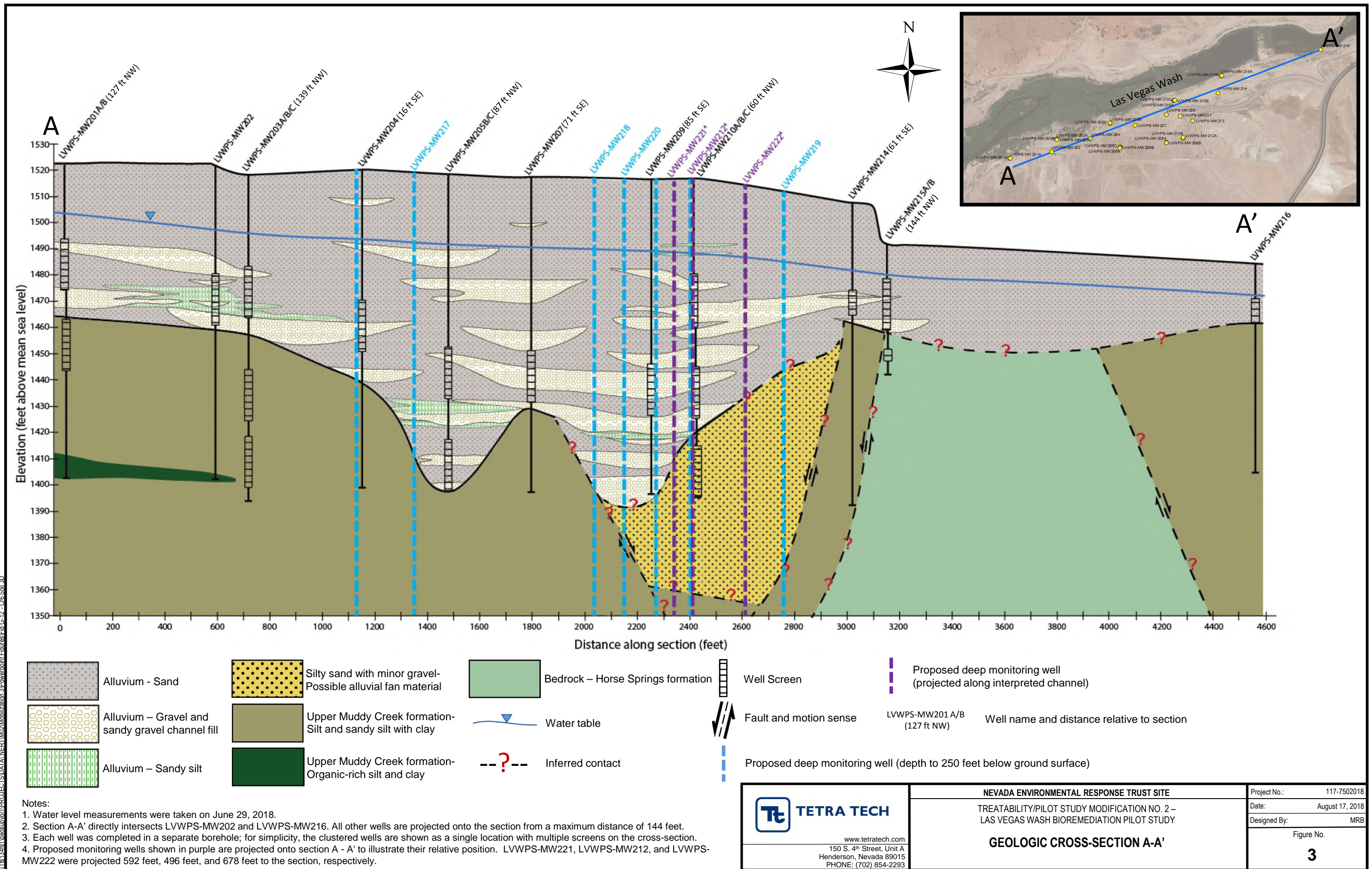

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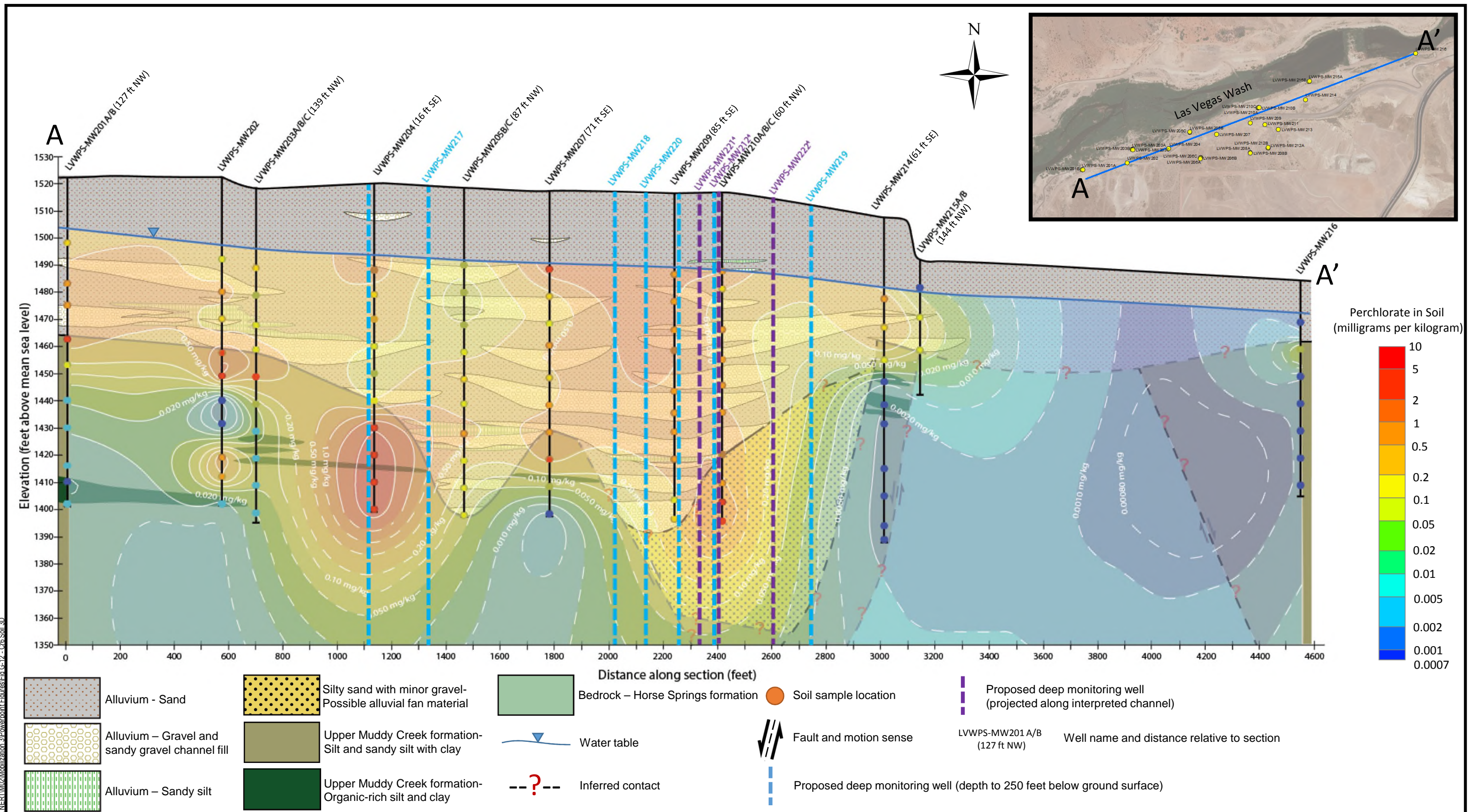
TREATABILITY/PILOT STUDY MODIFICATION NO. 2 -
LAS VEGAS WASH BIOREMEDIATION PILOT STUDY

PROPOSED LOCATIONS FOR ADDITIONAL INVESTIGATION
TRANSECT 1B VICINITY

Project No.:	117-750218
Date:	AUGUST 17, 2018
Designed By:	SRA
Figure No.	2



DRAFT/PRELIMINARY - SUBJECT TO REVISION PENDING ADDITIONAL INVESTIGATION



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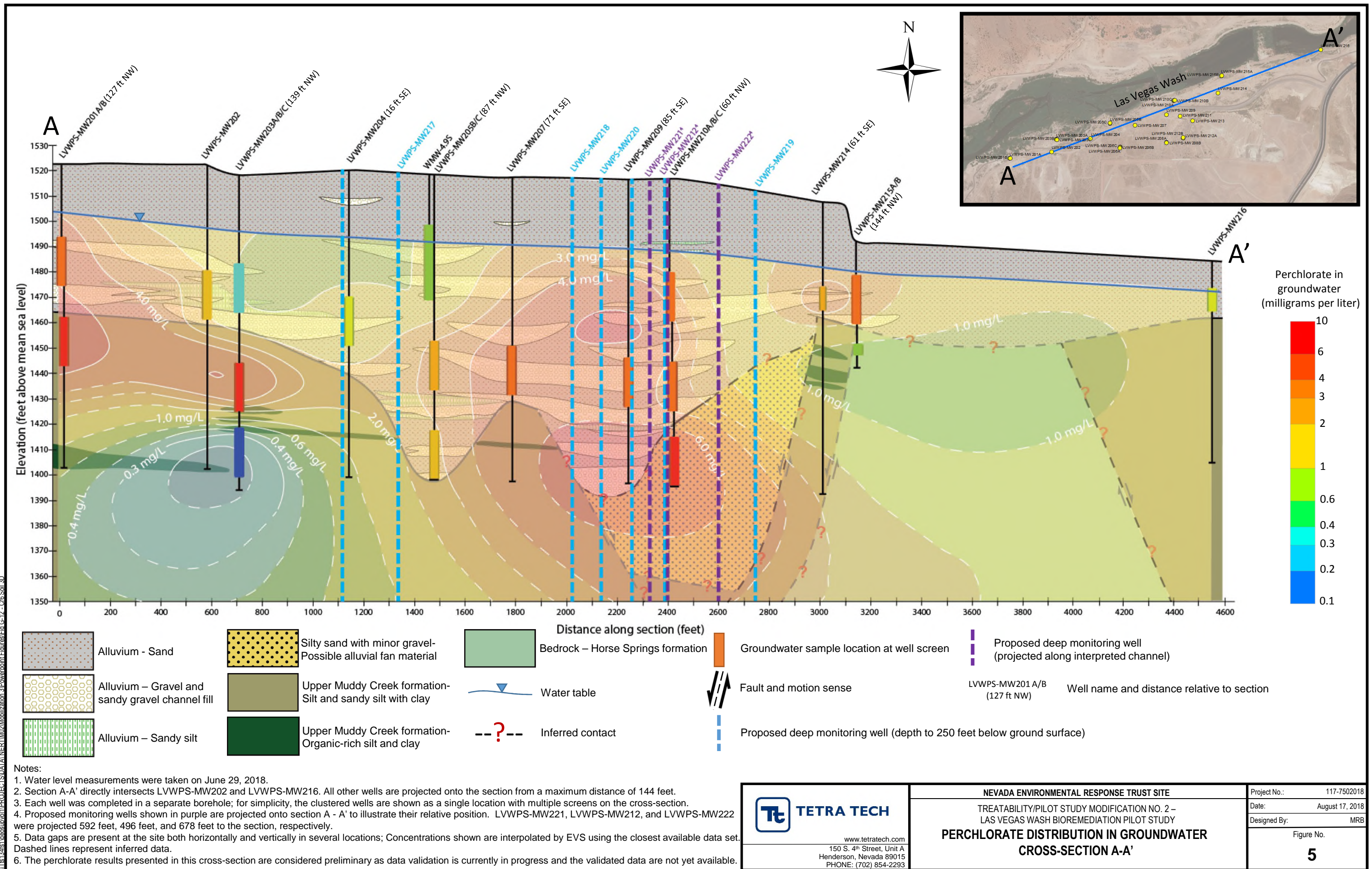
- Notes:**
1. Water level measurements were taken on June 29, 2018.
 2. Section A-A' directly intersects LVWPS-MW202 and LVWPS-MW216. All other wells are projected onto the section from a maximum distance of 144 feet.
 3. Each well was completed in a separate borehole; for simplicity, the clustered wells are shown as a single location with multiple screens on the cross-section.
 4. Proposed monitoring wells shown in purple are projected onto section A - A' to illustrate their relative position. LVWPS-MW221, LVWPS-MW212, and LVWPS-MW222 were projected 592 feet, 496 feet, and 678 feet to the section, respectively.
 5. Data gaps are present at the site both horizontally and vertically in several locations; Concentrations shown are interpolated by EVS using the closest available data set. Dashed lines represent inferred data.
 6. The perchlorate results presented in this cross-section are considered preliminary as data validation is currently in progress and the validated data are not yet available.

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NEVADA ENVIRONMENTAL RESPONSE TRUST SITE
 TREATABILITY/PILOT STUDY MODIFICATION NO. 2 –
 LAS VEGAS WASH BIOREMEDIATION PILOT STUDY
PERCHLORATE DISTRIBUTION IN SOIL
CROSS-SECTION A-A'

Project No.:	117-7502018
Date:	August 17, 2018
Designed By:	MRB
Figure No.	4

DRAFT/PRELIMINARY - SUBJECT TO REVISION PENDING ADDITIONAL INVESTIGATION



I:\GIS\Projects\PERCHLORATE\DATA\VERTICAL\M21\2018\Figures\Fig. G-12 - C66 Soil.3D

- Notes:**
1. Water level measurements were taken on June 29, 2018.
 2. Section A-A' directly intersects LVWPS-MW202 and LVWPS-MW216. All other wells are projected onto the section from a maximum distance of 144 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. Proposed monitoring wells shown in purple are projected onto section A - A' to illustrate their relative position. LVWPS-MW221, LVWPS-MW212, and LVWPS-MW222 were projected 592 feet, 496 feet, and 678 feet to the section, respectively.
 5. Data gaps are present at the site both horizontally and vertically in several locations; Concentrations shown are interpolated by EVS using the closest available data set. Dashed lines represent inferred data.
 6. The perchlorate results presented in this cross-section are considered preliminary as data validation is currently in progress and the validated data are not yet available.

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NEVADA ENVIRONMENTAL RESPONSE TRUST SITE
 TREATABILITY/PILOT STUDY MODIFICATION NO. 2 –
 LAS VEGAS WASH BIOREMEDIATION PILOT STUDY
PERCHLORATE DISTRIBUTION IN GROUNDWATER
CROSS-SECTION A-A'

Project No.:	117-7502018
Date:	August 17, 2018
Designed By:	MRB
Figure No.	5

DRAFT/PRELIMINARY - SUBJECT TO REVISION PENDING ADDITIONAL INVESTIGATION