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1. The contaminant mass (Perchlorate, chlorate, chromium and chloroform) used in this workplan was cited from the Unit 4 and 5 Buildings Investigation Second Mobilization (Tetra Tech, Inc., 2017). The contaminant mass in Unit 4 and 5 Buildings Investigation Second Mobilization was estimated with the "volumetrics" module of the Earth Volumetric Studio software. NDEP asked more details about the estimated mass in the letter of June 8, 2017. NERT submitted the RI Study Area Mass Estimate and Expanded Performance Metrics Technical Approach on October 5, 2017 and NDEP approved the mass estimate approach on October 20, 2017. NDEP requests that NERT revisit the perchlorate, chlorate, chromium, and chloroform mass estimated in the following the mass estimate approach dated on October 5, 2017. NDEP also suggests that the nitrate mass to be estimated. The refined mass estimate should be the baseline to measure the effects from the proposed treatability, so it must be done before the flushing, injection and extraction.	The perchlorate mass estimate provided for the Unit 4 and 5 Buildings Investigation Area of 140,000 pounds in the vadose zone and 220,000 pounds in the saturated zone was cited from the *Unit 4 and 5 Buildings Investigation Second Mobilization* technical memorandum dated May 4, 2017. The contaminant mass for the In-Situ Bioremediation Area were estimated generally following the mass estimate approach in the *RI Study Mass Estimate and Expanded Performance Metrics Technical Approach* dated October 5, 2017. Variations to that approach were the use of a more refined grid using soil concentrations and an average bulk soil density value of 1.5 grams per cubic centimeter for both the Qal and UMCf. Refined mass estimates for the Unit 4 Source Area Treatability Study area for perchlorate, chlorate, hexavalent chromium, chloroform and nitrate will be performed to establish the baseline prior to flushing, injection and extraction activities. The refined mass estimates will use the NDEP-approved methodology and incorporate the latest chemical and physical parameter data obtained during the Unit 4 and 5 Buildings Investigation third field mobilization. These refined mass estimates will be provided in a memorandum as an addendum to this work plan and submitted to NDEP for approval prior to field implementation of the flushing, injection, and extraction activities. The memorandum will also include any proposed modifications to the work plan based on results obtained from the Unit 4 and 5 Buildings Investigation third field mobilization and the UNLV bench-scale studies. Section 1.4 of the work plan has been updated to include this information.
2. American Pacific Corporation (AMPAC) reported the results from a similar in-situ bioremediation treatability study for their source area of perchlorate-impacted groundwater (Geosyntec Consultants, 2003). The system used was a recirculation loop consisting of a single injection and single extraction well. Groundwater impacted with perchlorate was extracted, amended with electron donor (initially ethanol, later citric acid) and reinjected back to the groundwater to promote the biodegradation of perchlorate. Operational challenges were biological and chemical fouling of the injection and extraction wells. NDEP requests that NERT review the study and explain how the fouling will be prevented or reduced in the proposed study.	The proposed Unit 4 Source Area In-Situ Bioremediation Treatability Study will employ in-situ bioremediation in a different manner than the approach used in the 2003 AMPAC pilot test. The AMPAC pilot test involved continuous extraction and re-infiltration of perchlorate laden groundwater with donor amendment. This previous approach tended to accumulate biomass in and around the injection wells. Nevertheless, the AMPAC pilot test report concluded that: “Operational challenges associated with fouling (biological and chemical) of the injection and extraction wells were overcome by using chlorine dioxide injections and pH control with citric acid. The results of this pilot test clearly indicate that in situ bioremediation is technically feasible and has the capability to biodegrade perchlorate to environmentally acceptable end products in groundwater at the Site.”

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	Tetra Tech recognizes that biomass will be formed as a result of in-situ bioremediation of the large masses of perchlorate and chlorate in the Unit 4 Source Area Treatability Study area. This may reduce the permeability of the formation, although it is anticipated that the permeability will recover over time as the biomass itself is consumed as an electron donor through biological decay. The Unit 4 Source Area In-Situ Bioremediation Treatability Study will employ a number of means to help overcome potential reductions in permeability in the formation. In contrast to the AMPAC pilot test, the Unit 4 Source Area In-Situ Bioremediation Treatability Study will not involve recirculation and re-injection of perchlorate (and chlorate) laden groundwater. Extracted groundwater will instead be conveyed to the GWETS for above-ground treatment. Employing groundwater extraction and above-ground treatment in the GWETS will help reduce the amount of in-situ biomass accumulation. Injections will consist of clean water, donor and other amendments. The injections will not be continuous and will likely be performed at higher pressures than the AMPAC pilot test. The recommendation of the AMPAC pilot test report that citric acid be used as an electron donor and pH modifier will be evaluated as part of the bench scale treatability work being performed by UNLV. As discussed in Section 5.4.4 of the Unit 4 Source Area In-Situ Bioremediation Treatability Study Work Plan, the amount of bioaccumulation in the wells will be monitored by observing changes in injection rates and injection pressures. This will also monitor for potential chemical precipitation. In addition, slug tests will be used to evaluate the effect of bioaccumulation in the surrounding formation and the injection wells. If significant bioaccumulation is observed that inordinately restricts injection, extraction, or monitoring activities, the wells will be mechanically scrubbed and/or anti-scalant or biocide may be used. The wells may also be redeveloped if necessary. Acknowledging the above, one objective of this treatability study is to test the proposed methods in the field and troubleshoot any problems that occur prior to considering this approach as part of the final remedy. Section 5.4.4 has been revised to clarify this approach to well maintenance and, as appropriate, further explanation will be included in the work plan addendum.

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3. The injection wells for the soil flushing were screened in deeper vadose zone, which means that the contaminants in the shallow vadose zone will not be flushed. This flushing proposed here is different from previous two soil flushing sites where the water was applied on the surface. Please explain how the limited injection wells will deliver the water to the contaminated mass between the injection wells and the zones above the injection well screen intervals. Did Tetra Tech or other companies have successful cases to flush the vadose zone with the screens of the injection wells set lower?	As noted in Section 3.1 of the Unit 4 Source Area In-Situ Bioremediation Treatability Study Work Plan, the proposed soil flushing approach consists of two flushing approaches: the down-flushing approach successfully utilized in the previous Soil Flushing Treatability Study and vadose-zone injection wells. The vadose zone injection wells will help minimize channelization of down-flushing water from the infiltration galleries, help fully saturate the vadose zone, and deliver carbon substrate. Soil flushing of the vadose zone will be implemented using down-flushing water delivery infrastructure installed at the surface. Therefore, the wells are not the primary method of soil flushing. The anticipated sequence for implementing soil flushing will be as follows: 1. Inject carbon substrate solution into the vadose zone injection wells to create a biologically reducing environment toward the bottom of the Qal to help treat COPCs that will be flushed down out of the vadose zone from the surface-applied down-flushing. 2. Commence down-flushing with approximately three pore volumes of SLMW or reclaimed water to flush some of the highest concentrations of COPCs out of the vadose zone and toward the biologically reducing zone established in step 1. This will utilize the bermed infiltration galleries described in Section 3.1. The infiltration galleries will require preparation or perforation of the Unit 4 basement slab and the asphalt concrete pavement in the area to the south east of the basement, as described in Sections 3.1, 4.4.1.2 and 5.2.1. The down-flushing from the infiltration galleries is intended to flush the contaminants in the vadose zone. 3. Inject carbon substrate solution again into the vadose zone injection wells within the soil flushing area. 4. Continue down-flushing from the infiltration galleries with approximately three additional pores volumes of carbon donor solution, as a polishing step.
4. NERT should consider nitrate and sulfate to be analyzed for soils and pore water because changes in their concentration can be related to the biodegradation processes.	Nitrate and sulfate sampling are included in the Unit 4 Source Area In-Situ Bioremediation Treatability Study Work Plan on Table 5 (soil sampling) and Table 6 (pore water sampling). Nitrate and sulfate analysis are part of the soluble anion analysis as described in Footnote 1 on Tables 5 and 6. In addition, nitrate and sulfate

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	are also included as part of baseline and performance groundwater monitoring as detailed in Table 7.
5. The groundwater water extracted may still have some substrate. If the groundwater extracted is then treated with the existing FBRs, what is the impact of the residue substrate to the GWETS operation?	It is anticipated that residual substrate in the extracted groundwater will have minimal effect on the performance of the FBRs. The anticipated flow rate of the extracted groundwater from Unit 4 is 25 gpm, which represents only approximately 3 percent of the total flow to the GWETS FBRs. Therefore, even if there is some substrate remaining in the extracted groundwater, the impact on the FBRs should be minimal due to the significant dilution. Tetra Tech conferred with Envirogen Technologies, Inc. (ETI), and the consensus was that if there is any impact on the FBRs, it may be beneficial in nature because it would tend to reduce the amount of ethanol electron donor that would have to be provided to the FBRs. Tetra Tech will track the total organic carbon (TOC) concentration in the extracted groundwater and share the information and confer with ETI. In this way, ETI will be able to make any adjustments to the ethanol feed to maintain a consistent TOC to the FBRs. Tetra Tech also considered whether residual substrate in the extracted groundwater would negatively impact the chromium treatment plant. The extracted groundwater from the Unit 4 Source Area Treatability Study will represent approximately one-third of the flow through the chromium treatment plant. Tetra Tech has conferred with ETI, and experts in both firms anticipate that residual substrate in the extracted groundwater will have no impacts to the treatment process and may have modest impacts to maintenance requirements for the chromium plant, but that these should be manageable.