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**TECHNICAL MEMORANDUM**

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ARCADIS Project No.:
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Subject:
**Addendum 2 to the *In-Situ Hexavalent Chromium Reduction Pilot Test Work Plan – Floodplain Reductive Zone Enhancement* for the Pacific Gas and Electric Company Topock Compressor Station**

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Consistent with the *In-Situ Hexavalent Chromium Reduction Pilot Test Work Plan – Floodplain Reductive Zone Enhancement* (*Work Plan*) prepared by MWH in August 2005, ARCADIS proposes several additional refinements to floodplain in-situ pilot test (ISPT) prior to the initiation of injections. This second addendum (Addendum 2) details the proposed refinements, which constitute deviations from and clarifications to the Work Plan and a previous addendum (Addendum 1), which was entitled the "Final Addendum to the In-Situ Hexavalent Chromium Reduction Pilot Test Work Plan – Floodplain Reductive Zone Enhancement," and was dated December 5, 2005. The Work Plan and Addendum 1 were approved by the California Department of Toxic Substances Control on December 12, 2005, and by the Bureau of Land Management on December 9, 2005.

The purpose of the floodplain ISPT is to evaluate the efficacy of using food grade materials to reduce hexavalent chromium in groundwater to form stable, insoluble trivalent chromium. As specified in the Work Plan, the results will be used to assess the feasibility and performance food grade organic carbon reductants under actual Site conditions. In addition, the results will provide additional information on Site conditions necessary for the development of an enhanced reductive zone along the river floodplain and assist with the selection of specific methodologies for long-term Site management. We believe the ISPT refinements presented below will improve the project execution and data obtained.

## Proposed Deviations and Clarifications

The following deviations from and clarifications to the Work Plan and Addendum 1 are proposed:

- Reduce the reductant concentration during the initial injection event;
- Modify the groundwater monitoring schedule and list of parameters;

- Clarify the target range of total dissolved solids (TDS) in the reductant solution make-up water, and
- Mix the reductant solution at MW-20 Bench.

These issues are discussed in detail below.

**Reductant Concentration**

Addendum 1 proposed initially injecting 500 pounds of the reductant lactate into each of the three injection wells (i.e. PTI-1S/M/D). Based on a solution volume of 6,000 gallons per injection well, the concentration of lactate in the injected solution would have been approximately 10,000 milligrams per liter (mg/L). ARCADIS proposes to reduce the concentration of lactate in this initial injection to 50 pounds per well, or equivalently, approximately 1,000 mg/L in the reductant solution.

ARCADIS believes that the lower concentration injection event will be adequate to achieve the primary objective of the test, namely to achieve demonstrable reduction of hexavalent chromium within the floodplain aquifer. As noted in the Work Plan and based on earlier bench-scale testing, 450 mg/L of reductant delivered to the aquifer is considered an upper bound of the dosage required to reduce chromium and potentially provide some longer-term chromium reducing potential within the aquifer matrix. It is hoped that by starting at the lower concentration we will gain greater insight into the appropriate lactate dosing. If the initial injection achieves only partial reduction within the monitored zone, we would expect to follow up with a second, higher concentration injection. We anticipate that data would be available to make the decision about the need for a second injection by approximately Day 90 (Month 3) following the start of the initial injection. The concentrations and types of other constituents in the reductant solution (i.e. yeast extract and tracers) will remain the same as they were proposed in Addendum 1.

**Groundwater Monitoring Program**

Groundwater monitoring will be conducted to evaluate the effectiveness of the reagent introduction to the aquifer. The Work Plan and Addendum 1 proposed that monitoring wells be sampled both prior to the initial injection event (two baseline events) and on a phased schedule post-injection (daily for the first week, weekly for the first month, and monthly for six months). The groundwater samples will be submitted for analysis for various specified parameters. In order to align the Work Plan and Addendum 1 with the recently issued Waste Discharge Requirements associated with the ISPT injections (Order No. R7-2006-0008), it is proposed that the post-injection monitoring program be modified slightly.

Table 1 presents the proposed monitoring schedule for the tracer test parameters and primary and secondary "baseline" parameters. The main change from Addendum 1 is the addition of secondary baseline parameters (calcium, magnesium, arsenic, potassium, sodium, carbonate/bicarbonate alkalinity, chloride, phosphorus and sulfide) during the following events: Day 3, Week 1, and Months 1, 2, 4, and 5. In addition, total organic carbon is treated as a tracer test parameter and will be analyzed at an increased frequency. Furthermore, if a second injection is to be performed, the monitoring schedule will be reevaluated to assess appropriate changes to obtain the most useful ISPT data.

**Reductant Solution Make-up Water**

The Work Plan discussed the use of treated groundwater from Interim Measure 3 (IM-3) for make-up water (i.e. dilution water) for the reductant solution. In addition, the Waste Discharge Requirements issued by the California Regional Water Quality Control Board require that the injections utilize treated water from the IM-3 plant. While the TDS of IM-3 effluent water is currently approximately 4,000 mg/L, neither the Work Plan nor Addendum 1 specified the target TDS of this make-up water. ARCADIS proposes to aim to use effluent water with a lower TDS (approximately 2,000 mg/L). With the addition of tracers and lactate, the final TDS of the water to be injected would be approximately 3,000 to 5,000 mg/L, which will be less than the TDS generally observed in each portion of the aquifer, but not so low that we would expect density differences to be a significant influence on groundwater flow.

**Reductant Solution Mixing**

As noted in Section 4.2 of the approved Work Plan, the reductant solution was to be conveyed to the injection wells from transportable containers (i.e., non-permanent tanks). The Work Plan did not specify exactly where the tank(s) were to be staged, but the tanks would best be staged as near as practicable to the injection wells (i.e., the MW-20 bench). The Work Plan did specify that these tanks were to be used for the mixing of the reductant solutions. Addendum 1 amended the Work Plan by proposing to mix the reagent solutions at the Topock Compressor Station and transporting the solutions to the Site in three tanker truck trips (one for each injection well).

To simplify operations, we now propose to follow an approach similar to the approved Work Plan, rather than Addendum 1. The treated water would be trucked from the treatment plant to the MW-20 bench. The mixing approach will make use of an existing 18,000-gallon tank for water storage and one transportable 6,000-gallon tank for reagent solution mixing and delivery via double-contained hoses to the injection wells. The overall impact at the Site would be reduced as a result of this change because truck trips to fill up the 18,000-gallon tank will be scheduled to minimize disruptions to other activities, and trips from the IM-3 treatment plant to the Compressor Station and back to the MW-20 Bench would be eliminated. Based on this arrangement, a 5000-gallon tanker truck will be used to deliver the treated water from the IM-3 treatment plant to the MW-20 Bench in a total of four trips. It should be noted that although double containment will be provided for the reductant solution containers and hoses, the solution is non-toxic and either readily degradable in the environment or naturally occurring. The transportable tank would be located within the existing containment on the MW-20 Bench for approximately three days.

This proposed transport and mixing approach is fully consistent with the procedure discussed in the approved Work Plan and will lead to fewer visual and traffic impacts than what was proposed in Addendum 1. Under the approach in Addendum 1, more trucking would have been required, as noted above. In addition, either a transportable tank would still have been required in the vicinity of the injection well (i.e., somewhere on the MW-20 Bench), or the tanker truck delivering the reductant solution would have to remain on the MW-20 Bench within a spill containment area during the entire injection process (expected to last two days).

# Table 1
## Field and Analytical Parameter Monitoring Schedule
PG&E Topock
Needles, California
Second Addendum to the In-Situ Hexavalent Chromium Reduction Pilot Test Work Plan

| Monitoring Location | Parameters | Prior to Injection (2 Events) | Daily (Day 1 to 6) | Day 3 | Week 1 (Day 7) | Weekly (Week 2 and 3) | Monthly (Month 1-5) | Month 6 |
|---|---|---|---|---|---|---|---|---|
| Injection Well PTI-1, Shallow, Middle and Deep Casings | Tracer Test Parameters | x | x | x | x | x | x | x |
| | Primary Parameter | x | | | | | | x |
| | Secondary Parameters | x | | | | | | x |
| Monitoring Well PT-1, Shallow, Middle, and Deep Casings | Tracer Test Parameters | x | x | x | x | x | x | x |
| | Primary Parameter | x | | x | x | x | x | x |
| | Secondary Parameters | x | | x | x | | x | x |
| Monitoring Well PT-2, Shallow, Middle, and Deep Casings | Tracer Test Parameters | x | | | | | x | x |
| | Primary Parameter | x | | | | | x | x |
| | Secondary Parameters | x | | | | | x | x |
| Monitoring Well PT-3, Shallow, Middle, and Deep Casings | Tracer Test Parameters | x | x | x | x | x | x | x |
| | Primary Parameter | x | | x | x | x | x | x |
| | Secondary Parameters | x | | x | x | | x | x |
| Monitoring Well PT-4, Shallow, Middle, and Deep Casings | Tracer Test Parameters | x | x | x | x | x | x | x |
| | Primary Parameter | x | | x | x | x | x | x |
| | Secondary Parameters | x | | x | x | | x | x |
| Monitoring Well PT-5, Shallow, Middle, and Deep Casings | Tracer Test Parameters | x | | | | | x | x |
| | Primary Parameter | x | | | | | x | x |
| | Secondary Parameters | x | | | | | x | x |
| Monitoring Well PT-6, Shallow, Middle, and Deep Casings | Tracer Test Parameters | x | | | x | x | x | x |
| | Primary Parameter | x | | | x | x | x | x |
| | Secondary Parameters | x | | | x | | x | x |
| Extraction Well TW-2D | Tracer Test Parameters | x | | | | | x | x |
| | Primary Parameter | x | | | | | x | x |
| | Secondary Parameters | x | | | | | x | x |
| Extraction Well TW-3D | Tracer Test Parameters | x | | | | | x | x |
| | Primary Parameter | x | | | | | x | x |
| | Secondary Parameters | x | | | | | x | x |
| Extraction Well PE-1 | Tracer Test Parameters | x | | | | | x | x |
| | Primary Parameter | x | | | | | x | x |
| | Secondary Parameters | x | | | | | x | x |

**Notes:**

Tracer Test Parameters — Groundwater levels, hexavalent chromium, pH, temperature, specific conductivity, total organic carbon, fluorescein, bromide, iodide

Primary Parameter — Hexavalent chromium, total chromium, nitrate, nitrite, total iron, dissolved (ferrous) iron, manganese, sulfate

Secondary Parameters — Calcium, magnesium, arsenic, potassium, sodium, carbonate/bicarbonate alkalinity, chloride, phosphorus, and sulfide