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29 September 2006

Mr. Christopher Guerre
Project Manager
Department of Toxic Substances Control
5796 Corporate Avenue
Cypress, California 90630

Subject: PG&E Topock Compressor Station, Needles, California
In Situ Hexavalent Chromium Reduction Pilot Test Work Plan
Upland Plume Treatment

Dear Mr. Guerre:

Enclosed is the revised In Situ Hexavalent Chromium Reduction Pilot Test Work Plan – Upland Plume Treatment (Work Plan) for the Topock Compressor Station. This Work Plan provides details on a proposed pilot test to be carried out at the Topock site to support the evaluation of technologies for remediation of hexavalent chromium in groundwater under the Resource Conservation and Recovery Act Corrective Measures Study and CERCLA Feasibility Study.

The enclosed document includes revisions made in response to verbal comments provided and discussed with DTSC staff during a meeting on September 8 and a telecon on September 26 regarding DTSC's review of the previous versions of the work plan dated August 4, 2006 and September 15, 2006. If you have any questions regarding this report, please call me at (805) 234-2257.

Sincerely,

Yvonne Meeks
Topock Project Manager

Enclosure:
In Situ Hexavalent Chromium Reduction Pilot Test Work Plan – Upland Plume Treatment

cc: John Earle, US Fish and Wildlife
Aaron Yue, DTSC

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In Situ Hexavalent Chromium Reduction Pilot Test Work Plan – Upland Plume Treatment

Pacific Gas & Electric Company
Topock Compressor Station
Needles, California

29 September 2006

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In Situ Hexavalent Chromium Reduction Pilot Test Work Plan – Upland Plume Treatment

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Tables

Figures

Appendices

1.0 Introduction

Pacific Gas and Electric Company (PG&E) is addressing the presence of hexavalent chromium (Cr[VI]) in groundwater at the Topock Compressor Station (Compressor Station, Figure 1), under the oversight of the California Environmental Protection Agency, Department of Toxic Substances Control (DTSC).To support the Resource Conservation and Recovery Act (RCRA) Corrective Measures Study and CERCLA Feasibility Study (CMS/FS) for the Topock site, PG&E is evaluating technologies for remediation of Cr(VI) in groundwater. Treatability studies, including pilot studies, are required when it is determined that insufficient data are available to evaluate or screen a remedial alternative. In addition, data produced from pilot studies are used to optimize the performance of a remedy and represent good engineering practice (United States Environmental Protection Agency [USEPA], 1989). This work plan presents the proposed approach and description of field activities for an in situ Cr(VI) reduction pilot test to be completed at the upland plume area of the Topock site.

The remainder of Section 1.0 of this work plan briefly describes the purpose of the pilot test and provides background information and a description of the Topock site. Section 2.0 presents an overview of the in situ Cr(VI) reduction technology and the reagent introduction and distribution system that will be tested during this pilot test. Section 3.0 describes the location evaluation criteria and introduces the proposed pilot test approach, while Section 4.0 presents the activities to be performed prior to implementation of the pilot test. The implementation plan and schedule for conducting the pilot test are discussed in Sections 5.0 and 7.0, respectively. Section 6.0 presents procedures for waste management and equipment decontamination to be followed during drilling, development and sampling of the proposed pilot test wells. References cited in this document have been listed in Section 8.0.

1.1 Purpose

The purpose of the pilot test is to evaluate how well recirculation wells can distribute reductant throughout the aquifer to achieve treatment across a transect (a line across the direction of groundwater flow) within, or at the edge of, the plume (creating an in situ barrier), and/or to treat zones within the source area. The specific aquifer characteristics at the Topock site indicate that the use of groundwater recirculation wells has the potential to maximize the volume of aquifer treated per injection well. Modeling of this injection approach, and experience at other sites, indicates that this approach should be effective at the Topock site; however, a pilot test should provide confirmatory data for the site-specific design evaluation.

1.1.1 Site Remedial Objectives that Guide the Pilot Test Approach

The Topock site remedial objective for groundwater is to treat Cr(VI) so that Cr(VI) is no longer present in the groundwater above a yet to be established site cleanup standard. In situ remediation of Cr(VI) by reduction and precipitation is one technology that is being evaluated prior to completion of the CMS/FS for inclusion into potential corrective measures. Currently, in situ Cr(VI) bioremediation treatment technology is being evaluated in the floodplain, adjacent to the Colorado River, at the Topock site. The upland pilot study proposed herein will evaluate other important aspects of the in situ treatment of Cr(VI), including the effective distribution of the reducing agents in the subsurface. The results of the upland pilot test will provide information to evaluate an in situ remedy which will:

- Minimize the overall impacts of a full-scale remedial system to the Topock site by:
  - Providing information to determine the minimum number of wells that are required to meet the remedial objective.
  - Limiting the installation of remedial components to the historically disturbed areas (e.g., freeway and road alignments), where possible.
  - Minimizing the operational time and frequency of site visits required to operate and maintain the remedial systems.
  - Minimizing the footprint of site support facilities.
  - Coordinating and consulting with stakeholders to assure potentially affected environmental, archaeological, and spiritual resources are best preserved.
- Achieve site cleanup in a reasonable time
  - By using a recirculation system, remediation of a larger area in a shorter time can be achieved reducing the duration of cleanup activities.
  - The upland pilot test will help determine if a reactive zone can be used to prevent Cr(VI) migration under either ambient or enhanced groundwater gradients. Enhanced groundwater gradients (which can be created by extraction or injection of water) may accelerate groundwater movement through the in situ reactive zone(s) and reduce the overall cleanup time.
- Create robust remedial systems
  - The remedy should be capable of maintaining effectiveness in widely variable aquifer conditions and, as feasible, enhancing the effectiveness of other components of the remedy. If in situ reduction is selected for the overall site groundwater remedy, it will likely be used in combination with other technologies; for instance, the combined effect of groundwater extraction and treatment and in situ Cr(VI) reduction is an example of a combined remedy. Even after the active treatment is ended, the previously created in situ reductive zones (IRZs) can continue to operate as a reactive barrier to treat

chromium-contaminated groundwater that flows across the zone. The reactive zones can also enhance the performance of monitored natural attenuation, by providing source area treatment and by creating a shrinking plume.

1.1.2 Technical Objectives

The overall technical objective of this pilot test is to determine if organic carbon reductant can be delivered into the subsurface in a sustainable manner via recirculation wells. The goal is to minimize the number of injection wells that will be needed to achieve treatment of a groundwater transect across the plume in a timely manner with the intent to minimize environmental, archaeological and spiritual impacts.

More specific technical objectives of this pilot study are to:

- Determine the maximum spacing between injection wells that still results in adequate chromium-precipitating conditions within the aquifer.

- Determine the loading rate of organic carbon required to transform naturally occurring iron in the aquifer to its reactive, reduced (ferrous) form between injection wells.

- Determine how often and for how long injection wells must be operated to maintain reduced iron in the aquifer. Reduced iron formed during the operational period will continue to precipitate Cr(VI) even when the organic carbon treatment reagent is not being injected.

1.2 Project Background

PG&E's Topock Compressor Station is located in San Bernardino County, approximately 15 miles southeast of Needles, California (Figure 1). The Topock site and adjacent lands are contained within a larger geographic area that is sacred to the Fort Mojave Indian people. In addition, the area includes the Topock Maze and historic Route 66, which are listed on the National Register of Historic Places. In February 1996, PG&E and DTSC entered into a Corrective Action Consent Agreement (CACA) pursuant to Section 25187 of the California Health and Safety Code. Under the terms of the CACA, PG&E was directed to conduct a RCRA Facility Investigation (RFI) and to implement corrective measures to address Cr(VI) released in the Bat Cave Wash Area near the PG&E Topock Compressor Station. The source was chromium salt historically used as a corrosion inhibitor in the station's cooling towers. DTSC is the lead administering agency for the project.

PG&E is proceeding with the corrective measures process to select and implement a long-term remedy for the Topock site. PG&E submitted the CMS work plan in December 2002, pursuant to the RCRA corrective action process, and in accordance with the CACA. The DTSC approved the CMS work plan in June 2003.

Concurrently with the CMS, and in compliance with DTSC's directive, PG&E commenced implementation of Interim Measures (IM) in March 2004. The objective of the IM is to provide hydraulic control of the Cr(VI) plume in the floodplain by maintaining a net landward groundwater gradient. The elements of the IM currently include the following: groundwater extraction from the pumping centers at wells TW-2D and TW-3D, and PE-1; groundwater treatment; and management of the treated groundwater. Evaluation of additional potential remedies and remediation strategies identified in the CMS Work Plan is ongoing.

1.3 Site Description

The following sections discuss the geology, hydrogeology, groundwater quality and the environmental, archaeological, and spiritual resources at the site.

1.3.1 Geology and Hydrogeology

The site is characterized by arid conditions with precipitation averaging less than 5 inches per year and high temperatures. Vegetation at the Topock site is very sparse, except in the southern part of the Colorado River floodplain where stands of tamarisk and occasional mesquite trees occur. Topography near the Topock site is abrupt, rising from around 450 feet above mean sea level (msl) at the Colorado River to over 1,200 feet msl within a mile to the south and southwest.

Groundwater occurs under unconfined to semi-confined conditions within the alluvial fan and fluvial sediments beneath most of the Topock site. The saturated portion of the alluvial fan and fluvial sediments are collectively referred as the Alluvial Aquifer. In the floodplain area adjacent to the Colorado River the fluvial deposits interfinger with, and are hydraulically connected to, the alluvial fan deposits. The unconsolidated alluvial and fluvial deposits are underlain by the Miocene conglomerate and pre-Tertiary metamorphic and igneous bedrock.

Groundwater monitoring well clusters, such as those at MW-20, MW-24, MW-34, MW-36, and MW-39 also include wells screened at deeper levels of the alluvial aquifer. The measured saturated thickness of the alluvial aquifer in the pilot study area range from as little as 30 feet in the southern floodplain area (at MW-32) to 260 feet in the IM-3 injection area and 340 feet in the northern floodplain area (MW-49). In the vicinity of the proposed pilot test, the subsurface shallow aquifer zone consists of alluvial deposits. These unconsolidated deposits are 150 to 200 feet thick. Approximately 100 feet of the unit is saturated. Lithologic logs and hydraulic testing suggest that the alluvial materials undergo facies changes across the Topock site such that the lower portion of the aquifer unit (lower 35 feet) is generally of lower conductivity in a portion of the pilot test area (Figure 2). Additionally, some interfingering of coarser material is observed throughout the sediments (CH2M Hill, 2005a).

The pilot test area is located in an upland area, near the Topock Compressor Station, where the topography is generally steep. There is an abrupt decline in elevation towards the Colorado River floodplain. Hydraulic gradients across the pilot test area are between 0.0001 to 0.001 feet per foot (ft/ft). Groundwater flow is generally towards the northeast towards the extraction wells located in the Colorado River floodplain (Figure 8).

1.3.2 Groundwater Quality

Groundwater in the Topock site area exhibits variable total dissolved solids (TDS) concentrations. In general, TDS concentrations increase with depth in the area of the proposed pilot test. Samples collected from most of the shallow monitoring wells exhibit TDS concentrations in the range of 1,000 to 3,000 milligrams per liter (mg/L). However, groundwater sampled in bedrock wells and the deeper alluvium wells contains higher TDS concentrations (8,000 to 14,000 mg/L). Water samples from the Colorado River exhibit TDS concentrations ranging from 400 to 800 mg/L.

Major ions are dominated by sodium and chloride, with sulfate also significant in some wells. Oxidation-reduction potential (ORP) measurements in wells in the upland portion of the alluvial aquifer generally reflect non-reducing conditions in which Cr(VI) is stable. Dissolved oxygen concentrations generally range from 3.0 to 7.0 mg/L. Nitrate concentrations up to 77 mg/L have been measured, but in the area of the proposed pilot test are approximately 5 to 20 mg/L. Table 1 includes the recent historical water quality data in the nearby monitoring.

Site characterization has been performed to quantify the distribution of Cr(VI) in groundwater at the Topock site. Monitoring wells have been installed throughout the Topock site including: near and along Bat Cave Wash, to the east of Bat Cave Wash, and in the Colorado River floodplain. Analytical results indicate that most of the chromium found in affected groundwater is in the hexavalent form. The areal extent of the Cr(VI) plume (Figure 3) is approximated by the green contour representing 0.05 mg/L, which is the California drinking water maximum contaminant level for total chromium (CH2M Hill 2006).

1.3.3 Environmental, Cultural and Spiritual Resources

The Topock site has a diverse ecological community. Five types of plant communities are in the vicinity of the project area. The terrestrial wildlife diversity and abundance is considered low at the site; however, the plant life does provide habitat for various wildlife species. Several threatened or endangered species of plants and animals (state and federally listed) could occur in or near the Topock site (CH2M Hill, 2005a).

The site has archaeological and spiritual resources of significance to the Fort Mojave Indian Tribe (FMIT) and other neighboring tribal peoples along the Colorado River corridor. These resources include the Topock Maze, which is listed on the National Register of Historic Places, and numerous other archeological sites. In addition, transportation developments such as Old Trails Highway, Route 66, Burlington Northern Santa Fe Railroad and Interstate-40 all represent historic transportation resources (CH2M Hill, 2005a).

The site has spiritual resources as well. As discussed in Section 1.2, the Topock site and adjacent lands are contained within a larger geographic area that is sacred to the Fort Mojave Indian people.

PG&E and their consultants are committed to preserving all of the resources of the Topock site.

2.0 Overview of Technology

The following subsections describe various aspects of in situ biological Cr(VI) reduction technology that will be evaluated in the proposed pilot test. Appendix A presents selected ARCADIS and other remediation industry in situ Cr(VI) reduction projects that have been performed throughout the country. As evidenced by both experience tables the state of knowledge of situ remediation for Cr(VI) reduction is fairly extensive. Successful chromium reduction and removal has been achieved across the country in various hydrogeologic settings. In some cases, the use of in situ remedies has reduced the time to closure by over 10 years, and one case cited has a reduction in closure time of 25 years.

2.1 In Situ Bioremediation Technology Description

Bioremediation of chromium-contaminated groundwater is a widely practiced approach that involves the injection of organic carbon substrates into chromium-containing groundwater to stimulate microbes that use the organic carbon as a nutrient and energy source. These microbes then use oxygen, nitrate, ferric iron, and other oxidized materials in the aquifer as electron acceptors.

$$\textbf{organic carbon + electron acceptor } (O_2, NO_3, Fe^{3+}, Cr_2O_7^{2-}, SO_4) \rightarrow$$

$$CO_2 + \textbf{water} + (N_2, Fe^{2+}, Cr^{3+}, HS^-)$$

When sufficient organic carbon is supplied, anaerobic conditions result, and a reduced zone is created in the aquifer. The term “reduced” refers to the oxidation state of the iron, manganese, and other oxidation/reduction (redox)-active elements present in the aquifer media.

Cr(VI) can be reduced by microbes while consuming organic carbon by the reaction:

$$2Cr_2O_7^{-2} + 3C + 16H^+ \rightarrow 4Cr^{+3} + 3CO_2 + 8H_2O$$

The Cr(III) forms chromium hydroxide, which binds to the aquifer matrix.

Cr(VI) can also be reduced to Cr(III) indirectly by the formation of reactive reduced (ferrous) iron compounds in the aquifer, and also, less importantly, by sulfide compounds.

A zone with available organic carbon and reduced iron is a type of IRZ that is effective in treating Cr(VI) in groundwater. The amount of naturally occurring iron in an aquifer varies due to parent mineral types, but some amount of iron is nearly universally present in aquifer matrices. At the Topock site, previous investigations showed approximately 0.3 percent ferric iron that could be reduced by citrate-bicarbonate-dithionite extractant (CH2M Hill, 2005c). It is expected that a significant fraction of this iron will be reduced under iron- and sulfate-reducing conditions. The ferric iron in the aquifer is generally transformed from the iron oxide coatings and structural minerals to become soluble ferrous iron and reduced iron aquifer minerals including ferrous iron bound on clay minerals and mixed valance iron oxides and hydroxides such as magnetite (Fe_3O_4) and green rust, $Fe_6(OH)_{12}(\{CO_3^{2-}$ or $SO_4^{2-}\}mH_2O)$. All of these reduced iron minerals are effective for reaction with hexavalent chromium, leading to precipitation of Cr(III) hydroxides and mixed iron-chromium hydroxides.

The ferrous ions in solution and on solid surfaces react with Cr(VI) according to:

$$\mathbf{HCrO_4^- + 3Fe^{+2} + 7H^+ \rightarrow Cr^{+3} + 3Fe^{+3} + 4H_20}$$

With the addition of organic carbon, some percent of the sulfate available in the aquifer will also be reduced to sulfide in succession after iron reduction. Sulfides formed will react with dissolved iron and form iron sulfide precipitates. Iron sulfides will also reduce Cr(VI) to Cr(III).

There are two important components of an in situ treatment that are required for the treatment to be both technically successful and efficient in remediating the full plume.

- Reagents must be delivered into the subsurface to achieve contact with the entire plume, and
- A reduced zone must be sustained in the subsurface without continuous injections.

This requirement for widespread and uniform distribution limits the potential use of insoluble substrates such as vegetable oils because these substrates often cannot easily be transported useful distances from the injection locations and may distribute non-uniformly. These substrates will not generally create sufficiently uniform reductive conditions across the plume to ensure a reliable reactive zone. For delivery between widely spaced wells, the optimal substrate would be a fully soluble one with viscosity less than or equal to water such as a short-chain carbon compound like alcohol, an organic acid, or a sugar. The amount of substrate delivered should be sufficient to deoxygenate and denitrify the aquifer and reduce the Cr(VI) and some fraction of the iron oxides in the aquifer.

The creation of a sustained reductive condition within the aquifer by adding these simple organic carbon molecules requires multiple steps. First, microbial growth must occur leading to enhanced rates of carbon consumption. Then sequential consumption of oxygen, chromium, nitrate, ferric iron, and sulfate must occur. As sufficient organic carbon is delivered, iron and sulfate that naturally occur in the subsurface will become reduced, leading to zones within the plume that have reduced iron and smaller zones with reduced iron and reduced sulfur (principally iron sulfide); once formed, these zones sustain chromium-reducing conditions for some time. The length of time the reduced zone can sustain chromium-reducing conditions is a factor of the rate at which oxidants (oxygen, nitrate, and Cr(VI)) re-enter the reduced zone. In areas where higher pumping rates lead to faster groundwater (and dissolved oxidant) movement, these reduced zones will become depleted and will require replenishment more frequently.

In summary, ferric iron oxide minerals naturally occur in the Topock aquifer (CH2M Hill, 2005c). The microbial and chemical reduction of naturally occurring iron oxides occurs with the addition of reductants (organic carbon) forming reduced (ferrous) iron minerals such as ferrous iron oxides and ferrous iron sulfides. Reduced iron minerals are reactive with Cr(VI) and precipitate chromium as Cr(III) hydroxides and mixed iron-chromium hydroxides. By creating a reduction zone (reducing and storing iron that is available in the aquifer), the reduction activity within an injection area can be maintained for long periods of time. These zones can continue to precipitate chrome between widely spaced injection events even after injection ceases and can form the basis for natural attenuation of the chromium plume.

2.2 Reagent Delivery System

In situ remediation systems are designed so chemically-affected groundwater comes into contact with a treatment medium or reagent within the aquifer or within the well. The treatment media can be a nutrient to stimulate chemical biodegradation by indigenous or introduced microorganisms, an oxidizing or reducing agent to chemically destroy the chemical, or a solid catalyst or sorbent. Groundwater recirculation wells have recently been demonstrated to be an effective method of achieving in situ contact between chemically-affected groundwater and a treatment medium (Huang and Goltz, 2005).

Generally, recirculation wells are installed in a line to allow spatial coverage of the plume perpendicular to groundwater flow. Recirculation wells are multiple screen wells that pump water in through one of the screens and release it back into the formation through the other. The screen intervals are located within the same aquifer but are hydraulically isolated from each other using packers. Treatment reagents are added to the groundwater in the well casing between the packers, or in a vault at the well head, so that the water being forced back into the aquifer through the well screen contains treatment reagents.

The recirculation system is designed to create a three dimensional circulation pattern in the aquifer. Groundwater is drawn into the well, pumped through the well casing and reintroduced into the aquifer at a different elevation.

Applying the same concept, a second well can be placed adjacent to a well designed as previously described, but operated in a reverse pumping pattern, such that alternating wells are pumping upward and downward. This technique, known as horizontal flow treatment wells (HFTWs), involves a pair, or series of pairs, of dual-screened treatment wells. The upflow well operates by capturing the chemically-affected water in the lower well screen, pumping it upward through a mixer, and then forcing the water out into the aquifer through the upper well screen. With both contaminant and treatment medium pumped into the aquifer, the second well draws water in through the upper well screen where it is then pumped downward, mixed with a treatment medium, and pumped out into the aquifer through the lower screen. In both cases the circulation pattern that results (termed a “conveyer belt” pattern because the circulation occurs between wells) is effective in delivering and mixing the chemically-affected groundwater with the treatment reagents. The recirculating water allows for one or multiple passes through the treatment zone created by the reagent injection as required to achieve efficient overall remediation of the groundwater (Huang and Goltz, 2005).

Any soluble carbon source can be used to create a reactive zone through recirculation wells, including reagents such as molasses, corn syrup, lactate, methanol or ethanol.

2.3 Groundwater Modeling of Recirculation Zone

A preliminary groundwater model was developed to aid in the design the groundwater recirculation well system at the selected pilot test area. The existing MODFLOW model for the site was refined to focus on the zone immediately surrounding the potential pilot test area to simulate groundwater flow under recirculation conditions. The resulting model covers an area of approximately 0.6 mile in the east-west dimension by 0.5 mile in the north-south dimension, or 0.3 of a square mile. The localized model was used to estimate the spacing of injection wells, the appropriate location of pilot test monitoring wells, and to help calculate the loading rate of reagents.

To develop the localized flow model, the known lithology from the MW-24 wells and PGE-6 was used to define 13 layers within the model with varying hydraulic conductivity, with a 10:1 horizontal to vertical anisotropy at each layer. The predicted water table generated by the localized groundwater model agreed with known water levels in the wells in the area.

To evaluate the potential distribution of the organic carbon substrate that would be injected during this pilot test, MODPATH was used in conjunction with the MODFLOW model to evaluate the reagent distribution and the effects of mixing, dilution, dispersion, and degradation. The MT3D99 computer code was used for this solute transport modeling. The purpose of this aspect of the modeling was to help define the potential breakthrough time for reagent, to calibrate the potential distances between circulation wells that would still have reagent coverage between the circulation wells, and to aid the decisions about monitoring wells location and frequency of monitoring.

Figure 4 presents the results of the flow model simulation for one set of coupled recirculation wells. Model results suggest that the desirable coverage will be achieved in a six-month period and show that 10 to 20 percent of the organic carbon injected will reach the opposing screens during this period. Figure 5 shows the modeled extent of reagent that is of sufficient concentration to achieve chromium treatment and iron reduction (10 percent of the injected alcohol concentration). For each well, the estimated radius of influence is approximately 150 feet. This concentration is sufficient to achieve the ferrous iron reduction required for chromium treatment. The conclusion of the groundwater model simulation is that recirculation wells could be successfully used at the selected pilot test area and coverage across the entire aquifer thickness can be achieved.

By comparison, radius of influence calculations indicate that if an injection well system was to be used without circulation with wells spaced every 20 feet, approximately 30,000 gallons of injectant would be required per injection per well. In addition, an injection well screened across the entire aquifer would require active management during injection to achieve uniform delivery and adequate coverage. Heterogeneity and anisotropy, in both vertical and horizontal directions, could limit coverage between injection points. Induced flow (horizontal and vertical) overcomes these injection difficulties.

The model results indicate that coverage can be achieved either by circulation between fully screened wells (Figure 6) or by two screened recirculation wells operating in reverse circulation patterns (Figure 4). The pilot test proposed, however, will most likely utilize the recirculation pattern in order to induce vertical flow. It is anticipated that this approach will more reliably increase the vertical coverage even in aquifer conditions with varying degrees of anisotropy.

2.4 Potential Full Scale Treatment Configuration

For effective pilot testing, a potential full scale configuration should be conceptualized to ensure that the configuration tested has relevance to potential full scale application at the Topock site. The general approach of a recirculation well system would be to install a series of wells on approximately 100 foot (or greater) intervals along Park Moabi Road or other locations (Figure 7). Other areas for potential application at the Topock site could include the source area in Bat Cave Wash and down the Bat Cave Wash to the east, along Interstate 40, along the railroad area (Figure 7). The conceptual approach involves operation of the recirculation wells for a period of several months at a time to reduce the ferrous iron in the aquifer and create reduced iron minerals such as iron oxides and iron sulfides. These iron minerals would continue to react with the chromium (and other oxidized compounds in the aquifer) for some period of time and, when a significant fraction of the reduced iron and organic carbon is depleted, the recirculation wells would be turned on again to regenerate the reductive capacity of the iron in the aquifer.

Currently, in situ Cr(VI) reduction technology is being evaluated in the floodplain, adjacent to the Colorado River, at the Topock site. Both pilot test results will be evaluated to assess a full scale site remedy. While remedy assessment is in its initial stages for the Topock site, it is not expected that any in situ treatment approach, if selected, would operate as a stand-alone remedy for the site – rather, it would be an enhancement to groundwater extraction or injection approaches (to enhance contact of the chromium with the reactive zone). In situ bioremediation would likely be used in combination with other technologies; for instance, the combined effect of groundwater extraction and treatment and in situ Cr(VI) reduction is an example of a combined remedy. Even after the active treatment is ended, the previously created in situ reductive zones (IRZs) can continue to operate as a reactive barrier to treat chromium-contaminated groundwater that flows across the zone. The reactive zones can also enhance the performance of monitored natural attenuation, by providing source area treatment and by creating a shrinking plume.

3.0 Pilot Test Design

The following sections discuss the pilot test location evaluation, the proposed pilot test layout location, aquifer testing and the pilot test approach.

3.1 Pilot Test Location Evaluation

Five potential pilot test areas (PTA) within the upland portion of the site were previously evaluated to compare their suitability as locations for the upland pilot test. Based on changes to the proposed approach to pilot test, three additional pilot test areas were identified and some of the original PTAs were eliminated or shifted somewhat to account for pilot test constraints. Three PTAs were still considered potentially acceptable based on current site understanding and objectives of the test. These PTA locations are shown on Figure 3. The assessment of PTAs involved evaluation of several characteristics that will allow results from the pilot test to be broadly applied across the site.

Potential PTAs were evaluated based upon the following criteria:

Representative of the Plume in Upland (Alluvial) Area

The PTA had to be representative of the groundwater plume in the upland (alluvial) area so that the effect of site hydrogeology on the remediation of the plume could be evaluated.

Availability of Existing Hydrology and Geochemistry Data

Detailed knowledge of the stratigraphy and groundwater chemistry within the pilot test area is essential in planning and executing a successful in situ pilot test. Therefore, a PTA located closer to monitoring wells with extensive historical data showing suitable in situ pilot test conditions is considered a good pilot test location. The available information from previous investigations in this area (CH2M Hill, 2003) indicates that hydraulic conductivities in the area of MW-24 are conducive to groundwater circulation.

Access

Due to the steep natural terrain at the Topock site, there are certain areas that are not readily accessible for a drill rig. Many of these locations would require extensive ground reconfiguration in order to be accessed. Figure 3 shows accessibility and topographic constraints at the Topock site. When evaluating a PTA the four items that should be considered in terms of access to the test area are:

- Road
- Power
- Minimize new disturbance
- Safety

Potential Impact on Cultural Resources

As mentioned above, the project area lies within a larger area of significant cultural value and within an area that is sacred to the Fort Mojave Indian people. In recognition of this, all activities are planned in a manner to minimize impact to this area. The work will be conducted in a manner that recognizes and respects these resources and site spiritual values. In addition, the Colorado River itself is of spiritual and cultural importance to local tribes.

Potential Impact on Biological Resources

There are minimal expected impacts to species and biological resources within the upland area containing the PTAs. Care will be taken to avoid animals and plants. No live, or recent signs of the, desert tortoise have been found in the proposed areas. Beavertail cacti, palo verde, and cat claw exist in the vicinity. Biological resource surveys will be conducted prior and post construction and if avoidance is not possible, these plant species will be transplanted. If transplanting is unsuccessful, the vegetation will be replaced.

Proximity to Existing Extraction Wells

The selected PTA has to be far enough from the current injection/extraction flow field in order to evaluate the recirculation well performance separate from the effect of the extraction wells. All of the PTAs are within the zone that may eventually be extracted by TW-2D and TW-3D, which ensures that any reagents injected through the recirculation wells may eventually be extracted in these wells.

3.2 Proposed Pilot Test Location Layout

At this time, PTA-8, located in the vicinity of monitoring well MW-24 (Figure 3) is favored because more geology and groundwater chemistry information is available than for other considered areas. PTA-8 is located immediately northwest of the Compressor Station and south of Interstate-40. It is also within the southern portion of the plume source area. It has easy access from the Compressor Station. The stratigraphy and the groundwater chemistry in the vicinity is relatively well-understood due to the presence of historical data obtained from wells MW-24 A/B, MW-11, PGE-6, PGE-7, MW-38 S/D, and TW-1, which are all within a 250-foot radius of PTA-8. PTA-8 is sufficiently far from the current extraction wells that the operation of the extraction well will not complicate the pilot test. Pump tests at TW-1 (near PTA-8) provided hydraulic information of the area.

It is recognized, after discussion with the FMIT, that all of the areas where a pilot test could potentially be performed are within a sacred area. This fact impacted a number of pilot test design factors.

- Where possible, existing wells will be utilized to provide groundwater monitoring information. For example at PTA-8, MW-24 (A, B, and BR), MW-11, and MW-38 (S and D) may provide significant groundwater monitoring information, thereby minimizing the need for new monitoring wells and the additional disturbance associated with well drilling.

- The total number of monitoring wells will be limited to the bare minimum to achieve the critical objective of the pilot test. At a site without sacred significance, additional monitoring wells would have been proposed that would have provided beneficial information, but not information critical to the core objectives of the pilot test. Thus, a streamlined test will be performed.

- All additional wells will be located in an area with prior disturbance associated with gas pipelines previously installed. Access to the PTA-8 site will utilize existing roads and infrastructure where possible.

- It is believed that injection wells proposed at PTA-8 could become part of the overall site remedy, if in situ is selected.

PG&E has met with the FMIT to discuss the pilot testing approach to solicit input about performing the pilot test in a manner that respects the cultural and spiritual significance of the area. PG&E has considered, and will continue to consider, the input of the FMIT and of others in the design and implementation of this pilot test.

PTA-8 is proposed as the location for the pilot test (Figure 3). Other locations are potential locations that could alternatively be considered (PTA-3 and PTA-4); however, geology, hydrology, and chemistry data equivalent to that available for PTA-8 are unavailable for these other potential pilot study locations. At these locations, additional disturbance would be necessary to obtain equivalent information equal to that which is currently known about PTA-8. For this reason, PTA-8 is the proposed location for this pilot test.

Well construction details are presented in a following section.

3.3 Aquifer Testing

The pilot test reagent delivery approach being tested is the use of groundwater recirculation wells. A pair of injection-extraction wells screened at high and low elevations in the aquifer will be installed within a 150 feet distance from each other providing between-well circulation. Twenty five foot screen intervals (near the top of the saturated portion of the aquifer) separated by 30 feet of well casing followed by 30 feet of screen will be used to create circulation between the injection and extraction well screens. The top screen interval will be located within 10 feet of the top of the aquifer, and the bottom screen interval will end next to the bedrock layer at the bottom of the relatively permeable aquifer unit. The remedial reagent will be added to each well between the two screened intervals through an in-well mixer.

The aquifer-testing program will include completing a circulation pump test in both recirculation wells for approximately 8 hours, collecting drawdown data, and analyzing the data. The objective of the circulation pump test is to determine final injection and recirculation rates and to obtain additional hydrogeologic information. The circulation pump tests will consist of four approximately 2-hour step tests to determine well yield. After the recirculation well is installed and developed, a 4-inch diameter submersible pump, appropriate packer and piping will be installed in the well and tested for reliable operation. The circulation pump tests will be performed to evaluate the potential maximum yield of the well and to approximate the sustainable yield for the well. The first step will have a pumping rate constant of approximately 5 gallons per minute (gpm) for approximately 120 minutes, the second step at approximately 10 gpm for approximately 120 minutes, the third step at approximately 20 gpm for approximately 120 minutes and the final step at approximately 30 gpm for approximately 120 minutes.

Should field conditions suggest that this procedure should be modified, PG&E will discuss with DTSC and obtain verbal approval prior to making any significant adjustments. The water yield from one well screen during the circulation pump test will be re-injected simultaneously in the other well screen within the same well.

Pressure transducers, connected to a data logger, will be placed in the recirculation well and the monitoring wells as practical. The data logger will be programmed to collect drawdown measurements. Two pressure transducers will be needed to monitor both the extraction and the injection. Throughout the circulation pump test, water-level displacement will be measured in the monitoring wells (PT-7 S/M/D, PT-8 S/M/D, PT-9 S/M/D, MW-24 A/B, and MW-11, Figure 8). Data from the closest monitoring well PT-7 and MW-24A will be collected on a high frequency (e.g. every 15 seconds). Data from wells further from the pumped well (PT-8, PT-9 and MW-11) will be collected less frequently (e.g. every minute) since the influence on these wells should be less. Manual measurements will be collected periodically from the wells equipped with the transducers to confirm the accuracy of the pressure transducers. Manual measurements will be made using either a chalked steel tape or a water level meter.

Baseline water level measurements will be collected from one monitoring well (PT-7 S/M/D) using a pressure transducer and data logger for one week prior to conducting the test. Immediately prior to starting the test, a comprehensive, synoptic round of water-level measurements will be collected to obtain baseline groundwater elevation data. The baseline water-level data, as well as barometric pressure and precipitation data, will be used to evaluate non-pumping conditions and identify potential interference or trends affecting groundwater levels during the test.

Recovery data will be collected to confirm the results of the circulation pump test by measuring water levels in selected monitoring wells with pressure transducers until water levels are within approximately 10 percent of the pre-test levels, or for a maximum of 24 hours after shutdown, whichever occurs first. The recovery rate may vary based on the actual materials screened and the availability of groundwater to recharge the system.

Data obtained during the circulation pump test will help determine the circulation rate of water. After the pumping rate is determined, both of the recirculation wells will be run at the same rate to balance the circulation flow rates between the two recirculation wells. Water levels will be monitored in the selected monitoring wells (PT-7 S/M/D, PT-8 S/M/D, PT-9 S/M/D, MW-24 A/B, and MW-11), as previously defined.

The results of both the circulation step test and the recirculation hydraulic connectivity test will be analyzed prior to the start of the pilot test injections. If necessary, modifications to the pilot test plan will be made.

3.4 Pilot Test Approach

The proposed test area is just to the northeast of the Topock Compressor Station, near monitoring well MW-24. This area was selected (as summarized in Section 3.1) for its location near the center of the Cr(VI) plume, as shown in Figure 2. Access to the area is along Park Moabi Road through the Compressor Station. The area also has power access from the Compressor Station on the access road or from close by existing power poles. There are four possible equipment staging areas for the well installation activities and other pilot test related activities: outside the north Compressor Station gate, the MW-24 bench next to pilot test area, within the fenced area of the Compressor Station, and adjacent to the Transwestern valve site on Compressor Station property (two of these locations are shown on Figure 8).

The proposed pilot test will be conducted by introducing a food-grade carbon source to be used by indigenous microbes coupled with the available electron acceptors in the aquifer to provide a reducing environment in the aquifer. By creating a reducing environment, chromium reduction will be achieved by two different methods. First, microbes will directly reduce Cr(VI) to Cr(III) while consuming organic carbon, and also indirectly by formation of reactive reduced iron compounds and to a lesser extent, sulfide compounds in the aquifer.

Ethanol (denatured by methanol) is the preferred carbon substrate due to its solubility, low viscosity, and minimized well biofouling. The introduction of a carbon source (denatured ethanol) promotes microbial activity contributing to the creation of a reducing environment; Section 5.2 discusses the proposed reagent dosage to be used during the pilot test. These dosages have been based on available Topock site data and experience with the use of in situ bioremediation at similar Cr(VI)-impacted sites.

Since only tracer and reductant solution (and no injection water) is added to the site, surface disturbance by running water lines between the injection wells is avoided. In a full scale application of the recirculation approach, the injection direction will be alternated between the recirculation wells to create the desired “conveyer belt” flow field between the series of recirculation wells.

Three additional monitoring well nests will also be installed to monitor multiple depth intervals and assess coverage and the propagation of the reduced zone on the downgradient side of the circulation zone. One well (PT-7 S/M/D) will be located near the injection well (approximately 30 feet away from the injection well); this well, and MW-24A, will provide rapid assessment of the circulation efficiency, and will be used to modify reagent concentrations and injection rate, and circulation pumping rate. Another well nest (PT-8 S/M/D) will be located equidistant between the circulation wells to monitor how well treatment is being achieved between the two recirculation wells. The third well nest (PT-9 S/M/D) will be located downgradient of the pilot test area to monitor the remediation effects observed downgradient of the area. The other existing monitoring wells in the area will be used to monitor the performance of the pilot study. MW-24 A/B will also be used to monitor the coverage between recirculation wells, MW-11 will be used to monitor the circulation extent to the north and MW-38 S/D will be used to monitor the upgradient water quality flowing into the circulation zone.

The recirculation wells will be operated until hydraulic steady state flow conditions are achieved and iron present in the aquifer is reduced and stored to maintain reduction activity within the injection area. Modeling suggests that hydraulic steady-state flow conditions will be achieved within a six-month period. Vertical and horizontal coverage will be documented by monitoring tracer concentrations and chromium treatment data. Each recirculation well will have reagent injected with a tracer, with fluorescein in pilot test recirculation well PTR-1, and rhodamine in PTR-2 (Figure 8).

Formation of reduced iron stored in the aquifer will be assessed to confirm that it can continue to precipitate chromium between widely spaced injection events and even after the injection ceases. This reduced iron can form the basis for natural attenuation of the chromium plume. A soil core will be removed from the circulation zone after the circulation phase is complete and the amount of reduced ferrous iron will be assessed, and compared with pre-test conditions. The monitoring wells will be used to assess the dissolved ferrous iron. Together these data will show all of the iron reduced during the circulation phase. Sulfate and sulfide will be similarly monitored to provide data on the sulfur-based stored reductive capacity in the aquifer.

As described further in Section 5.4, groundwater chemistry monitoring will be conducted to evaluate the effectiveness of the reagent introduction to the aquifer. It is anticipated that this monitoring information will yield useful information whether or not complete Cr(VI) removal is achieved. The suitability of injecting reagents into the groundwater using circulation wells, the effects of the remediation process on secondary water chemistry characteristics, and additional aquifer characterization in this area are examples of information that this pilot test will yield in addition to the Cr(VI) precipitation. All data will be used to evaluate the pilot test, which will be informative to selecting the overall site remedy options at the Topock site.

4.0 Pre-Implementation Considerations

The following sections describe activities that will be conducted prior to implementation of the pilot test.

4.1 Access Agreements

Permission for access and placement of components of the pilot test will be obtained from the Havasu National Wildlife Refuge.

4.2 Permitting and Approvals

It is anticipated that the injection of reductant and tracer solutions as proposed for the pilot test will require the issuance of Waste Discharge Requirements (WDR) by the Regional Water Quality Control Board (RWQCB). The WDR will specify how the test will be conducted and the monitoring and reporting that will be required by the RWQCB. This work plan, in addition to the completed Report of Waste Discharge (ROWD) Form 200, provides the information needed for the RWQCB staff to prepare the WDR. The WDR will be considered for approval by the RWQCB at a regular board meeting. Generally, at least three months is required from submittal of the ROWD until the WDR is approved.

Well construction permits will be obtained from the San Bernardino County Department of Public Health, Environmental Health Services Safe Drinking Water Permit Section for the additional wells that will be installed.

PG&E will work with the DTSC and federal agencies to determine and obtain those permits or approvals that are actually required prior to implementation of the pilot study.

4.3 Well Installation

Two recirculation wells (PTR-1 and PTR-2) with pumps and well-head vaults with pump controls and three new nested monitoring wells (PT-7 S/M/D, PT-8 S/M/D, and PT-9 S/M/D) will be installed in the locations shown on Figure 8. All drilling and field activities will be performed in accordance with the applicable procedures contained within the Sampling and Analysis Field Procedures, PG&E Topock Program (SAFPM) (CH2M Hill, 2006c) with modifications as necessary for the recirculation wells to enhance injectability.

The wells will be drilled using rotosonic techniques. The rotosonic drill rig will be equipped with drilling casing with an outside diameter of approximately 10 inches for the recirculation and monitoring well boreholes. Rotosonic drilling provides continuous highly representative, core samples that can be recovered in all formations without the use of air, water or additives, thus minimizing the waste produced. Soil samples will be continuously recovered and logged, and from this information the exact location of the screen intervals will be selected. The post-test soil sample for ferrous iron analysis will also be recovered using rotosonic techniques.

Recirculation wells will be 6-inches in diameter with two separate screened intervals. The upper screen interval will be approximately 25 feet long and the lower screen interval will be approximately 30 feet long, with approximately 30 feet of spacing between screens. The two injection wells will be spaced approximately 150 feet apart. The screen material used will be at least 0.02-inch V-shaped continuous stainless steel wire-wrapped screen (Figure 9). The stainless steel wire-wrapped screen will provide a stable, more permeable section to which the organic carbon substrate is less likely to clog during injection activities. The recirculation wells will be constructed with the upper screened interval from approximately 445 to 420 feet above msl and the lower screened interval from approximately 390 to 360 feet above msl.

The monitoring well nests are specified in the pilot treatment zone around the recirculation wells. Monitoring well PT-7 S/M/D and PT-8 S/M/D will be located between recirculation wells to monitor coverage of the injected reagents and the circulation between the wells, and PT-9 S/M/D will be located downgradient of the circulation zone to monitor the propagation of the reduced zone.

Construction of a single boring at each nest with three separate two-inch well completions was considered. However, this approach was rejected since it would likely require overdrilling upon removal, resulting in additional site disturbance. It is also more difficult with a 'triplet' to ensure proper placement of the well sand pack and bentonite seal. Therefore, two separate borings for each monitoring well nest (the PT-7, PT-8 and PT-9 series) will be advanced. One boring will contain two separate 2-inch well completions (shallow and deep) while the second boring will contain a single completion in the middle layer. It is anticipated that these wells will be abandoned using pressure grouting techniques. The wells will be constructed with Schedule 40 PVC casing and 0.02-inch slotted PVC screen (Figure 9). The suggested elevations for the screen intervals are the following approximate elevations: shallow interval from 440 to 430 feet above msl; intermediate interval from 410 to 400 feet above msl; and lower interval from 380 to 370 feet above msl.

Reagent storage tanks and reagent injection pumps, as well as in-well packer and in-line reagent mixer, will be used. No night work will be conducted during the pilot test implementation.

5.0 Implementation Plan

Following well installation, aquifer testing and baseline sampling (discussed below), the pilot test will commence with the introduction of ethanol and tracers. This section discusses the calculated required dosage and methodology for reagent injection.

5.1 Tracer Test

Concurrent with the pilot test injection, a tracer test will also be initiated to better understand the flow conditions in the pilot test area. Due to the substrate distribution system selected and the circulation mixing between the wells, the tracer study will be conducted with each injection well receiving its own tracer. PTR-1 will receive fluorescein and PTR-2 will receive rhodamine as tracers. The resulting information will be used to track groundwater movement at different depth intervals and also the distribution of substrate between the wells. The dyes will be introduced at a target concentration of 1 mg/L in the injection water and will be continuously injected for the first month of circulation. The monitoring wells will be sampled for both tracers at the same frequency as all other parameters for the full eight months to determine relative mixing of the dyes (and the associated groundwater) during the circulation test. Approximately 12 pounds of each dye will be injected in their respective wells during the one month dye injection period.

5.2 Reagent Dosage

The proposed reagent dosages are calculated based upon the pilot test area and experience with the use of carbon source addition at other sites.

Based on the desired IRZ zone for this pilot test of approximately 375 feet long by 375 feet wide across a fully saturated thickness (approximately 100 feet), with an estimated porosity of 20 percent, the volume of impacted groundwater within the test area is approximately 21 million gallons. Therefore, the amount of ethanol needed to reduce oxygen, nitrate and iron in the aquifer to create a reducing zone and result in chromium reduction by either microbes that couple the organic carbon oxidation with chromium reduction or by reduced iron is calculated as approximately 12,000 gallons. However, to avoid flammable reagent storage issues at the site, a diluted 40 percent ethanol solution will be used. A total of 38,000 gallons of 40 percent ethanol solution will be injected in two recirculation wells in six months. This amount is calculated based on the stoichiometric amount of organic carbon needed to reduce the oxygen, nitrate and iron content of the subsurface and an additional 20 percent as a safety factor (to account for some biomass inefficiency in carbon usage). Because it is not likely that the full 375 feet by 375 feet zone will be fully mixed initially, and the 20 percent safety factor is conservative, this reagent dosage is expected to be in excess of what is required for the reduction of just the oxygen, nitrate, chromium, and iron. Consequently it is expected that some sulfate reduction will also occur, which also may increase the beneficial storage of iron in the reduced zone. Sulfate and sulfide will therefore be monitored to document in situ reaction efficiency. Figure 4 presents the estimated total organic carbon coverage area over six months.

5.3 Reagent Introduction

The ethanol solution will be pumped into each of the two recirculation wells (PTR-1 and PTR-2). Data from monitoring wells will be used to adjust ethanol injection rate if needed, with required agency notification and concurrence. No permanent aboveground equipment will be employed during the pilot test. The proposed approach will minimize the duration and nature of site disruptions by placing temporary reagent tanks at well heads and using in-well packer and in-line reagent mixers. Diluted ethanol (and for the first month, a dye tracer) will be kept in double contained reagent tanks located at each well head. The reagent tanks (sized 3,000 gallons or less) will be re-filled approximately once a month. Reagent handling, transferring and delivery will follow existing site policies and procedures in compliance with the previously approved SAFPM (CH2M Hill, 2005b).

To minimize biofouling of the recirculation wells, the reagent will be injected multiple times daily at a high rate for a short period of time. For example, approximately 100 gallons of reagent will be injected each day in each well. Twenty-five gallons will be injected four times per day at a rate of 5 gallons per minute to rapidly inject the reagent into the aquifer. An automated reagent dosing system will be located within the well head vault to accomplish the reagent injection at regular intervals during each day of the pilot test.

5.4 Pilot Test Monitoring

Monitoring of reagent flow (rate and volume) into the injection well and water levels in nearby monitoring wells will be conducted daily throughout the first week of injection until the injection system is operating routinely. Thereafter, weekly monitoring visits will record volumes of reagent injected.

Groundwater chemistry monitoring will be conducted to evaluate the effectiveness of the reagent introduction to the aquifer. It is anticipated that the chemical nature of groundwater near the injection well will change soon after the introduction of the reagent. However, it may take some time for the effect to reach the monitoring wells. Monitoring wells will be sampled twice prior to the initial injection event (two baseline events) and on a phased schedule post-injection (weekly for the first month, bi-weekly for next three months, and monthly for the next five months), for a total of 17 monitoring events, plus any additional monitoring events required by the RWQCB WDRs. Monitoring will continue for a minimum of nine months (during the six months of injection and an addition three months to monitor the performance of the established reductive zone). Depending on the results obtained, post-test monitoring may continue beyond the nine-month timeframe.

Groundwater sampling, handling and analyses will be performed according to the methods in the SAFPM, including the Quality Assurance Project Plan (QAPP) presented in the SAFPM (CH2M Hill, 2005b). Monitoring will include field analysis of pH, temperature, and specific conductance (all events) and dissolved oxygen (only in the baseline sampling event), and any additional monitoring parameters required by the RWQCB WDRs. The groundwater samples will also be submitted for analyses for various specified parameters mentioned below. Water levels in each well will also be measured and recorded during each sampling event.

The baseline sampling events will include sampling and analyses of Cr(VI), total chromium, total and dissolved iron, total and dissolved manganese, dissolved arsenic, bicarbonate alkalinity, nitrate, total organic carbon (TOC), sulfide, and sulfate. Sampling and analyses during the pilot test will include: dissolved Cr(VI), total chromium, TOC, total iron and dissolved iron, sulfide and sulfate, rhodamine, and fluorescein plus any additional monitoring parameters required by the RWQCB WDRs. A more detailed sampling and analyses of all the parameters listed for the baseline sampling event will be conducted once every two months.

5.5 Reporting

It is anticipated that frequent communications between the PG&E project team and DTSC will occur during the course of the pilot test. Reporting will be coordinated, and where possible, combined with RWQCB WDR requirements. It is anticipated that quarterly update reports will be prepared and submitted beginning immediately after the introduction of reagents and continuing for the duration of the test period. All data will be used to evaluate the pilot test, which will be informative in selecting the overall site remedy options at the Topock site. These reports will contain all data obtained during the test. A final written summary report of findings, including a complete data set, will be submitted within approximately one month after completion of the pilot test. This report will include a discussion of treatment efficiencies, recommendations, and considerations for development of a possible full-scale in situ remedial plan.

6.0 Waste Management and Equipment Decontamination

Several waste materials will be generated during the drilling, development, and sampling of the proposed pilot test wells. These investigation-derived waste (IDW) materials will include groundwater, drill cuttings, decontamination rinsate, and incidental trash. PG&E and their consultants are committed to preserving the site's archaeological and spiritual resources, and all IDW will be handling according to policies and procedures in compliance with the SAFPM (CH2M Hill, 2005b).

6.1 IDW Management

Drill cuttings generated during drilling of the pilot test wells will be contained in lined roll-off bins temporarily staged at an approved staging area at or near the drilling sites. After sampling and characterization of the drill cuttings are completed, the cuttings bins will be removed from the drilling sites for disposal by PG&E. The drill cuttings will be screened for chromium. If the drill cuttings are characterized as a hazardous waste, they will be transported off site for disposal at a permitted hazardous waste treatment, storage, or disposal facility. Cuttings bins could be temporarily staged for up to 90 days

Water generated during drilling, well development, and sampling activities may be collected in drums or portable storage tanks temporarily located at each drilling site and transferred to a truck mounted storage tank over secondary containment and transported to storage tanks in a staging area for characterization. Elevated chromium concentrations are expected in the groundwater that will be removed from the pilot test wells. Therefore, secondary containment will be provided for the storage tanks in the staging area. This water will be analyzed in accordance with the procedures in the SAFPM (CH2M Hill 2005b) to confirm that treatment of this water will be performed at the IM-3 treatment system.

Incidental trash will be collected from the work area at the conclusion of each workday and placed in a trash collection bin.

All IDW management will be performed in accordance with the procedures specified in the SAFPM (CH2M Hill, 2005b). Section 3.4 discusses possible staging areas. These areas include: outside the north Compressor Station gate, the MW-24 bench next to pilot test area, within the Compressor Station fenced area, and adjacent to the Transwestern valve site on Compressor Station property (Figure 8).

6.2 Equipment Decontamination

Down-hole drilling and development equipment and the back end of the drill rig will be steam cleaned prior to starting work at each new drilling site. Steam cleaning will be performed on a decontamination pad such that all rinsate can be contained and collected. Rinsate from the decontamination of drilling equipment will be transferred to the cuttings bin or water storage tank that contains material from the borehole last drilled.

All equipment decontamination will be performed in accordance with the methods specified in the SAFPM (CH2M Hill, 2005b). Water used for sampling equipment decontamination will be transferred at the end of each workday into the water storage tank that contains water from the wells sampled that day. Section 3.4 discusses possible staging areas for the decontamination water. These areas include: outside the north Compressor Station gate, the MW-24 bench next to pilot test area, within the Compressor Station fenced area, and adjacent to the Transwestern valve site on Compressor Station property (Figure 8).

7.0 Schedule

The following preliminary schedule has been developed to clarify the sequencing and approximate duration of tasks. It does not include time required for permitting and work plan approval. The results of the pilot test will be used to develop alternatives in the CMS. Figure 10 presents the upland in situ pilot test project schedule.

- Drilling and installation of two recirculation wells and three monitoring well nests (approximately one month).

- Installation of pilot test equipment (reagent storage tanks, injection pumps, pump controls, flow meters) (approximately one week).

- Injection/recirculation of the organic substrate (approximately six months).

- Monitoring activities including water levels and water chemistry at the following frequency: two baseline events, Day 1 post-injection, Weeks 1, 2, 3, 4, 6, 8, 10, 12, 14, and 16, and Months 5 through 9. The post-injection monitoring will commence with the start of injections and will continue for approximately 3 months after injection/recirculation activities are anticipated to have been completed. Depending on the data collected, monitoring activities may extend beyond nine months.

During this project, PG&E is committed to the protection of environmental, archaeological and spiritual resources, and to ensuring that all impacts to those resources are minimized. The pilot test area impacts will be kept to a minimum; and site restoration will occur upon completion of the applicable phases of the site remedy.

8.0 References

CH2M Hill, February 28, 2005a. RCRA Facility Investigation/Remedial Investigation Report, PG&E Topock Compressor Station, Needles, California.

CH2M Hill, March 31, 2005b. Sampling, Analysis, and Field Procedures Manual, PG&E Topock Compressor Station, Needles, California.

CH2M Hill, May 20, 2005c. Summary of Results—Aerobic Zone Hexavalent Chromium Core Testing, PG&E Topock Compressor Station, Needles, California.

CH2M Hill, June 1, 2006. Groundwater Surface Water Monitoring Report First Quarter 2006, PG&E Topock Compressor Station, Needles, California.

Huang and Goltz. 2005. A three-dimensional analytical model to simulate groundwater flow during operation of recirculation wells. Journal of Hydrology 314 (2005) 67 – 77.

USEPA, December, 1989. Treatability Studies Under CERCLA: An Overview USEPA Office of Soil Waste and Emergency Response, United States Environmental Protection Agency, Publication No. 9380.3-02FS.

Table 1
Historical Groundwater Data Near Proposed Pilot Test
Pacific Gas & Electric
Topock Compressor Station
Needles, California
DRAFT In Situ Hexavalent Chromium Reduction Pilot Test Work Plan - Upland Plume Treatment

Location Name	Date	Screen Interval (ft bgs)	Mearsuring Point Eleveation (ft amsl)	Alkalinity as CaCO3 (mg/L)	Chloride (mg/L)	Hexavalent Chromium (mg/L)	Total Dissolved Chromium (mg/L)	Total Ferrous Iron (mg/L)	Manganese (mg/L)	Nitrate (mg/L)	pH	SC (µS/cm)	Sulfate (mg/L)	TDS (mg/L)	TOC (mg/L)	DO (mg/L)
MW-11	1-Jul-97	62.5-82.5	522.61	141	590	0.02	0.07	14.8	0.5	7.2	7.02	2,790	415	1,910	11	2.10
	1-Sep-97			---	---	0.466	0.45	---	---	---	7.52	2,750	---	---	---	---
	18-Feb-98			---	---	1.01	0.96	---	---	---	7.85	2,820	---	---	---	---
	15-Jun-98			---	---	1.71	1.7	---	---	---	7.43	2,680	---	---	---	---
	15-Jun-99			---	---	0.822	0.82	---	---	---	7.55	2,840	---	---	---	---
	14-Sep-99			---	---	1.39	1.4	---	---	---	7.33	3,090	---	---	---	---
	1-Dec-99			---	---	1.31	1.3	---	---	---	7.35	2,680	---	---	---	---
	25-Mar-00			---	---	0.959	0.82	---	---	---	7.29	9,150	---	---	---	---
	14-Jun-00			---	---	0.491	0.56	---	---	---	7.62	2,760	---	---	---	---
	1-Sep-00			108	592	0.747	0.72	0.11	0.0033	8.8	7.47	3,320	490	1,880	4.9	7.46
	1-Dec-00			---	---	0.914	0.89	---	---	---	7.47	2,810	---	---	---	---
	28-Mar-01			---	---	0.71	0.68	---	---	---	7.35	2,740	---	---	---	---
	6-Jun-01			---	---	0.468	0.46	---	---	---	7.57	2,570	---	---	---	---
	22-Aug-01			---	---	---	---	---	---	---	7.06	2,410	---	---	---	---
	12-Sep-01			---	---	0.46	0.46	---	---	---	7.46	2,530	---	---	---	---
	28-Nov-01			121	530	0.73	0.54	0.16	0.0035	2.3	7.45	2,570	425	1,590	2.3	6.80
	6-Mar-02			---	---	0.613	0.512	---	---	---	7.2	2,440	---	---	---	---
	12-Jun-02			---	---	0.459	0.371	---	---	---	7.36	2,450	---	---	---	8.65
	17-Sep-02			---	---	0.408	0.483	---	---	---	8.14	2,640	---	---	---	6.09
	10-Dec-02			---	---	0.584	0.696	---	---	---	8.24	4,020	---	---	---	4.62
	18-Mar-03			---	---	0.463	0.452	---	---	---	8.04	2,430	---	---	---	8.30
	12-Jun-03			126	418	0.429	0.453	0.73	0.5	8.6	8.1	2,520	344	1,540	0.5	6.48
	11-Sep-03			---	---	0.412	0.376	---	---	---	7.44	2,560	---	---	---	5.90
	12-Dec-03			---	---	0.566	0.772	---	---	---	7.37	2,350	---	---	---	4.50
	16-Mar-04			---	---	0.432	0.358	---	---	---	7.42	2,830	---	---	---	5.90
	10-Jun-04			100	460	0.424	1.4	0.5	0.01	---	7.17	2,510	320	---	---	7.04
	21-Sep-04			---	---	0.431	---	---	---	---	---	---	---	---	---	---
	17-Dec-04			---	---	0.393	0.392	---	---	---	---	---	---	---	---	---
	8-Mar-05			---	---	0.396	0.334	---	---	---	7.89	2,310	---	---	---	7.02
	16-Jun-05			---	---	0.362	0.617 FF	---	---	---	8.02	2,200	---	---	---	5.60
	3-Oct-05			---	---	0.649	0.306 FF	---	---	---	7.33	2,330	---	---	---	5.91
	12-Dec-05			---	---	0.323	---	---	---	---	7.47	2,360	---	---	---	8.10
	6-Mar-06			---	---	0.306	---	---	---	---	---	---	---	---	---	6.98

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Needles, California
DRAFT In Situ Hexavalent Chromium Reduction Pilot Test Work Plan - Upland Plume Treatment

Location Name	Date	Screen Interval (ft bgs)	Mearsuring Point Eleveation (ft amsl)	Alkalinity as CaCO3 (mg/L)	Chloride (mg/L)	Hexavalent Chromium (mg/L)	Total Dissolved Chromium (mg/L)	Total Ferrous Iron (mg/L)	Manganese (mg/L)	Nitrate (mg/L)	pH	SC (μS/cm)	Sulfate (mg/L)	TDS (mg/L)	TOC (mg/L)	DO (mg/L)
MW-24A	15-Jun-98	104-124	567.16	146	740	2.8	2.9	0.01	0.071	28	7.5	3,310	405	2,060	4.3	5.17
	15-Jun-99			---	---	2.93	3.7	---	---	---	7.85	4,140	---	---	---	---
	14-Sep-99			---	---	3.77	---	---	---	---	7.61	3,860	---	---	---	---
	3-Dec-99			---	---	3.67	3.9	---	---	---	7.49	3,470	---	---	---	---
	25-Mar-00			---	---	3.67	3.2	---	---	---	7.12	11,500	---	---	---	---
	13-Jun-00			---	---	3.42	3.4	---	---	---	7.68	2,990	---	---	---	---
	1-Sep-00			150	806	3.87	4	0.017	0.00079	18	7.55	4,350	355	2,020	2	6.31
	1-Dec-00			---	---	3.75	3.6	---	---	---	7.71	3,390	---	---	---	---
	8-Mar-01			---	---	3.22	3	---	---	---	7.6	4,130	---	---	---	---
	6-Jun-01			---	---	3.24	2.9	---	---	---	7.68	3,160	---	---	---	---
	22-Aug-01			---	---	---	---	---	---	---	7.85	3,500	---	---	---	---
	12-Sep-01			---	---	3.5	3.2	---	---	---	7.63	2,990	---	---	---	---
	29-Nov-01			158	880	3.4	2.9	0.016	0.0007	15.4	7.78	3,150	409	2,010	1	4.20
	8-Mar-02			---	---	3.03	2.99	---	---	---	8.53	3,210	---	---	---	---
	13-Jun-02			---	---	2.87	3.02	---	---	---	8.54	3,700	---	---	---	3.77
	17-Sep-02			---	---	3.29	3.49	---	---	---	8.35	4,290	---	---	---	5.71
	11-Dec-02			---	---	3.43	4.16	---	---	---	7.27	3,046	---	---	---	3.41
	18-Mar-03			---	---	2.77	2.61	---	---	---	8.5	3,650	---	---	---	3.31
	12-Jun-03			202	754	2.64	2.51	0.5	0.5	15.1	7.85	4,030	310	2,040	1.2	3.52
	11-Sep-03			---	---	2.97	2.62	---	---	---	7.66	3,430	---	---	---	2.90
	10-Dec-03			---	---	2.99	3.32	---	---	---	7.86	3,620	---	---	---	4.70
	17-Mar-04			---	---	2.6	2.27	---	---	---	7.96	3,350	---	---	---	6.53
	8-Jun-04			180	770	2.66	2.39	0.5	0.01	15	7.85	3,450	300	2,000	3	9.68
	20-Sep-04			---	---	---	---	---	---	---	7.39	3,530	---	---	---	4.24
	7-Mar-05			---	---	3.39	3.18	---	---	---	7.88	3,330	---	---	---	3.09
	16-Jun-05			---	---	3.28	2.64	---	---	---	8.09	3,180	---	---	---	2.70
	3-Oct-05			---	---	3.12	2.93 FF	---	---	---	7.63	3,200	---	---	---	3.26
	6-Mar-06			---	---	3.49	3.98 FF	---	---	---	7.62	3,100	---	---	---	5.17

Table 1
Historical Groundwater Data Near Proposed Pilot Test
Pacific Gas & Electric
Topock Compressor Station
Needles, California
DRAFT In Situ Hexavalent Chromium Reduction Pilot Test Work Plan - Upland Plume Treatment

Location Name	Date	Screen Interval (ft bgs)	Mearsuring Point Eleveation (ft amsl)	Alkalinity as CaCO3 (mg/L)	Chloride (mg/L)	Hexavalent Chromium (mg/L)	Total Dissolved Chromium (mg/L)	Total Ferrous Iron (mg/L)	Manganese (mg/L)	Nitrate (mg/L)	pH	SC (µS/cm)	Sulfate (mg/L)	TDS (mg/L)	TOC (mg/L)	DO (mg/L)
MW-24B	15-Jun-98	193-213	564.76	62	3830	3.41	3.71	0.05	0.24	14	7.97	13,800	1350	8,050	2.6	3.50
	15-Jun-99			---	---	3.12	3.5	---	---	---	8.17	6,550	---	---	---	---
	14-Sep-99			---	---	3.67	3.8	---	---	---	7.96	14,400	---	---	---	---
	3-Dec-99			---	---	3.05	2.8	---	---	---	7.87	12,400	---	---	---	---
	25-Mar-00			---	---	3.73	3.4	---	---	---	8.84	13,000	---	---	---	---
	15-Jun-00			---	---	3.9	3.8	---	---	---	7.96	11,200	---	---	---	---
	1-Sep-00			53	3830	3.97	4.4	0.05	0.11	39	8.07	13,100	1450	8,110	1	7.55
	1-Dec-00			---	---	0.741	0.68	---	---	---	7.79	11,200	---	---	---	---
	28-Mar-01			---	---	3.96	3.4	---	---	---	7.79	12,700	---	---	---	---
	6-Jun-01			---	---	4.15	3.5	---	---	---	7.75	12,400	---	---	---	---
	22-Aug-01			---	---	4.54	4	---	---	---	7.41	13,000	---	---	---	---
	12-Sep-01			---	---	4.7	3.9	---	---	---	7.57	11,700	---	---	---	---
	29-Nov-01			55.4	3700	4.4	4.4	0.39	0.07	30.8	7.97	12,500	1310	7,760	1	4.90
	8-Mar-02			---	---	4.92	4.6	---	---	---	8	13,200	---	---	---	---
	13-Jun-02			---	---	4.83	5.12	---	---	---	8.07	12,500	---	---	---	1.12
	10-Dec-02			---	---	4.62	5.38	---	---	---	8.83	12,400	---	---	---	1.31
	18-Mar-03			---	---	4.9	4.65	---	---	---	8.71	13,700	---	---	---	1.47
	12-Jun-03			63.4	3350	4.79	5.57	0.5	0.5	15.7	7.94	14,500	1270	8,130	1.1	1.87
	11-Sep-03			---	---	4.6	4.32	---	---	---	8.28	14,700	---	---	---	2.70
	10-Dec-03			---	---	4.84	6.05	---	---	---	7.99	12,700	---	---	---	2.90
	17-Mar-04			---	---	4.86	3.9	---	---	---	8.35	13,100	---	---	---	2.03
	8-Jun-04			51	3600	5.19	4.91	0.5	0.05	16	7.78	13,250	1300	9,200	3	---
	21-Sep-04			---	---	---	---	---	---	---	7.67	10,800	---	---	---	4.30
	7-Mar-05			---	---	5.32	4.95	---	---	---	8.13	13,400	---	---	---	1.70
	16-Jun-05			---	---	5.64	5.66	---	---	---	8.29	12,700	---	---	---	2.20
	3-Oct-05			---	---	5.24	4.93 FF	---	---	---	7.84	14,900	---	---	---	3.19
	7-Mar-06			---	---	5.65	5.97 FF	---	---	---	7.92	15,400	---	---	---	2.59
MW-38S	14-May-04	75-95	525.51	---	---	0.332	0.373	---	---	---	7.61	3,500	---	2,310	---	3.50
	11-Jun-04			210	770	0.509	0.493	0.5	0.12	9.7	7.22	4,430	500	2,400	3	---
	17-Jun-04			---	---	---	---	---	---	---	7.48	4,560	---	---	---	0.20
	24-Sep-04			---	---	---	---	---	---	---	6.94	394	---	---	---	4.88
	11-Mar-05			---	---	0.919	0.938	---	---	---	7.8	3,840	---	---	---	5.36
	17-Jun-05			---	---	0.807	0.73	---	---	---	7.72	3,790	---	---	---	2.87
	7-Oct-05			---	---	0.776	0.825 FF	---	---	---	7.47	3,430	---	---	---	2.17
	10-Mar-06			---	---	0.824	0.788 FF	---	---	---	7.53	3,700	---	---	---	3.44

Table 1
Historical Groundwater Data Near Proposed Pilot Test
Pacific Gas & Electric
Topock Compressor Station
Needles, California
DRAFT In Situ Hexavalent Chromium Reduction Pilot Test Work Plan - Upland Plume Treatment

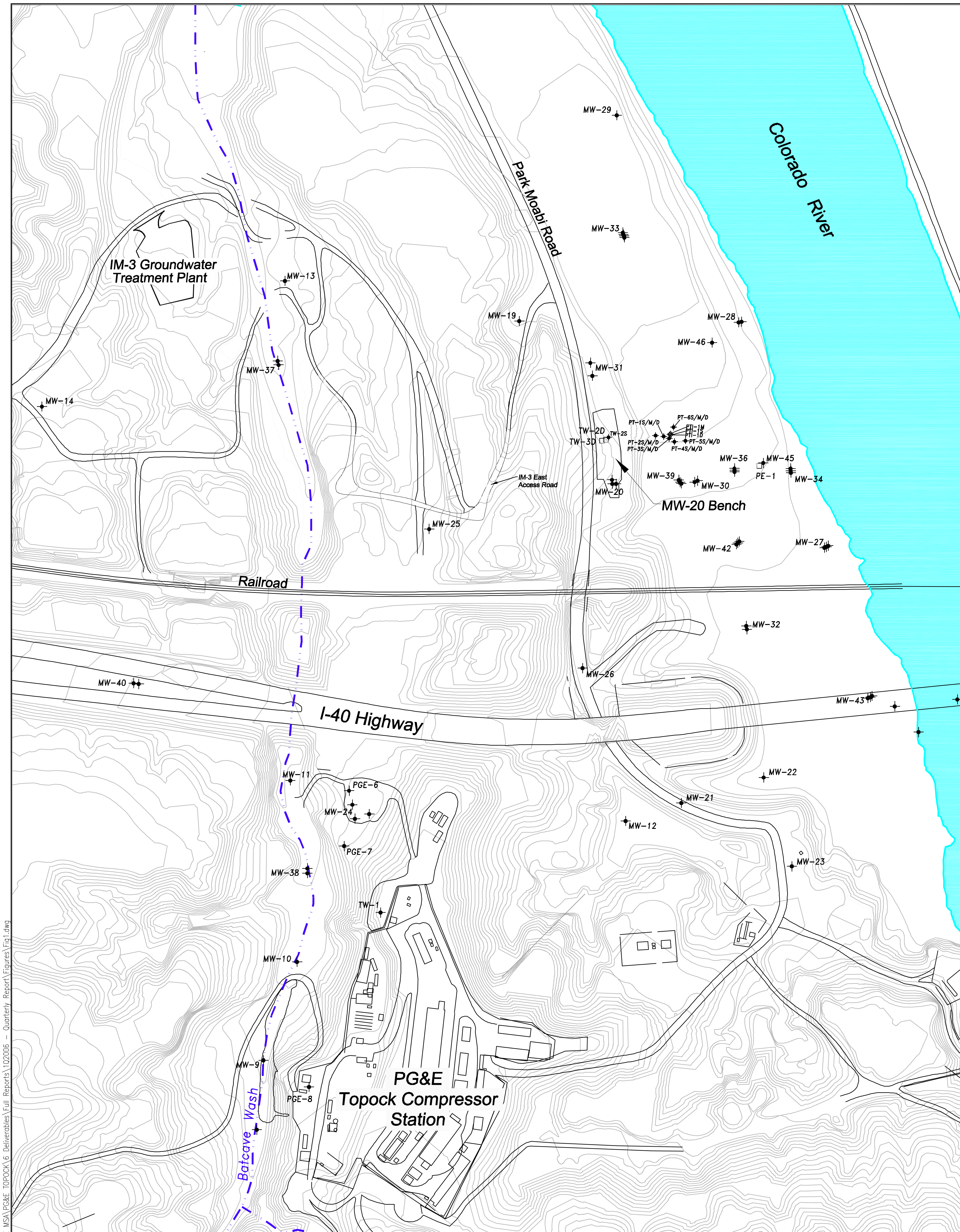
Location Name	Date	Screen Interval (ft bgs)	Mearsuring Point Eleveation (ft amsl)	Alkalinity as CaCO3 (mg/L)	Chloride (mg/L)	Hexavalent Chromium (mg/L)	Total Dissolved Chromium (mg/L)	Total Ferrous Iron (mg/L)	Manganese (mg/L)	Nitrate (mg/L)	pH	SC (µS/cm)	Sulfate (mg/L)	TDS (mg/L)	TOC (mg/L)	DO (mg/L)
MW-38D	5-May-04	163-183	525.31	---	---	0.0331	0.0296	---	---	---	7.96	17,900	---	14,000	---	2.20
	10-Jun-04			33	6500	0.0769	0.0835	0.5	0.09	1.3	7.75	21,900	750	13,000	3	0.48
	23-Sep-04			---	---	---	---	---	---	---	7.76	1,740	---	---	---	4.51
	11-Mar-05			---	---	0.328	0.323	---	---	---	8.01	20,000	---	---	---	3.95
	17-Jun-05			---	---	0.202	0.175	---	---	---	8.5	4,980	---	---	---	1.66
	7-Oct-05			---	---	0.227	0.227 FF	---	---	---	7.95	21,500	---	---	---	1.07
	10-Mar-06			---	---	0.111	0.106 FF	---	---	---	7.85	23,500	---	---	---	2.09

Notes:

ft amsl	feet mean sea level
mg/L	milligrams per liter
µS/cm	microSiemens per centimeter
ft bgs	feet below ground surface
TDS	total dissolved solids
TOC	total organic carbon
DO	dissolved oxygen
CaCO3	hardness
FF	field filtered
---	not available

Appendix A

ARCADIS Experience Matrix



Source: MWH Draft In-Situ Hexavalent Chromium Reduction Pilot Test Work Plan, Upland Plume Treatment, 2006.

Legend

- Monitoring Well Locations
- Extraction Well Locations
- Injection Well Locations

0 FEET 300
SCALE

Project Director: N. MORGAN-BUTCHER	Area Manager: J. PETERS
Task Manager: H. VOSCOTT	Technical Review:
Drawing Date: 05 APR 06	Drawn By: M. CHIU

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SITE PLAN
PG&E TOPOCK FACILITY
NEEDLES, CALIFORNIA

Project Number: RC000689.0001

Figure: 1

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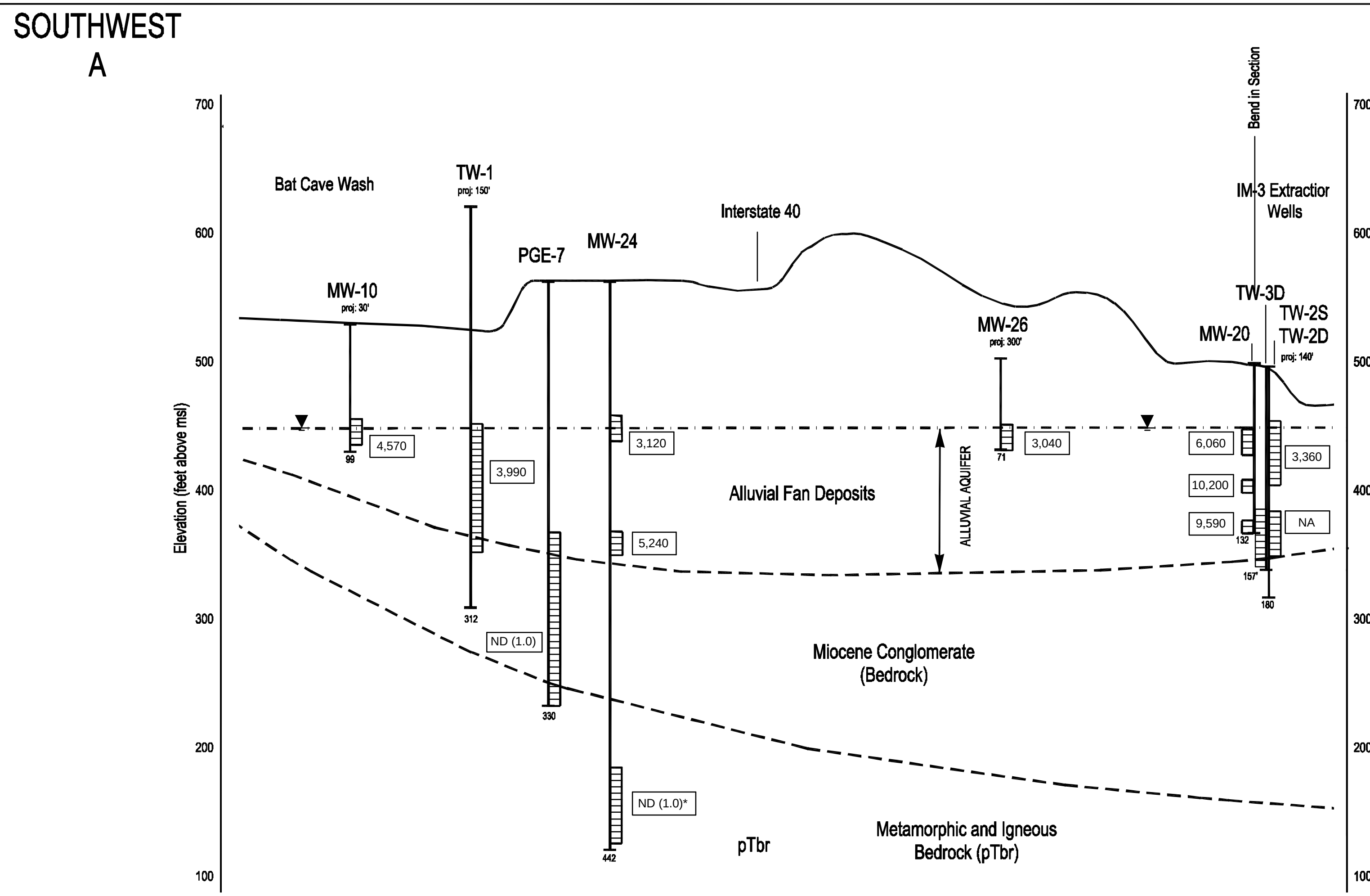

well ID MW-26

water level

well screen 3,040

total depth of boring 71

Hexavalent Chromium [Cr(VI)] Sampling Results, October 2005
Groundwater concentrations in micrograms per liter (ug/L)

Maximum Cr(VI) concentrations detected in October 2005 primary and duplicate samples
NA = Data not available
ND = Not detected at listed reporting limit
* = December 2005 sampling result presented when October 2005 data not available

NOTES:
Cross section prepared at approximate 3 times vertical exaggeration.

The contacts for primary hydrostratigraphic units (HS generalized for this cross-section.

Source: CH2MHILL Groundwater Monitoring Program, PG&E Topock Compressor Station, 2005 Annual Report.

Project Director	Area Manager
N. MORGAN-BUTCHER	J. PETERS
Task Manager	Technical Review
N. MORGAN-BUTCHER	J. ELY
Drawing Date	Drawn By
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VERTICAL CROSS SECTION
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Project Number
RC000689.0001

Figure
2

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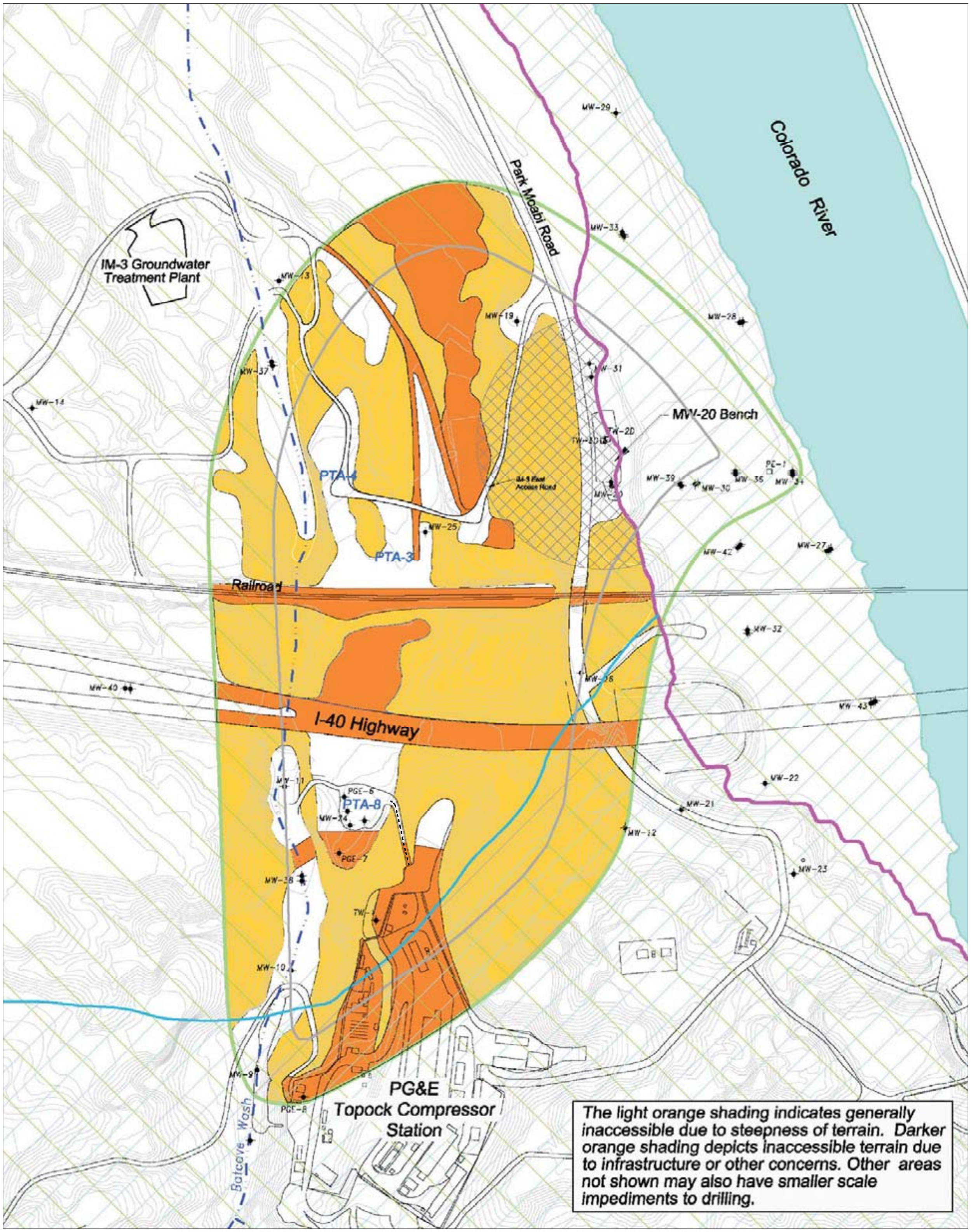

Source: MWH Draft In-Situ Hexavalent Chromium Reduction Pilot Test Work Plan, Upland Plume Treatment, 2006.

Contours based on March 2005 data

Legend

- Monitoring Well Locations
- Extraction Well Locations
- Interpreted Limit of Groundwater with a Concentration of Hexavalent Chromium that Exceeds 50 ppb
- Estimated Boundary Where Fluvial Deposits are Observed
- Estimated Boundary Where the Alluvial Aquifer Contains Less Than 50 Feet of Saturated Thickness
- PTA — Potential Pilot Test Area
- Area within 400 Feet of Extraction Well TW-3D
- Area within 200 Feet of Interpreted Limit of Groundwater with a Concentration of Hexavalent Chromium that Exceeds 50 ppb
- Area with Less than 50 Feet of Saturated Thickness of the Alluvial Aquifer or in Area of Fluvial Deposits
- Access route to pilot test area

0 FEET 300
SCALE

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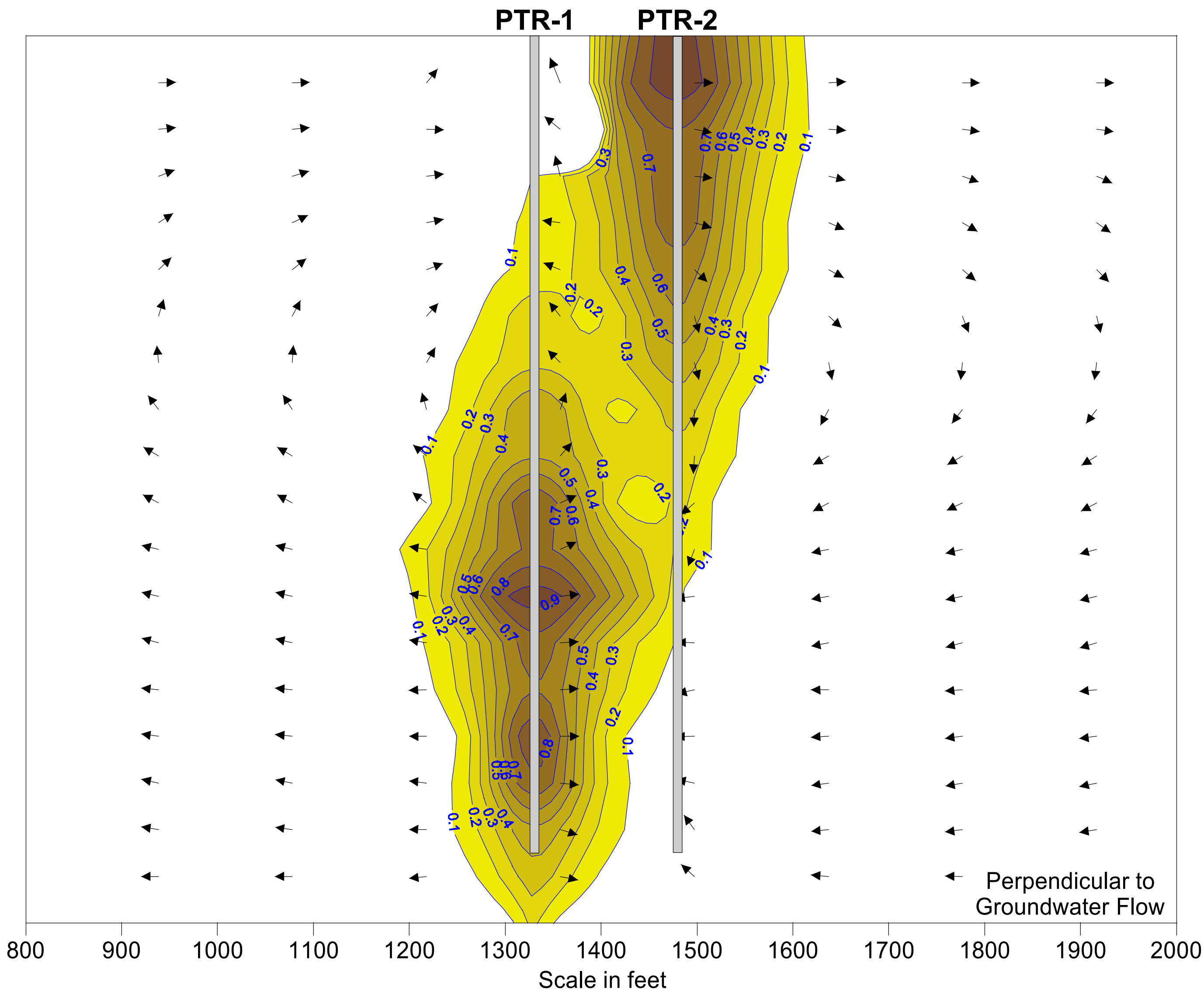
PROPOSED PILOT TEST AREAS
UPLAND AREA

PG&E TOPOCK FACILITY
NEEDLES, CALIFORNIA

PROJECT MANAGER	DEPARTMENT MANAGER
DRAFTER	CHECKED
PROJECT NUMBER RC000689.0001	DRAWING NUMBER 3



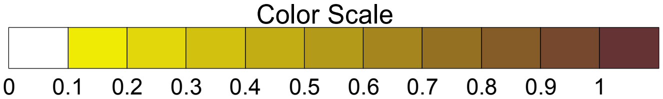
LEGEND

— 0.1 — Simulated Substrate Percent Fraction

↗ Groundwater Flow Direction

Coverage in wells over a six month time period

Simulated Substrate Percent Fraction
Color Scale



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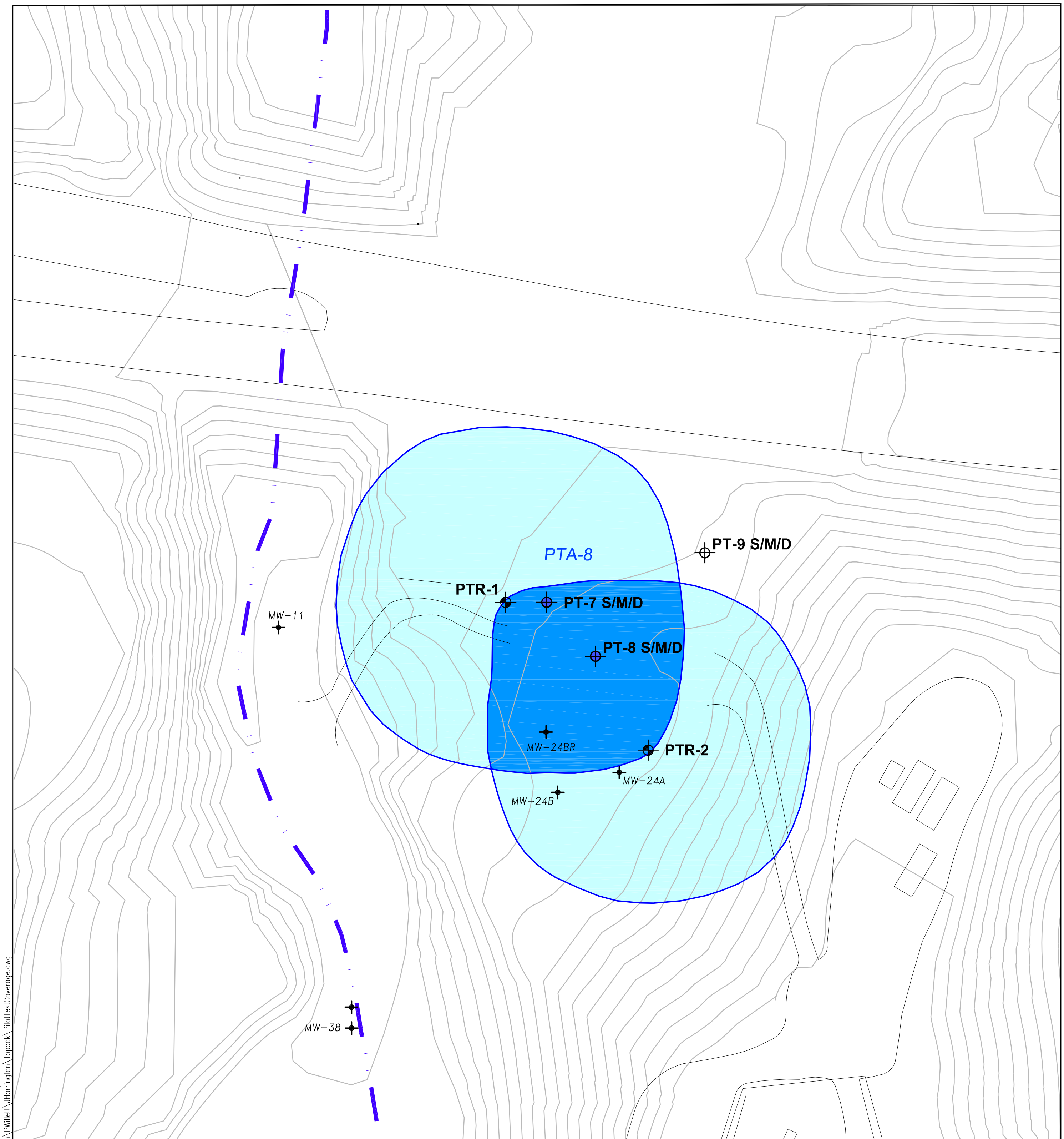
MODEL SIMULATION OF COVERAGE BY TWO RECIRCULATION WELLS OPERATING IN REVERSE CIRCULATION PATTERNS
UPLAND AREA

PG&E TOPOCK FACILITY
NEEDLES, CALIFORNIA

PROJECT MANAGER AJ	DEPARTMENT MANAGER MPK
DRAFTER JWR	CHECKED JE
PROJECT NUMBER RC000689.0001	DRAWING NUMBER 4



Source: MWH Draft In-Situ Hexavalent Chromium Reduction Pilot Test Work Plan, Upland Plume Treatment, 2006.

Legend

- *Existing Monitoring Well Locations*
- *Pilot Test Monitoring Well Locations*
- *Pilot Test Recirculation Well Locations*
- *Total Organic Carbon Coverage Area Over Six Months*

0 FEET 100
SCALE

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User Name : PWillett

Project Director	Area Manager
N. MORGAN-BUTCHER	J. PETERS
Task Manager	Technical Review
H. VOSCOTT	
Drawing Date	Drawn By
03 JUL 06	M. CHIU

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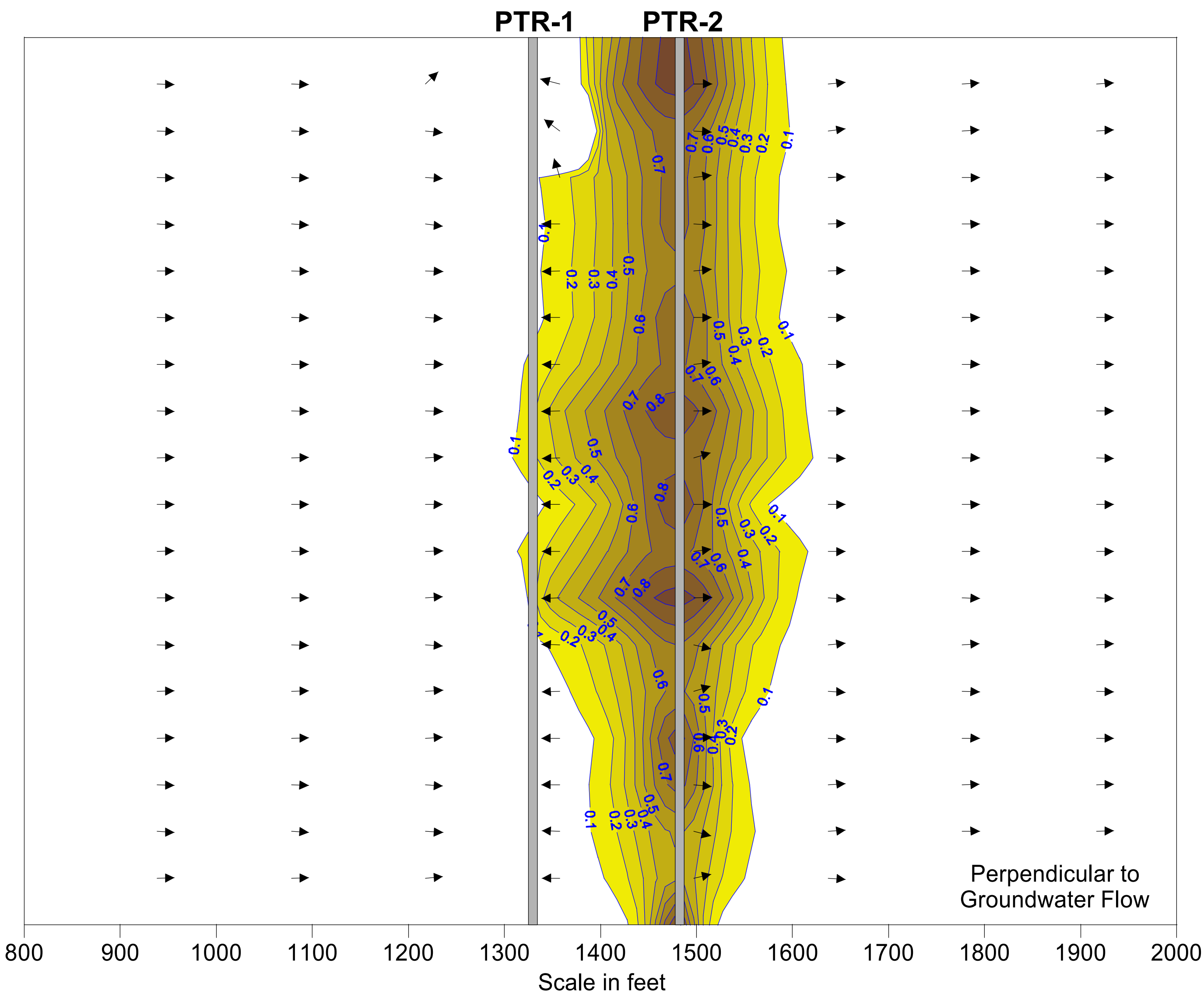
MODEL SIMULATION OF PILOT TEST LAYOUT COVERAGE OF TOTAL ORGANIC CARBON BETWEEN TWO RECIRCULATION WELLS UPLAND AREA

PG&E TOPOCK FACILITY
NEEDLES, CALIFORNIA

Project Number
RC000689.0001

Figure
5



LEGEND

0.1 Simulated Substrate Percent Fraction

Groundwater Flow Direction

Coverage in wells over a six month time period

Simulated Substrate Percent Fraction
Color Scale

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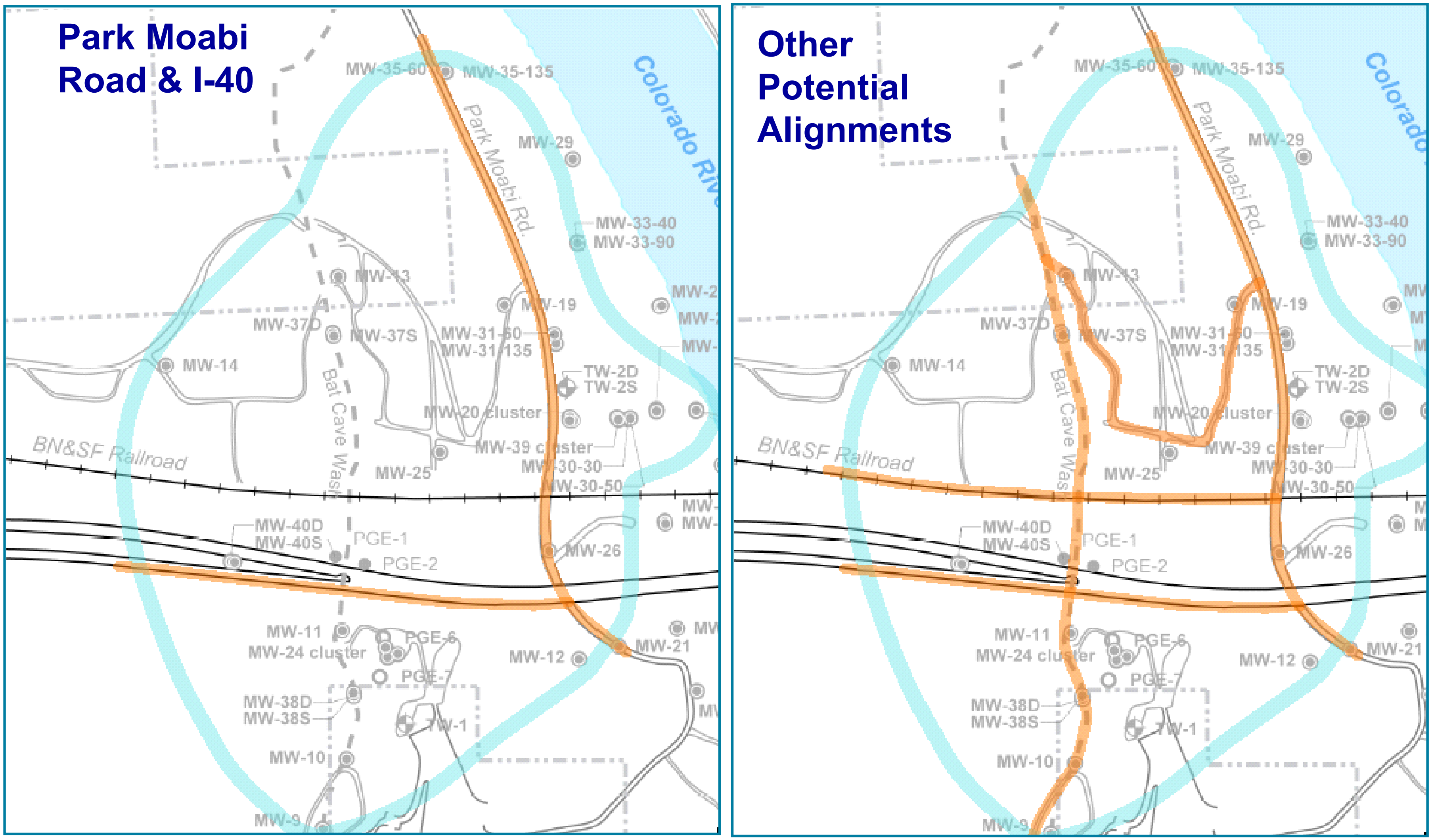
MODEL SIMULATION OF COVERAGE BY CIRCULATION BETWEEN TWO FULLY SCREENED WELLS
UPLAND AREA

PG&E TOPOCK FACILITY
NEEDLES, CALIFORNIA

PROJECT MANAGER AJ	DEPARTMENT MANAGER MPK
DRAFTER JWR	CHECKED JE
PROJECT NUMBER RC000689.0001	DRAWING NUMBER 6



LEGEND

Monitoring Well

Extraction Well

Potential Alignments

Approximate Hexavalent Chromium Groundwater Plume

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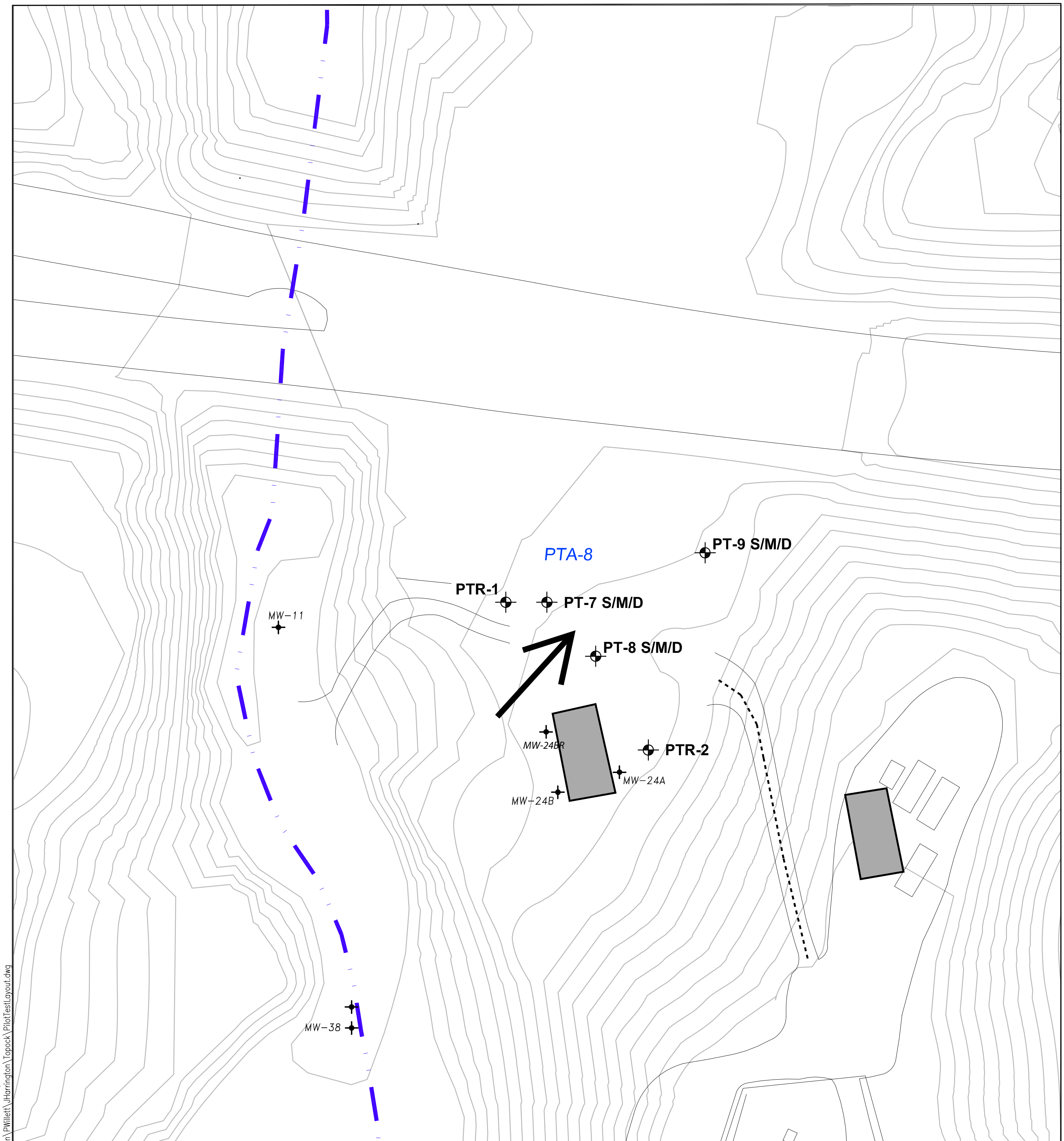
POTENTIAL FULL SCALE
IN-SITU BARRIER ALIGNMENTS

PG&E TOPOCK FACILITY
NEEDLES, CALIFORNIA

PROJECT MANAGER AJ	DEPARTMENT MANAGER MPK
DRAWN JWR	CHECKED JE
PROJECT NUMBER RC000689.0001	DRAWING NUMBER 7



Source: MWH Draft In-Situ Hexavalent Chromium Reduction Pilot Test Work Plan, Upland Plume Treatment, 2006.

Legend

- Monitoring Well Locations
- Extraction Well Locations
- Recirculation Well Locations
- Groundwater Flow Direction
- Access Route to Pilot Test Area
- Potential Staging Areas

0 FEET 100
SCALE

Project Director	Area Manager		
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Task Manager	Technical Review		
H. VOSCOTT			
Drawing Date	Drawn By		
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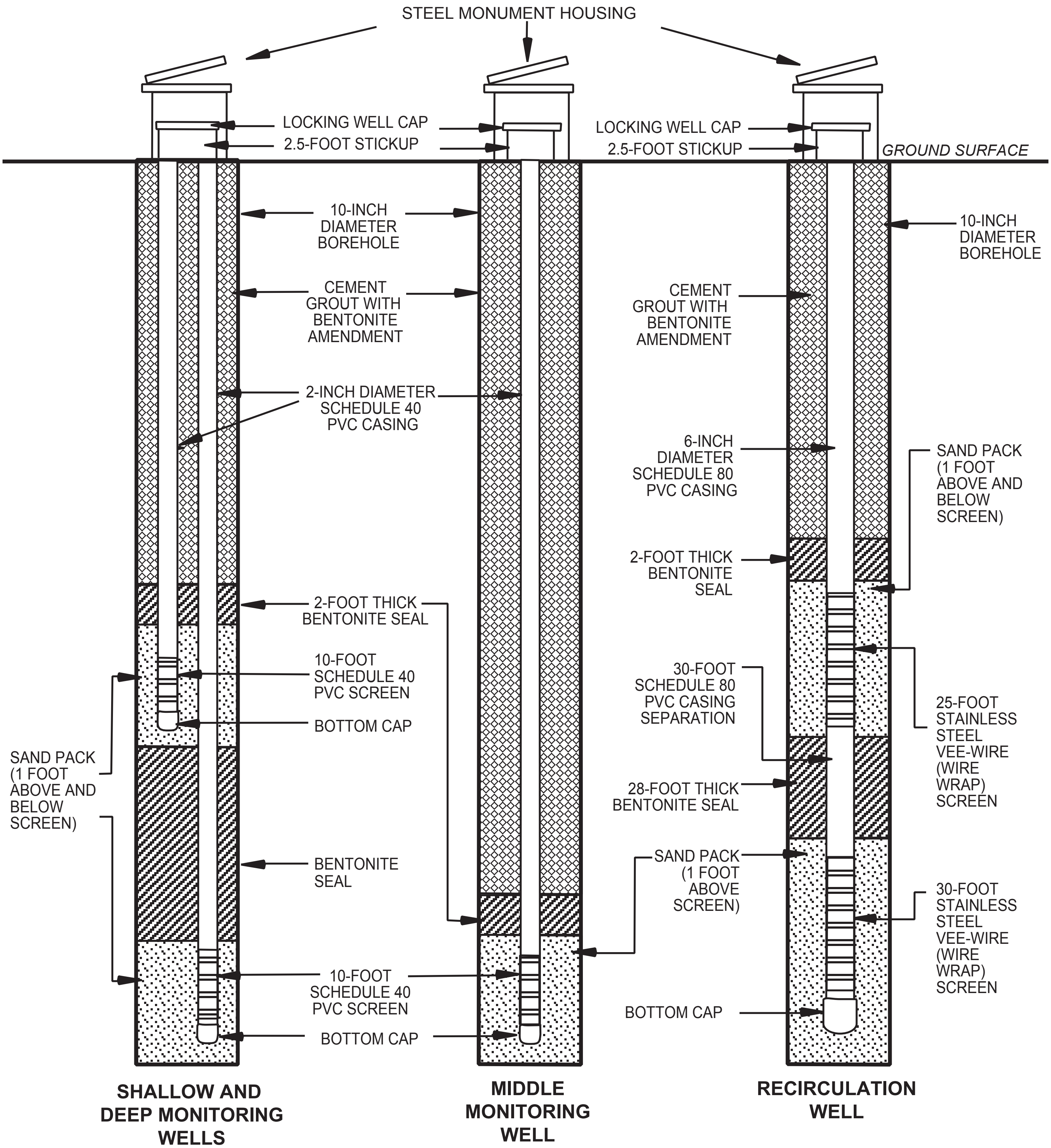
PILOT TEST LAYOUT
PLAN VIEW
UPLAND AREA

PG&E TOPOCK FACILITY
NEEDLES, CALIFORNIA

Project Number: RC000689.0001

Figure: 8



(DIAGRAMS NOT TO SCALE)

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Project Manager: N. MORGAN-BUTCHER	Project Director: J. PETERS
Task Manager: N. MORGAN0BUTCHER	Technical Review: J. ELY
Drawing Date: 28 SEP 06	Drawn By: M. CHIU

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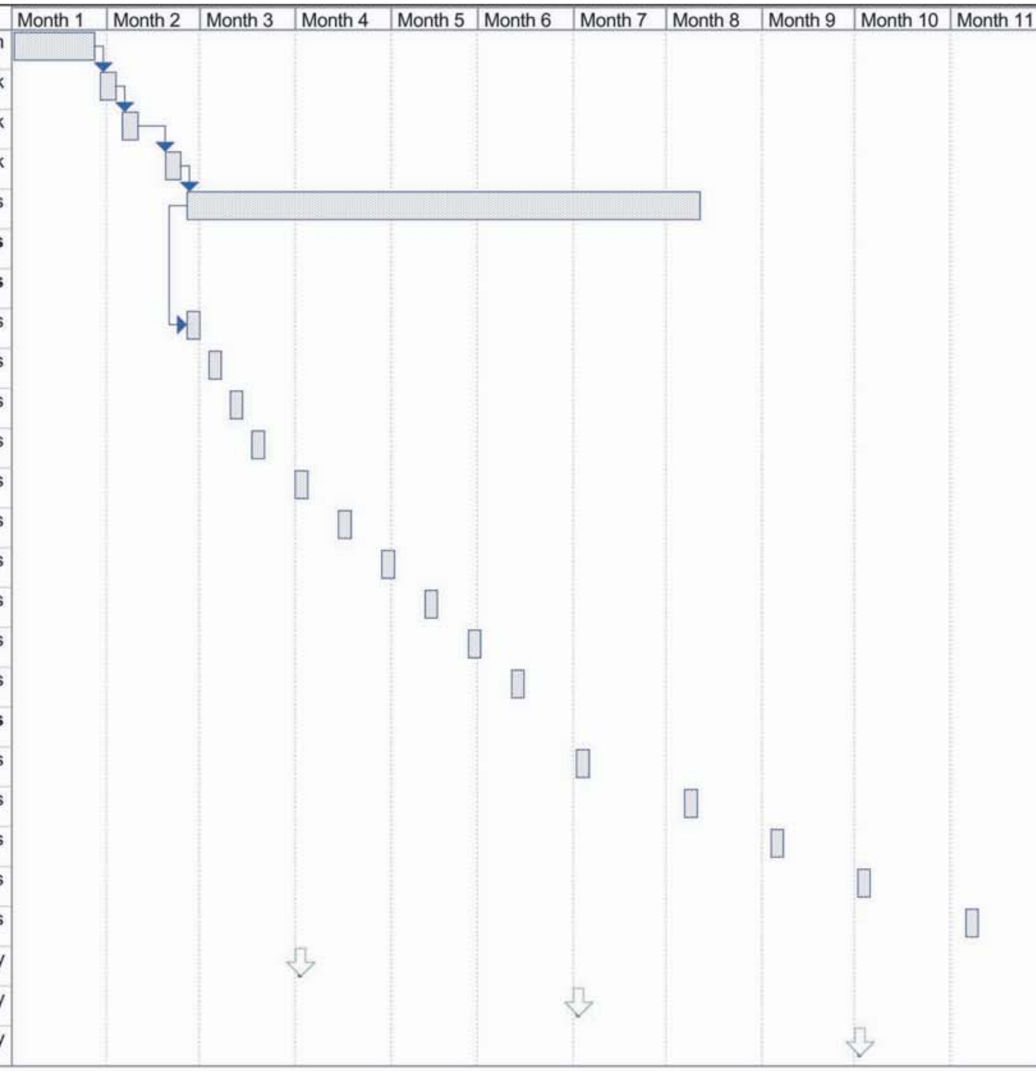
TYPICAL WELL CONSTRUCTION DIAGRAM

PG&E TOPOCK FACILITY
NEEDLES, CALIFORNIA

Project Number: RC000689.0001

Figure: 9

ID	Task Name	Duration
1	Well Installation	1 mon
2	Installation of pilot test equipment	1 wk
3	Baseline Sampling Event 1	1 wk
4	Baseline Sampling Event 2	1 wk
5	Injection/recirculation of the organic substrate	6 mons
6	**Groundwater Monitoring - Post Injection**	**184 days**
7	**Weekly Monitoring**	**79 days**
8	Weekly Monitoring Week 1	4 days
9	Weekly Monitoring Week 2	4 days
10	Weekly Monitoring Week 3	4 days
11	Weekly Monitoring Week 4	4 days
12	Weekly Monitoring Week 6	4 days
13	Weekly Monitoring Week 8	4 days
14	Weekly Monitoring Week 10	4 days
15	Weekly Monitoring Week 12	4 days
16	Weekly Monitoring Week 14	4 days
17	Weekly Monitoring Week 16	4 days
18	**Monthly Monitoring**	**94 days**
19	Monthly Monitoring Month 5	4 days
20	Monthly Monitoring Month 6	4 days
21	Monthly Monitoring Month 7	4 days
22	Monthly Monitoring Month 8	4 days
23	Monthly Monitoring Month 9	4 days
24	Quarterly Report Month 3	1 day
25	Quarterly Report Month 6	1 day
26	Quarterly Report Month 9	1 day



Project: PG&E Uplands Schedule Prelir
Date: Fri 7/28/06

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Project Director	Area Manager
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Drawing Date	Drawn By
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UPLAND IN SITU PILOT TEST SCHEDULE
PG&E TOPOCK FACILITY
NEEDLES, CALIFORNIA

Project Number
RC000689.0001

Figure
10

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