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April 6, 2007

Mr. Aaron Yue
Project Manager
California Department of Toxic Substances Control
5796 Corporate Avenue
Cypress, CA 90630

Subject: Phase II Chromium Isotope Study Work Plan
PG&E Topock Compressor Station, Needles, California

Dear Mr. Yue:

This letter transmits the *Phase II Chromium Isotope Study Work Plan.* The work plan is submitted in conformance with the California Department of Toxic Substances Control letter dated April 5, 2007. As discussed in the work plan, sampling of the wells for this study is intended to be performed concurrent with a routine sampling event under the Groundwater Monitoring Program and/or the Compliance Monitoring Program. A GMP/CMP event is scheduled for the week of April 30 – May 4, 2007 and PG&E would prefer to implement the sampling for this study at that time. Therefore DTSC approval of this work plan is requested by Tuesday April 24.

If you have any questions, please do not hesitate to contact me. I can be reached at (805) 234-2257.

Sincerely,

Yvonne Meeks

Enclosure

cc: Chris Guerre/DTSC
Karen Baker/DTSC
Casey Padgett/DOI
Peter Martin/USGS

Phase II Chromium Isotope Study Work Plan

PREPARED FOR: Pacific Gas and Electric

PREPARED BY: CH2M HILL

DATE: April 6, 2007

PROJECT NUMBER: 336424.NW.01

1.0 Introduction

Pacific Gas and Electric Company (PG&E) is addressing chromium in groundwater at the Topock Compressor Station in Needles, California, under the oversight of the California Environmental Protection Agency, Department of Toxic Substances Control (DTSC). The Topock Compressor Station is located in eastern San Bernardino County, approximately 15 miles southeast of Needles, California (Figure 1).

DTSC has directed PG&E to perform a groundwater study of stable chromium isotope signatures in and around the Topock Facility (DTSC, 2006a). The objectives of this Chromium Isotope Study are as follows:

- Assess whether chromium isotopes can be used to distinguish anthropogenic chromium from naturally occurring chromium in groundwater.
- If chromium isotopes can be used to distinguish anthropogenic and naturally occurring chromium, determine whether chromium isotopes can assist with delineation of the chromium plume.
- Evaluate the utility of chromium isotopes for the assessment of the degree of chromium reduction that is occurring in the floodplain area.

CH2M HILL is coordinating with the United States Geological Survey (USGS) to plan and conduct the Chromium Isotope Study.

Phase I of the Chromium Isotope Study was implemented in 2006 as approved by DTSC (DTSC, 2006b and 2006c). Phase I activities were performed in accordance with the work plan dated April 7, 2006 (CH2M HILL, 2006a). Phase I samples were collected from 27 existing wells in May 2006, and analytical results were reported to DTSC in August 2006 (CH2M HILL, 2006b). Following laboratory analysis and data interpretation by both CH2M HILL and USGS, results were discussed at Technical Workgroup (TWG) Meetings in September and December 2006, and were summarized at the Consultative Workgroup (CWG) Meeting in December 2006.

The Phase I study was determined to be inconclusive. Additional data were needed to determine if stable chromium isotopes could provide a useful tool for distinguishing between natural and anthropogenic chromium in groundwater at the Topock site. CH2M HILL and USGS collaborated to identify a set of potential wells to be sampled in a

Phase II isotope study. This list of wells was discussed in the TWG meeting on February 21, 2007. This work plan describes procedures for collection and analysis of samples, along with interpretation of data, for a Phase II Chromium Isotope Study.

2.0 Results of Phase I Study

This section provides a brief summary of the Phase I study results and describes the objectives for the Phase II study. A discussion on the chemistry of chromium, chromium isotope theory, and potential application at the Topock site is provided in the original (Phase I) work plan (CH2M HILL, 2006a).

Chromium isotope levels are expressed as parts per thousand (per mil) deviations from an international chromium isotope standard, and are denoted in the text as $\delta^{53}Cr$. Previous published studies have shown that both natural minerals and anthropogenic sources of chromium should have $\delta^{53}Cr$ values around 0.0 per mil. Over the long course of natural groundwater flowpaths, naturally occurring Cr(VI) is expected to develop a higher $\delta^{53}Cr$ value that reflects episodes of partial reduction along the flowpath. Reduction selectively removes the lighter fraction of chromium (i.e., the most common isotope, ^{52}Cr). This has the effect of slightly enriching the fraction of ^{53}Cr in groundwater and thereby increasing the $\delta^{53}Cr$ value above zero. By contrast, the value of $\delta^{53}Cr$ in any anthropogenic chromium in groundwater would be expected to remain around zero, since the flowpath of anthropogenic chromium in groundwater is generally much shorter than that of natural chromium in groundwater, resulting in fewer opportunities for chromium reduction along the way.

Figures 2 and 3 show the Phase I well locations for regional and Topock site areas, respectively. Figure 3 also provides the Phase I $\delta^{53}Cr$ results. On the basis of DTSC's direction, the 27 Phase I wells were grouped into three categories: reference wells (9), plume margin wells (8), and plume wells (10). Reference wells were those corresponding to Groundwater Background Study (GBS) (CH2M HILL, 2007) locations or wells located in the IM3 injection area (CW- or OW- wells). This nine-well group was limited to California wells, seven of which were within the Topock site area (Figure 3). Plume wells were those located within the area encompassed by the 50 µg/L plume contour interval, and plume margin wells were considered to be close to the edge yet outside of this area.

A plot of $\delta^{53}Cr$ vs. Cr(VI) concentrations is provided in Figure 4. The Cr(VI) concentrations are plotted on a logarithmic scale so that lower concentrations will not all plot as a cluster near the y-axis. Figure 4 shows most of the plume wells with $\delta^{53}Cr$ values in the range of 0 to 1 per mil. This observation follows the expected model of plume groundwater described above; i.e., it should be near zero due to limited opportunities for reduction to occur.

The sample from MW-39-60 was expected to demonstrate a rise in $\delta^{53}Cr$ in this floodplain location, where Cr(VI) is known to be undergoing chemical reduction. A distinct decrease in Cr(VI) has been observed at all wells in the MW-39 cluster over the past 3 years. The MW-39-60 sample, which contained only 1.1 µg/L Cr(VI), was expected to show an elevated $\delta^{53}Cr$ value because it was thought to contain the very last of the Cr(VI) that had not yet been chemically reduced. The measured $\delta^{53}Cr$ value for this well was 1.26 per mil, only slightly higher than the range of the other plume wells. Following examination of the data,

it was decided that additional plume samples with concentrations below 800 µg/L were needed to understand whether or not plume samples change their isotopic signature as concentrations decrease within the plume.

The $\delta^{53}Cr$ values in the plume margin and reference samples range between 0.62 and 3.95 per mil (Figure 4). Although there is significant overlap between the groups, the mean of margin well samples (3.01 per mil) is greater than the mean of reference well samples (2.29 per mil). The reason for this is unknown, and it was decided that additional reference well samples should be collected to more clearly identify the difference (or similarity) between these groups. There are no additional margin wells available that were not sampled in Phase I.

3.0 Phase II Study Approach

3.1 Wells to be Sampled

To address the additional data to be collected for plume wells and reference wells described in Section 2, groundwater samples will be collected from 26 monitoring and water-supply wells during Phase II. The samples will be collected from 8 wells within the plume in the alluvial fan deposits, 2 wells in the plume in the floodplain (fluvial) deposits, and 16 wells considered to be background wells on both the California and Arizona sides of the Colorado River. Table 1 provides a listing of the wells to be sampled for the Phase II study, and Figures 2 and 3 show the well locations. Two wells, MW-34-100 and OW-3M, proposed to be sampled in Phase II, were also sampled in Phase I, as described in Table 1.

3.2 Sample Collection and Analysis

The Phase II wells are proposed to be sampled concurrently with a routine sampling event under the Groundwater Monitoring Program and/or the Compliance Monitoring Program. Standard well purging procedures to be used in association with the study are presented in the Field Procedures Manual (CH2M HILL, 2005). The CH2M HILL field team will purge the wells, sample for total and hexavalent chromium and general chemistry parameters, and then collect an unpreserved sample to be shipped to the USGS laboratory in Menlo Park, California, for chromium isotope analysis. Duplicate samples will be collected from a minimum of 10 percent of the wells (i.e., at least three wells). Duplicates will be chosen at wells from the lower, middle, and upper ranges of the Cr(VI) concentration distribution.

Collected samples will be assigned a numerical identification number (1000 through 1039). The well identification/sample identification pairs will be entered into the Topock database and will not be made available to the analytical laboratories.

The chromium isotope sample will be filtered using a 0.2-micrometer (µm) filter. Upon arrival at the USGS laboratory, the Cr(VI) fraction will be extracted by passing the sample through an anion exchange resin. Extracted Cr(VI) then will be flushed off the resin and used in isotope analysis. Chromium isotope analysis will be accomplished using thermal-ionization mass spectrometry (TIMS) by application of extracted Cr to a solid source filament using the silica gel technique to enhance production of thermal ions (Ball, 1996).

Samples collected as part of the Phase II study will also be analyzed for the suite of general chemistry and metals parameters shown in Tables 2 and 3 by a California Department of

Health Services certified laboratory. In addition to chromium, 17 other trace metals were analyzed in Phase I samples. Of those metals, only arsenic, barium, molybdenum, and vanadium were consistently detected, and therefore were chosen to remain on the analyte list for Phase II. Holding times and quality assurance/quality control procedures for the general chemistry and metals analyses will follow standard procedures (CH2M HILL, 2005).

3.3 Quality Control and Data Management

Quality control procedures will be implemented for both field activities and laboratory work associated with the study. Detailed descriptions of quality control procedures specific to water quality sampling at the Topock site are provided in the *Quality Assurance Project Plan for Water Quality Sampling and Analysis* (QAPP) (Appendix D of the Topock Field Procedures Manual [CH2M HILL, 2005]). The quality control procedure used during laboratory purification of Cr fractions and measurement of Cr isotopic compositions involves processing of the National Institute of Standards and Testing (NIST) 979 Cr reference metal through the entire analytical procedure several times over the course of the study, and demonstrating consistency and accuracy of derived Cr isotopic compositions. Quality control procedures followed by USGS personnel are described in McCleskey et al. (2004).

3.3.1 Data Validation

The analytical results of groundwater samples will be evaluated to verify whether the data are sufficiently accurate, precise, and representative of site conditions for decision making purposes in support of ongoing site investigation and remediation activities. Details regarding data validation for the general chemistry and metals analyses are provided in the QAPP (CH2M HILL, 2005).

3.3.2 Data Management

Management of data generated from the study will be conducted in accordance with the *PG&E Program Data Management Plan* (CH2M HILL, 2004). The Data Management Plan outlines standardized procedures for field data collection and review, analytical data loading into the information system (environmental database), verification of the uploaded data, quality assurance/quality control procedures associated with data management, and reporting formats.

3.4 Data Evaluation

The objective of this sampling, as stated in Section 1.0, is to determine whether chromium isotopes may be useful in helping to distinguish anthropogenic Cr(VI) in groundwater from natural Cr(VI) in the Topock area. Data evaluation will be a cooperative effort between CH2M HILL and USGS. Both parties will conduct statistical analysis of the data, evaluate the geochemical data, and compare results during regular communications. Detailed data evaluation procedures are provided in the Phase I Chromium Isotope Study Workplan (CH2M HILL, 2006a).

3.5 Project Schedule

The schedule for the implementation of the Phase II Chromium Isotope Study is provided in Table 4. The implementation schedule is subject to obtaining work plan approval from DTSC, as well as access to offsite wells.

4.0 References

Ball, J.W. 1996. *Thermodynamic and isotope systematics of chromium chemistry*. Ph.D. Dissertation, University of Arizona, 288 p.

CH2M HILL. 2004. *PG&E Program Data Management Plan*. Report to PG&E. November.

CH2M HILL. 2005. *Sampling, Analysis, and Field Procedures Manual, PG&E Topock Program, Revision 1*. Report to PG&E. March 31.

CH2M HILL. 2006a. Chromium Isotope Study Workplan. Report submitted to DTSC. April 7.

CH2M HILL. 2006b. E-mail from Brian Schroth (CH2M HILL) to Chris Guerre, Norman Shopay, Karen Baker, Kate Burger, and Aaron Yue (DTSC) on August 11.

CH2M HILL. 2007. Groundwater Background Study Steps 3 and 4 Results. Report submitted to DTSC. January 26.

Department of Toxic Substances Control (DTSC). 2006a. Requirement for chromium isotope study, Pacific Gas & Electric Company, Topock Compressor Station, Needles, California. EPA ID No. CAT080011729. Letter to Yvonne Meeks (PG&E). January 13.

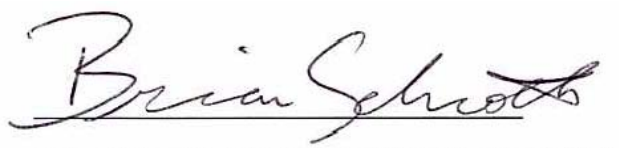
Department of Toxic Substances Control (DTSC). 2006b. Conditional Approval of Chromium Isotope Study Workplan, Pacific Gas & Electric Company, Topock Compressor Station, Needles, California. EPA ID No. CAT080011729. Letter to Yvonne Meeks (PG&E). March 22.

Department of Toxic Substances Control (DTSC). 2006c. E-mail from Norman Shopay (DTSC) to Brian Schroth (CH2M HILL) and Yvonne Meeks (PG&E) on April 28.

McCleskey, R.B., D.K. Nordstrom, and C.A. Naus. 2004. Questa Baseline and Pre-Mining Ground-Water-Quality Investigation. 16. Quality Assurance and Quality Control for Water Analyses. USGS Open-File Report 2004-1341. 105 p.

5.0 Certification

This work plan was prepared by CH2M HILL under the supervision of the professional whose seal and signature appears hereon, in accordance with currently accepted professional practices; no warranty, expressed or implied, is made.



Brian Schroth, Professional Geologist #7423

Tables

TABLE 1
Reference and Plume Wells Selected for Sampling in Phase II of Chromium Isotope Study
Chromium Isotope Study Phase II Work Plan

Well Name	Site Aquifer Depth Zone[1]	Geologic Material at Screen	State	Location	Average Cr(VI) (µg/L)	Scheduled Sampling of Well under other Topock Site Monitoring Programs	Comments
Reference Wells							
CW-03M	Deep	Alluvial	CA	Northeast of IW-2	8.5	CMP-Q (Jan, April, July, Oct)	
CW-04M	Medium-Deep	Alluvial	CA	Northwest of IW-2	13.5	CMP-Q (Jan, April, July, Oct)	
EPNG-2	NA	Alluvial	AZ	3.2 miles east of Topock Site	8.7	—	
GSRV-2	NA	Alluvial	AZ	1.9 miles northeast of Topock Site	27.1	—	
GSWC-2	NA	Alluvial	AZ	5.0 miles northeast of Topock Site	5	—	Close to GSWC-4, but shows low end of AZ Cr(VI) concentrations
GSWC-4	NA	Alluvial	AZ	4.5 miles northeast of Topock Site	10.1	—	
Langmaack	NA	Alluvial	AZ	3.4 miles northeast of Topock Site	20.7	—	
MW-15	Shallow	Alluvial	CA	North of Old Evaporation Ponds	10.9	—	Not in Groundwater Background Study
Needles MW-11	NA	Fluvial	CA	11 miles northwest of Topock Site	2.4	—	
OW-02S	Shallow	Alluvial	CA	East Mesa Injection Area	26.2	CMP-SA (April, Oct)	
OW-03M	Medium-Deep	Alluvial	CA	West Mesa	15.1	CMP- SA (April, Oct)	Sampled in Phase I, but had unusually low δ^{53}Cr; recommend resampling
OW-03S	Shallow	Alluvial	CA	West Mesa	17.9	CMP-SA (April, Oct)	
OW-05S	Shallow	Alluvial	CA	East Mesa Injection Area	25.3	CMP-SA (April, Oct)	
P-2	Deep	Alluvial	CA	New Ponds Area	29.2	—	
Tayloe	NA	Alluvial	CA	7.2 miles northwest of Topock Site	0.6	—	
TMLP-2	NA	Alluvial	AZ	6.3 miles east of Topock Site	17	—	

TABLE 1
Reference and Plume Wells Selected for Sampling in Phase II of Chromium Isotope Study
Chromium Isotope Study Phase II Work Plan

Well Name	Site Aquifer Depth Zone[1]	Geologic Material at Screen	State	Location	Average Cr(VI) (µg/L)	Scheduled Sampling of Well under other Topock Site Monitoring Programs	Comments
				Plume Wells			
MW-09	Shallow	Alluvial	CA	Bat Cave Wash near original discharge	342	GMP-A (October)	Upgradient of MW-10 with much lower Cr(VI)
MW-11	Shallow	Alluvial	CA	Bat Cave Wash near original discharge	625	GMP-A (October)	Downgradient of MW-10 with lower Cr(VI)
MW-31-135	Deep	Alluvial	CA	North end of 20-bench	285	GMP-A (October)	Near MW-50-095, but deeper screened depth with greater reduction potential
MW-34-100	Deep	Fluvial	CA	Eastern floodplain near river	671	GMP-(Biweekly)	Sampled in Phase I, but decreasing trend in Cr(VI) may help calibrate δ^{53}Cr
MW-38D	Deep	Alluvial	CA	Bat Cave Wash near original discharge	191	GMP-A (October)	Deep Bat Cave Wash well
MW-40D	Deep	Alluvial	CA	Western edge of plume at I-40 median	51	GMP-Q (Mar, May, Oct, Dec)	MW-40S showed high δ^{53}Cr; value from deeper well will provide additional data
MW-44-125	Deep	Alluvial	CA	Eastern floodplain north of PE-1	372	GMP-Q (Mar, May, Oct, Dec)	Deep downgradient well
MW-45-095	Deep	Fluvial	CA	Eastern floodplain near PE-1	228	Not Sampled	Deep fluvial well to compare to MW-34-100
MW-46-175	Deep	Alluvial	CA	Eastern floodplain at north edge of plume	191	GMP-Q (Mar, May, Oct, Dec)	Near plume edge
MW-47-055	Shallow	Alluvial	CA	Park Moabi Road at northern edge of plume	38.2	GMP-Q (Mar, May, Oct, Dec)	Two most recent samples were above 50 µg/L

Note:

[1]Aquifer depth zone is based on screen elevation and not hydrostratigraphy. It provides a relative comparison of screened intervals of Topock Site wells. The designation is not applicable to offsite wells, so the term "NA" is used for these wells.

GMP = Groundwater Monitoring Program

CMP = Compliance Monitoring Program

TABLE 2
Analytical Methods to be Used for General Chemistry Parameters
Chromium Isotope Study Phase II Work Plan

Parameter	Analytical Method
Alkalinity	EPA 310.1
Ammonia	EPA 350.3
Boron	SW6010B/SW7000 series
Calcium	SW6010B/SW7000 series
Chloride	EPA 300
Fluoride	EPA 300
Iron, total	SW6010B/SW7000 series
Magnesium	SW6010B/SW7000 series
Manganese	SW6010B/SW7000 series
Nitrate	EPA 300
pH (lab/field)	EPA 150.1/SW9040
Potassium	SW6010B/SW7000 series
Silica	SW6010B/SW7000 series
Sulfate	EPA 300.0
Sodium	SW6010B/SW7000 series
Specific Conductance (lab/field)	EPA 120.1/SW9050
Sulfide	EPA 376.1
Total dissolved solids	EPA 160.1
Total Kjeldahl nitrogen	EPA 351.4
Total organic carbon	EPA 415.1 / SM 5310 B-D
^{2}H	Laboratory SOP (continuous flow isotope ratio mass spectrometry [CF-IRMS])
^{18}O	Laboratory SOP (continuous flow isotope ratio mass spectrometry [CF-IRMS])

Notes:
SM – Standard Methods

SW – SW846 Update III EPA – EPA 600 Series for Chemical Analysis of Water and Wastes

SOP – standard operating procedure

TABLE 3
Analytical Methods to be Used for Trace Metal Analysis
Chromium Isotope Study Phase II Work Plan

Parameter	Analytical Method
Arsenic	SW6010B/SW7000 series
Barium	SW6010B/SW7000 series
Chromium (total dissolved)	SW6010B/SW7000 series
Hexavalent Chromium	SW7196A/SW7199
Molybdenum	SW6010B/SW7000 series
Vanadium	SW6010B/SW7000 series

TABLE 4
Project Implementation Schedule
Chromium Isotope Study Phase II Work Plan

Activity	Duration
Collect samples from Phase II wells.	5 days: This sampling event would be coordinated with other sampling events at the Topock site
Sample analysis and validation from Phase II sampling	2 months
Data evaluation. Following completion of this step, preliminary results will be presented to the TWG presenting conclusions of the study and an outline of the report.	5 weeks
Complete report of findings, including both Phase I and Phase II results.	7 weeks

Figures

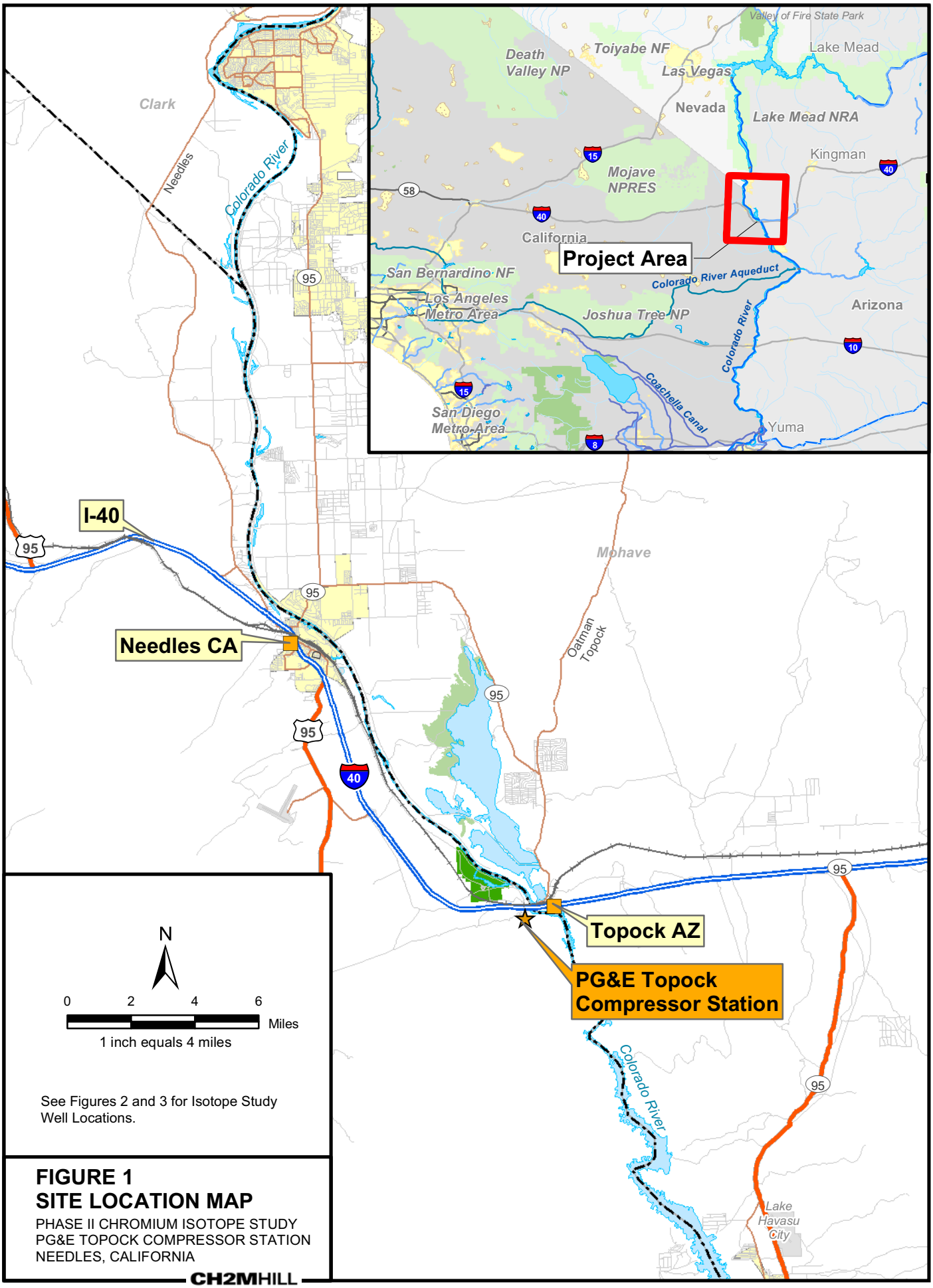


FIGURE 1
SITE LOCATION MAP
PHASE II CHROMIUM ISOTOPE STUDY
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

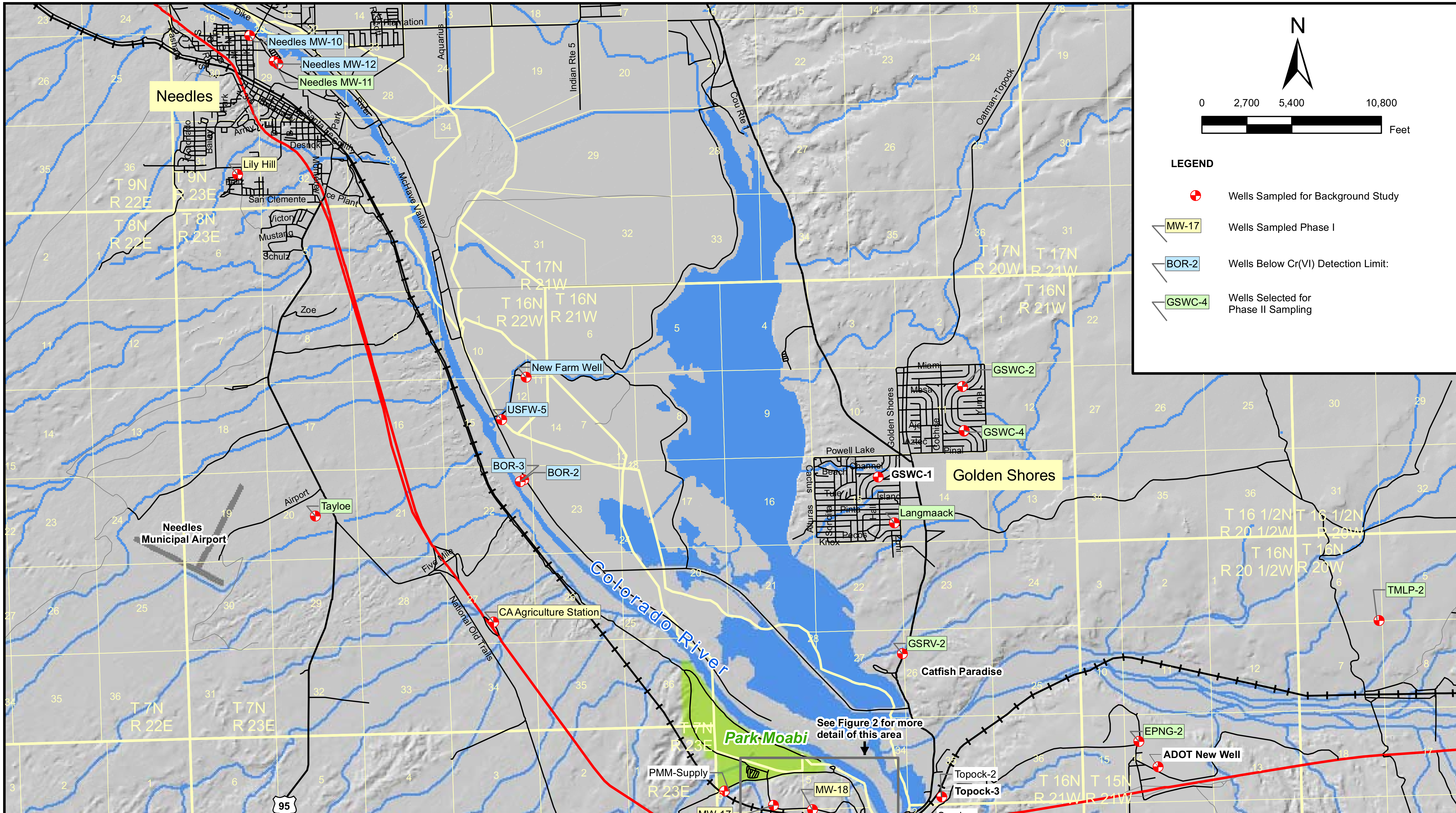


FIGURE 2
LOCATION OF CHROMIUM ISOTOPE STUDY WELLS
PHASE II CHROMIUM ISOTOPE STUDY
PG&E TOPOCK COMPRESSOR STATION AND VICINITY
NEEDLES, CALIFORNIA

CH2MHILL

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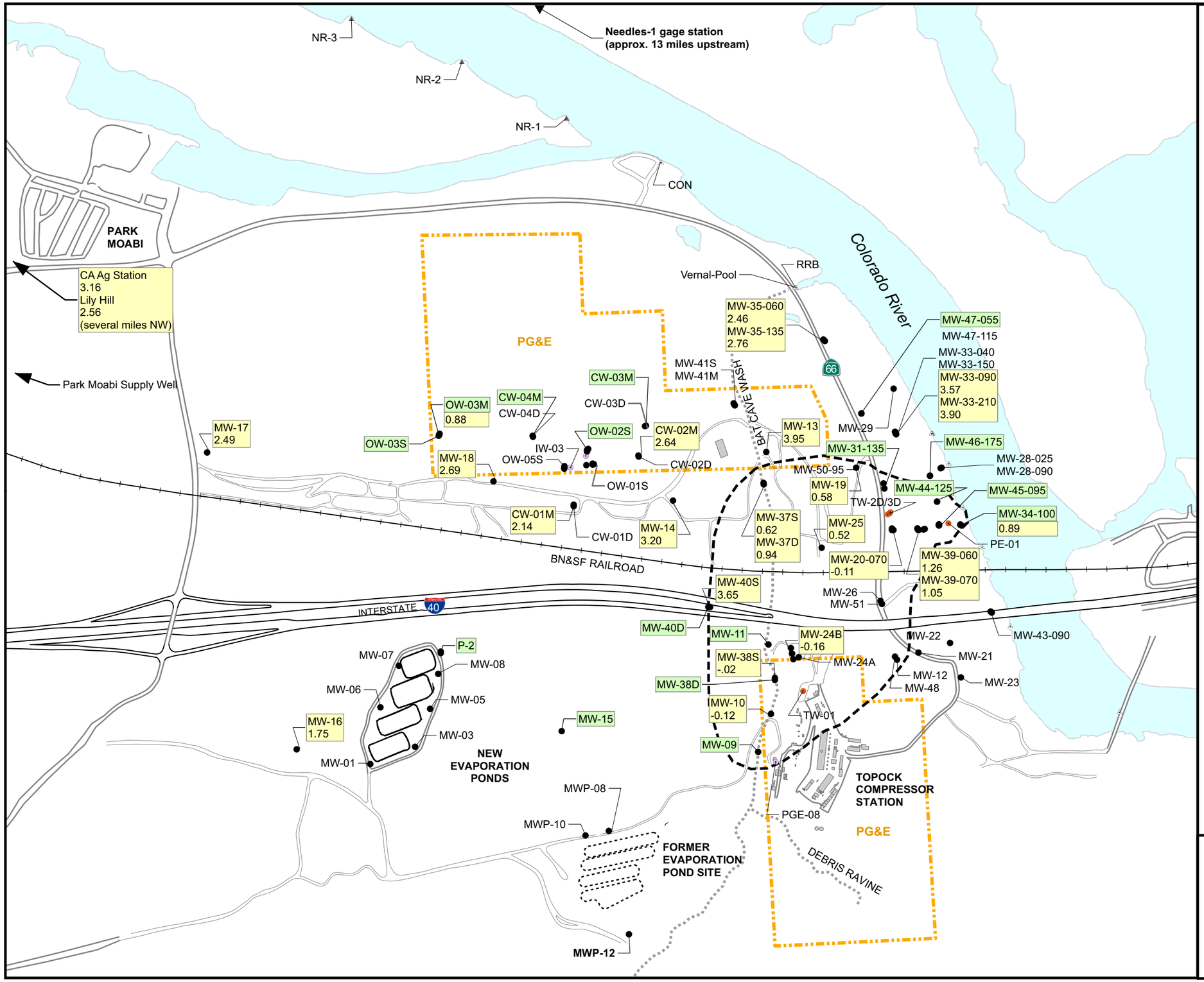

LEGEND

- Monitoring Well Cluster or Groundwater well
- Approximate 50 ppb Contour of Cr(VI) (varies with depth)
- MW-20-070 — Cr Isotope Study Wells Phase I
- MW-31-135 — Wells Selected for Phase II Sampling
- M or -70 = Specific well in cluster sampled in CIS Phase I
- 0.9 = δ^{53}Cr value, in ppt rel. to standard

Note:
Wells OW-3M and MW-34-100 were sampled in Phase I and will be resampled in Phase II. See text for explanation.

N

0 800 1,600 Feet

1 inch equals 800 feet

California State Plane NAD83 Zone 5 US Feet

FIGURE 3
PHASE I RESULTS AND SELECTED PHASE II WELLS

PHASE II CHROMIUM ISOTOPE STUDY
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

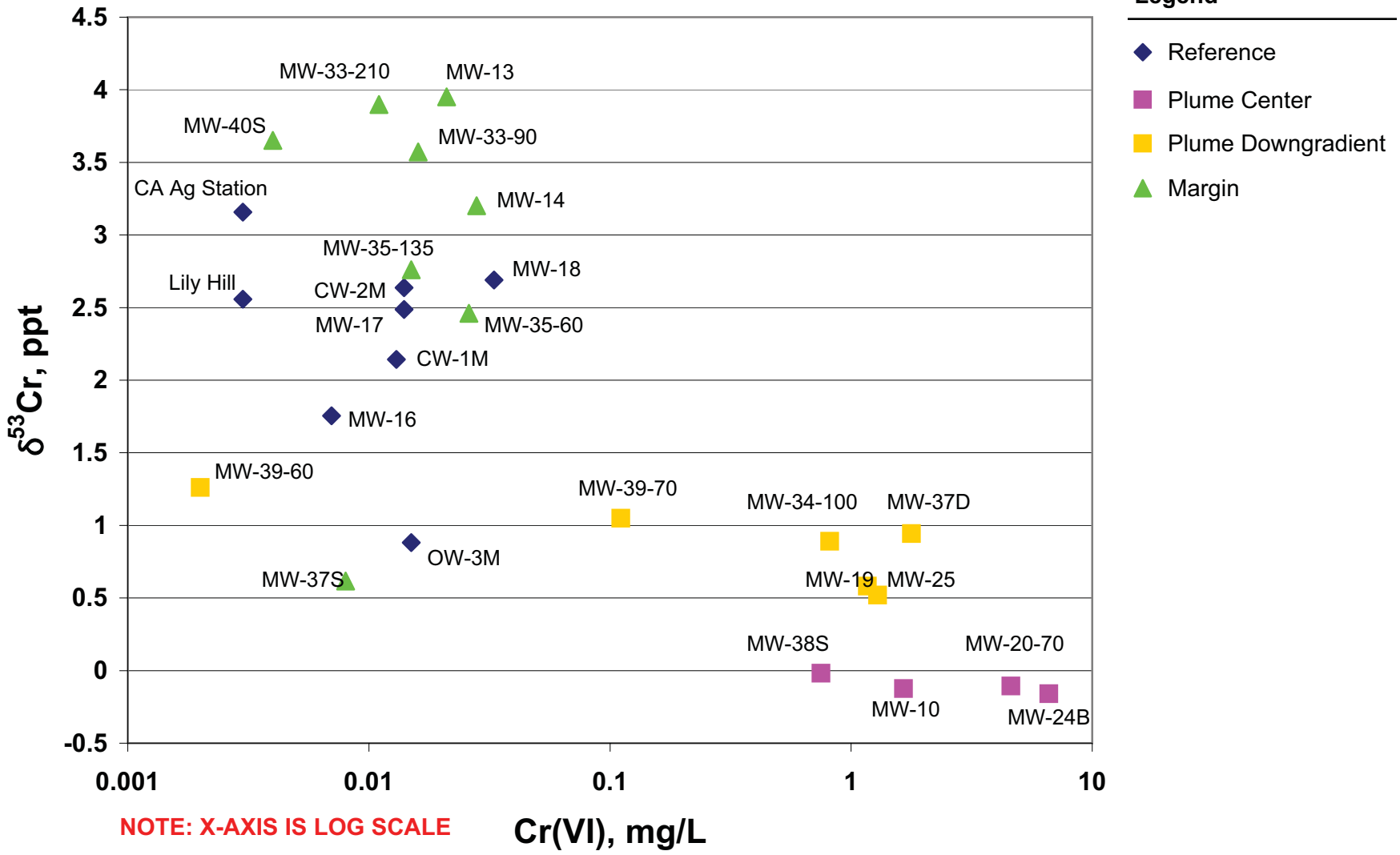

FIGURE 4
PHASE I CHROMIUM ISOTOPE VALUES VS. Cr(VI) CONCENTRATIONS
PHASE II CHROMIUM ISOTOPE STUDY
PG&E TOPOCK COMPRESSOR STATION & VICINITY
NEEDLES, CALIFORNIA

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