Pacific Gas and Electric Company

Yvonne J. Meeks
Topock Project Manager
Chromium Remediation Project Office
Gas Transmission & Distribution

6588 Ontario Road
San Luis Obispo, CA 93405

Mailing Address
4325 South Higuera Street
San Luis Obispo, CA 93401

805.546.5243
Internal: 664.5243
Fax:: 805.546.5232
E-Mail: YJM1@pge.com

November 30, 2006

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

Subject: Performance Assessment Report, Interim Measure No. 3, Injection Well Field, PG&E Topock Compressor Station, Needles, California

Dear Mr. Yue:

Enclosed is the *Performance Assessment Report* for the Interim Measure No. 3 Injection Well Field at the PG&E Topock Compressor Station. This report has been prepared in conformance with DTSC's conditional authorization (Condition 18) to begin operating the IM No. 3 facilities, dated July 15, 2005.

If you have any questions on the assessment report, please call me at (805) 546-5243.

Sincerely,

Paul Bitter for Yvonne Meeks

cc: Christopher Guerre, DTSC
Karen Baker, DTSC
Robert Perdue, RWQCB
Liann Chavez, RWQCB
Jose Cortez, RWQCB

Enclosure

Performance Assessment Report Interim Measure No. 3 Injection Well Field

Topock Compressor Station, Needles, California

Prepared for

California Department of Toxic Substances Control

on behalf of

Pacific Gas and Electric Company

November 30, 2006

CH2MHILL
155 Grand Avenue, Suite 1000
Oakland, CA 94612

Performance Assessment Report
Interim Measure No. 3
Injection Well Field

PG&E Topock Compressor Station
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On Behalf of

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This report was prepared by CH2M HILL under the supervision of

John Porcella, P.E.
Project Engineer

REGISTERED PROFESSIONAL ENGINEER
JOHN S. PORCELLA
No. C70145
Exp. 9/30/08
CIVIL
STATE OF CALIFORNIA

Contents

Section Page

Acronyms and Abbreviations v

1.0 Introduction **1-1**
- 1.1 History and Purpose of the Topock Interim Measure 1-1
- 1.2 Description of Groundwater Injection Well Field 1-2
- 1.3 Compliance Monitoring Program 1-4

2.0 Injection Well Operational Assessment **2-1**
- 2.1 Injection Well Performance 2-1
- 2.2 Effect of Injection on Groundwater Levels 2-2

3.0 Influence of Treated Water on Aquifer Water Quality **3-1**
- 3.1 Treatment Plant Effluent Water Quality and Groundwater Quality Before and After Injection 3-1
- 3.2 Water Quality Trends 3-2
- 3.3 Evaluation of Need for Shallow Compliance Monitoring Wells 3-3

4.0 Summary and Recommendations **4-1**

5.0 References **5-1**

Tables

- 1-1 Summary of Injection, Observation, and Compliance Wells Design Information and Installation Dates 1-3
- 1-2 Summary of Injection Field Monitoring Wells 1-3
- 2-1 Injection Rates and Volumes 2-1

Figures

- 1-1 Locations of IM No. 3 Groundwater Extraction, Conveyance, and Treatment Facilities
- 1-2 Monitoring Locations for Injection Well Field

- 2-1 Change in IW-2 Specific Injectivity with Backwashing
- 2-2 CW-01 Hydrographs and IW Injection Rate
- 2-3 CW-02 Hydrographs and IW Injection Rate
- 2-4 CW-03 Hydrographs and IW Injection Rate
- 2-5 CW-04 Hydrographs and IW Injection Rate
- 2-6 OW-01 Hydrographs and IW Injection Rate
- 2-7 OW-02 Hydrographs and IW Injection Rate

2-8 OW-05 Hydrographs and IW Injection Rate
2-9 Average Groundwater Elevation Contours for Mid-Depth Wells August 15 to September 15 2006
2-10 Average Groundwater Elevation Contours for Deep Wells August 15 to September 15 2006
2-11 Groundwater Elevation Contours for Mid-Depth Wells March 15 to April 15 2006
2-12 Groundwater Elevation Contours for Deep Wells March 15 to April 15 2006

3-1 OW-1/OW-2/OW-5 Shallow Water Quality Hydrographs
3-2 OW-1/OW-2/OW-5 Middle Water Quality Hydrographs
3-3 OW-1/OW-2/OW-5 Deep Water Quality Hydrographs
3-4 CW-1/CW-2/CW-3/CW-4 Middle Water Quality Hydrographs
3-5 CW-1/CW-2/CW-3/CW-4 Deep Water Quality Hydrographs

Acronyms and Abbreviations

bgs	below ground surface
Cr(T)	total chromium
Cr(VI)	hexavalent chromium
CW	compliance well
DTSC	State of California Environmental Protection Agency, Department of Toxic Substances Control
gpm	gallons per minute
IM	Interim Measure
IW	injection well
µg/L	micrograms per liter
mg/L	milligrams per liter
OW	observation well
PG&E	Pacific Gas and Electric Company
TDS	total dissolved solids
Water Board	California Regional Water Quality Control Board, Colorado River Basin
WDR	Waste Discharge Requirements

SECTION 1.0

Introduction

Pacific Gas and Electric Company (PG&E) is implementing an Interim Measure (IM) to address chromium concentrations in groundwater at the Topock Compressor Station near Needles, California. The IM is under the oversight of the State of California Environmental Protection Agency, Department of Toxic Substances Control (DTSC) and consists of groundwater extraction for hydraulic control of the plume boundaries near the Colorado River floodplain and management of extracted groundwater. The groundwater extraction, treatment, and injection systems collectively are referred to as Interim Measure No. 3 (IM No. 3). Currently, the IM No. 3 facilities include a groundwater extraction system, conveyance piping, a groundwater treatment plant, and an injection well (IW) field for the discharge of the treated groundwater. Figure 1-1 shows the location of the IM extraction, conveyance, treatment, and injection facilities. The IW field is composed of two IWs and a network of monitoring wells.

On July 15, 2005, DTSC conditionally authorized PG&E to begin operating the IM No. 3 facilities, including the IW field (DTSC 2005a). As part of the authorization, DTSC considered the injection of treated water from the IM No. 3 system as a limited-duration pilot study, authorized through January 31, 2007. DTSC further directed that PG&E assess the performance of the IW field and submit a report by November 30, 2006. DTSC will use this report to determine whether continued and/or final approval of the IW field past the pilot study period is appropriate.

This report is intended to meet the requirement of Condition 18 in DTSC's July 15, 2005 letter to assess the performance of the IW field as an appropriate methodology for management of treated water from the IM No. 3 system beyond the pilot study period. This report briefly describes the background of the project and the IM No. 3 system, including the design basis. The report also discusses injection system operational performance, injection system maintenance activities, and groundwater quality and hydraulic changes associated with the injection system, to provide the rationale for continued subsurface injection of treated groundwater.

1.1 History and Purpose of the Topock Interim Measure

The purpose of the IM at the PG&E Topock is to maintain hydraulic control of the groundwater plume boundaries in the Colorado River floodplain until the time that a final corrective action is in place at the site. As defined by DTSC, the performance standard for the IM is to "establish and maintain a net landward hydraulic gradient, both horizontally and vertically, that ensures that hexavalent chromium [Cr(VI)] concentrations at or greater than 20 micrograms per liter (µg/L) in the floodplain are contained for removal and treatment" (DTSC 2005b).

PG&E began implementing the IM at the PG&E Topock site in March 2004. Initially, groundwater was extracted from a monitoring well cluster located on a bench above and to the west of the Colorado River floodplain (commonly referred to as the MW-20 bench). This operation was eventually replaced by the current groundwater extraction well system. Groundwater extraction began at wells TW-2S and TW-2D in May 2004, at well TW-3D in December 2005, and at well PE-1 in early 2006. Of the four extraction wells, two are currently in normal operation (TW-3D and PE-1).

Prior to the construction and operation of the current groundwater treatment and injection system, a batch treatment plant was located on the MW-20 bench and treated groundwater was transported offsite for disposal at a permitted facility. While this operation was effective in controlling hydraulic gradients in the vicinity of the floodplain, it also generated a large number of truck trips from the site to the permitted disposal facility to manage the entire flow of extracted groundwater, and the treatment capacity was limited to approximately 80 gallons per minute (gpm) due to space limitations on the MW-20 bench.

Construction of the current IM No. 3 treatment and injection system began in September 2004 and was completed in July 2005. The existing groundwater treatment system is a continuous, multi-step process that involves removing chromium by chemical reduction, precipitation, and filtration, and reducing total dissolved solids (TDS) using reverse osmosis. The treatment plant is designed to treat up to 135 gpm of extracted groundwater. Treatment plant operation at 135 gpm of influent yields an effluent (injection) flow rate of approximately 120 gpm. The remaining flow (approximately 15 gpm) becomes a reverse osmosis brine stream which is transported offsite for disposal at a permitted facility. Additional information on the treatment process performance and capacities is contained in the *Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan Rev. 1* (CH2M HILL 2006a) and the *Construction Completion Report* (CH2M HILL 2005a).

Treated groundwater is returned to the aquifer through an injection system consisting of two IWs, IW-2 and IW-3. Injection of treated groundwater from IM No. 3 began on July 31, 2005, and treated groundwater from the Topock IM has been continuously managed through injection since that time. Injection of treated groundwater is authorized by Waste Discharge Requirements (WDR) Orders R7-2004-0103 (California Regional Water Quality Control Board [Water Board] 2004) and R7-2006-0060 (Water Board 2006). In compliance with the two orders, PG&E collects effluent samples for monitoring several parameters including total and Cr(VI), pH, specific conductivity, flow rate, and several metals and water quality indicator parameters. The results of these analyses are reported monthly to the Water Board along with other required information, including a summary of operations.

1.2 Description of Groundwater Injection Well Field

Treated effluent from the IM No. 3 treatment plant is pumped through an aboveground pipeline to the IW field, located nearly 2,000 feet west of the plant. The IW field, located on what is referred to as the East Mesa, is composed of two IWs (IW-2 and IW-3). Surrounding the IWs are three observation well clusters (OW-1, OW-2, and OW-5) located on the East Mesa. Surrounding the East Mesa are four additional monitoring well clusters, known as the compliance wells (CW-1, CW-2, CW-3 and CW-4). The locations of the IWs, OW clusters, and CW clusters are shown on Figure 1-2.

Table 1-1 summarizes information for the three different well types. The IWs, OW clusters, and CW clusters were installed between December 2004 and February 2005.

TABLE 1-1
Summary of Injection, Observation, and Compliance Wells Design Information and Installation Dates
Performance Assessment Report Interim Measure No. 3 Injection Well Field, Topock Compressor Station, Needles, California

Well Type (IDs)	Description	Work Plan	Installation Date	Installation Report
Injection (IW-2, IW-3)	6-inch diameter mild steel casing and stainless steel screen. 160 foot screened interval. 200 gpm each design injection capacity.	CH2M HILL, 2004a	December 2004	CH2M HILL, 2005c
Observation (OW-1, OW-2, OW-5)	Monitoring well clusters consisting of three individual completions at various depths. 2-inch Schedule 40 polyvinyl chloride casing and screen. 20 foot screened interval.	CH2M HILL, 2004b	September to December 2004	CH2M HILL, 2005c
Compliance (CW-1, CW-2, CW-3, CW-4)	Monitoring well clusters consisting of two individual completions at various depths. 2-inch Schedule 40 polyvinyl chloride casing and screen. 50 foot screened interval	CH2M HILL, 2005b	January to February 2005	CH2M HILL, 2005c

IW-2 and IW-3 were constructed using 6-inch diameter stainless steel louvered screens connected to mild steel risers using a mechanical coupling device. Well IW-2 was completed to 340 feet below ground surface (bgs), with a screened interval from 170 to 330 feet bgs. Well IW-3 was completed to 330 feet bgs, with the screened interval from 160 to 320 feet bgs. The design injection capacity of 200 gpm each provides 50 percent excess capacity above the plant design capacity in each well.

Two types of monitoring wells have been installed in the IW field. Table 1-2 lists the name, well identifications, and monitoring zone of each type.

TABLE 1-2
Summary of Injection Field Monitoring Wells
Performance Assessment Report Interim Measure No. 3 Injection Well Field, Topock Compressor Station, Needles, California

Group Name	Members	Distance from Injection Wells, feet	Monitoring Zones		
			Shallow	Mid-depth	Deep
Observation Wells	OW-1, OW-2, and OW-5	50 to 100	X	X	X
Compliance Wells	CW-1, CW-2, CW-3, and CW-4	300 to 550		X	X

Source: CH2M HILL 2005c.

The procedures for maintaining the IWs constructed as part of IM No. 3 are described in the IM No. 3 Injection Well Operation and Maintenance Plan (CH2M HILL 2005d).

1.3 Compliance Monitoring Program

In compliance with the WDRs, a *Groundwater Compliance Monitoring Plan for Interim Measures No. 3 Injection Area* (CH2M HILL 2005e) was prepared describing how the IW field would be monitored to assess IW performance. The OW clusters, located relatively close to the IWs, allow the measurement of changes in water chemistry and water levels across the entire aquifer thickness. Data from these wells provide a measure of the degree of vertical mixing of groundwater that is occurring during injection. Monitoring of the OWs also allows any effects to groundwater quality from injection to be identified and evaluated promptly during the operation of the groundwater injection system. Corrective action can be taken accordingly for any potential negative effects that may arise, such as aquifer plugging, excessive mounding, or mobilization of trace metals from the aquifer matrix, before the effect progresses beyond the injection points.

The four CW clusters, located approximately 500 feet from the IWs, monitor the influence of injection over a much larger area. They are primarily intended for monitoring groundwater quality and ensuring compliance with the waste discharge permit. The CW clusters were installed both upgradient and downgradient of the IWs. They were located so that groundwater would take several years to travel to them from the IWs (as estimated by groundwater modeling).

Under the Compliance Monitoring Program, as of November 2006, samples are collected from groundwater wells according to the following schedule:

- Nine observation wells (OW-01S, OW-01M, OW-01D, OW-02S, OW-02M, OW-02D, OW-05S, OW-05M, OW-05D) are sampled quarterly (the most recent OW data discussed in this report are for the third quarter 2006).
- Eight compliance monitoring wells (CW-01M, CW-01D, CW-02M, CW-02D, CW-03M, CW-03D, CW-04M, CW-04D) are sampled semiannually (the most recent CW data discussed in this report are for the period January to June 2006).

For both quarterly and semiannual sampling events, laboratory analyses include total dissolved chromium [Cr(T)], Cr(VI), metals, specific conductance, pH, TDS, turbidity, and major inorganic cations and anions. Groundwater elevation data and field water quality data—including specific conductance, temperature, pH, oxidation-reduction potential, dissolved oxygen, turbidity, and salinity—are also measured during each monitoring event (CH2M HILL 2005e).

Monitoring data from the Compliance Monitoring Program have been collected and submitted in conformance with requirements of the WDRs. Groundwater monitoring reports completed since start-up of the IM No. 3 injection system are as follows:

- *Groundwater Monitoring Report for Third Quarter 2005* for the Interim Measure Compliance Monitoring Program dated October 14, 2005 (CH2M HILL 2005f)
- *Groundwater Monitoring Report for Fourth Quarter 2005* for the Interim Measure Compliance Monitoring Program dated January 13, 2006 (CH2M HILL 2005g)

- *Groundwater Monitoring Report for First Quarter 2006* for the Interim Measure Compliance Monitoring Program dated April 14, 2006 (CH2M HILL 2006b)
- *Semiannual Groundwater Monitoring Report, June 2006* for the Interim Measure Compliance Monitoring Program dated July 14, 2006 (CH2M HILL 2006c)
- *Groundwater Monitoring Report for Third Quarter 2006* for the Interim Measure Compliance Monitoring Program dated October 13, 2006 (CH2M HILL 2006d).

SECTION 2.0

Injection Well Operational Assessment

2.1 Injection Well Performance

The IW field is designed to accept all of the treated water from the IM No. 3 treatment plant. This is the primary performance metric. Table 2-1 lists the average injection rate, monthly and cumulative total volume of water injected, and the primary wells in service from August 2005 through October 2006.

TABLE 2-1
Injection Rates and Volumes
Performance Assessment Report Interim Measure No. 3 Injection Well Field, Topock Compressor Station, Needles, California

Date	Average Injection rate (gpm)	Monthly total (gallons)	Cumulative total (gallons)	Primary Injection Wells in Service
August 05	58.8	2,626,360	2,626,360	IW-2
September 05	67.2	2,904,094	5,530,454	IW-2
October 05	80.6	3,597,275	9,127,729	IW-2
November 05	74.5	3,216,979	12,344,708	IW-2
December 05	103.5	4,622,252	16,966,960	IW-2
January 06	113.5	5,067,560	22,034,520	IW-2
February 06	121.4	4,896,522	26,931,042	IW-2
March 06	121.1	5,405,223	32,336,265	IW-2
April 06	116.7	5,039,655	37,375,920	IW-2
May 06	118.9	5,305,831	42,681,751	IW-2
June 06	116.9	5,050,593	47,732,344	IW-2
July 06	119.2	5,322,857	53,055,201	IW-2
August 06	121.6	5,429,628	58,484,829	IW-3
September 06	121.0	5,229,047	63,713,876	IW-3
October 06	122.6	5,473,384	69,187,260	IW-3

Source: The injection flow rate is measured by flow meters in the piping into IW-2 and IW-3. Data are logged in the IM No. 3 control system from which this information is reported.

For the first year of operation, IW-2 was used almost exclusively. Using only one of the two IWs allowed for development of maintenance frequency information and minimized the problems of balancing flow between the two wells. The performance of the IWs is measured by tracking the specific injectivity, defined as the injection rate in gpm divided by the water level rise in the well in feet. This is equivalent to the specific capacity of a pumping well. The performance of IWs typically declines over time as a result of well plugging.

The initial specific injectivity in well IW-2 was approximately 18 to 20 gpm per foot in summer 2005. After one year of operation, the well was taken off line for backwashing and maintenance. At this time, the specific injectivity had dropped to approximately 2 to 3 gpm per foot. A vacuum test revealed an air leak in the drop pipe, which likely allowed air bubbles to become entrained in the injected water stream and contributed to partial plugging of the well. In July 2006, backwashing was initiated on IW-2 to restore the performance of the well. IW-2 has been backwashed six times between July and November 2006. This effort so far has restored the specific injectivity at IW-2 to nearly 12 gpm per foot, with a gain of approximately 2 gpm per foot realized with each backwash event.

Figure 2-1 shows the improvement in specific injectivity with each backwash. Backwashing of IW-2 will continue until no further improvements in specific injectivity are observed with each backwash. At that point, a decision will be made about whether the well should be redeveloped using a pump rig. Based on the experience with IW-2, backwashing appears to be effective in restoring some of the lost performance of the well. Following restoration efforts at IW-2, routine backwashing will be conducted on IW-3 and IW-2 every other month. The wells will be operated on an alternating schedule with each well receiving injection for one month, then off-line for one month, and then backwashed before being returned to service. That schedule will result in six months of idle time and six backwash events per well per year. The wells will be backwashed more frequently than this schedule if performance indicates a drop in specific injectivity while in use.

The proposed schedule will evaluate the relative benefit of frequent backwashing during the year versus focusing backwashing efforts at the end of the year on an annual maintenance schedule.

2.2 Effect of Injection on Groundwater Levels

The injection has been operating at flow rates between 116 and 122 gpm since February 2005 (Table 2-1). Groundwater levels have been monitored in all OW and CW wells since several months prior to the initiation of injection. Figures 2-2 through 2-8 present hydrographs that illustrate groundwater elevation trends and vertical hydraulic gradients observed over the reporting period at the observation and compliance monitoring wells. Before injecting treated water, vertical gradients were slight but generally upwards in all but OW-5 and OW-1. Average vertical gradients have been upward at all OW and CW clusters since injection began. This is consistent with expectations. Because the IWs are screened in the deeper portions of the aquifer, the injection tends to increase the head in the deep and middle portions of the aquifer more than in the shallow portions.

Groundwater levels in the middle and deep OW and CW wells respond more quickly to changes in injection rate than shallow water levels. This is due primarily to the semi-confined nature of the aquifer in middle and lower zones. Confined and semi-confined aquifers typically have storage coefficients several orders of magnitude smaller than unconfined aquifer systems and, therefore, respond much more quickly to changes in hydraulic stress.

Current average water-level contour maps for middle and deep wells are provided as Figures 2-9 and 2-10. Water-level contour maps from March and April 2006, about a month after the injection rate was increased to the current level of approximately 120 gpm, are shown on Figures 2-11 and 2-12. The middle and deep zone gradients in August and September 2006 are comparable to those in March and April 2006. The groundwater levels in the middle and deep zones are currently in approximate hydraulic steady-state with the current rate of injection. It is, therefore, not anticipated that continued injection at the current rate will result in any further significant changes in groundwater level, flow directions, or velocities in the IW field.

The groundwater mound associated with injection is broader and flatter in the deep zone. The mound in the middle zone is more localized to the vicinity of the IWs. This is consistent with the spinner log results from both IWs, which showed higher permeability in the deep zone. The mound displays less than a foot of total height in either middle or deep zones, as measured by the difference between OW and CW groundwater elevations (Figures 2-9 and 2-10). This represents a slight increase in the magnitude of the horizontal gradient, although this increase is localized to the area of the mound itself. Outside of the defined mound area there is no significant affect of injection on groundwater levels.

The mound is elliptical in shape, with the major axis running in a southwest to northeast direction. The lower gradients (broader contours) in the direction of the major axis are an indication that the aquifer permeabilities are greater in this direction, indicating that there may be a preferred direction to flow in this area. In aquifers in alluvial fan depositional environments, the permeability is often higher in the down-fan direction and lower in the cross-fan direction. This is due to the higher degree of connectedness of the sand and gravel layers in the direction of stream flow. The orientation of the long axis of the mound near the IW field is northeast-southwest and generally consistent with the likely alignment of alluvial fans in the area.

SECTION 3.0

Influence of Treated Water on Aquifer Water Quality

3.1 Treatment Plant Effluent Water Quality and Groundwater Quality Before and After Injection

As required by WDR No. R7-2004-0103 and R7-2006-0060 for the IM No. 3 groundwater treatment system, PG&E is required to submit monthly monitoring reports on the operation of the treatment system. These reports contain the analytical results of treated water effluent sampling and, as such, are useful in evaluating the baseline water quality of the treated water being delivered to the IM No. 3 IW field. Since operations began, treated groundwater quality has always met or exceeded the limits specified in the WDR.

The treated water has certain characteristics that can be used as a "signature" to determine when that water reaches a monitoring well. Parameters that are relatively constant in treated groundwater effluent are most useful in identifying the effluent signature. These include Cr(VI), Cr(T), fluoride, molybdenum, nitrate as nitrogen, sulfate, and TDS. In general terms, treated water has the following characteristics (based August 2005 through August 2006 analytical results):

- Cr(VI): Typically below reporting limits (0.001) milligrams per liter (mg/L)
- Cr(T): Typically below reporting limits (0.001) mg/L
- Fluoride: Approximately 1.9 mg/L
- Molybdenum: Approximately 0.008 to 0.013 mg/L
- Nitrate as nitrogen: Approximately 2 to 4 mg/L
- Sulfate: Approximately 470 mg/L
- TDS: Approximately 4,000 mg/L

These treated water-quality characteristics are meant to serve as a general guideline and not as a statistically representative sampling of the treated water quality over time.

A full set of nine OW groundwater samples were collected on July 27 and 28, 2005, and a full set of eight CW groundwater samples were collected on September 13 through September 16, 2005. These samples are considered representative of conditions unaffected by injection and serve to characterize the pre-injection water quality. In comparing these analytical results to the treated injection water analytical results, most of the well samples show concentrations similar to the treated water for two or three constituents, but large differences in concentration from the treated water for the remaining four or five. By considering the set of seven parameters and focusing on those parameters that show differences, it is relatively easy to distinguish between the pre-injection water quality at the monitoring wells and the treated water effluent quality.

Wells OW-1M, OW-1D, OW-2M, OW-2D, and OW-5D are locations and depths where the treated water injection front has largely replaced the local pre-injection groundwater. Well OW-5M is a location and depth where the treated water injection front has arrived but has not yet completely displaced the local pre-injection groundwater. Over time, the water quality in this OW is expected to continue to change until it matches the general water quality of the treated water. To date, no shallow observations wells (wells OW-1S, OW-2S, and OW-5S) show water quality changes due to injection of treated water.

3.2 Water Quality Trends

Trends in water-quality monitoring data have been used to determine when a rapid change has occurred between sampling events, such as the arrival of the injection front. It can also be used to look at more gradual changes that occur over several sampling events, such as seasonal effects or the interaction of treated water with local groundwater and host aquifer material. Thirty-six analytes are currently monitored quarterly as part of the Compliance Monitoring Program for the IWs. Nineteen of these analytes are detected frequently enough (more than half the time) to make time-series analysis useful. Of these 19 analytes, the majority are in the general minerals category as common inorganic ionic constituents that are found in natural waters. Nine of the 19 analytes were selected for time-series analysis; these analytes are considered to be most representative of the IM No. 3 IW field area and include Cr(T), Cr(VI), molybdenum, nitrate as nitrogen, pH, sulfate, TDS, oxidation-reduction potential, and vanadium. Water quality hydrographs of all nine analytes in each observation and CW within the IM No. 3 IW field are presented in Figures 3-1 through 3-5. The graphs are segregated by the three depth intervals for the OWs followed by the two intervals for the CWs.

Observation wells that are identified as affected by treated water injection (OW-1M, OW-1D, OW-2M, OW-2D, and OW-5D) show a shift in water-quality response for characteristic parameters, while those identified as being unaffected by injection show no net trends. The water-quality change brought on by the arrival of the treated water injection front can be either gradual (OW-5M) or step-wise (OW-2D), with most affected wells showing a pattern of change somewhere between the two. Based on the variability in response, movement of treated water is non-uniform laterally between wells. That is, the treated water appears to preferentially move in one direction versus another. This variability in lateral movement of treated water is seen in both the middle and deep interval wells identified as affected by treated water injection.

The shallow-depth OW wells (OW-1S, OW-2S, and OW-5S) show little water-quality variation over time and generally have no net trends over time. During the third quarter 2006 sampling event, two samples exceeded the interim action level of 32.6 μg/L for Cr(VI). The September 8, 2006 primary and field duplicate samples from well OW-2S had concentrations of 40.4 μg/L and 38.2 μg/L, respectively. For these samples, the results were not considered to be the result of the injection of treated groundwater, as the average concentration of Cr(VI) in IM No. 3 treatment plant effluent is less than 1 μg/L (CH2M HILL 2006d). Cr(VI) concentrations at OW-2S have been consistently above the water-quality objectives since November 2005. In addition, other parameters that would indicate arrival of the injected water at OW-2S (such as a change in sulfate or TDS concentrations) are not observed in samples from this well. The results are thus considered reflective of the variance in background water quality.

3.3 Evaluation of Need for Shallow Compliance Monitoring Wells

The chemical signature of the injected water has been observed at three deep OWs, two middle OWs, and no shallow OWs. The absence of injected water in the nearby shallow OWs is consistent with an anisotropic aquifer system where horizontal permeability (Kh) is greater than vertical permeability (Kv). Anisotropy is typical of alluvial aquifer systems. Analysis of pumping tests conducted in IW-2 and IW-3 has shown Kh/Kv ratios ranging from 50 to 140. This ratio indicates that water would move preferentially in the horizontal direction, rather than the vertical direction. Based on the water-quality monitoring data from the OWs and the hydraulic data from the IW tests, the influence of the injection is expected to be seen first in the middle and deep monitoring wells, and only much later in the shallow wells.

It is not known when significant water quality changes will occur in the shallow OWs, but at a minimum it has lagged beyond the occurrence at deeper depths by 14 months. It is highly unlikely that adverse effects due to injected water would be observed in the shallow zone at the more distant CWs prior to being observed in the deeper zones at those locations. If any indication of adverse affects from injection is observed in the mid-depth or deep compliance monitoring wells, shallow wells could be installed in sufficient time to observe any effects of injection in the shallow zone. DTSC is currently reviewing a work plan for installation of shallow CWs; however, based on the performance of the injection system over the past year, it would appear to be unnecessary to install these wells at least until treated water had traveled to the deeper wells at the compliance points. Considering the cultural sensitivity of the area where CWs are installed, shallow compliance monitoring wells are not recommended for installation unless adverse effects from injection are observed in deep or middle wells.

SECTION 4.0

Summary and Recommendations

The IM No. 3 groundwater injection system has operated successfully since July 31, 2005, and has been shown to be an effective strategy for management of treated groundwater generated through implementation of the IM at the PG&E Topock Site. The following summarizes the performance highlights of the injection system.

- **Predicted aquifer response**: The aquifer has responded hydraulically to the injection as expected. The groundwater mound near the IWs is predominantly in the middle and deep aquifer zones and appears to show the influence of preferential permeability. The direction of preferential flow appears to be in a NE to SW direction parallel with the depositional grain of the alluvial fan in the area of the IWs. Preferential flow along the axis of an alluvial fan results from the alignment of sand and gravel layers along the stream channels as the fan is deposited (Fetter, 1994).

- **No adverse affect to aquifer water quality**: There are no indications of adverse affects to aquifer water quality as a result of the injection. No unexpected or adverse geochemical reactions have been observed. The water quality in the middle and deep zones is generally improving in areas where the injected water has displaced the native groundwater. Injected water has not directly affected the shallow aquifer zone, although some water quality changes observed in the shallow zone may be associated with changes in localized groundwater flow directions associated with the injection.

- **Limited effect on shallow groundwater**: As anticipated, injected water is moving almost entirely through the aquifer in the middle and deep zone. Very little effect has been seen in the shallow OWs. Adverse effects of injection, if any, would therefore be seen first in the middle and deep zones, with a significant lag in time before arriving at shallower depths. Installation of shallow CWs is not recommended unless adverse affects of injection are observed in the middle and deep zones.

- **Successful injection well operation**: The IWs have performed without significant problems over the past year, maintaining substantial excess capacity throughout operation. Routine backwash procedures performed on IW-2 have resulted in the well regaining approximately 90 percent of its original capacity without the need for more aggressive well redevelopment. Well redevelopment may not be necessary on this well for another year.

- **Improved environment and safer operations**: Operating the IWs reduces the adverse environmental and safety impacts associated with the trucking of treated groundwater to a permitted offsite facility (to dispose of 69 million gallons injected through October 2006 would have required over 15,000 truck trips). Reduced truck traffic results in lower vehicle emissions and reduces the chance of accidents.

For these reasons, final approval is recommended for continued operation of the injection system as an integral part of IM No. 3 system operations

SECTION 5.0

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Figures

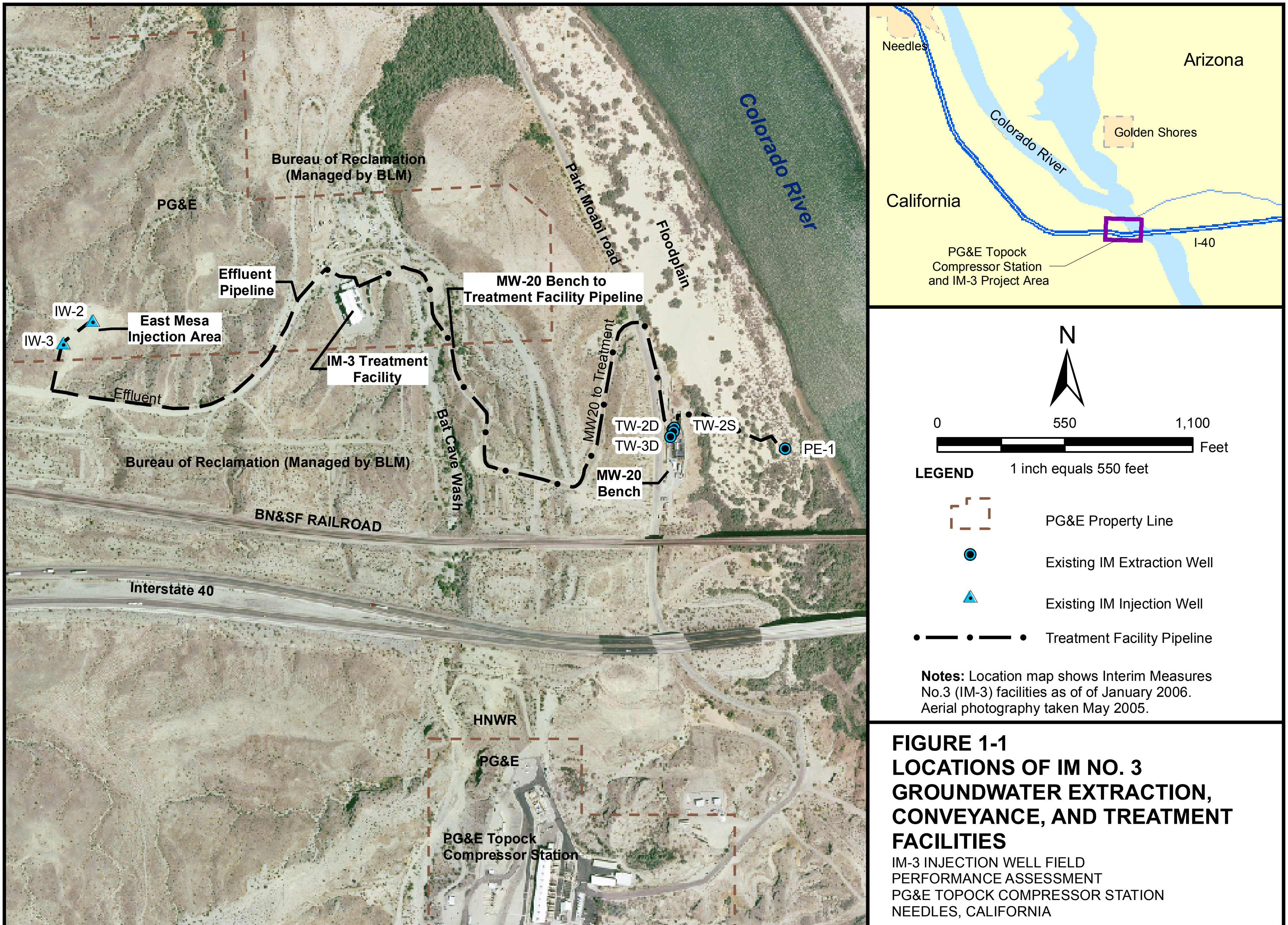

FIGURE 1-1
LOCATIONS OF IM NO. 3 GROUNDWATER EXTRACTION, CONVEYANCE, AND TREATMENT FACILITIES
IM-3 INJECTION WELL FIELD
PERFORMANCE ASSESSMENT
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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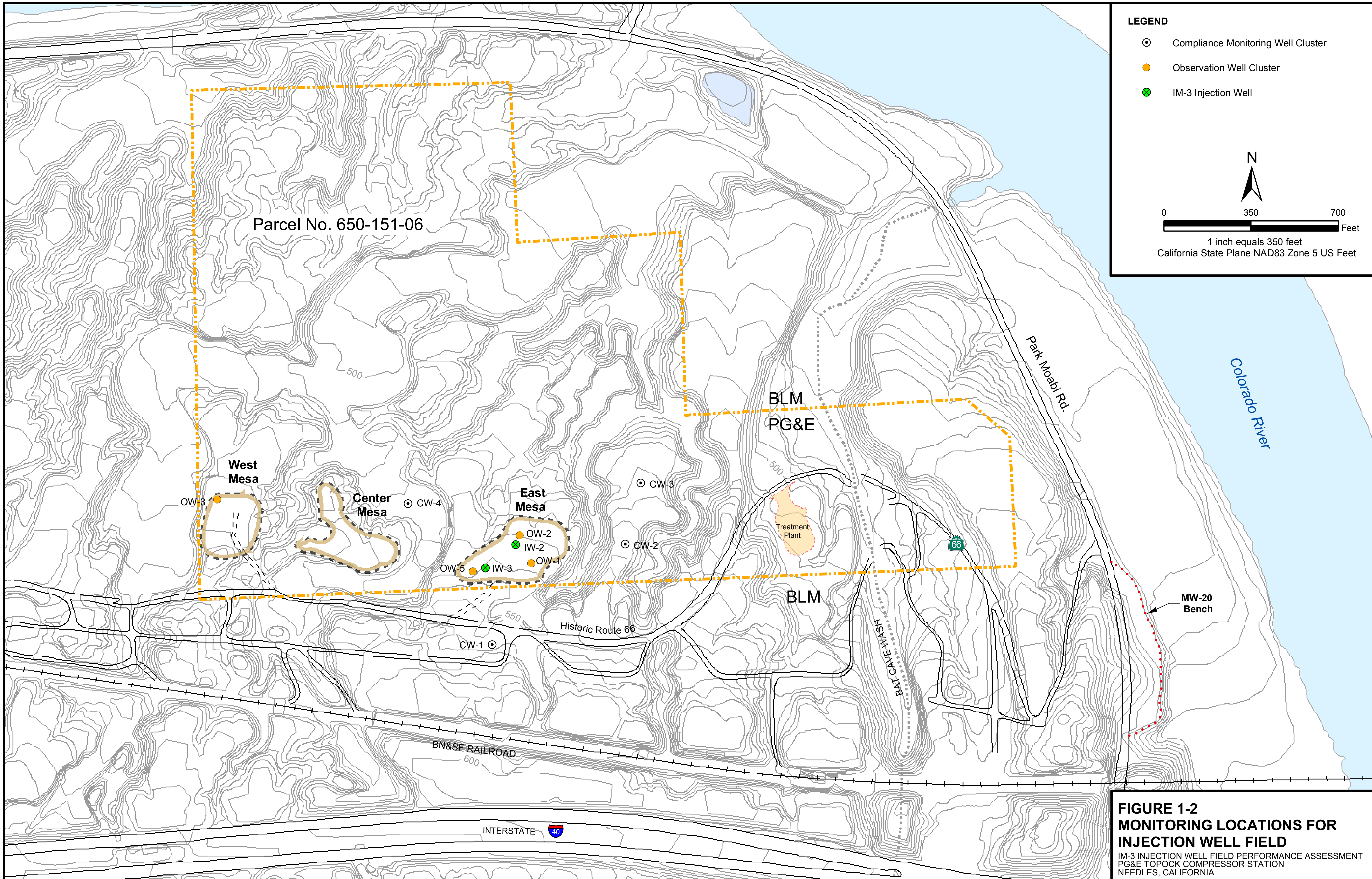

FIGURE 1-2
MONITORING LOCATIONS FOR INJECTION WELL FIELD
IM-3 INJECTION WELL FIELD PERFORMANCE ASSESSMENT
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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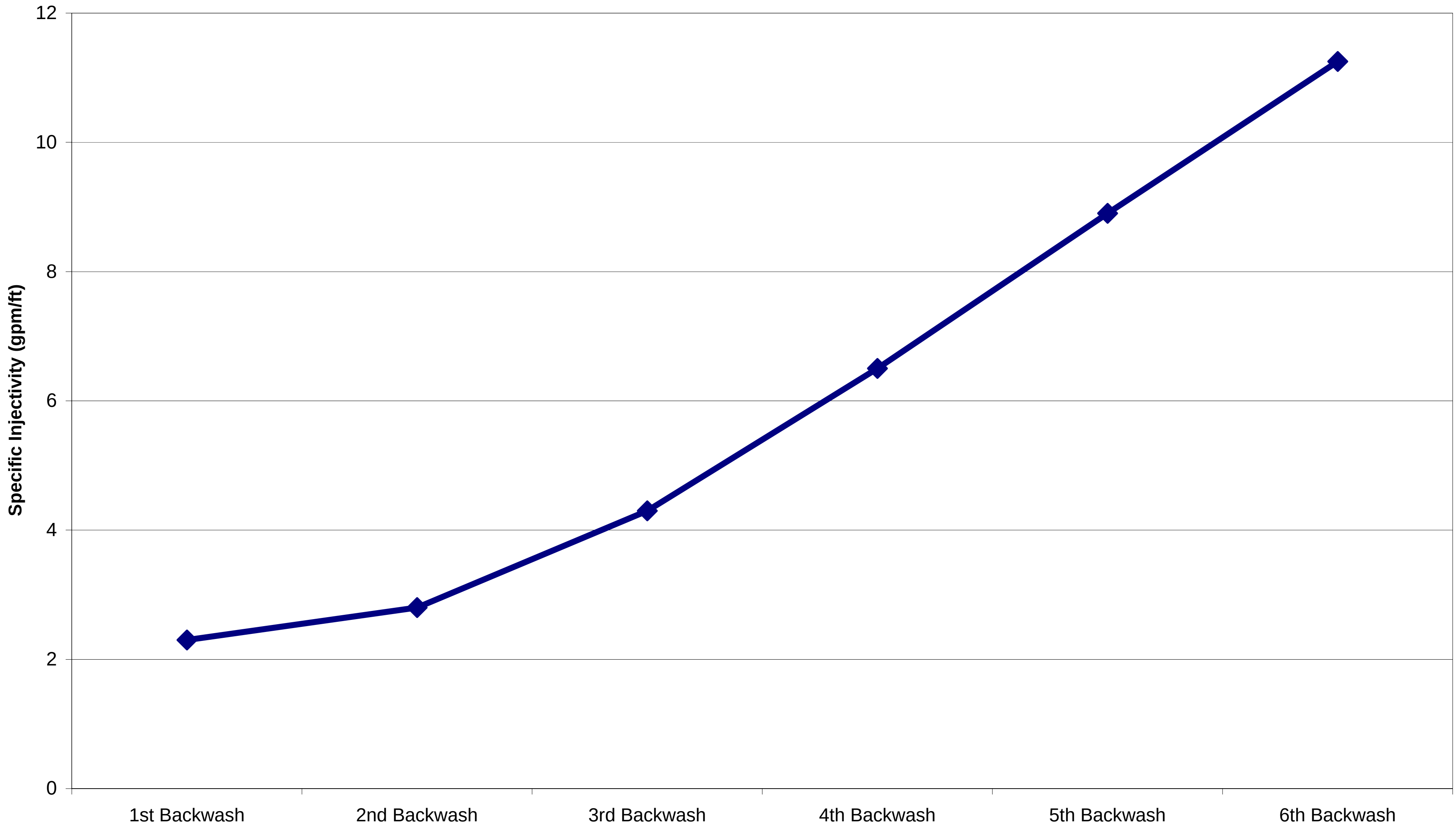

FIGURE 2-1
CHANGE IN IW-2 SPECIFIC INJECTIVITY WITH BACKWASHING
INJECTION WELL FIELD PERFORMANCE ASSESSMENT
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

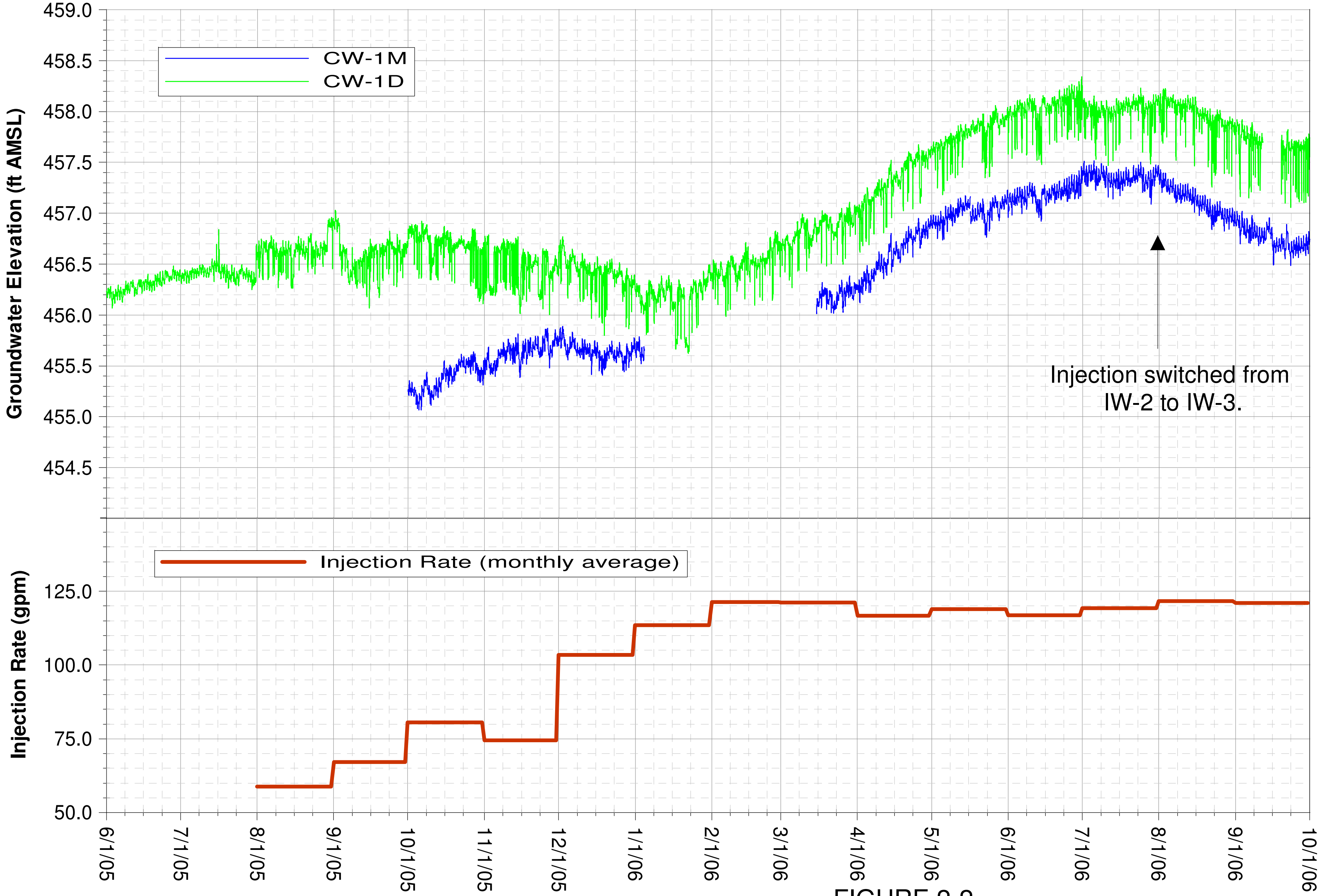

FIGURE 2-2
CW-1 HYDROGRAPHS AND IW INJECTION RATE
PERFORMANCE ASSESSMENT REPORT
INTERIM MEASURE NO. 3 INJECTION WELL FIELD
PG & E TOPOCK COMPRESSOR STATION, NEEDLES, CALIFORNIA

Note: Data subject to review.
Injection into IW-2 from 7/31/2005 through 8/2/2006.
Injection into IW-3 from 8/2/2006 to present.

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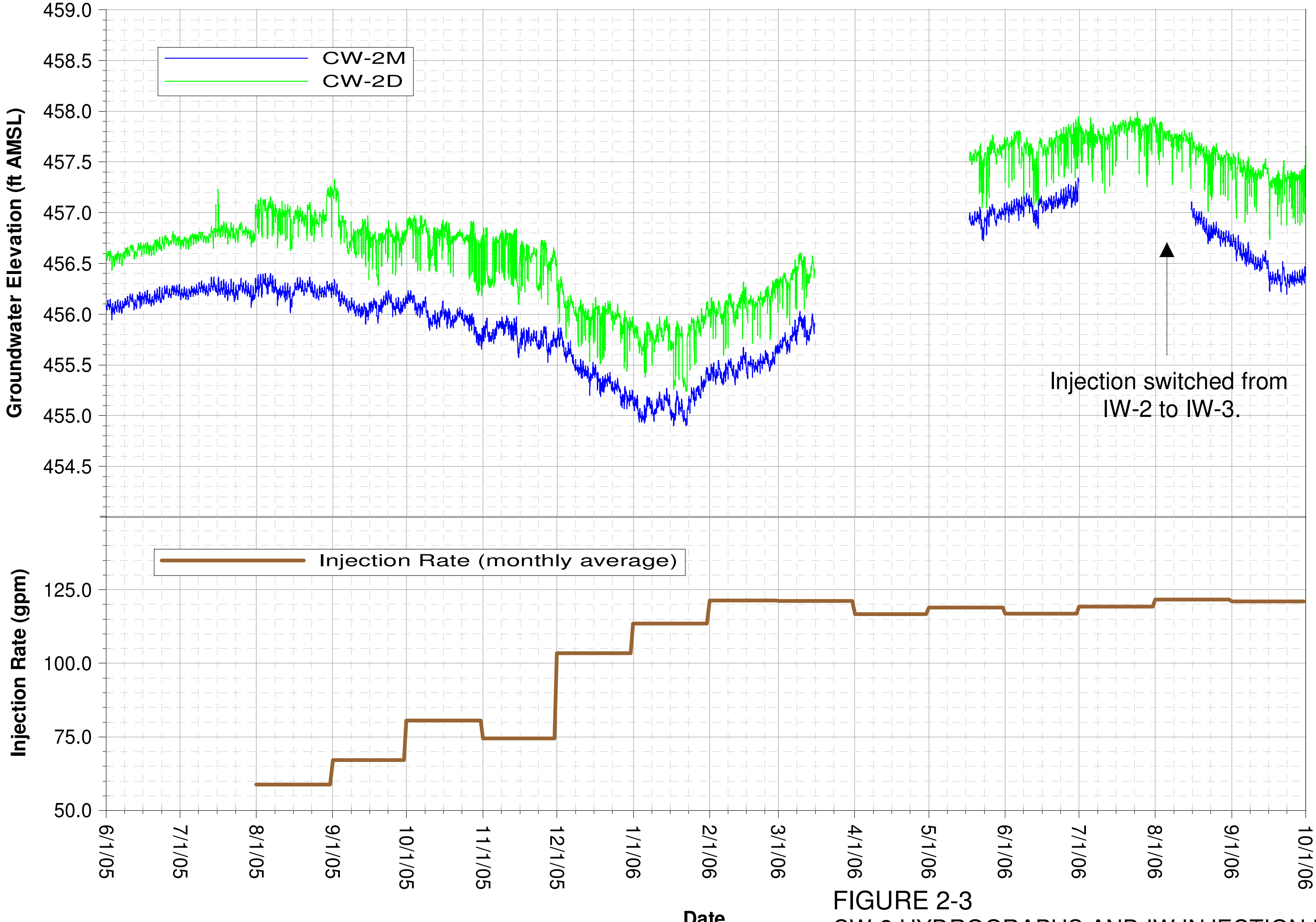

Note: Data subject to review.
Injection into IW-2 from 7/31/2005 through 8/2/2006.
Injection into IW-3 from 8/2/2006 to present.

FIGURE 2-3
CW-2 HYDROGRAPHS AND IW INJECTION RATE
PERFORMANCE ASSESSMENT REPORT
INTERIM MEASURE NO. 3 INJECTION WELL FIELD
PG & E TOPOCK COMPRESSOR STATION, NEEDLES, CALIFORNIA

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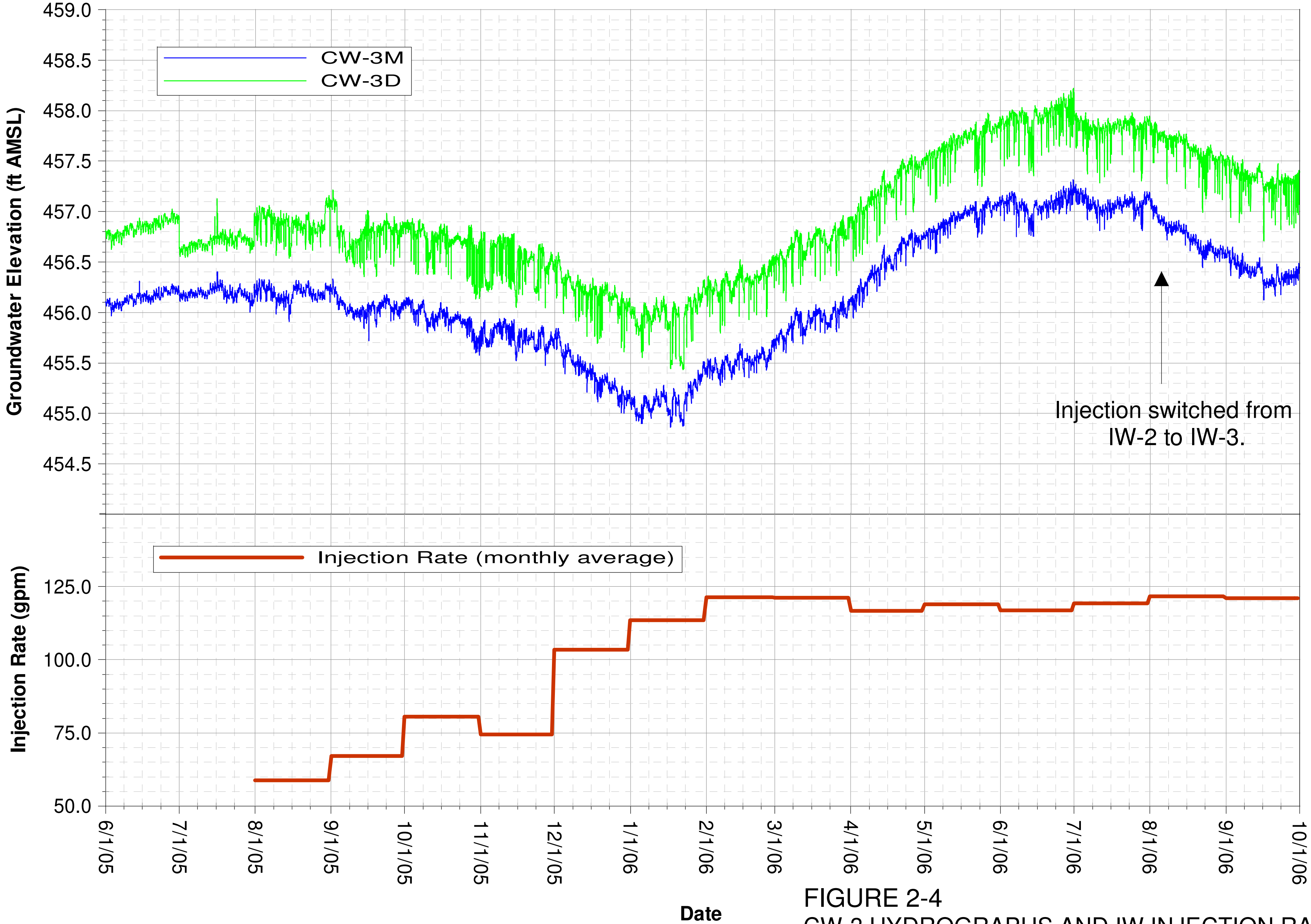

Note: Data subject to review.
Injection into IW-2 from 7/31/2005 through 8/2/2006.
Injection into IW-3 from 8/2/2006 to present.

FIGURE 2-4
CW-3 HYDROGRAPHS AND IW INJECTION RATE
PERFORMANCE ASSESSMENT REPORT
INTERIM MEASURE NO. 3 INJECTION WELL FIELD
PG & E TOPOCK COMPRESSOR STATION, NEEDLES, CALIFORNIA

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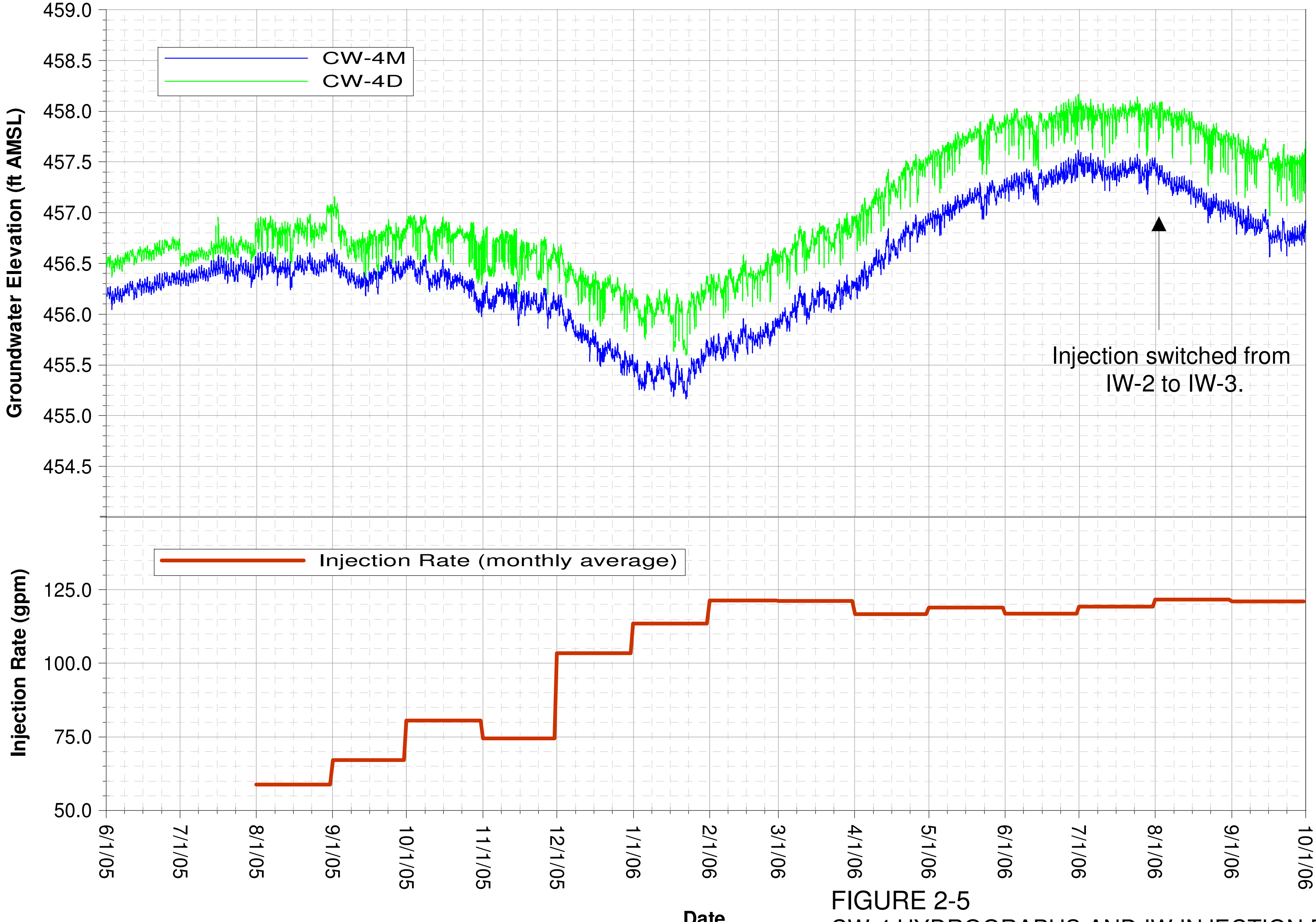

FIGURE 2-5
CW-4 HYDROGRAPHS AND IW INJECTION RATE
PERFORMANCE ASSESSMENT REPORT
INTERIM MEASURE NO. 3 INJECTION WELL FIELD
PG & E TOPOCK COMPRESSOR STATION, NEEDLES, CALIFORNIA

Note: Data subject to review.
Injection into IW-2 from 7/31/2005 through 8/2/2006.
Injection into IW-3 from 8/2/2006 to present.

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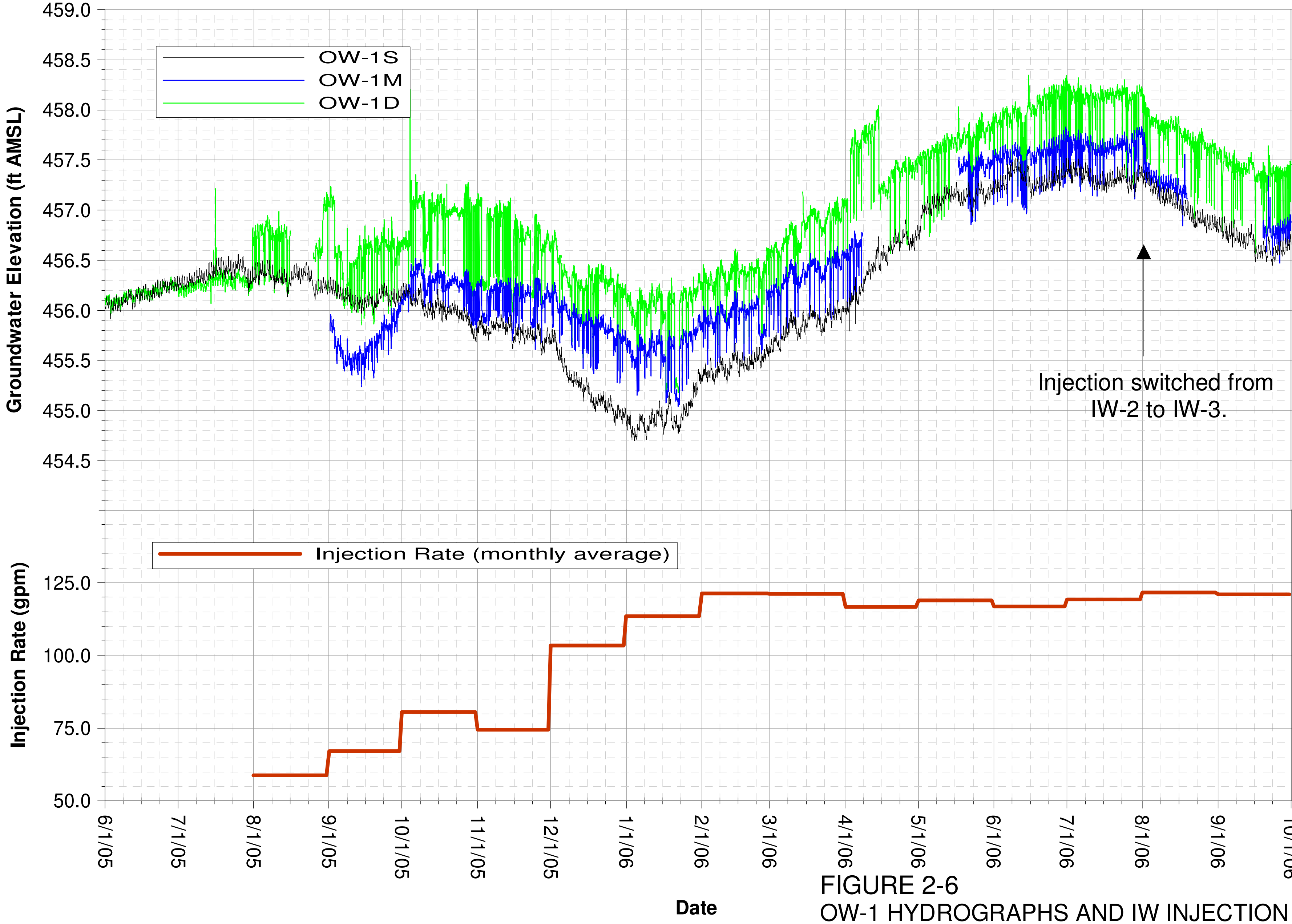

FIGURE 2-6
OW-1 HYDROGRAPHS AND IW INJECTION RATE
PERFORMANCE ASSESSMENT REPORT
INTERIM MEASURE NO. 3 INJECTION WELL FIELD
PG & E TOPOCK COMPRESSOR STATION, NEEDLES, CALIFORNIA

Note: Data subject to review.
Injection into IW-2 from 7/31/2005 through 8/2/2006.
Injection into IW-3 from 8/2/2006 to present.

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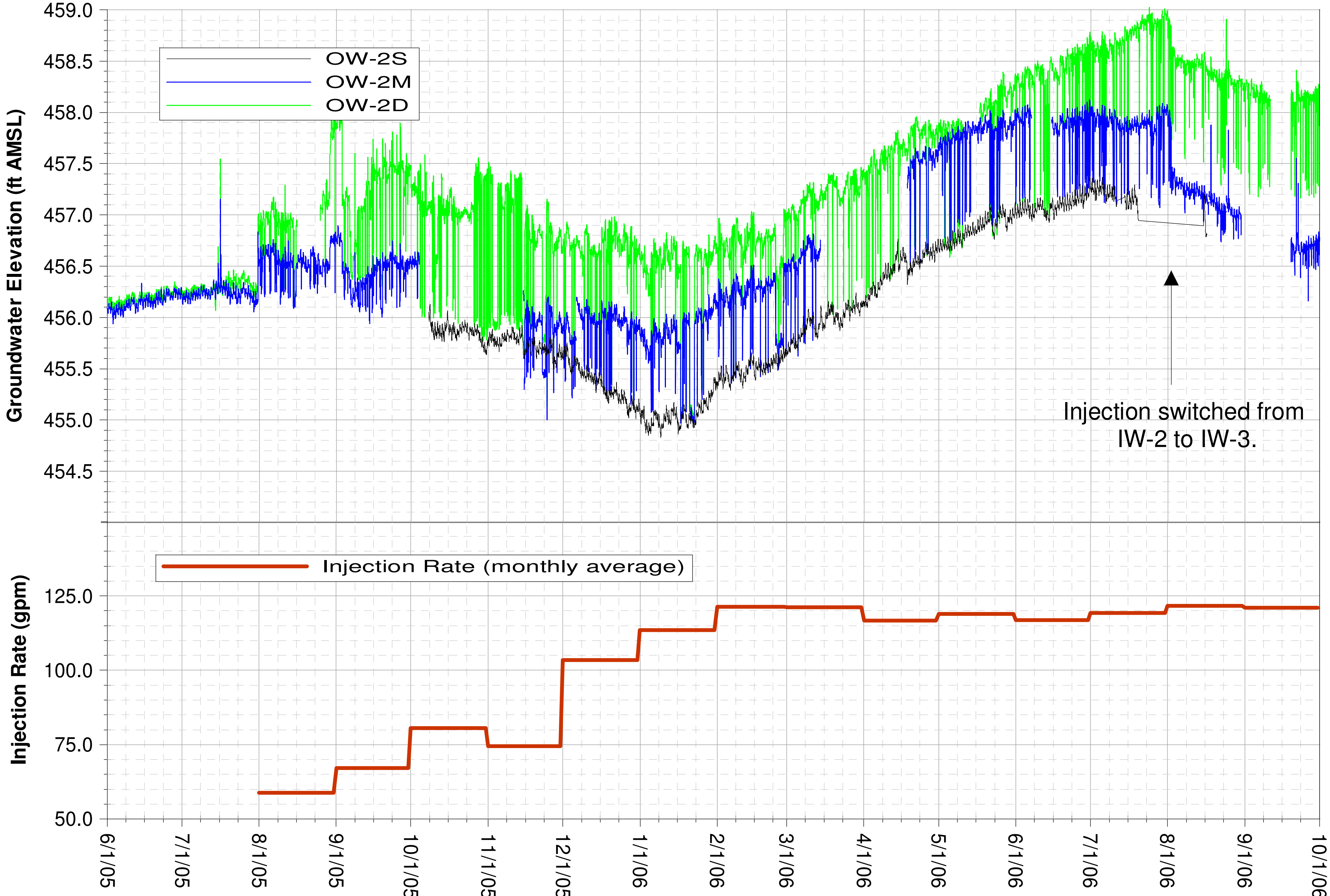

Note: Data subject to review.
Injection into IW-2 from 7/31/2005 through 8/2/2006.
Injection into IW-3 from 8/2/2006 to present.

FIGURE 2-7
OW-2 HYDROGRAPHS AND IW INJECTION RATE
PERFORMANCE ASSESSMENT REPORT
INTERIM MEASURE NO. 3 INJECTION WELL FIELD
PG & E TOPOCK COMPRESSOR STATION, NEEDLES, CALIFORNIA

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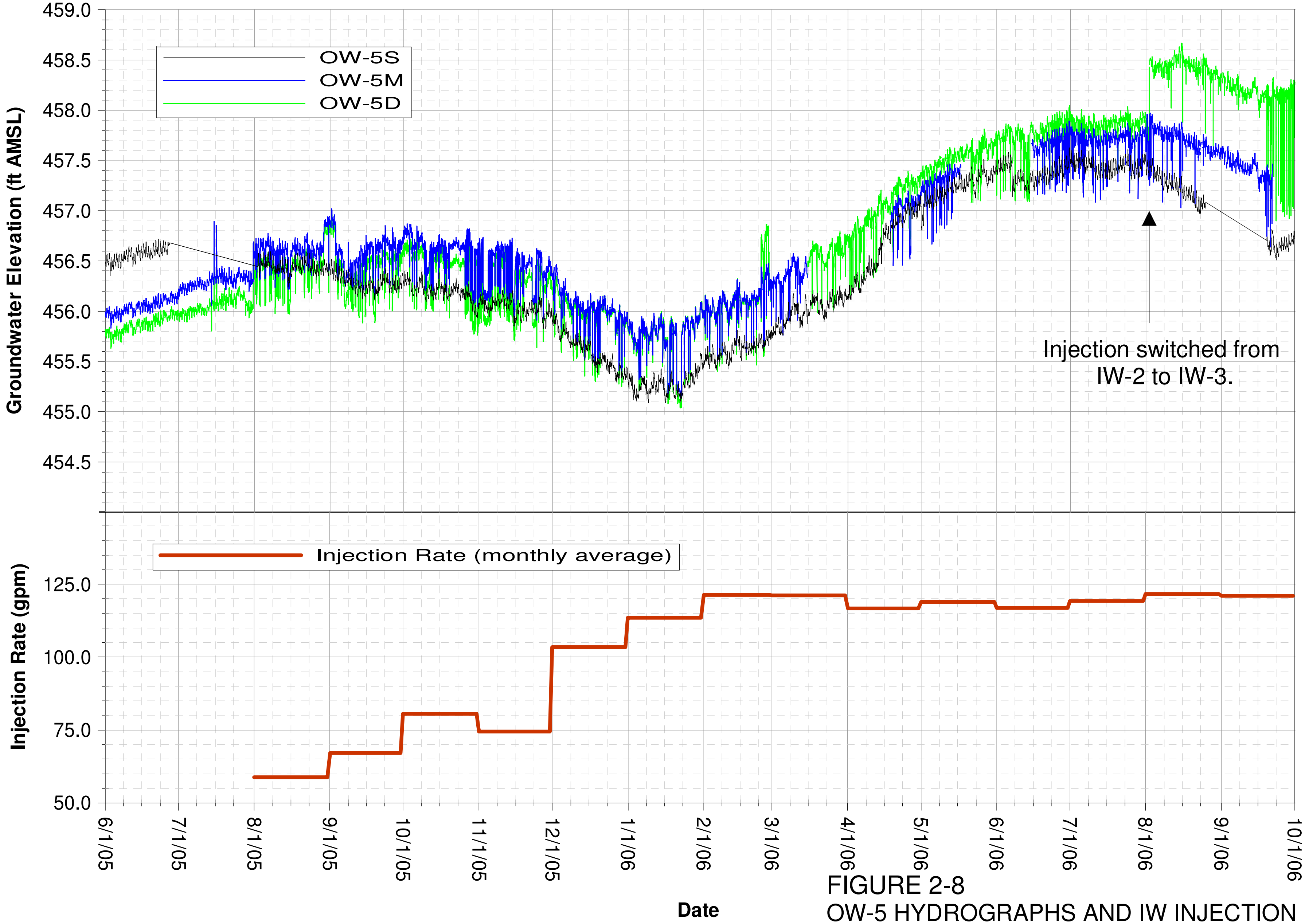

FIGURE 2-8
OW-5 HYDROGRAPHS AND IW INJECTION RATE
PERFORMANCE ASSESSMENT REPORT
INTERIM MEASURE NO. 3 INJECTION WELL FIELD
PG & E TOPOCK COMPRESSOR STATION, NEEDLES, CALIFORNIA

Note: Data subject to review.
Injection into IW-2 from 7/31/2005 through 8/2/2006.
Injection into IW-3 from 8/2/2006 to present.

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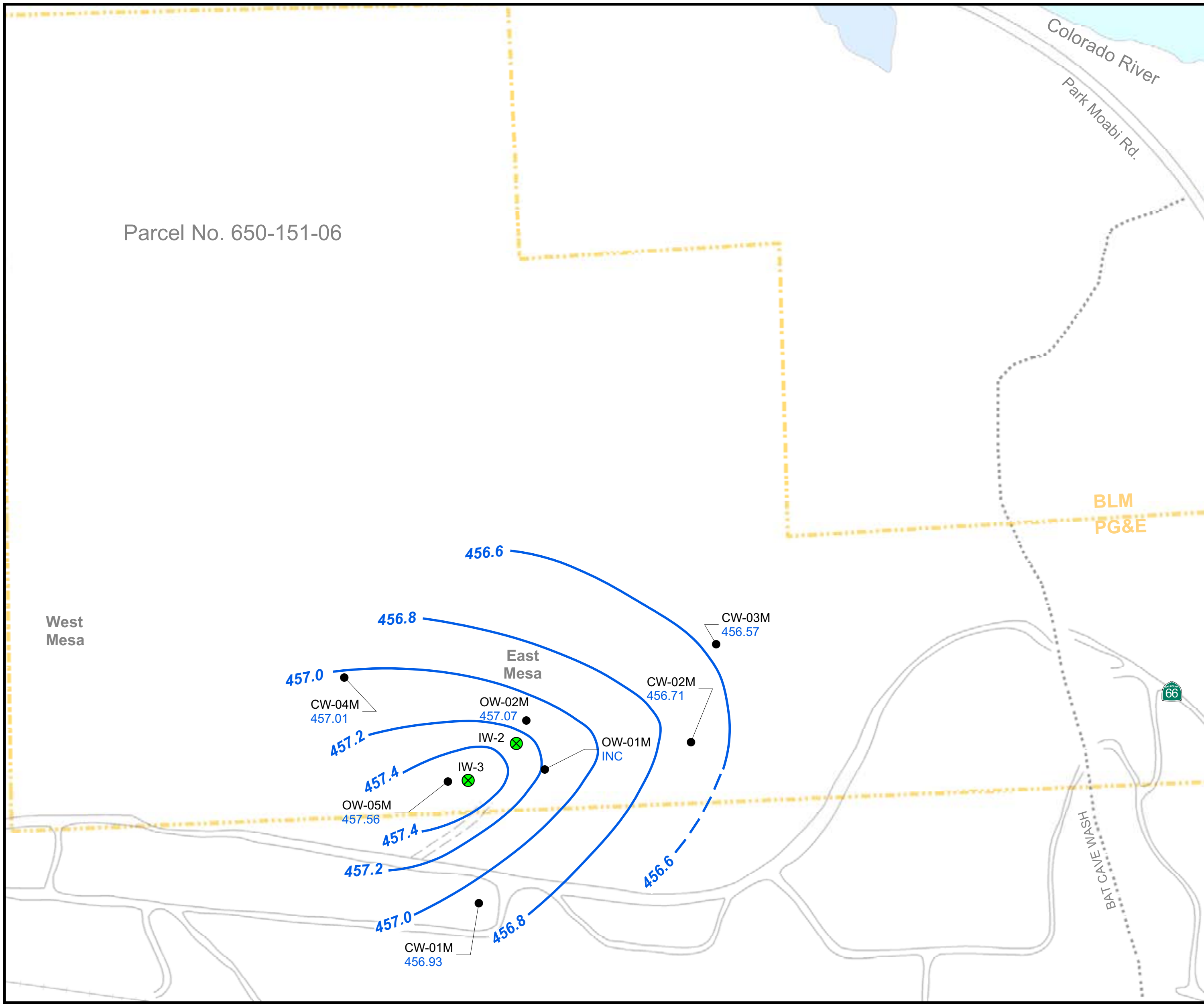

N

0 250 500 Feet

1 inch equals 250 feet

California State Plane NAD83 Zone 5 US Feet

LEGEND

- Groundwater Monitoring, Compliance, and Observation Well
- IM-3 Injection Well

Groundwater Elevations for Mid-depth Wells in IM-3 Injection Area

- **OW-02M** **454.75** — Salinity and temperature adjusted groundwater head elevation in feet above mean sea level (MSL)
- Groundwater elevation contour in feet above MSL (0.2 foot interval), dashed where inferred

Note: Average monthly groundwater elevations are calculated with pressure transducer data measured at 30 minute intervals. OW-1M transducer data incomplete over reporting period. OW-2M data is the average from 8/15/2006 through 8/30/2006, the transducer failed after this date.

FIGURE 2-9
AVERAGE GROUNDWATER ELEVATION CONTOURS FOR MID-DEPTH WELLS AUGUST 15 TO SEPTEMBER 15, 2006

INJECTION WELL FIELD PERFORMANCE ASSESSMENT
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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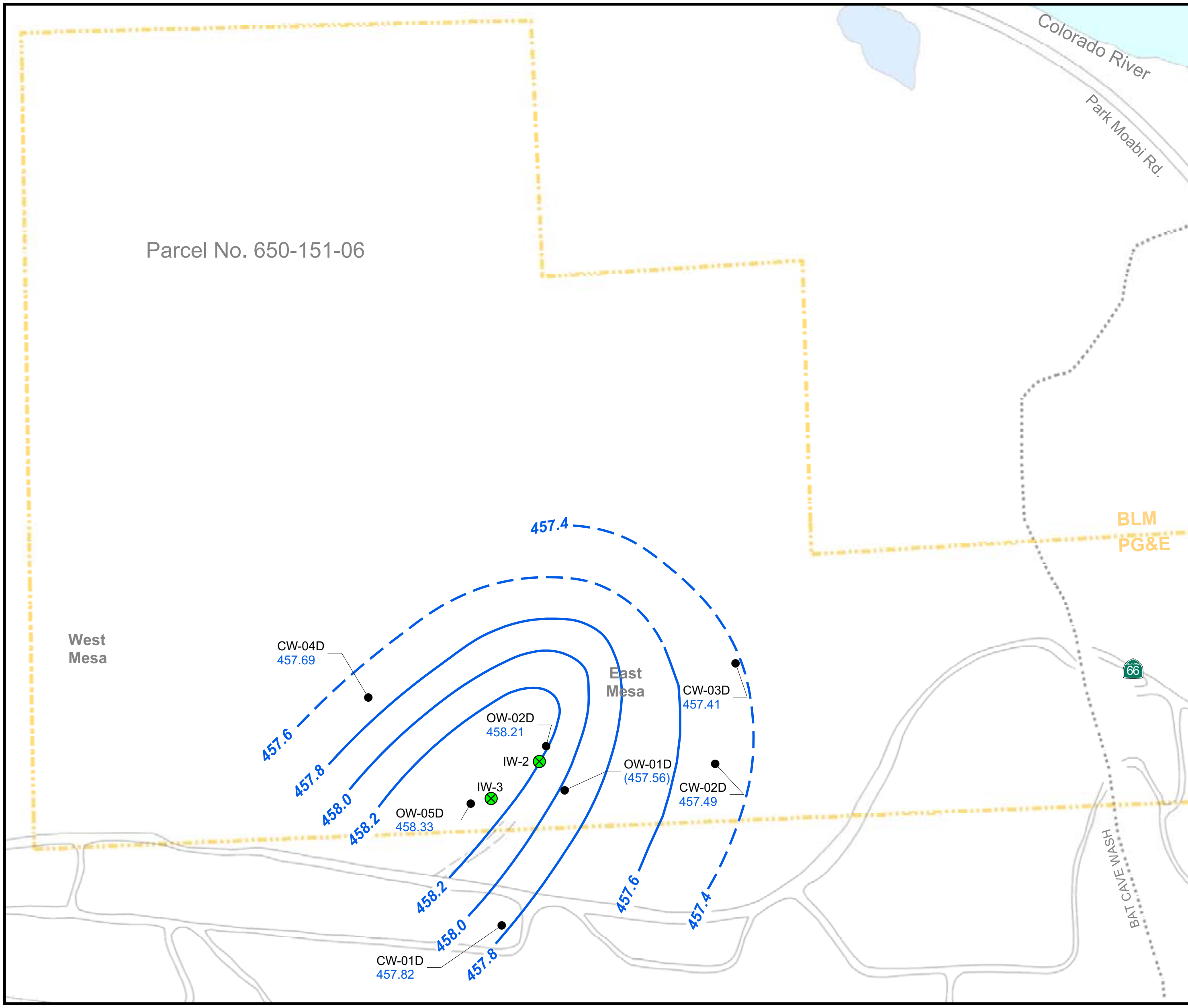

LEGEND

Groundwater Monitoring, Compliance, and Observation Well

IM-3 Injection Well

Groundwater Elevations for Deep Wells in IM-3 Injection Area

OW-05D **454.75** Salinity and temperature adjusted groundwater head elevation in feet above mean sea level (MSL)

Groundwater elevation contour in feet above MSL (0.2 foot interval), dashed where inferred

Notes:
Data posted and contoured from monthly average heads measured with tranducers at 30 minute intervals.
(OW-1D) excluded from contouring.

FIGURE 2-10
AVERAGE GROUNDWATER ELEVATION CONTOURS FOR DEEP WELLS AUGUST 15 TO SEPTEMEBER 15, 2006
INJECTION WELL FIELD PERFORMANCE ASSESSMENT
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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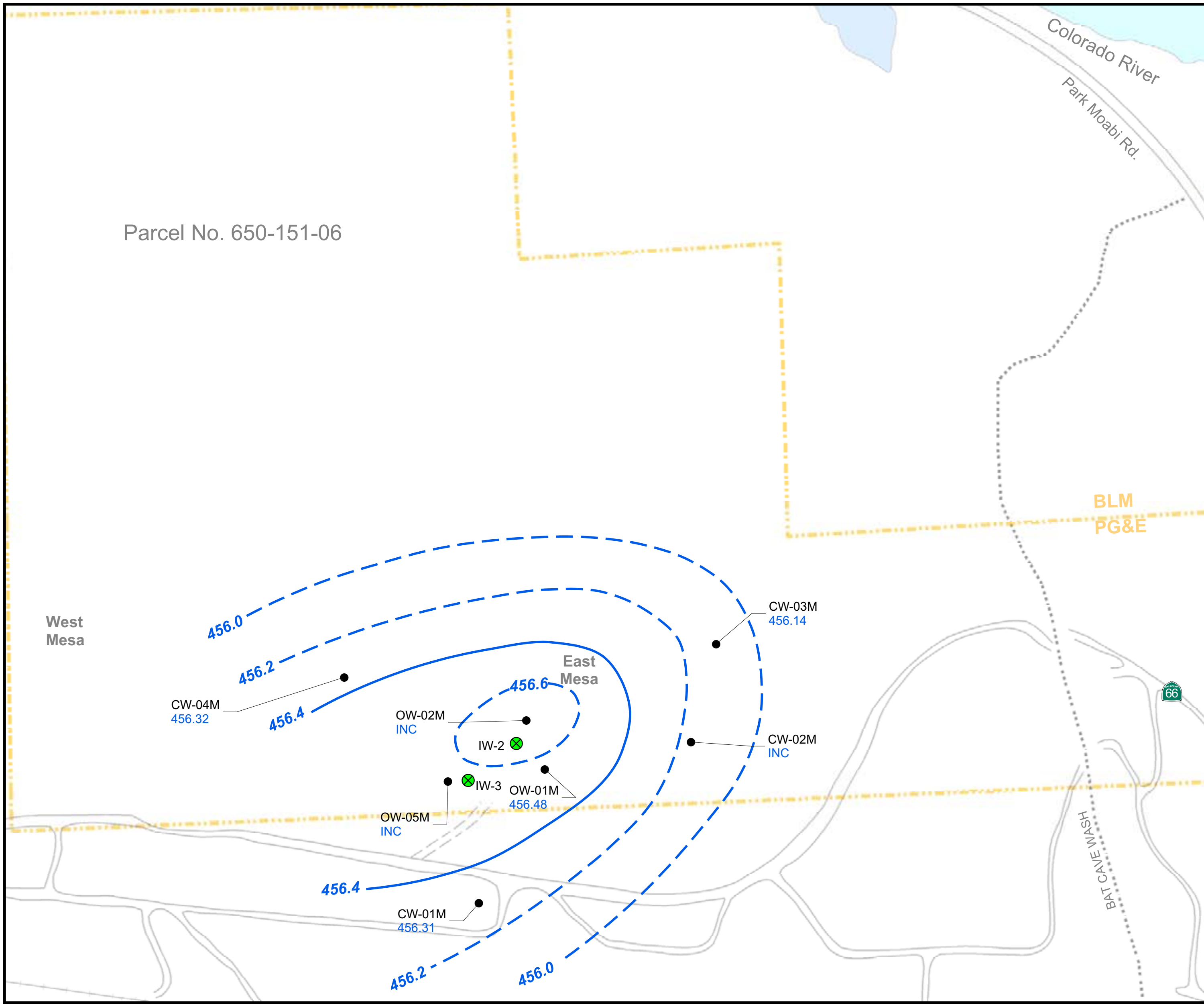

N

0 250 500 Feet

1 inch equals 250 feet

California State Plane NAD83 Zone 5 US Feet

LEGEND

Groundwater Monitoring, Compliance, and Observation Well

IM-3 Injection Well

Groundwater Elevations for Mid-depth Wells in IM-3 Injection Area

MW-41M **454.75** Salinity and temperature adjusted groundwater head elevation in feet above mean sea level (MSL)

Groundwater elevation contour in feet above MSL (0.2 foot interval), dashed where inferred

Note: Average monthly groundwater elevations are calculated with pressure transducer data measured at 30 minute intervals.
INC = Data incomplete or unavailable over reporting period.

FIGURE 2-11
GROUNDWATER ELEVATION CONTOURS FOR MID-DEPTH WELLS
MARCH 15 THROUGH APRIL 15, 2006
INJECTION WELL FIELD PERFORMANCE ASSESSMENT
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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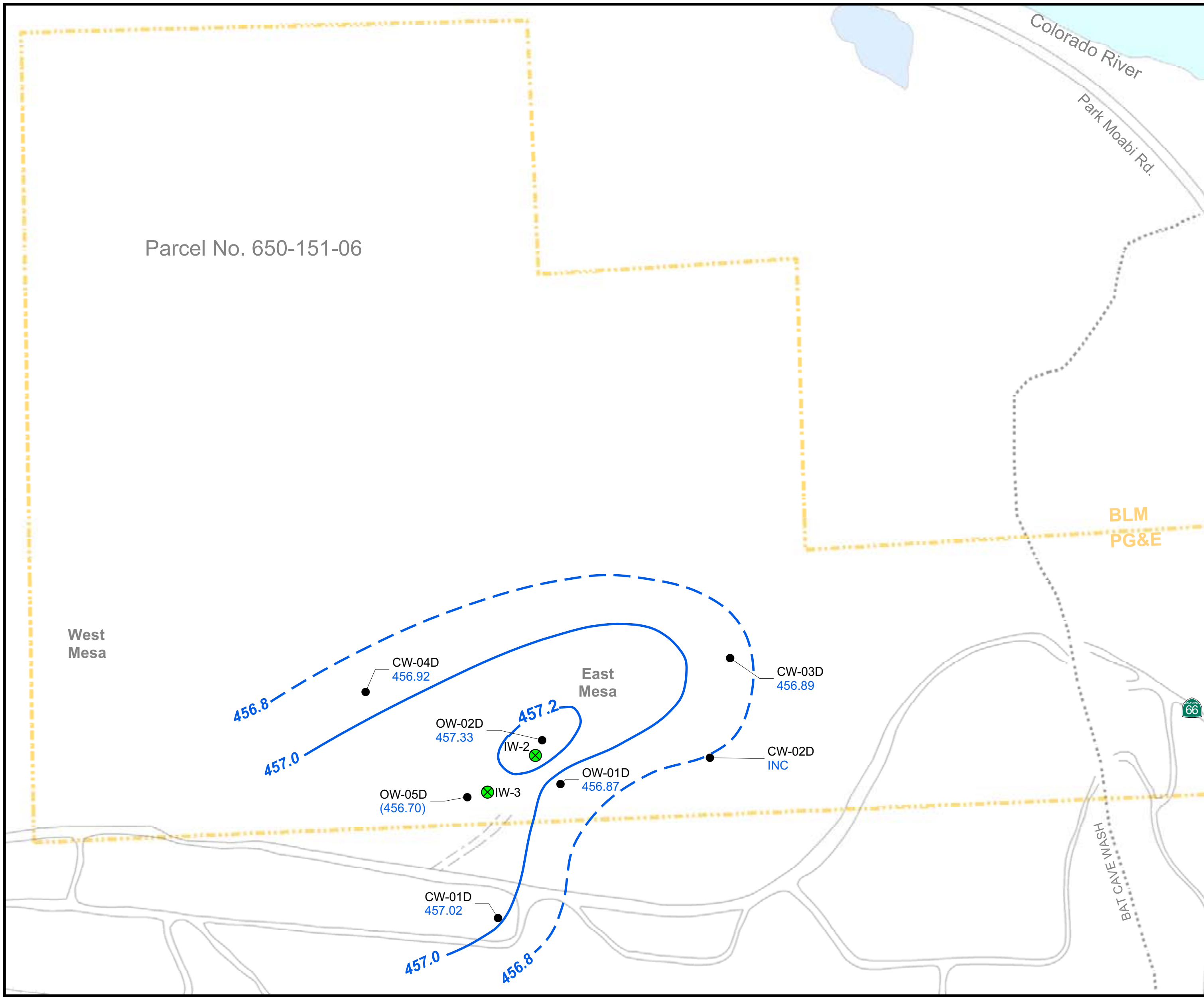

N

0 250 500 Feet

1 inch equals 250 feet

California State Plane NAD83 Zone 5 US Fee

LEGEND

Groundwater Monitoring, Compliance, and Observation Well

IM-3 Injection Well

G roundwater Elevations for Deep Wells in IM-3 Injection Area

MW-41M **454.75** Salinity and temperature adjusted groundwater head elevation in feet above mean sea level (MSL)

Groundwater elevation contour in feet above MSL (0.2 foot interval), dashed where inferred

Notes:
Gradients on this figure show transient conditions in the aquifer at the time of measurement and may not reflect the expected average annual groundwater flow directions.

OW-05D excluded from contouring.

Data posted and contoured from monthly average heads measured with tranducers at 30 minute intervals.

FIGURE 2-12
GROUNDWATER ELEVATION CONTOURS FOR DEEP WELLS
MARCH 15 THROUGH APRIL15, 2006

INJECTION WELL FIELD PERFORMANCE ASSESSMENT
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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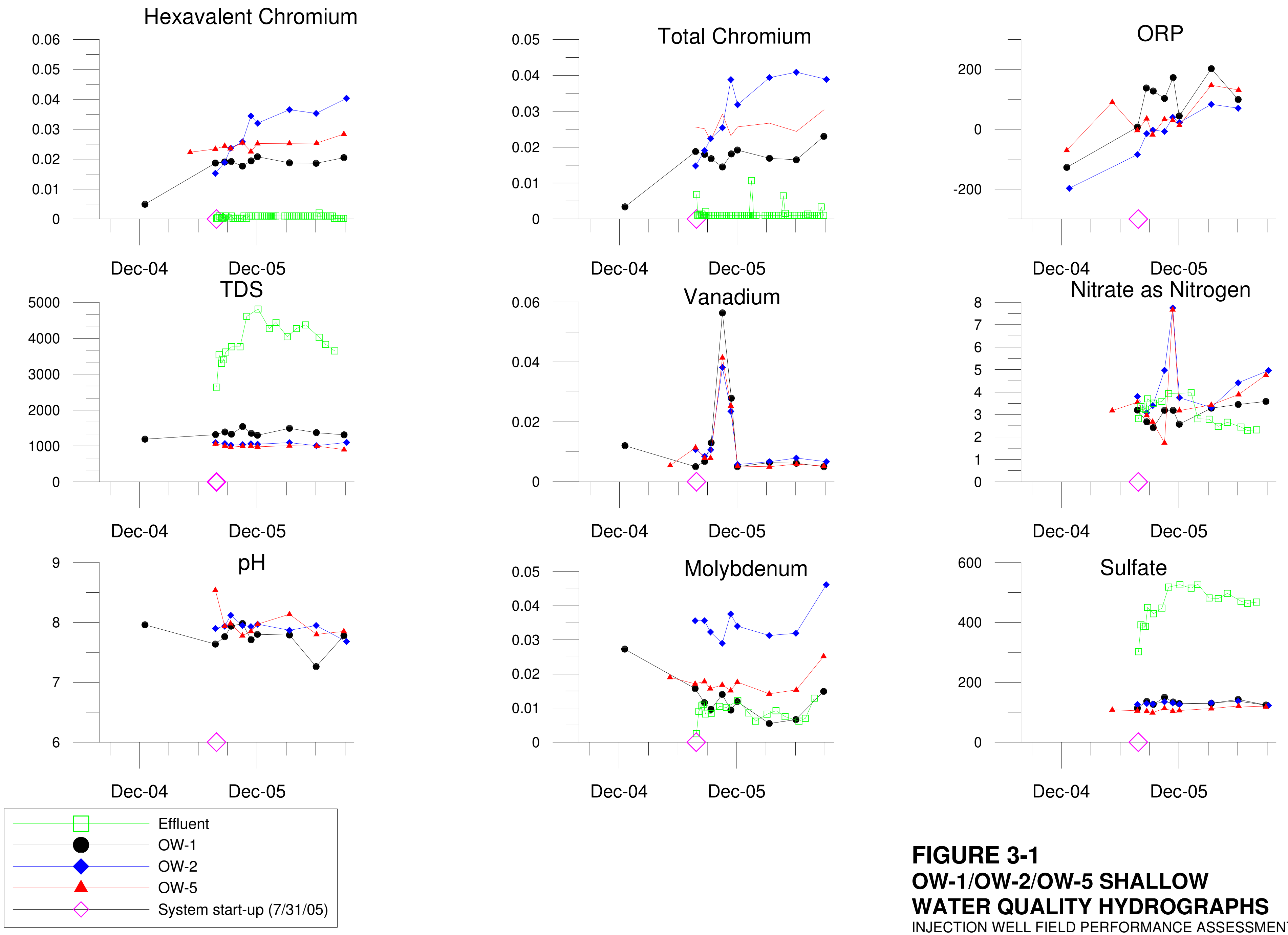

All concentration units in milligrams per liter. pH in pH units.
oxidation reduction potential in millivolts.

FIGURE 3-1
OW-1/OW-2/OW-5 SHALLOW WATER QUALITY HYDROGRAPHS
INJECTION WELL FIELD PERFORMANCE ASSESSMENT
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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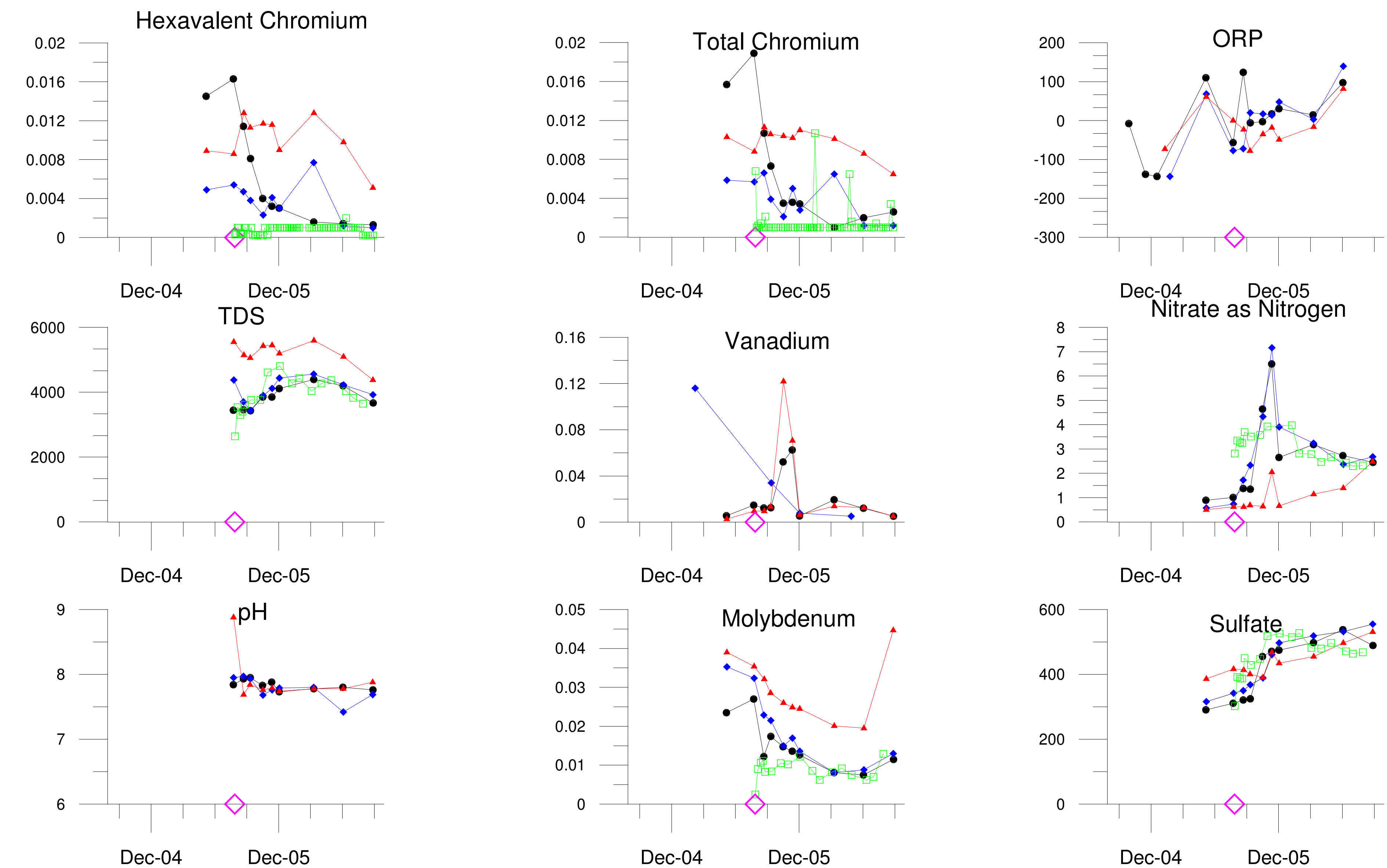
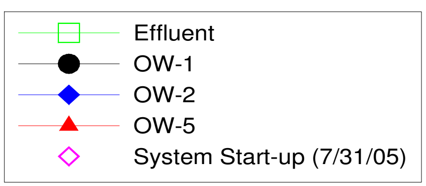
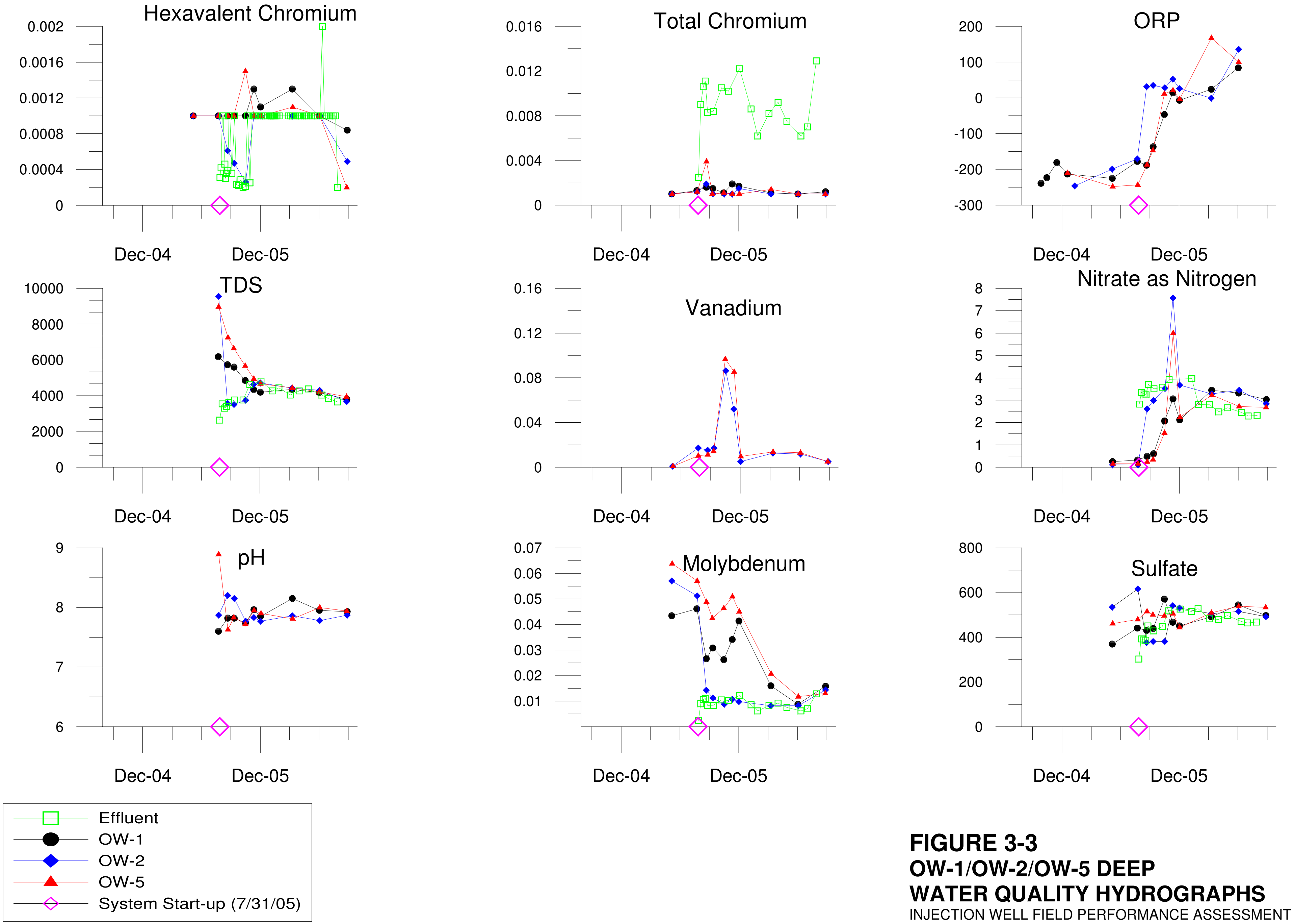




All concentration units in milligrams per liter. pH in pH units.
oxidation reduction potential in milli volts.

FIGURE 3-2
OW-1/OW-2/OW-5 MIDDLE
WATER QUALITY HYDROGRAPHS
INJECTION WELL FIELD PERFORMANCE ASSESSMENT
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



All concentration units in milligrams per liter. pH in pH units.
oxidation reduction potential in millivolts.

FIGURE 3-3
OW-1/OW-2/OW-5 DEEP
WATER QUALITY HYDROGRAPHS

INJECTION WELL FIELD PERFORMANCE ASSESSMENT
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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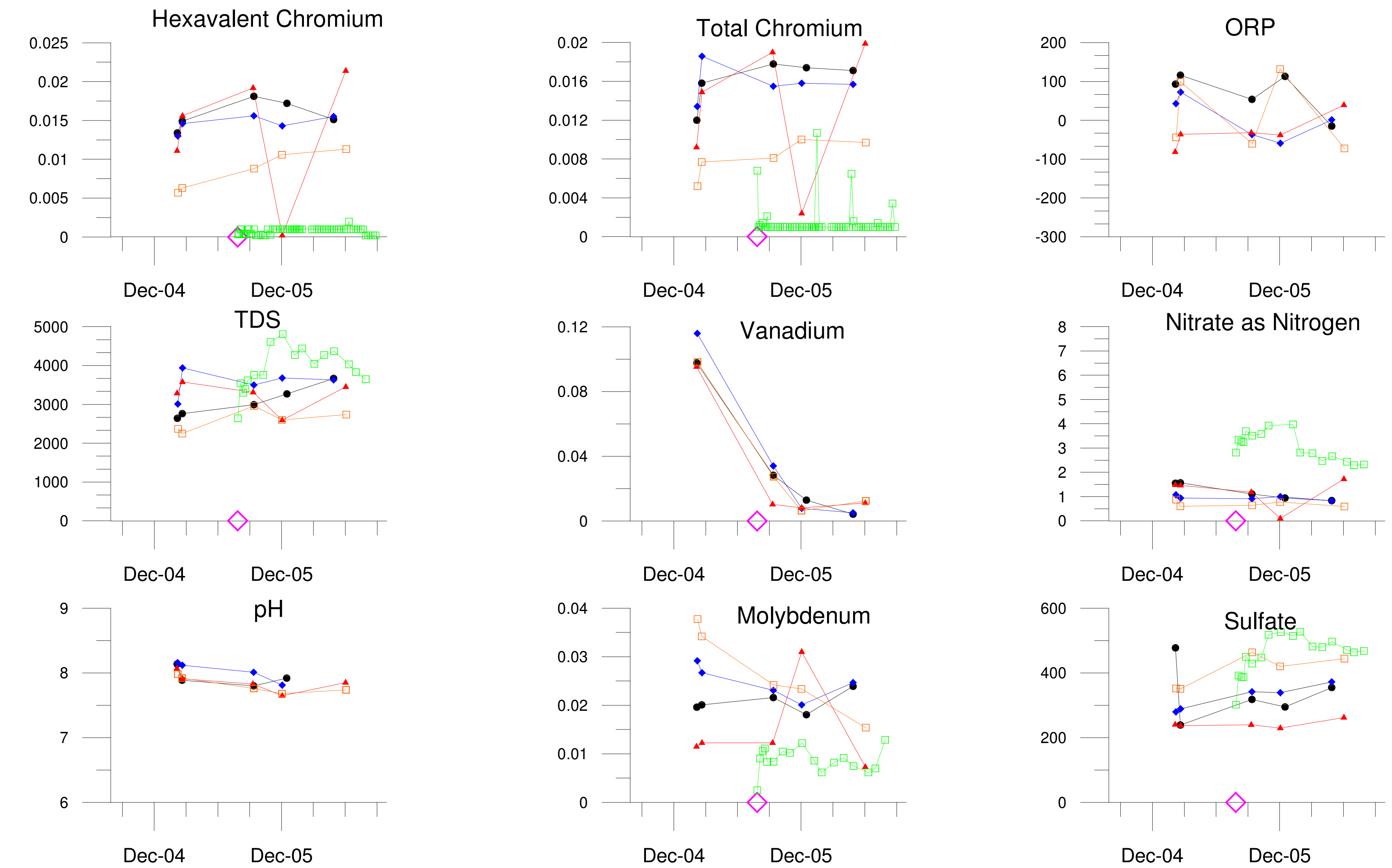
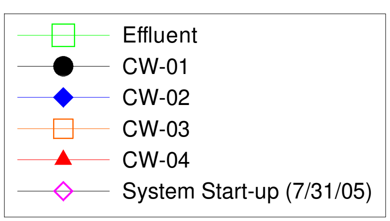
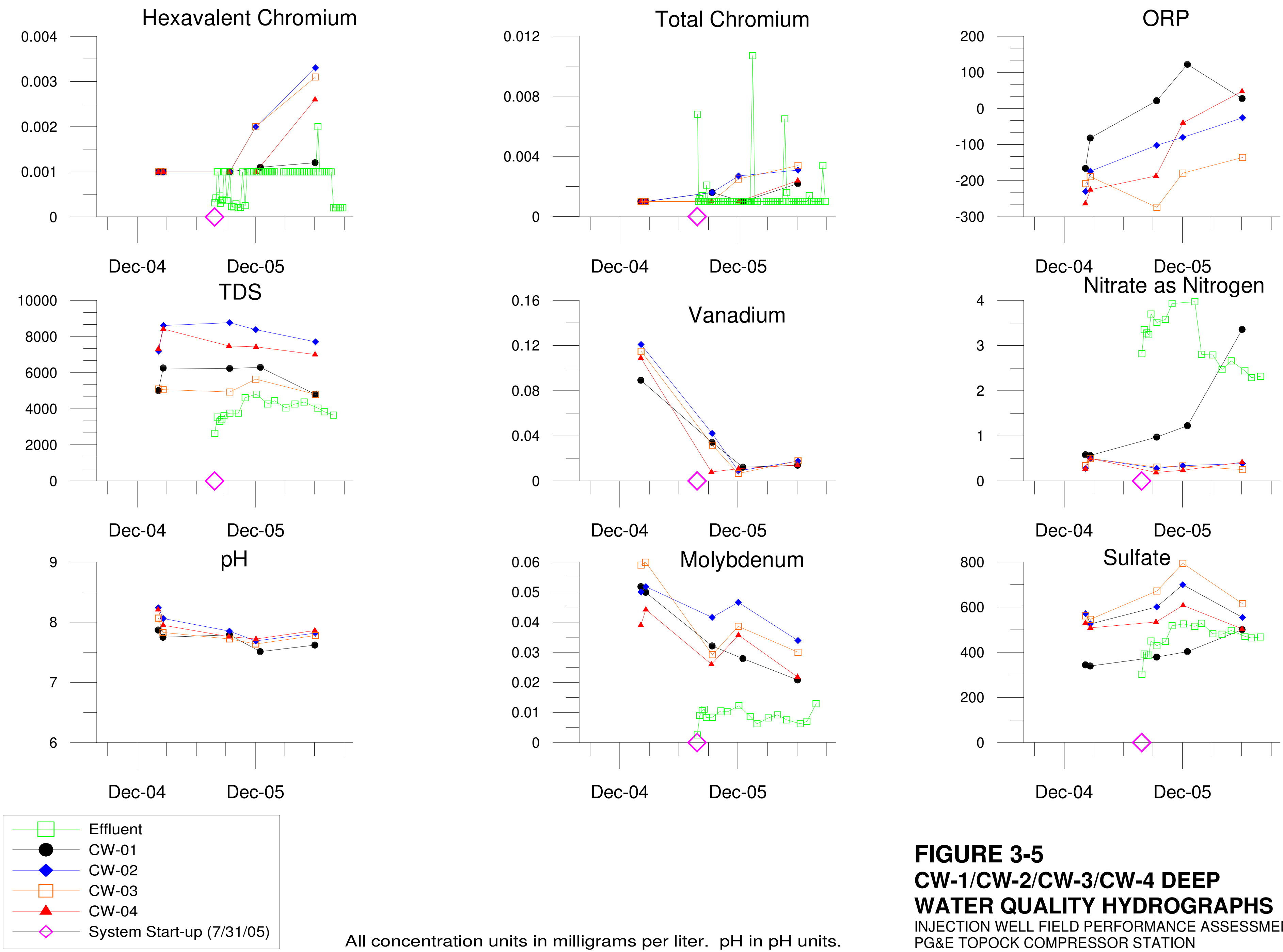




All concentration units in milligrams per liter. pH in pH units.
oxidation reduction potential in milli volts.

FIGURE 3-4
CW-1/CW-2/CW-3/CW-4 MIDDLE WATER QUALITY HYDROGRAPHS
INJECTION WELL FIELD PERFORMANCE ASSESSMENT
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



All concentration units in milligrams per liter. pH in pH units.
oxidation reduction potential in milli volts.

FIGURE 3-5
CW-1/CW-2/CW-3/CW-4 DEEP WATER QUALITY HYDROGRAPHS
INJECTION WELL FIELD PERFORMANCE ASSESSMENT
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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