Revision 1
AQUIFER CHARACTERIZATION REPORT

TASK 4 OF THE AQUIFER CHARACTERIZATION PLAN MITIGATION ORDER ON CONSENT DOCKET NO. P-121-07 COCHISE COUNTY, ARIZONA

Volume 1
(Text, Tables, and Figures)



Prepared for:

FREEPORT-MCMORAN CORPORATION
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December 15, 2010

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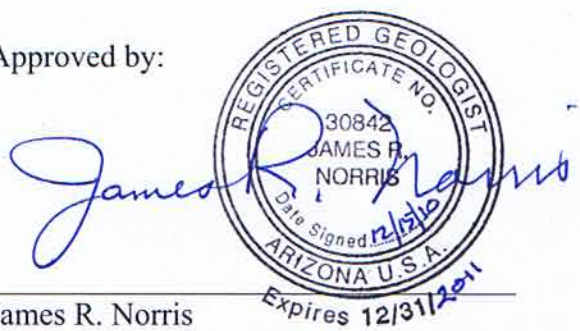
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Approved by:



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December 15, 2010

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LIST OF ABBREVIATIONS AND ACRONYMS

ac-ft/yr	acre-feet per year
ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Department of Water Resources
ARCH	air rotary casing hammer
AWC	Arizona Water Company
cm/s	centimeters per second
COB	City of Bisbee
CTSA	Concentrator Tailing Storage Area
CQB	Freeport-McMoRan Corporation, Copper Queen Branch
ELMA	Errol L. Montgomery and Associates
EPA	United States Environmental Protection Agency
ft amsl	feet above mean sea level
ft bls	feet below land surface
ft/day	feet per day
ft^2/day	square-feet per day
gpm	gallons per minute
hrs	hours
HGC	Hydro Geo Chem, Inc.
Kh	horizontal hydraulic conductivity
Kv	vertical hydraulic conductivity
MGD	million gallons per day
mg/L	milligrams per liter
NSD	Naco Sanitation District
NTS	Not to Scale
NWC	Naco Water Company
PD	Phelps Dodge Corporation
PWS	Public Water System
Sac LOGS1	Sacramento Low Ore Grade Storage No. 1
Sac LOGS2	Sacramento Low Ore Grade Storage No. 2
SAIC	Science Applications International Corporation
SET	Savci Environmental Technologies
SGC	Southwest Ground-water Consultants
TDS	total dissolved solids
TVI	Turquoise Valley, Inc.
UTM	Universal Transverse Mercator
Work Plan	Revision 1 Work Plan to Characterize and Mitigate Sulfate in Drinking Water Supplies in the Vicinity of the Concentrator Tailing Storage Area (Work Plan)
WIA	well inventory area
WMC	Water Management Consultants
WRD	ADWR Well Registry Database

1. INTRODUCTION

1.1 Purpose and Scope of the Aquifer Characterization Report

This report presents the results of work to characterize a groundwater sulfate plume in the vicinity of the Freeport-McMoRan Corporation, Copper Queen Branch (CQB) Concentrator Tailing Storage Area (CTSA) south of Bisbee, Arizona (Figure 1). The work reported here was conducted for Mitigation Order on Consent Docket No. P 121-07 between CQB and Arizona Department of Environmental Quality (ADEQ) (the Mitigation Order). The Mitigation Order requires CQB to characterize the extent of the groundwater sulfate plume originating from the CTSA and to develop a Mitigation Plan for drinking water supplies impacted by sulfate at concentrations in excess of 250 milligrams per liter (mg/L) attributable to the CTSA. The CTSA comprises several facilities as described in Section 2.1. One of the CTSA facilities, a former evaporation pond, was the primary source of sulfate to the groundwater plume (Section 6).

The Mitigation Order sets an action level for drinking water supplies of 250 mg/L sulfate at the point of use. There is no Arizona aquifer quality standard for sulfate. The 250 mg/L level for sulfate was set to align with the secondary maximum contaminant level established by the United States Environmental Protection Agency (EPA) to address aesthetic effects (e.g., taste) of sulfate in drinking water. The sulfate plume is considered to consist of groundwater with sulfate in excess of 250 mg/L attributable to the CTSA (Figure 2). The investigations reported here were conducted to describe the nature and extent of the sulfate plume and provide information for a Feasibility Study to evaluate potential mitigation action alternatives.

This Aquifer Characterization Report (ACR) is a requirement of Section III.C of the Mitigation Order. The scope of the ACR covers the hydrologic investigations conducted from February 2008 through October 2010 in accordance with the Aquifer Characterization Plan in Revision 1 Work Plan to Characterize and Mitigate Sulfate in Drinking Water Supplies in the Vicinity of the Concentrator Tailing Storage Area (Work Plan) (Hydro Geo Chem, Inc. (HGC), 2008a) and the Work Plan for Focused Bedrock Investigation (CQB, 2010c).

Section III.C of the Mitigation Order requires the ACR to address the following:

- Current sulfate plume delineation.
- Sulfate plume fate and transport.
- Identification of registered drinking water wells within a one-mile radius of the sulfate plume's down gradient and cross gradient edge.

This report provides the results of the following three aquifer characterization tasks conducted to address the Mitigation Order requirements and develop data for the Feasibility Study:

- Task 1 – Well Inventory – The well inventory identified and sampled drinking water supply wells in the sulfate plume and within one mile of the plume. CQB conducts ongoing monitoring of drinking water supplies on a monthly to quarterly basis pursuant to Section 4 of the Work Plan.
- Task 2 – Plume Characterization – Plume characterization work consisted of compiling existing information about environmental conditions in the plume area and field activities to further define the hydrogeology and groundwater quality in the vicinity of the plume. The primary field activities consisted of water quality monitoring; drilling, installation, and testing of new monitoring wells; and hydraulic testing at existing wells. Plume characterization was divided into the following subtasks:
    - Task 2.1 Data Compilation and Evaluation.

- Task 2.2 Groundwater Monitoring.
- Task 2.3 Well Installation and Testing.
- Task 2.4 Additional Hydraulic Testing.
- Task 3 – Sulfate Fate and Transport Evaluation – The sulfate fate and transport evaluation described and quantified the factors controlling the transport of sulfate in groundwater and migration of the sulfate plume. A numerical model of groundwater flow and sulfate transport was developed for use as a tool with which the Feasibility Study can assess potential mitigation actions.

The Work Plan detailed the scope, methods, and reporting schedule for the aquifer characterization tasks. This report was prepared for Task 4 of the Work Plan to describe the methods and results of the aquifer characterization tasks. The results of the aquifer characterization tasks are used to describe the hydrogeology of the sulfate plume, the nature and extent of sulfate in groundwater, and the fate and transport of the sulfate plume.

An initial version of the ACR was submitted to ADEQ on April 29, 2009 (HGC, 2009c). In March 2010, ADEQ provided detailed written comments on the ACR and requested modification of portions of the report (ADEQ, 2010a). In addition, ADEQ commented on the level of characterization and plume delineation in the bedrock aquifer in the vicinity of Bisbee Junction (Figure 2). CQB provided written responses to specific ADEQ comments in May 2010 (CQB, 2010b). ADEQ's comments on the ACR and CQB's responses to ADEQ comments are in Appendix A.1.

CQB's responses included a commitment to revise the ACR to address ADEQ comments and update the report with data collected since the original submittal. In addition, CQB proposed

a Work Plan for Focused Bedrock Investigation to evaluate further the conditions in bedrock in the vicinity of Bisbee Junction. A Work Plan for Focused Bedrock Investigation was submitted to ADEQ in June 2010 (CQB, 2010c). The purpose of the Focused Bedrock Investigation was to conduct additional characterization of the bedrock aquifer to determine if the conceptual and numerical models for the portion of the plume in bedrock could be improved. Work conducted for the Focused Bedrock Investigation constitutes additional plume characterization activities carried out using the methods of the 2008 Work Plan. Work conducted for the Focused Bedrock Investigation included:

- Installation and testing of two groundwater monitoring wells in bedrock.
- Hydraulic testing of new and existing bedrock wells.
- Analysis of existing geophysical data.
- Evaluation of the numerical model calibration.

In 2010 CQB also installed two new groundwater monitoring wells along Greenbush Draw north of Naco. The Greenbush Draw wells were installed at the request of Arizona Water Company. Although the Greenbush Draw Wells were not part of the 2008 Work Plan approved by ADEQ, groundwater monitoring results for these wells are presented in the revised ACR.

This revised ACR contains the information included in the initial version as modified to address ADEQ's comments, the results of additional well construction and groundwater monitoring conducted between the submittal of the initial ACR and October 2010, and the results of the Focused Bedrock Investigation.

1.2 Organization of Report

Revision 1 of the ACR is organized as follows:

- Section 2 – Site Background – Discusses the site history and hydrogeologic setting.
- Section 3 – Aquifer Characterization Methods and Results – Describes the methods and presents the results of the well inventory (Task 1) and plume characterization (Task 2 and Focused Bedrock Investigation) work.
- Section 4 – Geology and Hydrology of the Sulfate Plume Area – Describes the geology and groundwater hydrology of the sulfate plume area based on historical data and information collected for plume characterization.
- Section 5 – Nature and Extent of Sulfate – Discusses the physical extent of the sulfate plume, general water quality characteristics, and fate and transport considerations.
- Section 6 – Conceptual Site Model – Discusses the source, migration pathway, and potential receptors of the sulfate plume.
- Section 7 – Numerical Model of Groundwater Flow and Sulfate Transport – Presents the results of groundwater flow and sulfate transport modeling conducted for Task 3 and the Focused Bedrock Investigation to evaluate sulfate fate and transport and develop a model for simulating plume control strategies.
- Section 8 – Conclusions – Presents a summary and describes future deliverables for the Mitigation Order.
- Section 9 – References – Lists references for the ACR.

This report also includes referenced tables, figures, plates and appendices as listed in the Table of Contents. For completeness, the following reports that were previously prepared and submitted to ADEQ for the Mitigation Order are included in Portable Document Format on the compact disc in Appendix A.3:

- HGC. 2008a. Revision 1, Work Plan to Characterize and Mitigate Sulfate with Respect to Drinking Water Supplies in the Vicinity of the Concentrator Tailing Storage Area, Cochise County, Arizona. July 3, 2008.

- HGC. 2008b. Well Inventory Report, Task 1 of Aquifer Characterization Plan for Mitigation Order on Consent No. P-121-07, Cochise County, Arizona. July 28, 2008.

- HGC. 2008c. First and Second Quarters 2008, Groundwater Monitoring Report, Task 2.2 of Aquifer Characterization Plan, Mitigation Order on Consent Docket No. P-121-07, Cochise County, Arizona. July 30, 2008.

- HGC. 2008e. Third Quarter 2008, Groundwater Monitoring Report, Tasks 1.0, 2.2 and 2.3 of Aquifer Characterization Plan, Mitigation Order on Consent Docket No. P-121-07, Cochise County, Arizona. October 27, 2008.

- HGC. 2009a. Fourth Quarter 2008, Groundwater Monitoring Report, Tasks 1.0, 2.2 and 2.3 of Aquifer Characterization Plan, Mitigation Order on Consent Docket No. P-121-07, Cochise County, Arizona. January 23, 2009.

- HGC. 2009b. First Quarter 2009 Groundwater Monitoring Report, Tasks 1 and 2.2 of Aquifer Characterization Plan, Mitigation Order on Consent Docket No. P-121-07, Cochise County, Arizona. April 14, 2009.

- HGC. 2009d. Second Quarter 2009 Groundwater Monitoring Report, Tasks 1 and 2.2 of Aquifer Characterization Plan, Mitigation Order on Consent Docket No. P-121-07, Cochise County, Arizona. July 9, 2009.

- HGC. 2009e. Third Quarter 2009 Groundwater Monitoring Report, Tasks 1 and 2.2 of Aquifer Characterization Plan, Mitigation Order on Consent Docket No. P-121-07, Cochise County, Arizona. October 20, 2009.

- HGC and Clear Creek Associates, 2010. Fourth Quarter 2009 Groundwater Monitoring Report, Tasks 1 and 2.2 of Aquifer Characterization Plan, Mitigation Order on Consent Docket No. P-121-07, Cochise County, Arizona. January 8, 2010.

- Clear Creek Associates. 2010a. First Quarter 2010 Groundwater Monitoring Report, Tasks 1 and 2.2 of Aquifer Characterization Plan, Mitigation Order on Consent Docket No. P-121-07, Cochise County, Arizona. April 14, 2009.

- Clear Creek Associates. 2010b. Second Quarter 2010 Groundwater Monitoring Report, Tasks 1 and 2.2 of Aquifer Characterization Plan, Mitigation Order on Consent Docket No. P-121-07, Cochise County, Arizona. July 20, 2010.

- Clear Creek Associates. 2010c. Third Quarter 2010 Groundwater Monitoring Report, Tasks 1 and 2.2 of Aquifer Characterization Plan, Mitigation Order on Consent Docket No. P-121-07, Cochise County, Arizona. October 11, 2010.

Previously submitted reports are also available at the CQB Mitigation Order document repository at the Copper Queen Library in Bisbee and at the CQB document library website at http://www.fcx.com/bisbee/bisbee.htm.

Clear Creek Associates prepared Revision 1 of the ACR at the request of and under contract to CQB. This required that Clear Creek Associates rely on information and interpretations contained in the initial version of the ACR which was prepared by HGC who also conducted fieldwork required under the Work Plan. The responsibility for groundwater monitoring, installation of the Greenbush Draw wells, and the Focused Bedrock Investigation transitioned to Clear Creek Associates in 2010. The format, text, and content of the initial version of the ACR have been maintained to the degree possible to efficiently revise and update the report. The text of the ACR was revised to address specific ADEQ comments as described by CQB (2010b), update the ACR with new information (e.g., new groundwater monitoring data and the results of the bedrock investigation), and modify interpretations as needed to reflect current information (e.g., conceptual site model and numerical model). Figures, tables, and appendices taken directly from HGC (2009b) without modification are referenced as to their source. Figures, tables, and appendices not referenced to HGC (2009b) were modified or updated with new information collected by CQB.

2. SITE BACKGROUND

This section describes the CTSA, the regulatory history of the sulfate plume, and provides an introduction to the hydrogeology of the CTSA as a basis for later sections describing the methods, results, and interpretation of the aquifer characterization work.

2.1 Concentrator Tailing Storage Area

The CTSA is located approximately 3.5 miles southeast of Bisbee, approximately four miles northeast of Naco, and approximately one mile south of Warren (Figure 1). As defined by the Mitigation Order, the CTSA consists of two inactive tailing impoundments (the North Tailing Impoundment and the South Tailing Impoundment), a former evaporation pond, and a stormwater impoundment known as Horseshoe Pond (Figure 2). The North and South Tailing Impoundments and former evaporation pond cover an area of approximately 1,000 acres in Sections 27, 33, and 34, Range 24 East, Township 23 South, and Sections 3 and 4 in Range 24 East, Township 24 South.

The CTSA facilities and other facilities described in Section 2.1.1 were used variably from 1905 through 1987 for the storage and evaporation of excess mine water, the placement of tailing and mine materials, and containment of stormwater. The CTSA facilities are currently inactive and receive no process solids or liquids.

The North and South Tailing Impoundments are uncapped and unlined except for the north slope of the North Tailing Impoundment and the south slope of the South Tailing Impoundment. Capping and closure plans for the North and South Tailing Impoundments are in development. The upper surface of the South Tailing Impoundment collects incidental rainfall and stormwater runoff in its present configuration. The pond on the South Tailing Impoundment is currently being dewatered in anticipation of reclamation. Dewatering is needed to dry the surface to a point at which it can support heavy equipment for reclamation activities.

The former evaporation pond had a surface footprint of approximately 350 acres. Delivery of excess mine water to the former evaporation pond began in 1908 and ceased in 1987. Surficial pond sediments were excavated and placed on the south slope of the South Tailing Impoundment between 1989 and 1990.

Horseshoe Pond is an unlined stormwater impoundment covering an area of approximately six acres that was constructed within the footprint of the former evaporation pond in 1990. Horseshoe Pond collects incident rainfall and stormwater runoff from the North and South Tailing Impoundments, and areas north of the CTSA (Phelps Dodge Corporation [PD], 2004). Stormwater that collects in Horseshoe Pond is currently pumped to the Lavender Pit for evaporation to dry the pond area in anticipation of reclamation.

2.1.1 Historical Land Use of the CTSA and Vicinity

Mining activities in the Bisbee area began in 1880. Historical facilities in the vicinity of the CTSA include the former Warren Ranch irrigation area that used excess mine water south and southwest of the CTSA, the former Crawford Mill, the former Crawford Mill tailing pile, the former Sacramento concentrator, and the former low-grade ore stockpile areas (Sacramento Low Ore Grade Storage No. 1 [Sac LOGS1] and Sacramento Low Ore Grade Storage No. 2 [Sac LOGS2]) (PD, 1990) (Figure 2).

Mining and smelting of ore from the Sacramento Pit began in 1919 (Stegan, et al, 2005) and operation of the Sacramento Mill began in 1923. Low ore-grade material from the Sacramento Pit was stockpiled at Sac LOGS1 and Sac LOGS2 from 1923 to 1932 (PD, 2004) and tailing from the mill was piped as slurry to the North Tailing Impoundment until 1932 (PD, 1990). There was a hiatus in milling and tailing deposition from 1933 to at least 1945. Crawford Mill tailing produced from 1945 through 1954 was sent to the 12.6-acre Crawford Mill Tailing Impoundment (PD, 2004). Ore from the Lavender Pit was milled at the Lavender Mill from 1954 to 1974. The Lavender Mill tailing was sent to the North and South Tailing Impoundments. The North and South Tailing Impoundments last received tailing in 1974. The former Warren Ranch irrigation area is located in Sections 3, 4, 8, 9, and 10, Range 24 East, Township 24 South. Delivery of excess mine water to the irrigation area began in 1905 and ceased in 1985. In 1991 and 1992, the relatively small Crawford Mill Tailing Impoundment, the Sac LOGS1, and the Sac LOGS2 were excavated and placed on the North Tailing Impoundment (PD, 2004). The historical land uses in the CTSA and vicinity that involved processing and storing ore material

and tailing could have released sulfate-bearing seepage to the subsurface. However, as will be discussed in this report, previous investigations concluded that the primary source of the sulfate plume from the CTSA was the infiltration of excess mine water stored in the former evaporation pond and, to a lesser degree, excess mine water used for crops at the former Warren Ranch irrigation area (PD, 1990; SET, 1998a). Former mining facilities in the CTSA and vicinity are not considered to be current sources of sulfate or to constitute significant potential future sources of sulfate because they have been inactive for many years and have been managed to minimize potential infiltration.

Water was pumped from various shafts in the Warren Mining District to dewater underground workings throughout the history of underground mining (PD, 1990 and 2004; Water Management Consultants [WMC], 2006). The volume of groundwater pumped from underground workings from 1906 through 1987 is approximately 168.6 billion gallons (WMC, 2006). Water from underground workings was used in mining and excess mine water was pumped to the former evaporation pond or used at the former Warren Ranch irrigation area. Southwest Ground-water Consultants, Inc. (2004) provides additional description of historical underground pumping.

2.1.2 Historical Use of Excess Mine Water

The use of excess mine water for irrigation of the former Warren Ranch irrigation area started in 1905 and was followed by discharge of additional excess mine water to the former

evaporation pond commencing in 1908 (PD, 2004). Mine water was delivered to the former Warren Ranch irrigation area until 1985 and to the former evaporation pond until 1987. Research conducted by CQB for this investigation confirmed that discharges to the Warren Ranch irrigation area stopped in 1985 as reported by PD (1990) rather than in 1987 as reported by Savci Environmental Technologies (SET) (1998c) and PD (2004).

Mine water was reported by PD (2004) to have been pumped to the former Warren Ranch irrigation area at an average rate of approximately 2,350 acre-feet per year (ac-ft/yr), or 1,457 gallons per minute (gpm). The former evaporation pond received excess water from underground mine dewatering at an average rate of approximately 4,430 ac-ft/yr, or 2,746 gpm (PD, 2004). Based on descriptions of mine water use by PD (1990 and 2004), detailed records of the production and placement of mine water were not kept and the estimates above are likely the best available approximations. Section 3.2.7.2 discusses the former Warren Ranch irrigation area and former evaporation pond further in the context of artificial recharge.

There are limited water quality data for the mine water sent to the former Warren Ranch irrigation area and the former evaporation pond. PD (1990) provided a general characterization of the mine water pumped between 1954 and 1974 as consisting of 47 percent clean water, 45 percent hard water, and 8 percent mineralized water on a flow-weighted basis. The pHs of clean, hard, and mineralized waters were reported to be 7.5, 6.6, and 2.5, respectively. With respect to the mineral content of the mine waters, the hardness of the clean and hard waters was reported as 840 parts per million (ppm) and 3,100 ppm, respectively.

SET (1998c) and WMC (2006) report that a 1982 PD letter identifies a similar three-part classification of mine water. The former evaporation pond reportedly received mineralized water while the former Warren Ranch irrigation area received clean and hard water SET (1998c). WMC (2006) indicates that at least some mineralized water was reused in mining processes; that hard water, with high total dissolved solids (TDS) and a pH of approximately 5.3, was sent to the former evaporation pond and the former Warren Ranch irrigation area; and that the clean water was used at the mine.

There are few water quality analyses of the underground mine water. Water quality data for samples from the Junction Shaft in 1988 and 1990 indicate that sulfate concentrations ranged between approximately 4,000 mg/L and 6,000 mg/L (Southwest Ground-water Consultants [SGC], 2004; WMC, 2006). Although these analyses post-date operation of the former Warren Ranch irrigation area and the former evaporation pond, the analyses provide an example of the sulfate concentrations that could potentially have been in water pumped from some underground workings.

Estimation of the sulfate concentration in water delivered to Warren Ranch and the former evaporation pond is difficult based on the foregoing data. Presumably, the mineralized and hard waters would have been elevated in sulfate. Further, it is uncertain how or if the water quality of mine water changed over the history of its application because the source of underground pumpage changed over time as different mineral deposits were mined and accessed by different shafts (SGC, 2004). Section 7.1.7 discusses further the potential sulfate

concentrations in the recharge from the former Warren Ranch irrigation area and former evaporation pond.

2.2 Regulatory History

In 1987, groundwater south of the CTSA was reported to contain elevated sulfate (Littin, 1987). In 1988 and 1989, CQB installed a series of monitoring wells in the CTSA and defined a zone of elevated sulfate concentrations extending southwesterly and southerly from the former evaporation pond toward Naco and Bisbee Junction (PD, 1990). Between 1990 and 2007, the extent and characteristics of the sulfate plume were studied by various CQB consultants as a part of Aquifer Protection Permit investigations for the CTSA (e.g., Canonie Environmental, 1990; Steffan, Robertson and Kirsten [SRK], 1997; SET 1998a, 1998b, and 1998c; and PD 1990 and 2004).

In 2007, ADEQ determined that a drinking water source was, or was about to be, rendered unusable without treatment because sulfate concentrations approaching and exceeding 250 mg/L were found in drinking water supply wells downgradient of the CTSA (Mitigation Order Section II.A.5). For that reason, CQB and ADEQ entered into the Mitigation Order on November 14, 2007 to address the sulfate in groundwater attributable to the CTSA. The Mitigation Order requires CQB to characterize the extent of sulfate in groundwater and to develop a Mitigation Plan for existing drinking water supplies with sulfate concentrations greater

than 250 mg/L due to sulfate from the CTSA. A maximum average sulfate concentration of 250 mg/L at the point of use for drinking water supplies is stipulated in the Mitigation Order.

The Mitigation Order provides a structure for conducting additional environmental investigations and evaluating potential mitigation alternatives for sulfate from the CTSA. Sulfate is a non-hazardous constituent and the applicable legal criteria to address the plume are set forth in the Mitigation Order and Arizona Revised Statutes § 49-286.

In addition to investigation of the sulfate plume, the Mitigation Order also requires:

- Formation of a Community Advisory Group, requiring a minimum of eight people, which will meet four times yearly.
- Creation of a local information repository for the dissemination of information about the Mitigation Order.
- Submittal of quarterly status reports to ADEQ.

The Community Advisory Group initially met in January 2008 and the group has met since then in conformance with the Mitigation Order. CQB established and maintains an information repository at the Copper Queen Library in Bisbee. The information repository contains correspondence and reports associated with the Mitigation Order. CQB also maintains an internet site with an electronic document repository of project correspondence and reports that can be downloaded from http://www.fcx.com/bisbee/bisbee.htm. CQB has submitted quarterly status reports to ADEQ since February 2008 as required by the Mitigation Order. The status reports are available at the Copper Queen Library and the document repository on the internet site.

2.3 Hydrogeologic Setting

This section provides an overview of the hydrogeologic setting in the vicinity of the CTSA. The purpose of this discussion is to provide background on the general hydrogeology of the area. A detailed discussion of the hydrogeology of the sulfate plume based on the findings of the aquifer characterization tasks is contained in Sections 4 and 5.

The CTSA is located in the northeastern portion of the Bisbee-Naco physiographic basin south of the Mule Mountains (Figures 1 and 2). The Mule Mountains and the Cerro La Muela in Sonora, Mexico form the northern and eastern margins of the basin. The Sierra San Jose in Sonora, Mexico forms the southern boundary of the physiographic basin, approximately one-half of which lies in Mexico. The mountains surrounding the basin are composed of bedrock materials, and the basin area consists of clastic sediment underlain by bedrock. Surface runoff from the Bisbee-Naco physiographic basin drains into Greenbush Draw, which flows west and then northwest into the Upper San Pedro River (Figure 1).

Geologic data have been drawn from a number of sources including U.S. Geologic Survey publications, Arizona Geological Society publications, reports on environmental investigations, and a review of lithologic logs for area wells. The geology of the Mule Mountains and Bisbee-Naco basin has been mapped and described by Hayes (1970) and Hayes and Landis (1964). Stegan et al. (2005) describe the geology and mineralization of the Bisbee-Warren Mining District, and reference original detailed geologic studies of the mining district.

Mining in the Bisbee area is concentrated in the Mule Mountains, which are composed of Precambrian metamorphic rocks, Paleozoic and Cretaceous sedimentary formations, and Jurassic and Tertiary intrusive rocks. Mining activities focused primarily on the copper, lead, zinc, gold, and silver deposits occurring in the Paleozoic sedimentary and Jurassic intrusive rocks.

The geologic materials present in the Bisbee-Naco area and surrounding mountains can be divided into three generalized units: Recent alluvium, Quaternary and Tertiary basin fill deposits, and the bedrock complex. Recent alluvium consists of unconsolidated alluvial material. Basin fill consists of poorly to moderately lithified clastic material (Littin, 1987). The bedrock complex comprises older indurated units including sedimentary rocks of the Cretaceous Bisbee Group, Jurassic to Tertiary igneous rocks, Paleozoic sedimentary formations, and Precambrian metamorphic rocks. Figure 3 is a generalized geologic map of the area based on mapping by Hayes and Landis (1964). Table 1 is a generalized geologic column for the Bisbee-Naco area.

2.3.1 Recent Alluvium

Recent alluvium includes stream channel sediments, pediment and terrace gravel, sheet wash deposits and alluvial fans (Hayes and Landis, 1964). Recent alluvium occurs primarily along Greenbush Draw (Figure 3) and is not a significant aquifer because it typically is unsaturated.

2.3.2 Basin Fill

The Tertiary to Quaternary basin fill deposits are primarily poorly to moderately lithified sand and gravel lying unconformably on Cretaceous or older sedimentary bedrock. The basin fill consists of interbedded boulder to pebble conglomerate, gravel, sand, silt and clay (Littin, 1987). Caliche cementation is commonly present within the upper 40 to 130 feet of the basin fill penetrated by monitoring wells.

In the vicinity of the sulfate plume, the basin fill ranges in thickness from zero at its contact with surface outcrops of bedrock to more than 600 feet thick near Naco. Basin fill thickness data are not available for the southern portion of the Bisbee-Naco physiographic basin in Sonora, Mexico. The basin fill deposits south of the international border appear to form alluvial fans that slope north and east from the base of the Sierra San Jose toward Greenbush Draw (Figure 1).

2.3.3 Bedrock Complex

For the purposes of this report, bedrock refers to lithified rock units regardless of whether or not they are water-bearing. Bedrock in the vicinity of CTSA consists of the lower Cretaceous Bisbee Group formations. Paleozoic sedimentary rocks and Precambrian Pinal Schist have been intercepted beneath basin fill only in monitoring wells north of the CTSA (PD, 1990 and WMC, 2006).

2.3.3.1 Cretaceous Sedimentary Rocks

The Bisbee Group consists of four sedimentary formations, which are, in descending order, Cintura Formation, Mural Limestone, Morita Formation, and Glance Conglomerate. These formations have gradational contacts and are conformable with one another where they are exposed in the Mule Mountains north and east of the CTSA (Hayes, 1970). The Bisbee Group formations are the principal bedrock units underlying basin fill in the region of the CTSA.

The Cintura Formation is comprised of grayish red siltstone and mudstone, feldspathic sandstone, and minor amounts of green-gray calcareous claystone, with thin beds of fossiliferous limestone in its basal 100 feet. Hayes (1970) notes that the lithology of the Cintura Formation is so similar to that of the Morita Formation that distinguishing between the two formations would be difficult except for their relative stratigraphic positions with respect to the intervening Mural Limestone. Maximum preserved thickness of Cintura Formation in the Mule Mountains is 1,850 feet (Hayes and Landis, 1964).

The Mural Limestone is composed of an upper member of dark gray limestone that is up to 275 feet thick with subordinate sandstone in the upper 50 feet, and a lower member up to 453 feet thick consisting of interbedded calcareous sandstone, siltstone and impure fossiliferous limestone (Hayes and Landis, 1964).

The Morita Formation is generally composed of grayish red siltstone and mudstone, pale red feldspathic sandstone, minor amounts of greenish gray calcareous claystone, thin beds of

impure limestone in the upper part of the formation, and a small amount of pebble conglomerate in the lower part of the formation. The upper 300 feet of the Morita Formation is primarily sandstone. Siltstone and mudstone cyclically interbedded with sandstone constitute the remainder of the formation. The Morita Formation probably represents deposition on a slowly subsiding subaerial deltaic plain. Sandstone beds in cut-and-fill relation on underlying siltstone and mudstone are believed to represent channel deposits of meandering streams and intervening siltstone and mudstone units represent inter-fluvial flood deposits (Hayes, 1970). Where it outcrops in the Mule Mountains north and east of the CTSA, the formation is approximately 2,600 feet thick (Hayes, 1970).

The Glance Conglomerate is the basal unit of the Bisbee Group and lies unconformably on a variety of older lithologic units. The Glance Conglomerate outcrops north of the CTSA in and around the town of Warren, and over several square miles in the Mule Mountains east of the CTSA. Hayes and Landis (1964) estimated that the Glance Conglomerate ranges from zero to over 600 feet in thickness in the Mule Mountains. The Glance Conglomerate is an alluvial fan deposit made up of locally derived material with variable ratios of schist, limestone, and granitic clasts (Hayes, 1970); and consists of poorly sorted, poorly rounded, cobble- to pebble-sized clasts in a sandy and silty grayish-red to reddish brown mudstone matrix. Boulder-sized clasts are also locally present.

2.3.3.2 Paleozoic Rocks

Paleozoic sedimentary bedrock formations in the Mule Mountains are represented by, in descending order, the Naco Group, which includes the lower Permian Colina Limestone, upper Pennsylvanian Earp, and middle to upper Pennsylvanian Horquilla Limestone Formations; followed by the Mississippian Escabrosa Limestone, Devonian Martin Limestone, and the Cambrian Abrigo Limestone and Bolsa Quartzite (Table 1) (Hayes and Landis, 1964). Paleozoic sedimentary units, particularly the Abrigo, Martin, and Escabrosa Limestones, are important hosts to metal mineralization in the Warren-Bisbee Mining District (Stegan, et al., 2005).

2.3.3.3 Igneous and Metamorphic Rocks

Igneous and metamorphic rocks in the Mule Mountains include Tertiary quartz latite, Jurassic Juniper Flat Granite, a tuff of probable Jurassic age, the Jurassic Sacramento intrusive complex associated with copper mineralization, and the Precambrian Pinal Schist. The Pinal Schist is a light colored quartz-sericite phyllite to quartz-muscovite schist (Stegan, et al., 2005). Eroded Pinal Schist is the source of schist clasts in the Glance Conglomerate (Hayes, 1970).

2.3.4 Structure

As will be discussed further in Sections 4, the structural geology of the CTSA is complex and appears to have significant influence on groundwater flow. Four major fault zones have been identified in the CTSA area: the Bisbee West Fault and its eastward extension, the Gold

Hill Fault; the Abrigo Fault; the Black Gap Fault; and the Ninety-One Hills Fault zone (Figure 3).

The south-dipping Bisbee West and Abrigo Faults along the southern margin of the Mule Mountains trend west-northwest and are high-angle range front faults with normal offset. The subsurface projection of the Bisbee West Fault passes to the north of the former Sac LOGS1 and Sac LOGS2. The projected trace of the Abrigo Fault, as interpreted by SET (1998c), passes under the southwestern corner of the South Tailing Impoundment (Figure 3).

The Black Gap Fault trends north-northeast and dips steeply to the west. On the surface the Black Gap Fault is expressed by the offset of Paleozoic limestone beds and a topographic break known as Black Gap which forms a pass between Warren and the CTSA (Figure 3). From Black Gap, the fault extends to the north-northeast and is exposed again at the surface further north near the Dividend Fault in the Mule Mountains (Hays & Landis, 1964). To the south of Black Gap, the subsurface projection of the Black Gap Fault trace passes along the eastern margin of the North Tailing Impoundment and under the South Tailing Impoundment, where it meets the projected subsurface trace of the Abrigo Fault (SET, 1998c).

The Ninety-One Hills Fault zone is a west-northwest and west trending complex of faults paralleling the Abrigo and Bisbee West Faults. The fault zone is located south of the CTSA approximately one mile southeast of Bisbee Junction (Hayes and Landis, 1964). The

Ninety-One Hills Fault zone has been interpreted to extend under the basin fill towards the west (SET, 1998c).

2.3.5 Hydrostratigraphic Units

The groundwater hydrology of the Bisbee-Naco area is discussed by Littin (1987), and the hydrologic conditions in the vicinity of the CTSA and the sulfate plume by Canonie Environmental (1990), PD (1990), and SET (1998a, 1998b, and 1998c). The Greenbush Draw watershed is separate from the watershed containing the majority of mine workings in the Mule Mountains to the north. The hydrology of the mine area is discussed in WMC (2006).

Groundwater occurs in two hydrostratigraphic units in the vicinity of the CTSA: basin fill and bedrock of the Bisbee Group sedimentary formations. Recent alluvium is typically unsaturated and not a significant source of water to area wells.

2.3.5.1 Basin Fill

South of the Abrigo Fault and west of the Black Gap Fault, basin fill is the principal aquifer due to its high permeability and large saturated thickness. In this area, the basin fill provided about 95 percent of all water for domestic purposes in the Bisbee area in the 1980s (Littin, 1987). The thickness of the basin fill increases from zero at the margins to more than

600 feet in the central portion of the basin north of Naco. North of the Abrigo Fault and east of the Black Gap Fault, the basin fill is typically unsaturated.

2.3.5.2 Bedrock Complex

The bedrock complex generally has low permeability unless the intrinsic permeability is enhanced by secondary structures such as faults, fractures, and/or dissolution in the case of limestone. For this reason, the bedrock units typically do not yield as much water to wells as the basin fill (Litten, 1987), although the Bisbee Group is a source of water in portions of the Bisbee-Naco area. The Morita Formation and Glance Conglomerate are the primary water-bearing formations east of the Black Gap Fault where the basin fill is unsaturated and thin. The principal water-bearing bedrock formations west of the Black Gap Fault include the Cintura Formation, Mural Limestone, and Morita Formation. As reported in Sections 3 and 4, drilling conducted for the aquifer characterization intersected bedrock materials interpreted as Cintura Formation and Mural Limestone in the southwestern portion of the study area where they had not previously been identified.

Paleozoic sedimentary rocks, igneous rocks, and metamorphic rocks have not been intercepted in wells south of the Bisbee West-Gold Hill Fault except at Arizona Water Company (AWC) well No. 5 (AWC-05), near Naco which reportedly intercepted volcanic rock at a depth of 1,140 feet (Arizona Department of Water Resources [ADWR], 2008). Although Paleozoic sedimentary rocks, igneous rocks, and metamorphic rocks are not a source of water in the

vicinity of the plume area wells, in the Warren Mining District, highly fractured zones associated with faults in the Paleozoic units are capable of producing large volumes of water in localized areas (Littin, 1987; WMC, 2006).

2.3.6 Groundwater Flow

Groundwater flow in the vicinity of the CTSA is generally southward and westward from the area of the former evaporation pond toward Bisbee Junction and Naco. In detail, groundwater flow is highly influenced by the hydraulic properties of the hydrostratigraphic units and the geologic structure prevailing in different subregions of the area. Sections 3 and 4 present detailed information on water levels, hydraulic gradients, groundwater flow directions, and the hydraulic properties of hydrostratigraphic units.

3. AQUIFER CHARACTERIZATION METHODS AND RESULTS

The scope and methods followed by the aquifer characterization tasks are described in the 2008 Work Plan and the Work Plan for the Focused Bedrock Investigation. The specifics of the procedures and methods applied during implementation of the tasks are discussed in this section and the results are provided. The characterization work was conducted in accordance with procedures described in the Work Plan. ADEQ approval was obtained for deviations from the Work Plan as discussed in Section 3.4.4. Sections 4 and 5 provide interpretations of the results and discuss the results in the context of the site hydrogeology and water quality.

3.1 Task 1 – Well Inventory

Section III.A.4 of the Mitigation Order requires *"A plan to inventory all existing private wells used as a drinking water source and public water system wells located within a one (1) mile radius of the sulfate plume's down and cross-gradient outer edge."* Consistent with the Mitigation Order requirement, the objective of the well inventory was to identify and sample drinking water supply wells within one mile of the downgradient and crossgradient edge of the sulfate plume from the CTSA. The well inventory also evaluated the presence of drinking water wells within the footprint of the plume. The well inventory was conducted according to the specifications of the Work Plan.

Specific well inventory tasks identified by the Work Plan include:

- Identify drinking water supply wells within one mile downgradient and crossgradient of the outer edge of the plume using the ADWR Program 55 Well Registry Database (WRD).
- Categorize wells based on water use to identify potential drinking water wells.
- Cross-check potential drinking water wells identified from the WRD against ADEQ public water system data to identify any additional drinking water supply wells.
- Check with local water providers and Cochise County to identify any drinking water supply wells in the area of interest.
- Field check and obtain global positioning system coordinates for drinking water supply wells.
- Collect a water quality sample from or obtain recent water quality data for drinking water supply wells, and, if possible, determine the depth to groundwater.

The well inventory area (WIA), as defined by the Mitigation Order, consists of the area one-mile downgradient and cross gradient of the outer edge of the sulfate plume. To the extent that the boundary of the WIA would have extended into Mexico, the boundary was truncated at the U.S.-Mexico border. The "outer edge" of the sulfate plume for the well inventory was the 250 mg/L sulfate concentration contour delineated using sulfate concentration data for area wells. The well inventory was conducted in the first half of 2008 as reported by HGC (2008b). The initial estimate of the plume edge and the area of the well inventory was based on water quality data available at the time of the Work Plan. As described in Section 3.1.6, the WIA was modified over time as the shape of the sulfate plume was refined based on the results of groundwater sampling of drinking water supply wells for the well inventory, groundwater monitoring for Task 2.2 (Section 3.3), and groundwater sampling of new wells for Task 2.3

(Section 3.4). The identification and sampling of drinking water supply wells for the well inventory is updated as new data on the plume become available.

The initial well inventory consisted of three steps:

- Identification of all wells located within one mile downgradient and crossgradient of the outer edge of the sulfate plume and in the footprint of the plume.
- A primary well screening to identify potential drinking water supply wells on the basis of the well and water use information in the WRD, and a cross-check of ADEQ public water systems.
- Verification of potential drinking water wells by a review of well records, field inspection of wells and owner/operator contacts, including collection of water quality samples or data.

3.1.1 Identification of Potential Drinking Water Supply Wells

The well inventory was conducted using the ADWR WRD compiled in October 2007 (ADWR, 2007), which was provided in both Microsoft Access database and Geographic Information System formats. The Geographic Information System format allows the use of spatial queries to identify and extract well information from the database on the basis of well location. Spatial queries were constructed using ArcView software using the geo-referenced shape files.

The WIA evaluated consists of the area one mile downgradient and crossgradient of the outer edge of the sulfate plume and the area within the footprint of the sulfate plume as shown in Figure 4. This is a conservative approach to defining the WIA because it encompasses all wells

within one mile of the plume margin. Using ArcView software, a buffer of one mile around the plume margin was created based on the 250 mg/L sulfate contour line and used to create a search area polygon for the spatial query to identify wells within the WIA.

3.1.2 Well Search Process and Safety Factors

Wells within the WIA were identified using safety factors to account for uncertainty in location due to cadastral coordinates. Well locations in the ADWR WRD are described by cadastral coordinates based on township, range, and section. Each 640-acre section is divided into 160-acre quarters (NE, NW, SE, and SW). Location is further specified by a 40-acre quarter of the quarter section, and a 10-acre quarter of the 40-acre quarter, quarter section. For example: Section 25, NE, SW, NW describes a location in the NW 10-acre quarter of the SW 40-acre quarter of the NE 160-acre quarter of Section 25.

Although most well records in the ADWR WRD include information on the quarter, quarter, and quarter section, some records may only contain well location information accurate to the section; quarter section; or quarter, quarter section. Also, the cadastral coordinates impart an uncertainty to well locations because they are not exact. The WRD assigns the well location to the midpoint of the cadastral area, although the well can be anywhere in the described area. Thus, a well within the WIA might not be identified if the midpoint of the quarter, quarter, and quarter section lies outside the WIA boundary. Conversely, a well outside the WIA boundary could be identified as being in the WIA if the midpoint of its cadastral coordinate is within the

WIA boundary. To account for the uncertainty in well location due to cadastral coordinates and to ensure the well inventory is comprehensive and identifies wells potentially within the WIA, a series of safety factors were added to the search area to identify wells that might be in the WIA even though the midpoint of their cadastral coordinates are outside the WIA. An additional distance of 3,735 feet was added to the WIA search radius. The safety factor of 3,735 feet represents the distance from a corner of a 640-acre section to its midpoint and is meant to account for wells known only to the section. Again, a buffer was created to extract wells within the given number of feet outside of the original mile search area polygon. The data set was reviewed for any wells identified only by the section number with no quarter section information.

Next, all wells within 1,870 feet of the WIA were identified. The safety factor of 1,870 feet is the distance from a corner of a 160-acre quarter section to its midpoint. Another buffer and spatial query were created and the resulting data set was reviewed for any wells identified only by the section number and the 160-acre quarter.

This process was repeated using safety factors of 935 feet and 470 feet to account for the distance from the corner of a 40-acre quarter, quarter section to its midpoint and from the corner of a 10-acre quarter, quarter, and quarter section to its midpoint, respectively. From the set of wells identified on this basis, wells were removed only if they could be verified as being outside the search area based on more detailed cadastral coordinates. The final set of wells remaining after this process constitutes the inventory of wells potentially within the WIA.

The 2008 well inventory identified a total of 204 wells in the WIA. These wells included water production wells, monitor and piezometer wells, test wells, exploration and geotechnical boreholes, and cancelled, capped or abandoned wells. Appendix B lists information obtained from the ADWR WRD records for the wells identified in the WIA.

3.1.3 Primary Well Screening

The objective of the primary well screening was to identify potential drinking water supply wells for further evaluation from the 204 wells in the WIA and to eliminate from consideration those wells without a drinking water use. The primary well screening was conducted for the WIA based on the sulfate plume defined in the Work Plan.

3.1.3.1 Screening Based on Well Type, Well Use, and Water Use

Information in the WRD on all wells identified in the WIA was compiled into a spreadsheet and sorted according to well type, well uses, and water uses (Appendix B). This information was used to screen the population of wells in the WIA to identify potential drinking water supply wells and to eliminate wells without drinking water use.

For the primary well screening, wells listed with a water production well use and a domestic, domestic-irrigation, domestic-stock, municipal, utility, and stock water use were identified for further evaluation as potential drinking water wells. Water production wells listed

with an industrial water use were evaluated on a well-by-well basis to identify wells used for other non-drinking water uses. Wells with no well or water use listed were also included for further evaluation.

The primary well screening excluded from further evaluation as potential drinking water wells those wells listed as:

- Abandoned, cancelled (abandoned or not drilled), or capped wells.
- Wells associated with exploration, geotechnical, groundwater monitoring and observation.

3.1.3.2 ADEQ Public Water System Review

Wells identified in the WIA were also cross-checked against ADEQ Public Water System (PWS) data (ADEQ, 2007b) to identify potential drinking water supply wells in the WIA. Potential drinking water supply wells identified by the ADEQ data were cross-checked against the well inventory list to ensure inclusion of potential drinking water supply wells. After completing the cross-check, no additional wells were added to the well inventory list. The cross-check methods are described below.

ADEQ provided a database of all registered public water systems in the State of Arizona (ADEQ, 2007a). These include water systems that provide drinking water to a minimum of 25 users or 15 service connections. The data included the water system identification number, county, water system name, water system type, population served, number of connections, water

source, initial monitoring year, and the name of the principal city served. The following summarizes ADEQ public water system data evaluation procedures:

1. Water systems potentially in the WIA were identified using county and principal city served information. After sorting the data by county, water systems serving the cities of Bisbee and Naco were identified.

2. The Bisbee-Naco area PWS field inspector was contacted to verify any water systems not identified in ADEQ (2007b).

3. The water system names identified in step 1 were searched for in the WRD (ADWR, 2007) in three ways including: a) in the last name field, b) in the company field, and c) using a keyword search.

4. Matching records from the WRD were saved in a separate spreadsheet.

5. All wells compiled in the spreadsheet described in step 3 were plotted in ArcView as a layer on top of a layer representing wells identified in the WIA search.

6. Overlapping wells were assumed to have been included in the well inventory. All wells identified in this query had been previously identified by the WIA search.

3.1.3.3 Other Well Screening Methods

Additional sources of well information included: a cross-check of the registered wells with information from ADEQ PWS database; interviews with local residents regarding potential drinking water wells; contact with AWC, Naco Water Company (NWC), and Cochise County Health Department; use of INTELIUS records search engine to locate registered well owners; contact with residents receiving bottled water from data provided by CQB; contact with ADEQ public water system field inspector in Bisbee-Naco area; and contact with local real estate agents regarding properties and current owners.

3.1.3.4 Results of Primary Well Screening

Table 2 summarizes the results of the primary well screening. Of the 204 wells identified in the WIA in 2008, 123 wells were considered potential drinking water supply wells based on the primary well screening and cross-check of ADWR and ADEQ databases. The remaining 81 wells were classified as non-drinking water supply wells and eliminated from further consideration. The wells eliminated from the well inventory are described below and listed in Appendix B:

- Fifty (50) wells identified as abandoned, cancelled, or capped.
- Four (4) wells associated with geotechnical or exploration.
- Twenty-seven (27) wells associated with groundwater monitoring or observation use.

3.1.4 Verification of Potential Drinking Water Supply Wells

Wells identified by the primary screening as potential drinking water supply wells were verified by 1) review of the ADWR imaged records for the well to further research its water use, 2) field checks of wells to determine their location and operational status, and 3) contacts with well owner/operators to determine well operational status and water use.

Records for each of the wells identified as potential drinking water supply wells were downloaded from ADWR's online Imaged Records Database and cross-checked with information obtained from ADWR (2007). Information such as ownership, water use, additional

well identifiers, and well status was compiled and reviewed for information pertinent to well operational status and use.

A field check of wells identified as potential drinking water supply wells was conducted to verify the well location using a hand-held global positioning system unit, evaluate the operational status of the well, and gather supplemental well ownership information. Subsequent to the field check, well owners/operators were contacted on a case by case basis to verify water use and other well information.

The 123 potential drinking water supply wells identified in the WIA in 2008 consisted of: 114 wells listed with a water use of domestic, domestic-industrial, domestic-irrigation, domestic-municipal-industrial, domestic-stock, domestic-stock-irrigation, utility or stock; 1 well listed with no well use or water use; 2 wells listed as monitor wells that were verified by field interviews to be drinking water supply wells; and 6 wells identified during field interviews, from bottled water delivery information provided by CQB, and a search of the ADWR Program 35 database. Figure 5 shows wells evaluated as potential drinking water supply wells.

Table 3 summarizes the results of the verification of potential drinking water supply wells and indicates the status of each well as a drinking water supply. Of the 123 wells identified as potential drinking water supply wells, 43 wells were verified as having a current drinking water supply use. Five of the drinking water supply wells are operated by public water

companies, either AWC (one well in the WIA) or NWC (four wells), and the remaining wells are private domestic wells.

3.1.5 Water Quality Sampling

Forty-three active drinking water supply wells were identified out of 205 wells in the WIA. CQB requested permission from well owners/operators to sample wells that were verified as drinking water supply wells and report results to ADEQ. Where permission was granted, HGC collected water quality samples and depth to water measurements, if possible. In some cases, water quality samples were collected and analyzed by the owner/operator and the information was provided to HGC.

Groundwater sampling and analysis methods used for the well inventory are described in the Quality Assurance Project Plan contained in Appendix F of the Work Plan. Filtered water samples were collected and analyzed for sulfate by EPA Method 300. Prior to sampling, wells were purged to the degree permitted by site-specific circumstances. If it was not practical to purge three casing volumes from the well because of inconvenience to the owner/operator, wells were purged of less than three casing volumes. The purge condition under which the sample was collected was noted in the field logbook or on the groundwater sampling form. Some water quality data were provided by the operators of public drinking water systems. In those cases, the standard protocols of the water provider were used for sampling and analysis.

3.1.6 Results of Drinking Water Supply Sampling for 2008 Well Inventory

Water quality samples for the initial well inventory sampling were collected from 38 private drinking water supply wells, and water quality data was supplied by AWC for one public supply well. Four wells could not be sampled because access was denied. Of the 39 wells sampled, 13 private drinking water supply wells had sulfate concentrations greater than 250 mg/L (Figure 6)[1].

Residents using 10 of the 13 wells with sulfate concentrations greater than 250 mg/L were already receiving bottled water. CQB has offered to provide bottled water to residents as an interim action for the three wells not already receiving bottled water. A copy of the May 22, 2008 Interim Action Report (CQB, 2008a) submitted to ADEQ as required by the Mitigation Order is included in Appendix C.

3.1.7 Ongoing Drinking Water Supply Monitoring and Interim Actions

The WIA has been modified over time as the results of initial well inventory sampling and the groundwater monitoring for Tasks 2.2 and 2.3 provided new data on the limits of the sulfate plume. When the extent of the plume was determined to be beyond the plume footprint in the initial well inventory, drinking water supply wells within a mile of the revised plume margin were identified and sampled. Specifically, during the third quarter of 2008 the plume margin

[1] Note that Figure 6 shows the sulfate plume based on Work Plan data. Subsequent plume maps were updated based on well inventory information.

was extended to the southwest (based on Turquoise Valley, Inc. [TVI] 875, 274 mg/L sulfate) and northeast (based on NOTEMAN, 274 mg/L) due to the collection of additional samples which better define the plume extent. Therefore, the one-mile boundary downgradient and crossgradient of the outer edge of the sulfate plume also expanded to the southwest and northeast, resulting in the inclusion of AWC wells AWC-02, AWC-03, and AWC-04, and private well NESS, respectively. Additionally, new well construction in the WIA is monitored to identify new drinking water supply wells. In February 2009, a new private well (FLEMING) was installed within the WIA. To date, no pump has been installed in the well so it is not considered an active drinking water well. Information regarding the AWC, NESS, and FLEMING wells is included in Table 3 for completeness.

Ongoing monitoring of drinking water supplies is conducted pursuant to the Groundwater Monitoring Plan approved by ADEQ in April 2010 (ADEQ, 2010b). Since the third quarter of 2008 monitoring event, the boundary of the plume has not been significantly revised, although isoconcentration contours within the plume have been adjusted based on new data. Table 4 contains the results of ongoing monitoring of drinking water supply wells conducted since 2008. Figure 7 shows the results of sulfate analyses of drinking water supply wells in the third quarter of 2010.

Section 4 of the Work Plan specifies procedures for ongoing monitoring of drinking water supply wells and conducting interim actions if the sulfate concentration of the supply exceeds 250 mg/L due to the sulfate plume from the CTSA. Since the first quarter of 2008,

water supplies with a sulfate concentration less than 135 mg/L have been sampled quarterly, water supplies with a sulfate concentration between 135 mg/L and 250 mg/L were monitored monthly for at least five months and evaluated by a trend analysis to recommend a frequency for ongoing monitoring as specified in Section 4 of the Work Plan, and water supplies with sulfate greater than 250 mg/L have been offered bottled water as an interim action.

In February 2008, water quality sampling for the well inventory identified six wells (BIMA, BLOMMER, FULTZ, RAY, ROGERS 803, and SCHWARTZ) verified as drinking water supply wells that had a discrete sulfate concentration between 135 mg/L and 250 mg/L. These wells were sampled monthly for sulfate and a trend analysis was conducted. Based on the results of the trend analysis, it was recommended that wells BIMA, BLOMMER, FULTZ, RAY, and ROGERS 803 be monitored on a quarterly schedule (CQB, 2008b). The ROGERS 803 well was redesignated as the ROGERS 596 well starting the third quarter of 2009 to be consistent with the ADWR designation. SCHWARTZ, having a positive Mann-Kendall statistic indicating that the sulfate concentration may be increasing, was sampled monthly for an additional quarter (i.e., in October, November, and December 2008 [CQB, 2008b]). Subsequently, quarterly monitoring was recommended for SCHWARTZ based on a trend analysis of sulfate concentrations results (CQB, 2009). Copies of the trend analysis reports (CQB, 2008b and 2009) are in Appendix C.

Sampling of public drinking water supply wells operated by AWC and NWC has been conducted quarterly. AWC provided sulfate results for first and second quarters of 2008 and

CQB consultants (HGC and Clear Creek Associates) have collected samples since then. Analytical results for groundwater samples collected on October 23, 2008 from AWC-02, AWC-03, AWC-04, and AWC-05 reported sulfate concentrations of 15.9 mg/L, 41.8 mg/L, 24 mg/L, and 15.4 mg/L, respectively. Subsequent samples collected from the AWC wells have had sulfate concentrations consistent with the October 2008 results. Through the third quarter of 2010 the sulfate concentrations in AWC-02, AWC-03, AWC-04, and AWC-05 have been less than 19 mg/L, 65 mg/L, 28 mg/L, and 17 mg/L, respectively.

NWC provided sulfate data for wells NWC-03, NWC-04, and NWC-06 for the first and second quarters 2008. Samples from NWC wells in the third quarter of 2008 were not collected because an access agreement was still being developed. CQB consultants (HGC and Clear Creek Associates) have collected samples at wells NWC-02, NWC-03, NWC-04, and NWC-06 since the fourth quarter of 2008. Analytical results for groundwater samples collected on October 27, 2008 from NWC-02, NWC-03, NWC-04, and NWC-06 reported sulfate concentrations of 5.1 mg/L, 489 mg/L, 162 mg/L, and 6.4 mg/L, respectively. Subsequent water quality sampling has shown that sulfate concentrations are less than 20 mg/L at NWC-02 and NWC-06, greater than 135 mg/L but less than 250 mg/L at NWC-04, and greater than 250 mg/L at NWC-03.

NWC-04, having a sulfate concentration of 162 mg/L in October 2008, has been sampled monthly since then to identify any trend in sulfate concentration over time. NWC-04 was deepened in July 2008. The original screened interval was 322 to 462 ft bls. The new screened intervals are 540 to 580 ft bls and 755 to 795 ft bls. Prior to deepening the sulfate concentration

in samples collected in 2008 ranged from 231 mg/L to 240 mg/L (Table 4). The sulfate concentration in samples collected after deepening has ranged from 162 mg/L to 212 mg/L.

Based on the results of the fourth quarter 2008 sampling, three additional domestic wells (BIMA, COLLINS, and SCHWARTZ) and one public supply well (NWC-03) verified as drinking water supply wells were found to contain sulfate concentrations greater than or just below 250 mg/L (Figure 7). As an interim action, CQB offered to provide bottled water to the two private well owners whose well water contained a sulfate level above 250 mg/L and the one private well owner whose well water contained a sulfate concentration just below 250 mg/L (245 mg/L). The NWC-03 well is a public water supply well with approximately eleven service connections. Due to the sulfate concentration in water pumped from NWC-03 exceeding 250 mg/L, CQB notified NWC that it would provide bottled water to customers served by NWC-03 and, with NWC's cooperation has implemented bottled water delivery as an interim action. A copy of the December 19, 2008 Interim Action Report (CQB, 2008c) submitted to ADEQ is included in Appendix C.

3.2 Task 2.1 – Data Compilation and Evaluation

The compilation and evaluation of data relating to the environmental conditions in the vicinity of the CTSA was performed under Task 2.1 of the Aquifer Characterization Plan in the Work Plan. The objective of Task 2.1 is to provide a comprehensive compilation of historic site data relevant to describing the hydrogeology in the vicinity of the sulfate plume. The data

quality was evaluated for suitability of use for the aquifer characterization. The data compilation results were used for construction and calibration of the numerical model for groundwater flow and sulfate transport (Section 7). The data compiled and evaluated include the following:

- Geologic well logs and well construction diagrams.
- Elevations and distributions of geologic formations.
- Hydraulic testing of aquifer properties.
- Historical water levels.
- Historical water quality.
- Historical groundwater pumping.
- Historical aquifer recharge sources.

Information sources consulted in the data compilation included CQB files, ADWR databases and imaged records, reports of previous field and numerical modeling investigations, public and private well owners in the Bisbee-Naco area, and public works personnel for the City of Bisbee (COB) and the City of Naco, Sonora.

3.2.1 Geologic Logs and Well Construction Data

Geologic logs and well construction data for wells in the study area were obtained from the ADWR 55 Registry (ADWR, 2007) ADWR 35 and 55 image records databases (ADWR, 2008), and various hydrogeologic reports (PD, 1990 and 2006; SET, 1998a; WMC, 2006). Information was compiled for both abandoned wells and wells still in use. Figure 8 shows well

locations and Table 5 summarizes well construction and geologic information for wells existing as of 2009 and not installed for the Mitigation Order investigation. ADWR imaged records for wells in Table 5 are included electronically as Appendix D. Data for wells installed for the Mitigation Order Investigation are presented in Section 3.4.

The convention used in this report for well names refers to wells by their common identifier, in the case of monitoring wells or water company wells (i.e., TM-19A or AWC-05), or by the name of the well owner, in the case of private wells. The well names are in capital letters as shown on Table 5. In the event a well owner has multiple wells the last three digits of the ADWR registration number are added to the owner name to differentiate between wells.

3.2.2 Elevations of Geologic Formations

A database of the elevations to the top of geologic formations was compiled for the sulfate plume area using borehole data from private and public drinking water supply wells and water quality monitoring wells, and from drilling conducted during aquifer characterization. Data from logs of wells existing as of 2009 and not installed for the Mitigation Order investigation are presented in Table 5. Compiled data include the well location, well name, ADWR registration number, completion date, collar or measuring point elevation, depth drilled, screened interval, depth to bedrock, and bedrock formation or lithology underlying the basin fill (if known). Depth to bedrock and bedrock lithology were obtained from borehole logs for use in developing geologic cross sections (Section 4.1) and a groundwater flow model (Section 7).

Geophysical surveys were not useful for defining depths of geologic formations in the sulfate plume area. Two geophysical surveys of the Upper San Pedro River Basin conducted by the United States Geological Survey (Gettings and Houser, 2000; Wynn, 2006) did not extend as far east as the CTSA.

3.2.3 Historical Information on Aquifer Properties

Historical information on aquifer properties identified for the data compilation includes a step pumping test performed at well AWC-05 by The Weber Group, Inc. in July 2002 (Weber, 2002); 16 constant rate pumping tests at TM-series wells conducted in 1989 by Errol L. Montgomery and Associates (ELMA) and reported by SRK (1997); hydraulic conductivity estimates for a calibrated groundwater flow model (SET, 1998c); and estimates of aquifer transmissivity based on well specific capacities for wells AWC-02, AWC-03, AWC-04, and AWC-05 (Geoscience Support Services [Geoscience], 2006). These tests are discussed below. Backup data for the hydraulic properties information are presented in Appendix E.

3.2.3.1 AWC-05

A three-step pumping test was conducted at well AWC-05 on July 31, 2002 using pumping rates of approximately 500, 750, and 1,000 gpm (Weber, 2002). The total time of the pumping portion of the step test was approximately 15.5 hours (hrs), and the water level recovery was monitored for about 13.5 hrs. The water level drawdown versus time for the

AWC-05 test and tabulated drawdown values are provided in Appendix E. HGC attempted to interpret the test using Well Hydraulics Interpretation Program (WHIP) (HGC, 1988), but achieving a satisfactory fit to all of the drawdown data was unsuccessful, even when non-linear well losses were considered in the solution. Partial fits to the drawdown profile suggest a hydraulic conductivity value of about 1 foot per day. The interpretation of the hydraulic test data is further confounded because the well log for AWC-05 indicates that the well is screened across multiple lithologic units including basin fill, "red clay" which is interpreted here to be bedrock of either the Cintura Formation or Morita Formation, and "volcanics". Additionally, interpretation was difficult because the drawdown profile suggests the possibility of interference from nearby pumping wells. Only the data for the AWC-05 test are presented in Appendix E because the test results could not be satisfactorily modeled.

3.2.3.2 TM-Series Wells

Constant rate pumping tests at TM-series wells were conducted by ELMA (SRK, 1997). Test durations typically ranged between one and five days, and several tests include one or more observation wells in addition to the pumping wells. At the request of ADEQ (ADEQ, 2010a), drawdown and recovery hydrographs for the TM-series aquifer tests are provided in Appendix E.2. ELMA interpreted drawdown data for pumping and recovery periods using the log-log (Theis, 1935) and semi-log (Cooper and Jacob, 1946) methods (Appendix E.2). SRK (1997) reinterpreted the test using computer-aided solution methods that account for well losses, delayed yield, well storage, partial penetration of well screens, and/or fracture flow non-idealities

that are apparent in the pumping test drawdown profiles. At the request of ADEQ (ADEQ, 2010a) the SRK analysis is provided in Appendix E.3.

The values for the hydraulic conductivity estimated by SRK were typically lower than those estimated by ELMA by a factor of 2 to 3. A comparison of the ELMA and SRK estimates is provided in Table 6. Although the solution methods used by SRK account for non-idealities that were not considered in the methods used by ELMA, the validity of some of the SRK results is also questionable because several of their estimates (e.g., for wells TM-01, TM-11, and TM-13) were obtained using parameters that unrealistically assume a vertical hydraulic conductivity value that is much greater than the horizontal hydraulic conductivity value.

ELMA also estimated the storage coefficient. Tests conducted in Morita Formation had storage coefficients ranging from 2×10^{-6} to 0.01. Tests conducted in wells open to both basin fill and Morita Formation had storage coefficients ranging from 2×10^{-6} to 5×10^{-4}.

The interpretation of the aquifer test results for the TM wells is complicated by non-idealities that are apparent in the drawdown profiles. For wells screened in basin fill, the drawdown profiles frequently appear to exhibit a delayed yield effect (i.e., decrease in the drawdown slope at late times). Wells screened in the Morita Formation often show draw-down profiles that are indicative of large-scale aquifer heterogeneities (i.e., multiple drawdown slopes on the semi-log scale) and/or fracture flow (i.e., a slope of one on the log-log scale). Erratic drawdown profiles for some wells (TM-30, TM-30A, TM-19, and TM-37) suggest interferences

from other pumping wells or recharge sources or fluctuating pumping rates. Finally, several wells are screened across two formations (e.g., wells TM-01, TM-01A, TM-29, TM-29A, and TM-29B), which does not yield formation-specific hydraulic properties.

3.2.3.3 Estimates from SET (1998c)

SET (1998c) reported hydraulic conductivity estimates for a calibrated groundwater flow model of the sulfate plume area. Although not the results of field tests, the model-derived estimates are included in Table 6 for comparison because they represent an estimate of the volume-averaged hydraulic properties for the area.

3.2.3.4 Estimates from Specific Capacity

Transmissivities for wells AWC-02, AWC-03, AWC-04, and AWC-05 were estimated by Geoscience (2006) from the specific capacity of each well. Specific capacity is defined as the discharge rate divided by the difference between pumping water level and static water level of each well. The discharge rates were taken as the average pumping rate for 1998 through 2005, and static and pumping water levels were taken from measurements made in April 2005. Geoscience (2006) assumed a well efficiency of 70 percent, to compute transmissivities of 4,010 square-feet per day (ft^2/day) for AWC-02, 6,680 ft^2/day for AWC-03, 13,370 ft^2/day for AWC-04, and 1,740 ft^2/day for AWC-05. AWC-02, -03, and -04 are completed in basin fill. Assuming a saturated thickness of 300 feet, the hydraulic conductivity estimates for AWC-02, -03, and -04

are 13 feet per day (ft/day), 22 ft/day, and 45 ft/day, respectively. AWC-05 is completed in both basin fill and bedrock. Assuming a saturated thickness equal to the screen length (980 ft) yields a hydraulic conductivity estimate of 1.8 ft/day for AWC-05. The accuracy of these estimates is uncertain because the assumed well efficiency is not measurement-based and may not be representative of actual well efficiencies.

3.2.4 Historical Groundwater Levels

Sources for the compilation of historical groundwater levels included the following:

- Compilations of water level data (PD, 2006 and WMC, 2008).
- Data reports of PD (1990), SET (1998c), and WMC (2006).
- ADWR Groundwater Site Inventory database (ADWR, 1995; 2005 update).
- Municipalities and drinking water providers: COB, NWC, AWC, and Urbano Naco and Ejido Naco in Naco, Sonora, Mexico.
- Private well owners.

Appendix F lists, the measuring point elevation, depth to water, and groundwater elevation data assembled for each well in chronological order. The measuring point elevations provided by previous reports and databases are inconsistent over time for some wells. The measuring point elevation at several wells was re-surveyed in 2008 as part of the aquifer characterization. The re-surveyed measuring point elevations for most wells were found to be different from those reported in historical water level reports and databases. Twenty-four wells had previously measured elevation datum. The differences between previously measured and

re-surveyed datum ranged from essentially zero (0.02 feet) to approximately 20 feet, with the re-surveyed datum typically higher than the previously measured datum.

The measuring point, depth to water, and groundwater elevations reported in Appendix F have not been modified from the original reports to account for the different measuring point elevations used over time at certain wells. The data were not modified because in many cases the data were insufficient to confidently back-calculate either depth to water or measuring point elevation. Data users should be aware of the measuring point elevation differences because failure to consider these differences may lead to a false interpretation of groundwater level time-series data. Time-series water level data illustrated on hydrographs discussed in Section 4.4.3.3 were adjusted to the 2008 datum on a case by case basis. At the request of ADEQ (ADEQ, 2010a), hydrographs for all wells are provided in Appendix F.2. The hydrographs indicate the data for which new measuring point elevations are used. To illustrate recent water level data and datums, Appendix F also contains water level information for wells installed and monitored under the Mitigation Order.

3.2.5 Historical Groundwater Quality

Historical groundwater quality data were compiled for major element chemistry (calcium, magnesium, sodium, potassium, chloride, sulfate, alkalinity, fluoride, nitrate, nitrite, and pH) for wells in the CTSA area (Appendix G). Information sources consulted for the data compilation included the following:

- Compilations of water quality data (Clear Creek Associates, 2005; PD, 2006; and WMC, 2008).
- Data reported by PD (1990), Canonie Environmental (1990), SET (1998b, 1998c, and 1999), and Weiskopf (2006).
- Data provided by municipal entities and drinking water providers in the Naco area: Naco Sanitation District (NSD), NWC, and AWC.
- Data provided by entities in Mexico: Urbano Naco (City of Naco, Sonora), and Ejido Naco (El Oasis).

At the request of ADEQ (ADEQ, 2010a), sulfate concentration graphs for all wells are provided in Appendix G.2. Appendix G also contains water quality data for wells installed and monitored under the Mitigation Order so that concentration time series data are assembled in one table.

3.2.6 Historical Groundwater Pumping

Tables of water supply wells and historical pumping rates in the sulfate plume area are provided in Appendix H. Table H.1 lists the water supply wells identified in the study area. Many of these wells are dry or are otherwise no longer in service. The historic water uses in the Bisbee-Naco area have been domestic, stock, municipal supply, and irrigation. Tables H.2 through H.5 provide pumping information for municipal and irrigation wells compiled from existing records and reports. In general, detailed pumping records for area wells are scarce because there has been no requirement to report pumping until recently. Pumping rates used in the SET (1998c) numerical model are listed in Table H.6. The compilation of pumping information for domestic, stock, municipal, and irrigation wells is discussed below.

3.2.6.1 Domestic and Stock Wells

Most of the water supply wells are identified as being for domestic and/or stock supply use. Historical pumping information is unavailable for most of the wells. The pumping rates listed in Table H.1 are taken from well information reported in ADWR Program 55 imaged records and likely represent the maximum pumping rate for the period when the pump is on rather than the annual average pumping rate. Because all, or most, of the domestic and stock wells are pumped intermittently, average pumping rates are likely much lower. For example, assuming a per capita water demand for AWC of between 147 gallons per capita day and 178 gallons per capita day (ADWR, 2005) applies to the area's domestic demand, and further assuming that each domestic wells services between two and four individuals, the average pumping rates in domestic wells would range from 0.2 gpm to about 0.5 gpm if operated continuously. SET (1998c) used average pumping rates in their groundwater flow and sulfate transport model of 0.4 gpm for domestic wells. An average pumping rate of 1.8 gpm was used for stock supply wells (Table H.6).

3.2.6.2 Municipal Supply Wells

Limited historical production information is available for municipal supply wells. Data provided by AWC lists combined annual production totals from active AWC wells (AWC-02, AWC-03, AWC-04, and AWC-05) (Table H.2). Monthly totals for AWC-02, AWC-03, and AWC-04 are provided by Geoscience (2006) (Table H.3). These data indicate that AWC pumps an average of 377 million gallons per year, or at an average rate of just over 700 gpm. Monthly

production totals for AWC from 1998 through 2005 show that AWC-03 was the most productive well during this period (Table H.3).

Monthly production totals from NWC wells are available from the Arizona Corporation Commission (ACC) for the year 2006 through 2009 (ACC, 2007, 2008, 2009, and 2010) are provided in Table H.4. In 2006, NWC pumped a total of approximately 33 million gallons at an average rate of 62 gpm. In 2009, NWC pumped a total of approximately 28 million gallons at an average rate of 54 gpm.

Although not a Mitigation Order requirement, pumping data were also collected from a number of wells in Naco, Sonora to describe conditions south of the plume. The City of Naco, Sonora, Mexico has five wells historically used for public water supply, four that are currently in use and one that is no longer in service (Table H.5 and Figure 9)[2]. The pumping rates reported in Table H.5 likely represent maximum pumping rates and not annual average pumping rates. Also, the reported rates may be inflated estimates because the sum of the pumping rates (1,030 gpm) is greater than the total withdrawal rate of 635 gpm reported by the system operator (HGC, 2008d). A report published for the EPA in 1997 gives the total water supply production for the City of Naco, Sonora as 710,000 gpd, or 493 gpm (Science Applications International Corporation [SAIC], 1997). When the SAIC report was published, Naco, Sonora was served by only two wells. No information is available concerning changes in production rates since then.

[2] The Naco, Sonora wells are shown on Figure 9 along with aquifer recharge sources for convenience of map coverage and not to imply that these wells would be used for aquifer recharge.

3.2.6.3 Irrigation Wells

The principal irrigation wells north of the United States-Mexico border are associated with TVI, and are used to supply water to the TVI Golf Course. TVI has four irrigation supply wells located on the golf course: two located south of Greenbush Draw (TVI 236 and SOUTHSIDE WELL 2, located approximately 30 feet north of TVI 236) and two located north of Greenbush Draw (TVI 713 and TVI 875) (HGC, 2008c). Historically, water supply to the golf course was provided by TVI 236, which was installed in 1934. The estimated historic pumping rates in TVI 236 range from about 140 gpm to about 300 gpm (Table H.6) (SET, 1998c). TVI 713 was installed in 1998 but was immediately capped because the well diameter was insufficient for the pumping. TVI 713 was replaced two months later by TVI 875.

All TVI pumps run intermittently. TVI 236 and TVI 875 cycle on and off year round, and SOUTHSIDE WELL 2 is only cycled on from March through November (HGC, 2008f). During the winter months, TVI 236 cycles on for about 7 to 8 hrs and TVI 875 cycles on for about 8 to 11 hrs every one to two weeks. During the summer months, TVI 236 and Southside Well 2 cycle on for 4 hrs about once per day and TVI 875 cycles on for 8 to 11 hrs once per day. When on, the pumping rates in the wells are approximately 350 gpm at TVI 236, 400 gpm at SOUTHSIDE WELL 2, and 500 gpm at TVI 875 (HGC, 2008f).

Other historical irrigation supply wells located north of the border included Goar wells (GOAR 686, GOAR 693, and GOAR 697), the HAUBERT well, the Galloping Goose Properties wells (GGOOSE 546 and GGOOSE 547), and others (Table H.1). Pumping from all, or most, of

these wells has been discontinued or converted to stock or domestic use since the 1990s (Table H.6) (SET, 1998c).

El Oasis, the irrigation provider in Naco, Sonora has five irrigation supply wells, one of which (EN-01) is currently not in service (Table H.5) El Oasis estimates pumping rates in the active wells of between about 870 and 1,600 gpm (HGC, 2008b). These rates likely represent maximum pumping rates rather than annual averages. SET (1998c) estimates historic average pumping rates from the combined El Oasis wells of about 500 gpm in the 1960s and early 1970s and about 700 gpm thereafter (Table H.6).

3.2.7 Historical Aquifer Recharge Sources

Historically, the aquifer in the vicinity of the sulfate plume has been recharged by natural and artificial recharge sources. These recharge sources are depicted in Figure 9. A summary of the literature discussing natural and artificial recharges sources is provided in Table 7. The study with the scope of interest closest to that of the aquifer characterization for the Mitigation Order is the numerical model constructed and reported by SET (1998c). The recharge rates for all the natural and artificial recharge sources in the SET (1998c) model are provided in Table 8. Natural and artificial recharge sources are discussed below.

3.2.7.1 Natural Recharge Sources

Natural sources of potential recharge include infiltration of precipitation through soil (direct recharge), infiltration of surface runoff from mountain fronts (mountain front recharge), and recharge of water in streams and washes (river recharge). Several studies have estimated total natural recharge or individual components of natural recharge. The natural recharge estimates from the major studies are compiled in Table 7, and the estimates of direct recharge, mountain front recharge, river recharge and total natural recharge are discussed below.

Based on precipitation totals collected from 1893 through 2008, the Bisbee-Naco area receives about 18 inches of rainfall per year, with most of the rainfall occurring in July and August (Table 9). The percent of precipitation that directly recharges the aquifer is probably small except during occasions of heavy rains coupled with low evapotranspiration (Coes and Pool, 2005).

The Sierra San Jose mountain range located southwest of Naco, Sonora and the Mule Mountains to the northeast of Bisbee are sources of mountain front recharge. Although mountain fronts are located outside, or on the periphery, of the Greenbush Draw watershed, recharge from mountain fronts may extend to parts of the basin floor if it travels through rock fractures and faults in the subsurface (Littin, 1987) or is transported in ephemeral washes (Coes and Pool, 2005). Many studies do not distinguish mountain front recharge from other components of natural recharge, although SET (1998c) and Pool and Dickinson (2006) modeled higher natural recharge rates in the vicinity of mountain ranges (Table 7).

The main surface water drainage channel in the sulfate plume area is the ephemeral Greenbush Draw, which drains to the northwest toward the Upper San Pedro River. Recharge from Greenbush Draw was estimated to be 365 ac-ft/yr by Coes and Pool (2005) based on analysis of hydrologic properties, chloride concentrations, and isotopic studies. Assuming a stream length overlying alluvial deposits of 12.1 miles (Coes and Pool, 2005), the average recharge along Greenbush Draw is estimated to be 18.7 gpm per mile. This estimate is lower than the previous estimate of 973 ac-ft/yr (80.4 gpm per mile) by Correll et al. (1996). ADWR (2005) concluded that the Greenbush Draw recharge estimate of Correll et al. (1996) included artificial recharge.

Littin (1987) estimates the volumetric recharge rate via natural sources to range from 2,000 ac-ft/yr to 2,500 ac-ft/yr, or an aerial recharge rate ranging from 1.19×10^{-4} ft/day to 1.49×10^{-4} ft/day (using an area of 46,000 acres). The actual rate of natural recharge may be greater than this estimate because Littin (1987) was unable to close the water balance between recharge and discharge. Littin (1987) suggests that natural recharge is not uniform throughout the area. Areas of relatively high infiltration potential are inferred near the Mule Mountains to the north, the Sierra San Jose to the south, and immediately south of Greenbush Draw.

SET (1998c) started with the recharge rates of Littin (1987) and modified them during calibration of their numerical model. The range of areal natural recharge rates considered in SET (1998c) model calibration is 7.9×10^{-5} ft/day to 1.2×10^{-3} ft/day for "high" recharge areas

(mountain fronts and ephemeral drainages) and 1.3 x 10^{-6} ft/day to 1.6 x 10^{-5} ft/day for "low" recharge areas (Table 8). The SET (1998c) final calibrated areal natural recharge rates were 8.4 x 10^{-4} ft/day and 8.9 x 10^{-6} ft/day for high and low recharge areas, respectively, for a total recharge rate of 3,763.5 ac-ft/yr. The high and low natural recharge areas specified by SET (1998c) based on Littin (1987) are shown in Figure 9.

Pool and Dickinson (2006) modeled the Sierra Vista sub-basin, which includes the Naco area, using higher and lower natural recharge rates. Higher rates (6.6 x 10^{-5} ft/day to 4.4 x 10^{-4} ft/day) were applied within 1 mile of mountain fronts, and lower rates (3.3 x 10^{-6} ft/day to 6.6 x 10^{-5} ft/day) were applied in areas of sedimentary rocks and alluvial surfaces.

3.2.7.2 Artificial Recharge Sources

Potential artificial recharge sources in the sulfate plume area include the CTSA (North and South Tailing Impoundments, the former evaporation pond, and Horseshoe Pond), irrigated lands (former Warren Ranch irrigation area, TVI, and El Oasis), and wastewater treatment facilities (WWTFs) (the Warren, San Jose, NSD, and Naco, Sonora WWTFs). Artificial recharge sources are summarized in Table 7 and further discussed below.

North and South Tailing Impoundments

Tailing was deposited in the North and South Tailing Impoundments between 1923 and 1974 exclusive of 1933 to at least 1945 (Section 2.1.1). There are no data to indicate what

seepage rates may have been during the deposition of tailing. However, it is likely that some seepage did occur. Under current conditions, the water percolation rate through the North and South Tailing Impoundments is likely very low due to the low hydraulic conductivity of the tailing material, high evaporation rate, and the formation of a surface crust on the impoundments. SET (1998a) predicted net infiltration rates through the tailing impoundments using site-specific climate data and the HELP and SOILCOVER models. The infiltration modeling used hydraulic conductivity measurements of tailing made by in situ methods at seven locations and by laboratory testing of five samples. SET's study concluded that "The arid climate of the CTSA, combined with the unique hydrologic properties of the North and South Tailing Impoundments, result in a low net infiltration ranging from 3.6×10^{-7} centimeters per second (cm/s) to less than 2.4×10^{-10} cm/s. These site factors combine to provide a level of containment comparable to a clay underliner system having a saturated hydraulic conductivity of 10^{-7} cm/s."

SET's conclusion of low infiltration rates through the North and South Tailing Impoundments is supported by the operating history field observations, and groundwater quality data as follows:

- Tailing has not been pumped to the North and South Tailing Impoundments since 1974. Thirty-five years of drain-down has reduced the head within the tailing which significantly reduced percolation to the aquifer.

- Groundwater levels in monitor wells GL-03, BMO-2008-11G, BF-01, TM-02A, TM-03, COB-WL, BIMA, and SUNBELT do not indicate the presence of a groundwater mound under the North and South Tailing Impoundments.

- Boring TM-26, drilled through the south tailing impoundment in 1989, was dry to a depth of 800 feet or an elevation of 4117 feet amsl (WMC, 2006).

- Dry and dusty drill cuttings were observed at during drilling at BMO-2008-11G to a depth of 340 ft bls, 1100 feet west of the South Tailing Impoundment.

- Sulfate concentrations are less than 110 mg/L at GL-03, BMO-2008-11G TM-03, and COBWL in the vicinity of the impoundments, indicating that the tailing impoundments are not currently significant sources of sulfate to the aquifer.

- Resistivity geophysical data collected at the tailing impoundments in 1988 and 1989 were interpreted by Zonge Engineering and Research Organization, Inc., (Zonge) for the aquifer characterization as reported in Section 4.1.2.1 and Appendix I.2. The resistivity data indicate a high resistivity beneath the tailing impoundments which would not be expected if the subsurface were saturated or contained high-conductivity groundwater with elevated sulfate.

Former Evaporation Pond

The former evaporation pond received excess water from mine dewatering activities from 1908 through 1987 (PD, 2004). PD (1990) indicated that continuous detailed records of water application rates were not maintained. PD (2004) later reported that approximately 350,000 ac-ft, or 4,430 ac-ft/yr, of mine water were discharged to the former evaporation pond between 1908 and 1987. SRK (1997) used water delivery estimates in a water budget and model calibration to groundwater levels to calculate an aquifer recharge from the former evaporation pond of 488 ac-ft/yr, or about 12 percent of the total water delivered. In contrast, SET (1998c) used a higher recharge rate of 3,103 ac-ft/yr, or about 70 percent of the total water delivered as determined by model calibration.

Horseshoe Pond

No estimates of potential recharge to the aquifer from Horseshoe Pond are known to exist, and SET (1998c) did not include recharge from Horseshoe Pond in their model. The recharge potential from Horseshoe Pond is considered negligible given that it only periodically receives stormwater runoff and is pumped to maintain dry conditions in anticipation of reclamation.

Former Warren Ranch Irrigation Area

The former Warren Ranch irrigation area was irrigated with surplus mine water from 1905 to 1985. PD (2004) estimated that a total of approximately 188,000 acre feet of water was delivered to the former Warren Ranch irrigation area during that time period, at a delivery rate of 2,350 ac-ft/yr, (1,457 gpm). SET (1998c) applied a recharge rate for the former Warren Ranch irrigation area of 1,135 ac-ft/yr from 1905 through 1987, with specific rates of 0.9 ft/yr and 0.072 ft/yr west and east, respectively, of the Black Gap Fault. As discussed in Section 2.1.2, research by CQB has confirmed the discharges to the former Warren Ranch irrigation area ceased in 1985, not 1987 as assumed by SET (1998c).

El Oasis Irrigation Area

The El Oasis irrigation area east of Naco, Sonora is believed to have begun operation in the 1960s (SET, 1998c). Its current footprint is estimated from areal images, as approximately 630 acres. SET (1998c) represented El Oasis recharge as a constant rate of 315.3 ac-ft/yr over an

area of 306.4 acres (1.03 ft/yr). This recharge rate is about 14 percent of water pumped by El Oasis. In comparison, other models of the Sierra Vista sub-basin have assumed recharge rates of 30 percent of irrigation water (Pool and Dickinson, 2006).

Turquoise Valley Golf Course

The TVI golf course began operation on the south side of Greenbush Draw in 1934 and was expanded north of Greenbush Draw in about 1998. SET (1998c) modeled the golf course with a volumetric recharge rate of 33.2 ac-ft/yr before the expansion and 66.4 ac-ft/yr after the expansion, using a constant areal recharge rate of 1.68 ft/yr. This rate is between 7 and 10 percent of water delivered before the expansion, and between 14 and 21 percent after the expansion. In comparison, Pool and Dickinson (2006) assumed recharge rates of 30 percent of irrigation water for turf facilities; whereas ADWR (1999, 2005) assumed recharge rates of only 5 percent for turf facilities.

Warren Wastewater Treatment Facility

SET (1998c) reports that effluent began to be delivered to the Warren WWTF ponds in the early 1930s (SET, 1998c); whereas other sources report that the WWTF was constructed in the 1970s (EPA, 2003b, North American Development Bank, 2003). Originally, the Warren WWTF operated with three stabilization lagoons and one holding pond. A fourth lagoon was constructed in 2002 (EPA, 2003b). Effluent from the lagoons was applied to a 40-acre disposal area located immediately south of the lagoons. The peak design capacity of the Warren WWTF

was 0.39 million gallons per day (MGD), although flows of 1,200,000 MGD are reported (EPA, 2003b). SET (1998c) modeled the Warren WWTF with a recharge rate of 160 ac-ft/yr (0.143 MGD). Operations at the Warren WWTF were replaced with the opening of the expanded San Jose WWTF in 2006 (ADEQ, 2006).

San Jose Wastewater Treatment Facility

The San Jose WWTF was constructed in 1985 (EPA, 2003b). Prior to 2006, the San Jose WWTF had two lined lagoons and one holding pond. Effluent from the lagoons was applied to a 11-acre disposal area located southwest of the lagoons. During this period, the San Jose WWTF had a design treatment capacity of 0.137 MGD. The SET (1998c) model does not include aquifer recharge from the San Jose WWTF; however, recharge from the lagoons probably did occur because of the land disposal method (EPA, 2003b) and because the liners to the lagoons became damaged (North American Development Bank, 2003). In 2006, the San Jose WWTF was upgraded and expanded. In addition to handling the treatment requirements of the old San Jose WWTF, the expanded San Jose WWTF replaced the Warren and Mule Gulch WWTFs. The expanded San Jose WWTF is permitted to collect and treat 1.22 MGD (ADEQ, 2006), however, the effluent produced from the fourth quarter of 2006 through the end of 2008 averages only about one-third of the permitted amount (Table 10). Effluent from the expanded San Jose WWTF is permitted to discharge to the Greenbush Draw about 1.5 miles southwest of the facility, near where Greenbush Draw intersects the Naco Highway (ADEQ, 2006). Effluent-dependent surface flow in Greenbush Draw was observed throughout 2008 to occur for at least one mile downstream of the discharge point. In the future, all or part of the effluent from the San

Jose WWTF may be used to irrigate the TVI golf course or for other approved uses. However, there is no firm date for the implementation of the use of effluent from the San Jose WWTF.

Naco Sanitation District Wastewater Treatment Facility

The NSD WWTF includes four lagoons. ADWR (2005) reports that in 2002 NSD WWTF produced 80 ac-ft of effluent, and that all effluent was evaporated. The SET (1998c) model did not include recharge from the NSD WWTF.

Naco, Sonora Wastewater Treatment Facility

The Naco, Sonora WWTF was constructed in the 1960s (SAIC, 1997). The Naco, Sonora WWTF operates two sets of lagoons. The eastside lagoons are a series of seven lagoons that are currently lined with compacted clay. The westside lagoons consist of 3 unlined lagoons. Originally, effluent from the westside lagoons was used to irrigate the El Oasis irrigation area. Problems with pumping and conveyance systems prevented the effective implementation of this use. In the 1970s the westside lagoons were abandoned and all wastewater was sent to the eastside lagoons. In the early 1980s the westside lagoons and conveyance system were rehabilitated, but were no longer functional by 1987. This led to frequent system overflows that discharged wastewater to natural drainageways and across the United States-Mexico border (SAIC, 1997). Currently, the westside lagoons are seldom used (HGC, 2008d). SET (1998c) modeled the Naco, Sonora WWTF with a recharge rate of 158.5 ac-ft/yr.

3.3 Task 2.2 - Groundwater Monitoring

3.3.1 Overview of Groundwater Monitoring Program

Groundwater monitoring for Task 2.2 consisted of groundwater sample collection and water elevation measurement from wells in the vicinity of the CTSA. The Work Plan identifies two purposes for the groundwater monitoring program: regional monitoring and plume monitoring. Regional monitoring was conducted to characterize water levels and water quality away from the plume to develop information for fate and transport modeling. Regional monitoring encompasses wells that are generally more than a mile from the sulfate plume. Plume monitoring was conducted to track the position and concentration of the plume and includes wells that are in the plume or generally within a mile of the plume.

The Work Plan specified regional monitoring during only the first and third quarters of 2008 to characterize regional hydrologic conditions and any seasonality in water elevations. Samples for regional monitoring were analyzed for a suite of major element constituents to characterize general water quality conditions in addition to sulfate. Regional monitoring was conducted in both the first and third quarters of 2008.

Plume monitoring for the Work Plan was conducted quarterly at wells that are within or proximal to the sulfate plume in order to track the plume's location in the aquifer. Samples for plume monitoring were analyzed only for sulfate in accordance with the Work Plan.

Plume monitoring for Task 2.2 is ongoing. On January 25, 2010, CQB proposed a revised groundwater monitoring plan (CQB, 2010a). The revised plan was approved by ADEQ in April 2010 (ADEQ, 2010b) and implemented in the third quarter of 2010. Monitor wells installed under Task 2.3 (Section 3.4) are added to the plume monitoring program after the collection of an initial water quality sample during aquifer testing (Section 3.4).

Groundwater sampling and analysis methods used for groundwater monitoring are described in the Quality Assurance Project Plan (Appendix F of the Work Plan). Some groundwater monitoring data were reported to CQB by other parties that may have used different, but comparable, sampling protocols. In addition, CQB collected groundwater samples from wells belonging to La Commission National del Aqua and Ejido Naco in Sonora, Mexico. Groundwater monitoring in Sonora, Mexico was not a Mitigation Order requirement, but was conducted to further define groundwater elevation and sulfate conditions south of the Mitigation Order study area.

The measuring point elevations of wells used for water level monitoring were surveyed for this investigation to provide a consistent datum. Surveying was conducted by Arizona Land Specialists, Inc., and Gilbert Technical Services, Inc. Survey results are reported in the quarterly groundwater monitoring reports (Appendix A).

3.3.2 Results of Groundwater Monitoring

Data for the first quarter of 2008 through the third quarter of 2010 were collected and reported quarterly under the groundwater monitoring program (HGC, 2008c, 2008e, and 2009a, 2009b, 2009d, 2009e, HGC and Clear Creek Associates, 2010, and Clear Creek Associates, 2010a, 2010b, and 2010c). Appendix A contains copies of the quarterly groundwater monitoring reports. Tables 11 and 12 contain water quality and water level measurements, respectively, for Task 2.2 from the first quarter of 2008 through the third quarter of 2010[3]. Also included in Tables 11 and 12 are results of sampling for the well inventory (Section 3.1) and the initial sampling of newly installed monitoring wells (Section 3.4). The measuring point elevations in Table 12 are based on the survey conducted for the aquifer characterization. Elevation survey results, laboratory reports, field sampling forms, and data verification reports for the groundwater monitoring program are contained in the quarterly groundwater monitoring reports (Appendix A). The groundwater monitoring results are discussed in the context of the site hydrogeology and groundwater chemistry in Sections 4 and 5, respectively.

During October 2008, CQB collected groundwater samples from the City of Naco and Ejido Naco wells to augment the data collected for the Work Plan. Groundwater samples were collected from four Urbano Naco and four Ejido Naco wells. Tables 11 and 12 respectively contain the dissolved sulfate concentrations for wells sampled and groundwater elevations from

[3] The groundwater monitoring report for the third quarter of 2010 reported sulfate at ROGERS 596 as 169 mg/L. The concentration reported should have been attributed to ROGERS 803 based on discussion with the well owner subsequent to the report submittal. The correction is made in this report.

two Urbano Naco wells where water level measurements were collected in the fourth quarter 2008. The depth-to-water measurements were made under static conditions.

Data verification reports were prepared for each quarterly report for quality assurance and quality control purposes. As determined by the analytical data verification review, all groundwater monitoring data collected for Task 2.2 are of acceptable quality for use in the aquifer characterization program.

3.4 Task 2.3 - Monitoring Well Installation and Testing

Groundwater monitoring wells were installed in 2008 and 2010 under Work Plan Task 2.3 and the Work Plan for Focused Bedrock Investigation. The objectives and methods for well installation and testing in 2008 are described in Section 3.3.3 and Table 7 of the Work Plan. The BMO-2008-series monitoring wells were installed to further define the lateral and vertical extent of the sulfate plume, characterize aquifer materials and hydraulic properties, determine bedrock depth, evaluate conditions in the former source area, and provide installations for ongoing groundwater water level and water quality monitoring. At the request of AWC, two wells (BMO-2010-3M and BMO-2010-3B) were installed in 2010 along Greenbush Draw generally following the methods described in the Work Plan. The BMO-2010-3 wells further define conditions to the west of the leading edge of the plume near Naco. Two wells (BMO-2010-1M and BMO-2010-2M) were also installed in bedrock near Bisbee Junction for the Focused

Bedrock Investigation. The BMO-2010-Series monitoring wells were installed using the methods described in Section 3.3.3 of the Work Plan.

Well locations and design objectives were based on position in relation to the plume, the level of information available in the area of the proposed well, and the potential long-term use of the monitoring well. Wells within the sulfate plume were installed to characterize the quality of water within the plume and evaluate the vertical extent of sulfate into the subsurface. Wells on the periphery of the plume were installed to evaluate the lateral extent of sulfate in the basin fill and bedrock. Aquifer testing was conducted on each of the wells after well development to evaluate aquifer characteristics at each well location. An initial water quality sample was collected from each of the wells during aquifer testing to document water quality conditions at each well location. After the initial sampling, the new monitoring wells were added to the list of wells sampled for the groundwater monitoring program (Section 3.3).

3.4.1 Overview of Well Installation and Reconnaissance Sampling Program

3.4.1.1 2008 Well Installation

Completion of 16 monitor wells was accomplished from April 3 to December 12, 2008. Figure 10 shows the locations of wells installed in 2008 for Task 2.3. A total of 10,438 feet was drilled for the well installation and testing program. Table 13 lists the monitor well name, ADWR registration number, location, measuring point elevation, drilled depth, casing depth and diameter, screen interval depths, and water level for each well. Monitor wells were named using

a project prefix, the year of installation, the site number, and a suffix indicating the formation. For example, “BMO-2008-4B” stands for Bisbee Mitigation Order, 2008, installation in basin fill at Site 4. “B” stands for basin fill; “M” for Morita, Cintura, or Lower Mural Limestone; “G” for Glance Conglomerate; “GU” means the upper or shallower of a pair of wells completed in the Glance Conglomerate; and “GL” means the lower or deeper of a pair of wells completed in the Glance Conglomerate.

The monitoring wells were drilled, installed, and developed through airlifting by WDC Exploration and Wells, Inc. with onsite oversight, documentation, water sampling, and logging of lithologic materials by HGC personnel. Additional well development by swabbing, bailing, and pumping; pump testing the wells for aquifer characteristics; and equipping the wells with permanent submersible pumps were completed by the Verdad Group L.L.C. with oversight and data collection by HGC personnel.

3.4.1.2 2010 Well Installation

Completion of an additional four monitor wells was accomplished from July 7 to September 1, 2010. BMO-2010-1M and BMO-2010-2M were installed for the Focused Bedrock Investigation, and BMO-2010-3B installed upgradient of the AWC well field (Figure 10). A total of 1,823 feet was drilled for the well installation and testing program. Table 13 lists the monitor well name, ADWR registration number, location, measuring point elevation, drilled depth, casing depth and diameter, screen interval depths, and water level for each well. Monitor

wells were named using the same format used in 2008 using a project prefix, the year of installation, the site number, and a suffix indicating the formation. For example, "BMO-2010-3B" stands for Bisbee Mitigation Order, 2010, installation in basin fill at Site 3. "B" stands for basin fill and "M" for Morita, Cintura, or Lower Mural Limestone.

The monitoring wells were drilled, installed, and developed through airlifting by Yellow Jacket Drilling with onsite oversight, documentation, water sampling, and logging of lithologic materials by Clear Creek Associates personnel. Additional well development was conducted by pumping the wells once they were equipped with permanent submersible pumps. Pumping tests and pump installation were completed by the Yellow Jacket with oversight and data collection by Clear Creek Associates personnel.

3.4.2 Drilling, Construction, and Development Methods

Drilling, construction, and development were completed using guidelines established in the Work Plan. The same guidelines were used for wells installed in 2008 and 2010. The following sections detail the specific methods used during this phase of the investigation. Also included are procedures, such as video logging, that were not envisioned in the Work Plan.

3.4.2.1 Drilling Methods

In 2008, monitoring wells were drilled with George E. Failing Company Speedstar 50K-CH rotary drill rigs. Monitoring wells drilled in 2010 were drilled with a Versa-Drill V-2000

80K. Drilling methods were selected on the basis of site conditions, data collection objectives, relative cost, ease of well development, and rig capabilities. Drilling methods included Stratex under-reaming casing advance, air rotary casing hammer (ARCH), reverse-circulation air rotary using air lifting, conventional circulation air rotary drilling, and conventional mud rotary drilling. In most cases, drilling was accomplished without using bentonite ("mud") additives or other drilling fluids so that sampling of formation water could be performed during drilling for water quality evaluation.

The first boring drilled at each site was used to evaluate basin fill lithology and thickness, bedrock lithology, and water quality in the saturated materials encountered during drilling. Boreholes were typically started with Stratex or ARCH (casing advance methods) to penetrate unsaturated basin fill sediments and install temporary casing for borehole stability and conduct drill cuttings to the surface. Attempts were made to drive the temporary casing to the basin fill-bedrock interface so that groundwater in the basin fill could be isolated from that in the underlying bedrock. In many cases, formation conditions did not permit the casing to be safely driven all the way down to the bedrock contact.

Air rotary methods were used when further progress with casing advance methods was no longer possible or the bedrock aquifer was intercepted. Both conventional circulation and reverse circulation methods were used. The conventional air rotary method involves injecting air through the bit at the drilling face to lift cuttings up the annulus between the drill rods and borehole wall. This method was used when casing advance was no longer possible and there

was insufficient depth or water production to permit reverse-circulation drilling. Cuttings and formation water traveling up the annulus can be mixed with formation materials and groundwater from zones higher in the uncased portion of the borehole and may not be as reliable as the materials returned from a cased borehole.

The reverse-circulation method was used whenever possible in cases where casing advance was no longer possible. The method employed dual-wall drilling rods that carried air down the annulus between the inner and outer rod walls, and carried groundwater and cuttings up the center of the inner drilling rods. Air is passed from the annulus to the center of the drilling rods beneath the water table, which causes airlifting of the water and draws groundwater and cuttings up from the drilling face. This reverse-circulation technique lifts cuttings and groundwater from the drilling face and prevents interaction with materials and groundwater in transit to the surface. Procedures, relative quality, and results of water sampling during drilling are discussed in Section 3.4.2.2.

The direct mud rotary drilling method was used only for drilling BMO-2010-3M and BMO-2010-3B. Both of these wells were installed in an area known to be outside of the sulfate plume. Direct mud rotary was selected as the most expeditious drilling method, as there was no need to conduct reconnaissance groundwater sampling.

The quality of geologic information from drill cuttings is partially dependent upon the specific drilling technique used. All of the methods used during this investigation required

breaking down the formation into fragments small enough to be lifted out of the hole by the circulating medium (i.e., air or water). Size information for particles larger than fine gravel was unavoidably lost. The representativeness of the cuttings with respect to the formation being penetrated by the drill bit varied somewhat depending on the drilling technique. The cuttings from ARCH and Stratex drilling were considered the most representative because the temporary casing prevents materials from above from falling down and interacting with the cuttings. The representativeness of cuttings derived from reverse-circulation can be compromised by materials falling from the annulus between the outer wall of the drill string and the borehole wall, but the forces required to dislodge materials from the upper portion of the borehole are typically absent. The representativeness of cuttings from conventional rotary drilling are the most likely to be compromised, because fluids and cuttings are flowing rapidly upward between the borehole wall and outside of the drill string.

Drill cuttings were sampled at 10-foot intervals during drilling and placed in labeled zip-seal plastic bags or cloth Hubco bags. Representative splits from each sample were placed in chip trays for reference purposes. Lithologic logs that include a description of each sample were prepared by HGC (in 2008) and Clear Creek Associates (in 2010) (Appendix J). Basin fill material was logged according to the specifications of American Society of Testing of Materials D2488-00.

During drilling, cuttings and excess drilling fluids were collected in a hopper. Drilling fluids were pumped to an area away from the borehole to infiltrate before leaving the property or

entering jurisdictional waterways. Cuttings were dumped from the tilt hopper at locations away from the boreholes and spread on the site after completion of the drilling.

3.4.2.2 Reconnaissance Water Quality Sampling During Drilling

Samples of formation water were analyzed and the results used to evaluate progress of each borehole and make decisions concerning the construction of the well, as detailed in Section 3.4.4. Formation water samples were collected from the drilling return as soon as groundwater was encountered in the boreholes. The drilling methods used air to lift the cuttings either directly in the case of direct rotary, Stratex, and ARCH, or indirectly using airlifting to induce reverse circulation. Formation water was collected from the discharge at the cyclone, typically at 20-ft intervals.

Collected water was tested in the field with a portable meter for temperature, electrical conductance, TDS, and pH. In 2008, a portion of the sample was filtered using a 0.045 micron filter and analyzed for sulfate with a Thermo Orion Model AQ4000 colorimeter using AC 2082 reagent tablets. In 2010, the filtered sample was analyzed for sulfate with a Hach DR/890 colorimeter using SulfaVer®4 reagent. In 2008 and 2010, a portion of the filtered sample was also typically submitted to Turner Laboratories for analysis by ion chromatography.

Water samples recovered from the return had varying degrees of reliability in representing the groundwater quality at the drilling face. Samples recovered during ARCH

drilling were considered the most reliable, since the temporary casing driven behind the drilling face essentially sealed off portions of the formation above the drilling zone. Hence, water recovered from the return stream was from the uncased borehole from up to 20 feet above the drilling face.

Samples recovered during Stratex drilling were considered moderately reliable, since the method involves driving temporary casing behind the air hammer used to advance the borehole. However, the under-reaming bit creates a borehole with a diameter slightly larger than the casing, permitting some communication of water from the cased horizon to the drilling zone. The degree of this communication depends on the hydrostatic pressure (depth beneath the water table) and the productivity of the formation. The samples collected during Stratex drilling appeared to compare favorably with depth-specific water quality data from temporary wells in productive portions of the formation, and less favorably in unproductive portions of the formation. The latter was particularly apparent when transitioning from basin fill (productive) to bedrock (less productive). Samples recovered when transitioning from basin fill to bedrock appeared to be biased toward the concentration of the more productive basin fill. Consequently, Stratex drilling was typically discontinued and reverse-circulation or conventional rotary methods were used when bedrock was encountered. In these cases, the temporary casing was driven into the bedrock at the contact, if possible, in an attempt to isolate the overlying basin fill groundwater from interaction with the bedrock aquifer.

Samples of water recovered during reverse-circulation drilling were considered to have varying degrees of reliability depending on the productivity of the formation. Assessment of the reliability was based on changes in concentration with depth, verification through installation of temporary wells (Section 3.4.2.3), and relative productivity of the formation. Airlifting typically produced approximately 50 gpm during drilling. The length of borehole represented in the sample depended on the productivity of the formation. If the formation was productive, the samples appeared fairly reliable because most of the water produced was from near the drilling face. In bedrock formations with low productivity, the samples seemed to be a composite of the larger depth interval of the open borehole and were not considered representative of the formation water near the drilling face. In some cases (e.g., BMO-2008-8M [Section 3.4.4.7] and BMO-2008-13M [Section 3.4.4.11]), it seemed that the reverse-circulation drilling was pulling the sulfate-bearing water from the basin fill down into the fractured bedrock formation.

Samples of the water recovered using conventional air rotary were generally not considered reliable, since the formation water produced at the drilling face passed up the open borehole all the way to the surface. Therefore, all productive portions of the open borehole contribute to each sample. The exception to this assessment occurred when groundwater was first encountered. Water returned from the top of the water table was considered to accurately represent water quality at the top of the aquifer. Samples collected from greater depth had progressively more commingling of groundwater from the water-bearing portions of the borehole. Relative water quality of deeper samples was evaluated by changes in water quality. For example, a decrease in sulfate concentrations with depth was interpreted as indicating that

deeper portions of the aquifer had lower sulfate, but the concentrations of the samples were not considered strictly representative of the aquifer at the sampled depth. Transition to reverse-circulation methods was attempted as soon as possible to improve the representativeness of the samples.

In dry portions of boreholes BMO-2010-1 and BMO-2010-2, the reliability of reconnaissance sulfate concentrations is uncertain because there was no significant free liquid and the samples may have been affected by drilling foam. Efforts were made to reduce the effects of foam by purging zones prior to sampling.

3.4.2.3 Temporary Well Sampling

Temporary wells were sampled in some boreholes to further evaluate the water quality with respect to depth in the borehole, particularly for making well construction decisions for cases in which the purpose of the well was to establish the vertical extent of the sulfate plume (e.g., BMO-2008-7M, BMO-2008-8M, BMO-2008-9M, BMO-2008-10GU, BMO-2008-10GL, BMO-2008-13M, and BMO-2010-1M). Temporary wells developed and sampled over a limited (40 feet) interval were considered to provide an accurate approximation of the water quality obtainable from samples extracted from a permanent well completed in the same horizon.

Temporary wells at the BMO-2008 borings were constructed by inserting a 20-foot section of slotted 4-inch pipe at the end of dual-wall drill pipe to the desired depth, typically 10

feet from the bottom of the open borehole. Approximately 40 feet of No. 8 Tacna gravel filter pack was tremied into the borehole, from the base to approximately 10 feet above the top of the slotted section of pipe. An annular seal, typically 10 feet of bentonite chips, was tremied in on top of the filter pack and allowed to hydrate. Temporary wells at the BMO-2010 borings were constructed by inserting 20 feet of slotted PVC screen in the open borehole. No. 8 Tacna gravel filter pack was tremied into the borehole from the base to approximately five feet above the screen. An annular seal consisting of 10 feet of bentonite chips was tremied in on top of the filter pack and allowed to hydrate.

As an alternative to constructing temporary wells, the use of straddle packers was attempted in BMO-2008-10GU to isolate a portion of the borehole for water sampling. One sample was successfully collected using the straddle packers, but the second attempt resulted in irreparable damage to the packers. The roughness and variable diameter of the boreholes indicated that this was not a viable technique for this project.

Temporary wells were developed and pumped using airlifting in the same manner that airlifting was accomplished for the reverse-circulation drilling. Air was sent down the outside annulus of the double-walled pipe and injected into center of the pipe, lifting the water column. Water produced by airlifting was monitored for pH, EC, TDS, temperature, and sulfate concentration using field test methods. When these parameters stabilized, a final sulfate concentration was measured and a sample collected for laboratory analysis. Temporary wells in boreholes BMO-2010-1 and BMO-2010-2 did not produce large volumes of water. To purge the

temporary wells in these boreholes, a 20 foot bailer was used to purge the interval and collect the sample. This method allowed for accurate measurement of the purge volumes and the removal of drilling foam. Tabulated field and laboratory results are in Section 3.4.4 and Appendix K.

3.4.2.4 Well Construction

Monitor well construction was based on guidelines presented in Section 3.3.3.2 of the Work Plan. Typically, wells were completed with 100 feet of slotted casing placed within the depth interval to be sampled to accomplish the objective of the well. Casing and screen were constructed of welded ASTM A53B mild steel 5 inches in diameter. Factory cut slots 0.125 inch wide were arranged in vertical rows, resulting in approximately 3.6 percent open area. A sump of 10 feet of blank casing with a bottom cap was installed below the screen. A filter pack of No. 8 Tacna gravel was emplaced to a depth typically 10 to 20 feet above the top of the slotted casing. Transition sand consisting of 5 feet of 8-12 silica sand and 5 feet of No. 60 sand was placed between the filter pack and annular well seal. The annular well seal included approximately 10 feet of time-release bentonite pellets followed by high-solids bentonite grout to within 20 feet of the surface. The top 20 feet of annulus in each well was sealed with cement grout. Onsite personnel recorded well construction progress in a field notebook and on a well construction summary form, and created a diagram of the construction as the well was built. Section 3.4.4 provides references to documentation in this report for each of the wells constructed for the aquifer characterization.

3.4.2.5 Well Development

Well development activities included swabbing, airlifting, bailing, and pumping. Swabbing and airlifting were conducted by WDC Exploration and Wells, Inc. with oversight by HGC personnel (in 2008) and by Yellow Jacket Drilling with oversight by Clear Creek Associates personnel (in 2010) using the drill rig following well construction. Airlifting continued until the discharge water was clear and free of sediment and until the indicator water quality parameters of pH, electric conductivity, and temperature had stabilized.

In 2008, well development and testing activities were conducted by Verdad Group L.L.C. after the drill rig had been demobilized from the site. Verdad Group L.L.C. swabbed the screened interval and bailed sediment out of the sump prior to aquifer testing. Pursuant to the Work Plan, aquifer testing and collection of an initial water sample were conducted at each site following these well development activities. Aquifer testing typically consisted of step tests at 1/3 and 2/3 of the well's pumping capacity for one hour each followed by a constant rate test at full capacity for approximately 8 hrs. The well's production capacity was evaluated using flow rates observed during airlifting combined with test pumping the day before the aquifer test. Details of the pumping tests at the BMO-2008 wells are presented in Section 3.5 and Appendix N.1. Water produced by well development and aquifer testing was pumped to an area away from the borehole and allowed to infiltrate before leaving the property or entering a jurisdictional waterway.

In 2010, well development and testing activities were conducted by Yellow Jacket Drilling. The well was developed by airlifting, swabbing, and bailing after the well was constructed. Aquifer testing typically consisted of step tests at 1/3 and 2/3 of the well's pumping capacity for one hour each followed by a constant rate test at full capacity for approximately 8 hrs. The well's production capacity was evaluated using flow rates observed during airlifting combined with test pumping the day before the aquifer test. Details of the 2010 pumping tests are presented in Section 3.5 and Appendix N.4. Water produced by well development and aquifer testing at BMO-2010-1M and BMO-2010-2M was pumped to an area away from the borehole and allowed to infiltrate before leaving the property or entering a jurisdictional waterway. Water produced by well development and aquifer testing at BMO-2010-3B and BMO-2010-3M was pumped to Greenbush Draw under an Arizona Pollutant Discharge Elimination System de minimis permit.

Surface completion of the monitoring wells included equipping the wells with a sanitary seal, dedicated pump, sounding tube, control box, and protective box cover. A mark on the north side of the sounding tube establishes a permanent measurement datum for water levels. An Arizona Registered Land Surveyor, Arizona Land Specialists, Inc., surveyed this measuring point elevation to ± 0.01 ft. A locking painted steel box was installed around the well casing and control box on a concrete pad to protect the wellhead. The ADWR well registry number was stamped into the top of the well casing and the well name written on the concrete pad and well cover lid.

3.4.2.6 Downhole Logging

3.4.2.6.1 BMO-2008 Boreholes

Video logging was conducted on two of the wells during drilling to evaluate the condition of the borehole wall. Southwest Exploration Services, L.L.C. conducted video, caliper, and natural gamma surveys of boreholes BMO-2008-8M and BMO-2008-13M on October 30, 2008. Southwest Exploration Services, L.L.C.'s report, video logs, and caliper logs are presented in Appendix I.1. The purpose of the surveys was to evaluate the condition of the borehole wall and amount of fracturing in the bedrock penetrated by the boreholes. The surveys were initiated because the results of temporary wells installed and sampled in both of these boreholes contained elevated sulfate concentrations at unanticipated depths, and the productivity of the formation in the temporary wells was inconsistent with the geologic logging, suggesting fracture flow may have been circumventing the annular seal above the screened interval, corrupting the integrity of the results. The results of the video surveys are included in Appendix I.1.

The video logging procedure included lowering a video camera with side scan capabilities to the bottom of the well and videotaping the results. The camera was lowered to the bottom of the borehole or to the maximum depth attainable, videotaping the entire time. The side scan camera was used to obtain additional detail concerning the condition of the borehole at interesting zones observed from the down-looking camera. In both boreholes, the camera was not able to reach the bottom of the borehole. In BMO-2008-8M, the borehole had been enlarged just below the contact between basin fill and bedrock. The enlargement was asymmetrical,

which caused the centralizer to push the camera off to one side, causing it to bottom on a ledge. In BMO-2008-13M, temporary caving at 761 feet below land surface (ft bls) prevented deeper penetration of the camera and caliper tool.

Video logging was followed by a caliper/natural gamma survey. The caliper tool was lowered to the bottom of the open borehole to begin the survey. In BMO-2008-8M, this was the bottom of the borehole at 1,216 ft bls; in BMO-2008-13M, this was at 761 ft bls. Three arms extending from the caliper tool at 120° spacing were used to gauge the diameter of the borehole as the tool was slowly raised to the land surface. A detector on the caliper tool was used to record the flux of gamma rays generated by the borehole wall as the tool was elevated.

3.4.2.6.2 BMO-2010 Boreholes

Geophysical and video logging were conducted on two of the BMO-2010 boreholes. Southwest Exploration Services, L.L.C. conducted video, caliper, temperature, natural gamma, optical and acoustic borehole imaging (OBI and ABI) surveys of BMO-2010-1M and BMO-2010-2M boreholes. The purpose of the surveys was to evaluate the condition of the borehole wall and the degree of fracturing in the bedrock. In addition to the logging discussed above, electric and dual induction logs were run in borehole BMO-2010-1M to see if the basin fill-bedrock boundary had a distinctive signature that could be used to identify depths to bedrock in cased wells. The electric log consists of a spontaneous potential and a single point resistivity log, which are recorded simultaneously. The dual induction log was conducted in order to measure resistivity in the unsaturated bedrock portion of the borehole, since the electric log only provided

data from below the water table. Southwest Exploration Services, L.L.C.'s report, video logs, and geophysical logs are presented in Appendix I.1.

Video logging of BMO-2010-1M and BMO-2010-2M consisted of lowering a camera with side scan capabilities down the borehole and videotaping the results. In BMO-2010-1M, the borehole was only visible until the camera reached the water table. The turbidity of the water reduced the visibility and the video logging was stopped just below static water level at 234 ft bls. In BMO-2010-2M, the camera was able to reach the bottom and the borehole wall was visible throughout. In both wells, the side scan camera was used to obtain additional detail concerning the condition of the borehole.

A caliper, temperature, and natural gamma survey followed video logging. The caliper tool was lowered to the bottom of the open borehole to begin the survey. Three arms extending from the caliper tool at 120° spacing were used to gauge the diameter of the borehole as the tool was slowly raised to the land surface. As the caliper tool was elevated, a detector also measured the borehole temperature and the flux of naturally occurring gamma rays generated by the borehole wall.

The OBI and ABI surveys were conducted to evaluate the degree and orientation of the fractures in the bedrock. In each borehole, the OBI survey was performed from the bottom of the temporary conductor casing, approximately 25 ft bls, to the static water level. The ABI survey was performed from the static water level to the bottom of the borehole. The OBI and ABI were

then analyzed together to produce a summary log indicating the type, orientation, and relation of bedding and fracture features for the entire length of the borehole.

The OBI and ABI logs of BMO-2010-1M identified a total of 162 planar features intersecting the borehole including bedding planes, partially open fractures, minor open fractures, major open fractures, and filled fractures. The direction and degree of the dip of all the planar features are graphically represented on the feature summary included in Appendix I.1. The observed orientations of the features generally fall into three distinct groups. Group one includes fractures and the majority of all observed bedding planes. These features generally have a northwest strike and dip at a moderately steep angle toward the southwest. Group two only includes fractures, mostly partially open fractures, which generally have a west or west-northwest strike and dip at a moderately steep angle toward the north or north-northeast. Group three contains fewer features than the two previous groups, including a variety of fractures and one bedding plane, which generally have a northeast strike and dip steeply to the southeast.

The OBI and ABI logs of BMO-2010-2M counted a total of 255 planar features intersecting the borehole including bedding planes, partially open fractures, minor open fractures, major open fractures, and filled fractures. The direction and degree of the dip of all the planar features are graphically represented on the feature summary included in Appendix I.1. The observed orientations of the features generally fall into two distinct groups. Group one includes fractures and all observed bedding planes. These features generally have a northwest strike and dip at a moderately steep angle toward the southwest. Group two only includes

fractures, mostly filled and partially open fractures, which generally strike west-northwest and dip toward the north-northeast.

3.4.3 Geologic Summary

3.4.3.1 BMO-2008 Boreholes

Boreholes drilled at the BMO-2008 sites intercepted Quaternary to Tertiary basin fill deposits overlying Cretaceous clastic sedimentary and limestone bedrock. The basin fill is composed of unconsolidated to moderately consolidated gravel, sand, silt, and clay. Caliche cement was typically encountered from the surface or near surface to depths of 50 to 130 ft bls. Basin fill thicknesses encountered in the pilot boreholes drilled to bedrock ranged from a minimum of 50 ft bls in BMO-2008-1G to a maximum of 636 ft bls in BMO-2008-4B.

The gravel fraction of the basin fill ranges from fine to coarse, but actual sizing of the gravels is obscured by the grinding action of the drill bit. Most gravel clasts are subangular to subrounded. In places, the presence of cobbles was inferred based on drill rig performance in conjunction with the presence of angular fragments, which were interpreted to represent larger gravel or cobbles reduced in size by the drilling process. The presence of coarse cobbley zones was confirmed by video logging in BMO-2008-8M and BMO-2008-13M.

Composition of the gravel clasts in the basin fill sequence is polymictic and includes varying ratios of clastic, carbonate, metamorphic, volcanic and plutonic igneous rocks. Clastic sedimentary rocks include quartzose sandstones, arkosic sandstone, arkose, quartzite, siltstone, and mudstone. Chemical sediments include various limestones, silicified limestone, and chert. Metamorphic clasts include fine-grained quartz-mica phyllite, schist, and metamorphic quartz derived from the Precambrian Pinal Schist. Pre-erosional hydrothermal alteration was occasionally observed in both igneous and sedimentary clasts, represented by oxidized sulfides occurring as limonite, calcite veinlets, and silicification.

The sand fraction of the basin fill encountered in the BMO-2008 monitoring wells is coarse to fine, and typically well-graded, commonly grading to silt. The sand is composed primarily of quartz and sedimentary and metamorphic lithic grains with trace magnetite. The fine sand fraction is typically mostly quartz, whereas coarser sand is often predominantly lithic grains.

The fine fraction (silt and clay) of the basin fill was visually estimated during logging of the drill cuttings. No geotechnical testing of the material was conducted. Silt and clay occur primarily intermixed with variable amounts of sand and occasionally gravel, as clay and/or silt with sand, sandy clay, or sandy silt.

Bedrock formations encountered in the BMO-2008 wells penetrating bedrock are interpreted to be (in descending order) Cintura Formation, and Mural Limestone, Morita

Formation, and Glance Conglomerate. These four formations are members of the Bisbee Group sedimentary sequence. The Mural Limestone is divided into an upper and lower unit. The Glance Conglomerate is typically easy to recognize in drill cuttings. The other units of the Bisbee Group are sometimes difficult to differentiate in drill cuttings due to the similarity of their lithologies. As will be discussed in Section 4.2.2, the three Bisbee Group formations overlying Glance Conglomerate also have similar overlapping ranges of hydraulic properties. Hereafter, for groundwater modeling and other purposes, the Cintura Formation, Mural Limestone, and Morita Formation are sometimes grouped together and referred to as "undifferentiated Bisbee Group".

3.4.3.2 BMO-2010 Boreholes

Boreholes drilled at the BMO-2010 sites intercepted Quaternary to Tertiary basin fill deposits overlying Cretaceous clastic sedimentary bedrock. The basin fill is composed of unconsolidated to moderately consolidated gravel, sand, silt, and clay. Observations of basin fill lithology in 2010 were consistent with those made in 2008.

The gravel fraction of the basin fill ranges from fine to coarse, but actual sizing of the gravel is obscured by the grinding action of the drill bit. Most gravel clasts are subangular to subrounded. In places, the presence of cobbles was inferred based on drill rig performance (i.e. rig "chatter") in conjunction with the presence of angular fragments, which were interpreted to represent larger gravel or cobbles reduced in size by the drilling process.

Composition of the gravel clasts in the basin fill sequence is polymictic and includes varying ratios of clastic, carbonate, metamorphic, volcanic and plutonic igneous rocks. Clastic sedimentary rocks include quartzose sandstones, arkosic sandstone, arkose, quartzite, siltstone, and mudstone. Chemical sediments include various limestones, silicified limestone and chert. Metamorphic clasts include fine-grained quartz-mica phyllite, schist, and metamorphic quartz derived from the Precambrian Pinal Schist. Pre-erosional hydrothermal alteration was occasionally observed in both igneous and sedimentary clasts, represented by oxidized sulfides occurring as limonite, calcite veinlets, and silicification.

The sand fraction of the basin fill encountered in the BMO-2010 monitoring wells is coarse to fine, and typically well-graded, commonly grading to silt. The sand is composed primarily of quartz and sedimentary and metamorphic lithic grains with trace magnetite. The fine sand fraction is typically mostly quartz, whereas coarser sand is often predominantly lithic grains.

The fine fraction (silt and clay) of the basin fill was visually estimated during logging of the drill cuttings. No geotechnical testing of the material was conducted. Silt and clay occur primarily intermixed with variable amounts of sand and occasionally gravel, as clay and/or silt with sand, sandy clay, or sandy silt.

Bedrock formations encountered in the BMO-2010 wells penetrating bedrock are interpreted to be (in descending order) the Cintura Formation and the Morita Formation. These

units are sometimes difficult to differentiate in drill cuttings due to the similarity of their lithologies. Bedrock at BMO-2010-1M and BMO-2010-2M was determined to be Morita Formation, based on their locations and data from nearby boreholes. It was determined that bedrock at BMO-2010-3M was Cintura Formation based on the location of the well, geologic logging at nearby wells, and input from a CQB mine geologist.

3.4.4 Drilling and Construction of Individual Wells

This section describes the purpose and location of each site relative to the sulfate plume (defined by the 250 mg/L isoconcentration contour), the geology encountered, summarizes the drilling and construction of wells, and rationale for screen depths. A generalized stratigraphy for each site is presented based on interpretation of the geologic logs. Locations of the wells installed under this task are presented on Figure 10.

Wells were installed in 2008 at the 12 sites specified in the Work Plan with the following exceptions. All modifications of the drilling locations identified in the Work Plan were approved in advance by ADEQ (2008a, 2008b, 2008c, and 2008d). The proposed well at Site 2 was not installed because existing well, NWC-04, was deepened in 2008 and produced samples with sulfate concentrations below 250 mg/L, satisfying the objective of establishing the vertical extent of the sulfate plume in that location. The proposed well at Site 12 was not installed because an existing well, COB WL (Figure 10), was identified as being suitable to accomplish the stated goals for the well that was to be installed at Site 12. Wells constructed in the basin fill and

bedrock were added at Site 13 (Sec 3.4.4.11) to evaluate hydrologic parameters and vertical distribution of sulfate in the critical area of the sulfate plume. Well Sites 1, 5, and 6 were moved limited distances to accommodate land ownership issues and water quality data developed subsequent to the Work Plan.

In 2010, four wells were installed at 3 sites (Figure 10). BMO-2010-1M and BMO-2010-2M were installed in bedrock near Bisbee Junction as part of the Focused Bedrock Investigation to better delineate the depth of the plume and to provide additional groundwater level data. BMO-2010-3M and BMO-2010-3B were installed for plume monitoring in bedrock and basin fill, respectively, along Greenbush Draw downgradient of the sulfate plume.

Information including geologic logs, water quality data for reconnaissance samples and temporary wells, well construction diagrams, and well construction summaries for the BMO-2008-series and BMO-2010-series wells are provided in Appendices J, K, L, and M, respectively. In response to ADEQ comments (ADEQ, 2010a), the results of reconnaissance and temporary well water quality sampling are also presented in the following well by well discussions.

3.4.4.1 Site BMO-2008-1

Monitor well BMO-2008-1G was drilled south of Swan Road and north of the Bisbee Municipal Airport (Figure 10) in Section 2, Township 24 South, Range 24 East to evaluate the eastern limit of the sulfate plume near the former evaporation pond, determine hydraulic properties of the bedrock at this location, and to provide long-term water level and water quality data. Site 1 was moved approximately 1,000 feet to the east of the original Work Plan location because monitoring data developed as part of Task 2.1 showed the original Work Plan location was in the plume. ADEQ approved the site modification prior to drilling (ADEQ, 2008b).

BMO-2008-1G was drilled to total depth of 320 ft bls using Stratex and conventional air-rotary drilling methods. Bedrock was encountered at 50 ft bls and moisture was first noted at 70 ft bls. Inter-layered dry and damp zones were encountered to a depth of 210 ft bls, where inflow to the borehole became sufficient that reconnaissance water sampling was possible. The details of drilling and well construction are presented in Appendix M. Reconnaissance water samples were recovered approximately every 20 feet from 210 to 320 ft bls and analyzed in the field and laboratory, as shown below and in Table K.1. The water level rose to 61 ft bls within 24 hrs and persists at that approximate depth. The static water level in BMO-2008-1G may represent water table conditions that were slow to develop due to delayed inflow from low permeability Morita Formation from 50 to 170 ft bls, a confined condition in Glance Conglomerate encountered at 170 ft bls, or both.

BMO-2008-1G Reconnaissance Water Sampling Results						
Sample Depth ft bls	**pH SU**	**Temperature °C**	**EC µS/cm**	**TDS ppm**	**Field Sulfate mg/L**	**Laboratory Sulfate mg/L**
Reconnaissance Groundwater Samples						
210	7.89	28.6	854	422	128	100
230	7.86	30.7	905	455	135	120
240	8.04	27.6	908	452	140	120
260	8.01	28.7	932	465	143	120
280	8.25	26.3	933	465	148	130
300	8.26	27.7	938	469	148	130
320	8.14	29.4	983	488	155	160

Notes:
ft bls = feet below land surface
SU = Standard units
µS/cm = microsiemens per centimeter
°C = Degrees Celsius
ppm = parts per million
mg/L = milligrams per liter
Field sulfate measurements conducted with an Orion AQ4000 Colorimeter

Materials encountered in the borehole include basin fill sediments, Morita Formation, and Glance Conglomerate. The geologic log for BMO-2008-1G is in Appendix J. The stratigraphy at BMO-2008-1G can be summarized as follows:

- 0-50 ft bls: Basin fill; strongly caliche-cemented clayey to silty sand and gravel
- 50-170 ft bls: Morita Formation; reddish gray to brown sandy to clayey siltstone
- 170-320 ft bls: Glance Conglomerate; reddish brown conglomerate with sandy to silty matrix and few siltstone interbeds

BMO-2008-1G was completed in the Glance Conglomerate with well screen from a depth of 180 to 300 ft bls (Figure L.1). The basin fill is unsaturated in the borehole and water quality samples recovered during drilling from the bedrock aquifer contained sulfate concentrations below 250 mg/L (Table K.1), indicating the bedrock aquifer is outside of the plume at this location. Following the guidelines established in the Work Plan, the well was completed entirely in one formation (Glance Conglomerate) and monitors the unimpacted

bedrock outside of the plume and east of the source area. Initial sampling of the completed well conducted during hydraulic testing produced a sulfate concentration of 107 mg/L.

3.4.4.2 Site BMO-2008-3

Well BMO-2008-3B was constructed east of the City of Naco, Arizona to evaluate the southern lateral extent of the sulfate plume in this area, evaluate hydraulic properties of the basin fill at this location, and provide long-term water level and water quality data. The well is located east of Naco Highway and south of Purdy Lane on the Miller Ranch property (Figure 10) in Section 17, Township 24 South, Range 24 East.

BMO-2008-3B was drilled to a total depth of 590 ft bls using a combination of Stratex, ARCH, and reverse-circulation rotary drilling methods. The well encountered groundwater at approximately 136 ft bls and claystone bedrock at 470 ft bls. The details for drilling and well construction are presented in Appendix M. Reconnaissance water samples were recovered approximately every 20 feet from 156 to 580 ft bls and analyzed in the field and laboratory, as shown below and in Table K.2.

BMO-2008-3B Reconnaissance Water Sampling Results						
Sample Depth ft bls	**pH SU**	**Temperature °C**	**EC µS/cm**	**TDS ppm**	**Field Sulfate mg/L**	**Laboratory Sulfate mg/L**
Reconnaissance Groundwater Samples						
156	7.52	27.0	675	377	150	140
170	7.69	28.4	792	390	200	200
190	7.78	22.7	718	363	200	190
220	8.05	22.3	883	441	270	300
240	7.90	23.2	711	356	150	200
260	8.11	22.2	581	290	120	110
270	7.28	24.0	685	342	160	150
280	7.80	24.1	652	326	150	140
300	7.89	22.3	658	327	140	130
320	7.74	21.2	623	311	130	120
340	7.76	23.5	607	305	130	110
360	7.74	23.5	587	294	120	110
380	7.83	23.7	557	277	97	87
400	7.77	23.7	570	285	94	90
420	7.72	24.2	555	276	110	90
440	7.78	24.0	497	249	63	59
460	7.91	23.4	495	247	49	51
480	7.78	24.4	496	249	56	53
500	7.59	22.4	520	260	65	63
520	7.78	22.5	562	280	110	94
540	7.90	24.3	523	262	80	66
560	7.76	24.5	544	270	94	81
580	7.85	24.2	532	266	86	76

Notes:

ft bls = feet below land surface
SU = Standard units
µS/cm = microsiemens per centimeter
°C = Degrees Celsius
ppm = parts per million
mg/L = milligrams per liter
Field sulfate measurements conducted with an Orion AQ4000 Colorimeter

Materials encountered in the borehole include basin fill sediments and fine-grained clastic bedrock. The bedrock may be a portion of the Cintura Formation. Limestone intercepted at 580 feet is interpreted as the top of the Upper Mural Limestone. The geologic log for BMO-2008-3B is included in Appendix J. Summary geology for BMO-2008-3B is as follows:

- 0-70 ft bls: Basin fill; moderately caliche-cemented reddish brown silt and silty sand with gravel
- 70-418 ft bls: Basin fill; reddish brown gravel with silt and sand
- 418-470 ft bls: Basin fill; reddish brown sandy clay grading to silty sand transition to bedrock
- 470-580 ft bls: Cintura/Morita Formation; interbedded pale red, gray, yellow and brown claystone, mudstone, and sandstone
- 580-590 ft bls: Upper Mural Limestone; medium gray limestone

BMO-2008-3B was completed in the upper portion of the basin fill with well screen from a depth of 150 to 250 ft bls (Figure L.2). Reconnaissance water samples contained sulfate concentrations below 250 mg/L except the sample from 220 ft bls, which yielded a concentration of 300 mg/L. Reconnaissance samples from 170 to 240 ft bls had the highest sulfate concentrations whereas samples deeper than 240 ft bls exhibit a generally declining trend in sulfate concentrations with depth. This observation is consistent with observations in other BMO borings. That is, when sulfate is vertically zoned, concentrations would decline with depth. The reconnaissance data show that sulfate concentrations are vertically zoned at BMO-2008-3B. The vertical distribution of sulfate is discussed further in Section 5.1.1.3.

Following the guidelines established in the Work Plan, the well was screened in the upper 100 feet in the basin fill aquifer. Groundwater was first encountered in the borehole at 156 ft bls, but water levels in the completed well rose to approximately 136 ft bls. It is not unusual for initial observed water levels in an open borehole to vary from the water level in the completed well because saturation at the capillary fringe is not always free flowing and it can take some time for groundwater levels to equilibrate in a borehole. The well monitors basin fill outside of the southern margin of the plume east of the City of Naco, Arizona. Initial sampling of the

completed well conducted during hydraulic testing produced a sulfate concentration of 106 mg/L.

3.4.4.3 Site BMO-2008-4

Well BMO-2008-4B was drilled northeast of the City of Naco, Arizona to evaluate the vertical extent of sulfate near the downgradient toe of the sulfate plume, evaluate hydraulic properties of materials below the plume at this location, and provide long-term water level and water quality data. The well is located on the Rogers property on Mule Deer Road west of Naco Highway and south of Purdy Lane (Figure 10) in Section 18, Township 24 South, Range 24 East. BMO-2008-4B is located near two shallower wells that supply drinking water: the Rogers family private well (ROGERS 803) and public water supply well NWC-03. Groundwater samples from NWC-03 contain sulfate concentrations above 250 mg/L, indicating that its screened interval from 252 to 312 ft bls is within the plume.

BMO-2008-4B was drilled to a total depth of 660 ft bls using Stratex and reverse-circulation air-rotary drilling methods. The details of drilling and well construction are presented in Appendix M. Reconnaissance water samples were recovered approximately every 20 feet from 180 to 660 ft bls and analyzed in the field and laboratory, as shown below and in Table K.3.

BMO-2008-4B Reconnaissance Water Sampling Results						
Sample Depth ft bls	**pH SU**	**Temperature °C**	**EC µS/cm**	**TDS ppm**	**Field Sulfate mg/L**	**Laboratory Sulfate mg/L**
Reconnaissance Groundwater Samples						
180	7.00	23.0	939	499	324	430
200	7.19	15.1	1,143	577	666	570
220	7.32	15.4	1,637	819	813	700
240	7.42	18.6	1,471	735	--	--
260	7.41	19.0	893	443	--	260
280	7.42	20.7	797	398	--	190
300	7.66	19.3	751	374	192	170
320	7.70	21.8	1,005	503	--	300
340	7.48	22.0	922	460	--	280
360	7.33	22.3	903	452	300	270
380	7.50	22.0	912	458	--	280
400	7.39	22.3	888	444	--	260
420	7.39	21.5	880	439	262	250
436	7.27	18.7	853	426	271	260
440	7.54	18.9	960	482	--	310
460	7.60	19.8	878	437	--	240
480	7.43	21.3	848	423	--	230
500	7.36	22.9	801	400	--	220
520	7.57	22.9	826	413	--	220
540	7.40	22.9	814	407	--	220
560	7.33	20.1	811	406	254	210
580	7.51	20.3	810	405	--	200
600	7.58	20.5	822	410	260	220
620	7.64	21.6	791	394	244	210
640	7.64	21.7	778	390	242	210
660	7.63	22.4	735	367	186	190

Notes:

ft bls = feet below land surface

SU = Standard units

µS/cm = microsiemens per centimeter

°C = Degrees Celsius

ppm = parts per million

mg/L = milligrams per liter

- - = not measured

Field sulfate measurements conducted with an Orion AQ4000 Colorimeter

Materials encountered in the borehole include basin fill sediments to a depth of approximately 636 ft bls and limestone bedrock from 636 to 660 ft bls. The bedrock is

interpreted as Upper Mural Limestone. The geologic log of BMO-2008-4B is included in Appendix J. Summary geology for BMO-2008-4B is as follows:

- 0-75 ft bls: Basin fill; moderately caliche-cemented reddish brown to brown sand and silt with gravel
- 75-170 ft bls: Basin fill; weak to moderately cemented reddish brown sandy silt to silty sand with gravel
- 170-435 ft bls: Basin fill; reddish brown gravel with sand and silt to sandy gravel
- 435-636 ft bls: Basin fill; reddish brown gravelly sand with little silt
- 636-660 ft bls: Mural Limestone; light gray, fossiliferous, micritic limestone

BMO-2008-4B was completed in the lower portion of the basin fill with well screen from a depth of 500 to 600 ft bls (Figure L.3) for the purpose of monitoring groundwater in the basin fill beneath the sulfate plume. The saturated thickness of the basin fill at site BMO-2008-4 is approximately 506 feet, extending from the water table at approximately 130 ft bls to bedrock at 636 ft bls. Results of reconnaissance water sampling during drilling indicate that sulfate concentrations in excess of 250 mg/L may persist to a depth of 440 ft bls (Table K.3). Below 440 ft bls, sulfate concentrations in reconnaissance samples declined with depth from 240 mg/L at 460 ft bls to 190 mg/L at 660 ft bls. Following the guidelines established in the Work Plan, the annular seal extended 50 feet below the plume, resulting in the top of the screen being set at 500 ft bls, which is within 100 feet of the plume. Initial sampling of the completed well conducted during hydraulic testing yielded a sulfate concentration of 9.4 mg/L.

3.4.4.4 Site BMO-2008-5

Two monitor wells were drilled and installed at site BMO-2008-5 to evaluate the lateral extent and potential vertical zoning at the southwestern margin of the plume, evaluate hydraulic

properties of the basin fill and bedrock at this location, and provide long-term water level and water quality data. The site is located on the Miller Ranch property west of Naco Highway and immediately north of Purdy Lane (Figure 10) in Section 7, Township 24 South, Range 24 East. Site BMO-2008-5 was moved approximately 1,200 feet northeast from the location proposed by the Work Plan on the AWC property. The site was moved based on the request of AWC to install two additional wells on the banks of Greenbush Draw. The present location was selected to provide a more even spacing between the proposed Greenbush Draw wells and Site 6 wells (Section 3.4.4.5) and was approved by ADEQ prior to installation (ADEQ, 2008c).

BMO-2008-5M was drilled to a total depth of 460 ft bls using a combination of ARCH and reverse-circulation rotary drilling methods. The details of drilling and well construction are presented in Appendix M. Reconnaissance water samples were recovered approximately every 20 feet from 180 to 460 ft bls and analyzed in the field and laboratory, as shown below and in Table K.4. Sulfate concentrations in the reconnaissance water samples were all below 250 mg/L, indicating that the site is outside the sulfate plume.

BMO-2008-5M Reconnaissance Water Sampling Results						
Sample Depth ft bls	**pH SU**	**Temperature °C**	**EC µS/cm**	**TDS ppm**	**Field Sulfate mg/L**	**Laboratory Sulfate mg/L**
Reconnaissance Groundwater Samples						
180	7.48	25.2	690	344	179	160
200	7.71	24.2	748	374	193	200
220	7.75	25.5	759	379	199	200
240	8.06	24.3	757	378	199	200
280	7.50	25.4	578	288	119	94
300	7.53	25.3	720	358	188	160
320	7.87	21.9	697	348	186	220
340	8.29	22.4	734	367	198	190
360	7.87	24.9	739	369	191	190
380	7.83	26.4	750	375	193	190
400	7.88	23.8	744	371	196	190
420	7.89	23.1	749	375	193	190
440	7.92	23.1	746	373	193	190
460	7.89	22.9	736	368	181	190

Notes:

ft bls = feet below land surface

SU = Standard units

µS/cm = microsiemens per centimeter

°C = Degrees Celsius

ppm = parts per million

mg/L = milligrams per liter

Field sulfate measurements conducted with an Orion AQ4000 Colorimeter

Materials encountered in the borehole include basin fill sediments to a depth of approximately 290 ft bls and bedrock composed of sandstone to claystone from 290 to 460 ft bls. The bedrock is interpreted to be either part of the Cintura Formation, or possibly the part of the mixed clastic-carbonate sequence of the lower Mural Formation. The geologic log of BMO-2008-5M is included in Appendix J. Summary geology for BMO-2008-5M is as follows:

- 0-65 ft bls: Basin fill; strongly caliche-cemented brown to pink sandy silt and clay
- 65-165 ft bls: Basin fill; strongly cemented brown to reddish brown sandy silt with little gravel
- 165-255 ft bls: Basin fill; mottled gravel with sand and silt

- 255-290 ft bls: Basin fill; brownish to reddish sand with gravel
- 290-460 ft bls: Cintura/Lower Mural Formation; yellow, gray, and brown calcareous sandstone to siltstone grading to interbedded sandstone and claystone and rarely limestone

BMO-2008-5M was completed in the Lower Mural/Cintura Formation with well screen from a depth of 340 to 440 ft bls (Figure L.4). Reconnaissance sampling data from the borehole (Table K.4) indicated that groundwater in the bedrock (and basin fill) contained sulfate concentrations below 250 mg/L. Following the guidelines established in the Work Plan, the annular seal extended 50 feet below the contact between the basin fill and bedrock, resulting in the top of the screen being set at 340 ft bls. The well monitors the bedrock beneath the basin fill. The initial sample of groundwater from the completed well collected during hydraulic testing contained a sulfate concentration of 107 mg/L.

BMO-2008-5B was drilled to a total depth of 295 ft bls using ARCH and air rotary methods approximately 50 feet west of BMO-2008-5M. The geologic log for BMO-2008-5M describes conditions at BMO-2008-5B (Appendix J). The details of drilling and well construction are presented in Appendix M. This well was installed to monitor the basin fill aquifer outside of the plume at this location. The well was constructed with screen from 140 to 280 ft bls to span the basin fill aquifer (Figure L.5). Reconnaissance water samples collected from the basin fill during drilling of BMO-2008-5M (Table K.4) indicated that the sulfate plume has not reached this location. The initial sample of groundwater from the completed well collected during hydraulic testing contained a sulfate concentration of 193 mg/L.

3.4.4.5 Site BMO-2008-6

Two monitoring wells were drilled and installed at site BMO-2008-6 to evaluate the lateral extent of the sulfate plume at its northwest edge, changes in sulfate concentration with depth, hydraulic properties of materials in the basin fill and bedrock at this location, and provide long-term water level and water quality data. The site is located on the Miller Ranch north of Purdy Lane and west of Naco Highway (Figure 10) in Section 7, Township 24 South, Range 24 East. Well Site 6 was shifted approximately 1,500 feet southwest of the Work Plan location to accommodate the request of the land owner. ADEQ approved the modification of the well site location prior to drilling (ADEQ, 2008a).

BMO-2008-6M was drilled to a total depth of 460 ft bls using a combination of Stratex, ARCH, and air rotary drilling methods. The details of drilling and well construction are provided in Appendix M. Reconnaissance water samples were recovered approximately every 20 feet from 200 to 460 ft bls and analyzed in the field and laboratory, as shown below and in Table K.5. Sulfate concentrations in the reconnaissance water samples were all below 250 mg/L, indicating that the site is outside the sulfate plume.

BMO-2008-6M Reconnaissance Water Sampling Results						
Sample Depth ft bls	**pH SU**	**Temperature °C**	**EC µS/cm**	**TDS ppm**	**Field Sulfate mg/L**	**Laboratory Sulfate mg/L**
Reconnaissance Groundwater Samples						
200	7.73	14.1	390	194	91	63
240	7.91	27.3	492	246	57	62
260	8.11	23.0	616	307	154	150
290	7.91	26.5	441	220	105	110
300	7.89	26.1	477	239	106	97
320	8.15	23.6	650	323	177	170
340	8.24	23.3	658	328	181	180
360	8.23	22.7	660	330	181	180
380	8.01	23.4	672	337	181	180
400	8.09	24.4	643	321	178	170
420	8.17	22.0	630	314	164	170
440	8.07	23.7	646	322	175	170
460	8.10	23.6	635	318	174	160

Notes:

ft bls = feet below land surface

SU = Standard units

µS/cm = microsiemens per centimeter

°C = Degrees Celsius

ppm = parts per million

mg/L = milligrams per liter

Field sulfate measurements conducted with an Orion AQ4000 Colorimeter

Materials encountered in the borehole include basin fill sediments to a depth of approximately 240 ft bls and bedrock composed pale yellow sandstones with limey and silty interbeds. The basin fill-bedrock contact was initially interpreted to be at a depth of 270 ft bls. Review of the cuttings after the wells were constructed resulted in reinterpreting the contact at the base of a clay zone at 240 ft bls. The bedrock is interpreted as being Cintura Formation, but may also be part of the Lower Mural Limestone or Morita Formation. The geologic log for borehole BMO-2008-6M is in Appendix J. Summary geology for BMO-2008-6M is as follows:

- 0-95 ft bls: Basin fill; strongly caliche-cemented, pink, light brown, and reddish brown silt with sand

- 95-240 ft bls: Basin fill; moderately cemented reddish brown silty sand and gravel
- 240-460 ft bls: Cintura Formation; brown to yellow, calcareous arkosic sandstone interbedded with mudstone

BMO-2008-6M was completed in the upper portion of the bedrock with well screen from a depth of 340 to 440 ft bls (Figure L.6) for the purpose of monitoring groundwater in the bedrock west of the sulfate plume. Reconnaissance water sampling data from the borehole (Table K.5) indicated that groundwater in the bedrock and basin fill contained sulfate concentrations below 250 mg/L. Following the guidelines established in the Work Plan, the annular seal extended 80 feet below the contact between the basin fill and bedrock, resulting in the top of the screen being set at 340 ft bls. Initial sampling of the completed well conducted during hydraulic testing produced a sulfate concentration of 182 mg/L.

BMO-2008-6B was drilled to a total depth of 270 ft bls using Stratex and conventional air rotary drilling methods approximately 30 feet north of BMO-2008-6M to monitor the basin fill aquifer at this location. The geologic log for BMO-2008-6M describes conditions at BMO-2008-6B (Appendix J). The details of drilling and well construction are presented in Appendix M. The well was constructed with screen from 195 to 255 ft bls to span the basin fill aquifer (Figure L.7). The weathered clayey character of the basin fill-bedrock contact obscured the exact location of the contact. As a result, the upper 15 feet of the bedrock was included in the screened interval based on initial interpretation of the bedrock contact, which was later revised after further examination of the cuttings. The completed well was developed using swabbing, bailing, and pumping because airlift development of this well was not possible. Reconnaissance water samples collected from the basin fill during drilling of BMO-2008-6M (Table K.5)

indicated that the basin fill aquifer was outside of the plume at this location. Initial samples of groundwater from BMO-2008-6B collected during hydraulic testing contained a sulfate concentration of 53.3 mg/L.

3.4.4.6 Site BMO-2008-7

Well BMO-2008-7M was drilled near the COB's San Jose WWTF to evaluate the vertical extent of the sulfate plume, evaluate hydraulic properties of materials beneath the plume at this location, and provide long-term water level and water quality data. San Jose WWTF has a monitor well COB MW-1 on the facility site that is completed in basin fill within the plume. BMO-2008-7M is approximately 500 feet north-northwest of COB MW-1. BMO-2008-7M is located on CQB property north of Purdy Lane and west of the San Jose WWTF former recharge ponds (Figure 10) in Section 9, Township 24 South, Range 24 East.

BMO-2008-7M was drilled to a total depth of 750 ft bls, using a combination of ARCH, Stratex, and reverse-circulation rotary drilling methods. The details of drilling and well construction are provided in Appendix M. Reconnaissance water samples were recovered approximately every 20 feet from 240 to 750 ft bls and analyzed in the field and laboratory. Temporary wells were installed, developed and tested approximately every 70 feet in the bedrock aquifer from 300 to 750 ft bls. Field and laboratory analytical results are shown below and in Table K.6.

BMO-2008-7M Reconnaissance Water Sampling Results						
Sample Depth ft bls	**pH SU**	**Temperature °C**	**EC µS/cm**	**TDS ppm**	**Field Sulfate (mg/L)**	**Laboratory Sulfate mg/L**
Reconnaissance Groundwater Samples						
235	8.36	20.9	365	--	--	37
255	8.02	16.5	462	--	--	120
275	7.69	18.2	2,410	--	1,120	1,200
295	7.82	20.9	2,580	--	--	1,400
315	8.01	23.9	1,979	--	--	1,200
335	7.97	22.2	2,745	1,357	--	1,400
345	8.07	22.1	2,824	1,410	1,137	--
360	7.99	22.4	2,842	1,422	--	1,400
380	7.89	20.7	2,873	1,437	--	1,450
400	8.01	20.7	2,678	1,319	--	--
420	8.13	21.9	1,945	967	--	880
440	7.95	20.8	2,424	1,210	--	--
460	7.99	20.3	2,320	1,153	--	1,100
480	7.93	21.0	2,254	1,128	--	--
500	7.97	20.7	2,266	1,134	--	1,100
520	8.02	21.5	2,233	1,105	--	1,000
540	8.11	21.9	1,754	--	--	750
560	7.92	22.6	617	--	--	110
580	8.18	23.0	546	--	--	67
600	8.23	22.9	567	--	--	78
620	8.12	22.4	508	--	--	54
640	8.16	23.4	495	--	--	45
660	8.15	23.2	496	--	--	47
680	8.20	23.3	488	--	--	45
700	8.18	22.8	483	--	36	39
720	8.24	23.4	459	--	26	29
740	8.23	23.8	458	--	26	31
750	8.19	23.7	450	--	21	27
Temporary Well Groundwater Samples						
300-320	8.10	22.9	2,170	1,098	900	1,000
370-390	7.96	21.6	2,493	1,248	1,085	1,200
450-470	8.22	21.4	1,797	899	700	600
515-535	8.33	21.4	484	240	55	42
585-605	8.29	23.8	545	273	89	74
655-675	8.43	23.7	439	219	37	40
720-740	8.58	24.6	593	--	66	71

Notes:

ft bls = feet below land surface

SU = Standard units

µS/cm = microsiemens per centimeter

°C = Degrees Celsius

ppm = parts per million

mg/L = milligrams per liter

- - = not measured

Field sulfate measurements conducted with an Orion AQ4000 Colorimeter

Materials encountered in the borehole include basin fill sediments to a depth of approximately 490 ft bls and bedrock composed of mudstones to sandstones from 490 to 750 ft bls. The geologic log for borehole BMO-2008-7M is in Appendix J. Summary geology for BMO-2008-7M is as follows:

- 0-105 ft bls: Basin fill; strongly caliche-cemented, pink to reddish brown silty sand with gravel
- 105-140 ft bls: Basin fill; weakly cemented, light reddish brown clayey sand with gravel
- 140-210 ft bls: Basin fill; moderately cemented, light reddish brown sandy clay
- 210-400 ft bls: Basin fill; light reddish brown gravel with sand and clay with sandy gravel
- 400-490 ft bls: Basin fill; reddish brown sand with gravel, trace fines
- 490-750 ft bls: Morita Formation; reddish gray calcareous siltstone, sandstone, and mudstone, locally slightly carbonaceous or arkosic

BMO-2008-7M was completed in the upper portion of the Morita Formation with well screen from a depth of 560 to 660 ft bls (Figure L.8) for the purpose of monitoring groundwater in the bedrock beneath the plume contained in basin fill. Sulfate concentrations in groundwater from the basin fill were greater than 500 mg/L, but all below 250 mg/L in temporary well samples collected from Morita Formation (Table K.6). Following the guidelines established in the Work Plan, the annular seal extended 50 feet below the contact between the basin fill and bedrock, resulting in the top of the screen being set at 560 ft bls. Initial sampling of the completed well conducted during hydraulic testing produced a sulfate concentration of 31.4 mg/L.

3.4.4.7 Site BMO-2008-8

Two wells were installed at site BMO-2008-8 to evaluate the distribution of sulfate in the basin fill and Morita Formation west of the projection of the Black Gap Fault, evaluate hydraulic properties of materials in basin fill and bedrock, and provide long-term water level and water quality data. The wells at BMO-2008-8 were intended to evaluate the vertical extent of sulfate impacts at this location and explore the hydrologic influence of the Black Gap Fault in conjunction with the BMO-2008-9M well. The site is located on CQB property approximately 1,800 feet southwest of the former evaporation pond within the sulfate plume and approximately 1,500 feet west of site BMO-2008-9 (Figure 10) in Section 4, Township 24 South, Range 24 East.

BMO-2008-8M was drilled to a total depth of 1,220 ft bls using Stratex, conventional air rotary and reverse-circulation air rotary drilling methods. The details of drilling and well construction are presented in Appendix M. Groundwater was encountered at approximately 355 ft bls. Reconnaissance water samples were recovered at 20 foot intervals from 360 to 1,220 ft bls and analyzed in the field and laboratory, as shown below and in Table K.7.

BMO-2008-8M Reconnaissance Water Sampling Results						
Sample Depth ft bls	**pH SU**	**Temperature °C**	**EC µS/cm**	**TDS ppm**	**Field Sulfate (mg/L)**	**Laboratory Sulfate (mg/L)**
Reconnaissance Groundwater Samples						
360	7.94	22.5	3,140	1,666	1,671	1,700
380	7.53	25.0	3,220	1,703	1,859	1,800
400	7.70	23.4	3,346	1,772	1,787	1,900
420	7.61	23.2	3,170	1,682	1,826	1,800
440	7.64	23.9	2,958	1,567	1,666	1,700
460	7.51	23.9	2,895	1,533	1,666	1,700
480	7.55	22.5	2,926	1,548	1,615	1,600
500	7.84	22.4	2,847	1,507	1,506	1,500
520	7.77	23.3	2,707	1,432	1,507	1,400
540	7.41	26.1	2,690	1,425	1,562	1,500
560	7.81	22.9	2,763	1,464	1,553	1,500
580	7.28	21.9	2,914	1,456	1,679	1,400
600	7.28	22.8	2,875	1,441	1,670	1,400
620	7.12	22.6	2,854	1,425	1,668	1,400
640	7.25	22.5	2,953	1,463	1,678	1,400
660	7.24	22.8	2,829	1,414	1,602	1,300
680	7.83	23.2	2,806	1,401	1,517	1,300
700	7.26	19.9	2,708	1,354	1,470	1,300
720	7.25	23.4	2,709	1,352	1,530	1,300
740	7.41	23.0	2,628	1,313	1,540	1,300
760	7.26	23.1	2,570	1,285	1,449	1,200
780	7.23	22.4	2,585	1,291	1,482	1,200
800	7.25	22.0	2,494	1,246	1,348	1,100
820	7.24	22.5	2,551	1,275	1,320	1,300
840	7.41	25.7	2,547	1,349	1,418	1,200
860	7.58	14.2	2,690	1,429	1,308	1,100
880	7.19	23.5	2,527	1,265	1,300	1,200
900	7.20	21.5	2,537	1,268	1,305	1,100
920	7.12	21.6	2,395	1,209	1,296	1,200
940	7.28	21.4	2,564	1,271	1,308	1,200
960	7.28	21.6	2,574	1,284	1,333	1,200
980	7.36	20.3	2,554	1,276	1,378	1,200
1000	7.28	21.6	2,533	1,265	1,371	1,200
1020	7.29	22.1	2,588	1,292	1,272	1,200
1040	7.27	22.4	2,587	1,292	1,289	1,200
1060	7.29	24.5	2,582	1,289	1,351	1,300
1080	7.26	23.5	2,261	1,133	1,231	1,100
1100	7.16	22.6	2,263	1,128	1,396	1,100
1120	7.19	23.7	2,515	1,257	1,309	1,200
1140	7.06	23.3	2,480	1,241	1,372	1,000
1160	7.22	23.0	2,443	1,217	1,358	1,100
1180	7.25	23.2	2,434	1,217	1,342	1,100
1200	7.28	23.3	2,405	1,206	1,255	1,000
1220	7.23	23.5	2,546	1,272	1,262	1,100

BMO-2008-8M Reconnaissance Water Sampling Results						
Sample Depth ft bls	**pH SU**	**Temperature °C**	**EC µS/cm**	**TDS ppm**	**Field Sulfate (mg/L)**	**Laboratory Sulfate (mg/L)**
Temporary Well Groundwater Samples						
530-550	7.88	22.2	2,937	1,560	1,645	1,500
630-650	7.71	23.0	1,791	895	913	810
730-750	7.23	23.4	2,381	1,189	1,367	1,100
830-850	7.25	23.7	2,403	1,201	1,479	1,200
930-950	7.17	24.0	2,063	1,032	1,254	960
1030-1050	7.32	23.6	585	292	153	120
1175-1195	7.49	25.4	1,532	765	626	550

Notes:

ft bls = feet below land surface

SU = Standard units

µS/cm = microsiemens per centimeter

°C = Degrees Celsius

ppm = parts per million

mg/L = milligrams per liter

Field sulfate measurements conducted with an Orion AQ4000 Colorimeter

Materials encountered in the borehole include basin fill sediments to a depth of approximately 495 ft bls and Morita Formation bedrock composed of sandstones to mudstones from 495 to 1,220 ft bls. The geologic log for borehole BMO-2008-8M is in Appendix J. Summary geology for the borehole is as follows:

- 0-130 ft bls: Basin fill; moderate to strongly caliche-cemented, light pinkish gray to reddish brown gravel with silt, clay, and sand and few interbeds of sand with silt and gravel
- 130-220 ft bls: Basin fill; moderately cemented light reddish brown silty gravel with sand
- 220-350 ft bls: Basin fill; moderately cemented reddish brown clayey to silty sand with gravel, interbeds of clayey gravel with sand
- 350-495 ft bls: Basin fill; calcareous reddish brown sand with gravel, interbeds of gravel with sand
- 495-1220 ft bls: Morita Formation; reddish brown arkosic sandstone, interbeds of siltstone, claystone, and mudstone

Borehole video and caliper logs indicate the presence of significant fracturing in the borehole (Appendix I). The caliper tool measured a borehole diameter greater than 25 inches at several locations (including a 30 inch diameter at 500 ft bls, 31 inches at 690 ft bls, 27 inches at

910 ft bls, and 27 inches at 1050 ft bls), and the log and video show that the borehole wall was rough.

Temporary wells were installed, developed, and tested approximately every 100 feet from 530 to 1,195 ft bls. Field and laboratory analytical results from the temporary wells are shown in Table K.7. Sulfate concentrations in the temporary well samples were greater than 250 mg/L, except for the sample recovered from 1,030 to 1,050 ft bls, which had a concentration of 120 mg/L as determined by the laboratory.

The EC, sulfate, and TDS results obtained from temporary wells suggested that fracturing in the bedrock was allowing high-sulfate water in the borehole to by-pass the bentonite seal at the top of the temporary well. The high-sulfate content resulted from basin fill groundwater entering the open borehole during drilling. If the borehole water could by-pass the bentonite seal through fractures in the formation, the temporary well samples might not represent the aquifer conditions within the temporary well. Several lines of evidence seemed to support this hypothesis. First, the productivity of the temporary wells was greater than expected by the cemented, fine-grained nature of the bedrock as evaluated by drill cuttings. Second, fluctuations in sulfate concentration with depth were inconsistent with reconnaissance and temporary well sample results of previous wells, such as BMO-2008-7M (Table K.6), BMO-2008-9M (Table K.8), and BMO-2008-3B (Table K.2), which exhibited comparatively consistent declines in sulfate concentration with depth. Third, the turbidity of water removed from the temporary wells typically remained high, which is unexpected in temporary wells constructed in bedrock,

indicating that fine sediments from the well bore above the bentonite seal were being drawn into the temporary wells. Fourth, video and caliper logging (Appendix I) documented roughness of the borehole and the presence of large fractures that caused the borehole diameter to exceed 25 inches in several locations. Uncertainty concerning the reliability of the temporary well samples confounded attempts to apply the guidelines for well depth and construction articulated in the Work Plan.

BMO-2008-8M was completed in the Morita Formation with well screen from a depth of 1,100 to 1,200 ft bls (Figure L.9). The temporary well data from the borehole (Table K.7) were ambiguous concerning the depth of elevated sulfate in the bedrock aquifer. However, the results, particularly temporary well sample collected from 1,030 to 1,050 ft bls, suggested that groundwater in the bedrock might have sulfate concentrations below 250 mg/L at the completion depth. The specific conductivity (585 microsiemens per centimeter [µS/cm]) and TDS measurements (292 parts per million) from this interval were consistent with low sulfate concentrations. Following the guidelines established in the Work Plan, BMO-2008-8M was completed with 100 feet of well screen to monitor the bedrock beneath the plume. Initial sampling of the completed well conducted during hydraulic testing produced a sulfate concentration of 197 mg/L, reinforcing the validity of the low sulfate concentrations of the temporary well sample from 1,030 to 1,050 ft bls. Sulfate concentrations have continued to decline in this well since 2008. In the third quarter of 2010, sulfate was detected at a concentration of 94.7 mg/L.

BMO-2008-8B was drilled to a total depth of 492 ft bls using Stratex and conventional air rotary drilling methods approximately 30 feet north of BMO-2008-8M to monitor the plume in basin fill aquifer at this location. The geologic log for BMO-2008-8M describes conditions at BMO-2008-8B (Appendix J). The details of drilling and well construction are presented in Appendix M. The well was constructed with screen from 370 to 470 ft bls to span the saturated basin fill aquifer (Figure L.10). Initial samples of groundwater from BMO-2008-8B collected during hydraulic testing contained a sulfate concentration of 1,890 mg/L. Sulfate concentrations have declined over time in this well since installation, but still remain greater than 1,000 mg/L.

3.4.4.8 Site BMO-2008-9

Well BMO-2008-9M was drilled on the east side of the projection of the Black Gap Fault to evaluate the vertical extent of sulfate impacts to the Morita Formation east of the projection of the Black Gap Fault, evaluate hydraulic properties of materials below the plume at this location, and provide long-term water level and water quality data. The site is located on CQB property approximately 1,300 feet south of the footprint of the former evaporation pond (Figure 10) in Section 3, Township 24 South, Range 24 East. BMO-2008-9M was also intended to explore the hydrologic influence of the Black Gap Fault in conjunction with the BMO-2008-8M well.

BMO-2008-9M was drilled to a total depth of 785 ft bls using a combination of Stratex, conventional air rotary, and reverse-circulation air rotary drilling methods. Details of drilling methods and well construction are shown in Appendix M. Water was first encountered at 305 ft

bls and reconnaissance samples were recovered at 20-foot intervals from 305 to 780 ft bls, as shown below and in Table K.8.

BMO-2008-9M Reconnaissance Water Sampling Results						
Sample Depth ft bls	**pH SU**	**Temperature °C**	**EC µS/cm**	**TDS ppm**	**Field Sulfate mg/L**	**Laboratory Sulfate mg/L**
Reconnaissance Groundwater Samples						
305	7.53	28.9	1,718	858	897	730
320	7.57	28.1	1,857	927	883	780
340	7.68	28.1	1,902	951	940	830
360	7.77	28.0	2,436	1,218	978	1,200
380	7.88	24.8	1,760	1,760	669	760
400	7.98	24.2	1,766	880	786	750
420	7.83	21.7	1,628	813	603	660
440	7.88	24.1	1,764	882	698	700
460	7.92	24.4	1,721	858	602	660
480	7.79	23.4	1,846	920	699	700
500	7.81	23.5	1,876	936	637	720
520	7.81	23.3	1,880	940	662	720
540	7.80	23.7	1,885	942	751	710
560	7.81	23.8	1,863	933	642	710
580	7.70	22.5	1,860	927	719	730
600	7.75	22.5	1,904	951	747	780
620	7.73	23.6	1,873	936	724	750
640	7.91	21.8	1,966	982	913	790
660	7.83	23.1	1,893	946	892	720
680	7.81	23.2	1,881	942	840	680
700	7.67	23.4	1,895	946	879	760
720	7.79	24.0	1,868	935	860	700
740	7.92	22.0	1,229	614	347	380
760	7.71	22.3	1,891	945	932	700
780	7.85	22.4	1,907	952	925	720
Temporary Well Groundwater Samples						
555-575	8.25	24.0	1,553	776	657	560
655-675	8.13	24.0	628	314	116	94
765-785	8.25	24.4	566	281	87	62

Notes:

ft bls = feet below land surface

SU = Standard units

µS/cm = microsiemens per centimeter

°C = Degrees Celsius

ppm = parts per million

mg/L = milligrams per liter

Field sulfate measurements conducted with an Orion AQ4000 Colorimeter

Temporary wells were installed, developed, and sampled approximately every 100 feet in the bedrock aquifer from 550 to 785 ft bls. Reconnaissance samples collected during drilling in the upper portion of the bedrock were suspected of being unrepresentative of groundwater in the aquifer, as consistently elevated sulfate concentrations were detected to a depth of 780 ft bls. A sulfate concentration of 347 mg/L obtained from sampling the return water produced from a depth of 740 feet the first thing in the morning was inconsistent with the 800 to 900 mg/L sulfate concentrations observed above and below this interval. This anomalous result may have been a better reflection of actual aquifer conditions while the other reconnaissance samples appear to have been influenced by groundwater from shallower depths. In order to collect more reliable data, temporary wells were constructed to mitigate the influence of the high sulfate concentrations in the upper portion of the open borehole by isolating a 40-foot section of filter pack and well screen sealed by bentonite zones above and below. Data from the temporary wells are presented in Table K.8 and are considered to be more reliable than the reconnaissance water samples collected during drilling. The temporary well data indicated that the boring had advanced to a depth below the plume.

Materials encountered in the borehole include basin fill sediments to a depth of 130 ft bls and bedrock composed of Morita Formation from 130 to 780 ft bls. The geologic log for borehole BMO-2008-9M is in Appendix J. Summary geology for BMO-2008-9M is as follows:

- 0-65 ft bls: Basin fill; strongly caliche-cemented reddish brown silty sand interbedded with sandy silt with gravel
- 65-130 ft bls: Basin fill; moderately cemented, reddish brown silty gravel with sand, interbedded with gravelly silt with sand
- 130-785 ft bls: Morita Formation; weak red to light gray arkosic sandstone interbedded with reddish brown siltstone, mudstone, and claystone

BMO-2008-9M was completed in the Morita Formation with well screen from a depth of 665 to 765 ft bls (Figure L.11) for the purpose of monitoring groundwater in the Morita Formation beneath the plume on the east side of the Black Gap Fault. Temporary well data from the borehole (Table K.8) were used to calculate that the lower extent of sulfate impact is approximately 630 ft bls by multiplying the distance between the zones by the ratio of the difference between the high concentration and 250 mg/L and the difference between the concentrations in the two zones. The calculation assumes that the concentration gradient between the two temporary well samples is linear with depth. Following the guidelines established in the Work Plan, top of the well screen was set at 665 ft bls to be less than 100 feet from the bottom of the plume. Initial sampling of the completed well conducted during hydraulic testing produced a sulfate concentration of 47.3 mg/L.

3.4.4.9 Site BMO-2008-10

Two monitoring wells were installed at site BMO-2008-10 to monitor sulfate concentrations in the vicinity of the source area, evaluate the vertical extent of sulfate impact to groundwater in the bedrock, evaluate hydraulic properties of bedrock materials in the source area, and provide long-term water level and water quality data. The site is located on CQB property south of the South Tailing Impoundment within the footprint of the former evaporation pond (Figure 10) in Section 3, Township 24 South, Range 24 East.

BMO-2008-10GU was drilled to a total depth of 700 ft bls, using a combination of Stratex and conventional air rotary drilling methods. The details of drilling and well construction are presented in Appendix M. Glance Conglomerate bedrock was encountered at approximately 130 ft bls and groundwater was encountered at approximately 230 ft bls. Reconnaissance water samples were recovered approximately every 20 feet from 230 to 700 ft bls and analyzed in the field and laboratory, as shown in Table K.9. Temporary wells were installed, developed and tested at several intervals, some of which used a straddle packer. Field and laboratory analytical results from those temporary wells are also shown below and in Table K.9.

BMO-2008-10GU Reconnaissance Water Sampling Results						
Sample Depth ft bls	**pH SU**	**Temperature °C**	**EC µS/cm**	**TDS ppm**	**Field Sulfate mg/L**	**Laboratory Sulfate mg/L**
Reconnaissance Groundwater Samples						
230	7.07	28.5	3,573	1,787	--	2,100
240	7.53	26.2	3,620	1,816	1,640	1,800
260	7.36	26.7	3,600	1,804	1,648	1,900
280	7.38	26.8	3,652	1,820	1,680	1,800
300	7.93	28.1	3,546	1,774	1,609	1,900
320	7.18	28.2	3,504	1,752	1,638	1,900
340	7.27	28.4	3,554	1,774	1,555	1,800
360	7.46	23.0	3,584	1,794	1,659	1,800
380	7.15	24.0	3,278	1,641	1,451	1,900
400	7.11	23.9	3,497	1,756	1,554	1,900
420	7.13	25.5	3,378	1,670	1,513	1,900
440	7.14	25.5	3,078	1,543	1,552	1,900
460	7.22	24.6	3,208	1,598	1,492	2,000
480	7.21	24.5	3,232	1,621	1,503	1,900
500	7.21	27.6	3,420	1,725	1,477	2,000
520	7.51	22.0	2,720	--	1,029	1,800
540	7.47	24.0	3,390	--	1,522	1,900
560	7.49	23.5	3,350	--	1,563	1,800
580	7.54	23.6	3,330	--	1,607	1,800
610	7.49	23.8	3,180	--	1,522	1,900
620	7.47	24.5	3,240	--	1,597	1,800
640	7.42	23.5	2,740	--	1,545	1,800
660	7.39	26.2	3,250	--	1,589	1,800
680	7.36	24.2	3,070	--	1,593	1,900
700	7.46	25.0	2,570	--	1,562	1,900
Temporary Well Groundwater Samples						
424-464	7.94	22.0	3,760	--	1,778	1,800
460-480	7.38	28.2	3,810	--	1,661	1,800

Notes:

ft bls = feet below land surface

SU = Standard units

µS/cm = microsiemens per centimeter

°C = Degrees Celsius

ppm = parts per million

mg/L = milligrams per liter

- - = not measured

Field sulfate measurements conducted with an Orion AQ4000 Colorimeter

Materials encountered in the borehole include basin fill sediments to a depth of approximately 130 ft bls and Glance Conglomerate from 130 to 700 ft bls. The geologic log for borehole BMO-2008-10GU is in Appendix J. Summary geology for the borehole is as follows:

- 0-77 ft bls: Basin fill; strongly caliche-cemented, reddish brown silty gravel with sand, interbeds of silty sand with gravel, decreasing cementation from 55 to 77 ft bls
- 77-130 ft bls: Basin fill; moderate to weakly cemented, reddish brown gravel with clay and sand, interbeds of clayey to silty sand with gravel
- 130-700 ft bls: Glance Conglomerate; reddish brown, clasts of predominantly Pinal Schist in a sandy to silty matrix

Reconnaissance water samples and temporary well samples indicated sulfate concentrations greater than 250 mg/L throughout the saturated portion of the borehole. The sulfate samples collected from the completed borehole corroborate the presence of high sulfate throughout the upper portion of the Glance Conglomerate at this location. The borehole was completed as a well to monitor the upper portion of the saturated Glance Conglomerate at this location because caving prevented advancement past 700 ft bls. BMO-2008-10GU was completed in the upper portion of the Glance Conglomerate with well screen from a depth of 239 to 439 ft bls (Figure L.12). The borehole beneath a depth of 460 ft bls was backfilled with bentonite chips to seal off the lower portion of the borehole. The initial sample of groundwater from BMO-2008-10GU collected during hydraulic testing contained a sulfate concentration of 2,210 mg/L.

BMO-2008-10GL was drilled to a depth of 820 ft bls using a combination of Stratex and conventional air rotary drilling methods. The details of drilling and well construction are presented in Appendix M. The well was positioned approximately 120 feet south of BMO-2008-

10GU in an attempt to avoid caving problems encountered in 10GU. The borehole was dry to a depth of 340 ft bls where a small amount of water was encountered. Temporary casing was installed to a depth of approximately 350 ft bls and the borehole was advanced with conventional air rotary methods. The borehole remained essentially dry to a depth of 780 ft bls where a water-bearing zone was encountered. Reconnaissance water samples were recovered approximately every 20 feet from 780 to 820 ft bls and analyzed in the field and laboratory, as shown below and in Table K.10. Water levels in the borehole rose to approximately 550 ft bls.

BMO-2008-10GL Reconnaissance Water Sampling Results

Sample Depth ft bls	pH SU	Temperature °C	EC µS/cm	TDS ppm	Field Sulfate mg/L	Laboratory Sulfate mg/L
Reconnaissance Groundwater Samples						
460	7.40	24.7	2,266	1,195	1,587	--
560	7.30	29.4	3,068	1,536	1,542	--
780	8.48	33.3	487	245	90	69
790	8.27	32.4	499	250	94	71
800	8.17	31.5	507	253	71	67
820	7.97	30.7	502	250	92	70
Airlift Development Groundwater Sample						
700-800	8.59	26.8	580	290	120	96

Notes:

ft bls = feet below land surface
SU = Standard units
µS/cm = microsiemens per centimeter
°C = Degrees Celsius
ppm = parts per million
mg/L = milligrams per liter
- - = not measured
Field sulfate measurements conducted with an Orion AQ4000 Colorimeter

Materials encountered in the borehole include basin fill sediments to a depth of approximately 110 ft bls and Cretaceous Glance Conglomerate from 110 to 820 ft bls. The

geologic log for borehole BMO-2008-10GL is in Appendix J. Summary geology for the borehole is as follows:

- 0-65 ft bls: Basin fill; strongly caliche-cemented, light brown to reddish brown silty sand with gravel to silty gravel with sand
- 65-110 ft bls: Basin fill; moderately to weakly caliche-cemented, reddish brown sandy clay to sand with clay and gravel
- 110-820 ft bls: Glance Conglomerate; reddish brown, clasts of predominantly Pinal Schist in a sandy to silty matrix

BMO-2008-10GL was completed in the lower portion of the Glance Conglomerate with well screen from 700 to 800 ft bls (Figure L.13). Reconnaissance groundwater samples collected during drilling indicated that the sulfate concentration of the groundwater encountered from 780 to 820 ft bls was below 250 mg/L (Table K.10). The reconnaissance sample collected at 780 ft bls is considered reliable because the borehole was dry to that depth. The sulfate concentration of a groundwater grab sample collected after removing over 2,500 gallons of water during air lift development was 96 mg/L. In contrast to the reconnaissance sample results, initial sampling of the completed well conducted during hydraulic testing produced a sulfate concentration of 1,320 mg/L. The cause of conflicting results between the reconnaissance samples and the completed well samples is uncertain. Initially it was proposed that sulfate may have been pulled into the well through fractures during drilling, well development and hydraulic testing. However, two years of subsequent groundwater purging and monitoring have shown that the sulfate concentration in this well has ranged from 1320 mg/L to 1020 mg/L, indicating that the plume extends to the depth of the screened interval. The source of sulfate in BMO-2008-10GL would appear to be a fracture zone or permeable feature that does not intersect the saturated zone of BMO-2008-10GU given the significant difference in water levels between the wells. The

difference in static water level elevations between BMO-2008-10GU and BMO-2008-10GL indicates poor hydraulic connection between the water-bearing zones tapped by the wells.

3.4.4.10 Site BMO-2008-11

Well BMO-2008-11G was drilled northwest of the former evaporation pond (Figure 10) to evaluate the northern limit of the sulfate plume west of the source area, evaluate hydraulic properties of bedrock materials at this location, and provide long-term water level and water quality data. The well also provides water levels and groundwater quality data west of the South Tailing Impoundment. BMO-2008-11G is located on CQB property in Section 33, Township 23 South, Range 24 East.

BMO-2008-11G was drilled to a depth of 820 ft bls using Stratex, conventional air rotary, and reverse-circulation air rotary drilling methods. The details of drilling methods and well construction are presented in Appendix M. Reconnaissance water samples were recovered approximately every 20 feet from 680 to 820 ft bls and analyzed in the field and laboratory, as shown below and in Table K.11. Sulfate concentrations ranged from 18 to 23 mg/L.

BMO-2008-11G Reconnaissance Water Sampling Results						
Sample Depth ft bls	**pH SU**	**Temperature °C**	**EC µS/cm**	**TDS ppm**	**Field Sulfate mg/L**	**Laboratory Sulfate mg/L**
Reconnaissance Groundwater Samples						
500	7.60	22.2	399	199	27	24
680	8.29	30.3	365	193	23	22
700	8.22	28.8	322	180	21	18
720	8.17	28.6	355	190	24	19
740	8.43	29.0	365	193	25	19
760	8.17	29.3	387	208	24	23
780	8.19	29.8	387	202	26	23
800	8.28	28.2	423	225	27	18
820	8.49	24.2	410	218	21	18

Notes:

ft bls = feet below land surface
SU = Standard units
µS/cm = microsiemens per centimeter
°C = Degrees Celsius
ppm = parts per million
mg/L = milligrams per liter
Field sulfate measurements conducted with an Orion AQ4000 Colorimeter

Materials encountered in the borehole include basin fill sediments to a depth of approximately 240 ft bls, Morita Formation bedrock to 490 ft bls, and Glance Conglomerate to the total depth of the borehole. The geologic log for borehole BMO-2008-11G is in Appendix J. Summary geology for the borehole is as follows:

- 0-105 ft bls: Basin fill; strongly caliche-cemented, pinkish gray to light brown sand, silt, and gravel
- 105-240 ft bls: Basin fill; moderate to strongly cemented, light brown silty sand and gravel
- 240-490 ft bls: Morita Formation; light reddish brown, arkosic sandstone, interbeds of siltstone and mudstone
- 490-820 ft bls: Glance Conglomerate; reddish brown, clasts of predominantly Pinal Schist in a sandy to silty matrix

The basin fill is unsaturated at this location. A thin zone of groundwater appeared to be present at the interface between the Morita Formation and Glance Conglomerate. A sample of this groundwater recovered from the borehole (Table K.11) had a sulfate concentration of 24 mg/L. Drilling in the Glance Conglomerate produced dry cuttings until water was encountered at 680 ft bls.

BMO-2008-11G was completed in the Glance Conglomerate with well screen from a depth of 650 to 750 ft bls (Figure L.14) for the purpose of monitoring groundwater in the Glance Conglomerate bedrock outside of the sulfate plume west of the South Tailing Impoundment and northwest of the former evaporation pond. Groundwater encountered in the Glance Conglomerate at a depth of 680 ft bls contained sulfate concentrations below 250 mg/L. Following the guidelines established in the Work Plan, the well was completed with 100 feet of well screen to encompass the water bearing zone. The annular seal extends from 631 ft bls to the surface. Static water levels in the completed well rose to a depth of approximately 577 ft bls, indicating the fracture-controlled groundwater encountered at 680 ft bls has approximately 100 feet of hydraulic head where it was encountered in the borehole. The initial sample of groundwater from BMO-2008-11G contained 14.2 mg/L sulfate.

3.4.4.11 Site BMO-2008-13

Two wells were constructed at site BMO-2008-13 to evaluate hydraulic properties of basin fill and bedrock materials, identify the vertical extent of the plume, and provide long-term

water level and water quality data in the western portion of the plume. Well installation at this site was not envisaged in the Work Plan, but was added during execution of the program to provide additional geologic, hydrologic, and water quality information midway between sites BMO-2008-7 and BMO-2008-6. The site, approved in advance by ADEQ (ADEQ, 2008d), is located on CQB property east of Naco Highway and north of Purdy Lane in Section 8, Township 24 south, Range 24 East (Figure 10). The site was positioned midway between sites BMO-2008-6 and BMO-2008-7 along a line that approximates the apparent flow path in the aquifer. The shallow well was intended to document the water quality within the plume in the basin fill aquifer and the deep well was intended to evaluate the vertical extent of sulfate in groundwater in this area.

BMO-2008-13B was drilled to a total depth of 700 ft bls using Stratex, conventional air-rotary, and reverse-circulation air rotary drilling methods. The details of drilling and well construction are provided in Appendix M. Groundwater was encountered at approximately 238 ft bls and reconnaissance water samples were recovered at 20-foot intervals from 240 to 700 ft bls. One temporary well was constructed and sampled with screen from 550 to 570 ft bls. The results of field and laboratory water quality measurements are shown below and in Table K.12.

BMO-2008-13B Reconnaissance Water Sampling Results						
Sample Depth ft bls	**pH SU**	**Temperature °C**	**EC µS/cm**	**TDS ppm**	**Field Sulfate mg/L**	**Laboratory Sulfate mg/L**
Reconnaissance Groundwater Samples						
240	28.00	7.3	1,708	922	564	1,100
250	27.20	8.0	1,804	951	602	1,000
260	24.00	7.4	1,826	968	715	870
270	22.90	8.0	1,951	1,031	776	1,000
290	23.20	8.0	1,964	1,036	782	1,100
310	23.20	8.0	1,971	1,043	796	1,100
330	23.50	7.9	1,986	1,052	790	1,100
350	23.40	7.9	2,019	1,068	805	1,100
370	22.80	7.9	2,027	1,073	798	1,100
390	23.00	7.9	2,058	1,090	787	1,100
410	22.90	7.8	2,140	1,133	812	1,200
430	21.80	7.8	2,158	1,144	805	1,100
450	21.70	7.8	2,281	1,209	811	1,200
470	22.30	7.8	1,191	1,191	824	1,200
510	22.60	7.7	1,182	1,182	796	1,200
530	23.00	7.5	2,113	1,120	921	1,000
540	23.20	7.5	2,076	1,101	1,078	930
560	25.20	7.1	2,027	1,077	1,108	910
580	23.60	7.7	2,079	1,103	1,098	980
600	24.10	7.2	2,004	1,065	1,070	960
620	22.90	7.4	1,845	974	986	940
640	23.60	7.2	1,773	940	918	850
660	24.70	7.3	1,655	878	806	800
680	23.60	8.1	1,670	883	888	800
700	23.80	7.7	1,643	867	909	820
Temporary Well Groundwater Samples						
550-570	27.80	8.2	2,106	1,111	1,049	1,100

Notes:

ft bls = feet below land surface

SU = Standard units

µS/cm = microsiemens per centimeter

°C = Degrees Celsius

ppm = parts per million

mg/L = milligrams per liter

Field sulfate measurements conducted with an Orion AQ4000 Colorimeter

Materials encountered in the borehole include basin fill sediments to a depth of approximately 520 ft bls and limestone and calcareous clastic bedrock, interpreted as being part of the Mural Limestone from 520 to 700 ft bls. The geologic log for borehole BMO-2008-13B is in Appendix J. Summary geology for the borehole is as follows:

- 0-75 ft bls: Basin fill; strongly caliche-cemented, pink, brown, and reddish clayey sand, locally with gravel
- 75-105 ft bls: Basin fill; moderately cemented, reddish brown, clay with sand and gravel
- 105-245 ft bls: Basin fill; moderate to weakly cemented, light reddish brown to pinkish gray gravel with clay and sand, locally interbedded with sand
- 245-520 ft bls: Basin fill; weakly cemented, light reddish brown to pink gravel with sand, angular to subrounded
- 520-575 ft bls: Upper Mural Limestone; pinkish gray micritic limestone with clay, calcite, and iron staining on fracture fillings
- 575-700 ft bls: Lower Mural Limestone; light yellowish brown to gray calcareous siltstone and claystone to silty limestone

BMO-2008-13B was completed in the basin fill with well screen from 264 to 464 ft bls (Figure L.15). Borehole caving prevented this borehole from reaching its objective of evaluating the depth of the sulfate plume. Therefore, it was completed as a well to monitor the basin fill aquifer, which is approximately 280 feet thick from the water table at approximately 240 ft bls to bedrock at 520 ft bls. Reconnaissance water samples in the basin fill ranged in sulfate concentration from 870 to 1,200 mg/L (Table K.12). The well was constructed with 200 feet of well screen approximately centered within the saturated basin fill. This well construction followed the guidelines established in the Work Plan, which states that “wells constructed in impacted basin fill to monitor the impacted zone will have screened intervals up to 200 feet long”. The well monitors the plume in basin fill near the western margin of the plume. Initial

sampling of the completed well conducted during hydraulic testing produced a sulfate concentration of 980 mg/L.

BMO-2008-13M was drilled to a total depth of 1,100 ft bls approximately 120 feet south of BMO-2008-13B using Stratex, conventional air-rotary, and reverse-circulation air rotary drilling methods. The details of drilling and well construction are provided in Appendix M. Groundwater was encountered at approximately 240 ft bls and reconnaissance water samples were recovered at 20-foot intervals from 260 to 1100 ft bls. Four temporary wells were constructed and sampled with 20 feet of well screen set in approximately 40 feet of filter pack. The tops of the temporary screened intervals were 720, 820, 920, and 1,070 ft bls. The results of field and laboratory water quality measurements are shown below and in Table K.13.

BMO-2008-13M Reconnaissance Water Sampling Results						
Sample Depth ft bls	**pH SU**	**Temperature °C**	**EC µS/cm**	**TDS ppm**	**Field Sulfate mg/L**	**Laboratory Sulfate mg/L**
Reconnaissance Groundwater Samples						
260	7.88	23.2	1,933	1,024	1,205	890
300	7.88	23.3	1,937	1,026	1,059	900
340	7.77	23.6	1,998	1,058	1,139	940
380	7.56	23.6	2,054	1,089	1,125	990
420	7.82	22.6	2,135	1,128	1,171	1,000
460	7.62	22.0	2,078	1,099	1,098	1,000
500	7.46	22.5	2,075	1,099	1,100	920
540	7.34	23.2	1,779	942	849	820
580	7.34	26.3	1,935	1,027	996	820
620	7.38	22.6	1,824	966	951	800
660	7.60	25.2	1,905	1,010	1,024	860
700	7.53	21.7	1,851	985	968	830
720	7.56	23.6	1,974	1,046	1,083	870
740	7.62	23.2	1,861	986	980	820
780	8.27	22.8	1,992	1,055	1,081	920
800	8.14	22.3	1,934	1,023	1,044	900
820	8.16	21.5	2,016	1,066	1,240	960
840	7.75	22.5	1,860	983	1,299	890
860	7.48	24.3	1,747	897	1,080	860
880	7.49	22.4	1,697	846	1,074	880
900	7.13	22.3	1,889	945	996	810
920	7.24	22.6	1,857	929	962	820
940	7.25	23.4	1,842	921	960	810
960	7.51	23.4	1,990	989	1,187	970
980	7.50	22.4	1,853	928	973	930
1000	7.86	25.9	2,095	1,046	1,087	1,000
1020	7.84	23.6	1,987	996	1,008	880
1040	7.48	23.2	2,030	1,013	1,046	1,000
1060	7.54	22.3	1,902	951	1,027	890
1080	7.48	23.7	1,860	928	1,860	890
1100	7.51	23.3	1,873	942	1,873	900
Temporary Well Groundwater Samples						
720-740	7.86	23.3	1,360	722	510	500
820-840	7.86	23.7	1,788	949	1,191	850
920-940	7.47	25.4	1,856	925	899	800
1070-1090	8.51	19.9	1,392	696	424	410

Notes:

ft bls = feet below land surface

SU = Standard units

µS/cm = microsiemens per centimeter

°C = Degrees Celsius

ppm = parts per million

mg/L = milligrams per liter

Field sulfate measurements conducted with an Orion AQ4000 Colorimeter

Temporary well samples from BMO-2008-13M exhibited some indication of being unrepresentative of the groundwater in the zone in which the temporary well was completed. The issues and observations concerning the temporary wells were similar to those previously described for BMO-2008-8M (Section 3.4.4.7). The upper two temporary well zones had airlift pumping rates that were unexpectedly high for the lithology represented by the drill cuttings (43 to 50 gpm in the 720 to 740 ft bls temporary well and 25 to 15 gpm in the 820 to 840 ft bls temporary well). The video log for this well showed that a portion of the zone sampled by these two temporary wells (626 to 761 ft bls) appeared to have numerous fractures and an irregular borehole wall, as reflected in the caliper log (Appendix I.1). The high flow rates suggested the possibility that high-sulfate water from the borehole above the temporary well seal was bypassing the seal and flowing through fractures in the bedrock into the temporary well.

Temporary wells at 920 to 940 ft bls and 1,080 to 1,100 ft bls were constructed with thicker bentonite well seals to mitigate potential fracture flow from the borehole that would corrupt the representativeness of the temporary well samples. Figure 11 shows the change in concentrations of TDS and sulfate with respect to time during development of the 920 to 940 ft bls temporary well. Sulfate concentrations declined from 563 mg/L at 15 minutes to 154 mg/L at 170 minutes of airlifting before rising to 798 mg/L after 440 minutes of airlifting. Flow rates began at 3.6 gpm, declining to 1.2 gpm at the end of airlift pumping. These observations were interpreted as indicating reduction of sulfate concentrations in water in the temporary well due to influx of low-sulfate water from the formation during the first 170 minutes of development, followed by increasing influx of high sulfate water from the borehole due to fracture flow. The

reduction in concentration below 250 mg/L was interpreted as being a reliable indication that the groundwater at this depth interval was low in sulfate.

The temporary well from 1,080 to 1,100 ft bls began with a flow rate of 15 gpm, which declined to a rate of 1 gpm after 140 minutes of airlifting, accompanied by a decline in TDS from 967 ppm at 6 minutes to 693 ppm at 123 minutes before rising to 760 ppm at 206 minutes. Additional bentonite chips were added to increase the length of the seal, resulting in a decline in flow rate from 15 gpm at 4 minutes to 0.25 gpm at 290 minutes during airlifting the next day. However, the decline in flow rate did not result in declines in TDS or sulfate concentration and the turbidity of the water remained high with coloration changing from pale gray to reddish and then yellowish brown. These observations were interpreted as indicating that the productivity of the formation in the zone from 1,080 to 1,100 ft bls was insufficient to produce a representative groundwater sample and that high-sulfate waters from the borehole were drawn through fractures into the temporary well.

Materials encountered in the BMO-2008-13M borehole were similar to those encountered in BMO-2008-13B. However, the 13M borehole encountered 106 feet of upper Mural Limestone from 520 to 626 ft bls. This indicates that the contact between the upper and lower members of the Mural Limestone has an apparent dip of approximately 24 degrees to the south. The geologic log for borehole BMO-2008-13M is in Appendix J. Summary geology for the borehole is as follows:

- 0-125 ft bls: Basin fill; moderately caliche-cemented pink to light reddish brown clayey gravel and sand

- 125-245 ft bls: Basin fill; moderate to weakly cemented light reddish brown gravel with clay and sand; locally sandy
- 245-435 ft bls: Basin fill; weakly cemented gray to pale red gravel with sand, locally silty
- 435-520 ft bls: Basin fill; weakly cemented reddish brown silty gravel with sand to silty sand with gravel
- 520-626 ft bls: Upper Mural Limestone; light gray argillaceous micritic limestone with shell fragments and clay, calcite in fractures, and local iron staining on fractures
- 626-1095 ft bls: Lower Mural Limestone; thinly interbedded gray to yellow-brown calcareous claystone, fine-grained sandstone, siltstone, and mudstone and impure limestone
- 1095-1100 ft bls: Morita Formation; gray to reddish gray calcareous fine-grained sandstone

BMO-2008-13M was completed in the lower member of the Mural Limestone with well screen from 920 to 1,020 ft bls (Figure L.16). Temporary well samples from the borehole appeared to be dominated by fracture flow that permitted communication (short-circuiting) between the borehole and the temporary well, in which case the results would be unreliable. Factors suggesting short-circuiting included: persistent turbidity, initial dips in sulfate concentration followed by increases as airlifting progressed, and the decrease in flow rate from the same temporary well when the upper seal was lengthened to mitigate potential short-circuiting. The permanent well screen was positioned from 920 to 1,020 ft bls because the temporary well constructed at the top of this interval (920 to 940 ft bls) produced samples with sulfate concentrations below 250 mg/L for approximately 2 hrs (110 to 230 minutes of airlifting), before rising to 798 mg/L. The well monitors the bedrock beneath the basin fill. Initial samples of groundwater from BMO-2008-13M collected during hydraulic testing contained a sulfate concentration of 494 mg/L. Sulfate concentrations as low as 217 mg/L (April 2009) have been measured in BMO-2008-13M, suggesting this well is screened near the base of the plume.

3.4.4.12 Site BMO-2010-1

Well BMO-2010-1M was drilled to evaluate the vertical extent of sulfate in the Morita Formation east of the Black Gap Fault, evaluate hydraulic properties at this location, and provide long-term water level and water quality data. This well is located approximately 307 feet north of TM-16, which is screened from 65 to 115 feet bls within the sulfate plume. The BMO-2010-1M site is located north of Bisbee Junction on CQB property (Figure 10) in Section 10, Township 24 South, Range 24 East.

BMO-2010-1M was drilled to a total depth of 561 ft bls, using a combination of ARCH and conventional air rotary drilling methods. The details of drilling and well construction are presented in Appendix M. Morita Formation bedrock was encountered at approximately 56 ft bls and groundwater was encountered at approximately 222 ft bls. During drilling, two reconnaissance water samples were collected for field sulfate analysis. However, these reconnaissance groundwater sample results are not considered to be representative of formation water because drilling conditions required that foam and water be injected into the borehole through the entire drilling process (Table K.14).

Materials encountered in the borehole include basin fill to a depth of approximately 56 ft bls and Morita Formation from 56 to 561 ft bls. The geologic log for borehole BMO-2010-1M is in Appendix J. Summary geology for the borehole is as follows:

- 0-56 ft bls: Basin fill; reddish brown silty gravel with sand and gravel and sand containing subrounded siltstone, limestone, lithic-quartz sandstone, vein quartz, chert, and phyllite; orange to red desert varnish on gravel clasts

- 56-560 ft bls: Morita Formation; reddish grey to grey sandy siltstone with calcite vugs and veinlets, rare interbedded layers of fine grained sandstone; both friable and slightly calcareous

While drilling BMO-2010-1M, temporary wells were constructed to determine depth specific sulfate concentrations within the borehole in order to identify the vertical extent of the sulfate plume. Temporary wells were built at five intervals (designated as Zones 1-5). Each interval consisted of 20 feet of screen surrounded by filter pack that extended to five feet above the screen. The zones were isolated from the upper portion of the open borehole by a 10 foot thick bentonite seal. Field and laboratory analytical results from the temporary wells are shown below and in Table K.14.

Zone 1: Zone 1 was screened from 180-200 ft bls and produced minimal water. Later static water level measurements indicate that Zone 1 was constructed above the water table, which was 222 ft bls at the time of well construction. Therefore, the field and laboratory sample results appear to be for drilling water and are not representative of groundwater.

Zone 2: Zone 2 was screened from 260-280 ft bls and was sampled after three well volumes were purged. The field and laboratory results are considered representative of formation water.

Zone 3: Zone 3 was screened from 340-360 ft bls. The initial bentonite seal on Zone 3 was not effective and two more attempts were made to re-build and develop the temporary well. When these attempts did not result in an effective seal, Zone 3 was abandoned and not sampled.

Zone 4: Zone 4 was screened from 370-390 ft bls and produced sufficient water to purge three well volumes prior to sampling. The field and laboratory results are considered representative of formation water.

Zone 5: Zone 5 was screened from 460-480 ft bls and was purged of three well volumes prior to sampling. The field and laboratory are considered representative of formation water.

BMO-2010-1M Reconnaissance Water Sampling Results						
Sample Depth ft bls	**pH SU**	**Temperature °C**	**EC µS/cm**	**TDS ppm**	**Field Sulfate mg/L**	**Laboratory Sulfate mg/L**
Reconnaissance Groundwater Samples						
315	---	---	---	---	20	--
350	---	---	---	---	28	--
Temporary Well Groundwater Samples						
180-200[1]	8.25	24.7	930	500	140	170
260-280	8.59	22.3	940	490	260	250
340-360 [2]	---	---	---	---	---	---
370-390	8.44	25.9	640	330	72	84
460-480	8.07	25.3	990	520	168	190

Notes:
1. *Not Representative of formation water*
2. *No sample collected*

The base of the sulfate plume is estimated to be between 280 and 370 feet bls based on the analytical data from samples collected from temporary wells. BMO-2010-1M was completed in the Morita Formation with well screen from a depth of 440 to 540 ft bls following the guidelines in the Work Plan (Figure L.19). The initial sample of groundwater from BMO-2010-1M collected at the completion of hydraulic testing had a sulfate concentration of 150 mg/L.

3.4.4.13 Site BMO-2010-2

Well BMO-2010-2M was drilled on the east side of the projection of the Black Gap Fault to evaluate hydraulic properties of materials within the plume at this location, and provide long-term water level and water quality data. The site is located on CQB property, north of Bisbee Junction in Section 10, Township 24 South, and Range 24 East (Figure 10).

BMO-2010-2M was drilled to a total depth of 390 ft bls using a combination of ARCH and conventional air rotary drilling methods. Details of drilling methods and well construction are shown in Appendix M. Water was first encountered at 262 ft bls and two reconnaissance samples were recovered at 320 and 380 ft bls. The results of the field analyses were 660 mg/L at 320 ft bls and 550 mg/L at 380 ft bls, as shown below and in Table K.15.

BMO-2010-2M Reconnaissance Water Sampling Results						
Sample Depth ft bls	**pH SU**	**Temperature °C**	**EC µS/cm**	**TDS ppm**	**Field Sulfate mg/L**	**Laboratory Sulfate mg/L**
Reconnaissance Groundwater Samples						
320	7.90	---	1,910	1,010	600	---
380	8.31	25.2	1,970	1,040	550	---

Materials encountered in the borehole include basin fill sediments to a depth of 50 ft bls and bedrock composed of Morita Formation from 50 to 390 ft bls. The geologic log for borehole BMO-2010-2M is in Appendix J. Summary geology for BMO-2010-2M is as follows:

- 0-50 ft bls: Basin fill; reddish brown silty sand and gravel, primarily subangular clasts of siltstone, limestone, quartzite, vein quartz, and phyllite, red-orange desert varnish on gravel
- 50-390 ft bls: Morita Formation; reddish grey to grey sandy siltstone, slightly calcareous and friable, calcite vugs and veinlets, interbedded light grey arkosic sandstone with calcareous cement

BMO-2010-2M was completed in the Morita Formation with well screen from a depth of 268.5 to 370 ft bls (Figure L.20) for the purpose of monitoring the water level and water quality in the Morita Formation within the plume on the east side of the Black Gap Fault. Initial sampling of the completed well conducted at the completion of hydraulic testing produced a sulfate concentration of 915 mg/L.

3.4.4.14 Site BMO-2010-3

Two wells were constructed at site BMO-2010-3 to evaluate hydraulic properties of basin fill and bedrock materials, and provide long-term water level and water quality data southwest of the plume. The site is located southwest of the sulfate plume in an area just north of Greenbush Draw near Naco in Section 18, Township 24 South, Range 24 East (Figure 10). The land at the wellsite is owned by Rosemead Properties, Inc. The shallow well was intended to monitor the basin fill and the deep well was intended to monitor the upper portion of the bedrock aquifer in this area.

BMO-2010-3M was drilled using the air rotary drilling method for the 14-inch surface borehole to 15 ft bls. The direct mud rotary drilling method was then used for the 9.875-inch borehole from 15 ft bls to the total depth of 537 ft bls. The direct mud rotary method was chosen at this location because it is located in an area known to be outside the sulfate plume; therefore it was not necessary to collect reconnaissance groundwater samples. The details of drilling and well construction are provided in Appendix M.

Materials encountered in the borehole include basin fill to a depth of approximately 386 ft bls and calcareous clastic bedrock, interpreted as being part of the Cintura Formation, from approximately 386 to 537 ft bls. The geologic log for borehole BMO-2010-3M is in Appendix J. Summary geology for the borehole is as follows:

- 0-130 ft bls: Basin fill; Coarse sands and gravels consisting of sandstone, limestone, siltstones, and meta-sedimentary clasts, with reddish brown clayey silt.

- 130-240 ft bls: Basin fill; Medium sands and gravels, same composition as above with generally smaller clasts, and reddish brown clayey silt
- 240-360 ft bls: Basin fill; Medium sands and gravel, reddish brown to light grey clayey silt.
- 360-386 ft bls: Basin fill; Green-grey sticky calcareous clay and silt with less abundant sand and gravel.
- 386-537 ft bls: Cintura Formation; alternating layers of grey-green to brown mudstones and pink-grey to green-grey lithic-feldspathic quartz sandstone, both calcareous.

BMO-2010-3M was completed in the Cintura Formation bedrock with well screen from 416 to 522 ft bls. The well was constructed with 106 feet of well screen and sealed off from the basin fill with a 17-foot thick bentonite seal that spans the observed bedrock contact (Figure L.17). Initial samples of groundwater from BMO-2010-3M collected during hydraulic testing contained a sulfate concentration of 14.8 mg/L.

BMO-2010-3B was drilled approximately 30 feet southeast of BMO-2010-3M using the air-rotary method for the surface borehole to 15 ft bls. The direct mud rotary method was then used for the borehole from 15 ft bls to a total depth of 340 ft bls. The details of drilling and well construction are provided in Appendix M. Materials encountered in the BMO-2010-3B borehole down to the total depth of 340 bls were similar to those encountered in BMO-2010-3M as described above. The geologic log for borehole BMO-2010-3B is in Appendix J. BMO-2010-3B was completed in the basin fill with well screen from 120 to 320 ft bls (Figure L.18). Initial samples of groundwater from BMO-2010-3B collected during hydraulic testing contained a sulfate concentration of 16 mg/L.

3.5 Hydraulic Testing of BMO-2008, BMO-2010, and Existing Wells

This section describes hydraulic testing conducted at BMO-2008 groundwater monitoring wells and well nests installed under Task 2.3, select existing wells under Task 2.4 of the Work Plan and BMO-2010 and select existing bedrock wells under Task 2.3 and the Work Plan for Focused Bedrock Investigation. Well construction diagrams and well construction summaries for the tested wells are in Appendices L and M, respectively. Geologic logs for the BMO-2008 and BMO-2010 wells are in Appendix J and a description of each well is provided in the well installation section of the report (Section 3.4.4). The methods, analysis, and results of hydraulic testing are summarized in this section. Appendices N.1 and N.3 contain detailed reports on the 2008 and 2010 hydraulic testing, respectively, including discussion of individual tests.

The purpose of hydraulic testing was to evaluate aquifer hydraulic properties, including transmissivity, storage coefficient, and where possible, vertical hydraulic conductivity in the vicinity of each well. Hydraulic testing was conducted using the procedures described in the Work Plan. Most tests were conducted at multiple pumping rates (thereby constituting step rate tests), to enable evaluation of pumping well efficiency parameters. Pumping well efficiency parameters quantify the proportion of drawdown in the pumped well that is due to resistance to flow into the well bore and include non-linear head losses related to flow through well screen slots. In some cases, especially where the permeability of the aquifer is relatively high, the drawdown in the well is dominated by these head losses.

Hydraulic testing was conducted at each BMO-2008 and BMO-2010 well as described in the Work Plan. During hydraulic testing of the BMO-2008 and BMO-2010 wells, a water sample from each well was collected and analyzed for sulfate as an initial characterization of water quality. In addition, the BMO-2008 samples were analyzed for a suite of major elements. The results of the initial sampling of the BMO-2008 and BMO-2010 wells are included in Table 11.

3.5.1 Selection of Existing Wells

Hydraulic testing for Task 2.4 was conducted at existing wells to develop additional hydraulic properties data for aquifer characterization. Testing at existing wells required identifying appropriate and accessible wells. Wells identified by the well inventory (Section 3.1) were screened to eliminate previously tested wells, dry wells, and wells that were inappropriate due to obstructions, a lack of access ports, or a permanent cap. Additionally, wells were eliminated from testing if they were screened across more than a single geologic formation or if the geologic formation of the screened interval was unknown. Although there were a large number of potential wells considered, hydraulic testing was not practicable at the majority of them because of difficulty obtaining access, the inability to interrupt water supply pumping, or construction characteristics that made the well poorly suited to hydraulic testing.

Five existing wells were selected for hydraulic testing in 2008 COB MW-1, GARNER 635, TM-02A, NWC-03, and TVI 875. COB MW-1 was chosen because it served as a basin fill well near the location of BMO-2008-7M. GARNER 635 and TM-02A were chosen to test the

bedrock formations near the leading edge and source area of the sulfate plume, respectively. NWC-03 and TVI 875 were selected because they are in basin fill at the leading edge of the sulfate plume and have nearby wells that were used as observation wells.

In 2010, three existing wells were selected for hydraulic testing as part of the Focused Bedrock Investigation: FLEMING, TM-42, and TM-16. Bedrock monitor well TM-16 was tested to verify the anomalous drawdown hydrograph displayed in a 1989 test by ELMA (Section 3.2.3.2 and Appendix E) and for comparison with testing at the nearby BMO-2010-1M. TM-42 and FLEMING were tested to gather additional information on bedrock characteristics near Bisbee Junction.

3.5.2 2008 Hydraulic Test Procedures

HGC conducted and interpreted hydraulic tests in 2008. Hydraulic tests at the BMO-2008 wells and the selected existing wells largely consisted of step-rate pumping of the well, measuring the pumping rates, and measuring the water levels in the pumping well and nearby observation wells where available before, during, and after pumping. Constant-rate pumping was performed when step-rate pumping was not practical due to equipment constraints. Unfortunately, in most instances available observation wells were typically screened at intervals deeper or shallower than the pumped well and often within a different geologic formation than the pumped well. Barometric pressure was also measured during each test to allow correction for any barometrically induced water level changes. Collected data were analyzed to estimate

pumped well efficiency parameters and aquifer hydraulic properties in the vicinities of the well nests.

3.5.2.1 Pumping Procedures

Hydraulic tests were conducted subsequent to development of each new well. A sufficient time was allowed between well developments and testing to allow recovery after development. Submersible pumps for testing BMO-2008 series wells were supplied, deployed, and operated by Verdad Group L.L.C. Testing at existing wells was conducted using the dedicated submersible pumps in the wells. Each well was pumped at multiple increasing rates to allow analysis of pumping well efficiency parameters except COB MW-1, TM-02A, GARNER 635, NWC-03, and TVI 875, which were constant rate tests. Target pumping rates were approximately 15, 30, and 50 gpm for basin fill wells and 5, 10, and 20 gpm for bedrock wells. Actual pumping rates varied depending on pump capacities, well productivities, and aquifer properties. For example, most wells completed in the Glance Conglomerate were pumped at substantially lower rates due to the low productivity of the formation. In some cases (for example at BMO-2008-1G and BMO-2008-10GU), the tested well was pumped at only one or two rates due to low productivity. In general, the duration of pumping at the first two rates was approximately 1 hour for each, and at the maximum rate, approximately 8 hrs, although at some locations (i.e., BMO-2008-10GL) the initial low rate was sustained for approximately 8 hrs and the higher rates at about 1 hour each. Table 14 lists actual pumping rates and durations for each test.

Pumping rates were measured using in-line flowmeters supplied by Verdad Group L.L.C and by measuring the time to fill a vessel of known volume (the "bucket and stopwatch" method). In most cases, the vessel consisted of a calibrated, 55-gallon drum that allowed very accurate calculation of actual pumping rates because of its large capacity. Pumping rates for tests at pre-existing wells were measured using in-line flowmeters when possible or by the bucket and stopwatch method.

3.5.2.2 Water Level Monitoring

Water level monitoring consisted of continuous monitoring of water levels in pumping and observation wells where available prior to, during, and after pumping. Water levels were typically monitored at 30-second intervals using In-Situ Level Trolls. The Trolls, which are submersible instruments containing pressure transducers and data loggers, were initially placed at sufficient depths below the static water levels in the wells to remain submerged throughout each test. Some of the transducers used in the tests were vented to the atmosphere, and therefore measured gauge pressures, while others were absolute pressure transducers. In all cases, an absolute pressure transducer at the surface continuously recorded atmospheric pressure during each test. As an independent verification of the transducer data, water level measurements in pumping and observation wells were collected by hand using an electric water level sounder as frequently as practical. In cases where the drawdown in a well exceeded the depth of placement of the transducer, the hand collected data were used during the period that the transducer was not

submerged. In cases where the transducer data were of poor quality (excessively noisy), the hand collected data were used exclusively for analysis.

3.5.2.3 Data Analysis

Pressure data from the transducers were downloaded and converted to depths to water and to water level drawdowns for purposes of analysis. These data were corrected for changes in atmospheric pressure, however, the corrections were in most cases negligible with respect to drawdown. In many cases where sufficient measurements were available, the hand-collected depths to water were converted to water level drawdowns and analyzed independently.

The drawdown and pumping rate data were analyzed using WHIP, a well hydraulics interpretation package developed and marketed by HGC (HGC, 1988). WHIP has solutions that account for variable pumping rates, vertical flow and leakage, wellbore storage, and partial penetration of pumping and observation wells within a vertically anisotropic aquifer. WHIP also accounts for head losses in the pumped well resulting from well efficiency effects. Direct estimation of vertical hydraulic conductivities of the aquifer and an aquitard (if present) is available as part of the vertically anisotropic aquifer solution provided in WHIP.

Hydraulic properties and pumping well efficiency parameters were estimated using either the “homogeneous aquifer” solution or the “vertically anisotropic, partially penetrating well solution” (the partial penetration solution) available in WHIP. In many cases, both solutions

were used for comparison. The homogeneous aquifer solution assumes full well penetration, allows faster parameter estimation than the partial penetration solution, and accounts for well bore storage effects and vertical leakage (if present) into the aquifer. The homogeneous aquifer solution was used exclusively in cases where the pumped well fully penetrated the basin fill aquifer. The partial penetration solution accounts for partial penetration of pumping and observation wells, for vertical flow within an aquifer, and for leakage into the aquifer from an aquitard. The partial penetration solution was used for either basin fill or bedrock wells that did not fully penetrate the basin fill or bedrock unit within which they were completed. Appendix N.1 describes the conceptual models used to interpret the hydraulic tests.

Hydraulic parameters estimated from each test included transmissivity, storage coefficient, and pumped well efficiency parameters. Vertical hydraulic conductivity was estimated when the partially penetrating well solution was used. In each case, pumping and recovery data were analyzed together to obtain the best fit to all collected data. In cases where a good fit to both were not obtained, drawdown and recovery data were analyzed separately.

Because the only wells close enough to serve as observation wells were completed within a different formation than the pumped well or were completed within a different depth interval of the same formation in which the pumped well was completed, drawdowns were not detectable at observation wells in most cases. Accurate estimation of storage coefficient is usually not possible using only data from the pumped well. Drawdowns in the pumped well are often significantly affected by borehole storage and head losses due to low well efficiency. Therefore,

a storage coefficient value of 0.01 was initially assumed for wells completed in unconfined aquifers, and 1 x 10^{-5} for wells that were assumed to be completed in confined aquifers. In general, wells completed in basin fill were assumed to be under unconfined conditions, and those completed in bedrock aquifers located beneath either saturated basin fill or saturated bedrock of an overlying formation were assumed to be under confined conditions. During analysis, the storage coefficient was adjusted to improve the fit between measured and simulated drawdowns at the pumped well even though analyzable observation well data were not obtained.

3.5.3 Results—2008 Hydraulic Testing

The results of analyzing pumping rate and drawdown data at the wells tested in 2008 are described in detail in Appendix N.1. Table 15 summarizes the ranges and provides a set of final values. The results of the analyses for sulfate in samples collected at the time of testing are provided in Table 11.

3.5.4 2010 Hydraulic Test Procedures

Clear Creek Associates conducted and interpreted hydraulic tests in 2010. Hydraulic tests at the BMO-2010 wells, FLEMING, TM-42, and TM-16 consisted of step-rate pumping of the well, measuring the pumping rates, and measuring the water levels in the pumping well and nearby observation wells, where available, before, during, and after pumping. Constant-rate pumping was performed at BMO-2010-1M because step-rate pumping was not practical due to

the low flow rate. Unfortunately, in most instances, observation wells were typically screened at intervals deeper or shallower than the pumped well, often within a different geologic formation than the pumped well. Barometric pressure was measured during each test to allow correction for any barometrically induced water level changes.

3.5.4.1 Pumping Procedures

Hydraulic tests were conducted subsequent to development of each new well. A sufficient time was allowed between well development and testing to allow recovery after development. Submersible pumps for testing BMO-2010 series wells and TM-16 were supplied, deployed, and operated by Yellow Jacket Drilling. Submersible pumps for testing FLEMING and TM-42 were supplied, deployed, and operated by Verdad Group, L.L.C. Each well (with the exception of BMO-2010-1M) was pumped at multiple increasing rates to allow analysis of pumping well efficiency parameters. Pumping rates varied depending on pump capacities, well productivities, and aquifer properties. In general, the duration of pumping at the first two rates was approximately 1 hour for each, and at the maximum rate, approximately 8 hrs. Due to a low recharge rate, BMO-2010-1M was pumped at the initial flow rate for the entire 10 hour test. The TM-16 test was shortened due to drawdown constraints. Table 14 lists pumping rates and durations for each test.

Pumping rates were measured using in-line flowmeters supplied by Verdad Group L.L.C or Yellow Jacket Drilling. Flow meter readings were checked by measuring the time to fill a

vessel of known volume (the "bucket and stopwatch" method). In most cases, the vessel consisted of a calibrated, 55-gallon drum that allowed very accurate calculation of actual pumping rates because of its large capacity. Pumping rates for tests at pre-existing wells were measured using in-line flowmeters when possible or by the bucket and stopwatch method.

3.5.4.2 Water Level Monitoring

Water level monitoring consisted of continuous monitoring of water levels in pumping and observation wells, where available, prior to, during, and after pumping. Water levels were typically monitored at 10-second intervals using In-Situ Level Trolls placed at sufficient depths below the static water levels in the wells to remain submerged throughout each test. All of the transducers used in the 2010 tests were vented to the atmosphere, and therefore measured gauge pressures. In all cases, an absolute pressure transducer at the surface continuously recorded atmospheric pressure during each test so that corrections could be made if the vent did not operate properly. As an independent verification of the transducer data, water level measurements in pumping and observation wells were collected by hand using an electric water level sounder as frequently as practical.

3.5.4.3 Data Analysis

Pressure data from the transducers were downloaded and converted to depths to water and to water level drawdowns for purposes of analysis. Because only vented transducers were

used, correcting for atmospheric pressure was not necessary. The hand-collected depths to water were converted to water level drawdowns and compared with the transducer data for any inconsistencies.

The 2010 drawdown and pumping rate data were analyzed using AQTESOLV Pro version 4.50. This well hydraulics interpretation software features a variety of solutions to account for variable pumping rates; vertical flow and leakage; confined, leaky, unconfined or fractured aquifers; and fully- or partially-penetrating wells.

Hydraulic properties were estimated for each well using several solutions to arrive at the best curve match with reasonable storage coefficients. Appendix N.4 describes the conceptual models used to interpret the hydraulic tests.

Because the only wells close enough to serve as observation wells were completed within a different formation than the pumped well or were completed within a different depth interval of the same formation in which the pumped well was completed, drawdowns were not detectable at observation wells. Accurate estimation of storage coefficient is not possible using only data from the pumped well. Therefore, initial storage coefficients that were considered reasonable based on the 2008 data were assumed. For confined aquifers, a starting storage coefficient of 1×10^{-5} was used; for unconfined aquifers, a starting storage coefficient of 0.01 was used. During analysis, the storage coefficient was adjusted to improve the fit between measured and simulated drawdowns at the pumped well.

3.5.5 Results—2010 Hydraulic Testing

The results of analyzing pumping rate and drawdown data at the tested wells are described in detail in Appendix N.4. Table 15 summarizes the ranges and provides a set of final values. The results of the analyses for sulfate in samples collected at the time of testing are provided in Table 11.

3.5.6 Discussion of Hydraulic Testing

As shown in Table 15, transmissivities are highest in basin fill and lowest in the Glance Conglomerate and Mural Limestone, with the Cintura and Morita Formations having intermediate values. Calculated hydraulic conductivities over the entire assumed aquifer thicknesses (which represent vertically averaged values) are also highest in the basin fill and lowest in the Glance Conglomerate and Mural Limestone. Although a number of different conceptual models were used to interpret data at some of the test locations, the hydraulic conductivity estimates shown in Table 15 are similar to previous estimates for the TM wells (Table 6) and AWC wells (Section 3.2.3.1). The difference between maximum and minimum hydraulic conductivity estimates at individual test locations are greatest for bedrock wells, and are within a factor of two at all locations except at BMO-2008-5M, BMO-2008-7M, and BMO-2008-9M.

Some of the important results of the hydraulic testing include:

1. Vertical hydraulic conductivities in bedrock aquifers are likely small except in the areas where BMO-2008-5M and BMO-2008-7M were constructed.

2. Responses in basin fill to pumping in the Cintura and Morita Formations at BMO-2008-5M and BMO-2008-7M, respectively, imply that either the upper bedrock and basin fill have similar hydraulic properties or that permeable vertical structures exist that connect them hydraulically at these locations.

3. Vertically averaged horizontal hydraulic conductivities (calculated over the assumed aquifer thicknesses) can vary by two to three orders of magnitude in both basin fill and bedrock.

4. Hydraulic conductivities generally decrease with depth within the bedrock.

5. Flow within bedrock aquifers may be dominated (at least locally) by higher permeability zones of limited thickness and/or lateral extent (e.g., fractures, bedding planes, or thin beds of permeable strata).

6. In areas where relatively thin higher permeability zones dominate the bedrock flow system, the permeability of these zones could be substantially higher than the (vertically averaged) estimates shown in Table 15.

7. Aquifer tests in bedrock showed a large range in pumping capacities. Of the 18 bedrock wells tested, 8 wells (44%) could not be pumped at rates greater than 10 gpm, while 7 wells (39%) could be pumped at greater than 30 gpm (Table 15). The range of achievable pumping rates during these short-term tests highlights the heterogeneity of permeability in the bedrock.

The presence of relatively thin permeable zones in bedrock is indicated by the discontinuities in the measured drawdowns during pumping of BMO-2008-10GU. These discontinuities likely resulted from the development of seepage faces as the water level in the well dropped below a succession of relatively thin water bearing zones that presumably supplied most of the water to the well. The presence of these zones was evident at BMO-2008-10GU because the well was screened at a shallow depth near the water table. The shallow construction

and low permeability resulted in dewatering of a portion of the screened interval during the test, a necessary precondition for the development of seepage faces.

These thin water-bearing zones in the bedrock likely have higher conductivities due to fracturing, which would also imply relatively low effective porosities. Under these conditions the rate of sulfate transport in these zones could be similar to the rate of transport in basin fill even though the rate of mass transport in bedrock may be substantially smaller because the average transmissivity of the bedrock is small compared to the basin fill.

In addition, background water level monitoring in the basin fill in the vicinity of BMO-2008-4B indicated that variations in water level of a few tenths of a foot to more than 1 foot (that are only partially related to changes in barometric pressure) can occur in this area. Water level fluctuations in BMO-2008-4B, screened from 500 to 600 ft bls, correlate poorly with water level fluctuations in NWC-03, screened to a depth of only 312 feet. The poor correlation indicates that changes in hydraulic head within the basin fill in this area can vary significantly with depth. These results imply that the permeability and the potential rate of sulfate transport within the basin fill may vary with depth. For example, this could result in a non-uniform vertical distribution of sulfate such as observed at BMO-2008-4B where the sulfate plume is restricted to the upper portion of the saturated basin fill (Sections 3.4.4.3 and 5.1.1.3).

4. GEOLOGY AND HYDROLOGY OF THE SULFATE PLUME AREA

4.1 Geology

Drilling and construction of the BMO monitor wells provides new insight into the geology of the study area. The general geologic setting of the area is provided in Section 2.3 and a summary of the findings of the BMO drilling is provided in Section 3.4.3. Figure 3 presents a generalized geologic map of the area. This section focuses on the detailed stratigraphic, structural, and basin configuration information synthesized from the findings of this and other drilling programs in the CTSA area.

Boreholes for which relevant geologic information exists are shown on Plate 1. The total depth, screened interval, static water level, sulfate concentration, and geologic information were used to plot fence diagrams presented as Sections A-A' through H-H' on Plates 2 and 3. The information on these plates forms the basis for understanding of the basin configuration and the geology of the study area, which focuses on the sulfate plume and its immediate vicinity.

The cross sections in Plates 2 and 3 show the relative positions of caliche-cemented basin fill, basin fill, Cintura Formation, Upper Mural Limestone, Lower Mural Limestone, Morita Formation, and Glance Conglomerate. The complexity of the geology, wide spacing of boreholes, and the quality of geologic information available from drill cuttings complicated the development of a consistent depiction of the distribution of the Bisbee Group formations in the

subsurface beneath the plume. In some cases, stratigraphic position could be evaluated with confidence, such as when contacts were observed between Morita Formation and Glance Conglomerate and between Upper Mural Limestone and Lower Mural Limestone. In other cases, the absence of limestone and the similarity of lithologies in the Cintura and Morita Formations prevented determination of exact stratigraphic position. Therefore, the geology and structure depicted on Plates 2 and 3 represent one possible interpretation of the data.

4.1.1 Bedrock Lithology and Distribution

Information concerning the lithology of the bedrock was obtained at each of the sites drilled for this study, as presented in Section 3.4.4. The Glance Conglomerate was identifiable as deep reddish brown conglomerate of predominantly schist and limestone clasts in a sandy to silty matrix. It was observed in boreholes BMO-2008-1G, BMO-2008-10GU, BMO-2008-10GL, and BMO-2008-11G. Typical reddish brown Morita Formation sandstones, siltstones, and mudstones were encountered in BMO-2008-1G, BMO-2008-7M, BMO-2008-8M, BMO-2008-9M, BMO-2008-11G, BMO-2010-1M and BMO-2010-2M. The sandstones were typically arkosic and the finer grained sediments appeared to be thinly laminated, although comminution of the formation during the drilling process obscures the bedding relationship of the cutting fragments. Upper Mural Limestone composed of micritic, light to medium gray fossiliferous limestone was encountered in BMO-2008-13B, BMO-2008-13M, and BMO-2008-4B. Its contact with the underlying Lower Mural Limestone was identified in both boreholes at site BMO-2008-13 and indicated a southerly dip. The Lower Mural Limestone was typically

medium gray to yellowish gray sandy to silty limestone to calcareous sandstone and mudstone. Previously, Mural Limestone had only been identified in the area at TM-17 and in the Ninety-One Hills (Plate 1 and Figure 3). A yellowish gray to brown arkosic sandstone to siltstone and mudstone was encountered in BMO-2008-5M, BMO-2008-6M and BMO-2010-3M and was interpreted to be either Cintura Formation or Morita Formation. Ransome (1904) reports "tawny to buff-colored" beds in the upper Morita Formation and some tawny, buff, or pinkish sandstones in the Cintura Formation. The high degree of similarity between the lithologies of the Morita and Cintura Formations was noted by Hayes (1970). Reddish mudstones and claystones grading into sandstones and limestone intersected at site BMO-2008-3 are interpreted to represent the lower portion of the Cintura Formation.

The lithologic information provided by the boreholes drilled for this investigation are insufficient to produce a unique interpretation of the distribution of Bisbee Group formations. However, some significant findings concerning the distribution of bedrock lithologies include the following.

- The absence of Morita Formation bedrock above the Glance Conglomerate at site BMO-2008-10.
- Identification of the Morita Formation-Glance Conglomerate contact at sites BMO-2008-1 and BMO-2008-11.
- Identification of Cintura Formation in BMO-2008-3B and possibly its contact with the Mural Limestone.
- The presence of the Upper Mural Limestone at sites BMO-2008-13 and BMO-2008-4, and identification of the contact between the Upper and Lower Mural Limestone and possibly the contact between Morita Formation and Lower Mural Limestone in BMO-2008-13M.

- Identification of yellowish sandstones and siltstones at sites BMO-2008-6 and BMO-2008-5 and BMO-2010-3 that are interpreted to be Cintura Formation but could be either Lower Mural Limestone or Morita Formation.

Some general conclusions can be drawn concerning the bedrock geology beneath the study area, based on the above observations. The sequence of southwest-dipping Bisbee Group sediments is confirmed in the northern portion of the study area with the observation of Mural Limestone units at site BMO-2008-13. Thus, the pattern of dipping sedimentary beds is the same on both sides of the Black Gap Fault, even though the beds may be shifted by the vertical offset of the fault. The occurrence of the Mural Limestone in BMO-2008-13M and its repetition approximately 5,700 feet south in BMO-2008-4B, however, suggests that the beds may be folded into a syncline in the southern portion of the study area or faulted along east-west trending planes (Section F-F', Plate 3), such as that represented by the Ninety-One Hills Fault (Figure 3). The possibility of a syncline in the study area is fortified by the depiction of a syncline in the upper Bisbee Group mapped by Servico Geológico Mexicano (2003) across the international border to the southeast. This syncline projects into the study area, and the presence of Bisbee Group sediments in the foothills of Sierra San Jose to the southwest (Anderson and Nourse, 2005) support the hypothesis of a syncline in the southern portion of the study area.

4.1.2 Bedrock Structure

The study area lies on a block of the Cretaceous Bisbee Group on the southwestern limb of the southeast-plunging anticline that encompasses the Mule Mountains (Bilodeau, 1979). The southwest-tilting Bisbee Group beds have been eroded, exposing the lowermost formation,

Glance Conglomerate, in the northern part of the area near the range front, and stratigraphically higher formations, such as the Mural Limestone, in the south. Thus, the typical progression from north to south is up section from Glance Conglomerate to Morita Formation, Mural Limestone, and Cintura Formation.

The structural block on which the study area lies has been faulted northeastward by compressional forces during the Laramide orogeny (Bilodeau, 1979). According to Bilodeau (1979), the block is bounded on the north and east by the west-northwest-trending Abrigo, Bisbee West, and Gold Hill Faults, the latter wrapping around the eastern margin of the block. A sub-parallel, imbricate fault, the Glance Fault, repeats the Glance Conglomerate stratigraphy east of the study area (Figure 3). The southern and western boundaries of the block are concealed by basin fill. The structural block is broken by faults, the most prominent of which are a set of north-northeast-trending faults, typically dipping west, with normal (down on the west) displacement.

The Abrigo Fault has been projected by SET (1998c) to trend southeastward beneath the South Tailing Impoundment. Bilodeau (1979) interprets the Abrigo Fault as joining with the Bisbee West Fault to form the northern boundary of the structural block whereas Hayes and Landis (1964) show the east end of the Abrigo Fault as splaying into two faults, of which the southern splay projects toward the CTSA. The present investigation reveals no conclusive information concerning the trace of the Abrigo Fault. However, the geologic data do not support

significant displacement of the Bisbee Group sediments along the projection proposed by SET (1998c) (Plate 3, Sections D-D' and E-E').

The Black Gap Fault is the most prominent of the north-northeast-trending faults. It is present beneath the town of Warren, passing through Black Gap and southward through most of the study area. SET (1998c) projected the Black Gap Fault trend beneath the CTSA. The Black Gap Fault is associated with a pronounced thickening of the basin fill from east to west that is interpreted as indicating that the fault was active during deposition of the basin fill (Plate 2). The location of the Black Gap Fault in the study area is constrained by several pairs of boreholes that reflect this westward deepening (Plate 2, Sections A-A', B-B', and C-C'; Plate 3, Sections D-D' and H-H').

In a complimentary manner, the basin fill thins on the westside of the study area at sites BMO-2008-5 and BMO-2008-6 west of the Naco Highway (Plate 2, Section B-B' and C-C'). By analogy to the situation along the Black Gap Fault, it seems reasonable that the bedrock rise in the west may be the result of faulting during deposition of the basin fill. In that case, the sense of movement would be up to the west, making the central portion of the study area a down-dropped, fault-bounded structural block, or graben. The thinning can also be explained by an erosional surface sloping east-southeastward upon which the basin fill was deposited. Cross sections B-B' and C-C' on Plate 2 interpret this difference in elevation as the result of an irregular erosional surface. The presence of a fault is another interpretation that cannot be discounted, however.

The Ninety-One Hills Fault zone is a set of east-west trending faults in the southeastern part of the study area. Hayes and Landis (1964) mapped and interpreted the fault zone as a set of high-angle normal faults that dip to the north. Only one borehole, TM-17, is located south of this fault zone. This study relies on the Hayes and Landis interpretation of the Ninety-One Hills Fault zone.

The structure of the bedrock on the west side of the Black Gap Fault and south of the Abrigo Fault has been interpreted as a deformational basin as shown in cross-sections B-B', C-C', F-F', and G-G'. This interpretation accommodates the bedrock lithology, as logged in the BMO-2008 and 2010 series wells and is consistent with the thicknesses of the formations as mapped by Hayes and Landis (1964).

4.1.2.1 Evaluation of Historical Geophysical Survey Data

In 1988 and 1989, PD conducted surface geophysical surveys in the vicinity of the Black Gap Fault and the bedrock east of the fault. Nine lines of electrical resistivity data were acquired and reinterpreted for the Focused Bedrock Investigation. The objective of reinterpreting the historical data was to develop additional information on geologic structures in the bedrock that could influence groundwater flow. The data reinterpretation was conducted by Zonge and is reported in Appendix I.2.

Among the significant findings by Zonge were:

- Presence of a north-south lineament extending from Black Gap near Warren southward along the east side of the Bisbee Municipal Airport. The units on the west side of this lineament, which Zonge interpreted as a fault, had higher resistivity than those on east.

- Presence of a lineament, interpreted as a fault, oriented northwest-southeast from the west side of the South Tailing Impoundment to the Bisbee Municipal airport. This fault is in the approximate vicinity of the inferred Abrigo Fault and separates high resistivity units on the northeast from low resistivity units on the southwest.

- Presence of two northwest-southeast fault or fracture zones south of the former evaporation pond and approximately perpendicular to the Black Gap Fault.

- A near surface feature near the southern part of the investigation area that appears to be an extension of the Ninety-One Hills Fault zone south of Bisbee Junction.

- Resistivity maps prepared at different depths beneath the North and South Tailing Impoundments show that while tailing material has low resistivity, the resistivity of native materials underneath the tailing is consistent with that of the native materials to the east of the tailing impoundments at depths of approximately 300 to 400 feet. These data suggest that material below the tailing impoundments do not have a high moisture content or high conductance fluids such as groundwater with elevated sulfate. The low resistivity of the tailing is probably due to its residual pyrite content.

Zonge's interpretation of northwest-southeast oriented faults and fracture zones in the resistivity data is consistent with the predominance of northwest-southeast to west-northwest-east-southeast planar features observed in downhole televiewer surveys at BMO-2010-1M and BMO-2010-2M (Section 3.4.2.6.2). The surface geophysical resistivity and the downhole televiewer data both suggest the presence of a northwesterly to west-northwesterly system of structures. Observation of the northwest-southeast structures at both the scale of the geophysical survey (miles) and the scale of the televiewer survey (feet) suggests a widespread structural fabric that could cause anisotropy in the bedrock due to a preferred orientation permeable structures.

4.1.3 Basin Fill Composition and Thickness

Throughout most of the study area, the bedrock is covered with unconsolidated basin fill sediments. Basin fill is composed of clay, silt, sand, gravel, and cobbles, derived presumably from the surrounding bedrock areas. The entire area of the sulfate plume is blanketed by basin fill, although bedrock outcrops near the eastern edge of the plume (Figure 3). Basin fill intercepted in the monitor wells installed in Task 2.3 ranged from 50 ft in BMO-2008-1G and BMO-2010-2M to 636 feet in thickness in BMO-2008-4B.

The upper 50 to 165 feet of basin fill in most of the wells installed for Task 2.3 and for the Focused Bedrock Investigation was strongly cemented with caliche (Plates 2 and 3). Caliche was typically thickest and strongest in the northern wells, those closest to the range front. Caliche was not present to the southwest near Greenbush draw at BMO-2010-3M and BMO-2010-3B. Basin fill below the caliche zone commonly exhibited thin coatings of crystalline calcite and sand grains on gravel surfaces. These basin fill sediments are described as being "moderately cemented" or "calcareous."

The basin fill includes coarse-grained lithic fragments ranging in size from sand and gravel to cobbles and boulders. Maximum size of basin fill particles is poorly characterized because the drilling methods used during this and other well installation programs grind particles to a maximum of an inch or so prior to removal from the borehole. However, video logging (Section 3.4.2.6 and Appendix I.1) reveals cobbles in the basin fill greater than a foot in diameter. Lithology of the larger particles includes schist, limestone, sandstone, granite,

volcanics, and quartzite. Schist fragments derived from the Pinal Schist or weathered from Pinal Schist fragments in the Glance Conglomerate dominate the distribution of lithic particles. Limestone fragments are the next most common type observed in the drill cuttings, reflecting the dominant lithology of the Paleozoic section (Section 2.3.3.2).

The northern part of the study area typically exhibits approximately 200 feet of basin fill sediments (Plate 2, Section A-A'). Basin fill is absent east of the study area where Morita Formation and Glance Conglomerate are exposed at the surface (Figure 3). The thickness of basin fill east of the Black Gap Fault is typically less than 200 feet (Plate 2, Sections A-A', B-B', C-C', D-D', and H-H'). West of the Black Gap Fault, the basin fill thickens by up to 500 feet. The thickening increases from approximately 300 feet at TM-02 and TM-02A in the north to approximately 500 feet at GARNER 635 in the south (Plate 2, Sections A-A', B-B', C-C', and H-H').

The thickness of the basin fill persists at approximately 500 and 600 feet at BMO-2008-13M and BMO-2008-4B (Plate 3, Section F-F'). However, basin fill thins to 240 feet at BMO-2008-5M, 290 feet at BMO-2008-6M, and 386 feet at BMO-2010-3M to the west. This bedrock rise forms the western margin of the deep central portion of the basin fill in the study area.

The thickness of the basin fill at BMO-2008-3 is approximately 470 feet, suggesting thinning of the basin fill to the southeast. This bedrock rise correlates with outcrops of Mural Limestone in the hills south of Bisbee Junction (Figure 3), which taper off to the west toward

BMO-2008-3B. Additional information is lacking concerning the depth of basin fill in the southern portion of the study area and into northern Mexico.

4.2 Groundwater Hydrology

This section updates the groundwater hydrology based on the findings of the aquifer characterization. HGC (2008a) summarized the hydrology in the vicinity of the sulfate plume based on the reports of Littin (1987), PD (1990), and SET (1998a, 1998b, and 1998c).

4.2.1 Hydrostratigraphic Units

Groundwater occurs in two hydrostratigraphic units in the vicinity of the sulfate plume: the basin fill and the Bisbee Group bedrock.

4.2.1.1 Basin Fill

Basin fill is the principal aquifer south of the Abrigo Fault and west of the Black Gap Fault due to its relatively high permeability and large saturated thickness. In this area, the basin fill provides most of the water for domestic purposes in the Bisbee-Naco area. North of the Abrigo Fault and east of the Black Gap Fault, the basin fill is unsaturated.

Clay beds are locally interbedded with sand and gravel within the basin fill (PD, 1990; Wright, 2001). Although well logs indicate that there is interbedded clay and silt in the basin fill

in some TM-series wells, GARNER 635, and BMO-2008-6B, clay and silt beds cannot be correlated from well to well and do not form a significant portion of the basin fill intercepted by the BMO-2008 drilling. The clay and silt beds are not laterally continuous and do not appear to control groundwater flow. However, where present, clay and silt beds are expected to locally reduce vertical communication within the aquifer.

4.2.1.2 Bisbee Group Bedrock

The Bisbee Group is a source of water in the vicinity of the sulfate plume, particularly where the basin fill is unsaturated. The bedrock generally has a lower hydraulic conductivity than basin fill making it less productive as a water supply. However, there are instances in which bedrock may locally be nearly as productive as the basin fill. For example, the hydraulic conductivity of the Cintura Formation at BMO-2008-6M (Figure 10 and Table 15), near the center of the basin west of the Black Gap Fault, is more typical of basin fill than bedrock. The Morita Formation and Glance Conglomerate are the primary water-bearing units east of the Black Gap Fault. The Cintura Formation, Lower Mural Limestone, and Morita Formation are the water-bearing bedrock units identified in monitoring wells installed west of the Black Gap Fault and south of the Abrigo Fault.

4.2.2 Hydraulic Properties

Hydraulic conductivity data are available from pumping tests conducted at monitoring wells in the basin fill and bedrock aquifers. Data collected prior to the present investigation are summarized in Table 6. Data collected as part of the investigation are discussed in Section 3.5 and summarized in Table 15.

4.2.2.1 Previous Hydraulic Property Estimates

Hydraulic conductivity data summarized in Table 6 include estimates for basin fill, basin fill plus Morita Formation, and Morita Formation. Table 6 contains three sets of data. The two data sets reported by SRK (1997) consist of previously unpublished data for the original aquifer tests conducted by ELMA and SRK's reinterpretation of the results (Section 3.2.3.2). The third data set contains hydraulic conductivity estimates from the calibrated groundwater flow model of SET (1998c) (Section 7.2.3.3). The model-derived estimates are included for comparison because they represent volume-averaged hydraulic properties for the area. Most of the groundwater monitoring wells completed in basin fill are within the silty sand lithologic facies, and most of the monitoring wells completed in the Morita Formation are within the siltstone lithologic facies represented in the SET model (Figures 3-4 and 3-5 of SET, 1998c).

Based on the original pumping test interpretations by ELMA (SRK, 1997), estimates of the hydraulic conductivity in basin fill wells TM-11 and TM-13 range from 39.0 to 59.0 ft/day

and average 49.0 ft/day. Average hydraulic conductivities in co-located wells open to both basin fill and Morita Formation were estimated at 24.1 ft/day at TM-01 and TM-01A, and 4.9 ft/day at TM-29, TM-29A, and TM-29B. Estimates of hydraulic conductivities for the Morita Formation west of the Black Gap Fault average 9.3 ft/day based on pumping tests at TM-30, TM-30A, TM-19A and TM-38. TM-19A and TM-30A are now interpreted to be completed in the Cintura rather than Morita Formation. As discussed in Section 4.1, the Morita and Cintura Formations have similar lithologies.

East of the Black Gap Fault, the hydraulic conductivity of the Morita Formation was estimated to be 1.3 ft/day at TM-16. Hydraulic conductivities reported by WMC (2006) for the Morita Formation in the mining area range from 5.8×10^{-4} to 14.4 ft/day and generally appear to be lower than Morita Formation hydraulic conductivities in the vicinity of the CTSA.

PD (1990) reported estimates of porosity. For the basin fill an average porosity of 0.35 and an average effective porosity of 0.25 are reported, and for the Morita Formation, an average porosity of 0.25 and an average effective porosity of 0.15 are reported.

4.2.2.2 2008 and 2010 Hydraulic Property Estimates

Data collected for Tasks 2.3 and 2.4 of the Work Plan (Section 3.5) and the Focused Bedrock Investigation are summarized in Table 15 include estimates of hydraulic properties for the basin fill, Cintura Formation, Mural Limestone, Morita Formation, and Glance

Conglomerate. Hydraulic property estimates include transmissivity, horizontal hydraulic conductivity, and storage coefficient. Because most of the analyzed data were derived from the pumped wells, estimates of storage coefficient are less reliable than estimates of transmissivity and hydraulic conductivity (Section 3.5). Vertical hydraulic conductivity was also estimated at many of the test locations; however, estimates of vertical hydraulic conductivity are not considered as reliable as estimates of horizontal hydraulic conductivity. More reliable estimates of vertical conductivity would require observation wells completed in the same formation as the pumped well but at different depth intervals than the pumped well. The only location at which observation wells meeting these criteria were available was near BMO-2008-4B and BMO-2010-1M. In general, horizontal hydraulic conductivity estimates for the basin fill and Morita aquifers are similar to previous estimates.

Horizontal hydraulic conductivity estimates for basin fill range from 2.3 to 127.8 ft/day with an average of 37.7 ft/day and a geometric average of 27.0 ft/day; vertical hydraulic conductivity estimates range from 1.5×10^{-6} to 3.7 ft/day with an average of 1.3 ft/day and a geometric average of 0.17 ft/day. The vertical conductivity near BMO-2008-4B was estimated at 0.93 ft/day based on drawdowns measured at NWC-03 during pumping of BMO-2008-4B. The highest horizontal hydraulic conductivity for basin fill was estimated at COB MW-1 (127.8 ft/day) and the lowest at BMO-2008-6B (2.3 ft/day). The low value of 2.3 ft/day at BMO-2008-6B is representative of a mixture of basin fill and weathered Cintura Formation. The average basin fill horizontal hydraulic conductivity based on testing in 2008 and 2010 lies between the

average hydraulic conductivity of 49 ft/day estimated by ELMA and the SET model-derived value of 23 ft/day for silty sand.

Horizontal hydraulic conductivity estimates for the undifferentiated Bisbee Group formations stratigraphically above the Glance Conglomerate range from 0.01 to 33 ft/day with an average of 5.1 ft/day and a geometric average of 0.92 ft/day; and vertical hydraulic conductivity estimates range from 1.0×10^{-6} to 4.9 ft/day with an average of 0.82 ft/day and a geometric average of .024 ft/day. The highest horizontal hydraulic conductivity was estimated at TM-42 (in the Morita Formation) which had a horizontal conductivity of 33 ft/day. The second highest horizontal conductivity was for BMO-2008-6M at 16.2 ft/day (interpreted to be completed in Cintura Formation) and the lowest at BMO-2008-13M (completed in Mural Limestone) at 5.1×10^{-3} ft/day. The average horizontal hydraulic conductivity for the undifferentiated Bisbee Group lies between previous estimates of ELMA (SRK, 1997) and SET (1998c). The average ELMA hydraulic conductivity was 9.3 ft/day and the SET model-derived hydraulic conductivity was 3 ft/day for the siltstone facies. The Morita and Cintura Formations have a similar lithology and hydraulic conductivities. The average hydraulic conductivity for wells completed in the Cintura Formation (BMO-2008-5M, BMO-2008-6M, and BMO-2010-3M) was 8.1 ft/day, and the average hydraulic conductivity for wells completed in the Morita Formation (BMO-2008-7M, BMO-2008-8M, BMO-2008-9M, BMO-2010-1M, and BMO-2010-2M, TM-16 and TM-42) was 5.2 ft/day.

Horizontal hydraulic conductivity estimates for the Glance Conglomerate range from 3.3 x 10^{-3} to 0.35 ft/day with an average of 0.13 ft/day and a geometric average of 0.05 ft/day; and vertical hydraulic conductivity was estimated to be 5.0 x 10^{-7} ft/day at BMO-2008-1G and 1.0 x 10^{-2} ft/day at BMO-2008-10G. The highest horizontal conductivity was estimated at BMO-2008-11G and the lowest at BMO-2008-10GL.

As discussed in Appendices N.1 and N.3, direct evidence of vertical hydraulic interaction between the basin fill and Cintura or Morita Formation aquifers was detected at the locations of BMO-2008-5 and BMO-2008-7. BMO-2008-5M (completed in the Cintura Formation) responded to pumping at BMO-2008-5B (completed in the basin fill) and vice versa; and COB MW-1 (completed in the basin fill) responded to pumping at BMO-2008-7M (completed in the Morita Formation). The cross-formational responses suggest that either the upper portion of the bedrock at these locations is so weathered, fractured, poorly cemented, or coarse-grained, that its behavior is hydraulically similar to the basin fill, or that permeable structures hydraulically connect the bedrock and basin fill exist at these locations. In 2010, a connection was not observed between the Cintura Formation and basin fill at the BMO-2010-3 well pair.

4.2.3 Potentiometric Relationships

Groundwater elevations at the site vary with location, local geologic structure, depth below land surface, and the aquifer material. Structures that appear to influence groundwater elevations are the Abrigo and Black Gap Faults. Although these structures are used to define

subregions of distinct groundwater regimes, the boundaries between the subregions could be due to permeability contrasts across faults or sedimentary contacts, the extent of saturated basin fill, or separate aquifer systems. Subregions of interest include: the area east of the Black Gap Fault, the area south of the Abrigo Fault and west of the Black Gap Fault, and the area north of and in the vicinity of the Abrigo Fault and west of the Black Gap Fault. Past investigations (WMC, 2006) have generally considered the area north of the Abrigo and west of the Black Gap Faults to be hydraulically isolated from the other subregions in the study area.

The directions and magnitudes of the hydraulic gradients vary within the subregions. East of the Black Gap Fault, where the basin fill is unsaturated, groundwater elevations generally decrease to the south and southwest. Groundwater gradients are also generally steeper and more variable east of the Black Gap Fault than they are to the west of the fault. The steeper gradients east of the fault are primarily a function of the shallow water-bearing material, which is bedrock with lower hydraulic conductivity than the basin fill west of the fault. South of the Abrigo Fault and west of the Black Gap Fault, groundwater elevations generally decrease to the southwest and west. Basin fill is partially saturated south of the Abrigo Fault and west of the Black Gap Fault. Hydraulic gradients are shallower and groundwater levels are more consistent than east of the Black Gap Fault, probably, due to the higher hydraulic conductivity of the basin fill. North of and in the vicinity of the Abrigo Fault and west of the Black Gap Fault the basin fill is generally unsaturated and groundwater elevations in bedrock are deeper than would be expected based on water elevations south of the Abrigo Fault. The water level characteristics of the subregions are discussed further in Sections 4.2.3.1 to 4.2.3.3.

4.2.3.1 Water Level Maps

The depth to water in the study area varies from approximately 60 feet east of the Black Gap Fault to greater than 800 feet north of the Abrigo Fault under the South Tailing Impoundment. Figures 12 through 19 are potentiometric contour maps for the years 1989, 1996, 1999, and 2005, first quarter 2008, third quarter 2008, third quarter 2009, and third quarter 2010. Water level data shown in Figures 12 through 15 are compiled from CQB files, ADWR (2005), and previous hydrological investigations of the area. Fewer water level data are available for 1996, 1999, and 2005 than for 1989 because some of the monitoring points available in 1989 were not completed as wells and because some of the wells were abandoned by 1990 or went dry. The water level data shown for 1989, 1996, 1999, and 2005 are reported in Appendix F. Water level data for 2008 through 2010 are in Table 12.

To provide sufficient coverage in Figure 12, 1988 and 1990 water levels are included for NWC and AWC wells, respectively, because 1989 data were not available for these wells. The water level at TM-35 was not used in contouring the 1989 data due to its anomalously low water level relative to neighboring wells to the west. The 1989 water elevations east of the Black Gap Fault are interpreted to reflect mounding in the vicinity of the former evaporation pond.

Measuring point elevations of many wells were re-surveyed as part of the 2008 aquifer characterization investigation. Groundwater levels in Figures 12 through 15 are not based on re-surveyed measuring point elevations because many of the wells are abandoned and therefore unavailable for re-surveying (see also the discussion in Section 3.2.4). Changes in elevation due

to re-surveying were small enough (less than 20 feet) and uniform enough in most cases to only minimally affect the shapes and spacing of contour lines and the calculation of hydraulic gradients. Groundwater levels in Figures 16 through 19 are based on re-surveyed elevations only. Differences between the 2005 and 2008 water levels shown in Figures 15 and 16 respectively, are partly due to the use of re-surveyed elevations in the latter.

The water elevation contour lines in Figures 12 through 19 are interpretive. Water level contours are not shown crossing the Abrigo and Black Gap Faults in the vicinity of the tailing impoundments since differing water levels on either side of the faults indicate poor hydraulic communication across the faults in this area (i.e., contrast water elevations at well GL-03 with those at wells BF-01 and TM-02A south of the Abrigo Fault and well TM-03 east of the Black Gap Fault). Water level contours are shown crossing the southern portion of the Black Gap Fault south of the former evaporation pond in instances when the interpolated contours appear consistent with contours west of the fault.

The water level data shown in Figures 12 through 19 show a persistent pattern over time. Groundwater flows southwest and west on the west side of the Black Gap Fault and south and southwest on the east side of the fault. South of the CTSA, the groundwater flow direction shifts to westerly in the vicinity of Naco and Greenbush Draw. Saturated thickness of the basin fill increases to the southwest from less than 1 foot near BF-01 to as much as 500 feet at BMO-2008-4B based on groundwater elevations measured in the fourth quarter of 2008 (Figure 20). The lateral extent of the saturated basin fill also increases to the southwest.

4.2.3.2 2008 through 2010 Water Elevations

Groundwater elevations have been measured quarterly since 2008 for the Mitigation Order investigation (Section 3.3). Groundwater elevations for the first quarter of 2008, third quarter of 2008, third quarter of 2009, and the third quarter of 2010 are shown on Figures 16 through 19. Groundwater elevation contour maps for 2008, 2009, and 2010 for quarters other than those in Figures 16 through 19 are provided in Appendix F.3. In general, groundwater elevations decrease from north to south east of the Black Gap Fault in the region between the Bisbee airport and Bisbee Junction, and from east to west across the central portion of the study area west of the Black Gap Fault. Groundwater levels in wells in Naco, Sonora indicate groundwater elevations decrease northward, towards, and converging on Greenbush Draw (Figure 21).

The water level relationships are relatively complex due to the multiple hydrostratigraphic units monitored and the complicated structural geology of the area. The water level data can be interpreted to represent conditions in three hydrologic subregions: east of the Black Gap Fault, south of the Abrigo Fault and west of the Black Gap Fault, and north of and in the vicinity the Abrigo Fault west of the Black Gap Fault. The subregions are inferred based on the direction and magnitude of hydraulic gradients, and the magnitude and variability of groundwater elevations. In addition to the previously cited groundwater elevation maps and the hydrographs in Appendix F.2, Plates 2 and 3 also illustrate water level relationships in the study area.

The subregion east of the Black Gap Fault consists of the extreme eastern portion of the study area where wells are in shallow bedrock close to outcrops of the Glance Conglomerate and Morita Formation. The subregion east of the Black Gap Fault extends from well TM-03 in the north to Bisbee Junction in the south. The characteristics of this domain are a relatively steep south- to southwest-dipping hydraulic gradient and a large variability in groundwater elevations between wells.

The subregion south of the Abrigo Fault and west of the Black Gap Fault encompasses the area where the sulfate plume is primarily in basin fill and most public water supply wells are located. Groundwater in this subregion occurs in basin fill and undifferentiated Bisbee Group bedrock. The subregion south of the Abrigo Fault and west of the Black Gap Fault is characterized by shallow westerly to southwesterly dipping hydraulic gradients and similar water elevations in wells in both basin fill and bedrock.

The subregion north of and in the vicinity of the Abrigo Fault and west of the Black Gap Fault is at the northern margin of the study area. This subregion is characterized by groundwater elevations that are low compared to water elevations south of the Abrigo Fault and east of the Black Gap Fault.

East of the Black Gap Fault where groundwater is in the Morita Formation and Glance Conglomerate, the apparent hydraulic gradient is steeper than it is west of the fault where groundwater elevation measurements are primarily from wells in basin fill. The steeper

hydraulic gradient east of the Black Gap Fault may be due to a lower average hydraulic conductivity in the bedrock compared to basin fill.

The direction of the hydraulic gradient east of the Black Gap Fault is southerly from TM-03 towards the vicinity of Bisbee Junction and then westerly, whereas west of the Black Gap Fault and south of the Abrigo Fault the hydraulic gradient is predominantly westerly. The shift in the apparent groundwater flow direction may be due to a change in the character of the water bearing units. East of the Black Gap Fault, wells are completed in shallow bedrock as opposed to basin fill west of the fault.

Water levels east of the Black Gap Fault can display large differences in elevation (sometimes up to several hundred feet) between wells in relatively close proximity to one another. This variability in water elevation is evident at wells in the vicinity of Bisbee Junction area and, possibly, in the area east of the former evaporation pond. At Bisbee Junction, water levels in the third quarter 2010 (Figure 19) range from 4,412 feet above mean sea level (ft amsl) at BANKS 987 to 4,599 ft amsl at STEPHENS. East of the former evaporation pond, the water level at the BIMA well was 4,415 ft amsl and the SUNBELT well was dry (water level less than 4426 ft amsl), which is significantly lower than water levels in wells BMO-2008-1G, COB-WL, and SWAN to the east which range from 4,676 to 4,764 ft amsl. The water levels at BIMA and SUNBELT are lower than the water level at BMO-2008-10GU to the west which is at 4,504 ft amsl.

The variability of water elevations east of the Black Gap Fault may be because the hydraulic conductivity of the bedrock is low and heterogeneous so that certain portions of the bedrock are not hydraulically connected. Heterogeneity in hydraulic properties in bedrock would be due to the restriction of groundwater flow to permeable features such as local zones of strata with a high intrinsic permeability, bedding planes, or fracture systems within bedrock, which are not uniformly distributed throughout the area. A factor that may contribute to the apparent variability in water levels is that drawdown due to pumping in domestic wells in low-permeability bedrock could create zones of depressed water elevations that do not recover rapidly after pumping ceases.

Significant water level differences occur at the BMO-2008-10 wells east of the Black Gap Fault at the southern margin of the former evaporation pond. Water levels in BMO-2008-10GU, completed within a shallow horizon of the Glance Conglomerate, are more than 200 feet higher in elevation than water levels in BMO-2008-10GL, located 100 feet south of BMO-2008-10GU and completed within a deeper horizon of the Glance Conglomerate, indicating a poor hydraulic connection between the two screened intervals. In the Morita Formation, a similar situation exists between TM-16 and BMO-2010-1M located 300 feet to the north. TM-16, which is screened from a depth of 65 to 115 ft bls has a water elevation 140 feet higher than that of BMO-2010-1M, which is screened from 440 to 540 ft bls.

South of the Abrigo Fault and west of the Black Gap Fault, the apparent hydraulic gradient is westerly, water elevations do not show large fluctuations between nearby wells, and

water elevations in co-located wells in basin fill and shallow bedrock are similar, suggesting that the basin fill and bedrock aquifers are connected to some degree. In the third quarter of 2010, water elevations in the undifferentiated Bisbee Group south of the Abrigo Fault and west of the Black Gap Fault fell within a narrow range of elevations, from 4,431 ft amsl at BMO-2010-3M near Greenbush Draw to 4,452 ft amsl at BMO-2008-8M. In the western portion of the study area, water level elevations in co-located wells screened at different depths in the basin fill and the undifferentiated Bisbee Group vary by less than 3 feet. These data indicate a hydraulic connection between the basin fill and the upper portion of the undifferentiated Bisbee Group bedrock.

Groundwater elevations north of and in the vicinity of the Abrigo Fault and west of the Black Gap Fault are low compared to water elevations in the subregion south of the Abrigo Fault and west of the Black Gap Fault. Figures 17 through 19 show an area of low water elevations that straddles the projected trace of the Abrigo Fault and is defined by the BMO-2008-11G, BURKE, SRC and GL-03 wells. Water elevations in these wells are approximately 200 feet lower than in wells to the south. The low water levels in this subregion suggest these wells may be within a separate aquifer or a separate structural block with poor hydraulic communication with the subregion to the south. Another factor that may explain the low water levels in the wells north of and in the vicinity of the Abrigo Fault is well completion at depth in low permeability bedrock. According to well driller logs, SRC and BURKE are screened in "shale bedrock" and BMO-2008-11G and GL-03 are screened in the Glance Conglomerate, all at depths greater than 600 ft bls. Data from BMO-2008-11G, located just south of the projected trace of

the Abrigo Fault, and west of the Black Gap Fault, indicate that the basin fill and Morita Formation are unsaturated at this location.

Although complex, the water level data provide important information on the direction and magnitude of hydraulic gradients, which control the direction and movement of the sulfate plume. Comparison of the 2008 through 2010 water elevations (Figures 16, 17, 18, and 19 and additional maps in Appendix F.3) with those in 1989, 1996, and 2005 (Figures 12, 13, 14, and 15) indicates a similar pattern of groundwater elevations and consequent flow directions over this time range.

At the request of ADEQ (ADEQ, 2010a), groundwater elevation maps were prepared separately for wells screened in basin fill, undifferentiated Bisbee Group, Glance Conglomerate, and wells with deep screened intervals (greater than 650 feet deep). The purpose of the separate maps, which are provided in Appendices F.4, was evaluation of the potential influence of lithologic units and screen depth on water levels given the complicated water level patterns observed in the hydrologic subregions. The groundwater elevation maps were prepared with third quarter 2010 data (Figure 19) to take advantage of information from the BMO-2010 wells, but include two prior measurements from select wells that are no longer monitored.

Differentiating the water level data on the basis of lithology and screen depth provided some additional insight on the hydrologic subregions. However, the degree of saturation and water level conditions observed during drilling of the BMO-2010 wells (Section 3.4) reinforced

the recognition that the bedrock has multiple saturated zones as at BMO-2008-10 and BMO-2010-1, and that an interpretation of the water level data needs to account for data representative of multiple potentiometric[4] systems. Therefore, water elevation data were further evaluated considering their elevation range and the characteristics of the hydraulic subregions to provide a consistent interpretation.

Appendix F.5 contains water elevation maps for what are termed the shallow, deep, and intermediate potentiometric systems. The potentiometric systems were identified considering the evidence of multiple aquifers in bedrock, the spatial distribution of water elevations (i.e., water levels in a single potentiometric field should show a systematic relationship from location to location), and the spatial distribution of the hydrologic subregions. The degree of hydraulic connection between the potentiometric systems appears to be limited based on the different water elevations that characterize them.

The shallow potentiometric system is defined by wells in basin fill, undifferentiated Bisbee Group, and Glance Conglomerate in the hydrologic subregions west of the Black Gap Fault and south of the Abrigo Fault and east of the Black Gap Fault (Figure F.5.1). The sulfate plume occurs primarily in the shallow potentiometric system. Water elevations decrease from east to west and are similar in both basin fill and undifferentiated Bisbee Group wells in the subregion south of the Abrigo Fault and west of the Black Gap Fault, although the water elevation in bedrock is typically several feet lower than in basin fill at a given location. Water elevations decrease from east to west in the subregion east of the Black Gap Fault, but

[4] The term potentiometric is used generally to denote a system of related water levels, whether phreatic or confined.

interpretation of the potentiometric field is complicated by several wells with water elevations that appear to differ significantly from nearby wells. Examples of wells that have water elevations that differ from those in nearby wells are BIMA and SUNBELT compared to BMO-2008-10GU, BMO-2008-1G, and BMO-2010-2M; and FLEMING and BANKS 987 compared to BMO-2010-1M, PANAGAKOS, DODSON, STEPHENS, RAY, and EPPLE 641 (Figures 16 through 19 and Plates 2 and 3). Drilling observations (Section 3.4.4.12) and water level data for BMO-2010-1M (Table 12 and Figure 19) indicate that the well is in a different potentiometric system than the nearby TM-16. The water elevation at BMO-2010-1M appears to be in agreement with BMO-2010-2M, PANAGAKOS, DODSON, STEPHENS, RAY, and EPPLE 641 whereas TM-16 appears anomalously high compared to surrounding wells. Water elevations that appear to be systematically related to the bedrock water elevations at BMO-2008-9M, BMO-2010-1M, and BMO-2010-2M, and the majority of private wells were defined as the shallow potentiometric system (Figure F.4), including water elevations in Glance Conglomerate wells on the east side of the study area. The sulfate plume occurs primarily in the shallow potentiometric system.

The deep potentiometric system is identified by deep wells in Glance Conglomerate primarily in the hydraulic subregion north and in the vicinity of the Abrigo Fault and west of the Black Gap Fault (Figure F.5.2), although it also includes BMO-2008-10 GL. Wells in the deep potentiometric system have water elevations less than 4,300 ft amsl. The apparent hydraulic gradient of the deep potentiometric system dips to the north. Water level data for the BMO-2008-10 wells indicate that the deep potentiometric system represented by BMO-2008-10GL

underlies and is poorly connected with a shallower potentiometric system represented by BMO-2008-10GU. As discussed in Section 4.2.3.3, water levels in wells in the deep potentiometric system tend to increase over time. The NESS well on the east edge of the study area is an outlier to the deep potentiometric system in that it is the deepest water elevation measured in the study area and does not appear to fit the north-dipping water level distribution evident in the subregion north of the Abrigo Fault and east of the Black Gap Fault. As described in Section 5.1.1.1, a characteristic of the deep potentiometric system is that sulfate concentrations are less than 50 mg/L except at BMO-2008-10GL.

The intermediate potentiometric system is defined by the wells with water elevations that seem to be inconsistent with water elevations in nearby wells grouped in the shallow potentiometric system (Figure F.4.3). These wells occur in the subregion east of the Black Gap Fault and tend to have water elevations that are lower than water elevations in wells included in the shallow potentiometric system. TM-16, which has a relatively high water elevation, is an exception to the generalization. The extent of the intermediate potentiometric system is uncertain, although it appears to represent localized isolated zones in the bedrock. The intermediate potentiometric system may represent bedrock heterogeneity such as rock volumes that lack connectivity to the surrounding potentiometric system due a lack of uniform fracturing, a different degree of cementation or lithification, or a permeability dominated by a single fracture that can be dewatered by pumping.

The interpretation of different potentiometric systems is a working hypothesis for the observed geographic distribution of water elevations and the water elevation differences between wells. Groundwater elevation contours south of the Abrigo Fault and east of the Black Gap Fault for the third quarter 2010 (Figure 19) were interpreted based on the foregoing interpretation.

4.2.3.3 Temporal Trends

Since 1988, when systematic water level measurements began, water levels in monitoring wells south of the Abrigo Fault have generally declined. Wells in the vicinity of the former evaporation pond show the greatest decline. Hydrographs of wells BF-02, TM-02, TM-02A, TM-07, TM-19, and TM-19A located near and downgradient of the former evaporation pond are shown in Figure 22. Groundwater levels in Figure 22 are based on elevation datum re-surveyed in 2008. For wells that were not re-surveyed, corrections to groundwater elevation were based on differences in measuring point elevation between the non-re-surveyed and re-surveyed wells. The assumption was made that although the magnitude of older datum may differ from the re-surveyed datum, the relative differences in measuring point elevations between wells are accurate in the older survey.

Figure 22 shows a steady decline in water levels at BF-02, TM-02, TM-02A, TM-07, TM-19 and TM-19A from 1988 through 1997, probably reflecting the dissipation of a groundwater mound formed in response to infiltration of water discharged to the former

evaporation pond between 1908 and 1987. The rate of dissipation of the mound appears to have slowed after 1997. Wells TM-02, BF-02, TM-07, and TM-19 were dry in 2008 through 2010.

Since installation of the BMO-2008 wells, groundwater elevations of monitor wells screened in basin fill have generally decreased. The maximum decrease was at BMO-2008-3B, where the groundwater elevation decreased by 2.75 feet since July 2008.

Variations in groundwater elevations in BMO monitor wells screened in bedrock (Appendix F.3) varied depending on location or potentiometric system. In the subregion south of the Abrigo Fault and west of the Black Gap Fault where saturated basin fill is on top of bedrock, groundwater level changes in bedrock wells were minor or generally reflected water level declines observed in the overlying basin fill. One exception is BMO-2008-8M where groundwater levels rose by 0.09 feet, as compared with the corresponding basin fill well where groundwater levels fell by 0.70 feet.

Bedrock wells in the subregion north of and in the vicinity of the Abrigo Fault had increasing water levels. BMO-2008-10GL, BMO-2008-11G, BURKE, and GL-03 are wells that have increasing water elevations over time. The water level increase is best shown at GL-03 which has had a continuous rise in water levels since the well was installed in 1993 (Figure 23). The water level increase at GL-03 contrasts with the decline in water levels over time at TM-02, TM-02A, TM-03. TM-07, and BF-02 in the vicinity of the former evaporation pond (Figures 22 and 23). The increasing water levels over time in the subregion north and in the vicinity of the

Abrigo Fault and west of the Black Gap Fault, along with significantly lower water elevations, is a characteristic of wells in the deep potentiometric system. As discussed by SET (1998c), and WMC (2006), the water level increase at GL-03 matches water level increases in the mining area to the north. On that basis, WMC (2006) concluded that the portion of the CTSA north of the Abrigo Fault and west of the Black Gap Fault is in a structural block in a cone of depression resulting from historical mine dewatering.

Groundwater elevations in bedrock wells in the subregion east of the Black Gap Fault declined to varying degrees from 2008 to 2010. Monitoring wells BMO-2008-1G, BMO-2008-9M, TM 06 MILLER, and TM 16 declined less than 5 feet where as declines in private wells BIMA, SUNBELT, PANAGAKOS, BANKS 987, and FULTZ were on the order of 25 feet or more. The variation in water elevation in the private wells may be influenced by pumping for water supply.

4.2.3.4 Horizontal Hydraulic Gradients

As seen in Figures 12 through 19, hydraulic gradients in the shallow groundwater have been consistently steeper east of the Black Gap Fault than west of the fault. This is partly the result of the lower permeability of the bedrock hosting the shallow groundwater to the east of the fault compared to the higher permeability of the basin fill hosting the shallow groundwater west of the fault. West of the fault, hydraulic communication between the basin fill and shallow

bedrock likely results in hydraulic gradients in the shallow bedrock that are similar to those in the basin fill.

Horizontal hydraulic gradients overtime in basin fill were estimated for several time periods between well pairs TM-02 and TM-11, TM-02 and WEISKOPF, and between BMO-2008-8B and WEISKOPF (Table 16). These well pairs are along a northeast-southwest line between the CTSA and Naco. The WEISKOPF well was used for the 2005 and 2008 calculations rather than TM-11 because water level data were unavailable for TM-11, and WEISKOPF (shown as 641802 on Figure 15) is the well closest to TM-11 for which data were available (Figures 15 and 19). Likewise, well BMO-2008-8B was used for the 2008 and 2010 calculations rather than TM-02 because TM-02 is dry, and BMO-2008-8B is the well closest to TM-02 for which data were available (Figure 19). In addition, an east-west hydraulic gradient was calculated for basin fill between COB MW-1 and BMO-2006-6B using fourth quarter 2008 and third quarter 2010 data.

West of the Black Gap Fault, the southwesterly hydraulic gradient in basin fill was calculated in 1989 as approximately 0.0025 feet per foot between TM-02 and TM-11; in 2005 as approximately 0.0010 feet per foot between TM-02 and WEISKOPF; and in 2008 and 2010 as approximately 0.0011 feet per foot between BMO-2008-8B and WEISKOPF. The east-west hydraulic gradients in 2008 and 2010 between COB MW-1 and BMO-2008-6B were calculated as approximately 0.0014 and 0.0013 feet per foot respectively (Table 16).

East of the Black Gap Fault, groundwater gradients in bedrock range from generally north-south near the CTSA to west-southwest near Bisbee Junction. North-south groundwater gradients were estimated between Glance Conglomerate well TM-28 and Morita Formation well TM-16 (Figure 12), and between wells COB WL and TM-16 (Figure 19). East-west groundwater gradients were estimated between bedrock wells TM-16 and TM-19A. TM-16 is completed within the Morita Formation and TM-19A is reinterpreted to be within the Cintura Formation (Section 4.1).

East of the Black Gap Fault, the north-south hydraulic gradient was calculated in 1989 as approximately 0.0145 feet per foot between TM-28 and TM-16; and in 2008 and 2010 as approximately 0.0137 and 0.0130 feet per foot, respectively, between COB WL and TM-16. The north-south hydraulic gradient was not calculated in 2005 due to insufficient data. The east-west hydraulic gradient east of the fault between TM-16 and TM-19A was calculated in 1989 as 0.0146 feet per foot; in 2005 as 0.0181 feet per foot; and in 2008 as 0.0181 feet per foot, and in 2010 as 0.0182 feet per foot (Table 16).

Southwesterly groundwater gradients in the basin fill west of the Black Gap Fault diminished by nearly half between 1989 and 2005, and have not changed significantly between 2005 and the third quarter 2010. The reduction in hydraulic gradients west of the fault between 1989 and 2005 is interpreted as being due to the dissipation of a groundwater mound when discharges to the former evaporation pond ended in 1987 as discussed in Section 4.2.3.3.

The reduction in gradients was accompanied by a reduction in groundwater levels at wells near and downgradient of the former evaporation pond. Because groundwater levels near the former evaporation pond (for example, in well TM-02, Figure 22) diminished faster than levels downgradient of the pond (for example, in well TM-19A, Figure 22), a reduction in hydraulic gradient occurred. Rates of horizontal groundwater movement implied by hydraulic gradients measured between selected well pairs are provided in Section 4.2.4.

4.2.3.5 Vertical Hydraulic Gradients

Vertical hydraulic gradients defined by water level measurements at co-located wells installed prior to the present investigation, for example at TM-19 and TM-19A (Appendix F), were generally small and inconsistent as to direction. An exception is the large difference of more than 10 feet that existed between TM-02 and TM-02A prior to 1993 before TM-02 became dry. Vertical gradients as defined by water level measurements at co-located BMO-2008-series wells have been mostly downward, the single exception being a very slight upward gradient between BMO-2008-7M and COB MW-1 in 2010. West of the Black Gap Fault, differences in water levels measured in basin fill wells and the corresponding co-located wells completed in bedrock immediately beneath the basin fill ranged from approximately 0.56 feet and 1.64 feet at BMO-2008-6 in 2008 and 2010, respectively, to approximately 2.65 feet 1.86 feet at BMO-2008-8 in the fourth quarter of 2008 and the third quarter of 2010, respectively (Table 16). Water level differences were 1.63 feet at BMO-2008-5, 1.0 feet at BMO-2008-7, and 1.64 feet at BMO-2008-13. Similar differences were recorded in 2010, with the exception of the BMO-2008-7M/

COB MW-1 well pair in which the vertical gradient changed from downward in 2008 (head difference of 1.0 feet) to upward in 2010 (head difference of 0.47 feet). Implied vertical hydraulic gradients based on these differences and the vertical distances between the screened interval midpoints range from 0.0027 and 0.0061 feet per foot at BMO-2008-13 in 2008 and 2010, respectively, to 0.0091 and 0.0098 feet per foot at BMO-2008-5 in 2008 and 2010, respectively.

The largest water level difference at co-located wells was 225.90 and 224.11 feet between BMO-2008-10GU and BMO-2008-10GL in the fourth quarter of 2008 and third quarter of 2010, respectively. These wells are both completed in Glance Conglomerate east of the Black Gap Fault at the southern margin of the former evaporation pond. This water level difference implies a vertical hydraulic gradient of 0.99 feet per foot.

4.2.4 Groundwater Flow Rates

Apparent lateral groundwater flow velocities for the years 1989, 2005, 2008, and 2010 were estimated for the basin fill and bedrock aquifers using average horizontal hydraulic conductivity estimates, water level data for 1989, 2005, 2008, and 2010 (Figures 12, 15, 17 and 19), and effective porosities of 0.25 and 0.15 for the basin fill and bedrock, respectively. Vertical groundwater flow rates were not calculated because the vertical hydraulic conductivity estimates presented in Section 3.5 are not considered as reliable as estimates of horizontal conductivity.

Table 17 summarizes the calculation of lateral groundwater flow velocities. To evaluate a potential range for groundwater flow velocities, the average hydraulic conductivities from field tests (Tables 6 and 15) and the estimated hydraulic conductivities from numerical modeling by SET (1998c) were used. The average conductivity from field tests was 36.4 ft/day for basin fill and 5.7 ft/day for undifferentiated Bisbee Group (i.e., Morita Formation, Mural Limestone, and Cintura Formation). The calibrated model hydraulic conductivity was 23 ft/day for basin fill and 3 ft/day for the Morita Formation (SET, 1998c). These model-derived values correspond to the silty sand facies in the basin fill and siltstone facies in the Morita Formation which are the material types best correlating to the wells used in the calculations.

Groundwater pore velocities were estimated between the same well pairs used to calculate horizontal hydraulic gradients in Section 4.2.3.4. Using the field test and model-derived hydraulic conductivities, respectively, the following groundwater pore velocities were calculated for basin fill west of the Black Gap Fault:

- 0.36 to 0.23 ft/day between TM-02 and TM-11 in 1989
- 0.14 to 0.09 ft/day between TM-02 and WEISKOPF in 2005
- 0.16 to 0.10 ft/day between BMO-2008-8B and WEISKOPF in 2008 and 2010

Using the field test and model-derived hydraulic conductivities, respectively, the following north-south groundwater pore velocity estimates in bedrock east of the Black Gap Fault:

- 0.47 to 0.29 ft/day between TM-28 and TM-16 in 1989

- 0.52 to 0.27 ft/day between COB WL and TM-16 in 2008
- 0.50 to 0.26 ft/day between COB WL and TM-16 in 2010

Likewise, the pore velocity in the bedrock in the east-west direction between TM-16 and TM-19A using field test and model-derived hydraulic conductivities, respectively were estimated to range from 0.56 to 0.29 ft/day in 1989, and from 0.69 to 0.36 ft/day in both 2005, 2008, and 2010. Pore velocity in the bedrock in the north-south direction east of the Black Gap Fault in 2005 was not calculated due to insufficient water level data.

In summary, pore velocities based on the field hydraulic conductivity estimates are greater than those based on the SET (1998c) model estimates by a factor of approximately 1.8. The groundwater flow direction in the subregion south of the Abrigo Fault and west of the Black Gap Fault is generally to the west and southwest towards Naco. The groundwater flow direction in the subregion east of the Black Gap Fault is generally southerly, towards Bisbee Junction. Rates of groundwater movement in the basin fill west of the Black Gap Fault have diminished since 1989 due to a reduction in hydraulic gradients likely caused by the dissipation of mounding associated with historical mine water discharge. Rates of groundwater movement in the bedrock east of the Black Gap Fault have changed little between 1989 and 2005 and between 2005 and 2008 because little change in hydraulic gradient has occurred. Calculated rates of movement are currently higher for the bedrock aquifers compared to basin fill because of higher hydraulic gradients and lower effective porosities in the former.

4.2.5 Groundwater Sources and Sinks

Groundwater sources and sinks in the sulfate plume area include natural and artificial sources. Natural sources include mountain front recharge, recharge by precipitation within the basin, recharge from surface flow into the basin, and subsurface flow into the basin. Artificial sources include recharge from agriculture, infiltration resulting from municipal wastewater treatment, and infiltration from the former evaporation pond and tailing impoundments. Groundwater sources and sinks are discussed in detail in Sections 3.2.6 and 3.2.7.

5. NATURE AND EXTENT OF SULFATE

Water quality data collected since the 1980s indicate that sulfate concentrations in the vicinity of the CTSA vary with location, time, and depth. The spatial and temporal distribution of sulfate in groundwater, the major element chemistry of groundwater in the vicinity of the plume, and factors that influence the fate and transport of sulfate are discussed in the following sections.

5.1 Groundwater Chemistry

CQB has monitored groundwater quality in the sulfate plume area since the late 1980s. Water quality data have been generated primarily from the sampling of groundwater monitoring wells, although some data are also available for municipal and private water supply wells. Appendix G.1 provides sulfate concentration data compiled for this investigation and Appendix G.2 contains graphs of sulfate concentration over time. Table 11 contains water quality data collected from 2008 to 2010 for this investigation.

Water quality samples have been collected from wells completed in the three principal water-bearing units in the area: the basin fill, the undifferentiated Bisbee Group (e.g., the Morita Formation, Mural Limestone, and Cintura Formation), and the Glance Conglomerate. Many of the groundwater monitoring wells sampled in 1989 are no longer available for sampling because they were abandoned by 1990 or have gone dry.

Water samples collected from monitoring wells in the vicinity of the CTSA have been analyzed for metals, organic compounds, and inorganic parameters such as sulfate. As discussed in the Work Plan, metals and organic compounds are not of concern because detections have been infrequent and at low concentrations. Section 5 focuses on the distribution of sulfate, the subject of the Mitigation Order, and major element chemistry that may be useful for distinguishing different water types in the vicinity of the plume.

5.1.1 Sulfate Distribution

The areal, temporal, and vertical distributions of sulfate are described below.

5.1.1.1 Areal Distribution

Figures 24, 25, 26, and 27 are contour maps showing the areal distribution of sulfate in August 1989, summer 1996, August through November 2005, and the third quarter of 2010, respectively. Sulfate concentration contours on these maps are inferred using the maximum measured concentration at each location where differing concentrations were measured in closely spaced wells. This convention is a conservative method of plume delineation because it estimates the largest potential extent of the plume given the available data.

Figures 24 through 27 only show wells that have sulfate measurements for the period indicated with a few exceptions. The 1996 map shows 1997 data from wells for which 1996 data

were unavailable. The map for August through November 2005 shows the most recent data available for 2005 except that it also includes one data point from 2006.

The sulfate concentration contours are dashed to indicate that there is uncertainty in their exact locations. The sparse historical data and, in many cases, the lack of historical measurements from the same wells over time prevent precise positioning of contours and accurate determination of changes in contour positions over time. This is particularly true of the 250 mg/L contours, which are inferred over most of their extent for the older data sets. The large number of data points available for the third quarter 2010 constrain sulfate concentration contours to a greater degree than prior to the Mitigation Order investigation.

The sulfate concentration maps from 1998 through 2010 show sulfate extending from the area of the former evaporation pond and former irrigation area southwest to the vicinity of Naco, Arizona and to the south to Bisbee Junction. Data for the third quarter 2010 indicate that the sulfate plume extends over an area of approximately 2.8 miles in a northwest-southeast direction by 3.6 miles from northeast to southwest.

The historical and current data consist of sulfate concentrations in groundwater samples collected from the principal water-bearing units in the area: basin fill, undifferentiated Bisbee Group, and Glance Conglomerate. Appendix G.3 contains maps of the sulfate concentration in wells in basin fill, undifferentiated Bisbee Group, Glance Conglomerate, and with screens deeper than 650 feet bls. West of the Black Gap Fault, the sulfate plume occurs within the basin fill and

locally within the upper portion of the immediately underlying undifferentiated Bisbee Group. The plume is generally more laterally extensive in the basin fill than the bedrock. East of the Black Gap Fault, where the basin fill is unsaturated, the sulfate plume has been identified in the underlying Morita Formation and Glance Conglomerate. The sulfate plume does not occur in the subregion north of the Abrigo Fault and west of the Black Gap Fault, where wells are interpreted as intersecting a deep potentiometric system (Section 4.2.3) The areal distribution of sulfate is complicated in plan maps because the sulfate plume can be underlain and overlain by groundwater with low sulfate concentrations. This stratification of sulfate concentrations is evidenced on plan maps by extreme differences in concentration between nearby wells because one well is in the plume and the other well is outside the plume, either above or below it. The vertical distribution of sulfate is discussed further in Section 5.1.1.3 and depicted on Plates 2 and 3. At the request of ADEQ (ADEQ, 2010), sulfate contours for concentrations greater than 250 mg/L are depicted on the cross sections on Plates 2 and 3.

5.1.1.2 Temporal Trends

Figure 28 compares the areal extent of the sulfate plume in 1996, 2005, and 2010. As indicated in Figure 28, the general outline of the plume is similar in 1996, 2005, and 2010, with a few differences, as discussed below.

Figure 29 shows sulfate concentrations over time at wells in different portions of the plume. The margin of the plume migrated to the southwest between 1996 and 2005 and

impacted well NWC-03[5]. The average concentration at NWC-03 was 119 mg/L in August 1996, 460 and 390 mg/L in October and November 2005, 489 mg/L in the fourth quarter 2008, and 477 mg/L in the third quarter of 2010.

Elsewhere, between 1996 and 2005, changes in sulfate concentrations at the margin of the plume indicate that the plume expanded slightly, or, in places, contracted slightly. Concentrations at well TM-16 (in the southeastern portion of the plume near Bisbee Junction) increased from 500 mg/L in June 1996, to 528 and 619 mg/L in August and October 2005, respectively, indicating possible expansion of the plume (Figure 29). However, decreasing concentrations since 2005 at TM-16 indicate the plume contracted slightly. Similarly, sulfate concentrations at TM-42 in the southern portion of the plume near Purdy Lane decreased from 985 mg/L in July 1997 to 656 mg/L in October 2005 and 407 mg/L in 2010.

Sulfate concentrations at NWC-04[6] near Bisbee Junction also appear to have declined slightly over time. The sulfate concentration at NWC-04 CAP ranged from 248 mg/L to 314 mg/L between 1996 and 2002, whereas the concentration ranged from 200 mg/L to 240 mg/L between 2005 and July 2008 before the screen was deepened. The screen in NWC-04 was from 322 to 462 ft bls until July 2008 when the well was deepened and constructed with screened intervals from 540 to 580 bls and 755 to 795 ft bls. The August 2010 sample from NWC-04 has

[5] Note that NWC-03 is a replacement well for NWC-03 CAP, which is a capped well at the same location as NWC-03. Water quality data for NWC-03 and NWC-03CAP were combined for Figure 29, although NWC-03CAP was shallower than NWC-03 (Table 5).

[6] NWC-04 is a replacement well for NWC-04CAP, which is a capped well at the same location as NWC-04. Water quality data for NWC-04 and NWC-04CAP were combined for Figure 29. NWC-04 and NWC-04CAP had similar screen depths until July 2008 when NWC-04 was deepened (Table 5).

a sulfate concentration of 196 mg/L. Sulfate concentrations after July 2008 are representative of groundwater quality in the deeper portions of the bedrock at NWC-04. Nevertheless, sulfate concentrations at NWC-04 had declined somewhat prior to the deepening of the well.

Sulfate concentrations in the upgradient portion of the plume at TM-02 decreased substantially between 1989 and 1996 (from greater than 2,500 mg/L to less than 1,200 mg/L), although concentrations did not change significantly between 1996 and 2010 (Figure 29). Specifically, concentrations at well TM-02 were 1,200 mg/L in June 1996 and 1,280 mg/L in October 2005 (TM-02 was dry in 2008). The post-1989 drop in sulfate concentrations in TM-02 probably reflects the end of sulfate source loading when mine water discharge to the evaporation pond stopped in 1987. Sulfate concentrations in upgradient well BF-01 were 1,400 mg/L in October 1993, and 1,310 mg/L in July 2010, between 1,320 mg/L and 1,490 mg/L in 2008, and 1,310 mg/L in third quarter of 2010.

Changes in the general shape of the plume between 2005 and 2010 (Figure 28) are partly related to the additional data generated by the groundwater monitoring program and the drilling and installation of the BMO-2008 and BMO-2010 series wells that allow a more detailed definition of the plume boundary. For example, the “embayment” in the northern portion of the plume is defined by data from TM-07, and the RUIZ, BLOMMER, and COOPER wells. These wells have sulfate concentrations below 250 mg/L. Although this feature may have existed in 2005 (Figure 26), it would not have been defined because data from these wells were not available at that time. Data for TM-07 indicate sulfate concentrations greater than 250 mg/L in

1989 (up to 525 mg/L in April 1989) and 1996-1997 (Figures 24 and 25); but less than 250 mg/L in 2008, 2009, and 2010 (Figure 27), indicating a significant concentration decrease over time.

Differences between the 2005 and 2010 plume margins include a slight expansion to the west/southwest at the southwest extremity of the plume (defined by TVI 875), a slightly larger extension to the east in the northeastern portion of the plume (defined by NOTEMAN), and a slight contraction in the southeast portion of the plume near NWC-04. The slight expansion to the west/southwest at the southwest extremity of the plume is supported by the increase in sulfate concentration at NWC-03 from 390 to 477 mg/L between 2005 and the third quarter of 2010 (Figure 29). A slight contraction in the southeast portion of the plume near TM-16 is supported by the decrease in sulfate concentration from 619 to 474 mg/L between 2005 and the third quarter of 2010 (Figure 29) and the decrease in sulfate at TM-42 from 985 mg/L in 1997 to 407 mg/L in July 2010. In the northern portion of the plume, concentrations have changed little since 2005.

The rate of plume migration, based on the movement of the 250 mg/L contour over time (Figure 24 to 27), was likely higher between 1989 and 1996 than between 1996 and 2005 or between 2005 and 2010 due to reduced hydraulic gradients in the latter periods (Section 4.2.3.4). Because of dispersion and the reduction in hydraulic gradients over time, the plume may be relatively stagnant in some areas.

5.1.1.3 Vertical Distribution

Evaluation of the vertical distribution of sulfate is based on sampling data for wells located in close proximity, but completed with screen intervals at different elevations. Water quality sampling during drilling of the 2008 monitoring wells is also important in evaluating the vertical distribution of sulfate.

Historical sampling prior to the Mitigation Order indicated that west of the Black Gap Fault, where the basin fill is the principal aquifer, the sulfate plume was confined primarily to the basin fill. Wells completed in the underlying undifferentiated Bisbee Group formations or Glance Conglomerate west of the Black Gap Fault prior to the Mitigation Order investigation did not have sulfate concentrations greater than 250 mg/L. For example, at paired wells TM-02/TM-02A, TM-19/TM-19A, and GARNER 557/GARNER 635 in which one of the pair is screened in the plume in basin fill and the other in bedrock, samples from the bedrock aquifer had sulfate concentrations less than 250 mg/L (Appendix G and Tables 5 and 11). East of the Black Gap Fault, where the basin fill is unsaturated, historical sampling detected the sulfate plume within the Morita Formation and Glance Conglomerate but the vertical extent of sulfate was undetermined.

Work conducted for the Mitigation Order developed additional information on the vertical extent of sulfate. BMO-2008 and BMO-2010-series wells completed within the plume in basin fill, undifferentiated Bisbee Group, and Glance Conglomerate were installed at depths sufficient to define the depth of the plume in most cases. Also, the results of reconnaissance and

temporary well sampling during drilling (Section 3.4.4) were used to estimate the depth of the plume. Plates 2 and 3 illustrate the vertical distribution of sulfate by showing sulfate concentration data for monitoring wells in the fourth quarter of 2008 and for temporary wells. In order to depict all of the data, BMO-2010-1M and BMO-2010-2M data for the third quarter of 2010 have been added to the cross sections, even though the water quality and water level data were collected later than other wells in the cross-sections. The water quality data have been contoured in the cross-sections at the request of ADEQ (ADEQ, 2010a).

Sulfate concentrations from co-located wells and temporary wells demonstrate that some portions of the plume west of the Black Gap Fault in basin fill are underlain by bedrock that may or may not contain elevated sulfate. For example, well BMO-2008-7 is screened 50 feet below the basin fill-bedrock contact and has a fourth quarter 2008 sulfate concentration of 34.5 mg/L (Plate 2, Sections B-B' and H-H'). In contrast, sulfate in excess of 250 mg/L was found in both the basin fill and the upper portion of the Morita Formation at site BMO-2008-8 (Plate 2, Section H-H' and Plate 3, Section E-E') and in basin fill and Lower Mural Limestone at site BMO-2008-13 (Plate 2, Section B-B' and Plate 3, Section F-F').

BMO-2008-8M and BMO-2008-13M are screened approximately 620 feet and 400 feet below the basin fill contact, respectively. During drilling of BMO-2008-8M, sulfate concentrations in temporary wells constructed in the borehole ranged from 1,500 mg/L approximately 40 feet below the basin fill-bedrock contact to a low of 120 mg/L approximately 540 feet below the contact (Table K.7). During drilling of BMO-2008-13M, sulfate

concentrations in temporary wells ranged from a high of 840 mg/L approximately 200 feet below the basin-fill-bedrock contact to a low of 430 mg/L approximately 460 feet below the contact. BMO-2008-8M and BMO-2008-13M have fourth quarter 2008 sulfate concentrations of 197 and 494 mg/L, respectively. The concentration of 494 mg/L at BMO-2008-13M seems anomalous because it is located farther downgradient from the former evaporation pond than BMO-2008-7M which had a sulfate concentration of 34.5 mg/L. However, the sulfate concentration at BMO-2008-6M, located west and generally downgradient of BMO-2008-13M, is 199 mg/L, higher than the basin fill concentration of 60 mg/L at co-located well BMO-2008-6B.

Sulfate is vertically stratified within the basin fill west of the Black Gap Fault at the locations of GARNER 635 (Plate 2, Section C-C' and Plate 3, Section H-H') and BMO-2008-4B (Plate 3, Section F-F'). Depth-specific sampling during drilling of GARNER 635 in 2001 indicated that sulfate concentrations in the basin fill decreased from 632 mg/L to 25.8 mg/L between the depths of 280 feet and 345 feet bls (Wright, 2001). The total depth of basin fill at GARNER 635 is 540 feet and the static water level was measured at a depth of 184 feet in October 2001. Water quality samples collected at depths of 250 to 280, 345 to 375, 455 to 485, 545 to 575, and 630 to 670 ft bls had sulfate concentrations of 632, 25.8, 16.7, 39.8, and 54.2 mg/L, respectively (Plate 2). These data indicate that at the time of drilling, the sulfate plume was localized in the upper portion of the 360-foot saturated thickness of basin fill. The underlying bedrock in which GARNER 635 was completed has a fourth quarter 2008 sulfate concentration of 36 mg/L (Table 11), indicating that the sulfate plume does not extend into the bedrock at this location.

Reconnaissance sampling during drilling of BMO-2008-4B near well NWC-03 indicated that sulfate concentrations in the basin fill decreased from a maximum of 700 mg/L to 210 mg/L between the depths of 220 feet and 620 feet bls (Figure 30 and Plate 3, Section F-F'). A general decrease in concentrations occurred between 220 and 620 feet except for local minimum of 170 to 190 mg/L at 280 to 300 ft bls (likely related to the change from Stratex to reverse circulation drilling), and a local elevated concentration of 310 mg/L at 440 ft bls. The total depth of basin fill at BMO-2008-4B is approximately 630 feet and the static water level was measured at a depth of 131 feet in the fourth quarter 2008. These data indicate that the sulfate plume is localized in the upper half to two thirds (250 to 320 ft) of the 500-foot saturated thickness of basin fill.

East of the Black Gap Fault BMO-2008-9M, BMO-2008-10GU, BMO-2008-10GL, and BMO-2010-2M are screened in bedrock within the plume. BMO-2010-1M is screened in bedrock below the plume. The water table is in Morita Formation at BMO-2010-1M, BMO-2010-2M, (Plate 2, Section D-D'), BMO-2008-9M (Plate 2, Section H-H') and in Glance Conglomerate at BMO-2008-10GU and BMO-2008-10GL (Plate 2, Sections A-A' and H-H'). Reconnaissance and temporary well samples at BMO-2010-1M indicate that the sulfate plume extends to a depth between 280 and 390 ft bls, or approximately 55 to 165 ft below the water table (Section 3.4.4. 12 and Table K.14). BMO-2010-1M was screened below the plume from 440 to 540 ft bls, and third quarter 2010 sampling data indicate that the sulfate concentration at this depth was 150 mg/L. Reconnaissance samples and subsequent monitoring at BMO-2010-2M for the third quarter of 2010 indicate that the sulfate plume extends to the well's total depth of

380 feet bls (approximately 120 feet below the water table) (Section 3.4.4.13 and Table K.15). Sulfate was detected in BMO-2010-2M at a concentration of 915 mg/L during the third quarter of 2010.

Reconnaissance and temporary well samples at BMO-2008-9M indicate that the sulfate plume extends to a depth of approximately 600 ft bls or 320 feet below the water table (Table K.8). The sulfate concentration at BMO-2008-9M, completed below the plume with a screened interval of 665 ft bls to 765 ft bls, was 54.4 mg/L in the fourth quarter 2008 and 61 mg/L in the third quarter of 2010 (Table 11).

Sulfate concentrations at BMO-2008-10GU and BMO-2008-10GL in the fourth quarter 2008 were 1,390 mg/L and 1,290 mg/L, respectively. In the third quarter of 2010, the sulfate concentrations at BMO-2008-10GU and BMO-2008-10GL were 1670 mg/L and 1020 mg/L, respectively. Elevated sulfate was expected at BMO-2008-10GU based on reconnaissance and temporary well samples (Table K.9). Sulfate in excess of 250 mg/L at BMO-2008-10GL during quarterly groundwater monitoring was unexpected because reconnaissance water samples collected during drilling and airlift development indicated concentrations less than 100 mg/L in samples collected between 780 and 820 ft bls (Table K.10), as discussed in Section 3.4.4.9. The apparent vertical extent of the plume at BMO-2008-10GL is at least 800 ft bls based on samples from the well. The difference in static water level elevations between BMO-2008-10GU and BMO-2008-10GL indicates poor hydraulic connection between the water-bearing zones tapped

by the wells. Therefore, the source of sulfate in BMO-2008-10GL appears to be a fracture system or permeable zone that is not penetrated by BMO-2008-10GU.

5.1.2 Major Element Chemistry

5.1.2.1 Evaluation of Wells Within and Outside the Sulfate Plume

The composition of groundwater within and outside the sulfate plume was examined with regard to major ions, TDS, and pH. Figures 31 and 32A are trilinear diagrams or "Piper Diagrams" that display the major ion composition of water quality samples collected in 1996 and 2008, respectively. On a Piper plot, a water sample plots as a single point, with the location of the point on the diagram being a function of the relative concentrations of the constituents in the water sample. A group of samples representing a similar chemical composition will cluster around a single location on the plot, while samples representing different chemistries will plot in different locations. Samples representing a mixture between two different water sources, each with a different chemistry, will plot as a relatively straight "mixing line" between the clusters of points representing samples of each end member in the mixture. Figure 31 and Table 18 show data from selected wells completed within both the basin fill and undifferentiated Bisbee Group. Data selected for the diagram are from sample dates as close to June 1996 as possible. Figure 32A and Table 19A show data from wells completed in basin fill, undifferentiated Bisbee Group, and Glance Conglomerate that were sampled in the third quarter 2008. Five wells (AWC-03, TM-06, TM-15, TM-16, and TM-19A) are common to both Figure 31 and Figure 32A. At the

request of ADEQ (ADEQ(2010a), Stiff diagrams for the data in Tables 18 and 19A are provided in Appendix G.4.

There are two generally well-defined populations evident in Figure 31 that distinguish groundwater collected from inside the sulfate plume from groundwater collected from outside the plume. The distribution of data on the trilinear diagram indicates that the chemistry of groundwater outside the plume is generally similar in samples collected from both the undifferentiated Bisbee Group and basin fill. Likewise, the chemistry of groundwater inside the plume is also similar in both the undifferentiated Bisbee Group and basin fill. The obvious outlier in Figure 31 is the sample from NWC-05 that has a relatively high chloride concentration and may have been affected by the local infiltration of septage.

Figure 32A, depicting water quality data collected in 2008, also displays two populations that distinguish groundwater collected from inside the sulfate plume from groundwater collected from outside the plume, although there is a greater dispersion of data from wells outside the plume than in them. As with the 1996 data, the chemistry of groundwater inside the plume is similar in samples from basin fill, undifferentiated Bisbee Group, and Glance Conglomerate. The 2008 data show a larger range of water quality than do the 1996 data; particularly in samples from undifferentiated Bisbee Group and Glance Conglomerate. The majority of data for bedrock samples outside the plume lie along lines representing mixing between plume water and ambient groundwater.

The tight grouping of samples representing groundwater inside the plume, regardless of hydrostratigraphic unit (basin fill, undifferentiated Bisbee Group, or Glance Conglomerate), indicates a common origin for the high-sulfate water. Groundwater inside the plume is a calcium-sulfate type whereas groundwater outside the plume in basin fill is calcium-bicarbonate type, groundwater outside the plume in the undifferentiated Bisbee Group ranges from calcium-bicarbonate, calcium-sodium bicarbonate, and calcium-sodium-magnesium-bicarbonate types; and groundwater outside the plume from Glance Conglomerate is either calcium-bicarbonate or sodium-bicarbonate type.

Concentrations of calcium, magnesium, carbonate, and TDS strongly correlate with sulfate concentrations. This correlation exists for groundwater samples collected from the basin fill, undifferentiated Bisbee Group, and Glance Conglomerate. The concentration of TDS in a groundwater sample is a measure of the dissolved compounds in solution, whether ionized or not. Typically, the most abundant dissolved solids in groundwater are the major element cations of calcium, magnesium, sodium, and potassium, and the major anions of chloride, sulfate, and bicarbonate.

Appendix G.1 provides TDS, calcium, sulfate, and bicarbonate concentrations for historical groundwater samples. The data in Appendix G.1 indicate that the TDS concentration at TM-02 in the source area near the former evaporation pond ranged from a high of 5,530 mg/L to a low of 2,500 mg/L between January 1989 and November 1997. Sulfate, calcium, and bicarbonate can be seen to vary in rough proportion to TDS and to each other. Because there are

elevated concentrations of calcium, sulfate, and bicarbonate associated with the sulfate plume, the TDS within the plume is elevated. Mitigation actions that address sulfate would also address TDS because sulfate is a major component of the TDS.

On average, groundwater in the sulfate plume has a slightly lower pH than groundwater outside the plume. The pH of groundwater in the basin fill, undifferentiated Bisbee Group, and Glance Conglomerate outside the sulfate plume is neutral to slightly alkaline (generally between 7 and 8) and inside the plume is neutral to slightly acidic (generally between 6 and 7). Strongly acidic conditions (pH <5) have not been detected in groundwater near the former evaporation pond or tailing impoundments.

5.1.2.2 Evaluation of Bedrock Wells East of the Black Gap Fault

Figure 32B and Table 19B show third quarter 2008 data from wells completed in undifferentiated Bisbee Group and Glance Conglomerate east of the Black Gap Fault. These data were evaluated separately in an effort to identify chemical differences related to large head differences, different potentiometric systems, varying sources of water, and possibly different flow paths. The evaluation of major-element groundwater chemistry of the bedrock wells in the subregion east of the Black Gap Fault was conducted to look for any additional insight regarding the fate and transport of sulfate. The evaluation of these data was based on the premise that the major element chemistry of groundwater outside the plume would vary according to the geologic environment in which the water originated or through which it traveled, as a result of the water

trending toward chemical equilibrium with the minerals present along each flow path. Accordingly, groundwater from different sources, following separate and distinct flow paths, could have different geochemical signatures, provided the mineralogy and/or travel times along one flow path varied significantly from other flow paths.

This evaluation was restricted to data collected in 2008 from existing wells (Table 19B). No additional data were collected for this purpose. Only wells with a complete set of analytical data for major cations and anions were included. The Stiff diagrams and Piper plots generated for this analysis shown on Figure 32B and Figure 32C. All were generated using Waterloo Hydrogeologic's Aquachem (version 3.7) water quality data analysis software (Waterloo Hydrogeologic, 1997).

The water chemistry data for the wells were plotted as a series of Stiff diagrams, which allow a simple, visual comparison of the data from each well (Figure 32B). The data are plotted as concentrations in milliequivalents per liter, with the major cations (sodium, calcium and magnesium) plotted on the left and the major anions (chloride, bicarbonate and sulfate) plotted on the right of a central vertical axis. Higher concentrations plot farther from the central vertical axis, while lower concentrations plot closer to the central vertical access. Thus, the size of the diagram is directly proportional to the concentration of dissolved solids. The shape of the diagram reflects the relative abundance of the various constituents. Stiff diagrams with a similar shape and size indicate waters with similar major-element chemistry, whereas differences in the shape or size indicate variations in chemistry among the samples plotted.

The data were also plotted on a Piper trilinear diagram (Figure 32C). After plotting the data graphically, the patterns in the chemistry data were reviewed with respect to other data, including well location, well depth, water level, and the geologic formations in which the wells were screened. Although variations in the major ion chemistry were observed, they did not relate consistently to any other characteristics (well depth, water level, geology, etc.) that might support the notion that a difference in flow path was indicated. Most of the data from wells outside the plume indicated a calcium-bicarbonate-type water. Two samples (TM-06 MILLER and PALMER), and possibly a third (TM-08 SWAN), were a calcium-magnesium-sodium-bicarbonate-type water. However, the two groups of wells (i.e. those with calcium-bicarbonate type and those with the calcium-magensium sodium bicarbonate type water) did not appear to be distinct geographically or hydrogeologically. There did not appear to be any consistency within a small area; the two types of water could be found in close proximity to each other.

Regardless of the ambient water chemistry, the water quality data trended along a mixing line toward a calcium-sulfate dominated water. When plotted on a Piper diagram, there appeared to be a smooth continuum of water types from wells within the plume to wells outside the plume suggesting that from a chemistry standpoint and for the wells tested, the aquifer is acting as a homogenous medium over a large area.

5.2 Sulfate Fate and Transport

Sulfate is a naturally occurring, soluble, divalent anion (SO_4^{-2}) resulting from the oxidation of elemental sulfur, sulfide minerals (such as the minerals occurring in the ore deposits of the Warren Mining District), and organic sulfur. Anthropogenic sources of sulfate include the mining of sulfide minerals, sulfur-containing fossil fuels, household wastes and detergents, and industrial chemicals including sulfuric acid. Sulfate is a common ion in groundwater and is one of the major element ions used to chemically characterize water types (e.g., trilinear diagrams). Sulfate in solution tends to associate with cations, especially calcium and sodium.

Sulfate is non-volatile and does not partition into the vapor phase. Potential removal mechanisms for aqueous sulfate include reduction to a gaseous species such as hydrogen sulfide, precipitation as a solid phase, or sorption to solid phase aquifer materials. Sulfate reduction would require strongly reducing conditions, which are not seen in groundwater in the vicinity of the plume. Sulfate could precipitate as a metal sulfide in a reducing environment with aqueous metals, neither of which appear to be present in the plume area.

The concentration of sulfate in natural waters is controlled by the solubility of gypsum, which is less soluble than sodium or magnesium sulfates. Aqueous sulfate can precipitate as gypsum if concentrations of calcium and sulfate exceed the gypsum solubility limit. Hem (1985) identifies the concentration of sulfate in equilibrium with gypsum as between approximately 1,500 and 1,800 mg/L sulfate, although the actual concentration depends on the ionic composition of the water and chemical kinetics. Gypsum precipitation in the subsurface may

have occurred historically if sulfate concentrations in groundwater were large, but gypsum precipitation is not expected to be significant now because sulfate concentrations are generally less than gypsum saturation levels.

Research reported by EPA (2003c) indicates that sulfate does not adsorb strongly to soil and that sulfate is transmitted through unsaturated soil by percolating water. In general, soils retain sulfate weakly except in the presence of high amounts of ferric iron and aluminum oxides or organic matter (Bodeck et al., 1988). Sulfate can coprecipitate with calcium carbonate in soil, but this is not expected to be a significant sulfate removal process in the plume area.

Sulfate can be treated as a conservative ion for the purpose of evaluating migration of the sulfate plume because there are no significant chemical interactions at the site that would reduce the aqueous sulfate concentration in groundwater. Once dissolved in groundwater, the movement of the sulfate plume is affected primarily by physical properties.

The physical processes controlling movement of the plume are advection, dispersion, and dilution. Advection is the movement of sulfate along with the bulk movement of groundwater. The rate of advective transport is approximately the average pore velocity for a non- or poorly-sorbing constituent such as sulfate that is unsaturated with respect to it solubility limits. Dispersion refers to the real and apparent spreading of sulfate due to the mixing of waters with different concentrations as groundwater flows through saturated materials at different

groundwater velocities. Dilution is a process that reduces sulfate concentrations, and potentially the apparent plume movement, as recharge with low sulfate concentrations mix with the plume.

6. CONCEPTUAL SITE MODEL

The conceptual site model describes the sources, environmental pathways, and potential receptors of sulfate associated with the sulfate plume from the CTSA. This report provides a large amount of information on the hydrogeology of the CTSA area (Sections 3 and 4), the nature and extent of sulfate (Sections 3 and 5), and the concentrations of sulfate in drinking water supplies (Section 3.1). These previously discussed data on the sulfate plume are summarized in the conceptual site model. Figure 33 is a schematic diagram of the site conceptual model.

6.1 Sulfate Sources and Release Mechanisms

As currently understood, the potential historical sources of sulfate are the tailing impoundments, the former evaporation pond, and the former Warren Ranch irrigation area. These potential sources would have received water containing elevated sulfate concentrations. Water in the tailing impoundments would have elevated sulfate levels probably due to the oxidation of sulfide minerals contained in the ore. Water applied at the former evaporation pond and former Warren Ranch irrigation area came from dewatering operations in the mine area that had a range of sulfate concentrations depending on its origin in the underground workings of the Warren Mining District. Underground water from zones where sulfide minerals were oxidizing, were likely acidic, and had elevated concentrations of sulfate. Water pumped from unoxidized portions of the mineral deposits may have had low to moderate sulfate concentrations.

The primary sources of sulfate-bearing seepage to the sulfate plume were likely the former evaporation pond and the former Warren Ranch irrigation area. The former evaporation pond was likely the major source of seepage because the high average rate (2,746 gpm) and long duration (80 years) of water application combined with the high hydraulic conductivity of the basin fill on which the water was applied (Section 3.5) likely resulted in significant infiltration. Relative to the former evaporation pond, infiltration from the former Warren Ranch irrigation area was presumably less because of the lower average application rate (1,457 gpm) and the large area of agricultural land use would have resulted in a higher evapotranspiration rate.

Although it is likely that seepage from the tailing impoundments occurred during their operation, seepage from the tailing impoundments is believed to have been low relative to the former evaporation pond due to the low hydraulic conductivity of the tailing material (Section 3.2.7.2). Also, the tailing impoundments are largely north of the Abrigo Fault and west of the Black Gap Fault in a subregion that appears to be hydraulically isolated from the subregion containing the sulfate plume (Section 4.2.3.2). Present day seepage from the tailing impoundments is likely negligible based on the results of investigations by SET (1998a), the observation that sulfate concentrations in wells in the vicinity of the tailing impoundments do not exceed 250 mg/L (e.g., GL-03, BMO-2008-11G, COB WL, and TM-03), and other factors, including water level and geophysical data, discussed in Section 3.2.7.2.

The potential for the CTSA facilities to be a current or future source of sulfate is negligible because the facilities are inactive, only temporarily receive stormwater and rainfall,

and are pumped to maintain dry conditions in preparation for reclamation (Section 2.1). The current potential for the former Warren Ranch irrigation area to be a current or future source of sulfate is negligible because it has been inactive since 1985.

The release mechanism for sulfate-bearing water was land application of mine water for evaporation and irrigation. Water released to the surface of the former evaporation pond and former Warren Ranch irrigation area from approximately 1905 through 1987 infiltrated into the subsurface and migrated vertically to the groundwater table where it mixed with groundwater. The sulfate plume formed because the discharge of sulfate-bearing water to the former evaporation pond persisted for decades. The primary sources of sulfate-bearing seepage were eliminated when discharges to the former evaporation pond and former Warren Ranch irrigation area were eliminated in 1987 and 1985, respectively.

6.2 Environmental Pathways

The environmental pathway describes the transport medium and migration processes that may lead to exposure to sulfate-bearing groundwater. The environmental pathway of concern with respect to elevated concentrations of sulfate in drinking water supplies is groundwater flow. Although the sources of sulfate are inactive, groundwater in the plume still migrates in the subsurface under the current hydraulic gradients occurring in the hydrostratigraphic units in the vicinity of the plume. It is the migration of groundwater containing the plume by the process of

advection and dispersion that presents a risk of sulfate impact to drinking water supply wells in the vicinity of the plume.

Sulfate-bearing seepage into the shallow potentiometric system in the vicinity of the former evaporation pond mixed with groundwater in the basin fill and Morita Formation to the west of the Black Gap Fault and with groundwater in the Morita Formation and Glance Conglomerate to the east of the fault. Groundwater impacted by sulfate-bearing seepage then flowed downgradient in the direction of groundwater movement in each hydrostratigraphic unit (i.e., to the south, southwest, and west in basin fill and undifferentiated Bisbee Group bedrock on the west side of the Black Gap Fault, and to the south and southwest in the Glance Conglomerate and Morita Formation on the east side of the fault). As discussed in Sections 4.2.3.2 and 5.1.1.1, the sulfate plume is not present in the deep potentiometric system except at BMO-2008-10GL.

Groundwater flow in the shallow potentiometric system is currently southerly and westerly from the area of the former evaporation pond. As shown by Figure 27, the sulfate plume extends south to Bisbee Junction and southwest toward Naco. The leading edge of the plume appears to be moving southwest toward Naco even though the prevailing hydraulic gradient is to the west. This relationship is shown by Figure 34, which shows both the third quarter 2010 sulfate concentrations and groundwater elevations. The apparent movement of sulfate in a direction oblique to the direction of the hydraulic gradient in the shallow potentiometric system may be the result of historical hydraulic gradients due to groundwater mounding at the former evaporation pond or anisotropy in the bedrock and basin fill.

A factor that may influence the apparent inconsistency between sulfate distribution and current groundwater flow directions is the lack of pre-1989 groundwater level data. The development of a groundwater mound beneath the former evaporation pond could have increased the hydraulic gradient to the southwest, south, and southeast. As a result, the plume would have migrated southwest, south, and southeast under the influence of the mound until the mound dissipated and the regional hydraulic gradient became predominant, which now appears to be occurring. In that case, the apparent movement to the southwest may be the result of westward movement of sulfate that had migrated further south in the area east of Naco than is indicated in Figure 34. In addition to time varying hydraulic gradients, the shape of the plume is further influenced by transport through lower permeability, heterogeneous bedrock east of the Black Gap Fault, and higher permeability, homogeneous basin fill west of the fault.

Groundwater flow and sulfate transport can also be influenced by anisotropy in the bedrock and basin fill. Anisotropy in the bedrock can result from permeable features such as faults, fractures, and bedding planes having a preferred orientation. As discussed in Section 4.1.2.1, resistivity and borehole survey data show a structural fabric with preferred orientations in the northwest-southeast and north-south directions. Anisotropy in conjunction with south to southeast hydraulic gradients due to mounding at the former evaporation pond could have caused sulfate transport directions significantly different than those existing currently. Anisotropy in the basin fill may have resulted from a northeast-southwest trending sedimentary facies or structural fabric parallel to the trace of the Black Gap Fault (Figure 20). For example, anisotropy could occur if the basin fill were deposited as elongated bodies of higher and lower permeability

materials in a northeast-southwest basin adjacent to the Black Gap Fault or if a series of structures subparallel to the Black Gap Fault cut the basin fill. Such anisotropy in basin fill could result in a higher hydraulic conductivity in the northeast-southwest direction than the northwest-southeast direction peripheral to the Black Gap Fault.

The direction and rate of movement of the sulfate plume will also be locally influenced by areally non-uniform recharge rates and groundwater pumping. As sulfate moves downgradient, hydrodynamic mixing and dilution by low-sulfate recharge will act to reduce the average sulfate concentrations within the plume. This is evidenced by the apparent contraction of the plume on its southeastern boundary from 1996 to 2010 (Figure 28). Hydrodynamic mixing, dilution, and the absence of an ongoing source are important in reducing concentrations in both upgradient and downgradient portions of the plume. The reduction in hydraulic gradients over time due to dissipation of the groundwater mound has also acted to reduce, but not eliminate, the apparent rate of downgradient migration of the sulfate plume.

Sulfate is vertically stratified in basin fill along the southwestern margin of the plume (Section 5.1.1.3). Sulfate stratification was not observed in basin fill in the northern portion of the plume. The vertical stratification of sulfate in the basin fill may be enhanced by a high ratio of horizontal to vertical hydraulic conductivity in basin fill and bedrock.

Although movement of the plume has been primarily laterally in basin fill and bedrock, it has penetrated vertically into bedrock near the former evaporation pond. East of the Black Gap

Fault, the plume penetrated bedrock because the basin fill is thin. West of the Black Gap Fault, the plume penetrates bedrock below basin fill at BMO-2008-8M and BMO-2008-13M, but not at BMO-2008-7M, GARNER 635, or TM-19A. Sulfate may have migrated to depth at BMO-2008-8M because it is close to the former evaporation pond and proximal to the Black Gap Fault (Plate 2, Section H-H' and Plate 3, Section E-E'). Although there is a weak vertically downward hydraulic gradient between basin fill and bedrock (Section 4.2.3.5), rates of vertical movement into bedrock are expected to be small due to its lower hydraulic conductivity compared to basin fill and a high ratio of horizontal to vertical hydraulic conductivity (Section 3.5.3). The conditions that allow sulfate to penetrate to depth at BMO-2008-13M are uncertain.

6.2.1 Influence of Faults on Groundwater Flow and Sulfate Transport

Faults have been interpreted to play a role in controlling groundwater flow in the vicinity of the CTSA. The Abrigo and Black Gap Faults have been regarded as hydraulic barriers or aquitards in previous hydrologic modeling of the sulfate plume area (SET, 1998b and 1998c). Evidence cited for considering these features to be barriers to groundwater flow is the apparent discontinuity in water levels measured in wells on either side of the faults. Therefore, the influence of faults on groundwater flow in the area is largely inferred from potentiometric data.

SET (1998c) projected the Abrigo Fault from the Red Mountain area, northwest of the CTSA (Figure 3), to the south end of the South Tailing Impoundment. The fault trace is covered by basin fill and there is no definitive geologic evidence for the fault other than observed water

level data. However, as discussed in Section 4.1.2, resistivity geophysical data are interpreted as indicating a northwest-southeast structure in the vicinity of the inferred trace of the Abrigo Fault. Between 1989 and 2005, groundwater levels in monitoring wells north of the projected trace of the Abrigo Fault (for example, GL-03 and TM-9) were hundreds of feet lower than in monitor wells south of the fault (for example, BF-01 and TM-02A) as shown in Figures 12 through 15. Figures 17 through 19 show that from 2008 through 2010 GL-03 maintained water elevations several hundred feet less than in wells to the south. However, monitoring for this investigation also identified an area of low groundwater elevation that appears to straddle the trace of the Abrigo Fault based on measurements at BURKE, SRC, BMO-2008-11G, and GL-03. These data are the basis for interpreting a deep potentiometric system and the hydraulic subregion north of and in the vicinity of the Abrigo Fault and west of the Black Gap Fault (Section 4.2.3.2). The existing data suggest that the role of the Abrigo Fault may not be as simple as previously supposed because many wells interpreted as being in the deep potentiometric system are south of the inferred fault trace. Other differences between the subregions north and south of the Abrigo Fault are:

- Water elevations at GL-03, BMO-2008-10GL, BMO-2008-11G, and BURKE have been increasing over time while water levels at wells south of the fault have been decreasing or steady.

- Wells defining the subregion north of the fault are relatively deep, greater than 600 feet, and completed in bedrock whereas wells south of the fault range from shallow to deep with the shallow wells being completed in saturated basin fill.

- Sulfate concentrations in BURKE, SRC, BMO-2008-11G, and GL-03 are less than 50 mg/L (Table 11 and Figure 27) in contrast to wells in the subregion south of the fault which are in and marginal to the sulfate plume.

The Black Gap Fault is projected from Black Gap north-northeast of the CTSA (Figure 3). As discussed in Section 4.1, evidence for the Black Gap Fault includes a rapid increase in the thickness of basin fill to the west of the projected Black Gap Fault trace. Historically, groundwater levels in wells TM-02 and TM-02A west of the Black Gap Fault were tens to more than a hundred feet lower than in wells TM-29A and TM-41 east of the fault and south of the tailing impoundment (Figures 12 and 13). However, water level data collected from 2008 to 2010 from BMO-2008-8M, BMO-2008-8B, and BMO-2008-9M do not show large differences (about 20 feet) in water levels across the Black Gap Fault (Figures 18 and 19). These data suggest that water level differences across the Black Gap Fault south of the tailing impoundments may have diminished over time as the groundwater mound associated with the former evaporation pond dissipated. Apparent water elevation differences across the southern end of the Black Gap Fault in the study area, such as between TM-42 east of the fault and TM-19 and TM-19A west of the fault, have not been significant over time (Figures 13 through 19).

Although the evidence for the Black Gap Fault based on water elevation differences is not strong south of the tailing impoundments, SET (1998c) found that treating the fault as a low permeability zone in the numerical model improved the water level calibration. Furthermore, groundwater elevations east of the Black Gap Fault are anomalously low in some areas and vary widely over short distances in others (Figure 19) indicating a difference between bedrock-hosted groundwater regimes east and the basin fill and bedrock groundwater regime west of the fault.

As discussed in Section 4.2.3.2, potentiometric data can be interpreted to infer shallow, intermediate, and deep potentiometric systems. The shallow potentiometric system spans the Black Gap Fault and the intermediate potentiometric system is restricted to east of the Black Gap Fault, and the deep potentiometric system occurs in the northern part of the study area. The intermediate potentiometric system contains wells that show anomalously low (and high in the case of TM-16) water levels. The observed variations in water elevations east of the Black Gap Fault may be due to localized low permeability fault structures or other localized permeability variations within the bedrock. Lateral and vertical changes in bedrock permeability due to discontinuous fractures or variations in lithification or alteration can result in bedrock zones having significant permeability contrast and little or no connectivity to what is interpreted as the shallow potentiometric system. In those zones local pumping stresses may account for some of the observed variations in water levels because pumping in low permeability bedrock can cause localized dewatering and low water levels even at the low average pumping rates typical of domestic wells. The hydraulic subregion east of the Black Gap Fault was identified based on the observed variability of water elevations and distinctly different hydraulic gradients than those observed west of the fault.

Water levels in basin fill and bedrock of the shallow, deep, and intermediate potentiometric systems are interpreted to represent unconfined conditions. There is no evidence of confining beds or aquitards in the basin fill and bedrock, although perched conditions are indicated at BMO-2008-10 and BMO-2010-1. Localized confined conditions may occur, but would be hard to recognize unless associated with significant water level effects.

The traces of the Abrigo and Black Gap Faults have been inferred by projecting mapped surface expressions of the faults and on the basis of water level differences across the faults. The deep, shallow, and intermediate potentiometric systems are interpreted based on water level data that indicate multiple separate groundwater zones that are not in hydraulic equilibrium. The hydraulic subregions are defined with respect to the Abrigo and Black Gap Faults to identify areas that appear to possess different characteristics with respect to the magnitude of water levels, the variability of water levels with distance, and the direction of hydraulic gradients. The hydraulic behaviors that characterize the subregions can be due to contrasting hydraulic properties in the hydrostratigraphic units of the subregion, permeability contrasts that occur along fault zones that separate the subregions, or both. Although the degree to which individual faults exist and control groundwater flow is subject to interpretation, the traces of the Abrigo and Black Gap Faults do generally coincide with the transitions between the subregions and, therefore, are useful for representing the fundamental structural elements in the study area.

The sulfate plume occurs in the subregion south of the Abrigo Fault and west of the Black Gap Fault and in the subregion east of the Black Gap Fault. The subregion north of and in the vicinity of the Abrigo Fault and west of the Black Gap Fault contains the deep potentiometric system characterized by low-sulfate groundwater that does not appear to be hydraulically connected to the subregion to the south. The transition between the subregion north of the Abrigo Fault and that to the south may represent either a boundary between two different potentiometric systems or a difference between bedrock overlain by unsaturated basin fill (i.e. north of the Abrigo Fault) versus saturated basin fill (i.e. south of the Abrigo Fault). The

subregion north of the fault is not expected to significantly influence the hydrology of the subregion to the south, which contains the sulfate plume. The subregion south of the Abrigo Fault and west of the Black Gap Fault and the subregion east of the Black Gap Fault appear to have a hydraulic connection south of the tailing impoundments. The hydraulic communication across the Black Gap Fault south of the tailing impoundments is highly influenced by the character of the low permeability bedrock east of the fault. The groundwater flow and sulfate mass transfer from east of the Black Gap Fault to the subregion west of the fault will be controlled by both the relatively low hydraulic conductivities of the Glance Conglomerate and Morita Formation east of the fault, and any low permeability materials along the Black Gap Fault. The available data provide sufficient information on the distribution of the plume, the hydraulic properties of the hydrostratigraphic units, and potentiometric conditions in the subregions studied to understand the large-scale characteristics of groundwater flow and sulfate transport in the vicinity of the plume and to construct a flow and transport model.

6.3 Potential Exposure Pathway and Receptors

The Mitigation Order sets a sulfate concentration limit of 250 mg/L for drinking water. EPA's Drinking Water Advisory for sulfate (EPA, 2003a) states *"In order to enhance consumer acceptance of water resources, this advisory recommends reducing sulfate concentrations to or below 250 mg/L, the EPA's Secondary Maximum Contaminant Level (SMCL) for sulfate. The SMCL is based on taste considerations"*. With respect to health concerns, sulfate ingestion exerts a laxative effect with short-term as opposed to long-term exposure. EPA (2003a) states

"the health-based advisory value of 500 mg/L will protect against sulfate's laxative effects in the absence of high concentration of other osmotically active chemicals in the water".

The potential exposure pathway for sulfate is ingestion of sulfate-bearing water. The well inventory (Section 3.1) found that drinking water supply wells in the plume and near the plume edge include municipal and domestic water supply wells. A well that is screened entirely in the plume will produce water with a sulfate concentration greater than 250 mg/L. A well with a screen that only partially penetrates the plume may or may not have water that exceeds 250 mg/L sulfate depending on the proportions of plume and non-plume water drawn into the well. Figure 33 illustrates the source of sulfate, the migration pathway, and potential receptors.

Potential receptors of groundwater with sulfate in excess of 250 mg/L are users of municipal or private drinking water supply wells in the downgradient reaches of the plume near Bisbee Junction, Naco, and San Jose. Wells along the downgradient margin of the plume could be affected by sulfate if the plume migrates into the vicinity of the well screen. Wells completed below the plume could be affected by sulfate if downward migration of the plume occurs in response to naturally occurring or pumping-induced downward vertical hydraulic gradients. The potential for downward vertical migration of the plume depends on the ambient vertical hydraulic gradient, the hydraulic conductivity and the magnitude of any pumping induced vertical hydraulic gradient.

7. NUMERICAL MODEL OF GROUNDWATER FLOW AND SULFATE TRANSPORT

A numerical model for simulating groundwater flow and sulfate transport was developed for Task 3 of the Work Plan. HGC constructed and calibrated the model, and reported it in the initial version of the ACR (HGC, 2009c). The model was based on a pre-existing groundwater flow and sulfate transport model as described below. Clear Creek Associates obtained the model input files from HGC and ran the model in order to address ADEQ's specific questions on the model (ADEQ, 2010a) and to evaluate the potential to improve the model calibration in the portion of the model in bedrock east of the Black Gap Fault (Section 1.1).

The primary objective of the model is to evaluate potential mitigation actions for the Feasibility Study. To accomplish this objective, the model must predict the future distribution of hydraulic heads and sulfate concentrations resulting from implementation of potential mitigation actions. The model will also be used to estimate potential mitigation action pumping rates for use in developing preliminary designs and cost analyses for the Feasibility Study.

Prior to model development, an evaluation of the existing data indicated that although data are available for hydrologic conditions since 1989, historical information was lacking in several key areas. Limited data are available on the following: the application rates, exact locations, and chemistries of mine waters applied to the former evaporation pond and former Warren Ranch irrigation area; groundwater elevations prior to 1989; and groundwater quality

prior to 1989. Although some additional historical data not included in previous reports was compiled by this investigation, the paucity of pre-1989 data is still a significant data limitation.

Given the data limitations, model development focused on updating the existing groundwater flow and sulfate transport model developed by SET (1998c) (the SET Model) rather than constructing a new model, because the SET Model included most of the pre-1989 information that is available and many of the elements of the SET Model agree with the site conceptual model developed for this investigation. The updated SET Model developed for this investigation (hereafter referred to as the RSET Model) incorporates hydrogeologic data collected since 1998. Although the lack of data for calibration of historical conditions will provide little constraint on the pre-1989 predictions of the RSET model, the predictions of post-1989 conditions will be constrained by 19 years of hydrogeologic data, including information collected for this investigation. Constructing the RSET model to reflect new information on basin fill and bedrock geometry and calibrating it to potentiometric and water quality data since 1989 will allow the model to be used for simulation of current and potential future conditions.

Model development focused on simulating flow and transport in the basin fill because it hosts the majority of the plume and is the primary source of drinking water supply. In addition, the basin fill has high hydraulic conductivity compared to bedrock which has a lower hydraulic conductivity and, consequently, lower groundwater pumping capacity. The RSET Model will have a good ability to predict future conditions in the vicinity of the plume for evaluation potential mitigation actions.

This section documents the development of the RSET Model, including its construction, calibration, and sensitivity. The use of the RSET Model for predictive simulations will be reported as part of the Feasibility Study.

7.1 Model Construction

The RSET Model incorporates information acquired since the construction of the SET Model (SET, 1998c), including hydrogeological information reported in Sections 3, 4, and 5 and reflects the conceptual site model as reported in Section 6. This sub-section describes the components of the RSET Model and documents the revisions the SET Model and the rationale for those revisions. A summary of changes made to the SET Model is provided in Table 20. The model components described in this section include numerical codes, model domain, temporal discretization, boundary conditions, hydraulic stresses, flow and transport parameters, sulfate sources, and initial conditions.

7.1.1 Numerical Codes

The RSET Model retains the numerical codes used in the SET Model: MODFLOW (McDonald and Harbaugh, 1988) for groundwater flow and MT3D (Zheng, 1993) for sulfate transport. Groundwater Vistas, Version 5 (Environmental Simulations, Inc., 2007) was used for pre- and post-processing of modeling files.

7.1.2 Model Domain

The RSET Model applied the same spatial extents and discretization as the SET Model, but modified the number of model layers and the layer elevations. The extent, spatial discretization, and model layers of the RSET Model are described below.

7.1.2.1 Model Extent

The RSET Model extent, shown in Figure 35, covers an area of nearly 60 square miles and encompasses the sulfate plume. The model extends in the north-south direction from approximately the location of the North Tailing Impoundment on the north (Universal Transverse Mercator [UTM] 3,475,000 North) to the southern edge of current footprint of the El Oasis irrigation area which lies approximately two miles south of the United States-Mexico border (UTM 3,464,000 North). The model extends in the east-west direction from approximately two miles west of the NSD WWTF on the west (UTM 595,000 East) to approximately two miles east of the South Tailing Impoundment on the east (UTM 609,000 East). The model domain extends several miles beyond the current extent of the sulfate plume, and is sufficiently large to simulate long-term plume migration under different mitigation alternatives, including monitored natural attenuation.

7.1.2.2 Spatial Discretization

The RSET Model domain is discretized into 110 rows, 140 columns, and 4 layers. The size of each horizontal cell is 100 meters by 100 meters (length by width) (Figure 36).

7.1.2.3 Model Layers

The model layers of the RSET Model are modified from the SET Model to reflect information developed for this investigation on the geometries for the basin fill and bedrock as described in Sections 3, 4, and 5. The RSET Model contains three hydrostratigraphic units: 1) basin fill; 2) the undifferentiated Bisbee Group, consisting of the Morita Formation, Mural Limestone, and Cintura Formation; and 3) Glance Conglomerate. The RSET Model represents the undifferentiated Bisbee Group as two layers, rather than as a single layer as in the SET Model, to allow simulation of interactions between the shallow bedrock and basin fill. The RSET Model layering is as follows:

- Layer 1 = basin fill
- Layer 2 = shallow portion of the undifferentiated Bisbee Group
- Layer 3 = deep portion of the undifferentiated Bisbee Group
- Layer 4 = Glance Conglomerate

The shallow and deep portions of the undifferentiated Bisbee Group bedrock are specified to have equal thickness with the constraint that the thickness of the shallow portion

(Layer 2) could not exceed 400 feet. The layer elevations defining the bottom surfaces for the basin fill and the undifferentiated Bisbee Group were modified to agree with the bedrock surfaces developed from data compiled as part of Task 2.1 (Sections 3.2) and defined by drilling in 2008 (Section 3.4). Figure 37 shows bedrock surface contours interpreted from the bedrock elevations. The thickness of the undifferentiated Bisbee Group is interpreted from the observations of undifferentiated Bisbee Group lithologies in the BMO-2008 boreholes in the southern portion of the study area and the geologic interpretation in Section 4, including the assumption that the Bisbee Group-Glance contact dips to the south-southwest toward Greenbush draw at approximately 15 degrees. The 15-degree south-southwest dip of the Bisbee Group-Glance contact is maintained roughly to Greenbush Draw, and then reverses to approximately 15 degrees north-northwest. The reversal of dip is based on interpretation of regional folding (Section 4.1 and Plates 2 and 3).

7.1.3 Temporal Discretization

MODFLOW approximates transient groundwater flow with a series of steady-state "stress periods" that represent a specified time interval. Hydraulic stresses and boundary conditions may change from one stress period to another, but are constant within a given stress period. Each stress period is divided into computational "time steps" that correspond to real time sub-intervals. The SET Model used six stress periods for the historical simulation of 1905 through 1997. The RSET Model retains the definition of stress periods of the SET Model through SET Model stress period 6 (1997), although stress period 5 (1976 to 1987) was split into

two stress periods (1976 to 1985 and 1986 to 1987) for a total of 7 stress periods to simulate cessation of recharge from the former Warren Ranch irrigation area after 1985 (Sections 2.1.2). The RSET Model contains 11 stress periods following stress period 7, with each additional stress period representing one year to bring the historical simulation time through the end of 2008. A summary of each stress period and its relationship to real time is provided in Table 21.

7.1.4 Boundary Conditions

The RSET Model includes specified head and concentration, no flow, and specified flux and concentration boundary conditions. The first two boundary condition types are described below. Specified flux boundaries are described in the section discussing hydraulic stresses and sulfate sources (Sections 7.1.5 and 7.1.7 respectively).

7.1.4.1 Specified Head and Concentration Boundaries

The RSET Model retains the specified head boundaries of the SET Model because water level data collected for this investigation (Section 4.2.3) provided no justification for changing specified head locations. Specified head boundaries are assigned along portions of the south, east, and west boundaries of the model to establish hydraulic head conditions in areas where the model domain is not bordered by physical boundaries (Figure 38). The specified head boundary values are constant in time.

Specified sulfate concentrations are associated with specified head boundaries. When the specified head boundary induces groundwater inflow, the sulfate concentration in the inflowing groundwater is determined by the specified sulfate concentration at the boundary cells. The SET Model specified a sulfate concentration of zero. Sulfate concentrations at the specified head boundaries were assumed to be 8 mg/L for the RSET Model to provide a minimum background sulfate concentration. This value for background concentrations was selected based on sulfate concentrations measured in wells outside of the sulfate plume near Naco, Arizona and Naco Sonora. Actual background concentrations of sulfate are probably not spatially uniform, but rather vary with location depending on the source of recharge and the local geology. Thus, actual background sulfate concentrations can be greater than the 8 mg/L assumed for modeling.

7.1.4.2 No Flow Boundaries

No flow boundaries are used to represent physical or hydraulic barriers to groundwater flow. The RSET Model retains the no flow boundaries of the SET Model. No flow boundaries are specified on the north and east ends of the model domain (Figure 38). The northern no flow boundaries coincide with the Bisbee West-Gold Hill and Abrigo Faults in the northeast; and outcroppings of Paleozoic sedimentary rocks in the Naco Hills in the northwest. The eastern no flow boundaries in Layer 1 correspond to the outcropping of the undifferentiated Bisbee Group. The eastern boundary of Layers 2 and 3 is a no flow on the northern portion of the boundary and specified head on the southern portion. The eastern boundary of Layer 4 is a specified head

boundary rather than a no flow boundary because the Glance Conglomerate extends east of the model domain.

7.1.5 Hydraulic Stresses

Hydraulic stresses applied in the RSET Model include groundwater pumping and aquifer recharge. Information on historic pumping and recharge is described in Sections 3.2.6 and 3.2.7, respectively. The incorporation of these hydraulic stresses into the RSET Model is discussed below.

7.1.5.1 Groundwater Pumping

Groundwater withdrawals in the sulfate plume area are not required to be reported to ADWR. Consequently, detailed pumping records for area wells are scarce. This is also true for wells located in Mexico. The SET Model included 35 pumping wells, consisting of 11 domestic wells, 9 irrigation wells, 7 public supply wells, and 8 stock supply wells. Table 22 lists the water supply wells identified within the model domain, and lists the current status of the well, if known. The RSET Model retained the historical pumping rates specified in the SET Model through 1997 and updated pumping through the end of 2008. Wells and pumping rates used in the RSET Model are listed in Table 23.

Pumping rates for domestic wells not included in the SET Model were specified to pump at a constant rate of 0.3 gpm during years of operation. This pumping rate is based on an assumed domestic water demand of about 150 gallons per capita per day and a service of three individuals per domestic well. Pumping rates for stock supply wells not included in the SET Model were specified to pump at a constant rate of 1.8 gpm during the years of operation, which is the default rate used for stock supply wells in the SET Model. The years of operation are uncertain for some of the domestic and stock wells and had to be assumed. However, the model simulation results are expected to be insensitive to these assumptions because of the relatively low pumping rates in domestic and stock supply wells.

No changes to pumping in irrigation and municipal supply wells are made in the RSET Model prior to 1998. The SET Model did not include some municipal supply wells (e.g., AWC-02, NWC-2 and some Naco, Sonora wells); however the combined pumping rate from all wells associated with a given municipal supplier in the SET Model agreed with expected total production rates of that supplier, based on post-1997 pumping records (Section 3.2.6).

The RSET Model was modified to include post-1997 pumping data for water supply wells. The modifications include adding the municipal supply wells not explicitly included prior to 1998 and pumping wells that were installed after 1998 such as TVI 875 and AWC-05.

The pumping wells in the RSET Model are assigned to the model layer representing the corresponding wells' screened interval. For most wells, screened intervals were identified as

part of the data compilation (Section 3.2). For some wells, particularly older wells and wells located in Mexico, no well construction information is available. The screened intervals of wells with no construction data are specified as being in basin fill, the primary water supply aquifer, based primarily on the shallow depths of these wells.

7.1.5.2 Aquifer Recharge

The aquifer recharge sources specified in the RSET Model included all of the recharge sources from the SET Model, with some modifications, plus additional recharge sources identified in the data compilation (Section 3.2.7 and Table 7). The locations of the recharge sources in the RSET Model are shown in Figure 39 and include:

1. Natural recharge (high and low).
2. Evaporation pond (east and west).
3. Former Warren Ranch irrigation area (east and west).
4. Warren WWTF lagoons.
5. TVI Golf Course (original and expansion).
6. Naco, Sonora WWTF ponds (east and west).
7. El Oasis irrigation area (with added expansion area).
8. San Jose WWTF (original disposal and discharge to Greenbush Draw).

Natural recharge was grouped into "high" and "low" categories for the model domain, representing wash areas and mountain front recharge areas as "high" and areas between washes

as low (Figure 39). The "high" rate is representative of recharge along washes, and in the upland areas, representing mountain front recharge. The CTSA area represents an area between washes, and is thus classed as a "low" rate. As discussed in Section 3.2.7.2 of this report, data from borings conducted in the center of the tailing did not identify evidence of recharge, either under saturated conditions or unsaturated conditions. Water levels in surrounding wells also do not demonstrate evidence of mounding, or elevated recharge levels. In-situ testing of soils in the CTSA area demonstrated very low permeabilities, and the recharge rate applied to the CTSA was the "low natural" rate used in the remainder of the model domain. Additionally, HELP and SOILCOVER modeling evaluations (Section 3.2.7.2) have indicated that permeability of the tailing deposits is very low (ranging from 3.6×10^{-7} cm/s to less than 2.4×10^{-10} cm/s). For this reason, the "low" rate was applied to the CTSA area.

The RSET Model modified recharge from former Warren Ranch irrigation area to terminate at the end of 1985 rather than at the end of 1987 as specified in the SET Model as discussed in Section 2.1.2. Another modification was an increase in the recharge rate for the former Warren Ranch irrigation area on the east side of the Black Gap Fault. The SET Model specified the former Warren Ranch irrigation area recharge on the east side of the Black Gap Fault to be over 10 times less than on the west side of the fault. In the RSET Model the recharge rate for the former Warren Ranch irrigation area east of the Black Gap Fault was increased during model calibration to match the rate on the west side of the fault (Section 7.2.4).

The RSET Model adds recharge from effluent discharged from the San Jose WWTF. Recharge from the San Jose WWTF is applied as two sources as described in the data compilation (Section 3.2.7). From 1986 to 2006, effluent recharged the aquifer via an 11-acre land application effluent disposal site located next to the San Jose WWTF (EPA, 2003b). The recharge rate for this time period was assumed to be 48 gpm, which is approximately one-half of the design capacity of the treatment plan. In 2006, the San Jose WWTF was expanded and permitted to discharge 1.22 MGD of effluent to Greenbush Draw and ceased recharging effluent through land application at the San Jose WWTF. Data supplied by the COB shows that effluent production for the fourth quarter 2006 through the end of 2008 averaged about 0.41 MGD (Table 10). In 2008 effluent dependent flow was observed in Greenbush Draw for at least one mile downstream of the discharge point. The assumption made in the RSET model is that 90 percent of the effluent discharged to Greenbush Draw recharges the aquifer and that the recharge is distributed uniformly for one mile downstream of the discharge location.

The following additional changes were made to recharge sources in the RSET Model: 1) the source area of the Warren WWTF lagoons is increased to match its footprint as shown on aerial images, although the total recharge from the Warren WWTF lagoons was not changed; 2) recharge locations from the Naco, Sonora WWTF lagoons are slightly changed to match recent aerial images; and 3) the area representing the El Oasis irrigation area in Mexico was updated by increasing it from 306 acres in 1998 to 677 acres in 2008 based on recent aerial images. The per unit area recharge rate specified for the El Oasis irrigation area was kept constant, resulting in an

increase in the total aquifer recharge from 315 ac-ft/yr (the original rate specified in the SET Model) to 697 ac-ft/yr as the area expanded.

The SET Model assumed that natural and artificial recharge did not contain sulfate other than at the former evaporation pond and the former Warren Ranch irrigation area. The RSET Model modified recharge from WWTF sources and the El Oasis irrigation area to contain 46 mg/L sulfate. This value is the average sulfate concentration measured in samples taken from the effluent of the San Jose WWTF in 2006 and 2007 (Table 10). A sulfate concentration of 8 mg/L was assumed for natural recharge to be consistent with the lowest background concentrations in groundwater outside the plume (Section 7.1.4.1). However, background concentrations of sulfate vary across the study area. Sulfate concentrations in recharge from the former evaporation pond and former Warren Ranch irrigation area are discussed in Section 7.1.7.

Aside from changes described above, the recharge rates of the SET Model are used as the initial recharge rates for the RSET Model. Table 24 summarizes the areas and initial and final (calibrated) recharge rates of the recharge sources in the RSET Model.

7.1.5.3 Model Water Budget

Since little information was available to estimate a model-wide water budget, no attempt was made to create an overall conceptual water budget. This is primarily because there are inadequate water level data to construct flow nets or other approaches to derive boundary fluxes.

For this reason, the steady-state model was constructed to evaluate model-wide fluxes prior to pumping/recharge development in the area. To address the request of ADEQ (ADEQ, 2010a) for a discussion of a water balance for the groundwater flow model, the model water budget for the simulation conducted for this report is included in the following table.

Stress Period	Ending Year	Constant Heads	Well	Recharge	Net Storage Change	Balance
1	1930	-8015.2	-5.4	8766.3	-745.8	0.0
2	1954	-8293.6	-537.7	8905.9	-74.5	0.0
3	1961	-8014.7	-1820.3	8959.1	875.9	0.0
4	1975	-5662.1	-4632.4	9588.7	705.8	0.0
5	1985	-4724.1	-5369.4	9775.8	317.7	0.0
6	1987	-4514.2	-4755.5	7694.6	1575.1	0.0
7	1998	-3558.8	-4755.5	7697.2	617.0	0.0
8	1999	-2396.8	-4714.6	5061.0	2050.4	0.0
9	2000	-2291.3	-4905.9	5144.7	2052.5	0.0
10	2001	-2165.8	-5180.9	5225.8	2120.9	0.0
11	2002	-2036.1	-5283.7	5336.9	1982.9	0.0
12	2003	-1790.8	-5548.6	5402.6	1936.9	0.0
13	2004	-1594.5	-5703.1	5467.5	1830.1	0.0
14	2005	-1431.9	-5865.2	5532.4	1764.7	0.0
15	2006	-1267.0	-6020.8	5579.5	1708.3	0.0
16	2007	-953.8	-6169.1	5456.9	1666.0	0.0
17	2008	-818.8	-6138.0	5675.0	1281.7	0.0
18	2009	-691.2	-6136.2	5675.0	1152.3	0.0

Values are in acre-feet per year, derived from model simulated rates at end of stress period. This budget includes net boundary fluxes (constant head net flux), wells and recharge, and is presented as acre-feet/yr. Positive values indicate inflows. Negative values indicate outflows.

7.1.6 Flow and Transport Parameters

Flow and transport parameters in the model domain are defined by using zones, which are areas in the model domain with an equal value for a flow or transport parameter. Except for a few zones, the distribution of parameter zones is left unchanged from the SET Model, although parameter values for several zones were modified during calibration of the RSET Model. The

distribution and values for the flow and transport parameters used in the RSET Model are discussed below and a summary of the initial and final flow and transport parameters used in the RSET Model is provided in Table 25.

7.1.6.1 Saturated Hydraulic Conductivity

Hydraulic conductivity controls the ease at which groundwater can flow through pore spaces under a hydraulic gradient. The RSET Model initially used the hydraulic conductivity values and zones specified in the SET Model. Some of these values were adjusted during model calibration to achieve a better match between simulated and measured groundwater levels and sulfate concentrations. Adjustments to hydraulic conductivity values were guided by aquifer tests conducted during aquifer characterization (Sections 3.5 and 4.2.2, Tables 6 and 15, and Appendix N).

Table 25 lists the initial and final hydraulic conductivity values for the RSET Model. Model calibration to groundwater levels was more sensitive to changes in horizontal hydraulic conductivity than to vertical hydraulic conductivity. In general, estimated hydraulic conductivity values for the basin fill in the center portion of the basin were equal to or greater than values used in the SET Model. Measured values of horizontal hydraulic conductivity for the basin fill in the center of the basin ranged from approximately 23 ft/day to 100 ft/day, compared to the value of 23 ft/day used in the SET Model. The exception to this was a relatively low hydraulic conductivity value of 2.3 ft/day estimated for BMO-2008-6B. Values used in the SET Model for

the undifferentiated Bisbee Group (Layers 2 and 3) are consistent with aquifer test estimates for the undifferentiated Bisbee Group, except for the central portion of the basin, along Greenbush Draw. Here, 2008 aquifer tests yielded a much lower hydraulic conductivity value (1.2 ft/day) than used in the SET Model (20 ft/day). The SET Model hydraulic conductivity value for most of the Glance Conglomerate (1.6 ft/day) was generally greater than the hydraulic conductivity values (0.03 to 0.3 ft/day) estimated from tests in 2008 wells screened within the Glance Conglomerate. The Black Gap Fault is shown on Figure 40 as a linear zone of lower permeability cells in Layers 2, 3, and 4.

The RSET Model retains all of the hydraulic conductivity zones of the SET Model but adds a small lower conductivity zone in Layer 1 near BMO-2008-6B to match estimates from aquifer tests and to improve model calibration (Section 7.2.3). Figure 40 shows the final distribution of hydraulic conductivity zones in Layers 1 through 4.

7.1.6.2 Storage Coefficient and Specific Yield

The storage coefficient is the volume of water released from a unit area of aquifer in a confined aquifer under a unit decrease in hydraulic head. The specific yield defines the amount of water released from a unit area of aquifer in an unconfined aquifer for a unit decrease in the water table. Values for the storage coefficient and specific yield were adjusted during model calibration. The zones for storage coefficient, specific yield, and effective porosity are specified together. Although no changes to the original zones from the SET Model were required for

calibration of storage coefficient and specific yield, a new zone was added in Layer 1 (basin fill) on the west side of the Black Gap Fault and in Layers 2 and 3 (undifferentiated Bisbee Group) on the east side of the Black Gap Fault to accommodate the calibration of the effective porosity (Section 7.1.6.3). Figure 41 shows the final distribution of storage coefficient and specific yield zones in Layers 1 through 4. Table 25 gives the initial and final values for storage coefficients and specific yields used in the RSET Model.

7.1.6.3 Effective Porosity

Effective porosity is the fraction of the geologic material through which advective flow occurs. The transport velocity of the sulfate plume can be sensitive to value of the effective porosity. No site-specific measurements of effective porosities exist, but values of effective porosity are expected to be highest in the basin fill and lower in bedrock where most of the groundwater flow is limited to fractures. The SET Model values for effective porosity were generally within typical ranges for basin fill and bedrock materials except for a central zone of high effective porosity (0.55) in Layer 1 (basin fill) classified as silty-sand by SET (1998c) (Layer 1). Total porosities for fine sand are estimated to be between 0.26 and 0.55 (Domenico and Schwartz, 1998). Because an effective porosity of 0.55 is higher than the total porosity expected for silty sand, this effective porosity zone was modified during calibration of the transport model (Section 7.2.3). The effective porosity for zones in Layers 2 and 3 on the east side of the Black Gap Fault were also decreased during model calibration. Figure 41 shows the final distribution of effective porosity zones in Layers 1 through 4. Table 25 gives the initial and final effective porosity values used in the RSET Model.

7.1.6.4 Dispersivity

Dispersivity is an empirical parameter that determines the degree of hydrodynamic dispersion (mixing) of the sulfate in the longitudinal, transverse, and vertical directions relative to groundwater movement. No direct measurements of dispersivity exist for the model area. The simulated plume extent was relatively insensitive to the values of longitudinal, transverse, and vertical dispersivities; therefore adjusting dispersivity values was not emphasized during model calibration. Table 25 gives the initial and final dispersivity values used in the RSET Model. No changes were made to the distribution of dispersivity zones during model calibration. Figure 42 shows the distribution of dispersivity zones in Layers 1 through 4.

7.1.6.5 Solid-Water Distribution and Decay Coefficients

The RSET Model assumes sulfate to be a non-sorbing, conservative solute and specifies the solid-water distribution coefficient and the decay coefficient to be zero throughout the model domain.

7.1.7 Sulfate Plume Sources

The conceptual site model identifies the former evaporation pond and the former Warren Ranch irrigation area as the primary sources of the sulfate plume; however, exact recharge rates and sulfate concentrations for these two sources are unknown. Consequently, recharge rates and sulfate concentrations for the two sulfate plume sources were adjusted during calibration of the

RSET Model. Table 24 lists the initial and final recharge rates and sulfate concentrations specified for the former evaporation pond and former Warren Ranch irrigation area in the RSET Model. Additional discussion of sulfate sources is provided below. The rationale for the RSET Model specifications is discussed in Section 7.2.

The SET Model specified sulfate concentrations in recharge from the former evaporation pond and former Warren Ranch irrigation area on indirect evidence and model calibration. The SET Model used recharge sulfate concentrations of 3,000 mg/L and 1,500 mg/L for the evaporation pond and the former Warren Ranch irrigation area, respectively, plus two smaller zones of elevated sulfate concentrations in the former evaporation pond, one to the west of the Black Gap Fault (3,100 mg/L) and one to the east of the Black Gap Fault (3,650 mg/L). The sulfate concentration of recharge from the former evaporation pond was based on sulfate measurements between 2,500 mg/L and 2,950 mg/L taken from TM-02 shortly after water delivery to the former evaporation pond was terminated (Figure 29 and Appendix G). TM-02 is located directly west of the former evaporation pond. The degree to which concentrations from TM-02 represent the temporal and spatial average concentration in the recharge water from the former evaporation pond is unknown, because historical measurements of sulfate in recharge water at the former evaporation pond do not exist. Additional indirect evidence is sulfate concentrations measured in BF-01, directly west of the former evaporation pond. BF-01 sulfate concentrations ranged from 1,400 mg/L to 1,500 mg/L in samples taken in 1993, several years after delivery of mine water ceased (Figure 29). Sulfate concentrations in the recharge from the former Warren Ranch irrigation area are likewise poorly defined.

No documentation is available that gives specifics of the delivery rates or water quality for mine water sent to the former Warren Ranch irrigation area or to the former evaporation pond. The existing information, summarized in Section 2.1.2, indicates that from 1954 to 1974, 92 percent of the mine water was clean and hard in approximately equal proportions and the remainder was mineralized water. Potential sulfate concentrations in clean and hard water are described below.

Clean and hard water are reported to have representative hardness concentrations of 840 ppm and 3,100 ppm, respectively (Section 2.1.2). Groundwater samples collected in 2008 having a hardness between 700 mg/L and 900 mg/L contain sulfate concentrations ranging from approximately 250 mg/L to 720 mg/L while samples with hardness greater than 2000 mg/L had sulfate concentrations of approximately 1,300 mg/L to 2,900 mg/L (Table 11). Assuming the reported hardness values are based on calcium and magnesium, and that the ppm values are equivalent to mg/L as calcium carbonate equivalents, clean water may have had sulfate concentrations less than 1,000 mg/L and, perhaps, as low as 250 mg/L. Based on comparison to recent water samples, hard water probably had sulfate concentrations in the range of 3,000 mg/L, consistent with groundwater concentrations in the vicinity of the former evaporation pond, although lower concentrations could also have occurred. The sulfate concentration estimate for hard water is similar to, but lower than, the sulfate concentrations of 4,000 mg/L to 6,000 mg/L measured in Junction Shaft (Section 2.1.2).

Although there is no way to confidently characterize the rate and quality of water delivered to the former evaporation pond and the former Warren Ranch irrigation area, the comparison of hardness and sulfate provides possible ranges for sulfate in the clean and hard mine waters. Mine operations probably also influenced disposal of different types of water. For example, mine operations may have had an incentive to preferentially send clean water to the former Warren Ranch irrigation area for crops rather than hard water, which had a higher salt content. Additional factors impacting sulfate concentrations in the recharge from the former evaporation pond and the former Warren Ranch irrigation area are precipitation which would dilute sulfate and evaporation which would concentrate sulfate.

7.1.8 Initial Conditions

The initial condition for groundwater levels in the RSET Model is the hydraulic head distribution taken from the results of a steady-state simulation of pre-1905 aquifer conditions. The pre-1905 condition is used for steady-state conditions because this time pre-dates significant pumping and artificial recharge in the CTSA area. The steady-state model was calibrated as discussed in Section 7.2. To approximate background sulfate concentrations, the RSET Model specifies an initial sulfate concentration of 8 mg/L throughout the entire model domain as discussed in Section 7.1.4.1, although actual background values of sulfate probably varied with location.

7.2 Model Calibration

The RSET Model was calibrated for the steady-state flow conditions, transient flow conditions, and sulfate transport conditions. Model calibration consisted of adjusting flow and transport parameters and recharge sources so that the simulations better matched field-measured groundwater elevations and sulfate concentrations. The calibration of flow and transport proceeded iteratively because the calibration of the flow component affected the calibration of the transport component, and vice versa. The iterative calibration of flow and transport helped to constrain model parameters and reduce the non-uniqueness of the model. The discussion below explains the development of calibration targets, the calibration procedure, and the calibration results. A review of documents and files provided by HGC and SET did not identify a model run log, or other documentation of specific model calibration runs or activities. For this reason, no log has been included in this report, although it was requested by ADEQ (ADEQ, 2010a).

7.2.1 Calibration Targets

Calibration targets for the steady-state flow, transient flow, and transport model components were developed from targets used to calibrate the SET Model, data compiled for aquifer characterization (Section 3.2), and groundwater levels and groundwater quality sampling conducted during 2008 (Section 3.3). The development of calibration targets for each model condition is discussed below.

7.2.1.1 Steady-State Flow Targets

A challenge with using the pre-1905 period for the steady-state calibration is that no groundwater level measurements are available from that time period for use as calibration targets. The RSET Model used two inexact targets for calibration of the steady-state condition. The first target was the only target used to calibrate the steady-state flow condition of the SET Model, which is an indirect estimate of groundwater flux from the basin fill western boundary of 5,200 ac-ft/yr. This value was derived from an estimate made by Littin (1987) of the total groundwater flux leaving the basin in 1985. Because this target was estimated using a water balance, it can be considered approximate. The second steady-state target was a groundwater level measured at NWC-03 in 1930 (4,466 ft amsl) (Appendix F.1). This groundwater level measurement was considered useful for model calibration because it was early in the development history of the CTSA and provides a calibration target in the central portion of the basin; however, because it post-dates the steady-state calibration period it provides only an approximate calibration. The next groundwater level measured at NWC-03 was taken in 1960 and shows only a one-foot decline in the groundwater level. Both steady-state targets are inexact; therefore, they were used as a general guide, rather than hard constraints, for steady-state flow calibration. The two calibration targets for the steady-state flow condition are listed in Table 26.

7.2.1.2 Transient Flow Targets

Transient flow calibration targets for the RSET Model were identified from the groundwater level measurements compiled or collected for the aquifer characterization (Sections 3.2.4 and 3.3.2, respectively). Groundwater levels used for calibration targets were limited to area monitoring wells that represent static (non-pumping) conditions. Groundwater levels measured in wells east of the Black Gap Fault often have groundwater level measurements differing by several tens of feet between nearby wells due to bedrock heterogeneity. To avoid calibration residuals being dominated by wells east of the Black Gap Fault, they were excluded from use as quantitative calibration targets. They were used, however, to qualitatively evaluate the simulated groundwater gradients east of the Black Gap Fault and results for all potential target wells are presented in Table 27.

Ultimately, only groundwater levels measured in target wells west of the Black Gap Fault were used to calibrate the model, which includes groundwater level measurements from 49 wells between 1987 and 2008 for use as calibration targets. Final target values were developed by averaging multiple groundwater level measurements taken in a given year at the same well. The groundwater calibration targets used for the transient calibration are color coded in Table 27. All the wells available as targets are mapped in Figure 43. Wells not used (quantitatively) in the calibration are also presented in Table 27, but have been factored into overall calibration statistics (Section 7.2.3).

7.2.1.3 Transport Targets

Both qualitative and quantitative targets were used for calibration of the transport component. The highest priority for calibration was placed on a visual measure of how well the simulated sulfate plume agreed with major sulfate concentration contours (250, 500, 1,000, and 1,500 mg/L) interpreted from groundwater quality sampling in area wells conducted in the fourth quarter of 2008 (Figure 27). The fourth quarter 2008 sampling event provides the most comprehensive sulfate data set at the time of model calibration. The sulfate concentration contours interpreted from fourth quarter 2008 data provide the best approximation of the distribution of the sulfate plume at the end of the historical simulation period.

Quantitative targets for transport calibration were taken from groundwater quality measurements in individual wells. The RSET Model calibrated transport using sulfate concentration measurements compiled or collected for this report (Sections 3.2.5 and 3.3.2). Transport targets were developed from sulfate concentration measurements taken from 82 wells between 1985 and 2008. Final target values were developed by averaging multiple sulfate concentration measurements taken in a given year at the same well. The transport calibration target values are listed in Table 28 and the wells used for transport calibration targets are mapped in Figure 44.

7.2.2 Calibration Procedure

Calibration of both the flow and transport components focused on the parameter zones and calibration targets in the vicinity of the sulfate plume because the primary objective of the model is to evaluate plume control alternatives. This region also included most of the calibration target locations and aquifer characterization measurements. Parameter zones outside the current vicinity of the sulfate plume were left unchanged from the values used in the SET Model because calibration targets for outlying areas were limited or nonexistent.

Calibration parameters for groundwater flow included hydraulic conductivities, storage coefficients, specific yields, and artificial recharge rates. Specified-head boundary values were not adjusted during model calibration because recent water level measurements (Section 3.3.2) provided no justification for changing specified head locations or values from those in the SET Model. Natural recharge rates also were not adjusted during calibration to further constrain the number of calibration parameters. The values of the calibration parameters were varied manually or using automated calibration tools in order to have the simulation results better match calibration targets. The automated calibration tools used for calibration were PEST (Watermark Numerical Computing, 2008) and the automatic calibration package in Groundwater Vistas. Automated calibration tools allowed multiple parameters to be simultaneously considered in the calibration. Parameters were calibrated manually when only a single parameter was being tested.

The primary objective of model calibration for groundwater flow was to minimize the sum of squared residuals (differences between measured and simulated groundwater levels) and to have the mean residual (an indication of model bias) approach zero. Groundwater level measurements often fluctuate considerably both spatial and temporally, especially east of the Black Gap Fault, but also at some locations west of the Black Gap Fault (e.g., BMO-2008-11G), making large-scale reduction of residuals difficult. A qualitative evaluation of calibration was also performed by observing and attempting to remove spatial trends in residuals, such as areas with all positive or negative residuals.

Calibration parameters for transport included hydraulic conductivities (iterative with the flow calibration), effective porosities, dispersivities, and sulfate concentrations in recharge. The primary objective of transport calibration was to match the current sulfate plume distribution as interpreted from samples collected in the fourth quarter of 2008 (Figure 27). Secondary objectives were to minimize the sum of squared residuals (differences between measured and simulated sulfate values) and to have the mean residual (an indication of model bias) approach zero for time series data from the calibration targets.

7.2.3 Calibration Results

Measured water levels in fourth quarter 2008 for the calibrated transient flow condition are shown for the four model layers in Figures 45 through 48. Simulated sulfate concentration contours (maximum over all layers) with measured concentrations and contours are shown in

Figure 49. Initial and final parameters for the calibrated model are listed in Table 25, and statistics for the steady-state flow, transient flow, and transport calibration provided below and in Tables 26, 27, and 28 and Figure 50.

Transient groundwater flow calibration general statistics are presented in the table below as requested by ADEQ (2010a).

Transient Groundwater Flow Calibration Statistics		
	ALL TARGETS	TARGETS USED IN CALIBRATION
Data Count	252	157
Residual Mean	1.68 meters	-0.41 meters
Residual Standard Deviation	22.36 meters	6.32 meters
Sum of Squares	126,753.10 meters^2	6,266.59 meters^2
Absolute Residual Mean	11.79 meters	4.04 meters
Minimum Residual	-153.24 meters	-12.61 meters
Maximum Residual	44.91 meters	44.91 meters
Range in Target Values	197.78 meters	77.4 meters
Standard Deviation/Range	0.11	0.082
Root Mean Square Error	11.34%	8.16%

These statistics represent the differences between the calculated and actual heads, including all targets in the model. The mean residual is the average residual amount per data point, and the absolute residual mean is the mean of the residual absolute values. The overall root mean square error (RMSE) for the groundwater flow model was 11.34% when all the target values in Table 27 are considered. This RMSE is considered high, as the overall RMSE should ideally be less than 10%. (Spitz *et al*, 1996). In general, a limited number of targets will result in a higher RMSE. This was the case in this instance, as averaged values were used for many

targets. Also, a number of water level targets were not easy to simulate due to bedrock heterogeneity or proximity to fault features, which exhibit large head changes over small distances. The residual mean was near small (1.68) which indicates overall balance in heads in the model. In other words, high calculated values were approximately equal to low calculated values. The groundwater flow targets used for the transient simulations (as opposed to all targets) are highlighted in Table 27. Target statistics for wells used for model calibration (157 targets) are listed above, and the RMSE value for targets used in model calibration is 8.16%. The improvement in RMSE occurs for the calibration target set due to elimination of bedrock wells having widely varying water levels.

The calibrated RSET Model is able to match the 2008 plume extent in the basin fill and 2008 sulfate concentrations interior to the basin fill plume (Figure 49). The simulated 250 mg/L concentration contour closely matches the 250 mg/L sulfate concentration contour inferred from the fourth quarter 2008 groundwater quality monitoring. Interior to the basin fill sulfate plume, the simulated concentrations also provide a good match with the inferred 500 mg/L concentration contour at the southwest portion of the plume, although simulated concentrations are typically higher than the inferred concentrations farther into the plume interior.

The RSET Model is also able to simulate the sulfate plume in the bedrock layers in most areas. Sulfate concentrations at bedrock wells in the south-central portion of the former Warren Ranch irrigation area (e.g. TM-19A, GARNER 685) are accurately predicted to be between about 50 and 80 mg/L. West of the former evaporation pond, the model also accurately predicts

the edge of the sulfate plume in the undifferentiated Bisbee Group to be at the RUIZ well, although simulated concentrations north and east of the RUIZ well are unable to reproduce the apparent "embayment" of low concentrations in this area (Figure 27 and Section 5.1.1.2). This embayment may be a recent phenomenon because it is not manifest in 1989 (Figure 24) or 1996 (Figure 25). East of the Black Gap Fault, the simulated sulfate transport in the shallow bedrock is slightly lower than indicated by water quality measurements, however the sulfate time-series is closely approximated at the water supply well NWC-04 (Figure 51).

The simulated sulfate concentration time series at individual wells further illustrate the predictions of the calibrated model. Simulated and measured sulfate concentration times series for the NWC wells, AWC wells, and TM-19 and TM-19A are shown in Figures 51, 52, and 53, respectively. The simulated sulfate time-series at NWC-03, located near the south-western edge of the plume, predicts an earlier arrival of the sulfate plume than shown in measurements, but demonstrates the rapid rise in concentration and gives a good match to sulfate concentrations measured in 2008 (Figure 51). Farther downgradient, the model accurately simulates the plume as not reaching wells NWC-02, NWC-06, and the AWC wells (Figures 51 and 52). As mentioned previously, the model closely predicts the sulfate time series for NWC-04 on the east side of the Black Gap Fault. Interior to the sulfate plume, the model provides a good approximation of the concentration time series for TM-19, completed in basin fill (Figure 53) and for TM-19A, completed in the undifferentiated Bisbee Group (Figure 53).

Transient transport calibration general statistics are presented in the table below as requested by ADEQ (2010a).

Transient Sulfate Transport Calibration Statistics	
Data Count	241
Residual Mean	-7.5 mg/L
Residual Standard Deviation	442.1 mg/L
Sum of Squares	46139395.2 $(mg/L)^2$
Absolute Residual Mean	200.1 mg/L
Minimum Residual	-1317.1 mg/L
Maximum Residual	2753.0 mg/L
Range in Target Values	2747.4 mg/L
Standard Deviation/Range	0.2
Root Mean Square Error	16.09%

Overall RMSE for the groundwater transport model was 16.1%. This represents a relatively good calibration. Groundwater transport calibration is a much more sensitive process, and the error rate of 16.1% is considered satisfactory as a general rule of thumb. The residual mean, was near zero (-7.5) which indicates overall balance in concentration residual values in the model. As noted, the groundwater transport concentration targets for the transient simulations are listed in Table 28.

A review of documents and files provided by HGC and SET did not identify a model run log, or other documentation of specific model calibration runs or activities. For this reason, no log has been included in this report.

7.2.4 Modifications Made During Calibration

Three key modifications that were incorporated in the RSET Model provided the greatest improvement to the transport simulation. The key modifications were:

1. Reducing the effective porosity in a portion of "silty sand" zone of the SET Model (HGC Zone 4 of Layer 1) from 55 percent to 23.5 percent.

2. Reducing the sulfate concentration in the former Warren Ranch irrigation area recharge from 1,500 mg/L to 250 mg/L.

3. Increasing the rate of recharge from the former Warren Ranch irrigation area on the east side of the Black Gap Fault to match the rate on the west side of the fault.

Reducing the effective porosity and lowering the concentration in Warren Ranch recharge aided in reproducing the sulfate plume distribution on the west side of the Black Gap Fault, including the non-parallel plume orientation (Sections 5.2 and 6.2). Increasing the rate of recharge from Warren Ranch east of the Black Gap Fault improved the match between simulated and measured sulfate concentration time series for wells on the east side of the Black Gap Fault. Several other, more minor, modifications were also made to improve model calibration.

The key modifications and the other minor modifications are discussed below. Model sensitivities to these modifications are discussed in Section 7.3.

7.2.4.1 Reduction in Effective Porosity

As discussed in Sections 5.2 and 6.2, the sulfate plume on the west side of the Black Gap Fault has a southwest-northeast orientation; whereas a more east-west orientation would be expected based on the current hydraulic gradient in the basin fill. Section 6.2 discusses possible reasons for the apparent oblique orientation of the plume with respect to the current hydraulic gradient. These reasons include historical mounding due to recharge from the former evaporation pond and anisotropy in the basin fill.

Simulations that varied the estimated recharge rates for the former evaporation pond and former Warren Ranch irrigation area were unable to cause groundwater mounding sufficient to produce the southwestern hydraulic gradient necessary to reproduce the observed plume orientation. For example, increasing the recharge rate at the former evaporation pond alone or in the former evaporation pond and former Warren Ranch irrigation area to match their historical water delivery rates (i.e., 100 percent recharge efficiency) did not redirect the plume from a primarily west to a southwest orientation. The calibration to the current plume orientation could be significantly improved, however, by introducing material anisotropy and by reducing the sulfate concentration in the former Warren Ranch irrigation area.

Calibration simulations were conducted to simulate anisotropy by including zones of lower hydraulic conductivity and/or the effective porosity in the vicinity of the sulfate plume. Both approaches were able to improve the match to the current plume orientation; however, a

single zone of lower effective porosity in a portion of the "silty sand" zone (Zone 4) was selected over realizations with anisotropic hydraulic conductivity distributions because it provided the most reasonable mechanism to explain the current plume orientation. Modification of the hydraulic conductivity was rejected as an approach for simulating anisotropy because it did not agree with the hydraulic conductivity data estimated by field tests and could potentially bias simulation of mitigation actions that may use groundwater pumping for plume control.

Reducing the effective porosity in a portion of the "silty sand" zone (Zone 4) of the basin fill from 0.55 to 0.235 aided in guiding plume migration between the former evaporation pond and the current plume edge. The lower effective porosity zone may represent anisotropy in the basin fill due to contrasting sedimentary facies deposited by a historic drainage toward Greenbush Draw or a contrast in basin fill material types due to deposition along the scarp of the Black Gap Fault. Regardless of its origin, the effective porosity zone of 0.235 is a more reasonable value for basin fill than a value of 0.55.

7.2.4.2 Reduction in Sulfate Concentration in Former Warren Ranch Recharge

Lowering the sulfate concentration in recharge from for the former Warren Ranch irrigation area recharge from 1,500 mg/L to 250 mg/L significantly improved the calibration to the current plume distribution by preventing the simulated plume from migrating too far to the west (Section 7.3.1). The sulfate concentration in the water delivered to the former Warren Ranch irrigation area is uncertain (Section 7.1.7). Relatively low sulfate concentrations in

Warren Ranch recharge are consistent with the interpretation that the sulfate plume primarily originated from the former evaporation pond and that the contribution from the former Warren Ranch irrigation area recharge was a less significant source. The improvement to the transport calibration when the sulfate concentration in the former Warren Ranch irrigation area is reduced supports this supposition.

7.2.4.3 Increasing in Rate of Former Warren Ranch Recharge East of the Black Gap Fault

Increasing the rate of recharge from the former Warren Ranch irrigation area on the east side of the Black Gap Fault to match the rate on the west side of the fault improved the transport calibration on the east side of the Black Gap Fault. The SET Model divided the former evaporation pond and the former Warren Ranch irrigation area each into two zones, one zone each on either side of the Black Gap Fault. The recharge rate in the zone west of the Black Gap Fault was specified in the SET Model to be greater than the rate for the zone east of the fault. Increasing the recharge rate on the east side of the fault to match the rate on the west side of the fault during calibration of the RSET Model resulted in the build-up of hydraulic gradients sufficient to drive sulfate southeast of the former Warren Ranch irrigation area and better match measured sulfate concentrations in the undifferentiated Bisbee group east of the Black Gap Fault, such as at NWC-04.

7.2.4.4 Other Modifications

Other, less significant modifications were also made during model calibration. These modifications included the following:

1. Sulfate concentrations in the recharge from the former evaporation pond were reduced. The SET Model specified sulfate concentrations for the former evaporation pond recharge of 3,000 mg/L plus two small zones of 3,100 mg/L and 3,650 mg/L. The sulfate concentration was reduced to 2,500 mg/L for all recharge zones in the former evaporation pond. The lower concentrations improved the transport calibration, although model sensitivity to the adjustment in these concentrations was low.

2. Hydraulic conductivity values for the central portion of the basin fill (zone 4 of Layer 1) and the undifferentiated Bisbee Group (Zones 5 and 6 of Layers 2 and 3) were adjusted from the original values in the SET Model (Table 25). Horizontal hydraulic conductivity values were approximately doubled in the central portion of the basin fill (Zone 4) from about 23 ft/day to 39 ft/day. Conversely, horizontal hydraulic conductivity values in the undifferentiated Bisbee Group were reduced by a factor of two or three from the original values. These changes improved model calibration and agree with hydraulic conductivity estimates made in basin fill and bedrock wells (Table 15).

3. A small inclusion of lower hydraulic conductivity (2.3 ft/day) was created in the basin fill (Layer 1) around BMO-2008-5B to match estimates made from aquifer testing at that well (Table 15).

4. The effective porosities for zones in Layers 2 and 3 on the east side of the Black Gap Fault were reduced from 0.051 and 0.1 to 0.04 in order to facilitate sulfate transport on the east side of the fault.

5. Adjustments to storage coefficients and specific yield were made as a result of modifying the hydraulic conductivity values.

7.2.4.5 Model Review and Analysis

Clear Creek Associates conducted additional review of the RSET groundwater flow model provided by HGC, including parameter estimation calibration techniques using PEST and

review of model assumptions and limitations. This review focused on the flow model, including boundary conditions and model calibration improvements, particularly with respect to improving the calibration in bedrock east of the Black Gap Fault. Additional water level targets were identified and added to the model (including the areas east of the Bisbee Airport), and PEST calibration efforts were conducted to determine whether additional model calibration would be feasible. The PEST analysis improved the model calibration slightly, achieving an improvement in RMS error from 11.3% to 9.1%[7], but significant changes in model hydraulic parameters were noted. This level of improvement was insufficient to justify a full-scale recalibration of the model (which would require a further recalibration of the transport model) without further evaluation of the structural elements of the model.

Review of the model's structure included an analysis of the boundary conditions for the model domain. The model boundaries are defined by constant head cells, with proscribed values for the duration of the simulation. A review of the few long term hydrographs available suggested that heads in the aquifer have varied somewhat, with a downward trend evident in a well west of the western border of approximately 15 feet from 1949 to approximately 1985. The RSET Model uses fixed heads throughout the model simulation, which is likely to be appropriate for the eastern boundary (it straddles a groundwater divide), but may not be appropriate for the western and southern boundaries. These changes are not particularly large, and since the boundaries are far from the area of transport, it may be a relatively insignificant change. The

[7] The number of targets in the model was increased to 1411 data points from the 252 used in the HGC model. This was accomplished through a review of available data from ADWR GWSI, Well 55 and other sources. The larger number of targets results in a lower overall error rate for the original RSET model.

primary problem is that there are generally too few data to accurately set the boundary heads, so the heads would have to be set conceptually, relying upon a conceptual view of flow in the aquifer(s). A model evaluation experiment with a new boundary dataset did achieve a 6.1% RMS error, as heads nearer the boundaries could be improved. However, altering the boundary head configuration is not recommended at this time, without a more thorough review of model structure.

7.3 Model Sensitivity

A model sensitivity analysis is an evaluation of how changing model parameters affects model calibration and model predictions. Model sensitivities were evaluated specifically for the key modifications during model calibration, and more generally for most flow and transport parameters. Both groundwater flow parameters and groundwater transport parameters were evaluated with regard to sensitivity.

7.3.1 Sensitivity to Key Modifications

The key modifications made during model calibration were reducing the sulfate concentration in recharge from the former Warren Ranch irrigation area from 1,500 mg/L to 250 mg/L, reducing the effective porosity in a portion of the central basin fill zone from 0.55 to 0.235, and increasing the rate of recharge for the portion of the former Warren Ranch irrigation area east of the Black Gap Fault. These adjustments primarily affect only the transport simulation; therefore, model sensitivity was evaluated only with respect to sulfate transport.

Sensitivity was evaluated by comparing simulations of the following realizations with the calibrated model simulation:

1. Original SET effective porosity of 0.55 and the calibrated sulfate concentration in the recharge from the former Warren Ranch irrigation area of 250 mg/L.

2. Original SET effective porosity of 0.55 and sulfate concentration in the recharge from the former Warren Ranch irrigation area of 1,500 mg/L.

3. Original sulfate concentration in the former Warren Ranch irrigation area of 1,500 mg/L and calibrated effective porosity zone of 0.235.

4. Original recharge rate for the portion of the former Warren Ranch irrigation area east of the Black Gap Fault.

Simulated sulfate concentration contours (maximum across all model layers) for 2008 are shown for the first three sensitivity realizations in Figures 54 through 56. The fourth sensitivity realization is evaluated with the time series of sulfate concentrations at NWC-04 in Figure 57. When the calibrated recharge concentration of 250 mg/L is included for the former Warren Ranch irrigation area and the lower effective porosity zone is not included, the simulated plume is about 4,500 feet short of its current southwest extent (Figure 54). When neither the SET Model recharge concentration of 1,500 mg/L for the former Warren Ranch irrigation area nor the lower effective zone are included, the sulfate plume in the basin fill is simulated to be approximately 2,000 feet beyond the measured plume extent on the west and about 1,300 feet short of the measured plume extent on the south (Figure 55). When the calibrated effective porosity zone is included with a recharge concentration of 1,500 mg/L for the former Warren Ranch irrigation area, the simulated plume in the basin fill is close to the measured plume extent on the south but approximately 3,300 feet beyond the measured plume extent on the west (Figure

56). Only by including both the calibrated recharge concentration and the calibrated effective porosity, was it possible to match both the southern and western extents of the measured plume.

The sulfate time series at NWC-04 is sensitive to the recharge rate in the portions of the former Warren Ranch irrigation area east of the Black Gap Fault (Figure 57). Increasing the recharge rate in the former Warren Ranch irrigation area east of the Black Gap Fault results in sulfate migration to the south and east of the former Warren Ranch irrigation area footprint to match the elevated concentrations observed at NWC-04. Without the increase in recharge for the former Warren Ranch irrigation area, simulated concentrations at NWC-04 increase only slightly above background.

7.3.2 Sensitivity to Parameter Zones

The sensitivity of the flow solution to parameter values in individual zones was investigated by conducting a series of simulations in which the value of hydraulic conductivity for a specific zone was adjusted up and down. The following multipliers were used to adjust the value of horizontal hydraulic conductivity in each zone: 0.5, 0.75, 1, 1.25, and 1.5. For each simulation, the changes in the sum of squared residuals of groundwater level targets and the change in average change in hydraulic head were observed. The change in the sum of squared residuals is a measure of the sensitivity of the flow calibration to a particular zone. The change in the average hydraulic head is a measure of the sensitivity of the global flow solution to a particular zone.

The results of the sensitivity analysis are summarized in Table 29. The results of the sensitivity analysis reveal that the zones of relatively high sensitivity to the sum of square residual were Zones 4 (basin fill) and 5 (undifferentiated Bisbee Group). The sum of squared residuals showed a relatively moderate sensitivity for Zone 6 (undifferentiated Bisbee Group) and was relatively insensitive to other zones. In comparison, the average change in hydraulic head showed relatively high sensitivity to Zones 4 and 5 and also to Zone 13 (Glance Conglomerate); relatively moderate sensitivity to Zones 1 (basin fill), 9 (undifferentiated Bisbee Group), and 12 (Glance Conglomerate); and relatively low sensitivity to other zones. These results indicate that, except for Zone 13, zones which most influence the overall flow solution are also constrained by calibration targets.

7.4 Strengths and Limitations

The RSET Model will be used to evaluate potential sulfate plume mitigation alternatives. To use this tool appropriately, the strengths and limitations of the model need to be understood. The RSET Model has several strengths that make it the best available tool for evaluation of mitigation alternatives. The strengths of the RSET Model include the following:

- The large spatial extents of the model domain that reduce the influence of boundary conditions within the vicinity of the current plume extent.
- The long temporal extent, beginning in 1905, prior to the start of significant mining operations at the CTSA and other artificial groundwater withdrawal and recharge sources, minimizes the effect of initial conditions on future simulations.

- The revision and recalibration of the previously calibrated SET Model incorporates the most comprehensive datasets on aquifer characteristics, hydrogeological processes, and groundwater monitoring.

- The ability of the model to replicate hydraulic gradients downgradient of the former evaporation pond.

- The ability of the model to simulate the current (2008) plume extent as well as the sulfate concentrations over time in key wells within the plume (e.g., NWC-03, TM-19, TM-19A).

As with all numerical models, the RSET Model is a simplification of a more complex natural system. In particular, the history and hydrogeology of the sulfate plume have several complexities that are still not well understood conceptually. These complexities include, the historical rates, concentrations, and locations for water delivery to the former Warren Ranch irrigation area and former evaporation pond; the degree of faulting and its effects on local- and regional-scale hydrology and solute transport; the degree of heterogeneity in hydraulic properties within hydrostratigraphic units; and the degree of continuity in potentiometric conditions in deep bedrock. These uncertainties are common to numerical modeling and are not easily addressed, nor would addressing them provide substantial improvement to the predictions of the RSET Model versus the assumptions made for calibration.

The model can be expected to simulate the behavior of the sulfate plume, particularly in the basin fill where most of the sulfate plume is located and the majority of calibration measurements exist. However, the model is not expected to be an exact predictor of concentrations at precise locations or times. This is generally true because the RSET Model, like other numerical models, gives grid-cell and time-step averages of processes and properties that

vary continuously in space and time. For highly heterogeneous systems, such as the bedrock complex, model predictions may have difficulty matching point-scale values even as it provides a satisfactory representation of larger-scale hydraulic and plume behavior needed to evaluate potential mitigation alternatives. This will be particularly true in areas of steep hydraulic and concentration gradients such as near faults and at the margins of the sulfate plume.

With an understanding of the strengths and limitations of the RSET Model, the model can be used as a tool to evaluate potential mitigation alternatives. The predictive ability of the model will improve if it is periodically recalibrated as new data is collected. Additionally, to the degree that a mitigation alternative is implemented based on model predictions, field measurements would be used to validate and update the numerical model through a process of adaptive management.

8. CONCLUSIONS

Hydrologic field investigations required by the Aquifer Characterization Plan were implemented and completed between February 2008 and October 2010 in accordance with the 2008 Work Plan and the Work Plan for Focused Bedrock Investigation. This Aquifer Characterization Report is the final deliverable for the Aquifer Characterization Plan, although groundwater monitoring for Task 2.2 will be ongoing until superseded by a revised groundwater monitoring plan.

Significant accomplishments of the aquifer characterization work reported here include:

- Completion of a well inventory of drinking water supply wells within one mile of the sulfate plume, implementation of interim actions at 17 drinking water wells with sulfate concentration greater than 250 mg/L, and ongoing water quality monitoring at drinking water supply wells within one mile of the plume.

- Determination of the vertical and lateral extent of the sulfate plume through the installation of 20 monitoring wells and the collection and analysis of 956 groundwater samples from monitoring and drinking water supply wells.

- Characterization of hydrostratigraphic units, potentiometric relationships from 2008 through 2010, and hydraulic properties through compilation and evaluation of existing hydrogeologic information, geologic analysis of borehole data for new and existing wells, quarterly measurement of groundwater elevations at more than 50 wells, and the completion and analysis of 28 pumping tests at new and existing wells.

- Construction and calibration of a numerical model that simulates groundwater flow and sulfate transport to evaluate potential sulfate mitigation actions.

The aquifer characterization results reported here will be used to develop additional deliverables required under the Work Plan. Those deliverables currently in development are the Feasibility Study and a Mitigation Plan.

ADEQ (2010a) identified deficiencies in the original ACR with respect to the delineation of the plume in the bedrock aquifer and the poor calibration of the portion of the groundwater flow and sulfate transport model in bedrock east of the Black Gap Fault. An objective of the revised ACR and Focused Bedrock Investigation was to provide additional characterization of the groundwater flow system in bedrock east of the Black Gap Fault to improve the conceptual site model and address ADEQ's comments. The additional characterization activities better delineated the sulfate plume and reinforced the conceptualization of bedrock east of the Black Gap Fault as dominated by heterogeneous, low permeability conditions. Recognition of the bedrock heterogeneity is important because it indicates that conditions can vary significantly from place to place depending on highly localized features that make it difficult to calibrate the groundwater flow and transport model. It also implies that further bedrock characterization may not result in added improvement of the conceptual and numerical models at the scale of the sulfate plume. Unlike the relatively permeable and uniform basin fill west of the Black Gap Fault, the bedrock east of the fault is characterized by a low hydraulic conductivity relative to basin fill, discontinuous saturated conditions, hydraulic head conditions that can vary significantly over short distances, and wells with highly variable pumping capacities. These characteristics and their impacts on potentially applicable mitigation actions will be considered in the Feasibility Study.

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TABLES

Table 1
Generalized Geologic Column for the Bisbee-Naco Area

Age		Hydro-geologic Unit	GEOLOGIC UNIT
QUATERNARY	RECENT	ALLUVIUM	**Recent Alluvium** Unconsolidated stream channel sediments
QUATERNARY	Pliocene - Pleistocene	BASIN FILL	**Basin Fill** Valley fill, pediment, terrace and fan deposits; weakly to moderately consolidated interbedded gravel, sand, silt, and clay
TERTIARY		BEDROCK COMPLEX	**Intrusive Porphyry** Quartz latite porphyry
CRETACEOUS	*BISBEE GROUP*		**Cintura Formation** Grayish-red siltstone and mudstone, pale-red feldspathic sandstone, and minor greenish-gray calcareous claystone, few thin beds of limestone in basal 100 feet
			Mural Limestone Upper member: medium dark-gray limestone with subordinate sandstone in upper 50 feet Lower member: interbedded light-gray calcareous sandstone and siltstone and impure fossiliferous limestone
			Morita Formation Grayish-red siltstone and mudstone, pinkish-gray to pale-red feldspathic sandstone, minor greenish-gray calcareous claystone; few thin beds of impure limestone in the upper part and very subordinate pebble conglomerate in the lower part
			Glance Conglomerate Locally derived boulder to pebble conglomerate with grayish-red matrix
JURASSIC			**Jurassic Intrusive Complex** Stocks and dikes of porphyritic leucratic alkali granite
PALEOZOIC	*NACO GROUP*		**Colina Limestone** Medium-gray thick bedded limestone, locally slightly cherty
			Earp Formation Pale-red calcareous siltstone and mudstone with subordinate medium-gray thin bedded limestone and marl.
			Horquilla Limestone Light-gray, medium-bedded limestone with subordinate pale-red calcareous siltstone and silty limestone
	MISSISSIPPIAN		**Escabrosa Limestone** Medium- to light-gray thick-bedded to massive crinoidal limestone and medium- to dark-gray thin-bedded limestone
	DEVONIAN		**Martin Limestone** Medium- to dark-gray limestone, marl, dolomite and sandy dolomite, and calcareous siltstone
	CAMBRIAN		**Abrigo Limestone** Laminated hornfels with subordinate limestone, silty and argillaceous limestone with chert; overlain by interlaminated silty limestone and chert; glauconitic sandy dolomite, dolomitic sandstone, with minor interbedded marl, medium-gray locally dolomitized laminitic limestone
			Bolsa Quartzite Resistant yellowish- to reddish-brown-weathering siliceous sandstone
PRE-CAMBRIAN	*LOWER PRE-CAMBRIAN*		**Pinal Schist** Muscovite, sericite, chlorite and quartz schist

Source: Hayes and Landis 1964; Stegan et al, 2005

Table 2
Summary of Primary Well Screening for Well Inventory

Well Type	Well Use	Water Use	Number of Wells	Evaluated as Potential Drinking Water Supply Well
Monitor/Piezometer	Abandoned, Cancelled or Capped	Monitoring	50	0
Geotechnical/Exploration	Geotechnical/Cathodic	None	4	0
Monitor/Piezometer	Monitor/Observation/None	Monitoring/Test/None	29	2
Exempt	None Listed	None Listed	1	1
Exempt/Non-Exempt	Water Production	Domestic/Domestic-Irrigation/Domestic-Municipal-Industrial/Domestic-Stock/Domestic-Stock-Irrigation/Irrigation/Stock/Utility (Water Company)	115	115
Domestic Wells Identified During; Field Interviews, Bottled Water Deliveries List provided by Freeport and ADWR Program 35 Database	None Listed	None Listed	6	6
		Total	**204**	**123**

Notes:

CQB = Freeport-McMoRan Copper Queen Branch
ADWR = Arizona Department of Water Resources

Table 3
Summary of Well Verification for Well Inventory

Owner/Operator	ADWR 55 Registry No.	Well Name	Operational?	Active Drinking Water Supply Well?	Information Summary
Alvarez, Maria	650255	ALVAREZ	No Data	No Data	No Response
Anderson, David	613396	ANDERSON	Yes	Yes	Active Drinking Water Supply Well
Anderson, Mary	616775	ANDERSON 775	No Data	No Data	Owner Declined Participation in Program
Anderson, Mary	616776	ANDERSON 776	No Data	No Data	Owner Declined Participation in Program
Arizona State Land Department	616436	ASLD	No	No	ADWR Records indicate Stock Well
Arizona Water Company	616586	AWC-02	Yes	Yes	Active Drinking Water Supply Well; Public Water System
Arizona Water Company	616585	AWC-03	Yes	Yes	Active Drinking Water Supply Well; Public Water System
Arizona Water Company	616584	AWC-04	Yes	Yes	Active Drinking Water Supply Well; Public Water System
Arizona Water Company	590620	AWC-05	Yes	Yes	Active Drinking Water Supply Well; Public Water System
Banks, Douglas	647986	BANKS 986	Yes	Yes	Active Drinking Water Supply Well
Banks, Douglas	647987	BANKS 987	No	No	Inactive Drinking Water Supply Well
Barton, Loyd	85010	BARTON 010	No	No	Inactive Drinking Water Supply Well
Barton, Loyd	644919	BARTON 919	No	No	Inactive Drinking Water Supply Well
Bernal, Luz	648363	BERNAL	No Data	No Data	Owner Deceased; unable to contact relatives
Bisbee Municipal Airport, LLC	577927	BIMA	Yes	Yes	Active Drinking Water Supply Well
Bisbee, City of	903992	COB MW-1	Yes	No	San Jose Wastewater Treatment Plant Industrial Water Well
Blommer, Connie	633472	BLOOMER	Yes	Yes	Active Drinking Water Supply Well
Blommer, Connie	645536	BLOMMER	No	No	Interview with owner confirmed same well as 633472
Brindley, Lou	86775	BRINDLEY	No Data	No Data	Unable to Contact Owner
Bullard, Bob	602134	BULLARD	No	No	Inactive Drinking Water Supply Well
Burke, James	212268	BURKE	No	No	Inactive Drinking Water Supply Well
Campbell, Don	215509	CAMPBELL	No	No	Inactive Drinking Water Supply Well
Chambers, Terry	629807	CHAMBERS	Yes	Yes	Active Drinking Water Supply Well
Chase, Charles	648359	CHASE	No Data	No Data	Unable to Contact Owner
Cooper, Charles	637069	COOPER C	Yes	Yes	Active Drinking Water Supply Well
Cooper, Teresa	623564	COOPER	Yes	Yes	Active Drinking Water Supply Well
Cota, Barbara	651116	COTA	No Data	No Data	Well Not Located
Crowley	510298	CROWLEY	No	No	Inactive Drinking Water Supply Well
Dodson, John	644927	DODSON	Yes	Yes	Active Drinking Water Supply Well
Douglass, James	592791	DOUGLASS 791	No	No	Inactive Drinking Water Supply Well
Douglass, James	592792	DOUGLASS 792	No	No	Inactive Drinking Water Supply Well
Durazo, Neltiz	NR	DURAZO	No Data	No Data	No Response
East, Leon	599796	EAST	Yes	Yes	Active Drinking Water Supply Well
Eberwein, Geraldo	641726	EBERWEIN	No	No	Inactive Drinking Water Supply Well
Englund, Lee	565260	ENGLUND	Yes	No	Inactive Drinking Water Supply Well
Eppele, Geneva	805641	EPPELE 641	Yes	Yes	Active Drinking Water Supply Well
Eppele, Geneva	805643	EPPELE 643	No	No	Inactive Irrigation Well
Eppele, Geneva	805642	EPPELE 642	No	No	Well used for landscape Irrigation
Fleming, Kenneth	218386	FLEMING	No	No	Inactive Drinking Water Supply Well
Franco, Irma	500101	FRANCO	Yes	Yes	Active Drinking Water Supply Well
Fultz, Richard	212447	FULTZ	Yes	Yes	Active Drinking Water Supply Well
Galloping Goose Properties, LLC	628546	GGOOSE 546	No	No	Inactive Drinking Water Supply Well
Galloping Goose Properties, LLC	628547	GGOOSE 547	No	No	Inactive Drinking Water Supply Well
Garner, Terry	587635	GARNER 635	Yes	Yes	Active Drinking Water Supply Well
Garner, Terry	558557	GARNER 557	Yes	No	Inactive Drinking Water Supply Well
Goar, Sheila	610694	GOAR	No	No	Inactive Drinking Water Supply Well
Goar, Sheila	610695	GOAR RANCH	No	No	Inactive Drinking Water Supply Well
Goar, Sheila	610686	GOAR 686	No	No	Well Dry
Goar, Sheila	610687	GOAR 687	No	No	Well Dry
Goar, Sheila	610688	GOAR 688	No	No	Well Dry
Goar, Sheila	610689	GOAR 689	No	No	Well Dry
Goar, Sheila	610690	GOAR 690	No	No	Well Dry
Goar, Sheila	610691	GOAR 691	No	No	Well Dry
Goar, Sheila	610692	GOAR 692	No	No	Well Dry
Goar, Sheila	610693	GOAR 693	No	No	Well Dry
Gregg, Diane	630852	GREGG	No	No	Well Dry
Haubert, John	801607	HAUBERT	No Data	No Data	Owner Declined Participation in Program
Heck, Harold	507823	HECK	No	No	Inactive Drinking Water Supply Well
Hoban, Barbara	805290	HOBAN	Yes	Yes	Active Drinking Water Supply Well
Howard, Joel	NR	HOWARD	Yes	Yes	Active Drinking Water Supply Well
Hull, Charles	606854	HULL 854	No	No	ADWR Records indicate Irrigation Well; Owner indicated that well collapsed
Hull, Charles	606855	HULL 855	No	No	Inactive Drinking Water Supply Well
Humphrey, Manuela	649153	HUMPHREY	No Data	No Data	Owner Deceased; unable to contact relatives
Irons, Lee	632924	IRONS	No Data	No Data	Owner Declined Participation in Program
Jackson, Joseph	506034	JACKSON	No Data	No Data	No Response from Current Resident
Jayln Associates, LLC	209737	JAYLN	No	No	Inactive Drinking Water Supply Well
Keefer, Craig	209744	KEEFER	Yes	Yes	Active Drinking Water Supply Well
Kennedy, David	647003	KENNEDY	No	No	Interview with owner confirmed same well as ASLD 616436
Lesnik, Ron	587749	LESNIK	No	No	Vacant Lot; Inactive Drinking Water Supply Well
Lucero, Marcos	618175	LUCERO	No	No	Owner indicated well not operational
McConnell, Russell	590386	MCCONNELL 386	No	No	Inactive Drinking Water Supply Well; Incomplete NOI on file with ADWR
McConnell, Virginia	539265	MCCONNELL 265	Yes	Yes	Active Drinking Water Supply Well
Mendez, Alfredo	650256	MENDEZ	No	No	Well Dry
Metzler, Triny	35-71891	METZLER	Yes	Yes	Active Drinking Water Supply Well
Miller, Charles	522699	TM-15 MILLER	Yes	Yes	Active Drinking Water Supply Well
Miller, Charles	641342	MILLER 342	No	No	Well Dry
Miller, Charles	641340	MILLER 340	No	No	Well Dry - Stock Well
Miller, Charles	641341	MILLER 341	No	No	Well Dry - Stock Well
Minnerly, Herbert	650662	MINNERLY	No Data	No Data	Well Not Located
Minor, Lawrence	633316	MINOR 316	No	No	Inactive Drinking Water Supply Well
Minor, Lawrence	633317	MINOR 317	No	No	Inactive Drinking Water Supply Well
Moore, Patrick	538847	MOORE	Yes	Yes	Active Drinking Water Supply Well
Moroyoqui, Helen	647847	MOROYOQUI	No	No	Inactive Drinking Water Supply Well
Naco Water Company	627682	NWC-01	No Data	No	Inactive Drinking Water Supply Well
Naco Water Company	562944	NWC-02	Yes	Yes	No Response to Request for Data
Naco Water Company	203321	NWC-03	Yes	Yes	No Response to Request for Data
Naco Water Company	551849	NWC-04	Yes	Yes	No Response to Request for Data
Naco Water Company	627685	NWC-04 CAP	Yes	Yes	No Response to Request for Data
Naco Water Company	627696	NWC-05	No Data	No	Inactive Drinking Water Supply Well

CLEAR CREEK ASSOCIATES

Table 3
Summary of Well Verification for Well Inventory

Owner/Operator	ADWR 55 Registry No.	Well Name	Operational?	Active Drinking Water Supply Well?	Information Summary
Naco Water Company	575700	NWC-06	Yes	Yes	No Response to Request for Data
Naco Water Company	627683	NWC-02 CAP	No	No	Inactive Drinking Water Supply Well; Replaced by NWC 02
Naco Water Company	627684	NWC-03 CAP	No	No	Inactive Drinking Water Supply Well; Replaced by NWC 03
Ness, Martha	509127	NESS	Yes	Yes	Active Drinking Water Supply Well
Noble, Alice	618611	NOBLE	No Data	No Data	Unable to Contact Owner
Noteman, Russell	212483	NOTEMAN	Yes	Yes	Active Drinking Water Supply Well
Osborn, Dale	643436	OSBORN	Yes	Yes	Active Drinking Water Supply Well
Palmer, Patrick	578819	PALMER	Yes	Yes	Active Drinking Water Supply Well
Panagakos, Alfred	35-76413	PANAGAKOS	Yes	Yes	Active Drinking Water Supply Well
Parra, Steve	576415	PARRA	Yes	Yes	Active Drinking Water Supply Well
Pionke, Jim	613395	PIONKE	Yes	Yes	Active Drinking Water Supply Well
Pool, Joan	509518	POOL	Yes	Yes	Active Drinking Water Supply Well
Ramirez, Roberto	216425	RAMIREZ	Yes	Yes	Active Drinking Water Supply Well
Ray, Maria	803772	RAY	Yes	Yes	Active Drinking Water Supply Well
Rodriguez, Manuel	648360	RODRIQUEZ	No	No	Well Dry
Rogers, Ernest D	641803	ROGERS 803	Yes	Yes	Active Drinking Water Supply Well
Rogers, Ernest D	641801	ROGERS 801	No	No	Inactive Drinking Water Supply Well
Rogers, Ernest D	573596	ROGERS 596	No Data	No Data	Well Not Located
Rogers, Ernest M	216018	ROGERS E	Yes	Yes	Active Drinking Water Supply Well
Rollins, Mary	641750	ROLLINS	No Data	No Data	Unable to Contact Owner; Vacant Lot
Ross, Richard	517526	ROSS	No Data	No Data	Unable to Contact Owner
Ruiz, David	531770	RUIZ	Yes	Yes	Active Drinking Water Supply Well
Schwartz, Elizabeth	210865	SCHWARTZ	Yes	Yes	Active Drinking Water Supply Well
Shafer, Earnest	649994	SHAFER	No	No	Well Dry; Owner interview indicated no well on property, well bulldozed
Stark-Campbell	643481	STARK-CAMPBELL	No	No	Inactive Drinking Water Supply Well
Stephens	808560	STEPHENS	No	No	Inactive Drinking Water Supply Well
Sunbelt Marketing, Inc.	201531	SUNBELT	No	No	Inactive Drinking Water Supply Well
Sunnyside Holdings, LLC	588270	SUNNYSIDE	No	No	Inactive Drinking Water Supply Well
Swan, Charles	NR	SWAN	Yes	Yes	Active Drinking Water Supply Well
Swan, Charles	522817	TM-08 SWAN	Yes	Yes	Active Drinking Water Supply Well
Turquoise Valley, Inc.	568875	TVI 875	Yes	No	Golf Course Irrigation
Turquoise Valley, Inc.	802236	TVI 236	Yes	No	Golf Course Irrigation
Turquoise Valley, Inc.	567713	TVI 713	No	No	Well Capped
Valenzuela, Gustavo	645050	VALENZUELA	No Data	No Data	Owner Declined Participation in Program
Weed, Peggy	544535	WEED	Yes	Yes	Active Drinking Water Supply Well
Weiskopf, Tom	641802	WEISKOPF	Yes	Yes	Active Drinking Water Supply Well
Willson, Thomas	648362	WILSON 362	No	No	ADWR Records indicate Stock Well
Willson, Thomas	648361	WILSON 361	No	No	Inactive Drinking Water Supply Well
Zander, Paul	205126	ZANDER	Yes	Yes	Active Drinking Water Supply Well

Notes:

ADWR = Arizona Department of Water Resources

35-71891 = ADWR Program 35 ID

NR = No Record

Table 4
Results of Drinking Water Supply Monitoring

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)
ANDERSON	613396	3/20/08	7.25	21.1	1176	431
		5/5/08	7.03	21.8	1231	452
		7/14/08	7.11	21.6	1260	472
		10/15/08	7.10	21.3	1252	475
		1/27/09	7.27	21	965	488
		4/14/09	7.12	21.8	1229	534
		7/14/09	7.03	22.2	1372	550
		10/12/09	6.98	21.5	1375	510
		1/27/10	7.93	20.1	1449	523
		4/21/10	7.40	20.7	1439	627
		7/19/10	6.93	24.1	1420	648
AWC-02	616586	1/7/08	ND	ND	ND	14
		3/3/08	ND	ND	ND	16
		5/5/08	ND	ND	ND	13.3
		8/12/08	7.01	22.3	630	14.3
		10/23/08	7.31	23.1	464	15.9
		3/11/09	7.19	21.8	420	15.5
		4/22/09	7.17	22.6	430	14.7
		7/22/09	7.24	22.7	444	14.2
		10/21/09	7.19	21.3	468	16.8
		2/3/10	7.44	19.7	449	18.6
		4/23/10	7.56	19.7	526	18.3
		7/20/10	7.27	23.9	450	18.2
AWC-03	616585	1/7/08	ND	ND	ND	41
		3/3/08	ND	ND	ND	38
		5/5/08	ND	ND	ND	37.3
		8/12/08	7.28	22.4	469	38.8
		10/23/08	7.48	21.0	462	41.8
		3/11/09	7.25	21.2	445	64.2
		4/22/09	7.30	21.4	452	42.4
		7/22/09	7.39	22.6	456	41.8
		10/21/09	7.48	21.3	540	50.5
		2/3/10	7.44	19.7	449	42.0
		4/23/10	7.57	19.7	468	44.4
		7/20/10	7.29	23.8	460	46.7
AWC-04	616584	2/4/08	ND	ND	ND	18
		4/7/08	ND	ND	ND	18
		6/2/08	ND	ND	ND	14.3
		8/12/08	7.08	22.5	458	21.6
		10/23/08	6.91	22.2	616	24
		3/11/09	7.02	21.3	539	27.2
		4/22/09	6.93	22.1	560	26.1
		7/22/09	7.13	22.5	587	26.2
		10/21/09	7.00	21.2	607	25.7
		2/3/10	7.35	19.3	438	16.3
		4/23/10	7.14	19.2	625	27.4
		7/20/10	7.02	24.1	600	26.6

Table 4
Results of Drinking Water Supply Monitoring

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)
AWC-05	590620	2/4/08	ND	ND	ND	13
		4/7/08	ND	ND	ND	14
		6/2/08	ND	ND	ND	14.3
		8/12/08	6.74	23.3	425	14.9
		10/23/08	7.45	21.0	422	15.4
		3/11/09	7.31	22.1	398	16.5
		6/3/09	7.33	22.0	418	12.1
		7/22/09	7.49	24.4	423	14.1
		10/21/09	7.37	21.1	433	16.5
		2/3/10	7.35	19.3	438	16.3
		4/23/10	7.62	18.9	443	17.6
		7/20/10	7.62	24.2	440	19.1
BANKS 986	647986	2/27/08	7.53	21.8	980	44
		5/12/08	7.40	22.1	1021	65.2
		7/21/08	7.43	22.9	1034	82.2
		10/13/08	7.28	21.7	980	53
		1/21/09	7.66	21.6	872	164
		4/8/09	7.56	22.7	933	47
		7/9/09	7.59	23.1	871	70.9
		10/7/09	7.50	22.2	838	67.7
		2/25/10	7.56	21.1	1020	50.5
		4/20/10	7.71	22.8	1013	53.9
		7/20/10	7.70	23.2	828.3	71.5
BIMA	577927	2/6/08	6.69	22.2	1335	210
		4/25/2008[1]	6.37	23.1	1521	190
		5/13/2008[1]	6.58	22.7	1489	195
		6/23/2008[1]	6.30	23.3	1572	225
		6/23/08 DUP	6.30	23.3	1572	196
		7/29/2008[1]	6.44	23.0	1647	204
		8/28/2008[1]	M	23.0	1776	256
		9/23/2008[1]	6.29	23.0	1741	296
		10/22/08	6.41	22.3	1801	285
		1/20/09	6.40	21.7	1233	190
		1/20/09 DUP	6.40	21.7	1233	200
		4/7/09	6.45	23.4	1436	212
		7/8/09	6.31	23.4	1483	189
		10/5/09	6.34	22.7	1525	233
		1/20/10	6.88	17.0	NA	222
		4/19/10	6.70	21.9	1533	256
		7/12/10	6.70	24.0	1577	273
BLOMMER	633472	2/5/08	7.43	20.2	714	206
		4/21/2008[1]	7.06	21.9	753	201
		5/15/2008[1]	7.16	22.2	845	211
		6/23/2008[1]	6.93	21.5	903	193
		7/29/2008[1]	7.21	22.2	921	203
		8/27/2008[1]	7.12	22.1	864	189
		9/23/2008[1]	7.16	22.3	818	193
		10/22/08	7.17	21.3	873	200

Table 4
Results of Drinking Water Supply Monitoring

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)
BURKE	212268	2/7/08	7.17	23.0	411	29.5
		4/22/08	7.13	27.0	423	26
		8/5/08	7.06	26.8	496	21.9
		10/20/08	7.57	26.0	466	20.5
		2/11/09	7.23	25.0	363	23.9
		4/28/09	7.16	26.1	369	24.2
		8/19/09	7.36	26.7	486	22.5
		12/16/09	7.28	25.7	488	26
		3/2/10	7.56	12.3	432	23.8
		4/22/10	7.49	16.4	452	24.8
		7/21/10	7.56	25.6	423.7	33.1
CHAMBERS	629807	3/6/08	7.73	17.8	408	7.7
		5/5/08	7.15	22.1	421	6
		7/14/08	7.43	23.2	434	5.8
		10/15/08	7.41	22.5	420	4
		1/27/09	7.57	21.5	312	5.3
		4/14/09	7.42	22.4	384	6.8
		7/15/09	7.83	23.4	414	4.3
		10/13/09	7.41	22.6	410	6.5
		1/26/10	7.31	21.3	416	5.7
		4/23/10	7.47	20.9	427.5	8.34
		7/21/10	7.49	23.1	430	7.75
COLLINS	565260	2/12/08	6.88	21.6	1470	520
		5/29/08	7.01	22.0	1459	520
		7/31/08	6.86	21.6	1502	536
		10/20/08	8.44	24.7	1510	518
		2/11/09	6.68	21.4	1147	567
		4/21/09	6.92	22.5	1150	499
		7/22/09	7.00	22.4	1413	460
		10/20/09	6.60	21.9	1432	513
		2/2/10	6.98	21.2	1439	471
		4/23/10	6.99	20.6	1472	561
		7/20/10	6.69	25.0	1420	569
COOPER	623564	2/14/08	7.02	20.8	371	33
		5/14/08	8.08	22.1	419	34.2
		7/31/08	7.81	28.4	455	33.7
		10/20/08	8.44	24.7	448	31.2
		2/11/09	7.32	19.2	333	34.3
		4/21/09	8.19	24.9	346	33.4
		7/20/09	8.45	29.8	430	32.3
		10/14/09	7.85	24.6	423	33.6
		2/1/10	7.83	13.6	433	32.4
		4/22/10	7.82	17.9	433	34.5
		7/19/10	7.98	29.3	420	35.0

Table 4
Results of Drinking Water Supply Monitoring

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)
COOPER C	637069	3/20/08	6.93	21.3	2081	880
		5/5/08	6.78	22.4	2139	990
		7/15/08	6.86	22.3	2162	1040
		7/15/08 DUP	6.86	22.3	2162	960
		10/16/08	6.80	21.4	2078	1020
		1/27/09	6.92	20.5	1489	950
		4/14/09	6.85	21.6	1833	930
		7/14/09	6.75	22.1	1972	910
		10/12/09	6.70	21.8	1858	830
		1/27/10	7.27	19.6	1930	620
		4/22/10	6.76	19.5	1921	884
		7/21/10	6.84	22.9	1761	921
DODSON	644927	2/20/08	7.61	17.3	857	54
		5/12/08	7.11	21.1	1118	34.2
		7/24/08	7.25	21.6	1233	49.3
		10/13/08	7.15	20.5	1095	56.9
		1/22/09	7.20	20.4	892	51.8
		4/9/09	7.09	21.4	1103	50.1
		7/8/09	7.18	21.1	1153	55.9
		10/6/09	7.07	21.1	1140	49.3
		1/21/10	7.15	18.9	1227	44.6
		4/19/10	7.46	19.9	1261	48.8
		4/19/10 DUP	7.46	19.9	1261	48.6
		7/20/10	7.16	22.7	1260	47.5
DURAZO	NR	2/10/09	7.22	18.8	848	386
		4/20/09	7.37	22.7	901	367
		7/15/09	7.57	22.8	1102	332
		10/14/09	7.17	21.9	1048	377
		2/1/10	7.30	21.1	1105	344
		4/26/10	7.22	23.1	1099	388
		7/20/10	7.28	23.0	1070	405
EAST	599796	2/8/08	7.45	19.9	423	10.6
		5/14/08	7.31	20.9	595	14.8
		7/23/08	7.34	20.8	605	11.8
		10/14/08	7.33	20.3	531	8.9
		1/20/09	7.33	20.0	482	12.5
		4/8/09	7.32	20.6	555	15.9
		7/13/09	7.33	21.2	613	13.8
		10/8/09	7.29	20.8	593	13.4
		1/25/10	7.08	19.0	585	10.7
		4/21/10	7.42	20.5	616	14.4
		4/21/10 DUP	7.42	20.5	616	13.9
		7/14/10	7.45	22.2	577.1	12.1
EPPELE 641	805641	3/11/08	7.98	21.4	646	21.7
		5/12/08	7.21	21.7	667	24.7
		7/21/08	7.49	23.9	605	19
		10/14/08	7.56	20.4	642	21.8
		1/21/09	7.60	21.1	500	22.7
		4/8/09	7.56	22.4	538	19.7
		7/9/09	7.43	24.3	550	17.5
		7/20/10	7.58	23.3	529.2	21.1
FLEMING	218386	7/15/10	6.98	24.2	1390	573

Table 4
Results of Drinking Water Supply Monitoring

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)
FRANCO	500101	2/6/08	7.47	19.6	1301	670
		5/5/08	6.93	23.1	1557	680
		7/14/08	7.00	22.7	1586	680
		10/15/08	7.20	20.5	1560	680
		1/22/09	7.19	20.1	1178	740
		4/14/09	7.24	23.1	1416	690
		7/13/09	7.30	27.3	1532	670
		10/12/09	7.16	24.2	1493	650
		1/26/10	6.91	18.5	1529	640
		4/23/10	7.43	15.8	1559	699
		7/13/10	7.48	28.6	901.6	188
FULTZ	212447	2/27/08	6.76	21.1	1827	152
		4/21/2008[1]	6.74	22.0	1739	137
		5/14/2008[1]	6.88	22.3	1532	131
		6/23/2008[1]	6.74	22.0	1788	111
		7/29/2008[1]	6.74	22.2	1989	152
		8/28/2008[1]	M	21.6	1889	137
		9/23/2008[1]	6.82	21.9	1821	137
		10/22/08	6.80	21.4	1940	145
		1/21/09	6.74	21.2	1481	82
		4/9/09	6.78	21.5	1695	138
		7/13/09	7.04	23.4	1452	81
		10/8/09	7.00	21.6	1262	72
		10/8/09 DUP	7.00	21.6	1262	71.8
		1/25/10	7.11	21.8	1282	66.7
		4/20/10	7.32	21.2	1202	68.3
		7/14/10	7.75	22.2	1132	57.0
GALLANT	502527	2/11/08	7.46	20.2	604	17.9
		7/23/08	7.26	21.2	925	20.9
GARNER 635	587635	2/4/08	7.61	22.7	479	37.8
		5/5/08	7.26	24.9	468	35.8
		7/15/08	7.63	25.6	480	37.4
		10/15/08	7.65	24.1	472	36
		1/28/09	7.69	23.4	368	37.4
		4/15/09	7.83	24.1	412	36.9
		7/16/09	7.56	25.1	445	35.7
		10/14/09	7.58	25.2	446	36.1
		2/2/10	7.79	22.8	465	35.1
		4/22/10	7.84	23.7	464.1	36.9
		7/20/10	7.57	25.3	458.2	38.8
GGOOSE 547	628547	5/21/08	7.08	22.7	856	199
		8/15/08	7.02	24.8	915	178
		10/29/08	7.27	22.6	897	216
		2/24/09	7.06	23.8	851	186
		5/14/09	7.15	23.9	743	174
		8/19/09	7.20	23.8	887	175
		11/11/09	7.15	23.1	897	188

Table 4
Results of Drinking Water Supply Monitoring

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)
HOBAN	805290	2/27/08	6.93	22.1	1359	510
		5/7/08	6.88	22.3	1532	670
		7/14/08	6.88	23.1	1719	690
		10/16/08	6.98	22.4	1624	692
		1/28/09	6.82	21.3	1220	580
		4/15/09	7.07	21.7	1423	700
		7/14/09	6.78	22.6	1551	670
		10/15/09	6.75	22.7	1487	670
		10/15/09 DUP	6.75	22.7	1487	780
		3/2/10	7.12	19.8	1575	580
HOWARD	NR	3/4/08	7.06	20.4	1280	571
		5/8/08	6.95	21.0	1494	673
		7/14/08	7.00	21.1	1566	610
		10/15/08	7.00	20.6	1598	683
		1/28/09	6.82	21.0	1203	640
		1/28/09 DUP	6.82	21.0	1203	640
		4/15/09	7.02	21.5	1397	620
		7/15/09	7.16	21.5	1539	640
		10/12/09	6.89	21.4	1414	600
		1/27/10	7.35	20.0	1714	440
		1/27/10 DUP	7.35	20.0	1714	520
		4/21/10	7.16	20.8	1490	710
		7/19/10	6.94	24.6	1350	548
KEEFER	209744	2/6/08	7.70	19.0	378	6.8
		5/6/08	7.19	20.3	512	9
		7/16/08	7.21	21.4	539	8
		10/28/08	7.32	20.1	534	21.2
		1/28/09	7.42	19.5	356	6.1
		4/16/09	7.29	20.0	452	7.7
		7/14/09	7.35	22.1	533	7
		10/13/09	7.24	20.7	516	8.7
		1/26/10	7.15	18.8	483	7.3
		4/20/10	7.44	20.5	540.9	8.77
		7/15/10	7.50	22.2	535.8	8.84
MCCONNELL 265	539265	2/20/08	7.21	21.1	1435	720
		5/6/08	6.77	21.6	1668	737
		7/15/08	6.91	22.3	1775	700
		10/15/08	6.82	21.3	1686	703
		1/28/09	6.85	21	1274	660
		4/15/09	7.04	21.3	1472	657
		7/15/09	7.01	22.2	1607	662
		10/12/09	6.77	21.7	1594	666
		1/26/10	6.71	21.5	1641	685
		4/22/10	6.95	20.1	1691	811
		7/21/10	6.86	23.5	1560	805

Table 4
Results of Drinking Water Supply Monitoring

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)
METZLER	35-71891	3/5/08	7.27	21.6	1055	317
		5/15/08	7.12	22.8	1051	329
		7/31/08	7.16	22.5	1078	317
		10/20/08	7.24	22.2	1080	305
		10/20/08 DUP	7.24	22.2	1080	326
		2/11/09	7.12	21.3	818	321
		4/20/09	7.22	23.2	845	313
		7/15/09	7.41	22.9	1031	293
		7/15/09 DUP	7.41	22.9	1031	309
		10/14/09	7.1	22.7	989	315
		2/1/10	7.22	21.7	1021	286
		5/18/10	7.56	21.0	1053	330
		7/16/10	7.20	24.1	1007	330
MOORE	538847	2/20/08	7.69	22.2	362	7.1
		5/8/08	7.09	22.4	432	7.5
		7/16/08	7.34	23.0	482	9.8
		10/29/08	7.32	22.4	452	19.2
		1/29/09	7.11	21.7	328	6.6
		4/16/09	7.40	22.1	374	6.4
		7/15/09	7.44	23.3	439	5.8
		10/13/09	7.36	22.6	429	7.1
		1/26/10	7.54	19.6	423	6.3
		4/22/10	7.47	20.6	433	7.40
		7/15/10	7.44	24.1	431.3	7.54
		7/15/10 DUP	7.44	24.1	431.3	7.11
NESS	509127	7/24/08	7.35	26.5	563	50.2
		10/16/08	7.47	21.4	542	48.9
		1/26/09	7.39	17.2	422	52.3
		5/11/09	7.52	28.8	472	45.9
		8/11/09	7.56	28.7	525	39.8
		11/12/09	7.53	24.5	537	51.3
		2/2/10	7.67	19.7	535	48.7
		4/21/10	7.70	23.5	518.9	42.1
		7/19/10	7.58	28.9	524.7	48.1
NOTEMAN	212483	2/5/08	6.70	19.9	1317	310
		5/13/08	6.67	23.0	1445	272
		7/24/08	6.68	24.2	1539	274
		10/23/08	6.57	23.2	1643	356
		1/19/09	6.38	22.9	1098	322
		4/7/09	6.56	23.8	1375	303
		7/8/09	6.55	24.6	1405	260
		10/5/09	6.48	24.1	1442	281
		1/20/10	6.79	20.3	1450	289
		4/19/10	6.81	22.4	1446	307
		7/19/10	6.77	24.6	1438	309

Table 4
Results of Drinking Water Supply Monitoring

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)
NWC-02	562944	10/27/08	7.47	22.2	438	5.1
		2/12/09	7.58	21.6	330	6.6
		4/23/09	7.39	23.8	373	6.4
		7/21/09	7.62	23.9	408	5
		10/21/09	7.32	22.6	436	6.8
		2/3/10	7.68	19.6	423	8.5
		4/21/10	7.57	22.1	413	7.26
		7/20/10	7.36	23.7	412.5	6.87
NWC-03	203321	3/4/08	ND	ND	ND	560
		6/9/08	ND	ND	ND	524
		10/27/08	7.07	21.9	1374	489
		2/12/09	7.06	20.2	1023	412
		4/23/09	6.98	21.9	1129	466
		4/23/09 DUP	6.98	21.9	1129	460
		7/21/09	7.21	22.9	1194	458
		10/21/09	6.94	21.8	1224	444
		2/3/10	7.24	20.7	1214	444
		4/21/10	7.22	21.6	1178	433
		7/20/10	7.04	22.8	1229	477
NWC-04	551849	3/4/08	ND	ND	ND	240
		6/9/08	ND	ND	ND	231
		10/27/08	7.32	25.0	856	162
		1/22/09	7.23	22.9	688	184
		2/12/09	7.20	19.8	699	181
		2/12/09 DUP	7.20	19.8	699	198
		3/11/09	7.15	23.4	846	197
		4/23/09	7.21	24.1	797	188
		5/28/09	7.01	24.1	933	210
		6/24/09	6.93	25.6	792	169
		7/21/09	7.48	24.3	859	193
		8/19/09	7.12	24.5	906	183
		9/23/09	7.16	23.8	953	202
		10/21/09	7.18	24.3	875	191
		11/18/09	7.24	22.9	909	191
		12/16/09	7.28	22.3	926	193
		2/3/10	7.49	22.3	844	167
		3/8/10	7.33	22.5	880	182
		4/21/10	7.34	22.8	913	218
		5/18/10	7.68	25.8	901.3	210
		6/15/10	7.31	24.5	917.5	212
		7/20/10	7.28	28.3	873.2	188
		8/25/10	7.55	24.8	820.9	196
		9/29/10	7.38	24.5	920.2	205

Table 4
Results of Drinking Water Supply Monitoring

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)
NWC-06	575700	3/4/08	ND	ND	ND	7.9
		6/9/08	ND	ND	ND	7.2
		10/27/08	7.35	23.3	414	6.4
		2/12/09	7.54	21.8	306	8
		4/23/09	7.30	24.5	354	7.3
		7/21/09	7.63	23.5	388	6.4
		10/21/09	7.26	23.2	413	8
		2/3/10	7.61	20.5	404	7.5
		2/3/10 DUP	7.61	20.5	404	7.4
		4/21/10	7.54	22.4	387	8.49
		7/20/10	7.33	26.0	388.6	8.59
OSBORN	643436	2/25/08	7.35	22.4	508	16.4
		5/13/08	7.22	22.2	576	17.2
		7/22/08	7.24	22.9	618	17.7
		7/22/08 DUP	7.24	22.9	618	17.5
		10/16/08	7.39	22.4	595	15.9
		1/20/09	7.33	22.4	469	16
		4/7/09	7.25	24.0	542	17
		8/18/09	7.16	24.6	643	17.4
		10/5/09	7.14	22.9	599	17.9
		1/21/10	7.47	19.5	591	15.6
		4/19/10	7.60	21.5	601.9	19.3
		7/12/10	7.69	24.2	594.0	18.4
PALMER	578819	2/14/08	7.91	17.5	435	15.9
		5/13/08	7.92	22.9	508	16.6
		7/22/08	7.64	25.8	548	16.2
		10/16/08	7.61	17.0	527	15.9
		1/20/09	7.33	19.4	441	14.3
		4/8/09	7.65	19.1	475	15.4
		7/8/09	7.47	27.2	521	14.3
		10/5/09	7.81	22.2	538	16.2
		1/20/10	7.72	11.9	510	13.8
		4/22/10	7.97	13.6	520	16.7
		7/12/10	7.62	30.2	518.8	15.7
PANAGAKOS	35-76413	4/21/08	6.80	20.5	1228	410
		7/21/08	6.95	21.9	1390	444
		10/13/08	6.86	21.2	1386	480
		10/13/08 DUP	6.86	21.2	1386	500
		1/22/09	6.92	19.7	997	397
		4/9/09	6.81	21.7	1228	431
		4/9/09 DUP	6.81	21.7	1228	426
		7/9/09	6.89	22.3	1469	490
		10/6/09	6.83	21.1	1328	472
		1/21/10	7.06	18.8	1291	318
		4/20/10	7.25	21.0	1528	608
		7/20/10	6.90	24.0	1560	706

Table 4
Results of Drinking Water Supply Monitoring

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)
PARRA	576415	2/11/08	7.08	21.8	1067	360
		5/15/08	7.10	21.8	1200	405
		7/31/08	7.00	22.4	1248	423
		7/31/08 DUP	7.00	22.4	1248	404
		10/20/08	7.07	22.9	1246	387
		2/13/09	7.24	22.1	965	405
		4/20/09	7.10	22.6	971	372
		7/20/09	7.17	23.9	1174	375
		10/20/09	6.80	22.5	1188	388
		2/1/10	7.07	21.5	1197	353
		4/22/10	6.91	20.3	1219	417
		7/14/10	7.13	22.2	1201	403
		7/14/10 DUP	7.13	22.2	1201	391
PIONKE	613395	2/6/08	7.53	19.9	910	394
		5/7/08	7.08	21.4	1100	391
		7/17/08	6.99	21.9	1209	420
		10/27/08	7.03	20.8	1175	460
		1/29/09	7.13	19.9	847	385
		4/14/09	7.58	20.7	1053	411
		7/13/09	7.35	21.5	1165	472
		10/7/09	7.43	21.1	1100	403
		3/8/10	7.72	18.6	1201	406
		4/26/10	7.22	21.9	1224	438
		7/15/10	7.32	22.3	1158	474
POOL	509518	2/20/08	7.95	20.9	497	134
		5/19/08	7.40	22.2	585	122
		7/31/08	7.47	22.3	599	117
		10/21/08	7.51	21.4	598	120
		2/13/09	7.62	20.8	473	141
		4/21/09	7.73	22.6	470	124
		7/20/09	7.76	22.9	579	122
		10/20/09	7.22	21.2	577	122
		2/24/10	7.56	22.4	577	110
		4/22/10	7.75	20.2	606.5	130
		7/14/10	7.38	21.7	580.9	117
POWER	624535	2/12/08	7.11	18.9	428	15.5
		7/22/08	7.10	21.7	795	20.2
RAMIREZ	216425	2/4/08	7.47	21.7	408	7.6
		5/6/08	7.19	22.7	405	8.3
		7/17/08	7.32	24.5	439	8.8
		10/27/08	7.41	22.2	412	7.3
		1/29/09	7.24	22.2	301	8.3
		4/16/09	7.49	22.4	344	7.6
		7/10/09	7.52	23.9	411	6.4
		10/6/09	7.30	23.8	388	8.4
		1/25/10	7.48	22.4	390	7.8
		4/21/10	7.45	22.6	397	9.04
		7/21/10	7.38	25.1	420	8.98

Table 4
Results of Drinking Water Supply Monitoring

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)
RAY	803772	2/15/08	7.30	19.1	1540	159
		4/21/2008[1]	6.92	21.3	1418	125
		5/13/2008[1]	7.05	20.9	1418	123
		6/23/2008[1]	6.87	21.1	1593	130
		7/29/2008[1]	6.98	21.8	1411	120
		8/28/2008[1]	M	21.1	1519	129
		9/23/2008[1]	6.90	22.2	1519	125
		10/22/08	6.96	20.8	1604	145
		1/20/09	6.92	20.6	1355	88
		4/8/09	6.85	21.4	1759	178
		7/9/09	6.93	22.3	1434	126
		10/7/09	6.98	21.3	1288	127
		1/26/10	6.82	20.6	1352	125
		4/20/10	7.14	21.5	1318	134
		7/14/10	7.11	23.8	1313	137
ROGERS 803	641803	2/7/08	7.45	18.6	601	138
		4/21/2008[1]	7.32	21.4	552	128
		5/8/2008[1]	7.14	21.2	622	141
		6/23/2008[1]	7.06	22.9	660	129
		7/29/2008[1]	6.78	23.1	339	134
		8/28/2008[1]	7.18	21.6	635	128
		9/23/2008[1]	7.24	21.9	599	133
		10/22/08	7.36	21.3	650	144
		2/10/09	7.42	17.9	475	141
		4/29/09	7.52	21.9	506	211
		8/3/09	7.39	24.2	674	150
ROGERS 596[2]	573596	10/19/09	6.89	23.3	1360	590
		11/5/09	6.79	21.9	1418	540
		2/25/10	6.99	19.6	1603	520
		4/22/10	7.21	18.2	1641	710
		7/16/10	7.46	23.9	643.4	169
ROGERS E	216018	2/4/08	7.40	21.0	435	4.6
		5/7/08	7.18	22.2	415	5.9
		7/17/08	7.28	23.0	446	7.1
		10/27/08	7.38	21.4	434	15.7
		2/10/09	7.51	20.7	322	5.4
		4/16/09	7.48	22.0	361	4.9
		7/13/09	7.34	22.6	420	3.8
		10/6/09	7.31	22.3	407	5.8
		1/25/10	7.52	20.6	414	5.1
		4/21/10	7.44	21.1	421	6.04
		7/21/10	7.37	23.8	430	6.47

Table 4
Results of Drinking Water Supply Monitoring

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)
RUIZ	531770	2/5/08	7.73	18.2	445	263
		5/15/08	7.23	25.9	965	265
		7/30/08	6.99	22.1	999	243
		10/20/08	7.04	22.0	995	238
		2/12/09	6.94	20.9	748	254
		4/21/09	7.18	22.3	759	227
		8/3/09	7.05	22.9	1029	221
		10/28/09	7.09	20.6	920	227
		2/1/10	7.08	20.9	934	236
		4/26/10	7.01	22.5	920.1	240
		7/20/10	7.08	22.5	880	240
SCHWARTZ	210865	2/8/08	7.52	21.5	506	158
		4/21/2008[1]	7.23	21.7	563	122
		5/19/2008[1]	7.38	22.4	629	130
		6/23/2008[1]	7.02	22.1	674	129
		7/29/2008[1]	7.25	22.4	955	245
		8/28/2008[1]	M	22.3	669	131
		9/23/2008[1]	7.27	22.2	607	124
		10/22/2008[1]	7.31	22.0	653	135
		11/19/2008[1]	7.38	21.1	612	140
		12/17/2008[1]	6.78	21.6	472	144
		1/29/2009[1]	7.08	22.0	475	124
		2/23/2009[1]	7.33	22.1	610	123
		4/17/09	7.46	22.2	520	120
		7/10/09	7.52	22.8	651	116
		7/10/09 DUP	7.52	22.8	651	117
		10/6/09	7.27	22.5	613	120
		1/22/10	7.79	19.5	664	133
		4/21/10	7.50	20.9	638	129
		7/21/10	7.43	22.0	650	134
SWAN	NR	2/13/08	7.28	20.7	467	24.1
		5/14/08	7.24	21.2	479	23.7
		7/24/08	7.35	22.4	506	18
		10/16/08	7.32	20.7	488	19
		1/20/09	7.05	20.4	391	19.8
		4/7/09	7.21	21.5	447	19.9
		7/8/09	7.18	23.1	473	18.5
		10/5/09	7.18	21.4	496	19.7
		1/21/10	7.49	19.5	501	18.4
		4/21/10	7.42	20.3	512.1	20.9
		7/19/10	7.13	23.8	518.6	22.2
TM-06 MILLER	522695	2/27/08	7.44	19.6	457	13.9
		5/20/08	7.50	20.7	506	32.7
		8/4/08	7.41	20.7	529	31.3
		10/29/08	7.55	20.2	531	34.5
		2/26/09	7.18	20.4	574	32.7
		5/13/09	7.35	20.9	465	30.6
		8/18/09	7.50	20.9	560	30.9
		8/18/09 DUP	7.50	20.9	560	29.9
		11/12/09	7.53	20.4	530	31.1
		4/14/10	7.35	19.4	461	29.0
		7/2/10	7.24	20.1	438	29.8

Table 4
Results of Drinking Water Supply Monitoring

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)
TM-08 SWAN	522817	2/13/08	7.63	24.1	511	24.1
		5/14/08	7.44	24.4	480	12.6
		7/23/08	7.76	28.1	522	12.6
TM-15 MILLER	522699	2/27/08	7.66	21.9	344	14
		5/23/08	7.54	22.1	371	14.4
		8/5/08	7.42	23.3	413	13.7
		10/28/08	7.63	22.6	387	18.6
		10/28/08 DUP	7.63	22.6	387	18.8
		2/26/09	7.57	22.0	373	14.6
		5/13/09	7.61	23.1	344	13.7
		8/17/09	7.73	23.2	398	14.2
		11/3/09	7.73	23.4	414	14.8
		2/24/10	7.66	22.8	381	14.4
		4/27/10	7.71	23.0	383.6	14.9
		7/20/10	7.77	23.0	324	14.3
WALKER	200393	2/13/08	7.05	20.2	650	20
		7/23/08	7.25	20.7	740	45.4
WEED	544535	2/14/08	7.74	21.7	323	11.1
		5/15/08	7.22	22.7	365	12.6
		7/30/08	7.42	32.0	407	11.5
		10/20/08	8.10	31.6	405	10.2
		2/13/09	7.66	21.0	303	12.6
		4/22/09	7.46	22.2	368	11.6
		7/16/09	7.50	21.9	365	10.8
		10/20/09	7.34	21.6	381	12.7
		2/1/10	7.60	20.8	382	12.2
		4/26/10	7.69	22.1	366	13.4
		7/21/10	7.36	22.1	354.9	13.6
		7/21/10 DUP	7.36	22.1	354.9	13.5
WEISKOPF	641802	2/15/08	7.48	20.0	1072	500
		5/7/08	7.10	21.8	1251	483
		7/16/08	7.07	22.2	1399	560
		10/28/08	6.98	20.8	1401	602
		1/29/09	6.79	20.7	1014	503
		4/15/09	7.53	21.1	1164	503
		7/15/09	7.84	22.1	1317	486
		10/15/09	6.89	21.4	1216	484
		2/2/10	7.22	20.4	1319	451
		4/22/10	7.30	19.3	1329	572
		7/19/10	7.06	23.1	1330	573

Table 4
Results of Drinking Water Supply Monitoring

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)
ZANDER	205126	2/4/08	7.24	19.7	392	5.7
		5/6/08	7.26	21.2	404	6.3
		7/16/08	6.92	22.9	441	6.9
		10/28/08	7.40	21.2	415	15
		2/10/09	7.50	20.4	317	6
		4/16/09	7.47	21.7	352	5.5
		7/14/09	7.36	22.9	418	4.5
		10/13/09	7.41	21.7	407	6.3
		1/26/10	7.49	20.3	411	5.7
		4/2/10	7.55	20.0	416	6.70
		7/21/10	7.38	22.7	388.2	6.78

ADWR = Arizona Department of Water Resources

deg C = degrees Celsius

M = pH Meter Malfunction

NA = Not Analyzed

NR = No Record

ND = No Data

SC = Specific Conductance

SU = Standard Units

µS/cm = microsiemens per centimeter

[1] Verified drinking water supply well, sample collected for sulfate trend analysis and interim action evaluation

[2] Well Previousely identified as ROGERS 803

Table 5
Well Information for Existing Wells

Well Name	ADWR 55 Registry No.	UTM E	UTM N	Coordinate Source[1]	Well Use	Installed	Total Well Depth (ft bgs)	Casing Depth (ft bgs)	Screened Interval (ft bgs)	Screened Formation Lithology	Depth to Bedrock (ft bgs)	Comment
ACKER CAP	214612	598847	3472874	ADWR	WATER PRODUCTION	06/08/07	905	905	860-905	Granite	825	Geologic Log
ALVAREZ	650255	601096	3467466	ADWR	WATER PRODUCTION	01/01/38	160	100	ND	ND	ND	No Log
ANDERSON	613396	601135	3468816	HGC	WATER PRODUCTION	01/01/54	236	110	ND	QTbf	NA	Based on well depth and geology map; Hayes and Landis (1964)
ANDERSON 775	616775	600793	3468573	ADWR	WATER PRODUCTION	05/17/82	ND	ND	ND	ND	ND	No Log
ANDERSON 776	616776	599996	3467763	ADWR	WATER PRODUCTION	01/01/16	200	ND	ND	ND	ND	No Log
ASLD	616436	601488	3469690	ADWR	WATER PRODUCTION	07/15/20	150	ND	ND	QTbf	NA	Based on well depth and geology map; Hayes and Landis (1964)
AWC-02	616586	598908	3468549	HGC	WATER PRODUCTION	01/01/55	330	333	100-215	QTbf	NA	Geologic Log
AWC-03	616585	599090	3468682	HGC	WATER PRODUCTION	07/20/56	270	269	83-269	QTbf	NA	Geologic Log
AWC-04	616584	598950	3468717	HGC	WATER PRODUCTION	01/01/59	250	ND	106-187	QTbf	NA	Geologic Log
AWC-05	590620	599270	3468542	HGC	WATER PRODUCTION	06/24/02	1183	1183	163-603 / 623-1163	Km/Volcanics	400	Geologic Log
BANKS 986	647986	606723	3469137	ADWR	WATER PRODUCTION	06/23/80	445	ND	ND	Km	NA	Based on well depth and geology map; Hayes and Landis (1964)
BANKS 987	647987	606982	3469206	HGC	WATER PRODUCTION	06/10/82	339	339	ND	Km	NA	Based on well depth and geology map; Hayes and Landis (1964)
BARTON 010	085010	606201	3469047	HGC	WATER PRODUCTION	01/01/81	300	300	180-300	Km	NA	Geologic Log
BARTON 919	644919	606244	3469077	HGC	WATER PRODUCTION	NR	130	130	ND	QTbf	NA	Based on well depth and geology map; Hayes and Landis (1964)
BERNAL	648363	600796	3467767	ADWR	WATER PRODUCTION	NR	125	ND	ND	ND	ND	No Log
BF-01	539783	604169	3472152	HGC	MONITOR	08/15/93	400	400	325-385	QTbf/Km	350	Geologic Log
BF-02	539786	603480	3471513	ADWR	MONITOR	08/05/93	326	265	265-305	QTbf	NA	Geologic Log
BIMA	577927	606001	3471853	HGC	WATER PRODUCTION	03/03/00	465	465	345-465	Km	27	Based on well drillers report to ADWR (1994)
BINYON	594938	608545	3468542	ADWR	WATER PRODUCTION	12/05/02	260	260	220-260	Km	60	Geologic Log
BLOMMER	633472	602726	3471529	ADWR	WATER PRODUCTION	11/01/78	380	380	ND	Km	245	Based on well depth and geology map; Hayes and Landis (1964)
BRINDLEY	5586775	601263	3472095	ADWR	WATER PRODUCTION	01/01/81	360	360	340-360	Km	295	Geologic Log
BULLARD	602134	602079	3470901	ADWR	WATER PRODUCTION	09/06/74	300	300	215-300	QTbf	NA	Based on well depth and geology map; Hayes and Landis (1964)
BURKE	212268	602230	3473030	HGC	WATER PRODUCTION	10/11/06	781	781	661-781	Km	150	Based on well drillers report to ADWR (1994)
CHAMBERS	629807	600097	3467462	ADWR	WATER PRODUCTION	01/01/77	245	245	ND	QTbf	NA	Based on well depth and geology map; Hayes and Landis (1964)
CHASE	648359	599695	3468062	ADWR	WATER PRODUCTION	01/01/70	100	100	ND	QTbf	NA	Based on well depth and geology map; Hayes and Landis (1964)
COB MW-1	903992	603153	3469890	HGC	WATER PRODUCTION	03/02/06	420	420	350-410	QTbf	NA	Geologic Log
COB MW-2	903984	600973	3468115	HGC	MONITOR	01/20/06	170	170	92-152	QTbf	NA	Geologic Log
COB MW-3	906823	599169	3468726	ADWR	MONITOR	04/20/07	269	269	83-269	QTbf	NA	Geologic Log
COB WL	593116	606358	3472502	HGC	MONITOR	07/22/02	150	150	90-150	Km	36	Geologic Log
COB WL ABND	570012	607673	3473952	ADWR	ABANDONED	08/31/98	118	148	108-148	Km	115	Geologic Log
COLLINS	565260	602551	3471341	HGC	WATER PRODUCTION	12/16/97	320	320	260-320	Km	40	Based on well drillers report to ADWR (1994)
CONNOR ABND	516399	600251	3472678	HGC	ABANDONED	01/20/87	220	220	ND	Granite	32	Geologic Log
COOPER	623564	602668	3472105	ADWR	WATER PRODUCTION	12/20/79	325	325	ND	QTbf	NA	Based on well depth and geology map; Hayes and Landis (1964)
COOPER C	637069	601350	3468913	HGC	WATER PRODUCTION	07/29/66	220	220	ND	QTbf	NA	Based on well depth and geology map; Hayes and Landis (1964)
COTA	651116	600197	3467563	ADWR	WATER PRODUCTION	NR	160	150	ND	ND	ND	No Log
CROWLEY	510298	602461	3473109	ADWR	WATER PRODUCTION	04/19/85	788	22	NA	Kg	22	Geologic Log; open hole
DODSON	644927	605595	3469064	HGC	WATER PRODUCTION	10/01/59	200	200	ND	Km	ND	Based on well depth and geology map; Hayes and Landis (1964)
DOUGLASS 791	592791	607633	3470223	HGC	WATER PRODUCTION	09/19/02	200	200	0-200	Kg	4	Geologic Log
DOUGLASS 792	592792	607608	3469829	HGC	WATER PRODUCTION	09/21/09	200	200	0-200	Kg	4	Geologic Log
DURAZO	NR	602041	3471284	HGC	WATER PRODUCTION	NR	NR	NR	NR	NR	NR	No ADWR Record
EAST	599796	607076	3468712	HGC	WATER PRODUCTION	10/24/03	125	125	85-125	Km	50	Geologic Log
EBERWEIN	641726	600185	3467214	ADWR	WATER PRODUCTION	NR	249	ND	ND	ND	ND	Based on well completion depth and lithology of nearby wells
EPPELE 641	805641	607165	3469230	HGC	WATER PRODUCTION	NR	265	265	ND	Km	ND	Based on well depth and geology map; Hayes and Landis (1964)
EPPELE 642	805642	607126	3469140	ADWR	WATER PRODUCTION	12/31/00	40	40	ND	Km	ND	Based on well depth and geology map; Hayes and Landis (1964)
EPPELE 643	805643	607126	3469140	ADWR	WATER PRODUCTION	NR	165	165	ND	Km	ND	Based on well depth and geology map; Hayes and Landis (1964)
FLEMING	218386	605565	3469342	ADWR	WATER PRODUCTION	02/07/09	445	445	385-445	Km	ND	Based on well depth and geology map; Hayes and Landis (1964)
FRANCO	500101	602850	3468836	HGC	WATER PRODUCTION	07/01/81	200	200	180-200	QTbf	NA	Geologic Log
FULTZ	212447	607153	3469064	ADWR	WATER PRODUCTION	06/23/06	300	300	200-300	Km	10	Based on well depth and geology map; Hayes and Landis (1964)
GALLANT	502527	607770	3468524	HGC	WATER PRODUCTION	04/26/82	190	190	40-60 / 80-140	Km	5	Geologic Log
GARNER 557	558557	602659	3468962	HGC	WATER PRODUCTION	09/04/96	300	310	180-220 / 240-300	QTbf	NA	Geologic Log
GARNER 635	587635	602665	3468968	HGC	WATER PRODUCTION	10/12/01	680	660	580-660	Km	540	Geologic Log
GGOOSE 546	628546	606115	3469534	ADWR	WATER PRODUCTION	02/11/63	800	430	ND	Km	ND	Based on well depth and geology map; Hayes and Landis (1964)
GGOOSE 547	628547	606257	3469820	HGC	WATER PRODUCTION	08/18/61	800	800	ND	Km	ND	Based on well depth and geology map; Hayes and Landis (1964)
GL-01	539785	605076	3473336	ADWR	MONITOR	08/20/93	833	468	768-808	Kg	230	Geologic Log
GL-02 ABND	539784	605889	3472943	ADWR	ABANDONED	08/08/93	400	20	NA	Kg	47	Geologic Log; well not constructed
GL-03	539782	604387	3473748	HGC	MONITOR	08/11/93	825	825	780-820	Kg	175	Geologic Log
GOAR 687	610687	602406	3468588	ADWR	WATER PRODUCTION	01/01/50	250	250	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
GOAR 688	610688	602406	3468588	ADWR	WATER PRODUCTION	01/01/50	250	250	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
GOAR 689	610689	602406	3468588	ADWR	WATER PRODUCTION	01/01/50	250	250	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
GOAR 690	610690	601596	3468580	ADWR	WATER PRODUCTION	01/01/50	250	250	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
GOAR 691	610691	602406	3468588	ADWR	WATER PRODUCTION	01/01/50	250	250	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
GOAR 692	610692	602406	3468588	ADWR	WATER PRODUCTION	01/01/50	250	250	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
GOAR 686	610686	602406	3468588	ADWR	WATER PRODUCTION	01/01/50	250	250	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
GOAR	610694	602217	3468916	HGC	WATER PRODUCTION	01/01/50	250	250	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
GOAR 693	610693	602406	3468588	ADWR	WATER PRODUCTION	01/01/50	250	250	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
GOAR RANCH	610695	602455	3468892	HGC	WATER PRODUCTION	01/01/50	250	250	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
GREGG	630852	607024	3469240	ADWR	WATER PRODUCTION	NR	ND	ND	ND	ND	ND	No Log
HAUBERT	801607	601596	3468580	ADWR	WATER PRODUCTION	01/01/55	195	195	ND	ND	ND	No Log
HECK	507823	602077	3471101	ADWR	WATER PRODUCTION	05/04/84	313	313	208-308	Kg	0	Geologic Log
HOBAN	805290	601706	3468880	HGC	WATER PRODUCTION	03/02/64	316	316	188-316	QTbf	NA	Geologic Log
HOWARD	NR	601282	3468769	HGC	WATER PRODUCTION	11/08/89	NR	NR	NR	NR	NR	No ADWR Record
HULL 854	606854	601475	3470899	ADWR	WATER PRODUCTION	01/01/15	25	ND	NA	QTbf	NA	Geologic Log; open hole
HULL 855	606855	601467	3471697	ADWR	WATER PRODUCTION	01/01/15	400	200	ND	Km	ND	Based on well completion depth and lithology of nearby wells
HUMPHREY	649153	600395	3468167	ADWR	WATER PRODUCTION	01/01/38	160	20	ND	ND	ND	No Log
IRONS	632924	602204	3468788	ADWR	WATER PRODUCTION	12/12/55	175	175	ND	ND	ND	No Log
JACKSON	506034	602479	3471103	ADWR	WATER PRODUCTION	08/16/83	342	342	2-342	Kg	20	Geologic Log
JALYN	209737	601496	3468680	ADWR	WATER PRODUCTION	11/16/05	245	245	185-245	QTbf	NA	Geologic Log
KEEFER	209744	599879	3468119	HGC	WATER PRODUCTION	11/15/05	245	245	185-245	QTbf	NA	Geologic Log
LESNICK	587749	607516	3470145	ADWR	WATER PRODUCTION	05/04/02	400	400	360-400	QTbf	NA	Geologic Log
LUCERO	618175	601293	3468274	ADWR	WATER PRODUCTION	06/26/72	301	301	ND	ND	ND	No Log
M-01 ABND	539787	604070	3472924	ADWR	ABANDONED	08/14/93	605	600	560 - 600	Km/Kg	185	Geologic Log
MCCONNELL 265	539265	601463	3468840	HGC	WATER PRODUCTION	07/06/93	216	216	174-216	QTbf	NA	Geologic Log
MCCONNELL 386	590386	601438	3468846	HGC	WATER PRODUCTION	NR	ND	ND	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
MENDEZ	650256	601096	3467466	ADWR	WATER PRODUCTION	01/01/38	160	100	ND	ND	ND	No Log
METZLER	35-71891	602091	3471381	HGC	WATER PRODUCTION	04/10/79	351	351	245-345	Km	ND	Based on well depth and geology map; Hayes and Landis (1964)
MILLER 340	641340	600090	3469474	ADWR	WATER PRODUCTION	01/01/40	200	200	ND	QTbf	NA	Based on well depth and geology map; Hayes and Landis (1964)
MILLER 341	641341	601699	3467875	ADWR	WATER PRODUCTION	01/01/20	100	100	ND	QTbf	NA	Based on well depth and geology map; Hayes and Landis (1964)
MILLER 342	641342	604520	3467499	ADWR	WATER PRODUCTION	01/01/57	200	200	ND	QTbf	NA	Based on well depth and geology map; Hayes and Landis (1964)
MINNERLY	650662	607223	3469441	ADWR	WATER PRODUCTION	NR	ND	ND	ND	ND	ND	No Log
MINOR 316	633316	601173	3468487	HGC	WATER PRODUCTION	01/01/55	208	208	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
MINOR 317	633317	601172	3468568	HGC	WATER PRODUCTION	01/01/56	155	155	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
MOORE	538847	599495	3468060	ADWR	WATER PRODUCTION	04/24/93	220	220	180-220	QTbf	NA	Geologic Log
MOROYOQUI	647847	600395	3468167	ADWR	WATER PRODUCTION	06/18/69	280	280	ND	Km	ND	Based on well completion depth and lithology of nearby wells
NESS	509127	607866	3471419	ADWR	WATER PRODUCTION	01/30/85	812	20	NA	Kg	20	Geologic Log; open hole
NOBLE	618611	602608	3468792	ADWR	WATER PRODUCTION	NR	ND	ND	ND	ND	ND	No Log
NOTEMAN	212483	606054	3471576	HGC	WATER PRODUCTION	06/26/06	400	400	0-400	Km	NA	Based on well depth and geology map; Hayes and Landis (1964)
NSD-01	NR	598080	3468647	ADWR	NR	NR	NR	NR	NR	NR	NR	No ADWR Record
NSD-02	527587	598884	3468847	HGC	MONITOR	05/12/90	120	120	75-115	QTbf	NA	Geologic Log
NSD-03	527586	598077	3468637	HGC	MONITOR	05/12/90	100	100	55-95	QTbf	NA	Geologic Log
NWC-01	627682	600144	3467140	HGC	WATER PRODUCTION	09/24/51	215	215	ND	QTbf	NA	Geologic Log
NWC-02 CAP	627683	600183	3467457	HGC	CAPPED	08/02/59	210	210	ND	QTbf	NA	Geologic Log
NWC-02	562944	600177	3467475	HGC	WATER PRODUCTION	06/11/97	312	312	212-312	QTbf	NA	Geologic Log
NWC-03 CAP	627684	601148	3468343	HGC	CAPPED	01/01/30	179	160	ND	QTbf	NA	Geologic Log
NWC-03	203321	601154	3468351	HGC	WATER PRODUCTION	06/22/04	312	312	252-312	QTbf	NA	Geologic Log
NWC-04 (prior to 11/2008)	551849	605830	3469072	HGC	WATER PRODUCTION	08/24/95	795	795	322-462	Km	19	Geologic Log--well was deepened in Nov 2008
NWC-04 (after 11/2008)	551849	605830	3469072	HGC	WATER PRODUCTION	08/24/95	795	795	540-580 / 755-795	Km	19	Geologic Log--well was deepened in Nov 2008
NWC-04 CAP	627685	605915	3469113	HGC	CAPPED	12/31/26	379	379	ND	QTbf	NA	Geologic Log
NWC-05	627696	606980	3469446	HGC	WATER PRODUCTION	01/01/60	175	86	ND	QTbf	NA	Geologic Log

Table 5
Well Information for Existing Wells

Well Name	ADWR 55 Registry No.	UTM E	UTM N	Coordinate Source[1]	Well Use	Installed	Total Well Depth (ft bgs)	Casing Depth (ft bgs)	Screened Interval (ft bgs)	Screened Formation Lithology	Depth to Bedrock (ft bgs)	Comment
NWC-06	575700	599823	3467750	HGC	WATER PRODUCTION	09/15/99	410	340	180-279 / 302-340	QTbf	NA	Geologic Log
OSBORN	643436	607032	3470271	HGC	WATER PRODUCTION	08/05/93	258	258	122-258	Kg	150	Deepened from ~ 150' to 250'
PALMER	578819	607724	3469545	ADWR	WATER PRODUCTION	01/10/00	220	220	200-220	Km	80	Geologic Log
PANAGAKOS	35-76413	605312	3469321	HGC	WATER PRODUCTION	07/01/57	200	200	140-200	Km	100	Geologic Log
PARRA	576415	602171	3471264	HGC	WATER PRODUCTION	10/06/99	355	355	255-355	Km	ND	Based on well depth and geology map; Hayes and Landis (1964)
PAVLOVICH	502193	601238	3474910	ADWR	WATER PRODUCTION	04/01/82	535	20	NA	Km	3	Geologic Log; open hole
PIONKE	613395	601045	3468961	HGC	WATER PRODUCTION	01/01/64	300	300	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
POOL	509518	599684	3470014	HGC	WATER PRODUCTION	12/12/84	313	313	213-300	QTbf	NA	Geologic Log
POWER	624535	608379	3472739	HGC	WATER PRODUCTION	01/01/67	100	100	60-99	Km	ND	Based on well depth and geology map; Hayes and Landis (1964)
RAMIREZ	216425	599731	3467584	ADWR	WATER PRODUCTION	NR	300	300	250-300	QTbf	NA	Based on well depth and geology map; Hayes and Landis (1964)
RAY	803772	607083	3469195	HGC	WATER PRODUCTION	NR	100	ND	ND	Km	ND	Based on well depth and geology map; Hayes and Landis (1964)
RICHARDS	531595	608716	3471353	ADWR	WATER PRODUCTION	05/03/91	445	20	NA	Granite	0	Geologic Log; well not constructed
RODRIGUEZ	648360	600697	3467464	ADWR	WATER PRODUCTION	NR	ND	ND	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
ROGERS 596	573596	600894	3468271	ADWR	WATER PRODUCTION	09/16/99	290	290	230-290	QTbf	NA	Based on well completion depth and lithology of BMO-2008-4B
ROGERS 801	641801	601092	3468676	ADWR	WATER PRODUCTION	01/01/60	142	142	ND	QTbf	NA	Based on well completion depth and lithology of BMO-2008-4B
ROGERS 803	641803	600978	3468417	HGC	WATER PRODUCTION	01/01/60	140	140	ND	QTbf	NA	Based on well completion depth and lithology of BMO-2008-4B
ROGERS E	216018	600450	3467636	ADWR	WATER PRODUCTION	09/10/07	290	290	240-285	Km	165	Geologic Log
ROLLINS	641750	601096	3467667	ADWR	WATER PRODUCTION	NR	126	ND	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
ROSS 351 CAP	513351	600254	3472688	ADWR	CAPPED	02/08/86	740	20	ND	Granite	200	Geologic Log
ROSS 398 ABND	516398	600052	3472887	ADWR	ABANDONED	01/21/87	200	21	ND	Granite	40	Geologic Log
ROSS 525	517525	599654	3472078	ADWR	WATER PRODUCTION	04/17/87	400	20	ND	Km	250	Geologic Log
ROSS 526	517526	599666	3471480	ADWR	WATER PRODUCTION	04/16/87	425	425	ND	Km	300	volcanics 300' - 375'; sandstone 375' - 425'
RUIZ	531770	602857	3471424	HGC	WATER PRODUCTION	05/29/91	312	312	252-312	QTbf/Km	265	Geologic Log
SCHWARTZ	210865	600812	3468268	HGC	WATER PRODUCTION	06/11/06	305	305	260-305	QTbf	NA	Geologic Log
SHAFER	649994	600497	3467463	ADWR	WATER PRODUCTION	07/15/66	162	162	ND	ND	ND	No Log
SILVESTRI	557742	600251	3473493	ADWR	WATER PRODUCTION	07/10/96	380	380	340-380	QTbf	NA	Geologic Log
SRC	211345	599722	3472503	HGC	WATER PRODUCTION	02/06/07	965	965	845-965	Km	500	Geologic Log
STEPHENS	808560	606982	3469073	HGC	WATER PRODUCTION	NR	NR	NR	NR	NR	NR	No ADWR Record
SUNBELT	201531	605998	3471735	HGC	WATER PRODUCTION	01/15/04	380	380	300-380	Km/Kg	2	Geologic Log
SUNNYSIDE	588270	601293	3468476	ADWR	WATER PRODUCTION	08/28/01	200	200	160-200	QTbf	NA	Geologic Log
SWAN	NR	607379	3470648	HGC	WATER PRODUCTION	NR	NR	NR	NR	Kg	ND	Based on well completion depth and lithology of nearby wells
TM-01 ABND	522569	604096	3470517	ADWR	ABANDONED	11/01/88	265	265	215-265	Km	215	Geologic Log
TM-01A ABND	525557	604096	3470517	ADWR	ABANDONED	09/09/89	265	265	204-265	QTbf/Km	217	Geologic Log
TM-01B ABND	525556	604096	3470517	ADWR	ABANDONED	09/11/89	265	265	204-265	QTbf/Km	211	Geologic Log
TM-02	522573	604078	3471921	ADWR	MONITOR	12/14/88	640	360	280-360	QTbf	NA	Geologic Log
TM-02A	522574	604152	3472009	HGC	MONITOR	02/10/89	925	925	825-925	Kg	345	Geologic Log
TM-03	522575	606366	3473711	ADWR	MONITOR	12/16/88	200	200	150-200	Kg	32	Geologic Log
TM-04 ABND	522693	606105	3471539	ADWR	ABANDONED	01/17/89	175	175	125-175	Kg	75	Geologic Log
TM-05 MILLER	522694	603900	3467190	HGC	MONITOR	01/13/89	160	160	120-160	QTbf	NA	Geologic Log
TM-06 MILLER	522695	606056	3468377	ADWR	MONITOR	01/24/89	200	200	150-200	Km	15	Geologic Log
TM-07	522576	603073	3471909	ADWR	MONITOR	11/04/88	350	350	259-349	Km	195	Geologic Log
TM-08 SWAN	522817	607787	3470667	HGC	WATER PRODUCTION	01/20/89	817	817	757-817	Kg	80	Geologic Log
TM-09 ABND	522577	603062	3473315	ADWR	ABANDONED	11/03/88	940	930	870-930	Kg	174	Geologic Log
TM-10 USBP	522696	601666	3471898	ADWR	MONITOR	11/08/88	290	290	240-290	Km	185	Geologic Log
TM-11 PIONKE	522815	600892	3468876	ADWR	MONITOR	11/18/88	160	159	99-159	QTbf	NA	Geologic Log
TM-12 MILLER	522697	601518	3467147	HGC	MONITOR	01/12/89	175	171	121-171	QTbf	NA	Geologic Log
TM-13 MILLER	522698	601284	3469891	ADWR	MONITOR	01/05/89	200	200	140-200	QTbf	NA	Geologic Log
TM-14 NELSON	522816	599624	3470112	ADWR	MONITOR	01/12/89	215	215	165-215	QTbf	NA	Geologic Log
TM-15 MILLER	522699	599617	3471428	HGC	WATER PRODUCTION	01/11/89	325	320	260-320	Km	220	Geologic Log
TM-16 MILLER	522578	605588	3469842	HGC	MONITOR	12/15/88	115	115	65-115	Km	40	Geologic Log
TM-17	522700	603915	3468504	ADWR	MONITOR	01/17/89	200	200	150-200	Kml	70	Geologic Log
TM-18 ABND	522579	603451	3475529	ADWR	ABANDONED	10/27/88	787.5	780	680-780	PC	0	Geologic Log
TM-19	522581	602506	3469093	ADWR	MONITOR	11/17/88	210	210	150-210	QTbf	NA	Geologic Log
TM-19A	522580	602459	3469197	HGC	MONITOR	11/16/88	700	695	585-695	Km	535	Geologic Log
TM-20 ABND	525147	605061	3475745	ADWR	ABANDONED	08/20/89	625	20	NA	Pz	0	Geologic Log; open hole
TM-21 ABND	525148	605061	3475745	ADWR	ABANDONED	11/08/89	630	20	NA	Pz	0	Geologic Log; open hole
TM-22 ABND	525146	605066	3475143	ADWR	ABANDONED	11/04/89	1000	1000	900-1000	Pz	0	Geologic Log
TM-23 ABND	525555	605067	3474741	ADWR	ABANDONED	08/18/89	220	215	155-215	QTbf/Km	169	Geologic Log
TM-24 ABND	525547	605872	3474350	ADWR	ABANDONED	09/10/89	106	105	44-105	Kg	33	Geologic Log
TM-25 ABND	525145	605071	3473737	ADWR	ABANDONED	08/18/89	805	104	NA	Kg	240	Geologic Log; well not constructed
TM-26	525144	605086	3472533	ADWR	MONITOR	09/07/89	800	199	NA	Kg	250	Geologic Log; well not constructed
TM-27 ABND	525143	603669	3472719	ADWR	ABANDONED	09/05/89	410	367	306-367	Km	239	Geologic Log
TM-28 ABND	525142	606098	3472542	ADWR	ABANDONED	08/04/89	140	140	55-140	Kg	60	Geologic Log
TM-29 ABND	525141	604891	3471328	ADWR	ABANDONED	08/10/89	140	140	85-140	QTbf/Km	95	Geologic Log
TM-29A ABND	525137	604891	3471328	ADWR	ABANDONED	08/09/89	165	165	85-165	QTbf/Km	99	Geologic Log
TM-29B ABND	525136	604891	3471328	ADWR	ABANDONED	08/06/89	165	165	85-165	QTbf/Km	106	Geologic Log
TM-30 ABND	525548	602500	3469496	ADWR	ABANDONED	09/25/89	700	700	555-700	Km	520	Geologic Log
TM-30A ABND	525558	602500	3469496	ADWR	ABANDONED	09/13/89	700	700	555-700	Km	465	Geologic Log
TM-30B ABND	525559	602500	3469496	ADWR	ABANDONED	09/26/89	210	210	149-210	QTbf	NA	Geologic Log
TM-32 ABND	525550	603457	3474725	ADWR	ABANDONED	11/08/89	293	98	NA	Kg	188	Geologic Log; open hole
TM-33 ABND	525140	604468	3473729	ADWR	ABANDONED	10/26/89	500	500	439-500	Kg	188	Geologic Log
TM-35 ABND	525139	607286	3473348	ADWR	ABANDONED	10/03/89	380	310	249-310	Kg	20	Geologic Log
TM-36 ABND	525138	607672	3474555	ADWR	ABANDONED	10/09/89	660	660	610-660	Pz	59	Geologic Log
TM-37 ABND	525552	602891	3470303	ADWR	ABANDONED	10/09/89	700	700	464-700	Km/Kg	451	Geologic Log
TM-38 ABND	525553	603502	3469707	ADWR	ABANDONED	10/03/89	700	700	375-700	Km	476	Geologic Log
TM-39 ABND	525554	604710	3469520	ADWR	ABANDONED	10/22/89	424	424	118-424	QTbf/Km	158	Geologic Log
TM-41	562555	604840	3471306	HGC	MONITOR	06/12/97	210	201	145-200	Km	95	Geologic Log
TM-42	562554	603698	3469105	HGC	MONITOR	06/13/97	250	241	180-240	Km	65	Geologic Log
TM-43	564729	605365	3474671	HGC	MONITOR	11/10/97	830	820	720-800	Km	70	Geologic Log
TM-43A	564726	605358	3474661	HGC	MONITOR	10/28/97	215	210	130-190	QTbf/Km	150	Geologic Log
TM-43B	565004	605814	3474380	HGC	MONITOR	10/29/97	215	210	150-190	Km	80	Geologic Log
TM-43C	565005	605872	3474752	ADWR	MONITOR	11/12/97	270	259	199-239	Km	50	Geologic Log
TM-44	564730	605267	3475146	ADWR	MONITOR	10/26/97	1150	1130	1020-1150	Pz	0	Geologic Log
TM-45	564728	604463	3474733	ADWR	MONITOR	11/17/97	520	500	400-480	Km	180	Geologic Log
TM-46	564727	604461	3475135	ADWR	MONITOR	12/12/97	1080	1060	940-1040	Pz	0	Geologic Log
TVI 236	802236	600552	3467978	HGC	WATER PRODUCTION	02/14/34	222	222	ND	QTbf	NA	Geologic Log
TVI 713 CAP	567713	600729	3468413	HGC	CAPPED	04/14/98	200	144	80-144	QTbf	NA	Geologic Log
TVI 875	568875	600694	3468471	ADWR	WATER PRODUCTION	06/14/98	330	330	166-320	QTbf	NA	Geologic Log
VALENZUELA	645050	600395	3468167	ADWR	WATER PRODUCTION	01/01/47	167	150	ND	ND	ND	No Log
WALKER	200393	607565	3468577	HGC	WATER PRODUCTION	11/12/03	120	120	80-100	Km	18	Geologic Log
WEED	544535	601276	3470699	ADWR	WATER PRODUCTION	07/09/94	320	320	280-320	Km/Kg	270	Geologic Log
WEISKOPF	641802	601155	3468659	HGC	WATER PRODUCTION	01/01/60	200	200	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
WILLSON 361	648361	602002	3468181	ADWR	WATER PRODUCTION	01/01/29	160	160	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
WILLSON 362	648362	601293	3468879	ADWR	WATER PRODUCTION	01/01/47	180	180	ND	QTbf	NA	Based on well completion depth and lithology of nearby wells
ZANDER	205126	599679	3467998	HGC	WATER PRODUCTION	02/10/05	280	260	220-260	QTbf	NA	Geologic Log

Notes:

[1]Coordinate Sources:
HGC = Survey or hand-held global positioning system
ADWR = Arizona Department of Water Resources Groundwater Services Index (GWSI)
UTM E = Universal Transverse Mercator, North American Datum 1983 (NAD83) Easting (meters)
UTM N = Universal Transverse Mercator, North American Datum 1983 (NAD83) Northing (meters)
QTbf = Quaternary - Tertiary basin fill
Kg = Cretaceous Glance Conglomerate
Km = Cretaceous Morita Formation
Pz = Paleozoic Rocks
PC = Precambrian
NR = not reported
NA = not applicable
ND = not determined
ft bgs = feet below ground surface

Table 6
Summary of Hydraulic Conductivity Estimates

Well or Boring	Aquifer Material	Hydraulic Conductivity (ft/day)		
		ELMA, 1989 as reported by SRK (1997)	SRK (1997) re-interpretation of ELMA, 1989 data	SET (1998c)
TM-11	basin fill	39.0	1.2	
TM-13	basin fill	59.0	19.1	
	average, basin fill	**49.0**	**10.1**	
TM-01	basin fill-Morita Formation	21.4	11	
TM-01A	basin fill-Morita Formation	26.8	not calculated	
	average, TM-01, TM-01A	**24.1**		
TM-29	basin fill-Morita Formation	6.7	not calculated	
TM-29A	basin fill-Morita Formation	4.0	1.3	
TM-29B	basin fill-Morita Formation	4.0	1.8	
	average, TM-29, TM-29B	**4.0**	1.6	
	average, all basin fill-Morita Formation	**12.6**	**4.7**	
TM-30	Morita Formation, west of Black Gap fault	12.0	not calculated	
TM-30A	Morita Formation, west of Black Gap fault	1.3	not calculated	
	average, TM-30, TM-30A	**6.7**		
TM-19A	Morita Formation, west of Black Gap fault	12.0	5.8	
TM-38	Morita Formation, west of Black Gap fault	12.0	not calculated	
	average, all Morita Formation, west of Black Gap fault	**9.3**	**5.8**	
TM-16	Morita Formation, east of Black Gap fault	1.3	2.2	
Flow and Transport Model (SET,1998c)	basin fill, gravel			72
	basin fill, gravelly sand			65
	basin fill, sand			30
	basin fill, silty sand			23
	average, basin fill			**48**
	Morita Formation, sandstone			20
	Morita Formation, siltstone			3
	Morita/Mural Formations, siltstone/limestone			2
	Morita Formation, siltstone/mudstone			1
	Morita Formation, mudstone			2
	average, Morita Formation			**6**
	Glance Conglomerate, silty matrix			2
	Glance Conglomerate, clayey matrix			1
	average, Glance Conglomerate			**1**

Notes:
ft/day = feet per day

Table 7
Aquifer Recharge Estimates

NATURAL RECHARGE SOURCES				
Recharge Type	**Reference**	**Volumetric Recharge Rate**	**Specific Recharge Rate**	**Notes**
Total Natural Recharge	Littin (1987)	2,000 to 2,500 ac-ft/yr	1.19E-4 to 1.49E-4 ft/d	1. Recharge may be underestimated because groundwater budget has a discrepancy of about 4,000 ac-ft/yr 2. Specific rate based on a study area of 46,000 acres
	SET (1998c)	3763.5 ac-ft/yr	8.49E-4 ft/d (high), 1.64E-5 ft/d (low)	1. Calibrated rates based on Littin (1987) 2. High recharge areas near mountain fronts and immediately south of Greenbush Draw (see Figure A.13)
Total Natural Recharge for Sierra-Vista Sub-basin	ADWR (2005)	18,000 ac-ft/yr		Modified estimate from Correll et al. (1996)
	Correll et al. (1996)	19,000 ac-ft/yr		Includes 1,000 ac-ft/yr from Greenbush Draw that may include discharge from mine water (ADWR, 2005)
Recharge from Greenbush Draw	Coes and Pool (2005)	365 ac-ft/yr	30.1 ac-ft/yr/mile	1. Estimated using tracer studies and stream monitoring 2. Specific rate based on a 19.5 km of alluvial stream reach
Recharge from Areas of Crystalline Rock	Pool and Dickinson (2006)		0 ft/d	
Recharge from Areas of Sedimentary Rock			3.29E-6 to 6.57E-5 ft/d	
Recharge Within 1.6 km of Mountain Fronts (mountain front recharge)			6.57E-5 to 4.38E-4 ft/d	
Recharge from Areas of Alluvium			3.29E-6 ft/d	

ARTIFICIAL RECHARGE SOURCES	
Potential Recharge Source	**Notes**
Concentrator Tailing Storage Area	
North and South Tailing Impoundments	- Percolation rate estimated to be between $3.6x10^{-7}$ and $2.4x10^{-7}$ cm/s (SET, 1998a)
	- No recharge to aquifer included in model of SET (1998c)
Evaporation Pond	- SRK (1997) estimated recharge rate of 488 ac-ft/yr
	- SET (1998c) modeled recharge rate of 3,103 ac-ft/yr
	- SET (1998c) modeled sulfate concentration of 3,000 mg/L, with two "elevated zones" of 3,100 mg/L (22.2 acres) and 3,650 mg/L (14.8 acres)
Horseshoe Pond	- 2008 - Water is pumped to the South Tailing Impoundment and then to Lavender Pit; no drainage or recharge estimates available
	- No recharge to aquifer included in model of SET (1998c)
Irrigation Areas	
Warren Ranch Irrigation Area	- Water delivery rates variable - up to 2,350 ac-ft/yr through 1985
	- SRK (1997) estimated recharge rate of 479 ac-ft/yr
	- SET (1998c) modeled recharge rate of 1,135 ac-ft/yr with a sulfate concentration of 1,500 mg/L
El Oasis Irrigation Area	- SET (1998c) modeled recharge rate of 315.3 ac-ft/yr
	- SET (1998c) modeled an area of 306.4 acres; the current area is 630 acres based on satellite imagery
Turquoise Valley Golf Course	- 1934 Golf course opens; golf course expands north of Greenbush Draw in 1998
	- SET (1998c) modeled recharge rate of 33.2 ac-ft/yr before expansion and 66.4 ac-ft/yr after expansion
Waste Water Treatment Facilities	
Warren WWTF Ponds	- Warren WWTF Ponds begin in 1930s (SET 1998c) or 1970s (EPA, 2003b) and terminates in 2006. Use of unlined ponds (NADB, 2003) and land disposal of effluent (EPA,
	- SET (1998c) modeled recharge of 159.9 ac-ft/yr during period of operation
San Jose WWTF	- 1985 - Effluent discharge to lined lagoons then land-disposed (EPA, 2003b). 0.137 MGD design capacity. Liners became damaged (NADB, 2003).
	- 2006 - Facility expanded and permitted for 1.22 MGD with effluent discharged to Greenbush Draw (ADEQ, 2006); discharge to lagoons ended
	- 2006 - Effluent discharged to Greenbush Draw (31° 20' 35"N, 109° 56' 10"W). Discharge to San Jose lagoons terminated.
	- SET (1998c) did not estimate recharge to aquifer from lagoons
	- 2008 - Effluent-dependent flow in Greenbush Draw persists for at least one mile downstream of discharge point.
	- In the future all or part of effluent may be used by TVI golf course
Naco Sanitation District (Arizona)	- ADWR (2005) estimated effluent production of 80 ac-ft/yr in 2002 with all effluent evaporated (no recharge)
	- No recharge to aquifer from lagoons included in model of SET (1998c)
Naco, Sonora WWTF	- Early 1960s - East (7 lagoons) and west (3 lagoons) constructed (SAIC, 1997)
	- SET (1998c) modeled recharge of 158.5 ac-ft/yr (half to east lagoon and half to west lagoon)
	- 2008 - Discharge to lagoons is approximately 589 ac-ft/yr with east lagoon lined with compacted clay and the unlined west lagoon "rarely used" (HGC, 2008d)
Combined Sources	
Combined WWTFs	- 1985 - All WWTFs estimated to have combined inflow of 500,000 gpd (560 ac-ft/yr) (Littin, 1987)
	- 1985 - All WWTFs estimated to have combined recharge rate of 250 ac-ft/yr (Littin, 1987)
	- 2005 - Combined effluent production in City of Bisbee of 610 ac-ft/yr. Some effluent infiltrates (ADWR, 2005)
Combined Artificial Recharge	- Littin (1987) estimated combined artificial recharge to range from 6,720 ac-ft/yr to 7,150 ac-ft/yr

Notes:
ac-ft/yr = acre-feet per year
cm/s = centimeters per second
ft/d = feet per day
gpd = gallons per day
km = kilometers
mg/L = milligrams per liter

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Table 8
Recharge Estimates from SET (1998c)

Recharge Source	Area (acres)	Years Applied	Volumetric Rate			Areal Rate		
			Final (ac-ft/yr)	Upper Limit (ac-ft/yr)	Lower Limit (ac-ft/yr)	Final (ft/d)	Upper Limit (ft/d)	Lower Limit (ft/d)
Natural Recharge - High	12,133.7	1905 - 2098	3707.7	5321.7	349.0	8.37E-04	1.20E-03	7.87E-05
Natural Recharge - Low	17,240.0	1905 - 2098	55.8	103.3	8.3	8.86E-06	1.64E-05	1.31E-06
Natural Recharge Total	**29,373.7**	**1905 - 2098**	**3763.5**	**5425.0**	**357.2**			
Evaporation Pond - West	106.3	1905 - 1997[1]	1847.0	6369.1	445.8	4.76E-02	1.64E-01	1.15E-02
Evaporation Pond - East	249.6	1905 - 1997	1256.2	14955.1	299.1	1.38E-02	1.64E-01	3.28E-03
Evaporation Pond Total	**355.9**	**1905 - 1997[1]**	**3103.3**	**21324.2**	**744.9**			
Warren Ranch Irrigation Area - West	1,178.7	1905 - 1987	1059.4	1059.4	53.7	2.46E-03	2.46E-03	1.25E-04
Warren Ranch Irrigation Area - East	1,057.6	1905 - 1987	76.0	329.5	63.4	1.97E-04	8.53E-04	1.64E-04
Warren Ranch Irrigation Area Total	**2,236.3**	**1905 - 1987**	**1135.4**	**1388.9**	**117.0**			
Warren WWTF Pond	7.4	1931 - 2098[2]	159.6	177.4	63.8	5.91E-02	6.56E-02	2.36E-02
TVI Golf Course - Original	19.8	1931 - 2098	33.2	49.8	16.6	4.59E-03	6.89E-03	2.30E-03
TVI Golf Course - Expansion	19.8	1998 - 2098	33.2	49.8	16.6	4.59E-03	6.89E-03	2.30E-03
Naco, Sonora, WWTF	19.8	1962 - 2098	158.5	268.1	158.5	2.19E-02	3.71E-02	2.19E-02
El Oasis Irrigation Area	306.4	1962 - 2098	315.4	804.1	268.0	2.82E-03	7.19E-03	2.40E-03

Notes:

ac-ft/yr = acre-feet per year

ft/d = feet per day

[1]Rate of Evaporation Pond-West reduced to 0.419 ft/d from 1988 to 1997

[2]Rate of Warren WWTF Pond only 14.37 ft/d from 1931 to 1954

Table 9
Precipitation Data for Bisbee-Naco Area

Year	January	February	March	April	May	June	July	August	September	October	November	December
1893	0.03	0.88	2.05	0	0.52	0	5.2	4.15	1.71	0.05	0	0.2
1894	0.61	1.25	1.87	0	0	0	1.63	8.73	0.39	1.47	z	1.31
1895	1.2	0.08	0	0.2	0.23	0.1	2.02	4.7	2.44	1.12	2.23	0.48
1896	0.55	1.04	0.27	0.23	0	0.45	2.8	3.1	2.35	7.82	0.4	0.36
1897	2.5	0.35	0.1	0	0.05	0.18	7.36	2.95	3.14	0.52	0	0.44
1898	2.57	0.26	1.94	0.47	0	1.91	8.86	3.84	2.11	0	1.01	2.9
1899	0.52	0.51	0.4	0	0	0.25	4.83	4.77	2.85	1.69	0.16	0.06
1900	0.54	1.41	2.23	0.97	0	0	1.12	1.38	6.54	0	1.31	0.28
1901	1.72	2.57	0.88	0.12	0.17	0	3.11	2.97	0.94	2.56	0.59	0.1
1902	0.68	0	0.29	0	0.4	0.3	0.54	5.17	1.64	z	1.55	1.85
1903	0.3	1.17	1.71	0	0.43	0.6	1.2	6.28	0.3	z	z	z
1904	0.12	0.4	0	0	1.12	0.22	2.59	5.77	0.43	1.34	0.16	1.33
1905	1.12	5.71	5.26	4.04	0	z	z	z	z	z	z	z
1906	1.36	2.29	1.11	0.05	0.01	0.02	4.86	2.75	0.74	0.44	1.23	5.1
1907	5.36	1.38	0.48	1.03	1.67	0	4.62	4.97	1.19	0.96	2.93	0
1908	1.09	2.11	0.24	0.4	0.23	0	4.51	8.17	1.9	0	0.45	1.79
1909	0.21	1.18	1.52	0	0	0.78	5.66	9.59	0.65	0	0.23	1.5
1910	0.26	0.15	0.07	0.07	0	0.54	5.72	3.22	1.84	0.24	0.61	0.13
1911	1.42	3.7	0.6	0.9	0.02	2.18	2.38	3.56	3.32	3.37	0.1	1.57
1912	0.03	1.2	2.32	0.59	0.06	0.53	5.34	10.15	z	0.3	0.22	0.52
1913	0.62	5.05	0	0.1	0.2	z	z	z	z	z	z	0.54
1914	0.75	0.81	1.6	0	0	0.36	3.81	4.78	2.16	3.43	1.58	7.4
1915	2.52	1.35	2.17	0.46	0	0	6.64	1.4	1.55	0	1.85	1.95
1916	3.42	0.45	1.29	1.19	z	z	6.67	4.78	0.22	0.76	z	0.5
1917	0.53	0.55	z	0.23	1.07	0.14	4.56	6.2	3.99	0	0	0
1918	1.77	1.41	0.12	0	0.1	0.46	3.18	2.03	0.1	0.63	1.9	1.95
1919	0.46	1.31	0.34	1.99	0.54	0.41	7.86	3.01	4.02	1.69	5.2	0.03
1920	2.66	0.89	1.42	0.79	0.38	0.52	2.69	2.14	0.6	0.64	0.16	0.29
1921	0.38	1.21	0.7	0.08	0	0.63	8.48	3.78	0.49	1.05	0.57	0.59
1922	0.92	0.14	0.67	0.27	0.1	1.87	4.61	7.4	1.22	0.51	1.46	0.38
1923	0.05	1.64	0.83	1.43	0	0.04	4.4	3.7	2.77	0.19	2.81	6.34
1924	0.03	0.08	2.78	0.43	0.05	0.46	5.8	2.27	0.44	0	0.08	1.2
1925	0.3	0.06	0.1	0.09	0.27	6.34	4.13	3.54	1.25	1.97	1.06	1.41
1926	0.86	1.2	3.17	2.78	0.73	0.04	3.94	1.68	9.05	1.46	0	2.55

Table 9
Precipitation Data for Bisbee-Naco Area

Year	January	February	March	April	May	June	July	August	September	October	November	December
1927	0	0.69	0.87	0	0	0.72	6.31	5.82	3.85	0.67	0.32	2
1928	0	0.97	0	0.04	0.67	0	2.55	7.5	0.06	2.39	0.39	0.56
1929	1.24	1.46	0.18	0	0	0.7	5.69	5.53	1.29	1.7	0.4	0.87
1930	1.39	0.89	1.88	0.19	0.54	1.18	7.06	5.3	1.14	0.65	2.2	0.9
1931	0.92	5.57	0.28	1.16	0.28	1.65	2.32	7.99	5.52	0.33	2.27	1.23
1932	1.89	1.23	0.2	0.09	0	0.79	4.4	5.99	0.06	0.58	0	2.09
1933	1.98	1.79	0	0.04	0	0.77	3.23	2	5.1	2.45	0.97	0.01
1934	0.38	0.71	0.5	0.12	0.13	0.43	4.37	5.46	0.83	0.58	0.71	2.78
1935	0.54	2.07	0.49	0.01	0.58	0.13	1.43	5.68	1.88	0	2.37	1.46
1936	0.46	0.84	0.66	0.02	0.01	0.77	3.08	1.12	3.67	0.42	1.47	1.28
1937	1.2	0.29	0.57	0	0.01	0.23	3.02	5.8	3.39	2.83	0.04	0.41
1938	0.93	0.81	1.15	0.45	0.07	1.35	6.37	5.36	1.84	0.11	0	2.46
1939	1.28	1.36	0.43	0.32	0	0.01	4.32	4.69	4.03	0.73	1.56	0.68
1940	1.32	3.09	0.18	0.13	0.51	2.04	2.42	3.56	2.61	0.45	0.72	2.94
1941	1.55	2.01	0.92	1.58	0.38	0.42	1.16	4.09	2.46	0.87	0.09	2.3
1942	0.68	2.37	0.53	1.29	0	0	2.52	2.45	2.99	0.91	0	1.91
1943	1.2	0	0.68	0	0.16	2.54	2.92	7.24	3.34	0.56	0.06	0.82
1944	1.24	1.18	1.77	0.7	0	0.01	4.03	2.4	3.56	1.98	0.95	1.4
1945	1.29	0.16	2.69	0.14	0	0	3.67	3.87	0.11	1.09	0	0.42
1946	3.66	0.05	0.6	0.16	0	1.11	3.44	3.57	2.32	0.99	0.46	0.89
1947	0.92	0.08	0.32	0.14	0.69	0.54	3.29	2.57	0	0.17	0.93	0.82
1948	0.07	1.28	0.2	0.03	0	0	1.29	4.75	3.35	0.68	0	1.95
1949	4.8	1.79	0.06	0	0	0.14	6.94	2.28	1.2	0.52	0.01	2.16
1950	0.98	1.22	0.46	0	0	2.52	4.18	1.68	0.48	0	0	0
1951	1.48	0.76	0.34	1.53	0.09	0	1.89	4.01	1.09	1.61	1.14	1.61
1952	0.41	0.07	2.92	3.12	0.01	2.08	1.14	4.86	0.42	0	1.49	1.17
1953	0.06	0.64	2.4	0.05	0	0.1	5.41	2.37	0	0.08	0.16	0.17
1954	1.02	0.37	0.73	0.02	0.29	0.41	4.9	5.81	1.62	1.22	0	0.02
1955	2.37	0.44	0.93	0	0.06	0.55	8.31	6.07	0.23	0.42	0.24	0.53
1956	0.89	0.21	0	0.19	0	0.94	5.35	2.58	0.24	0.4	0.06	0.18
1957	2.45	0.09	1.94	0.03	1.32	1.33	4.11	5.59	0.78	1.45	0.68	0.53
1958	0.06	1.59	2.9	1.05	0	0.53	3.44	6.29	3.43	1.4	0.65	0
1959	0	1.12	0.01	0.25	0	1.95	3.71	7.96	0.05	1.49	1.73	1.71
1960	3.33	0.35	0.16	0	0.07	0.12	3.11	3.8	1.29	2.37	0	0.42

Table 9
Precipitation Data for Bisbee-Naco Area

Year	January	February	March	April	May	June	July	August	September	October	November	December
1961	0.86	0.05	0.02	z	z	0.39	2.58	4.06	1.49	1.42	0.36	2.49
1962	1.76	0.16	1.31	0.11	0	0.42	2.29	0.69	1.55	0.06	1.59	1.39
1963	0.79	0.47	0.26	0.08	0.03	0.04	3.6	3.7	1.45	0.72	z	0.48
1964	0.32	z	z	0.13	0	0	4.76	2.94	2.73	0.63	0.82	0.2
1965	1.48	z	z	z	z	z	6.12	z	z	z	z	z
1966	z	z	z	z	0	0.37	5.81	4.15	2.62	0.08	0.22	0.23
1967	0	0.4	0.2	0.1	0.26	0.96	5.39	1.73	4.36	z	z	4.71
1968	0.81	2.34	1.76	0.53	0	0.07	3.72	z	0.4	0.23	0.68	0.72
1969	0.68	0.37	0.13	0	0.63	0.02	4.76	5.09	0.57	0	0.55	0.75
1970	0	0.04	1.07	0.41	0.07	0.23	1.92	6.46	2.03	0	0.13	0.49
1971	0	0.68	0	0.91	0.04	0.06	5.08	4.91	1.39	1.96	0.4	0.94
1972	0.04	0	0	0	0.85	1.24	3.08	3.16	2.63	2.92	0.75	0.82
1973	0.76	2.01	1.61	0	0.41	0.42	5.04	0.94	0.06	0	0.34	0
1974	1.5	0	0.05	0	0	0	6.51	5.78	0.63	3.04	0.4	0.07
1975	1.21	0.24	0.69	0.37	0	0	3.81	3.6	3.45	0.02	0.78	0.24
1976	0.27	0.76	0.2	0.43	0.3	0.25	5.61	4.51	1.33	z	1.14	1.23
1977	1.89	0	0	0.16	0	0.43	4.22	2.82	1.12	5.81	0.23	0.64
1978	2.43	2.32	1.98	0.02	0.24	0	4.03	3.13	0.89	2.04	1.94	z
1979	z	0	0	z	z	z	3.1	3.01	0.25	0	0	0.84
1980	0.55	1.83	0.15	z	z	0.37	0.48	0.6	0.22	0	0	z
1981	0.16	0.54	2.08	0.13	0.12	1.48	4.55	0.46	0.98	1.2	1.26	0
1982	z	z	0.41	0	1.32	0.02	2.33	5.94	3.21	0	1.2	4.07
1983	2.36	2.12	3.03	0.71	0	0	2.13	2.6	4.1	1.87	0.52	0.66
1984	2.09	0	0	1.08	0.23	2.1	z	8.89	0.53	2.12	1.42	4.4
1985	2.2	1.21	1.03	1.86	0	0.42	3.77	2.92	5	4.17	2.82	0.37
1986	0.2	2.41	2.23	0	0.12	1.74	8.83	8.9	0.85	0.68	1.03	3.64
1987	1.09	2.11	0.55	3.56	0.34	1.92	3.08	5.02	3.01	0.62	0.21	3.75
1988	2.19	0.42	0.44	1.86	0.02	0.46	4.4	3.86	3.22	3.77	0.94	1.01
1989	1.58	0.18	0.77	0.02	0.86	0	6.21	4.74	0.35	1.28	0.17	0.33
1990	1.49	1.1	0.49	0.18	0.14	0.71	8.11	6.71	2.4	1.52	1.51	2.63
1991	2.1	3.43	2.54	0	0.05	0.44	3.72	3.29	2.81	0.35	1.22	4.49
1992	2.8	1.25	2.01	0.31	z	z	z	z	z	z	z	z
1993	z	z	z	z	z	z	z	z	z	z	z	z
1994	z	z	z	z	z	z	z	z	z	z	z	z

Table 9
Precipitation Data for Bisbee-Naco Area

Year	January	February	March	April	May	June	July	August	September	October	November	December
1995	z	z	z	z	z	z	z	z	z	z	z	z
1996	z	z	z	z	z	z	z	z	z	z	z	z
1997	z	z	z	z	z	z	0.63	3.48	z	0.74	1.39	3.56
1998	0.1	3.03	0.83	0.01	0	0.25	4.4	1.77	0.75	0.44	0.94	0.52
1999	0	0	0	0.2	0	0.17	4.58	4.71	2.29	0	0	0
2000	0.05	0	0.42	0	0	2.93	2.75	6.73	0	8.71	2.06	0
2001	1.35	0.62	0.42	1.83	0.16	0.63	5.09	3.87	0.31	0.49	0.08	1.07
2002	0.46	1.3	0	0	0.01	0	3.91	5.67	0.58	0.6	0.28	1.54
2003	0.16	1.64	0.5	0	0.25	0.05	2.43	2.01	1.23	0.56	0.71	0.09
2004	2.4	0.93	1.3	1.87	0.08	0.39	1.52	1.92	2.87	0.6	0.94	1.15
2005	2.76	2.43	0.04	0.15	1.01	z	2.98	5.24	1.18	0.2	z	0.22
2006	0	0.32	0.73	z	z	z	z	z	z	z	z	0.38
2007	z	0.42	z	0.18	0	2.13	6.49	3	0.9	0.71	z	1.33
2008	0.19	z	z	z	0.26	0.21	z	4.72	2.5	0.12	0.24	z
Average	1.13	1.12	0.91	0.47	0.21	0.65	4.12	4.31	1.86	1.13	0.81	1.29
Maximum	5.36	5.71	5.26	4.04	1.67	6.34	8.86	10.15	9.05	8.71	5.20	7.40
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.46	0.00	0.00	0.00	0.00

Average Annual	**18.0**

Notes:

All precipitation values in inches

z = 26 days or more of missing data. Month not included in statistics

Source: Western Regional Climate Center Summaries for the following stations:

Bisbee (020768) - January 1893 to May 1961; May 1982 to February 1985

Bisbee (020773) - June 1961 to April 1982; May 1992 to December 1997

Bisbee (020775) - March 1985 to April 1992; July 1992 to December 2008

Table 10
Discharge Rate and Sulfate Concentration of Effluent Released to Greenbush Draw from the San Jose Wastewater Treatment Facility

Period	Discharge Rate			Effluent Concentration	
	Total (MGD)	Average (MGD)	Maximum (MGD)	Sample Date	Sulfate (mg/L)
July 2006				07/27/06	56.0
October 2006	11.426	0.369	0.469	10/11/06	29.8
November 2006	12.612	0.420	0.630		
December 2006	11.997	0.387	0.859		
4th Quarter 2006	**36.035**	**0.392**	**0.859**		
January 2007	10.539	0.340	0.502	01/18/07	53.0
February 2007	8.731	0.312	0.376		
March 2007	12.187	0.393	0.798		
April 2007	10.663	0.355	0.6	04/11/07	41.6
May 2007	11.629	0.375	0.439		
June 2007	12.64	0.421	0.508		
July 2007	16.024	0.517	1	07/30/07	62.5
August 2007	20.108	0.649	1.246		
September 2007	13.671	0.456	0.523		
October 2007	12.946	0.418	0.494	10/30/07	35.4
November 2007	12.514	0.417	0.531		
December 2007	12.642	0.408	0.529		
2007	**154.294**	**0.423**	**1.246**		
January 2008	11.733	0.378	0.476		
February 2008	12.193	0.420	0.479		
March 2008	12.241	0.395	0.457		
April 2008	10.555	0.352	0.501		
May 2008	12.696	0.410	0.504		
June 2008	11.022	0.367	0.542		
July 2008	14.203	0.458	0.583		
August 2008	15.202	0.490	0.7		
September 2008	12.157	0.405	0.728		
October 2008	11.997	0.387	0.5		
November 2008	11.319	0.377	0.461		
December 2008	11.687	0.377	0.476		
2008	**147.005**	**0.403**	**0.728**	**Average**	**46.4**

Notes:
Data provided by the City of Bisbee
MGD = million gallons per day
mg/L = milligrams per liter

CLEAR CREEK ASSOCIATES

Table From HGC (2009c)
L:\Projects\G & K\055038_Copper Queen Branch Mitigation Order\Aquifer Characterization Report\Task 4 ACR\tables\ Table 10 Discharge Rate and Sulfate Concentration of Effluent.xls: T10 Effint

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)	Chloride, dissolved	Fluoride, dissolved	Nitrate as N, dissolved	Nitrate/Nitrite as N, dissolved	Nitrite as N, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	Hydroxide as CaCO3	Total Alkalinity	Residue, Filterable (TDS) @ 180ºC	TDS (calculated)	TDS Ratio (measured/ calculated)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Cation-Anion Balance (%)
ANDERSON	613396	3/20/08	7.25	21.1	1176	431	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/5/08	7.03	21.8	1231	452	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/14/08	7.11	21.6	1260	472	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/15/08	7.10	21.3	1252	475	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/27/09	7.27	21	965	488	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/14/09	7.12	21.8	1229	534	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/14/09	7.03	22.2	1372	550	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/12/09	6.98	21.5	1375	510	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/27/10	7.93	20.1	1449	523	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/10	7.40	20.7	1439	627	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/19/10	6.93	24.1	1420	648	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AWC-02	616586	1/7/08	ND	ND	ND	14	14	-	2.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/3/08	ND	ND	ND	16	16	-	2.41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/5/08	ND	ND	ND	13.3	15.9	-	2.22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/12/08	7.01	22.3	630	14.3	17.8	0.2	2.42	2.42	<0.01	66.4	9.1	2.1	20.0	181	5	<2	186	280	255	1.10	4.7	5.0	3.1
		10/23/08	7.31	23.1	464	15.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/11/09	7.19	21.8	420	15.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/22/09	7.17	22.6	430	14.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/22/09	7.24	22.7	444	14.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/21/09	7.19	21.3	468	16.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/3/10	7.44	19.7	449	18.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/23/10	7.56	19.7	526	18.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/10	7.27	23.9	450	18.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AWC-03	616585	1/7/08	ND	ND	ND	41	14	-	2.09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/3/08	ND	ND	ND	38	14	-	2.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/5/08	ND	ND	ND	37.3	12.2	-	2.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/12/08	7.28	22.4	469	38.8	15.5	0.2	2.28	2.28	<0.01	62.8	8.6	2.1	22.8	156	5	<2	162	290	260	1.12	4.6	4.9	3.2
		10/23/08	7.48	21.0	462	41.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/11/09	7.25	21.2	445	64.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/22/09	7.30	21.4	452	42.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/22/09	7.39	22.6	456	41.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/21/09	7.48	21.3	540	50.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/3/10	7.44	19.7	449	42.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/23/10	7.57	19.7	468	44.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/10	7.29	23.8	460	46.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AWC-04	616584	2/4/08	ND	ND	ND	18	40	-	2.26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/7/08	ND	ND	ND	18	45	-	2.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6/2/08	ND	ND	ND	14.3	48	-	2.18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/12/08	7.08	22.5	458	21.6	47.5	0.1	1.94	1.94	<0.01	88.7	11.6	2.6	22.8	206	<2	<2	206	380	328	1.16	6.0	6.4	3.2
		10/23/08	6.91	22.2	616	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/11/09	7.02	21.3	539	27.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/22/09	6.93	22.1	560	26.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/22/09	7.13	22.5	587	26.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/21/09	7.00	21.2	607	25.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/3/10	7.35	19.3	438	16.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/23/10	7.14	19.2	625	27.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/10	7.02	24.1	600	26.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AWC-05	590620	2/4/08	ND	ND	ND	13	15	-	1.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/7/08	ND	ND	ND	14	14	-	1.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6/2/08	ND	ND	ND	14.3	15.6	-	1.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/12/08	6.74	23.3	425	14.9	16.1	0.1	2.02	2.02	<0.01	50.6	6.2	2.2	35.6	164	8	<2	172	280	242	1.16	4.3	4.6	3.4
		10/23/08	7.45	21.0	422	15.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/11/09	7.31	22.1	398	16.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6/3/09	7.33	22.0	418	12.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/22/09	7.49	24.4	423	14.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/21/09	7.37	21.1	433	16.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/3/10	7.35	19.3	438	16.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/23/10	7.62	18.9	443	17.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/10	7.62	24.2	440	19.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)	Chloride, dissolved	Fluoride, dissolved	Nitrate as N, dissolved	Nitrate/Nitrite as N, dissolved	Nitrite as N, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	Hydroxide as CaCO3	Total Alkalinity	Residue, Filterable (TDS) @ 180ºC	TDS (calculated)	TDS Ratio (measured/ calculated)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Cation-Anion Balance (%)
BANKS 986	647986	2/27/08	7.53	21.8	980	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/12/08	7.40	22.1	1021	65.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/08	7.43	22.9	1034	82.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/13/08	7.28	21.7	980	53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/21/09	7.66	21.6	872	164	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/8/09	7.56	22.7	933	47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/9/09	7.59	23.1	871	70.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/7/09	7.50	22.2	838	67.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/25/10	7.56	21.1	1020	50.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/20/10	7.71	22.8	1013	53.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/10	7.70	23.2	828.3	71.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BF-01	539783	3/4/08	6.46	21.9	2745	1320	30.4	<0.1	0.92	0.92	<0.01	621.0	100.0	4.5	60.2	610	<2	<2	610	2850	2510	1.14	40.8	42.0	1.4
		5/23/08	6.41	18.3	2698	1450	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/5/08	6.11	22.4	3095	1330	30	<2	1.09	1.09	<0.01	624	107	4.5	61.3	579	<2	<2	579	2820	2510	1.12	40.4	42.8	2.9
		11/5/08	6.33	19.9	3027	1490	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/20/09	6.42	19.2	1477	1330	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/6/09	5.98	23.9	2632	1280	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/17/09	6.21	29.7	2948	1250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/4/09	6.24	23.0	2846	1280	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/1/10	6.34	21.1	2945	1260	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/7/10	5.83	20.4	1853	1450	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/6/10	5.93	22.6	1403	1310	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BIMA	577927	2/6/08	6.69	22.2	1335	210	105	0.1	6.80	6.80	<0.01	224.0	48.4	12.4	65.9	510	<2	<2	510	980	1000	0.98	18.0	18.4	1.1
		4/25/2008[1]	6.37	23.1	1521	190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/13/2008[1]	6.58	22.7	1489	195	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6/23/2008[1]	6.30	23.3	1572	225	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6/23/08 DUP	6.30	23.3	1572	196	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/29/2008[1]	6.44	23.0	1647	204	101	0.1	7.85	7.85	<0.01	209	46.5	12.2	63.6	456	<2	<2	456	1040	945	1.10	16.8	17.4	1.8
		8/28/2008[1]	M	23.0	1776	256	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		9/23/2008[1]	6.29	23.0	1741	296	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/22/08	6.41	22.3	1801	285	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/20/09	6.40	21.7	1233	190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/20/09 DUP	6.40	21.7	1233	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/7/09	6.45	23.4	1436	212	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/8/09	6.31	23.4	1483	189	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/5/09	6.34	22.7	1525	233	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/20/10	6.88	17.0	NA	222	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/19/10	6.70	21.9	1533	256	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/12/10	6.70	24.0	1577	273	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BLOMMER	633472	2/5/08	7.43	20.2	714	206	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/2008[1]	7.06	21.9	753	201	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/15/2008[1]	7.16	22.2	845	211	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6/23/2008[1]	6.93	21.5	903	193	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/29/2008[1]	7.21	22.2	921	203	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/27/2008[1]	7.12	22.1	864	189	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		9/23/2008[1]	7.16	22.3	818	193	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/22/08	7.17	21.3	873	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMO-2008-1G	909474	8/27/08	7.09	24.2	808	107	76.3	0.1	13.5	13.5	<0.01	124	32.2	6.4	35.7	229	9	<2	238	580	588	0.99	10.1	10.6	2.4
		11/11/08	7.00	20.8	721	143	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/25/09	7.01	22.0	860	109	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/28/09	7.04	22.2	762	198	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/4/09	7.23	22.8	950	104	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/27/09	7.11	21.9	922	103	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/17/10	7.36	20.5	899.3	98.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/15/10	7.04	22.2	711	95.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/7/10	6.91	21.5	640	88.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/7/10 DUP	6.91	21.5	640	87.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)	Chloride, dissolved	Fluoride, dissolved	Nitrate as N, dissolved	Nitrate/Nitrite as N, dissolved	Nitrite as N, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	Hydroxide as CaCO3	Total Alkalinity	Residue, Filterable (TDS) @ 180ºC	TDS (calculated)	TDS Ratio (measured/ calculated)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Cation-Anion Balance (%)
BMO-2008-3B	909147	7/18/08	7.35	23.9	615	106	24	0.3	3.68	3.72	0.04	64.5	12.0	2.9	53.6	151	3	<2	154	390	373	1.05	6.2	6.6	3.1
		11/4/08	7.36	21.4	599	179	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/4/08 DUP	7.36	21.4	599	177	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/19/09	7.24	21.4	664	155	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/11/09	7.23	22.1	631	149	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/6/09	7.33	21.4	718	151	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/6/09 DUP	7.33	21.4	718	156	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/26/09	7.32	21.8	684	153	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/3/10	7.38	21.4	695	164	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/8/10	6.47	21.3	585	162	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/1/10	6.92	21.4	541	157	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMO-2008-4B	910096	12/11/08	7.34	22.8	374	9.4	4.3	0.2	0.78	0.78	<0.01	49.2	7.1	1.4	33.4	183	<2	<2	183	240	228	1.05	4.2	4.5	3.4
		2/18/09	7.17	23.2	370	13.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/30/09	7.33	24.5	376	11.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/30/09 DUP	7.33	24.5	376	11.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/6/09	7.53	24.6	397	11.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/27/09	7.53	23.7	379	11.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/24/10	7.48	21.8	362	9.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/16/10	7.70	23.4	330	9.73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/2/10	7.25	23.6	323	10.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMO-2008-5B	909653	9/30/08	7.08	22.0	688	193	15	0.3	2.02	2.02	<0.01	108	17.0	2.8	40.1	155	<2	<2	155	510	478	1.07	7.7	8.6	5.5
		2/18/09	7.03	21.5	691	192	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/27/09	7.32	22.1	605	177	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/4/09	7.35	22.3	724	174	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/29/09	7.29	21.8	731	181	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/29/09 DUP	7.29	21.8	731	185	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/15/10	7.22	21.7	720	185	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/15/10	7.21	23.0	571	194	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/7/10	6.94	22.2	551	183	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMO-2008-5M	909552	10/2/08	7.13	23.6	551	107	15.1	0.2	1.85	1.85	<0.01	75.8	11.4	2.6	34.1	138	<2	<2	138	390	337	1.16	5.5	6.2	6.0
		2/18/09	7.06	22.5	562	122	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/27/09	7.50	22.9	501	111	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/4/09	7.53	23.1	605	122	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/29/09	7.35	22.4	610	123	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/15/10	7.31	22.5	581	123	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/16/10	7.28	22.6	509	125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/16/10 DUP	7.28	22.6	509	124	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/7/10	7.02	23.5	482	123	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMO-2008-6B	909146	7/16/08	7.36	24.1	475	53.3	13	0.4	1.97	1.97	<0.01	59.7	10.2	3.0	26.2	151	9	<2	160	300	274	1.09	4.8	5.0	2.0
		11/4/08	7.41	21.5	398	60.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/19/09	7.23	21.1	444	54.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/27/09	7.55	21.7	389	52.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/4/09	7.48	23.4	470	48.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/26/09	7.29	22.5	448	48.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/15/10	7.53	21.2	391	33.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/15/10	7.47	21.0	362	37.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/1/10	7.24	22.2	361	40.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMO-2008-6M	909019	7/10/08	M	22.1	702	182	16	0.3	1.98	1.98	<0.01	104	17.9	3.60	32.5	144	9	<2	153	480	460	1.04	7.4	8.1	4.5
		11/4/08	7.33	21.8	621	199	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/20/09	7.11	22.0	702	193	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/28/09	7.34	22.4	595	119	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/4/09	7.40	23.3	750	189	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/26/09	7.18	22.4	727	187	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/15/10	7.29	20.8	733	193	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/15/10	7.36	20.2	619	208	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/1/10	7.15	22.0	571	198	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMO-2008-7M	908794	7/14/08	7.63	25.2	500	31.4	10.4	0.3	1.55	1.55	<0.01	32.4	11.4	2.70	60.8	188	13	<2	201	290	282	1.03	5.1	5.3	1.9
		11/6/08	7.53	22.6	380	34.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/18/09	7.31	23.3	452	27.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/11/09	7.43	24.4	426	26.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/6/09	7.81	24.1	486	25.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/27/09	7.53	23.0	470	26.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/17/10	7.57	23.4	452	25.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/17/10 DUP	7.57	23.4	452	25.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/15/10	7.52	23.2	415	26.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/6/10	7.28	23.5	391	22.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)	Chloride, dissolved	Fluoride, dissolved	Nitrate as N, dissolved	Nitrate/Nitrite as N, dissolved	Nitrite as N, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	Hydroxide as CaCO3	Total Alkalinity	Residue, Filterable (TDS) @ 180ºC	TDS (calculated)	TDS Ratio (measured/ calculated)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Cation-Anion Balance (%)
BMO-2008-8B	910097	12/5/08	6.47	20.1	2480	1890	80	0.1	2.91	2.93	0.02	529	195	14.4	46.4	630	<2	<2	630	3080	3150	0.98	54.7	44.9	-9.8
		2/19/09	6.19	21.0	2958	1570	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/5/09	6.18	21.3	2888	1370	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/10/09	6.42	21.5	2897	1250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/9/09	6.33	21.8	2889	1510	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/9/09 DUP	6.33	21.8	2889	1520	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/3/10	6.51	20.4	3016	1320	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/16/10	6.06	21.4	1682	1470	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/1/10	6.10	21.4	1594	1440	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMO-2008-8M	909711	12/9/08	7.16	23.4	852	197	13	0.3	1.78	1.78	<0.01	89	43.0	5.80	64.9	260			260	640	576	1.11	9.8	11.0	5.8
		2/19/09	7.27	23.5	758	147	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/19/09 DUP	7.27	23.5	758	149	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/5/09	7.19	25.1	680	122	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/10/09	7.49	24.8	673	107	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/5/09	7.30	25.4	675	104	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/3/10	7.70	24.1	641	99.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/16/10	7.29	24.5	541	97.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/1/10	6.99	25.0	502	94.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMO-2008-9M	909255	8/8/08	7.72	25.7	415	47.3	14	0.10	1.90	1.93	0.03	28.0	17.8	3.4	64.6	193	6	<2	199	320	306	1.05	5.5	5.7	1.8
		11/5/08	7.89	21.4	444	54.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/26/09	7.71	24.5	482	28.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/12/09	7.76	24.8	449	51.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/17/09	7.76	25.6	534	53.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/3/09	7.82	24.9	552	56.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/4/10	8.07	22.4	520	58.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/6/10	6.74	23.8	484	60.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/1/10	7.40	24.6	425	61.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMO-2008-10GL	909435	8/20/08	6.22	29.5	2924	1320	30.0	<2	<0.02	<0.02	<0.01	579	167	10.5	90.5	870	<2	<2	870	2970	2720	1.09	46.0	46.9	1.0
		11/5/08	6.47	25.3	2573	1290	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/25/09	6.34	26.8	2646	1180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/12/09	6.35	26.2	2402	1120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/11/09	6.52	27.3	2661	1030	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/2/09	6.52	26.7	2565	1100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/4/10	6.76	24.1	2937	1080	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/8/10	6.03	25.6	1575	1260	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/2/10	6.16	26.3	1338	1020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMO-2008-10GU	909272	8/4/08	6.41	23.6	3660	2210	60	<2	0.13	0.16	<0.01	649	311	15.3	37.6	984	<2	<2	984	3810	3870	0.98	67.8	60.0	-6.1
		11/5/08	6.15	20.2	3343	1890	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/25/09	5.96	22.7	3426	1740	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/6/09	5.99	23.2	3359	1710	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/11/09	6.28	22.5	3348	1690	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/2/09	6.27	21.8	3157	1730	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/10/10	6.67	19.1	3951	1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/7/10	5.96	20.4	3210	1510	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/6/10	5.90	21.8	1610	1670	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMO-2008-11G	909434	8/22/08	8.02	28.2	359	14.2	2.8	0.2	0.56	0.56	<0.01	10.7	5.1	1.7	64.2	149	14	<2	163	220	205	1.07	3.6	3.8	2.7
		11/12/08	7.96	24.2	257	13.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/26/09	7.92	25.1	319	12.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/28/09	8.14	25.5	273	11.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/12/09	8.24	25.3	365	11.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/9/09	8.03	25.5	339	13.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/1/10	8.37	23.2	338	13.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/9/10	6.88	24.5	301	13.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/1/10	6.97	25.4	298	12.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMO-2008-13B	909551	10/3/08	6.49	21.6	2180	980	23	<0.2	1.92	1.92	<0.01	420	79.8	6.8	53.0	347	<2	<2	347	2040	1780	1.15	28.3	30.1	3.1
		2/17/09	6.51	20.9	1941	1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/6/09	6.55	22.0	1891	930	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/5/09	6.63	21.5	2137	950	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/28/09	6.81	19.7	2259	1010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/16/10	6.87	20.8	2093	997	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/14/10	6.38	21.2	1346	974	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/6/10	6.37	21.8	1208	972	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)	Chloride, dissolved	Fluoride, dissolved	Nitrate as N, dissolved	Nitrate/Nitrite as N, dissolved	Nitrite as N, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	Hydroxide as CaCO3	Total Alkalinity	Residue, Filterable (TDS) @ 180ºC	TDS (calculated)	TDS Ratio (measured/ calculated)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Cation-Anion Balance (%)
BMO-2008-13M	909760	12/3/08	7.73	24.1	1463	494	20	0.7	0.02	0.02	<0.01	35.1	13.2	3.4	286	259	3	<2	262	970	1010	0.96	16.2	15.5	-2.2
		2/17/09	8.21	22.7	1340	441	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/29/09	8.04	24.8	1126	217	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/5/09	8.04	25.4	1392	387	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/28/09	8.12	21.4	1347	403	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/16/10	8.07	24.9	1297	375	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/13/10	8.06	23.2	1130	398	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/2/10	8.30	23.9	1027	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMO-2010-1M	219957	9/9/10	7.82	24.6	727.0	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMO-2010-2M	219958	9/15/10	6.66	22.6	2054	915	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMO-2010-3B	219970	7/29/10	7.48	23.1	420	16.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMO-2010-3M	219969	7/31/10	7.73	24.3	390	14.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BURKE	212268	2/7/08	7.17	23.0	411	29.5	31.8	0.3	1.83	1.83	<0.01	62.3	22.8	2.8	26.0	212	<2	<2	212	360	311	1.16	5.9	6.2	2.5
		4/22/08	7.13	27.0	423	26	11	0.2	2.88	2.88	<0.01	52.1	22.0	2.3	16.9	191	<2	<2	191	260	-	-	-	-	-
		8/5/08	7.06	26.8	496	21.9	10	0.2	2.81	2.85	<0.01	52.5	22.3	2.3	16.1	187	<2	<2	187	260	250	1.04	4.6	5.2	6.1
		10/20/08	7.57	26.0	466	20.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/11/09	7.23	25.0	363	23.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/28/09	7.16	26.1	369	24.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/19/09	7.36	26.7	486	22.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		12/16/09	7.28	25.7	488	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/2/10	7.56	12.3	432	23.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/22/10	7.49	16.4	452	24.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/10	7.56	25.6	423.7	33.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CAMPBELL	215509	02/05/08	7.87	18.3	823	211	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CHAMBERS	629807	3/6/08	7.73	17.8	408	7.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/5/08	7.15	22.1	421	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/14/08	7.43	23.2	434	5.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/15/08	7.41	22.5	420	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/27/09	7.57	21.5	312	5.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/14/09	7.42	22.4	384	6.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/09	7.83	23.4	414	4.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/13/09	7.41	22.6	410	6.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/26/10	7.31	21.3	416	5.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/23/10	7.47	20.9	427.5	8.34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/10	7.49	23.1	430	7.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
COB MW-1	903992	2/22/08	6.93	21.2	1401	720	19.8	0.3	2.33	2.33	<0.01	257.0	64.5	7.7	56.5	206	11	<2	217	1360	1270	1.07	20.2	20.8	1.5
		5/20/08	6.88	22.0	2050	980	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/30/08	6.88	21.7	1780	730	19.8	0.1	2.50	2.50	<0.01	273	69.3	8.0	58.9	223	<2	<2	223	1500	1300	1.15	20.5	22.1	3.8
		10/23/08	6.95	21.2	1690	750	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/12/09	6.92	21.1	1313	750	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/09	7.15	22.7	1366	720	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/22/09	6.94	21.6	1570	680	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/22/09 DUP	6.94	21.6	1570	730	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/22/09	6.81	22.3	1582	820	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/4/10	7.04	21.1	1653	680	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/20/10	6.92	21.8	1836	783	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/13/10	7.02	22.3	2004	919	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
COB MW-2	903984	2/22/08	7.28	20.2	417	41	19.4	0.3	6.49	6.49	<0.01	66.4	9.0	2.1	25.5	156	12	<2	168	340	298	1.14	5.2	5.2	0
		5/20/08	7.32	21.2	490	40.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/30/08	7.34	20.8	511	37.6	19.9	<0.1	6.80	6.80	<0.01	66.3	9.0	2.1	26.6	158	<2	<2	158	330	286	1.15	4.9	5.2	3.0
		10/23/08	7.36	20.3	498	34.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/12/09	7.35	20.2	379	35.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/23/09	7.33	21.8	431	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/22/09	7.36	21.3	483	33.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/22/09	7.24	21.0	454	32.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/3/10	7.55	19.7	450	33.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/26/10	7.28	21.3	479.6	34.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/13/10	6.91	21.2	479.5	30.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/13/10 DUP	6.91	21.2	479.5	30.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)	Chloride, dissolved	Fluoride, dissolved	Nitrate as N, dissolved	Nitrate/Nitrite as N, dissolved	Nitrite as N, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	Hydroxide as CaCO3	Total Alkalinity	Residue, Filterable (TDS) @ 180ºC	TDS (calculated)	TDS Ratio (measured/ calculated)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Cation-Anion Balance (%)
COB MW-3	906823	2/28/08	7.39	21.0	416	57.8	16.2	0.2	2.0	2.0	<0.01	62.2	8.9	2.2	25.5	159	<2	<2	159	300	277	1.08	5.0	5.0	0.0
		3/27/08	ND	ND	ND	57.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/30/08	ND	ND	ND	37	16.1	0.2	2.41	2.41	<0.01	66.1	9.2	2.4	26.5	149	<2	<2	149	320	288	1.11	5.0	5.2	2.0
		5/20/08	7.56	22.3	473	35.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/24/08	ND	ND	ND	64.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/30/08	7.64	22.3	541	67.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/9/08	ND	ND	ND	52.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/23/08	7.43	20.8	507	76.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/12/09	7.35	21.1	432	112	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/23/09	7.35	22.6	407	43.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/22/09	7.38	21.5	460	52.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/22/09	7.40	21.3	466	74.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/22/09 DUP	7.40	21.3	466	73.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/3/10	7.36	21.1	480	102	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/26/10	7.35	22.0	497.9	77.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/13/10	7.41	21.7	456.7	46.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
COB WL	593116	2/22/08	6.99	20.6	919	90	106	0.3	3.91	3.91	<0.01	128	34.3	7.2	47.8	269	11	<2	280	650	603	1.08	10.8	11.5	3.1
		3/24/08	ND	ND	ND	98.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/28/08	ND	ND	ND	98.7	110	0.1	4.02	4.02	<0.01	130	35.0	7.5	51.5	274	<2	<2	274	700	613	1.14	10.9	11.8	4.0
		5/20/08	7.30	21.9	1053	98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/30/08	7.17	22.0	1098	97.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/30/08	ND	ND	ND	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/15/08	ND	ND	ND	107	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/23/08	7.23	21.4	1075	104	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/12/09	6.98	20.6	814	94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/23/09	7.29	22.2	923	98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/22/09	7.17	22.5	1037	97.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/22/09	7.17	22.4	988	96.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/3/10	7.48	21.1	1030	97.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/26/10	7.36	21.9	1038	97.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/26/10 DUP	7.36	21.9	1038	97.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/13/10	7.18	22.3	1013	88.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
COLLINS	565260	2/12/08	6.88	21.6	1470	520	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/29/08	7.01	22.0	1459	520	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/31/08	6.86	21.6	1502	536	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/20/08	8.44	24.7	1510	518	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/11/09	6.68	21.4	1147	567	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/09	6.92	22.5	1150	499	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/22/09	7.00	22.4	1413	460	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/20/09	6.60	21.9	1432	513	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/2/10	6.98	21.2	1439	471	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/23/10	6.99	20.6	1472	561	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/10	6.69	25.0	1420	569	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
COOPER	623564	2/14/08	7.02	20.8	371	33	17.5	0.3	2.82	2.82	<0.01	47.9	13.8	2.2	25.3	154	9	<2	163	270	254	1.06	4.6	4.7	1.1
		5/14/08	8.08	22.1	419	34.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/31/08	7.81	28.4	455	33.7	16.9	0.2	2.68	2.68	<0.01	48.9	13.3	2.1	24.6	150	7	<2	157	260	249	1.04	4.5	4.6	1.1
		10/20/08	8.44	24.7	448	31.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/11/09	7.32	19.2	333	34.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/09	8.19	24.9	346	33.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/09	8.45	29.8	430	32.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/14/09	7.85	24.6	423	33.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/1/10	7.83	13.6	433	32.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/22/10	7.82	17.9	433	34.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/19/10	7.98	29.3	420	35.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
COOPER C	637069	3/20/08	6.93	21.3	2081	880	49	<0.1	3.09	3.10	0.01	393	59.8	6.0	45.0	229	<2	<2	229	1810	1690	1.07	27.0	26.7	0.6
		5/5/08	6.78	22.4	2139	990	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/08	6.86	22.3	2162	1040	46.5	<0.1	3.24	3.24	<0.01	386	58.8	5.8	43.3	235	<2	<2	235	1860	1740	1.07	28.1	26.2	-3.5
		7/15/08 DUP	6.86	22.3	2162	960	46.4	0.1	3.25	3.25	<0.01	398	61.7	6.1	46.2	234	<2	<2	234	1860	1670	1.11	26.4	27.2	1.5
		10/16/08	6.80	21.4	2078	1020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/27/09	6.92	20.5	1489	950	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/14/09	6.85	21.6	1833	930	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/14/09	6.75	22.1	1972	910	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/12/09	6.70	21.8	1858	830	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/27/10	7.27	19.6	1930	620	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/22/10	6.76	19.5	1921	884	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/10	6.84	22.9	1761	921	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)	Chloride, dissolved	Fluoride, dissolved	Nitrate as N, dissolved	Nitrate/Nitrite as N, dissolved	Nitrite as N, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	Hydroxide as CaCO3	Total Alkalinity	Residue, Filterable (TDS) @ 180ºC	TDS (calculated)	TDS Ratio (measured/ calculated)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Cation-Anion Balance (%)
DODSON	644927	2/20/08	7.61	17.3	857	54	129	0.3	10.70	10.70	<0.01	111	37.5	12.3	41.2	252	14	<2	266	590	598	0.99	10.8	10.8	0
		5/12/08	7.11	21.1	1118	34.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/24/08	7.25	21.6	1233	49.3	160	0.2	13.1	13.1	<0.01	124	43.3	13.7	51.3	223	12	<2	235	740	646	1.15	11.2	12.4	5.1
		10/13/08	7.15	20.5	1095	56.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/22/09	7.20	20.4	892	51.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/9/09	7.09	21.4	1103	50.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/8/09	7.18	21.1	1153	55.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/6/09	7.07	21.1	1140	49.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/21/10	7.15	18.9	1227	44.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/19/10	7.46	19.9	1261	48.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/19/10 DUP	7.46	19.9	1261	48.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/10	7.16	22.7	1260	47.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DURAZO	NR	2/10/09	7.22	18.8	848	386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/20/09	7.37	22.7	901	367	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/09	7.57	22.8	1102	332	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/14/09	7.17	21.9	1048	377	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/1/10	7.30	21.1	1105	344	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/26/10	7.22	23.1	1099	388	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/10	7.28	23.0	1070	405	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EAST	599796	2/8/08	7.45	19.9	423	10.6	31.2	0.4	6.3	6.3	<0.01	59.9	24.3	2.5	31.6	227	<2	<2	227	320	325	0.98	6.1	6.4	2.4
		5/14/08	7.31	20.9	595	14.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/23/08	7.34	20.8	605	11.8	33.3	0.4	6.10	6.10	<0.01	59.5	24.4	2.4	31.4	217	6	<2	223	350	326	1.07	6.0	6.4	3.2
		10/14/08	7.33	20.3	531	8.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/20/09	7.33	20.0	482	12.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/8/09	7.32	20.6	555	15.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/13/09	7.33	21.2	613	13.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/8/09	7.29	20.8	593	13.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/25/10	7.08	19.0	585	10.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/10	7.42	20.5	616	14.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/10 DUP	7.42	20.5	616	13.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/14/10	7.45	22.2	577.1	12.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EN-02	NA	10/21/08	7.24	22.5	361	7.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EN-03	NA	10/21/08	7.39	23.9	346	8.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EN-05	NA	10/21/08	7.43	22.4	391	6.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EN-06	NA	10/21/08	7.35	22.5	349	9.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EPPELE 641	805641	3/11/08	7.98	21.4	646	21.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/12/08	7.21	21.7	667	24.7	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/08	7.49	23.9	605	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/14/08	7.56	20.4	642	21.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/21/09	7.60	21.1	500	22.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/8/09	7.56	22.4	538	19.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/9/09	7.43	24.3	550	17.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/10	7.58	23.3	529.2	21.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FLEMING	218386	7/15/10	6.98	24.2	1390	573	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FRANCO	500101	2/6/08	7.47	19.6	1301	670	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/5/08	6.93	23.1	1557	680		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/14/08	7.00	22.7	1586	680	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/15/08	7.20	20.5	1560	680	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/22/09	7.19	20.1	1178	740	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/14/09	7.24	23.1	1416	690	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/13/09	7.30	27.3	1532	670	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/12/09	7.16	24.2	1493	650	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/26/10	6.91	18.5	1529	640	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/23/10	7.43	15.8	1559	699	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/13/10	7.48	28.6	901.6	188	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)	Chloride, dissolved	Fluoride, dissolved	Nitrate as N, dissolved	Nitrate/Nitrite as N, dissolved	Nitrite as N, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	Hydroxide as CaCO3	Total Alkalinity	Residue, Filterable (TDS) @ 180ºC	TDS (calculated)	TDS Ratio (measured/ calculated)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Cation-Anion Balance (%)
FULTZ	212447	2/27/08	6.76	21.1	1827	152	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/2008[1]	6.74	22.0	1739	137	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/14/2008[1]	6.88	22.3	1532	131	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6/23/2008[1]	6.74	22.0	1788	111	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/29/2008[1]	6.74	22.2	1989	152	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/28/2008[1]	M	21.6	1889	137	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		9/23/2008[1]	6.82	21.9	1821	137	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/22/08	6.80	21.4	1940	145	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/21/09	6.74	21.2	1481	82	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/9/09	6.78	21.5	1695	138	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/13/09	7.04	23.4	1452	81	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/8/09	7.00	21.6	1262	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/8/09 DUP	7.00	21.6	1262	71.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/25/10	7.11	21.8	1282	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/20/10	7.32	21.2	1202	68.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/14/10	7.75	22.2	1132	57.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GALLANT	502527	2/11/08	7.46	20.2	604	17.9	12.7	0.2	3.0	3.04	<0.01	106	15.9	4.3	25.6	344	<2	<2	344	400	402	1.00	7.8	7.8	0
		7/23/08	7.26	21.2	925	20.9	56.9	0.1	19.2	19.2	<0.01	138	19.8	4.8	29.6	303	<2	<2	303	560	537	1.04	9.4	9.9	2.6
GARNER 557	558557	02/21/08	6.70	20.9	822	123	14.3	0.2	1.70	1.70	<0.01	62.2	10.2	2.5	58.1	171	13	<2	184	420	394	1.07	6.7	6.5	-1.5
GARNER 635	587635	2/4/08	7.61	22.7	479	37.8	13.7	0.2	1.68	1.69	0.01	39.2	8.2	2.8	65.0	182	<2	<2	182	290	284	1.02	4.9	5.5	5.8
		5/5/08	7.26	24.9	468	35.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/08	7.63	25.6	480	37.4	13.5	0.2	1.92	1.92	<0.01	37.6	7.8	2.5	60.2	163	16	<2	179	300	281	1.07	4.0	5.2	4.0
		10/15/08	7.65	24.1	472	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/28/09	7.69	23.4	368	37.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/15/09	7.83	24.1	412	36.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/16/09	7.56	25.1	445	35.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/14/09	7.58	25.2	446	36.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/2/10	7.79	22.8	465	35.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/22/10	7.84	23.7	464.1	36.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/10	7.57	25.3	458.2	38.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GGOOSE 547	628547	5/21/08	7.08	22.7	856	199	37.1	0.1	7.14	7.14	<0.01	113	32.9	5.5	25.6	194	<2	<2	194	600	561	1.07	9.6	9.6	0
		8/15/08	7.02	24.8	915	178	35.4	0.1	8.90	8.90	<0.01	117	32.4	5.6	25.4	187	<2	<2	187	590	545	1.08	9.1	9.7	3.2
		10/29/08	7.27	22.6	897	216	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/24/09	7.06	23.8	851	186	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/14/09	7.15	23.9	743	174	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/19/09	7.20	23.8	887	175	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/11/09	7.15	23.1	897	188	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GL-03	539782	3/4/08	7.43	25.7	417	20.3	20.3	<0.1	0.75	0.77	0.02	46.7	22.8	2.6	18.7	192	<2	<2	192	260	250	1.04	4.8	5.1	3.0
		5/22/08	7.06	25.3	647	43.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/4/08	7.10	26.8	673	36.1	21.4	<0.1	0.60	0.62	0.02	68.7	38.9	3.4	19.5	278	<2	<2	278	400	358	1.12	6.9	7.5	4.2
		11/12/08	7.21	25.2	478	34.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/26/09	7.05	26.5	603	54.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/5/09	6.91	28.1	682	43.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/1/09	7.12	27.4	768	43.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/10/09	6.96	27.0	692	49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/2/10	7.36	24.9	693	43.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/2/2010 DUP	7.36	24.9	693	45.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/9/10	6.17	25.6	556	48.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/7/10	6.48	26.3	546	44.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HOBAN	805290	2/27/08	6.93	22.1	1359	510	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/7/08	6.88	22.3	1532	670	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/14/08	6.88	23.1	1719	690	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/16/08	6.98	22.4	1624	692	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/28/09	6.82	21.3	1220	580	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/15/09	7.07	21.7	1423	700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/14/09	6.78	22.6	1551	670	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/15/09	6.75	22.7	1487	670	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/15/09 DUP	6.75	22.7	1487	780	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/2/10	7.12	19.8	1575	580	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)	Chloride, dissolved	Fluoride, dissolved	Nitrate as N, dissolved	Nitrate/Nitrite as N, dissolved	Nitrite as N, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	Hydroxide as CaCO3	Total Alkalinity	Residue, Filterable (TDS) @ 180ºC	TDS (calculated)	TDS Ratio (measured/ calculated)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Cation-Anion Balance (%)
HOWARD	NR	3/4/08	7.06	20.4	1280	571	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/8/08	6.95	21.0	1494	673	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/14/08	7.00	21.1	1566	610	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/15/08	7.00	20.6	1598	683	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/28/09	6.82	21.0	1203	640	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/28/09 DUP	6.82	21.0	1203	640	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/15/09	7.02	21.5	1397	620	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/09	7.16	21.5	1539	640	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/12/09	6.89	21.4	1414	600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/27/10	7.35	20.0	1714	440	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/27/10 DUP	7.35	20.0	1714	520	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/10	7.16	20.8	1490	710	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/19/10	6.94	24.6	1350	548	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KEEFER	209744	2/6/08	7.70	19.0	378	6.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/6/08	7.19	20.3	512	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/16/08	7.21	21.4	539	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/28/08	7.32	20.1	534	21.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/28/09	7.42	19.5	356	6.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/16/09	7.29	20.0	452	7.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/14/09	7.35	22.1	533	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/13/09	7.24	20.7	516	8.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/26/10	7.15	18.8	483	7.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/20/10	7.44	20.5	540.9	8.77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/10	7.50	22.2	535.8	8.84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MCCONNELL 265	539265	2/20/08	7.21	21.1	1435	720	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/6/08	6.77	21.6	1668	737	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/08	6.91	22.3	1775	700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/15/08	6.82	21.3	1686	703	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/28/09	6.85	21	1274	660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/15/09	7.04	21.3	1472	657	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/09	7.01	22.2	1607	662	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/12/09	6.77	21.7	1594	666	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/26/10	6.71	21.5	1641	685	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/22/10	6.95	20.1	1691	811	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/10	6.86	23.5	1560	805	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
METZLER	35-71891	3/5/08	7.27	21.6	1055	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/15/08	7.12	22.8	1051	329	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/31/08	7.16	22.5	1078	317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/20/08	7.24	22.2	1080	305	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/20/08 DUP	7.24	22.2	1080	326	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/11/09	7.12	21.3	818	321	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/20/09	7.22	23.2	845	313	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/09	7.41	22.9	1031	293	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/09 DUP	7.41	22.9	1031	309	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/14/09	7.1	22.7	989	315	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/1/10	7.22	21.7	1021	286	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/18/10	7.56	21.0	1053	330	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/16/10	7.20	24.1	1007	330	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOORE	538847	2/20/08	7.69	22.2	362	7.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/8/08	7.09	22.4	432	7.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/16/08	7.34	23.0	482	9.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/29/08	7.32	22.4	452	19.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/29/09	7.11	21.7	328	6.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/16/09	7.40	22.1	374	6.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/09	7.44	23.3	439	5.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/13/09	7.36	22.6	429	7.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/26/10	7.54	19.6	423	6.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/22/10	7.47	20.6	433	7.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/10	7.44	24.1	431.3	7.54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/10 DUP	7.44	24.1	431.3	7.11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)	Chloride, dissolved	Fluoride, dissolved	Nitrate as N, dissolved	Nitrate/Nitrite as N, dissolved	Nitrite as N, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	Hydroxide as CaCO3	Total Alkalinity	Residue, Filterable (TDS) @ 180ºC	TDS (calculated)	TDS Ratio (measured/ calculated)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Cation-Anion Balance (%)
NESS	509127	7/24/08	7.35	26.5	563	50.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/16/08	7.47	21.4	542	48.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/26/09	7.39	17.2	422	52.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/11/09	7.52	28.8	472	45.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/11/09	7.56	28.7	525	39.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/12/09	7.53	24.5	537	51.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/2/10	7.67	19.7	535	48.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/10	7.70	23.5	518.9	42.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/19/10	7.58	28.9	524.7	48.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NOTEMAN	212483	2/5/08	6.70	19.9	1317	310	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/13/08	6.67	23.0	1445	272	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/24/08	6.68	24.2	1539	274	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/23/08	6.57	23.2	1643	356	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/19/09	6.38	22.9	1098	322	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/7/09	6.56	23.8	1375	303	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/8/09	6.55	24.6	1405	260	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/5/09	6.48	24.1	1442	281	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/20/10	6.79	20.3	1450	289	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/19/10	6.81	22.4	1446	307	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/19/10	6.77	24.6	1438	309	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NSD-02	527587	2/5/08	ND	ND	ND	43	52.5	0.201	<1.0	-	<0.01	-	-	-	-	-	-	-	-	388	-	-	-	-	-
		7/7/08	8.02	21.0	609	44	42	0.0431	0.641	-	0.007	-	-	-	-	-	-	-	-	369	-	-	-	-	-
NSD-03	527586	2/5/08	ND	ND	ND	70.7	14.1	0.186	3.2	-	<0.010	-	-	-	-	-	-	-	-	396	-	-	-	-	-
		7/7/08	7.64	21.0	570	58.9	11.6	0.041	3.20	-	0.011	-	-	-	-	-	-	-	-	372	-	-	-	-	-
NWC-02	562944	10/27/08	7.47	22.2	438	5.1	20.7	0.1	2.74	2.74	<0.01	63.6	8.3	1.1	20.2	176	<2	<2	176	280	237	1.18	4.4	4.7	3.3
		2/12/09	7.58	21.6	330	6.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/23/09	7.39	23.8	373	6.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/09	7.62	23.9	408	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/21/09	7.32	22.6	436	6.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/3/10	7.68	19.6	423	8.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/10	7.57	22.1	413	7.26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/10	7.36	23.7	412.5	6.87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NWC-03	203321	3/4/08	ND	ND	ND	560	30	-	4.64	-	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6/9/08	ND	ND	ND	524	-	-	4.75	-	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/27/08	7.07	21.9	1374	489	30	<0.1	4.41	4.41	<0.01	222	34.1	3.5	47.2	181	<2	<2	181	1010	954	1.06	15.10	16.1	3.20
		2/12/09	7.06	20.2	1023	412	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/23/09	6.98	21.9	1129	466	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/23/09 DUP	6.98	21.9	1129	460	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/09	7.21	22.9	1194	458	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/21/09	6.94	21.8	1224	444	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/3/10	7.24	20.7	1214	444	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/10	7.22	21.6	1178	433	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/10	7.04	22.8	1229	477	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NWC-04	551849	3/4/08	ND	ND	ND	240	41	-	-	-	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6/9/08	ND	ND	ND	231	41.9	-	6.25	-	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/27/08	7.32	25.0	856	162	41.4	0.1	6.54	6.54	<0.01	91.5	36.7	6.2	41.5	182	<2	<2	182	540	518	1.04	8.6	9.5	5.0
		1/22/09	7.23	22.9	688	184	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/12/09	7.20	19.8	699	181	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/12/09 DUP	7.20	19.8	699	198	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/11/09	7.15	23.4	846	197	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/23/09	7.21	24.1	797	188	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/28/09	7.01	24.1	933	210	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6/24/09	6.93	25.6	792	169	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/09	7.48	24.3	859	193	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/19/09	7.12	24.5	906	183	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		9/23/09	7.16	23.8	953	202	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/21/09	7.18	24.3	875	191	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/18/09	7.24	22.9	909	191	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		12/16/09	7.28	22.3	926	193	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/3/10	7.49	22.3	844	167	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/8/10	7.33	22.5	880	182	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/10	7.34	22.8	913	218	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/18/10	7.68	25.8	901.3	210	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6/15/10	7.31	24.5	917.5	212	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/10	7.28	28.3	873.2	188	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/25/10	7.55	24.8	820.9	196	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)	Chloride, dissolved	Fluoride, dissolved	Nitrate as N, dissolved	Nitrate/Nitrite as N, dissolved	Nitrite as N, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	Hydroxide as CaCO3	Total Alkalinity	Residue, Filterable (TDS) @ 180ºC	TDS (calculated)	TDS Ratio (measured/ calculated)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Cation-Anion Balance (%)
NWC-06	575700	3/4/08	ND	ND	ND	7.9	13	-	1.71	-	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6/9/08	ND	ND	ND	7.2	12.9	-	1.78	-	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/27/08	7.35	23.3	414	6.4	13.4	0.2	1.86	1.86	<0.01	54.5	7.4	1.4	26.4	173	<2	<2	173	260	222	1.17	4.1	4.5	4.7
		2/12/09	7.54	21.8	306	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/23/09	7.30	24.5	354	7.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/09	7.63	23.5	388	6.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/21/09	7.26	23.2	413	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/3/10	7.61	20.5	404	7.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/3/10 DUP	7.61	20.5	404	7.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/10	7.54	22.4	387	8.49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/10	7.33	26.0	388.6	8.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OSBORN	643436	2/25/08	7.35	22.4	508	16.4	18.2	0.3	3.76	3.76	<0.01	84.4	15.4	4.3	25.2	246	29	<2	275	370	357	1.04	6.6	6.7	0.8
		5/13/08	7.22	22.2	576	17.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/22/08	7.24	22.9	618	17.7	19.7	0.4	4.4	4.4	<0.01	80.3	15.0	4.2	24.7	252	29	<2	281	350	362	0.97	6.8	6.4	-3.0
		7/22/08 DUP	7.24	22.9	618	17.5	19.6	0.3	4.7	4.7	<0.01	80.9	15.1	4.2	25.0	250	31	<2	281	350	364	0.96	6.8	6.4	-3.0
		10/16/08	7.39	22.4	595	15.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/20/09	7.33	22.4	469	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/7/09	7.25	24.0	542	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/18/09	7.16	24.6	643	17.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/5/09	7.14	22.9	599	17.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/21/10	7.47	19.5	591	15.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/19/10	7.60	21.5	601.9	19.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/12/10	7.69	24.2	594.0	18.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PALMER	578819	2/14/08	7.91	17.5	435	15.9	11.3	0.4	2.13	2.13	<0.01	31.9	27.1	5.4	50.1	235	15	< 2	251	300	308	0.97	5.8	6.1	2.5
		5/13/08	7.92	22.9	508	16.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/22/08	7.64	25.8	548	16.2	11.3	0.4	2.34	2.34	<0.01	30	25.4	5.1	47.9	226	39	<2	265	300	321	0.93	6.1	5.8	-2.5
		10/16/08	7.61	17.0	527	15.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/20/09	7.33	19.4	441	14.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/8/09	7.65	19.1	475	15.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/8/09	7.47	27.2	521	14.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/5/09	7.81	22.2	538	16.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/20/10	7.72	11.9	510	13.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/22/10	7.97	13.6	520	16.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/12/10	7.62	30.2	518.8	15.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PANAGAKOS	35-76413	4/21/08	6.80	20.5	1228	410	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/08	6.95	21.9	1390	444	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/13/08	6.86	21.2	1386	480	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/13/08 DUP	6.86	21.2	1386	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/22/09	6.92	19.7	997	397	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/9/09	6.81	21.7	1228	431	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/9/09 DUP	6.81	21.7	1228	426	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/9/09	6.89	22.3	1469	490	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/6/09	6.83	21.1	1328	472	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/21/10	7.06	18.8	1291	318	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/20/10	7.25	21.0	1528	608	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/10	6.90	24.0	1560	706	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PARRA	576415	2/11/08	7.08	21.8	1067	360	33.4	0.1	4.17	< 0.04	<0.01	178	50.4	4.4	31.6	177	<2	<2	177	880	783	1.12	12.3	14.5	8.2
		5/15/08	7.10	21.8	1200	405	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/31/08	7.00	22.4	1248	423	33.5	<0.1	4.23	4.23	<0.01	181	49.8	4.5	32.4	213	<2	<2	213	930	871	1.07	14.4	14.7	1.0
		7/31/08 DUP	7.00	22.4	1248	404	33.5	<0.1	4.33	4.33	<0.01	177	48.5	4.3	30.9	212	<2	<2	212	920	845	1.09	14.0	14.3	1.1
		10/20/08	7.07	22.9	1246	387	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/13/09	7.24	22.1	965	405	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/20/09	7.10	22.6	971	372	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/09	7.17	23.9	1174	375	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/20/09	6.80	22.5	1188	388	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/1/10	7.07	21.5	1197	353	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/22/10	6.91	20.3	1219	417	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/14/10	7.13	22.2	1201	403	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/14/10 DUP	7.13	22.2	1201	391	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)	Chloride, dissolved	Fluoride, dissolved	Nitrate as N, dissolved	Nitrate/Nitrite as N, dissolved	Nitrite as N, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	Hydroxide as CaCO3	Total Alkalinity	Residue, Filterable (TDS) @ 180ºC	TDS (calculated)	TDS Ratio (measured/ calculated)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Cation-Anion Balance (%)
PIONKE	613395	2/6/08	7.53	19.9	910	394	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/7/08	7.08	21.4	1100	391	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/17/08	6.99	21.9	1209	420	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/27/08	7.03	20.8	1175	460	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/29/09	7.13	19.9	847	385	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/14/09	7.58	20.7	1053	411	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/13/09	7.35	21.5	1165	472	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/7/09	7.43	21.1	1100	403	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/8/10	7.72	18.6	1201	406	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/26/10	7.22	21.9	1224	438	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/10	7.32	22.3	1158	474	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
POOL	509518	2/20/08	7.95	20.9	497	134	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/19/08	7.40	22.2	585	122	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/31/08	7.47	22.3	599	117	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/21/08	7.51	21.4	598	120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/13/09	7.62	20.8	473	141	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/09	7.73	22.6	470	124	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/09	7.76	22.9	579	122	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/20/09	7.22	21.2	577	122	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/24/10	7.56	22.4	577	110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/22/10	7.75	20.2	606.5	130	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/14/10	7.38	21.7	580.9	117	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
POWER	624535	2/12/08	7.11	18.9	428	15.5	6.1	0.1	7.00	7.00	<0.01	95	7.6	3.8	7.4	242	<2	< 2	242	310	312	0.99	5.8	5.8	0.0
		7/22/08	7.10	21.7	795	20.2	37.8	<0.1	24.1	24.1	<0.01	124	11.0	3.8	13.6	222	29	<2	251	550	479	1.15	8.2	7.8	-2.5
RAMIREZ	216425	2/4/08	7.47	21.7	408	7.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/6/08	7.19	22.7	405	8.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/17/08	7.32	24.5	439	8.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/27/08	7.41	22.2	412	7.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/29/09	7.24	22.2	301	8.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/16/09	7.49	22.4	344	7.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/10/09	7.52	23.9	411	6.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/6/09	7.30	23.8	388	8.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/25/10	7.48	22.4	390	7.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/10	7.45	22.6	397	9.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/10	7.38	25.1	420	8.98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RAY	803772	2/15/08	7.30	19.1	1540	159	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/2008[1]	6.92	21.3	1418	125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/13/2008[1]	7.05	20.9	1418	123	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6/23/2008[1]	6.87	21.1	1593	130	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/29/2008[1]	6.98	21.8	1411	120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/28/2008[1]	M	21.1	1519	129	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		9/23/2008[1]	6.90	22.2	1519	125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/22/08	6.96	20.8	1604	145	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/20/09	6.92	20.6	1355	88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/8/09	6.85	21.4	1759	178	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/9/09	6.93	22.3	1434	126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/7/09	6.98	21.3	1288	127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/26/10	6.82	20.6	1352	125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/20/10	7.14	21.5	1318	134	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/14/10	7.11	23.8	1313	137	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROGERS 803	641803	2/7/08	7.45	18.6	601	138	13.2	0.2	4.69	4.71	0.02	94	11.7	3.0	26.6	148	<2	<2	148	410	383	1.07	6.3	6.9	4.5
		4/21/2008[1]	7.32	21.4	552	128	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/8/2008[1]	7.14	21.2	622	141	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6/23/2008[1]	7.06	22.9	660	129	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/29/2008[1]	6.78	23.1	339	134	13.1	0.2	4.3	4.3	<0.01	92.5	12.6	3.3	28.7	149	<2	<2	149	430	393	1.09	6.4	7.0	4.5
		8/28/2008[1]	7.18	21.6	635	128	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		9/23/2008[1]	7.24	21.9	599	133	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/22/08	7.36	21.3	650	144	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/10/09	7.42	17.9	475	141	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/29/09	7.52	21.9	506	211	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/3/09	7.39	24.2	674	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/16/10	7.46	23.9	643.4	169	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROGERS 596[2]	573596	10/19/09	6.89	23.3	1360	590	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/5/09	6.79	21.9	1418	540	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/25/10	6.99	19.6	1603	520	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/22/10	7.21	18.2	1641	710	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)	Chloride, dissolved	Fluoride, dissolved	Nitrate as N, dissolved	Nitrate/Nitrite as N, dissolved	Nitrite as N, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	Hydroxide as CaCO3	Total Alkalinity	Residue, Filterable (TDS) @ 180ºC	TDS (calculated)	TDS Ratio (measured/ calculated)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Cation-Anion Balance (%)
ROGERS E	216018	2/4/08	7.40	21.0	435	4.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/7/08	7.18	22.2	415	5.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/17/08	7.28	23.0	446	7.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/27/08	7.38	21.4	434	15.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/10/09	7.51	20.7	322	5.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/16/09	7.48	22.0	361	4.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/13/09	7.34	22.6	420	3.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/6/09	7.31	22.3	407	5.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/25/10	7.52	20.6	414	5.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/10	7.44	21.1	421	6.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/10	7.37	23.8	430	6.47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RUIZ	531770	2/5/08	7.73	18.2	445	263	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/15/08	7.23	25.9	965	265	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/30/08	6.99	22.1	999	243	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/20/08	7.04	22.0	995	238	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/12/09	6.94	20.9	748	254	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/09	7.18	22.3	759	227	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/3/09	7.05	22.9	1029	221	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/28/09	7.09	20.6	920	227	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/1/10	7.08	20.9	934	236	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/26/10	7.01	22.5	920.1	240	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/10	7.08	22.5	880	240	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SCHWARTZ	210865	2/8/08	7.52	21.5	506	158	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/2008[1]	7.23	21.7	563	122	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/19/2008[1]	7.38	22.4	629	130	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6/23/2008[1]	7.02	22.1	674	129	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/29/2008[1]	7.25	22.4	955	245	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/28/2008[1]	M	22.3	669	131	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		9/23/2008[1]	7.27	22.2	607	124	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/22/2008[1]	7.31	22.0	653	135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/19/2008[1]	7.38	21.1	612	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		12/17/2008[1]	6.78	21.6	472	144	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/29/2009[1]	7.08	22.0	475	124	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/23/2009[1]	7.33	22.1	610	123	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/17/09	7.46	22.2	520	120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/10/09	7.52	22.8	651	116	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/10/09 DUP	7.52	22.8	651	117	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/6/09	7.27	22.5	613	120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/22/10	7.79	19.5	664	133	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/10	7.50	20.9	638	129	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/10	7.43	22.0	650	134	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SRC	211345	4/23/08	7.57	25.8	380	19	10	0.2	3.61	3.61	<0.01	25.8	16.3	2.1	48.2	174	<2	<2	174	230	-	-	-	-	-
		8/5/08	7.40	27.2	452	15.4	10.4	0.2	3.74	3.74	<0.01	26.8	17.8	2.0	44.6	173	<2	<2	173	250	238	1.05	4.3	4.8	5.5
SWAN	NR	2/13/08	7.28	20.7	467	24.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/14/08	7.24	21.2	479	23.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/24/08	7.35	22.4	506	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/16/08	7.32	20.7	488	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/20/09	7.05	20.4	391	19.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/7/09	7.21	21.5	447	19.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/8/09	7.18	23.1	473	18.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/5/09	7.18	21.4	496	19.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/21/10	7.49	19.5	501	18.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/21/10	7.42	20.3	512.1	20.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/19/10	7.13	23.8	518.6	22.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TM-02A	522574	3/4/08	8.67	22.6	302	12.3	8.6	0.3	<0.02	0.02	0.02	12.6	5.8	2.2	58.0	146	9	<2	155	190	196	0.97	3.6	3.7	1.4
		5/23/08	7.75	22.9	321	14.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/15/08	7.84	26.4	369	14.4	8.2	0.2	0.3	0.3	<0.01	14.7	5.2	2.4	60.2	143	8	<2	151	190	200	0.95	3.5	3.8	4.1
		10/30/08	8.07	23.9	375	21.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/24/09	8.10	24.8	340	20.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/6/09	8.06	26.7	320	18.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/12/09	8.34	26.9	398	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/4/09	8.16	26.3	381	21.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/10/10	8.13	25.2	351	21.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/10/10 DUP	8.13	25.2	351	21.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/6/10	6.96	24.6	363	25.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/6/10	7.38	24.6	343	22.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)	Chloride, dissolved	Fluoride, dissolved	Nitrate as N, dissolved	Nitrate/Nitrite as N, dissolved	Nitrite as N, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	Hydroxide as CaCO3	Total Alkalinity	Residue, Filterable (TDS) @ 180ºC	TDS (calculated)	TDS Ratio (measured/ calculated)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Cation-Anion Balance (%)
TM-03	522575	5/20/08	7.51	22.2	778	110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/6/08	7.08	21.6	828	97	40.7	0.2	7.68	7.68	<0.01	94.3	36.6	3.5	27.8	221	<2	<2	221	510	467	1.09	8.1	9.0	5.3
		11/12/08	7.47	20.5	590	128	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/26/09	7.21	21.8	737	107	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/26/09 DUP	7.21	21.8	737	102	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/13/09	7.47	22.2	695	109	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/18/09	7.48	22.4	822	98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/10/09	7.55	21.8	761	106	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/2/10	7.56	21.6	748	99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/14/10	7.55	20.6	635	103	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/7/10	7.19	21.4	566	103	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TM-06 MILLER	522695	2/27/08	7.44	19.6	457	13.9	7.1	0.3	0.96	0.96	<0.01	42.2	19.0	1.7	54.3	218	<2	<2	218	310	274	1.13	4.9	6.1	10.9
		5/20/08	7.50	20.7	506	32.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/4/08	7.41	20.7	529	31.3	18.0	0.7	0.89	0.89	<0.01	37.8	19.5	1.9	52.1	210	<2	<2	210	300	291	1.03	5.4	5.8	3.6
		10/29/08	7.55	20.2	531	34.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/26/09	7.18	20.4	574	32.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/13/09	7.35	20.9	465	30.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/18/09	7.50	20.9	560	30.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/18/09 DUP	7.50	20.9	560	29.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/12/09	7.53	20.4	530	31.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/14/10	7.35	19.4	461	29.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/2/10	7.24	20.1	438	29.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TM-07	522576	3/6/08	7.54	20.8	726	22.5	9	0.2	3.04	3.04	<0.01	49	15.8	2.0	22.6	133	9	<2	142	220	223	0.10	3.7	4.7	11.9
		5/22/08	6.96	20.1	385	22.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/6/08	7.04	22.8	519	22.2	8.9	0.2	2.52	2.52	<0.01	45.8	14.7	1.9	20.5	157	<2	<2	159	240	220	1.09	4.0	4.4	4.8
		11/4/08	7.76	20.6	347	31.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/20/09	7.77	19.9	376	22.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/13/09	7.30	22.9	559	130	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/17/09	7.60	22.6	442	134	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/3/09	7.85	21.8	441	134	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/2/10	7.67	21.6	422	124	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/25/10	7.77	21.2	398	42.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/6/10	7.58	22.0	350	44.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TM-08 SWAN	522817	2/13/08	7.63	24.1	511	24.1	32.1	0.3	5.3	5.3	<0.01	43.4	21.4	4.9	35.5	204	<2	< 2	204	310	296	1.1	5.6	5.6	0
		5/14/08	7.44	24.4	480	12.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/23/08	7.76	28.1	522	12.6	14.8	0.3	2.86	2.86	<0.01	<0.02	<0.02	1.1	128	204	11	<2	215	310	303	1.02	5.2	5.6	3.7
TM-14 NELSON	522816	02/08/08	7.64	21.6	319	32.9	12.5	0.3	1.82	1.82	<0.01	56.1	10.0	2.8	23.6	166	<2	<2	166	250	246	1.02	4.5	4.7	2.2
TM-15 MILLER	522699	2/27/08	7.66	21.9	344	14	7.1	0.4	1.56	1.56	<0.01	32.9	18.0	2.0	32.4	181	2	<2	183	220	224	0.98	4.2	4.6	4.5
		5/23/08	7.54	22.1	371	14.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/5/08	7.42	23.3	413	13.7	7.0	0.3	1.99	1.99	<0.01	29.8	18.9	2.0	32.0	173	<2	<2	174	210	216	0.97	4.1	4.5	4.7
		10/28/08	7.63	22.6	387	18.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/28/08 DUP	7.63	22.6	387	18.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/26/09	7.57	22.0	373	14.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/13/09	7.61	23.1	344	13.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/17/09	7.73	23.2	398	14.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/3/09	7.73	23.4	414	14.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/24/10	7.66	22.8	381	14.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/27/10	7.71	23.0	383.6	14.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/20/10	7.77	23.0	324	14.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TM-16	522578	3/5/08	7.17	20.6	1351	497	28.9	<0.1	6.80	6.90	<0.01	225	51.7	13.4	30.7	205	<2	<2	205	1030	1000	1.03	15.8	17.2	4.2
		5/22/08	7.05	20.5	1304	522	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/6/08	6.67	20.9	1410	466	28.1	<0.1	8.07	8.07	<0.01	215	52.7	13.3	30.0	191	<2	<2	191	1070	955	1.12	15.0	16.7	5.4
		11/5/08	7.14	19.8	1162	547	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/20/09	6.90	21.1	1292	492	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/13/09	6.93	21.1	1179	484	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/19/09	7.08	21.2	1354	468	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/10/09	7.02	21.0	1310	505	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/2/10	7.13	20.4	1313	451	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/14/10	6.90	19.9	987	484	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/2/10	6.81	20.8	858	474	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)	Chloride, dissolved	Fluoride, dissolved	Nitrate as N, dissolved	Nitrate/Nitrite as N, dissolved	Nitrite as N, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	Hydroxide as CaCO3	Total Alkalinity	Residue, Filterable (TDS) @ 180ºC	TDS (calculated)	TDS Ratio (measured/ calculated)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Cation-Anion Balance (%)
TM-19A	522581	3/6/08	8.02	22.2	240	56.1	15.4	0.1	0.26	0.26	<0.01	37.9	11.6	3.0	57.7	119	19	<2	138	280	273	1.03	4.3	5.4	11.3
		5/22/08	7.36	24.0	501	64.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/6/08	7.32	22.6	494	55.3	15.4	0.1	0.09	0.09	<0.01	37.3	10.8	2.9	53.0	153	5	<2	158	270	272	0.99	4.7	5.1	4.1
		11/18/08	7.79	24.3	365	66.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/3/09	7.41	24.5	489	66.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/22/09	7.44	24.3	494	62.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/12/09	7.61	24.4	554	61.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/4/09	7.47	24.2	522	63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/10/10	7.54	22.9	511	60.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/9/10	6.49	23.0	435	66.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/7/10	6.93	23.8	428	63.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TM-42	562554	3/5/08	7.10	20.8	1342	482	27	0.2	6.55	6.55	<0.01	185	55.8	10.4	37.9	186	<2	<2	186	980	939	1.04	15.1	15.8	2.3
		5/22/08	7.05	21.4	1270	483	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/6/08	6.69	22.0	1388	467	27.3	0.2	7.20	7.20	<0.01	191	60.7	10.1	38.7	208	<2	<2	208	1010	952	1.04	15.3	16.5	3.8
		11/6/08	6.90	21.0	1025	477	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/18/09	6.72	22.3	1245	429	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/7/09	6.88	24.5	1155	430	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/7/09 DUP	6.88	24.5	1155	445	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8/18/09	7.04	24.4	1336	428	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/3/09	7.07	23.1	1266	430	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/24/10	7.13	22.7	1236	390	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/19/10	6.87	21.5	985	444	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/2/10	6.81	23.9	827	407	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TM-43	564729	3/3/08	8.57	21.0	341	2.1	7.7	0.3	0.04	0.04	<0.01	10.1	5.7	2.2	79.4	197	20	<2	217	250	246	1.02	4.6	4.5	-1.1
		8/4/08	8.14	25.7	436	<5	12.0	<1	0.25	0.25	<0.01	10.4	5.8	2.0	79.7	174	12	<2	186	270	227	1.19	4.0	4.5	5.9
TM-43A	564726	3/3/08	6.17	19.9	2788	1420	31	<0.2	0.99	0.99	<0.01	570	181	4.5	42.1	713	<2	<2	713	3000	2680	1.19	45.0	45.0	0.3
		8/4/08	6.03	21.6	3149	1320	30.0	<0.2	1.31	1.31	<0.01	577	188	4.7	40.5	658	<2	<2	658	2950	2560	1.15	41.8	46.2	5.0
		3/3/08	6.79	20.6	514	0.7	5	<0.1	0.05	0.06	0.01	54.6	23.8	2.9	47.9	338	<2	<2	338	350	338	1.04	6.9	6.8	-0.7
		8/5/08	6.89	21.0	507	31.8	4.7	<0.1	0.03	0.03	<0.01	47.5	21.5	2.6	44.9	231	<2	<2	231	300	292	1.03	5.4	6.1	6.1
		8/5/08 DUP	6.89	21.0	507	32.5	4.7	<0.1	0.11	0.11	<0.01	47.9	21.7	2.5	44.9	234	<2	<2	234	310	295	1.05	5.5	6.2	6.0
TM-43B	565004	03/03/08	6.79	20.6	514	0.7	5	<0.1	0.05	0.06	0.01	54.6	23.8	2.9	47.9	338	<2	<2	338	350	338	1.04	6.9	6.8	-0.7
		08/05/08	6.89	21.0	507	31.8	4.7	<0.1	0.03	0.03	<0.01	47.5	21.5	2.6	44.9	231	<2	<2	231	300	292	1.03	5.4	6.1	6.1
		8/5/08 DUP	6.89	21.0	507	32.5	4.7	<0.1	0.11	0.11	<0.01	47.9	21.7	2.5	44.9	234	<2	<2	234	310	295	1.05	5.5	6.2	6.0
TVI 236	802236	3/20/08	7.48	20.0	488	31.3	26	0.1	3.90	3.93	0.03	70.5	9.3	1.9	25.6	178	<2	<2	178	310	289	1.07	5.2	5.4	1.9
		5/7/08	7.13	20.4	494	32.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/08	7.39	21.9	532	37.6	23.5	0.2	3.46	3.46	<0.01	70.4	9.3	1.8	26.3	161	11	<2	173	310	292	1.06	5.1	5.4	2.9
		10/15/08	7.45	22.3	490	36.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/11/09	7.32	20.1	391	27.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/17/09	7.36	19.3	418	28.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/17/09 DUP	7.36	19.3	418	28.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/09	7.59	22.9	484	31.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/19/09	7.31	22.1	513	33.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/2/10	7.39	20.4	497	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/23/10	7.46	20.0	504.6	30.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/10	7.37	21.5	499.4	39.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TVI 875	568875	2/21/08	7.28	21.1	739	244	20.1	0.2	2.99	2.99	<0.01	120	16.1	2.9	41.1	161	11	<2	172	630	565	1.12	9.3	9.2	-0.5
		5/7/08	7.09	21.2	833	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/08	7.27	22.4	925	274	20.2	0.2	3.0	3.0	<0.01	131	17.4	2.8	39.6	148	11	<2	160	640.0	598	1.07	9.7	9.7	0
		10/15/08	7.26	22.1	878	245	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/11/09	7.20	20.7	738	312	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/17/09	7.31	21.5	690	251	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/09	7.47	22.2	812	236	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/19/09	7.23	21.9	822	247	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/2/10	7.32	20.8	939	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/23/10	7.34	20.2	930.4	294	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/10	7.46	21.8	842.5	262	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UN-02	NA	10/14/08	7.63	22.6	356	6.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UN-03	NA	10/14/08	7.59	22.1	356	6.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UN-04	NA	10/14/08	7.39	21.4	376	6.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UN-05	NA	10/14/08	7.44	22.8	351	6.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WALKER	200393	2/13/08	7.05	20.2	650	20	4	0.2	2.26	2.26	<0.01	117	14.4	3.6	14.3	355	<2	<2	355	440	396	1.11	7.8	7.7	-0.6
		7/23/08	7.25	20.7	740	45.4	37.8	0.3	7.24	7.24	<0.01	89	27.9	2.9	28.6	250	7	<2	257	450	421	1.07	7.6	8.0	2.6

Well Name	ADWR 55 Registry No.	Sample Date	pH (SU)	Temp (deg C)	SC (µS/cm)	Sulfate, dissolved (mg/L)	Chloride, dissolved	Fluoride, dissolved	Nitrate as N, dissolved	Nitrate/Nitrite as N, dissolved	Nitrite as N, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	Hydroxide as CaCO3	Total Alkalinity	Residue, Filterable (TDS) @ 180ºC	TDS (calculated)	TDS Ratio (measured/ calculated)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Cation-Anion Balance (%)
WEED	544535	2/14/08	7.74	21.7	323	11.1	9	-	1.72	1.72	<0.02	35.6	14.5	2.2	30.0	162	5	<2	168	230	212	1.08	3.9	4.3	4.9
		5/15/08	7.22	22.7	365	12.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/30/08	7.42	32.0	407	11.5	10.1	0.3	1.92	1.92	<0.01	34.1	13.6	2.2	29.4	163	2	<2	165	230	209	1.10	3.9	4.1	2.5
		10/20/08	8.10	31.6	405	10.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/13/09	7.66	21.0	303	12.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/22/09	7.46	22.2	368	11.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/16/09	7.50	21.9	365	10.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/20/09	7.34	21.6	381	12.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/1/10	7.60	20.8	382	12.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/26/10	7.69	22.1	366	13.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/10	7.36	22.1	354.9	13.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/10 DUP	7.36	22.1	354.9	13.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WEISKOPF	641802	2/15/08	7.48	20.0	1072	500	33.1	0.2	4.74	4.74	<0.01	218	31.4	4.3	35.7	177	<2	<2	177	1010	950	1.06	15.3	15.2	-0.3
		5/7/08	7.10	21.8	1251	483	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/16/08	7.07	22.2	1399	560	26.0	0.1	4.29	4.29	<0.01	248	34.3	4.4	38.6	170	3	<2	173	1060	1040	1.0	16.3	17.0	2.1
		10/28/08	6.98	20.8	1401	602	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/29/09	6.79	20.7	1014	503	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/15/09	7.53	21.1	1164	503	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/15/09	7.84	22.1	1317	486	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/15/09	6.89	21.4	1216	484	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/2/10	7.22	20.4	1319	451	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/22/10	7.30	19.3	1329	572	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/19/10	7.06	23.1	1330	573	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ZANDER	205126	2/4/08	7.24	19.7	392	5.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/6/08	7.26	21.2	404	6.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/16/08	6.92	22.9	441	6.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/28/08	7.40	21.2	415	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2/10/09	7.50	20.4	317	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/16/09	7.47	21.7	352	5.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/14/09	7.36	22.9	418	4.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10/13/09	7.41	21.7	407	6.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1/26/10	7.49	20.3	411	5.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4/2/10	7.55	20.0	416	6.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/21/10	7.38	22.7	388.2	6.78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes:

ADWR = Arizona Department of Water Resources

All units are in milligrams per liter (mg/L) unless otherwise noted

deg C = degrees Celsius

meq/L = milliequivalent per liter

EN = Ejido Naco, Sonora, Mexico

M = pH Meter Malfunction

NA = Not Applicable

NR = No Record

- = Not Analyzed

ND = No Data

SC = Specific Conductance

SU = Standard Units

TDS = Total Dissolved Solids

UN = Urbano Naco, Sonora, Mexico

µS/cm = microsiemens per centimeter

[1] *Verified drinking water supply well, sample collected for sulfate trend analysis for interim action evaluation*

[2] Well Previousely identified as ROGERS 803

Table 12
Water Level Data

Well Name	ADWR 55 Registry No.	UTM East (meters)	UTM North (meters)	Measuring Point Elevation[1] (ft amsl)	Date	Depth To Water (feet)	Groundwater Elevation (ft amsl)
ANDERSON	613396	601134.729	3468816.065	4580.34	3/20/08	145.46	4434.88
					5/5/08	145.84	4434.50
					7/14/08	146.16	4434.18
					10/15/08	146.21	4434.13
					1/27/09	145.97	4434.37
					4/14/09	146.21	4434.13
					7/14/09	146.88	4433.46
					10/12/09	147.31	4433.03
					1/27/10	147.31	4433.03
					4/21/10	147.57	4432.77
					7/19/10	148.34	4432.00
AWC-02	616586	598907.911	3468549.357	4547.64	8/27/08	121.12	4426.52
					4/8/08[2]	116	4431.64
					10/23/08[3]	115	4432.64
					4/22/09[3]	118	4429.64
					10/9/09[3]	117	4430.64
					4/23/10[3]	119	4428.64
AWC-03	616585	599090.322	3468681.898	4539.52	8/27/08	119.40	4420.12
					4/8/2008[2]	112	4427.52
					10/23/08[3]	106	4433.52
					4/22/09[3]	114	4425.52
					10/9/09[3]	116	4423.52
					4/23/10[3]	116	4423.52
AWC-04	616584	598949.929	3468717.084	4540.48	8/18/08	112.56	4427.92
					4/8/2008[2]	108	4432.48
					10/23/08[3]	111.31	4429.17
					4/22/09[3]	110	4430.48
					10/9/09[3]	110	4430.48
					4/23/10[3]	109	4431.48
AWC-05	590620	599269.904	3468541.692	4542.51	8/27/08	299.65	4242.86
					4/8/08	284	4258.51
					10/23/08	284	4258.51
					4/22/09	286	4256.51
					6/3/09	125	4417.51
					10/9/09[3]	289	4253.51
					4/23/10[3]	278	4264.51
BANKS 987	647987	606981.921	3469206.175	4648.18	2/27/08	208.00	4440.18
					5/12/08	216.30	4431.88
					7/21/08	228.95	4419.23
					10/13/08	228.20	4419.98
					1/21/09	206.64	4441.54
					4/8/09	205.50	4442.68
					7/9/09	235.68	4412.50
					10/7/09	236.71	4411.47
					2/25/10	216.98	4431.20
					4/20/10	219.35	4428.83
					7/20/10	235.60	4412.58

Table 12
Water Level Data

Well Name	ADWR 55 Registry No.	UTM East (meters)	UTM North (meters)	Measuring Point Elevation[1] (ft amsl)	Date	Depth To Water (feet)	Groundwater Elevation (ft amsl)
	644919	606243.850	3469076.689	4692.36	5/12/08	113.71	4578.65
					7/23/08	113.56	4578.80
					10/16/08	113.20	4579.16
					3/11/09	112.92	4579.44
					4/10/09	112.89	4579.47
					7/7/09	112.86	4579.50
BF-01	539783	604169.077	3472151.593	4835.23	3/4/08	348.99	4486.24
					5/23/08	348.80	4486.43
					8/5/08	348.66	4486.57
					11/5/08	348.94	4486.29
					2/20/09	348.78	4486.45
					5/6/09	348.73	4486.50
					8/17/09	348.73	4486.50
					11/4/09	348.65	4486.58
					3/1/10	348.84	4486.39
					4/7/10	348.70	4486.53
					7/6/10	348.69	4486.54
BIMA	577927	606001.245	3471852.804	4802.05	5/13/08	367.31	4434.74
					8/18/08	370.24	4431.81
					10/23/08	353.96	4448.09
					1/20/09	353.07	4448.98
					4/7/09	357.76	4444.29
					7/8/09	365.44	4436.61
					10/5/09	370.11	4431.94
					4/19/10	382.25	4419.80
					7/21/10	386.89	4415.16
BMO-2008-1G	909474	606467.681	3471723.644	4805.10	8/27/08	62.05	4743.05
					11/11/08	60.95	4744.15
					2/25/09	61.43	4743.67
					4/28/09	62.01	4743.09
					8/4/09	62.96	4742.14
					10/27/09	63.61	4741.49
					2/17/10	64.51	4740.59
					4/15/10	65.05	4740.05
					7/7/10	65.83	4739.27
BMO-2008-3B	909147	602012.923	3467919.582	4583.97	7/18/08	138.05	4445.92
					11/4/08	137.95	4446.02
					2/19/09	138.19	4445.78
					5/11/09	138.46	4445.51
					8/6/09	139.02	4444.95
					10/26/09	139.60	4444.37
					3/3/10	140.03	4443.94
					4/8/10	140.07	4443.90
					7/1/10	140.70	4443.27

Table 12
Water Level Data

Well Name	ADWR 55 Registry No.	UTM East (meters)	UTM North (meters)	Measuring Point Elevation[1] (ft amsl)	Date	Depth To Water (feet)	Groundwater Elevation (ft amsl)
BMO-2008-4B	910096	601099.405	3468383.430	4573.17	12/11/08	130.77	4442.40
					2/18/09	130.58	4442.59
					4/30/09	131.24	4441.93
					8/6/09	131.96	4441.21
					10/27/09	132.04	4441.13
					2/24/10	131.82	4441.35
					4/16/10	132.65	4440.52
					7/2/10	133.20	4439.97
BMO-2008-5B	909653	600438.159	3468994.715	4585.10	9/30/08	145.10	4440.00
					2/18/09	144.35	4440.75
					4/27/09	144.78	4440.32
					8/4/09	145.36	4439.74
					10/29/09	145.88	4439.22
					2/15/10	145.42	4439.68
					4/15/10	145.80	4439.30
					7/7/10	146.59	4438.51
BMO-2008-5M	909552	600445.071	3468994.282	4585.02	10/2/08	146.65	4438.37
					2/18/09	145.97	4439.05
					4/27/09	146.46	4438.56
					8/4/09	147.13	4437.89
					10/29/09	147.68	4437.34
					2/15/10	147.07	4437.95
					4/16/10	147.34	4437.68
					7/7/10	148.28	4436.74
BMO-2008-6B	909146	600366.523	3469820.644	4627.44	7/16/08	190.13	4437.31
					11/4/08	190.23	4437.21
					2/19/09	189.71	4437.73
					4/27/09	189.99	4437.45
					8/4/09	190.80	4436.64
					10/26/09	191.04	4436.40
					2/15/10	190.82	4436.62
					4/15/10	190.75	4436.69
					7/1/10	191.43	4436.01
BMO-2008-6M	909019	600367.943	3469813.885	4626.90	7/10/08	191.63	4435.27
					11/4/08	190.25	4436.65
					2/20/09	190.70	4436.20
					4/28/09	190.98	4435.92
					8/4/09	191.77	4435.13
					10/26/09	192.14	4434.76
					2/15/10	191.78	4435.12
					4/15/10	191.64	4435.26
					7/1/10	192.53	4434.37
BMO-2008-7M	908794	603099.165	3470029.283	4688.33	7/14/08	238.31	4450.02
					11/6/08	239.69	4448.64
					2/18/09	238.90	4449.43
					5/11/09	239.03	4449.30
					8/6/09	239.17	4449.16
					10/27/09	239.55	4448.78
					2/17/10	239.98	4448.35
					4/15/10	240.13	4448.20
					7/6/10	240.28	4448.05

Table 12
Water Level Data

Well Name	ADWR 55 Registry No.	UTM East (meters)	UTM North (meters)	Measuring Point Elevation[1] (ft amsl)	Date	Depth To Water (feet)	Groundwater Elevation (ft amsl)
BMO-2008-8B	910097	604171.347	3471141.719	4753.25	12/5/08	297.94	4455.31
					2/19/09	297.63	4455.62
					5/5/09	297.37	4455.88
					8/10/09	297.53	4455.72
					11/9/09	297.85	4455.40
					3/3/10	298.37	4454.88
					4/16/10	298.46	4454.79
					7/1/10	298.64	4454.61
BMO-2008-8M	909711	604167.912	3471127.902	4752.45	12/9/08	299.79	4452.66
					2/19/09	298.32	4454.13
					5/5/09	298.27	4454.18
					8/10/09	298.57	4453.88
					11/5/09	298.81	4453.64
					3/3/10	299.18	4453.27
					4/16/10	299.42	4453.03
					7/1/10	299.70	4452.75
BMO-2008-9M	909255	604668.669	3471121.675	4762.61	8/8/08	287.17	4475.44
					11/5/08	287.65	4474.96
					2/26/09	285.65	4476.96
					5/12/09	285.28	4477.33
					8/17/09	286.09	4476.52
					11/3/09	286.55	4476.06
					3/4/10	287.45	4475.16
					4/6/10	287.81	4474.80
					7/1/10	288.26	4474.35
BMO-2008-10GL	909435	605264.072	3471702.043	4792.21	8/20/08	521.75	4270.46
					11/5/08	520.50	4271.71
					2/25/09	516.72	4275.49
					5/12/09	514.68	4277.53
					8/11/09	513.23	4278.98
					11/2/09	509.43	4282.78
					3/4/10	510.88	4281.33
					4/8/10	506.31	4285.90
					7/2/10	511.80	4280.41
BMO-2008-10GU	909272	605267.551	3471731.866	4793.45	8/4/08	299.28	4494.17
					11/5/08	295.89	4497.56
					2/25/09	289.84	4503.61
					5/6/09	289.35	4504.10
					8/11/09	289.09	4504.36
					11/2/09	289.77	4503.68
					3/10/10	289.58	4503.87
					4/7/10	289.5	4503.95
					7/6/10	288.93	4504.52
BMO-2008-11G	909434	603800.995	3472626.482	4844.67	8/22/08	577.76	4266.91
					11/12/08	576.80	4267.87
					2/26/09	575.91	4268.76
					4/8/09	575.46	4269.21
					8/12/09	574.84	4269.83
					11/9/09	573.41	4271.26
					3/1/10	573.68	4270.99
					4/9/10	573.56	4271.11
					7/1/10	572.97	4271.70

Table 12
Water Level Data

Well Name	ADWR 55 Registry No.	UTM East (meters)	UTM North (meters)	Measuring Point Elevation[1] (ft amsl)	Date	Depth To Water (feet)	Groundwater Elevation (ft amsl)
BMO-2008-13B	909551	601657.612	3470076.358	4649.21	10/3/08	206.42	4442.79
					2/17/09	206.11	4443.10
					5/6/09	206.32	4442.89
					8/5/09	206.79	4442.42
					10/28/09	207.08	4442.13
					2/16/10	207.26	4441.95
					4/14/10	207.27	4441.94
					7/6/10	207.68	4441.53
BMO-2008-13M	909760	601650.495	3470040.455	4647.15	12/3/08	206.00	4441.15
					2/17/09	208.74	4438.41
					4/29/09	208.53	4438.62
					8/5/09	208.85	4438.30
					10/28/09	208.91	4438.24
					2/16/10	209.16	4437.99
					4/13/10	209.20	4437.95
					7/2/10	209.30	4437.85
BMO-2010-1M	219957	605581.263	3469935.750	4718.40	9/7/10	223.98	4494.42
BMO-2010-2M	219958	605685.549	3470564.646	4746.01	9/7/10	263.98	4482.03
BMO-2010-3B	219970	599977.962	3468347.363	4550.44	7/28/10	115.23	4435.21
BMO-2010-3M	219969	599970.801	3468353.543	4550.38	7/30/10	118.48	4431.90
BURKE	212268	602230.087	3473029.816	4856.30	4/22/08	606.55	4249.75
					8/5/08	605.86	4250.44
					10/28/08	604.88	4251.42
					2/19/09	603.91	4252.39
					4/28/09	603.70	4252.60
					8/19/09	602.66	4253.64
COB MW-1	903992	603153.259	3469889.889	4683.26	2/22/08	232.47	4450.79
					5/20/08	233.12	4450.14
					7/30/08	233.37	4449.89
					10/23/08	233.62	4449.64
					2/12/09	234.05	4449.21
					4/21/09	234.99	4448.27
					7/22/09	234.34	4448.92
					10/22/09	234.69	4448.57
					2/4/10	235.15	4448.11
					4/20/10	235.47	4447.79
					7/13/10	235.68	4447.58
COB MW-2	903984	600973.257	3468114.836	4566.21	2/22/08	122.85	4443.36
					5/20/08	123.00	4443.21
					7/30/08	123.53	4442.68
					10/23/08	124.02	4442.19
					2/12/09	123.39	4442.82
					4/23/09	124.16	4442.05
					7/22/09	124.91	4441.30
					10/22/09	125.33	4440.88
					3/3/10	124.93	4441.28
					4/26/10	125.47	4440.74
					7/13/10	126.54	4439.67

Table 12
Water Level Data

Well Name	ADWR 55 Registry No.	UTM East (meters)	UTM North (meters)	Measuring Point Elevation[1] (ft amsl)	Date	Depth To Water (feet)	Groundwater Elevation (ft amsl)
COB MW-3	906823	599169.225	3468726.000	4538.63	2/28/08	120.84	4417.79
					5/20/08	125.00	4413.63
					7/30/08	118.50	4420.13
					10/23/08	117.93	4420.70
					2/12/09	110.91	4427.72
					4/23/09	125.13	4413.50
					7/22/09	124.09	4414.54
					10/22/09	118.03	4420.60
					3/3/10	120.14	4418.49
					4/26/10	123.12	4415.51
					7/13/10	128.60	4410.03
COB WL	593116	606357.506	3472502.012	4832.06	2/22/08	56.50	4775.56
					5/20/08	57.50	4774.56
					7/30/08	58.64	4773.42
					10/23/08	58.76	4773.30
					2/12/09	58.89	4773.17
					4/23/09	59.73	4772.33
					7/22/09	61.27	4770.79
					10/22/09	62.82	4769.24
					3/3/10	65.24	4766.82
					4/26/10	66.13	4765.93
					7/13/10	67.52	4764.54
COLLINS	565260	602551.286	3471341.335	4733.72	2/12/08	289.47	4444.25
					5/29/08	288.53	4445.19
					7/31/08	290.08	4443.64
					10/20/08	290.15	4443.57
					4/21/09	290.66	4443.06
					7/20/09	290.78	4442.94
					10/20/09	290.52	4443.20
					2/2/10	291.64	4442.08
					4/23/10	291.96	4441.76
					7/20/10	292.21	4441.51
COOPER C	637069	601349.987	3468913.011	4595.06	3/4/08	155.08	4439.98
					5/5/08	155.34	4439.72
					7/15/08	156.01	4439.05
					10/16/08	155.85	4439.21
					1/27/09	155.62	4439.44
					4/14/09	155.86	4439.20
					7/14/09	156.50	4438.56
					10/12/09	156.89	4438.17
					1/27/10	157.03	4438.03
					4/22/10	157.31	4437.75
					7/21/10	158.00	4437.06

Table 12
Water Level Data

Well Name	ADWR 55 Registry No.	UTM East (meters)	UTM North (meters)	Measuring Point Elevation[1] (ft amsl)	Date	Depth To Water (feet)	Groundwater Elevation (ft amsl)
DODSON	644927	605594.560	3469063.772	4686.34	5/12/08	81.38	4604.96
					7/24/08	82.20	4604.14
					10/13/08	81.82	4604.52
					1/22/09	82.33	4604.01
					4/9/09	82.84	4603.50
					7/8/09	86.88	4599.46
					10/6/09	87.27	4599.07
					1/21/10	88.54	4597.80
					4/19/10	89.53	4596.81
					7/20/10	90.79	4595.55
DOUGLASS 791	592791	607632.993	3470222.677	4703.27	2/13/08	22.11	4681.16
					5/13/08	24.60	4678.67
					7/22/08	27.00	4676.27
					10/16/08	23.60	4679.67
					1/19/09	26.51	4676.76
					4/8/09	28.53	4674.74
					7/7/09	31.04	4672.23
					10/5/09	31.49	4671.78
					1/21/10	34.55	4668.72
					4/19/10	36.40	4666.87
					7/12/10	36.74	4666.53
DOUGLASS 792	592792	607607.541	3469829.115	4681.73	2/13/08	87.76	4593.97
					5/13/08	87.21	4594.52
					7/22/08	86.90	4594.83
					10/16/08	86.45	4595.28
					1/20/09	86.26	4595.47
					4/8/09	86.04	4595.69
					7/7/09	86.16	4595.57
					10/5/09	86.19	4595.54
					1/21/10	86.45	4595.28
					4/19/10	87.19	4594.54
					7/12/10	87.55	4594.18
EAST	599796	607076.365	3468712.215	4626.01	2/8/08	50.20	4575.81
					5/14/08	52.45	4573.56
					7/23/08	52.16	4573.85
					10/14/08	52.19	4573.82
					1/20/09	50.52	4575.49
					4/8/09	51.91	4574.10
					7/13/09	56.93	4569.08
					10/8/09	60.95	4565.06
					1/25/10	59.35	4566.66
					4/21/10	58.88	4567.13
					7/14/10	61.86	4564.15
EPPELE 641	805641	607165.354	3469229.942	4642.86	3/11/08	29.52	4613.34
					5/12/08	30.64	4612.22
					7/21/08	25.59	4617.27
					10/14/08	24.53	4618.33
					1/21/09	27.35	4615.51
					4/8/09	29.08	4613.78
					7/9/09	31.51	4611.35
					10/7/09	29.92	4612.94
					7/20/10	50.38	4592.48

Table 12
Water Level Data

Well Name	ADWR 55 Registry No.	UTM East (meters)	UTM North (meters)	Measuring Point Elevation[1] (ft amsl)	Date	Depth To Water (feet)	Groundwater Elevation (ft amsl)
FLEMING	218386	605565.701	3469342.523	4693.68	2/18/09	299.30	4394.38
					4/8/09	301.81	4391.87
					7/7/09	304.60	4389.08
					10/6/09	307.84	4385.84
					1/21/10	311.73	4381.95
					4/20/10	315.26	4378.42
					7/15/10	318.32	4375.36
FULTZ	212447	607153.306	3469063.892	4642.92	10/22/08	40.59	4602.33
					1/21/09	40.66	4602.26
					4/9/09	42.88	4600.04
					7/13/09	54.94	4587.98
					10/8/09	56.16	4586.76
					1/25/10	53.45	4589.47
					4/20/10	63.82	4579.10
					7/14/10	119.86	4523.06
GARNER 557	558557	602659.240	3468962.415	4626.44	2/21/08	191.05	4435.39
					5/5/08	191.28	4435.16
					7/15/08	191.44	4435.00
					10/16/08	191.83	4434.61
					1/28/09	191.92	4434.52
					4/15/09	192.09	4434.35
					7/16/09	192.52	4433.92
					10/14/09	192.82	4433.62
					2/2/10	193.33	4433.11
					4/22/10	193.49	4432.95
					7/20/10	193.93	4432.51
GARNER 635	587635	602665.352	3468967.902	4628.29	2/4/08	193.20	4435.09
					5/5/08	195.90	4432.39
					7/15/08	193.58	4434.71
					10/15/08	194.35	4433.94
					1/28/09	194.80	4433.49
					4/15/09	195.54	4432.75
					7/16/09	194.88	4433.41
					10/14/09	196.36	4431.93
					2/2/10	195.32	4432.97
					4/22/10	196.01	4432.28
					8/25/10	195.57	4432.72
GGOOSE 547	628547	606256.657	3469820.260	4717.11	5/21/08	220.91	4496.20
					8/15/08	238.48	4478.63
					10/29/08	235.90	4481.21
					2/24/09	236.13	4480.98
					5/14/09	236.17	4480.94
					8/19/09	236.01	4481.10
					8/19/09	236.01	4481.10
					11/11/09	237.66	4479.45
					3/9/10	238.84	4478.27
					4/27/10	239.17	4477.94

Table 12
Water Level Data

Well Name	ADWR 55 Registry No.	UTM East (meters)	UTM North (meters)	Measuring Point Elevation[1] (ft amsl)	Date	Depth To Water (feet)	Groundwater Elevation (ft amsl)
GL-03	539782	604386.940	3473747.943	4924.31	5/22/08	660.15	4264.16
					8/4/08	659.79	4264.52
					12/2/08	658.25	4266.06
					2/26/09	658.62	4265.69
					5/5/09	657.23	4267.08
					8/12/09	656.56	4267.75
					8/12/09	656.56	4267.75
					11/10/09	655.31	4269.00
					3/2/10	655.52	4268.79
					4/9/10	655.35	4268.96
					7/7/10	655.05	4269.26
GOAR RANCH	610695	602454.751	3468892.471	4631.13	2/21/08	183.90	4447.23
					5/5/08	188.11	4443.02
					7/16/08	184.41	4446.72
					10/22/08	184.68	4446.45
					1/27/09	184.87	4446.26
					4/15/09	184.96	4446.17
					7/7/09	185.36	4445.77
					10/12/09	185.72	4445.41
					2/2/10	186.25	4444.88
					4/22/10	186.44	4444.69
					7/13/10	186.76	4444.37
HOBAN	805290	601705.848	3468880.329	4597.21	2/27/08	163.05	4434.16
					5/7/08	163.28	4433.93
					7/14/08	163.87	4433.34
					10/16/08	163.95	4433.26
					1/28/09	163.82	4433.39
					4/15/09	164.16	4433.05
					7/14/09	164.59	4432.62
					10/15/09	165.00	4432.21
					3/2/10	165.32	4431.89
					5/18/10	165.71	4431.50
					7/20/10	166.17	4431.04
HOWARD	NR	601281.159	3468770.377	4593.91	3/4/08	150.10	4443.81
					5/8/08	150.70	4443.21
					7/14/08	150.91	4443.00
					10/15/08	150.67	4443.24
					1/28/09	150.67	4443.24
					4/15/09	151.15	4442.76
					7/15/09	151.76	4442.15
					10/12/09	152.08	4441.83
					1/27/10	152.20	4441.71
					4/21/10	152.30	4441.61
					7/19/10	153.16	4440.75

Table 12
Water Level Data

Well Name	ADWR 55 Registry No.	UTM East (meters)	UTM North (meters)	Measuring Point Elevation[1] (ft amsl)	Date	Depth To Water (feet)	Groundwater Elevation (ft amsl)
KEEFER	209744	599879.175	3468119.015	4572.03	2/6/08	134.67	4437.36
					5/6/08	135.28	4436.75
					7/16/08	136.24	4435.79
					10/28/08	135.87	4436.16
					1/28/09	134.88	4437.15
					4/16/09	135.00	4437.03
					7/14/09	136.07	4435.96
					10/13/09	136.67	4435.36
					1/26/10	136.26	4435.77
					4/20/10	136.26	4435.77
					7/15/10	137.29	4434.74
MCCONNELL 265	539265	601463.094	3468840.139	4600.70	2/20/08	156.15	4444.55
					5/6/08	156.40	4444.30
					7/15/08	157.07	4443.63
					11/19/08	157.17	4443.53
					1/28/09	156.70	4444.00
					4/15/09	157.22	4443.48
					7/15/09	157.59	4443.11
					10/12/09	158.13	4442.57
					1/26/10	158.35	4442.35
					4/22/10	158.68	4442.02
					7/21/10	159.37	4441.33
METZLER	35-71891	602091.308	3471381.176	4728.53	3/5/08	288.30	4440.23
					5/15/08	286.53	4442.00
					7/31/08	286.82	4441.71
					10/20/08	287.09	4441.44
					2/11/09	287.74	4440.79
					4/20/09	287.47	4441.06
					7/15/09	287.58	4440.95
					10/14/09	287.99	4440.54
					2/1/10	288.38	4440.15
					5/18/10	288.65	4439.88
					7/16/10	288.88	4439.65
NESS	509127	607866.391	3471419.494	4761.23	7/24/08	557.90	4203.33
					10/16/08	549.30	4211.93
					2/25/09	536.40	4224.83
					5/11/09	544.64	4216.59
					8/11/09	566.87	4194.36
					11/12/09	537.34	4223.89
					2/2/10	531.85	4229.38
					4/21/10	568.11	4193.12
					7/19/10	573.02	4188.21
NOTEMAN	212483	606053.800	3471576.400	4800.68	5/13/08	339.77	4460.91
					8/27/08	344.34	4456.34
					11/22/08	322.26	4478.42
					2/25/09	327.54	4473.14
NSD-02	527587	598820.051	3468821.474	4531.38	10/7/09	101.17	4430.21
					3/16/10	99.43	4431.95
					5/25/10	101.63	4429.75
					8/25/10	102.38	4429.00

Table 12
Water Level Data

Well Name	ADWR 55 Registry No.	UTM East (meters)	UTM North (meters)	Measuring Point Elevation[1] (ft amsl)	Date	Depth To Water (feet)	Groundwater Elevation (ft amsl)
NSD-03	527586	598070.538	3468694.259	4518.28	10/7/09	85.62	4432.66
					3/16/10	83.51	4434.77
					5/25/10	84.49	4433.79
					8/25/10	85.70	4432.58
NWC-02	562944	600177.435	3467474.673	4600.44	10/27/08	160.51	4439.93
					4/29/09[4]	160.5	4439.94
					9/10/09[4]	155	4445.44
					4/2010[4]	131	4469.44
NWC-03	203321	601153.857	3468350.838	4574.99	11/3/08	131.48	4443.51
					4/29/09[4]	130	4444.99
					9/10/09[4]	126	4448.99
					10/9/09[4]	125	4449.99
NWC-03 CAP	627684	601151.704	3468343.653	4572.82	2/2/09	130.03	4442.79
					4/23/09[5]	130.62	4442.20
					7/21/09	131.26	4441.56
					10/21/09	131.60	4441.22
					2/3/10	131.34	4441.48
					4/21/10	131.86	4440.96
					7/20/10	131.50	4441.32
NWC-04	551849	605829.808	3469071.959	4690.77	12/2/08	352.11	4338.66
					4/29/09[4]	328	4362.77
					9/10/09[4]	324	4366.77
					4/2010[4]	216	4474.77
NWC-06	575700	599822.821	3467749.954	4592.50	4/29/09[4]	156	4436.50
					9/10/09[4]	155	4437.50
					10/9/09[4]	148	4444.50
					4/2010[4]	140	4452.50
OSBORN	643436	607031.823	3470270.548	4711.95	5/13/08	68.65	4643.30
					8/5/08	69.53	4642.42
					10/16/08	69.83	4642.12
					1/20/09	69.23	4642.72
					4/7/09	69.60	4642.35
					7/8/09	96.61	4615.34
					10/5/09	75.09	4636.86
					1/21/10	75.37	4636.58
					4/19/10	81.59	4630.36
					7/12/10	83.00	4628.95
PANAGAKOS	35-76413	605304.234	3469323.140	4691.40	1/22/09	155.28	4536.12
					4/9/09	156.15	4535.25
					7/9/09	161.61	4529.79
					10/6/09	167.20	4524.20
					1/21/10	166.92	4524.48
					4/20/10	167.11	4524.29
					7/20/10	171.78	4519.62
PARRA	576415	602170.716	3471263.549	4727.21	5/15/08	279.78	4447.43
					8/18/08	280.06	4447.15
					11/3/08	280.39	4446.82
					2/13/09	280.75	4446.46
					4/28/09	280.88	4446.33
					7/20/09	280.99	4446.22

Table 12
Water Level Data

Well Name	ADWR 55 Registry No.	UTM East (meters)	UTM North (meters)	Measuring Point Elevation[1] (ft amsl)	Date	Depth To Water (feet)	Groundwater Elevation (ft amsl)
PIONKE	613395	601045.471	3468960.981	4592.13	7/17/08	149.88	4442.25
					11/3/08	150.99	4441.14
					2/25/09	149.68	4442.45
					4/14/09	150.01	4442.12
					7/13/09	150.47	4441.66
					10/7/09	150.96	4441.17
					3/8/10	151.11	4441.02
					4/26/10	151.32	4440.81
					7/15/10	151.90	4440.23
POOL	509518	599683.603	3470013.823	4639.09	2/20/08	204.22	4434.87
					5/19/08	204.72	4434.37
					7/31/08	205.56	4433.53
					10/21/08	205.06	4434.03
					2/13/09	204.74	4434.35
					4/21/09	204.87	4434.22
					7/20/09	205.69	4433.40
					10/20/09	206.06	4433.03
					2/24/10	205.59	4433.50
					4/22/10	205.48	4433.61
					7/14/10	206.58	4432.51
RAMIREZ	216425	599730.649	3467584.363	4596.61	10/27/08	159.45	4437.16
					1/29/09	158.74	4437.87
					4/16/09	158.66	4437.95
					7/10/09	159.64	4436.97
					10/6/09	160.36	4436.25
					1/25/10	160.10	4436.51
					4/21/10	159.96	4436.65
					7/21/10	161.05	4435.56
RAY	803772	607083.422	3469195.147	4647.91	2/15/08	40.85	4607.06
					5/13/08	43.82	4604.09
					7/29/08	45.25	4602.66
					10/22/08	44.54	4603.37
					1/20/09	44.31	4603.60
					4/8/09	44.68	4603.23
					7/9/09	48.99	4598.92
					10/7/09	49.87	4598.04
					1/26/10	47.61	4600.30
					4/20/10	49.78	4598.13
					7/14/10	51.36	4596.55
ROGERS 596	573596	601001.503	3468491.639	4577.35	11/11/09	135.46	4441.89
					2/25/10	135.89	4441.46
					4/22/10	135.62	4441.73
					7/16/10	136.63	4440.72
ROGERS 750[6]	641750	600977.690	3468417.386	4579.02	2/7/08	129.85	4449.17
					7/29/08	131.86	4447.16
					10/22/08	132.08	4446.94
					2/10/09	130.62	4448.40
					4/29/09	131.33	4447.69
					8/3/09	135.07	4443.95

Table 12
Water Level Data

Well Name	ADWR 55 Registry No.	UTM East (meters)	UTM North (meters)	Measuring Point Elevation[1] (ft amsl)	Date	Depth To Water (feet)	Groundwater Elevation (ft amsl)
ROGERS E	216018	600449.648	3467636.029	4590.66	7/17/08	149.65	4441.01
					11/3/08	150.15	4440.51
					2/10/09	149.02	4441.64
					4/16/09	149.53	4441.13
					7/13/09	150.31	4440.35
					10/6/09	150.76	4439.90
					1/25/10	150.64	4440.02
					4/21/10	150.97	4439.69
					8/25/10	151.15	4439.51
RUIZ	531770	602857.357	3471424.219	4735.18	2/5/08	293.29	4441.89
					5/15/08	293.57	4441.61
					7/30/08	293.86	4441.32
					10/20/08	294.18	4441.00
					2/12/09	294.62	4440.56
					4/21/09	294.66	4440.52
					8/3/09	294.98	4440.20
					10/28/09	295.33	4439.85
					2/1/10	295.70	4439.48
					4/26/10	295.96	4439.22
					7/20/10	296.29	4438.89
SCHWARTZ	210865	600811.014	3468269.622	4564.49	2/8/08	121.80	4442.69
					5/19/08	123.49	4441.00
					7/29/08	122.64	4441.85
					10/22/08	123.39	4441.10
					1/29/09	122.87	4441.62
					4/17/09	123.53	4440.96
					7/10/09	124.15	4440.34
					10/6/09	124.55	4439.94
					1/22/10	124.32	4440.17
					4/21/10	124.65	4439.84
					7/21/10	125.80	4438.69
STEPHENS	808560	606981.766	3469072.799	4651.22	5/13/08	44.94	4606.28
					8/5/08	46.61	4604.61
					10/16/08	46.60	4604.62
					1/21/09	47.19	4604.03
					4/8/09	48.45	4602.77
					7/7/09	49.41	4601.81
					10/7/09	50.33	4600.89
					1/26/10	51.13	4600.09
					4/20/10	51.24	4599.98
					7/14/10	51.91	4599.31
SUNBELT	201531	605998.250	3471735.149	4806.52	2/6/08	352.10	4454.42
					5/15/08	358.97	4447.55
					8/5/08	Dry	<4426
					10/16/08	347.00	4459.52
					1/21/09	344.78	4461.74
					4/10/09	349.64	4456.88
					7/8/09	356.99	4449.53
					10/5/09	Dry	<4426
					1/21/10	Dry	<4426
					4/19/10	Dry	<4426
					7/12/10	Dry	<4426

Table 12
Water Level Data

Well Name	ADWR 55 Registry No.	UTM East (meters)	UTM North (meters)	Measuring Point Elevation[1] (ft amsl)	Date	Depth To Water (feet)	Groundwater Elevation (ft amsl)
SWAN	NR	607378.547	3470648.298	4716.59	2/13/08	26.50	4690.09
					5/14/08	30.69	4685.90
					7/24/08	32.06	4684.53
					10/16/08	27.53	4689.06
					1/20/09	29.77	4686.82
					4/7/09	31.47	4685.12
					7/8/09	33.61	4682.98
					10/5/09	35.12	4681.47
					1/21/10	36.64	4679.95
					4/21/10	38.06	4678.53
					7/19/10	39.67	4676.92
TM-02A	522574	604152.059	3472008.794	4808.43	3/4/08	346.62	4461.81
					5/23/08	346.16	4462.27
					8/15/08	353.91	4454.52
					10/30/08	349.45	4458.98
					2/24/09	348.64	4459.79
					5/6/09	349.38	4459.05
					8/12/09	349.13	4459.30
					11/4/09	348.97	4459.46
					3/10/10	348.19	4460.24
					4/6/10	353.86	4454.57
					7/6/10	349.20	4459.23
TM-03	522575	606366.130	3473711.046	4897.85	3/12/08	127.14	4770.71
					5/20/08	127.40	4770.45
					8/6/08	128.02	4769.83
					11/12/08	128.00	4769.85
					2/26/09	126.94	4770.91
					5/13/09	113.86	4783.99
					8/18/09	128.80	4769.05
					11/10/09	125.38	4772.47
					3/2/10	128.02	4769.83
					4/14/10	130.56	4767.29
					7/7/10	131.25	4766.60
TM-06 MILLER	522695	606055.975	3468376.658	4707.88	2/26/08	158.78	4549.10
					5/20/08	158.76	4549.12
					8/4/08	158.80	4549.08
					10/29/08	158.85	4549.03
					2/16/09	159.28	4548.60
					5/13/09	158.81	4549.07
					8/18/09	158.91	4548.97
					11/12/09	158.96	4548.92
					3/8/10	158.99	4548.89
					4/14/10	159.02	4548.86
					7/2/10	159.13	4548.75

Table 12
Water Level Data

Well Name	ADWR 55 Registry No.	UTM East (meters)	UTM North (meters)	Measuring Point Elevation[1] (ft amsl)	Date	Depth To Water (feet)	Groundwater Elevation (ft amsl)
TM-16	522578	605588.075	3469842.199	4717.71	3/5/08	81.00	4636.71
					5/22/08	81.24	4636.47
					8/6/08	81.65	4636.06
					11/5/08	81.75	4635.96
					2/26/09	81.88	4635.83
					5/13/09	82.01	4635.70
					8/19/09	82.37	4635.34
					11/10/09	82.83	4634.88
					3/2/10	83.09	4634.62
					4/14/10	83.22	4634.49
					7/2/10	83.51	4634.20
TM-19A	522581	602458.710	3469197.426	4645.87	3/6/08	199.85	4446.02
					5/22/08	199.50	4446.37
					8/6/08	199.19	4446.68
					11/18/08	199.46	4446.41
					3/3/09	199.81	4446.06
					4/22/09	200.57	4445.30
					8/12/09	201.46	4444.41
					11/4/09	201.16	4444.71
					3/10/10	201.34	4444.53
					4/9/10	201.55	4444.32
					7/7/10	202.35	4443.52
TM-42	562554	603698.271	3469104.903	4666.67	3/5/08	211.04	4455.63
					5/22/08	210.98	4455.69
					8/6/08	211.55	4455.12
					11/6/08	207.05	4459.62
					2/18/09	212.31	4454.36
					5/7/09	212.37	4454.30
					8/18/09	212.77	4453.90
					11/3/09	213.05	4453.62
					2/24/10	213.36	4453.31
					4/19/10	213.51	4453.16
					7/2/10	213.52	4453.15
TVI 236	802236	600552.215	3467978.431	4561.98	5/7/08	123.30	4438.68
					7/15/08	121.55	4440.43
					10/15/08	122.35	4439.63
					2/11/09	121.28	4440.70
					4/17/09	122.73	4439.25
					7/21/09	123.96	4438.02
					10/19/09	123.88	4438.10
					2/2/10	122.26	4439.72
					4/23/10	122.70	4439.28
					7/15/10	125.08	4436.90
TVI 713	567713	600729.095	3468412.946	4567.22	5/7/08	127.10	4440.12
					7/14/08	126.30	4440.92
					10/15/08	130.00	4437.22
					2/11/09	149.87	4417.35
					4/17/09	126.73	4440.49
					7/21/09	127.36	4439.86
					10/19/09	127.79	4439.43
					2/2/10	126.71	4440.51
					4/23/10	127.53	4439.69
					7/15/10	129.14	4438.08

Table 12
Water Level Data

Well Name	ADWR 55 Registry No.	UTM East (meters)	UTM North (meters)	Measuring Point Elevation[1] (ft amsl)	Date	Depth To Water (feet)	Groundwater Elevation (ft amsl)
WEISKOPF	641802	601154.951	3468658.855	4586.89	2/15/08	143.31	4443.58
					5/7/08	143.90	4442.99
					7/16/08	144.22	4442.67
					10/28/08	145.81	4441.08
					1/29/09	143.99	4442.90
					4/15/09	144.38	4442.51
					7/15/09	144.99	4441.90
					10/15/09	145.66	4441.23
					2/2/10	145.28	4441.61
					4/22/10	145.72	4441.17
					7/19/10	146.46	4440.43
ZANDER	205126	599678.880	3467998.486	4580.94	2/4/08	144.85	4436.09
					5/6/08	145.33	4435.61
					7/16/08	146.40	4434.54
					10/28/08	146.01	4434.93
					2/10/09	144.83	4436.11
					4/16/09	144.94	4436.00
					7/14/09	146.14	4434.80
					10/13/09	146.77	4434.17
					1/26/10	146.34	4434.60
					4/22/10	146.27	4434.67
					7/21/10	147.81	4433.13

ADWR = Arizona Department of Water Resources

UTM = Universal Transverse Mercator Zone 12, North American Datum 1983 (NAD83)

ft amsl = feet above mean sea level

NA = Not Applicable

NR = No Record

[1] Survey Source: Survey conducted by Gilbert Technical Service, Inc and Arizona Land Sepcialists, Inc. (measuring point elevation = top of well casing)

[2] Measuring point elevation for third quarter 2008 changed to reflect well survey completed on September 18, 2008

[3] Depth to Water measurement provided by Arizona Water Company

[4] Depth to Water measurement provided by Naco Water Company

[5] Measuring point elevation for second quarter 2009 changed to reflect well survey completed on April 27, 2009

[6] Well previously identified as ROGERS 803

Table 13
BMO-2008 and BMO-2010 Well Construction Information

Well Name	ADWR 55 Registry No.	UTM N NAD 83	UTM E NAD 83	Measuring Point Elevation (NAVD 88 feet)	Drilled Depth (ft bls)	Cased Depth (ft bls)	Casing Diameter (inches)	Screened Interval (ft bls)	Static Water Depth (ft bmp)	Static Water Elevation (NAVD 88 feet)
BMO-2008-1G	909474	3,471,723.644	606,467.681	4,805.10	320	310	5	180-300	62.05	4,743.05
BMO-2008-3B	909147	3,467,919.582	602,012.923	4,583.97	590	260	5	150-250	138.05	4,445.92
BMO-2008-4B	910096	3,468,383.430	601,099.405	4,573.17	660	610	5	500-600	130.77	4,442.40
BMO-2008-5B	909653	3,468,994.395	600,438.375	4,585.10	295	285	5	140-280	145.10	4,440.00
BMO-2008-5M	909552	3,468,993.961	600,445.302	4,585.02	460	450	5	340-440	146.65	4,438.37
BMO-2008-6B	909146	3,469,820.644	600,366.523	4,627.44	270	265	5	195-255	190.13	4,437.31
BMO-2008-6M	909019	3,469,813.885	600,367.943	4,626.90	460	450	5	340-440	191.63	4,435.27
BMO-2008-7M	908794	3,470,029.282	603,099.165	4,688.33	750	670	5	560-660	238.31	4,450.02
BMO-2008-8B	910097	3,471,141.719	604,171.347	4,753.25	492	480	5	370-470	297.94	4,455.31
BMO-2008-8M	909711	3,471,127.902	604,167.912	4,752.45	1,220	1,210	5	1100-1200	299.79	4,452.66
BMO-2008-9M	909255	3,471,121.675	604,668.669	4,762.61	785	775	5	665-765	287.17	4,475.44
BMO-2008-10GU	909272	3,471,731.866	605,267.551	4,793.45	700	449	5	239-439	299.28	4,494.17
BMO-2008-10GL	909435	3,471,702.043	605,264.072	4,792.21	820	810	5	700-800	521.75	4,270.46
BMO-2008-11G	909434	3,472,626.482	603,800.995	4,844.67	820	760	5	650-750	577.76	4,266.91
BMO-2008-13B	909551	3,470,076.358	601,657.612	4,649.21	700	474	5	264-464	206.42	4,442.79
BMO-2008-13M	909760	3,470,040.455	601,650.495	4,647.15	1,100	1,030	5	920-1020	206.00	4,441.15
BMO-2010-1M	219957	3,469,935.750	605,581.263	4,718.40	556	550	5	440-540	223.98	4,494.42
BMO-2010-2M	219958	3,470,564.646	605,685.549	4,746.00	390	380	5	268.5-370	263.98	4,482.02
BMO-2010-3B	219970	3,468,347.363	599,977.962	4,549.80	340	330	5	120-330	117.55	4,432.25
BMO-2010-3M	219969	3,468,353.543	599,970.801	4,549.74	537	532	5	416-522	119.34	4,430.40

Table14
Summary of Hydraulic Test Conditions

Well	Rate 1 (gpm)	Duration (minutes)	Rate 2 (gpm)	Duration (minutes)	Rate 3 (gpm)	Duration (minutes)	Rate 4 (gpm)	Duration (minutes)
BMO-2008-1G	3.5	127	6.0	482	NA	NA	NA	NA
BMO-2008-3B	15.0	62	41.0	65	62.0	480	NA	NA
BMO-2008-4B	21.0	65	48.0	78	60.5	461	NA	NA
BMO-2008-5B	20.0	60	43.0	60	61.0	480	NA	NA
BMO-2008-5M	3.5	60	6.0	62	8.5	602	NA	NA
BMO-2008-6B	1.0	62	1.7	65	3.9	484	NA	NA
BMO-2008-6M	10-24	60	42.0	74	60.0	368	NA	NA
BMO-2008-7M	11.0	62	23.0	63	34.0	484	NA	NA
BMO-2008-8B	15.0	61	30.0	65	53.0	476	NA	NA
BMO-2008-8M	3.0	60	8.3	61	14.0	479	NA	NA
BMO-2008-9M	20.0	60	25.0	60	38.0	480	NA	NA
BMO-2008-10GU	1.4	56	2.3	483	NA	NA	NA	NA
BMO-2008-10GL	1.1	483	2.2	89	3.6	62	NA	NA
BMO-2008-11G	1.0	118	1.7	197	4.6	362	NA	NA
BMO-2008-13B	8.8-12	60	42.5	60	58.0	480	NA	NA
BMO-2008-13M	1.8	60	3.8	421	NA	NA	NA	NA
GARNER 635	15.0	357	NA	NA	NA	NA	NA	NA
MW-01	11.0	601	NA	NA	NA	NA	NA	NA
NWC-03	52.0	21	NA	NA	NA	NA	NA	NA
TM-02A	9.0	15	NA	NA	NA	NA	NA	NA
TVI 875	380.0	2079	NA	NA	NA	NA	NA	NA
TM-42	8.0	60	14.0	60	17.0	480	NA	NA
FLEMING	5.0	60	17.0	60	28.5	60	51.0	420
BMO-2010-1M	2.6	600	NA	NA	NA	NA	NA	NA
BMO-2010-2M	26.0	60	31.0	60	42.0	30	NA	NA
BMO-2010-3M	23.0	60	35.0	60	46.0	480	NA	NA
BMO-2010-3B	20.0	60	40.0	60	62.0	480	NA	NA
TM-16	17.0	60	30.0	415	NA	NA	NA	NA

Notes:

NA = not applicable

gpm = gallons per minute

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Table 15
Hydraulic Properties Estimates Based on 2008 and 2010 Testing

Pumped Well	Geologic Unit	T (ft^2/day)	S	Kv (ft/day)	Kh (ft/day)	Range in Kh
BMO-2008-1G	Glance Conglomerate	44.9	5.39E-06	5.00E-07	0.2	0.17 - 0.29
BMO-2008-3B	Basin Fill	4,000	6.70E-05	NA	30.8	23.1 - 34.6
BMO-2008-4B	Basin Fill	19,950	4.33E-04	0.9335	39.5	39.4 - 39.6
BMO-2008-5B	Basin Fill	15,400	0.023	3.65	55.0	22.3 - 79.4
BMO-2008-5M	Cintura Fm.	1,238	0.013	2.045	5.4	1.7 - 7.6
BMO-2008-6B	Basin Fill	170	1.04E-04	NA	2.3	2.27
BMO-2008-6M	Cintura Fm.	2,613	1.00E-05	1.00E-06	15.5	15.1 - 16.2
BMO-2008-7M	Morita Fm.	152	0.21	1.83E-01	1.0	0.55 - 1.7
BMO-2008-8B	Basin Fill	3,500	0.010	0.1	17.8	17.8
BMO-2008-8M	Morita Fm.	106	0.30	3.40E-04	0.2	0.15 - 0.30
BMO-2008-9M	Morita Fm.	64	0.13	NA	0.5	0.21 - 0.78
BMO-2008-10GU	Glance Conglomerate	4.92	0.21	NA	0.0	0.035
BMO-2008-10GL	Glance Conglomerate	0.45	0.014	NA	0.0	0.0033
BMO-2008-11G	Glance Conglomerate	88	5.50E-05	0.010	0.3	0.33 - 0.35
BMO-2008-13B	Basin Fill	7,500	0.010	1	24.0	24
BMO-2008-13M	Mural Limestone	0.661	0.019	1.00E-03	0.0	0.0051
COB MW-1	Basin Fill	12,198	0.033	1.50E-06	100.9	74.7 - 127.8
NWC-03	Basin Fill	21,000	4.53E-04	3.45	41.6	41.6
GARNER 635	Cintura Fm.	142	1.00E-05	NA	1.2	1.18
TM-02A	Glance Conglomerate	8.9	0.021	NA	0.0	0.020 - 0.045
TVI 875	Basin Fill	24,900	2.42E-02	0.69	49.3	43.3 - 57.1
TM-42	Morita Fm.	727	1.20E-02	4.87	27.1	20.7-33.4
TM-16	Morita Fm.	221	1.00E-06	0.70	7.0	6.96 - 7.57
BMO-2010-1M	Morita Fm.	11.1	3.00E-01	0.01	0.03	0.034
BMO-2010-2M	Morita Fm.	39	5.30E-10	0.03	0.3	0.26-0.37
BMO-2010-3M	Cintura Fm.	530	1.00E-05	0.35	3.5	3.5
BMO-2010-3B	Basin Fill	4,221	1.25E-01	0.6	15.5	10.3-20.7
FLEMING	Morita Fm.	DATA COULD NOT BE RELIABLY INTERPRETED				

Notes:

T = Transmissivity
S = Storage coefficient
K_V = Vertical hydraulic conductivity
Kh = horizontal hydraulic conductivity
Fm. = Formation
ft/day = feet per day
ft^2/day = square feet per day
NA = Not Applicable

Table 16
Estimated Hydraulic Gradients in the Vicinity of the CTSA

HORIZONTAL HYDRAULIC GRADIENT	h1 (ft)	h2 (ft)	dH (ft)	dL (ft)	grad (ft/ft)
1989 Basin Fill: TM-02 to TM-11	4460.8	4497.72	-36.92	15000	-0.0025
2005 Basin Fill: TM-02 to WEISKOPF	4443	4457.9	-14.9	15000	-0.0010
2008 Basin Fill: BMO-2008-8B to WEISKOPF	4441.08	4455.31	-14.23	12800	-0.0011
2010 Basin Fill: BMO-2008-8B to WEISKOPF	4440.43	4454.61	-14.18	12800	-0.0011
2008 Basin Fill (East-West): COB MW-1 to BMO-2008-6B	4437.21	4449.64	-12.43	9150	-0.0014
2010 Basin Fill (East-West): COB MW-1 to BMO-2008-6B	4436.01	4447.58	-11.57	9150	-0.0013
1989 Bedrock (North-South): TM-28 to TM-16	4623.64	4750.59	-126.95	8750	-0.0145
2008 Bedrock (North-South): COB WL to TM-16	4635.96	4773.3	-137.34	10000	-0.0137
2010 Bedrock (North-South): COB WL to TM-16	4634.2	4764.54	-130.34	10000	-0.0130
1989 Bedrock (East-West): TM-16 to TM19A	4470.07	4623.64	-153.57	10500	-0.0146
2005 Bedrock (East-West): TM-16 to TM-19A	4435.5	4625.8	-190.3	10500	-0.0181
2008 Bedrock (East-West): TM-16 to TM-19A	4446.41	4635.96	-189.55	10500	-0.0181
2010 Bedrock (East-West): TM-16 to TM-19A	4443.52	4634.2	-190.68	10500	-0.0182
VERTICAL HYDRAULIC GRADIENT (Fourth Quarter 2008)					
BMO-2008-5B,M	4438.37	4440	-1.630	180	-0.0091
BMO-2008-6B,M	4436.65	4437.21	-0.560	165	-0.0034
COB MW-1, BMO-2008-7M	4448.64	4449.64	-1.000	230	-0.0043
BMO-2008-8B,M	4452.66	4455.31	-2.650	730	-0.0036
BMO-2008-13B,M	4441.15	4442.79	-1.640	606	-0.0027
BMO-2008-10GU,10GL	4271.7	4497.6	-225.9	226	-0.9996
VERTICAL HYDRAULIC GRADIENT (Fourth Quarter 2010)					
BMO-2008-5B,M	4436.74	4438.51	-1.770	180	-0.0098
BMO-2008-6B,M	4434.37	4436.01	-1.640	165	-0.0099
COB MW-1, BMO-2008-7M	4448.05	4447.58	0.470	230	0.0020
BMO-2008-8B,M	4452.75	4454.61	-1.860	730	-0.0025
BMO-2008-13B,M	4437.85	4441.53	-3.680	606	-0.0061
BMO-2008-10GU,10GL	4280.41	4504.52	-224.11	226	-0.9916
BMO-2010-3B,M	4482.03	4494.42	-12.39	249	-0.0498

Notes:

h1 = downgradient water level
h2 = upgradient water level
dH = water level difference
dL = for horizontal gradient: distance between water level measurement locations,
= for vertical gradient: distance between midpoint of screens. Negative gradient is downward.
grad = hydraulic gradient
ft = feet

Table 17
Estimated Groundwater Flow Velocities in the Vicinity of the CTSA

Description	K (ft/d)	n	h1 (ft)	h2 (ft)	dH (ft)	dX (ft)	v (ft/d)
1989 Basin Fill: TM-02 to TM-11							
Average field-based hydraulic conductivity	36.4	0.25	4460.8	4497.72	-36.92	15000	**0.36**
Model-derived hydraulic conductivity (SET, 1998c)	23	0.25	4460.8	4497.72	-36.92	15000	**0.23**
2005 Basin Fill: TM-02 to WEISKOPF							
Average field-based hydraulic conductivity	36.4	0.25	4443	4457.9	-14.9	15000	**0.14**
Model-derived hydraulic conductivity (SET, 1998c)	23	0.25	4443	4457.9	-14.9	15000	**0.09**
2008 Basin Fill: BMO-2008-8B to WEISKOPF							
Average field-based hydraulic conductivity	36.4	0.25	4441.08	4455.31	-14.23	12800	**0.16**
Model-derived hydraulic conductivity (SET, 1998c)	23	0.25	4441.08	4455.31	-14.23	12800	**0.10**
2010 Basin Fill: BMO-2008-8B to WEISKOPF							
Average field-based hydraulic conductivity	36.4	0.25	4440.43	4454.61	-14.18	12800	**0.16**
Model-derived hydraulic conductivity (SET, 1998c)	23	0.25	4440.43	4454.61	-14.18	12800	**0.10**
2008 Basin Fill (East-West): COB MW-1 to BMO-2008-6B							
Average field-based hydraulic conductivity	36.4	0.25	4437.21	4449.64	-12.43	9150	**0.20**
Model-derived hydraulic conductivity (SET, 1998c)	23	0.25	4437.21	4449.64	-12.43	9150	**0.12**
2010 Basin Fill (East-West): COB MW-1 to BMO-2008-6B							
Average field-based hydraulic conductivity	36.4	0.25	4436.01	4447.79	-11.78	9150	**0.19**
Model-derived hydraulic conductivity (SET, 1998c)	23	0.25	4436.01	4447.79	-11.78	9150	**0.12**
1989 Bedrock (North-South): TM-28 to TM-16							
Average field-based hydraulic conductivity	5.7	0.15	4623.64	4750.59	-126.95	8750	**0.55**
Model-derived hydraulic conductivity (SET, 1998c)	3	0.15	4623.64	4750.59	-126.95	8750	**0.29**
2008 Bedrock (North-South): COB WL to TM-16							
Average field-based hydraulic conductivity	5.7	0.15	4635.96	4773.3	-137.34	10000	**0.52**
Model-derived hydraulic conductivity (SET, 1998c)	3	0.15	4635.96	4773.3	-137.34	10000	**0.27**
2010 Bedrock (North-South): COB WL to TM-16							
Average field-based hydraulic conductivity	5.7	0.15	4634.2	4764.54	-130.34	10000	**0.50**
Model-derived hydraulic conductivity (SET, 1998c)	3	0.15	4634.2	4764.54	-130.34	10000	**0.26**
1989 Bedrock (East-West): TM-16 to TM-19A							
Average field-based hydraulic conductivity	5.7	0.15	4470.07	4623.64	-153.57	10500	**0.56**
Model-derived hydraulic conductivity (SET, 1998c)	3	0.15	4470.07	4623.64	-153.57	10500	**0.29**
2005 Bedrock (East-West): TM-16 to TM-19A							
Average field-based hydraulic conductivity	5.7	0.15	4435.5	4625.8	-190.3	10500	**0.69**
Model-derived hydraulic conductivity (SET, 1998c)	3	0.15	4435.5	4625.8	-190.3	10500	**0.36**
2008 Bedrock (East-West): TM-16 to TM-19A							
Average field-based hydraulic conductivity	5.7	0.15	4446.41	4635.96	-189.55	10500	**0.69**
Model-derived hydraulic conductivity (SET, 1998c)	3	0.15	4446.41	4635.96	-189.55	10500	**0.36**
2010 Bedrock (East-West): TM-16 to TM-19A							
Average field-based hydraulic conductivity	5.7	0.15	4443.52	4634.2	-190.68	10500	**0.69**
Model-derived hydraulic conductivity (SET, 1998c)	3	0.15	4443.52	4634.2	-190.68	10500	**0.36**

Assumptions:

1. *Unidimensional (horizontal) groundwater flow in direction of measurement locations.*
2. *Linear water table with distance*
3. *Homogeneous, isotropic properties between well locations.*

Notes:

ft = feet
ft/d = feet per day
h1 = downgradient water level
h2 = upgradient water level

$$v = (-K/n)[dH/dx]$$

where:
v = groundwater flow velocity
K = hydraulic conductivity
n = porosity
dH = change in water elevation between locations
dX = distance between locations

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Table 18
1996 Water Quality Data Used for Piper Diagram (Figure 31)

Well No.	Database	Formation	Sample Date	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Cl (mg/L)	SO4 (mg/L)	HCO3 (mg/L)	CO3 (mg/L)	pH (standard units)	TDS (mg/L)
AWC-03	AWC-03	QTbf	08/06/96	60.4	7.6	15.7	2.27	8.0	5.0	109	0.3	7.6	248
BF-02	BF-02	QTbf	06/25/96	958	206	30.1	4.1	33	2000	602	0.3	6.3	3800
NWC-05	NWC-05	Kbu	08/07/96	158	33.0	25.8	4.56	180	78.9	77	0.3	7.4	888
TM-02	TM-02	QTbf	06/20/96	628	147	35.6	4.9	28	1200	457	0.3	6.4	2700
TM-05	TM-05 MILLER	QTbf	06/26/96	50.5	5.6	19.8	1.6	24	10	90	0.3	7.8	240
TM-06	TM-06 MILLER	Kbu	06/26/96	36.1	18.2	54	1.5	18	29	137	0.3	7.9	320
TM-12	TM-12 MILLER	QTbf	06/26/96	57.7	7.5	23.3	1.8	25	7	110	0.3	7.7	270
TM-15	TM-15 MILLER	QTbf	06/27/96	26	16.4	30.3	1.9	7.2	14	114	0.3	7.8	230
TM-16	TM-16	Kbu	06/27/96	200	44.1	28.2	11.1	28	500	126	0.3	7.4	1100
TM-19	TM-19	QTbf	06/20/96	427	55.6	41.3	4.3	19	1100	126	0.3	7.2	2100
TM-19A	TM-19A	Kbu	06/25/96	43.8	10.2	58.6	2.5	14	56	119	0.3	7.8	320
TM-41	TM-41	Kbu	07/30/97	620	250	47	28	22	1940	488	0.3	6.2	3600

Notes:
mg/L = milligrams per liter.
QTbf = basin fill
Kbu = undifferentiated Bisbee Group

Table 19A
2008 Water Quality Data Used for Piper Diagram (Figure 32A)

Well Name	Sample Date	Screened Formation	Field pH (SU)	Sulfate, dissolved	Chloride, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	TDS (calculated)
AWC-02	08/12/08	QTbf	7.01	14.3	17.8	66.4	9.1	2.1	20.0	181	5	255
AWC-03	08/12/08	QTbf	7.28	38.8	15.5	62.8	8.6	2.1	22.8	156	5	260
AWC-04	08/12/08	QTbf	7.08	21.6	47.5	88.7	11.6	2.6	22.8	206	<2	328
AWC-05	08/12/08	Kbu/ Volcanics	6.74	14.9	16.1	50.6	6.2	2.2	35.6	164	8	242
BF-01	08/05/08	QTbf/Kbu	6.11	1330	30	624	107	4.5	61.3	579	<2	2510
BIMA	07/29/08[1]	Kbu	6.44	204	101	209	46.5	12.2	63.6	456	<2	945
BMO-2008-1G	08/27/08	Kg	7.09	107	76.3	124	32.2	6.4	35.7	229	9	588
BMO-2008-3B	07/18/08	QTbf	7.35	106	24	64.5	12.0	2.9	53.6	151	3	373
BMO-2008-6B	07/16/08	QTbf	7.36	53.3	13	59.7	10.2	3.0	26.2	151	9	274
BMO-2008-6M	07/10/08	Kbu	-	182	16	104	17.9	3.60	32.5	144	9	460
BMO-2008-7M	07/14/08	Kbu	7.63	31.4	10.4	32.4	11.4	2.70	60.8	188	13	282
BMO-2008-9M	08/08/08	Kbu	7.72	47.3	14	28.0	17.8	3.4	64.6	193	6	306
BMO-2008-10GU	08/04/08	Kg	6.41	2210	60	649	311	15.3	37.6	984	<2	3870
BMO-2008-10GL	08/20/08	Kg	6.22	1320	30.0	579	167	10.5	90.5	870	<2	2720
BMO-2008-11G	08/22/08	Kg	8.02	14.2	2.8	10.7	5.1	1.7	64.2	149	14	205
BURKE	08/05/08	Kbu	7.06	21.9	10	52.5	22.3	2.3	16.1	187	<2	250
COB MW-1	07/30/08	QTbf	6.88	730	19.8	273	69.3	8.0	58.9	223	<2	1300
COB MW-2	07/30/08	QTbf	7.34	37.6	19.9	66.3	9.0	2.1	26.6	158	<2	286
COB MW-3	07/30/08	QTbf	7.64	67.3	16.1	66.1	9.2	2.4	26.5	149	<2	288
COB WL	07/30/08	Kbu	7.17	97.1	110	130	35.0	7.5	51.5	274	<2	613
COOPER	07/31/08	QTbf	7.81	33.7	16.9	48.9	13.3	2.1	24.6	150	7.0	249
COOPER C	07/15/08	QTbf	6.86	1040	46.5	386	58.8	5.8	43.3	235	<2	1740
COOPER C DUP	07/15/08	QTbf	6.86	960	46.4	398	61.7	6.1	46.2	234	<2	1670
DODSON	07/24/08	Kbu	7.25	49.3	160	124	43.3	13.7	51.3	223	12	646
EAST	07/23/08	Kbu	7.34	11.8	33.3	59.5	24.4	2.4	31.4	217	6	326
GALLANT	02/11/08	Kbu	7.46	17.9	12.7	106	15.9	4.3	25.6	344	<2	402
GALLANT	07/23/08	Kbu	7.26	20.9	56.9	138	19.8	4.8	29.6	303	<2	537
GARNER 557	02/21/08	QTbf	6.70	123	14.3	62.2	10.2	2.5	58.1	171	13	394
GARNER 635	07/15/08	Kbu	7.63	37.4	13.5	37.6	7.8	2.5	60.2	163	16	281
GGOOSE 547	08/15/08	Kbu	7.02	178	35.4	117	32.4	5.6	25.4	187	<2	545
GL-03	08/04/08	Kg	7.10	36.1	21.4	68.7	38.9	3.4	19.5	278	<2	358
OSBORN	07/22/08	Kg	7.24	17.7	19.7	80.3	15.0	4.2	24.7	252	29	362
OSBORN DUP	07/22/08	Kg	7.24	17.5	19.6	80.9	15.1	4.2	25.0	250	31	364
PALMER	07/22/08	Kbu	7.64	16.2	11.3	30	25.4	5.1	47.9	226	39	321
PARRA	07/31/08	Kbu	7.00	423	33.5	181	49.8	4.5	32.4	213	<2	871
PARRA DUP	07/31/08	Kbu	7.00	404	33.5	177	48.5	4.3	30.9	212	<2	845
POWER	07/22/08	Kbu	7.10	20.2	37.8	124	11.0	3.8	13.6	222	29	479
ROGERS 803	07/29/08[1]	QTbf	6.78	134	13.1	92.5	12.6	3.3	28.7	149	<2	393
SRC	08/05/08	Kbu	7.40	15.4	10.4	26.8	17.8	2.0	44.6	173	<2	238
TM-02A	08/15/08	Kg	7.84	14.4	8.2	14.7	5.2	2.4	60.2	143	8	200
TM-03	08/06/08	Kg	7.08	97	40.7	94.3	36.6	3.5	27.8	221	<2	467
TM-06 MILLER	08/04/08	Kbu	7.41	31.3	18.0	37.8	19.5	1.9	52.1	210	<2	291
TM-07	08/06/08	Kbu	7.04	22.2	8.9	45.8	14.7	1.9	20.5	157	<2	220
TM-08 SWAN	07/23/08	Kg	7.76	12.6	14.8	<0.02	<0.02	1.1	128	204	11	303
TM-14 NELSON	02/08/08	QTbf	7.64	32.9	12.5	56.1	10.0	2.8	23.6	166	<2	246
TM-15 MILLER	08/05/08	Kbu	7.42	13.7	7.0	29.8	18.9	2.0	32.0	173	-	216
TM-16	08/06/08	Kbu	6.67	466	28.1	215	52.7	13.3	30.0	191	<2	955
TM-19A	08/06/08	Kbu	7.32	55.3	15.4	37.3	10.8	2.9	53.0	153	5	272
TM-43B	08/05/08	Kbu	6.89	31.8	4.7	47.5	21.5	2.6	44.9	231	<2	292
TM-43B DUP	08/05/08	Kbu	6.89	32.5	4.7	47.9	21.7	2.5	44.9	234	<2	295
TVI 236	07/15/08	QTbf	7.39	37.6	23.5	70.4	9.3	1.8	26.3	161	11	292
TVI 875	07/15/08	QTbf	7.27	274	20.2	131	17.4	2.8	39.6	148	11	598
WALKER	07/23/08	Kbu	7.25	45.4	37.8	89	27.9	2.9	28.6	250	7	421
WEED	07/30/08	Kbu/Kg	7.42	11.5	10.1	34.1	13.6	2.2	29.4	163	2	209
WEISKOPF	07/16/08	QTbf	7.07	560	26.0	248	34.3	4.4	38.6	170	3	1040

Notes:

All units are in milligrams per liter (mg/l) unless otherwise noted

- = Not Analyzed

SU = Standard Units

TDS = Total Dissolved Solids

Kbu = undifferentiated Bisbee group

QTbf = basin fill

Kg = Glance Conglomerate

[1] Verified drinking water supply well, sample collected for sulfate trend analysis for interim action evaluation

Table 19B
Water Quality Data Used for Stiff and Piper Diagrams (Figures 32B and 32C)

Well Name	Sample Date	Screened Formation	Field pH (SU)	Sulfate, dissolved	Chloride, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sodium, dissolved	Bicarbonate as CaCO3	Carbonate as CaCO3	TDS (calculated)
BIMA	07/29/08[1]	Kbu	6.44	204	101	209	46.5	12.2	63.6	456	<2	945
BMO-2008-1G	08/27/08	Kg	7.09	107	76.3	124	32.2	6.4	35.7	229	9	588
DODSON	07/24/08	Kbu	7.25	49.3	160	124	43.3	13.7	51.3	223	12	646
EAST	07/23/08	Kbu	7.34	11.8	33.3	59.5	24.4	2.4	31.4	217	6	326
GALLANT	02/11/08	Kbu	7.46	17.9	12.7	106	15.9	4.3	25.6	344	<2	402
GGOOSE 547	08/15/08	Kbu	7.02	178	35.4	117	32.4	5.6	25.4	187	<2	545
NWC-04	10/27/08	Kbu	7.32	162	41.4	91.5	36.7	6.2	41.5	182	<2	518
OSBORN	07/22/08	Kg	7.24	17.7	19.7	80.3	15.0	4.2	24.7	252	29	362
PALMER	07/22/08	Kbu	7.64	16.2	11.3	30	25.4	5.1	47.9	226	39	321
PANAGAKOS	01/23/97	Kbu	7.52	130	65.8	132	40.3	16	22.2	262	<1	612
TM-06 MILLER	08/04/08	Kbu	7.41	31.3	18.0	37.8	19.5	1.9	52.1	210	<2	291
TM-08 SWAN	07/23/08	Kg	7.76	12.6	14.8	<0.02	<0.02	1.1	128	204	11	303
TM-16	08/06/08	Kbu	6.67	466	28.1	215	52.7	13.3	30.0	191	<2	955
WALKER	07/23/08	Kbu	7.25	45.4	37.8	89	27.9	2.9	28.6	250	7	421

Notes:

All units are in milligrams per liter (mg/l) unless otherwise noted

- = Not Analyzed

SU = Standard Units

TDS = Total Dissolved Solids

Kbu = undifferentiated Bisbee group

QTbf = basin fill

Kg = Glance Conglomerate

[1] Verified drinking water supply well, sample collected for sulfate trend analysis for interim action evaluation

Table 20
Comparison of the SET (1998c) and RSET Models

Feature	SET (1998c)	HGC RSET
Spatial and Temporal Domain		
Extent	60 square miles	No change
Layers	3 layers representing (1) basin fill, (2) Morita Formation, and (3) Glance Conglomerate	4 layers representing 1) basin fill, 2) shallow bedrock composed of undifferentiated Bisbee Group (e.g., Morita Formation, Mural Limestone, or Cintura Formation, 3) deeper bedrock composed of undifferentiated Bisbee Group, and 4) Glance Conglomerate. Basin fill and undifferentiated Bisbee Group bottom surfaces reinterpreted to reflect additional lithologic information.
Spatial discretization	100 meter by 100 meter grid cell size	No change
Temporal discretization	6 stress periods simulating 1905 - 1997 (historical) and 1 stress period simulating 1998 - 2098 (predictive)	No change to first 6 stress periods; adding stress periods 7 to 17 to simulate 1998 - 2008 (historical)
Boundary and Initial Conditions		
Specified head/concentration boundaries	Located on southern, western, and portions of eastern boundaries. Specified sulfate concentration of zero.	No change to locations or head values. Modified specified sulfate concentration to be 8 mg/L
No flow boundaries	Located on north and portions of eastern boundary	No change
Initial conditions	Groundwater levels from calibrated steady-state model; sulfate concentrations set to zero.	Re-calibrated steady-state model and set initial sulfate background concentrations to be 8 mg/L
Hydraulic Stresses		
Groundwater Pumping	35 pumping wells, including domestic, irrigation, municipal, and stock	Added domestic and stock wells not included in SET Model and added all well types installed after 1997 (and thus not in SET Model). Updated pumping for 1998 - 2008 from historical records (if available).
Groundwater Recharge	Included natural recharge and recharge from former evaporation pond, irrigation areas, wastewater treatment facilities, and a golf course.	Modified or expanded locations of some recharge sources based on aerial images; included recharge to Greenbush Draw due to discharge of San Jose WWTF effluent (post-1998).

Table 20
Comparison of the SET (1998c) and RSET Models

Feature	SET (1998c)	HGC RSET
Model Parameters		
Hydraulic Conductivity	Four zones in basin fill (23 - 72 ft/d), five zones in Morita Formation (1.4 - 20 ft/d), two zones in Glance Conglomerate (0.6, 1.6 ft/d), and two fault zones (9.8E-5, 2.0E-4 ft/d)	Values recalibrated; low permeability zones (2.3 ft/d) added in basin fill near BMO-2008-6B to match field measurements. Other values recalibrated.
Storage Coefficient	Five zones in Morita Formation (1E-5 - 3.2E-3), two zones in Glance Conglomerate (2.8E-4, 3.3E-4), and two fault zones (1.5E-4, 1.5E-4 ft/d)	Values recalibrated
Specific Yield	Four zones in basin fill (0.08 - 0.2), five zones in Morita Formation (0.01 - 0.0955), two zones in Glance Conglomerate (0.068, 0.072), and two fault zones (0.028, 0.028)	Values recalibrated
Effective Porosity	Four zones in basin fill (0.212 - 0.55), five zones in Morita Formation (0.051 - 0.122), two zones in Glance Conglomerate (0.035, 0.080), and two fault zones (0.12, 0.12)	Values recalibrated; added lower effective porosity zone (0.22) in central basin fill
Longitudinal Dispersivity	Four zones in basin fill (33 - 121 ft), five zones in Morita Formation (17 - 66 ft), two zones in Glance Conglomerate (33 - 48 ft), and two fault zones (3, 16)	Values recalibrated
Sulfate Sources		
Evaporation Pond	Sulfate concentration of 3,000 mg/L plus two zones of elevated concentration (3,100 mg/L and 3,650 mg/L). Recharge from 1908 to 1987	Reduced sulfate concentration to 2,500 mg/L plus two zones of 3,000 mg/L. Recharge from 1908 to 1987
Warren Ranch Irrigation Area	Sulfate concentration of 1,500 mg/L. Recharge from 1905 to 1987	Reduced sulfate concentration to 250 mg/L. Recharge from 1905 to 1985
Other	No sulfate in recharge except for evaporation pond and Warren Ranch irrigation area	Added 8 mg/L sulfate in natural, irrigation, and golf course recharge; 46 mg/L to recharge from San Jose WWTF

Notes:
mg/L = milligrams per liter
ft/d = feet per day

Table 21
Summary of Stress Periods in RSET Model

Stress Period	Years	Number Time Steps	Historical Summary	References
1	1905 - 1930	4	Pumping of water to CTSA, Evaporation Ponds, and Warren Ranch Irrigation Area began. Only one pumping well (stock watering) and no artificial recharge to aquifer.	SRK (1997), SET (1998c)
2	1931 - 1954	4	Construction of Turquoise Valley Golf Course. Naco Water Company (NWC) drills two municipal supply wells. Warren WWTF began operation. Several stock and 4 domestic wells operational[1].	SET (1998c), EPA (2003b)
3	1955 - 1961	2	NWC drills a third municipal supply well. Arizona Water Company (AWC) drills one municipal supply well. Irrigation wells drilled northeast of Naco. The number of domestic and stock wells increase.	SET (1998c)
4	1962 - 1975	4	Construction of east and west Naco-Sonora WWTF (1960s). El Oasis irrigation area established (1960s). The number of domestic and stock wells increase.	SAIC (1997), SET (1998c)
5	1976 - 1985	8	Increased groundwater development, particularly in Mexico. Water delivery to Warren Ranch irrigation area terminated in 1985[2].	SRK (1997), SET (1998c), PD (2004)
6	1986 - 1987	2	Water delivery to evaporation pond terminated in 1987.	PD (1990, 2004)
7	1988 - 1997	11	No water delivery to the evaporation pond and Warren Irrigation District. Irrigation north of the border declines.	SET (1998c)
8	1998	4	TVI Golf Course expands north of Greenbush Draw and installs two new pumping wells.	SET (1998c)
9	1999	4	No significant development.	
10	2000	4	No significant development.	
11	2001	4	No significant development.	
12	2002	4	No significant development.	
13	2003	4	No significant development.	
14	2004	4	No significant development.	
15	2005	4	No significant development.	
16	2006	4	San Jose Wastewater Treatment Facility expands and begins discharging effluent to Greenbush Draw. Warren WWTF closes.	ADEQ (2006)
17	2007	4	No significant development.	
18	2008	4	No significant development.	

Notes:

[1] SET (1998c) states that the Warren WWTF Ponds began operating in the 1930's. This is contradicted by EPA (2003b), which states they began operating in the 1970s.

[2] PD (1990), SRK (1997), and Pool and Dickinson (2006) report 1985 as the year when water delivery to the Warren Irrigation Area terminated. PD (2004) reports a termination date of 1987. Research by Copper Queen Branch found 1985 to be the correct termination date.

References:

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Table 22
Water Supply Wells in the
RSET Model Domain

Well Name	ADWR 55 Registry No.	Water Use	Used In SET (1998b)	UTM E 83	UTM N 83	Date Installed	Reported Pumping Rate[1] (gpm)	Status
85343	55-85343	DOMESTIC		606721	3469338	Not Installed	NA	Cancelled
500431	55-500431	DOMESTIC		600096	3467864	Not Installed	NA	Cancelled
500881	55-500881	DOMESTIC		599896	3468063	Not Installed	NA	Cancelled
ACKER	55-214612	DOMESTIC		598847	3472874	6/8/2007		No Response
ALVAREZ	55-650255	IRRIGATION		601096	3467466	1938		Cancelled
ANDERSON	55-613396	DOMESTIC		601135	3468816	1954		Operational
ANDERSON M	55-616775	DOMESTIC/IRRIGATION		600793	3468573			Declined participation in monitoring program
ANDERSON M	55-616776	DOMESTIC		599996	3467763	1916		Declined participation in monitoring program
ASLD	55-616436	STOCK	X	601488	3469690	7/15/1920		Dry
AWC-02	55-616586	MUNICIPAL		598891	3468566	1955		Operational
AWC-03	55-616585	MUNICIPAL	X	599016	3468660	7/20/1956	850	Operational
AWC-04	55-616584	MUNICIPAL	X	599000	3468695	1959	1,400	Operational
AWC-05	55-590620	MUNICIPAL		599278	3468526	6/24/2002		Operational
BANKS 986	55-647986	DOMESTIC		606723	3469137	6/23/1980	10	Operational
BANKS 987	55-647987	DOMESTIC	X	606982	3469206	< 1982	10	Not Operational
BARTON 010	55-85010	DOMESTIC		606201	3469047	1981	13	Not Operational
BARTON 919	55-644919	DOMESTIC		606244	3469077	< 1982	15	Not Operational
BERNAL	55-648363	DOMESTIC		600796	3467767	< 1948		Not Operational
BIMA	55-577927	DOMESTIC		606001	3471853	3/3/2000		Operational, deepened
BINYON	55-594938	DOMESTIC		608545	3468542	12/5/2002	5	Operational
BLOMMER	55-633472	DOMESTIC	X	601376	3470798	11/13/1978	35	Not Operational; declined participation Q1 09
BLOMMER	55-645536	Duplicate registration of BLOMMER 633472						
BRINDLEY	55-86775	DOMESTIC	X	601263	3472095	4/30/1981	10	Not Located
BULLARD	55-602134	DOMESTIC	X	602079	3470901	9/6/1974	12	Not Operational
BURKE	55-212268	DOMESTIC		602230	3473030	10/11/2006		Capped
BURKE 236	55-207236	DOMESTIC		602261	3473107			Not Operational
BUSK	55-581107	DOMESTIC		605515	3469127	Not Installed	NA	Cancelled - not installed
CAMPBELL	55-643481	DOMESTIC		606519	3469336	1996		Operational
CHAMBERS	55-629807	DOMESTIC		600097	3467462	1977	26	Operational
CHASE	55-648359	DOMESTIC		599695	3468062	1970	15	Operational
COLLINS	55-565260	DOMESTIC		602551	3471341	12/16/1997	10	Operational
CONNOR	55-516399	DOMESTIC		600251	3472678	1/20/1987		Abandoned
COOPER	55-623564	DOMESTIC/IRRIGATION		602668	3472105	12/20/1979	30	Operational
COOPER C	55-637069	DOMESTIC		601350	3468913	7/29/1966	35	Operational
COTA	55-651116	DOMESTIC		600197	3467563	< 1962	30	Not Located
CROWLEY	55-510298	DOMESTIC		602461	3473109	4/19/1985	NA	Dry at installation
DODSON	55-644927	DOMESTIC	X	605595	3469064	10/1/1959	15	Operational
DOUGLASS 791	55-592791	DOMESTIC		607633	3470223	9/21/2002	20	Not Operational
DOUGLASS 792	55-592792	DOMESTIC		607608	3469829	9/19/2002	20	Not Operational
DURAZO	NR	DOMESTIC		602041	3471284	10/24/2003	15	Operational
EAST	55-599796	DOMESTIC		607076	3468712	10/24/2003	15	Operational
EBERWEIN	55-641726	DOMESTIC				1976	30	Not Operational
EN-1 (Ejido Naco)	NA (Mexico)	IRRIGATION		601753	3464463			Not Operational
EN-2 (Ejido Naco)	NA (Mexico)	IRRIGATION	X	601886	3465282	1962 - 1975		Operational
EN-3 (Ejido Naco)	NA (Mexico)	IRRIGATION	X	602356	3465212	1962 - 1975		Operational

Table 22
Water Supply Wells in the
RSET Model Domain

Well Name	ADWR 55 Registry No.	Water Use	Used In SET (1998b)	UTM E 83	UTM N 83	Date Installed	Reported Pumping Rate[1] (gpm)	Status
EN-5 (Ejido Naco)	NA (Mexico)	IRRIGATION		602140	3466051			Operational
EN-6 (Ejido Naco)	NA (Mexico)	IRRIGATION		601962	3466114			Operational
EPPELE 641	55-805641	DOMESTIC/IRRIGATION		607165	3469230		6	Operational
EPPELE 642	55-805642	DOMESTIC/IRRIGATION		607126	3469140	early 1900s	5	Not Operational
EPPELE 643	55-805643	DOMESTIC		607126	3469140		25	Not Operational
FLEMING	55-218386	DOMESTIC		605567	3469335	2/1/2009	35	Not Operational - never used
FRANCO	55-500101	DOMESTIC		602850	3468836	7/1/1981	25	Operational
FULTZ	55-212447	DOMESTIC		606924	3469139	6/23/2006	25	Operational
GALLANT	55-502527	DOMESTIC		607770	3468524	4/26/1982	35	Operational
GARNER 557	55-558557	DOMESTIC		602659	3468962	9/4/1996	16	Not Operational
GARNER 635	55-587635	DOMESTIC		602665	3468968	10/12/2001	20	Operational
GGOOSE 546	55-628546	DOMESTIC/IRRIGATION	X	606115	3469534	2/11/1963	100	Not Operational
GGOOSE 547	55-628547	DOMESTIC/IRRIGATION	X	606257	3469820	8/18/1961	100	Not Operational
GOAR	55-610686	IRRIGATION	X	602406	3468588	late 1940s or early 1950s	60	Dry
GOAR	55-610687	IRRIGATION	X	602406	3468588	late 1940s or early 1950s	60	Dry
GOAR	55-610688	IRRIGATION		602406	3468588	late 1940s or early 1950s	60	Dry
GOAR	55-610689	IRRIGATION	X	602406	3468588	late 1940s or early 1950s	60	Dry
GOAR	55-610690	STOCK/DOMESTIC		601596	3468580	late 1940s or early 1950s	60	Dry
GOAR	55-610692	STOCK/DOMESTIC		602406	3468588	late 1940s or early 1950s	Windmill	Dry
GOAR	55-610694	DOMESTIC		602217	3468916	late 1940s or early 1950s	15	Not Operational since 1995
GOAR	55-610691	DOMESTIC		602406	3468588	late 1940s or early 1950s	60	Dry
GOAR	55-610693	DOMESTIC		602406	3468588	late 1940s or early 1950s	15	Dry
GOAR RANCH	55-610695	DOMESTIC		602455	3468892	late 1940s or early 1950s	15	Not Operational since 1995
GREGG	55-630852	DOMESTIC	X	607024	3469240	< 1982		Dry
HAUBERT	55-801607	DOMESTIC/IRRIGATION	X	601596	3468580	~ 1955	60	Declined participation in monitoring program
HECK	55-507823	DOMESTIC		602077	3471101	5/4/1984		Not Operational
HOBAN	55-805290	DOMESTIC		601706	3468880	3/2/1964	15	Operational
HULL 854	55-606854	IRRIGATION	X	601475	3470899	< 1915		Not Located
HULL 855	55-606855	DOMESTIC		601467	3471697	< 1915	35	Not Located
HUMPHREY	55-649153	DOMESTIC		600395	3468167	1938		Declined participation in monitoring program
IRONS	55-632924	DOMESTIC/IRRIGATION		602204	3468788	12/12/1955	200	Declined participation in monitoring program
JACKSON	55-506034	DOMESTIC		602479	3471103	8/16/1983	35	No Response
JALYN	55-209737	DOMESTIC		601496	3468680	11/16/2005	25	Not Operational
KEEFER	55-209744	DOMESTIC		599879	3468119	11/15/2005	25	Operational
KENNEDY	55-647003	Duplicate registration of ASLD 616436						
LESNICK	55-587749	DOMESTIC		607516	3470145	5/4/2002	25	Not Located
LUCERO	55-618175	DOMESTIC		601293	3468274	6/26/1972	100	No Response
MCCONNELL 265	55-539265	DOMESTIC		601463	3468840	7/6/1993	20	Operational
MCCONNELL 386	55-590386	DOMESTIC		601438	3468846	2002	0	Well Installed; Not Operational
MENDEZ	55-650256	IRRIGATION		601096	3467466	1938		Dry
METZLER	35-71891	DOMESTIC		602091	3471381	4/10/1979		Operational
MILLER 340	55-641340	STOCK/DOMESTIC		600090	3469474	1940	10	Dry
MILLER 341	55-641341	STOCK	X	601699	3467875	1920	10	Dry
MILLER 342	55-641342	STOCK	X	604520	3467499	1957	10	Dry
MINNERLY	55-650662	DOMESTIC		607223	3469441			Not Located

Table 22
Water Supply Wells in the
RSET Model Domain

Well Name	ADWR 55 Registry No.	Water Use	Used In SET (1998b)	UTM E 83	UTM N 83	Date Installed	Reported Pumping Rate[1] (gpm)	Status
MINOR 316	55-633316	DOMESTIC	X	601173	3468487	1955	35	Declined participation Q2 08
MINOR 317	55-633317	DOMESTIC		601172	3468568	1956	35	Operational, declined participation Q2 08
MOORE	55-538847	DOMESTIC		599495	3468060	4/24/1993	10	Operational
MOROYOQUI	55-647847	DOMESTIC		600395	3468167	6/18/1969	25	Dry
NESS	55-509127	DOMESTIC		607912	3471347	1/30/1985	6	Operational
NOBLE	55-618611	DOMESTIC		602608	3468792			Not Located
NOTEMAN	55-212483	DOMESTIC		606054	3471576	5/9/2006		Operational
NSD-02	55-527587	MUNICIPAL		598884	3468847			Operational
NSD-03	55-527586	MUNICIPAL		598077	3468637			Operational
NWC-01	55-627682	MUNICIPAL	X	600144	3467140	9/24/1951	75	Not Operational
NWC-02	55-562944	MUNICIPAL		600348	3467817	6/11/1997		Operational
NWC-02 CAPPED	55-627683	MUNICIPAL		600183	3467457	8/2/1959	175	Not Operational, replaced by 562944
NWC-03	55-203321	MUNICIPAL		601149	3468343			Operational
NWC-03 CAPPED	55-627684	MUNICIPAL	X	601148	3468343	1930	35	Not Operational, replaced by 203321
NWC-04	55-551849	MUNICIPAL		605837	3469075	8/24/1995		Operational, deepened
NWC-04 CAPPED	55-627685	MUNICIPAL		605915	3469113	12/31/1926	180	Capped 3/29/2005, replaced by 551849
NWC-05	55-627696	MUNICIPAL	X	606980	3469446	1960	< 35	Not Operational
NWC-06	55-575700	MUNICIPAL		599826	3467742	9/15/1999	130	Operational
OSBORN	55-643436	DOMESTIC	X	607032	3470271	8/5/1993	20	Operational
PALMER 819	55-578819	DOMESTIC		607724	3469545	1/10/2000	25	Operational
PALMER 937	55-642937	STOCK				prior to 1925	20	Not Operational
PANAGAKOS	35-76143	DOMESTIC		605312	3469321	7/1/1957		Operational
PARRA	55-576415	DOMESTIC		602171	3471264	10/6/1999	25	Operational
PATSIS	55-544685	DOMESTIC		602673	3471705	Not Installed	NA	Not Installed
PAVLOVICH	55-502193	DOMESTIC		601238	3474910	4/1/1982	35	
PIONKE	55-613395	IRRIGATION		600936	3468837	1964	200	Operational
POOL	55-509518	DOMESTIC	X	599684	3470014	12/12/1984	30	Operational
POWER	55-624535	STOCK/DOMESTIC	X	608379	3472739	1967	15	Operational
RAMIREZ	55-216425	DOMESTIC		599696	3467661			Operational
RAY	55-803772	DOMESTIC		607083	3469195		< 35	Operational
RICHARDS	55-531595	DOMESTIC		608716	3471353	5/3/1991		Operational
RODRIGUEZ	55-648360	DOMESTIC		600697	3467464	~ 1930		Dry
ROGERS 596	55-573596	DOMESTIC		600894	3468271	9/16/1999	20	Not Operational
ROGERS 801	55-641801	DOMESTIC		601092	3468676	1960	20	Not Operational
ROGERS 803	55-641803	DOMESTIC		600978	3468417	1960	20	Operational
ROGERS E	55-216018	DOMESTIC		599895	3468264	9/10/2007	20	Operational
ROLLINS	55-641750	DOMESTIC		601096	3467667			Not Operational
ROSS	55-513351	DOMESTIC		600254	3472688	2/8/1986	500	Capped - never used
ROSS	55-516398	DOMESTIC		600052	3472887	1/21/1987		Cancelled - never used
ROSS	55-517525	DOMESTIC		599654	3472078	4/17/1987		Dry at installation
ROSS	55-517526	DOMESTIC		599666	3471480	4/16/1987	35	No Response
RUIZ	55-531770	DOMESTIC		602857	3471424	5/29/1991	10	Operational
SCHWARTZ	55-210865	DOMESTIC		600812	3468268		16	Operational
SHAFER	55-649994	DOMESTIC		600497	3467463	7/15/1966	30	Bulldozed
SILVESTRI	55-557742	DOMESTIC		600251	3473493	7/10/1996	28	Not Operational

Table 22
Water Supply Wells in the
RSET Model Domain

Well Name	ADWR 55 Registry No.	Water Use	Used In SET (1998b)	UTM E 83	UTM N 83	Date Installed	Reported Pumping Rate[1] (gpm)	Status
SRC	55-211345	DOMESTIC		599722	3472503	2/6/2007		Capped - never used
STARK-CAMPBELL	55-215509	DOMESTIC		606421	3469320	4/11/2007		Not Operational
STEPHENS	55-808560	DOMESTIC		606982	3469073			Not Operational
SUNBELT	55-201531	DOMESTIC		605998	3471735	1/15/2004	25	Dry 2008
SUNNYSIDE	55-588270	DOMESTIC		601293	3468476	8/28/2001	10	Not Operational
TVI 161	55-556161	DOMESTIC		599895	3468264	Not Installed	NA	Cancelled, never installed
TVI 236[2]	55-802236	IRRIGATION	X	600552	3467978	2/14/1934	600	Operational
TVI 713[2]	55-567713	IRRIGATION		600729	3468413	4/14/1998		Capped - never used
TVI 875[2]	55-568875	IRRIGATION		600694	3468471	6/14/1998	500	Operational
TVI Southside 2[2,3]		IRRIGATION		600052	3467988	~1970	400	Operational
UN-1 (Urbano Naco)	NA (Mexico)	MUNICIPAL	X	600000	3466343	1962 - 1975		Not Operational
UN-2 (Urbano Naco)	NA (Mexico)	MUNICIPAL		600013	3465397	before 1993		Operational
UN-3 (Urbano Naco)	NA (Mexico)	MUNICIPAL	X	599949	3465797	1962 - 1975		Operational
UN-4 (Urbano Naco)	NA (Mexico)	MUNICIPAL		601213	3466298	1996 - 1998		Operational
UN-5 (Urbano Naco)	NA (Mexico)	MUNICIPAL		600743	3464444	~ 2005		Operational
UNION PACIFIC RR	55-626702	MUNICIPAL		605916	3469131	1/31/1918	175	Capped 2005
VALENZUELA	55-645050	DOMESTIC		600395	3468167	1947		Declined participation in monitoring program
WALKER	55-200393	DOMESTIC		607565	3468577	11/12/2003		Operational
WEED	55-544535	DOMESTIC		601276	3470699	7/9/1994	25	Operational
WEISKOPF	55-641802	DOMESTIC		601155	3468659	< 1960	25	Operational
WILSON 361	55-648361	STOCK		602002	3468181	1929		Not Operational
WILSON 362	55-648362	STOCK		601293	3468879	1947		Not Operational
ZANDER	55-205126	DOMESTIC		599679	3467998	2/10/2005	10	Operational

Notes:

[1] The pumping rates listed represent maximum pumping rates. Information obtained from ADWR Image Records for wells in the United States. Data for Mexico wells [2] from personal communication with well operators.

[2] from HGC (2008c)

[3] Location, installation year, and pumping rate are approximate

UTM E = Universal Transverse Mercator, North American 1983 Datum Easting (meters)

UTM N = Universal Transverse Mercator, North American 1983 Datum Northing (meters)

gpm = gallons per minute

NA = not applicable

Table 23
Pumping Wells and Pumping Rates in RSET Model
(all rates in gallons per minute)

WellName	ADWR 55 Registry No.	Water Use	Screen Top[1] (ft amsl)	Screen Bottom[1] (ft amsl)	Stress Period Year	1 1905 - 1930	2 1931 - 1954	3 1955 - 1961	4 1962 - 1975	5 1976 - 1987	6 1988 - 1997	7 1998	8 1999	9 2000	10 2001	11 2002	12 2003	13 2004	14 2005	15 2006	16 2007	17 2008
ACKER	55-214612	DOMESTIC	4492	4405		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3
ANDERSON	55-613396	DOMESTIC	4330	4280		0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
ANDERSON M	55-616775	DOMESTIC/IRRIGATION	4395	4335		0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
ANDERSON M	55-616776	DOMESTIC	3735	3615		0.2	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ASLD	55-616436	STOCK	4610	4466		0.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	0.0	0.0	0.0	0.0	0.0	0.0
AWC-02	55-616586	MUNICIPAL	4500	4385		0.0	0.0	0.0	0.0	0.0	0.0	26.9	29.3	42.6	28.3	39.8	48.9	38.9	78.9	71.4	63.8	63.8
AWC-03	55-616585	MUNICIPAL	4517	4331		0.0	0.0	340.5	340.5	340.5	366.9	576.4	561.7	362.4	390.7	551.5	504.0	514.6	483.6	330.1	176.7	176.7
AWC-04	55-616584	MUNICIPAL	4459	4378		0.0	0.0	0.0	340.5	340.5	366.9	80.6	101.6	346.0	285.6	166.3	144.1	21.6	17.4	76.0	134.5	134.5
AWC-05	55-590620	MUNICIPAL	4397	3397		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.4	158.3	137.8	220.3	302.8	302.8
BANKS 986	55-647986	DOMESTIC	4425	4380		0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
BANKS 987	55-647987	DOMESTIC	4610	4320		0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BARTON 010	55-85010	DOMESTIC	4489	4439		0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BARTON 919	55-644919	DOMESTIC	4492	4442		0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BERNAL	55-648363	DOMESTIC	4370	4320		0.0	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BIMA	55-577927	DOMESTIC	4602	4552		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
BINYON	55-594938	DOMESTIC	4452	4402		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3
BJ-7			4577	4452		0.0	0.0	0.4	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BLOMMER	55-633472	DOMESTIC	4724	4385		0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BRINDLEY	55-86775	DOMESTIC	4724	4416		0.0	0.0	0.0	0.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	0.0	0.0
BULLARD	55-602134	DOMESTIC	4675	4388		0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BURKE	55-212268	DOMESTIC	4656	4606		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
CAMPBELL	55-643481	DOMESTIC	4494	4444		0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0
CHAMBERS	55-629807	DOMESTIC	4400	4350		0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
CHASE	55-648359	DOMESTIC	4357	4307		0.0	0.0	0.0	0.1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
COLLINS	55-565260	DOMESTIC	4534	4484		0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
CONNOR	55-516399	DOMESTIC	4636	4586		0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
COOPER	55-623564	DOMESTIC/IRRIGATION	4643	4593		0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
COOPER C	55-637069	DOMESTIC	4395	4345		0.0	0.0	0.0	0.2	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DODSON	55-644927	DOMESTIC	4659	4469		0.0	0.0	0.0	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DOUGLASS 791	55-592791	DOMESTIC	4503	4453		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.3	0.0	0.0	0.0
DOUGLASS 792	55-592792	DOMESTIC	4482	4432		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.3	0.0	0.0	0.0
DURAZO	NR	DOMESTIC	4334	4224		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3
EAST	55-599796	DOMESTIC	4452	4410		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3
EN-01	NA (Mexico)	IRRIGATION	4659	4232		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EN-02	NA (Mexico)	IRRIGATION	4659	4232		0.0	0.0	0.0	495.3	697.1	697.1	278.8	306.7	334.6	362.5	390.4	418.3	446.1	474.0	501.9	501.9	501.9
EN-03	NA (Mexico)	IRRIGATION	4642	4298		0.0	0.0	0.0	495.3	697.1	697.1	278.8	306.7	334.6	362.5	390.4	418.3	446.1	474.0	501.9	501.9	501.9
EN-05	NA (Mexico)	IRRIGATION	4659	4232		0.0	0.0	0.0	0.0	0.0	0.0	278.8	306.7	334.6	362.5	390.4	418.3	446.1	474.0	501.9	501.9	501.9
EN-06	NA (Mexico)	IRRIGATION	4659	4232		0.0	0.0	0.0	0.0	0.0	0.0	278.8	306.7	334.6	362.5	390.4	418.3	446.1	474.0	501.9	501.9	501.9
EPPELE 641	55-805641	DOMESTIC/IRRIGATION	4458	4398		0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EPPELE 642	55-805642	DOMESTIC/IRRIGATION	4442	4392		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
EPPELE 643	55-805643	DOMESTIC	4442	4392		0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FRANCO	55-500101	DOMESTIC	4436	4386		0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
FULTZ	55-212447	DOMESTIC	4451	4351		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.3
GALLANT	55-502527	DOMESTIC	4400	4350		0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
GARNER 557	55-558557	DOMESTIC	4371	4271		0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GARNER 635	55-587635	DOMESTIC	4428	4378		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
GGOOSE 546	55-628546	DOMESTIC/IRRIGATION	4692	3905		0.0	0.0	0.0	76.9	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GGOOSE 547	55-628547	DOMESTIC/IRRIGATION	4692	4271		0.0	0.0	0.0	76.9	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GOAR	55-610686	IRRIGATION	4610	4363		0.0	0.0	100.0	100.0	100.0	18.3	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
GOAR	55-610687	IRRIGATION	4593	4353		0.0	0.0	100.0	100.0	100.0	18.3	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
GOAR	55-610689	IRRIGATION	4610	4363		0.0	0.0	100.0	100.0	100.0	18.3	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
GOAR RANCH	55-610695	DOMESTIC	4431	4381		0.0	0.0	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GREGG	55-630852	DOMESTIC	4626	4320		0.0	0.0	0.4	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HAUBERT	55-801607	DOMESTIC/IRRIGATION	4458	4408		0.0	0.0	100.0	100.0	100.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
HECK	55-507823	DOMESTIC	4724	4324		0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOBAN	55-805290	DOMESTIC	4417	4297		0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
HULL 854	55-606854	IRRIGATION	4675	4490		1.8	1.8	1.8	1.8	1.8	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HULL 855	55-606855	DOMESTIC	4734	4404		0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HUMPHREY	55-649153	DOMESTIC	4354	4304		0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IRONS	55-632924	DOMESTIC/IRRIGATION	4416	4366		0.0	0.0	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JACKSON	55-506034	DOMESTIC	4524	4424		0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
JALYN	55-209737	DOMESTIC	4396	4346		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0
KEEFER	55-209744	DOMESTIC	4372	4322		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3
L-1		STOCK	4495	4085		0.0	0.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
L-2		STOCK	4478	4052		0.0	0.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
L-3		DOMESTIC	4478	4052		0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LUCERO	55-618175	DOMESTIC	4377	4327		0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
M-1		STOCK	4610	4421		0.0	0.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
MCCONNELL 265	55-539265	DOMESTIC	4401	4351		0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
MENDEZ	55-650256	IRRIGATION	4380	4330		0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
METZLER	35-71891	DOMESTIC	4484	4384		0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
MILLER 340	55-641340	STOCK/DOMESTIC	4516	4496		0.0	0.2	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MILLER 341	55-641341	STOCK	4544	4463		0.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	0.0	0.0	0.0	0.0	0.0	0.0

Table 23
Pumping Wells and Pumping Rates in RSET Model
(all rates in gallons per minute)

WellName	ADWR 55 Registry No.	Water Use	Screen Top[1] (ft amsl)	Screen Bottom[1] (ft amsl)	Stress Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
					Year	1905 - 1930	1931 - 1954	1955 - 1961	1962 - 1975	1976 - 1987	1988 - 1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
MILLER 342	55-641342	STOCK	4610	4424		0.0	1.8	1.8	0.4	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MINNERLY	55-650662	DOMESTIC	4456	4436		0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
MINOR 316	55-633316	DOMESTIC	4544	4352		0.0	0.0	0.4	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MINOR 317	55-633317	DOMESTIC	4379	4329		0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
MOORE	55-538847	DOMESTIC	4354	4304		0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
MOROYOQUI	55-647847	DOMESTIC	4360	4310		0.0	0.0	0.0	0.2	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NESS	55-509127	DOMESTIC	4597	4547		0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NOBLE	55-618611	DOMESTIC	4439	4389		0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0
NOTEMAN	55-212483	DOMESTIC	4541	4496		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.3
NSD-02	55-527587	MUNICIPAL	4445	4405		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3
NSD-03	55-527586	MUNICIPAL	4467	4427		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3
NWC-01	55-627682	MUNICIPAL	4560	4167		0.0	0.0	50.1	50.1	50.1	62.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NWC-02	55-562944	MUNICIPAL	4363	4263		0.0	0.0	0.0	0.0	0.0	0.0	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
NWC-02 CAPPED	55-627683	MUNICIPAL	4363	4263		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NWC-03	55-203321	MUNICIPAL	4318	4258		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.1	1.1	1.1	1.1
NWC-03 CAPPED	55-627684	MUNICIPAL	4318	4258		0.0	22.0	22.0	32.1	50.1	50.1	1.1	1.1	1.1	1.1	1.1	1.1	0.0	0.0	0.0	0.0	0.0
NWC-04	55-551849	MUNICIPAL	4593	4544		0.0	0.0	0.0	0.0	0.0	0.0	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3
NWC-04 CAPPED	55-627685	MUNICIPAL	4675	4610		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NWC-05	55-627696	MUNICIPAL	4659	4281		0.0	5.1	13.8	9.2	9.2	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NWC-06	55-575700	MUNICIPAL	4415	4255		0.0	0.0	0.0	0.0	0.0	0.0	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4
OSBORN	55-643436	DOMESTIC	4692	4547		0.0	0.0	0.0	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PALMER 819	55-578819	DOMESTIC	4456	4406		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
PANAGAKOS	35-76143	DOMESTIC	4590	4490		0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
PARRA	55-576415	DOMESTIC	4527	4477		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
PAVLOVICH	55-502193	DOMESTIC	4918	4868		0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0
PIONKE	55-613395	DOMESTIC	4410	4360		0.0	0.0	0.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
POOL	55-509518	DOMESTIC	4610	4308		0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
POWER	55-624535	STOCK/DOMESTIC	4806	4718		0.0	0.0	0.0	1.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RAMIREZ	55-216425	DOMESTIC	4323	4283		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
RAY	55-803772	DOMESTIC	4396	4336		0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
RICHARDS	55-531595	DOMESTIC	4510	4470		0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
RODRIGUEZ	55-648360	DOMESTIC	4387	4337		0.0	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ROGERS 596	55-573596	DOMESTIC	4364	4314		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
ROGERS 801	55-641801	DOMESTIC	4380	4330		0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ROGERS 803	55-641803	DOMESTIC	4379	4329		0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
ROGERS E	55-216018	DOMESTIC	4351	4301		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
ROLLINS	55-641750	DOMESTIC	4380	4330		0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
ROSS	55-517526	DOMESTIC	4656	4606		0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
RUIZ	55-531770	DOMESTIC	4535	4485		0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
SCHWARTZ	55-210865	DOMESTIC	4352	4302		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3
SHAFER	55-649994	DOMESTIC	4489	4429		0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SILVESTRI	55-557742	DOMESTIC	4545	4465		0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUNBELT	55-201531	DOMESTIC	4607	4557		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.0
SUNNYSIDE	55-588270	DOMESTIC	4383	4333		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.0	0.0	0.0
TVI 236	55-802236	IRRIGATION	4528	4320		0.0	300.3	300.3	300.3	200.0	137.6	101.0	39.0	39.0	39.0	39.0	39.0	39.0	39.0	39.0	39.0	39.0
TVI 875	55-568875	IRRIGATION	4400	4245		0.0	0.0	0.0	0.0	0.0	0.0	62.0	124.0	124.0	124.0	124.0	124.0	124.0	124.0	124.0	124.0	124.0
TVI-SS2		IRRIGATION	4528	4320		0.0	0.0	0.0	0.0	0.0	0.0	39.0	39.0	39.0	39.0	39.0	39.0	39.0	39.0	39.0	39.0	39.0
UN-01	NA (Mexico)	MUNICIPAL	4659	4232		0.0	0.0	0.0	182.7	244.7	365.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UN-02	NA (Mexico)	MUNICIPAL	4659	4232		0.0	0.0	0.0	0.0	0.0	0.0	332.9	332.9	332.9	332.9	332.9	332.9	332.9	332.9	332.9	332.9	332.9
UN-03	NA (Mexico)	MUNICIPAL	4675	4249		0.0	0.0	0.0	63.5	85.4	126.9	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2
UN-04	NA (Mexico)	MUNICIPAL	4659	4232		0.0	0.0	0.0	0.0	0.0	0.0	153.6	153.6	153.6	153.6	153.6	153.6	153.6	153.6	153.6	153.6	153.6
UN-05	NA (Mexico)	MUNICIPAL	4659	4232		0.0	0.0	0.0	0.0	0.0	0.0	230.4	230.4	230.4	230.4	230.4	230.4	230.4	230.4	230.4	230.4	230.4
UNION PACIFIC RR	55-626702	MUNICIPAL	4550	4500		1.0	1.8	1.8	1.8	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VALENZUELA	55-645050	DOMESTIC	4354	4304		0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
WALKER	55-200393	DOMESTIC	4402	4352		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3
WEED	55-544535	DOMESTIC	4488	4438		0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
WEISKOPF	55-641802	DOMESTIC	4387	4337		0.0	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0
WILSON 361	55-648361	STOCK	4387	4337		0.0	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WILSON 362	55-648362	STOCK	4400	4350		0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
ZANDER	55-205126	DOMESTIC	4381	4331		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.3

Notes:

[1] Elevations are estimated from available well information and may not be exact
UTM E = Universal Transverse Mercator, North American 1983 Datum Easting (meters)
UTM N = Universal Transverse Mercator, North American 1983 Datum Northing (meters)
ft amsl = feet above mean sea level
NA = not applicable

Table 24
Aquifer Recharge in the RSET Model

Source	Number of Model Cells	Area		Initial Rate			Final Rate			Initial Concentration	Final Concentration
		(m^2)	(acres)	in/yr	(ac-ft/yr)	(gpm)	in/yr	(ac-ft/yr)	(gpm)	(mg/L)	(mg/L)
Natural Recharge - high (1904-2008)	7,173	71,730,000	17,725	3.67	5,416	3,356	3.67	5,416	3,356	8	8
Natural Recharge - low (1904-2008)	7,025	70,250,000	17,359	0.00388	5.62	3.48	3.88E-03	5.62	3.48	8	8
Natural Recharge - total	**14,198**	**141,980,000**	**35,084**		**5,422**	**3,359**		**5,422**	**3,359**	**8**	**8**
Evaporation Pond - east (1905-1987)	101	1,010,000	250	60.4	1,256	778	60.4	1,256	778	3,000	2,500
Evaporation Pond - west (1905-1987)	43	430,000	106	208.5	1,846	1,144	208.5	1,846	1,144	3,000	2,500
Evaporation Pond - total	**144**	**1,440,000**	**356**	**269**	**3,102**	**1,922**	**269**	**3,102**	**1,922**	**3,000**	**2,500**
Warren Ranch Irrigation Area - east (1905-1985)	428	4,280,000	1,058	0.863	76.0	47.1	11.2	987	612	1,500	250
Warren Ranch Irrigation Area - west (1905-1985)	477	4,770,000	1,179	10.8	1,059	656	11.2	1,100	682	1,500	250
Warren Ranch Irrigation Area - total	**905**	**9,050,000**	**2,236**		**1,135**	**703**		**2,087**	**1,293**	**varies**	**varies**
Warren WWTF Ponds (1931-2005)	**5**	**50,000**	**12.4**	**155**	**160**	**99.1**	**155**	**160**	**99.1**	**46**	**46**
Golf Course - existing (1931-2008)	**8**	**80,000**	**19.8**	**20.1**	**33.2**	**20.5**	**20.1**	**33.2**	**20.5**	**8**	**8**
Golf Course - expansion (1998-2008)	**8**	**80,000**	**19.8**	**20.1**	**33.2**	**20.5**	**20.1**	**33.2**	**20.5**	**8**	**8**
Naco Sonora WWTF Pond - east (1962-2008)	4	40,000	9.9	96.1	79.1	49.0	96.1	79.1	49.0	46	46
Naco Sonora WWTF Pond - west (1962-2008)	4	40,000	9.9	96.1	79.1	49.0	96.1	79.1	49.0	46	46
Naco Sonora WWTF Pond - total	**8**	**80,000**	**20**		**158**	**98**		**158**	**98**	**25**	**25**
El Oasis Irrigation Ponds (1962-2008)	**124**	**1,240,000**	**306**	**95.9**	**2,449**	**1,517**	**25.9**	**661**	**409**	**8**	**8**
El Oasis Irrigation Ponds (1998-2008)	**155**	**1,550,000**	**383**	**95.9**	**3,061**	**1,896**	**20.9**	**666**	**412**	**8**	**8**
San Jose WWTF (lagoons, 2000-2006)	**5**	**50,000**	**12.4**	**75**	**77**	**48**	**75**	**77**	**48**	**46**	**46**
San Jose WWTF (Greenbush Draw, 2007-2008)	**16**	**160,000**	**39.5**	**140**	**460**	**285**	**140**	**460**	**285**	**46**	**46**

Notes:

m^2 = square meters
in/yr = inches per year
ac-ft/yr = acre-feet per year
gpm = gallons per minute
mg/L = milligrams per liter

Table 25
Initial and Final Flow and Transport Parameters in the RSET Model

Zone	Kh (ft/d)		Kv (ft/d)		S (ft/ft)		Sy (-)		θ_{eff} (-)		α_L (-)	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Layer 1 (Basin Fill)												
Zone 1	29.5	29.5	0.230	0.033	0.0001	0.001	0.2	0.2	0.212	0.212	1	1
Zone 2	72.4	72.4	2.62	2.62	0.0001	0.001	0.175	0.175	0.22	0.22	37	37
Zone 3	65.2	65.2	2.30	2.30	0.0001	0.001	0.2	0.2	0.22	0.22	37	37
Zone 4	23.0	39.4	3.61	3.28	0.0001	0.001	0.08	0.19	0.55	0.55	29.5	30
Zone 15[1]		39.4		3.28		0.001		0.19		0.235		
Layer 2/3 (Undifferentiated Bisbee Group)												
Zone 5	2.95	1.48	0.098	0.098	0.0001	0.001	0.01	0.001	0.1	0.1	9.5	9.5
Zone 6	1.39	0.44	0.0328	0.0033	0.0032	0.001	0.0955	0.001	0.06	0.06	20	20
Zone 7	1.97	1.97	2.62E-04	2.62E-04	0.00025	0.001	0.042	0.001	0.051	0.051	5.2	5.2
Zone 8	3.28E-03	3.28E-03	0.098	0.098	0.00015	0.0015	0.0275	0.0015	0.12	0.12	2.5	2.5
Zone 9	19.7	1.0	0.131	0.003	0.0005	0.001	0.05	0.001	0.08	0.08	12	12
Zone 10	0.0246	0.0610	0.098	0.098	0.00033	0.0033	0.074	0.0033	0.08	0.08		
Zone 11	1.64	0.33	1.02	0.33	1.00E-05	1.20E-05	0.01	0.000012	0.122	0.122		
Zone 16[2]						1.00E-03		0.03		0.04		
Layer 4 (Glance)												
Zone 8	3.28E-03	3.28E-03	0.0984	0.0984	0.00015	0.0015	0.0275	0.0015	0.12	0.12	2.5	5.2
Zone 10	0.0246	0.0610	0.0984	0.0984	0.00033	0.0033	0.08	0.0033	0.08	0.08	14.5	12
Zone 12	0.591	0.591	3.28E-03	3.28E-03	0.00028	0.0028	0.068	0.0028	0.035	0.035		
Zone 13	1.64	0.66	9.84E-03	9.84E-03								

Notes:

[1] Added during model calibration, replacing a portion of zone 4 on west side of Black Gap fault

[2] Added during model calibration, replacing a portions of zones 5 and 7 on east side of Black Gap fault

Kh = horizontal hydraulic conductivity

Kv = vertical hydraulic conductivity

S = storage coefficient

Sy = specific yield

θ_{eff} = effective porosity

α_L = longitudinal dispersivity

ft/d = feet per day

CLEAR CREEK ASSOCIATES

Table 26
Simulated and Estimated Target Values for Steady-State Simulation

Target	Target Value	Simulated Value
Groundwater flux through western boundary in basin fill; estimated by Littin, 1987 (ac-ft/yr)	5,200	7,647
Groundwater elevation in NWC-3; approximated from 1930 measurement (ft amsl)	4,466	4,458

Notes:
ac-ft/yr = acre-feet per year
ft amsl = feet above mean sea level

Table 27
Simulated and Measured Target Values for Transient Flow Simulation

Well Name	Time	Date	X	Y	Layer	Observed Water Elevation (meters)	Computed Water Elevation (meters)	Weight	Group	Residual (meters)	Residual Squared (meters ^{2})	Residual (feet)
BF-1	32120	12/9/1992	604203.7	3472151.6	2	1370.49	1433.87	0.0001	1	***-63.39***	4018.19	***-207.97***
BF-1	32485	12/9/1993	604203.7	3472151.6	2	1370.50	1433.74	0.0001	1	***-63.24***	3999.35	***-207.48***
BF-1	33215	12/9/1995	604203.7	3472151.6	2	1367.91	1433.49	0.0001	1	***-65.58***	4300.48	***-215.15***
BF-1	33580	12/8/1996	604203.7	3472151.6	2	1368.08	1433.41	0.0001	1	***-65.33***	4267.84	***-214.33***
BF-1	33945	12/8/1997	604203.7	3472151.6	2	1368.03	1433.34	0.0001	1	***-65.31***	4265.27	***-214.27***
BF-1	34310	12/8/1998	604203.7	3472151.6	2	1368.91	1372.53	0.0001	1	-3.62	13.09	-11.87
BF-1	34675	12/8/1999	604203.7	3472151.6	2	1368.05	1368.36	0.0001	1	-0.32	0.10	-1.04
BF-1	35040	12/7/2000	604203.7	3472151.6	2	1367.60	1366.12	0.0001	1	1.48	2.18	4.84
BF-1	35405	12/7/2001	604203.7	3472151.6	2	1367.62	1364.65	0.0001	1	2.98	8.85	9.76
BF-1	35770	12/7/2002	604203.7	3472151.6	2	1367.81	1363.61	0.0001	1	4.20	17.68	13.79
BF-1	36135	12/7/2003	604203.7	3472151.6	2	1367.92	1362.83	0.0001	1	5.09	25.91	16.70
BF-1	36500	12/6/2004	604203.7	3472151.6	2	1367.76	1362.19	0.0001	1	5.57	31.06	18.28
BF-1	36865	12/6/2005	604203.7	3472151.6	2	1367.61	1361.66	0.0001	1	5.96	35.48	19.54
BF-1	37230	12/6/2006	604203.7	3472151.6	2	1367.48	1361.19	0.0001	1	6.29	39.58	20.64
BF-1	37595	12/6/2007	604203.7	3472151.6	2	1367.41	1360.78	0.0001	1	6.62	43.85	21.73
BF-1	37960	12/5/2008	604203.7	3472151.6	2	1367.46	1360.42	0.0001	1	7.05	49.67	23.12
BF-2	32120	12/9/1992	603479.9	3471513.0	1	1361.99	1354.14	1	1	7.85	61.64	25.76
BF-2	32485	12/9/1993	603479.9	3471513.0	1	1361.69	1354.14	1	1	7.56	57.10	24.79
BF-2	33215	12/9/1995	603479.9	3471513.0	1	1358.90	1354.14	1	1	4.76	22.69	15.63
BF-2	33580	12/8/1996	603479.9	3471513.0	1	1358.45	1354.14	1	1	4.32	18.63	14.16
BF-2	33945	12/8/1997	603479.9	3471513.0	1	1358.22	1354.14	1	1	4.08	16.66	13.39
BF-2	37960	12/5/2008	603479.9	3471513.0	1	1367.46	1354.14	1	1	13.33	177.60	43.72
BIMA	37960	12/5/2008	606001.2	3471852.8	4	1352.77	1420.86	0.01	1	***-68.09***	4635.98	***-223.39***
BMO-2008-1G	37960	12/5/2008	606467.7	3471723.6	4	1445.85	1421.11	0.1	1	24.74	611.85	81.15
BMO-2008-3B	37960	12/5/2008	602012.9	3467919.6	1	1355.13	1354.74	1	1	0.40	0.16	1.30
BMO-2008-5B	37960	12/5/2008	600449.7	3468994.4	1	1353.50	1352.46	1	1	1.04	1.09	3.43
BMO-2008-5M	37960	12/5/2008	600445.3	3468994.0	3	1353.00	1352.96	1	1	0.05	0.00	0.15
BMO-2008-6B	37960	12/5/2008	600366.5	3469820.6	1	1352.48	1352.74	1	1	-0.26	0.07	-0.87
BMO-2008-6M	37960	12/5/2008	600367.9	3469813.9	3	1352.08	1352.32	1	1	-0.24	0.06	-0.78
BMO-2008-7M	37960	12/5/2008	603099.2	3470029.3	3	1356.16	1359.55	1	1	-3.40	11.55	-11.15
BMO-2008-9M	37960	12/5/2008	604668.7	3471121.7	3	1364.04	1368.25	1	1	-4.21	17.72	-13.81
BMO-2008-10GL	37960	12/5/2008	605264.1	3471702.0	4	1301.83	1380.73	0.01	1	***-78.90***	6225.28	***-258.86***
BMO-2008-10GU	37960	12/5/2008	605267.6	3471731.9	4	1370.34	1380.76	0.01	1	-10.42	108.58	-34.19
BMO-2008-11G	37960	12/5/2008	603801.0	3472626.5	4	1300.70	1363.01	0.01	1	***-62.31***	3882.46	***-204.43***
COBWL	37595	12/6/2007	606357.5	3472502.0	4	1455.59	1429.82	0.01	1	25.77	664.05	84.54
COBWL	37960	12/5/2008	606357.5	3472502.0	4	1455.04	1429.78	0.01	1	25.27	638.41	82.90
TM-01	30295	12/11/1987	604096.2	3470517.0	1	1369.45	1339.53	1	1	29.92	895.17	98.16
TM-01	30660	12/10/1988	604096.2	3470517.0	1	1367.95	1339.53	1	1	28.42	807.55	93.23
TM-01	31025	12/10/1989	604096.2	3470517.0	1	1367.44	1339.53	1	1	27.91	778.84	91.56
TM-01A	30660	12/10/1988	604096.2	3470517.0	1	1367.75	1339.53	1	1	28.22	796.12	92.57
TM-01B	30660	12/10/1988	604096.2	3470517.0	3	1368.32	1369.22	1	1	-0.90	0.82	-2.97
TM-02	30295	12/11/1987	604077.6	3471921.0	1	1372.37	1355.38	1	1	17.00	288.93	55.77
TM-02	30660	12/10/1988	604077.6	3471921.0	1	1371.47	1355.38	1	1	16.10	259.15	52.82
TM-02	31025	12/10/1989	604077.6	3471921.0	1	1370.50	1355.38	1	1	15.12	228.63	49.61
TM-02	32120	12/9/1992	604077.6	3471921.0	1	1363.90	1355.38	1	1	8.52	72.67	27.97
TM-02	32485	12/9/1993	604077.6	3471921.0	1	1363.72	1355.38	1	1	8.34	69.58	27.37
TM-02	33215	12/9/1995	604077.6	3471921.0	1	1360.74	1355.38	1	1	5.37	28.79	17.60
TM-02	33580	12/8/1996	604077.6	3471921.0	1	1360.13	1355.38	1	1	4.75	22.61	15.60
TM-02	33945	12/8/1997	604077.6	3471921.0	1	1359.44	1355.38	1	1	4.06	16.50	13.33
TM-02	34310	12/8/1998	604077.6	3471921.0	1	1359.39	1355.38	1	1	4.01	16.10	13.16
TM-02	34675	12/8/1999	604077.6	3471921.0	1	1359.89	1355.38	1	1	4.52	20.40	14.82
TM-02	35040	12/7/2000	604077.6	3471921.0	1	1359.63	1355.38	1	1	4.26	18.13	13.97
TM-02	35405	12/7/2001	604077.6	3471921.0	1	1359.45	1355.38	1	1	4.07	16.57	13.36
TM-02	35770	12/7/2002	604077.6	3471921.0	1	1359.29	1355.38	1	1	3.91	15.33	12.84
TM-02	36135	12/7/2003	604077.6	3471921.0	1	1359.10	1355.38	1	1	3.72	13.87	12.22
TM-02	36500	12/6/2004	604077.6	3471921.0	1	1358.81	1355.38	1	1	3.43	11.80	11.27
TM-02	36865	12/6/2005	604077.6	3471921.0	1	1358.45	1355.38	1	1	3.07	9.45	10.09
TM-02A	30660	12/10/1988	604152.1	3472008.8	4	1368.47	1371.48	1	1	-3.01	9.06	-9.88
TM-02A	31025	12/10/1989	604152.1	3472008.8	4	1369.82	1371.42	1	1	-1.60	2.56	-5.25
TM-02A	32120	12/9/1992	604152.1	3472008.8	4	1358.77	1371.38	1	1	-12.61	159.02	-41.37
TM-02A	32485	12/9/1993	604152.1	3472008.8	4	1365.69	1371.36	1	1	-5.68	32.22	-18.62
TM-02A	33215	12/9/1995	604152.1	3472008.8	4	1364.67	1371.34	1	1	-6.67	44.52	-21.89
TM-02A	33580	12/8/1996	604152.1	3472008.8	4	1364.47	1371.33	1	1	-6.86	47.05	-22.51
TM-02A	33945	12/8/1997	604152.1	3472008.8	4	1364.28	1371.33	1	1	-7.05	49.65	-23.12
TM-02A	34310	12/8/1998	604152.1	3472008.8	4	1363.59	1364.40	1	1	-0.81	0.65	-2.65
TM-02A	34675	12/8/1999	604152.1	3472008.8	4	1363.46	1364.28	1	1	-0.83	0.68	-2.71
TM-02A	35040	12/7/2000	604152.1	3472008.8	4	1363.55	1364.16	1	1	-0.61	0.37	-1.99
TM-02A	35405	12/7/2001	604152.1	3472008.8	4	1363.46	1364.09	1	1	-0.63	0.40	-2.08
TM-02A	35770	12/7/2002	604152.1	3472008.8	4	1362.98	1363.91	1	1	-0.93	0.86	-3.05
TM-02A	36135	12/7/2003	604152.1	3472008.8	4	1362.15	1363.87	1	1	-1.72	2.96	-5.65
TM-02A	36500	12/6/2004	604152.1	3472008.8	4	1361.23	1363.83	1	1	-2.60	6.76	-8.53
TM-02A	36865	12/6/2005	604152.1	3472008.8	4	1360.61	1363.78	1	1	-3.16	10.02	-10.38
TM-02A	37230	12/6/2006	604152.1	3472008.8	4	1360.21	1363.75	1	1	-3.54	12.51	-11.60
TM-02A	37595	12/6/2007	604152.1	3472008.8	4	1359.96	1363.73	1	1	-3.77	14.23	-12.37
TM-02A	37960	12/5/2008	604152.1	3472008.8	4	1358.98	1363.69	1	1	-4.71	22.18	-15.45
TM-04	30295	12/11/1987	606104.5	3471539.0	4	1426.46	1422.54	0.1	1	3.92	15.39	12.87
TM-04	30660	12/10/1988	606104.5	3471539.0	4	1426.14	1422.48	0.1	1	3.66	13.38	12.00
TM-04	31025	12/10/1989	606104.5	3471539.0	4	1426.34	1422.47	0.1	1	3.88	15.02	12.71
TM-05(MILLER)	30295	12/11/1987	603999.4	3467185.3	1	1361.03	1361.82	1	1	-0.79	0.63	-2.60
TM-05(MILLER)	30660	12/10/1988	603999.4	3467185.3	1	1360.90	1361.74	1	1	-0.84	0.70	-2.74
TM-05(MILLER)	31025	12/10/1989	603999.4	3467185.3	1	1360.68	1361.65	1	1	-0.97	0.95	-3.19
TM-05(MILLER)	33215	12/9/1995	603999.4	3467185.3	1	1356.09	1361.21	1	1	-5.11	26.16	-16.78
TM-05(MILLER)	33580	12/8/1996	603999.4	3467185.3	1	1355.68	1361.16	1	1	-5.47	29.97	-17.96
TM-05(MILLER)	33945	12/8/1997	603999.4	3467185.3	1	1355.11	1361.11	1	1	-6.00	35.98	-19.68
TM-05(MILLER)	34310	12/8/1998	603999.4	3467185.3	1	1355.29	1361.05	1	1	-5.75	33.10	-18.88
TM-05(MILLER)	34675	12/8/1999	603999.4	3467185.3	1	1356.00	1360.98	1	1	-4.98	24.78	-16.33
TM-06(MILLER)	30295	12/11/1987	606124.4	3468324.0	3	1384.96	1386.76	1	1	-1.80	3.24	-5.91
TM-06(MILLER)	30660	12/10/1988	606124.4	3468324.0	3	1385.15	1386.63	1	1	-1.48	2.19	-4.86
TM-06(MILLER)	31025	12/10/1989	606124.4	3468324.0	3	1386.93	1386.51	1	1	0.41	0.17	1.36

Table 27
Simulated and Measured Target Values for Transient Flow Simulation

Well Name	Time	Date	X	Y	Layer	Observed Water Elevation (meters)	Computed Water Elevation (meters)	Weight	Group	Residual (meters)	Residual Squared (meters ^{2})	Residual (feet)
TM-06(MILLER)	33215	12/9/1995	606124.4	3468324.0	3	1384.70	1385.97	1	1	-1.27	1.60	-4.16
TM-06(MILLER)	33580	12/8/1996	606124.4	3468324.0	3	1384.69	1385.92	1	1	-1.23	1.51	-4.04
TM-06(MILLER)	33945	12/8/1997	606124.4	3468324.0	3	1386.03	1385.89	1	1	0.14	0.02	0.45
TM-06(MILLER)	34310	12/8/1998	606124.4	3468324.0	3	1386.68	1385.09	1	1	1.59	2.53	5.22
TM-06(MILLER)	34675	12/8/1999	606124.4	3468324.0	3	1386.71	1384.98	1	1	1.73	3.00	5.68
TM-06(MILLER)	35040	12/7/2000	606124.4	3468324.0	3	1386.72	1384.79	1	1	1.93	3.74	6.34
TM-06(MILLER)	35405	12/7/2001	606124.4	3468324.0	3	1386.73	1384.67	1	1	2.05	4.22	6.74
TM-06(MILLER)	35770	12/7/2002	606124.4	3468324.0	3	1386.70	1384.47	1	1	2.23	4.98	7.32
TM-06(MILLER)	36500	12/6/2004	606124.4	3468324.0	3	1402.73	1384.28	0.01	1	18.45	340.54	60.54
TM-06(MILLER)	36865	12/6/2005	606124.4	3468324.0	3	1386.57	1384.18	1	1	2.39	5.72	7.85
TM-06(MILLER)	37230	12/6/2006	606124.4	3468324.0	3	1386.57	1384.12	1	1	2.46	6.05	8.07
TM-06(MILLER)	37595	12/6/2007	606124.4	3468324.0	3	1386.57	1384.07	1	1	2.49	6.22	8.18
TM-06(MILLER)	37960	12/5/2008	606124.4	3468324.0	3	1386.56	1383.96	1	1	2.60	6.76	8.53
TM-07	30295	12/11/1987	603072.9	3471909.0	3	1368.40	1368.47	1	1	-0.08	0.01	-0.25
TM-07	30660	12/10/1988	603072.9	3471909.0	3	1368.92	1368.23	1	1	0.68	0.47	2.24
TM-07	31025	12/10/1989	603072.9	3471909.0	3	1367.74	1368.09	1	1	-0.36	0.13	-1.17
TM-07	31390	12/10/1990	603072.9	3471909.0	3	1365.43	1368.00	1	1	-2.57	6.62	-8.44
TM-07	31755	12/10/1991	603072.9	3471909.0	3	1363.99	1367.94	1	1	-3.94	15.54	-12.93
TM-07	32120	12/9/1992	603072.9	3471909.0	3	1362.49	1367.87	1	1	-5.38	28.94	-17.65
TM-07	32485	12/9/1993	603072.9	3471909.0	3	1361.58	1367.80	1	1	-6.22	38.74	-20.42
TM-07	32850	12/9/1994	603072.9	3471909.0	3	1360.52	1367.74	1	1	-7.22	52.14	-23.69
TM-07	33215	12/9/1995	603072.9	3471909.0	3	1359.28	1367.69	1	1	-8.41	70.77	-27.60
TM-07	33580	12/8/1996	603072.9	3471909.0	3	1358.67	1367.66	1	1	-8.98	80.70	-29.47
TM-07	33945	12/8/1997	603072.9	3471909.0	3	1357.88	1367.64	1	1	-9.75	95.15	-32.00
TM-07	34310	12/8/1998	603072.9	3471909.0	3	1357.60	1363.36	1	1	-5.77	33.25	-18.92
TM-07	34675	12/8/1999	603072.9	3471909.0	3	1357.70	1362.68	1	1	-4.97	24.74	-16.32
TM-07	35040	12/7/2000	603072.9	3471909.0	3	1357.06	1362.14	1	1	-5.08	25.85	-16.68
TM-07	35405	12/7/2001	603072.9	3471909.0	3	1356.24	1361.83	1	1	-5.60	31.31	-18.36
TM-08(SWAN)	30660	12/10/1988	607787.0	3470666.8	4	1257.82	1411.13	0.01	1	***-153.31***	23505.43	***-503.00***
TM-08(SWAN)	31025	12/10/1989	607787.0	3470666.8	4	1259.80	1411.12	0.01	1	***-151.32***	22898.08	***-496.46***
TM-10(USBP)	30295	12/11/1987	601666.4	3471898.0	3	1369.23	1361.03	1	1	8.20	67.26	26.91
TM-10(USBP)	30660	12/10/1988	601666.4	3471898.0	3	1366.06	1360.87	1	1	5.19	26.91	17.02
TM-10(USBP)	31025	12/10/1989	601666.4	3471898.0	3	1365.50	1360.79	1	1	4.71	22.18	15.45
TM-10(USBP)	32485	12/9/1993	601666.4	3471898.0	3	1362.77	1360.61	1	1	2.16	4.65	7.07
TM-10(USBP)	33215	12/9/1995	601666.4	3471898.0	3	1360.97	1360.54	1	1	0.43	0.19	1.42
TM-11(ANDERSON)	30295	12/11/1987	600892.3	3468876.0	1	1359.72	1356.79	1	1	2.94	8.64	9.64
TM-11(ANDERSON)	30660	12/10/1988	600892.3	3468876.0	1	1359.22	1356.64	1	1	2.58	6.68	8.48
TM-11(ANDERSON)	31025	12/10/1989	600892.3	3468876.0	1	1359.45	1356.50	1	1	2.96	8.75	9.70
TM-12(MILLER)	30295	12/11/1987	601576.8	3467164.3	1	1360.01	1357.73	1	1	2.28	5.22	7.49
TM-12(MILLER)	30660	12/10/1988	601576.8	3467164.3	1	1359.59	1357.62	1	1	1.97	3.88	6.46
TM-12(MILLER)	31025	12/10/1989	601576.8	3467164.3	1	1358.80	1357.51	1	1	1.29	1.66	4.23
TM-12(MILLER)	33215	12/9/1995	601576.8	3467164.3	1	1354.27	1357.00	1	1	-2.73	7.47	-8.97
TM-12(MILLER)	33580	12/8/1996	601576.8	3467164.3	1	1354.06	1356.96	1	1	-2.90	8.40	-9.51
TM-12(MILLER)	33945	12/8/1997	601576.8	3467164.3	1	1353.71	1356.93	1	1	-3.22	10.37	-10.57
TM-13(MILLER)	30295	12/11/1987	601283.9	3469891.0	1	1359.84	1358.85	1	1	0.99	0.98	3.25
TM-13(MILLER)	30660	12/10/1988	601283.9	3469891.0	1	1359.46	1358.66	1	1	0.80	0.63	2.61
TM-13(MILLER)	31025	12/10/1989	601283.9	3469891.0	1	1359.41	1358.48	1	1	0.93	0.87	3.05
TM-13(MILLER)	32485	12/9/1993	601283.9	3469891.0	1	1355.06	1357.94	1	1	-2.88	8.29	-9.44
TM-13(MILLER)	35040	12/7/2000	601283.9	3469891.0	1	1355.54	1356.75	1	1	-1.21	1.47	-3.98
TM-14(NELSON)	37595	12/6/2007	599624.3	3470111.6	1	1350.78	1351.09	1	1	-0.31	0.10	-1.03
TM-14(NELSON)	37960	12/5/2008	599624.3	3470111.6	1	1351.00	1351.00	1	1	0.00	0.00	0.01
TM-14(PRESSLEY)	30295	12/11/1987	599687.6	3470076.0	1	1362.92	1353.55	1	1	9.37	87.79	30.74
TM-14(PRESSLEY)	30660	12/10/1988	599687.6	3470076.0	1	1362.32	1353.43	1	1	8.89	79.01	29.16
TM-14(PRESSLEY)	31025	12/10/1989	599687.6	3470076.0	1	1360.09	1353.32	1	1	6.77	45.78	22.20
TM-15(MILLER)	30295	12/11/1987	599617.3	3471427.5	3	1359.52	1354.26	1	1	5.27	27.73	17.28
TM-15(MILLER)	30660	12/10/1988	599617.3	3471427.5	3	1359.40	1354.15	1	1	5.24	27.49	17.20
TM-15(MILLER)	31025	12/10/1989	599617.3	3471427.5	3	1359.95	1354.11	1	1	5.85	34.18	19.18
TM-15(MILLER)	33215	12/9/1995	599617.3	3471427.5	3	1354.97	1353.97	1	1	1.00	1.00	3.28
TM-15(MILLER)	34310	12/8/1998	599617.3	3471427.5	3	1354.64	1353.18	1	1	1.46	2.14	4.79
TM-15(MILLER)	34675	12/8/1999	599617.3	3471427.5	3	1354.24	1353.08	1	1	1.16	1.36	3.82
TM-15(MILLER)	35405	12/7/2001	599617.3	3471427.5	3	1353.52	1352.87	1	1	0.66	0.43	2.16
TM-15(MILLER)	36500	12/6/2004	599617.3	3471427.5	3	1397.34	1352.44	0.01	1	44.91	2016.67	147.33
TM-15(MILLER)	36865	12/6/2005	599617.3	3471427.5	3	1351.61	1352.35	1	1	-0.74	0.55	-2.43
TM-15(MILLER)	37230	12/6/2006	599617.3	3471427.5	3	1351.56	1352.24	1	1	-0.68	0.46	-2.23
TM-15(MILLER)	37595	12/6/2007	599617.3	3471427.5	3	1351.59	1352.19	1	1	-0.60	0.36	-1.96
TM-16	30295	12/11/1987	606056.0	3468376.7	3	1412.02	1386.76	0.01	1	25.26	638.25	82.89
TM-16	30660	12/10/1988	606056.0	3468376.7	3	1412.71	1386.63	0.01	1	26.09	680.43	85.58
TM-16	31025	12/10/1989	606056.0	3468376.7	3	1412.20	1386.50	0.01	1	25.69	660.19	84.30
TM-16	31390	12/10/1990	606056.0	3468376.7	3	1411.95	1386.41	0.01	1	25.53	652.03	83.78
TM-16	31755	12/10/1991	606056.0	3468376.7	3	1411.47	1386.34	0.01	1	25.13	631.41	82.44
TM-16	32120	12/9/1992	606056.0	3468376.7	3	1410.91	1386.25	0.01	1	24.66	607.91	80.89
TM-16	32485	12/9/1993	606056.0	3468376.7	3	1410.59	1386.14	0.01	1	24.45	597.88	80.22
TM-16	32850	12/9/1994	606056.0	3468376.7	3	1410.45	1386.04	0.01	1	24.42	596.23	80.11
TM-16	33215	12/9/1995	606056.0	3468376.7	3	1410.47	1385.96	0.01	1	24.51	600.88	80.42
TM-16	33580	12/8/1996	606056.0	3468376.7	3	1410.64	1385.91	0.01	1	24.74	611.93	81.16
TM-16	33945	12/8/1997	606056.0	3468376.7	3	1412.20	1385.88	0.01	1	26.32	692.80	86.36
TM-16	34310	12/8/1998	606056.0	3468376.7	3	1413.35	1385.06	0.01	1	28.30	800.74	92.84
TM-16	34675	12/8/1999	606056.0	3468376.7	3	1414.14	1384.94	0.01	1	29.20	852.49	95.79
TM-16	35040	12/7/2000	606056.0	3468376.7	3	1414.62	1384.75	0.01	1	29.87	892.43	98.01
TM-16	35405	12/7/2001	606056.0	3468376.7	3	1414.68	1384.63	0.01	1	30.04	902.67	98.57
TM-16	35770	12/7/2002	606056.0	3468376.7	3	1414.35	1384.43	0.01	1	29.92	895.29	98.17
TM-16	36135	12/7/2003	606056.0	3468376.7	3	1413.91	1384.34	0.01	1	29.57	874.66	97.03
TM-16	36500	12/6/2004	606056.0	3468376.7	3	1413.67	1384.23	0.01	1	29.44	866.67	96.59
TM-16	36865	12/6/2005	606056.0	3468376.7	3	1413.66	1384.13	0.01	1	29.53	871.99	96.88
TM-16	37230	12/6/2006	606056.0	3468376.7	3	1413.33	1384.06	0.01	1	29.26	856.20	96.00
TM-16	37595	12/6/2007	606056.0	3468376.7	3	1413.27	1384.02	0.01	1	29.25	855.55	95.96
TM-16	37960	12/5/2008	606056.0	3468376.7	3	1413.12	1383.90	0.01	1	29.21	853.50	95.85
TM-17	30295	12/11/1987	603914.7	3468504.0	3	1361.96	1366.15	1	1	-4.19	17.59	-13.76
TM-17	30660	12/10/1988	603914.7	3468504.0	3	1361.66	1365.98	1	1	-4.32	18.65	-14.17

Table 27
Simulated and Measured Target Values for Transient Flow Simulation

Well Name	Time	Date	X	Y	Layer	Observed Water Elevation (meters)	Computed Water Elevation (meters)	Weight	Group	Residual (meters)	Residual Squared (meters ^{2})	Residual (feet)
TM-17	31025	12/10/1989	603914.7	3468504.0	3	1362.01	1365.88	1	1	-3.88	15.02	-12.72
TM-17	32485	12/9/1993	603914.7	3468504.0	3	1357.91	1365.69	1	1	-7.78	60.60	-25.54
TM-19	30660	12/10/1988	602458.7	3469189.8	3	1362.58	1361.40	1	1	1.17	1.38	3.85
TM-19	31025	12/10/1989	602458.7	3469189.8	3	1361.43	1361.34	1	1	0.09	0.01	0.31
TM-19	31390	12/10/1990	602458.7	3469189.8	3	1360.13	1361.30	1	1	-1.17	1.37	-3.84
TM-19	31755	12/10/1991	602458.7	3469189.8	3	1359.38	1361.28	1	1	-1.90	3.60	-6.23
TM-19	32120	12/9/1992	602458.7	3469189.8	3	1358.13	1361.25	1	1	-3.12	9.75	-10.25
TM-19	32485	12/9/1993	602458.7	3469189.8	3	1357.53	1361.21	1	1	-3.68	13.52	-12.06
TM-19	32850	12/9/1994	602458.7	3469189.8	3	1356.66	1361.18	1	1	-4.51	20.35	-14.80
TM-19	33215	12/9/1995	602458.7	3469189.8	3	1355.64	1361.15	1	1	-5.51	30.41	-18.09
TM-19	36500	12/6/2004	602458.7	3469189.8	3	1350.10	1359.10	1	1	-9.00	80.94	-29.52
TM-19	36865	12/6/2005	602458.7	3469189.8	3	1350.35	1359.00	1	1	-8.65	74.75	-28.37
TM-19	37230	12/6/2006	602458.7	3469189.8	3	1349.85	1358.91	1	1	-9.06	82.02	-29.71
TM-19A	30660	12/10/1988	602523.7	3469075.7	2	1366.98	1359.46	1	1	7.51	56.47	24.65
TM-19A	31025	12/10/1989	602523.7	3469075.7	2	1367.96	1359.28	1	1	8.67	75.25	28.46
TM-19A	32485	12/9/1993	602523.7	3469075.7	2	1361.85	1358.74	1	1	3.12	9.71	10.23
TM-19A	33215	12/9/1995	602523.7	3469075.7	2	1359.67	1358.54	1	1	1.13	1.29	3.72
TM-19A	33580	12/8/1996	602523.7	3469075.7	2	1359.20	1358.48	1	1	0.73	0.53	2.38
TM-19A	34310	12/8/1998	602523.7	3469075.7	2	1359.67	1358.22	1	1	1.44	2.08	4.73
TM-19A	34675	12/8/1999	602523.7	3469075.7	2	1359.01	1357.82	1	1	1.18	1.40	3.88
TM-19A	35040	12/7/2000	602523.7	3469075.7	2	1358.46	1357.40	1	1	1.06	1.12	3.47
TM-19A	35405	12/7/2001	602523.7	3469075.7	2	1357.77	1357.03	1	1	0.75	0.56	2.45
TM-19A	35770	12/7/2002	602523.7	3469075.7	2	1357.35	1356.66	1	1	0.69	0.48	2.28
TM-19A	36135	12/7/2003	602523.7	3469075.7	2	1356.75	1356.33	1	1	0.43	0.18	1.40
TM-19A	36500	12/6/2004	602523.7	3469075.7	2	1356.34	1356.02	1	1	0.32	0.11	1.07
TM-19A	37230	12/6/2006	602523.7	3469075.7	2	1355.39	1355.45	1	1	-0.06	0.00	-0.19
TM-19A	37595	12/6/2007	602523.7	3469075.7	2	1355.15	1355.24	1	1	-0.09	0.01	-0.30
TM-19A	37960	12/5/2008	602523.7	3469075.7	2	1355.29	1355.04	1	1	0.25	0.06	0.81
TM-27	30660	12/10/1988	603668.6	3472719.0	3	1382.51	1375.67	1	1	6.84	46.76	22.44
TM-27	31025	12/10/1989	603668.6	3472719.0	3	1382.56	1375.49	1	1	7.07	50.02	23.20
TM-28	30660	12/10/1988	606097.7	3472542.0	4	1447.75	1433.57	0.01	1	14.18	201.06	46.52
TM-28	31025	12/10/1989	606097.7	3472542.0	4	1447.57	1433.56	0.01	1	14.01	196.39	45.98
TM-29	30660	12/10/1988	604891.4	3471328.0	3	1423.47	1388.95	0.01	1	34.52	1191.62	113.25
TM-29	31025	12/10/1989	604891.4	3471328.0	3	1423.25	1388.11	0.01	1	35.14	1234.69	115.28
TM-29A	30660	12/10/1988	604891.4	3471328.0	3	1424.01	1388.95	0.01	1	35.06	1229.29	115.03
TM-29B	30660	12/10/1988	604891.4	3471328.0	3	1424.01	1388.95	0.01	1	35.06	1229.29	115.03
TM-30	30660	12/10/1988	602500.4	3469496.0	1	1364.03	1360.03	1	1	4.00	16.00	13.12
TM-30A	30660	12/10/1988	602500.4	3469496.0	1	1364.30	1360.03	1	1	4.28	18.29	14.03
TM-30A	31025	12/10/1989	602500.4	3469496.0	1	1364.17	1359.83	1	1	4.34	18.81	14.23
TM-30B	30660	12/10/1988	602500.4	3469496.0	3	1363.05	1361.71	1	1	1.34	1.79	4.39
TM-30B	31025	12/10/1989	602500.4	3469496.0	3	1362.65	1361.64	1	1	1.01	1.02	3.31
TM-35	30660	12/10/1988	607285.8	3473348.0	4	1413.78	1448.24	0.1	1	-34.46	1187.30	-113.05
TM-35	31025	12/10/1989	607285.8	3473348.0	4	1413.75	1448.23	0.1	1	-34.48	1189.16	-113.14
TM-37	30660	12/10/1988	602890.9	3470303.0	1	1364.02	1362.26	1	1	1.76	3.09	5.77
TM-37	31025	12/10/1989	602890.9	3470303.0	1	1365.08	1362.03	1	1	3.05	9.30	10.00
TM-38	30660	12/10/1988	603502.4	3469707.0	1	1365.23	1362.06	1	1	3.16	10.00	10.37
TM-38	31025	12/10/1989	603502.4	3469707.0	1	1365.27	1361.84	1	1	3.43	11.77	11.26
TM-39	30660	12/10/1988	604709.7	3469520.0	3	1375.89	1386.72	1	1	-10.83	117.37	-35.54
TM-39	31025	12/10/1989	604709.7	3469520.0	3	1375.45	1386.50	1	1	-11.05	122.08	-36.25
TM-41	33580	12/8/1996	604839.6	3471299.4	3	1406.48	1385.90	0.01	1	20.58	423.51	67.52
TM-41	33945	12/8/1997	604839.6	3471299.4	3	1405.01	1385.80	0.01	1	19.21	368.91	63.02
TM-41	34310	12/8/1998	604839.6	3471299.4	3	1403.74	1376.37	0.01	1	27.37	749.10	89.80
TM-41	34675	12/8/1999	604839.6	3471299.4	3	1403.62	1373.55	0.01	1	30.08	904.53	98.67
TM-41	35040	12/7/2000	604839.6	3471299.4	3	1405.15	1372.09	0.01	1	33.06	1093.28	108.48
TM-41	35405	12/7/2001	604839.6	3471299.4	3	1404.77	1371.20	0.01	1	33.57	1126.78	110.13
TM-41	35770	12/7/2002	604839.6	3471299.4	3	1402.53	1370.51	0.01	1	32.03	1025.62	105.07
TM-41	36135	12/7/2003	604839.6	3471299.4	3	1399.22	1370.03	0.01	1	29.18	851.72	95.75
TM-41	36500	12/6/2004	604839.6	3471299.4	3	1397.75	1369.66	0.01	1	28.08	788.73	92.14
TM-41	36865	12/6/2005	604839.6	3471299.4	3	1396.88	1369.35	0.01	1	27.53	758.09	90.33
TM-42	33580	12/8/1996	603698.3	3469104.9	3	1363.26	1367.77	1	1	-4.51	20.34	-14.80
TM-42	33945	12/8/1997	603698.3	3469104.9	3	1362.93	1367.73	1	1	-4.80	23.05	-15.75
TM-42	34310	12/8/1998	603698.3	3469104.9	3	1363.00	1365.68	1	1	-2.69	7.22	-8.81
TM-42	34675	12/8/1999	603698.3	3469104.9	3	1361.99	1365.37	1	1	-3.39	11.48	-11.12
TM-42	35040	12/7/2000	603698.3	3469104.9	3	1361.43	1365.04	1	1	-3.61	13.06	-11.86
TM-42	35405	12/7/2001	603698.3	3469104.9	3	1360.71	1364.85	1	1	-4.14	17.12	-13.57
TM-42	35770	12/7/2002	603698.3	3469104.9	3	1360.24	1364.58	1	1	-4.34	18.83	-14.24
TM-42	36135	12/7/2003	603698.3	3469104.9	3	1359.70	1364.44	1	1	-4.73	22.40	-15.53
TM-42	36500	12/6/2004	603698.3	3469104.9	3	1359.34	1364.27	1	1	-4.93	24.28	-16.17
TM-42	36865	12/6/2005	603698.3	3469104.9	3	1358.80	1364.12	1	1	-5.32	28.29	-17.45
TM-42	37230	12/6/2006	603698.3	3469104.9	3	1358.36	1364.01	1	1	-5.64	31.85	-18.52
TM-42	37595	12/6/2007	603698.3	3469104.9	3	1358.08	1363.93	1	1	-5.85	34.22	-19.19
TM-42	37960	12/5/2008	603698.3	3469104.9	3	1358.44	1363.78	1	1	-5.35	28.60	-17.55
UN01(NS-1)	37960	12/5/2008	599993.6	3466349.0	1	1349.06	1353.40	1	1	-4.34	18.81	-14.23
UN05(NS-5)	37960	12/5/2008	602139.9	3466050.6	1	1364.75	1353.88	1	1	10.87	118.07	35.65

-153.31	Residual is greater than 2 standard deviations from the residual mean
	Wells used in model calibration

Table 28
Simulated and Measured Target Values for Transport Simulation

Name	Time	Date	X	Y	Layer	Observed	Computed	Weight	Group	Residual (mg/l)	Residual Squared
ANDERSON	37595	12/6/2007	601134.73	3468816.06	1	431.00	501.91	1	1	-70.91	5028.52
ANDERSON	37960	12/5/2008	601134.73	3468816.06	1	462.00	511.70	1	1	-49.70	2469.99
AWC-02	32850	12/9/1994	598890.64	3468565.91	1	15.10	9.76	1	1	5.34	28.55
AWC-02	33215	12/9/1995	598890.64	3468565.91	1	19.40	9.89	1	1	9.51	90.39
AWC-02	34675	12/8/1999	598890.64	3468565.91	1	6.68	10.33	1	1	-3.65	13.32
AWC-02	35040	12/7/2000	598890.64	3468565.91	1	7.03	10.58	1	1	-3.55	12.60
AWC-02	35405	12/7/2001	598890.64	3468565.91	1	6.75	10.76	1	1	-4.01	16.11
AWC-02	35770	12/7/2002	598890.64	3468565.91	1	7.34	10.86	1	1	-3.51	12.35
AWC-02	36135	12/7/2003	598890.64	3468565.91	1	7.98	10.98	1	1	-3.01	9.04
AWC-02	36500	12/6/2004	598890.64	3468565.91	1	12.57	11.05	1	1	1.53	2.33
AWC-02	36865	12/6/2005	598890.64	3468565.91	1	12.72	11.17	1	1	1.55	2.40
AWC-02	37230	12/6/2006	598890.64	3468565.91	1	10.39	11.33	1	1	-0.95	0.90
AWC-02	37595	12/6/2007	598890.64	3468565.91	1	14.00	11.59	1	1	2.41	5.78
AWC-02	37960	12/5/2008	598890.64	3468565.91	1	14.30	11.82	1	1	2.48	6.17
AWC-03	32485	12/9/1993	599016.36	3468659.58	1	22.50	14.57	1	1	7.93	62.87
AWC-03	34675	12/8/1999	599016.36	3468659.58	1	24.32	16.95	1	1	7.37	54.32
AWC-03	35040	12/7/2000	599016.36	3468659.58	1	19.90	17.74	1	1	2.16	4.65
AWC-03	35405	12/7/2001	599016.36	3468659.58	1	23.50	18.26	1	1	5.24	27.46
AWC-03	35770	12/7/2002	599016.36	3468659.58	1	27.54	18.54	1	1	9.00	81.01
AWC-03	36135	12/7/2003	599016.36	3468659.58	1	30.26	19.00	1	1	11.25	126.61
AWC-03	36500	12/6/2004	599016.36	3468659.58	1	34.09	19.26	1	1	14.82	219.74
AWC-03	36865	12/6/2005	599016.36	3468659.58	1	36.52	19.82	1	1	16.70	278.74
AWC-03	37230	12/6/2006	599016.36	3468659.58	1	40.59	20.58	1	1	20.00	400.19
AWC-03	37595	12/6/2007	599016.36	3468659.58	1	26.50	21.41	1	1	5.09	25.91
AWC-03	37960	12/5/2008	599016.36	3468659.58	1	38.80	22.12	1	1	16.68	278.14
AWC-04	31390	12/10/1990	598999.71	3468695.17	1	20.00	14.36	1	1	5.64	31.81
AWC-04	34310	12/8/1998	598999.71	3468695.17	1	19.00	17.96	1	1	1.04	1.09
AWC-04	34675	12/8/1999	598999.71	3468695.17	1	22.00	18.37	1	1	3.63	13.15
AWC-04	35040	12/7/2000	598999.71	3468695.17	1	23.30	19.15	1	1	4.15	17.25
AWC-04	35405	12/7/2001	598999.71	3468695.17	1	25.03	19.70	1	1	5.33	28.43
AWC-04	35770	12/7/2002	598999.71	3468695.17	1	30.90	20.08	1	1	10.82	116.97
AWC-04	37960	12/5/2008	598999.71	3468695.17	1	18.80	23.73	1	1	-4.93	24.33
AWC-05	35405	12/7/2001	599277.56	3468526.31	2	9.60	8.10	1	1	1.50	2.24
AWC-05	36135	12/7/2003	599277.56	3468526.31	2	10.40	8.12	1	1	2.28	5.19
AWC-05	36500	12/6/2004	599277.56	3468526.31	2	16.55	8.13	1	1	8.42	70.85
AWC-05	36865	12/6/2005	599277.56	3468526.31	2	11.08	8.14	1	1	2.94	8.64
AWC-05	37230	12/6/2006	599277.56	3468526.31	2	19.70	8.15	1	1	11.55	133.29
AWC-05	37960	12/5/2008	599277.56	3468526.31	2	14.90	8.18	1	1	6.72	45.13
BANKS986	37595	12/6/2007	606722.70	3469137.00	3	44.00	47.61	1	1	-3.61	13.01
BANKS986	37960	12/5/2008	606722.70	3469137.00	3	73.70	47.34	1	1	26.36	695.06
BF-1	32120	12/9/1992	604169.08	3472151.59	2	1450.00	2717.14	1	1	-1267.14	1605646.31
BF-1	33215	12/9/1995	604169.08	3472151.59	2	1400.00	2717.12	1	1	-1317.12	1734791.92
BF-1	37595	12/6/2007	604169.08	3472151.59	2	1320.00	2505.93	1	1	-1185.93	1406439.45
BF-1	37960	12/5/2008	604169.08	3472151.59	2	1390.00	2494.19	1	1	-1104.19	1219235.56
BF-2	32120	12/9/1992	603479.90	3471513.00	1	1900.00	906.44	1	1	993.56	987162.86
BF-2	33215	12/9/1995	603479.90	3471513.00	1	1640.00	912.39	1	1	727.61	529413.98
BIMA	37595	12/6/2007	606001.24	3471852.80	4	200.00	287.77	1	1	-87.77	7703.10
BIMA	37960	12/5/2008	606001.24	3471852.80	4	220.00	269.83	1	1	-49.83	2483.45
BINYON	37960	12/5/2008	608544.70	3468542.00	4	13.00	8.00	1	1	5.00	25.00
BLOMMER	33215	12/9/1995	601375.70	3470798.00	1	292.00	350.37	1	1	-58.37	3406.90
BLOMMER	37595	12/6/2007	601375.70	3470798.00	1	203.50	334.79	1	1	-131.29	17237.17
BLOMMER	37960	12/5/2008	601375.70	3470798.00	1	199.00	328.33	1	1	-129.33	16725.21
BURKE	37595	12/6/2007	602230.09	3473029.82	4	26.00	8.00	1	1	18.00	324.03
BURKE	37960	12/5/2008	602230.09	3473029.82	4	21.90	8.00	1	1	13.90	193.23
CHAMBERS	37595	12/6/2007	600096.90	3467462.00	1	109.35	8.00	1	1	101.35	10272.39
CHAMBERS	37960	12/5/2008	600096.90	3467462.00	1	5.90	8.00	1	1	-2.10	4.41
COBMW-1	36865	12/6/2005	603153.26	3469889.89	1	1306.67	1598.91	1	1	-292.24	85405.04
COBMW-1	37595	12/6/2007	603153.26	3469889.89	1	720.00	1581.37	1	1	-861.37	741961.03
COBMW-1	37960	12/5/2008	603153.26	3469889.89	1	855.00	1578.30	1	1	-723.30	523162.31
COBMW-2	37595	12/6/2007	600973.26	3468114.84	1	41.00	146.04	1	1	-105.04	11033.21
COBMW-2	37960	12/5/2008	600973.26	3468114.84	1	39.05	146.26	1	1	-107.21	11493.06
COBMW-3	37595	12/6/2007	599292.20	3468660.00	1	57.80	30.27	1	1	27.53	757.85
COBMW-3	37960	12/5/2008	599292.20	3468660.00	1	51.55	31.38	1	1	20.17	406.86
COBWL	37595	12/6/2007	606357.51	3472502.01	4	90.00	8.26	1	1	81.74	6682.10
COBWL	37960	12/5/2008	606357.51	3472502.01	4	97.55	8.33	1	1	89.22	7960.02
COOPER	37595	12/6/2007	602668.40	3472105.00	2	33.00	101.06	1	1	-68.06	4632.61
COOPER	37960	12/5/2008	602668.40	3472105.00	2	33.95	96.14	1	1	-62.19	3867.45
COOPERC	37595	12/6/2007	601349.99	3468913.01	1	935.00	727.15	1	1	207.85	43203.33
COOPERC	37960	12/5/2008	601349.99	3468913.01	1	1015.00	736.85	1	1	278.15	77367.87
DODSON	37595	12/6/2007	605594.56	3469063.77	2	54.00	240.23	1	1	-186.23	34679.97
DODSON	37960	12/5/2008	605594.56	3469063.77	2	41.75	240.15	1	1	-198.40	39364.50
EAST	37595	12/6/2007	607076.36	3468712.21	2	10.60	110.32	1	1	-99.72	9944.04
EAST	37960	12/5/2008	607076.36	3468712.21	2	13.30	109.59	1	1	-96.29	9272.35
EPPELE641	37595	12/6/2007	607165.35	3469229.94	3	21.70	18.07	1	1	3.63	13.14
EPPELE641	37960	12/5/2008	607165.35	3469229.94	3	21.85	17.63	1	1	4.22	17.83
FULTZ	37595	12/6/2007	606924.10	3469139.00	2	141.00	52.53	1	1	88.47	7826.37
FULTZ	37960	12/5/2008	606924.10	3469139.00	2	131.33	49.96	1	1	81.37	6621.70
GALLANT	37595	12/6/2007	607769.64	3468524.36	2	17.90	38.58	1	1	-20.68	427.66
GALLANT	37960	12/5/2008	607769.64	3468524.36	2	20.90	37.93	1	1	-17.03	290.19
GARNER635	37595	12/6/2007	602665.35	3468967.90	2	80.40	51.52	1	1	28.88	833.80
GARNER635	37960	12/5/2008	602665.35	3468967.90	2	36.60	51.61	1	1	-15.01	225.32
GGOOSE547	37960	12/5/2008	606256.66	3469820.26	4	188.50	8.14	1	1	180.36	32530.45
HOBAN	37595	12/6/2007	601705.85	3468880.33	1	510.00	1116.13	1	1	-606.13	367396.61
HOBAN	37960	12/5/2008	601705.85	3468880.33	1	680.00	1120.83	1	1	-440.83	194332.06

Table 28
Simulated and Measured Target Values for Transport Simulation

Name	Time	Date	X	Y	Layer	Observed	Computed	Weight	Group	Residual (mg/l)	Residual Squared
HOWARD	37595	12/6/2007	601281.94	3468768.62	1	571.00	639.21	1	1	-68.21	4652.55
HOWARD	37960	12/5/2008	601281.94	3468768.62	1	641.50	649.00	1	1	-7.50	56.22
KEEFER	37595	12/6/2007	599879.18	3468119.02	1	6.80	23.27	1	1	-16.47	271.26
KEEFER	37960	12/5/2008	599879.18	3468119.02	1	8.50	23.85	1	1	-15.35	235.61
MCCONNELL265	37595	12/6/2007	601463.09	3468840.14	1	720.00	852.80	1	1	-132.80	17636.90
MCCONNELL265	37960	12/5/2008	601463.09	3468840.14	1	720.67	861.37	1	1	-140.70	19797.19
METZLER	37595	12/6/2007	602091.31	3471381.18	2	317.00	11.01	1	1	305.99	93627.25
METZLER	37960	12/5/2008	602091.31	3471381.18	2	323.00	10.93	1	1	312.07	97384.94
MOORE	37595	12/6/2007	599494.90	3468060.00	1	7.10	10.67	1	1	-3.57	12.74
MOORE	37960	12/5/2008	599494.90	3468060.00	1	8.65	10.79	1	1	-2.14	4.58
NESS	37960	12/5/2008	607911.50	3471347.00	4	50.20	8.00	1	1	42.20	1780.87
NOTEMAN	37595	12/6/2007	606053.80	3471576.40	4	310.00	117.48	1	1	192.52	37065.14
NOTEMAN	37960	12/5/2008	606053.80	3471576.40	4	273.00	114.54	1	1	158.46	25110.62
NSD01	33580	12/8/1996	598080.40	3468647.00	1	14.00	8.00	1	1	6.00	36.00
NSD01	35770	12/7/2002	598080.40	3468647.00	1	11.60	8.01	1	1	3.59	12.87
NSD01	36135	12/7/2003	598080.40	3468647.00	1	26.00	8.02	1	1	17.98	323.43
NSD01	36500	12/6/2004	598080.40	3468647.00	1	14.33	8.02	1	1	6.31	39.87
NSD01	36865	12/6/2005	598080.40	3468647.00	1	9.00	8.02	1	1	0.98	0.96
NSD01	37230	12/6/2006	598080.40	3468647.00	1	17.75	8.03	1	1	9.72	94.55
NSD02	33580	12/8/1996	598884.42	3468847.30	1	25.00	17.68	1	1	7.32	53.65
NSD02	35040	12/7/2000	598884.42	3468847.30	1	18.20	19.76	1	1	-1.56	2.45
NSD02	35770	12/7/2002	598884.42	3468847.30	1	34.20	20.85	1	1	13.35	178.33
NSD02	36135	12/7/2003	598884.42	3468847.30	1	16.00	21.38	1	1	-5.38	28.94
NSD02	36500	12/6/2004	598884.42	3468847.30	1	45.00	21.90	1	1	23.10	533.41
NSD02	36865	12/6/2005	598884.42	3468847.30	1	73.00	22.46	1	1	50.54	2554.35
NSD02	37230	12/6/2006	598884.42	3468847.30	1	60.65	23.08	1	1	37.57	1411.56
NSD02	37595	12/6/2007	598884.42	3468847.30	1	43.00	23.76	1	1	19.24	370.24
NSD03	29383	6/11/1985	601148.45	3468342.96	1	71.00	202.97	1	1	-131.97	17415.37
NSD03	33215	12/9/1995	601148.45	3468342.96	1	109.00	386.27	1	1	-277.27	76879.32
NSD03	33580	12/8/1996	601148.45	3468342.96	1	135.00	403.79	1	1	-268.79	72249.62
NSD03	35405	12/7/2001	601148.45	3468342.96	1	215.00	469.15	1	1	-254.15	64593.54
NSD03	36135	12/7/2003	601148.45	3468342.96	1	94.00	491.80	1	1	-397.80	158246.19
NSD03	36500	12/6/2004	601148.45	3468342.96	1	170.98	502.14	1	1	-331.17	109671.05
NSD03	36865	12/6/2005	601148.45	3468342.96	1	39.00	511.69	1	1	-472.69	223439.71
NSD03	37230	12/6/2006	601148.45	3468342.96	1	38.07	519.65	1	1	-481.58	231921.80
NSD03	37595	12/6/2007	601148.45	3468342.96	1	70.70	523.29	1	1	-452.59	204838.79
NWC-02	33215	12/9/1995	600183.34	3467457.31	1	31.33	7.99	1	1	23.35	545.13
NWC-03	33580	12/8/1996	601148.45	3468342.96	1	148.00	403.79	1	1	-255.79	65430.01
NWC-03	35405	12/7/2001	601148.45	3468342.96	1	215.00	469.15	1	1	-254.15	64593.54
NWC-03	36500	12/6/2004	601148.45	3468342.96	1	425.00	502.14	1	1	-77.14	5950.76
NWC-03	36865	12/6/2005	601148.45	3468342.96	1	360.00	511.69	1	1	-151.69	23011.10
NWC-03	37595	12/6/2007	601148.45	3468342.96	1	560.00	523.29	1	1	36.71	1347.54
NWC-03	37960	12/5/2008	601148.45	3468342.96	1	524.00	525.97	1	1	-1.97	3.90
NWC-04	32850	12/9/1994	605836.91	3469074.74	2	219.00	239.51	1	1	-20.51	420.46
NWC-04	33580	12/8/1996	605836.91	3469074.74	2	314.00	239.68	1	1	74.32	5523.58
NWC-04	35405	12/7/2001	605836.91	3469074.74	2	255.00	237.08	1	1	17.92	321.15
NWC-04	36500	12/6/2004	605836.91	3469074.74	2	210.00	233.60	1	1	-23.60	556.95
NWC-04	36865	12/6/2005	605836.91	3469074.74	2	210.00	232.06	1	1	-22.06	486.81
NWC-04	37595	12/6/2007	605836.91	3469074.74	2	240.00	228.54	1	1	11.46	131.41
NWC-04	37960	12/5/2008	605836.91	3469074.74	2	231.00	226.46	1	1	4.54	20.58
NWC-06	34310	12/8/1998	599825.80	3467741.72	1	8.10	8.05	1	1	0.05	0.00
NWC-06	37595	12/6/2007	599825.80	3467741.72	1	7.90	8.09	1	1	-0.19	0.04
NWC-06	37960	12/5/2008	599825.80	3467741.72	1	7.20	8.09	1	1	-0.89	0.80
OSBORN	37595	12/6/2007	607031.82	3470270.55	4	16.40	8.00	1	1	8.40	70.55
OSBORN	37960	12/5/2008	607031.82	3470270.55	4	17.35	8.00	1	1	9.35	87.41
PALMER819	37595	12/6/2007	607724.40	3469545.00	4	15.90	8.00	1	1	7.90	62.41
PALMER819	37960	12/5/2008	607724.40	3469545.00	4	16.40	8.00	1	1	8.40	70.56
PANAGAKOS	37595	12/6/2007	605311.68	3469320.99	2	410.00	237.51	1	1	172.49	29753.15
PANAGAKOS	37960	12/5/2008	605311.68	3469320.99	2	444.00	237.38	1	1	206.62	42690.67
PARRA	37595	12/6/2007	602170.72	3471263.55	2	360.00	25.98	1	1	334.02	111571.16
PARRA	37960	12/5/2008	602170.72	3471263.55	2	404.50	25.82	1	1	378.68	143398.39
PIONKE	37595	12/6/2007	600936.29	3468836.65	1	394.00	366.10	1	1	27.90	778.26
PIONKE	37960	12/5/2008	600936.29	3468836.65	1	421.50	375.26	1	1	46.24	2138.43
POOL	37595	12/6/2007	599683.60	3470013.82	1	134.00	21.63	1	1	112.37	12625.92
POOL	37960	12/5/2008	599683.60	3470013.82	1	119.50	22.37	1	1	97.13	9434.46
POWER	37595	12/6/2007	608379.42	3472738.94	4	15.50	8.00	1	1	7.50	56.26
POWER	37960	12/5/2008	608379.42	3472738.94	4	20.20	8.00	1	1	12.20	148.86
RAMIREZ	37595	12/6/2007	599695.90	3467661.00	1	7.60	8.00	1	1	-0.40	0.16
RAMIREZ	37960	12/5/2008	599695.90	3467661.00	1	8.55	8.00	1	1	0.55	0.30
RAY	37595	12/6/2007	607083.42	3469195.15	2	142.00	26.20	1	1	115.80	13408.55
RAY	37960	12/5/2008	607083.42	3469195.15	2	125.50	24.62	1	1	100.88	10176.31
ROGERS803	37595	12/6/2007	600977.69	3468417.39	1	130.33	403.28	1	1	-272.95	74501.32
ROGERS803	37960	12/5/2008	600977.69	3468417.39	1	133.00	414.02	1	1	-281.02	78973.48
ROGERSE	37595	12/6/2007	599895.40	3468264.00	1	4.60	36.66	1	1	-32.06	1027.53
ROGERSE	37960	12/5/2008	599895.40	3468264.00	1	6.50	37.91	1	1	-31.41	986.29
RUIZ	37595	12/6/2007	602857.36	3471424.22	2	263.00	246.82	1	1	16.18	261.65
RUIZ	37960	12/5/2008	602857.36	3471424.22	2	254.00	239.64	1	1	14.36	206.29
SCHWARTZ	37595	12/6/2007	600811.53	3468268.06	1	140.00	224.83	1	1	-84.83	7196.32
SCHWARTZ	37960	12/5/2008	600811.53	3468268.06	1	158.75	230.32	1	1	-71.57	5122.26
SRC	37595	12/6/2007	599722.47	3472503.26	3	19.00	8.00	1	1	11.00	121.02
SRC	37960	12/5/2008	599722.47	3472503.26	3	15.40	8.00	1	1	7.40	54.78
SWAN	37595	12/6/2007	607378.55	3470648.30	4	21.40	8.00	1	1	13.40	179.55
SWAN	37960	12/5/2008	607378.55	3470648.30	4	121.85	8.00	1	1	113.85	12961.78
TM-01	30660	12/10/1988	604096.20	3470517.00	1	1581.11	883.11	1	1	698.00	487206.65

Table 28
Simulated and Measured Target Values for Transport Simulation

Name	Time	Date	X	Y	Layer	Observed	Computed	Weight	Group	Residual (mg/l)	Residual Squared
TM-01	31025	12/10/1989	604096.20	3470517.00	1	1480.00	897.64	1	1	582.36	339142.12
TM-02	30660	12/10/1988	604077.60	3471921.00	1	2752.00	-1.00	1	1	2753.00	7579009.00
TM-02	31025	12/10/1989	604077.60	3471921.00	1	2750.00	-1.00	1	1	2751.00	7568001.00
TM-02	32120	12/9/1992	604077.60	3471921.00	1	2200.00	-1.00	1	1	2201.00	4844401.00
TM-02	33215	12/9/1995	604077.60	3471921.00	1	959.67	-1.00	1	1	960.67	922880.51
TM-02	33580	12/8/1996	604077.60	3471921.00	1	1250.00	-1.00	1	1	1251.00	1565001.00
TM-02	35405	12/7/2001	604077.60	3471921.00	1	1320.00	-1.00	1	1	1321.00	1745041.00
TM-02A	30660	12/10/1988	604152.06	3472008.79	4	26.56	16.15	1	1	10.41	108.28
TM-02A	31025	12/10/1989	604152.06	3472008.79	4	26.50	16.34	1	1	10.16	103.23
TM-02A	32120	12/9/1992	604152.06	3472008.79	4	20.00	16.94	1	1	3.06	9.36
TM-02A	33215	12/9/1995	604152.06	3472008.79	4	15.00	17.60	1	1	-2.60	6.74
TM-02A	37595	12/6/2007	604152.06	3472008.79	4	12.30	18.53	1	1	-6.23	38.84
TM-02A	37960	12/5/2008	604152.06	3472008.79	4	14.55	18.58	1	1	-4.03	16.22
TM-06(MILLER)	33215	12/9/1995	606124.40	3468324.00	2	29.00	84.35	1	1	-55.35	3063.52
TM-06(MILLER)	37595	12/6/2007	606124.40	3468324.00	2	13.90	89.79	1	1	-75.89	5759.83
TM-06(MILLER)	37960	12/5/2008	606124.40	3468324.00	2	32.00	89.93	1	1	-57.93	3355.76
TM-07	30660	12/10/1988	603072.90	3471909.00	2	460.00	1313.86	1	1	-853.86	729077.58
TM-07	31025	12/10/1989	603072.90	3471909.00	2	456.00	1310.91	1	1	-854.91	730870.60
TM-07	31755	12/10/1991	603072.90	3471909.00	2	313.00	1304.92	1	1	-991.92	983913.82
TM-07	32120	12/9/1992	603072.90	3471909.00	2	317.00	1302.05	1	1	-985.05	970321.14
TM-07	33215	12/9/1995	603072.90	3471909.00	2	310.50	1294.04	1	1	-983.54	967352.90
TM-07	33580	12/8/1996	603072.90	3471909.00	2	294.00	1291.65	1	1	-997.65	995300.53
TM-07	35770	12/7/2002	603072.90	3471909.00	2	219.00	993.50	1	1	-774.50	599853.19
TM-07	37595	12/6/2007	603072.90	3471909.00	2	22.50	761.13	1	1	-738.63	545578.56
TM-07	37960	12/5/2008	603072.90	3471909.00	2	22.55	721.96	1	1	-699.41	489170.57
TM-08(SWAN)	37595	12/6/2007	607787.04	3470666.77	4	12.60	8.00	1	1	4.60	21.16
TM-08(SWAN)	37960	12/5/2008	607787.04	3470666.77	4	12.60	8.00	1	1	4.60	21.16
TM-10(USBP)	30660	12/10/1988	601666.40	3471898.00	2	15.36	8.00	1	1	7.37	54.27
TM-10(USBP)	31025	12/10/1989	601666.40	3471898.00	2	17.00	8.00	1	1	9.00	81.05
TM-11(PIONKE)	30660	12/10/1988	600892.30	3468876.00	1	9.73	160.10	1	1	-150.37	22610.48
TM-11(PIONKE)	31025	12/10/1989	600892.30	3468876.00	1	9.00	168.43	1	1	-159.43	25419.17
TM-14(NELSON)	37595	12/6/2007	599687.60	3470076.00	1	32.90	21.86	1	1	11.04	121.77
TM-15(MILLER)	33215	12/9/1995	599617.33	3471427.50	2	14.00	8.00	1	1	6.00	36.01
TM-15(MILLER)	37595	12/6/2007	599617.33	3471427.50	2	14.00	8.00	1	1	6.00	35.98
TM-15(MILLER)	37960	12/5/2008	599617.33	3471427.50	2	14.05	8.00	1	1	6.05	36.58
TM-16	30660	12/10/1988	606055.97	3468376.66	2	527.09	106.58	1	1	420.51	176828.24
TM-16	31025	12/10/1989	606055.97	3468376.66	2	520.00	107.83	1	1	412.17	169882.05
TM-16	33215	12/9/1995	606055.97	3468376.66	2	485.00	114.04	1	1	370.96	137611.10
TM-16	33580	12/8/1996	606055.97	3468376.66	2	496.67	114.90	1	1	381.76	145743.37
TM-16	37595	12/6/2007	606055.97	3468376.66	2	497.00	120.61	1	1	376.39	141666.27
TM-16	37960	12/5/2008	606055.97	3468376.66	2	494.00	120.85	1	1	373.16	139244.65
TM-19	30660	12/10/1988	602506.40	3469093.00	1	1118.64	1202.89	1	1	-84.26	7098.98
TM-19	31025	12/10/1989	602506.40	3469093.00	1	1120.00	1213.52	1	1	-93.52	8746.18
TM-19	32120	12/9/1992	602506.40	3469093.00	1	1100.00	1245.24	1	1	-145.24	21095.01
TM-19	33215	12/9/1995	602506.40	3469093.00	1	1110.00	1276.11	1	1	-166.11	27591.44
TM-19	33580	12/8/1996	602506.40	3469093.00	1	1140.00	1286.36	1	1	-146.36	21420.75
TM-19A	30660	12/10/1988	602458.71	3469197.43	2	54.91	45.56	1	1	9.34	87.32
TM-19A	31025	12/10/1989	602458.71	3469197.43	2	62.00	46.08	1	1	15.92	253.57
TM-19A	32120	12/9/1992	602458.71	3469197.43	2	63.00	47.53	1	1	15.47	239.31
TM-19A	33215	12/9/1995	602458.71	3469197.43	2	56.00	48.91	1	1	7.09	50.26
TM-19A	37595	12/6/2007	602458.71	3469197.43	2	56.10	52.59	1	1	3.51	12.33
TM-19A	37960	12/5/2008	602458.71	3469197.43	2	59.90	52.75	1	1	7.15	51.11
TM-41	33580	12/8/1996	604839.63	3471305.65	2	1920.00	2221.87	1	1	-301.87	91127.97
TM-42	33580	12/8/1996	603698.27	3469104.90	2	971.50	202.93	1	1	768.57	590702.00
TM-42	37595	12/6/2007	603698.27	3469104.90	2	482.00	202.29	1	1	279.71	78239.03
TM-42	37960	12/5/2008	603698.27	3469104.90	2	475.00	202.15	1	1	272.85	74446.58
TVI236	37595	12/6/2007	600552.22	3467978.43	1	34.83	35.48	1	1	-0.65	0.42
TVI236	37960	12/5/2008	600552.22	3467978.43	1	35.10	35.77	1	1	-0.67	0.45
TVI875	37595	12/6/2007	600693.90	3468471.00	1	244.00	236.92	1	1	7.08	50.14
TVI875	37960	12/5/2008	600693.90	3468471.00	1	262.00	246.71	1	1	15.29	233.77
WALKER	37595	12/6/2007	607564.69	3468577.47	2	20.00	70.39	1	1	-50.39	2539.47
WALKER	37960	12/5/2008	607564.69	3468577.47	2	45.40	69.78	1	1	-24.38	594.24
WEED	37595	12/6/2007	601275.90	3470699.00	1	11.10	343.97	1	1	-332.87	110805.03
WEED	37960	12/5/2008	601275.90	3470699.00	1	12.05	339.94	1	1	-327.89	107511.00
WEISKOPF	37595	12/6/2007	601154.95	3468658.85	1	500.00	495.68	1	1	4.32	18.64
WEISKOPF	37960	12/5/2008	601154.95	3468658.85	1	521.50	505.65	1	1	15.85	251.23
ZANDER	37595	12/6/2007	599678.88	3467998.49	1	5.70	11.18	1	1	-5.48	30.00
ZANDER	37960	12/5/2008	599678.88	3467998.49	1	6.60	11.31	1	1	-4.71	22.15

Table 29
Sensitivity of Hydraulic Conductivity Zones

Percent Change in Sum of Squared Residuals for Variations in Hydraulic Conductivity					
Zone	Multiplier				
	0.5	0.75	1	1.25	2
1	2%	1%	0%	1%	2%
2	0%	0%	0%	0%	0%
3	0%	0%	0%	0%	0%
4	38%	13%	0%	7%	18%
5	146%	44%	0%	23%	53%
6	5%	2%	0%	2%	6%
7	0%	0%	0%	0%	0%
8	2%	1%	0%	1%	3%
9	1%	0%	0%	0%	1%
10	0%	0%	0%	0%	0%
11	0%	0%	0%	0%	0%
12	1%	0%	0%	0%	1%
13	8%	2%	0%	1%	2%

Average Change in Hydraulic Head (feet)					
Zone	Multiplier				
	0.5	0.75	1	1.25	2
1	1.60	1.35	1.19	1.09	0.94
2	1.19	1.19	1.19	1.19	1.19
3	1.24	1.21	1.19	1.18	1.15
4	0.38	0.87	1.19	1.44	1.95
5	0.66	0.98	1.19	1.36	1.74
6	1.21	1.21	1.19	1.19	1.17
7	1.25	1.21	1.19	1.16	1.13
8	1.30	1.24	1.19	1.14	1.04
9	1.03	1.12	1.19	1.26	1.41
10	1.24	1.21	1.19	1.18	1.11
11	1.22	1.21	1.19	1.18	1.14
12	1.39	1.27	1.19	1.12	0.96
13	0.54	0.93	1.19	1.38	1.72

FIGURES

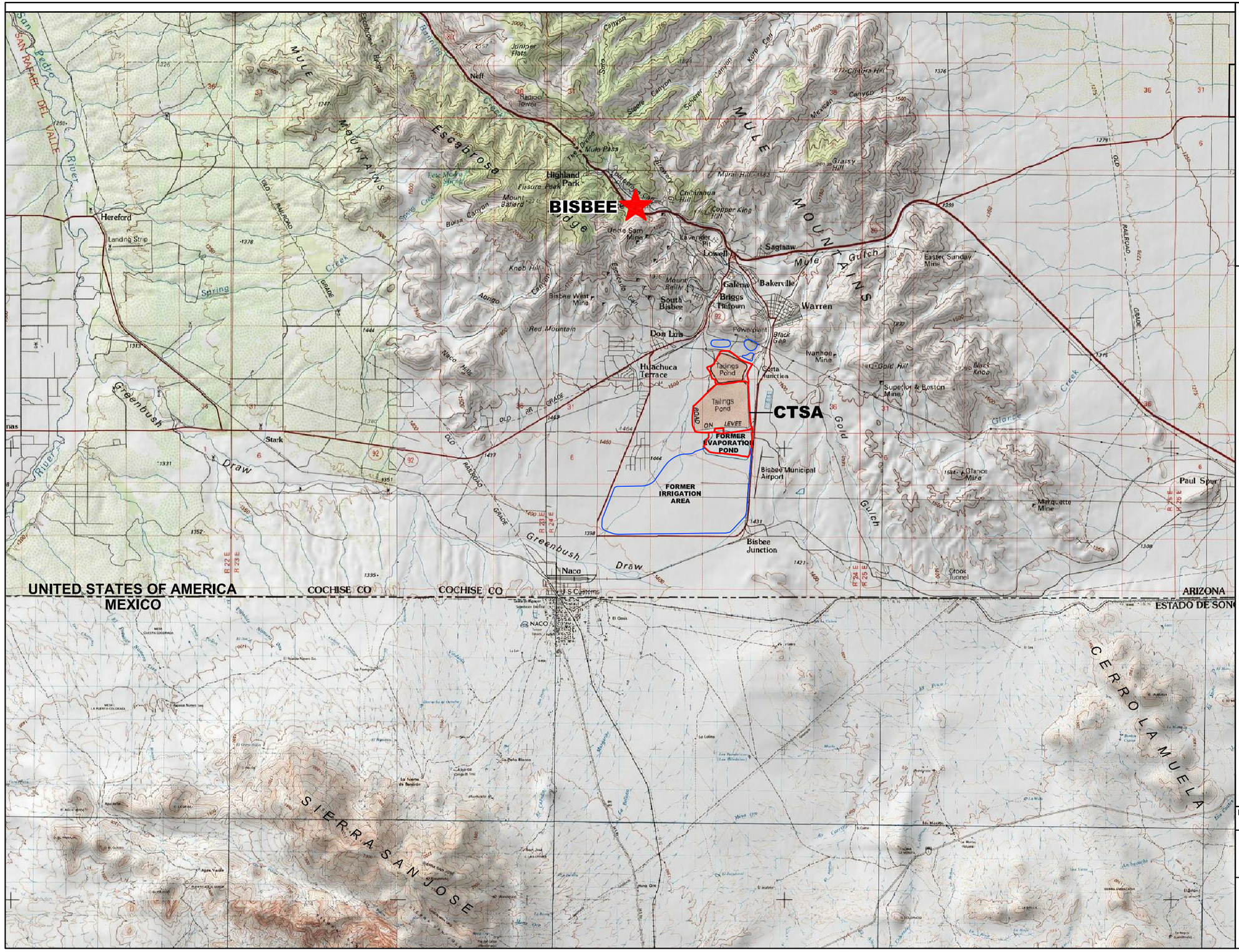
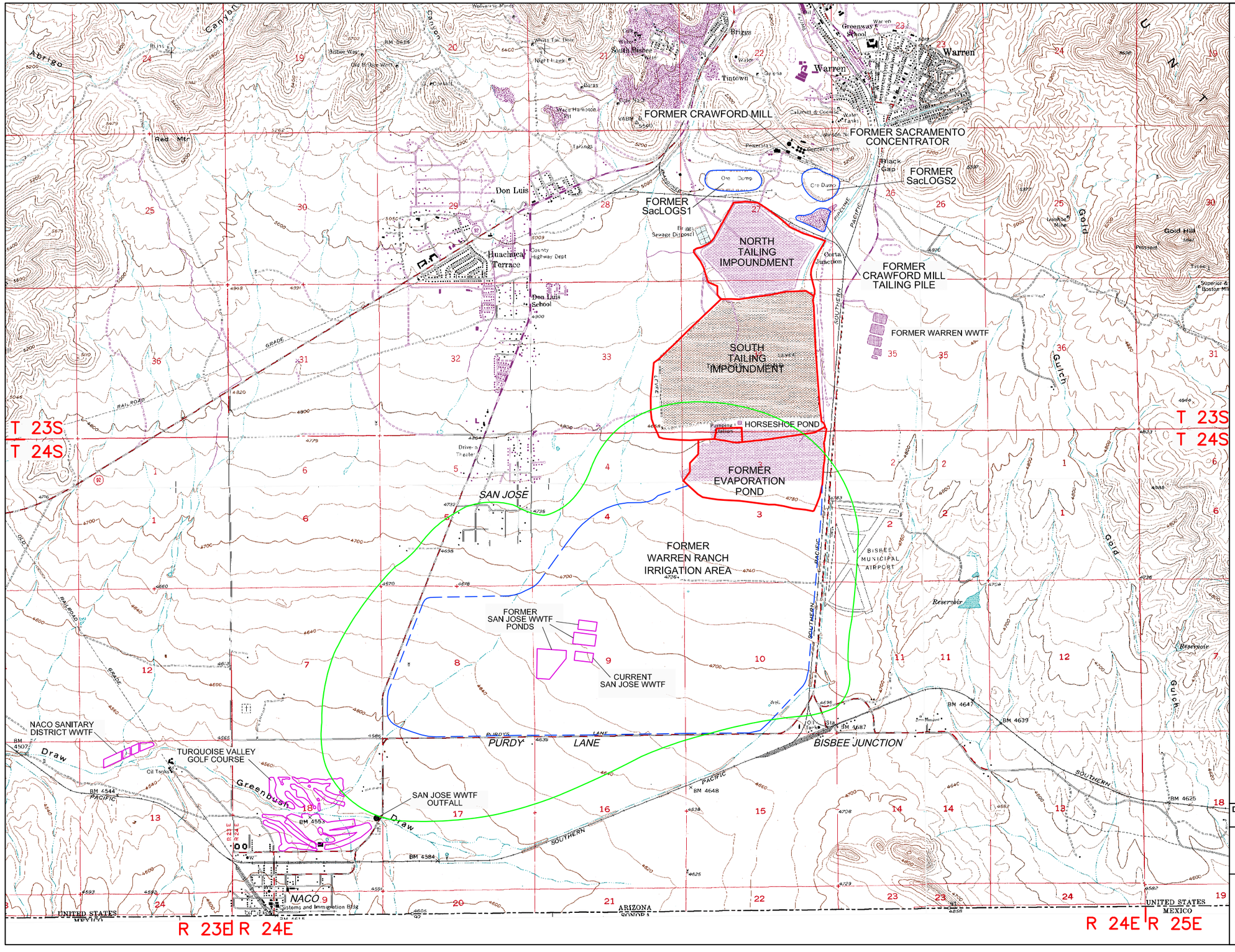


Figure 1
LOCATION MAP
BISBEE - NACO AREA



LEGEND

- CTSA FACILITY
- FACILITY DISCUSSED IN TEXT
- 250 mg/L SULFATE ISOLINE (BASED ON THIRD QUARTER 2010 DATA)

SCALE (FEET)

0 1000 2000

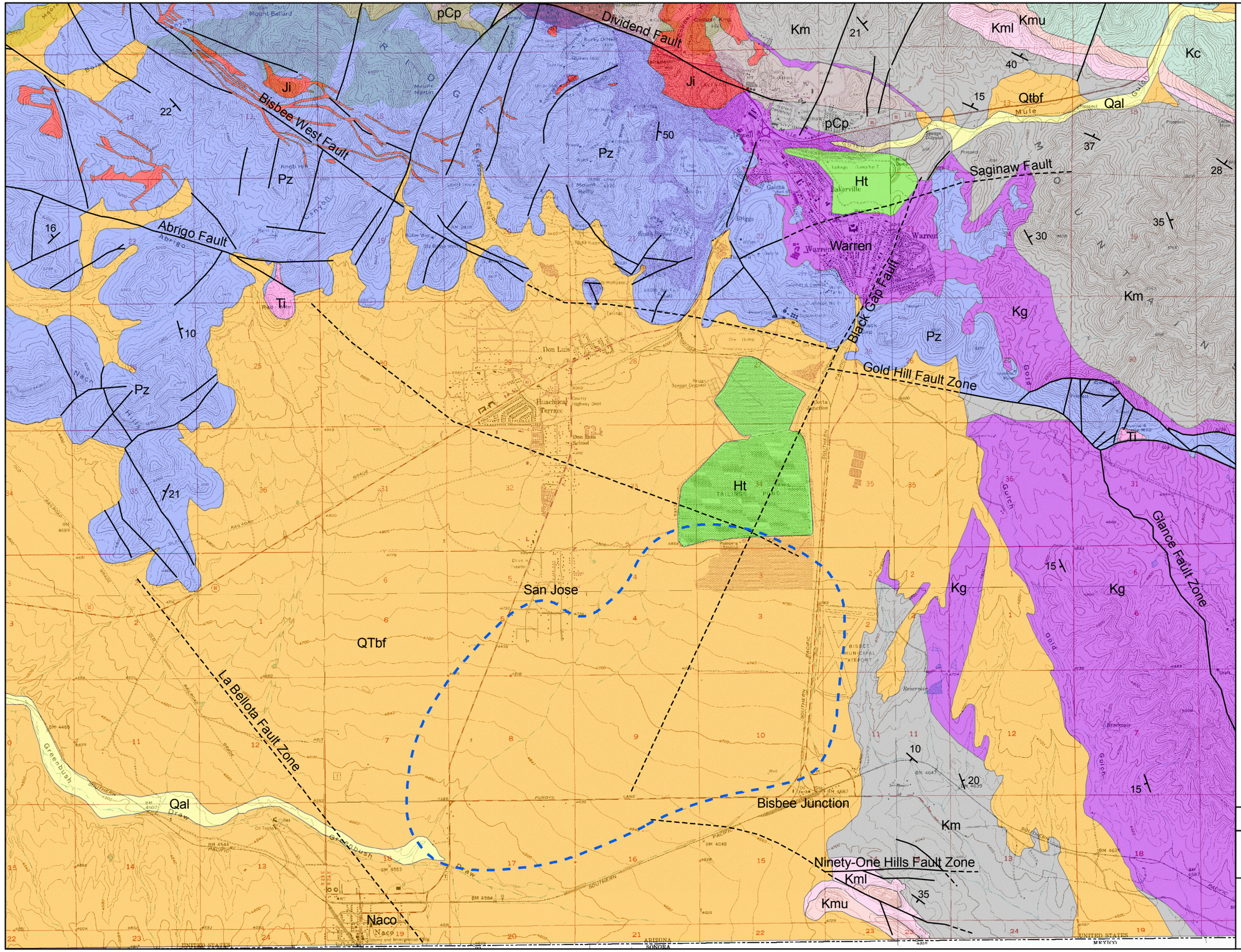
MAP SOURCE: USGS 7.5 MIN QUADS: BISBEE, BISBEE NE, BISBEE SE, AND NACO, ARIZONA. NAD 27 ZONE 12 CENTRAL, METERS

FIGURE FROM HGC (2009c)

Date	File ID
11/24/2010	055038-107

CLEAR CREEK ASSOCIATES

Figure 2
FACILITIES IN THE VICINITY OF THE CONCENTRATOR TAILING STORAGE AREA



LEGEND

RECENT ALLUVIUM

- Ht — HOLOCENE MINE DUMPS AND TAILINGS
- Qal — QUATERNARY ALLUVIUM

BASIN FILL

- QTbf — QUATERNARY - TERTIARY BASIN FILL

BEDROCK COMPLEX

- Ti — TERTIARY INTRUSIVE

CRETACEOUS BISBEE GROUP

- Kc — CINTURA FORMATION
- Kmu — UPPER MURAL LIMESTONE
- Kml — LOWER MURAL LIMESTONE
- Km — MORITA FORMATION
- Kg — GLANCE CONGLOMERATE

BEDROCK COMPLEX

- Ji — JURASSIC INTRUSIVE COMPLEX
- Pz — PALEOZOIC SEDIMENTARY FORMATIONS, UNDIFFERENTIATED
- pCp — PRECAMBRIAN PINAL SCHIST

FAULT (DASHED WHERE INFERRED)

250 mg/L SULFATE ISOLINE (BASED ON THIRD QUARTER 2010 DATA)

37 — STRIKE AND DIP OF BEDDING

SOURCES:
GEOLOGY FROM HAYES AND LANDIS (1964)
FAULT PROJECTIONS FROM SET (1998c)
GLANCE AND LA BELLOTA FAULTS FROM ANDERSON AND NOURSE (2005)

Scale (Feet)

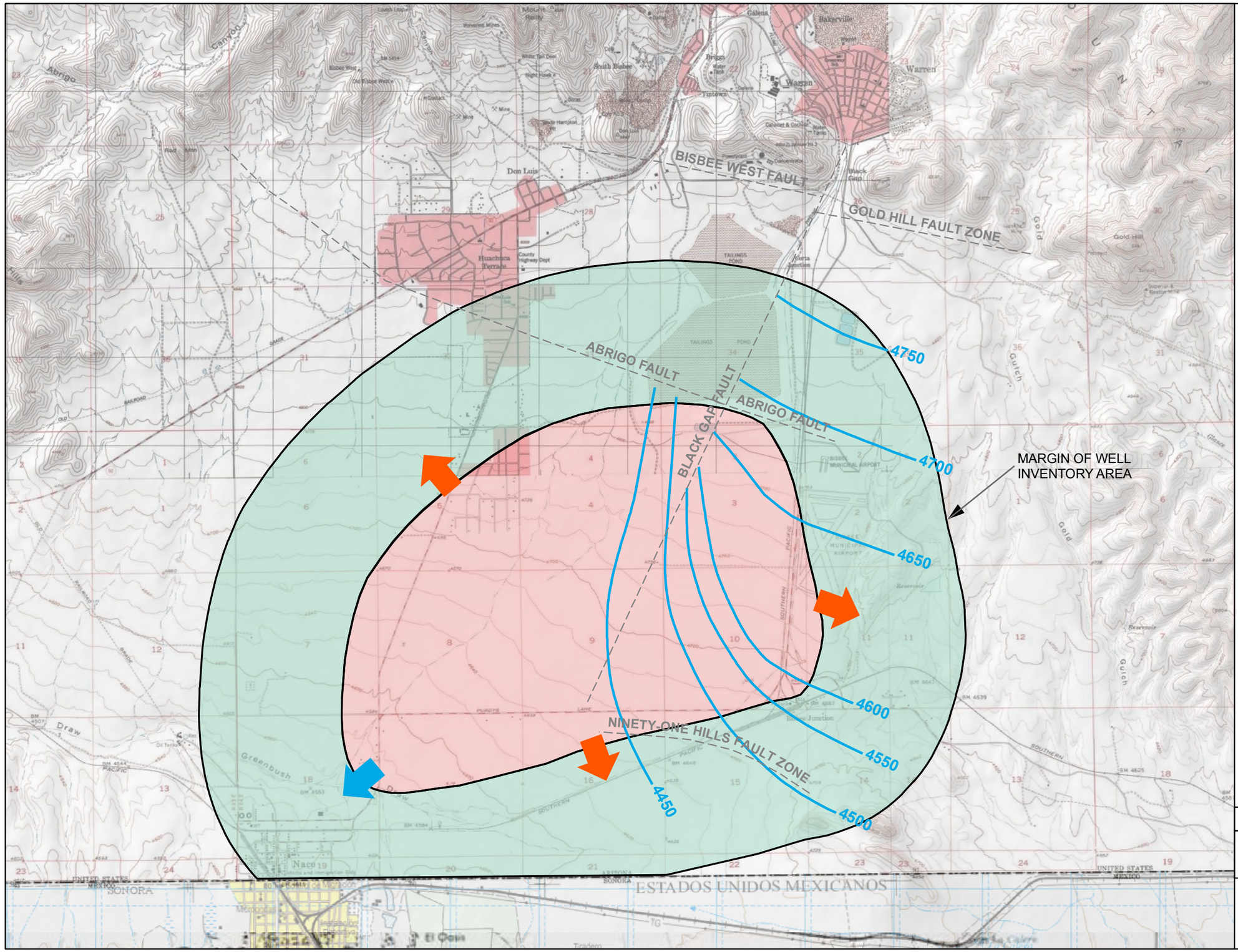
0 — 4,000 — 8,000

Notes:
Projection: UTM Zone 12N NAD83

Date	File ID
11/18/10	055038-108

CLEAR CREEK ASSOCIATES

Figure 3
GEOLOGICAL MAP OF THE CTSA AND VICINITY



Legend

- Groundwater Elevation Contour (ft amsl, 50 ft interval) (September 2005, Work Plan Data)
- >250 mg/L Sulfate Plume Footprint (Based on Work Plan Data)
- 1 Mile Search Radius Area
- Downgradient Direction
- Cross-Gradient Direction
- Faults (inferred)

Scale (Feet)

0 3,500 7,000

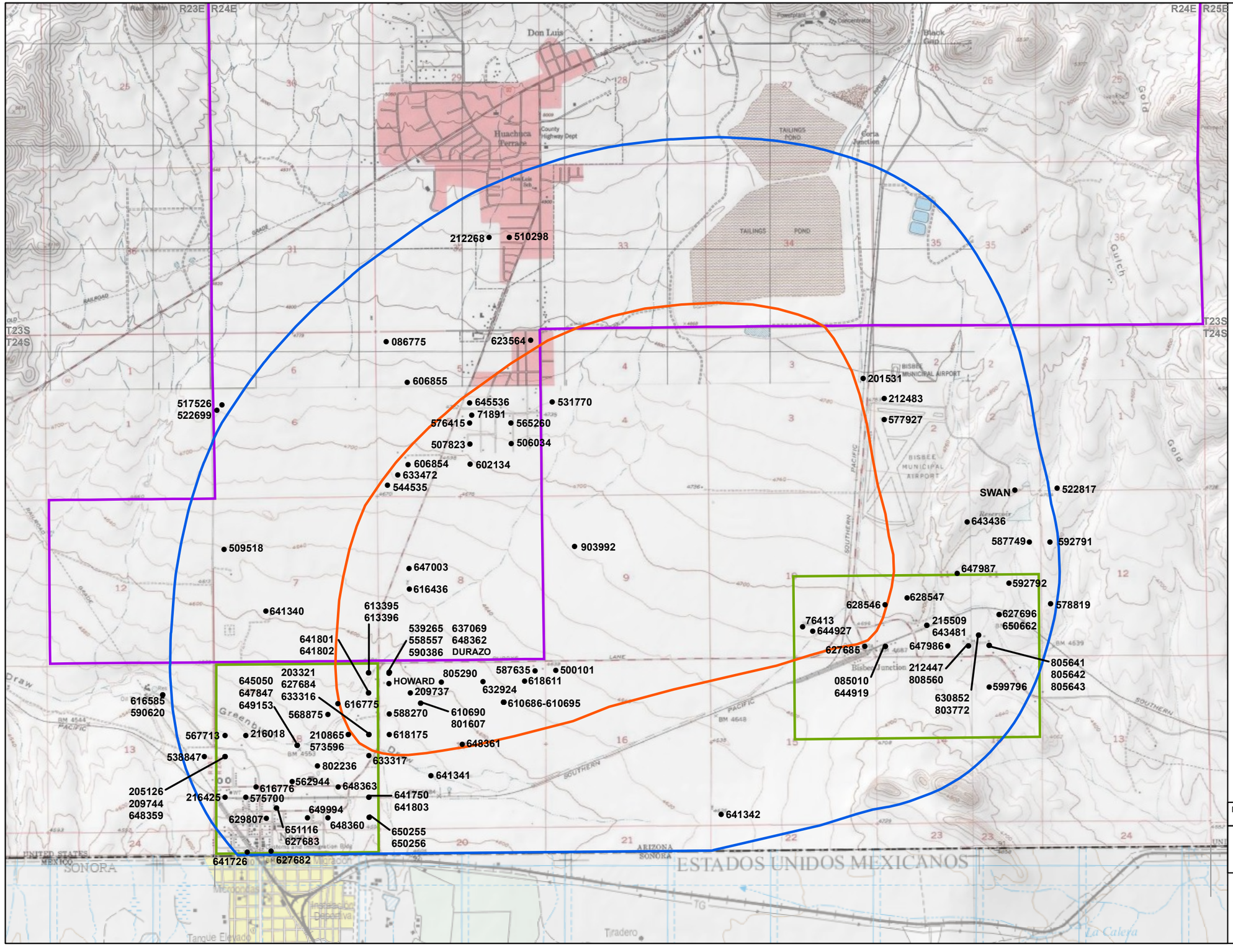
Notes:
Projection: UTM Zone 12N NAD83

FIGURE FROM HGC (2009c)

Date	File ID
11/24/10	055038-109

CLEAR CREEK ASSOCIATES

Figure 4
WELL INVENTORY AREA, SULFATE PLUME, GROUNDWATER ELEVATIONS, AND HYDRAULIC GRADIENT DIRECTIONS



Legend

- Well Location and ID
- Naco Water Company Service Area
- Arizona Water Company Service Area
- Well Inventory Area
- 250 mg/L Sulfate Isoline (Based on Work Plan Data)

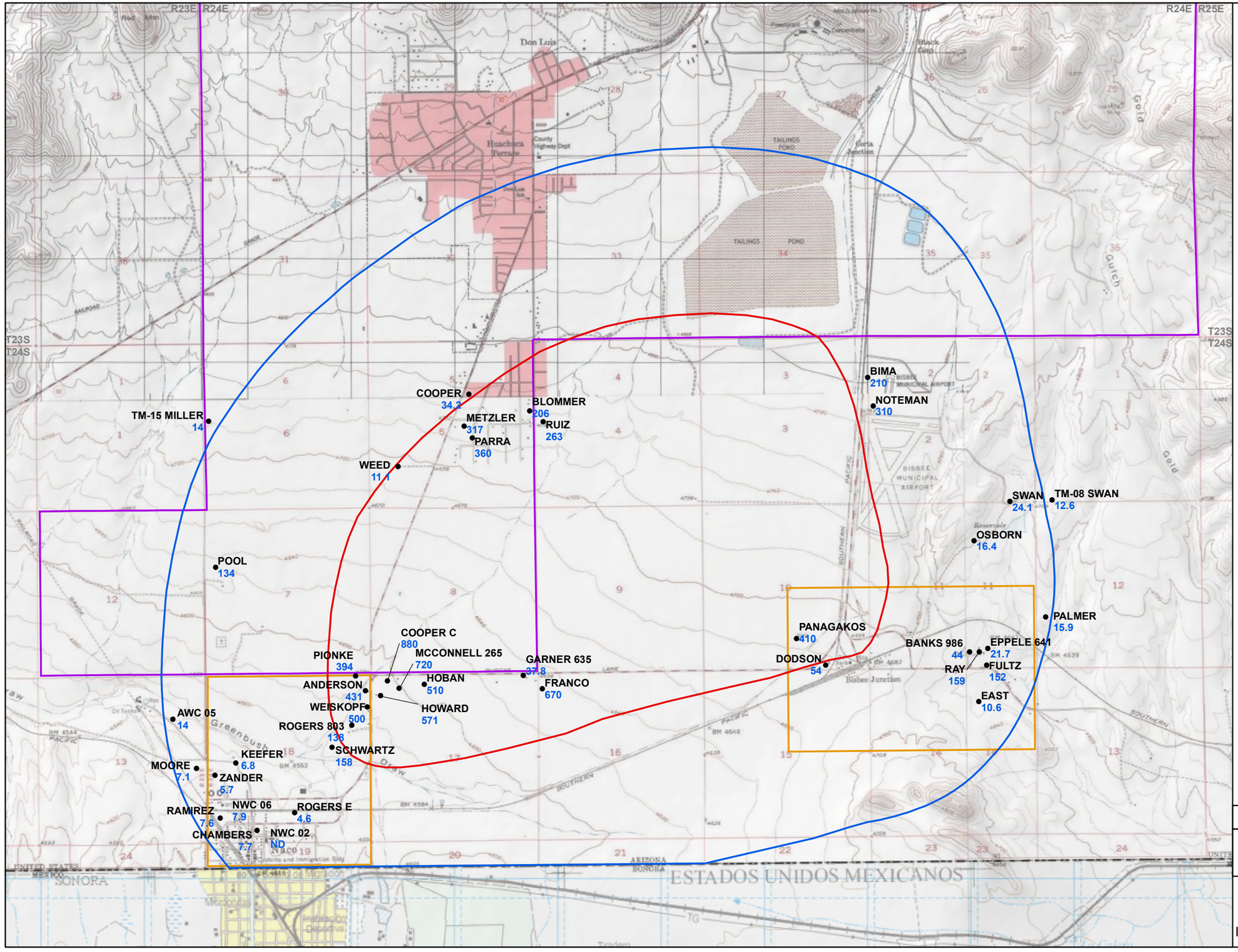
Notes:
Projection: UTM Zone 12N NAD83

FIGURE FROM HGC (2009c)

Date	File ID
11/29/10	055038-110

CLEAR CREEK ASSOCIATES

Figure 5
WELLS EVALUATED AS POTENTIAL DRINKING WATER SUPPLY WELLS



Legend

- **RUIZ** 263 — Well Location and ID; Sulfate Concentration (mg/L)
- Naco Water Co. Service Area
- Arizona Water Co. Service Area
- Well Inventory Area
- 250 mg/L Sulfate Isoline (Based on Work Plan Data)

ND = No Data

Scale (Feet)

0 3,000 6,000

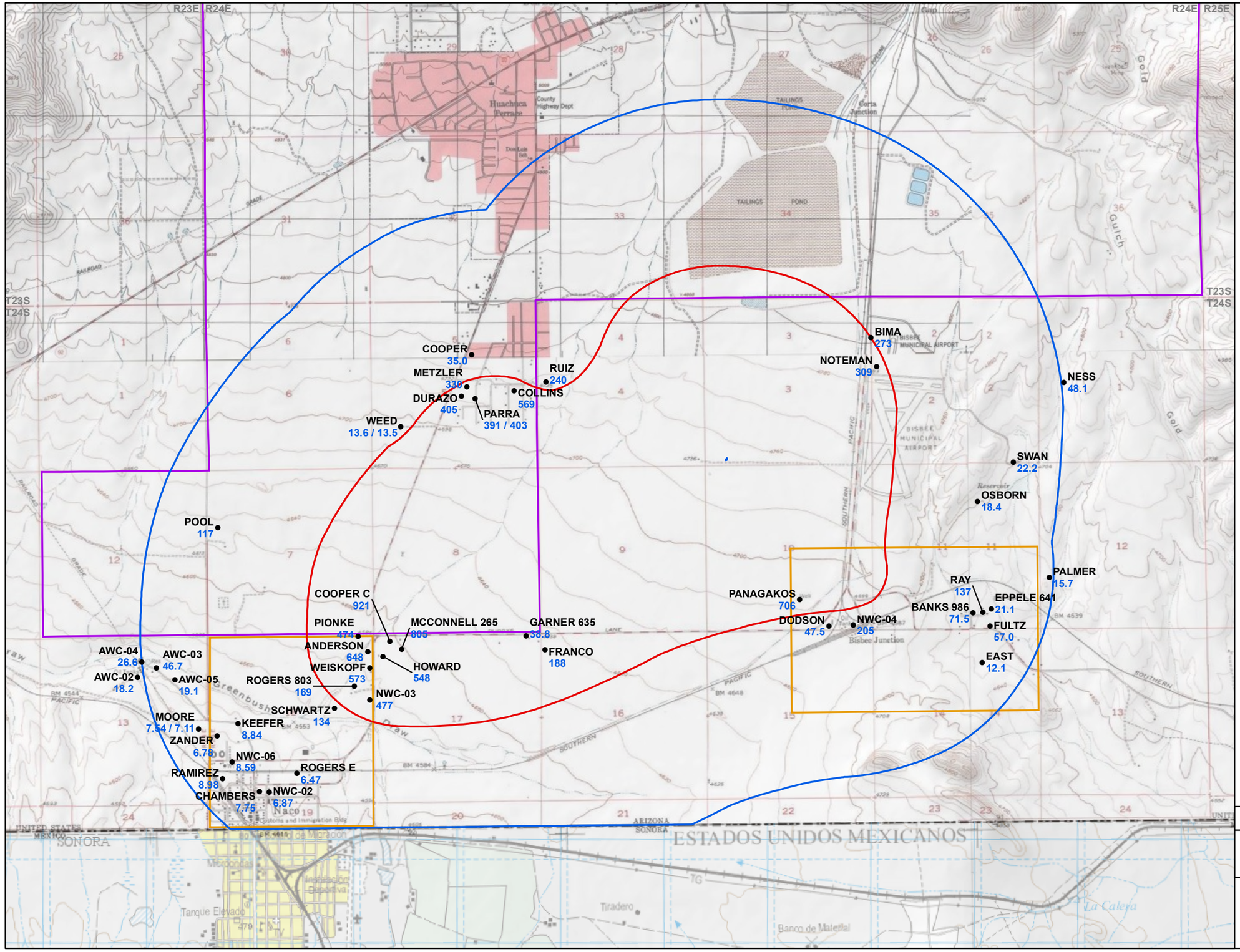
Notes:

Projection: UTM Zone 12N NAD83

Date	File ID
11/18/10	055038-111

CLEAR CREEK ASSOCIATES

Figure 6
SULFATE CONCENTRATIONS IN DRINKING WATER SUPPLY WELLS IN FEBRUARY THROUGH APRIL 2008



Legend

- **AWC 02** 18.2 — Well Location and ID; Sulfate Concentration (mg/L)
- Arizona Water Co. Service Area
- Naco Water Co. Service Area
- Well Inventory Area
- 250 mg/L Sulfate Isoline (Third Quarter 2010 Data)

ND = No Data

Scale (Feet)

0 3,000 6,000

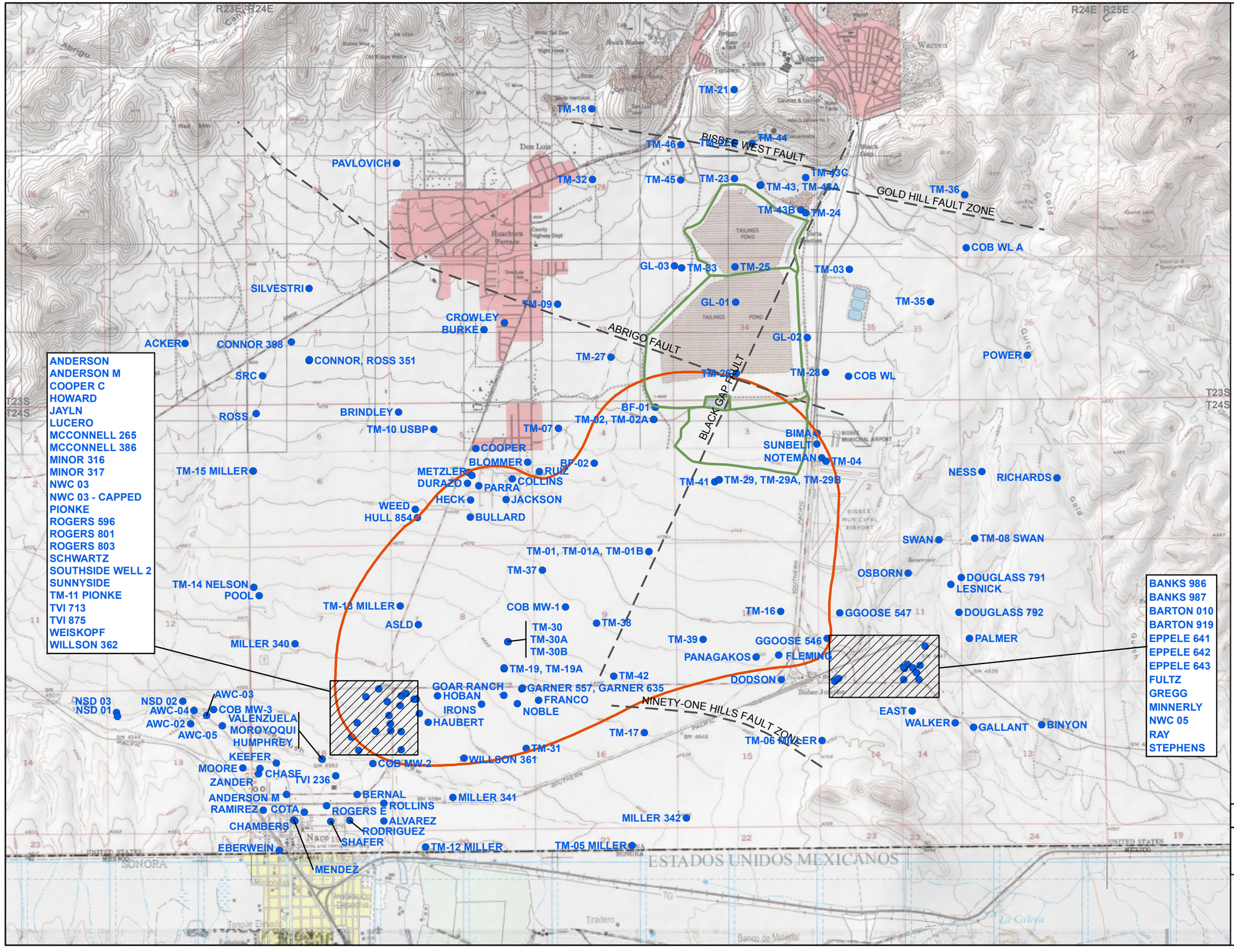
Notes:

Projection: UTM Zone 12N NAD83

Date	File ID
11/30/10	055038-112

CLEAR CREEK ASSOCIATES

Figure 7
SULFATE CONCENTRATIONS IN DRINKING WATER SUPPLY WELLS
THIRD QUARTER 2010



Legend

- Well Location and ID
- 250 mg/L Sulfate Isoline (Third Quarter 2010 Data)
- CTSA Facility
- Faults (inferred)

Scale (Feet)

0 3,500 7,000

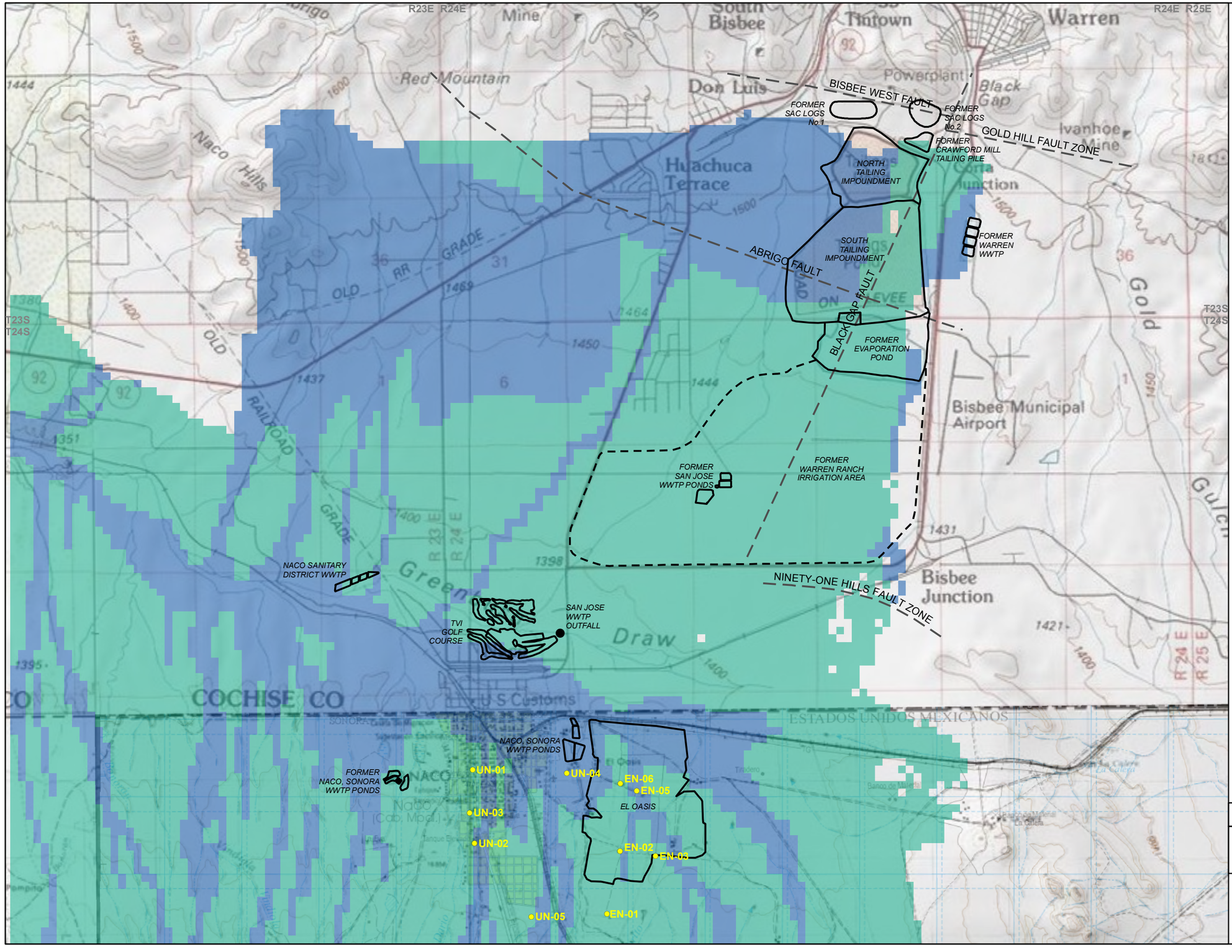
Notes:

Projection: UTM Zone 12N NAD83

Date	File ID
11/24/10	055038-113

CLEAR CREEK ASSOCIATES

Figure 8
WELLS IDENTIFIED FOR DATA COMPILATION (TASK 2.1)



Legend

- Well Location and ID
- Natural Recharge – High (SET, 1998b)
- Natural Recharge – Low (SET, 1998b)

Scale (Feet)

0 4,000 8,000

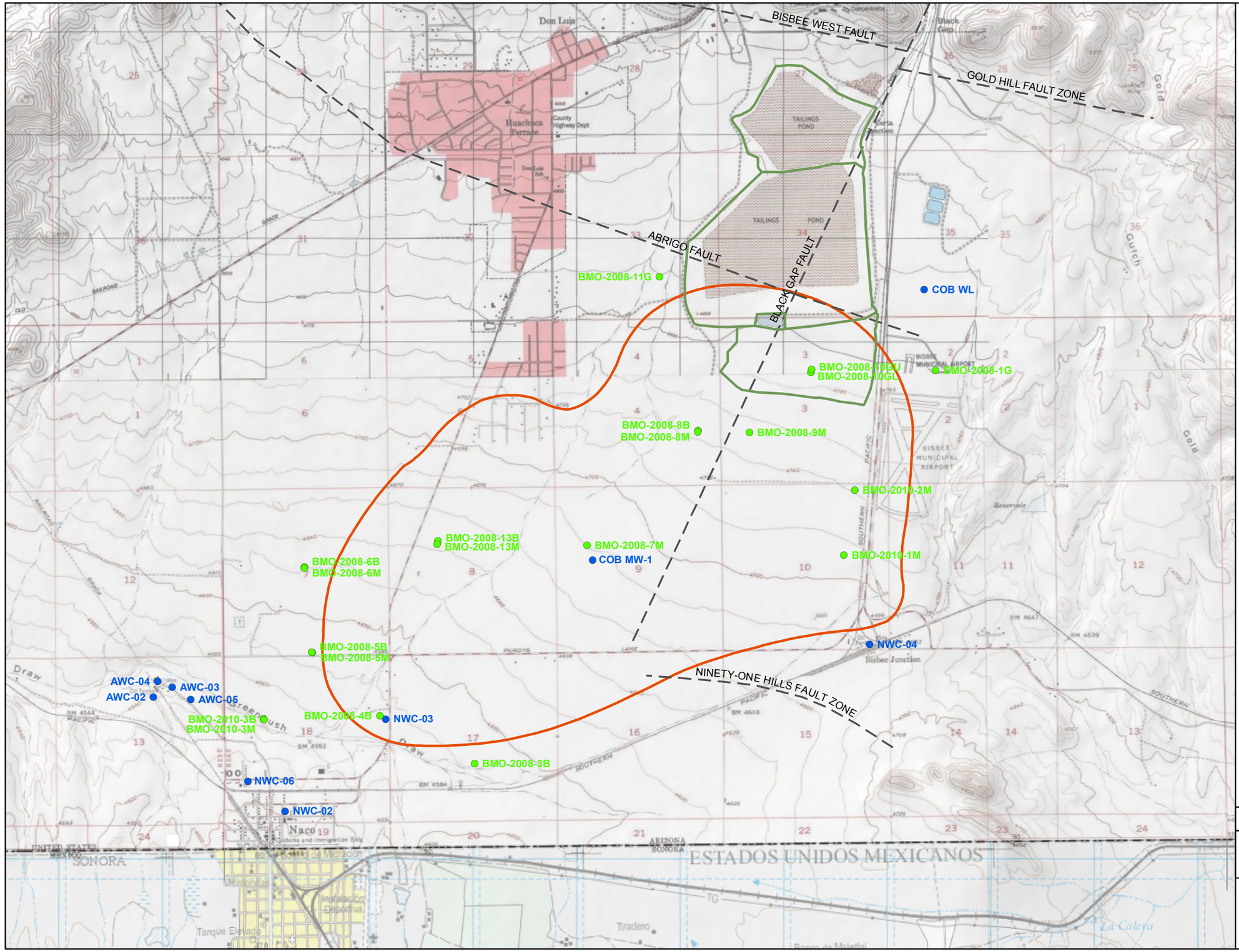
Notes:
Projection: UTM Zone 12N NAD83

FIGURE FROM HGC (2009c)

Date	File ID
11/24/10	055038-114

CLEAR CREEK ASSOCIATES

Figure 9
NACO, SONORA WELLS AND AQUIFER RECHARGE SOURCES



Legend

- Existing Well Location and ID
- BMO Well Location and ID, as Discussed in Section 3.4
- Fault
- Fault (Inferred)
- 250 mg/L Sulfate Isoline (Third Quarter 2010 Data)
- CTSA Facility

Scale (Feet)

0 3,000 6,000

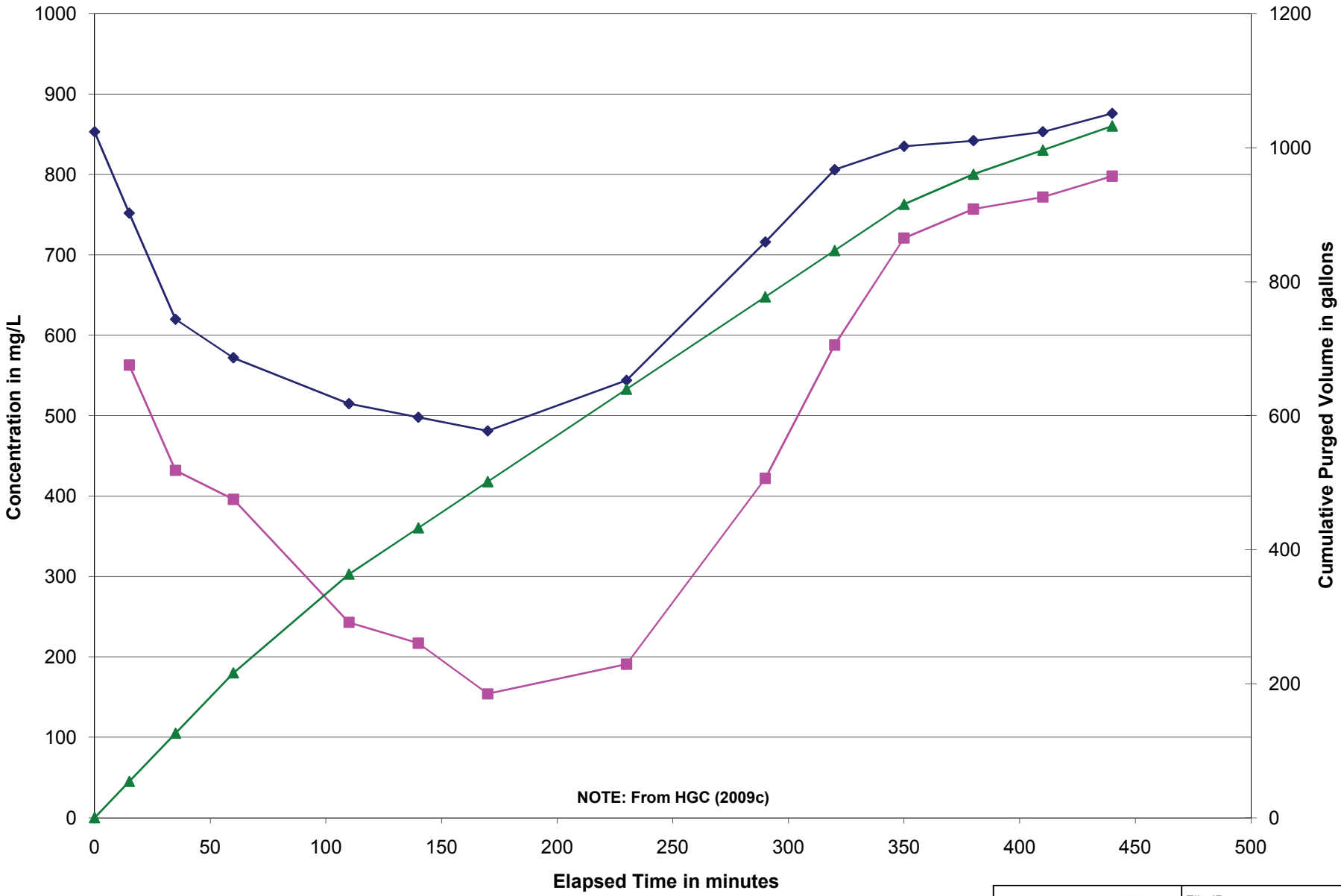
Notes:

Projection: UTM Zone 12N NAD83

Date	File ID
11/24/10	055038-115

CLEAR CREEK ASSOCIATES

Figure 10
MITIGATION ORDER
MONITORING WELL LOCATIONS



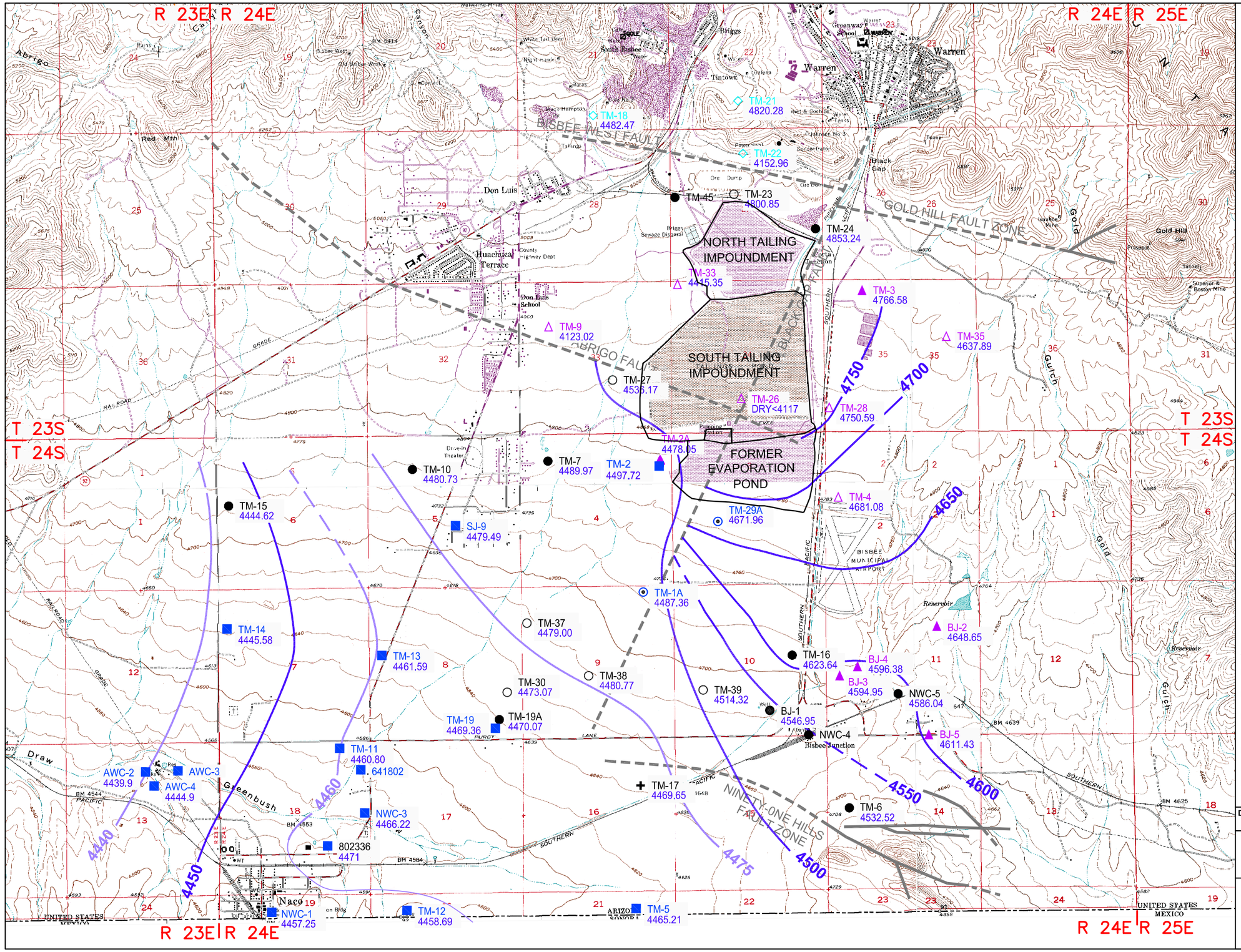
CLEAR CREEK ASSOCIATES

File ID 055038-048

Date 10-11-2010

Figure 11
BMO-2008-13M TEMPORARY WELL DATA
920 TO 940 FT BLS

L:\Projects\G & K\055038_Copper Queen Branch Mitigation Order\055038 Figures and GIS\055038 Figures and Maps\055038-048 BMO-13M TW Data.xls



LEGEND

- BASIN FILL
- MORITA FORMATION
- GLANCE CONGLOMERATE
- PALEOZOIC SEDIMENTS
- MIXED, BASIN FILL & MORITA FORMATION
- MURAL LIMESTONE

TM-1 WELL ID
4443.2 WATER ELEVATION (FT AMSL)

WATER CONTOUR LINE (DASHED WHERE INFERRED)

INTERMEDIATE WATER CONTOUR LINE (DASHED WHERE INFERRED)

FAULT (DASHED WHERE INFERRED) FROM SET 1998c

OPEN SYMBOL DENOTES ABANDONED WELL AS OF 2007

SCALE (FEET)

0 1000 2000

NOTES:

MAP SOURCE: USGS 7.5 MIN QUADS: BISBEE, BISBEE NE, BISBEE SE, AND NACO, ARIZONA.

NAD 27 ZONE 12 CENTRAL, METERS

FIGURE TAKEN FROM HGC (2009c)

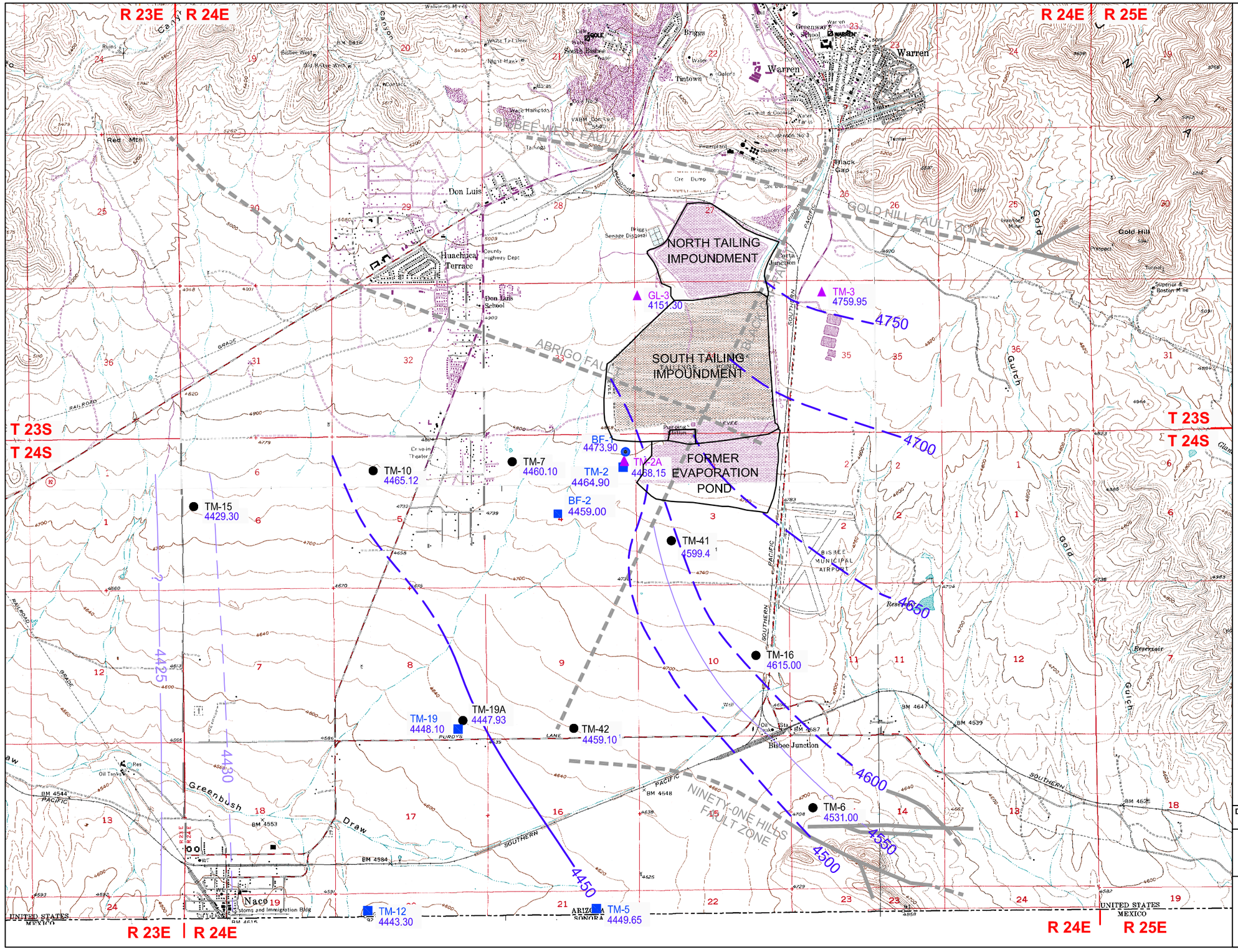
WATER LEVELS NOT UPDATED WITH 2008 RE-SURVEY

1988 AND 1990 WATER LEVELS ARE PLOTTED FOR AWC AND MWC WELLS PER SECTION 4.2.3.1 OF TEXT

Date	11/24/2010	File ID	055038-116

CLEAR CREEK ASSOCIATES

Figure 12
WATER LEVEL MAP 1989 CONCENTRATOR TAILING STORAGE AREA AND VICINITY BISBEE, ARIZONA



LEGEND

- BASIN FILL
- MORITA FORMATION
- GLANCE CONGLOMERATE
- PALEOZOIC SEDIMENTS
- MIXED, BASIN FILL & MORITA FORMATION
- MURAL LIMESTONE

TM-1 WELL ID
4443.2 WATER ELEVATION (FT AMSL)

WATER CONTOUR LINE (DASHED WHERE INFERRED)

INTERMEDIATE WATER CONTOUR LINE (DASHED WHERE INFERRED)

FAULT (DASHED WHERE INFERRED) FROM SET 1998c

[1] WATER LEVELS FROM TM-41 & TM-42 ARE FROM 1997

SCALE (FEET)

0 1000 2000

NOTES:

MAP SOURCE: USGS 7.5 MIN QUADS: BISBEE, BISBEE NE, BISBEE SE, AND NACO, ARIZONA.

NAD 27 ZONE 12 CENTRAL, METERS

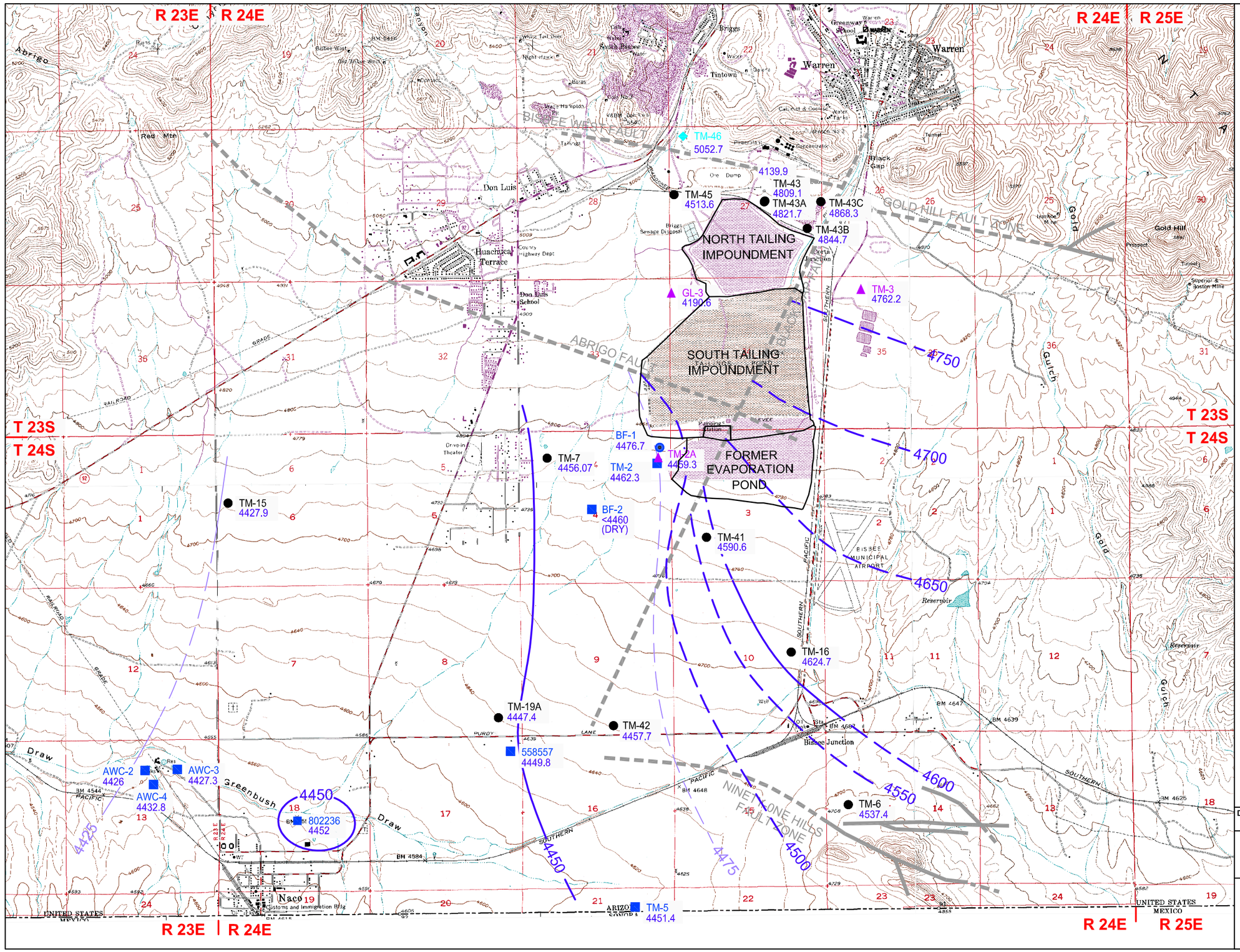
FIGURE TAKEN FROM HGC (2009c)

WATER LEVELS NOT UPDATED WITH 2008 RE-SURVEY

Date	File ID
11/24/2010	055038-117

CLEAR CREEK ASSOCIATES

Figure 13
WATER LEVEL MAP 1996 CONCENTRATOR TAILING STORAGE AREA AND VICINITY BISBEE, ARIZONA



LEGEND

- BASIN FILL
- MORITA FORMATION
- GLANCE CONGLOMERATE
- PALEOZOIC SEDIMENTS
- MIXED, BASIN FILL & MORITA FORMATION
- MURAL LIMESTONE

TM-1 WELL ID
4443.2 WATER ELEVATION (FT AMSL)

- WATER CONTOUR LINE (DASHED WHERE INFERRED)
- INTERMEDIATE WATER CONTOUR LINE (DASHED WHERE INFERRED)
- FAULT (DASHED WHERE INFERRED) FROM SET 1998c

SCALE (FEET)

0 1000 2000

NOTES:

MAP SOURCE: USGS 7.5 MIN QUADS: BISBEE, BISBEE NE, BISBEE SE, AND NACO, ARIZONA.

NAD 27 ZONE 12 CENTRAL, METERS

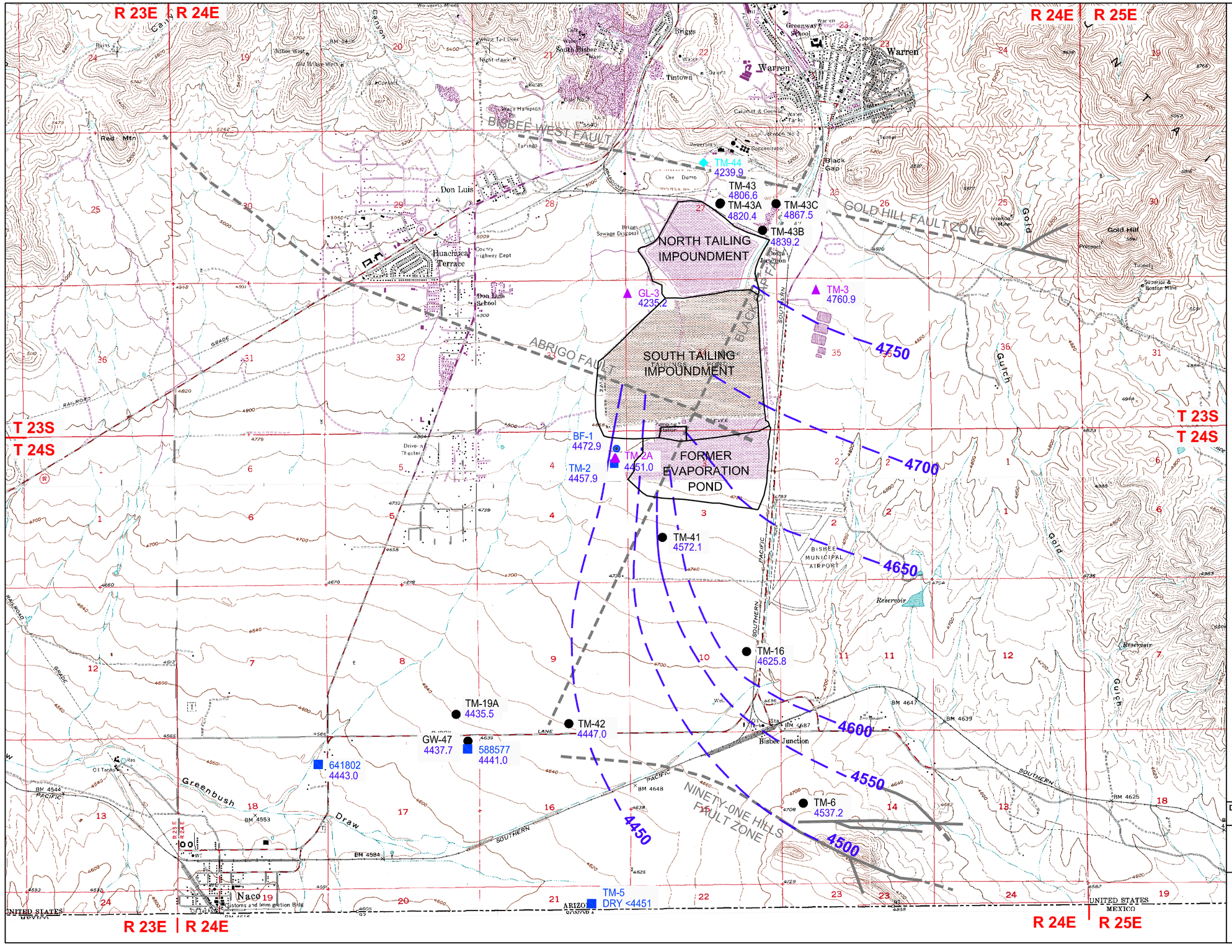
FIGURE TAKEN FROM HGC (2009c)

WATER LEVELS NOT UPDATED WITH 2008 RE-SURVEY

Date	File ID
11/24/2010	055038-118

CLEAR CREEK ASSOCIATES

Figure 14
WATER LEVEL MAP 1999 CONCENTRATOR TAILING STORAGE AREA AND VICINITY BISBEE, ARIZONA



LEGEND

- BASIN FILL
- MORITA FORMATION
- GLANCE CONGLOMERATE
- PALEOZOIC SEDIMENTS
- MIXED, BASIN FILL & MORITA FORMATION
- MURAL LIMESTONE

TM-1 WELL ID
4443.2 WATER ELEVATION (FT AMSL)

WATER CONTOUR LINE (DASHED WHERE INFERRED)

FAULT (DASHED WHERE INFERRED) FROM SET 1998c

SCALE (FEET)

0 1000 2000

NOTES:

MAP SOURCE: USGS 7.5 MIN QUADS: BISBEE, BISBEE NE, BISBEE SE, AND NACO, ARIZONA.

NAD 27 ZONE 12 CENTRAL, METERS

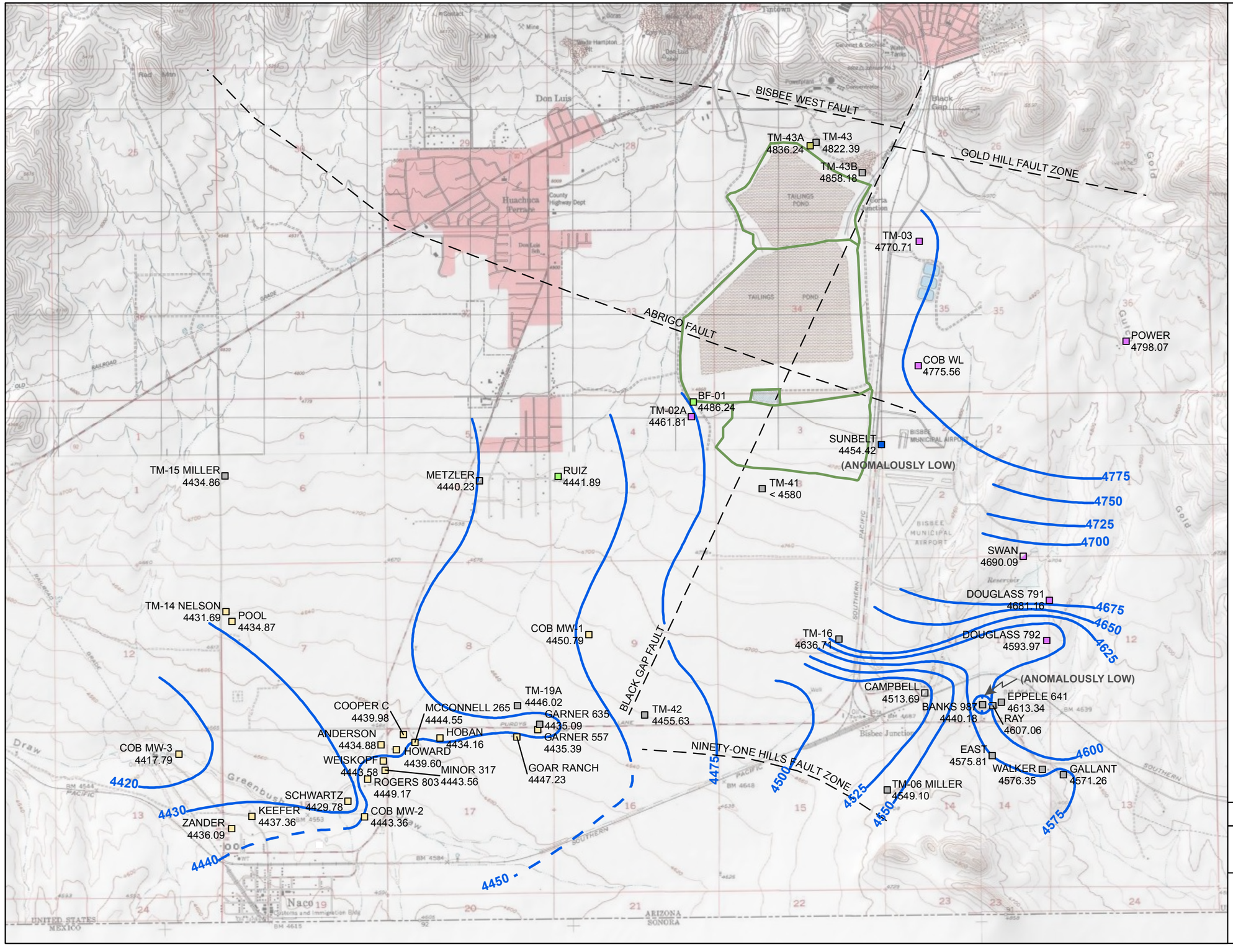
FIGURE TAKEN FROM HGC (2009c)

WATER LEVELS NOT UPDATED WITH 2008 RE-SURVEY

Date	File ID
11/24/2010	055038-119

CLEAR CREEK ASSOCIATES

Figure 15
WATER LEVEL MAP SEPTEMBER 2005
CONCENTRATOR TAILING STORAGE AREA AND VICINITY
BISBEE, ARIZONA



Legend

- ZANDER 4436.09 — Well ID; Groundwater Elevation (ft amsl)
- Faults (inferred)
- Groundwater Contours
- CTSA Facility

Screened Formation

- Basin Fill
- Basin Fill and Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group - Estimated
- Undifferentiated Bisbee Group and Glance Conglomerate
- Glance Conglomerate
- Glance Conglomerate-Estimated

Undifferentiated Bisbee Group: Cintura, Mural Limestone, and Morita Formations

Scale (Feet)

0 3,000 6,000

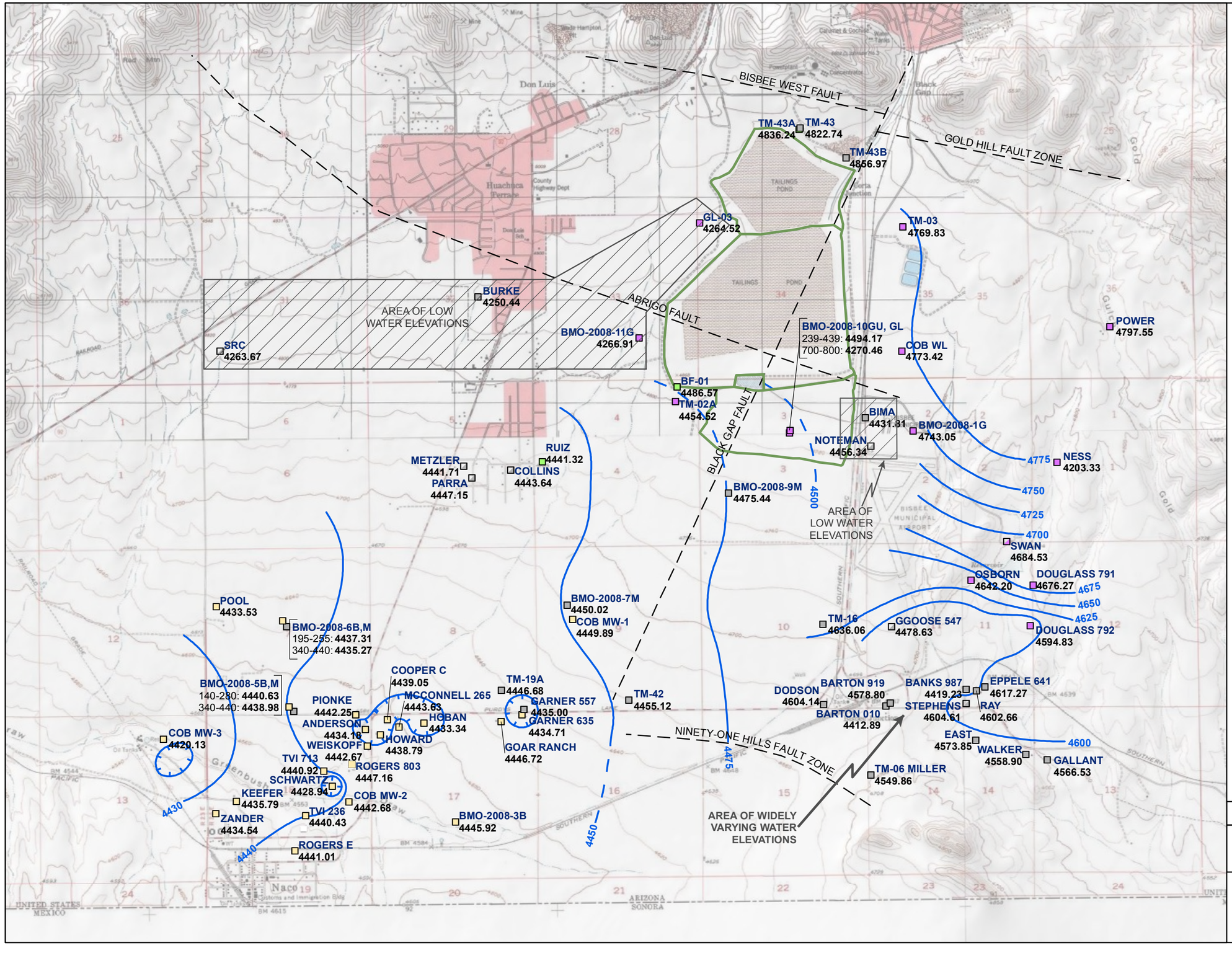
Notes:
Projection: UTM Zone 12N NAD83

FIGURE FROM HGC (2009c)

Date	File ID
11/29/10	055038-058

CLEAR CREEK ASSOCIATES

Figure 16
GROUNDWATER ELEVATIONS FOR FIRST QUARTER 2008



Legend

- TVI-713 — Well ID
- 4440.92 — Groundwater Elevation (ft amsl)

Co-located Wells

- Well ID
- Screen (ft bgs): Water Elevation (ft amsl)

- Groundwater Elevation Contours (dashed where inferred)
- Groundwater Depression
- Faults (inferred)
- CTSA Facility

Screened Formation

- Basin Fill
- Basin Fill and Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group - Estimated
- Glance Conglomerate
- Glance Conglomerate-Estimated

Undifferentiated Bisbee Group: Cintura, Mural Limestone, and Morita Formations

Scale (Feet)

0 3,000 6,000

Notes:

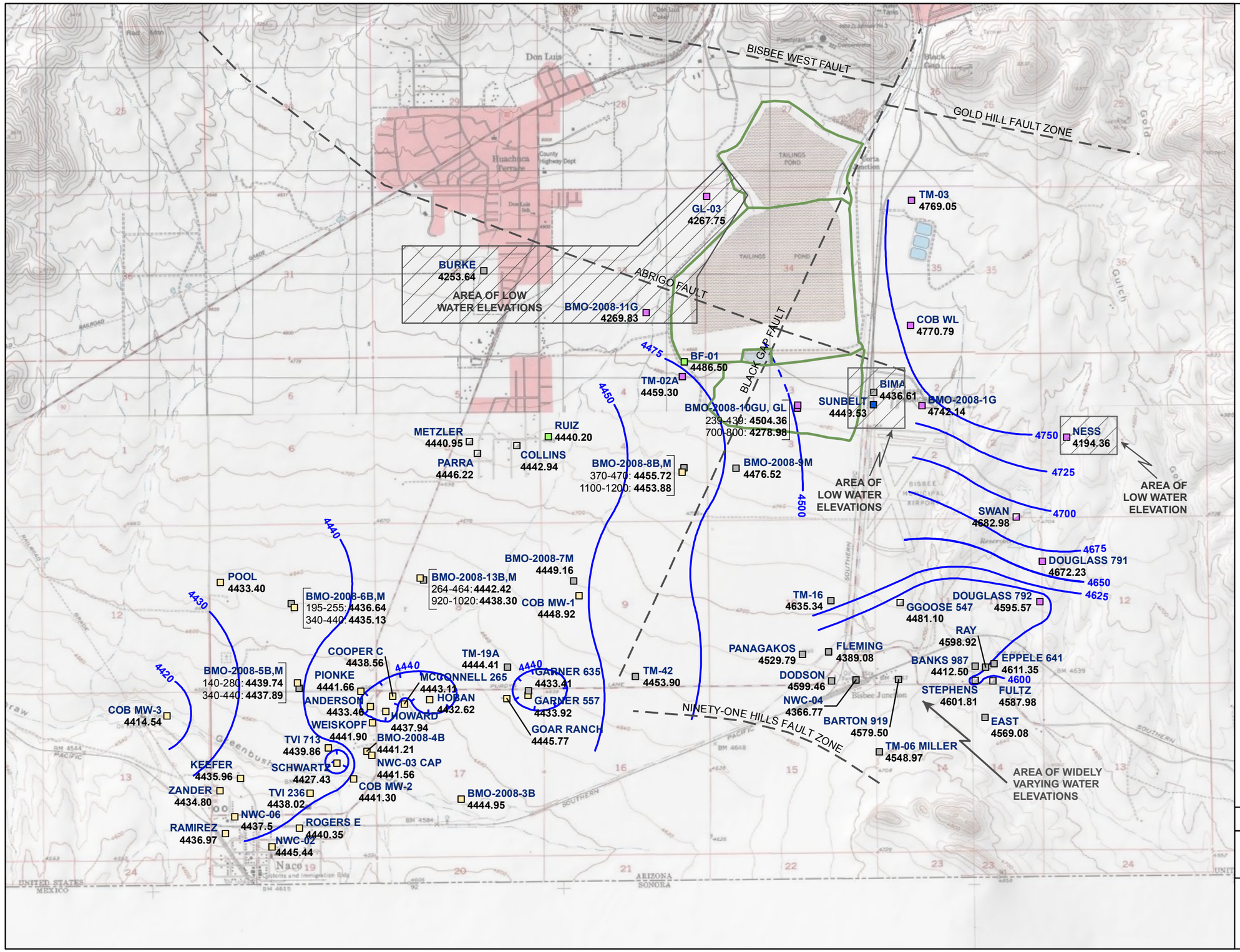
Projection: UTM Zone 12N NAD83

FIGURE FROM HGC (2009c)

Date	File ID
11/29/10	055038-059

CLEAR CREEK ASSOCIATES

Figure 17
GROUNDWATER ELEVATIONS FOR THIRD QUARTER 2008



Legend

- POOL — Well ID
- 4433.40 — Groundwater Elevation (ft amsl)
- Groundwater Elevation Contours (dashed where inferred)
- Groundwater Depression
- Faults (inferred)
- CTSA Facility

Co-Located Wells

- Well ID
- Screen (ft bgs): Water Elevation (ft amsl)

Screened Formation

- Basin Fill
- Basin Fill and Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group - Estimated
- Undifferentiated Bisbee Group and Glance Conglomerate
- Glance Conglomerate
- Glance Conglomerate-Estimated

Undifferentiated Bisbee Group: Cintura, Mural Limestone, and Morita Formations

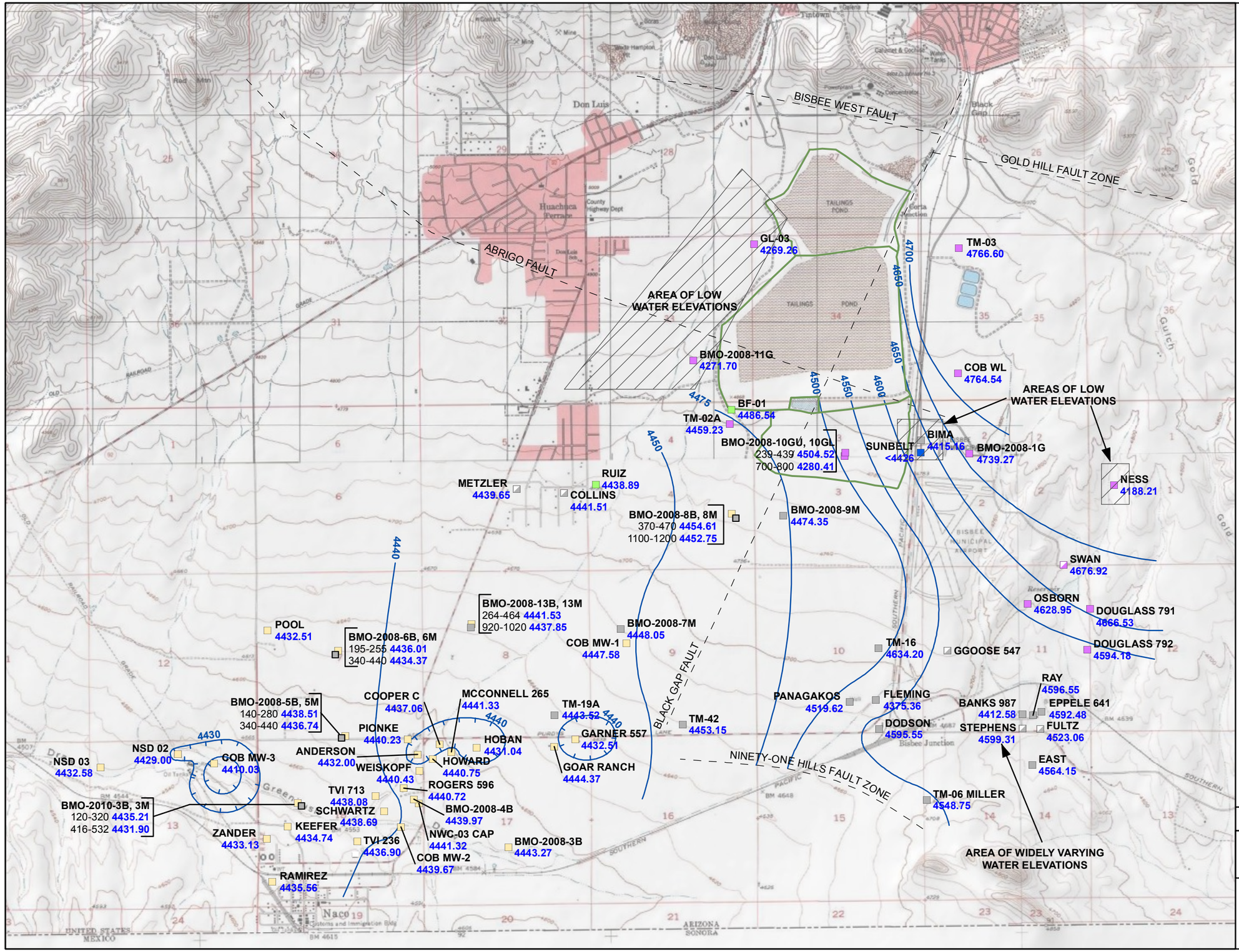
Notes:
Projection: UTM Zone 12N NAD83

FIGURE FROM HGC (2009e)

Date	File ID
11/29/10	055038-060

CLEAR CREEK ASSOCIATES

Figure 18
GROUNDWATER ELEVATIONS
THIRD QUARTER 2009



Legend

- POOL — Well ID
- 4433.61 — Groundwater Elevation (ft amsl)
- Groundwater Elevation Contours (dashed where inferred)
- Groundwater Depression
- Faults (inferred)
- CTSA Facility

Co-located Wells
- Well ID
- Screen (ft bgs): Water Elevation (ft amsl)

Screened Formation
- Basin Fill
- Basin Fill and Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group - Estimated
- Undifferentiated Bisbee Group and Glance Conglomerate
- Glance Conglomerate
- Glance Conglomerate-Estimated

Undifferentiated Bisbee Group: Cintura, Mural Limestone, and Morita Formations

Scale (Feet)

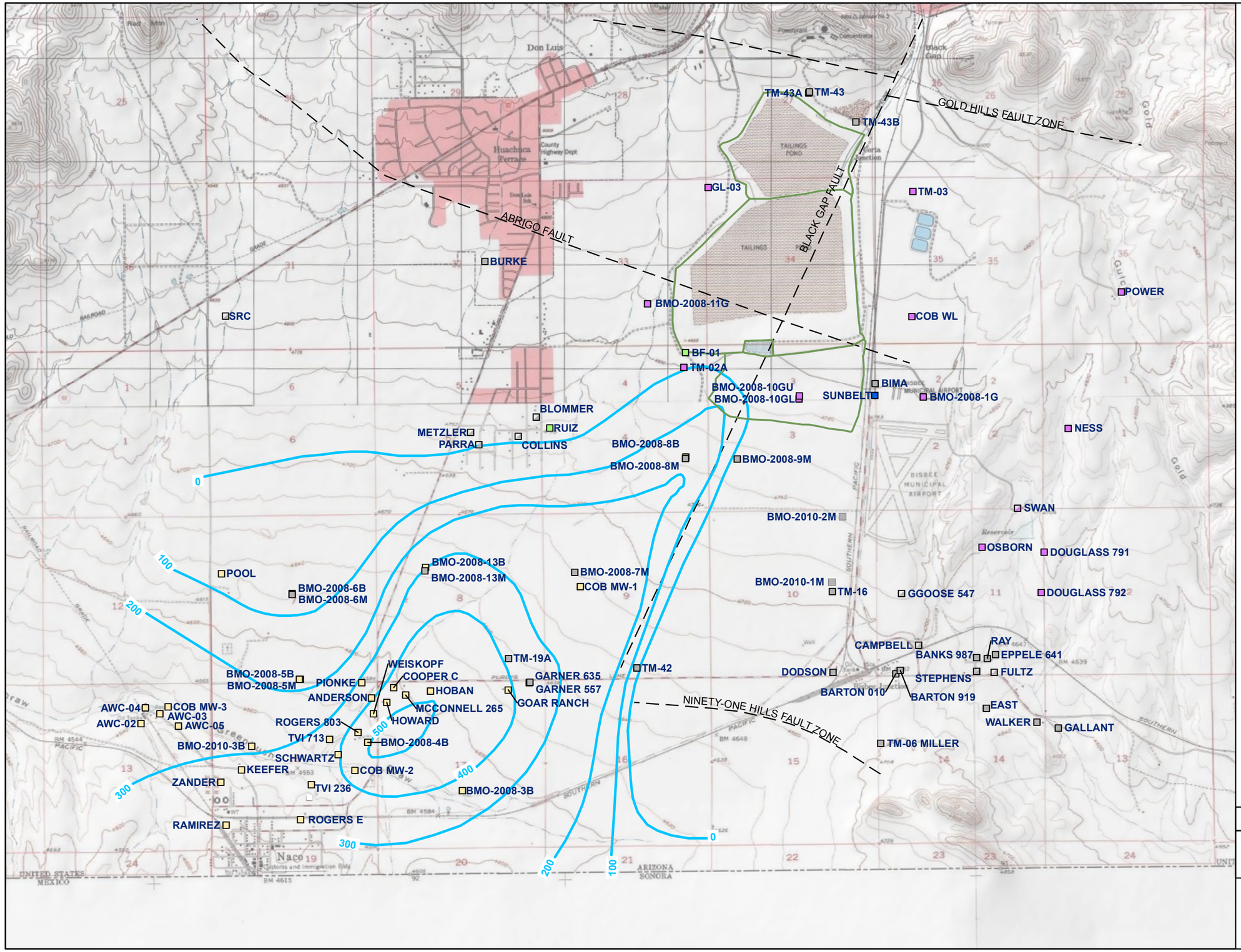
0 3,000 6,000

Notes:
Projection: UTM Zone 12N NAD83

Date	File ID
11/29/10	055038-053A

CLEAR CREEK ASSOCIATES

Figure 19
GROUNDWATER ELEVATIONS
THIRD QUARTER 2010



Legend

- TVI-713 Well ID
- Basin Fill Thickness Contours
- Faults (inferred)
- CTSA Facility

Screened Formation

- Basin Fill
- Basin Fill and Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group - Estimated
- Undifferentiated Bisbee Group and Glance Conglomerate
- Glance Conglomerate
- Glance Conglomerate-Estimated

Undifferentiated Bisbee Group: Cintura, Mural Limestone, and Morita Formations

Thickness of basin fill based on 4th Quarter 2008 Water Elevations

Scale (Feet)

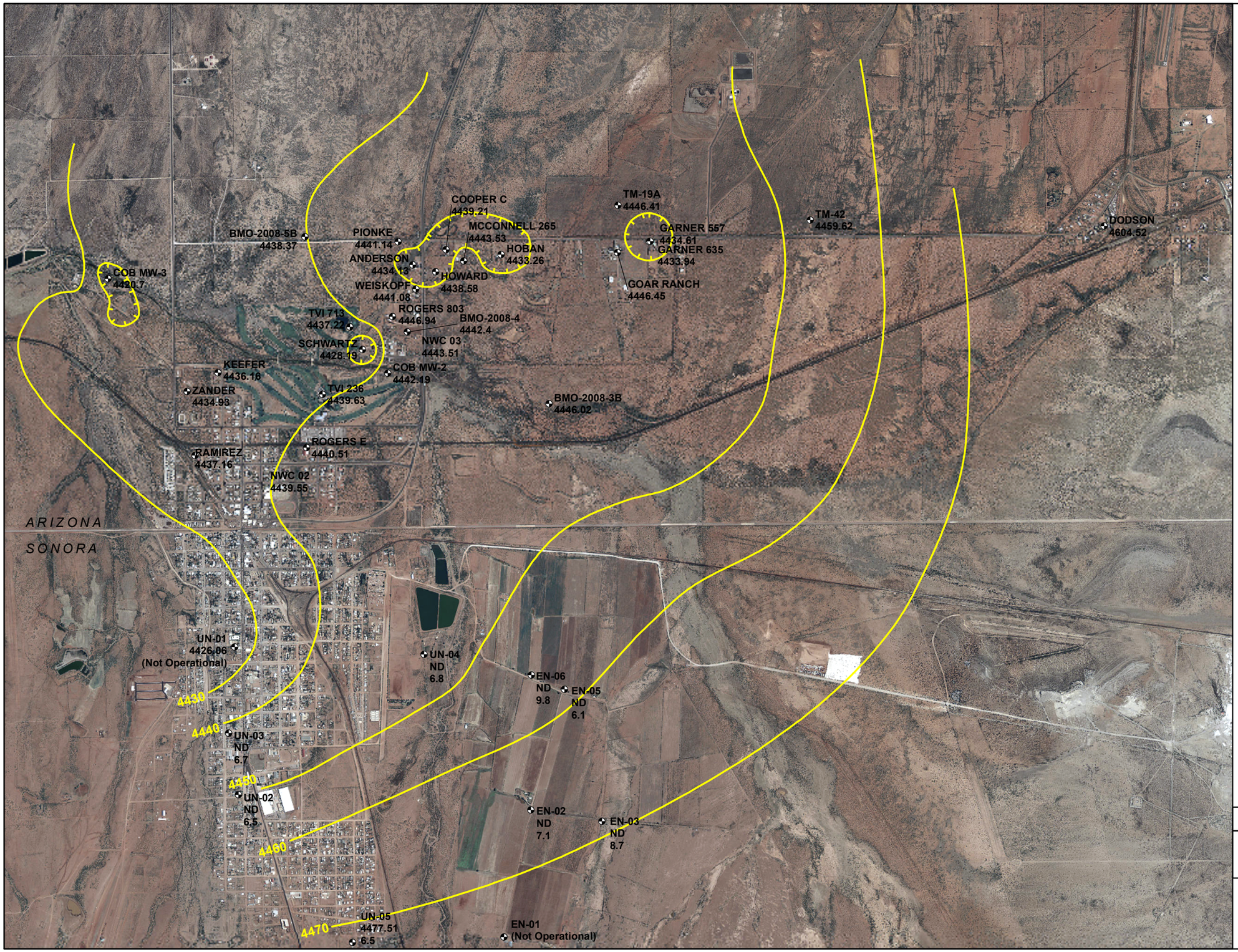
0 3,000 6,000

Notes:
Projection: UTM Zone 12N NAD83

Date	File ID
11/29/10	055038-077

CLEAR CREEK ASSOCIATES

Figure 20
SATURATED THICKNESS OF BASIN FILL



Legend

TVI-713	Well ID
4440.92	Groundwater Elevation (ft amsl)
10	Sulfate Concentration (mg/L)
	Groundwater Contours

ND = No Data, no sounding tube
EN = Ejido Naco
UN = Urbano Naco

Scale (Feet)

0 2,000 4,000

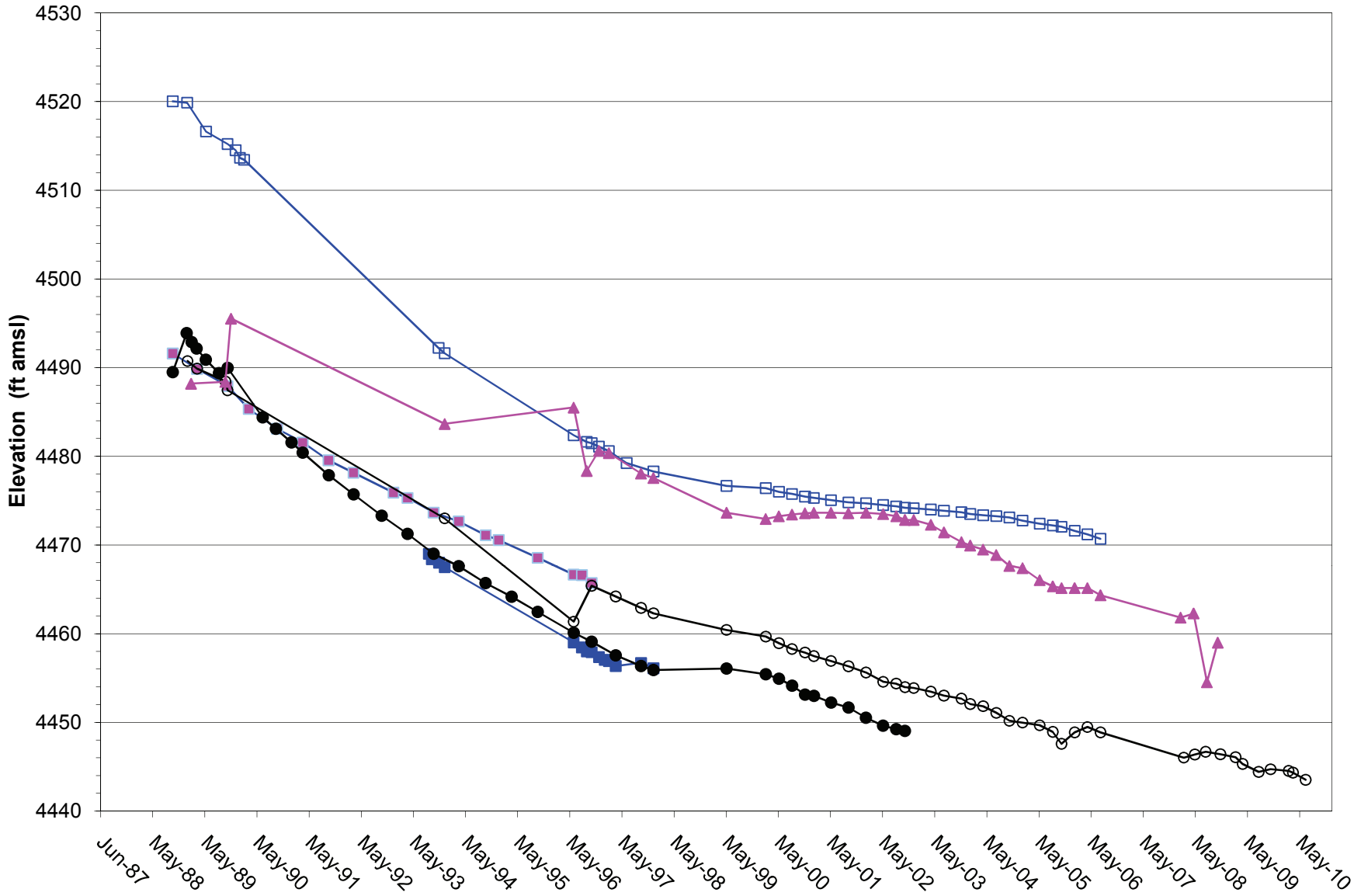
Notes:
Projection: UTM Zone 12N NAD83

FIGURE FROM HGC (2009c)

Date	File ID
11/18/10	055038-078

CLEAR CREEK ASSOCIATES

Figure 21
SULFATE CONCENTRATIONS AND GROUNDWATER ELEVATIONS FOR NACO, SONORA OCTOBER 2008



EXPLANATION

- TM-02, Basin Fill
- TM-19, Basin Fill
- BF-02, Basin Fill
- TM-07, Undifferentiated Bisbee Group
- TM-19A, Undifferentiated Bisbee Group
- TM-02A, Glance Conglomerate

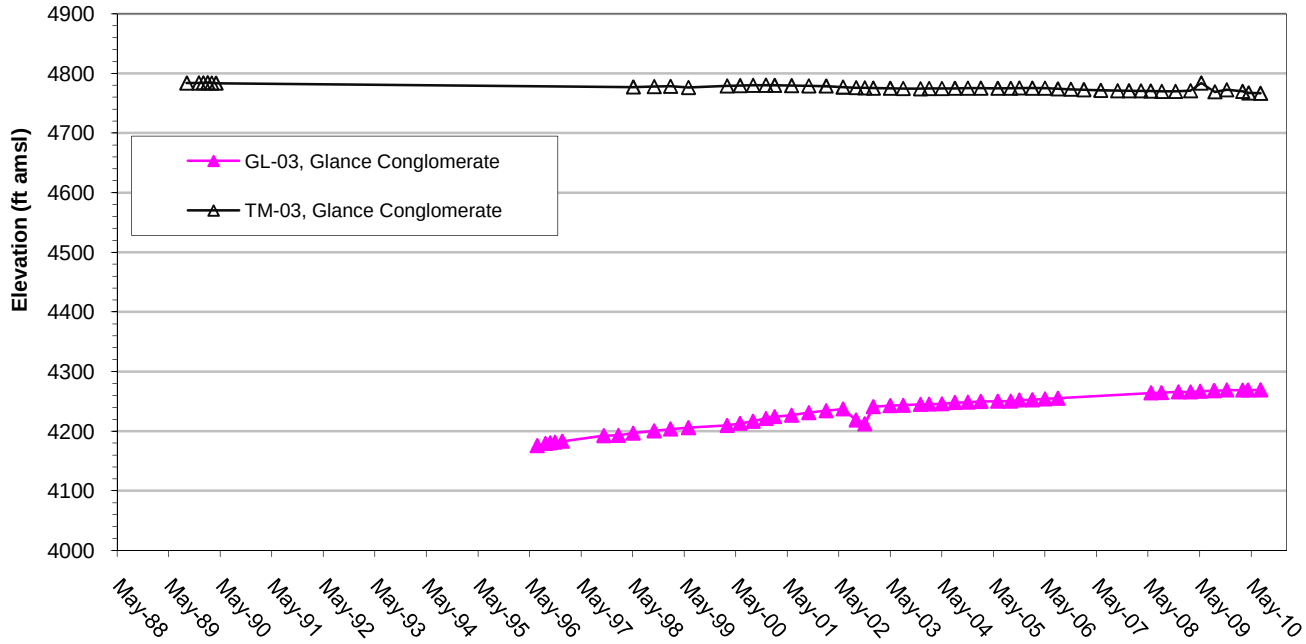
CLEAR CREEK ASSOCIATES

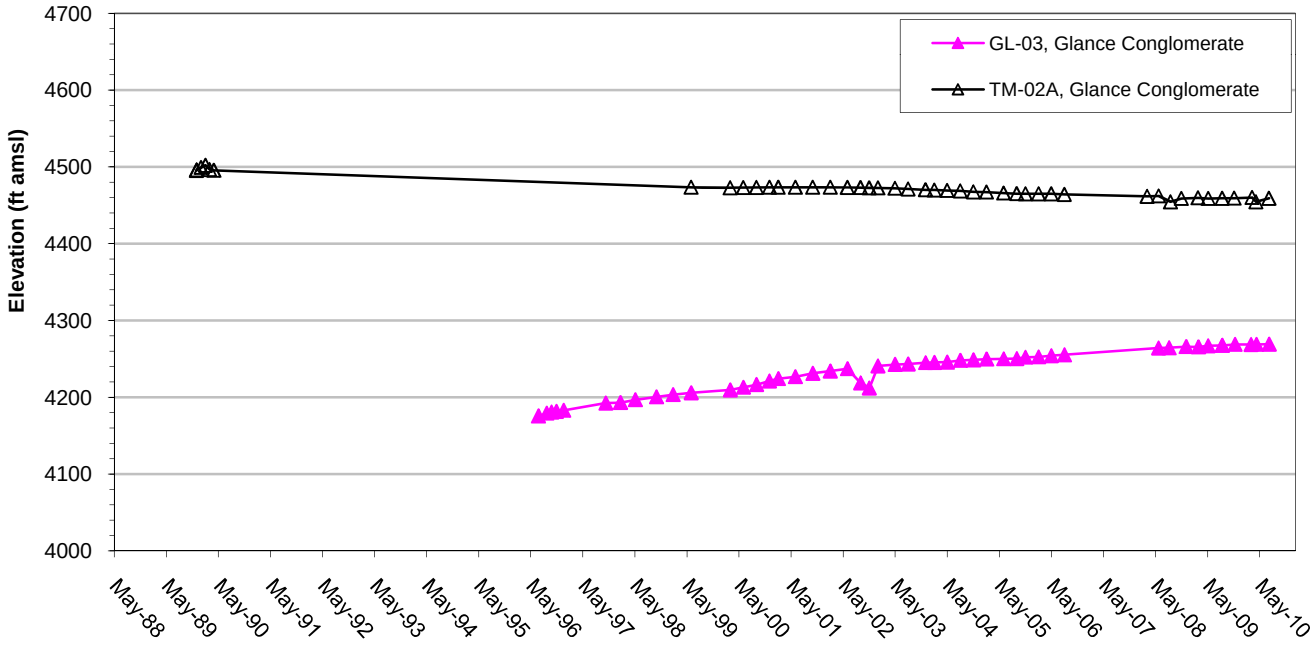
File ID 055038-079

Date 10-11-2010

Figure 22
HYDROGRAPHS FOR BF-02, TM-02, TM-02A, TM-07, TM-19, AND TM-19A

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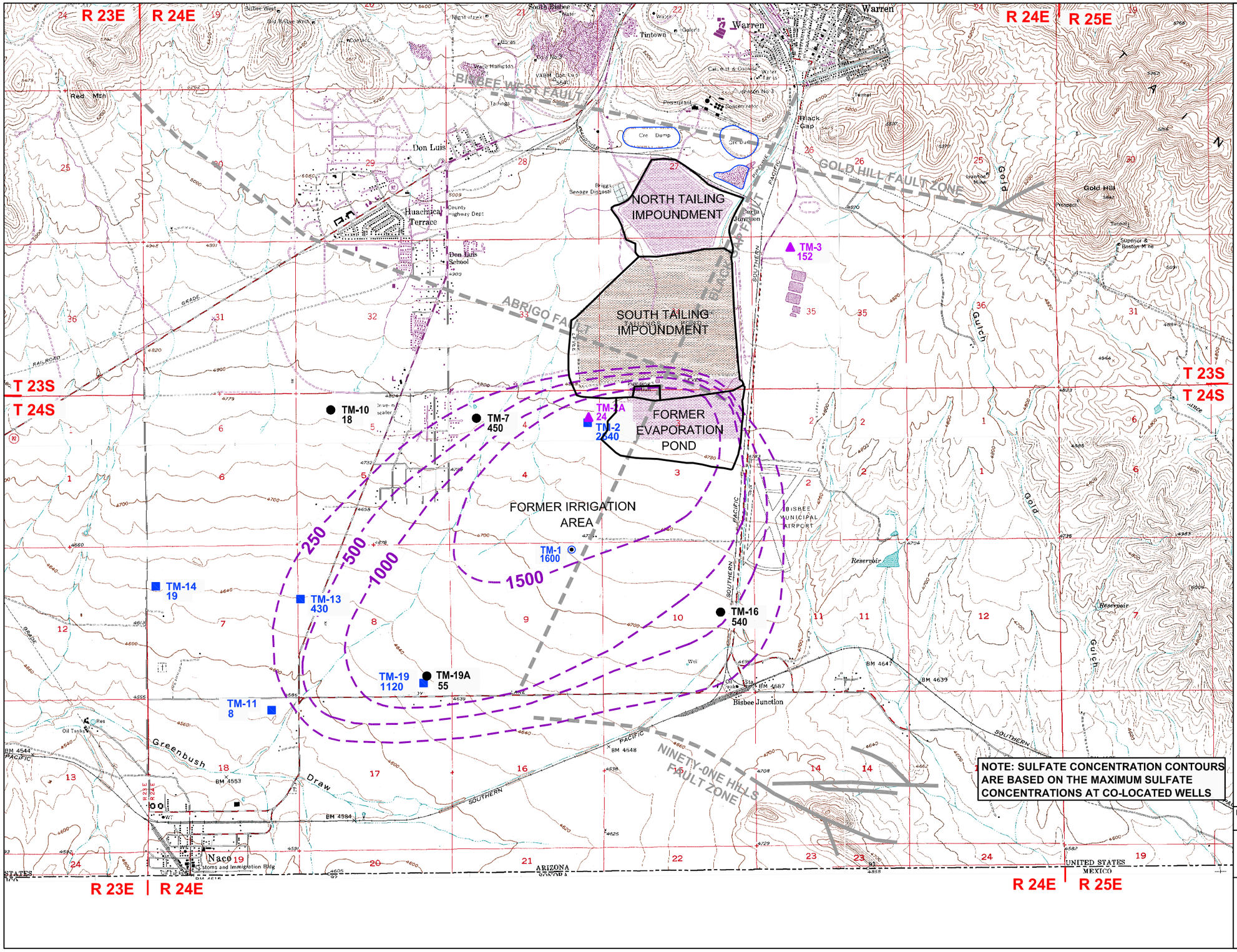
CLEAR CREEK ASSOCIATES

File ID **055038-080**

Date **10-11-2010**

Figure 23
HYDROGRAPHS OF GL-03

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LEGEND

- BASIN FILL
- MORITA FORMATION
- GLANCE CONGLOMERATE
- MIXED, BASIN FILL, AND MORITA FORMATION
- FAULT (DASHED WHERE INFERRED) FROM SET 1998c
- SULFATE CONCENTRATION LINE
- TM-19 1120.0 — WELL ID, SULFATE CONCENTRATION

OPEN SYMBOL DENOTES ABANDONED WELL AS OF 2007

SCALE (FEET)

0 1000 2000

NOTES:

MAP SOURCE: USGS 7.5 MIN QUADS: BISBEE, BISBEE NE, BISBEE SE, AND NACO, ARIZONA.

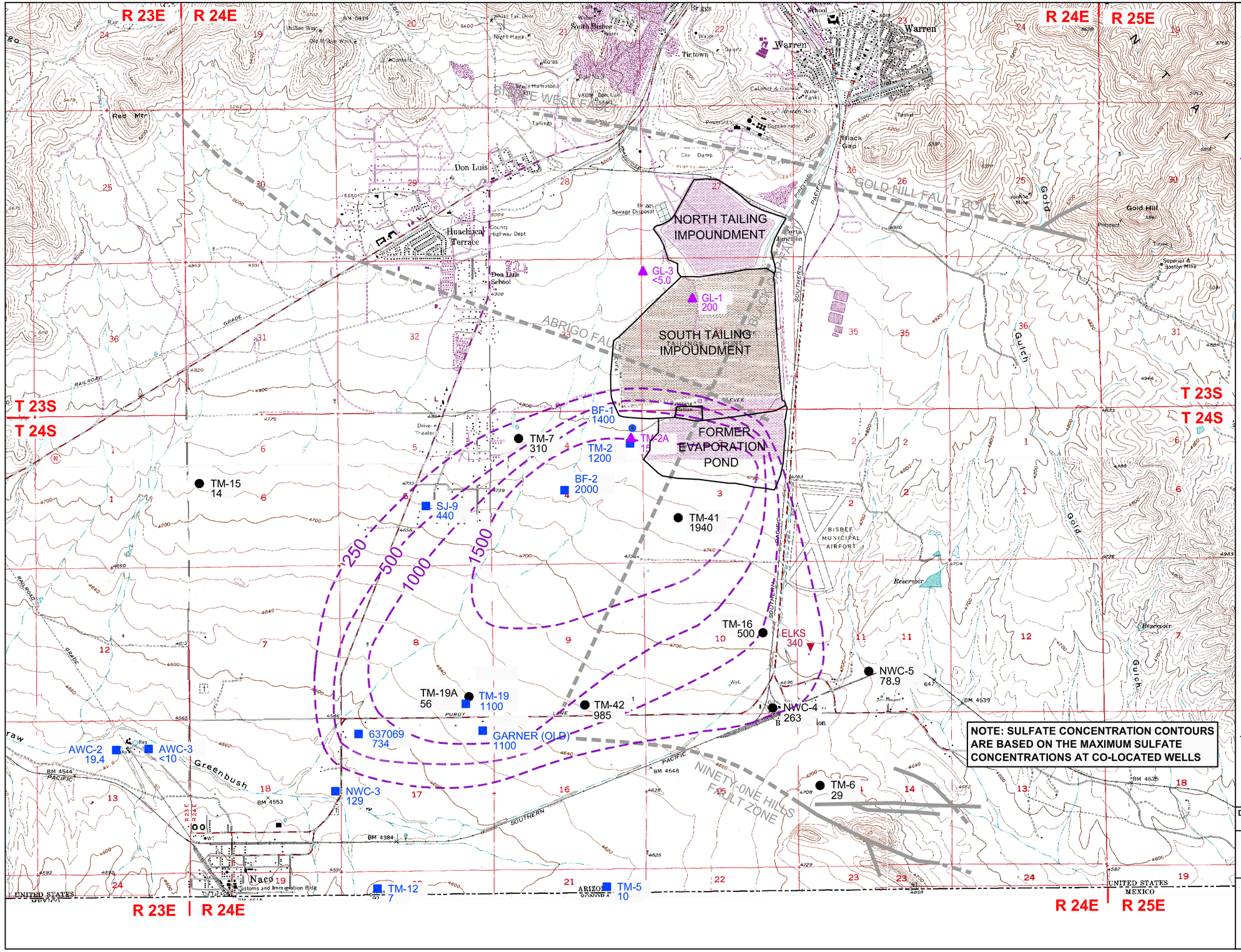
NAD 27 ZONE 12 CENTRAL, METERS

FIGURE FROM HGC (2009c)

Date	File ID
11/29/2010	055038-082

CLEAR CREEK ASSOCIATES

Figure 24
SULFATE CONCENTRATION MAP, JULY 1989



LEGEND

- BASIN FILL
- MORITA FORMATION
- GLANCE CONGLOMERATE
- MIXED, BASIN FILL, AND MORITA FORMATION
- FAULT (DASHED WHERE INFERRED) FROM SET 1998c
- SULFATE CONCENTRATION LINE
- TM-19 1100 — WELL ID, SULFATE CONCENTRATION
- UNKNOWN

[1] DATA FOR JULY 1997

SCALE (FEET)

0 1000 2000

NOTE: SULFATE CONCENTRATION CONTOURS ARE BASED ON THE MAXIMUM SULFATE CONCENTRATIONS AT CO-LOCATED WELLS

NOTES:

MAP SOURCE: USGS 7.5 MIN QUADS: BISBEE, BISBEE NE, BISBEE SE, AND NACO, ARIZONA.

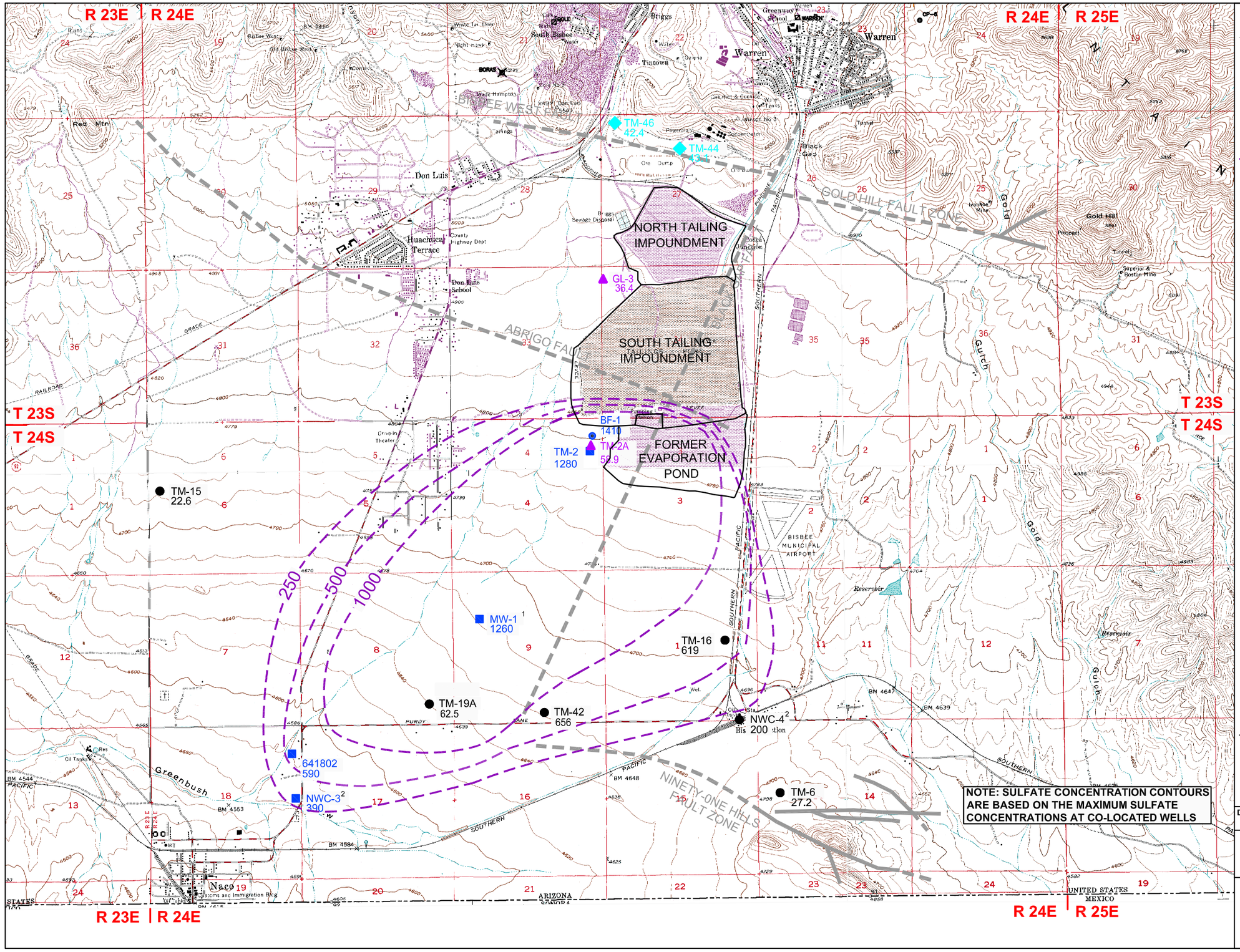
NAD 27 ZONE 12 CENTRAL, METERS

FIGURE FROM HGC (2009c)

Date	File ID
11/29/2010	055038-083

CLEAR CREEK ASSOCIATES

Figure 25
SULFATE CONCENTRATION MAP, SUMMER 1996



LEGEND

- BASIN FILL
- MORITA FORMATION
- GLANCE CONGLOMERATE
- MIXED, BASIN FILL, AND MORITA FORMATION
- FAULT (DASHED WHERE INFERRED) FROM SET 1998c
- SULFATE CONCENTRATION LINE
- TM-19A 62.5 — WELL ID, SULFATE CONCENTRATION
- PALEOZOIC SEDIMENTS

[1] SULFATE CONCENTRATION FROM APRIL 2006

[2] MOST RECENT 2005 CONCENTRATION IS PLOTTED

NOTE: SULFATE CONCENTRATION CONTOURS ARE BASED ON THE MAXIMUM SULFATE CONCENTRATIONS AT CO-LOCATED WELLS

SCALE (FEET)

0 1000 2000

NOTES:

MAP SOURCE: USGS 7.5 MIN QUADS: BISBEE, BISBEE NE, BISBEE SE, AND NACO, ARIZONA.

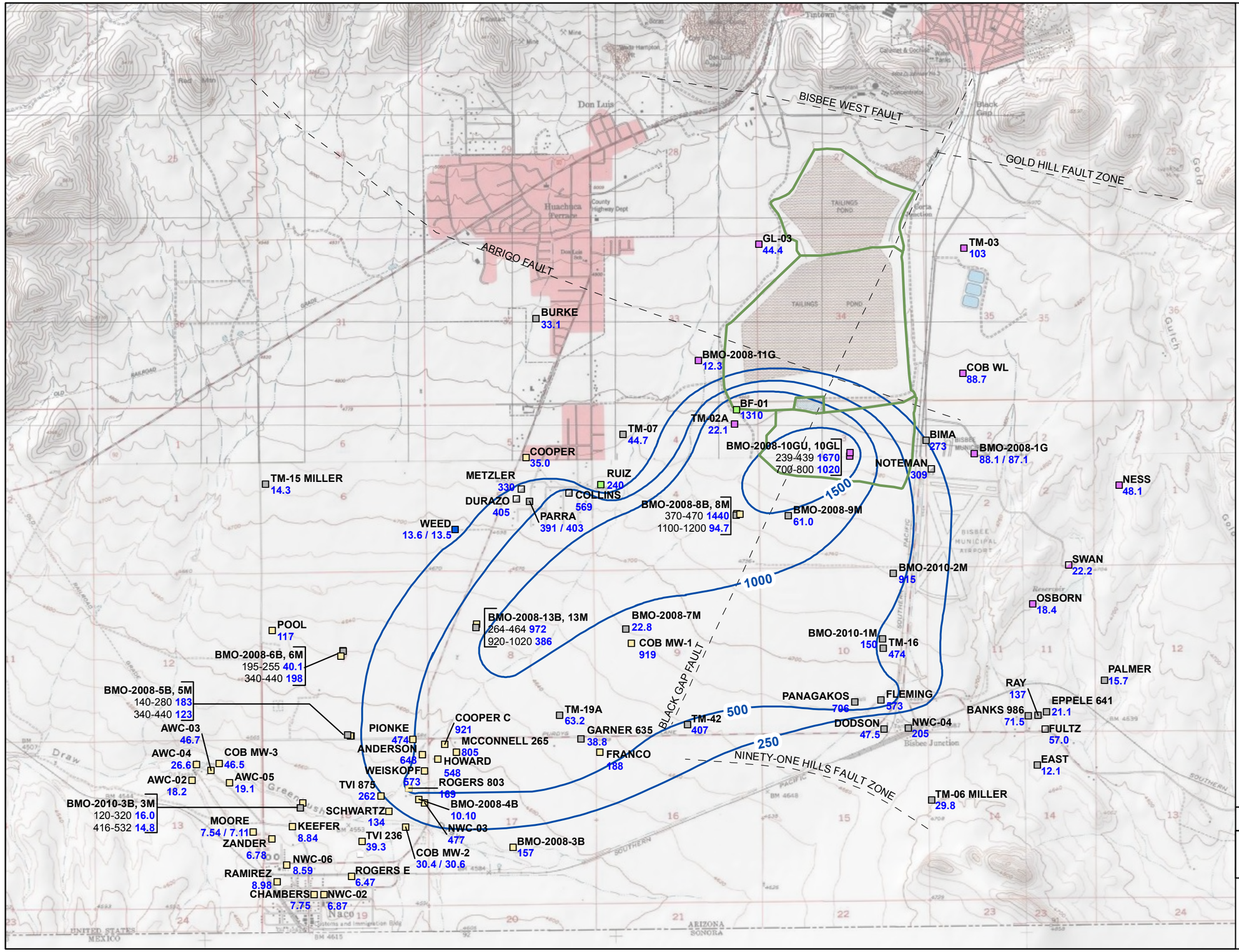
NAD 27 ZONE 12 CENTRAL, METERS

FIGURE FROM HGC (2009c)

Date	File ID
11/29/2010	055038-084

CLEAR CREEK ASSOCIATES

Figure 26
SULFATE CONCENTRATION MAP, AUGUST THROUGH NOVEMBER 2005



Legend

- POOL — Well ID
- 117 — Sulfate Concentration (mg/L)
- Sulfate Concentration Contour (mg/L)
- Faults (inferred)
- CTSA Facility

Co-located Wells
- Well ID
- Screen (ft bls): SO4 Concentration (mg/L)

Screened Formation
- Basin Fill
- Basin Fill and Undifferentiated
- Bisbee Group
- Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group - Estimated
- Undifferentiated Bisbee Group and Glance Conglomerate
- Glance Conglomerate
- Glance Conglomerate-Estimated

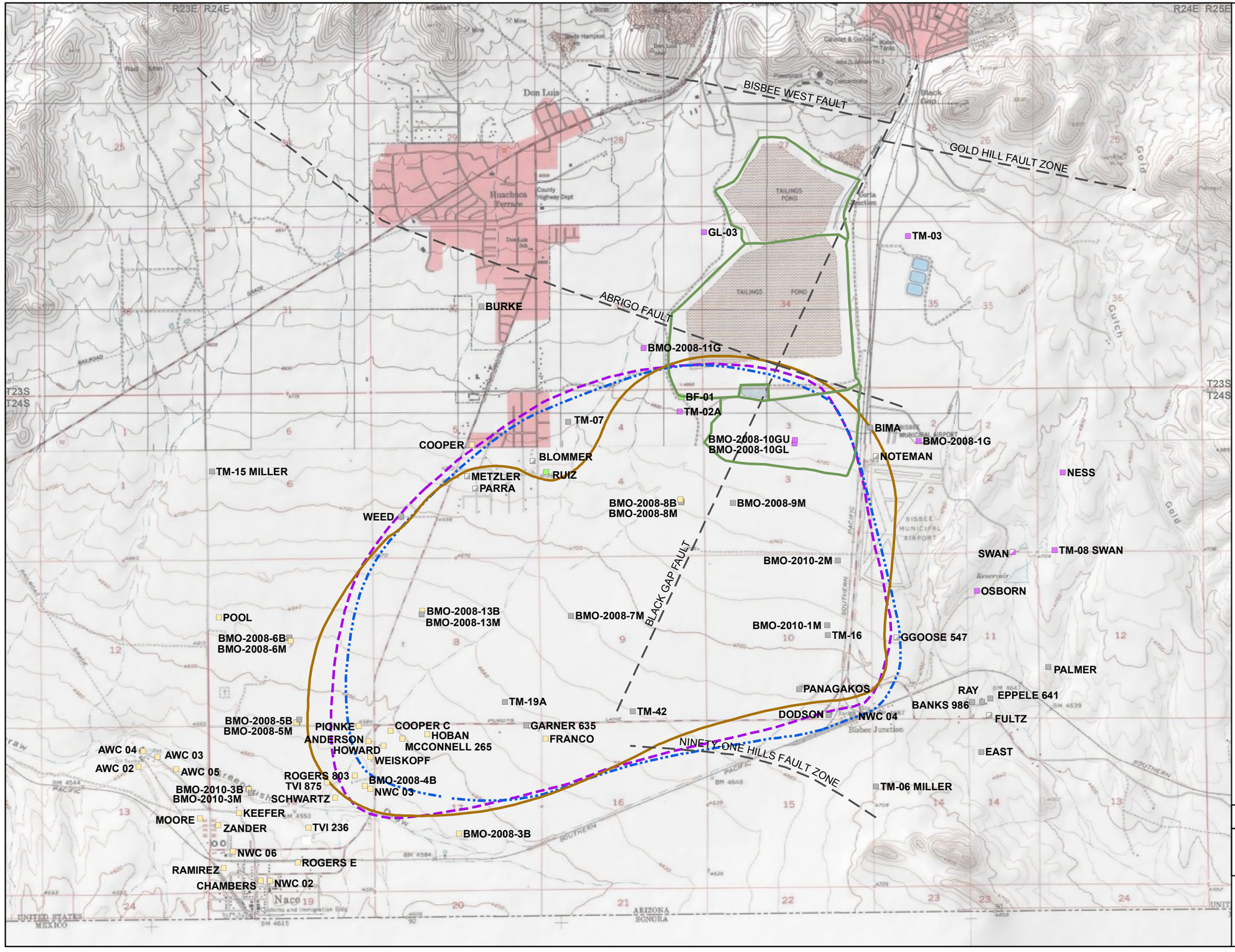
Undifferentiated Bisbee Group: Cintura, Mural Limestone, and Morita Formations

Notes:
Projection: UTM Zone 12N NAD83

Date	File ID
11/29/10	055038-054A

CLEAR CREEK ASSOCIATES

Figure 27
SULFATE CONCENTRATION MAP FOR THIRD QUARTER 2010



Legend

- **MOORE** Well Location and ID
- 3rd Quarter 2010 - 250 mg/L Sulfate Isoline
- 2005 - 250 mg/L Sulfate Isoline
- 1996 - 250 mg/L Sulfate Isoline
- Faults (inferred)
- CTSA Facility

Screened Formation

- Basin Fill
- Basin Fill and Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group - Estimated
- Glance Conglomerate
- Glance Conglomerate-Estimated

Undifferentiated Bisbee Group: Cintura, Mural Limestone, and Morita Formations

Scale (Feet)

0 3,000 6,000

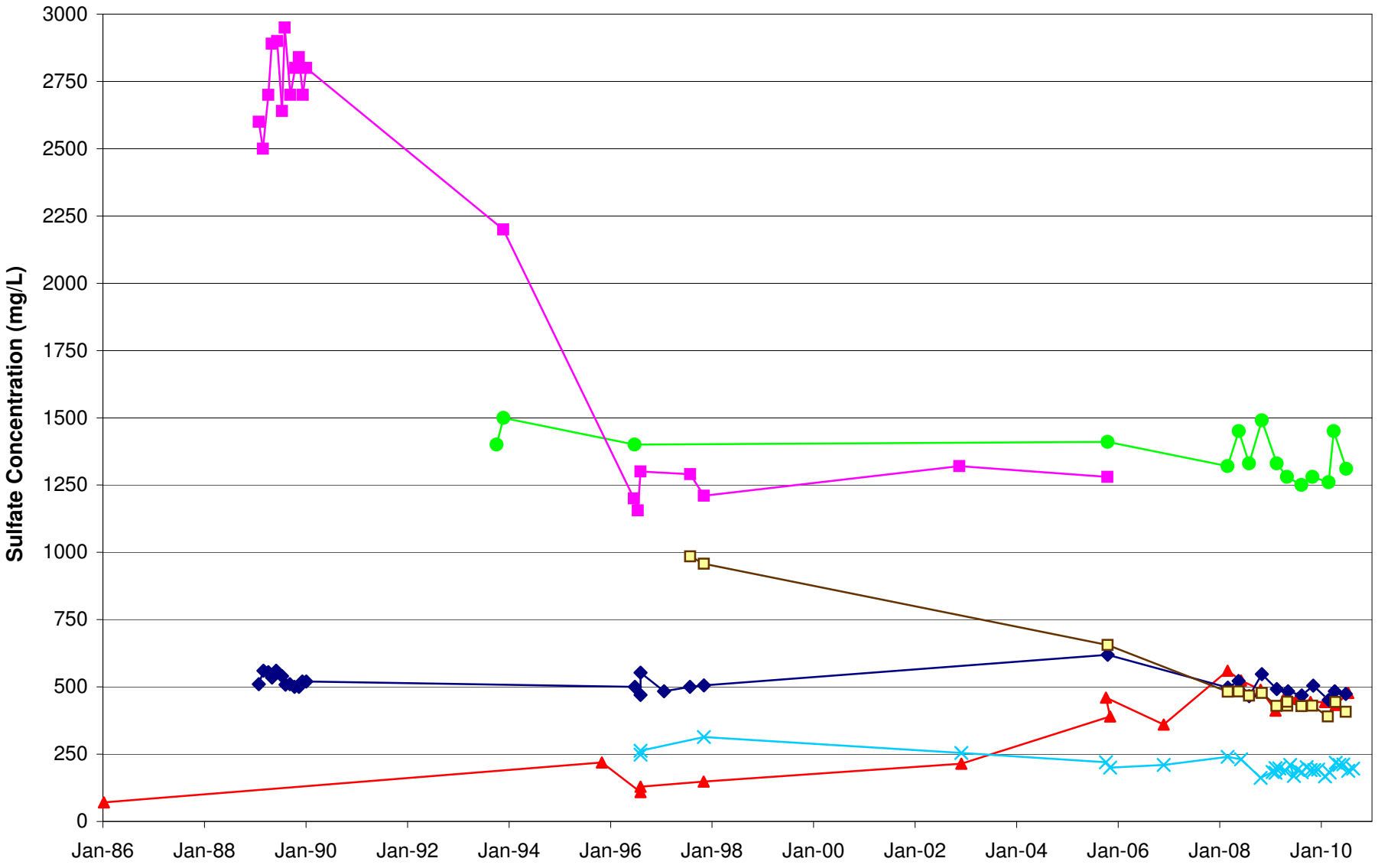
Notes:

Projection: UTM Zone 12N NAD83

Date	File ID
11/29/10	055038-086

CLEAR CREEK ASSOCIATES

Figure 28
COMPARISON OF 1996, 2005, AND 2010 SULFATE PLUME BOUNDARIES



EXPLANATION

- BF-01 Basin Fill and Morita Formation
- NWC-03 Basin Fill (includes data for NWC-03 CAP)
- NWC-04 Undifferentiated Bisbee Group (includes data for NWC-04 CAP)
- TM-02 Basin Fill
- TM-16 Undifferentiated Bisbee Group
- TM-42 Undifferentiated Bisbee Group

Note: August 6, 1996 TM-02 value of 523 mg/L not shown

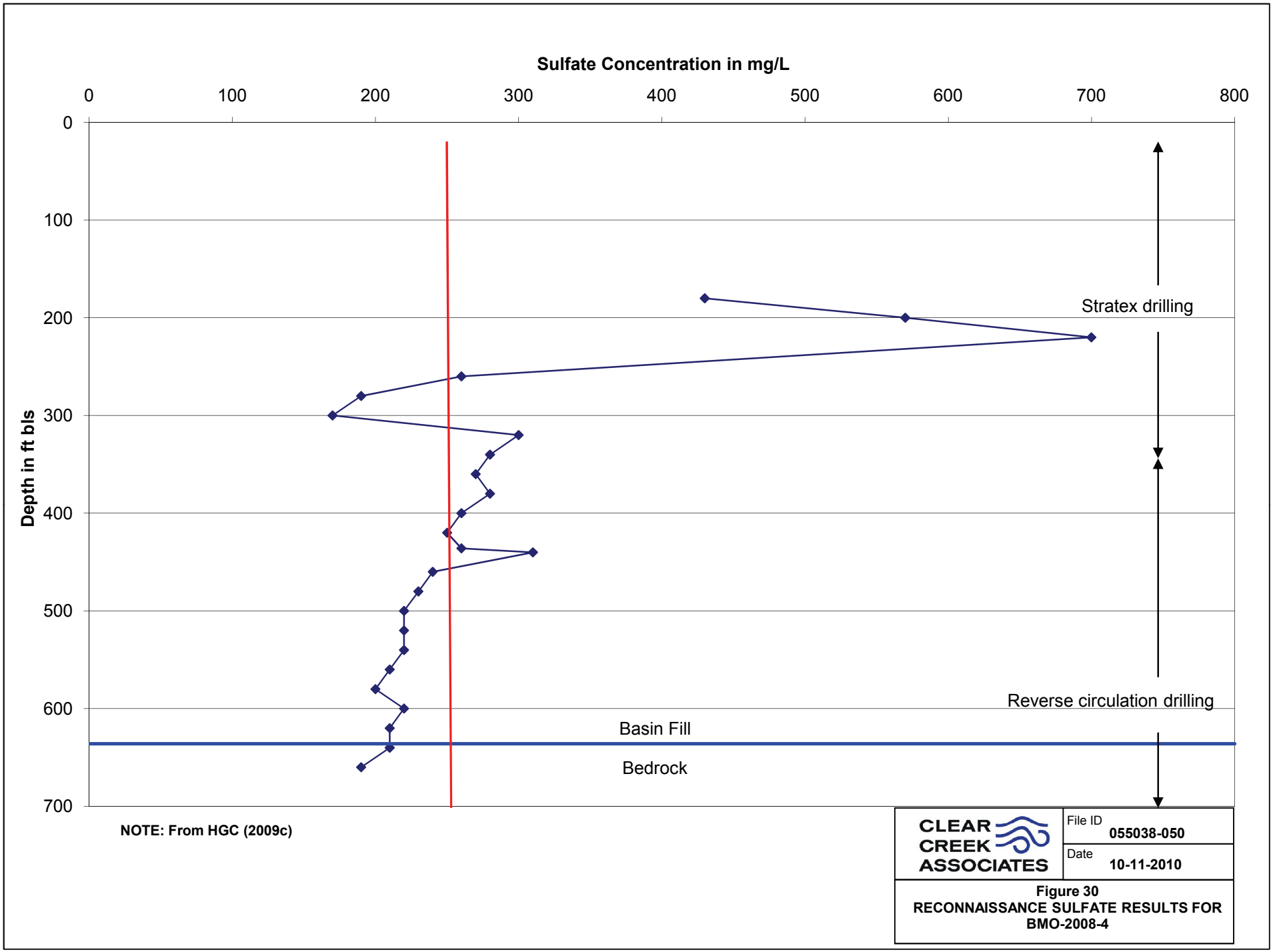
CLEAR CREEK ASSOCIATES

File ID **055038-081**

Date **10-11-2010**

Figure 29
SULFATE CONCENTRATIONS IN WELLS
BF-01, NWC-03, NWC-04, TM-02, TM-16, and TM-42

N:\Projects\G & K\055038_Copper Queen Branch Mitigation Order\Aquifer Characterization Report\Task 4 ACR\figures\ Figure 29revised2010.xls: F29



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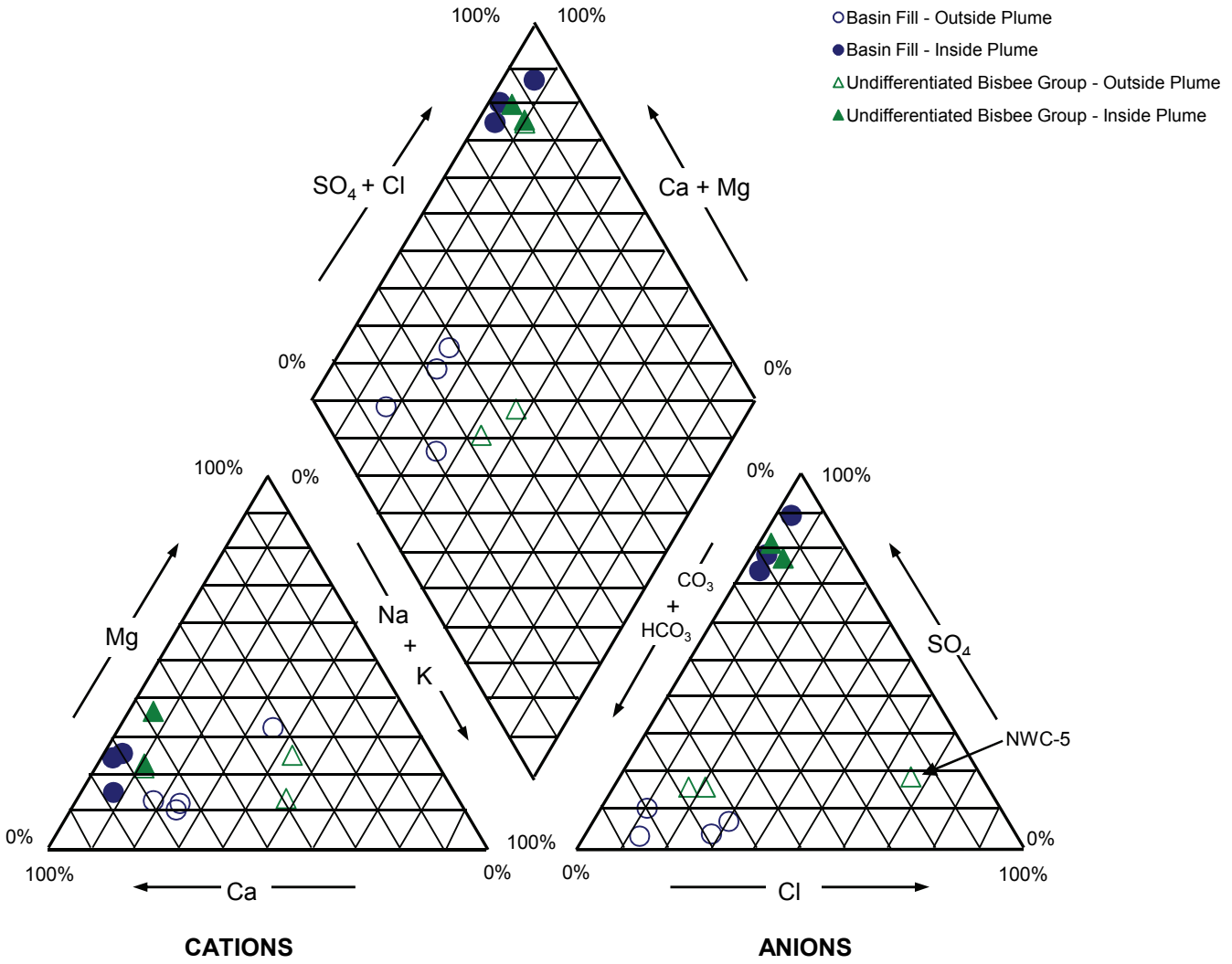


Figure From HGC (2009c)

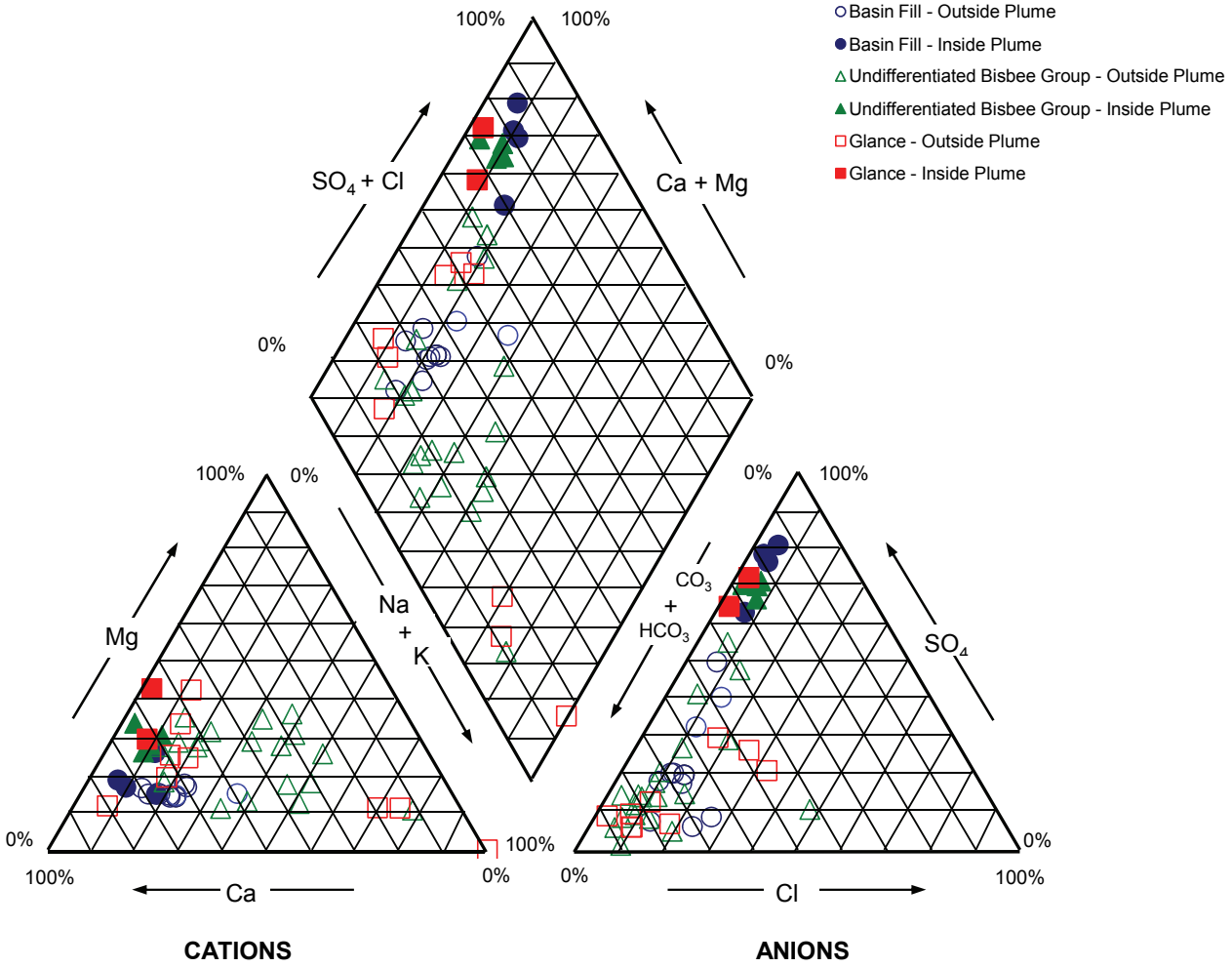
CLEAR CREEK ASSOCIATES

File ID

Date **10-11-2010**

Figure 31
Piper Diagram for 1996 Data

L:\Projects\G & K\055038_Copper Queen Branch Mitigation Order\Aquifer Characterization Report\Task 4 ACR\figures\Figure 31.xls: piper graph



NOTE: From HGC (2009c) Figure 32

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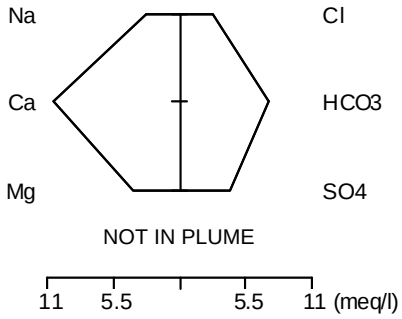
File ID **055038-079**

Date **10-11-2010**

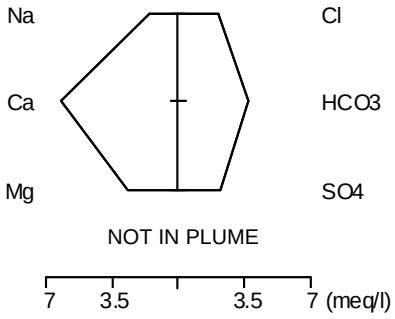
Figure 32A
Piper Diagram for 2008 Data

L:\Projects\G & K\055038_Copper Queen Branch Mitigation Order\055038 Figures and GIS\055038 Figures and Maps\055038-052 Piper Diagram for 2008 Data.xls: piper graph

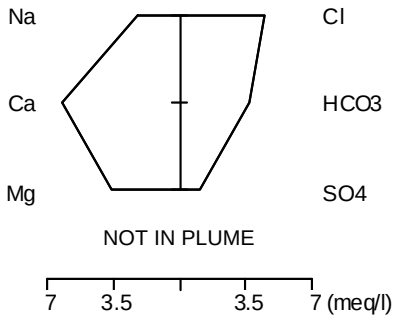
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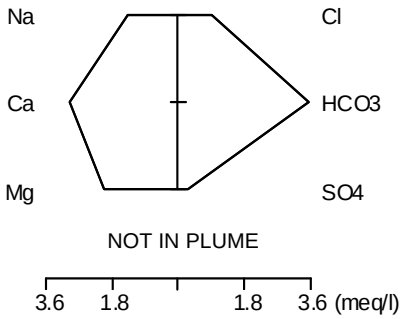
BMO-2008-1G



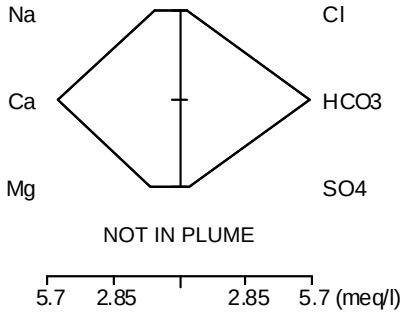
DODSON



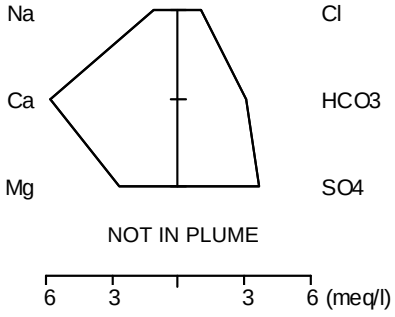
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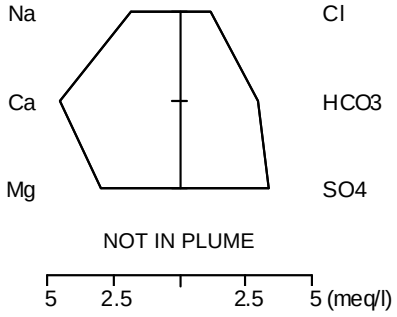
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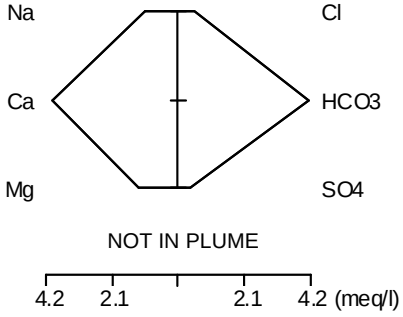
GGOOSE 547



NWC-04



OSBORN



Note: Source Data - Table 19B

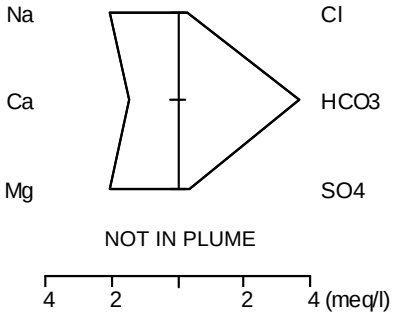
CLEAR CREEK ASSOCIATES

FILE ID
STIFF DIAGRAM

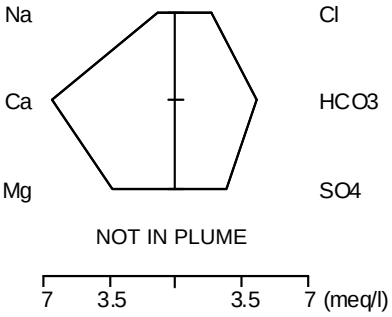
DATE
10/12/10

Figure 32B
Stiff Diagrams For Selected Bedrock Wells East Of The Black Gap Fault
Page 1 of 2

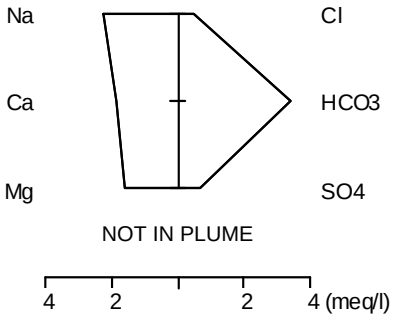
PALMER



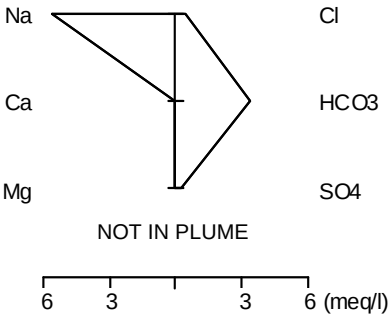
PANAGAKOS



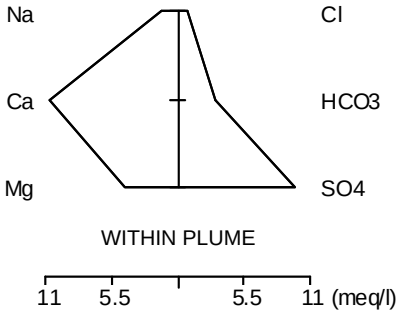
TM-06 MILLER



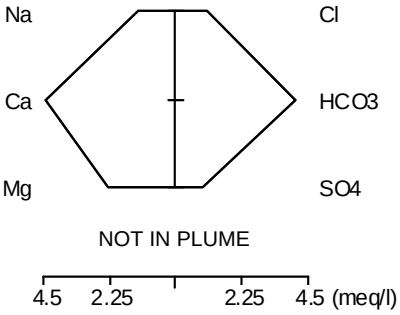
TM-08 SWAN



TM-16



WALKER



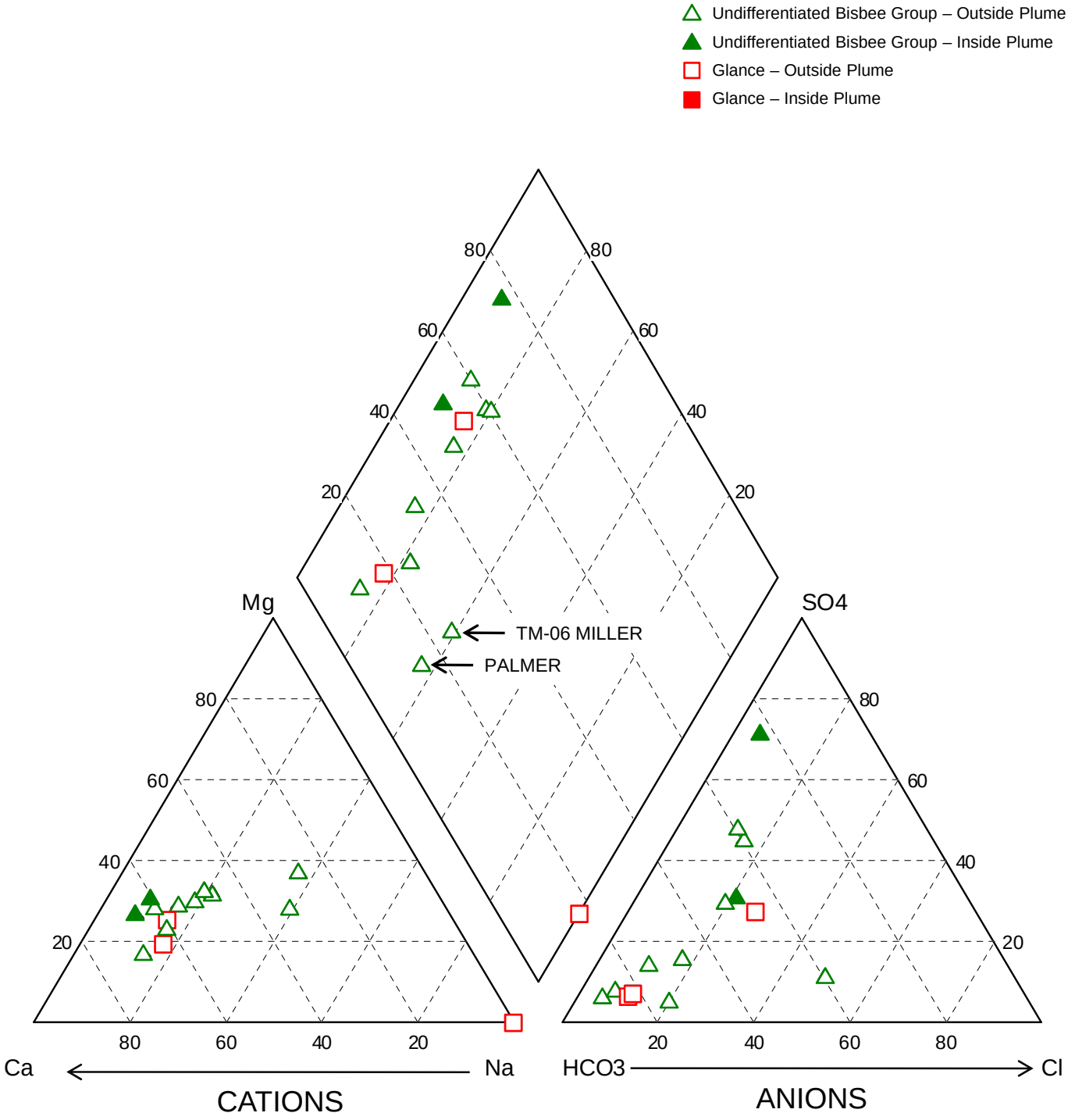
Note: Source Data - Table 19B

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FILE ID
STIFF DIAGRAM

DATE
10/12/10

Figure 32B
Stiff Diagrams For Selected Bedrock Wells East Of The Black Gap Fault
Page 2 of 2



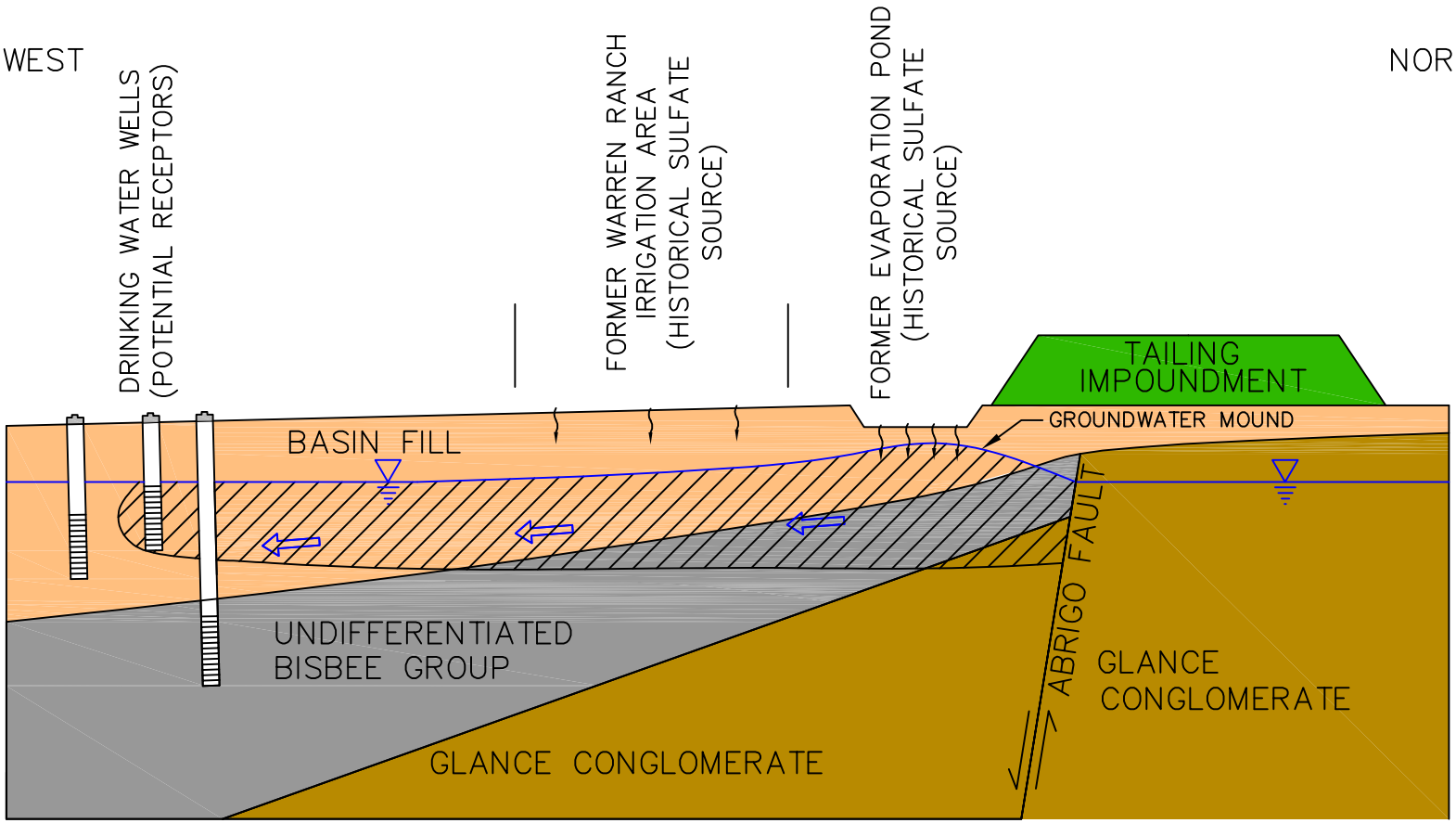
Note: Source Data - Table 19B

CLEAR CREEK ASSOCIATES

FILE ID
PIPER PLOT

DATE
10/12/10

Figure 32C
Piper Diagram
For Selected Bedrock Wells East Of The Black Gap Fault



LEGEND

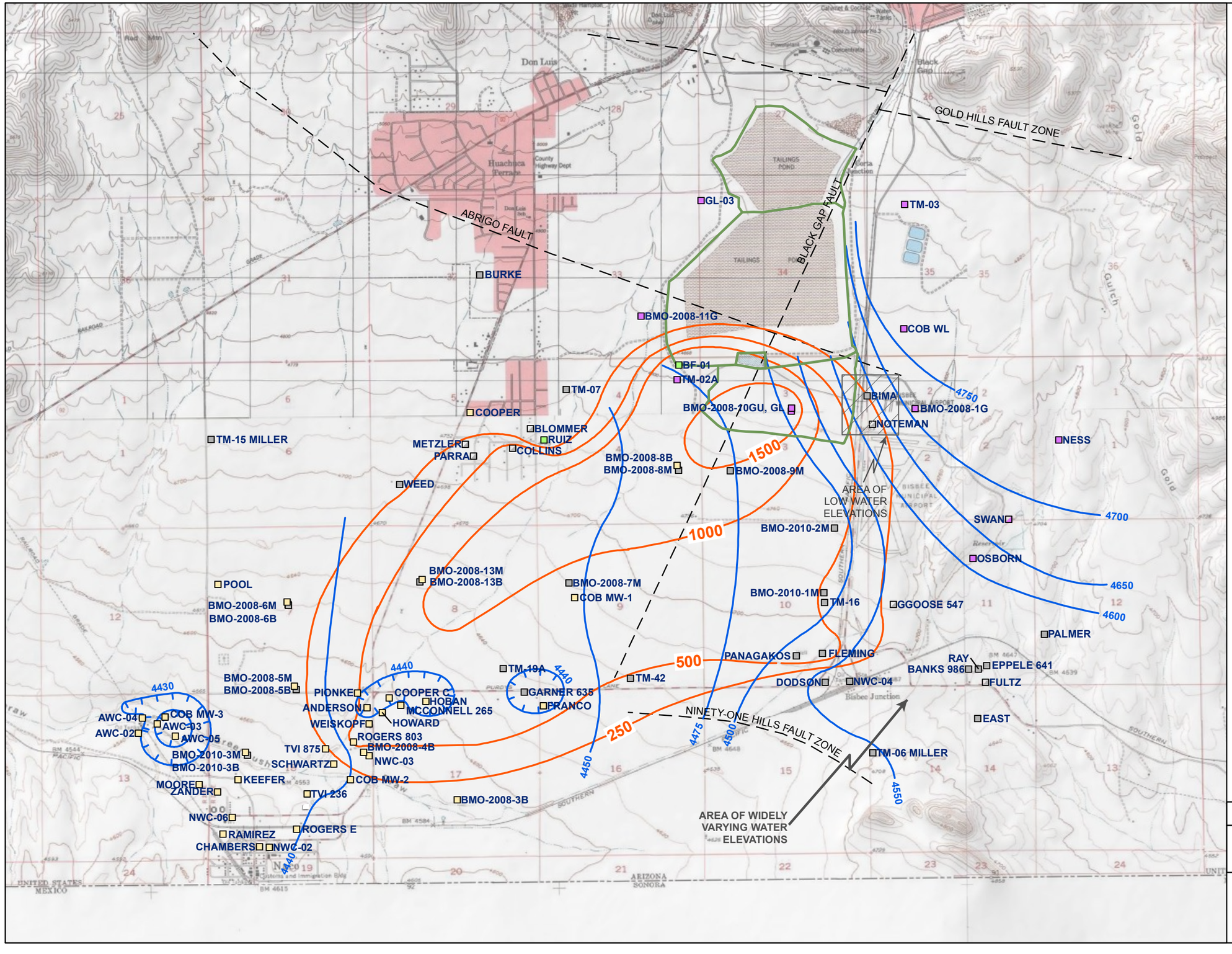
- WATER TABLE
- SULFATE–BEARING SEEPAGE THROUGH VADOSE ZONE
- GROUNDWATER FLOW DIRECTION (MIGRATION PATHWAY)
- SULFATE – BEARING GROUNDWATER
- WELL
- SCREENED INTERVAL

FIGURE FROM HGC (2009c)

N.T.S.

11/15/2010	File ID 055038-120
N	CLEAR CREEK ASSOCIATES

Figure 33
SCHEMATIC DIAGRAM OF CONCEPTUAL SITE MODEL FOR HISTORICAL SULFATE SOURCES



Legend

- TM-19A — Well ID
- 250 — Sulfate Isoline (mg/L)
- Faults (inferred)
- CTSA Facility
- 4500 — Groundwater Elevation Contour (ft amsl) (dashed where inferred)

Screened Formation

- Basin Fill
- Basin Fill and Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group - Estimated
- Glance Conglomerate
- Glance Conglomerate-Estimated

Undifferentiated Bisbee Group: Cintura, Mural Limestone, and Morita Formations

Scale (Feet)

0 — 3,000 — 6,000

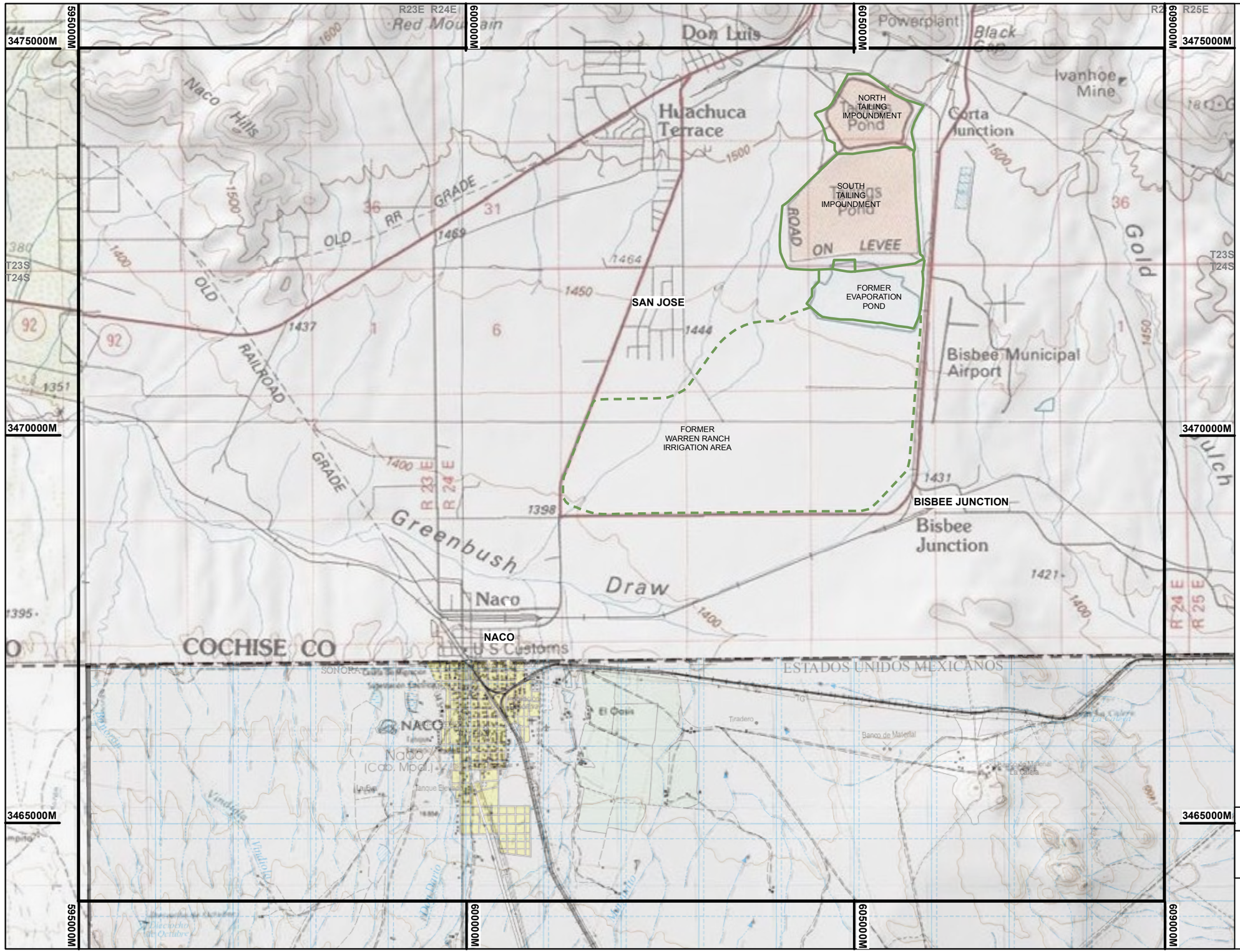
Notes:

Projection: UTM Zone 12N NAD83

Date	File ID
11/29/10	055038-087

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Figure 34
SULFATE CONCENTRATIONS AND GROUNDWATER ELEVATIONS FOR THIRD QUARTER 2010



Legend

- Numerical Model Extent
- CTSA Facility
- Former Warren Ranch Irrigation Area

Scale (Feet)

0 4,000 8,000

Notes:
Projection: UTM Zone 12N NAD83

FIGURE FROM HGC (2009c)

Date	File ID
11/29/10	055038-088

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Figure 35
RSET MODEL EXTENT

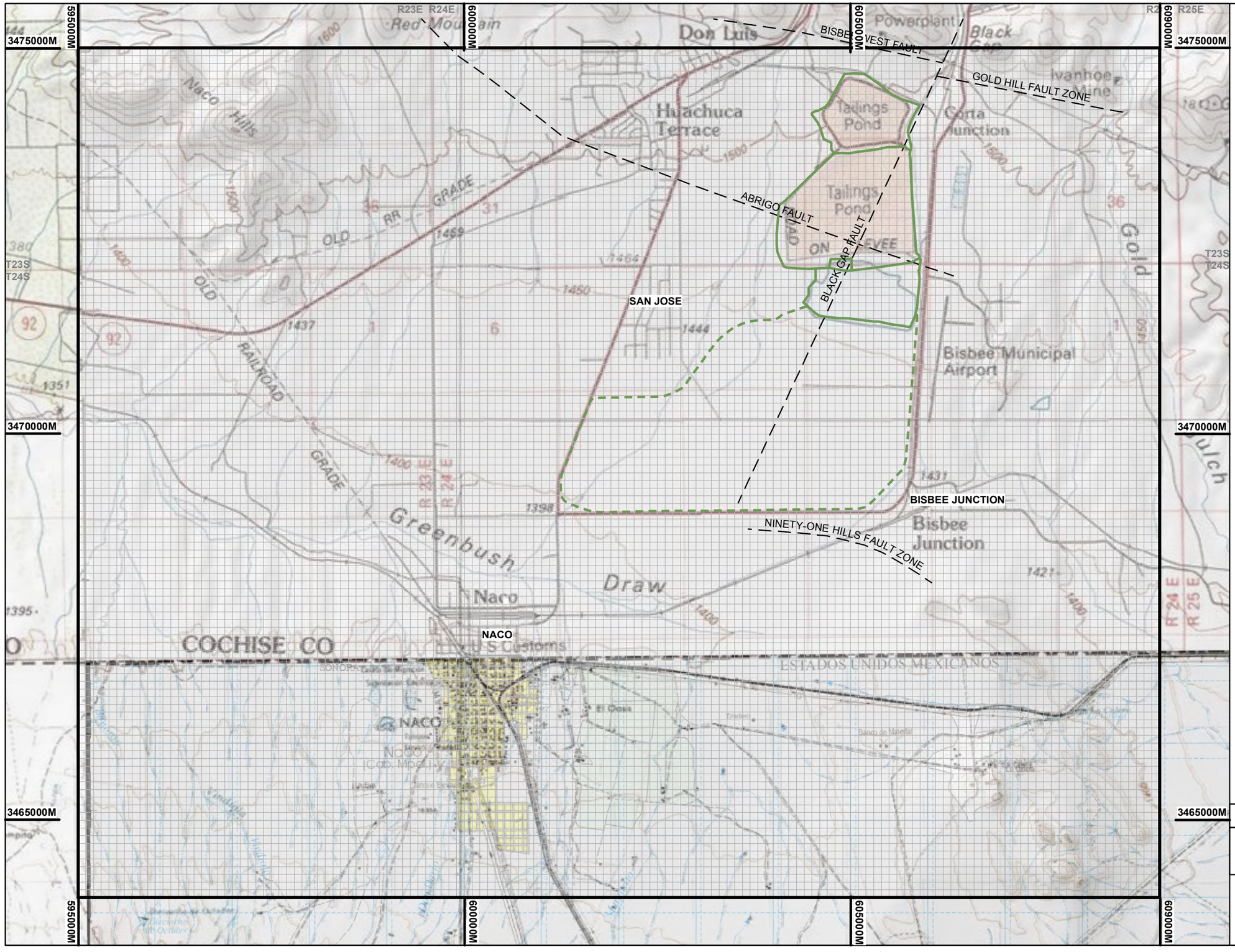
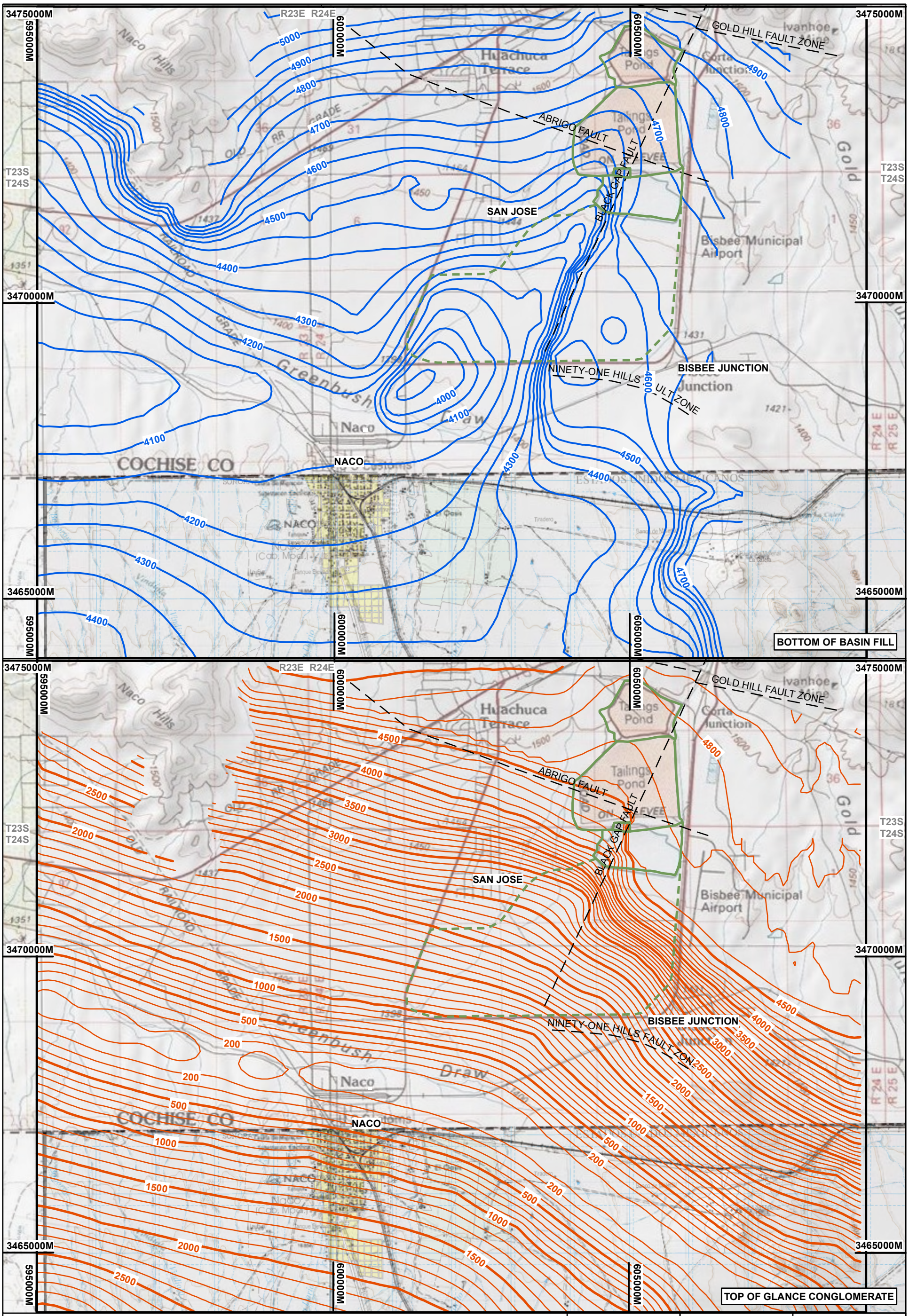


Figure 36
RSET MODEL DISCRETIZATION



Legend

- Numerical Model Extent
- Top of Glance Conglomerate - 100 ft Contour Intervals
- Bottom of Basin Fill - 50 ft Contour Intervals
- CTSA Facility
- Former Warren Ranch Irrigation Area
- Faults (inferred)

Scale (Feet)

0 2,500 5,000

Notes:

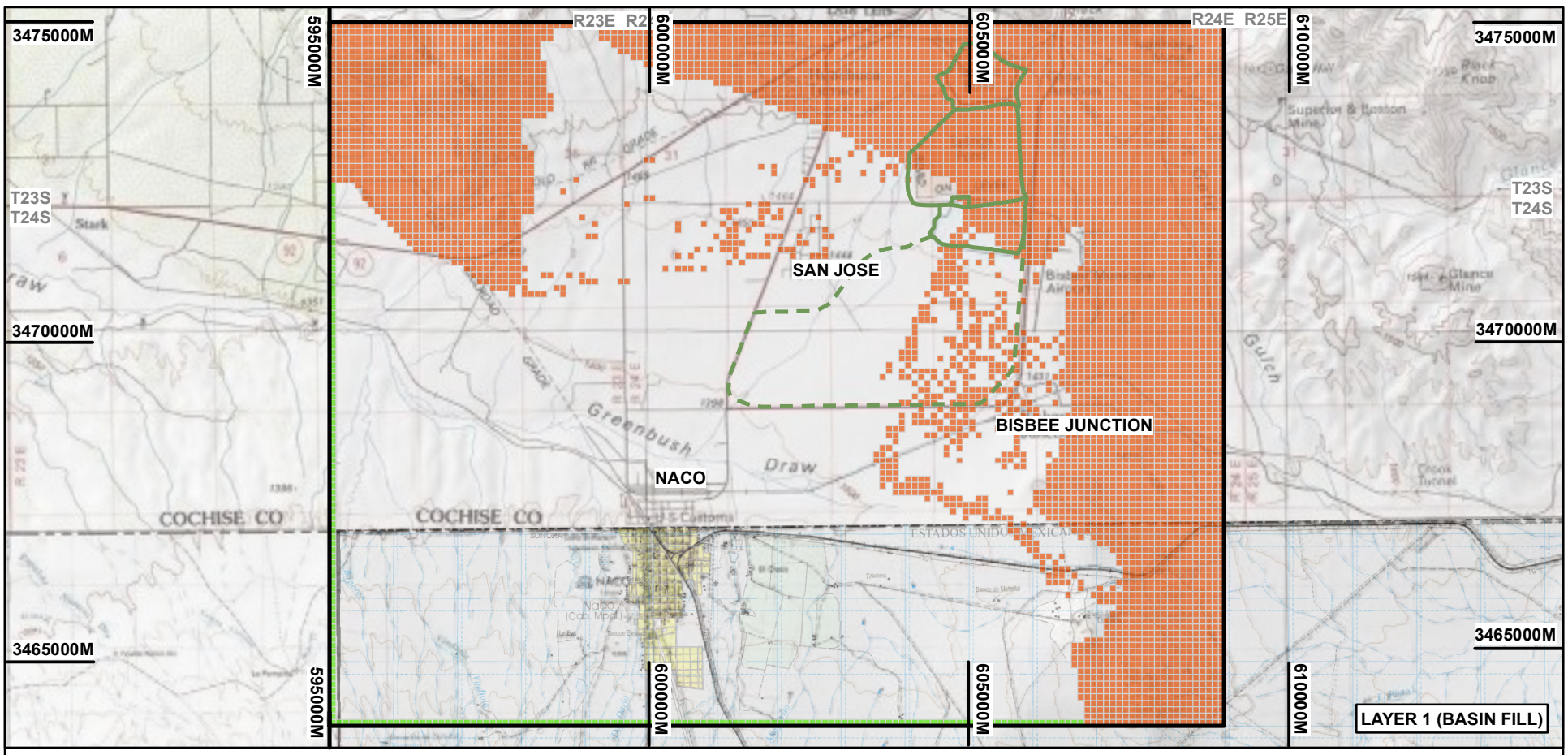
Projection: UTM Zone 12N NAD83
FIGURE FROM HGC (2009c)

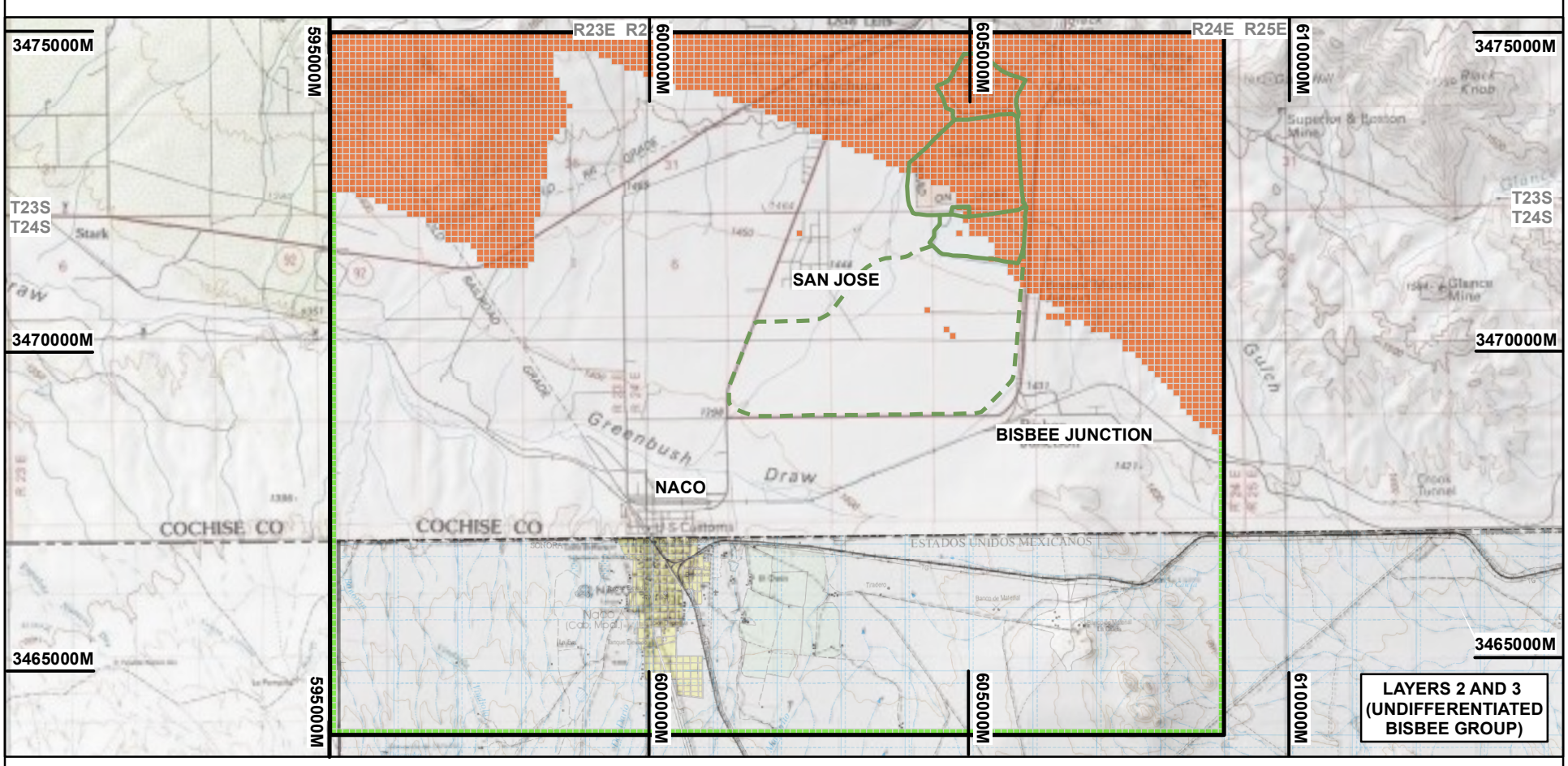
CLEAR CREEK ASSOCIATES

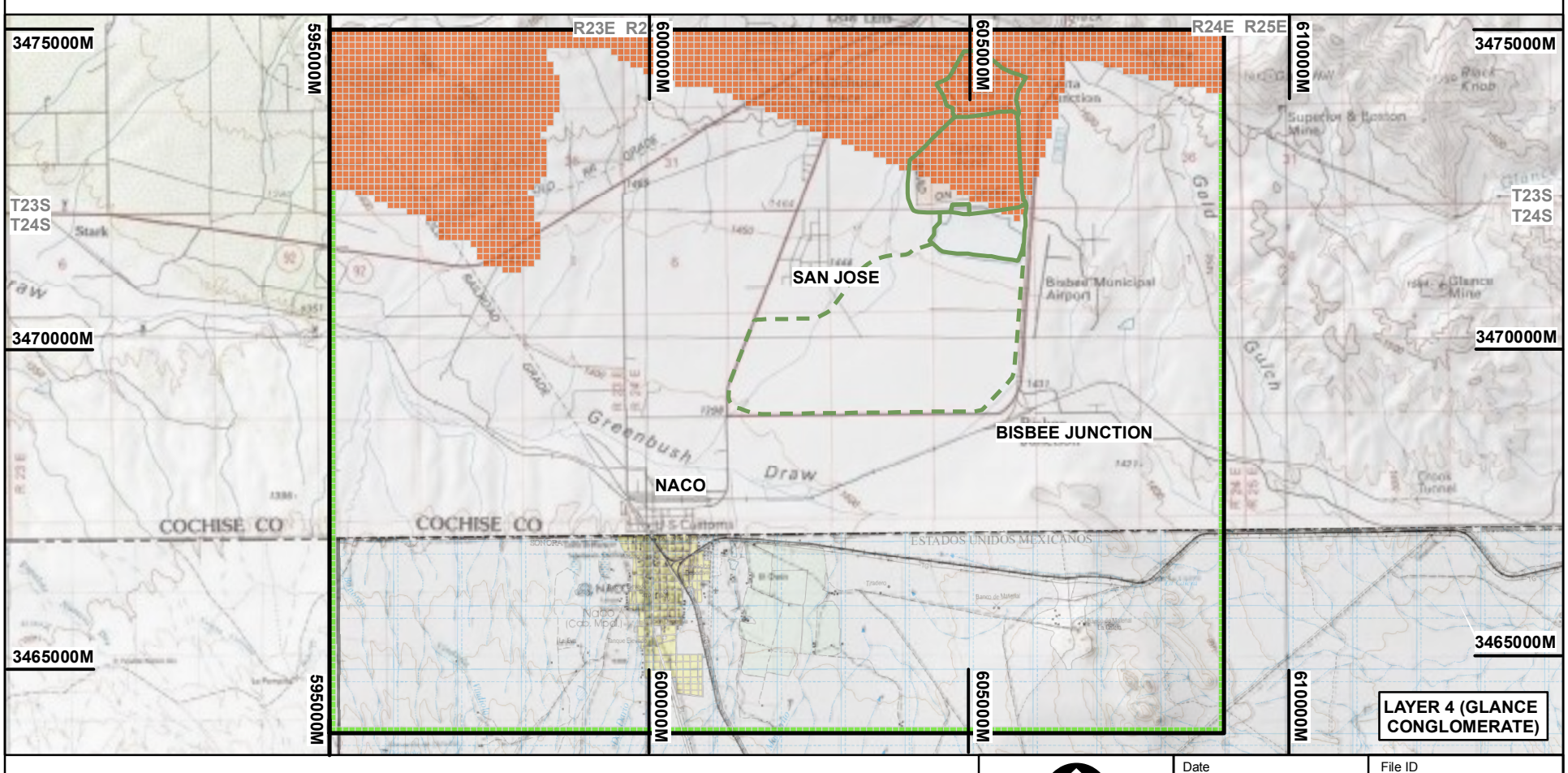
Date 12/08/10

File ID 055038-090

Figure 37
BEDROCK SURFACE CONTOURS







Legend

- Numerical Model Extent
- Specified Head Boundary
- No Flow Boundary
- CTSA Facility
- Former Warren Ranch Irrigation Area

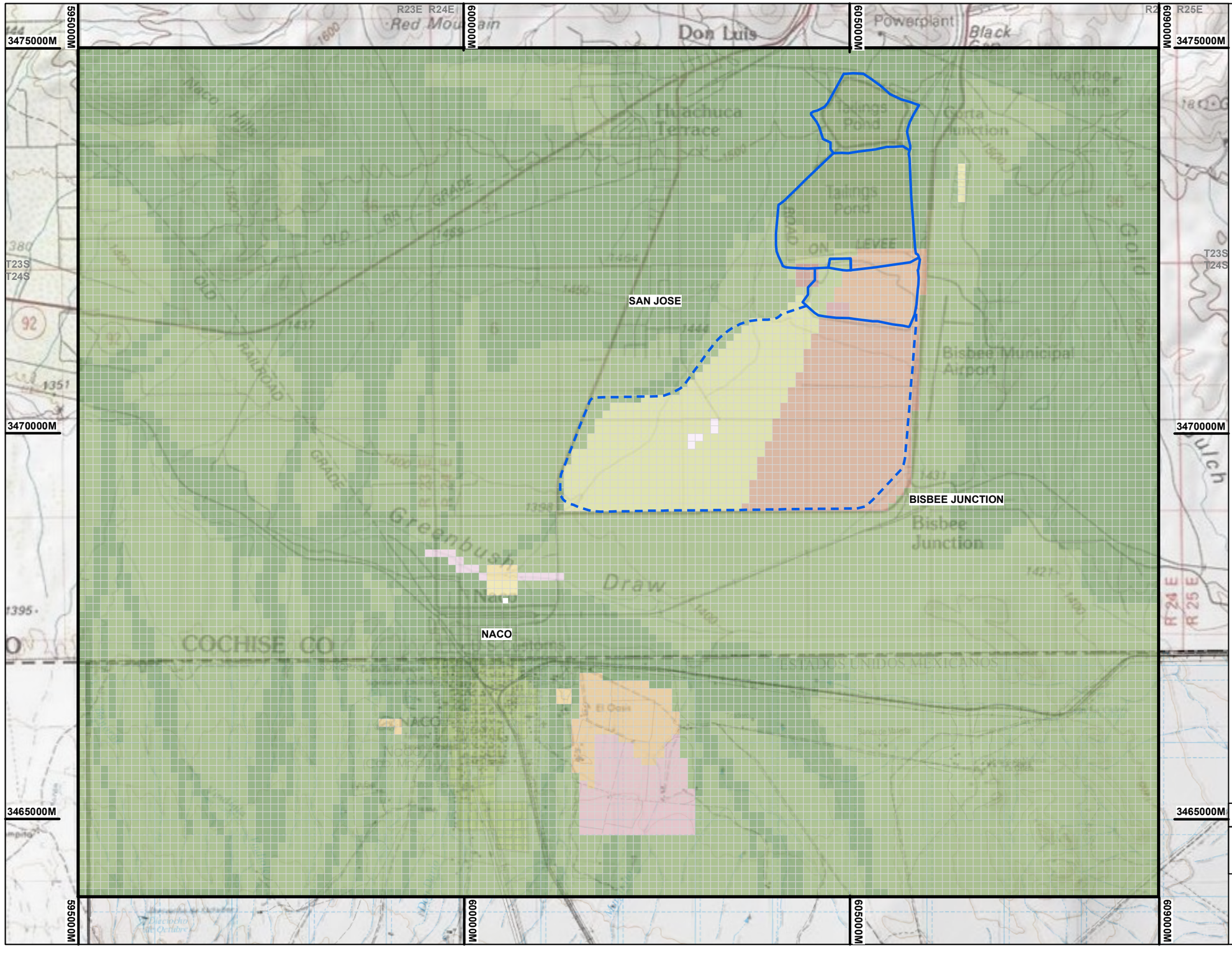
0 4,000 8,000 Feet

Notes:
Projection: UTM Zone 12N NAD83
FIGURE FROM HGC (2009c)

CLEAR CREEK ASSOCIATES

Date: 11/29/10
File ID: 055038-091

Figure 38
SPECIFIED HEAD AND NO FLOW BOUNDARY LOCATIONS



Legend

- Numerical Model Extent
- CTSA Facility
- Former Warren Ranch Irrigation Area

Recharge Zones

- Natural Recharge - High
- Natural Recharge - Low
- Former Evaporation Pond - West
- Warren Ranch Irrigation Area - West
- Warren WWTF Lagoons
- TVI Golf Course - Original
- TVI Golf Course - Expansion
- Naco, Sonora WWTF Lagoons
- El Oasis Irrigation - Original
- Former Evaporation Pond - East
- Warren Ranch Irrigation Area - East
- Elevated Concentration Zone - West
- Elevated Concentration Zone - East
- El Oasis - Expansion
- San Jose WWTF Discharge to Greenbush
- San Jose WWTF Lagoons

Scale (Feet)

0 4,000 8,000

Notes:

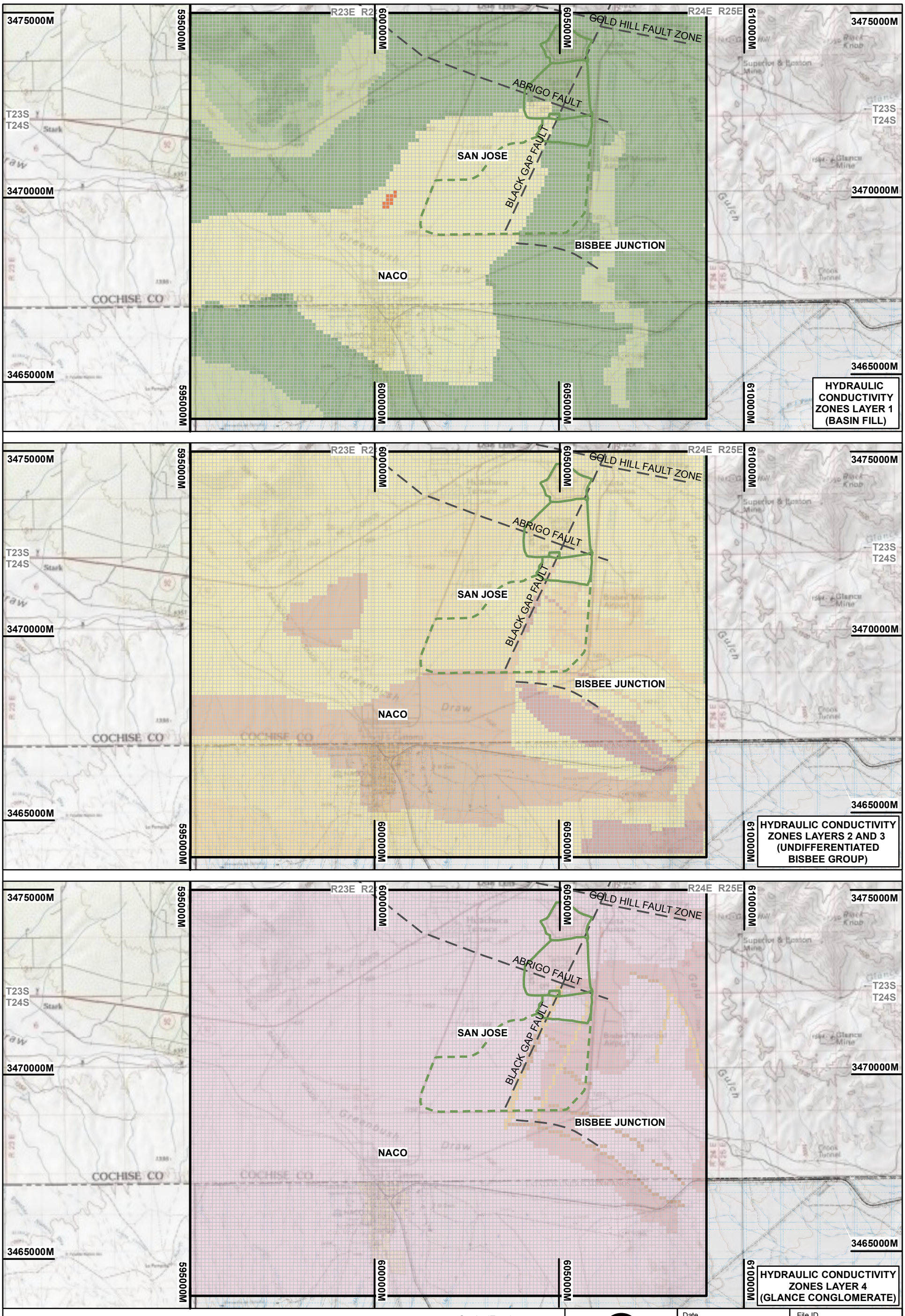
Projection: UTM Zone 12N NAD83

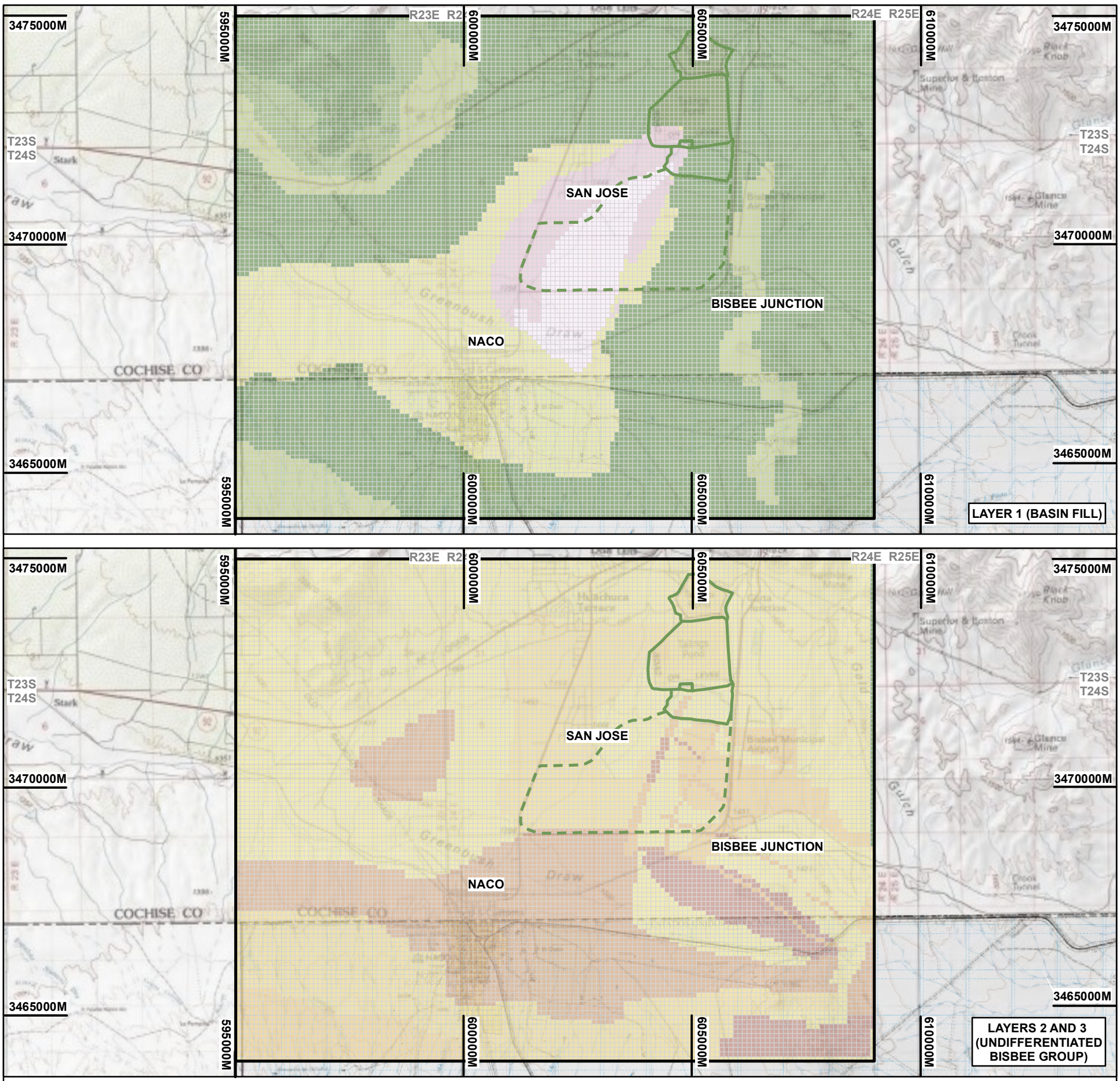
FIGURE FROM HGC (2009c)

Date	File ID
11/29/10	055038-092

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Figure 39
RECHARGE ZONES USED IN RSET MODEL


3475000M
3470000M
3465000M
595000M
600000M
605000M
610000M
R23E
R24E
R25E
T23S
T24S
GOLD HILL FAULT ZONE
ABRIGO FAULT
BLACK GAP FAULT
SAN JOSE
BISBEE JUNCTION
NACO
COCHISE CO
HYDRAULIC CONDUCTIVITY ZONES LAYER 1 (BASIN FILL)
HYDRAULIC CONDUCTIVITY ZONES LAYERS 2 AND 3 (UNDIFFERENTIATED BISBEE GROUP)
HYDRAULIC CONDUCTIVITY ZONES LAYER 4 (GLANCE CONGLOMERATE)
Legend
Numerical Model Extent
CTSA Facility
Former Warren Ranch Irrigation Area
Faults (inferred)
Zone
1 2 3 4 5 6 7 8 9 10 11 12 13 15
Scale (Feet)
0 4,000 8,000
Notes:
Projection: UTM Zone 12N NAD83
FIGURE FROM HGC (2009c)
CLEAR CREEK ASSOCIATES
Date 12/08/10
File ID 055038-093
Figure 40
HYDRAULIC CONDUCTIVITY ZONES IN RSET MODEL LAYERS 1 THROUGH 4



Legend

- Numerical Model Extent
- CTSA Facility
- Former Warren Ranch Irrigation Area

Zone

1 2 3 4 5 6 7 8 9 10 11 12 14 15

Scale (Feet)

0 4,000 8,000

Notes:

Projection: UTM Zone 12N NAD83

FIGURE FROM HGC (2009c)

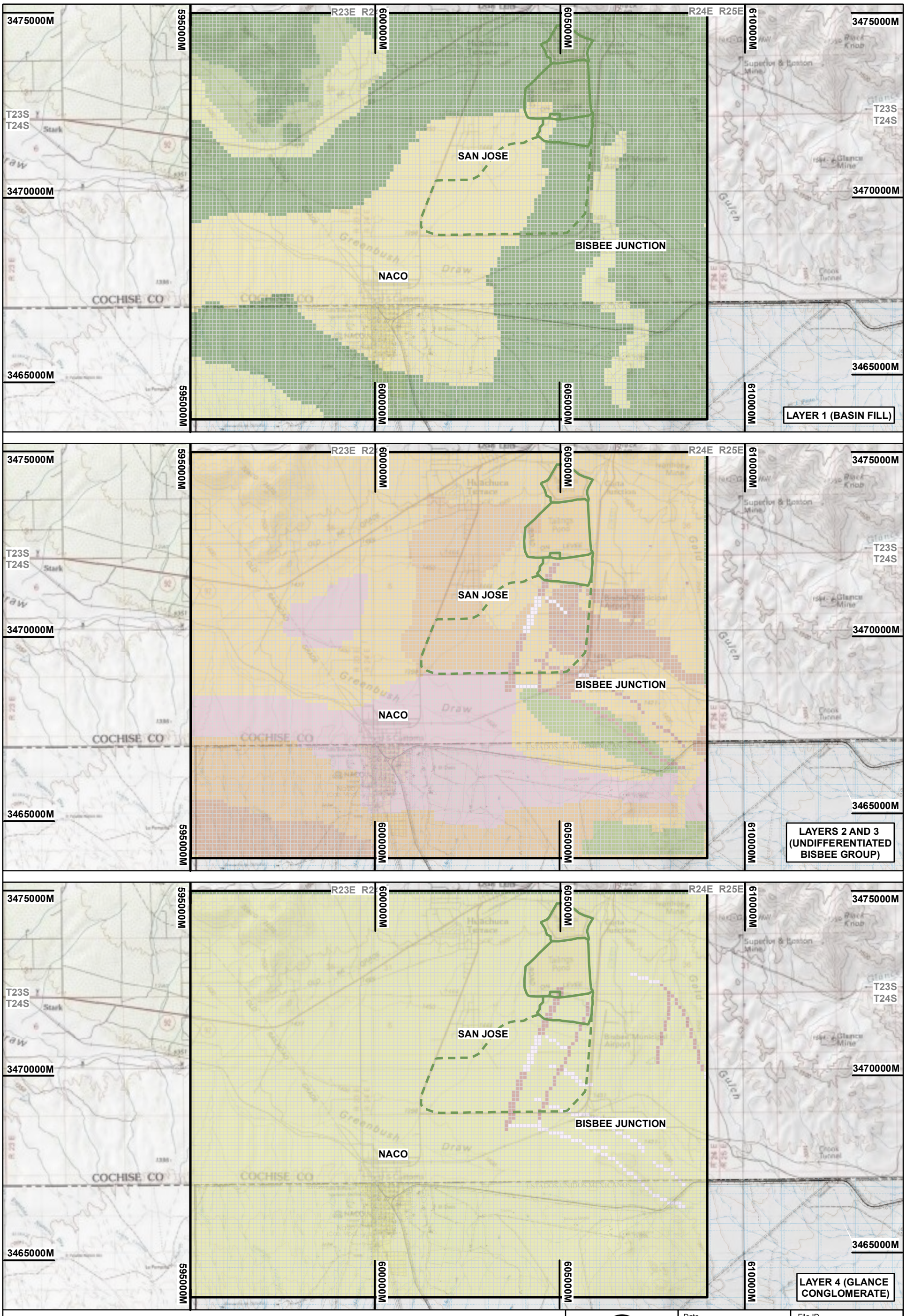
CLEAR CREEK ASSOCIATES

Date 11/29/10

File ID 055038-094

Figure 41

STORAGE COEFFICIENT, SPECIFIC YIELD, AND POROSITY ZONES LAYERS 1 THROUGH 4



Legend

- Numerical Model Extent
- CTSA Facility
- Former Warren Ranch Irrigation Area

Zone

1 2 3 4 5 6 7 8 9 10

Scale (Feet)

0 4,000 8,000

Notes:

Projection: UTM Zone 12N NAD83

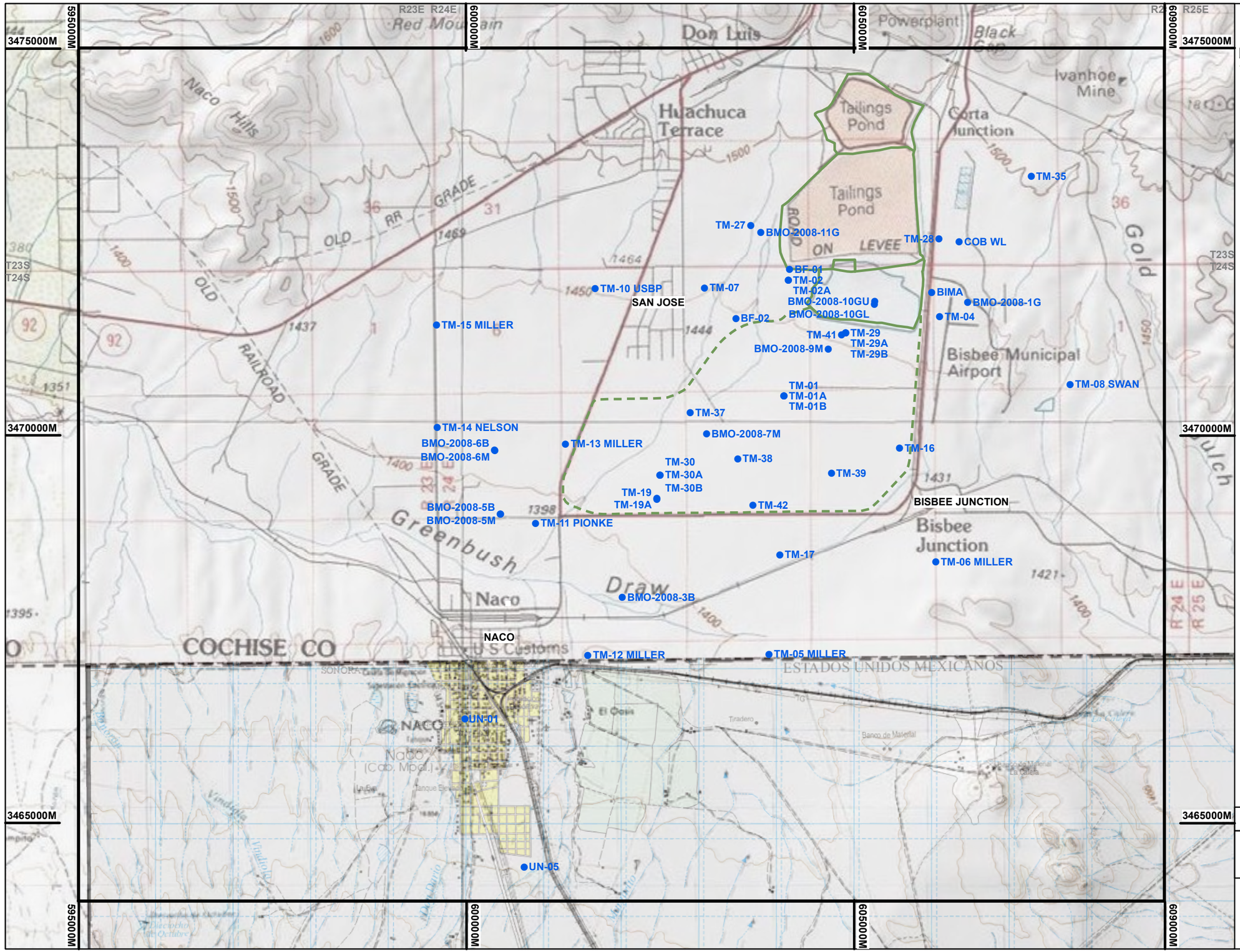
FIGURE FROM HGC (2009c)

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Date 11/29/10

File ID 055038-095

Figure 42
DISPERSIVITY ZONES IN LAYERS 1 THROUGH 4



Legend

- Well ID
- Numerical Model Extent
- CTSA Facility
- Former Warren Ranch Irrigation Area

Scale (Feet)

0 4,000 8,000

Notes:
Projection: UTM Zone 12N NAD83

Date	File ID
11/29/10	055038-096

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Figure 43
GROUNDWATER LEVEL TARGET LOCATIONS

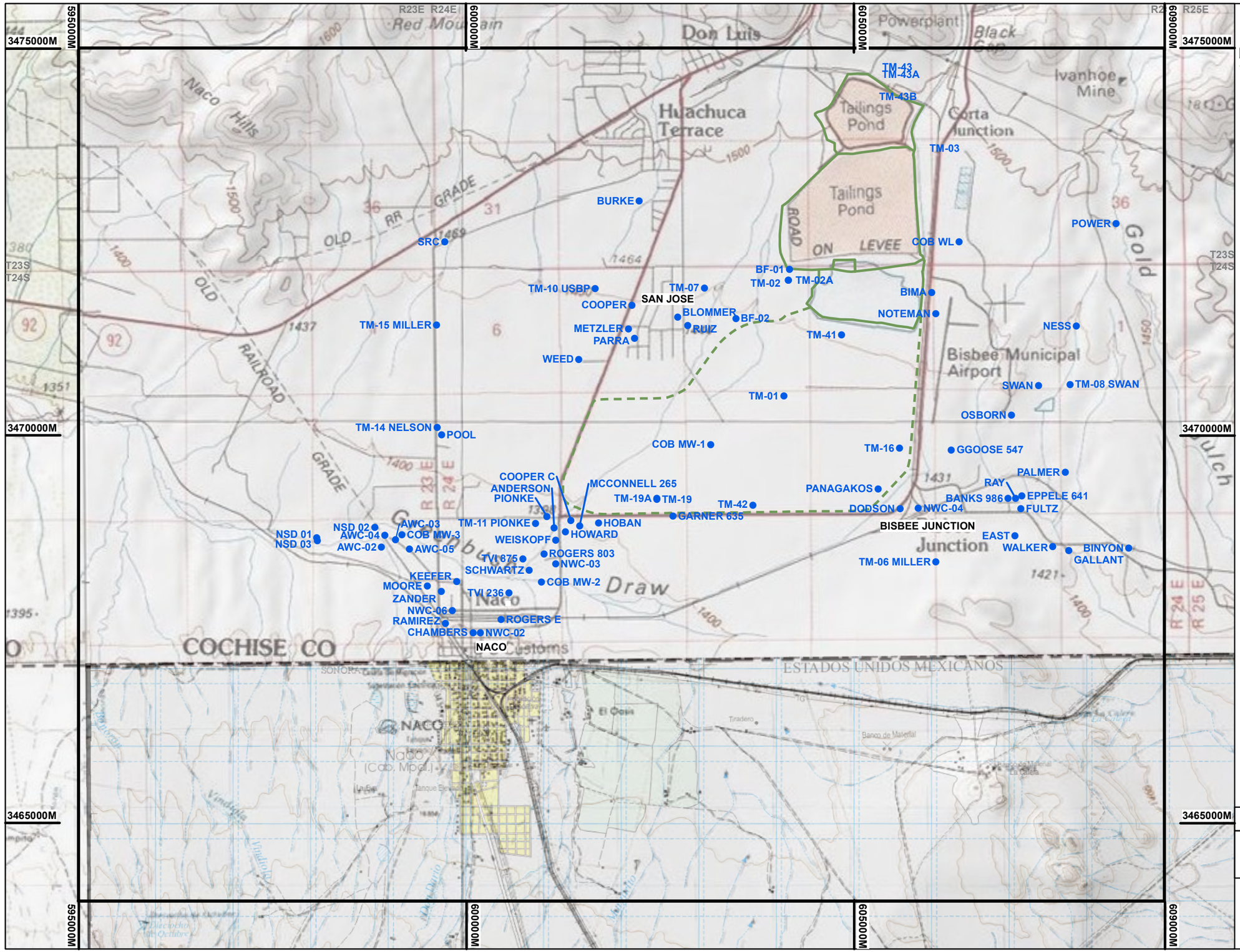
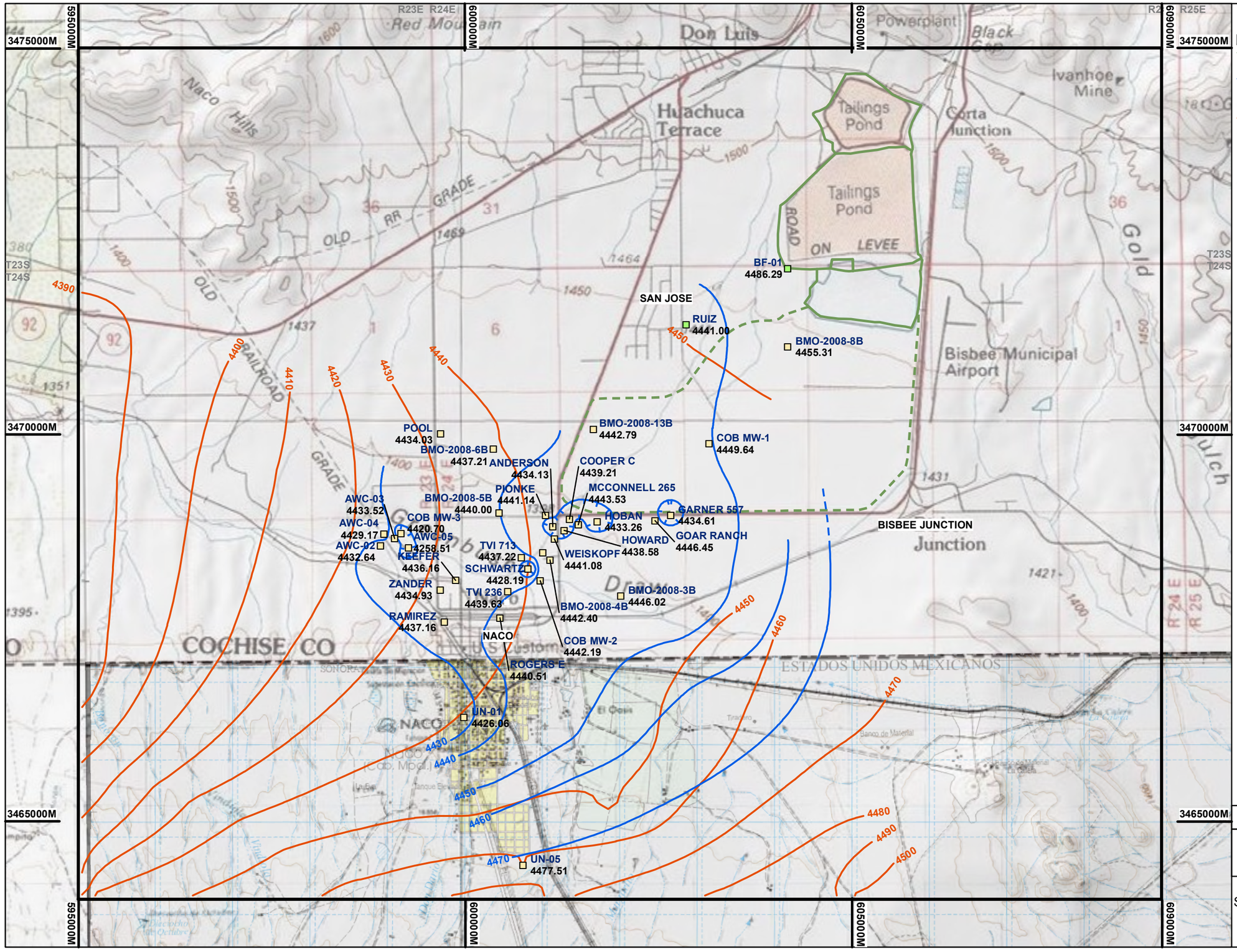
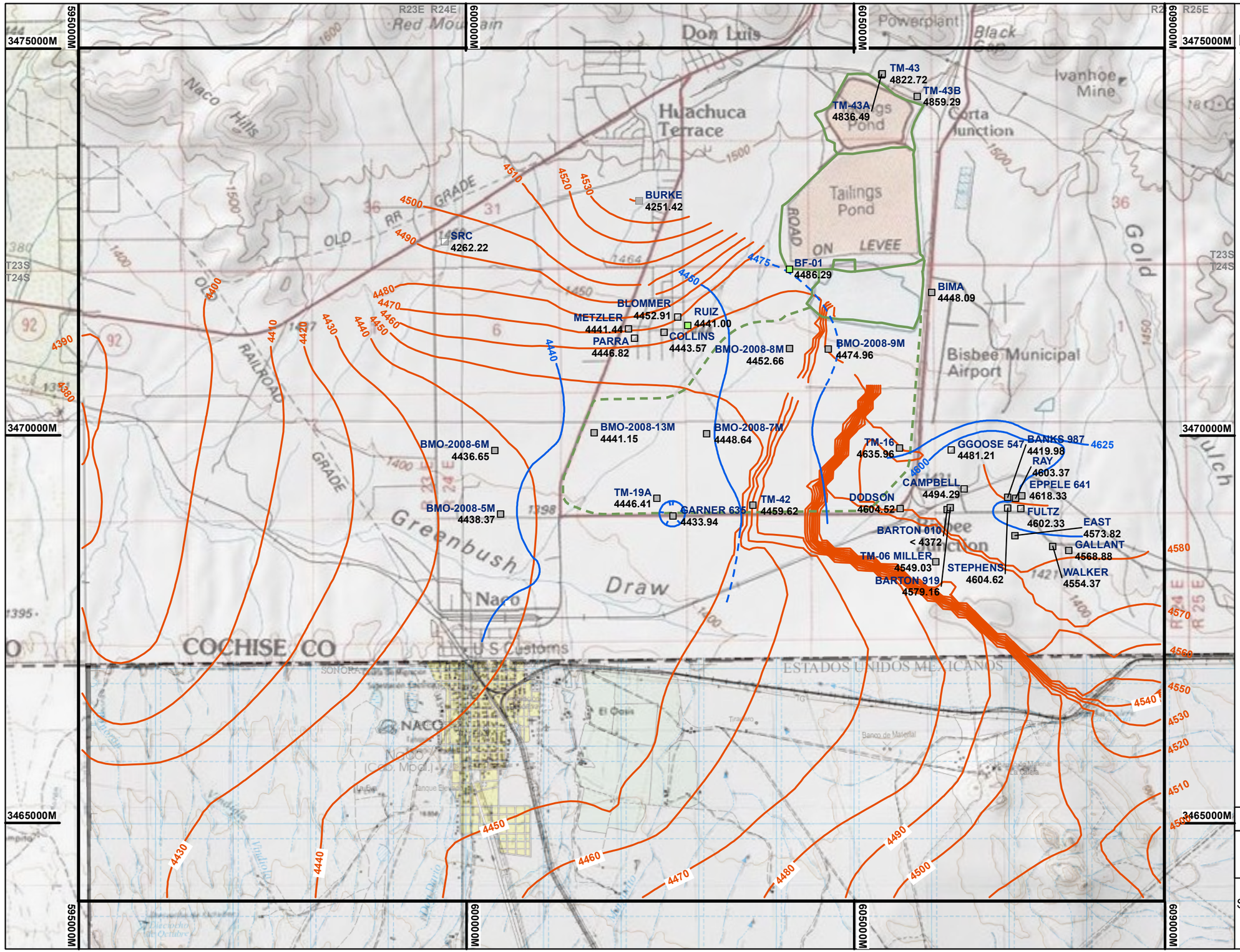


Figure 44
SULFATE CONCENTRATION TARGET LOCATIONS


Legend
Numerical Model Extent
CTSA Facility
Former Warren Ranch Irrigation Area
Groundwater Contour
Inferred Groundwater Contour
Groundwater Depression
Simulated Groundwater Contour
Screened Formation
Basin Fill
Basin Fill and Undifferentiated Bisbee Group
Well ID and Information
COB WM-1 Well ID
4449.64 Water Elevation (ft amsl)
Scale (Feet)
0
4,000
8,000
Notes:
Projection: UTM Zone 12N NAD83
Date
11/29/10
File ID
055038-098
CLEAR CREEK ASSOCIATES
Figure 45
SIMULATED LAYER 1 GROUNDWATER LEVELS WITH MEASURED VALUES FOR FOURTH QUARTER 2008
3475000M
3470000M
3465000M
595000M
600000M
605000M
R23E
R24E
R25E
T23S
T24S
Red Mountain
Don Luis
Powerplant
Black Cap
Ivanhoe Mine
Huachuca Terrace
Naco Hills
Tailings Pond
Corta Junction
Bisbee Municipal Airport
Gold Gulch
BISBEE JUNCTION
Junction
SAN JOSE
NACO
COCHISE CO
ESTADOS UNIDOS MEXICANOS
BF-01 4486.29
RUIZ 4441.00
BMO-2008-8B 4455.31
BMO-2008-13B 4442.79
COB MW-1 4449.64
POOL 4434.03
BMO-2008-6B 4437.21
ANDERSON 4434.13
COOPER C 4439.21
PIONKE 4441.14
MCCONNELL 265 4443.53
BMO-2008-5B 4440.00
AWC-03 4433.52
AWC-04 4429.17
AWC-02 4432.64
COB MW-3 4420.70
AWC-05 4258.51
KEEFER 4436.16
HOBAN 4433.26
GARNER 557 4434.61
HOWARD 4438.58
GOAR RANCH 4446.45
TVI 713 4437.22
SCHWARTZ 4428.19
WEISKOPF 4441.08
ZANDER 4434.93
TVI 236 4439.63
BMO-2008-3B 4446.02
BMO-2008-4B 4442.40
RAMIREZ 4437.16
COB MW-2 4442.19
ROGERS E 4440.51
UN-01 4426.06
UN-05 4477.51
4390
4400
4410
4420
4430
4440
4450
4460
4470
4480
4490
4500



Legend

- Numerical Model Extent
- CTSA Facility
- Former Warren Ranch Irrigation Area
- Groundwater Contour
- Inferred Groundwater Contour
- Groundwater Depression
- Simulated Groundwater Contours

Screened Formation

- Basin Fill and Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group - Estimated

Well ID and Information

- **BURKE** Well ID
- **4251.42** Water Elevation (ft amsl)

Scale (Feet)

0 4,000 8,000

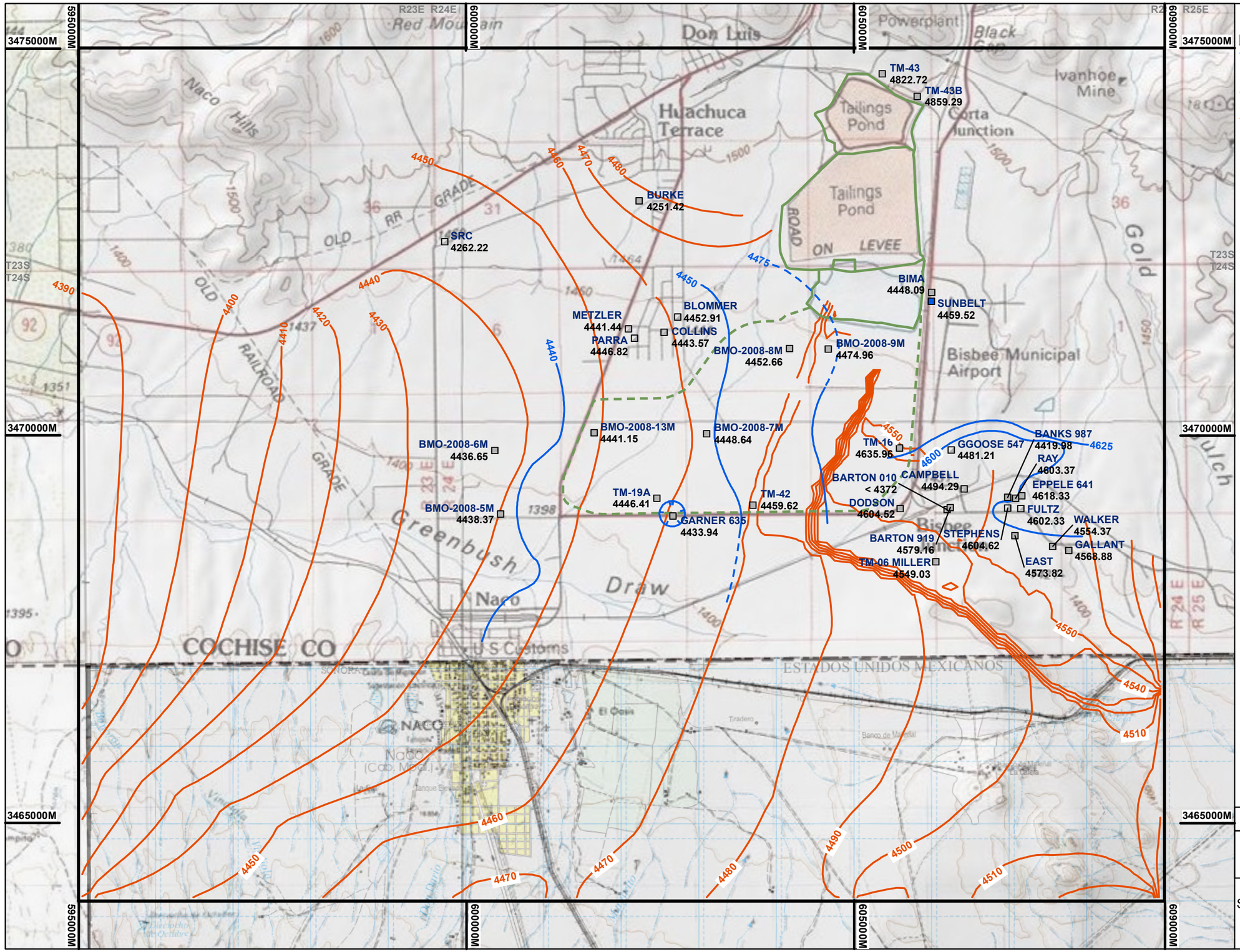
Notes:

Projection: UTM Zone 12N NAD83

Date	File ID
11/29/10	055038-099

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Figure 46
SIMULATED LAYER 2 GROUNDWATER LEVELS WITH MEASURED VALUES FOR FOURTH QUARTER 2008



Legend

- Numerical Model Extent
- Groundwater Contour
- Inferred Groundwater Contour
- Groundwater Depression
- CTSA Facility
- Former Warren Ranch Irrigation Area
- Simulated Groundwater Contours

Screened Formation

- Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group - Estimated
- Undifferentiated Bisbee Group and Glance Conglomerate

Well ID and Information

- TM-42 — Well ID
- 4459.62 — Water Elevation (ft amsl)

Scale (Feet)

0 4,000 8,000

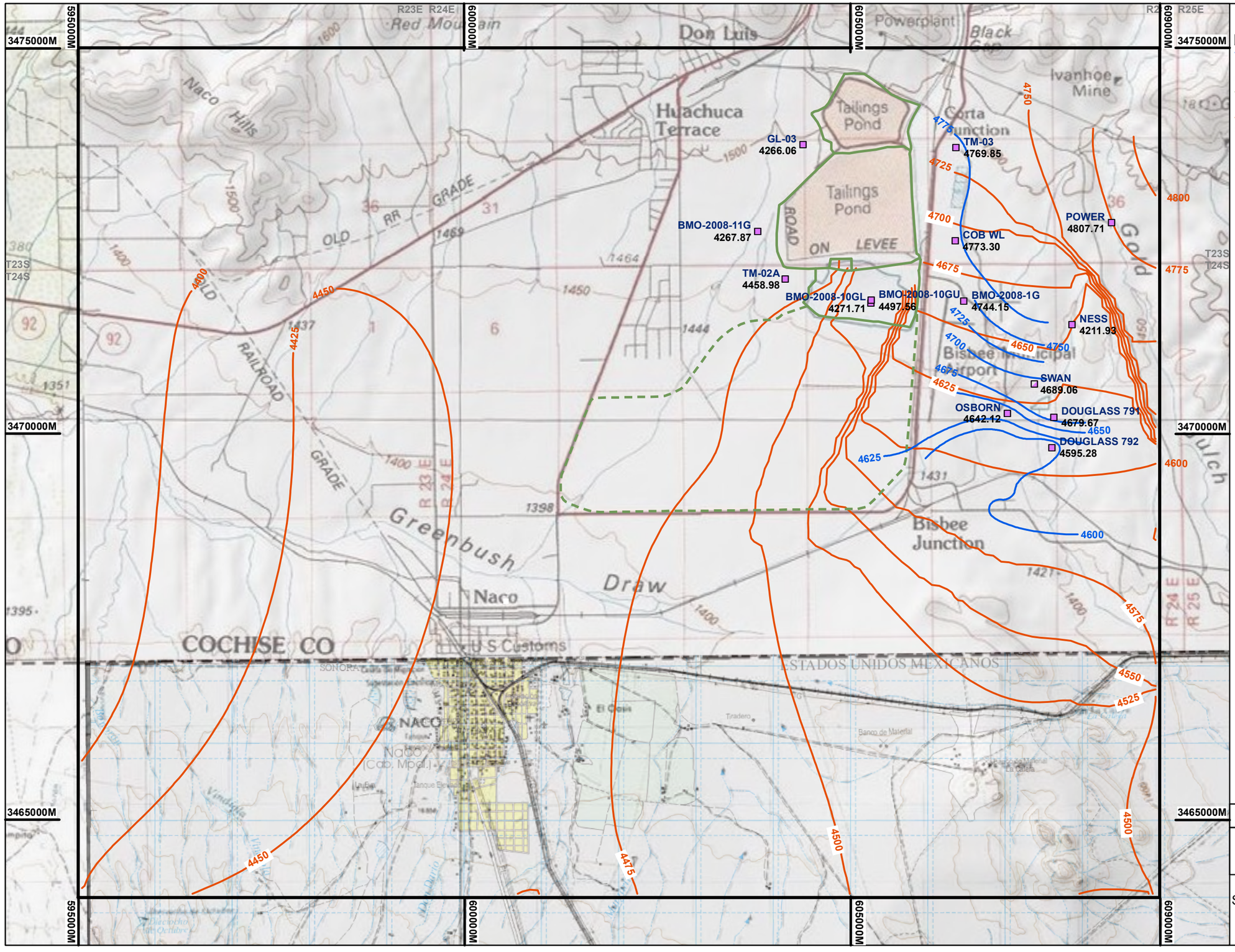
Notes:

Projection: UTM Zone 12N NAD83

Date	File ID
11/29/10	055038-100

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Figure 47
SIMULATED LAYER 3 GROUNDWATER LEVELS WITH MEASURED VALUES FOR FOURTH QUARTER 2008



Legend

- Numerical Model Extent
- Groundwater Contour
- Inferred Groundwater Contour
- Groundwater Depression
- CTSA Facility
- Former Warren Ranch Irrigation Area
- Simulated Groundwater Contours

Screened Formation

- Glance Conglomerate
- Glance Conglomerate-Estimated

Well ID and Information

SWAN — Well ID
4689.06 — Water Elevation (ft amsl)

Scale (Feet)

0 — 4,000 — 8,000

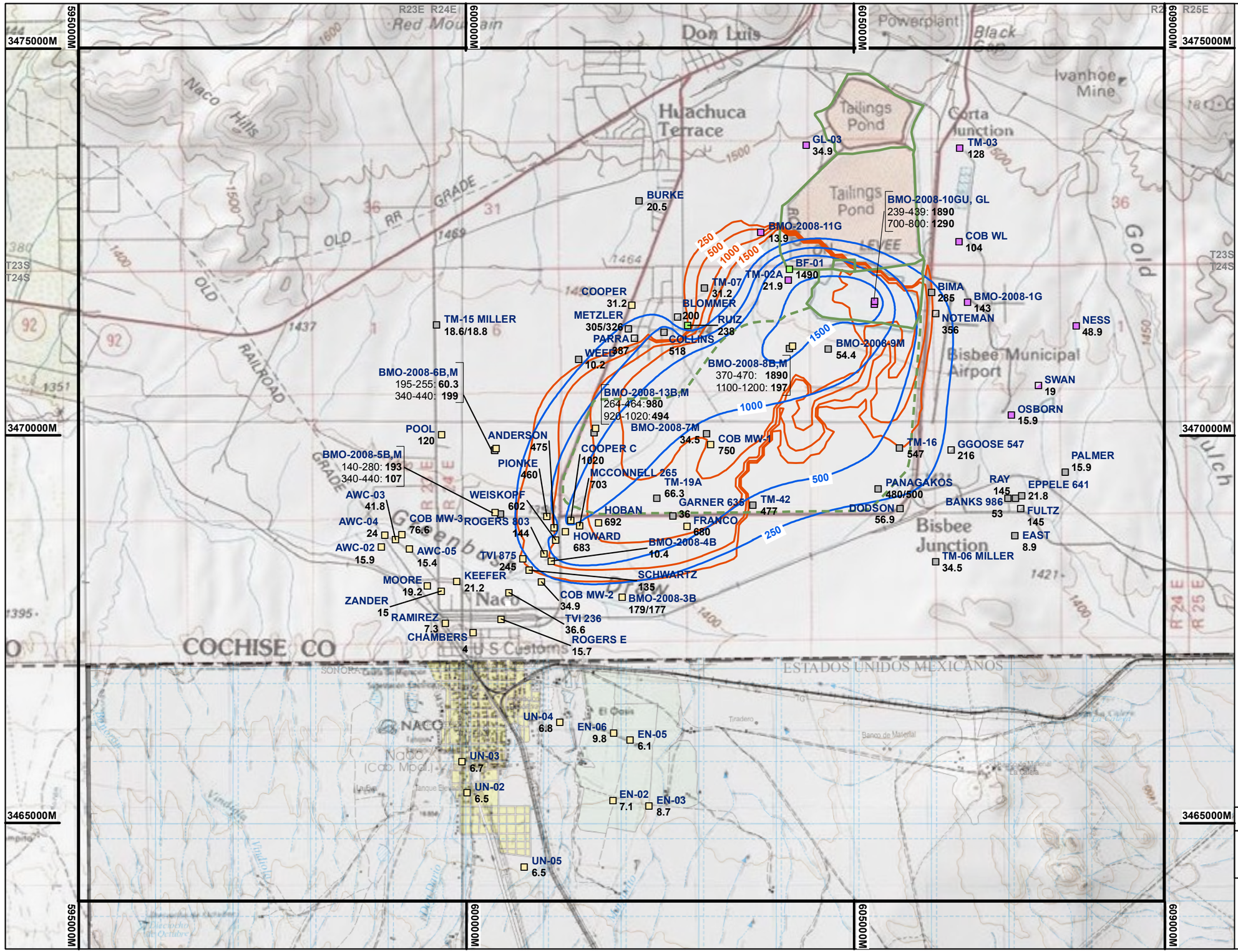
Notes:

Projection: UTM Zone 12N NAD83

Date	File ID
11/29/10	055038-101

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Figure 48
SIMULATED LAYER 4 GROUNDWATER LEVELS WITH MEASURED VALUES FOR FOURTH QUARTER 2008



Legend

- Numerical Model Extent
- CTSA Facility
- Former Warren Ranch Irrigation Area
- Simulated Sulfate Concentration Isolines
- Measured 4th Quarter 2008 Sulfate Concentration Isolines

Screened Formation

- Basin Fill
- Basin Fill and Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group - Estimated
- Glance Conglomerate
- Glance Conglomerate-Estimated

Well ID and Information

- KEEFER — Well ID
- 21.2 — Sulfate Concentration (mg/L)

Co-located Wells

- Well ID
- Screen (ft bgs): SO4 Concentration (mg/L)

Scale (Feet)

0 — 4,000 — 8,000

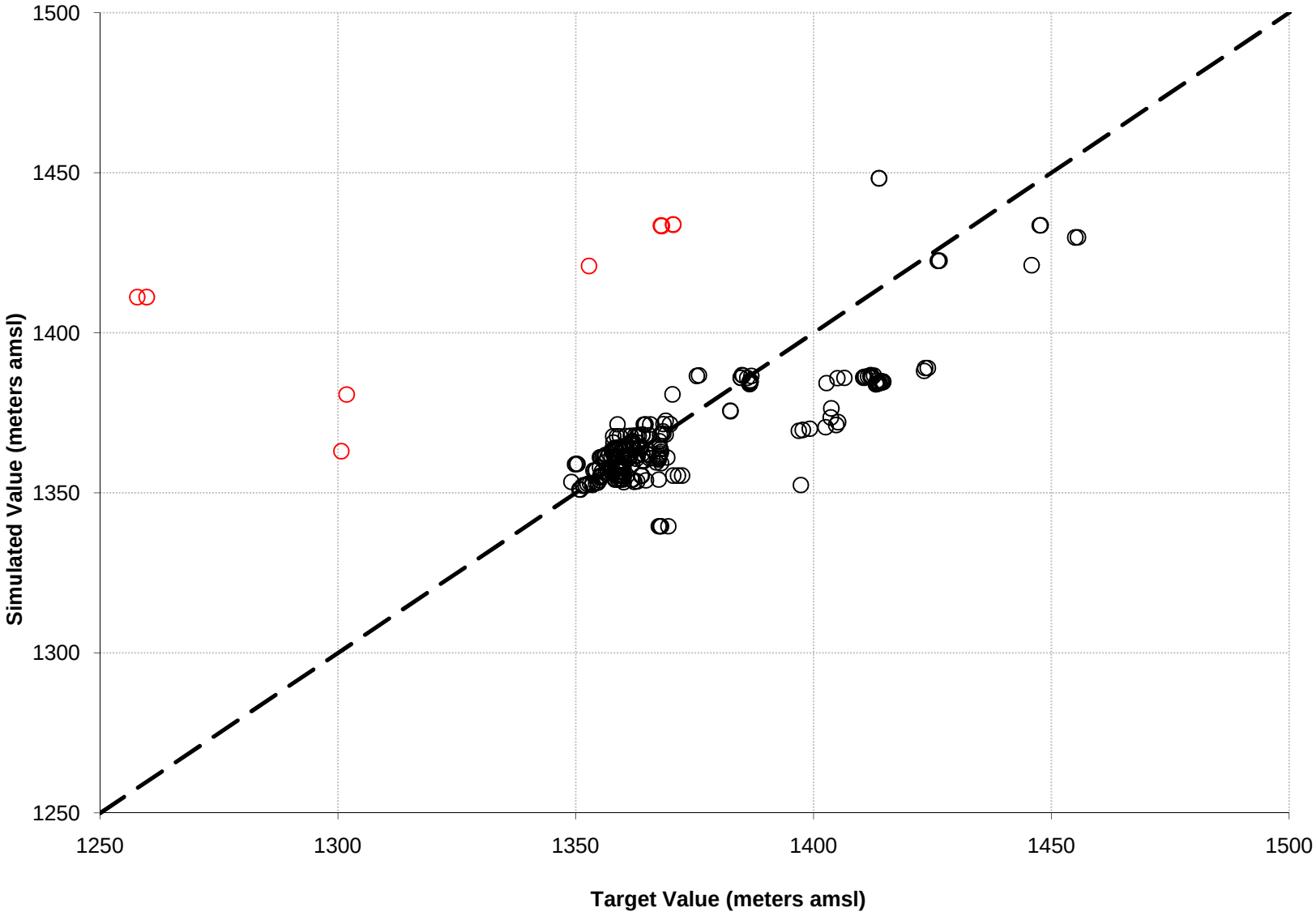
Notes:
Projection: UTM Zone 12N NAD83

FIGURE FROM HGC (2009c)

Date	File ID
11/29/10	055038-102

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Figure 49
MAXIMUM SIMULATED SULFATE CONCENTRATION CONTOURS WITH MEASURED VALUES FOR FOURTH QUARTER 2008



Data from Table 27

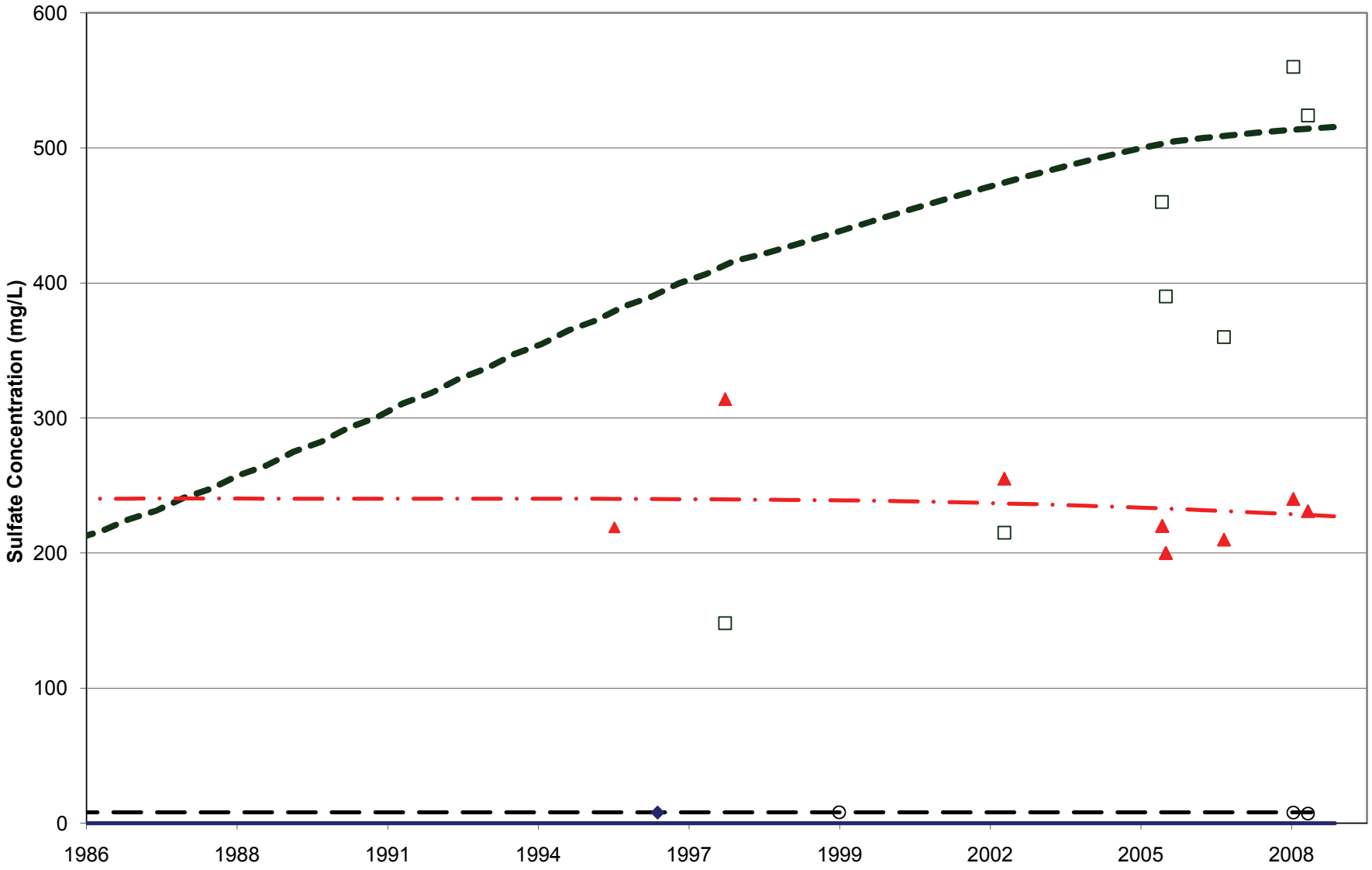
Note: Residuals that are greater than two standard deviations from the residual mean are noted in red and on Table 27.

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File ID

Date **11-29-10**

Figure 50
Simulated Versus Measured Groundwater Levels at Target Locations



NOTE: From HGC (2009c)

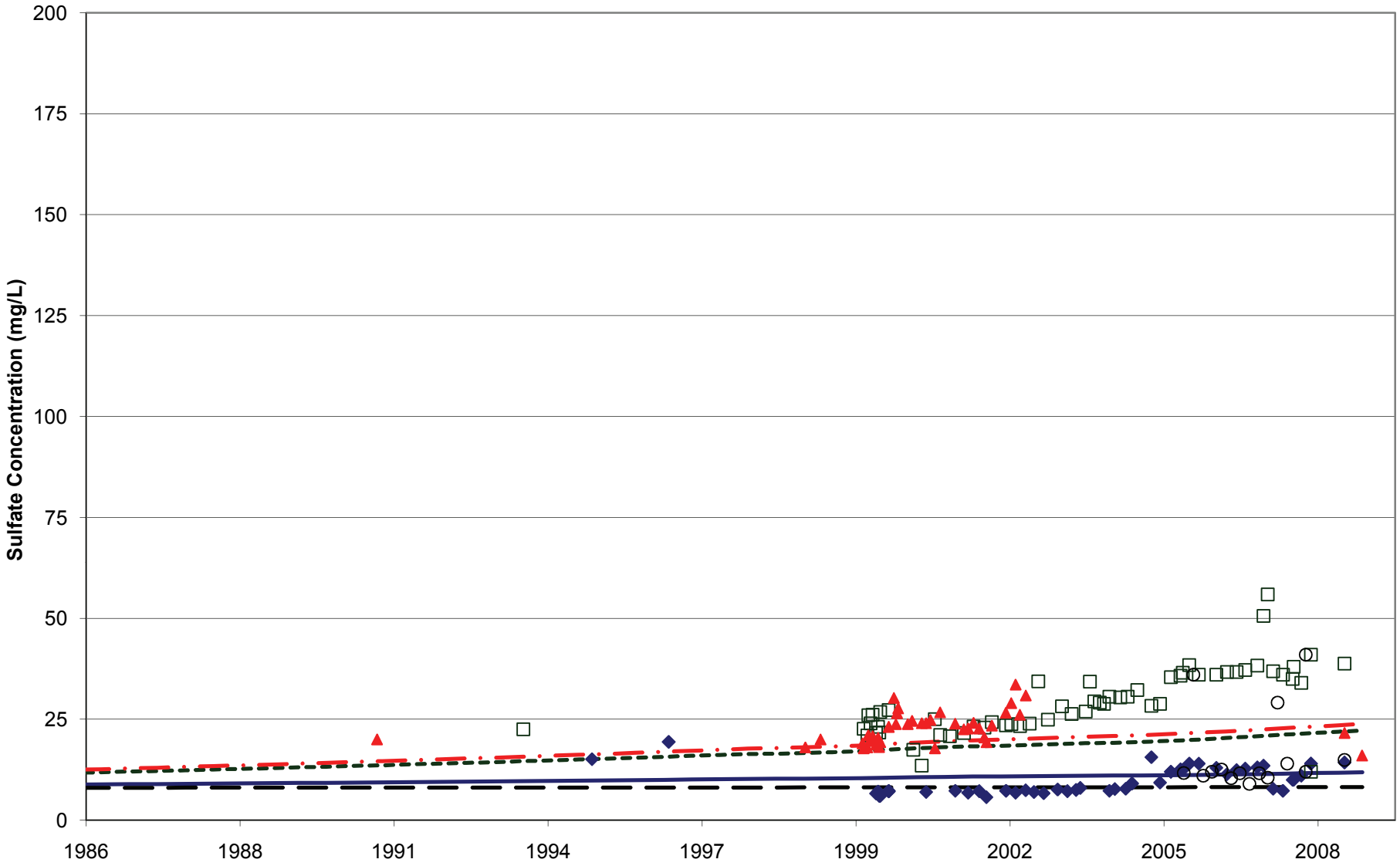
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File ID **055038-87**

Date **10-11-2010**

Figure 51
Simulated And Measured Sulfate Concentrations in NWC Wells

L:\Projects\G & K\055038_Copper Queen Branch Mitigation Order\055038 Figures and GIS\055038 Figures and Maps\055038-87-90b.xls: F51 NWC Concs



NOTE: From HGC (2009c)

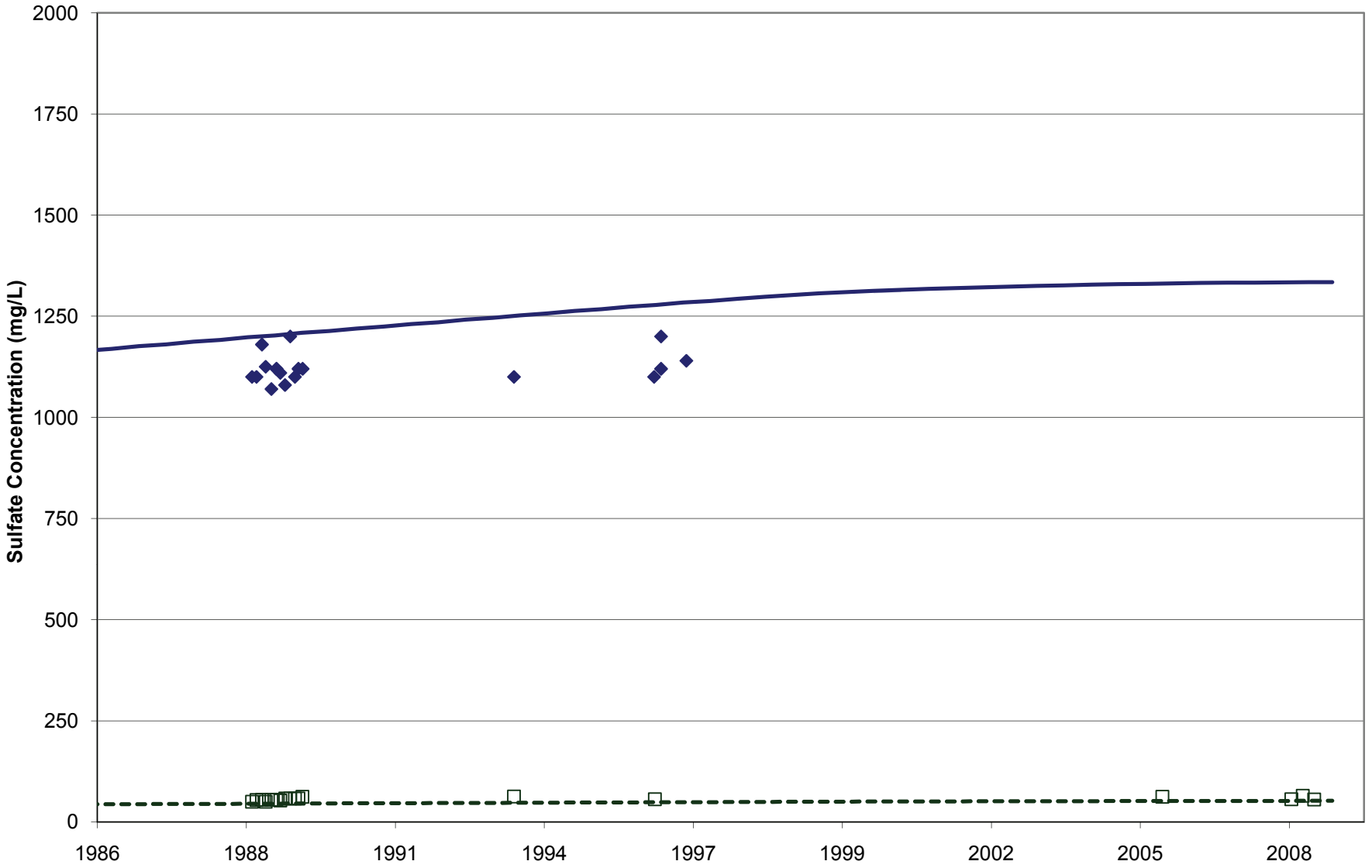
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File ID **055038-88**

Date **10-11-2010**

Figure 52
Simulatted And Measured Sulfate Concentrations in AWC Wells

L:\Projects\G & K\055038_Copper Queen Branch Mitigation Order\055038 Figures and GIS\055038 Figures and Maps\055038-87-90b.xls: F52 AWC Concs



NOTE: From HGC (2009c)

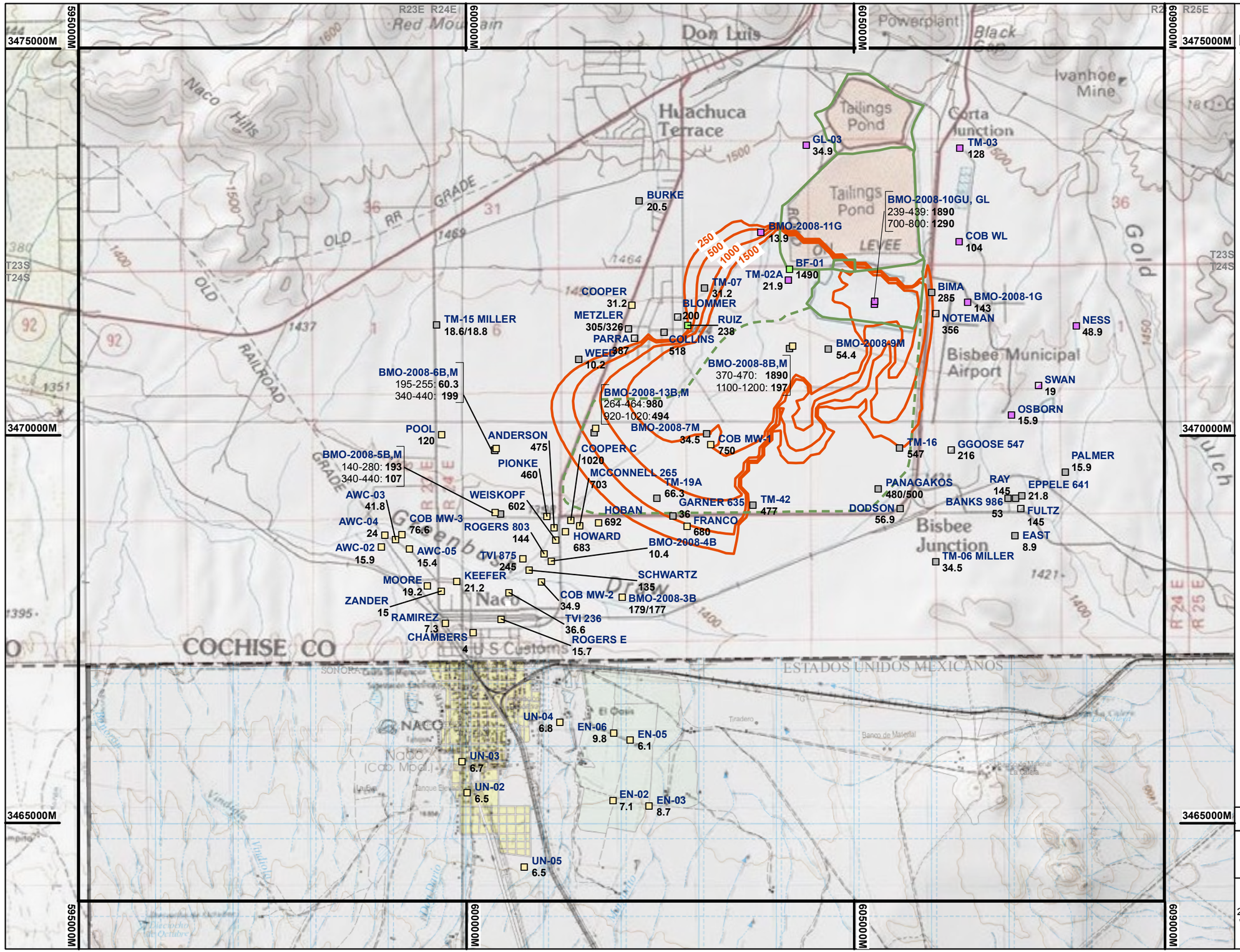
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File ID **055038-89**

Date **10-11-2010**

Figure 53
Simulated And Measured Sulfate Concentrations in TM-19 and TM-19A

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Legend

- Numerical Model Extent
- CTSA Facility
- Former Warren Ranch Irrigation Area
- Simulated Sulfate Plume Isolines

Screened Formation

- Basin Fill
- Basin Fill and Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group - Estimated
- Glance Conglomerate
- Glance Conglomerate-Estimated

Well ID and Information

- KEEFER — Well ID
- 21.2 — Sulfate Concentration (mg/L)

Co-located Wells

- Well ID
- Screen (ft bgs): SO4 Concentration (mg/L)

Scale (Feet)

0 4,000 8,000

Notes:

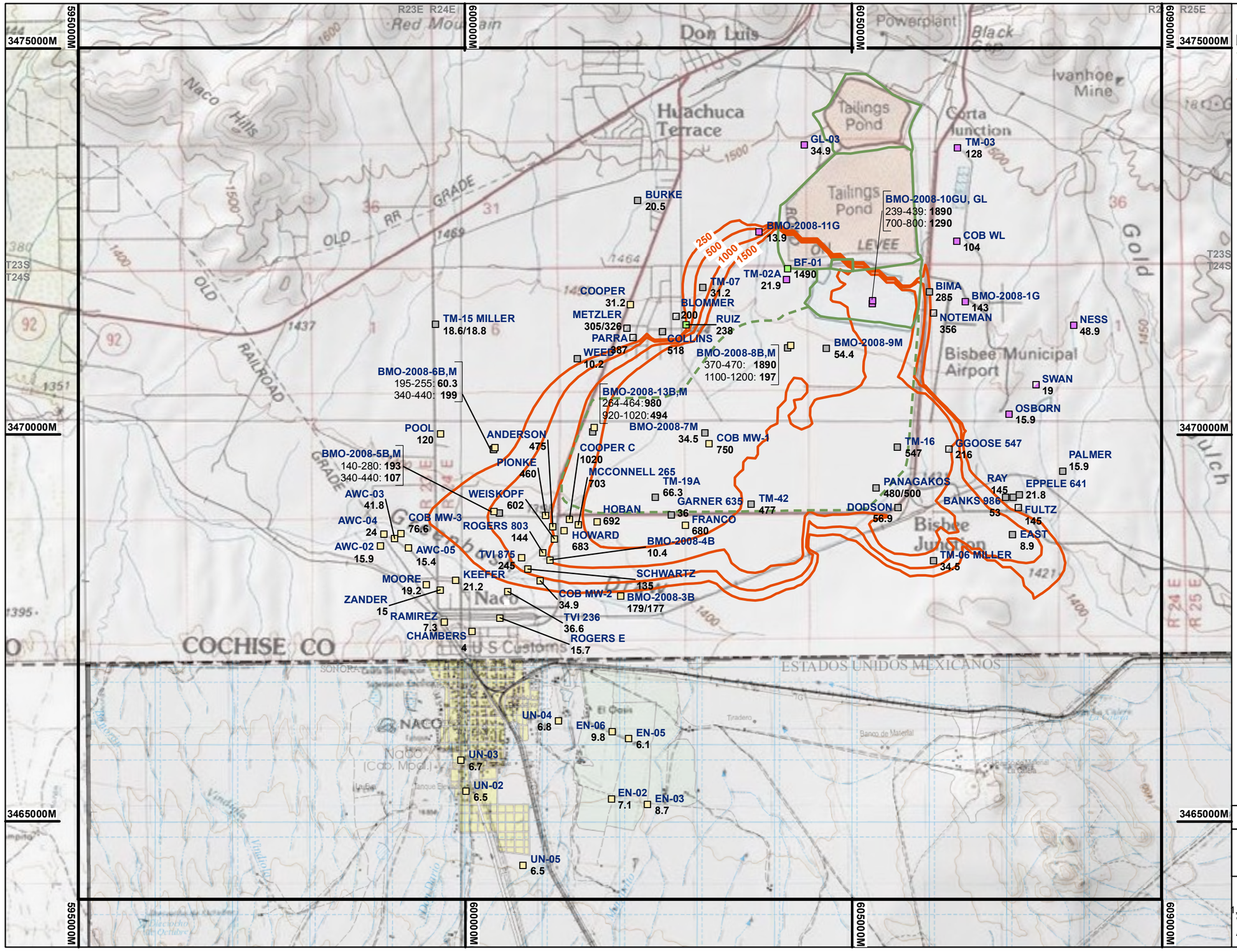
Projection: UTM Zone 12N NAD83

FIGURE FROM HGC (2009c)

Date	File ID
11/29/10	055038-103

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Figure 54
SIMULATED SULFATE PLUME FOR 2008 WITH 250 mg/L SULFATE CONCENTRATION IN FORMER WARREN RANCH IRRIGATION AREA RECHARGE AND W/O LOWER EFFECTIVE POROSITY ZONE



Legend

- Numerical Model Extent
- CTSA Facility
- Former Warren Ranch Irrigation Area
- Simulated Sulfate Plume Isolines

Screened Formation

- Basin Fill
- Basin Fill and Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group - Estimated
- Glance Conglomerate
- Glance Conglomerate-Estimated

Well ID and Information

- KEEFER — Well ID
- 21.2 — Sulfate Concentration (mg/L)

Co-located Wells

- Well ID
- Screen (ft bgs): SO4 Concentration (mg/L)

Scale (Feet)

0 4,000 8,000

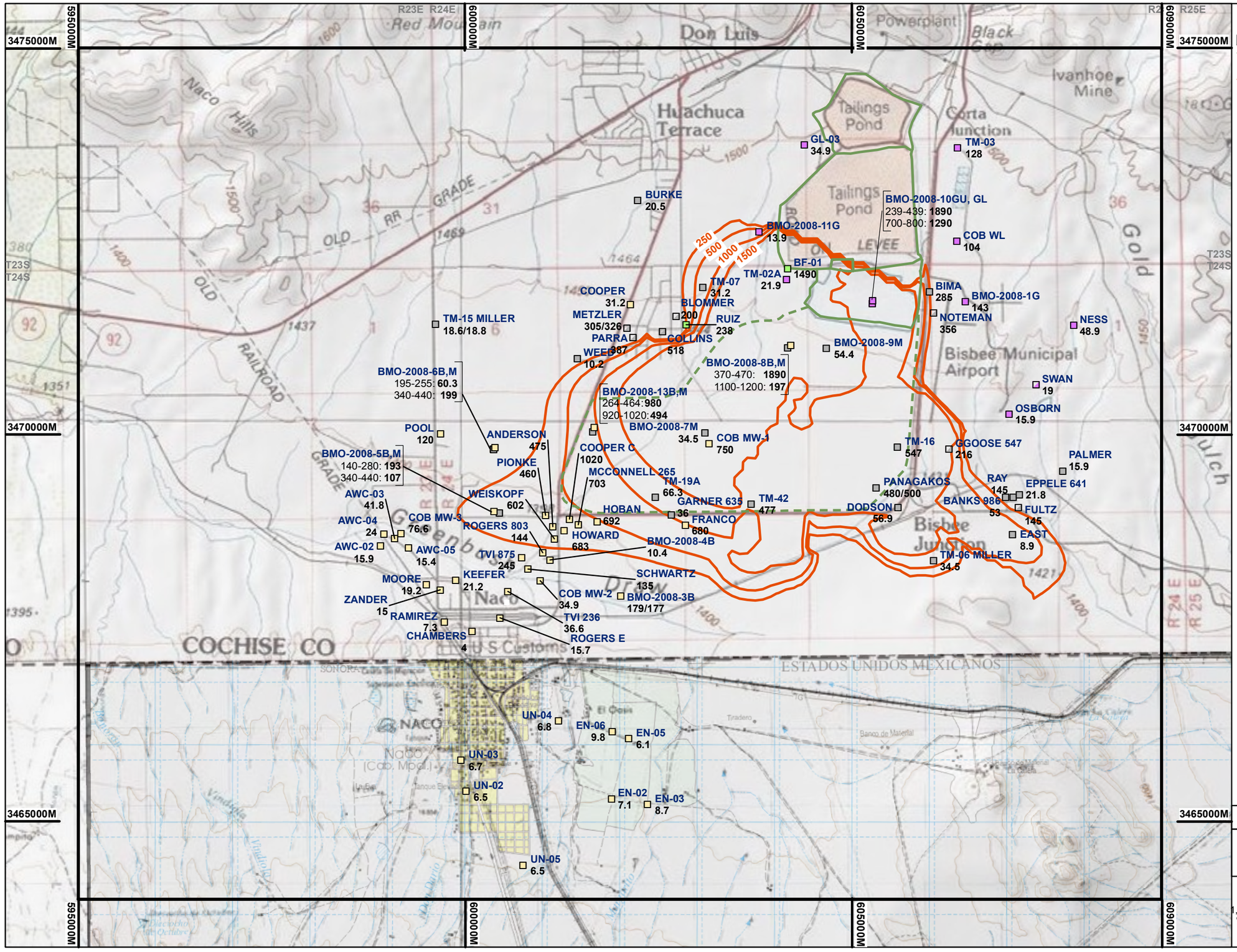
Notes:
Projection: UTM Zone 12N NAD83

FIGURE FROM HGC (2009c)

Date	File ID
11/29/10	055038-104

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Figure 55
SIMULATED SULFATE PLUME FOR 2008 WITH 1,500 mg/L SULFATE CONCENTRATION IN FORMER WARREN RANCH IRRIGATION AREA RECHARGE AND WITH LOWER EFFECTIVE POROSITY ZONE



Legend

- Numerical Model Extent
- CTSA Facility
- Former Warren Ranch Irrigation Area
- Simulated Sulfate Plume Isolines

Screened Formation

- Basin Fill
- Basin Fill and Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group
- Undifferentiated Bisbee Group - Estimated
- Glance Conglomerate
- Glance Conglomerate-Estimated

Well ID and Information

- KEEFER — Well ID
- 21.2 — Sulfate Concentration (mg/L)

Co-located Wells

- Well ID
- Screen (ft bgs): SO4 Concentration (mg/L)

Scale (Feet)

0 4,000 8,000

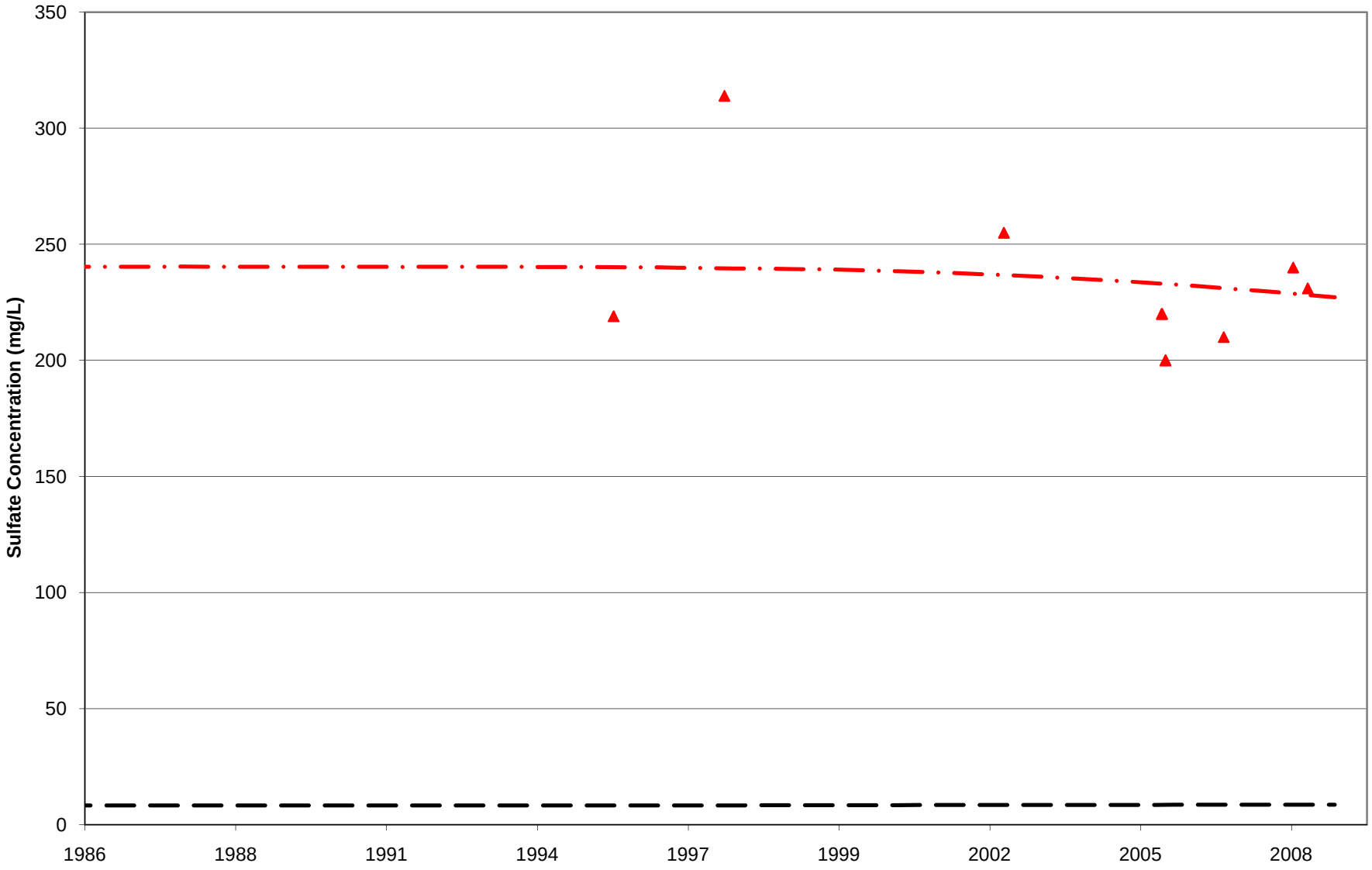
Notes:
Projection: UTM Zone 12N NAD83

FIGURE FROM HGC (2009c)

Date	File ID
11/29/10	055038-105

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Figure 56
SIMULATED SULFATE PLUME FOR 2008 WITH 1,500 mg/L SULFATE CONCENTRATION IN FORMER WARREN RANCH IRRIGATION AREA RECHARGE AND W/O LOWER EFFECTIVE POROSITY ZONE



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File ID 055038-90

Date 10-11-2010

Figure 57
Sensitivity Of Simulated Concentrations At NWC-04 To Recharge In Former Warren Ranch Irrigation Area East Of Black Gap Fault

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