FLORENCE COPPER, INC.

UIC PERMIT APPLICATION

FLORENCE COPPER PROJECT – PRODUCTION TEST FACILITY

ATTACHMENT A – AREA OF REVIEW

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A.1. Introduction

This Attachment has been prepared in support of an application (Application) by Florence Copper, Inc. (Florence Copper) to the United States Environmental Protection Agency (USEPA) for issuance of an Underground Injection Control Class III (Area) Permit (UIC Permit) for the planned Production Test Facility (PTF), to be located at the Florence Copper Project (FCP) in Pinal County, Arizona. USEPA originally issued a UIC Permit (No. AZ396000001) to BHP Copper Inc. (BHP Copper) on May 1, 1997, authorizing BHP Copper to operate an in-situ copper recovery (ISCR) facility on the FCP property, which was then owned by BHP Copper. This UIC Permit application is for a separate and overlying operational area that lies entirely within the area covered by UIC Permit No. AZ396000001. Following issuance of UIC Permit No. AZ396000001, the FCP property was sold and the UIC Permit was subsequently transferred to the new owner in December 2001.

The proposed PTF is located within the FCP property for which USEPA issued UIC Permit No. AZ396000001. The PTF is located approximately 2 miles northwest of the business district of Florence, Arizona. The proposed PTF infrastructure will be constructed within an area of approximately 13.8 acres in size, located on Arizona State Mineral Lease No. 11-26500 (State Land Lease). The State Land Lease is surrounded on three sides by property owned by Florence Copper; the western edge of the State Land Lease borders undeveloped private land. The proposed PTF will be constructed on a portion of Section 28 of Township 4 South, Range 9 East, of the Gila River Baseline and Meridian.

UIC Permit No. AZ396000001 described an Area of Review (AOR) that extended 500 feet beyond the active ISCR well field area planned by BHP Copper. This area coincides with the area for which USEPA granted the aquifer exemption in 1997. The AOR being requested in conjunction with this UIC Permit application covers an area measuring roughly 300 feet by 300 feet, plus a circumscribing area of 500 feet. This Attachment describes work completed to determine the AOR, as per requirements in 40 Code of Federal Regulations (CFR) 146.6, including an evaluation of BHP Copper's justification of the AOR as submitted to USEPA in their 1996 UIC Permit application, and generation of a new computer model to calculate an updated AOR for the PTF. A description of the model construction, calibration, inputs, and output is provided as Exhibit A-1 of this Application.

The updated model indicates an AOR boundary that is significantly less than 500 feet beyond the PTF well field area. However, Florence Copper proposes an AOR that includes the active PTF well field plus a circumscribing area of 500 feet, similar to the earlier BHP UIC Permit. In this Attachment, Florence Copper provides justification for an AOR that is equal to the area of the active PTF well field and a circumscribing width of 500 feet.

The proposed PTF and AOR are shown on Figure A-9.

The groundwater model documentation provided in Exhibit A-1 was submitted to the Arizona Department of Environmental Quality (ADEQ) on March 1, 2012 as Attachment 14A of the application for a Temporary Aquifer Protection Permit (APP). Exhibit A-1 was prepared in response to Arizona Administrative Code (A.A.C.) R18-9-A202A.8 which requires a hydrologic study that defines the Discharge Impact Area (DIA) associated with the permitted activities for the planned life of the proposed PTF. Exhibit A-1 is a report describing the basis of groundwater flow model construction, calibration, and predictive model runs.

The report included in Exhibit A-1 describes a numerical, three-dimensional (3-D) groundwater flow model that is representative of groundwater flow conditions within the PTF study area. The model is based on both site-specific and regional geologic and hydrologic data derived from studies conducted by previous property owners, and data and information that is publicly available from the Arizona Department of Water Resources (ADWR). The model development process consisted of the generation of both regional and local scale 3-D geologic models, which were then imported into the groundwater modeling software along with measurements and estimates of aquifer hydraulic properties and components of the hydrologic water budget. The model grid consists of 298 rows and 305 columns covering an area of approximately 124 square miles.

Grid cell spacing has a minimum discretization of 12.5 feet by 12.5 feet in the area of the PTF site, and telescopes out to 500 feet by 500 feet at the edges of the PTF model domain. The hydrostratigraphy of the PTF Model is divided into 10 layers. The top of the highest active layer at any location within the model represents ground surface. Layers 1 and 2 represent the Upper Basin Fill Unit (UBFU), layer 3 represents the Middle Fine-Grained Unit (MFGU), and, layers 4 and 5 represent the Lower Basin Fill Unit (LBFU). Layers 6 through 10 represent the Bedrock Oxide Unit, with layer 6 representing the uppermost 40 feet of that unit, which is excluded from injection.

Once the model was refined and calibrated, it was used to simulate pre-development (steady state), historic, present day, and predicted future groundwater conditions under a variety of operating and closure scenarios.

Electronic groundwater model files are included on a CD provided as Exhibit A-4 of this Application. The basis of the groundwater flow model is described in the Exhibit A-1, which includes a report describing model construction, calibration, and predictive runs.

Attachments 14B and 14C of the Temporary APP application include additional hydrologic data and information and are provided as Exhibits A-2 and A-3 of this Application. Exhibits A-2 and A-3 contain data and information identified in A.A.C. R18-9-A202A.8 that are not directly referenced in the groundwater flow model report included in Exhibit A-1 as described above, and additional information not identified in A.A.C. R18-9-A202A.8 but that was requested by ADEQ during the APP application review process. These exhibits contain supplemental hydrologic data and information including surface water and groundwater data describing site-specific and regional conditions. Included in these exhibits are site and regional groundwater hydrographs, floodplain delineation, discussion of groundwater quality, historical groundwater quality trends, known soil contamination, groundwater gradients, hydraulic control, water rights, geologic cross sections, and information describing the potential for earth fissures and subsidence.

ADEQ found that Exhibits A-1, A-2, and A-3 collectively met the requirements for the hydrologic study described in A.A.C. R18-9-A202A.8 and subsequently issued Temporary APP No. 106360 based in part on the groundwater model described in these Attachments. APP No. 106360 was granted on September 28, 2012 and was amended on July 5, 2013. It should be noted that the proposed point-of-compliance (POC) wells O13-O and P-13-O listed in the Temporary APP application materials were replaced with proposed POC wells M54-O and M54-LBF at the request of ADEQ prior to issuance of APP No. 106360. A description of the ADEQ approved, but not yet constructed, POC wells M54-O and M54-LBF is included in Attachment P of this Application.

A.2. Background

In 1997 and 1998, BHP Copper conducted a hydraulic control test as was required by APP No. 101704, issued by the ADEQ to BHP Copper in conjunction with USEPA's issuance of UIC Permit No. AZ396000001. This test was conducted to demonstrate that hydraulic control could be maintained within the portion of the oxide zone, where process solutions were being injected and recovered. The oxide zone is the upper portion of the bedrock underlying the FCP property in which soluble copper is located. The test successfully demonstrated that hydraulic control could be maintained. The successful completion of the test was reported to ADEQ in a letter, dated April 6, 1998 (BHP Copper, 1998). Although fully permitted by ADEQ and the USEPA to conduct full-scale commercial copper production by ISCR methods, BHP Copper deferred constructing the full-scale facility required for this purpose, and later sold the property to Vanguard Properties, who later formed Merrill Mining LLC.

A.2.1 Hydraulic Control

Florence Copper's proposed PTF well field includes injection wells and recovery wells that will be constructed in accordance with USEPA's UIC Program Class III well standards and designed specifically for the purpose of mineral production. The injection and recovery wells will be surrounded by an additional ring of observation wells constructed outside of the outermost ring of recovery wells for the purpose of documenting hydraulic control. Within this system, the proposed Class III injection wells will be surrounded by recovery wells that will recover a volume of fluid that exceeds the volume injected to ensure that injected process fluids are recovered and an inward hydraulic gradient is maintained.

Because the Class III injection wells will be directly paired with recovery wells that will recover more fluid than is injected, the net hydraulic effect of the proposed Class III injection and recovery well array will be a groundwater gradient that slopes inward, toward the PTF well field from all sides. The inward sloping hydraulic gradient will be of a magnitude sufficient to overcome the natural groundwater gradient, preventing injected solutions from escaping the PTF well field area, thereby establishing hydraulic control.

Hydraulic control serves a twofold purpose: it prevents the loss of injected solution to underground sources of drinking water (USDWs), and it is a fundamental business requirement of the proposed copper recovery method. The BHP Copper test demonstrated that hydraulic control could be achieved. From a business perspective, the injected solutions represent a capital investment arising from both the generation of the solution and the energy required to inject it. Without hydraulic control, a substantial investment is put at risk by partial or failed recovery. Consequently, under normal operating conditions, there is no incentive to continue injection if loss of hydraulic control has occurred. Both regulatory and economic incentives dictate that if hydraulic control has been lost, injection will cease immediately and work will commence immediately to recover injected solutions and re-establish hydraulic control.

Under normal operating conditions of the proposed PTF well field, injection and recovery rates and the resultant pressure effects will be balanced such that the operator can be certain of recovering the injected solutions with sufficient additional formation water necessary to maintain an inward hydraulic gradient and hydraulic control. Balancing the injection and recovery rates has the effect of limiting the extent of the pressure influence generated by injection to the area within the outermost ring of recovery wells, and eliminating pressure effects outside of the active PTF well field area that have the potential to cause the migration of injected fluids or formation fluids into a USDW. Formation fluids present in the vicinity of the FCP property consist of groundwater of a quality generally suitable for agricultural and industrial uses, and in some cases drinking water.

The nearest USDW to the proposed PTF facility is defined as well beyond the proposed AOR, which extends 500 feet horizontally beyond the PTF well field area. The PTF well field area and the proposed AOR are located entirely within the previously approved aquifer exemption area. The aquifer exemption extends vertically to the base of the MFGU or 200 feet above the top of the Bedrock Oxide Zone, whichever is deepest.

A.2.2 Area of Review

The proposed AOR boundary reflects the limits of the well field as defined by the physical installation of injection, recovery, and hydraulic control observation wells. 40 CFR Part 146.6(a)(ii) describes the AOR as the "…lateral distance from the perimeter of the project area, in which the pressures of the injection zone may cause the migration of the injection and/or formation fluid into an underground source of drinking water." It is Florence Copper's understanding that this description of the AOR refers to project facilities that exert a hydrologic influence in the subsurface, rather than non-hydrologic project infrastructure located at or above ground surface. The injection and recovery wells are the only project infrastructure that have the potential to cause the migration of the injected fluid or formation fluid into a USDW, and thus represent the extent of the project area as described in 40 CFR 146.6(a)(ii).

The distance between the point of injection and the outer boundary of the AOR is defined in 40 CFR 146.6 as either a fixed radius of ¼ mile or a linear distance described as the "zone of endangering influence" (ZEI). The ZEI is the lateral distance from the point of injection in which the pressures in the injection zone may cause the migration of injected solutions or formation fluid into a USDW. The distance of the ZEI is a calculated value.

The method for calculating the ZEI given in 40 CFR 146.6 is effectively a one dimensional mathematical model, one version of which is the Theis (1935) equation; however, other mathematical models are permitted.

Because the proposed Class III injection and recovery well array will maintain an inward hydraulic gradient throughout operations, the calculation method defined in 40 CFR 146.6 results in a ZEI radius that does not extend beyond the edge of the active PTF well field, and is well within lands owned or leased by Florence Copper.

Florence Copper proposes a radial distance for the AOR that significantly exceeds the distance that injected solutions may migrate as a result of pressure generated during the maximum permissible excursion described in the Operations Plan included as Exhibit K-2 of Attachment K of this Application. The maximum permissible excursion described in the Operations Plan conforms to the maximum permissible excursion defined in Part II.H.1.b - Contingency Plans, of UIC Permit No. AZ396000001. The Operations Plan requires that injection cease within 48 hours of the loss of hydraulic control, while pumping at recovery wells continues in an effort to re-establish hydraulic control. The proposed AOR is approximately 7.5 times the distance that injected solutions may migrate during the maximum permissible excursion (48 hours without hydraulic control), and more than 2.5 times the distance that injected fluid may migrate under a worst case scenario of 30 days injection with no hydraulic control.

As described above, there are neither operational nor economic incentives to continue injection once loss of hydraulic control has been detected. Consequently, Florence Copper has no intention of continuing injection after loss of hydraulic control; however, the 48-hour period cited in the Operations Plan was used as the basis for calculating how far injected fluids may travel under a maximum permissible excursion scenario. In addition, at the request of USEPA, additional ZEI calculations were made to determine the horizontal and vertical extent of fluid migration during a worst case scenario where a single well continues injecting for 30 days with no hydraulic control.

The ZEI calculations were performed assuming that the injection continues for the entire 48-hour and 30-day periods with no hydraulic control, using an average injection rate of 60 gallons per minute (gpm) as proposed by Florence Copper for the PTF and average hydraulic characteristics of the oxide zone. These calculations effectively generate a ZEI that includes both the immediate area chemically affected by injected solutions under normal operating conditions and a larger area potentially chemically affected by excursion of injected solutions.

Beyond the larger chemically affected area, pressure effects generated by injection during any period of time when hydraulic control has been lost will only serve to drive formation fluid (clean groundwater) away from the site of injection until hydraulic control is resumed.

A.3. Method of AOR Calculation

As defined in 40 CFR 146.6, the AOR may be calculated using the Theis (1935) equation, or other mathematical model, which calculates the radial distance of injection impacts emanating from a single injection well. The Theis equation is a mathematical function designed to represent transient well impacts in a confined aquifer system, and is limited to a radial, or two-dimensional, representation of groundwater conditions. The Theis method has limited application when considering the impact of injection within a multi-layer, confined to semi-confined aquifer system such as occurs at the FCP property.

For these reasons, Florence Copper has chosen a different mathematical model that is more appropriate for site conditions and which represents industry standard methods for the calculation of groundwater flow. The selected method consists of a combination of MODFLOW (Harbaugh, et. al., 2000), a three-dimensional groundwater flow model, and MT3D (Zheng, 1990), a 3-D solute transport model. Combined, these two modeling tools can be used to predict how far injected solutions may travel during the maximum permissible excursion.

Although MODFLOW and the Theis equation employ different mathematical methodologies to estimate the flow of groundwater and impacts to water levels attributable to pumping or injection, they are both based upon the same fundamental flow equation describing hydraulic head in a confined aquifer system. Due to the common basis for both MODFLOW and the Theis equation, either method will produce essentially identical results provided that the inherent and applied assumptions for each method are consistent. Given the relatively complex hydrogeologic setting at the FCP property, the MODFLOW code coupled with the MT3D solute fate and transport code were selected to estimate the linear extent of migration of injected fluids during the maximum permissible excursion at the PTF.

A.3.1 MODFLOW Groundwater Flow Equation

The MODFLOW code is a computer based, finite difference mathematical model designed for the purpose of calculating three-dimensional groundwater pumping and injection impacts in various types of aquifers. The finite-difference technique essentially solves for hydraulic head by discretizing the flow domain into a computational grid composed of orthogonal blocks, with a node located at the center of each block. In general, the finite-difference approximation assumes that all hydraulic parameters, stresses, and inputs are constant over the area of a single cell and over the time elapsed during a stress period. Likewise, calculated hydraulic head and groundwater fluxes are also averaged over the areal extent of a single cell. Using the model for a specific application requires the definition of boundary and initial conditions, estimates of key hydraulic parameters, and definitions of groundwater inflows and outflows as a function of time.

The governing equation for MODFLOW is presented below. It is the partial-differential equation of groundwater flow as given in McDonald and Harbaugh (1988):

$$\frac{\partial}{\partial x}\left(Kxx\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(Kyy\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(Kzz\frac{\partial h}{\partial z}\right)+W=S_S\frac{\partial h}{\partial t} \qquad (1)$$

Where,

- Kxx, Kyy, and Kzz are values of hydraulic conductivity along the x, y, and z coordinate axes, respectively, which are assumed to be parallel to the major axes of hydraulic conductivity (Length/Time);
- h is the potentiometric head (Length);
- W is a volumetric flux per unit volume representing sources and/or sinks of water, with $W<0.0$ for flow out of the ground-water system, and $W>0.0$ for flow in ($Time^{-1}$);
- S_S is the specific storage of the porous material ($Length^{-1}$); and
- t is Time.

Equation 1, when combined with boundary and initial conditions, describes transient three-dimensional groundwater flow in a heterogeneous and anisotropic medium, provided that the principal axes of hydraulic conductivity are aligned with the coordinate directions.

Note that the hydraulic conductivity values represented in Equation 1 reflect the primary, three-dimensional flow directions for a finite difference model. Essentially, the “x” and “y” dimensions represent flow in the plan view, and are analogous to the dimensions of results from the Theis equation. The “z” dimension represents vertical groundwater flow and potential hydraulic impacts.

A.3.2 MODFLOW/MT3D Groundwater Model

A MODFLOW groundwater flow model, representing geologic conditions observed and hydraulic properties measured at the FCP property, was used to simulate a worst case scenario reflecting continued injection of solutions at 60 gpm at a single well over the maximum permissible excursion period of 48 hours.

The MODFLOW model was constructed using hydrostratigraphic unit thicknesses and hydraulic parameters measured during studies conducted at the FCP property which are described in Attachment I of this Application. The model construction included ten layers representing the UBFU, MFGU, and LBFU that immediately overlies the bedrock under the FCP property, the uppermost 40 feet of the Bedrock Oxide Zone, and the Bedrock Oxide Zone.

In the MODFLOW model, the LBFU was allowed to be in hydraulic communication with the underlying Bedrock Oxide Zone, but was confined by the overlying MFGU. In accordance with the Operations Plan, the MODFLOW model excluded the uppermost 40 feet of the Bedrock Oxide Zone from injection.

The MODFLOW model generated a three-dimensional flow field that was imported into MT3D. MT3D was then used to model the advective and dispersive transport of the injected solution at the rate and time period given. Modeling advective and dispersive transport of injected solutions results in a more conservative estimate of the ZEI radius than does modeling fluid migration using the Theis method, because advection and dispersion have the potential to allow dissolved constituents in the injected fluid to move further than would be calculated using the Theis method.

Groundwater flow and transport scenarios were run using an array of porosity and hydraulic conductivity values representative of site conditions to determine approximate maximum and minimum transport distances of injected fluids. Porosity values ranged between 2 and 20 percent, and hydraulic conductivity values ranged between 0.2 and 2.5 feet per day for each of the model layers, and up to 40 feet per day in the primary fault zones. At the request of USEPA, additional scenarios were run to determine the horizontal and vertical extent of fluid migration during a worst case scenario where a single well injected for 30 days with no hydraulic control. The model produced three dimensional results that illustrate the extent of horizontal and vertical migration of injected fluid. The horizontal extent of migration results were used to develop the proposed AOR. The vertical extent of migration results were used to support the proposed aquifer exemption described in Attachment S of this Application.

Results of the MODFLOW/MT3D simulations are described below.

A.3.3 MODFLOW/MT3D Simulation Results

Figures A-1 through A-8 are north-south cross sections depicting the horizontal and vertical extent of migration of injected fluid under selected injection scenarios. Figures A-1a through A-8a are east-west cross sections depicting fluid migration under the same conditions. The selected injection scenarios are described in Table A-1, and were simulated as permutations of the base groundwater flow model.

Table A-1. Groundwater Model Results of Selected Injection Scenarios

	Simulation Time	Number of Wells Injecting	Injection Rate (GPM)	Number of Wells Pumping	Pumping Rate	Porosity of Oxide Layers (%)	Fault Zone Porosity (%)	Fault Zone Hydraulic Conductivity (ft/day)	MFGU Hydraulic Conductivity
Scenario 1	30 days	1	60	0	0	Base Model	10	40	Base Model
	48 hours	1	60	0	0	Base Model	10	40	Base Model
Scenario 2	30 days	1	60	0	0	Base Model	13	40	Base Model
Scenario 3	30 days	1	60	0	0	Base Model	20	40	Base Model
Scenario 4	30 days	1	60	0	0	2	Base Model	Base Model	Base Model
Scenario 5	30 days	1	60	0	0	8	Base Model	Base Model	Base Model

Table A-1. Groundwater Model Results of Selected Injection Scenarios

	Simulation Time	Number of Wells Injecting	Injection Rate (GPM)	Number of Wells Pumping	Pumping Rate	Porosity of Oxide Layers (%)	Fault Zone Porosity (%)	Fault Zone Hydraulic Conductivity (ft/day)	MFGU Hydraulic Conductivity
Scenario 6	30 days	1	60	0	0	13	Base Model	Base Model	Base Model
Scenario 7	30 days	1	60	0	0	13	Base Model	Base Model	Set Equal to LBFU Value

A description of the model results that includes consideration of both the north-south and east-west cross sections shown in Figures A-1 through A-8 and A-1a through A-8a is included below.

Scenario 1: Sidewinder Fault hydraulic conductivity set at 40 feet/day and porosity at 10 percent.

Figure A-1 provides a cross-sectional view (north-south transect) of vertical and horizontal migration of sulfate from a single well within the PTF well field after operating without hydraulic control for a period of 30 days, and using the fault hydrologic parameters described above. Under these simulated conditions, lixiviant migrates northward approximately 201 feet horizontally from the PTF injection well, and approximately 40 feet vertically into the exclusion zone. Figure A-1a (east-west transect) shows that injected solution migrated approximately 150 feet to the west in model layer 10. Injected solution did not reach the LBFU in significant concentrations after 30 days without hydraulic control. The estimated horizontal migration distance of 201 feet was the maximum observed from all model scenarios and associated simulations involving 30-day lixiviant injection without hydraulic control.

Figure A-2 is a cross-sectional view (north-south transect) of vertical and horizontal migration of sulfate from a single well within the PTF well field after operating without hydraulic control for a period of 48 hours, and using a fault hydraulic conductivity of 40 feet per day and porosity of 10 percent. Figure A-2 shows that under these conditions, after 48 hours, sulfate migrates northward approximately 67 feet horizontally from the PTF injection well along the Sidewinder fault in layer 10, and approximately 40 feet vertically into the exclusion zone. Figure A-2a (east-west transect) shows that injected solution migrated approximately 63 feet to the west in model layer 10. No significant migration of injected solution into the LBFU occurred after 48 hours without hydraulic control. This simulation scenario reflects the greatest estimated extent of lateral migration during a 48-hour period for all scenarios without hydraulic control. Given this fact, only the conservative 30-day simulation results are presented below as measures of maximum lateral and vertical lixiviant migration distances after injecting for 30-days without hydraulic control.

Scenario 2: Sidewinder Fault hydraulic conductivity set at 40 feet/day and fault porosity at 13 percent.

Given the assumed hydraulic parameters described above, the simulated results shown on Figure A-3 (north-south transect) show that lixiviant migrates northward approximately 163 feet horizontally from the PTF injection well along the Sidewinder fault in model layer 10, and approximately 40 feet vertically into the exclusion zone within a very limited lateral extent. Figure A-3a (east-west transect) shows that injected solution migrated approximately 125 feet to the west in model layer 10. Injected solution was not estimated to reach the LBFU in significant concentrations after 30 days without hydraulic control.

Scenario 3: Sidewinder Fault hydraulic conductivity set at 40 feet/day and fault porosity at 20 percent.

Given the assumed hydraulic parameters described above, the simulated results shown on Figure A-4 (north-south transect) show that lixiviant migrates northward approximately 125 feet horizontally from the PTF injection well along the Sidewinder fault in model layer 10, and approximately 40 feet vertically into the exclusion zone within a very limited lateral extent. Figure A-4a (east-west transect) shows that injected solution migrated approximately 100 feet to the east and west in model layer 10. Injected solution did not reach the LBFU in significant concentrations after 30 days without hydraulic control.

Scenario 4: Oxide porosity set at 2 percent. Fault zone hydraulic parameters at base FCP model values.

Given the assumed hydraulic parameters noted above for the oxide unit, the simulated results shown on Figure A-5 (north-south transect) shows that lixiviant migrates northward approximately 125 feet horizontally from the PTF injection well along the Sidewinder fault in model layer 10, and approximately 40 feet vertically into the exclusion zone. The lateral extent of the lixiviant migration is limited to an area within the footprint of the PTF well field. Figure A-5a (east-west transect) shows that injected solution migrated approximately 125 feet to the west in model layer 8. Dilute concentrations of injected solution also migrate vertically upwards approximately 55 feet into the LBFU.

Scenario 5: Oxide porosity set at 8 percent. Fault zone hydraulic parameters at base FCP model values.

Given the assumed hydraulic parameters noted above for the oxide unit, the simulated results shown on Figure A-6 (north-south transect) show that lixiviant migrates northward approximately 125 feet horizontally from the PTF injection well along the Sidewinder fault in model layer 10, approximately 40 feet vertically into the exclusion zone, and approximately 54 feet vertically into the LBFU. The lateral extent of the lixiviant migration is limited to an area within the footprint of the PTF well field. Figure A-6a (east-west transect) shows that injected solution migrated approximately 125 feet to the east and west in model layer 10. The estimated horizontal migration distance is identical to the previous scenarios because the maximum migration distance occurs along the Sidewinder fault zone and the hydraulic parameters for the fault zone are the same in Scenarios 4 through 7.

Scenario 6: Oxide porosity set at 13 percent. Fault zone hydraulic parameters at base FCP model values.

Given the assumed hydraulic parameters noted above for the oxide unit, the simulated results shown on Figure A-7 (north-south transect) show that lixiviant migrates northward approximately 125 feet horizontally from the PTF injection well along the Sidewinder fault in model layer 10, approximately 40 feet vertically into the exclusion zone, and approximately 54 feet vertically into the LBFU. The lateral extent of the lixiviant migration is limited to an area within the footprint of the PTF well field. Figure A-7a (east-west transect) shows that injected solution migrated approximately 125 feet to the east and west in model layer 10. The estimated horizontal migration distance is identical to the previous scenarios because the maximum migration distance occurs along the Sidewinder fault zone, and the hydraulic parameters for the fault zone are the same in Scenarios 4 through 7.

Scenario 7: No MFGU – MFGU given hydraulic parameters of LBFU. Fault zone hydraulic parameters at base FCP model values.

Given the assumed hydraulic parameters noted above for the MFGU, the simulated results shown on Figure A-8 (north-south transect) show that lixiviant migrates north and south approximately 125 feet horizontally from the PTF injection well along the Sidewinder fault in model layer 10, approximately 40 feet vertically into the exclusion zone, and approximately 54 feet vertically into the LBFU. The lateral extent of the lixiviant migration is limited to an area within the footprint of the PTF well field. Figure A-7a (east-west transect) shows that injected solution migrated approximately 125 feet to the east and west in model layer 10. The estimated horizontal migration distance is identical to the previous scenarios because the maximum migration distance occurs along the Sidewinder fault zone and the hydraulic parameters for the fault zone are the same in Scenarios 4 through 7.

A.3.4 Summary

The maximum horizontal migration distance estimated with the FCP model, given the specified variations in hydraulic and transport parameters and loss of hydraulic control for 30 days, was approximately 201 feet horizontally within the fault zone of model layer 10 (deepest model layer) and 55 feet vertically into the LBFU. Minimum transport distances for the 30-day scenarios were approximately 125 feet horizontally and 0 feet vertically above the exclusion zone. No significant sulfate mass was estimated to penetrate into the MFGU nor the upper portion of the LBFU. When considering loss of hydraulic control for 48 hours, the maximum estimated horizontal migration distance of lixiviant was only approximately 67 feet along the deepest model layer (layer 10 within the fault zone). Increasing hydraulic conductivities and porosities within the Sidewinder fault zone, decreased porosity values within the oxide unit, and the lack of a confining unit demonstrated no adverse sensitivity effect or undue impact upon vertical or horizontal migration of injected solutions without hydraulic control.

It should be noted that under no circumstances will Florence Copper continue to inject lixiviant after determination of loss of hydraulic control. If hydraulic control is lost, Florence Copper will cease injection upon determination of loss of hydraulic control and will not resume injection until hydraulic control has been reestablished. Model scenarios simulating injection without hydraulic control extending from initiation of injection through 48 hours to a total of 30 days were developed at the request of USEPA; however, they do not represent planned PTF operations. Model runs conducted in response to USEPA comments assumed injection would continue for periods of up to 30 days without hydraulic control. Injection without hydraulic control for such extended periods is not realistic. Attachment K of this Application specifies that hydraulic control will be monitored daily, and Table K-1 of that Attachment summarizes the responses Florence Copper will take to the loss of hydraulic control.

A.4. Proposed AOR

Florence Copper proposes an AOR that is equivalent to the PTF well field area and a circumscribing width of 500 feet. This AOR is conservative with respect to protecting USDWs because it provides a factor of safety of between 2.5 and 4 times the actual distance that lixiviant may migrate under worst-case conditions (30-day excursion) that significantly exceeds the maximum permissible excursion (48-hour excursion) described in the Operations Plan at the average injection rate proposed by Florence Copper for the PTF. The proposed AOR provides a safety factor of 7.5 times the actual distance (67 feet) that lixiviant might travel during the maximum permissible excursion of 48 hours.

The proposed AOR is shown on Figure A-9 together with the planned PTF well field area, Florence Copper's property boundary, and other pertinent features.

A.5. References

BHP Copper Inc., 1998. Correspondence, Letter to Julie Collins, ADEQ Compliance Officer, From Corolla Hoag, BHP Copper, *Report of Results of Hydraulic Control Test.*

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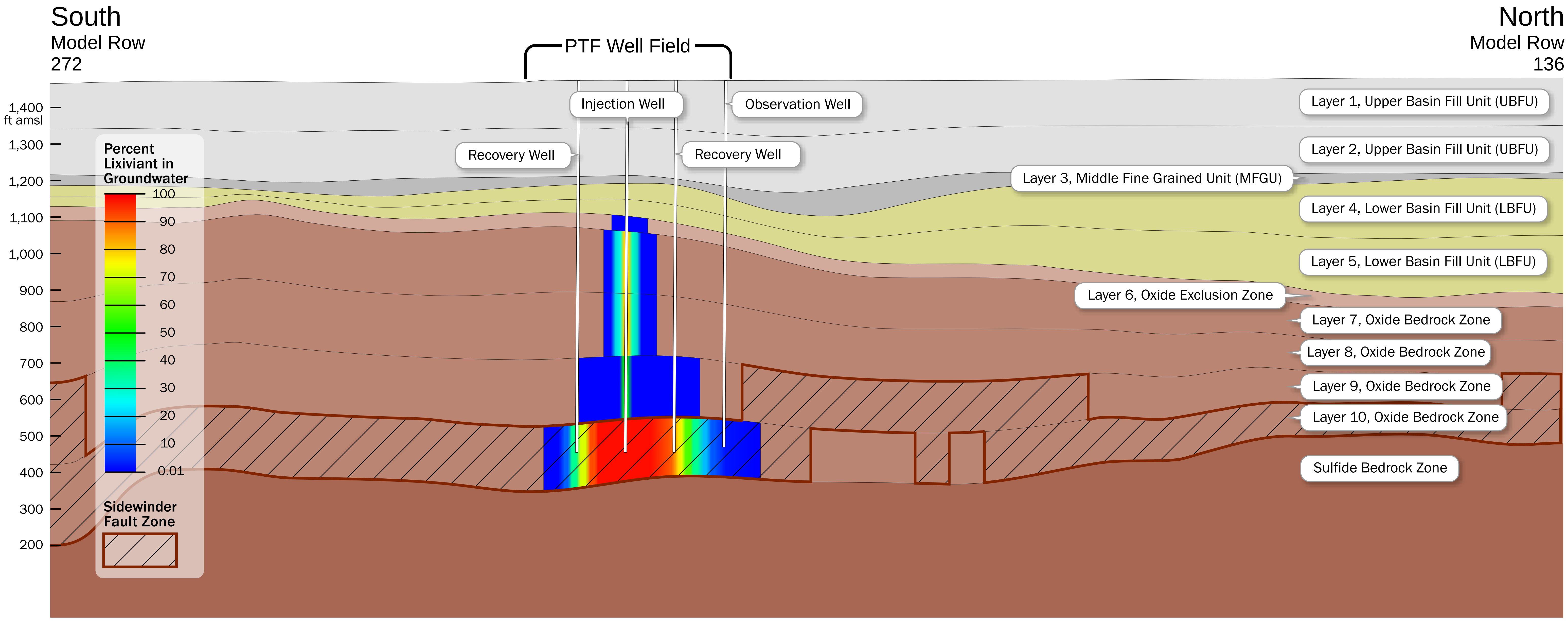
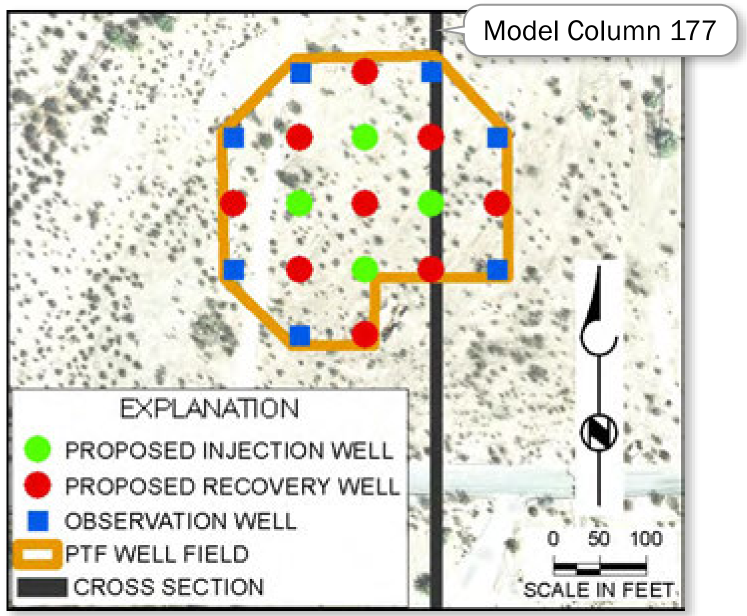
McDonald, M.G., and Harbaugh, A.W., 1988. *A Modular Three Dimensional Finite-Difference Groundwater Flow Model.* U.S. Geological Survey Techniques of Water Resource Investigations Book6, ChapterA1.

Theis, C.V., 1935. *The Lowering of the Piezometer Surface and the Rate and Discharge of a Well Using Groundwater Storage.* Transactions, American Geophysical Union 16:519-24

Zheng, C., 1990. MT3D, a Modular Three-Dimensional Transport Model, S.S. Papadopulos and Associates, Bethesda, Md.

Cross-Section along Model Column 177





Scenario 1 Simulation Details and Variations from Base FCP Model:

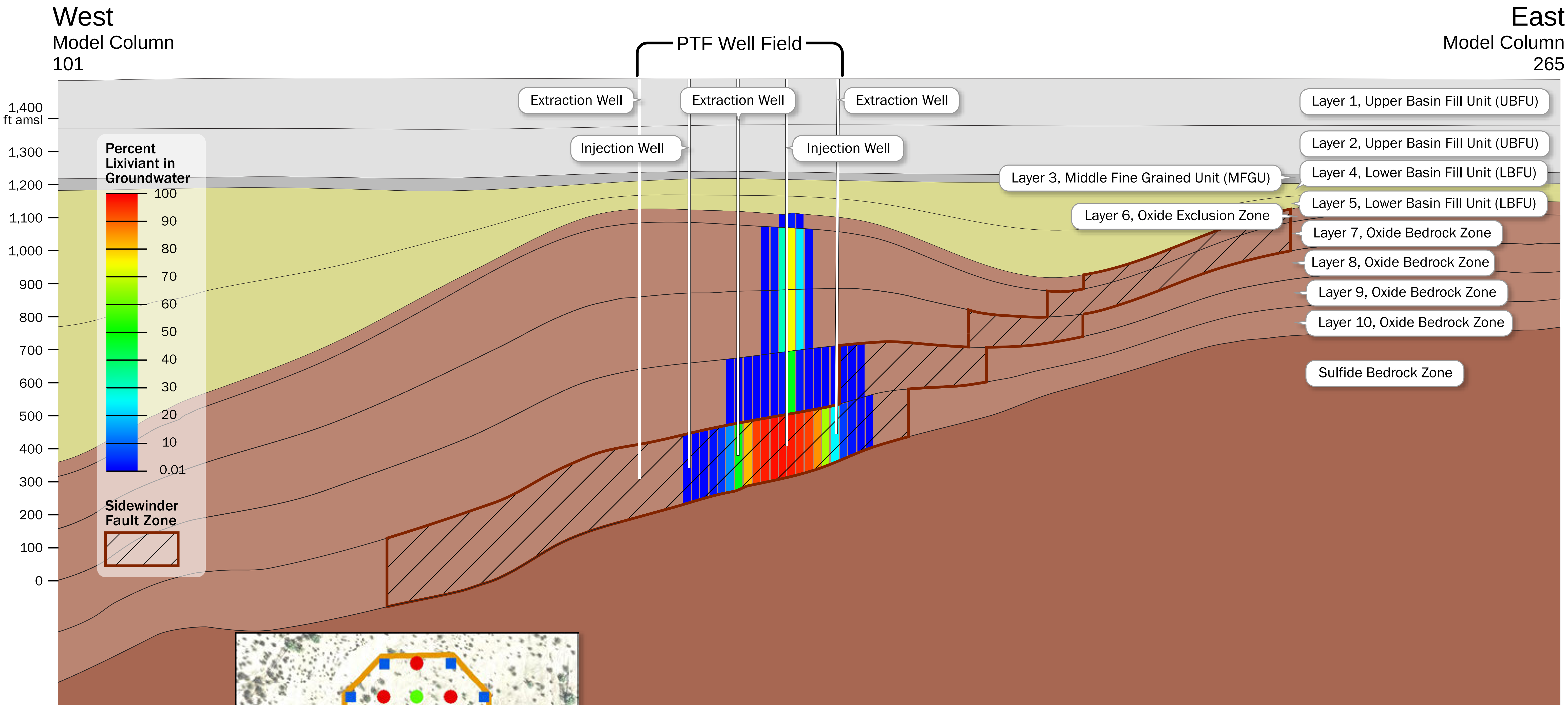
- 30 days simulation time
- One well injecting at 60 gpm, no recovery pumping
- Hydraulic conductivity of Sidewinder Fault Zone = 40 feet/day
- Porosity of Sidewinder Fault Zone = 10% (same as Base FCP Model)
- Other hydrologic parameters same as base FCP Model (Table 10-1)

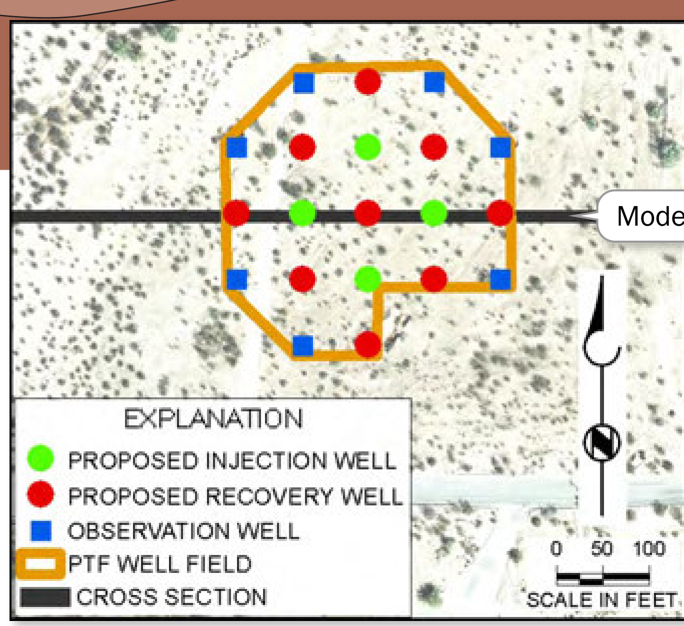
Brown AND Caldwell

HORIZONTAL SCALE
(feet)
0 12.5 25 50 100 250

Figure A-1
Model Predicted Migration of Lixiviant – Scenario 1
Florence Copper Project Groundwater Model

Cross-Section along Model Row 231





Scenario 1 Simulation Details and Variations from Base FCP Model:

- 30 days simulation time
- One well injecting at 60 gpm, no recovery pumping
- Hydraulic conductivity of Sidewinder Fault Zone = 40 feet/day
- Porosity of Sidewinder Fault Zone = 10% (same as Base FCP Model)
- Other hydrologic parameters same as base FCP Model (Table 10-1)

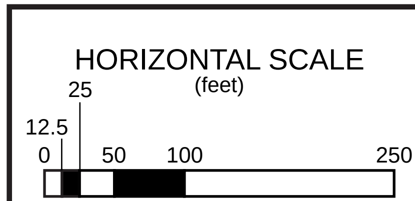
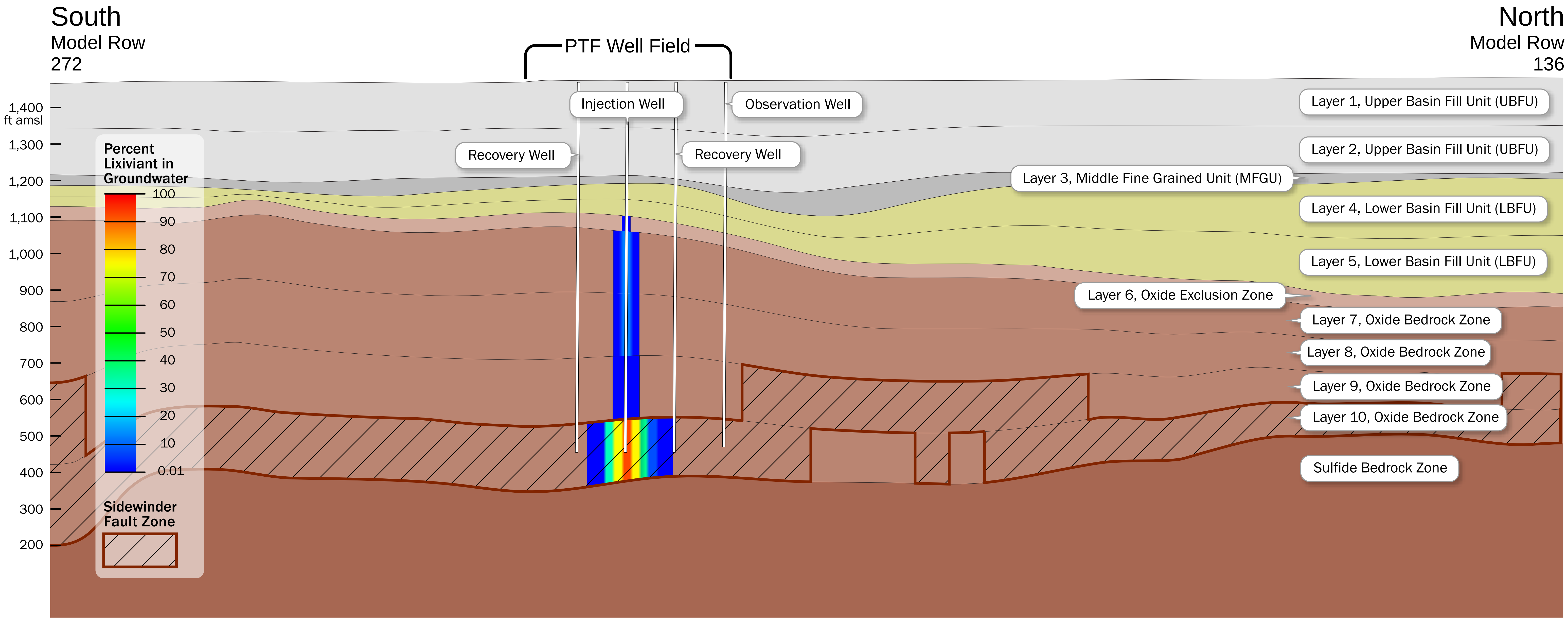
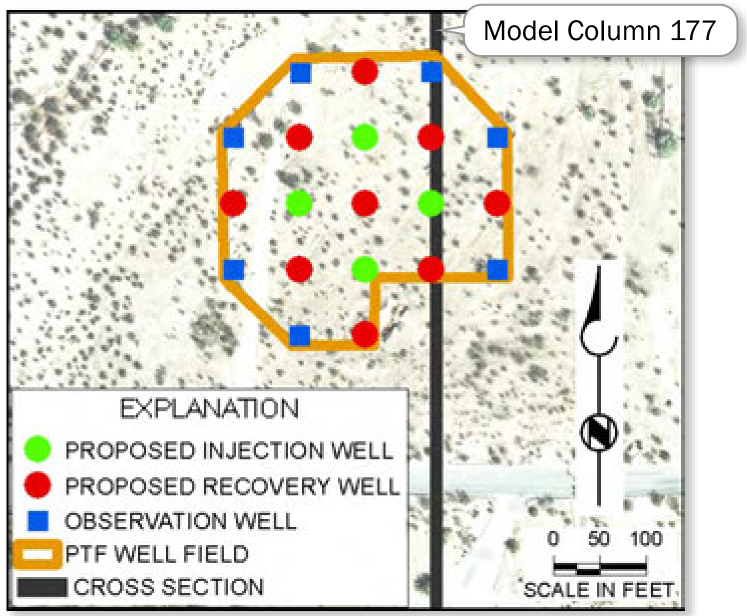


Figure A-1a
Model Predicted Migration of Lixiviant – Scenario 1
North-facing Cross Section
Florence Copper Project Groundwater Model

Brown AND Caldwell

Cross-Section along Model Column 177





Scenario 1 Simulation Details and Variations from Base FCP Model:

- 48 hours simulation time
- One well injecting at 60 gpm, no recovery pumping
- Hydraulic conductivity of Sidewinder Fault Zone = 40 feet/day
- Porosity of Sidewinder Fault Zone = 10% (same as Base FCP Model)
- Other hydrologic parameters same as base FCP Model (Table 10-1)

Brown AND Caldwell

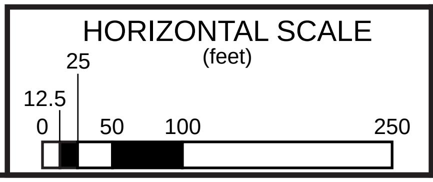
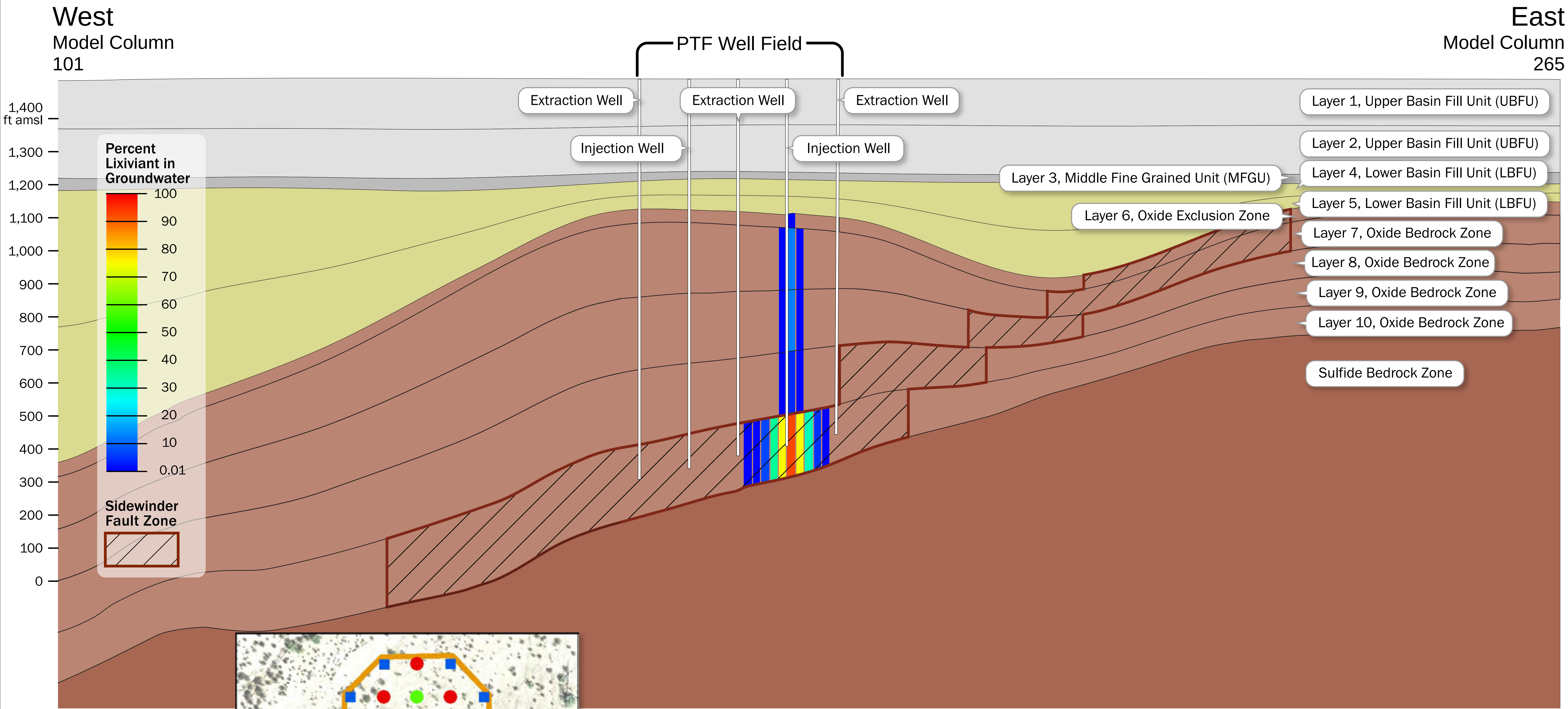
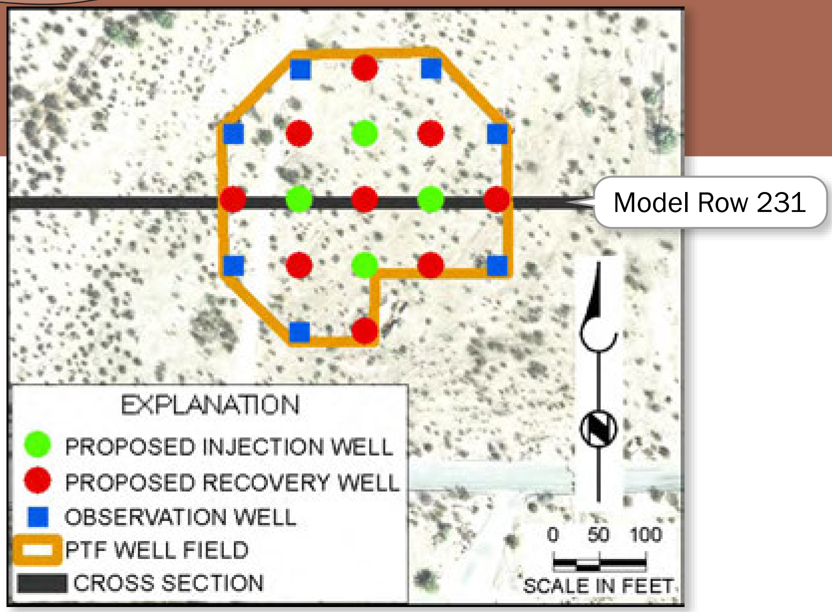


Figure A-2
Model Predicted Migration of Lixiviant – Scenario 1
Florence Copper Project Groundwater Model

Cross-Section along Model Row 231





Scenario 1 Simulation Details and Variations from Base FCP Model:

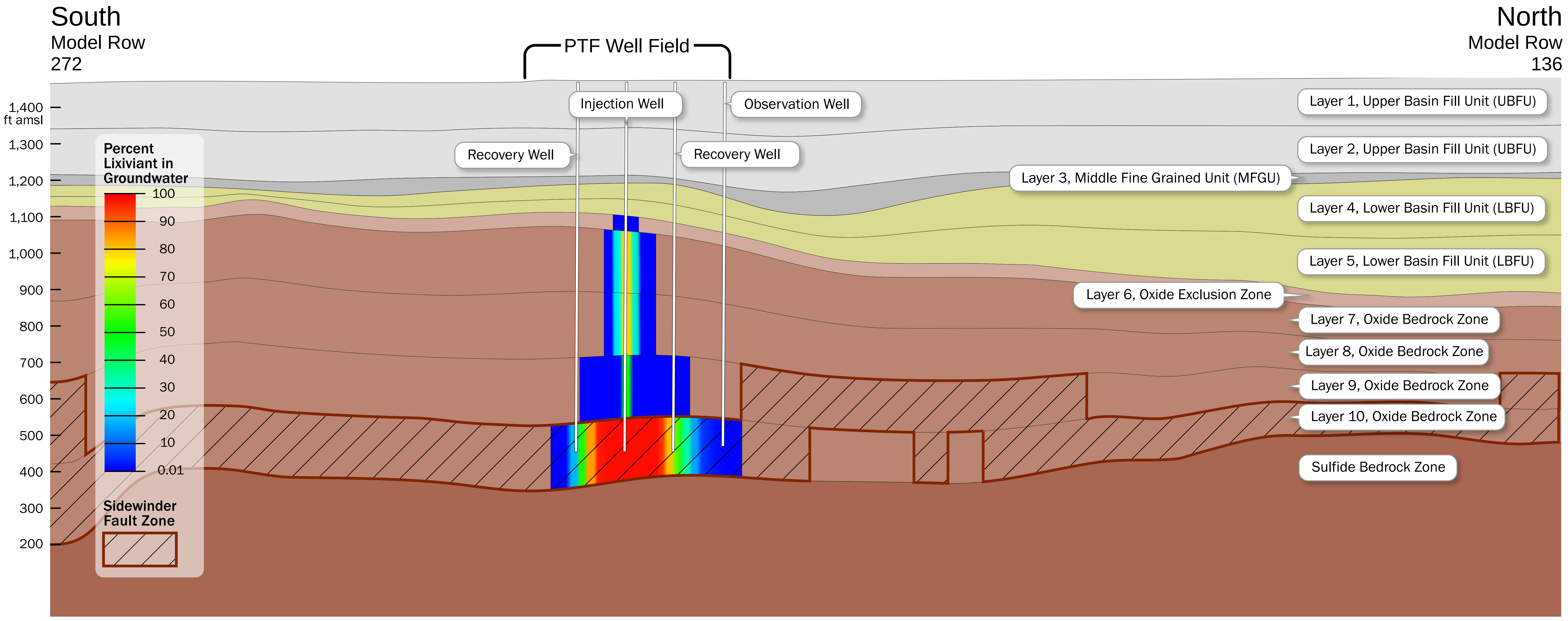
- 48 hours simulation time
- One well injecting at 60 gpm, no recovery pumping
- Hydraulic conductivity of Sidewinder Fault Zone = 40 feet/day
- Porosity of Sidewinder Fault Zone = 10% (same as Base FCP Model)
- Other hydrologic parameters same as base FCP Model (Table 10-1)

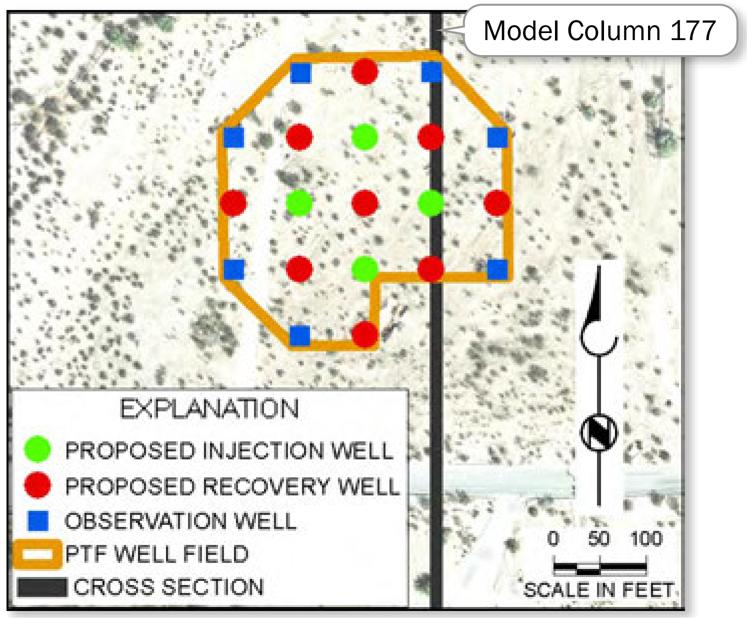
HORIZONTAL SCALE (feet)
12.5 25
0 50 100 250

Brown AND Caldwell

Figure A-2a
Model Predicted Migration of Lixiviant – Scenario 1
North-facing Cross Section
Florence Copper Project Groundwater Model

Cross-Section along Model Column 177





Scenario 2 Simulation Details and Variations from Base FCP Model:

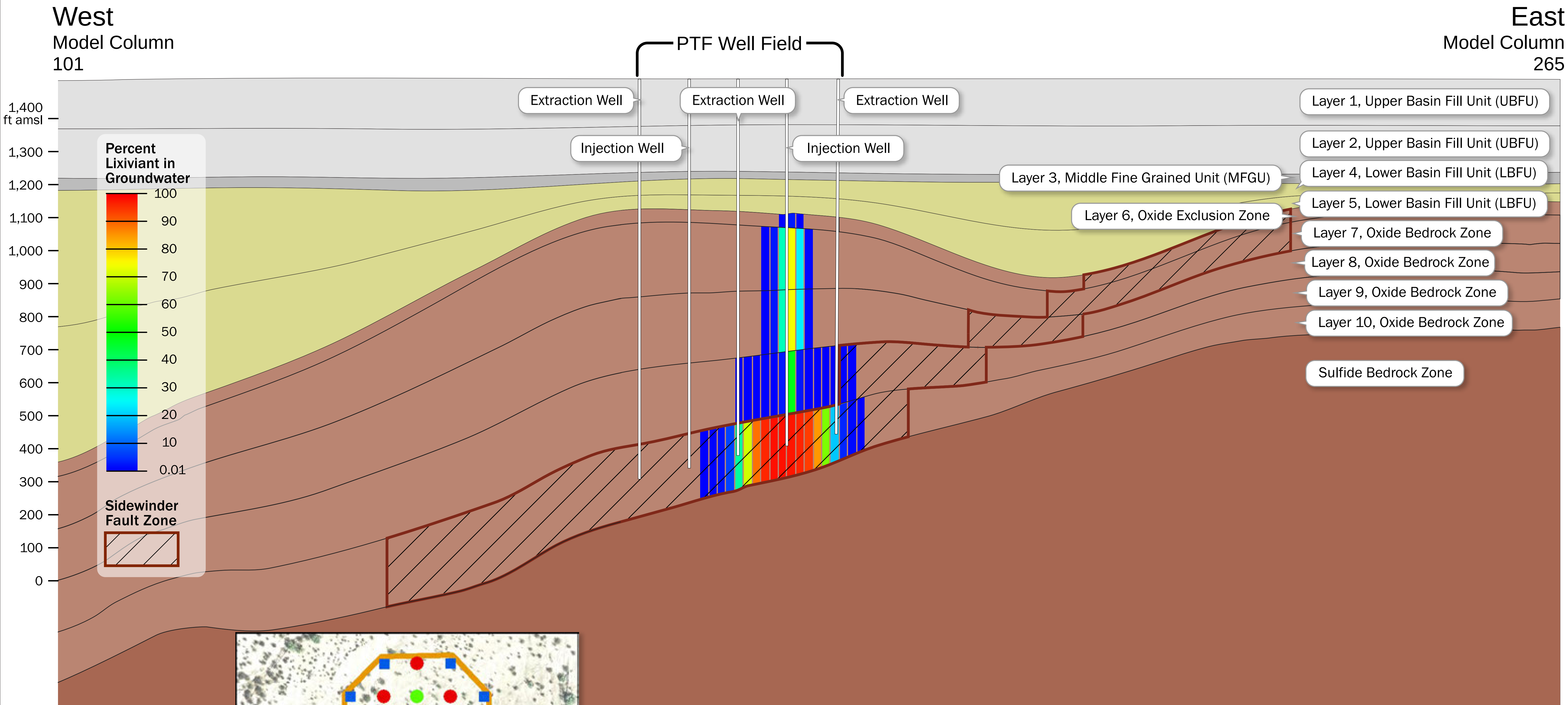
- 30 days simulation time
- One well injecting at 60 gpm, no recovery pumping
- Hydraulic conductivity of Sidewinder Fault Zone = 40 feet/day
- Porosity of Sidewinder Fault Zone = 13%
- Other hydrologic parameters same as base FCP Model (Table 10-1)

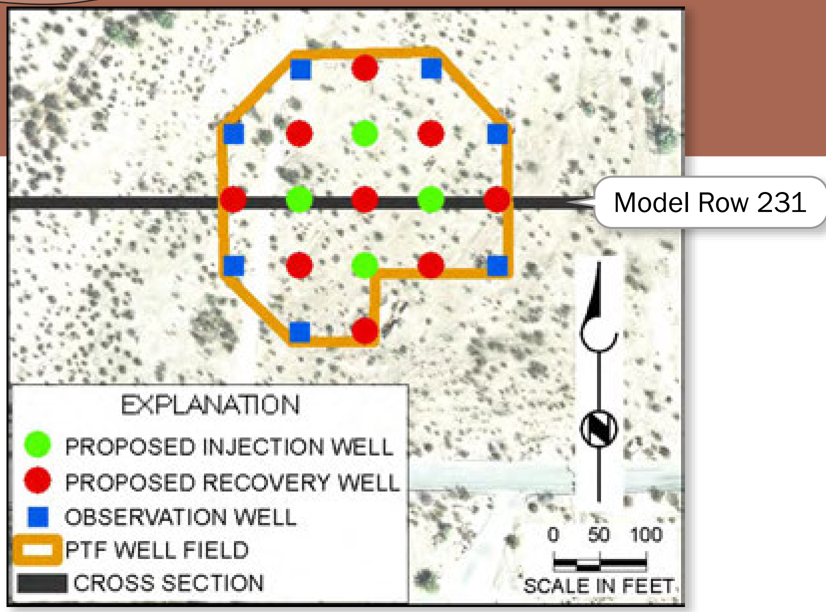
Brown AND Caldwell

HORIZONTAL SCALE (feet)
0 12.5 25 50 100 250

Figure A-3
Model Predicted Migration of Lixiviant – Scenario 2
Florence Copper Project Groundwater Model

Cross-Section along Model Row 231





Scenario 2 Simulation Details and Variations from Base FCP Model:

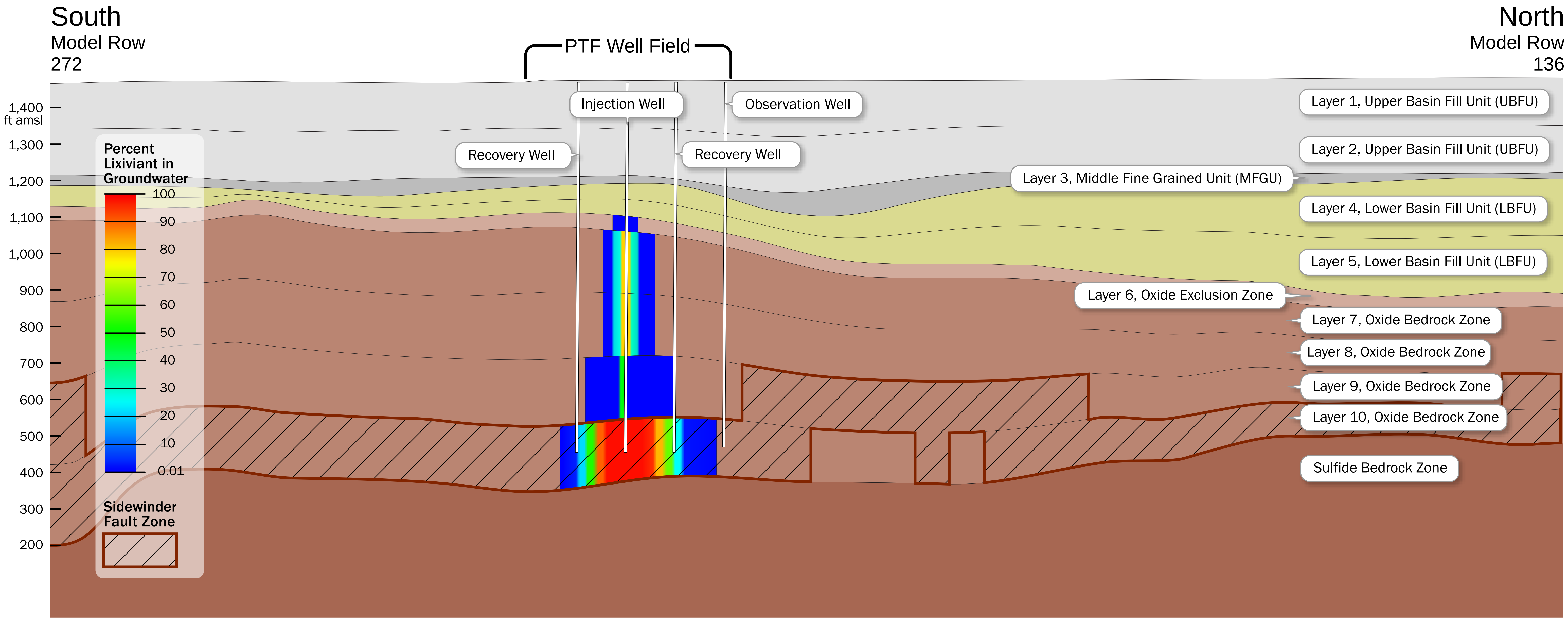
- 30 days simulation time
- One well injecting at 60 gpm, no recovery pumping
- Hydraulic conductivity of Sidewinder Fault Zone = 40 feet/day
- Porosity of Sidewinder Fault Zone = 13%
- Other hydrologic parameters same as base FCP Model (Table 10-1)

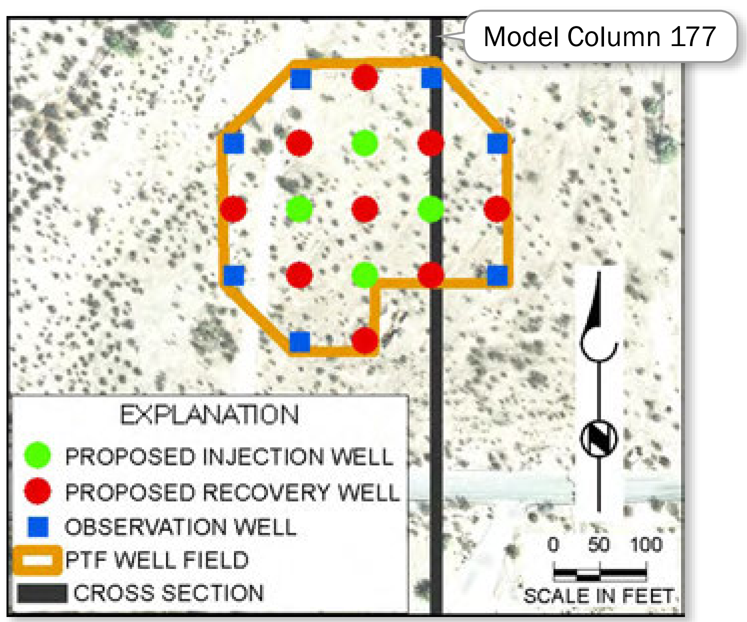
Brown AND Caldwell

HORIZONTAL SCALE
(feet)
12.5 25
0 50 100 250

Figure A-3a
Model Predicted Migration of Lixiviant – Scenario 2
North-facing Cross Section
Florence Copper Project Groundwater Model

Cross-Section along Model Column 177





Scenario 3 Simulation Details and Variations from Base FCP Model:

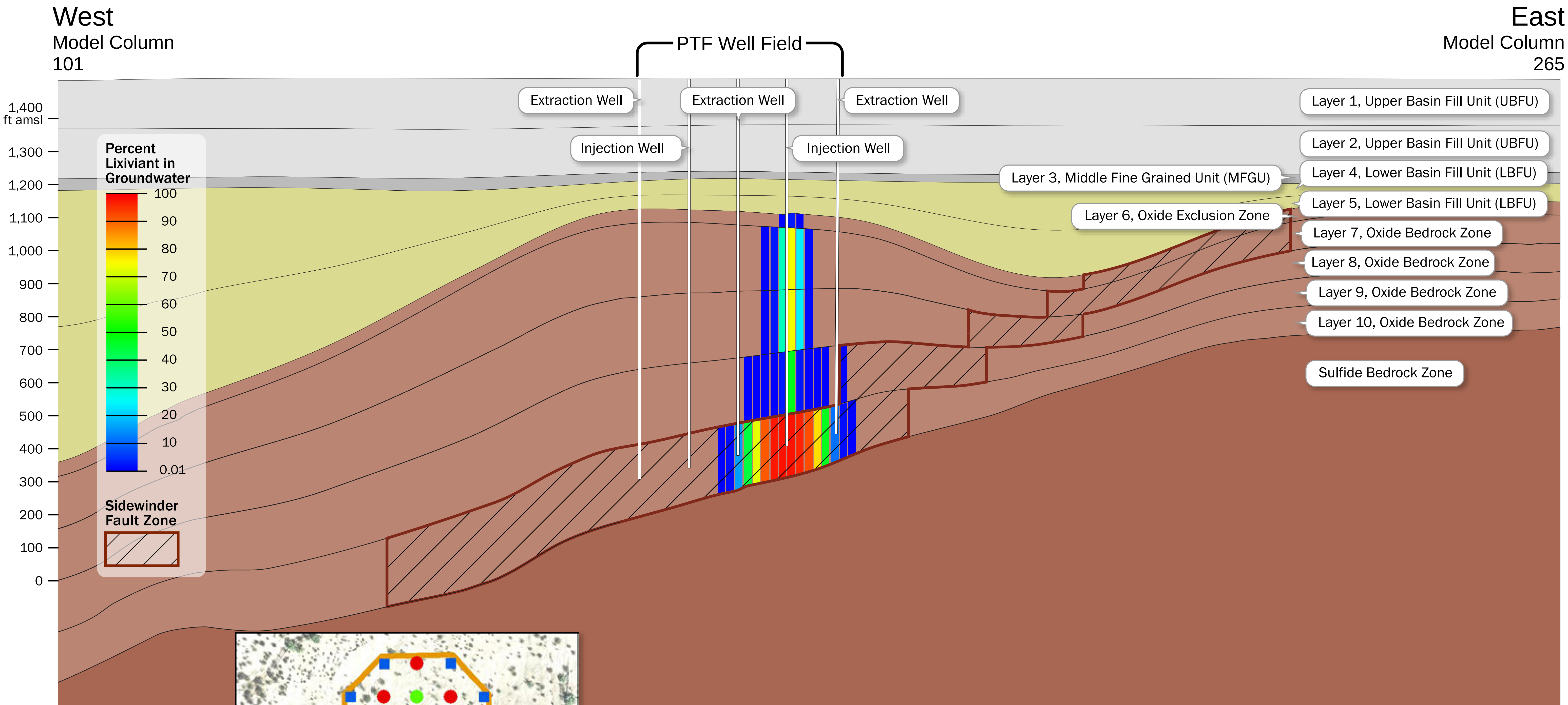
- 30 days simulation time
- One well injecting at 60 gpm, no recovery pumping
- Hydraulic conductivity of Sidewinder Fault Zone = 40 feet/day
- Porosity of Sidewinder Fault Zone = 20%
- Other hydrologic parameters same as base FCP Model (Table 10-1)

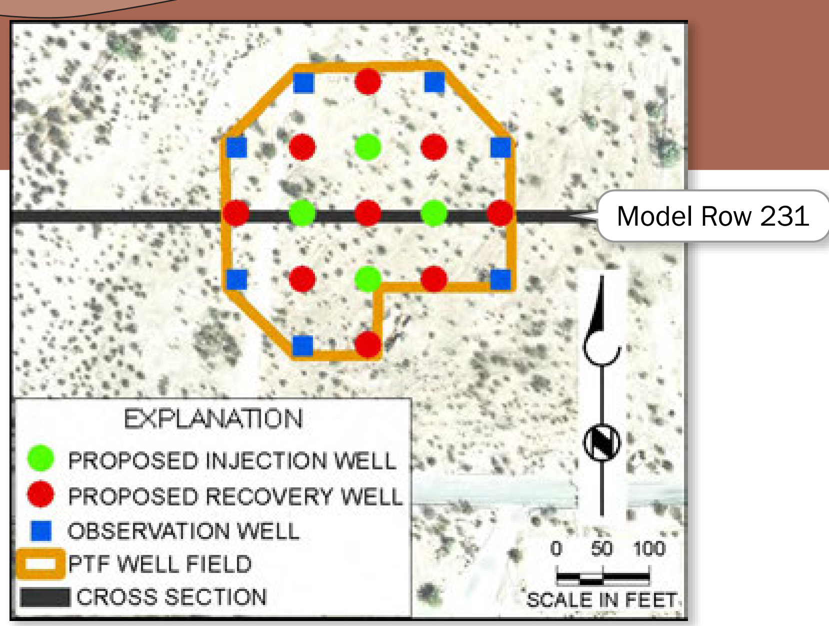
Brown AND Caldwell

HORIZONTAL SCALE
(feet)
0 12.5 25 50 100 250

Figure A-4
Model Predicted Migration of Lixiviant – Scenario 3
Florence Copper Project Groundwater Model

Cross-Section along Model Row 231





Scenario 3 Simulation Details and Variations from Base FCP Model:

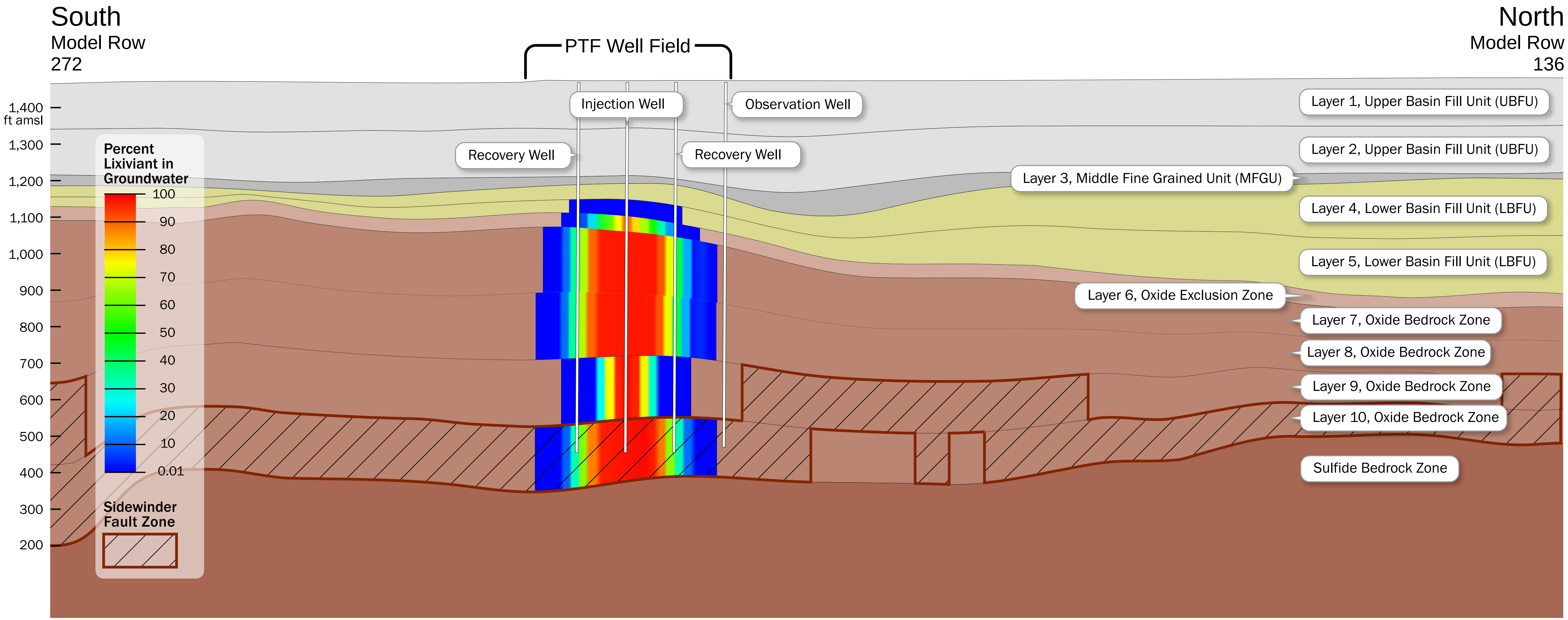
- 30 days simulation time
- One well injecting at 60 gpm, no recovery pumping
- Hydraulic conductivity of Sidewinder Fault Zone = 40 feet/day
- Porosity of Sidewinder Fault Zone = 20%
- Other hydrologic parameters same as base FCP Model (Table 10-1)

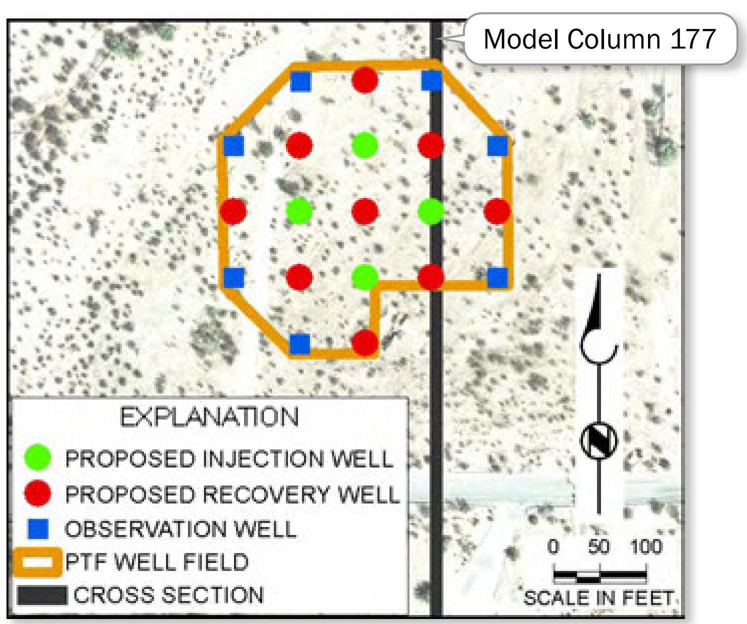
Brown AND Caldwell

HORIZONTAL SCALE
(feet)
0 12.5 25 50 100 250

Figure A-4a
Model Predicted Migration of Lixiviant – Scenario 3
North-facing Cross Section
Florence Copper Project Groundwater Model

Cross-Section along Model Column 177





Scenario 4 Simulation Details and Variations from Base FCP Model:

- 30 days simulation time
- One well injecting at 60 gpm, no recovery pumping
- Porosity of Oxide Layers = 2%
- Other hydrologic parameters same as base FCP Model (Table 10-1)

Brown AND Caldwell

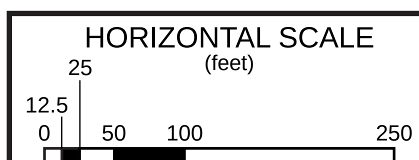
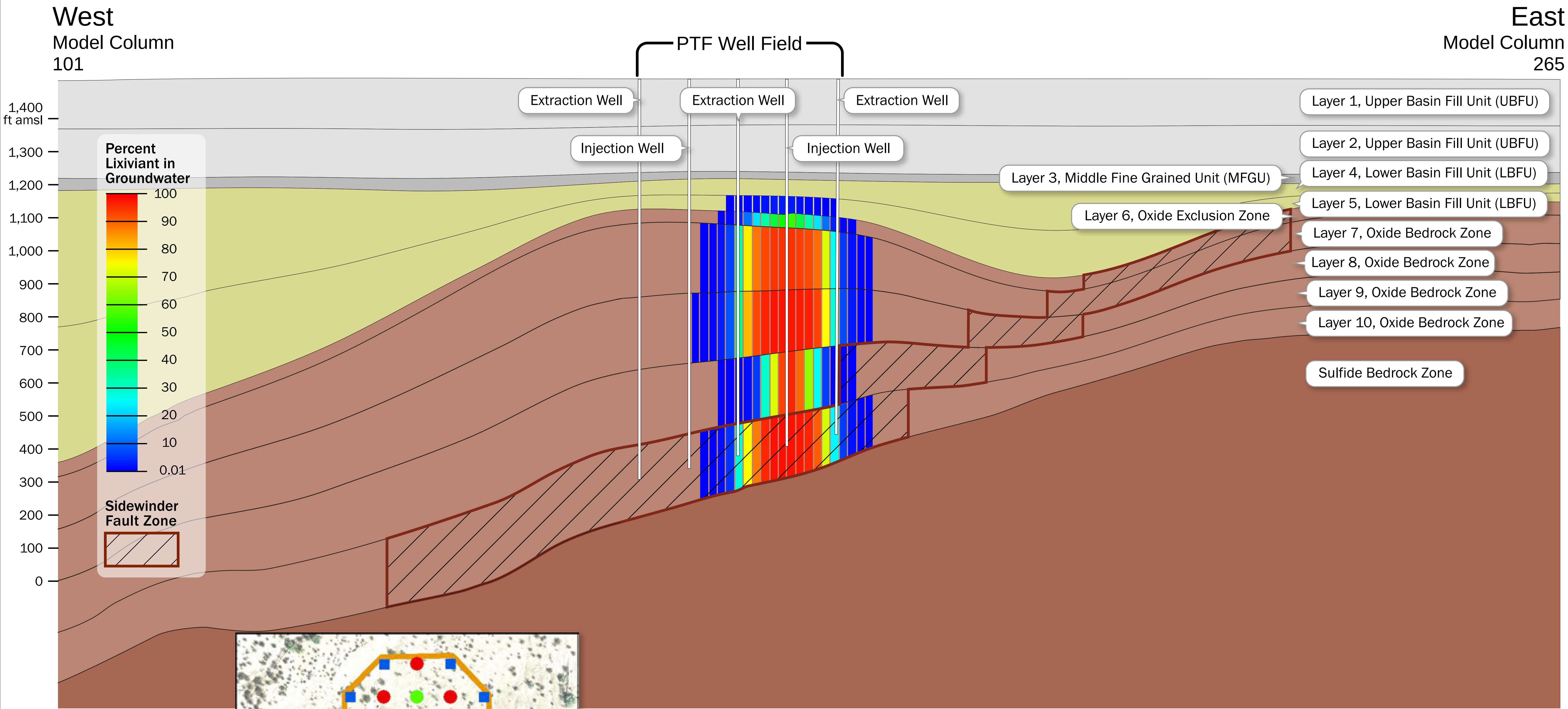
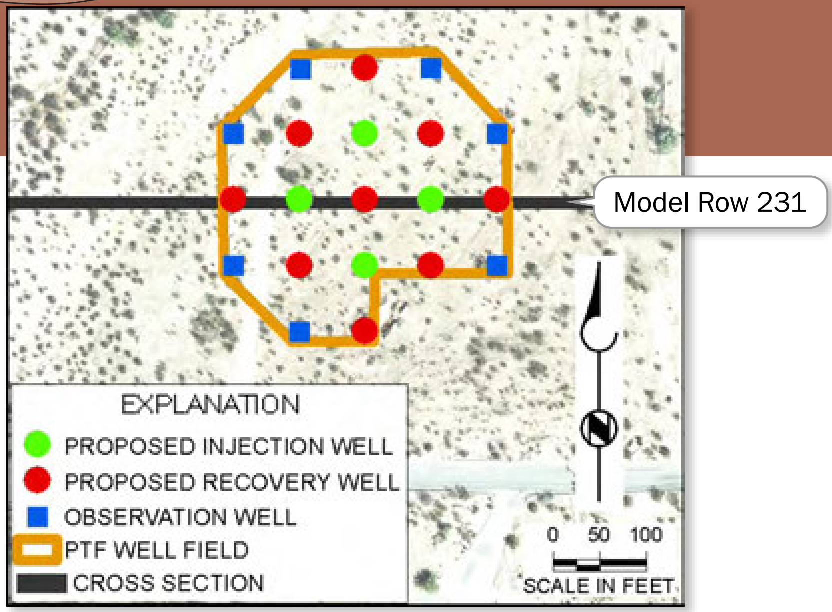


Figure A-5
Model Predicted Migration of Lixiviant – Scenario 4
Florence Copper Project Groundwater Model

Cross-Section along Model Row 231





Scenario 4 Simulation Details and Variations from Base FCP Model:

- 30 days simulation time
- One well injecting at 60 gpm, no recovery pumping
- Porosity of Oxide Layers = 2%
- Other hydrologic parameters same as base FCP Model (Table 10-1)

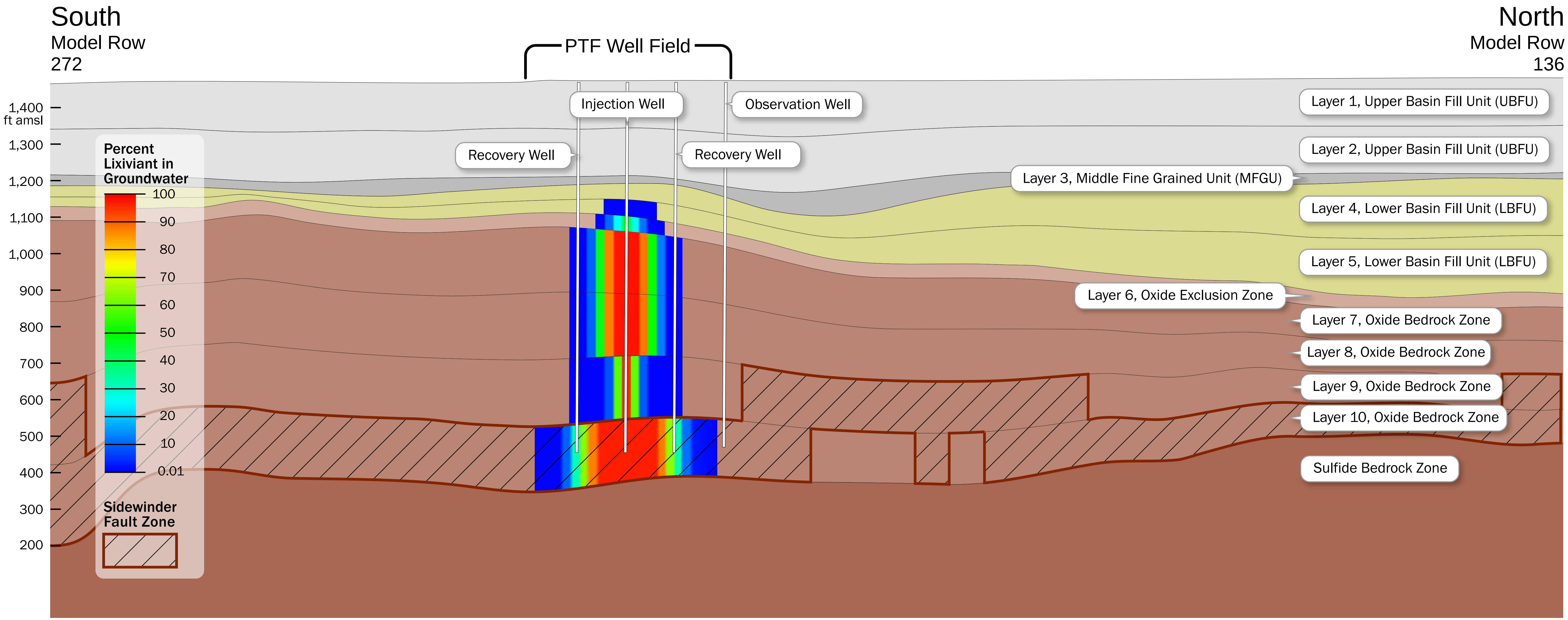
HORIZONTAL SCALE (feet)

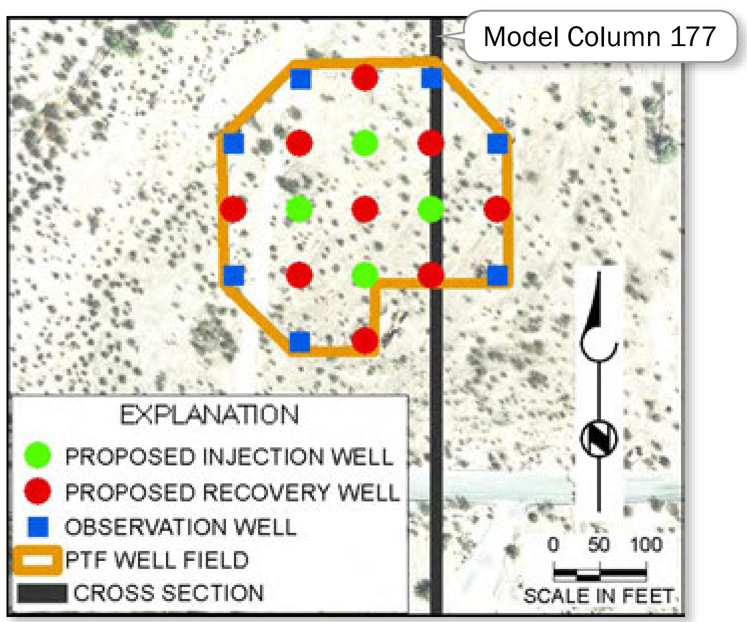
0 12.5 25 50 100 250

Brown AND Caldwell

Figure A-5a
Model Predicted Migration of Lixiviant – Scenario 4
North-facing Cross Section
Florence Copper Project Groundwater Model

Cross-Section along Model Column 177





Scenario 5 Simulation Details and Variations from Base FCP Model:

- 30 days simulation time
- One well injecting at 60 gpm, no recovery pumping
- Porosity of Oxide Layers = 8%
- Other hydrologic parameters same as base FCP Model (Table 10-1)

Brown AND Caldwell

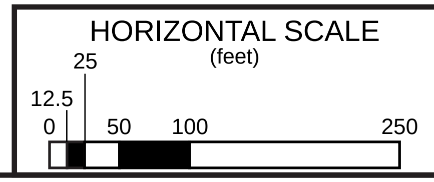
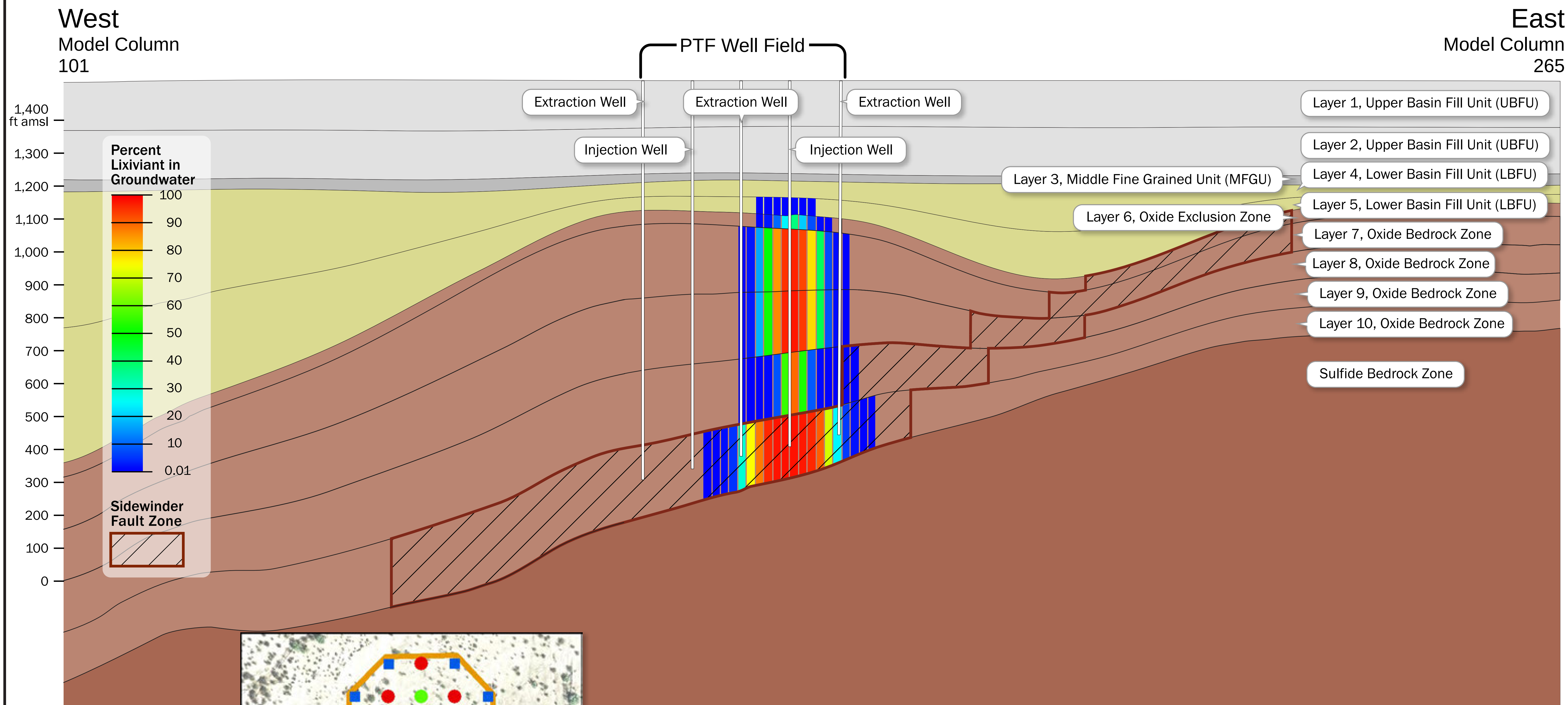
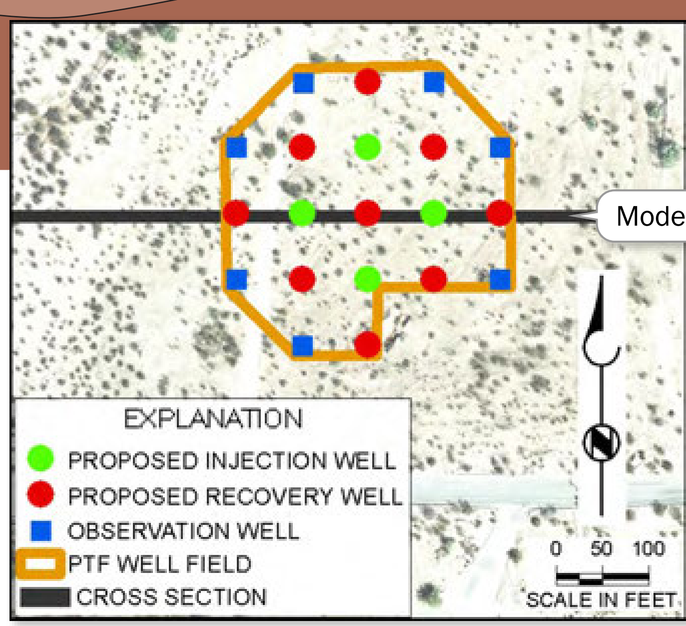


Figure A-6
Model Predicted Migration of Lixiviant – Scenario 5
Florence Copper Project Groundwater Model

Cross-Section along Model Row 231





Scenario 5 Simulation Details and Variations from Base FCP Model:

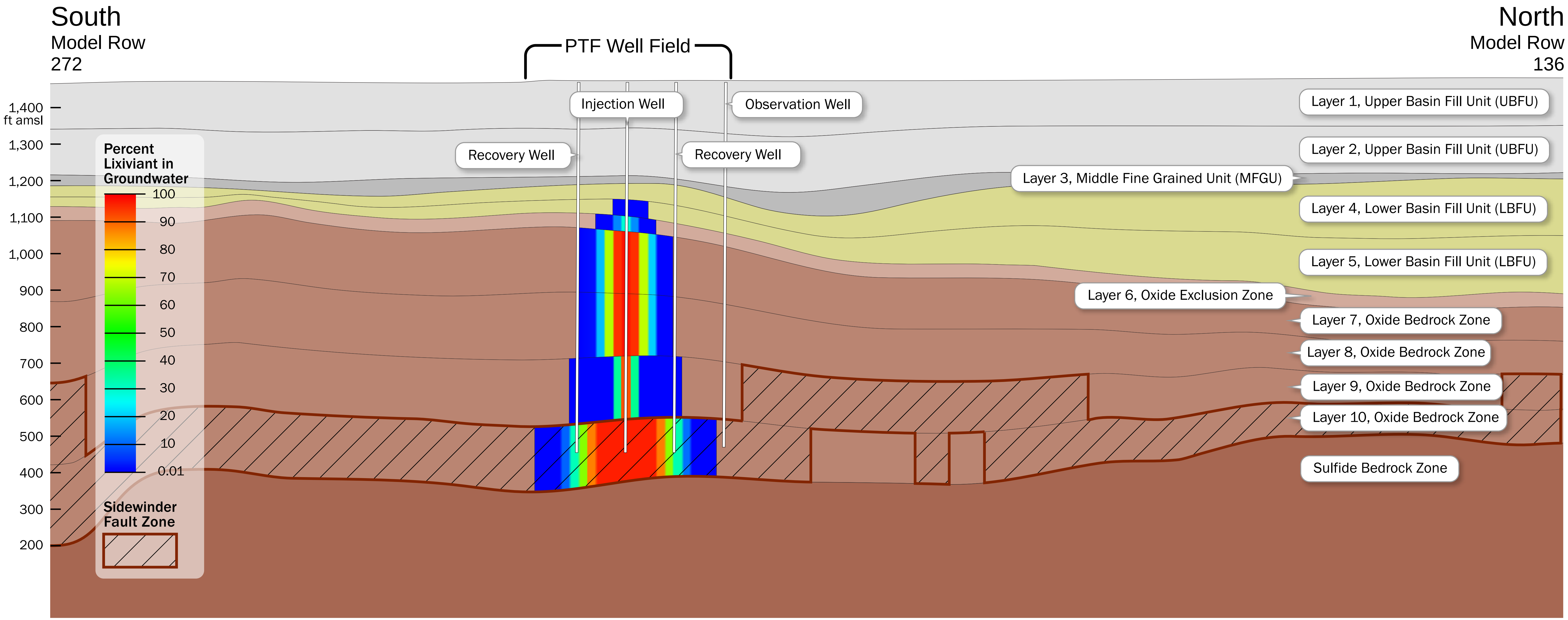
- 30 days simulation time
- One well injecting at 60 gpm, no recovery pumping
- Porosity of Oxide Layers = 8%
- Other hydrologic parameters same as base FCP Model (Table 10-1)

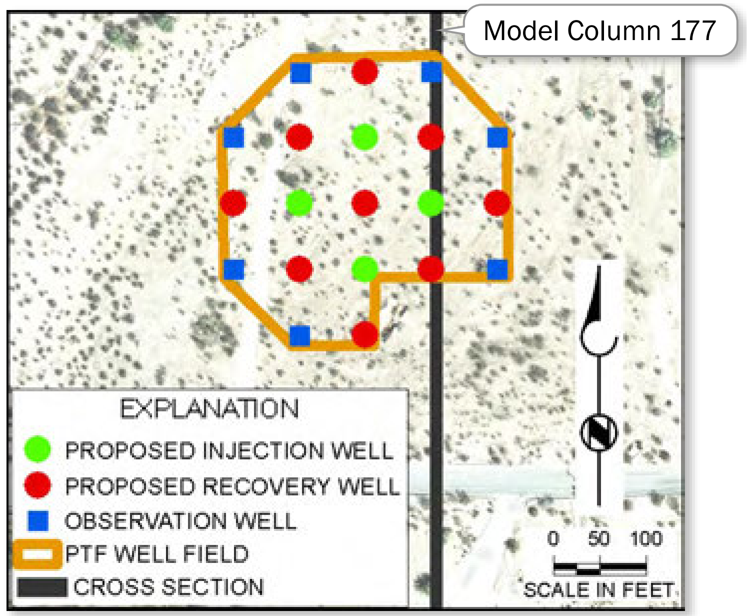
HORIZONTAL SCALE
(feet)
0 12.5 25 50 100 250

Figure A-6a
Model Predicted Migration of Lixiviant – Scenario 5
North-facing Cross Section
Florence Copper Project Groundwater Model

Brown AND Caldwell

Cross-Section along Model Column 177





Scenario 6 Simulation Details and Variations from Base FCP Model:

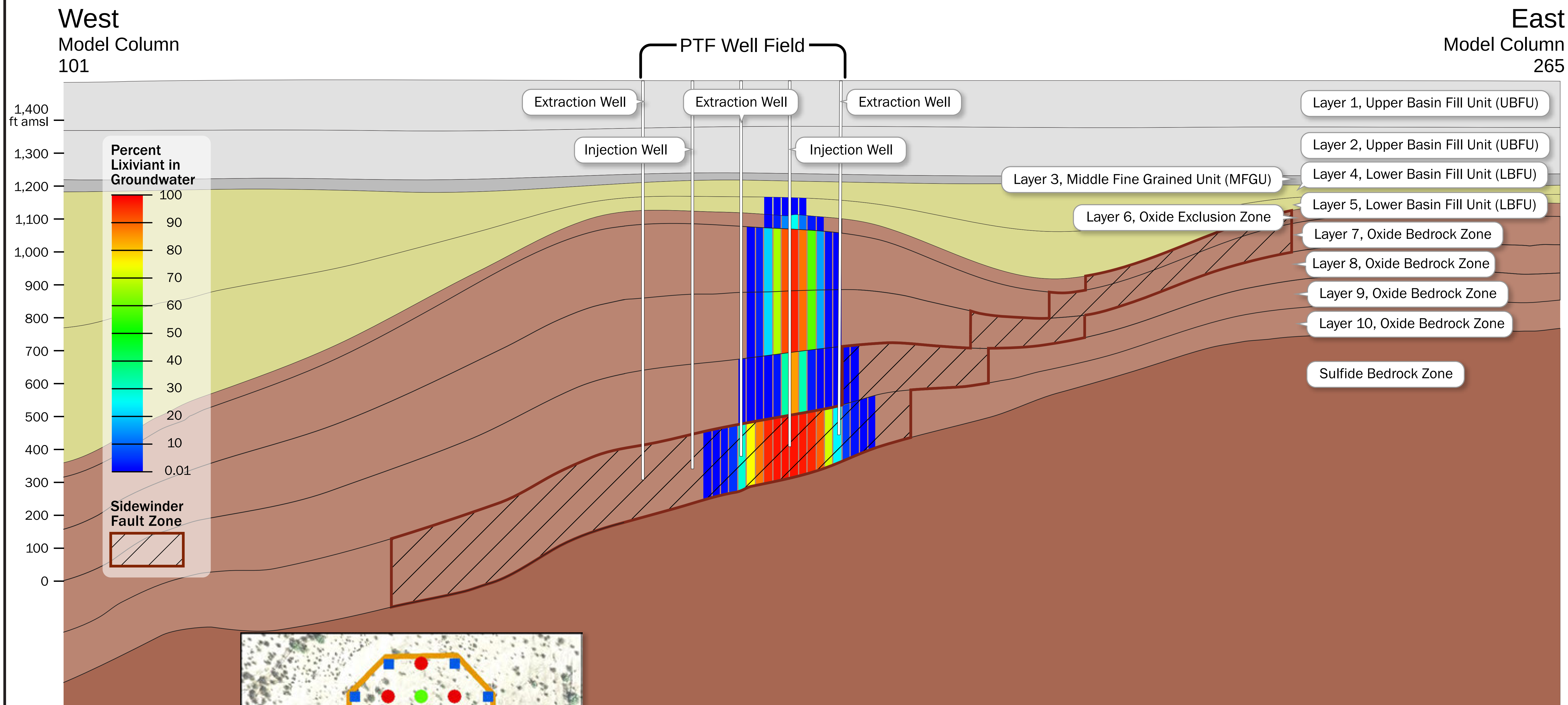
- 30 days simulation time
- One well injecting at 60 gpm, no recovery pumping
- Porosity of Oxide Layers = 13%
- Other hydrologic parameters same as base FCP Model (Table 10-1)

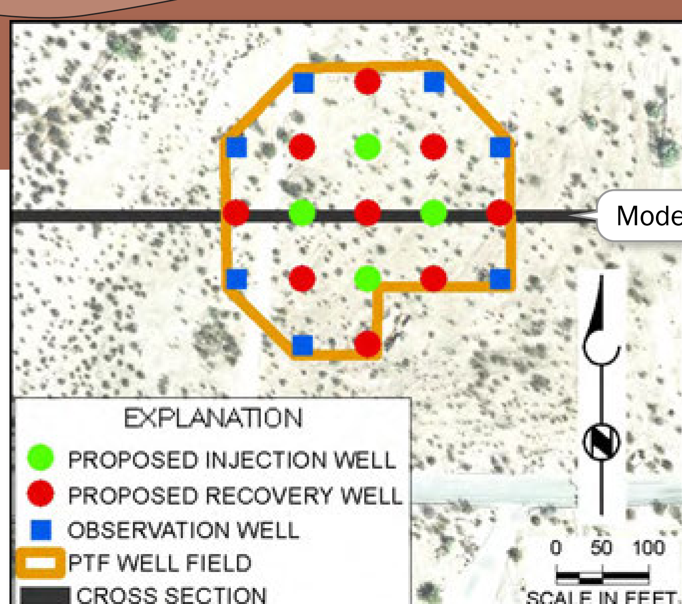
Brown AND Caldwell

HORIZONTAL SCALE
(feet)
0 12.5 25 50 100 250

Figure A-7
Model Predicted Migration of Lixiviant – Scenario 6
Florence Copper Project Groundwater Model

Cross-Section along Model Row 231





Scenario 6 Simulation Details and Variations from Base FCP Model:

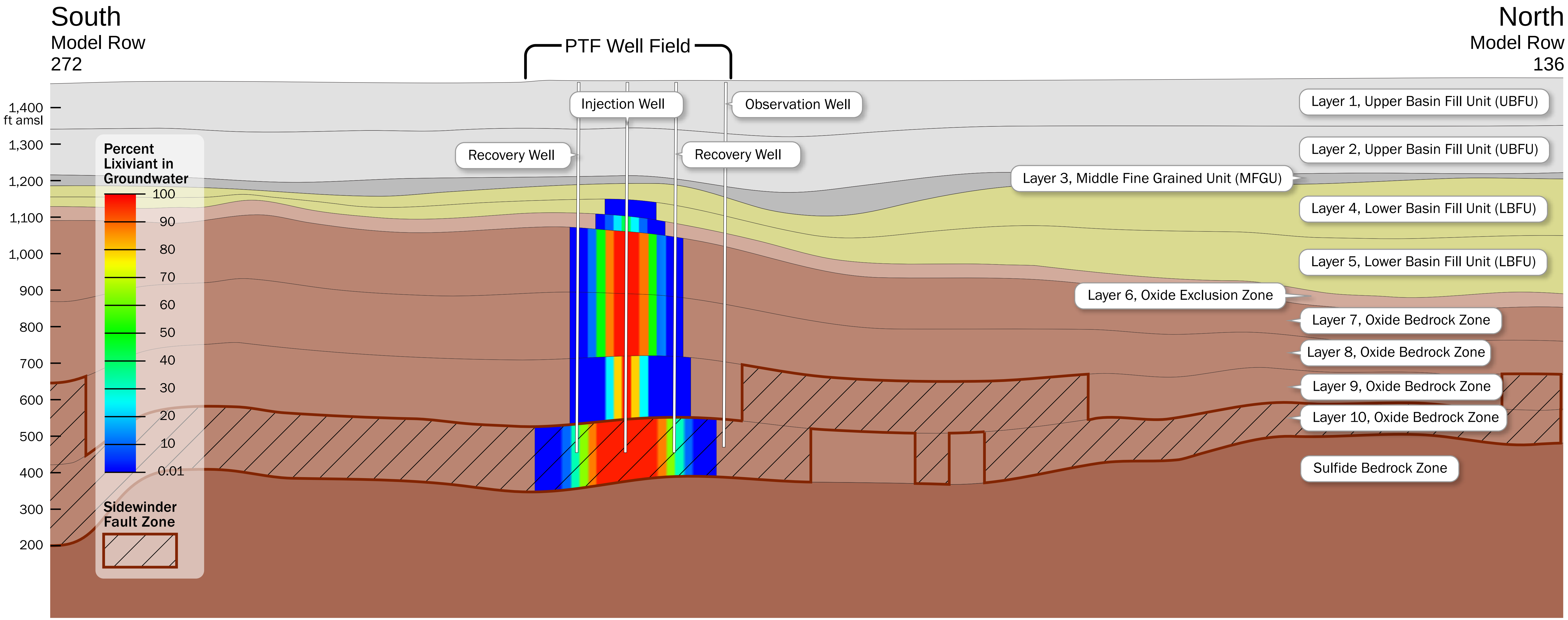
- 30 days simulation time
- One well injecting at 60 gpm, no recovery pumping
- Porosity of Oxide Layers = 13%
- Other hydrologic parameters same as base FCP Model (Table 10-1)

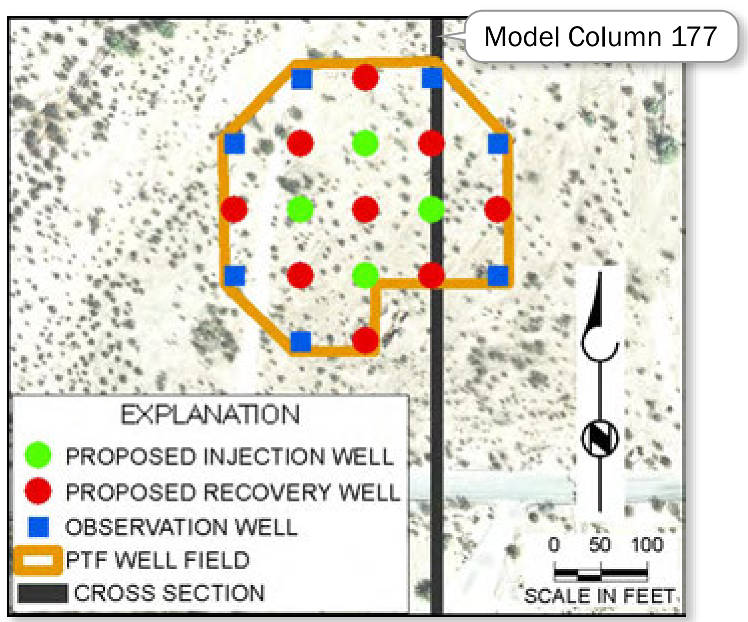
HORIZONTAL SCALE
(feet)
0 12.5 25 50 100 250

Brown AND Caldwell

Figure A-7a
Model Predicted Migration of Lixiviant – Scenario 6
North-facing Cross Section
Florence Copper Project Groundwater Model

Cross-Section along Model Column 177





Scenario 7 Simulation Details and Variations from Base FCP Model:

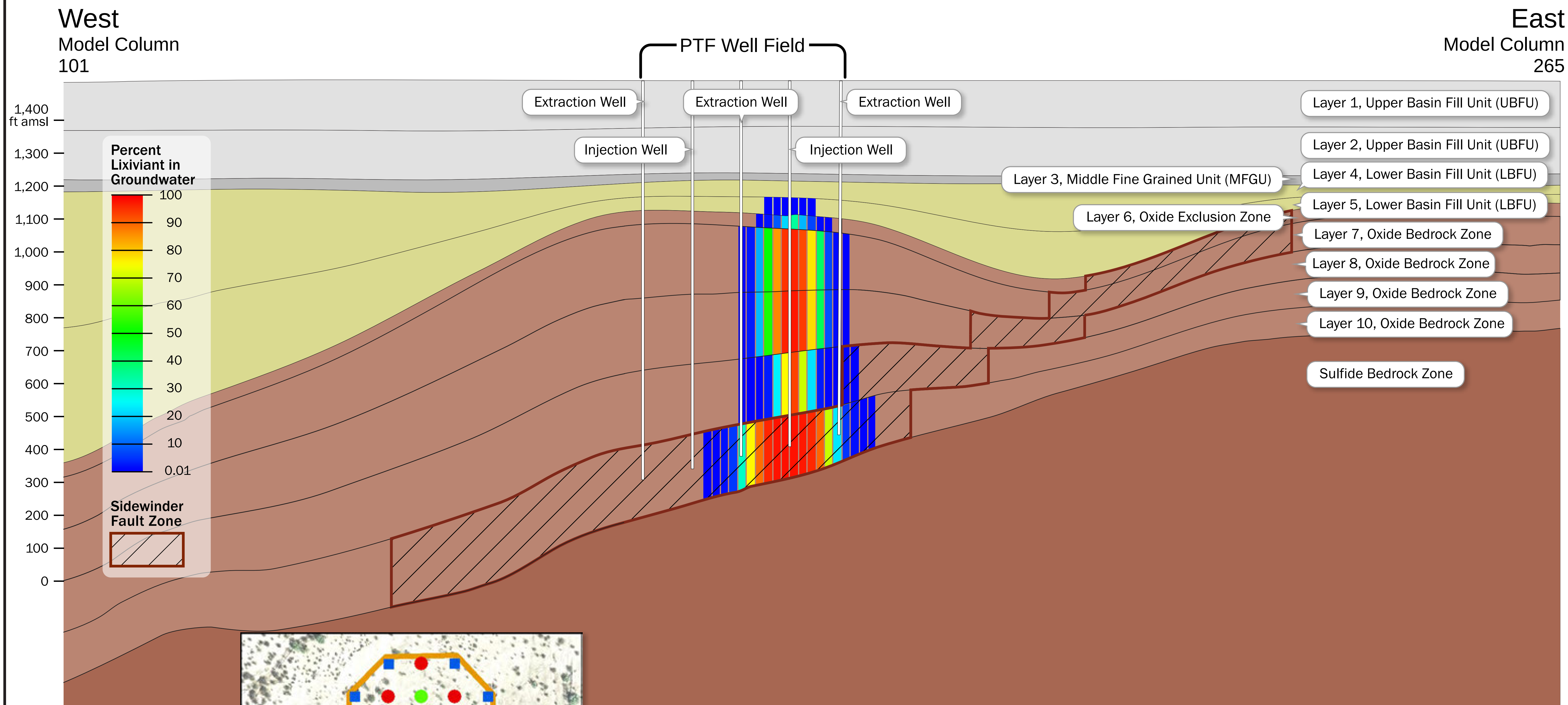
- 30 days simulation time
- One well injecting at 60 gpm, no recovery pumping
- No confining unit in vicinity of PTF
- Hydraulic conductivity of MFGU (Layer 3) set to magnitude of LBFU
- Other hydrologic parameters same as base FCP Model (Table 10-1)

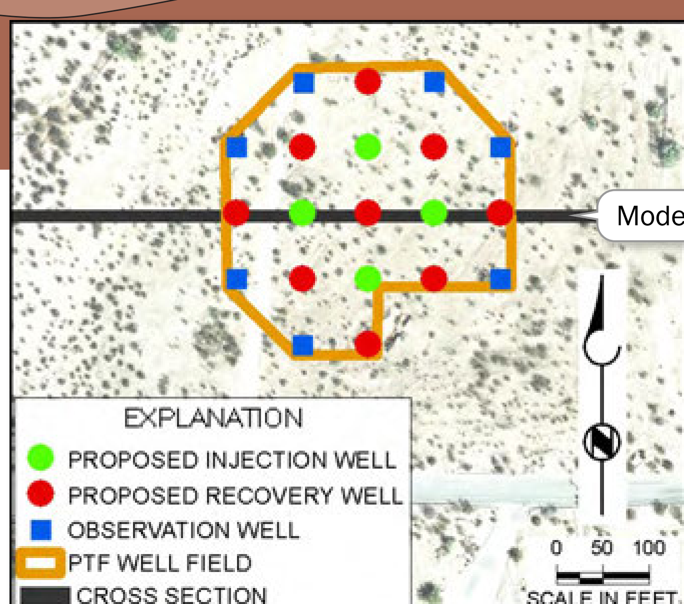
Brown AND Caldwell

HORIZONTAL SCALE
(feet)
0 12.5 25 50 100 250

Figure A-8
Model Predicted Migration of Lixiviant – Scenario 7
Florence Copper Project Groundwater Model

Cross-Section along Model Row 231





Scenario 7 Simulation Details and Variations from Base FCP Model:

- 30 days simulation time
- One well injecting at 60 gpm, no recovery pumping
- No confining unit in vicinity of PTF
- Hydraulic conductivity of MFGU (Layer 3) set to magnitude of LBFU
- Other hydrologic parameters same as base FCP Model (Table 10-1)

Brown AND Caldwell

HORIZONTAL SCALE (feet)
0 12.5 25 50 100 250

Figure A-8a
Model Predicted Migration of Lixiviant – Scenario 7
North-facing Cross Section
Florence Copper Project Groundwater Model

LEGEND

- MW-01 OPERATIONAL MONITORING WELL (APPROXIMATE LOCATION BASED ON REQUIREMENTS OF APP 106360)
- EXISTING POC WELL
- APPROVED POC WELL - NOT DRILLED YET
- NON-POC WELL
- DRY POC WELL TO BE PLUGGED AND ABANDONED
- NON-POC WELL TO BE PLUGGED AND ABANDONED
- ABANDONED VADOSE ZONE CHARACTERIZATION PIEZOMETER
- ABANDONED VADOSE ZONE CHARACTERIZATION BORING
- PROPOSED SUPPLEMENTAL MONITORING WELL
- EXPLORATION CORE HOLE
- CORE HOLE-ABANDONED

PROPOSED TEST WELLS

- INJECTION
- OBSERVATION
- RECOVERY
- MULTI-LEVEL SAMPLING WELL

ABANDONED GEOTECHNICAL BORINGS

- KNIGHT PIESOLD, OCTOBER 2011
- TERRACON, 1995-1996
- CONOCO UNDERGROUND MINE WORKINGS
- STATE MINERAL LEASE BOUNDARY
- PROPERTY BOUNDARY
- PTF WELL FIELD AREA
- 500-FOOT AREA OF REVIEW
- TOPOGRAPHIC CONTOUR

N
W E
S

0 300 600 1,200

SCALE IN FEET

HALEY & ALDRICH

FLORENCE COPPER INC.
FLORENCE, ARIZONA

AREA OF REVIEW
PRODUCTION TEST FACILITY (PTF)

FLORENCE COPPER INC.

SCALE: AS SHOWN
JULY 2014

FIGURE A-9

G:\38706_CurisResources\Global\GIS\MapProjects\2014-07\3876-119_A9_Area of Review_PTF.mxd

EXHIBIT A-1

Hydrologic Study Part A, Groundwater Flow Model (Temporary APP Application Attachment 14A)

CURIS RESOURCES (ARIZONA) INC.

APPLICATION FOR TEMPORARY
INDIVIDUAL AQUIFER PROTECTION PERMIT

ATTACHMENT 14A – HYDROLOGIC STUDY PART A, GROUNDWATER FLOW MODEL (ITEM 25.H)

REGISTERED GEOLOGIST CERTIFICATE NO. 19369 MARK D. NICHOLLS Date Signed 3/1/12 ARIZONA, U.S.A. Exp. 9/30/2012

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14A.1 Introduction

This attachment has been prepared in response to the information requirements of Item 25.H of the Individual Aquifer Protection Permit (APP) Application Form (Form). Arizona Administrative Code (A.A.C.) R18-9-A202A.8 requires a hydrologic study that defines the Discharge Impact Area (DIA) associated with the permitted activities for the planned life of the proposed Production Test Facility (PTF). Requirements of the hydrologic study are defined in A.A.C. R18-9-A202A.8 as follows:

a. The hydrologic study is required to demonstrate:
   i. That the facility will not cause or contribute to a violation of an Aquifer Water Quality Standard (AWQS) at the applicable point of compliance (POC); or
   ii. If an AWQS for a pollutant is exceeded in an aquifer at the time of permit issuance, and that no additional degradation of the aquifer relative to that pollutant and determined at the applicable POC will occur as a result of the discharge from the proposed facility.

b. Based on the quantity and characteristics of pollutants discharged, methods of disposal, and Site conditions, the Department may require the applicant to provide:
   i. A description of the surface and subsurface geology, including a description of all borings;
   ii. The location of any perennial, intermittent, or ephemeral surface water bodies;
   iii. The characteristics of the aquifer and geologic units with limited permeability, including depth, hydraulic conductivity, and transmissivity;
   iv. The rate, volume, and direction of surface water and groundwater flow, including hydrographs, if available, and equipotential maps;
   v. The precise location or estimate of the location of the 100-year flood plain and an assessment of the 100-year flood surface flow and potential impacts on the facility;
   vi. Documentation of the existing quality of the water in the aquifers underlying the Site, including, where available, the method of analysis, quality assurance (QA), and quality control (QC) procedures associated with the documentation;
   vii. Documentation of the extent and degree of any known soil contamination at the Site;
   viii. An assessment of the potential of the discharge to cause the leaching of pollutants from surface soils or vadose materials;
   ix. For an underground water storage facility, an assessment of the potential of the discharge to cause the leaching of pollutants from surface soils, or vadose materials, or cause the migration of contaminated groundwater. (Not applicable to the PTF).
   x. Any changes in the water quality expected because of the discharge;
   xi. A description of any expected changes in the elevation or flow directions of the groundwater expected to be caused by the facility;
   xii. A map of the facility's DIA; or
   xiii. The criteria and methodologies used to determine the DIA.

Of the hydrologic study requirements outlined above, items A.A.C. R18-9-A202A.8.a.i, 8.b.i-iv, and 8.b.x-xiii are addressed in this Attachment. Item 8.a.ii is described in detail in Attachment 12, *Compliance with Aquifer Water Quality Standards*. Item 8.b.ix is not applicable to the present application, and items 8.b.v-viii are described in Attachment 14B, *Hydrologic Study Part B*. Table 14A-1 includes a directory of the requirements outlined in A.A.C. R18-9-A202.A.8, and where each are addressed in this application.

14A.1.1 Background

Curis Resources (Arizona) Inc. (Curis Arizona) has proposed development of a small, pilot-scale test facility referred to as the PTF located on undeveloped desert land 2.5 miles from the business district of the Town of Florence, Pinal County, Arizona (Figure 14A-1). The proposed PTF will be constructed on State land within an Arizona State Mineral Lease held by Curis Arizona that is fully encompassed by property owned by Curis Arizona. The proposed facility will be constructed on portions of Section 28 of Township 4 South, Range 9 East, of the Gila River Baseline and Meridian.

The proposed PTF consists of a small number of test injection and recovery wells that will be used to dissolve copper bearing minerals within the ore body, and to recover the copper in solution. The injection wells will be used to inject a sulfuric acid-based lixiviant solution that will dissolve copper oxide minerals, liberating the copper into solution. The copper laden solution, referred to as pregnant leach solution (PLS), will be recovered from the formation by a closely-spaced array of recovery wells. The copper will be extracted from the PLS by solvent extraction/electrowinning (SX/EW). A schematic of the PTF well field is shown in Figure 14A-2.

The anticipated injection rate is expected to be approximately 240 gallons per minute (gpm), and the extraction is expected to be approximately 300 gpm. At completion of the PTF injection and recovery process, the ore body will be rinsed with native groundwater until permit closure conditions are met. The PTF and SX/EW plant are described in greater detail in Attachments 2 and 9. Chemistry of the lixiviant and PLS solutions are described in detail in Attachment 10, Characterization of Discharge.

This Attachment documents the development and calibration of, and predictive simulations produced from, a sub-regional scale computer-based groundwater flow model that includes the proposed PTF site and approximately 124 square miles around the proposed PTF.

14A.2 Study Area Setting

14A.2.1 Physiography

The PTF site is located within the Sonoran Desert portion of the Basin and Range Physiographic province, which is characterized by gently sloping alluvial valleys separated by north-northwest trending fault block mountain ranges. The PTF site is located on relatively flat land within an unnamed alluvial basin between the Santan and Tortilla Mountains that straddles the boundary between the Eloy sub-basin of the Upper Gila Watershed (Eloy sub-basin) and the East Salt River Valley (ESRV). The PTF site is located a few miles to the south of this boundary, within the Eloy sub-basin.

The Eloy sub-basin is a hydrographic basin bounded on the east by the Tortilla and Tortolita Mountains, on the south by a topographic divide at the margin of the Aguirre Valley, to the west by a groundwater divide to the west of Casa Grande, and on the north by the Santan Mountains and a topographic divide at the margin of the ESRV. The study area includes an area of approximately 124 square miles located at the northern margin of the Eloy sub-basin. The study area straddles the Eloy-ESRV topographic divide and covers less than 10 percent of the greater Eloy sub-basin.

The PTF site is located on undeveloped desert land approximately 0.6 mile north of the Gila River, which drains the Eloy sub-basin. Ground surface at the PTF site generally slopes southward toward the Gila River and has ground surface elevations ranging between approximately 1,470 and 1,490 feet above mean sea level (amsl).

14A.2.2 Climate

The climate in the vicinity of the proposed PTF site is typical of an arid to semi-arid desert region with low precipitation, low humidity, and high summer temperatures. Temperatures often exceed 100 degrees Fahrenheit (°F) during summer months and seldom fall below freezing during the winter. Precipitation is seasonal and bimodal with winter rainfall resulting from cold fronts originating over the Pacific Ocean occurring from December through March; and summer precipitation resulting from convection of moist air originating over the Gulf of Mexico and Gulf of California occurring from July through September.

Precipitation is generally lower intensity, longer duration in the winter and higher intensity, lower duration in the summer. Mean relative humidity ranges from 19 percent in the winter to 65 percent in the summer (Montgomery and Harshbarger, 1989). Average annual precipitation is 10.3 inches (National Oceanic and Atmospheric Administration [NOAA], 2010). Histograms showing monthly mean precipitation and annual precipitation totals for the period 1931 to 2008 are shown on Figures 14A-3 and 14A-4, respectively.

Evaporation exceeds precipitation in the region, consequently little recharge is received from direct infiltration of precipitation. Estimated potential evaporation is approximately 65 inches (Montgomery and Harshbarger, 1989). The combined effects of evaporation and transpiration (evapotranspiration) are discussed in more detail in Section 14A.3.

14A.2.3 Surface Water

The study area is drained by the Gila River which lies approximately 0.6 mile south of the proposed PTF. The Gila River is a regionally extensive river that originates at headwaters in southwestern New Mexico. The Gila River is the principal surface water feature in the vicinity of the PTF site and traverses the central portion of the 124 square mile study area.

Coolidge Dam is located approximately 55 miles to the east of the PTF site and has regulated Gila River flow in the vicinity of the PTF site since it was completed in 1928. The San Pedro River flows into the Gila River below Coolidge Dam and is the primary source of unregulated flow in the Gila River. Most surface water flowing in the Gila River upstream of the PTF site is diverted into the Florence-Casa Grande Canal at the Ashurst-Hayden Diversion Dam. In the vicinity of the PTF site, the Gila River flows from northeast to southwest and is dry most of the year, except during extended periods of local precipitation and runoff. A hydrograph of historic monthly mean Gila River flows measured at Kelvin, Arizona, located 26 miles east of and hydrographically above the PTF site, is included in Figure 14A-5. The Gila River system and the various irrigation projects that receive water from it are described in greater detail in Brown and Caldwell (1996a).

Besides the Gila River, there are no other significant naturally occurring perennial or ephemeral surface water bodies within the PTF model study area.

14A.2.4 Land and Water Use

The PTF model domain covers an area of approximately 124 square miles or approximately 79,350 acres. Within this area, principal land uses include agricultural, urban, industrial, and undeveloped desert. Approximately 24,500 acres (31 percent of the study area) are currently, or historically have been, under cultivation. Urban areas account for approximately 5,700 acres or slightly more than 7 percent of the PTF model study area. Industrial land uses include primarily aggregate mining operations covering approximately 1,400 acres, less than two percent of the PTF model study area. Undeveloped desert lands account for the majority of the PTF model study area, covering an area of approximately 47,750 acres or 60 percent of the study area. The PTF well field is approximately 4.5 acres in size. Land use within the PTF model study area is shown on Figure 14A-6.

Agricultural land uses account for the largest proportion of developed land use and water use with the PTF model domain. Both surface water and groundwater are used to irrigate fields growing a wide variety of food and fiber crops. Urban water uses within the study area rely solely on groundwater and include residential and public space irrigation, domestic uses, and other incidental uses. Industrial water use within the study area also relies solely on groundwater and consists primarily of material washing at aggregate mines. Anthropogenic water use in the undeveloped desert areas within the PTF model study area is insignificant in magnitude.

Groundwater pumping was not segregated by water use during development of the current PTF groundwater flow model. The groundwater pumping rates used in the model were obtained from the Arizona Department of Water Resources (ADWR), and are described in detail in Section 14A.4.7.

14A.3 Hydrogeology and Conceptual Model

14A.3.1 Previous Studies

Portions of the PTF model study area have been the subject of numerous geologic and hydrologic studies since the 1950s, when the potential for copper oxide mineralization was identified in the vicinity of Poston Butte. Previous studies described herein are limited to relevant hydrologic and groundwater modeling studies covering all or portions of the PTF model study area:

- Brown and Caldwell, 1996a. Magma Florence In-Situ Project Aquifer Protection Permit Application, Volume II of V, Site Characterization Report.
- Brown and Caldwell, 1996b. Magma Florence In-Situ Project Aquifer Protection Permit Application, Volume IV of V, Modeling Report.
- ADWR, 1990. Pinal Active Management Area Regional Groundwater Flow Model.
- ADWR, 1994. Salt River Valley Regional Groundwater Flow Model.

Brown and Caldwell (1996a)

Magma Copper Company (Magma) originally proposed production of cathode copper at the site by using combined in-situ copper recovery (ISCR) and SX/EW in the mid 1990s. Magma retained Brown and Caldwell to perform hydrologic and geochemical studies in support of applications for the required environmental and operational permits from State and Federal agencies. Brown and Caldwell (1996a) summarized geologic and hydrogeologic characteristics of the proposed ISCR site, associated property, and the surrounding vicinity using existing published and unpublished data and data generated during site-specific investigations.

Site-specific investigations performed in support of Brown and Caldwell (1996a) included, but were not limited to:

- Assessment of bedrock properties based on lithologic logs of approximately 700 coreholes drilled into the ore body and the surrounding vicinity.
- Analysis of lithologic and hydrologic data collected from 52 boreholes drilled at the site and surrounding vicinity in 1994 and 1995 to depths ranging from 240 to 1,580 feet.
- Downhole geophysical logging of 16,340 linear feet of boreholes drilled in 1994 and 1995.
- Construction data, water quality data, and water level data available from eighteen monitoring wells constructed in six clusters in and around the ore body.
- Twenty-six aquifer tests conducted at test well and monitoring well clusters at the site and surrounding vicinity.
- Fourteen hydraulic (packer) tests conducted in open boreholes.

The aquifer parameters and hydrostratigraphic unit descriptions developed from data collected in support of Brown and Caldwell (1996a) were used to support the creation of a sub-regional groundwater flow model described in Brown and Caldwell (1996b). These data remain the best available data describing hydrogeologic characteristics at the PTF site and surrounding vicinity. No significant additional hydrogeologic characterization activities have been conducted at the PTF site and surrounding vicinity since the Brown and Caldwell (1996a) study was completed. Data developed in support of Brown and Caldwell (1996a) were used as direct input into the current PTF groundwater flow model described in this report. Hydrostratigraphic unit descriptions presented in Brown and Caldwell (1996a) serve as the conceptual basis for hydrostratigraphic units represented in the PTF groundwater flow model described herein.

Brown and Caldwell (1996b)

Following the hydrogeologic characterization of the PTF site and surrounding vicinity described in Brown and Caldwell (1996a), Brown and Caldwell prepared a sub-regional numerical groundwater flow model for the purpose of simulating the potential effects of ISCR activities on the regional alluvial aquifer. The flow field represented in the 1996 groundwater model was developed using the MODFLOW (McDonald and Harbaugh, 1988) computer code, and particle tracking simulations were performed using PATH 3D (Zheng, 1989).

The 1996 groundwater flow model included a domain that covered approximately 100 square miles, centered roughly on the PTF site and surrounding vicinity. The model grid used a 1,000-foot by 1,000-foot cell size at the periphery of the domain and reduced to a cell size of 50 feet by 50 feet at the center of the domain at the PTF site, and was divided into eight layers corresponding to the various hydrostratigraphic units.

Model inputs included temporal head, recharge, and pumping inputs, and used a one year calibration period. The groundwater flow model drew heavily from the site-specific hydrogeologic data reported in Brown and Caldwell (1996a) and data available from ADWR.

Advances in groundwater modeling software, modeling techniques, and changing groundwater conditions at the PTF site have necessitated the development of the current PTF groundwater model described herein as a replacement for the groundwater model described in Brown and Caldwell (1996b). However, the Brown and Caldwell (1996b) groundwater model provided the basic framework for the current model with minor adjustments to the PTF model domain and a revision of the model layering to reflect the full body of geologic data currently available.

Hydraulic parameters used as inputs to the Brown and Caldwell (1996b) groundwater flow model were developed and reported in the Brown and Caldwell (1996a) Site Characterization Report, which also serves as the primary source for hydrologic properties used in the current groundwater flow model. Other inputs used in the 1996 groundwater model such as General Head Boundaries (GHBs), temporal head distributions, recharge values, and groundwater pumping were not carried forward to the current model because a greater temporal range of detailed data are now available from ADWR.

ADWR, 1990

In 1990, ADWR released a numerical groundwater flow model for the Pinal Active Management Area (AMA) which covers an area of approximately 4,100 square miles located within portions of Pinal, Pima, and Maricopa Counties and includes the PTF site. The Pinal AMA groundwater model was developed using the MODFLOW (McDonald and Harbaugh, 1988) computer code and had a model domain equivalent to the approximate 4,100 square mile AMA area. ADWR developed this model for the purpose of developing a groundwater management tool that would be useful in predicting future groundwater conditions within the AMA. The Brown and Caldwell (1996b) and the current PTF groundwater flow models cover a domain that is less than 2 percent of the 1990 Pinal AMA groundwater flow model.

The original Pinal AMA model used two layers to represent the three hydrogeologic units generally recognized to extend throughout the AMA. The hydrogeologic units are the Upper Alluvial Unit (UAU), the Middle Silt and Clay Unit (MSCU), and the Lower Conglomerate Unit (LCU). The layer thicknesses were defined using more than 2,000 driller's logs; however, the actual thicknesses of the MSCU and LCU are not represented in the model. The 1990 Pinal AMA model grid used a uniform cell size of one square mile roughly oriented to correspond with the Township-Range-Section grid.

The hydrogeologic units used in the 1990 Pinal AMA model and their associated properties roughly correspond to the hydrogeologic units used in the 1996 groundwater model prepared by Brown and Caldwell (1996b). The Brown and Caldwell model used hydrogeologic unit names and descriptions reported in Brown and Caldwell (1996a), namely; the Upper Basin Fill Unit (UBFU), Middle Fine Grained Unit (MFGU), and Lower Basin Fill Unit (LBFU). However, the UBFU corresponds with the UAU, the MFGU corresponds with the MSCU and the LBFU corresponds with the LCU. The hydrogeologic unit names and descriptions used in Brown and Caldwell (1996b) are used in the current PTF groundwater flow model.

Although the 1990 Pinal AMA model grid discretization and layering are too coarse to provide the localized high resolution required for the present modeling effort, the extensive published datasets associated with the model have been a valuable resource in constructing and calibrating the current PTF groundwater flow model.

ADWR is currently in the process of redeveloping and refining the Pinal AMA groundwater flow model to represent expanded pumping and recharge datasets, a refined understanding of the basin and sub-basin morphology, and more refined hydrographic boundaries at the downstream edge of the model. The revised model was planned to be completed in 2010, however it had not yet been made available at the time of this publication. However, ADWR graciously made several of the updated Pinal AMA model input datasets available to Brown and Caldwell on a provisional basis in support of development of the current PTF groundwater flow model. Provisional updated Pinal AMA groundwater model datasets made available by ADWR for use in the current model are described in Section 14A.4.7.

ADWR, 1994

In 1994, ADWR released a computer model that represented the groundwater flow regime of the Salt River Valley (SRV). The SRV is an extensive and complex groundwater basin that includes seven sub-basins and the confluence of four rivers that together drain more than 50 percent of the State. The domain of the 1994 SRV model covers only about 2,500 square miles and does not include the entire SRV, but focuses on the most significant hydrologic features of the valley for the purpose of developing a groundwater management tool. ADWR is currently in the process of updating the SRV model and expanding the model domain, however the results of that effort are not yet available.

Similar to the 1990 Pinal AMA model, the 1994 SRV model used a cell size of one square mile, but differed in that it used three layers to represent the three principal hydrogeologic units within the basin. The layers were designed to discretely represent the three principal hydrogeologic units occurring within the SRV, which units generally correspond to those described in the 1990 Pinal AMA groundwater flow model. The SRV layers include the UAU, Middle Alluvial Unit (MAU), and Lower Alluvial Unit (LAU).

The domain of the 1996 (Brown and Caldwell, 1996b) and the current (2010) PTF sub-regional groundwater flow model lies primarily within the domain of the Pinal AMA groundwater model. However, because the PTF site location is very near the boundary between the Pinal AMA and the Phoenix AMA, a small portion of the PTF model domain lies within the domain of the SRV model. Approximately 20 percent of the PTF model domain lies within the domain of the 1994 SRV model, an area located at the extreme southeast corner of the SRV model domain that represents less than one percent of the entire SRV model domain.

Recognizing that the current PTF groundwater flow model has less than 20 percent of its domain in common with the SRV model, the SRV model construction details such as grid discretization, layering, and boundary conditions were not incorporated in the current modeling effort. However, datasets from the SRV model that were useful in construction and calibration of the current (2010) PTF groundwater model included updated geology and temporal head distributions. Input datasets for the current PTF groundwater model are described in Section 14A.4.

14A.3.2 Regional Geology and Hydrostratigraphy

14A.3.2.1 Structural Geology

The PTF site is located within the Sonoran Desert portion of the Basin and Range Physiographic Province. The Basin and Range Province is defined by the residual effects of extensional forces that stretched the earth's crust throughout western North America, resulting in a series of pull-apart physiographic features that include alternating elongated mountain ranges separated by alluvial basins bounded by normal faults. The basins and ranges are the surface expression of alternating down-thrown blocks of crust (grabens) lying between crustal blocks that remain elevated (horsts) relative to the surrounding terrain.

The Basin and Range Orogeny, an extensional event, was the last major orogenic event to affect the Western United States and occurred from the early Miocene to the Pleistocene (17-5 Ma). Tectonic processes associated with the Basin and Range Orogeny exposed metamorphic core complexes and resulted in igneous activity that included batholith, stock and dike emplacement, and volcanism (Nason and others, 1982).

Basin and Range faulting resulted in partial to complete erosion of older Oligocene to Miocene sediments. Consequently, as much as 4,000 feet of basin-fill has been deposited in the resulting Tertiary alluvial fan and lake bed environments. Figure 14A-7 shows a bedrock surface of the PTF site and limited surrounding vicinity based on well log and corehole data.

Basin and Range faulting and tilting in the vicinity of the PTF resulted in north-northwest trending horst and graben structures bounded by normal faults with large displacements to the west (Nason and others, 1982). The ore body associated with the PTF occurs on a complex horst block which is bounded on the east and west by grabens. The Party Line Fault, a major normal fault on the east side of the ore body, strikes north 35 degrees west and dips 45 to 55 degrees southwest. This fault is reported to have a vertical displacement of over 1,000 feet (Conoco, 1976; Nason and others, 1982). Field studies (Brown and Caldwell, 1996a) have shown that intense fracturing in the vicinity of the fault zone has resulted in elevated hydraulic conductivity parallel to the fault. A series of en-echelon normal faults striking north-south to northwest occur west of the Party Line Fault, which form the transition to the graben structure west of the proposed PTF well field.

The Sidewinder Fault occurs near the west side of the proposed PTF well field and has a displacement of more than 1,200 feet (Conoco, 1976), and represents a continuation of a complex of northwest-southeast trending normal faults east of the PTF site. Field studies (Brown and Caldwell, 1996a) have shown that intense fracturing in the vicinity of the fault zone has resulted in elevated hydraulic conductivity. Additionally, an east-west trending fault system has truncated the south end of the horst, causing bedrock elevations south of the Gila River to drop away by more than 1,500 feet (Conoco, 1976). Additional en-echelon, north to northwest trending normal faults located east of the Sidewinder Fault form the transition to another graben structure east of the PTF site, which strikes north to northwest.

Following the Basin and Range Orogeny, alluvial basin-fill sediments were deposited over the Precambrian bedrock surface in the vicinity of the PTF site. The sediments consist of unconsolidated to moderately well-consolidated interbedded clay, silt, sand, and gravel in variable proportions and thicknesses. Interbedded basalt flows were emplaced during basin fill deposition to the west and northwest of the proposed PTF well field. Total thickness of basin-fill materials in the vicinity of the property ranges from 300 to over 900 feet, and exceeds 2,000 feet at a distance of 1.5 miles southwest of the proposed PTF well field.

14A.3.2.2 Hydrostratigraphy

The saturated geologic formations underlying the PTF site have been divided into three distinct water bearing hydrostratigraphic units referred to as the UBFU, LBFU, and the Bedrock Oxide Unit. Although locally productive, the Bedrock Oxide Unit is considered to be hydrologic bedrock by the ADWR (1989). The UBFU and LBFU are separated by a thin regionally extensive aquitard referred to as the MFGU. Each of these units generally corresponds to regionally extensive hydrostratigraphic units described by ADWR (1989). Generalized cross sections depicting the distribution and thickness of the hydrostratigraphic units are shown on Figures 14A-8 and 14A-9. Recent water levels (2008) within the PTF model domain are shown on Figure 14A-10.

The geologic and hydrologic characteristics of these units have been defined by a series of studies conducted by previous companies associated with the PTF site including Conoco, Magma, and BHP Copper.

Conoco began hydrologic characterization of the ore body in 1971 in order to determine the dewatering requirements for a planned underground mine, and later an open pit mine to be developed at the PTF site. Between 1973 and 1976, Conoco conducted a total of 34 aquifer (pumping) tests that included tests conducted in individual water bearing units and various combinations of the LBFU and Bedrock Oxide Units. No aquifer tests were conducted in the period between 1976 and 1992, when Magma began hydrologic characterization for the purpose of completing a pre-feasibility study.

Magma purchased the PTF site and surrounding vicinity from Conoco in 1992, and initiated an intensive hydrologic characterization program that included a series of 49 pumping tests conducted at 17 locations at the PTF site and surrounding vicinity. The tests, conducted by Brown and Caldwell, included 17 pumping wells and 46 monitoring wells screened within the various water bearing units. Eight wells were completed within the UBFU, 17 within the LBFU, and 38 wells within the Bedrock Oxide Unit including the hanging wall and footwall zones of the major faults. Each of the pumping tests was conducted at pumping rates of at least 0.25 gpm per foot of screen. After completion of the pumping tests, Golder Associates (Golder, 1995) analyzed the pump test data to derive hydrologic parameter values describing each of the water bearing units. The values derived by Golder Associates for each of the water bearing units confirmed, and expanded on, those derived by Conoco. A copy of the 1995 Golder Associates report is submitted as Exhibit 14A-1.

In January 1996, BHP Copper acquired Magma and the PTF site and surrounding vicinity, and continued hydrologic characterization of the associated ore body. BHP Copper did not conduct any additional aquifer tests. However, in order to further characterize hydrologic properties of the ore body, BHP Copper installed a pilot five-spot ISCR well pattern with adjacent, perimeter, and observation wells for the purpose of conducting a commercial-scale pilot test to demonstrate the feasibility of establishing and maintaining hydraulic control. No additional hydrologic characterization activities were completed between the conclusion of the BHP Copper pilot test in 1998 and the purchase of the PTF site and surrounding vicinity by Curis Arizona.

Curis Arizona acquired the PTF site and surrounding vicinity in the first quarter of 2010. The only hydrologic characterization activities conducted by Curis Arizona since their acquisition of the site have been laboratory testing of two samples of MFGU sediments to determine hydraulic conductivity. The results of those tests are described below. The laboratory reports for those analyses are included as Exhibit 14A-2.

The range of hydraulic conductivity values measured for each of the water bearing units are shown on Figure 14A-11. Hydraulic conductivity values plotted on Figure 14A-11 include values derived from tests of individual water bearing units conducted by Conoco and Magma. Hydraulic conductivity values derived from tests that included multiple water bearing units were excluded from Figure 14A-11.

No vadose zone characterization activities have been conducted since 1995 when BHP completed site characterization. Vadose zone characterization activities performed in support of the BHP site characterization are described in Section 2.3.1, Volume II, of that application. A copy of Section 2.3.1, Volume II of the 1996 APP application is included as Exhibit 14A-3.

14A.3.2.2.1 Upper Basin Fill Unit (UBFU)

The UBFU is locally overlain by recent alluvial floodplain sediments emplaced by the Gila River and tributary washes in the vicinity of the PTF site. The recent alluvium is unsaturated, and consists of unconsolidated silt, sand, gravel, and boulders that locally overlie the basin fill deposits of the UBFU. The width of recent alluvium emplacement is approximately one mile on either side of the Gila River. The thickness of the recent alluvium at the PTF site ranges from zero near the bedrock outcrops to approximately 60 feet at the Gila River (Brown and Caldwell, 1996a).

The UBFU consists primarily of unconsolidated to slightly consolidated sands and gravel, with lenses of finer-grained material and ranges in thickness between 50 feet near mountain fronts to approximately 1,200 feet in the basin center. The thickness of the corollary unit within the ESRV Sub-basin is typically between 100 and 200 feet (ADWR, 1993). The UBFU is estimated to range between 200 and 220 feet in thickness within the proposed PTF well field.

The upper portion of the UBFU is not saturated and forms the lower vadose zone, which extends to depths ranging from 100 to 150 feet below ground surface (bgs). The upper portions of the unit are generally fine-grained and calcareous, consisting of a gradational succession of poorly graded, moist silt and sand with minor gravel. The lower portions are generally coarser-grained, with gravel interbeds common at depth. Although more cohesive than the overlying recent alluvium, the UBFU is generally described as unconsolidated (Brown and Caldwell, 1996a).

The UBFU is primarily unconfined with locally confined conditions apparent in portions of the Eloy sub-basin (ADWR, 1989). However, unconfined conditions prevail within the UBFU in the proposed PTF well field. Hydraulic conductivity within the UBFU in the study area ranges from 20 to 130 feet per day and specific yield ranges from approximately 13 to 20 percent (ADWR, 2010).

Based on 2011 groundwater level measurements, the saturated portion of the UBFU within the proposed PTF well field is estimated to be between approximately 275 and 295 feet thick. Depth to groundwater measurements at proposed POC wells completed in the UBFU are provided in Attachment 14B Table 14B-2.

14A.3.2.2.2 Middle Fine Grained Unit (MFGU)

The MFGU underlies the UBFU along a very gently sloping contact that is interpreted to be an unconformity, based on a basin-wide shift in lithofacies. The unit is generally 20 to 30 feet thick at the proposed ISCR site but increases to a maximum thickness of about 55 feet at the southwest corner of the site. The unit is nearly continuous, although it may pinch out or grade to coarser-grained materials in some locations (Brown and Caldwell, 1996a).

Locally, the MFGU ranges from calcareous clay to silty sand, and includes desiccation cracks, reworked broken clay clasts, carbonaceous film, and thin interbeds of fine sand or pebbles up to 1-inch thick. In places, the unit is massive with no detectable internal structure. It is generally calcareous and may be associated with thin zones of caliche. The base of the unit slopes very gently (one to two percent) to the southwest and is generally marked by a change from silty sand to gravel. In light of the numerous faults that are known to affect the bedrock at the in-situ mine site, the relatively flat-lying base of the MFGU is an indication that faulting ceased prior to the deposition of this unit (Brown and Caldwell, 1996a).

The MFGU in the Eloy sub-basin ranges in thickness from less than 50 feet near the sub-basin margins to greater than 6,500 feet in the sub-basin center, and can be locally productive if the well penetrates a sand and gravel lens within the unit; however well productivity in the MFGU is otherwise limited (ADWR, 1989).

No aquifer tests have been conducted within the MFGU. The MFGU is too thin and exhibits a hydraulic conductivity that is too low to support aquifer pumping tests. The thinness of the MFGU also precludes reliable construction of test wells that might be used to perform slug tests. For this reason, Magma Copper

Company, a previous owner of the site and surrounding vicinity elected to collect a sample from bore hole M16-GU for laboratory analysis to determine hydraulic properties of the MFGU. Curis Arizona recently collected two additional MFGU samples from core hole CMP-11-03, which was drilled in August of 2011. The laboratory hydraulic conductivity values determined for these samples are listed in Table 14A-2.

Copies of the original laboratory reports for each of the samples listed in Table 14A-2 are included herewith as Exhibit 14A-2.

The depth, thickness, and extent of the MFGU within the PTF well field, as determined from core hole logs, is shown on detailed cross sections included in Attachment 14C as Figures 14C-48 through 14C-51.

14A.3.2.2.3 Lower Basin fill Unit (LBFU)

The LBFU underlies the MFGU at the proposed PTF site and comprises the lower portion of the sedimentary fill overlying Precambrian bedrock. The MFGU-LBFU contact at the proposed PTF site ranges in depth from 260 to 300 feet bgs. The thickest deposits of LBFU occur west of the proposed PTF well field, along the east flank of a graben structure. The increased thickness is the result of faulting, subsidence, and lithostatic loading of the basin. The thinnest deposits overlie a 400- to 500-foot wide bedrock ridge west of the proposed PTF well field. Beneath the eastern portion of the PTF site, the thickness of the LBFU generally ranges from about 30 to 80 feet.

The LBFU consists of coarse gravel, fanglomerate, conglomerate, and breccia, and is distinguished by a greater degree of consolidation than is exhibited by the UBFU. Lithologically, clasts appear similar to the overlying UBFU, with the exception of the occurrence of bedrock derived gravel conglomerate, immediately above the bedrock contact that is locally well-lithified. The conglomerate portion of the LBFU may correlate with the Gila and Whitetail Conglomerates described in the region (Conoco, 1976).

Where overlain by the MFGU, the LBFU typically exhibits confined or semi-confined characteristics (ADWR, 1989). Hydraulic conductivity within the LBFU ranges from 5 to 25 feet per day and specific storage is approximately 1e-5 ft-1 (ADWR, 2010). Hydraulic conductivity for the LBFU calculated by Montgomery (1994) was approximately 93.0 ft/day. Aquifer parameters reported for the Gila Conglomerate include transmissivities reported by Halpenny (1976) that range from 113,000 to 233,000 gallons per day per foot (gpd/ft). Studies performed by Halpenny and Green (1972) suggest that a transmissivity value of 125,000 gpd/ft is a reasonable mean value.

Beneath the proposed PTF well field, the LBFU is fully saturated and exhibits confined to semi-confined characteristics. As noted on the cross sections submitted in Attachment 14C (Figures 14C-48 through 14C-51), the water levels in the LBFU are measured at points well above the top of that unit. Aquifer tests conducted at the PTF site, and measured groundwater elevations, have demonstrated that the LBFU and Bedrock Oxide Unit are in hydrologic communication with one another. Depth to groundwater measurements for proposed POC wells completed in the LBFU are included in Attachment 14B, Table 14B-2.

14A.3.2.2.4 Oxide Bedrock Zone

Bedrock underlying the LBFU in the proposed PTF well field consists primarily of Precambrian quartz monzonite and Tertiary granodiorite porphyry. Based on the copper mineral assemblage, the bedrock is divided into an upper oxide zone and lower sulfide zone. The oxide bedrock zone is estimated to range in thickness from approximately 200 feet to over 1,500 feet (Brown and Caldwell, 1996a). The depth and extent of the Oxide Bedrock Zone beneath the PTF well field is shown on the generalized geologic cross sections in Figures 14A-8 and 14A-9.

The top of the oxide bedrock zone consists of a weathered rubbly mixture of fracture filling and angular bedrock fragments, and is expected to be a zone of enhanced hydraulic conductivity. On available well logs, this zone is included with the LBFU in some locations as it is difficult to distinguish in-place weathering products from overlying colluvial materials. Below this weathered zone, the oxide consists of extensively fractured quartz monzonite, granodiorite, and associated dikes. Movement of groundwater through the oxide bedrock zone is expected to be largely controlled by secondary permeability resulting from faults, fractures, and associated brecciation.

Fracture intensity is greatest near the Party Line and Sidewinder faults, and decreases further away from these features. The Party Line fault post-dates mineralization and partially bounds mineralization in the eastern portion of the ore body. A vertical displacement of approximately 1,000 feet has been estimated on the Party Line fault. The Sidewinder fault occurs in the western portion of the in-situ mine site and exhibits an estimated 1,200 feet of vertical displacement. Rubblization and subsequent erosion associated with the Sidewinder fault has resulted in a bedrock trough that underlies the western portion of the PTF site.

Hydraulic conductivity within the oxide bedrock zone ranges from 0.1 to 2.51 ft/day and specific storage ranges from 5e-6 to 1e-5 ft-1 (Brown and Caldwell, 1996a). Transmissivity within the oxide bedrock zone in the vicinity of the PTF site has been estimated to range from 10,000 to 12,000 gpd/ft (Halpenny and Green, 1972).

Beneath the proposed PTF well field, the Bedrock Oxide Unit is fully saturated and exhibits confined to semi-confined characteristics. As noted on the cross sections submitted in Attachment 14C (Figures 14C-48 through 14C-51), the water levels measured in wells completed in the Bedrock Oxide Unit are observed at points well above the top of that unit. Due to the low hydraulic conductivity of the Sulfide Unit, there is no demonstrable hydraulic connection between it and the Bedrock Oxide Unit.

14A.3.2.2.5 Hydrologic Bedrock

The oxide bedrock zone is underlain locally by a zone of sulfide mineralization that occurs in the same quartz monzonite and granodiorite rocks that compose the oxide zone, and is of unknown lateral and vertical extent. The fracture frequency and resulting permeability of the fracture network within the sulfide zone is significantly less than that observed in the overlying oxide zone.

The Sulfide Unit is a bedrock unit that underlies the Bedrock Oxide Unit, and is distinguished from that unit by differences in mineralogical composition. In addition to having a different mineralogical composition than the Bedrock Oxide Unit, the Sulfide Unit is substantially less fractured, and consequently has a much lower hydraulic conductivity. Pumping and injection tests conducted in 1995 included tests conducted in wells constructed in the Sulfide Unit. During these tests, it was observed that the Sulfide Unit wells dewatered quickly and did not recover within a timeframe that allowed meaningful analysis of test data. For this reason, slug tests were conducted in the Sulfide Unit wells which produced hydraulic conductivity values between one and three orders of magnitude lower than those measured in the Bedrock Oxide Unit. Sulfide bedrock hydraulic conductivity values, developed by Brown and Caldwell (1996a), ranged from 0.0055 to 0.05 ft/day.

Within the broader study area, hydrologic bedrock consists primarily of Precambrian granite, gneiss, and schist with Mesozoic granite and related crystalline intrusive rocks, volcanic flows, sedimentary and metamorphic rocks and is assumed to be impermeable (ADWR, 1989). In the context of defining regional groundwater resources, the sulfide bedrock zone does not yield appreciable quantities of water (ADWR, 1989). Local areas of intense fracturing may yield groundwater from the bedrock complex; however; previous ADWR groundwater models (ADWR, 1990 and 1994) have assumed all bedrock (including the oxide bedrock zone) within the study area is impermeable. No flow bedrock areas are shown on Figure 14A-10.

14A.3.3 Regional Hydrogeologic System

The Eloy sub-basin is a structurally controlled hydrographic basin in the middle reach of the upper Gila River watershed that is bounded by topographic divides on the north, east, and south and by a groundwater divide on the west. The Eloy sub-basin represents a series of graben structures that have been overlain with basin fill sediments shed from the surrounding mountains. The basin fill sediments extend in depth to more than 4,000 feet at the center of the sub-basin and are generally water bearing in the uppermost 1,800 feet of thickness, with the exception of a series of fine grained deposits that extend nearly basin wide. The ephemeral Gila River is a losing stream within the Eloy sub-basin and also drains the sub-basin.

In the eastern portion of the Eloy sub-basin, and the eastern portion of the PTF model domain, groundwater flow generally follows the course of the Gila River but turns north-northwest in the vicinity of the Town of Florence and the PTF site.

The PTF model study area lies principally within the Eloy sub-basin. Groundwater inflows and outflows of the Eloy sub-basin that pertain to the domain of the PTF groundwater model are described below.

14A.3.3.1 <u>Inflows</u>

14A.3.3.1.1 Surface Water Flow and Groundwater Subflow

The Gila River is an ephemeral losing stream within the PTF model domain and is the principal source of groundwater recharge in the region. The flow control and diversion structures located on the Gila River are described in Brown and Caldwell (1996a). Within the study area, there are no other significant ephemeral or perennial surface water bodies that contribute to groundwater recharge. All other drainages within the PTF model domain consist of dry ephemeral washes that are tributaries to the Gila River and only flow during infrequent heavy precipitation events. Surface water infiltration estimates used in the model were compiled by ADWR for the ongoing update of the Pinal AMA groundwater flow model and were provided by ADWR on provisional basis for use in the current PTF groundwater flow model. Estimated surface water infiltration values are discussed in Section 14A.4.7

There is no documented sub-flow associated with the Gila River entering the Eloy sub-basin at the eastern margin of the basin, and no other potential sources of sub-flow exist within the Eloy sub-basin.

14A.3.3.1.2 Gila River Recharge

The Gila River is the primary source of recharge to the alluvial aquifers in the vicinity of the PTF site. Both historical and recent water level records demonstrate that there is a close relationship between the magnitude of flows in the Gila River and local groundwater elevations. This relationship is illustrated by the hydrographs plotted on Figure 14A-12. Figure 14A-12 is a map with hydrographs for Groundwater Site Inventory (GWSI) wells and PTF and surrounding vicinity wells plotted relative to a discharge hydrograph of the Gila River. The hydrographs plotted on Figure 14A-12 clearly show that as Gila River flow increases, groundwater elevations also increase shortly thereafter. As Gila River flows decrease, groundwater pumping causes groundwater elevations to decline. Hydrographs plotted on Figure 14A-12 show that recharge derived from Gila River flows affects groundwater elevations as far as approximately 3.5 miles from the Gila River.

No direct measurements of groundwater recharge derived from Gila River flows are available. The best available quantification of recharge derived from Gila River flow was developed by ADWR in conjunction with the groundwater model the Department developed to simulate groundwater conditions in the Pinal AMA (ADWR, 1990). The recharge array used in this model was directly imported from provisional data files prepared for the update of the Pinal AMA groundwater flow model (ADWR, 1990). These data were made available to Curis Arizona by ADWR on a provisional basis.

14A.3.3.1.3 Mountain Front Recharge

Analyses performed by ADWR (1989) demonstrated that mountain front recharge is negligible within the domain of the Pinal AMA groundwater flow model. Based on provisional data provided by ADWR, the revision of the Pinal AMA groundwater flow model that is currently in progress will validate the earlier ADWR conclusion that there is no significant mountain front recharge within the domain of the Pinal AMA groundwater flow model. Accordingly, the current PTF groundwater flow model does not include mountain front recharge.

14A.3.3.1.4 Canal Leakage

Three irrigation districts serve water to farms within the PTF model study area through a network of unlined canals: New Magma Irrigation and Drainage District, Maricopa Stanfield Irrigation and Drainage District, and the San Carlos Irrigation and Drainage District. Seasonally, canal water is obtained from surface water diversions on the Gila River and from the Central Arizona Project (CAP). When insufficient surface water supplies are available to meet irrigation demand, the irrigation districts pump groundwater into the canal network to meet the demand. The location of these canals within the model domain is shown on Figure 14A-6. Leakage from the unlined canals is a significant source of recharge water within the Eloy sub-basin and the PTF model domain. Canal leakage data used in this model were compiled by ADWR for the ongoing update of the Pinal AMA groundwater flow model and were provided by ADWR on a provisional basis for use in the current PTF groundwater flow model. Canal leakage model input values are discussed in Section 14A.4.7.

14A.3.3.1.5 Permitted Recharge Facilities

There is one permitted Underground Storage Facility (USF) no. 70-431125 within the PTF model study area. The USF is permitted to recharge 135 acre-feet per year (AFY) of reclaimed wastewater generated at the North Florence Wastewater Treatment Plant operated by the Town of Florence. The location of the North Florence recharge facility is shown on Figure 14A-1. Permitted USFs seldom operate at the maximum permitted volume on a continuous basis, and typically are permitted for excess capacity to allow for facility expansion. Based on ADWR records, the Town of Florence groundwater Long-Term Storage Account increased by a total of 73 acre-feet between 2007 and 2010 due to recharge from this facility.

The amount of recharge contributed by the North Florence USF is relatively insignificant compared to the recharge received from the nearby Gila River, which can fluctuate by as much as 10,000 to 100,000 AFY. Consequently recharge from the North Florence USF was not included in the current PTF groundwater flow model.

14A.3.3.1.6 Agricultural Returns

Because much of the agricultural land within the PTF model domain is irrigated by flood (furrow) methods, typical irrigation efficiency is assumed by ADWR to be in the range of 65 to 70 percent, which means that 30 to 35 percent of all water applied to the surface infiltrated beyond the root zone and is recharged to groundwater. Because there is a relatively large volume of irrigation water used within the study area, agricultural returns are a significant source of recharge used in the model. Irrigation return data used in the model were compiled by ADWR for the ongoing update of the Pinal AMA groundwater flow model and were provided by ADWR on a provisional basis for use in the current PTF groundwater flow model. Agricultural return model input values are discussed in Section 14A.4.7.

14A.3.3.2 Outflows

14A.3.3.2.1 Groundwater Pumping

Groundwater pumping is the principal outflow of groundwater within the study area. Pumping for irrigation generally makes up more than half of the groundwater extracted from the aquifer on an annual basis. Groundwater pumping data used in the model were compiled by ADWR for the ongoing update of the Pinal AMA groundwater flow model and were provided by ADWR on a provisional basis for use in the current PTF groundwater flow model. Pumping data from 1984 to 2006 was compiled by ADWR from San Carlos Irrigation Project (SCIP) reports and from the Registry of Groundwater Rights (RoGR) database. Pumping data after 2006 was compiled by Brown and Caldwell from the ADWR wells 55 database, specifically the pump-year data within that database. Annual groundwater extraction within the study area ranges from 21,100 to 73,100 AFY.

14A.3.3.2.2 Evapotranspiration

Evapotranspiration is associated with vegetation along the Gila River. Due to the depth of the water table, evapotranspiration from the aquifer is minimal. Significant evapotranspiration only occurs during flood years when water levels in, and adjacent to, the Gila River channel are higher than the evapotranspiration extinction depth. Evapotranspiration data used in the PTF groundwater flow model were compiled by ADWR for the ongoing update of the Pinal AMA groundwater flow model and were provided by ADWR on a provisional basis for use in the current PTF groundwater flow model. The evapotranspiration rate used by ADWR (1990) is discussed in Section 14A.4.7.

14A.3.3.2.3 Underflow

The PTF model domain does not encompass the entire Eloy sub-basin; consequently, underflow identified by ADWR (2010) does not represent underflow simulated at the perimeter of the PTF study area. Underflow out of the 124 square mile study area is comprised of underflow from the study area toward the south and west into the broader Eloy sub-basin, and underflow northward into the SRV. Estimates of underflow were calculated by examining measured groundwater gradients over time.

14A.3.4 Groundwater Elevations and Gradients

Hammett (1992) reported that prior to about 1900, the groundwater system in the PTF study area was in dynamic equilibrium, with the amount of water entering the groundwater system approximately equal to that extracted, with no appreciable change in storage. During the pre-development period (circa 1900), the general direction of groundwater flow through the PTF study area was from the east-southeast to the west-northwest, with a gradient of 8 or 9 feet per mile (Hammett, 1992).

By the 1980s, the groundwater flow direction and gradient had changed from that observed in the pre-development period (circa 1900) to a more pronounced southeast to northwest pattern, toward areas of greatest groundwater pumping. By the 1980s flows in the Gila River had also been eliminated in all but the wettest years, limiting infiltration of river water into the basin-fill sediments to periods of flooding.

In 1995, Brown and Caldwell (1996a) observed that groundwater flow was generally to the northwest at an approximate gradient of 33 feet per mile in alluvial units in the northern portion of the PTF study area. Montgomery (1994) reported the hydraulic gradient across the proposed PTF well field to range from approximately 25 to 65 feet per mile in the UBFU and LBFU.

Beginning in the fall of 1995, Brown and Caldwell has conducted quarterly water level monitoring at the proposed PTF well field in conjunction with a quarterly groundwater quality monitoring program. Observations resulting from the water level monitoring program are described below.

Seasonal changes in groundwater elevations and flow direction were observed in each of the water producing zones beneath the PTF site. Seasonal fluctuations in groundwater elevations in the LBFU and Oxide Zone have been as great as 20 feet, but typically range between 10 and 15 feet in magnitude. Seasonal fluctuations in groundwater elevations in the UBFU are less pronounced, ranging between 5 and 8 feet.

Hydrographs depicting seasonal groundwater elevation changes at the PTF site during the years 1996 through 2011 are included in Attachment 14C Figures 14C-1 through 14C-31.

Potentiometric surface maps depicting groundwater elevations and flow directions at the PTF site during the years 1996 through 2011 in each of the three water bearing units beneath the PTF site are included in Attachment 14C Figures 14C-32 through 14C-46.

Recent hydrographs depicting groundwater elevations in four key wells located at and near Curis Arizona property are shown on Figure 14A-12. These wells were selected as key wells based on the relatively extensive length of the monitoring record, and the distribution within the active portion of the model domain. The water level data plotted in Figure 14A-12 was obtained from the ADWR GWSI database.

Regional potentiometric maps depicting groundwater elevations and flow directions in the vicinity of the PTF site are included in Attachment 14C Figures 14C-1 through 14C-31. Current (December 2010) groundwater gradients within the PTF study area range between approximately 12 feet per mile in the eastern and southern portions of the study area, to approximately 22 feet per mile in the northern portion of the PTF study area. Groundwater gradients at the site of the proposed PTF well field range between approximately 11 feet per mile in the UBFU and approximately 22 feet per mile in the Bedrock Oxide Unit, with a northwest groundwater flow direction in the UBFU, LBFU, and Oxide Zone.

14A.4 Production Test Facility Groundwater Model

14A.4.1 Production Test Facility Model Development

The conceptual model described above was used as the basis to develop a numerical, three-dimensional (3-D) groundwater flow model that is representative of groundwater flow conditions within the PTF study area. The model development process consisted of the generation of both regional and local scale 3-D geologic models, which were then imported into the groundwater modeling software along with estimates of aquifer hydraulic properties and components of the hydrologic water budget. Once the model was refined and calibrated, it was used to simulate pre-development (or steady state), historic, present day, and predicted future groundwater conditions under a variety of operating and closure scenarios.

This section summarizes model specifications, model development, and the methods and assumptions used for estimating initial numerical model inputs. An overview of the numerical model specifications are presented in Table 14A-3.

14A.4.2 Computer Code Description

The computer code used to simulate both groundwater flow and solute transport was MODFLOW-SURFACT™ (Version 3.0), a modular, finite-difference, 3-D groundwater modeling program based on the U.S. Geological Survey (USGS) code MODFLOW (HydroGeoLogic, Inc., 1996; Harbaugh et al., 2000). MODFLOW-SURFACT™ adds additional features to the MODFLOW code in order to better simulate desaturation/resaturation of aquifers as well as unsaturated flow conditions. MODPATH (Pollock, 1994) was used in conjunction with the results from the groundwater flow model to perform particle tracking simulations, which estimate the travel distances of the recharged water. Groundwater Vistas™ Version 5.48 (Environmental Simulations, Inc. [ESI], 2008) was used as the pre- and post-processor and was coupled with ArcGIS™ (ESRI, 2006) to facilitate the development of input files and analyses of model output. The generation of 2-D gridded and contour data by geostatistical interpolation techniques (i.e., kriging) was performed using the Surfer® software package (Golden Software, Inc., 2008), which produces output that can be imported into the numerical model or geographic information system (GIS).

The transport and migration of sulfate was modeled using the Analysis of Contaminant Transport (ACT) modules, which are fully integrated and consistent with MODFLOW SURFACT™ (HydroGeoLogic, Inc., 1996). These modules are fully integrated with the MODFLOW-SURFACT code and greatly expand the capabilities of traditional MODFLOW-compatible solute transport modules by running simultaneously with the MODFLOW-SURFACT flow solution and allowing for advanced solute fate and transport mechanisms to be considered explicitly within the fully integrated MODFLOW flow solution.

14A.4.2.1 Solution Techniques

MODFLOW-SURFACT™ supports two solution packages: the Preconditioned Conjugate Gradient Version 4 (PCG4); and Version 5 (PCG5). All model simulations presented in this report were generated using the PCG5 package.

14A.4.2.2 Assumptions

MODFLOW uses a finite-difference numerical method for solving a form of the 3-D groundwater flow equation. This technique essentially solves for hydraulic head by discretizing the flow domain into a computational grid composed of orthogonal blocks, with a node located at the center of each block. In general, the finite-difference approximation assumes that all hydraulic parameters, stresses, and inputs are constant over the area of a single cell and over the time elapsed during a stress period. Likewise, calculated hydraulic head and groundwater fluxes are also averaged over the areal extent of a single cell. Using the model for a specific application requires the definition of boundary and initial conditions, estimates of key hydraulic parameters, and groundwater inflows and outflows as a function of time.

14A.4.2.3 Limitations

Numerical solutions using MODFLOW-SURFACT™ are dependent upon the scale of the model grid, the time frame of interest, and the behavior of the various model inputs and boundary conditions. For large-scale applications such as the PTF Model, results may have limited usefulness in investigating groundwater issues with: 1) spatial scales smaller than a single cell or small grouping of cells; and 2) substantially varying groundwater stresses or inputs at a time scale less than a single stress period.

Model cells are sized at 500 feet by 500 feet at the model periphery and telescope down to 12.5 feet by 12.5 feet in size at the model center. At 4.5 acres, the PTF well field represents roughly 1,254 model cells in size. Consequently, the model grid discretization is fine enough to appropriately simulate groundwater conditions at the PTF well field scale and the domain is sufficiently large to ensure that regional and sub-regional factors are considered in those simulations.

Model stress periods vary in length. Input datasets available from ADWR and other sources are typically compiled at annual intervals rather than monthly, weekly, or smaller time increments. Input datasets were kept at one year intervals, and stress periods of various shorter lengths were used to simulate the 23-month active pumping period and portions of the five year post pumping closure period. The model stress periods of one year are sufficient to simulate the impacts of PTF activities five years after closure.

Large water level changes that are basin-wide, or intersect model boundary conditions, have the potential to introduce some error into the model results along basin boundaries due to large numbers of dry cells and losses of groundwater stresses, such as pumping or recharge. However, such large water level changes within the Eloy sub-basin are more likely to occur during predictive scenario time periods based on committed demands and other administrative conditions rather than during the historical, transient time period to which the model was calibrated. No large water level declines and associated loss of stresses were observed in the predictive model runs.

The finite-difference solution technique also assumes that the majority of groundwater flow occurs orthogonal to the cell faces, and error can be introduced into the simulation if significant vertical or oblique-angle flow components are evident within a single layer at a local scale. Extrapolation or interpolation of the model results over large time frames are subject to uncertainties inherent in long-term, transient, predictive model stresses. Such uncertainties arise from differences in population growth and climatic conditions relative to predicted values for related groundwater pumping or recharge parameters.

The use of a finite-difference modeling scheme applies stresses and inputs to the model evenly across a model cell. Likewise, hydraulic parameters are uniform within a model cell, limiting the resolution of the model to the size of the grid. The grid cell spacing for the PTF Model has a minimum 12.5 feet by 12.5 feet, equal to 178,421 cells per square mile. Model results, such as groundwater elevations or drawdown are also averaged across each model cell and may not be appropriate for assessing conditions at a small scale adjacent to major pumping stresses.

14A.4.3 Model Domain

The areal extent of the active PTF groundwater model domain is shown on Figure 14A-10. The domain includes the PTF site and an area that extends at least five miles from the Site in all directions. This domain was chosen because it includes a sufficient portion of the Eloy sub-basin to include key hydrographic features and boundaries affecting the PTF site and the immediate vicinity. The PTF model domain extends from the Santan Mountains on the west, to the Tortilla Mountains on the east, and straddles the boundary between the Eloy sub-basin and the ESRV. The PTF model domain is 10.4 miles across from north to south, and approximately 12 miles across from east to west, covering a total area of approximately 124 square miles. The northernmost portion of the PTF model domain extends approximately three miles into the ESRV, with the southern seven miles extending into the Eloy sub-basin.

Within this domain, mountains and mountain front regions are considered to be "no-flow" areas and are represented numerically as inactive cells. Areal extent of the entire active PTF model domain is approximately 97 square miles.

No continuity issues related to joining the boundaries of the ADWR Pinal and Phoenix AMA groundwater models were encountered. No such issues were encountered because no effort was made to join and run the Pinal and Phoenix AMA models together to create the PTF groundwater model. The 125 square mile PTF model domain only covers a very small fraction of the larger Pinal and Phoenix AMA groundwater model domains, which cover a combined area of approximately 6,600 square miles. The effort required to join and run the Pinal and Phoenix AMA models was not warranted to simulate groundwater conditions at, or in the vicinity of the PTF site.

Approximately 20 percent of the PTF model domain lies within the domain of the 1994 Phoenix AMA model; the remaining 80 percent of the model domain lies within the Pinal AMA groundwater model domain. Grid discretization, layering, and boundary conditions from the Phoenix AMA model were not incorporated into the PTF Model, but were analyzed to develop an understanding of ADWR interpretations of geologic and hydrologic properties. Layering and boundary conditions from the Pinal AMA groundwater model were incorporated at the periphery of the model domain. Updated geology and temporal head distributions recently developed by ADWR for the Phoenix and Pinal AMA groundwater model were used for construction and calibration of the PTF Model.

During calibration of the PTF Model, both model heads and fluxes across the northern boundary were reviewed against the Phoenix and Pinal AMA model heads and fluxes for the same time period. This comparison was one of many such comparisons performed during calibration of the PTF Model and showed that heads and fluxes predicted by the PTF Model and the Phoenix AMA model were consistent.

14A.4.3.1 Units and Coordinate System

The PTF Model uses linear units of feet, temporal units of days, and all model features georeferenced within the State Plane NAD27 Central Arizona projection.

14A.4.3.2 Boundary Conditions

As stated previously, ADWR is in the process of updating the Pinal AMA groundwater flow model and has made selected data supporting that update available for use on a provisional basis for the PTF groundwater model. ADWR no-flow boundaries were generally maintained along the front of the Santan and Tortilla Mountains, and a dewatered area of approximately five square miles in the southeastern portion of the domain. No-flow boundaries to the northwest and northeast were refined from the ADWR data during the model layering process. Areas within the interior of the PTF model domain that were too thin for saturation were converted to no-flow.

GHBs were placed to represent the underflow from the Pinal AMA to the Salt River AMA to the north, and flow to the broader Eloy sub-basin in the southwest. Reference heads for the GHBs were set to approximate groundwater elevations two miles away from the PTF model domain. GHB cell widths, lengths, and thicknesses correspond exactly to individual grid cell dimensions. Hydraulic conductivity for all GHBs was set to the hydraulic conductivity values for each model layer. During model calibration, GHB reference heads were adjusted to produce a groundwater flow regime representative of regional water level elevations and gradients over time.

14A.4.3.3 Model Grid Discretization and Layering

The PTF Model grid consists of 298 rows and 305 columns covering an area of approximately 124 square miles. Grid cell spacing has a minimum discretization of 12.5 feet by 12.5 feet in the area of the PTF site and telescopes out to 500 feet by 500 feet at the edges of the PTF model domain. The model grid for the entire study area is shown on Figure 14A-13, and the grid in the vicinity of the proposed PTF well field is shown on Figure 14A-14. The model is georeferenced in the coordinate system as noted in Section 14A.4.3.1.

The hydrostratigraphy of the PTF Model is divided into 10 layers. The top of the highest active layer at any location within the model represents ground surface. Elevations were interpolated from a 30-meter Digital Elevation Model (DEM).

Layers 1 and 2 represent the UBFU, layer 3 represents the MFGU, and, layers 4 and 5 represent the LBFU. Layers 6 through 10 represent the Bedrock Oxide Unit, with layer 6 representing the uppermost 40 feet of that unit, which is excluded from injection.

Data used to determine layer contact elevations and extent was obtained from historic on-site corehole data (SRK, 2010), on-site well lithologic logs (Brown and Caldwell, 1996a), and geologic layering of the Pinal AMA model (ADWR, 1990). The historic site corehole database includes Rock Quality Descriptions (RQD) data generated by previous owners of the Site of the past 40 years, and includes data from approximately 700 on-site or near-site coreholes. On-site well lithologic logs were developed in 1994 and 1995 when Brown and Caldwell (1996a) drilled and installed 52 exploratory wells and observation wells at the PTF site.

In the vicinity of the PTF site, the corehole database was used to define the extent and thickness of the UBFU, MFGU, LBFU, and Bedrock Oxide Unit. Throughout the remainder of the PTF model domain, the extent and thickness of the UBFU, MFGU, and LBFU were derived from the Pinal AMA (ADWR, 1990) and SRV (ADWR, 1993) groundwater flow models.

The Bedrock Oxide Unit is not identified within the Pinal AMA model (ADWR, 1990) as a water bearing unit. The extent and water bearing characteristics of the Bedrock Oxide Unit are defined entirely by data collected on site and near site during mineral exploration and ore body characterization activities. The extent and depth of the Bedrock Oxide Unit was interpolated from RQD data included in the historic corehole database, and was truncated or pinched out at appropriate structural features near the edges of the available corehole data coverage. Bedrock beneath the Bedrock Oxide Unit and beyond the extent of the corehole data coverage is considered to be impermeable.

14A.4.4 Stress Periods

The calibrated model consists of 28 annual (365.25 days) stress periods from 1984 to 2010. Stress period 1 is a steady state stress period that precedes the transient portion of the model representing conditions in 1900. Stress periods 2 through 28 represent the 1984 to 2010 time period. The Adaptive Time-Stepping and Output Control (ATO4) package was utilized allowing for automatic time step generation. Time steps were allowed to fall to a minimum of 0.1 days and grow to a maximum of 200 days using a 1.2 multiplier.

The predictive model simulates the time period from 2012 through 2014, and consists of seven stress periods of various lengths. The first two stress periods include 14 months of PTF operational pumping, and 9 months of PTF well field rinsing. The last five stress periods a one year in length and represent the 5-year closure period. The ATO4 package was utilized to optimize time step sizes and improve model performance.

14A.4.5 Initial Conditions

The steady state stress period 1 uses the drain down method to solve for a steady state head array. Since this array represents conditions from 1900, these heads are not allowed to carry over as starting heads for the transient portion of the model. Instead water levels for the year 1984 were obtained from the GWSI database. These data were then spatially interpolated, contoured, and attached to model grid nodes to serve as initial heads for the beginning of the transient portion of the model simulation. Water table elevations were used for starting heads in every model layer. Initial water level elevations are shown on Figure 14A-15.

14A.4.6 Hydraulic Parameterization

Horizontal hydraulic conductivity, vertical hydraulic conductivity, specific storage, specific yield, and porosity were used by ADWR in the Pinal AMA model (ADWR, 1990) for layers 1 through 5. In layer 3 where the MFGU pinches out to the east, the model was assigned values associated with the UBFU rather than those of the MFGU because as bedrock elevations rise, the LBFU thins in this area. Bedrock Oxide Unit and fault hydraulic conductivity and porosity values were derived from aquifer tests conducted in 1994 and 1995 (Brown and Caldwell, 1996a). Figures 14A-16 through 14A-25 show the hydraulic conductivity distribution for each model layer.

14A.4.7 Sources and Sinks

The PTF Model contains groundwater sources of recharge and underflow. Groundwater outflow is represented in evapotranspiration (ET), wells, and underflow. Recharge was directly imported from the ADWR Pinal AMA model. The ADWR recharge array represents recharge from the Gila River, agriculture, canals, Gila River Indian Community, and Picacho effluent.

To estimate recharge derived from Gila River flows, ADWR calculated the difference between flow at the Ashurst-Hayden Spilled and Sluiced gage and the Laveen or Maricopa gage (Maricopa was used post-1995), and distributed it in a non-linear fashion across each reach of the river based on reach specific parameters. This method assigns a fixed percentage of Gila River recharge to each model cell based on the length of river segments assigned to each model cell, relative to the total length of the river within the model domain. The ADWR methodology results in larger volumes of Gila River derived recharge to the regional aquifer system in the upper reaches of the river, which is consistent with physical observations of conditions in the groundwater basin.

Recharge values included in the ADWR recharge array for the year 1993 are provided as example estimates of groundwater recharge derived from Gila River flow during that year. Gila River flow in 1993 was more than six times greater than the long-term annual average flow, and was greater than any recorded annual flow before or since. For the year 1993, the ADWR recharge calculation method yields a recharge range of approximately 447 to 17,363 acre feet per model cell for the uppermost 25 miles of the Gila River, and 74 to 9,986 acre feet per model cell for the lower 25-mile portion of the Gila River.

In the vicinity of the PTF site, groundwater recharge derived from Gila River flow during 1993 ranged from 6,930 to 12,221 acre feet per model cell. In the ADWR groundwater model, four model cells measuring 0.5 miles square are located adjacent to the south side of the PTF site. This recharge represents a small fraction of the total recharge of approximately 364,400 acre feet received from the Gila River within the 125 square-mile domain of the Curis Arizona groundwater model for the year 1993.

The Gila River induced recharge calculated by ADWR was reduced by half for input into the Curis Arizona groundwater model based on the assumption that Gila River flood flows during that year reached a limiting condition with respect to the amount of recharge that was able to infiltrate to the regional aquifer system. This adjustment was made to the ADWR recharge value for 1993 because direct application of the ADWR recharge for that year caused groundwater elevations to rise significantly higher than observed levels. The ADWR recharge values were not adjusted for any other year of the 28-year simulation period.

In 2010, total recharge within the model domain was 35,405 acre feet. The total recharge for 1993 within the model domain was 184,254 acre feet after adjustment.

Evapotranspiration was also imported directly from the ADWR Pinal AMA model. Evapotranspiration was applied in the western portion of the model along the Gila River with a rate of 0.015 feet per day, with a 30-foot extinction depth. However, this extinction depth results in little evapotranspiration in the model.

GHBs represent underflow into the SRV to the north and underflow to and from the remainder of the Eloy sub-basin in the southwest.

Provisional data provided by ADWR (2010) included pumping values derived from SCIP reports for the period of 1984 to 2006. These data were then extended to 2010 by assuming 2006 pumping values for 2007 through 2010. ADWR (2010) also used pumping data from the RoGR database for 1984 through 2006. These pumping values were not extended into 2010; instead pumping data for 2007 and 2008 were obtained from the pump-year dataset within ADWR's wells 55 database. The 2008 pumping values obtained from the pump-year dataset were then extended for 2009 and 2010. Model water budget elements within the study area are shown on Figure 14A-26.

14A.5 Model Results and Calibration

14A.5.1 Approach

Calibration is the process of adjusting model parameters to achieve a good match between the simulated and observed hydraulic heads or other relevant hydrologic data such as water budget components. These observed data are called calibration "targets". Initial estimates for hydrogeologic parameters are varied within an observed or estimated range of values to improve the model's ability to simulate these targets.

The calibration exercise is completed prior to performing predictive simulations to provide confidence that the model is capable of simulating the historical and observed groundwater conditions. The range of plausible estimates for hydrogeologic parameters provides constraints on the calibration exercise to ensure that inputs remain defensible, and to limit the non-unique nature of the model results to a set of realistic input conditions. The adjustable model variables include hydrogeologic parameters such as hydraulic conductivity, specific storage, and specific yield.

The model was calibrated from 1984 through 2010. Additionally a qualitative steady state calibration was performed for conditions in 1900. Water level elevations from the GWSI database and PTF site water level monitoring data were used as calibration targets.

14A.5.2 Qualitative Calibration

Prior to the calculation of calibrations statistics, a qualitative review of the model-calculated flow regime was performed to assess the general groundwater flow system and to provide a subjective indication of the agreement between model-calculated groundwater elevations and flow gradients relative to observed conditions. This qualitative review was performed for the steady state simulation as well as the initial set of transient calibration simulations.

Initially, a steady state calibration was used to match regional groundwater levels across the PTF model domain by adjusting the GHB conditions. Steady state water levels for the year 1900 provided by ADWR were used as the qualitative calibration target. Steady state water levels range from a high of approximately 1,500 feet amsl where the Gila River enters the PTF model domain, to a low of approximately 1,380 feet amsl where the Gila River exits the model. Model simulated water levels generally had good agreement between regional groundwater elevations and flow directions. Groundwater flow proceeds from the east and southeast edges of the PTF model domain towards the west and northwest. This flow regime is consistent with the conceptual model, which assumes that the bulk of model inflows are from Gila River flows and incidental recharge from irrigated lands within the PTF model domain. The dominant outflow components are groundwater underflow along the north and west model boundaries, where the model domain adjoins to the regional aquifer systems for the SRV and central Pinal AMA groundwater basins, respectively.

14A.5.3 Simulated Water Levels and Quantitative Calibration

The quantitative analysis of the model calibration utilized both statistical measures of model residuals and direct comparisons of simulated and observed water levels to assess the accuracy and precision of the PTF modeling tool. Variations between the simulated and observed water levels were analyzed as functions of space and time.

14A.5.3.1 Calibration Statistics and Targets

Groundwater elevations and depths to water recorded for monitoring well locations within the model domain were compiled in a GIS-compatible database (geodatabase). The integration of the water levels with GIS coverages of well locations allows for the interpretation of water level trends both spatially and temporally during the model development and calibration process. Two sources of observed water levels were combined into the PTF Model water level geodatabase: 1) ADWR's GWSI database; and 2) the water level database for the PTF site that has been maintained by Brown and Caldwell since 1995. The compiled water levels were used to develop interpolated water level distributions at various times and serve as target values for the quantitative model calibration. The recorded water levels from ADWR's GWSI database were primarily used during the calibration of the regional groundwater flow regime; whereas, the more localized and higher resolution distribution of water levels and monitoring wells from the PTF database were used in refinement of the localized calibration for the refined portion of the model grid surrounding the PTF well field.

Although water levels from wells located outside of the PTF model domain were used to conceptualize regional flow conditions and identify temporal water level trends along model boundaries, these data were removed from the final target data set. Likewise, water level data from wells located within model no flow areas were also removed, as no simulated water levels were produced for these areas. Target wells were assigned to specific model layers based upon their total depths and assumed or known screened intervals to improve the vertical resolution and accuracy of the final model calibration.

Following calibration of the model to industry accepted standards (Anderson and Woessner, 1992), water levels from wells located within cells that had "dried out" by the end of the simulation were also removed from the target data set. These wells were all located in regions of the model where saturated aquifer units thin to the point where they should no longer be considered to be significant component of the regional aquifer system.

Generally, American Society of Testing Materials (ASTM) standards were followed whenever possible during the quantitative calibration of the model (ASTM, 2008). During calibration, residuals are calculated to assess the "fit" of the model-calculated (or simulated) heads to those actually observed. A residual is defined as the observed (or field-measured) water level minus the simulated water level at the same location. Positive residuals represent a model-calculated head value that is lower than the observed head value, and negative residuals represent a model-calculated head value that is higher than the observed value. A residual value of 0 represents a perfect fit between the model-calculated and observed values. During calibration, the goal is to minimize the residual statistics while remaining within the acceptable range for water budget components, hydraulic parameters, and flow regime requirements.

Plotting the residuals on a map with simulated water level contours provides an indication of the spatial distribution of model error and helps guide the calibration process. Trends in the distribution of error, such as clusters of values that are all too high or too low, indicate spatial bias. The spatial distribution of PTF model residual values for 2008-2010 is shown on Figure 14A-27 along with simulated water levels. From review of the residual distribution for this time frame as well as all simulated model time frames, no substantial spatial bias was observed that would significantly affect the results of predictive simulations.

Calibration statistics based on the residual values are used as a quantitative measure of the overall ability of the model to match calibration targets. Calibration statistics that were calculated to quantify the average error included:

- Absolute Residual Mean (ARM), the arithmetic average of the absolute value of the residuals;
- Residual Mean (RM), the arithmetic average of the residuals; and
- Residual Standard Deviation (RSD), the standard deviation of the residuals.

When the ratio of the ARM to the range of observed head values in the system is small, discrepancies between simulated and observed values comprise only a small part of the overall model response (Anderson and Woessner, 1992). One of the goals of the quantitative calibration process was for the ratio of the ARM to the range in observed heads to be less than five percent for any given calibration period. Total interpreted head change across the PTF model domain is approximately 400 feet based on the range of observed heads over the full 28-year model simulation time period; therefore, the ARM should be less than 20 feet to meet this goal. A listing of the key calibration metrics for the PTF Model is presented in Table 14A-5. All calibration statistics and metrics are reflective of the water level target values for the entire simulation time period of 1984 through the end of 2010. The ARM is approximately 12 feet, producing a ratio of ARM to observed head range of three percent, well below the predefined calibration goal. The principle industry standards for model calibration are an ARM/Head Range of less than 5 percent and a RSD/Head Range of less than 10 percent. Model calibration metrics are well within industry standard guidelines for successful model calibration.

14A.5.3.2 <u>Simulated Water Level Conditions 2010</u>

Simulated water levels at the end of the calibrated model simulation time frame (end of 2010) are shown on Figure 14A-27. The model reproduces the general flow gradients and absolute water level elevations throughout the PTF model domain. Simulated flow gradients are generally directed along the course of the Gila River and flow exits the PTF model domain along the northern and western GHBs. By the end of the simulation time period, groundwater underflow into the PTF Model is observed along the southern model boundary. Localized pumping and Gila River recharge produces a saddle-shaped water table feature in the central portion of the PTF model domain, causing diverging flow gradients to the north towards the PTF site and towards the south and the central portion of the Pinal AMA regional aquifer system. Overall, the simulated groundwater conditions match the conceptual understanding of the water levels and flow within the Eloy sub-basin, as well as matching observed water level measurements.

14A.5.3.3 Simulated Water Budget

The simulated water budget for the PTF study area for 1984, 2003, and at the end of the calibrated time period in 2010 is presented in Table 14A-6 and for the entire simulation time frame in Figure 14A-28. Water budget components that exhibit the largest changes from 1984 to 2010 include storage, fluxes from general head cells, and recharge. Recharge in 1984 represents a "wetter" year and therefore storage outflows represent addition of water to aquifer reserves.

Inflows from storage in 1984 were very low or negligible because that year followed a high precipitation year during which the Gila River experienced extremely high flood flows. These flows and high precipitation caused a large amount of groundwater recharge along the course of the river and also caused a reduction in the amount of agricultural pumping. The net effect was that groundwater levels rose throughout the model area, hence the large amount of storage outflows (refilling of the regional aquifer) and no storage inflows (no net aquifer depletion). The recharge and pumping reduction was so pronounced for this year that there was no simulated groundwater depletion at the spatial scale of the model cells. Higher fluxes in the general head cells in 1984 corroborate with higher water levels and increased flows out of the study area.

In the lowest recharge year of the simulation time frame (2003), storage inflows represent depletion of the aquifer, pumping increases, and there is a drastic reduction in general head flux out of the study area compared to 1984. Although 2003 was a dry year, the relatively higher GHB flux out of the study area represents continued drain down of recharge received in earlier years. The year 2010 has recharge value typical of an average year and fluxes adjust accordingly compared to 1984 and 2003.

14A.6 Predictive Simulations

The calibrated PTF Model was adjusted to simulate and predict future conditions at and in the vicinity of the PTF well field. This was accomplished by keeping all model groundwater fluxes at 2010 magnitudes and distributions and shifting the time frame to cover a specified future period of time. Two predictive scenarios were developed to assess 1) the migration potential of groundwater away from the PTF well field using a full fate and transport model and advective particle tracking, and 2) the impact of groundwater containment pumping over the estimated, cumulative 23-month timeframe of PTF activities and rinsing periods.

14A.6.1 Predictive Scenario Development

Two predictive scenarios were developed that differ primarily by the presence or absence of containment pumping at the PTF well field over a 23-month timeframe. These two scenarios and associated simulations are identified as "pumping" and "no pumping", respectively. For the pumping predictive simulation, an additional 5 years (2014 through 2019) was included after the initial 23 months to facilitate the simulation of potential post-closure sulfate transport.

Simulation of the future DIA was performed using modeled groundwater conditions that prevailed following cessation of PTF pumping. For the advective particle tracking analysis, the 3-D groundwater flow field at the end of the calibrated model (end of 2010) was used to simulate flowpaths after pumping had stopped. A comparison of the results of the PTF pumping and agricultural-only pumping predictive scenarios over the 23-month PTF well field life allowed the estimation of the impact of PTF pumping on future water levels by comparing simulated water levels both with and PTF operations at the end of the 23-month period.

14A.6.2 Discharge Impact Area

The DIA is defined in Arizona Revised Statutes (A.R.S.) § 49-201 as the "potential areal extent of pollutant migration, as projected on the land surface, as the result of discharge from a facility." The simulated DIA is based on the potential areal extent of sulfate migration from the proposed PTF facility following completion of copper recovery and restoration activities. The DIA was defined using sulfate because the proposed lixiviant is a sulfuric acid based solution, and over the life of the proposed PTF project, a substantial quantity of the lixiviant will be circulated through the associated ore body. By mass, sulfate comprises the greatest quantity of material to be removed during restoration activities.

Site restoration activities consist primarily of post-production rinsing of the ore body using native groundwater to remove residual lixiviant and residual constituents dissolved by the lixiviant. During restoration, rinsing the pH of the residual fluids will rise to the point that it is near background levels. As the pH rises, constituents of interest such as metals will complex out of solution or otherwise precipitate in insoluble forms. There is expected to be sufficient gypsum precipitated in the ore body during PTF operations to ensure that sulfate will exist in residual formation water in substantial quantities as the other constituents are immobilized by the elevated pH. Geochemical modeling presented in Attachment 10 has demonstrated that no constituent other than sulfate will migrate to the POC after cessation of PTF operations.

Simulation of the future migration of sulfate and delineation of the DIA was performed using the MODFLOW SURFACT™ ACT module, described in Section 14A.4.2, fully coupled with the transient groundwater flow simulated for the pumping predictive scenario. Post-closure sulfate mass was allowed to migrate through and away from the PTF well field via advection, dispersion, and diffusion for 5 years, commencing immediately after the cessation of containment pumping. The horizontal distribution of initial sulfate concentrations is shown on Figure 14A-29. The discretization of model layers relative to the hydrostratigraphic units described above is shown on Figure 14A-30. Figures 14A-31 through 14A-36 show the maximum extent of sulfate migration at the DIA concentration criterion of two milligrams per liter (mg/L) above background in each model layer with sulfate concentrations above that level.

Sulfate transport simulations did not result in any sulfate migration into model layers 1 through 4 (Figure 14A-30), which represent the upper portion of the LBFU or the UBFU. Transport simulations indicate that following restoration, sulfate generally remains confined to the Bedrock Oxide Unit, with limited migration into the LBFU over time. The maximum extent of sulfate migration in the Bedrock Oxide Unit is shown on Figure 14A-37, and for the LBFU on Figure 14A-31

The DIA is the vertical projection of the maximum aerial extent of sulfate migration from the PTF well field at 5 years after closure in all model layers combined. Combination of the sulfate migration extent in each model layer results in a composite image of the maximum horizontal extent of sulfate migration 5 years after PTF well field closure. As described above, beside sulfate, no other residual water quality constituents are transported beyond the PTF well field boundary once restoration has been completed. The DIA as defined by sulfate migration 5 years after PTF well field closure is shown on Figure 14A-38.

14A.6.2.1 <u>Transport Simulation Initial Conditions and Parameters</u>

Geochemical modeling originally performed by Brown and Caldwell (1996b), and subsequently updated as presented in Attachment 10 to this application, has demonstrated that the process of post-production rinsing of the ore body to a target sulfate concentration of 750 mg/L, will remove other constituents of interest from the ore body to near background concentrations, or below AWQS levels. For this reason, proposed restoration activities include rinsing of the ore body until sulfate concentrations reach a level of 750 mg/L, at which point restoration will be complete. Therefore, for the purposes of the transport simulation, this sulfate concentration was used as an initial condition and was emplaced in model layers 7 though 10 within the boundaries of the PTF well field (Figure 14A-27). This distribution of initial sulfate concentrations represents the volume of Bedrock Oxide Unit targeted for injection and recovery and excludes the uppermost 40 feet of the Bedrock Oxide Unit.

A uniform dispersivity value of 10 feet was used for all model cells, and a uniform diffusion coefficient of 1 x 10-3 ft^2/day was also applied. The transport of sulfate was assumed to be fully conservative; therefore, no solute degradation was considered in the simulation and all model cells were assigned a sulfate distribution coefficient of zero. Porosity of the basin fill porous media, as well as the oxide and fault zones, are presented in Table 14A-4 and range from 0.05 for the lower oxide to 0.20 for the LBFU.

14A.6.2.2 DIA Evaluation Criterion

The DIA described herein is defined by the Practical Quantitation Limit (PQL), for sulfate concentration as determined by USEPA Test Method 300. The current PQL for sulfate analyses performed by the laboratory used for site water quality analyses (Test America, Phoenix) is 2.0 mg/L. Consequently, the laboratory cannot certify sulfate analytical results below this concentration, and cannot reliably reproduce analytical results with a precision of less than 2.0 mg/L using USEPA Test Method 300. Therefore, the greatest areal extent of sulfate migration as a result of operation of discharging facilities proposed under this APP application was defined at a sulfate concentration of 2 mg/L above background conditions.

14A.6.2.3 Results of DIA Transport Simulation

For model layers 1 through 4 (representing the UBFU, MFGU, and upper LBFU) (Figure 14A-28) there were no sulfate concentrations simulated to be greater than 2 mg/L above background conditions 5 years after closure. The maximum extent of simulated sulfate concentrations greater than or equal to 2 mg/L above background for layers 5 through 10 are shown on Figures 14A-31 through 14A-36. The simulated maximum distance of down-gradient migration of sulfate, approximately 150 feet beyond the edge of the PTF well field in the lower bedrock oxide unit (Layer 10).

Although sulfate appears to migrate from the Bedrock Oxide Unit into the LBFU, sulfate concentrations in the LBFU were simulated to be substantially lower than those within the Oxide Bedrock Unit, reaching a maximum of less than 10 mg/L above background in a relatively small area (Figure 14A-31). Sulfate concentrations in the Bedrock Oxide Unit 5 years after closure were simulated to be approximately 500 mg/L above background concentrations near the center of the PTF well field in model layers 7 through 10. The transport distances and areal distribution of sulfate within the Bedrock Oxide Unit layers are relatively limited, migrating only approximately 150 feet down-gradient along the trend of the more permeable Sidewinder fault zone.

14A.6.3 Particle Tracking

14A.7 Water Level Impacts of ISCR

Localized water level impact was defined as the change in simulated water levels at seven days after the end of PTF operations as a result of pumping within the PTF well field. Water level impacts were calculated by subtracting the simulated water levels of the PTF Pump Scenario from the simulated water levels of the No PTF Pump Scenario (agricultural pumping only) after 23 months of future PTF pumping. Water levels were allowed to recover for seven days following the 23 month pumping period. This analysis of impact reflects the relative water level change due to pumping at the PTF well field without bias from regional hydrologic declines or increases.

Pumping at the PTF well field was assumed to be a total of 60 gpm for a period of 14 months, and 260 gpm for a period of 9 months, distributed evenly the PTF well field. This pumping represents the planned over pumping necessary to maintain hydraulic control during PTF operations. To distribute the pumping evenly across the site, four extraction points were used that are not intended to represent production phases or operational conditions. The 43 extraction points represent an evenly spaced array that is used to distribute pumping evenly across the Site for the period of PTF operations. Simulated water levels after 23 months of pumping reflect residual water level impact that is less than 1 foot and less than the ability of the model to quantify, given that regional water levels fluctuate between 1 and 4 feet in response to recharge form the Gila River and agricultural groundwater pumping. Similar to the residual water level impacts simulated in the LBFU, water levels in the Bedrock Oxide Unit after 23 months of pumping are less than regional water level fluctuations induced by recharge irrigation pumping stresses, and are therefore indiscernible from background fluctuations.

14A.8 Impacts from Off-Site Pumping

This groundwater model was developed using site-specific and published regional geologic and hydrologic data. The groundwater model included the most up to date groundwater pumping data available from ADWR at the time of model development. ADWR is the official repository of groundwater data generated and reported throughout the State of Arizona. No other entity, public or private, maintains as thorough or current hydrologic datasets, including groundwater pumping datasets, for the State of Arizona.

As described above, groundwater pumping data used in the PTF Model were compiled by ADWR for the ongoing update of the Pinal AMA groundwater flow model and were provided by ADWR on a provisional basis for use in the PTF groundwater flow model. Pumping data from 1984 to 2006 were compiled by ADWR from SCIP reports and from the RoGR database. Pumping data after 2006 were compiled by Brown and Caldwell from the ADWR wells 55 database, specifically the pump-year dataset within that database. Future groundwater pumping conditions were simulated based on these historical records, and were projected into the future using annual stress periods.

Given that the most current groundwater pumping data available were used to develop the PTF groundwater flow model, the groundwater elevation impacts on the proposed PTF facility resulting from off-site pumping are already represented in the PTF groundwater model. Groundwater pumping represented in the PTF groundwater model was distributed at the locations identified by ADWR throughout the PTF model domain. ADWR assigned groundwater pumping to individual model cells where reporting wells were located. The finite-difference approximation assumes that all hydraulic parameters, stresses, and inputs are constant over the area of a single cell and over the time elapsed during a stress period. Likewise, calculated hydraulic head and groundwater fluxes, such as pumping, are also averaged over the areal extent of a single cell. Within the PTF groundwater model, cells sizes range from 500 feet by 500 feet at the model periphery to 12.5 feet by 12.5 feet in size at the PTF well field, in center of the model.

Pumping trends, both on and off site were projected for a period of 23 months, using stress periods of various lengths. Based on this simulation, off site pumping does not materially affect groundwater flow direction or gradients at the proposed PTF well field relative to current groundwater conditions, and will not materially affect PTF operations.

14A.9 References

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0 3,000 6,000

SCALE IN FEET

EXPLANATION

- MODEL EXTENT
- PTF WELL FIELD
- STATE MINERAL LEASE BOUNDARY
- CURIS PROPERTY BOUNDARY

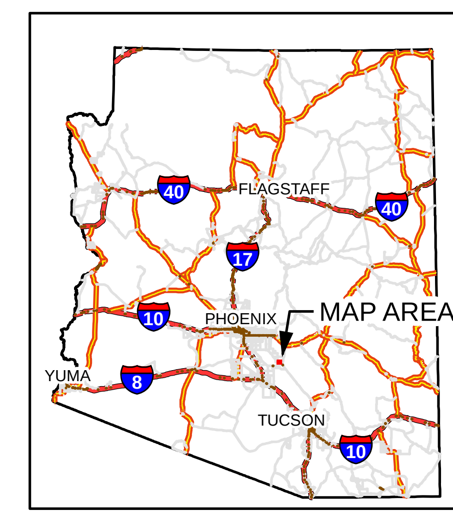

Figure 14A-1
LOCATION MAP

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

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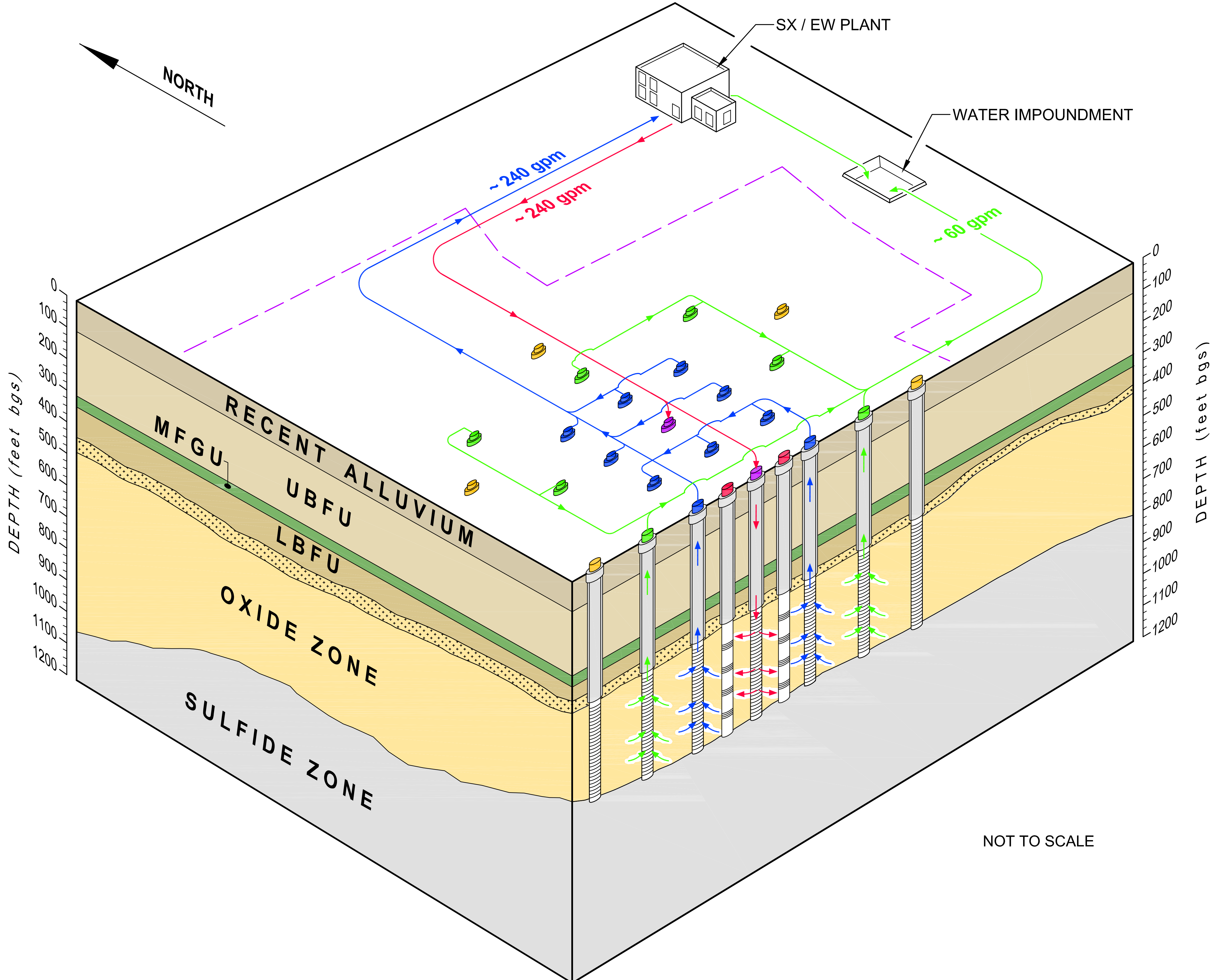

EXPLANATION

- RECOVERY WELL
- INJECTION WELL
- PERIMETER WELL
- OBSERVATION WELL
- WESTBAY WELL
- CEMENT SEAL
- 40-FOOT OXIDE EXCLUSION ZONE
- ISCR BOUNDARY

NOTE: A TOTAL OF FOUR WESTBAY WELLS ARE TO BE USED DURING PTF ISCR ACTIVITIES TO STUDY FORMATION CHEMISTRY. NO WESTBAY WELLS ARE PLANNED FOR USE DURING LATER PHASES OF ISCR ACTIVITIES.

NOT TO SCALE

HDI CURIS

Figure 14A-2

BLOCK DIAGRAM SHOWING TYPICAL PTF WELLS

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

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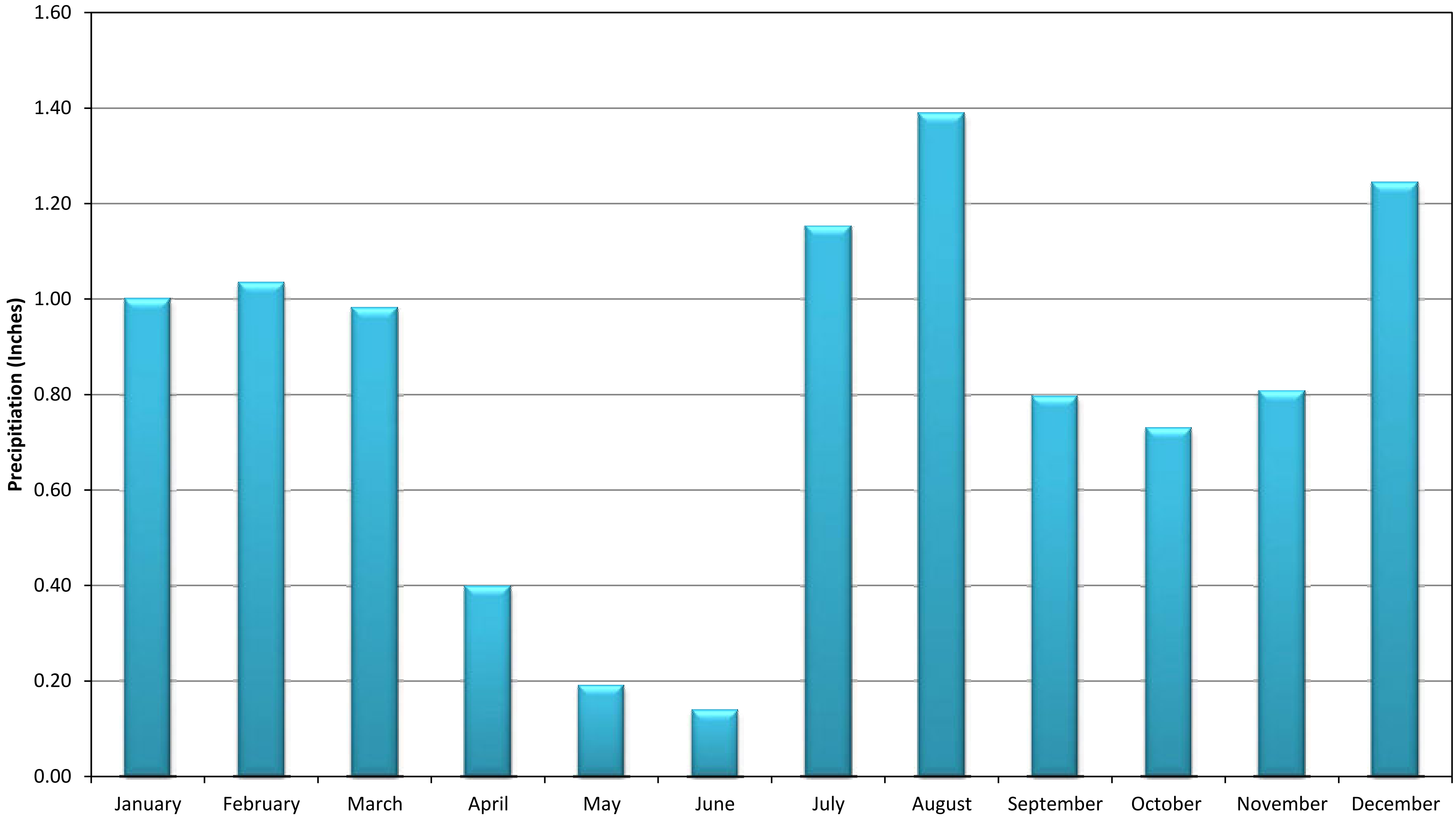
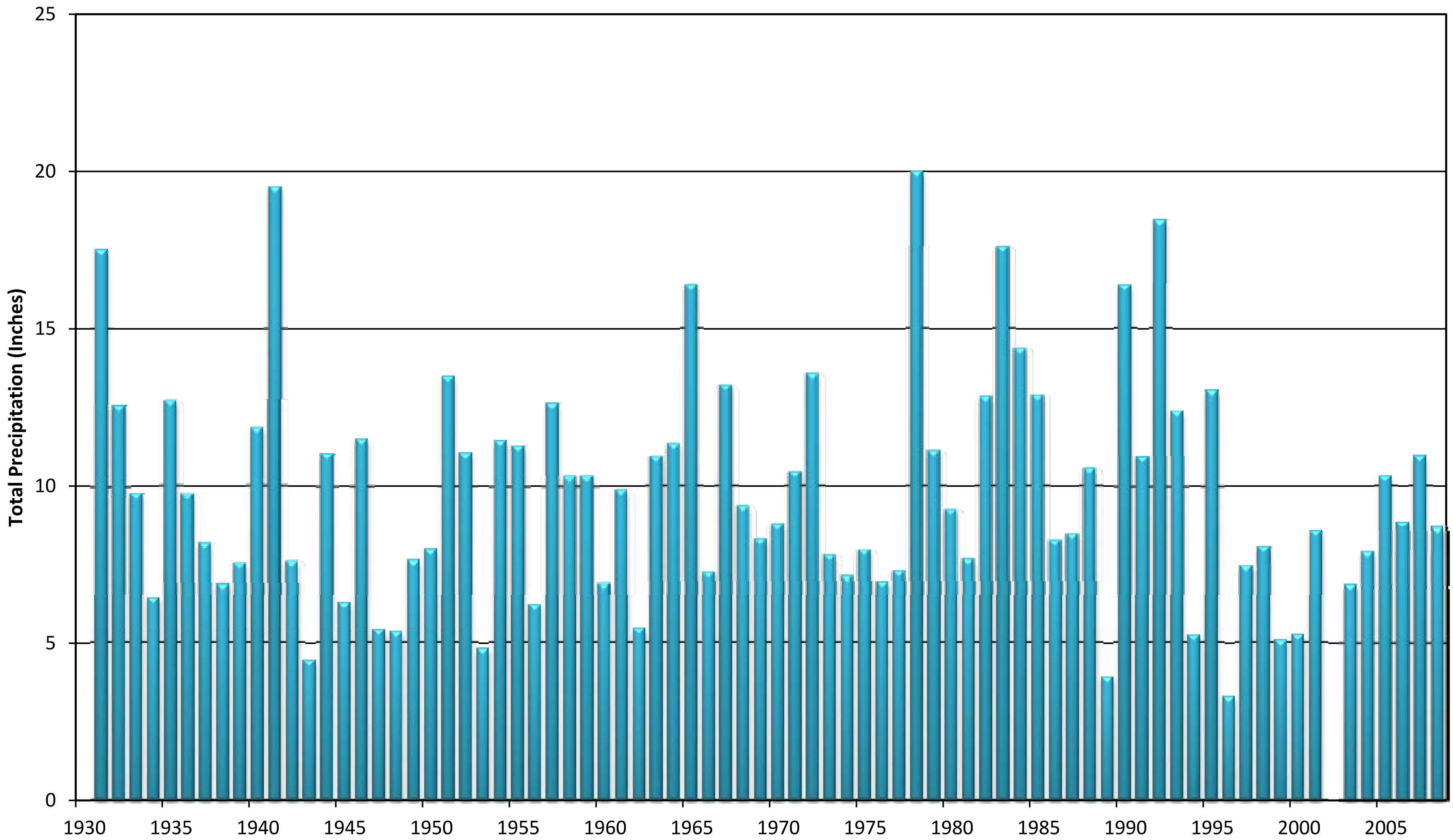


Average Precipitation Values based on 30 year record 1978-2008
NOAA, 2010

Brown AND Caldwell

Figure 14A-3
Mean Monthly Precipitation
Florence, Arizona

Curis Resources (Arizona) Inc.
Florence, Arizona



Brown AND Caldwell

NOAA, 2010
Cooperative Station ID 023027
For the year 2002, the record is missing nine months of data

Figure 14A-4
Total Annual Precipitation
Florence, Arizona

Curis Resources (Arizona) Inc.
Florence, Arizona

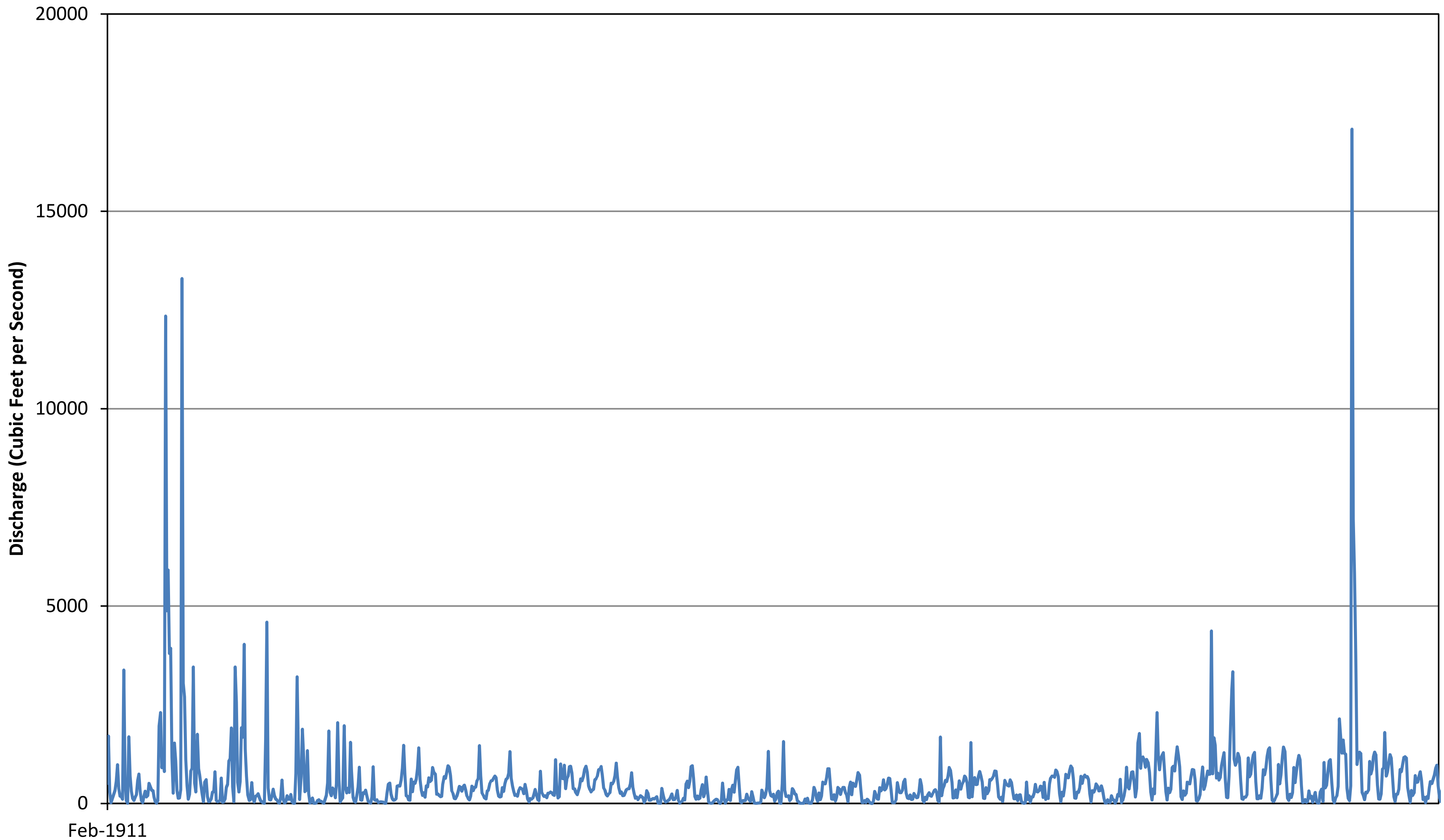


Figure 14A-5
Monthly Mean Gila River Stage Values
Kelvin, Az

Brown AND Caldwell

Curis Resources (Arizona) Inc.
Florence, Arizona

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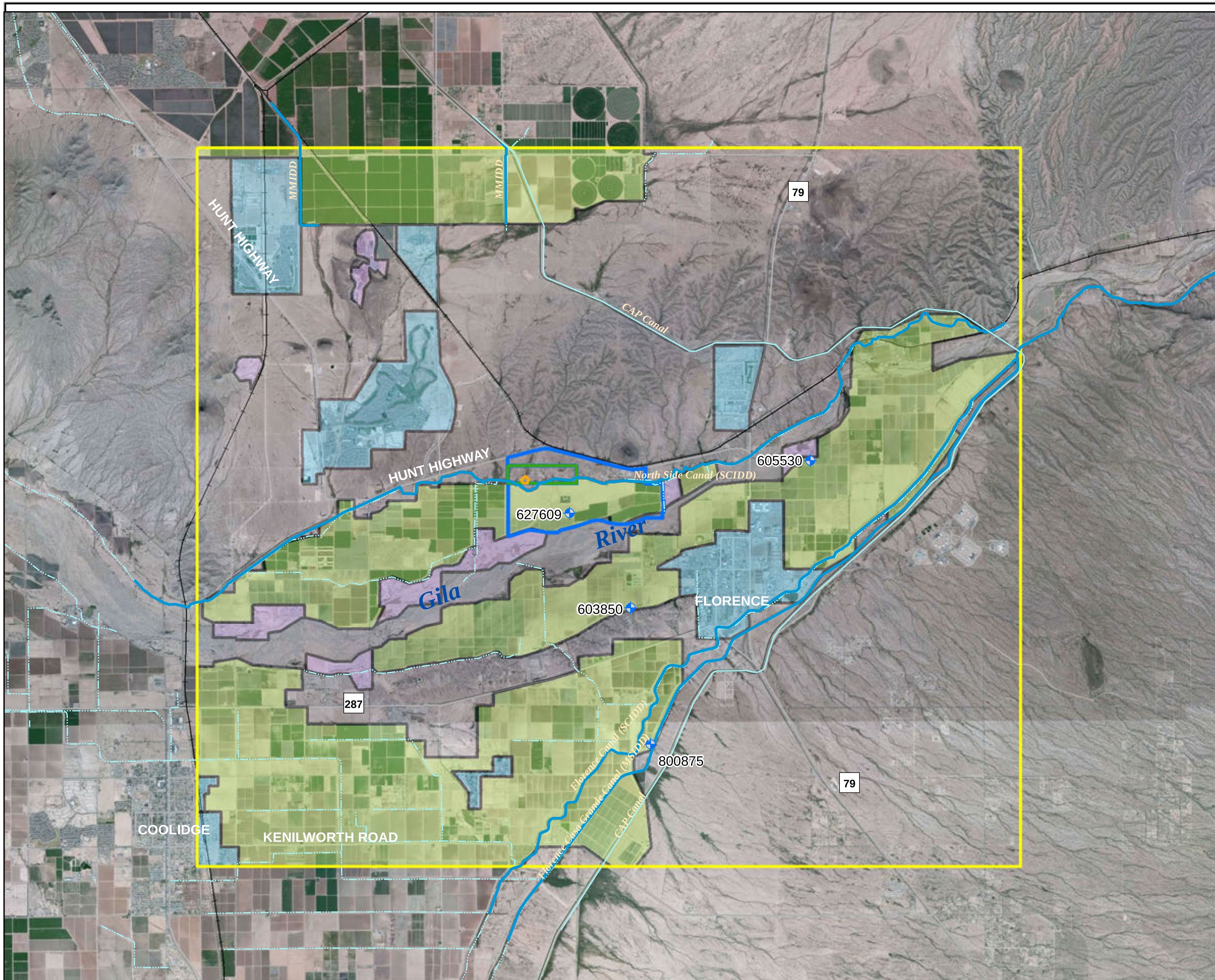

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SCALE IN FEET

EXPLANATION

- KEY WELLS
- CANAL
- MODEL EXTENT
- PTF WELL FIELD
- STATE MINERAL LEASE BOUNDARY
- CURIS PROPERTY BOUNDARY

LAND USE

- Agriculture
- Industrial
- Urban

Figure 14A-6
LAND USE AND
KEY WELLS

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

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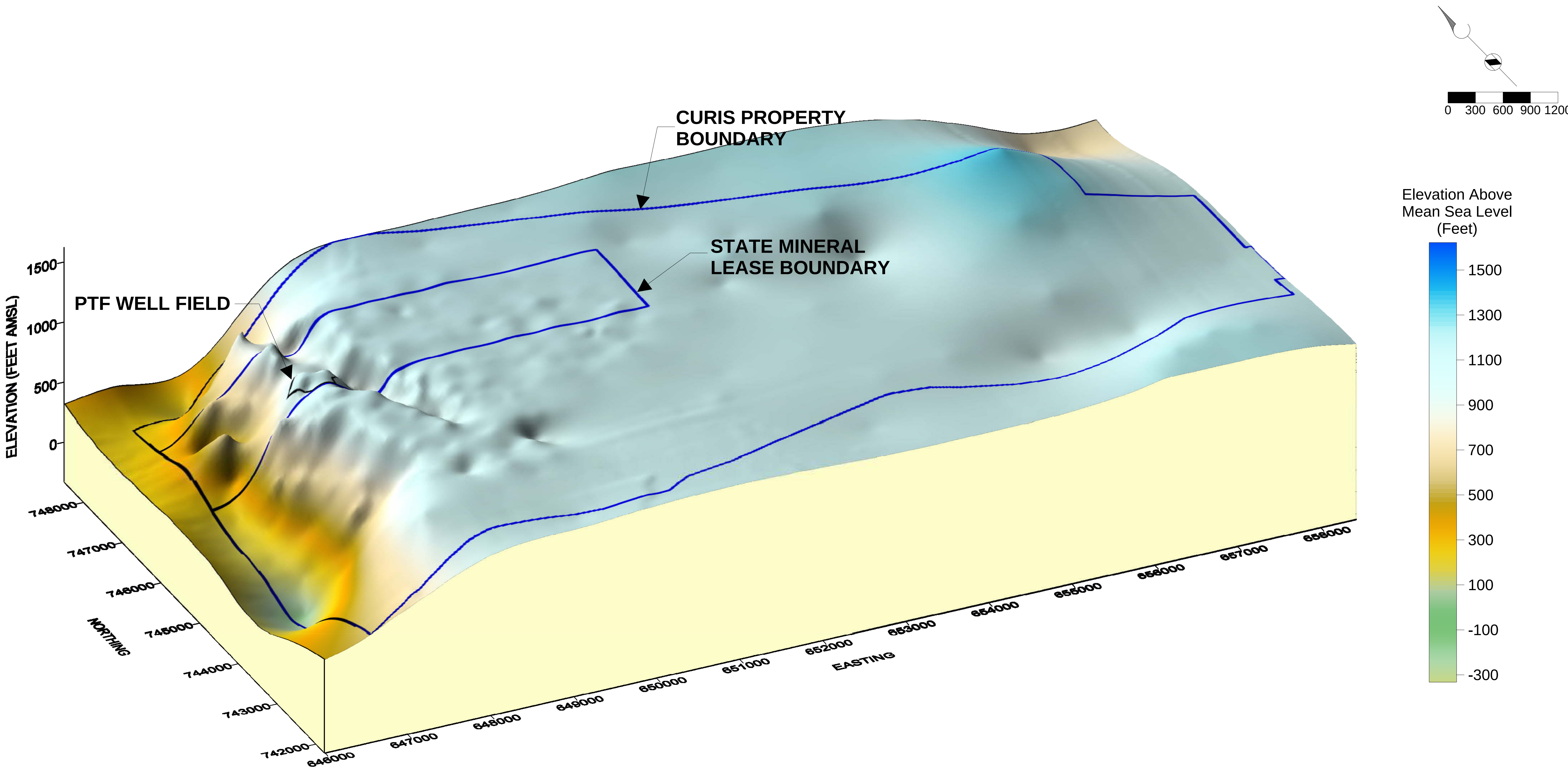

HDI CURIS

Brown AND Caldwell

Figure 14A-7
BEDROCK TOPOGRAPHY

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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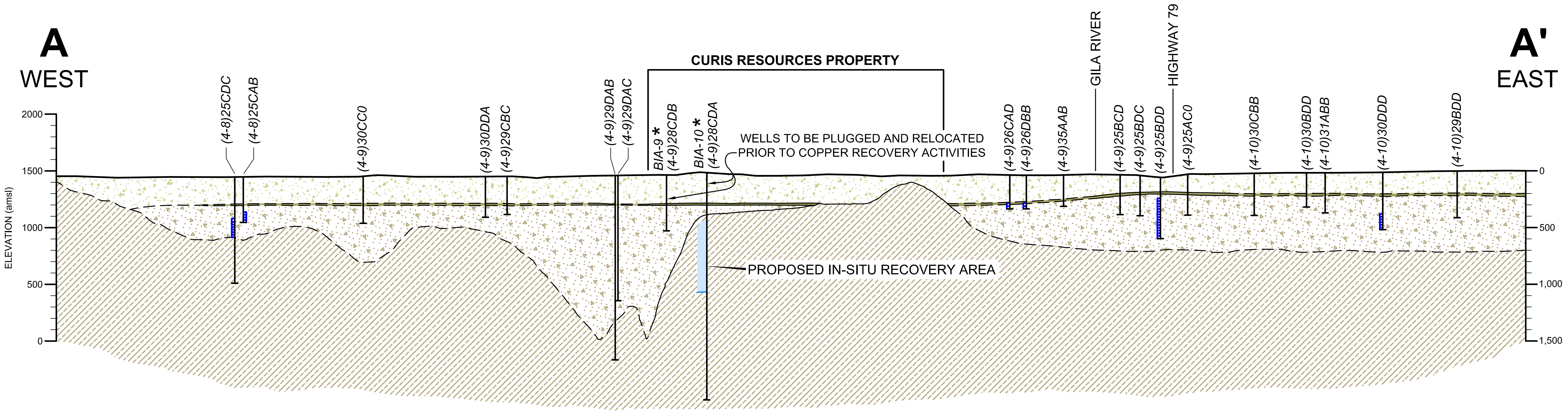

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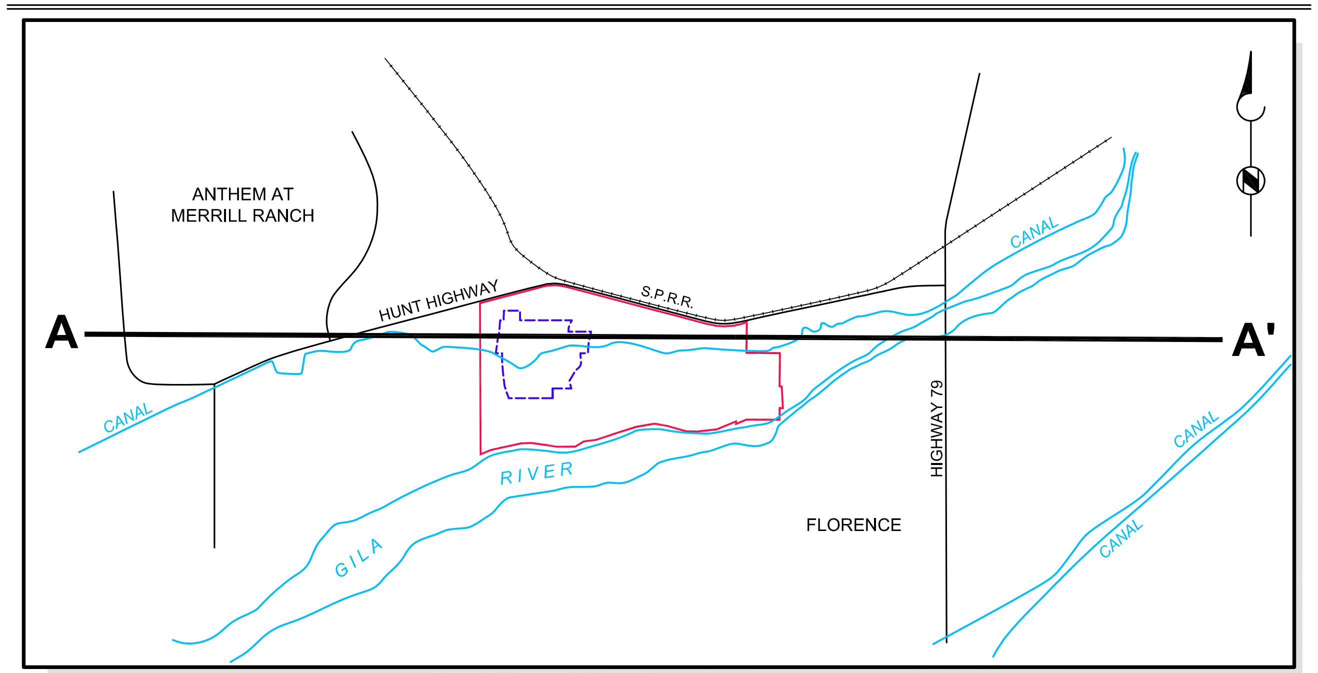

EXPLANATION

UPPER BASIN FILL ALLUVIAL UNIT

MIDDLE FINE-GRAINED UNIT

LOWER BASIN FILL ALLUVIAL UNIT

BEDROCK

APPROXIMATE WELL LOCATION
(GENERALLY PROJECTED ONTO CROSS-SECTION)

SCREENED INTERVAL (WHERE DATA IS AVAILABLE)

TOTAL DEPTH OF BOREHOLE

NOTES: BEDROCK SURFACE CONTOURS COMPILED BY BROWN AND CALDWELL FROM EXISTING WATER WELL LOGS, EXPLORATORY CORE LOGS AND REGIONAL GRAVITY SURVEYS (MAGMA COPPER COMPANY APP APPLICATION, VOLUME II FIGURES 3.4-2 (II) AND 3.4-3 (II), 1996).

* WELLS BIA-9 AND BIA-10 (LOCATED IN THE PROPOSED IN-SITU RECOVERY AREA) WILL BE PLUGGED AND RELOCATED PRIOR TO INITIATING COPPER RECOVERY ACTIVITIES.

UNIT CONTACTS DASHED WHERE INFERRED

HORIZONTAL SCALE: 1" = 4,000'
VERTICAL SCALE: 1" = 1,000'
4X VERTICAL EXAGGERATION

Brown AND Caldwell

HDI CURIS

Figure 14A-8

GENERALIZED REGIONAL GEOLOGIC CROSS-SECTION A-A'

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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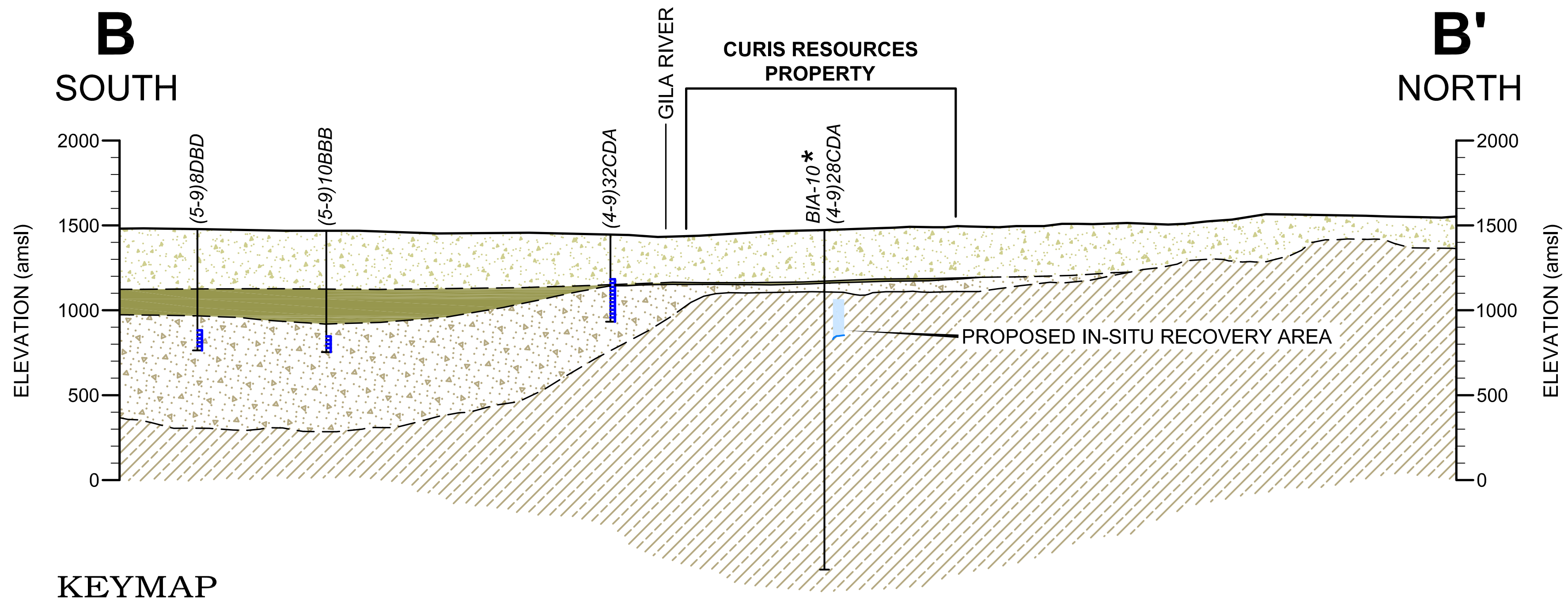
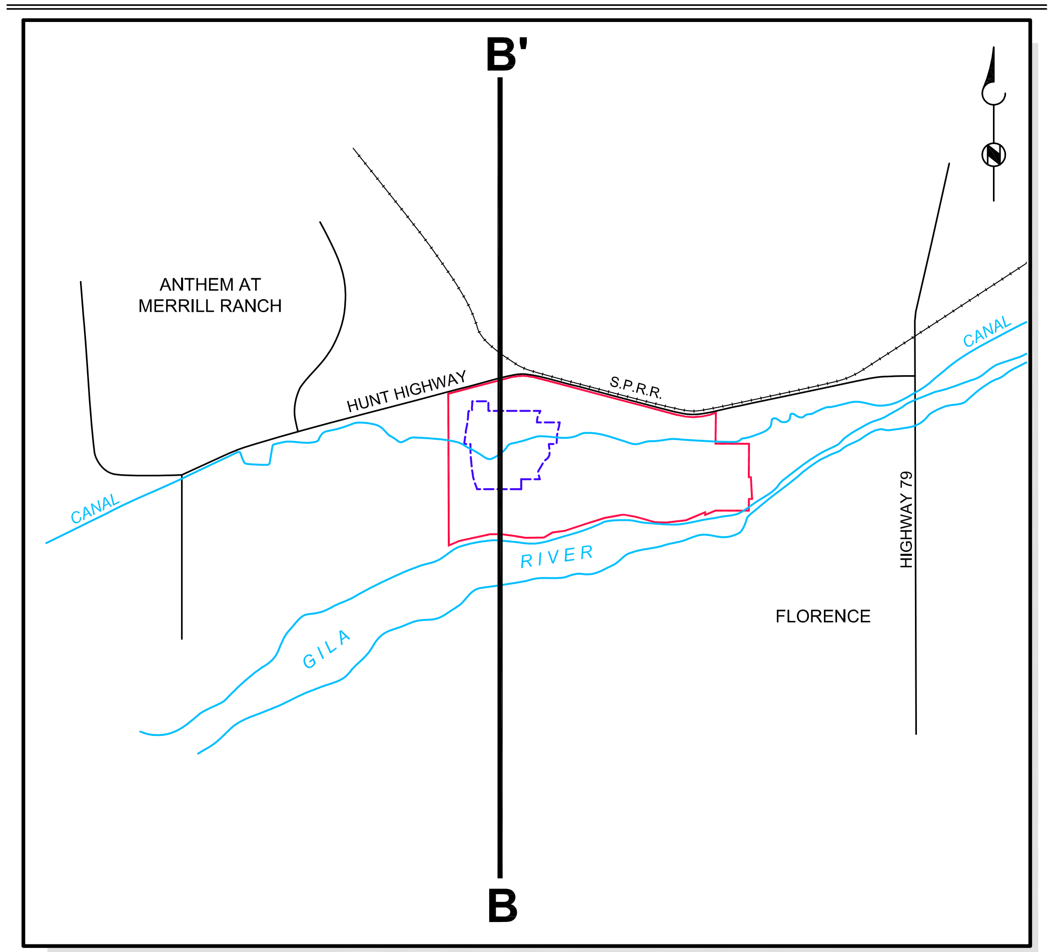


KEYMAP



EXPLANATION

UPPER BASIN FILL ALLUVIAL UNITS

MIDDLE FINE-GRAINED UNIT

LOWER BASIN FILL ALLUVIAL UNIT

BEDROCK

APPROXIMATE WELL LOCATION
(GENERALLY PROJECTED ONTO CROSS-SECTION)

SCREENED INTERVAL (WHERE DATA IS AVAILABLE)

TOTAL DEPTH OF BOREHOLE

NOTES: BEDROCK SURFACE CONTOURS COMPILED BY BROWN AND CALDWELL FROM EXISTING WATER WELL LOGS, EXPLORATORY CORE LOGS AND REGIONAL GRAVITY SURVEYS (MAGMA COPPER COMPANY APP APPLICATION, VOLUME II FIGURES 3.4-2 (II) AND 3.4-3 (II), 1996).

* WELL BIA-10 (LOCATED IN THE PROPOSED IN-SITU RECOVERY AREA) WILL BE PLUGGED AND RELOCATED PRIOR TO INITIATING COPPER RECOVERY ACTIVITIES.

MIDDLE FINE-GRAINED UNIT SHOWN AT WELLS (5-9)8DBD, (5-9)10BBB AND (4-9)32CDA ESTIMATED FROM ADWR WELL REPORTS.

UNIT CONTACTS DASHED WHERE INFERRED.

HORIZONTAL SCALE: 1" = 4,000'
VERTICAL SCALE: 1" = 1,000'

4X VERTICAL EXAGGERATION

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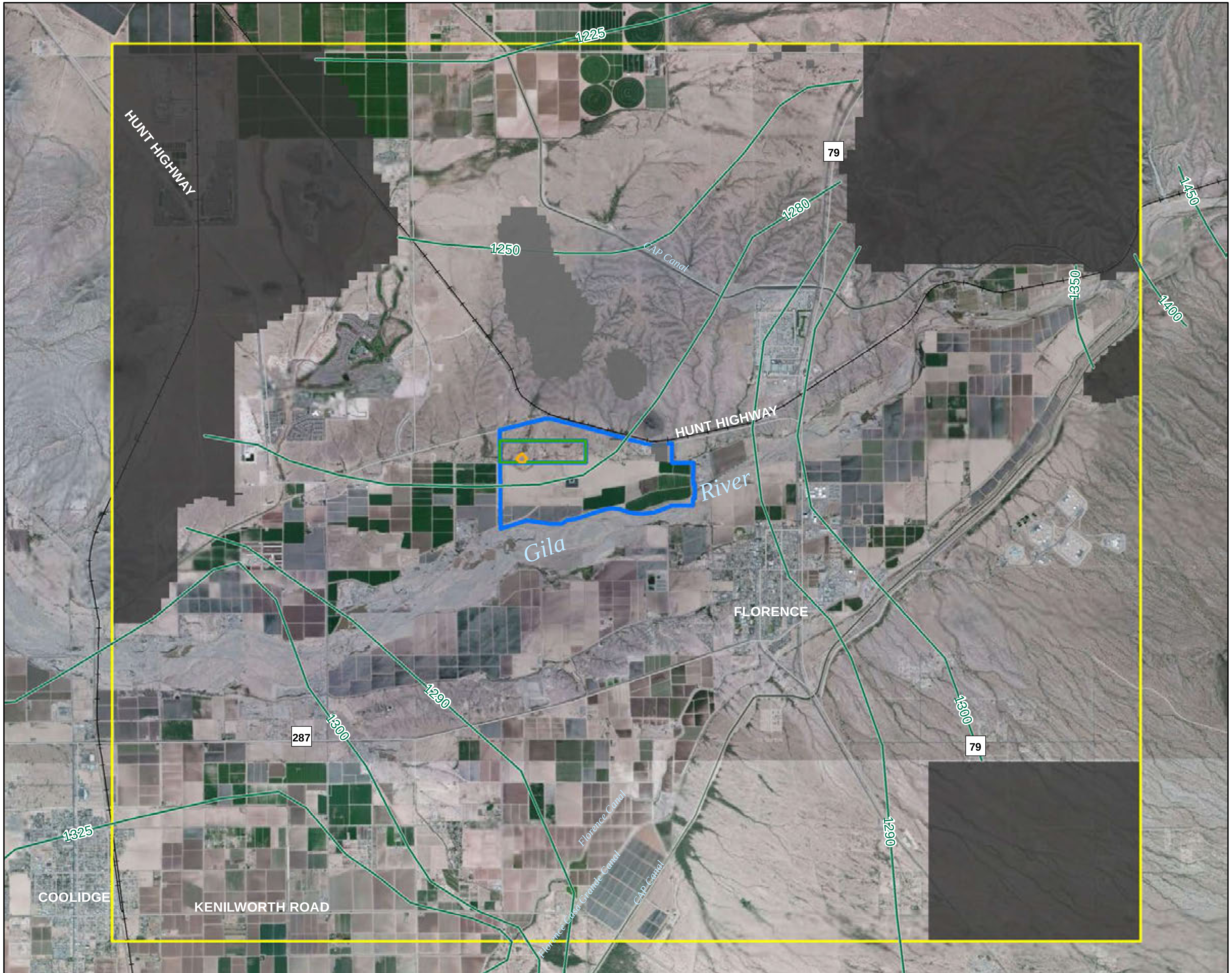
Figure 14A-9

GENERALIZED REGIONAL GEOLOGIC CROSS-SECTION B-B'

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA



0 3,000 6,000

SCALE IN FEET

EXPLANATION

- DRY CELLS
- GROUNDWATER ELEVATION CONTOUR
- MODEL EXTENT
- PTF WELL FIELD
- NO FLOW CELLS
- STATE MINERAL LEASE BOUNDARY
- CURIS PROPERTY BOUNDARY

Figure 14A-10
MEASURED GROUNDWATER ELEVATIONS
2008

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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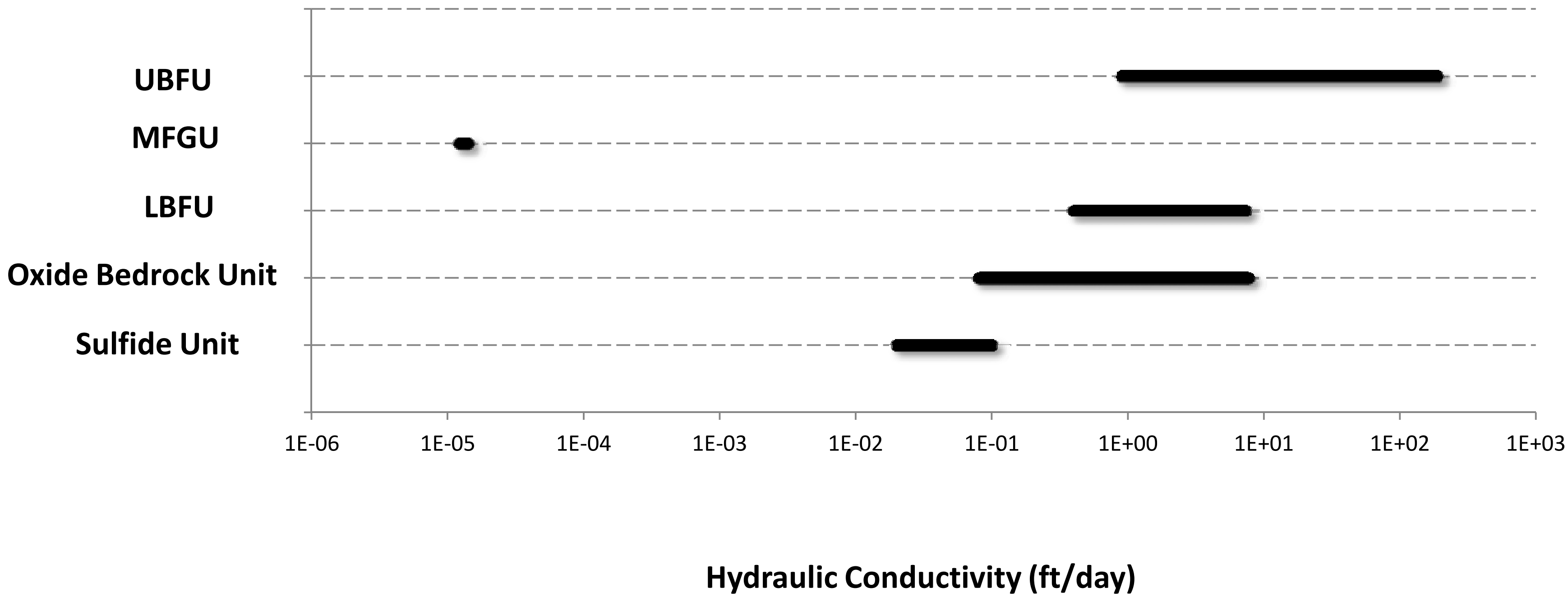
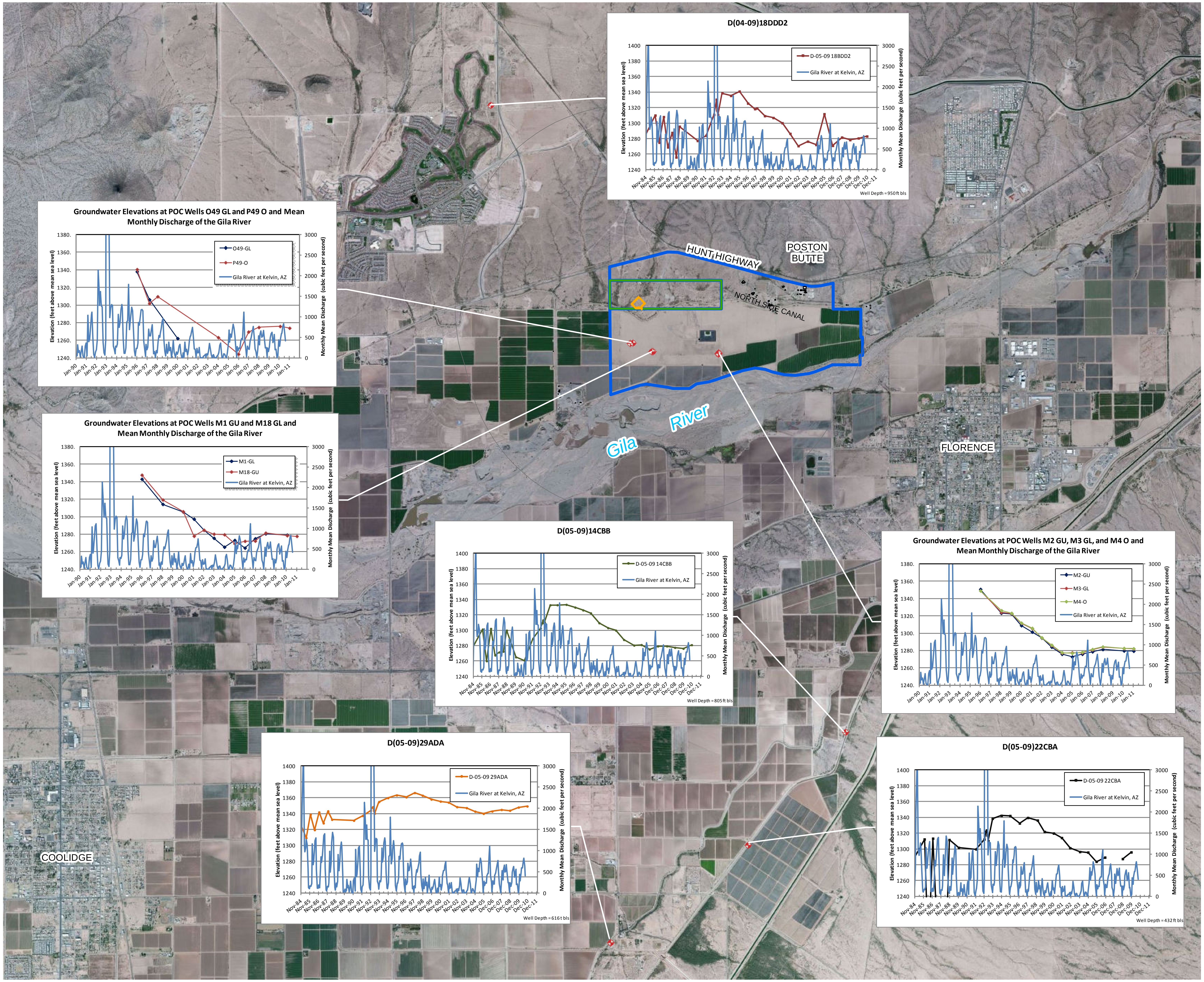


Brown AND Caldwell

FIGURE 14A-11
HYDRAULIC CONDUCTIVITY
OF BASIN FILL AND BEDROCK UNITS
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

J:\Hunter Dickinson\138799 - Curis Florence Copper Permitting\Working\Significant Amendment\Figures\Figure 14A-11.xlsx



0 1,500 3,000

SCALE IN FEET

EXPLANATION

- HYDROGRAPH WELL
- PTF WELL FIELD
- STATE MINERAL LEASE BOUNDARY
- CURIS PROPERTY BOUNDARY

Groundwater elevation data for wells D(04-09)18DDD2, D(04-09)14CBB, and D(05-09)22CBA obtained from ADWR GWSI database, October 2011.

Groundwater elevation data for wells M1-GL, M18-GU, M2-GU, M3-GL, M4-O, O49-GL AND P49-GL were obtained from Curis Arizona project files.

Gila River discharge data obtained from the USGS October 2011.

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Figure 14A-12
WELL HYDROGRAPHS
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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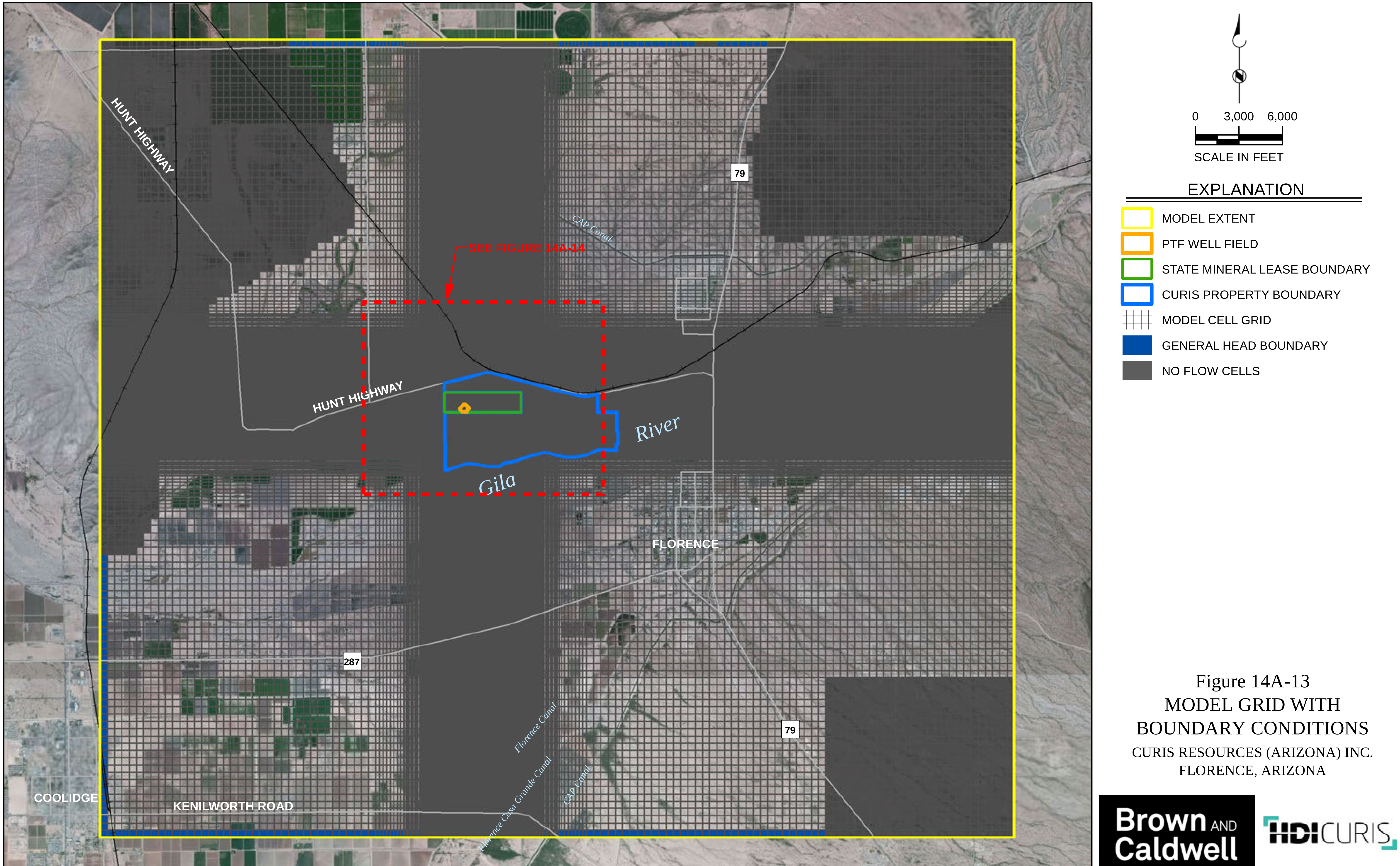

Figure 14A-13
MODEL GRID WITH
BOUNDARY CONDITIONS

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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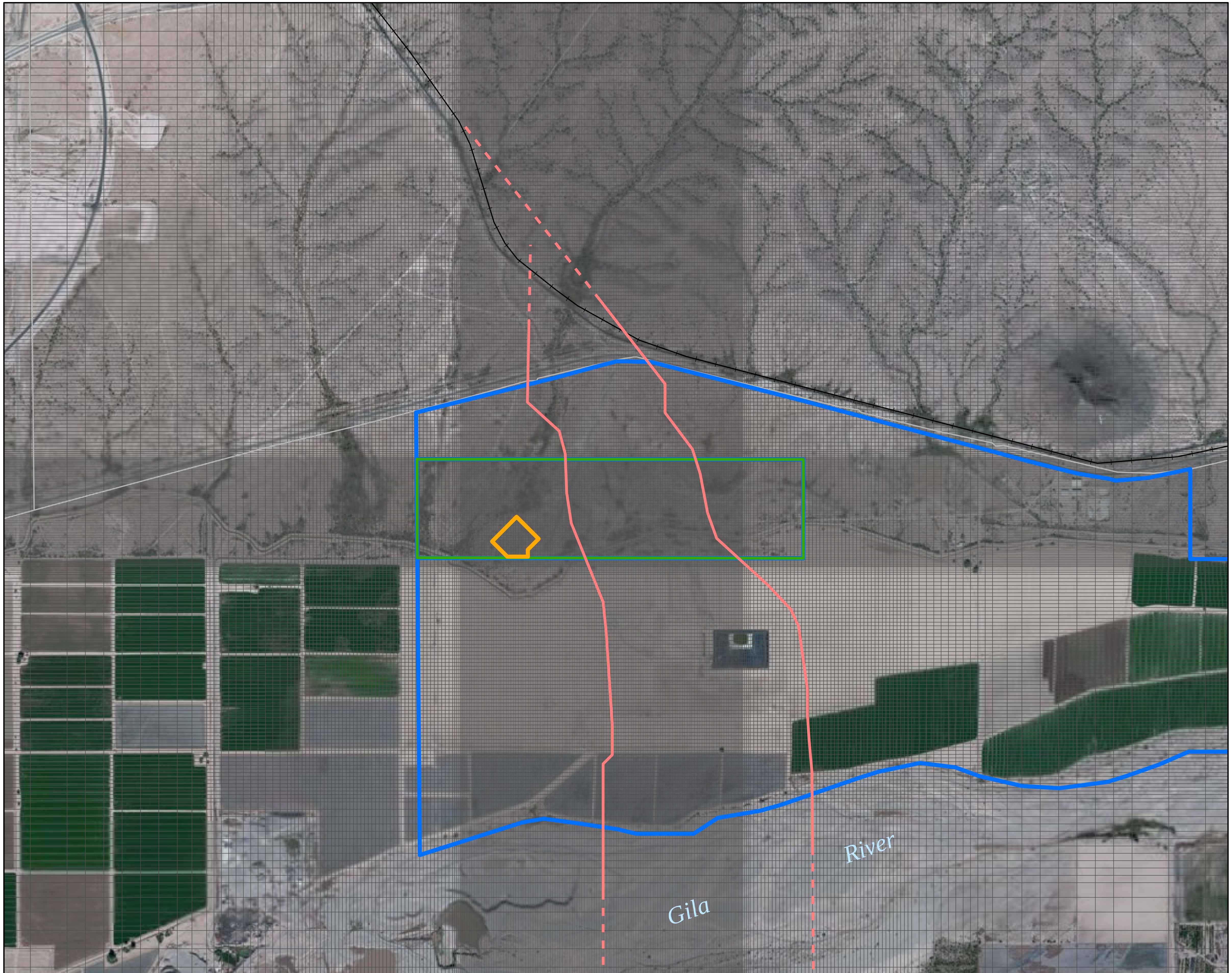

0 750 1,500

SCALE IN FEET

EXPLANATION

- FAULT TRACE
- INFERRED FAULT TRACE
- PTF WELL FIELD
- STATE MINERAL LEASE BOUNDARY
- CURIS PROPERTY BOUNDARY

Figure 14A-14
REFINED MODEL GRID

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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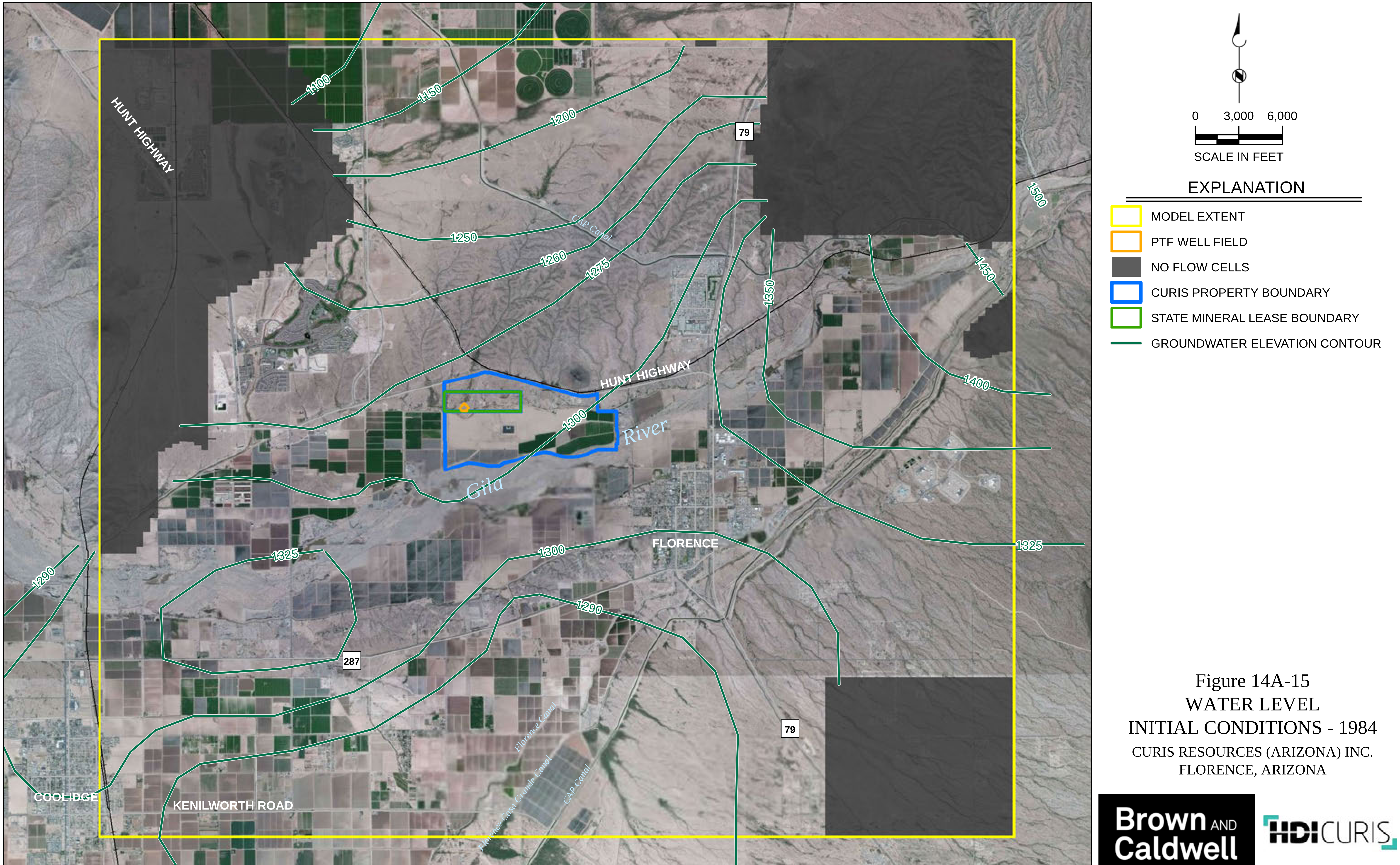

Figure 14A-15
WATER LEVEL
INITIAL CONDITIONS - 1984
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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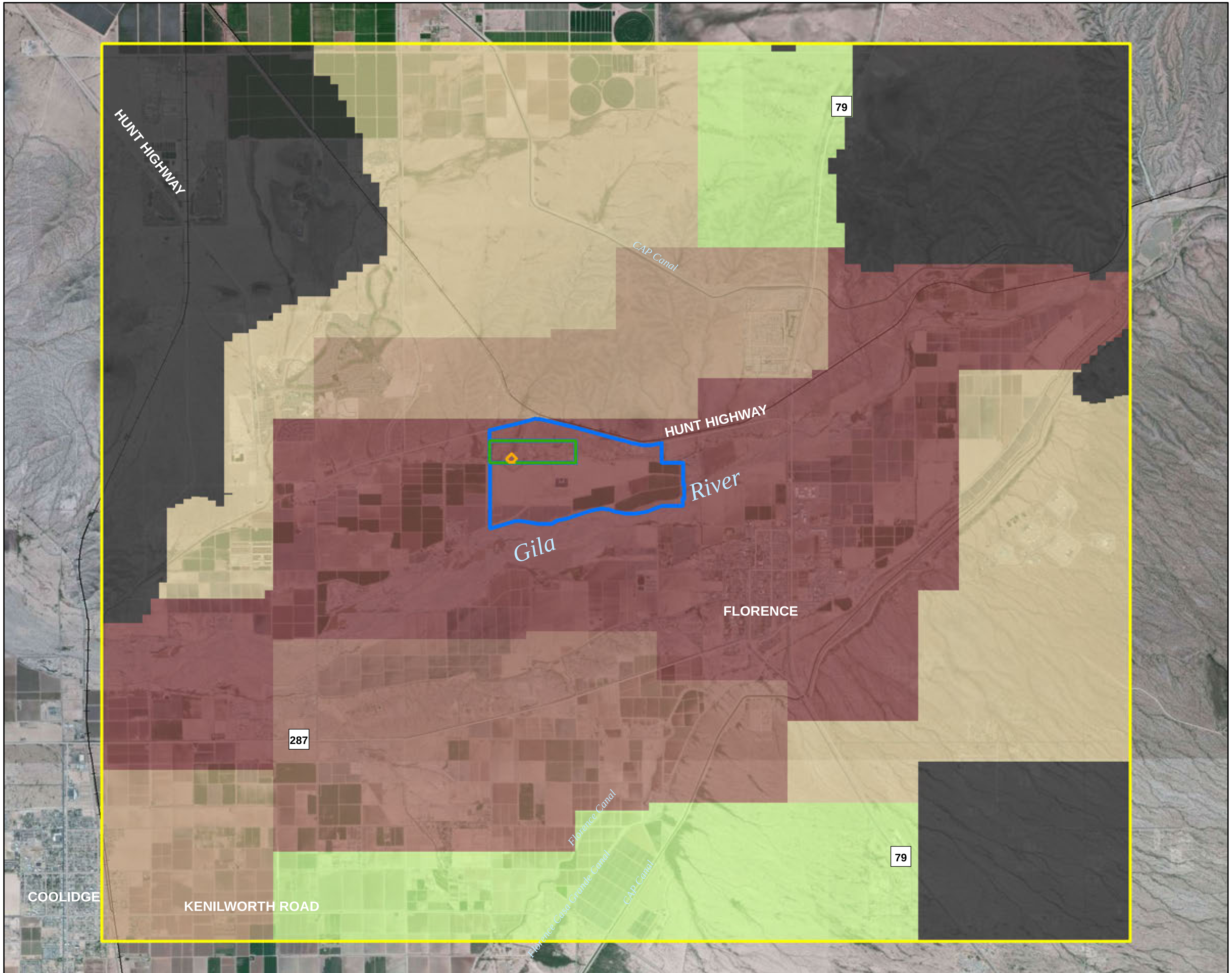
\\BCPHX03\projects\Hunter Dickinson\Curis GIS\MXDs\Temp Permit2012\G14075334014A15.mxd Updated: 1/27/2012



0 3,000 6,000

SCALE IN FEET

EXPLANATION

- MODEL EXTENT
- PTF WELL FIELD
- NO FLOW CELLS
- STATE MINERAL LEASE BOUNDARY
- CURIS PROPERTY BOUNDARY

HYDRAULIC CONDUCTIVITY (ft/day)

- 0.1
- 0.57
- 1
- 2.51
- 5
- 10
- 15
- 20
- 25
- 30
- 80
- 100
- 130

Figure 14A-16
HYDRAULIC CONDUCTIVITY
MODEL LAYER 1

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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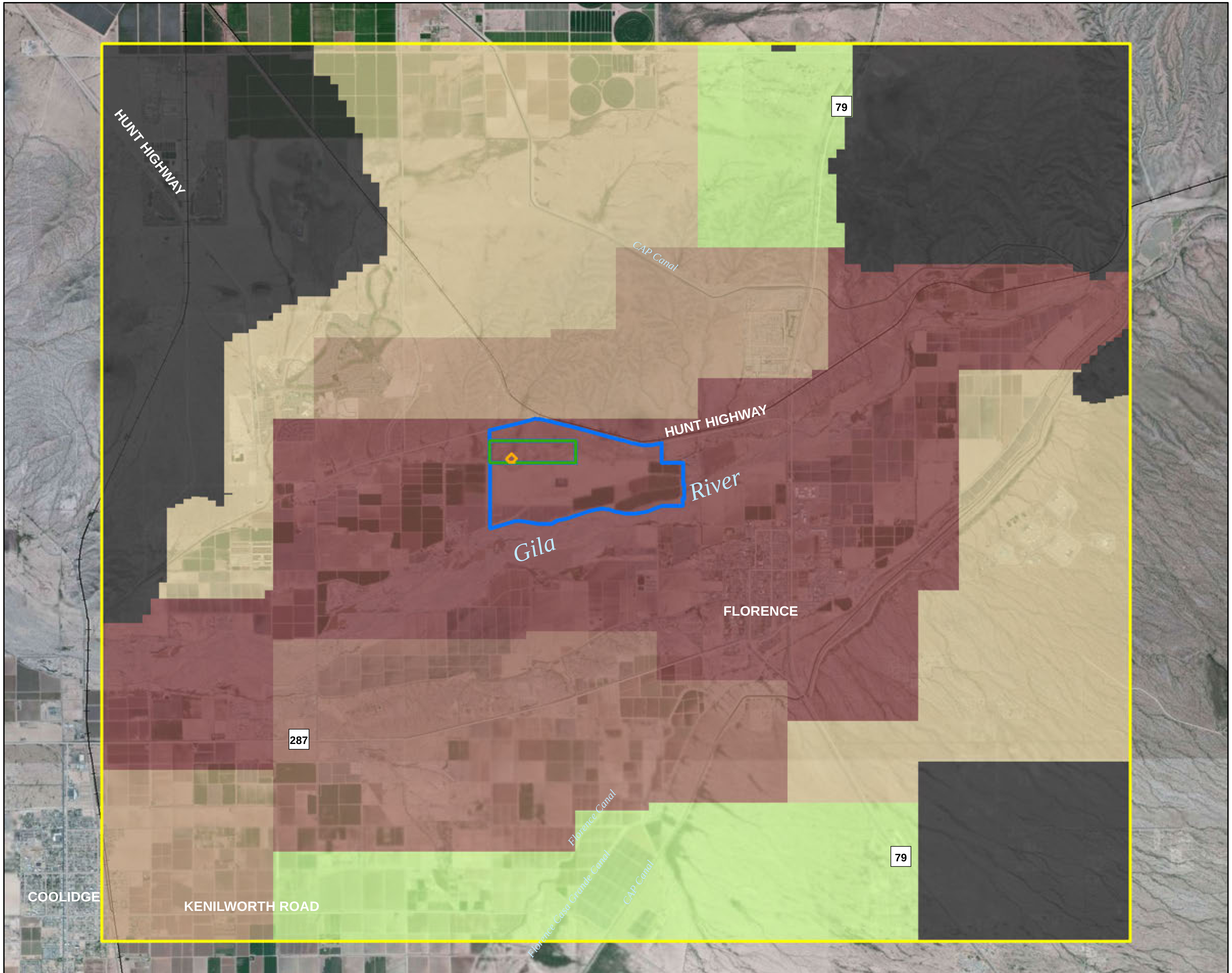

0 3,000 6,000
SCALE IN FEET

EXPLANATION

- MODEL EXTENT
- PTF WELL FIELD
- NO FLOW CELLS
- STATE MINERAL LEASE BOUNDARY
- CURIS PROPERTY BOUNDARY

HYDRAULIC CONDUCTIVITY (ft/day)

- 0.1
- 0.57
- 1
- 2.51
- 5
- 10
- 15
- 20
- 25
- 30
- 80
- 100
- 130

Figure 14A-17
HYDRAULIC CONDUCTIVITY
MODEL LAYER 2

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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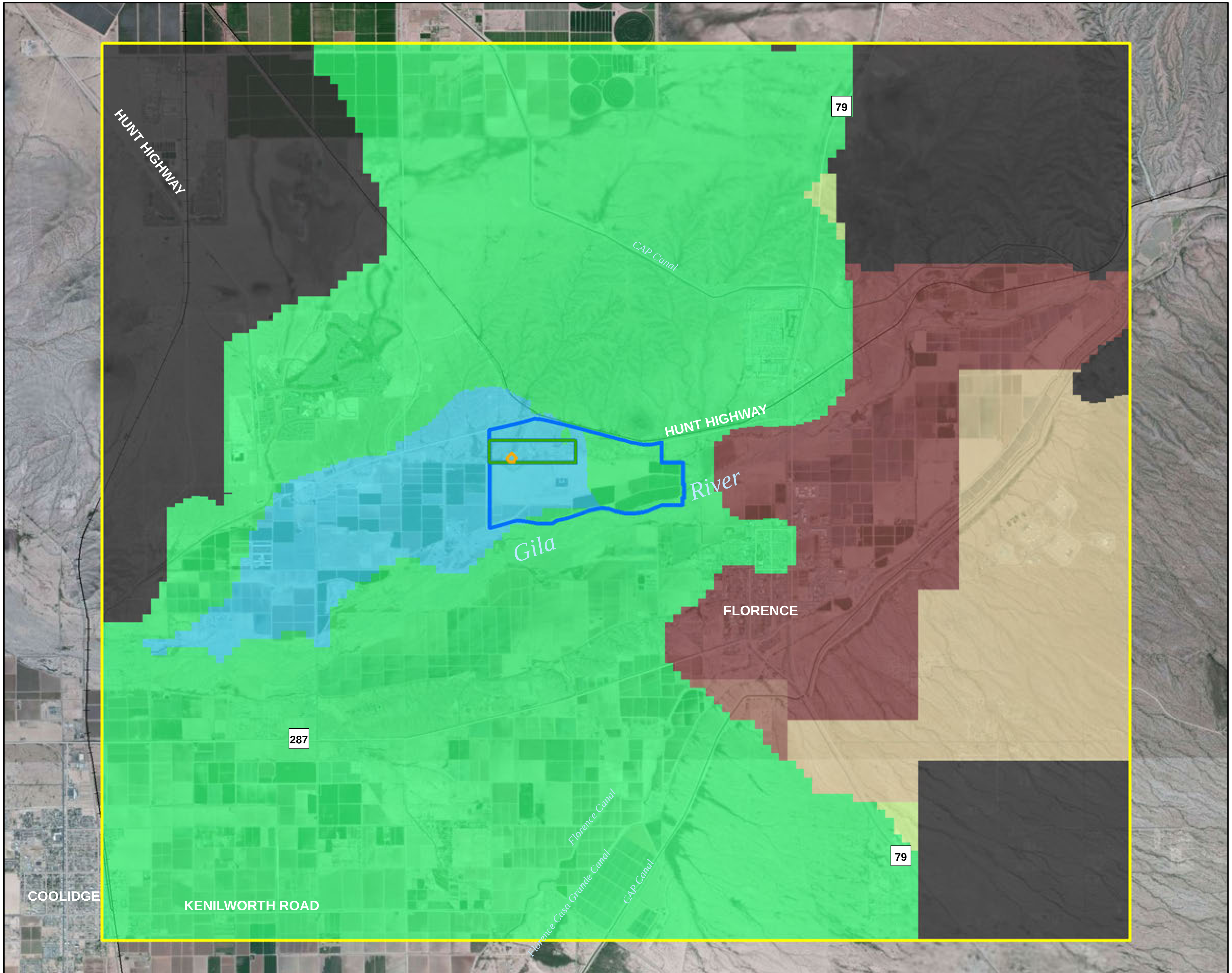
\\BCPHX03\projects\Hunter Dickinson\Curis GIS\MXDs\Temp Permit2012\G14075334014A16.mxd Updated: 1/27/2012



0 3,000 6,000

SCALE IN FEET

EXPLANATION

- MODEL EXTENT
- PTF WELL FIELD
- NO FLOW CELLS
- STATE MINERAL LEASE BOUNDARY
- CURIS PROPERTY BOUNDARY

HYDRAULIC CONDUCTIVITY (ft/day)

- 0.1
- 0.57
- 1
- 2.51
- 5
- 10
- 15
- 20
- 25
- 30
- 80
- 100
- 130

Figure 14A-18
HYDRAULIC CONDUCTIVITY
MODEL LAYER 3

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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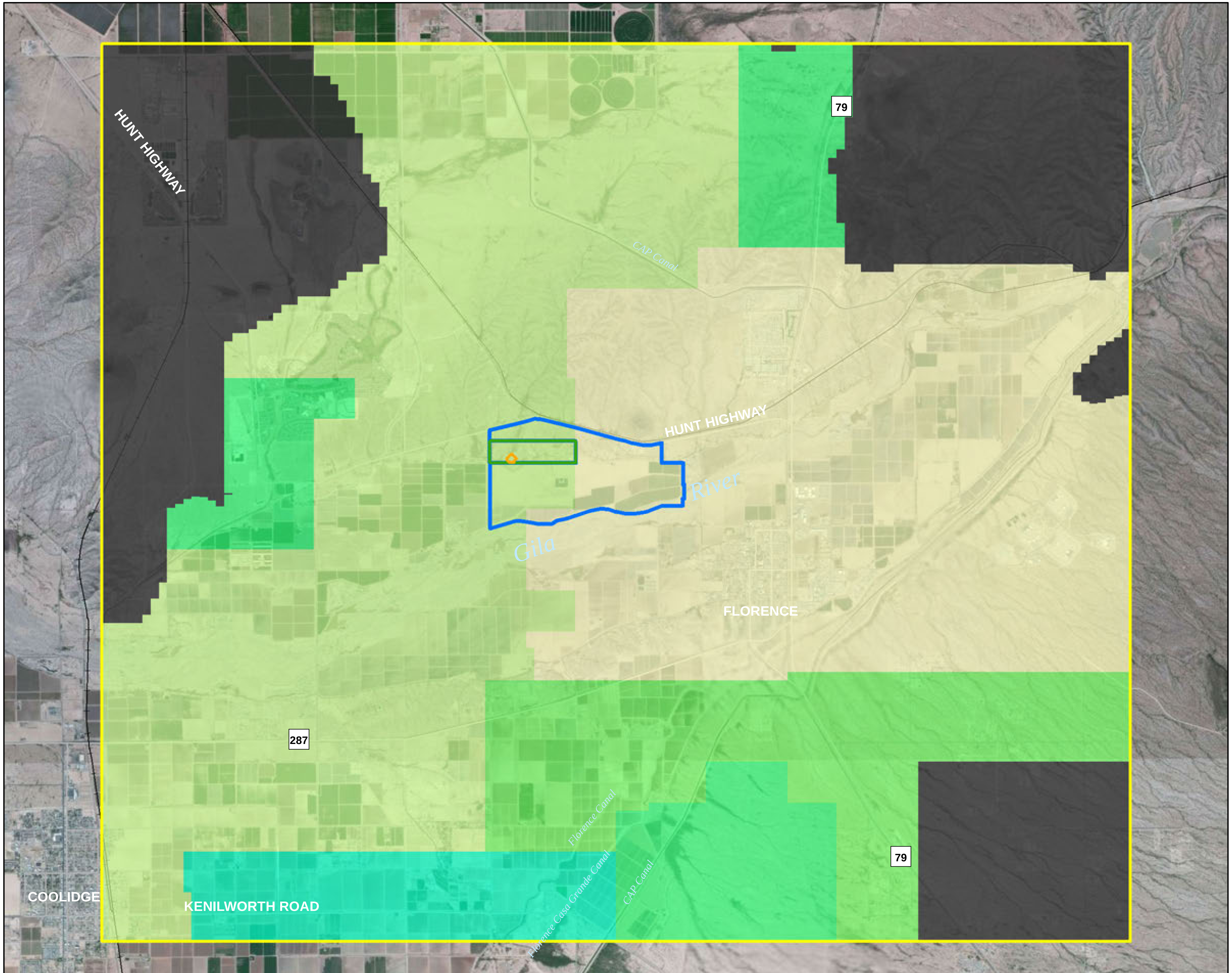
\\BCPHX03\projects\Hunter Dickinson\Curis GIS\MXDs\Temp Permit2012\G14075334014A16.mxd Updated: 1/27/2012



0 3,000 6,000

SCALE IN FEET

EXPLANATION

- MODEL EXTENT
- PTF WELL FIELD
- NO FLOW CELLS
- STATE MINERAL LEASE BOUNDARY
- CURIS PROPERTY BOUNDARY

HYDRAULIC CONDUCTIVITY (ft/day)

- 0.1
- 0.57
- 1
- 2.51
- 5
- 10
- 15
- 20
- 25
- 30
- 80
- 100
- 130

Figure 14A-19
HYDRAULIC CONDUCTIVITY
MODEL LAYER 4

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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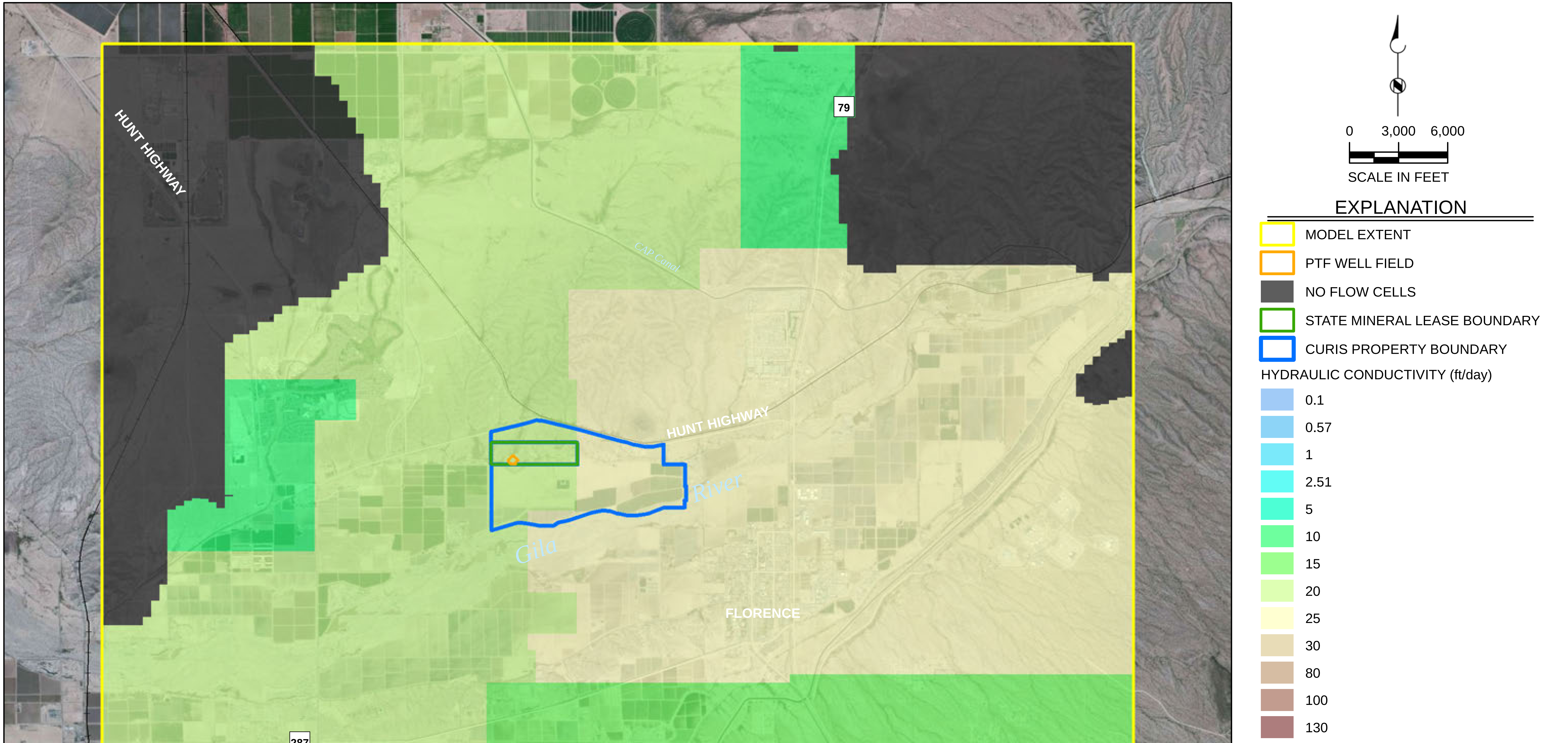

Figure 14A-20
HYDRAULIC CONDUCTIVITY
MODEL LAYER 5

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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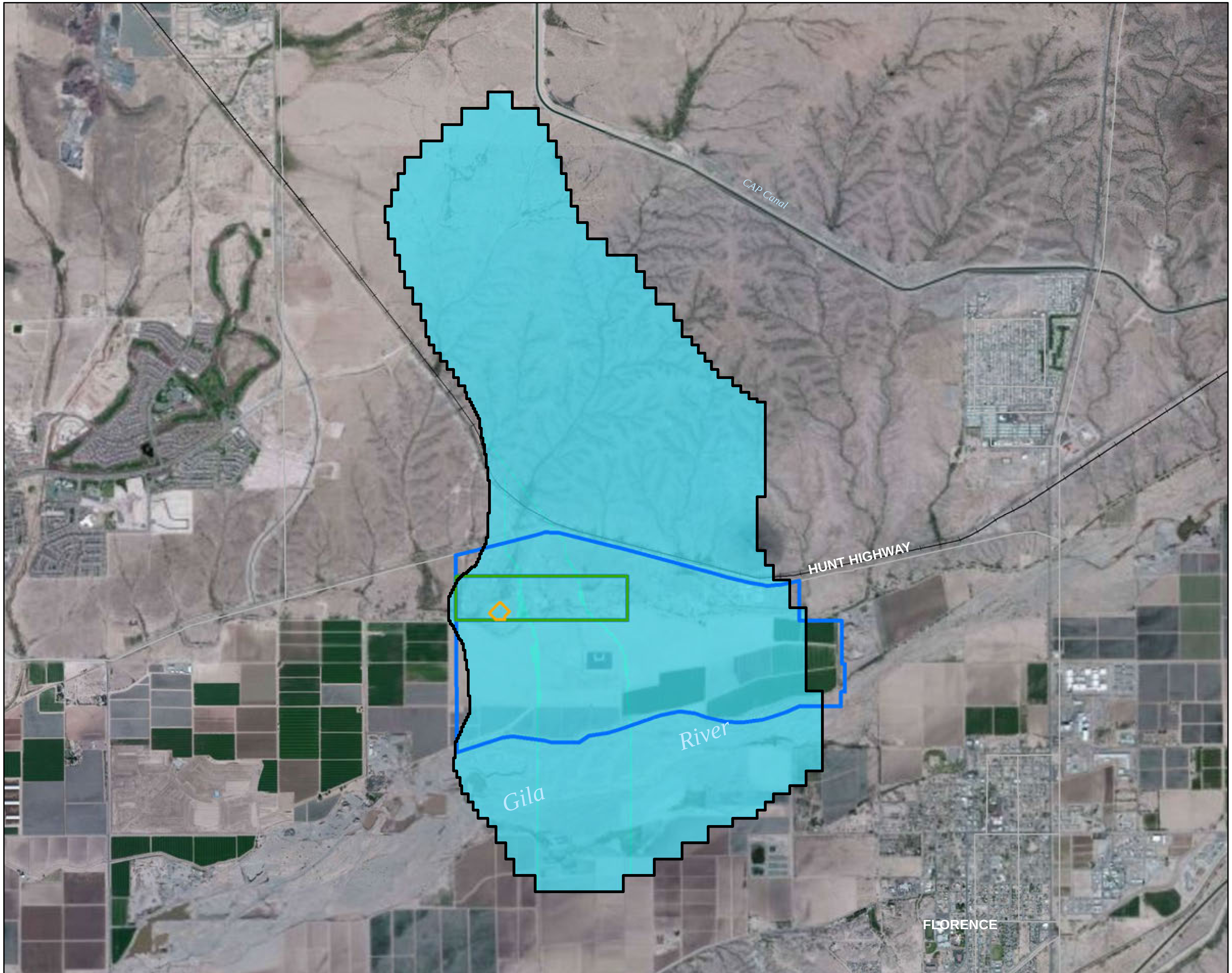

Figure 14A-21
HYDRAULIC CONDUCTIVITY
MODEL LAYER 6

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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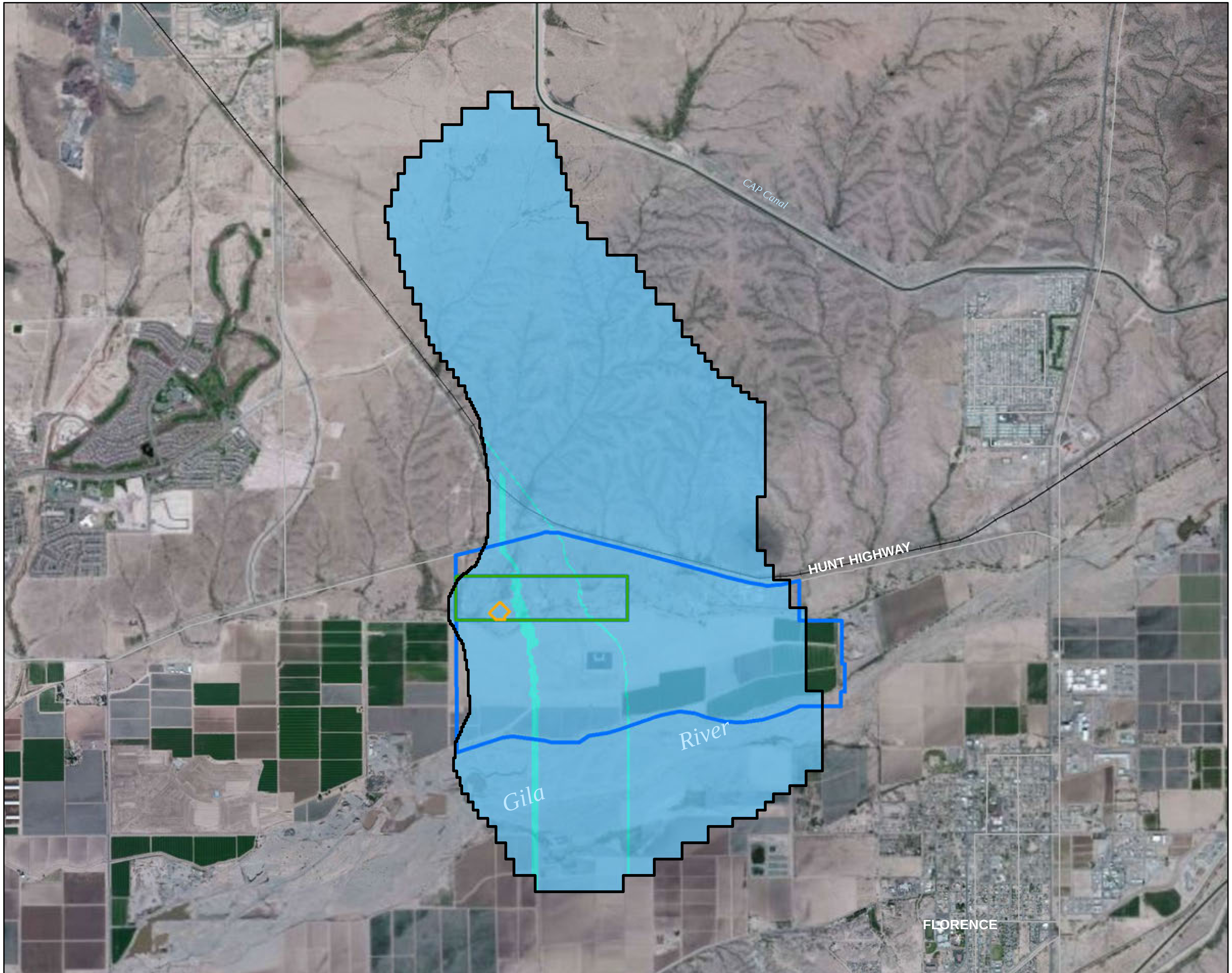

0 1,500 3,000
SCALE IN FEET

EXPLANATION

- ACTIVE AREA
- MODEL EXTENT
- PTF WELL FIELD
- STATE MINERAL LEASE BOUNDARY
- CURIS PROPERTY BOUNDARY

HYDRAULIC CONDUCTIVITY (ft/day)

- 0.1
- 0.57
- 1
- 2.51
- 5
- 10
- 15
- 20
- 25
- 30
- 80
- 100
- 130

Figure 14A-22
HYDRAULIC CONDUCTIVITY
MODEL LAYER 7

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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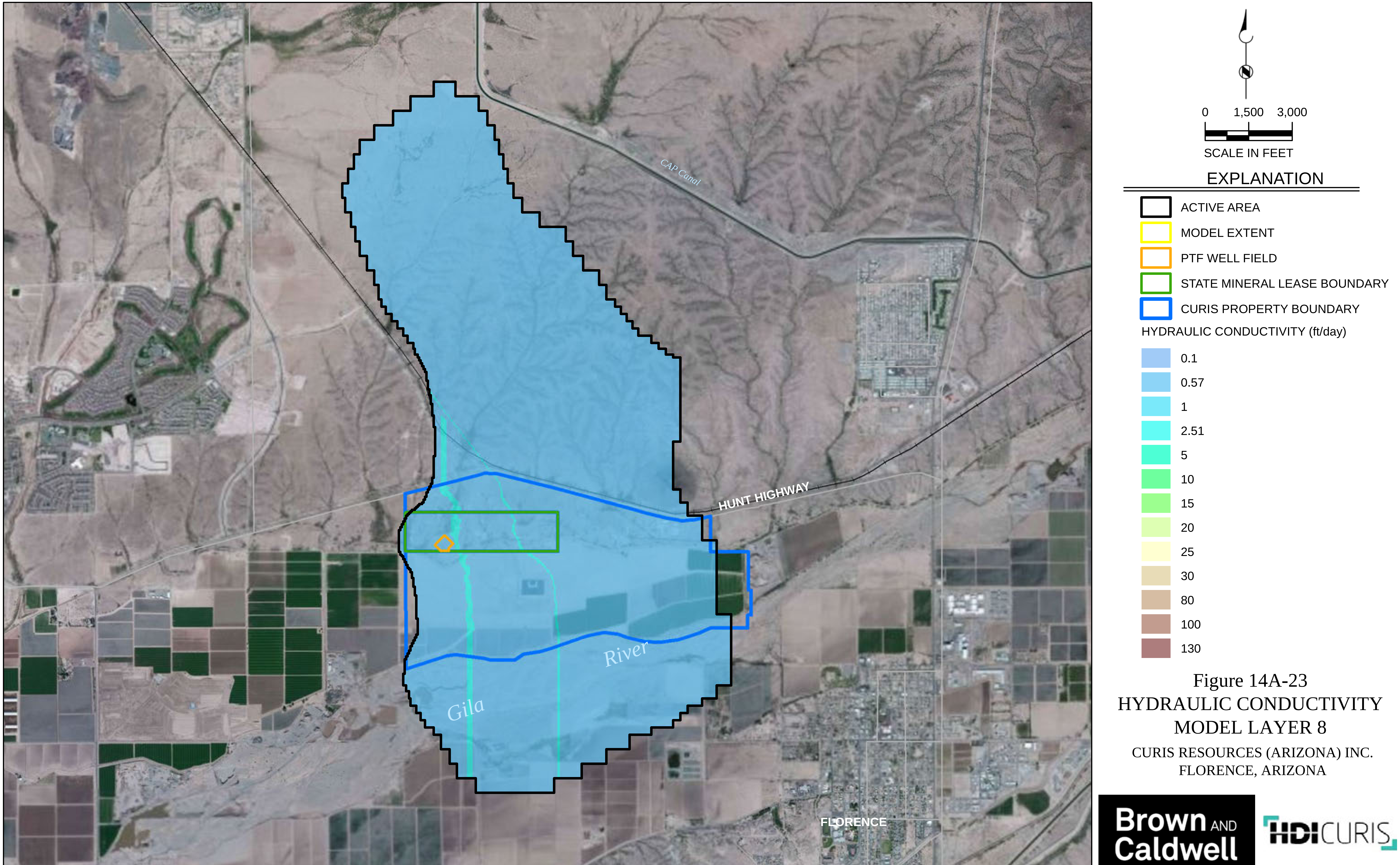

Figure 14A-23
HYDRAULIC CONDUCTIVITY
MODEL LAYER 8

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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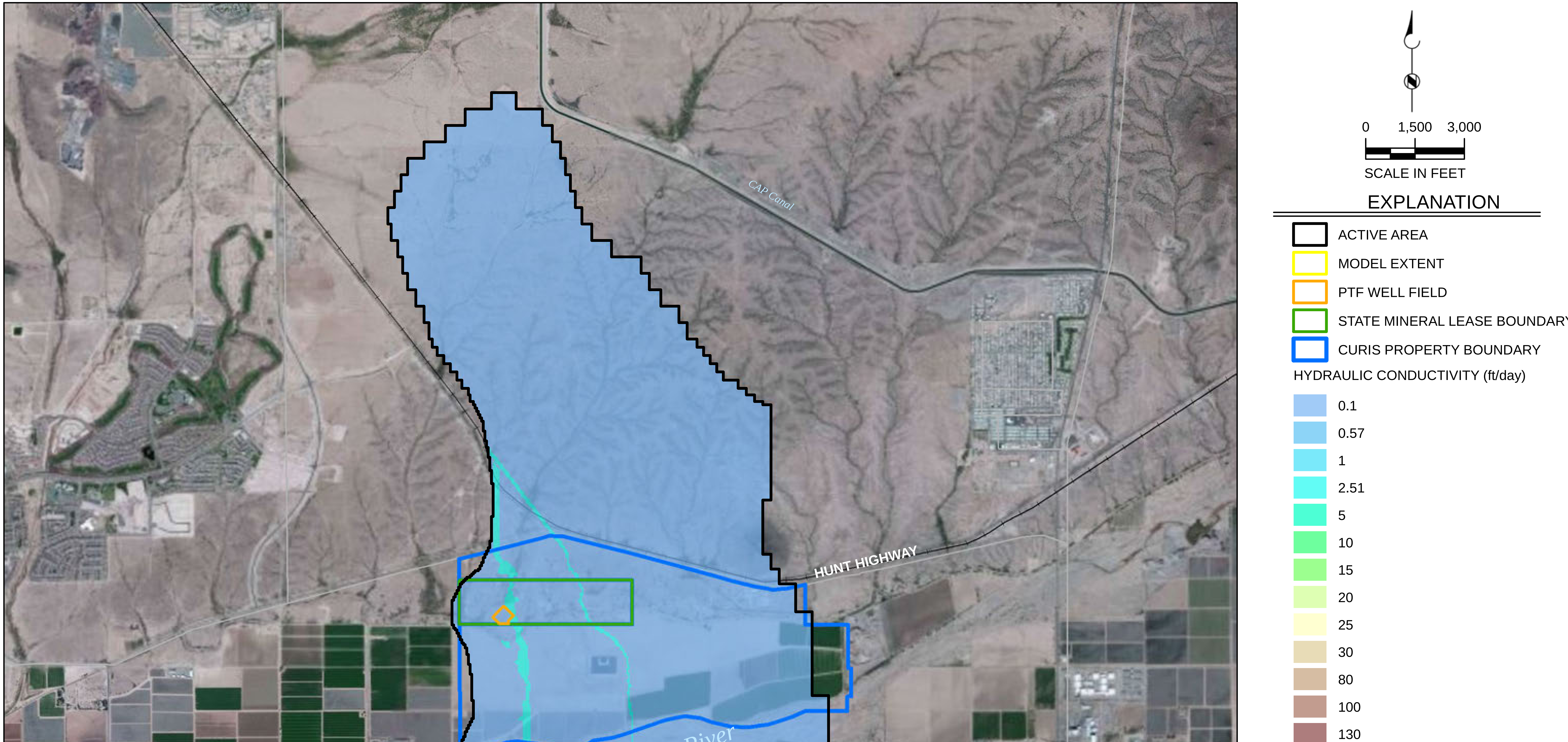

Figure 14A-24
HYDRAULIC CONDUCTIVITY
MODEL LAYER 9

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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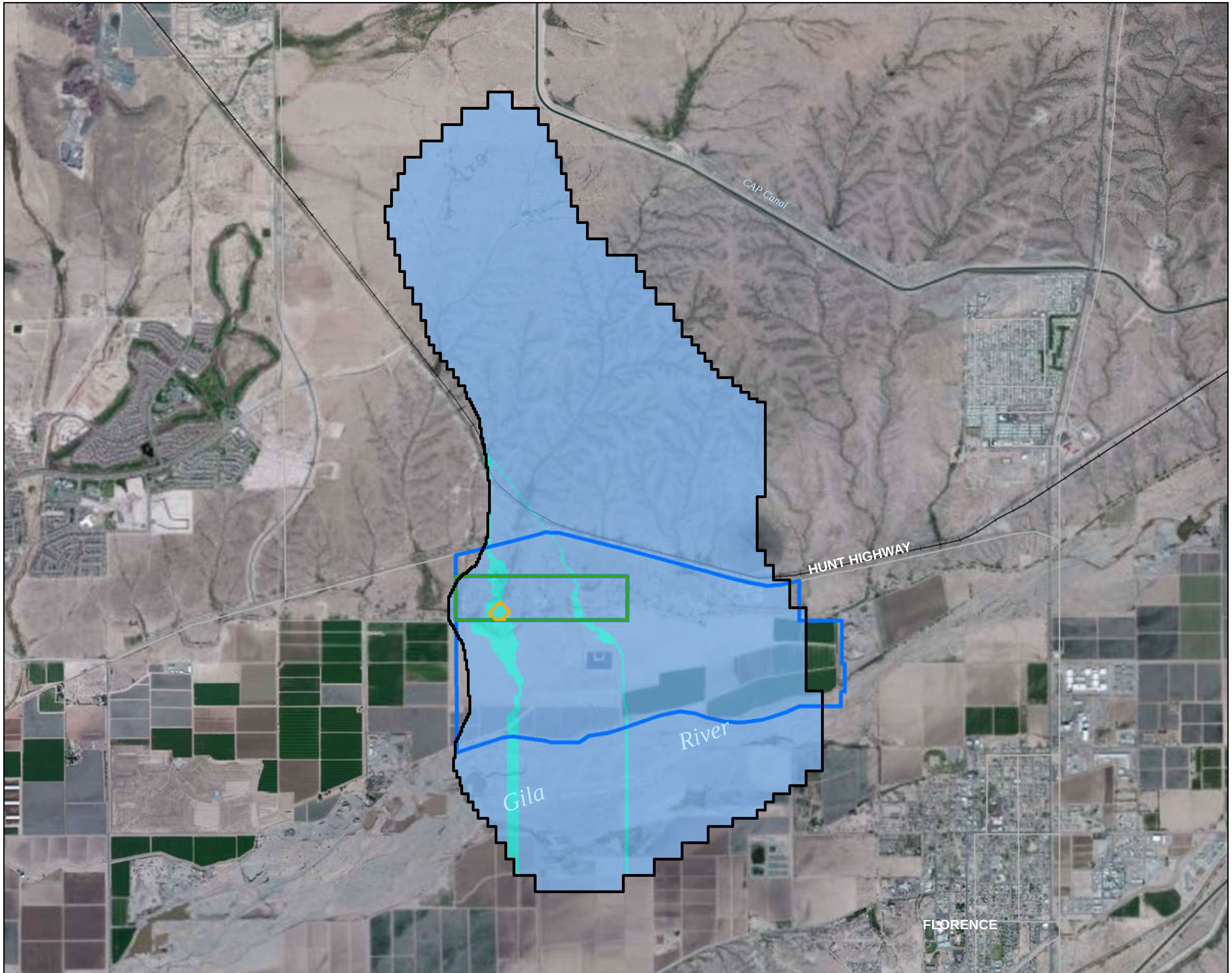

0 1,500 3,000
SCALE IN FEET

EXPLANATION

- ACTIVE AREA
- MODEL EXTENT
- PTF WELL FIELD
- STATE MINERAL LEASE BOUNDARY
- CURIS PROPERTY BOUNDARY

HYDRAULIC CONDUCTIVITY (ft/day)

- 0.1
- 0.57
- 1
- 2.51
- 5
- 10
- 15
- 20
- 25
- 30
- 80
- 100
- 130

Figure 14A-25
HYDRAULIC CONDUCTIVITY
MODEL LAYER 10

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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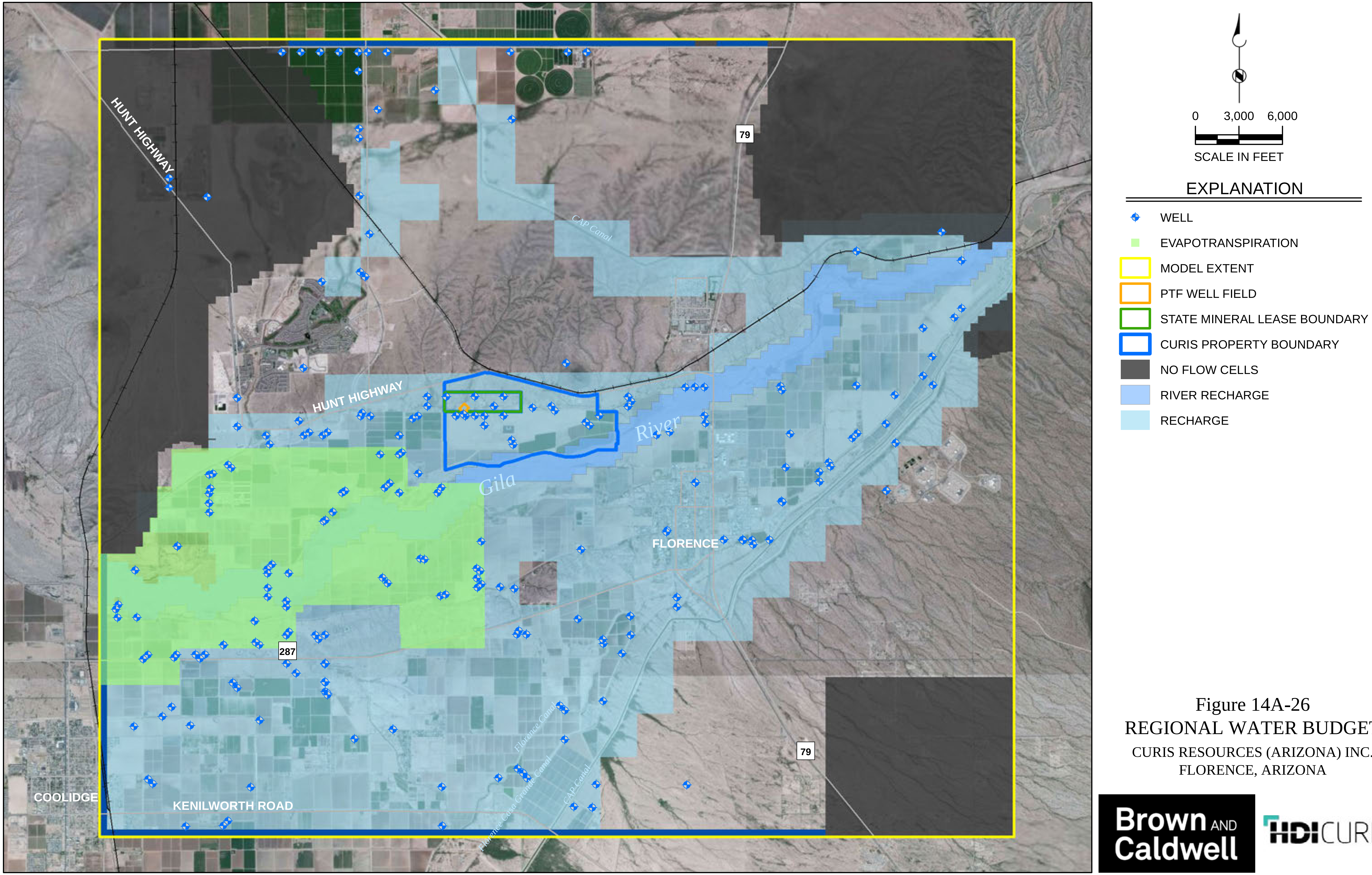

Figure 14A-26
REGIONAL WATER BUDGET
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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\\BCPHX03\projects\Hunter Dickinson\Curis GIS\MXDs\Temp Permit2012\G14075334014A26_RegionalWBudget.mxd Updated: 1/27/2012

0 3,000 6,000
SCALE IN FEET

EXPLANATION

RESIDUALS (YEARS 2000-2010)

Residual

- 75 - -60
- -59 - -40
- -39 - -20
- -19 - 0
- 1 - 20
- 21 - 40
- 41 - 60
- 61 - 75
- MODEL EXTENT
- PTF WELL FIELD
- STATE MINERAL LEASE BOUNDARY
- CURIS PROPERTY BOUNDARY
- NO FLOW CELLS
- CALIBRATED WATER LEVEL

Figure 14A-27
CALIBRATED WATER LEVELS AND RESIDUALS

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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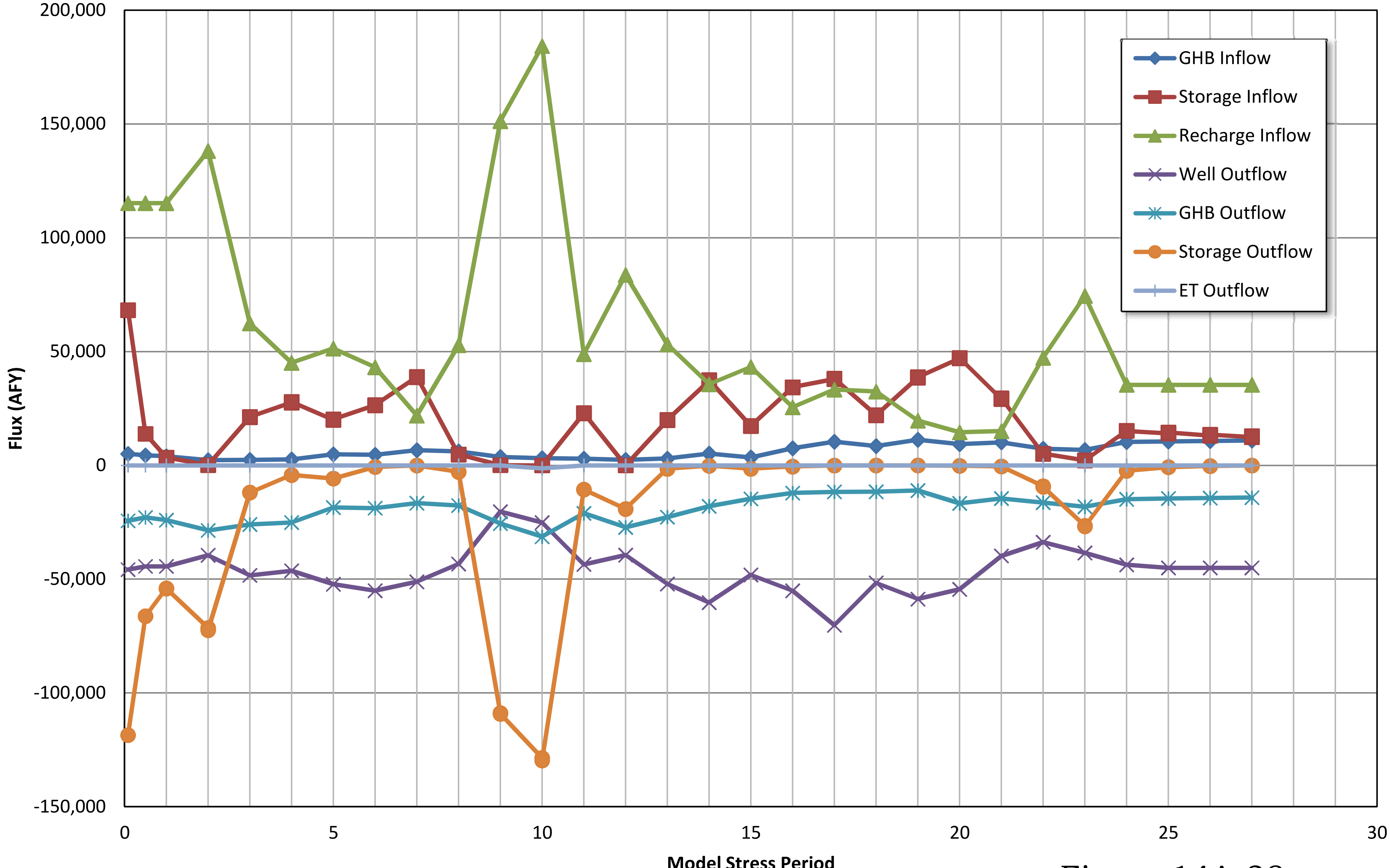

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Figure 14A-28
Simulated Transient Water Budget

Curis Resources (Arizona) Inc.
Florence, Arizona

J:\Hunter Dickinson\138799 - Curis Florence Copper Permitting\Working\Significant Amendment\Figures\Modeling Report\Water Budget_Figure.xlsx 1/24/2012

EXPLANATION

- INITIAL SULFATE CONCENTRATION DISTRIBUTION 750 mg/L
- PTF WELL FIELD
- STATE MINERAL LEASE BOUNDARY
- CURIS PROPERTY BOUNDARY

Figure 14A-29
INITIAL CONCENTRATIONS
SULFATE DISTRIBUTION
TRANSPORT SIMULATIONS

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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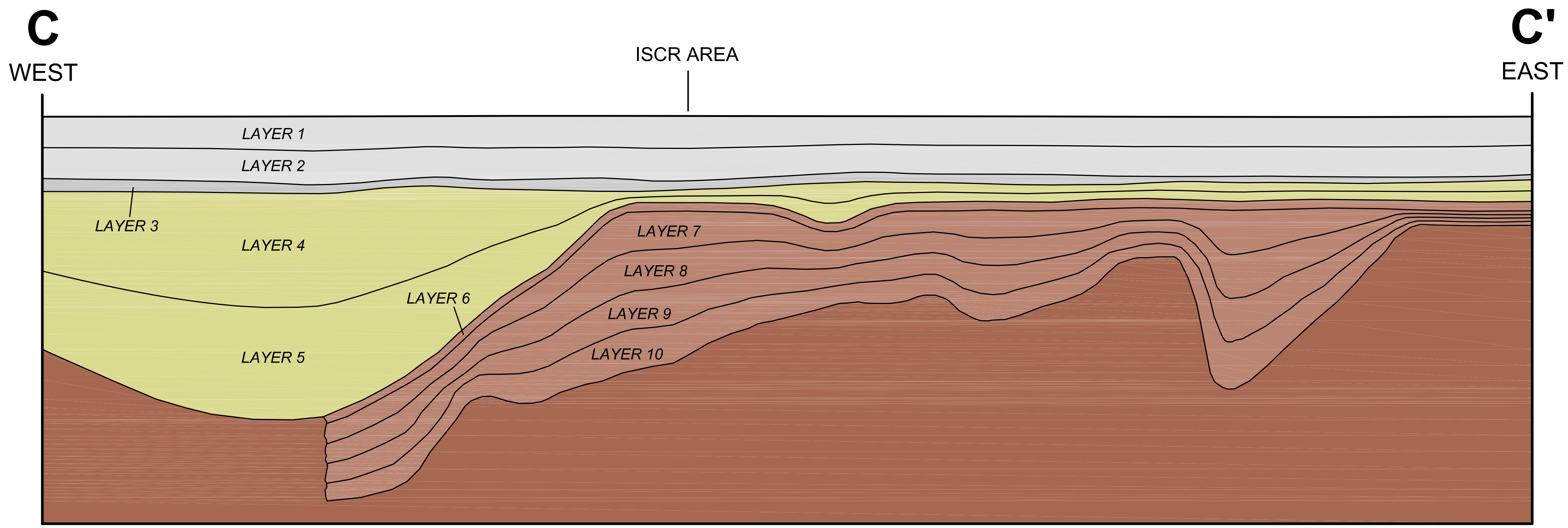
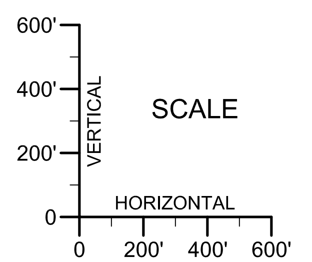
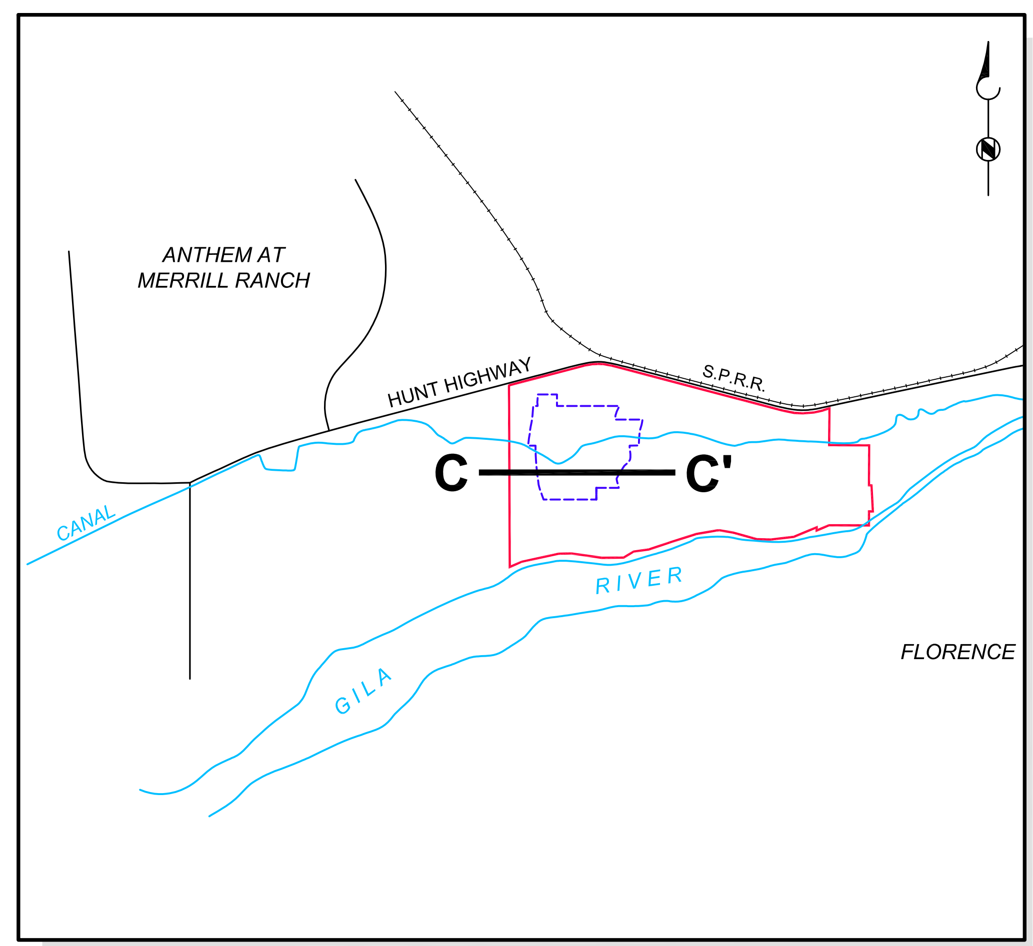




KEYMAP

NOT TO SCALE



EXPLANATION

- UPPER BASIN FILL UNIT (UBFU)
- MIDDLE FINE GRAINED UNIT (MFGU)
- LOWER BASIN FILL UNIT (LBFU)
- OXIDE BEDROCK ZONE
- SULFIDE BEDROCK ZONE

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Figure 14A-30

MODEL LAYERING IN THE VICINITY OF THE ISCR AREA

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

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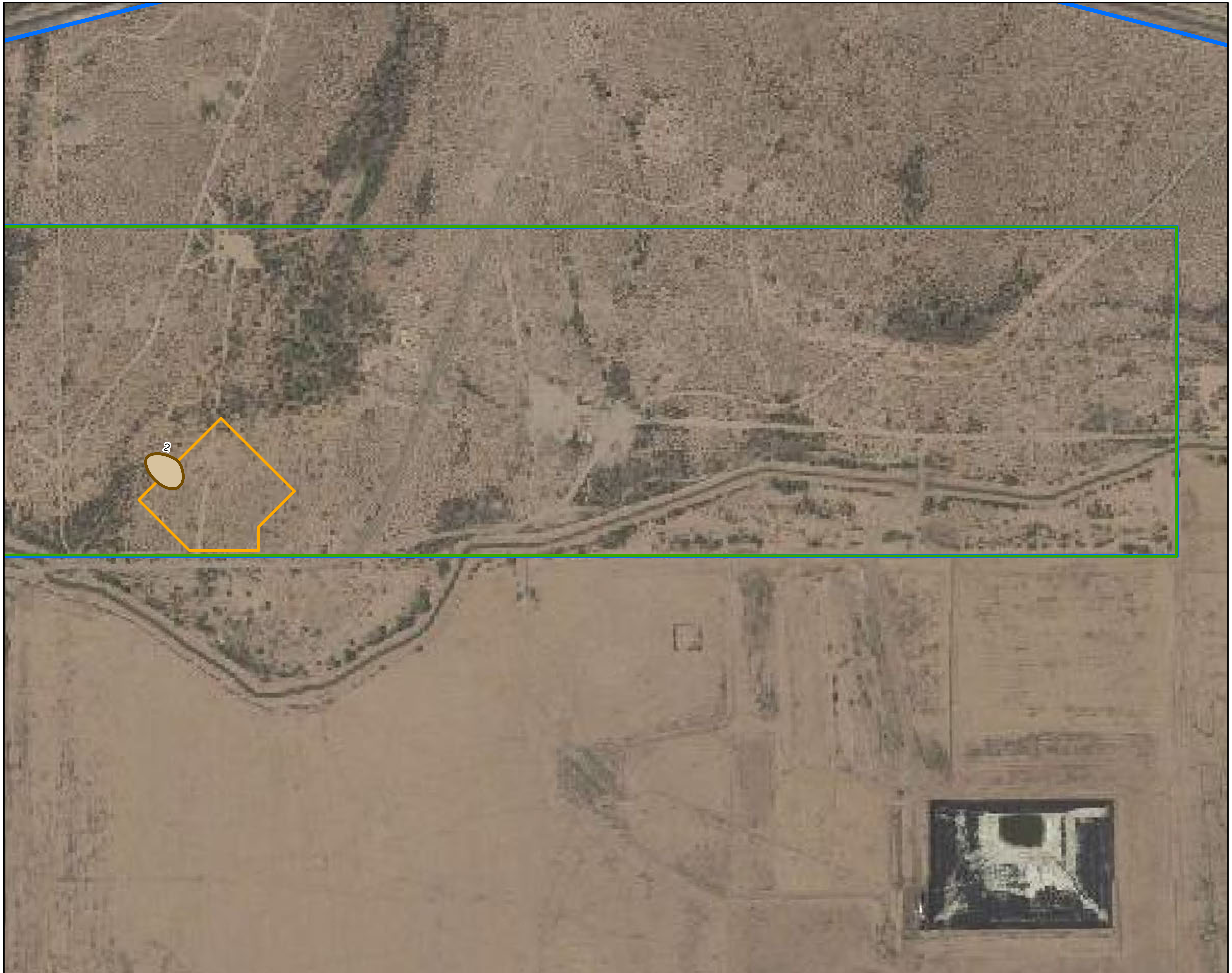

0 200 400
SCALE IN FEET

EXPLANATION

- SIMULATED SULFATE DISTRIBUTION AND CONCENTRATION ABOVE BACKGROUND (mg/L)
- PTF WELL FIELD
- CURIS PROPERTY BOUNDARY
- STATE MINERAL LEASE BOUNDARY

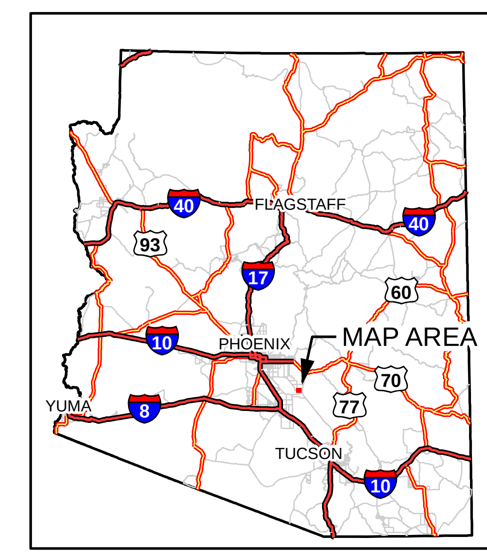

Figure 14A-31
SIMULATED SULFATE DISTRIBUTION
MODEL LAYER 5 (LOWER LBFU)
5 YEARS AFTER CLOSURE
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

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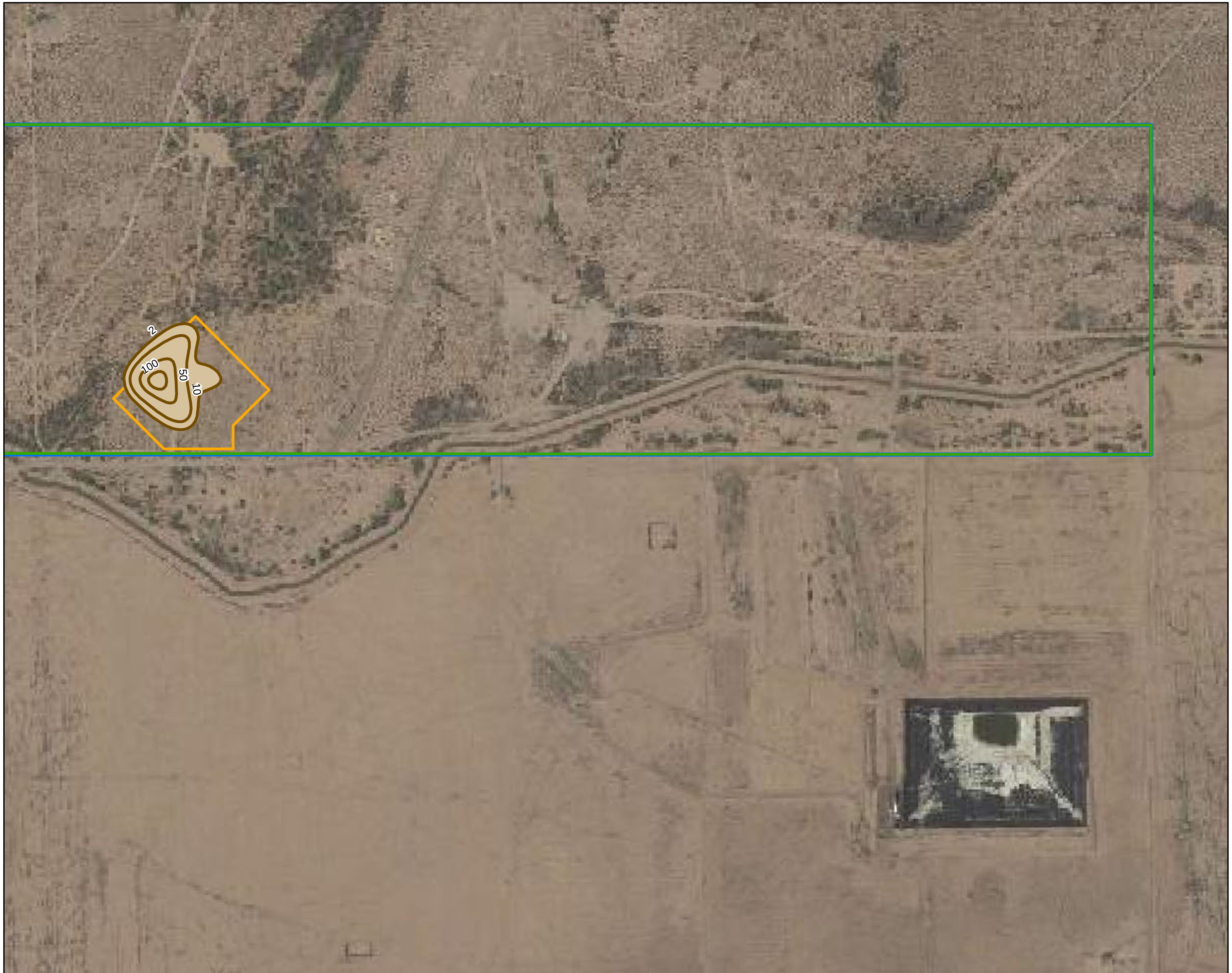

0 200 400
SCALE IN FEET

EXPLANATION

- SIMULATED SULFATE DISTRIBUTION AND CONCENTRATION ABOVE BACKGROUND (mg/L)
- PTF WELL FIELD
- STATE MINERALS LEASE BOUNDARY
- CURIS PROPERTY BOUNDARY

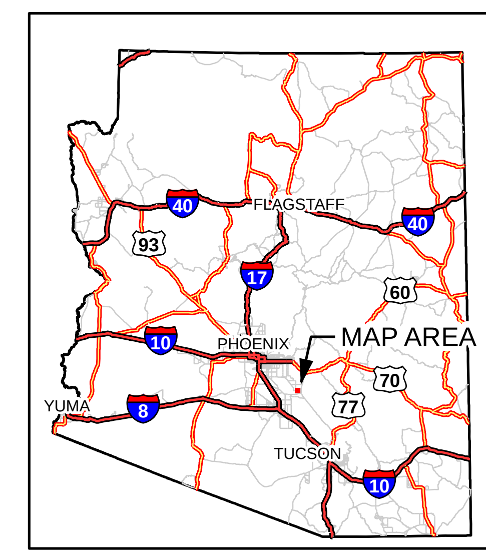

Figure 14A-32
SIMULATED SULFATE DISTRIBUTION
MODEL LAYER 6 (OXIDE EXCLUSION ZONE)
5 YEARS AFTER CLOSURE

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

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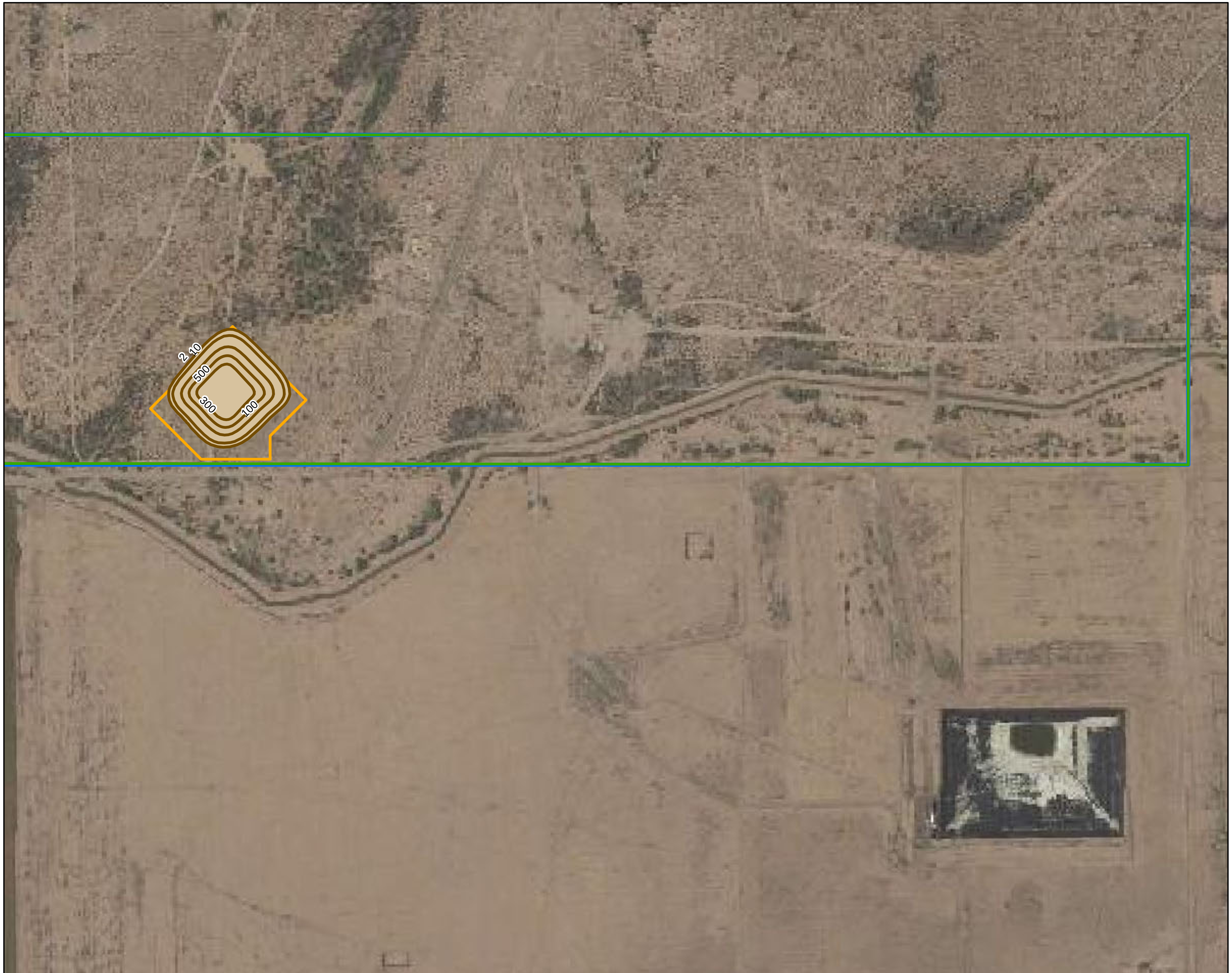
\\BCPHX03\projects\Hunter Dickinson\Curis GIS\MXDs\Temp Permit2012\14075334031_L6 Discharge Impact Oxide Excl.mxd Updated: 1/26/2012



EXPLANATION

SIMULATED SULFATE DISTRIBUTION AND CONCENTRATION ABOVE BACKGROUND (mg/L)

PTF WELL FIELD

CURIS PROPERTY BOUNDARY

STATE MINERALS LEASE BOUNDARY

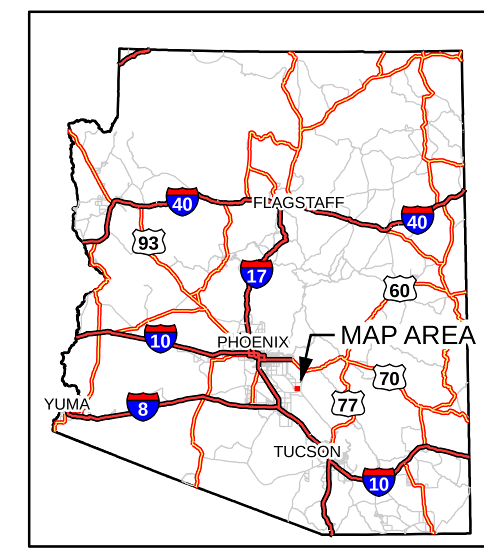
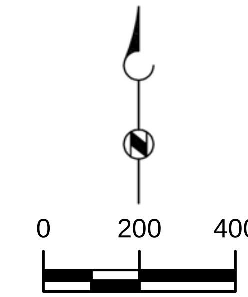


Figure 14A-33
SIMULATED SULFATE DISTRIBUTION
MODEL LAYER 7 (UPPER OXIDE)
5 YEARS AFTER CLOSURE

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

HDI CURIS



EXPLANATION

- SIMULATED SULFATE DISTRIBUTION AND CONCENTRATION ABOVE BACKGROUND (mg/L)
- PTF WELL FIELD
- CURIS PROPERTY BOUNDARY
- STATE MINERALS LEASE BOUNDARY

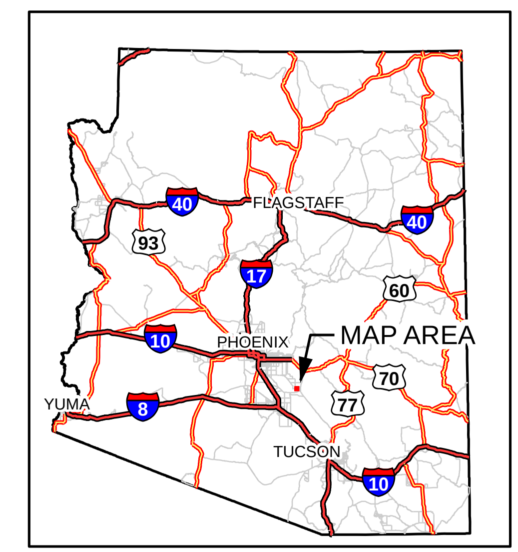


Figure 14A-34
SIMULATED SULFATE DISTRIBUTION
MODEL LAYER 8 (UPPER OXIDE)
5 YEARS AFTER CLOSURE

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

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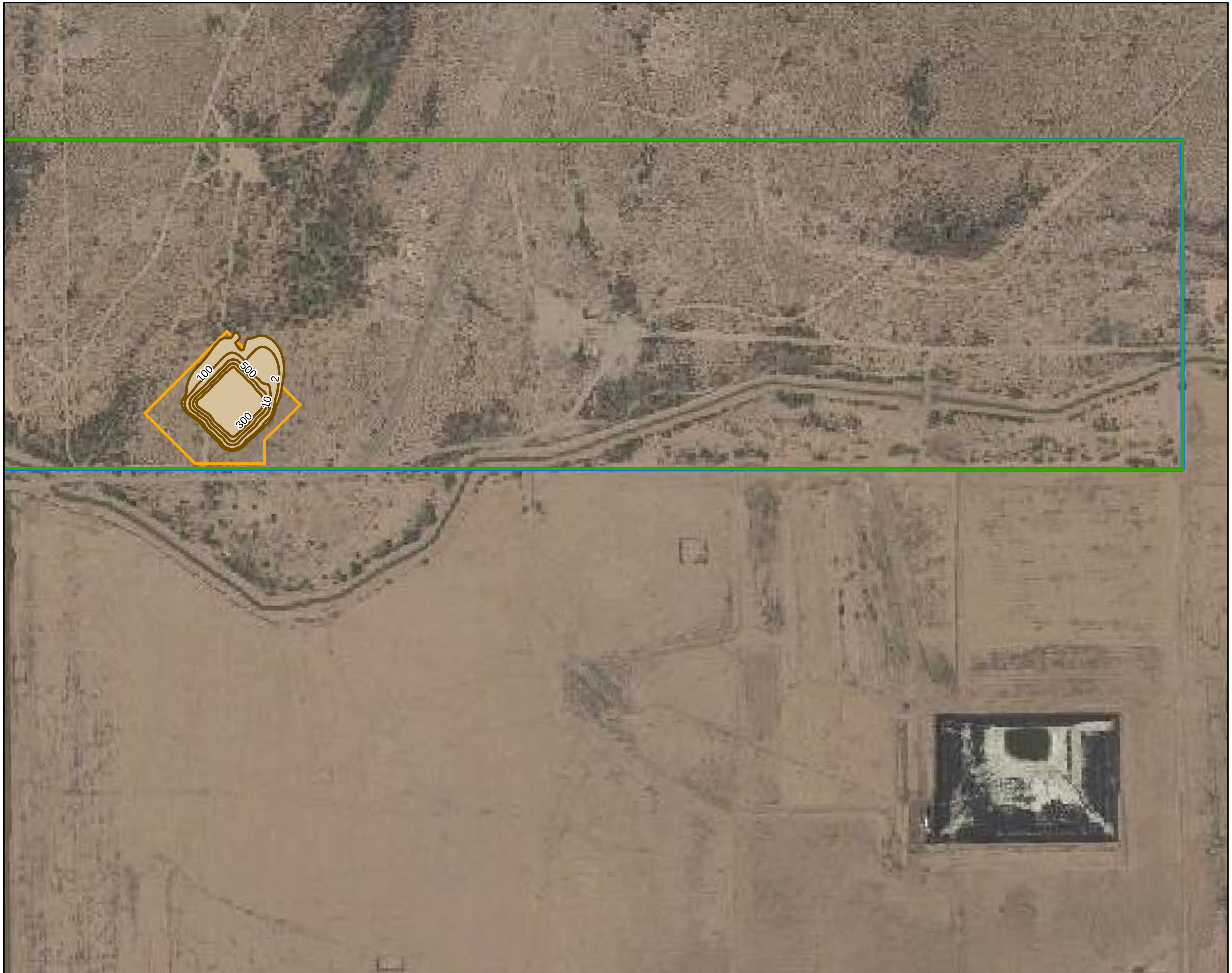

0 200 400

SCALE IN FEET

EXPLANATION

- SIMULATED SULFATE DISTRIBUTION AND CONCENTRATION ABOVE BACKGROUND (mg/L)
- PTF WELL FIELD
- STATE MINERALS LEASE BOUNDARY
- CURIS PROPERTY BOUNDARY

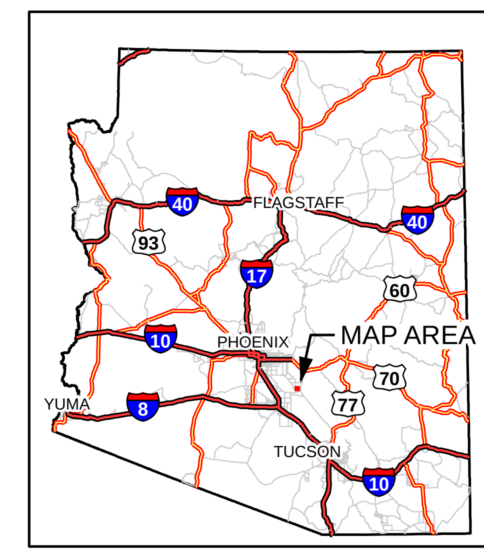

Figure 14A-35
SIMULATED SULFATE DISTRIBUTION
MODEL LAYER 9 (LOWER OXIDE)
5 YEARS AFTER CLOSURE

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

HDI CURIS

0 200 400

SCALE IN FEET

EXPLANATION

- SIMULATED SULFATE DISTRIBUTION AND CONCENTRATION ABOVE BACKGROUND (mg/L)
- PTF WELL FIELD
- STATE MINERALS LEASE BOUNDARY
- CURIS PROPERTY BOUNDARY

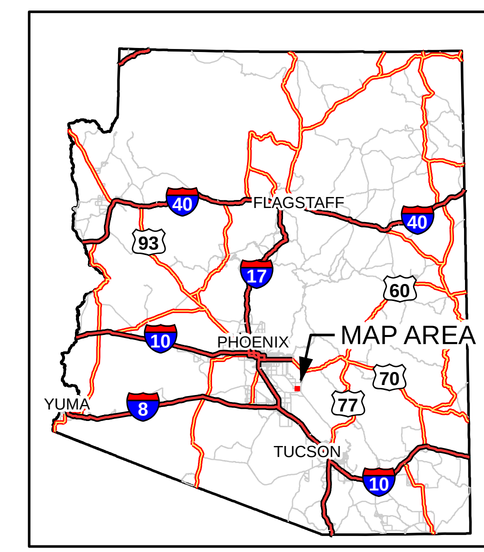

Figure 14A-36
SIMULATED SULFATE DISTRIBUTION
MODEL LAYER 10 (LOWER OXIDE)
5 YEARS AFTER CLOSURE

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

HDI CURIS

Figure 14A-37
EXTENT OF SULFATE MIGRATION WITHIN THE OXIDE (ALL LAYERS)
5 YEARS AFTER CLOSURE

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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HDI CURIS

\\BCPHX03\projects\Hunter Dickinson\Curis GIS\MXDs\Temp Permit2012\G140753340_Composite_5Years.mxd Updated: 1/27/2012

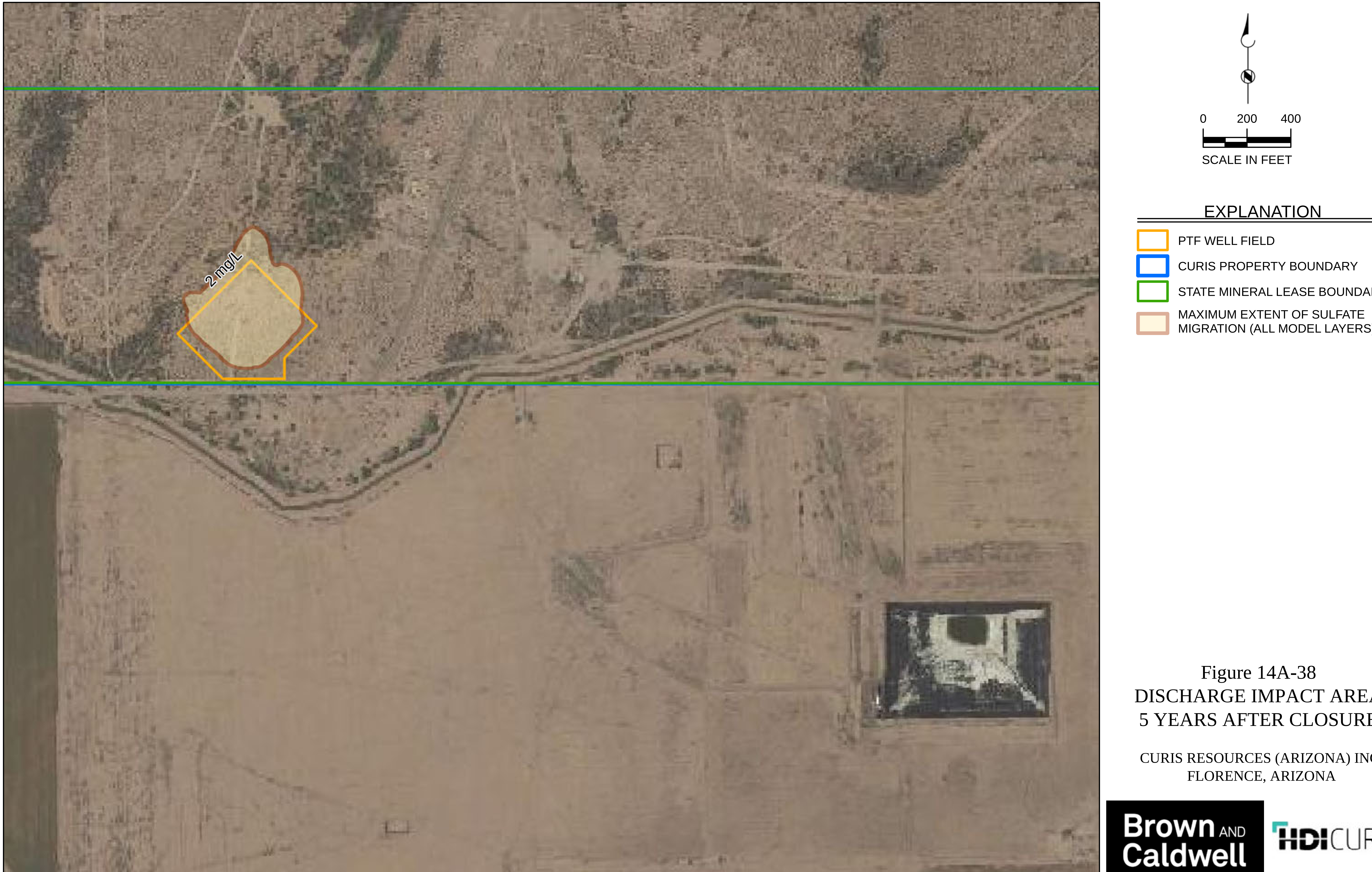


Figure 14A-38
DISCHARGE IMPACT AREA
5 YEARS AFTER CLOSURE

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

HDI CURIS

Table 14A-1. Application Attachments Addressing Hydrologic Study Requirements Defined in A.A.C. R18-9-A202A.8

Requirement	Addressed in Attachment
8.a.i	Attachment 14A (This Attachment)
8.a.ii	Attachment 12
8.b.i	Attachment 14A (This Attachment)
8.b.ii	Attachment 14A (This Attachment)
8.b.iii	Attachment 14A(This Attachment)
8.b.iv	Attachment 14A (This Attachment)
8.b.v	Attachment 14B
8.b.vi	Attachment 14B
8.b.vii	Attachment 14B
8.b.viii	Attachment 14B
8.b.ix	Does not pertain to the present application
8.b.x	Attachment 14A (This Attachment)
8.b.xi	Attachment 14A (This Attachment)
8.b.xii	Attachment 14A (This Attachment)
8.b.xiii	Attachment 14A (This Attachment)

Table 14A-2. Measured Hydraulic Conductivity Values for MFGU Samples

Sample Name	Date of Analysis	Hydraulic Conductivity (cm/sec)	Hydraulic Conductivity (ft/day)
M16-60-300	October 11, 1995	5.0×10^{-9}	1.41×10^{-5}
CMP-11-03, 283-288 ft	August 11, 2011	4.4×10^{-9}	1.25×10^{-5}
CMP-11-03, 292.5-297.5 ft	August 11, 2011	4.3×10^{-9}	1.22×10^{-5}

cm/sec = centimeters per second
ft/day = feet per day

Table 14A-3. Specifications of the PTF Groundwater Model

Model Characteristics	Specifications
Active Model Domain	~ 97 Square Miles
Units	Time: Days Length: Feet (lateral and vertical)
Coordinate System	State Plane NAD27 Arizona Central
Model Grid	392 rows by 540 columns, 2,116,800 total cells, 1,646,985,860 active cells Origin X: 622750 Y: 716500 (No rotation)
Cell Size	12.5 x 12.5 feet up to 500 by 500 feet
Layering –10 Layers	Layer 1 and 2: UBFU Layer 3: MFGU Layer 4 and 5: LBFU Layer 6: Oxide Exclusion Zone Layer 7 through 10: Oxide
Groundwater Flow Model Packages	MODFLOW SURFACT (ver. 3), BCF4, ATO, BAS, GHB, PG5, RCH, WEL
Solute Transport Packages	Solution Fate and Transport: MODFLOW SURFACT - ACT Modules
Simulation Time	Steady State: ~1900 Transient: 1984 to 2010 Predictive: 6 Years and 1 month (14 months with hydraulic control pumping at the ISCR, 9 months formation rinsing pumping, and 5 years with no hydraulic control pumping during closure)
Stress Periods (SP's)	Calibrated Model: 1 Steady State SP; 27 annual transient SPs Predictive Models: 7 SPs of varying lengths
Recharge	Variable, ranging from ~14,500 to ~188,200 AFY
Wells	General Head Boundaries along the central portion of the northern boundary, southern portion of the western boundary, and western portion of the southern boundary. "No flow" conditions along remainder of model boundaries.
Boundary Conditions	Interpolated water levels from observed 1984 groundwater conditions
Initial Conditions	Contoured and kriged water levels from 1984
Solution Method	Preconditioned-Conjugate Gradient 5 (PCG5)

Table 14A-4. Aquifer Parameter Value Ranges by Model Layer

	Horizontal Hydraulic Conductivity Kx (feet/day)	Vertical Hydraulic Conductivity Kz (feet/day)	Specific Storage Ss (feet-1)	Specific Yield Sy (Unitless)	Porosity n (Unitless)
Layers 1 and 2 (UBFU)	20 to 130	2 to 13	1e-5	0.13 to 0.2	0.13 to 0.2
Layer 3 (MFGU/UBFU)	1 to 130	0.01 to 13	5e-6 to 1 e-5	0.08 to 0.2	0.15 to 0.2
Layers 4 and 5 (LBFU)	5 to 25	0.5 to 2.5	1e-5	0.08 to 0.1	0.2
Layer 6	1	1	1e-5	0.08	0.08
Layer 7	0.57	0.57	5e-6	0.08	0.08
Layer 8	0.57	0.57	5e-6	0.08	0.08
Layer 9	0.1	0.1	5e-6	0.05	0.05
Layer 10	0.1	0.1	5e-6	0.05	0.05
Faults	2.51	2.51	5e-6	0.1	0.1

Table 14A-5. Transient Model Calibration Statistics

	Residual Mean (RM) (ft)	Absolute Residual Mean (ARM) (ft)	Residual Standard Deviation (RSD) (ft)	Simulated Range of Heads Values (Range) (ft)	RM/Range (%)	ARM/Range (%)	RSD/Range (%)
1984 to 2010	-2.80	12.10	15.61	398	0.71	3.0	3.9

Table 14A-6. Simulated Water Budget Values

Inflow Source	1984 Simulated Water Budget (AFY)	2003 Simulated Water Budget (AFY)	2010 Simulated Water Budget (AFY)
Recharge	116,776	14,538	35,541
Storage	-	47,831	12,749
TOTAL INFLOWS	116,776	62,369	48,290

Outflow Source	1984 Simulated Water Budget (AFY)	2003 Simulated Water Budget (AFY)	2010 Simulated Water Budget (AFY)
Evapotranspiration	0	0	0
Pumping Wells	44,352	54,453	45,010
General Head Boundary	20,819	8,180	3,900
Storage	55,183	-	-
TOTAL OUTFLOWS	120,354	62,633	48,910

Exhibit 14A-1

**Aquifer Test Data, Volume II, Appendix E
1996 Florence APP Application**

APPENDIX E

CURRENT INVESTIGATION AQUIFER TEST ANALYSIS INFORMATION

Table E-1 Summary of Aquifer Test Field Program							
Pumping Well	**Observation Wells**	**Screened Interval (ft bgs)**	**Pump Rate (gpm)**	**Maximum Drawdown (ft)**	**Hydraulic Conductivity (ft/day)**	**Date Test Performed**	**Comments**
PW7-1		540 - 880	38	109.0	0.2	6/16/95 to 6/22/95	Irrigation wells BIA-10B & WW-3 pumped during test.
	OB7-1	540 - 880		67.9	0.1		
	O3-GL	325 - 365		8.7	N/A		
	Corehole OB-1	Not Screened		6.3[3]	N/A		
P5-O		414 - 770	66	51.8	N/A	10/18/95 to 10/24/95	Irrigation wells BIA-10B & BIA-9 pumped during test.
	O5.1-O	674 - 832		29.5	N/A		
	O5.2-O	712 - 771		31.7	N/A		
P8.1-O		400 - 580	12	212.7	N/A	9/7/95 to 9/13/95	Irrigation well BIA-9 is pumped during test.
	P8.2-O	396 - 576		4.5	N/A		
	P8-GU	128 - 248		0.49	N/A		
	08-O	401 - 579		72.6	N/A		
	08-GU	133 - 251		0	N/A		
P8-GU		128 - 248	85	6.9	61.3	9/18/95 to 9/22/95	Irrigation wells BIA-10B & BIA-9 pumped during test.
	P8.1-O	400 - 580		9.2	N/A		
	P8.2-O	396 - 576		9.5	N/A		
	O8-O	401 - 579		8.9	N/A		
	O8-GU	133 - 251		6.9	N/A		
P12-O		440 - 940	64	35.5	0.4	6/1/95 to 6/8/95	Irrigation well WW-3 is pumped during test.
	O12-O	434 - 939		42.8	0.6		
	O12-GL	125 - 165		N/A[4]	N/A		
P13.1-O		772 - 1,449	46	93.1	N/A	10/9/95 to 10/16/95	No irrigation wells pumped during test.
	P13.2-O	781 - 1,379		19.2	N/A		
	P13-GL	690 - 760		0	N/A		
	O13-O	770 - 1,393		4.4	N/A		
P15-O		580 - 1,300	59	40.9	N/A	9/29/95 to 10/5/95	Irrigation wells BIA-10B & BIA-9 pumped during test.
	O15-O	632 - 1,296		22.4	N/A		
	O15-GL	421 - 481		1.3	N/A		

Table E-1 Summary of Aquifer Test Field Program

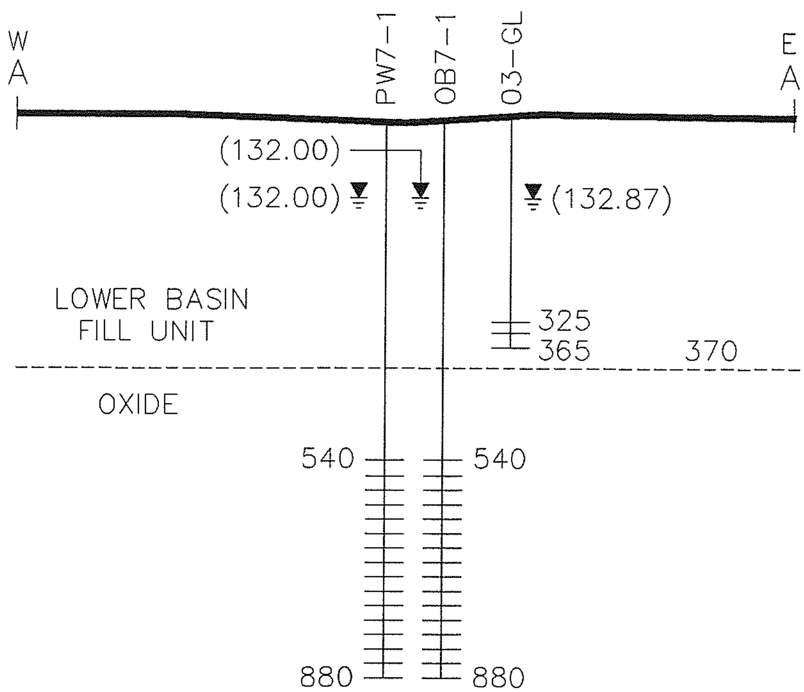
Pumping Well	Observation Wells	Screened Interval (ft bgs)	Pump Rate (gpm)	Maximum Drawdown (ft)	Hydraulic Conductivity (ft/day)	Date Test Performed	Comments
P19.1-O		402 - 600	24	155.2	0.3	7/3/95 to 7/6/95	Irrigation wells BIA-10B & WW-3 pumped during test.
	P19.2-O	404 - 602		25.7	0.2		
	019-O	410 - 608		16.9	0.2		
	019-GL	375 - 435		2.4	N/A		
	Corehole 138	Not Screened		0	N/A		
P28.1-O		395 - 495	30	7.9	7.7	8/15/95 to 8/21/95	Low pump rate test. No irrigation wells pumped during test.
	P28.2-O	398 - 497		5.4	N/A		
	P28-GL	279 - 309		1.03	N/A		
	028.1-O	394 - 494		4.7	N/A		
	028.2-S	454 - 494		3.2	N/A		
	028-GL	277 - 307		1.7	N/A		
P28.1-O		395 - 495	85	50.4	3.6	9/7/95 to 9/13/95	High pump rate test conducted. Irrigation well BIA-9 pumped during test.
	P28.2-O	398 - 497		28.3	2.7		
	P28-GL	279 - 309		7.1	N/A		
	028.1-O	394 - 494		22.8	N/A		
	028.2-S	454 - 494		14.2	N/A		
	028-GL	277 - 307		10.1	N/A		
P28-GL		279 - 309	75	115.2	8.3	9/18/95 to 9/28/95	Irrigation wells BIA-10B & BIA-9 pumped during test.
	P28.1-O	395 - 495		11.7	N/A		
	P28.2-O	398 - 497		11.6	N/A		
	O28.1-O	394 - 494		11.9	N/A		
	O28.2-S	454 - 494		12.2	N/A		
	O28-GL	277 - 307		18.8	25.5		
P28.2-O		398 - 497	80	33.8	3.1	10/2/95 to 10/5/95	Irrigation wells BIA-10B & BIA-9 pumped until 10/5/95.
	P28.1-O	395 - 495		2.3	N/A		
	P28-GL	279 - 309		8.7	N/A		
	O28.1-O	394 - 494		18.5	3.0		
	O28.2-S	454 - 494		15.4	N/A		
	O28-GL	277 - 307		11.9	N/A		

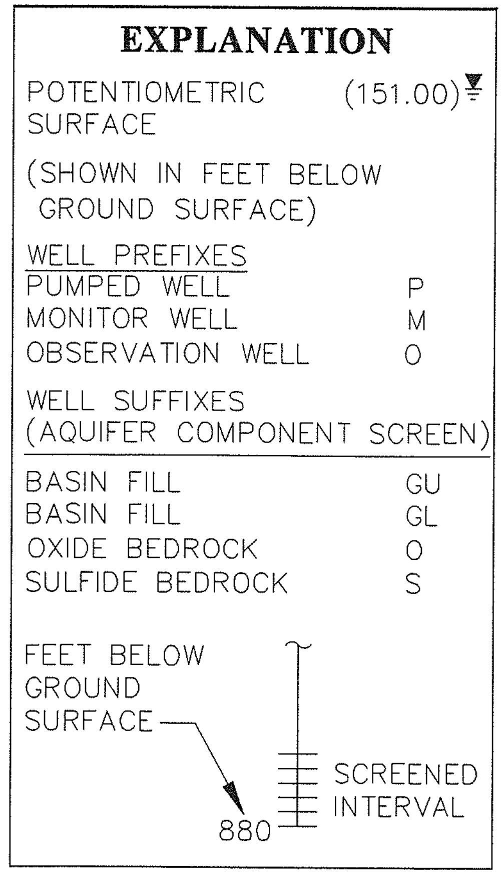
Table E-1 Summary of Aquifer Test Field Program							
Pumping Well	**Observation Wells**	**Screened Interval (ft bgs)**	**Pump Rate (gpm)**	**Maximum Drawdown (ft)**	**Hydraulic Conductivity (ft/day)**	**Date Test Performed**	**Comments**
P39-O		471 - 826	55	108	0.3	5/19/95 to	No irrigation wells pumped during test.
	O39-O	474 - 890		23	0.3	5/21/95	
P49-O		808 - 1,222	40	298	N/A	10/11/95 to	No irrigation wells pumped during test.
	O49-O	812 - 1,227		091	N/A	10/16/95	
	O49-GL	661 - 721		0.47	N/A		
M2-GU		198 - 237	10	0.38	N/A	7/25/95 to	Short duration test(1). Irrigation wells BIA-10B & England No. 3 pumped during test.
	M3-GL	298 - 338		0	N/A	7/26/95	
	M4-O	405 - 465		0	N/A		
	M5-S	516 - 576		0	N/A		
M3-GL		298 - 338	10	5.6	15.9	7/26/95 to	Short duration test(1). Irrigation well England No. 3 pumped during test.
	M2-GU	198 - 237		0	N/A	7/27/95	
	M4-O	405 - 465		0.58	N/A		
	M5-S	516 - 576		0	N/A		
M4-O		405 - 465	15	190.4	0.6	7/28/95 to	Short duration test(1). Irrigation well England No. 3 pumped during test.
	M2-GU	198 - 237		0.445	N/A	7/30/95	
	M3-GL	298 - 338		1.09	14.8		
	M5-S	516 - 576		0	N/A		
M10-GU		218 - 258	15	0.508	N/A	7/25/95 to	Short duration test(1). Irrigation wells BIA-10B & England No.3 pumped during test.
	M11-GL	290 - 330		0.222	N/A	7/29/95	
	M12-O	420 - 480		0.318	N/A		
	M13-S	851 - 911		0	N/A		
M11-GL		290 - 330	15	16.7	N/A	7/29/95 to	Short duration test(1). Irrigation well England No. 3 pumped during test.
	M10-GU	218 - 258		4.5	N/A	7/31/95	
	M12-O	420 - 480		4.6	N/A		
	M13-S	851 - 911		0	N/A		

Table E-1 Summary of Aquifer Test Field Program							
Pumping Well	**Observation Wells**	**Screened Interval (ft bgs)**	**Pump Rate (gpm)**	**Maximum Drawdown (ft)**	**Hydraulic Conductivity (ft/day)**	**Date Test Performed**	**Comments**
M12-O		420 - 480	14	19.5	N/A	7/31/95 to 8/2/95	Short duration test[1]. Irrigation wells BIA-10B & England No. 3 pumped during test.
	M10-GU	218 - 258		1.36	N/A		
	M11-GL	290 - 330		3.08	N/A		
	M13-S	851 - 911		0	N/A		
M18-GU		178 - 218	10	7.7	19.6	8/8/95 to 8/9/95	Short duration test[1].
	M1-GL	315 - 355		0	N/A		
M1-GL		315 - 355	10	5.4	17.3	8/11/95 to 8/12/95	Short duration test[1].
	M18-GU	178 - 218		0.157	N/A		
M15-GU		554 - 594	10	47.5	2.6	8/8/95 to 8/9/95	Short duration test[1].
	M14-GL	778 - 838		0	N/A		
M14-GL		778 - 838	10	30.1	1.7	8/11/95 to 8/12/95	Short duration test[1].
	M15-GU	554 - 594		1.56	N/A		
WW-3[2]		240 - 930	2000	N/A	N/A	8/23/95 to 8/29/95	Large scale aquifer test. No other irrigation well pumped during test.
	OB7-1	540 - 880		13.3	N/A		
	O3-GL	325 - 365		12.5	N/A		
	O12-O	434 - 939		23.2	N/A		
	O12-GL	125 - 165		29.9	N/A		
	P15-O	580 - 1,300		32.7	N/A		
	O15-O	632 - 1,296		26.7	N/A		
	O15-GL	421 - 481		7.4	N/A		
	O19-O	410 - 608		5.19	N/A		
	O19-GL	375 - 435		5.3	N/A		
	P28.1-O	395 - 495		2.1	N/A		
	P28.2-O	398 - 497		2.05	N/A		
	O28.1-O	394 - 494		2.06	N/A		
	028-GL	277 - 307		1.9	N/A		
	M14-GL	778 - 838		10.7	N/A		
	M15-GL	554 - 594		9.9	N/A		
	AIRSHAFT	Not Screened		5.0	N/A		

Table E-1 Summary of Aquifer Test Field Program							
Pumping Well	**Observation Wells**	**Screened Interval (ft bgs)**	**Pump Rate (gpm)**	**Maximum Drawdown (ft)**	**Hydraulic Conductivity (ft/day)**	**Date Test Performed**	**Comments**
BIA-9[2]		80 - 494	2350	N/A	N/A	8/29/95 to 9/6/95	Large scale aquifer test. BIA-10B pumped during test.
	OB7-1	540 - 880		21.5	N/A		
	O3-GL	325 - 365		26.2	N/A		
	O12-O	434 - 939		10.3	N/A		
	O12-GL	125 - 165		10.2	N/A		
	P15-O	580 - 1,300		10.3	N/A		
	O15-O	632 - 1,296		5.3	N/A		
	O15-GL	421 - 481		4.7	N/A		
	O19-O	410 - 608		4.3	N/A		
	O19-GL	375 - 435		3.9	N/A		
	P28.1-O	395 - 495		4.1	N/A		
	P28.2-O	398 - 497		4.1	N/A		
	O28.1-O	394 - 494		4.3	N/A		
	028-GL	277 - 307		4.4	N/A		
	M14-GL	778 - 838		6.3	N/A		
	M15-GL	554 - 594		3.9	N/A		
	AIRSHAFT	Not Screened		11.6	N/A		

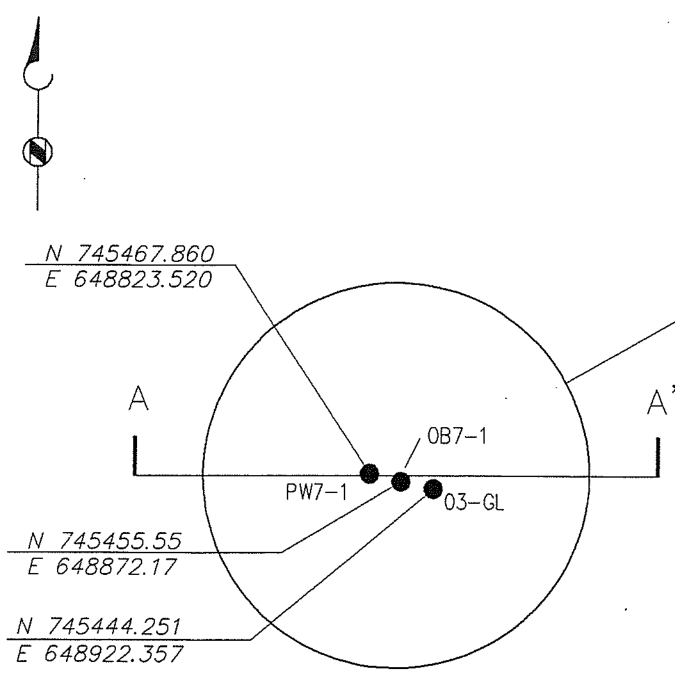
[1] Short duration tests performed at the monitoring well clusters. Each test was performed by pumping each well in the cluster for approximately 24 hours (Except sulfide wells).
[2] Regional tests performed using existing high discharge irrigation wells.
[3] Drawdown due to irrigation well not test pumping well.
[4] No information available, transducer malfunctioned.
ft bgs - feet below ground surface
ft/day - feet per day
gpm - gallons per minute
See section 2.3.5 (II) for discussion of aquifer tests.
Additional Aquifer test data is presented in Appendix E (II).

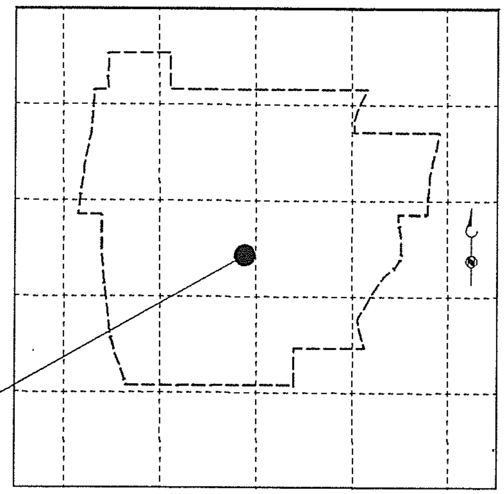




SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'





WELL LOCATION MAP

Approximate Scale: 1"= 2000'

WELL PLAN VIEW

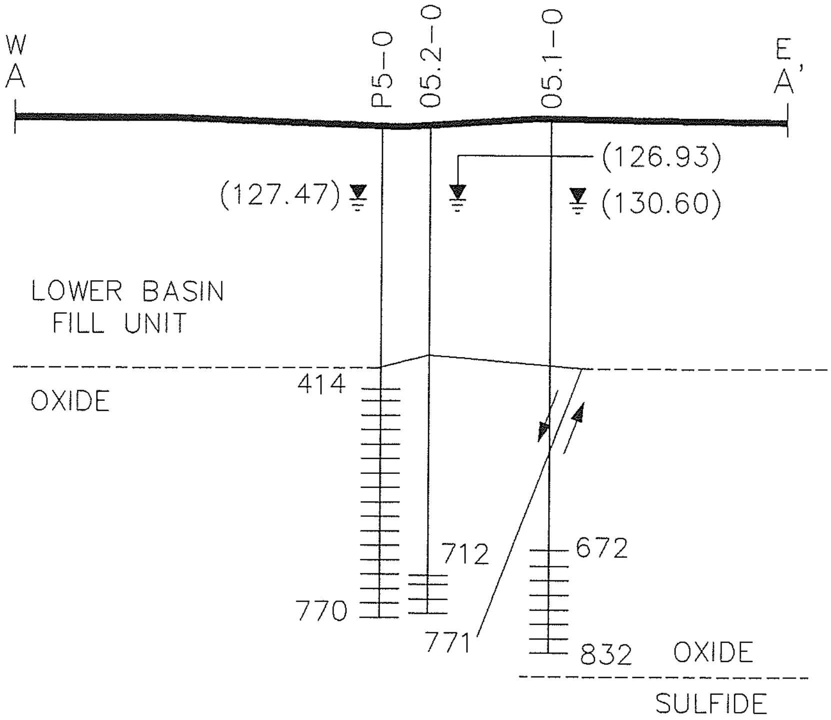
Approximate Scale: 1"= 300'

Figure E-1 (II)
LOCATION SUMMARY
AQUIFER TEST CLUSTER NO. 3

MAGMA
MAGMA COPPER COMPANY
Florence, Arizona

BROWN AND CALDWELL

E-1_2 12-01-95 DanH



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

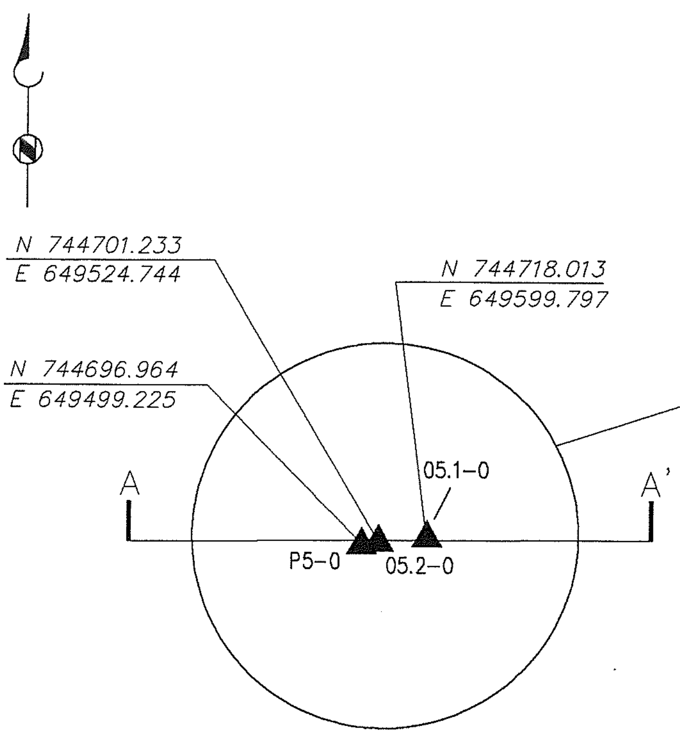
PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES
(AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

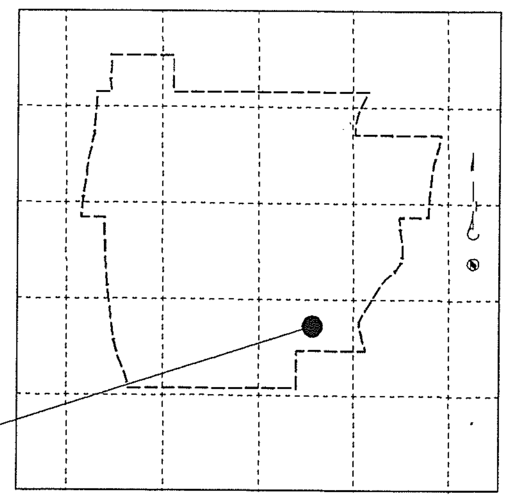
FEET BELOW GROUND SURFACE — 832

SCREENED INTERVAL



WELL PLAN VIEW

Approximate Scale: 1"= 300'



WELL LOCATION MAP

Approximate Scale: 1"= 2000'

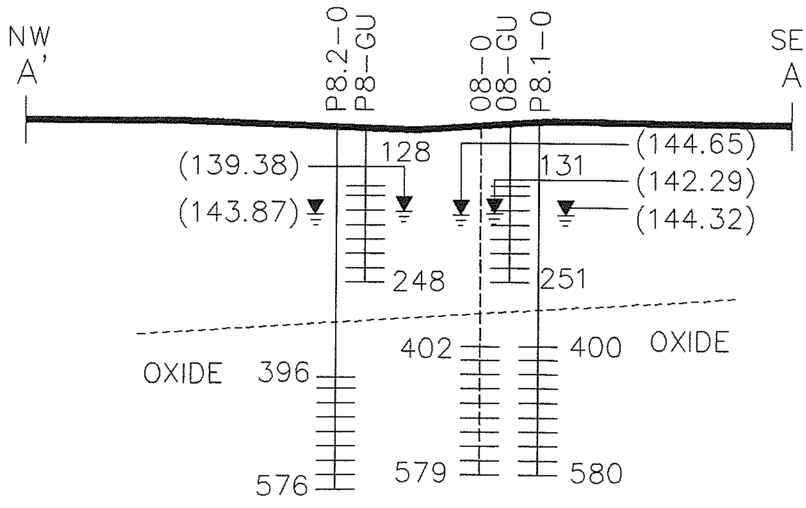
Figure E-2 (II)
LOCATION SUMMARY AQUIFER TEST CLUSTER 5

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

BROWN AND CALDWELL

E-2_2 12-01-95 DanH



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

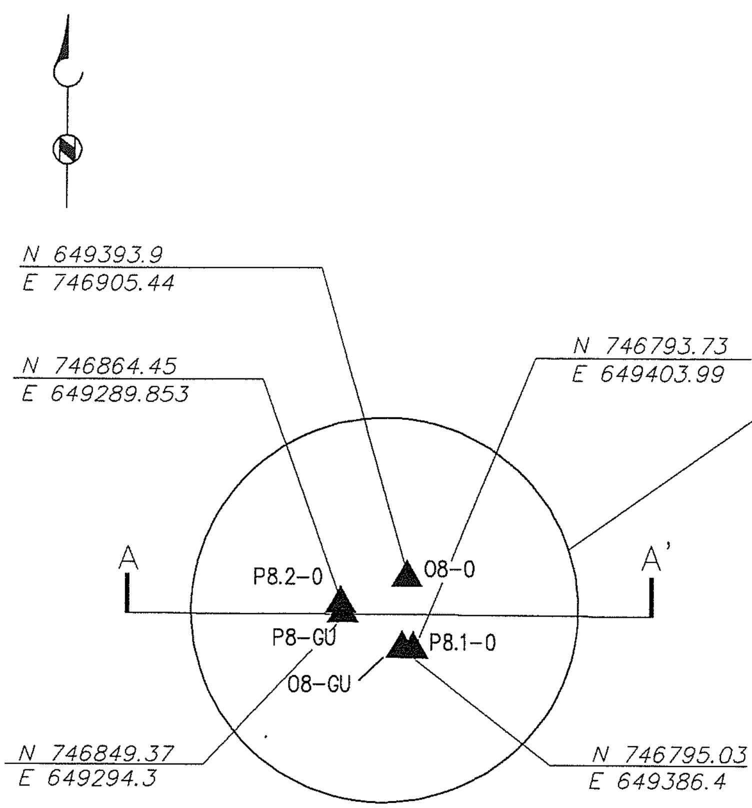
PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES
(AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

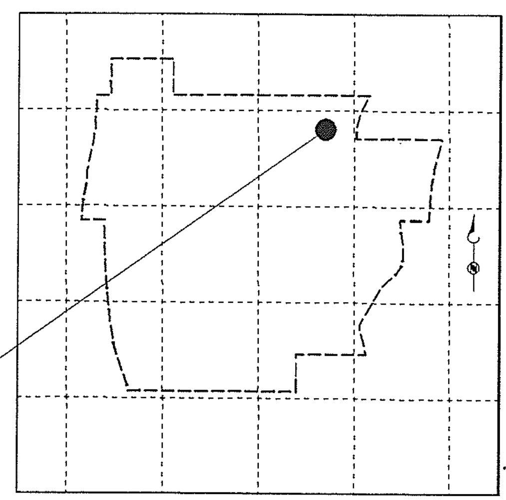
FEET BELOW GROUND SURFACE — 550

SCREENED INTERVAL



WELL PLAN VIEW

Approximate Scale: 1"= 300'



WELL LOCATION MAP

Approximate Scale: 1"= 2000'

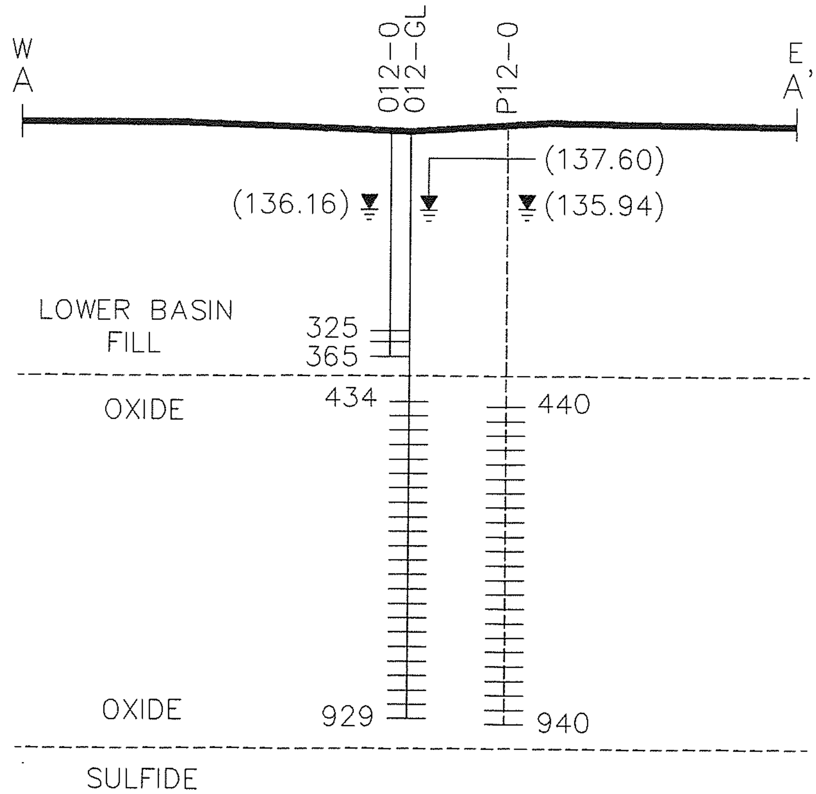
Figure E-3 (II)
LOCATION SUMMARY
AQUIFER TEST
CLUSTER 8

BROWN AND CALDWELL

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

E-3_2 12-01-95 DanH



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

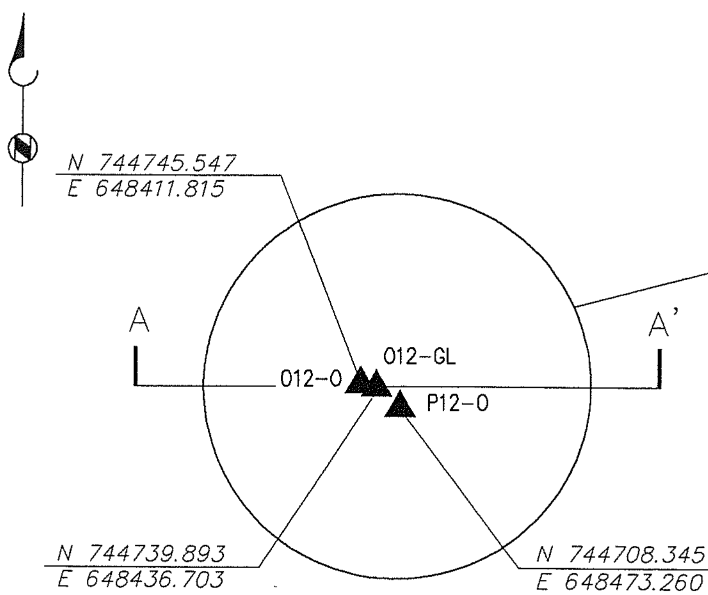
PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES (AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

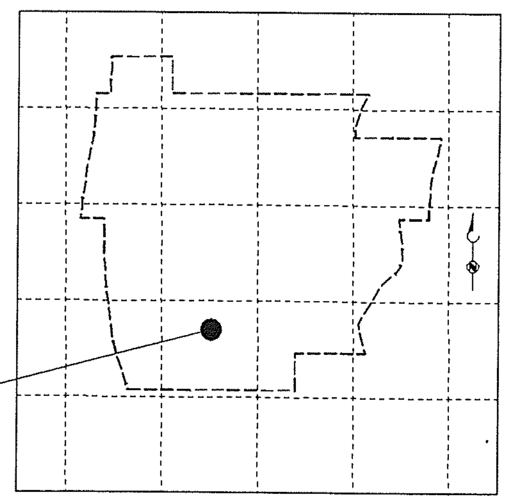
FEET BELOW GROUND SURFACE — 940

SCREENED INTERVAL



WELL PLAN VIEW

Approximate Scale: 1"= 300'



WELL LOCATION MAP

Approximate Scale: 1"= 2000'

Figure E-4 (II)

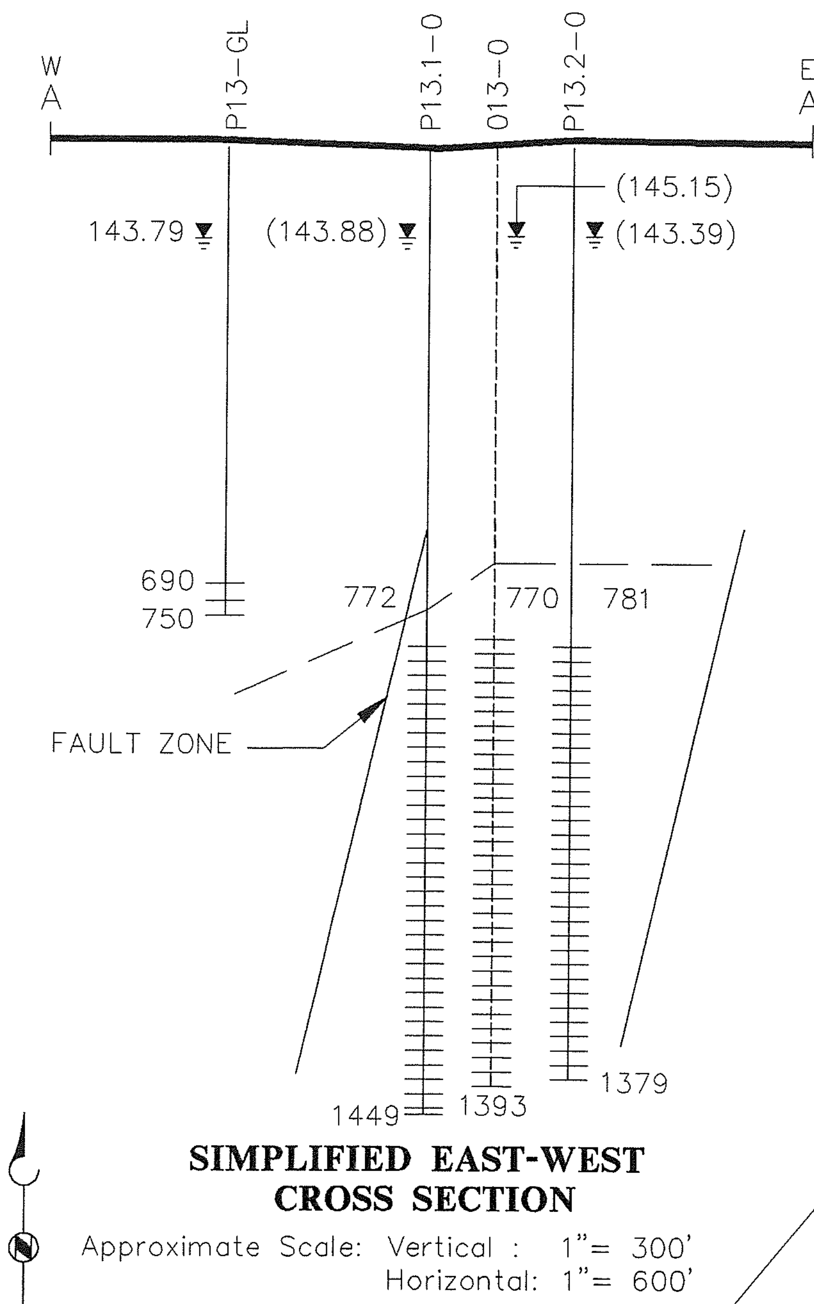
LOCATION SUMMARY AQUIFER TEST CLUSTER 12

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

BROWN AND CALDWELL

E-4_2 12-01-95 DanH



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 600'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

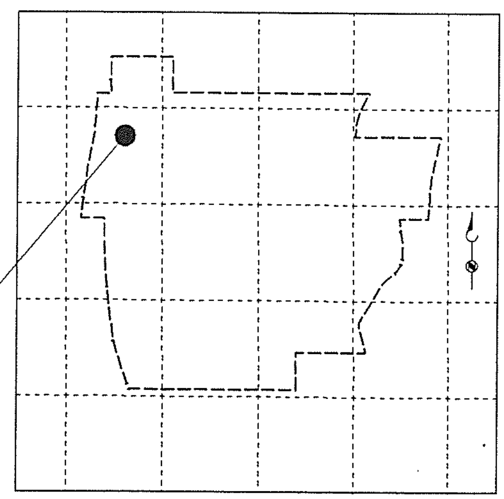
WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES (AQUIFER COMPONENT SCREEN)

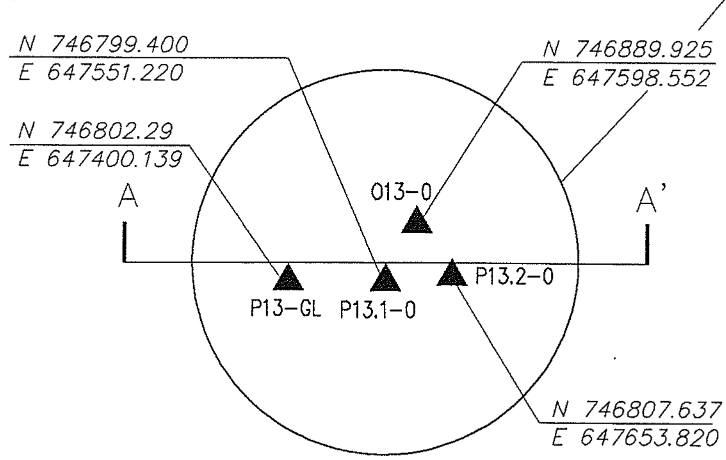
BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

FEET BELOW GROUND SURFACE — 1450 — SCREENED INTERVAL



WELL LOCATION MAP

Approximate Scale: 1"= 2000'



WELL PLAN VIEW

Approximate Scale: 1"= 300'

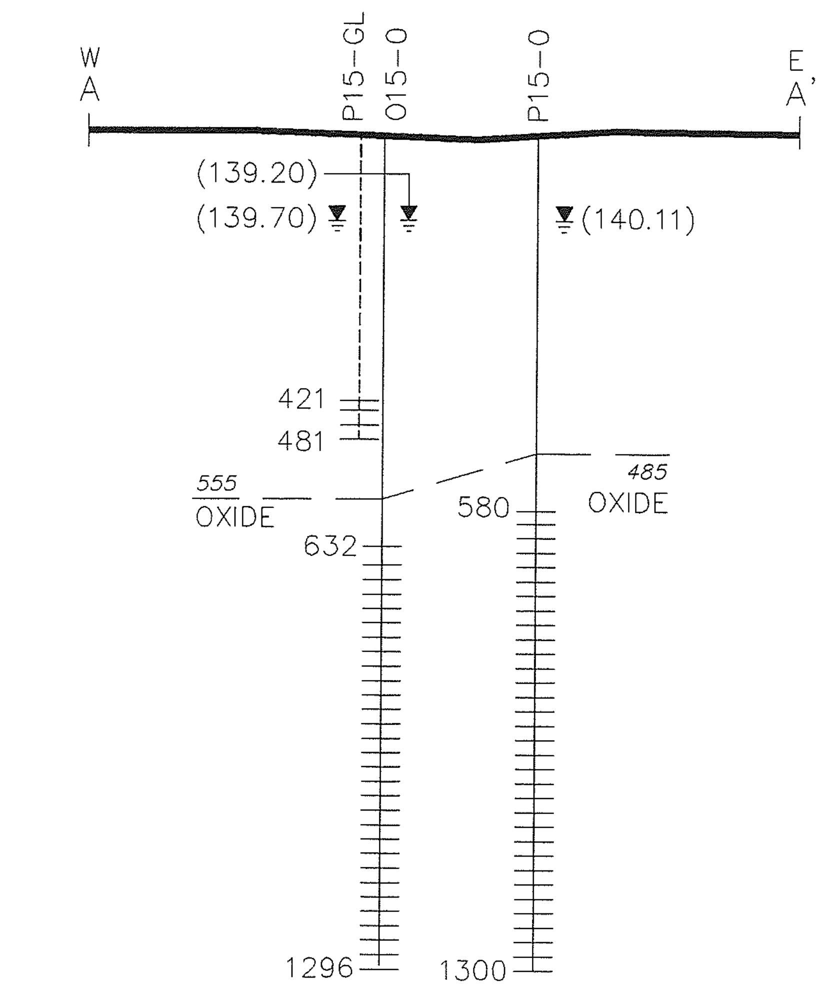
Figure E-5 (II) LOCATION SUMMARY AQUIFER TEST CLUSTER 13

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

BROWN AND CALDWELL

E-5_2 12-01-95 DanH



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

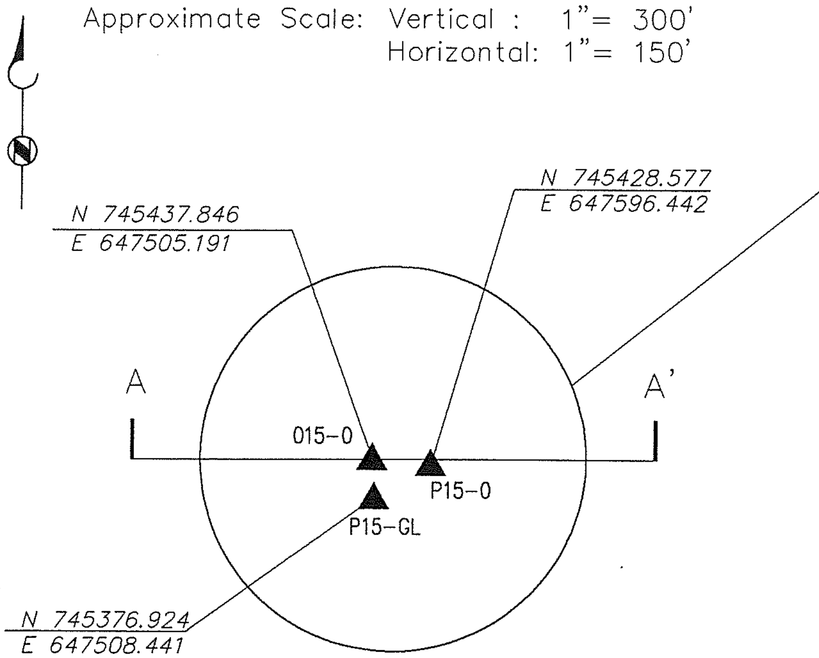
PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES
(AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

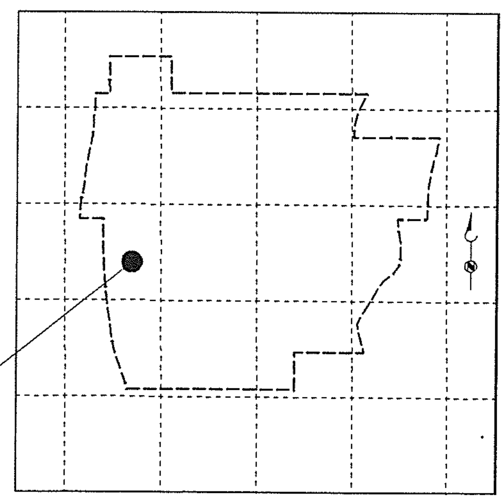
FEET BELOW GROUND SURFACE — 610

SCREENED INTERVAL



WELL PLAN VIEW

Approximate Scale: 1"= 300'



WELL LOCATION MAP

Approximate Scale: 1"= 2000'

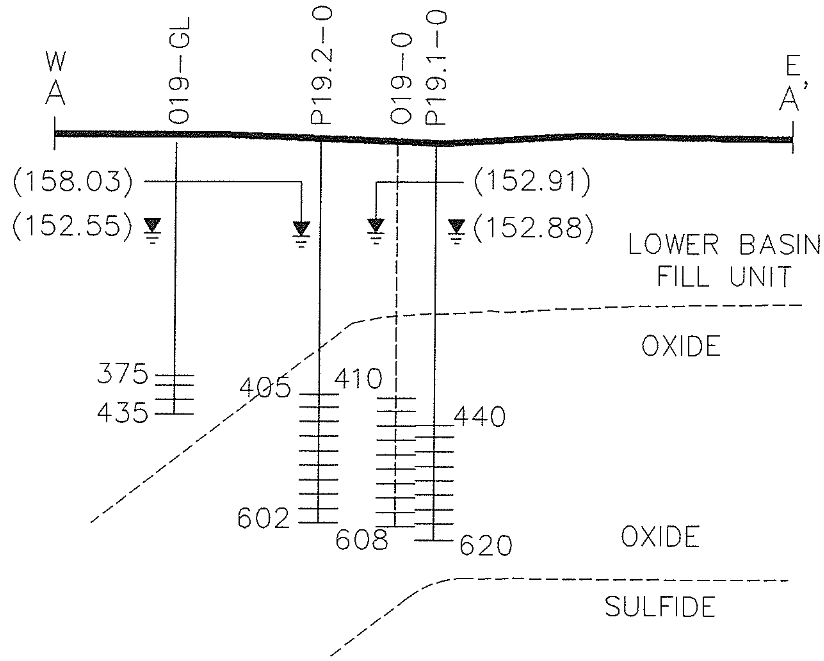
Figure E-6 (II)
LOCATION SUMMARY AQUIFER TEST CLUSTER 15

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

BROWN AND CALDWELL

E-6_2 12-01-95 DanH



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

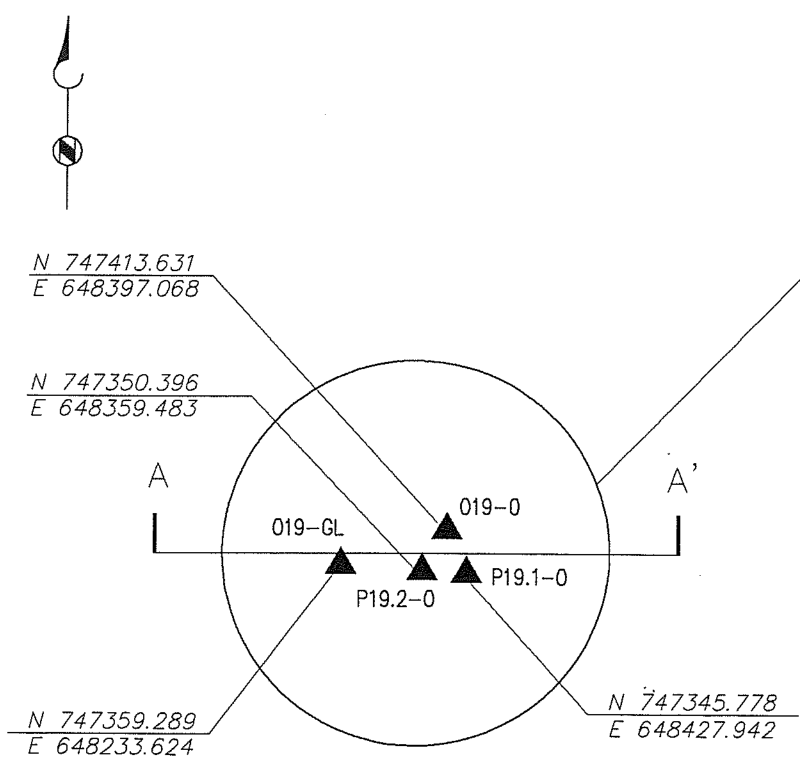
WELL SUFFIXES (AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

FEET BELOW GROUND SURFACE

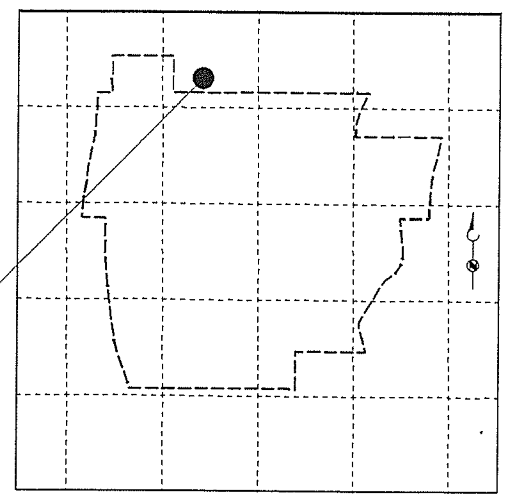
610

SCREENED INTERVAL



WELL PLAN VIEW

Approximate Scale: 1"= 300'



WELL LOCATION MAP

Approximate Scale: 1"= 2000'

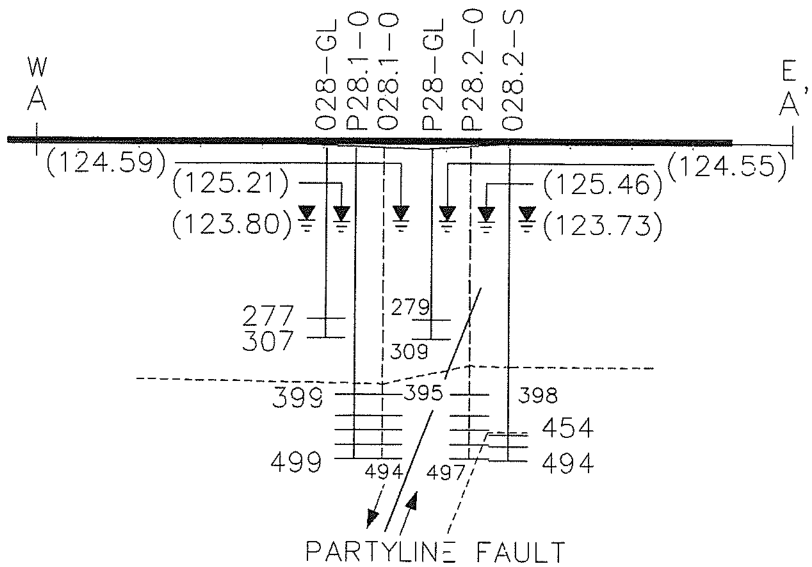
Figure E-7 (II)
LOCATION SUMMARY
AQUIFER TEST
CLUSTER 19

B R O W N AND C A L D W E L L

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

E-7_2 12-01-95 DanH



NOTE:
WELLS 028.1-O AND P28.2-O ARE SCREENED ACROSS FAULT ZONE.

SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

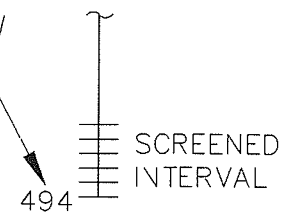
(SHOWN IN FEET BELOW GROUND SURFACE)

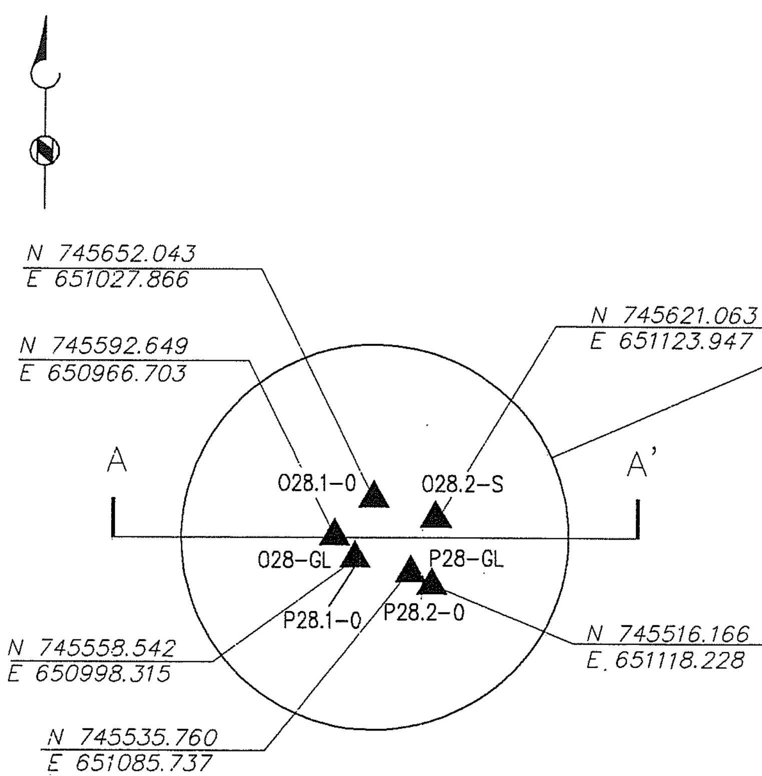
WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES
(AQUIFER COMPONENT SCREEN)

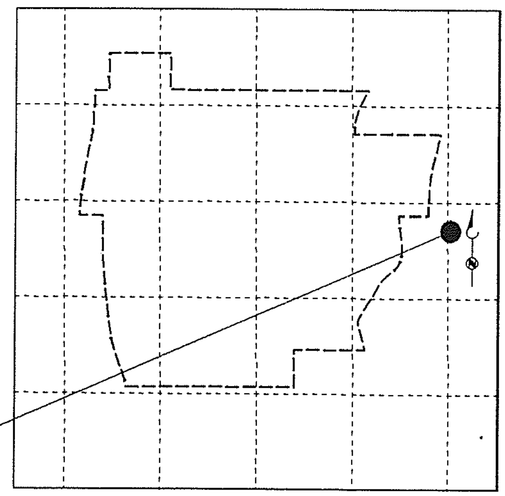
BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S





WELL PLAN VIEW

Approximate Scale: 1"= 300'



WELL LOCATION MAP

Approximate Scale: 1"= 2000'

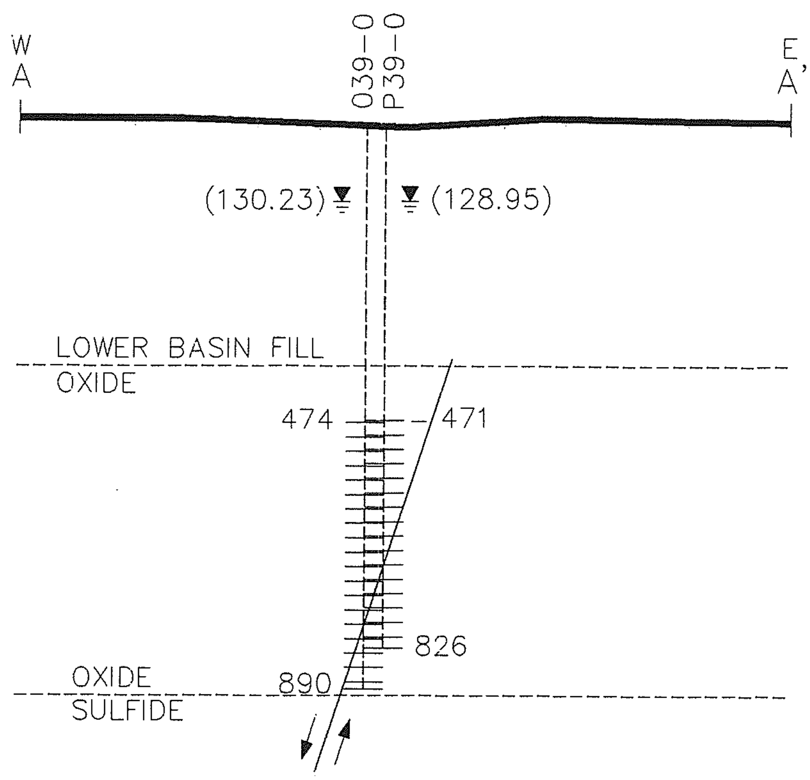
Figure E-8 (II)
LOCATION SUMMARY
AQUIFER TEST
CLUSTER 28

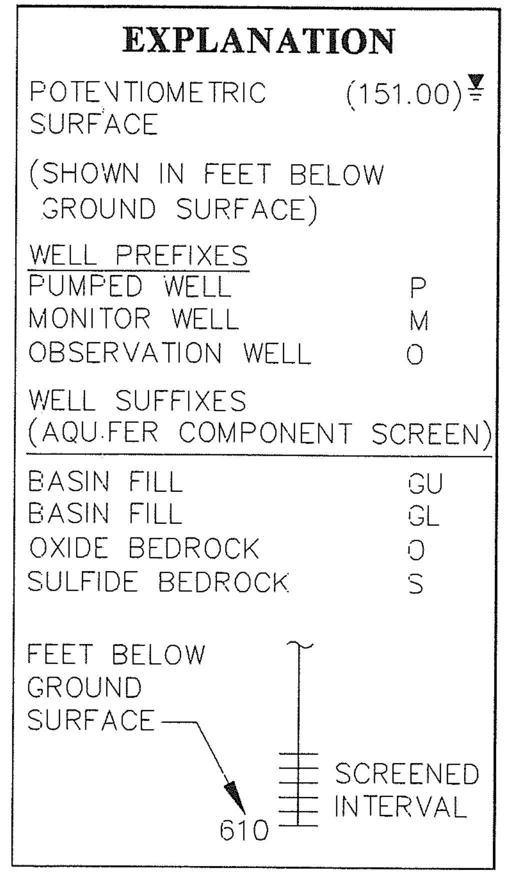
BROWN AND CALDWELL

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

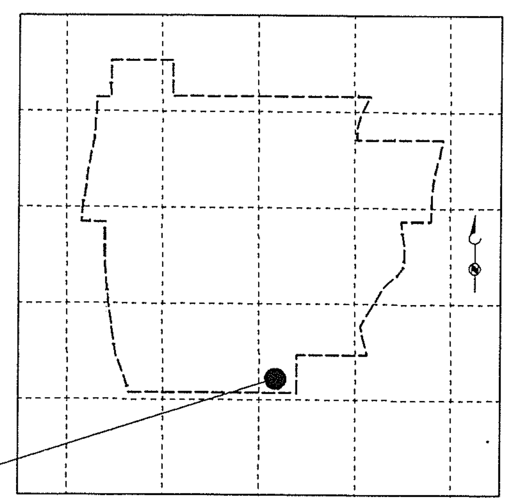
E-8_2 12-01-95 DanH

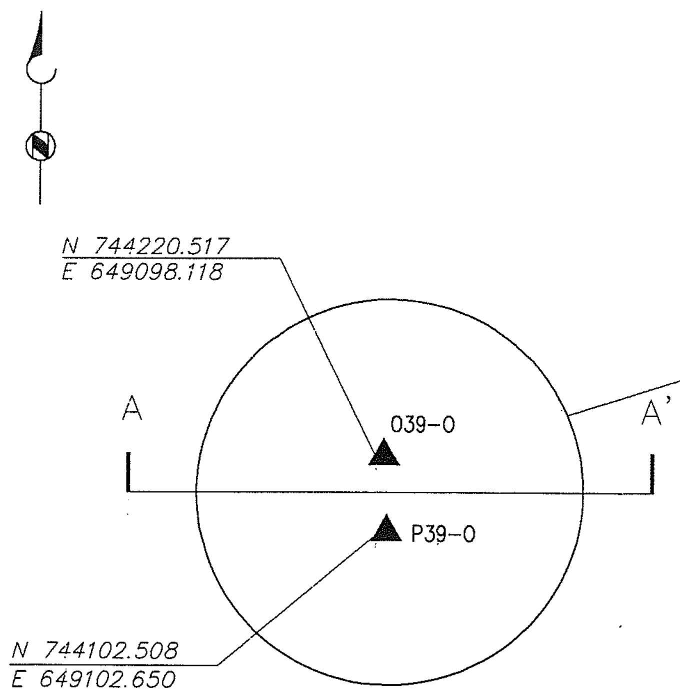




SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'





WELL PLAN VIEW

Approximate Scale: 1"= 300'

WELL LOCATION MAP

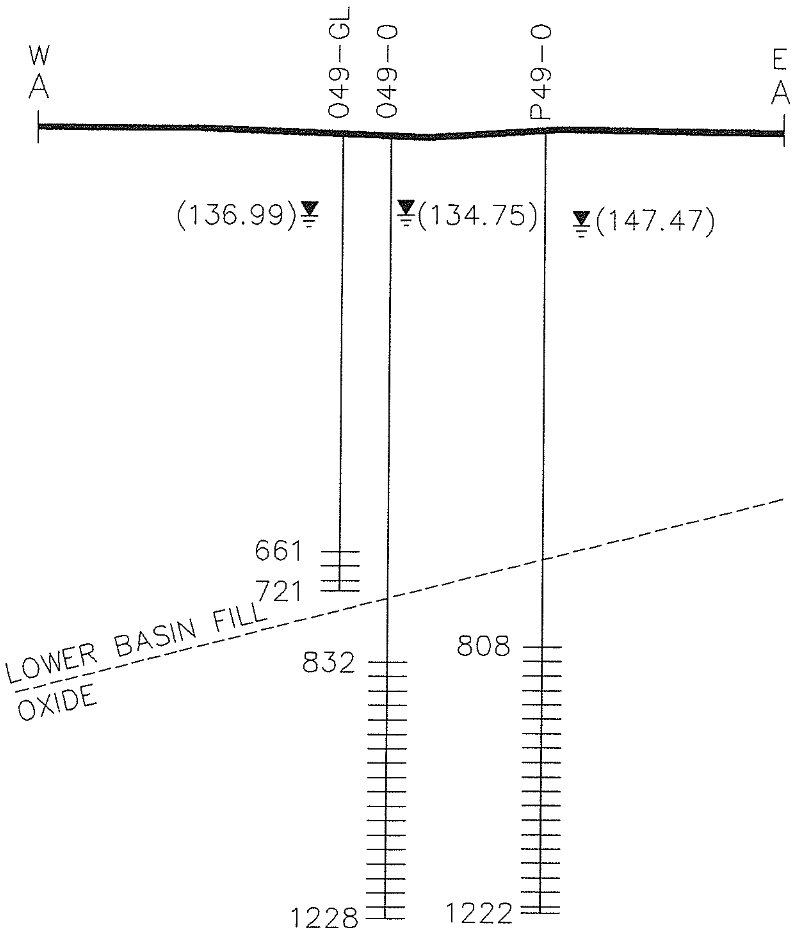
Approximate Scale: 1"= 2000'

Figure E-9 (II) LOCATION SUMMARY AQUIFER TEST CLUSTER 39

BROWN AND CALDWELL

MAGMA COPPER COMPANY
Florence, Arizona

E-9_2 12-01-95 DanH



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

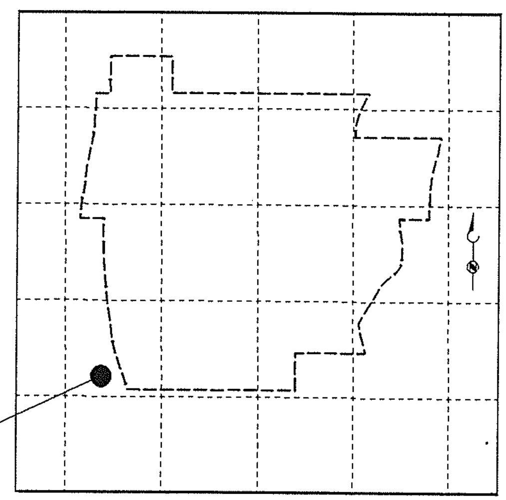
PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES (AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

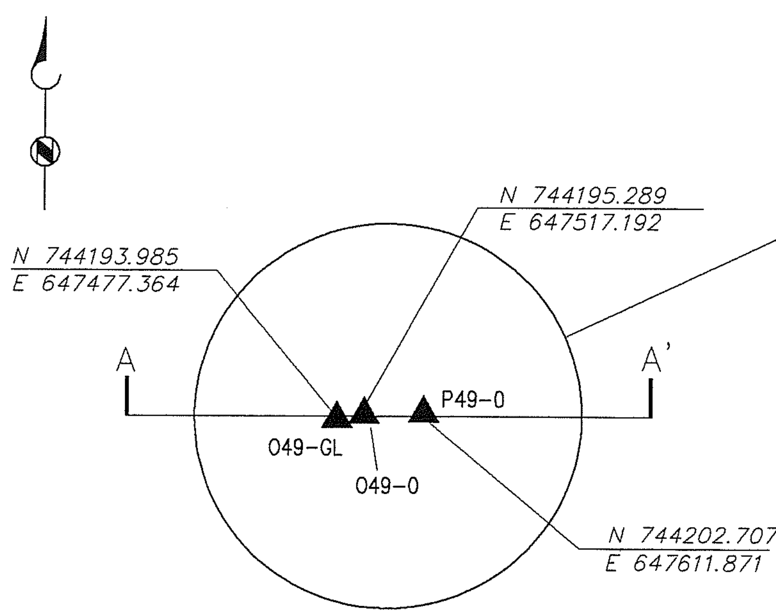
FEET BELOW GROUND SURFACE — 890

SCREENED INTERVAL



WELL LOCATION MAP

Approximate Scale: 1"= 2000'



WELL PLAN VIEW

Approximate Scale: 1"= 300'

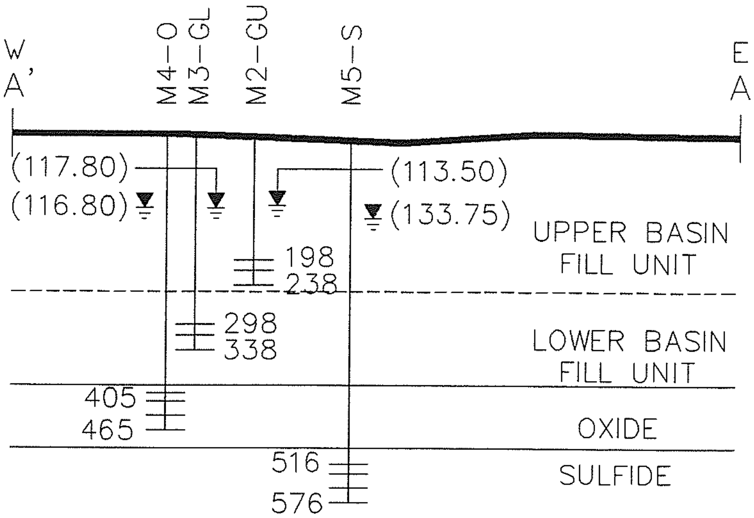
Figure E-10 (II) LOCATION SUMMARY AQUIFER TEST CLUSTER 49

BROWN AND CALDWELL

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

E-10_2 12-01-95 DonH



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

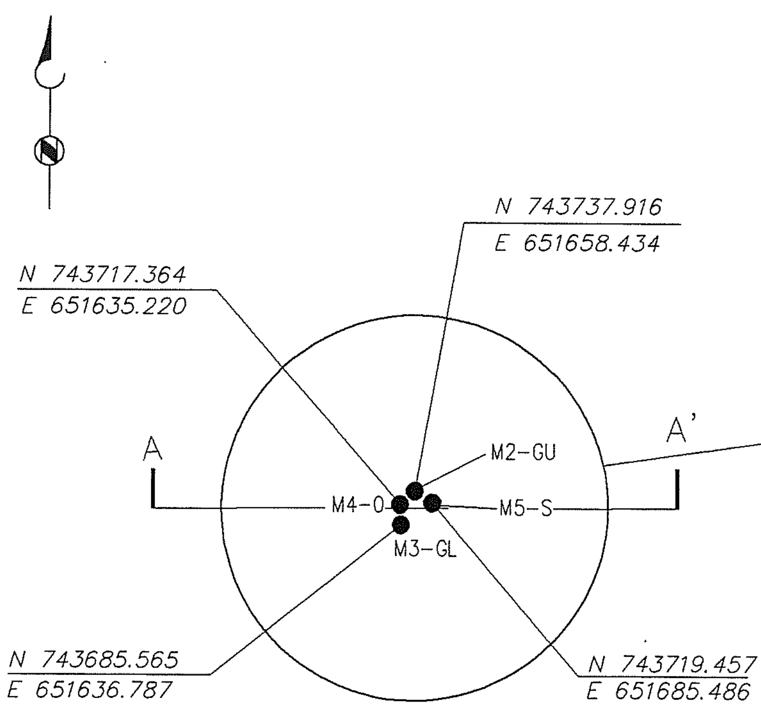
WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES
(AQUIFER COMPONENT SCREEN)

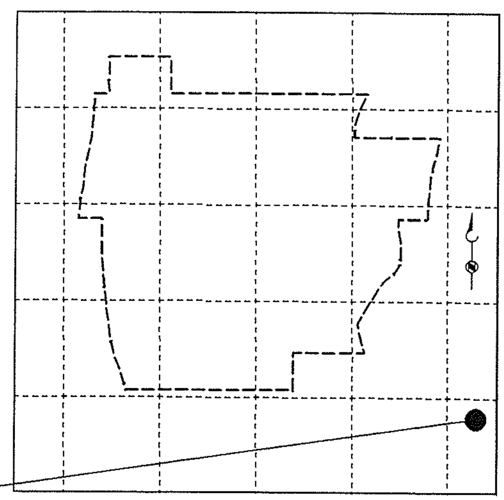
BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

FEET BELOW GROUND SURFACE 576 — SCREENED INTERVAL



WELL PLAN VIEW

Approximate Scale: 1"= 300'



WELL LOCATION MAP

Approximate Scale: 1"= 2000'

Figure E-11 (II)

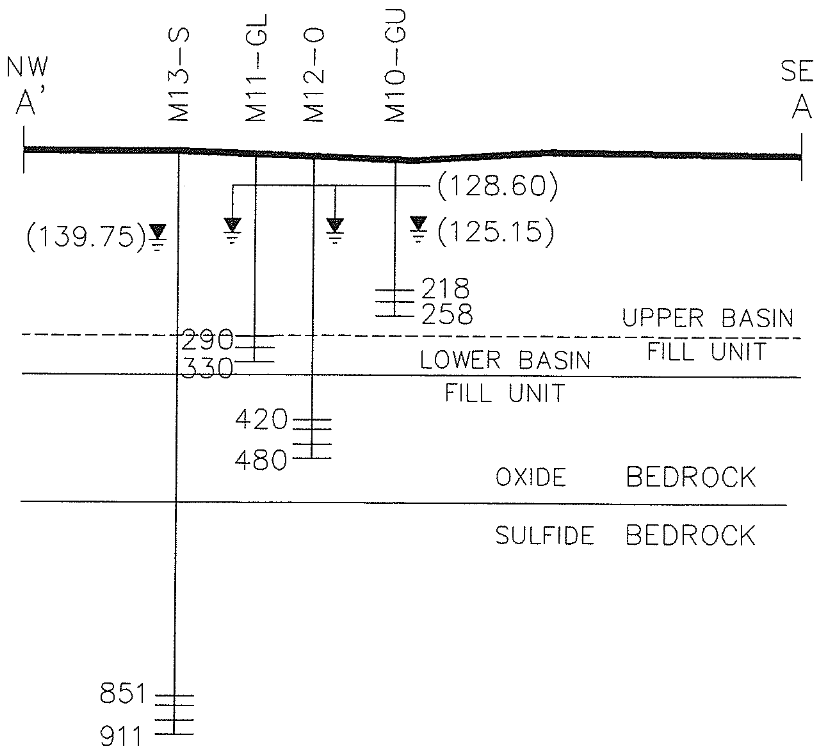
LOCATION SUMMARY SOUTHEAST MONITORING WELL CLUSTER

BROWN AND CALDWELL

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

E-11_2 12-01-95 DonH



SIMPLIFIED NORTHWEST-SOUTHEAST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

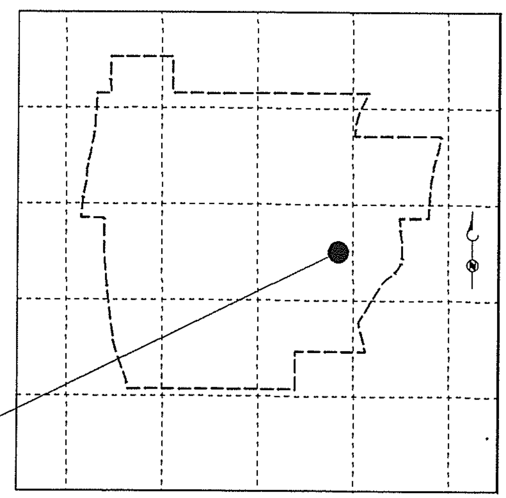
WELL SUFFIXES
(AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

FEET BELOW GROUND SURFACE

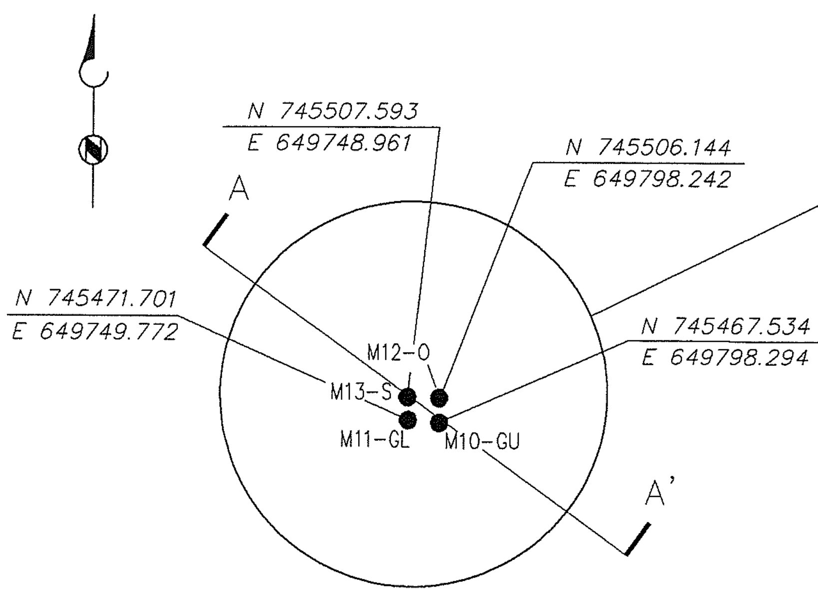
480

SCREENED INTERVAL



WELL LOCATION MAP

Approximate Scale: 1"= 2000'



WELL PLAN VIEW

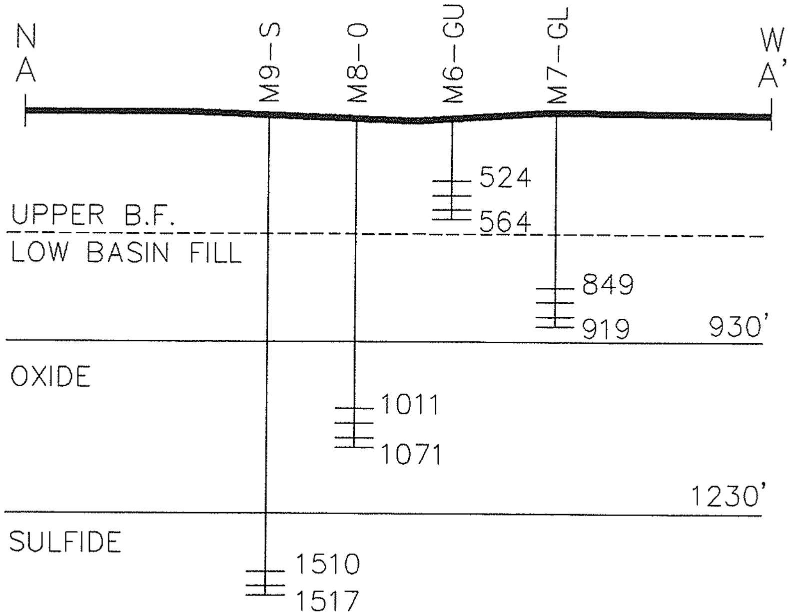
Approximate Scale: 1"= 300'

Figure E-12 (II)
LOCATION SUMMARY MIDDLE MONITORING WELL CLUSTER

BROWN AND CALDWELL

MAGMA
MAGMA COPPER COMPANY
Florence, Arizona

E-12_2 12-01-95 DonH



SIMPLIFIED NORTH-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

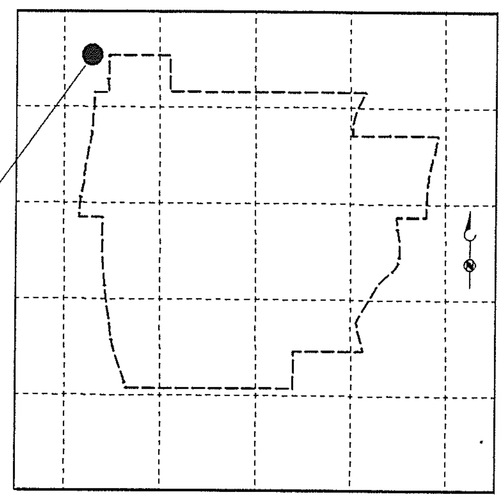
PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES (AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

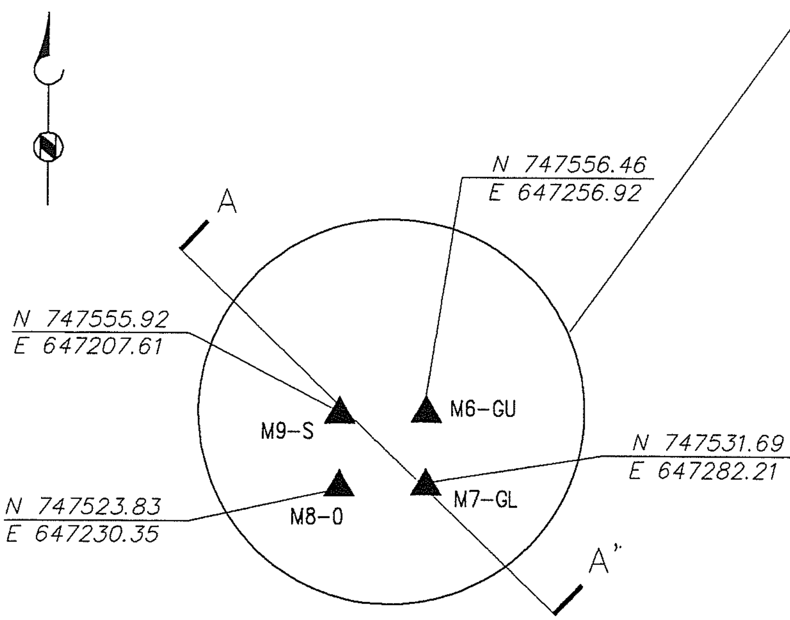
FEET BELOW GROUND SURFACE — 890

SCREENED INTERVAL



WELL LOCATION MAP

Approximate Scale: 1"= 2000'



WELL PLAN VIEW

Approximate Scale: 1"= 300'

BROWN AND CALDWELL

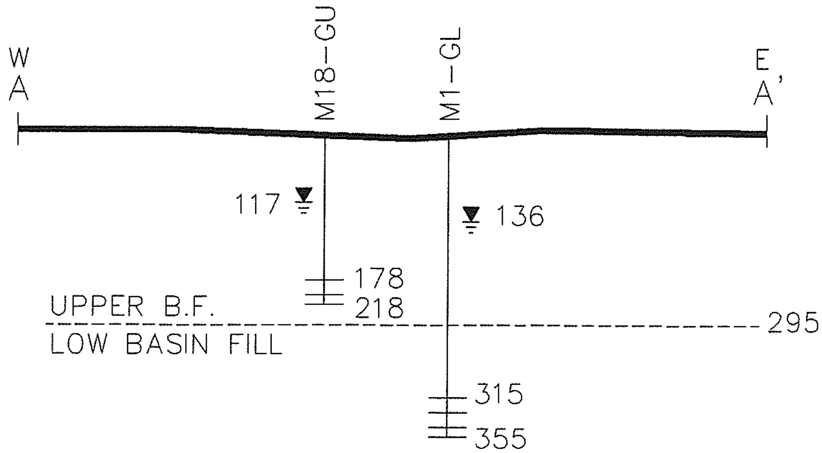
Figure E-13 (II)

LOCATION SUMMARY NORTHWEST MONITORING WELL CLUSTER

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

E-13_2 12-01-95 DanH



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

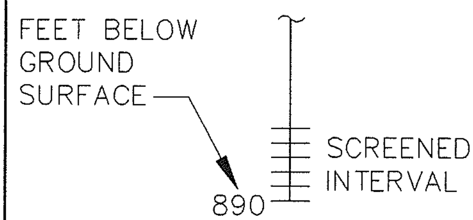
POTENTIOMETRIC SURFACE (151.00)
(SHOWN IN FEET BELOW GROUND SURFACE)

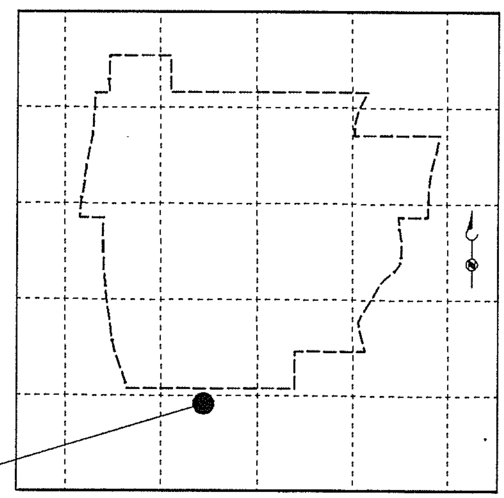
WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

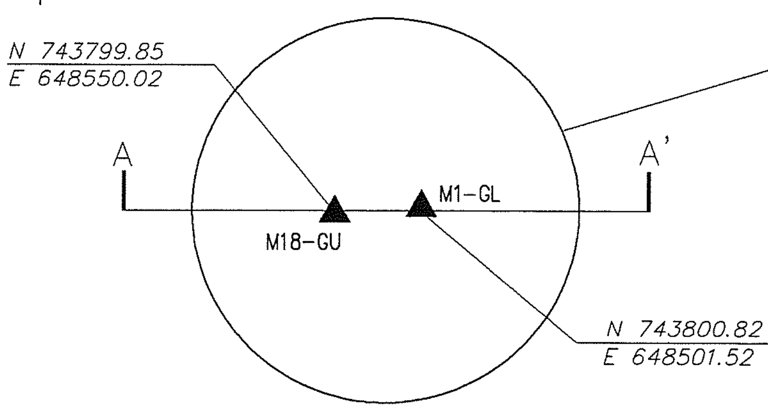
WELL SUFFIXES
(AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S





WELL LOCATION MAP
Approximate Scale: 1"= 2000'



WELL PLAN VIEW
Approximate Scale: 1"= 300'

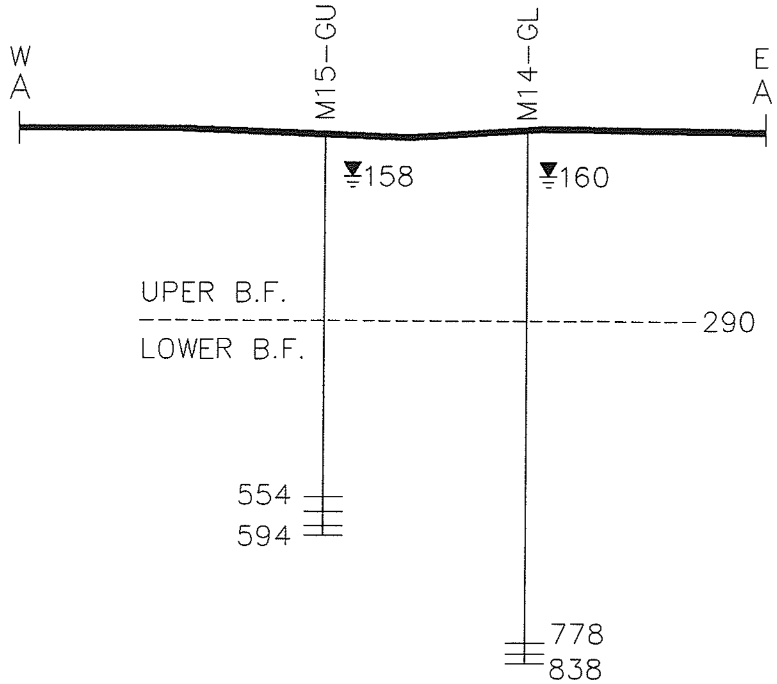
Figure E-14 (II)

LOCATION SUMMARY MONITORING WELL CLUSTER 1 & 18

BROWN AND CALDWELL

MAGMA
MAGMA COPPER COMPANY
Florence, Arizona

E-14_2 12-01-95 DanH



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

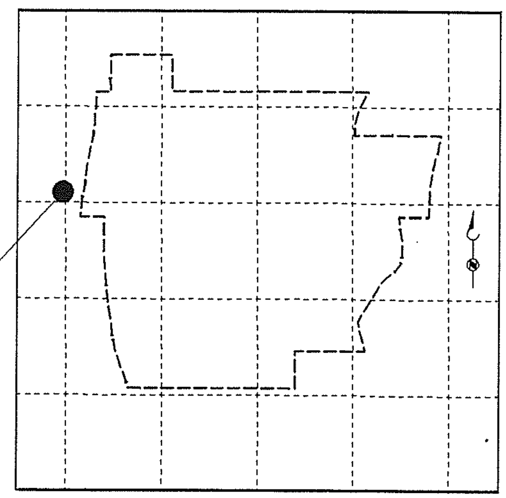
PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES (AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

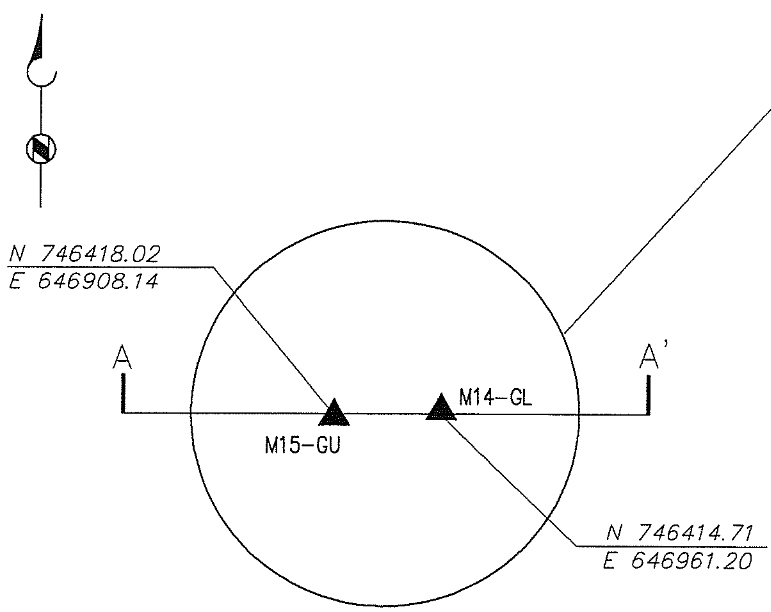
FEET BELOW GROUND SURFACE 890

SCREENED INTERVAL



WELL LOCATION MAP

Approximate Scale: 1"= 2000'



WELL PLAN VIEW

Approximate Scale: 1"= 300'

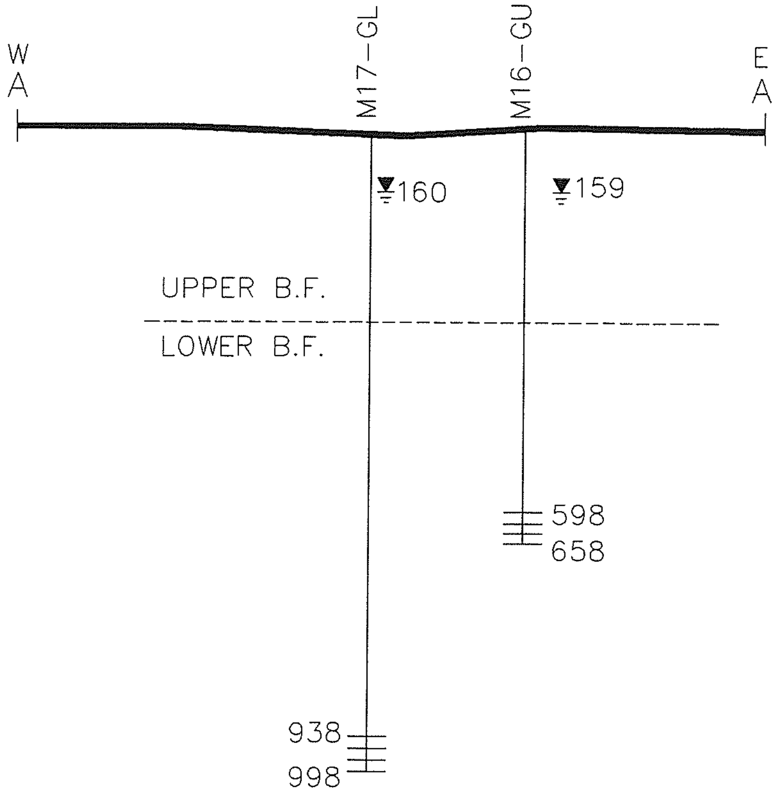
Figure E-15 (II)

LOCATION SUMMARY MONITORING WELL CLUSTER 14 & 15

BROWN AND CALDWELL

MAGMA COPPER COMPANY
Florence, Arizona

E-15_2 12-01-95 DonH



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIAMENTRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

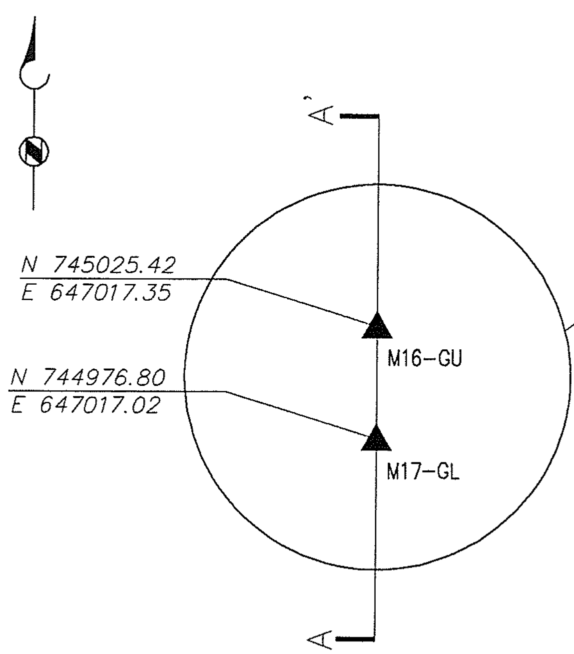
WELL SUFFIXES
(AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

FEET BELOW GROUND SURFACE

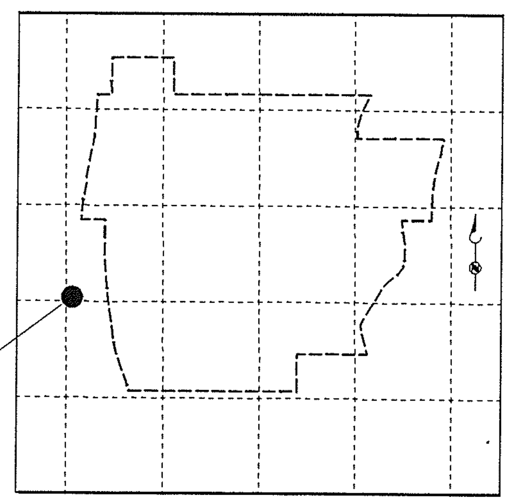
890

SCREENED INTERVAL



WELL PLAN VIEW

Approximate Scale: 1"= 300'



WELL LOCATION MAP

Approximate Scale: 1"= 2000'

Figure E-16 (II)
LOCATION SUMMARY
AQUIFER TEST
CLUSTER 16/17

E-16_2 12-01-95 DanH

BROWN AND CALDWELL

MAGMA
MAGMA COPPER COMPANY
Florence, Arizona

Golder Associates Inc.

4730 N. Oracle Road
Suite 210
Tucson, AZ USA 85705
Telephone (520) 888-8818
Facsimile (520) 888-8817

Golder Associates

Data Report for Initial Interpretation of the Hydraulic Tests at the Florence Mine Site

for

Magma Copper Company Aquifer Protection Permit Florence In Situ Leaching Project

Prepared for:

Magma Copper Company
Resource and Development Group
7400 N. Oracle Road, Suite 162
Tucson, Arizona 85704

Prepared by:

Golder Associates Inc.
4700 N. Oracle Road, Suite 210
Tucson, Arizona 85704

Distribution:
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2 Copies - Dan Ramey, Magma Copper Company
2 Copies - Steve Mellon, Brown and Caldwell
2 Copies - Golder Associates

November 1995

Golder Associates

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Appendix C; **Test Analysis Reports**

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1.0 INTRODUCTION

This report presents the results of the interpretation of hydraulic tests in the area of Magma Copper Company's (Magma) proposed in-situ mining project near Florence, Arizona. The purpose of this report is to provide a technical basis for hydraulic parameter estimation for site characterization in support of state and federal environmental review and permitting requirements.

This report has been prepared as a technical appendix to the Aquifer Protection Permit (APP) Application document prepared by Brown and Caldwell (1995). As such, only hydrogeologic information pertinent to test data interpretation is discussed in this report. The interested reader is directed to the above reference for additional detail.

The analyses presented in this report are based on standard methods developed in the oil and gas industry. These methods are applied to data collected and provided by Brown and Caldwell. Interpretation of the field data is performed with the FLOWDIM™ software of Golder Associates.

This report is divided into three major sections. Chapter 2 presents the mathematical foundation for the well test analysis. A brief discussion of each test and application of this theory to the aquifer test at the Florence Site is presented in Chapter 3. Tables and graphical representation of these analyses are provided in Appendixes A through C. The field data used in these analyses are included in electronic format in the attached diskette.

1.1 Background

Magma has undertaken field studies to characterize the hydrogeologic conditions near its proposed in-situ mining site in the Poston Butte porphyry copper deposit. The proposed mine site is located in the Basin and Range Physiographic Province of southern Arizona, in the Eloy Sub-basin of the Pinal Active Management Area (AMA), and is about 1 mile southwest of Poston Butte and 2 miles northwest of the Town of Florence, Arizona.

The rock units in the study area range in age from Precambrian to Quaternary. The floodplain alluvium is Quaternary in age and consists mainly of unconsolidated silt, sand, gravel and boulders. The Cenozoic basin fill deposits have been divided into three major units; the Upper (UBFU), Middle (MBFU) and the Lower (LBFU) Basin Fill Units. The UBFU is composed of unconsolidated to weakly cemented, interbedded clay, silt, sand gravel and boulders. The thickness of the UBFU ranges from 200 to about 500 feet in the vicinity of the mine site. The MBFU is a discontinuous layer composed by silt and clay that varies in thickness from zero to about 80 feet. Weakly to moderately cemented sand, silt and clay constitute the lower unit (LBFU). The thickness of this latter unit varies from less than 50 feet on the east to about 800 feet to the west of the mine site. The bedrock complex consists of quartz monzonite and granodiorite porphyry, and diabase, basalt and other volcanic rocks.

Magma has retained Brown and Caldwell of Phoenix, Arizona to prepare the APP application for the Florence in-situ project. As part of this APP-site characterization effort, Brown and Caldwell has installed forty six (46) monitoring wells and seventeen (17) test wells around the site. Eight (8) of these wells are completed within the UBF Unit, seventeen (17) within the LBF Unit and thirty eight (38) within the bedrock complex. To date, Brown and Caldwell has conducted twenty five (25) aquifer tests which include monitoring wells as well as test boreholes. Magma requested that Golder Associates assist Brown and Caldwell with the design and interpretation of the hydraulic tests required as part of the APP process. Nineteen (19) aquifer test locations were selected for interpretation. These locations cover the range of typical hydrogeologic conditions observed at the site. The following sections present an overview of the theory and methods of interpretation, and the analytical results for a portion of these aquifer tests.

2.0 THEORY AND METHODS OF INTERPRETATION

Well testing provides a means of acquiring knowledge of the properties of hydrogeological formations. In the process of a well test, a known signal (usually a change in flow rate) is applied to the formation and the resulting output signal or response is measured (usually in terms of a change in pressure). Well test interpretation is therefore an inverse problem in that the formation parameters are inferred by comparing a simulated model response to the measured response. The formation parameters are derived by adjusting the flow model parameters to obtain a simulation response that matches the measured data. Clearly, there can be significant ambiguity and non-uniqueness involved in this process, as more than one flow model with different physical assumptions and attributes may match the data. In most situations this can be minimized by careful validation of the selected model using other data.

The overall methodology for the detailed well test analysis of the Florence Project data was as follows:

- the data set was divided into its major components, such as the drawdown period and the shut-in or recovery period;
- appropriate parts were then analyzed separately, with different methods of analysis for flow periods and shut-in periods;
- the analyses of the different periods were checked for consistency.

2.1 Analysis of Recovery Period

The analysis of recovery (shut-in) periods is usually based on the assumption that the shut-in period corresponds to an event of zero flow rate following a fixed period of known finite, constant flow rate. If the flow rate prior to the shut-in period is variable, then this flow history can be included in the analysis by using the superposition of a number of different but constant flow rates of different durations.

The next step in an hydraulic test analysis involves the selection of an appropriate flow model. these models are generally divided into three basic components.

- inner boundary conditions (i.e., wellbore storage and skin effects, and fracture flow effects);
- formation flow component (i.e., homogeneous formation, dual porosity, and composite model);.
- outer boundary conditions (i.e., infinite extent condition, no flow or constant pressure conditions).

In practice, recognition of a suitable model is performed using diagnostic plots. The data are plotted in different coordinate systems (such as, log-log plots, semi-log Horner plots, etc.) to help the analyst identify the appropriate model from the shape of the data. One key diagnostic plot is the derivative plot where the derivative of the pressure with respect to the natural logarithm of elapsed time is plotted against the log of time. The pressure derivative is extremely sensitive to the shape of the pressure data and as such constitutes the most useful tool for diagnostic purposes. For example, a horizontal line on a derivative plot (presented in a log-log scale) indicates infinite-acting radial flow behavior.

Data from shut-in periods are examined in both log-log and semi-log diagnostic plots. This approach allows the analyst to review the characteristics of the shut-in period. For example, when the effects of the pre-test injection/extraction flows during drilling are significant, the shut-in pressure data reach a peak before starting to decline at late time. This form of data is referred to as a 'rollover' and can be easily diagnosed on the log-log and semi-log plots. The log-log and the semi-log diagnostic plots are also used to fit selected portions of the shut-in data with appropriate straight lines and obtain initial estimates of formation parameters.

After the flow model has been selected, the quality of the fit of the data with the model response (called 'type curves') is adjusted by using automated regression methods. During this stage of the analysis, the entire data from the selected shut-in period is considered. However, during the final regression stages, emphasis is always placed on the fit of the type curves to specific portions of the data. Judgment of the relative goodness of fit to specific portions of the shut-in data comprises one of the most important aspects of the automated data fitting procedure. Once a suitable and consistent fit of the data is obtained to the type curves, the fit is reviewed for final refinement. The entire measured data set from the shut-in period generated using the best flow model parameters derived from the shut-in analysis is displayed in a cartesian plot.

After the flow model has been selected and a consistent set of analysis results obtained, a sensitivity analysis could be conducted. This exercise is designed to quantify the likely uncertainty in the estimated hydraulic conductivity. When carried out, it helps to determine the range of the parameter within which a reasonably good fit is retained between the model response and the data. The ranges of this parameter therefore reflect uncertainty in the analysis.

2.2 Analysis of Drawdown Period

If a sufficient hydraulic head change is achieved during the drawdown period, the available data were analyzed as a constant discharge test. Otherwise, the data were not use in the interpretation.

In an analysis of the main flow period, the source signal is assumed to be in the form of an instantaneous pressure change from undisturbed in-situ conditions. The data for this flow period is the measured hydraulic head decrease during the test resulting from fluid extraction from the formation. The analysis used a simple set of type curves which correspond to a single interpretation model :

- inner boundary condition: wellbore storage and skin;
- formation: homogeneous; and
- outer boundary condition: infinite lateral extent.

Only one of two parameter sets can be determined from this analysis: hydraulic conductivity and wellbore skin (the static water level being an input parameter for this analysis) or hydraulic conductivity and storativity. The best fit of the data to the type curves therefore corresponds to finding the optimum set of the two output parameters.

The following section (Section 2.3) describes the general theory underlying hydraulic test analysis. Section 2.4 presents the governing equations and related assumptions. The parameters for various flow models are discussed in Section 2.5. Section 2.6 outlines general methods that are applied to the analysis of hydraulic tests. The reader interested in the specific methodology of detailed test interpretation is therefore directed to Section 2.6.

2.3 Theoretical Background

The purpose of this discussion is to provide a summary of the mathematical and physical background of the aspects of well test analysis that are relevant to the Florence Site. The presentation is divided into three parts:

Part one defines the basic rock and fluid parameters used in the analysis of transient well tests (Section 2.3.1). The second part presents the 'diffusion equation' that governs the flow in porous media, identifies its underlying assumptions, and describes some special solutions (Section 2.4). Data analyses of Florence hydraulic tests are based on various solutions of the diffusion equation. Finally, the third part describes the interpretation models that have been applied to analyze the Florence hydraulic test data (Section 2.6).

Aspects of theoretical well testing have been documented in numerous papers and textbooks, both in the petroleum engineering and the groundwater literature. The interested reader is directed to the following summarizing references: Kruseman and de Ridder (1991) and Dawson and Istok (1991) for theoretical aspects of pump test analyses written mainly for the 'hydrogeology audience' and Earlougher (1977), Streltsova (1988), Horne (1990) and Sabet (1991) targeted mainly at the 'petroleum formation evaluation audience.'

2.3.1 Rock and Fluid Properties

2.3.1.1 Porosity and Compressibility

Fluid properties such as water compressibility, density, viscosity, and in some cases the thermal expansion coefficient, have to be estimated prior to analysis of the test data. Formation compressibility and porosity must be known (or a reasonable value assumed) in order to analyze transient tests and to obtain estimates for the skin coefficient.

Rock porosity, ϕ, is defined as the ratio of the void volume to the total bulk volume. For analysis of fluid movement the effective porosity of the rock is used. It represents the interconnected volume of pores available for fluid transport. For the Florence hydraulic tests, it was assumed that the average porosity of the Oxide and unconsolidated alluvial sediments is 0.05 and 0.10 respectively. Fractured reservoir rocks can be represented as comprising of two overlapping continua with different porosities. One is the intergranular matrix porosity and the other is the porosity created by the void spaces of fractures. These two types of porosity are called primary and secondary porosity respectively. The total porosity (or total effective porosity) of the double-porosity system is the sum of the primary and secondary porosities. Laboratory measurements on various types of fractured rock have shown that the fracture porosity is usually significantly less than the matrix porosity (von Golf-Racht, 1982)

The isothermal compressibility of water (and rock) is generally defined as:

$$c = \frac{1}{V}\frac{dV}{dP}\Big|_T \qquad 2.1$$

where the derivative is taken under the condition of constant temperature. In Eq. 2.1, V is the total volume of a given mass of material, and dV is the instantaneous change in volume induced by an instantaneous change in pressure dP.

The total compressibility of the rock-fluid system with 100% water saturation is made up of two components;

$$c_T = c_W + c_R \qquad 2.2$$

where:

c_T	=	total compressibility	Pa^{-1}
c_W	=	compressibility of water	Pa^{-1}
c_R	=	compressibility of rock	Pa^{-1}

Total compressibility was assumed equal to 5.4×10^{-4} Pa^{-1} for the analyses of the aquifer tests at the Florence site. Water compressibility data are readily available as a function of salinity, temperature and pressure. The correct estimation of the rock compressibility, however, is difficult. Data in the literature cited in Belanger et al. (1989) give a possible range of the fractured rock compressibility as 2.0 x10^{-9} kPa^{-1} to 2.0 x10^{-5} kPa^{-1}.

Specific storage, S_S, of a saturated confined aquifer is defined as the volume of water that a unit volume of aquifer releases from storage under a unit decline in hydraulic head. This parameter depends directly on the ϕc_T product (Earlougher, 1977):

$$S_S = \phi c_T(\rho g) \qquad m^{-1} \qquad 2.3$$

where:

ρ	=	density of water	kg/m^3
g	=	acceleration of gravity	ms^{-2}.

2.3.1.2 Wellbore Storage

Another form of compressibility, of the fluid inside the borehole, is wellbore storage. During a hydraulic test, wellbore storage causes the downhole flow rate to change more slowly than the surface flow rate. The borehole storage is equal to the change in the volume of fluid in the wellbore, per unit change in the downhole pressure. The wellbore storage coefficient is defined by

$$C = \frac{\Delta V}{\Delta P} \qquad m^3 Pa^{-1} \qquad 2.4$$

noting that ΔV refers to the change in volume of fluid inside the wellbore, and ΔP refers to the change in the downhole (borehole) pressure.

In a wellbore with a changing fluid level (for example during a constant rate pumping period) the wellbore storage coefficient is given by:

$$C = \frac{\pi r_t^2}{\rho g} \qquad 2.5$$

where:

πr_t^2 = volume of tubing per unit length

ρg = change in pressure per unit length

When the fluid level is fixed (for example during a shut-in period) the wellbore storage coefficient is given by

$$C = \pi r_W^2 h c_{WW} = V_W c_{WW} \qquad 2.6$$

where V_W is the test section volume (h is the test section length and r_W the wellbore radius) and c_{WW} is the compressibility of the water in the wellbore. The wellbore storage coefficient varies by orders of magnitude depending on the mode of storage within a test. For example, assuming ρg = 10 kPa/m, h = 50 m, r_W = 0.079 m, r_t = 0.035 m and $c_{WW} = 4 \times 10^{-7}$ kPa^{-1}, values of C from equations 2.5 and 2.6 are calculated to be 3.8×10^{-4} m^3/kPa and 3.9×10^{-7} m^3/kPa, respectively.

2.3.1.3 Permeability and Hydraulic Conductivity

The estimation of hydraulic conductivity was the primary objective of the aquifer testing at the Florence site. This parameter is related to both the fluid and fluid transmitting characteristics of the formation. This relationship can be illustrated through the well-known Darcy equation:

$$q = -K\frac{dH}{dL} \qquad 2.7$$

where:

q	=	Darcy flux	ms^{-1},
K	=	hydraulic conductivity	ms^{-1},
dH/dL	=	hydraulic gradient	*unitless*,
H	=	hydraulic head	*m*,
L	=	length or distance	*m*.

The Darcy flux assumes that flow occurs over the entire flow area. In other words, it is a macroscopic velocity. Darcy's law holds only for laminar flow.

The same equation can be expressed in terms of intrinsic permeability (k) which represents the conductance that the rock offers to fluid flow:

$$q = -\frac{k}{\mu}\frac{dP}{dL} \qquad 2.8$$

where:

P	=	pressure	*Pa*,
μ	=	dynamic viscosity	*Pa-s*,
k	=	intrinsic permeability	m^2.

Intrinsic permeability is defined for a single fluid flowing through the rock and represents a transmissive property of only the rock system. Equating Eq. 2.8 with Eq. 2.7 and including the head-pressure correlation, results in an equation relating hydraulic conductivity and intrinsic permeability:

$$K = \frac{k}{\mu} \rho g \qquad 2.9$$

2.3.1.4 Hydraulic Head

The hydraulic head is expressed in terms of the pressure (P) and an elevation (Z) relative to a known datum. It can be thought of as a column of fluid of length H with a specific density ρ, assuming an atmospheric pressure of P_{atm}, and acceleration of gravity g,

$$H = \frac{P - P_{atm}}{\rho g} - Z \qquad 2.10$$

2.4 Assumptions and Governing Equation

The general well test analysis approach is based on solutions to the diffusion equation (also known, in the petroleum literature, as the diffusivity equation) for various sets of initial and boundary conditions. There are two common ways of presenting these solutions:

a) Hydraulic head, hydraulic conductivity and storage, or
b) Pressure, permeability, porosity, compressibility and fluid viscosity.

When expressed in terms of pressure, the diffusion equation is (see, for example, Lee, 1982):

$$\frac{\partial^2 P}{\partial r^2} + \frac{1}{r}\frac{\partial P}{\partial r} = \frac{\phi \mu c_t}{k}\frac{\partial P}{\partial t} \qquad 2.11$$

where:

r	=	radial distance	*m*,
t	=	time	*s*.

This equation is a linear parabolic partial differential equation, that is derived using the following assumptions (Horne, 1990):

a) Darcy's Law applies;
b) Porosity, permeability, viscosity and rock compressibility are constant;
c) Fluid compressibility is small and constant;
d) Pressure gradients in the formation are small;
e) Flow is single phase;
f) Gravity and thermal effects are negligible;
g) Permeability is isotropic; and
h) Only horizontal radial flow is considered.

The solutions of the diffusion equation are usually given in terms of dimensionless parameters. The dimensionless variables lead to both a simplification and generalization of the mathematics (Dake, 1978). Moreover, with dimensionless variables, the solutions are invariant in form, irrespective of the units system used. The dimensionless pressure, P_D, is a solution to Eq. 2.11 for specific initial and boundary conditions. In the case of the constant surface flow rate (q), the pressure at any point in the formation penetrated by the well is described by the generalized solution below (Earlougher, 1977):

$$P_i - P(r,t) = \frac{qB\mu}{2\pi kh}[P_D(t_D, r_D, C_D, \omega, \lambda, ...) + s] \qquad 2.12$$

where B is the formation volume factor, equal to a volume of fluid at well pressure and temperature normalized to standard surface conditions (B is considered to be unity during the analyses of the Florence data). The variables t_D and r_D are the dimensionless time and radius, respectively; C_D is the dimensionless wellbore storage. The other parameters are defined in the Nomenclature section (Section 6.0).

The physical pressure drop is equal to a dimensionless pressure drop times a scaling factor. The scaling factor depends only on flow rate and reservoir properties. The concept applies in general, even for complex situations. It is this generality that makes the dimensionless solution approach useful. P_D is a function of time, location, system geometry and other variables (Earlougher, 1977).

The dimensionless time, t_D, in Eq. 2.12 is defined by:

$$t_D = \frac{kt}{\phi \mu c_t r_W^2} \qquad 2.13$$

where r_W is the radius of the well. The definitions for the dimensionless radius and the dimensionless wellbore storage are:

$$r_D = \frac{r}{r_W} \qquad 2.14$$

and,

$$C_D = \frac{C}{2\pi \phi c_t r_W^2 h} \qquad 2.15$$

Equations 2.13 through 2.15 are expressed in a consistent set of units. In the simple case of steady state radial flow, P_D is equal to ln (r_e/r_w), where r_e is the radius of the circular constant pressure boundary, and Eq. 2.12 becomes the well known steady-state radial form of Darcy's Equation (Earlougher, 1977), or the Thiem Equation (see Section 2.1.1 of Kruseman and de Ridder, 1991). For transient flow, P_D is always a function of dimensionless time (Eq. 2.13), dimensionless radius (Eq. 2.14), and other parameters related to the flow geometry (Earlougher, 1977). Dimensionless pressure can be applied easily, and results in simple general equations that apply to any sort of reservoir properties. It is easily adapted to mathematical manipulation and superposition so that more complex systems can be considered.

In order to account for tests that do not have a constant flow rate (the assumption used to derive Eq. 2.12), the superposition technique is applied. This approach makes it possible to describe a variable rate event (including a shut-in, which is an event with a zero surface flow rate) using a number of constant rate events. The variable rate superposition has been described in detail in well testing literature (Earlougher, 1977; Lee, 1982; Horne, 1990).

The principle of superposition holds for systems that can be described mathematically as 'linear systems' (Horne, 1990). Since most well test solutions are derived from linear diffusive flow equations with linear boundary conditions, the principle of superposition is applicable for most of the standard response functions. The superposition theorem simply states that the sum of individual solutions of a linear flow equation is also a solution of that equation (Drake, 1978). For a variable rate event, the principle of superposition in time can be used to describe the flow response, using a series of constant rate solutions. If a variable rate event is separated (discretized) into 'n' constant rate flow periods, a solution for the n^{th} flow period can be found by solving the diffusivity equation for each flow rate individually and superposing the solutions according to the following equation (Gringarten, 1979; Bourdet et al., 1989):

$$P_D = \sum_{i=1}^{n-1} \frac{q_i - q_{i-1}}{q_{n-1} - q_n} [P_D(\sum_{j=1}^{n-1} \Delta t_{jD}) - P_D(\sum_{j=1}^{n-1} \Delta t_{jD} + \Delta t_D)] + P_D(\Delta t_D) \qquad 2.16$$

where each of the 'n' flow periods has a flow rate of q_i ($q_i \geq 0$) and a duration of Δt_i with Δt being the elapsed time in the 'n[th]' flow sequence. The subscript 'D' for the time refers to dimensionless time, which is proportional to real time and is given by Eq 2.13.

2.5 Interpretation Models

Type curve matching for pumping test data was first introduced by Theis (1935) for interpreting crosshole responses in homogeneous aquifers. Since then, type curve matching has become one of the most common tools in the interpretation of well test data, both in petroleum and groundwater areas. A type curve is a graphical representation of the theoretical response during a test of an interpretation model that represents the well and the formation being tested. A type curve is therefore specific to the type of test for a given flow system. The type curve analysis of well test data essentially consists of selecting a type curve that can adequately describe the actual response of the wellbore and the formation during the test.

Type curves, therefore, include the entire dynamic behavior of an interpretation model during a test; in other words, type curves include all the individual 'flow regimes' of an interpretation model. 'Flow regimes' are but characteristic features for the various components of an interpretation model. The individual components of an interpretation model dominate the well test response at different times. These responses are broadly divided into three groups: early time, middle time, and late time (Earlougher, 1977).

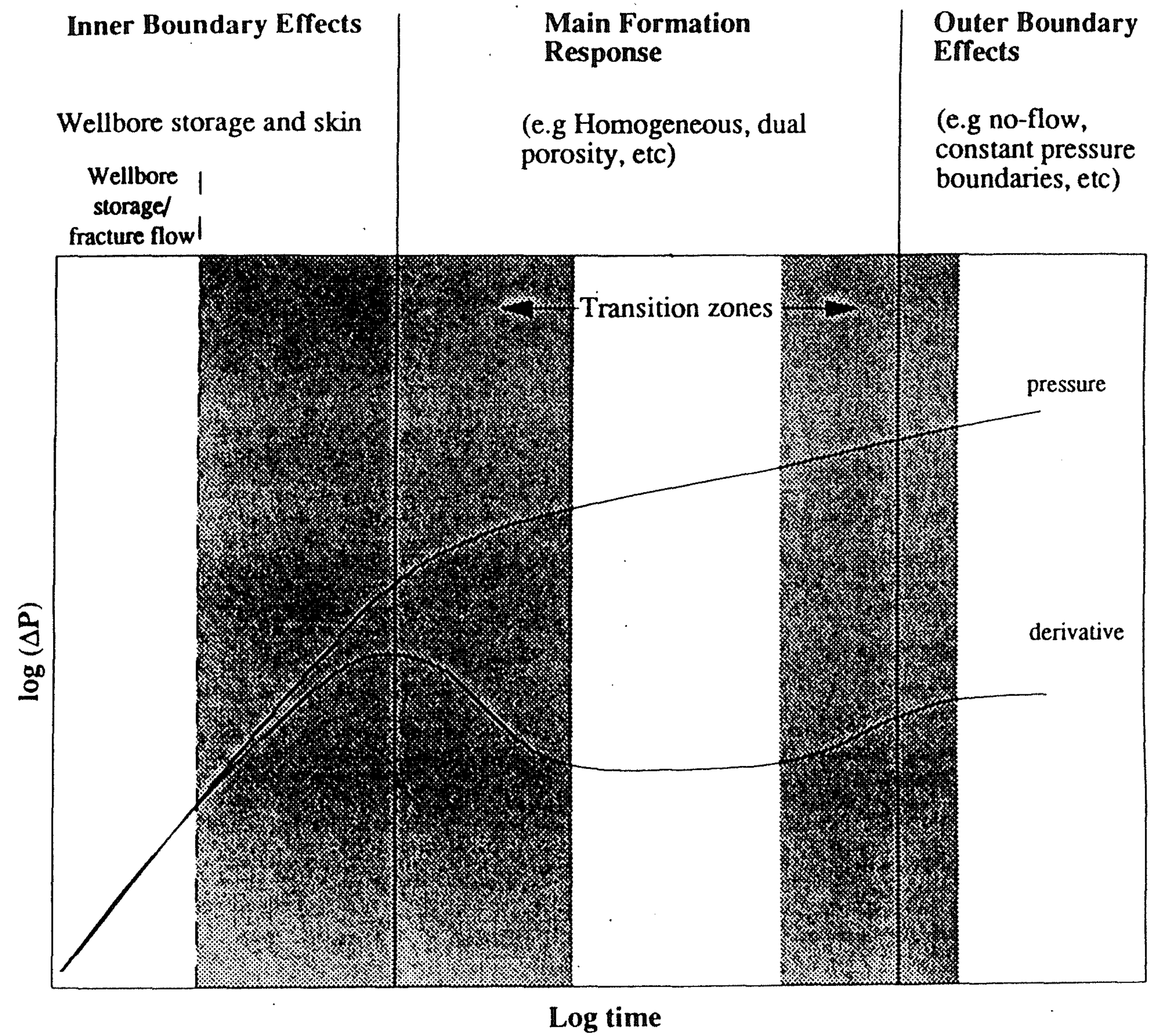
As a given test starts, the pressure transients generated by the test move away from the generator (ie. the source/sink well) and into the formation. At early time, the pressure signals are dominated by features in the flow system close to the source - such as wellbore storage and skin, presence of fractures intersecting the source, etc. As the test progresses, the pressure transients move farther away from the source and the test section pressure response reflects the transmission of pressure through each of the significant features in the flow system in succession. The development of the individual flow regimes in the pressure responses does not occur in discreet steps but are separated by 'transition periods' in which the influences of parameters characterizing the two regimes are combined. After the early time effects are over, the pressure response is indicative of larger scale conditions in the formation. During this phase of the pressure response, features such as double porosity, homogeneous behavior, etc. dominate the pressure response. As the test duration increases, the pressure response reflects the formation conditions farther away from the borehole and features such as boundary effects may affect the pressure response. Until the boundary effects are 'seen' by the pressure signals, the formation effectively responds as if it were of 'infinite lateral extent'.

Type curves combine all the flow regimes, including the transition periods, for specific interpretation models. Well test interpretation models are used to define the complete theoretical flow system and the characteristics of the interpretation models are divided into these distinct periods:

1. Inner Boundary (wellbore storage, fracture flow etc.);
2. Formation Flow Behavior (homogeneity, dual porosity etc.); and
3. Outer Boundary (infinite acting, constant pressure etc.).

These periods are illustrated in Figure 1 for pressure and pressure derivative curves. The first period represents the inner boundary condition of the interpretation model and governs the early time response of the model. The formation flow behavior is the flow regime when the pressure response at the pumping well is dominated by formation flow parameters. The outer boundary condition, as the name implies, characterizes the late-time effects.

In an idealized data set the pressure or pressure derivative will have a recognizable shape which can be related to what is happening in the formation. When analyzing well test data it is now common practice to plot the pressure derivative (derivative of pressure change with respect to the natural



CLIENT/PROJECT						TITLE
Magma Florence			Golder Associates, Tucson, Arizona			FIGURE 1
DRAWN AMG	CHECKED AGG	REVIEWED AGG	DATE NOV 1995	SCALE NO SCALE	JOB NO. 953-2908	Hydraulic Test Interpretation - Flow Periods

logarithm of time) in addition to the pressure because it is easier to recognize the characteristic shapes of the test periods on the pressure derivative (Bourdet et al, 1983; Bourdet et al. 1989). Examination of pressure derivative plots allows the analyst to determine the extent of each of the three periods and, from diagnostic curve shapes, identify different types of formation response and boundary effects. The following interpretation models are available in Golder's FLOWDIM™ code:

Inner Boundary Conditions:

a) Wellbore storage and skin;

b) Infinite conductivity or uniform flux fracture; and

b) Finite conductivity fracture.

Formation Flow Behavior:

a) Homogeneous -standard 'porous medium' flow;

b) Dual porosity -fractures in a less permeable matrix; and

c) Fractional Dimension -fracture controlled flow with "imperfect" connections.

Outer Boundary Conditions:

I) Single boundary -constant pressure or no flow.

The following sections discuss only the interpretation models and parameters, which are applied to the analyses of the Florence data. The models are:

- Inner Boundary -Wellbore storage and Skin, and Fractures;
- Formation Flow -Homogeneous and Dual Porosity; and
- Outer Boundary -Infinite Acting.

Different sets of constitutive parameters are used to represent each of the components of the well test interpretation models. The parameters are:

C:	wellbore storage;
h:	total thickness of the formation (equals the test section length, for a 'fully penetrating well' assumption);
k:	formation permeability;
k_f:	fracture permeability in a double porosity system;
k_{fw}:	permeability of finite conductivity fracture;
s:	skin factor;
w:	fracture width;
x_f:	fracture half length;
ω:	interporosity storativity ratio; and
λ:	interporosity flow coefficient.

These components of the interpretation models are described in the following sections.

2.5.1 Inner Boundary

2.5.1.1 Wellbore Storage and Skin

The wellbore storage effect prevents the downhole flow rate from instantaneously following the surface flow rate in the case of constant rate tests. This affects the early-time transient pressure response to a considerable extent. The wellbore storage effect can mask the formation response in tests of very low permeability formations. Wellbore storage is characterized by a wellbore storage constant, C, which is the change in wellbore fluid volume with pressure. For a well filled with a single phase fluid occupying a fixed volume V_W, this constant is given by Eq. 2.6. For a well with a changing liquid level (open tubing flow) the wellbore storage constant is given by Eq. 2.5.

To account for the wellbore storage effect in the solutions of Eq. 2.11, a dimensionless wellbore storage constant C_D was introduced (Eq. 2.15) and P_D becomes a function of t_D, C_D and s, together with other system parameters.

It is important to note that the compressibility on Eq. 2.6 is that of the fluid in the wellbore. In fractured formations, the actual wellbore storage values can exceed those computed with Eq. 2.6 because part of the storage is due to the volume of fractures in communication with the wellbore. The difference can be a factor of 10 to 100 depending on borehole conditions (Ostrowski and Kloska, 1989). Other effects, such as tool compliance or tool induced injections, can also increase the apparent wellbore storage and cause the wellbore storage constant to be higher than calculated.

Another important dimensionless variable is the skin factor (s) which quantifies the near-borehole flow conditions. Skin factors estimated from transient testing include all features that affect the efficiency of fluid flow into the wellbore. The skin factor represents a steady sate dimensionless pressure drop at the well face in addition to the normal transient pressure drop in the formation. The additional pressure drop is assumed to occur in an infinitesimally thin "skin zone" (van Everdingen, 1953). The additional pressure drop can be the result of local permeability alteration (for example, caused by plugging of flow paths by fines in the drilling fluid, etc.). This pressure drop could also be caused by deviation from purely 2-D radial flow near the well (for example, caused by a fracture near the well giving rise to more linear than cylindrical symmetry flow at early time); this is also called 'pseudo-skin' (Earlougher, 1977). The skin factor is related to this additional pressure drop by the following equation (Earlougher, 1977):

$$s = \frac{2\pi k h}{q B \mu} \Delta P_s \qquad 2.17$$

where Δp_s, is the additional pressure drop in the skin zone. A more physically realistic concept of skin is obtained by assuming that the skin effect is due to an altered zone of radius r_S with a skin zone hydraulic conductivity (K_S); for such a case the skin effect can be calculated from the following equation (Earlougher, 1977):

$$s = [\frac{K}{K_s} - 1] \ln[\frac{r_s}{r_W}] \quad (unitless) \qquad 2.18$$

It can be seen from this equation that when the skin zone hydraulic conductivity (K_S) is higher than the formation hydraulic conductivity (K) the skin effect is negative. There is clearly a practical limit to how large the magnitude of skin can become; for the Florence tests, skin coefficients typically vary between -7.5 and 12.0.

Pseudo-skins result from situations such as partial penetration of the water bearing formations, turbulent flow, multiphase effects, and fractures intersecting the wellbore. The important difference between mechanical skins and pseudo-skins is that the pseudo-skins penetrate the formation, creating transient pressure drops that become stable only some time after the beginning of flow in the well (Dowell Schlumberger, 1985). The total skin effect is the combination of the mechanical and all pseudo-skins.

2.5.1.2 Fracture Flow

When the borehole penetrates a single fracture, the early time pressure response is determined by wellbore storage and the flow behavior within the fracture. Two different kinds of fractures are considered, an infinite conductivity fracture and a finite conductivity fracture. In both these models, the flow is assumed to take place from the formation to the fracture and from the fracture into the wellbore. For the infinite conductivity fracture, a negligible pressure drop is assumed to occur within the fracture itself. For this model, the flow goes through two flow regimes:

a) Linear flow towards the fracture from the formation, and then
b) A global radial flow in the formation.

These two successive flow regimes are also shown by a 'uniform flux' fracture (Earlougher, 1977;

Horne, 1990). A uniform flux fracture is a fully penetrating vertical fracture with a uniform flow into the fracture along its length. Both the infinite conductivity and the uniform flux fracture models are based on the following assumption:

a) There is no wellbore storage;
b) The fracture is vertical and fully penetrating;
c) Pressure within the fracture and the borehole is the same at all points;
d) The fracture is characterized by a half-length (x_f); and
e) The fracture is in a homogeneous aquifer.

Analysis using these models yields an estimate of:

x_f = Fracture half-length

In a finite conductivity fracture model, pressure drop is allowed to take place within the fracture. For a finite conductivity fracture, the flow goes through three regimes:

a) Linear flow within the fracture;
b) Linear flow toward the fracture and within the fracture (bilinear flow); and
c) Global radial flow.

In this case, the flow is determined by the fracture half length as in the case of the infinite conductivity fracture and also by the product of fracture permeability and fracture width. Fracture permeability is not a parameter for the case of an infinite conductivity fracture model, since it is considered to be infinitely large. Analysis with the finite conductivity vertical fracture yields estimates for:

x_f = Fracture half-length

k_{fw} = Fracture permeability

None of the Florence tests analyzed so far have shown a response that could be associated to either of these models. In other words, all of the tests analyzed to date have hydraulic responses typical of porous media flow.

2.5.2 Formation Flow Behavior

Many theoretical models have been developed to describe the flow of fluids through different types of formations in the subsurface. Flow models have been developed to account for a multitude of heterogeneous formation behaviors. These models have increased in complexity in line with the increased computational and graphical display powers of desktop computers. To discuss all the models and combinations of models currently available is beyond the scope of this report. Therefore, only the models that are or might be potentially useful for the analyses of the Florence data are discussed here, namely; homogeneous and dual porosity flow models.

2.5.2.1 Homogeneous

The homogeneous model is the simplest formation flow model. It describes flow through the pore spaces of a homogeneous isotropic formation. Analysis with this model in FLOWDIM™ yields estimates of:

k = permeability; and
s = skin.

This flow model is typically combined with the wellbore storage and skin (Inner boundary) and infinite acting (Outer boundary) models to produce the theoretical model of the simplest formation response.

2.5.2.2 Dual Porosity

A different method of analysis is applied to fractured formations in which flow occurs through both the matrix and through a network of fractures. To analyze tests conducted in these formations, a dual porosity flow model was developed by Warren and Root (1963). They showed that a model which included two fracture related parameters, in addition to permeability and skin, could be used to describe the pressure-time behavior of a fractured formation. These additional parameters represent the storativity ratio of the fractures and the matrix, and the ratio of the matrix permeability to the fracture permeability. It should be noted that the dual porosity model may also be used to represent flow in a fracture system, where relatively low conductivity and less well connected 'background fractures' can be equated with the 'matrix' and more dominant transmissive features with the 'fractures.'

The dual porosity models available in the well testing literature are characterized by the way flow in the more permeable flow conduits (i.e., the fractures) interacts with that in the less permeable flow medium (i.e. the matrix). There are two types of dual porosity models available within FLOWDIM™ depending on the different types of interporosity flow:

a) Restricted Interporosity Flow: In this model there is a skin between the more permeable medium (the fissures) and the less permeable medium (the matrix blocks) which restricts flow; and

b) Unrestricted Interporosity Flow: In this model there is no impediment to flow between the two media and the less permeable medium is assumed to be shaped either like slabs or spheres.

Analysis using the dual porosity model in FLOWDIM™ yields estimates of:

k_f	=	permeability of the more permeable medium;
s	=	skin factor of the well;
s_f	=	skin factor between fissures and the matrix;
ω	=	interporosity storativity ratio; and
λ	=	interporosity flow coefficient.

The definitions of permeability and skin are similar to those in Section 2.3.1.3 and 2.5.1.1. The modifications necessary to fit them into the dual porosity model are noted below. The first of the parameters specific to the dual porosity model, interporosity storativity ratio 'ω', is defined by:

$$\omega = \frac{(\phi c_t)_f}{(\phi c_t)_f + (\phi c_t)_m} \qquad 2.19$$

This relationship characterizes the relative storage capacity of the two media, fracture and matrix (characterized by subscripts 'f' and 'm' respectively). The interporosity flow coefficient 'λ', characterizes the ability of the matrix to flow into the fractures and is defined by:

$$\lambda = \alpha \frac{k_m}{k_f} r_w^2 \qquad 2.20$$

where α is a geometrical factor which depends on the shape of the matrix block. For spherical matrix blocks of radius r_m,

$$\alpha = \frac{15}{r_m^2} \qquad 2.21$$

and for horizontal slab matrix blocks of thickness h_m.

$$\alpha = \frac{12}{h_m^2} \qquad 2.22$$

The theory of the Warren and Root model (Warren and Root, 1963) is extensively discussed in the well test literature (Earlougher, 1977; Streltsova, 1988; Horne, 1990; Sabet, 1991). Therefore, only practical aspects and the physical meaning of the dual-porosity flow parameters are discussed below.

The interporosity storativity ratio, ω, represents the ratio between storage capacity of the fracture network and the total storage capacity of the formation. A value of ω close to zero corresponds to a formation with a very small fracture storage capacity; $\omega = 1$ represents a reservoir with a single dominant flow medium. Small values of ω (<0.1) typically reflect the small storage capacity of fractures relative to the much larger storage capacity of the rock matrix.

The interporosity flow coefficient, λ, represents the dimensionless interporosity flow capacity which depends, primarily, on the ratio of the matrix permeability to the fracture permeability, k_m/k_f. For a given block shape factor α, small λ values correspond to a large contrast between fracture and matrix block permeability. A permeability ratio equal to 1 represents a single porosity (homogeneous) reservoir.

Alternatively, if k_m/k_f is known (e.g. k_m from laboratory tests and k_f from hydraulic testing), it is possible to estimate the characteristics of the fractures. High α values mean large contact surface and consequently smaller matrix blocks (high fracture density). A low value of α corresponds to a smaller contact surface, large matrix blocks and consequently low fracture density.

To date, none of the Florence hydraulic test responses have shown a dual-porosity behavior.

2.5.3 Outer Boundary

2.5.3.1 Infinite Lateral Extent

The model that simulates an infinite acting formation response requires no additional parameters. In this model there is no outer boundary response different from the formation flow response.

2.6 Well Test Analysis

Pressure transient testing has been a subject of extensive work both in the field of groundwater hydrogeology and in the oil industry for the past forty years. Over this period better measuring devices have become available, providing more reliable field data and this, together with the advent of powerful desktop computers, has given rise to the development of more sophisticated interpretation techniques.

In general, transient well tests can be separated into three basic types based on the nature of the source signal:

a) constant rate;
b) constant pressure; and
c) slug and pulse tests.

For constant rate and constant pressure tests, the surface rate and the surface pressure, respectively, are kept constant during the testing period. A slug test is initiated by an instantaneous pressure change (withdraw or injection) and then the groundwater is allowed to flow to the open borehole and to return to initial conditions. A pulse test is very similar to a slug test, the only difference is that the interval is shut-in so that the fluid volume is kept constant. The hydraulic tests conducted at the Florence site are constant rate type tests.

Depending on the type of test, different analysis methods have been developed and documented in numerous papers and manuals. The interested reader is directed to the following summarizing references: Earlougher (1977), Gringarten (1979), Lee (1982), and Bourdet et al. (1983 and 1989) for the analysis of constant rate tests, including multi-rate and shut-in tests; Grisak et al. (1985) for the analysis of wellbore storage dominated pulse and slug, where practical and theoretical aspects of testing in low permeability formations are also discussed; and Pickens et al. (1987) present some interesting practical considerations on interpretation of hydraulic tests in low permeability formations. For detailed descriptions of the various well test analysis methods currently in use, the interested reader is referred to the following additional references: Streltsova (1988), Sabet (1991) and Dawson and Istok (1991).

The purpose of this section is to present some aspects of the test analysis methods that are found to be important for interpretation of the Florence test data. The only tests that will be described in detail are the constant rate tests since these are the type of tests used at the Florence site.

The principles governing the test analysis can be considered as a special pattern recognition problem (Gringarten, 1986). In a well test, a known signal (e.g. pumping rate) is applied to an unknown system and the response of that system (e.g. the change in water pressure) is measured during the test. This type of problem is known as the 'inverse problem.' Its solution involves finding a well defined theoretical system, whose response to the same input signal is as close as possible to that of the actual flow system. Normally this solution is not unique, but with reasonable assumptions and information from other sources like geophysical and geological data, in most cases it is possible to give at least a confined range of solutions.

2.6.1 Constant Rate Tests

The analysis methods for a constant rate test can be divided into two general classes:

a) Straight line analysis methods; and

b) Type curve matching.

After plotting the data in specific coordinate systems, straight lines can be fitted to specific segments of the data set and reservoir parameters determined from the slope and intercept of these lines. This approach requires the data to be divided into discrete sections representing the near wellbore, formation, and outer boundary responses. Each section is then analyzed separately.

The type curve matching approach considers the data as a continuous record. In this approach the data is matched to type curves that represent pressure response models for different combinations of formation and boundary conditions. The type curves are represented in terms of the dimensionless parameters which were introduced in Section 2.4. The formation parameters are calculated from the match points between the measured data and the type curves. These two methods are discussed in more detail in the sections that follow.

2.6.2 Straight Line Analysis Methods

A commonly used method of obtaining reservoir parameters is by straight line analysis. In this approach, pressure data is plotted on specialized plots, e.g. versus log(t), and straight lines fitted to specific portions of the data are used to derive formation parameters. The theory behind straight line methods, especially semilog Horner and MDH has been extensively described in the literature (Earlougher, 1977). Therefore only the application of this method will be discussed here.

Straight lines fitted to the early time portion of the data can be used to obtain estimates of the wellbore storage (pressure versus time or log pressure versus log time) or near well fracture flow parameters (pressure vs. $t^{1/2}$ or $t^{1/4}$). Straight line fits to semilog plots (pressure versus log time), or log (Horner time) can be used to obtain estimates of wellbore storage, skin, permeability and initial pressure; Horner time is defined later in this section. Straight lines fitted to multiple periods of pseudo radial flow can also be used to identify a dual porosity response and estimate the appropriate flow parameters (λ and ω, see nomenclature).

Straight line analysis methods can also be applied to data presented on log-log plots. A horizontal line fitted to a pseudo radial flow portion of the pressure derivative will provide an estimate of the formation permeability, similar to the Horner approach. Distances to outer boundaries and the existence of multiple boundaries can also be estimated by fitting lines to the log-log plot.

The necessary condition for application of the straight line approach to determine initial hydraulic head and hydraulic conductivity is that the aquifer must be 'infinite acting.' This means that the pressure response must extend beyond the influence of wellbore storage and skin effects and into a period of pseudo-radial flow. In the case of heterogeneous behavior, the total system response must be obtained for the method to be applied. When these conditions are met, the basic reservoir parameters (e.g. hydraulic conductivity) can be derived. The straight line method was in many cases not applicable to the Florence test data, even for the estimation of basic formation parameters, because many of the hydraulic tests are strongly affected by pumping in nearby irrigation wells, rendering the pseudo-radial flow period difficult to identify.

Nonetheless, the basic ideas of the straight line analysis are presented here for the benefit of the reader. A special application of this method is the case of the analysis of a shut-in period after a constant rate flow period. According to the superposition principle, the solution for this case is (Horne, 1990):

$$P_D = P_D[t_{pD} + \Delta t_D] - P_D[\Delta t_D] \qquad 2.23$$

where t_{pD} is the dimensionless flow period duration and Δt_D is the dimensionless elapsed time from the start of the shut-in. The dimensionless pressure (P_D) and the dimensionless time are defined in Section 2.5.2. For infinite acting radial flow during both the flow period and the shut-in, Eq. 2.23

leads to the following solution for the source well in a homogeneous reservoir:

$$P(\Delta t) = P_i - \frac{qB\mu}{4\pi kh} \ln \frac{t_p + \Delta t}{\Delta t} \qquad 2.24$$

Therefore when the pressure is plotted against the natural logarithm of $(t_p + \Delta t)/\Delta t$, where t_p is the flow period duration and Δt is the shut-in time, the data will show a straight line with a slope of

$$m = \frac{qB\mu}{4\pi kh} \qquad 2.25$$

during a period of infinite acting radial flow. The pressure axis intercept represents the initial formation pressure (P_i) or equivalently the static water level. Such a plot is known as a Horner plot and $(t_p + \Delta t)/\Delta t$ is referred to as Horner time which is a dimensionless quantity. For a multiple rate transient test this method can be generalized by plotting (Gringarten et al., 1980):

$$P(\Delta t) \ vs. \ \frac{1}{|q_{n-1} - q_n|} [\sum_{i=1}^{n-1} (q_i - q_{i-1}) \log [\sum_{j=1}^{n-1} \Delta t_j + \Delta t] - (q_{n-1} - q_n) \log \Delta t] \qquad 2.26$$

where Δt_j is the duration of each constant rate event. In Eq, 2.26 the time/rate function is referred to as the superposition function, and the plot is known as a generalized Horner plot.

2.6.3 Type Curve Matching and Automatic Regression

A transient well test generally comprises an input impulse (e.g. a change in flow rate) which is imposed on the test interval, and the recorded response (e.g. a change in pressure). The nature and shape of the response is governed by test geometry parameters (interval volume, flow rate, etc.), fluid parameters (viscosity, compressibility, etc), and formation flow parameters (permeability, porosity, etc.). Some of these are known directly or can be measured either in-situ during the test or in laboratory tests. However, some of the parameters which control the formation response cannot be measured directly and must be inferred from the test response. An analytical mathematical model of the dependence of the formation response on the formation flow parameters can be developed and solved. Then by matching the measured test response to the model response it can be inferred that the model parameters have the same values as the actual reservoir parameters. This process is known as 'Type Curve Matching.'

2.6.4 Theory of Type Curve Matching

We will consider the single constant rate case to present the basic theory of type curve matching. For a constant rate case, the dimensionless pressure is defined as (Horne, 1990):

$$P_D = \frac{2\pi kh}{qB\mu}(P_i - P) = A\,\Delta P \qquad 2.27$$

where A is a function of k, h, q, B, and μ.

Re-arranging Eq.'s 2.13 and 2.27, we get:

$$\frac{t_D}{C_D} = B\left(\frac{\Delta t}{C}\right) \qquad 2.28$$

where B is a function of k, h, and μ. Or in logarithmic terms:

$$Log P_D = Log \Delta P + Log A \qquad 2.29$$

$$Log(\frac{t_D}{C_D}) = Log \Delta t + Log(\frac{B}{C}) \qquad 2.30$$

The combination of the dimensionless time and wellbore storage is a way to reduce the number of independent variables and make the type curves easier to distinguish from each other. Since, by definition, the dimensionless pressure and time/storage are linear functions of actual pressure and time, the log of actual pressure change will differ from the log of the dimensionless pressure drop by a constant amount. The same is also true for the log of actual time. Thus when the appropriate interpretation model has been selected, the actual pressure vs. (time) curve and the theoretical curve P_D vs. (T_D/C_D) have identical shapes, but are shifted with respect to one and other when plotted on the same log-log scale.

The objective of this type curve analysis is to evaluate the amount of shift between the two sets of curves. When the actual data is matched to the theoretical curve on the log-log axes, a match point is selected and the reservoir parameters obtained by rearranging and substituting P_D and ΔP, and (T_D/c_D) and Δt into the above equations as follows:

$$[\frac{P_D}{\Delta P}] \, matchpoint = A \Rightarrow permeability \qquad 2.31$$

$$[\frac{t_D/C_D}{\Delta t}] \, matchpoint = (B/C) + permeability \Rightarrow wellbore\ storage \qquad 2.32$$

Originally P_D was plotted versus t_D on a series of distinct curves for welbore storage/skin and infinite acting radial flow (Agarwal et al., 1970). Manipulation of the dimensionless pressure equation, created a combined storage and skin variable, $C_D e^{2s}$ that could be used to generate a series of type curves (Gringarten, 1979) for different $C_D e^{2s}$ values. The skin factor is obtained by substitution of the calculated dimensionless storage into the $C_D e^{2s}$ value obtained from the type curve that gives the best match, and the corresponding $C_D e^{2s}$ appropriate to that curve. Other type curves have been developed for fractured reservoirs (see, for example, Bourdet and Gringarten, 1980) and for formations with composite behavior.

For further details of the theoretical aspects of type curve matching, the interested reader is referred to Gringarten (1987), Chapter 4 of Sabet (1991), and Section 3.3 of Earlougher (1977).

2.6.5 Dimensionless Type Curves

The solutions to the analytical models can be expressed as a series of dimensionless variables (Section 2.5.1). These dimensionless variables are important because they simplify the formation response models by representing the transient test parameters in terms of model parameters which remain fixed during the test, thus reducing the total number of unknowns which need to be considered. They also have the additional advantage of providing model solutions that are independent of units. The definition of these dimensionless variables assumes that the test parameters (flow rate, interval volume), the fluid parameters (viscosity, compressibility), and the reservoir parameters (permeability, compressibility, porosity, and reservoir thickness) all remain constant throughout the test.

Theoretical models of reservoir behavior can be presented as a family of dimensionless type curves, expressed in terms of dimensionless pressure (P_D), that are a function of t_D and other dimensionless variables. Each curve in the family is characterized by dimensionless variables that depend on the particular model. These parameters are defined as the product of a measured parameter (e.g. pressure or time change) and parameters characterizing the reservoir (porosity, permeability, etc.).

The type curves used for the analysis of a pumped withdrawal test in a formation are called drawdown type curves and are defined as:

$$P_D = P_D[(\Delta t)_D] \qquad 2.33$$

The actual data for type curve analysis are defined as:

$$\Delta P = P_i - P(\Delta t) \qquad 2.34$$

The change in pressure (ΔP) is plotted against the change in time (Δt) where Δt is the elapsed time since the start of the pumping sequence, and ΔP is the corresponding pressure reading.

Interpretation models can be obtained by a combination of the appropriate component (inner boundary, formation behavior, and outer boundary) models which have been developed. Their dimensionless solutions are superposed (in space and time) to obtain the type curves required for analysis. Type curves have been published for most of the common reservoir configurations (e.g. homogeneous, dual porosity, etc).

The drawdown type curves are not strictly valid for analyzing flow periods (drawdowns or build-ups) after the first drawdown. For each drawdown type curve there exists a 'family' of build-up type curves that depend on the production period, t_p. The corresponding theoretical build-up type curve is obtained from the appropriate drawdown curve by superposition as follows (Gringarten et al., 1980):

$$(P_D)_{BU} = P_D(T_{pD}) - P_D(t_{pD} + \Delta t_D) + P_D(\Delta t_D) \qquad 2.35$$

The build-up type curves must be calculated for each test, because they depend upon the test conditions. For a multi rate (MR) flow test the type curve can be expressed by Eq. 2.16 in Section 2.5.

2.6.6 Derivative Type Curves

A relatively recent innovation (Bourdet et al., 1983), made much easier with the introduction of computer aided techniques, is to plot the derivative of P_D with respect to ln (t_D/C_D) on the same axes as the P_D vs. T_D/C_D. The derivative is useful as a diagnostic plot when trying to determine the different flow regimes that may occur during the test. The advantage of the derivative plot is that it is able to display in a single graph many separate characteristics that would otherwise require different plots.

During pure wellbore storage (Earlougher, 1977) showed that:

$$P_D = \frac{t_D}{C} \tag{2.36}$$

then taking the derivative

$$\frac{dP_D}{d\left(\frac{t_D}{C_D}\right)} = P_D^{/} = 1 \tag{2.37}$$

During infinite acting radial flow (which does not show a characteristic response on a log-log scale) in a homogeneous formation (Bourdet et al., 1983):

$$P_D = 0.5[\ln(\frac{t_D}{C_D}) + 0.80907 + \ln(C_D e^2 s)] \quad 2.38$$

then taking the derivative

$$\frac{dP_D}{d(\frac{t_D}{C_D})} = P_D' = 0.5/(\frac{t_D}{C_D}) \quad 2.39$$

Therefore, both at early and late times, all P_D' behaviors are identical and independent of the C_De^{2s} values. At early time, all the curves merge into a straight line corresponding to $P_D' = 1$. At late time the curves merge into a single straight line of slope = -1, corresponding to $P_D' = 0.5/(t_D/C_D)$. Between these two asymptotes, each of the C_De^{2s} curves exhibit a specific shape. It is more useful however, to plot the type curves as P_D' (t_D/C_D) versus (t_D/C_D). This is a better choice of axes because the pressure and time axes are now consistent with the dimensioless pressure axes described earlier.

At early time, the type curves follow a unit slope log-log straight line. When infinite acting radial flow is reached, the derivative curves become horizontal at P_D' $(t_D/C_D) = 0.5$. Between these two asymptotes, the type curves and derivatives are distinctly different for the combined 'family' of C_de^{2s} curves. This makes it easier to correctly identify the correct C_de^{2s} curve corresponding to the data. The derivative shape also provides an improved diagnostic tool for other formation models such as dual porosity, composite, fracture flow, and outer boundary responses.

Modern well test analysis has been greatly enhanced by the introduction of the pressure derivative type curves. The advent of computer aided interpretation has made calculation of the derivative of real data relatively straightforward. The advantage of the derivative plot is that it is able to display in a single graph many separate characteristics of the flow system that would otherwise require different plots (Horne, 1990). The power of the pressure derivative arises from the fact that it magnifies the differences in shapes between the various flow regimes that can be present during a given flow period, thereby enhancing the diagnostic capabilities of the analyst by a significant amount (Gringarten, 1986).

The interpretation method implemented in FLOWDIM, a Golder Associates proprietary software, takes full advantage of the derivative approach as discussed above. Test interpretation of the aquifer tests in the Florence study area were conducted using this software. The following section presents a brief discussion of the interpretation of each test.

3.0 TEST INTERPRETATION RESULTS

This section provides a brief description of the conditions during each aquifer test, general comments on the quality of the data, and results from the analytical interpretation. One critical piece of information during any hydraulic test program is the location of nearby active wells and their pumping rates and duration of pumping periods. In the case of the Florence aquifer tests, a precise discharge rate history for nearby agricultural wells is, in general, not available. Complete interpretation of the affected aquifer tests is not possible without this information, and the resulting estimated hydraulic conductivity may be inaccurate.

In some cases, boundary effects and abrupt changes in the pumped well discharge rate complicated the interpretation of the drawdown and recovery data, not to mention the effect of nearby agricultural wells. To the extent permitted by the data, an attempt was made to discern amongst effects produced by geological controls and those produced by the cycling of nearby agricultural wells. Information about the hydraulic tests conducted to date is summarized in Table 1 (See Appendix A). Also shown in this table are the name designations of the wells participating in a given test, starting and ending date of the test, and available information regarding geologic formation, screen location, drawdown and discharge data.

Table 2 (See Appendix A) presents a summary of the hydraulic conductivity estimates resulting from our interpretation. Also included in this table is the name of the formation penetrated by the particular well(s), and comments and qualifiers on the conductivity estimates. The available data are classified into three different categories; fair, acceptable and good. A fair data set is one that is interpretable but the estimated hydraulic conductivity should be used with caution. An acceptable data set represents a test with some uncertainty and usually results in an underestimate of the formation hydraulic parameters. A good data set results in a hydraulic conductivity that is deemed as a close representation of the formation conductivity.

The following table is considered useful for the understanding of subsequent section ans is therefore included in the text. The table provides an abbreviated summary of the estimate hydraulic

Well Identification	Active/Observation	K (feet/day)
Basin Fill Deposits		
M1-GL	Active	17.3
M3-GL	Active	15.9
M14-GL	Active	1.7
M14-GL3d	Active	0.1
M15-GU	Active	2.6
M18-GL	Active	19.6
P28-GL	Active	8.3
O28-GL	Observation (P28-GL)	23.2
M3-GL	Observation (M4-O)	14.8
P8-GU	Active	61.3
Oxide		
M4-O	Active	0.6
PW2-1	Active	1.4
PW4-1	Active	3.8
PW7-1	Active	0.2
OB7-1	Observation (PW7-1)	0.1
P12-O	Active	0.4
O12-O	Observation (P12-O)	0.6
P19.1-O	Active	0.3
P19-O	Observation (P19.1-O)	0.2
P19.2-O	Observation (P19.1-O)	0.2
P19.1-O3d	Active	1.00E-02
P19-O3d	Observation (P19.1-O)	2.39E-04
P19.2-O3d	Observation (P19.1-O)	1.99E-04
P39-O	Active	0.3
O39-O	Observation (P39-O)	0.3
P28.1-O	Active	7.7
P28.1-O (2)	Active	3.6
P28.2 -O	Observation (P28.1-O)	2.7
P28.2-O	Active	3.1
O28.1-O	Observation (P28.2-O)	3.0
P13.1-O	Active	0.3
P49-O3d	Active/Recovery Data	7.75E-03
P15-O	Active	0.5

conductivity presented in Table 2 in Appendix A. This abbreviated table divides wells into those testing the Basin Fill Units, and those testing the mineralized bedrock.

As seen from this table, the hydraulic conductivity for the Basin Fill Units vary from 1.7 to 61.3 feet per day (ft/day), whereas that for the quartz monzonite and the granodiorite porphyry vary from 0.1 to 7.7 ft/day (with exception of the 3-D analyses). The maximum conductivity value for the Basin Fill units was derived from a test in the Upper Unit. The smaller variation in the hydraulic conductivity suggest a greater degree of heterogeneity than that of the mineralized bedrock.

Appendix A contains a summary sheet for each test interpretation, including a calculation of hydraulic conductivity in feet per minute (ft/min), feet/day (ft/day), meter per second (m/sec), and centimeter per second (cm/sec), as well as the estimated value of the skin factor. Appendix B presents the log-log plots of the type curve selected for the analysis, and observed drawdown versus time. Appendix C includes report forms from the FLOWDIM interpretation for each test. This form contains the well name, type of test, and date of the test. Well geometry information, such as well radius, interval length, formation tested, total depth, as well as discharge rate and test duration are also included in this form. In addition, this form presents also the model assumptions and numerical values for hydraulic parameters.

The following paragraphs offer a cursory description of test conditions and hydraulic conductivity estimates for each test. The first few tests are discussed in detail to provide the reader with a basis for understanding the remaining tests presented in Appendix A through C. Detailed discussion for unique and interesting tests is given as warranted by test response.

Aquifer Test on M1-GL

This constant rate test involved a single well with a discharge of 10 gallons per minute (gpm). Well M1-GL is a monitoring borehole completed within the lower basin fill unit (LBFU). Nearby agricultural wells BIA-9 and BIA-10B were reported to be active during the test. The test response shows a slight "recovery" of the hydraulic head during the test. This effect is responsible for the decrease in drawdown (circles) in the late time data presented in Figure 1B in Appendix B. Final recovery of the hydraulic head resulted in a water elevation higher than the elevation reported at the beginning of the test; indicating that the observed hydraulic head response is a superposition of more than one stress on the aquifer (namely; the transient effects from wells BIA-9 and BIA-10B).

The log-log plot presented in Figure 1B shows both the drawdown data and its derivative with respect to the natural log of time (triangles) versus time, and the dimensionless type curve that was selected for interpretation of this test. In this particular case the selected type curve corresponds to a two-dimensional (notice the asymptotic approach to $p_D' = 0.5$), homogeneous flow model, with a C_De^{2s} parameter equal to 2×10^{8} . This value, in turn, results in a skin coefficient of 3.3 (see summary interpretation in Figure 1A in Appendix A) indicating some possible formation clogging near the well face. Figure 1B shows the transient effects produced by nearby pumping, and that the match between the data and the type curve is poor. The pressure derivative of the data shows a large amount of random variation in late time, making it difficult to better assess the hydraulic parameters. The hydraulic conductivity estimate is 17.3 ft/day. It is our opinion that this conductivity value most likely overestimates the actual conductivity of the formation in that the observed drawdown appears to be affected by a recovery trend that limits its final magnitude. The effect of nearby pumping (recovery) may be responsible for the extremely small estimate of the storage coefficient (8.4×10^{-9}).

Aquifer Test on M3-GL

Aquifer test on monitoring well M3-GL (Figure 14B) involved wells M2-GU, M4-O and M5-S as observation points. Average discharge from M3-GL during this test was reported at 10 gpm. Well M3-GL is completed in the Lower Basin Fill Unit, while M2-GU and M4-O are completed in the Upper Basin Fill Unit (UBFU) and the oxide unit, respectively. Irrigation Well ENGLAND #3 was on during the test but no information regarding its pumping rate is available. Observation wells M2-GU and M5-S showed recovery 100 minutes into the test. The hydraulic response for wells M2-GU and M4-O is minimal and quite erratic. This small response between M2-GU and M3-GL may indicate a limited hydraulic connection between the lower and Upper Basin Fill Unit in this area of the site. After shut in of well M3-GL, observation wells M2-GU and M4-O showed a slight recovery and then began to drop off again which may be the result of cycling of agricultural pumping. The hydraulic response of well M5-S appears completely independent of pumping on well M3-GL. Due to the above conditions, the hydraulic responses from the observation wells were considered not suitable for interpretation.

Data interpretation for this test was accomplished by means of a 2-D, homogeneous model (as indicated by the approach of the derivative of $p_D = 0.5$) with a C_De^{2s} parameter equal to 1×10^{6} (Figure 14B). The skin parameter was estimated to be 1.16 (Figure 14A); indicating slight formation clogging near the well face. The overall fit of the drawdown data and the selected type curve is relatively good up to about 10 hours into the test. However, the pressure derivative data deviates sharply from the type curve just after about 0.1 hour into the test. The estimated hydraulic conductivity for the Lower Basin Fill Unit is 15.9 ft/day with a storage coefficient of 3×10^{-7}. The deviation of the data from the derivative and this small storage coefficient may be an effect produced by pumping from ENGLAND #3 well.

Aquifer Test on M14-GL

Well M14-GL was tested under a constant discharge of about 10 gpm. This well is completed within the Lower Basin Fill Unit (LBFU). Well M15-GU, in the Upper Basin Fill Unit, serves as an observation well. Irrigation Wells BIA-9 and BIA-10B were on during the test but no information is available regarding their pumping rate history. Additionally, M1-GL was pumping during testing. Very little drawdown was seen in the observation well (M15-GU). However, a sharp increase in hydraulic head was observed at about 1,000 minutes after pumping in M14-GL ceased. Recovery in the pumping well went beyond initial reported static water level. It is suspected that one or both of the pumping agricultural wells may be responsible for these effects. Field data from the observation well was not considered suitable for interpretation.

Two interpretation models were applied to the drawdown data from well M14-GL. First, a 2-D, homogeneous model (Figure 3A) was used to match the field data. It was seen (Figure 3B) that only the early data (t < 50 min) closely approximated both the pressure and pressure derivative of the 2-D type curve. At later times, the derivative of the field data deviated sharply from the type curve. As discussed in Section 2.6, this type of deviation is characteristic of a 3-D flow regime. Analyses of these data using a 3-D model (Figures 4A and 4B) shows that the overall fit to both pressure and pressure derivative improved significantly. Given the relatively short length of the screened interval as compared to the thickness of the Lower Basin Fill Unit in that location, it is not surprising that the test response suggests 3-D flow (typical of a partially penetrating well). Hydraulic conductivity estimates from these two different models are reported in Table 2 as well as in Figures 3C and 4C. The resulting conductivity estimates are 1.7 and 0.1 ft/day for the 2-D and 3-D models respectively. Although the 3-D type-curve better represents this field data, it is recommended, for the sake of conservatism, that numerical simulation of flow and transport be conducted with the larger hydraulic conductivity estimate. As will be discussed later for some of the other tests, 3-D conductivity estimates are typically smaller than corresponding 2-D estimates.

Aquifer Test on M15-GU

This constant rate test involved a single pumping well (M15-GU) discharging at 10 gpm from the upper consolidated unit (UBFU) and one observation well (M14-GL) which was completed in the Lower Basin Fill Unit (LBFU). Irrigation Wells BIA-9 and BIA-10B were on during the test but no information is available regarding their pumping rate history. The pumping well recovery rose above the static water level. It may be that one or both of the irrigation wells were shut off during testing, causing these effects. Due to the above effects the data form the observation well were not considered suitable for interpretation. Only the data for M15-GU was analyzed.

The selected type curve for the pumping well data (M15-GU) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 10 (see Figure 5C). This value, in turn, results in a skin coefficient of 6.6 indicating (Figure 5A), perhaps, some formation clogging near the well face. As shown in the log-log plot (Figure 5B), the match between the data and the type curve is good. The hydraulic conductivity estimate is 2.6 ft/day. The estimate for the storage coefficient is 1.1×10^{-11} which is clearly too small and another indication of the difficulty involved in modeling marginal data.

Aquifer Test on M18-GU

This constant rate test involved a single pumping well (M18-GU) with a discharge of 10 gpm from the Upper Basin Fill Unit (UBFU). This was a short duration test with no observation wells. The data set is fair for interpretation.

The selected type curve for the pumping well data (M18-GU) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 1.0×10^{15}. This value, in turn, results in a skin coefficient of 11.4 (Figure 6A) indicating significant formation clogging near the well face. As shown in the log-log plot (Figure 6B), the match between the data and the type curve is good. The hydraulic conductivity estimate is 19.6 ft/day. The estimate for the storage coefficient is 8.7×10^{-16} which is clearly much too small and another indication of only a fair data set.

Aquifer Test on P39-O

This constant rate test involved a single pumping well (P39-O) with a discharge of 55 gpm pumping from the oxide zone. It had a single observation well (O39-O) which was also completed in the oxide zone. The data appears to be good and suitable for analysis.

The selected type curve for the pumping well data (P39-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 100. This value, in turn, results in a skin coefficient of -1.8 (Figure 7A). As shown in the log-log plot (Figure 7B), the match between the data and the type curve is good. The hydraulic conductivity estimate is 0.3 ft/day and the estimate for the storage coefficient is 9.6 x 10^{-4}.

The selected type curve for the observation well data (O39-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 2.0. As shown in this log-log plot (Figure 8B), the match between the data and the type curve is good. The hydraulic conductivity estimate is 0.3 ft/day and the estimate for the storage coefficient is 4.3 x 10^{-4} (Figure 8C).

Aquifer Test on PW7-1

This constant rate test involved a single pumping well (PW7-1) with a discharge of 38 gpm from the oxide zone. Observation wells OB7-1 and OB-1 are also completed in the oxide zone. Observation well O3-GL straddles the interface between the basin fill deposits and the oxide. Irrigation wells BIA-10B and WW-3 were on during testing and appear to have had some effect on the data as shown by early recovery in these wells. However, data sets from PW7-1 and OB7-1 appear acceptable and suitable for analysis.

The selected type curve for the pumping well data (PW7-1) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 100. This value, in turn, results in a skin coefficient of -2.1 (Figure 17A) which indicates enhanced hydraulic conductivity near the well. As shown in the log-log plot (Figure 17B), and in spite of the transient effects produced by nearby pumping, the match between the data and the type curve is good. The hydraulic conductivity estimate is 0.2 ft/day and the estimate for the storage coefficient is 1.8 x 10^{-3} (Figure 17C).

The selected type curve for the observation well data (OB7-1) corresponds to a 2-D, homogeneous flow model. As shown in this log-log plot (Figure 9B), and due to the transient effects produced by nearby pumping, the match between the data and the type curve is fair. The hydraulic conductivity estimate is 0.1 ft/day and the estimate for the storage coefficient is 1.3×10^{-4} (Figure 9C).

Aquifer Test on P12-O

This constant rate test involved a single pumping well (P12-O) with a discharge of 64 gpm from the oxide zone. Observation well O12-O was also completed in the oxide zone whereas observation well O12-GL was completed within the LBFU. The data appear to show multiple pumping well effects. Drawdown increased at approximately 500 minutes into the test, recovery was observed at 3,000 minutes, additional drawdown was seen at 7,000 minutes, and more recovery was observed at approximately 9,000 minutes. Large drawdown variations were also recorded the observation wells. Due to the above effects, this test is considered marginal for interpretation, and only the first 3,000 minutes of data from wells P12-O and O12-O were used.

The selected type curve for the pumping well data (P12-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 3.0. This value, in turn, results in a skin coefficient of -4.3 which indicates enhanced hydraulic conductivity near the well. This enhanced conductivity could be natural, as resulting from nearby fractures, or it could be due to the drilling and well development process. As shown in the log-log plot (Figure 19B), the match between the data and the type curve is fair. The hydraulic conductivity estimate is 0.4 ft/day and the estimate for the storage coefficient is 4.2×10^{-1}.

The selected type curve for observation well data (O12-O) corresponds to a 2-D, homogeneous flow model. As shown in this log-log plot (Figure 10B), the match between the data and the type curve is fair. The hydraulic conductivity estimate is 0.6 ft/day and the estimate for the storage coefficient is 2.2×10^{-3}.

Aquifer Test on P28-GL

This constant rate test involved a single pumping well (P28-GL) with a discharge of 75 gpm from the Lower Basin Fill Unit (LBFU). Observation well O28-GL was completed in the Lower Basin Fill Unit (LBFU) and observation wells P28.1-O, P28.2-O and O28.1-O were completed in the oxide zone. Observation well O28.2-S was completed in the sulfide zone. Irrigation Wells BIA-9 and BIA-10B were on during the test but no information is available regarding their pumping rate history. Additionally ENGLAND #3 and WW-3 were on briefly for sampling toward the beginning of the test, and P8-GU was also pumping during this test. The test results appear good and suitable for analysis, however, only data from P28-O and O29-GL were interpreted.

The selected type curve for the pumping well data (P28-GL) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 1.0 x 10^6 . This value, in turn, results in a skin coefficient of 1.3 which may indicate some formation damage near the well face. As shown in the log-log plot (Figure 29B), and in spite of the transient effects produced by nearby pumping, the match between the data and the type curve is good. The hydraulic conductivity estimate is 8.3 ft/day and the estimate for the storage coefficient is 3.4 x 10^{-7}.

The selected type curve for the observation well data (O28-GL) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 2.0. As shown in this log-log plot (Figure 11B), and in spite of the transient effects produced by nearby pumping, the match between the data and the type curve is fair. The hydraulic conductivity estimate is 23.2 ft/day. The estimate for the storage coefficient is 2.7 x 10^{-5}.

Aquifer Test on P28.2-O

This constant rate test involved a single pumping well (P28.2-O) with a discharge of 77 gpm pumping from the oxide zone. Observation wells P28-GL and O28-GL were completed in the Lower

Basin Fill Unit (LBFU), observation well O28.1-O and P28.1-O were completed in the oxide zone. and observation well O28.2-S was completed in the sulfide zone. Irrigation Wells BIA-9 and BIA10-B were on during the test but no information is available regarding their pumping rate history. These wells did affect the data in all observation wells as evidenced by decrease in the drawdown at later time in all observation wells. Also, the recovery in the pumping well went beyond static water level, indicating that the observations in the pumping well are not ideal for interpretation. However, overall, the test is judged to be acceptable for interpretation.

The selected type curve for the pumping well data (P28.2-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 10. This value, in turn, results in a skin coefficient of -6.5 which indicates enhanced hydraulic conductivity near the well. This enhanced conductivity could result from nearby fractures, or it could be due to the drilling and well development process. As shown in the log-log plot (Figure 33B), and due to the transient effects produced by nearby pumping, the match between the data and the type curve is only fair. The hydraulic conductivity estimate is 3.1 ft/day. The estimate for the storage coefficient turns out to be 3.8 which is clearly unreasonable (S is a dimensionless quantity smaller than one). This unreasonable storage coefficient estimate results, most likely, from a data set affected by pumping from wells BIA-9 and BIA 10-B. The resulting storativity estimates are, therefore, not reliable.

The selected type curve for the observation well data (O28.1-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 2.0. As shown in this log-log plot (Figure 12B), and in spite of the transient effects produced by nearby pumping, the match between the data and the type curve is acceptable. The hydraulic conductivity estimate is 3.0 ft/day. The estimate for the storage coefficient is 1.1×10^{-3} (a much better result than was obtained from the pumping well).

Aquifer Test on PW2-1

This constant rate test involved a single pumping well (PW2-1) and one observation well OB2-1, both on the oxide unit. Only the drawdown data for PW2-1 was analyzed; however, the observation well data appear suitable for analysis.

The selected type curve for the pumping well data (PW2-1) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 2.0×10^8. The estimated skin coefficient is 4.3 indicating, perhaps, some formation clogging near the well face. As shown in the log-log plot (Figure 13B), the match between the data and the type curve is good. The hydraulic conductivity estimate is 1.4 ft/day. Interestingly, the estimated storage coefficient (3.2×10^{-9}) seems too small compared to that computed for other tests on the oxide unit.

Aquifer Test on PW4-1 (Test 1)

This constant rate test involved a single pumping well (PW4-1) and one observation well OB4-1. Only the drawdown data for PW4-1 was analyzed; however, the observation data appear to be good and suitable for analysis.

The selected type curve for the pumping well data (PW4-1) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 2.0×10^8 which results in a skin coefficient of 4.6 indicating (Figure 15A), perhaps, some formation clogging near the well face. As shown in the log-log plot (Figure 15B), the match between the data and the type curve is good. The hydraulic conductivity estimate is 3.8 ft/day, however the estimate for the storage coefficient seems to small (2.5×10^{-9}).

Aquifer Test on M4-O

The aquifer test on monitoring well M4-O involved wells M2-GU, M3-GL and M5-S as observation points. Average discharge from M4-O during this test was reported at 15 gpm. Irrigation Well

ENGLAND #3 was on during the test but no information is available regarding its pumping rate history. Little or no drawdown was seen in any of the observation wells. However, at about 550 minutes into the test, the hydraulic head in all the wells shows a sharp decrease. After turning the pump off in well M4-O, the observation wells in the unconsolidated unit showed some partial recovery and then, at about 1,900 minutes, show a sharp drawdown. The hydraulic connection between the oxide unit and the overlain unconsolidated units seems limited at this location. Observation well M5-S (completed in the sulfide unit) did not show any drawdown, but instead recovered throughout the test indicating a very limited connection to the oxide unit. Due to these conditions, the test response from the observation wells M2-GU and M5-S was not considered suitable for interpretation.

FLOWDIM interpretation for the pumping well results in a fair match (Figure 16B) between the homogeneous 2-D model ($C_De^{2s} = 2 \times 10^8$) and the field data. The hydraulic conductivity estimate is 0.6 ft/day, with a skin factor of 3.8. The hydraulic conductivity is, however, deemed an underestimation of the actual formation conductivity due to the effect of pumping well ENGLAND #3.

Interpretation of observation well M3-GL used a 2-D model and resulted in a permeability estimate of 14.8 ft/day, and storativity of 8.8×10^{-2}. The match to the selected type curve is presented in Figure 2B.

<u>Aquifer Test on P8-GU</u>

This aquifer test involved a single pumping well (P8-GU) with a discharge of 85 gpm from the Upper Basin Fill Unit (UBFU). Four observations wells (P8.1-O, P8.2-O, O8-O, and O8-GL) were monitored. Irrigation wells BIA-9 and BIA-10B were on during the test but no information is available regarding their pumping rate history. Additionally, irrigation well WW-3 was turned on briefly for sampling toward the beginning of testing, and P28-GL was also pumped during testing. These wells did affect the measurements in the observation wells as evidenced by their lack of recovery when the pumping in P8-GU was stopped at about 3200 minutes into the test. Also, the recovery in the pumping well did not reach static water level, indicating that the observations in the pumping well are only fair for interpretation.

Field data interpretation was attempted with a type curve for the drawdown data (P8-GU) corresponding to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 1.0×10^6. This value, in turn, results in a skin coefficient of 0.9 indicating, perhaps, only minor formation clogging near the well face. As shown in the log-log plot (Figure 18B), the match between the data and the type curve is fair. The hydraulic conductivity estimate is 61.3 ft/day and the estimate for the storage coefficient is 3.2×10^{-6}.

Aquifer Test on P13.1-O

This constant rate test involved a single pumping well (P13.1-O) with a discharge of 46 gpm. All irrigation wells are reported to be off during the test. Observation well P13-GL data shows some irregularity, but the pumping well and observation well P13.2-O appear suitable for analysis. Observation well O13-O showed no response during this test.

The selected type curve corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 1×10^6. This value, in turn, results in a skin coefficient of -3.4 which indicates enhanced hydraulic conductivity near the well. This enhanced conductivity could be the result of natural fractures or it might be due to the drilling and well development process. As shown in the log-log plot (Figure 20B), there is a good match between the data and the type curve so results of this test are judged to be good. The hydraulic conductivity estimate is 0.3 ft/day which is a typical value for the oxide zone and the storage coefficient estimate is 4.7×10^{-7}.

The hydraulic response for observation well P13.2-O shows a strong 3-D component (Figure 21B). Analyses of these data result in a hydraulic conductivity of 1.3×10^{-4} ft/day and a storativity of 7.0

x10^{-7}.

Aquifer Test on P15-O

This constant rate test involved a single pumping well (P15-O) with a discharge of 60 gpm. However, irrigation Wells BIA-9 and BIA-10B were on during the test but no information is available regarding their pumping rates. These wells did affect observation wells (P15-GL and O15-O) as evidenced by the sudden change in drawdown near the end of the test. The sudden change in drawdown is superimposed upon the drawdown due to P15-O and is difficult to separate. These irregularities indicate that the observation wells are not suitable for interpretation. The pumping well is suitable, however.

The selected type curve corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 1 x 10^2. This value, in turn, results in a skin coefficient of -5.0 which indicates enhanced hydraulic conductivity near the well. As shown in the log-log plot (Figure 22B), there is a fair match between the data and the type curve so results of this test are judged to be acceptable when considering the complications introduced by additional pumping wells (BIA-9 and BIA-10B). The hydraulic conductivity estimate is 0.5 ft/day which is a typical value for the oxide zone and the storage coefficient estimate is 1.3 x 10^{-2}.

Aquifer Test on P19.1-O

This constant rate test involved a single pumping well (P19.1-O) with a discharge of 24 gpm pumping from the oxide zone. Observation wells P19-O and P19.2-O were also completed in the oxide zone. Two additional observations wells were also monitored during this test (O19-GL and well 138). The data from these two wells were strongly affected by pumping in irrigation wells BIA-10B and WW-3. However, the data sets for the oxide wells appear acceptable for analysis.

The selected type curve for the pumping well data (P19.1-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 2.0 x 10^{8} . This value, in turn, results in a skin coefficient of 5.1 indicating some formation damage or clogging near the well face. As shown in the log-log plot (Figure 25B), the match between the data and the type curve is acceptable. The hydraulic conductivity estimate is 0.3 ft/day and the estimate for the storage coefficient is 6.2 x 10^{-10}.

The selected type curve for observation well data (P19-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 3.0. As shown in this log-log plot (Figure 23B), the match between the data and the type curve is good. The hydraulic conductivity estimate is 0.2 ft/day and the estimate for the storage coefficient is 7.7 x 10^{-4}.

The selected type curve for observation well data (P19.2-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 2.0. As shown in this log-log plot (Figure 27B), the match between the data and the type curve is fair. The hydraulic conductivity estimate is 0.2 ft/day and the estimate for the storage coefficient is 1.5 x 10^{-4}.

The above analyses show that the data deviates strongly from the 2-D flow model. Therefore, these data were reinterpreted using a 3-D model. For this interpretation, the selected type curve for the pumping well data.(P19.1-O) corresponds a C_De^{2s} parameter equal to 10. As shown in the log-log plot (Figure 26B), the match between the data and the type curve is slightly better than that obtained with the 2-D model. The estimated skin coefficient is -3.3 which indicates enhanced hydraulic conductivity near the well as opposed to the formation clogging indicated by the 2-D interpretation. The hydraulic conductivity estimate is 0.01 ft/day and the estimate for the storage coefficient is 5.6 x 10^{-3}.

The selected 3-D type curve for observation well data (P19-O) corresponds a C_De^{2s} parameter equal to 3.0. As shown in this log-log plot (Figure 24B), the match between the data and the type curve is only slightly better than that obtained with the 2-D model. The hydraulic conductivity estimate is 2.4 x 10^{-4} ft/day and the estimate for the storage coefficient is 1.4 x 10^{-6}.

The selected 3-D type curve for observation well data (P19.2-O) corresponds a C_De^{2s} parameter equal to 3.0. As shown in this log-log plot (Figure 28B), the match between the data and the type curve is acceptable. The hydraulic conductivity estimate is 2.0 x 10^{-4} ft/day and the estimate for the storage coefficient is 3.4 x 10^{-7}.

Aquifer Test on P28.1-O (Test #1)

This constant rate test involved a single pumping well (P28.1-O) with a discharge of 28 gpm from the oxide zone. Observation wells P28-GL and O28-GL were completed in the Lower Basin Fill Unit (LBFU) and observation wells P28.2-O and O28.1-O were completed in the oxide zone. Irrigation Well England #3 was on during the test but no information is available regarding its pumping rate history. Also, the recovery in the pumping well went beyond static water level. Test interpretation included only the data set from the pumping well.

The selected type curve for the pumping well data (P28.1-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 10. This value, in turn, results in a skin coefficient of -6.7 which indicates enhanced hydraulic conductivity near the well. This enhanced conductivity could be natural, as resulting from nearby fractures, or it could be due to the drilling and well development process. As shown in the log-log plot (Figure 30B), and due to the transient effects produced by nearby pumping, the match between the data and the type curve is only fair. The hydraulic conductivity estimate is 7.7 ft/day. The estimate for the storage coefficient is 5.2 which is clearly unreasonable (S is a dimensionless quantity smaller than one). This impossible storage coefficient estimate results from a data set affected by pumping from irrigation well England #3. This data set is hard to match with a type curve.

Aquifer Test on P28.1-O (Test #2)

This constant rate test involved a single pumping well (P28.1-O) with a discharge of 86 gpm from the oxide zone. Observation wells P28-GL and O28-GL were completed in the Lower Basin Fill Unit (LBFU) and observation wells P28.2-O and O28.1-O were completed in the oxide zone. Irrigation Well BIA-9 was on during testing, as was well P8.1-O. However, the data appear well-behaved and suitable for analysis.

The selected type curve for the pumping well data (P28.1-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 10. This value, in turn, results in a skin coefficient of -4.2 which indicates enhanced hydraulic conductivity near the well. This enhanced conductivity could be natural, as resulting from nearby fractures, or it could be due to the drilling and well development process. As shown in the log-log plot (Figure 31B), and in spite of the transient effects produced by nearby pumping, the match between the data and the type curve is good. The hydraulic conductivity estimate is 3.6 ft/day and the estimate for the storage coefficient is 3.4×10^{-2}.

The selected type curve for the observation well data (P28.2-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 2.0. As shown in this log-log plot (Figure 32B), and in spite of the transient effects produced by nearby pumping, the match between the data and the type curve is good. The hydraulic conductivity estimate is 2.7 ft/day. The estimate for the storage coefficient is 2.9×10^{-4}.

Aquifer Test on P49-O

The aquifer test conducted on well P49-O consisted of a constant discharge of about 40 gpm. Two observation wells were monitored during this test; well O49-O, completed in the oxide unit, and well O49-GL completed in the Lower Basin Fill Unit. More than 180 ft of drawdown in the pumping well rendered the pressure transducer dry. Pressure response on the observation wells was relatively clean, with well O49-O showing a drawdown of about 95 ft, and a drawdown in the basin fill well of about 0.5 ft. No other wells were reported in operation during this test, so the quality of the data is good. As mentioned before, only partial data was collected during drawdown in the pumping well, so the hydraulic conductivity for this test was estimated from the shut in data.

The log-log plot (Figure 34B) for this test shows that a 3-D model represents the observed data quite well. A type-curve parameter C_De^{2s} of 0.3 produces and estimated hydraulic conductivity value of 7.8×10^{-3} ft/day and a skin coefficient of -7.7. The estimated storage coefficient is however surprisingly high (0.8). The reason for this extreme value is not apparent at this time.

4.0 DISCUSSION

The hydraulic conductivity estimates from aquifer tests in the basin fill are quite variable, ranging from 0.1 to 61.3 ft/day and, as expected, they are about an order of magnitude larger than the hydraulic conductivity estimates for the oxide zone. The majority of hydraulic conductivity estimates in the Basin Fill and oxide zone are reasonable. A large variation in storativity is observed and some of these estimates are unrealistically small. The smallest values are usually derived from interpretation of pumping well data. As commonly found in most filed tests, and also indicated by the Florence data, test analyses in observation wells tend to give more reasonable storativity estimates than analyses of pumping well data.

Analyses of many of the tests described above show the effects from multiple pumping wells with unknown pumping rate history. It is our opinion that further analyses of these tests would be better accomplished by inverse techniques that use available drawdown data to simultaneously estimate the unknown flow rate history in the agricultural wells and the aquifer parameters. Golder Associates has initiated work to accomplish these analyses. The actual effect of additional pumping from wells in the vicinity of a test on the magnitude of the estimated hydraulic parameters is not well understood. It would depend on whether a particular well is pumping or shut in after some period of pumping. When a nearby well is pumping, the estimates would more likely underestimate the actual aquifer parameters. The true effect needs, however, to be evaluated through analytical studies that simulate typical conditions observed in the field.

Several of the hydraulic responses for the tests analyzed in this report seem to be better interpreted by assuming a 3-D flow geometry. However, the estimated hydraulic conductivity and storativity obtained through the 3-D analysis are two or three orders of magnitude smaller than those obtained from the traditional 2-D radial flow model. The reason for the smaller hydraulic parameters is clear when one considers the area available for flow under each of these models. Under the 2-D radial flow model this area increases as a linear function of the distance from the pumping well, whereas for the 3-D model, it increases with the square of this distance.

In terms of predicting the producing capacity of a well, the distinction between alternative flow geometries is not crucial. However, for evaluation of transport of solutes through the aquifer this distinction becomes extremely relevant. It is important to notice, however, that for the simulation of solute transport in the context of the APP process, use of the 2-D hydraulic parameters results in conservative estimates of solute migration. By using a "reduced" area for solute transport (interaction) one would necessarily overestimate the potential migration of solutes. It is recommended that numerical simulations of flow and transport be carried out with the 2-D hydraulic parameter estimates.

Of paramount importance for the in-situ operation and for environmental protection, is the distinction between porous media flow and that resulting from discrete features. So far, the available field data indicate that flow at the Florence Site can safely be simulated with a porous media approach such as that built within numerical flow models like MODFLOW.

Golder Associates will continue interpreting the available hydraulic test data to support potential needs for the APP process and future mining needs. The next phase of aquifer test interpretation will concentrate on data from observation wells using inverse procedures as briefly described above. The three-dimensional model does not seem to fit the data sets any better than the two-dimensional model. Again, for the sake of conservatism, and due to the large uncertainty in the interpretation of these tests, it is recommended that the values obtained from the 2-D model be used for subsequent numerical simulations.

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6.0 NOMENCLATURE

Symbol		Unit
B	formation volume factors	-
c_r	rock compressibility	Pa^{-1}
c_t	total compressibility	Pa^{-1}
c_w	water compressibility	Pa^{-1}
c_{ww}	water compressibility in wellbore	Pa^{-1}
C	wellbore storage coefficient	m^3/Pa
C_D	dimensionless wellbore storage coefficient	-
d_i	distance to boundary "I"	m
g	acceleration due to gravity	ms^{-2}
h	test section length	m
h_m	thickness of matrix blocks	m
H	head	m
k	intrinsic permeability (1 milli Darcy = 10^{-15} m^2)	m^2
k_f	fracture permeability (in a double porosity system)	m^2
k_{fD}	dimensionless fracture permeability	-
k_{fw}	fracture permeability	m^2
k_m	matrix permeability	m^2
$(kh/\mu)_{1/2}$	mobility ratio	-
K	hydraulic conductivity	ms^{-1}
K_s	hydraulic conductivity of the skin zone	ms^{-1}
l	linear distance	m
m	meters	m
P	pressure	Pa
P_{atm}	atmospheric pressure	Pa
P_D	dimensionless pressure	-
q	flow rate	m^3/day
q_i	the i^{th} constant rate flow period	m^3/s
r	radial distance	m
r_D	dimensionless radius	-
r_e	radius of circular constant pressure boundary	m
r_1	radius of the composite discontinuity	m
r_w	wellbore radius	m
r_{we}	effective well radius	m
s	skin factor of the well	-
s_f	skin factor between the fractures and the matrix	-
S	formation storage (storativity)	-
S_S	specific storage	m^{-1}

NOMENCLATURE - *continued*

Symbol		Unit
t	time	s
t_m	thickness of the matrix blocks	m
t_p	flow period duration	s
t_{pD}	dimensionless flow period duration	-
t_D	dimensionless time	-
V	volume of fluid	m^3
V_w	test section volume	m^3
x_f	fracture half-length	m
Z	elevation	m
α	dual porosity block geometry scale factor	-
ϕ	porosity	fraction
ϕ_f	fracture porosity	fraction
ϕ_m	matrix porosity	fraction
$(\phi c_t h)_{½}$	storativity ratio	-
λ	interporosity flow coefficient	-
μ	dynamic viscosity	Pa-s
ω	interporosity storativity ratio	-
ρ	density	Kg m^{-3}
Δt	time change	s
Δt_I	duration of the i^{th} constant rate event	s

Tables

Table 1 Summary of Available Hydraulic Test Data

Active Well	Observation Wells	Start Date	End Date	Well Location	Screen Location	Drawdown Data	Rate Data	Summary Sheet
M1-GL		11-Aug	13-Aug	X	X	X	X	X
	none							
M2-GU		25-Jul	26-Jul	X	X	X	X	X
	M3-GL			X	X	X		X
	M4-O			X	X	X		X
	M5-S			X	?	X		X
M3-GL		26-Jul	27-Jul	X	X	X	X	X
	M2-GU			X	X	X		X
	M4-O			X	X	X		X
	M5-S			X	X	X		X
M4-O		28-Jul	29-Jul	X	X	X	X	X
	M2-GU			X	X	X		X
	M3-GL			X	X	X		X
	M5-S			X	?	X		X
M10-GU		25-Jul	26-Jul	X	X	X	X	X
	M11-GL			X	X	X		X
	M12-O			X	X	X		X
	M13-S			X	X	X		X
M11-GL		29-Jul	30-Jul	X	X	X	X	X
	M10-GU			X	X	X		X
	M12-O			X	X	X		X
	M13-S			X	X	X		X
M12-O		31-Jul	1-Aug	X	X	X	X	X
	M10-GU			X	X	X		X
	M11-GL			X	X	X		X
	M13-S			X	?	X		X
M14-GL		11-Aug	13-Aug	X	X	X	X	X
	M15-GU			X	X	X		X
M15-GU		8-Aug	11-Aug	X	X	X	X	X
	M14-GL			X	X	X		X
M18-GU		8-Aug	11-Aug	X	X	X	X	X
	none							
PW2-1		8-Mar	?	X	X	X	X	N/A
	OB2-1			X	X			
PW3-1		24-Mar	1-Apr	X	X	X	?	N/A
	OB3-1			X	X	X		
PW4-1	(Test 1)	19-May	?	X	X	X	X	N/A
	OB4-1			X	X	X		
PW4-1	(Test 2)	23-May	31-May	X	X	X	X	N/A
	OB4-1			X	X			
P5-O		18-Oct	24 0ct	X	X	X	X	X
	O5.1-O			X	X	X		X
	O5.2-O			X	X	X		X
P5-O-MOD		18-Oct	24 0ct	X	X	X	X	X
	O5.1-O			X	X	X		X
	O5.2-O			X	X	X		X

Table 1 Summary of Available Hydraulic Test Data

Active Well	Observation Wells	Start Date	End Date	Well Location	Screen Location	Drawdown Data	Rate Data	Summary Sheet
PW7-1		16-Jun	21-Jun	X	X	X	X	N/A
	OB7-1			X	X	X		
	O3-GL			X	X	X		
	OB-1			X	X	X		
P8.2-O		?	?	X	X	?	X	?
	P8-GL			X	X	?		
	P8.1-O			X	X	?		
	O8-O			X	X	?		
	O8-GL			X	X	?		
P8.1-O		8-Sep-95	11-Sep	X	X	X	X	X
	P8-GU			X	X	X		X
	P8.2-O			X	X	X		X
	O8-O			X	X	X		X
	O8-GU			X	X	X		X
P8-GU		18-Sep	22-Sep	X	X	X	X	X
	P8.1-O			X	X	X		X
	P8.2-O			X	X	X		X
	O8-O			X	X	X		X
	O8-GU			X	X	X		X
P12-O		1-Jun	7-Jun	X	X	X	X	X
	O12-O			X	X	X		X
	O12-GL			X	X	X		X
P13.1-O		9-Oct	16-Oct	X	X	X	X	X
	P13-GL			X	X	X		X
	P13.2-O			X	X	X		X
	O13-O			X	X	X		X
P15-O		29-Sep	5-Oct	X	X	X	X	X
	P15-GL			X	X	X		X
	O15-O			X	X	X		X
	WW3			?	?	?		X
	BIA-9			?	?	?		X
P19.1-O		3-Jul	6-Jul	X	X	X	X	N/A
	P19-O			X	X	X		
	P19.2-O			X	X	X		
	O19-GL			X	X	X		
	138			X	X	X		
P28-GL		20-Sep	25-Sep	X	X	X	X	X
	P28.1-O			X	X	No Data		
	P28.2-O			X	X	X		X
	O28-GL			X	X	X		X
	O28.1-O			X	X	X		X
	O28.2-S			X	X	X		X
P28.1-O		15-Aug	18-Aug	X	X	X	X	X
(Test 1)	P28.2-O			X	X	X		X
	P28-GL			X	X	X		X
	O28-GL			X	X	X		X
	O28.1-O			X	X	X		X
	O28.2-S			X	X	No Data		

Table 1 Summary of Available Hydraulic Test Data

Active Well	Observation Wells	Start Date	End Date	Well Location	Screen Location	Drawdown Data	Rate Data	Summary Sheet
P28.1-O		8-Sep	11-Sep	X	X	X	X	X
(Test 2)	P28.2-O			X	X	X		X
	P28-GL			X	X	X		X
	O28-GL			X	X	X		X
	O28.1-O			X	X	X		X
	O28.2-S			X	X	No Data		
P28.2-O		2-Oct	5-Oct	X	X	X	X	X
	P28-GL			X	X	X		X
	P28.1-O			X	X	X		X
	O28.1-O			X	X	X		X
	O28-GL			X	X	X		X
	O28.2-O			X	X	X		X
P39-O		19-May	20-May	X	X	X	X	X
	O39-O			X	X	X		X
P49-O		11-Oct	16-Oct	X	X	X	X	X
	O49-O			X	X	X		X
	O49-GL			X	X	X		X

Table 2. Hydraulic Conductivity Estimates

Well	Active/Observation	K (feet/day)	Screened Formation	Comments
M1-GL	Active	17.3	LBFU	(1), (2); Acceptable
M3-GL	Active	15.9	LBFU	(1), (3); Acceptable
M14-GL	Active	1.7	LBFU	(1), (2); Acceptable
M14-GL3d	Active	0.1	LBFU	(1), (2); Acceptable
M15-GU	Active	2.6	LBFU	(1), (2), (3); Acceptable
M18-GL	Active	19.6	LBFU	(1); Fair
P28-GL	Active	8.3	LBFU	(1), (3); Acceptable
O28-GL	Observation (P28-GL)	23.2	LBFU	(1), (3); Acceptable
M3-GL	Observation (M4-O)	14.8	LBFU	(1), (3); Acceptable
P8-GU	Active	61.3	UBFU	(1), (2), (3); Fair

M4-O	Active	0.6	Oxide	(1), (3); Acceptable
PW2-1	Active	1.4	Oxide	Good
PW4-1	Active	3.8	Oxide	Good
PW7-1	Active	0.2	Oxide	(1), (3); Acceptable
OB7-1	Observation (PW7-1)	0.1	Oxide	(1), (3); Acceptable
P12-O	Active	0.4	Oxide	(1), (2), (3); Fair
O12-O	Observation (P12-O)	0.6	Oxide	(1), (2), (3); Fair
P19.1-O	Active	0.3	Oxide	(1), (2), (3); Acceptable
P19-O	Observation (P19.1-O)	0.2	Oxide	(1), (2), (3); Acceptable
P19.2-O	Observation (P19.1-O)	0.2	Oxide	(1), (2), (3); Fair
P19.1-O3d	Active	1.00E-02	Oxide	(1), (2), (3); Acceptable
P19-O3d	Observation (P19.1-O)	2.39E-04	Oxide	(1), (2), (3); Acceptable
P19.2-O3d	Observation (P19.1-O)	1.99E-04	Oxide	(1), (2), (3); Acceptable
P39-O	Active	0.3	Oxide	Good
O39-O	Observation (P39-O)	0.3	Oxide	Good
P28.1-O	Active	7.7	Oxide	(1), (3); Fair
P28.1-O (2)	Active	3.6	Oxide	(1); Good
P28.2 -O	Observation (P28.1-O)	2.7	Oxide	(1); Good
P28.2-O	Active	3.1	Oxide	(1), (3); Fair
O28.1-O	Observation (P28.2-O)	3.0	Oxide	(1), (3); Acceptable
P13.1-O	Active	0.3	Oxide	Good
				Obs. Well shows 3-D behavior
P49-O3d	Active/Recovery Data	7.75E-03	Oxide	Good, Clear 3-D behavior
P15-O	Active	0.5	Oxide	(1),(3); Acceptable

(1) Other wells were pumping during this test at an unknown rate
(2) Data indicates recovery over the initial "static" water table
(3) Observation wells show effects of recovery or drawdown produced by other wells

Qualifiers	Description
Good	The reported K value is a good indication of the formation hydraulic conductivity
Acceptable	The reported K value is most likely an under-estimation of the formation conductivity
Fair	The reported K value has a large uncertainty due to conditions during test

Figures

APPENDIX A

FlowDim Analysis File : **m1-gld.dat**

	Parameter		Units
r_w	Well radius	**0.064**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**10.00**	%
C	Wellbore storage	**4.35E-06**	m^3/Pa
h	Length of aquifer tested	**12.19**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln \left(C_D e^{2s}\, 2 \pi \phi c_t h r_w^2 / C \right)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+08
P (kPa)	7.5335E-01
T (hr)	3.9350E+02

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
7.43E-04	**1.20E-02**	**17.29**	**6.10E-05**	**6.10E-03**	**3.32**

FlowDim Analysis File : m3gloddb.fd1

	Parameter		Units
r_w	Well radius	0.064	m
μ	Groundwater viscosity	1.000E-03	Pa s
ρ	Groundwater density	1.000E+03	kg/m^3
c_t	Total compressibility	5.400E-10	1/Pa
ϕ	Porosity of formation	5.00	%
C	Wellbore storage	N/A	m^3/Pa
h	Length of aquifer tested	18.29	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	N/A
P (kPa)	6.4470E-01
T (hr)	4.1462E-01

Results

$T (m^2/sec)$	K (feet/min)	K(feet/dat)	K (m/s)	K (cm/s)	Skin
9.53E-04	1.03E-02	14.77	5.21E-05	5.21E-03	########

FlowDim Analysis File : m14-gld.dat

	Parameter		Units
r_w	Well radius	0.064	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	10.00	%
C	Wellbore storage	2.35E-06	m^3/Pa
h	Length of aquifer tested	18.29	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s} \, 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+06
P (kPa)	1.1410E-01
T (hr)	1.1015E+02

Results

T(m^2/sec)	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
1.12E-04	1.21E-03	1.74	6.15E-06	6.15E-04	1.18

FlowDim Analysis File : m14gld3d.dat

	Parameter		Units
r_w	Well radius	**0.064**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**10.00**	%
C	Wellbore storage	**2.22E-06**	m^3/Pa
h	Length of aquifer tested	**18.29**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\, 2\, \pi\, \phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+01
P (kPa)	1.0766E-02
T (hr)	1.1022E+01

Results

T(m^2/sec)	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
5.31E-06	**5.71E-05**	**0.08**	**2.90E-07**	**2.90E-05**	**-4.54**

FlowDim Analysis File : **m15-gud.dat**

	Parameter		Units
r_w	Well radius	**0.064**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**10.00**	%
C	Wellbore storage	**2.78E-07**	m^3/Pa
h	Length of aquifer tested	**12.19**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln\left(C_D e^{2s}\, 2\,\pi\,\phi\, c_t\, h\, r_w^2 / C \right)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+10
P (kPa)	1.1287E-01
T (hr)	9.2222E+02

Results

T(m²/sec)	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
1.11E-04	**1.80E-03**	**2.59**	**9.14E-06**	**9.14E-04**	**6.65**

FlowDim Analysis File : m18-gud.dat

	Parameter		Units
r_w	Well radius	0.064	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	10.00	%
C	Wellbore storage	2.25E-06	m^3/Pa
h	Length of aquifer tested	12.19	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s} \, 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+15
P (kPa)	8.5570E-01
T (hr)	8.6654E+02

Results

T(m^2/sec)	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
8.44E-04	1.36E-02	19.64	6.93E-05	6.93E-03	11.36

FlowDim Analysis File : mf39pwpd.dat

	Parameter		Units
r_w	Well radius	0.130	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	5.00	%
C	Wellbore storage	1.04E-06	m^3/Pa
h	Length of aquifer tested	108.20	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_De^{2s}\ 2\ \pi\ \phi\ c_t\ h\ r_w^{\ 2} / C)}{2}$$

Match Point Parameters From Analysis

C_De^{2s}	1.0000E+02
P (kPa)	2.0728E-02
T (hr)	2.4897E+02

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
1.12E-04	2.04E-04	0.29	1.04E-06	1.04E-04	-1.76

FlowDim Analysis File : mf39owpd.dat

	Parameter		Units
r_w	Well radius	**0.127**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**50.00**	%
C	Wellbore storage	**NA**	m^3/Pa
h	Length of aquifer tested	**126.80**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\, 2\, \pi\, \phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+00
P (kPa)	2.6738E-02
T (hr)	9.3173E-01

Results

$T (m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
1.44E-04	**2.24E-04**	**0.32**	**1.14E-06**	**1.14E-04**	########

FlowDim Analysis File : **ob7-1dda.fd1**

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.000E-03**	Pa s
ρ	Groundwater density	**1.000E+03**	kg/m^3
c_t	Total compressibility	**5.400E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**N/A**	m^3/Pa
h	Length of aquifer tested	**103.63**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	N/A
P (kPa)	1.2560E-02
T (hr)	5.7458E+00

Results

T(m²/sec)	K (feet/min)	K(feet/dat)	K (m/s)	K (cm/s)	Skin
4.95E-05	**9.40E-05**	**0.14**	**4.78E-07**	**4.78E-05**	########

FlowDim Analysis File : **012-oddc.fd1**

	Parameter		Units
r_w	Well radius	**0.051**	m
μ	Groundwater viscosity	**1.000E-03**	Pa s
ρ	Groundwater density	**1.000E+03**	kg/m^3
c_t	Total compressibility	**5.400E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**N/A**	m^3/Pa
h	Length of aquifer tested	**152.40**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s} \, 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	N/A
P (kPa)	5.0164E-02
T (hr)	1.0792E+00

Results

$T (m^2/sec)$	K (feet/min)	K(feet/dat)	K (m/s)	K (cm/s)	Skin
3.21E-04	**4.15E-04**	**0.60**	**2.11E-06**	**2.11E-04**	########

FlowDim Analysis File : **o28-gld.dat**

	Parameter		Units
r_w	Well radius	**0.051**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**10.00**	%
C	Wellbore storage	**NA**	m^3/Pa
h	Length of aquifer tested	**9.14**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s} \, 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+00
P (kPa)	1.0130E-01
T (hr)	6.1809E+01

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
7.49E-04	**1.61E-02**	**23.22**	**8.19E-05**	**8.19E-03**	########

FlowDim Analysis File : o281-od.dat

	Parameter		Units
r_w	Well radius	0.051	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	5.00	%
C	Wellbore storage	NA	m^3/Pa
h	Length of aquifer tested	30.48	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln(C_D e^{2s}\, 2\,\pi\,\phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+00
P_{DM}	4.2352E-02
T_{DM}	4.3542E-01

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
3.17E-04	2.05E-03	2.95	1.04E-05	1.04E-03	#########

FlowDim Analysis File : pw2-1d.dat

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**2.36E-06**	m^3/Pa
h	Length of aquifer tested	**67.06**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2\ \pi\ \phi\ c_t\ h\ r_w^{\ 2} / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+08
P (kPa)	6.5031E-02
T (hr)	3.1235E+02

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
3.20E-04	**9.41E-04**	**1.35**	**4.78E-06**	**4.78E-04**	**4.31**

FlowDim Analysis File : pm3-glda.fd1

	Parameter		Units
r_w	Well radius	0.064	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	10.00	%
C	Wellbore storage	8.16E-07	m^3/Pa
h	Length of aquifer tested	12.19	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln(C_D e^{2s}\, 2\pi\, \phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+06
P (kPa)	6.9300E-01
T (hr)	1.9300E+03

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
6.83E-04	1.10E-02	15.88	5.60E-05	5.60E-03	1.51

FlowDim Analysis File : **pw4-1.dat**

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**1.87E-06**	m^3/Pa
h	Length of aquifer tested	**103.63**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+08
P (kPa)	1.9640E-01
T (hr)	1.6933E+03

Results

$T (m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
1.37E-03	**2.61E-03**	**3.76**	**1.33E-05**	**1.33E-03**	**4.65**

FlowDim Analysis File : pm4-od.fd1

	Parameter		Units
r_w	Well radius	**0.06**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**1.38E-06**	m^3/Pa
h	Length of aquifer tested	**18.29**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln(C_D e^{2s}\, 2\pi\, \phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+08
P (kPa)	2.4300E-02
T (hr)	6.0000E+01

Results

$T (m^2/sec)$	K (feet/min)	K (feet/day)	K (m/s)	K (cm/s)	Skin
3.59E-05	**3.86E-04**	**0.56**	**1.96E-06**	**1.96E-04**	**3.75**

FlowDim Analysis File : PW7-1dda.fd1

	Parameter		Units
r_w	Well radius	0.076	m
μ	Groundwater viscosity	1.000E-03	Pa s
ρ	Groundwater density	1.000E+03	kg/m^3
c_t	Total compressibility	5.400E-10	1/Pa
ϕ	Porosity of formation	5.00	%
C	Wellbore storage	6.871E-07	m^3/Pa
h	Length of aquifer tested	103.63	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2\ \pi\ \phi\ c_t\ h\ r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+02
P (kPa)	2.1298E-02
T (hr)	2.8162E+02

Results

$T (m^2/sec)$	K (feet/min)	K (feet/day)	K (m/s)	K (cm/s)	Skin
8.40E-05	1.59E-04	0.23	8.10E-07	8.10E-05	-2.10

FlowDim Analysis File : p8-gud.dat

	Parameter		Units
r_w	Well radius	0.076	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	10.00	%
C	Wellbore storage	1.19E-05	m^3/Pa
h	Length of aquifer tested	36.58	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s} \, 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+06
P (kPa)	9.0703E-01
T (hr)	1.5374E+03

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
7.91E-03	4.26E-02	61.31	2.16E-04	2.16E-02	0.90

FlowDim Analysis File : **P12-oddc.fd1**

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.000E-03**	Pa s
ρ	Groundwater density	**1.000E+03**	kg/m^3
c_t	Total compressibility	**5.400E-10**	1/Pa
ϕ	Porosity of formation	**10.00**	%
C	Wellbore storage	**4.640E-06**	m^3/Pa
h	Length of aquifer tested	**152.40**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2\pi\ \phi\ c_t\ h\ r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	3.0000E+00
P (kPa)	3.1823E-02
T (hr)	1.0126E+02

Results

$T (m^2/sec)$	K (feet/min)	K (feet/day)	K (m/s)	K (cm/s)	Skin
2.04E-04	**2.63E-04**	**0.38**	**1.34E-06**	**1.34E-04**	**-4.27**

FlowDim Analysis File : P131od.dat

	Parameter		Units
r_w	Well radius	0.076	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	0.05	%
C	Wellbore storage	1.75E-03	m^3/Pa
h	Length of aquifer tested	206.35	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2\ \pi\ \phi\ c_t\ h\ r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+06
P (kPa)	4.2200E-02
T (hr)	2.5150E+02

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
1.91E-04	1.82E-04	0.26	9.26E-07	9.26E-05	-3.38

FlowDim Analysis File : **P132od3d.dat**

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**0.05**	%
C	Wellbore storage	**N/A**	m^3/Pa
h	Length of aquifer tested	**182.27**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2\ \pi\ \phi\ c_t\ h\ r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	N/A
P (kPa)	3.6000E-05
T (hr)	4.2500E-01

Results

$T (m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
8.18E-08	**8.84E-08**	**1.27E-04**	**4.49E-10**	**4.49E-08**	########

FlowDim Analysis File : **P150d.dat**

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**0.05**	%
C	Wellbore storage	**4.94E-06**	m^3/Pa
h	Length of aquifer tested	**219.46**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_De^{2s}\, 2\,\pi\,\phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

C_De^{2s}	1.0000E+02
P (kPa)	6.6100E-02
T (hr)	1.7940E+02

Results

$T (m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
3.84E-04	3.44E-04	0.50	1.75E-06	1.75E-04	-5.02

FlowDim Analysis File : **p19-od.dat**

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**NA**	m^3/Pa
h	Length of aquifer tested	**60.35**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s} \, 2 \, \pi \, \phi \, c_t \, h \, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	3.0000E+00
P (kPa)	1.8917E-02
T (hr)	3.7000E-01

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
4.10E-05	**1.34E-04**	**0.19**	**6.80E-07**	**6.80E-05**	########

FlowDim Analysis File : p19-od3d.dat

	Parameter		Units
r_w	Well radius	0.076	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	5.00	%
C	Wellbore storage	NA	m^3/Pa
h	Length of aquifer tested	60.35	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	3.0000E+00
P (kPa)	4.6825E-05
T (hr)	2.4582E-01

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
5.08E-08	1.66E-07	0.00	8.41E-10	8.41E-08	########

FlowDim Analysis File : p191-od.dat

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**4.58E-07**	m^3/Pa
h	Length of aquifer tested	**60.35**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2\ \pi\ \phi\ c_t\ h\ r_w^{\ 2} / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+08
P (kPa)	2.9442E-02
T (hr)	3.2135E+02

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
6.39E-05	**2.08E-04**	**0.30**	**1.06E-06**	**1.06E-04**	**5.08**

FlowDim Analysis File : p191od3d.dat

	Parameter		Units
r_w	Well radius	0.076	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	5.00	%
C	Wellbore storage	4.19E-07	m^3/Pa
h	Length of aquifer tested	60.35	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s} \, 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+01
P (kPa)	2.1754E-03
T (hr)	2.5952E+01

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
2.36E-06	7.70E-06	0.01	3.91E-08	3.91E-06	-3.28

FlowDim Analysis File : p192-od.dat

	Parameter		Units
r_w	Well radius	0.051	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	5.00	%
C	Wellbore storage	NA	m^3/Pa
h	Length of aquifer tested	60.35	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\, 2\, \pi\, \phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+00
P (kPa)	1.4484E-02
T (hr)	1.7103E+00

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
3.14E-05	1.02E-04	0.15	5.20E-07	5.20E-05	########

FlowDim Analysis File : p192od3d.dat

	Parameter		Units
r_w	Well radius	0.051	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	5.00	%
C	Wellbore storage	NA	m^3/Pa
h	Length of aquifer tested	60.35	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\, 2\,\pi\, \phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	3.0000E+00
P (kPa)	3.8942E-05
T (hr)	1.0011E+00

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
4.22E-08	1.38E-07	0.00	7.00E-10	7.00E-08	########

FlowDim Analysis File : p28-gld.dat

	Parameter		Units
r_w	Well radius	0.064	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	10.00	%
C	Wellbore storage	8.71E-07	m^3/Pa
h	Length of aquifer tested	9.14	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2\ \pi\ \phi\ c_t\ h\ r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+06
P (kPa)	3.6017E-02
T (hr)	7.0454E+02

Results

$T (m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
2.66E-04	5.73E-03	8.26	2.91E-05	2.91E-03	1.33

FlowDim Analysis File : p281-oad.dat

	Parameter		Units
r_w	Well radius	0.067	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	5.00	%
C	Wellbore storage	1.50E-04	m^3/Pa
h	Length of aquifer tested	30.48	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln(C_De^{2s}\, 2\, \pi\, \phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

C_De^{2s}	1.0000E+01
P (kPa)	2.8879E-01
T (hr)	1.2647E+01

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
8.25E-04	5.33E-03	7.68	2.71E-05	2.71E-03	-6.69

FlowDim Analysis File : p281-obd.dat

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**1.28E-06**	m^3/Pa
h	Length of aquifer tested	**30.48**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s} \, 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+01
P (kPa)	4.6017E-02
T (hr)	6.9315E+02

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
3.86E-04	**2.49E-03**	**3.59**	**1.26E-05**	**1.26E-03**	**-4.18**

FlowDim Analysis File : p282-obd.dat

	Parameter		Units
r_w	Well radius	**0.051**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**NA**	m^3/Pa
h	Length of aquifer tested	**30.18**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s} \, 2 \pi \, \phi \, c_t \, h \, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+00
P (kPa)	3.3963E-02
T (hr)	3.9303E+00

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
2.84E-04	**1.86E-03**	**2.67**	**9.43E-06**	**9.43E-04**	########

FlowDim Analysis File : p282-od.dat

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**1.41E-04**	m^3/Pa
h	Length of aquifer tested	**30.18**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_De^{2s} \, 2 \, \pi \, \phi \, c_t \, h \, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

C_De^{2s}	1.0000E+01
P (kPa)	4.4105E-02
T (hr)	5.4115E+00

Results

T(m^2/sec)	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
3.30E-04	**2.15E-03**	**3.10**	**1.09E-05**	**1.09E-03**	**-6.53**

FlowDim Analysis File : **P49Od.dat**

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**0.05**	%
C	Wellbore storage	**1.78E-06**	m^3/Pa
h	Length of aquifer tested	**126.19**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2 \pi \phi c_t h r_w^2 / C)}{2}$$

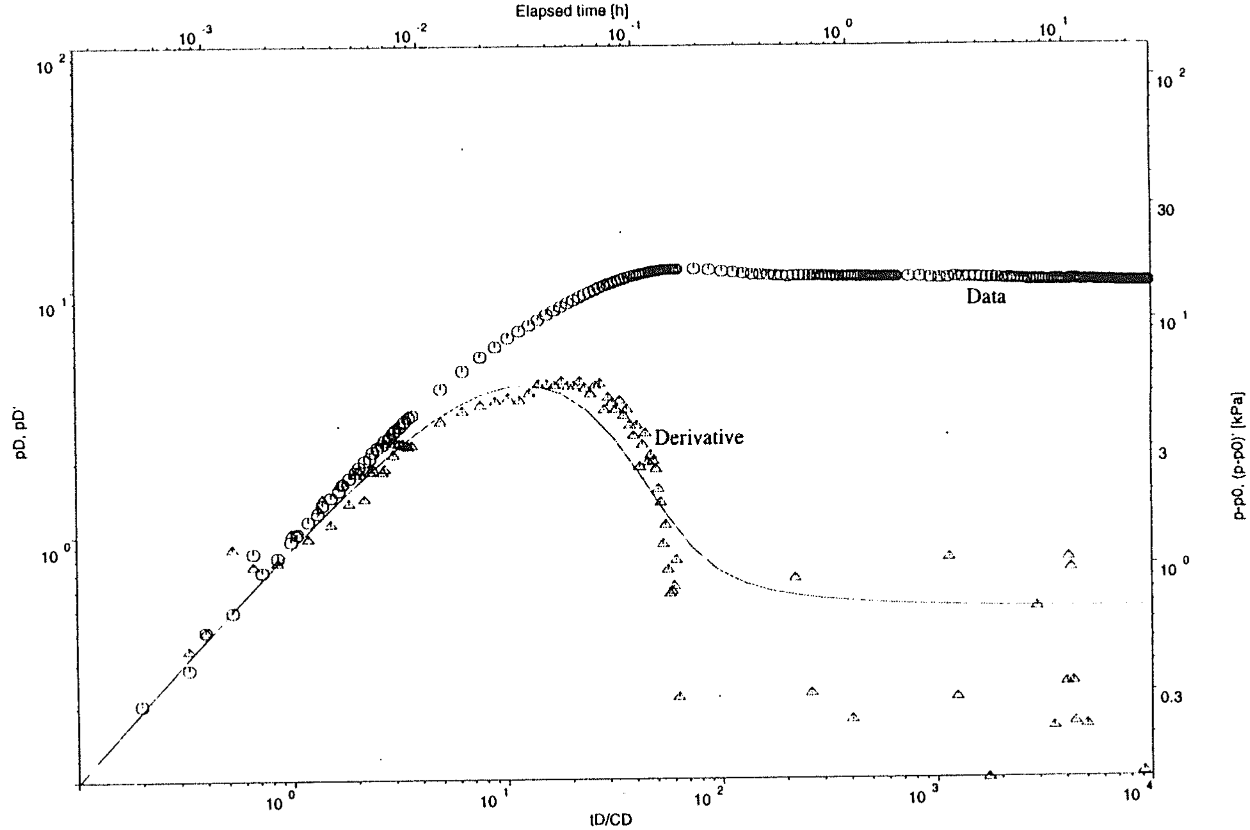
Match Point Parameters From Analysis

$C_D e^{2s}$	3.0000E-01
P (kPa)	1.7500E-03
T (hr)	8.9400E+00

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
3.45E-06	**5.38E-06**	**7.75E-03**	**2.73E-08**	**2.73E-06**	**-7.69**

APPENDIX B

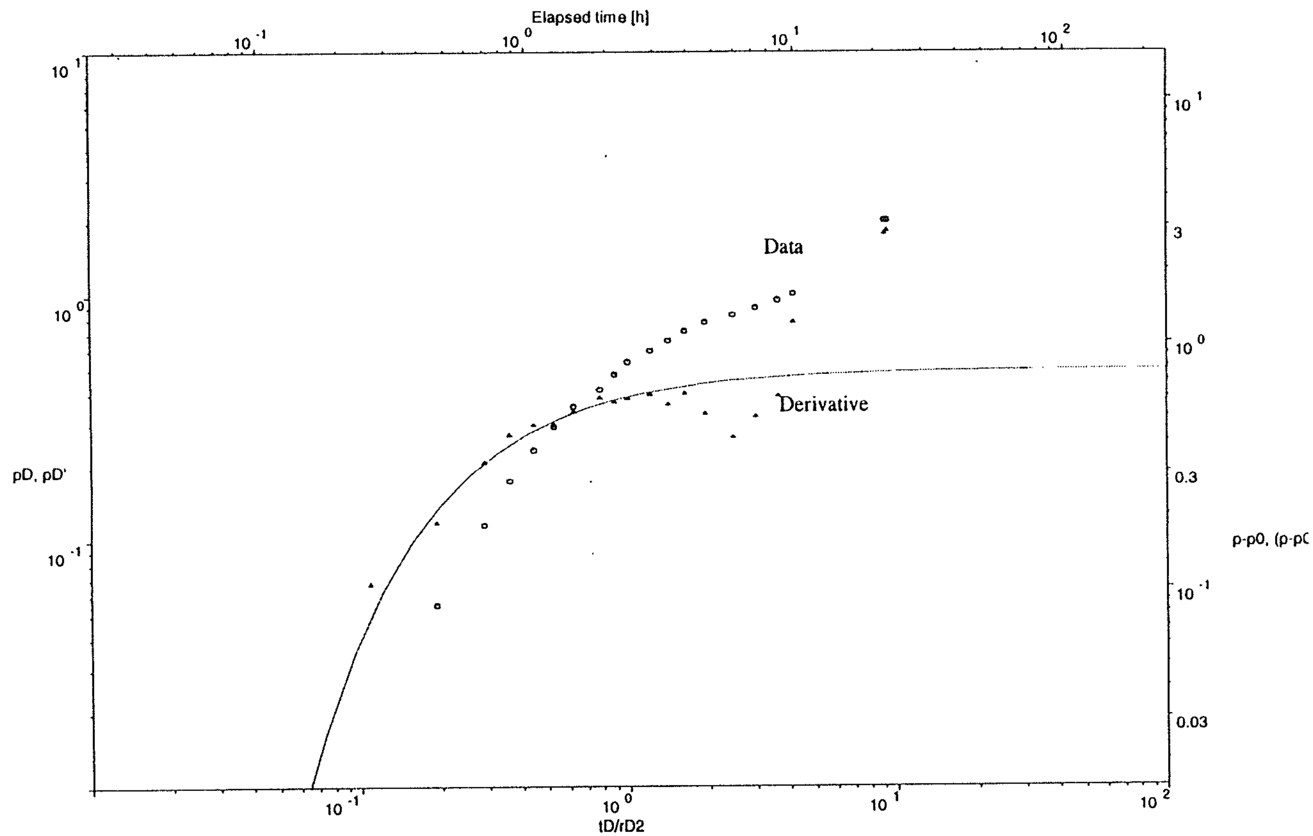


FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	4.35E-06	m3/Pa
T=	7.43E-04	m2/s
S=	8.43E-09	-
s=	0.00E+00	-
n=	2.00E+00	-

Florence, Arizona / M3-GL
Lower Gila / Obs Well

FlowDim Version
(c) Golder Associates



FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-

T=	9.53E-04	m2/s
S=	8.78E-02	-
rD=	1.53E+02	-
n=	2.00E+00	-

Figure 2B

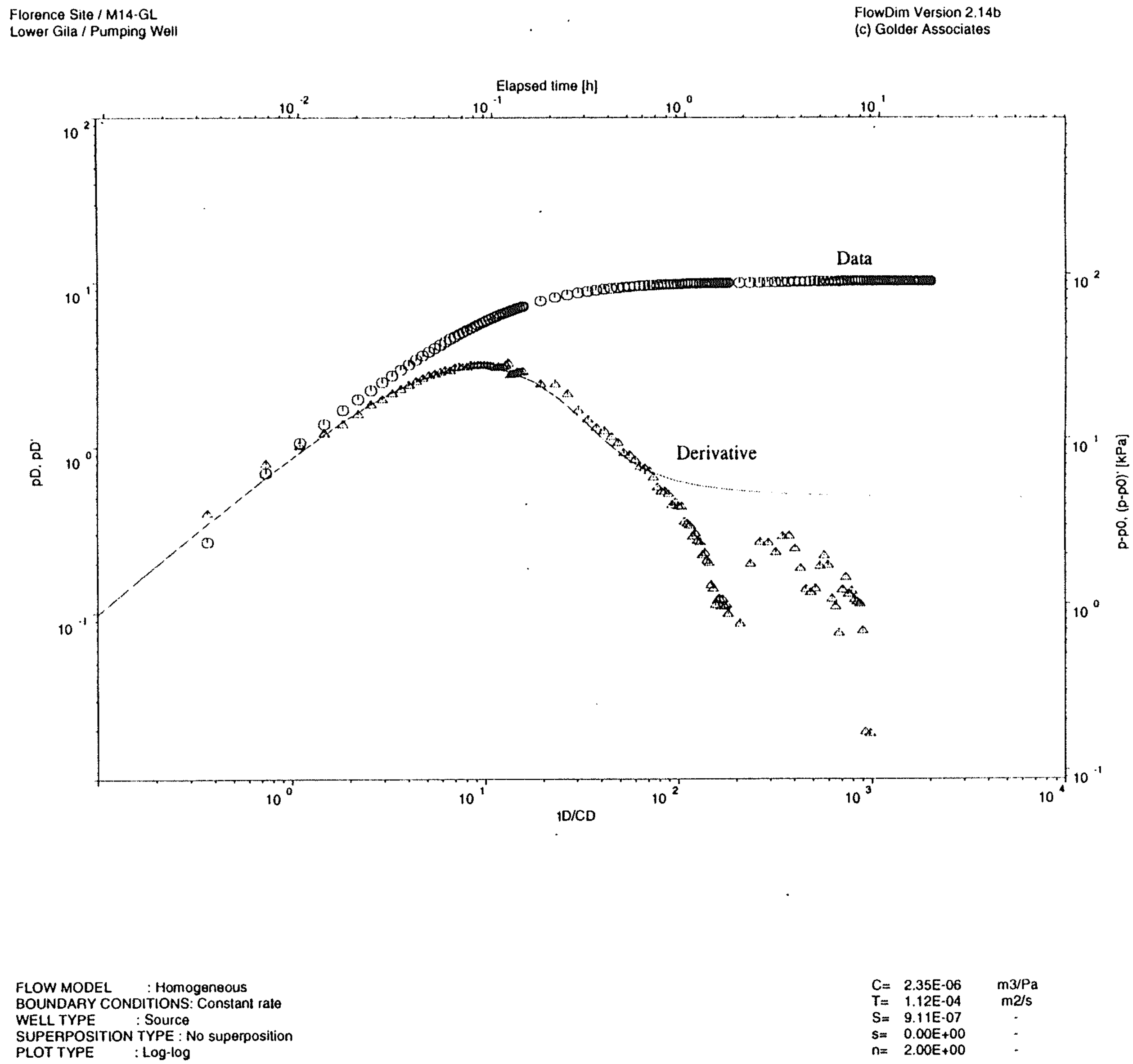
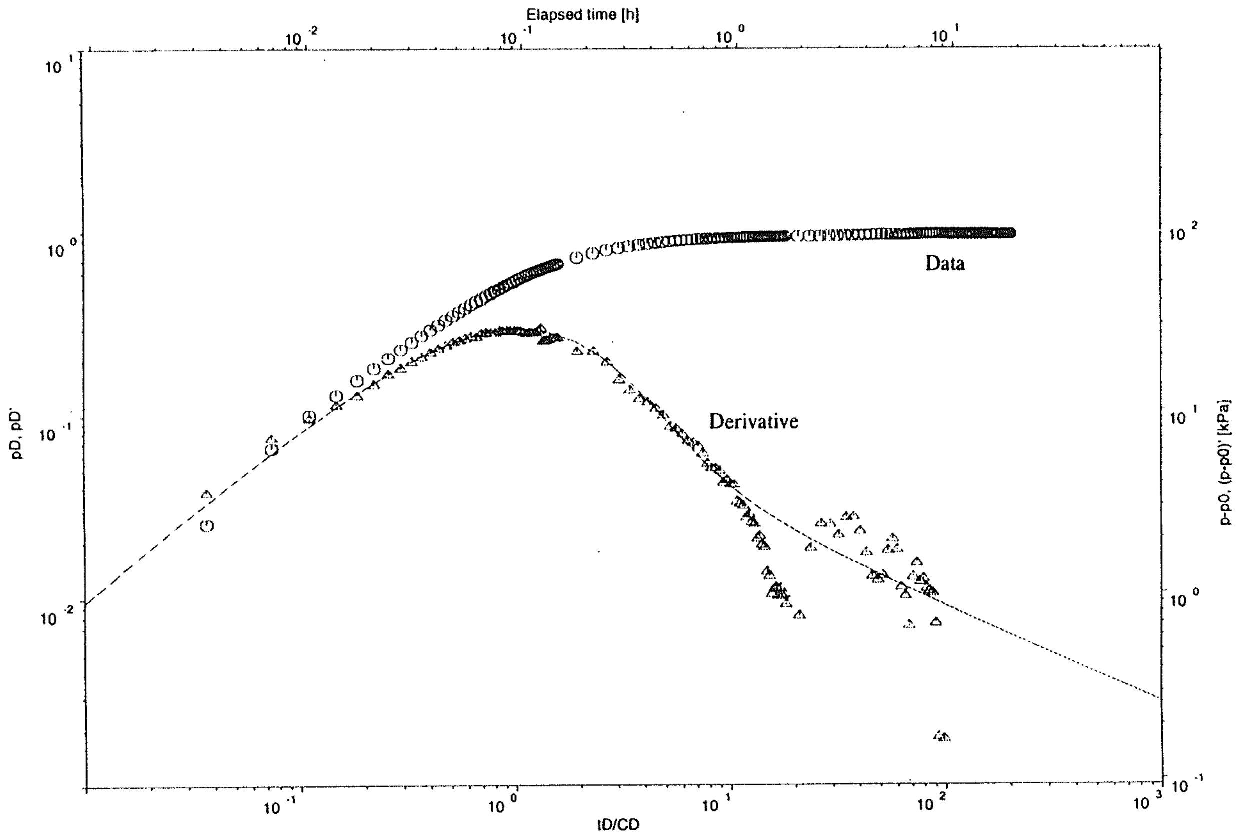

Florence Site / M14-GL
Lower Gila / Pumping Well
FlowDim Version 2.14b
(c) Golder Associates
Elapsed time [h]
Data
Derivative
pD, pD'
p-p0, (p-p0)' [kPa]
tD/CD
FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log
C= 2.35E-06 m3/Pa
T= 1.12E-04 m2/s
S= 9.11E-07 -
s= 0.00E+00 -
n= 2.00E+00 -

Figure 3B



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	2.22E-06	m3/Pa
T=	5.31E-06	m2/s
S=	4.30E-02	-
s=	0.00E+00	-
n=	3.00E+00	-

Figure 4B

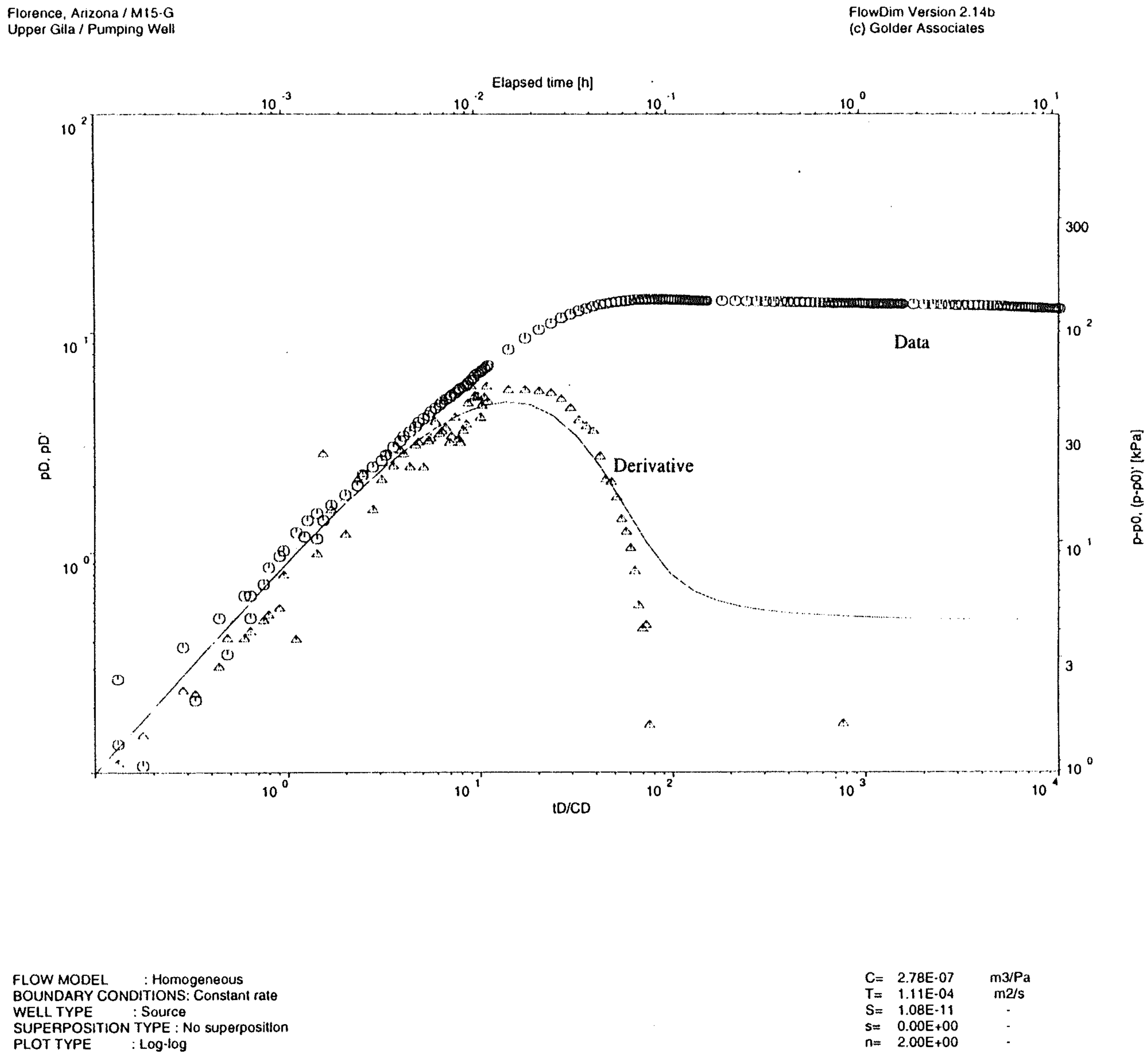
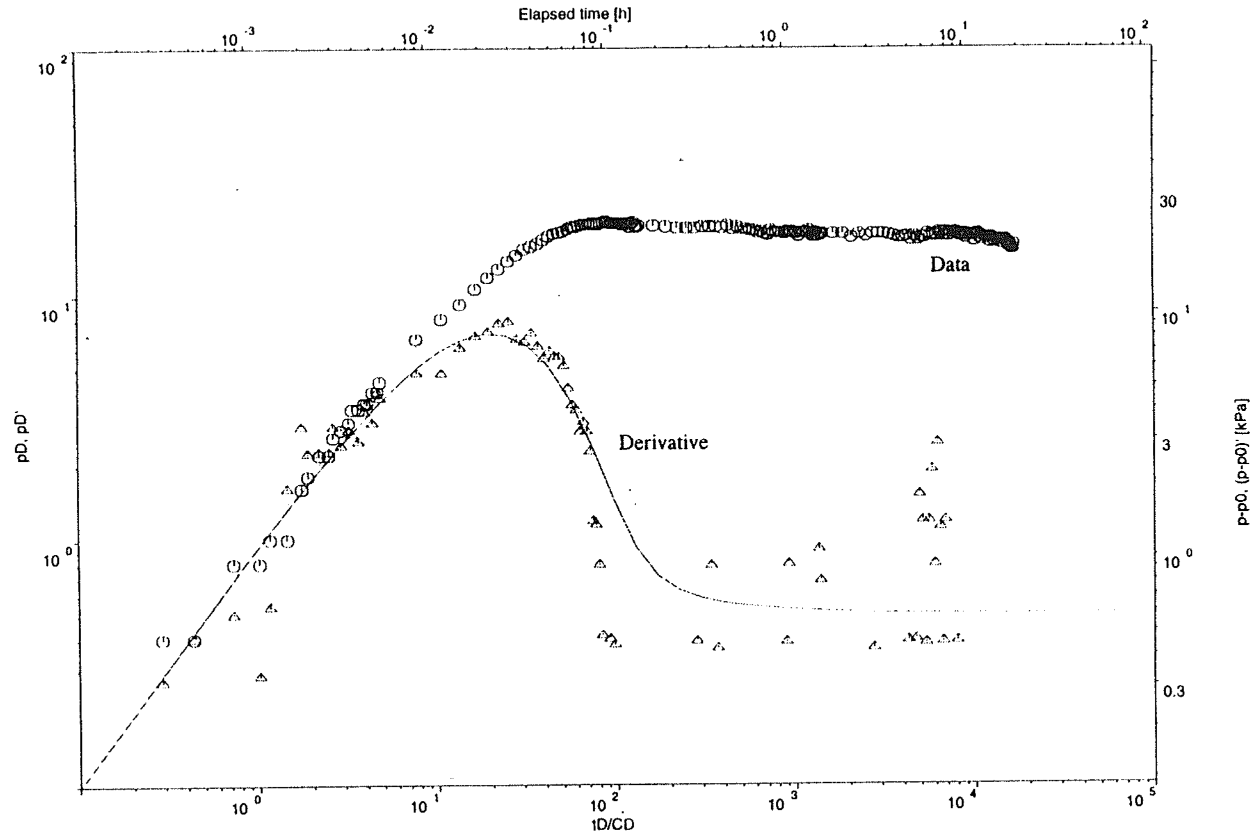


Figure 5B **Golder Associates**

Florence, Arizona / M18-G
Upper Gila / Pumping Well

FlowDim Version 2.14b
(c) Golder Associates



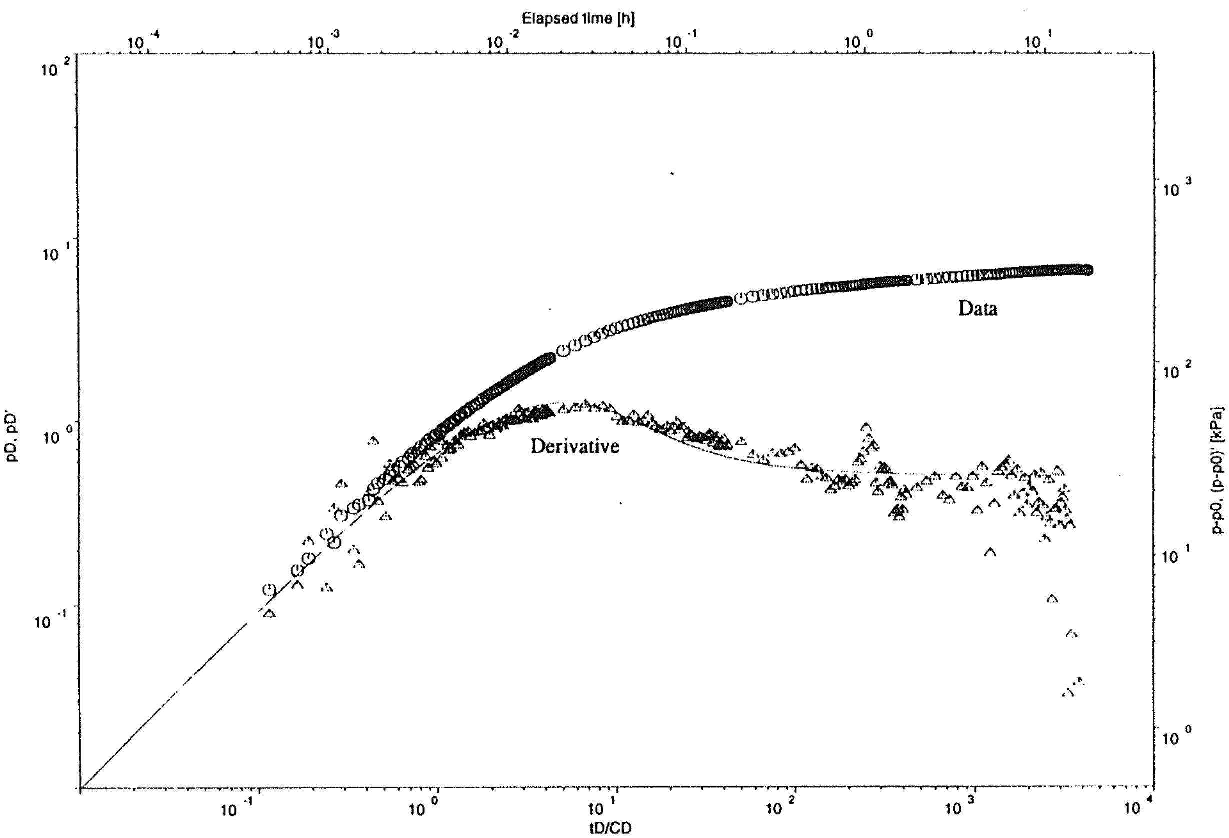
FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	2.25E-06	m3/Pa
T=	8.44E-04	m2/s
S=	8.70E-16	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 6B

Florence, Arizona / P30-O
Oxide / Pumping Well

FlowDim Version 2.14b
(c) Golder Associates



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	1.04E-06	m3/Pa
T=	1.12E-04	m2/s
S=	9.60E-04	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 7B

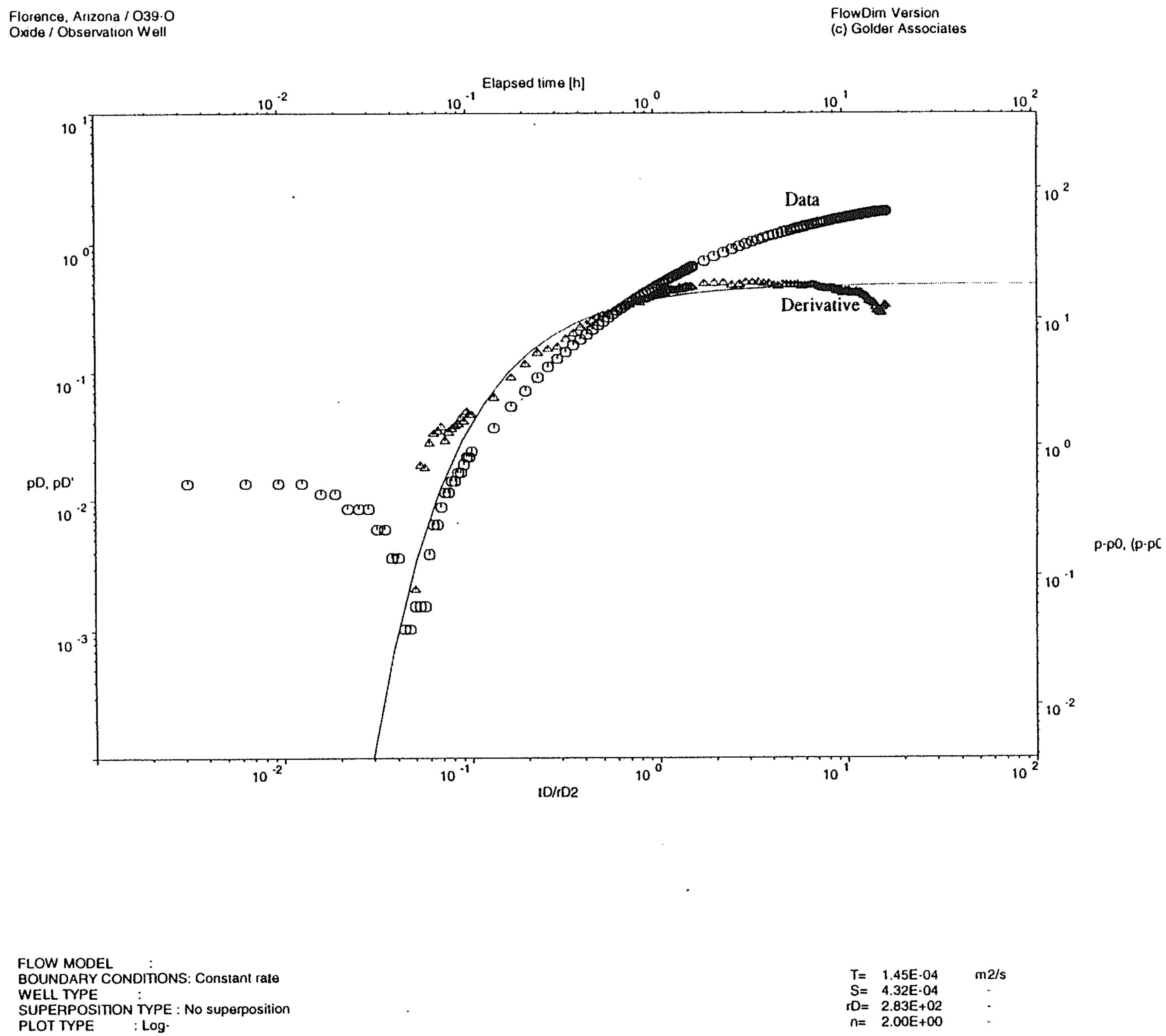

Florence, Arizona / O39-O
Oxide / Observation Well
FlowDim Version
(c) Golder Associates
Elapsed time [h]
Data
Derivative
pD, pD'
p-p0, (p-pC
tD/rD2
FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-
T= 1.45E-04 m2/s
S= 4.32E-04 -
rD= 2.83E+02 -
n= 2.00E+00 -

Figure 8B

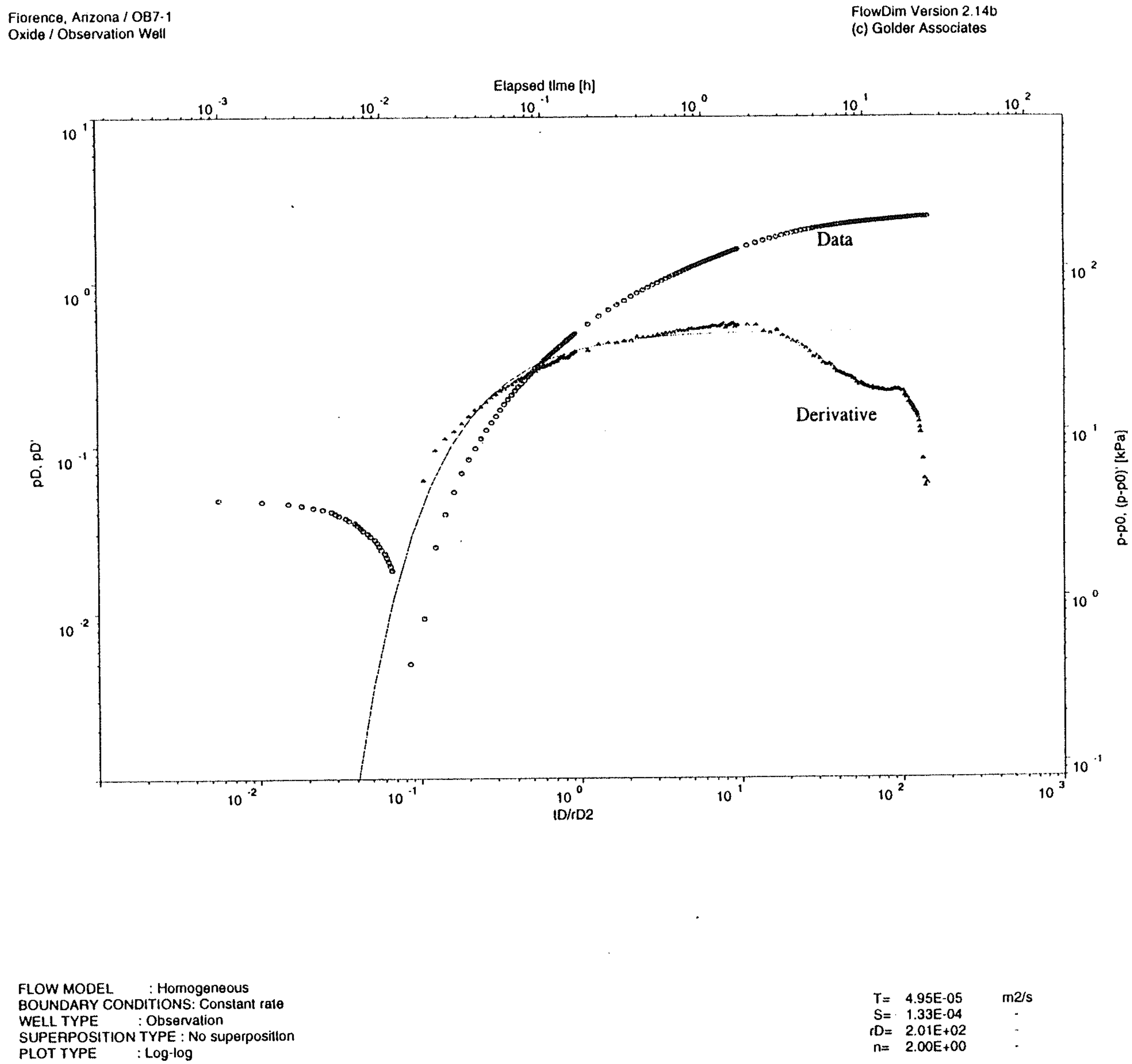
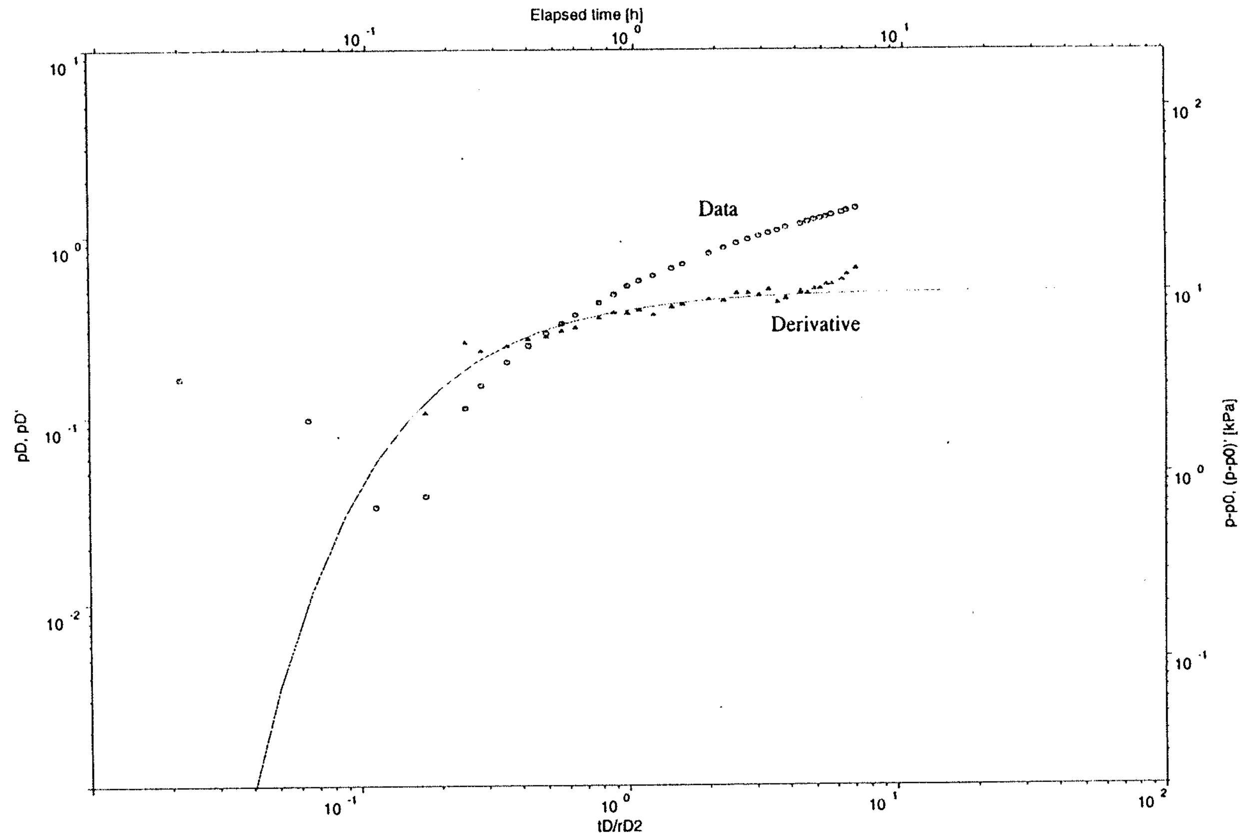

Florence, Arizona / OB7-1
Oxide / Observation Well
FlowDim Version 2.14b
(c) Golder Associates
Elapsed time [h]
Data
Derivative
pD, pD'
p-p0, (p-p0)' [kPa]
tD/rD2
FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Observation
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log
T= 4.95E-05 m2/s
S= 1.33E-04 -
rD= 2.01E+02 -
n= 2.00E+00 -

Figure 9B

Florence, Arizona / O12-O
Oxide / Observation Well

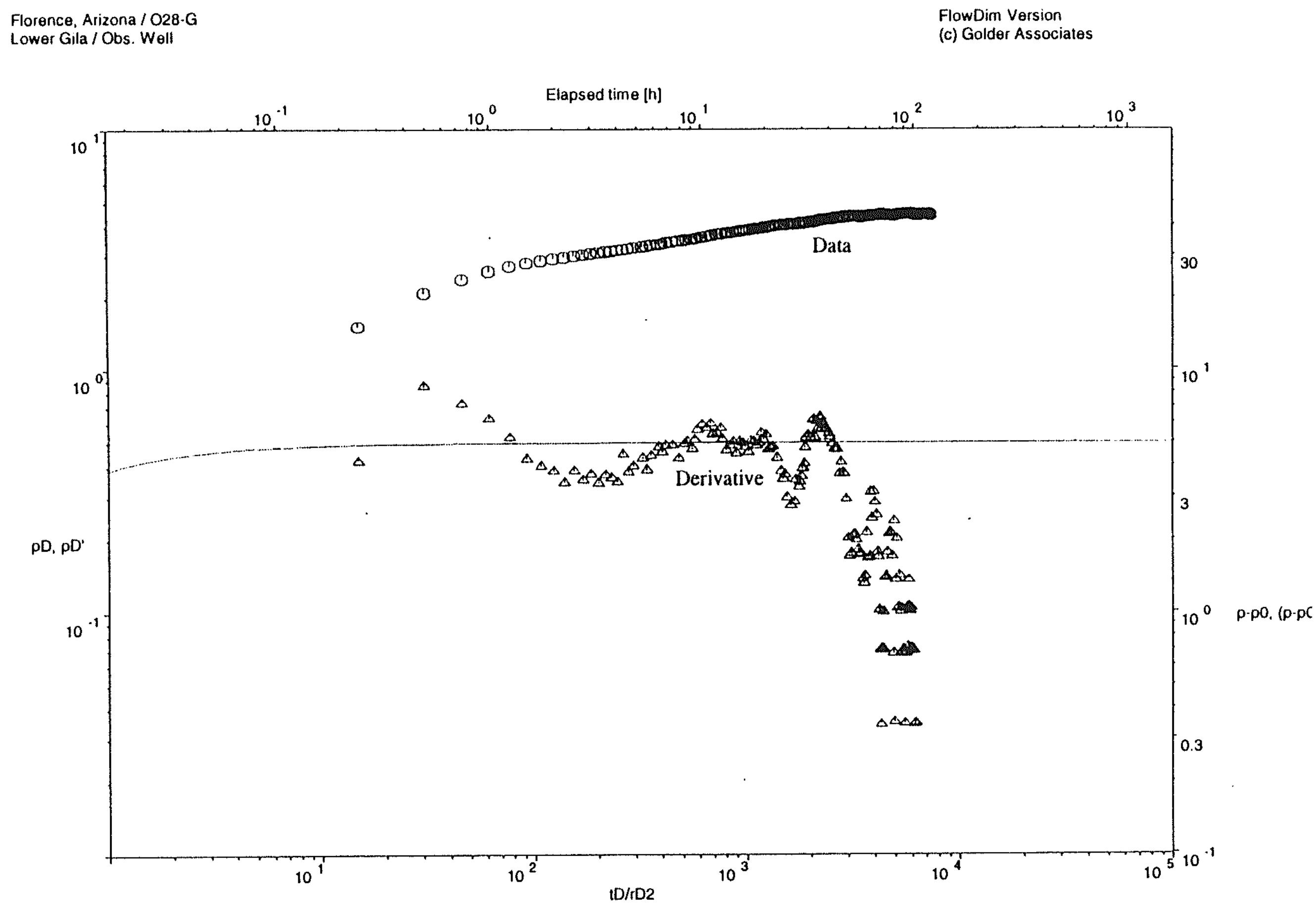
FlowDim Version 2.14b
(c) Golder Associates



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Observation
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

T=	3.21E-04	m2/s
S=	2.24E-03	-
rD=	2.87E+02	-
n=	2.00E+00	-

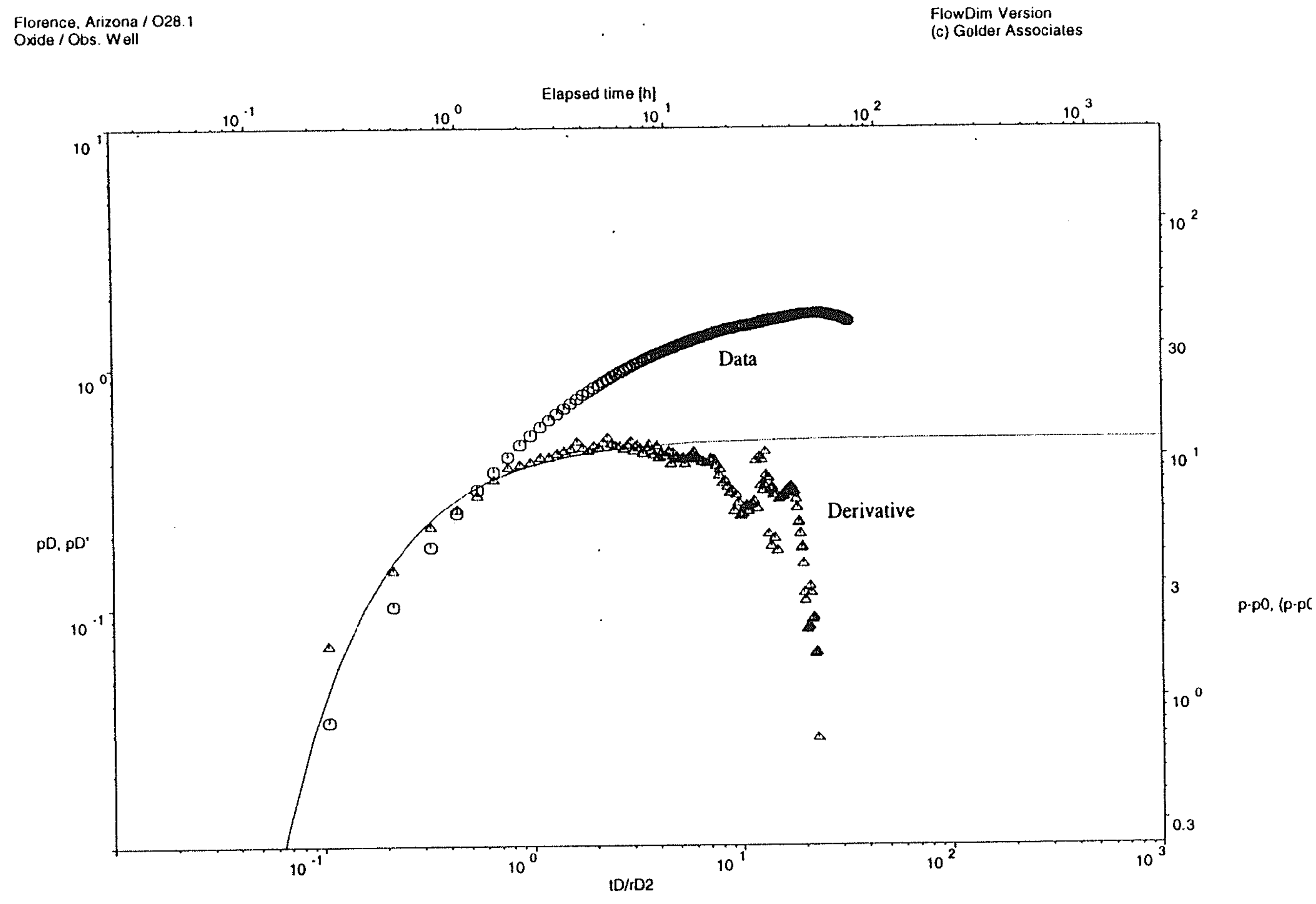
Figure 10B



FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-

T=	7.49E-04	m2/s
S=	2.70E-05	-
rD=	7.92E+02	-
n=	2.00E+00	-

Figure 11B



FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-

T=	3.17E-04	m2/s
S=	1.06E-03	-
rD=	9.79E+02	-
n=	2.00E+00	-

Figure 12B

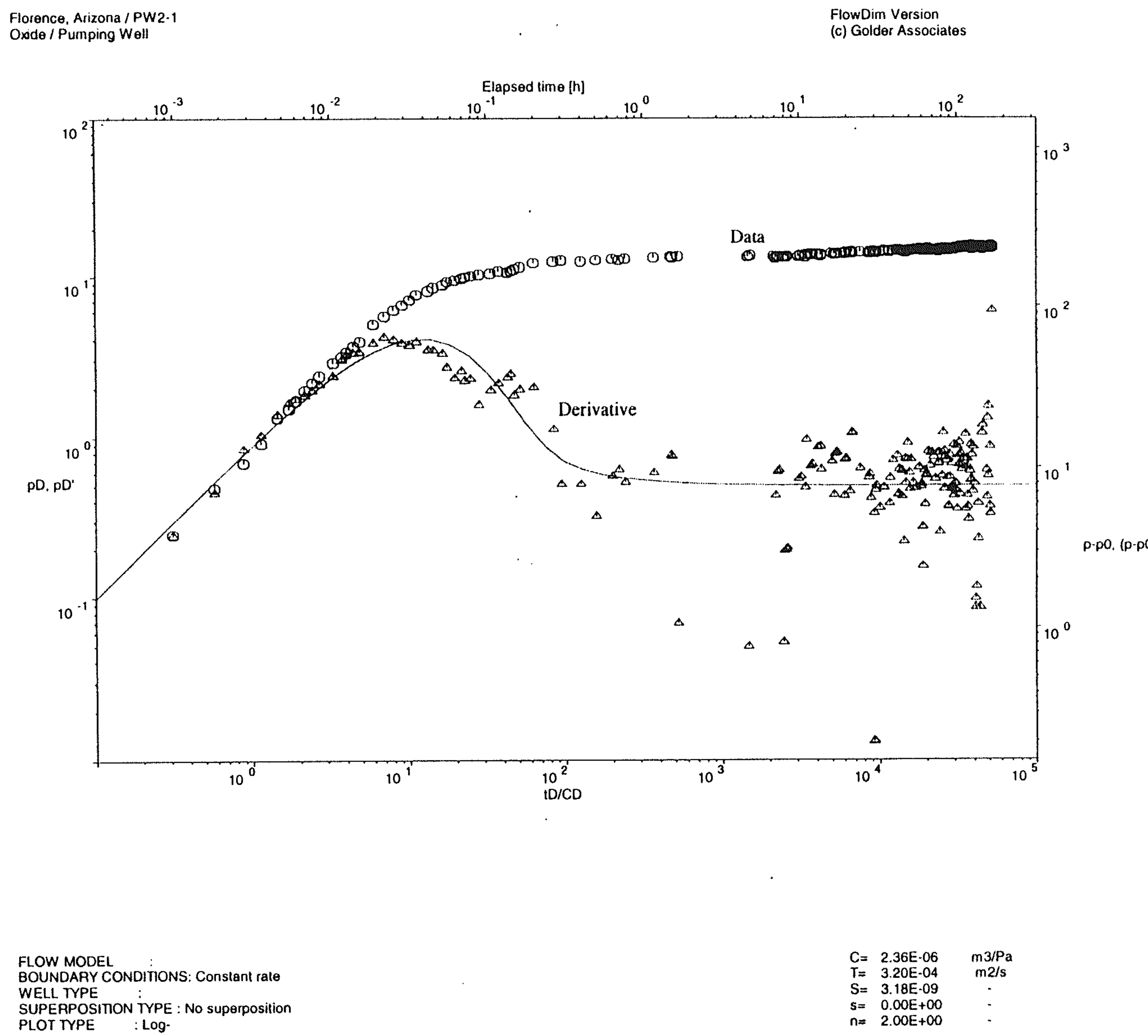
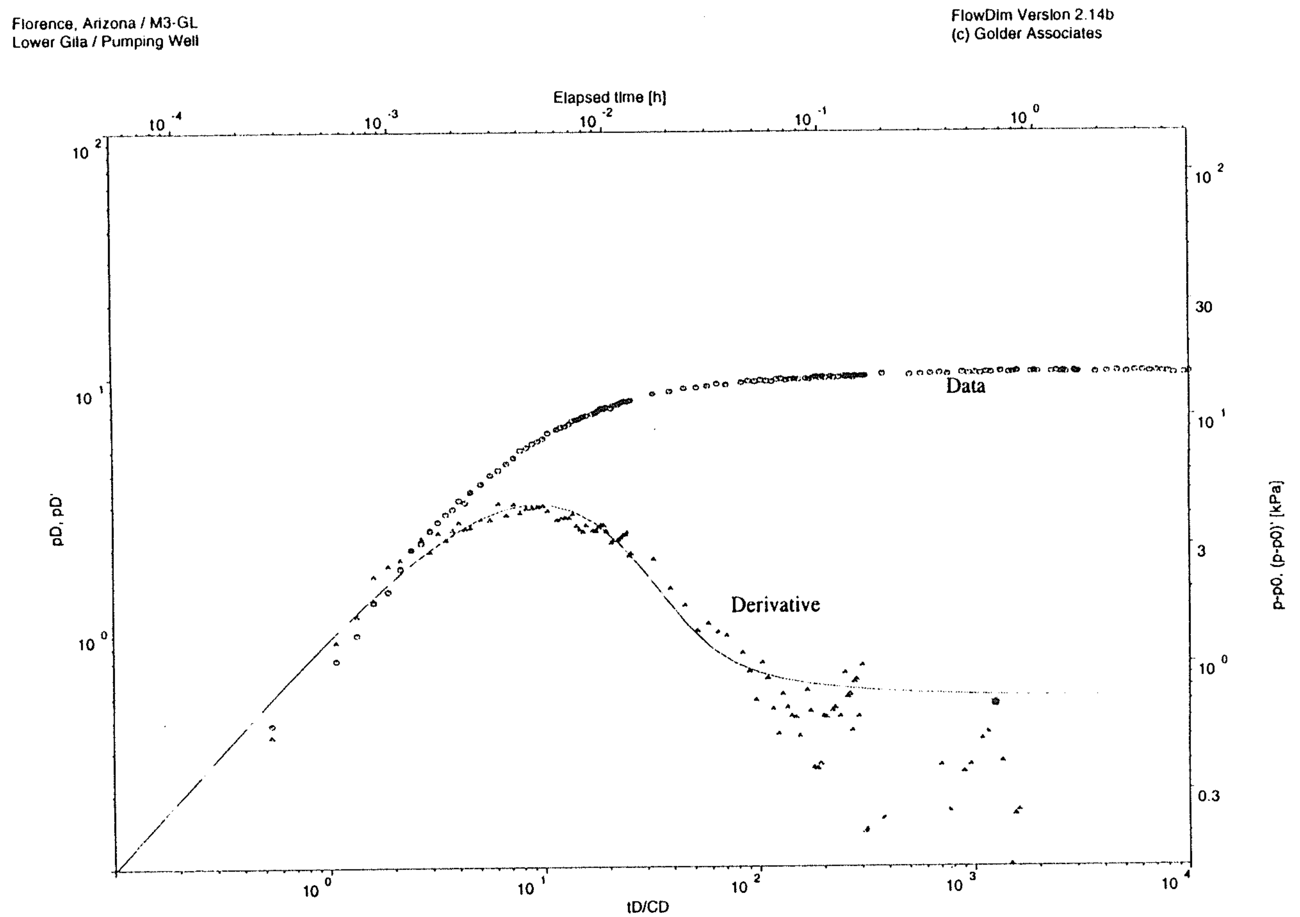

Florence, Arizona / PW2-1
Oxide / Pumping Well
FlowDim Version
(c) Golder Associates
Elapsed time [h]
Data
Derivative
pD, pD'
p-p0, (p-p0
tD/CD
FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-
C= 2.36E-06 m3/Pa
T= 3.20E-04 m2/s
S= 3.18E-09 -
s= 0.00E+00 -
n= 2.00E+00 -

Figure 13B



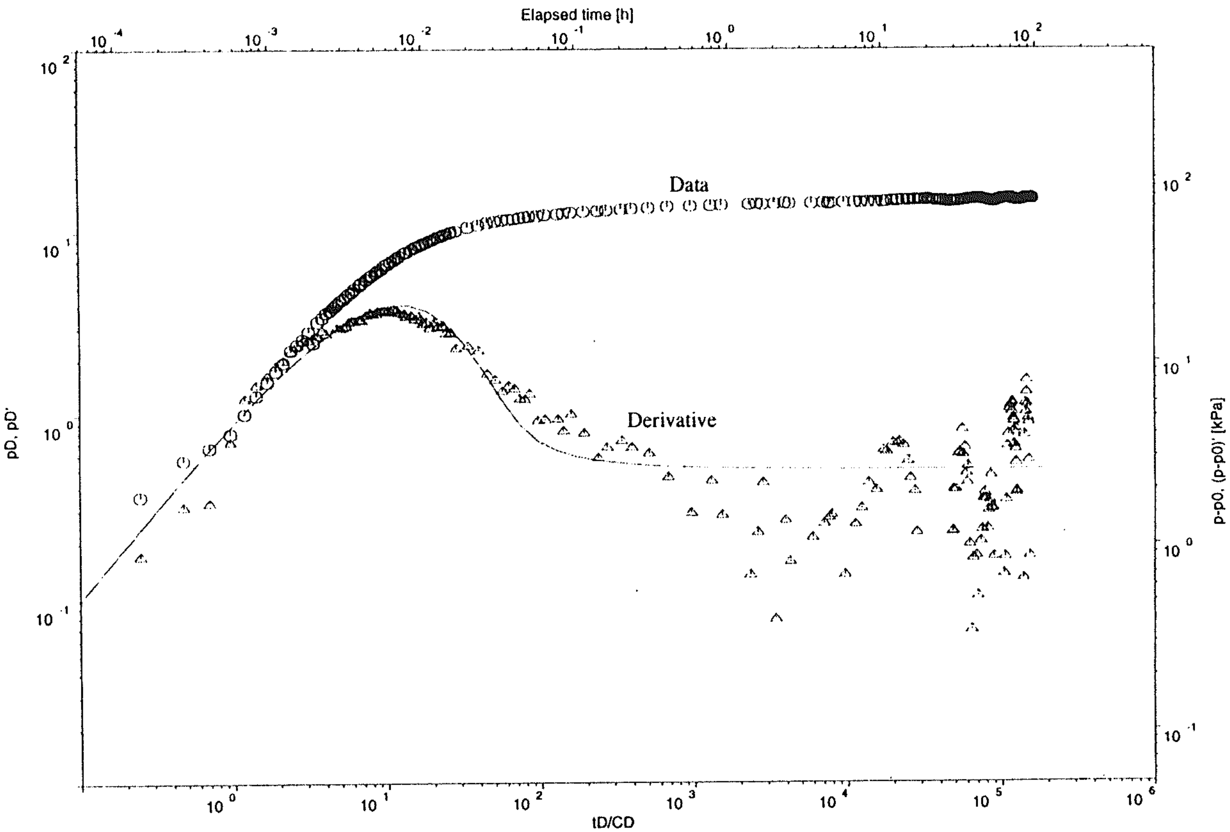
FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	8.16E-07	m3/Pa
T=	6.83E-04	m2/s
S=	3.16E-07	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 14B

Florence, Arizona / PW4-1
Oxide / Pumping Well

FlowDim Version 2.14b
(c) Golder Associates



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	1.87E-06	m3/Pa
T=	1.37E-03	m2/s
S=	2.52E-09	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 15B

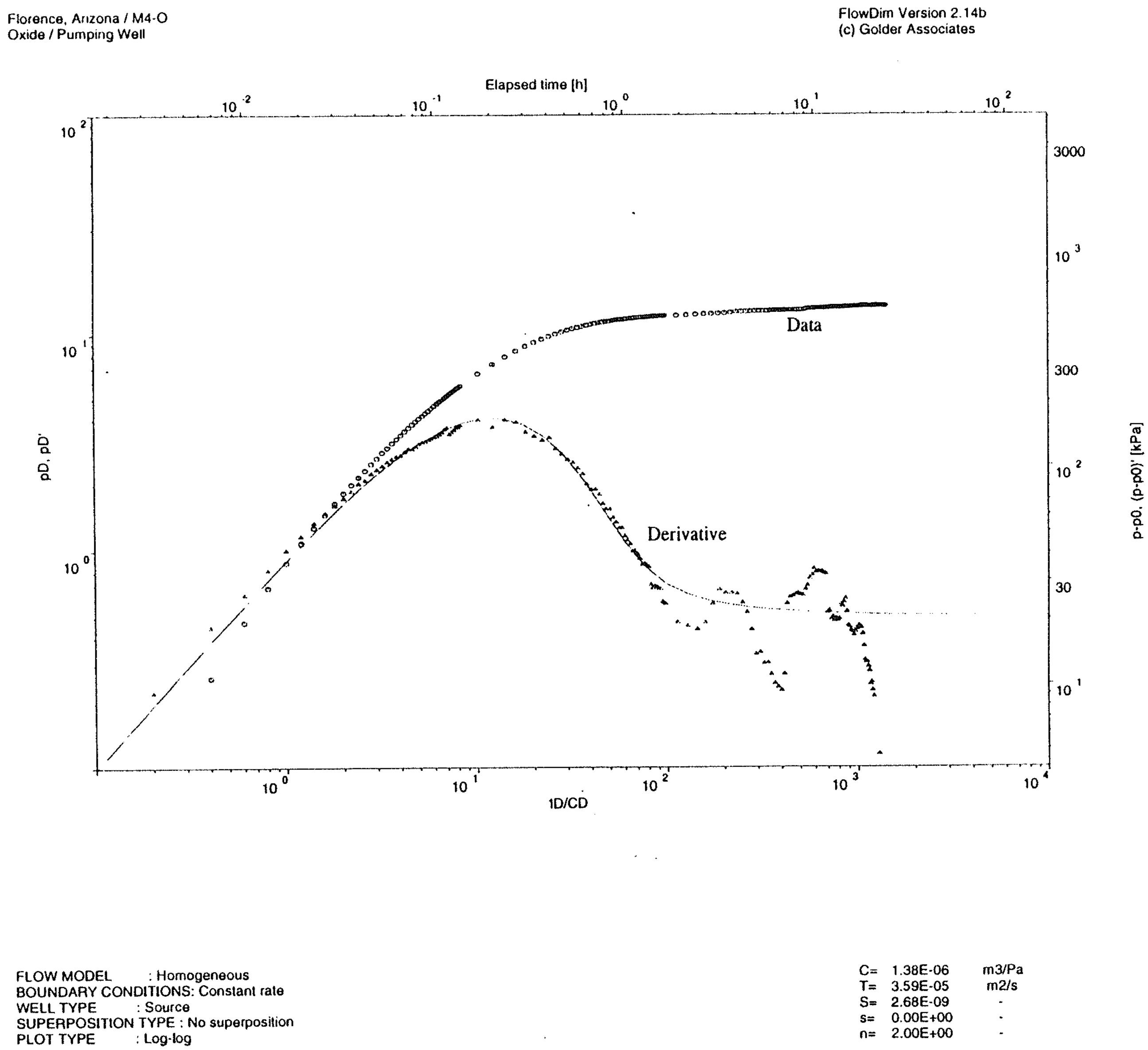
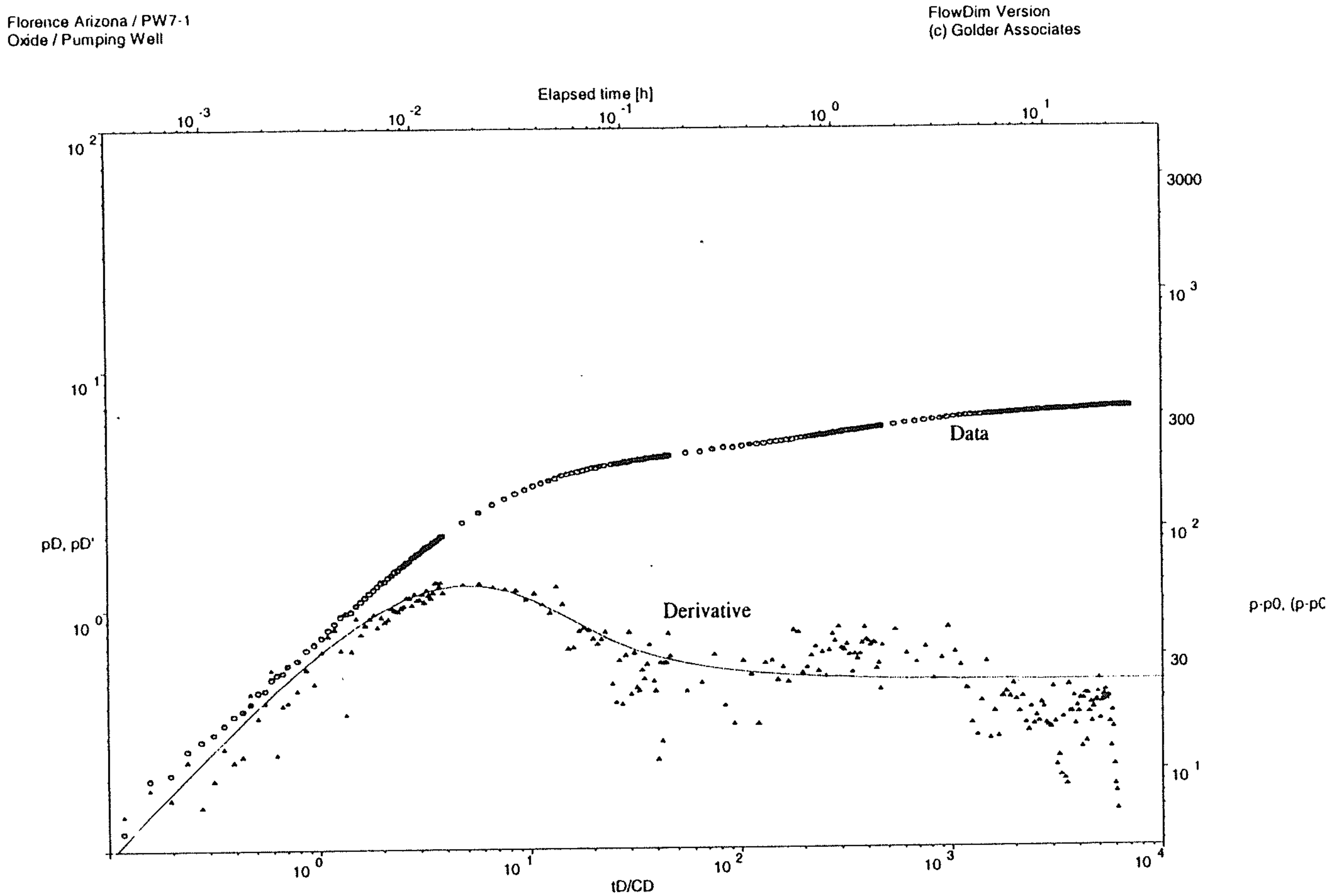

Florence, Arizona / M4-O
Oxide / Pumping Well
FlowDim Version 2.14b
(c) Golder Associates
Elapsed time [h]
pD, pD'
p-p0, (p-p0)' [kPa]
1D/CD
Data
Derivative
FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log
C= 1.38E-06 m3/Pa
T= 3.59E-05 m2/s
S= 2.68E-09 -
s= 0.00E+00 -
n= 2.00E+00 -

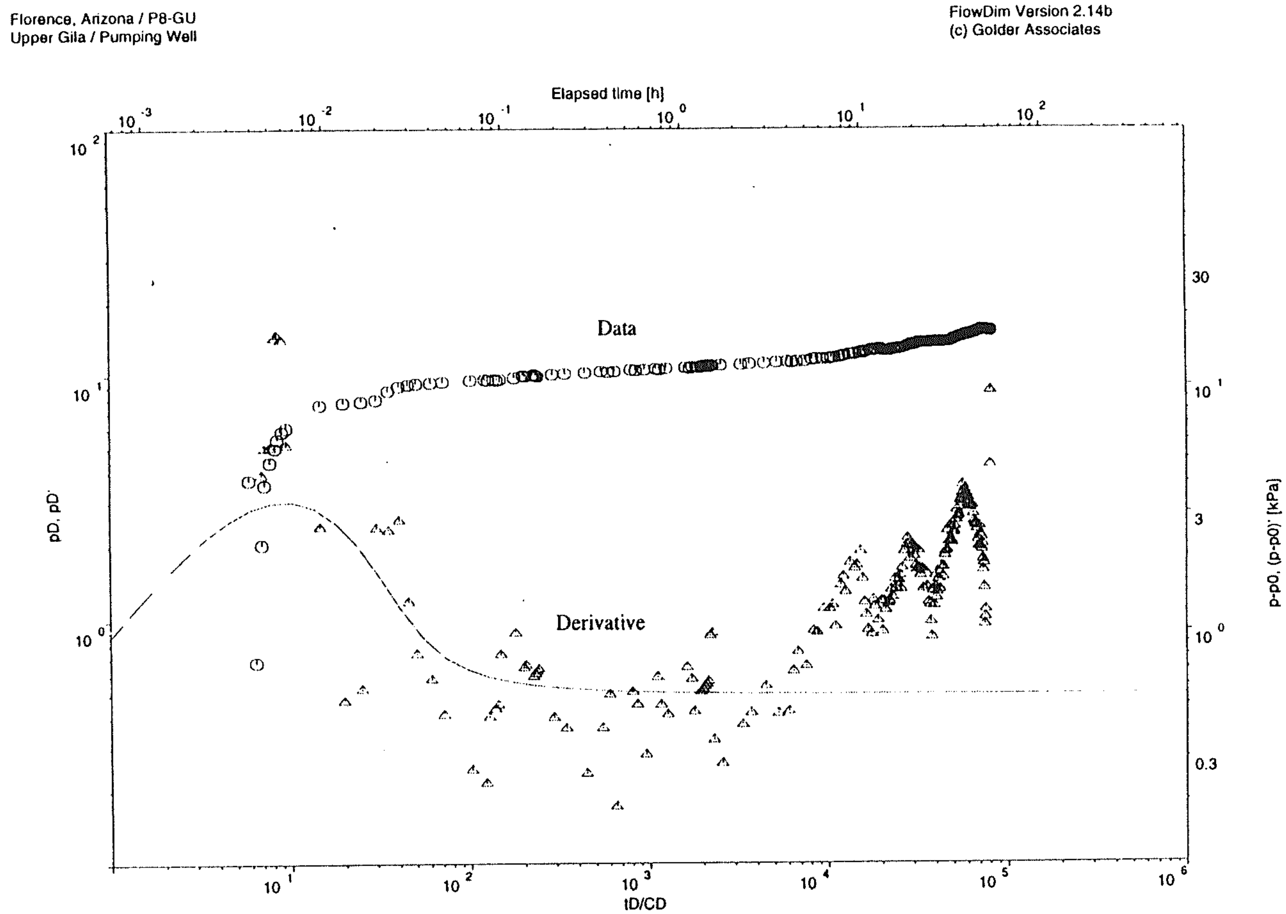
Figure 16B



FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-

C=	6.87E-07	m3/Pa
T=	8.40E-05	m2/s
S=	1.85E-03	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 17B



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	1.19E-05	m3/Pa
T=	7.91E-03	m2/s
S=	3.19E-06	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 18B

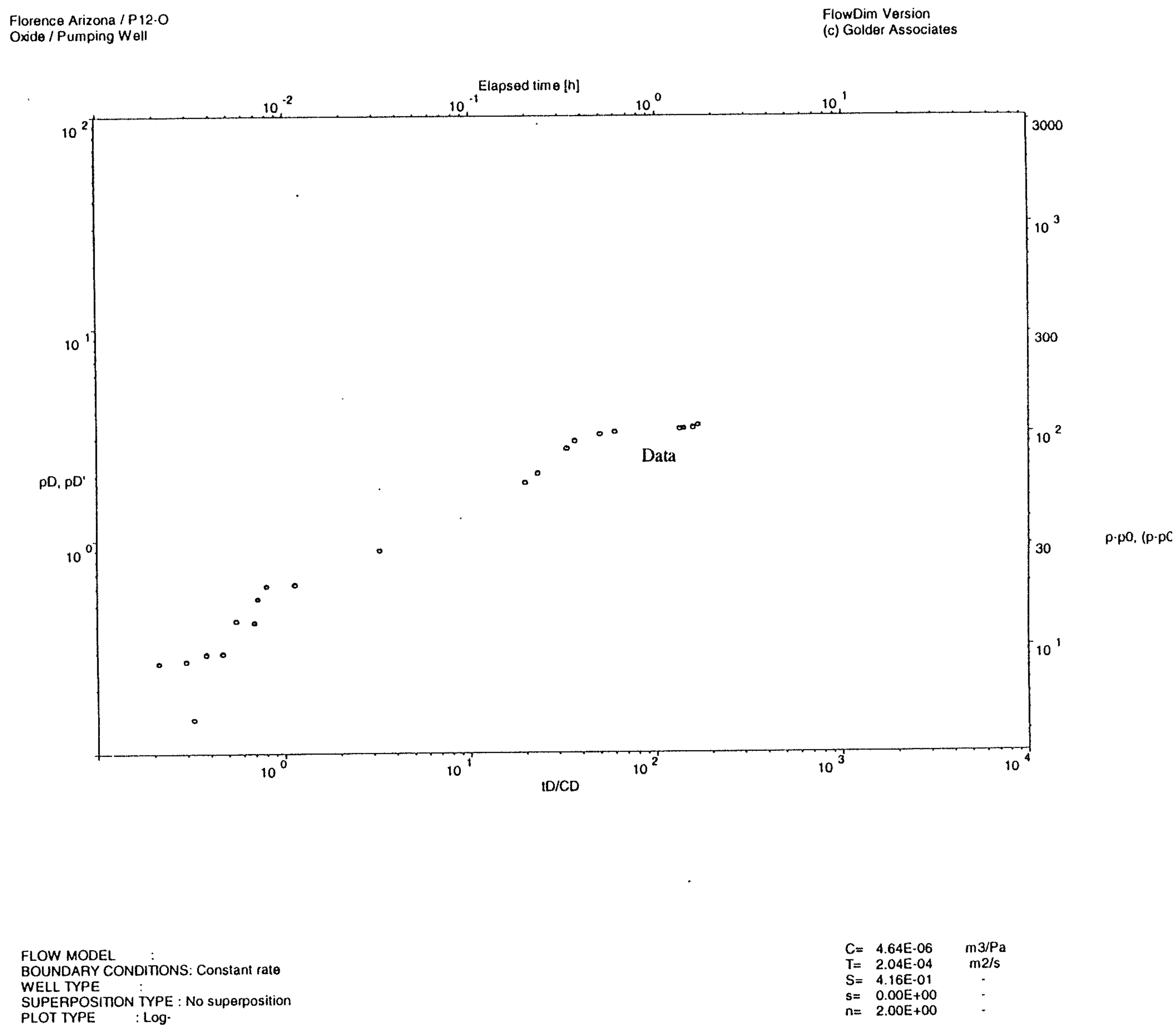
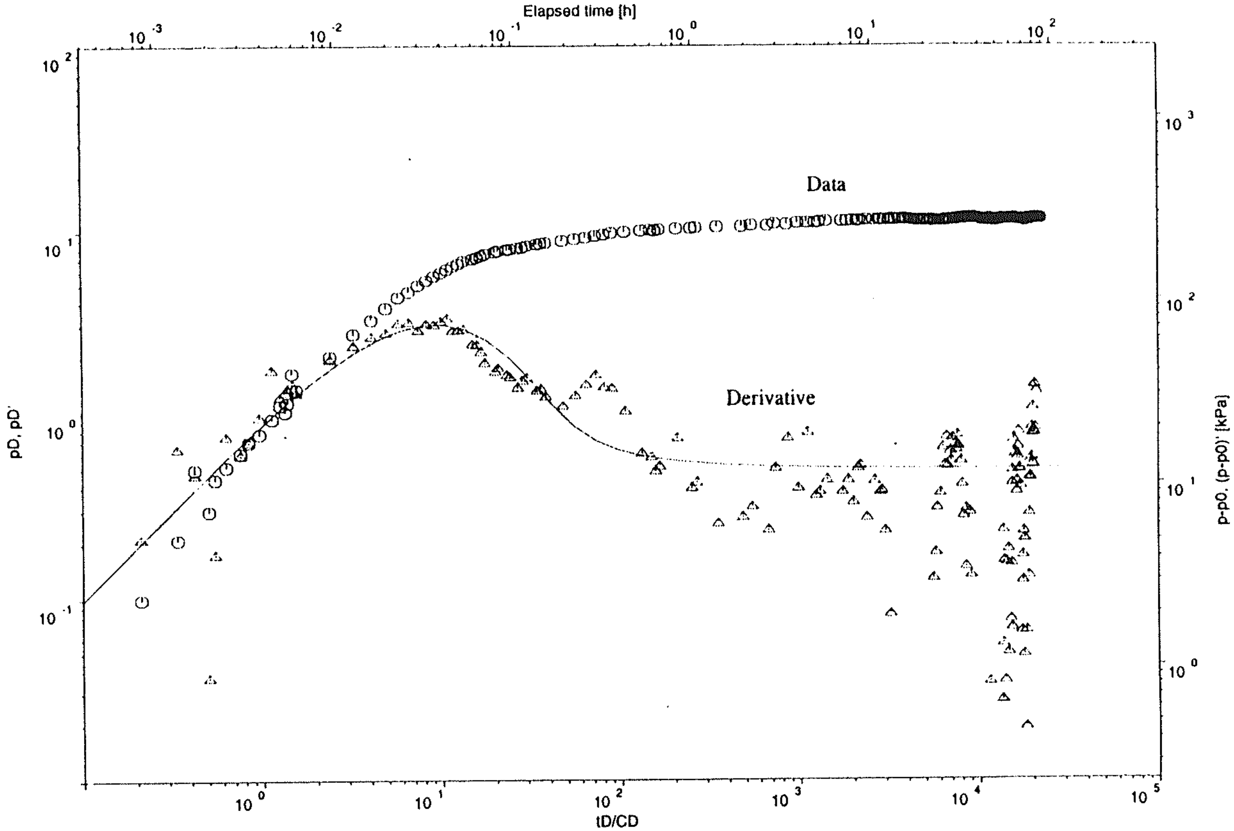

Florence Arizona / P12-O
Oxide / Pumping Well
FlowDim Version
(c) Golder Associates
Elapsed time [h]
pD, pD'
p-p0, (p-pC
tD/CD
Data
FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-
C= 4.64E-06 m3/Pa
T= 2.04E-04 m2/s
S= 4.16E-01 -
s= 0.00E+00 -
n= 2.00E+00 -

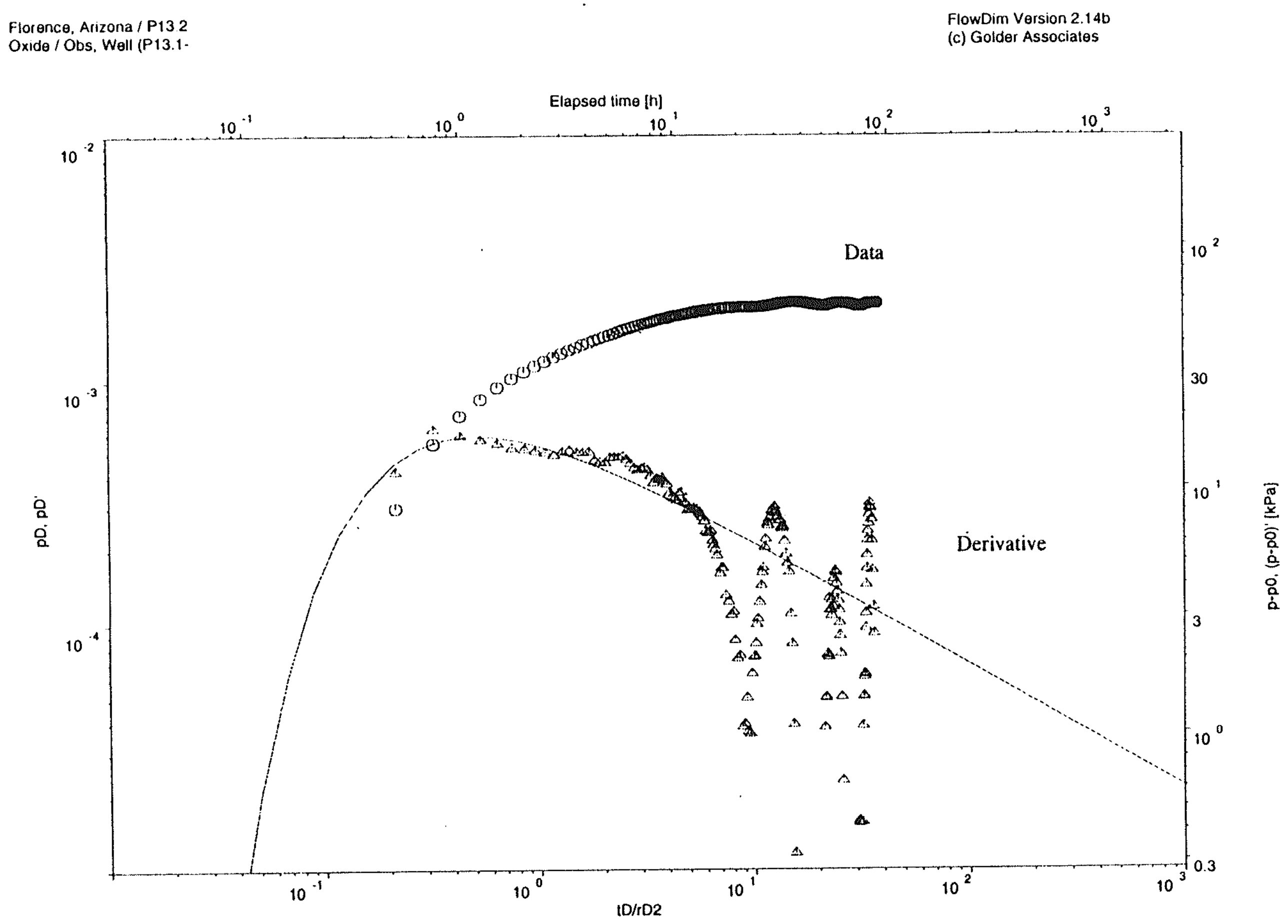
Figure 19B



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	1.75E-06	m3/Pa
T=	1.91E-04	m2/s
S=	4.72E-07	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 20B



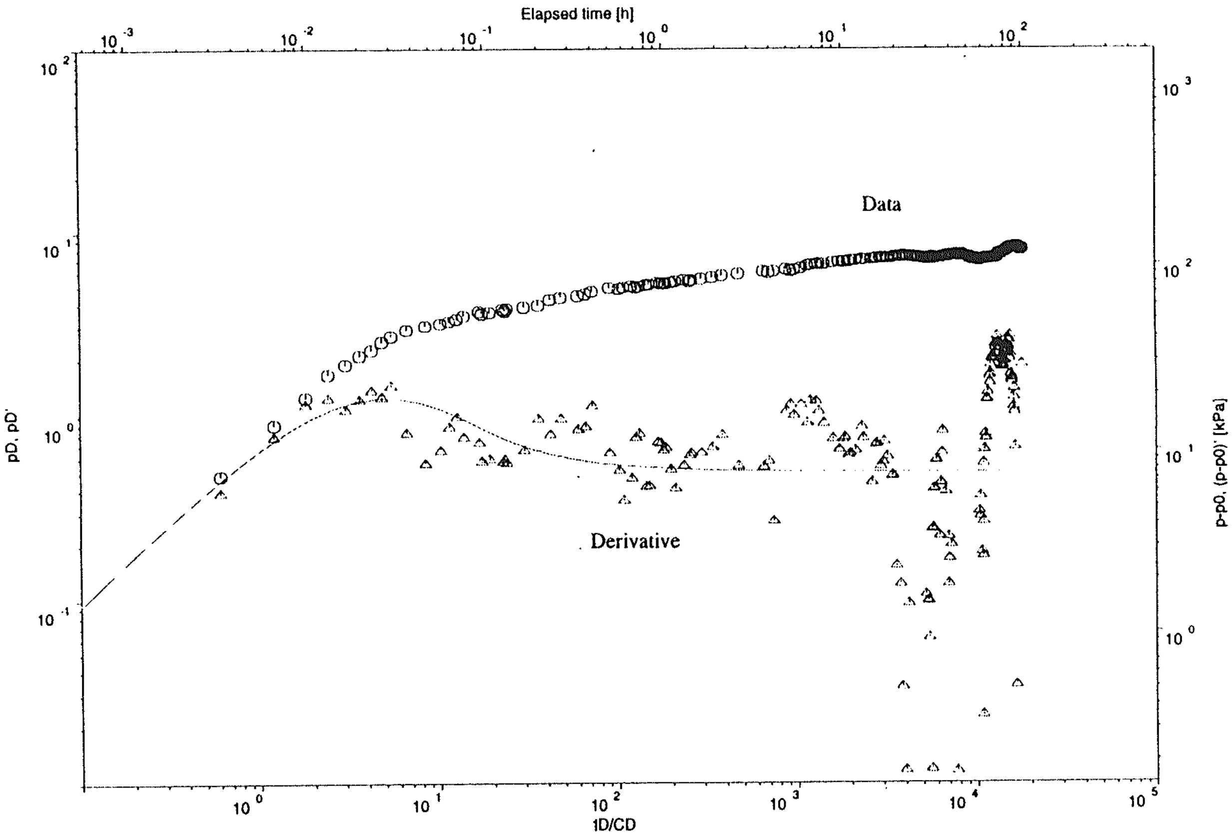
FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Observation
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

T=	8.18E-08	m2/s
S=	7.04E-07	-
rD=	4.12E+02	-
n=	3.00E+00	-

Figure 21B

Florence, Arizona / P15-O
Oxide / Pumping Well

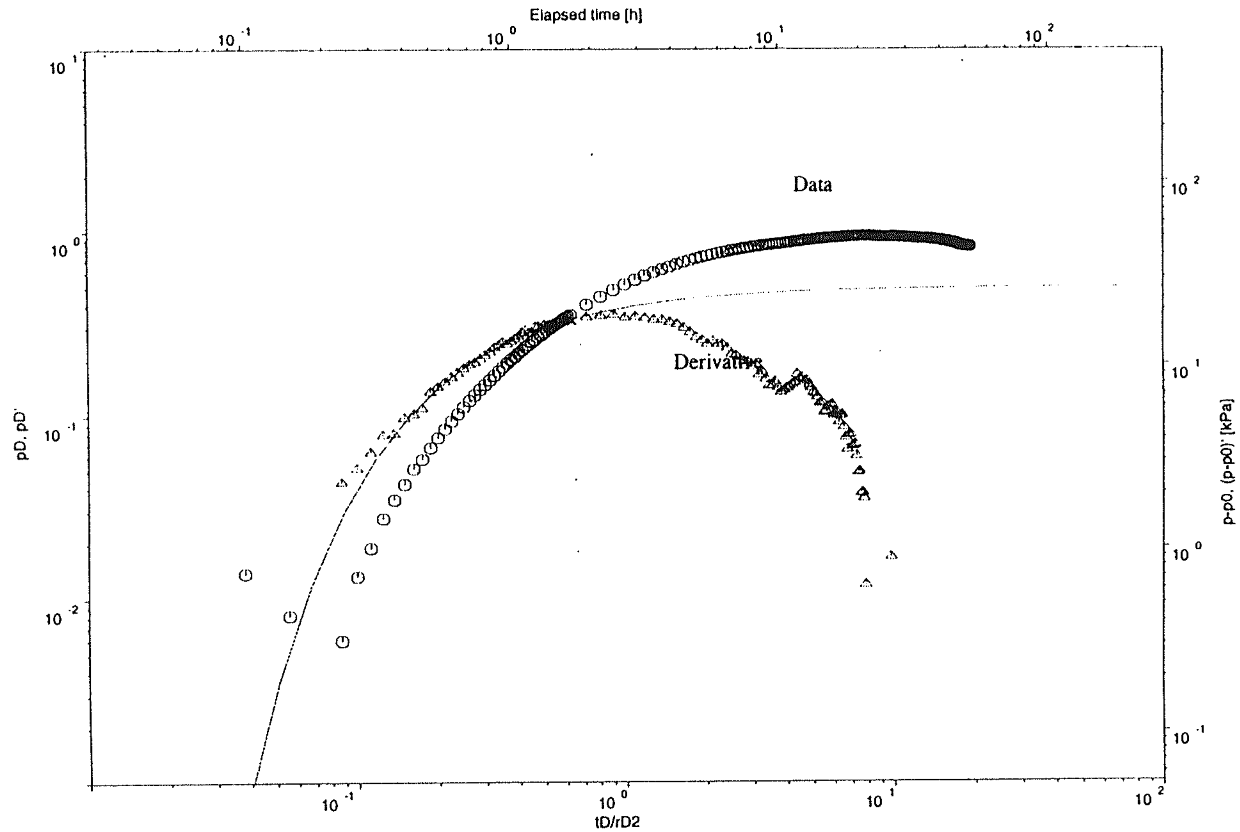
FlowDim Version 2.14b
(c) Golder Associates



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	4.94E-06	m3/Pa
T=	3.84E-04	m2/s
S=	1.33E-02	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 22B



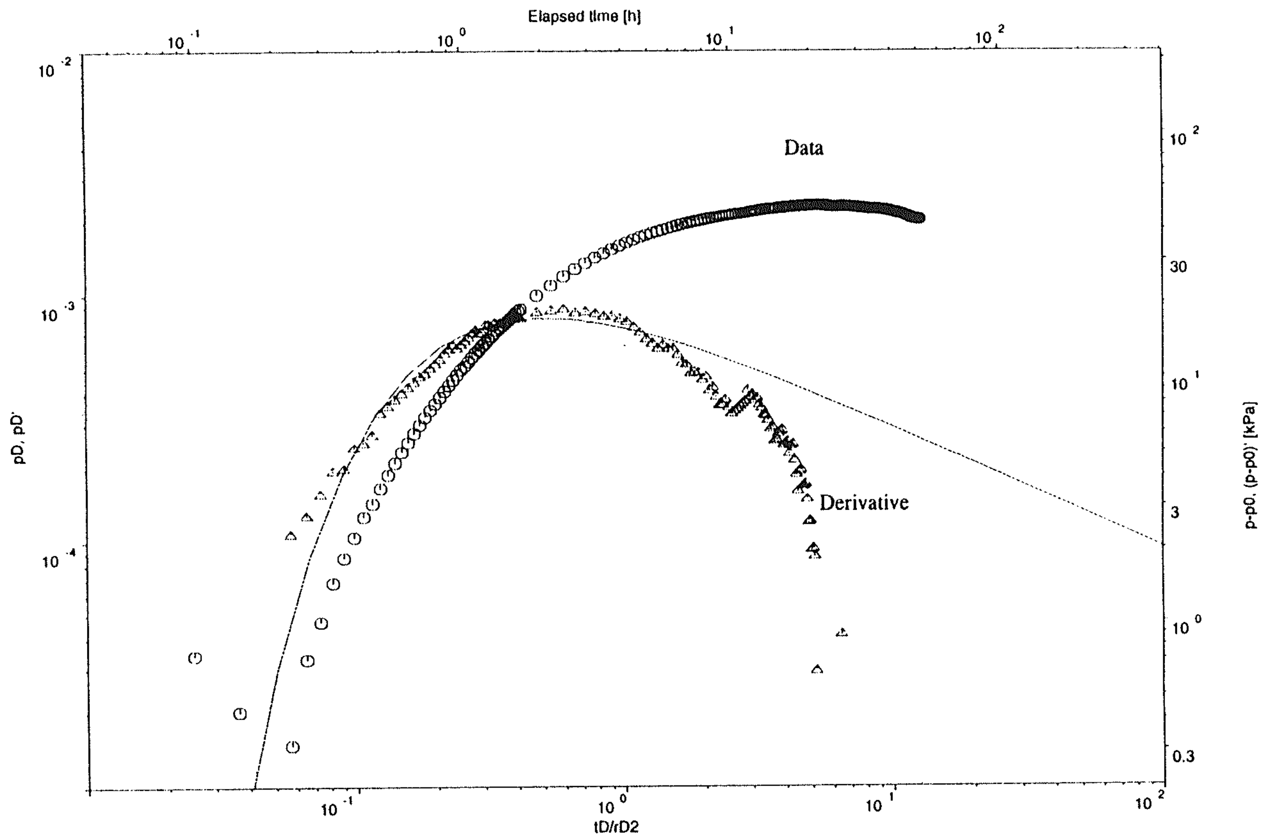
FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Observation
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

T=	4.10E-05	m2/s
S=	7.66E-04	-
rD=	2.98E+02	-
n=	2.00E+00	-

Figure 23B

Florence, Arizona / P19-O
Oxide / Observ. Well

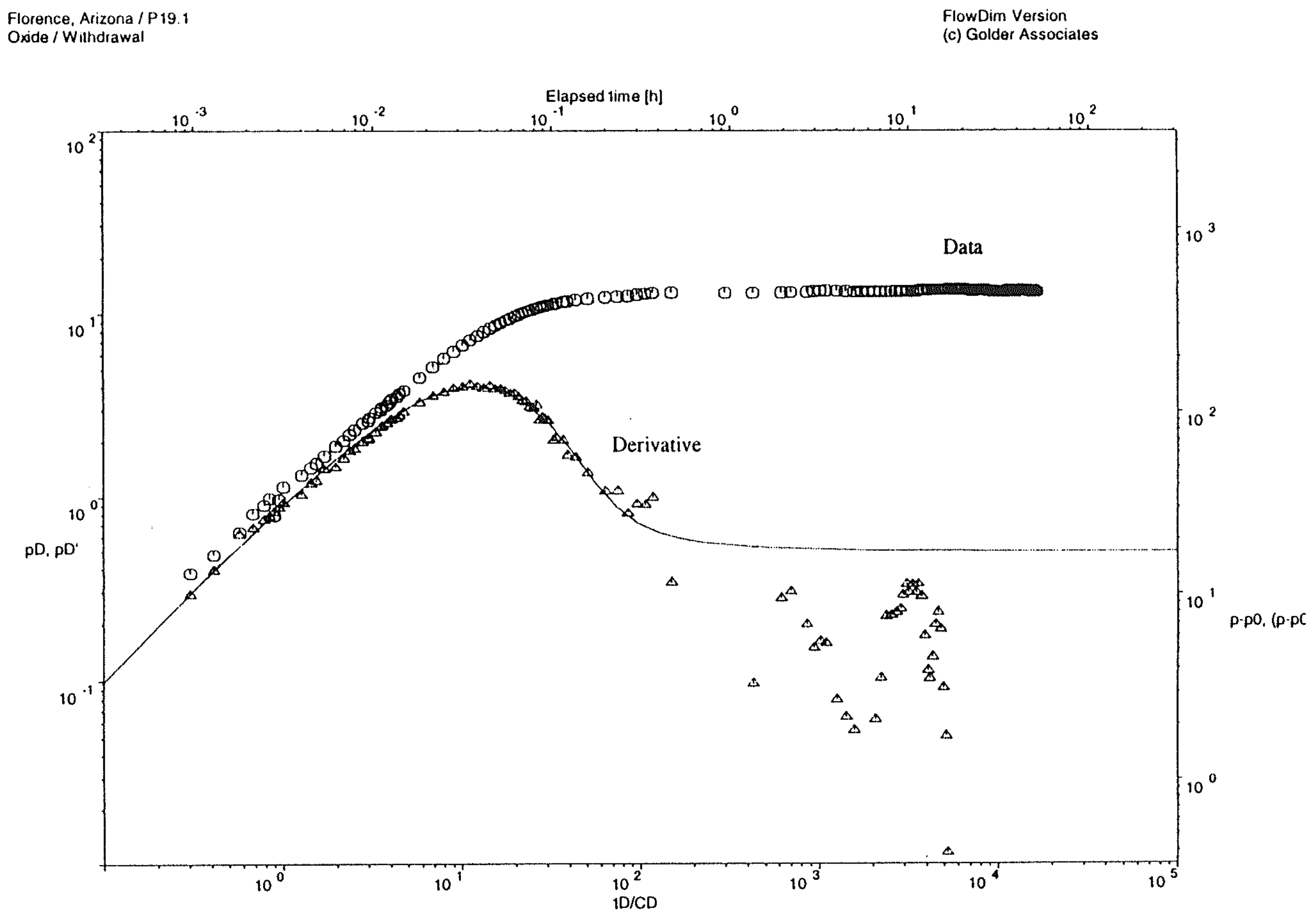
FlowDim Version 2.14b
(c) Golder Associates



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Observation
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

T=	5.08E-08	m2/s
S=	1.44E-06	-
rD=	2.98E+02	-
n=	3.00E+00	-

Figure 24B



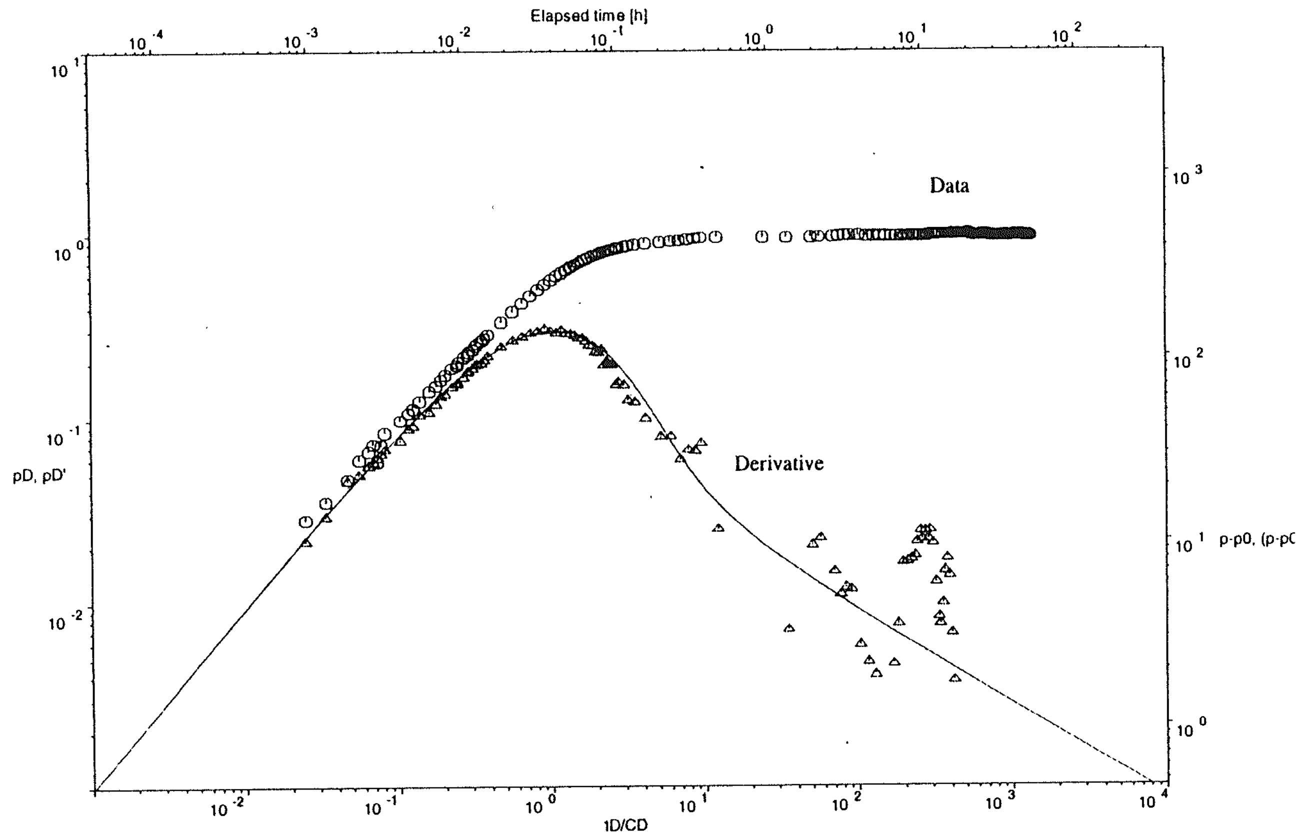
FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-

C=	4.58E-07	m3/Pa
T=	6.39E-05	m2/s
S=	6.16E-10	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 25B **Golder Associates**

Florence, Arizona / P19.1
Oxide / Withdrawal

FlowDim Version
(c) Golder Associates



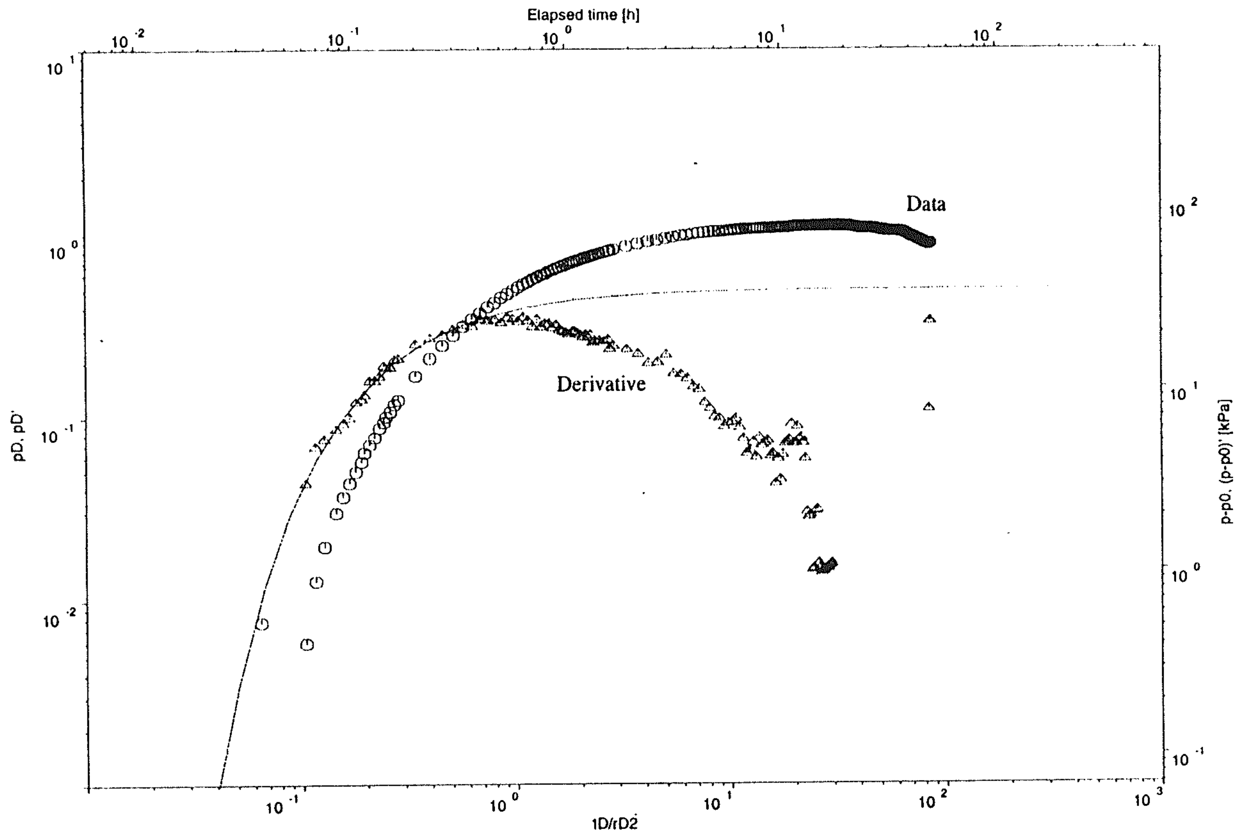
FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-

C=	4.19E-07	m3/Pa
T=	2.36E-06	m2/s
S=	5.64E-03	-
s=	0.00E+00	-
n=	3.00E+00	-

Figure 26B

Florence, Arizona / P19.2
Oxide / Observ. Well

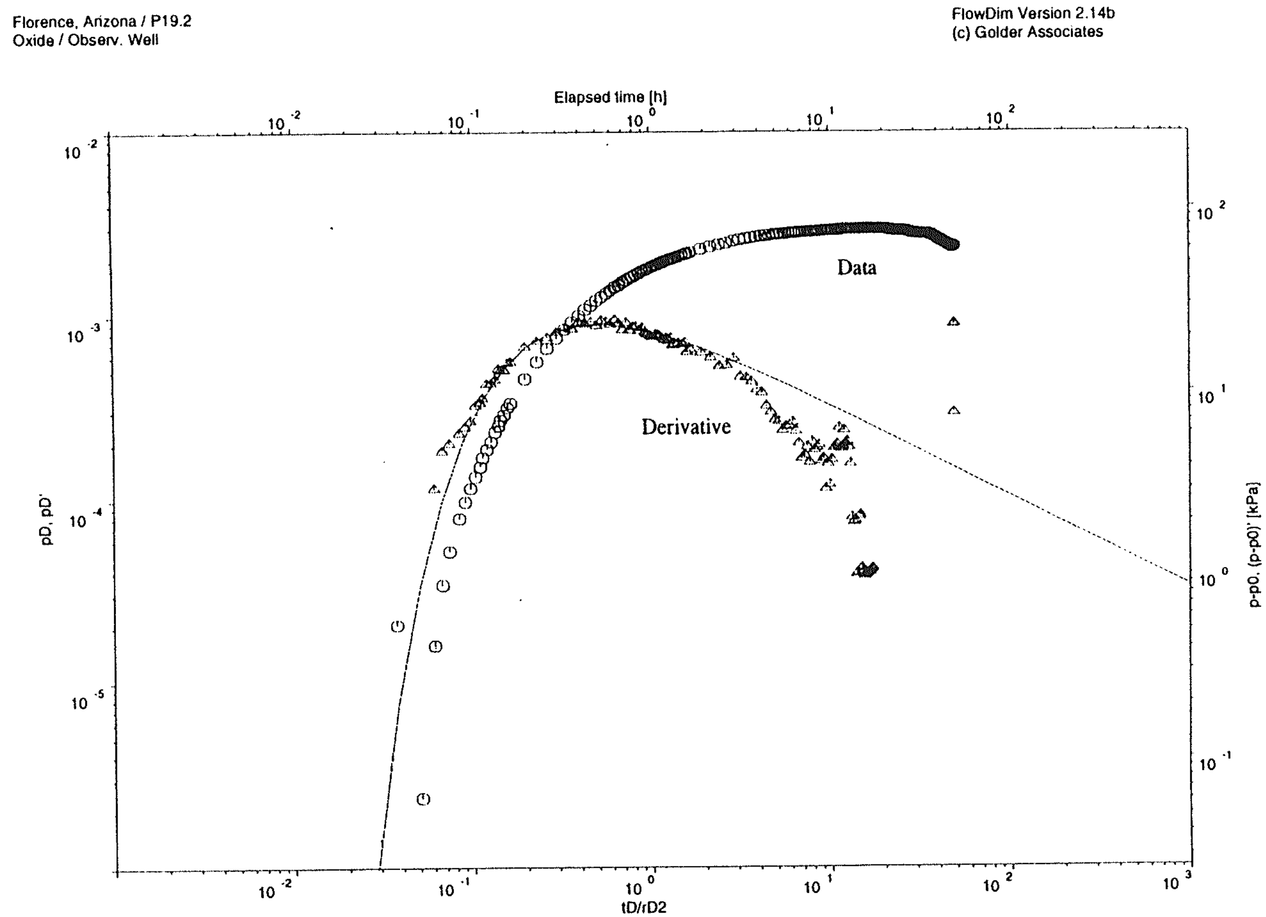
FlowDim Version 2.14b
(c) Golder Associates



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Observation
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

T=	3.14E-05	m2/s
S=	1.47E-04	-
rD=	2.68E+02	-
n=	2.00E+00	-

Figure 27B



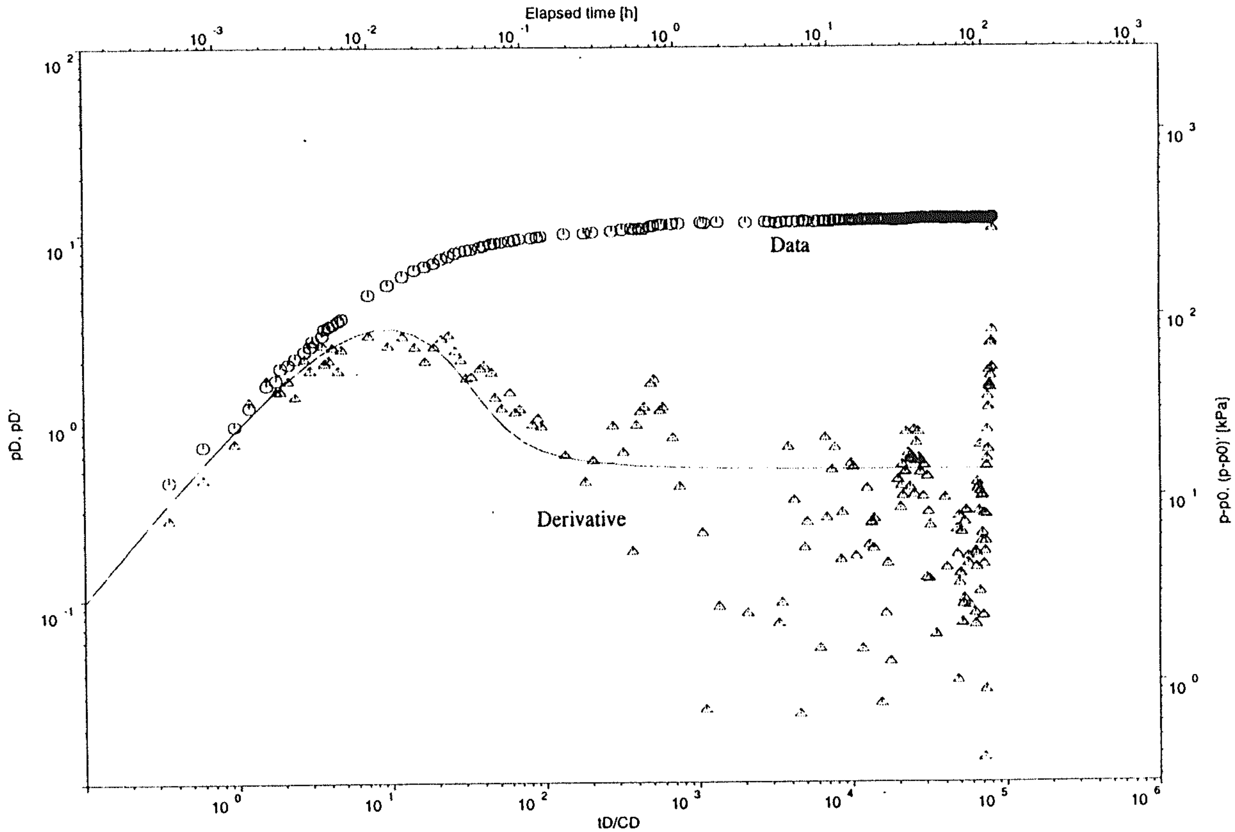
FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Observation
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

T=	4.22E-08	m2/s
S=	3.38E-07	-
rD=	2.68E+02	-
n=	3.00E+00	-

Figure 28B

Florence, Arizona / P28-G
Lower Gila / Pumping Well

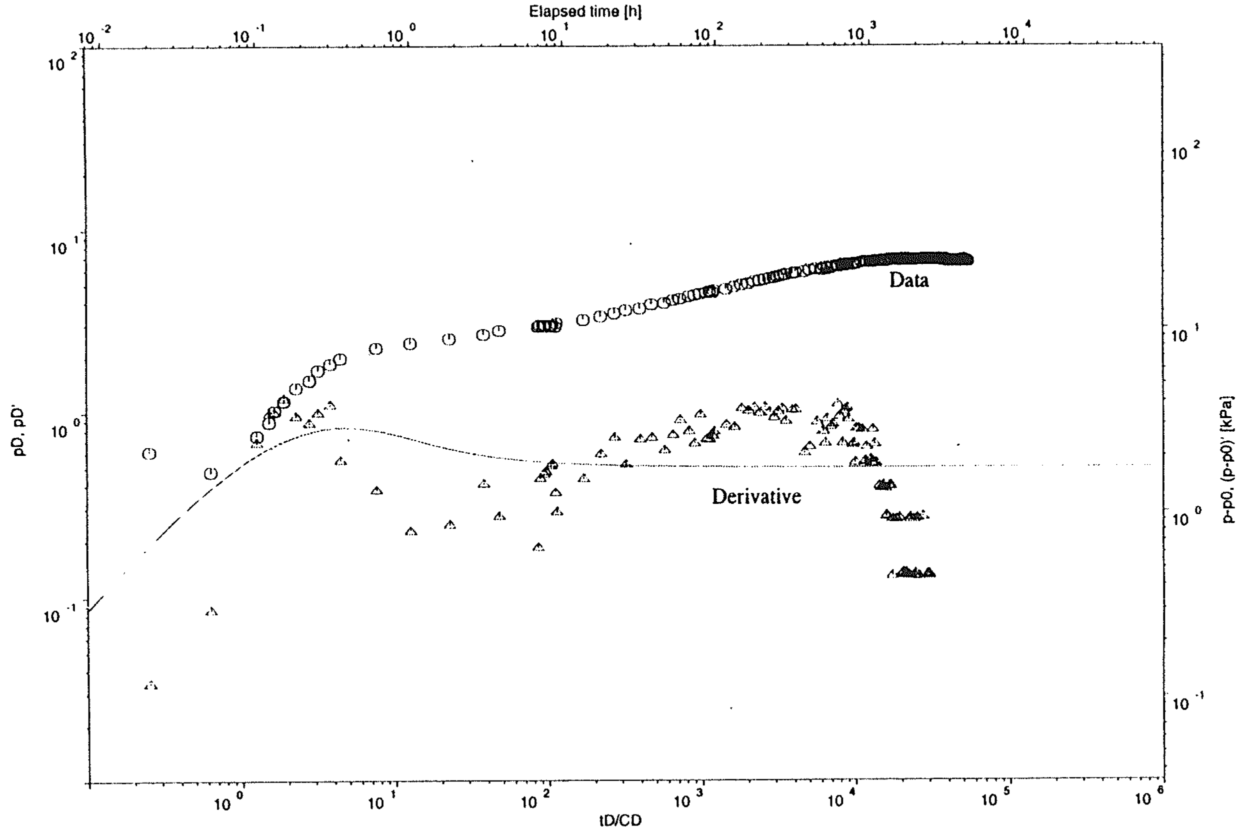
FlowDim Version 2.14b
(c) Golder Associates



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	8.71E-07	m3/Pa
T=	2.66E-04	m2/s
S=	3.37E-07	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 29B



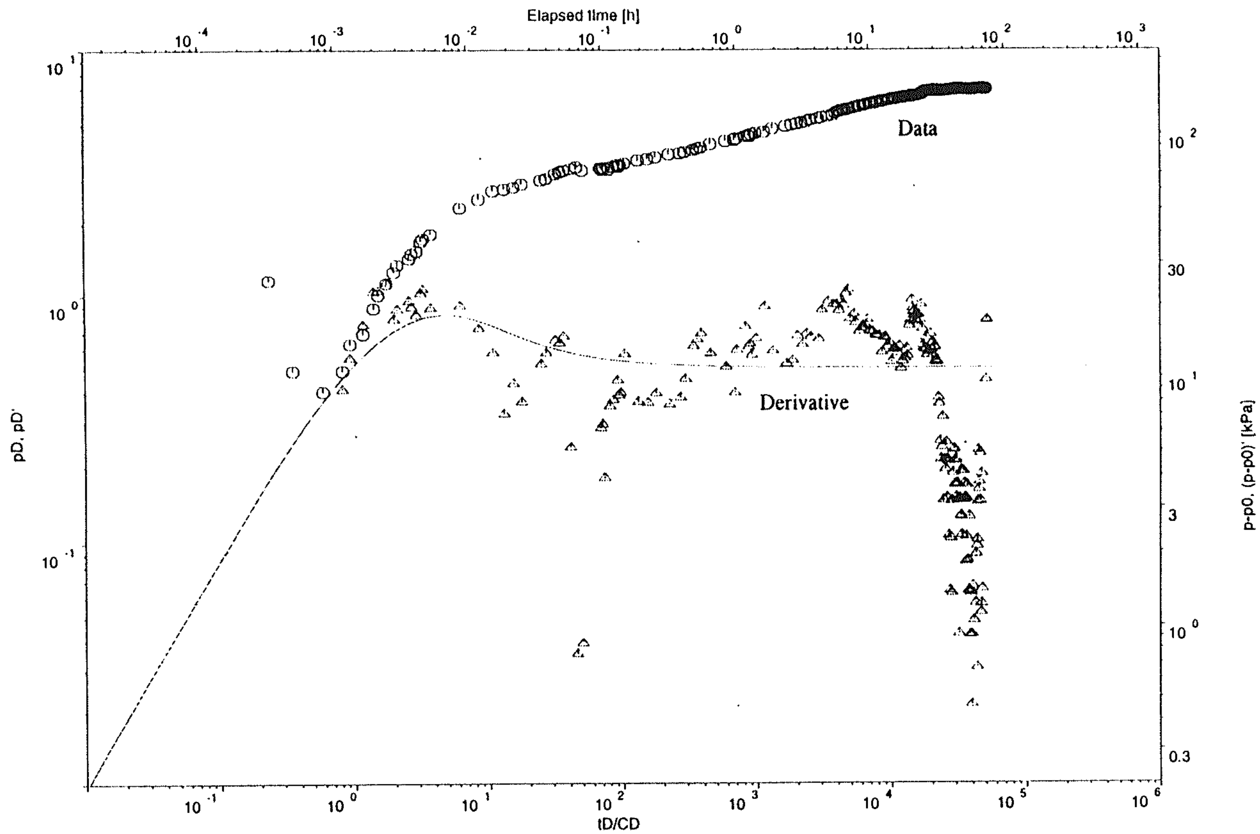
FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	1.50E-04	m3/Pa
T=	8.25E-04	m2/s
S=	5.20E+00	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 30B

Forence, Anzona / P28.1-
Oxide / Pumping Well

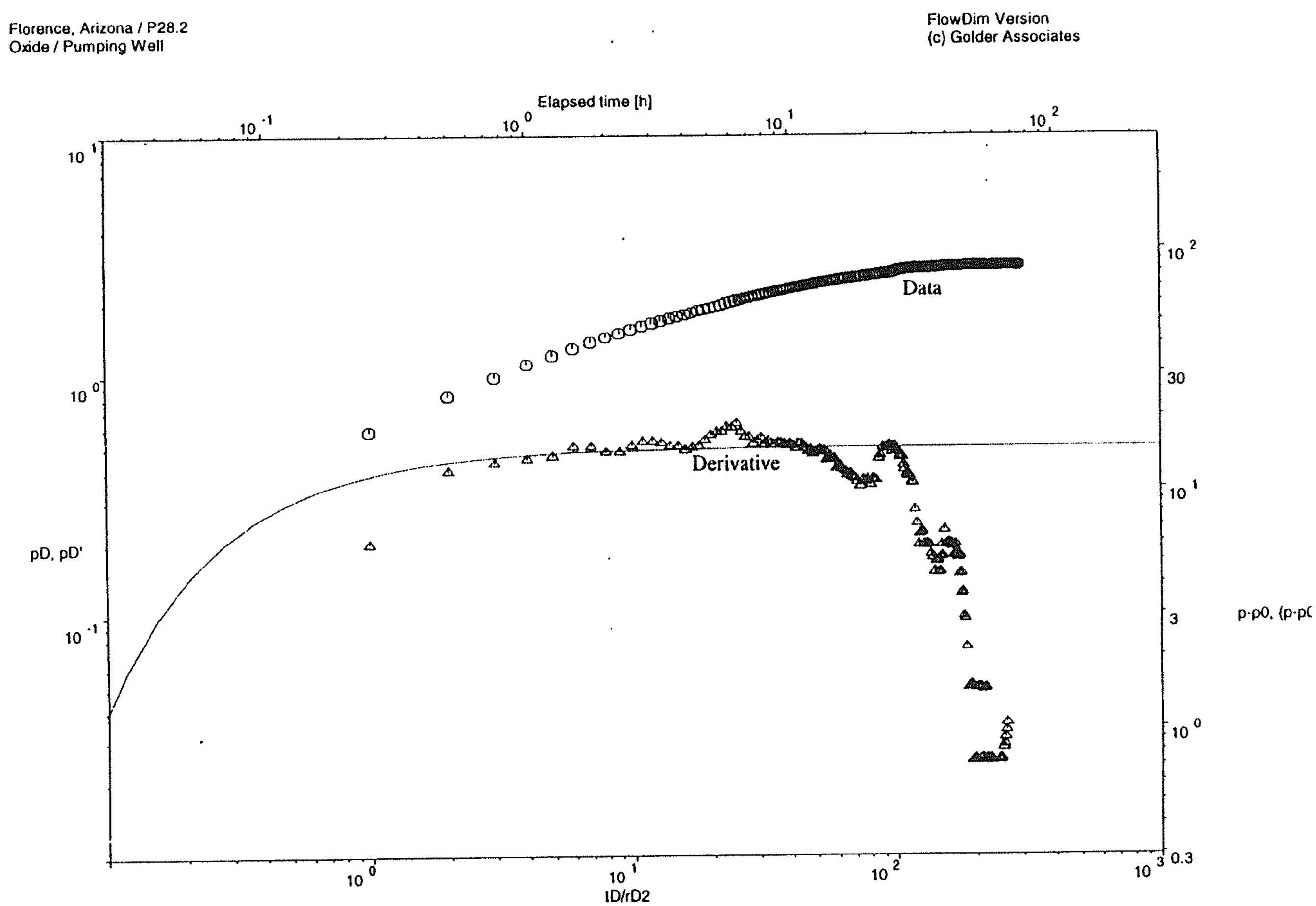
FlowDim Version 2.14b
(c) Golder Associates



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	1.28E-06	m3/Pa
T=	3.86E-04	m2/s
S=	3.45E-02	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 31B



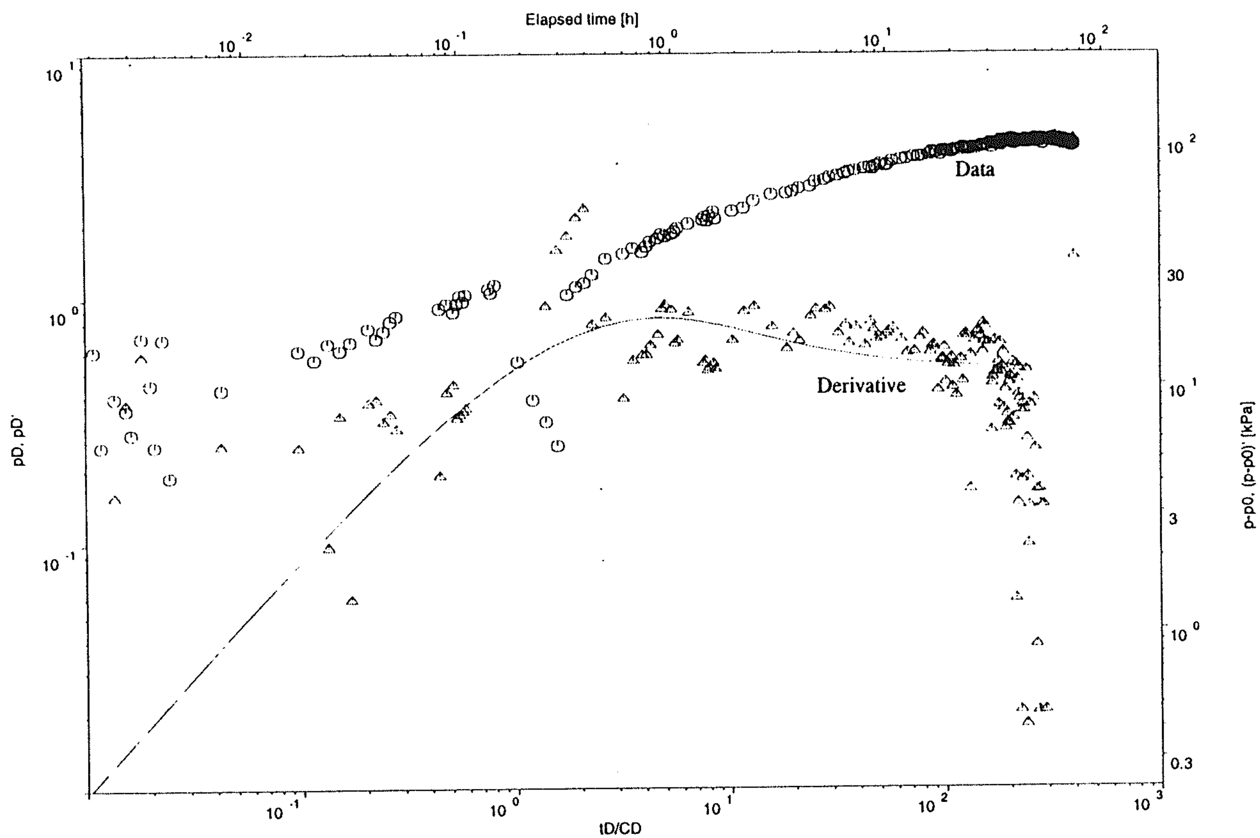
FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-

T=	2.84E-04	m2/s
S=	2.91E-04	-
rD=	5.89E+02	-
n=	2.00E+00	-

Figure 32B

Florence, Arizona / P28.2
Oxide / Pumping Well

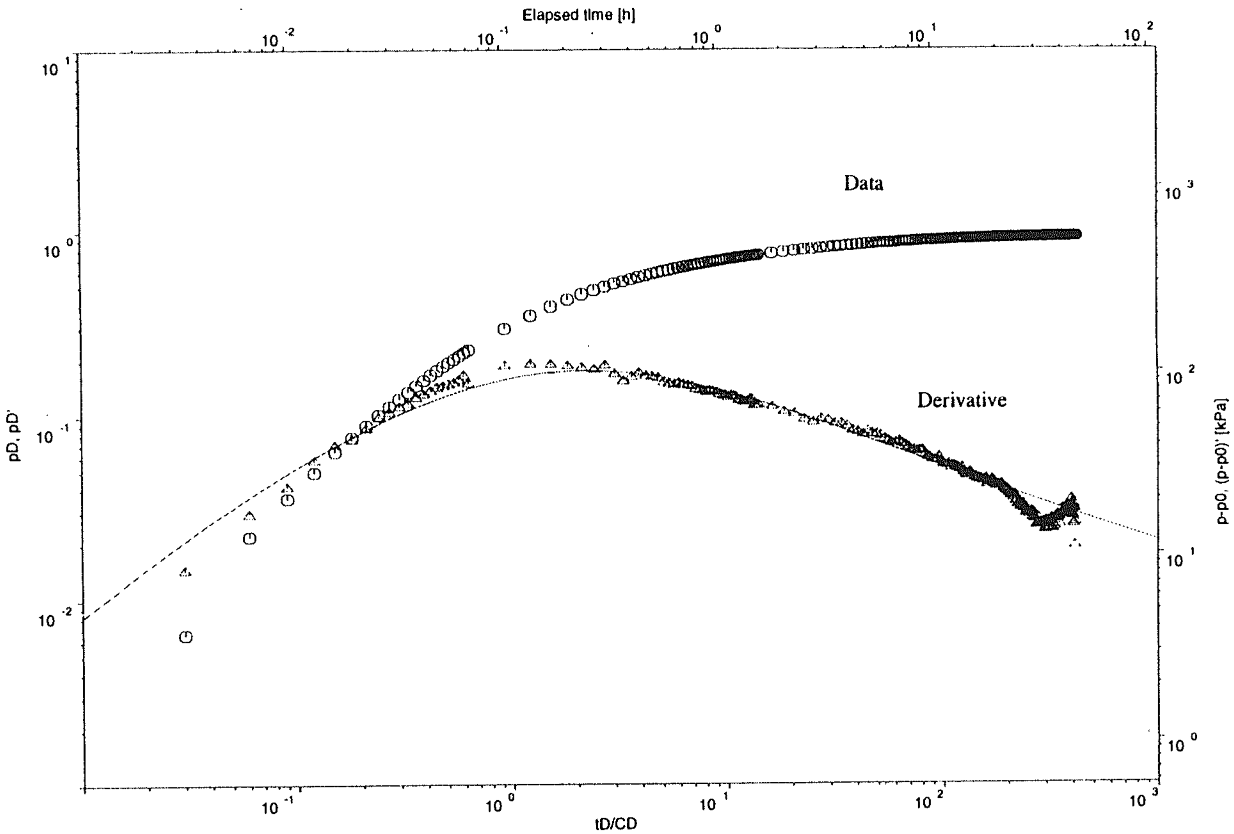
FlowDim Version 2.14b
(c) Golder Associates



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	1.41E-04	m3/Pa
T=	3.30E-04	m2/s
S=	3.78E+00	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 33B



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : Build-up TC
PLOT TYPE : Log-log

C=	1.78E-06	m3/Pa
T=	3.45E-06	m2/s
S=	7.99E-01	-
s=	0.00E+00	-
n=	3.00E+00	-

Figure 34B

APPENDIX C

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	M1-GL
Interval name	Lower Gila
Event name	Pumping Well
Test date	11 - 13 Aug. 1995
Input file name	m1-gld.rec

Well parameters

Well depth	[m brp]	1.2802E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	1.2190E+01

Testparameter

Flow rate	[l/min]	3.7900E+01
Test duration	[h]	2.4458E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	7.5775E-11
Transmissivity	[m2/s]	7.4335E-04
Storage	[m/Pa]	8.5961E-13
Storativity	[-]	8.4327E-09
Wellbore storage	[m3/Pa]	4.3535E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	3.9350E+02
Pressure match	[1/kPa]	7.5335E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 29.10.1995

Identification

Site name	Florence, Arizona
Well name	M3-GL
Interval name	Lower Gila
Event name	Observation Well (M4-O)
Test date	28 - 29 July, 1995
Input file name	m3gloddb.fd1

Well parameters

Well depth	[m bgl]	1.5545E+02
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	1.8290E+01
Distance to active well	[m]	9.7100E+00
Active wellbore radius	[m]	6.3500E+02

Testparameter

Flow rate	[l/min]	5.6780E+01
Test duration	[h]	2.2171E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	9.7150E-11
Transmissivity	[m2/s]	9.5304E-04
Storage	[m/Pa]	8.9465E-06
Storativity	[-]	8.7765E-02
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	1.5291E+02
Time match	[1/h]	4.1462E-01
Pressure match	[1/kPa]	6.4470E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence Site
Well name	M14-GL
Interval name	Lower Gila
Event name	Pumping Well
Test date	11 - 12 Aug. 1995
Input file name	m14-gld.rec

Well parameters

Well depth	[m brp]	2.8956E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	1.8290E+01

Testparameter

Flow rate	[l/min]	3.7850E+01
Test duration	[h]	1.8180E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	1.1462E-11
Transmissivity	[m2/s]	1.1244E-04
Storage	[m/Pa]	9.2897E-11
Storativity	[-]	9.1132E-07
Wellbore storage	[m3/Pa]	2.3524E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	1.1015E+02
Pressure match	[1/kPa]	1.1410E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence Site
Well name	M14-GL
Interval name	Lower Gila
Event name	Pumping Well
Test date	11 - 12 Aug. 1995
Input file name	m14gld3d.rec

Well parameters

Well depth	[m brp]	2.8956E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	1.8290E+01

Testparameter

Flow rate	[l/min]	3.7850E+01
Test duration	[h]	1.8180E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	5.4085E-13
Transmissivity	[m2/s]	5.3057E-06
Storage	[m/Pa]	4.3810E-06
Storativity	[-]	4.2977E-02
Wellbore storage	[m3/Pa]	2.2182E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	3.0000E+00
Time match	[1/h]	1.1022E+01
Pressure match	[1/kPa]	1.0766E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	M15-GU
Interval name	Upper Gila
Event name	Pumping Well
Test date	8 - 9 Aug. 1995
Input file name	m15-gud.rec

Well parameters

Well depth	[m brp]	1.9202E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	1.2190E+01

Testparameter

Flow rate	[l/min]	3.7900E+01
Test duration	[h]	1.6695E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	1.1353E-11
Transmissivity	[m2/s]	1.1137E-04
Storage	[m/Pa]	1.0991E-15
Storativity	[-]	1.0782E-11
Wellbore storage	[m3/Pa]	2.7832E-07
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	9.2222E+02
Pressure match	[1/kPa]	1.1287E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	M18-GU
Interval name	Upper Gila
Event name	Pumping Well
Test date	8 - 11 Aug. 1995
Input file name	m18-gud.rec

Well parameters

Well depth	[m brp]	7.3150E+01
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	1.2190E+01

Testparameter

Flow rate	[l/min]	3.7900E+01
Test duration	[h]	1.9194E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	8.6070E-11
Transmissivity	[m2/s]	8.4434E-04
Storage	[m/Pa]	8.8678E-20
Storativity	[-]	8.6993E-16
Wellbore storage	[m3/Pa]	2.2455E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	8.6654E+02
Pressure match	[1/kPa]	8.5570E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 15.11.1995

Identification

Site name	Florence, Arizona
Well name	P39-O
Interval name	Oxide
Event name	Pumping Well
Test date	19 - 20 May, 1995
Input file name	mf39pwpd.rec

Well parameters

Well depth	[m brp]	2.7890E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	1.3000E-01
Interval length	[m]	1.0820E+02

Testparameter

Flow rate	[l/min]	2.0800E+02
Test duration	[h]	1.6917E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	1.1442E-11
Transmissivity	[m2/s]	1.1225E-04
Storage	[m/Pa]	9.7900E-08
Storativity	[-]	9.6040E-04
Wellbore storage	[m3/Pa]	1.0390E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	2.4897E+02
Pressure match	[1/kPa]	2.0728E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 15.11.1995

Identification

Site name	Florence, Arizona
Well name	039-O
Interval name	Oxide
Event name	Observ. Well (P39-O)
Test date	19 - 20 May, 1995
Input file name	mf39owpd.rec

Well parameters

Well depth	[m brp]	2.7920E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	1.2700E-01
Interval length	[m]	1.2680E+02
Distance to active well	[m]	3.6000E+01

Testparameter

Flow rate	[l/min]	2.0800E+02
Test duration	[h]	1.6857E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	1.4760E-11
Transmissivity	[m2/s]	1.4479E-04
Storage	[m/Pa]	4.4004E-08
Storativity	[-]	4.3168E-04
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	2.8346E+02
Time match	[1/h]	9.3173E-01
Pressure match	[1/kPa]	2.6738E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 27.10.1995

Identification

Site name	Florence, Arizona
Well name	OB7-1
Interval name	Oxide
Event name	Observation Well
Test date	16 - 21 June, 1995
Input file name	ob7-1dda.fd1

Well Parameters

Well depth	[m bgl]	2.7432E+02
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	1.0363E+02
Distance to active well	[m]	1.5300E+01

Test Parameters

Flow rate	[l/min]	1.5142E+02
Test duration	[h]	2.4666E+01

Fluid and Formation Parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	5.0475E-12
Transmissivity	[m2/s]	4.9516E-05
Storage	[m/Pa]	1.3510E-08
Storativity	[-]	1.3253E-04
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	2.0079E+02
Time match	[1/h]	5.7458E+00
Pressure match	[1/kPa]	1.2560E-02
Type Curve Match	[-]	

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 27.10.1995

Identification

Site name	Florence, Arizona
Well name	012-O
Interval name	Oxide
Event name	Observation Well
Test date	1 - 7 June, 1995
Input file name	o12-oddc.fd1

Well Parameters

Well depth	[m bgl]	2.9570E+02
Wellbore radius	[m]	5.0800E-02
Interval length	[m]	1.5240E+02
Distance to active well	[m]	2.1900E+01
Radius of active well	[m]	7.6200E-02

Test Parameters

Flow rate	[l/min]	2.4610E+02
Test duration	[h]	6.6313E+00

Fluid and Formation Parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	3.2764E-11
Transmissivity	[m2/s]	3.2141E-04
Storage	[m/Pa]	2.2788E-07
Storativity	[-]	2.2355E-03
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	2.8740E+02
Time match	[1/h]	1.0792E+00
Pressure match	[1/kPa]	5.0164E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	O28-GL
Interval name	Lower Gila
Event name	Obs. Well (P28-GL)
Test date	20 - 25 Sep. 1995
Input file name	o28-gld.rec

Well parameters

Well depth	[m brp]	9.7540E+01
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	5.0800E-02
Interval length	[m]	9.1400E+00
Distance to active well	[m]	4.0220E+01

Testparameter

Flow rate	[l/min]	2.8391E+02
Test duration	[h]	1.1873E+02

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	7.6324E-11
Transmissivity	[m2/s]	7.4874E-04
Storage	[m/Pa]	2.7481E-09
Storativity	[-]	2.6959E-05
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	7.9173E+02
Time match	[1/h]	6.1809E+01
Pressure match	[1/kPa]	1.0130E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	O28.1-O
Interval name	Oxide
Event name	Obs. Well (P28.2-O)
Test date	2 - 5 Oct. 1995
Input file name	o281-od.rec

Well parameters

Well depth	[m brp]	1.6154E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	5.0800E-02
Interval length	[m]	3.0480E+01
Distance to active well	[m]	4.9730E+01

Testparameter

Flow rate	[l/min]	2.8770E+02
Test duration	[h]	7.3888E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	3.2337E-11
Transmissivity	[m2/s]	3.1723E-04
Storage	[m/Pa]	1.0811E-07
Storativity	[-]	1.0605E-03
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	9.7894E+02
Time match	[1/h]	4.3542E-01
Pressure match	[1/kPa]	4.2352E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	PW2-1
Interval name	Oxide
Event name	Pumping Well
Test date	8 Mar. 1995
Input file name	pw2-1d.rec

Well parameters

Well depth	[m brp]	1.9507E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	6.7060E+01

Testparameter

Flow rate	[l/min]	1.8927E+02
Test duration	[h]	1.6767E+02

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	3.2665E-11
Transmissivity	[m2/s]	3.2045E-04
Storage	[m/Pa]	3.2419E-13
Storativity	[-]	3.1803E-09
Wellbore storage	[m3/Pa]	2.3643E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	3.1235E+02
Pressure match	[1/kPa]	6.5031E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 27.10.1995

Identification

Site name	Florence, Arizona
Well name	M3-GL
Interval name	Lower Gila
Event name	Pumping Well
Test date	26 - 27 July, 1995
Input file name	pm3-glda.fd1

Well parameters

Well depth	[m bgl]	1.1278E+02
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	1.2190E+01

Test parameters

Flow rate	[l/min]	3.7850E+01
Test duration	[h]	2.6919E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	6.9585E-11
Transmissivity	[m2/s]	6.8263E-04
Storage	[m/Pa]	3.2211E-11
Storativity	[-]	3.1599E-07
Wellbore storage	[m3/Pa]	8.1567E-07
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	1.9287E+03
Pressure match	[1/kPa]	6.9273E-01
Type Curve Match	[-]	1.0000E+06

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	PW4-1
Interval name	Oxide
Event name	Pumping Well
Test date	19 May, 1995
Input file name	pw4-1.rec

Well parameters

Well depth	[m brp]	2.4384E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	1.0363E+02

Testparameter

Flow rate	[l/min]	2.6876E+02
Test duration	[h]	9.5190E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	1.4008E-10
Transmissivity	[m2/s]	1.3742E-03
Storage	[m/Pa]	2.5645E-13
Storativity	[-]	2.5158E-09
Wellbore storage	[m3/Pa]	1.8703E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	1.6933E+03
Pressure match	[1/kPa]	1.9640E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 27.10.1995

Identification

Site name	Florence, Arizona
Well name	M4-O
Interval name	Oxide
Event name	Pumping Well
Test date	28 - 29 July, 1995
Input file name	pm4-od.fd1

Well parameters

Well depth	[m bgl]	1.5240E+02
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	1.8290E+01

Test parameters

Flow rate	[l/min]	5.6780E+01
Test duration	[h]	2.3641E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	3.6643E-12
Transmissivity	[m2/s]	3.5947E-05
Storage	[m/Pa]	2.7270E-13
Storativity	[-]	2.6752E-09
Wellbore storage	[m3/Pa]	1.3811E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	5.9983E+01
Pressure match	[1/kPa]	2.4317E-02
Type Curve Match	[-]	2.0000E+08

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 26.10.1995

Identification

Site name	Florence, Arizona
Well name	PW7-1
Interval name	Oxide
Event name	Pumping Test
Test date	16 - 21 June 1995
Input file name	pw7-1dda.fd1

Well parameters

Well depth	[m bgl]	2.7432E+02
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	1.0363E+02

Test parameter

Flow rate	[l/min]	1.5142E+02
Test duration	[h]	2.4919E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	8.5587E-12
Transmissivity	[m2/s]	8.3960E-05
Storage	[m/Pa]	1.8842E-07
Storativity	[-]	1.8484E-03
Wellbore storage	[m3/Pa]	6.8707E-07
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	2.8162E+02
Pressure match	[1/kPa]	2.1298E-02
Type Curve Match	[-]	1.0000E+02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P8-GU
Interval name	Upper Gila
Event name	Pumping Well
Test date	18 - 22 Sep. 1995
Input file name	p8-gud.rec

Well parameters

Well depth	[m brp]	8.2300E+01
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	3.6580E+01

Testparameter

Flow rate	[l/min]	3.3501E+02
Test duration	[h]	5.3012E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	8.0643E-10
Transmissivity	[m2/s]	7.9111E-03
Storage	[m/Pa]	3.2522E-10
Storativity	[-]	3.1904E-06
Wellbore storage	[m3/Pa]	1.1859E-05
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	1.5374E+03
Pressure match	[1/kPa]	9.0703E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 26.10.1995

Identification

Site name	Florence Arizona
Well name	P12-O
Interval name	Oxide
Event name	Pumping Test
Test date	1 - 7 June, 1995
Input file name	p12-oddc.fdt

Well parameters

Well depth	[m bgl]	1.0000E+02
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	1.5240E+02

Test parameters

Flow rate	[l/min]	2.4610E+02
Test duration	[h]	1.6624E+00

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	2.0785E-11
Transmissivity	[m2/s]	2.0390E-04
Storage	[m/Pa]	4.2419E-05
Storativity	[-]	4.1613E-01
Wellbore storage	[m3/Pa]	4.6404E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	1.0126E+02
Pressure match	[1/kPa]	3.1823E-02
Type Curve parameter	[-]	3.0000E+00

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 23.11.1995

Identification

Site name	Florence, Arizona
Well name	P13.1-O
Interval name	Oxide
Event name	Pumping Well
Test date	9 - 16 Oct. 1995
Input file name	p131od.rec

Well parameters

Well depth	[m brp]	4.4958E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	2.0635E+02

Testparameter

Flow rate	[l/min]	1.7413E+02
Test duration	[h]	8.8082E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	1.9503E-11
Transmissivity	[m2/s]	1.9133E-04
Storage	[m/Pa]	4.8082E-11
Storativity	[-]	4.7168E-07
Wellbore storage	[m3/Pa]	1.7533E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	2.5149E+02
Pressure match	[1/kPa]	4.2203E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 24.11.1995

Identification

Site name	Florence, Arizona
Well name	P13.2-O
Interval name	Oxide
Event name	Obs, Well (P13.1-O)
Test date	9 - 16 Oct. 1995
Input file name	p132od3d.rec

Well parameters

Well depth	[m brp]	4.2672E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	1.8227E+02
Distance to active well	[m]	3.1370E+01

Testparameter

Flow rate	[l/min]	1.7413E+02
Test duration	[h]	8.8176E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	8.3410E-15
Transmissivity	[m2/s]	8.1825E-08
Storage	[m/Pa]	7.1721E-11
Storativity	[-]	7.0358E-07
Inner shell flow dimension	[-]	3.0000E+00
Dimensionles obs. point distance	[-]	4.1168E+02
Time match	[1/h]	4.2545E-01
Pressure match	[1/kPa]	3.6089E-05

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 25.11.1995

Identification

Site name	Florence, Arizona
Well name	P15-O
Interval name	Oxide
Event name	Pumping Well
Test date	29 Sep-5 Oct. 1995
Input file name	p15od.rec

Well parameters

Well depth	[m brp]	4.2062E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	2.1946E+02

Testparameter

Flow rate	[l/min]	2.2330E+02
Test duration	[h]	1.0083E+02

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	3.9175E-11
Transmissivity	[m2/s]	3.8431E-04
Storage	[m/Pa]	1.3542E-06
Storativity	[-]	1.3285E-02
Wellbore storage	[m3/Pa]	4.9380E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	1.7936E+02
Pressure match	[1/kPa]	6.6105E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P19-O
Interval name	Oxide
Event name	Observ. Well
Test date	3 - 6 Jul. 1995
Input file name	p19-0d.rec

Well parameters

Well depth	[m brp]	2.0726E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	6.0350E+01
Distance to active well	[m]	2.2720E+01

Testparameter

Flow rate	[l/min]	8.3280E+01
Test duration	[h]	5.1266E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	4.1810E-12
Transmissivity	[m2/s]	4.1016E-05
Storage	[m/Pa]	7.8809E-08
Storativity	[-]	7.7311E-04
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	2.9816E+02
Time match	[1/h]	3.7000E-01
Pressure match	[1/kPa]	1.8917E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P19-O
Interval name	Oxide
Event name	Observ. Well
Test date	3 - 6 Jul. 1995
Input file name	p19-od3d.rec

Well parameters

Well depth	[m brp]	2.0726E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	6.0350E+01
Distance to active well	[m]	2.2720E+01

Testparameter

Flow rate	[l/min]	8.3280E+01
Test duration	[h]	5.1266E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	5.1759E-15
Transmissivity	[m2/s]	5.0775E-08
Storage	[m/Pa]	1.4684E-10
Storativity	[-]	1.4405E-06
Inner shell flow dimension	[-]	3.0000E+00
Dimensionles obs. point distance	[-]	2.9816E+02
Time match	[1/h]	2.4582E-01
Pressure match	[1/kPa]	4.6825E-05

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P19.1-O
Interval name	Oxide
Event name	Withdrawal
Test date	3 - 6 Jul. 1995
Input file name	p191-od.rec

Well parameters

Well depth	[m brp]	2.0726E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	6.0350E+01

Testparameter

Flow rate	[l/min]	8.3300E+01
Test duration	[h]	5.1267E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	6.5087E-12
Transmissivity	[m2/s]	6.3851E-05
Storage	[m/Pa]	6.2788E-14
Storativity	[-]	6.1595E-10
Wellbore storage	[m3/Pa]	4.5791E-07
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	3.2135E+02
Pressure match	[1/kPa]	2.9442E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P19.1-O
Interval name	Oxide
Event name	Withdrawal
Test date	3 - 6 Jul. 1995
Input file name	p191od3d.rec

Well parameters

Well depth	[m brp]	2.0726E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	6.0350E+01

Testparameter

Flow rate	[l/min]	8.3300E+01
Test duration	[h]	5.1267E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	2.4052E-13
Transmissivity	[m2/s]	2.3595E-06
Storage	[m/Pa]	5.7460E-07
Storativity	[-]	5.6368E-03
Wellbore storage	[m3/Pa]	4.1894E-07
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	3.0000E+00
Time match	[1/h]	2.5952E+01
Pressure match	[1/kPa]	2.1754E-03

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P19.2-O
Interval name	Oxide
Event name	Observ. Well
Test date	3 - 6 Jul. 1995
Input file name	p192-od.rec

Well parameters

Well depth	[m brp]	1.9111E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	5.0800E-02
Interval length	[m]	6.0350E+01
Distance to active well	[m]	2.1200E+01

Testparameter

Flow rate	[l/min]	8.3280E+01
Test duration	[h]	4.9513E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	3.2012E-12
Transmissivity	[m2/s]	3.1404E-05
Storage	[m/Pa]	1.4992E-08
Storativity	[-]	1.4707E-04
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	2.6835E+02
Time match	[1/h]	1.7103E+00
Pressure match	[1/kPa]	1.4484E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P19.2-O
Interval name	Oxide
Event name	Observ. Well
Test date	3 - 6 Jul. 1995
Input file name	p192od3d.rec

Well parameters

Well depth	[m brp]	1.9111E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	5.0800E-02
Interval length	[m]	6.0350E+01
Distance to active well	[m]	2.1200E+01

Testparameter

Flow rate	[l/min]	8.3280E+01
Test duration	[h]	4.9513E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	4.3045E-15
Transmissivity	[m2/s]	4.2228E-08
Storage	[m/Pa]	3.4441E-11
Storativity	[-]	3.3786E-07
Inner shell flow dimension	[-]	3.0000E+00
Dimensionles obs. point distance	[-]	2.6835E+02
Time match	[1/h]	1.0011E+00
Pressure match	[1/kPa]	3.8942E-05

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P28-GL
Interval name	Lower Gila
Event name	Pumping Well
Test date	20 - 25, Sep. 1995
Input file name	p28-gld.rec

Well parameters

Well depth	[m brp]	9.7540E+01
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	9.1400E+00

Testparameter

Flow rate	[l/min]	2.8390E+02
Test duration	[h]	1.1539E+02

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	2.7137E-11
Transmissivity	[m2/s]	2.6622E-04
Storage	[m/Pa]	3.4388E-11
Storativity	[-]	3.3735E-07
Wellbore storage	[m3/Pa]	8.7080E-07
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	7.0454E+02
Pressure match	[1/kPa]	3.6017E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P28.1-O
Interval name	Oxide
Event name	Pumping Well
Test date	15 - 18 Aug, 1995
Input file name	p281-oad.rec

Well parameters

Well depth	[m brp]	1.5850E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	6.7200E-02
Interval length	[m]	3.0480E+01

Testparameter

Flow rate	[l/min]	1.0978E+02
Test duration	[h]	4.2844E+03

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	8.4137E-11
Transmissivity	[m2/s]	8.2539E-04
Storage	[m/Pa]	5.3035E-04
Storativity	[-]	5.2027E+00
Wellbore storage	[m3/Pa]	1.5040E-04
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	1.2647E+01
Pressure match	[1/kPa]	2.8879E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 15.11.1995

Identification

Site name	Forence, Arizona
Well name	P28.1-O
Interval name	Oxide
Event name	Pumping Well
Test date	8 - 11 Sep, 1995
Input file name	p281-obd.rec

Well parameters

Well depth	[m brp]	1.5850E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	3.0480E+01

Testparameter

Flow rate	[l/min]	3.2180E+02
Test duration	[h]	7.4053E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	3.9300E-11
Transmissivity	[m2/s]	3.8554E-04
Storage	[m/Pa]	3.5153E-06
Storativity	[-]	3.4485E-02
Wellbore storage	[m3/Pa]	1.2818E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	6.9315E+02
Pressure match	[1/kPa]	4.6017E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 15.11.1995

Identification

Site name	Florence, Arizona
Well name	P28.2-O
Interval name	Oxide
Event name	Obs. Well (P28.1-O)
Test date	8 - 11 Sep, 1995
Input file name	p282-obd.rec

Well parameters

Well depth	[m brp]	1.6150E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	5.0800E-02
Interval length	[m]	3.0180E+01
Distance to active well	[m]	2.9910E+01

Testparameter

Flow rate	[l/min]	3.2170E+02
Test duration	[h]	7.3898E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	2.8996E-11
Transmissivity	[m2/s]	2.8446E-04
Storage	[m/Pa]	2.9688E-08
Storativity	[-]	2.9124E-04
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	5.8878E+02
Time match	[1/h]	3.9303E+00
Pressure match	[1/kPa]	3.3963E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P28.2-O
Interval name	Oxide
Event name	Pumping Well
Test date	2 - 5 Oct. 1995
Input file name	p282-od.rec

Well parameters

Well depth	[m brp]	1.5820E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	3.0180E+01

Testparameter

Flow rate	[l/min]	2.8769E+02
Test duration	[h]	7.4052E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	3.3674E-11
Transmissivity	[m2/s]	3.3035E-04
Storage	[m/Pa]	3.8581E-04
Storativity	[-]	3.7848E+00
Wellbore storage	[m3/Pa]	1.4068E-04
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	5.4115E+00
Pressure match	[1/kPa]	4.4105E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 25.11.1995

Identification

Site name	Florence, Arizona
Well name	P49-O
Interval name	Oxide
Event name	Recovery
Test date	11 - 16 Oct. 1995
Input file name	p490r.rec

Well parameters

Well depth	[m brp]	3.9258E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	1.2619E+02

Testparameter

Production/Injection time	[h]	4.5700E+01
Flow rate	[l/min]	1.5142E+02
Test duration	[h]	4.7164E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-03

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Buildup

Results of analysis

Transmissibility	[m3]	3.5205E-13
Transmissivity	[m2/s]	3.4536E-06
Storage	[m/Pa]	8.1397E-05
Storativity	[-]	7.9851E-01
Wellbore storage	[m3/Pa]	1.7804E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	3.0000E+00
Time match	[1/h]	8.9386E+00
Pressure match	[1/kPa]	1.7517E-03

Comments

FlowDim V2.14b

MEMORANDUM

TO: Mr. Steven A. Mellon
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FROM: Amado Guzman
Tucson Office

Golder Associates

Our Reference: 953-2908

DATE: December 1, 1995

RE: Florence Electronic Data

Dear Steve:

Please find enclosed the reduced data files for the hydraulic tests included in our interpretation report. I have prepared a list of these files and their relationship to the figures presented in Appendix B. Please let me know if you need any additional information.

Cheers!

Enc. (12) Diskettes

cc. Mr. John Kline
Magma Copper Co.
Resource Development Technology Group
7400 N. Oracle Rd. Suite 162
Tucson, Arizona 85704
WITH ENCLOSURES (1) Diskette

Reduced data files and corresponding figures within Appendix B. Files contain two columns; time (hours) versus head (KPa).

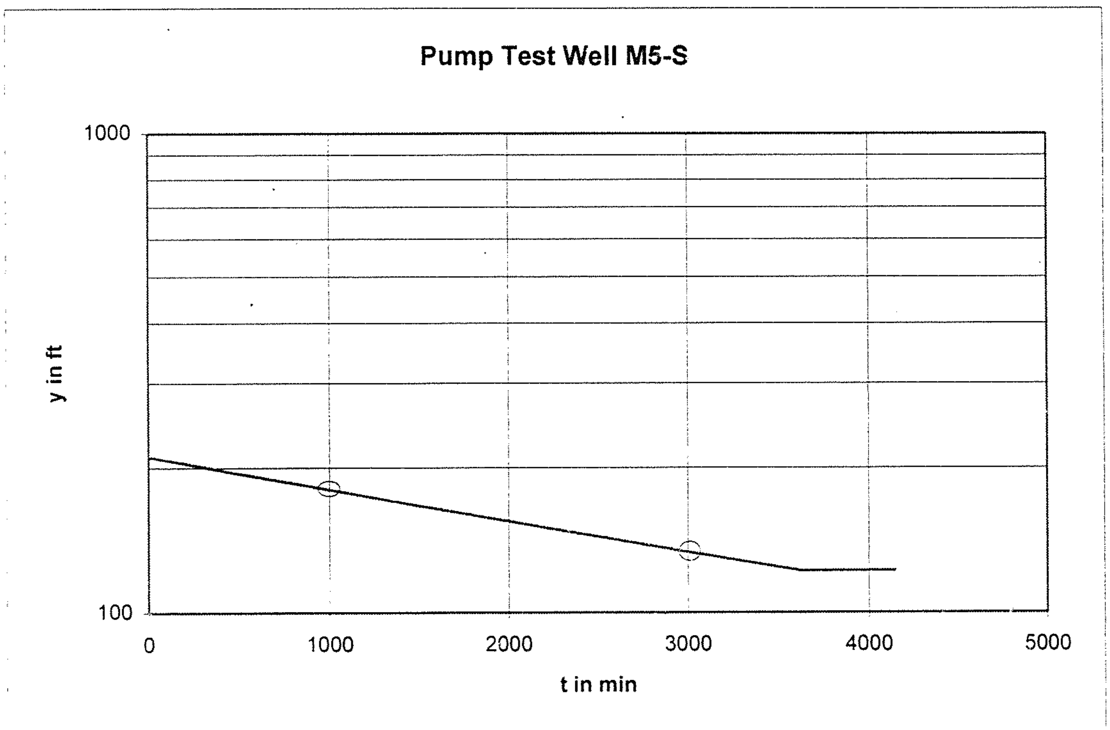
Figure	Well ID	Name of Data File			
1B,	M1-GL	M1-GLD DAT	7,342	11-16-95	3:41a
2B,	M3-GL	M3GLPD DAT	6,354	08-29-95	9:31p
3B,	M14-GL	M14-GLD DAT	5,302	11-16-95	3:43a
4B,	M14-GL (3-D)	Same as previous			
5B,	M15-GU	M15-GUD DAT	7,138	11-16-95	3:42a
6B,	M18-GL	M18-GUD DAT	6,186	11-16-95	3:40a
7B,	P39-O	MF39PWPD DAT	7,920	11-15-95	12:01p
8B,	O39-O	MF39OWPD DAT	4,758	11-15-95	12:02p
9B,	OB7-1	OB7-1OD DAT	8,328	12-01-95	2:25p
10B,	O12-O	O12-ODDC FD1	22,449	10-27-95	11:44a
11B,	O28-GL	O28-GLD DAT	6,458	11-16-95	2:29a
12B,	O28.1-O	O281-OD DAT	6,220	11-16-95	1:24a
13B,	PW2-1	PW2-1D DAT	8,498	11-16-95	4:54p
14B,	M3-GL	M3GLODDB FDT	746	10-29-95	3:18p
15B,	PW4-1	PW4-1 DAT	7,478	11-16-95	4:29p
16B,	M4-O	M4OPD DAT	5,469	08-29-95	9:57p
17B,	PW7-1	PW7-1OD DAT	8,158	12-01-95	2:27p
18B,	P8-GU	P8-GUD DAT	6,696	11-16-95	2:26a
19B,	P12-O	P12-ODDB FDT	2,684	10-22-95	7:22p
20B,	P13.1-O	P131OD DAT	7,988	11-23-95	12:41p
21B,	P13.2-O (3-D)	P132OD DAT	8,294	11-23-95	12:44p
22B,	P15-O	P15OD DAT	8,260	11-25-95	12:06p
23B,	P19-O	P19-OD DAT	8,396	11-16-95	11:30a
24B,	P19-O (3-D)	Same as previous			
25B,	P19.1-O	P191-OD DAT	6,390	11-16-95	11:29a
26B,	P19.1-O (3-D)	Same as Previous			
27B,	P19.2-O	P192-OD DAT	8,838	11-16-95	11:32a
28B,	P19.2-O (3-D)	Same as Previous			
29B,	P28-GL	P28-GLD DAT	8,770	11-16-95	2:27a
30B,	P28.1-O	P281-OAD DAT	7,444	11-15-95	1:33p
31B,	P28.1-O (Test #2)	P281-OBD DAT	7,852	11-15-95	2:06p
32B,	P28.2-O (Test #2)	P282-OBD DAT	6,662	11-15-95	2:06p
33B,	P28.2-O	P282-OD DAT	8,090	11-16-95	1:22a
34B,	P49-O (3-D)	P49OR DAT	8,498	11-24-95	7:21p

M5-S Pump Out Slug Test
Brown and Caldwell

Project: 1899 for Magma Copper Company, Florence, AZ
Test Date: July 25-28, 1995

Depth of well, Dw=	380	ft
Depth to water Dd=	122.13	ft
D=Dw-Dd	257.87	ft
b=D	257.87	ft
d=	60	ft
y=	211	ft
rc=	0.2	ft
rw=	0.35	ft
d/rw=	171.4286	
b/rw=	736.7714	
from Fig 16.6		
C=	11.6	
ln(Re/rw)	4.268473	
K=	3.1E-04	ft/day

t=tx-to=	2005
ln(ho/ht)=	0.300301
slope=	0.00015



Reference: Bouwer, H., The Bouwer and Rice Slug Test - An Update. Ground Water
Vol. 27, No. 3, 1989

M13-S Pump Out Slug Test
Brown and Caldwell

Project: 1899 for Magma Copper Company, Florence, AZ
Test Date: July 28 - Aug 1, 1995

Depth of well, Dw=	345	ft
Depth to water Dd=	150.79	ft
D=Dw-Dd	194.21	ft
b=D	194.21	ft
d=	60	ft
y=	349	ft
rc=	0.2	ft
rw=	0.35	ft

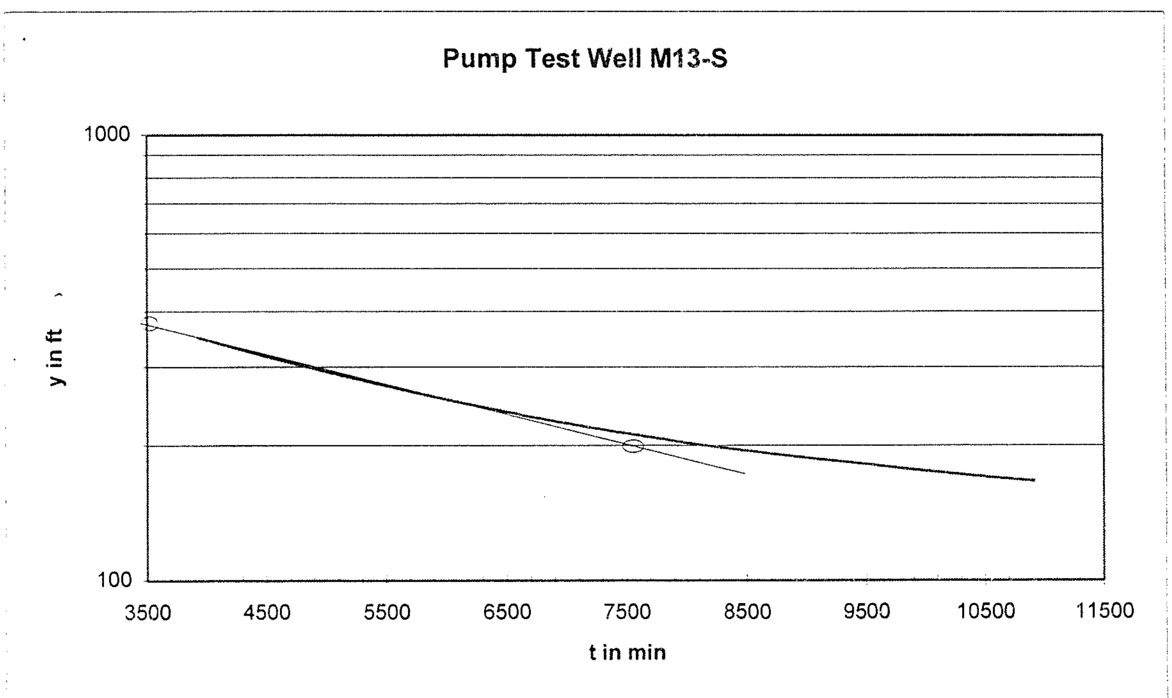
t=tx-to=	4050
ln(ho/ht)=	0.641854
slope=	0.000158

d/rw= 171.4286
b/rw= 554.8857

from Fig 16.6
C= 11.6

ln(Re/rw) 4.136481

K= 3.1E-04 ft/day



Reference: Bouwer, H., The Bouwer and Rice Slug Test - An Update. Ground Water
Vol. 27, No. 3, 1989

Exhibit 14A-2

- **MFGU Hydraulic Conductivity Testing Laboratory Report (300), 1995**
- **MFGU Hydraulic Conductivity Testing Laboratory Report (283-288), 2011**
- **MFGU Hydraulic Conductivity Testing Laboratory Report (292-297), 2011**

CORE LAB

CORE LABORATORIES

PARTICLE-SIZE ANALYSIS RESULTS

MAGMA FLORENCE

CL AURORA FILE # 57209-954427
CL BKRSFLD FILE # 57111-095334

PERFORMED BY:
CORE LABORATORIES
3430 UNICORN ROAD
BAKERSFIELD, CA 93308
(805) 392-8600

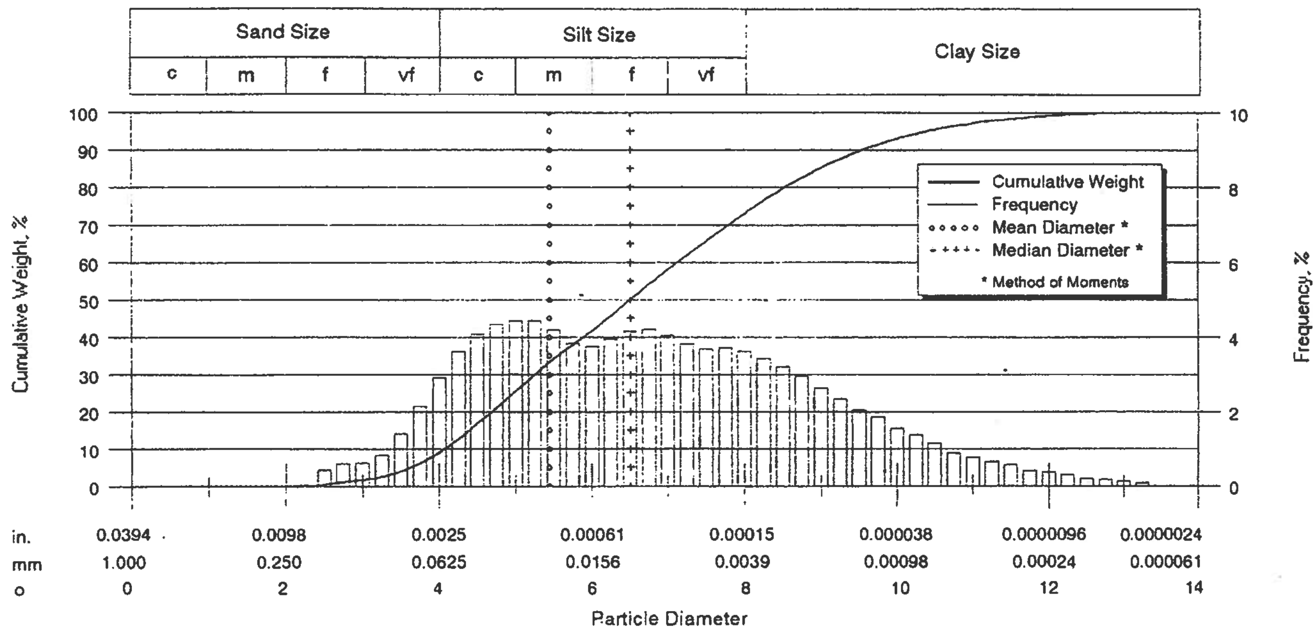
FINAL REPORT PRESENTED
OCTOBER 12, 1995

CORE LAB

CORE LABORATORIES

Company	CORE LAB. - AURORA	Sample	P1-80-55	File Number	57111-95334
I.D.	954427-1	Proj.	Magma Florence	Date	11-OCT-95
County		State		Analysts	GC

Laser Particle Size Analysis



Particle Size Distribution

	[U.S. Sieve]	Diameter [in]	[mm]	[phi]	Weight. % [Inc.]	[Cum.]
Coarse Sand	20	0.0331	0.84	0.25	0.00	0.00
	25	0.0280	0.71	0.50	0.00	0.00
	30	0.0232	0.59	0.75	0.00	0.00
	35	0.0197	0.50	1.00	0.00	0.00
Medium Sand	40	0.0165	0.42	1.25	0.00	0.00
	45	0.0138	0.35	1.50	0.00	0.00
	50	0.0118	0.30	1.75	0.00	0.00
	60	0.0098	0.25	2.00	0.00	0.00
Fine Sand	70	0.0083	0.210	2.25	0.03	0.03
	80	0.0070	0.177	2.50	0.44	0.47
	100	0.0059	0.149	2.75	0.60	1.07
	120	0.0049	0.125	3.00	0.62	1.69
Very Fine Sand	140	0.0041	0.105	3.25	0.84	2.53
	170	0.0035	0.088	3.50	1.40	3.93
	200	0.0029	0.074	3.75	2.15	6.08
	230	0.0025	0.063	4.00	2.92	9.00
Silt	270	0.0021	0.053	4.25	3.62	12.62
	325	0.0017	0.044	4.50	4.11	16.73
	400	0.0015	0.037	4.75	4.32	21.05
	450	0.0012	0.031	5.00	4.44	25.49
	500	0.0010	0.025	5.32	5.65	31.14
	635	0.0008	0.020	5.64	5.16	36.30
		0.00061	0.0156	6.00	5.41	41.71
		0.00031	0.0078	7.00	16.36	58.07
		0.00015	0.0039	8.00	14.85	72.92
Clay		0.000079	0.0020	9.00	12.21	85.13
		0.000039	0.00098	10.0	7.80	92.93
		0.000019	0.00049	11.0	4.18	97.11
		0.0000094	0.00024	12.0	2.00	99.11
		0.0000047	0.00012	13.0	0.80	99.91
		0.0000039	0.00010	13.3	0.09	100.00

Sorting Statistics

Parameter	[Moment]	[Trask]	[Inman]	[Folk]
Mean, in	0.0009	0.0004	0.0004	0.0004
Mean, mm	0.0229	0.0106	0.0098	0.0102
Mean, phi	5.4472	6.5619	6.6725	6.6187
Median, in	0.0004	0.0004	0.0004	0.0004
Median, mm	0.0110	0.0110	0.0110	0.0110
Median, phi	6.5103	6.5110	6.5110	6.5110
Std Deviation, in	0.0012	0.0161	0.0084	0.0089
Std Deviation, mm	0.0298	0.4116	0.2152	0.2280
Std Deviation, phi	5.0700	1.2805	2.2160	2.1331
Skewness	2.5040	0.9561	0.2286	0.1113
Kurtosis	8.2100	0.2899	0.5264	0.8717
Mode, mm	0.0296			
95% Confidence	0.0171			
Limits, mm	0.0288			
Variance, mm2	0.0009			
Coef. of Variance, %	129.80			

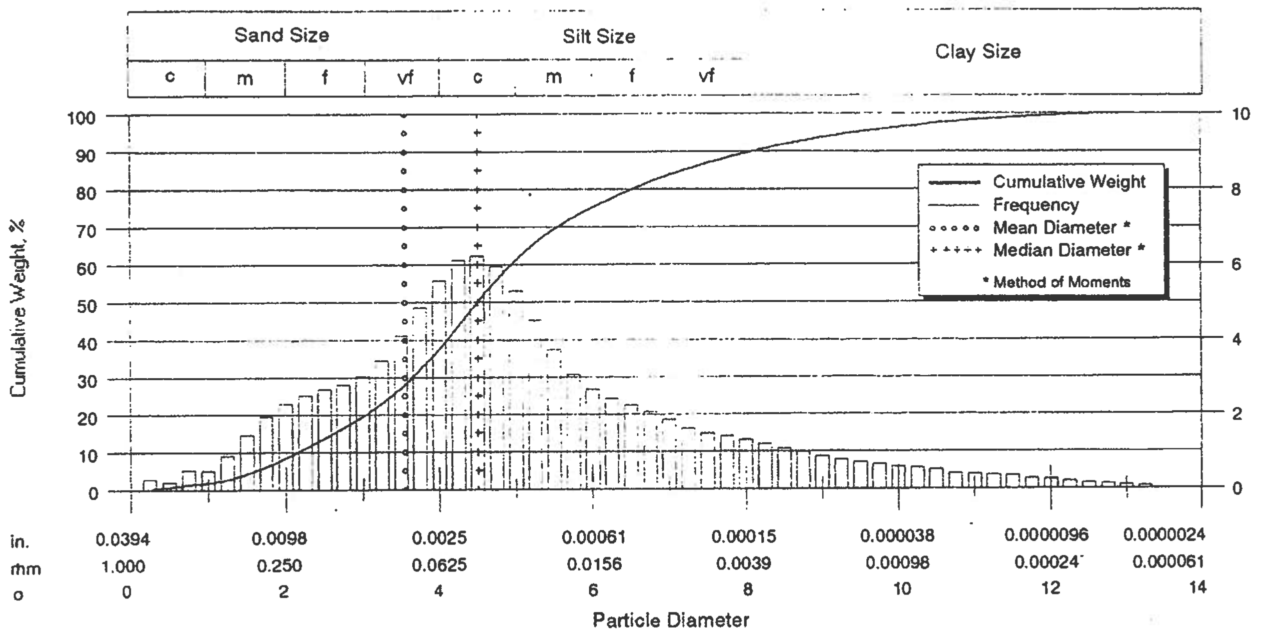
Percentiles [Weight, %]	Particle Diameter [in]	[mm]	[phi]
5	0.0031	0.0805	3.6349
10	0.0023	0.0593	4.0749
16	0.0018	0.0455	4.4565
25	0.0012	0.0319	4.9716
50	0.0004	0.0110	6.5110
75	0.0001	0.0035	8.1523
84	0.0001	0.0021	8.8885
90	0.0001	0.0013	9.5609
95	0.0000	0.0007	10.4002

CORE LAB

CORE LABORATORIES

Company	CORE LAB. - AURORA	Sample	P1-80-80	File Number	57111-95334
I.D.	954427-2	Proj.	Magma Florence	Date	11-OCT-95
County		State		Analysts	GC

Laser Particle Size Analysis



Particle Size Distribution

	U.S. Sieve	Diameter [in]	Diameter [mm]	Diameter [phi]	Weight, % [Inc.]	Weight, % [Cum.]
Coarse Sand	20	0.0331	0.84	0.25	0.58	0.58
	25	0.0280	0.71	0.50	0.20	0.78
	30	0.0232	0.59	0.75	0.52	1.30
	35	0.0197	0.50	1.00	0.52	1.82
Medium Sand	40	0.0165	0.42	1.25	0.90	2.72
	45	0.0138	0.35	1.50	1.45	4.17
	50	0.0118	0.30	1.75	1.96	6.13
	60	0.0098	0.25	2.00	2.29	8.42
Fine Sand	70	0.0083	0.210	2.25	2.52	10.94
	80	0.0070	0.177	2.50	2.69	13.63
	100	0.0059	0.149	2.75	2.81	16.44
	120	0.0049	0.125	3.00	3.03	19.47
Very Fine Sand	140	0.0041	0.105	3.25	3.46	22.93
	170	0.0035	0.088	3.50	4.11	27.04
	200	0.0029	0.074	3.75	4.85	31.89
	230	0.0025	0.063	4.00	5.58	37.47
Silt	270	0.0021	0.053	4.25	6.12	43.59
	325	0.0017	0.044	4.50	6.24	49.83
	400	0.0015	0.037	4.75	5.93	55.76
	450	0.0012	0.031	5.00	5.29	61.05
	500	0.0010	0.025	5.32	5.64	66.69
	635	0.0008	0.020	5.64	4.39	71.08
		0.00061	0.0156	6.00	3.94	75.02
		0.00031	0.0078	7.00	8.57	83.59
		0.00015	0.0039	8.00	5.83	89.42
Clay		0.000079	0.0020	9.00	4.13	93.55
		0.000039	0.00098	10.0	2.73	96.28
		0.000019	0.00049	11.0	1.88	98.16
		0.0000094	0.00024	12.0	1.20	99.36
		0.0000047	0.00012	13.0	0.57	99.93
		0.0000039	0.00010	13.3	0.07	100.00

Sorting Statistics

Parameter	[Moment]	[Trask]	[Inman]	[Folk]
Mean, in	0.0033	0.0015	0.0013	0.0014
Mean, mm	0.0854	0.0388	0.0338	0.0369
Mean, phi	3.5495	4.6896	4.8856	4.7592
Median, in	0.0017	0.0017	0.0017	0.0017
Median, mm	0.0440	0.0440	0.0440	0.0440
Median, phi	4.5067	4.5065	4.5065	4.5065
Std Deviation, in	0.0047	0.0155	0.0086	0.0080
Std Deviation, mm	0.1217	0.3973	0.2215	0.2058
Std Deviation, phi	3.0386	1.3318	2.1745	2.2808
Skewness	3.0590	0.9986	0.4808	0.2199
Kurtosis	11.7700	0.2194	0.8113	1.2338
Mode, mm	0.0511			
95% Confidence	0.0616			
Limits, mm	0.1093			
Variance, mm2	0.0148			
Coef. of Variance, %	142.50			

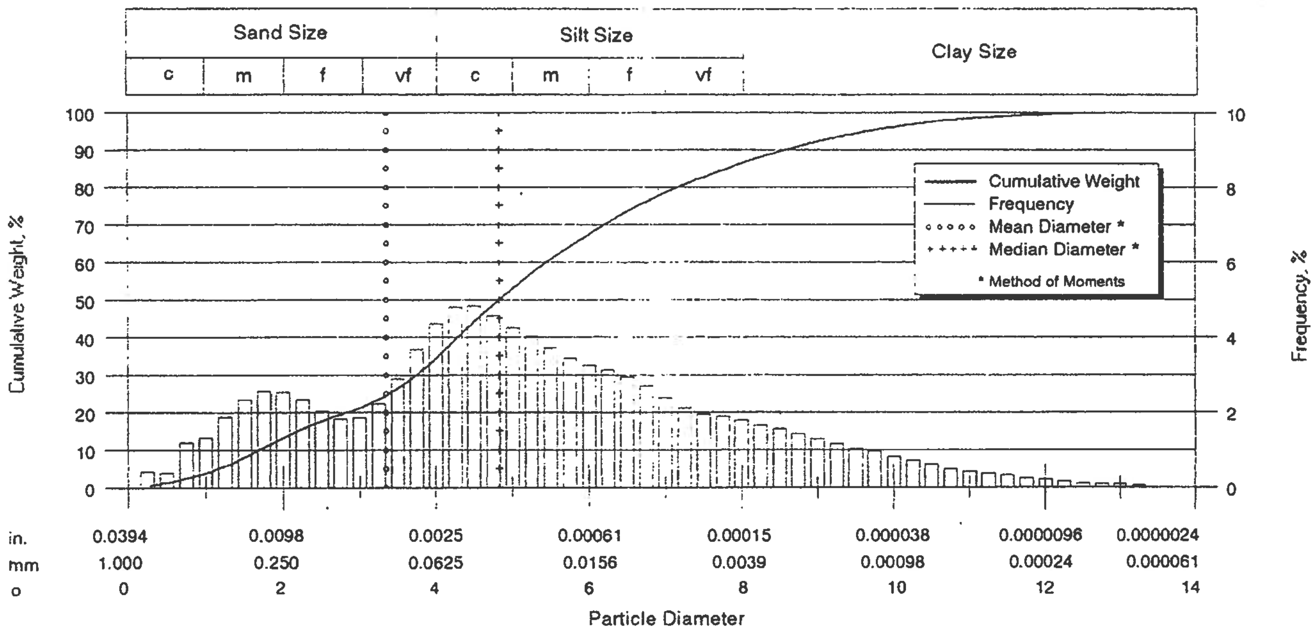
Percentiles [Weight, %]	Particle Diameter [in]	Particle Diameter [mm]	Particle Diameter [phi]
5	0.0127	0.3268	1.6134
10	0.0087	0.2242	2.1572
16	0.0060	0.1527	2.7111
25	0.0037	0.0960	3.3813
50	0.0017	0.0440	4.5065
75	0.0006	0.0156	5.9979
84	0.0003	0.0075	7.0600
90	0.0001	0.0036	8.1190
95	0.0001	0.0014	9.4907

CORE LAB

CORE LABORATORIES

Company	CORE LAB. - AURORA	Sample	P2-90-45	File Number	57111-95334
I.D.	954427-3	Proj.	Magma Florence	Date	11-OCT-95
County		State		Analysts	GC

Laser Particle Size Analysis



Particle Size Distribution

	U.S. Sieve	Diameter [in]	Diameter [mm]	Diameter [phi]	Weight, % [Inc.]	Weight, % [Cum.]
Coarse Sand	20	0.0331	0.84	0.25	0.95	0.95
	25	0.0280	0.71	0.50	0.39	1.34
	30	0.0232	0.59	0.75	1.19	2.53
	35	0.0197	0.50	1.00	1.34	3.87
Medium Sand	40	0.0165	0.42	1.25	1.86	5.73
	45	0.0138	0.35	1.50	2.34	8.07
	50	0.0118	0.30	1.75	2.57	10.64
	60	0.0098	0.25	2.00	2.55	13.19
Fine Sand	70	0.0083	0.210	2.25	2.35	15.54
	80	0.0070	0.177	2.50	2.03	17.57
	100	0.0059	0.149	2.75	1.82	19.39
	120	0.0049	0.125	3.00	1.85	21.24
Very Fine Sand	140	0.0041	0.105	3.25	2.22	23.46
	170	0.0035	0.088	3.50	2.90	26.36
	200	0.0029	0.074	3.75	3.68	30.04
	230	0.0025	0.063	4.00	4.37	34.41
Silt	270	0.0021	0.053	4.25	4.80	39.21
	325	0.0017	0.044	4.50	4.85	44.06
	400	0.0015	0.037	4.75	4.56	48.62
	450	0.0012	0.031	5.00	4.26	52.88
	500	0.0010	0.025	5.32	5.08	57.96
	635	0.0008	0.020	5.64	4.60	62.56
		0.00061	0.0156	6.00	4.74	67.30
		0.00031	0.0078	7.00	11.16	78.46
		0.00015	0.0039	8.00	7.73	86.19
Clay		0.000079	0.0020	9.00	5.92	92.11
		0.000039	0.00098	10.0	3.95	96.06
		0.000019	0.00049	11.0	2.28	98.34
		0.0000094	0.00024	12.0	1.15	99.49
		0.0000047	0.00012	13.0	0.46	99.95
		0.0000039	0.00010	13.3	0.05	100.00

Sorting Statistics

Parameter	[Moment]	[Trask]	[Inman]	[Folk]
Mean, in	0.0038	0.0012	0.0012	0.0013
Mean, mm	0.0981	0.0308	0.0313	0.0325
Mean, phi	3.3498	5.0195	4.9989	4.9421
Median, in	0.0014	0.0014	0.0014	0.0014
Median, mm	0.0352	0.0352	0.0352	0.0352
Median, phi	4.8287	4.8286	4.8286	4.8286
Std Deviation, in	0.0060	0.0148	0.0060	0.0063
Std Deviation, mm	0.1551	0.3789	0.1544	0.1606
Std Deviation, phi	2.6887	1.4001	2.6952	2.6387
Skewness	2.4990	0.9669	0.2200	0.1012
Kurtosis	6.4300	0.2355	0.5809	1.0724
Mode, mm	0.0511			
95% Confidence Limits, mm	0.0677 0.1285			
Variance, mm2	0.0241			
Coef. of Variance, %	158.10			

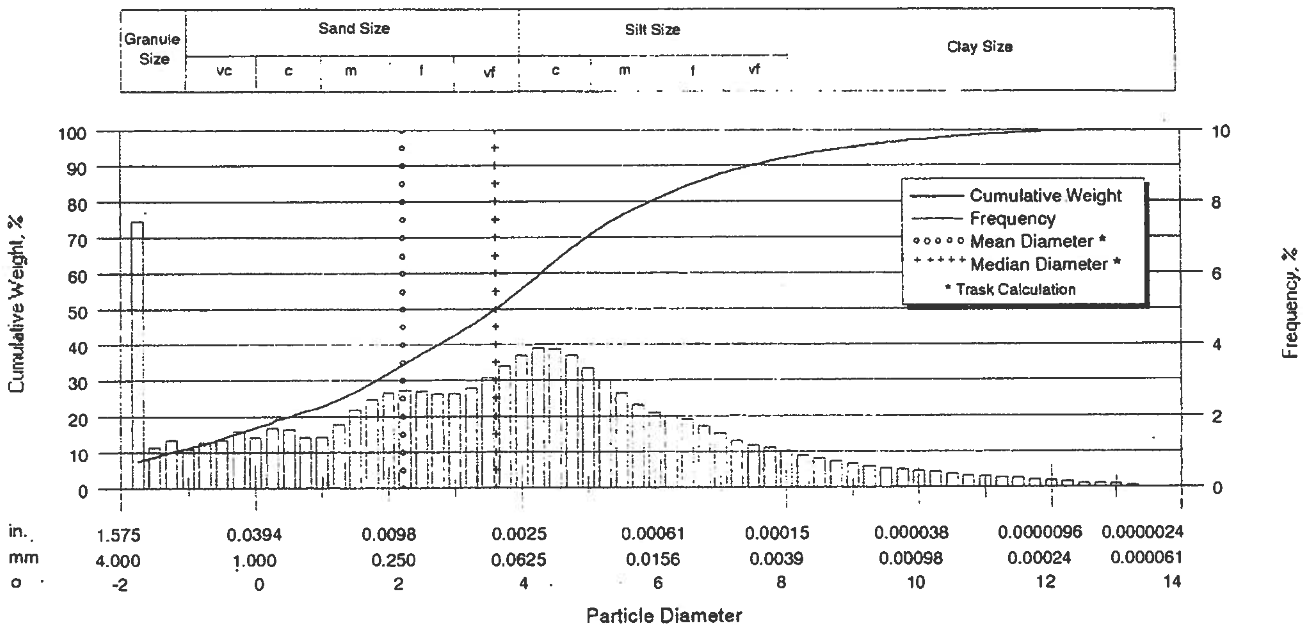
Percentiles [Weight, %]	Particle Diameter [in]	Particle Diameter [mm]	Particle Diameter [phi]
5	0.0174	0.4472	1.1609
10	0.0121	0.3104	1.6877
16	0.0079	0.2025	2.3037
25	0.0037	0.0953	3.3911
50	0.0014	0.0352	4.8286
75	0.0004	0.0100	6.6479
84	0.0002	0.0048	7.6941
90	0.0001	0.0026	8.6029
95	0.0000	0.0012	9.6825

CORE LAB

CORE LABORATORIES

Company	CORE LAB. - AURORA	Sample	P2-90-70	File Number	57111-95334
I.D.	954427-4	Proj.	Magma Florence	Date	11-OCT-95
County		State		Analysts	GC

Sieve and Laser Particle Size Analysis



Particle Size Distribution

	U.S. Sieve	Diameter [in]	Diameter [mm]	Diameter [phi]	Weight, % [Inc.]	Weight, % [Cum.]
Granule	6	0.1324	3.36	-1.75	7.46	7.46
	8	0.0936	2.38	-1.25	2.46	9.92
V Coarse Sand	12	0.0662	1.68	-0.75	2.35	12.27
	16	0.0468	1.19	-0.25	2.93	15.20
Coarse Sand	20	0.0331	0.84	0.25	3.08	18.28
	25	0.0280	0.71	0.50	1.63	19.91
	30	0.0232	0.59	0.75	1.42	21.33
	35	0.0197	0.50	1.00	1.43	22.76
Medium Sand	40	0.0165	0.42	1.25	1.78	24.54
	45	0.0138	0.35	1.50	2.18	26.72
	50	0.0118	0.30	1.75	2.47	29.19
	60	0.0098	0.25	2.00	2.66	31.85
Fine Sand	70	0.0083	0.210	2.25	2.74	34.59
	80	0.0070	0.177	2.50	2.70	37.29
	100	0.0059	0.149	2.75	2.63	39.92
	120	0.0049	0.125	3.00	2.63	42.55
Very Fine Sand	140	0.0041	0.105	3.25	2.77	45.32
	170	0.0035	0.088	3.50	3.08	48.40
	200	0.0029	0.074	3.75	3.39	51.79
	230	0.0025	0.063	4.00	3.70	55.49
Silt	270	0.0021	0.053	4.25	3.90	59.39
	325	0.0017	0.044	4.50	3.90	63.29
	400	0.0015	0.037	4.75	3.67	66.96
	450	0.0012	0.031	5.00	3.35	70.31
	500	0.0010	0.025	5.32	3.79	74.10
	635	0.0008	0.020	5.64	3.17	77.27
		0.00061	0.0156	6.00	3.07	80.34
		0.00031	0.0078	7.00	7.09	87.43
		0.00015	0.0039	8.00	4.58	92.01
Clay		0.000079	0.0020	9.00	3.09	95.10
		0.000039	0.00098	10.0	2.05	97.15
		0.000019	0.00049	11.0	1.43	98.58
		0.0000094	0.00024	12.0	0.93	99.51
		0.0000047	0.00012	13.0	0.44	99.95
		0.0000039	0.00010	13.3	0.05	100.00

Sorting Statistics

Parameter	Trask*	Inman**	Folk**
Mean, in	0.0083	0.0043	0.0039
Mean, mm	0.2139	0.1112	0.1002
Mean, phi	2.2249	3.1682	3.3191
Median, in	0.0032	0.0032	0.0032
Median, mm	0.0813	0.0813	0.0813
Median, phi	3.6209	3.6209	3.6209
Standard Deviation, in	0.1614	0.0039	
Standard Deviation, mm	4.1392	0.1013	
Standard Deviation, phi	-2.0493	3.3036	
Skewness	1.4436		
Kurtosis	0.0810		

* calculated using mm values
**calculated using phi values

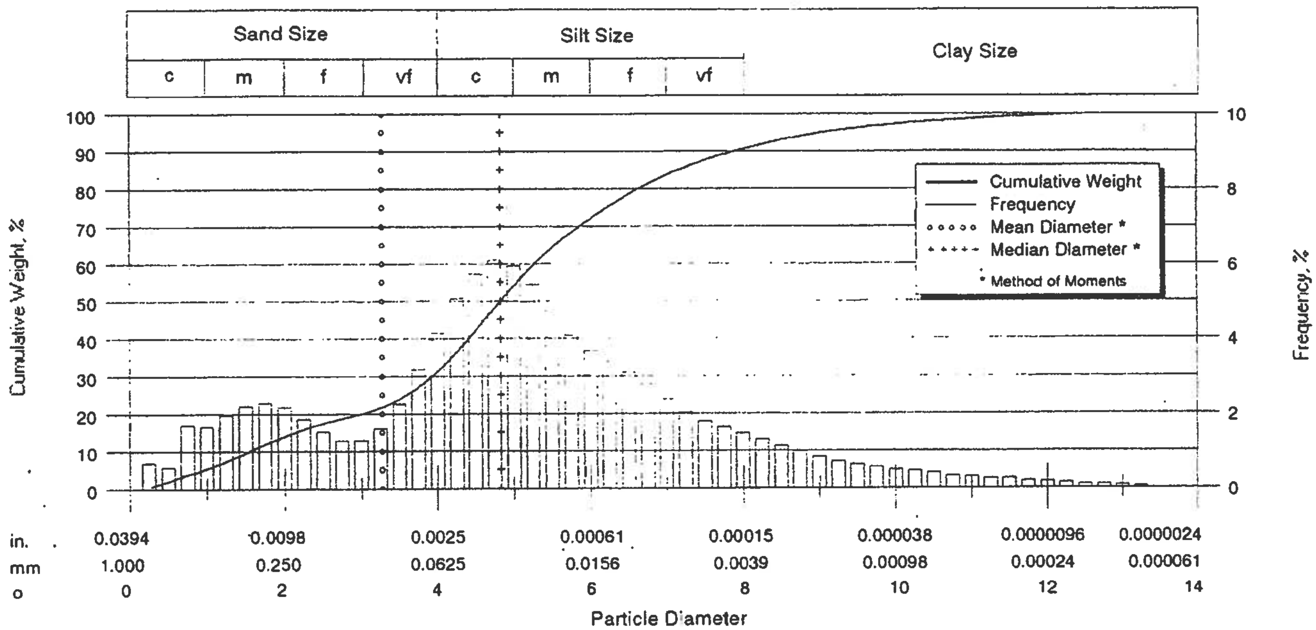
Percentiles [weight, %]	Particle Diameter [in]	Particle Diameter [mm]	Particle Diameter [phi]
5	ERR 5	ERR 5	ERR 5
10	0.0918	2.3543	-1.2353
16	0.0428	1.0983	-0.1353
25	0.0158	0.4042	1.3068
50	0.0032	0.0813	3.6209
75	0.0009	0.0236	5.4054
84	0.0004	0.0113	6.4718
90	0.0002	0.0054	7.5201
95	0.0001	0.0020	8.9587

CORELAB

CORE LABORATORIES

Company	CORE LAB. - AURORA	Sample	B1-35	File Number	57111-95334
I.D.	954427-5	Proj.	Magma Florence	Date	11-OCT-95
County		State		Analysts	GC

Laser Particle Size Analysis



Particle Size Distribution

	[U.S. Sieve]	Diameter [in]	[mm]	[phi]	Weight, % [Inc.]	[Cum.]
Coarse Sand	20	0.0331	0.84	0.25	1.47	1.47
	25	0.0280	0.71	0.50	0.57	2.04
	30	0.0232	0.59	0.75	1.68	3.72
	35	0.0197	0.50	1.00	1.64	5.36
Medium Sand	40	0.0165	0.42	1.25	1.97	7.33
	45	0.0138	0.35	1.50	2.22	9.55
	50	0.0118	0.30	1.75	2.30	11.85
	60	0.0098	0.25	2.00	2.17	14.02
Fine Sand	70	0.0083	0.210	2.25	1.87	15.89
	80	0.0070	0.177	2.50	1.52	17.41
	100	0.0059	0.149	2.75	1.28	18.69
	120	0.0049	0.125	3.00	1.29	19.98
Very Fine Sand	140	0.0041	0.105	3.25	1.61	21.59
	170	0.0035	0.088	3.50	2.26	23.85
	200	0.0029	0.074	3.75	3.17	27.02
	230	0.0025	0.063	4.00	4.14	31.16
Silt	270	0.0021	0.053	4.25	5.06	36.22
	325	0.0017	0.044	4.50	5.75	41.97
	400	0.0015	0.037	4.75	6.06	48.03
	450	0.0012	0.031	5.00	5.95	53.98
	500	0.0010	0.025	5.32	6.84	60.82
	635	0.0008	0.020	5.64	5.68	66.50
		0.00061	0.0156	6.00	5.38	71.88
		0.00031	0.0078	7.00	11.64	83.52
		0.00015	0.0039	8.00	6.92	90.44
Clay		0.000079	0.0020	9.00	4.25	94.69
		0.000039	0.00098	10.0	2.41	97.10
		0.000019	0.00049	11.0	1.50	98.60
		0.0000094	0.00024	12.0	0.91	99.51
		0.0000047	0.00012	13.0	0.44	99.95
		0.0000039	0.00010	13.3	0.05	100.00

Sorting Statistics

Parameter	[Moment]	[Trask]	[Inman]	[Folk]
Mean, in	0.0040	0.0013	0.0015	0.0015
Mean, mm	0.1036	0.0331	0.0395	0.0380
Mean, phi	3.2709	4.9156	4.6609	4.7174
Median, in	0.0014	0.0014	0.0014	0.0014
Median, mm	0.0352	0.0351	0.0351	0.0351
Median, phi	4.8303	4.8305	4.8305	4.8305
Std Deviation, in	0.0067	0.0157	0.0074	0.0072
Std Deviation, mm	0.1707	0.4018	0.1901	0.1852
Std Deviation, phi	2.5505	1.3155	2.3950	2.4327
Skewness	2.4870	0.9614	0.0821	-0.0113
Kurtosis	5.8340	0.2063	0.7020	1.2704
Mode, mm	0.0389			
95% Confidence	0.0702			
Limits, mm	0.1371			
Variance, mm2	0.0291			
Coef. of Variance, %	164.70			

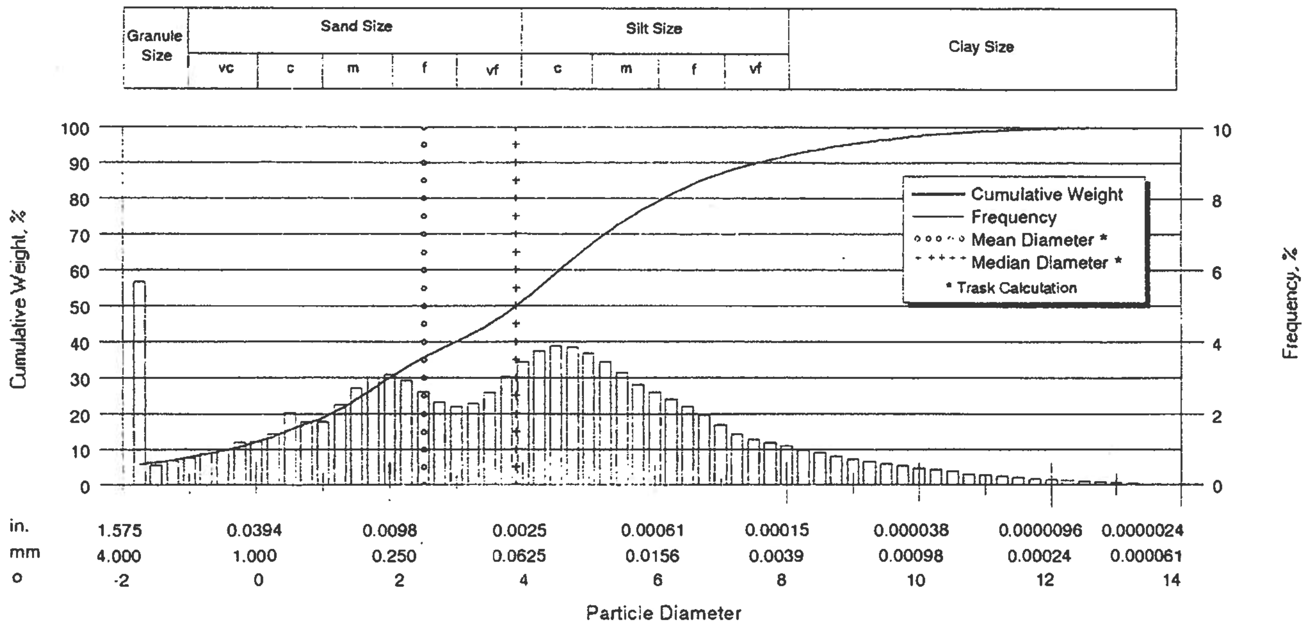
Percentiles [Weight, %]	Particle Diameter [in]	[mm]	[phi]
5	0.0202	0.5174	0.9508
10	0.0133	0.3419	1.5482
16	0.0081	0.2079	2.2659
25	0.0032	0.0824	3.6005
50	0.0014	0.0351	4.8305
75	0.0005	0.0133	6.2306
84	0.0003	0.0075	7.0558
90	0.0002	0.0041	7.9224
95	0.0001	0.0018	9.1034

CORE LAB

CORE LABORATORIES

Company	CORE LAB. - AURORA	Sample	B1-90	File Number	57111-95334
I.D.	954427-6	Proj.	Magma Florence	Date	11-OCT-95
County		State		Analysts	GC

Sieve and Laser Particle Size Analysis



Particle Size Distribution

	[U.S. Sieve]	Diameter [in]	[mm]	[phi]	Weight, % [Inc.]	[Cum.]
Granule	6	0.1324	3.36	-1.75	5.67	5.67
	8	0.0936	2.38	-1.25	1.22	6.88
V Coarse	12	0.0662	1.68	-0.75	1.64	8.52
Sand	16	0.0468	1.19	-0.25	2.21	10.73
	20	0.0331	0.84	0.25	2.66	13.39
Coarse	25	0.0280	0.71	0.50	2.03	15.42
Sand	30	0.0232	0.59	0.75	1.76	17.18
	35	0.0197	0.50	1.00	1.78	18.96
	40	0.0165	0.42	1.25	2.24	21.20
Medium	45	0.0138	0.35	1.50	2.71	23.91
Sand	50	0.0118	0.30	1.75	3.01	26.92
	60	0.0098	0.25	2.00	3.10	30.02
	70	0.0083	0.210	2.25	2.92	32.94
Fine	80	0.0070	0.177	2.50	2.61	35.55
Sand	100	0.0059	0.149	2.75	2.32	37.87
	120	0.0049	0.125	3.00	2.19	40.06
	140	0.0041	0.105	3.25	2.29	42.35
Very Fine	170	0.0035	0.088	3.50	2.59	44.94
Sand	200	0.0029	0.074	3.75	3.03	47.97
	230	0.0025	0.063	4.00	3.45	51.42
	270	0.0021	0.053	4.25	3.75	55.17
Silt	325	0.0017	0.044	4.50	3.89	59.06
	400	0.0015	0.037	4.75	3.83	62.89
	450	0.0012	0.031	5.00	3.69	66.58
	500	0.0010	0.025	5.32	4.38	70.96
	635	0.0008	0.020	5.64	3.84	74.80
		0.00061	0.0156	6.00	3.78	78.58
		0.00031	0.0078	7.00	8.26	86.84
		0.00015	0.0039	8.00	4.98	91.82
		0.000079	0.0020	9.00	3.44	95.26
Clay		0.000039	0.00098	10.0	2.26	97.52
		0.000019	0.00049	11.0	1.37	98.89
		0.0000094	0.00024	12.0	0.75	99.64
		0.0000047	0.00012	13.0	0.33	99.97
		0.0000039	0.00010	13.3	0.03	100.00

Sorting Statistics

Parameter	Trask*	Inman**	Folk**
Mean, in	0.0068	0.0032	0.0030
Mean, mm	0.1756	0.0830	0.0773
Mean, phi	2.5097	3.5905	3.6937
Median, in	0.0026	0.0026	0.0026
Median, mm	0.0670	0.0670	0.0670
Median, phi	3.9000	3.9000	3.9000
Standard Deviation, in	0.1596	0.0048	
Standard Deviation, mm	4.0914	0.1243	
Standard Deviation, phi	-2.0326	3.0085	
Skewness	1.4621		
Kurtosis	0.1156		

* calculated using mm values
**calculated using phi values

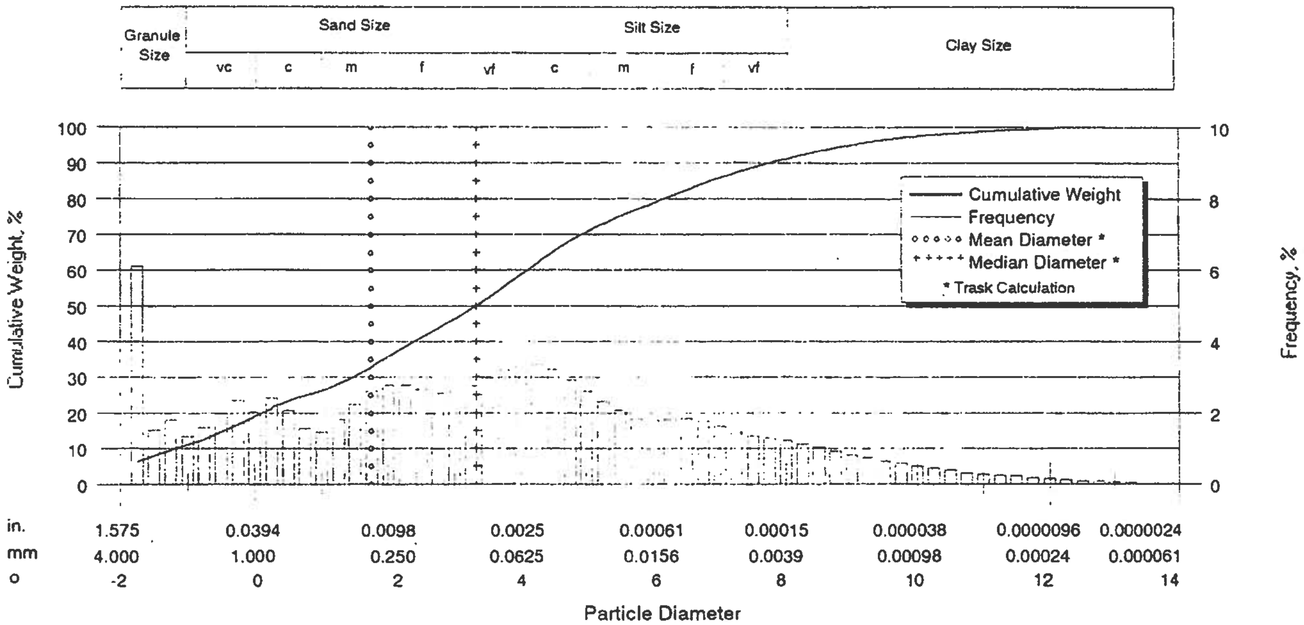
Percentiles [weight, %]	Particle Diameter [in]	[mm]	[phi]
5	ERR 5	ERR 5	ERR 5
10	0.0528	1.3527	-0.4359
16	0.0261	0.6680	0.5820
25	0.0129	0.3314	1.5934
50	0.0026	0.0670	3.9000
75	0.0008	0.0198	5.6586
84	0.0004	0.0103	6.5990
90	0.0002	0.0052	7.5926
95	0.0001	0.0021	8.9080

CORE LAB

CORE LABORATORIES

Company	CORE LAB. - AURORA	Sample	B2-55	File Number	57111-95334
I.D.	954427-7	Proj.	Magma Florence	Date	11-OCT-95
County		State		Analysts	GC

Sieve and Laser Particle Size Analysis



Particle Size Distribution

	Diameter [U.S. Sieve]	[in]	[mm]	[phi]	Weight, % [Inc.]	[Cum.]
Granule	6	0.1324	3.36	-1.75	6.11	6.11
	8	0.0936	2.38	-1.25	3.32	9.42
V Coarse Sand	12	0.0662	1.68	-0.75	2.93	12.35
	16	0.0468	1.19	-0.25	4.32	16.68
Coarse Sand	20	0.0331	0.84	0.25	4.45	21.12
	25	0.0280	0.71	0.50	2.06	23.18
	30	0.0232	0.59	0.75	1.57	24.75
	35	0.0197	0.50	1.00	1.45	26.20
Medium Sand	40	0.0165	0.42	1.25	1.83	28.03
	45	0.0138	0.35	1.50	2.25	30.28
	50	0.0118	0.30	1.75	2.61	32.89
	60	0.0098	0.25	2.00	2.79	35.68
Fine Sand	70	0.0083	0.210	2.25	2.77	38.45
	80	0.0070	0.177	2.50	2.66	41.11
	100	0.0059	0.149	2.75	2.56	43.67
	120	0.0049	0.125	3.00	2.60	46.27
Very Fine Sand	140	0.0041	0.105	3.25	2.76	49.03
	170	0.0035	0.088	3.50	2.99	52.02
	200	0.0029	0.074	3.75	3.21	55.23
	230	0.0025	0.063	4.00	3.33	58.56
Silt	270	0.0021	0.053	4.25	3.36	61.92
	325	0.0017	0.044	4.50	3.23	65.15
	400	0.0015	0.037	4.75	2.94	68.09
	450	0.0012	0.031	5.00	2.60	70.69
	500	0.0010	0.025	5.32	2.92	73.61
	635	0.0008	0.020	5.64	2.50	76.11
		0.00061	0.0156	6.00	2.58	78.69
		0.00031	0.0078	7.00	7.06	85.75
		0.00015	0.0039	8.00	5.31	91.06
Clay		0.000079	0.0020	9.00	3.86	94.92
		0.000039	0.00098	10.0	2.45	97.37
		0.000019	0.00049	11.0	1.45	98.82
		0.0000094	0.00024	12.0	0.79	99.61
		0.0000047	0.00012	13.0	0.35	99.96
		0.0000039	0.00010	13.3	0.04	100.00

Sorting Statistics

Parameter	Trask*	Inman**	Folk**
Mean, in	0.0117	0.0043	0.0041
Mean, mm	0.2988	0.1092	0.1057
Mean, phi	1.7428	3.1953	3.2415
Median, in	0.0039	0.0039	0.0039
Median, mm	0.0992	0.0992	0.0992
Median, phi	3.3339	3.3339	3.3339
Standard Deviation, in	0.1984	0.0034	
Standard Deviation, mm	5.0879	0.0862	
Standard Deviation, phi	-2.3471	3.5360	
Skewness	1.3002		
Kurtosis	0.1236		

* calculated using mm values
**calculated using phi values

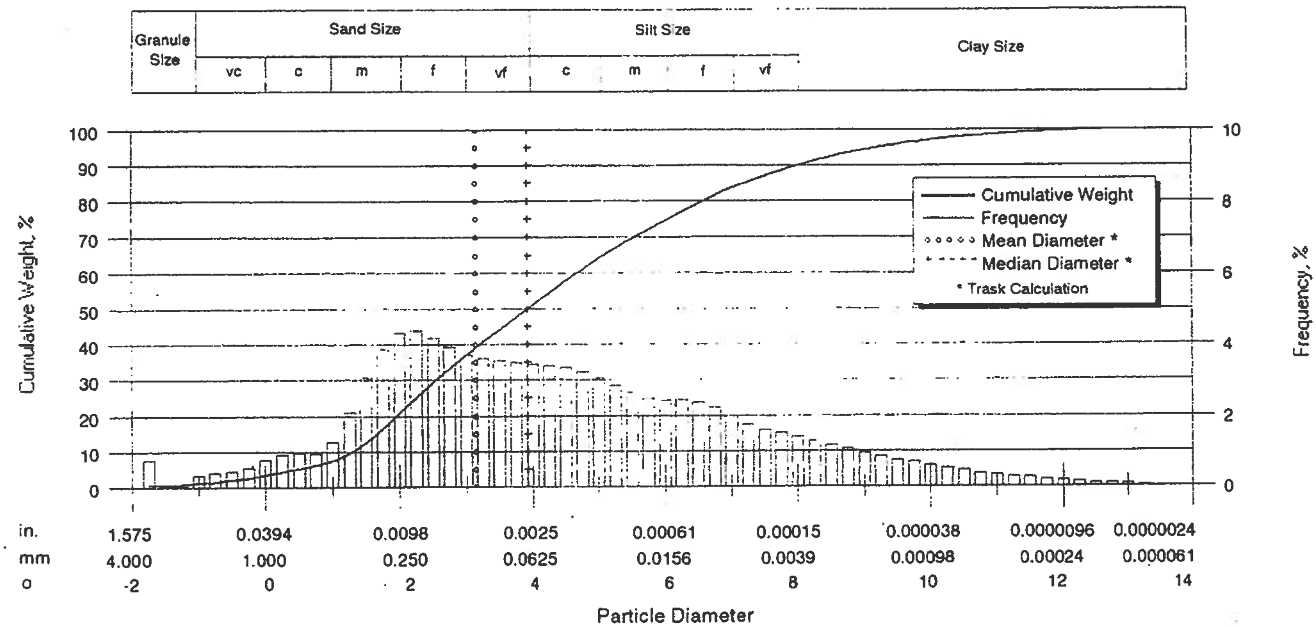
Percentiles [weight, %]	Particle Diameter [in]	[mm]	[phi]
5	ERR 5	ERR 5	ERR 5
10	0.0874	2.2415	-1.1645
16	0.0494	1.2663	-0.3407
25	0.0224	0.5754	0.7975
50	0.0039	0.0992	3.3339
75	0.0009	0.0222	5.4916
84	0.0004	0.0094	6.7313
90	0.0002	0.0045	7.7816
95	0.0001	0.0019	9.0256

CORE LAB

CORE LABORATORIES

Company	CORE LAB. - AURORA	Sample	B2-75	File Number	57111-95334
I.D.	954427-8	Proj.	Magma Florence	Date	11-OCT-95
County		State		Analysts	GC

Sieve and Laser Particle Size Analysis



Particle Size Distribution

	Diameter [U.S. Sieve]	[in]	[mm]	[phi]	Weight, % [Inc.]	Weight, % [Cum.]
Granule	6	0.1324	3.36	-1.75	0.75	0.75
	8	0.0936	2.38	-1.25	0.06	0.81
V Coarse Sand	12	0.0662	1.68	-0.75	0.75	1.56
	16	0.0468	1.19	-0.25	1.00	2.56
Coarse Sand	20	0.0331	0.84	0.25	1.68	4.24
	25	0.0280	0.71	0.50	0.97	5.21
	30	0.0232	0.59	0.75	0.94	6.15
	35	0.0197	0.50	1.00	1.26	7.41
Medium Sand	40	0.0165	0.42	1.25	2.09	9.50
	45	0.0138	0.35	1.50	3.07	12.57
	50	0.0118	0.30	1.75	3.87	16.44
	60	0.0098	0.25	2.00	4.32	20.76
Fine Sand	70	0.0083	0.210	2.25	4.39	25.15
	80	0.0070	0.177	2.50	4.19	29.34
	100	0.0059	0.149	2.75	3.92	33.26
	120	0.0049	0.125	3.00	3.72	36.98
Very Fine Sand	140	0.0041	0.105	3.25	3.60	40.58
	170	0.0035	0.088	3.50	3.54	44.12
	200	0.0029	0.074	3.75	3.48	47.60
	230	0.0025	0.063	4.00	3.44	51.04
Silt	270	0.0021	0.053	4.25	3.39	54.43
	325	0.0017	0.044	4.50	3.37	57.80
	400	0.0015	0.037	4.75	3.22	61.02
	450	0.0012	0.031	5.00	3.06	64.08
	500	0.0010	0.025	5.32	3.61	67.69
	635	0.0008	0.020	5.64	3.27	70.96
		0.00061	0.0156	6.00	3.51	74.47
		0.00031	0.0078	7.00	9.02	83.49
		0.00015	0.0039	8.00	6.26	89.75
Clay		0.000079	0.0020	9.00	4.46	94.21
		0.000039	0.00098	10.0	2.83	97.04
		0.000019	0.00049	11.0	1.65	98.69
		0.0000094	0.00024	12.0	0.89	99.58
		0.0000047	0.00012	13.0	0.38	99.96
		0.0000039	0.00010	13.3	0.04	100.00

Sorting Statistics

Parameter	Trask*	Inman**	Folk**
Mean, in	0.0044	0.0019	0.0021
Mean, mm	0.1133	0.0475	0.0529
Mean, phi	3.1421	4.3969	4.2394
Median, in	0.0026	0.0026	0.0026
Median, mm	0.0659	0.0659	0.0659
Median, phi	3.9244	3.9244	3.9244
Standard Deviation, in	0.1463	0.0061	0.0061
Standard Deviation, mm	3.7512	0.1569	0.1572
Standard Deviation, phi	-1.9074	2.6723	2.6694
Skewness	0.7329	0.3417	0.1922
Kurtosis	0.2437	0.6464	0.9453

* calculated using mm values

**calculated using phi values

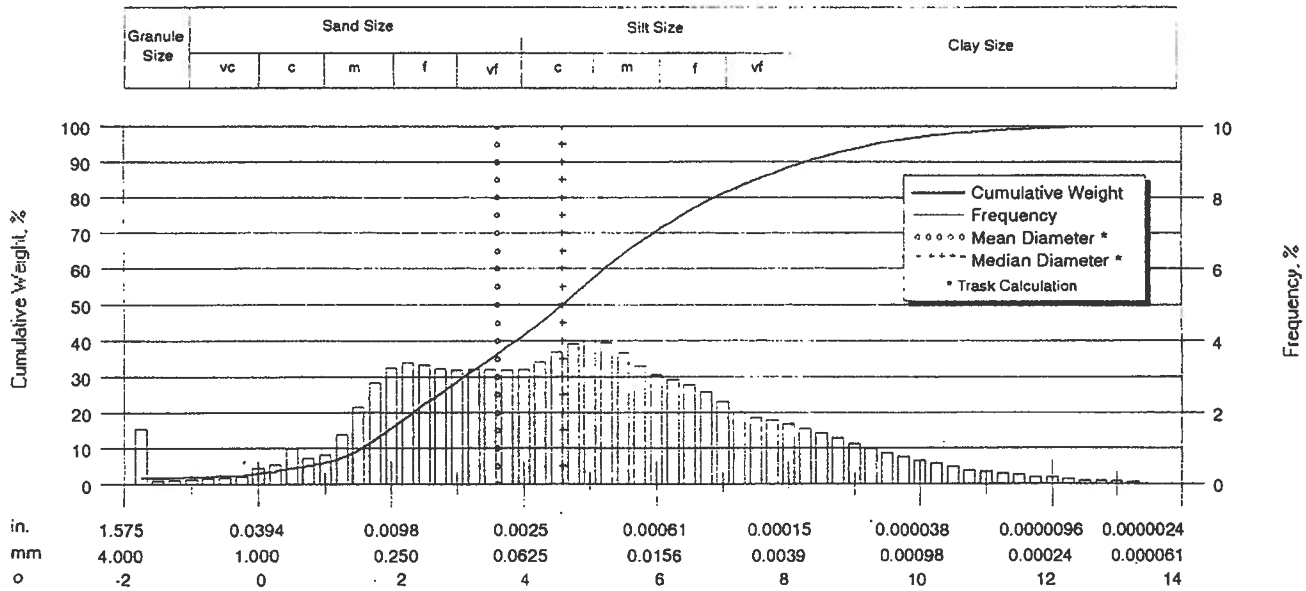
Percentiles [weight, %]	Particle Diameter [in]	[mm]	[phi]
5	0.0288	0.7382	0.4379
10	0.0159	0.4069	1.2973
16	0.0118	0.3026	1.7246
25	0.0082	0.2115	2.2412
50	0.0026	0.0659	3.9244
75	0.0006	0.0150	6.0559
84	0.0003	0.0074	7.0692
90	0.0001	0.0038	8.0461
95	0.0001	0.0017	9.2371

CORELAB

CORE LABORATORIES

Company	CORE LAB. - AURORA	Sample	B3-10	File Number	57111-95334
I.D.	954427-9	Proj.	Magma Florence	Date	11-OCT-95
County		State		Analysts	GC

Sieve and Laser Particle Size Analysis



Particle Size Distribution

	U.S. Sieve	Diameter [in]	Diameter [mm]	Diameter [phi]	Weight, % [Inc.]	Weight, % [Cum.]
Granule	6	0.1324	3.36	-1.75	1.53	1.53
	8	0.0936	2.38	-1.25	0.20	1.73
V Coarse Sand	12	0.0662	1.68	-0.75	0.27	2.00
	16	0.0468	1.19	-0.25	0.38	2.39
Coarse Sand	20	0.0331	0.84	0.25	0.99	3.38
	25	0.0280	0.71	0.50	0.97	4.35
	30	0.0232	0.59	0.75	0.71	5.06
	35	0.0197	0.50	1.00	0.81	5.87
Medium Sand	40	0.0165	0.42	1.25	1.38	7.25
	45	0.0138	0.35	1.50	2.15	9.40
	50	0.0118	0.30	1.75	2.84	12.24
	60	0.0098	0.25	2.00	3.24	15.48
Fine Sand	70	0.0083	0.210	2.25	3.40	18.88
	80	0.0070	0.177	2.50	3.33	22.21
	100	0.0059	0.149	2.75	3.23	25.44
	120	0.0049	0.125	3.00	3.20	28.64
Very Fine Sand	140	0.0041	0.105	3.25	3.20	31.84
	170	0.0035	0.088	3.50	3.22	35.06
	200	0.0029	0.074	3.75	3.18	38.24
	230	0.0025	0.063	4.00	3.22	41.46
Silt	270	0.0021	0.053	4.25	3.41	44.87
	325	0.0017	0.044	4.50	3.71	48.58
	400	0.0015	0.037	4.75	3.89	52.47
	450	0.0012	0.031	5.00	3.99	56.46
	500	0.0010	0.025	5.32	5.01	61.47
	635	0.0008	0.020	5.64	4.50	65.97
		0.00061	0.0156	6.00	4.46	70.43
		0.00031	0.0078	7.00	10.56	80.99
		0.00015	0.0039	8.00	7.32	88.31
Clay		0.000079	0.0020	9.00	5.32	93.63
		0.000039	0.00098	10.0	3.25	96.88
		0.000019	0.00049	11.0	1.77	98.65
		0.0000094	0.00024	12.0	0.92	99.57
		0.0000047	0.00012	13.0	0.38	99.95
		0.0000039	0.00010	13.3	0.05	100.00

Sorting Statistics

Parameter	Trask*	Inman**	Folk**
Mean, in	0.0032	0.0015	0.0015
Mean, mm	0.0821	0.0382	0.0393
Mean, phi	3.6067	4.7091	4.6700
Median, in	0.0016	0.0016	0.0016
Median, mm	0.0415	0.0415	0.0415
Median, phi	4.5917	4.5917	4.5917
Standard Deviation, in	0.1397	0.0061	0.0062
Standard Deviation, mm	3.5815	0.1569	0.1600
Standard Deviation, phi	-1.8406	2.6722	2.6437
Skewness	1.0514	0.1680	0.0740
Kurtosis	0.2085	0.6149	0.9609

* calculated using mm values
**calculated using phi values

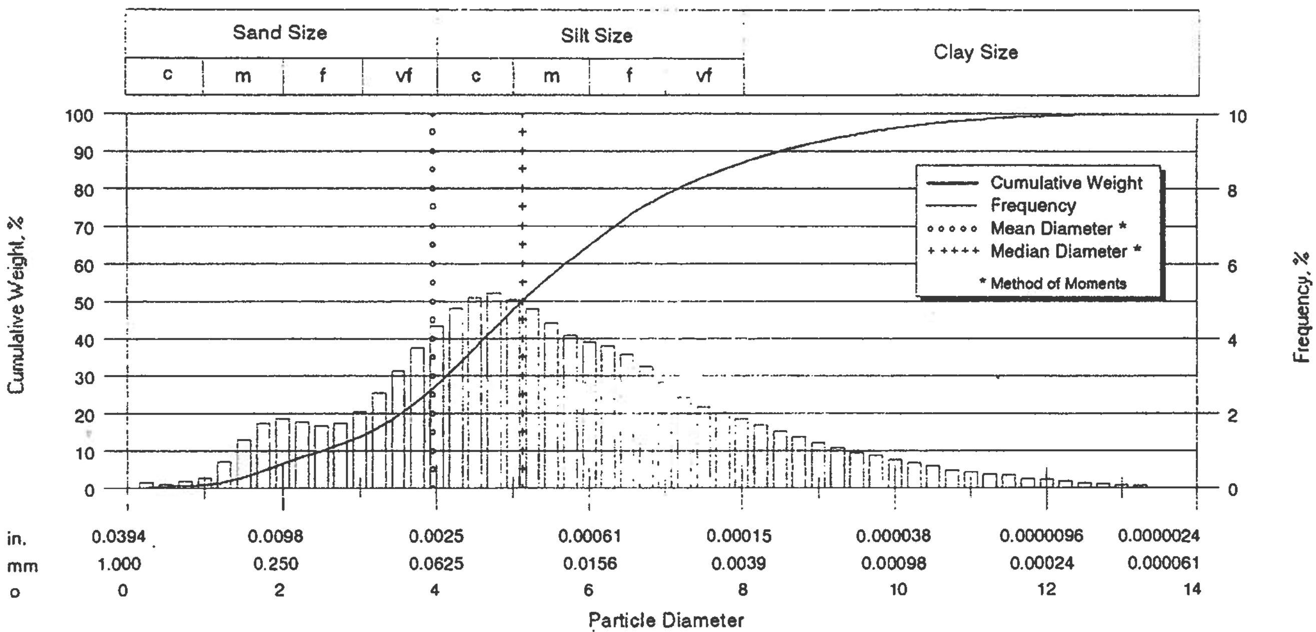
Percentiles [weight, %]	Particle Diameter [in]	Particle Diameter [mm]	Particle Diameter [phi]
5	0.0236	0.6048	0.7254
10	0.0133	0.3399	1.5567
16	0.0095	0.2437	2.0369
25	0.0059	0.1523	2.7150
50	0.0016	0.0415	4.5917
75	0.0005	0.0119	6.3961
84	0.0002	0.0060	7.3812
90	0.0001	0.0032	8.2768
95	0.0001	0.0015	9.3558

CORE LAB

CORE LABORATORIES

Company	CORE LAB. - AURORA	Sample	B3-45	File Number	57111-95334
I.D.	954427-10	Proj.	Magma Florence	Date	11-OCT-95
County		State		Analysts	GC

Laser Particle Size Analysis



Particle Size Distribution

	U.S. Sieve	Diameter [in]	Diameter [mm]	Diameter [phi]	Weight, % [Inc.]	Weight, % [Cum.]
Coarse Sand	20	0.0331	0.84	0.25	0.33	0.33
	25	0.0280	0.71	0.50	0.09	0.42
	30	0.0232	0.59	0.75	0.19	0.61
	35	0.0197	0.50	1.00	0.26	0.87
Medium Sand	40	0.0165	0.42	1.25	0.71	1.58
	45	0.0138	0.35	1.50	1.30	2.88
	50	0.0118	0.30	1.75	1.74	4.62
	60	0.0098	0.25	2.00	1.87	6.49
Fine Sand	70	0.0083	0.210	2.25	1.78	8.27
	80	0.0070	0.177	2.50	1.67	9.94
	100	0.0059	0.149	2.75	1.73	11.67
	120	0.0049	0.125	3.00	2.04	13.71
Very Fine Sand	140	0.0041	0.105	3.25	2.54	16.25
	170	0.0035	0.088	3.50	3.12	19.37
	200	0.0029	0.074	3.75	3.75	23.12
	230	0.0025	0.063	4.00	4.32	27.44
Silt	270	0.0021	0.053	4.25	4.80	32.24
	325	0.0017	0.044	4.50	5.13	37.37
	400	0.0015	0.037	4.75	5.18	42.55
	450	0.0012	0.031	5.00	5.04	47.59
	500	0.0010	0.025	5.32	6.06	53.65
	635	0.0008	0.020	5.64	5.46	59.11
		0.00061	0.0156	6.00	5.66	64.77
		0.00031	0.0078	7.00	13.42	78.19
		0.00015	0.0039	8.00	8.46	86.65
Clay		0.000079	0.0020	9.00	5.78	92.43
		0.000039	0.00098	10.0	3.66	96.09
		0.000019	0.00049	11.0	2.17	98.26
		0.0000094	0.00024	12.0	1.18	99.44
		0.0000047	0.00012	13.0	0.50	99.94
		0.0000039	0.00010	13.3	0.06	100.00

Sorting Statistics

Parameter	[Moment]	[Trask]	[Inman]	[Folk]
Mean, in	0.0025	0.0010	0.0009	0.0010
Mean, mm	0.0649	0.0255	0.0231	0.0248
Mean, phi	3.9456	5.2916	5.4380	5.3334
Median, in	0.0011	0.0011	0.0011	0.0011
Median, mm	0.0287	0.0287	0.0287	0.0287
Median, phi	5.1243	5.1242	5.1242	5.1242
Std Deviation, in	0.0040	0.0156	0.0084	0.0079
Std Deviation, mm	0.1031	0.4008	0.2161	0.2038
Std Deviation, phi	3.2779	1.3189	2.2099	2.2947
Skewness	3.3970	0.9887	0.2723	0.1476
Kurtosis	15.2300	0.2375	0.7766	1.1264
Mode, mm	0.0426			
95% Confidence Limits, mm	0.0447 0.0851			
Variance, mm2	0.0106			
Coef. of Variance, %	158.80			

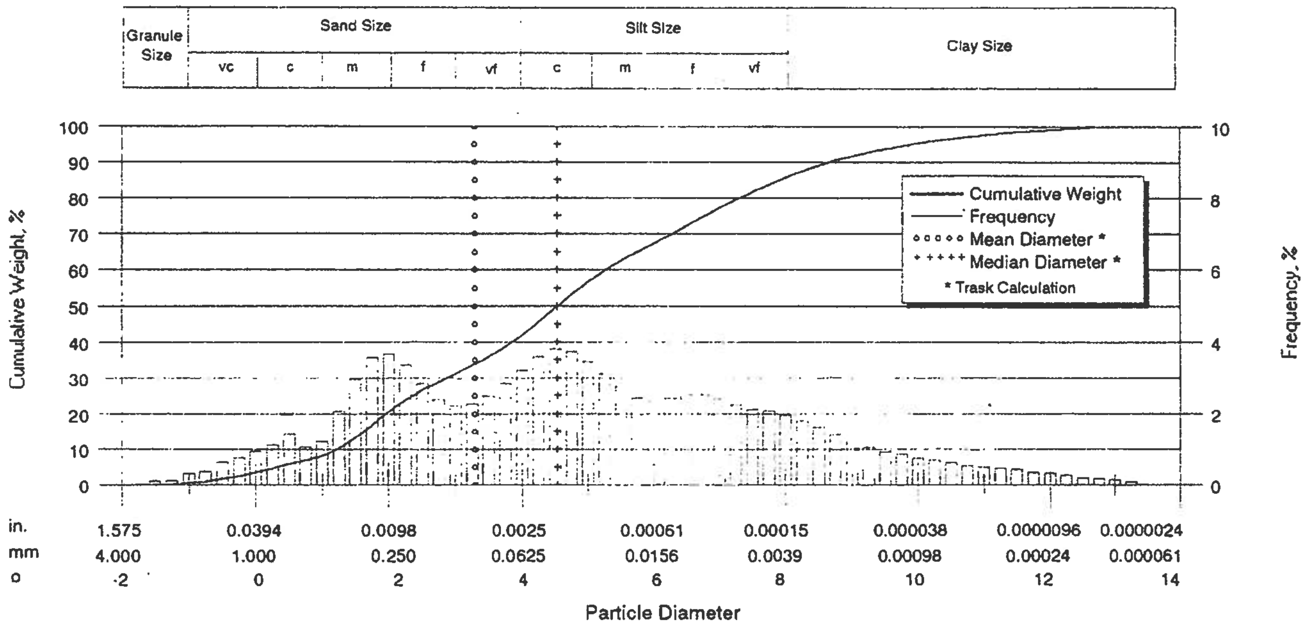
Percentiles [Weight, %]	Particle Diameter [in]	Particle Diameter [mm]	Particle Diameter [phi]
5	0.0112	0.2872	1.7998
10	0.0068	0.1755	2.5102
16	0.0042	0.1067	3.2280
25	0.0027	0.0687	3.8631
50	0.0011	0.0287	5.1242
75	0.0004	0.0095	6.7201
84	0.0002	0.0050	7.6479
90	0.0001	0.0027	8.5259
95	0.0000	0.0012	9.6520

CORE LAB

CORE LABORATORIES

Company	CORE LAB. - AURORA	Sample	B3-65	File Number	57111-95334
I.D.	954427-11	Proj.	Magma Florence	Date	11-OCT-95
County		State		Analysts	GC

Sieve and Laser Particle Size Analysis



Particle Size Distribution

	U.S. Sieve	Diameter [in]	Diameter [mm]	Diameter [phi]	Weight, % [Inc.]	Weight, % [Cum.]
Granule	6	0.1324	3.36	-1.75	0.00	0.00
	8	0.0936	2.38	-1.25	0.23	0.23
V Coarse Sand	12	0.0662	1.68	-0.75	0.70	0.93
	16	0.0468	1.19	-0.25	1.40	2.33
Coarse Sand	20	0.0331	0.84	0.25	2.06	4.39
	25	0.0280	0.71	0.50	1.42	5.81
	30	0.0232	0.59	0.75	1.08	6.89
	35	0.0197	0.50	1.00	1.22	8.11
Medium Sand	40	0.0165	0.42	1.25	2.05	10.16
	45	0.0138	0.35	1.50	2.98	13.14
	50	0.0118	0.30	1.75	3.56	16.70
	60	0.0098	0.25	2.00	3.67	20.37
Fine Sand	70	0.0083	0.210	2.25	3.36	23.73
	80	0.0070	0.177	2.50	2.85	26.58
	100	0.0059	0.149	2.75	2.40	28.98
	120	0.0049	0.125	3.00	2.21	31.19
Very Fine Sand	140	0.0041	0.105	3.25	2.26	33.45
	170	0.0035	0.088	3.50	2.50	35.95
	200	0.0029	0.074	3.75	2.84	38.79
	230	0.0025	0.063	4.00	3.21	42.00
Silt	270	0.0021	0.053	4.25	3.59	45.59
	325	0.0017	0.044	4.50	3.83	49.42
	400	0.0015	0.037	4.75	3.73	53.15
	450	0.0012	0.031	5.00	3.46	56.61
	500	0.0010	0.025	5.32	3.93	60.54
	635	0.0008	0.020	5.64	3.36	63.90
		0.00061	0.0156	6.00	3.39	67.29
		0.00031	0.0078	7.00	9.93	77.22
		0.00015	0.0039	8.00	8.38	85.60
Clay		0.000079	0.0020	9.00	6.02	91.62
		0.000039	0.00098	10.0	3.58	95.20
		0.000019	0.00049	11.0	2.35	97.55
		0.0000094	0.00024	12.0	1.58	99.13
		0.0000047	0.00012	13.0	0.77	99.90
		0.0000039	0.00010	13.3	0.10	100.00

Sorting Statistics

Parameter	Trask*	Inman**	Folk**
Mean, in	0.0040	0.0015	0.0015
Mean, mm	0.1023	0.0372	0.0391
Mean, phi	3.2897	4.7478	4.6777
Median, in	0.0017	0.0017	0.0017
Median, mm	0.0431	0.0431	0.0431
Median, phi	4.5373	4.5373	4.5373
Standard Deviation, in	0.1801	0.0047	0.0049
Standard Deviation, mm	4.6169	0.1211	0.1268
Standard Deviation, phi	-2.2069	3.0457	2.9794
Skewness	0.9653	0.1909	0.0951
Kurtosis	0.2204	0.5782	0.8926

* calculated using mm values
**calculated using phi values

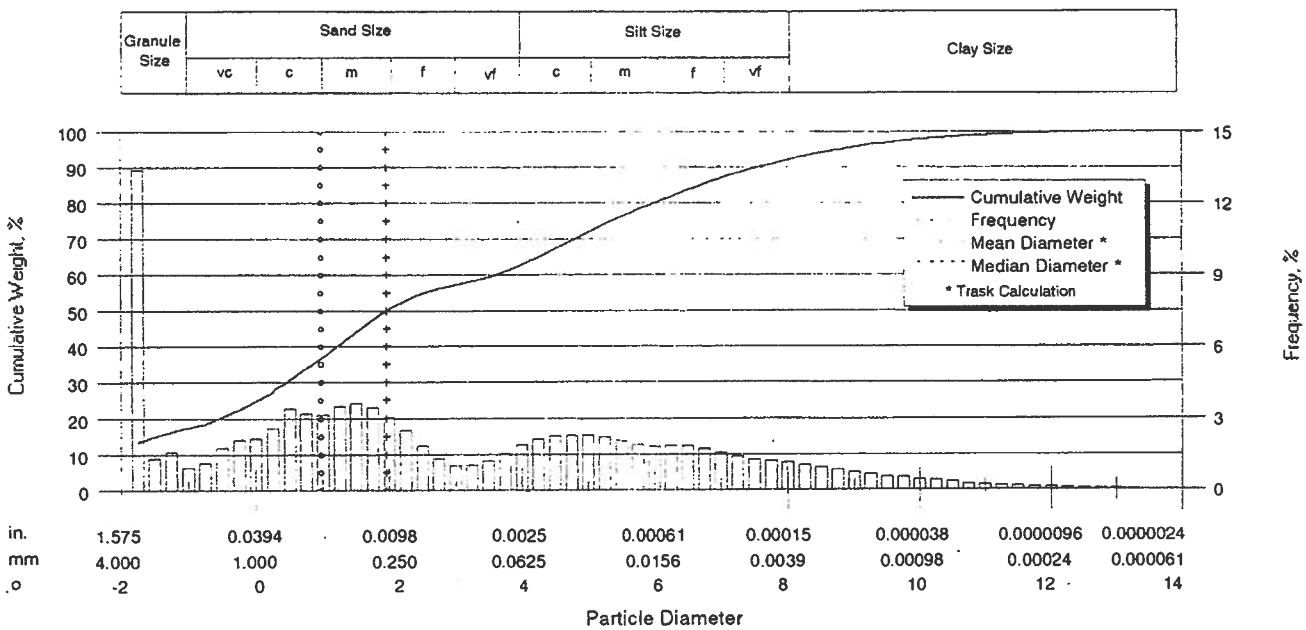
Percentiles [weight, %]	Particle Diameter [in]	Particle Diameter [mm]	Particle Diameter [phi]
5	0.0314	0.8054	0.3123
10	0.0166	0.4249	1.2347
16	0.0120	0.3073	1.7022
25	0.0076	0.1954	2.3558
50	0.0017	0.0431	4.5373
75	0.0004	0.0092	6.7697
84	0.0002	0.0045	7.7935
90	0.0001	0.0024	8.6768
95	0.0000	0.0010	9.9254

CORE LAB

CORE LABORATORIES

Company	CORE LAB. - AURORA	Sample	B4-55	File Number	57111-95334
I.D.	954427-12	Proj.	Magma Florence	Date	11-OCT-95
County		State		Analysts	GC

Sieve and Laser Particle Size Analysis



Particle Size Distribution

	Diameter [U.S. Sieve]	[in]	[mm]	[phi]	Weight, % [Inc.]	[Cum.]
Granule	6	0.1324	3.36	-1.75	13.39	13.39
	8	0.0936	2.38	-1.25	2.93	16.32
V Coarse Sand	12	0.0662	1.68	-0.75	2.12	18.44
	16	0.0468	1.19	-0.25	3.91	22.35
Coarse Sand	20	0.0331	0.84	0.25	4.76	27.11
	25	0.0280	0.71	0.50	3.39	30.50
	30	0.0232	0.59	0.75	3.19	33.69
	35	0.0197	0.50	1.00	3.16	36.85
Medium Sand	40	0.0165	0.42	1.25	3.49	40.34
	45	0.0138	0.35	1.50	3.62	43.96
	50	0.0118	0.30	1.75	3.43	47.39
	60	0.0098	0.25	2.00	3.05	50.44
Fine Sand	70	0.0083	0.210	2.25	2.49	52.93
	80	0.0070	0.177	2.50	1.86	54.79
	100	0.0059	0.149	2.75	1.35	56.14
	120	0.0049	0.125	3.00	1.04	57.18
Very Fine Sand	140	0.0041	0.105	3.25	1.02	58.20
	170	0.0035	0.088	3.50	1.23	59.43
	200	0.0029	0.074	3.75	1.56	60.99
	230	0.0025	0.063	4.00	1.88	62.87
Silt	270	0.0021	0.053	4.25	2.15	65.02
	325	0.0017	0.044	4.50	2.28	67.30
	400	0.0015	0.037	4.75	2.29	69.59
	450	0.0012	0.031	5.00	2.29	71.88
	500	0.0010	0.025	5.32	2.80	74.68
	635	0.0008	0.020	5.64	2.53	77.21
		0.00061	0.0156	6.00	2.66	79.87
		0.00031	0.0078	7.00	6.98	86.85
		0.00015	0.0039	8.00	5.08	91.93
Clay		0.000079	0.0020	9.00	3.62	95.55
		0.000039	0.00098	10.0	2.21	97.76
		0.000019	0.00049	11.0	1.26	99.02
		0.0000094	0.00024	12.0	0.67	99.69
		0.0000047	0.00012	13.0	0.28	99.97
		0.0000039	0.00010	13.3	0.03	100.00

Sorting Statistics

Parameter	Trask*	Inman**	Folk**
Mean, in	0.0199	0.0063	0.0074
Mean, mm	0.5098	0.1621	0.1889
Mean, phi	0.9721	2.6254	2.4040
Median, in	0.0100	0.0100	0.0100
Median, mm	0.2568	0.2568	0.2568
Median, phi	1.9612	1.9612	1.9612
Standard Deviation, in	0.2492	0.0025	
Standard Deviation, mm	6.3901	0.0652	
Standard Deviation, phi	-2.6758	3.9398	
Skewness	0.3677		
Kurtosis			

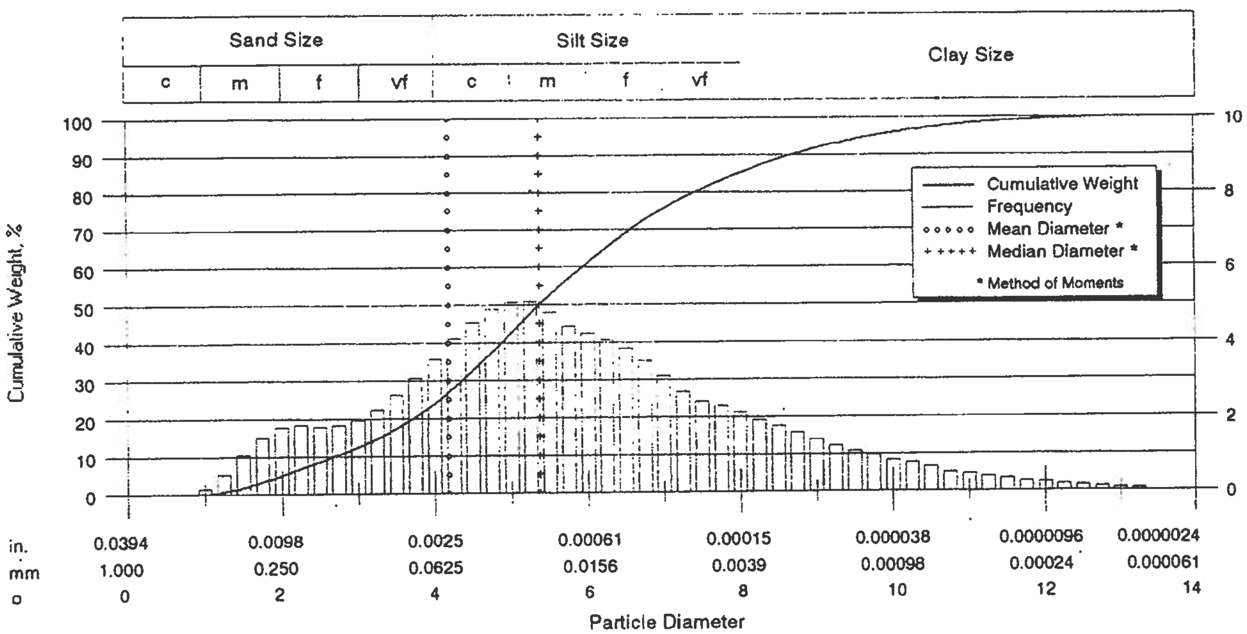
* calculated using mm values
* *calculated using phi values

Percentiles [weight, %]	Particle Diameter [in]	[mm]	[phi]
5	ERR 5	ERR 5	ERR 5
10	ERR 5	ERR 5	ERR 5
16	0.0970	2.4870	-1.3144
25	0.0388	0.9951	0.0070
50	0.0100	0.2568	1.9612
75	0.0010	0.0244	5.3587
84	0.0004	0.0106	6.5652
90	0.0002	0.0052	7.5895
95	0.0001	0.0022	8.8171

CORE LABORATORIES

Company	CORE LAB. - AURORA	Sample	B4-80	File Number	57111-95334
I.D.	954427-13	Proj.	Magma Florence	Date	11-OCT-95
County		State		Analysts	GC

Laser Particle Size Analysis



Particle Size Distribution

	[U.S. Sieve]	Diameter [in]	[mm]	[phi]	Weight, % [Inc.]	[Cum.]
Coarse Sand	20	0.0331	0.84	0.25	0.00	0.00
	25	0.0280	0.71	0.50	0.00	0.00
	30	0.0232	0.59	0.75	0.01	0.01
	35	0.0197	0.50	1.00	0.14	0.15
Medium Sand	40	0.0165	0.42	1.25	0.52	0.67
	45	0.0138	0.35	1.50	1.05	1.72
	50	0.0118	0.30	1.75	1.50	3.22
	60	0.0098	0.25	2.00	1.77	4.99
Fine Sand	70	0.0083	0.210	2.25	1.83	6.82
	80	0.0070	0.177	2.50	1.80	8.62
	100	0.0059	0.149	2.75	1.81	10.43
	120	0.0049	0.125	3.00	1.96	12.39
Very Fine Sand	140	0.0041	0.105	3.25	2.23	14.62
	170	0.0035	0.088	3.50	2.62	17.24
	200	0.0029	0.074	3.75	3.06	20.30
	230	0.0025	0.063	4.00	3.57	23.87
Silt	270	0.0021	0.053	4.25	4.11	27.98
	325	0.0017	0.044	4.50	4.56	32.54
	400	0.0015	0.037	4.75	4.85	37.39
	450	0.0012	0.031	5.00	5.06	42.45
	500	0.0010	0.025	5.32	6.46	48.91
	635	0.0008	0.020	5.64	5.94	54.85
		0.00061	0.0156	6.00	6.13	60.98
		0.00031	0.0078	7.00	14.50	75.48
		0.00015	0.0039	8.00	9.49	84.97
Clay		0.000079	0.0020	9.00	6.64	91.61
		0.000039	0.00098	10.0	4.14	95.75
		0.000019	0.00049	11.0	2.39	98.14
		0.0000094	0.00024	12.0	1.26	99.40
		0.0000047	0.00012	13.0	0.54	99.94
		0.0000039	0.00010	13.3	0.06	100.00

Sorting Statistics

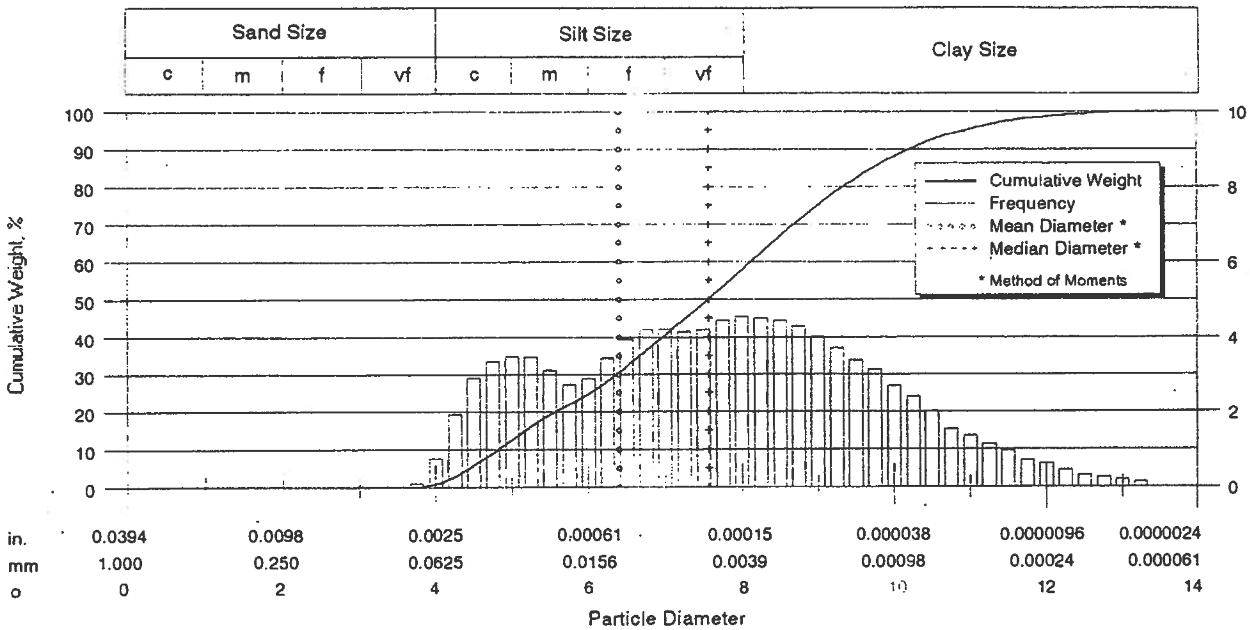
Parameter	[Moment]	[Trask]	[Inman]	[Folk]
Mean, in	0.0021	0.0009	0.0008	0.0008
Mean, mm	0.0550	0.0219	0.0201	0.0214
Mean, phi	4.1836	5.5159	5.6354	5.5490
Median, in	0.0009	0.0009	0.0009	0.0009
Median, mm	0.0241	0.0241	0.0241	0.0241
Median, phi	5.3760	5.3764	5.3764	5.3764
Std Deviation, in	0.0032	0.0158	0.0082	0.0079
Std Deviation, mm	0.0822	0.4041	0.2104	0.2028
Std Deviation, phi	3.6042	1.3072	2.2487	2.3021
Skewness	2.6410	0.9805	0.2274	0.1234
Kurtosis	7.5020	0.2396	0.7283	1.1036
Mode, mm	0.0296			
95% Confidence	0.0389			
Limits, mm	0.0711			
Variance, mm2	0.0068			
Coef. of Variance, %	149.40			

Percentiles [Weight, %]	Particle Diameter [in]	[mm]	[phi]
5	0.0097	0.2498	2.0014
10	0.0060	0.1548	2.6912
16	0.0037	0.0956	3.3866
25	0.0023	0.0594	4.0727
50	0.0009	0.0241	5.3764
75	0.0003	0.0080	6.9591
84	0.0002	0.0042	7.8841
90	0.0001	0.0024	8.7136
95	0.0000	0.0011	9.7742

CORE LABORATORIES

Company	CORE LAB. - AURORA	Sample	M16-60-300	File Number	57111-95334
I.D.	954427-14	Proj.	Magma Florence	Date	11-OCT-95
County		State		Analysts	GC

Laser Particle Size Analysis



Particle Size Distribution

	[U.S. Sieve]	Diameter [in]	[mm]	[phi]	Weight, % [Inc.]	[Cum.]
Coarse Sand	20	0.0331	0.84	0.25	0.00	0.00
	25	0.0280	0.71	0.50	0.00	0.00
	30	0.0232	0.59	0.75	0.00	0.00
	35	0.0197	0.50	1.00	0.00	0.00
Medium Sand	40	0.0165	0.42	1.25	0.00	0.00
	45	0.0138	0.35	1.50	0.00	0.00
	50	0.0118	0.30	1.75	0.00	0.00
	60	0.0098	0.25	2.00	0.00	0.00
Fine Sand	70	0.0083	0.210	2.25	0.00	0.00
	80	0.0070	0.177	2.50	0.00	0.00
	100	0.0059	0.149	2.75	0.00	0.00
	120	0.0049	0.125	3.00	0.00	0.00
Very Fine Sand	140	0.0041	0.105	3.25	0.00	0.00
	170	0.0035	0.088	3.50	0.00	0.00
	200	0.0029	0.074	3.75	0.09	0.09
	230	0.0025	0.063	4.00	0.76	0.85
Silt	270	0.0021	0.053	4.25	1.91	2.76
	325	0.0017	0.044	4.50	2.92	5.68
	400	0.0015	0.037	4.75	3.33	9.01
	450	0.0012	0.031	5.00	3.50	12.51
	500	0.0010	0.025	5.32	4.38	16.89
	635	0.0008	0.020	5.64	3.74	20.63
		0.00061	0.0156	6.00	4.05	24.68
		0.00031	0.0078	7.00	15.78	40.46
		0.00015	0.0039	8.00	17.31	57.77
Clay		0.000079	0.0020	9.00	17.24	75.01
		0.000039	0.00098	10.0	12.88	87.89
		0.000019	0.00049	11.0	7.32	95.21
		0.0000094	0.00024	12.0	3.40	98.61
		0.0000047	0.00012	13.0	1.26	99.87
		0.0000039	0.00010	13.3	0.13	100.00

Sorting Statistics

Parameter	[Moment]	[Trask]	[Inman]	[Folk]
Mean, in	0.0005	0.0002	0.0002	0.0002
Mean, mm	0.0119	0.0055	0.0057	0.0056
Mean, phi	6.3990	7.5125	7.4508	7.4897
Median, in	0.0002	0.0002	0.0002	0.0002
Median, mm	0.0053	0.0053	0.0053	0.0053
Median, phi	7.5672	7.5674	7.5674	7.5674
Std Deviation, in	0.0006	0.0167	0.0085	0.0092
Std Deviation, mm	0.0147	0.4287	0.2178	0.2354
Std Deviation, phi	6.0841	1.2221	2.1988	2.0870
Skewness	1.7450	0.9469	0.0621	-0.0056
Kurtosis	2.4310	0.2755	0.4821	0.8983
Mode, mm	0.0036			
95% Confidence	0.0090			
Limits, mm	0.0147			
Variance, mm2	0.0002			
Coef. of Variance, %	124.40			

Percentiles [Weight, %]	Particle Diameter [in]	[mm]	[phi]
5	0.0018	0.0459	4.4450
10	0.0014	0.0354	4.8196
16	0.0010	0.0262	5.2520
25	0.0006	0.0154	6.0256
50	0.0002	0.0053	7.5674
75	0.0001	0.0020	8.9994
84	0.0000	0.0012	9.6496
90	0.0000	0.0008	10.2156
95	0.0000	0.0005	10.9629

SUMMARY OF HYDRAULIC CONDUCTIVITY CORE LABORATORIES, AURORA PROJECT NAME: MAGMA - FLORENCE			
Sample I.D.	**DEPTH, feet**	**Hydraulic Conductivity, md**	**Hydraulic Conductivity, cm/sec**
P1 - 80 - 80	NA	32.2	2.76×10^{-5}
P2 - 90 - 45	NA	1.2	1.07×10^{-6}
B2 - 55	NA	0.618	5.30×10^{-7}
B3 - 45	NA	8.1	6.94×10^{-6}
B4 - 80	NA	0.613	5.26×10^{-7}
M16 - GU - 300	NA	0.0058	5.00×10^{-9}

HYDRAULIC CONDUCTIVITY TEST REPORT
ASTM D5084

Project Name	Claridge - Hanlon #91100A	***Project No.***	106200-19
Client Name	Geosystems Analysis, Inc.	***Date Received***	8/11/2011
Client Address		***Date Tested***	8/11/2011
		Date Issued	8/18/2011
Boring No.	CMP-11-03		
Sample Type	Undisturbed		
Sample Depth	283-288 feet		
Sample Description	Clay, very stiff, brown to red brown		

	Before	***After***	***Units***
Moisture Content, w	28.6	29.2	*%*
Dry Unit Weight, Dd	94.8	95.0	*pcf*
Height, L	1.81	1.80	*inches*
Diameter, d	3.19	3.19	*inches*
Degree of Saturation, Sr	97.2	99.5	*%*

Chamber Pressure:	83.3	**psi**
Applied Pressure (influent):	78.3	**psi**
Applied Pressure (effluent):	75.0	**psi**
Consolidation Pressure:	5	**psi**

Test Number		***Temp. Deg. C***	***Time (sec)***	***Influent Reading***	***Effluent Reading***	***Hydraulic Conductivity (cm/sec)*** **@ Test Temp.**	***Hydraulic Conductivity (cm/sec)*** **@ 20° C**	***Hydraulic Gradient h/L***
1	Start	22.4	0	7.60	19.85			
	Finish	22.2	59220	8.20	19.30	4.52E-09	4.3E-09	53.09
2	Start	22.2	59220	8.20	19.30			
	Finish	22.5	90480	8.50	19.00	4.49E-09	4.3E-09	52.96
3	Start	22.5	90480	8.50	19.00			
	Finish	22.6	140400	9.05	18.55	4.70E-09	4.4E-09	52.73
4	Start	22.6	140400	9.05	18.55			
	Finish	22.7	229140	10.00	17.70	4.79E-09	4.5E-09	52.33

Average Hydraulic Conductivity "k" (cm/sec) @ Test Temp. 4.6E-09

Average Hydraulic Conductivity "k" (cm/sec) @ 20° C **4.4E-09**

Assumed Specific Gravity, SG 2.75
Area of Tube (cm^2), a (Pipette) 0.9721
Permeant : Deaired Tap Water
Formulas:
Permeability (Falling Head-Rising Tailwater Test)
k = [(a*L/(2*A*t)] ln(ho/h1)
k = Hydraulic Conductivity (cm/sec)
a = Area of Tube (cm^2)
L = Height or Length of Sample (cm)
A = Area of Sample (cm^2)
t = Time of Test Interval (sec)
h_o = Height of Head at Start of Test Interval (cm)
h_1 = Height of Head at End of Test Interval (cm)

Degree of Saturation
Sr = w*SG/e Dd = (SG/1+e)Dw
Therefore:
Sr = (w*SG)/((SG*Dw/Dd)-1)
Sr = Degree of Saturation (%)
w = Moisture Content (%)
SG = Specific Gravity
e = Void Ratio
Dd =Dry Unit Weight (pcf)
Dw = Unit Weight of Water (62.4 pcf)

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HYDRAULIC CONDUCTIVITY TEST RESULTS (ASTM D5084)

Project Name	Claridge - Hanlon #91100A	***Job No.***	106200-19
Client Name	Geosystems Analysis, Inc.	***Date Received***	8/11/2011
Client Address		***Date Tested***	8/11/2011
		Date Issued	8/18/2011
Boring No.	CMP-11-03		
Sample Type	Undisturbed		
Sample Depth	283-288 feet		
Sample Description	Clay, very stiff, brown to red brown		
	0.0		

	Deviation from Average	Change in Influent(ml)	Change in Effluent (ml)	Ratio Effluent/Influent Change
Test1	0.98	0.58	-0.53	0.92
Test 2	0.97	0.29	-0.29	1.00
Test 3	1.02	0.53	-0.44	0.82
Test 4	1.04	0.92	-0.83	0.89
	ok if within 0.75-1.25			**ok if within 0.75-1.25**

1.0231881

0.022923341

HYDRAULIC CONDUCTIVITY TEST REPORT
ASTM D5084

Project Name	Claridge - Hanlon #91100A	***Project No.***	106200-19
Client Name	Geosystems Analysis, Inc.	***Date Received***	8/11/2011
Client Address		***Date Tested***	8/11/2011
		Date Issued	8/18/2011
Boring No.	CMP-11-03		
Sample Type	Undisturbed		
Sample Depth	292.5-297.5 feet		
Sample Description	Clay, very stiff, brown to red brown		

	Before	***After***	***Units***
Moisture Content, w	28.8	28.0	*%*
Dry Unit Weight, Dd	95.9	96.6	*pcf*
Height, L	1.95	1.95	*inches*
Diameter, d	3.16	3.16	*inches*
Degree of Saturation, Sr	100.4	99.0	*%*

Chamber Pressure:	83.5	**psi**
Applied Pressure (influent):	78.5	**psi**
Applied Pressure (effluent):	75.0	**psi**
Consolidation Pressure:	5	**psi**

Test Number		***Temp. Deg. C***	***Time (sec)***	***Influent Reading***	***Effluent Reading***	***Hydraulic Conductivity (cm/sec)*** **@ Test Temp.**	***Hydraulic Conductivity (cm/sec)*** **@ 20° C**	***Hydraulic Gradient h/L***
1	Start	22.4	0	7.60	19.70			
	Finish	22.2	59220	8.15	19.20	4.22E-09	4.0E-09	51.94
2	Start	22.2	59220	8.15	19.20			
	Finish	22.5	90480	8.50	18.85	5.35E-09	5.1E-09	51.80
3	Start	22.5	90480	8.50	18.85			
	Finish	22.6	140400	8.95	18.40	4.32E-09	4.1E-09	51.61
4	Start	22.6	140400	8.95	18.40			
	Finish	22.7	229140	9.80	17.60	4.48E-09	4.2E-09	51.27

Average Hydraulic Conductivity "k" (cm/sec) @ Test Temp. 4.6E-09

Average Hydraulic Conductivity "k" (cm/sec) @ 20° C **4.3E-09**

Assumed Specific Gravity, SG 2.75

Area of Tube (cm^2), a (Pipette) 0.9721

Permeant : Deaired Tap Water

Formulas:

Permeability (Falling Head-Rising Tailwater Test)

k = [(a*L/(2*A*t)] ln(ho/h1)

k = Hydraulic Conductivity (cm/sec)

a = Area of Tube (cm^2)

L = Height or Length of Sample (cm)

A = Area of Sample (cm^2)

t = Time of Test Interval (sec)

h_o = Height of Head at Start of Test Interval (cm)

h_1 = Height of Head at End of Test Interval (cm)

Degree of Saturation

Sr = w*SG/e Dd = (SG/1+e)Dw

Therefore:

Sr = (w*SG)/((SG*Dw/Dd)-1)

Sr = Degree of Saturation (%)

w = Moisture Content (%)

SG = Specific Gravity

e = Void Ratio

Dd =Dry Unit Weight (pcf)

Dw = Unit Weight of Water (62.4 pcf)

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HYDRAULIC CONDUCTIVITY TEST RESULTS (ASTM D5084)

Project Name	Claridge - Hanlon #91100A	***Job No.***	106200-19
Client Name	Geosystems Analysis, Inc.	***Date Received***	8/11/2011
Client Address		***Date Tested***	8/11/2011
		Date Issued	8/18/2011
Boring No.	CMP-11-03		
Sample Type	Undisturbed		
Sample Depth	292.5-297.5 feet		
Sample Description	Clay, very stiff, brown to red brown		

0.0

	Deviation from Average	Change in Influent(ml)	Change in Effluent (ml)	Ratio Effluent/Influent Change
Test1	0.92	0.53	-0.49	0.91
Test 2	1.16	0.34	-0.34	1.00
Test 3	0.94	0.44	-0.44	1.00
Test 4	0.98	0.83	-0.78	0.94

ok if within 0.75-1.25 **ok if within 0.75-1.25**

1.0231881

0.022923341

Exhibit 14A-3

**Site Characterization Report Section 2.3.1
Florence 1996 APP Application**

and data storage procedures. Users of the data management plan include Magma, Brown and Caldwell and others involved with the completion of the environmental permit support investigations.

Purposes of the data management plan include: (1) to ensure that the necessary information is collected; (2) to provide a means of communication between individuals involved in the project; (3) to optimize time spent on data management; and (4) to ensure that different types of data can be combined to meet information goals.

As shown on Figure 2.2-1[II], the data management and analysis system consists of a number of components, including statistics, graphical data analysis and data presentation modules. All modules are accessible from a central database (Microsoft ACCESS).

Two types of QA/QC, technical and accuracy, are performed on all data types. Technical QA consists of a review to ensure that data is consistent, both with expectations and with other data. Accuracy QA is a review to ensure that the data are transferred correctly from the raw data format into the data management and analysis system. Generalized procedures for lithologic, water quality, aquifer test, packer test and other data sets include the following elements:

- Manual measurements are obtained, when possible, to verify data collected on data loggers.
- Field data hard copies are generated and reviewed by qualified personnel.
- Field data are compiled, edited and summarized. Hard copies are then signed, dated and stored.
- Electronic copies of the data are used for input into the database system, and subsequently verified.
- Any unusual findings are identified and discussed with the appropriate parties.

Further discussions of QA protocols concerning groundwater quality sampling are presented in Volume III of this application. Further details concerning data management are presented in the project-specific Data Management Plan (BC, 1995h).

2.3 INVESTIGATION DESIGN AND PROCEDURES

This section describes the design of the field investigation, including scope of work, and field and laboratory procedures, where appropriate.

2.3.1 Vadose Zone Characterization

As discussed in Section 2.1.1, the following aspects of the vadose zone in the proposed in-situ mine area were investigated: (1) the general physical and chemical baseline conditions; (2) the geotechnical conditions; and (3) the soil quality. This section addresses the general baseline characterization. Potential soil quality impacts are discussed in Section 4.4.2 and Appendix G of this volume, and the geotechnical results are presented and discussed in Volume V of this application. Geochemical discussions relative to vadose zone baseline conditions are presented in Volume IV of this application.

The vadose zone baseline characterization investigation was conducted in September and October 1995. The vadose zone baseline field work included advancing a total of eight soil borings. Piezometers (permeameters) P1-80, P2-90, P3-60, and P4-40 were installed in 4 of the borings in order to conduct field hydraulic conductivity tests. A summary of vadose characterization boring and piezometer construction details is presented in Table 2.3-1. Locations of vadose zone baseline and geotechnical borings are illustrated on Figure 2.1-1[II]. Vadose characterization boring logs and piezometer construction details are presented in Appendix A.

2.3.1.1 Drilling Methods

Percussion hammer drilling techniques were employed to advance borings for soil sampling and hydraulic conductivity testing. A Becker AP-1000 dual-tube percussion hammer drilling rig was used to advance borings to a maximum depth of 95 feet below ground surface (bgs). Piezometer construction details are presented in Table 2.3-1.

The borings were advanced using 10-inch outside diameter, dual-tube drill pipe driven into the subsurface with a hydraulic hammer. The pipe was marked every foot to measure rate of penetration. The rate of penetration was recorded on the boring log as hammer blows per foot (usually at 1-foot intervals). The boring cuttings were brought to the surface by a pressurized pipe and discharged to a cyclone next to the rig. The cuttings were used to backfill the borehole in cases where a piezometer was not installed. If water was encountered, the hole was backfilled with bentonite grout, followed by a Portland cement cap.

2.3.1.2 Soil Sampling Procedures

Soil samples were collected from the vadose zone borings at depths ranging from ground surface to 95 feet bgs. Soil samples were collected at depths of 2 feet bgs and at 5-foot intervals beginning at 5 feet bgs to the total depth of each soil boring. Four soil borings, B1, B2, B3, and B4 were advanced to a maximum depth of 95 feet bgs. The borings for piezometers P3-60 and P4-40 were not sampled as they were installed approximately 10 feet from B3 and B4, respectively.

Soil Sampling Equipment:

- The soil samples were collected using a California-modified, split-spoon 2.5-inch diameter sampler that was 18 inches in length.

- Sample rings were 2.5 inches in diameter and 6 inches in length, and were constructed of brass.

Soil Sampling Procedures:

- The clean sampler was opened and clean sample collection rings and sand retainer were inserted.
- The sampler was closed and the end cap and drive shoe were hand tightened. No grease was used on the end cap or drive shoe threads.
- The clean, loaded sampler was attached to the downhole 140-pound sample hammer, and lowered into the boring.
- The sampler was driven ahead of the bit into undisturbed soil using a standard 140-pound weight that was allowed to drop 30 inches per blow.
- The number of blows required to drive the sampler 18 inches past the end of the drill bit was recorded on the boring logs.
- The sampler was then retrieved from the borehole, removed from the hammer, and opened.
- Teflon sheets were placed over the 2 exposed ends of the middle sample ring. Plastic endcaps were placed over the Teflon sheets. The sample was labeled, placed in a zip-lock bag and stored in a cooler maintained at approximately 4 degrees Celsius.
- To detect any potential volatile organic presence in the soil samples in the field, a portion of the sample was placed in a zip-lock bag and the bag was sealed. The sample was allowed to be heated by the sun for a few minutes to allow any volatile substances in the soil sample to volatilize. The presence of volatile organics was measured by placing the probe of an Organic Vapor Analyzer (OVA) into the bag. The OVA reading was recorded on the boring log.
- A soil sample was collected from the drive shoe, and described on the lithologic log form using American Society for Testing and Materials (ASTM) Methods D-1452, D-2487, and D-2488.

2.3.1.3 Hydraulic Conductivity Testing

Each of the 4 vadose zone piezometers (permeameters) listed in Table 2.3-1 was constructed using 2 3/8-inch (outside diameter) Schedule 80 PVC pipe, with a 10-foot screened section at the indicated depth interval in each boring. A filter pack consisting of No. 69 Colorado silica sand was installed to a depth of 5 feet above the top of the screen. One 100-pound bag of No. 30 silica sand (approximately 3 feet of annular length) was installed on top of the No. 6 - No. 9 mesh sand. Bentonite grout was installed to within 1 to 2 feet of the surface, followed by a Portland cement cap.

In October 1995, soil hydraulic conductivity tests were conducted in the piezometers (permeometers) installed during this investigation. The field permeability tests were performed in accordance with U.S. Bureau of Reclamation E-18 test methods, (Bureau of Reclamation [BOR], 1974). Hydraulic conductivity values were calculated using Method E-18 (BOR, 1974) and procedures described in Lamb and Whitman (1969). This test method assumes saturated conditions while testing, therefore pre-wetting was performed prior to conducting each of the tests. The tests were performed using constant head conditions.

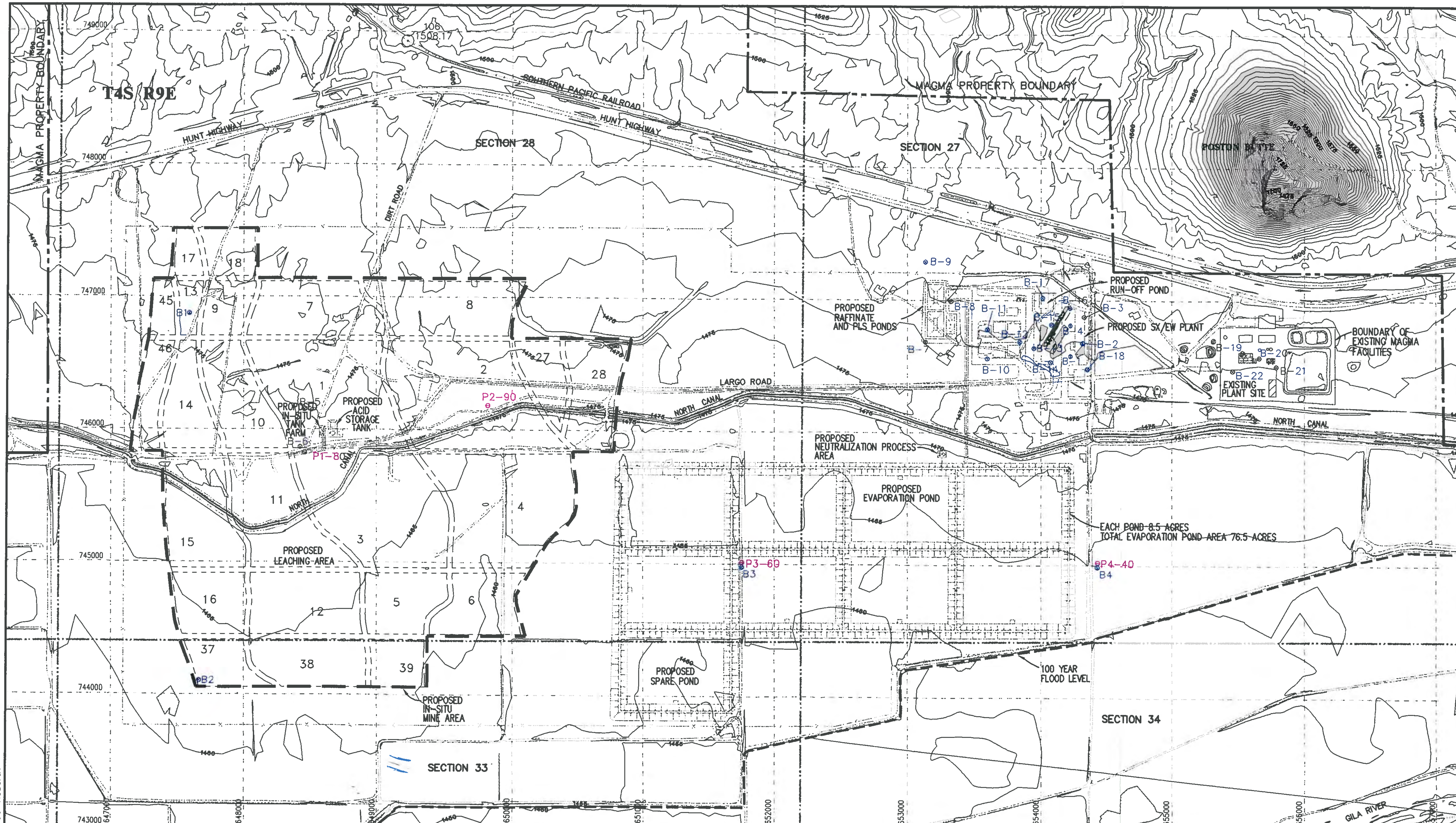
Each field piezometer installation was pre-soaked for 24 to 48 hours prior to testing by filling the casings with water from a truck-mounted 1,000-gallon water tank. The piezometers were filled by pumping the water with a centrifugal pump until all air inside the casing was expelled and water spilled over the top of the casing. A flow meter pressure gauge and an air escape valve were connected to the top of the field piezometers using a well head attachment. A hose was connected from the attachment to the centrifugal pump and a hose was connected from the pump to the water tank. The water was pumped into the piezometer with the air escape valve opened until all air was expelled from the system. The air escape valve was closed, pressurizing the well. The pump rate was regulated to prevent the pressure from exceeding a static pressure level of 10 pounds per square inch (psi). The amount of water pumped into the well to maintain a static pressure was monitored using the flow meter. This procedure was repeated several times, providing results at several static pressure levels. Results of the soil hydraulic conductivity tests are discussed in Section 4.0. A report summarizing the field hydraulic conductivity vadose zone investigation conducted by AGRA E&E is presented in Appendix F of this volume.

2.3.1.4 Laboratory Analyses

Selected soil samples retrieved during the baseline vadose zone investigation were chemically and physically tested to measure background geochemical and attenuation properties, and assist in the description of the various soil types. Laboratory analyses were performed by Core Laboratories in Denver, Colorado on 13 soil samples collected as part of the vadose zone baseline investigation. The samples chosen for analyses were fine-grained soils such as clay, silt, and sandy silts. A summary of the vadose zone laboratory testing program is presented in Table 2.3-2. Soil samples selected for laboratory analyses included the following:

P1-80:	2 samples from 55 and 80 feet bgs;
P2-90:	2 samples from 45 and 70 feet bgs;
B1:	2 samples from 35 and 90 feet bgs;
B2:	2 samples from 55 and 75 feet bgs;
B3:	3 samples from 10, 45, and 65 feet bgs; and
B4:	2 samples from 55 and 80 feet bgs.

Each sample submitted was analyzed for each of the chemical constituents or properties listed on Table 2.3-2, except for triaxial permeability. One sample from each boring was analyzed for triaxial permeability. Physical laboratory results from Core Laboratories are presented in Appendix F and are discussed in Section 4.0. Chemical laboratory results associated with the vadose zone investigation are presented and discussed in Volume IV of the application.



0 350 700

SCALE IN FEET

EXPLANATION

⊖ P1-80	= VADOSE ZONE CHARACTERIZATION PIEZOMETER
⊗ B1,B2,B3,B4	= VADOSE ZONE CHARACTERIZATION BORING
⊗ B-1	= GEOTECHNICAL BORING

F2-1-1_2 11-30-95 RobertK

BROWN AND CALDWELL

MAGMA

MAGMA COPPER COMPANY

Florence, Arizona

Figure 2.1-1 (II)

VADOSE CHARACTERIZATION AND GEOTECHNICAL BORING LOCATIONS

Table 2.3-1 Summary of Vadose Zone Characterization Borings and Piezometer Construction Details			
Boring Identification	**Drilling Method**	**Total Depth (feet bgs)**	**Piezometer Screen Interval (feet bgs)**
B1	Percussion Hammer	95	NA
B2	Percussion Hammer	80	NA
B3	Percussion Hammer	80	NA
B4	Percussion Hammer	95	NA
P1-80	Percussion Hammer	80	70'to 80'
P2-90	Percussion Hammer	90	80' to 90'
P3-60	Percussion Hammer	60	50' to 60'
P4-40	Percussion Hammer	40	30' to 40'

NA - Not Applicable
Percussion Hammer Drilling Method - AP-1000 Drilling Rig
See Figure 2.1-1[II] for Boring and Piezometer Locations
Lithologic Logs and Piezometer Construction Diagrams are presented in Appendix A [II].
bgs - below ground surface

Table 2.3-2 Summary of Vadose Zone Investigation Laboratory Analysis Program			
Analyses	**Analytical Method**	**Detection Limit**	**Reporting Units**
Geochemical Parameters			
Acid Neutralization Potential (ANP)	EPA 600 3.2.3	0.1	tons $CaCO_3$/Kt
Cation Exchange Capacity (CEC)	SW-846 9081	0.01	meq/100gm
Exchangeable Cations: Sodium	USDA 60 18	0.01	meq/100gm
Total Organic Carbon (TOC)	Agronomy 90-3	0.01	Percent
Total Sulfur as S Total Sulfur	ASTM D4239-85C	0.01 0.3	Percent (Leco Furnace) tons $CaCO_3$/Kt
Total Metals[a]			
Mercury	SW-846 7471	0.02	mg/Kg
Arsenic (As) Beryllium (Be) Cadmium (Cd) Chromium (Cr) Copper (Cu) Lead (Pb) Selenium (Se) Silver (Ag) Zinc (Zn)	SW-846 6010	0.05 0.005 0.005 0.01 0.01 0.05 0.1 0.01 0.01	mg/Kg mg/Kg mg/Kg mg/Kg mg/Kg mg/Kg mg/Kg mg/Kg mg/Kg
Miscellaneous Geochemical Parameters[b]			
Alkalinity	EPA 310.1	5	mg/L $CaCO_3$
Bicarbonate	SM 2320 B	5	mg/L
Chloride	EPA 325.2	0.5	mg/L
Nitrate and Nitrite	EPA 353.2	0.05	mg/L
Sulfate	EPA 375.2	NA	NA
Soluble Metals Analyses Calcium (Ca) Magnesium (Mg) Sodium (Na)	SW-846 6010	 0.1 0.1 1	 mg/L mg/L mg/L

Table 2.3-2 Summary of Vadose Zone Investigation Laboratory Analysis Program			
Analyses	**Analytical Method**	**Detection Limit**	**Reporting Units**
Physical Parameters			
Particle Size Distribution	ASTM D4464	NA	NA
Triaxial Permeability	ASTM 5048	NA	NA
Plasticity Index	ASTM D4318	NA	NA

[a]Performed with Solids Acid Digestion preparation (SW-846-3050)
[b]Performed with Soluble Soil Paste preparation (USDA Method 60 2)
NA - Not Applicable
mg/Kg - milligrams per Kilogram
meq/100gm - milliequivalent per 100 grams
mg/L - milligrams per Liter
Kt - Kiloton
$CaCO_3$ - Calcium Carbonate

EXHIBIT A-2

Hydrologic Study Part B
(Temporary APP Application Attachment 14B)

CURIS RESOURCES (ARIZONA) INC.

APPLICATION FOR TEMPORARY
INDIVIDUAL AQUIFER PROTECTION PERMIT

ATTACHMENT 14B – HYDROLOGIC STUDY
PART B (ITEM 25.H)

REGISTERED GEOLOGIST
CERTIFICATE NO. 39869
MARK D. NICHOLLS
Date Signed: 3/1/12
ARIZONA U.S.A.
Exp. 9/30/2012

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14B.1 Introduction

This attachment has been prepared in response to the information requirements of Item 25.H of the Individual Aquifer Protection Permit (APP) Application Form (Form) and Arizona Administrative Code (A.A.C.) R18-9-A202A.8 relating to the hydrologic study. This attachment specifically addresses the requirements of A.A.C. R18-9-A202A.8 b.v-viii as they relate to the proposed Production Test Facility (PTF) well field as follows:

b. Based on the quantity and characteristics of pollutants discharged, methods of disposal, and Site conditions, the Department may require the applicant to provide:
   v. The precise location or estimate of the location of the 100-year flood plain and an assessment of the 100-year flood surface flow and potential impacts on the facility;
   vi. Documentation of the existing quality of the water in the aquifers underlying the Site, including, where available, the method of analysis, quality assurance (QA), and quality control (QC) procedures associated with the documentation;
   vii. Documentation of the extent and degree of any known soil contamination at the Site;
   viii. An assessment of the potential of the discharge to cause the leaching of pollutants from surface soils or vadose materials;

The other hydrologic study requirements listed in A.A.C. R18-9-A202A.8 are described in Attachment 14A, *Hydrologic Study Part A*, *Groundwater Flow Model* and Attachment 12, *Compliance with Aquifer Water Quality Standards*. Table 14B-1 includes a directory of the requirements outlined in A.A.C. R18-9-A202A.8, and where each are addressed in this application.

14B.2 Delineation of the 100-Year Flood Plain (8.b.v)

The Federal Emergency Management Agency (FEMA) has produced a series of Flood Insurance Rate Maps (FIRM) for use in delineating the probable maximum extent of inundation (100-year flood plain) due to a precipitation event with a 24-hour duration and a recurrence interval of 100 years. Current FIRM maps (dated December 4, 2007) numbered 04021C0867E, 04021C0870E, and 04021C0875E (Exhibit 14B-1) show the extent of the 100-year flood plain in the vicinity of the PTF site, the Town of Florence, the City of Coolidge, and certain unincorporated areas of Pinal County. The effective date of the most recent FIRM maps available is December 4, 2007. The boundaries of the Curis Arizona property, the proposed pollutant management area (PMA), and the PTF well field have been superimposed on the FIRM maps provided in Exhibit 14B-1.

As shown in Exhibit 14B-1, one irrigation canal (North Side Canal) in the vicinity of the PTF site receives storm water flow. The North Side Canal traverses the PTF site and the proposed PTF well field from east to west. The North Side Canal does not receive any storm water at, or up-gradient of, the PTF well field. As shown in Exhibit 14B-1, the North Side Canal receives storm water from an unnamed drainage that intersects the canal at a location approximately 2.9 miles (distance along the canal) west and down-gradient of the PTF site. As shown in Exhibit 14B-1, the unnamed drainage poses no threat of inundation to the PTF site under 100-year event conditions. Also shown in Exhibit 14B-1 is the fact that no other drainages or washes pose a threat of inundation to the PTF site under 100-year event conditions.

No canals, washes, or surface water drainages on or near the PTF site pose a threat of inundation at a magnitude sufficient to impact PTF operations under 100-year event conditions.

The proposed PTF well field, beneficiation areas, and flood zone designations are shown on Figure 14B-1. The 100-year floodplain boundary nearest the proposed PTF well field is associated with the Gila River channel, located approximately 0.6 mile to the south of the proposed PTF well field. At the nearest point, the proposed PTF well field is 3,300 feet north of and up-slope from the Gila River 100-year floodplain. All future project facilities have been sited outside the 100-year floodplain.

Portions of the property owned by Curis Resources (Arizona) Inc. (Curis Arizona) lay within flood Zone A and close to Zone AE, but are limited to agricultural uses only. No portion of the proposed project facilities lies within the zone of projected inundation classified on the FIRM maps as Zones A and AE. The PTF well field and associated beneficiation facilities lie within Zone X, an area of minimal flood hazard that is typically outside the 500-year floodplain.

In the event of local inundation to the limits of the 100-year floodplain of the Gila River, proposed PTF facilities and beneficiation areas will be unaffected by inundation. Lower portions of the property owned by Curis Arizona that are restricted to agricultural uses may be inundated. Inundation of the lower elevation agricultural lands will not affect access to or operation of the proposed PTF well field and associated beneficiation facilities.

14B.3 Existing Groundwater Quality (8.vi)

Existing groundwater quality beneath the PTF site has been characterized by means of laboratory analyses performed on samples collected from on-site wells. A series of 31 point of compliance (POC) wells were constructed at the site in 1995 and 1996 to facilitate groundwater quality monitoring in accordance with APP No. 101704 and Underground Injection Control Permit No. AZ396000001 (UIC Permit). Two of the original 31 POC wells have gone dry due to regionally declining groundwater levels. The remaining 29 active POC wells have been sampled quarterly since late 1997, with the exception of the year 2009 (all four quarters) when the prior owner of the facility was insolvent.

Curis Arizona herein proposes to use 4 of the existing 29 POC wells associated with APP No. 1001704, to convert two existing test wells to POC wells, and replace one of the POC wells that have gone dry, for a total of seven POC wells to be used for the proposed project and temporary APP. Groundwater quality data are available for four of the proposed POC wells. Construction details for each of the four existing POC wells are shown in Table 14B-2.

Recent water quality samples collected from the existing POC wells include quarterly (Level 1) and biennial (Level 2) compliance monitoring samples collected on February 15 through March 3, 2010 (First Quarter 2010), between January 25 and January 28, 2011 (First Quarter 2011), between May 22 and June 7, 2011 (Second Quarter 2011), and between September 7 and September 30, 2011 (Third Quarter 2011). Laboratory analytical results and associated laboratory quality assurance/quality control documentation is included in Exhibit 14B-2.

14B.3.1 Hydrostratigraphic Units

The saturated geologic formations underlying the PTF site have been divided into three distinct water bearing hydrostratigraphic units referred to as the Upper Basin Fill Unit (UBFU), Lower Basin Fill Unit (LBFU), and the Bedrock Oxide Unit. Although water bearing where fractured, the Bedrock Oxide Unit is considered to be hydrologic bedrock (impermeable) by the Arizona Department of Water Resources (ADWR, 1989). The UBFU and LBFU are separated by a regionally extensive aquitard referred to as the Middle Fine Grained Unit (MFGU). Each of these units generally corresponds to regionally extensive hydrostratigraphic units described by ADWR (1989). The hydrostratigraphic units are defined in greater detail in Attachment 14A, *Groundwater Flow Model, Florence Copper Project, Pinal County, Arizona.*

The four active POC wells, two converted test wells, and one proposed POC well are located on State land, outside of the proposed PMA (Figure 14B-1), and are constructed such that they produce water representative of the three principal water bearing hydrostratigraphic units. No POC wells have been or are proposed to be completed in the MFGU aquitard. Table 14B-2 includes a list of the existing and proposed POC wells, their screened intervals, and the hydrostratigraphic unit in which each is completed.

14B.3.2 Water Quality Parameters

The current list of water quality constituents included in the Level 1 and Level 2 monitoring program was developed based on the constituents forecasted by the geochemical model (Brown and Caldwell, 1996a) to occur in the injected fluid. The injected fluid will consist of a sulfuric acid enhanced solution that, at maturity, includes constituents dissolved from the Bedrock Oxide Unit that are not removed during the solvent extraction/electrowinning (SX/EW) process. Curis Arizona has reviewed and revised the geochemical modeling conducted in 1996, and has developed a new forecasted injectate composition. The revised injectate composition is described in detail in Attachment 10.

As described in Exhibit 10B of Attachment 10 of this application, the previous models and forecast compositions have been updated to incorporate available data and advances in geochemical modeling. The updated forecast constituent compositions confirm the validity of constituents that were for the monitoring program required by APP No. 101704, which constituents are discussed below.

The current Alert Levels (ALs) and Aquifer Quality Limits (AQLs) pertaining to the existing four POC wells to be used in conjunction with the PTF were accepted by the Arizona Department of Environmental Quality (ADEQ) and United States Environmental Protection Agency (USEPA) in April 2000. The procedure by which the current AQLs and ALs were established is described in Attachment 15. A discussion of existing groundwater quality relative to AQLs and ALs is included in Attachment 12.

14B.3.3 Historical Groundwater Quality Trends

It is apparent that analyte concentrations in certain wells have been gradually increasing over the period of record, and are approaching the established AL values. This observation has prompted the detailed trend analysis for all ALs described briefly below, and described in greater detail in Attachment 15.

Historic water quality trends were projected to approximate continuation of the trend exhibited by each analyte and well combination. This process revealed that analyte concentrations were generally increasing in some wells and decreasing in others. These trends are likely the result of declining groundwater levels in the vicinity of the site. As groundwater levels decline, the groundwater contribution from the various aquifer zones to a given well change both in quantity and character. These changes are dependent on location and the aquifer profile contributing groundwater to the well, and may have either increasing or decreasing concentration effects.

Based on available data, the increases in analyte concentrations described above are related to natural processes, not facility operations. Groundwater levels have declined at the site by as much as 65 feet in the past 15 years. This groundwater level decline has been the principal cause of analyte concentration increases at the site. As groundwater levels decline, the groundwater contribution from the various aquifer zones to a given well change both in quantity and character. These changes are dependent on location and the aquifer profile contributing groundwater to the well, and may have either positive or negative effects on groundwater quality. Other than the limited hydraulic control test conducted in 1997-1998, no in-situ copper recovery (ISCR) injection of lixiviant as occurred at the site since the permits were issued in 1997. Hydraulic control was maintained throughout the hydraulic control test and afterward until 2004. Consequently, any fluids injected during that test could not have migrated away from the test area or contributed to the increase in analyte concentrations described above.

14B.3.4 Current Groundwater Quality

14B.3.4.1 UBFU Groundwater Quality

Level 1 samples were collected from existing POC wells screened in the UBFU during January, May-June, and September 2011. Laboratory analytical results from these sampling events for the one existing UBFU POC well (M23-UBF) proposed for use in conjunction with the PTF are provided in Table 14B-3.

Level 2 water quality samples were collected from wells screened in the UBFU in February 2010. The Level 2 samples were analyzed for concentrations of nitrate as nitrogen and trace metals. Analytical results from these sampling events for M23-UBF are provided in Table 14B-4. Because no ALs or AQLs for trace metals were exceeded, only metals detected above the reporting limits are included in table 14B-4.

Level 2 samples were also analyzed for SX/EW-related organic compounds including extractable fuel hydrocarbons (diesel range organics), benzene, ethylbenzene, toluene, and total xylenes; all results for organic compounds were below instrument reporting limits.

A summary of the UBFU radiochemical results is presented on Table 14B-5. Radiation concentration values for Ra-226, Ra-228, and radium were below the instrument reporting limits. The APP (No. 101704) and the UIC Permit (No. AZ396000001)require that the analyses be performed to determine the concentration of total uranium only if the gross alpha is greater than 15 pico Curies per liter (pCi\L). Total uranium was not analyzed for the UBFU sample collected in 2010 because gross alpha radiation was below 15 pCi\L in all of the samples.

14B.3.4.2 LBFU Groundwater Quality

Level 1 samples were collected from POC wells screened in the LBFU during January, May-June, and September 2011. Laboratory analytical results from these sampling events for the two existing LBFU POC wells proposed for use in conjunction with the PTF (M14-GL and M15-GU) are listed in Table 14B-6.

Level 2 water quality samples were collected from wells screened in the LBFU in February 2010. The Level 2 samples were analyzed for the concentrations of nitrate as nitrogen and trace metals. A summary of nitrate as nitrogen and trace metals concentrations above the instrument reporting limit is included in Table 14B-7. Concentrations of aluminum, antimony, beryllium, cadmium, lead, mercury, thallium, and zinc were below the reporting limit for both existing POC wells screened in the LBFU.

Level 2 samples were also analyzed for SX/EW-related organic compounds including extractable fuel hydrocarbons (diesel range organics), benzene, ethylbenzene, toluene, and total xylenes; all results for organic compounds were reported below instrument reporting limits.

A summary of the LBFU radiochemical results is presented in Table 14B-8. Radiation concentration values for Ra-226, Ra-228, and radium were below the reporting limits of the instrument. Total uranium was not analyzed because gross alpha radiation was below 15 pCi\L for the samples collected from the LBFU.

14B.3.4.3 Bedrock Oxide Unit Water Quality

Level 1 samples were collected from POC wells screened in the Bedrock Oxide Unit during February, May, and July 2010. Laboratory analytical results from these sampling events for the one existing Oxide POC well proposed for use in conjunction with the PTF (M22-O) are listed in Table 14B-9.

Level 2 water quality samples were collected in February and March 2010. Level 2 samples were analyzed for the concentrations of nitrate as nitrogen and trace metals. A summary of trace metals concentrations above the instrument reporting limit is included in Table 14B-10. Concentrations of aluminum, antimony, beryllium, cadmium, lead, mercury, thallium, and zinc were below the instrument reporting limit for the existing POC well screened in the Bedrock Oxide Unit and proposed for use in conjunction with the PTF.

Radiochemical sample results are included in Table 14B-11. POC well M22-O reported detectable Ra-226 and radium radiation concentrations. Total uranium was not analyzed because gross alpha radiation was below 15 pCi\L for the sample collected from M22-O.

14B.3.5 QA/QC Procedures

The four active POC wells, as a sub-set of the existing 29 active POC associated with APP No. 101704, have been sampled for the Level 2 analytes during 2010, and Level 1 analytes quarterly since 1997. During each sampling event, approximately 32 samples (29 wells and 3 duplicates) were collected. Prior to sampling, groundwater parameters including pH, temperature, and conductivity were measured immediately before and during purging to ensure that representative aquifer conditions were attained. All field activities were documented in field notes and purging data were recorded on field data sheets. POC wells were purged and groundwater samples were collected in accordance with APP No. 101704 sampling protocols.

Blind duplicate samples were collected at the rate of one per ten samples, which is approximately one duplicate sample per day. Field personnel wore disposable nitrile gloves when collecting samples. Field personnel completed the sample labels and chain-of-custody forms. Samples were stored in ice chests containing wet ice or in an on-site refrigerator until they were delivered to the laboratory, generally at the end of each day's sampling.

Brown and Caldwell reviewed all data received from the field and the laboratory to ensure that QA/QC procedures for field and laboratory operations were followed in accordance with APP No. 101704, and related ADEQ/USEPA guidance. Laboratory QA/QC procedures are summarized in the laboratory analytical reports included as Exhibit 14B-2.

Analytical data was received electronically from the laboratory by Brown and Caldwell and downloaded into the dedicated project database. Field parameters were also entered into the database. As part of the QA/QC review, all results were compared to the ALs established in APP No. 101704 and analyzed for trends or deviations from the historical ranges.

Analytical results generated as a result of each 2010 sampling event were summarized, together with significant observations and site status, and were reported to the USEPA and ADEQ in accordance with requirements delineated in APP No. 101704.

14B.4 Known Soil Contamination at the PTF Site (8.vii)

Attachment 10 includes detailed discussions of activities conducted at the PTF site and surrounding area since the Poston Butte copper deposit was discovered and the Continental Oil Company (Conoco) began focused exploration activities in 1970. Activities conducted on State land by Conoco were primarily limited to the construction of a small pilot-scale mine and the installation of wells and coreholes. The underground mine was abandoned during the mid-1970s. The Magma Copper Company (Magma) and, later, the BHP Copper Company (BHP Copper) drilled additional wells and coreholes for exploration purposes, preparation of permit applications, and groundwater monitoring at the four POC wells discussed in Section 14.B-3. Since APP No. 101704 was issued in 1997, activities on the State land have been primarily limited to monitoring groundwater at the four POC wells.

Brown and Caldwell conducted a focused facilities investigation at the PTF site and surrounding vicinity on behalf of BHP Copper, and in support of the APP application that was submitted to ADEQ in January 1996 (Brown and Caldwell, 1996b), included as Exhibit 14B-3. The investigation covered areas within the State land and beyond the State land. Samples were collected from the area of the mine shafts, which are on State land, and from ore storage and processing areas east of the State land. Sample results from the laboratory did not indicate concentrations of metals above ADEQ Health Based Guidance Levels then in effect.

14B.5 Potential for Discharge to Cause Leaching of Pollutants from Surface Soils or the Vadose Zone (8.viii)

The potential for a discharge to cause the leaching of pollutants from surface soils or the vadose zone is extremely limited because the PTF components have been designed to prevent discharges to surface soils and the vadose zone. In addition, none of the PTF components are located in, or up-gradient of, any area such spill or disposal site where pollutants in the soil and vadose zone are expected to exist in concentrations above natural background. As discussed in Attachments 9 and 11, Curis Arizona has proposed designs throughout the PTF to enhance the protection of surface soil, the vadose zone, and groundwater.

The design for injection and recovery wells is substantially more protective than required to meet the stringent UIC regulations. More specifically, Curis Arizona proposes to install an extra casing and to cement the resulting additional annular space in each injection and recovery well from the surface to at least 40 feet below the top of the Bedrock Oxide Zone. Curis Arizona has also proposed to place an impermeable liner in a containment area for each well head in the well field, with impermeable liners extending for piping from the individual well heads to the beneficiation area. The PTF components in the beneficiation area will be equipped with an impermeable base/liner and will be designed to meet the exemption requirements of Arizona Revised Statutes (A.R.S.) §§ 49-250.B.21 and 22.

The water impoundment and runoff pond have been designed to meet the prescriptive Best Available Demonstrated Control Technology (BADCT) criteria provided in ADEQ's Mining BADCT Manual regarding construction, operation, maintenance, closure, and post-closure. The impoundment has two impermeable liners and a leak detection and recovery system, and its closure is designed to prevent discharges during and after closure. The runoff pond is designed with one impermeable liner but it will have a sump from which liquids will be promptly pumped either to the plant or to the water impoundment. A standby generator will be available in the event that the runoff pond contains liquid during a power outage. The runoff pond's closure is designed to prevent discharges during and after closure.

Attachments 9 and 11 also describe hydraulic control and other features related to the operation of the injection and recovery wells that have been designed to meet the individual BADCT criteria for injection wells. This includes steps to prevent the migration of ISCR solutions beyond the injection and recovery zone (IRZ) during operation and restoration of groundwater in the IRZ at closure. Table 9A-1 summarizes a facility-wide operations plan that includes electronic monitoring and automatic shut-offs to maintain hydraulic control in the IRZ and to minimize the potential for a process upset to result in the discharge on to surface soil or the vadose zone.

14B.6 References

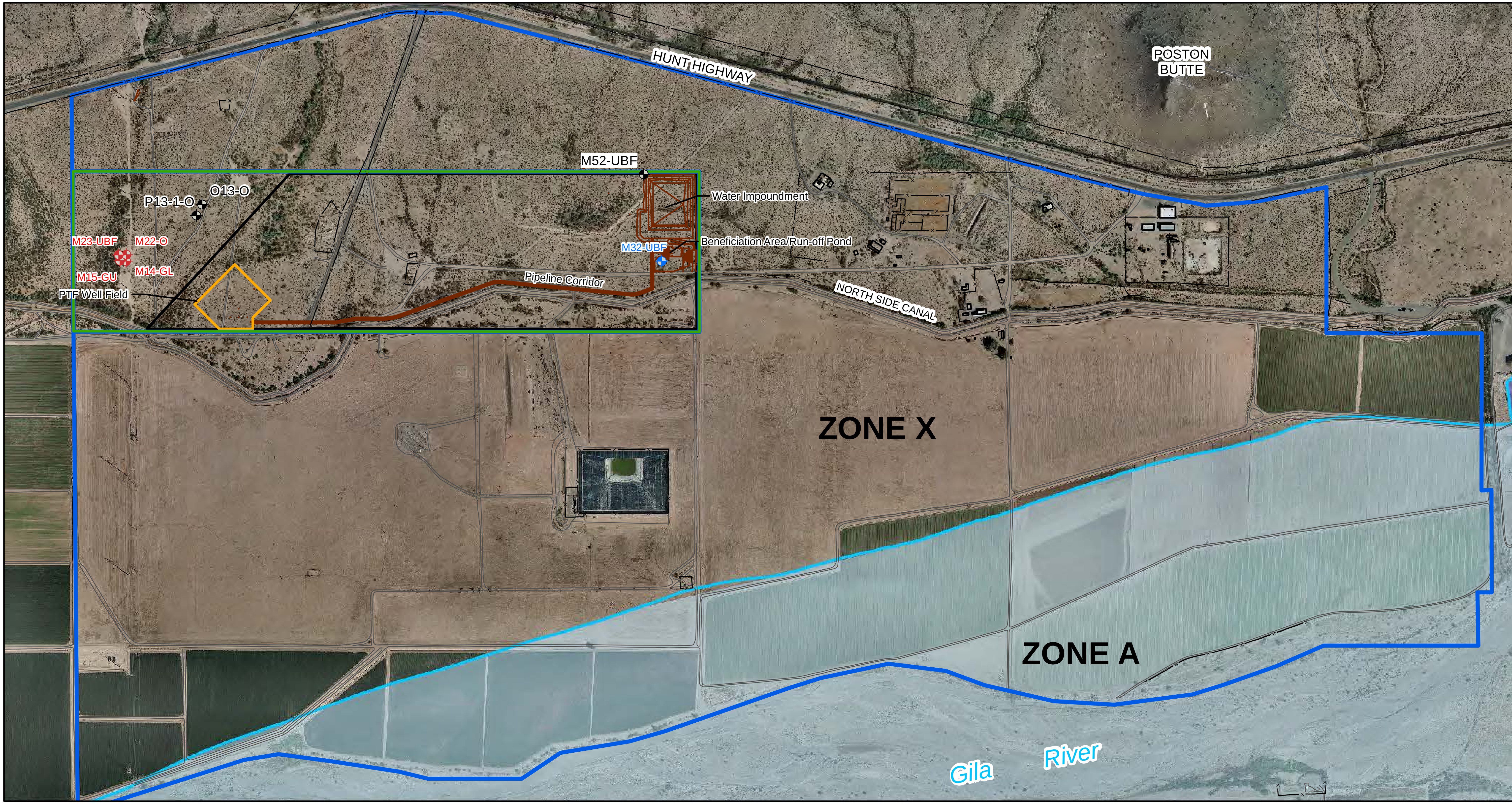
Arizona Department of Water Resources (ADWR), 1989. *Pinal Active Management Area Regional Groundwater Flow Model, Phase One: Hydrogeologic Framework, Water Budget and Phase One Recommendations, Model Report 1*.

Brown and Caldwell, 1996a. Magma Florence In-Situ Project Aquifer Protection Permit Application, Volume IV of V, Modeling Report. January 1996.

Brown and Caldwell, 1996b. *Focused Facilities Investigation October 1995*, Magma Florence In-Situ Project.

Brown and Caldwell, 2007. *Site Investigation Plan for the Closure of the Florence Copper In-Situ Mine Project*, *Merrill Mining LLC, Florence Arizona*. January 10, 2007

BHP Copper Inc., 1998. Correspondence, Letter to Julie Collins, ADEQ Compliance Officer, From Corolla Hoag, BHP Copper, *Report of Results of Hydraulic Control Test.*



AERIAL SOURCE: COOPER AERIAL SURVEYS CO., OCTOBER 2010

HDI CURIS

Brown AND Caldwell

0 400 800
SCALE IN FEET

EXPLANATION

- EXISTING POC WELL
- PROPOSED POC WELL
- POC WELL TO BE ABANDONED
- COMPONENTS OF PROPOSED PRODUCTION TEST FACILITY (PTF)
- PTF WELL FIELD
- PMA BOUNDARY
- STATE LAND LEASE
- CURIS PROPERTY BOUNDARY
- 100 YEAR FLOOD PLAIN

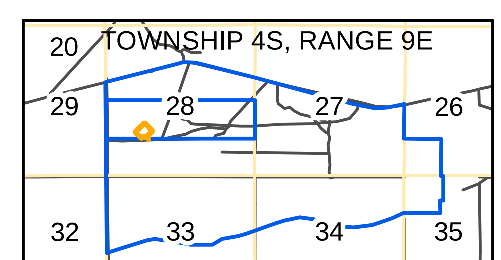


Figure 14B-1
100 YEAR FLOOD PLAIN
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Path(BCPhx03): P:\Hunter Dickinson\Curis GIS\MXDs\Temp Permit2012\G14075334014B1.mxd Updated: 2/28/2012

Table 14B-1. Application Attachments Addressing Hydrologic Study Requirements Defined in A.A.C. R18-9-A202A.8

Requirement	Addressed in Attachment
8.a.i	Attachment 14A
8.a.ii	Attachment 12
8.b.i	Attachment 14A
8.b.ii	Attachment 14A
8.b.iii	Attachment 14A
8.b.iv	Attachment 14A
8.b.v	Attachment 14B (This Attachment)
8.b.vi	Attachment 14B (This Attachment)
8.b.vii	Attachment 14B (This Attachment)
8.b.viii	Attachment 14B (This Attachment)
8.b.ix	Does not pertain to the present application
8.b.x	Attachment 14A
8.b.xi	Attachment 14A
8.b.xii	Attachment 14A
8.b.xiii	Attachment 14A

Table 14B-2. POC Well Screened Intervals and Aquifer Units

Well ID*	Screened Interval (feet)[b]	Screened Aquifer Unit	ADWR No.	Location Coordinates (Northing Easting)	Cadastral Coordinates	Total Depth (feet)[b]	Date Installed	Reference Point Elevation (feet)[a]	Land Elevation (feet)[a]
M14-GL	778-838	LBFU	55-549172	746461.52 N 846750.23 E	D(4-9)28cdc	859	6/2/95	1474.58	1473.2
M15-GU	554-594	LBFU	55-547813	746464.82 N 846697.174 E	D(4-9)28cbc	615	6/6/95	1474.01	1473.1
M22-O	932-1,130	Oxide	55-555831	746514.47 N 846751.26 E	D(4-9)28cbc	1,140	4/12/96	1476.06	1473.3
M23-UBF	210-250	UBFU	55-555824	746512.48 N 846688.13 E	D(4-9)28cbc	250	4/13/96	1475.16	1473.3
O13-O	770-1,393	Oxide	55-547812	746936.74 N 847387.59 E	D(4-9)28cba	1,440	8/2/95	1481.48	1479.4
P13-GL	690-760	LBFU	55-547811	746849.10 N 847189.17 E	D(4-9)28cba	770	8/11/95	1479.29	1477.4
M52-UBF	200-275	UBFU	Not Drilled Yet		Not Drilled Yet	276	2012	N/A	N/A

[a] *Feet above mean sea level (amsl)*

[b] *Feet below ground surface (bgs)*

Table 14B-3. 2010 UBFU Level 1 Water Quality Results

POC Well	TDS (mg\L)			Magnesium (mg\L)			Sulfate (mg\L)			Fluoride (mg\L)			Field pH (SU)		
	Jan 2011	May 2011	Sep 2011	Jan 2011	May 2011	Sep 2011	Jan 2011	May 2011	Sep 2011	Jan 2011	May 2011	Sep 2011	Jan 2011	May 2011	Sep 2011
M23-UBF	1,200	1,400	1,300	33	38	37	242	267	283	0.68	0.63	0.68	7.15	6.92	6.95
Range of Concentrations	1,200– 1,400			330 – 38			242 – 283			0.63 – 0.68			6.92 – 7.15		

mg/L = milligrams per liter
POC = point of compliance
SU = standard units
TDS = total dissolved solids
UBFU = Upper Basin Fill Unit

Table 14B-4. Summary of Water Quality Results for Nitrate as Nitrogen and Metals in the UBFU
February 2010

POC Well	Nitrate as nitrogen (mg\L)	Arsenic (mg\L)	Barium (mg\L)	Chromium, total (mg\L)	Cobalt (mg\L)	Copper (mg\L)	Nickel (mg\L)
M23-UBF	9.6	0.002	0.074	0.0011	0.0019	0.0019	0.0049

Note: Concentrations of aluminum, antimony, beryllium, cadmium, iron, lead, manganese, mercury, selenium, thallium, and zinc were below the instrument reporting limit for all POC wells screened in the UBFU.

mg/L = milligrams per liter

POC = point of compliance

Table 14B-5. Summary of Radionuclide Results for the UBFU, February 2010

POC Well	Alpha (pCi\L)	Ra-226 (pCi\L)	Ra-228 (pCi\L)	Radium (pCi\L)
M23-UBF	6.7 ± 1.3	<0.4	<0.3	<0.4

POC = point of compliance

pCi/L = picoCuries per liter

Table 14B-6. 2010 LBFU Level 1 Water Quality Results

POC Well	TDS (mg\L)			Magnesium (mg\L)			Sulfate (mg\L)			Fluoride (mg\L)			Field pH (SU)		
	Jan 2011	May 2011	Sep 2011	Jan 2011	May 2011	Sep 2011	Jan 2011	May 2011	Sep 2011	Jan 2011	May 2011	Sep 2011	Jan 2011	May 2011	Sep 2011
M14-GL	420	410	390	2	1.9	2	58.9	57.6	63	0.58	0.59	0.56	8.6	8.31	8.42
M15-GU	800	840	720	23	25	24	84.7	81.6	80.6	0.47	0.5	0.45	7.49	7.29	7.33
Range of Concentrations	390 – 840			1.9 – 25			57.6 – 84.7			0.45 – 0.59			7.33 – 8.6		

mg/L = milligrams per liter
POC = point of compliance
SU = standard units
TDS = total dissolved solids
UBFU = Upper Basin Fill Unit

Table 14B-7. LBFU Water Quality Results for Nitrate as Nitrogen and Metals
February and March 2010

POC Well	Nitrate as Nitrogen (mg\L)	Arsenic (mg\L)	Barium (mg\L)	Chromium, total (mg\L)	Cobalt (mg\L)	Copper (mg\L)	Iron (mg\L)	Manganese (mg\L)	Nickel (mg\L)	Selenium (mg\L)
M14-GL	0.86	<0.001	0.018	0.003	0.0027	0.0013	<0.05	<0.005	<0.001	<0.002
M15-GU	6.1	0.0018	0.005	0.0017	<0.001	0.0015	<0.05	<0.005	0.0029	<0.002
Range of Concentrations	0.86 – 6.1	<0.001 – 0.0018	0.005 – 0.018	0.003 – 0.0017	<0.001 – 0.0027	0.0013 – 0.15	NA	NA	<0.001 – 0.29	NA

Note: Concentrations of aluminum, antimony, beryllium, cadmium, lead, mercury, thallium, and zinc were below the reporting limit for all POC wells screened in the LBFU.

mg/L = milligrams per liter

POC = point of compliance

NA = not applicable

Table 14B-8. LBFU Radionuclide Results, February and March 2010

POC Well	Alpha (pCi\L)	Ra-226 (pCi\L)	Ra-228 (pCi\L)	Radium (pCi\L)
M14-GL	2.3 ± 0.7	<0.5	<0.4	<0.5
M15-GU	5.8 ± 1.1	<0.3	<0.4	<0.4
Range of Concentrations	2.3 ± 0.7 to 5.8 ± 1.15	<0.3 to <0.5	NA	<0.4 to <0.5

pCi/L = picoCuries per liter

POC = point of compliance

Table 14B-9. 2010 Oxide Bedrock Unit Level 1 Water Quality Results

POC Well	TDS (mg\L)			Magnesium (mg\L)			Sulfate (mg\L)			Fluoride (mg\L)			Field pH (SU)		
	Jan 2011	May 2011	Sep 2011	Jan 2011	May 2011	Sep 2011	Jan 2011	May 2011	Sep 2011	Jan 2011	May 2011	Sep 2011	Jan 2011	May 2011	Sep 2011
M22-O	430	420	420	6.1	5.4	5.9	55.7	54.2	59.1	0.7	0.65	0.72	8.08	7.81	8.11
Range of Concentrations	420-430			5.4 – 6.1			54.2 – 59.1			0.65 – 0.72			7.81 – 8.11		

mg/L = milligrams per liter

POC = point of compliance

SU = standard units

TDS = total dissolved solids

UBFU = Upper Basin Fill Unit

Table 14B-10. Summary of Water Quality Results for Nitrate as Nitrogen and Metals in the Oxide Unit
February and March 2010

POC Well	Nitrate as nitrogen (mg\L)	Arsenic (mg\L)	Barium (mg\L)	Chromium, total (mg\L)	Cobalt (mg\L)	Copper (mg\L)	Iron (mg\L)	Manganese (mg\L)	Nickel (mg\L)	Selenium (mg\L)
M22-O	0.71	<0.001	0.0042	<0.001	<0.001	0.0012	0.069	0.014	<0.001	<0.002

Note: Concentrations of aluminum, antimony, beryllium, cadmium, lead, mercury, thallium, and zinc were below the instrument reporting limit for all POC wells screened in the Oxide Unit.

mg/L = milligrams per liter

POC = point of compliance

Table 14B-11. Summary of Radionuclide Results for the Oxide Unit
February 2010

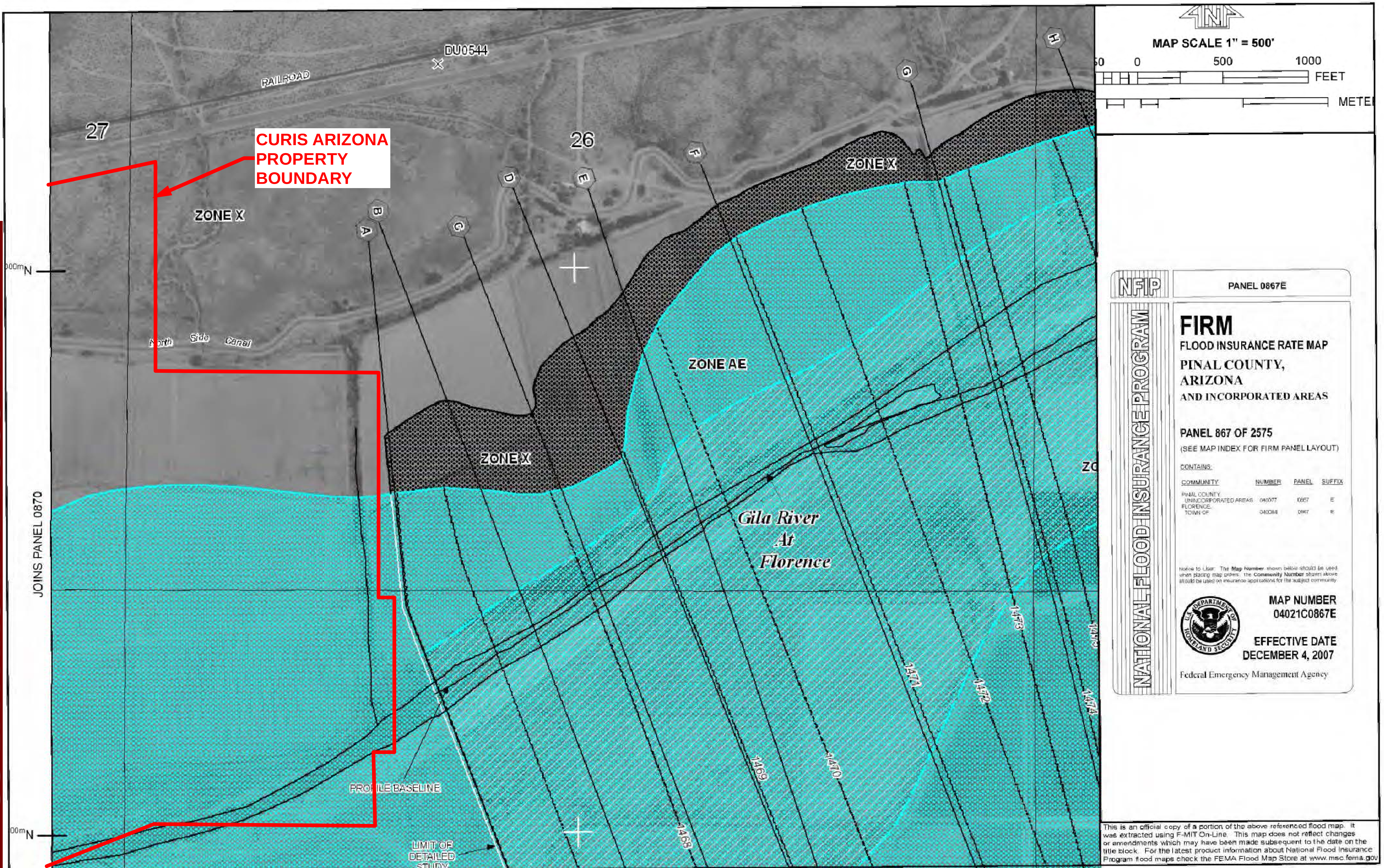
POC Well	Alpha (pCi\L)	Ra-226 (pCi\L)	Ra-228 (pCi\L)	Radium (pCi\L)
M22-O	4.4 ± 1.0	0.4 ± 0.1	<0.3	0.4 ± 0.1

pCi/L = picoCuries per liter

POC = point of compliance

EXHIBIT 14B-1

FIRM MAPS



MAP SCALE 1" = 500'
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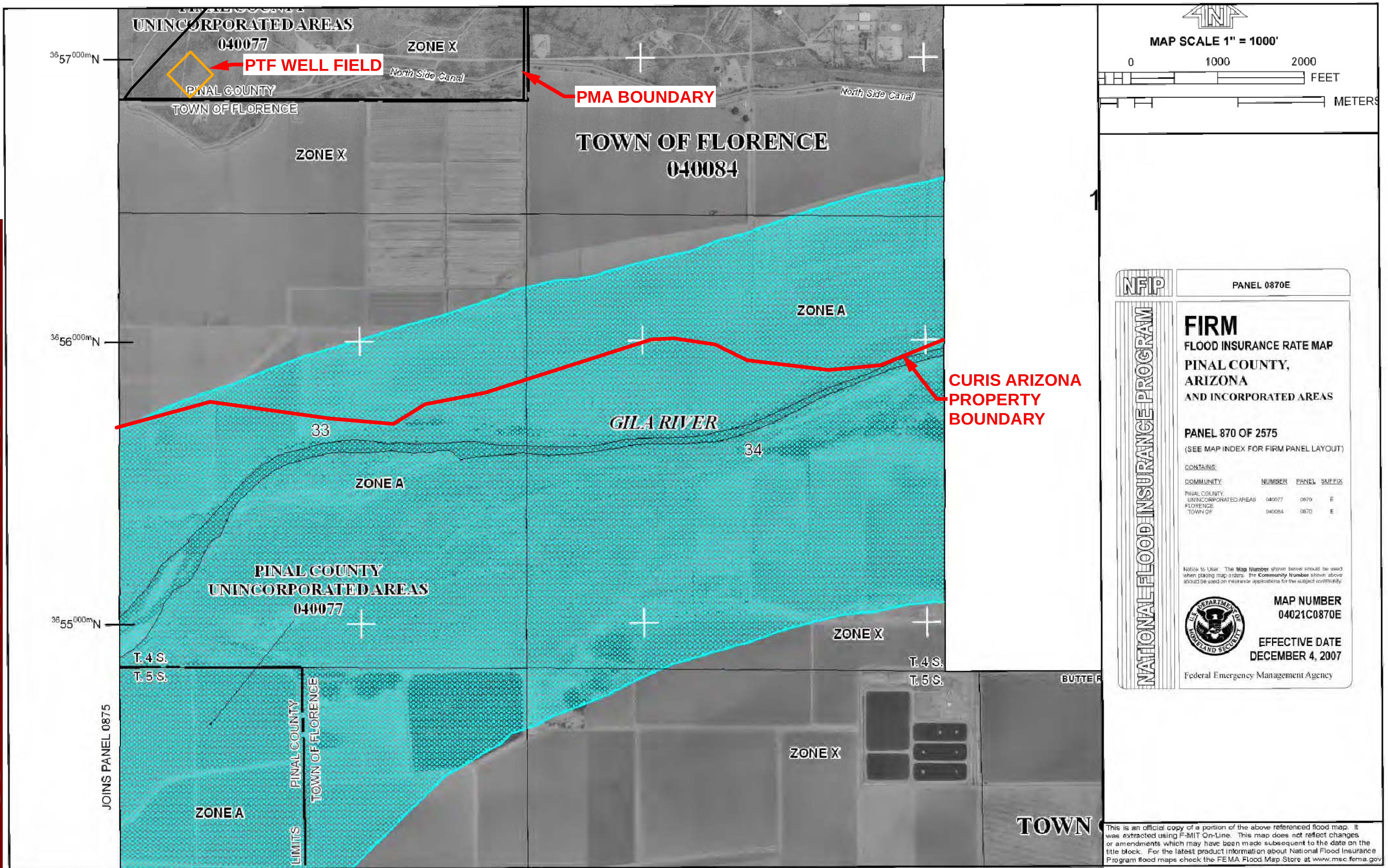
500
1000
FEET
DU0544
RAILROAD
27
26
CURIS ARIZONA PROPERTY BOUNDARY
ZONE X
ZONE X
ZONE X
ZONE AE
North Side Canal
Gila River At Florence
JOINS PANEL 0870
PROFILE BASELINE
LIMIT OF DETAILED STUDY
1468
1469
1470
1471
1472
1473
1474
NFIP
NATIONAL FLOOD INSURANCE PROGRAM
PANEL 0867E
FIRM
FLOOD INSURANCE RATE MAP
PINAL COUNTY, ARIZONA
AND INCORPORATED AREAS
PANEL 867 OF 2575
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)
CONTAINS:
COMMUNITY NUMBER PANEL SUFFIX
PINAL COUNTY UNINCORPORATED AREAS 040077 0867 E
FLORENCE, TOWN OF 040084 0867 E
MAP NUMBER 04021C0867E
EFFECTIVE DATE DECEMBER 4, 2007
Federal Emergency Management Agency
This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov



PINAL COUNTY UNINCORPORATED AREAS 040077
ZONE X
PTF WELL FIELD
North Side Canal
PINAL COUNTY
TOWN OF FLORENCE
PMA BOUNDARY
ZONE X
TOWN OF FLORENCE 040084
ZONE A
CURIS ARIZONA PROPERTY BOUNDARY
GILA RIVER
33
34
ZONE A
PINAL COUNTY UNINCORPORATED AREAS 040077
ZONE X
T. 4 S.
T. 5 S.
JOINS PANEL 0875
PINAL COUNTY
TOWN OF FLORENCE
LIMITS
ZONE A
ZONE X
BUTTE R
TOWN
MAP SCALE 1" = 1000'
0
1000
2000
FEET
METERS
NFIP
PANEL 0870E
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
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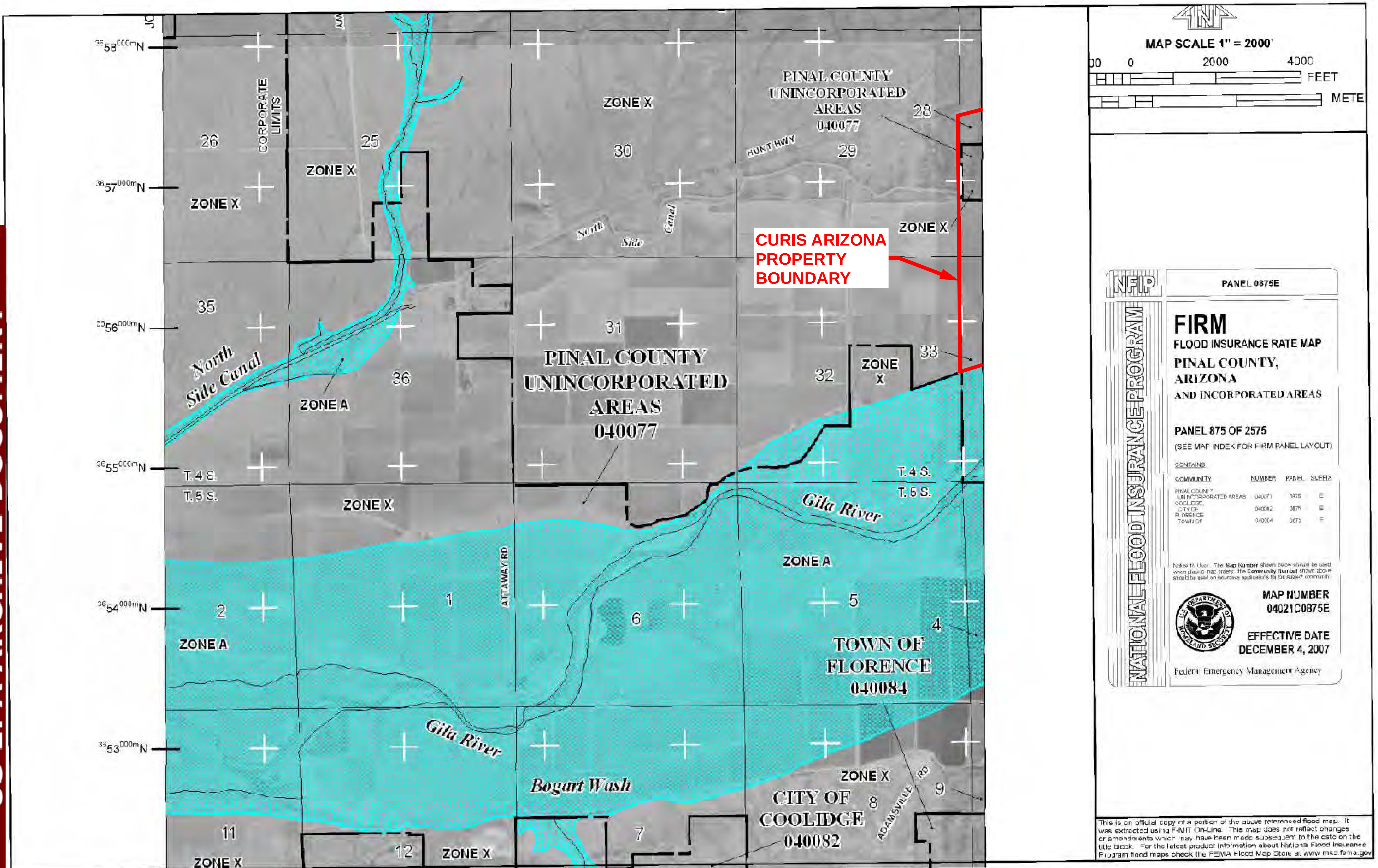
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2000
4000
FEET
CURIS ARIZONA
PROPERTY
BOUNDARY
PINAL COUNTY
UNINCORPORATED
AREAS
040077
TOWN OF
FLORENCE
040084
CITY OF
COOLIDGE
040082
ZONE X
ZONE A
North Side Canal
Gila River
Bogart Wash
HUNT HWY
ATTAWAY RD
ADAMSVILLE RD
CORPORATE LIMITS
T. 4 S.
T. 5 S.
NFIP
PANEL 0875E
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FLOOD INSURANCE RATE MAP
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DECEMBER 4, 2007
Federal Emergency Management Agency
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EXHIBIT 14B-2

ANALYTICAL RESULTS & QA/QC DOCUMENTATION

EXHIBIT 14B-3

FOCUSED FACILITIES INVESTIGATION

(BROWN AND CALDWELL, 1996)

FOCUSED FACILITIES INVESTIGATION
OCTOBER 1995

MAGMA FLORENCE IN-SITU PROJECT

JANUARY 1996

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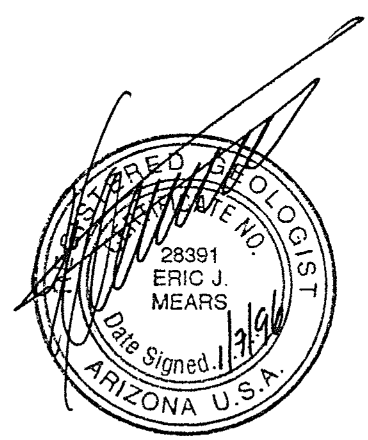

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SECTION 1.0

INTRODUCTION

Brown and Caldwell was retained by Magma Copper Company to perform a Focused Facility Investigation at the Magma Florence proposed in-situ leaching project located in Florence, Arizona. See Figure 1 for the facility location. The investigation concentrated on two specific areas at site: the pilot plant and mine shaft areas. See Figure 2 for the location of the pilot plant and mine areas.

1.1 PURPOSE AND LIMITATIONS

This report has been prepared for the exclusive use of Magma Copper Company for the sole purpose of assisting in evaluating potential environmental impairments associated with the existing property located at the Magma Florence proposed in-situ leaching project, Florence, Arizona. The findings presented herein are based upon observations of current operations and historical records. The conclusions presented herein are not necessarily indicative of future conditions or operating practices on this property. This document is not a Phase I site assessment, although some aspects of this investigation did follow the American Society for Testing and Materials (ASTM) Phase I standards.

In the course of this assessment, Brown and Caldwell has relied on information provided by outside parties, such as regulatory agencies and interview sources. For the purposes of this assessment, such third-party information is assumed to be accurate unless contradictory evidence is noted, and Brown and Caldwell does not express or imply any warranty regarding information provided by third-party sources.

Brown and Caldwell performed the following five tasks as part of this Focused Facility Investigation:

Task 1 Records Review - Obtained and reviewed records that identified *recognized environmental conditions* in connection with the property.

Task 2 Site Reconnaissance - Through site visits, obtained information indicating the likelihood of identifying *recognized environmental conditions* in connection with the property.

Task 3 Interviews - Obtained information regarding *recognized environmental conditions* through interviews with individuals familiar with the property.

Task 4 Limited Soil Sampling - Conducted limited soil sampling based on the results of Tasks 1, 2, and 3.

Task 5 Evaluation and Report Preparation - Prepared this report listing the findings of the above-listed tasks.

SECTION 2.0

SITE DESCRIPTION AND PHYSIOGRAPHIC FEATURES

The following subsections describe the conditions of the subject site and immediate surroundings as of October 31, 1995.

2.1 LOCATION AND LEGAL DESCRIPTION

The Florence Project is located in the Poston Butte mining district, approximately 2.5 miles northwest of the Town of Florence in Pinal County, Arizona. It is adjacent to a prominent hill known as Poston Butte which rises about 250 feet above the surrounding flat terrain. The project lies in Township 4 South, Range 9 East, Sections 27, 28, 33, and 34. The latitude and longitude for the in-situ mine area is described as 33° 02' 90" North and 111° 25' 70' West. Site location and site plan maps are presented as Figures 1 and 2, respectively.

2.2 SITE AND VICINITY CHARACTERISTICS

Magma intends to mine 1.7 billion pounds of copper oxide with a grade of 0.239 percent acid soluble copper and 0.339 percent total copper by in-situ mining techniques. The in-situ mining project at Florence, Arizona will be a closed-loop, self-contained, in-situ recovery system that is protective of the environment and economically viable. The planned surface facilities supporting the in-situ mine operation will consist of a solution extraction/electrowinning (SX/EW) process plant, including a tank farm and three impoundments as shown on Figure 1.1-2(I). Diluted sulfuric acid will be injected into the oxidized ore body and circulated until the pregnant leach solution (PLS) contains sufficient copper for processing by the SX/EW plant. Two of the three impoundments will be used to control flow into and out of the SX/EW plant. Kerosene will be used in the extraction process of the SX/EW plant. A third evaporation impoundment, with nine separate cells, will be used to retain salts produced during the mining operation.

2.3 PHYSIOGRAPHIC FEATURES

The following information is based on Brown and Caldwell's records review.

2.3.1 Topography

According to the United States Geological Survey (USGS), Florence Quadrangle 7.5-Minute Series Topographical Map, the surface land elevation is approximately 1,480 feet above mean sea level. The site topography slopes gently toward the southwest at a gradient of approximately 20 feet per mile.

2.3.2 Climate

The climate in the Florence area is typical of desert regions with low annual rainfall, high summer temperatures, and low relative humidity. Temperatures range from approximately 32 degrees F in January to 118 degrees F in July. Average annual rainfall is approximately 8 inches, with precipitation generally occurring in winter and summer. Flooding in the Gila River occasionally results from heavy local rainfall and releases from upstream reservoirs.

2.3.3 Local and Regional Geology

The Florence Project area is located in central Arizona within the Basin and Range Physiographic Province. The geology of this province is characterized by generally northwest-trending mountain ranges separated by valleys filled with sediments. The proposed in-situ mine area is situated in a basin near a transition zone between basin-fill deposits and bedrock outcrops. Igneous extrusive and intrusive rocks crop out within approximately 1 mile from the proposed in-situ area. The in-situ mine area is underlain by 400 to 800 feet of consolidated and unconsolidated basin-fill deposits, increasing in thickness to the west across the site. Bedrock located beneath the basin-fill deposits generally consists of igneous intrusive rock.

2.3.4 Local and Site Hydrogeology

In and around the Florence Project area, the occurrence and flow characteristics of groundwater have changed significantly in the past 100 years. Significant cultural effects influencing these changes include upstream dams, diversions of the Gila River, and development of municipal, industrial and agricultural land uses. Changes in the groundwater flow regime include declines in groundwater levels of up to several hundred feet, changes in regional groundwater flow direction in response to substantial groundwater pumping, and a change in the Gila River from being an aquifer discharge zone to an area of aquifer recharge during flood events. The primary aquifer component in central Arizona and in the vicinity of the proposed in-situ mine area is the basin-fill deposits.

The groundwater flow direction across the in-situ mine area is to the west-northwest. Depth to groundwater across the site ranges from approximately 100 to 150 feet below ground surface. Seasonal variations in depth to water of up to approximately 50 feet occur in the general area as the result of agricultural pumping in the summer months.

SECTION 3.0

RECORDS REVIEW

The objective of the records review was to obtain information in order to assist in the identification of *recognized environmental conditions* in connection with the subject property.

Two sub-tasks were undertaken in the records review:

- ***Environmental Records Sources*** - An environmental record search of federal and state records pertaining to the site and the surrounding area was conducted.
- ***Historical Use Sources*** - Aerial photographs, and US Geological Survey (USGS) 7.5 Minute Topographic Maps were reviewed.

3.1 ENVIRONMENTAL RECORDS SOURCES

At the request of Brown and Caldwell, Environmental Data Resources, Inc. (EDR) conducted a review of state and federal records for information relating to the subject site and surrounding properties. Database types and search distances from the subject site are described in Table 3-1. The complete report provided by EDR is included in Appendix A.

Table 3-1. Environmental Database Descriptions and Search Distances

Database	Search Radius (miles)	Description
National Priorities List (NPL)	1.25	United States Environmental Protection Agency (USEPA) listing of uncontrolled or abandoned hazardous waste sites. These sites are listed as sites qualifying for possible long-term remedial action under the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS).
CERCLIS	0.75	USEPA listing of known or suspected uncontrolled hazardous waste sites. These sites have been investigated or are currently under investigation as WPL candidates.
Resource Conservation and Recovery Information System (RCRIS)	SG[a] 0.50 LG[b] 0.50 TSD[c] 1.25	USEPA listing of facilities regulated by Resource Conservation and Recovery Act (RCRA) that generate, store, dispose, or treat hazardous waste.
Emergency Response Notification System (ERNS)	Subject Property	USEPA listing of sudden and/or accidental release of hazardous substances, including petroleum into the environment.
Underground Storage Tank (UST) Program	0.50	Arizona Department of Environmental Quality's (ADEQ) listing of all registered USTs in Arizona.
Leaking Underground Storage Tank (LUST) Program	0.75	ADEQ's listing of all reported LUSTs in Arizona.

Table 3-1. Environmental Database Descriptions and Search Distances		
Database	**Search Radius (miles)**	**Description**
Arizona Hazardous Waste Sites (HWS) List	1.25	ADEQ's listing of confirmed or suspected hazardous waste sites.
Arizona Solid Waste Facility (SWF) List	0.75	ADEQ's listing of all opened and closed solid waste disposal facilities in Arizona.
Drywell Registration (DRL) List	Subject Property	ADEQ's listing of registered drywells.
Water Quality Assurance Revolving Fund (WQARF)	1.0	ADEQ's listing of State Superfund sites.
Toxic Substances Control Act (TSCA) Regulated Facilities	Subject Property	EPA's database of manufacturers and importers of chemical substances included on the TSCA Chemical Substance Inventory list.
Arizona Spills	Subject Property	ADEQ's Emergency Response Unit documents chemical spills and incidents which are referred to the unit.

[a] SG - small-quantity generators
[b] LG - large-quantity generators
[c] TSD - treatment, storage, disposal facilities

A summary of database search findings is presented in Table 3-2.

Table 3-2. Database Search Findings						
Database	**Number of Sites Listed for the Subject Property**	**Number of Sites Listed with a Specific Radius From the Subject Property**				
		< 0.125 miles	**0.125 to 0.25 miles**	**0.25 to 0.5 miles**	**0.5 to 1.0 miles**	**Total Sites Listed on Database Search**
NPL	0	0	0	0	0	0
CERCLIS	0	0	0	0	-	0
RCRIS -TSD	0	0	0	0	0	0
RCRIS -LG	0	0	0	-	-	0
RCRIS -SG	0	0	0	-	-	0
ERNS	0	-	-	-	-	0
UST	0	0	0	-	-	0
LUST	0	0	0	0	-	0
SWF	0	0	0	0	-	0
HWS	0	0	0	0	0	0
DRL	0	-	-	-	-	0
TSCA	0	-	-	-	-	0
Arizona Spills	0	0	0	0	0	0

3.2 DATABASE FINDINGS

3.2.1 NPL Database

The NPL is a list of sites prioritized for cleanup under the Superfund Program. EDR did not identify any sites listed on the NPL database that are located within a 1.25-mile radius of the target site.

3.2.2 CERCLIS Database

The CERCLIS is a database of facilities that the USEPA considers to be potential superfund sites. If the EPA's preliminary assessment and site investigation results indicate that the site is a candidate for remediation, then the site is ranked for placement on the Superfund NPL. EDR did not identify any sites listed on the CERCLIS database within 0.75 miles of the target site.

3.2.3 RCRIS-SG/RCRIS-LG

The USEPA maintains RCRIS-SG and RCRIS-LG databases that track facilities generating hazardous waste. RCRIS-SG facilities generate between 100 to 1,000 kilograms (kg) of hazardous waste per month, whereas RCRIS-LG facilities generate quantities greater than 1,000 kg of hazardous waste per month.

EDR did not identify sites listed on the RCRIS-SG or RCRIS-LG databases located within a 0.50-mile radius of the target site.

3.2.4 RCRIS-TSD Databases

The USEPA maintains the RCRIS-TSD database which contains information pertaining to facilities that either treat, store, or dispose of hazardous waste.

EDR did not identify any sites in the RCRIS-TSD database located within a 1.25-mile radius of the target site.

3.2.5 ERNS Database

The ERNS database is maintained by the USEPA. This system is used to store information on the sudden and/or accidental release of hazardous substances into the environment.

EDR's review found no cases of emergency response notification within the target site.

3.2.6 UST List

The ADEQ maintains a comprehensive listing of all registered USTs in the State of Arizona. EDR did not identify any sites in the UST database located within a 0.50-mile radius of the target site.

3.2.7 LUST List

The ADEQ maintains a list of sites known to have LUSTs. EDR did not identify any sites in the LUST database located within a 0.75-mile radius of the target site.

3.2.8 SWFs

ADEQ maintains a listing of all opened and closed solid waste landfills in Arizona. EDR's review of the list did not identity any sites on the State Landfill List within a 0.75-mile radius of the target site.

3.2.9 HWSs

ADEQ maintains a listing of facilities that are deemed hazardous. This listing is also known as the Arizona CERCLA Information Data System (ACIDS). These sites failed to meet all of the applicable requirements to be included on the federal EPA's CERCLIS list. EDR's review did not identify any sites on the ACIDS within a 1.25-mile radius of the target site.

3.2.10 Drywell Registration List (DWL)

Drywells are typically constructed solely for the disposal of stormwater. However, through intentional or inadvertent releases, regulated substances may sometimes be discharged to the sub-surface through a drywell. Consequently, Arizona State statutes now require that the owner of a drywell register it with ADEQ.

EDR's review of the listing indicates that there are no registered drywells located on the target site.

3.2.11 TSCA Chemical Substance Inventory List

The USEPA maintains a database on manufacturers and importers of chemical substances regulated by TSCA.

EDR's review of the database indicates there are no facilities regulated by TSCA on the target site.

3.2.12 Arizona Spills

The ADEQ Emergency Response Unit documents, into a Hazardous Materials Logbook, chemical spills and incidents which are referred to the unit. The logbooks track the location, date, chemical, and quantity of each incident.

EDR's review of the Arizona Spills' database indicates that no reported spills occurred on the target site.

3.2.13 Additional Records Review

In addition to the records review performed by EDR, Brown and Caldwell researched the WQARF file maintained by the ADEQ.

3.2.13.1 WQARF

The WQARF is Arizona's equivalent of the federal "Superfund." WQARF is used for payment of reasonable costs for cleanup actions when contamination affects, or potentially affects, waters of the state, and when responsible parties are unknown or do not clean up the contamination.

This site is not in a WQARF site according to the ADEQ listing of WQARF and Federal Superfund Programs dated May 1995.

3.3 HISTORICAL USE SOURCES

The objective of reviewing historical sources was to evaluate the previous uses or occupancies of the subject site and the surrounding area in order to assess those uses and occupancies that are likely to lead to *recognized environmental conditions* in connection with the subject site. Standard historical sources listed and their availability for the study site are listed in Table 3-3.

Table 3-3. Listing of Historical Sources and Availability

Historical Sources as Required by ASTM E•1527-94	Available for this Site	Source of Information
Aerial Photographs	Yes	Florence mine files
USGS 7.5-Minute Maps	Yes	USGS
Other Historical Sources	Yes	Interviews with person(s) familiar with property

3.3.1 Zoning/Land Use Information

Subject Site

Mining has a statutory exemption from zoning as noted in Section 303 of the Pinal County Zoning Ordinance.

3.3.2 USGS 7.5 Minute Maps

Brown and Caldwell reviewed the USGS Florence Quadrangle map. This map was produced in 1969. This map does not show any significant detail relating to the subject property.

SECTION 4.0

SITE DESCRIPTION

4.1 THE PILOT MINE

To facilitate metallurgical, mining, and geological investigations, an underground pilot mine was developed through two (2) 700-foot drilled shafts. The pilot mine was reportedly located in a unique area of the ore body to intercept both oxide and sulfide ores at a single drift elevation.

The pilot mine utilized a 250-horsepower Vulcan double drum hoist with a combination hoist house, shop, and change room located at the 72-inch diameter production shaft.

The 42-inch emergency and ventilation shaft installation included a smaller headframe with a 20-horsepower emergency hoist, diesel generator, and a 40-horsepower exhaust fan.

Two transformers were located in the main substation for mine operation. A 1,500 kilovoltampere (kVa) transformer was installed to operate the main hoist and power the underground workings. A smaller 500 kVa transformer was installed to power the remaining surface equipment and lighting.

Underground mining began on December 29, 1974 and ended on December 23, 1975. An average production rate of approximately 250 tons per day was achieved with mined ore being transported by haul trucks for pilot plant processing. Slightly greater than 5,400 feet of drifts were developed during mine operation, resulting in approximately 31,700 tons of oxide ore, 16,900 tons sulfide ore, and 1,500 tons of waste rock production.

All mining equipment, rail, piping, pumps, and electrical service was removed from the mine and shaft following the termination of mining operations. When salvaging was completed, the mine was allowed to flood and surface facilities were dismantled.

4.2 THE PILOT PLANT

The pilot plant site is the location of the administration, process, and maintenance buildings in addition to various structures relating to the processing of oxide and sulfide ore. Magma documents indicate that the mine and pilot plant operated for approximately 1 year from 1975 to 1976. Refer to Figure 2 for the location of the pilot plant.

4.3 OPERATIONAL SUMMARY

The pilot plant site can be subdivided into several discrete operating areas including the crushing circuit; vat leach area; solution extraction (SX) area; process building; administration and warehouse buildings; and various support, utilities, and storage facilities. Refer to Figure 3 for details of the pilot plant. The following operational description has been summarized from Volume V of the Phase III Feasibility Study prepared for the Conoco Minerals Department in 1976.

4.3.1 Crushing Circuit

Ore was transported via truck and stockpiled directly adjacent to the western boundary of the pilot plant where separate stockpiles were maintained for both the sulfide and oxide ore types. A front-end loader was utilized to place ore into the hopper and apron feeder (Figure 3).

The apron feeder then directed ore to the primary crushing circuit where discharge could either be directed to a waste stockpile for road materials or to the secondary crushing circuit. Desired materials from the primary jaw crusher were conveyed to a double-deck vibrating screen where oversized materials would be directed to the secondary cone crushing circuit. Discharge from the cone crusher would be returned to the discharge from the primary jaw crusher. Undersized material from the double-deck vibrating screen was further processed in the roll crusher.

Discharge from the roll crusher was conveyed to the transfer tower where it was directed either to the vat leaching unit, the vat leaching unit via a desliming (spiral) classifier, or the fine ore bins.

4.3.2 Oxide Vat Leaching

Conoco operated the 100-ton per day vat leaching plant for 9-1/2 months from March 31, 1975 to January 15, 1976.

Crushed oxide ore was conveyed directly to the ten (10) leaching vats via an overhead conveyor from the transfer tower and a shuttle conveyor over the leaching vats (Figure 3). Approximately 90 to 100 tons of ore were placed in the individual concrete vats for leaching operations using either upflow or downflow conditions.

Raffinate was introduced to the vats and was apparently circulated through a group of vats in series for approximately six cycles. Pregnant leach solution (PLS) was then transferred to the unclarified PLS tank for use in the southern SX circuit. Leached ore was rinsed three times to remove any PLS residue with the last rinse consisting of fresh water.

Leach residue was removed by loader from the side doors located on the east side of the vats. The residue was loaded into trucks and transferred to the oxide tailings pond (Figure 3) located in the northeast corner of the pilot plant area.

The entire vat leach area was built on a concrete slab with acid-resistant coating. Built-in channels and sumps captured any spillage from the area and returned the liquids to the leach vats or the oxide tailings pond.

4.3.3 Solution Extraction (SX)

Unclarified PLS from vat leaching operation was pumped from a storage tank through a clarifying filter for the removal of suspended particulates. Clarified PLS was transferred from a storage tank to the first stage of the four stage SX circuit. Please refer to Figure 4 for details of the SX area.

Loaded organic from the extraction circuit was pumped to a storage tank and was then transferred to the first stage of the stripping circuit. The stripped organic was then transferred to a tank and then returned to fourth stage of the SX circuit.

Conoco experimented with numerous commonly-available copper extractants and ion exchange solvents to improve copper recovery during the extraction process. The chemical composition of these additives or the volumes consumed during the operation of the pilot plant are not presently known but is generally discussed in Volume V of the Phase III Feasibility Study

All equipment in the SX area, with the exception of tanks and transfer piping, was located in a lined concrete containment area. Any fluid release from the SX area could either be pumped to individual storage tanks or discharged into the tailings ponds. Releases from the transfer piping or storage tanks, if any, would contact native soils in the SX area.

4.3.4 Oxide Agitation Leaching

Conoco experimented with an agitation leach (AL) process as an alternative to the vat leaching. The AL process reportedly operated for approximately 11 months at an average capacity of approximately six (6) tons per day.

Fine crushed ore from the ore bins fed two rod mills located in the process building. The rod mills operated in either a closed or open circuit with the discharge from the two rod mills being directed to the pH-adjusted agitated tank.

A four tank leach circuit was operated in the process building and PLS from the circuit was pumped to an unclarified PLS storage tank. Following filtration, the clarified PLS was stored in a 33,000-gallon tank for processing in the northern SX circuit (Figure 4).

Fluid releases in the process building, with the exception of the reagent mixing area, would flow to lined sumps in the concrete floor. Sump discharge could be directed to storage tanks in the process building or tailings ponds located in the eastern portion of the pilot plant.

The northern extraction circuit has four stages and the stripping circuit had three stages. As with the southern (vat leach) SX area, all equipment in the northern (agitation leach) SX area, except for tanks and transfer piping, was located in a lined concrete containment area. Any fluid release from the SX area could be pumped to individual storage tanks or discharged into the tailings ponds. Releases from the transfer piping or storage tanks, if any, would contact native soils in the northern SX area.

4.3.5 Electrowinning (EW)

Conoco operated a single electrowinning (EW) cell from April 1975 to June 1976. This cell received pregnant electrolyte from both (agitation and vat leaching) SX circuits. Total EW cathode production exceeded 104,000 pounds averaging 99.9 percent copper.

Cell feed solution was pumped from a storage tank to the EW cell. Spent electrolyte overflowed from the cell to a lined sump in the process building where it was recycled back to the cell feed pump or discharged into the spent electrolyte storage tank.

The EW plant was completely enclosed in the process building which was built in a lined and bermed concrete containment area. Spills or EW cell overflow was directed to a lined sump.

4.3.6 Sulfide Flotation

Conoco operated a fifty (50) ton-per-day conventional flotation sulfide pilot plant from April 30 to November 17, 1975.

Two fine sulfide ore storage bins, located intermediate of the process building and transfer tower (Figure 3), discharged fine ore to the process building via belt conveyor. Belt discharge was directed to a ball or rod mill located in the process building.

Process water and various grinding agents were manually metered into the mill feed. Rod mill discharged in a closed circuit with the ball mill to a classifier where sands would be redirected to the ball mill. Classifier overflow would be directed to the rougher flotation circuit or to a cyclone in closed circuit with the ball mill and classifier overflow.

Concentrates from the four-stage rougher flotation cells would be thickened and pumped to a regrind mill in closed circuit with a classifier. The discharge from this circuit went to the first and second stage flotation cleaning and scavenger flotation circuit.

The copper concentrate from the second stage cleaning was thickened, filtered, and discharged to the concentrate storage bin. Tailings from the roughing and scavenging units were combined and thickened in a 33,000-gallon tailings thickener tank. Underflow from the thickener was directed to the sulfide tailings pond located in the southeast corner of the pilot plant (Figure 3). Water reclaimed in the thickener was reused in the concentrator process.

With the exception of the fine ore bins and the 33,000-gallon tailings thickener, all sulfide operations were located in the process building. Releases in the process building, with the exception of the reagent mixing area and the concentrate storage bin, would flow to lined sumps in the concrete floor. Sump discharge could be directed to storage tanks or tailings ponds located in the eastern portion of the pilot plant.

Releases in the reagent mixing area would flow to a floor drain and discharge to the chemical and sanitary pond located in the tailings pond area (Figure 3). Spills at the concentrate storage bin, if any, would impact native soils adjacent to the process building.

4.3.7 Operations and Shop and Warehouse Buildings

The operations building contains offices for administrative and technical staff, laboratories for analytical and metallurgical testing, and sample preparation and core analysis rooms. Refer to Figure 3 for the location of the operations building.

Sanitary and chemical waste from the operations building were historically discharged to the chemical and sanitary pond located in the northeast portion of the pilot plant site. Sanitary waste was conveyed via a sewage lift station into a prefabricated aerobic digester (Figure 3). Effluent from the digester, in addition to chemical waste from the analytical and metallurgical laboratories, was then discharged to the chemical and sanitary pond.

Presently, no chemical wastes are discharged from the operations building. Sanitary wastes are currently discharged to an in-ground septic system and leach field located to the east of the operations building.

The warehouse building (Figure 3) is a steel-framed structure located in the north-central portion of the pilot plant. The structure formerly housed core storage areas and maintenance facilities for servicing plant and mobile equipment. Separate areas were located in this building for instrument storage and repair as well as change room facilities for plant personnel.

Sanitary waste formerly discharged from the warehouse building was directed to the prefabricated aerobic digester (Figure 3). Effluent from the digester was then discharged to the chemical and sanitary pond. No floor drains or sumps are located in the warehouse building.

SECTION 5.0

FACILITY INSPECTION

Brown and Caldwell personnel inspected the pilot mine and mill site on October 2, 5, 11, 12, and 16, 1995. On October 12, 1995 our visit was accompanied by Mr. Jim McBroom of the Magma Copper Company.

The subject property can be subdivided into two areas consisting of the pilot mine and the pilot plant. Refer to Figure 2 for the location of these areas. The following sections describe our observations during the inspection of these two areas.

5.1 PILOT MINE AREA

Presently, most of the surface structures have been removed from the mine site. Concrete foundations are present at the former locations of the mine headframe and change house. A concrete pad surrounded by four wooden poles is located at the former electrical service area located south of the mine shaft. Several pole-mounted electrical transformers were located in this area during mine operations. Refer to Figure 5 for details of the pilot mine area.

Both the mine and ventilation shafts are covered by steel plates and the concrete pads surrounding these areas are fenced. Several mine cars and one locomotive are presently stored within the fenced area of the mine shaft. Mr. McBroom indicated that neither the mine nor ventilation shafts have been closed.

Some minor oil staining was noted on the concrete transformer pad. There were no other indications of potential environmental impacts at this location.

5.2 PILOT PLANT AREA

As previously noted, the pilot plant site is the location of the administration, process and maintenance buildings in addition to various structures relating to the processing of oxide and sulfide ore. Refer to Figure 2 for the location of the pilot plant.

A discussion of the pilot plant site inspection has been subdivided into the discrete operating areas including the crushing circuit; vat leach area; solution extraction (SX) area; process building; administration and warehouse buildings; and various support, utilities, and storage facilities. Refer to Figure 3 for details of the pilot plant area.

The following sections detail our observations of these aforementioned pilot plant operating areas.

5.2.1 Crushing Circuit

At least three separate stockpiles of sulfide, oxide and waste rock materials totalling approximately 10,000 cubic yards are presently located near the western property boundary. No significant indications of acid mine drainage, distressed vegetation, or materials oxidation were noted during our inspections.

The crushing circuit was electrically-driven and operated from an electrical control building. Refer to Photo 13 of Figure 12 for a picture of the electrical control building. It was not determined if the electrical components within the control building contained polychlorinated biphenyls (PCBs).

Our inspection of the crushing circuit revealed no other significant environmental concerns. Refer to Photo 1 of Figure 6 for a picture of the crushing circuit.

5.2.2 Main Water Supply

The facility utilizes a 50,000-gallon above-ground steel tank as the nonpotable facility water supply and fire protection. Refer to Figure 3 for the tank location.

The fire protection system is run by a diesel-powered pump and storage tank located adjacent to the water tank. Soil staining was noted below the location of the 500-gallon above-ground diesel tank. Refer to Photo 2 of Figure 6 for a picture of the fire protection system.

5.2.3 Vat Leaching Area

As previously discussed, the entire area surrounding the Vat Leach area was lined with coated concrete. Any fluid discharges in the vat leach area would be collected in the lined sumps and returned to the process area or discharged to the oxide tailings pond.

An inspection of the raffinate and pregnant leaching solution tanks located to the west of the vat leach area indicated no evidence of a release. An inspection of the former sulfuric acid tank and lime pit location revealed significant soil and concrete staining. Refer to Photo 5 of Figure 8 for a picture of the acid storage area and vat leach area.

5.2.4 Solution Extraction (SX) Area

As previously noted, all equipment in the SX area, with the exception of tanks and transfer piping, was located in a lined concrete containment area. Any fluid release from the SX area could be captured and pumped to individual storage tanks or discharged into the tailings ponds. Although not well documented, MP Environmental was reportedly retained subsequent to Magma's acquisition of the property to decommission the SX equipment within the pilot plant. Several manways were observed to have been cut into the fiberglass tanks at the facility and no significant liquid or sludge residues were noted within these tanks. Hazardous waste manifests are present in the facility files which document the transport and disposal of tank contents.

An inspection of the SX area indicated no evidence of a release, except for the 1,200-gallon loaded organic tank which revealed some staining of the tank and underlying concrete pad and soils. Refer to Photo 3 of Figure 7 for a picture of the SX area.

5.2.5 Process Building

As discussed, Conoco operated three systems within the process building. These included agitation leaching of oxide ore; flotation of sulfide ore; and electrowinning. Refer to Figure 3 for the location of the process building.

Fluid releases in the process building, with the exception of the reagent mixing area, would flow to lined sumps in the concrete floor. Refer to Photo 7 of Figure 9 for a picture of a typical sump in the process building. Sump discharge could then be directed to the process units, storage tanks, or tailings ponds located in the eastern portion of the pilot plant.

Releases in the reagent mixing area would flow to a floor drain and discharge to the chemical and sanitary pond located in the tailings pond area.

An inspection of the process area indicated no evidence of a release, except for minor staining of the concrete pad and underlying soils adjacent to the concentrate storage area. Refer to Photo 8 of Figure 9 for a picture of the concentrate storage area.

In addition, no evidence of a release was noted near the 33,000-gallon tanks containing sulfide tailings, clarified PLS, or raffinate. Refer to Photo 4 of Figure 7 for a picture of a typical 33,000-gallon storage tank.

5.2.6 Sulfide and Oxide Tailings

As previously mentioned, Conoco utilized two unlined tailings impoundments for the disposal of sulfide and oxide tailings. Sulfide and agitation leach oxide tailings were piped in slurry to their respective impoundments in above-ground piping while the vat leach oxide tailings were transported to the oxide impoundment with trucks.

Our observations of the area indicated that the tailings impoundments were in relatively sound condition with no significant erosion or damage. Both tailings impoundments were approximately fifty (50) percent filled. Although some vegetation was encountered in both the tailings impoundments, significantly more vegetation was noted in the sulfide area.

No significant indications of acid mine drainage, tailings oxidation or distressed vegetation were noted during our inspections. Refer to Photos 11 and 12 of Figure 11 for pictures of the sulfide and oxide tailings, respectively.

5.2.7 Operations and Shop and Warehouse Buildings

As discussed, the operations building contains offices for administrative and technical staff, laboratories for analytical and metallurgical testing, and sample preparation and core analysis rooms.

The warehouse building formerly housed core storage areas and maintenance facilities for servicing plant and mobile equipment. Separate areas were located in this building for instrument storage and repair as well as change room facilities for plant personnel. Refer to Figure 3 for the location of the operations and warehouse buildings.

Our inspection of the operations building revealed numerous unused containers of chemical reagents previously utilized in the metallurgical and analytical laboratories. In addition, one empty 5-gallon plastic container was marked with "Uranium Leach Liquor."

Our inspection of the warehouse building indicated that the facility is currently being used to stockpile core, drilling supplies and other miscellaneous equipment. No floor drains or sumps are located in the warehouse building.

No other significant environmental concerns were noted in the warehouse or operations buildings.

5.2.8 Chemical and Sanitary Pond

Sanitary waste from the administration and warehouse buildings were historically discharged to the chemical and sanitary pond located in the northeast portion of the pilot plant site. Sanitary waste was treated in a prefabricated aerobic digester (Figure 3) prior to pond discharge. Refer to Photo 6 of Figure 8 for a picture of aerobic digester.

Chemical wastes from the analytical and metallurgical laboratories and the reagent mixing area in the process building were also discharged to the chemical and sanitary pond via the chemical pumping station. Refer to Photos 9 and 10 of Figure 10 for pictures of the chemical and sanitary pond and chemical pumping system.

Our observations of the area indicated that the unlined impoundment was in relatively sound condition with no significant erosion or damage. Significant vegetation was encountered in the impoundment area.

No significant indications of distressed vegetation, soil discoloration or unusual odors were noted during our inspection of the chemical and sanitary pond.

5.2.9 Support Areas

Several areas along the southern boundary of the pilot plant site are currently utilized to store drilling supplies; previously decommissioned pilot plant equipment; drill cuttings and ore, rock and tailings samples for metallurgical testing; several empty steel and fiberglass tanks, and several 55-gallon drums containing petroleum and other chemical liquids. Refer to Figure 3 for the location of these equipment storage areas.

As discussed in greater detail in Section 6.0, miscellaneous equipment associated with a previously-abandoned mine project in Yuma, Arizona is currently stored in the southwest corner of the facility. This equipment includes a portable crushing plant and conveyor, a portable 20,000-gallon diesel above ground storage tank (AST), numerous agitation leach cylinders and other equipment associated with the mine and subsequent gold leaching pilot test.

Magma personnel are actively working in this area to organize the stored materials and properly dispose of solid wastes and 55-gallon drums. Our inspection of the area noted no significant soil staining, unusual odors, or distressed vegetation. Refer to Photo 14 of Figure 12 for a picture of the equipment storage area.

SECTION 6.0

INTERVIEWS

Brown and Caldwell conducted several personnel interviews regarding operations at the Florence pilot plant and mine. Personnel interviewed had previously worked at the facility or were knowledgeable about the previous and current activities at the site.

Although not specifically cited in this section, numerous discussions with Mr. Jim McBroom, Project Technician at the Florence project, were conducted during our facility inspections and records review. Specific information obtained from Mr. McBroom is detailed in Sections 4 and 5 of this report.

The following sections detail our discussions with these individuals.

On October 4, 1995 Mr. Fred Celaya of the Magma Copper Company was interviewed. Mr. Celaya reported that he had worked on a single polychlorinated biphenyl (PCB) issue with Mr. Jim Glasston, then at MP Environmental, and Mr. Fred Hays of Magma Copper.

On October 6, 1995, Mr. Glasston, now of Magma Copper Company, was interviewed. Mr. Glasston is currently an Environmental Engineer at the San Manuel Facility, but had previously worked for MP Environmental (MP) on the Florence Project.

Mr. Glasston indicated that he worked on two projects at Florence while he was with MP. The first project related to a PCB spill and cleanup resulting from fallen transformers on September 6, 1993. His activities were documented by MP in the October 5, 1993 Report of Fallen Transformers.

Mr. Glasston also reported that he supervised the pilot plant decommissioning for MP. He stated that, at the direction of Mr. Hays, process tanks and vessels were sampled and decontaminated.

He also stated that some residual products, including sulfuric acid and organic lixiviate, were transported to the San Manuel facility for reuse. Other waste materials were reportedly transported and disposed of as hazardous waste. Copies of the uniform hazardous waste manifests are located in the facility files.

On October 11, 1995 Mr. Dick Bean of the Magma Copper Company was interviewed. Mr. Bean reported that he was directed by Magma, following the facility acquisition, to inventory the metallurgical and chemical laboratories in the operations building.

During his inspection and inventory, Mr. Bean reported that he encountered a 5-gallon plastic container marked "Uranium Leach Liquor." He added further that many oil companies were actively developing uranium mineral deposits in the 1970s, and his initial concern was that uranium ore processing had occurred at the facility.

On November 17, 1995, Mr. Bob Linton of the Magma Copper Company was interviewed. Mr. Linton worked at the Florence Facility for Conoco from 1975 to 1988 and is presently an electrician at the Magma San Manuel Mine. In his capacity as field and maintenance supervisor at Florence, Mr. Linton was knowledgeable of most operational issues at both the mine and pilot plant locations.

Mr. Linton stated that many companies expressed an interest in leasing or buying the pilot plant following the cessation of Conoco operations but no agreements were ever formalized. In fact, he stated that several companies forfeited cash deposits on the property when purchase or lease negotiations were terminated.

Although no other companies reportedly utilized the pilot plant, Mr. Linton stated that Conoco had experimented with an agitation leach process at the facility. He stated that Conoco had transported from 100 to 300 tons of gold-bearing ore from the Burselam (spelling unknown) mine near Yuma, Arizona. This ore was reportedly tested in the southwest corner of the pilot plant facility using a cyanide agitation leach process. Mr. Linton stated that all process liquids were contained in tanks or were stored in plastic-lined pits excavated in the test area.

The test was reportedly discontinued when the leaching process was determined to be ineffectual. The portable crushing plant and other equipment used at the mine site, in addition to the process equipment used for the agitation leach test, is currently stored in the southwest corner of the pilot plant facility.

Mr. Linton identified the previous locations of several gasoline and diesel fuel storage tanks at the facility. He stated that up to four (4) tanks were located at the property. The following paragraphs summarize Mr. Linton's statements regarding fuel storage at the property.

An underground gasoline storage tank (UST) of unknown size was formerly located north of the warehouse building at the pilot plant. This UST was reportedly tested and removed in 1988. No evidence of a release was noted by Mr. Linton.

A 20,000-gallon aboveground diesel storage (AST) was reportedly used by the mining contractor at the site. The AST was apparently located next to the headframe and was used from approximately 1975 to 1976. The AST was subsequently removed by the contractor when mining activities were discontinued at the site. Mr. Linton recalled that no fuel spills occurred at the AST location.

Mr. Linton stated that two (2) additional USTs were utilized at the facility following mine and plant closure. These tanks were located on Magma-owned ranch land which is presently leased to the Terry Brothers. Mr. Linton stated that these tanks were approximately 5,000- and 3,000-gallons in size and supplied both gasoline and diesel fuels. Mr. Linton also reported that these tanks were in service when he left the property in 1988.

On November 20, 1995, Mr. John Kline of the Magma Copper Company contacted Mr. Tim Terry at the Magma-owned ranch property in Florence. Mr. Kline reported that Mr. Terry had removed the 8,000- and 10,000-gallon USTs in 1992. Mr. Terry reportedly stated that no soil sampling was conducted but that no release was evident at the former tank locations.

SECTION 7.0

FACILITIES INSPECTION SUMMARY

Brown and Caldwell has prepared the following summary of significant environmental issues resulting from the focused facilities inspection. Results of these investigations are summarized below. Specific areas relating to the historic operations of the mine and pilot plant have been subdivided into two sections to simplify this discussion.

7.1 PILOT MINE AREA

As previously discussed, minor oil staining was noted on the concrete transformer pad located adjacent to the former headframe location. This suggests that oils contained within transformers used at the mine may have been released to this area.

Based on these observations, Brown and Caldwell recommends that this area be sampled to determine if a significant transformer release has occurred in the area.

7.2 PILOT PLANT AREA

As previously noted, the pilot plant site is the location of the administration, process and maintenance buildings in addition to various structures relating to the processing of oxide and sulfide ore (Figure 2).

A discussion of the pilot plant issues has been subdivided into the discrete operating areas including the crushing circuit; vat leach area; solution extraction (SX) area; process building; administration and warehouse buildings; and various support, utilities, and storage facilities (Figure 3).

7.2.1 Crushing Circuit

As previously noted, approximately 10,000 cubic yards of stockpiled waste rock and sulfide and oxide ore are presently located adjacent to the crushing circuit.

Although no evidence of acid mine drainage (AMD) was present, Brown and Caldwell recommends that this material be reused at another facility or relocated to a more suitable disposal location at the site. No other issues are present at the crushing circuit.

7.2.2 Main Water Supply

As previously noted, the facility utilizes a 550-gallon diesel fuel above ground storage tank (AST) to fuel a water pump for fire protection. Field observations indicated that diesel fuel has been periodically spilled near the AST location.

Therefore, Brown and Caldwell recommends that soil samples be collected to determine if a significant diesel release has occurred in the area of the AST.

7.2.3 Vat Leaching Area

As previously discussed, all process liquids were contained within the lined vat leach areas. Chemical wastes or tailings removed from the area were used in other process areas or conveyed to the oxide tailings impoundment. Therefore, Brown and Caldwell recommends that no further investigations be conducted in this area.

Field observations did indicate that the former sulfuric acid storage tank location and associated lime pit may be significantly impacted by historic acid releases. Therefore, Brown and Caldwell recommends that soil samples be collected to determine if a significant acid release has occurred in the area.

7.2.4 Solution Extraction (SX) Area

As previously noted, all equipment in the SX area, with the exception of tanks and transfer piping, was located in a lined concrete containment area. Any fluid release from the SX area would be captured and pumped to individual storage tanks or discharged into the tailings ponds suggesting that no significant release could occur from this location.

Our inspection noted that the 1,200-gallon loaded organic tank and underlying soils were stained suggesting that fluid releases from unlined tanks and piping may have occurred in the past. Therefore, Brown and Caldwell recommends that representative soil samples be collected near select tank locations including the acid/organic unloading station in the SX area.

7.2.5 Process Building

As discussed, fluid releases in the process building would flow to lined sumps in the concrete floor. Sump discharge could be directed to the process units, storage tanks, or tailings ponds located in the eastern portion of the pilot plant suggesting that no significant release could occur from this location.

Based on our observation of minor staining of the concrete pad and underlying soils adjacent to the copper concentrate storage area, Brown and Caldwell recommends that soil sampling be conducted adjacent to the concentrate storage area to determine if a significant copper concentrate release has occurred.

7.2.6 Sulfide and Oxide Tailings

As previously mentioned, Conoco utilized two unlined tailings impoundments for the disposal of sulfide and oxide tailings. Our observations of the area indicated that the tailings impoundments were in relatively sound condition with no significant erosion, distressed vegetation, or soil staining.

However, the documented disposal practices in these areas suggest that the underlying soils beneath the impoundments could become impacted if tailings contain elevated metals or low pH conditions. Therefore, Brown and Caldwell recommends that representative soil samples be collected in the impoundments to evaluate the chemical characteristics of the tailing materials.

7.2.7 Operations and Shop and Warehouse Buildings

As discussed, our inspection of the buildings revealed numerous unused containers of chemical reagents previously utilized in the metallurgical and analytical laboratories. In addition, one empty 5-gallon plastic container was marked with "Uranium Leach Liquor."

Based on conflicting personnel interviews, file documentation, and the presence of the uranium leach liquor container, sufficient information exists to suggest that uranium processing may have occurred at the facility. Therefore, Brown and Caldwell recommends that a radiation survey be conducted at the facility to determine if uranium ore processing or uranium leach experiments were conducted at the facility.

7.2.8 Chemical and Sanitary Pond

As previously discussed, chemical wastes from the analytical and metallurgical laboratories and the reagent mixing area in the process building were discharged to the chemical and sanitary pond.

Although no distressed vegetation, soil discoloration, or unusual odors were noted during our inspection of the chemical and sanitary pond, the documented disposal practices in this area suggests that underlying soils beneath the impoundment could potentially be impacted.

Therefore, Brown and Caldwell recommends that a representative soil sample be collected in the impoundment to evaluate the chemical characteristics of the soils underlying the waste discharge area.

7.2.9 Support Areas

Several areas along the southern boundary of the pilot plant site are currently utilized to store drilling supplies; previously decommissioned pilot plant equipment; drill cuttings and ore, rock and tailings samples; several empty steel and fiberglass tanks, and numerous 55-gallon drums containing petroleum and other liquids.

Considering that no evidence of the prior leaching test is apparent and that Magma personnel are actively working in these areas to organize the stored materials and properly dispose of solid wastes and 55-gallon drums, Brown and Caldwell is recommending that no further investigation be conducted in this area. We do suggest, however, that Magma personnel properly document the transportation and disposal of any regulated materials encountered at the site.

SECTION 8.0

FIELD ACTIVITIES

8.1 RADIATION SURVEY

The records search at Florence produced a Conoco interoffice communication indicating that a company named UOCO had approached Conoco about the possibility of leasing the Florence facilities to conduct small-scale uranium vat leaching operations. The interoffice communication indicated Conoco should not consider the proposal further, however, additional documentation was not found to determine whether Conoco followed the interoffice communications recommendations. In addition, a 5-gallon container marked "uranium leach liquor" was found in the metallurgical laboratory during the facility inspection.

As a consequence, Brown and Caldwell conducted a limited radiation survey in the pilot processing plant and its associated facilities on October 16, 1995. The survey was conducted using a Victoreen 190 hand held radiation survey meter. The survey included establishing background levels from the area surrounding the facility and measuring surface radiation levels at various areas of the pilot processing plant. Background levels from the area surrounding the facility ranged from 10 to 22 microRoentgens per hour (μR/hr) while background levels in enclosed areas of the facility ranged from 0.5 to 15 μR/hr.

The limited survey revealed that radiation levels in the pilot processing plant and its associated facilities are consistent with background levels. The 5-gallon "uranium leach liquor" container also displayed background levels. The oxide and sulfide tailings ponds level ranged from 20 to 45 μR/hr. LIX tanks 3 and 4 levels ranged from 110 to 240 μR/hr. LIX tanks 1 and 2, and strip tanks 1 and 2 displayed background levels. In addition, the unprocessed ore stockpile areas, the vat leach areas, and the other equipment areas also displayed background levels.

The radiation levels in LIX tanks 3 and 4 were elevated moderately above background radiation levels, however, the levels do not pose a threat to human health. The radiation levels in the remaining areas are consistent with background levels. No further radiation testing has been completed.

8.2 FIELD METHODS AND PROCEDURES

Brown and Caldwell contracted Kajima Engineering and Construction (Kajima) to provide excavation services to excavate test trenches and facilitate soil sampling from 16 test trenches. Trench locations are presented in Figures 3, 4, and 5. Prior to excavation, a private utility company was subcontracted to locate underground utilities in the investigation area.

Soil sampling was conducted on October 26, 1995 in the pilot plant area and the pilot mine area of the Magma Florence facility. Sampling and decontamination procedures are described below.

1. The backhoe bucket was decontaminated prior to excavating each test trench using a pressurized steam cleaner. Field sampling equipment and brass sampling tubes were decontaminated by washing in deionized water and alconox followed by double rinsing in deionized water.

2. The backhoe excavated the test trench to the desired sampling depth and the base of the excavation was cleaned of loose debris. The backhoe collected previously undisturbed soil from the base of the trench from each sample depth.

3. Soil samples were collected in two types of containers based on analytical methods. Samples collected for volatile chemical analyses were collected in 6-inch by 2-inch diameter brass tubes. Soil samples collected for non-volatile chemical analyses were collected in 8-ounce glass jars with Teflon-coated lids.

4. The soil samples for volatile chemical analyses were collected by pushing the brass tube into the soil in the backhoe bucket. The brass tube was completely filled to prevent the formation of headspace. The ends of the brass tube were covered with Teflon sheets and capped with plastic end caps. The brass tube was labeled with time, date of collection, discrete sample identification, logged onto the chain-of-custody form, and placed in a Ziplock baggie.

5. The soil samples for non-volatile chemical analyses were collected by filling the glass jars using a previously decontaminated hand spade. The jar was labeled with time, date of collection, discrete sample identification, logged onto the chain-of-custody form, and placed in a Ziplock baggie.

6. The brass tubes and jars were placed in an ice chest maintained at approximately 4°C with blue ice. The samples remained chilled in the ice chest until delivered to the state-certified analytical laboratory. Chain-of-custody documentation accompanied the samples during delivery from the field to the laboratory.

7. The trenches were immediately backfilled, and the backhoe bucket was decontaminated between each trench excavation.

8. The soil samples were identified according to the following:

   Each sample was prefixed by the facility name:
   MCF - Magma Copper Florence

   Followed by the sampling area:
   MWS - Main Water Supply;
   CSA - Concentrate Storage Area;
   LCP - Large Clarified Pregnant Solution Tank;
   SUP - Small Unclarified Pregnant Solution Tank;
   SLO - Small Loaded Organic Storage Tank;
   SRS - Small Raffinate Storage Tank;
   LLO - Large Loaded Organic Storage Tank;

ALS - Acid Loading Station;
SUL - Sulfuric Acid Tank;
LUP - Large Unclarified Pregnant Solution Tank;
CSP - Chemical/Sanitary Pond;
MSA - Mine Shaft Trench A;
MSB - Mine Shaft Trench B;
BAK - Background Sample;
OTP - Oxide Tailings Pond Samples A and B; and
STP - Sulfide Tailings Pond Samples A, B, C, and D.

The sample location descriptions were followed by the sampling depth. For instance, the sample collected from 2.5 feet below ground surface (bgs) adjacent to the acid loading station was labeled MCF-ALS-2.5.

8.3 SOIL CONDITIONS

The sample interval, soil type, field observations and laboratory analyses for each soil sample from each of the test trenches are discussed below.

Main Water Supply (MWS) - Soil samples were collected at 1, 2.5, and 5 feet bgs immediately south of a 550-gallon diesel above ground storage tank (AST). The soil was a gravelly sand with cobbles and boulders to the maximum depth of 5 feet bgs. No odors or staining were observed in this test trench. One soil sample, MCF-MWS-1, was submitted to the laboratory to be analyzed for total recoverable petroleum hydrocarbons (TRPH) using US Environmental Protection Aency (EPA) Method 418.1 and volatile aromatic compounds using EPA Method 8020. Laboratory analytical results are summarized in Table 8.3-1.

Concentrate Storage Area (CSA) - Soil samples were collected at 1, 2.5, and 5 feet bgs at the southwest corner of the process building where green surface staining was observed. The soil was a gravelly sand with cobbles and boulders to the maximum depth of 5 feet bgs. The green surface staining was observed to penetrate the soil 6 inches bgs. Two soil samples, MCF-CSA-1 and MCF-CSA-2.5, were submitted to the laboratory to be analyzed for the Resource Conservation and Recovery Act (RCRA) eight metals plus zinc, copper, and iron using EPA Method 6010/7000 (Table 8.3-1).

Large Clarified Pregnant Solution Storage Tank (LCP) - Soil samples were collected at 1, 2.5, and 5 feet bgs northwest of the 33,000-gallon clarified pregnant solution storage tank. The soil was a gravelly sand with cobbles and boulders to the maximum depth of 5 feet bgs. A faint solvent odor was detected at 1 foot bgs and became slightly stronger at 2.5 feet bgs. Field organic vapor analyzer (OVA) readings were non-detect. The odor was not present at 5 feet bgs. Some iron oxide staining was observed from ground surface to approximately 6 inches bgs. Three soil samples, MCF-LCP-1, MCF-LCP-2.5 and MCF-LCP-5, were submitted to the laboratory to be analyzed for the RCRA 8 metals plus zinc, copper, and iron using EPA Method 6010/7000 and pH using EPA Method 9045 (Table 8.3-1).

Small Unclarified Pregnant Solution Tank (SUP) - Soil samples were collected at 1, 2.5, and 5 feet bgs north of the 1,200-gallon unclarified pregnant solution storage tank. The soil was a gravelly sand with cobbles and boulders to the maximum depth of 5 feet bgs. Heavy iron oxide staining was observed to 1 foot bgs and some green mineral chips were observed at 1 foot bgs. Two soil samples, MCF-SUP-1 and MCF-SUP-2.5, were submitted to the laboratory to be analyzed for the RCRA 8 metals plus zinc, copper, and iron using EPA Method 6010/7000 and pH using EPA Method 9045 (Table 8.3-1).

Small Loaded Organic Storage Tank (SLO) - Soil samples were collected at 1, 2.5, and 5 feet bgs east of the 330-gallon loaded organic storage tank. The soil was a gravelly sand with cobbles and boulders to the maximum depth of 5 feet bgs. No odors or staining were observed in this test trench. Two soil samples, MCF-SLO-1 and MCF-SLO-2.5, were submitted to the laboratory to be analyzed for the RCRA 8 metals plus zinc, copper, and iron using EPA Method 6010/7000 and TRPH using EPA Method 418.1 (Table 8.3-1).

Small Raffinate Storage Tank (SRS) - Soil samples were collected at 1, 2.5, and 5 feet bgs northwest of the 11,750-gallon raffinate storage tank. The soil was a gravelly sand with cobbles and boulders to the maximum depth of 5 feet bgs. No odors or staining were observed in this test trench. Three soil samples, MCF-SRS-1, MCF-SRS-2.5, and MCF-SRS-5, were submitted to the laboratory to be analyzed for the RCRA 8 metals plus zinc, copper, and iron using EPA Method 6010/7000 and pH using EPA Method 9045 (Table 8.3-1).

Large Loaded Organic Storage Tank (LLO) - Soil samples were collected at 1, 2.5, and 5 feet bgs northeast of the 1,200-gallon loaded organic storage tank. The soil was a gravelly sand with cobbles and boulders to the maximum depth of 5 feet bgs. A very faint solvent odor was observed at 5 feet bgs in this test trench. Field OVA readings were non-detect. Three soil samples, MCF-LLO-1, MCF-LLO-2.5 and MCF-LLO-5, were submitted to the laboratory to be analyzed for the RCRA 8 metals plus zinc, copper, and iron using EPA Method 6010/7000 and TRPH using EPA Method 418.1 (Table 8.3-1).

Acid Loading/Unloading Station (ALS) - Soil samples were collected at 1, 2.5, and 5 feet bgs east of the acid loading/unloading station. The soil was a gravelly sand with cobbles and boulders to the maximum depth of 5 feet bgs. No odors or staining were observed in this test trench. One soil sample, MCF-ALS-1, was submitted to the laboratory to be analyzed for TRPH using EPA Method 418.1 and pH using EPA Method 9045 (Table 8.3-1).

Sulfuric Acid Tank (SUL) - Soil samples were collected at 3, 6, and 10 feet bgs in a lime pit adjacent to the previously-removed 6,300-gallon sulfuric acid storage tank. The soil was a gravelly sand and had increasing cobbles and boulders to the maximum depth of 10 feet bgs. A purplish, light yellow, and yellow stain was observed to 3 feet bgs with the light yellow staining extending to 10 feet bgs. Three soil samples, MCF-SUP-3, MCF-SUP-6 and MCF-SUP-10, were submitted to the laboratory to be analyzed for the RCRA 8 metals plus zinc, copper, and iron using EPA Method 6010/7000 and pH using EPA Method 9045 (Table 8.3-1).

Large Unclarified Pregnant Solution Tank (LUP) - Soil samples were collected at 1, 2.5, and 5 feet bgs west of the 11,750-gallon unclarified pregnant solution storage tank. The soil was a gravelly sand with cobbles and boulders to the maximum depth of 5 feet bgs. No odors or staining were observed in this test trench. Three soil samples, MCF-LUP-1, MCF-LUP-2.5, and MCF-LUP-5, were submitted to the laboratory to be analyzed for the RCRA 8 metals plus zinc, copper, and iron using EPA Method 6010/7000 and pH using EPA Method 9045 (Table 8.3-1).

Sulfide Tailings Pond (STP) - Samples were collected in 4 locations, the northwest, northeast, southeast, and southwest corners of the pond, at 2 feet bgs. The northwest sample location was sulfide tailings, the three remaining samples were native gravelly sand with cobbles and boulders to the maximum depth of 2 feet bgs. Native gravelly sand and cobbles were encountered in the base of the pond suggesting that the pond was constructed of native materials without the use of man-made liners. No odors or staining were observed in these test trenches. The four samples, MCF-STPA-2, MCF-STPB-2, MCF-STPC-2, and MCF-STPD-2, were submitted to the laboratory, composited by the laboratory and is identified as COMP1 in this report. The composited sample, COMP1, was analyzed by the laboratory for the RCRA 8 metals plus zinc, copper, and iron using EPA Method 6010/7000, pH using EPA Method 9045 and TRPH using EPA Method 418.1 (Table 8.3-1).

Oxide Tailings Pond (OTP) - Soil samples were collected in 2 locations, the northwest and northeast corners of the pond, at 2 feet bgs. The northwest sample was oxide tailings consisting of highly decomposed powder to 6 inches bgs and clay to 2 feet bgs. The northeast sample was a gravelly sand with cobbles and boulders to the maximum depth of 2 feet bgs suggesting that the pond was constructed of native materials without the use of man-made liners. The tailings sample contained heavy iron oxide staining. No staining was observed in the native soils encountered in the northeast test trench. The two samples, MCF-OTPA-2, and MCF-OTPB-2, were submitted to the laboratory, composited by the laboratory, and is identified as COMP2 in this report. The composited sample, COMP2, was analyzed by the laboratory for the RCRA 8 metals plus zinc, copper, and iron using EPA Method 6010/7000, pH using EPA Method 9045 and TRPH using EPA Method 418.1 (Table 8.3-1).

Chemical/Sanitary Pond (CSP) - A soil sample was collected in the center of the pond at 2 feet bgs immediately south of the overhead discharge pipe. The sample was a gravelly sand with cobbles and boulders to the maximum depth of 2 feet bgs. Native gravelly sand and cobbles were encountered in the base of the pond suggesting that the pond was constructed of native materials without the use of man-made liners. No odors or staining were observed in this test trench. One soil sample, MCF-CSP-2.5, was submitted to the laboratory to be analyzed for the RCRA 8 metals plus zinc, copper, and iron using EPA Method 6010/7000, Volatile Organic Compounds (VOCs) using EPA Method 8240, Semi-Volatile Organic Compounds (SVOCs) using EPA Method 8270, TRPH using EPA Method 418.1 and pH using EPA Method 9045 (Table 8.3-1).

Pilot Mineshaft (MS) - Two test trenches were located immediately north and south of the former transformer pad. Soil samples were collected at 1, 2.5, and 5 feet bgs in each trench. The soil in each trench was a gravelly sand with cobbles and boulders to the maximum depth of 5 feet bgs. No odors or staining were observed in these test trenches. Two soil samples, MCF-MSA-1 and MCF-MSB-1, were submitted to the laboratory to be analyzed for polychlorinated biphenyls (PCBs) using EPA Method 8080 and TRPH using EPA Method 418.1. In addition two soil samples, MCF-MSA-2.5 and MCF-MSB-2.5, were submitted to the laboratory to be analyzed for TRPH using EPA Method 418.1 (Table 8.3-1).

Background Sample (BAK) - A soil sample was collected at 2 feet bgs in an undisturbed and undeveloped location of the site near the pilot mineshaft. The sample was a gravelly sand with cobbles and boulders to the maximum depth of 2 feet bgs. No odors or staining were observed in this test trench. One soil sample, MCF-BAK-2, was submitted to the laboratory to be analyzed for the RCRA 8 metals plus zinc, copper, and iron using EPA Method 6010/7000 and pH using EPA Method 9045 (Table 8.3-1).

Table 8.3-1. [illegible]mmary of Laboratory Analytical Results - Vadose Zone Investigation

Analyses	Units	Sample Designation													
		MCF													
		BAK-2	ALS-1	CSA-1	CSA-2.5	CSP-2.5	LCP-1	LCP-2.5	LCP-5	LLO-1	LLO-2.5	LLO-5	LUP-1	LUP-2.5	LUP-5
Total Metals(1)			N/A												
Arsenic	mg/kg	1.6		0.93	1.9	0.54	0.95	1.1	0.90	1.2	1.3	0.55	1.3	1.8	1.2
Barium	mg/kg	120		93	74	41	78	91	66	89	73	52	100	90	31
Cadmium	mg/kg	0.63		<0.5	N/T	<0.5	0.53	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium	mg/kg	11		11	5.8	8.7	9.2	10	8.4	9.4	8.3	5.7	12	9.7	9.9
Copper	mg/kg	15		290	9.0	6.7	47	14	8.9	48	440	8.1	65	390	7.9
Iron	mg/kg	12,000		11,000	5,800	9,500	9,000	9,800	8,100	9,000	8,300	9,000	11,000	8,400	12,000
Lead	mg/kg	6.1		6.8	<5	5.3	6.1	5.5	5.4	7.1	7.0	5.9	7.3	13	<5
Mercury	mg/kg	<0.1		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium	mg/kg	<0.4		<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Silver	mg/kg	<1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Zinc	mg/kg	30		35	16	20	27	18	18	22	23	19	24	51	19
pH (EPA 9045)	units	6.04	7.9	N/T	N/T	9.0	8.3	8.8	8.4	N/T	N/T	N/T	7.7	8.0	8.7
Total Petroleum Hydrocarbons (TPH as diesel) (EPA 8015M)	mg/kg	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T
Volatile Aromatic (EPA 8020)		N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T
1,2-Dichlorobenzene	mg/kg														
1,2-Dichlorobenzene	mg/kg														
1,2-Dichlorobenzene	mg/kg														
Benzene	mg/kg														
Chlorobenzene	mg/kg														
Ethylbenzene	mg/kg														
Toluene	mg/kg														
Total xylenes	mg/kg														
PCB (EPA 8080)		N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T
Aroclor 1016	mg/kg														
Aroclor 1221	mg/kg														
Aroclor 1232	mg/kg														
Aroclor 1242	mg/kg														
Aroclor 1248	mg/kg														
Aroclor 1254	mg/kg														
Aroclor 1260	mg/kg														
Total Recoverable Petroleum Hydrocarbons (EPA 418.1)	mg/kg	N/T	13	N/T	N/T	<10	N/T	N/T	N/T	11	27	<10	N/T	N/T	N/T
Semi-Volatile Organic Compounds(2) (EPA 8270)	mg/kg	N/T	N/T	N/T	N/T	ND	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T
Volatile Organic Compounds(3) (EPA 8240)	mg/kg	N/T	N/T	N/T	N/T	ND	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T

Table 8.3-1 (continued). Summary of Laboratory Analytical Results - Vadose Zone Investigation

Analyses	Units	Sample Designation														
		MCF														
		BAK-2	MSB-1	MSB-2.5	MWS-1	SLO-1	SLO-2.5	SRS-1	SRS-2.5	SRS-5	SUL-3	SUL-6	SUL-10	SUP-1	SUP-1 (dup.)	SUP-2.5
Total Metals[1]			N/T	N/T	N/T											
Arsenic	mg/kg	1.6				0.80	1.3	1.0	1.3	0.79	1.2	1.2	0.92	0.91	N/T	1.4
Barium	mg/kg	120				91	28	120	82	43	110	100	42	87	N/T	67
Cadmium	mg/kg	0.63				0.66	<0.5	0.78	<0.5	0.55	0.91	<0.5	<0.5	0.58	N/T	<0.5
Chromium	mg/kg	11				9.1	3.0	10	8.3	12	9.8	7.9	13	9.1	N/T	6.2
Copper	mg/kg	15				22	29	290	340	18	22	18	9.7	8,900	8,100	12
Iron	mg/kg	12,000				10,000	6,400	11,000	8,600	12,000	7,700	4,200	9,100	9,600	N/T	6,800
Lead	mg/kg	6.1				<5	5.6	8.9	13	5.3	<5	8.7	8.0	<5	N/T	8.8
Mercury	mg/kg	<0.1				<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	N/T	<0.1
Selenium	mg/kg	<0.4				<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	N/T	<0.4
Silver	mg/kg	<1				<1	<1	<1	<1	<1	<1	<1	<1	<1	N/T	<1
Zinc	mg/kg	35				26	17	27	30	22	28	30	19	45	N/T	20
pH (EPA 9045)	units	6.04	N/T	N/T	N/T	N/T	N/T	7.7	7.8	8.2	7.7	7.9	7.8	7.8	N/T	8.1
Total Petroleum Hydrocarbons (TPH as diesel) (EPA 8015M)	mg/kg	N/T	N/T	N/T	<10	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T
Volatile Aromatic (EPA 8020)		N/T	N/T	N/T		N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T
1,2-Dichlorobenzene	mg/kg				<0.005											
1,2-Dichlorobenzene	mg/kg				<0.005											
1,2-Dichlorobenzene	mg/kg				<0.005											
Benzene	mg/kg				<0.005											
Chlorobenzene	mg/kg				<0.005											
Ethylbenzene	mg/kg				<0.005											
Toluene	mg/kg				<0.005											
Total xylenes	mg/kg				<0.01											
PCB (EPA 8080)		N/T		N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T
Aroclor 1016	mg/kg		<0.03													
Aroclor 1221	mg/kg		<0.03													
Aroclor 1232	mg/kg		<0.03													
Aroclor 1242	mg/kg		<0.03													
Aroclor 1248	mg/kg		<0.03													
Aroclor 1254	mg/kg		<0.03													
Aroclor 1260	mg/kg		<0.03													
Total Recoverable Petroleum Hydrocarbons (EPA 418.1)	mg/kg	N/T	10	16	N/T	<10	26	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T
Semi-volatile Organic Compounds[2] (EPA 8270)	mg/kg	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T
Volatile Organic Compounds[3] (EPA 8240)	mg/kg	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T

Table 8.3-1 (Continued). Summary of Laboratory Analytical Results - Vadose Zone Investigation

Analyses	Units	Sample Designation				
		MCF				
		BAK-2	MSA-1	MSA-2.5	COMP1[4]	COMP2[2]
Total Metals[1]			N/T	N/T		
Arsenic	mg/kg	1.6			0.58	0.51
Barium	mg/kg	120			44	31
Cadmium	mg/kg	0.63			<0.5	<0.5
Chromium	mg/kg	11			6.5	6.0
Copper	mg/kg	15			710	560
Iron	mg/kg	12,000			9,600	10,000
Lead	mg/kg	6.1			5.1	7.4
Mercury	mg/kg	<0.1			<0.1	<0.1
Selenium	mg/kg	<0.4			3.4	<0.4
Silver	mg/kg	<1			<1	<1
Zinc	mg/kg	35			20	23
pH (EPA 9045)	units	6.04	N/T	N/T	6.9	5.0
Total Petroleum Hydrocarbons (TPH as diesel) (EPA 8015M)	mg/kg	N/T	N/T	N/T	N/T	N/T
Volatile Aromatic (EPA 8020)		N/T	N/T	N/T	N/T	N/T
1,2-Dichlorobenzene	mg/kg					
1,2-Dichlorobenzene	mg/kg					
1,2-Dichlorobenzene	mg/kg					
Benzene	mg/kg					
Chlorobenzene	mg/kg					
Ethylbenzene	mg/kg					
Toluene	mg/kg					
Total xylenes	mg/kg					
PCB (EPA 8080)		N/T		N/T	N/T	N/T
Aroclor 1016						
Aroclor 1221	mg/kg		<0.03			
Aroclor 1232	mg/kg		<0.03			
Aroclor 1242	mg/kg		<0.03			
Aroclor 1248	mg/kg		<0.03			
Aroclor 1254	mg/kg		<0.03			
Aroclor 1260	mg/kg		<0.03			
	mg/kg		<0.03			
Total Recoverable Petroleum Hydrocarbons (EPA 418.1)	mg/kg	N/T	20	20	21	12
Semi-volatile Organic Compounds[2] (EPA 8270)	mg/kg	N/T	N/T	N/T	N/T	N/T
Volatile Organic Compounds[3] (EPA 8240)	mg/kg	N/T	N/T	N/T	N/T	N/T

1 RCRA Metals (EPA 6010/7000) with the addition of zinc, copper, and iron.
2 Semi-volatile organic analytes not listed unless detected above analyte detection limit.
3 Volatile organic analytes not listed unless detected above analyte detection limit.
4 Composite sample composed of MCF-STPA-2, MCF-STPB-2, MCF-STPC-2, MCF-STPD-2. Composited in laboratory.
5 Composite sample composed of MCF-OTPA-2, MCF-OTPB-2. Composited in laboratory.
mg/kg milligrams/kilogram
N/T Sample not tested in laboratory by described analytical method.
ND Not detected. No constituents detected above method detection limit (MDL).

The following samples were collected, but not analyzed by the laboratory: ALS-2.5; ALS-5; CSA-5; MSA-5; MSB-5; MWS-2.5; MWS-5; OTPA-2; OTPB-2; SLO-5; STPA-2; STPB-2; STPC-2; STPD-2; and SUP-5.

8.4 DISCUSSION OF LABORATORY ANALYTICAL RESULTS

A total of 44 samples were collected at 16 locations throughout the Florence Project area. Selected soil samples were submitted to the laboratory to be analyzed for VOCs using EPA Method 8240, SVOCs using EPA Method 8270, TPH as diesel using EPA Method 8015 modified, TRPH using EPA Method 418.1, RCRA 8 Metals (plus copper, iron and zinc) using EPA Methods 6010/7000, PCBs using EPA Method 8080 and volatile aromatic compounds using EPA Method 8020. Laboratory analyses of selected soil samples did not detect VOCs, SVOCs, TPH as diesel, PCBs, and volatile aromatic compounds above the method detection limits. Therefore, this discussion will focus on TRPH and metals concentrations by comparing the specific sample levels with the background soil sample levels and with the Human Health Based Guidance Levels (HBGLs) for ingestion of contaminants in soil established by the ADEQ (June 1992). The HBGLs values for each chemical constituent are not the cleanup criteria, however, the values may be used as a criteria for determining the risk to human health based on an average daily ingestion of soil during a 30-year exposure. The HBGLs and background levels for each chemical constituent is presented in Table 8.4-1.

A total of 13 soil samples from eight sample locations were submitted to the laboratory to be analyzed for TRPH. Laboratory analyses indicate that concentrations of TRPH in the soil is extremely low, ranging between not detected above the method detection limit to 27 mg/Kg. The interim remedial concentration promulgated by the State of Arizona for residential property is 7,000 mg/Kg and 24,500 mg/Kg for commercial property.

A total of 25 soil samples were submitted to the laboratory to be analyzed for RCRA 8 metals plus copper, iron, and zinc. Laboratory analyses did not detect mercury and silver above the method detection limit in any sample at the site. In addition, concentrations of arsenic, barium, cadmium, chromium, iron, lead and zinc were detected at levels consistent with or below background concentrations (See Table 8.4-1).

Copper was detected above the background concentration in a total of eight samples from six sampling locations. Copper concentrations above background levels were detected at the 1 foot level in a total of four samples, MCF-CSA-1, MCF-LUP-1, MCF-SRS-1, and MCF-SUP-1. Copper concentrations above background levels were detected at the 2.5-foot levels in two samples, MCF-LUP-2.5 and MCF-SRS-2.5, while the concentrations of copper in MCF-CSA-2.5 and MCF-SUP-2.5 had attenuated to background concentrations. No copper concentrations at the 5-foot level exceeded background concentrations (See Table 8.4-2).

Results of composite samples collected from the oxide and sulfide tailings ponds were evaluated in the following manner to compensate for the sampling methodology.

A theoretical maximum sample concentration (MSC) for each constituent was determined by multiplying the sample concentration by the number of discrete samples included within the composite. Therefore, constituent concentrations from the composite samples collected from the sulfide (COMP1) and oxide (COMP2) tailings ponds were multiplied by four (4) and two (2), respectively.

Following this determination, only the theoretical MSCs of copper and selenium significantly exceeded their respective background concentrations at the site. These results are detailed below.

The theoretical MSC for copper was calculated to be approximately 2,840 mg/Kg and 1,120 mg/Kg for COMP1 and COMP2, respectively. The HBGL for copper is listed as 22,000 mg/Kg.

Selenium was detected in the sulfide tailings sample (COMP1) at a concentration of 3.4 mg/Kg. The theoretical MSC for selenium in this composite sample was calculated to be approximately 13.6 mg/Kg which is well below the HBGL of 840 mg/Kg.

Table 8.4-1 Summary of HBGL, Background Concentrations, and Sample Concentration Ranges for TRPH and Selected Metals			
Analyte	**HGBL[1] (mg/Kg)**	**Background Concentrations[3] (mg/Kg)**	**Sample Concentration Range (mg/Kg)**
TRPH	7,000[2]	N/T	ND to 27
Arsenic	840	1.6	0.51 to 1.9
Barium	33,000	120	28 to 120
Cadmium	58	0.63	ND to 0.91
Chromium	1,700	11	3 to 13
Copper	22,000	15	6.7 to 8,900
Iron	N/A[4]	12,000	4,200 to 12,000
Lead	84	6.1	ND to 13
Mercury	35	ND	ND
Selenium	840	ND	ND to 3.4
Silver	840	ND	ND
Zinc	23,000	35	16 to 51

[1] HBGL: Health Based Guidance Levels.
[2] State of Arizona interim cleanup level for residential property.
[3] Background concentrations are reported for soil sample MCF-BAK-2.
[4] The State of Arizona has not promulgated HBGL for this constituent.
mg/Kg - milligram per kilogram.
N/T - Not Tested.
ND - Not detected above the method detection limit.

SECTION 9.0

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Brown and Caldwell has prepared the following summary of significant environmental issues resulting from the focused facilities inspection and limited soil sampling. Results of these investigations are summarized below. Specific areas relating to the historic operations of the mine and pilot plant have been subdivided into two sections to simplify this discussion.

9.1 PILOT MINE AREA

Minor oil staining was noted on the concrete transformer pad located near the former headframe location suggesting that transformer oils may have been released at the site.

Two test trenches (MCF-MSA and MCF-MSB) were excavated adjacent to the transformer pad. Analytical results indicated that low levels of total petroleum hydrocarbons (TPH), less than 50 parts per million (ppm), were present at the 1-foot sampling interval with no detectable concentrations of PCBs.

No detectable concentrations of TPH were present at the 2.5-foot sampling interval suggesting that the vertical extent of hydrocarbon-impacted soils has been defined at this location.

Based on field observations and analytical data, Brown and Caldwell recommends that no further investigation or remediation activities be conducted in this area.

9.2 PILOT PLANT AREA

As previously noted, the pilot plant site is the location of the administration, process, and maintenance buildings in addition to various structures relating to the processing of oxide and sulfide ores.

The following discussion of the pilot plant site issues has been subdivided into the discrete operating areas including the crushing circuit; vat leach area; solution extraction (SX) area; process building; administration and warehouse buildings; and various support, utilities, and storage facilities.

9.2.1 Crushing Circuit

Approximately 10,000 cubic yards of stockpiled waste rock and sulfide and oxide ore are present adjacent to the crushing circuit.

Although no evidence of acid mine drainage (AMD) was present, Brown and Caldwell recommends that this material be reused at another facility or relocated to a more suitable disposal location at the site.

9.2.2 Main Water Supply

The facility utilizes a 550-gallon diesel fuel above ground storage tank (AST) to fuel a water pump for fire protection. Field observations indicated that diesel fuel has periodically been spilled near the tank location.

One test trench (MCF-MWS) was excavated adjacent to the 550-gallon AST. Analytical results indicated that no detectable concentrations of TPH or volatile organic hydrocarbons (VOCs) were present at the 1.0-foot sampling interval.

Based on field observations and analytical data, Brown and Caldwell recommends that no further investigation or remediation activities be conducted in this area.

9.2.3 Vat Leaching Area

All process liquids were contained within the lined vat leach areas, and any chemical wastes or tailings removed from the area were used in other areas or conveyed to the oxide tailings impoundment. Therefore, no additional investigations are warranted for this area.

Field observations suggested that the former sulfuric acid storage tank location and associated lime pit may have been significantly impacted by acid releases.

One test trench (MCF-SUL) was excavated adjacent to the former sulfuric acid tank. Analytical results indicated that no significant concentrations of metals or pH, above background levels, were present at the 3.0, 6.0, and 10-foot sampling intervals.

Based on field observations and analytical data, Brown and Caldwell recommends that no further investigation or remediation activities be conducted in this area.

9.2.4 Solution Extraction (SX) Area

All equipment in the SX area, with the exception of tanks and transfer piping, was located in a lined concrete containment area. Any fluid release from the SX area would be captured and pumped to individual storage tanks or discharged into the tailings ponds.

However, fluid releases from unlined tanks and piping may have occurred in this area suggesting that additional investigations were warranted.

Brown and Caldwell collected representative soil samples from seven locations in the SX area including the two 33,000-gallon raffinate and clarified PLS storage tanks (MCF-LCP); the 1,200-gallon unclarified PLS storage tank (MCF-SUP); the 330-gallon loaded organic storage tank (MCF-SLO); the 11,750-gallon unclarified PLS storage tank (MCF-LUP); the two 11,750-gallon clarified PLS and raffinate storage tanks (MCF-SRS); the 1,200-gallon loaded and stripped organic storage tanks; and the acid unloading station (MCF-ALS).

Analytical results indicated that no constituents were detected at levels significantly above background concentrations with the exception of copper and TRPH.

Concentrations of copper above background levels were present at most sampling locations in the 1.0-foot sampling intervals with the maximum copper concentration of 8,900 ppm detected in Test Trench (MCF-SUP-1.0).

Copper concentrations above background levels were present at three sampling locations in the 2.5-foot sampling interval with the maximum copper concentration of 440 ppm detected in Test Trench (MCF-LLO-2.5).

No significant copper concentrations were detected above background levels in any locations at the 5.0-foot sampling interval suggesting that the vertical extent of copper-impacted soils is limited to the shallow soils around the SX area.

Detectable TPH concentrations (below HBGLs) were present at two locations at the 1.0-foot sampling interval with the maximum TPH concentration of 26 ppm detected in Test Trench (MCF-SLO-1.0).

No detectable TPH concentrations were present in any locations at the 5.0-foot sampling interval suggesting that the vertical extent of hydrocarbon-impacted soils has been defined at this location.

Although elevated TPH and copper concentrations were detected at levels below HBGLs in several shallow sampling locations, the limited vertical extent, removal of further contaminant source by facility decommissioning, and the significant depth to groundwater suggests that no further investigation or remediation activities are required in this area.

9.2.5 Process Building

Any fluid releases in the process building were captured in lined sumps, and sump discharge could be directed to the process units, storage tanks, or tailings ponds located in the eastern portion of the pilot plant.

Although no sampling is warranted for the process building, minor staining of the concrete pad and underlying soils adjacent to the concentrate storage area suggested that copper concentrate may have been historically released in this area.

One test trench (MCF-CSA) was excavated adjacent to the concentrate storage area. Analytical results indicated that a copper concentration of 290 ppm was present in the 1.0-foot sampling interval.

No significant copper concentrations were present in the 2.5-foot sampling interval suggesting that the vertical extent of copper-impacted soils has been defined at this location.

Based on field observations and analytical data, Brown and Caldwell recommends that no further investigation or remediation activities be conducted in this area.

9.2.6 Sulfide and Oxide Tailings

Conoco utilized two unlined tailings impoundments for the disposal of sulfide and oxide tailings. Documented disposal practices in these areas suggest that materials within these impoundments could potentially be impacted by elevated metals or low pH conditions.

Brown and Caldwell collected four representative samples from the sulfide tailings pond and two representative samples from the oxide tailings pond. These locations were identified as Test Trenches MCF-STPA through MCF-STPD for the sulfide area and Test Trenches MCF-OTPA and MCF-OTPB for the oxide area. These samples were composited in the laboratory and identified in this report as COMP1 and COMP2 for the sulfide and oxide areas, respectively.

Analytical results indicated that no constituents were detected at concentrations significantly greater than background conditions, with the exception of copper at a concentrations of 710 ppm and 560 ppm for COMP1 and COMP2, respectively. As discussed in Section 8.4, the maximum theoretical copper concentrations for these two samples are significantly below the HBGL.

Although pH levels were detected slightly below background levels, field observations suggested that the tailings impoundments were in relatively sound condition with no significant indications of acidic mine drainage. It is recommended however, that these impoundments be closed to eliminate the potential for future acidic mine drainage to effect underlying soils or groundwater.

9.2.7 Operations and Shop and Warehouse Buildings

Our inspection of the buildings revealed numerous unused containers of chemical reagents previously utilized in the metallurgical and analytical laboratories. In addition, one empty 5-gallon plastic container was marked with "Uranium Leach Liquor."

Personnel interviews, file documentation and the presence of the "Uranium Leach Liquor" container suggested that uranium processing may have occurred at the facility. As a consequence, Brown and Caldwell conducted a limited radiation survey at the facility.

Although some radiation readings were above background levels, no radiation readings approached levels considered to be a threat to human health. The results of this survey suggest that no uranium processing occurred at the site. Therefore, no further investigation or remediation activities are required.

9.2.8 Chemical and Sanitary Pond

Chemical wastes from the analytical and metallurgical laboratories and the reagent mixing area in the process building were discharged to the chemical and sanitary pond. These disposal practices suggested that soils beneath the pond may have been adversely impacted by organic and inorganic contaminants.

One test trench (MCF-CSP) was excavated in the chemical and sanitary pond. Analytical results indicated that no significant concentrations of metals, pH, semi-volatile, or volatile hydrocarbons were present at the 2.5-foot sampling interval.

Although no significant soil contamination was noted during our investigation of the chemical and sanitary pond, it is recommended that this impoundment be closed in conjunction with the closure activities associated with the sulfide and oxide tailings pond.

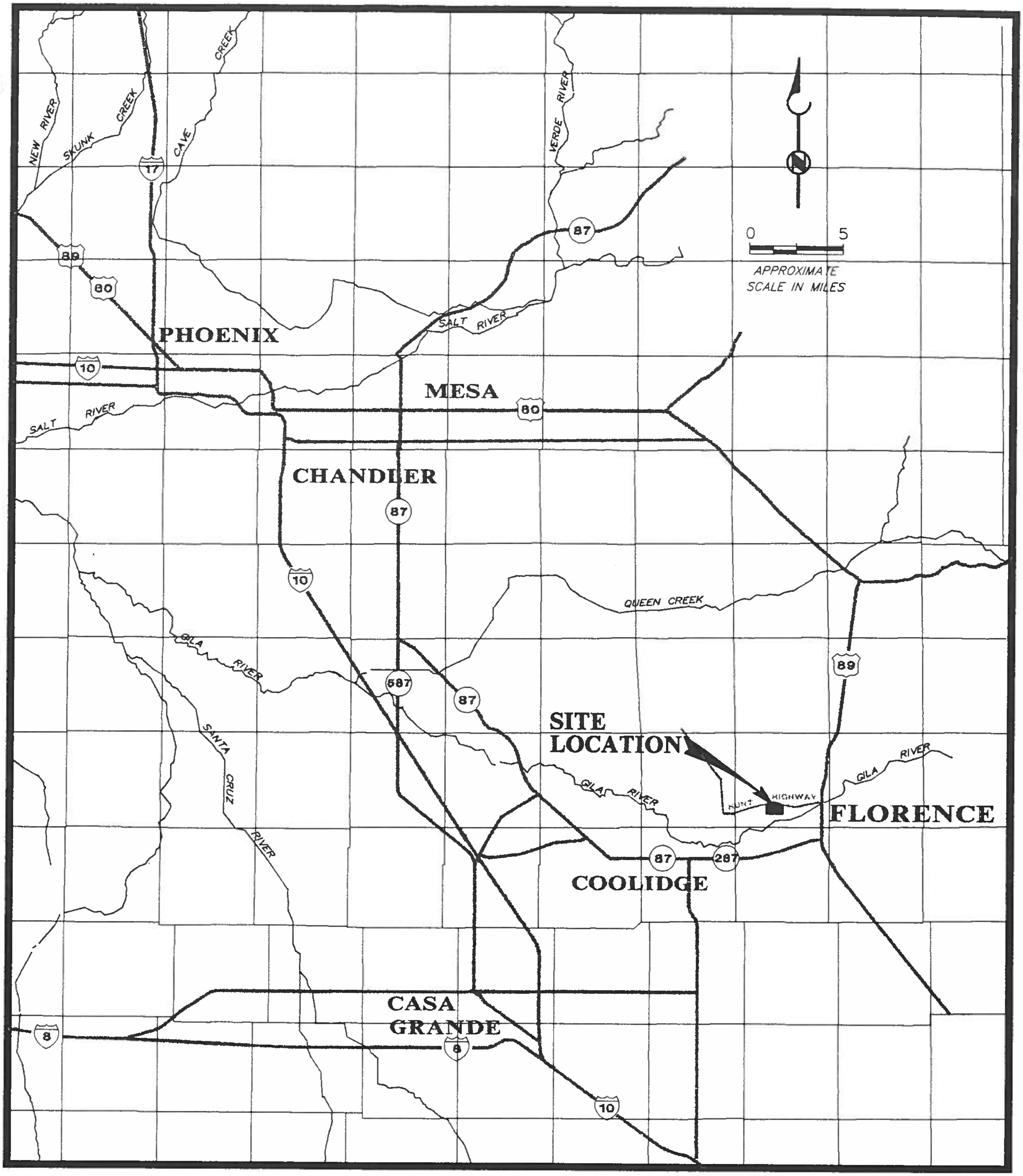
9.2.9 Support Areas

Magma personnel are actively working in several areas along the southern boundary of the pilot plant site to organize and dispose of stockpiled drilling supplies; previously decommissioned pilot plant equipment; stored drill cuttings and ore, rock and tailings samples; several empty steel and fiberglass tanks, and numerous 55-gallon drums containing petroleum and other liquids.

Brown and Caldwell is recommending that no further investigation be conducted in this area unless Magma personnel specifically retain Brown and Caldwell to document the transportation and disposal of any regulated materials encountered in these areas.

Field observations and personnel interviews indicate that up to one AST and several USTs were previously located at the site. In addition, personnel interviews also indicate that a small-scale agitation leach test was conducted in the southwest corner of the pilot plant.

Although no field observations, laboratory data, or anecdotal evidence of a release was indicated, soil and groundwater conditions in these locations are presently undefined. Therefore, Brown and Caldwell cannot speculate on soil or groundwater conditions until representative sampling is conducted in these areas.



SITE LOCATION MAP

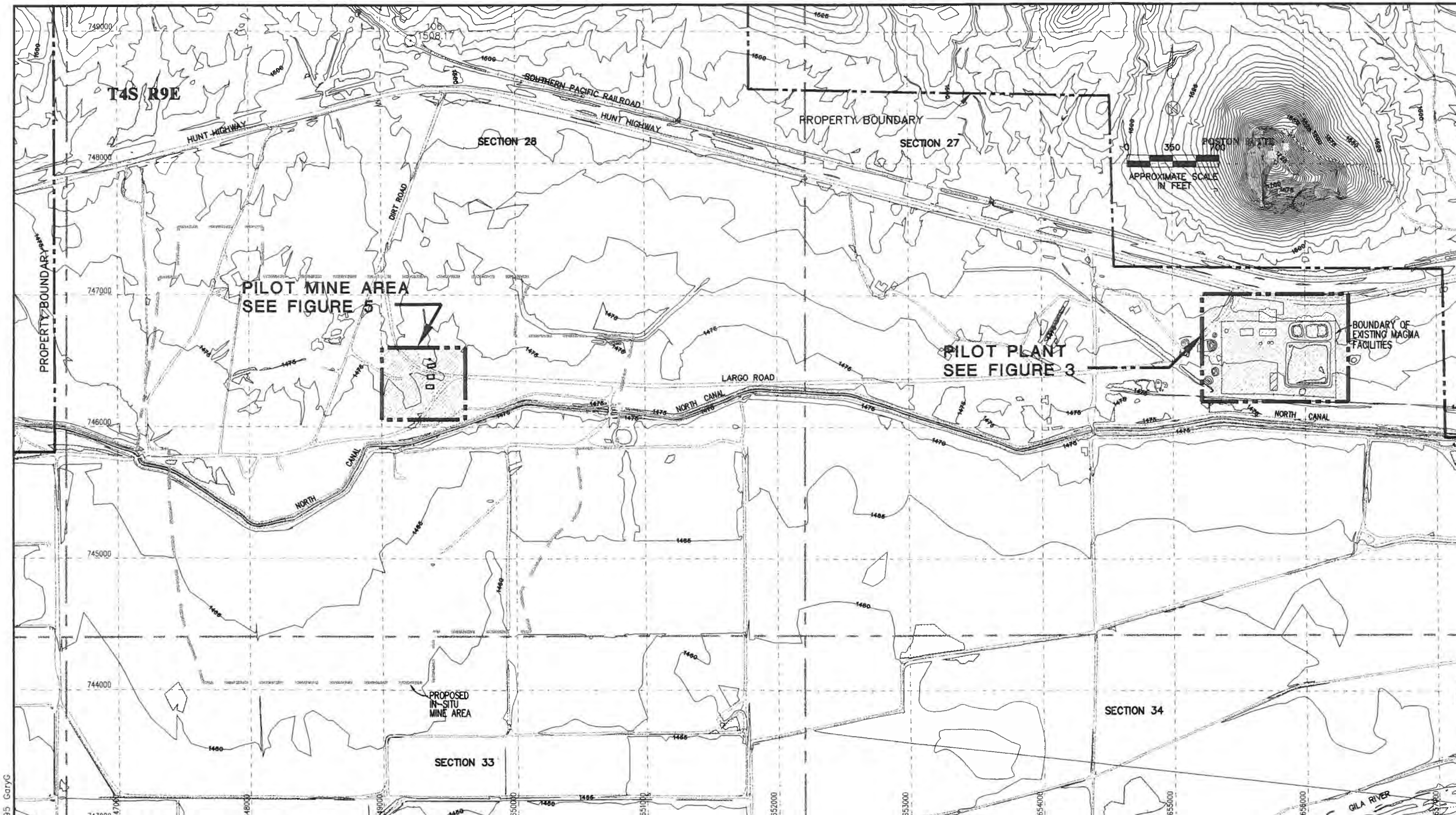
FIGURE 1

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

BROWN AND CALDWELL

F1899117 1 -95 GaryG



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BROWN AND CALDWELL

SITE PLAN

FIGURE 2

MAGMA COPPER COMPANY
Florence, Arizona

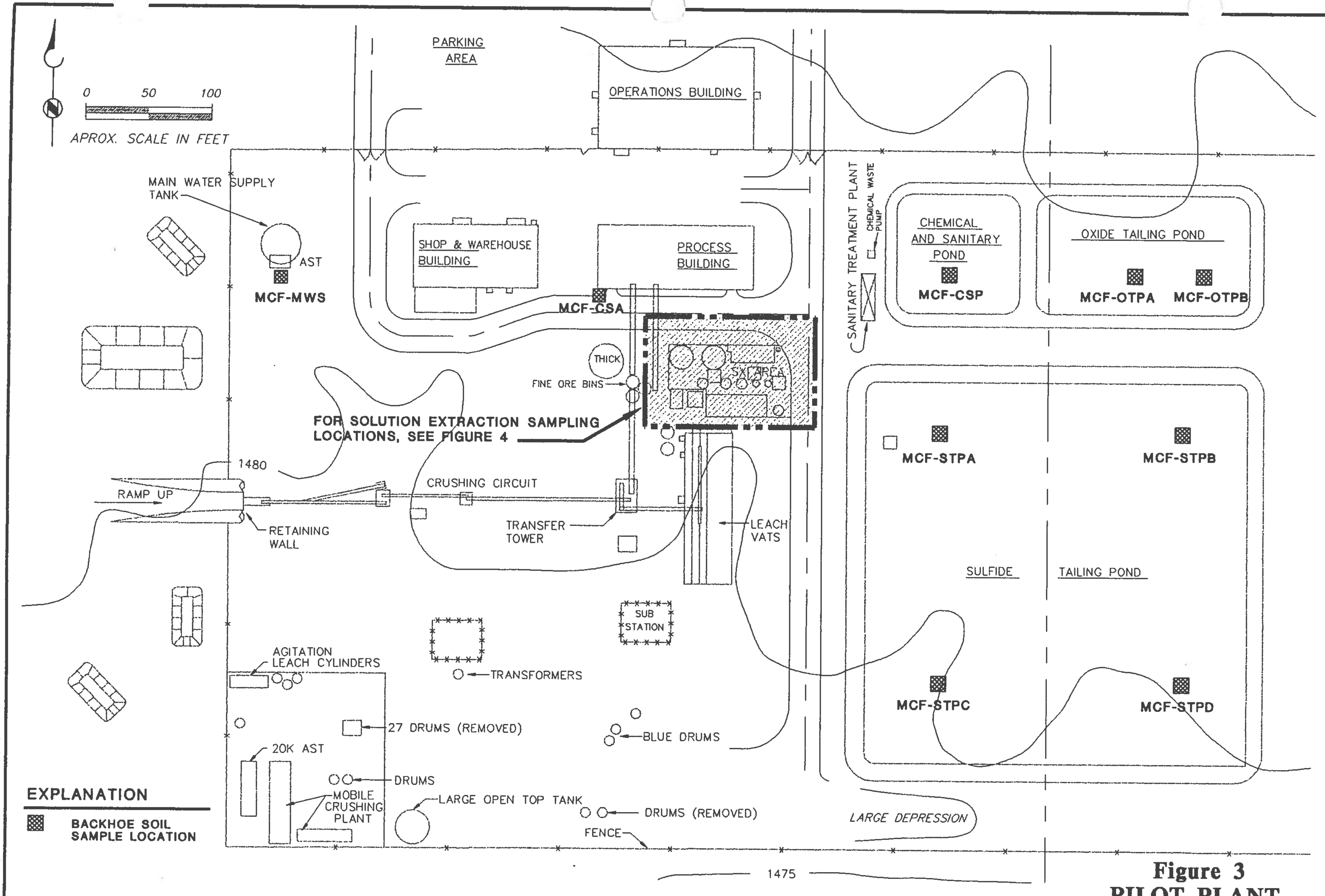

Figure 3
PILOT PLANT PLOT PLAN

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

BROWN AND CALDWELL

11-27-95 Roberta

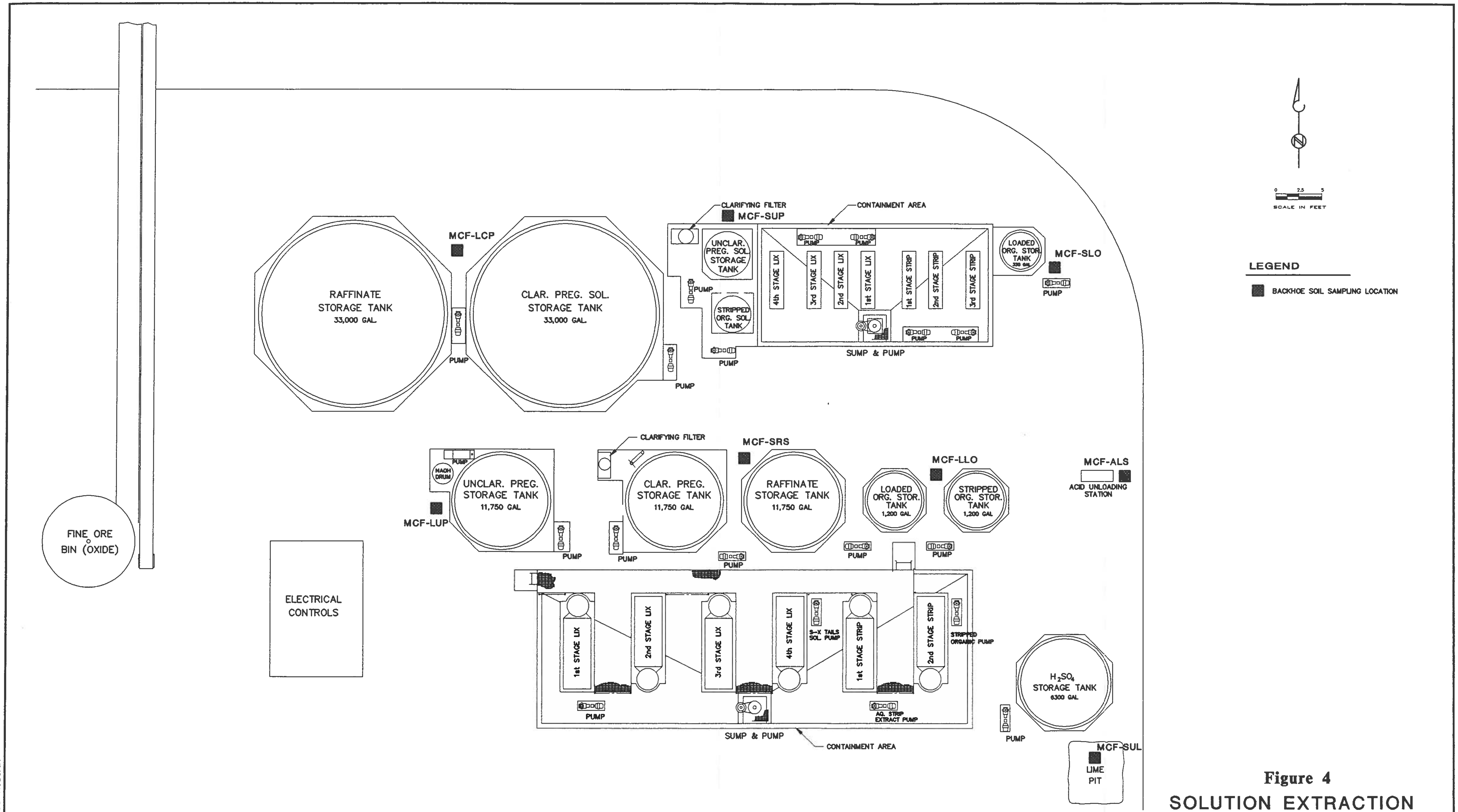

Figure 4
SOLUTION EXTRACTION AREA DETAIL SAMPLING LOCATIONS

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Florence, Arizona

BROWN AND CALDWELL

F1899104 11-27-95 RobertK

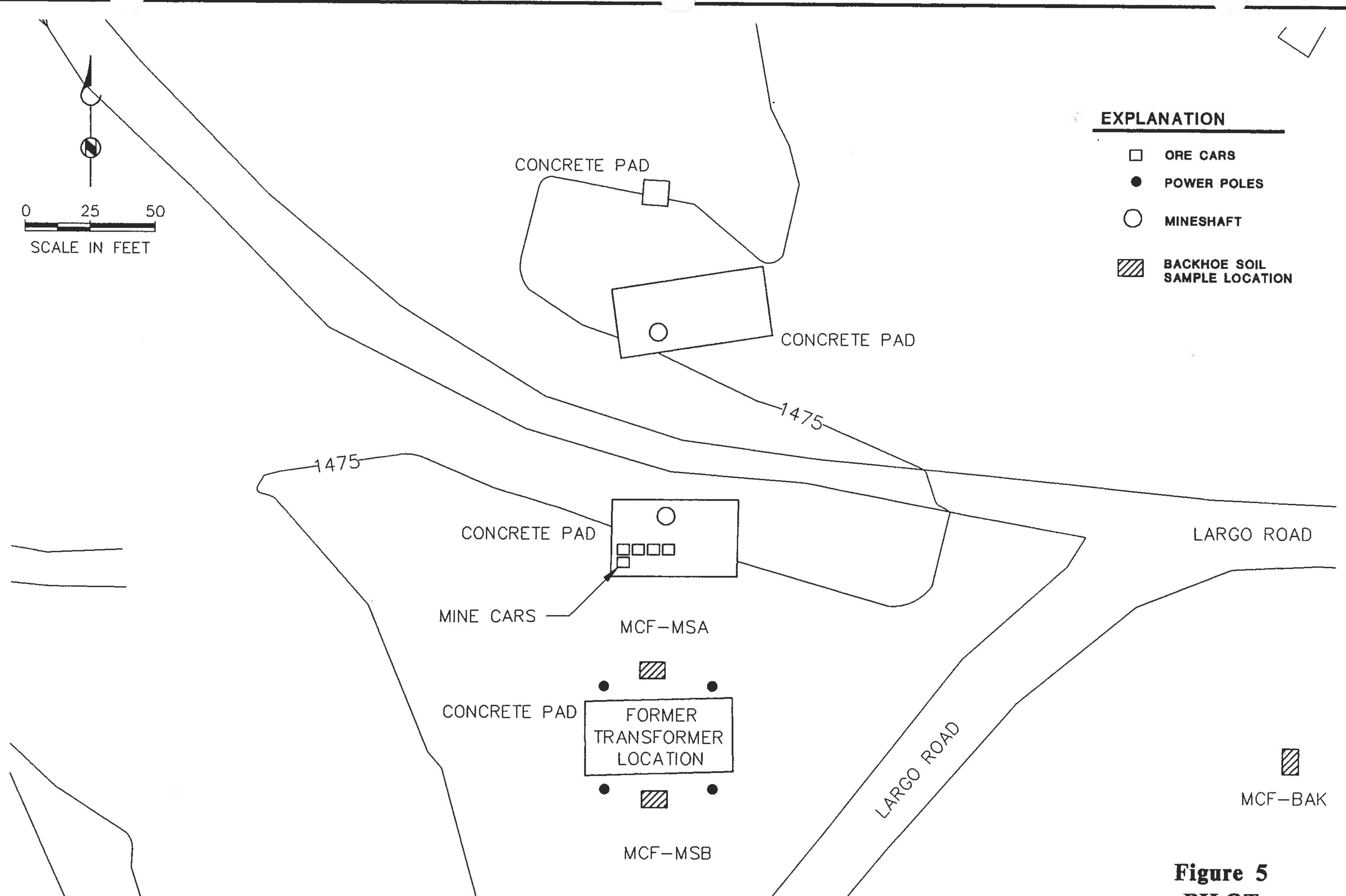

Figure 5
PILOT
MINE AREA

MAGMA
MAGMA COPPER COMPANY
Florence, Arizona

BROWN AND CALDWELL

PHOTO 1: CRUSHING CIRCUIT LOOKING SOUTHWEST

PHOTO 2: MAIN WATER SUPPLY LOOKING SOUTHWEST

PROJECT NO.	CHECKED BY	FIGURE 6
1899	W	SITE PHOTOS 1 AND 2

BROWN AND CALDWELL
Phoenix, Arizona

1899PIC1 1:1 11-14-95 RobertK

PHOTO 3: SOLUTION EXTRACTION AREA LOOKING SOUTHWEST

PHOTO 4: THICKNER(LEFT)AND FINE ORE BINS (RIGHT) LOOKING NORTH

PROJECT NO.	CHECKED BY	
1899		**FIGURE 7**

SITE PHOTOS 3 AND 4

BROWN AND CALDWELL
Phoenix, Arizona

1899PIC2 1:1 11-10-95 RobertK

PHOTO 5: ACID STORAGE AREA WITH LIME PIT LOOKING SOUTH AND VAT LEACH AREA IN BACKGROUND

PHOTO 6: SANITARY PRETREATMENT SYSTEM LOOKING WEST

PROJECT NO.	CHECKED BY	FIGURE 8
1899		

SITE PHOTOS 5 AND 6

BROWN AND CALDWELL
Phoenix, Arizona

1899PIC4 1:1 11-14-95 RobertK

PHOTO 7: SUMP IN PROCESS BUILDING (TYPICAL)

PHOTO 8: CONCENTRATE STORAGE BIN LOOKING NORTH

PROJECT NO.	CHECKED BY	FIGURE 9
1899		

SITE PHOTOS 7 AND 8

BROWN AND CALDWELL
Phoenix, Arizona

1899PIC3 1:1 11-14-95 RobertK

PHOTO 9: CHEMICAL AND SANITARY POND LOOKING NORTHWEST

PHOTO 10: CHEMICAL PUMPING SYSTEM

PROJECT NO.	CHECKED	FIGURE 10
1899	[signature]	SITE PHOTOS 9 AND 10

BROWN AND CALDWELL
Phoenix, Arizona

1899PIC5 1:1 11-10-95 RobertK

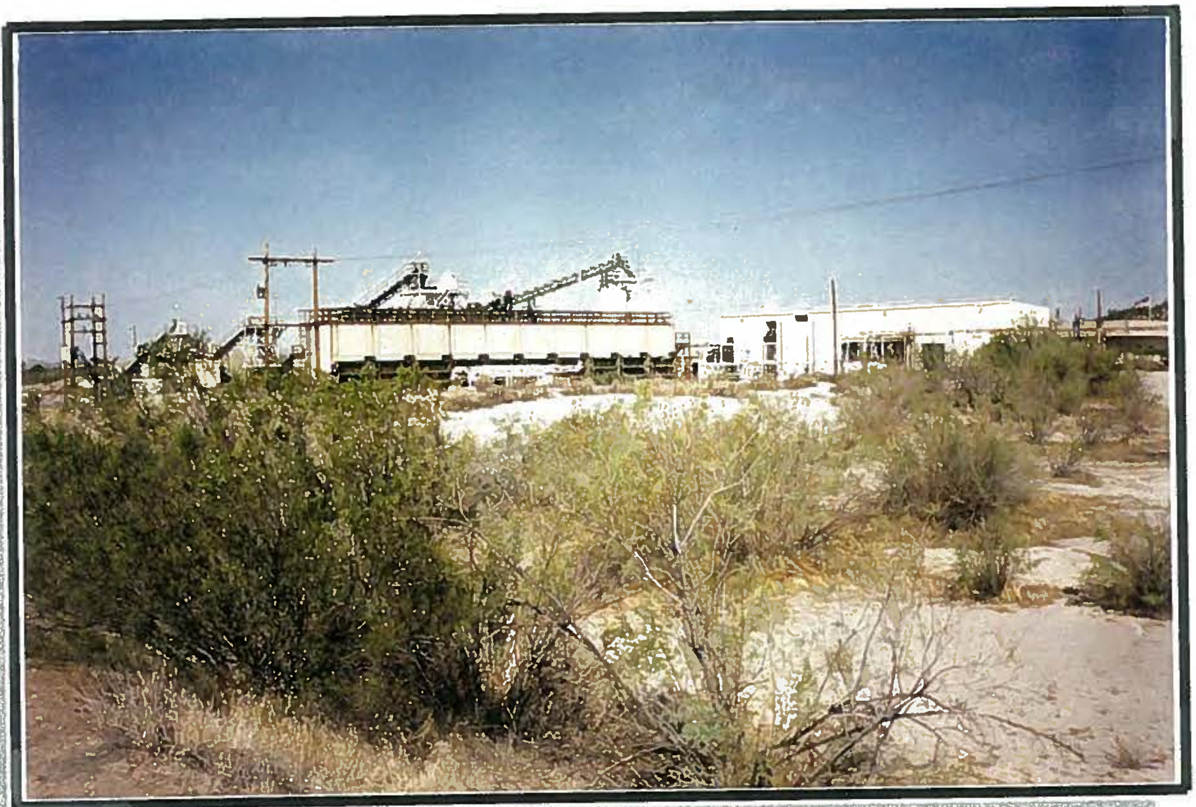

PHOTO 11: SULFIDE TAILINGS LOOKING NORTHWEST
VAT LEACH AREA IN BACKGROUND

PHOTO 12: OXIDE TAILINGS POND LOOKING NORTHWEST
ADMINISTRATION AND PROCESS BUILDINGS IN BACKGROUND

PROJECT NO.	CHECKED BY	FIGURE 11
1899	[signature]	

SITE PHOTOS 11 AND 12

BROWN AND CALDWELL
Phoenix, Arizona

1899PIC6 1:1 11-10-95 RobertK

PHOTO 13: ELECTRICAL CONTROL BUILDING (TYPICAL)

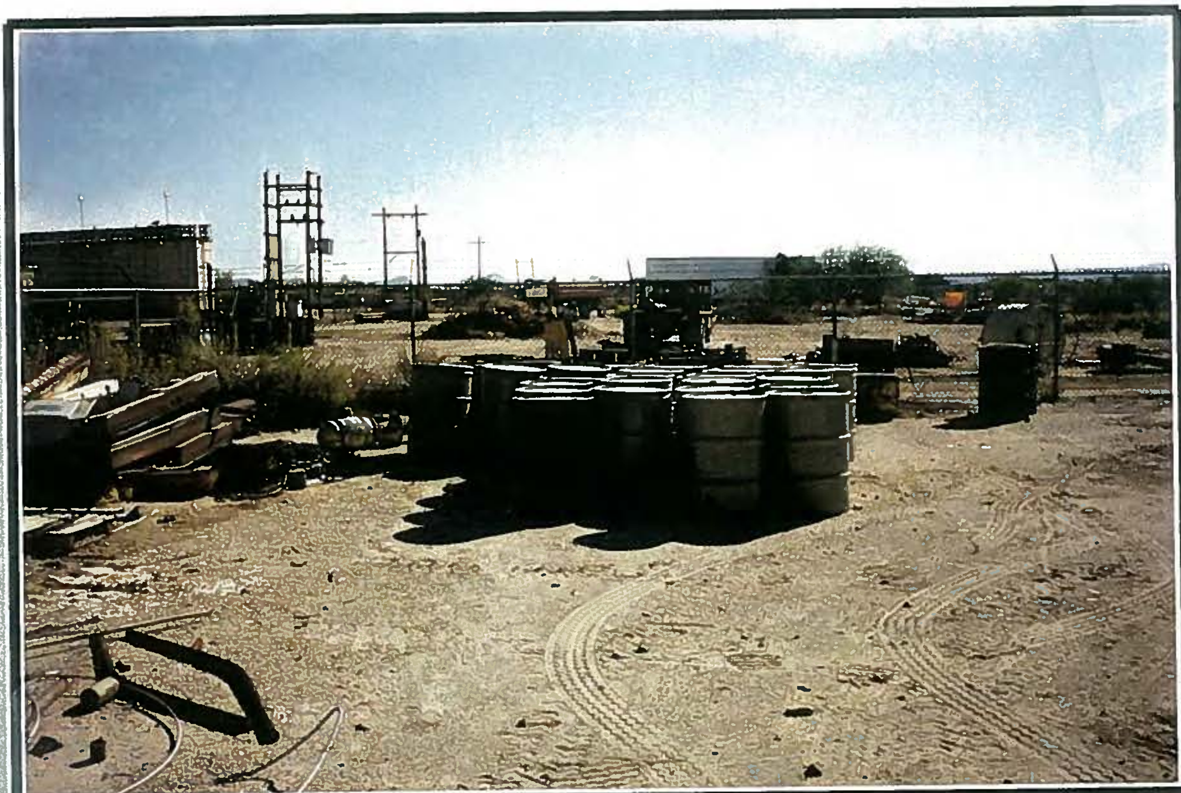

PHOTO 14: EQUIPMENT STORAGE AREA LOOKING EAST

PROJECT NO.	CHECKED BY	FIGURE 12
1899		SITE PHOTOS 13 AND 14

BROWN AND CALDWELL
Phoenix, Arizona

1899PIC7 1:1 11-10-95 RobertK

The EDR-Radius Map
with GeoCheck™

Magma Florence
Magma Florence
Florence, AZ 85232

Inquiry Number: 91278.1s

October 02, 1995

EDR Environmental Data Resources, Inc.

Creators of Toxicheck/®

The Source
For Environmental
Risk Management
Data

3530 Post Road
Southport, Connecticut 06490

Nationwide Customer Service

Telephone: 1-800-352-0050
Fax: 1-800-231-6802

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APPENDICES

Thank you for your business.
Please contact EDR at 1-800-352-0050
with any questions or comments.

EXECUTIVE SUMMARY

A search of available environmental records was conducted by Environmental Data Resources, Inc. (EDR). The search met the specific requirements of ASTM Standard Practice for Environmental Site Assessments, E 1527-94, or custom distances requested by the user.

The address of the subject property for which the search was intended is:

MAGMA FLORENCE
FLORENCE, AZ 85232

No mapped sites were found in EDR's search of available ("reasonably ascertainable ") government records either on the subject property or within the ASTM E 1527-94 search radius around the subject property for the following Databases:

NPL:........................ National Priority List
Delisted NPL:............... NPL Deletions
RCRIS-TSD:.................. Resource Conservation and Recovery Information System
State Haz. Waste:........... ZipAcids
CERCLIS:.................... Comprehensive Environmental Response, Compensation, and Liability Information System
CERC-NFRAP:................. Comprehensive Environmental Response, Compensation, and Liability Information System
CORRACTS:................... Corrective Action Report
State LF:................... Municipal Solid Waste Landfills.../Closed Solid Waste Landfills...
LUST:....................... LUST File Listing by Zip Code
UST:........................ Arizona UST - DMS Facility and Tank Data Listing By City
RAATS:...................... RCRA Administrative Action Tracking System
RCRIS-SQG:.................. Resource Conservation and Recovery Information System
RCRIS-LQG:.................. Resource Conservation and Recovery Information System
HMIRS:...................... Hazardous Materials Information Reporting System
PADS:....................... PCB Activity Database System
ERNS:....................... Emergency Response Notification System
FINDS:...................... Facility Index System
TRIS:....................... Toxic Chemical Release Inventory System
NPL Liens:.................. Federal Superfund Liens
TSCA:....................... Toxic Substances Control Act
MLTS:....................... Material Licensing Tracking System
RODS:....................... Records Of Decision
CONSENT:.................... Superfund (CERCLA) Consent Decrees
Az Dry Wells:............... Drywell Registration
Az Spills:.................. Hazardous Material Logbook
Az Aquifers:................ Not reported
Coal Gas:................... Former Manufactured gas (Coal Gas) Sites

Unmapped (orphan) sites are not considered in the foregoing analysis.

Search Results:

Search results for the subject property and the search radius, are listed below:

Subject Property:

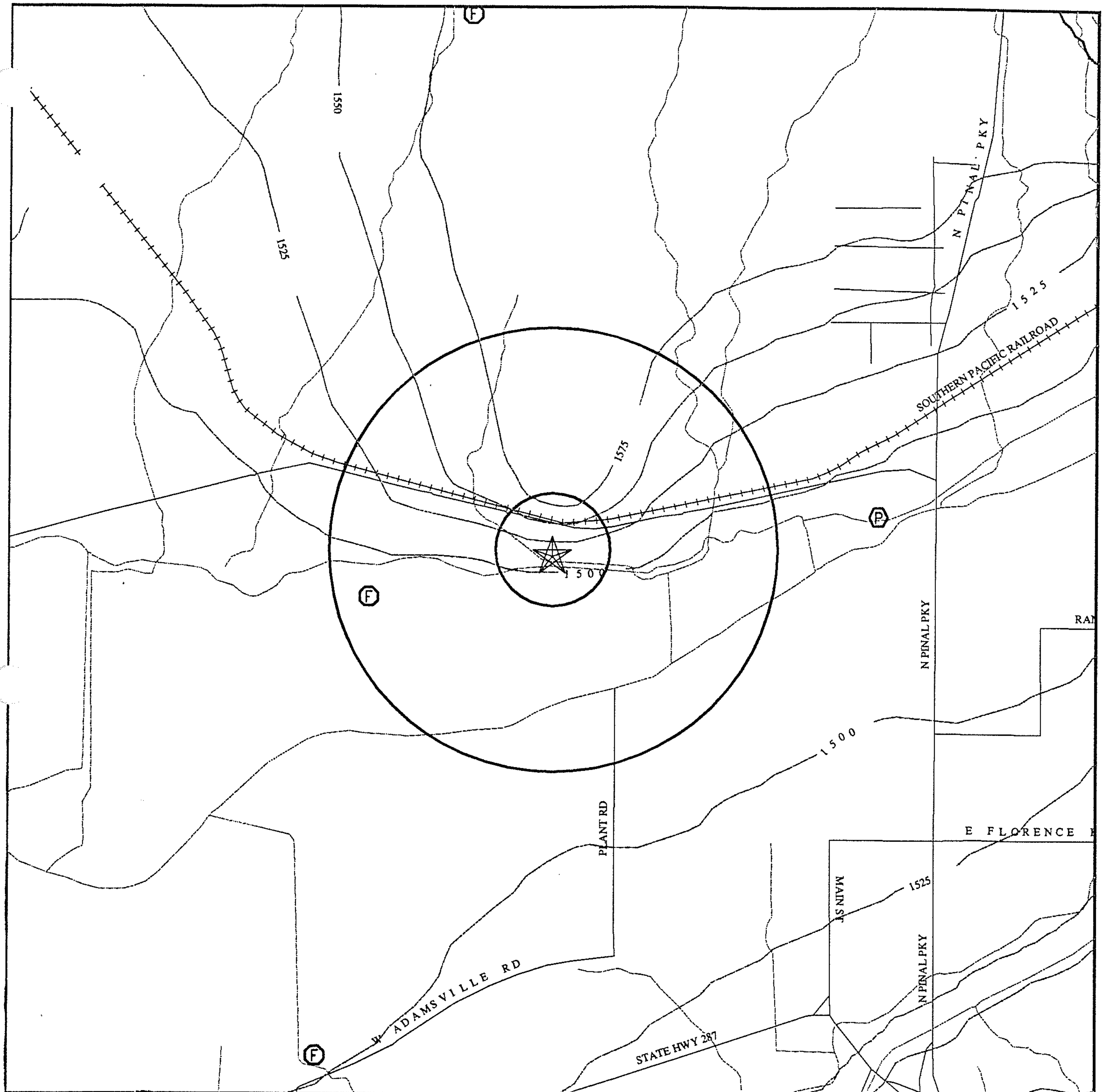
The subject property was not listed in any of the databases searched by EDR.

EXECUTIVE SUMMARY

Due to poor or inadequate address information, the following sites were not mapped:

Site Name	Database(s)
FLORENCE P.O.W. CAMP	State Haz. Waste
FLORENCE AIR FORCE AUX FACILITY	State Haz. Waste
DAVIS MONTHAN AFB AF FAC S-16	State Haz. Waste
WILLIAMS FIELD BOMB TGT RANGE #21	State Haz. Waste
DAVIS MONTHAN AFB AF FAC S-17	State Haz. Waste
FLORENCE MILITARY RESERVATION	FINDS,CERC-NFRAP
SAN MANUEL PSWLF	State LF
COOLIDGE MSWLF	State LF
DUDLEYVILLE MSWLF	State LF
ADAMSVILLE MSWLF	State LF
ADAMSVILLE FEEDLOT	State LF
APACHE JUNCTION	State LF
CASA GRANDE	State LF
COOLIDGE	State LF
DUDLEYVILLE	State LF
MAMMOTH	State LF
STANFIELD	State LF
MAMMOTH MSWLF	State LF
APACHE JUNCTION MSWLF	State LF
CASA GRANDE MSWLF	State LF
ELOY MSWLF	State LF
STANFIELD MSWLF	State LF
FLORENCE UNIFIED SCHOOL DIST	LUST
FLORENCE TIGERMART	UST,LUST
ERNEST W MCFARLAND ESTATE	UST
UNIT TRAINING EQUIPMENT SITE	UST
ARIZONA STATE FLORENCE ACI	UST
FLORENCE UNIFIED SCHOOL DIST	UST
AMERICAN TELEPHONE & TELEGRAPH	UST
SMITTY'S	UST
FLORENCE WASTE WATER TREATMENT	UST
L & M FARM INC	UST
AT&T COMMUNICATIONS FLORENCE	UST
PINAL COUNTY RIVERSIDE-KELVIN YD	UST
AZ NATIONAL GUARD UTES	RCRIS-SQG,FINDS
ARIZONA CORRECTIONAL INDUSTRIES	RCRIS-SQG,FINDS
FLORENCE TOWN OF	FINDS
FLORENCE RANGE	FINDS
FLORENCE USD 1	FINDS
LATTER DAY SAINTS - FLORENCE, AZ	Az Dry Wells

TOPOGRAPHIC MAP - 91278.1s - Brown and Caldwell



Source: US Geological Survey 1-Degree Digital Elevation Model
Compiled 09/15/92

0 1/4 1/2 1 2
Miles

- Major Roads
- Contour lines (25 foot interval unless otherwise shown)
- Waterways

- Earthquake epicenter, Richter 5 or greater.
- Closest well according to (F)ederal or (S)tate database in quadrant.
- Closest public water supply well.

TARGET PROPERTY:	Magma Florence	CUSTOMER:	Brown and Caldwell
ADDRESS:	Magma Florence	CONTACT:	Steve Zembrowski
CITY/STATE/ZIP:	Florence AZ 85232	INQUIRY #:	91278.1s
LAT/LONG:	33.0510 / 111.4091	DATE:	October 02, 1995

GEOCHECK VERSION 2.1
SUMMARY

GEOLOGIC AGE IDENTIFICATION†

Geologic Code:	Q
Era:	Cenozoic
System:	Quaternary
Series:	Quaternary

ROCK STRATIGRAPHIC UNIT†

Category: Stratifed Sequence

GROUNDWATER FLOW INFORMATION

General Topographic Gradient: General South

General Hydrogeologic Gradient: The hydrogeologic data for this report indicates that groundwater flow generally is to the North. However, because of the number and/or location of wells, the various depths of aquifers or other insufficient data, the direction of groundwater flow is uncertain.

Note: In a general way, the water table typically conforms to surface topography.‡

USGS TOPOGRAPHIC MAP ASSOCIATED WITH THIS SITE

Target Property: 2433111-A4 FLORENCE, AZ

FEDERAL DATABASE WELL INFORMATION

WELL QUADRANT	DISTANCE FROM TP	LITHOLOGY	DEPTH TO WATER TABLE
North	>2 Miles	Not Reported	Not Reported
South	>2 Miles	Not Reported	115 ft.
West	1/2 - 1 Mile	Not Reported	213 ft.

PUBLIC WATER SUPPLY SYSTEM INFORMATION (EPA-FRDS)

Searched by Nearest Well.

Location Relative to TP: 1 - 2 Miles East

PWS Name: ARIZONA SIERRA UTILITY C
451 NORTH GILBERT ROAD, A-198
GILBERT, AZ 85234

Well currently has or has had major violation(s): Yes

AREA RADON INFORMATION

Zip Code: 85232

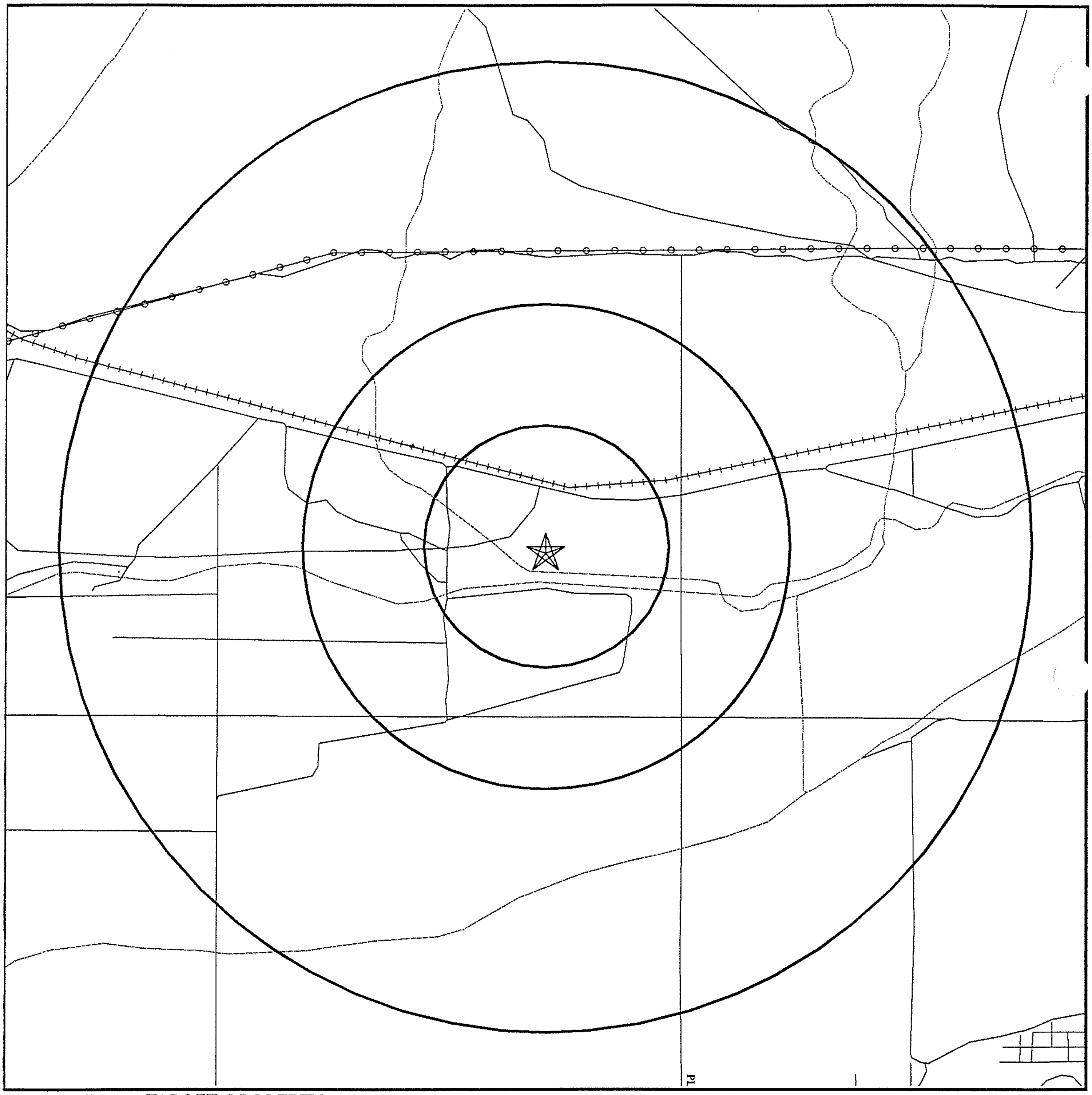
Number of sites tested: 0

Area	Average Activity	% <4 pCi/L	% 4-20 pCi/L	% >20 pCi/L
Living Area - 1st Floor	Not Reported	Not Reported	Not Reported	Not Reported
Living Area - 2nd Floor	Not Reported	Not Reported	Not Reported	Not Reported
Basement	Not Reported	Not Reported	Not Reported	Not Reported

† Source: P.G. Schruben, R.E. Arndt and W.J. Bawiec, Geology of the Conterminous U.S. at 1:2,500,000 Scale - A digital representation of the 1974 P.B. King and H.M. Beikman Map, USGS Digital Data Series DDS - 11 (1994).

‡ U.S. EPA Ground Water Handbook, Vol I: Ground Water and Contamination, Office of Research and development EPA/625/6-90/016a,Chapter 4, page 78, September 1990.

OVERVIEW MAP - 91278.1s - Brown and Caldwell



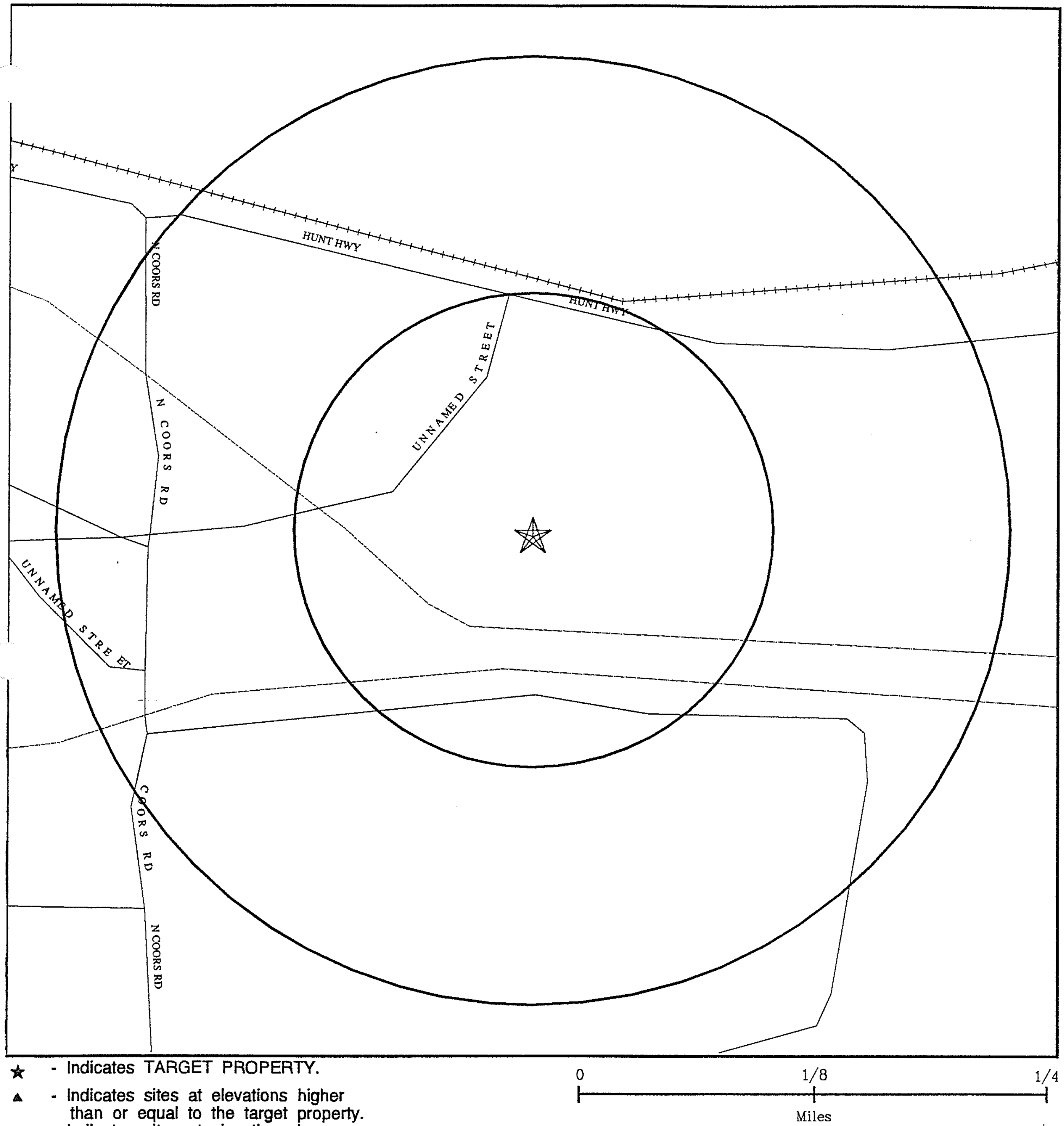
- ★ - Indicates TARGET PROPERTY.
- ▲ - Indicates sites at elevations higher than or equal to the target property.
- ◆ - Indicates sites at elevations lower than the target property.
- Coal Gasification Sites (if requested)
- National Priority List Sites

0 1/4 1/2 1
Miles

- Power transmission lines (USGS DLG, 1993)
- Oil & Gas pipelines (USGS DLG, 1993)

TARGET PROPERTY:	Magma Florence	CUSTOMER:	Brown and Caldwell
ADDRESS:	Magma Florence	CONTACT:	Steve Zembrowski
CITY/STATE/ZIP:	Florence AZ 85232	INQUIRY #:	91278.1s
LAT/LONG:	33.0510 / 111.4091	DATE:	October 02, 1995

DETAIL MAP - 91278.1s - Brown and Caldwell



★ - Indicates TARGET PROPERTY.

▲ - Indicates sites at elevations higher than or equal to the target property.

◆ - Indicates sites at elevations lower than the target property.

- Coal Gasification Sites (if requested)

- Sensitive Receptors

- National Priority List Sites

- Power transmission lines (USGS DLG, 1993)

- Oil & Gas pipelines (USGS DLG, 1993)

TARGET PROPERTY:	Magma Florence	CUSTOMER:	Brown and Caldwell
ADDRESS:	Magma Florence	CONTACT:	Steve Zembrowski
CITY/STATE/ZIP:	Florence AZ 85232	INQUIRY #:	91278.1s
LAT/LONG:	33.0510 / 111.4091	DATE:	October 02, 1995

MAP FINDINGS SUMMARY SHOWING ALL SITES

Database	Target Property	Search Distance (Miles)	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
NPL		1.000	0	0	0	0	NR	0
Delisted NPL		TP	NR	NR	NR	NR	NR	0
RCRIS-TSD		1.000	0	0	0	0	NR	0
State Haz. Waste		1.000	0	0	0	0	NR	0
CERCLIS		0.500	0	0	0	NR	NR	0
CERC-NFRAP		TP	NR	NR	NR	NR	NR	0
CORRACTS		1.000	0	0	0	0	NR	0
State Landfill		0.500	0	0	0	NR	NR	0
LUST		0.500	0	0	0	NR	NR	0
UST		0.250	0	0	NR	NR	NR	0
RAATS		TP	NR	NR	NR	NR	NR	0
RCRIS Sm. Quan. Gen.		0.250	0	0	NR	NR	NR	0
RCRIS Lg. Quan. Gen.		0.250	0	0	NR	NR	NR	0
HMIRS		TP	NR	NR	NR	NR	NR	0
PADS		TP	NR	NR	NR	NR	NR	0
ERNS		TP	NR	NR	NR	NR	NR	0
FINDS		TP	NR	NR	NR	NR	NR	0
TRIS		TP	NR	NR	NR	NR	NR	0
NPL Liens		TP	NR	NR	NR	NR	NR	0
TSCA		TP	NR	NR	NR	NR	NR	0
MLTS		TP	NR	NR	NR	NR	NR	0
Az. Dry Well		TP	NR	NR	NR	NR	NR	0
Arizona Spills		TP	NR	NR	NR	NR	NR	0
Az Aquifers		1.000	0	0	0	0	NR	0
ROD		1.000	0	0	0	0	NR	0
CONSENT		1.000	0	0	0	0	NR	0
Coal Gas		1.000	0	0	0	0	NR	0

TP = Target Property

NR = Not Requested at this Search Distance

* Sites may be listed in more than one database

MAP FINDINGS SUMMARY SHOWING
ONLY SITES HIGHER THAN OR THE SAME ELEVATION AS TP

Database	Target Property	Search Distance (Miles)	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
NPL		1.000	0	0	0	0	NR	0
Delisted NPL		TP	NR	NR	NR	NR	NR	0
RCRIS-TSD		1.000	0	0	0	0	NR	0
State Haz. Waste		1.000	0	0	0	0	NR	0
CERCLIS		0.500	0	0	0	NR	NR	0
CERC-NFRAP		TP	NR	NR	NR	NR	NR	0
CORRACTS		1.000	0	0	0	0	NR	0
State Landfill		0.500	0	0	0	NR	NR	0
LUST		0.500	0	0	0	NR	NR	0
UST		0.250	0	0	NR	NR	NR	0
RAATS		TP	NR	NR	NR	NR	NR	0
RCRIS Sm. Quan. Gen.		0.250	0	0	NR	NR	NR	0
RCRIS Lg. Quan. Gen.		0.250	0	0	NR	NR	NR	0
HMIRS		TP	NR	NR	NR	NR	NR	0
PADS		TP	NR	NR	NR	NR	NR	0
ERNS		TP	NR	NR	NR	NR	NR	0
FINDS		TP	NR	NR	NR	NR	NR	0
TRIS		TP	NR	NR	NR	NR	NR	0
NPL Liens		TP	NR	NR	NR	NR	NR	0
TSCA		TP	NR	NR	NR	NR	NR	0
MLTS		TP	NR	NR	NR	NR	NR	0
Az. Dry Well		TP	NR	NR	NR	NR	NR	0
Arizona Spills		TP	NR	NR	NR	NR	NR	0
Az Aquifers		1.000	0	0	0	0	NR	0
ROD		1.000	0	0	0	0	NR	0
CONSENT		1.000	0	0	0	0	NR	0
Coal Gas		1.000	0	0	0	0	NR	0

TP = Target Property

NR = Not Requested at this Search Distance

* Sites may be listed in more than one database

Map ID Direction Distance Elevation	Site	Database(s)	EDR ID Number EPA ID Number

Coal Gas Site Search: No site was found in a search of Real Property Scan's ENVIROHAZ database.

NO SITES FOUND

ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)	Facility ID
FLORENCE	S100253079	FLORENCE P.O.W. CAMP		85232	SHWS	0672
FLORENCE	S101570524	FLORENCE AIR FORCE AUX FACILITY		85232	SHWS	
FLORENCE	S101570523	DAVIS MONTHAN AFB AF FAC S-16		85232	SHWS	
FLORENCE	S101570525	WILLIAMS FIELD BOMB TGT RANGE #21		85232	SHWS	
FLORENCE	S100253077	DAVIS MONTHAN AFB AF FAC S-17		85232	SHWS	0693
FLORENCE	U001626295	ERNEST W MCFARLAND ESTATE	RT 1 BOX 8	85232	UST	0-003099
FLORENCE	U001157868	UNIT TRAINING EQUIPMENT SITE	HWY 80 & 89 NORTH	85232	UST	0-003463
FLORENCE	1000307604	AZ NATIONAL GUARD UTES	HWY 80 & 89 NORTH	85232	RCRIS-SQG, FINDS	
FLORENCE	1000443513	ARIZONA CORRECTIONAL INDUSTRIES	HWY 89 & BUTTE AVE	85232	RCRIS-SQG, FINDS	
FLORENCE	U000015372	ARIZONA STATE FLORENCE ACI	BUTTE AVE	85232	UST	0-000726
FLORENCE	1000589020	FLORENCE TOWN OF	W END OF BUTTE AVE	85232	FINDS	
FLORENCE	1000589803	FLORENCE RANGE	1001 NORTH FLORENCE	85232	FINDS	
FLORENCE	U001157864	FLORENCE UNIFIED SCHOOL DIST	230 S FLORENCE HEIGHTS ROAD	85232	UST	0-007419
FLORENCE	S100985067	FLORENCE UNIFIED SCHOOL DIST	230 S FLORENCE HEIGHTS ROAD	85232	LUST	0007419
FLORENCE	1000588339	FLORENCE USD 1	1810 E MAIN ST	85232	FINDS	
FLORENCE	U000999563	FLORENCE TIGERMART	1501 MAIN STREET	85232	UST, LUST	0005115
FLORENCE	U001157856	AMERICAN TELEPHONE & TELEGRAPH	6.4 MILES ON HWY 287 SOUTH 2.8	85232	UST	0-007616
FLORENCE	1000885552	FLORENCE MILITARY RESERVATION	1.5 MI N OF FLORENCE	85232	FINDS, CERC-NFRAP	
FLORENCE	U001628027	SMITTY'S	770 PINAL PARKWAY HWY 89	85232	UST	0-006483
FLORENCE	U001625813	FLORENCE WASTE WATER TREATMENT	300 S PLANT ROAD	85232	UST	0-002159
FLORENCE	U001626198	L & M FARM INC	STAR RTE 1 BOX 3	85232	UST	0-002907
FLORENCE	S101431215	LATTER DAY SAINTS - FLORENCE, AZ	SW-C MAIN STREET / VAN HAREN STREET	85232	Dry Well	
FLORENCE	U000999557	AT&T COMMUNICATIONS FLORENCE	VALLEY FARM RD HWY 287	85232	UST	0-000582
KELVIN	U001626707	PINAL COUNTY RIVERSIDE-KELVIN YD	1/2 MILE W OF HWY 177 KELVIN HWY	85232	UST	0-003918
PINAL COUNTY	S101165382	SAN MANUEL PSWLF	MCNAB PKWY THRU TOWN TO DEAD END; L		SWF/LF	
PINAL COUNTY	S101165379	COOLIDGE MSWLF	.5 MI WEST OF AZ. 87 ON BARLETT ROA		SWF/LF	
PINAL COUNTY	S101165341	DUDLEYVILLE MSWLF	.4 MI S OF MILEPOST 132 ON EAST SID		SWF/LF	
PINAL COUNTY	S101165338	ADAMSVILLE MSWLF	2 MILES WEST OF FLORENCE ON ADAMSVI		SWF/LF	
PINAL COUNTY	S100293375	ADAMSVILLE FEEDLOT	.2 MILES NORTH OF MILEPOST 140 ON A		SWF/LF	
PINAL COUNTY	S100293376	APACHE JUNCTION	2.6 MILES S OF AZ. 60/80/89 ON TOMA		SWF/LF	
PINAL COUNTY	S100293377	CASA GRANDE	3.2 MILES SOUTH OF CASA GRANDE ON F		SWF/LF	
PINAL COUNTY	S100293378	COOLIDGE	.5 MILES WEST OF AZ. 87 ON BARTLETT		SWF/LF	
PINAL COUNTY	S100293379	DUDLEYVILLE	.4 MILES S OF MILEPOST 132 ON THE E		SWF/LF	
PINAL COUNTY	S100293380	MAMMOTH	.9 MILES N OF SAN PEDRO BRDG ON THE		SWF/LF	
PINAL COUNTY	S100293381	STANFIELD	1.2 MILES WEST OF MARICOPA ROAD ON		SWF/LF	
PINAL COUNTY	S101165380	MAMMOTH MSWLF	1 MI N OF SAN PEDRO BRIDGE ON E. SI		SWF/LF	
PINAL COUNTY	S101215518	APACHE JUNCTION MSWLF	2.6 MI S OF AZ. 60/80/89 ON TOMAHAW		SWF/LF	
PINAL COUNTY	S101165340	CASA GRANDE MSWLF	3.2 MI S OF CASA GRANDE AT 5200 S C		SWF/LF	
PINAL COUNTY	S101165342	ELOY MSWLF	2 MI S OF I-10 ON TOLTEC RD		SWF/LF	
PINAL COUNTY	S101165343	STANFIELD MSWLF	1.2 MI W OF MARICOPA RD. ON AZ. 84		SWF/LF	

GEOCHECK VERSION 2.1 ADDENDUM
FEDERAL DATABASE WELL INFORMATION

Well Closest to Target Property (North Quadrant)

BASIC WELL DATA

Site ID:	330516111245601	Distance from TP:	>2 Miles
Site Type:	Single well, other than collector or Ranney type		
Year Constructed:	Not Reported	County:	Pinal
Altitude:	1565.00 ft.	State:	Arizona
Well Depth:	Not Reported	Topographic Setting:	Undulating
Depth to Water Table:	Not Reported	Prim. Use of Site:	Test
Date Measured:	Not Reported	Prim. Use of Water:	Not Reported

LITHOLOGIC DATA

Not Reported

WATER LEVEL VARIABILITY

Not Reported

GEOCHECK VERSION 2.1
FEDERAL DATABASE WELL INFORMATION

Well Closest to Target Property (South Quadrant)

BASIC WELL DATA

Site ID:	330059111254101	Distance from TP:	>2 Miles
Site Type:	Single well, other than collector or Ranney type		
Year Constructed:	1957	County:	Pinal
Altitude:	1460.00 ft.	State:	Arizona
Well Depth:	500.00 ft.	Topographic Setting:	Not Reported
Depth to Water Table:	115.00 ft.	Prim. Use of Site:	Withdrawal of water
Date Measured:	03011957	Prim. Use of Water:	Irrigation

LITHOLOGIC DATA

Not Reported

WATER LEVEL VARIABILITY

Water Level: 115.00 ft.
Date Measured: 03/01/57

GEOCHECK VERSION 2.1
FEDERAL DATABASE WELL INFORMATION

Well Closest to Target Property (West Quadrant)

BASIC WELL DATA

Site ID:	330252111252601	Distance from TP:	1/2 - 1 Mile
Site Type:	Single well, other than collector or Ranney type		
Year Constructed:	Not Reported	County:	Pinal
Altitude:	1465.00 ft.	State:	Arizona
Well Depth:	700.00 ft.	Topographic Setting:	Not Reported
Depth to Water Table:	213.00 ft.	Prim. Use of Site:	Not Reported
Date Measured:	10071974	Prim. Use of Water:	Not Reported

LITHOLOGIC DATA

Not Reported

WATER LEVEL VARIABILITY

Water Level: 213.00 ft.
Date Measured: 10/07/74

GEOCHECK VERSION 2.1
PUBLIC WATER SUPPLY SYSTEM INFORMATION

Searched by Nearest Well.

PWS SUMMARY:

PWS ID:	AZ0411056	PWS Status:	Active	Distance from TP:	1 - 2 Miles
Dir relative to TP:	East	Date Initiated:	June / 1972	Date Deactivated:	Not Reported
PWS Name:	ARIZONA SIERRA UTILITY C 451 NORTH GILBERT ROAD, A-198 GILBERT, AZ 85234				

Addressee / Facility Type: System Owner/Responsible Party
Facility Name: ARIZONA SIERRA UTILITY CO.
459 N. GILBERT ROAD SUITE A198
GILBERT, AZ 85234

Facility Latitude:	33 03 12	Facility Longitude:	111 22 50
Facility Latitude:	33 03 12	Facility Longitude:	111 22 58
Facility Latitude:	33 21 10	Facility Longitude:	111 47 17
City Served:	FLORENCE		
Treatment Class:	Untreated	Population Served:	2,501 - 3,300 Persons

Well currently has or has had major violation(s): Yes

VIOLATIONS INFORMATION:

Not Reported

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

To maintain currency of the following federal and state databases, EDR contacts the appropriate governmental agency on a monthly or quarterly basis, as required.

Elapsed ASTM days: Provides confirmation that this EDR report meets or exceeds the 90-day updating requirement of the ASTM standard.

FEDERAL ASTM RECORDS:

CERCLIS: Comprehensive Environmental Response, Compensation, and Liability Information System
Source: EPA/NTIS
Telephone: 703-416-0702
CERCLIS: CERCLIS contains data on potentially hazardous waste sites that have been reported to the USEPA by states, municipalities, private companies and private persons, pursuant to Section 103 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). CERCLIS contains sites which are either proposed to or on the National Priorities List (NPL) and sites which are in the screening and assessment phase for possible inclusion on the NPL.

Date of Government Version: 06/30/95 | Date of Data Arrival at EDR: 08/09/95
Date Made Active at EDR: 09/13/95 | Elapsed ASTM days: 35

ERNS: Emergency Response Notification System
Source: EPA
Telephone: 202-260-2342
ERNS: Emergency Response Notification System. ERNS records and stores information on reported releases of oil and hazardous substances.

Date of Government Version: 12/31/94 | Date of Data Arrival at EDR: 04/11/95
Date Made Active at EDR: 05/25/95 | Elapsed ASTM days: 44

NPL: National Priority List
Source: EPA
Telephone: 703-603-8852
NPL: National Priorities List (Superfund). The NPL is a subset of CERCLIS and identifies over 1,200 sites for priority cleanup under the Superfund Program. NPL sites may encompass relatively large areas. As such, it is EDR's policy to plot NPL sites greater than approximately 500 acres in size as areas (polygons). Sites smaller in size are point-geocoded at the site's address.

Date of Government Version: 05/26/95 | Date of Data Arrival at EDR: 06/06/95
Date Made Active at EDR: 06/06/95 | Elapsed ASTM days: 0

RCRIS: Resource Conservation and Recovery Information System
Source: EPA/NTIS
Telephone: 703-308-7907
RCRIS: Resource Conservation and Recovery Information System. RCRIS includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA).

Date of Government Version: 05/31/95 | Date of Data Arrival at EDR: 06/28/95
Date Made Active at EDR: 08/22/95 | Elapsed ASTM days: 55

FEDERAL NON-ASTM RECORDS:

CONSENT: Superfund (CERCLA) Consent Decrees
Source: EPA Regional Offices
Telephone: Varies
Major legal settlements that establish responsibility and standards for cleanup at NPL (Superfund) sites. Released periodically by United States District Courts after settlement by parties to litigation matters.

Date of Government Version: Varies — Date of Next Scheduled Update: 09/01/95

CORRACTS: Corrective Action Report
Source: EPA
Telephone: 703-308-7907
CORRACTS: CORRACTS identifies hazardous waste handlers with RCRA corrective action activity.

Date of Government Version: 04/10/95 — Date of Next Scheduled Update: 12/18/95

FINDS: Facility Index System
Source: EPA/NTIS
Telephone: 800-908-2493
FINDS: Facility Index System. FINDS contains both facility information and "pointers" to other sources that contain more detail. These include: RCRIS, PCS (Permit Compliance System), AIRS (Aerometric Information Retrieval System), FATES (FIFRA [Federal Insecticide Fungicide Rodenticide Act] and TSCA Enforcement System, FTTS [FIFRA/TSCA Tracking System]), CERCLIS, DOCKET (Enforcement Docket used to manage and track information on civil judicial enforcement cases for all environmental statutes), FURS (Federal Underground Injection Control), FRDS (Federal Reporting Data System), SIA (Surface Impoundments), CICIS (TSCA Chemicals in Commerce Information System), PADS, RCRA-J (medical waste transporters/disposers), TRIS and TSCA.

Date of Government Version: 07/27/94 — Date of Next Scheduled Update: 10/16/95

HMIRS: Hazardous Materials Information Reporting System
Source: U.S. Department of Transportation
Telephone: 202-366-4555
HMIRS: Hazardous Materials Incident Report System. HMIRS contains hazardous material spill incidents reported to DOT.

Date of Government Version: 12/31/94 — Date of Next Scheduled Update: 12/04/95

MLTS: Material Licensing Tracking System
Source: Nuclear Regulatory Commission
Telephone: 301-415-7169
MLTS is maintained by the Nuclear Regulatory Commission and contains a list of approximately 8,100 sites which possess or use radioactive materials and which are subject to NRC licensing requirements. To maintain currency, EDR contacts the Agency on a quarterly basis.

Date of Government Version: 01/01/95 — Date of Next Scheduled Update: 10/16/95

NPL LIENS: Federal Superfund Liens
Source: EPA
Telephone: 202-260-8969
NPL LIENS: Federal Superfund Liens. Under the authority granted the USEPA by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, the USEPA has the authority to file liens against real property in order to recover remedial action expenditures or when the property owner receives notification of potential liability. USEPA compiles a listing of filed notices of Superfund Liens.

Date of Government Version: 10/15/91 — Date of Next Scheduled Update: 11/27/95

PADS: PCB Activity Database System
Source: EPA
Telephone: 202-260-3992
PADS: PCB Activity Database. PADS Identifies generators, transporters, commercial storers and/or brokers and disposers of PCB's who are required to notify the EPA of such activities.

Date of Government Version: 10/14/94 — Date of Next Scheduled Update: 10/23/95

RAATS: RCRA Administrative Action Tracking System
Source: EPA
Telephone: 202-564-4104
RAATS: RCRA Administration Action Tracking System. RAATS contains records based on enforcement actions issued under RCRA pertaining to major violators and includes administrative and civil actions brought by the EPA.

Date of Government Version: 04/17/95 Date of Next Scheduled Update: 10/02/95

ROD: Records Of Decision
Source: NTIS
Telephone: 703-416-0703
Record of Decision. ROD documents mandate a permanent remedy at an NPL (Superfund) site containing technical and health information to aid in the cleanup.

Date of Government Version: 03/31/95 Date of Next Scheduled Update: 12/04/95

TRIS: Toxic Chemical Release Inventory System
Source: EPA/NTIS
Telephone: 202-260-2320
TRIS: Toxic Release Inventory System. TRIS identifies facilities which release toxic chemicals to the air, water and land in reportable quantities under SARA Title III Section 313.

Date of Government Version: 12/31/92 Date of Next Scheduled Update: 10/09/95

TSCA: Toxic Substances Control Act
Source: EPA/NTIS
Telephone: 202-260-1444
TSCA: Toxic Substances Control Act. TSCA identifies manufacturers and importers of chemical substances included on the TSCA Chemical Substance Inventory list. It includes data on the production volume of these substances by plant site. USEPA has no current plan to update and/or re-issue this database.

Date of Government Version: 05/15/86 Date of Next Scheduled Update: 12/11/95

STATE OF ARIZONA ASTM RECORDS:

AZ SHWS: ZipAcids
Source: Department of Environmental Quality
Telephone: 602-207-2202

Date of Government Version: 08/03/95 | Date of Data Arrival at EDR: 08/28/95
Date Made Active at EDR: 09/20/95 | Elapsed ASTM days: 23

LUST: LUST File Listing by Zip Code
Source: Department of Environmental Quality
Telephone: 602-207-4345
LUST: Leaking Underground Storage Tank Incident Reports. LUST records contain an inventory of reported leaking underground storage tank incidents. Not all states maintain these records, and the information stored varies by state.

Date of Government Version: 07/07/95 | Date of Data Arrival at EDR: 08/07/95
Date Made Active at EDR: 09/05/95 | Elapsed ASTM days: 29

SWF/LS: Municipal Solid Waste Landfills.../Closed Solid Waste Landfills...
Source: Department of Environmental Quality
Telephone: 602-207-4132
SWF/LS: Solid Waste Facilities/Landfill Sites. SWF/LS type records typically contain an inventory of solid waste disposal facilities or landfills in a particular state. Depending on the state, these may be active or inactive facilities or open dumps that failed to meet RCRA Section 2004 criteria for solid waste landfills or disposal sites.

Date of Government Version: 10/31/94 | Date of Data Arrival at EDR: 01/20/95
Date Made Active at EDR: 03/01/95 | Elapsed ASTM days: 40

UST: Arizona UST - DMS Facility and Tank Data Listing By City
Source: Department of Environmental Quality
Telephone: 602-207-4345
UST: Registered Underground Storage Tanks. UST's are regulated under Subtitle I of the Resource Conservation and Recovery Act (RCRA) and must be registered with the state department responsible for administering the UST program. Available information varies by state program.

Date of Government Version: 08/01/95 | Date of Data Arrival at EDR: 08/08/95
Date Made Active at EDR: 09/05/95 | Elapsed ASTM days: 28

STATE OF ARIZONA NON-ASTM RECORDS:

AQUIFER: Waster Water Treatment Facilities
Source: Department of Environmental Quality
Telephone: 602-207-4688
AQUIFER: Waste Water Treatment Facilities with APP (Aquifer Protection Permits.)

Date of Government Version: 08/14/95 | Date of Next Scheduled Update:

DRY WELLS: Drywell Registration
Source: Department of Environmental Quality
Telephone: 602-207-2202
Dry Wells: Arizona Dry Well List. Constructed solely for the disposal of storm water, more than 3,400 dry wells have been registered with the state under A.R.S. 49-331 through 336.

Date of Government Version: 04/19/95 | Date of Next Scheduled Update: 11/20/95

SPILLS: Hazardous Material Logbook
Source: Department of Environmental Quality
Telephone: 602-207-2202
SPILLS: ADEQ Emergency Response Unit. The ADEQ Emergency Response Unit documents chemical spills and incidents which are referred to the Unit. The logbook information for 1984-1986 consists of handwritten entries of the date, incident number and name of facility if known. Current logbooks are computerized and can be sorted by date, incident number, name, city (zip codes are not included), county, chemical and quantity.

Date of Government Version: 12/31/94 | Date of Next Scheduled Update: 10/09/95

Historical and Other Database(s)

Depending on the geographic area covered by this report, the data provided in these specialty databases may or may not be complete. For example, the existence of wetlands information data in a specific report does not mean that all wetlands in the area covered by the report are included. Moreover, the absence of any reported wetlands information does not necessarily mean that wetlands do not exist in the area covered by the report.

Former Manufactured Gas (Coal Gas) Sites: The existence and location of Coal Gas sites is provided exclusively to EDR by Real Property Scan, Inc. ©Copyright 1993 Real Property Scan, Inc. For a technical description of the types of hazards which may be found at such sites, contact your EDR customer service representative.

Disclaimer Provided by Real Property Scan, Inc.

The information contained in this report has predominantly been obtained from publicly available sources produced by entities other than Real Property Scan. While reasonable steps have been taken to insure the accuracy of this report, Real Property Scan does not guarantee the accuracy of this report. Any liability on the part of Real Property Scan is strictly limited to a refund of the amount paid. No claim is made for the actual existence of toxins at any site. This report does not constitute a legal opinion.

DELISTED NPL: Delisted NPL Sites
Source: EPA
Telephone: 703-603-8769
DELISTED NPL: The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) establishes the criteria that the EPA uses to delete sites from the NPL. In accordance with 40 CFR 300.425.(e), sites may be deleted from the NPL where no further response is appropriate.

NFRAP: No Further Remedial Action Planned
Source: EPA/NTIS
Telephone: 703-416-0702
NFRAP: As of February 1995, CERCLIS sites designated "No Further Remedial Action Planned" (NFRAP) have been removed from CERCLIS. NFRAP sites may be sites where, following an initial investigation, no contamination was found, contamination was removed quickly without the need for the site to be placed on the NPL, or the contamination was not serious enough to require Federal Superfund action or NPL consideration. EPA has removed approximately 25,000 NFRAP sites to lift the unintended barriers to the redevelopment of these properties and has archived them as historical records so EPA does not needlessly repeat the investigations in the future. This policy change is part of the EPA's Brownfields Redevelopment Program to help cities, states, private investors and affected citizens to promote economic redevelopment of unproductive urban sites.

FRDS: Federal Reporting Data System
Source: EPA/Office of Drinking Water
FRDS provides information regarding public water supplies and their compliance with monitoring requirements, maximum contaminant levels (MCL's), and other requirements of the Safe Drinking Water Act of 1986.

Area Radon Information: The National Radon Database has been developed by the U.S. Environmental Protection Agency (USEPA) and is a compilation of the EPA/State Residential Radon Survey and the National Residential Radon Survey. The study covers the years 1986 - 1992. Where necessary data has been supplemented by information collected at private sources such as universities and research institutions.

Oil/Gas Pipelines/Electrical Transmission Lines: This data was obtained by EDR from the USGS in 1994. It is referred to by USGS as GeoData Digital Line Graphs from 1:100,000-Scale Maps. It was extracted from the transportation category including some oil, but primarily gas pipelines and electrical transmission lines.

Sensitive Receptors: There are individuals who, due to their fragile immune systems, are deemed to be especially sensitive to environmental discharges. These typically include the elderly, the sick, and children. While the exact location of these sensitive receptors cannot be determined, EDR indicates those facilities, such as schools, hospitals, day care centers, and nursing homes, where sensitive receptors are likely to be located.

USGS Water Wells: In November 1971 the United States Geological Survey (USGS) implemented a national water resource information tracking system. This database contains descriptive information on sites where the USGS collects or has collected data on surface water and/or groundwater. The groundwater data includes information on more than 900,000 wells, springs, and other sources of groundwater.

Flood Zone Data: This data, available in select counties across the country, was obtained by EDR in 1994 from the Federal Emergency Management Agency (FEMA). Data depicts 100-year and 500-year flood zones as defined by FEMA.

Epicenters: World earthquake epicenters, Richter 5 or greater
Source: Department of Commerce, National Oceanic and Atmospheric Administration

B C Analytical

801 Western Avenue
Glendale, CA 91201
818/247-5737
Fax: 818/247-9797

RECEIVED
NOV 15 1995
BROWN AND CALDWELL
PHOENIX

November 13, 1995

Brown and Caldwell Consultants
3636 N. Central Ave., Suite 300
Phoenix, Arizona 85012

Dear Mr. Mears,

The following soil samples were received at the BCA laboratory in Glendale on 10/27/95. All samples were received intact and in a chilled state. They were assigned BCA order number G9510553.

Sample ID	BCA ID	Matrix	Sample Date	Analysis Requested
MCF-MWS-1	G9510553-1	SO	10/26/95	8015, 8020
MCF-CSA-1	G9510553-4	SO	10/26/95	RCRA Metals
MCF-LCP-1	G9510553-7	SO	10/26/95	R. Metals, pH
MCF-LCP-2.5	G9510553-8	SO	10/26/95	R. Metals, pH
MCF-SUL-3	G9510553-28	SO	10/26/95	R. Metals, pH
MCF-SUL-6	G9510553-29	SO	10/26/95	R. Metals, pH
MCF-BAK-2	G9510553-42	SO	10/26/95	R. Metals, pH
MCF-LCP-5	G9510553-9	SO	10/26/95	R. Metals, pH
MCF-SRS-1	G9510553-13	SO	10/26/95	R. Metals, pH
MCF-LUP-1	G9510553-16	SO	10/26/95	R. Metals, pH
MCF-SUL-10	G9510553-30	SO	10/26/95	R. Metals, pH
MCF-ALS-1	G9510553-19	SO	10/26/95	418.1, pH
MCF-SLO-1	G9510553-22	SO	10/26/95	418.1, R. Metals
MCF-LLO-1	G9510553-25	SO	10/26/95	418.1, R. Metals
MCF-LLO-2.5	G9510553-26	SO	10/26/95	418.1, R. Metals
MCF-LLO-5	G9510553-27	SO	10/26/95	418.1, R. Metals
MCF-CSP-2.5	G9510553-31	SO	10/26/95	418.1, R. Metals, pH, 8270, 8240
Composite*	G9510553-32	SO	10/26/95	418.1,R. Met, pH,8240
Composite**	G9510553-33	SO	10/26/95	418.1,R. Met, pH,8240

* Composite STPA, STPB, STPC, STPD
** Composite OTPA, OTPB

BCA

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Glendale, CA 91201
818/247-5737
Fax: 818/247-9797

Sample ID	BCA ID	Matrix	Sample Date	Analysis Requested
MCF-MSA-1	G9510553-40	SO	10/26/95	418.1, 8080
MCF-MSB-1	G9510553-41	SO	10/26/95	418.1, 8080
MCF-CSA-2.5	G9510553-5	SO	10/26/95	RCRA Metals
MCF-SUP-1	G9510553-10	SO	10/26/95	R. Metals, pH
MCF-SUP-2.5	G9510553-11	SO	10/26/95	R. Metals, pH
MCF-SRS-2.5	G9510553-14	SO	10/26/95	R. Metals, pH
MCF-LUP-2.5	G9510553-17	SO	10/26/95	R. Metals, pH
MCF-SLO-2.5	G9510553-23	SO	10/26/95	R. Metals, 418.1
MCF-MSA-2.5	G9510553-43	SO	10/26/95	418.1
MCF-MSB-2.5	G9510553-45	SO	10/26/95	418.1
MCF-SUP-1	G9510553-47	SO	10/26/95	Cu (Dup/Re-Run)

17 Samples were on hold per clients request.

If you have any questions regarding these samples, please do not hesitate to call me at (818) 247-5737.

Very truly yours,

R. Yaghoubi

Roobik Yaghoubi
Program Specialist

BCA

B C Analytical

801 Western Avenue
Glendale, CA 91201
818/247-5737
Fax: 818/247-9797

Case Narrative

All quality objectives were met including holding times, LCS/LCSD, MS/MSD, Duplicate samples, and Method Blanks as applicable with the following exceptions:

No analytical difficulties were encountered with any project samples

Barium Batch 951897:

Both matrix spikes of sample 9510553*4 (MCF-CSA-1), were below control limit. LCS/LCSD and RPD's were within control limit.

Copper Batch 951897:

Both matrix spikes of sample 9510553*4 (MCF-CSA-1), were flagged "NC," (Not Calculated) because the amount of spike added was not at least 50% of what was originally found in the sample (Cu = 290 ppm). LCS/LCSD and RPD's were within control limit.

Iron Batch 951897:

Both matrix spikes of sample 9510553*4 (MCF-CSA-1), were flagged "NC," (Not Calculated) because the amount of spike added was not at least 50% of what was originally found in the sample (Fe = 11000 ppm). LCS/LCSD and RPD's were within control limit.

8240 Batch 9529190:

1,1-Dichloroethane, Methylene chloride, Trichloroethene, and cis-1,2-Dichloroethene were above control limit in LCS (C511200*1), and 1,1-Dichloroethane, Bromomethane, and Vinyl acetate were below control limit in LCSD (C511201*1). Both LCS and LCSD were within control limit. 1,2-Dichloroethane-d4 (surrogate) was below control limit in Method Blank (B511099*1).

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8270 Batch 95214:

Hexachlorocyclopentadiene was above control limit in LCS (C5103539*1), and LCSD (C5103540*1). All acid surrogates were above control limit in LCS (C5103539*1) due to double spiking of surrogate in that LCS. LCS/LCSD, MS/MSD and RPD's were within control limit.

Diesel Batch 95183:

Naphthalene (surrogate) was above control limit in LCS (C5103533*1) due to elevated baseline. LCS/LCSD, MS/MSD and RPD's were within control limit.

BC Analytical (BCA) is certified by the state of Arizona to perform environmental testing for all parameters and methods of analysis listed in this analytical report. All methods documented in this analytical report are included in BCA's current Arizona certification. Please refer to BCA's Arizona certification number AZ0512.

BCA

B C Analytical

ANALYTICAL REPORT

801 Western Avenue
Glendale, CA 91201
818/247-5737
Fax: 818/247-9797

LOG NO: G95-10-553

Received: 27 OCT 95

Mailed: NOV 13 1995

Mr. Eric Mears
Brown and Caldwell
3636 N. Central Ave., Suite 300
Phoenix, Arizona 85012

Project: FLORENCE

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-1	MCF-MWS-1	26 OCT 95

PARAMETER	10-553-1
TPH (8015M)	
Date Extracted	10/30/95
Date Analyzed	10/30/95
Dilution Factor, Times	1
TPH (Diesel Range), mg/kg	<10
Carbon Range, .	C10-C25
Surrogates **	
Naphthalene Reported, mg/kg	2.16
Naphthalene Theoretical, mg/kg	2.00

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-1	MCF-MWS-1	26 OCT 95

PARAMETER	10-553-1
Vol. Aromatics (8020)	
Date Analyzed	10/30/95
Date Confirmed	10/30/95
Dilution Factor, Times	1
1,2-Dichlorobenzene, mg/kg	<0.005
1,3-Dichlorobenzene, mg/kg	<0.005
1,4-Dichlorobenzene, mg/kg	<0.005
Benzene, mg/kg	<0.005
Chlorobenzene, mg/kg	<0.005
Ethylbenzene, mg/kg	<0.005
Toluene, mg/kg	<0.005
Total Xylene Isomers, mg/kg	<0.01
Other Vol. Aromatics (8020)	---
Surrogates **	
a,a,a-Trifluorotoluene Rep., mg/kg	0.0409
a,a,a-Trifluorotoluene Th., mg/kg	0.0500

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-2	MCF-MWS-2.5	26 OCT 95
10-553-3	MCF-MWS-5	26 OCT 95
10-553-6	MCF-CSA-5	26 OCT 95
10-553-12	MCF-SUP-5	26 OCT 95
10-553-15	MCF-SRS-5	26 OCT 95

PARAMETER	10-553-2	10-553-3	10-553-6	10-553-12	10-553-15
Sample Held, Not Analyzed	HOLD	HOLD	HOLD	HOLD	HOLD

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-18	MCF-LUP-5	26 OCT 95
10-553-20	MCF-ALS-2.5	26 OCT 95
10-553-21	MCF-ALS-5	26 OCT 95
10-553-24	MCF-SLO-5	26 OCT 95
10-553-34	MCF-STPA-2	26 OCT 95

PARAMETER	10-553-18	10-553-20	10-553-21	10-553-24	10-553-34
Sample Held, Not Analyzed	HOLD	HOLD	HOLD	HOLD	HOLD

BCA

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-35	MCF-STPB-2	26 OCT 95
10-553-36	MCF-STPC-2	26 OCT 95
10-553-37	MCF-STPD-2	26 OCT 95
10-553-38	MCF-OTPA-2	26 OCT 95
10-553-39	MCF-OTPB-2	26 OCT 95

PARAMETER	10-553-35	10-553-36	10-553-37	10-553-38	10-553-39
Sample Held, Not Analyzed	HOLD	HOLD	HOLD	HOLD	HOLD

BCA

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Project: FLORENCE

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-44	MCF-MSA-5	26 OCT 95
10-553-46	MCF-MSB-5	26 OCT 95

PARAMETER	10-553-44	10-553-46
Sample Held, Not Analyzed	HOLD	HOLD

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Received: 27 OCT 95

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Project: FLORENCE

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-4	MCF-CSA-1	26 OCT 95

PARAMETER	10-553-4
Arsenic (7060), mg/kg	0.93
Barium (6010), mg/kg	93
Cadmium (6010), mg/kg	<0.5
Chromium (6010), mg/kg	11
Copper (6010), mg/kg	290
Iron (6010), mg/kg	11000
Lead (6010), mg/kg	6.8
Mercury (7471), mg/kg	<0.1
Selenium (7740), mg/kg	<0.4
Silver (6010), mg/kg	<1
Zinc (6010), mg/kg	35
Digestion (3050), Date	10/30/95
Furnace Digestion (3050), Date	10/30/95

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-7	MCF-LCP-1	26 OCT 95
10-553-8	MCF-LCP-2.5	26 OCT 95
10-553-28	MCF-SUL-3	26 OCT 95
10-553-29	MCF-SUL-6	26 OCT 95
10-553-42	MCF-BAK-2	26 OCT 95

PARAMETER	10-553-7	10-553-8	10-553-28	10-553-29	10-553-42
pH (9045), Units	8.3	8.8	7.7	7.9	6.04
Arsenic (7060), mg/kg	0.95	1.1	1.2	1.2	1.6
Barium (6010), mg/kg	78	91	110	100	120
Cadmium (6010), mg/kg	0.53	<0.5	0.91	<0.5	0.63
Chromium (6010), mg/kg	9.2	10	9.8	7.9	11
Copper (6010), mg/kg	47	14	22	18	15
Iron (6010), mg/kg	9000	9800	7700	4200	12000
Lead (6010), mg/kg	6.1	5.5	<5	8.7	6.1
Mercury (7471), mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium (7740), mg/kg	<0.4	<0.4	<0.4	<0.4	<0.4
Silver (6010), mg/kg	<1	<1	<1	<1	<1
Zinc (6010), mg/kg	27	18	28	30	30
Digestion (3050), Date	10/30/95	10/30/95	10/30/95	10/30/95	10/30/95
Furnace Digestion (3050), Date	10/30/95	10/30/95	10/30/95	10/30/95	10/30/95

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Mr. Eric Mears
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Project: FLORENCE

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-9	MCF-LCP-5	26 OCT 95
10-553-13	MCF-SRS-1	26 OCT 95
10-553-16	MCF-LUP-1	26 OCT 95
10-553-30	MCF-SUL-10	26 OCT 95

PARAMETER	10-553-9	10-553-13	10-553-16	10-553-30
¬H (9045), Units	8.4	7.7	7.7	7.8
senic (7060), mg/kg	0.90	1.0	1.3	0.92
Barium (6010), mg/kg	66	120	100	42
Cadmium (6010), mg/kg	<0.5	0.78	<0.5	<0.5
Chromium (6010), mg/kg	8.4	10	12	13
Copper (6010), mg/kg	8.9	290	65	9.7
Iron (6010), mg/kg	8100	11000	11000	9100
Lead (6010), mg/kg	5.4	8.9	7.3	8.0
Mercury (7471), mg/kg	<0.1	<0.1	<0.1	<0.1
Selenium (7740), mg/kg	<0.4	<0.4	<0.4	<0.4
Silver (6010), mg/kg	<1	<1	<1	<1
Zinc (6010), mg/kg	18	27	24	19
Digestion (3050), Date	10/30/95	10/30/95	10/30/95	10/30/95
Furnace Digestion (3050), Date	10/30/95	10/30/95	10/30/95	10/30/95

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-19	MCF-ALS-1	26 OCT 95

PARAMETER	10-553-19
TRPH (418.1), mg/kg	13
pH (9045), Units	7.9

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-22	MCF-SLO-1	26 OCT 95
10-553-25	MCF-LLO-1	26 OCT 95

PARAMETER	10-553-22	10-553-25
TRPH (418.1), mg/kg	<10	11
Arsenic (7060), mg/kg	0.80	1.2
Barium (6010), mg/kg	91	89
Cadmium (6010), mg/kg	0.66	<0.5
Chromium (6010), mg/kg	9.1	9.4
Copper (6010), mg/kg	22	48
Iron (6010), mg/kg	10000	9000
Lead (6010), mg/kg	<5	7.1
Mercury (7471), mg/kg	<0.1	<0.1
Selenium (7740), mg/kg	<0.4	<0.4
Silver (6010), mg/kg	<1	<1
Zinc (6010), mg/kg	26	22
Digestion (3050), Date	10/30/95	10/30/95
Furnace Digestion (3050), Date	10/30/95	10/30/95

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-26	MCF-LLO-2.5	26 OCT 95
10-553-27	MCF-LLO-5	26 OCT 95

PARAMETER	10-553-26	10-553-27
TRPH (418.1), mg/kg	27	<10
Arsenic (7060), mg/kg	1.3	0.55
Barium (6010), mg/kg	73	52
Cadmium (6010), mg/kg	<0.5	<0.5
Chromium (6010), mg/kg	8.3	5.7
Copper (6010), mg/kg	440	8.1
Iron (6010), mg/kg	8300	9000
Lead (6010), mg/kg	7.0	5.9
Mercury (7471), mg/kg	<0.1	<0.1
Selenium (7740), mg/kg	<0.4	<0.4
Silver (6010), mg/kg	<1	<1
Zinc (6010), mg/kg	23	19
Digestion (3050), Date	10/30/95	10/30/95
Furnace Digestion (3050), Date	10/30/95	10/30/95

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-31	MCF-CSP-2.5	26 OCT 95

PARAMETER	10-553-31
TRPH (418.1), mg/kg	<10
pH (9045), Units	9.0
Arsenic (7060), mg/kg	0.54
Barium (6010), mg/kg	41
Cadmium (6010), mg/kg	<0.5
Chromium (6010), mg/kg	8.7
Copper (6010), mg/kg	6.7
Iron (6010), mg/kg	9500
Lead (6010), mg/kg	5.3
Mercury (7471), mg/kg	<0.1
Selenium (7740), mg/kg	<0.4
Silver (6010), mg/kg	<1
Zinc (6010), mg/kg	20
Digestion (3050), Date	10/30/95
Furnace Digestion (3050), Date	10/30/95

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-31	MCF-CSP-2.5	26 OCT 95

PARAMETER	10-553-31
Semi-volatiles (8270)	
Date Analyzed	10/31/95
Date Extracted	10/30/95
Dilution Factor, Times	1
1,2,4-Trichlorobenzene, mg/kg	<0.2
1,2-Dichlorobenzene, mg/kg	<0.2
1,2-Diphenylhydrazine, mg/kg	<0.2
1,3-Dichlorobenzene, mg/kg	<0.2
1,4-Dichlorobenzene, mg/kg	<0.2
2,4,5-Trichlorophenol, mg/kg	<0.2
2,4,6-Trichlorophenol, mg/kg	<0.2
2,4-Dichlorophenol, mg/kg	<0.2
2,4-Dimethylphenol, mg/kg	<0.2
2,4-Dinitrophenol, mg/kg	<0.4
2,4-Dinitrotoluene, mg/kg	<0.2
2,6-Dinitrotoluene, mg/kg	<0.2
2-Chloronaphthalene, mg/kg	<0.2
2-Chlorophenol, mg/kg	<0.2
2-Methyl-4,6-dinitrophenol, mg/kg	<0.2
2-Methylnaphthalene, mg/kg	<0.2
2-Methylphenol (o-Cresol), mg/kg	<0.2
2-Nitroaniline, mg/kg	<0.2
2-Nitrophenol, mg/kg	<0.2
3,3'-Dichlorobenzidine, mg/kg	<0.4
3-Nitroaniline, mg/kg	<0.2
4-Bromophenylphenylether, mg/kg	<0.2
4-Chloro-3-methylphenol, mg/kg	<0.2

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-31	MCF-CSP-2.5	26 OCT 95

PARAMETER	10-553-31
4-Chloroaniline, mg/kg	<0.2
4-Chlorophenylphenylether, mg/kg	<0.2
4-Methylphenol (p-Cresol), mg/kg	<0.4
4-Nitroaniline, mg/kg	<0.2
-Nitrophenol, mg/kg	<0.2
Acenaphthene, mg/kg	<0.2
Acenaphthylene, mg/kg	<0.2
Aniline, mg/kg	<0.2
Anthracene, mg/kg	<0.2
Benzidine, mg/kg	<4
Benzo(a)anthracene, mg/kg	<0.2
Benzo(a)pyrene, mg/kg	<0.2
Benzo(b)fluoranthene, mg/kg	<0.2
Benzo(g,h,i)perylene, mg/kg	<0.2
Benzo(k)fluoranthene, mg/kg	<0.2
Benzyl Alcohol, mg/kg	<0.4
Benzoic acid, mg/kg	<2
Butylbenzylphthalate, mg/kg	<0.2
Chrysene, mg/kg	<0.2
Di-n-octylphthalate, mg/kg	<0.2
Dibenzo(a,h)anthracene, mg/kg	<0.2
Dibenzofuran, mg/kg	<0.2
Dibutylphthalate, mg/kg	<0.2
Diethylphthalate, mg/kg	<0.2
Dimethylphthalate, mg/kg	<0.2
Fluoranthene, mg/kg	<0.2
Fluorene, mg/kg	<0.2

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-31	MCF-CSP-2.5	26 OCT 95

PARAMETER	10-553-31
Hexachlorobenzene, mg/kg	<0.2
Hexachlorobutadiene, mg/kg	<0.2
Hexachlorocyclopentadiene, mg/kg	<0.2
Hexachloroethane, mg/kg	<0.2
Indeno(1,2,3-c,d)pyrene, mg/kg	<0.2
Isophorone, mg/kg	<0.2
N-Nitrosodimethylamine, mg/kg	<0.2
N-Nitrosodiphenylamine, mg/kg	<0.2
N-Nitrosodi-n-propylamine, mg/kg	<0.2
Nitrobenzene, mg/kg	<0.2
Naphthalene, mg/kg	<0.2
Phenanthrene, mg/kg	<0.2
Phenol, mg/kg	<0.2
Pentachlorophenol, mg/kg	<0.2
Pyrene, mg/kg	<0.2
Pyridine, mg/kg	<0.4
Bis(2-chloroethoxy)methane, mg/kg	<0.2
Bis(2-chloroethyl)ether, mg/kg	<0.2
Bis(2-chloroisopropyl)ether, mg/kg	<0.2
Bis(2-ethylhexyl)phthalate, mg/kg	<0.4
Surrogates **	
2-Fluorobiphenyl Reported, mg/kg	48.0
2-Fluorobiphenyl Theo., mg/kg	50.0
2-Fluorophenol Reported, mg/kg	62.6
2-Fluorophenol Theoretical, mg/kg	75.0
2,4,6-Tribromophenol Rep., mg/kg	61.7
2,4,6-Tribromophenol Theo., mg/kg	75.0

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-31	MCF-CSP-2.5	26 OCT 95

PARAMETER	10-553-31
Nitrobenzene-d5 Reported, mg/kg	44.5
Nitrobenzene-d5 Theoretical, mg/kg	50.0
Phenol-d5 Reported, mg/kg	57.6
Phenol-d5 Theoretical, mg/kg	75.0
Terphenyl-d14 Reported, mg/kg	44.4
Terphenyl-d14 Theoretical, mg/kg	50.0

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-31	MCF-CSP-2.5	26 OCT 95

PARAMETER	10-553-31
Vol.Pri.Poll. (8240)	
Date Analyzed	10/31/95
Date Extracted	10/31/95
Dilution Factor, Times	1
1,1,1-Trichloroethane, mg/kg	<0.005
1,1,2,2-Tetrachloroethane, mg/kg	<0.005
1,1,2-Trichloroethane, mg/kg	<0.005
1,1-Dichloroethane, mg/kg	<0.005
1,1-Dichloroethene, mg/kg	<0.005
1,2-Dichloroethane, mg/kg	<0.005
1,2-Dichlorobenzene, mg/kg	<0.005
1,2-Dichloropropane, mg/kg	<0.005
1,3-Dichlorobenzene, mg/kg	<0.005
1,4-Dichlorobenzene, mg/kg	<0.005
2-Chloroethylvinylether, mg/kg	<0.005
2-Hexanone, mg/kg	<0.03
Acetone, mg/kg	<0.1
Acrolein, mg/kg	<0.3
Acrylonitrile, mg/kg	<0.3
Bromodichloromethane, mg/kg	<0.005
Bromomethane, mg/kg	<0.005
Benzene, mg/kg	<0.005
Bromoform, mg/kg	<0.005
Chlorobenzene, mg/kg	<0.005
Carbon Tetrachloride, mg/kg	<0.005
Chloroethane, mg/kg	<0.005
Chloroform, mg/kg	<0.005

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-31	MCF-CSP-2.5	26 OCT 95

PARAMETER	10-553-31
Chloromethane, mg/kg	<0.005
Carbon Disulfide, mg/kg	<0.01
Dibromochloromethane, mg/kg	<0.005
Ethylbenzene, mg/kg	<0.005
Freon 113, mg/kg	<0.01
Methyl ethyl ketone, mg/kg	<0.03
Methyl isobutyl ketone, mg/kg	<0.03
Methylene chloride, mg/kg	<0.005
Styrene, mg/kg	<0.005
Trichloroethene, mg/kg	<0.005
Trichlorofluoromethane, mg/kg	<0.005
Toluene, mg/kg	<0.005
Tetrachloroethene, mg/kg	<0.005
Vinyl acetate, mg/kg	<0.05
Vinyl chloride, mg/kg	<0.005
Total Xylene Isomers, mg/kg	<0.02
cis-1,2-Dichloroethene, mg/kg	<0.005
cis-1,3-Dichloropropene, mg/kg	<0.005
trans-1,2-Dichloroethene, mg/kg	<0.005
trans-1,3-Dichloropropene, mg/kg	<0.005
Surrogates **	
1,2-Dichloroethane-d4 Rep., mg/kg	0.0371
1,2-Dichloroethane-d4 Theo., mg/kg	0.0500
4-Bromofluorobenzene Rep., mg/kg	0.0477
4-Bromofluorobenzene Theo., mg/kg	0.0500
Toluene-d8 Reported, mg/kg	0.0493
Toluene-d8 Theo., mg/kg	0.0500

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-32	Composite STPA, STPB, STPC, STPD	26 OCT 95
10-553-33	Composite OTPA, OTPB	26 OCT 95

PARAMETER	10-553-32	10-553-33
TRPH (418.1), mg/kg	21	12
Compositing , Date	10/30/95	10/30/95
pH (9045), Units	6.9	5.0
Arsenic (7060), mg/kg	0.58	0.51
Barium (6010), mg/kg	44	31
Cadmium (6010), mg/kg	<0.5	<0.5
Chromium (6010), mg/kg	6.5	6.0
Copper (6010), mg/kg	710	560
Iron (6010), mg/kg	9600	10000
Lead (6010), mg/kg	5.1	7.4
Mercury (7471), mg/kg	<0.1	<0.1
Selenium (7740), mg/kg	3.4	<0.4
Silver (6010), mg/kg	<1	<1
Zinc (6010), mg/kg	32	23
Digestion (3050), Date	10/30/95	10/30/95
Furnace Digestion (3050), Date	10/30/95	10/30/95

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-32	Composite STPA, STPB, STPC, STPD	26 OCT 95
10-553-33	Composite OTPA, OTPB	26 OCT 95

PARAMETER	10-553-32	10-553-33
Vol.Pri.Poll. (8240)		
Date Analyzed	10/31/95	10/31/95
Date Extracted	10/31/95	10/31/95
Dilution Factor, Times	1	1
1,1,1-Trichloroethane, mg/kg	<0.005	<0.005
1,1,2,2-Tetrachloroethane, mg/kg	<0.005	<0.005
1,1,2-Trichloroethane, mg/kg	<0.005	<0.005
1,1-Dichloroethane, mg/kg	<0.005	<0.005
1,1-Dichloroethene, mg/kg	<0.005	<0.005
1,2-Dichloroethane, mg/kg	<0.005	<0.005
1,2-Dichlorobenzene, mg/kg	<0.005	<0.005
1,2-Dichloropropane, mg/kg	<0.005	<0.005
1,3-Dichlorobenzene, mg/kg	<0.005	<0.005
1,4-Dichlorobenzene, mg/kg	<0.005	<0.005
2-Chloroethylvinylether, mg/kg	<0.005	<0.005
2-Hexanone, mg/kg	<0.03	<0.03
Acetone, mg/kg	<0.1	<0.1
Acrolein, mg/kg	<0.3	<0.3
Acrylonitrile, mg/kg	<0.3	<0.3
Bromodichloromethane, mg/kg	<0.005	<0.005
Bromomethane, mg/kg	<0.005	<0.005
Benzene, mg/kg	<0.005	<0.005
Bromoform, mg/kg	<0.005	<0.005
Chlorobenzene, mg/kg	<0.005	<0.005
Carbon Tetrachloride, mg/kg	<0.005	<0.005
Chloroethane, mg/kg	<0.005	<0.005

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REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-32	Composite STPA, STPB, STPC, STPD	26 OCT 95
10-553-33	Composite OTPA, OTPB	26 OCT 95

PARAMETER	10-553-32	10-553-33
Chloroform, mg/kg	<0.005	<0.005
Chloromethane, mg/kg	<0.005	<0.005
Carbon Disulfide, mg/kg	<0.01	<0.01
Dibromochloromethane, mg/kg	<0.005	<0.005
Ethylbenzene, mg/kg	<0.005	<0.005
Freon 113, mg/kg	<0.01	<0.01
Methyl ethyl ketone, mg/kg	<0.03	<0.03
Methyl isobutyl ketone, mg/kg	<0.03	<0.03
Methylene chloride, mg/kg	<0.005	<0.005
Styrene, mg/kg	<0.005	<0.005
Trichloroethene, mg/kg	<0.005	<0.005
Trichlorofluoromethane, mg/kg	<0.005	<0.005
Toluene, mg/kg	<0.005	<0.005
Tetrachloroethene, mg/kg	<0.005	<0.005
Vinyl acetate, mg/kg	<0.05	<0.05
Vinyl chloride, mg/kg	<0.005	<0.005
Total Xylene Isomers, mg/kg	<0.02	<0.02
cis-1,2-Dichloroethene, mg/kg	<0.005	<0.005
cis-1,3-Dichloropropene, mg/kg	<0.005	<0.005
trans-1,2-Dichloroethene, mg/kg	<0.005	<0.005
trans-1,3-Dichloropropene, mg/kg	<0.005	<0.005
Surrogates **		
1,2-Dichloroethane-d4 Rep., mg/kg	0.0375	0.0382
1,2-Dichloroethane-d4 Theo., mg/kg	0.0500	0.0500
4-Bromofluorobenzene Rep., mg/kg	0.0482	0.0463
4-Bromofluorobenzene Theo., mg/kg	0.0500	0.0500

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LOG NO: G95-10-553

Received: 27 OCT 95

Mr. Eric Mears
Brown and Caldwell
3636 N. Central Ave., Suite 300
Phoenix, Arizona 85012

Project: FLORENCE

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-32	Composite STPA, STPB, STPC, STPD	26 OCT 95
10-553-33	Composite OTPA, OTPB	26 OCT 95

PARAMETER	10-553-32	10-553-33
Toluene-d8 Reported, mg/kg	0.0518	0.0496
Toluene-d8 Theo., mg/kg	0.0500	0.0500

B C Analytical

801 Western Avenue
Glendale, CA 91201
818/247-5737
Fax: 818/247-9797

LOG NO: G95-10-553

Received: 27 OCT 95

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Brown and Caldwell
3636 N. Central Ave., Suite 300
Phoenix, Arizona 85012

Project: FLORENCE

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-40	MCF-MSA-1	26 OCT 95
10-553-41	MCF-MSB-1	26 OCT 95

PARAMETER	10-553-40	10-553-41
TRPH (418.1), mg/kg	20	10
PCBs (8080)		
Date Analyzed	11/03/95	11/03/95
Date Extracted	11/03/95	11/03/95
Dilution Factor, Times	1	1
Aroclor 1016, mg/kg	<0.03	<0.03
Aroclor 1221, mg/kg	<0.03	<0.03
Aroclor 1232, mg/kg	<0.03	<0.03
Aroclor 1242, mg/kg	<0.03	<0.03
Aroclor 1248, mg/kg	<0.03	<0.03
Aroclor 1254, mg/kg	<0.03	<0.03
Aroclor 1260, mg/kg	<0.03	<0.03
Surrogates **		
Decachlorobiphenyl Reported, mg/kg	0.0035	0.0043
Decachlorobiphenyl Theoretical, mg/kg	0.0083	0.0083
Tetrachloro-meta-xylene Rpt., mg/kg	0.0074	0.0095
Tetrachloro-meta-xylene Theor., mg/kg	0.0083	0.0083

BCA

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Project: FLORENCE

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-5	MCF-CSA-2.5	26 OCT 95

PARAMETER	10-553-5
Arsenic (7060), mg/kg	1.9
Barium (6010), mg/kg	74
Chromium (6010), mg/kg	5.8
Copper (6010), mg/kg	9.0
Iron (6010), mg/kg	5800
Lead (6010), mg/kg	<5
Mercury (7471), mg/kg	<0.1
Selènium (7740), mg/kg	<0.4
Silver (6010), mg/kg	<1
Zinc (6010), mg/kg	16
Digestion (3050), Date	11/03/95
Furnace Digestion (3050), Date	11/06/95

BCA

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LOG NO: G95-10-553

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Phoenix, Arizona 85012

Project: FLORENCE

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-10	MCF-SUP-1	26 OCT 95

PARAMETER	10-553-10
pH (9045), Units	7.8
Arsenic (7060), mg/kg	0.91
Barium (6010), mg/kg	87
Cadmium (6010), mg/kg	0.58
Chromium (6010), mg/kg	9.1
Copper (6010), mg/kg	8900
Iron (6010), mg/kg	9600
Lead (6010), mg/kg	<5
Mercury (7471), mg/kg	<0.1
Selenium (7740), mg/kg	<0.4
Silver (6010), mg/kg	<1
Zinc (6010), mg/kg	45
Digestion (3050), Date	10/30/95
Furnace Digestion (3050), Date	10/30/95

BCA

B C Analytical

801 Western Avenue
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818/247-5737
Fax: 818/247-9797

LOG NO: G95-10-553

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Brown and Caldwell
3636 N. Central Ave., Suite 300
Phoenix, Arizona 85012

Project: FLORENCE

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-11	MCF-SUP-2.5	26 OCT 95
10-553-14	MCF-SRS-2.5	26 OCT 95
10-553-17	MCF-LUP-2.5	26 OCT 95

PARAMETER	10-553-11	10-553-14	10-553-17
pH (9045), Units	8.1	7.8	8.0
Arsenic (7060), mg/kg	1.4	1.3	1.8
Barium (6010), mg/kg	67	82	90
Cadmium (6010), mg/kg	<0.5	<0.5	<0.5
Chromium (6010), mg/kg	6.2	8.3	9.7
Copper (6010), mg/kg	12	340	390
Iron (6010), mg/kg	6800	8600	8400
Lead (6010), mg/kg	8.8	13	13
Mercury (7471), mg/kg	<0.1	<0.1	<0.1
Selenium (7740), mg/kg	<0.4	<0.4	<0.4
Silver (6010), mg/kg	<1	<1	<1
Zinc (6010), mg/kg	20	30	51
Digestion (3050), Date	11/03/95	11/03/95	11/03/95
Furnace Digestion (3050), Date	11/06/95	11/06/95	11/06/95

BCA

B C Analytical

801 Western Avenue
Glendale, CA 91201
818/247-5737
Fax: 818/247-9797

LOG NO: G95-10-553

Received: 27 OCT 95

Mr. Eric Mears
Brown and Caldwell
3636 N. Central Ave., Suite 300
Phoenix, Arizona 85012

Project: FLORENCE

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-23	MCF-SLO-2.5	26 OCT 95

PARAMETER	10-553-23
TRPH (418.1), mg/kg	26
Arsenic (7060), mg/kg	1.3
Barium (6010), mg/kg	28
Cadmium (6010), mg/kg	<0.5
Chromium (6010), mg/kg	3.0
Copper (6010), mg/kg	29
Iron (6010), mg/kg	6400
Lead (6010), mg/kg	5.6
Mercury (7471), mg/kg	<0.1
Selenium (7740), mg/kg	<0.4
Silver (6010), mg/kg	<1
Zinc (6010), mg/kg	17
Digestion (3050), Date	11/03/95
Furnace Digestion (3050), Date	11/06/95

BCA

B C Analytical

801 Western Avenue
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LOG NO: G95-10-553

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Project: FLORENCE

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-43	MCF-MSA-2.5	26 OCT 95
10-553-45	MCF-MSB-2.5	26 OCT 95

PARAMETER	10-553-43	10-553-45
TRPH (418.1), mg/kg	20	16

BCA

B C Analytical

801 Western Avenue
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LOG NO: G95-10-553

Received: 27 OCT 95

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Brown and Caldwell
3636 N. Central Ave., Suite 300
Phoenix, Arizona 85012

Project: FLORENCE

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, NON-AQUEOUS SAMPLES	DATE SAMPLED
10-553-47	MCF-SUP-1 (DUP)	26 OCT 95

PARAMETER	10-553-47
Copper (6010), mg/kg	8100
Digestion (3050), Date	10/07/95

Jane Freemyer, Laboratory Director

BCA

: ORDER PLACED FOR CLIENT: Brown and Caldwell 9510553 :
: BC ANALYTICAL : GLEN LAB : 10:02:56 09 NOV 1995 - P. 1 :

SAMPLES...	SAMPLE DESCRIPTION..	DETERM.........	DATE...... ANALYZED	METHOD.....	EQUIP.	BATCH..	ID.NO
9510553*1	MCF-MWS-1	DIESEL.3550	10.30.95	8015M	536-25	95183	8042
		8020	10.30.95	8020	536-33	9529189	8501
9510553*2	MCF-MWS-2.5	HOLD	10.30.95				7362
9510553*3	MCF-MWS-5	HOLD	10.30.95				7362
9510553*6	MCF-CSA-5	HOLD	10.30.95				7362
9510553*12	MCF-SUP-5	HOLD	10.30.95				7362
9510553*15	MCF-SRS-5	HOLD	10.30.95				7362
9510553*18	MCF-LUP-5	HOLD	10.30.95				7362
9510553*20	MCF-ALS-2.5	HOLD	10.30.95				7362
9510553*21	MCF-ALS-5	HOLD	10.30.95				7362
9510553*24	MCF-SLO-5	HOLD	10.30.95				7362
9510553*34	MCF-STPA-2	HOLD	10.30.95				7362
9510553*35	MCF-STPB-2	HOLD	10.30.95				7362
9510553*36	MCF-STPC-2	HOLD	10.30.95				7362
9510553*37	MCF-STPD-2	HOLD	10.30.95				7362
9510553*38	MCF-OTPA-2	HOLD	10.30.95				7362
9510553*39	MCF-OTPB-2	HOLD	10.30.95				7362
9510553*44	MCF-MSA-5	HOLD	10.30.95				7362
9510553*46	MCF-MSB-5	HOLD	10.30.95				7362
9510553*4	MCF-CSA-1	AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488
		PB	10.31.95	6010	535-02	951897	8488
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620

Notes: Equipment = BC Analytical identification number for a particular piece of analytical equipment.

ID.NO = BC Analytical employee identification number of analyst.

SAMPLES...	SAMPLE DESCRIPTION..	DETERM.........	DATE...... ANALYZED	METHOD.....	EQUIP.	BATCH..	ID.NO
		DIG,NAQ,GFA	10.30.95	3050		951896	7620
		HG,SO	10.31.95	7471	534-06	951903	8488
		CU	10.31.95	6010	535-02	951897	8488
9510553*7	MCF-LCP-1	PH,NA	10.30.95	9045	533-21	9546	8604
		AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488
		PB	10.31.95	6010	535-02	951897	8488
		HG,SO	11.07.95	7471	534-06	951958	7093
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620
		DIG,NAQ,GFA	10.30.95	3050		951896	7620
		CU	10.31.95	6010	535-02	951897	8488
9510553*8	MCF-LCP-2.5	PH,NA	10.30.95	9045	533-21	9546	8604
		AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488
		PB	10.31.95	6010	535-02	951897	8488
		HG,SO	11.07.95	7471	534-06	951958	7093
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620

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SAMPLES...	SAMPLE DESCRIPTION..	DETERM.........	DATE...... ANALYZED	METHOD.....	EQUIP.	BATCH..	ID.NO
		DIG,NAQ,GFA	10.30.95	3050		951896	7620
		CU	10.31.95	6010	535-02	951897	8488
9510553*28	MCF-SUL-3	PH,NA	10.30.95	9045	533-21	9546	8604
		AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488
		PB	10.31.95	6010	535-02	951897	8488
		HG,SO	11.07.95	7471	534-06	951958	7093
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620
		DIG,NAQ,GFA	10.30.95	3050		951896	7620
		CU	10.31.95	6010	535-02	951897	8488
9510553*29	MCF-SUL-6	PH,NA	10.30.95	9045	533-21	9546	8604
		AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488
		PB	10.31.95	6010	535-02	951897	8488
		HG,SO	11.07.95	7471	534-06	951958	7093
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620
		DIG,NAQ,GFA	10.30.95	3050		951896	7620

Notes: Equipment = BC Analytical identification number for a particular piece of analytical equipment.

ID.NO = BC Analytical employee identification number of analyst.

SAMPLES...	SAMPLE DESCRIPTION..	DETERM.........	DATE...... ANALYZED	METHOD.....	EQUIP.	BATCH..	ID.NO
		CU	10.31.95	6010	535-02	951897	8488
9510553*42	MCF-BAK-2	PH,NA	10.30.95	9045	533-21	9546	8604
		AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488
		PB	10.31.95	6010	535-02	951897	8488
		HG,SO	11.07.95	7471	534-06	951958	7093
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620
		DIG,NAQ,GFA	10.30.95	3050		951896	7620
		CU	10.31.95	6010	535-02	951897	8488
9510553*9	MCF-LCP-5	PH,NA	10.30.95	9045	533-21	9546	8604
		AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488
		PB	10.31.95	6010	535-02	951897	8488
		HG,SO	10.31.95	7471	534-06	951903	8488
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620
		DIG,NAQ,GFA	10.30.95	3050		951896	7620
		CU	10.31.95	6010	535-02	951897	8488

Notes: Equipment = BC Analytical identification number for a particular piece of analytical equipment.

ID.NO = BC Analytical employee identification number of analyst.

SAMPLES...	SAMPLE DESCRIPTION..	DETERM.........	DATE...... ANALYZED	METHOD.....	EQUIP.	BATCH..	ID.NO
9510553*13	MCF-SRS-1	PH,NA	10.30.95	9045	533-21	9546	8604
		AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488
		PB	10.31.95	6010	535-02	951897	8488
		HG,SO	10.31.95	7471	534-06	951903	8488
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620
		DIG,NAQ,GFA	10.30.95	3050		951896	7620
		CU	10.31.95	6010	535-02	951897	8488
9510553*16	MCF-LUP-1	PH,NA	10.30.95	9045	533-21	9546	8604
		AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488
		PB	10.31.95	6010	535-02	951897	8488
		HG,SO	10.31.95	7471	534-06	951903	8488
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620
		DIG,NAQ,GFA	10.30.95	3050		951896	7620
		CU	10.31.95	6010	535-02	951897	8488
9510553*30	MCF-SUL-10	PH,NA	10.30.95	9045	533-21	9546	8604

Notes: Equipment = BC Analytical identification number for a particular piece of analytical equipment.

ID.NO = BC Analytical employee identification number of analyst.

SAMPLES...	SAMPLE DESCRIPTION..	DETERM.........	DATE...... ANALYZED	METHOD.....	EQUIP.	BATCH..	ID.NO
		AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488
		PB	10.31.95	6010	535-02	951897	8488
		HG,SO	10.31.95	7471	534-06	951903	8488
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620
		DIG,NAQ,GFA	10.30.95	3050		951896	7620
		CU	10.31.95	6010	535-02	951897	8488
9510553*19	MCF-ALS-1	IR.PETROHC	10.28.95	418.1	533-17	95171	8106
		PH,NA	10.30.95	9045	533-21	9546	8604
9510553*22	MCF-SLO-1	IR.PETROHC	10.28.95	418.1	533-17	95171	8106
		AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488
		PB	10.31.95	6010	535-02	951897	8488
		HG,SO	10.31.95	7471	534-06	951903	8488
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620
		DIG,NAQ,GFA	10.30.95	3050		951896	7620
		CU	10.31.95	6010	535-02	951897	8488

Notes: Equipment = BC Analytical identification number for a particular piece of analytical equipment.

ID.NO = BC Analytical employee identification number of analyst.

: ORDER PLACED FOR CLIENT: Brown and Caldwell 9510553 :
: BC ANALYTICAL : GLEN LAB : 10:02:58 09 NOV 1995 - P. 7 :

SAMPLES...	SAMPLE DESCRIPTION..	DETERM.........	DATE...... ANALYZED	METHOD.....	EQUIP.	BATCH..	ID.NO
9510553*25	MCF-LLO-1	IR.PETROHC	10.28.95	418.1	533-17	95171	8106
		AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488
		PB	10.31.95	6010	535-02	951897	8488
		HG,SO	10.31.95	7471	534-06	951903	8488
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620
		DIG,NAQ,GFA	10.30.95	3050		951896	7620
		CU	10.31.95	6010	535-02	951897	8488
9510553*26	MCF-LLO-2.5	IR.PETROHC	10.28.95	418.1	533-17	95171	8106
		AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488
		PB	10.31.95	6010	535-02	951897	8488
		HG,SO	11.07.95	7471	534-06	951958	7093
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620
		DIG,NAQ,GFA	10.30.95	3050		951896	7620
		CU	10.31.95	6010	535-02	951897	8488
9510553*27	MCF-LLO-5	IR.PETROHC	10.28.95	418.1	533-17	95171	8106

Notes: Equipment = BC Analytical identification number for a particular piece of analytical equipment.

ID.NO = BC Analytical employee identification number of analyst.

SAMPLES...	SAMPLE DESCRIPTION..	DETERM.........	DATE...... ANALYZED	METHOD.....	EQUIP.	BATCH..	ID.NO
		AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488
		PB	10.31.95	6010	535-02	951897	8488
		HG,SO	11.07.95	7471	534-06	951958	7093
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620
		DIG,NAQ,GFA	10.30.95	3050		951896	7620
		CU	10.31.95	6010	535-02	951897	8488
9510553*31	MCF-CSP-2.5	IR.PETROHC	10.28.95	418.1	533-17	95171	8106
		PH,NA	10.30.95	9045	533-21	9546	8604
		AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488
		PB	10.31.95	6010	535-02	951897	8488
		HG,SO	10.31.95	7471	534-06	951903	8488
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620
		DIG,NAQ,GFA	10.30.95	3050		951896	7620
		8270.HSL	10.30.95	8270	537-14	95214	6763
		8240.HSL	10.31.95	8240	537-05	9529190	8659

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ID.NO = BC Analytical employee identification number of analyst.

SAMPLES...	SAMPLE DESCRIPTION..	DETERM.........	DATE...... ANALYZED	METHOD.....	EQUIP.	BATCH..	ID.NO
		CU	10.31.95	6010	535-02	951897	8488
9510553*32	Composite STPA, STPB, STPC, STPD	IR.PETROHC	10.28.95	418.1	533-17	95171	8106
		COMPOSITE	10.30.95				7620
		PH,NA	10.30.95	9045	533-21	9546	8604
		AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488
		PB	10.31.95	6010	535-02	951897	8488
		HG,SO	10.31.95	7471	534-06	951903	8488
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620
		DIG,NAQ,GFA	10.30.95	3050		951896	7620
		8240.HSL	10.31.95	8240	537-05	9529190	8659
		CU	10.31.95	6010	535-02	951897	8488
9510553*33	Composite OTPA, OTPB	IR.PETROHC	10.28.95	418.1	533-17	95171	8106
		COMPOSITE	10.30.95				7620
		PH,NA	10.30.95	9045	533-21	9546	8604
		AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488
		PB	10.31.95	6010	535-02	951897	8488
		HG,SO	10.31.95	7471	534-06	951903	8488

Notes: Equipment = BC Analytical identification number for a particular piece of analytical equipment.

ID.NO = BC Analytical employee identification number of analyst.

SAMPLES...	SAMPLE DESCRIPTION..	DETERM.........	DATE...... ANALYZED	METHOD.....	EQUIP.	BATCH..	ID.NO
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620
		DIG,NAQ,GFA	10.30.95	3050		951896	7620
		8240.HSL	10.31.95	8240	537-05	9529190	8659
		CU	10.31.95	6010	535-02	951897	8488
9510553*40	MCF-MSA-1	IR.PETROHC	10.28.95	418.1	533-17	95171	8106
		8080,PCB	11.03.95	8080	536-27	95167	7616
9510553*41	MCF-MSB-1	IR.PETROHC	10.28.95	418.1	533-17	95171	8106
		8080,PCB	11.03.95	8080	536-27	95167	7616
9510553*5	MCF-CSA-2.5	AS,GFA	11.06.95	7060	534-07	951961	7396
		BA	11.03.95	6010	535-03	951948	7396
		CR	11.03.95	6010	535-03	951948	7396
		CU	11.03.95	6010	535-03	951948	7396
		FE	11.03.95	6010	535-03	951948	7396
		PB	11.03.95	6010	535-03	951948	7396
		HG,SO	11.07.95	7471	534-06	951958	7093
		SE,GFA	11.06.95	7740	534-07	951961	7396
		AG	11.03.95	6010	535-03	951948	7396
		ZN	11.03.95	6010	535-03	951948	7396
		DIG,NAQ.HCL	11.03.95	3050		951948	8488
		DIG,NAQ,GFA	11.06.95	3050		951961	7093
9510553*10	MCF-SUP-1	PH,NA	10.30.95	9045	533-21	9546	8604
		AS,GFA	10.31.95	7060	534-04	951896	7725
		BA	10.31.95	6010	535-02	951897	8488
		CD	10.31.95	6010	535-02	951897	8488
		CR	10.31.95	6010	535-02	951897	8488
		FE	10.31.95	6010	535-02	951897	8488

Notes: Equipment = BC Analytical identification number for a particular piece of analytical equipment.

ID.NO = BC Analytical employee identification number of analyst.

SAMPLES...	SAMPLE DESCRIPTION..	DETERM.........	DATE...... ANALYZED	METHOD.....	EQUIP.	BATCH..	ID.NO
		PB	10.31.95	6010	535-02	951897	8488
		HG,SO	10.31.95	7471	534-06	951903	8488
		SE,GFA	10.31.95	7740	534-04	951896	7725
		AG	10.31.95	6010	535-02	951897	8488
		ZN	10.31.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	10.30.95	3050		951897	7620
		DIG,NAQ,GFA	10.30.95	3050		951896	7620
		CU	10.31.95	6010	535-02	951897	8488
9510553*11	MCF-SUP-2.5	PH,NA	11.03.95	9045	533-21	9548	8604
		AS,GFA	11.06.95	7060	534-07	951961	7396
		BA	11.03.95	6010	535-03	951948	7396
		CD	11.03.95	6010	535-03	951948	7396
		CR	11.03.95	6010	535-03	951948	7396
		CU	11.03.95	6010	535-03	951948	7396
		FE	11.03.95	6010	535-03	951948	7396
		PB	11.03.95	6010	535-03	951948	7396
		HG,SO	11.07.95	7471	534-06	951958	7093
		SE,GFA	11.06.95	7740	534-07	951961	7396
		AG	11.03.95	6010	535-03	951948	7396
		ZN	11.03.95	6010	535-03	951948	7396
		DIG,NAQ.HCL	11.03.95	3050		951948	8488
		DIG,NAQ,GFA	11.06.95	3050		951961	7093
9510553*14	MCF-SRS-2.5	PH,NA	11.03.95	9045	533-21	9548	8604
		AS,GFA	11.06.95	7060	534-07	951961	7396
		BA	11.03.95	6010	535-03	951948	7396
		CD	11.03.95	6010	535-03	951948	7396
		CR	11.03.95	6010	535-03	951948	7396
		CU	11.03.95	6010	535-03	951948	7396
		FE	11.03.95	6010	535-03	951948	7396

Notes: Equipment = BC Analytical identification number for a particular piece of analytical equipment.

ID.NO = BC Analytical employee identification number of analyst.

SAMPLES...	SAMPLE DESCRIPTION..	DETERM.........	DATE...... ANALYZED	METHOD.....	EQUIP.	BATCH..	ID.NO
		PB	11.03.95	6010	535-03	951948	7396
		HG,SO	11.07.95	7471	534-06	951958	7093
		SE,GFA	11.06.95	7740	534-07	951961	7396
		AG	11.03.95	6010	535-03	951948	7396
		ZN	11.03.95	6010	535-03	951948	7396
		DIG,NAQ.HCL	11.03.95	3050		951948	8488
		DIG,NAQ,GFA	11.06.95	3050		951961	7093
9510553*17	MCF-LUP-2.5	PH,NA	11.03.95	9045	533-21	9548	8604
		AS,GFA	11.06.95	7060	534-07	951961	7396
		BA	11.03.95	6010	535-03	951948	7396
		CD	11.03.95	6010	535-03	951948	7396
		CR	11.03.95	6010	535-03	951948	7396
		CU	11.03.95	6010	535-03	951948	7396
		FE	11.03.95	6010	535-03	951948	7396
		PB	11.03.95	6010	535-03	951948	7396
		HG,SO	11.07.95	7471	534-06	951958	7093
		SE,GFA	11.06.95	7740	534-07	951961	7396
		AG	11.03.95	6010	535-03	951948	7396
		ZN	11.03.95	6010	535-03	951948	7396
		DIG,NAQ.HCL	11.03.95	3050		951948	8488
		DIG,NAQ,GFA	11.06.95	3050		951961	7093
9510553*23	MCF-SLO-2.5	IR.PETROHC	11.04.95	418.1	533-17	95176	8106
		AS,GFA	11.06.95	7060	534-07	951961	7396
		BA	11.03.95	6010	535-03	951948	7396
		CD	11.03.95	6010	535-03	951948	7396
		CR	11.03.95	6010	535-03	951948	7396
		CU	11.03.95	6010	535-03	951948	7396
		FE	11.03.95	6010	535-03	951948	7396
		PB	11.03.95	6010	535-03	951948	7396

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ID.NO = BC Analytical employee identification number of analyst.

SAMPLES...	SAMPLE DESCRIPTION..	DETERM.........	DATE...... ANALYZED	METHOD.....	EQUIP.	BATCH..	ID.NO
		HG,SO	11.07.95	7471	534-06	951958	7093
		SE,GFA	11.06.95	7740	534-07	951961	7396
		AG	11.03.95	6010	535-03	951948	7396
		ZN	11.03.95	6010	535-03	951948	7396
		DIG,NAQ.HCL	11.03.95	3050		951948	8488
		DIG,NAQ,GFA	11.06.95	3050		951961	7093
9510553*43	MCF-MSA-2.5	IR.PETROHC	10.28.95	418.1	533-17	95171	8106
9510553*45	MCF-MSB-2.5	IR.PETROHC	10.28.95	418.1	533-17	95171	8106
9510553*47	MCF-SUP-1 (DUP)	CU	11.07.95	6010	535-02	951897	8488
		DIG,NAQ.HCL	11.07.95	3050		951897	7093

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ID.NO = BC Analytical employee identification number of analyst.

BC ANALYTICAL, GLENDALE
QC RE.   FOR 9510553
DATE PRINTED: 09 NOV 1995

NON-AQUEOUS SAMPLES

	Method Blank				Lab Control									Matrix QC								
	UNITS	RESULT	RDL	FLG	LCS %REC	FLG	LCSD %REC	FLG	LCL	UCL	RPD	RPD UCL	RPD FLG	MS %REC	FLG	MSD %REC	FLG	LCL	UCL	RPD	RPD UCL	RPD FLG
Batch: PH,NA*9546 Method: 9045 - Soil pH																						
pH	Units	-	-	-	100	-	101	-	99	101	0	20	-	8.4	*	8.5	*	-	-	-	20	-
Batch: PH,NA*9548 Method: 9045 - Soil pH																						
pH	Units	-	-	-	99	-	100	-	99	101	1	20	-	8.1	*	8.2	*	-	-	-	20	-
Batch: IR*95171 Method: 418.1 - Petroleum Hydrocarbons, Total, Spectrophotometric, Infrared																						
TRPH	mg/kg	0	10	-	132	-	-	-	43	168	-	-	-	82	-	75	-	19	153	7	30	-
Batch: IR*95176 Method: 418.1 - Petroleum Hydrocarbons, Total, Spectrophotometric, Infrared																						
TRPH	mg/kg	4.8	10	-	143	-	-	-	43	168	-	-	-	59	-	58	-	19	153	1	30	-
Batch: AS,GFA*951896 Method: 7060 - Arsenic, AA, Furnace																						
Arsenic	mg/kg	0.06	0.2	-	96	-	96	-	81	123	1	-	-	110	-	109	-	18	167	1	30	-
Batch: SE,GFA*951896 Method: 7740 - Selenium, AA, Furnace																						
Selenium	mg/kg	0	0.4	-	100	-	100	-	83	114	0	-	-	68	-	71	-	4	148	4	30	-
Batch: 951897 Method: 6010 - ICAP Metals																						
Silver	mg/kg	0	1	-	94	-	89	-	72	117	5	-	-	90	-	90	-	51	127	0	30	-
Barium	mg/kg	0.231	0.5	-	88	-	84	-	75	114	4	-	-	49	Q	48	Q	63	129	1	30	-
Cadmium	mg/kg	0	0.5	-	90	-	87	-	75	118	4	-	-	86	-	87	-	55	125	1	30	-
Chromium	mg/kg	0	1	-	91	-	88	-	76	110	3	-	-	69	-	71	-	40	137	3	30	-
Copper	mg/kg	0	2	-	88	-	85	-	70	110	4	-	-	-	NC	-	NC	54	122	-	30	NC
Iron	mg/kg	0.22	4	-	92	-	93	-	80	110	2	-	-	-	NC	-	NC	41	160	-	30	NC
Lead	mg/kg	1.9	5	-	93	-	88	-	73	116	6	-	-	75	-	76	-	42	139	1	30	-
Zinc	mg/kg	0	1	-	87	-	89	-	76	117	0	-	-	48	-	45	-	43	142	2	30	-
Batch: HG,SO*951903 Method: 7471 - Mercury (Solids), Cold Vapor AA, Manual																						
Mercury	mg/kg	0	0.1	-	88	-	95	-	83	124	8	-	-	88	-	92	-	65	136	4	30	-
Batch: 951948 Method: 6010 - ICAP Metals																						
Silver	mg/kg	0	1	-	76	-	77	-	72	117	2	-	-	71	-	71	-	51	127	1	30	-
Barium	mg/kg	0.077	0.5	-	88	-	87	-	75	114	1	-	-	91	-	86	-	63	129	3	30	-
Cadmium	mg/kg	0	0.5	-	89	-	89	-	75	118	0	-	-	75	-	75	-	55	125	1	30	-
Chromium	mg/kg	0	1	-	89	-	89	-	76	110	0	-	-	81	-	81	-	40	137	0	30	-
Copper	mg/kg	0	2	-	90	-	89	-	70	110	1	-	-	85	-	86	-	54	122	1	30	-
Iron	mg/kg	0.90	4	-	88	-	87	-	80	110	0	-	-	70	-	67	-	41	160	2	30	-
Lead	mg/kg	0	5	-	93	-	91	-	73	116	2	-	-	87	-	89	-	42	139	1	30	-
Zinc	mg/kg	0.24	1	-	88	-	87	-	76	117	0	-	-	85	-	85	-	43	142	1	30	-

BC A[illegible]YTICAL, GLENDALE
QC R[illegible]T FOR 9510553
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NON-AQUEOUS SAMPLES

	METHOD BLANK				LAB CONTROL									MATRIX QC								
	UNITS	RESULT	RDL	FLG	LCS %REC	FLG	LCSD %REC	FLG	LCL	UCL	RPD	RPD UCL	RPD FLG	MS %REC	FLG	MSD %REC	FLG	LCL	UCL	RPD	RPD UCL	RPD FLG
Batch: HG,SO*951958 Method: 7471 - Mercury (Solids), Cold Vapor AA, Manual																						
Mercury	mg/kg	0	0.1	-	113	-	108	-	83	124	5	-	-	99	-	99	-	65	136	0	30	-
Batch: AS,GFA*951961 Method: 7060 - Arsenic, AA, Furnace																						
Arsenic	mg/kg	0	0.2	-	108	-	109	-	81	123	0	-	-	106	-	104	-	18	167	1	30	-
Batch: SE,GFA*951961 Method: 7740 - Selenium, AA, Furnace																						
Selenium	mg/kg	0	0.4	-	105	-	102	-	83	114	3	-	-	47	-	43	-	4	148	7	30	-
Batch: 8020*9529189 Method: 8020 - Aromatic Volatile Organics																						
1,2-Dichlorobenzene	mg/kg	0	0.005	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,3-Dichlorobenzene	mg/kg	0	0.005	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,4-Dichlorobenzene	mg/kg	0	0.005	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzene	mg/kg	0	0.005	-	111	-	-	-	64	138	-	-	-	116	-	127	-	69	141	9	24	-
Chlorobenzene	mg/kg	0	0.005	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	mg/kg	0	0.005	-	85	-	-	-	76	120	-	-	-	93	-	107	-	-	-	14	-	-
Toluene	mg/kg	0	0.005	-	83	-	-	-	75	122	-	-	-	87	-	86	-	73	135	1	24	-
Total Xylene Isomers	mg/kg	0	0.01	-	94	-	-	-	75	117	-	-	-	87	-	92	-	-	-	7	-	-
[a,a,a-Trifluorotoluene]	Percent	95	-	-	102	-	-	-	65	139	-	-	-	109	-	108	-	81	140	-	-	-

BC ANALYTICAL, GLENDALE
QC REF FOR 9510553
DATE PRINTED: 09 NOV 1995

NON-AQUEOUS SAMPLES

	METHOD BLANK				LAB CONTROL									MATRIX QC								
	UNITS	RESULT	RDL	FLG	LCS %REC	FLG	LCSD %REC	FLG	LCL	UCL	RPD	RPD UCL	RPD FLG	MS %REC	FLG	MSD %REC	FLG	LCL	UCL	RPD	RPD UCL	RPD FLG
Batch: 8240*9529190 Method: 8240 - GC/MS for Volatile Organics																						
1,1,1-Trichloroethane	mg/kg	0	0.005	-	93	-	91	-	67	135	1	20	-	-	-	-	-	-	-	-	-	-
1,1,2,2-Tetrachloroethane	mg/kg	0	0.005	-	87	-	88	-	63	173	1	28	-	-	-	-	-	-	-	-	-	-
1,1,2-Trichloroethane	mg/kg	0	0.005	-	90	-	89	-	62	156	1	21	-	-	-	-	-	-	-	-	-	-
1,1-Dichloroethane	mg/kg	0	0.005	-	132	Q	78	Q	79	118	51	20	Q	-	-	-	-	-	-	-	-	-
1,1-Dichloroethene	mg/kg	0	0.005	-	112	-	89	-	68	131	23	28	-	-	-	-	-	-	-	-	-	-
1,2-Dichloroethane	mg/kg	0	0.005	-	106	-	83	-	77	129	24	20	Q	-	-	-	-	-	-	-	-	-
1,2-Dichlorobenzene	mg/kg	0	0.005	-	98	-	98	-	85	118	0	25	-	-	-	-	-	-	-	-	-	-
1,2-Dichloropropane	mg/kg	0	0.005	-	107	-	90	-	79	125	17	20	-	-	-	-	-	-	-	-	-	-
1,3-Dichlorobenzene	mg/kg	0	0.005	-	106	-	103	-	84	118	2	21	-	-	-	-	-	-	-	-	-	-
1,4-Dichlorobenzene	mg/kg	0	0.005	-	104	-	101	-	85	117	3	20	-	-	-	-	-	-	-	-	-	-
2-Chloroethylvinylether	mg/kg	0	0.005	-	74	-	81	-	21	189	9	-	-	-	-	-	-	-	-	-	-	-
2-Hexanone	mg/kg	0	0.03	-	64	-	57	-	18	254	12	54	-	-	-	-	-	-	-	-	-	-
Acetone	mg/kg	0.0076	0.1	-	94	-	70	-	6	220	30	68	-	-	-	-	-	-	-	-	-	-
Acrolein	mg/kg	0	0.3	-	102	-	77	-	72	134	27	-	-	-	-	-	-	-	-	-	-	-
Acrylonitrile	mg/kg	0	0.3	-	121	-	92	-	64	143	28	-	-	-	-	-	-	-	-	-	-	-
Bromodichloromethane	mg/kg	0	0.005	-	92	-	90	-	73	132	1	20	-	-	-	-	-	-	-	-	-	-
Bromomethane	mg/kg	0	0.005	-	100	-	54	Q	61	142	61	33	Q	-	-	-	-	-	-	-	-	-
Benzene	mg/kg	0	0.005	-	119	-	98	-	70	125	19	25	-	-	-	-	-	-	-	-	-	-
Bromoform	mg/kg	0	0.005	-	91	-	89	-	65	160	3	23	-	-	-	-	-	-	-	-	-	-
Chlorobenzene	mg/kg	0	0.005	-	99	-	100	-	69	137	1	19	-	-	-	-	-	-	-	-	-	-
Carbon Tetrachloride	mg/kg	0	0.005	-	124	-	98	-	61	141	23	20	Q	-	-	-	-	-	-	-	-	-
Chloroethane	mg/kg	0	0.005	-	114	-	85	-	48	143	29	38	-	-	-	-	-	-	-	-	-	-
Chloroform	mg/kg	0	0.005	-	116	-	97	-	77	123	18	20	-	-	-	-	-	-	-	-	-	-
Chloromethane	mg/kg	0	0.005	-	113	-	80	-	64	133	34	24	Q	-	-	-	-	-	-	-	-	-
Carbon Disulfide	mg/kg	0	0.01	-	116	-	97	-	61	128	18	25	-	-	-	-	-	-	-	-	-	-
Dibromochloromethane	mg/kg	0	0.005	-	94	-	92	-	55	159	3	20	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	mg/kg	0	0.005	-	86	-	87	-	70	137	1	20	-	-	-	-	-	-	-	-	-	-
Freon 113	mg/kg	0	0.01	-	129	-	97	-	66	133	28	-	-	-	-	-	-	-	-	-	-	-
Methyl ethyl ketone	mg/kg	0	0.03	-	91	-	62	-	27	230	38	60	-	-	-	-	-	-	-	-	-	-
Methyl isobutyl ketone	mg/kg	0	0.03	-	72	-	64	-	44	207	13	37	-	-	-	-	-	-	-	-	-	-
Methylene chloride	mg/kg	0	0.005	-	134	Q	105	-	78	119	24	20	Q	-	-	-	-	-	-	-	-	-
Styrene	mg/kg	0	0.005	-	97	-	100	-	65	140	3	20	-	-	-	-	-	-	-	-	-	-
Trichloroethene	mg/kg	0	0.005	-	132	Q	104	-	72	129	24	29	-	-	-	-	-	-	-	-	-	-
Trichlorofluoromethane	mg/kg	0	0.005	-	115	-	78	-	66	134	39	25	Q	-	-	-	-	-	-	-	-	-
Toluene	mg/kg	0	0.005	-	98	-	99	-	68	139	1	19	-	-	-	-	-	-	-	-	-	-
Tetrachloroethene	mg/kg	0	0.005	-	106	-	103	-	63	144	3	20	-	-	-	-	-	-	-	-	-	-
Vinyl acetate	mg/kg	0	0.05	-	112	-	67	Q	74	141	51	27	Q	-	-	-	-	-	-	-	-	-
Vinyl chloride	mg/kg	0	0.005	-	130	-	99	-	54	148	27	35	-	-	-	-	-	-	-	-	-	-

BC A[illegible]TICAL, GLENDALE
QC R[illegible]T FOR 9510553
DATE PRINTED: 09 NOV 1995

NON-AQUEOUS SAMPLES

	------ METHOD BLANK ------				--------------- LAB CONTROL --------------									---------------- MATRIX QC ----------------									
	UNITS	RESULT	RDL	FLG	LCS %REC	FLG	LCSD %REC	FLG	LCL	UCL	RPD	RPD UCL	RPD FLG	MS %REC	FLG	MSD %REC	FLG	LCL	UCL	RPD	RPD UCL	RPD FLG
Batch: 8240*9529190 Method: 8240 - GC/MS for Volatile Organics, con't																						
Total Xylene Isomers	mg/kg	0	0.02	-	99	-	98	-	85	115	1	20	-	-	-	-	-	-	-	-	-	-
cis-1,2-Dichloroethene	mg/kg	0	0.005	-	123	Q	107	-	74	122	14	-	-	-	-	-	-	-	-	-	-	-
cis-1,3-Dichloropropene	mg/kg	0	0.005	-	91	-	92	-	73	131	1	20	-	-	-	-	-	-	-	-	-	-
trans-1,2-Dichloroethene	mg/kg	0	0.005	-	113	-	89	-	73	122	24	20	Q	-	-	-	-	-	-	-	-	-
trans-1,3-Dichloropropene	mg/kg	0	0.005	-	91	-	93	-	55	147	2	41	-	-	-	-	-	-	-	-	-	-
[1,2-Dichloroethane-d4]	Percent	77	-	Q	108	-	86	Q	87	125	-	-	-	-	-	-	-	-	-	-	-	-
[4-Bromofluorobenzene]	Percent	97	-	-	102	-	106	-	85	111	-	-	-	-	-	-	-	-	-	-	-	-
[Toluene-d8]	Percent	98	-	-	96	-	96	-	94	113	-	-	-	-	-	-	-	-	-	-	-	-
Batch: 8080,PCB*95167 Method: 8080 - Organochlorine Pesticides and PCBs																						
Aroclor 1016	mg/kg	0	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1221	mg/kg	0	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1232	mg/kg	0	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1242	mg/kg	0	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1248	mg/kg	0	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1254	mg/kg	0	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1260	mg/kg	0	0.03	-	113	-	107	-	78	129	5	55	-	-	-	-	-	-	-	-	-	-
[Decachlorobiphenyl]	Percent	88	-	-	104	-	89	-	20	147	-	-	-	-	-	-	-	-	-	-	-	-
[Tetrachloro-meta-xylene]	Percent	105	-	-	101	-	101	-	30	142	-	-	-	-	-	-	-	-	-	-	-	-

NON-AQUEOUS SAMPLES

	METHOD BLANK				LAB CONTROL									MATRIX QC								
	UNITS	RESULT	RDL	FLG	LCS %REC	FLG	LCSD %REC	FLG	LCL	UCL	RPD	RPD UCL	RPD FLG	MS %REC	FLG	MSD %REC	FLG	LCL	UCL	RPD	RPD UCL	RPD FLG
Batch: 8270*95214 Method: 8270 - GC/MS for Semivolatile Organics, Capillary column																						
1,2,4-Trichlorobenzene	mg/kg	0	0.2	-	99	-	91	-	44	116	9	-	-	-	-	-	-	-	-	-	-	-
1,2-Dichlorobenzene	mg/kg	0	0.2	-	97	-	90	-	35	127	7	-	-	-	-	-	-	-	-	-	-	-
1,2-Diphenylhydrazine	mg/kg	0	0.2	-	102	-	95	-	43	128	7	-	-	-	-	-	-	-	-	-	-	-
1,3-Dichlorobenzene	mg/kg	0	0.2	-	95	-	89	-	32	110	6	-	-	-	-	-	-	-	-	-	-	-
1,4-Dichlorobenzene	mg/kg	0	0.2	-	94	-	88	-	35	110	7	-	-	-	-	-	-	-	-	-	-	-
2,4,5-Trichlorophenol	mg/kg	0	0.2	-	114	-	106	-	23	154	8	-	-	-	-	-	-	-	-	-	-	-
2,4,6-Trichlorophenol	mg/kg	0	0.2	-	95	-	91	-	37	144	4	-	-	-	-	-	-	-	-	-	-	-
2,4-Dichlorophenol	mg/kg	0	0.2	-	107	-	99	-	39	129	8	-	-	-	-	-	-	-	-	-	-	-
2,4-Dimethylphenol	mg/kg	0	0.2	-	98	-	93	-	32	119	6	-	-	-	-	-	-	-	-	-	-	-
2,4-Dinitrophenol	mg/kg	0	0.4	-	96	-	92	-	1	191	4	-	-	-	-	-	-	-	-	-	-	-
2,4-Dinitrotoluene	mg/kg	0	0.2	-	110	-	101	-	39	139	9	-	-	-	-	-	-	-	-	-	-	-
2,6-Dinitrotoluene	mg/kg	0	0.2	-	78	-	71	-	50	152	10	-	-	-	-	-	-	-	-	-	-	-
2-Chloronaphthalene	mg/kg	0	0.2	-	76	-	70	-	32	110	8	-	-	-	-	-	-	-	-	-	-	-
2-Chlorophenol	mg/kg	0	0.2	-	97	-	93	-	35	116	4	-	-	-	-	-	-	-	-	-	-	-
2-Methyl-4,6-dinitrophenol	mg/kg	0	0.2	-	87	-	82	-	1	181	6	-	-	-	-	-	-	-	-	-	-	-
2-Methylnaphthalene	mg/kg	0	0.2	-	100	-	94	-	5	165	6	-	-	-	-	-	-	-	-	-	-	-
2-Methylphenol (o-Cresol)	mg/kg	0	0.2	-	101	-	95	-	36	114	6	-	-	-	-	-	-	-	-	-	-	-
2-Nitroaniline	mg/kg	0	0.2	-	109	-	102	-	38	144	6	-	-	-	-	-	-	-	-	-	-	-
2-Nitrophenol	mg/kg	0	0.2	-	102	-	96	-	32	130	7	-	-	-	-	-	-	-	-	-	-	-
3,3'-Dichlorobenzidine	mg/kg	0	0.4	-	129	-	123	-	1	262	5	-	-	-	-	-	-	-	-	-	-	-
3-Nitroaniline	mg/kg	0	0.2	-	107	-	100	-	30	152	7	-	-	-	-	-	-	-	-	-	-	-
4-Bromophenylphenylether	mg/kg	0	0.2	-	102	-	96	-	56	127	6	-	-	-	-	-	-	-	-	-	-	-
4-Chloro-3-methylphenol	mg/kg	0	0.2	-	106	-	98	-	35	130	7	-	-	-	-	-	-	-	-	-	-	-
4-Chloroaniline	mg/kg	0	0.2	-	98	-	91	-	31	126	8	-	-	-	-	-	-	-	-	-	-	-
4-Chlorophenylphenylether	mg/kg	0	0.2	-	102	-	94	-	48	132	8	-	-	-	-	-	-	-	-	-	-	-
4-Methylphenol (p-Cresol)	mg/kg	0	0.4	-	89	-	79	-	25	124	12	-	-	-	-	-	-	-	-	-	-	-
4-Nitroaniline	mg/kg	0	0.2	-	122	-	108	-	3	187	11	-	-	-	-	-	-	-	-	-	-	-
4-Nitrophenol	mg/kg	0	0.2	-	124	-	114	-	1	132	8	-	-	-	-	-	-	-	-	-	-	-
Acenaphthene	mg/kg	0	0.2	-	111	-	102	-	47	132	8	-	-	103	-	92	-	47	122	11	34	-
Acenaphthylene	mg/kg	0	0.2	-	110	-	102	-	35	132	7	-	-	-	-	-	-	-	-	-	-	-
Aniline	mg/kg	0	0.2	-	82	-	76	-	1	164	8	-	-	-	-	-	-	-	-	-	-	-
Anthracene	mg/kg	0	0.2	-	95	-	89	-	39	130	6	-	-	-	-	-	-	-	-	-	-	-
Benzidine	mg/kg	0	4	-	34	-	38	-	1	200	9	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)anthracene	mg/kg	0	0.2	-	117	-	110	-	44	138	7	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)pyrene	mg/kg	0	0.2	-	80	-	74	-	36	128	7	-	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	mg/kg	0	0.2	-	82	-	74	-	24	137	10	-	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	mg/kg	0	0.2	-	111	-	101	-	25	157	9	-	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	mg/kg	0	0.2	-	59	-	58	-	39	142	3	-	-	-	-	-	-	-	-	-	-	-

NON-AQUEOUS SAMPLES

	UNITS	METHOD BLANK RESULT	RDL	FLG	LAB CONTROL LCS %REC	FLG	LCSD %REC	FLG	LCL	UCL	RPD	RPD UCL	RPD FLG	MATRIX QC MS %REC	FLG	MSD %REC	FLG	LCL	UCL	RPD	RPD UCL	RPD FLG
Batch: 8270*95214 Method: 8270 - GC/MS for Semivolatile Organics, Capillary column, con't																						
Benzyl Alcohol	mg/kg	0	0.4	-	101	-	93	-	3	161	8	-	-	-	-	-	-	-	-	-	-	-
Benzoic acid	mg/kg	0	2	-	53	-	62	-	1	183	16	-	-	-	-	-	-	-	-	-	-	-
Butylbenzylphthalate	mg/kg	0	0.2	-	109	-	101	-	37	151	8	-	-	-	-	-	-	-	-	-	-	-
Chrysene	mg/kg	0	0.2	-	106	-	91	-	43	147	15	-	-	-	-	-	-	-	-	-	-	-
Di-n-octylphthalate	mg/kg	0	0.2	-	62	-	59	-	21	146	5	-	-	-	-	-	-	-	-	-	-	-
Dibenzo(a,h)anthracene	mg/kg	0	0.2	-	94	-	86	-	30	154	9	-	-	-	-	-	-	-	-	-	-	-
Dibenzofuran	mg/kg	0	0.2	-	102	-	95	-	54	121	8	-	-	-	-	-	-	-	-	-	-	-
Dibutylphthalate	mg/kg	0.036	0.2	-	101	-	94	-	53	125	7	-	-	-	-	-	-	-	-	-	-	-
Diethylphthalate	mg/kg	0	0.2	-	107	-	97	-	47	142	10	-	-	-	-	-	-	-	-	-	-	-
Dimethylphthalate	mg/kg	0	0.2	-	105	-	96	-	32	142	8	-	-	-	-	-	-	-	-	-	-	-
Fluoranthene	mg/kg	0	0.2	-	104	-	97	-	39	137	7	-	-	-	-	-	-	-	-	-	-	-
Fluorene	mg/kg	0	0.2	-	103	-	96	-	59	121	7	-	-	-	-	-	-	-	-	-	-	-
Hexachlorobenzene	mg/kg	0	0.2	-	103	-	96	-	48	129	7	-	-	-	-	-	-	-	-	-	-	-
Hexachlorobutadiene	mg/kg	0	0.2	-	101	-	93	-	29	116	8	-	-	-	-	-	-	-	-	-	-	-
Hexachlorocyclopentadiene	mg/kg	0	0.2	-	180	Q	170	Q	18	143	5	-	-	-	-	-	-	-	-	-	-	-
Hexachloroethane	mg/kg	0	0.2	-	99	-	93	-	40	113	6	-	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg	0	0.2	-	100	-	91	-	25	162	9	-	-	-	-	-	-	-	-	-	-	-
Isophorone	mg/kg	0	0.2	-	86	-	72	-	27	134	17	-	-	-	-	-	-	-	-	-	-	-
N-Nitrosodimethylamine	mg/kg	0	0.2	-	94	-	88	-	17	115	6	-	-	-	-	-	-	-	-	-	-	-
N-Nitrosodiphenylamine	mg/kg	0	0.2	-	75	-	70	-	11	110	7	-	-	-	-	-	-	-	-	-	-	-
N-Nitrosodi-n-propylamine	mg/kg	0	0.2	-	79	-	73	-	32	136	8	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	mg/kg	0	0.2	-	101	-	93	-	39	115	7	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	mg/kg	0	0.2	-	98	-	91	-	39	114	8	-	-	-	-	-	-	-	-	-	-	-
Phenanthrene	mg/kg	0	0.2	-	103	-	95	-	54	120	8	-	-	-	-	-	-	-	-	-	-	-
Phenol	mg/kg	0	0.2	-	94	-	89	-	7	110	6	-	-	-	-	-	-	-	-	-	-	-
Pentachlorophenol	mg/kg	0	0.2	-	102	-	97	-	14	163	5	-	-	-	-	-	-	-	-	-	-	-
Pyrene	mg/kg	0	0.2	-	104	-	97	-	52	149	7	-	-	114	-	102	-	52	115	11	36	-
Pyridine	mg/kg	0	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bis(2-chloroethoxy)methane	mg/kg	0	0.2	-	108	-	99	-	37	130	8	-	-	-	-	-	-	-	-	-	-	-
Bis(2-chloroethyl)ether	mg/kg	0	0.2	-	101	-	94	-	40	123	7	-	-	-	-	-	-	-	-	-	-	-
Bis(2-chloroisopropyl)ether	mg/kg	0	0.2	-	129	-	120	-	36	140	8	-	-	-	-	-	-	-	-	-	-	-
Bis(2-ethylhexyl)phthalate	mg/kg	0	0.4	-	104	-	96	-	41	147	8	-	-	-	-	-	-	-	-	-	-	-
[2-Fluorobiphenyl]	Percent	110	-	-	119	Q	108	-	43	116	-	-	-	102	-	97	-	38	110	-	-	-
[2-Fluorophenol]	Percent	93	-	-	102	Q	93	-	21	100	-	-	-	-	-	-	-	-	-	-	-	-
[2,4,6-Tribromophenol]	Percent	92	-	-	112	-	102	-	40	123	-	-	-	-	-	-	-	-	-	-	-	-
[Nitrobenzene-d5]	Percent	101	-	-	114	-	103	-	37	114	-	-	-	110	-	98	-	34	110	-	-	-
[Phenol-d5]	Percent	87	-	-	99	Q	90	-	10	93	-	-	-	-	-	-	-	-	-	-	-	-
[Terphenyl-d14]	Percent	98	-	-	106	-	96	-	33	141	-	-	-	72	-	69	-	18	130	-	-	-

BC ANALYTICAL, GLENDALE
QC REI FOR 9510553
DATE PRINTED: 09 NOV 1995

NON-AQUEOUS SAMPLES

	METHOD BLANK				LAB CONTROL										MATRIX QC								
					LCS		LCSD					RPD	RPD	MS		MSD					RPD	RPD
	UNITS	RESULT	RDL	FLG	%REC	FLG	%REC	FLG	LCL	UCL	RPD	UCL	FLG	%REC	FLG	%REC	FLG	LCL	UCL	RPD	UCL	FLG
Batch: DIESEL*95183 Method: 8015M - Modified 8015																						
TPH (Diesel Range)	mg/kg	0	10	-	75	-	71	-	53	155	6	-	-	66	-	54	-	43	151	21	38	-
[Naphthalene]	Percent	103	-	-	138	Q	121	-	55	127	-	-	-	106	-	98	-	52	145	-	-	-

BC ANA[illegible]ICAL, GLENDALE
SUPPL[illegible]AL QC REPORT FOR 9510553
DATE PRINTED: 09 NOV 1995

NON-AQUEOUS SAMPLES

Batch: PH,NA*9546 Method: 9045 - Soil pH

		N/A	C5103891*1		C5103892*1		N/A	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
pH	-	-	6.01	6.00	6.04	6.00	-	-	-	-	-

Batch: PH,NA*9548 Method: 9045 - Soil pH

		N/A	C511499*1		C511500*1		N/A	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
pH	-	-	5.95	6.00	6.02	6.00	-	-	-	-	-

Batch: IR*95171 Method: 418.1 - Petroleum Hydrocarbons, Total, Spectrophotometric, Infrared

		B5102078*1	C5103697*1		N/A		9510553*19	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
TRPH	mg/kg	0	228	173	-	-	13	-	79.1	73.9	94

Batch: IR*95176 Method: 418.1 - Petroleum Hydrocarbons, Total, Spectrophotometric, Infrared

		B511308*1	C511597*1		N/A		9510553*23	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
TRPH	mg/kg	4.8	247	173	-	-	26	-	72.9	72.0	105

Batch: DIG,NAQ,GFA*951896 Method: 3050 - Acid Digestion of Sediments, etc.

		(BLANK)	(LCS)		(LCSD)		(MTX QC)	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Furnace Digestion	Date	10/30/95	10/30/95	10/30/95	10/30/95	10/30/95	10/30/95	10/30/95	10/30/95	10/30/95	10/30/95

Batch: AS,GFA*951896 Method: 7060 - Arsenic, AA, Furnace

		B5102167*1	C5103843*1		C5103844*1		9510553*4	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Arsenic	mg/kg	0.06	4.79	5.00	4.82	5.00	0.93	-	5.83	5.78	5.39

Batch: SE,GFA*951896 Method: 7740 - Selenium, AA, Furnace

		B5102168*1	C5103845*1		C5103846*1		9510553*4	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Selenium	mg/kg	0	9.98	10.0	10.0	10.0	<0.4	-	3.04	3.17	4.46

NON-AQUEOUS SAMPLES

Batch: DIG,NAQ*951897 Method: 3050 - Acid Digestion of Sediments, etc.

		(BLANK)	(LCS)		(LCSD)		(MTX QC)	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Digestion	Date	10/07/95	10/07/95	10/07/95	10/07/95	10/07/95	10/07/95	10/07/95	10/07/95	10/07/95	10/07/95

Batch: AG*951897 Method: 6010 - ICAP Metals

		B5102170*1	C5103849*1		C5104007*1		9510553*4	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Silver	mg/kg	0	46.9	50.0	44.6	50.0	<1	-	42.5	42.5	47.2

Batch: BA*951897 Method: 6010 - ICAP Metals

		B5102171*1	C5103850*1		C5104008*1		9510553*4	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Barium	mg/kg	0.231	88.0	100	84.3	100	93	-	139	138	187

Batch: CD*951897 Method: 6010 - ICAP Metals

		B5102173*1	C5103852*1		C5104009*1		9510553*4	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Cadmium	mg/kg	0	90.3	100	86.9	100	<0.5	-	40.6	41.1	47.2

Batch: CR*951897 Method: 6010 - ICAP Metals

		B5102174*1	C5103853*1		C5104010*1		9510553*4	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Chromium	mg/kg	0	90.5	100	87.6	100	11	-	43.4	44.5	58.2

Batch: CU*951897 Method: 6010 - ICAP Metals

		B5102257*1	C5104014*1		C5104015*1		9510553*4	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Copper	mg/kg	0	88.3	100	84.5	100	290	-	252	253	341

Batch: FE*951897 Method: 6010 - ICAP Metals

		B5102175*1	C5103854*1		C5104011*1		9510553*4	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Iron	mg/kg	0.22	513	560	521	560	11000	-	6590	6660	15700

NON-AQUEOUS SAMPLES

Batch: PB*951897 Method: 6010 - ICAP Metals

		B5102176*1	C5103855*1	....	C5104012*1	....	9510553*4	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Lead	mg/kg	1.9	92.8	100	87.7	100	6.8	-	77.3	78.2	101

Batch: ZN*951897 Method: 6010 - ICAP Metals

		B5102177*1	C5103856*1	....	C5104013*1	....	9510553*4	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Zinc	mg/kg	0	89.2	102	89.3	100	35	-	57.6	56.3	82.2

Batch: HG,SO*951903 Method: 7471 - Mercury (Solids), Cold Vapor AA, Manual

		B5102268*1	C5104034*1	....	C5104035*1	....	9510553*4	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Mercury	mg/kg	0	1.75	2.00	1.90	2.00	<0.1	-	2.20	2.30	2.50

Batch: DIG,NAQ*951948 Method: 3050 - Acid Digestion of Sediments, etc.

		(BLANK)	(LCS)	....	(LCSD)	....	(MTX QC)	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Digestion	Date	11/03/95	11/03/95	11/03/95	11/03/95	11/03/95	11/03/95	11/03/95	11/03/95	11/03/95	11/03/95

Batch: AG*951948 Method: 6010 - ICAP Metals

		B511288*1	C511558*1	....	C511559*1	....	9510553*5	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Silver	mg/kg	0	38.0	50.0	38.7	50.0	<1	-	35.7	35.4	50.0

Batch: BA*951948 Method: 6010 - ICAP Metals

		B511289*1	C511560*1	....	C511561*1	....	9510553*5	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Barium	mg/kg	0.077	88.0	100	87.2	100	74	-	165	160	174

Batch: CD*951948 Method: 6010 - ICAP Metals

		B511295*1	C511572*1	....	C511573*1	....	9510553*5	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Cadmium	mg/kg	0	88.8	100	88.5	100	<0.5	-	37.5	37.3	50.0

NON-AQUEOUS SAMPLES

Batch: CR*951948 Method: 6010 - ICAP Metals

		B511290*1	C511562*1		C511563*1		9510553*5	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Chromium	mg/kg	0	89.1	100	88.8	100	5.8	-	46.1	46.2	55.8

Batch: CU*951948 Method: 6010 - ICAP Metals

		B511291*1	C511564*1		C511565*1		9510553*5	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Copper	mg/kg	0	89.7	100	89.1	100	9.0	-	51.6	52.0	59.0

Batch: FE*951948 Method: 6010 - ICAP Metals

		B511292*1	C511566*1		C511567*1		9510553*5	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Iron	mg/kg	0.90	438	500	436	500	5800	-	9310	9160	10800

Batch: PB*951948 Method: 6010 - ICAP Metals

		B511293*1	C511568*1		C511569*1		9510553*5	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Lead	mg/kg	0	92.6	100	91.1	100	<5	-	87.3	88.5	100

Batch: ZN*951948 Method: 6010 - ICAP Metals

		B511294*1	C511570*1		C511571*1		9510553*5	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Zinc	mg/kg	0.24	89.5	102	89.2	102	16	-	58.7	58.4	66.0

Batch: HG,SO*951958 Method: 7471 - Mercury (Solids), Cold Vapor AA, Manual

		B511397*1	C511760*1		C511761*1		9510553*5	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Mercury	mg/kg	0	2.25	2.00	2.15	2.00	<0.1	-	1.98	1.98	2.00

Batch: DIG,NAQ,GFA*951961 Method: 3050 - Acid Digestion of Sediments, etc.

		(BLANK)	(LCS)		(LCSD)		(MTX QC)	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Furnace Digestion	Date	11/06/95	11/06/95	11/06/95	11/06/95	11/06/95	11/06/95	11/06/95	11/06/95	11/06/95	11/06/95

NON-AQUEOUS SAMPLES

Batch: AS,GFA*951961 Method: 7060 - Arsenic, AA, Furnace

		B511363*1	C511697*1		C511698*1		9510553*5	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Arsenic	mg/kg	0	5.42	5.00	5.43	5.00	1.9	-	7.19	7.12	6.90

Batch: SE,GFA*951961 Method: 7740 - Selenium, AA, Furnace

		B511364*1	C511699*1		C511700*1		9510553*5	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Selenium	mg/kg	0	10.5	10	10.2	10	<0.4	-	2.33	2.17	5.00

Batch: 8020*9529189 Method: 8020 - Aromatic Volatile Organics

		B5102239*1	C5103970*1		N/A		9509987*1	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Date Analyzed	Date	10/30/95	10/30/95	10/30/95	-	-	10/30/95	-	10/30/95	10/30/95	10/30/95
Date Confirmed	Date	10/30/95	10/30/95	10/30/95	-	-	10/30/95	-	10/30/95	10/30/95	10/30/95
Dilution Factor	Times	1	1	1	-	-	1	-	1	1	1
1,2-Dichlorobenzene	mg/kg	0	-	-	-	-	<0.005	-	-	-	-
1,3-Dichlorobenzene	mg/kg	0	-	-	-	-	<0.005	-	-	-	-
1,4-Dichlorobenzene	mg/kg	0	-	-	-	-	<0.005	-	-	-	-
Benzene	mg/kg	0	0.0169	0.0152	-	-	<0.005	-	0.0177	0.0193	0.0152
Chlorobenzene	mg/kg	0	-	-	-	-	<0.005	-	-	-	-
Ethylbenzene	mg/kg	0	0.0174	0.0204	-	-	<0.005	-	0.0190	0.0219	0.0204
Toluene	mg/kg	0	0.0807	0.0974	-	-	<0.005	-	0.0849	0.0840	0.0974
Total Xylene Isomers	mg/kg	0	0.112	0.119	-	-	<0.01	-	0.103	0.110	0.119
a,a,a-Trifluorotoluene Rep.	mg/kg	0.0477	0.0509	0.0500	-	-	0.0546	-	0.0545	0.0538	0.0500
a,a,a-Trifluorotoluene Th.	mg/kg	0.0500	0.0500	0.0500	-	-	0.0500	-	0.0500	0.0500	0.0500

NON-AQUEOUS SAMPLES

Batch: 8240*9529190 Method: 8240 - GC/MS for Volatile Organics

		B511099*1	C511200*1		C511201*1		N/A	....	....	....	
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Date Analyzed	Date	10/31/95	10/31/95	10/31/95	10/31/95	10/31/95	-	-	-	-	-
Date Extracted	Date	-	-	-	-	-	-	-	-	-	-
Dilution Factor	Times	1	1	1	1	1	-	-	-	-	-
1,1,1-Trichloroethane	mg/kg	0	0.0463	0.0500	0.0457	0.0500	-	-	-	-	-
1,1,2,2-Tetrachloroethane	mg/kg	0	0.0433	0.0500	0.0438	0.0500	-	-	-	-	-
1,1,2-Trichloroethane	mg/kg	0	0.0450	0.0500	0.0447	0.0500	-	-	-	-	-
1,1-Dichloroethane	mg/kg	0	0.0659	0.0500	0.0390	0.0500	-	-	-	-	-
1,1-Dichloroethene	mg/kg	0	0.0562	0.0500	0.0444	0.0500	-	-	-	-	-
1,2-Dichloroethane	mg/kg	0	0.0531	0.0500	0.0417	0.0500	-	-	-	-	-
1,2-Dichlorobenzene	mg/kg	0	0.0488	0.0500	0.0490	0.0500	-	-	-	-	-
1,2-Dichloropropane	mg/kg	0	0.0535	0.0500	0.0452	0.0500	-	-	-	-	-
1,3-Dichlorobenzene	mg/kg	0	0.0528	0.0500	0.0517	0.0500	-	-	-	-	-
1,4-Dichlorobenzene	mg/kg	0	0.0520	0.0500	0.0507	0.0500	-	-	-	-	-
2-Chloroethylvinylether	mg/kg	0	0.0368	0.0500	0.0403	0.0500	-	-	-	-	-
2-Hexanone	mg/kg	0	0.0320	0.0500	0.0283	0.0500	-	-	-	-	-
Acetone	mg/kg	0.0076	0.0471	0.0500	0.0348	0.0500	-	-	-	-	-
Acrolein	mg/kg	0	0.509	0.500	0.387	0.500	-	-	-	-	-
Acrylonitrile	mg/kg	0	0.606	0.500	0.459	0.500	-	-	-	-	-
Bromodichloromethane	mg/kg	0	0.0458	0.0500	0.0452	0.0500	-	-	-	-	-
Bromomethane	mg/kg	0	0.0502	0.0500	0.0268	0.0500	-	-	-	-	-
Benzene	mg/kg	0	0.0593	0.0500	0.0488	0.0500	-	-	-	-	-
Bromoform	mg/kg	0	0.0457	0.0500	0.0445	0.0500	-	-	-	-	-
Chlorobenzene	mg/kg	0	0.0494	0.0500	0.0501	0.0500	-	-	-	-	-
Carbon Tetrachloride	mg/kg	0	0.0621	0.0500	0.0491	0.0500	-	-	-	-	-
Chloroethane	mg/kg	0	0.0569	0.0500	0.0426	0.0500	-	-	-	-	-
Chloroform	mg/kg	0	0.0582	0.0500	0.0487	0.0500	-	-	-	-	-
Chloromethane	mg/kg	0	0.0564	0.0500	0.0401	0.0500	-	-	-	-	-
Carbon Disulfide	mg/kg	0	0.0581	0.0500	0.0484	0.0500	-	-	-	-	-
Dibromochloromethane	mg/kg	0	0.0471	0.0500	0.0459	0.0500	-	-	-	-	-
Ethylbenzene	mg/kg	0	0.0429	0.0500	0.0433	0.0500	-	-	-	-	-
Freon 113	mg/kg	0	0.0645	0.0500	0.0485	0.0500	-	-	-	-	-
Methyl ethyl ketone	mg/kg	0	0.0456	0.0500	0.0309	0.0500	-	-	-	-	-
Methyl isobutyl ketone	mg/kg	0	0.0361	0.0500	0.0318	0.0500	-	-	-	-	-
Methylene chloride	mg/kg	0	0.0668	0.0500	0.0525	0.0500	-	-	-	-	-
Styrene	mg/kg	0	0.0483	0.0500	0.0499	0.0500	-	-	-	-	-
Trichloroethene	mg/kg	0	0.0661	0.0500	0.0521	0.0500	-	-	-	-	-
Trichlorofluoromethane	mg/kg	0	0.0573	0.0500	0.0388	0.0500	-	-	-	-	-

NON-AQUEOUS SAMPLES

Batch: 8240*9529190 Method: 8240 - GC/MS for Volatile Organics, con't

		B511099*1	C511200*1		C511201*1		N/A	....	....	....	
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Toluene	mg/kg	0	0.0492	0.0500	0.0496	0.0500	-	-	-	-	-
Tetrachloroethene	mg/kg	0	0.0530	0.0500	0.0514	0.0500	-	-	-	-	-
Vinyl acetate	mg/kg	0	0.0562	0.0500	0.0335	0.0500	-	-	-	-	-
Vinyl chloride	mg/kg	0	0.0650	0.0500	0.0493	0.0500	-	-	-	-	-
Total Xylene Isomers	mg/kg	0	0.148	0.150	0.147	0.150	-	-	-	-	-
cis-1,2-Dichloroethene	mg/kg	0	0.0613	0.0500	0.0535	0.0500	-	-	-	-	-
cis-1,3-Dichloropropene	mg/kg	0	0.0453	0.0500	0.0458	0.0500	-	-	-	-	-
trans-1,2-Dichloroethene	mg/kg	0	0.0563	0.0500	0.0444	0.0500	-	-	-	-	-
trans-1,3-Dichloropropene	mg/kg	0	0.0454	0.0500	0.0464	0.0500	-	-	-	-	-
1,2-Dichloroethane-d4 Rep.	mg/kg	0.0387	0.0540	0.0500	0.0430	0.0500	-	-	-	-	-
1,2-Dichloroethane-d4 Theo.	mg/kg	0.0500	0.0500	0.0500	0.0500	0.0500	-	-	-	-	-
4-Bromofluorobenzene Rep.	mg/kg	0.0487	0.0510	0.0500	0.0530	0.0500	-	-	-	-	-
4-Bromofluorobenzene Theo.	mg/kg	0.0500	0.0500	0.0500	0.0500	0.0500	-	-	-	-	-
Toluene-d8 Reported	mg/kg	0.0491	0.0481	0.0500	0.0481	0.0500	-	-	-	-	-
Toluene-d8 Theo.	mg/kg	0.0500	0.0500	0.0500	0.0500	0.0500	-	-	-	-	-

Batch: 8080,PCB*95167 Method: 8080 - Organochlorine Pesticides and PCBs

		B511321*1	C511619*1		C511620*1		N/A	....	....	....	
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Date Analyzed	Date	11/03/95	11/03/95	11/03/95	11/03/95	11/03/95	-	-	-	-	-
Date Extracted	Date	11/03/95	11/03/95	11/03/95	11/03/95	11/03/95	-	-	-	-	-
Dilution Factor	Times	0	1	1	1	1	-	-	-	-	-
Aroclor 1016	mg/kg	0	-	-	-	-	-	-	-	-	-
Aroclor 1221	mg/kg	0	-	-	-	-	-	-	-	-	-
Aroclor 1232	mg/kg	0	-	-	-	-	-	-	-	-	-
Aroclor 1242	mg/kg	0	-	-	-	-	-	-	-	-	-
Aroclor 1248	mg/kg	0	-	-	-	-	-	-	-	-	-
Aroclor 1254	mg/kg	0	-	-	-	-	-	-	-	-	-
Aroclor 1260	mg/kg	0	0.375	0.333	0.356	0.333	-	-	-	-	-
Decachlorobiphenyl Reported	mg/kg	0.0073	0.0086	0.0083	0.0074	0.0083	-	-	-	-	-
Decachlorobiphenyl Theoretical	mg/kg	0.0083	0.0083	0.0083	0.0083	0.0083	-	-	-	-	-
Tetrachloro-meta-xylene Rpt.	mg/kg	0.0087	0.0084	0.0083	0.0084	0.0083	-	-	-	-	-
Tetrachloro-meta-xylene Theor.	mg/kg	0.0083	0.0083	0.0083	0.0083	0.0083	-	-	-	-	-

NON-AQUEOUS SAMPLES

Batch: 8270*95214 Method: 8270 - GC/MS for Semivolatile Organics, Capillary column

		B5102152*1	C5103539*1	....	C5103540*1	....	9510554*1	....	....	....	....
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Date Analyzed	Date	10/30/95	10/30/95	10/30/95	10/30/95	10/30/95	11/03/95	-	11/03/95	11/03/95	11/03/95
Date Extracted	Date	10/30/95	10/30/95	10/30/95	10/30/95	10/30/95	10/30/95	-	10/30/95	10/30/95	10/30/95
Dilution Factor	Times	1	1	1	1	1	1	-	1	1	1
1,2,4-Trichlorobenzene	mg/kg	0	3.31	3.33	3.04	3.33	-	-	-	-	-
1,2-Dichlorobenzene	mg/kg	0	3.23	3.33	3.01	3.33	-	-	-	-	-
1,2-Diphenylhydrazine	mg/kg	0	3.41	3.33	3.17	3.33	-	-	-	-	-
1,3-Dichlorobenzene	mg/kg	0	3.15	3.33	2.97	3.33	-	-	-	-	-
1,4-Dichlorobenzene	mg/kg	0	3.14	3.33	2.94	3.33	-	-	-	-	-
2,4,5-Trichlorophenol	mg/kg	0	3.81	3.33	3.53	3.33	-	-	-	-	-
2,4,6-Trichlorophenol	mg/kg	0	3.15	3.33	3.02	3.33	-	-	-	-	-
2,4-Dichlorophenol	mg/kg	0	3.55	3.33	3.29	3.33	-	-	-	-	-
2,4-Dimethylphenol	mg/kg	0	3.28	3.33	3.10	3.33	-	-	-	-	-
2,4-Dinitrophenol	mg/kg	0	3.19	3.33	3.08	3.33	-	-	-	-	-
2,4-Dinitrotoluene	mg/kg	0	3.66	3.33	3.36	3.33	-	-	-	-	-
2,6-Dinitrotoluene	mg/kg	0	2.61	3.33	2.37	3.33	-	-	-	-	-
2-Chloronaphthalene	mg/kg	0	2.54	3.33	2.34	3.33	-	-	-	-	-
2-Chlorophenol	mg/kg	0	3.23	3.33	3.09	3.33	-	-	-	-	-
2-Methyl-4,6-dinitrophenol	mg/kg	0	2.91	3.33	2.73	3.33	-	-	-	-	-
2-Methylnaphthalene	mg/kg	0	3.33	3.33	3.13	3.33	-	-	-	-	-
2-Methylphenol (o-Cresol)	mg/kg	0	3.37	3.33	3.16	3.33	-	-	-	-	-
2-Nitroaniline	mg/kg	0	3.62	3.33	3.41	3.33	-	-	-	-	-
2-Nitrophenol	mg/kg	0	3.41	3.33	3.19	3.33	-	-	-	-	-
3,3'-Dichlorobenzidine	mg/kg	0	8.59	6.67	8.19	6.67	-	-	-	-	-
3-Nitroaniline	mg/kg	0	3.57	3.33	3.33	3.33	-	-	-	-	-
4-Bromophenylphenylether	mg/kg	0	3.40	3.33	3.20	3.33	-	-	-	-	-
4-Chloro-3-methylphenol	mg/kg	0	3.53	3.33	3.28	3.33	-	-	-	-	-
4-Chloroaniline	mg/kg	0	3.28	3.33	3.03	3.33	-	-	-	-	-
4-Chlorophenylphenylether	mg/kg	0	3.40	3.33	3.13	3.33	-	-	-	-	-
4-Methylphenol (p-Cresol)	mg/kg	0	2.96	3.33	2.63	3.33	-	-	-	-	-
4-Nitroaniline	mg/kg	0	4.05	3.33	3.61	3.33	-	-	-	-	-
4-Nitrophenol	mg/kg	0	4.13	3.33	3.81	3.33	-	-	-	-	-
Acenaphthene	mg/kg	0	3.69	3.33	3.41	3.33	<0.2	-	1.72	1.54	1.67
Acenaphthylene	mg/kg	0	3.67	3.33	3.41	3.33	<0.2	-	-	-	-
Aniline	mg/kg	0	2.74	3.33	2.54	3.33	-	-	-	-	-
Anthracene	mg/kg	0	3.18	3.33	2.98	3.33	<0.2	-	-	-	-
Benzidine	mg/kg	0	2.30	6.67	2.52	6.67	-	-	-	-	-
Benzo(a)anthracene	mg/kg	0	3.91	3.33	3.66	3.33	<0.2	-	-	-	-

NON-AQUEOUS SAMPLES

Batch: 8270*95214 Method: 8270 - GC/MS for Semivolatile Organics, Capillary column, con't

		B5102152*1	C5103539*1		C5103540*1		9510554*1				
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Benzo(a)pyrene	mg/kg	0	2.65	3.33	2.46	3.33	<0.2	-	-	-	-
Benzo(b)fluoranthene	mg/kg	0	2.72	3.33	2.46	3.33	<0.2	-	-	-	-
Benzo(g,h,i)perylene	mg/kg	0	3.68	3.33	3.35	3.33	<0.2	-	-	-	-
Benzo(k)fluoranthene	mg/kg	0	1.98	3.33	1.93	3.33	<0.2	-	-	-	-
Benzyl Alcohol	mg/kg	0	3.35	3.33	3.09	3.33	-	-	-	-	-
Benzoic acid	mg/kg	0	1.76	3.33	2.07	3.33	-	-	-	-	-
Butylbenzylphthalate	mg/kg	0	3.64	3.33	3.35	3.33	-	-	-	-	-
Chrysene	mg/kg	0	3.52	3.33	3.03	3.33	<0.2	-	-	-	-
Di-n-octylphthalate	mg/kg	0	2.06	3.33	1.95	3.33	-	-	-	-	-
Dibenzo(a,h)anthracene	mg/kg	0	3.14	3.33	2.88	3.33	<0.2	-	-	-	-
Dibenzofuran	mg/kg	0	3.40	3.33	3.15	3.33	-	-	-	-	-
Dibutylphthalate	mg/kg	0.036	3.36	3.33	3.14	3.33	-	-	-	-	-
Diethylphthalate	mg/kg	0	3.57	3.33	3.23	3.33	-	-	-	-	-
Dimethylphthalate	mg/kg	0	3.48	3.33	3.20	3.33	-	-	-	-	-
Fluoranthene	mg/kg	0	3.46	3.33	3.22	3.33	<0.2	-	-	-	-
Fluorene	mg/kg	0	3.44	3.33	3.20	3.33	<0.2	-	-	-	-
Hexachlorobenzene	mg/kg	0	3.44	3.33	3.21	3.33	-	-	-	-	-
Hexachlorobutadiene	mg/kg	0	3.36	3.33	3.11	3.33	-	-	-	-	-
Hexachlorocyclopentadiene	mg/kg	0	5.98	3.33	5.67	3.33	-	-	-	-	-
Hexachloroethane	mg/kg	0	3.29	3.33	3.11	3.33	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg	0	3.34	3.33	3.04	3.33	<0.2	-	-	-	-
Isophorone	mg/kg	0	2.86	3.33	2.40	3.33	-	-	-	-	-
N-Nitrosodimethylamine	mg/kg	0	3.13	3.33	2.94	3.33	-	-	-	-	-
N-Nitrosodiphenylamine	mg/kg	0	2.50	3.33	2.33	3.33	-	-	-	-	-
N-Nitrosodi-n-propylamine	mg/kg	0	2.64	3.33	2.44	3.33	-	-	-	-	-
Nitrobenzene	mg/kg	0	3.35	3.33	3.11	3.33	-	-	-	-	-
Naphthalene	mg/kg	0	3.28	3.33	3.02	3.33	<0.2	-	-	-	-
Phenanthrene	mg/kg	0	3.44	3.33	3.18	3.33	<0.2	-	-	-	-
Phenol	mg/kg	0	3.14	3.33	2.96	3.33	-	-	-	-	-
Pentachlorophenol	mg/kg	0	3.40	3.33	3.24	3.33	-	-	-	-	-
Pyrene	mg/kg	0	3.46	3.33	3.23	3.33	<0.2	-	1.90	1.70	1.67
Pyridine	mg/kg	0	-	-	-	-	-	-	-	-	-
Bis(2-chloroethoxy)methane	mg/kg	0	3.59	3.33	3.30	3.33	-	-	-	-	-
Bis(2-chloroethyl)ether	mg/kg	0	3.35	3.33	3.12	3.33	-	-	-	-	-
Bis(2-chloroisopropyl)ether	mg/kg	0	4.31	3.33	3.99	3.33	-	-	-	-	-
Bis(2-ethylhexyl)phthalate	mg/kg	0	3.47	3.33	3.20	3.33	-	-	-	-	-
2-Fluorobiphenyl Reported	mg/kg	1.83	1.99	1.67	1.80	1.67	1.68	-	1.70	1.62	1.67

NON-AQUEOUS SAMPLES

Batch: 8270*95214 Method: 8270 - GC/MS for Semivolatile Organics, Capillary column, con't

		B5102152*1	C5103539*1		C5103540*1		9510554*1	....	....	....	
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
2-Fluorobiphenyl Theo.	mg/kg	1.67	1.67	1.67	1.67	1.67	1.67	-	1.67	1.67	1.67
2-Fluorophenol Reported	mg/kg	2.32	2.54	2.50	2.33	2.50	-	-	-	-	-
2-Fluorophenol Theoretical	mg/kg	2.50	2.50	2.50	2.50	2.50	-	-	-	-	-
2,4,6-Tribromophenol Rep.	mg/kg	2.30	2.79	2.50	2.54	2.50	-	-	-	-	-
2,4,6-Tribromophenol Theo.	mg/kg	2.50	2.50	2.50	2.50	2.50	-	-	-	-	-
Nitrobenzene-d5 Reported	mg/kg	1.69	1.90	1.67	1.72	1.67	1.73	-	1.83	1.64	1.67
Nitrobenzene-d5 Theoretical	mg/kg	1.67	1.67	1.67	1.67	1.67	1.67	-	1.67	1.67	1.67
Phenol-d5 Reported	mg/kg	2.17	2.48	2.50	2.25	2.50	-	-	-	-	-
Phenol-d5 Theoretical	mg/kg	2.50	2.50	2.50	2.50	2.50	-	-	-	-	-
Terphenyl-d14 Reported	mg/kg	1.64	1.77	1.67	1.61	1.67	1.32	-	1.20	1.15	1.67
Terphenyl-d14 Theoretical	mg/kg	1.67	1.67	1.67	1.67	1.67	1.67	-	1.67	1.67	1.67

Batch: DIESEL*95183 Method: 8015M - Modified 8015

		B5102148*1	C5103533*1		C5103534*1		9510553*1	....	....	....	
	UNITS	MB	LC	LT	LC	LT	R1	R2	S1	S2	T
Date Extracted	Date	10/30/95	10/30/95	10/30/95	10/30/95	10/30/95	10/30/95	-	10/30/95	10/30/95	10/30/95
Date Analyzed	Date	10/30/95	10/30/95	10/30/95	10/30/95	10/30/95	10/30/95	-	10/30/95	10/30/95	10/30/95
Dilution Factor	Times	1	1	1	1	1	1	-	1	1	1
TPH (Diesel Range)	mg/kg	0	29.8	40.0	28.2	40.0	<10	-	26.3	21.4	40.0
Carbon Range	.	C10-C25	-	-	-	-	C10-C25	-	-	-	-
Naphthalene Reported	mg/kg	2.06	2.75	2.00	2.42	2.00	2.16	-	2.12	1.95	2.00
Naphthalene Theoretical	mg/kg	2.00	2.00	2.00	2.00	2.00	2.00	-	2.00	2.00	2.00

: SURROGATE RECOVERIES :
: BC ANALYTICAL : GLEN LAB : 08:59:48 13 NOV 1995 - P. 1 :

METHOD	ANALYTE	BATCH	ANALYZED	REPORTED	TRUE	%REC	FLAG
9510553*1							
8015M	Naphthalene	95183	10/30/95	2.16	2.00	108	
8020	a,a,a-Trifluorotoluene Re	9529189	10/30/95	0.0409	0.0500	82	
9510553*31							
8270	2-Fluorophenol	95214	10/30/95	62.6	75.0	83	
	Phenol-d5	95214	10/30/95	57.6	75.0	77	
	Nitrobenzene-d5	95214	10/30/95	44.5	50.0	89	
	2-Fluorobiphenyl	95214	10/30/95	48.0	50.0	96	
	2,4,6-Tribromophenol Rep.	95214	10/30/95	61.7	75.0	82	
	Terphenyl-d14	95214	10/30/95	44.4	50.0	89	
8240	1,2-Dichloroethane-d4 Rep	9529190	10/31/95	0.0371	0.0500	74	
	Toluene-d8	9529190	10/31/95	0.0493	0.0500	99	
	4-Bromofluorobenzene Rep.	9529190	10/31/95	0.0477	0.0500	95	
9510553*32							
8240	1,2-Dichloroethane-d4 Rep	9529190	10/31/95	0.0375	0.0500	75	
	Toluene-d8	9529190	10/31/95	0.0518	0.0500	104	
	4-Bromofluorobenzene Rep.	9529190	10/31/95	0.0482	0.0500	96	
9510553*33							
8[illegible]	1,2-Dichloroethane-d4 Rep	9529190	10/31/95	0.0382	0.0500	76	
	Toluene-d8	9529190	10/31/95	0.0496	0.0500	99	
	4-Bromofluorobenzene Rep.	9529190	10/31/95	0.0463	0.0500	93	
9510553*40							
8080	Tetrachloro-meta-xylene R	95167	11/03/95	0.0074	0.0083	89	
	Decachlorobiphenyl	95167	11/03/95	0.0035	0.0083	42	
9510553*41							
8080	Tetrachloro-meta-xylene R	95167	11/03/95	0.0095	0.0083	114	
	Decachlorobiphenyl	95167	11/03/95	0.0043	0.0083	52	

METHOD	ANALYTE	BATCH	ANALYZED	REPORTED	TRUE	%REC	FLAG
9510553*1*R1							
8015M	Naphthalene	95183	10/30/95	2.16	2.00	108	
9510553*1*S1							
8015M	Naphthalene	95183	10/30/95	2.12	2.00	106	
9510553*1*S2							
8015M	Naphthalene	95183	10/30/95	1.95	2.00	98	
9510553*1*T							
8015M	Naphthalene	95183	10/30/95	2.00	2.00	100	
B5102148*1*MB							
8015M	Naphthalene	95183	10/30/95	2.06	2.00	103	
B5102152*1*MB							
8270	2-Fluorophenol	95214	10/30/95	2.32	2.50	93	
	Phenol-d5	95214	10/30/95	2.17	2.50	87	
	Nitrobenzene-d5	95214	10/30/95	1.69	1.67	101	
	2-Fluorobiphenyl	95214	10/30/95	1.83	1.67	110	
	2,4,6-Tribromophenol Rep.	95214	10/30/95	2.30	2.50	92	
	Terphenyl-d14	95214	10/30/95	1.64	1.67	98	
B5102239*1*MB							
8020	a,a,a-Trifluorotoluene Re	9529189	10/30/95	0.0477	0.0500	95	
B511099*1*MB							
8240	1,2-Dichloroethane-d4 Rep	9529190	10/31/95	0.0387	0.0500	77	
	Toluene-d8	9529190	10/31/95	0.0491	0.0500	98	
	4-Bromofluorobenzene Rep.	9529190	10/31/95	0.0487	0.0500	97	
B511321*1*MB							
8080	Tetrachloro-meta-xylene R	95167	11/03/95	0.0087	0.0083	105	
	Decachlorobiphenyl	95167	11/03/95	0.0073	0.0083	88	
C5103533*1*LC							
8015M	Naphthalene	95183	10/30/95	2.75	2.00	138	
C5103533*1*LT							
8[illegible]	Naphthalene	95183	10/30/95	2.00	2.00	100	
C5103534*1*LC							
8015M	Naphthalene	95183	10/30/95	2.42	2.00	121	

METHOD	ANALYTE	BATCH	ANALYZED	REPORTED	TRUE	%REC	FLAG
C5103534*1*LT							
8015M	Naphthalene	95183	10/30/95	2.00	2.00	100	
C5103539*1*LC							
8270	2-Fluorophenol	95214	10/30/95	2.54	2.50	102	
	Phenol-d5	95214	10/30/95	2.48	2.50	99	
	Nitrobenzene-d5	95214	10/30/95	1.90	1.67	114	
	2-Fluorobiphenyl	95214	10/30/95	1.99	1.67	119	
	2,4,6-Tribromophenol Rep.	95214	10/30/95	2.79	2.50	112	
	Terphenyl-d14	95214	10/30/95	1.77	1.67	106	
C5103539*1*LT							
8270	2-Fluorophenol	95214	10/30/95	2.50	2.50	100	
	Phenol-d5	95214	10/30/95	2.50	2.50	100	
	Nitrobenzene-d5	95214	10/30/95	1.67	1.67	100	
	2-Fluorobiphenyl	95214	10/30/95	1.67	1.67	100	
	2,4,6-Tribromophenol Rep.	95214	10/30/95	2.50	2.50	100	
	Terphenyl-d14	95214	10/30/95	1.67	1.67	100	
C5103540*1*LC							
8270	2-Fluorophenol	95214	10/30/95	2.33	2.50	93	
	Phenol-d5	95214	10/30/95	2.25	2.50	90	
	Nitrobenzene-d5	95214	10/30/95	1.72	1.67	103	
	2-Fluorobiphenyl	95214	10/30/95	1.80	1.67	108	
	2,4,6-Tribromophenol Rep.	95214	10/30/95	2.54	2.50	102	
	Terphenyl-d14	95214	10/30/95	1.61	1.67	96	
C5103540*1*LT							
8270	2-Fluorophenol	95214	10/30/95	2.50	2.50	100	
	Phenol-d5	95214	10/30/95	2.50	2.50	100	
	Nitrobenzene-d5	95214	10/30/95	1.67	1.67	100	
	2-Fluorobiphenyl	95214	10/30/95	1.67	1.67	100	
	2,4,6-Tribromophenol Rep.	95214	10/30/95	2.50	2.50	100	
	Terphenyl-d14	95214	10/30/95	1.67	1.67	100	
C5103970*1*LC							
8020	a,a,a-Trifluorotoluene Re	9529189	10/30/95	0.0509	0.0500	102	
C5103970*1*LT							
8020	a,a,a-Trifluorotoluene Re	9529189	10/30/95	0.0500	0.0500	100	
C511200*1*LC							
8240	1,2-Dichloroethane-d4 Rep	9529190	10/31/95	0.0540	0.0500	108	
	Toluene-d8	9529190	10/31/95	0.0481	0.0500	96	
	4-Bromofluorobenzene Rep.	9529190	10/31/95	0.0510	0.0500	102	
C511200*1*LT							

METHOD	ANALYTE	BATCH	ANALYZED	REPORTED	TRUE	%REC	FLAG
8240	1,2-Dichloroethane-d4 Rep	9529190	10/31/95	0.0500	0.0500	100	
	Toluene-d8	9529190	10/31/95	0.0500	0.0500	100	
	4-Bromofluorobenzene Rep.	9529190	10/31/95	0.0500	0.0500	100	
C511201*1*LC							
8240	1,2-Dichloroethane-d4 Rep	9529190	10/31/95	0.0430	0.0500	86	
	Toluene-d8	9529190	10/31/95	0.0481	0.0500	96	
	4-Bromofluorobenzene Rep.	9529190	10/31/95	0.0530	0.0500	106	
C511201*1*LT							
8240	1,2-Dichloroethane-d4 Rep	9529190	10/31/95	0.0500	0.0500	100	
	Toluene-d8	9529190	10/31/95	0.0500	0.0500	100	
	4-Bromofluorobenzene Rep.	9529190	10/31/95	0.0500	0.0500	100	
C511619*1*LC							
8080	Tetrachloro-meta-xylene R	95167	11/03/95	0.0084	0.0083	101	
	Decachlorobiphenyl	95167	11/03/95	0.0086	0.0083	104	
C511619*1*LT							
8080	Tetrachloro-meta-xylene R	95167	11/03/95	0.0083	0.0083	100	
	Decachlorobiphenyl	95167	11/03/95	0.0083	0.0083	100	
C511620*1*LC							
8080	Tetrachloro-meta-xylene R	95167	11/03/95	0.0084	0.0083	101	
	Decachlorobiphenyl	95167	11/03/95	0.0074	0.0083	89	
C511620*1*LT							
8080	Tetrachloro-meta-xylene R	95167	11/03/95	0.0083	0.0083	100	
	Decachlorobiphenyl	95167	11/03/95	0.0083	0.0083	100	

CHAIN OF CUSTODY RECORD

BCA Log Number G95-10-553

lient name: Magma Copper Co.
Project or PO#: Florence
ddress: 14605 E Hunt Highway
Phone #: (602) 722-4456
ity, State, Zip: Florence, Az 85232
Report attention: Eric Mears
Sampled by: Michael L. Daniel

Analyses required: EPA 8015 Mod. for diesel; EPA 8020; RCRA 8 Metals 6010-7000; EPA 9090 pH; EPA 418.1 TRPH

Lab ample umber	Date sampled	Time sampled	Type* See key below	Sample description	Number of containers	EPA 8015 Mod. for diesel	EPA 8020	RCRA 8 Metals 6010-7000	EPA 9090 pH	EPA 418.1 TRPH			Hazardous sample	Special handling required	Remarks
	10-26-95	0952	SO	MCF-MWS-1	1	X	X								
	10-26-95	0956	SO	MCF-MWS-2.5	1	X	X	[illegible]							
	10-26-95	0959	SO	MCF-MWS-5	1	X	X	[illegible]							
	10-26-95	1017	SO	MCF-CSA-1	1			X							
	10-26-95	1021	SO	MCF-CSA-2.5	1			X							
	10-26-95	1028	SO	MCF-CSA-5	1			X							
	10-26-95	1043	SO	MCF-LCP-1	1			X	X						
	10-26-95	1046	SO	MCF-LCP-2.5	1			X	X						
	10-26-95	1051	SO	MCF-LCP-5	1			X	X						
	10-26-95	1142	SO	MCF-ALS-1	1				X	X					
	10-26-95	1149	SO	MCF-ALS-2.5	1				X	X					
	10-26-95	1154	SO	MCF-ALS-5	1				X	X					

	Signature	Print Name	Company	Date	Time
Relinquished by	Michael L. Daniel	Michael L. Daniel	Brown + Caldwell	10-26-95	1600
Received by	M. Tolliver	M. Tolliver	Top Speed	10-26-95	16:00
Relinquished by					
Received by	Sharon Malone	Sharon Malone	BCA	10/27/95	0930
Relinquished by					
Received by Laboratory					

C ANALYTICAL
- 1085 Shary Circle, Concord, CA 94518 (510) 825-3894
- 801 Western Avenue, Glendale, CA 91201 (818) 247-5737
- 1200 Gene Autry Way, Anaheim, CA 92805 (714) 978-0113

Note: Samples are discarded 30 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client's expense.

Disposal arrangements: ______

*KEY: AQ—Aqueous NA—Nonaqueous SL—Sludge GW—Groundwater SO—Soil PE—Petroleum WW—Wastewater

CHAIN OF CUSTODY RECORD

BCA Log Number G95-10-553

Client name: Magma Copper Co.
Address: 14605 E. Hunt Highway
City, State, Zip: Florence, AZ 85232
Project or PO#: Florence
Phone #: (602)222-4456
Report attention: Eric Mears
Sampled by: Michael L. Daniel

Analyses required: EPA 9040 pH; RCRA 8 Metals 6010-7000; EPA 418.1 TRPH

Lab Sample number	Date sampled	Time sampled	Type* See key below	Sample description	Number of containers	EPA 9040 pH	RCRA 8 Metals 6010-7000	EPA 418.1 TRPH					Hazardous sample Special handling required	Remarks
	10-26-95	1108	SO	MCF-SUP-1	1	X	X							
	10-26-95	1111	SO	MCF-SUP-2.5	1	X	X							
	10-26-95	1114	SO	MCF-SUP-5	1	X	X							
	10-26-95	1125	SO	MCF-SLO-1	1		X	X						
	10-26-95	1128	SO	MCF-SLO-2.5	1		X	X						
	10-26-95	1132	SO	MCF-SLO-5	1		X	X						
	10-26-95	1255	SO	MCF-SRS-1	1	X	X							
	10-26-95	1258	SO	MCF-SRS-2.5	1	X	X							
	10-26-95	1302	SO	MCF-SRS-5	1	X	X							
	10-26-95	1312	SO	MCF-LLO-1	1		X	X						
	10-26-95	1315	SO	MCF-LLO-2.5	1		X	X						
	10-26-95	1319	SO	MCF-LLO-5	1		X	X						

	Signature	Print Name	Company	Date	Time
Relinquished by	Michael L. Daniel	Michael L. Daniel	Brown & Caldwell	10-26-95	1600
Received by	M. Tulliver	M. Tulliver	Top Speed	10-26-95	16:00
Relinquished by					
Received by	Sharon Malone	Sharon Malone	BCA	10/27/95	0930
Relinquished by					
Received by Laboratory					

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- [ ] 1085 Shary Circle, Concord, CA 94518 (510) 825-3894
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BCA Log Number G95-10-553

Client name: Magma Copper Co.

Project or PO#:

Address: 14605 E. Hunt Highway

Phone #: (602) 222-4454

City, State, Zip: Florence AZ 85232

Report attention: Eric Mears

Sampled by: Michael L. Daniel

Analyses required

Lab Sample number	Date sampled	Time sampled	Type* See key below	Sample description	Number of containers	EPA 9040 pH	EPA 418.1 TRPH	EPA 8270 S.VOCs	EPA 8240 VOC	RCRA 8 Metals 6010-7000		Hazardous sample	Special handling required	Remarks
	10-26-95	1530	SO	MCF-CSP-2.5	2	X	X	X	X	X				

	Signature	Print Name	Company	Date	Time
Relinquished by	Michael L. Daniel	Michael L. Daniel	Brown & Caldwell	10-26-95	1600
Received by	M. Tolliver	M. Tolliver	Top Speed	10-26-95	16:00
Relinquished by					
Received by	Sharon Malone	Sharon Malone	BCA	10/27/95	0930
Relinquished by					
Received by Laboratory					

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1200 Gene Autry Way, Anaheim, CA 92805 (714) 978-0113

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CHAIN OF CUSTODY RECORD

BCA Log Number ______

Client name: Magma Copper Co.

Address: 14605 E. Hunt Highway

City, State, Zip: Florence, AZ 85232

Project or PO#: Florence

Phone #: (602)222-4456

Report attention: Eric Mears

Sampled by: Michael L. Daniel

Lab Sample number	Date sampled	Time sampled	Type* See key below	Sample description	Number of containers	418.1 TRPH	RCRA 8 Metals	pH EPA 9040					Hazardous sample Special handling required	Remarks
	10-26-95	1632	SO	MCF-MSA-1	1	X								RUSH
	10-26-95	1634	SO	MCF-MSA-2.5	1	X								HOLD
	10-26-95	1636	SO	MCF-MSA-5	1	X								HOLD
	10-26-95	1641	SO	MCF-MSB-1	1	X								RUSH
	10-26-95	1644	SO	MCF-MSB-2.5	1	X								HOLD
	10-26-95	1646	SO	MCF-MSB-5	1	X								HOLD
	10-26-95	1652	SO	MCF-BAK-2	1		X	X						NORMAL

ADD TO ALL RCRA-8 METALS Zn, Cu, & FE

	Signature	Print Name	Company	Date	Time
Relinquished by	Michael L. Daniel	Michael L. Daniel	Brown & Caldwell	10-26-95	1700
Received by	[signature]	Gene Smith	BCA	10/28/95	9:45
Relinquished by					
Received by					
Relinquished by					
Received by Laboratory					

B C ANALYTICAL

- ☐ 1085 Shary Circle, Concord, CA 94518 (510) 825-3894
- ☐ 801 Western Avenue, Glendale, CA 91201 (818) 247-5737
- ☐ 1200 Gene Autry Way, Anaheim, CA 92805 (714) 978-0113

Note: Samples are discarded 30 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client's expense.

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CHAIN OF COUSTODY RECORD

BCA Log Number G95-10-553

Client name: Magma Copper Co.
Address: 14605 E. Hunt Highway
City, State, Zip: Florence, AZ 85232
Project or PO#: Florence
Phone #: (602) 222-4456
Report attention: Eric Meors
Sampled by: Michael L. Daniel

Lab Sample number	Date sampled	Time sampled.	Type* See key below	Sample description	Number of containers	EPA 9040	RCRA 8 Metals	EPA 418.1 TRPH	EPA 8240 SVOC				Hazardous sample Special handling required	Remarks
	10-26-95	1332	SO	MCF-SUL-3	1	X								MCF-OTPB-2
	10-26-95	1336	SO	MCF-SUL-6	1	X								recieved broken. (SM)
	10-26-95	1343	SO	MCF-SUL-10	1	X								
	10-26-95	1401	SO	MCF-LUP-1	1	X	X							
	10-26-95	1404	SO	MCF-LUP-2.5	1	X	X							
	10-26-95	1408	SO	MCF-LUP-5	1	X	X							
	10-26-95	1423	SO	MCF-STPA-2	2	X	X	X	X					Composite STPA, STPB,
	10-26-95	1428	SO	MCF-STPB-2	2	X	X	X	X					STPC + STPD, for one
	10-26-95	1436	SO	MCF-STPC-2	2	X	X	X	X					analysis.
	10-26-95	1431	SO	MCF-STPD-2	2	X	X	X	X					
	10-26-95	1503	SO	MCF-OTPA-2	2	X	X	X	X					Composite OTPA + OTPB
	10-26-95	1506	SO	MCF-OTPB-2	2	X	X	X	X					for one analysis

	Signature	Print Name	Company	Date	Time
Relinquished by	Michael L. Daniel	Michael L. Daniel	Brown & Caldwell	10-26-95	1600
Received by	M. Tolliver	M. Tolliver	Top Speed	10-26-95	16:00
Relinquished by					
Received by	Sharon Malone	Sharon Malone	BCA	10/27/95	0930
Relinquished by					
Received by Laboratory					

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Disposal arrangements: ______

*KEY: AG—Aqueous NA—Nonaqueous SL—Sludge GW—Groundwater SO—Soil PE—Petroleum

EXHIBIT A-3

Hydrologic Study Part C, Supplemental Data
(Temporary APP Application Attachment 14C)

CURIS RESOURCES (ARIZONA) INC.

APPLICATION FOR TEMPORARY
INDIVIDUAL AQUIFER PROTECTION PERMIT

ATTACHMENT 14C – HYDROLOGIC STUDY PART C
SUPPLEMENTAL DATA (ITEM 25.H)

REGISTERED GEOLOGIST
CERTIFICATE NO.
MARK D. NICHOLLS
Date Signed 3/11/12
ARIZONA, U.S.A.
Exp. 9/30/2012

Table of Contents

List of Figures

List of Exhibits

14C.1 Introduction

This attachment has been prepared to provide supplemental data in support of requirements of Item 25.H of the Individual Aquifer Protection Permit (APP) Application Form (Form) and Arizona Administrative Code (A.A.C.) R18-9-A202.A.8 relating to the hydrologic study. This attachment specifically provides additional data in support of requirements enumerated in A.A.C. R18-9-A202.A.8

Hydrologic study requirements listed in A.A.C. R18-9-A202.A.8 are described in Attachments 14A and 14B, *Hydrologic Study Part A*, *Groundwater Flow Model, Hydrologic Study Part B,* and Attachment 12, *Compliance with Aquifer Water Quality Standards*. Table 14B-1 includes a directory of the requirements outlined in A.A.C. R18-9-A202A.8, and where each are addressed in this application.

14C.2 Site Groundwater Conditions

14C.2.1 Hydrographs

Figures 14C-1 through 14C-31 are groundwater elevation hydrographs depicting groundwater elevations in each of three water bearing units existing beneath the Production Test Facility (PTF) site (Upper Basin Fill Unit [UBFU], Lower Basin Fill Unit [LBFU], and Bedrock Oxide Unit) for each of the years during which active site monitoring was conducted. Active site monitoring was conducted from 1996 to 2011, excluding 2009 when a previous site owner allowed monitoring to lapse.

Groundwater elevation data were collected in conjunction with a quarterly groundwater quality monitoring program. Water level data were not specifically collected for the purpose of generating groundwater hydrographs or analyzing groundwater elevation conditions. These data were collected prior to purging each point of compliance (POC) well under APP No. 101704, and prior to the collection of each sample, to determine the degree of water level recovery prior to sampling. Although APP No. 101704 has not required water level data to be reported to the Arizona Department of Environmental Quality (ADEQ), these data have historically been provided to the Department with the quarterly Self-Monitoring Report Forms (SMRFs) as a courtesy.

Given that the available water level data were not collected with the intent of analyzing groundwater elevation data at the site, certain irregularities may become evident as these data are used for this purpose. Irregularities in the groundwater elevation data set may arise from the fact that:

1. Each sampling event required a minimum of eight days to complete; consequently water levels at each POC were not measured on the same day.
2. Sampling events are required to be completed each quarter, and due to logistical circumstances, occasionally extended over a period of weeks for a single sampling event.
3. Scheduling considerations required that water levels be measured while purging of other POC wells was ongoing.
4. No control of off-site pumping could be exercised when water level measurements were made.
5. No observations of off-site pumping were made in conjunction with the water level measurements.
6. Because these data were collected incidental to a groundwater quality sampling program rather than a water level monitoring program, there are no objective means to validate water level measurements that appear to be in error.

The groundwater elevation data plotted on the hydrographs in Figures 14C-1 through 14C-31 reflect quarterly groundwater elevation measurements at each of the POC wells included in the groundwater quality monitoring program required under APP No. 101704.

14C.2.2 Vertical Groundwater Gradients

Comparison of groundwater elevations measured at wells located at the PTF site and surrounding vicinity has demonstrated that a weak but consistent downward vertical gradient exists between the water bearing units across the PTF site. Water levels measured in each of the water bearing units consistently show higher water level elevations in the upper units than are measured in the lower units. Differences between water level elevations in each unit show that this relationship persists with consistently higher groundwater elevations measured in the UBFU than in the LBFU, and higher elevations measured in the LBFU than the Bedrock Oxide Unit. These relationships demonstrate that where these units are in hydraulic communication, groundwater will flow downward from the upper units into the lower units. However, the rate of vertical groundwater movement is much less that the rate of horizontal groundwater flow.

The differences in water level elevation observed in the UBFU and LBFU are greater than differences observed between the LBFU and the Bedrock Oxide Unit. This relationship demonstrates that the Middle Fine Grained Unit (MFGU) acts as an aquitard between the UBFU and the LBFU, while the LBFU and the Bedrock Oxide Unit are in closer hydraulic communication.

During seasons when agricultural pumping is reduced and recharge from the Gila River is increased, the downward gradients are reduced in magnitude and approach an equilibrium condition across most of the PTF site and surrounding vicinity. At POC wells located southeast of the proposed PTF well field, a downward gradient exists for the majority of each year of record; however, a weak upward vertical groundwater gradient develops during the high recharge, low pumping season. Groundwater flow direction within the LBFU will not affect PTF in-situ copper recovery (ISCR) operations, which occur within the deeper Bedrock Oxide Unit.

Apparent downward groundwater gradients observed at well clusters located on Curis Arizona property have ranged from a few inches to as much as 20 feet in magnitude since 1996. The variation in vertical gradient direction and magnitude at the proposed PTF well field is likely the result of fluctuation in recharge pulses from the Gila River, and variation in off-site groundwater pumping. A summary of effects of off-site pumping on the proposed ISCR operations is included later in this Attachment.

Site-specific testing conducted by BHP Copper in 1997 and 1998 demonstrated that the proposed method of hydraulic control will be sufficient to overcome the observed vertical gradients to prevent solution migration during PTF operations.

14C.2.3 Potentiometric Surface Maps

Figures 14C-32 through 14C-46 are groundwater elevation contour maps depicting groundwater elevation conditions at POC wells associated with APP No. 101704 in each of three water bearing units beneath the PTF site and surrounding vicinity (UBFU, LBFU, and Bedrock Oxide Unit) for each of the years during which active site monitoring was conducted. Active site monitoring was conducted from 1996 to 2011, excluding 2009 when a previous site owner allowed monitoring to lapse.

Groundwater elevation data were collected in conjunction with a quarterly groundwater quality monitoring program. Water level data were not specifically collected for the purpose of generating groundwater contour maps, or calculating groundwater flow direction. These data were collected prior to purging each existing POC well and prior to the collection of each sample to determine the degree of water level recovery prior to sampling. Although APP No. 101704 has not required water level data to be reported to ADEQ, these data have historically been provided to the Department with the quarterly SMRF reports as courtesy.

Given that the available water level data were not collected with the intent of mapping groundwater conditions at the PTF site, certain irregularities may become evident as these data are used for this purpose. Irregularities in the groundwater elevation data set may arise from the same six limiting factors identified in the hydrograph discussion included above.

The criteria used to plot groundwater elevation contours shown on Figures 14C-32 through 14C-46 included:

1. Groundwater elevations were only plotted at selected POC wells constructed within the same water bearing unit and screened at, or near, the same elevation.

   Beneath the PTF site and surrounding vicinity, the LBFU and Bedrock Oxide Unit exhibit significant variation in depth and thickness. As a result, POC wells (APP No. 101704) constructed in the LBFU range in depth from 240 to 1,009 feet below ground surface (bgs), and POC wells (APP No. 101704) constructed in the Bedrock Oxide Unit range in depth from 510 to 1,269 feet bgs.

   Basic hydrologic principles dictate that wells completed at depths that differ significantly within the same water bearing unit should not be contoured together because doing so will introduce any existing vertical groundwater gradients into the analysis as apparent horizontal flow components.

2. Groundwater elevations were only plotted for sampling events that had three or more groundwater level observations for each water bearing unit at wells complying with criterion No. 1 above. When sampling events resulted in two or less groundwater elevation measurements, groundwater elevations at the subject wells are shown but no groundwater contours are plotted.

The groundwater elevation data plotted on Figures 14C-32 through 14C-46 reflect groundwater elevation measurements made during the first quarter of each year that active monitoring was conducted, and encompass the historical POC wells selected based on Criterion No. 1 described above. Groundwater flow directions depicted on Figures 14C-32 through 14C-46 are predominantly toward the north-northwest, with apparent seasonal shifts toward the west during some years, likely resulting from off-site agricultural or industrial groundwater pumping. Groundwater flow directions revert toward the predominant north-northwest direction following the end of apparent seasonal pumping influences.

14C.2.4 Transient Groundwater Flow Direction Variation from Off-site Pumping

Although the primary groundwater flow direction remains toward the north-northwest during the entire period of record, certain of the contour maps included in Figures 14C-32 through 14C-46 show transient shifts in groundwater flow directions in the UBFU and LBFU during several monitoring periods that may be related to off-site pumping.

Groundwater contours plotted on Figures 14C-38, 14C-39, 14C-40, 14C-41, and 14C-42 potentially show the effects of off-site pumping in the LBFU to the west of the PTF site. These figures show groundwater elevation conditions in the first quarter of 2002, 2003, 2004, 2005, and 2006. Each of these figures shows a primarily northwest groundwater flow direction in the LBFU at the southeast corner of the Curis Arizona property site, which turns towards the west as groundwater flow progresses across the site. The turn in groundwater flow direction toward the west within the LBFU may be a result of pumping at irrigation wells or industrial wells west of the PTF site. Groundwater flow direction within the LBFU will not affect PTF ISCR operations, which occur within the deeper Bedrock Oxide Unit.

Groundwater contours plotted on Figures 14C-37 and 14C-38 potentially show the effects of off-site pumping in the UBFU, to the west of the PTF site. These figures show a groundwater flow direction toward the west and southwest within the UBFU during the first quarter of 2001 and 2002. The western and southwestern groundwater flow direction observed in the UBFU in Figures 14C-37 and 14C-38 may be the result of groundwater pumping from irrigation wells or industrial wells constructed in the UBFU to the west and southwest of the PTF site.

No significant and enduring groundwater flow direction shift within the Bedrock Oxide Unit is evident in Figures 14C-32 through 14C-46. Groundwater flow direction within the Bedrock Oxide Unit is less susceptible to off-site pumping and recharge pulse influences from the Gila River due to its greater depth and reduced hydraulic conductivity relative to the UBFU and LBFU. The groundwater flow direction within the Bedrock Oxide Unit has remained consistently toward the north-northwest throughout the period of record with little variation. The northward turn observed in groundwater flow direction within the Bedrock Oxide Unit is the result of groundwater flow toward the Sidewinder fault zone.

The primary groundwater flow direction in each of the three water bearing units beneath the PTF site is toward the north-northwest. This groundwater flow trend has continued from 1995 to the present, with some transient apparent variations in the uppermost water bearing units evident at certain periods. The source of these transient variations in groundwater flow direction in the UBFU and the LBFU may be from off-site pumping in those units, but may also be influenced by the waning of recharge pulses from the Gila River. No pumping schedule data are available for off-site wells to validate that pumping has a causal influence of the transient shifts in groundwater flow direction for the years listed above.

14C.2.5 Declining Groundwater Elevations

Groundwater elevations in the vicinity of the PTF site were observed to fall between 1995, the inception of monitoring, and 2004. Analysis of available data has demonstrated that the falling groundwater elevations were the result of dissipation of a recharge impulse originating from higher than normal flows in the Gila River during the early 1990s.

Groundwater elevation data obtained from the Groundwater Site Inventory (GWSI) database maintained by the Arizona Department of Water Resources (ADWR) does not typically include monthly or quarterly data, and so does not have sufficient resolution to determine the month during which groundwater elevations began to rise; however, available data are sufficient to illustrate that groundwater elevations rose significantly between 1991 and 1994.

Comparison of hydrographs from on-site wells, and local GWSI wells, with stage data for the Gila River indicates that groundwater elevations in the vicinity of the PTF site began to rise during the winter of 1991 following a dry period on the Gila River that lasted through 1989 and 1990. The winters of 1992 and 1993 produced Gila River flows that were significantly greater than those observed in 1991. In particular, the Gila River flows observed in the winter of 1993 were greater than any observed during the entire period of record, which began at Kelvin, Arizona in 1911. Hydrographs showing groundwater elevations at selected GWSI wells, mean monthly discharge of the Gila River at Kelvin, Arizona, and hydrographs for the POC wells located in proximity to the Gila River are shown on Figure 14A-12 of Attachment 14A of this application.

Groundwater elevation data obtained from the GWSI shows that groundwater elevations rose each year from 1991 to 1994, and began falling from the highest observed elevations in 1996. Starting in 1996, groundwater elevations declined each year until 2003 (well D-05-09 18BDD2) and 2006 (wells D-05-09 14CBB, D-05-09 22CBA, and D-05-09 18BDD2). Flows in the Gila River also declined significantly during increasingly dry conditions that progressed from 1996 to 2003.

As shown on Figure 14A-12, the recovery of groundwater elevations and flows in the Gila River following 2003 closely mirror one another. The relationship between flows in the Gila River and local groundwater elevations demonstrates that the Gila River is the primary source of recharge to aquifers in the vicinity of the PTF site.

Groundwater monitoring began at the PTF site and surrounding vicinity in 1995, after the significant rise in groundwater elevations observed in GWSI wells between 1991 and 1994. The on-site water level record began shortly after the peak in groundwater elevations observed in GWSI wells. Consequently, groundwater elevations observed in the vicinity of the PTF were noted to decline by an average of 69 feet from the inception of monitoring until 2004, when they briefly stabilized before rising again. Groundwater elevations were observed to begin to rise in the vicinity of the PTF site between 2004 and 2007 and have risen an average of approximately 13 feet since that time.

During the period from 1995 to 2004, declining groundwater elevations were observed at all wells completed in the UBFU, LBFU, and Bedrock Oxide Unit. Similarly, the stabilization of groundwater elevations observed in 2004, and subsequent increases in groundwater elevations, were observed in each of the wells completed in the UBFU, LBFU, and Bedrock Oxide Unit. Hydrographs for each POC well under APP No. 101704 are provided in Figures 14C-1 through 14C-31 of this attachment.

14C.2.6 Groundwater Mounding

Curis Arizona submitted an application for Other Amendment to transfer APP No. 101704 on May 19, 2010, which included a Technical Memorandum (as Attachment 5) that described groundwater elevation observations made in the vicinity of the PTF site during the period of 1995 to 2010. The Technical Memorandum included a discussion of apparent groundwater mounding that had been observed at the PTF site in October of 1995, and presented groundwater contour maps showing those conditions. A copy of the October 1995 water level elevation map that accompanied the Technical Memorandum is included as Figure 14C-47.

Water level data used to generate the contours shown in Figure 14C-47 were not specifically collected for the purpose of generating groundwater contour maps, or calculating groundwater flow direction. These data were collected over a period of approximately two weeks during October 1995 for a variety of purposes that included recording groundwater elevation conditions at each well prior to purging in preparation for sampling, and water level monitoring to establish a groundwater elevation baseline at individual wells.

Given that the water level data were not collected specifically for the purpose of plotting groundwater elevation contours or determination of groundwater flow direction, the data used to plot the water level contours shown in Figure 14C-47 may be affected by the following conditions:

1. In generating the contours, no effort was made to segregate wells by depth of screened interval within the respective water bearing units.
2. Water levels may have been measured while purging of other wells was ongoing.
3. No control of off-site pumping could be exercised during the period when water level measurements were made.
4. No observations of off-site pumping were made in conjunction with the water level measurements.
5. Given the amount of time that has passed, and the fact these data were collected under at least two studies ongoing at the time, there are no objective means to validate water level measurements that may appear to be in error.

The current groundwater monitoring well network in the vicinity of the PTF site consists of 29 POC wells that are sampled on a quarterly basis under APP No. 101704. The first groundwater elevation observations available from this network of monitoring wells were made in 1995, when the first 12 of the POC wells were drilled. During 1996, the remainder of the POC well network was constructed.

During 1995, several groundwater level measurements were made at on-site wells that are not included in the monitoring well network and that have no subsequent groundwater level observations. When combined, groundwater elevation data collected from the existing POC wells and other on-site wells in the vicinity of the PTF site during October 1995 show apparent groundwater mounding within the LBFU and Bedrock Oxide Unit in the interior of the site. No mounding is apparent in the UBFU.

The cause of the apparent groundwater mounding observed in October 1995 may be downward groundwater flow at wells completed across multiple water bearing units. The downward groundwater flow may occur within the screened interval of the wells or within the annulus of older wells constructed without the benefit of annular seals. A downward groundwater gradient has been consistently noted to exist at the existing POC wells in the vicinity of the PTF site. The downward gradient in wells that are screened across multiple water bearing units will cause those wells to reflect the water level of the higher units, resulting in an apparent groundwater mound that may not exist at any distance from the subject well.

Groundwater elevations have not been collected at any wells other than the existing POC wells on a consistent basis. Consequently, insufficient data exist to validate or confirm observations of apparent groundwater mounding since 1995.

14C.2.6.1 Magnitude of Apparent Groundwater Mounding

The apparent groundwater mounding observed in the LBFU, consists of groundwater elevations that are 1 to 2 feet higher than they might otherwise be near the center of the proposed PTF well field. This apparent groundwater mounding appears to be related to the downward groundwater flow in well BIA-10B, as observed at well O3-GL.

The apparent groundwater mounding observed in the Bedrock Oxide Unit consists of groundwater elevations that are 2 to 3 feet higher than they might otherwise be near the center of the western edge of the proposed PTF well field. This apparent groundwater mounding may be related to downward flow in well WW-3 as observed at wells PW3-1 and O15-O.

No groundwater mounding was observed in the UBFU during October 1995.

Insufficient groundwater quality data exist to characterize the effect of downward flow of groundwater through wells BIA-10B and WW-3, or the resultant effect of groundwater mounding on water quality of the deeper water bearing units.

14C.2.6.2 Effects of Apparent Mounding on Groundwater Flow Direction

As noted above, the effects of the apparent groundwater mounding observed in the vicinity of the PTF site in October of 1995 amounted to a groundwater increase of approximately 1 to 2 feet in the LBFU, and 2 to 3 feet in the Bedrock Oxide Unit. The principal groundwater flow direction in both the LBFU and Bedrock Oxide Unit remained toward the north-northwest, with a minor western flow component introduced by the apparent mounding.

The principal effect on PTF site groundwater gradients resulting from the apparent mounding observed in October of 1995 was the creation of a relatively low gradient area near the center of the proposed PTF well field in both the LBFU and the Bedrock Oxide Unit. Groundwater gradients in the LBFU, down-gradient of the low gradient area, do not appear to be any steeper than those observed up gradient of the apparent mounding. In the Bedrock Oxide Unit, the groundwater gradient west of the apparent mounding are relatively steeper than other gradients observed in the Bedrock Oxide Unit during October 1995. However, the steeper apparent gradient noted in the Bedrock Oxide Unit may be the result of wells completed at substantially different depths that were contoured together, thereby converting the known downward gradient into an apparent horizontal flow component.

The apparent groundwater mounding observed in October of 1995 may have been a transient condition induced by the reduction of pumping at the end of the agricultural pumping season. Given that a downward gradient exists across much of the PTF site, once groundwater pumping for irrigation is reduced in the fall each year, there is the potential that groundwater will flow downward through irrigation wells screened across multiple water bearing units.

After 1995, groundwater elevations were only collected at POC wells under APP No. 101704. Consequently, the apparent mounding observed in October 1995, which was defined by groundwater elevations measured in the interior of the proposed PTF well field, is not evident in subsequent water level data.

If the apparent mounding was indeed real, insufficient data exist to determine whether it was a transient seasonal condition, or was related to higher than normal recharge from the Gila River, or whether it persists in recent years. Even if the apparent mounding is real, and persists to the present, the magnitude of the mounding is too small (1 to 3 feet) to materially affect hydraulic control.

During PTF operations, solution migration will be prevented by establishing and maintaining continuous hydraulic control. A description of site-specific testing performed to establish and maintain hydraulic control, and results of the hydraulic control testing conducted in the immediate vicinity of the PTF site, is provided below. The results of the hydraulic control testing were reported to ADEQ on April 6, 1998. The April 6, 1998 memo is included as Exhibit 14C-1.

Apparent groundwater mounding observed in October 1995 is of a small enough magnitude that it will not affect PTF operations, formation rinsing, water balance calculations, or solution recovery because Curis Arizona will establish positive and continuous hydraulic control during PTF operations.

14C.3 Regional Groundwater Flow Conditions

Review of hydrologic maps produced by ADWR over a period of time spanning from 1983 to 2006 illustrate that groundwater flow directions within the alluvial units at and near the PTF site have remained consistently toward the north-northwest for the entire period of record. The maps reviewed were produced as part of the Hydrologic Map Series (HMS) and included water levels measured at key wells throughout the Pinal and eastern Phoenix Active Management Areas (AMA). Review of hydrologic maps included those produced for the Phoenix AMA because the PTF site is located approximately 2.5 miles from the Phoenix AMA boundary, and groundwater generally flows toward that boundary. A summary of the maps reviewed is provided below.

- Exhibit 14C-2 Map HMS 12 (ADWR, 1983) shows groundwater elevation and flow conditions within the Phoenix AMA, and includes groundwater flow direction information for the East Salt River sub-basin which is located directly north of the PTF site. HMS 12 shows that groundwater flowed in a northwest direction into the Phoenix AMA, at a point approximately 2.5 miles north of the PTF site in 1983. The location of the PTF site relative to the map included as Exhibit 14C-2 is indicated on that map.
- Exhibit 14C-3: Map HMS 23 (ADWR, 1989) shows groundwater elevation and flow conditions in the Pinal AMA and includes the Eloy sub-basin in which the PTF site is located. HMS 23 shows that groundwater flowed north-northwest across the PTF site, away from the Gila River and toward the Phoenix AMA boundary approximately 2.5 miles north of the PTF site in 1989. The location of the PTF site is indicated on the map included as Exhibit 14C-3.
- Exhibit 14C-4: Similar to the groundwater flow direction reported by ADWR in 1983, map HMS 27 (ADWR, 1992) shows that groundwater continued to flow into the East Salt River sub-basin in a northwesterly direction from the Eloy sub-basin at a point located approximately 2.5 miles north of the PTF site during, 1992. The location of the PTF site relative to the map included as Exhibit 14C-4 is indicated on that map.
- Exhibit 14C-5: Similar to the groundwater flow direction reported by ADWR in 1983, map HMS 35 (ADWR, 2005) shows that groundwater continued to flow into the East Salt River sub-basin in a northwesterly direction from the Eloy sub-basin at a point located approximately 2.5 miles north of the PTF site during the years 2002-2003. The location of the PTF site relative to the map included as Exhibit 14C-5 is indicated on that map.
- Exhibit 14C-6: Map HMS 36 (ADWR, 2006) shows groundwater elevations and flow conditions within the Pinal AMA and the Eloy sub-basin for a period of time spanning November 2002 to February 2003. HMS 36 illustrates that the groundwater flow direction within the alluvial units in the vicinity of the PTF site remained toward the northwest between November 2002 and February 2003. The location of the PTF site is indicated on the map included as Exhibit 14C-6.

14C.4 Hydraulic Control

To ensure that injected solutions are recovered and the economic benefit of those solutions are preserved, Curis Arizona will establish and maintain positive hydraulic control of injected solutions throughout the period of the injection and rinsing.

Effective operation of the PTF site requires positive and verifiable control of injected solutions. To accomplish this important task, measurable hydraulic control must be established and maintained throughout the period of injection and rinsing. If control of the injected solutions is not closely maintained, the economic recovery of copper cannot be accomplished because of loss of solution to surrounding geologic formations where recovery has not been established. It is critical to the success of the PTF that injected solutions be recovered.

Hydraulic control will be established by extracting a greater volume of fluid than is injected. The excess fluid will be principally composed of groundwater extracted from a series of hydraulic control wells located at the perimeter of the PTF well field. The hydraulic control wells will establish a measurable and continuously monitored cone of depression that ensures that groundwater is drawn inward toward the injection and recovery wells, physically preventing any fluids, either natural or injected, from flowing outward from the PTF well field. The cone of depression will be monitored by means of a series of observation wells located outside of, but paired with, the network of hydraulic control wells.

14C.4.1 Groundwater Elevation Changes

During the proposed project, hydraulic control will be maintained by means of a measurable and continuously monitored cone of depression formed around the PTF well field. If a groundwater elevation increase such as that observed from 1991 to 1996 were to develop as a result of increased Gila River flows, the recharge impulse would be detected at the observation wells located outside of the hydraulic control wells. The increased water level may require that some recovery wells be pumped at a higher rate for a short period of time until water levels stabilize, but will not have a measureable effect on the hydraulic control, PTF operations, formation rinsing, or the overall operational water balance.

Similarly, a decrease in groundwater level elevation such as that noted from 1996 through 2004 would not occur at a fast enough rate to affect hydraulic control, PTF operations, formation rinsing, or the overall operational water balance. Such a water level decline would also be detected at the observation wells located outside of the hydraulic control wells, and would not likely trigger an increase or decrease in pumping to maintain hydraulic control.

A water level decline of the type and magnitude observed from 1995 through 2004 would only affect PTF operations if the groundwater elevations fell below the top of the Bedrock Oxide Unit. Such a water level decline would require that the UBFU and LBFU be totally dewatered, a combined saturated thickness of approximately 200 feet. A groundwater elevation decline of this magnitude is far in excess of any observed historical groundwater elevation fluctuations and is unlikely.

14C.4.2 Preferential Pathways

Weathered, fractured, and rubblized zones do occur within the proposed injection zone. Site-specific aquifer testing has demonstrated that the upper most weathered zone of the Bedrock Oxide Unit, fractured areas, and rubblized areas of the Bedrock Oxide Unit exhibit higher hydraulic conductivities than do areas of non-fractured, non-weathered rock.

Areas of increased hydraulic conductivity will not adversely affect the ability to maintain hydraulic control during PTF operations. The array of injection, recovery, perimeter, and observation wells will be so closely spaced together that no injection well will be installed within an area of increased hydraulic conductivity without at least one recovery well and one observation well installed in the same structural feature.

Areas of increased hydraulic conductivity will serve to maximize hydraulic control within those areas. Hydraulic control is based on the fact that recovery wells will draw groundwater in toward the PTF well field, creating a cone of depression around the PTF well field. Areas that have higher hydraulic conductivity will serve to allow greater amounts of groundwater to flow in toward the perimeter wells than would otherwise be the case. Recovery wells placed in such areas will inherently draw more water inward than perimeter wells placed in areas of the Bedrock Oxide Unit that have lower hydraulic conductivities.

14C.4.3 Faults

Faults such as the Sidewinder fault and Party Line fault are highly fractured and rubblized zones of the Bedrock Oxide Unit that have increased hydraulic conductivity relative to other portions of the Bedrock Oxide Unit. The effect of these features on hydraulic control will be the same as the fractures and rubblized zones.

When constructing injection wells in areas of increased hydraulic conductivity, Curis Arizona will increase the pump rate at wells in locations that will ensure adequate extraction capacity is paired with each injection well and that hydraulic control is maintained at all times. If necessary, Curis Arizona will increase the recovery/perimeter well pumping rate, tighten the well spacing, or otherwise adjust the well configuration in these areas, to ensure hydraulic control is maintained.

Faults and rubblized zones will not have an effect on the ability to maintain hydraulic control within the PTF injection and recovery zone (IRZ). Because hydraulic control will be maintained, groundwater elevations, flow direction, gradient, or groundwater quality outside of the PTF will not be affected by PTF operations..

14C.4.4 Underground Workings

Conoco, a previous owner of the site, advanced a series of underground workings during 1973 and 1974 for the purpose of assessing the feasibility of underground mining at the PTF site and surrounding vicinity. The underground workings were constructed at the contact between the Bedrock Oxide Unit and the Sulfide Unit, specifically for the purpose of collecting bulk samples from both units. As they presently stand, there are no discrete groundwater sinks (i.e., no pumping and no discrete outflow point) associated with the underground workings. Consequently, groundwater currently flows into and out of the underground workings under ambient flow conditions, and in response to the natural groundwater gradient. By definition, with no groundwater sinks present, groundwater inflow to the underground workings must equal groundwater outflow from those workings.

Aquifer testing conducted by BHP Copper demonstrated that the Sulfide Unit is effectively impermeable to groundwater flow. The minerals of the Sulfide Unit are insoluble to the proposed lixiviant solution. Consequently, no groundwater flow from the Bedrock Oxide Unit into the Sulfide Unit is presently occurring, and none will occur during or after PTF operations.

The proposed injection and recovery of solutions will be more than 500 feet from the underground workings, and will not induce fluid flow into the underground workings or the Sulfide Unit. The underground workings will not have an effect on groundwater elevations, flow direction, gradient, groundwater quality, or the maintenance of hydraulic control at the proposed PTF well field.

14C.4.5 Hydraulic Control is Feasible

The feasibility of establishing and maintaining hydraulic control by the method described above was demonstrated by testing conducted by BHP Copper over a 90-day period spanning from November 1997 to February 1998. Following the conclusion of injection testing, hydraulic control was maintained for a period of approximately 9 months during rinsing operations. The results of the 90-day injection and recovery testing were reported to ADEQ on April 6, 1998. The April 6, 1998 memo is included herewith as Exhibit 14C-1.

14C.5 Right to Withdraw Groundwater

Curis Arizona has rights to three separate sources of water for use at the PTF site and surrounding vicinity. Pursuant to a federal court decree, Curis Arizona has water rights appurtenant to the lands it owns within the San Carlos Irrigation District (SCIDD). Those lands have decreed rights for approximately 1,400 acre-feet per year (AFY) of comingled surface water rights from the Gila River and groundwater withdrawn from wells located within SCIDD's boundaries. Curis Arizona also has rights to groundwater withdrawn from wells on Curis Arizona property outside SCIDD's boundaries. These state-issued water rights include grandfathered irrigation rights (58-105084.0004, 58-112948.0005, and 58-112949.0004), Type II non-irrigation groundwater rights, and rights to groundwater pursuant to a Mineral Extraction permit (59-562120.0002). In addition, Curis Arizona may withdraw groundwater from wells located on State Trust Lands subject to its Mineral Lease 11-026500. Thus, Curis Arizona has sufficient water rights to meet the project's needs.

Groundwater conditions beneath the PTF site and throughout the Eloy sub-basin are dynamic in nature and are calculated as a balance between hydrologic fluxes into and out of the sub-basin. Groundwater storage is defined as groundwater flux into the basin that exceeds groundwater flux out of the basin.

There is no legal or regulatory requirement that groundwater pumped in support of the proposed PTF operations be designated as groundwater from storage. Neither Curis Arizona, nor previous owners of the PTF site, have accumulated or tabulated groundwater storage credits for the purpose of supporting PTF operations. Rather the water to be pumped in support of PTF operations is groundwater, legally pumped in accordance with the water rights that Curis Arizona holds for that purpose.

There are no regulatory or legal restrictions regarding which water bearing units Curis Arizona may choose to pump groundwater for use as make-up water, or whether that water is to be produced from storage or from the dynamic groundwater supply.

Aquifer tests conducted at the PTF site and surrounding vicinity, described in Exhibit 14A-1, have demonstrated that sufficient groundwater resources are available to support proposed PTF operations. The aquifer tests have also demonstrated that sufficient production capacity exists to produce the 60 to 260 gallons per minute (gpm) groundwater requirement from the various water bearing units beneath the PTF site on a continuous basis.

A discussion of water level impacts resulting from 60 to 130 gpm of groundwater extraction hydraulic control and formation rinsing for the proposed 23-month life of the proposed PTF well field is provided in Attachment 14A.

14C.6 Detailed Geologic Cross Sections

Curis Arizona has created a set of detailed cross sections depicting geologic conditions beneath the PTF site. Figures 14C-48 through 14C-51 are a set of detailed geologic cross sections depicting:

- Recent water levels at existing POC wells (see APP No. 101704) completed in each water bearing unit;
- POC well screened intervals in the UBFU, LBFU, and Bedrock Oxide water bearing units;
- Generalized schematic of proposed Phase 1 injection, recovery, and observation wells including screened intervals;
- Lateral extent of the MFGU;
- Depth of the Sulfide Unit;
- Geologic contacts;
- Location of faults and associated rubblized zones; and
- Location of the underground workings.

Figures 14C-48 through 14C-51 do not extend beyond the Curis Arizona property and consequently do not show down-gradient wells. Figures 14C-48 through 14C-51 do not show cones of depression, groundwater mounding, or subsidence zones within the area covered by the cross sections. The cross sections were generated from geologic data obtained from corehole logs prepared by Conoco, Magma, and BHP Copper. The coreholes used to create the cross sections are depicted on each cross section. No geologic data from the existing POC wells (see APP No. 101704) were used to create the cross sections. The existing POC wells (see APP No. 101704) shown on the cross sections were projected to the cross sections to show where they are screened relative to key geologic contacts.

To avoid confusion, if projection of a POC well to the cross section resulted in a conflict between the actual and apparent geologic unit in which the well was constructed, the well was not shown on the cross section. Because of lateral changes in lithology across the site, projection of wells M4-O, M7-GL, M22-O, and M28-LBF onto cross sections shown in Figures 14C-48 through 14C-51 would result in the depiction of well screens and completion depths in incorrect geologic units for these existing POC wells. Consequently wells M4-O, M7-GL, M22-O, and M28-LBF are not shown on these cross sections.

As described above, groundwater mounding and cones of depression observed in the vicinity of the PTF site are transient in nature and Curis Arizona does not have access to data describing the magnitude or frequency of their recurrence. Consequently, any depiction of these features would require greater interpolation than is suitable for detailed cross sections.

No subsidence zones are shown on Figures 14C-48 through 14C-51 because none are known to exist within the area represented by the cross sections.

Figure 14C-52 is a detailed geologic cross section depicting BHP Copper test wells (past injection/ recovery/observation wells) showing the screened interval and other details relative to key geologic features. This cross section was created because projection of these wells onto cross sections shown on Figures 14C-48 through 14C-52 would result in depiction of well screens and completion depths in incorrect geologic units due to lateral changes in lithology across the site.

14C.7 Earth Fissures and Subsidence

The Arizona Geological Survey (AZGS) has responsibility for mapping earth fissures and ground surface subsidence throughout the State of Arizona. In March 2011, AZGS published a map of earth fissures within Pinal County, Arizona (AZGS, 2011). The map shows that the nearest known earth fissures are located approximately 7 miles to the south of the PTF site, in the vicinity of Coolidge Municipal Airport, Coolidge, Arizona. The next nearest earth fissures are located approximately 15 miles to the northwest of the PTF site, in the vicinity of Chandler Heights, Chandler, Arizona. Earth fissure locations near the Coolidge Airport and Chandler Heights area, as published by AZGS (2011), are shown on Figure 14C-53. A copy of the AZGS map is included as Exhibit 14C-7. No earth fissures or measurable subsidence has been reported in the vicinity of the PTF site.

Groundwater withdrawal induced subsidence occurs primarily in unconsolidated fine grained sediments that lose buoyancy as they are dewatered. The groundwater flow model described in Attachment 14A of the this Application has demonstrated that the LBFU and MFGU remain fully saturated throughout the planned duration of the proposed PTF operations. The model also demonstrates that the UBFU, which is presently partially saturated, will remain partially saturated at near present levels for the duration of the proposed PTF operations.

14C.7.1 Estimates of Subsidence

A theoretical subsidence estimate was prepared for the PTF site and surrounding vicinity in conjunction with an APP application submitted in January 1996. That estimate was prepared based on work performed by Ahlness and Triplett (1994), two researchers employed by the U.S. Bureau of Mines to study the potential for subsidence at the Santa Cruz In-Situ Copper Project. The method developed by Ahlness and Triplett (1994) was derived from a series of triaxial compression tests on leached and unleached core samples of ore from the Santa Cruz In-situ Copper Mine project. Curis Arizona has been unable to locate a copy of the publication detailing the method and assumptions used by Ahlness and Triplett (1994).

Ahlness and Triplett were employed by the U.S. Bureau of Mines when they produced their research in 1994. The Bureau of Mines was disbanded in early 1995, and responsibility for publications in progress was transferred to several federal government entities including the United States Geological Survey (USGS).

Curis Arizona has searched Arizona State University, University of Arizona, and an Arizona State library, has contacted the AZGS and USGS, and has attempted to contact the author directly.

Based on the description included in the 1996 APP application, work performed by Ahlness and Triplett (1994) suggests that, in theory, full commercial scale ISCR operations may result in minor subsidence at the ground surface. The theoretical subsidence values derived by Ahlness and Triplett (1994) were based on laboratory examination of unleached and laboratory leached core samples. No follow-up studies were performed to validate their methods or assumptions in the field.

Although the theoretical subsidence calculated by Ahlness and Triplett (1994) for the Santa Cruz project was very minor, several factors suggest that the potential for ISCR-induced subsidence at the PTF site is negligible. The minerals that are targeted for dissolution by the injected lixiviant at the PTF site are non-load bearing fracture filling minerals. These minerals are oxidation byproducts formed during the decomposition of sulfide copper-bearing minerals. The targeted minerals only exist within naturally occurring fractures that are open to groundwater flow. Fractures that are not open to groundwater flow are not open to the injected lixiviant, and consequently will not be dissolved. There will be no corresponding loss of rock strength as the targeted fracture lining minerals are dissolved because the open fractures and the fracture lining minerals do not have significant compressive strength. After dissolution of the fracture lining copper oxide minerals, the fractures will remain open and fully saturated. No loss of buoyancy will occur within the Bedrock Oxide Unit because the fractures will remain fully saturated.

Given that no subsequent studies were conducted to validate the assumptions made by Ahlness and Triplett (1994) regarding subsidence predicted and observed at the Santa Cruz site, and no formal comparison of geologic structure and geochemical differences between the Santa Cruz and PTF sites has been conducted, it is not clear that their study has any application to the PTF site.

Using the assumptions developed by Ahlness and Triplett (1994), a subsidence value of 0.1 to 0.3 inches was reported for the PTF site in the 1996 APP application. Review of the text description of the calculations included in the 1996 APP application seems to indicate that there may have been a unit conversion error in the calculation and that the actual value calculated should have been between 1.2 and 3.6 inches of subsidence. However, without access to the publication produced by Ahlness and Triplett (1994), it is not possible to verify either the calculations or the potential conversion error reported in the 1996 APP application.

14C.7.2 Subsidence Monitoring

Although ISCR-induced subsidence is anticipated to be immeasurable, Curis Arizona proposes to survey a series of fixed control points located in the vicinity of the proposed PTF well field prior to the commencement of PTF operations as a precaution. Curis Arizona will monitor changes in elevation at those control points annually. The cumulative results of the annual surveys, and a description of the reasons for any changes in elevation, will be reported to ADEQ at completion of the proposed PTF operations.

14C.8 References

Ahlness, J.K., and Triplett, T.L., 1994, Evaluation of Surface Subsidence Potential of the Santa Cruz In-Situ Copper Mining Research Project, U.S. Department of the Interior, Bureau of Mines, Open file Report 51-94.

Arizona Department of Water Resources (ADWR), 1983. Hydrologic Map Series (HMS), Report No. 12, Depth to Water and Altitude of the Water Level, 1983, Maps Showing Conditions in the West Salt River, East Salt River, Lake Pleasant, Carefree and Fountain Hill Sub-Basins of the Phoenix Active Management Area, Maricopa, Pinal and Yavapai Counties, Arizona, 1983.

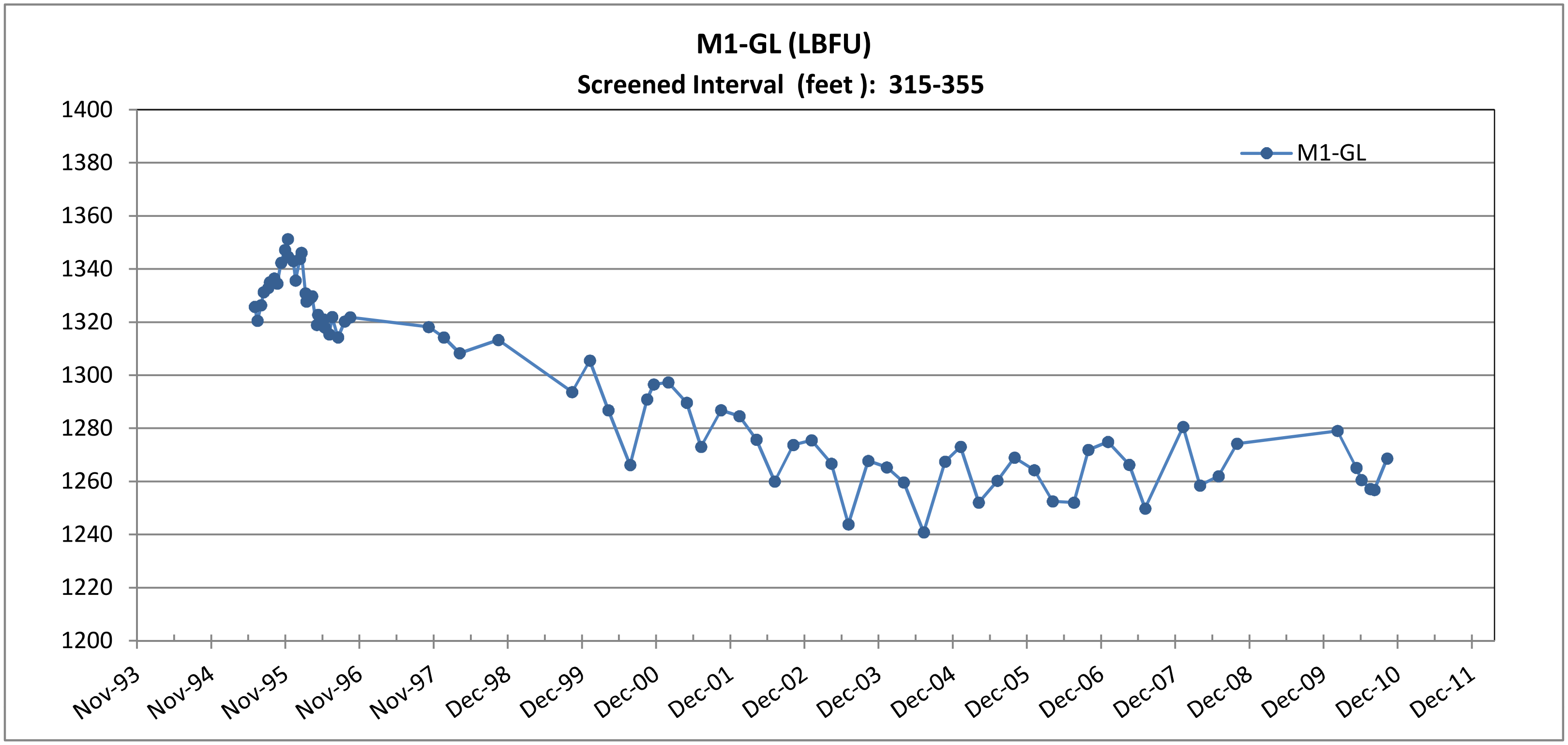
ADWR, 1989. HMS 23, Hydrologic Map Series (HMS), Report No. 23, Maps Showing Groundwater Conditions in the Eloy and Maricopa-Stanfield Sub-Basins of the Pinal Active Management Area, Pinal Pima, and Maricopa Counties, Arizona, 1989.

ADWR, 1992. HMS 27, Hydrologic Map Series (HMS), Report No. 27, Maps Showing Groundwater Conditions in the Phoenix Active Management Area, Maricopa, Pinal, and Yavapai Counties, Arizona, 1992.

ADWR, 2005. HMS 35, Hydrologic Map Series (HMS), Report No. 35, Maps Showing Groundwater Conditions in the Phoenix Active Management Area, Maricopa, Pinal, and Yavapai Counties, Arizona, Nov. 2002 – Feb 2003.

ADWR, 2006. HMS 36, Hydrologic Map Series (HMS), Report No. 36, Maps Showing Groundwater Conditions in the Eloy and Maricopa-Stanfield Sub-Basins of the Pinal Active Management Area, Pinal Pima, and Maricopa Counties, Arizona, Nov. 2002 – Feb 2003.

AZGS, 2011. Compilation Earth Fissure Map for all of Pinal County (1:250,000 scale), and Earth Fissure Maps for Sacaton Butte, White Horse Pass, and Santa Rosa Wash. http://repository.azgs.az.gov/sites/default/files/dlio/files/nid996/pinal_county_03_11.pdf.


M1-GL (LBFU)
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M1-GL
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1360
1340
1320
1300
1280
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1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
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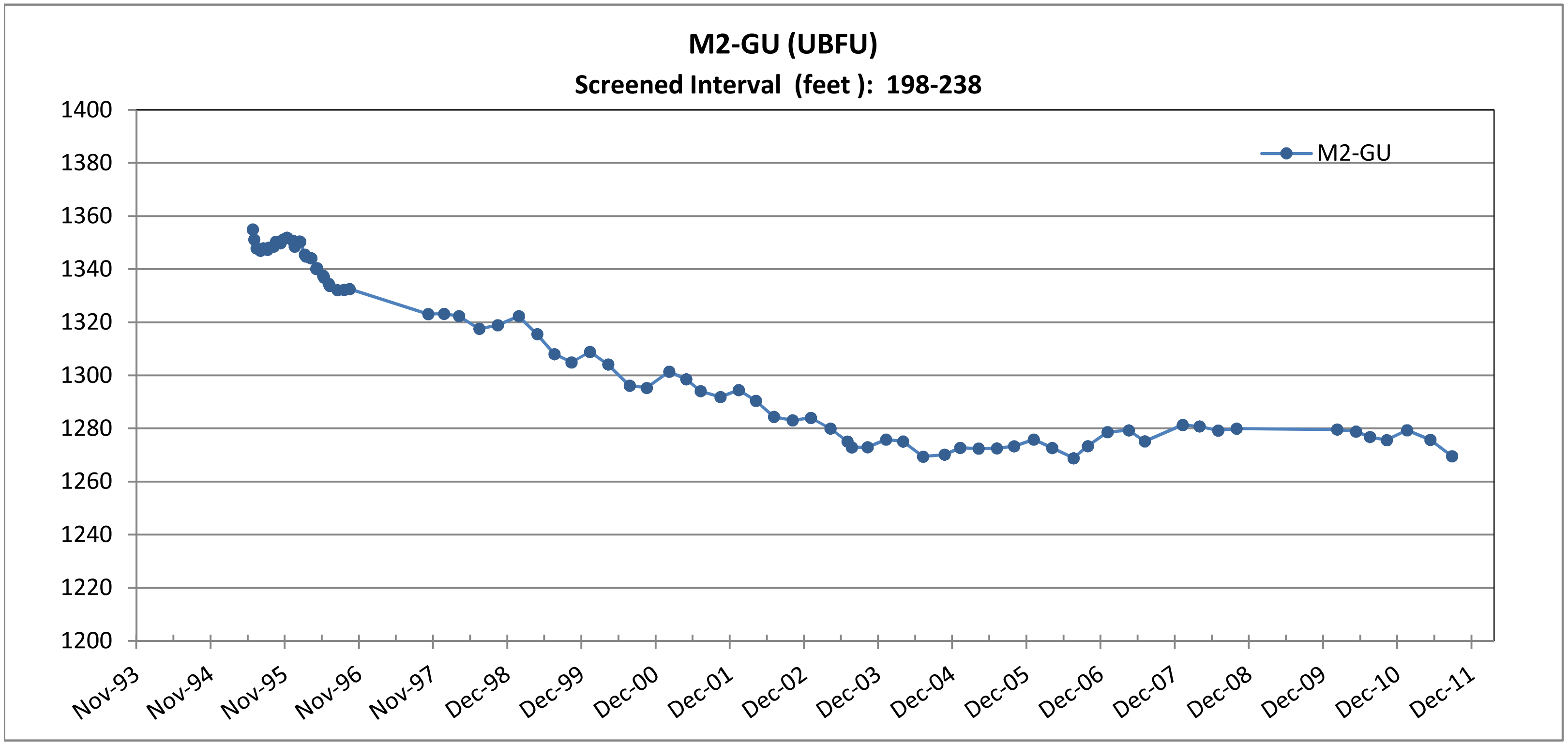
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1200
Nov-93
Nov-94
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Nov-96
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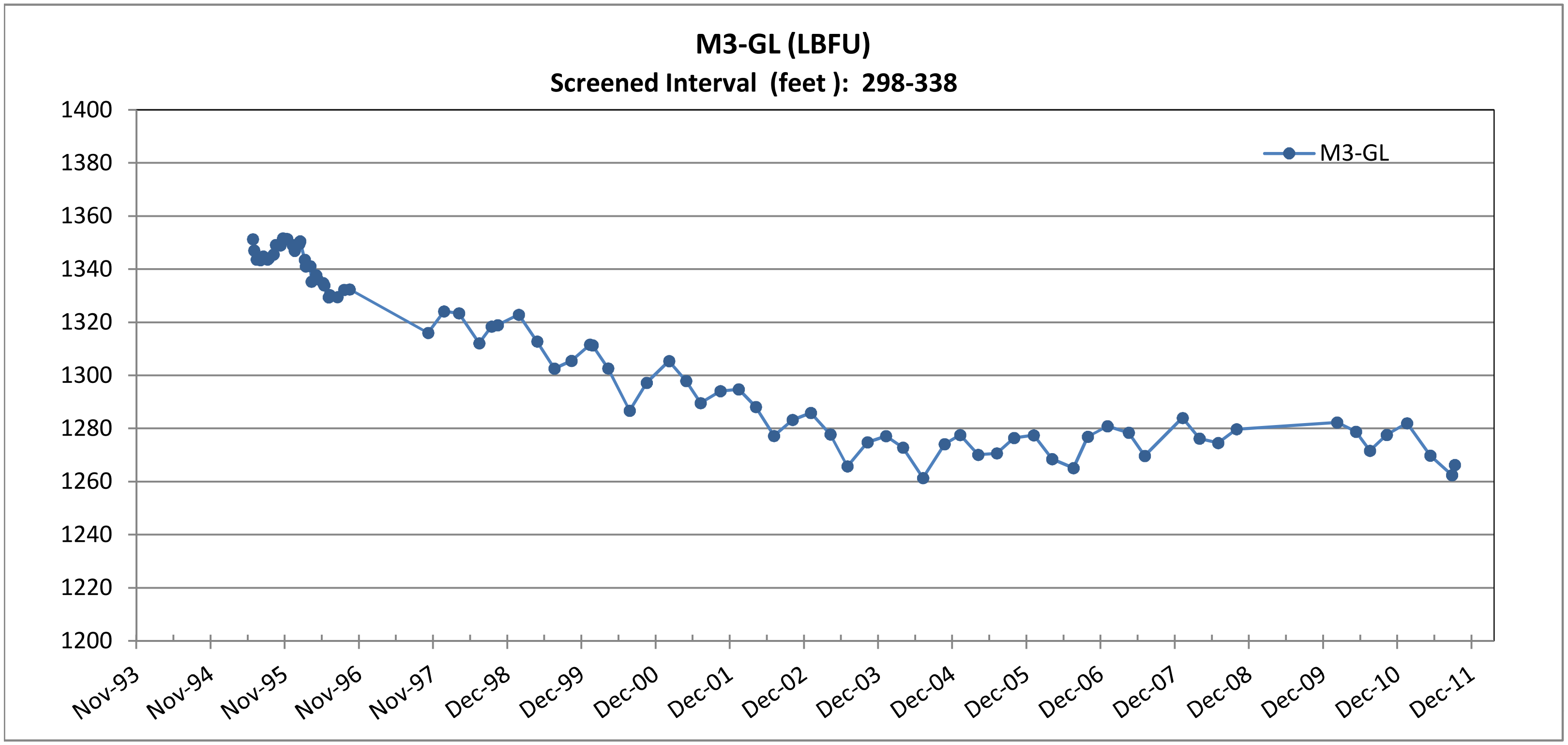
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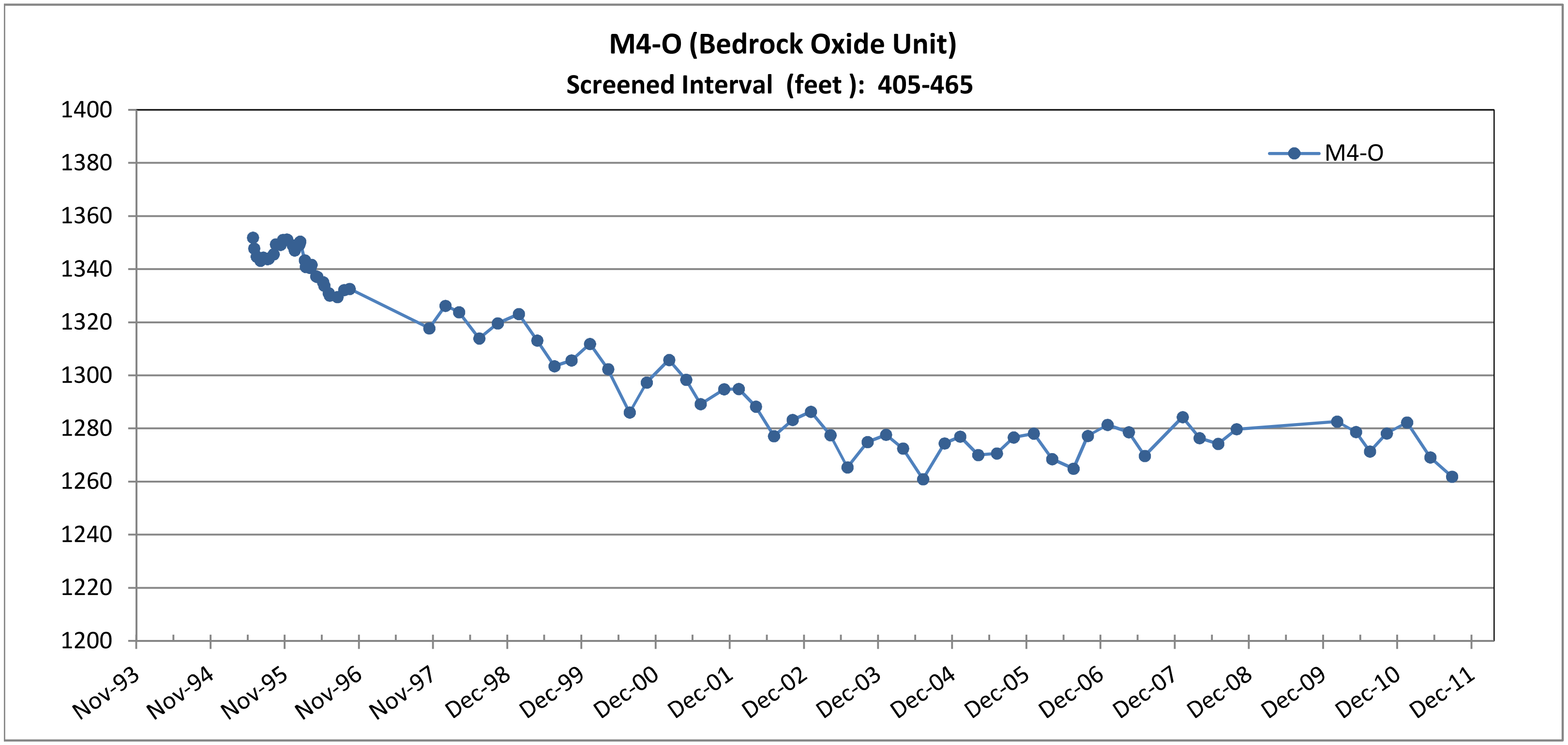
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Screened Interval (feet): 405-465
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1380
1360
1340
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1300
1280
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1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
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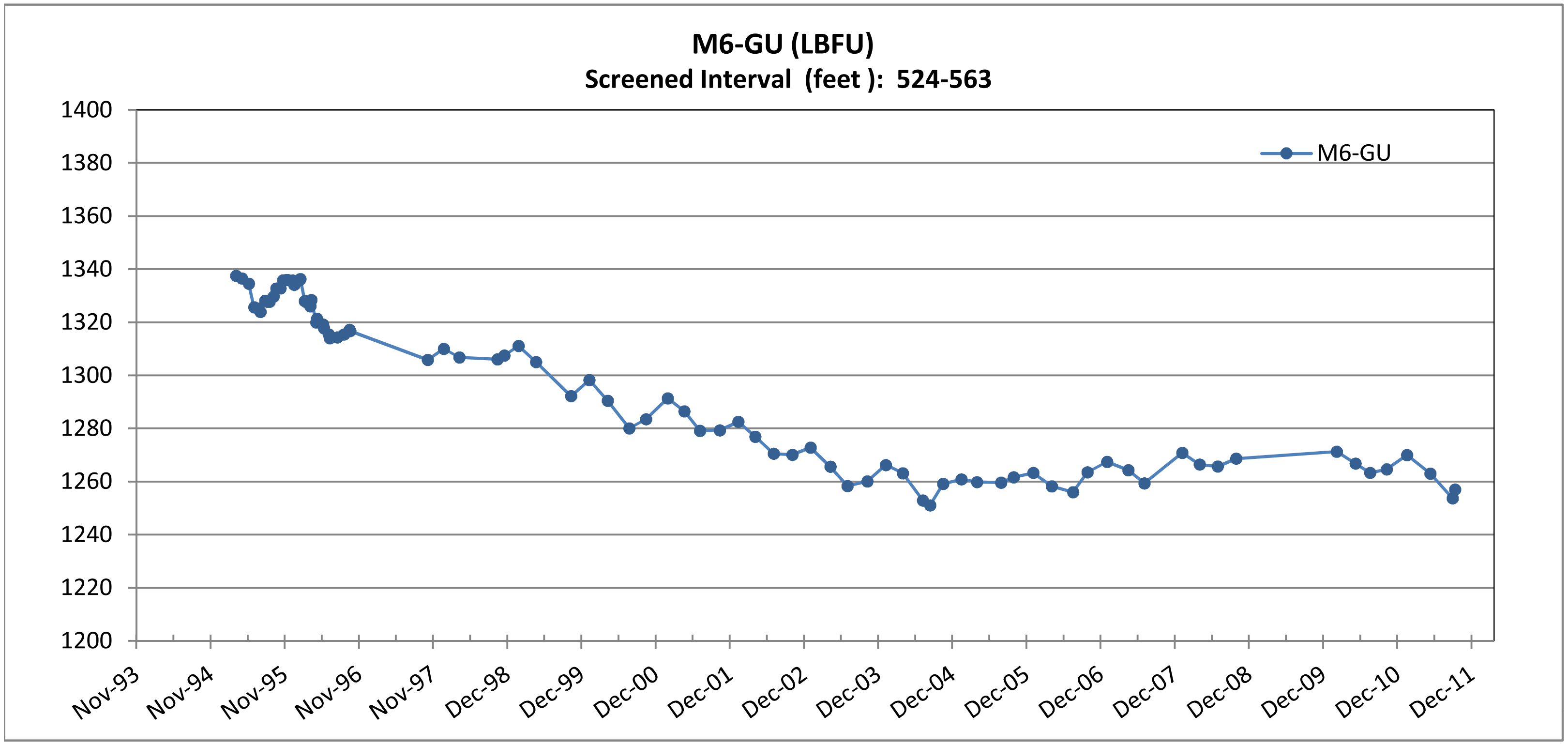
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1280
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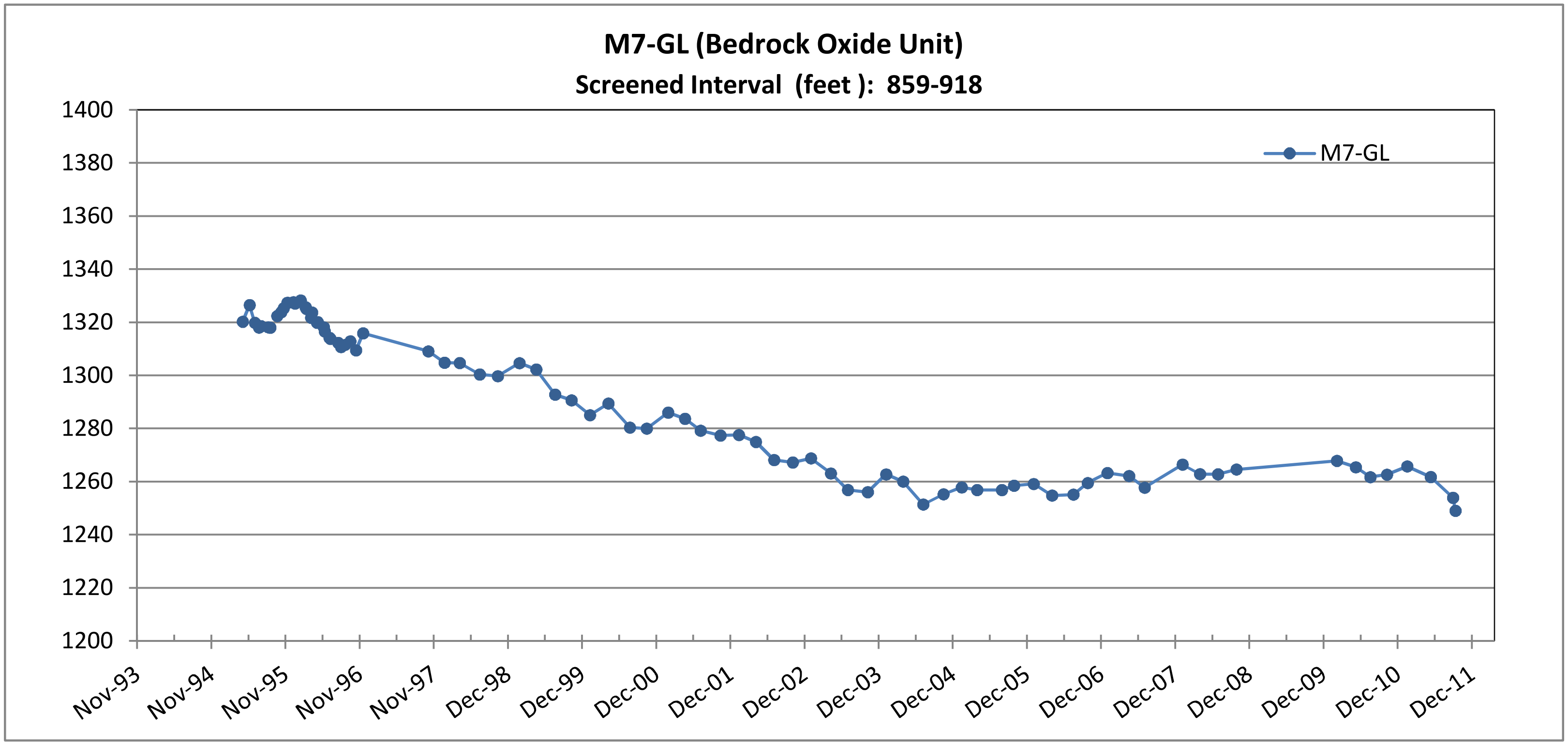
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Screened Interval (feet): 859-918
M7-GL
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1300
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1240
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Nov-96
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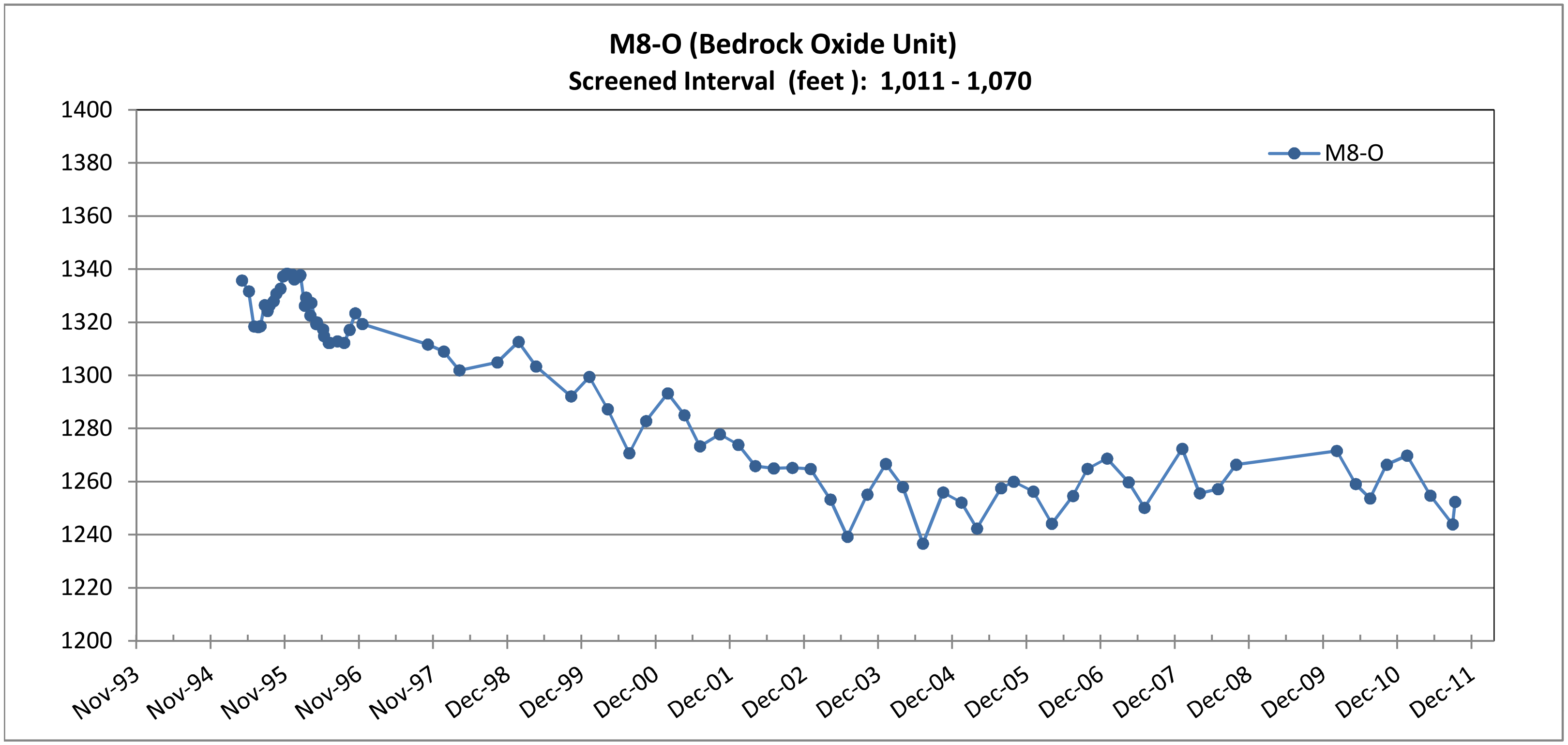
Dec-11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Screened Interval (feet): 1,011 - 1,070
M8-O
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1300
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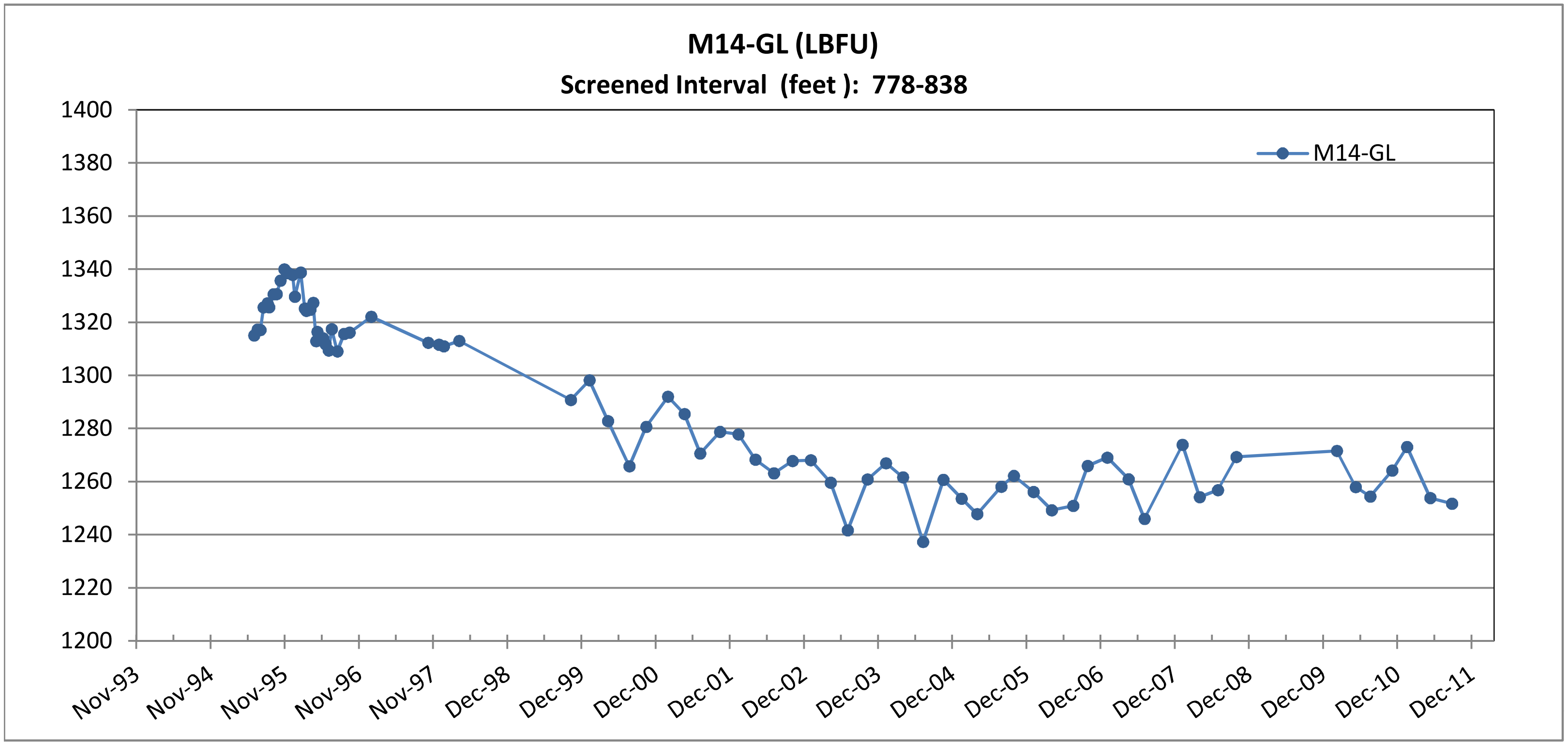
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Screened Interval (feet): 778-838
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1380
1360
1340
1320
1300
1280
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1220
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Nov-94
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Nov-97
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Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
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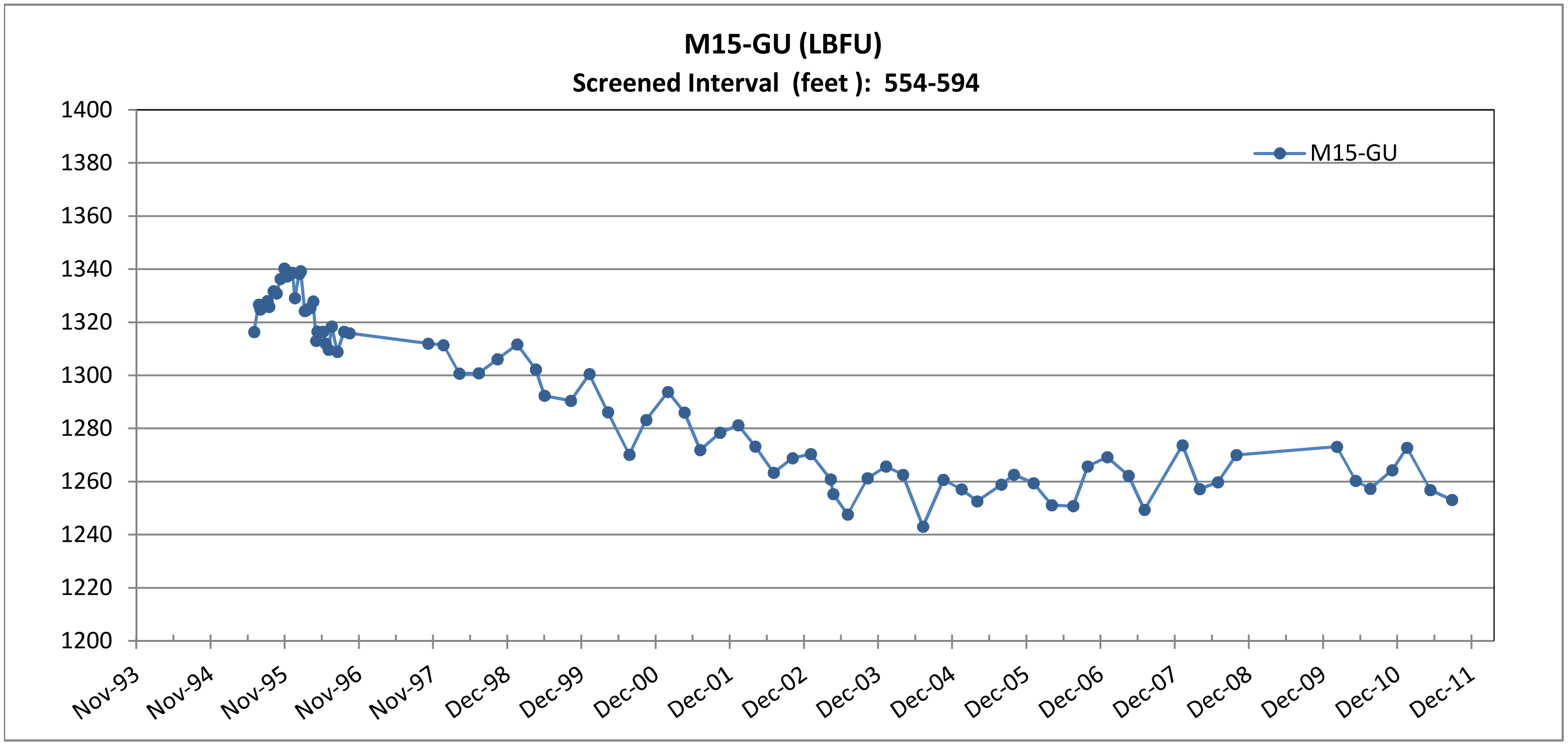
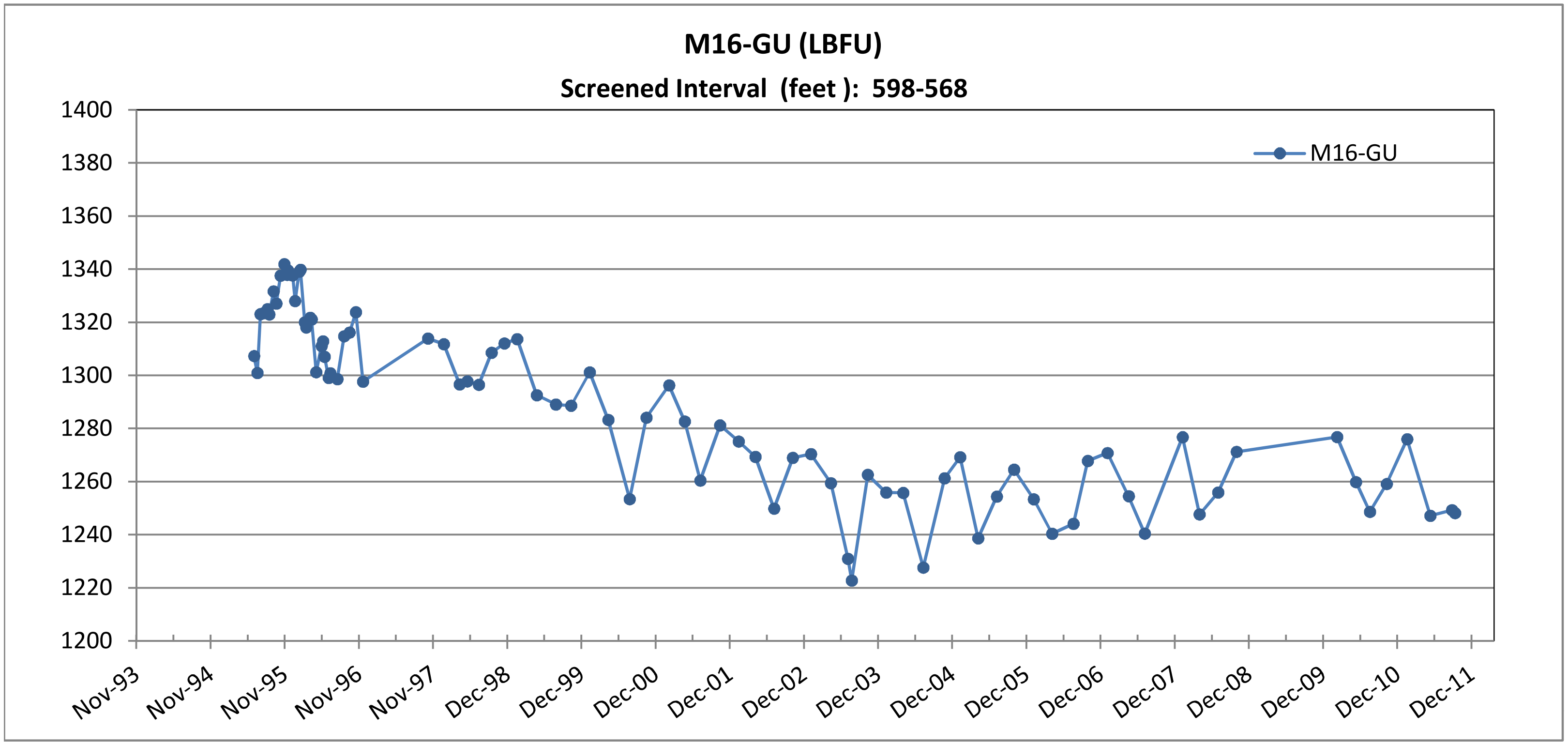
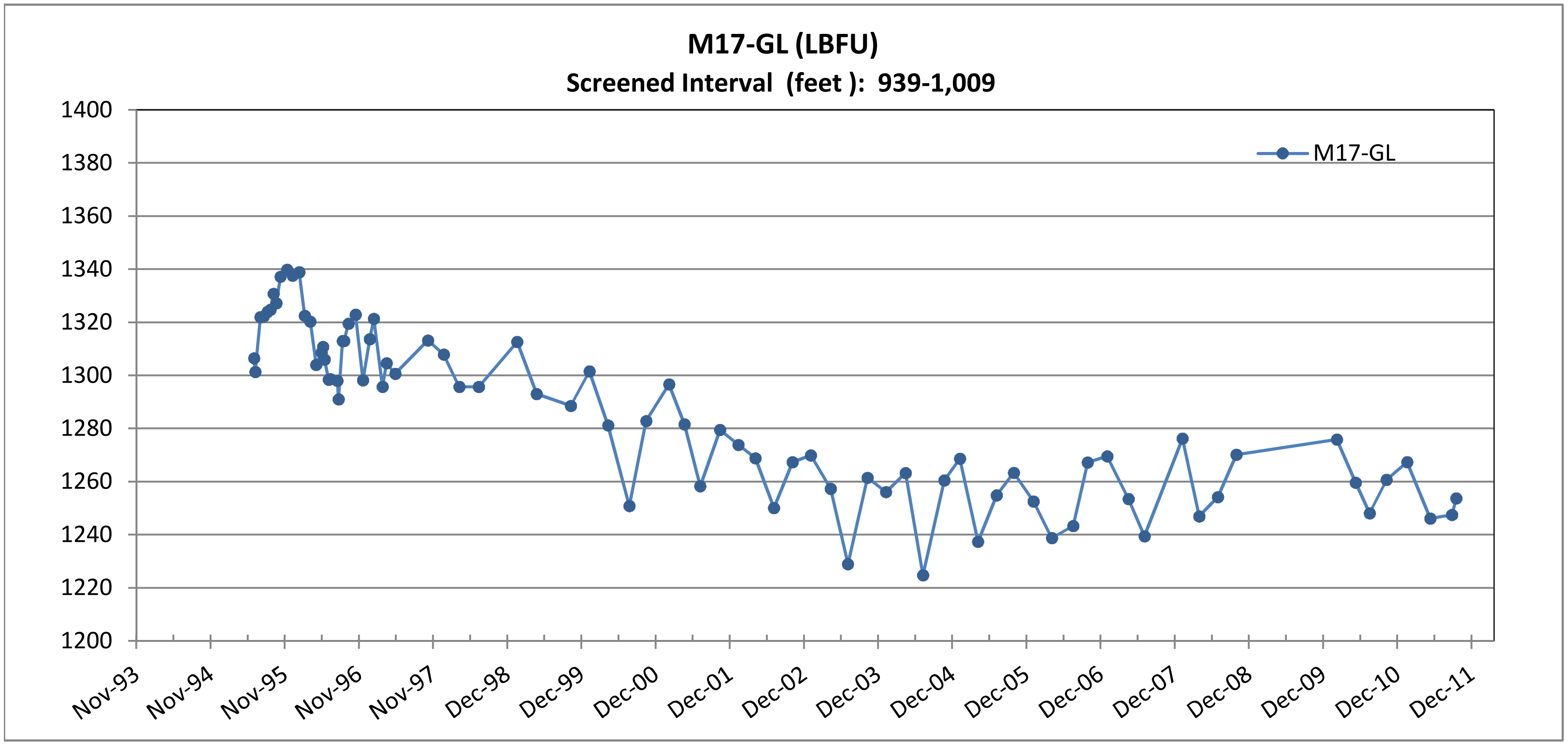
Dec-10
Dec-11


M15-GU (LBFU)
Screened Interval (feet): 554-594
M15-GU
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11


M16-GU (LBFU)
Screened Interval (feet): 598-568
M16-GU
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11


M17-GL (LBFU)
Screened Interval (feet): 939-1,009
M17-GL
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
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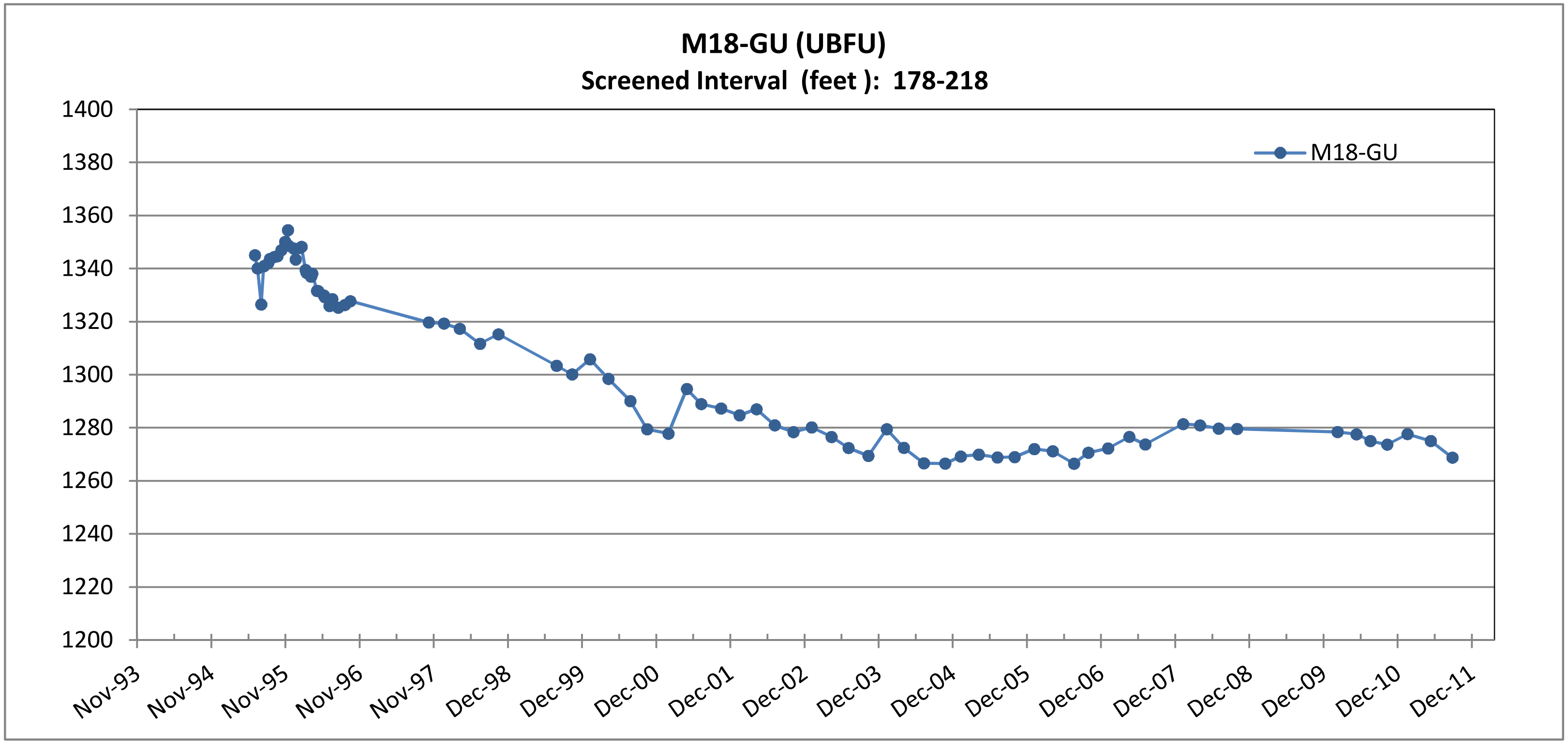
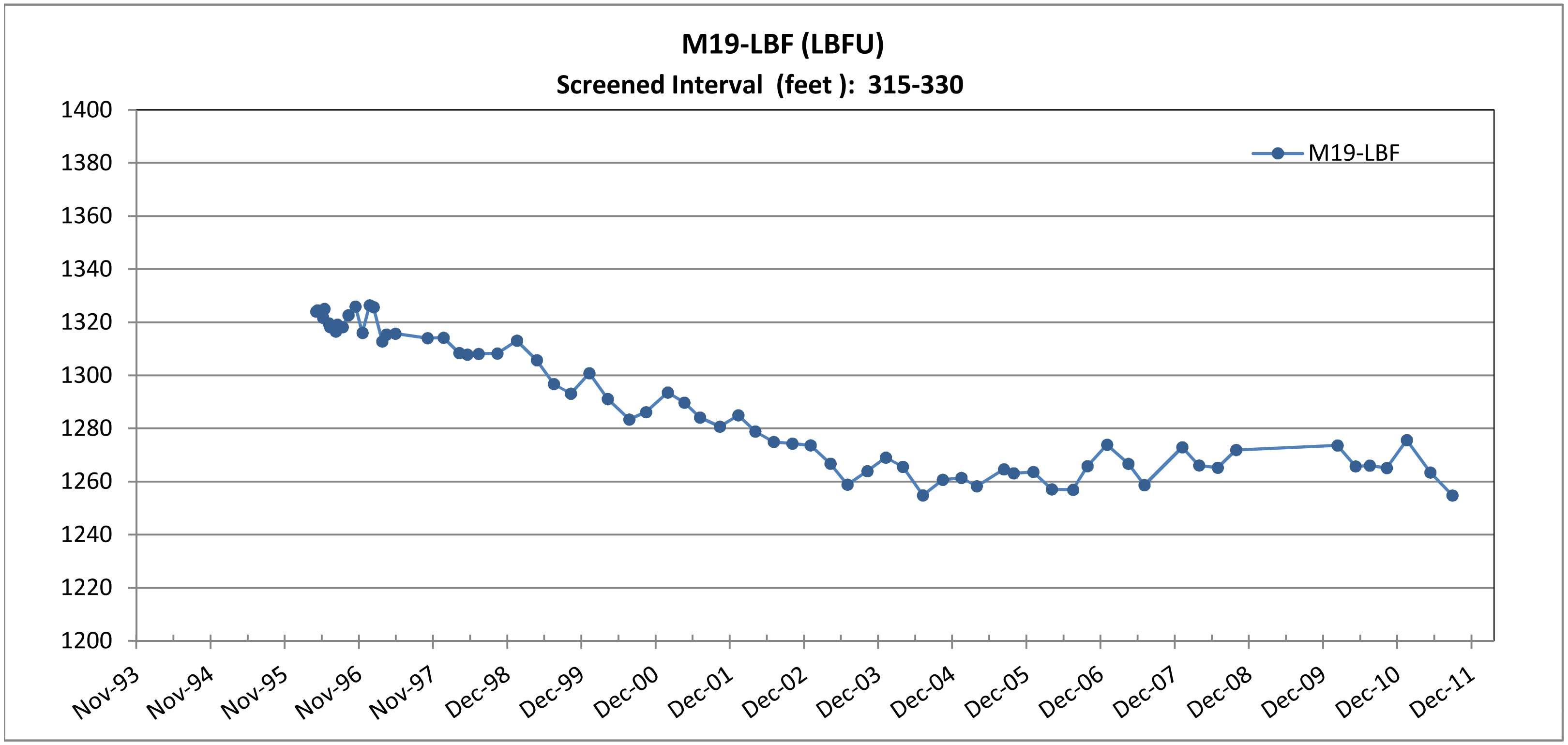
Dec-09
Dec-10
Dec-11


M18-GU (UBFU)
Screened Interval (feet): 178-218
M18-GU
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11


M19-LBF (LBFU)
Screened Interval (feet): 315-330
M19-LBF
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
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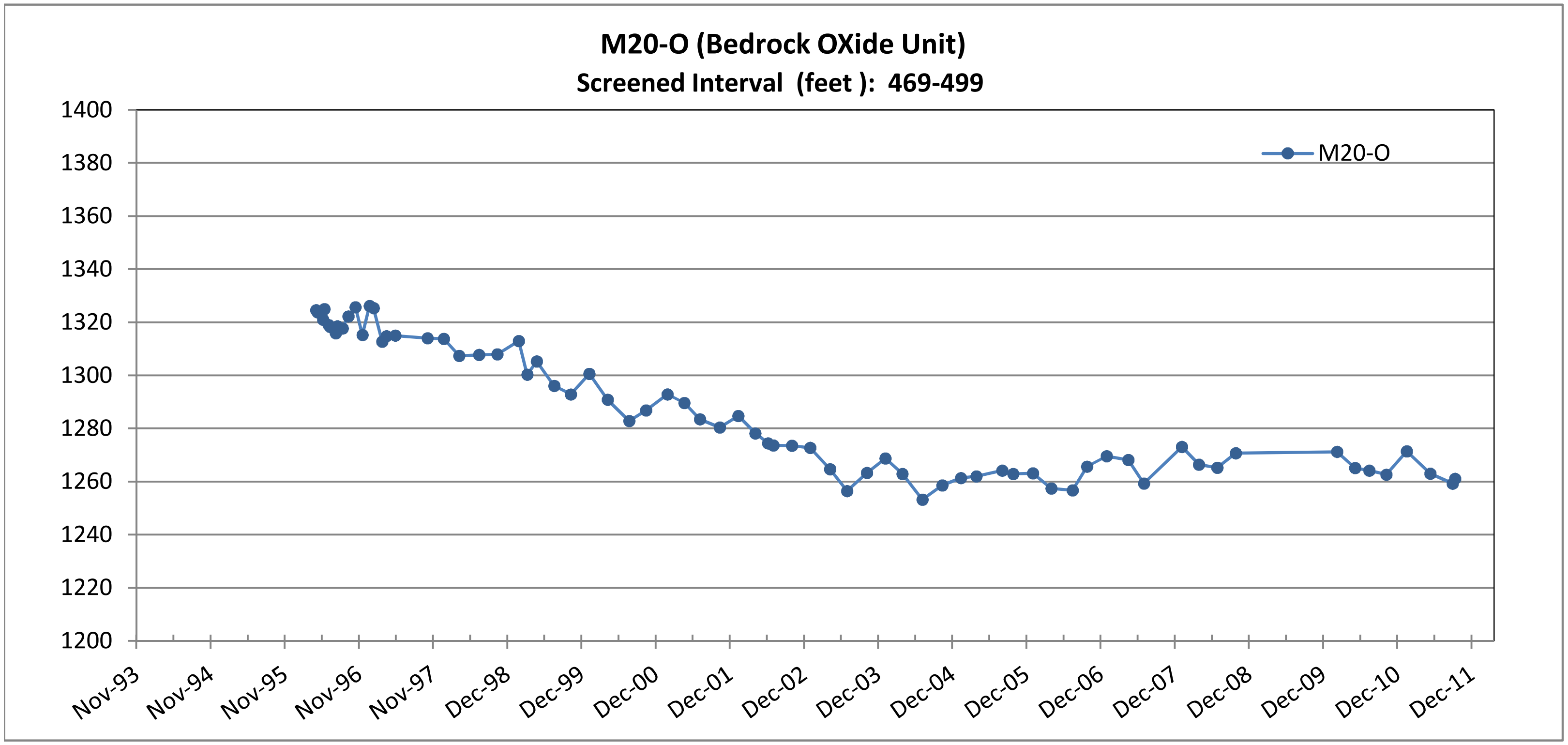
Dec-09
Dec-10
Dec-11


M20-O (Bedrock OXide Unit)
Screened Interval (feet): 469-499
M20-O
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
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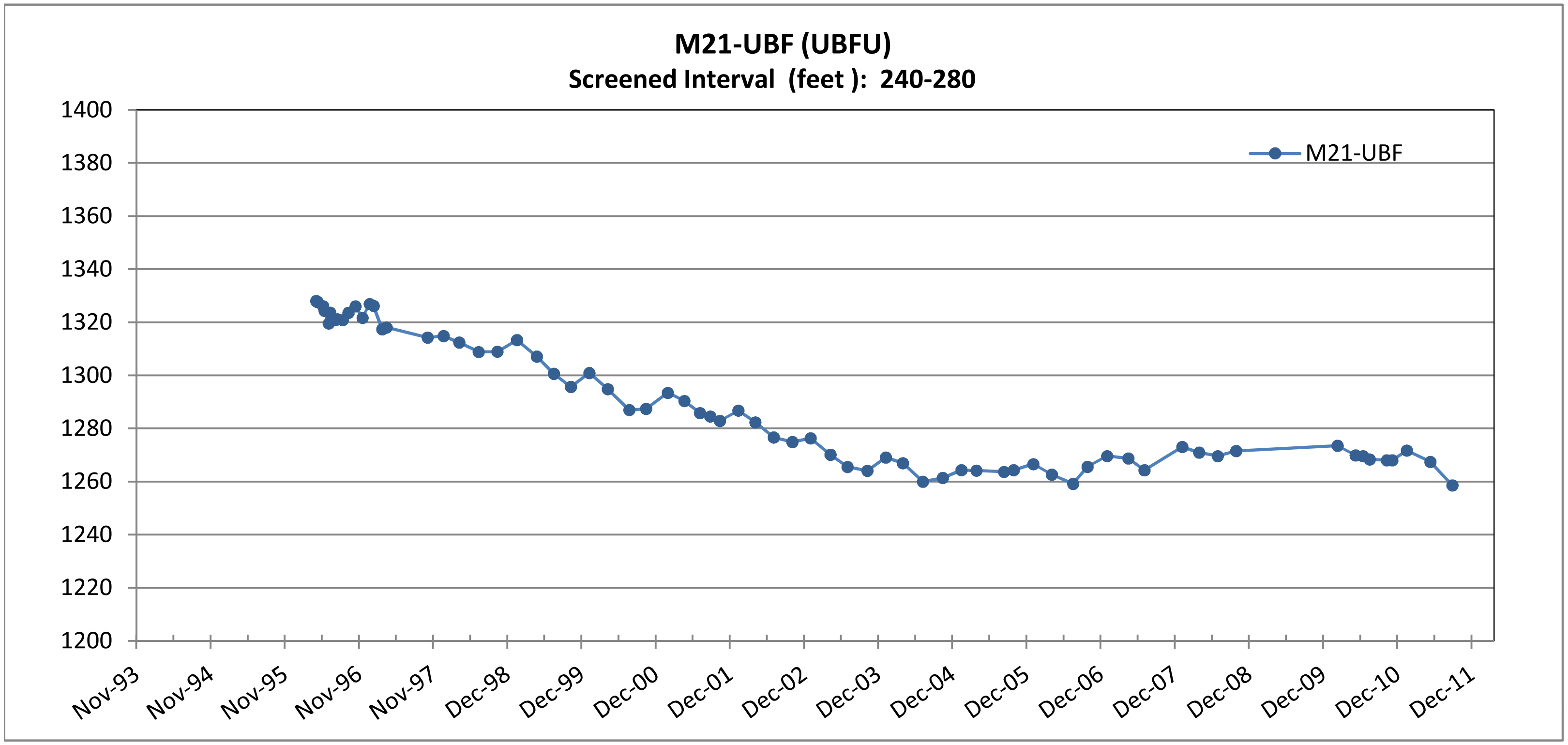
Dec-09
Dec-10
Dec-11


M21-UBF (UBFU)
Screened Interval (feet): 240-280
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
M21-UBF
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
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Dec-09
Dec-10
Dec-11

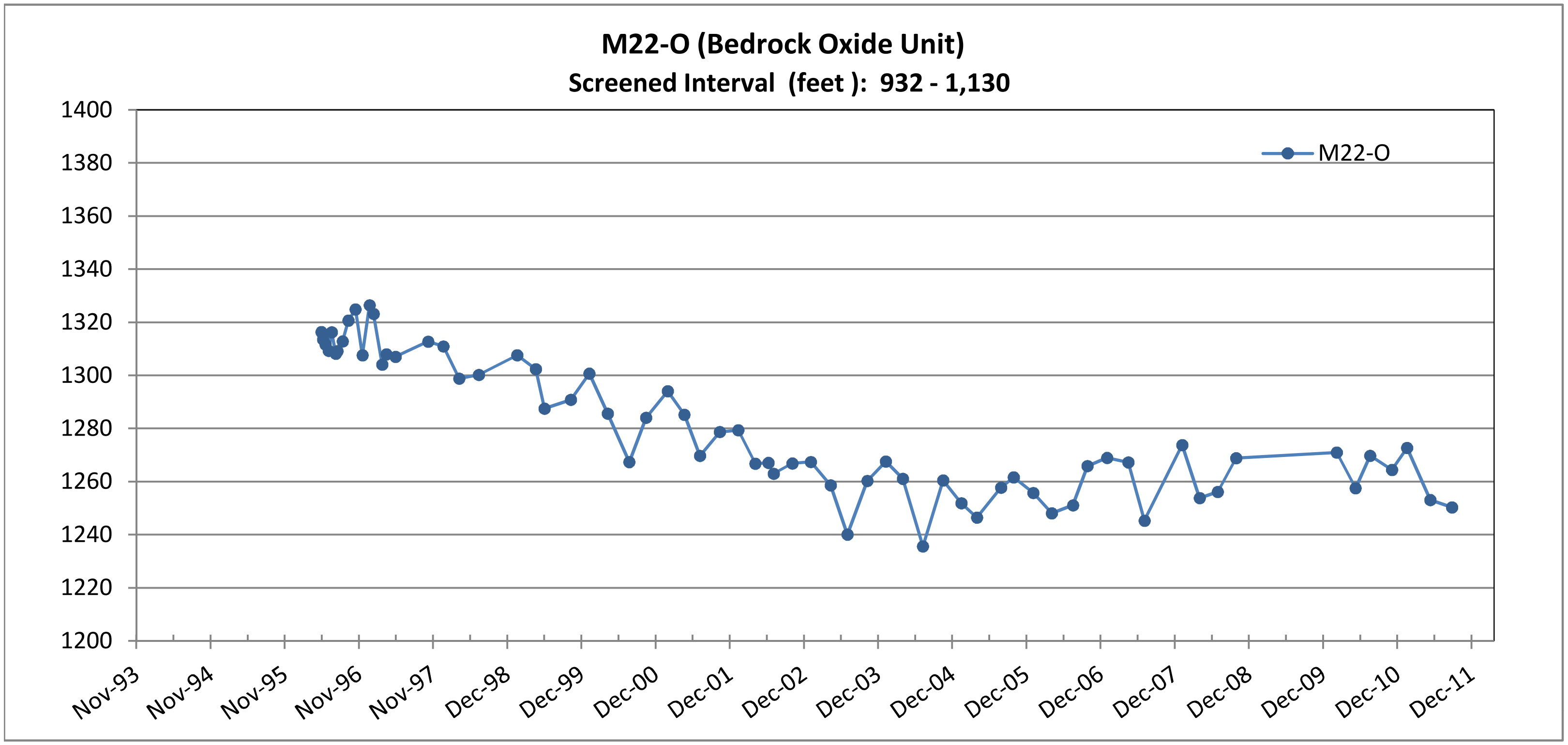
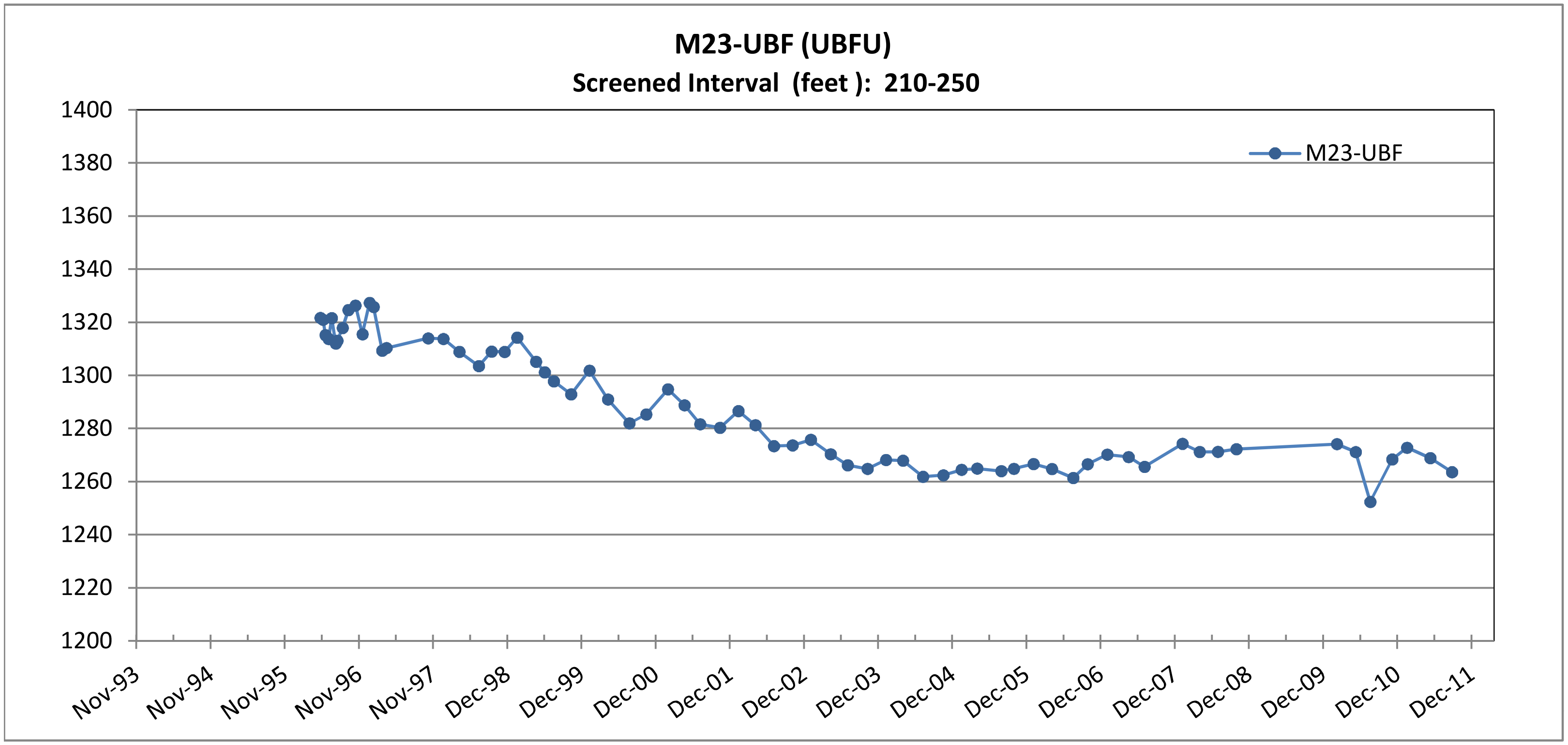
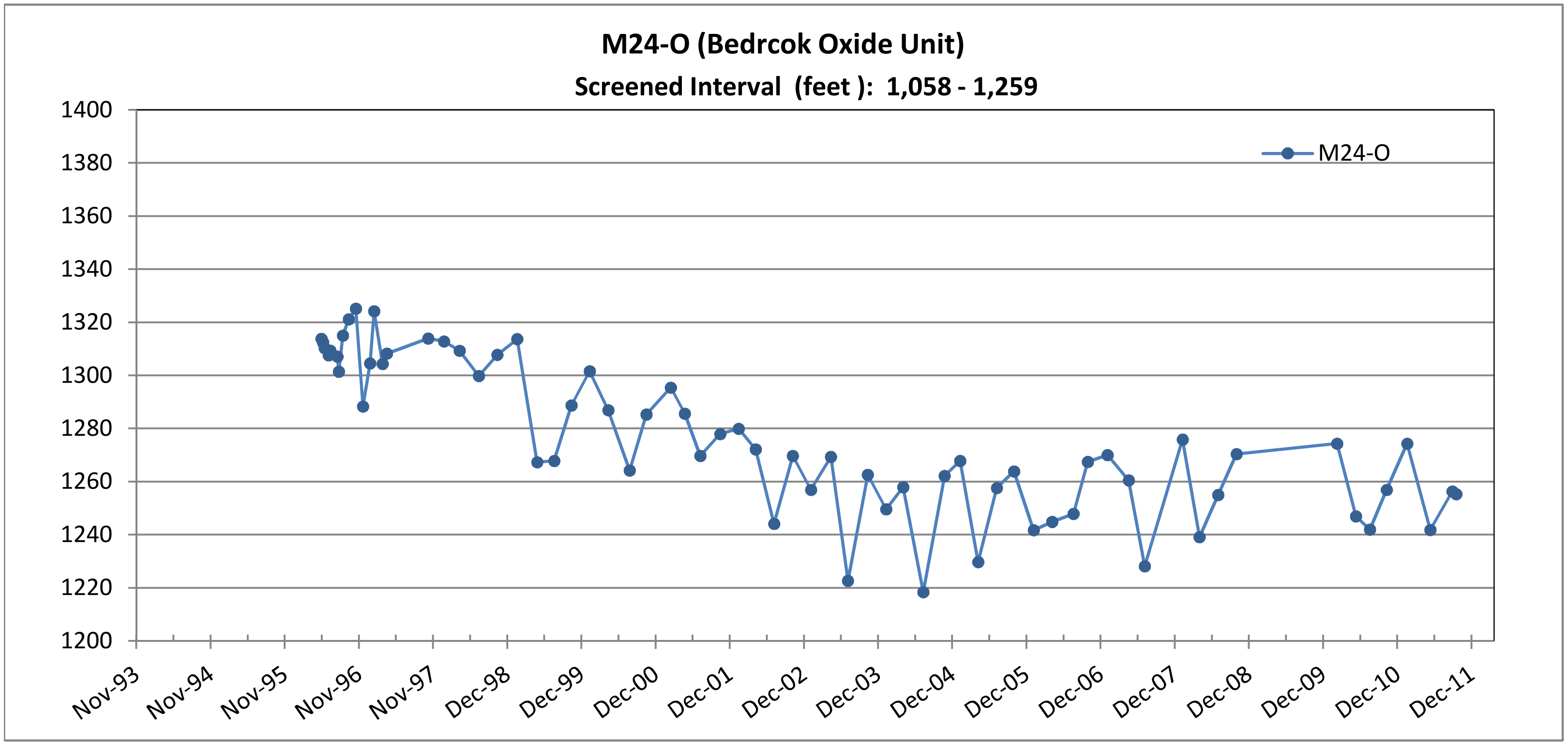

M22-O (Bedrock Oxide Unit)
Screened Interval (feet): 932 - 1,130
M22-O
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11

Figure 14C-17




M24-O (Bedrcok Oxide Unit)
Screened Interval (feet): 1,058 - 1,259
M24-O
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
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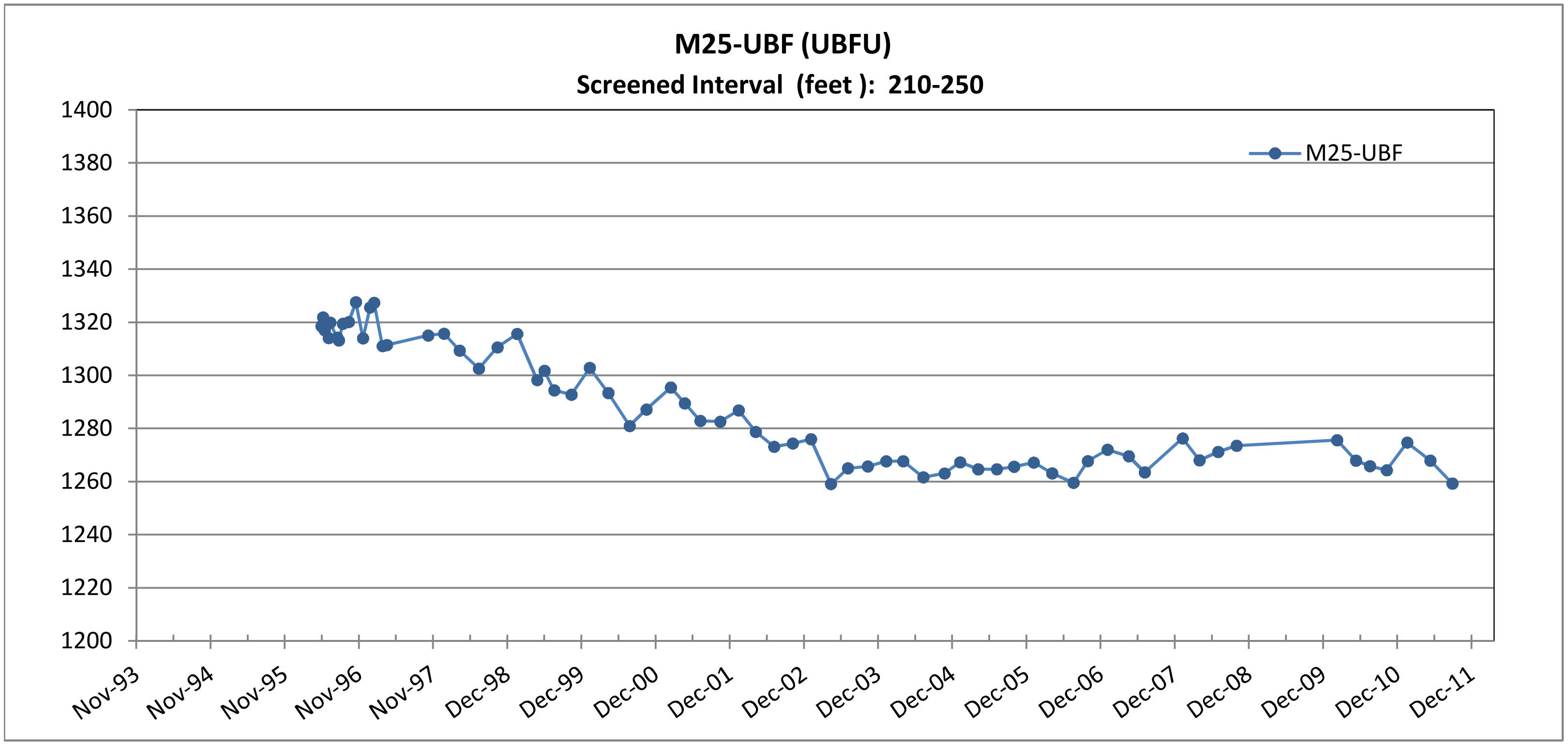
Dec-09
Dec-10
Dec-11


M25-UBF (UBFU)
Screened Interval (feet): 210-250
M25-UBF
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
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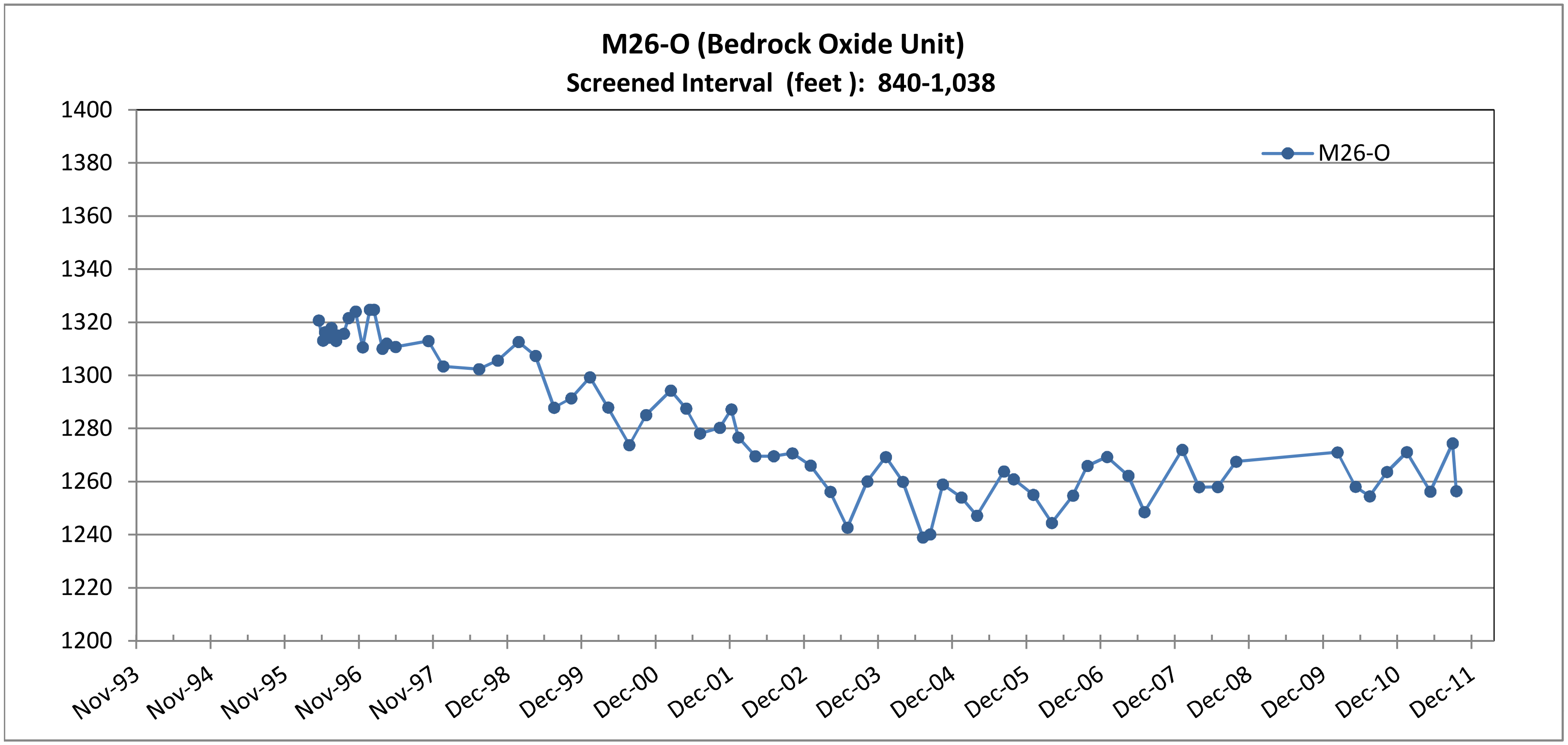
Dec-08
Dec-09
Dec-10
Dec-11


M26-O (Bedrock Oxide Unit)
Screened Interval (feet): 840-1,038
M26-O
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
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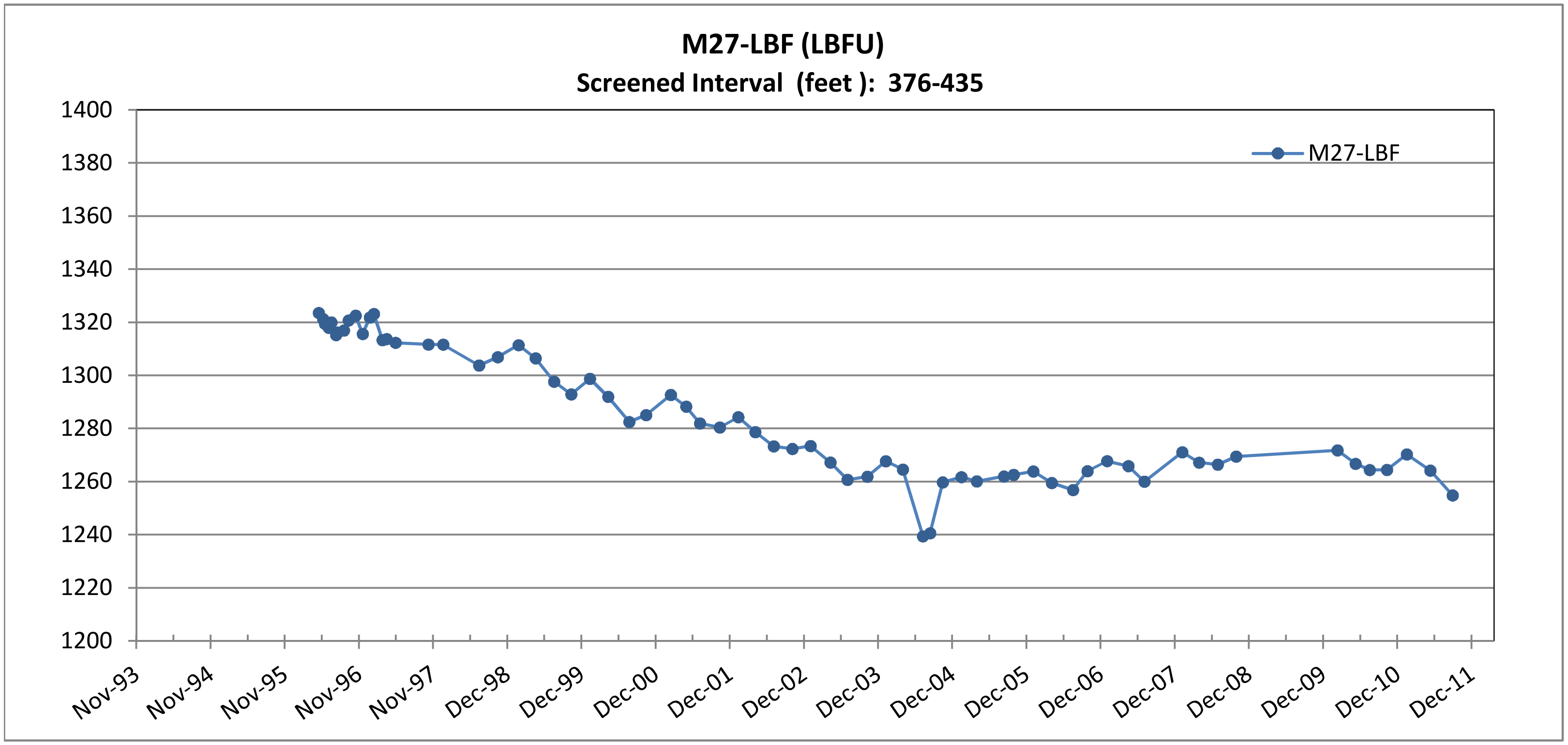
Dec-08
Dec-09
Dec-10
Dec-11


M27-LBF (LBFU)
Screened Interval (feet): 376-435
M27-LBF
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
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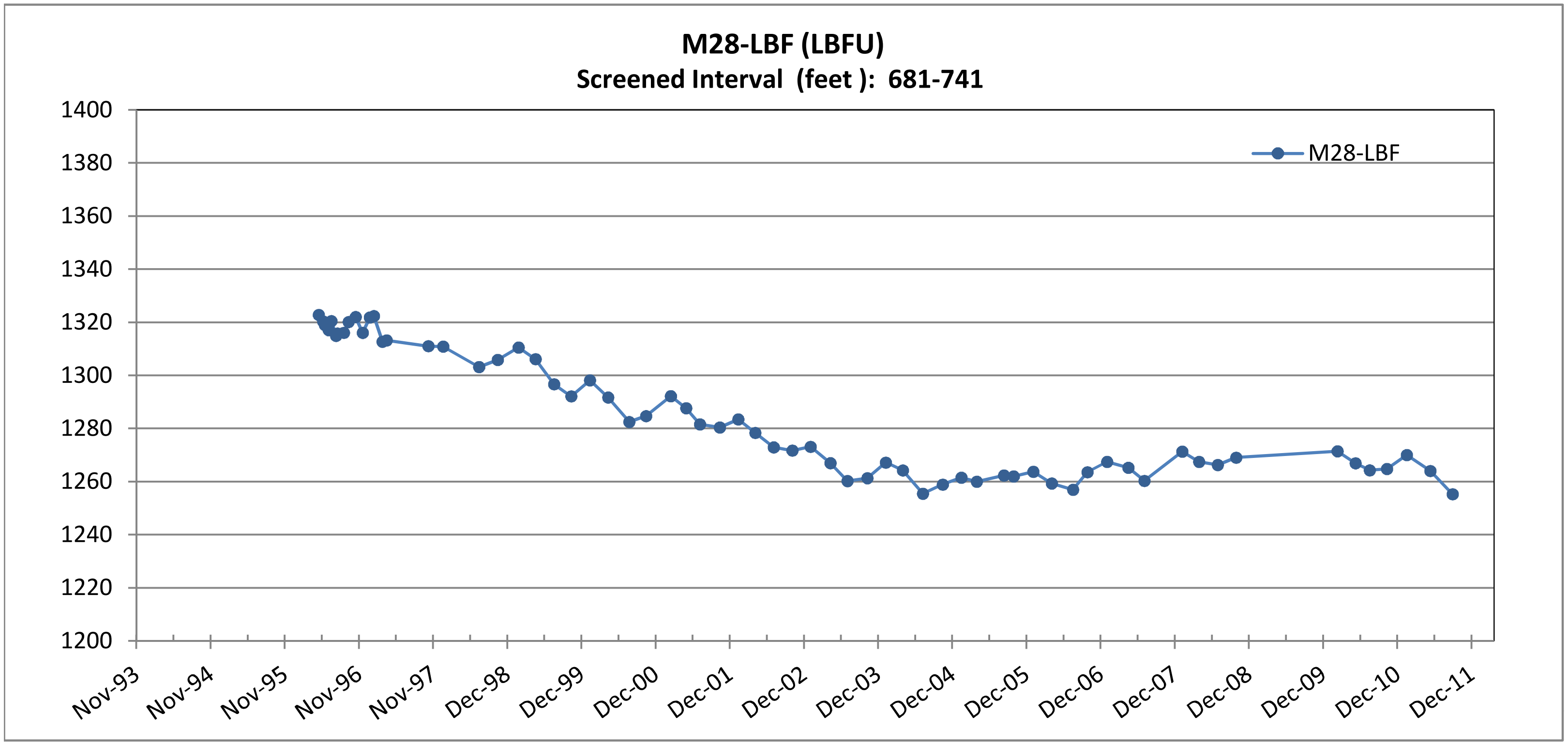
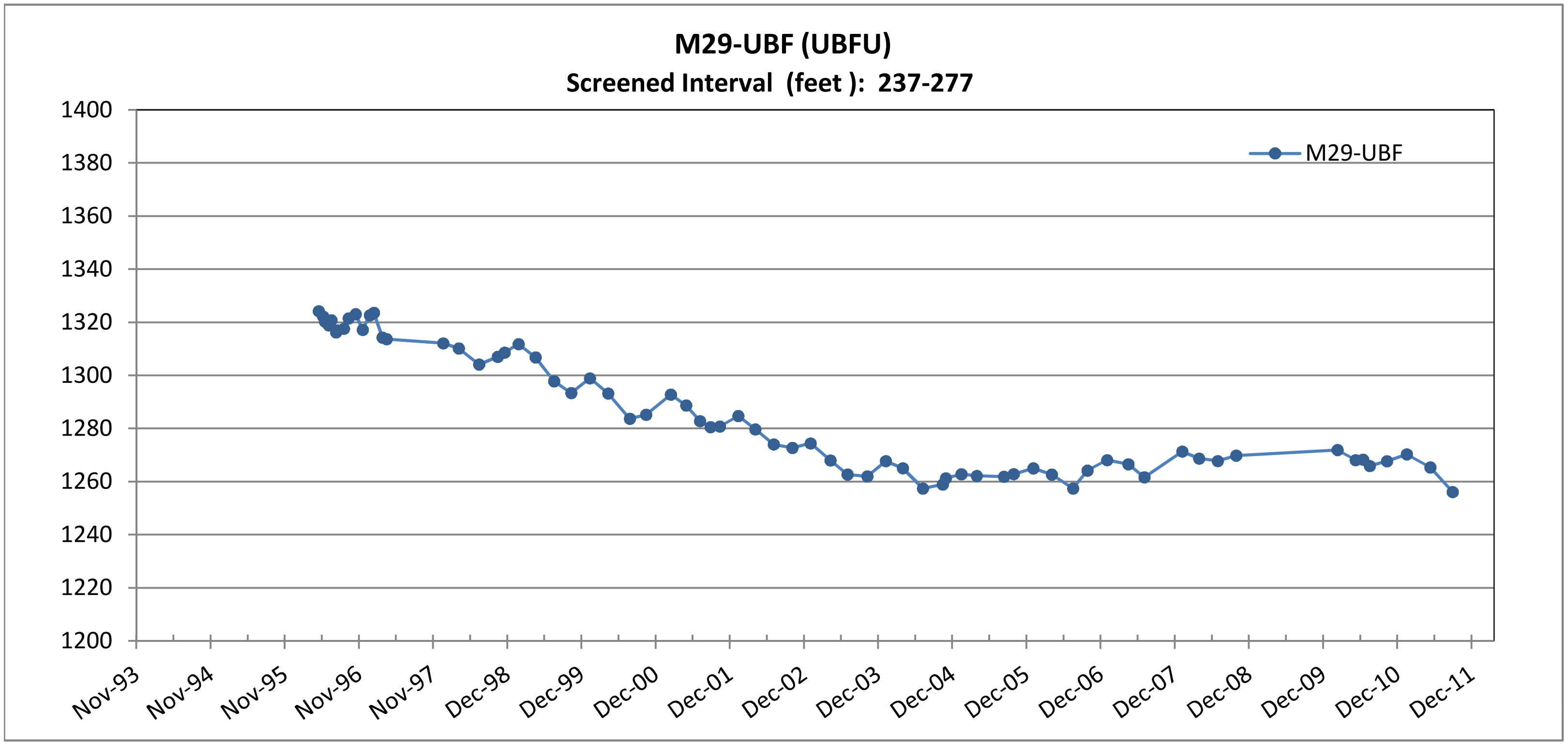
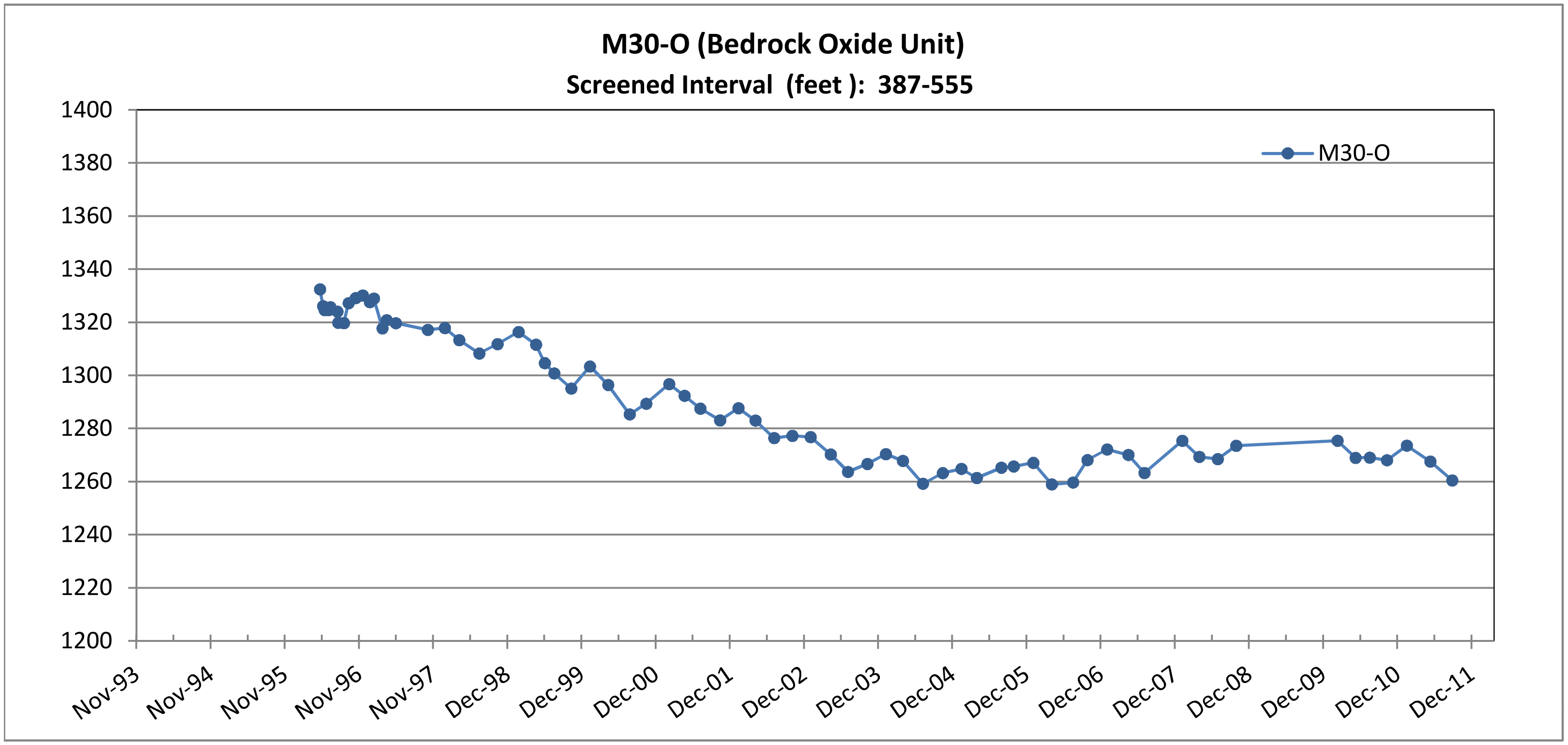
Dec-09
Dec-10
Dec-11


M28-LBF (LBFU)
Screened Interval (feet): 681-741
M28-LBF
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11


M29-UBF (UBFU)
Screened Interval (feet): 237-277
M29-UBF
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11


M30-O (Bedrock Oxide Unit)
Screened Interval (feet): 387-555
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
M30-O
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
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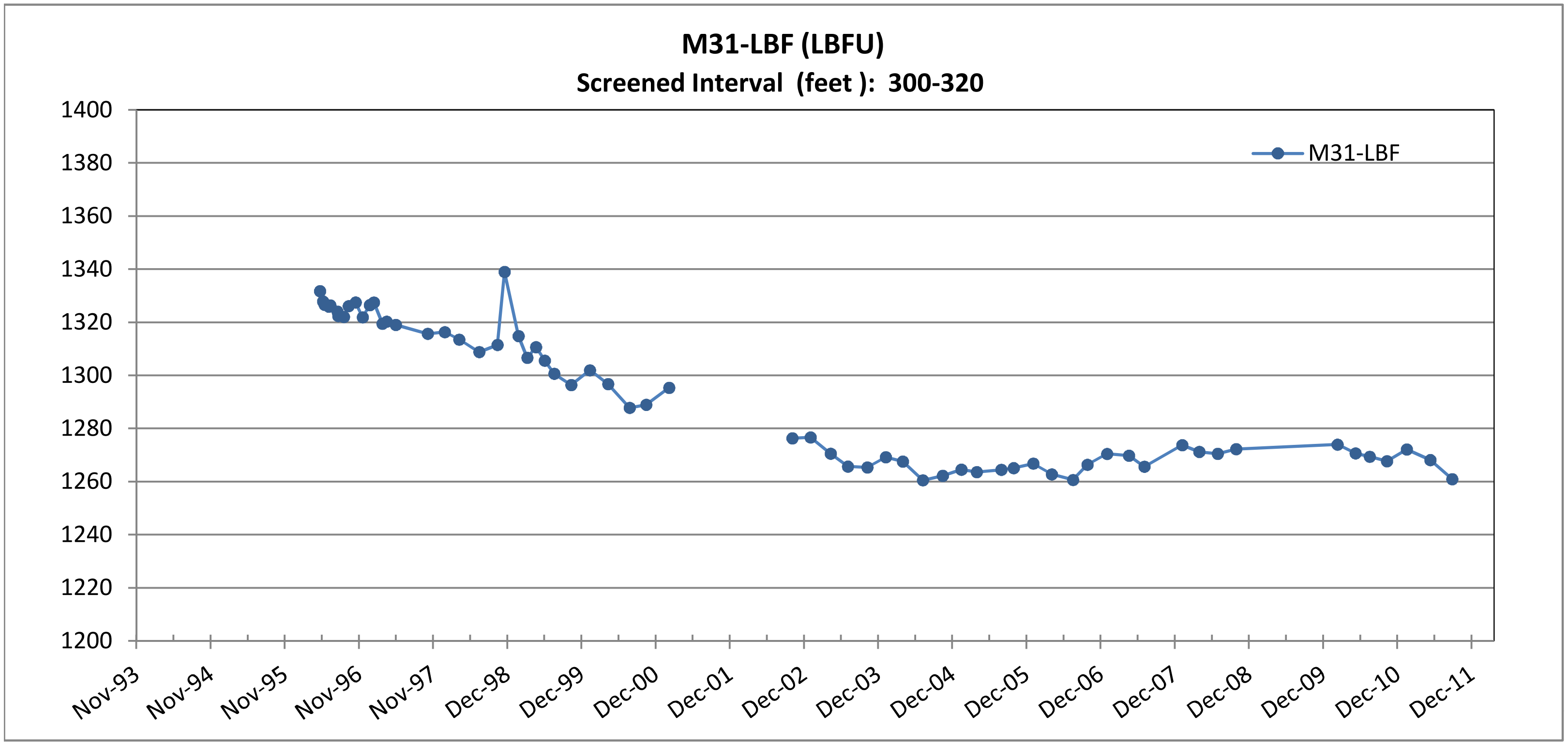
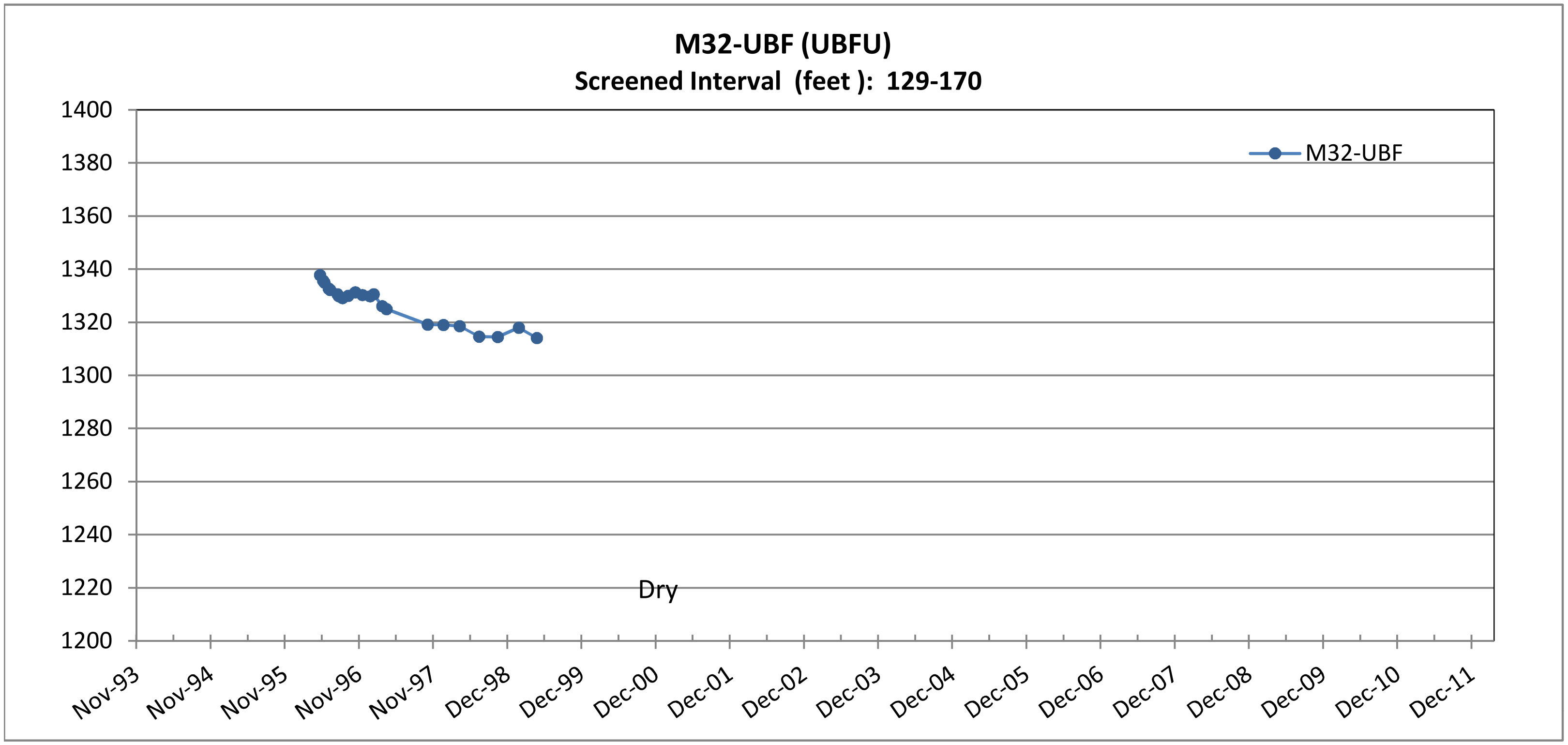
Dec-09
Dec-10
Dec-11


M31-LBF (LBFU)
Screened Interval (feet): 300-320
M31-LBF
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11


M32-UBF (UBFU)
Screened Interval (feet): 129-170
M32-UBF
Dry
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
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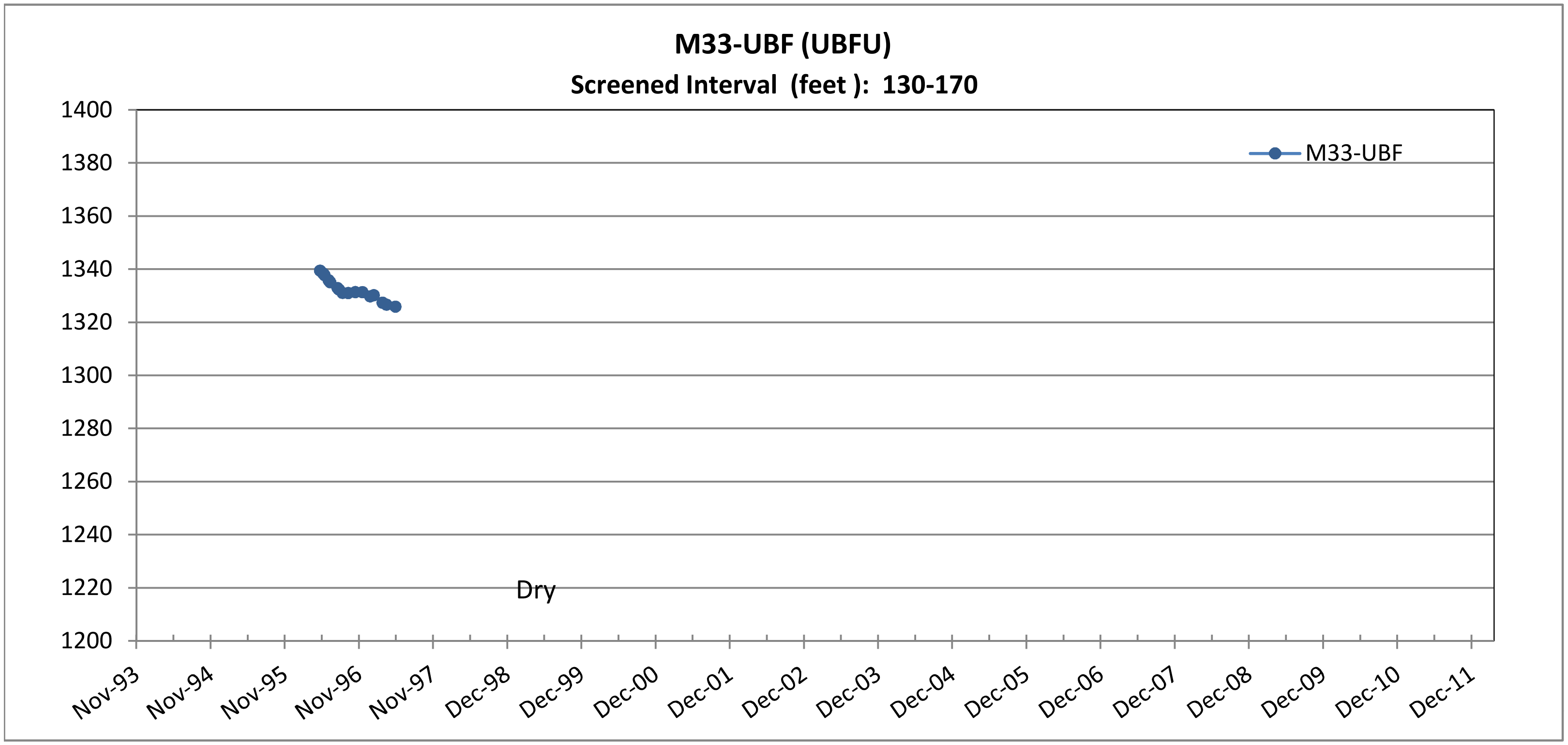
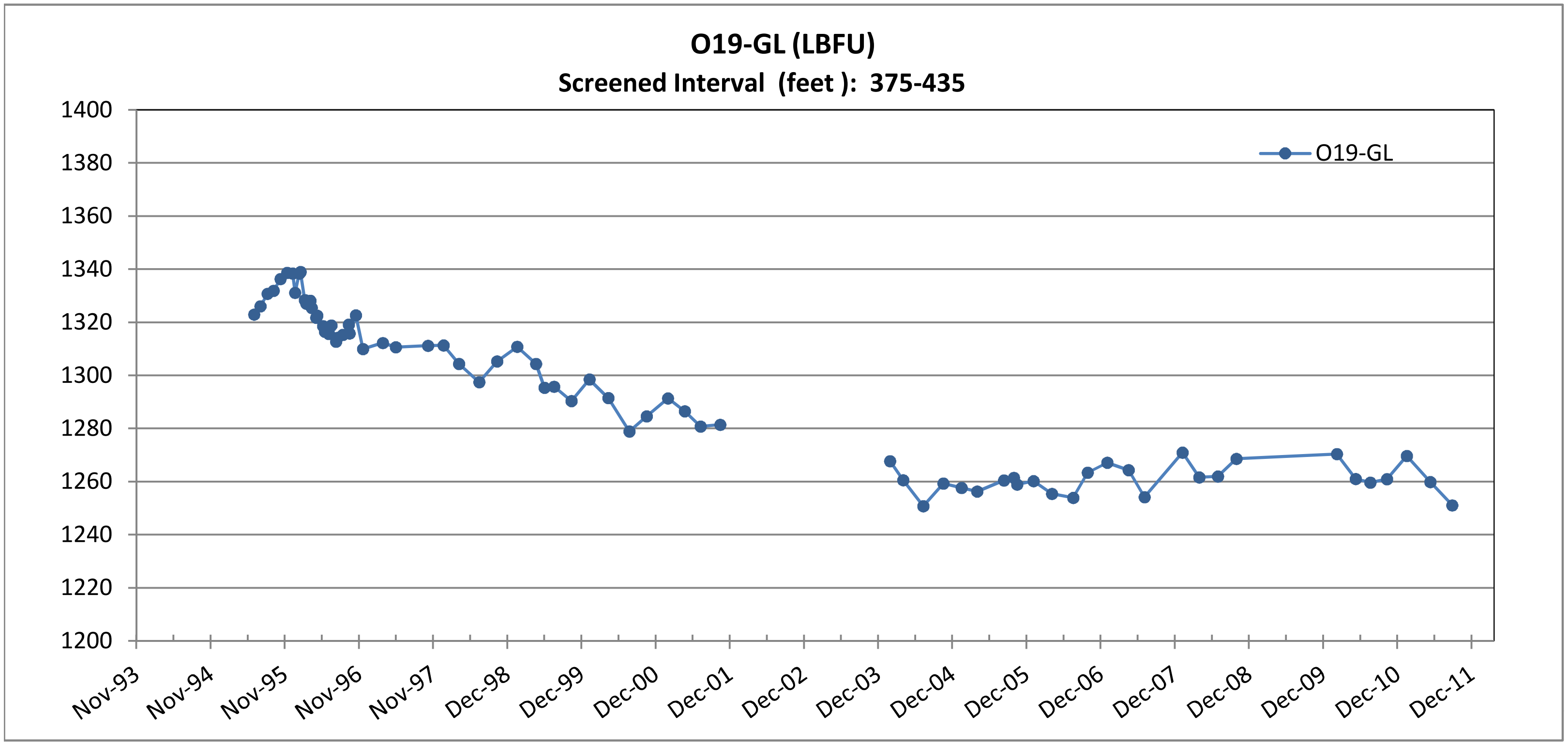
Dec-08
Dec-09
Dec-10
Dec-11


M33-UBF (UBFU)
Screened Interval (feet): 130-170
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
M33-UBF
Dry
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11


O19-GL (LBFU)
Screened Interval (feet): 375-435
O19-GL
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
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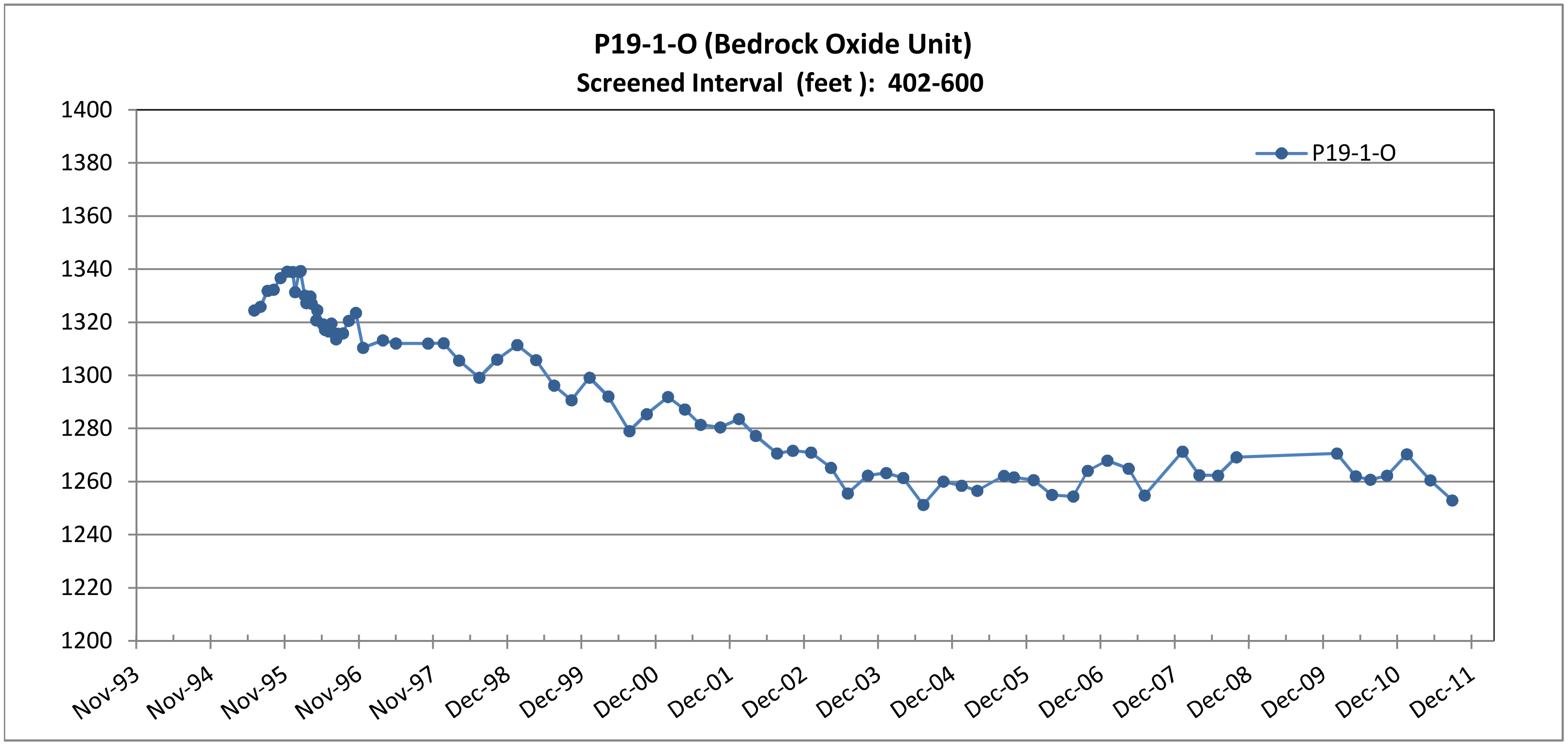
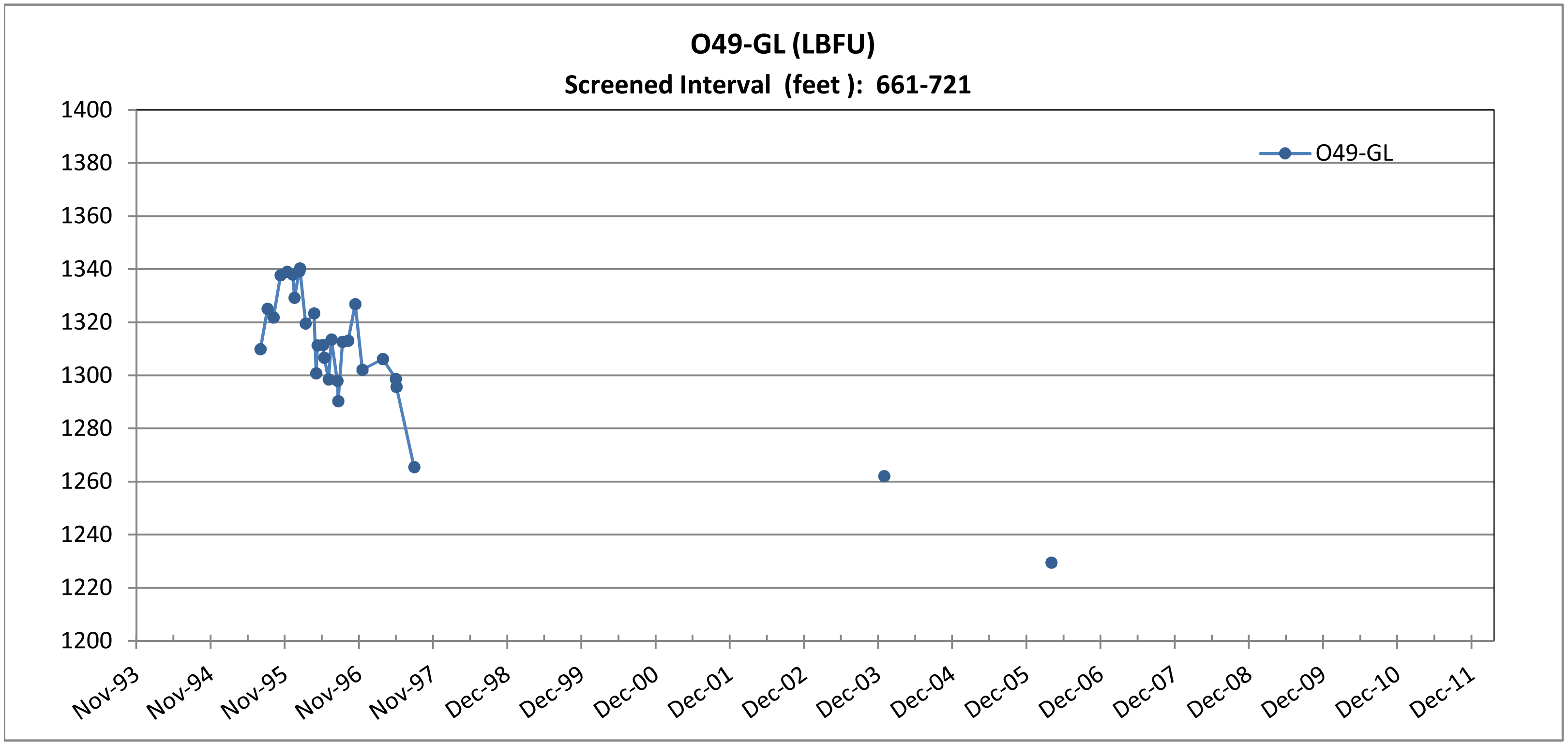
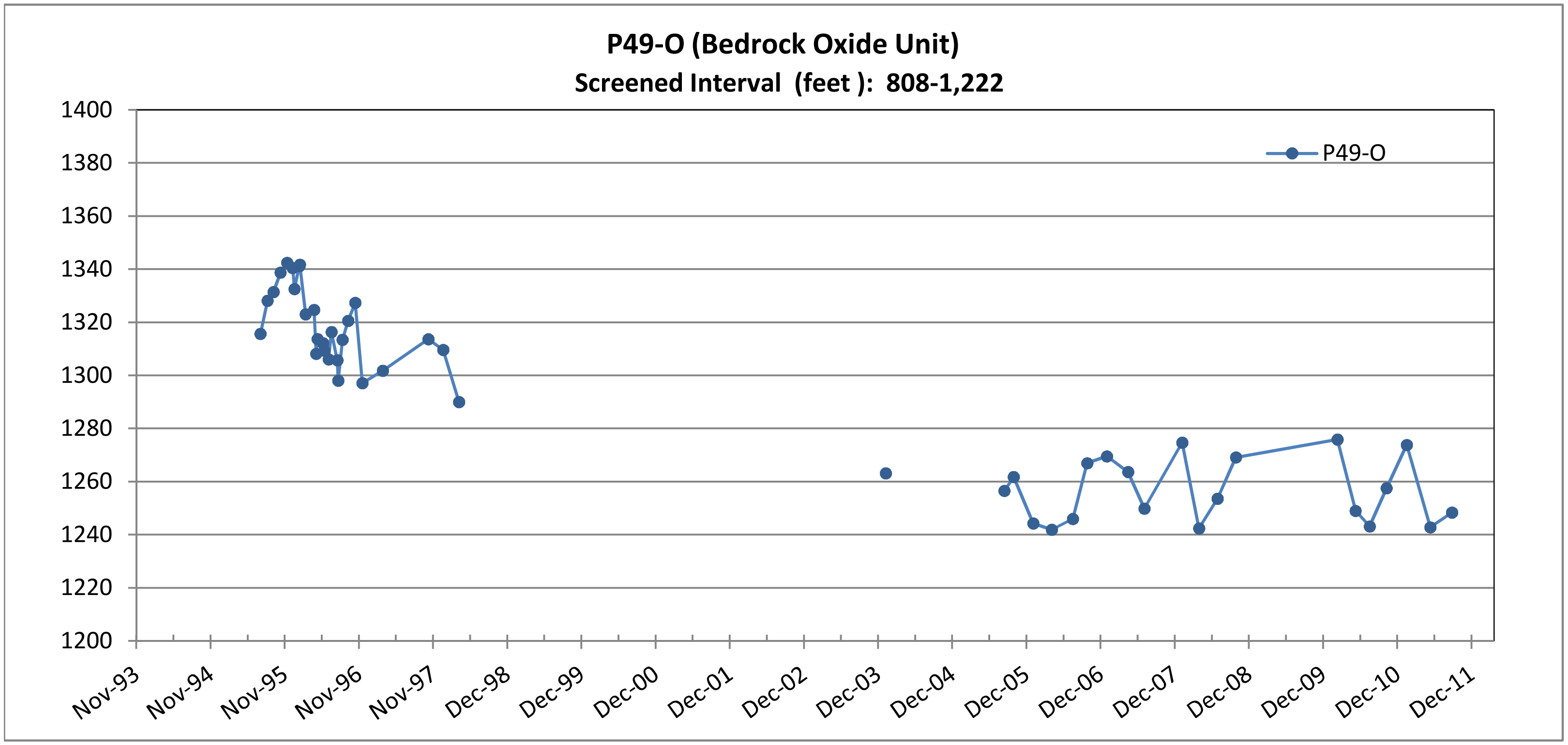
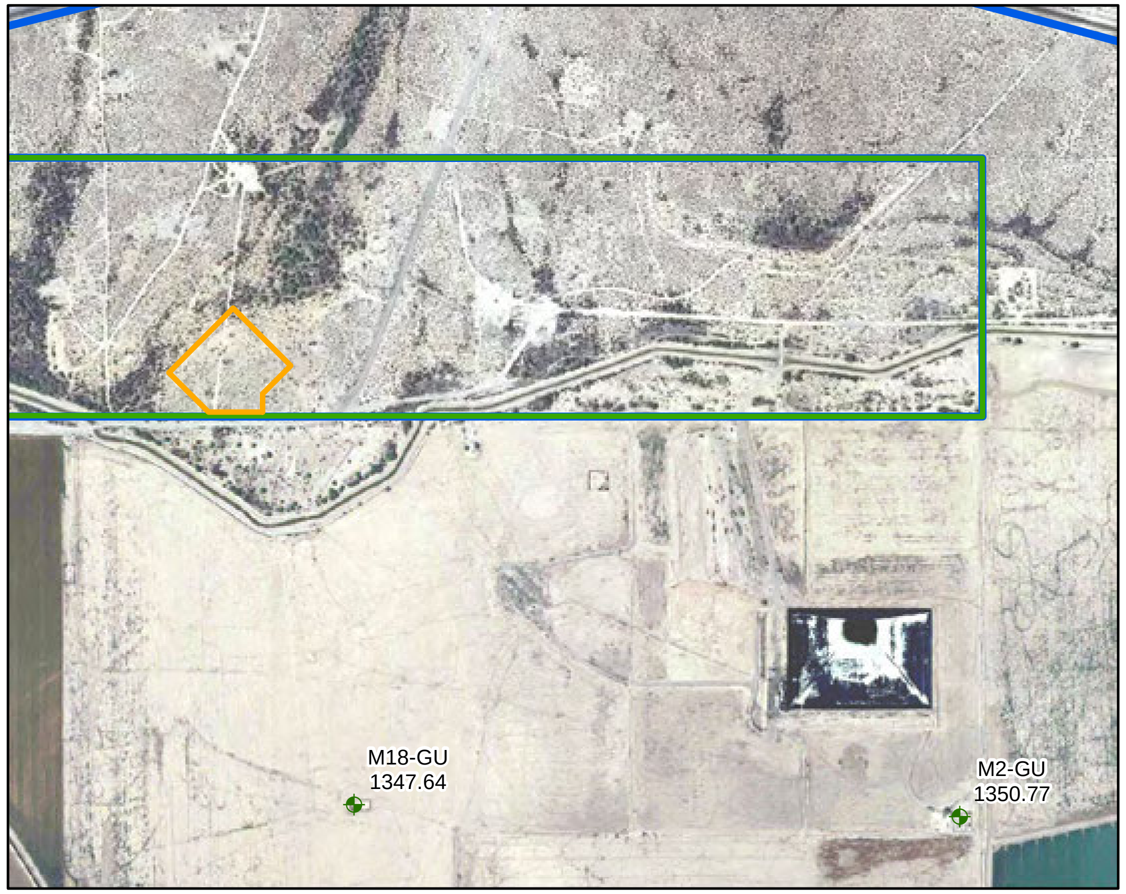
Dec-08
Dec-09
Dec-10
Dec-11

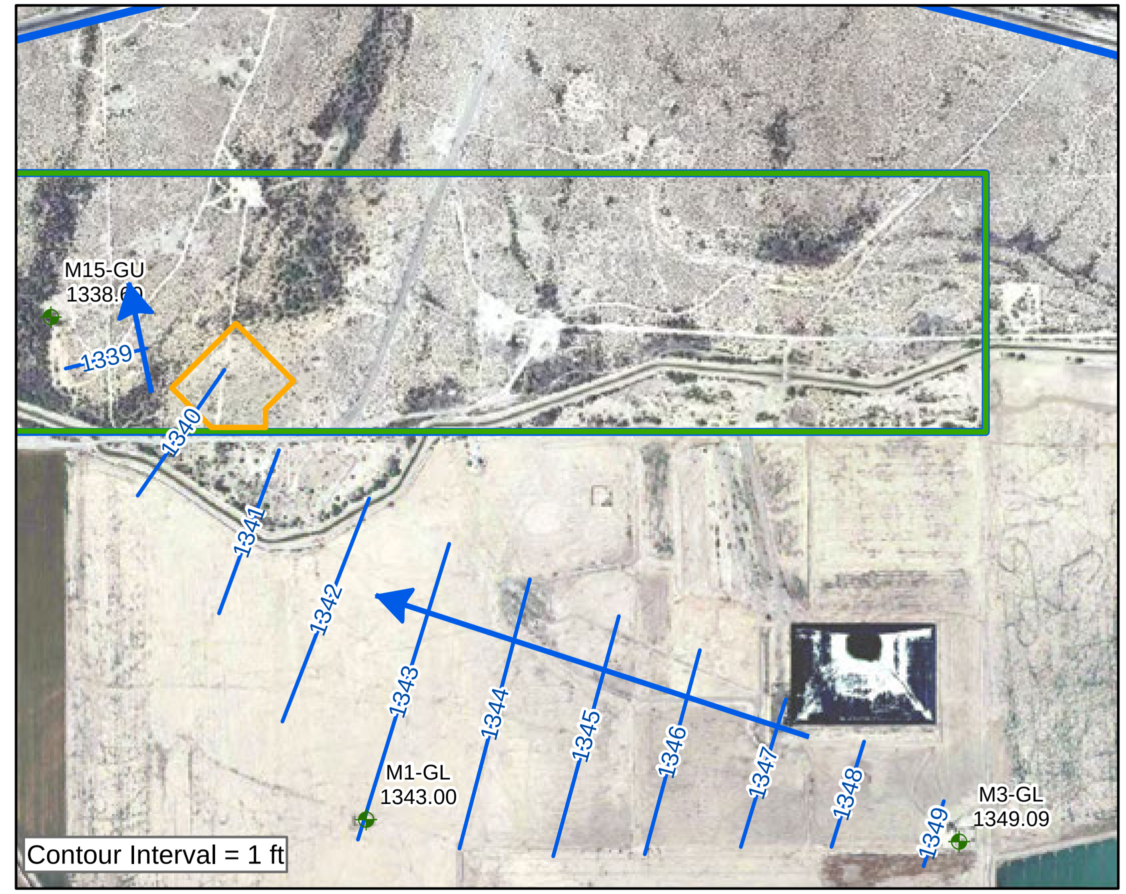

P19-1-O (Bedrock Oxide Unit)
Screened Interval (feet): 402-600
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
P19-1-O
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11


O49-GL (LBFU)
Screened Interval (feet): 661-721
O49-GL
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11

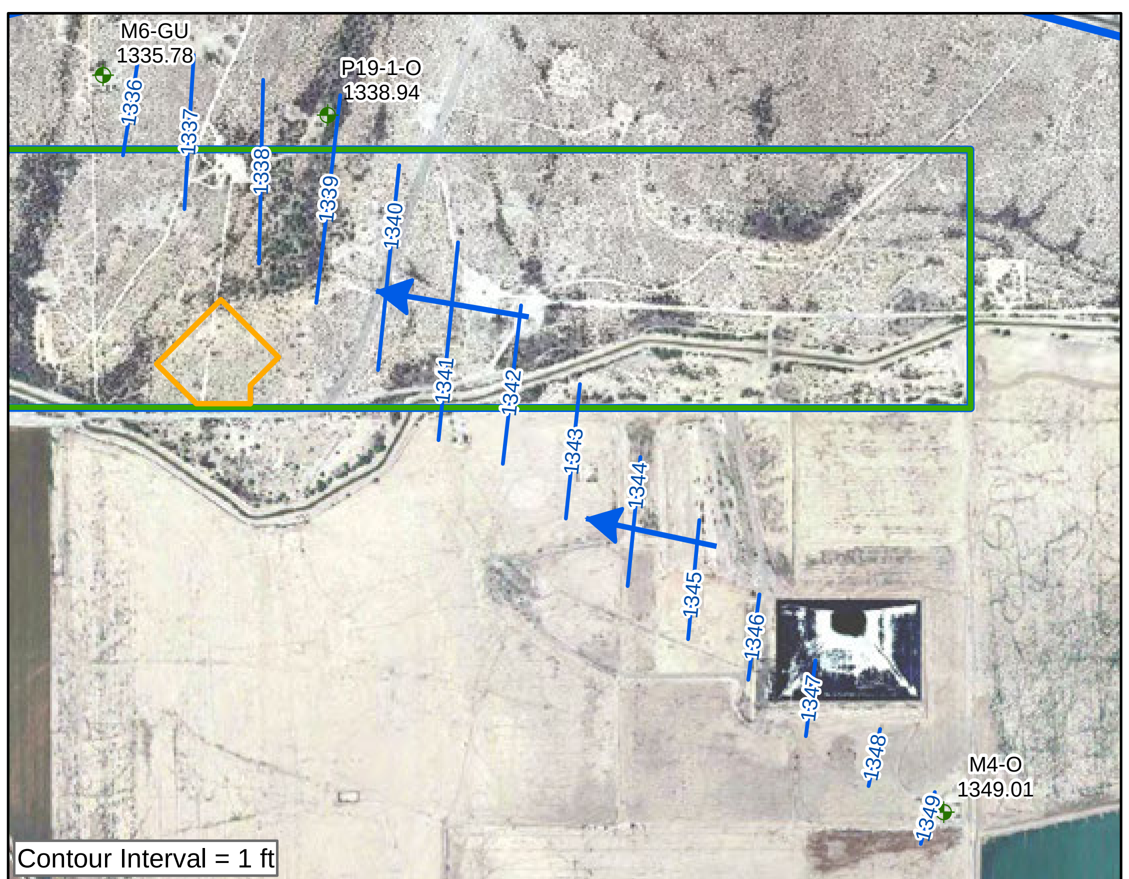

P49-O (Bedrock Oxide Unit)
Screened Interval (feet): 808-1,222
P49-O
1400
1380
1360
1340
1320
1300
1280
1260
1240
1220
1200
Nov-93
Nov-94
Nov-95
Nov-96
Nov-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11



JANUARY 1996 - UPPER BASIN FILL UNIT



JANUARY 1996 - LOWER BASIN FILL UNIT



JANUARY 1996- BEDROCK OXIDE UNIT

0 500 1,000

SCALE IN FEET

EXPLANATION

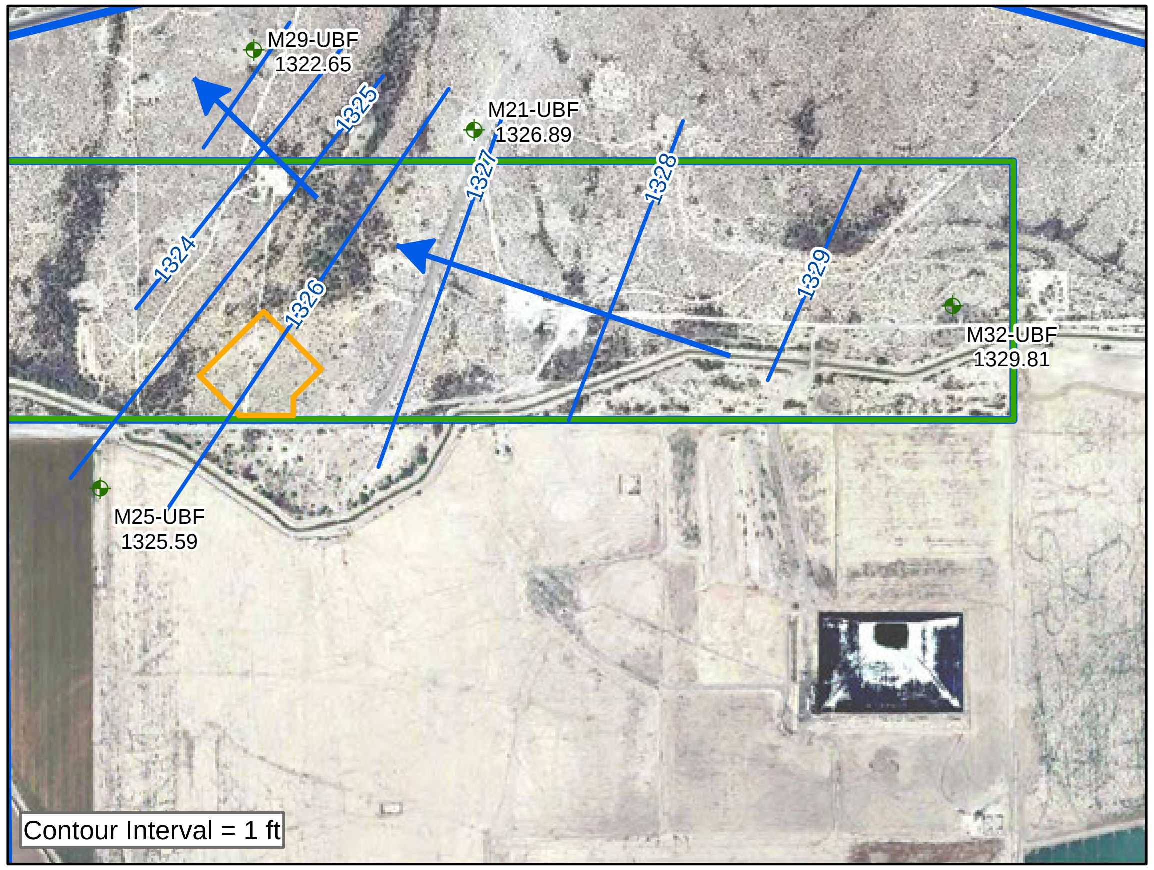
- MONITOR WELL LOCATION
  1343.00 Groundwater Elevation (ft msl)
- PTF WELL FIELD
- STATE LAND LEASE
- CURIS PROPERTY BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION

Figure 14C-32
1996
GROUNDWATER
ELEVATIONS

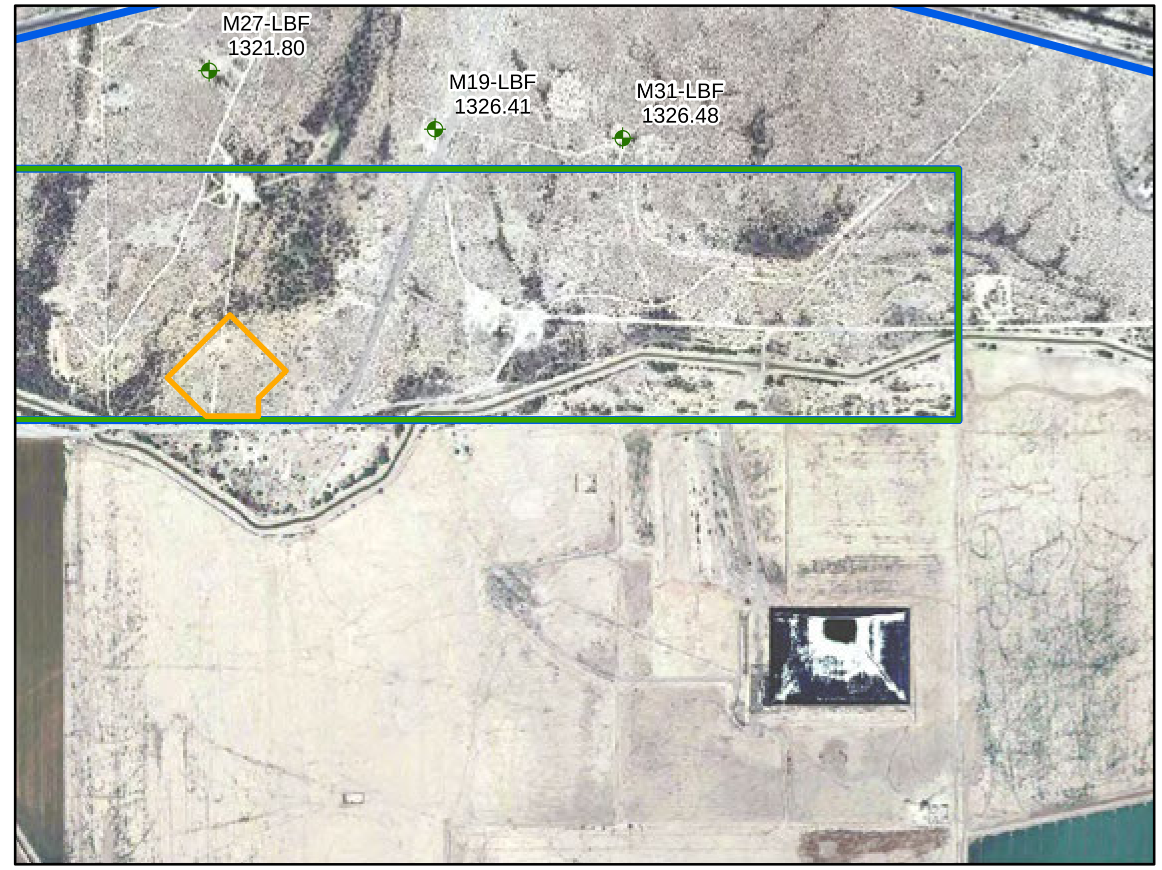
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

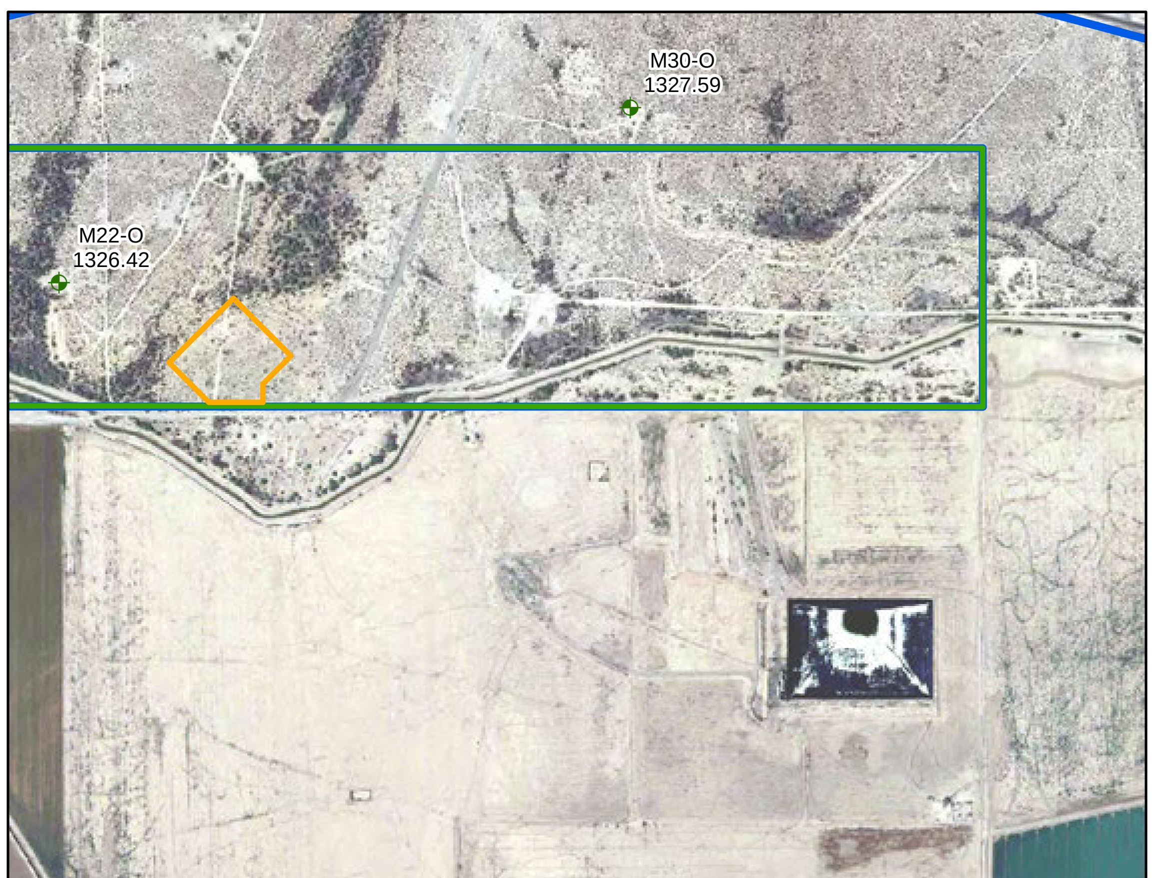
\\BCPHX03\projects\Hunter Dickinson\Curis GIS\MXDs\Temp Permit2012\WaterElevationContours_1996.mxd Updated: 2/10/2012



JANUARY 1997 -UPPER BASIN FILL UNIT



JANUARY 1997 - LOWER BASIN FILL UNIT



JANUARY 1997- BEDROCK OXIDE UNIT

0 500 1,000

SCALE IN FEET

EXPLANATION

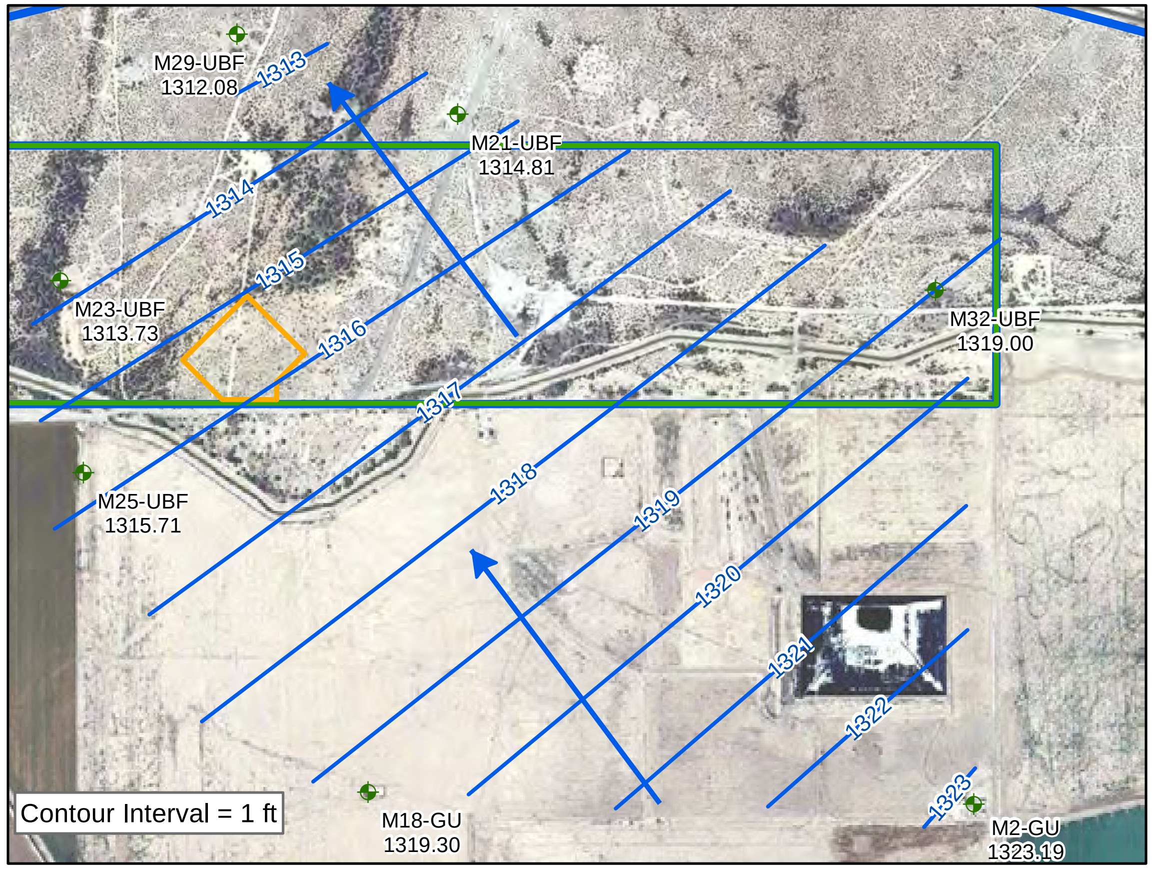
- MONITOR WELL LOCATION
  1325.59 Groundwater Elevation (ft msl)
- PTF WELL FIELD
- STATE LAND LEASE
- CURIS PROPERTY BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION

Figure 14C-33
1997
GROUNDWATER ELEVATIONS

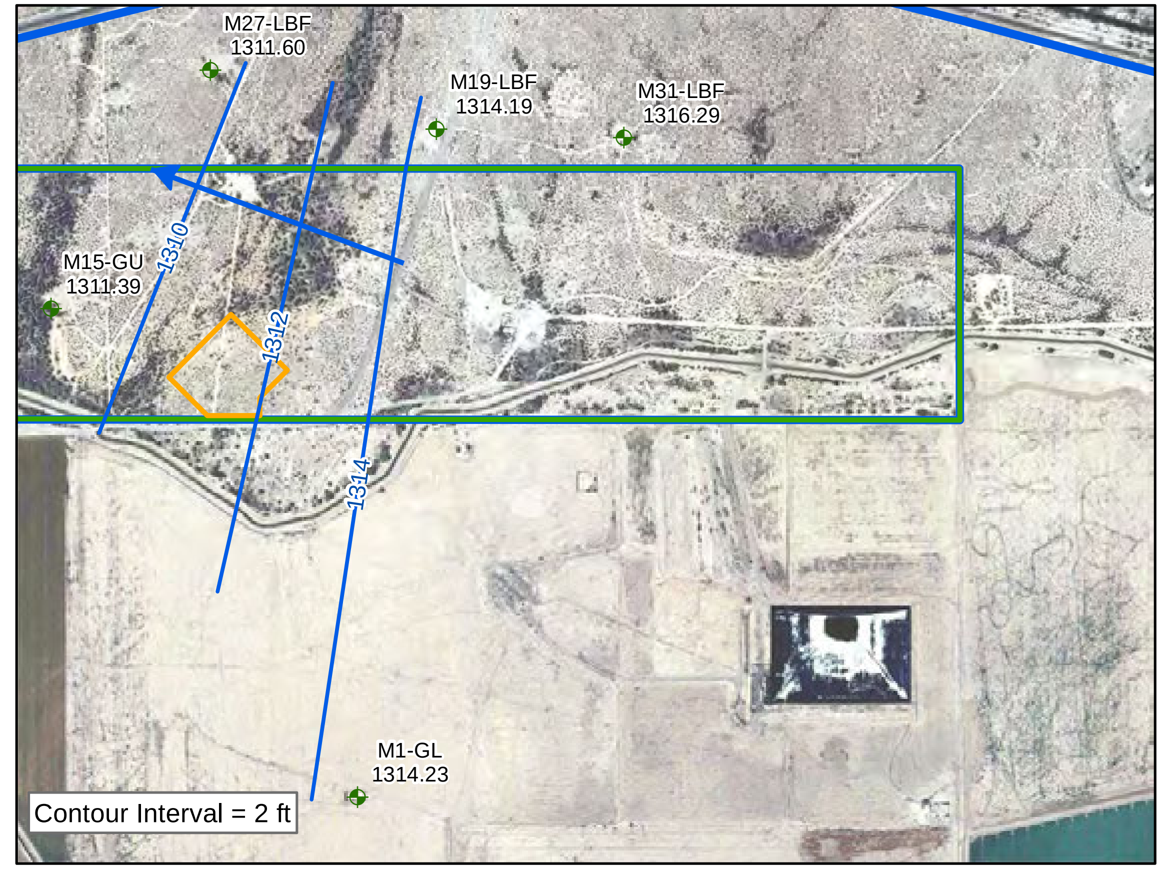
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

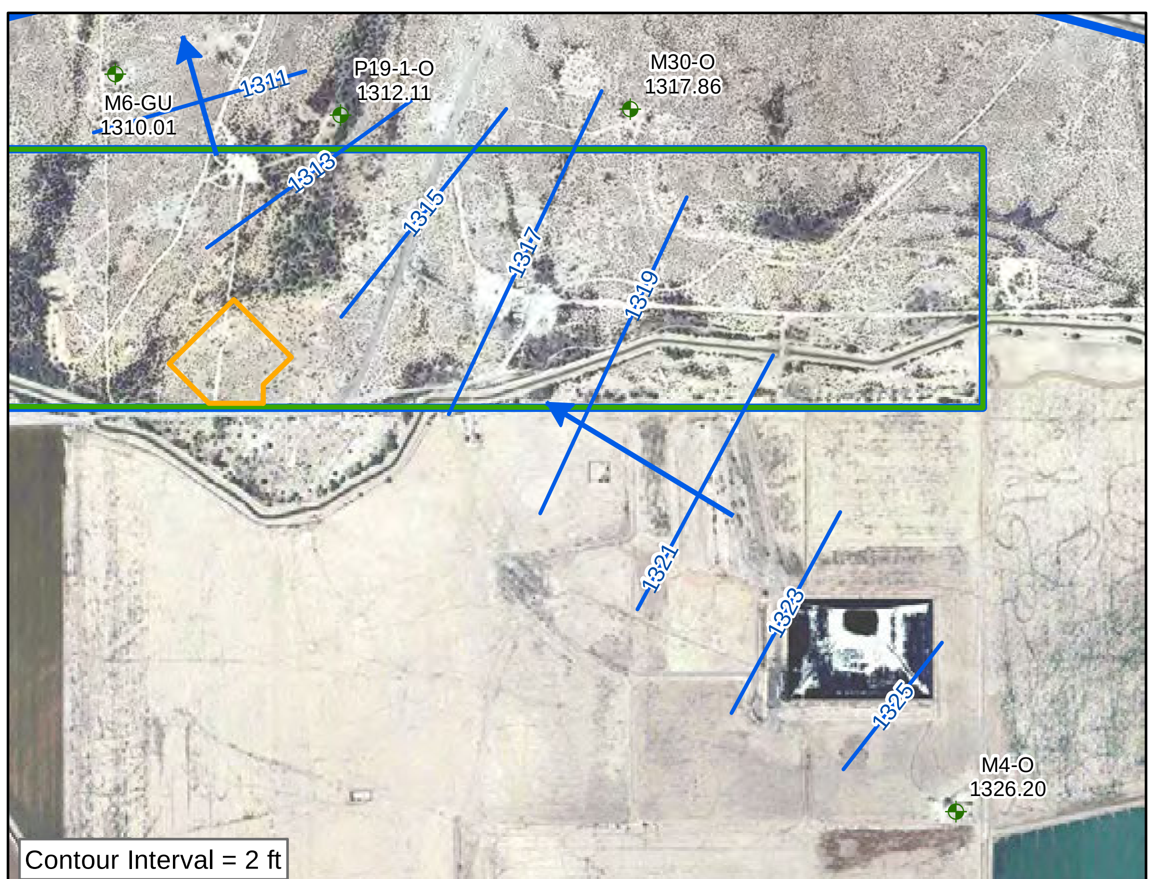
\\BCPHX03\projects\Hunter Dickinson\Curis GIS\MXDs\Temp Permit2012\G14075334014C16_WLContour_1997.mxd Updated: 2/10/2012



JANUARY 1998 - UPPER BASIN FILL UNIT



JANUARY 1998 - LOWER BASIN FILL UNIT



JANUARY 1998- BEDROCK OXIDE UNIT

0 500 1,000
SCALE IN FEET

EXPLANATION

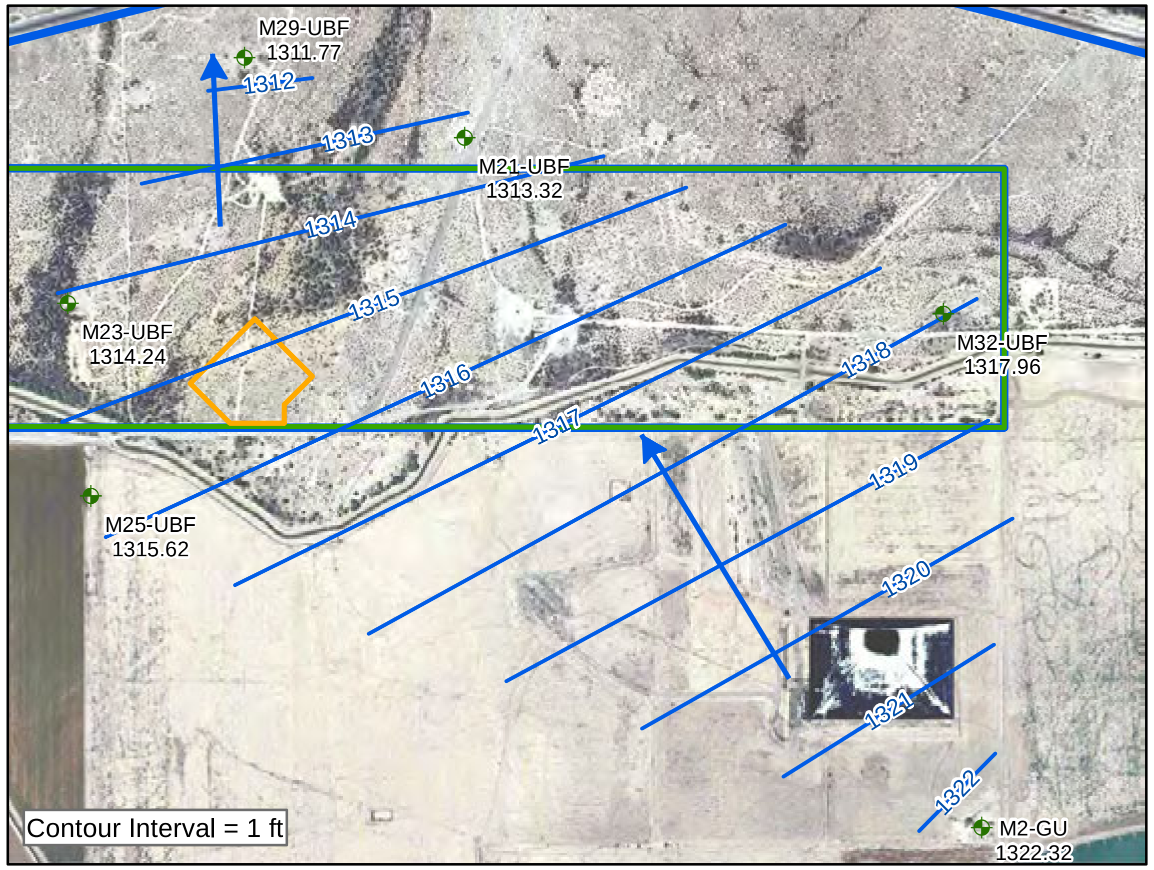
- MONITOR WELL LOCATION
  1312.11 Groundwater Elevation (ft msl)
- PTF WELL FIELD
- STATE LAND LEASE
- CURIS PROPERTY BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION

Figure 14C-34
1998
GROUNDWATER
ELEVATIONS

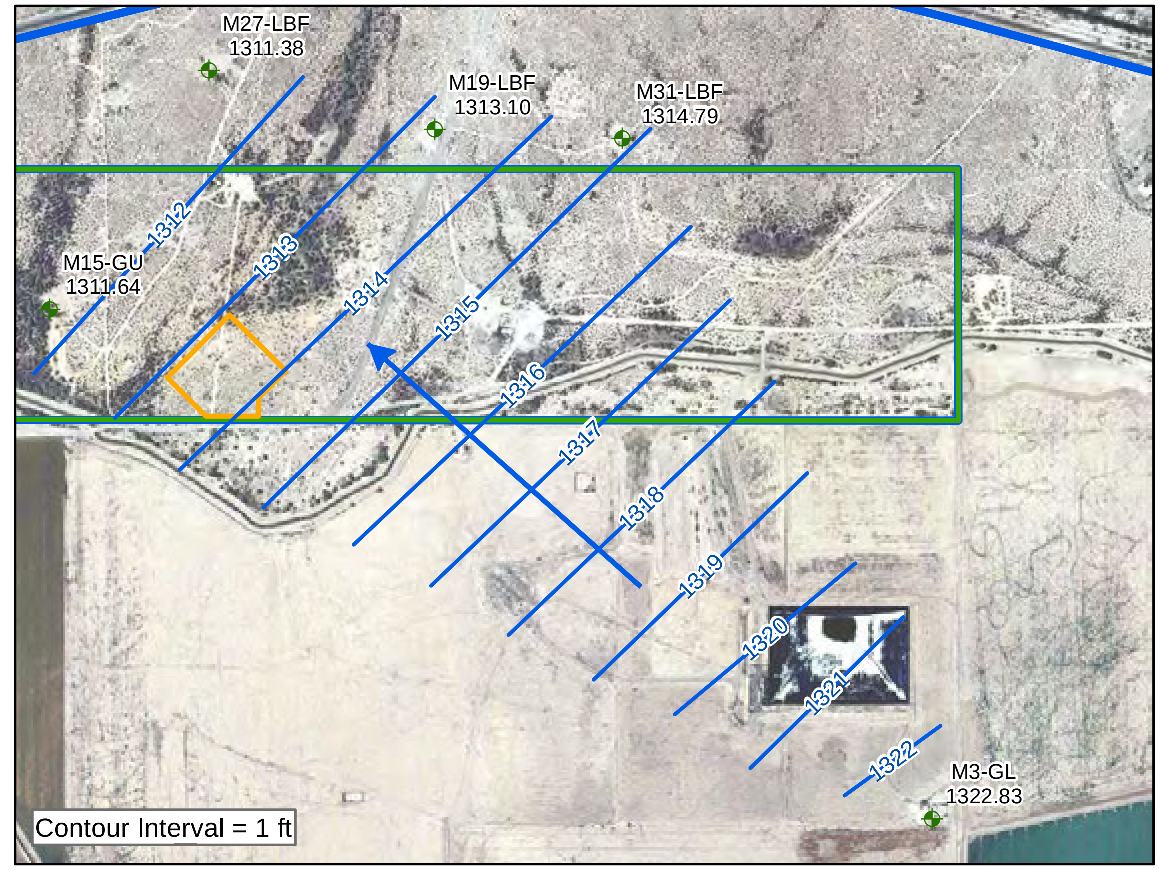
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

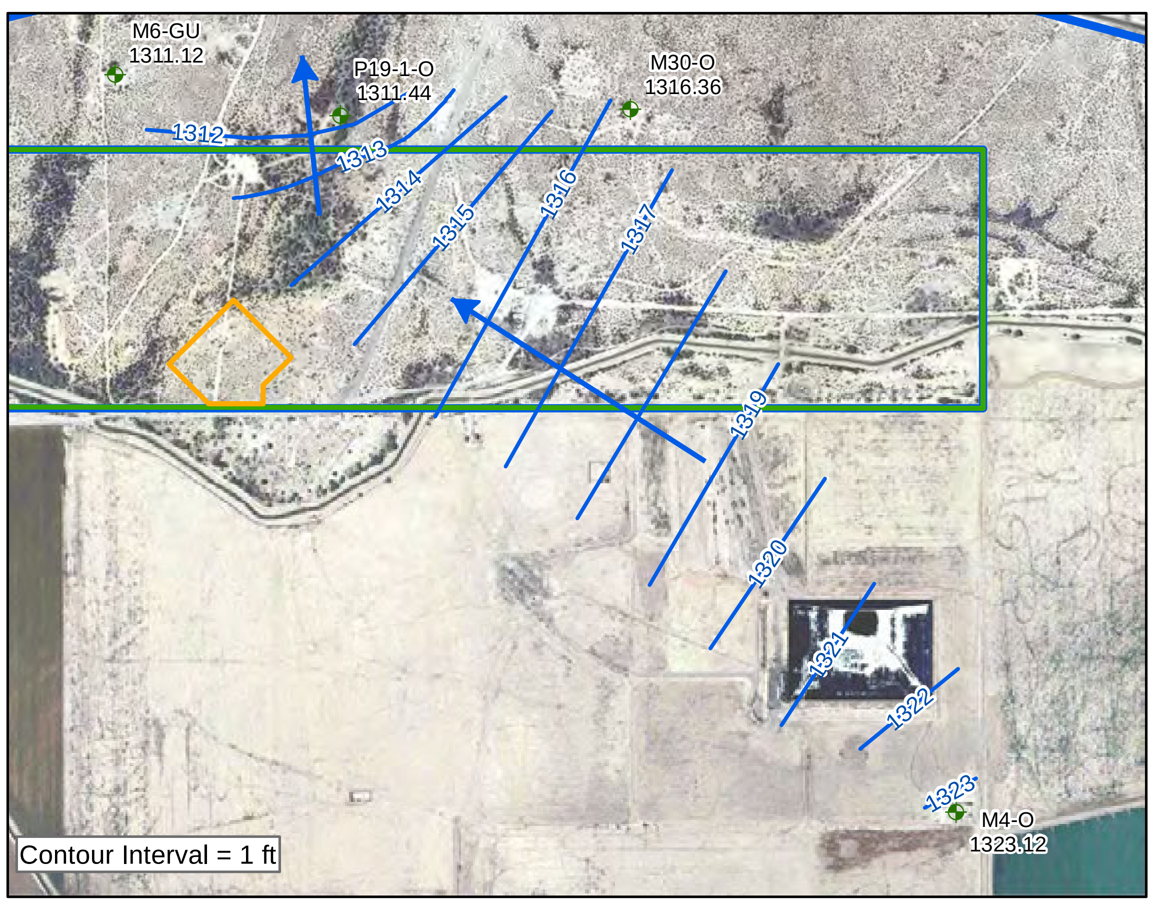
\\BCPHX03\projects\Hunter Dickinson\Curis GIS\MXDs\Temp Permit2012\G14075334014C17_WLContour_1998.mxd Updated: 1/23/2012



JANUARY 1999 - UPPER BASIN FILL UNIT



JANUARY 1999 - LOWER BASIN FILL UNIT



JANUARY 1999- BEDROCK OXIDE UNIT

0 500 1,000

SCALE IN FEET

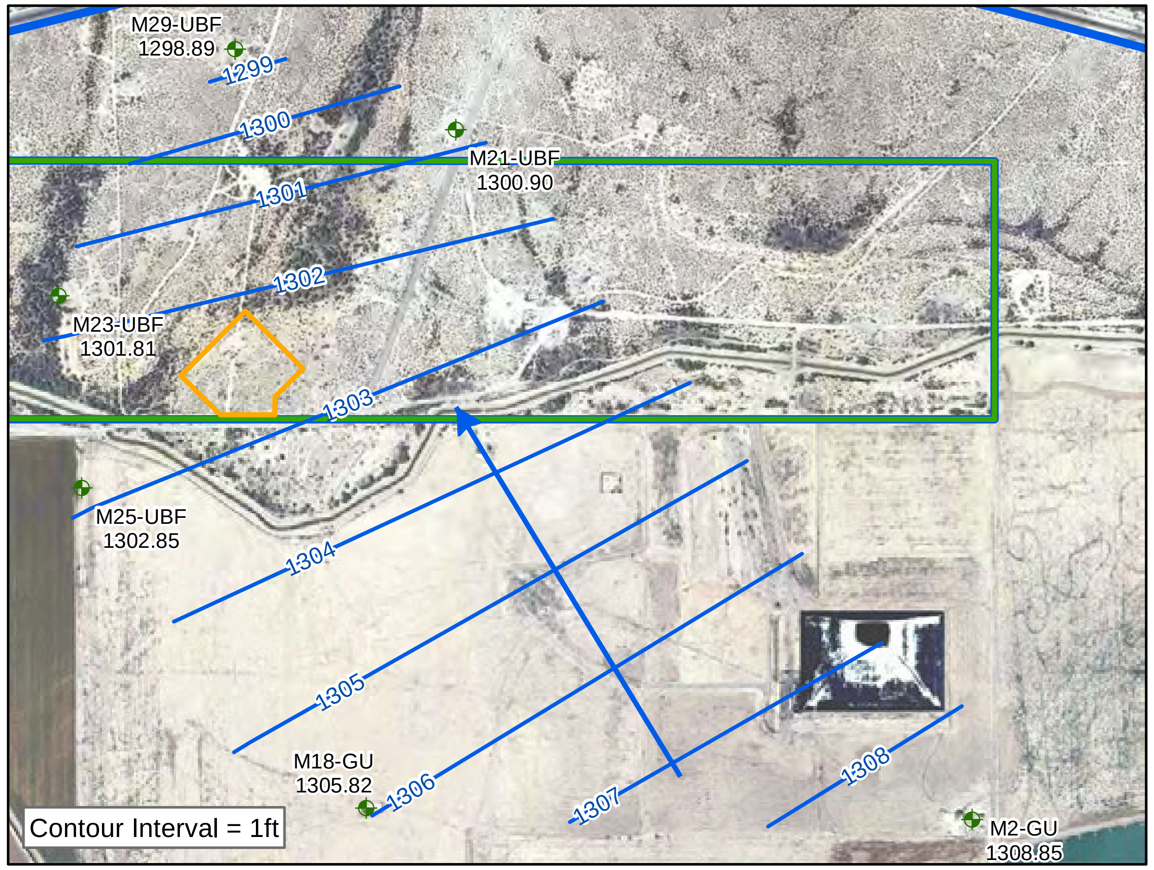
EXPLANATION

- MONITOR WELL LOCATION
  1311.12 Groundwater Elevation (ft msl)
- PTF WELL FIELD
- STATE LAND LEASE
- CURIS PROPERTY BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION

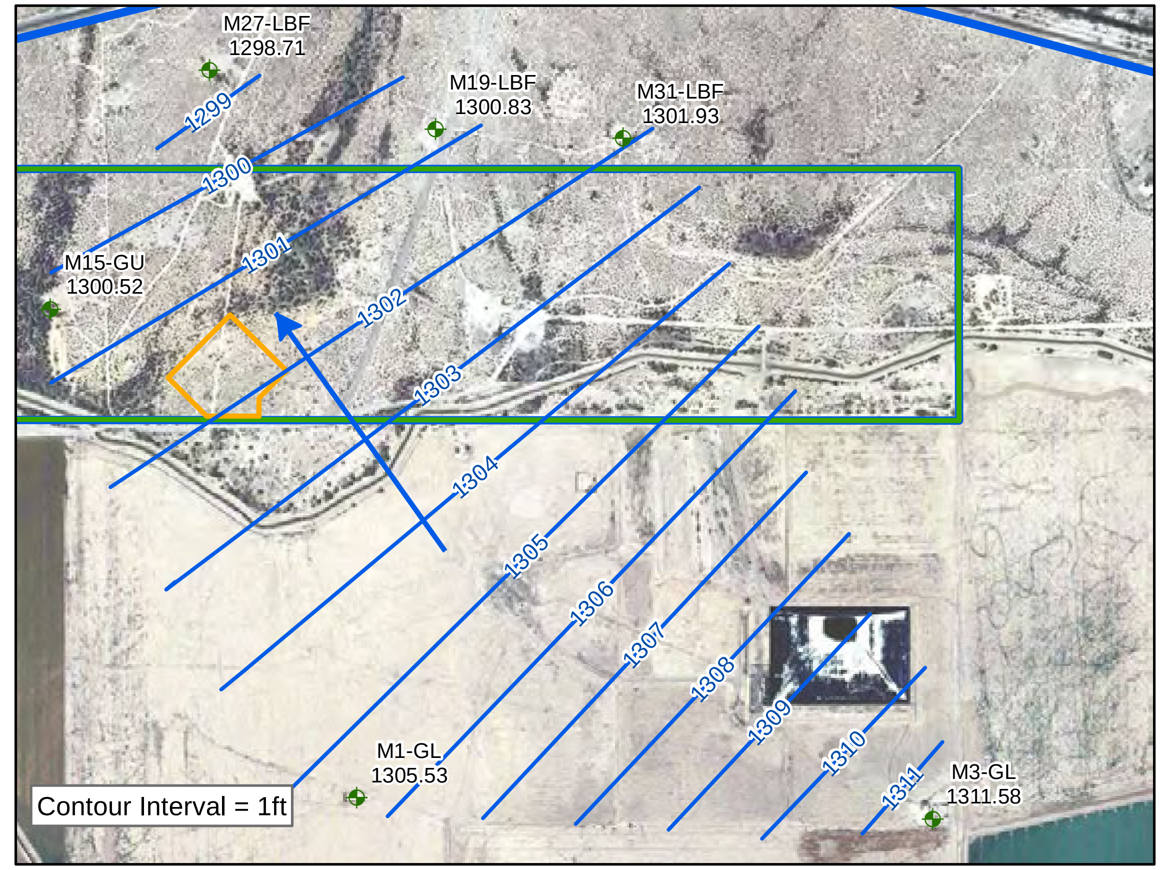
Figure 14C-35
1999
GROUNDWATER ELEVATIONS

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

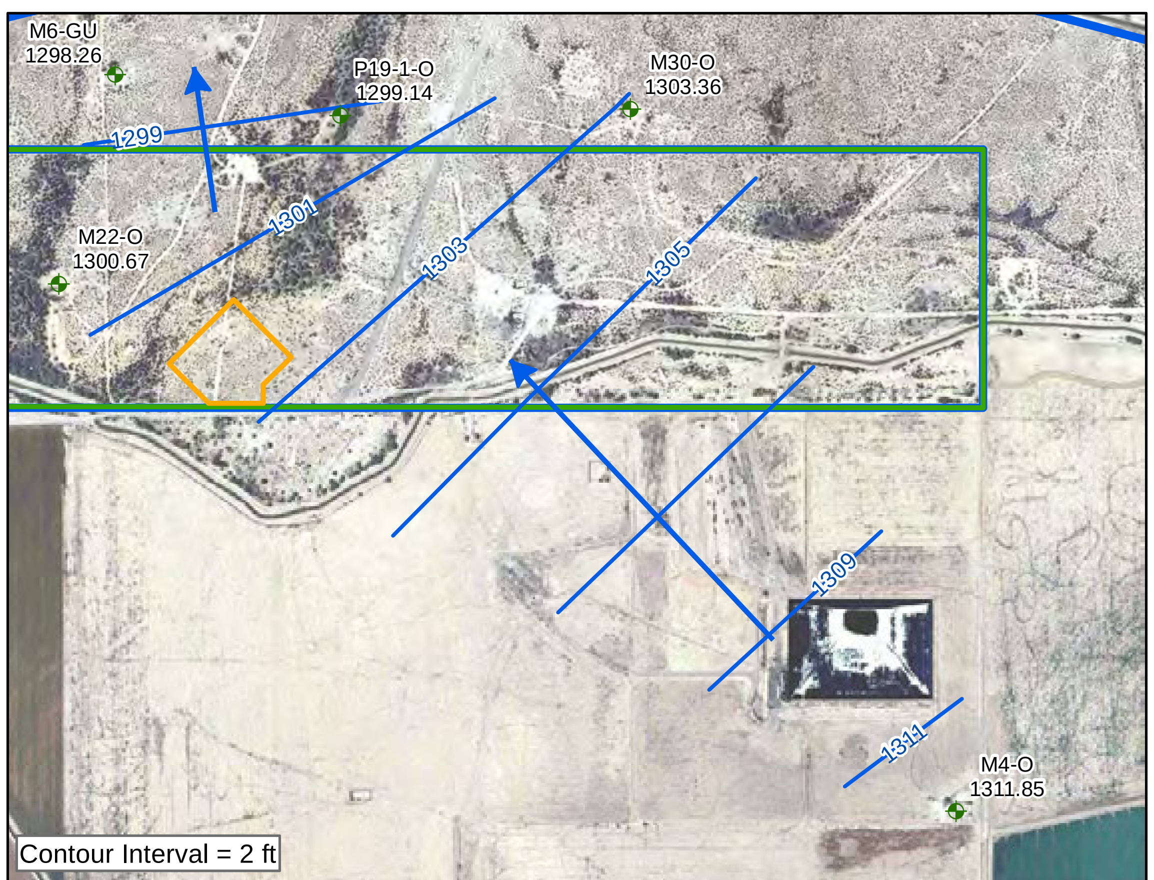
Brown AND Caldwell



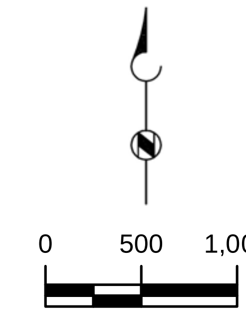
JANUARY 2000 - UPPER BASIN FILL UNIT



JANUARY 2000 - LOWER BASIN FILL UNIT



JANUARY 2000- BEDROCK OXIDE UNIT



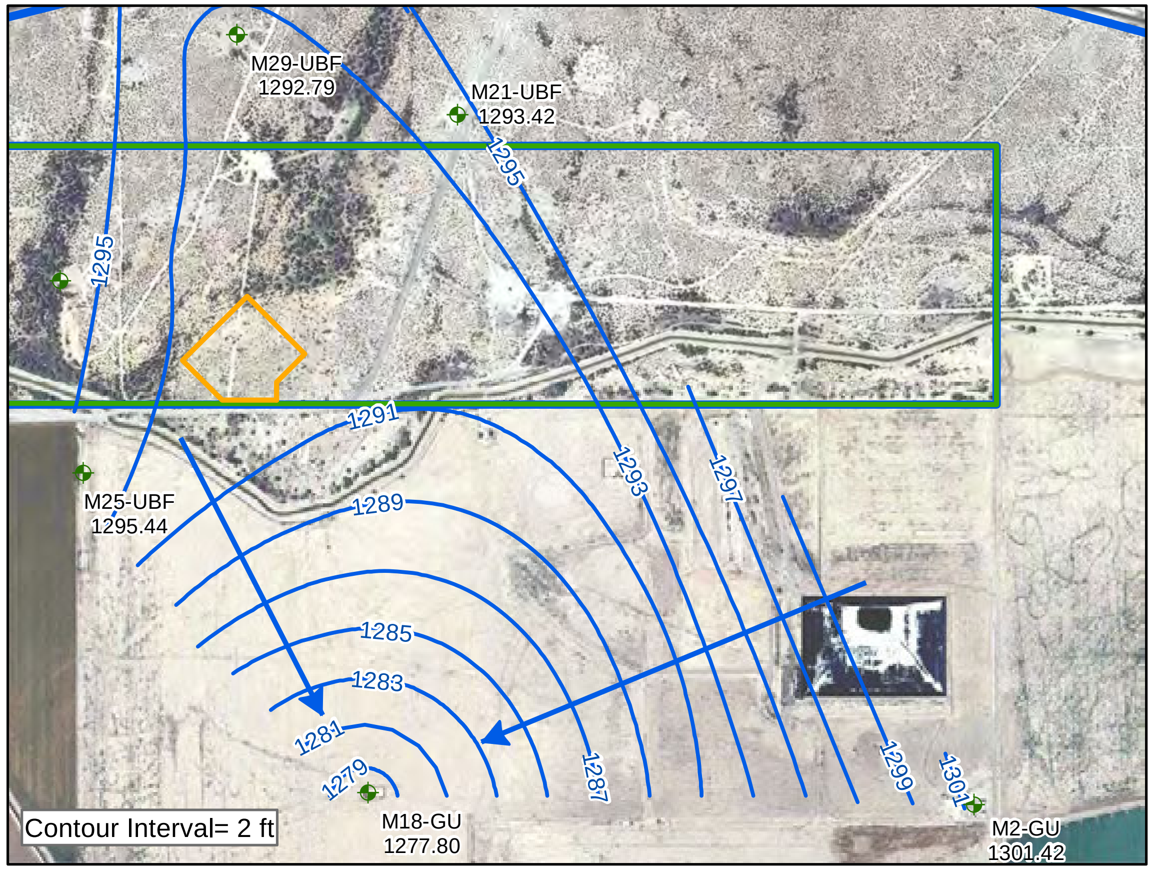
EXPLANATION

- MONITOR WELL LOCATION
  1305.53 Groundwater Elevation (ft msl)
- PTF WELL FIELD
- STATE LAND LEASE
- CURIS PROPERTY BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION

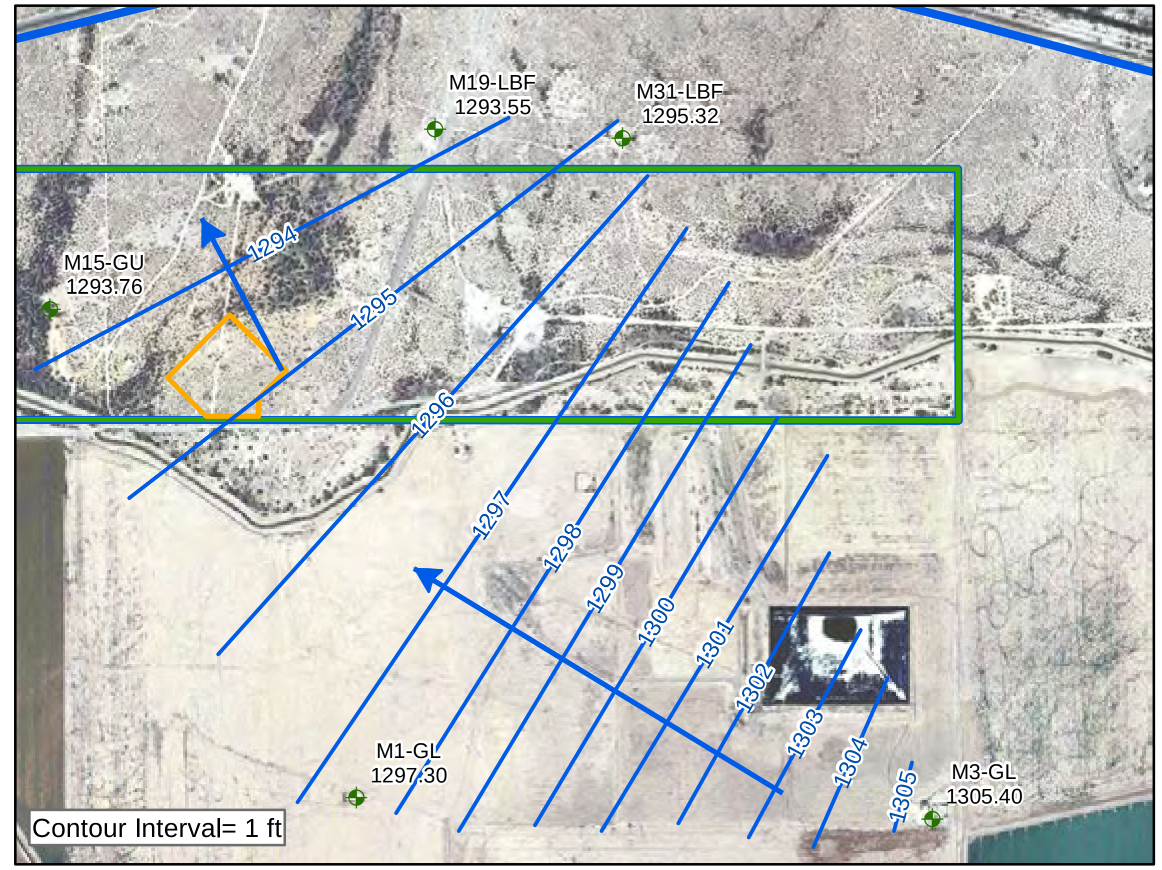
Figure 14C-36
2000
GROUNDWATER
ELEVATIONS
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

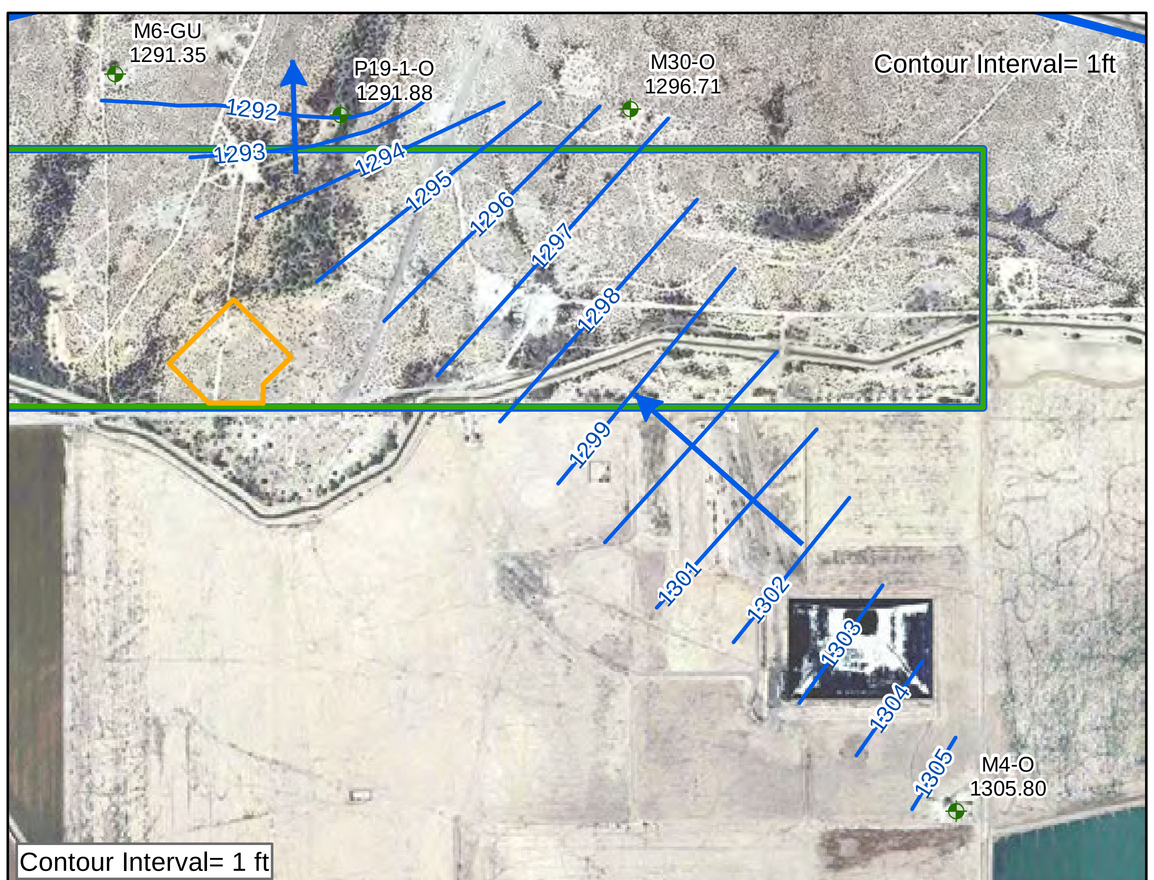
\\BCPHX03\projects\Hunter Dickinson\Curis GIS\MXDs\Temp Permit2012\G14075334014C19_WLContour_2000.mxd Updated: 1/23/2012



FEBRUARY 2001 - UPPER BASIN FILL UNIT



FEBRUARY 2001- LOWER BASIN FILL UNIT



FEBRUARY 2001- BEDROCK OXIDE UNIT

0 500 1,000
SCALE IN FEET

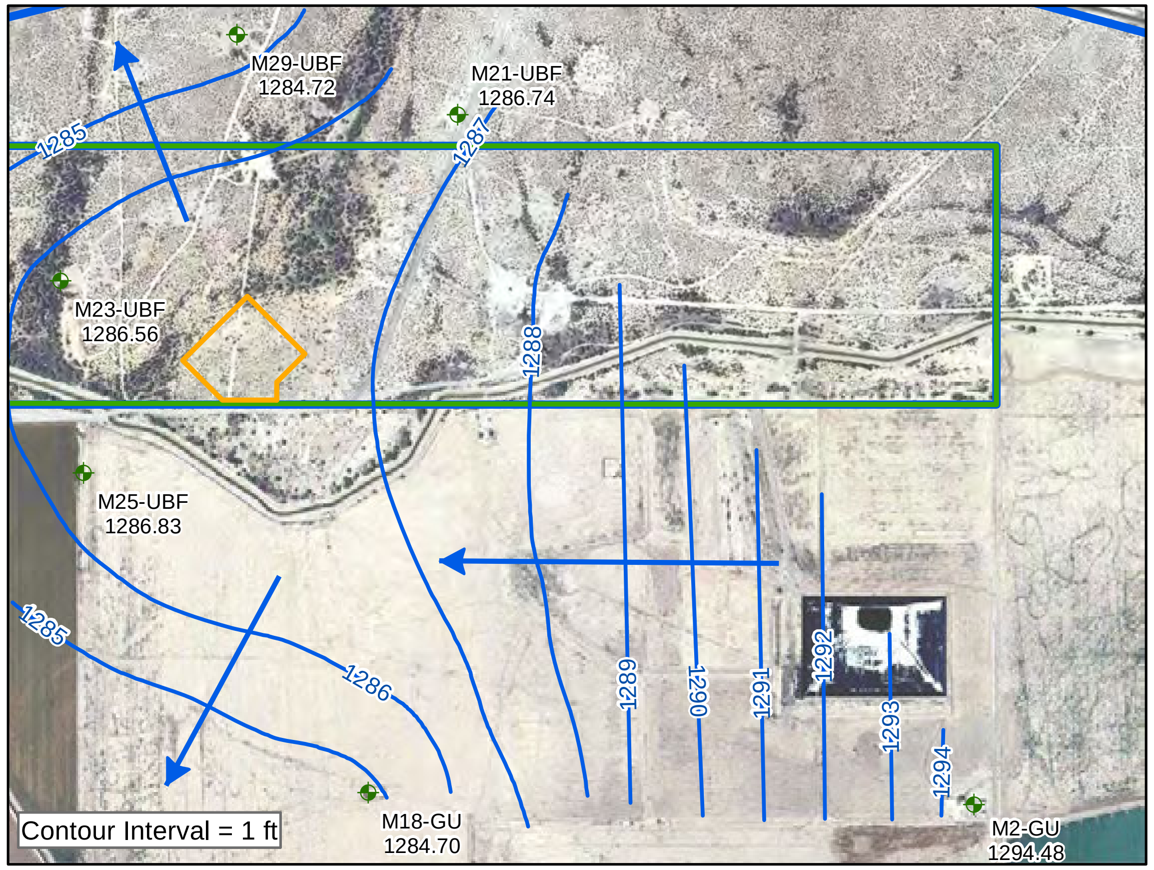
EXPLANATION

- MONITOR WELL LOCATION
  1292.79 Groundwater Elevation (ft msl)
- PTF WELL FIELD
- STATE LAND LEASE
- CURIS PROPERTY BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION

Figure 14C-37
2001
GROUNDWATER
ELEVATIONS

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell



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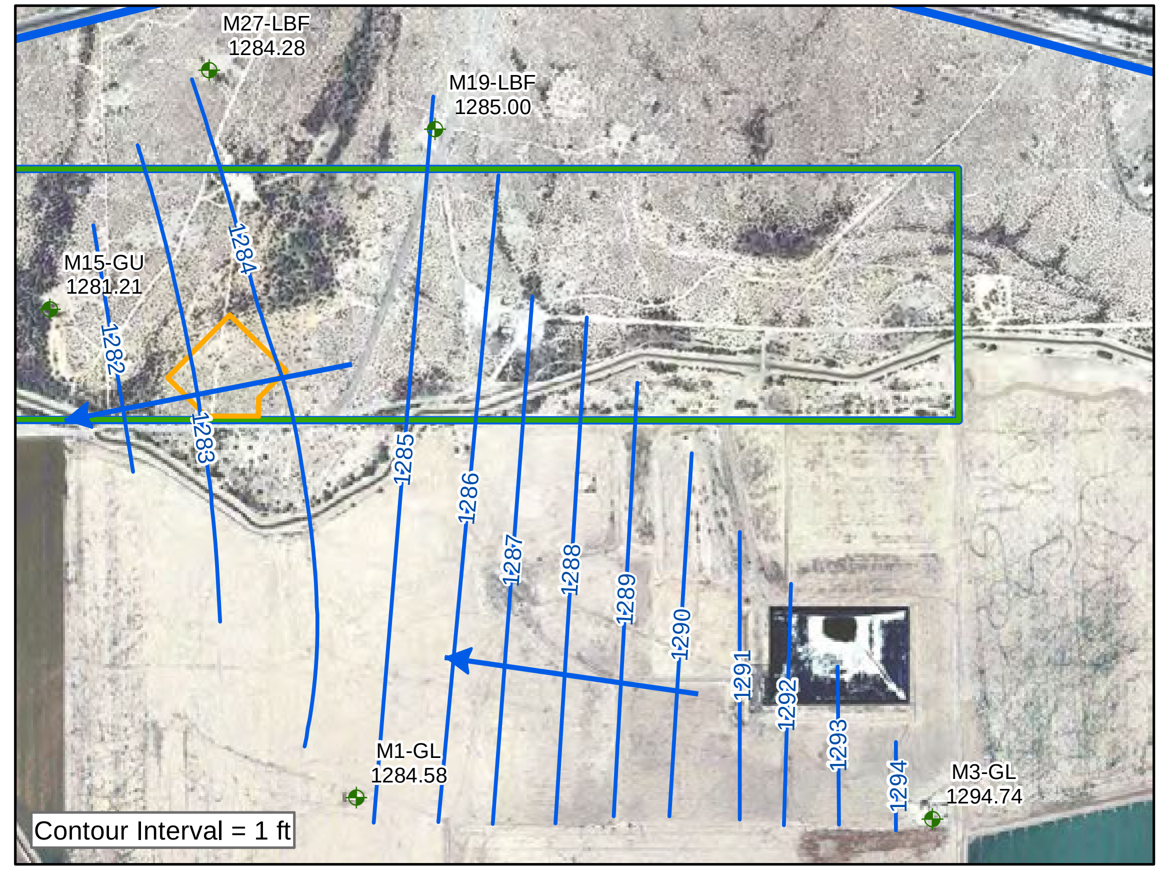
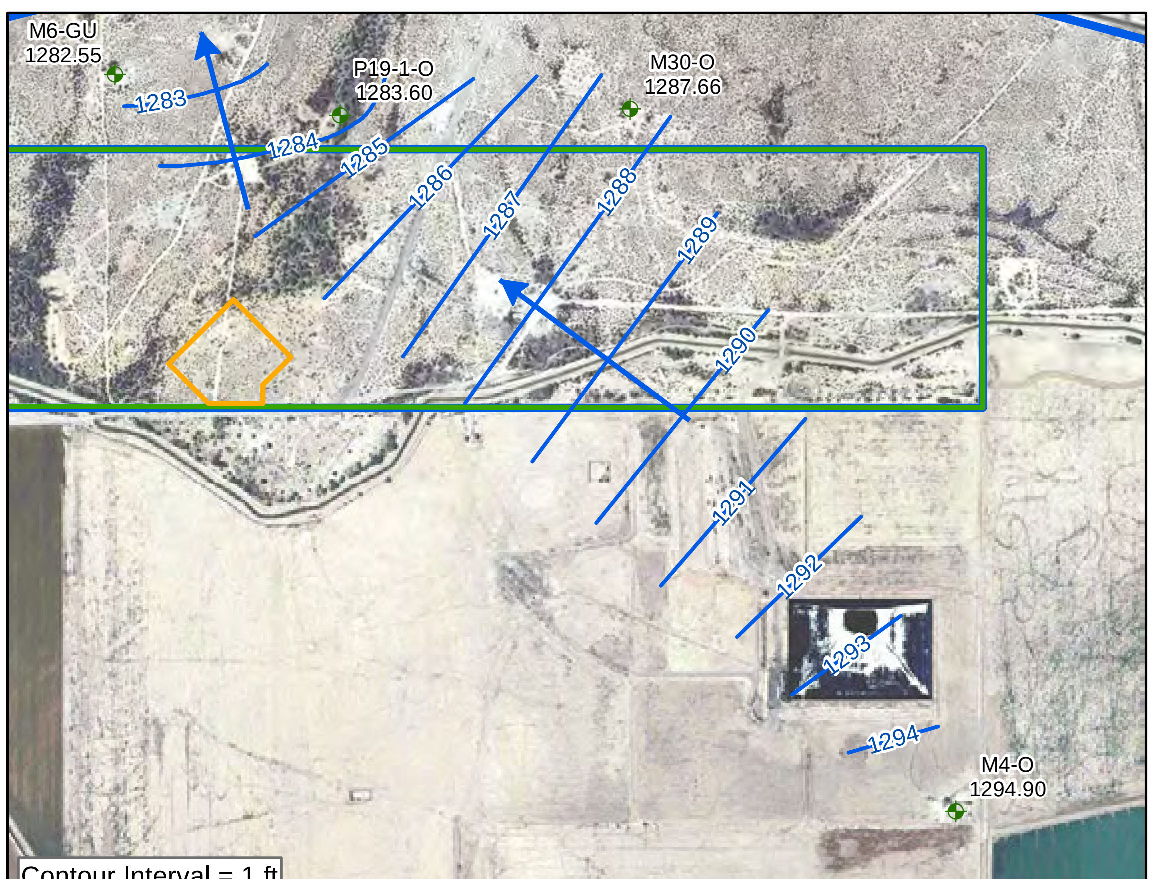
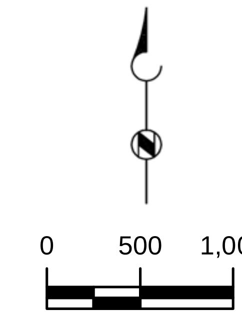


JANUARY 2002- LOWER BASIN FILL UNIT



JANUARY 2002- BEDROCK OXIDE UNIT



EXPLANATION

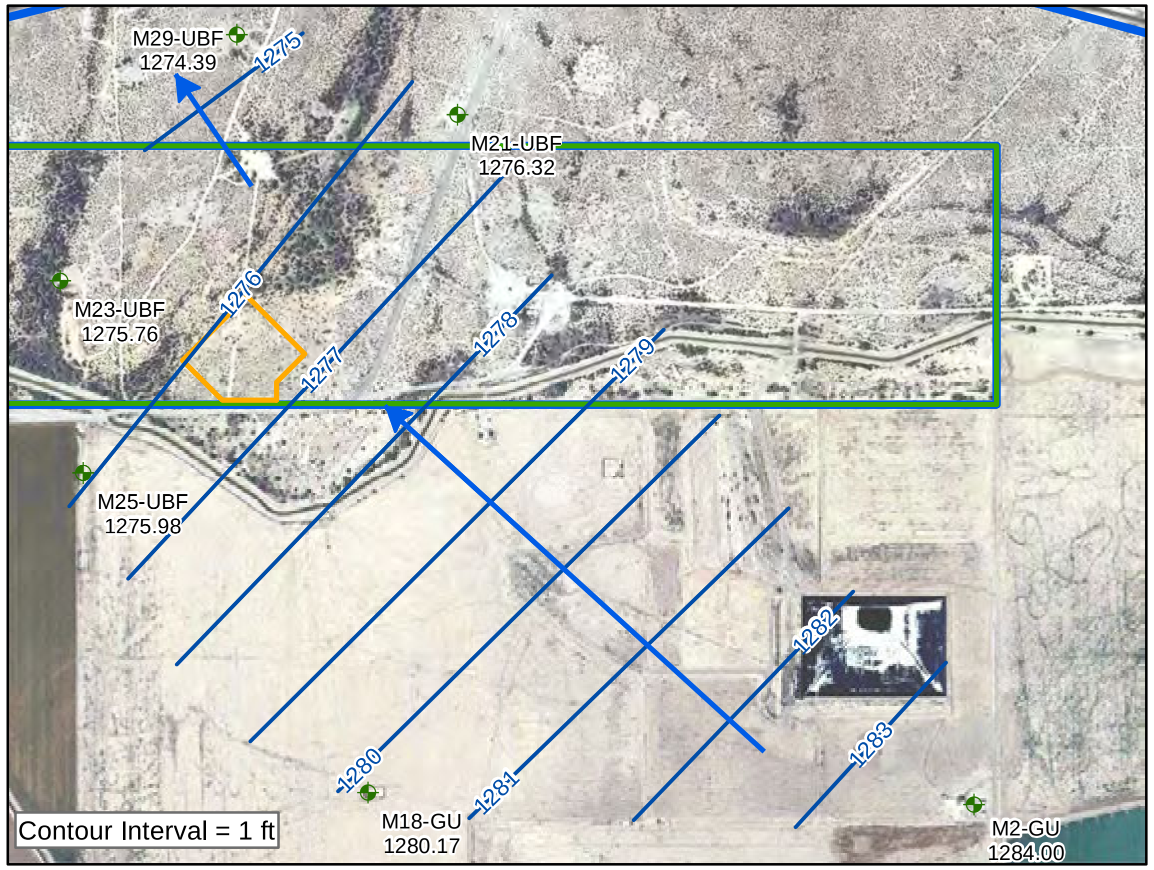
- MONITOR WELL LOCATION
  1285.00 Groundwater Elevation (ft msl)
- PTF WELL FIELD
- STATE LAND LEASE
- CURIS PROPERTY BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION

Figure 14C-38
2002
GROUNDWATER
ELEVATIONS

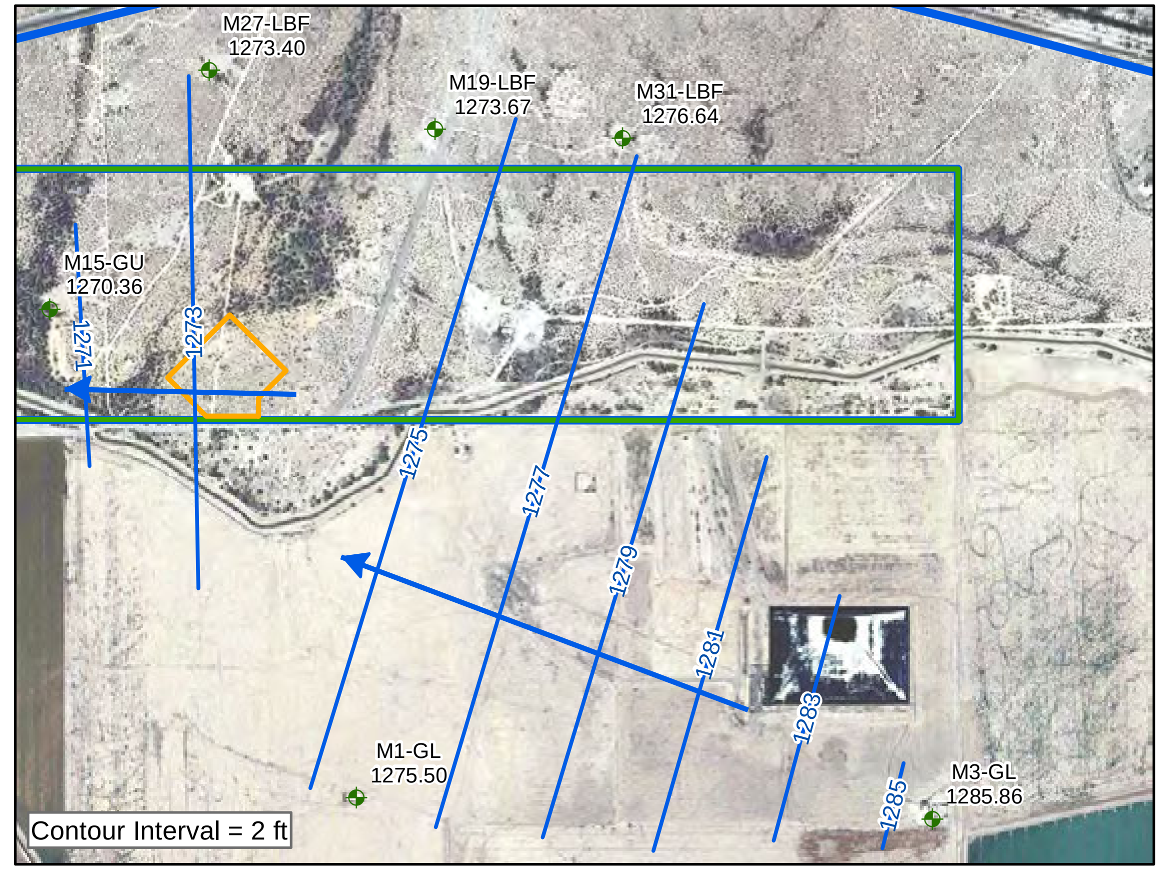
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

\\BCPHX03\projects\Hunter Dickinson\Curis GIS\MXDs\Temp Permit 2012\140753 14C21_WLContour_2002.mxd Updated: 1/23/2012



JANUARY 2003 - UPPER BASIN FILL UNIT



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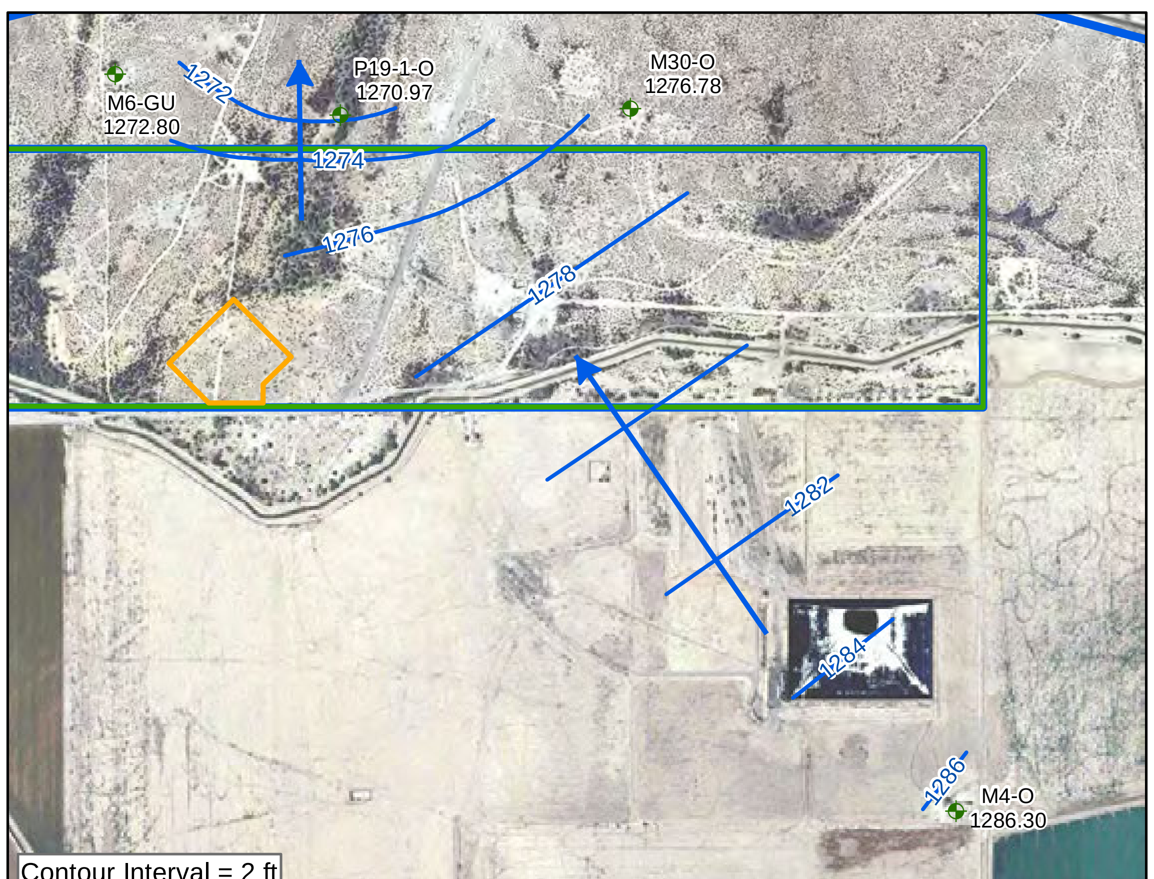


JANUARY 2003- BEDROCK OXIDE UNIT

0 500 1,000

SCALE IN FEET

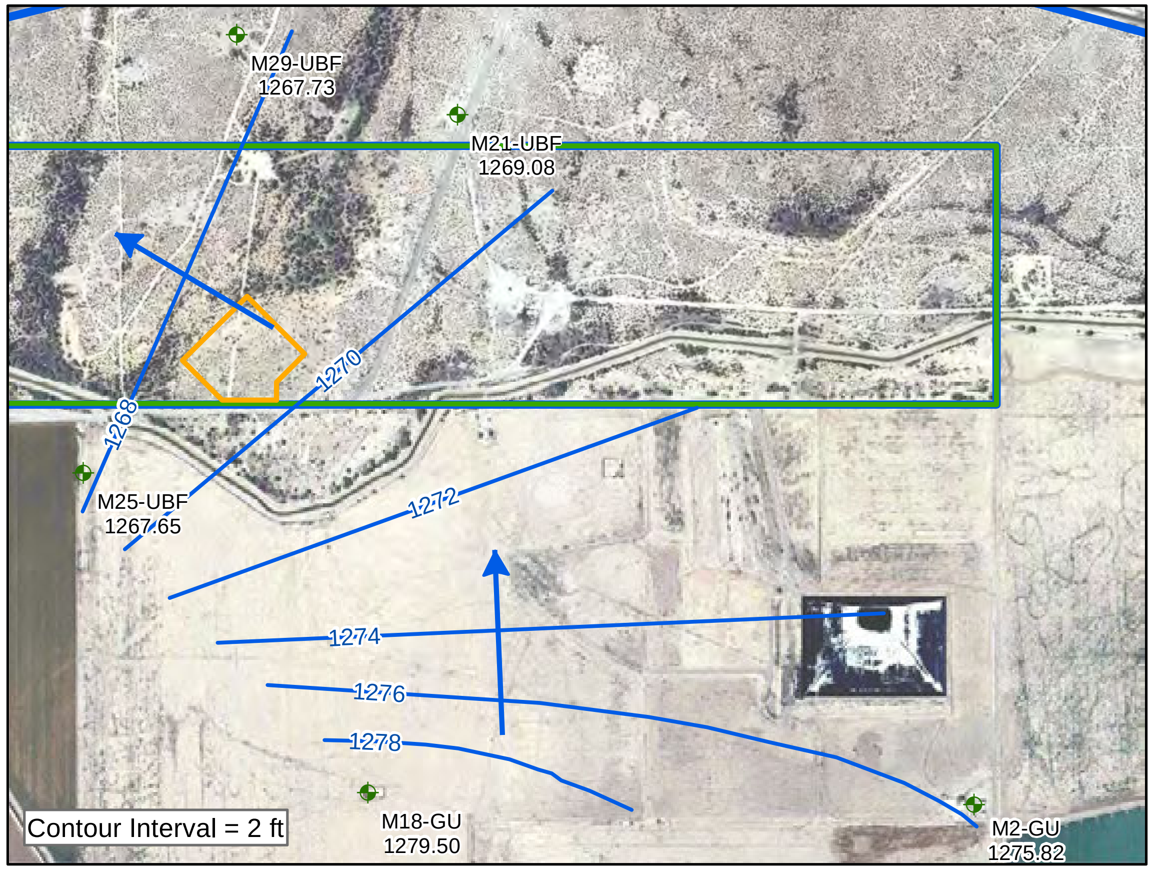
EXPLANATION

- MONITOR WELL LOCATION
  1276.64 Groundwater Elevation (ft msl)
- PTF WELL FIELD
- STATE LAND LEASE
- CURIS PROPERTY BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION

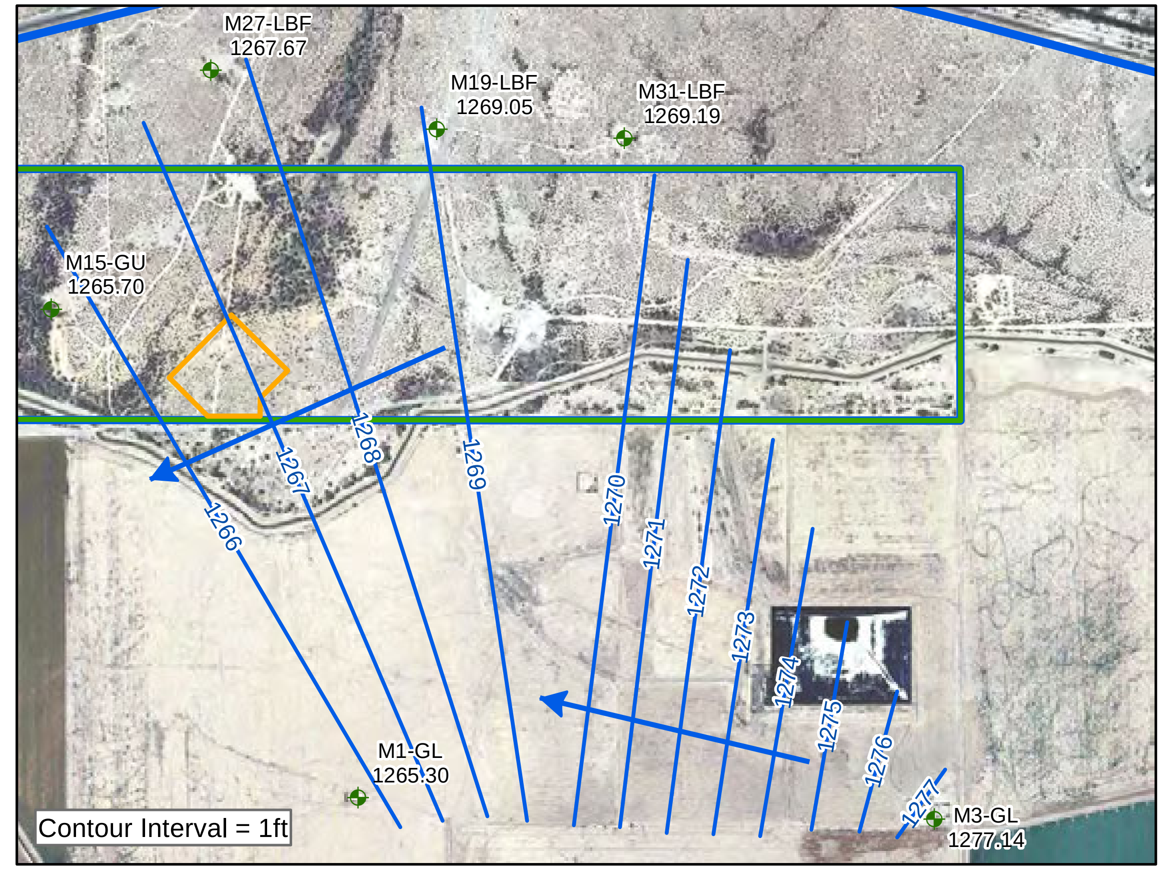
Figure 14C-39
2003
GROUNDWATER
ELEVATIONS

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell



JANUARY 2004 - UPPER BASIN FILL UNIT

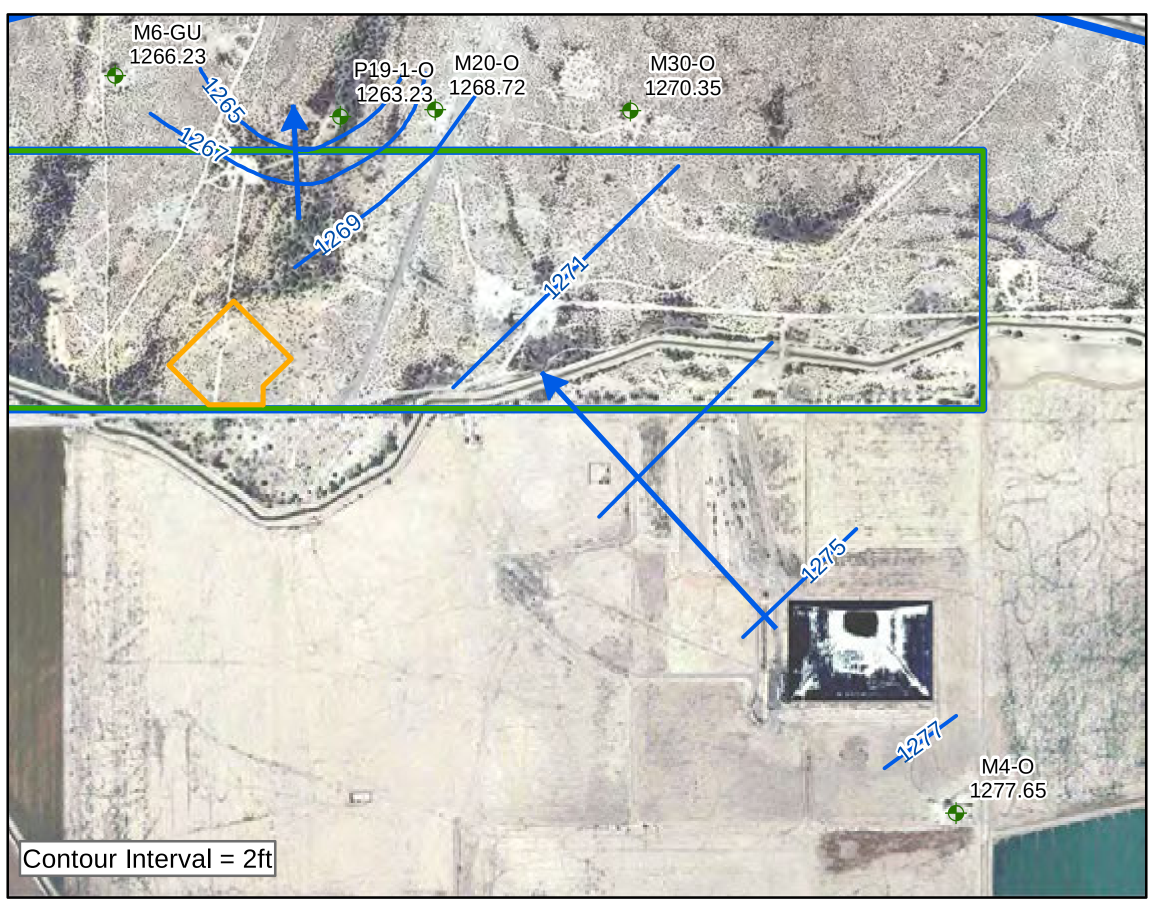


JANUARY 2004- LOWER BASIN FILL UNIT

0 500 1,000
SCALE IN FEET

EXPLANATION

- MONITOR WELL LOCATION
  1279.50 Groundwater Elevation (ft msl)
- PTF WELL FIELD
- STATE LAND LEASE
- CURIS PROPERTY BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION



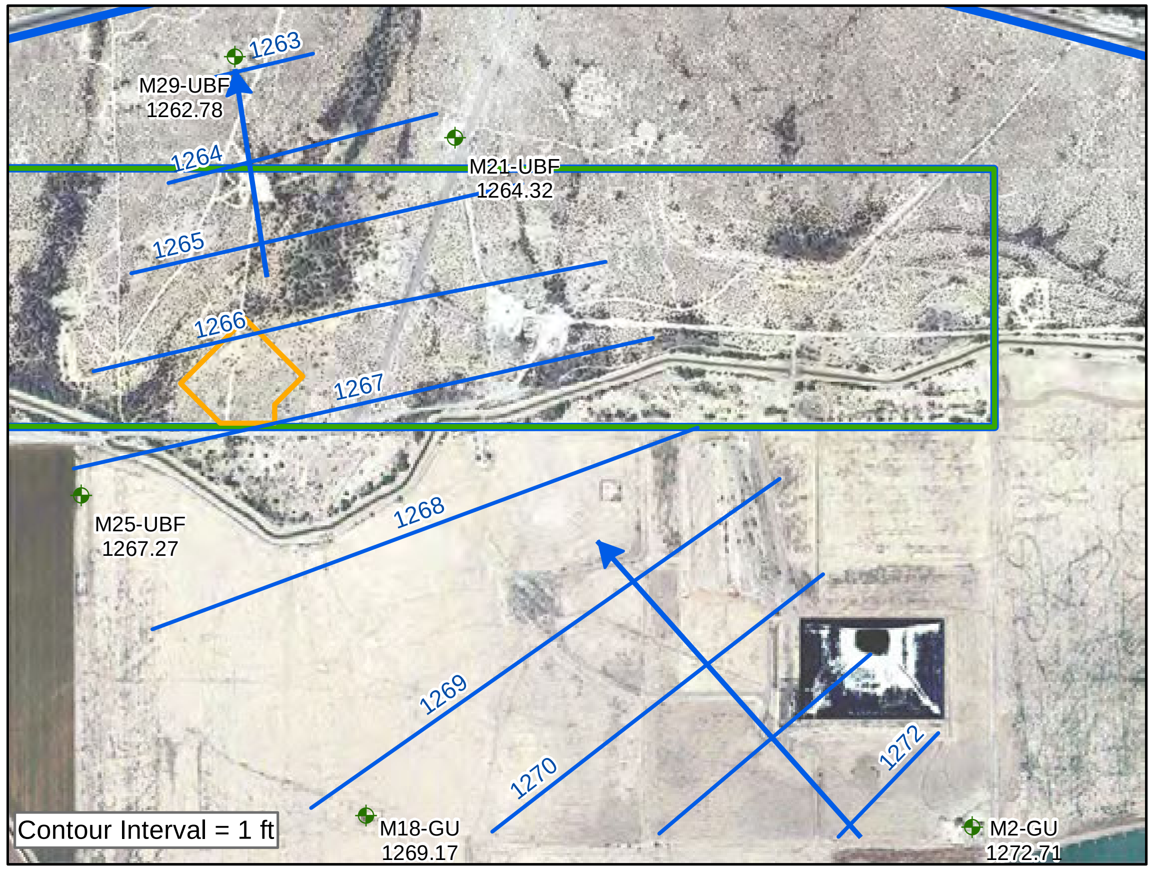
JANUARY 2004- BEDROCK OXIDE UNIT

Figure 14C-40
2004 GROUNDWATER ELEVATIONS

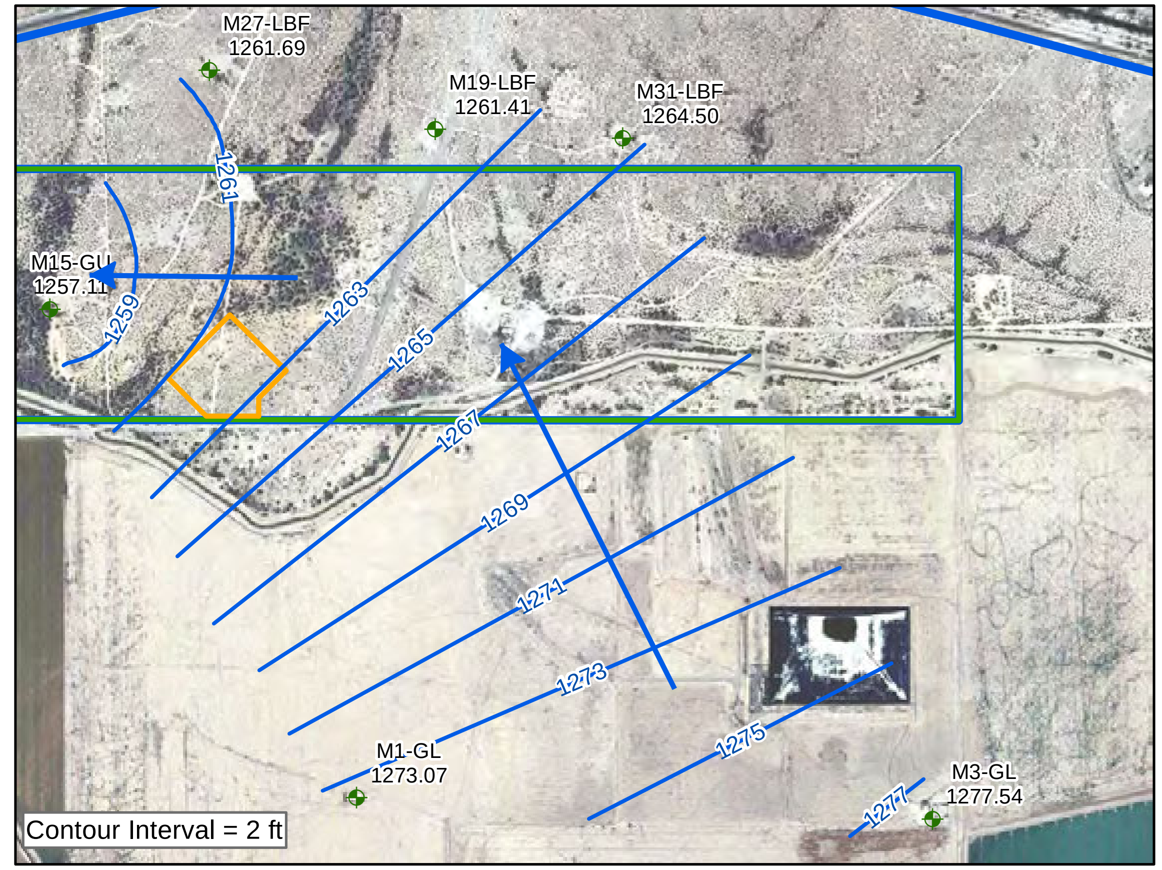
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

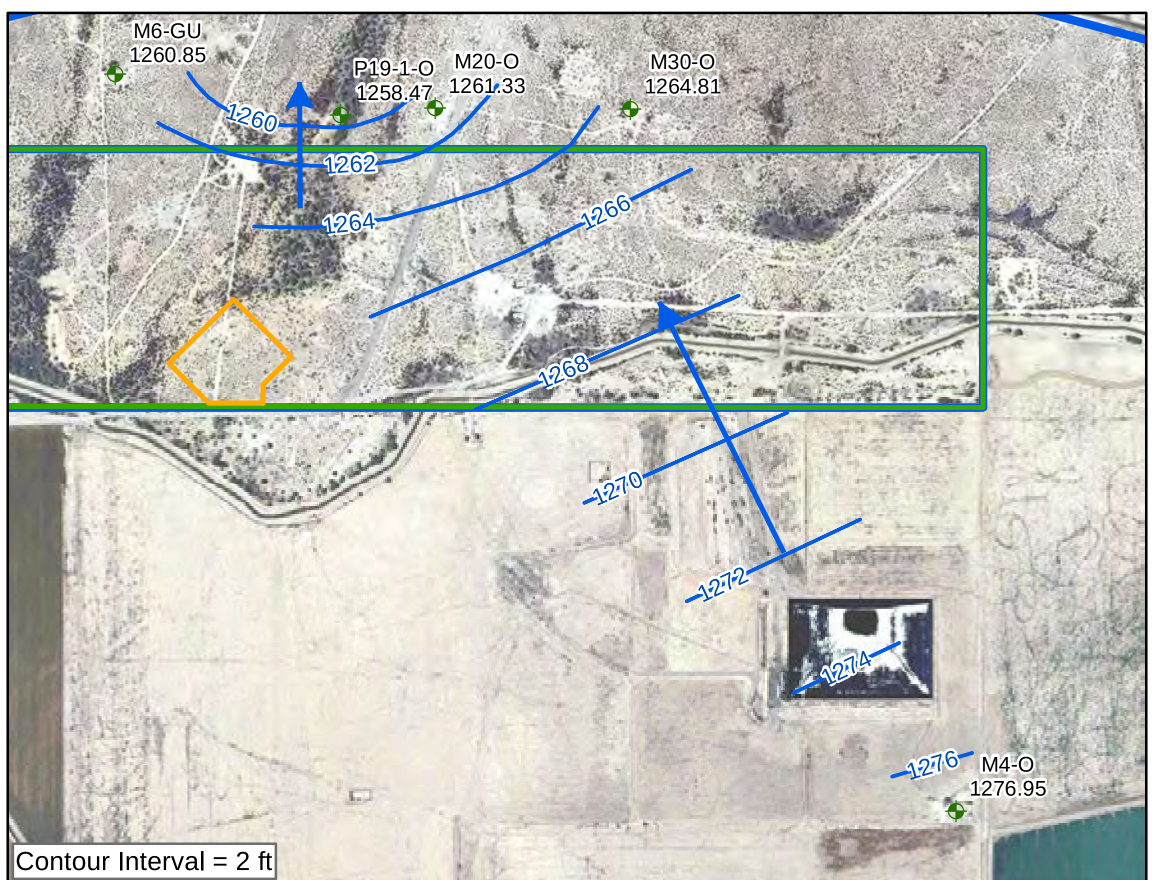
\\BCPHX03\projects\Hunter Dickinson\Curis GIS\MXDs\Temp Permit2012\G14075334014C23_WLContour_2004.mxd Updated: 1/23/2012



JANUARY 2005 - UPPER BASIN FILL UNIT



JANUARY 2005- LOWER BASIN FILL UNIT



JANUARY 2005- BEDROCK OXIDE UNIT

0 500 1,000
SCALE IN FEET

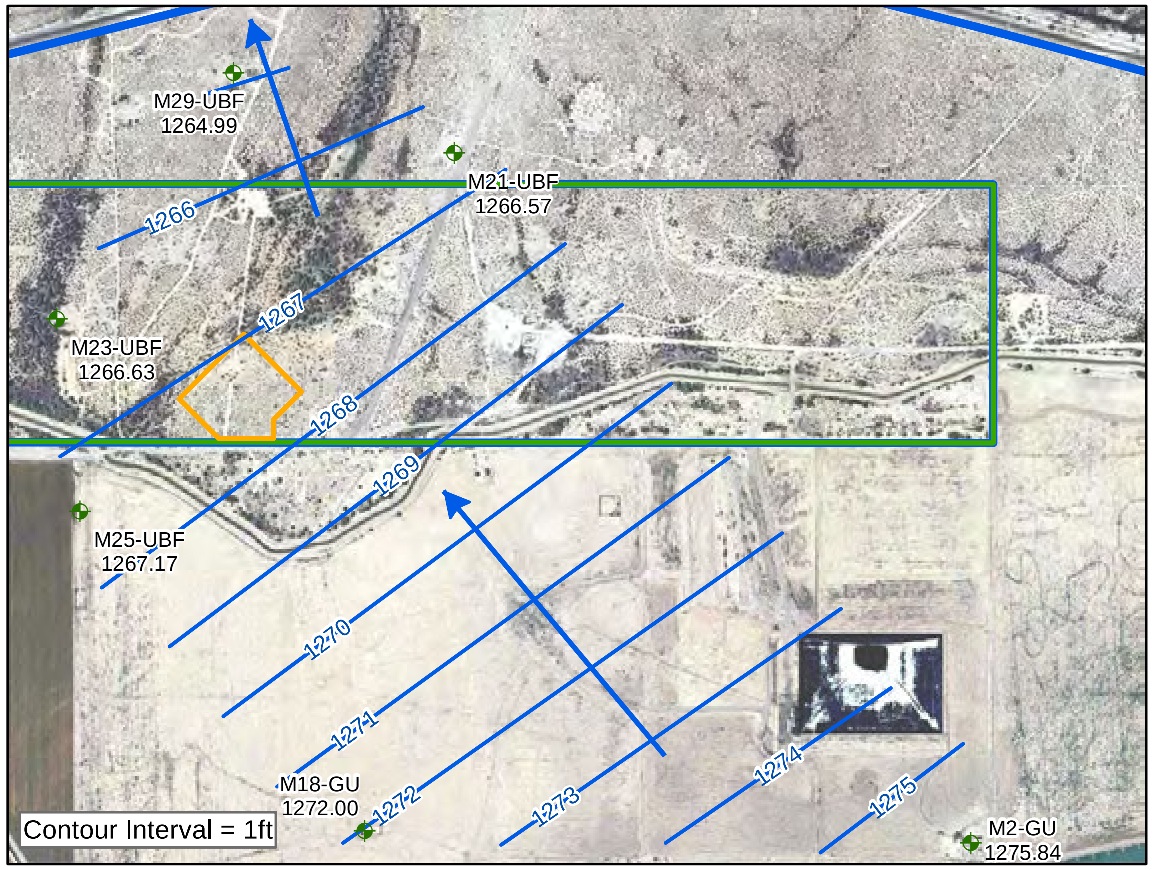
EXPLANATION

- MONITOR WELL LOCATION
  1273.07 Groundwater Elevation (ft msl)
- PTF WELL FIELD
- STATE LAND LEASE
- CURIS PROPERTY BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION

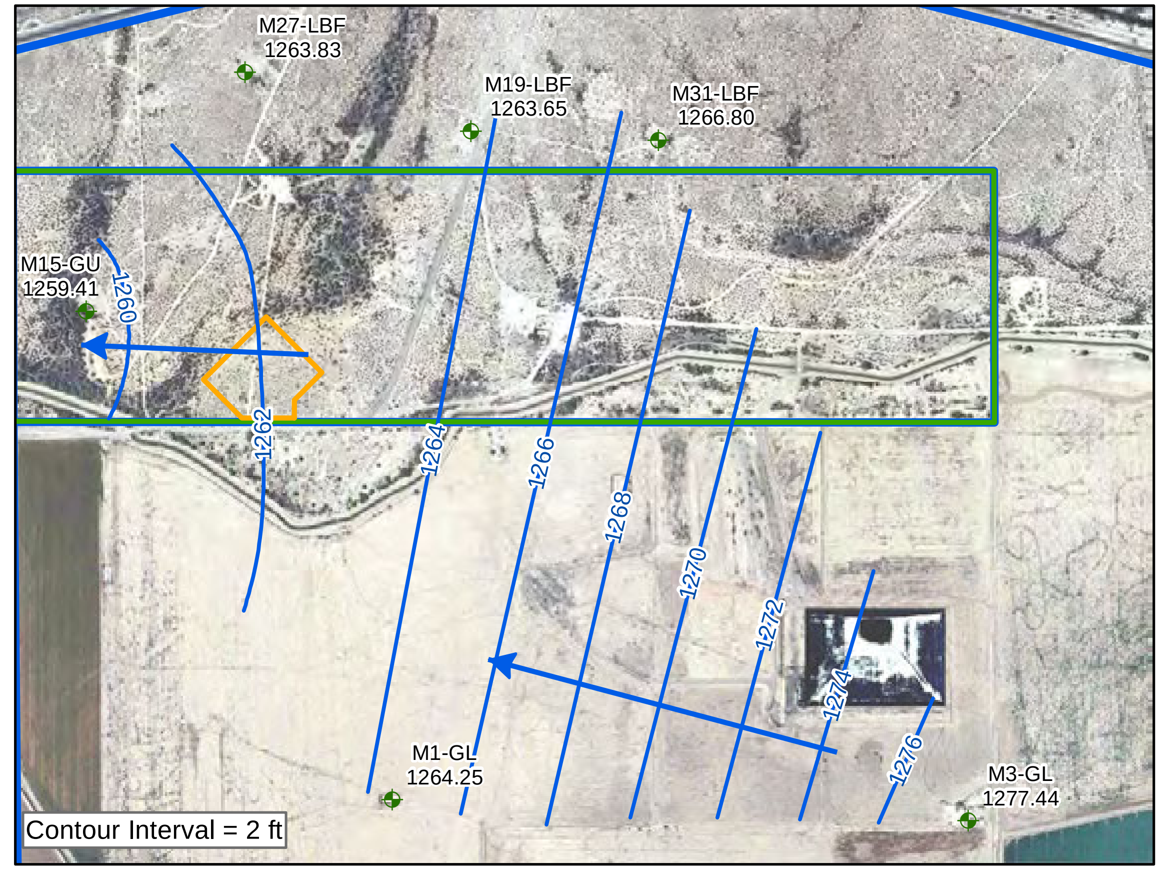
Figure 14C-41
2005
GROUNDWATER ELEVATIONS

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

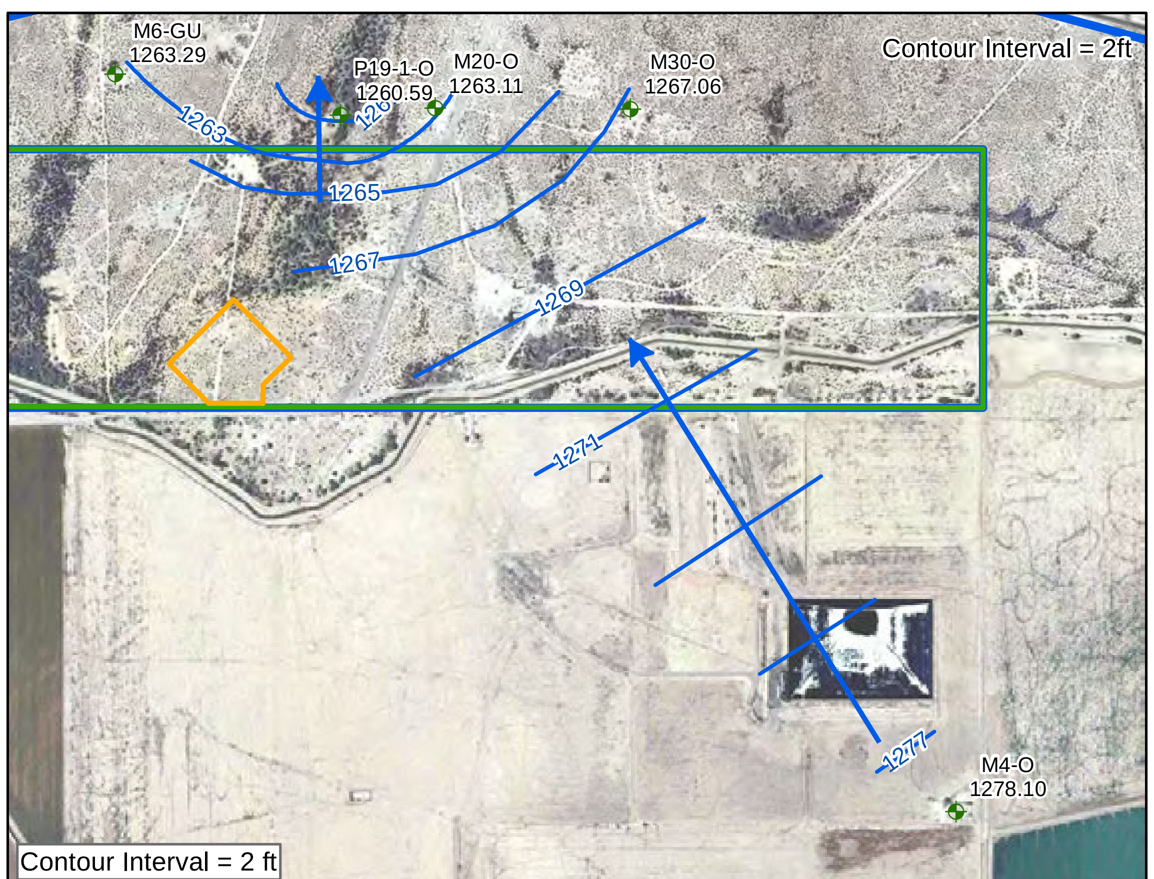
Brown AND Caldwell



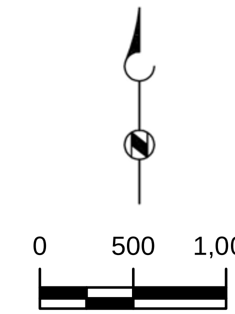
JANUARY 2006 - UPPER BASIN FILL UNIT



JANUARY 2006- LOWER BASIN FILL UNIT



JANUARY 2006- BEDROCK OXIDE UNIT



EXPLANATION

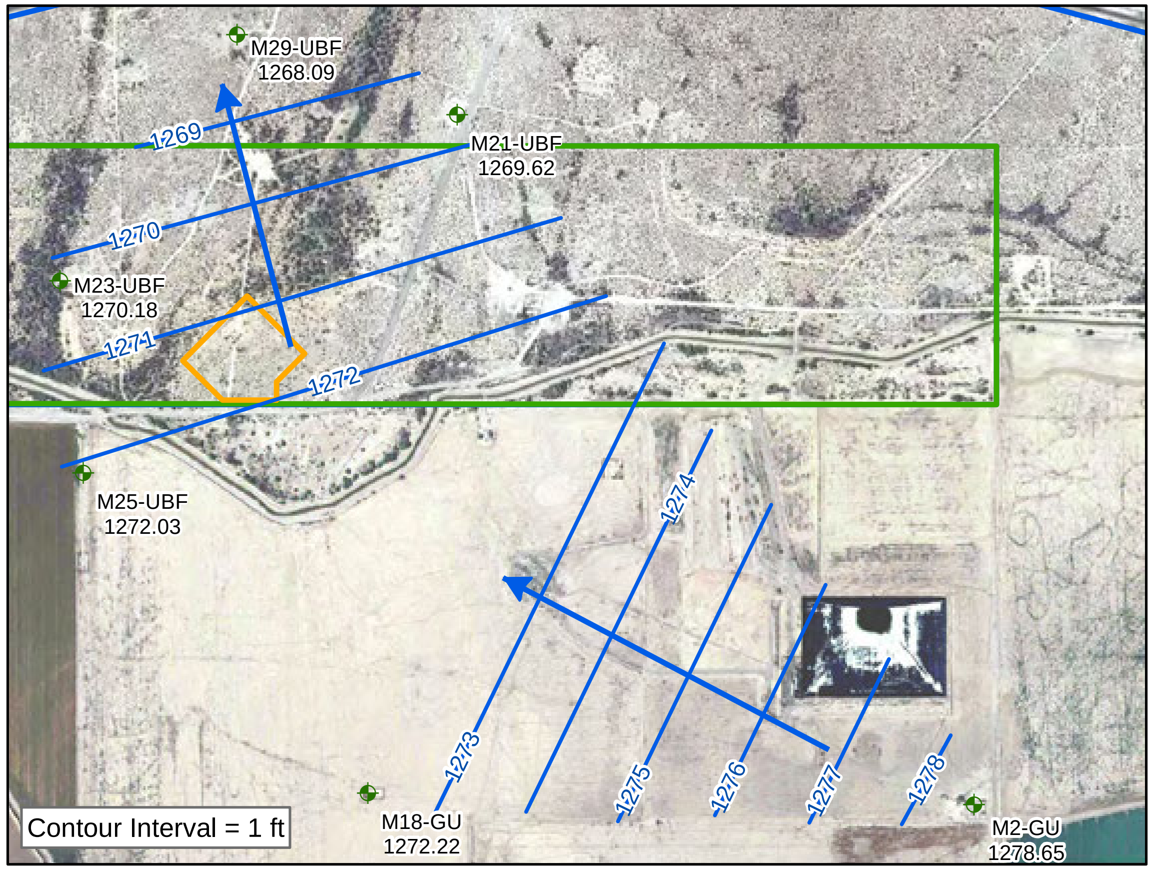
- MONITOR WELL LOCATION 1278.10 Groundwater Elevation (ft msl)
- PTF WELL FIELD
- STATE LAND LEASE
- CURIS PROPERTY BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION

Figure 14C-42
2006 GROUNDWATER ELEVATIONS

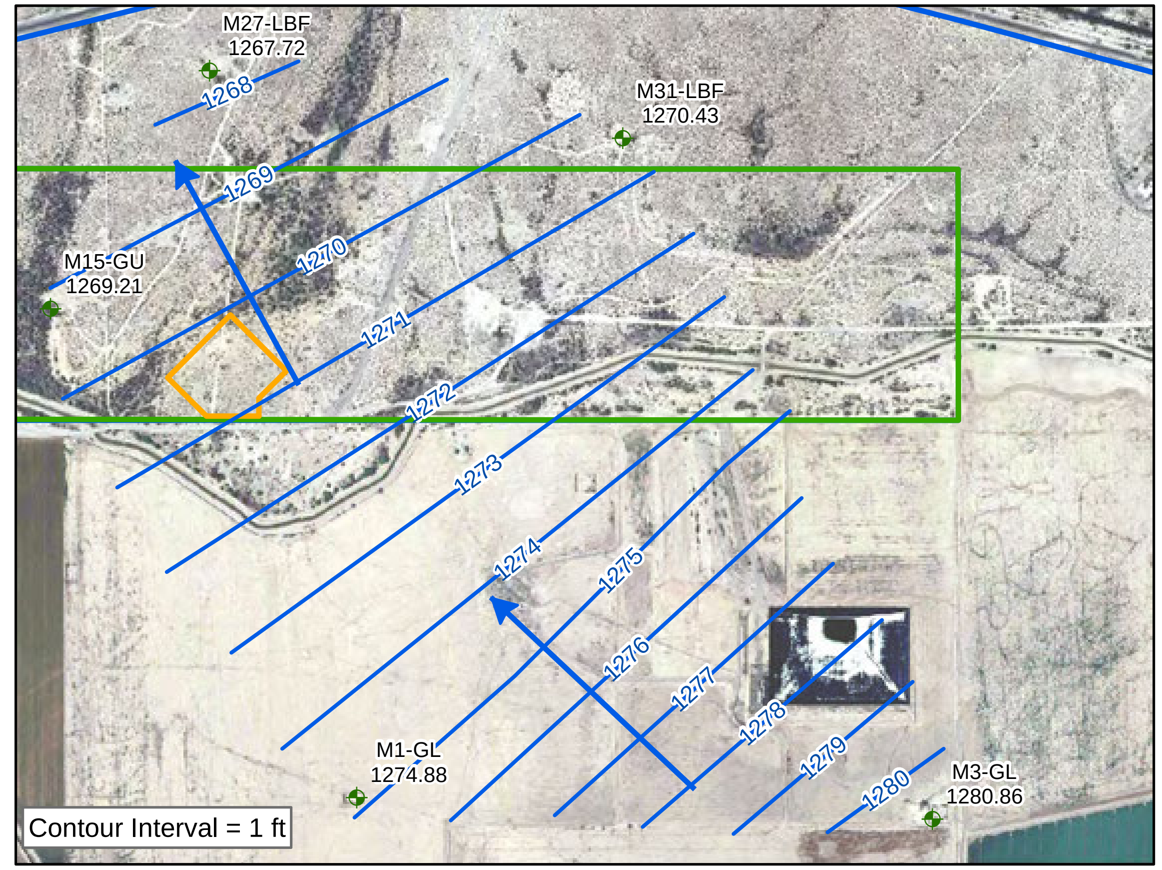
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

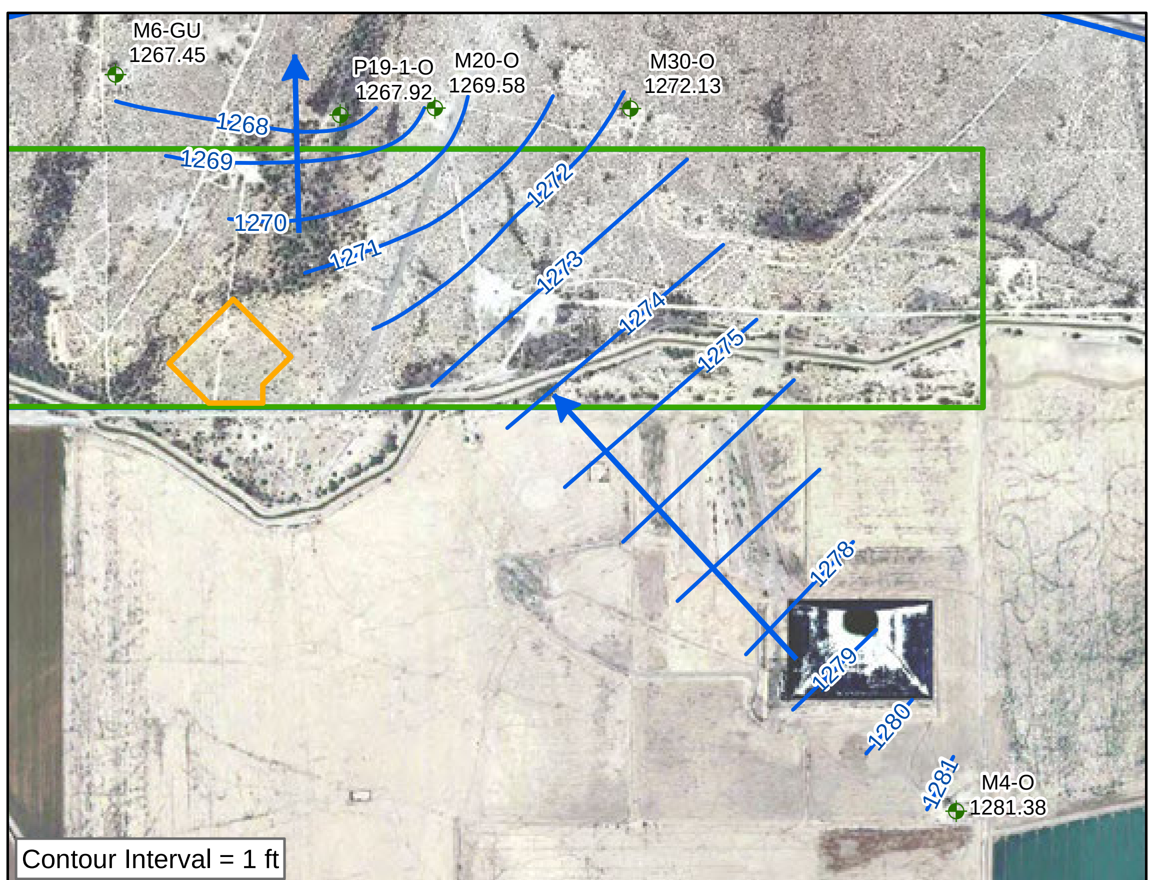
\\BCPHX03\projects\Hunter Dickinson\Curis GIS\MXDs\Temp Permit2012\G14075334014C25_WLContour_2006.mxd Updated: 1/23/2012



JANUARY 2007 - UPPER BASIN FILL UNIT



JANUARY 2007- LOWER BASIN FILL UNIT



JANUARY 2007- BEDROCK OXIDE UNIT

0 500 1,000

SCALE IN FEET

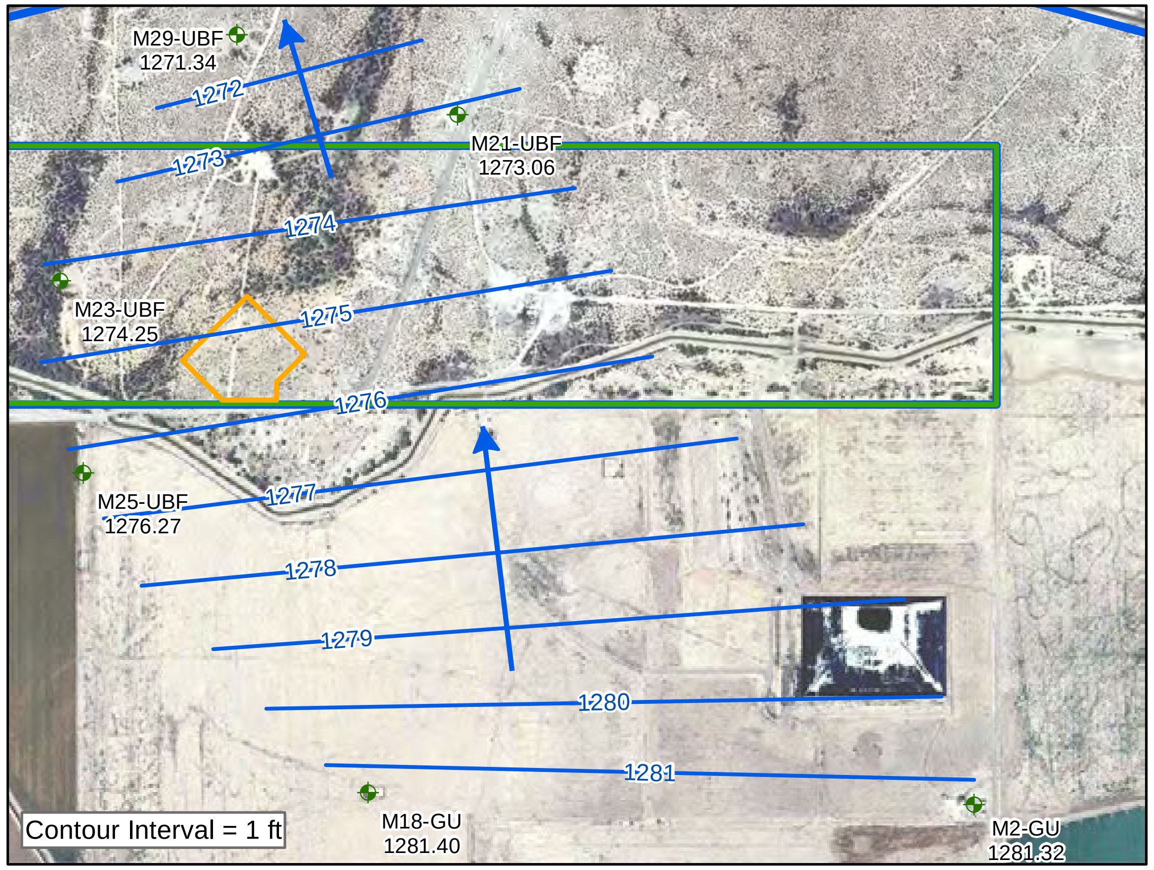
EXPLANATION

- MONITOR WELL LOCATION
  1272.22 Groundwater Elevation (ft msl)
- PTF WELL FIELD
- STATE LAND LEASE
- CURIS PROPERTY BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION

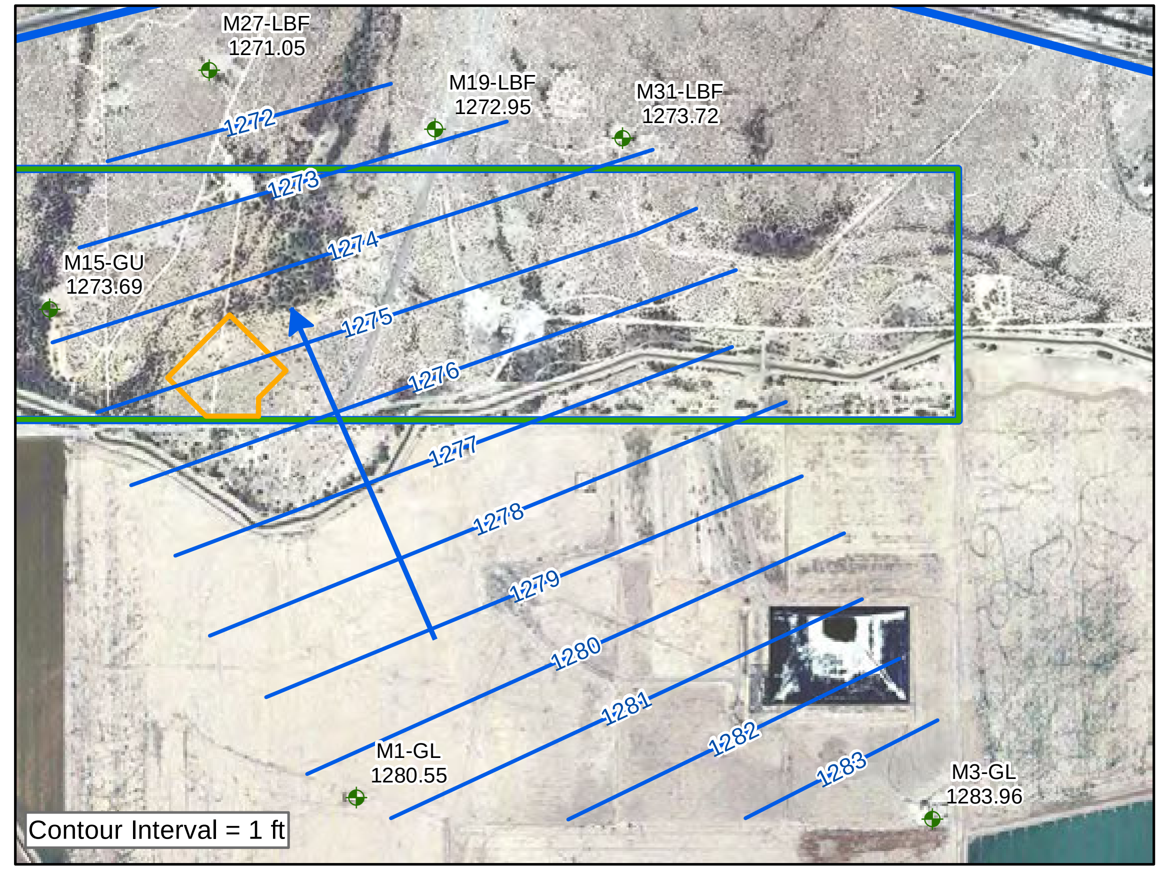
Figure 14C-43
2007
GROUNDWATER ELEVATIONS

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

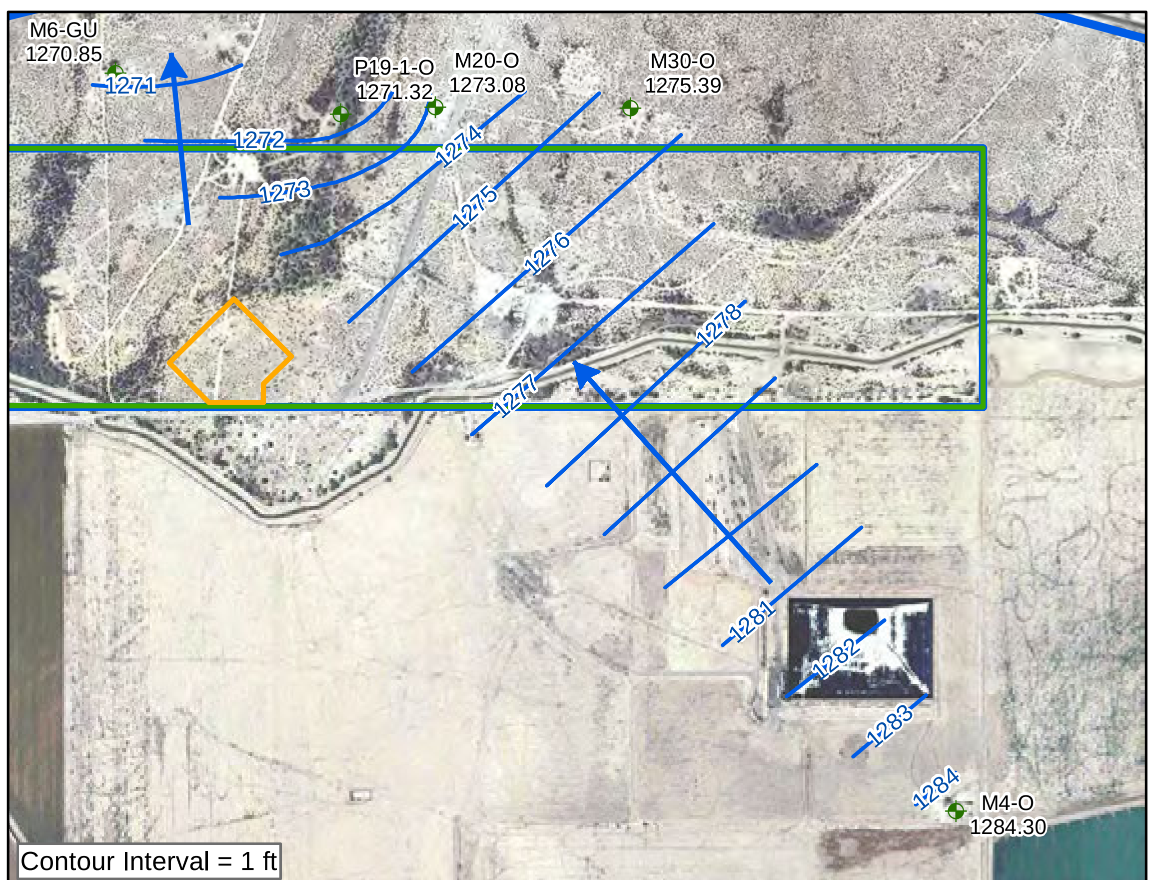
Brown AND Caldwell



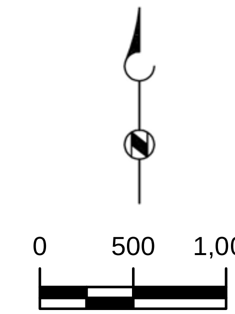
JANUARY 2008 - UPPER BASIN FILL UNIT



JANUARY 2008- LOWER BASIN FILL UNIT



JANUARY 2008- BEDROCK OXIDE UNIT



EXPLANATION

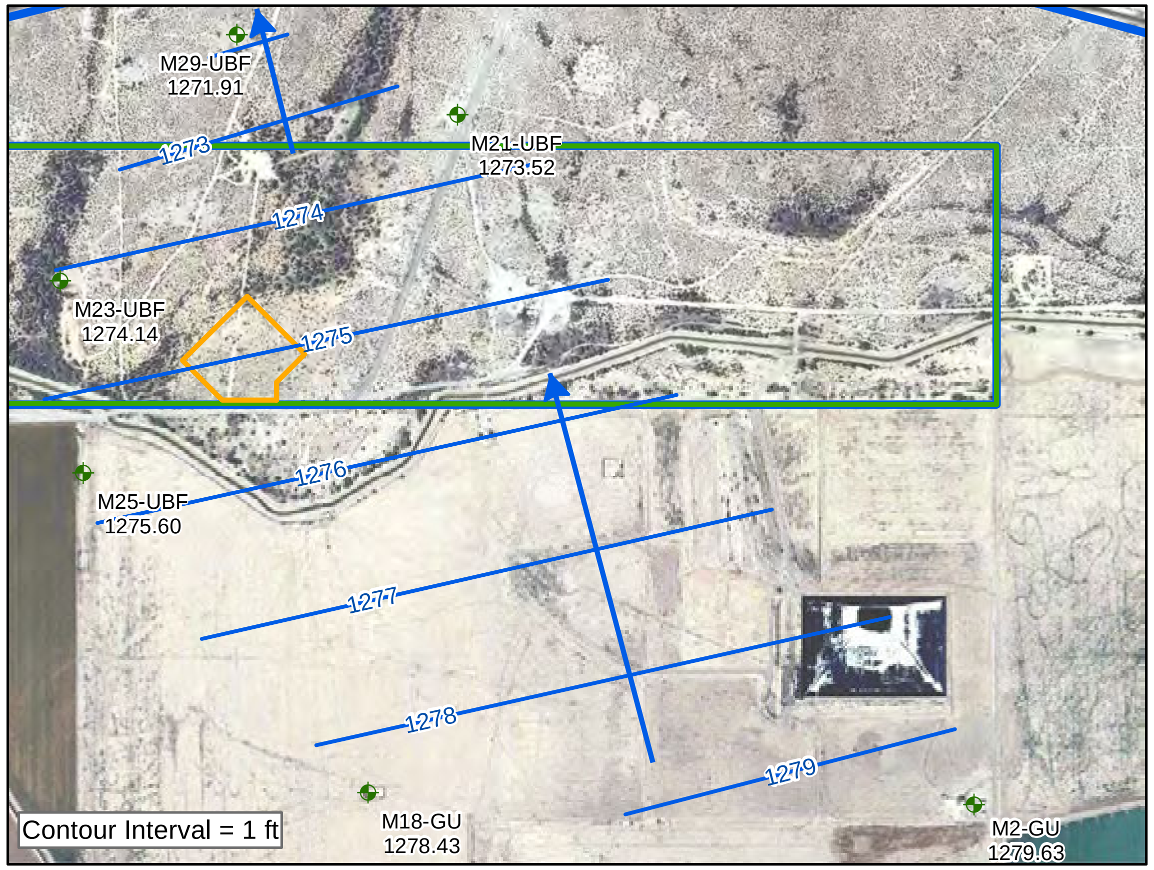
- MONITOR WELL LOCATION
  1273.06 Groundwater Elevation (ft msl)
- PTF WELL FIELD
- STATE LAND LEASE
- CURIS PROPERTY BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION

Figure 14C-44
2008
GROUNDWATER
ELEVATIONS

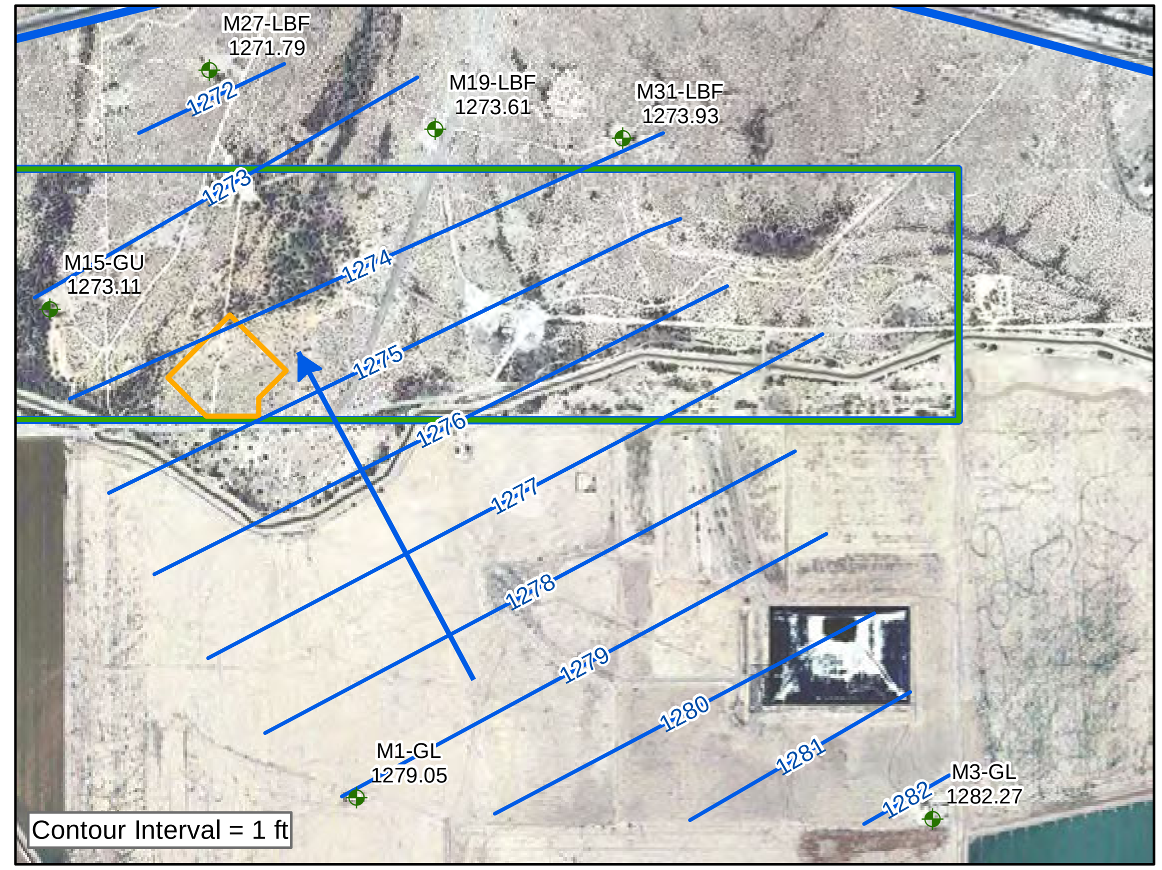
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

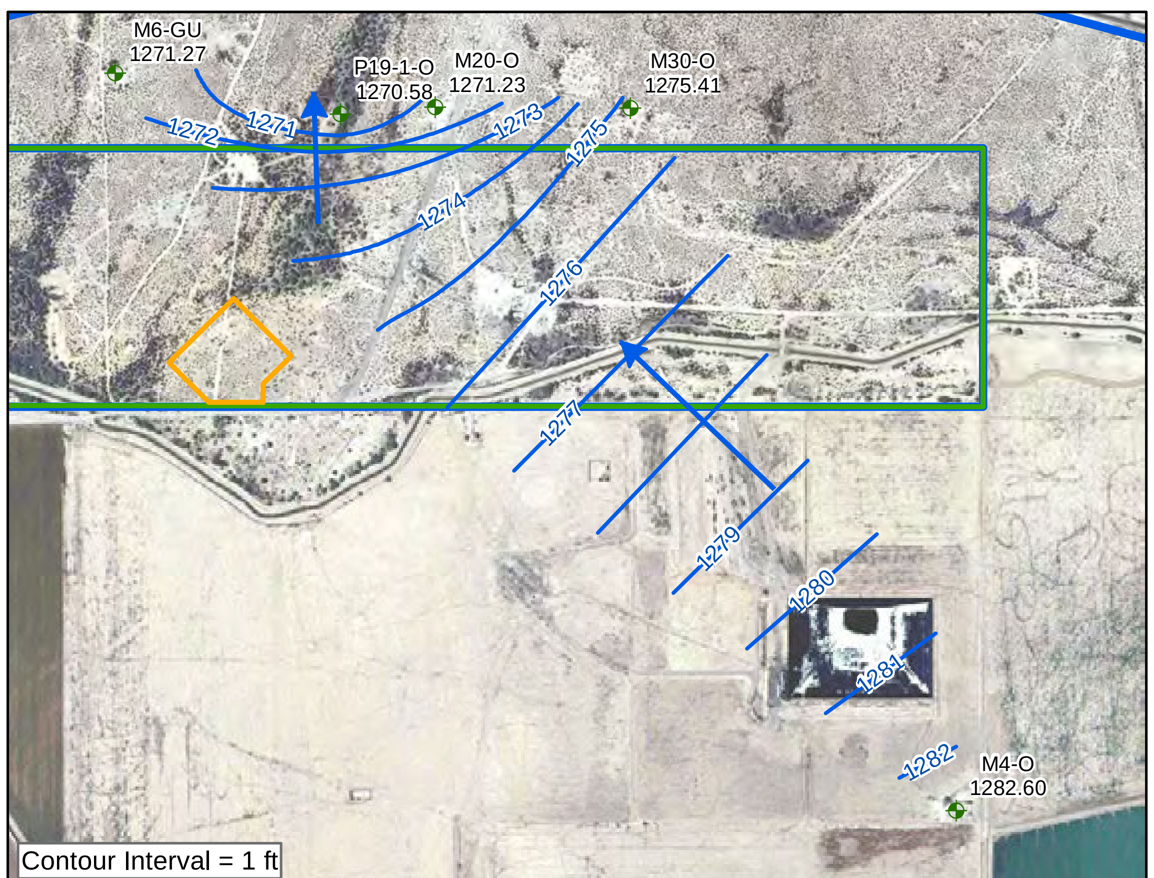
\\BCPHX03\projects\Hunter Dickinson\Curis GIS\MXDs\Temp Permit2012\G14075334014C27_WLContour_2008.mxd Updated: 1/23/2012



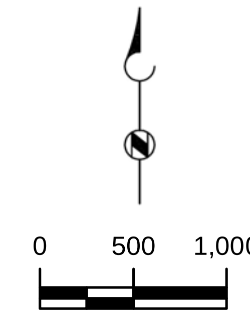
FEBRUARY 2010 - UPPER BASIN FILL UNIT



FEBRUARY 2010- LOWER BASIN FILL UNIT



FEBRUARY 2010- BEDROCK OXIDE UNIT



EXPLANATION

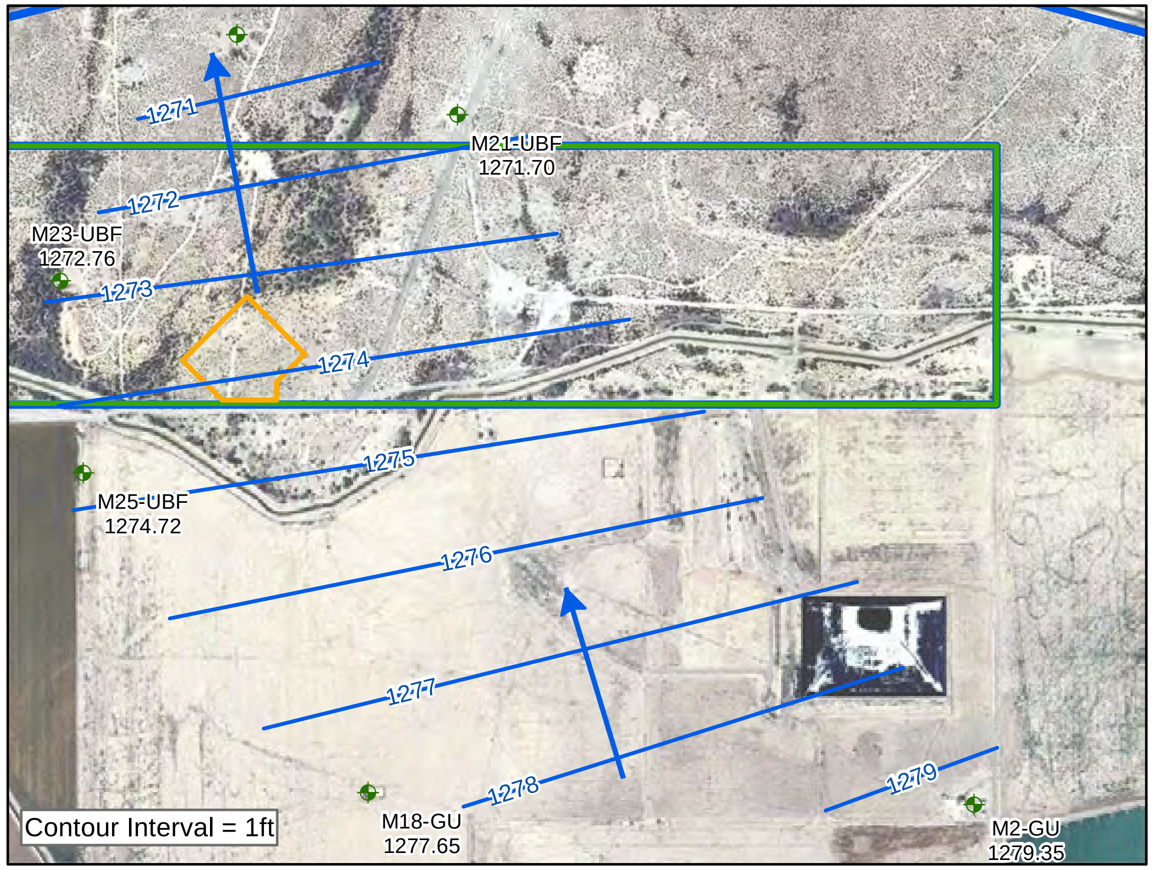
- MONITOR WELL LOCATION
  1275.60 Groundwater Elevation (ft msl)
- PTF WELL FIELD
- STATE LAND LEASE
- CURIS PROPERTY BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION

Figure 14C-45
2010
GROUNDWATER
ELEVATIONS

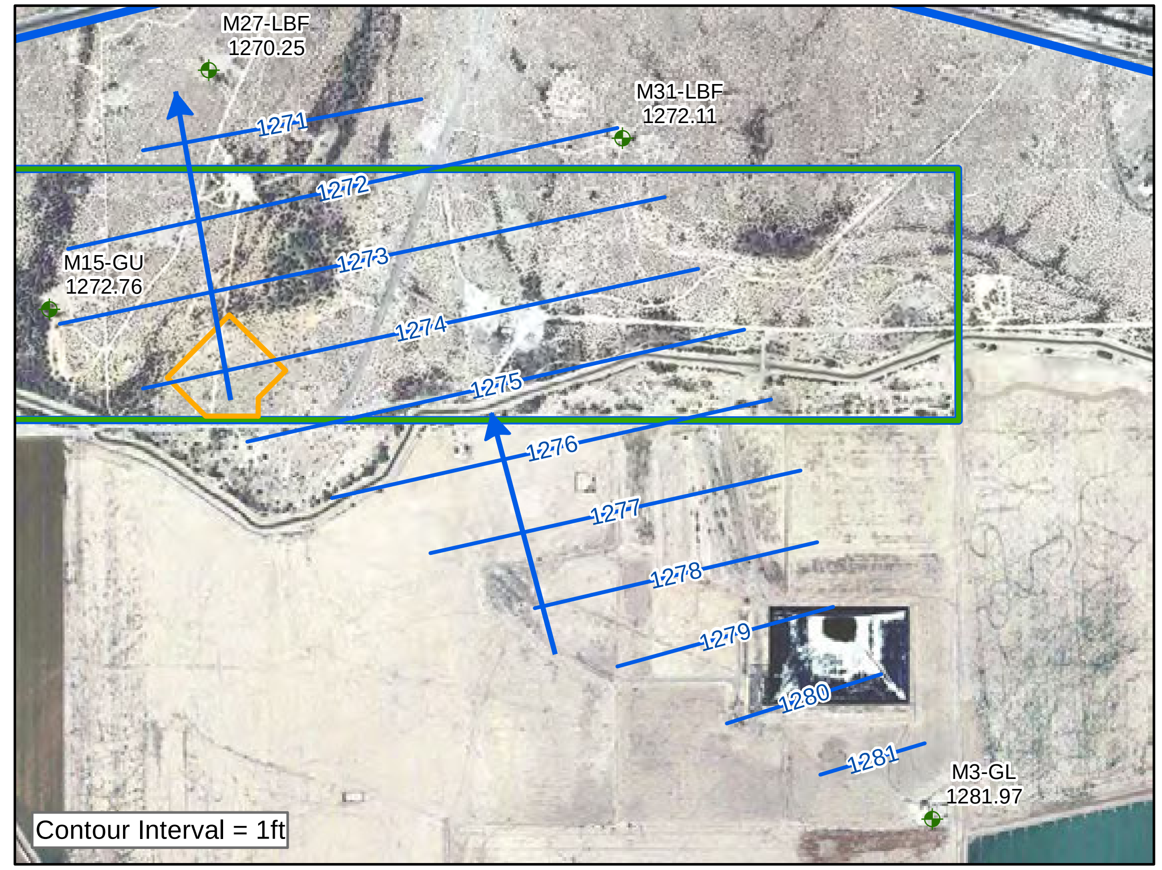
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

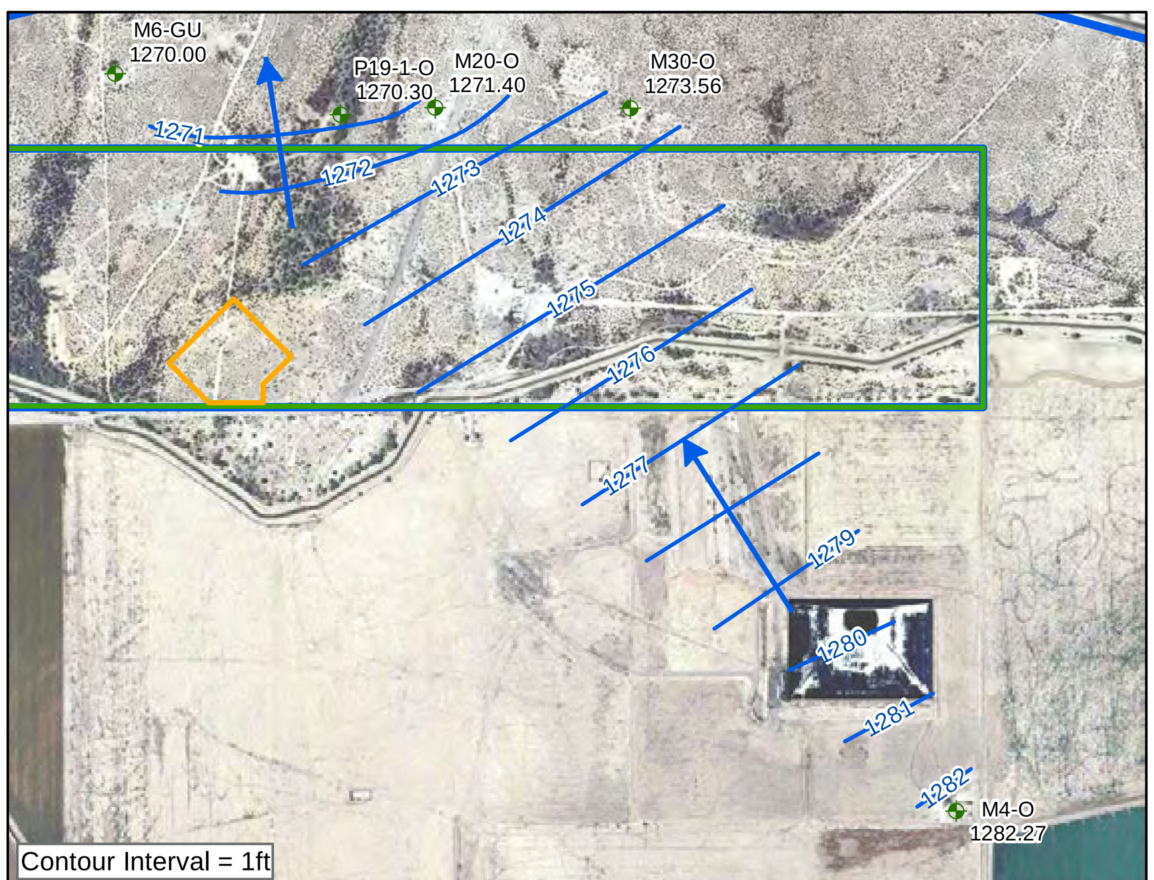
\\BCPHX03\projects\Hunter Dickinson\Curis GIS\MXDs\Temp Permit2012\G14075334014C28_WLContour_2010.mxd Updated: 1/23/2012



JANUARY 2011 - UPPER BASIN FILL UNIT



JANUARY 2011- LOWER BASIN FILL UNIT



JANUARY 2011- BEDROCK OXIDE UNIT

0 500 1,000

SCALE IN FEET

EXPLANATION

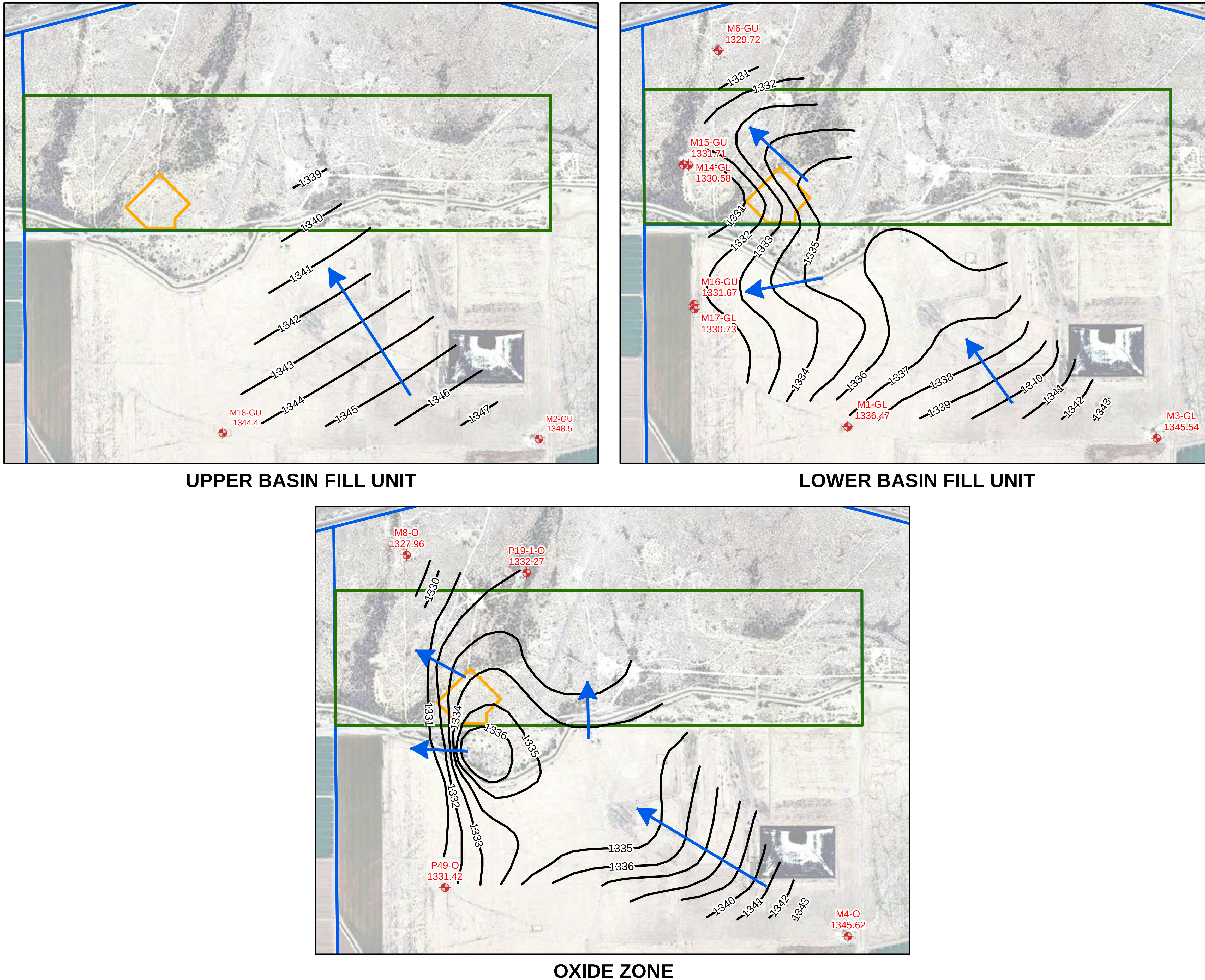
- MONITOR WELL LOCATION
  1277.65 Groundwater Elevation (ft msl)
- PTF WELL FIELD
- STATE LAND LEASE
- CURIS PROPERTY BOUNDARY
- GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION

Figure 14C-46
2011 GROUNDWATER ELEVATIONS

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

\\BCPHX03\projects\Hunter Dickinson\Curis GIS\MXDs\Temp Permit2012\G14075334014C29_WLContour_2011.mxd Updated: 1/23/2012



0 500 1,000

SCALE IN FEET

EXPLANATION

- WATER LEVEL DATA POINT
- GROUNDWATER ELEVATION CONTOUR
- PTF WELL FIELD
- STATE LAND LEASE
- CURIS PROPERTY BOUNDARY
- GROUNDWATER FLOW DIRECTION

Figure 14C-47
OCTOBER 1995 GROUNDWATER ELEVATIONS

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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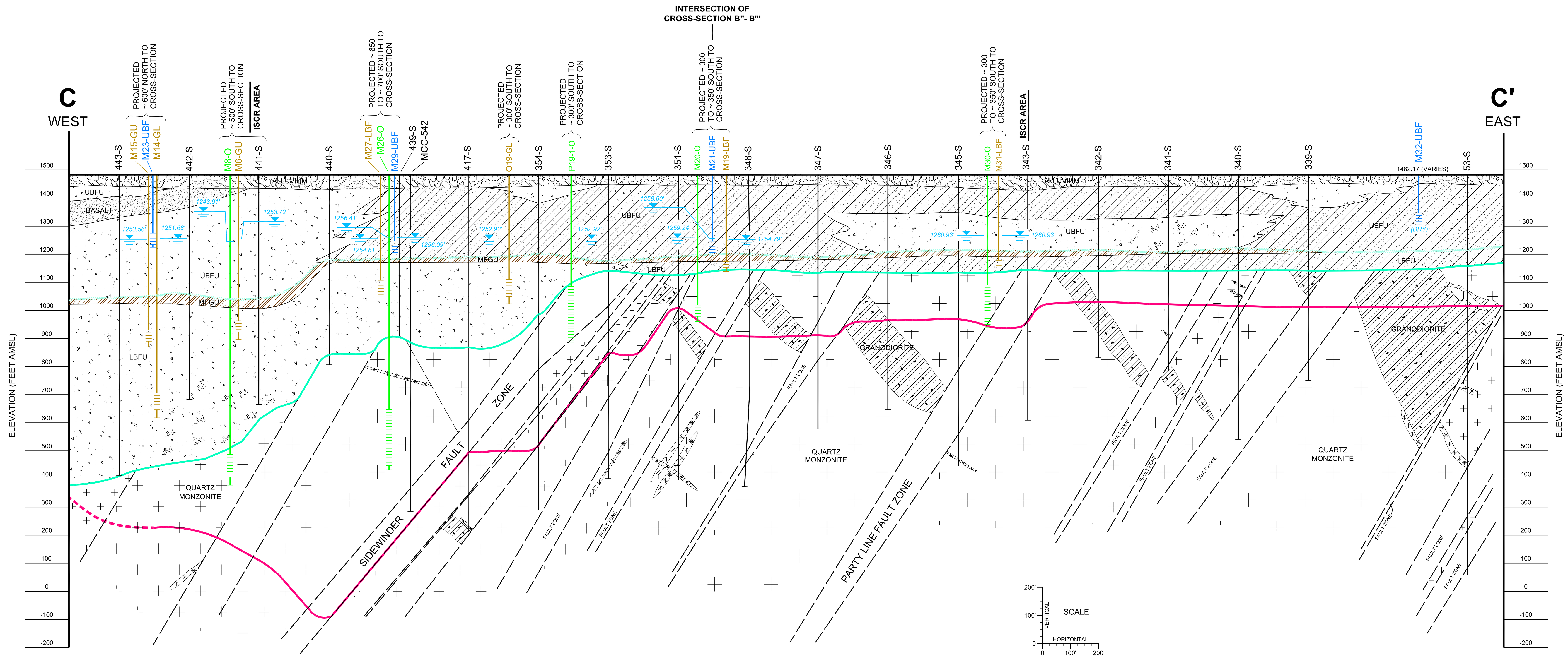
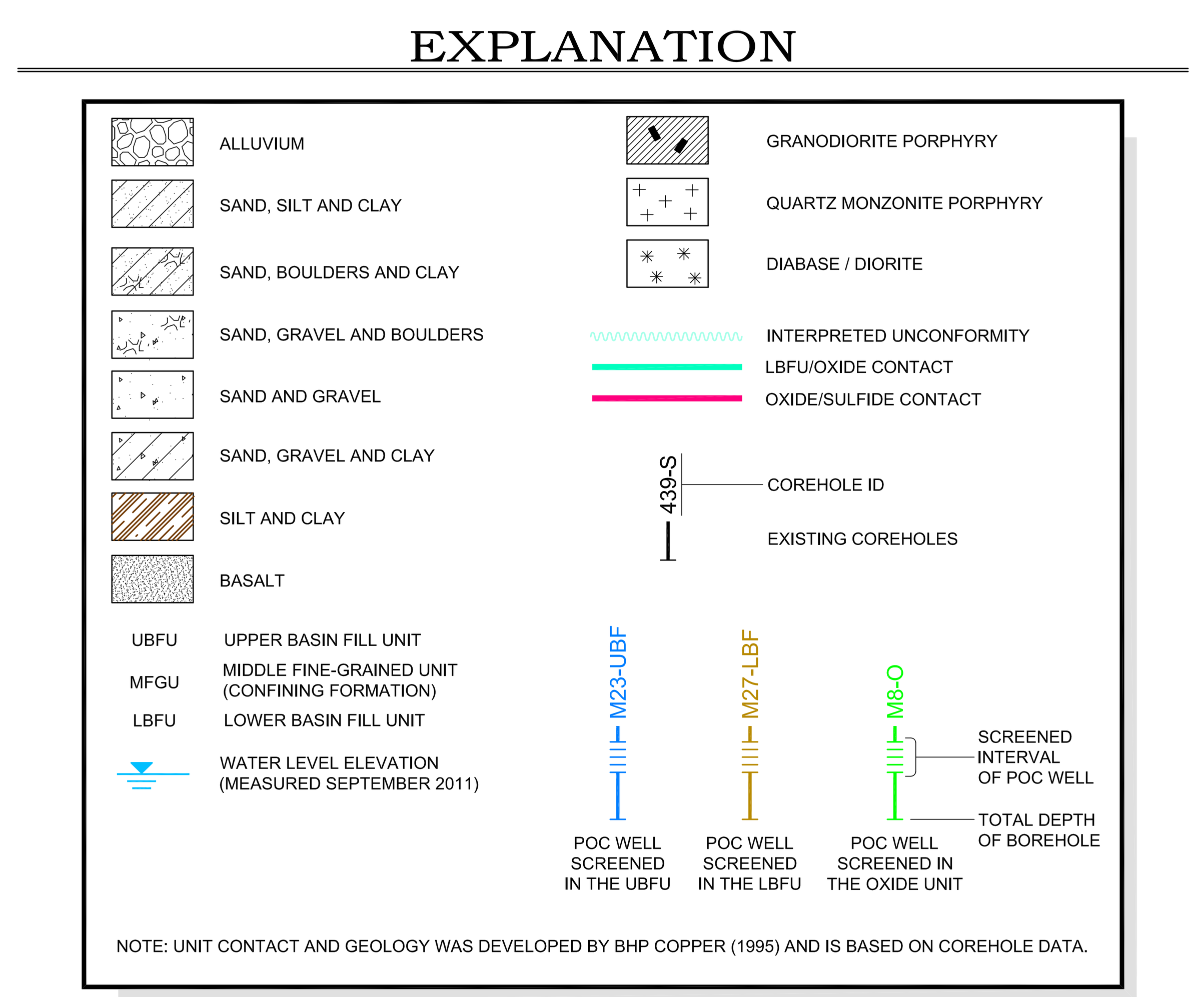
HDI CURIS

Figure 14C-48
GEOLOGIC
CROSS SECTION B''-B'''
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

P:\Hunter Dickinson\140913 - Curis - 2011 Mine Plan and GServ\Drawings\ES\140913027.dwg Jan 24, 2012 - 6:18am jcollier





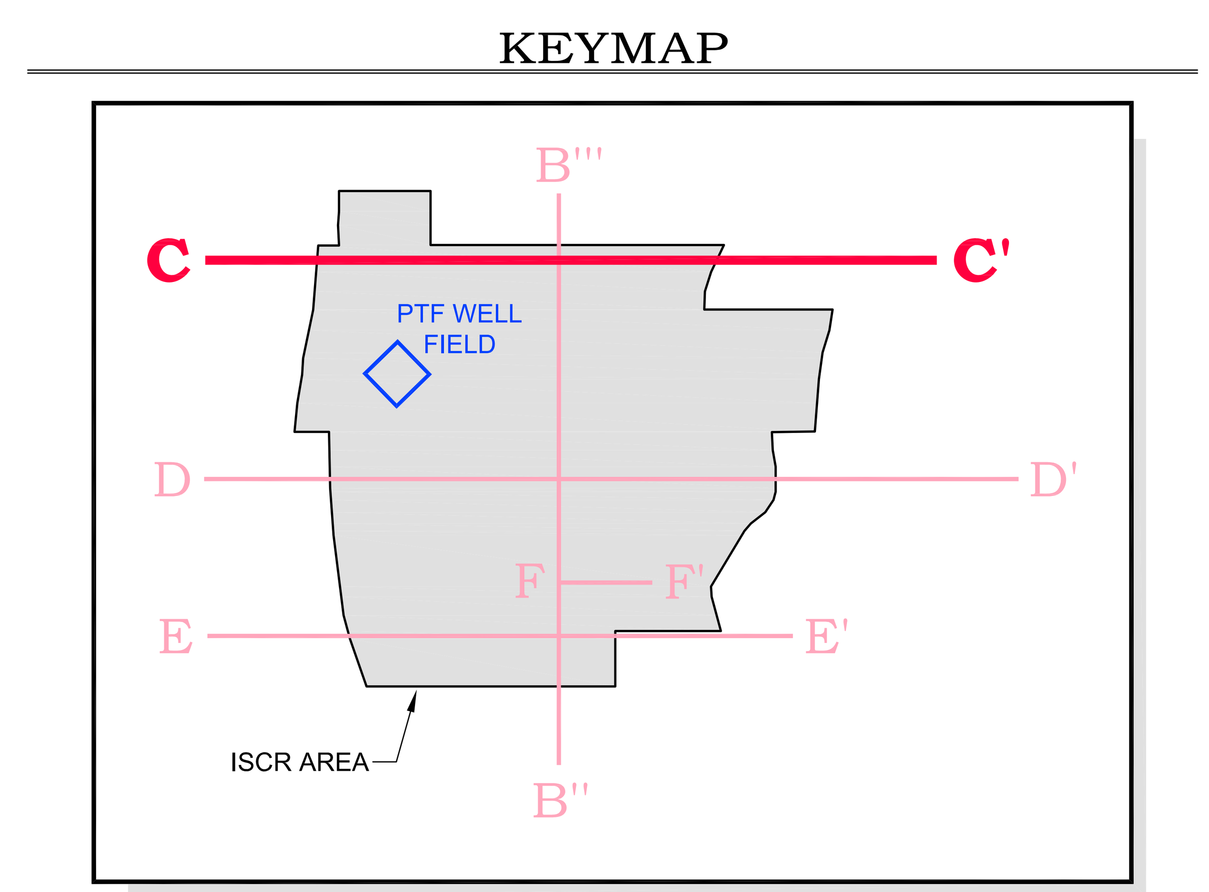


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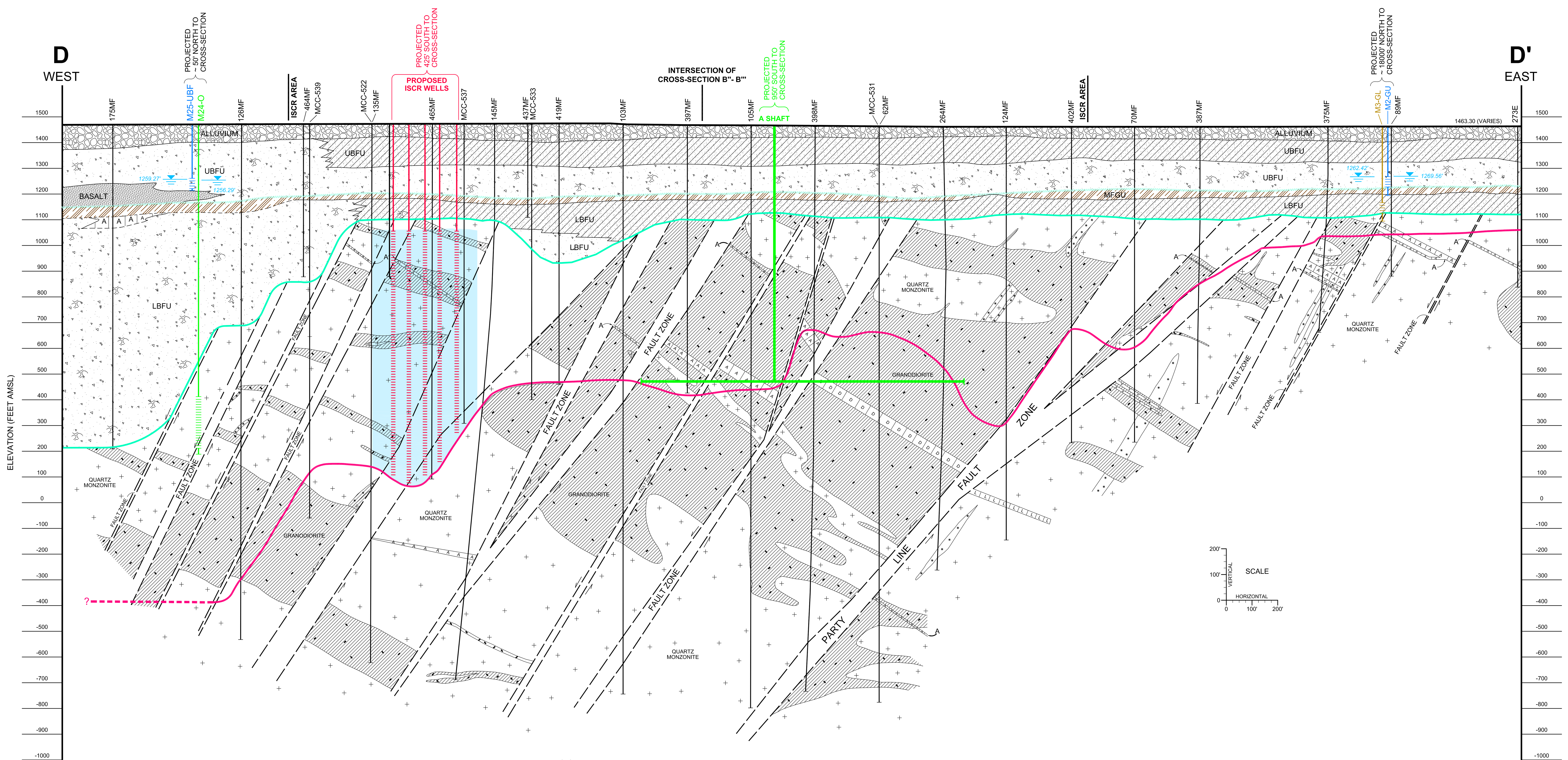
Figure 14C-49
GEOLOGIC
CROSS SECTION C-C'
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

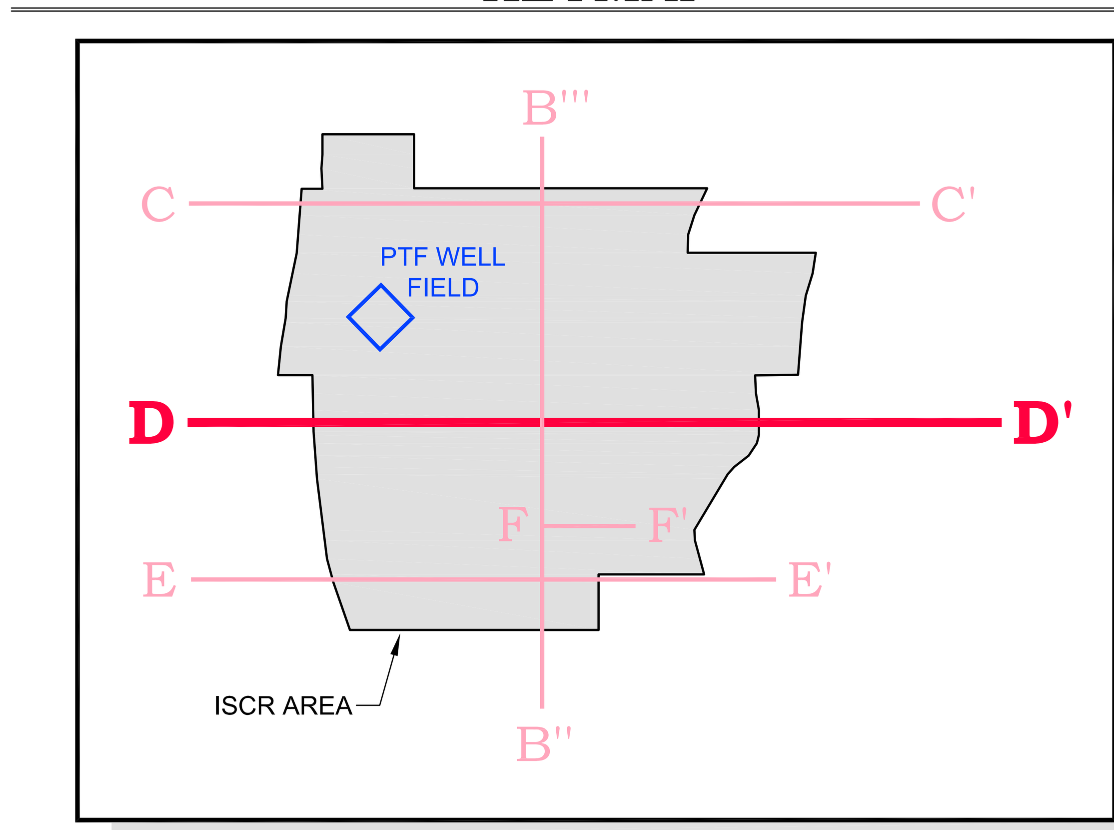


EXPLANATION

- ALLUVIUM
- SAND, SILT AND CLAY
- SAND, BOULDERS AND CLAY
- SAND, GRAVEL AND BOULDERS
- SAND AND GRAVEL
- SAND, GRAVEL AND CLAY
- SILT AND CLAY
- BASALT
- UBFU — UPPER BASIN FILL UNIT
- MFGU — MIDDLE FINE-GRAINED UNIT (CONFINING FORMATION)
- LBFU — LOWER BASIN FILL UNIT
- PROPOSED INJECTION ZONE
- WATER LEVEL ELEVATION (MEASURED SEPTEMBER 2011)
- GRANODIORITE PORPHYRY
- QUARTZ MONZONITE PORPHYRY
- DIABASE / DIORITE
- A — ANDESITE
- D — DACITE
- L — QUARTZ LATITE
- INTERPRETED UNCONFORMITY
- LBFU/OXIDE CONTACT
- OXIDE/SULFIDE CONTACT
- 419MF — COREHOLE ID
- EXISTING COREHOLES
- CONOCO UNDERGROUND WORKINGS
- M25-UBF — POC WELL SCREENED IN THE UBFU
- M15-GU — POC WELL SCREENED IN THE LBFU
- M24-O — POC WELL SCREENED IN THE OXIDE UNIT
- SCREENED INTERVAL OF POC WELL
- TOTAL DEPTH OF BOREHOLE

NOTE: UNIT CONTACT AND GEOLOGY WAS DEVELOPED BY BHP COPPER (1995) AND IS BASED ON COREHOLE DATA.

KEYMAP



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HDI CURIS

Figure 14C-50

GEOLOGIC CROSS SECTION D-D'

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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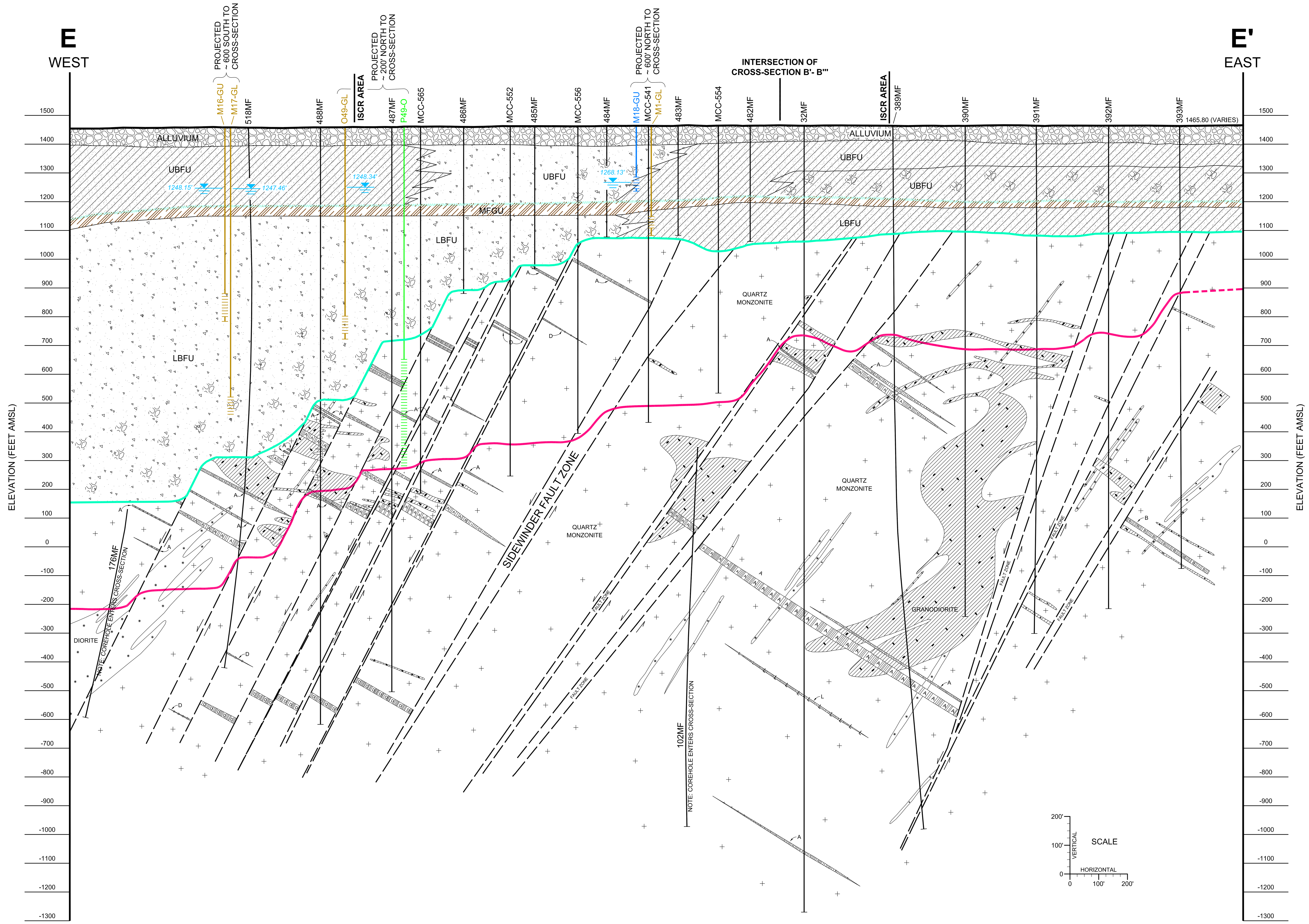


EXPLANATION

- ALLUVIUM
- SAND, SILT AND CLAY
- SAND, BOULDERS AND CLAY
- SAND, GRAVEL AND BOULDERS
- SAND AND GRAVEL
- SAND, GRAVEL AND CLAY
- SILT AND CLAY
- BASALT
- GRANODIORITE PORPHYRY
- QUARTZ MONZONITE PORPHYRY
- DIABASE / DIORITE
- A — ANDESITE
- D — DACITE
- L — QUARTZ LATITE
- INTERPRETED UNCONFORMITY
- LBFU/OXIDE CONTACT
- OXIDE/SULFIDE CONTACT

UBFU — UPPER BASIN FILL UNIT
MFGU — MIDDLE FINE-GRAINED UNIT (CONFINING FORMATION)
LBFU — LOWER BASIN FILL UNIT

WATER LEVEL ELEVATION (MEASURED SEPTEMBER 2011)

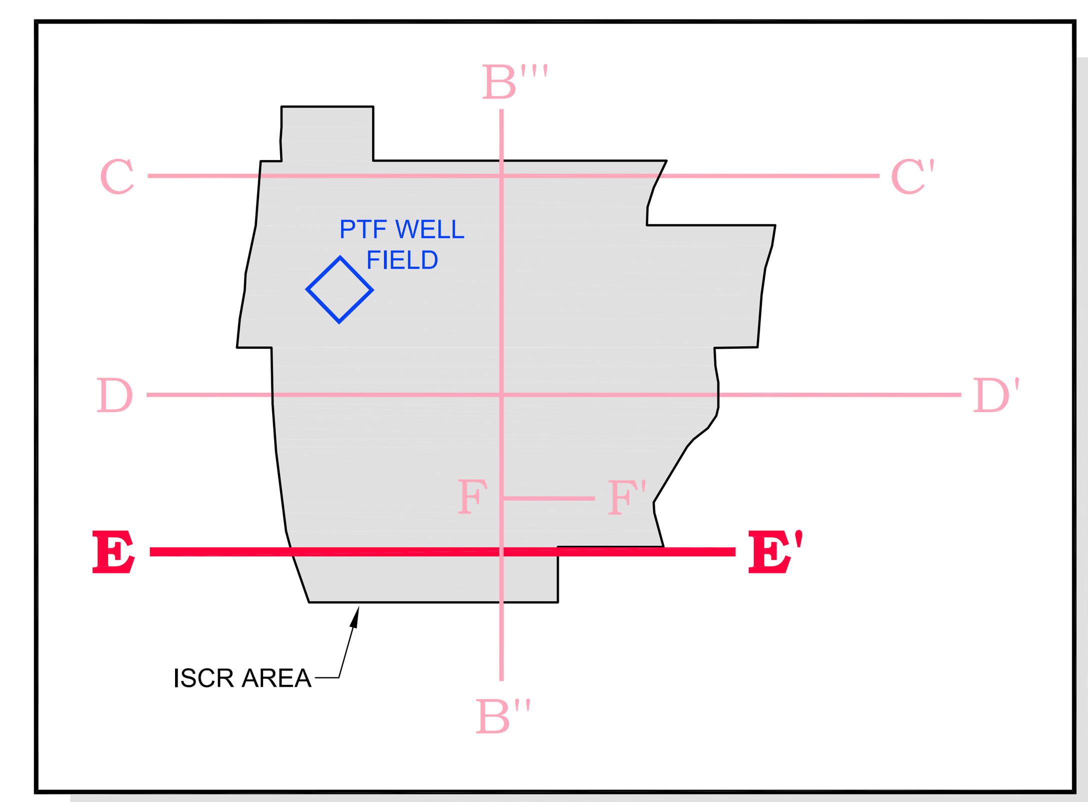
391MF — COREHOLE ID
EXISTING COREHOLES

M2-GU — POC WELL SCREENED IN THE UBFU
M17-GL — POC WELL SCREENED IN THE LBFU
P49-O — POC WELL SCREENED IN THE OXIDE UNIT

SCREENED INTERVAL OF POC WELL
TOTAL DEPTH OF BOREHOLE

NOTE: UNIT CONTACT AND GEOLOGY WAS DEVELOPED BY BHP COPPER (1995) AND IS BASED ON COREHOLE DATA.

KEYMAP



Brown AND Caldwell

HDI CURIS

Figure 14C-51
GEOLOGIC
CROSS SECTION E-E'
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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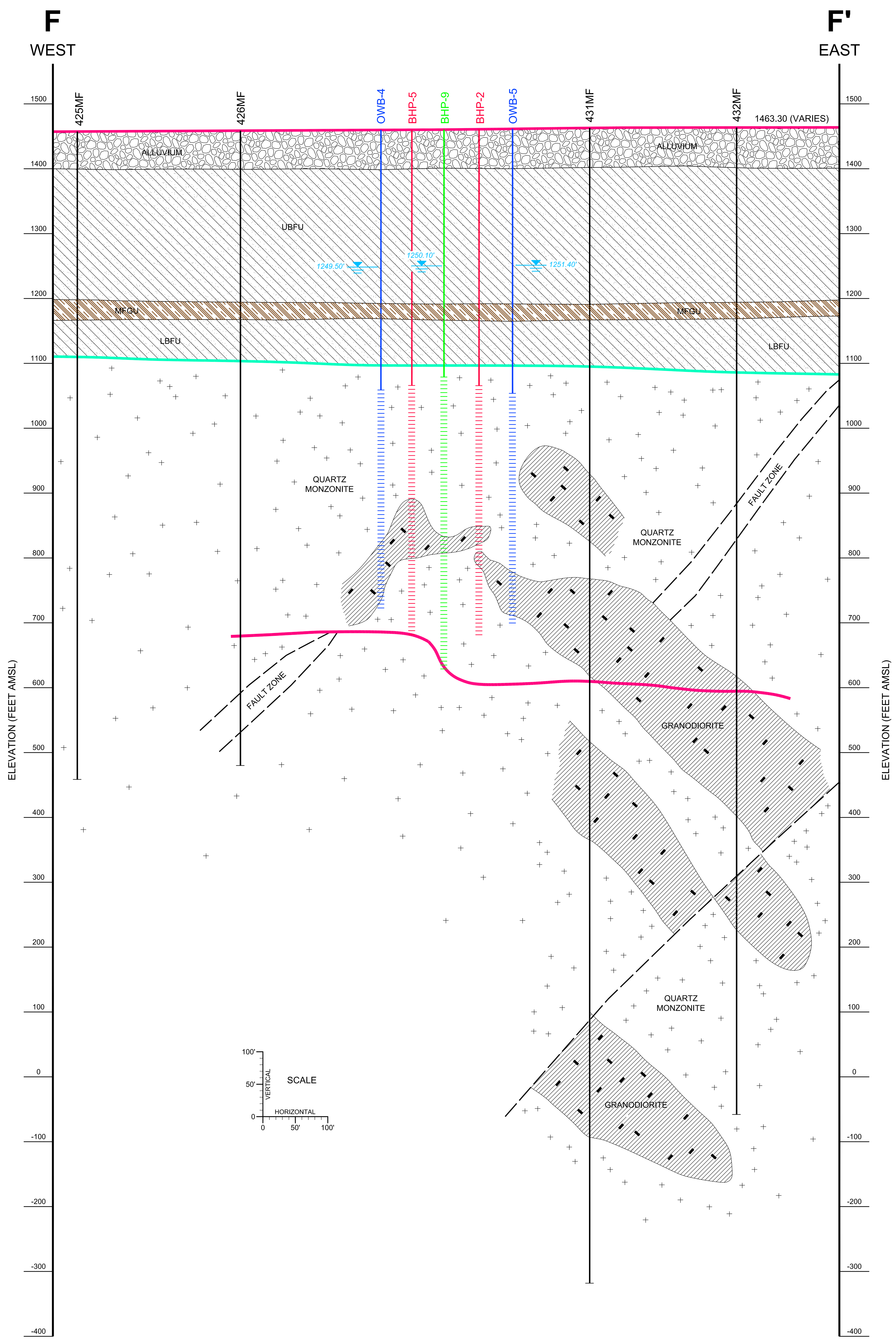
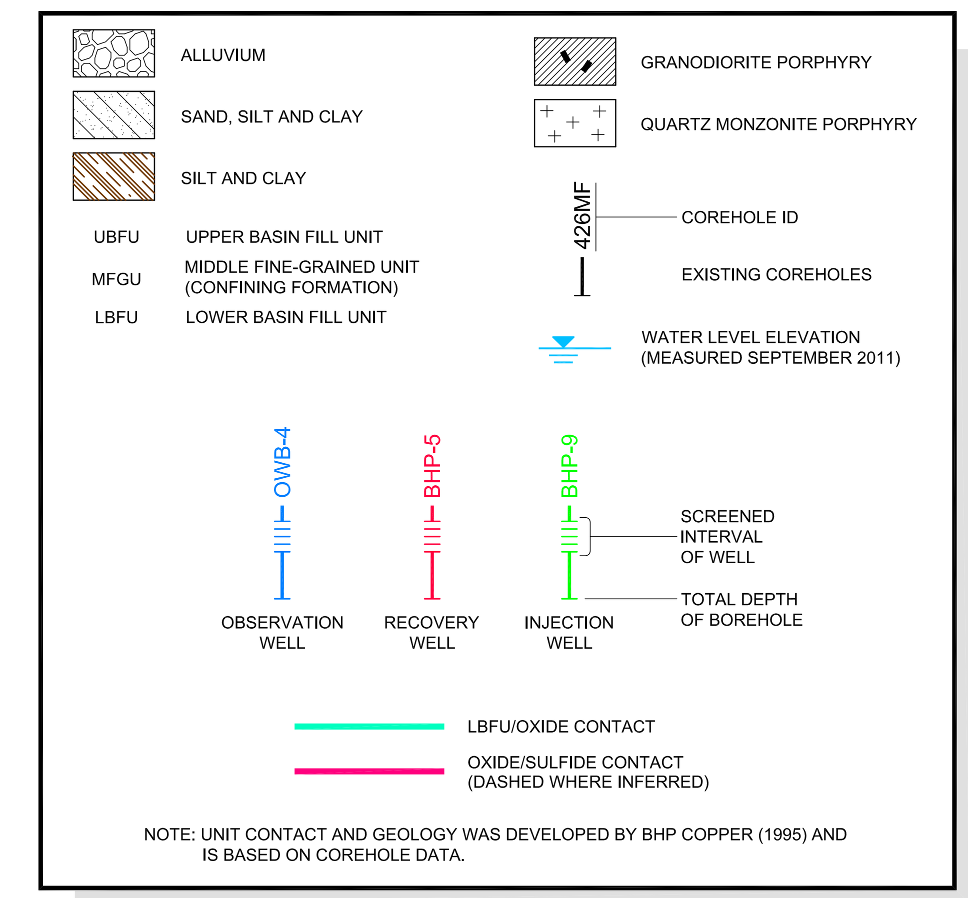
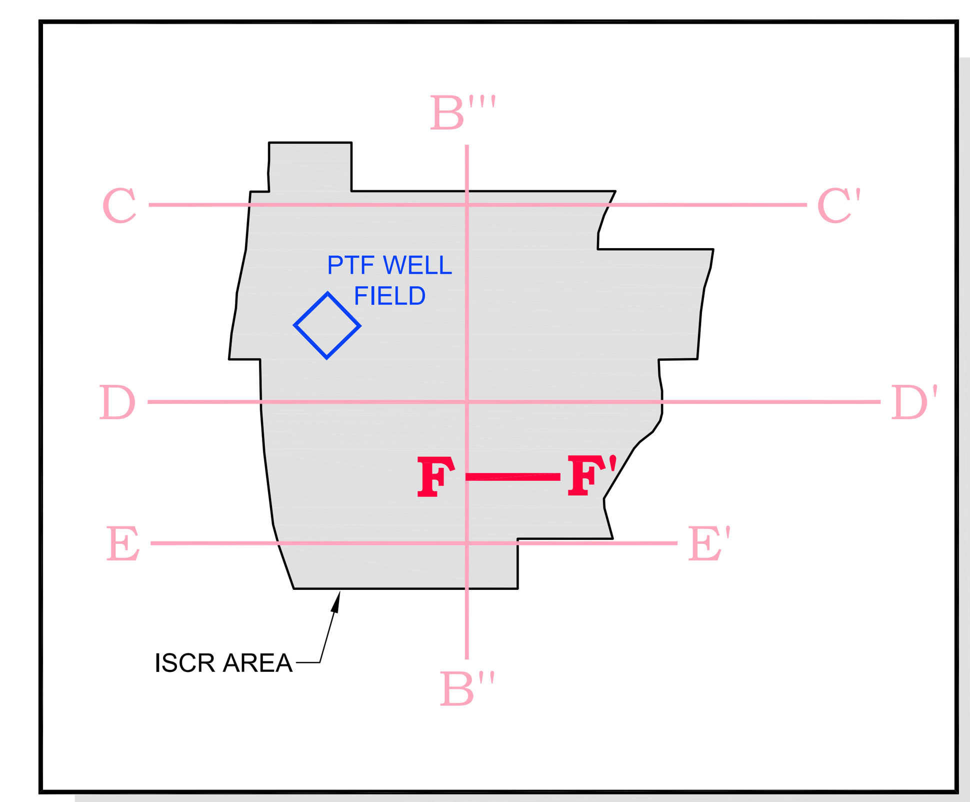


EXPLANATION



KEYMAP



Brown AND Caldwell

HDI CURIS

Figure 14C-52
GEOLOGIC
CROSS SECTION F-F'
CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

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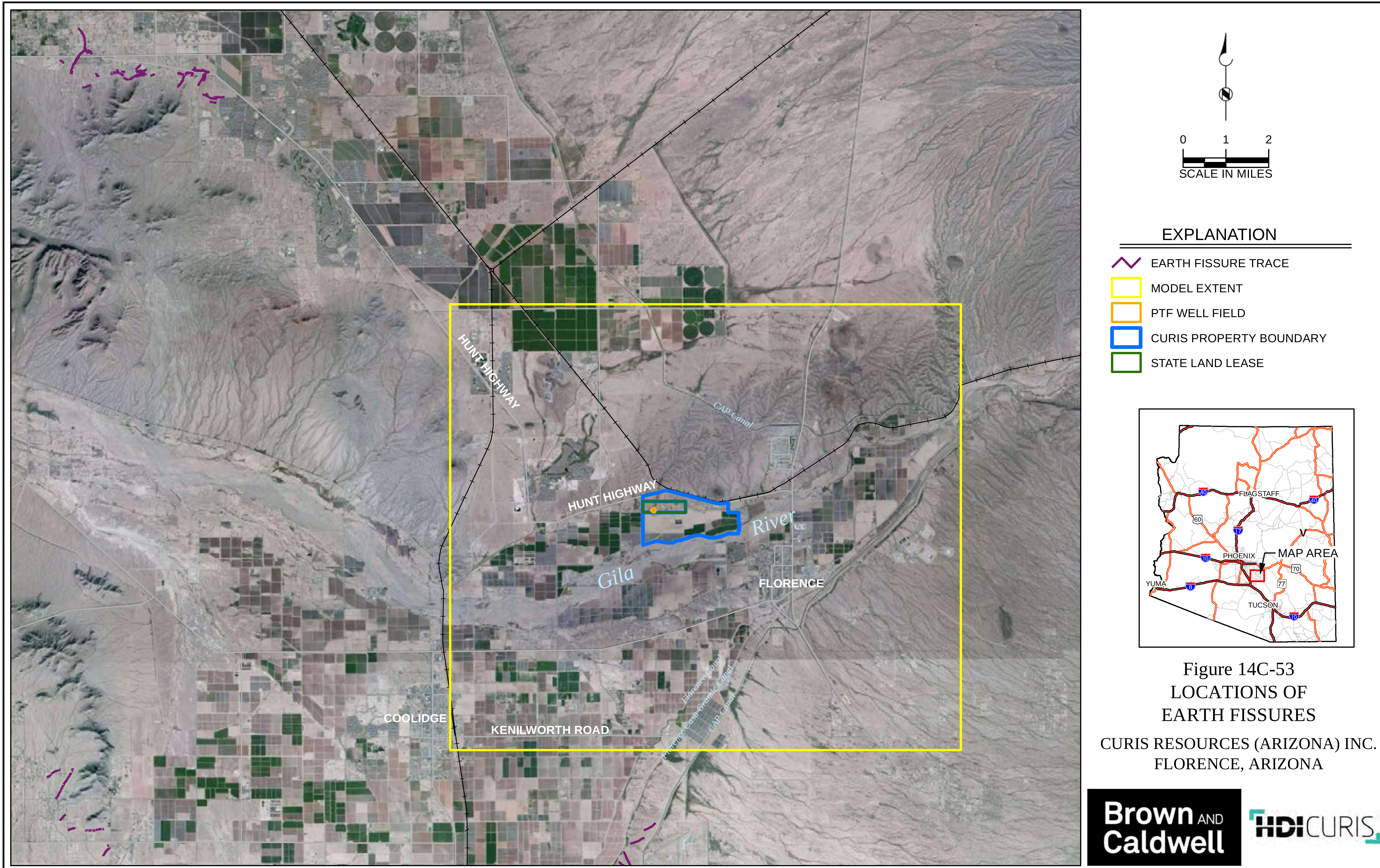


Figure 14C-53
LOCATIONS OF
EARTH FISSURES

CURIS RESOURCES (ARIZONA) INC.
FLORENCE, ARIZONA

Brown AND Caldwell

HDI CURIS

\\BCPHX03\projects\Hunter Dickinson\Curis GIS\MXDs\Temp Permit2012\G14075334006EarthFissure.mxd Updated: 1/24/2012

Exhibit 14C-1

Hydraulic Control Testing Memo (April 6, 1998)

BHP

BHP Copper

6 April 1998

Ms. Julie Collins
ADEQ Compliance Officer
Arizona Department of Environmental Quality
3033 N. Central Ave.
Phoenix, AZ 85012

Dear Ms. Collins,

In order to satisfy Part II.E.1.a of Aquifer Protection Permit #101704 (permit page 7), BHP Copper is submitting data demonstrating that hydraulic control was maintained during a 90-day pre-operational period. The pre-operational compliance test was conducted from November 8, 1997 until February 10, 1998. The attached information and graphs are based on two data sets. The first set is the electrical conductivity readings measured by field technicians on daily composite samples. The second set of data includes the elevation of the water table for four pairs of pumping and observation wells. These pairs are located in the four quadrants of the compliance test area and are representative of conditions in the field area. Each pair consists of a pumping well and an observation well located 50 feet to the east or west of the pumping well. The pairs are:

Quadrant	Pumping Well	Observation Well
Northwest	BHP4	OWB3
Northeast	BHP3	OWB1
Southwest	BHP5	OWB4
Southeast	BHP2	OWB5

The data for electrical conductivity was measured by hand. The samples were taken by two methods. The wells labeled as BHP2, BHP3, BHP4, and BHP5 were continuously running pumping wells. The samples on these wells were made from a 24-hour composite, with each individual sample being a 0.25 gallon sample taken every six hours. These samples were blended and a portion taken for analysis. Observation wells OWB1, OWB3, OWB4, and OWB5 did not have pumps in them during the test. These wells were sampled using a sample baler with a small pump attached to guarantee a good sample. The procedure for this sampling was to turn the pump

BHP Copper Inc. 7400 North Oracle Road Suite 200 Tucson Arizona 85704
Telephone (520) 575-5600
BHP Copper is a Business Group of The Broken Hill Proprietary Company Limited

on for five minutes and then let the sample collect for another two minutes before retrieving the baler. This sample was then analyzed. The conductivity readings were conducted on site with a YSI meter by the person doing the sampling.

The data for the water elevation levels was gathered electronically using the controllers in the well field on each individual well. The controllers upload this information continuously to the well field computer at the operator control room. The water levels of the individual wells were taken from 12 hour (12 o'clock to 12 o'clock) electronic shift files. Each well has an electronic file for each shift; these files contain readings taken every five minutes. The readings were averaged over the shift, and entered into a spread sheet.

Aberrations in the conductivity data are a result of operator error and instrument error including interference of hand-held radios used in the same room as the conductivity probe. Aberrations in the water level data are primarily a result of instrument error including maintenance problems with pressure transducers and temporary adjustments to the pumps. On OWB5, there is a period of missing or unreliable data between December 21 to December 29, 1997 caused by the malfunction of the pressure transducer in the well head. Replacements also malfunctioned, but a properly performing unit was eventually in place. If you have any questions about the data or graphs, please call me at (520) 868-5092. Thank you.

Yours sincerely,

Corolla Hoag

Ms. Corolla (Cori) Hoag

Attached: graphs showing electrical conductivity and water levels, and field measurements.

BHP

To: Corolla Hoag Sr. Geologist

This sheet only for our files. C.H.

CC: File

From: Michael Kline

Date: April 3, 1998

Compliance Test Report Information

Data for Compliance test and explanation

The data consists of two sets of readings. The first is the electrical conductivity. The second is elevation of water table for observation pairs in the well field. This is grouped into pairs corresponding to the four sides of the well field. These pairs are: North West (BHP4,OWB3), North East (BHP3,OWB1), South West (BHP5,OWB4), South East (BHP2,OWB5).

The Data for electrical conductivity was taken by hand. These samples were taken two ways. The wells labeled as BHP2, BHP3, BHP4, and BHP5 were used as continuously running pumping wells. The samples on these wells are made from a twenty four hour composite, with each individual sample being a ¼ gallon sample taken every 6 hours. These samples were blended, and a portion cut for analysis. The wells labeled as OWB1, OWB3, OWB4, and OWB5 did not have pumps in them during the test. These wells were sampled using a sample baler with a small pump attached to guarantee a good sample. The procedure for this sampling was to turn the pump on for five minutes and then let the sample set for another two before retrieving the baler. This sample was then analyzed. The analysis used for electrical conductivity was performed by the person doing the sampling. This was done on sight using the YSI meter located in the control room.

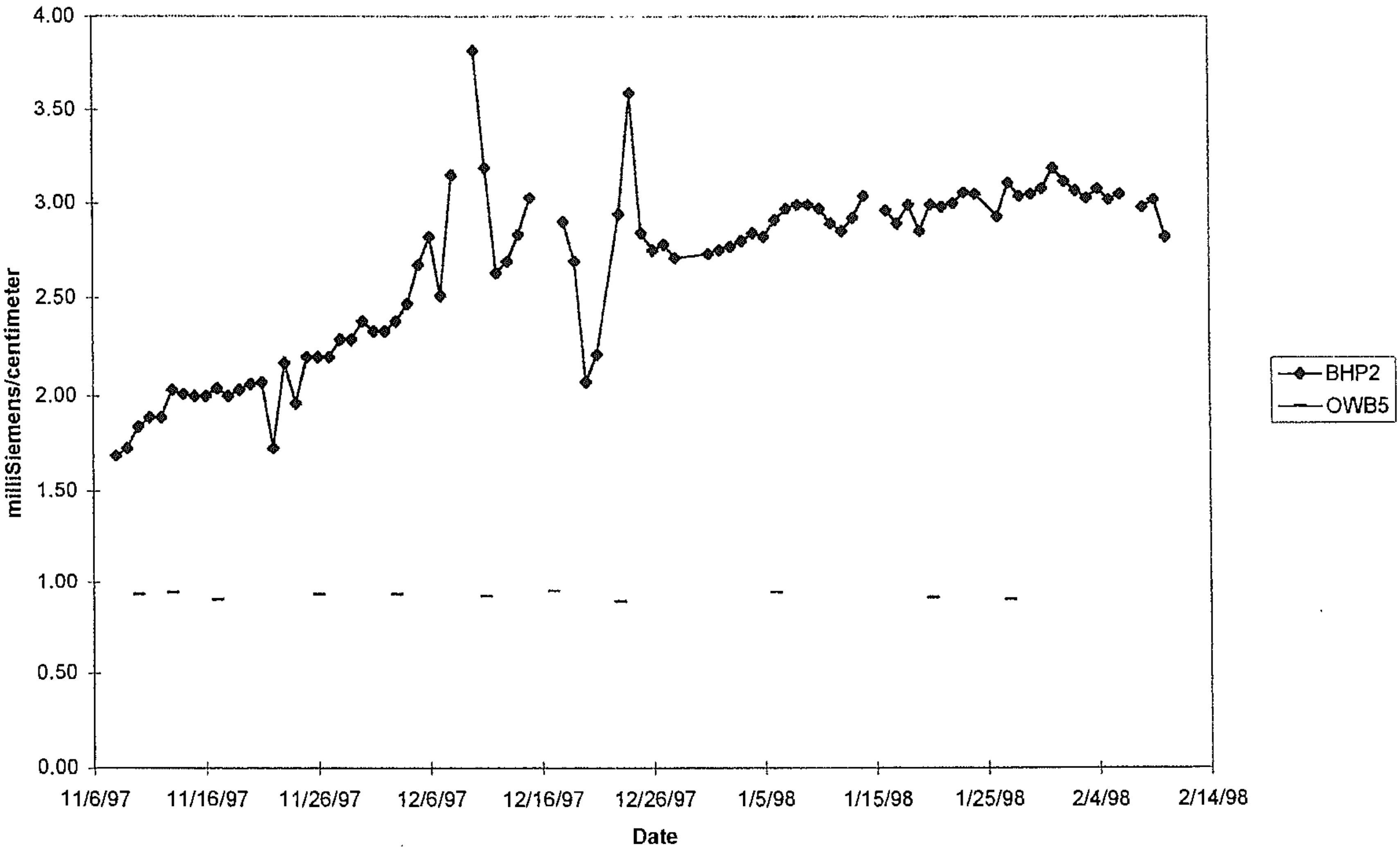
The data for the Water levels was gathered electronically using the controllers in the well field on each individual well. The controllers download this information continuously to the well field computer at the operator trailer. The water levels of the individual wells were taken from 12 hour (12 o'clock to 12 o'clock) shift files. Each well has its own individual file for each shift. These files contain readings taken every five minutes. These readings where averaged over the shift, and entered onto a spread sheet (d:\data\daily average.xls). This data was translated from depth of water table from surface to Elevation of water table using Excel.

On OWB5 there is a period of missing and corrupted data (12/21/97 to 12/29/970) this was caused by malfunction of pressure transducer in well head. A replacement was placed in within a day but this was also malfunctioning.

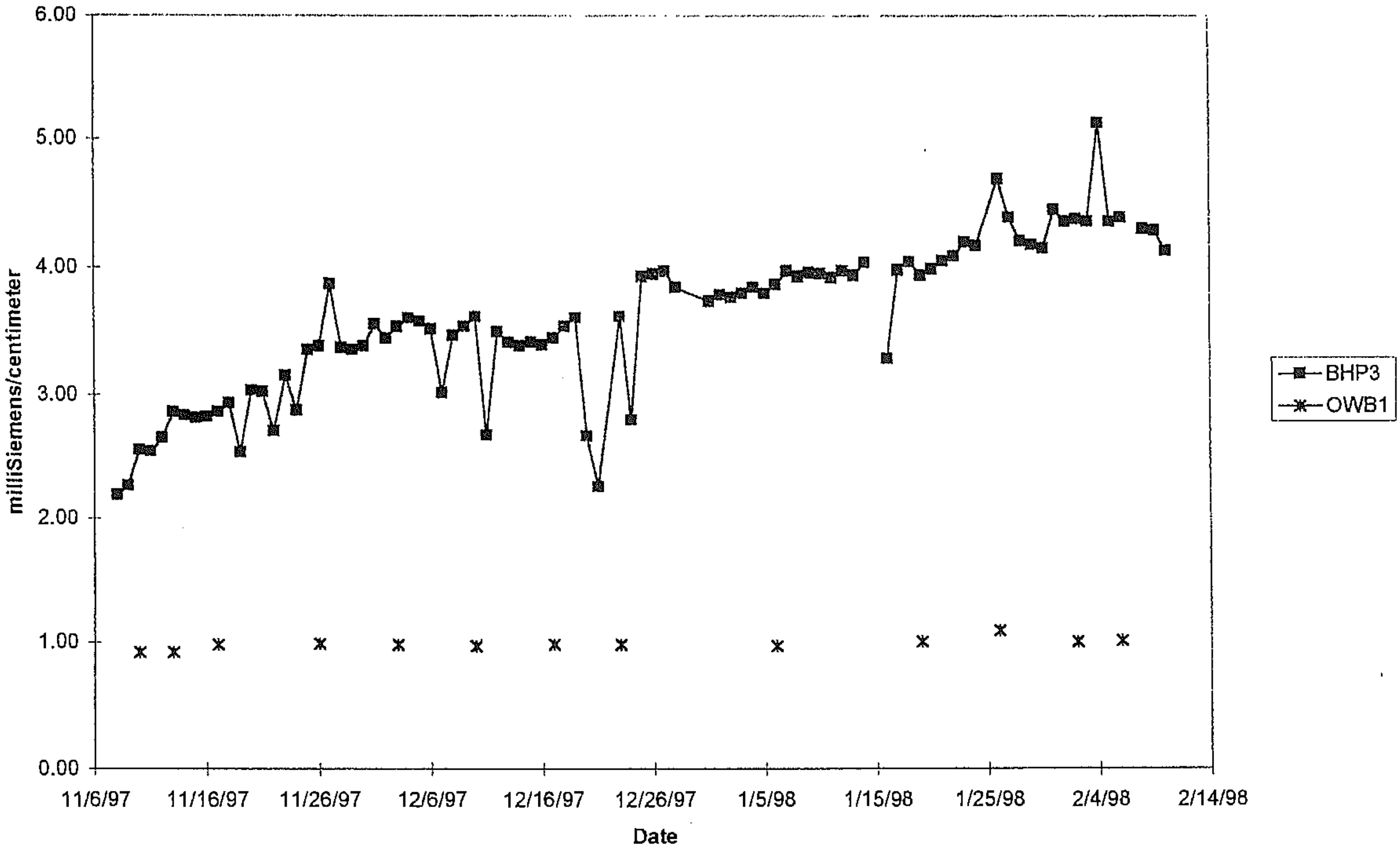
The following pages contain graphs of the electrical conductivity and the water table elevation versus time. Also included is a copy of the data for these graphs.

Michael Kline

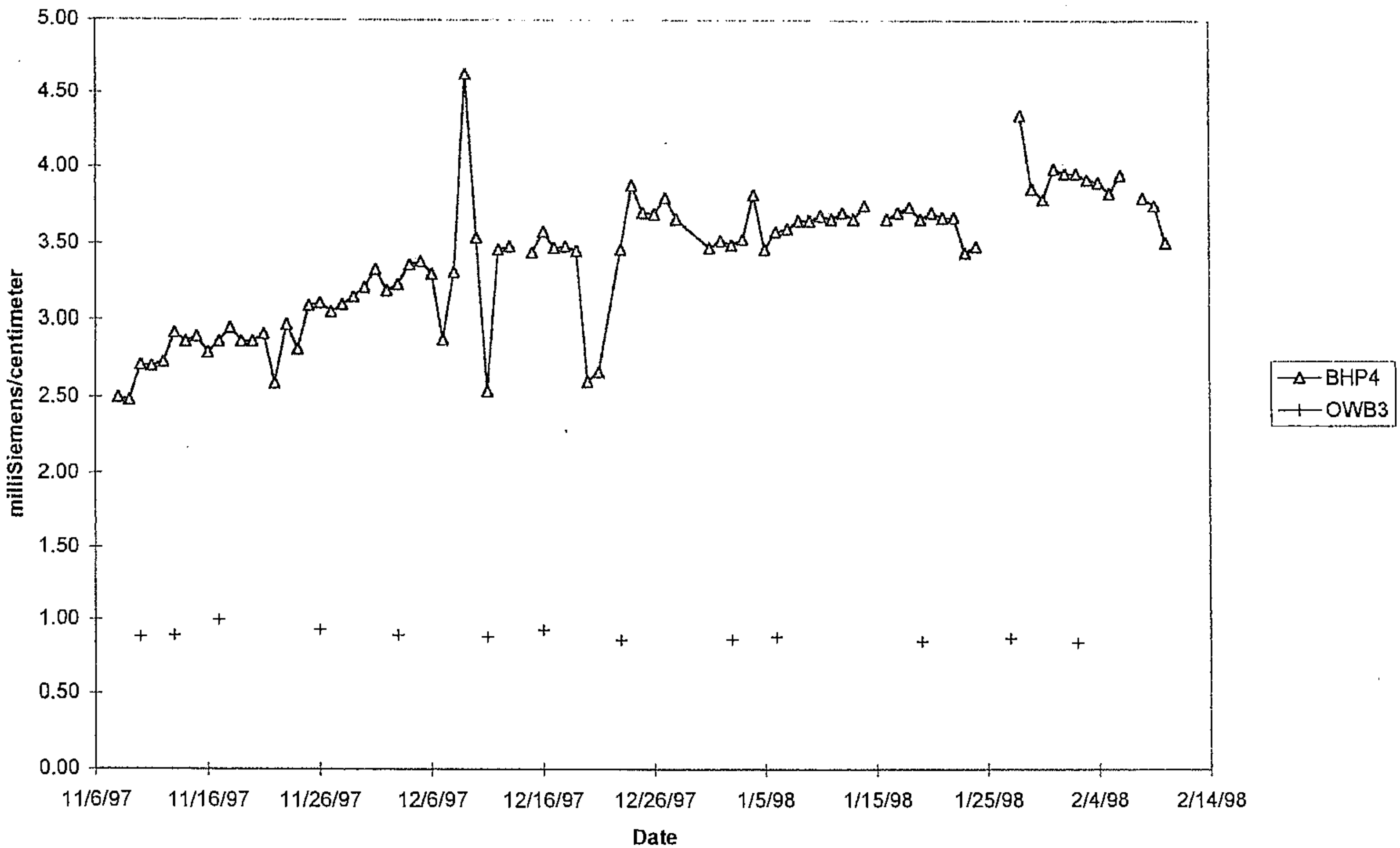
Electrical Conductivities for Observation Well Pair



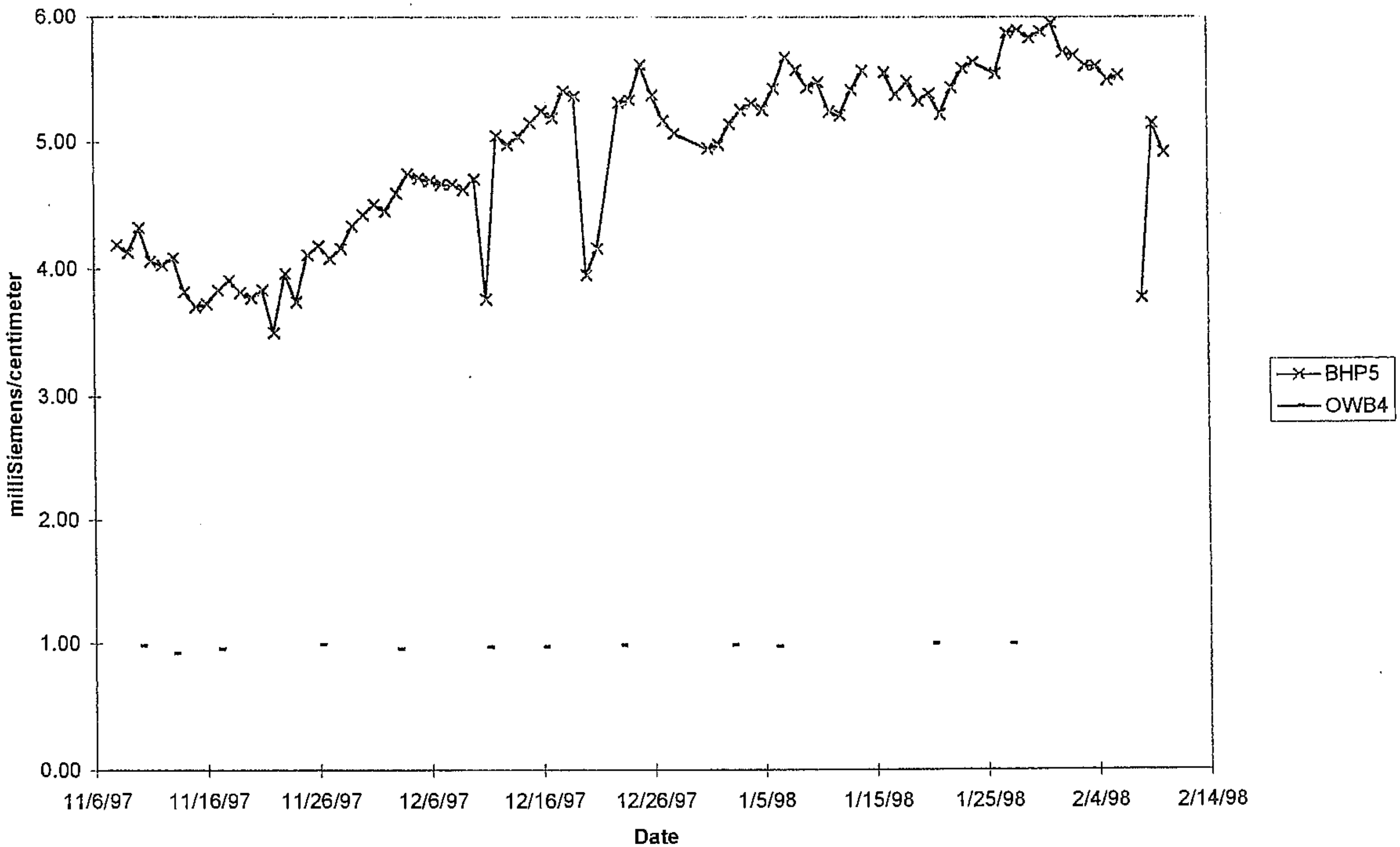
Electrical Conductivities for Observation Well Pair



Electrical Conductivities for Observation Well Pair



Electrical Conductivities for Observation Well Pair

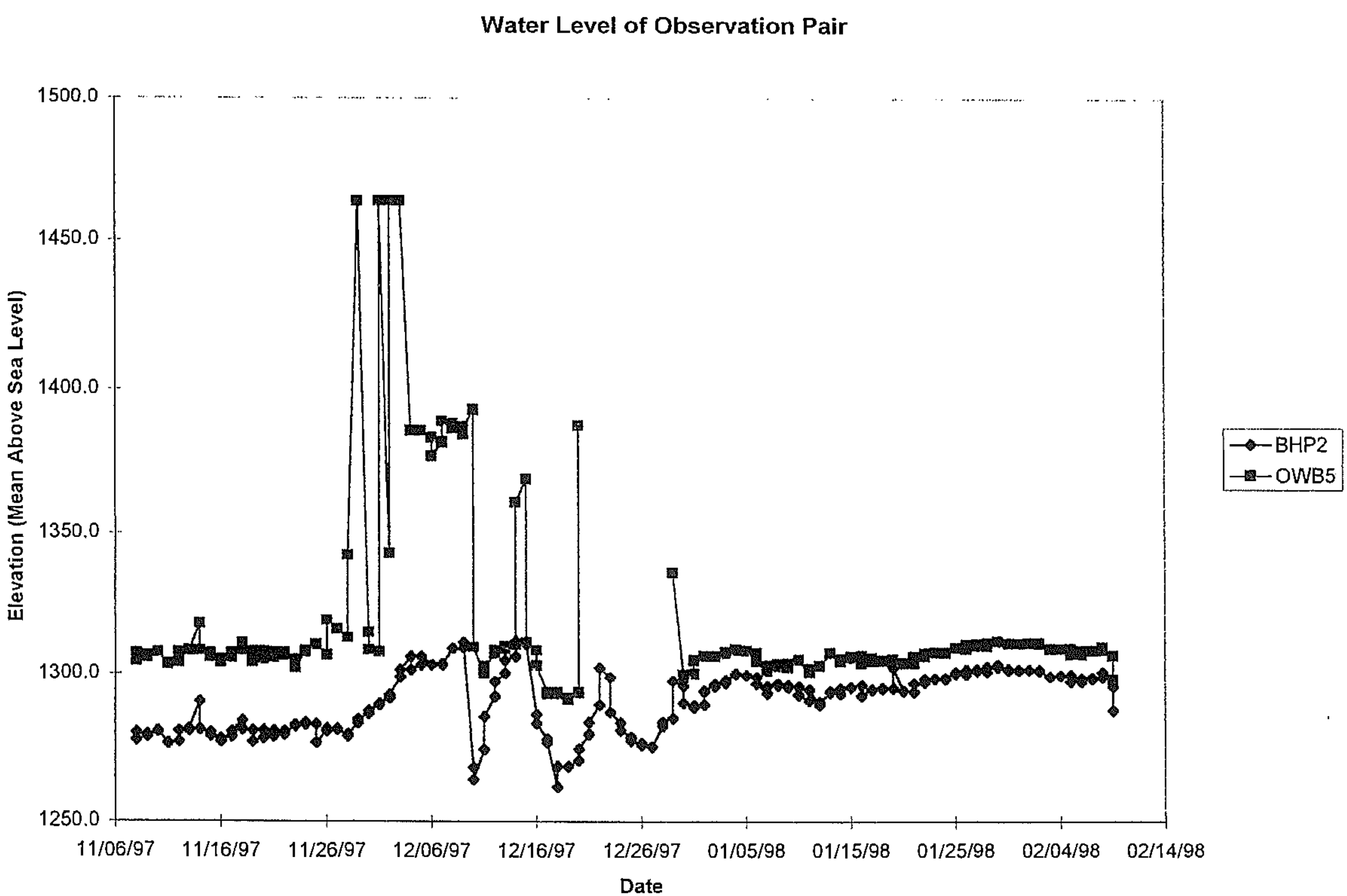


Electrical Conductivity Readings in milliSiemens/centimeter

Date	BHP5	OWB1	OWB2	OWB3	OWB4	OWB5	OWB6
11/8/97	4.19		1.89				
11/9/97	4.13		1.96				
11/10/97	4.33	0.92	1.87	0.88	0.98	0.93	0.91
11/11/97	4.06		1.94				
11/12/97	4.03		1.86				
11/13/97	4.09	0.92	1.95	0.89	0.92	0.94	0.87
11/14/97	3.82		1.91				
11/15/97	3.70		2.13				
11/16/97	3.72		1.86				
11/17/97	3.83	0.98	1.88	1.00	0.95	0.90	0.92
11/18/97	3.91		1.88				
11/19/97	3.81						
11/20/97	3.77		1.93				
11/21/97	3.83		1.92				
11/22/97	3.50						
11/23/97	3.96		1.91				
11/24/97	3.74						
11/25/97	4.11						
11/26/97	4.18	0.99	1.91	0.93	0.99	0.93	0.92
11/27/97	4.08						
11/28/97	4.16						
11/29/97	4.34						
11/30/97	4.43						
12/1/97	4.51						
12/2/97	4.46						
12/3/97	4.60	0.98	1.89	0.89	0.95	0.93	0.85
12/4/97	4.75						
12/5/97	4.72		1.91				
12/6/97	4.70						
12/7/97	4.67						
12/8/97	4.67		1.98				
12/9/97	4.63						
12/10/97	4.71	0.97	1.88				
12/11/97	3.76			0.88	0.97	0.92	0.93
12/12/97	5.05		1.93				
12/13/97	4.98						
12/14/97	5.04						
12/15/97	5.15						
12/16/97	5.24			0.93	0.97		
12/17/97	5.19	0.98	1.92			0.95	0.89
12/18/97	5.40						
12/19/97	5.36		2.15				
12/20/97	3.95						
12/21/97	4.16						
12/23/97	5.31	0.98		0.86	0.98	0.89	0.89
12/24/97	5.33						
12/25/97	5.61						
12/26/97	5.37		1.87				
12/27/97	5.17						
12/28/97	5.07						

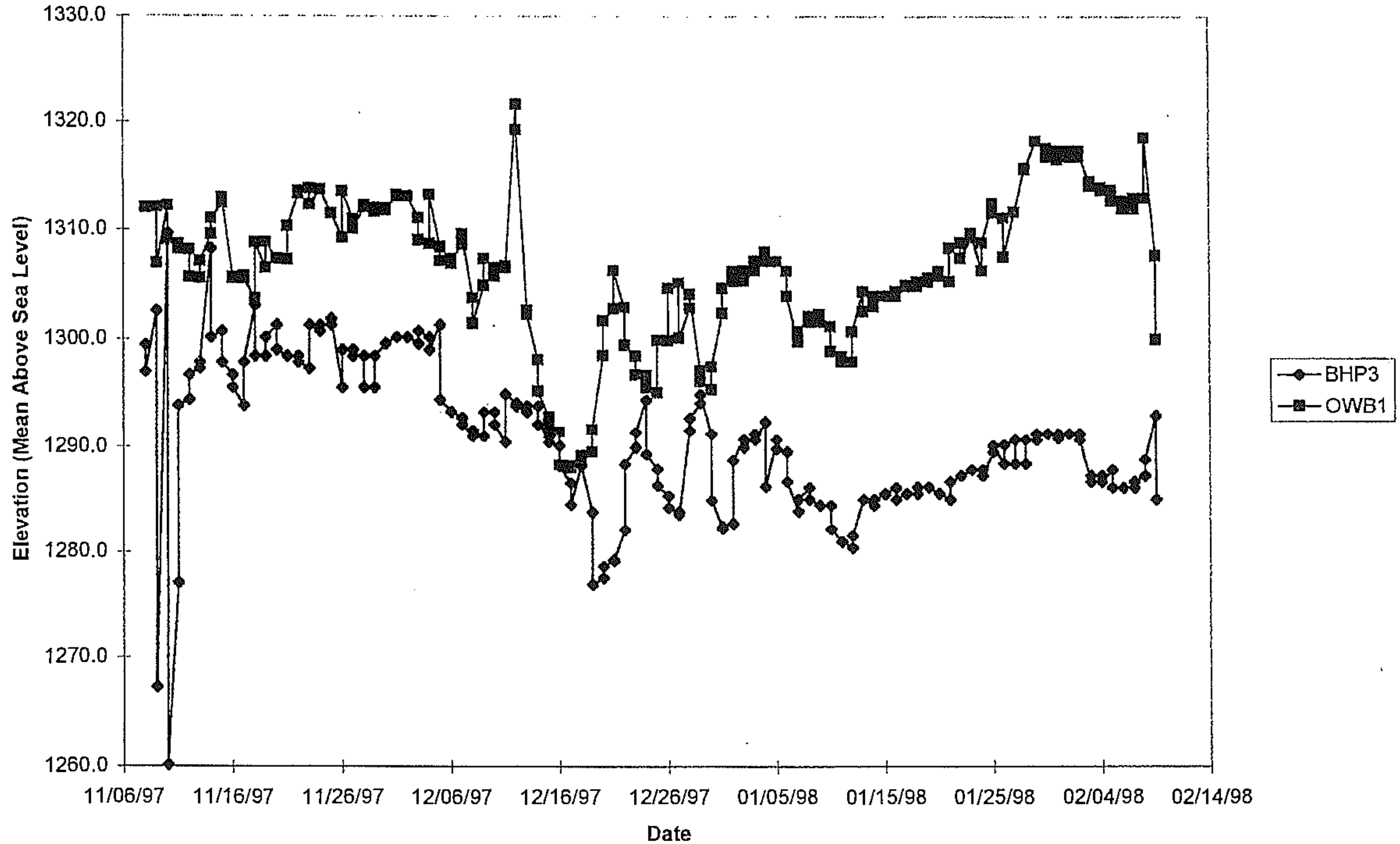
Electrical Conductivity Readings in milliSiemens/centimeter

12/31/97	4.95						
1/1/98	4.98						
1/2/98	5.14			0.86	0.98		
1/3/98	5.25						
1/4/98	5.30						
1/5/98	5.25		1.90				
1/6/98	5.42	0.97		0.88	0.97	0.94	0.90
1/7/98	5.67						
1/8/98	5.57						
1/9/98	5.43		1.88				
1/10/98	5.47						
1/11/98	5.24						
1/12/98	5.21		1.90				
1/13/98	5.41						
1/14/98	5.56						
1/15/98							
1/16/98	5.55						
1/17/98	5.37						
1/18/98	5.48						
1/19/98	5.32	1.00	1.90	0.85			
1/20/98	5.38				0.99	0.91	0.87
1/21/98	5.22						
1/22/98	5.43						
1/23/98	5.58		1.87				
1/24/98	5.63						
1/26/98	5.54	1.09	1.87				
1/27/98	5.87			0.87	0.99	0.90	
1/28/98	5.89		1.91				
1/29/98	5.83						
1/30/98	5.88						0.89
1/31/98	5.95						
2/1/98	5.71						
2/2/98	5.69	1.00	1.82	0.84			
2/3/98	5.60						
2/4/98	5.60						
2/5/98	5.49						
2/6/98	5.53	1.01					
2/7/98							
2/8/98	3.77						
2/9/98	5.15						
2/10/98	4.92						

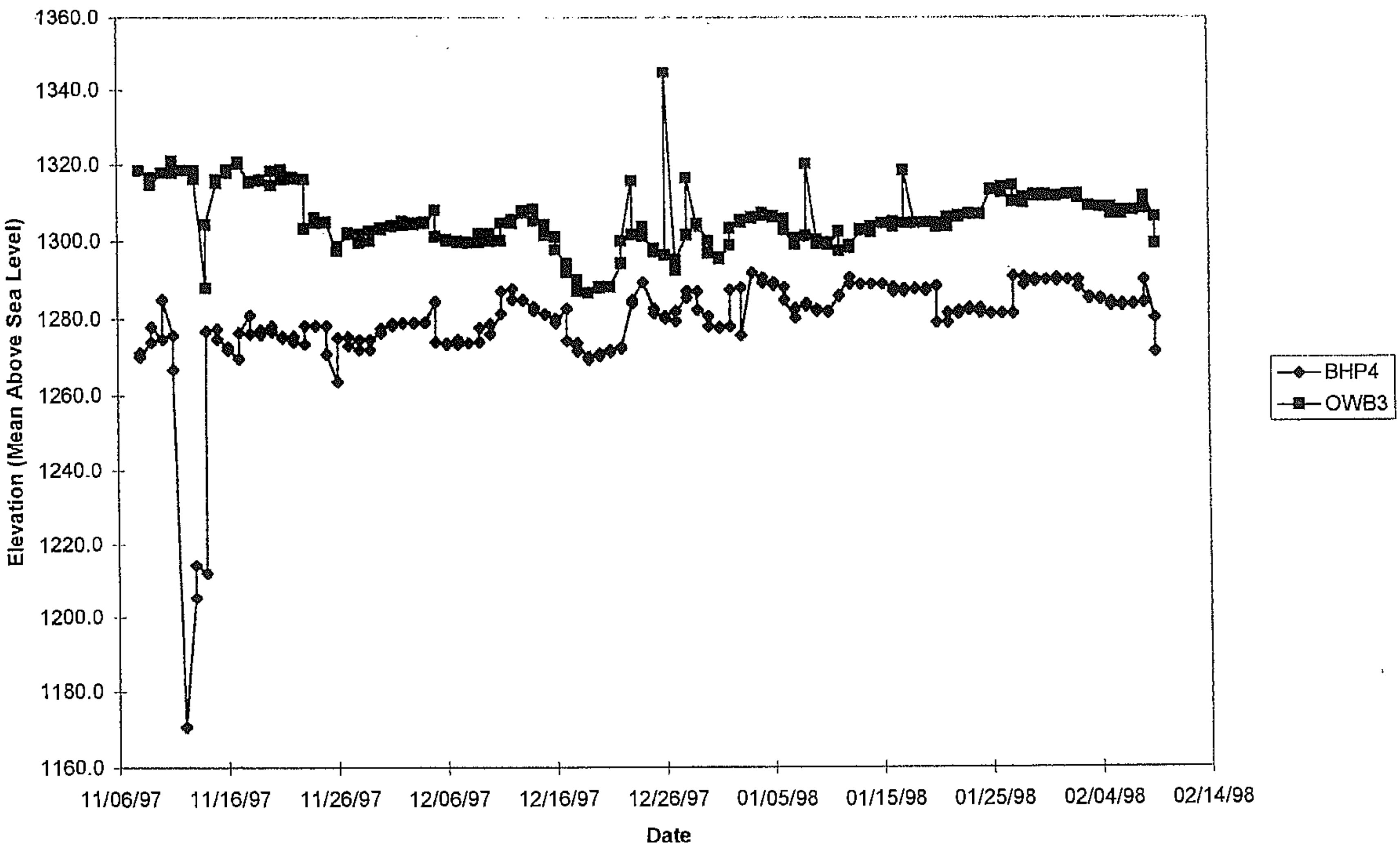


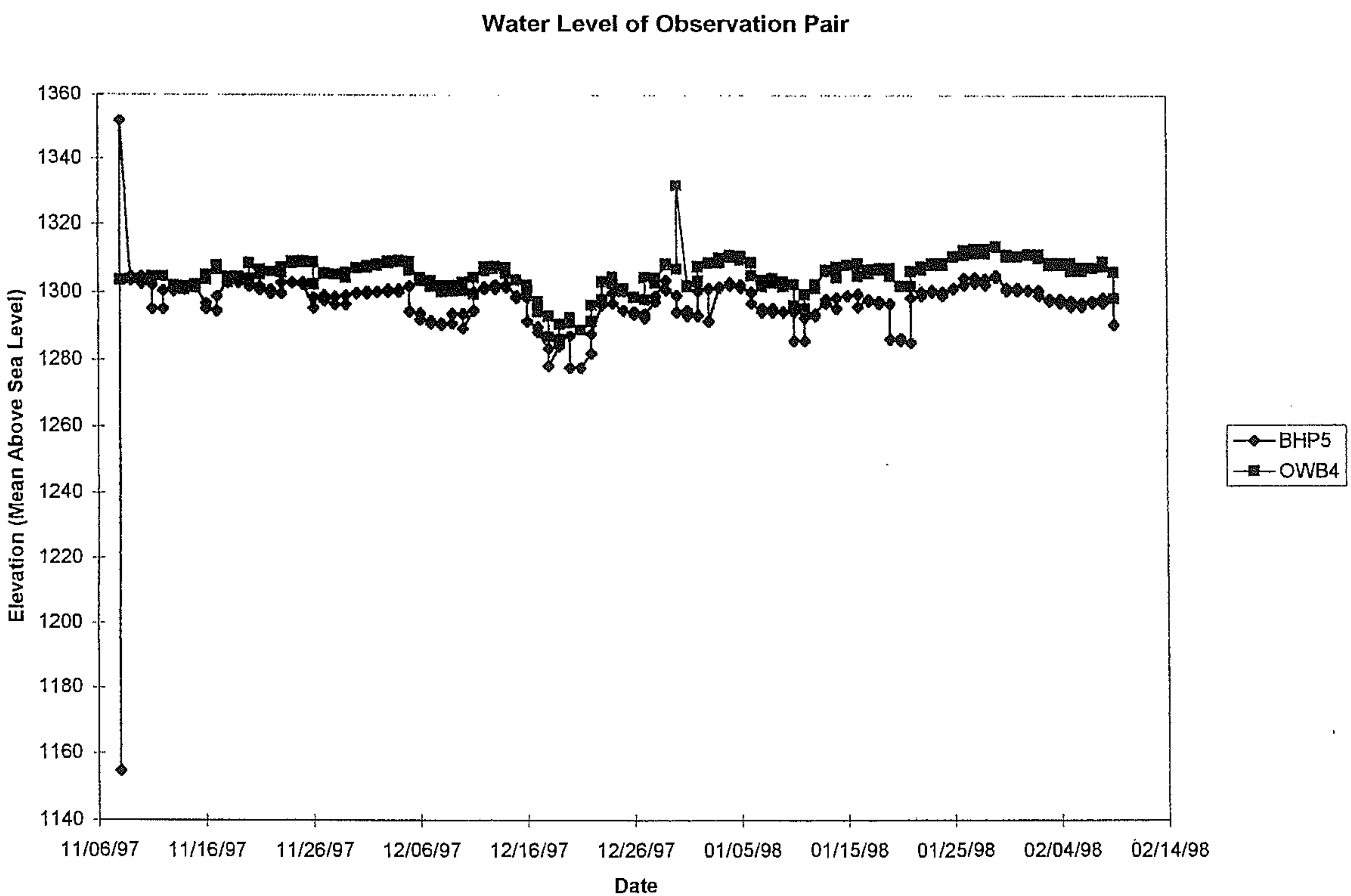
Water Level of Observation Pair
Elevation (Mean Above Sea Level)
1500.0
1450.0
1400.0
1350.0
1300.0
1250.0
11/06/97
11/16/97
11/26/97
12/06/97
12/16/97
12/26/97
01/05/98
01/15/98
01/25/98
02/04/98
02/14/98
Date
BHP2
OWB5

Water Level of Observation Pair



Water Level of Observation Pair




Water Level of Observation Pair
Elevation (Mean Above Sea Level)
1360
1340
1320
1300
1280
1260
1240
1220
1200
1180
1160
1140
11/06/97
11/16/97
11/26/97
12/06/97
12/16/97
12/26/97
01/05/98
01/15/98
01/25/98
02/04/98
02/14/98
Date
BHP5
OWB4

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12 Hour Averages

DATE	BHP4	OWB3
11/08/97	1271.3	1318.4
11/08/97	1270.2	1318.4
11/09/97	1274.0	1316.5
11/09/97	1277.9	1314.6
11/10/97	1274.8	1317.7
11/10/97	1284.9	1317.7
11/11/97	1275.8	1317.7
11/11/97	1266.8	1320.8
11/12/97	1170.7	1318.4
11/12/97	1170.7	1318.4
11/13/97	1205.5	1318.4
11/13/97	1214.3	1316.0
11/14/97	1212.3	1287.7
11/14/97	1276.9	1304.1
11/15/97	1277.4	1314.9
11/15/97	1274.9	1315.9
11/16/97	1272.9	1317.7
11/16/97	1272.0	1318.5
11/17/97	1269.7	1320.1
11/17/97	1276.5	1320.5
11/18/97	1281.0	1315.2
11/18/97	1276.2	1315.5
11/19/97	1276.0	1315.9
11/19/97	1277.1	1315.5
11/20/97	1278.1	1314.5
11/20/97	1276.7	1318.3
11/21/97	1275.1	1316.0
11/21/97	1275.6	1318.6
11/22/97	1275.6	1316.6
11/22/97	1274.0	1316.1
11/23/97	1273.5	1316.1
11/23/97	1278.3	1303.0
11/24/97	1278.3	1305.9
11/24/97	1278.3	1304.6
11/25/97	1278.3	1304.8
11/25/97	1270.9	1304.7
11/26/97	1263.6	1297.2
11/26/97	1275.1	1298.5
11/27/97	1275.3	1301.8
11/27/97	1273.1	1301.6
11/28/97	1274.7	1301.6
11/28/97	1272.0	1299.4
11/29/97	1272.0	1300.0
11/29/97	1274.8	1302.4
11/30/97	1276.5	1303.0
11/30/97	1277.6	1303.2
12/01/97	1278.3	1303.6
12/01/97	1278.7	1303.8
12/02/97	1279.0	1304.0
12/02/97	1279.0	1305.0
12/03/97	1279.0	1304.2
12/03/97	1279.1	1304.6
12/04/97	1279.1	1304.8

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12 Hour Averages

DATE	BHP4	OWB3
12/04/97	1279.2	1304.4
12/05/97	1284.4	1308.0
12/05/97	1274.0	1301.0
12/06/97	1273.8	1300.2
12/06/97	1273.3	1300.0
12/07/97	1273.3	1299.6
12/07/97	1274.8	1299.8
12/08/97	1273.8	1299.4
12/08/97	1273.8	1299.6
12/09/97	1274.1	1299.6
12/09/97	1277.7	1301.6
12/10/97	1278.7	1301.6
12/10/97	1276.1	1299.8
12/11/97	1281.4	1300.0
12/11/97	1286.9	1304.4
12/12/97	1287.4	1305.4
12/12/97	1284.9	1304.4
12/13/97	1284.8	1307.2
12/13/97	1284.8	1307.8
12/14/97	1283.0	1308.2
12/14/97	1282.0	1305.0
12/15/97	1281.1	1304.0
12/15/97	1281.2	1301.4
12/16/97	1280.0	1300.9
12/16/97	1278.9	1297.5
12/17/97	1282.5	1293.9
12/17/97	1274.3	1291.6
12/18/97	1271.5	1289.8
12/18/97	1273.8	1286.7
12/19/97	1269.5	1286.4
12/19/97	1270.1	1286.4
12/20/97	1270.4	1287.6
12/20/97	1270.9	1288.0
12/21/97	1271.4	1287.9
12/21/97	1271.8	1287.9
12/22/97	1272.3	1294.0
12/22/97	1272.7	1299.8
12/23/97	1284.0	1315.5
12/23/97	1284.6	1301.4
12/24/97	1289.2	1303.5
12/24/97	1289.2	1301.1
12/25/97	1282.6	1297.8
12/25/97	1281.4	1296.9
12/26/97	1280.7	1296.1
12/26/97	1280.0	1344.7
12/27/97	1279.4	1292.3
12/27/97	1281.9	1295.0
12/28/97	1285.3	1301.3
12/28/97	1286.9	1316.3
12/29/97	1286.8	1303.6
12/29/97	1282.3	1304.3
12/30/97	1280.5	1299.8
12/30/97	1278.0	1296.6

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12 Hour Averages

DATE	BHP4	OWB3
12/31/97	1277.7	1295.4
12/31/97	1277.5	1295.2
01/01/98	1278.0	1298.7
01/01/98	1287.2	1303.1
01/02/98	1287.7	1305.3
01/02/98	1275.7	1304.6
01/03/98	1291.7	1305.6
01/03/98	1291.7	1306.1
01/04/98	1290.4	1307.3
01/04/98	1289.1	1306.3
01/05/98	1289.1	1305.9
01/05/98	1288.4	1306.3
01/06/98	1287.9	1305.7
01/06/98	1284.7	1302.7
01/07/98	1280.1	1298.9
01/07/98	1282.6	1300.5
01/08/98	1283.8	1301.1
01/08/98	1283.3	1320.1
01/09/98	1281.9	1300.1
01/09/98	1282.4	1299.1
01/10/98	1281.9	1299.5
01/10/98	1281.7	1298.7
01/11/98	1285.7	1302.3
01/11/98	1285.7	1297.3
01/12/98	1290.4	1297.9
01/12/98	1288.7	1298.7
01/13/98	1288.7	1302.5
01/13/98	1288.7	1302.7
01/14/98	1288.7	1302.1
01/14/98	1288.7	1303.5
01/15/98	1288.7	1304.4
01/15/98	1288.7	1304.3
01/16/98	1287.9	1304.9
01/16/98	1286.8	1303.5
01/17/98	1286.8	1304.3
01/17/98	1287.5	1318.3
01/18/98	1287.5	1304.3
01/18/98	1287.4	1304.4
01/19/98	1287.4	1304.4
01/19/98	1286.9	1304.5
01/20/98	1288.1	1304.5
01/20/98	1278.9	1303.4
01/21/98	1278.9	1303.5
01/21/98	1281.4	1306.0
01/22/98	1281.2	1305.9
01/22/98	1281.9	1306.5
01/23/98	1282.6	1307.1
01/23/98	1282.2	1306.7
01/24/98	1282.6	1306.7
01/24/98	1281.5	1306.9
01/25/98	1281.2	1313.1
01/25/98	1281.2	1313.3
01/26/98	1281.2	1312.5

BHP
Florence Project

12 Hour Averages

DATE	BHP4	OWB3
01/26/98	1281.2	1313.9
01/27/98	1281.2	1314.3
01/27/98	1290.7	1310.1
01/28/98	1290.4	1309.9
01/28/98	1288.6	1311.1
01/29/98	1289.3	1311.5
01/29/98	1290.0	1311.9
01/30/98	1289.8	1311.9
01/30/98	1289.8	1311.5
01/31/98	1289.5	1311.5
01/31/98	1290.2	1311.5
02/01/98	1289.8	1311.9
02/01/98	1289.8	1311.9
02/02/98	1289.8	1312.1
02/02/98	1287.9	1311.1
02/03/98	1285.2	1308.9
02/03/98	1284.9	1308.9
02/04/98	1284.9	1308.7
02/04/98	1284.7	1308.7
02/05/98	1283.9	1308.7
02/05/98	1283.3	1306.9
02/06/98	1283.3	1306.9
02/06/98	1283.5	1307.9
02/07/98	1283.5	1307.9
02/07/98	1283.5	1307.9
02/08/98	1284.0	1308.3
02/08/98	1289.7	1311.5
02/09/98	1280.1	1306.1
02/09/98	1271.1	1299.1

BHP
Florence Project

12 Hour Averages

DATE	BHP3	OWB1
11/08/97	1299.5	1312.0
11/08/97	1297.0	1312.0
11/09/97	1302.6	1312.0
11/09/97	1267.3	1306.9
11/10/97	1309.7	1312.2
11/10/97	1260.2	1309.0
11/11/97	1277.0	1308.6
11/11/97	1293.9	1308.2
11/12/97	1294.5	1308.1
11/12/97	1296.8	1305.6
11/13/97	1297.3	1305.5
11/13/97	1297.9	1307.1
11/14/97	1308.3	1309.5
11/14/97	1300.2	1311.0
11/15/97	1300.8	1312.5
11/15/97	1297.9	1312.9
11/16/97	1296.8	1305.5
11/16/97	1295.6	1305.6
11/17/97	1293.9	1305.7
11/17/97	1297.9	1305.5
11/18/97	1303.1	1303.7
11/18/97	1298.5	1308.8
11/19/97	1298.5	1306.5
11/19/97	1300.2	1308.8
11/20/97	1301.4	1307.3
11/20/97	1299.1	1307.3
11/21/97	1298.5	1307.3
11/21/97	1298.5	1310.3
11/22/97	1298.5	1313.3
11/22/97	1297.9	1313.6
11/23/97	1297.3	1313.8
11/23/97	1301.4	1312.3
11/24/97	1300.8	1313.7
11/24/97	1301.4	1313.7
11/25/97	1301.4	1311.5
11/25/97	1301.9	1311.5
11/26/97	1295.6	1309.3
11/26/97	1299.1	1313.6
11/27/97	1299.1	1311.0
11/27/97	1298.5	1310.1
11/28/97	1298.5	1312.1
11/28/97	1295.6	1312.3
11/29/97	1295.6	1312.0
11/29/97	1298.5	1311.6
11/30/97	1299.6	1311.8
11/30/97	1299.6	1311.9
12/01/97	1300.2	1313.1
12/01/97	1300.2	1313.2
12/02/97	1300.2	1313.1
12/02/97	1300.2	1313.1

BHP
Florence Project

12 Hour Averages

DATE	BHP3	OWB1
12/03/97	1299.6	1311.1
12/03/97	1300.8	1309.0
12/04/97	1300.2	1308.7
12/04/97	1299.1	1313.3
12/05/97	1301.4	1308.4
12/05/97	1294.5	1307.1
12/06/97	1293.3	1306.9
12/06/97	1293.3	1307.3
12/07/97	1292.7	1308.6
12/07/97	1292.1	1309.5
12/08/97	1291.0	1303.7
12/08/97	1291.6	1301.4
12/09/97	1291.0	1304.9
12/09/97	1293.3	1307.3
12/10/97	1293.3	1306.5
12/10/97	1292.1	1305.7
12/11/97	1290.4	1306.7
12/11/97	1295.0	1306.5
12/12/97	1294.1	1321.6
12/12/97	1293.8	1319.2
12/13/97	1293.3	1302.6
12/13/97	1293.8	1302.2
12/14/97	1293.8	1298.1
12/14/97	1292.1	1295.2
12/15/97	1291.0	1292.8
12/15/97	1290.4	1291.7
12/16/97	1290.1	1291.4
12/16/97	1288.1	1288.2
12/17/97	1286.5	1287.9
12/17/97	1284.4	1288.2
12/18/97	1288.1	1288.8
12/18/97	1288.3	1289.1
12/19/97	1283.7	1289.5
12/19/97	1276.9	1291.6
12/20/97	1277.5	1298.5
12/20/97	1278.6	1301.7
12/21/97	1279.1	1302.8
12/21/97	1279.3	1306.2
12/22/97	1282.1	1302.8
12/22/97	1288.3	1299.4
12/23/97	1289.9	1298.4
12/23/97	1291.4	1296.7
12/24/97	1294.4	1296.6
12/24/97	1289.3	1295.5
12/25/97	1287.9	1295.1
12/25/97	1286.3	1299.8
12/26/97	1285.3	1299.8
12/26/97	1284.1	1304.6
12/27/97	1283.8	1305.0
12/27/97	1283.5	1300.1

12 Hour Averages

DATE	BHP3	OWB1
12/28/97	1291.6	1302.8
12/28/97	1292.7	1304.1
12/29/97	1294.1	1297.1
12/29/97	1294.9	1296.1
12/30/97	1291.2	1295.3
12/30/97	1284.9	1297.4
12/31/97	1282.2	1302.3
12/31/97	1282.4	1304.6
01/01/98	1282.7	1305.3
01/01/98	1288.7	1306.2
01/02/98	1290.7	1306.2
01/02/98	1290.0	1305.3
01/03/98	1291.2	1306.2
01/03/98	1290.7	1307.1
01/04/98	1292.4	1308.0
01/04/98	1286.2	1307.1
01/05/98	1290.7	1307.1
01/05/98	1289.8	1307.1
01/06/98	1289.5	1306.2
01/06/98	1286.7	1303.9
01/07/98	1283.8	1299.8
01/07/98	1285.0	1300.7
01/08/98	1286.1	1302.1
01/08/98	1285.0	1301.6
01/09/98	1284.4	1301.6
01/09/98	1284.4	1302.2
01/10/98	1284.4	1301.1
01/10/98	1282.2	1298.9
01/11/98	1281.0	1298.4
01/11/98	1281.0	1297.9
01/12/98	1280.4	1297.9
01/12/98	1281.5	1300.7
01/13/98	1285.0	1304.3
01/13/98	1285.0	1302.5
01/14/98	1284.4	1303.0
01/14/98	1285.0	1303.9
01/15/98	1285.5	1303.9
01/15/98	1285.5	1303.9
01/16/98	1286.1	1304.3
01/16/98	1285.0	1303.9
01/17/98	1285.5	1304.8
01/17/98	1285.5	1304.9
01/18/98	1285.5	1304.8
01/18/98	1286.1	1305.2
01/19/98	1286.1	1305.2
01/19/98	1286.1	1305.6
01/20/98	1285.5	1306.2
01/20/98	1285.5	1305.7
01/21/98	1285.0	1305.3
01/21/98	1286.7	1308.3

BHP
Florence Project

12 Hour Averages

DATE	BHP3	OWB1
01/22/98	1287.2	1308.8
01/22/98	1287.2	1307.4
01/23/98	1287.8	1309.2
01/23/98	1287.8	1309.7
01/24/98	1287.8	1306.2
01/24/98	1287.2	1308.8
01/25/98	1289.5	1312.5
01/25/98	1290.1	1311.5
01/26/98	1288.4	1311.1
01/26/98	1290.2	1307.5
01/27/98	1290.7	1311.6
01/27/98	1288.4	1311.6
01/28/98	1288.4	1315.7
01/28/98	1290.7	1315.6
01/29/98	1290.7	1318.2
01/29/98	1291.2	1318.2
01/30/98	1291.2	1317.5
01/30/98	1291.2	1316.8
01/31/98	1291.2	1317.3
01/31/98	1290.8	1316.5
02/01/98	1291.2	1316.8
02/01/98	1291.2	1317.3
02/02/98	1291.2	1316.8
02/02/98	1290.7	1317.3
02/03/98	1286.7	1314.1
02/03/98	1287.2	1314.5
02/04/98	1287.2	1313.7
02/04/98	1286.7	1313.9
02/05/98	1287.8	1313.7
02/05/98	1286.1	1312.7
02/06/98	1286.1	1312.7
02/06/98	1286.1	1311.9
02/07/98	1286.1	1311.9
02/07/98	1286.7	1312.9
02/08/98	1287.2	1312.9
02/08/98	1288.8	1318.5
02/09/98	1292.9	1307.7
02/09/98	1285.0	1300.0

BHP
Florence Project

12 Hour Averages

DATE	BHP5	OWB4
11/08/97	1154.97	1303.454
11/08/97	1351.91	1303.454
11/09/97	1303.65	1303.749
11/09/97	1304.72	1303.749
11/10/97	1304.72	1303.749
11/10/97	1302.58	1303.719
11/11/97	1302.11	1304.11
11/11/97	1295.09	1304.5
11/12/97	1295.09	1304.5
11/12/97	1300.44	1304.5
11/13/97	1300.97	1301.853
11/13/97	1300.44	1301.691
11/14/97	1300.97	1301.605
11/14/97	1300.97	1300.762
11/15/97	1301.51	1301.38
11/15/97	1301.51	1302.124
11/16/97	1296.7	1303.551
11/16/97	1295.09	1304.99
11/17/97	1294.56	1306.381
11/17/97	1298.84	1307.844
11/18/97	1303.11	1302.806
11/18/97	1302.91	1304.294
11/19/97	1302.9	1304.219
11/19/97	1302.91	1304.406
11/20/97	1302.91	1303.957
11/20/97	1301.84	1308.387
11/21/97	1301.84	1305.148
11/21/97	1300.77	1306.67
11/22/97	1300.77	1305.962
11/22/97	1299.7	1306
11/23/97	1299.7	1305.655
11/23/97	1302.91	1307.153
11/24/97	1302.91	1308.567
11/24/97	1302.91	1308.884
11/25/97	1302.37	1308.9
11/25/97	1302.9	1309.031
11/26/97	1295.42	1308.625
11/26/97	1298.61	1302.342
11/27/97	1299.16	1305.61
11/27/97	1297.56	1305.483
11/28/97	1298.63	1305.163
11/28/97	1296.49	1305.096
11/29/97	1296.48	1304.237
11/29/97	1299.16	1305.734
11/30/97	1299.69	1306.977
11/30/97	1299.7	1307.049
12/01/97	1299.69	1307.17
12/01/97	1300.23	1307.595
12/02/97	1300.23	1307.8
12/02/97	1300.23	1308.03

BHP
Florence Project

12 Hour Averages

DATE	BHP5	OWB4
12/03/97	1300.23	1308.563
12/03/97	1300.77	1308.793
12/04/97	1300.77	1308.938
12/04/97	1300.23	1309.175
12/05/97	1301.84	1308.9
12/05/97	1294.35	1306.313
12/06/97	1293.81	1304.224
12/06/97	1292.21	1303.25
12/07/97	1291.67	1303.127
12/07/97	1290.99	1301.669
12/08/97	1290.46	1301.669
12/08/97	1290.99	1300.21
12/09/97	1290.99	1300.407
12/09/97	1293.64	1301.889
12/10/97	1293.6	1302.79
12/10/97	1289.4	1300.432
12/11/97	1294.7	1299.354
12/11/97	1300	1304.275
12/12/97	1301.06	1306.199
12/12/97	1301.59	1307.401
12/13/97	1301.06	1306.878
12/13/97	1302.12	1307.449
12/14/97	1301.59	1307.186
12/14/97	1302.12	1305.386
12/15/97	1298.94	1303.52
12/15/97	1298.41	1303.446
12/16/97	1298.41	1302.049
12/16/97	1291.52	1299.455
12/17/97	1289.93	1297.242
12/17/97	1288.34	1294.219
12/18/97	1283.53	1292.871
12/18/97	1278.27	1286.862
12/19/97	1284.1	1286.089
12/19/97	1285.16	1290.625
12/20/97	1287.28	1292.506
12/20/97	1277.74	1291.14
12/21/97	1277.74	1288.807
12/21/97	1277.74	1288.909
12/22/97	1281.98	1291.413
12/22/97	1287.81	1296.234
12/23/97	1296.29	1297.817
12/23/97	1298.41	1303.065
12/24/97	1300	1304.393
12/24/97	1296.82	1302.525
12/25/97	1294.7	1300.21
12/25/97	1294.7	1300.947
12/26/97	1294.17	1298.512
12/26/97	1293.64	1298.369
12/27/97	1292.58	1297.853
12/27/97	1293.64	1304.188

BHP
Florence Project

12 Hour Averages

DATE	BHP5	OWB4
01/22/98	1298.95	1306.5
01/22/98	1300.01	1307.36
01/23/98	1300.01	1308.22
01/23/98	1300.54	1307.79
01/24/98	1300.01	1307.79
01/24/98	1298.95	1308.22
01/25/98	1301.07	1310.37
01/25/98	1301.07	1310.37
01/26/98	1302.13	1310.8
01/26/98	1304.12	1312.09
01/27/98	1304.25	1312.52
01/27/98	1302.66	1311.23
01/28/98	1302.13	1311.23
01/28/98	1303.72	1312.52
01/29/98	1304.25	1312.95
01/29/98	1304.78	1313.38
01/30/98	1301.07	1310.8
01/30/98	1300.54	1310.37
01/31/98	1300.54	1310.37
01/31/98	1301.07	1310.37
02/01/98	1300.54	1310.8
02/01/98	1300.54	1310.8
02/02/98	1300.54	1310.8
02/02/98	1298.95	1309.94
02/03/98	1297.36	1308.22
02/03/98	1297.89	1307.82
02/04/98	1296.83	1307.79
02/04/98	1297.89	1308.22
02/05/98	1297.36	1308.22
02/05/98	1295.77	1306.07
02/06/98	1295.77	1306.07
02/06/98	1296.83	1306.93
02/07/98	1296.83	1306.93
02/07/98	1297.36	1306.93
02/08/98	1296.83	1307.36
02/08/98	1298.29	1308.74
02/09/98	1298.42	1305.64
02/09/98	1290.47	1297.9

BHP
Florence Project

12 Hour Averages

DATE	BHP2	OWB5
11/08/97	1277.4	1304.4
11/08/97	1280.0	1307.0
11/09/97	1279.3	1306.3
11/09/97	1278.7	1305.7
11/10/97	1280.3	1307.3
11/10/97	1280.5	1307.5
11/11/97	1276.2	1303.2
11/11/97	1276.5	1303.5
11/12/97	1276.9	1303.9
11/12/97	1280.5	1307.5
11/13/97	1280.8	1307.8
11/13/97	1281.2	1308.2
11/14/97	1290.6	1317.6
11/14/97	1281.0	1308.0
11/15/97	1280.0	1307.0
11/15/97	1278.8	1305.8
11/16/97	1277.9	1304.9
11/16/97	1276.9	1303.9
11/17/97	1278.6	1305.6
11/17/97	1280.3	1307.3
11/18/97	1283.9	1310.9
11/18/97	1281.0	1308.0
11/19/97	1280.8	1307.8
11/19/97	1277.0	1304.0
11/20/97	1278.1	1305.1
11/20/97	1280.8	1307.8
11/21/97	1278.6	1305.6
11/21/97	1280.5	1307.5
11/22/97	1280.3	1307.3
11/22/97	1279.3	1306.3
11/23/97	1282.4	1304.7
11/23/97	1282.2	1302.1
11/24/97	1282.7	1307.9
11/24/97	1283.2	1307.4
11/25/97	1282.7	1310.4
11/25/97	1276.7	1310.0
11/26/97	1280.5	1306.4
11/26/97	1281.2	1318.8
11/27/97	1281.0	1315.7
11/27/97	1281.2	1315.7
11/28/97	1278.8	1312.7
11/28/97	1279.6	1342.0
11/29/97	1283.2	1463.2
11/29/97	1284.3	1463.2
11/30/97	1286.3	1314.6
11/30/97	1287.2	1308.3
12/01/97	1289.4	1307.7
12/01/97	1289.9	1463.2
12/02/97	1291.8	1342.8
12/02/97	1292.7	1463.2

BHP
Florence Project

12 Hour Averages

DATE	BHP2	OWB5
12/28/97	1282.2	
12/28/97	1283.4	
12/29/97	1284.8	
12/29/97	1297.7	1336.0
12/30/97	1295.9	1299.6
12/30/97	1290.1	1298.7
12/31/97	1289.2	1299.9
12/31/97	1288.5	1304.8
01/01/98	1289.5	1306.1
01/01/98	1294.1	1306.1
01/02/98	1296.6	1306.1
01/02/98	1295.8	1306.1
01/03/98	1297.0	1307.0
01/03/98	1297.8	1307.7
01/04/98	1299.9	1308.6
01/04/98	1300.2	1308.2
01/05/98	1299.7	1308.2
01/05/98	1299.7	1307.9
01/06/98	1299.0	1307.2
01/06/98	1296.8	1304.5
01/07/98	1293.4	1301.0
01/07/98	1295.8	1302.9
01/08/98	1296.6	1303.3
01/08/98	1296.1	1302.6
01/09/98	1296.1	1302.4
01/09/98	1295.4	1303.6
01/10/98	1295.6	1304.9
01/10/98	1292.9	1305.0
01/11/98	1290.8	1300.6
01/11/98	1294.5	1301.8
01/12/98	1289.4	1302.9
01/12/98	1290.3	1302.9
01/13/98	1293.7	1307.1
01/13/98	1293.9	1307.4
01/14/98	1293.2	1304.5
01/14/98	1294.9	1305.2
01/15/98	1295.4	1305.6
01/15/98	1295.4	1305.9
01/16/98	1296.1	1306.3
01/16/98	1292.5	1303.8
01/17/98	1294.6	1305.4
01/17/98	1294.6	1304.4
01/18/98	1294.9	1304.7
01/18/98	1295.1	1304.5
01/19/98	1295.1	1304.5
01/19/98	1302.3	1305.1
01/20/98	1294.2	1303.7
01/20/98	1294.2	1303.7
01/21/98	1293.9	1303.7
01/21/98	1296.8	1305.9

BHP
Florence Project

12 Hour Averages

DATE	BHP5	OWB4
12/28/97	1297.35	1302.79
12/28/97	1298.94	1304.08
12/29/97	1303.44	1307.984
12/29/97	1300.77	1308.292
12/30/97	1299.16	1306.814
12/30/97	1294.17	1331.709
12/31/97	1293.11	1301.654
12/31/97	1294.7	1301.775
01/01/98	1293.12	1303.131
01/01/98	1300.54	1307.552
01/02/98	1301.07	1308.485
01/02/98	1291.53	1308.549
01/03/98	1301.6	1308.762
01/03/98	1301.6	1309.93
01/04/98	1302.66	1310.8
01/04/98	1302.13	1310.37
01/05/98	1302.13	1310.37
01/05/98	1301.6	1309.5
01/06/98	1300.01	1308.63
01/06/98	1296.83	1304.85
01/07/98	1294.18	1301.67
01/07/98	1295.24	1303.41
01/08/98	1295.24	1303.85
01/08/98	1294.18	1302.7
01/09/98	1294.18	1302.98
01/09/98	1294.18	1301.67
01/10/98	1294.18	1302.11
01/10/98	1285.7	1296.06
01/11/98	1285.7	1295.15
01/11/98	1292.59	1299.3
01/12/98	1293.12	1301.24
01/12/98	1293.65	1302.11
01/13/98	1297.89	1306.45
01/13/98	1296.83	1306.02
01/14/98	1295.24	1304.28
01/14/98	1298.42	1307.32
01/15/98	1298.95	1307.76
01/15/98	1298.95	1307.76
01/16/98	1299.48	1308.19
01/16/98	1295.77	1304.72
01/17/98	1297.89	1306.45
01/17/98	1297.36	1305.47
01/18/98	1297.36	1306.45
01/18/98	1296.54	1306.9
01/19/98	1296.54	1306.9
01/19/98	1286.23	1304.69
01/20/98	1286.5	1301.64
01/20/98	1285.7	1301.67
01/21/98	1285.17	1301.67
01/21/98	1298.42	1306.07

BHP
Florence Project

12 Hour Averages

DATE	BHP2	OWB5
12/03/97	1298.9	1463.2
12/03/97	1301.6	1463.2
12/04/97	1306.1	1385.7
12/04/97	1301.6	1385.7
12/05/97	1303.2	1385.7
12/05/97	1306.1	1385.7
12/06/97	1303.2	1383.4
12/06/97	1303.2	1377.2
12/07/97	1303.2	1381.9
12/07/97	1303.5	1389.1
12/08/97	1308.8	1388.1
12/08/97	1309.0	1386.6
12/09/97	1309.0	1384.6
12/09/97	1311.2	1387.1
12/10/97	1268.3	1393.0
12/10/97	1264.2	1309.2
12/11/97	1274.2	1300.1
12/11/97	1285.3	1302.5
12/12/97	1292.2	1307.0
12/12/97	1297.3	1308.1
12/13/97	1300.4	1308.6
12/13/97	1304.7	1309.6
12/14/97	1306.2	1310.1
12/14/97	1311.7	1361.0
12/15/97	1311.5	1369.3
12/15/97	1310.1	1311.0
12/16/97	1285.9	1308.1
12/16/97	1283.0	1302.9
12/17/97	1277.8	1293.5
12/17/97	1276.6	1293.1
12/18/97	1261.7	1293.1
12/18/97	1268.6	1293.4
12/19/97	1268.6	1291.0
12/19/97	1268.6	1291.5
12/20/97	1270.6	1293.3
12/20/97	1274.5	1387.4
12/21/97	1279.5	
12/21/97	1283.3	
12/22/97	1289.3	
12/22/97	1302.1	
12/23/97	1298.8	
12/23/97	1286.8	
12/24/97	1283.3	
12/24/97	1280.8	
12/25/97	1278.5	
12/25/97	1277.2	
12/26/97	1276.4	
12/26/97	1275.8	
12/27/97	1275.3	
12/27/97	1275.3	

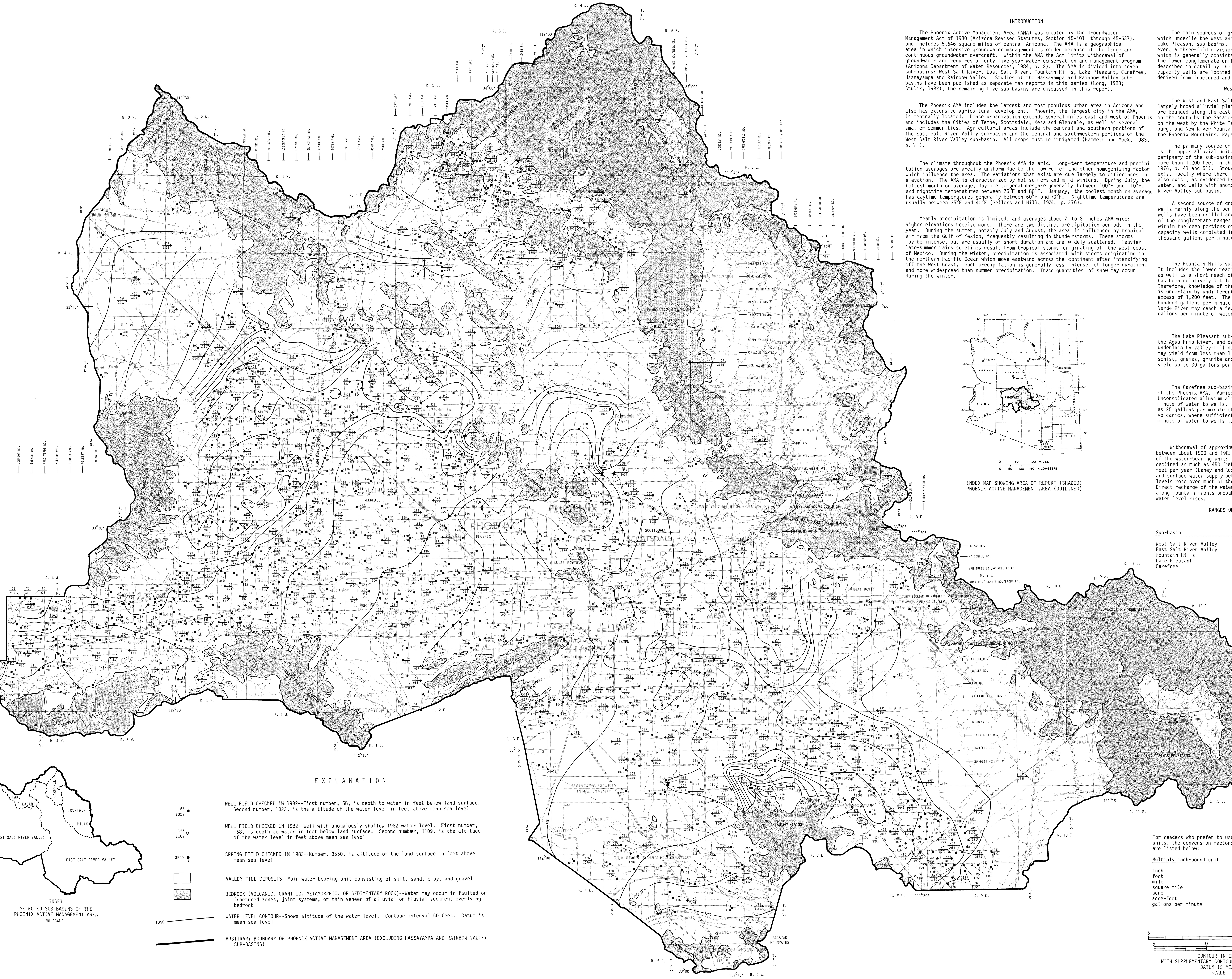
BHP
Florence Project

12 Hour Averages

DATE	BHP2	OWB5
12/28/97	1282.2	
12/28/97	1283.4	
12/29/97	1284.8	
12/29/97	1297.7	1336.0
12/30/97	1295.9	1299.6
12/30/97	1290.1	1298.7
12/31/97	1289.2	1299.9
12/31/97	1288.5	1304.8
01/01/98	1289.5	1306.1
01/01/98	1294.1	1306.1
01/02/98	1296.6	1306.1
01/02/98	1295.8	1306.1
01/03/98	1297.0	1307.0
01/03/98	1297.8	1307.7
01/04/98	1299.9	1308.6
01/04/98	1300.2	1308.2
01/05/98	1299.7	1308.2
01/05/98	1299.7	1307.9
01/06/98	1299.0	1307.2
01/06/98	1296.8	1304.5
01/07/98	1293.4	1301.0
01/07/98	1295.8	1302.9
01/08/98	1296.6	1303.3
01/08/98	1296.1	1302.6
01/09/98	1296.1	1302.4
01/09/98	1295.4	1303.6
01/10/98	1295.6	1304.9
01/10/98	1292.9	1305.0
01/11/98	1290.8	1300.6
01/11/98	1294.5	1301.8
01/12/98	1289.4	1302.9
01/12/98	1290.3	1302.9
01/13/98	1293.7	1307.1
01/13/98	1293.9	1307.4
01/14/98	1293.2	1304.5
01/14/98	1294.9	1305.2
01/15/98	1295.4	1305.6
01/15/98	1295.4	1305.9
01/16/98	1296.1	1306.3
01/16/98	1292.5	1303.8
01/17/98	1294.6	1305.4
01/17/98	1294.6	1304.4
01/18/98	1294.9	1304.7
01/18/98	1295.1	1304.5
01/19/98	1295.1	1304.5
01/19/98	1302.3	1305.1
01/20/98	1294.2	1303.7
01/20/98	1294.2	1303.7
01/21/98	1293.9	1303.7
01/21/98	1296.8	1305.9

Exhibit 14C-2

Map HMS 12 (ADWR, 1983)



INTRODUCTION

The Phoenix Active Management Area (AMA) was created by the Groundwater Management Act of 1980 (Arizona Revised Statutes, Section 45-401 through 45-637), and includes 5,646 square miles of central Arizona. The AMA is a geographical area in which intensive groundwater management is needed because of the large and continuous groundwater overdraft. Within the AMA the Act limits withdrawal of groundwater and requires a forty-five year water conservation and management program (Arizona Department of Water Resources, 1984, p. 2). The AMA is divided into seven sub-basins; West Salt River, East Salt River, Fountain Hills, Lake Pleasant, Carefree, Hassayampa and Rainbow Valley. Studies of the Hassayampa and Rainbow Valley sub-basins have been published as separate map reports in this series (Long, 1983; Stulik, 1982); the remaining five sub-basins are discussed in this report.

The Phoenix AMA includes the largest and most populous urban area in Arizona and also has extensive agricultural development. Phoenix, the largest city in the AMA, is centrally located. Dense urbanization extends several miles east and west of Phoenix and includes the Cities of Tempe, Scottsdale, Mesa and Glendale, as well as several smaller communities. Agricultural areas include the central and southern portions of the East Salt River Valley sub-basin and the central and southwestern portions of the West Salt River Valley sub-basin. All crops must be irrigated (Hammett and Mock, 1983, p. 1).

The climate throughout the Phoenix AMA is arid. Long-term temperature and precipi tation averages are areally uniform due to the low relief and other homogenizing factor which influence the area. The variations that exist are due largely to differences in elevation. The AMA is characterized by hot summers and mild winters. During July, the hottest month on average, daytime temperatures are generally between 100°F and 110°F, and nighttime temperatures between 75°F and 80°F. January, the coolest month on average has daytime temperatures generally between 60°F and 70°F. Nighttime temperatures are usually between 35°F and 40°F (Sellers and Hill, 1974, p. 376).

Yearly precipitation is limited, and averages about 7 to 8 inches AMA-wide; higher elevations receive more. There are two distinct precipitation periods in the year. During the summer, notably July and August, the area is influenced by tropical air from the Gulf of Mexico, frequently resulting in thunderstorms. These storms may be intense, but are usually of short duration and are widely scattered. Heavier late-summer rains sometimes result from tropical storms originating off the west coast of Mexico. During the winter, precipitation is associated with storms originating in the northern Pacific Ocean which move eastward across the continent after intensifying off the West Coast. Such precipitation is generally less intense, of longer duration, and more widespread than summer precipitation. Trace quantities of snow may occur during the winter.

INDEX MAP SHOWING AREA OF REPORT (SHADED)
PHOENIX ACTIVE MANAGEMENT AREA (OUTLINED)

HYDROGEOLOGY

The main sources of groundwater in the Phoenix AMA are the valley-fill deposits which underlie the West and East Salt River Valley, Fountain Hills and part of the Lake Pleasant sub-basins. The valley-fill deposits are extremely heterogenous. However, a three-fold division of the water-bearing units is possible based on lithology, which is generally consistent throughout the AMA. The units are in ascending order: the lower conglomerate unit, middle fine-grained unit, and upper alluvial unit, and are described in detail by the U.S. Bureau of Reclamation (1976, p. 11-14). Most large-capacity wells are located in areas underlain by valley-fill. Locally, water may be derived from fractured and weathered bedrock and the thin sediments along streams.

West and East Salt River Valley Sub-basins

The West and East Salt River Valley sub-basins include 3,177 square miles and are largely broad alluvial plains drained by the Salt and Gila Rivers. The sub-basins are bounded along the east by the Mazatzal, Usery, Goldfield, and Superstition Mountains; on the south by the Sacaton, Sierra Estrella, and South Mountains and the Buckeye Hills; on the west by the White Tank Mountains; and on the north by the Hieroglyphic, Wickenburg, and New River Mountains and New River Mesa. The two sub-basins are separated by the Phoenix Mountains, Papago Buttes and the Union Hills.

The primary source of groundwater in the West and East Salt River Valley sub-basins is the upper alluvial unit. The thickness of the unit ranges from 0 feet near the periphery of the sub-basins to more than 1,100 feet in the area east of Chandler, and more than 1,200 feet in the area southwest of El Mirage (U.S. Bureau of Reclamation, 1976, p. 41 and 51). Groundwater is usually unconfined, but semi-confined conditions exist locally where there is an increase of finer-grained materials. Perched conditions also exist, as evidenced by numerous wells throughout both sub-basins with cascading water, and wells with anomolously shallow water levels; particularly in the East Salt River Valley sub-basin.

A second source of groundwater is from the lower congomerate unit, penetrated by wells mainly along the periphery of the sub-basins on the south and east sides. New wells have been drilled and older wells deepened to penetrate this unit. The thickness of the conglomerate ranges from 0 to 2,000 feet or more; the thickest sections occur within the deep portions of sub-basins (U.S. Bureau of Reclamation, 1976, p. 41). Large-capacity wells completed in the valley-fill deposits yield several hundred to a few thousand gallons per minute.

Fountain Hills Sub-basin

The Fountain Hills sub-basin includes 377 square miles and is an alluvial plain. It includes the lower reach of the Verde River to its confluence with the Salt River, as well as a short reach of the Salt River and associated small drainage areas. There has been relatively little groundwater development in the Fountain Hills sub-basin. Therefore, knowledge of the hydrogeology is sparse. However, much of the sub-basin is underlain by undifferentiated valley-fill deposits that attain a thickness in excess of 1,200 feet. The valley-fill deposits may yield from a few tens to several hundred gallons per minute of water to wells. Unconsolidated alluvium along the Verde River may reach a few tens of feet thick and yield from 50 to several hundred gallons per minute of water to wells (Ross, 1977).

Lake Pleasant Sub-basin

The Lake Pleasant sub-basin covers 246 square miles and includes a short reach of the Agua Fria River, and drainages from the Hieroglyphic Mountains. The area is partly underlain by valley-fill deposits, which are generally in excess of 800 feet thick and may yield from less than 1 to 1,600 gallons per minute of water to wells. Locally, schist, gneiss, granite and volcanics, where sufficiently fractured or weathered, may yield up to 30 gallons per minute of water to wells (Littin, 1979).

Carefree Sub-basin

The Carefree sub-basin includes an area of 153 square miles in the northern part of the Phoenix AMA. Varied hydrogeologic conditions prevail in the Carefree sub-basin. Unconsolidated alluvium along Cave Creek yields from less than 1 to 50 gallons per minute of water to wells. A conglomerate, found in much of the area, yields as much as 25 gallons per minute of water to wells. Locally, schist, gneiss, granite and volcanics, where sufficiently fractured or weathered, may yield up to 30 gallons per minute of water to wells (Littin, 1979).

CHANGE IN WATER LEVEL

Withdrawal of approximately 81,000,000 acre-feet of water from the Phoenix AMA between about 1900 and 1982 (see pumpage table, sheet 2) has resulted in overdrafting of the water-bearing units. The overdrafts are reflected by water levels that have declined as much as 450 feet since 1923 at a rate that has varied between 2 and 8 feet per year (Laney and Ross, 1978; Ross, 1978). Due to an abundance of rainfall and surface water supply between 1976 and 1982, pumpage was greatly reduced and water levels rose over much of the basin during that time (see sheet 2 and table below). Direct recharge of the water-bearing units in the Phoenix AMA from rivers, washes and along mountain fronts probably accounts for a substantial portion of the observed water level rises.

RANGES OF DEPTHS TO WATER AND WATER LEVEL CHANGES

Sub-basin	Depth to Water 1983 Minimum-Maximum		Change in Water Level 1976 to 1983 Minimum-Maximum	
West Salt River Valley	4	651	- 34	+65
East Salt River Valley	12	793	-175	+93
Fountain Hills	22	490	- 59	+ 3
Lake Pleasant	10	383	- 2	+63
Carefree	9	223	+ 6	+34

For readers who prefer to use metric units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric unit
inch	25.4	millimeter
foot	0.3048	meter
mile	1.609	kilometer
square mile	2.590	square kilometer
acre	0.4047	square hectometer
acre-foot	0.001233	cubic hectometer
gallons per minute	0.06309	liters per second

5 0 5 MILES
5 0 5 10 KILOMETERS

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100-FOOT INTERVALS
DATUM IS MEAN SEA LEVEL
SCALE 1:125,000

INSET
SELECTED SUB-BASINS OF THE
PHOENIX ACTIVE MANAGEMENT AREA
NO SCALE

E X P L A N A T I O N

68 / 1022 — WELL FIELD CHECKED IN 1982--First number, 68, is depth to water in feet below land surface. Second number, 1022, is the altitude of the water level in feet above mean sea level

168 / 1109 — WELL FIELD CHECKED IN 1982--Well with anomalously shallow 1982 water level. First number, 168, is depth to water in feet below land surface. Second number, 1109, is the altitude of the water level in feet above mean sea level

3550 — SPRING FIELD CHECKED IN 1982--Number, 3550, is altitude of the land surface in feet above mean sea level

VALLEY-FILL DEPOSITS--Main water-bearing unit consisting of silt, sand, clay, and gravel

BEDROCK (VOLCANIC, GRANITIC, METAMORPHIC, OR SEDIMENTARY ROCK)--Water may occur in faulted or fractured zones, joint systems, or thin veneer of alluvial or fluvial sediment overlying bedrock

1050 — WATER LEVEL CONTOUR--Shows altitude of the water level. Contour interval 50 feet. Datum is mean sea level

ARBITRARY BOUNDARY OF PHOENIX ACTIVE MANAGEMENT AREA (EXCLUDING HASSAYAMPA AND RAINBOW VALLEY SUB-BASINS)

BASE FROM U.S. GEOLOGICAL SURVEY
PHOENIX, AZ., 1954, REV. 1969, 1:250,000
MESA, AZ., 1954, REV. 1978, 1:250,000

DEPTH TO WATER AND ALTITUDE OF THE WATER LEVEL, 1983 --

MAPS SHOWING GROUNDWATER CONDITIONS IN THE WEST SALT RIVER, EAST SALT RIVER, LAKE PLEASANT, CAREFREE AND FOUNTAIN HILLS SUB-BASINS OF THE PHOENIX ACTIVE MANAGEMENT AREA, MARICOPA, PINAL AND YAVAPAI COUNTIES, ARIZONA--1983

BY

R. W. REETER AND W. H. REMICK

These hydrologic maps are available upon request from the Department of Water Resources, Basic Data Unit, 2810 South 24th Street, Suite 122, Phoenix, Arizona, 85034. The hydrologic data on which these maps are based are available, for the most part, in computer-printout form and may be consulted at the Department of Water Resources and at the U.S. Geological Survey offices located at: Federal Building, 301 West Congress Street, Tucson, and Valley Center, 241 North Central Avenue, Suite 1880, Phoenix, Arizona.

Exhibit 14C-3

Map HMS 23 (ADWR, 1989)

PREPARED IN COOPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY

ARIZONA DEPARTMENT OF WATER RESOURCES

D.W.R. HYDROLOGIC MAP SERIES REPORT NO. 23
SHEET 1 OF 3
DEPTH TO WATER AND ALTITUDE OF THE WATER LEVEL

EXPLANATION

493/1280 ● WELL IN WHICH DEPTH TO WATER WAS MEASURED IN 1988-89, AND WHICH REFLECTS GROUNDWATER CONDITIONS IN THE LOWER MAIN WATER ZONE--First number, 493, is depth to water in feet below land surface. Second number, 1280, is the altitude of the water level in feet

107/1326 ● WELL IN WHICH DEPTH TO WATER WAS MEASURED IN 1988-89, AND WHICH REFLECTS GROUNDWATER CONDITIONS IN THE UPPER MAIN WATER ZONE--First number, 107, is depth to water in feet below land surface. Second number, 1326, is the altitude of the water level in feet

48/1312 ○ WELL IN WHICH DEPTH TO WATER WAS MEASURED IN 1988-89, AND WHICH REFLECTS GROUNDWATER CONDITIONS IN A SIGNIFCANT LOCAL WATER ZONE--First number, 48, is depth to water in feet below land surface. Second number, 1312, is the altitude of the water level in feet

283/1298 ○ WELL IN WHICH DEPTH TO WATER WAS MEASURED IN 1988-89, AND WHICH REFLECTS ANOMALOUS GROUNDWATER CONDITIONS--First number, 283, is depth to water in feet below land surface. Second number, 1298, is the altitude of the water level in feet

ROCKS OF THE MOUNTAINS (MOSTLY GRANITIC, METAMORPHIC, OR VOLCANIC ROCK)--Water may occur in weathered or fractured zones, joint systems, or thin veneer of alluvial or fluvial deposits overlying consolidated rocks

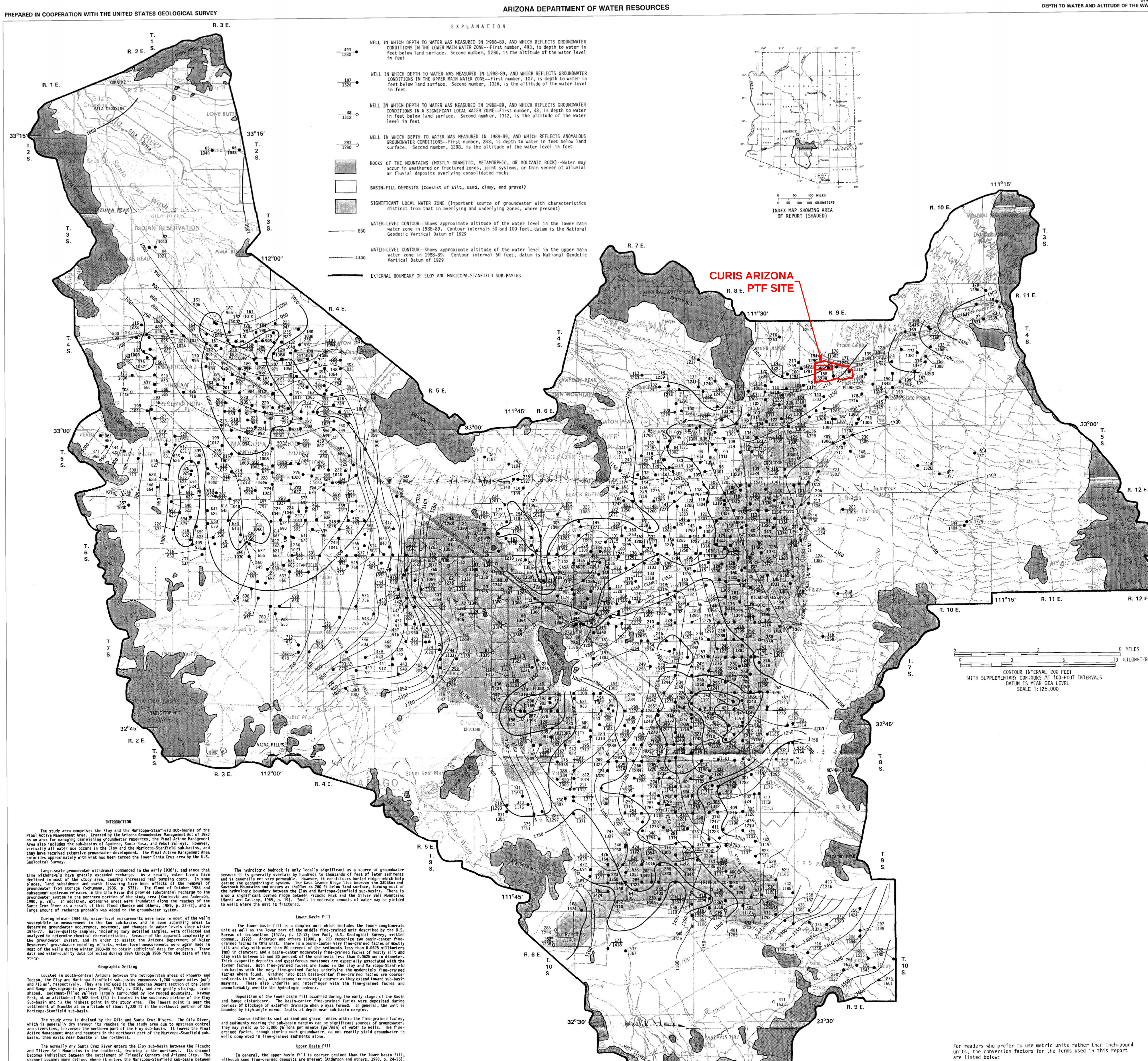
BASIN-FILL DEPOSITS (Consist of silt, sand, clay, and gravel)

SIGNIFICANT LOCAL WATER ZONE (Important source of groundwater with characteristics distinct from that in overlying and underlying zones, where present)

850 WATER-LEVEL CONTOUR--Shows approximate altitude of the water level in the lower main water zone in 1988-89. Contour intervals 50 and 100 feet, datum is the National Geodetic Vertical Datum of 1929

1300 WATER-LEVEL CONTOUR--Shows approximate altitude of the water level in the upper main water zone in 1988-89. Contour interval 50 feet, datum is National Geodetic Vertical Datum of 1929

EXTERNAL BOUNDARY OF ELOY AND MARICOPA-STANFIELD SUB-BASINS



INTRODUCTION

The study area comprises the Eloy and Maricopa-Stanfield sub-basins of the Pinal Active Management Area. Created by the Arizona Groundwater Management Act of 1980 as an area for managing diminishing groundwater resources, the Pinal Active Management Area also includes the sub-basins of Aguirre, Santa Rosa, and Vekol Valleys. However, virtually all water use occurs in the Eloy and the Maricopa-Stanfield sub-basins, and they have received extensive groundwater development. The Pinal Active Management Area coincides approximately with what has been termed the lower Santa Cruz area by the U.S. Geological Survey.

[illegible]

Geographic Setting

Located in south-central Arizona between the metropolitan areas of Phoenix and Tucson, the Eloy and Maricopa-Stanfield sub-basins encompass 1,260 square miles (mi^2) and 715 mi^2, respectively. [illegible]

[illegible]

Groundwater Occurrence and Movement

The 1988-89 water-level data and associated water-quality data define a lower main water zone and upper main water zone in both the Eloy and Maricopa-Stanfield sub-basins. Also defined is a significant local water zone straddling the two sub-basins approximately coextensive with the Casa Grande Ridge, and is herein called the Casa Grande water zone. Another local zone, which extends from near the Gila River to several miles southwest of Eloy and averages about 5 mi wide, is called the Picacho Reservoir water zone. Finally, a local zone which extends from the southeast part of T. 9 S., R. 8 E. to the northeast part of T. 10 S., R. 6 E., and averages about 3 mi wide, is called the Friendly Corners water zone. Other local water zones probably exist, but data are lacking to delineate them.

Lower Main Water Zone--This zone is the most extensive one in the two sub-basins. It is largely contained in the lower basin fill except along the sub-basins' margins where it may be partially in the upper basin fill. In the Eloy sub-basin, the zone is assumed to be continuous, even though no wells penetrate it in much of T. 6 S., R. 8 E., T. 7 S., R. 7 E., and T. 7 S., R. 8 E. The lack of wells here is probably due to the thickness of unproductive fine-grained facies and because groundwater is readily obtainable in wells completed in shallower zones. Unconfined, confined, and semi-confined conditions are found in the lower main water zone.

Several groundwater depressions exist toward which movement occurs. These are caused by the large-scale, long-term withdrawal of groundwater from wells in the immediate area of the depression. In the Eloy sub-basin two major depressions exist northeast of Casa Grande and south and east of the Casa Grande Mountains. A minor one is present south and southeast of Eloy. One major depression dominates the Maricopa-Stanfield sub-basin. It extends from the northeast part of T. 5 S., R. 2 E., to the southwest part of T. 6 S., R. 3 E. Some groundwater movement in the lower main zone occurs toward the Gila River in the northern part of the Eloy sub-basin where the groundwater probably discharges to the upper main water zone. There may be underflow into the East Salt River Valley sub-basin of the Phoenix Active Management Area in the area north of the Gila River west of Florence, but this is not clear.

Most recharge to the lower main water zone is probably from natural sources. In the Eloy sub-basin a major underflow from the Avra Valley sub-basin of the Tucson Active Management Area occurs between Picacho Peak and the Silver Bell Mountains. There is also some underflow between the Sawtooth and West Silver Bell Mountains from the Aguirre Valley sub-basin (Hollett and Garrett, 1984, sheet 1). Some recharge moves into the area between Florence and Eloy, presumably mountain-front recharge from the unnamed highlands to the east and the Picacho Mountains. In addition, significant flow into the lower main zone appears to occur from overlying saturated sediments, especially around some of the margins of the upper main zone, and from the release of water in the fine-grained facies.

In the Maricopa-Stanfield sub-basin some underflow occurs between the Vaiva Hills and the Tat Momoli Mountains from the Santa Rosa sub-basin (Hollett and Garrett, 1984, sheet 1). There also appears to be underflow between the Haley Hills and Palo Verde Mountains from the Rainbow Valley sub-basin of the Phoenix Active Management Area. The Casa Grande water zone appears to be a major source of flux into the lower main zone, especially in the western part of T. 6 S., R. 5 E. Other sources of water include the dewatering of fine-grained facies, the upper main water zone along its margins, and recharge from the northern part of the sub-basin in the vicinity of the Gila River.

Depth to water in the lower main water zone in the Eloy sub-basin ranges from about 200 ft below land surface in the area southeast of Coolidge, to nearly 550 ft below land surface in the area southeast of Friendly Corners. In the Maricopa-Stanfield sub-basin depth to water ranges from more than 100 ft below land surface in the northern part near the Santa Cruz River, to more than 725 ft below land surface in the area southwest of Stanfield.

Upper Main Water Zone--Contained mostly within the upper basin fill, this zone generally overlies the extensive fine-grained facies in both sub-basins. It is the primary zone of groundwater for well production in the area, although it is somewhat more important in the Eloy sub-basin than the Maricopa-Stanfield sub-basin, as it probably does not exist in the area south and east of Stanfield. Part of the zone is probably contained within the stream alluvium in the Gila River sediments east of Florence in the Eloy sub-basin and in the northern part of the Maricopa-Stanfield sub-basin.

Groundwater depressions in this zone are located primarily around its periphery in each sub-basin, and these correspond with depressions in the lower main water zone. The depressions are probably largely caused by discharge to the lower zone, and are not solely the result of groundwater withdrawal from the upper main water zone. Exceptions to this are depressions in the immediate vicinity of Eloy in the Eloy sub-basin which are caused primarily by groundwater withdrawal in this zone, as well as an extensive depression in the vicinity of Maricopa in the Maricopa-Stanfield sub-basin.

In the Eloy sub-basin, groundwater in the upper main water zone moves out as underflow into the East Salt River Valley sub-basin between Florence and the Santan Mountains, and between the Santan and Sacaton Mountains. In the Maricopa-Stanfield sub-basin there is underflow into the West Salt River Valley sub-basin between the Sierra Estrella and South Mountains.

Man-induced and natural sources contribute recharge to this zone. In both sub-basins, excess irrigation water filters downward in the form of deep percolation. In the Eloy sub-basin there are also extensive unlined canals for the distribution of surface water and groundwater which allow infiltration of large volumes of water into the subsurface to this zone. A prominent feature in the Eloy sub-basin is a groundwater ridge or divide which extends approximately along the Casa Grande Canal alignment. The groundwater divide largely prevents flow in this zone between the northern and southern halves of the sub-basin.

Underflow into this zone in the Eloy sub-basin occurs under the Gila River and between the Sawtooth and West Silver Bell Mountains from the Aguirre Valley sub-basin. Discharge into the upper main water zone occurs from the Casa Grande and Picacho Reservoir water zones. Recharge occurs from the major drainages as a result of storm events or releases from storage. Some recharge also probably comes from the mountain-front areas in the eastern part of the sub-basin.

The underflow into this zone in the Maricopa-Stanfield sub-basin is primarily from the Gila River area in the East Salt River Valley sub-basin. Some underflow may also occur between the Sierra Estrella and Palo Verde Mountains from the Rainbow Valley sub-basin, but this is not clear.

Depth to water in the upper main water zone in the Eloy sub-basin is from about 20 ft below land surface where the Gila River enters, to nearly 450 ft below land surface in the area north of Friendly Corners. In the Maricopa-Stanfield sub-basin it ranges from over 50 ft below land surface in the area of the Gila River in the north, to more than 400 ft below land surface in sec. 18, T. 6 S., R. 3 E.

Local Water Zones--The local water zones are significant sources of water in their respective areas. The Casa Grande water zone lies mainly on top of the Casa Grande Ridge, but may be perched along its western edge and in a large area south and east of Casa Grande and south of the Casa Grande Mountains. Presumably, it is perched on fine-grained deposits in the upper basin fill. The zone discharges to underlying sediments along its margins and receives mostly man-induced recharge, although it probably received considerable natural recharge during the flood of October 1983 along the Santa Cruz River. Depth to water ranges from about 25 ft below land surface in the north part of the zone, to more than 150 ft below land surface in the south part.

The Picacho Reservoir water zone is at least partially perched, presumably on fine-grained deposits in the upper basin fill. It also discharges to the underlying sediments, primarily along its margins, and receives mostly man-induced recharge. Depth to water ranges from about 50 ft below land surface in the vicinity of Picacho Reservoir, to more than 300 ft below land surface in the area between Eloy and Friendly Corners.

The Friendly Corners water zone is situated between the lower and upper main water zones. It probably discharges to the lower zone, primarily in its northwest part and around some of its margin, and receives water from the lower zone in the area west of Picacho Peak and Silver Bell Mountains, and perhaps underflow from the Aguirre Valley sub-basin. Depth to water ranges from more than 350 ft below land surface near the mouth of the Aguirre Valley sub-basin, to almost 500 ft below land surface at the eastern terminus of the zone.

For readers who prefer to use metric units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric unit
inch	25.4	millimeter
foot	0.3048	meter
mile	1.609	kilometer
square mile	2.590	square kilometer
acre	0.4047	square hectometer
acre-foot	0.001233	cubic hectometer
gallons per minute	0.06309	liters per second

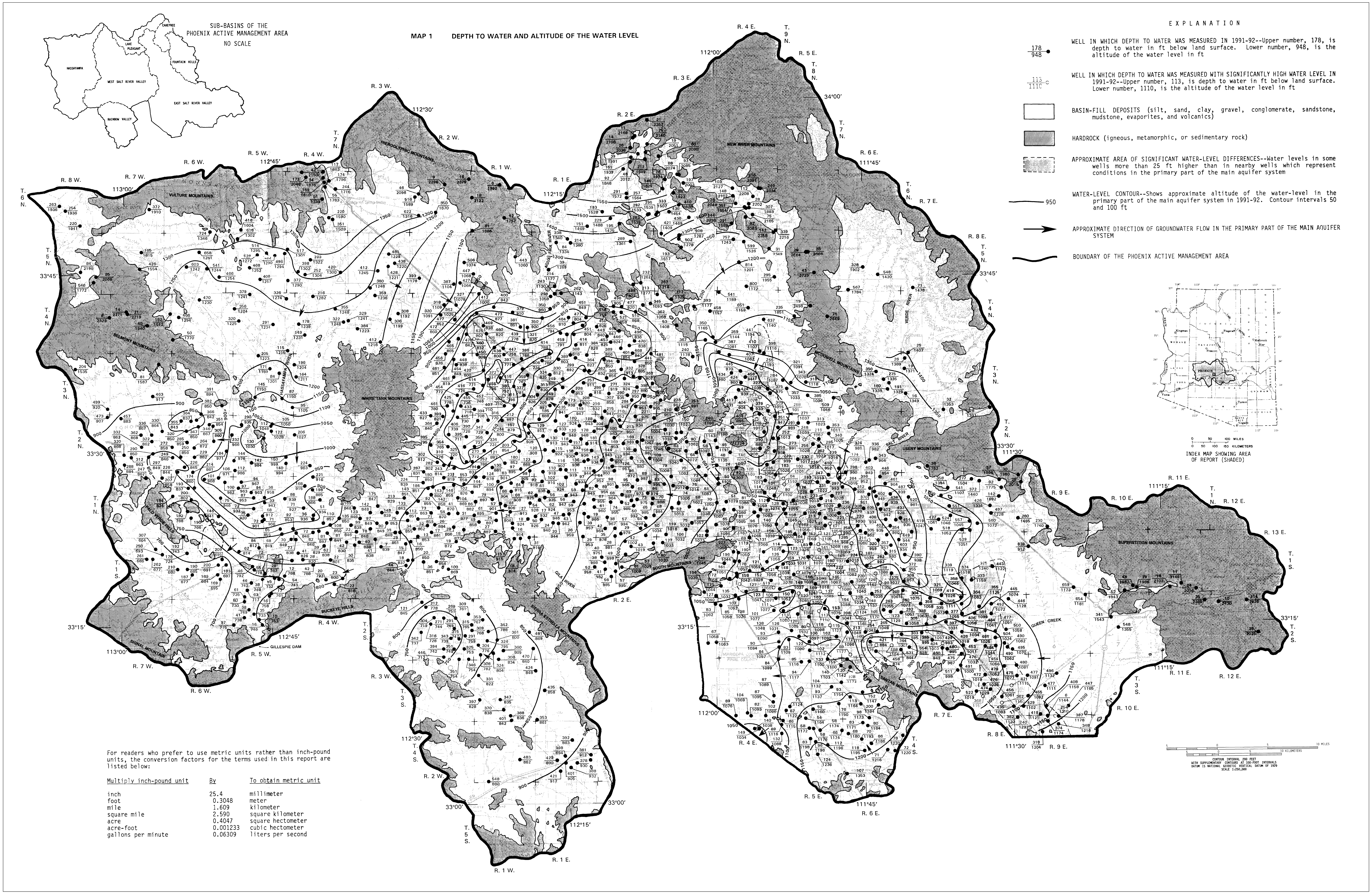
MAPS SHOWING GROUNDWATER CONDITIONS IN THE ELOY AND MARICOPA-STANFIELD SUB-BASINS OF THE PINAL ACTIVE MANAGEMENT AREA, PINAL, PIMA, AND MARICOPA COUNTIES, ARIZONA--1989

BY

B. A. HAMMETT

Exhibit 14C-4

Map HMS 27 (ADWR, 1992)



EXPLANATION

178 / 948 ● WELL IN WHICH DEPTH TO WATER WAS MEASURED IN 1991-92--Upper number, 178, is depth to water in ft below land surface. Lower number, 948, is the altitude of the water level in ft

113 / 1110 ○ WELL IN WHICH DEPTH TO WATER WAS MEASURED WITH SIGNIFICANTLY HIGH WATER LEVEL IN 1991-92--Upper number, 113, is depth to water in ft below land surface. Lower number, 1110, is the altitude of the water level in ft

BASIN-FILL DEPOSITS (silt, sand, clay, gravel, conglomerate, sandstone, mudstone, evaporites, and volcanics)

HARDROCK (igneous, metamorphic, or sedimentary rock)

APPROXIMATE AREA OF SIGNIFICANT WATER-LEVEL DIFFERENCES--Water levels in some wells more than 25 ft higher than in nearby wells which represent conditions in the primary part of the main aquifer system

950 WATER-LEVEL CONTOUR--Shows approximate altitude of the water-level in the primary part of the main aquifer system in 1991-92. Contour intervals 50 and 100 ft

APPROXIMATE DIRECTION OF GROUNDWATER FLOW IN THE PRIMARY PART OF THE MAIN AQUIFER SYSTEM

BOUNDARY OF THE PHOENIX ACTIVE MANAGEMENT AREA

For readers who prefer to use metric units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric unit
inch	25.4	millimeter
foot	0.3048	meter
mile	1.609	kilometer
square mile	2.590	square kilometer
acre	0.4047	square hectometer
acre-foot	0.001233	cubic hectometer
gallons per minute	0.06309	liters per second

BASE FROM U.S. GEOLOGICAL SURVEY
PHOENIX, ARIZONA, 1954, REV. 1969, 1:250,000
MESA, ARIZONA, 1954, REV. 1978, 1:250,000
AJO, ARIZONA, 1953, REV. 1969, 1:250,000
HOLBROOK, ARIZONA, 1954, REV. 1970, 1:250,000

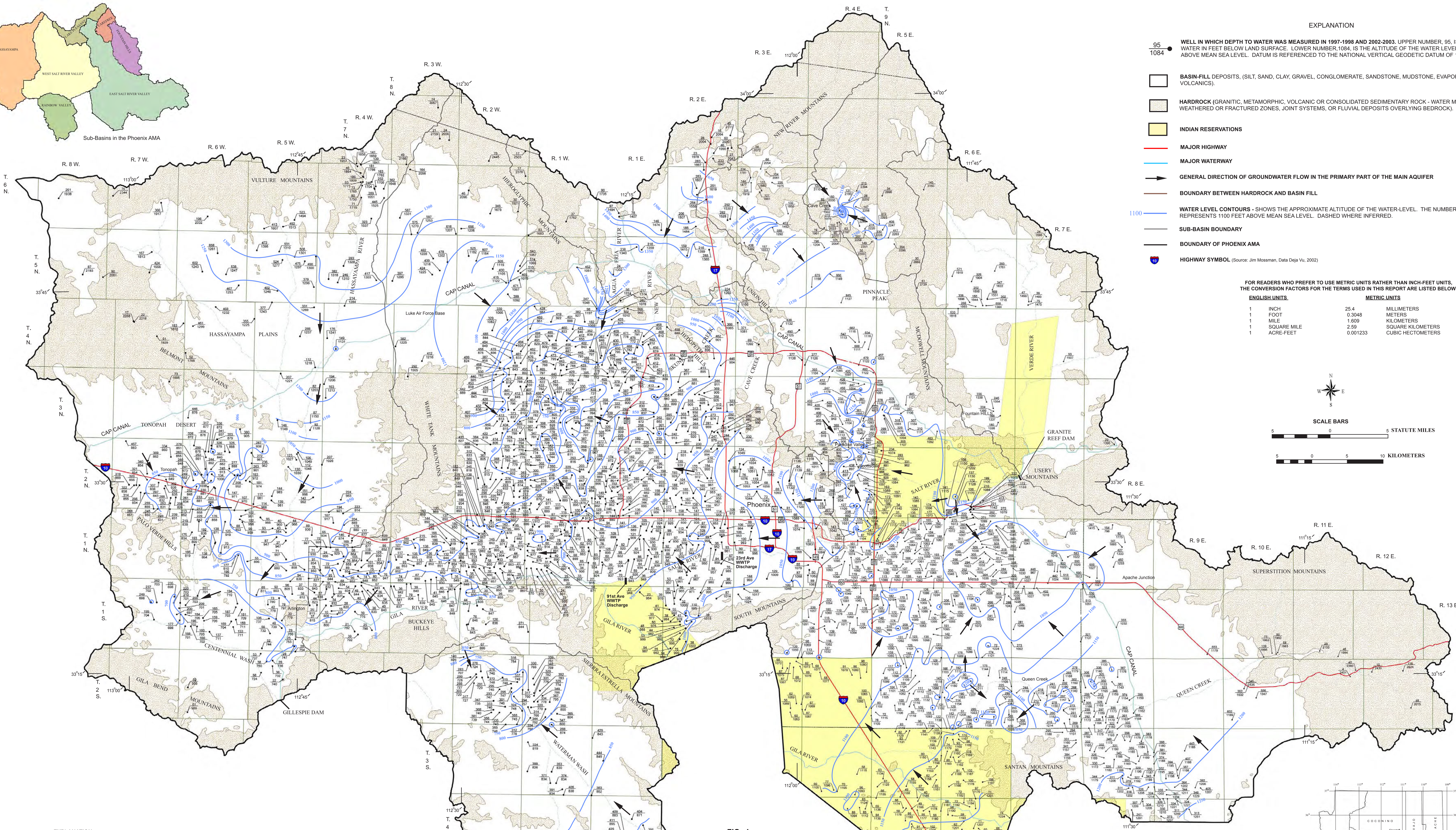
MAPS SHOWING GROUNDWATER CONDITIONS IN THE PHOENIX ACTIVE MANAGEMENT AREA
MARICOPA, PINAL, AND YAVAPAI COUNTIES, ARIZONA--1992

BY
B. A. HAMMETT AND R. L. HERTHER

These hydrologic maps are available upon request from the Department of Water Resources, Basic Data Section, 2810 South 24th Street, Suite 122, Phoenix, Arizona, 85034. The hydrologic data on which these maps are based are available, for the most part, in computer-printout form and may be consulted at the Department of Water Resources and at the U. S. Geological Survey offices located at: 375 S. Euclid, Tucson, Arizona, 85719, and 1545 West University, Tempe, Arizona, 85281.

Exhibit 14C-5

Map HMS 35 (ADWR, 2005)



EXPLANATION

95 / 1084 — **WELL IN WHICH DEPTH TO WATER WAS MEASURED IN 1997-1998 AND 2002-2003.** UPPER NUMBER, 95, IS DEPTH TO WATER IN FEET BELOW LAND SURFACE. LOWER NUMBER,1084, IS THE ALTITUDE OF THE WATER LEVEL IN FEET ABOVE MEAN SEA LEVEL. DATUM IS REFERENCED TO THE NATIONAL VERTICAL GEODETIC DATUM OF 1929.

BASIN-FILL DEPOSITS, (SILT, SAND, CLAY, GRAVEL, CONGLOMERATE, SANDSTONE, MUDSTONE, EVAPORITES, AND VOLCANICS).

HARDROCK (GRANITIC, METAMORPHIC, VOLCANIC OR CONSOLIDATED SEDIMENTARY ROCK - WATER MAY OCCUR IN WEATHERED OR FRACTURED ZONES, JOINT SYSTEMS, OR FLUVIAL DEPOSITS OVERLYING BEDROCK).

INDIAN RESERVATIONS

MAJOR HIGHWAY

MAJOR WATERWAY

GENERAL DIRECTION OF GROUNDWATER FLOW IN THE PRIMARY PART OF THE MAIN AQUIFER

BOUNDARY BETWEEN HARDROCK AND BASIN FILL

1100 — **WATER LEVEL CONTOURS -** SHOWS THE APPROXIMATE ALTITUDE OF THE WATER-LEVEL. THE NUMBER 1100 REPRESENTS 1100 FEET ABOVE MEAN SEA LEVEL. DASHED WHERE INFERRED.

SUB-BASIN BOUNDARY

BOUNDARY OF PHOENIX AMA

HIGHWAY SYMBOL (Source: Jim Mossman, Data Deja Vu, 2002)

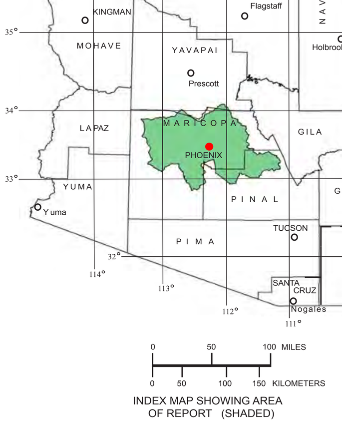
FOR READERS WHO PREFER TO USE METRIC UNITS RATHER THAN INCH-FEET UNITS, THE CONVERSION FACTORS FOR THE TERMS USED IN THIS REPORT ARE LISTED BELOW:

ENGLISH UNITS		METRIC UNITS	
1	INCH	25.4	MILLIMETERS
1	FOOT	0.3048	METERS
1	MILE	1.609	KILOMETERS
1	SQUARE MILE	2.59	SQUARE KILOMETERS
1	ACRE-FEET	0.001233	CUBIC HECTOMETERS

SCALE BARS

STATUTE MILES

KILOMETERS



INDEX MAP SHOWING AREA OF REPORT (SHADED)

EXPLANATION

The Phoenix Active Management Area (AMA) is subdivided into seven legislatively defined sub-basins (fig. 1, sheet 1): three hydrologically interconnected east valley sub-basins [East Salt River Valley (ESRV), Carefree and Fountain Hills] and four hydrologically interconnected west valley sub-basins [West Salt River Valley (WSRV), Lake Pleasant, Hassayampa and Rainbow Valley]. Hydrologic interconnection between the east and west valley sub-basins is minimal. Hydrographs and maps showing groundwater level contours are presented for each of the sub-basins. Discussion of groundwater conditions and water-level changes focuses on the larger East and West Salt River Valley sub-basins. The sub-basins of the Phoenix AMA are located almost entirely within Maricopa County except for a portion of the southeastern ESRV, which is located in Pinal County and small hardrock areas of the northern Hassaymapa, WSRV and Lake Pleasant Sub-basins located in Yavapai County.

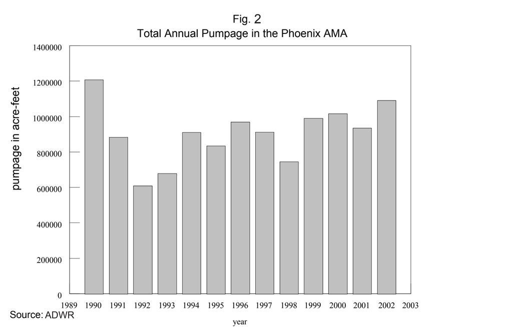
Water-level data presented in this report were collected and compiled by the Field Services Section of the Arizona Department of Water Resources from November 2002 to February 2003. Historic pumpage data were compiled by the Hydrology Division and the Phoenix AMA Office.

Land and Water Use

Land use within the Phoenix AMA has become increasingly urban with the expansion of the Phoenix metropolitan area into native desert and previously irrigated agricultural areas. The population of Maricopa County, which includes the Phoenix metropolitan area, has increased more than 50 percent since 1990 from approximately 2,122,100 to 3,194,800 in 2001 (U.S. Census Bureau, 2003). By 1995, urban land use in the Phoenix AMA (Maricopa county portion only and excluding the Gila River Indian Reservation) exceeded agricultural land use (ASU CAPLTER, 2003). Combined irrigated acreage of agricultural land in the East and West sub-basins (Maricopa county only and excluding the Gila River Indian Reservation) decreased from approximately 264,000 acres in 1995 to less than 200,000 acres in 2000 while urban land use has increased from approximately 280,000 acres to more than 420,000 over the same time period (ASU CAPLTER, 2003). Prior to the early 1990's agriculture was the dominant land use in the Phoenix AMA.

Despite the decrease in agricultural land use, groundwater withdrawn for agriculture still exceeds that withdrawn for municipal and industrial use. In 2000, agricultural use accounted for approximately 54.7% of all groundwater withdrawn in the AMA, and municipal (including domestic) and industrial (including mining and turf-related facilities) use was approximately 31.9% and 13.4%, respectively. From 1990 to 2002, the highest total groundwater pumpage in the AMA was in 1990 while the lowest was in 1992. However, since 1992 the trend has been a general increase in total annual pumpage (fig. 2, sheet 1).

Fig. 2
Total Annual Pumpage in the Phoenix AMA



Source: ADWR

Physiographical Setting

The Phoenix AMA is located primarily in south-central Arizona. This area is part of the Basin and Range physiographic province described by Fenneman (1931). It is characterized by alluvium filled basins separated by elongated fault-block mountain ranges.

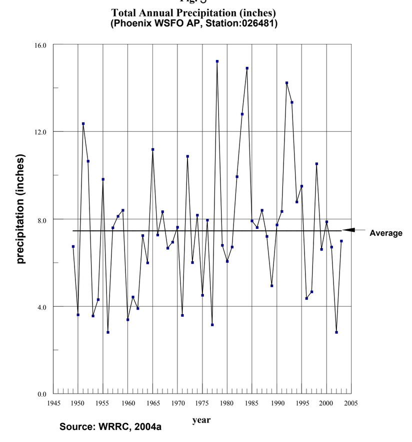
The major drainages include the Salt, Gila, Verde, Hassayampa, Agua Fria and New Rivers, Queen, Cave and Skunk Creeks and Indian Bend Wash. Upstream dams and diversions prevent all but the upper reach of Cave Creek and the Verde River from having natural perennial flow within the Phoenix AMA. The entire flow of the Salt River below Stewart Mountain Dam (except for minor overflow and during infrequent periods of extreme flooding) is diverted at Granite Reef Dam (10 miles downstream) for irrigation and municipal use in the Phoenix AMA (McCormack and others, 2003). Effluent dominated perennial flow is also present in the Salt River below the City of Phoenix 23rd and 91st Ave. wastewater treatment plants. Flows below the City of Phoenix 23rd and 91st Ave wastewater treatment plants are comprised primarily of treated effluent discharged by the plants but may also include irrigation return flows from agricultural fields and rainfall runoff from urban land.

Perennial flow in the Hassayampa River near Arlington is also dependant on effluent discharged by the City of Phoenix 91st Ave wastewater treatment plant. The effluent is mixed with groundwater in the Buckeye Canal and used to irrigate cotton and other crops. Downstream, effluent and irrigation return flows in the Buckeye Canal are discharged into the river near Arlington (Cordy and others, 2000

The Central Arizona Project (CAP), a 336-mile aqueduct designed to carry about 1.5 million acre-feet of surface water annually from the Colorado River to Maricopa, Pinal and Pima Counties, began delivery to the Phoenix metropolitan area in 1985. In 2003, deliveries of CAP water to the Phoenix AMA totaled more than 300,000 acre-feet (CAP, 2004).

Climate in the Phoenix AMA is semi-arid. Precipitation averages about 7.6 inches per year (WRCC, 2004a). The Phoenix area as well as much of the State of Arizona is in the midst of a drought that began in 1996 (fig. 3, sheet 1). During this drought, average annual precipitation has been below normal in six of the past eight years.

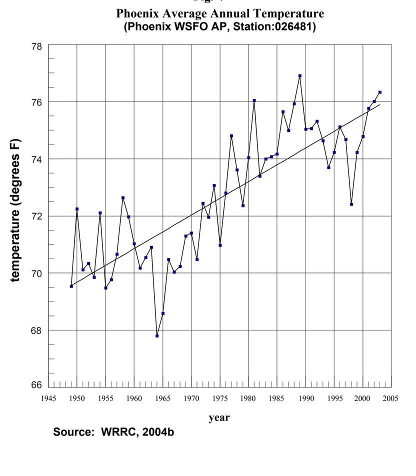
Fig. 3
Total Annual Precipitation (inches)
(Phoenix WSFO AP, Station:026481)



Source: WRRC, 2004a

The average daily temperature in the Phoenix metropolitan area has been increasing steadily during the past 50 years (fig. 4, sheet 1). The average daily temperature for 2003 was 76.3 ºF, (WRCC, 2004b).

Fig. 4
Phoenix Average Annual Temperature
(Phoenix WSFO AP, Station:026481)



Source: WRRC, 2004b

Groundwater

Groundwater occurs under generally unconfined conditions throughout most of the alluvial-filled basins and local hardrock areas of the Phoenix AMA. Depths to water range from just below land surface to more than 800 feet below land surface.

The main aquifer systems of both the east and west sub-basins are composed primarily of basin-fill deposits. Previous investigations by the U.S. Bureau of Reclamation (1976) divided these deposits into three hydrogeologic units.

The units were further defined as the Upper Alluvial Unit (UAU), Middle Alluvial Unit (MAU) and the Lower Alluvial Unit (LAU) by Corkhill and others (1993) in the East and West Salt River Valley Sub-basins. Location, thickness and composition of the units are described in detail by Brown & Pool (1989) and Laney & Hahn (1986). Each of the units is characterized by distinct hydrologic properties that vary in extent and thickness throughout the Phoenix AMA. Detailed hydrologic properties of the units in the East and West Salt River Valley Sub-basins are listed by Township, Range and section in ADWR Modeling Report No. 6 (Correll and Corkhill, 1994).

Prior to extensive pumping in the AMA, groundwater flowed primarily from ESRV to the WSRV along or toward the Salt and Gila Rivers. Groundwater exited the AMA near the former Gillespie Dam (Freethey and Anderson, 1986). By1964, a large groundwater depression had formed east of the White Tank Mountains, redirecting flow from virtually all directions in the WSRV toward the depression. (ADWR, 2003a). By 1983, localized groundwater depressions caused primarily by decades of agricultural pumping had formed throughout the AMA (Reeter and Remick, 1986). As a result, a groundwater divide has formed in the southwest quarter of Township 1N, Range 4E that essentially severed the hydraulic connection between the ESRV and WSRV sub-basins (Corkhill and others, 1993).

Although groundwater levels in the ESRV have risen somewhat, the map prepared for this report (fig. 1, sheet 1) shows that most of the groundwater depressions depicted on the 1983 and 1992 maps (Reeter and Remick, 1986 and Hammett and Herther, 1995, respectively) are still evident. The groundwater divide that developed around 1983 between the East and West Salt River Valley sub-basins is still present.

West Salt River Valley Sub-basin

The sources of groundwater in the WSRV are spread almost evenly among the three alluvial units: 32 percent from the UAU, 33 percent from the MAU, and 35 percent from the LAU (ADWR, 2003a). About 6,817,500 acre-feet of groundwater was withdrawn from the WSRV from 1990 to 2002.

Major sources of groundwater recharge in the WSRV include incidental recharge of agricultural irrigation (approx. 200,000 acre-feet/year) and effluent discharged from the City of Phoenix 23rd and 91st Ave. wastewater treatment plants (approx. 40,000 acre-feet/year). An increasing amount of aquifer recharge of surface water and effluent is currently managed at 10 permitted underground storage facilities (USFs) in the WSRV. Approximately 125,950 acre-feet was stored from 1996 to 2002 via USFs in the WSRV. From 1996 to 2002, 4,220,088 acre-feet from all sources was recharged in the WSRV (ADWR, 2003a).

Withdrawal of groundwater in the WSRV from 1990 to 2002 exceeded recharge by almost 2.6 million acre-feet. This fact, along with historic overpumping in the area around Luke Air Force Base has resulted in a large groundwater depression known locally as the Luke cone of depression. Coinciding with this large groundwater depression, land subsidence of up to 18 feet has been recorded in the vicinity of Luke Air Force Base (Schuman and O'day, 1995). ADWR is currently monitoring land subsidence in the WSRV. In addition to the area around Luke Air Force Base, preliminary results have identified several areas of active land subsidence as high as 7 cm (2.75 inches) per year between 1997 and 2000. (ADWR, 2003b).

Hassayampa Sub-basin

The Hassayampa Sub-basin is further divided into the upper Hassayampa Plain and the Lower Hassayampa Area. Groundwater in the upper Hassayampa Plain occurs primarily under unconfined conditions in the basin-fill deposits (Long, 1983). The upper Hassayampa Plain is predominantly undeveloped with few existing wells scattered over a large area.

Groundwater in the Lower Hassayampa Area occurs primarily under unconfined conditions in the basin-fill deposits (Stulik, 1974), with smaller amounts under locally confined, artesian, or perched conditions (Long, 1983). Agricultural development in the Lower Hassayampa Area began in the early 1950's (Stulik, 1974) and continues to the present, particularly in the area near Tonopah.

Groundwater pumpage from the Hassyampa Sub-Basin (primarily from the Lower Hassayampa Area) was about 49,000 acre-feet in 2002. Although this is only half as much pumped throughout the 1970's and 80's, groundwater depressions are still present in both the Centennial Wash and the Tonopah areas. (fig. 1, sheet 1). Recent water-level declines are limited to the Tonopah area (sheet 2). Three newly constructed power plants have also recently begun operation in the Lower Hassayampa Area with a total projected annual water use of more than 17,000 acre-feet.

Rainbow Valley Sub-basin

Groundwater in the Rainbow Valley Sub-basin (also known as the Waterman Wash Area) occurs under unconfined conditions in the basin-fill alluvial deposits that underlie the valley (Stulik, 1982). Groundwater pumping in the sub-basin began in the 1940's with the development of agriculture in the area. By 1952, continued pumpage resulted in the development of a groundwater depression in the northwest portion of the sub-basin (Stulik, 1982). Although annual pumpage has declined from a high of 72,000 acre-feet in 1972 (Stulik, 1982) to less than 7,000 acre-feet in 2002, the groundwater depression is still evident. (fig. 1, sheet 1).

Lake Pleasant Sub-basin

The hydrogeologic units of the Lake Pleasant Sub-basin consist of unconsolidated basin fill and streambed alluvium underlain by sedimentary sandstone and conglomerate. The sedimentary layer is underlain locally by Tertiary volcanics and Precambrian schist. The unconsolidated basin fill, interbedded with volcanics, intrusives and conglomerate make up the main water-producing aquifer in the sub-basin (Clear Creek & Associates, 2003).

Annual pumpage in the Lake Pleasant Sub-basin is minimal. Since 1992, reported pumpage has averaged about 1,550 acre-feet per year and has exceeded 2,000 acre-feet in only three of the past 13 years.

East Salt River Valley Sub-basin

The primary source of groundwater in the ESRV is the LAU. Nearly half (49 percent) of the total pumpage in the ESRV is withdrawn from the LAU, 40 percent from the MAU, and only 11 percent from the UAU (ADWR, 2003a). About 4,257,500 acre-feet of groundwater was withdrawn in the ESRV from 1990 to 2002 (ADWR, 2003a).

Major sources of groundwater recharge in the ESRV include agricultural irrigation (approx. 250,000 acre-feet/year), canal leakage (approx. 22,000 acre-feet/year), and storage at USFs. Aquifer recharge of surface water and effluent is currently managed at 12 permitted USFs in the ESRV. Approximately 789,500 acre-feet was stored from 1995 to 2002 at USFs in the ESRV, and about 6,946,430 acre-feet from all sources was recharged from 1990 to 2002 (ADWR, 2003a). Recharge of groundwater in the ESRV from 1990 to 2002 exceeded withdrawals by almost 2.7 million acre-feet.

Localized pumping near Apache Junction area in the ESRV may be the cause of past earth fissuring and ongoing land subsidence of up to 2.5 cm (about 1 inch) per year (ADWR, 2003b). Other areas in the ESRV with documented earth fissures and/or land subsidence are in the vicinities of Queen Creek, North Scottsdale and Paradise Valley (ADWR, 2003b).

Carefree Sub-basin

Groundwater in the Carefree Sub-basin occurs under a variety of conditions. Water bearing units may consist of unconsolidated streambed alluvium, and various members of the Carefree Formation (HydroSystems, 2000). Local areas of fractured schist, gneiss and granite also yield water to wells (Littin, 1979).

The Carefree Formation is the major water-producing unit, with the majority of water pumped in the basin coming from its various members (HydroSystems, 2000). Pumpage in the Carefree Sub-basin is primarily for domestic use, municipal use and golf course irrigation. Reported pumpage in the sub-basin has decreased from approximately 3,700 acre-feet in 1990 to less than 2,100 acre-feet in 2002.

As a result of historic heavy pumping, cones of depression formed near the Carefree Airport in the south-central portion of the basin and in the northern part of the Town of Cave Creek. The depression near the airport reached its largest extent in 1993 (Bernier, 2001), and is currently less pronounced. However, the cone of depression centered in the southeast quarter of section 21 in Township 6N, Range 4E in the northern part of the Town of Cave Creek, is still well defined. (fig 1, sheet 1.)

Fountain Hills Sub-basin

The hydrogeology of the Fountain Hills Sub-basin is not well documented. A geologic cross-section through the Town of Fountain Hills prepared by HydroSystems (1999), indicates a confined aquifer system consisting primarily of clays and interbedded conglomerates. Separate aquifer systems occur within the recent alluvium in the streams and washes around the Town of Fountain Hills (HydroSystems 1999) and along the Verde River. In the area on the west side of the Verde River, east of Pinnacle Peak and north of the McDowell Mountains, groundwater is present in an aquifer comprised of decomposed and fractured granites (ADWR, 2001). East of this area, a clay sequence as thick as 600 feet is encountered toward the Verde River. The clay acts as a barrier to groundwater flow between the shallow alluvial aquifer along the Verde River and the decomposed and fractured granites (ADWR, 2001).

Most of the groundwater development in the Fountain Hills Sub-basin is limited to the area around the town of Fountain Hills and the area west of the retirement community of Rio Verde. Groundwater pumpage is primarily for domestic use, municipal use and golf course irrigation. Both the number of wells and the volume of groundwater pumped in the sub-basin has increased steadily since 1990. Reported pumpage in 2002 was about 4,700 acre-feet compared to 1990 when pumpage was just over 2,500 acre-feet.

Water Level Changes

Since 1997, significant changes in water levels have been recorded throughout the AMA. The area with the largest increases in water levels from 1997 to 2000 (from +25 to +75 feet) is in the southeast portion of the ESRV while the largest and most extensive area of decline (from -25 to -50 feet) is in the WSRV (sheet 2).

The areas where substantial water-level rises have occurred coincide with sizeable decreases of agriculture combined with increased use of surface water, (primarily CAP) in lieu of groundwater on the remaining agricultural land. From 1992 to 2001 more than1.3 million acre-feet of in lieu CAP water was 'stored' in the Phoenix AMA (ADWR, 2003c). Of the 1.3 million acre-feet, most (approx. 75 percent) was 'stored' in the ESRV. Other small local areas of water-level rise have resulted from artificial recharge at many of the permitted USFs located throughout the AMA

Within the large area of water-level decline in the WSRV, agricultural land use has continued to decrease due to expanding urbanization. The extent of the recent water level decline is a result of increased groundwater pumping over the past five years due in large part to the ongoing drought. Salt River Project (SRP) operates a high number of large-capacity wells in this area of water-level decline and has had to rely heavily on pumping these wells during times when surface water is not readily available. At the center of the decline in Township 2N, Range 1E, withdrawals have increased from less than 40,000 acre-feet in 1997 to more than 60,000 acre-feet in 2002. Throughout the AMA, SRP pumped over 300,000 acre-feet of groundwater in 2002 compared to only 77,000 acre-feet in 1998, when surface water was readily available and demand was lower due to above average annual rainfall.

Hydrographs for selected wells throughout the AMA are presented in Sheet 3. The Hydrographs were prepared using data from ADWR's Groundwater Site Inventory (GWSI) Database.

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BASE MAP FROM U.S. GEOLOGICAL SURVEY
PHOENIX, ARIZONA, 1954,REV.1969,1:250,000
MESA, ARIZONA, 1954, REV. 1978, 1:125,000
HOLBROOK, ARIZONA, 1954, REV. 1970, 1:250,000
AJO, ARIZONA, 1953, REV. 1969, 1:250,000

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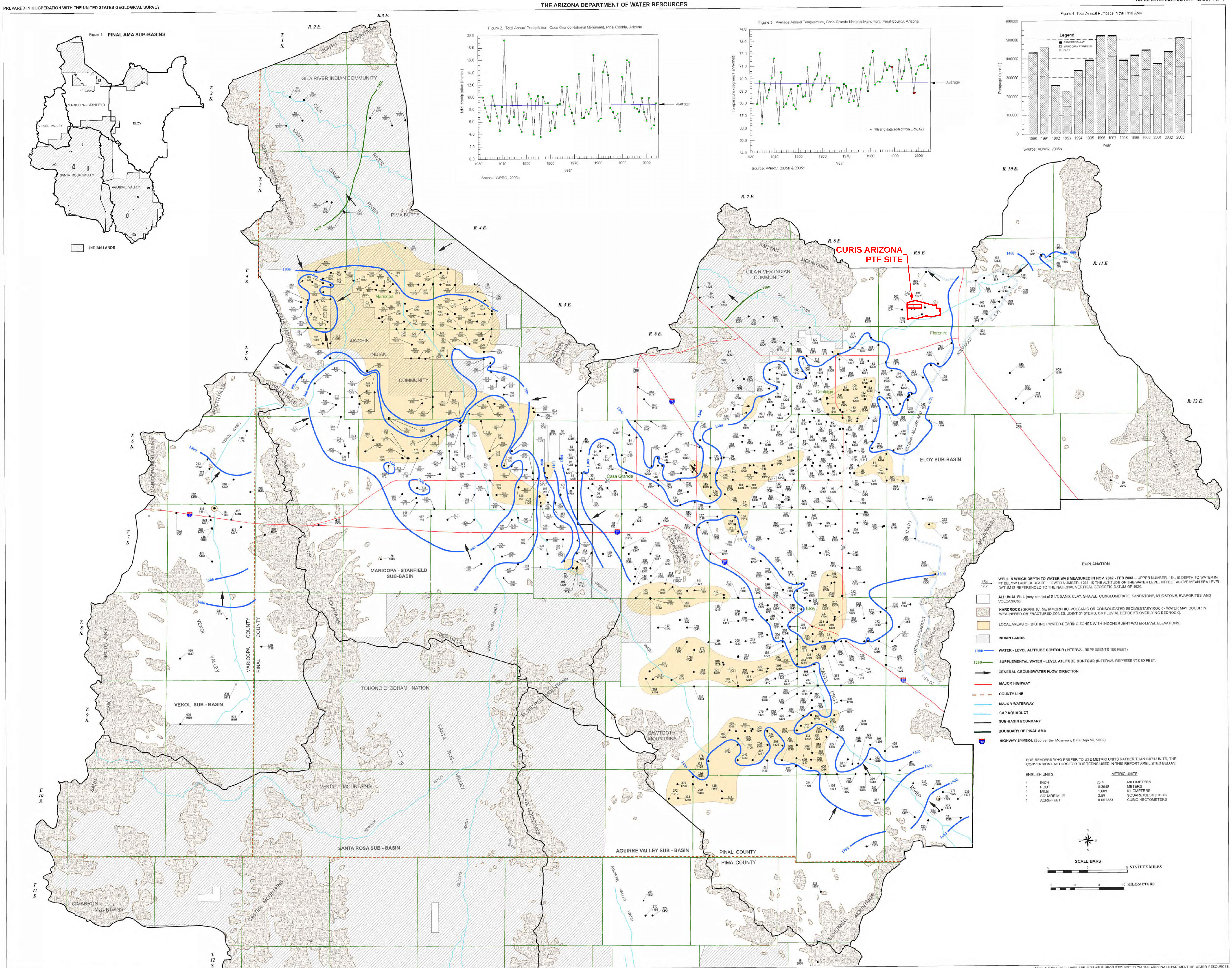
MAPS SHOWING GROUNDWATER CONDITIONS IN THE PHOENIX ACTIVE MANAGEMENT AREA
MARICOPA, PINAL, AND YAVAPAI COUNTIES, ARIZONA—NOV. 2002- FEB. 2003

BY
S.J. RASCONA

THESE HYDROLOGIC MAPS ARE AVAILABLE UPON REQUEST FROM THE ARIZONA DEPARTMENT OF WATER RESOURCES, INFORMATION CENTRAL, 3550 NORTH CENTRAL AVE, PHOENIX, ARIZONA, 85012. THE HYDROLOGIC DATA ON WHICH THESE MAPS ARE BASED ARE AVAILABLE AT THE ADWR BOOKSTORE. (602) 771-8638

Exhibit 14C-6

Map HMS 36 (ADWR, 2006)



BASE MAP FROM U.S. GEOLOGICAL SURVEY
PHOENIX, ARIZONA 1954, REV. 1969, 1:250,000
TUCSON, ARIZONA, 1956, REV. 1977, 1:250,000
MESA, ARIZONA, 1954, REV. 1978, 1:125,000
AJO, ARIZONA, 1953,REV.1969,1:250,000

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MAPS SHOWING GROUNDWATER CONDITIONS IN THE PINAL ACTIVE MANAGEMENT AREA
MARICOPA, PINAL, AND PIMA COUNTIES, ARIZONA—NOV. 2002 - FEB. 2003
BY

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Exhibit 14C-7

AZGS Earth Fissure Map of Pinal County, Arizona

Earth Fissure Map of Pinal County, Arizona

March 2011
Arizona Geological Survey

Digital Map Series - Earth Fissure Map 21 (DM-EF-21)

NOTICE
THE STATE OF ARIZONA HAS MADE A REASONABLE EFFORT TO ENSURE THE ACCURACY OF THIS MAP WHEN IT WAS PRODUCED, BUT ERRORS MAY BE PRESENT AND THE STATE OF ARIZONA DOES NOT GUARANTEE ITS ACCURACY. THE MAP SUPPLEMENTS, AND IS NOT A SUBSTITUTE FOR, A PROFESSIONAL INSPECTION OF PROPERTY FOR DEFECTS AND CONDITIONS.

This is one of a series of earth fissure maps prepared by the Arizona Geological Survey ("AZGS") in accordance with Ariz. Rev. Stat. § 27-152.01(3). AZGS collected location information from previously conducted earth fissure studies, reviewed available remote-sensing aerial and satellite imagery, and conducted surface site investigations throughout the study area. A reasonable effort was made to identify all earth fissures in the study area. Nonetheless, some fissures may remain unmapped as a result of one or more of the following:
1) existing fissures may have been masked by construction or agricultural activities;
2) incipient fissures may lack clear surface expression;
3) the surface expression of fissures changes constantly as new earth fissures develop and old earth fissures fill in.
A blank area on the map does not guarantee earth fissures are not present. However, blank areas within the study area boundary have been investigated, and no surface evidence of fissures was found as of the date of map publication. Determining the presence or absence of a fissure at any specific site may require additional mapping and/or geotechnical analysis.

For more detailed maps, see these other publications:

Earth Fissure Map of the Chandler Heights Study Area: Pinal and Maricopa Counties, Arizona, August 2008, Arizona Geological Survey Digital Map Series - Earth Fissure Map 1 (DM-EF-1)

Earth Fissure Map of the Apache Junction Study Area: Pinal and Maricopa Counties, Arizona, April 2008, Arizona Geological Survey Digital Map Series - Earth Fissure Map 2 (DM-EF-2).

Earth Fissure Map of the Picacho Study Area: Pinal County, Arizona, February 2009, Arizona Geological Survey Digital Map Series - Earth Fissure Map 3 (DM-EF-3).

Earth Fissure Map of the Toltec Buttes Study Area: Pinal County, Arizona, August 2008, Arizona Geological Survey Digital Map Series - Earth Fissure Map 6 (DM-EF-6).

Earth Fissure Map of the Pete's Corner Study Area: Pinal County, Arizona, November 2008, Arizona Geological Survey Digital Map Series - Earth Fissure Map 7 (DM-EF-7).

Earth Fissure Map of the Heaton Study Area: Pinal County, Arizona, February 2009, Arizona Geological Survey Digital Map Series - Earth Fissure Map 9 (DM-EF-9).

Earth Fissure Map of the Tator Hills Study Area: Pinal County, Arizona, June 2009, Arizona Geological Survey Digital Map Series - Earth Fissure Map 11 (DM-EF-11).

Earth Fissure Map of the Friendly Corners Study Area: Pinal County, Arizona, June 2009, Arizona Geological Survey Digital Map Series - Earth Fissure Map 12 (DM-EF-12).

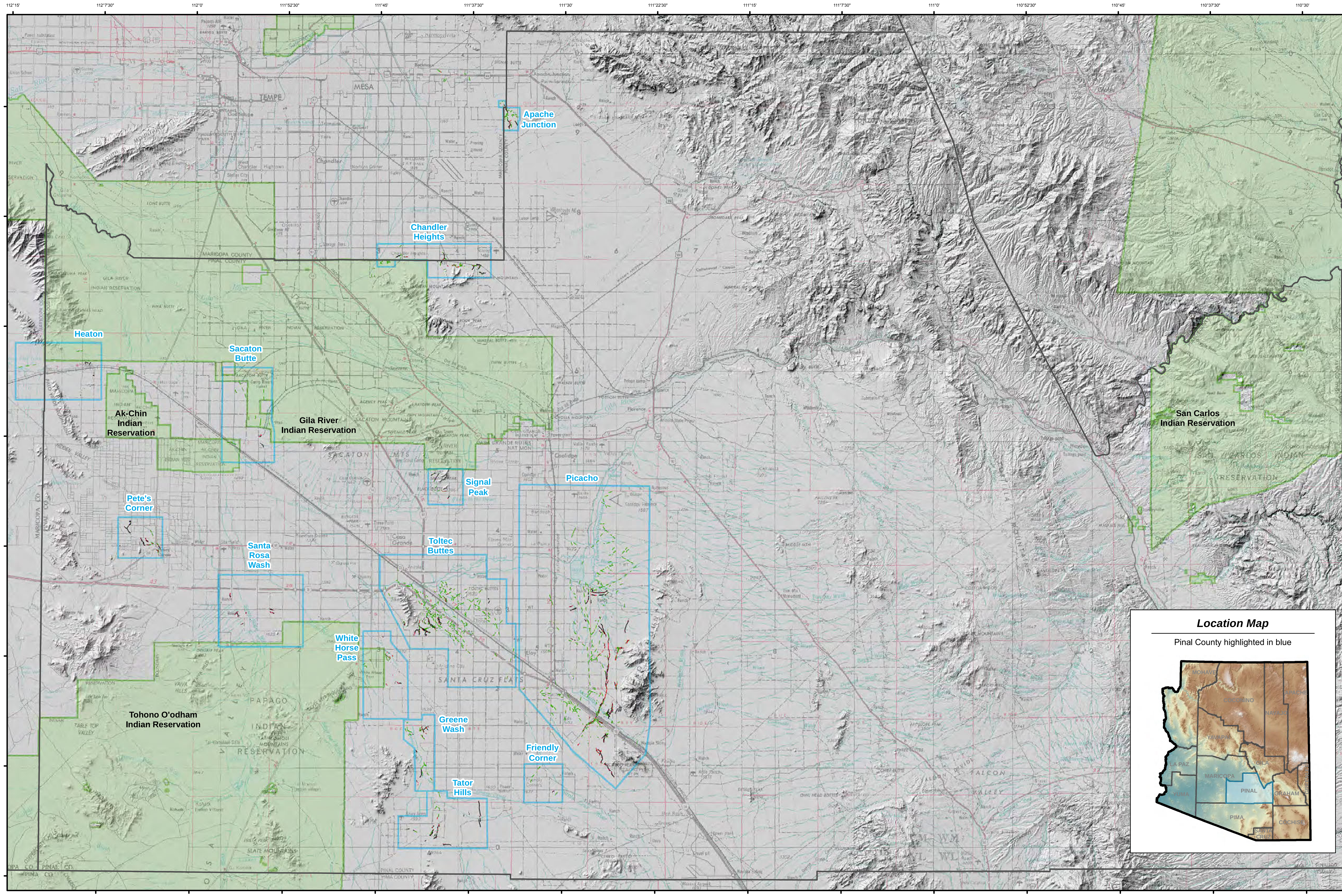
Earth Fissure Map of the Signal Peak Study Area: Pinal County, Arizona, June 2009, Arizona Geological Survey Digital Map Series - Earth Fissure Map 13 (DM-EF-13).

Earth Fissure Map of the Greene Wash Study Area: Pinal County, Arizona, December 2009, Arizona Geological Survey Digital Map Series - Earth Fissure Map 15 (DM-EF-15).

Earth Fissure Map of the Sacaton Butte Study Area: Pinal County, Arizona, March 2011, Arizona Geological Survey Digital Map Series - Earth Fissure Map 18 (DM-EF-18).

Earth Fissure Map of the Santa Rosa Wash Study Area: Pinal County, Arizona, March 2011, Arizona Geological Survey Digital Map Series - Earth Fissure Map 19 (DM-EF-19).

Earth Fissure Map of the White Horse Pass Study Area: Pinal County, Arizona, March 2011, Arizona Geological Survey Digital Map Series - Earth Fissure Map 20 (DM-EF-20).



Shaded relief basemap produced from 10m NED Digital Elevation Model

Topographic basemap from USGS 1:250,000-scale quadrangle series Originally published 1954, revised 1969

Map projection: Universal Transverse Mercator, zone 12. North American Datum of 1983 HARN

1:250,000 Scale

N

10 5 0 10 Miles

10 5 0 10 Kilometers

0 10,000 20,000 30,000 40,000 50,000 Feet

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MAP EXPLANATION

Solid black lines represent the location of continuous earth fissures manifested as open cracks or gullies.

Solid red lines represent the location of discontinuous earth fissures manifested as elongated to circular depressions or as abbreviated or irregular linear depressions. These discontinuous surface features frequently represent an incipient surface expression of an earth fissure.

Dashed green lines represent the approximate locations of unconfirmed earth fissures, defined as fissures which could not be confirmed by surface investigations by AZGS geologists, but which have been previously reported by Professional Geologists in published documents or maps.

The outline of the Study Area is shown in blue. Historical and modern aerial photos taken within this area were searched for anomalous lineaments. These lineaments were then investigated in the field to determine if there was any evidence of earth fissures.

EXHIBIT A-4

**Florence Copper Groundwater Model Files
(provided on CD)**