12 Appendix C – Technical Memoranda

12.6 Seepage Recovery Assessment

Eagle Mountain Pumped Storage Project Seepage Recovery Assessment

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Introduction

Eagle Crest Energy Company (ECEC) is in the licensing stages of a two reservoir hydroelectric project known as the Eagle Mountain Pumped Storage Project (Project). The Colorado River Aqueduct (CRA) passes within about one mile east of the Lower Reservoir, and is located between the reservoir and the proposed location of the groundwater supply wells, near Desert Center, that will be used to draw water for the initial fill and annual makeup water for the reservoirs. The potential effects of Project operations on groundwater elevations beneath the CRA are of particular interest, since significant changes in the subsurface saturated conditions could result in land subsidence and impact the integrity and function of the CRA.

Two particular groundwater-related issues associated with the Project are: 1) the potential effects of groundwater extraction in the Desert Center area as water supply for the initial filling and replacement of annual losses from evaporation and seepage; and 2) the potential effects of seepage from the reservoirs. The first issue is addressed in a separate memorandum titled *Groundwater Supply Pumping Effects*, dated April 20, 2009. This memorandum describes the approach and results to address the second issue, the potential impacts of seepage from the reservoirs on groundwater levels.

Approach

This technical memorandum provides an assessment of the groundwater impacts due to seepage, and seepage recovery schemes to address the Lower and Upper reservoirs separately. Different approaches are required to address the Lower and Upper reservoirs since subsurface conditions are dramatically different. The Lower Reservoir is partially situated on unconsolidated alluvium and is evaluated using a groundwater flow model to develop a seepage recovery system design. The Upper Reservoir sits atop fractured bedrock, and a seepage recovery system is defined by performing a review of known faults that intersect the reservoir footprint.

For the Lower Reservoir, the model set-up, analysis results, and proposed seepage recovery design are discussed. For the Upper Reservoir, this memo includes a description of the geology beneath the reservoir and the proposed seepage recovery system. A groundwater model was not developed for the Upper Reservoir as application of the model would require data that does not currently exist.

Lower Reservoir Seepage Assessment

Portions of the Lower Reservoir overlie saturated alluvium, while the remainder sits atop fractured bedrock. A groundwater model was developed to assess the effects of seepage from the reservoir on local groundwater conditions for the portion overlying saturated alluvium. Because of the close proximity of the bedrock to the saturated alluvium it was assumed that the faults and fractures would be hydraulically connected to the alluvium.

Upon review of the geologic conditions at the Project site, it was decided that a numerical model built in MODFLOW would be the most cost-effective and beneficial approach to evaluating groundwater conditions in the vicinity of the CRA. The model was developed using MODFLOW-2000 (version 1.18.00, released on 8/23/2007).

Modeling Goals and Objectives

Upon filling of the Lower Reservoir, some seepage from the reservoir is expected. That seepage needs to be controlled to prevent adverse changes in water elevations beneath the CRA that could cause subsidence and hydrocompaction.

The model objectives are to:

- Create a model that can accurately simulate current groundwater conditions in the vicinity of the Lower Reservoir and the CRA based on the available data.
- Evaluate the impacts of seepage from the Lower Reservoir into the saturated alluvium.
- Simulate the effects of seepage recovery wells to capture the seepage lost from the Lower Reservoir.
- Prepare a plan for the seepage recovery array to adequately capture Lower Reservoir seepage, but not significantly raise or depress the groundwater elevations beneath the CRA.

This analysis defines an optimum number and spacing of the recovery wells, and presents hydrographs at hypothetical observation wells located adjacent to the CRA to document the effects of seepage/pumping on the CRA. The potential impacts of seepage from the Lower Reservoir and extraction from the seepage recovery wells were determined by comparing the baseline model results with those of the different scenarios.

Final design of the monitoring and recovery well system will be based upon a refined modeling effort during final engineering design based upon measured aquifer hydraulic characteristics. The model developed for this evaluation can be re-applied to support the final design phase.

Hydrogeology

Figure 1 shows the general project area. The regional hydrogeology and the basis for model development are based on:

- Descriptions of geologic conditions in the Lower Reservoir (CH2MHill, 1996).
- Water elevations obtained from monitoring wells constructed for the Eagle Mountain Landfill and Recycling Center Project.
- Subsurface logs from coring performed for the Eagle Mountain Mine.
- Well drillers' logs from Eagle Mountain Mine water supply wells.
- Cross-sections developed by ECEC, shown on Figures 2 and 3.

- Cross-sections developed by GeoPentech for a groundwater banking project in the area, shown on Figures 4 and 5.

- Geophysical survey (gravity survey) from GeoPentech shown on Figure 6.

The regional hydrogeology is characterized by fractured bedrock at the surface, with recent and older alluvium overlapping onto the sloping surface of the bedrock. The alluvium is part of the Chuckwalla Groundwater Basin. The alluvium in the upper portions of the Chuckwalla Groundwater Basin can be grouped into three units with similar sediments and hydraulic parameters. Figures 2 through 5 show the geologic layering of the alluvial sediments in the vicinity of the Lower Reservoir.

The first alluvial layer is about 300 feet thick and consists of sand and gravel with a few discontinuous layers of silt and clay. Approximately 150 feet of the alluvium is saturated. Exposures of the alluvium in the eastern face of the Lower Reservoir were described as a coarse fanglomerate (CH2MHill, 1996). Underlying the first layer are lake deposits consisting primarily of clay. The lakebed thickness varies and may be thinner near the margins of the basin and thicker towards the central portions of the basin based on geophysical surveys (gravity). However, no wells have fully penetrated the lakebeds to determine their actual thickness. One well (CW-1) penetrated over 900 feet of clayey lakebed deposits before being terminated. The lakebed deposits are potentially underlain by coarser sediments, based on geophysical surveys, but there are no wells to confirm the presence of this layer (GeoPentech, 2003). The sediments are likely to have a lower permeability than the first alluvial layer because of compaction and development of clay due to weathering.

The alluvial sediments were deposited on an irregular bedrock surface. Geophysical surveys suggest the bedrock surface is a large bowl opposite the reservoirs (GeoPentech, 2003). The southern edge of the bowl aligns with a narrow bedrock ridge that juts easterly into the basin. The upper coarse-grained sediments were deposited above the bowl rim, whereas the lakebed sediments are below the rim. This configuration would create confining conditions in the underlying coarse sediment and prevent outflow from these sediments. The northern edge of the bowl connects to the Pinto Groundwater Basin where inflow into the Chuckwalla Groundwater Basin occurs. A basalt flow and several faults are present, as shown on Figure 4, but their effects on groundwater levels are not defined.

The bedrock beneath the Lower Reservoir is broken by the inactive East Pit Fault. The East Pit Fault appears to offset the bedrock by about 300 feet, which creates a near vertical bedrock contact on the western side of the valley starting near the reservoirs and extending to the south. Figure 2 shows the difference in the bedrock surface. West of the fault the alluvium is thin and unsaturated. Portions of the CRA, south of hypothetical monitoring well OW03 (Figure 1), rests on this unsaturated alluvium. The East Pit fault consists of about a 30-foot zone of broken rock and is in hydraulic continuity with the alluvial deposits.

Groundwater level measurements near the reservoirs are available for a two-year period between 1992 and 1994, after the time when significant pumping for the Eagle Mountain Mine and jojoba agricultural activities occurred in the 1960’s through the1980s. The measurements occurred during a period when there were no quantifiable or significant stresses applied to the aquifer that could be used for calibration. There was some pumping in the Desert Center area for domestic uses and limited agricultural uses during this period.

Groundwater occurs in the sediments above the lakebeds at a depth of about 25 feet below the lowest point in theEast Pit, in the west bowl. The west bowl of the East Pit is the western portion of the East Pit, and is outside and to the west of, the portion of the East Pit proposed to be used for the project's lower reservoir. The groundwater surface generally is deeper, progressing easterly into the valley. The nature of the sediments infer – and groundwater levels show – that the aquifer is unconfined.

Only one groundwater level measurement is available for the lakebed deposits at groundwater monitoring well (C-10) located near the eastern edge of the model area. It showed the groundwater level was about 60 feet below the top of the clay surface and over 200 feet below the water surface in the overlying sediments as shown on Figure 4. There is great uncertainty regarding this single data point due to this significant difference.

No groundwater levels are available for the coarse-grained sediments underlying the lakebeds. If present, this aquifer would be confined.

The groundwater flow direction in the alluvium is relatively uniform while flow in the bedrock is variable. Figure 1 shows the groundwater flow directions. The flow direction in the saturated alluvium above the lakebeds is generally to the southeast (CH2MHill, 1996). Groundwater flow in the bedrock is towards the Eagle Creek Canyon, from both the northwest and southwest.

Hydraulic characteristics of the sediments overlying the lakebeds were estimated during the investigation for the landfill. The hydraulic conductivities were estimated to be between 0.02 and 7.1 feet per day as shown in Table 1. Descriptions of the fanglomerate from monitoring well construction describe the sediments as ranging from boulders to coarse sand, and therefore the estimated K appear to be too low. Typical K values for well-sorted sand and gravel are from 3 to 180 feet/day (Fetter, 1988). Because the fanglomerate are part of older continental deposits and could be weathered and compacted, a conservative K of 25 feet per day and an S of 0.05 were used in the model.

Conceptual Model

The model area was defined to include both the Upper and Lower Reservoirs, but is centered on the Lower Reservoir and the closest portion of the CRA as shown in Figure 1. The area modeled is the alluvial aquifers, which will extend from the alluvium–bedrock contact at the Lower Reservoir to about 2 miles east of the CRA. As described above, the model is only set up to simulate groundwater conditions for the portion of the model area overlying saturated alluvium, with the portion of the model overlying bedrock, including the Upper Reservoir, designated as *inactive*. The following assumptions were made in development of the model:

1. A 3-layer model simulates the geologic conditions present in the vicinity of the reservoir. Layer 1 represents the saturated alluvium above the lakebeds, Layer 2 represents the lakebeds, and Layer 3 represents the underlying coarse-grained sediments.

2. The model is run under steady-state conditions because of the short period of available groundwater level measurements, and those data obtained during a period when there was little to no stress on the aquifer to calibrate the model.

3. The model boundaries are generally oriented to be parallel and perpendicular with the regional groundwater flow direction in the alluvial basin.

4. Layer 3, the confined aquifer, has no outflow, either naturally or by pumping wells. The aquifer is full and water is neither flowing into nor out of the aquifer. Therefore, assigning very small hydraulic conductivities is appropriate to both Layers 2 and 3,

essentially making the model a 1-layer model at this time. The deeper layers are built into the model for use during final engineering design.

5. The upgradient and downgradient boundaries are specified to keep the system in balance under current conditions so the seepage from the Lower Reservoir can be added after the model performance is verified.

6. Seepage from the reservoir instantaneously percolates through the unsaturated sediments and reaches the groundwater surface.

7. There are no other sources or outflows of water such as wells, streams, evaporation, or precipitation.

Model Development

The groundwater flow model was developed as follows.

Model Grid

The model cells are square, with a two-step nodal spacing. The node spacing in the central portion of the model area, which is in the vicinity of the Lower Reservoir and the closest stretch of CRA, is 200 feet by 200 feet. The node spacing expands to 400 feet by 400 feet for the extremities of the model area. Figure 7 shows the model grid.

Layers

The model was constructed with three layers to simulate the hydrogeologic conditions in the Upper Chuckwalla Groundwater Basin. Layer 1 is the saturated sands and gravels above the lakebeds. Layer 2 is the lakebed deposits. Layer 3 is the coarse sediments that may underlie the lakebeds.

The top of Layer 1 is the groundwater surface and was determined from the general gradient in the area and extrapolated as a uniform planar surface to best fit actual groundwater elevations, particularly in those areas close to the reservoir and aqueduct as shown on Figure 8. Given the limited measurements available, Layer 1 has been assigned a uniform thickness of 150 feet over the entire modeled area. This assumed thickness resulted in a reasonable fit to the few clay surface elevations shown on Figure 9. Layer 1 slopes to the southeast with edges partially controlled by the bedrock contact and partially by no flow and constant head boundaries as discussed in the Boundary Conditions section of this memo.

The lakebed deposits extent is poorly defined and may have a variable thickness as shown on Figures 4 and 5. Because of the limited data points available an average and uniform thickness of 400 feet was used to create Layer 2. Definition of Layer 3 is also limited, so an average and uniform thickness of 850 feet was used. Both Layer 2 and Layer 3 surfaces were assumed to be parallel to the top of Layer 1. Both layers were created to extend throughout the modeled area.

Seepage Infiltration

The average seepage from the Lower Reservoir assuming a 0.5 foot thick seepage blanket is constructed would have seepage losses of about 890 acre-feet per year (AFY), or about 550 gpm (GEI, *Seepage Analyses for Upper and Lower Reservoirs*, dated January 5, 2009). The maximum seepage would be about 1,600 AFY if only limited seepage control improvements were made. For the current analysis, the average seepage was distributed evenly over the eastern portion of the reservoir overlying alluvium, even though it is possible that some of the seepage could migrate through the bedrock via the crushed zone of the East Pit Fault.

Based on this interpretation of the subsurface conditions, it appears the fault intersects the alluvium near the Lower Reservoir. To simplify the modeling approach and provide a reasonable worst-case scenario, all seepage is assumed to be entering the system through the alluvial sediments.

Aquifer Parameters

Layer 1 was assigned a hydraulic conductivity (K) of 25 feet per day (ft/day) and a storativity (S) of 0.05. Layers 2 and 3 were assigned a K = 3 x 10^{-6} ft/day (1 x 10^{-9} centimeters per second) and S = 0.0001, which creates an essentially impermeable lower boundary for Layer 1. The aquifer characteristics of these deeper layers may be adjusted based upon measurements made to support final engineering design.

Initial and Boundary Conditions

The model is oriented such that the east and west boundaries are parallel to the direction of groundwater flow and therefore are no-flow boundaries. The upgradient and downgradient boundaries are general head boundaries assuming a total volumetric flow of 6,625 AFY (estimated outflow through the southern edge of the modeled area) through the system (790,120 ft^3/day), and an aquifer thickness of 150 feet. The flow was distributed across an up gradient length of 20,600 feet and across a down gradient length of 14,600 feet. The down gradient length is shorter due to the model area coinciding with a bedrock ridge that juts easterly into the valley.

The initial heads for Layer 1 were based on groundwater levels measured in monitoring wells constructed for the landfill. A uniform planar surface was developed that provided a best fit near the Lower Reservoir. Because Layers 2 and 3 have no hydraulic head measurements the heads were assumed to be at the top of Layer 2.

Modeling Runs

The overall approach to simulating the groundwater conditions in the vicinity of the Lower Reservoir and CRA was performed using the model runs outlined below. All runs are steady-state simulations.

Run 1 – Simulate current groundwater conditions and compare results of model analysis with current groundwater elevations interpolated by observation wells to evaluate the model performance.

Run 2 – Add seepage from the Lower Reservoir to Run 1 and observe changes in water elevations around the reservoir and at simulated observation wells along the CRA.

Run 3 – Add seepage recovery wells to Run 2 and observe changes in water elevations around the reservoir and at simulated observation wells along the CRA.

Transient simulations were performed for both Runs 2 and 3 to develop hydrographs showing the projected changes in groundwater levels beneath the CRA and when steady state conditions are reached. This allows the timing of groundwater changes in response to seepage, and seepage mitigation, to be evaluated. Water balance results for each modeling run are also provided.

Run 1 - Model Performance

The model performance was evaluated by observing the model's ability to replicate the current groundwater conditions using the given aquifer parameters, boundary conditions, and initial conditions. General agreement was observed between the initial groundwater gradient and the steady-state elevations simulated by the model after Run 1. As shown on Figure 10, the up gradient and down gradient elevations were accurately estimated and the model reasonably matched the uniform initial gradient.

It was expected that the uniform gradient projected over the entire alluvial portion of the model would not be as accurately replicated near the encroaching bedrock contact along the southwestern portion of the model since the extrapolated gradient does not take into account the no-flow boundary effects. It would appear that the model better approximated the groundwater elevations in this area. Overall, the model appears to reasonably replicate the current groundwater conditions in the alluvial area.

Run 2 – Seepage

Run 2 was performed following verification of the model's ability to replicate the current groundwater conditions. The purpose of Run 2 was to assess the impacts of seeping 890 AFY from the Lower Reservoir on groundwater elevations and did not include seepage recovery wells. The estimated seepage is based on the analysis found in the Technical Memorandum on Seepage (Section 12.5). Run 2 is based on an assumed placement of a 5-feet thick liner consisting of grouting, seepage blanket, and RCC or soil cement treatment over alluvium.

As shown in Figure 11, Run 2 showed that a groundwater mound is created in the vicinity of the Lower Reservoir and a rise in groundwater elevations occur across the model. Groundwater levels rose about 8 feet beneath the reservoir, far less than the 25 feet of unsaturated alluvium. A series of hypothetical observation wells were placed along the CRA as monitoring points to evaluate groundwater elevation changes. As shown on Figures 12 through 14, groundwater elevations at the closest observation well, OW05, rose 1.88 feet in response to seepage from the Lower Reservoir. Down gradient observation well OW03.2 rose about 2.65 feet.

A transient analysis was performed to evaluate the change of groundwater elevations over time. Figure 12 showed that groundwater elevations at OW05 rose 1.64 feet (87 percent of elevation change at steady state) after three years in response to seepage from the Lower Reservoir, and reached 1.87 feet (99 percent) after 10 years.

Run 3 – Seepage Recovery and Alternatives Evaluation

Run 3 consisted of multiple runs varying the number, pumping rates, and preliminary locations of the seepage recovery wells. In all runs the seepage from the reservoirs was captured, using 5 to 7 wells, but the drawdown beneath the CRA varied from about 1 to 4 feet. Consideration was given to placement of the wells away from the reservoir to effectively capture the seepage. Model Run 2 showed that a saturated mound would not rise high enough to connect to the reservoir bottom. Therefore, the seepage will migrate mostly vertically through unsaturated alluvium before reaching the water surface. To allow the seeped water to reach the groundwater surface the recovery wells' array design consisted of six wells distributed about 1500 to 2000 feet from the eastern and southern edges of the Lower Reservoir at a spacing of about 1000 feet, each pumping 92 gpm. The locations of the wells are shown on Figure 15. Figure 16 shows the results of Run 3. Groundwater elevations in the vicinity of the CRA were maintained between 0 and 3 feet below the initial groundwater conditions. Pumping the seepage recovery wells would result in less than 6 feet of drawdown in these wells.

A transient analysis was performed to evaluate the change of groundwater elevations over time. Figures 12 through 14 show that the seepage recovery wells reduced the water elevations at OW05 to 1.86 feet (89 percent of elevation change at steady state) below the initial groundwater elevations after three years, and reached 2.08 feet (greater than 99 percent) after 10 years. The other observation wells reached steady state conditions in a similar time frame.

Water Balances

Figure 17 shows the mass balance for all three runs. The inflow and outflow values are within a fraction of a percent of each other, indicating that model parameters are being accounted for and the model is valid.

Landfill Compatibility

The water surface elevation in the Lower Reservoir will range from elevation 925 and 1,092 feet msl. The landfill is proposed to be constructed in four phases. Phases 1 through 3 will be constructed at elevations above the lower reservoir's maximum water surface elevation and therefore cannot be affected by the seepage from the lower reservoir. Phase 4 is located to the north of the lower reservoir and its foundation finish grade at its lowest point is about 1,040 feet msl (about 800 feet from the reservoir), below the maximum reservoir water surface. This portion of the landfill is being built at least in part over the older alluvium exposed in the eastern portion of the Lower Reservoir, however the area is currently covered by tailing piles so the exact extent of the alluvium is unknown.

The groundwater model covered this area and can approximate the change in the groundwater level beneath this portion of the landfill. Groundwater levels directly beneath the reservoir, if not controlled by seepage recovery wells, would be expected to rise a maximum of 8 feet. Existing monitoring well MW-1 is the closest monitoring well in the alluvium to Phase 4. The groundwater elevation in well MW-1 was 706 feet msl in 1992. The water surface elevation with uncontrolled recharge mounding, projects to be about 714 feet elevation, far below the landfill foundation. With seepage control wells, as shown on Figure 16, groundwater levels are expected to change by about one to four feet.

Upper Reservoir Seepage Assessment

The Upper Reservoir is entirely underlain by bedrock. The bedrock is fractured and seepage from the Upper Reservoir will likely be through these fractures. These groundwater conditions do not readily lend themselves to modeling. Therefore, a geologic assessment of the major faulting pattern was prepared to develop a preliminary seepage recovery well network to capture all of the seepage from the Upper Reservoir.

Hydrogeology

Bedrock geologic units present at the site can be generally classified as igneous or meta-sedimentary (including the iron ore) with little to no primary permeability. The meta-sediments have been folded into an anticline with the Upper Reservoir on the north limb. Subsequent to the folding and fracturing volcanic dikes intruded the rock in a northeast–southwest trend.

Fracturing and faulting of the rock created secondary permeability that can convey water from the reservoir. Geologic mapping of the Upper Reservoir was performed prior to the excavation of the pit by the Eagle Mountain Mine and shows the location of the major faults. Figure 18 shows the location of these major faults (digitized from Proctor, 1992). For purposes of this analysis, it was assumed that the fractures would be connected to these major faults. The faults near and beneath the Upper Reservoir (Fault "A") have a similar northwest-southeast trend to the East Pit Fault, which crosses through the Lower Reservoir. Although no dips are provided for faults in the Upper Reservoir it is believed they would be similar to the East Pit Fault, which is nearly vertical (dips about 80 degrees to the east).

Two borings were completed in the Upper Reservoir site vicinity (MW-10 and CH-10). Rock core obtained from boring CH-10 provides insights on the hydrogeologic character of the bedrock. The boring was drilled to a total depth of 1,389 feet. Water was first observed at a depth of 1,309 feet. Rock in the upper 350 feet of the boring was found to be moderately fractured, interbedded igneous and meta-sedimentary rock. Monitoring well MW-10 was drilled to a total depth of 1,214 feet. Water was first encountered at a depth of 506 feet. The water surface subsequently dropped and later stabilized at a depth of 1,018 feet. The observations suggest that water may be present in joints and fractures at various depths and that lower fractures are either dry or at lower heads.

The groundwater flow direction in the bedrock is regionally towards the southeast, in the direction of Eagle Creek Canyon as shown on Figure 1 (CH2MHill, 1996). It is possible there are either faults or fractures in the rock that are concealed beneath the thin alluvium in the canyon. Faults and fractures typically create weak zones where erosion can create canyons. The orientation of the canyon would suggest a fault or fracture could convey water to the east into the saturated alluvium where it could be captured by the Lower Reservoir seepage recovery wells.

The depth to groundwater in the bedrock beneath portions of the CRA is about 450 feet below ground surface, as shown on Figure 2. Groundwater levels in the bedrock would have to rise by about 180 feet before saturating the alluvium overlying bedrock.

Hydraulic Characteristics

Hydraulic characteristics of the bedrock joint and fractures were estimated during the investigation for the landfill. The hydraulic conductivities were estimated to be between 0.02 and 5.1 feet per day as shown in Table 1.

Few wells in the area obtain water from the fractured bedrock. The former Eagle Mountain school well (School Well) was drilled to a depth of about 750 feet before encountering adequate flow to support a small well. The well could be pumped at a rate of about 75 gpm.

Seepage

The Upper Reservoir may seep an average of 738 acre-feet of water annually or about 460 gallons per minute (GEI, *Seepage Analyses for Upper and Lower Reservoirs*, dated January 5, 2009). Raising and lowering of water levels in the reservoir during normal operations would allow some of the seepage, especially in the sidewalls, to drain back into the reservoir during low water level periods.

Seepage Recovery Wells

A preliminary seepage recovery network was designed assuming that the average well would be capable of pumping only 70 gallons per minute, similar to the School Well. About seven seepage recovery wells may be needed. Five of the seven seepage recovery wells were positioned around the Upper Reservoir outside of the landfill perimeter at currently known locations of faults that extend beneath the reservoir. Figure 18 shows the location of the proposed seepage recovery well system.

In addition to the seepage recovery well system near the Upper Reservoir, additional seepage recovery wells will be constructed along the axis of the Eagle Creek Canyon at the intersections of the faults that cross beneath the Upper Reservoir. These wells in conjunction with the wells near the Upper Reservoir will be used to maintain the water levels below the elevation of the liner for the proposed landfill operations in this area and to prevent a rise in groundwater levels in the bedrock beneath the CRA.

Conclusions

The results of the MODFLOW model for the Lower Reservoir indicate that groundwater levels in the vicinity of the CRA would increase by up to three feet by seepage from the Lower Reservoir if not controlled through seepage recovery wells. A preliminary seepage recovery well array design consists of six wells, each pumping 92 gpm, and resulted in capture of all of the seepage, with groundwater elevations only being reduced beneath the CRA by about three feet. The absolute elevations are reflected in Figure 13 with the elevation increasing from about 629 feet msl to about 632 feet msl without the network and decreasing from about 629 to 626 with the network. Although the seeped water could be allowed to flow unimpeded to offset drawdown related to water supply pumping, this does not allow for unanticipated conditions. Therefore, seepage recovery wells will be installed and equipped. Once the reservoirs are at full capacity and the actual operating conditions are observed, groundwater management alternatives will be employed to minimize groundwater level changes beneath the CRA.

The maximum seepage from the Lower Reservoir with limited seepage control improvements is estimated to be about 1,600 AFY, about double the average seepage that was analyzed in this assessment. Therefore, worst case projections would suggest the seepage, if not controlled by pumping, would raise groundwater levels by about 6 feet beneath the CRA. The seepage could be controlled by pumping wells.

Seepage from the Upper Reservoir will be along joints, fractures, and faults that cross beneath the reservoir. About seven seepage control wells will be needed to control the seepage losses, assuming they will each pump about 70 gpm. Since the faults are near-vertical angle drilling may be an effective method. Additional seepage recovery wells will be constructed along the axis of the Eagle Creek Canyon to provide secondary control to prevent groundwater levels from rising beneath this area of the proposed landfill.

Mitigation Measures

Mitigation SR-1:

Aquifer tests will be performed during final engineering design to confirm the seepage recovery well pumping rates and aquifer characteristics. The tests will be performed by constructing one of the seepage recovery wells and pumping the well while observing the drawdown in at least two seepage recovery or monitoring wells. If available, additional observation wells will be monitored. Upon completion of this testing the model will be re-run and the optimal locations of the remainder of the seepage recovery wells will be determined to effectively capture water from the Lower Reservoir and maintain groundwater level rises and drawdown at less than significant levels beneath the CRA.

Mitigation SR-2:

A testing program will also be employed for seepage recovery wells for the Upper Reservoir. However, the purpose of these tests is to assess the interconnectedness of the joints and fractures and the pumping extraction rate. Drawdown observations will be made in nearby observation wells to support final engineering design.

Mitigation SR-3:

A groundwater level monitoring network will be developed to confirm that seepage recovery well pumping is effective at managing groundwater levels beneath the CRA and in the Eagle Creek Canyon portion of the proposed landfill. The monitoring network will consist of both existing and new monitoring wells to assess changes in groundwater levels beneath the landfill and the CRA. In addition to the proposed monitoring wells, groundwater levels, water quality, and production will be recorded at the Project seepage recovery wells.

Mitigation SR-4:

Seepage from the upper reservoir will be maintained below the bottom elevation of the landfill liner. Seepage from the Lower Reservoir will be maintained to prevent significant rise in water levels beneath the CRA.

Alternative Mitigation Measure:

As shown in the analyses for the Project water supply well pumping assessment, the cumulative change in groundwater levels beneath the CRA (near OW03) over the 50-year life of the Project are projected to be drawn down by about 14 feet as a result of pumping for the proposed projects – pumped-storage project, landfill project, and solar projects – and other existing uses in the basin (GEI, 2009). The Project water supply pumping will result in about 6 feet of drawdown. Project pumping drawdown could be mitigated by managing seepage from the reservoirs, which, if left unimpeded, could raise groundwater levels by up to 3 feet. Implementation of this option would require confirmation of groundwater level rises and water quality of the resulting seepage.

Mitigation SR-5:

Groundwater monitoring will be performed on a quarterly basis for the first four years of Project pumping and thereafter may be extended to bi-annually or annually depending on the findings. Annual reports will be prepared and distributed to interested parties.

References

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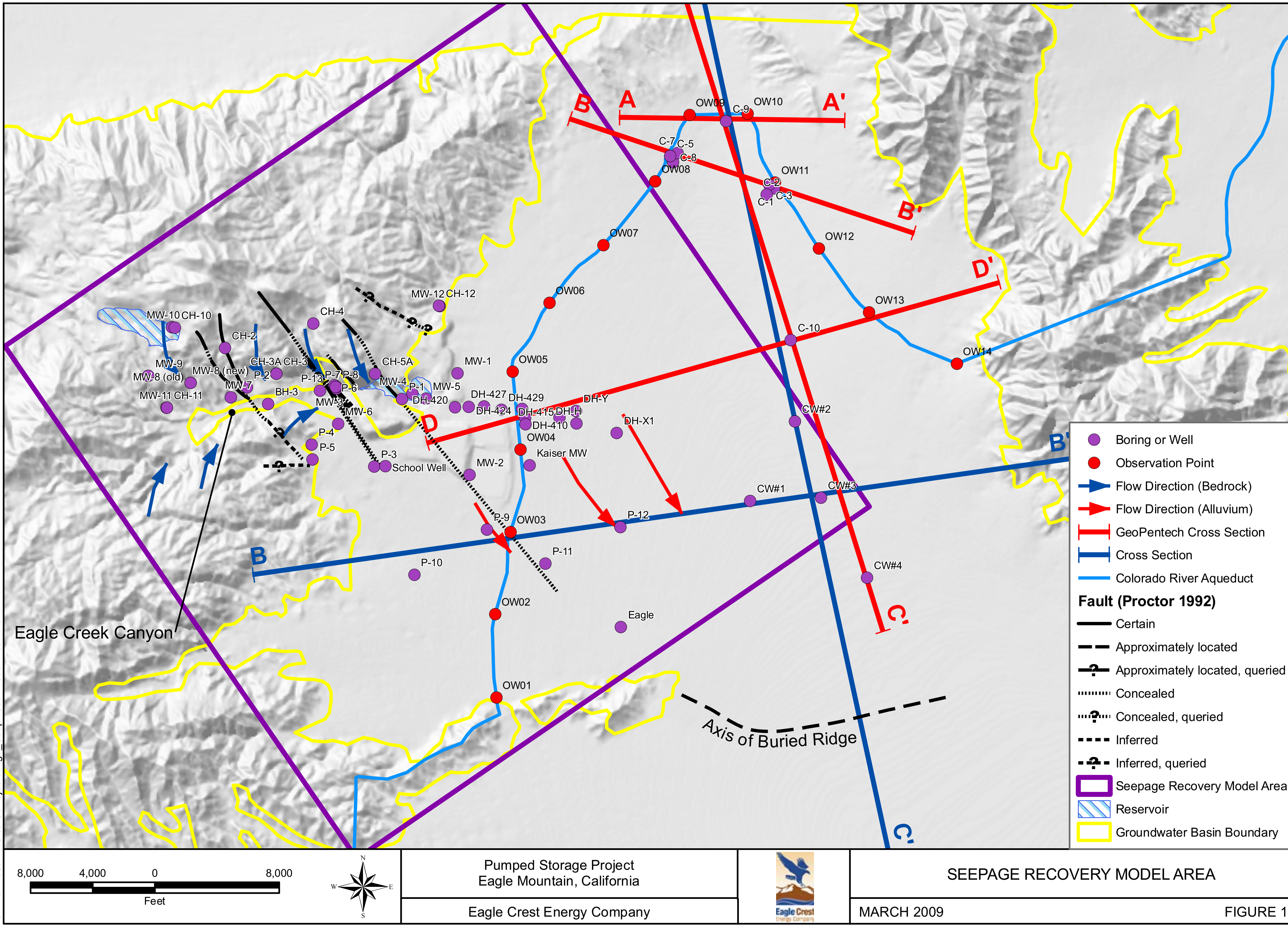
Figures



Pumped Storage Project
Eagle Mountain, California

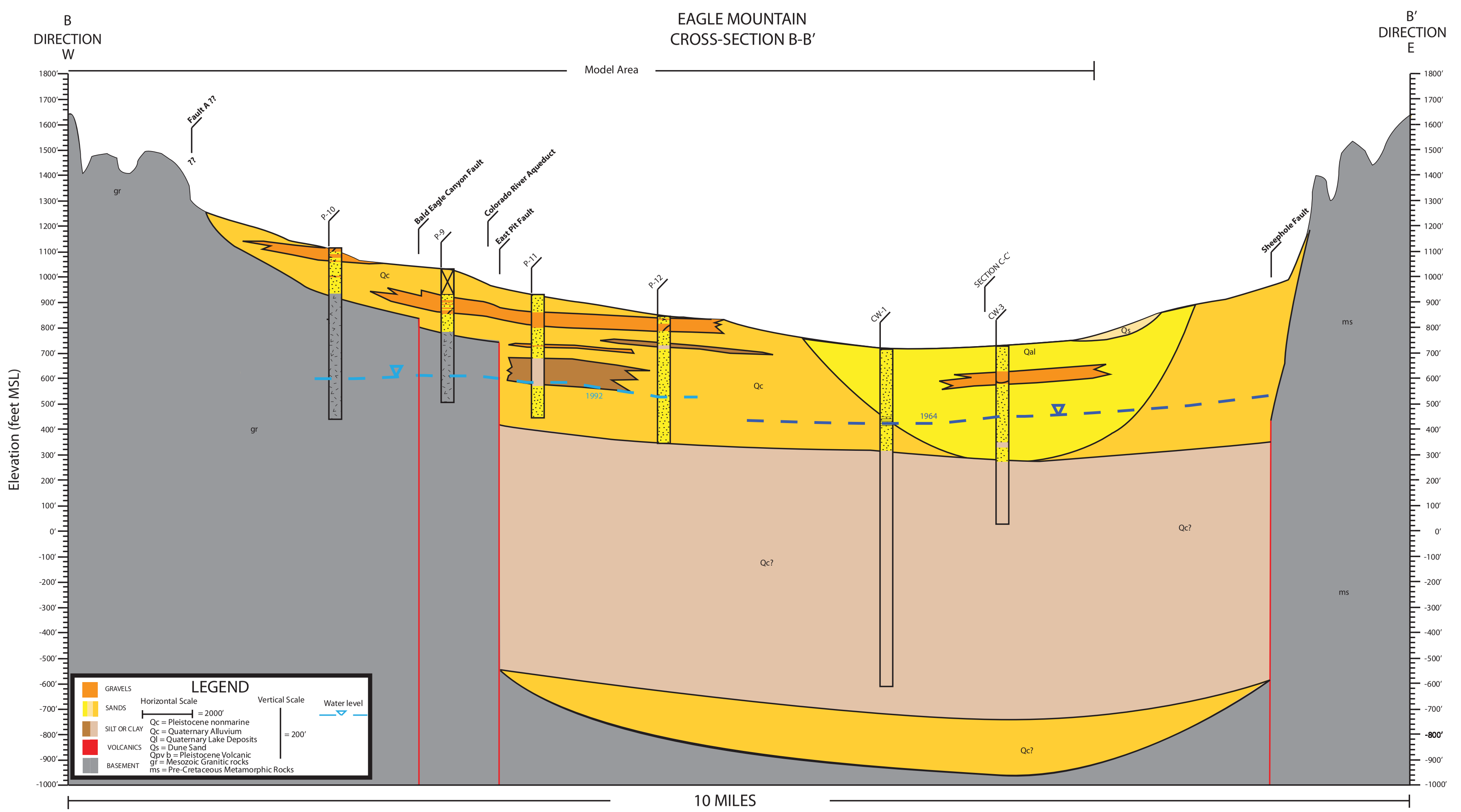
Eagle Crest Energy Company

SEEPAGE RECOVERY MODEL AREA

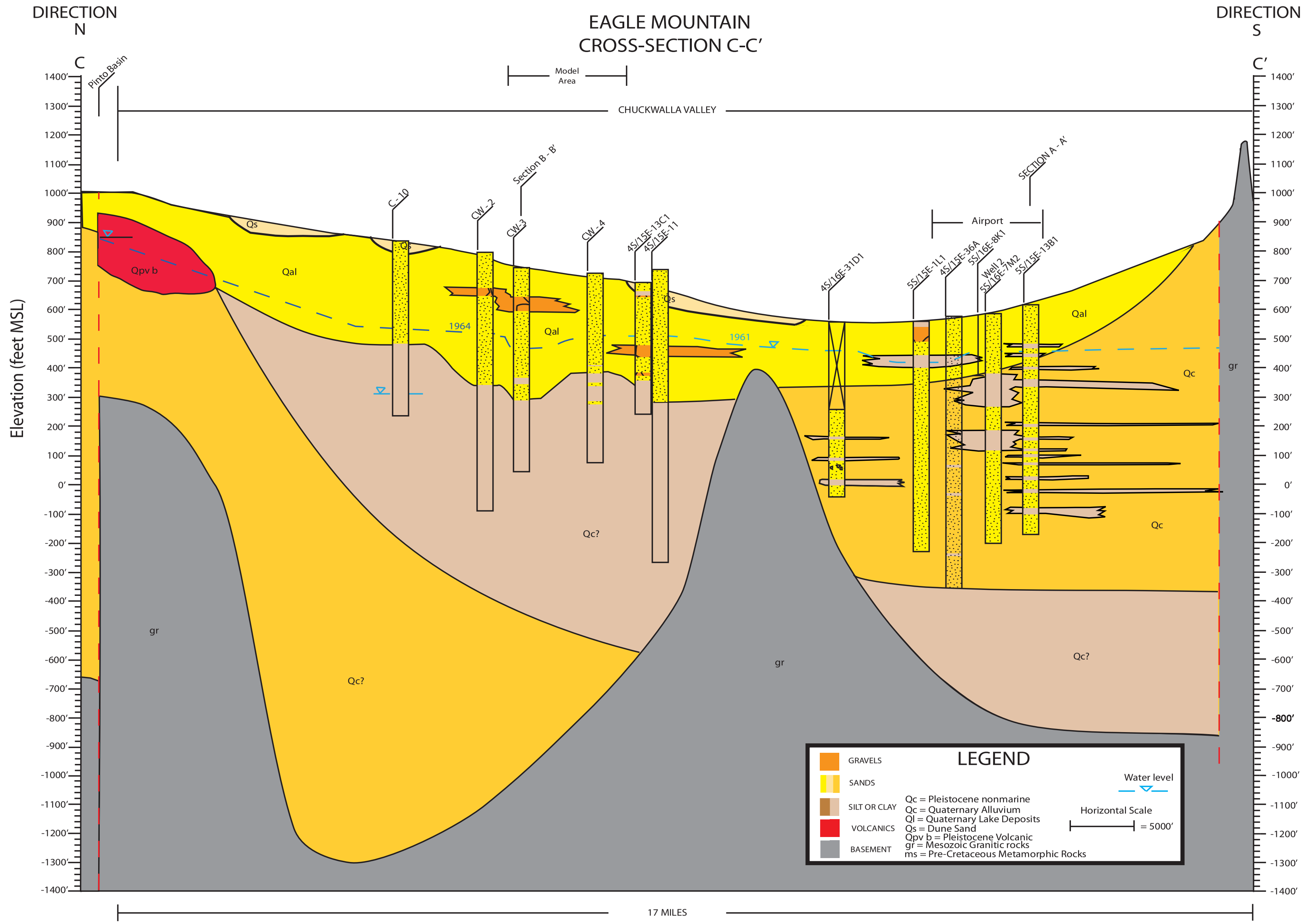
MARCH 2009

FIGURE 1

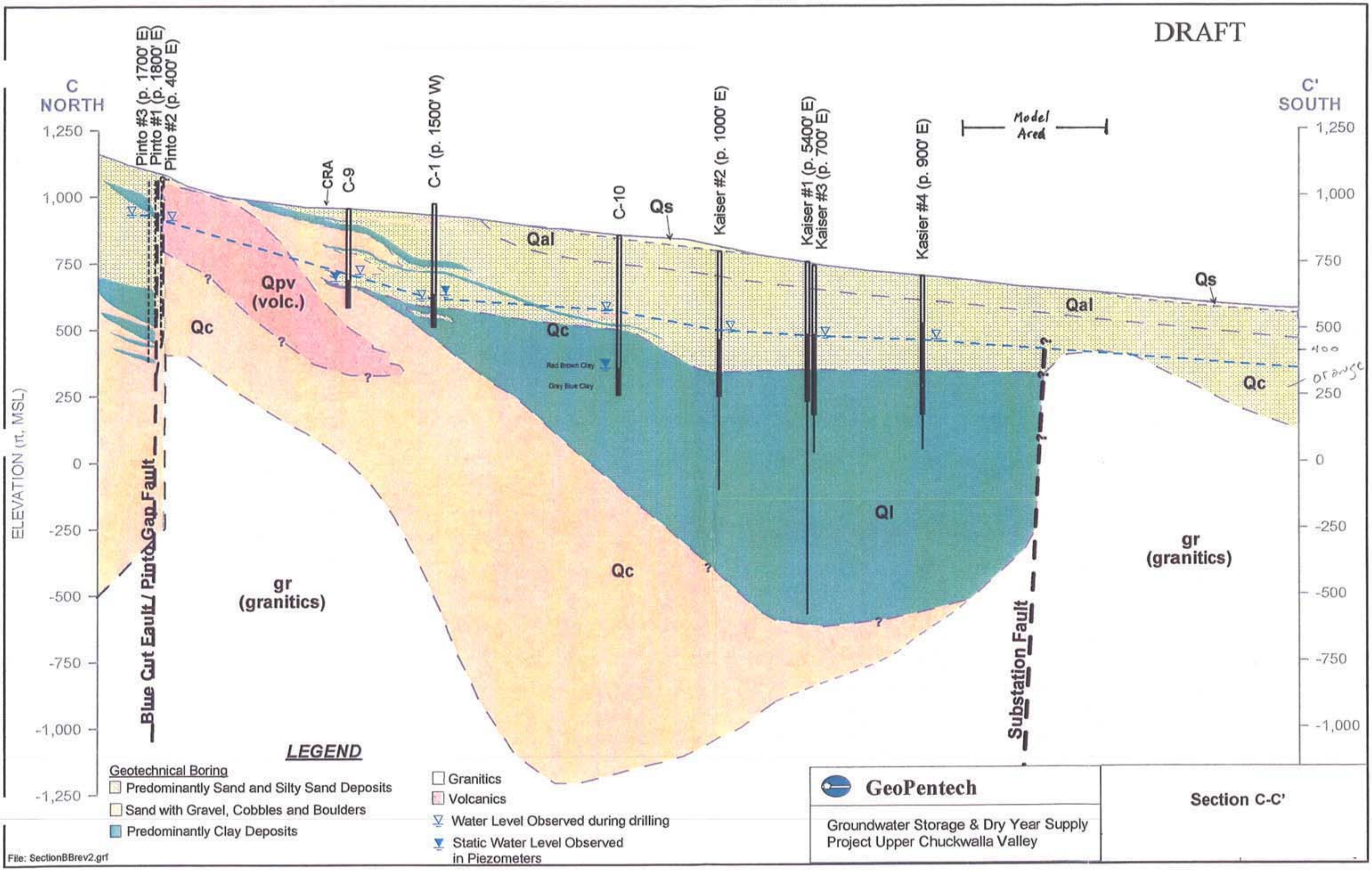
31-Mar-2009 S:\GIS\Projects\Fig1_SeepRecovModelArea.mxd DLF



EAGLE MOUNTAIN PUMPED STORAGE EAGLE MOUNTAIN, CA		CROSS-SECTION B-B'
EAGLE CREST ENERGY COMPANY		MARCH 2009 — FIGURE 2



EAGLE MOUNTAIN PUMPED STORAGE EAGLE MOUNTAIN, CALIFORNIA	Eagle Crest Energy Company	CROSS-SECTION C - C'
EAGLE CREST ENERGY COMPANY		MARCH 2009 FIGURE 3



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31-Mar-2009

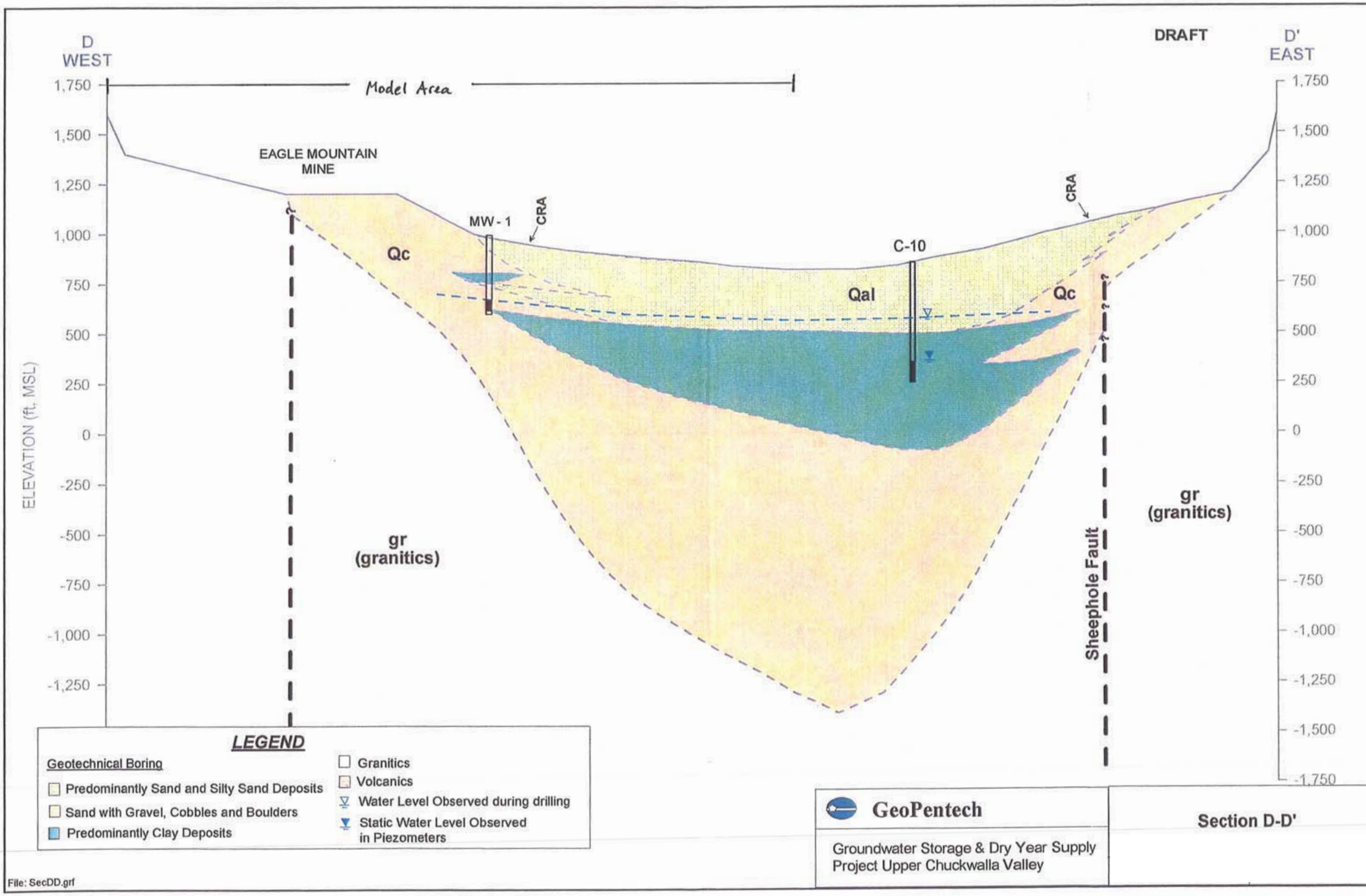
Pumped Storage Project
Eagle Mountain, California

Eagle Crest Energy Company

GEOPENTECH CROSS SECTION C-C'

MARCH 2009

FIGURE 4



GeoPentech

Groundwater Storage & Dry Year Supply
Project Upper Chuckwalla Valley

Section D-D'

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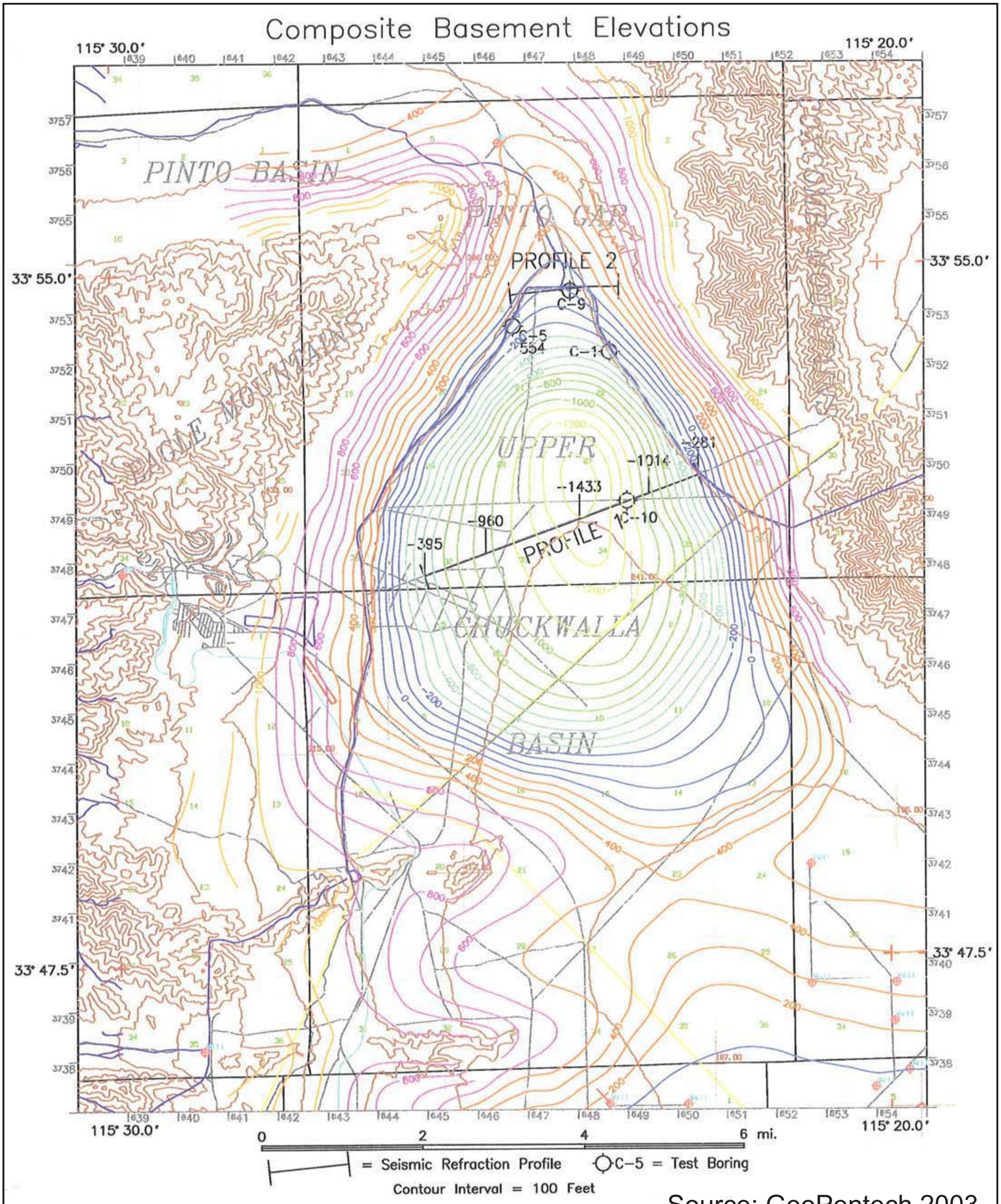
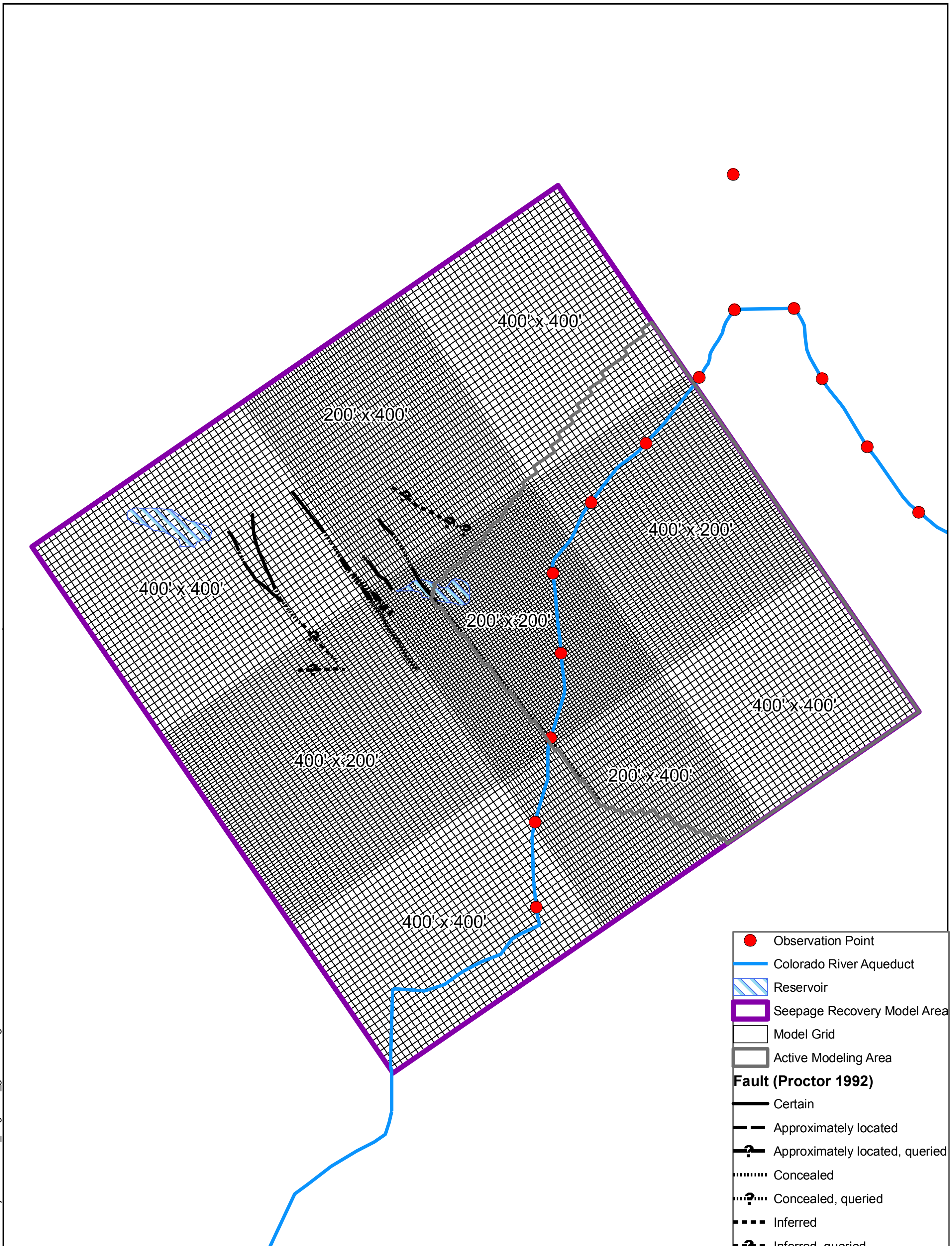
31-Mar-2009

Pumped Storage Project Eagle Mountain, California		GEOPENTECH CROSS SECTION D-D'	
Eagle Crest Energy Company	Eagle Crest Energy Company	MARCH 2009	FIGURE 5

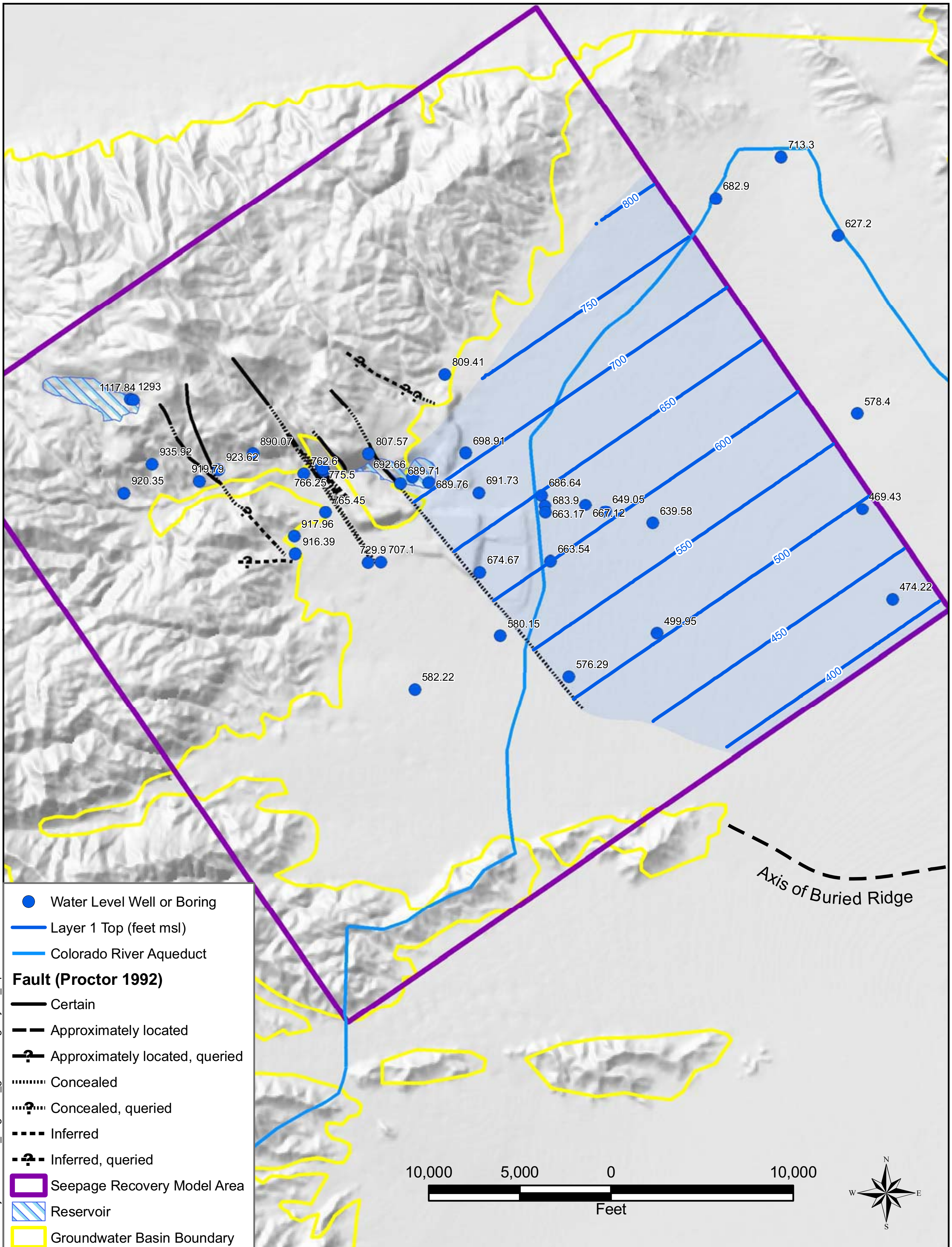


Source: GeoPentech 2003.

Pumped Storage Project Eagle Mountain, California	Eagle Crest Energy Company	BEDROCK ELEVATION MAP BASED ON BOUGOUR ANOMALIES
Eagle Crest Energy Company		MARCH 2009 FIGURE 6



Pumped Storage Project Eagle Mountain, California	Eagle Crest Energy Company	MODEL GRID	
Eagle Crest Energy Company		MARCH 2009	FIGURE 7



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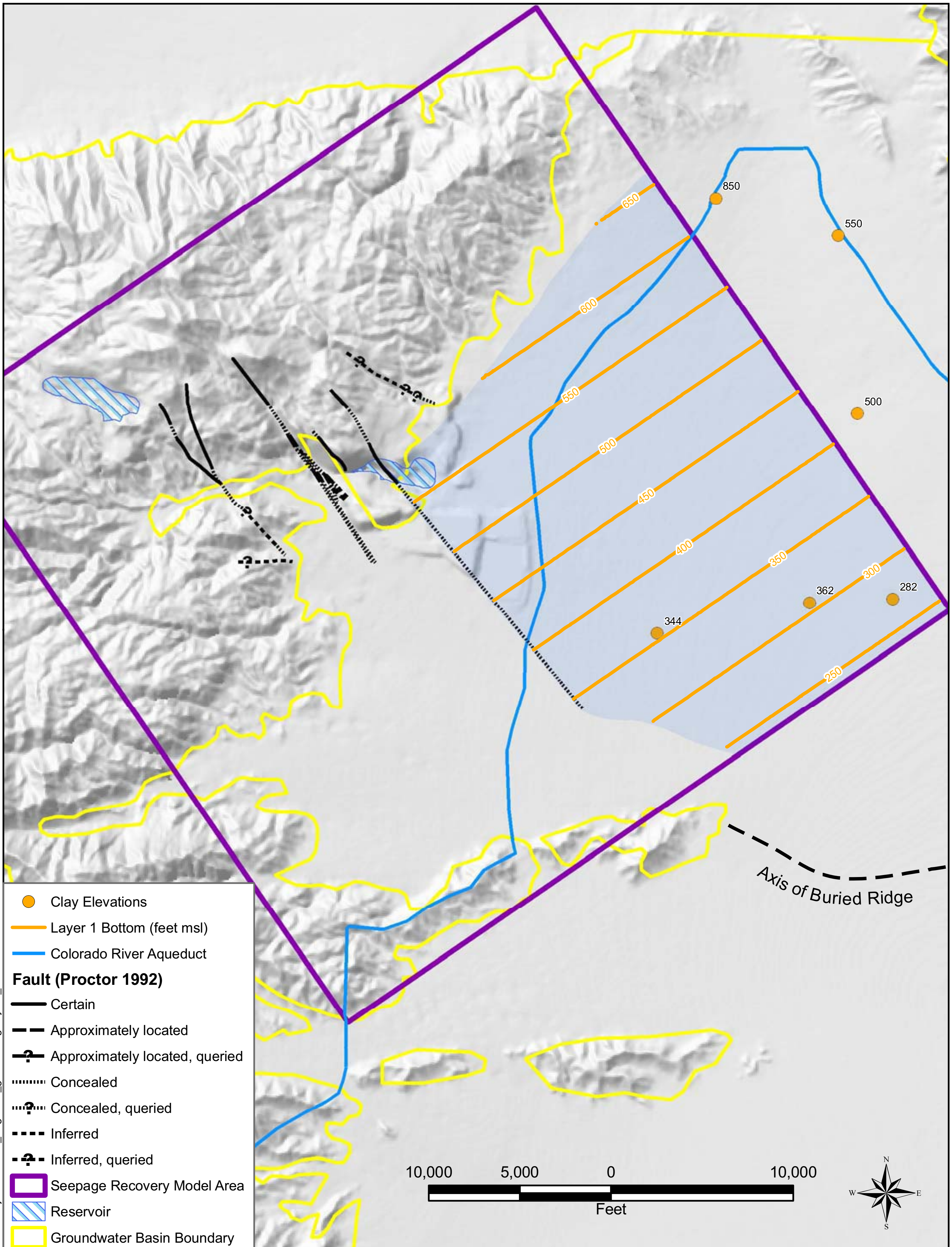
30-Mar-2009

Pumped Storage Project Eagle Mountain, California		TOP OF LAYER 1
Eagle Crest Energy Company		MARCH 2009 FIGURE 8



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30-Mar-2009

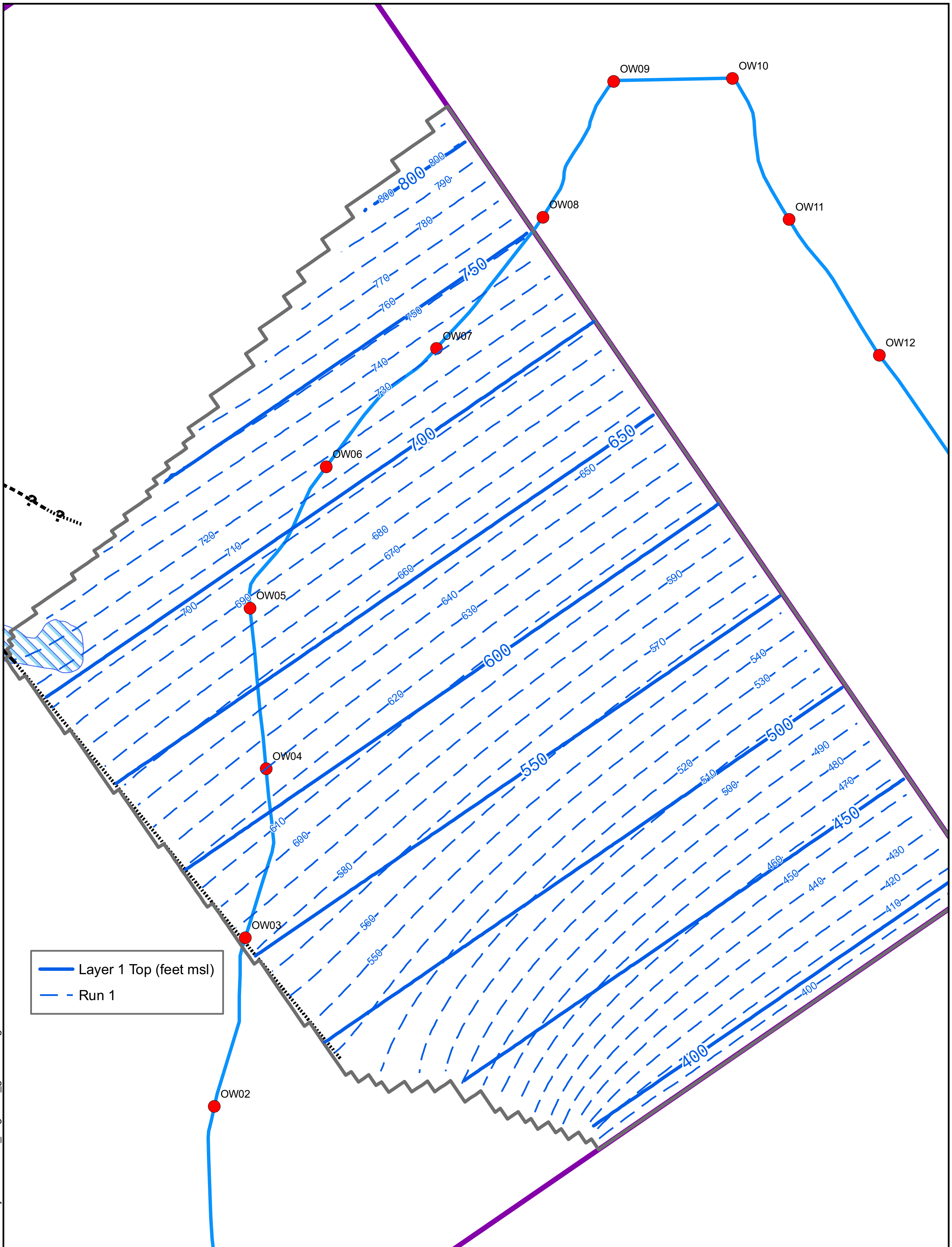
Pumped Storage Project
Eagle Mountain, California

Eagle Crest Energy Company

BOTTOM OF LAYER 1

MARCH 2009

FIGURE 9



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30-Mar-2009

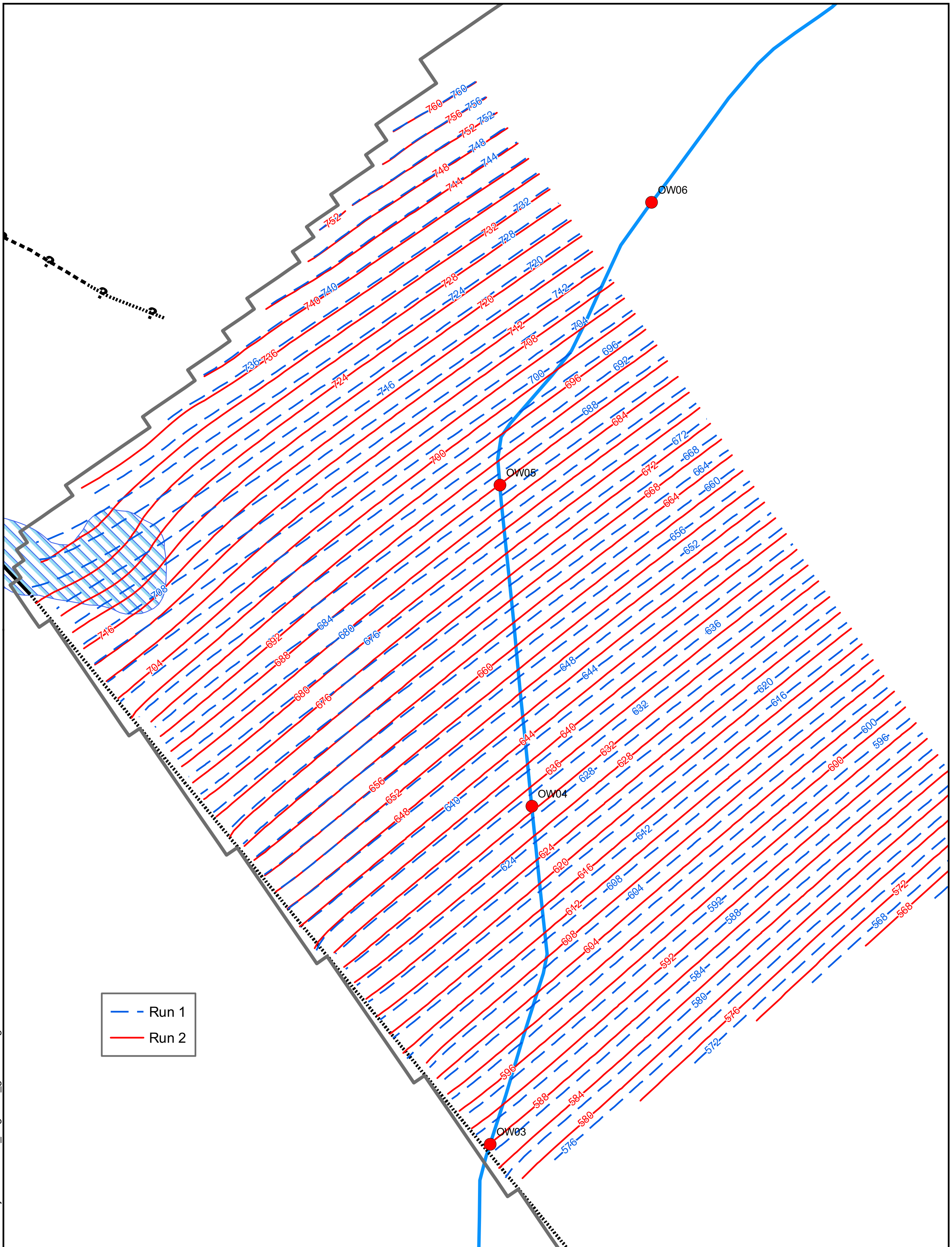
Pumped Storage Project
Eagle Mountain, California

Eagle Crest Energy Company

LAYER 1 INPUT AND
MODEL RESULTS RUN 1

MARCH 2009

FIGURE10



Pumped Storage Project
Eagle Mountain, California

Eagle Crest Energy Company

MODEL RESULTS RUNS 1 AND 2

MARCH 2009

FIGURE11

30-Mar-2009 S:\GIS\Projects\083850_EagleMtn_gwmodeling\ModelRun2.mxd DLF

FIGURE 12
GROUNDWATER LEVEL CHANGE OVER TIME AT OW03.2

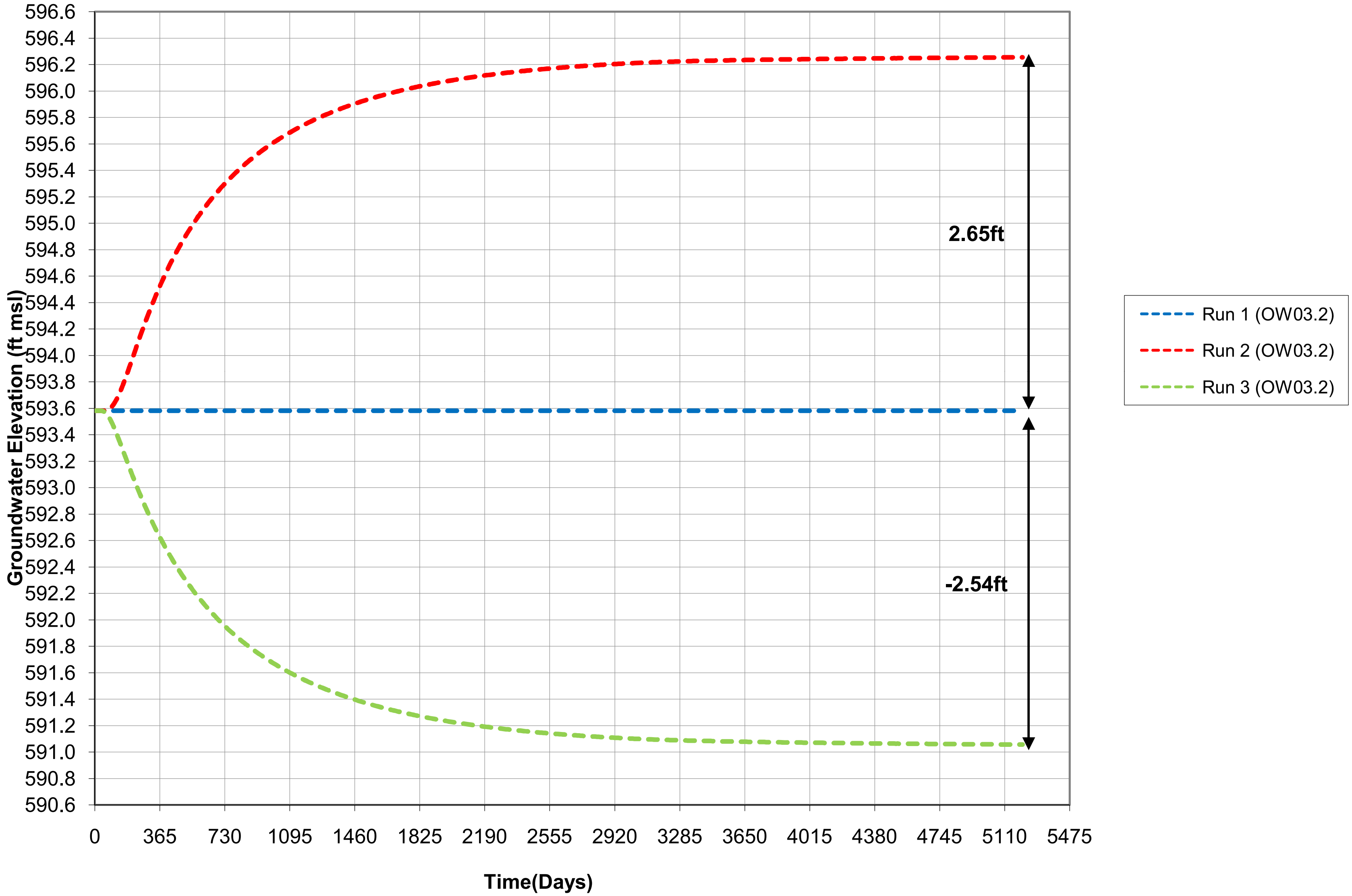


FIGURE 13
GROUNDWATER LEVEL CHANGE OVER TIME AT OW04

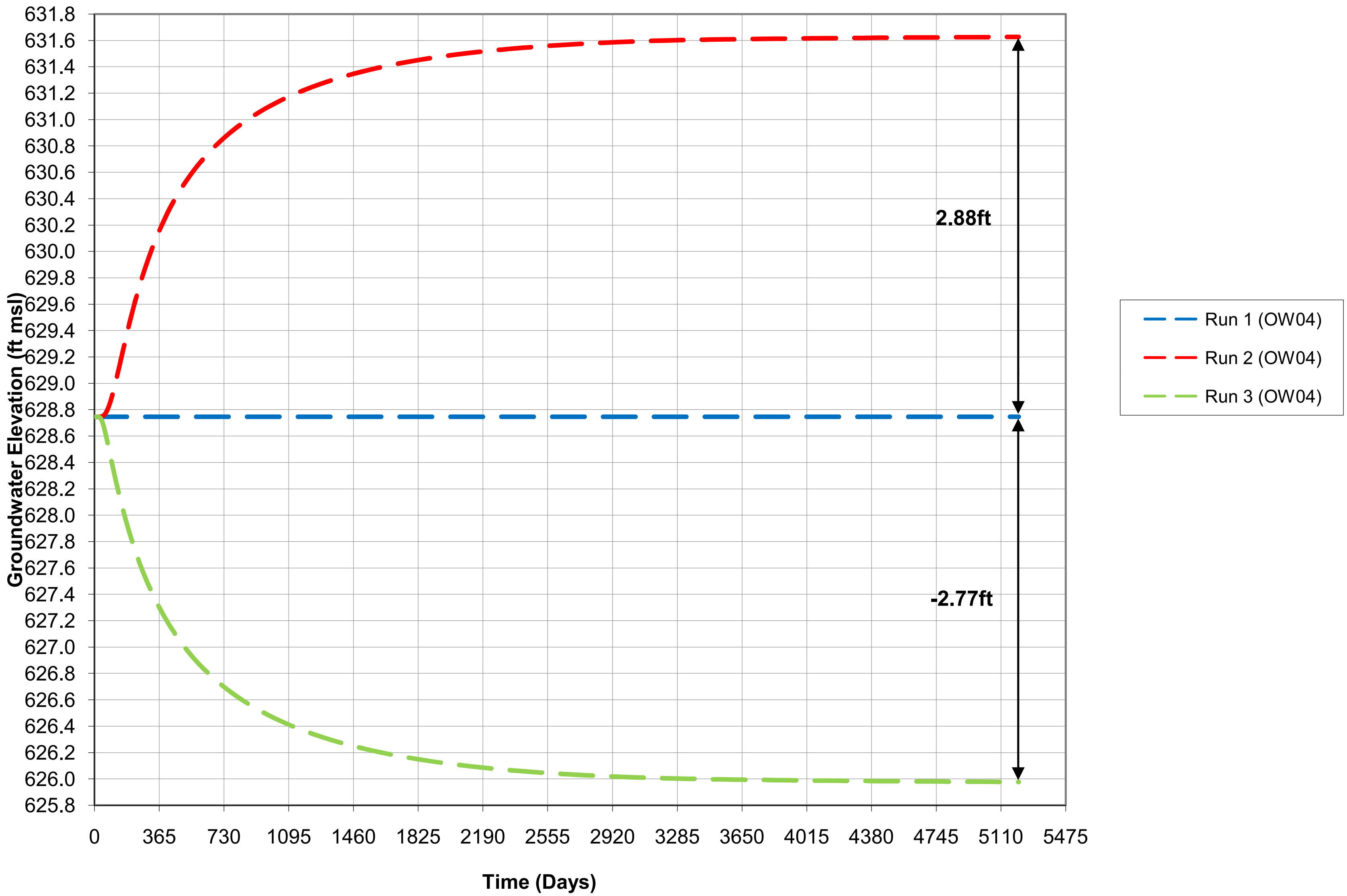
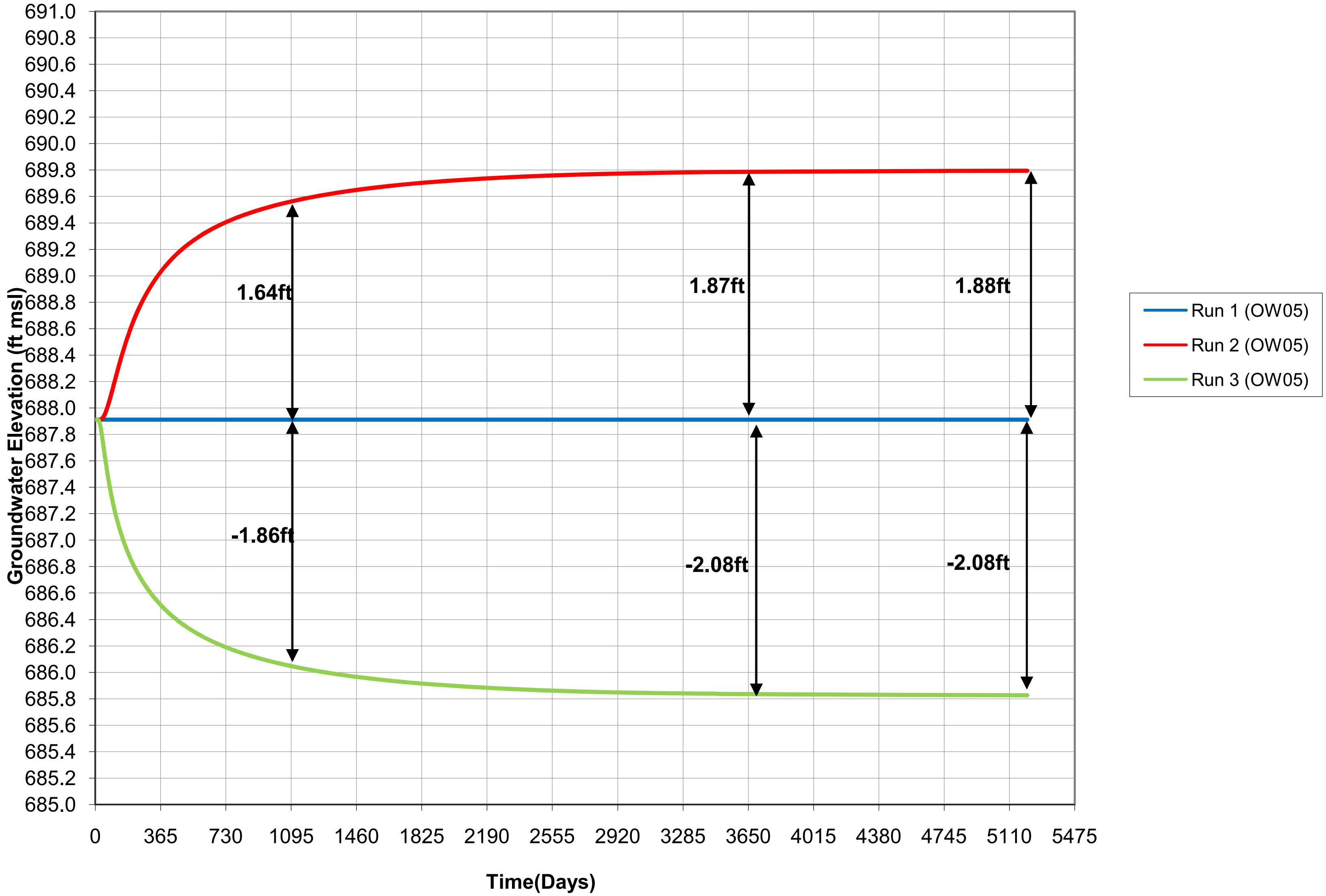
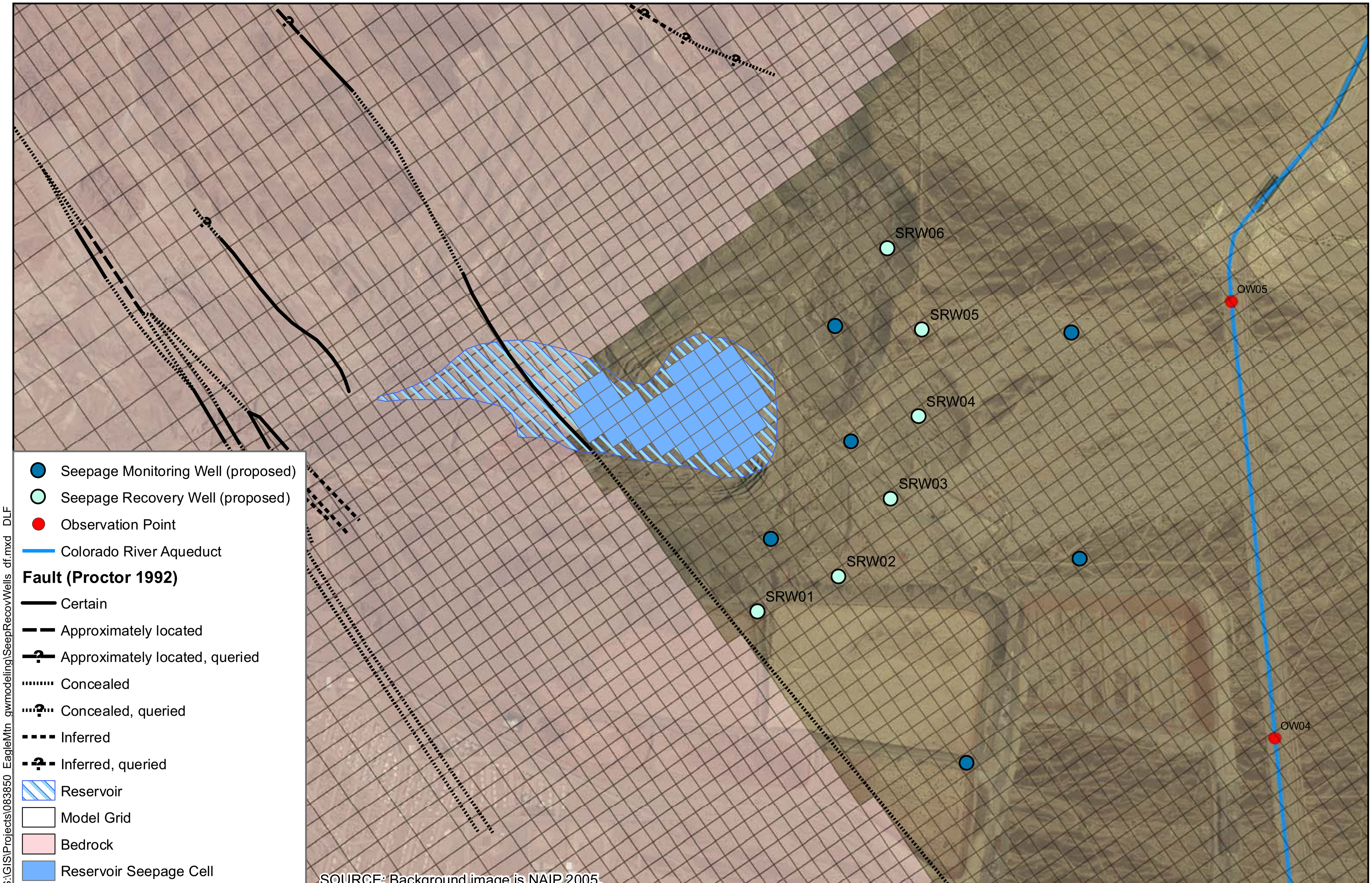


FIGURE 14
GROUNDWATER LEVEL CHANGE OVER TIME AT OW05





Pumped Storage Project
Eagle Mountain, California

Eagle Crest Energy Company

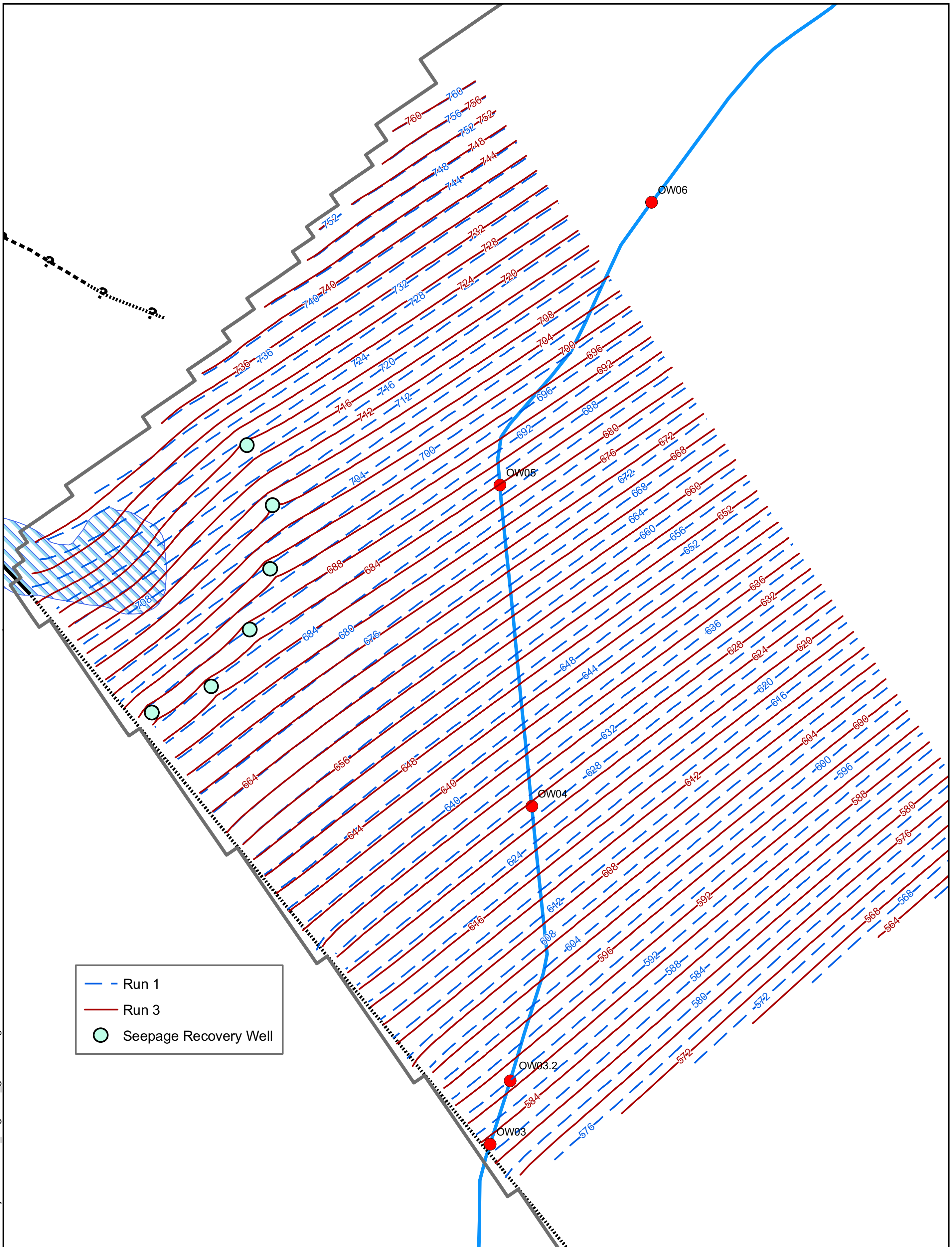
LOCATION OF SEEPAGE RECOVERY WELLS

MARCH 2009

FIGURE 15

S:\GIS\Projects\083850_EagleMtn_gwmodeling\SeepRecovWells_df.mxd DLF

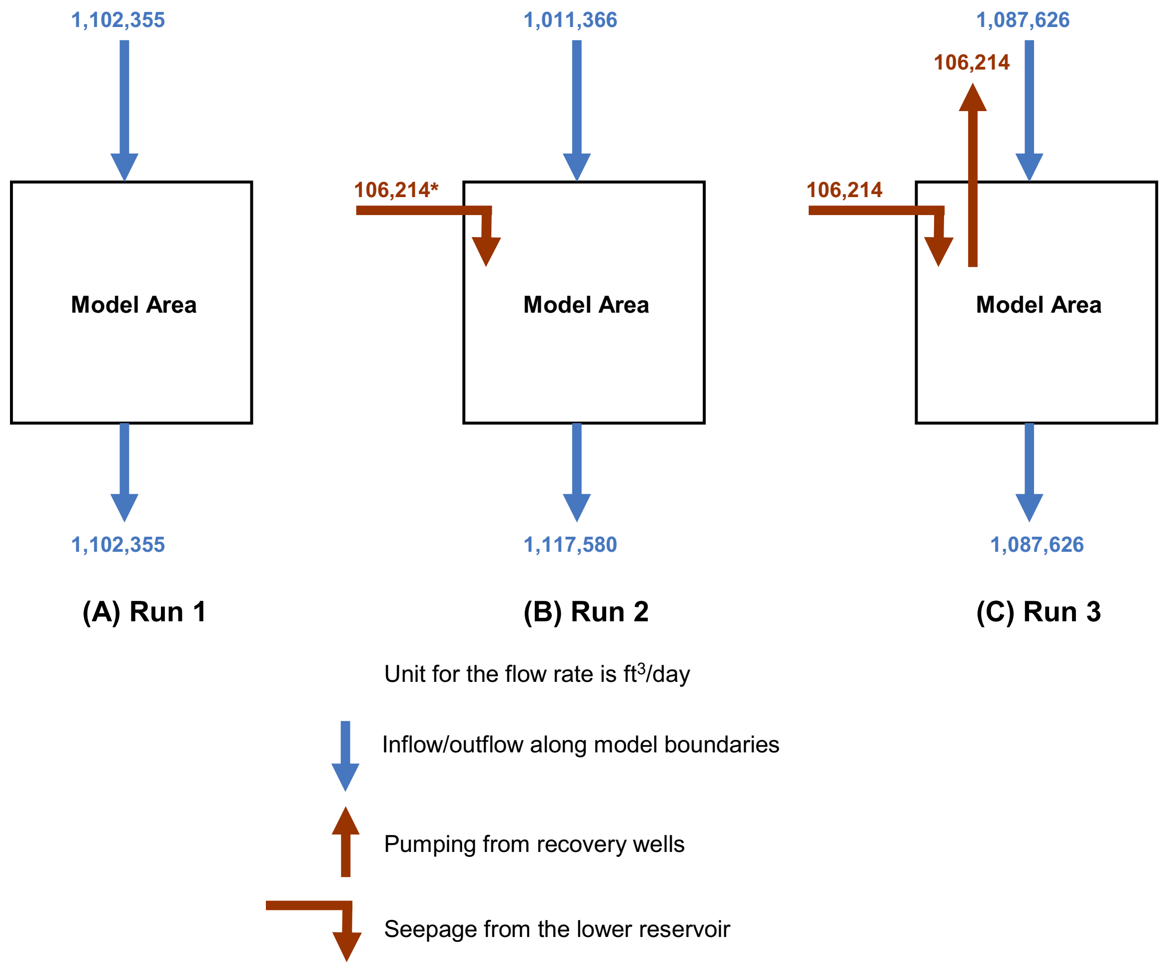
27-Mar-2009



Pumped Storage Project Eagle Mountain, California		MODEL RESULTS RUNS 1 AND 3
Eagle Crest Energy Company		MARCH 2009 FIGURE16

30-Mar-2009 S:\GIS\Projects\083850_EagleMtn_gwmodeling\ModelRun3.mxd DLF

Figure 17 Mass Balance for Three Model Runs



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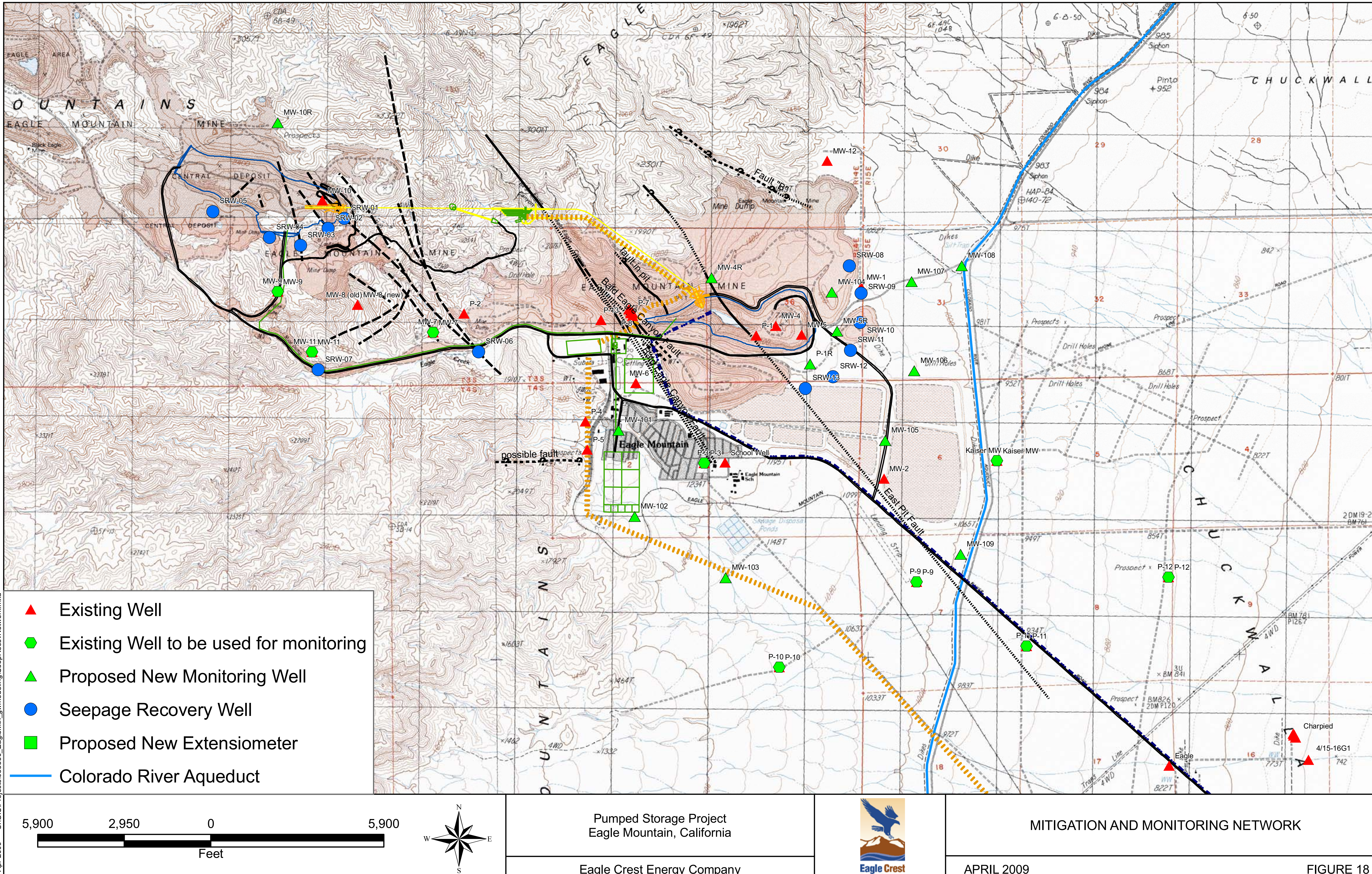

Pumped Storage Project
Eagle Mountain, California

Eagle Crest Energy Company

MITIGATION AND MONITORING NETWORK

APRIL 2009

FIGURE 18

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Tables

Table 1
Aquifer Characteristics Near Project Site

Well No./Name	Aquifer Material	Screen Interval (feet bgs)	Flow Rate (gpm)	Drawdown (feet)	Saturated Aquifer Thickness (feet)	Hydraulic Conductivity (ft/day)	Transmissivity (gpd/ft)
MW-1	Alluvium	325 - 385			51	7.1	2,700
MW-2	Alluvium	394-455	33	37	65	0.02	10
MW-2					65	0.37	180
MW-3	Bedrock	289 - 350	3.3	33			200
MW-4	Bedrock	60 - 140	3.5	47	40	0.02	6
MW-4					40	0.50	150
MW-5	Alluvium	180 - 240	20	25	30	2.0	450
MW-5					30	2.2	500
MW-5					30	7.1	1,600
MW-6	Bedrock	560 - 620	5	12	65	0.1	50
					65	1.4	680
					65	1.8	870
School Well	Bedrock	475-740	75	11	265	0.5	1,000
					265	5.1	10,105

Source: CH2MHill, 1996

TABLE 2

Proposed Mitigation Well Network and Maximum Allowable Changes From Seepage Recovery Pumping[1]

Existing Monitoring Wells or Piezometer

Well No./Name	Aquifer Material	Monitoring Purpose	Total Borehole Depth (feet)	Borehole Diameter (inches)	Casing Diameter (inches)	Screen Interval (feet bgs)		Maximum Allowable Drawdown (feet)	Maximum Allowable Water Elevation (feet msl)
						Top	Bottom		
P-2	Bedrock	Water Level Beneath Landfill	960	6.5	2	905	955		1,620
P-3	Bedrock	Brine Pond Downgradient	675	6.0	Unknown	613	663		
P-4	Bedrock	Brine Pond Upgradient	625	5.5	Unknown	575	625		
P-5	Bedrock	Brine Pond Upgradient	625	5.5	Unknown	575	625		
P-9	Bedrock	Lower Reservoir Seepage	525	5.6	Unknown	470	520		
P-10	Bedrock	Upper Reservoir Seepage	675	5.6	Unknown	625	675		
P-11	Alluvium	Lower Reservoir Seepage	485	5.5	Unknown	350	470	2	
MW-7	Bedrock	Water Level Beneath Landfill	785	10.6	4	666	726		1,560
MW-8	Bedrock	Water Level Beneath Landfill	871	13.5	Unknown	792	844		1,880
MW-9	Bedrock	Water Level Beneath Landfill	1,544	6.5	Unknown	Unknown	Unknown		2,350
MW-11	Bedrock	Water Level Beneath Landfill	1,130	13.5	Unknown	663	917		1,940
Kaiser MW	Alluvium	CRA	Unknown	Unknown	Unknown	Unknown	Unknown	3	
Existing Monitoring Wells to be Replaced									
P-1R	Alluvium	Lower Reservoir Pumping Contol	550	10	4	490	540	6	
MW-4R	Bedrock	Background Lower Reservoir	774	10	4	704	764		
MW-5R	Alluvium	Lower Reservoir Pumping Contol	418	10	4	348	408	6	
MW-10R	Bedrock	Background Upper Reservoir	1,672	10	4	1,558	1,662		1,464
New Monitoring Wells to be Constructed									
MW-101A	Alluvium	Brine Pond Downgradient	110	10	4	60	100	dry	
MW-101B	Bedrock	Brine Pond Downgradient	599	10	4	549	589		
MW-102A	Alluvium	Brine Pond Downgradient	110	10	4	60	100	dry	
MW-102B	Bedrock	Brine Pond Downgradient	658	10	4	608	648		
MW-103A	Alluvium	Brine Pond Downgradient	200	10	4	150	190	dry	
MW-103B	Bedrock	Brine Pond Downgradient	658	10	4	608	648		
MW-104	Alluvium	Lower Reservoir Pumping Contol	575	10	4	525	565	6	
MW-105	Alluvium	Lower Reservoir Seepage	552	10	4	502	542	4	
MW-106	Alluvium	Lower Reservoir Seepage	383	10	4	333	373	4	
MW-107	Alluvium	Lower Reservoir Seepage	353	10	4	303	343	4	
MW-108	Alluvium	CRA	318	10	4	268	308	2	
MW-109	Alluvium	CRA	497	10	4	447	487	3	

Seepage Recovery Wells to be Constructed

Well No./Name	Aquifer Material	Purpose	Total Borehole Depth (feet)	Borehole Diameter (inches)	Casing Diameter (inches)	Screen Interval (feet bgs)		Maximum Allowable Drawdown (feet)	Maximum Allowable Water Elevation (feet msl)
						Top	Bottom		
SRW-01	Bedrock	Upper Reservoir Seepage Recovery	1,477	10	6	1,353	1,467		2,540
SRW-02	Bedrock	Upper Reservoir Seepage Recovery	1,421	10	6	1,297	1,411		586
SRW-03	Bedrock	Upper Reservoir Seepage Recovery	1,359	10	6	1,235	1,349		586
SRW-04	Bedrock	Upper Reservoir Seepage Recovery	1,297	10	6	1,173	1,287		586
SRW-05	Bedrock	Upper Reservoir Seepage Recovery	1,522	10	6	1,398	1,512		586
SRW-06	Bedrock	Upper Reservoir Seepage Recovery	696	10	6	614	686		940
SRW-07	Bedrock	Upper Reservoir Seepage Recovery	1,043	10	6	969	1,033		2,060
SRW-08	Alluvium	Lower Reservoir Seepage Recovery	650	18	12	493	640	7	
SRW-09	Alluvium	Lower Reservoir Seepage Recovery	495	18	12	328	485	7	
SRW-10	Alluvium	Lower Reservoir Seepage Recovery	645	18	12	463	635	7	1,560
SRW-11	Alluvium	Lower Reservoir Seepage Recovery	575	18	12	385	565	7	
SRW-12	Alluvium	Lower Reservoir Seepage Recovery	640	18	12	453	630	7	
SRW-13	Alluvium	Lower Reservoir Seepage Recovery	695	18	12	513	685	7	

Footnote: [1] Drawdown projections soley due to Seepage Recovery Pumping