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# Second Interim Effectiveness Monitoring Report

# Penn Mine Environmental Restoration Project

Prepared for

East Bay Municipal Utility District and Regional Water
Quality Control Board-Central Valley Region

Project No. 144069.08.45

July 1999

**CH2MHILL**
Oakland, California

SECOND INTERIM MONITORING REPORT, JULY 1999

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# Second

# Interim Effectiveness Monitoring Report

## Penn Mine Environmental Restoration

## July 1999

## 1.0 Introduction

The first Interim Effectiveness Monitoring Report for the Penn Mine Environmental Restoration Project, dated April 1999, presented surface water quality data and Mine Run confirmation sampling data collected during January, February, and March 1999 at the Penn Mine site (CH2M HILL, 1996). This second Interim Effectiveness Monitoring Report presents groundwater quality data and Hinckley Run confirmation sampling data collected by CH2M HILL for the East Bay Municipal Utility District (EBMUD) during April 1999. Data were collected in accordance with Addendum 3, Monitoring and Evaluation of Stage II Site Activities (CH2M HILL, 1999a) of the Water Quality Management Plan (WQMP) for the project (Dames & Moore, 1998).

Water quality monitoring activities are being conducted concurrently with restoration activities at the site. Site restoration activities conducted during April 1999 consisted of waste rock removal from Hinckley Run. Geologic mapping and confirmation sampling in Hinckley Run were performed after the waste rock was removed.

This interim report also presents the technical justification for removal of Mine Run Dam as part of the restoration construction activities to be completed this season. Specifically, the technical basis is provided for:

- Estimating the reduction in metal loading to Camanche Reservoir as a result of the removal of waste rock,
- Restoring Hinckley Run, after completion of the waste removal, but prior to exposure to a year of rainfall,
- Applying alkaline soil amendments to the exposed residual soil and *in situ* bedrock as a mitigation measure for residual acidity in pore water and natural acid generating capacity,
- Estimating water quality impacts of runoff from Penn Mine to Camanche Reservoir under normal and low-flow conditions after site restoration, and
- Estimating the average annual, low flow, and "first-flush" metal loading to Camanche Reservoir once restoration is complete.

Related documents include the *Confirmation of Waste Removal and Characterization of Baseline Conditions for Mine and Hinckley Runs,* (CH2M HILL, 1999c and 1999e)); and the *Revegetation Plan* prepared by H T Harvey & Associates (H.T. Harvey, 1999). In addition, a final Effectiveness Monitoring Report will be prepared at the completion of restoration activities and beginning of post-restoration monitoring.

The following sections present the results of the data collected in April 1999, the technical justifications outlined above, and a discussion of the site water budget and mass loading estimates. Data results are presented in Section 2. A discussion of residual acidity and acid generating capacity of residual soil and bedrock in Hinckley Run follows in Section 3. Revised water budgets for the pre-restoration, restoration, and post-restoration site conditions are presented in Section 4. An evaluation of the use of soil amendments as mitigation measures is presented in Section 5. Estimates of the mass loading for post-restoration conditions are presented in Section 6, followed by a discussion of the estimated pre-mining conditions in Section 7. The estimated impacts to receiving water attributable to runoff from the restored site, and the post-restoration monitoring plan are presented in Sections 8 and 9, respectively. Section 10 summarizes the key points of the report.

# 2.0 Summary of Data Collected

This section presents the results of groundwater quality monitoring conducted during April 1999, confirmation samples collected from Hinckley Run, and precipitation data from the Pardee Dam weather station. No surface water samples were collected during April, 1999 due to lack of flow.

## 2.1 Groundwater

On April 14, 1999, CH2M HILL installed groundwater monitoring wells, CHMW-2 and –3, as described in the Monitoring Well Installation, Decommissioning, and Sampling Program memorandum, prepared by CH2M HILL for EBMUD (CH2M HILL, 1999d). Existing well B-24 was renamed CHMW-1. The borehole and well installation logs are included in Appendix A.

Groundwater samples were collected from 11 monitoring wells on April 22 and 25, 1999. Well locations are shown on Figure 1. Samples were collected from monitoring wells W-2D, W-2S, W-1, W-5, CHMW-2, and CHMW-3 to monitor groundwater quality within Mine and Hinckley Runs. Samples were planned from three additional wells, EW-1, EW-2, and CHMW-1; however, well EW-1 could not be located in the field and wells EW-2 and CHMW-1 were dry. Samples were collected from monitoring wells GS-7, GS-8A, GS-14, GS-4A, and W-1D to evaluate water quality down-gradient of Mine Run Reservoir.

All groundwater samples were analyzed by Chromalab, Inc. for total and soluble copper, iron, and zinc, and for alkalinity and sulfate. Analytical results are presented in Table 1 and laboratory reports are provided in Appendix B. Table 2 lists well diameter, well depth, depth to water, purge volume, and water quality parameter readings for each well for the April sampling event.

## 2.2 Residual Soil and Bedrock

Four samples were collected of residual soil and bedrock in Hinckley Run on April 25, 1999 as part of the confirmation sampling program to document removal of waste material and characterize baseline conditions. The samples were analyzed by Chromalab, Inc. for: total aluminum, cadmium, copper, iron, nickel, and zinc; deionized water-extractable aluminum, cadmium, copper, lead, nickel, and zinc; moisture content; pH; sulfur; potential acidity; and neutralization potential. The data were used in the analysis of mass loading presented in Section 6. Tables 3 and 4 present the results of laboratory analyses of the four samples. Laboratory reports are provided in Appendix B.

Sample locations and descriptions are presented in the memorandum *Confirmation of Waste Removal and Characterization of Baseline Conditions —Hinckley Run* (CH2M HILL, 1999e). A description of material comprising the confirmation samples is also included in Table 4.

Surficial mapping revealed that most of the waste in Hinckley Run has been removed, but localized areas of residual mining waste, pyretic rock, and reactive rock are present throughout Hinckley Run. A map showing surficial geology is provided in the memorandum referenced above.

## 2.3 Precipitation

Precipitation data from the Department of Water Resources (DWR) station at Pardee Dam, approximately 3 miles northeast of the Penn Mine site, from the DWR station at New Hogan Lake, approximately 6 miles southeast of the site and from an on-site rain gauge are included in Appendix C. Data from the Pardee Dam station are used in this report because data from the on-site rain gauge were incomplete for the reporting period. Data from the New Hogan Lake station are provided to allow comparison of data from rain gauges located within the site vicinity. Cumulative rainfall at Pardee Dam in calendar year 1999 is tabulated as a function of time in Appendix C, Table C - I. As indicated in the tabulated data, 0.04 inches of precipitation were measured at Pardee Dam and 1.14 inches were measured at New Hogan Lake during April. Daily rainfall amounts for April are shown for the three stations in Appendix C, Table C - 2.

## 2.4 Releases from Pardee Dam

Water release data from Pardee Dam for the period of October 1, 1993 to May 6, 1999 were used in the evaluation of the post-restoration impact of water discharge from the Penn Mine site to water quality in Camanche Reservoir during first flush, low, and annual average flow conditions. The California Department of Water Resources (DWR), Division of Flood Management web site was the source of the data used. The DWR data used are provided in Appendix D.

## 2.5 Site Water Budget

The site water budget has been recalculated to reflect three distinct periods: pre-restoration, during restoration, and post-restoration. The updated calculations were made to facilitate forecasts of post-restoration water quality and mass loading in comparison with the pre-restoration and during-restoration periods. The major components of the water budget model are tabulated in Table 5. The water budget calculations are presented in Appendix E, and summary tables of the calculation results are presented as Tables 6 through 8.

Schematics of the flow components are shown on Figures 2 through 4. The water budget is discussed in detail in Section 4.

The post-restoration water budget is subdivided into monthly intervals as shown in Table 9. This refinement is used later in the body of this report to forecast Penn Mine site water quality during annual average, low-flow, and first flush conditions.

# 3.0 Evaluation of Baseline Conditions in Hinckley Run

## 3.1 Hinckley Run Pore Water Composition

After completion of waste excavation, four residual soil and bedrock samples were collected and chemically analyzed to assess baseline conditions in Hinckley Run after overlying mine waste was removed. The results of deionized water extraction testing of the samples and other data included in Table 3 were used to estimate the concentrations of metals in and the pH of pore water. Metal concentrations and pH estimates for each of the Hinckley Run samples are shown in Table 10, and nominal average values for Hinckley and Mine Runs are given in Table 11.

The average concentrations of metals and pH in Hinckley Run confirmation sample pore water were higher (lower, in the case of pH) than were observed in Mine Run during confirmation sampling that was performed earlier this year and reported in the first Interim Effectiveness Monitoring Report. In particular, the average copper concentration in Hinckley Run was nearly 60-times the concentration in Mine Run pore water, whereas the zinc was about 14-times higher. The calculated pH in pore water in Hinckley Run confirmation samples was 1.75, compared to 2.33 in Mine Run samples.

The differences between pore water in samples from Mine and Hinckley Runs are attributed to several factors. Primarily, a small portion of Hinckley Run intersects a highly enriched ore zone that does not extend into Mine Run (TRC, 1998). This zone was further mapped by CH2M HILL after waste removal. The alteration zone is shown on the map included in the *Confirmation of Waste Removal and Characterization of Baseline Conditions —Hinckley Run* (CH2M HILL, 1999e). The samples for analysis were collected from areas most likely to be acid-forming, based on their location and their visual appearance.

## 3.2 Hinckley Run Pore Water Flushing Effectiveness

In the first *Interim Effectiveness Monitoring Report* (CH2M HILL, 1999b), a leaching effectiveness factor of –0.19 was estimated from surface water data from Mine Run. If it is assumed that the factor applies to the overall site, an estimate can be made for how long it might take for pore water in Hinckley Run soil to reach the copper concentration currently observed for surface water in Mine Run.

$$C_t/C_0 = [72\ \mathrm{mg/L}/4{,}140\ \mathrm{mg/L}] = e^{-ft/T}$$

| | | |
|---|---|---|
| where, | $C_t/C_o$ | is the fractional decrease in copper concentration (0.01739) |
| | $e$ | is the base of the natural log |
| | $f$ | is an empirical "leaching efficiency" factor (-0.19) |
| | $t$ | is the pore water displacement rate (inches per year) |
| | $T$ | is the effective pore water column height (10.853 inches) |

From this calculation it is estimated that it would take over 200 years for the Hinckley Run pore water copper concentration to drop to the concentration in Mine Run pore water. Even if a more optimistic estimate for the leaching efficiency factor of –0.5 were used, it would still take nearly 90 years for copper concentrations in pore water in Hinckley Run to reach the estimated current pore water copper concentration in Mine Run.

Metal concentrations in pore water in Hinckley Run confirmation samples are significantly higher than had been observed in Mine Run samples. Displacing the pore water by relying on natural precipitation or surface water application would take an impractically long time in Hinckley Run and Mine Run. Therefore exposing the recently excavated surfaces to an additional year of natural precipitation would not remove a significant volume of copper and zinc from residual acidity in the pore water.

Section 5 describes the use of soil amendments as a best management practice to mitigate the effects of residual acidity in the pore water in Mine Run and Hinckley Run.

# 4.0 Water Budget Evaluation

Preliminary site water budget calculations have been discussed in *Addendum 3, Monitoring and Evaluation of Stage II Site Activities*, (CH2M HILL, 1999a), and in the first *Interim Effectiveness Monitoring Report* (CH2M HILL, 1999b). Appendix E of the current report describes refinements to the previous calculations to reflect not only pre-restoration conditions, but also to include conditions during and after restoration.

In the following subsections, pre-restoration, post-waste removal/pre-restoration, and post-restoration conditions are discussed further. The water budget is used with water quality data to estimate the loading of copper and zinc to Camanche Reservoir from various sources (i.e. surface water, shallow alluvial groundwater, and deeper groundwater). Water budget components and the estimated loads are summarized on Tables 12 and 13 for the pre- and post- restoration conditions, respectively.

## 4.1 Pre-Restoration Conditions

### 4.1.1 Hydraulic Budget

The water budget components and flows for pre-restoration conditions are summarized on Table 12. Prior to the removal of mining waste from Mine and Hinckley Runs, metal-bearing water was evaporated during the dry season, and water that reached the impoundment behind Mine Run Dam (Mine Run Dam Reservoir) was treated by the In-line Treatment System (ILS) to neutralize acidity and precipitate metals. Only treated water which contained low residual concentrations of metals was discharged from the site.

The water budget prior to the commencement of waste excavation can be closed with five terms that describe the flows into and out of the site. The first and major source of water entering the 60.4-acre Penn Mine site, prior to mine waste excavation, was direct precipitation $Q_1$ (see Figure 2). The historic annual average precipitation rate for the area is 106.6 acre-feet per year. The second source of water entering the site is shallow groundwater flowing through fractured bedrock and from Mine Shaft 4, $Q_2$. The groundwater contribution is 43.5 acre-feet per year, 32.3 acre-feet from Mine Shaft 4, and 11.2 acre-feet of non-specific flow. The volume of water discharging from Mine Shaft 4 during pre-restoration was estimated at 20 to 25 gallons per minute (gpm) (Wisser, 1961). A third potential source of water entering the site is upland watershed flow, $Q_6$. Currently, diversion structures carry this large flow around the site, directly into Camanche Reservoir to minimize the transport of metals from the site, into the reservoir. Consequently, water from the upland watershed did not affect the site during the pre-restoration period.

There are three routes through which water can leave the Penn Mine site: evapotranspiration ($Q_3$), flow through shallow bedrock to Camanche Reservoir ($Q_5$), and surface and alluvial groundwater discharge to Camanche Reservoir ($Q_4$). The pre-restoration water budget in Appendix E shows pond evaporation and transporation are estimated at 94 acre-feet per year. Losses of water through bedrock beneath Mine Run Dam have been estimated by various investigators, with the consistent result that the flow rate, $Q_5$, is very low. The value of $Q_5$ used in the current work is 0.12 acre-foot per year. The majority of the flow leaves the Penn Mine site as surface water and alluvial groundwater. The annual average flow rate for $Q_4$ is 56.2 acre-feet per year.

### 4.1.2 Metal Mass Load

Estimates of what the metal mass load from the Penn Mine site would be in the absence of the ILS plant have been made previously, and are updated in this report to reflect the improved water budget calculations included in Appendix E. Loading rates are summarized on Table 12.

The average annual copper mass load that would leave the site if the ILS treatment plant were not in operation is estimated at about 19,380 pounds per year, and the zinc mass load is estimated at 35,930 pounds per year. Of these estimated total metal loads, the copper entering from up-gradient shallow bedrock contributes about 3.3 pounds per year and acidic drainage from Mine Shaft 4 adds an estimated 1,580 pounds per year. The zinc load in up-gradient shallow bedrock brings approximately 14 pounds per year into the mine site, and Mine Shaft 4 contributes an estimated 4,500 pounds of zinc per year.

The origin of the large metal mass load leaving the Penn Mine site prior to removing the waste material was attributable to sulfide minerals in the mine waste. These sulfide minerals underwent oxidation, generated acidity, and released metals into the pore water of the waste residue. Natural precipitation and surface run-on displaced pore water and conveyed the metal load into Camanche Reservoir. The oxidation process continued through the dry period, in the moist, aerobic, subsurface environment, and the cycle was repeated in the following wet season. Removal of the waste rock has removed the vast majority of the 19,380 pounds of copper and 35,930 pounds of zinc per year that drain from the site.

Although removing the mine waste has eliminated the immediate source of the massive metal load being treated in the ILS plant, drainage from Mine Shaft 4 and residual pore water in the alluvium and shallow fractured bedrock, which drains during and following rainfalls remain. The effects of residual acidity in pore water have been observed during the restoration period. The potential copper and zinc loading from the residual acidity in pore water is discussed below.

It is important to note that pore water metal concentrations in residual soil and bedrock in both Mine Run and Hinckley Run are significantly greater than in the pre-restoration surface water samples from the waste ponds reported in the WQMP (Dames and Moore

1998). The WQMP listed copper concentrations between 105 and 149 mg/L for Mine Run ponds, and between 29 and 87 for Hinckley Run ponds. Zinc values were between 467 and 623 mg/L in Mine Run, and between 83 and 164 mg/L for Hinckley Run.

The difference in metal concentrations between pre-restoration surface water and post-waste-excavation residual soil and bedrock samples is attributed primarily to the fact that confirmation sampling was performed on newly-exposed rock surfaces which had not had pore water displaced by many years of direct precipitation, as had the pre-restoration waste piles.

## 4.2 Restoration Period

### 4.2.1 Hydraulic Budget

The hydraulic conditions of the Penn Mine site during restoration (Figure 3) are similar, but not identical, to conditions during the pre-restoration period. Major flows from the upland watershed, $Q_6$, continue to be diverted around Mine Run and Hinckley Run in order to avoid releasing metal-bearing pore water that is stored in the residual soil and bedrock. The ILS remains in service to treat site surface water and alluvial groundwater before it is discharged to Camanche Reservoir. Direct precipitation, $Q_1$, groundwater flow through shallow bedrock, $Q_2$, and discharge through shallow bedrock under Mine Run Dam, $Q_5$, also are unchanged.

One important factor is different: the intermediate storage ponds have been removed from Mine Run and Hinckley Run as a result of removing mine waste from the Penn Mine site. These ponds provided the necessary interim storage to prevent rapid drainage of direct precipitation down the two onsite channels, and kept Mine Run Dam Reservoir from exceeding its storage capacity. In effect, these ponds protected against the release of untreated water into Camanche Reservoir. Elimination of the interim storage ponds has the effect of reducing the evaporation rate, $Q_3$, to 13.2 acre-feet per year. In addition, $Q_4$ is reduced because of the removal of mine waste. The removal of waste rock at the entrance to Mine Shaft 4 resulted in a noticeable increase in flow out of the shaft. The average flow after waste rock removal, is estimated to be 60 gpm or 96.9 acre-feet per year (EBMUD personal communication, 1999).

### 4.2.2 Metal Mass Load

The metal mass loads entering the Penn Mine site from the upland watershed and from up-gradient flow through shallow bedrock remain the same as for the pre-restoration case. With the removal of mine waste, however, the acid formation potential and the dissolution of metal into pore water is greatly reduced. It is difficult to quantify the difference between mass copper and zinc levels from the waste rock and residual acidity in pore water. This is due to several factors:

- The displacement of pore water held by surface tension is dependent on many interrelated factors such as the length of exposure to rainfall, evaporation rates, and amount of rainfall.
- The rate of future acid generation is a dynamic process not readily modeled.

Loading will decline over time as trapped pore water is displaced. Conservative estimates, such as presented for Mine Run in the first interim report indicate potential loadings as high as produced by the excavated mine waste.

The primary source of metal loading on the Penn Mine site, mine waste material, has been removed. This source was estimated at 19,380 pounds copper and 35,930 pounds zinc. A secondary source of metal remains: copper- and zinc-containing pore water, which drains from the residual soil and shallow fractured bedrock zone.

## 4.3 Post-Restoration

### 4.3.1 Hydraulic Budget

The hydraulic condition of the site will be significantly altered after restoration is completed, as shown in Figure 4 and Table 13. Two of the flow components remain unchanged from the pre-restoration period. Direct precipitation onto the site, $Q_1$ remains at 106.6 acre-feet. Similarly, the flow rate of groundwater out of the site through shallow bedrock, $Q_5$, continues at about 0.12 acre-foot per year.

The other four water budget components are changed. Discharge from Mine Shaft 4 once plugged, is assumed to be reduced to about 1 percent of the current rate (about 60 ppm). Residual flow from Mine Shaft 4 plus flow from up-gradient shallow bedrock, $Q_2$, will therefore decrease to about 12.2 acre-feet per year. The evapotranspiration component, $Q_3$, will be comprised almost entirely of transpiration with the introduction of plantings and application of seed (evaporation will not be a significant factor in the overall site water budget). Surface water and alluvial groundwater from the upland watershed, $Q_6$, will no longer be diverted. Water from upland areas flows through Mine and Hinckley Runs at a combined annual average flow rate of 150.7 acre-feet per year. The reintroduction of water from upland sources and alteration of the balance between evaporation and transpiration alters the surface water and shallow alluvial groundwater discharge rate from the site, $Q_4$. The post-restoration annual average surface and shallow alluvial water discharge rate from the site is estimated at 186.3 acre-feet per year.

### 4.3.2 Metal Mass Load

The metal mass load from upland surface water and alluvial flows and in groundwater flowing through shallow bedrock, now enters the site. The metal mass load contribution from Mine Shaft 4 decreases to about one percent of its historic rate. The major change from the pre-restoration condition is the removal of mine waste material (the primary source of metal in run off from the site). Metal will continue to be released with pore water in the residual soil and shallow bedrock fractures, and by oxidation of sulfide minerals in native bedrock. The metal loads on Table 13 assume that residual soils and bedrock on site have been amended to neutralize residual acidity and natural acid generating capacity. The technical justification for the soil amendments used is provided in Section 5.0. The discussion of potential metal loads is included in Section 6.0.

# 5.0 Soil Amendments

This section discusses soil amendments and certain other mitigation measures that will be used to control residual acidity, naturally occurring acid generation, and the subsequent release of copper and zinc from the Penn Mine site. The overall site restoration plan will influence both metal sources and water, which is the mobilizing medium for metal transport.

The site restoration plan is designed to restore the site to pre-mining conditions through implementation of Best Management Practices (BMPs) for mines containing sulfide ores and sulfide-containing residues. For the Penn Mine site, BMPs include excavating and secure disposal of sulfide residues, plugging Mine Shaft 4, neutralizing residual acidity in pore water, reestablishing surface water flow from upland areas through the site, and preparing the site for natural revegetation. More details of the basis for selection of soil amendments as mitigation measures for residual acidity and acid generating capacity are contained in the Design Basis Memorandum for Mitigation of Residual Acidity and Acid Generating Capacity in Appendix F.

Site restoration design addresses the following main criteria:

- Does not include active treatments to mitigate poor quality (acidic, metal-enriched) drainage from the site through use of passive mitigation measures.
- Minimize esthetic impacts (precipitates) to Camanche Reservoir, especially during periods of low flow in the Mokelumne River when water from the two sources mix.

The goal of the restoration is to incorporate BMPs that limit metal content in site drainage while avoiding an elevated pH which could cause alkaline precipitates to form in the interface zone between site drainage and water in Camanche Reservoir. The pH range within which the design goal is achieved is 8.5 to 9.5, and the condition under which the goal would be most difficult to meet is during periods of low upland surface water and alluvial flow.

## 5.1 Discussion of Soil Amendments

### 5.1.1 Optional Amendments

A variety of soil amendments are available for controlling acidic drainage from sulfide mineral oxidation. A commonly-used class is the limestone family, which includes limestone (calcium carbonate), dolomite (calcium magnesium carbonate), their calcined derivatives; and cement kiln dust. Other minerals are also available, including phosphate rock (calcium phosphate), magnesium hydroxide or magnesium oxide (which is converted into magnesium hydroxide by reaction with moisture); and synthetic materials such as dicalcium silicate. Several potential soil amendments were identified and evaluated for use at the site. They are summarized in Table 14.

Different groups of amendments operate on different principles. For example, limestone and dolomite dissolve in acid and release carbon dioxide into the water. Treatment with limestone-based amendments keeps the pH of the aqueous phase below about 5.0 to 6.0, until the carbon dioxide is released to the atmosphere, allowing metals to remain in solution at higher-than-desired concentrations. Calcined derivatives of limestone, such as lime (calcium oxide and calcium hydroxide) and cement kiln dust, do not exhibit this behavior, but could produce a drainage of high pH, potentially above 12.0.

Phosphate rock inhibits the acid-formation reaction in pyrite deposits by precipitating ferric iron (III), which is the agent that is directly responsible for forming acid. Ferric phosphate can encapsulate the pyretic minerals, permanently isolating them and shutting down acid-formation.

Magnesium hydroxide has the attribute of elevating the pH to about 9.0, irrespective of how much of it is applied. The limiting pH is controlled by the intrinsic solubility of magnesium hydroxide: when the pH drops below about 9.0, more magnesium hydroxide goes into solution, restoring it to about 9.0, whereas above 9.0, the magnesium hydroxide remains unreactive, until (or unless) it is again exposed to acidic water.

Dicalcium silicate is an alkaline material of approximate composition $Ca_2SiO_4$ that is commercially available as a by-product of magnesium metal production by the Magnetherm™ Process. It has an intrinsic pH of approximately 11.0, irrespective of how much dicalcium silicate is used, a limit that is imposed by its intrinsic solubility in aqueous media, such as pore water in residual soil or bedrock. Its neutralizing capacity is about 85 to 90 percent that of limestone on a weight-equivalent basis.

### 5.1.2 Soil Amendment Recommendations

#### Dicalcium silicate

Dicalcium silicate has several characteristics that favor its use at the Penn Mine site as an amendment for acidic alluvial material.

First, dicalcium silicate is sufficiently alkaline to render the principle metals at the site (copper and zinc) insoluble. At the same time, the intrinsic pH of dicalcium silicate, 11, is low enough that secondary dissolution of zinc at high pH will not occur. Raising the pH of the residual soil and bedrock will neutralize the pore water, immobilize the metals, and produce only a small quantity of alkaline drainage, once the soil cover is in place.

Second, dicalcium silicate produces residual alkalinity in any runoff, which will neutralize acidity when it is encountered. That is, surface water that infiltrates the amended residual soils and bedrock will neutralize underlying residual acidity in pore water and the natural acid generating capacity. This is an important consideration in Mine Run and Hinckley Run because some of the residual acidity resides in shallow bedrock fractures where it is less likely to come into direct contact with insoluble alkalis that may be placed above it such as a limestone channel lining.

Third, dicalcium silicate has weak pozzolanic properties that may reduce the mobility of particulate matter, reduce the permeability of the residual soil and bedrock, and partially bind the metal in a silicate matrix.

Dicalcium silicate is usually less expensive on unit weight and weight-effectiveness bases than cement kiln dust and other soil amendments with similar characteristics.

Alkaline drainage from dicalcium silicate is expected to flow through the fractured bedrock structure into the drainage channels in Mine and Hinckley Runs, where it will be neutralized by buffered water of lower pH drainage flowing in the stream channel.

## Phosphate Rock (Calcium Phosphate)

Calcium phosphate is a naturally occurring compound used in agriculture. It also has been used to suppress acid formation by pyrite. As a suppressant for pyrite oxidation (and therefore acid formation), its mode of operation is to form ferric phosphate by reacting with ferric iron, the immediate oxidizing agent in acid rock formation. Iron phosphate forms a tightly-adhering precipitate around the pyrite, isolating it to prevent further oxidation.

Crushed phosphate rock can be co-placed with dicalcium silicate to shut down the formation of new acidity. After the dicalcium silicate and phosphate rock are mixed with residual material, the amended material will be covered by top soil. Dissolved phosphate will be immobilized by precipitation with ferric iron, aluminum and other metals, and by anion exchange. Through co-placement of the phosphate rock with dicalcium silicate and covering it with top soil, phosphate can be prevented from entering Camanche Reservoir.

## Magnesium Hydroxide

Magnesium hydroxide neutralizes acidic drainage, raising the pH of the runoff up to a maximum pH of approximately 9.0. The maximum pH is constrained by the solubility of magnesium hydroxide. As the pH rises above about 8.0, magnesium hydroxide dissolves progressively more slowly, finally reaching its solubility limit, where it ceases to dissolve. When the pH reaches 8.5 to 9.0, the solubility of copper and zinc in acidic drainage will fall to concentrations less than 1 milligram per liter.

Magnesium hydroxide can be placed in an excavated trench beneath the stream beds in Mine Run and Hinckley Run and then back filled to neutralize acidity in water trapped in the shallow subsurface fracture system. During low flow conditions, acidic drainage would work its way to the surface of the stream channel through subsurface fractures and contact the magnesium hydroxide prior to surfacing. The amount of magnesium hydroxide to be placed in Mine Run would be designed in excess of the amount needed to neutralize residual acidity for the projected period during which the shallow fracture zone is expected to drain. The amount of magnesium hydroxide to be placed in Hinckley Run would be about twice that placed in Mine Run, and may or may not be sufficient to neutralize the residual acid resident in the subsurface fracture system.

Magnesium hydroxide can also be applied to the side slopes of Mine and Hinckley Runs, to neutralize residual acidity that remains from contact with mine waste. The magnesium hydroxide can be applied as a dilute slurry and held in place with an organic tackifying agent of the type used in hydroseeding.

## Summary of Recommended Amendments

Application of a combination of dicalcium silicate, phosphate rock and magnesium hydroxide is recommended for the Penn Mine Site. Dicalcium silicate has superior metal immobilization characteristics compared to limestone and related products, when applied to residual soil and bedrock material. It leaves a small residual neutralizing capacity in the aqueous phase, making it effective in treating pore water in shallow fractured bedrock, immediately beneath the residual soil. Dicalcium silicate also may bind the residual soil and bedrock through pozzolanic reactions similar to Portland cement.

Phosphate rock reacts with ferric iron to suppress the formation of new acidity. It also precipitates with aluminum and other metals, thereby remaining essentially immobile when used in small quantities in conjunction with higher application rates of another alkaline amendment such as dicalcium silicate.

Magnesium hydroxide will raise the pH of acidic drainage in Mine Run and Hinckley Run stream channels to a maximum of approximately 9.0. Magnesium hydroxide can be blended with a tackifying agent and spray-applied to the steep side slopes of Mine and Hinckley Runs to condition the slopes for subsequent seeding and to produce a runoff of pH not over 9.0. This pH is high enough to precipitate copper and zinc, resulting in predicted drainage concentrations below 1 milligram per liter. The soluble magnesium that results from dissolution of magnesium hydroxide below the stream bed, and bicarbonate in runoff from upland areas will help neutralize excess alkali draining from zones adjacent to the stream beds that cannot be treated with dicalcium silicate.

## 5.2 Major Components of Water and Metal Control Strategies

In the current transition period, with mine wastes having been removed, but with restoration not yet completed, metal (copper and zinc) is being carried to the Mine Run Dam Reservoir for treatment in the ILS plant for discharge. The metal that reaches the ILS is primarily, but not exclusively, in dissolved form.

In developing the site restoration program, mitigation measures were developed that address the point-of-origin of the metal relative to the overall water budget components. Soil amendment with an alkaline additive must work in concert with other site restoration activities, including containment of Mine Shaft 4 drainage, neutralization of seepage, and prevention of acid formation from pyretic deposits.

### 5.2.1 Site Residual Soil and Bedrock and Entrained Pore Water

The site baseline sampling program consisted of collecting residual soil and bedrock samples for various analyses and evaluations. The sampling was conducted following waste excavation from Mine Run and Hinckley Run.

Testing was performed to determine the acid-formation potential and total metal content of the residual soil and bedrock, as well as the acidity and metal concentrations that are present in pore water. The information on the total metal concentrations and the acid-formation potential of the exposed material, and on the metal concentrations and acidity in pore water for Hinckley Run is contained in Tables 3, 4, 10 and 11 in this report. (The information for Mine Run was presented in the first *Interim Effectiveness Monitoring Report*, CH2M HILL, 1999b.)

Pore water can be regarded as coming from two sources: moisture trapped in fine-grain residual soil in Mine Run and Hinckley Run; and water in the bedrock fractures immediately below the residual soil. Water from both sources will drain toward the centerline of the streambed channels and then into Camanche Reservoir, during periods of precipitation and runoff.

The fractured bedrock also contains sulfide mineralization that can oxidize and introduce fresh metal into pore water, even though the pore water may previously have been displaced by clean precipitation or upland surface water. Oxidation of pyrite requires that oxygen be available: if the pyretic minerals are submerged, oxidation occurs at a negligible rate and metals will not be released.

Residual soil and bedrock material will be treated with an alkali, dicalcium silicate, an industrial by-product from the manufacture of magnesium by the Magnitherm™ Process (Northwest Alloys, Inc.). Dicalcium silicate has an acid neutralizing capacity of 85 to 90 percent of that of calcium carbonate. Unlike calcium carbonate, its pH in water does not exceed about 11.0, but it does not produce a low-pH solution (about 5.0 to 6.0) upon reaction with acid, which would leave copper and zinc relatively soluble in runoff from the site.

Residual soil and bedrock will also receive a small application of (insoluble) phosphate rock to suppress acid formation in pyrite-rich zones. Phosphate is readily attenuated during groundwater transport, combining with native iron, aluminum, and other metals and minerals, and will not persist in water discharged form the site.

Pore water from the fractured bedrock structure will surface primarily within the graded stream channel. This water will typically be acidic and metal-bearing until it is displaced by clean water from natural precipitation and from up-gradient sources. Displacement will require an extended but uncertain period of time. Acidity in the pore water that surfaces in the stream channels (Mine Run and Hinckley Run) will be neutralized *in situ* by placing a magnesium hydroxide layer beneath the channel, prior to final grading. The equilibrium pH of magnesium hydroxide in water is 9.0, placing an upper limit on water in the main drainage channels.

### 5.2.2 Mine Shaft No. 4

The amount of groundwater entering the Penn Mine workings during operation is estimated at about 20 gpm of water (Wisser, 1961). The current flow from the spring in the vicinity of Mine Shaft 4, located in Hinckley Run, which almost certainly originates in the mine workings, is about 60 gpm.

The spring near Mine Shaft 4 is acidic (pH 2.8 to 4.2) and contains dissolved metals, including copper (0.06 to 36 mg/L) and zinc (41 to 62 mg/L) (Hamlin and Alpers, 1996). The mass loads of copper and zinc from this source are 5.3 to 3,200 pounds per year, and 3,500 to 5,400 pounds per year, respectively.

These metal mass loads will be controlled by plugging Mine Shaft 4.

### 5.2.3 Exposed Sulfide Minerals

Excavation of mine-related waste material has exposed bedrock deposits containing native sulfide minerals that may be subject to oxidation, acid formation, and metal dissolution. The sulfide deposits observed to date appear to be pyretic and contain undetermined concentrations of copper and zinc.

Exposed knobs of pyrite or other sulfide minerals found to contribute excess metal load may be grouted with Portland cement mix that contains insoluble phosphate. The phosphate suppresses acid forming reactions, encapsulates the pyrite, and protects the grout layer from acid attack. This would not be undertaken as part of the original restoration design, but would occur as needed during post-restoration monitoring.

The acid forming potential of mineral sulfides that are intimately associated with residual soil and bedrock will be suppressed by applying phosphate rock and an alkaline amendment across the site.

### 5.2.4 Minor Seeps and Springs

The contribution that each seep or spring makes to the overall metal load will be evaluated on a case-by-case basis. Most of the seeps are small and localized, and water quality will be controlled by increasing the amount of alkali amendment at the base of the seep. Periodic replacement of the alkali may occur as part of routine maintenance.

### 5.2.5 Hot Spots

Localized low pH and potentially acid-forming areas have been identified during confirmation sampling. These areas will receive an increased amount of alkali amendment, compared to the surrounding areas.

### 5.2.6 Side Slopes

Steep side slopes of Mine and Hinckley Runs have been in contact with mine waste material, and contain some residual acidity. It is not feasible to apply soil amendments directly to the side slopes with the same methods used for the main stream channel. An insoluble neutralizing agent will be applied with a binder or tackifier to prepare the side slopes for subsequent hydroseeding.

## 5.3 Soil Amendment Performance

Following are discussions of the neutralizing capacity of dicalcium silicate, a field quality control plan for monitoring and adjusting the application of amendments, immobilizing metals in the sub-grade fracture system, and the added safeguard of a limestone lined channel prior to discharge to Camanche Reservoir. Detailed information on the location and placement of the soil amendments is included in the rough and final grading plans and specifications prepared for the project.

### 5.3.1 Neutralizing Capacity

Dicalcium silicate has an acid neutralizing capacity about 85 to 90 percent of that found in limestone. Consequently, it must be applied at about 1.15-times the weight per mass of residual soil and bedrock that would be needed for limestone. The typical application rate for limestone or limestone equivalents is 3- to 5-times the net acid-forming potential.

It is estimated that in Mine Run, about 2.7 to 4.4 tons of limestone would be needed per thousand tons of residual soil and bedrock. The application rate for dicalcium silicate would be about 1.15-times this rate, or between 3.1 and 5.1 tons per thousand tons of residual soil and bedrock.

Hinckley Run residual soil and bedrock has a net acid-forming potential significantly greater than was found in Mine Run. Using the limestone application rates mentioned above, Hinckley Run would receive between 25 and 41 tons of calcium carbonate per thousand tons of residual soil and bedrock. The application rate for dicalcium silicate would be about 29 to 47 tons per thousand tons of residual soil and bedrock.

Phosphate rock will be co-applied at a small fraction of the application rate of dicalcium silicate. The application rate will be approximately 5 tons per thousand tons of soil in the most acidic area, an estimated 2.83 acres based on the geologic mapping of the site, where ongoing acid formation is occurring. Other areas will receive about one-fifth this amount per acre. The application rate was determined by the ability to uniformly distribute the phosphate rock over the less acidic zones, rather than by known stoichiometric requirement.

Magnesium hydroxide will be applied in the Mine Run stream channel at a rate of about 2.5 tons (dry weight) per hundred lineal feet of channel. This application rate is governed by the practical 12-inch limit to which the shallow bedrock zone immediately beneath the residual soil might be penetrated with conventional excavation equipment. The magnesium hydroxide will be applied as a 50 weight-percent slurry, about one-half full. The excavated bedrock will be returned to the trench as backfill over the top of the magnesium hydroxide-treated zone. This installation technique is feasible primarily in Hinckley Run and the upper reaches of Mine Run.

Magnesium hydroxide will be spray-applied to the side slopes of Mine and Hinckley Runs at a rate of about 800 pounds per acre. The magnesium hydroxide will be held in place with a tackifying agent of the type used in hydroseeding.

### 5.3.2 Field Quality Control

The dicalcium silicate application rates for Mine Run and Hinckley Run are best estimates. Field testing will be used to maintain an application rate sufficient to raise the pH of treated residual soil to at least 9.5 at a depth of 12 inches or less where residual soil cover is less then 12 inches deep. The dicalcium silicate will first be co-distributed with crushed phosphate rock, then worked into the residual soil by one of several methods. In zones where the pH cannot be raised to 9.5, a supplemental application of dicalcium silicate will be used to raise the pH to at least 9.5. No separate quality control measure is planned for phosphate rock application.

Magnesium hydroxide will be placed along the excavated streambed trench as uniformly as possible. If the slurry flows too fast along the trench, a series of small widened zones may be created to provide time for the magnesium hydroxide solids to settle. In areas where groundwater visibly surfaces or where magnesium hydroxide rapidly dissolves, a supplemental application of dicalcium silicate may be added to augment neutralization in that immediate location, plus the quantity of magnesium hydroxide that is placed downstream may be increased to elevate the overall neutralization capacity of the streambed.

### 5.3.3 Treatment of Acidity in Shallow Fractured Bedrock

Because dicalcium silicate releases a small amount of alkali to the water that it contacts, it will transport this residual into acidic zones as the water passes into the shallow fractured bedrock beneath the residual soil and bedrock. The residual alkalinity will partially neutralize acidity in the sub-grade fracture system, suppressing metal mobility at the point intermixing occurs.

### 5.3.4 Mixing Zone Control

As an additional safeguard to mitigate acidic runoff from the site, the main drainage channel at the confluence of Mine and Hinckley Runs will be a lined limestone bed. While limestone will neutralize strong acidity and provide some metal immobilization, the submerged rock bed will also act as a filter to trap precipitates originating within Mine and Hinckley Runs. The limestone bed will also provide some mixing between Penn Mine runoff and water from Camanche Reservoir, allowing precipitation reactions an opportunity to deposit suspended solids within the limestone bed.

## 5.4 Failure Mode Analysis

The effectiveness of the proposed soil amendments as mitigation measures for residual acidity will be monitored during post closure operations. Occurrence of the following would be indications of system failure:

- The **pH of runoff from the site is low** enough to drive the pH of Camanche Reservoir below a point at which impacts occur.
- The **pH is high** enough to cause precipitation of alkaline compounds such as calcium carbonate or magnesium hydroxide in Camanche Reservoir, creating an aesthetic problem
- **Nutrients from the site enter Camanche Reservoir**, leading to eutrophication
- **Revegetation at the site is impaired** by soil amendments

Site conditions under which these types of failures could occur were identified and evaluated. Possible corrective measures were also identified. The failure types and proposed remedies are summarized in Table 15.

The post restoration monitoring program will be designed to specifically address the potential failure mechanisms identified in Table 15. The post restoration monitoring program will be prepared and submitted to the PAC under separate cover. It will identify details of monitoring locations, sampling frequency, and analytical suites.

# 6.0 Mass Loading Estimates for Post Restoration Conditions

Post-restoration mass loadings of copper and zinc from the Penn Mine site have been evaluated under three scenarios: annual average conditions; "first flush" conditions; and Pardee Dam low-flow conditions. The mass loads of copper and zinc were calculated based on the assumption that the average pH of drainage within and from the restored site is within the design goal of 8.5 to 9.5. To be conservative, a pH of 8.5, and the solubility of copper and zinc at this pH were used in the calculations.

Each of the three scenarios is described in a separate section below and summarized in Table 16.

## 6.1 Annual Average Conditions

Dicalcium silicate and phosphate rock were chosen as soil amendments to the residual soil because of their ability to raise the pH of the amended residual soil to at least 9.5, and the pH of water that comes in contact with amended residual soil to a pH approaching this value. Pore water from amended residual soil /bedrock will mix with water from other sources, both on- and off-site, which would reduce the pH somewhat. The design is intended to maintain the pH of drainage from the Penn Mine site at a pH of at least 8.5 throughout the site.

At a pH of approximately 8.5, the intrinsic solubilities of copper and zinc are limited by their chemical properties. The solubility of copper at this pH is less than about 0.1 mg/L, and the solubility of zinc is less than about 0.6 mg/L (Patterson, et al., 1977).

Treated residual soil on the mine site will be at a sufficiently high pH that copper and zinc originating within the mine site will not exceed their solubility at a pH of about 8.5. Water from the upland watershed has even lower concentrations of these metals, except during the precipitation season's first flush runoff, when the copper may exceed 0.4 mg/L and zinc may exceed 1.8 mg/L (CH2M HILL 1999b, Table 6). Ignoring first flush effects, the estimated average concentrations of copper and zinc should not exceed about 0.1 mg/L and 0.6 mg/L, respectively, in groundwater from up-gradient shallow bedrock and in neutralized residual water from direct precipitation, assuming the design goal of pH 8.5 is achieved. (Surface water and alluvial groundwater from up-gradient are assumed to remain unchanged by site soil amendments.)

At the expected post-restoration copper and zinc concentrations, the nominal long-term mass loads in surface water and residual soil and bedrock flows would average about 117 pounds per year for copper, and about 348 pounds per year of zinc.

Groundwater flowing through shallow bedrock will carry an additional mass load. The estimated annual copper load is about 5 pounds per year, and the zinc load is about 72 pounds per year.

As shown on Tables 13 and 16, the estimated total annual average mass loads of copper and zinc leaving the Penn Mine site are 122 pounds per year of copper, and 420 pounds per year of zinc. The metal load from upland watershed inflow is approximately 40 percent of the total metal load leaving the site.

## 6.2 First Flush Conditions

The rainfall year's "first-flush" discharge from the Penn Mine site will carry metal loads from a number of discrete components within and up-gradient from the Penn Mine site. The mass load estimates need to be made on the basis of a finite flow increment. We have assumed that the first flush occurs in October, when the average hydraulic discharge rate rises after an extended period of low rainfall (see Table 9), and that first flush conditions will span ten percent of the rain year.

Copper and zinc in water that has a pH of about 8.5 through contact with site soil amendments will have copper and zinc concentrations with an upper limit that is pH-dependent. We have assumed that groundwater from up-gradient bedrock and runoff from direct precipitation will come into contact with amended residual soil and bedrock. Under these conditions, the metal concentrations are estimated to be 0.1 mg/L copper and 0.6 mg/L zinc.

Groundwater exiting the site through shallow bedrock makes a small but essentially constant contribution to the mass load from the site. The copper mass load leaving the site in groundwater is about 5 pounds per year of copper and 72 pounds per year of zinc.

Surface water and alluvial flows from the upland watershed show a pronounced first flush effect. In the first rainfall of the 1999 season, the total copper concentration from upland runoff was 0.28 to 0.4 mg/L and the total zinc concentration was 1.4 to 1.8 mg/L (CH2M HILL 1999b, Table 6). After other metal contributing streams are accounted for, the instantaneous first flush metal concentrations in surface water and alluvial groundwater leaving the post-restoration Penn Mine site were calculated to be 0.43 mg/L copper and 1.7 mg/L zinc. These concentrations represent an instantaneous 1.9-fold increase in copper and 3.1-fold increase in zinc, compared to the average concentrations in effluent from the restored site.

As shown in Table 16, these first flush metal concentrations will raise the post-restoration mass loads to an estimated 128 pounds per year of copper (average copper load is about 117 pounds per year) and an estimated 407 pounds per year of zinc (up from an annual average of 348 pounds per year).

## 6.3 Pardee Dam Low-Flow Conditions

In the period extending from October 1, 1993 through May 6, 1999, releases from Pardee Dam fell to low flow rates on three occasions; November 13 through 20, 1995 (5 cfs for nine days); August 1 through 8, 1994 (8 cfs for eight days); and January 10 through February 4, 1994 (10 cfs for 26 days). All three of these low flow releases occurred during extended dry periods, when no precipitation was recorded at the Camp Pardee meteorological station.

The evaluation of low-flow conditions was calculated for a release rate from Pardee Dam of 5 cfs. The flow and metal mass loading for the low-flow conditions are summarized in Table 16.

The Pardee Dam low-flow condition assumed smaller contributions to the metal mass load from the site, since larger contributions such as runoff from the upland watershed would not occur during dry weather. The main contributors of metals from the Penn Mine site during low flow would be groundwater flowing through shallow bedrock, pore water trapped in sub-alluvial fractures, and residual seepage from the plug in Mine Shaft 4.

Flow through shallow bedrock would contribute about 11.3 acre-feet per year (7 gallons per minute). The incoming metal load from this flow would consist of about 0.009 pound per day of copper and about 0.037 pound per day of zinc. However, this water also would contact pore water trapped in the sub-alluvial fracture zone. It was assumed that about 15 percent of the pore water exchanges with incoming groundwater, releasing copper and zinc. Of the remaining 85 percent, it was assumed that half was intimately contacted with treated residual soil and bedrock at a pH of about 9 and the rest maintained its original composition. This groundwater flow was joined by seepage around the seal of Mine Shaft 4, which is assumed to pass 1 percent of the original 60 gpm. The estimated metal mass load in the combined 7.6 gpm groundwater stream is about 0.14 pound per day (53 pound per year) of copper and 0.48 pound per day (178 pound per year) of zinc.

Groundwater in shallow bedrock leaves the site beneath what is now Mine Run Dam. As shown in Table 16, the average metal mass load leaving through this pathway is about 0.013

pound per day copper and 0.2 pound per day zinc. During low-flow conditions following restoration, however, the hydraulic gradient for groundwater movement in shallow bedrock beneath Mine Run Dam is decreased. The metal mass load into Camanche Reservoir from shallow bedrock during low flow conditions is probably much smaller than the preceding estimate.

# 7.0 Pre-Mining Condition

## 7.1 Methods for Estimating Pre-Mining Conditions

Information about pre-mining conditions can be gained with confidence only through a comprehensive and long-term baseline monitoring program, prior to commencement of ore exploration and mining. Pre-mining conditions in historic mining districts are, almost without exception, undocumented. There are several techniques for estimating the pre-mining water quality and general environmental conditions at a mine site.

One common method is geochemical modeling. Contemporary geochemical modeling is predicated on having "complete" information of all the mineral phases that are present, and having full thermodynamic knowledge about their interactions in liquid, solids and gas phases. Even with this full suite of information, quantitative predictive modeling falls short, because it is unable to take into account rates of reaction, bulk liquid and solid behavior, and dynamic field conditions. Consequently, geochemical modeling is most useful for conducting sensitivity analyses and trends, and is unsuitable for making quantitative predictions about real-world conditions.

A second common method is to compare the disturbed mine site with a "geologically similar" but un-mined location. This method produces a low-biased estimate of baseline conditions for a mine site, because if the reference site were similarly mineralized, it, too would have been mined. Nevertheless, this is often the only method available. At best, reconstructing pre-mining conditions based on "geologically similar" locations gives a lower limit for contaminant metal concentrations. Hence, pre-mining background conditions would almost certainly have been worse than estimates based on the reference locations.

## 7.2 Pre-Mining Background Water Quality from Up-Gradient Runoff and Shallow Groundwater

Water quality data were collected for Mine Run and Hinckley Run Diversions and were reported in the first *Interim Effectiveness Monitoring Report* (CH2M HILL, 1999b, Table 6). During the period that followed, several new groundwater monitoring wells were installed, and both new and pre-existing wells were sampled for metal concentrations and general water quality parameters (Table 1 and 2, current report).

### 7.2.1 Surface Water Component of Background Metal Loads

Total metals data for Mine Run and Hinckley Run Diversions were used to estimate the metal load from upland areas (and by analogy, the contribution from the Penn Mine site before mining occurred). Total metal concentrations were used to implicitly account for erosion-derived suspended sediment contributions to the metal mass load. Hydraulically, the upland areas and the mine site would produce an average combined flow into the

Mokelumne River (Camanche Reservoir) of 217.6 acre-feet per year, pre-mining, based on analogy with post-restoration conditions described in Appendix E, but assuming a 43.5 acre-foot per year up-gradient groundwater component.

Metal mass load calculations were performed for each discrete time increment preceding the sample dates listed in Table 6 of the first *Interim Effectiveness Monitoring Report* (CH2M HILL, 1999b). In addition, the concentrations were apportioned according to the flow contribution from each drainage area: 13.1 percent of the surface water and alluvial flows passing through Mine Run and 86.9 percent passing through Hinckley Run.

The estimated lower mass limit for copper in surface water and shallow alluvial flow is 54.8 pounds per year, and the lower-limit estimate for zinc is 136.3 pounds per year. To estimate the total mass load lower limit for water leaving the Penn Mine site, it is necessary to add the metal mass load contribution of groundwater flowing through shallow bedrock.

### 7.2.2 Groundwater in Shallow Bedrock

Table 1 presents analytical results for groundwater samples for up- and down-gradient wells surrounding Mine and Hinckley Runs. Of the up-gradient wells, three appear to be unaffected by acidic, metal-containing drainage from mine-derived wastes, based on the sulfate data: wells W-1, W-2S, and W-5. These wells were assumed to be indicative of background water quality in up-gradient shallow groundwater flowing through bedrock.

Average concentrations for soluble copper and for soluble zinc were calculated, and the average values were used to estimate the metal mass loads entering the Penn Mine site in up-gradient shallow groundwater in fractured bedrock. The average soluble copper concentration is 0.11 mg/L and the average zinc concentration is 0.44 mg/L.

The groundwater flow rate through shallow bedrock was assumed to be 43.5 acre-feet per year as indicated in Table 6 and Appendix E (pre-restoration). Using this estimated flow rate and the metal concentrations in the preceding paragraph, it is estimated that groundwater in shallow bedrock contributed about 12.7 pounds of copper per year and 52 pounds of zinc per year to the Mokelumne River, pre-mining.

### 7.2.3 Estimated Pre-Mining Metal Mass Load

Combining the lower-limit estimates of metal mass loads for surface water and shallow alluvium with estimates for groundwater flowing through shallow bedrock gives estimated overall pre-mining metal mass loads of 68 pounds per year of copper, and of 188 pounds per year of zinc. Actual metal mass loadings were probably higher than these estimates.

## 8.0 Water Quality Impacts of Post-Restoration Site

A series of estimates have been made of metal concentrations and mass loads in surface water and subsurface flow from the Penn Mine site, both pre-mining and post-restoration. These estimates and the copper and zinc concentrations in Camanche Reservoir are presented in Tables 16 and 17.

The release rate from Pardee Dam has ranged from 5 cubic feet per second (cfs) to 6,483 cfs over the past 10 years. The contribution of copper and zinc in surface and alluvial runoff from the Penn Mine site can be illustrated by showing the incremental concentration increase in Camanche Reservoir for the different site runoff conditions listed in Table 16.

Table 17 shows the concentration increase that would result from runoff from the post restoration Penn Mine site under three release rates from Pardee Dam: 5 cfs, 50 cfs, and 500 cfs. The table shows that copper and zinc concentration increases in the estimated pre-mining condition would be about the same for pre-mining as for the estimated post-restoration low-flow condition. The table also shows that the first flush condition makes a greater impact on Camanche Reservoir than any other condition: a significant result, since most of the metal load and high concentrations originate in upland areas that were not affected by mining.

The post-restoration conditions were based on the design goals of the restoration project, primarily that the pH of water on the site and of site runoff be above 8.5. The small contributions of metals from the restored Penn Mine to the concentrations in Camanche Reservoir indicate that the design goal is reasonable, and should be implemented as fully as possible.

# 9.0 Post-Restoration Monitoring Program

Post-restoration monitoring of Mine and Hinckley Run will begin after site restoration activities are completed, as described in the WQMP. The monitoring information will be interpreted in the context of the "Simplified Annual Average Water Budget" conceptual model presented in *Addendum 3, Monitoring and Evaluation of Stage II Site Activities (CH2M HILL, 1999a).*

The objectives of post-restoration monitoring include:

- Monitoring metal mass loads entering Camanche Reservoir from the Penn Mine site per the WQMP
- Monitoring the effectiveness of mitigation alternatives, such as the seal in the Mine Shaft 4 area
- Documenting the improvements in metal mass loads, compared with pre-restoration metal mass loads

This activity will include monitoring the quality of surface water and groundwater inflows to Mine Run and Hinckley Run, as well as outflow from Penn Mine, using existing and newly established surface and subsurface sampling locations. Groundwater quality will be monitored using a network of monitoring wells. Surface water flow through Mine Run and Hinckley Run will be monitored using permanent weirs. The monitoring program will include measurement of pH, and electrical conductivity, flow rate, and selected metals.

The percentage decrease in post-construction metal loads, from the pre-restoration phase will be estimated over the course of several sampling events. Post-restoration metal concentrations and metal loads will also be compared with estimates of baseline conditions, as appropriate. A post-closure Water Quality Monitoring Plan will be prepared and submitted to the EPA for review and approval. This plan will document the location and frequency of sample collection, the analytical suite, QC procedures and reporting events.

# 10.0 Summary

Mine waste has been removed from both Mine Run and Hinckley Run, and confirmation sampling and analysis has been performed. Water quality monitoring has begun. The monitoring program will be revised to reflect post-closure conditions.

The water budget for the site was re-calculated to better distinguish between pre-restoration, restoration, and post-restoration conditions, and to facilitate simulation of variability in site discharge conditions.

Mitigation measures to address residual acidity were evaluated relative to reducing the acidity of water discharged from the site. Soil amendments that could achieve water quality goals were selected. Quality control measures for the application of the amendments and additives have been summarized, and potential modes of failure have been identified.

Metal mass loads and concentrations in site runoff have been estimated for four conditions: pre-mining; post-restoration, low Pardee Dam release rate; post-restoration, average conditions; and post-restoration, first flush of the rainy season.

Incremental effects that would be caused by runoff from the Penn Mine site were evaluated. The largest impact comes from first flush conditions, contributed primarily by runoff from un-mined upland areas. This indicates that the Penn Mine site should have minimal impact on water quality in Camanche Reservoir after restoration is completed.

# 11.0 References

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# Tables

# Table 1
## Groundwater Sample Results (in mg/L)
## April 22 and 25, 1999
## Second Interim Effectiveness Monitoring Report, July 1999
## Penn Mine Environmental Restoration Project

| Parameter | W-2D | W-2S | W-1 | W-5 | CHMW-2 | CHMW-3 | GS-7 | GS-8A | GS-14 | GS-4A | W-1D |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Copper, total | 0.0085 | 0.022 | 0.10 | 0.11 | <0.10 | 2.2 | 38 | 0.017 | 42 | 0.12 | 2.2 |
| Copper, soluble | <0.050 | 0.062 | 0.10 | 0.16 | 0.12 | 2.3 | 37 | 0.035 | 41 | 0.15 | 2.3 |
| Iron, total | <0.10 | <0.10 | 29 | 0.76 | 130 | <2.0 | 1.6 | 0.15 | 40 | <2.0 | <2.0 |
| Iron, soluble | <1.0 | <1.0 | 10 | <1.0 | 140 | <1.0 | 1.8 | <0.10 | 46 | <1.0 | <1.0 |
| Zinc, total | <0.01 | 0.38 | 0.14 | 0.84 | 110 | 40 | 120 | 0.043 | 140 | 17 | 47 |
| Zinc, soluble | <0.10 | 0.41 | <0.10 | 0.86 | 120 | 39 | 120 | 0.084 | 140 | 15 | 48 |
| Alkalinity (1) | 350 | 250 | 64 | 66 | < 5 | 67 | <5.0 | 37 | 47 | 110 | 37 |
| Sulfate | 1700 | 190 | 9.6 | 20 | 1400 | 3600 | 3000 | 200 | 3400 | 2100 | 1900 |

Notes:

(1) total alkalinity as $CaCO_3$

## Table 2
## Summary of Groundwater Sampling Parameters
## April 22 and 25, 1999
## Second Interim Effectiveness Monitoring Report, July 1999
## Penn Mine Environmental Restoration Project

| WELL ID | CASING DIAMETER (INCHES) | TOTAL DEPTH (FEET) | DEPTH TO WATER (FEET) | TOTAL PURGE VOLUME (GALLONS) | FINAL WATER QUALITY PARAMETER READINGS | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | TEMP (F) | pH | E.C. (ms) | Turbidity |
| W-2D | 4 | 58 | 9.28 | 25 | 64.6 | 7.1 | 2.99 | 70.8 |
| W-2S | 4 | 18 | 12.12 | 19 | 67.5 | 7.11 | 0.686 | 7 |
| W-1 | 4 | 19.5 | 18.82 | 4 | 60.9 | 5.44 | 0.009 | 372 |
| W-5 | 4 | 18 | 8.5 | 23 | 59.4 | 5.7 | 0.146 | 6.6 |
| EW-2 (1) | 4 | 53.5 | Dry | 3 | --- | --- | --- | --- |
| CHMW-2 | 2 | 102 | 49.22 | 85 | 68.3 | 5.36 | 2.34 | 14 |
| CHWM-3 | 2 | 34.8 | 14.42 | 50 | 66.4 | 5.33 | 4.46 | 200 |
| GS-7 | 8 | 47.5 | 6.41 | 360 | 66.2 | 3.82 | 3.78 | 0.4 |
| GS-8A | 8 | 19.5 | 6.23 | 138 | 63.2 | 6.8 | 0.406 | 6.2 |
| GS-14 | 8 | 67 | 4.71 | 500 | 63.1 | 3.62 | 4.08 | 3.8 |
| GS-4A | 8 | 51 | 9.11 | 140 | 65.7 | 6.33 | 3.02 | 100.1 |
| W1-D | 8 | --- | 11.65 | 1300 | 69.6 | 5.5 | 2.39 | 32.1 |

Notes:
(1) EW-2 not sampled due to insufficient water in well.

## Table 3
## Residual Soil and Bedrock Sample Analytical Results
## 25-Apr-99
## Second Interim Effectiveness Monitoring Report, July 1999
## Penn Mine Environmental Restoration Project

| Parameter | Units | HK-C3 | HK-C5 | HK-C8 | HK-C10 |
|---|---|---|---|---|---|
| Aluminum, total | mg/kg (2) | 9,200 | 3,800 | 14,000 | 5,500 |
| Aluminum, soluble (1) | mg/L (3) | 260 | 150 | 460 | 72 |
| Cadmium, total | mg/kg | <50 | <50 | <50 | <50 |
| Cadmium, soluble (1) | mg/L | 0.99 | 0.13 | 2.7 | <1.0 |
| Copper, total | mg/kg | 1,200 | 6,600 | 4,800 | 11,000 |
| Copper, soluble (1) | mg/L | 97 | 100 | 700 | 760 |
| Iron, total | mg/kg | 55,000 | 200,000 | 44,000 | 22,000 |
| Lead, soluble (1) | mg/L | <0.5 | <0.5 | <5.0 | <5.0 |
| Nickel, total | mg/kg | <100 | <100 | <100 | <100 |
| Nickel, soluble (1) | mg/L | 0.53 | <0.5 | <5.0 | <5.0 |
| Zinc, total | mg/kg | 2,400 | 760 | 5,000 | 830 |
| Zinc, soluble (1) | mg/L | 190 | 22 | 580 | 76 |
| Percent Moisture | % | 6.02 | 5.19 | 18.4 | 9.15 |
| pH | pH unit | 3.15 | 3.34 | 2.73 | 3.36 |
| Sulfur | % | 0.93 | 0.69 | 1.84 | 0.75 |

Notes:

(1) soluble metals analysis by California Waste Extraction Test (WET) using DI Water

(2) mg/kg = milligrams per kilogram

(3) mg/L = milligrams per liter

## Table 4
## Acid Base Accounting
## Second Interim Effectiveness Monitoring Report, July 1999
## Penn Mine Environmental Restoration Project

| SAMPLE NAME | MATERIAL DESCRIPTION | ACID/BASE ACCOUNTING | | | |
|---|---|---|---|---|---|
| | | NP[1][2] (t/kt) | Acid Potential (AP) (t/kt) | Net Neutralization Potential (NP-AP)[3] (t/kt) | Ratio of NP/AP[4] |
| HK-C3 | Dark red sapprodite and re-worked material with possible pods of waste with greenish sulphide precipitates. | 35.5 | 27.07 | 8.43 | 1.3 |
| HK-C5 | Highly mineralized waste rock, grayish brown. | 12.5 | 20.78 | -8.28 | 0.6 |
| HK-C8 | Light blueish white malacite interspersed with bedrock, waste, slag, and float. | 95.3 | 51.54 | 43.76 | 1.8 |
| HK-C10 | Reactive waste rock with marcasite. | 20.1 | 22.27 | -2.17 | 0.9 |

Notes:

[1] Acid Neutralizing Potential

[2] Units are tons $CaCO_3$ per kiloton.

[3] A positive value indicates material has excess neutralization potential.

[4] A ratio of greater than 3 indicates material is not likely to be acid generating.

## Table 5
## Penn Mine Site Water Budget Components
## Second Interim Effectiveness Monitoring Report, July 1999
## Penn Mine Environmental Restoration Project

| Component | Designation |
|---|---|
| **Inflows** | |
| Inflow from direct precipitation | Q1 |
| Groundwater inflow from shallow bedrock | Q2 |
| Upland watershed inflow (surface water and shallow alluvial groundwater) | Q6 |
| **Outflows** | |
| Evapotranspiration | Q3 |
| Surface water and shallow alluvial groundwater discharge to Camanche Reservoir | Q4 |
| Groundwater discharge from shallow bedrock to Camanche Reservoir | Q5 |

## Table 6
## Penn Mine Site Pre-Restoration Water Budget
## Second Interim Effectiveness Monitoring Report, July 1999
## Penn Mine Environmental Restoration Project

| **Component** | **Flow (ac-ft/yr)** | **Comments** |
|---|---|---|
| Inflow from Direct Precipitation, Q1 | 106.56 | Has not contacted mine waste |
| Groundwater Inflow from Shallow Bedrock, Q2 | 43.5 | Acidified from contact with natural bedrock |
| Evapotranspiration, Q3 | 27.77 Evaporation<br>66.0 Transpiration | Carries no metals or acidity off site. |
| Surface Water and Shallow Alluvial Groundwater Discharge to Camanche Reservoir, Q4 | 56.2 | Contacts mine waste |
| Groundwater Discharge from Shallow Bedrock to Camanche Reservoir, Q5 | 0.12 | Contacts mine waste and naturally acidifying bedrock |
| Upland Watershed Inflow (Surface water and shallow alluvial groundwater), Q6 | 0 | All intercepted by diversion structures |

## Table 7
## Penn Mine Site Restoration Period Water Budget
## Second Interim Effectiveness Monitoring Report, July 1999
## Penn Mine Environmental Restoration Project

| **Component** | **Flow** (ac-ft/yr) | **Comments** |
|---|---|---|
| Inflow from Direct Precipitation, Q1 | 106.56 | Has not contacted mine waste |
| Groundwater Inflow from Shallow Bedrock, Q2 | 43.5 | Acidified from contact with natural bedrock |
| Evapotranspiration, Q3 | 13.2 Evaporation<br>0 Transpiration | Carries no metals or acidity off site. |
| Surface Water and Shallow Alluvial Groundwater Discharge to Camanche Reservoir, Q4 | 136.7 | Contacts mine waste |
| Groundwater Discharge from Shallow Bedrock to Camanche Reservoir, Q5 | 0.12 | Contacts mine waste and naturally acidifying bedrock |
| Upland Watershed Inflow (Surface water and shallow alluvial groundwater), Q6 | 0 | All intercepted by diversion structures |

# Table 8
# Penn Mine Site Post-Restoration Water Budget
## Second Interim Effectiveness Monitoring Report, July 1999
## Penn Mine Environmental Restoration Project

| Component | Flow (ac-ft/yr) | Comments |
|---|---|---|
| Inflow from Direct Precipitation, Ql | 106.56 | Has not contacted mine waste |
| Groundwater Inflow from Shallow Bedrock, Q2 | 12.2 | Acidified from contact with natural bedrock. Mitigated by dicalcium silicate and magnesium hydroxide in residual soil/bedrock. |
| Evapotranspiration, Q3 | 0 Evaporation<br>83.07 Transpiration | Carries no metals or acidity off site. |
| Surface Water and Shallow Alluvial Groundwater Discharge to Camanche Reservoir, Q4 | 186.3 | Surface water does not contact mine waste. Shallow alluvial groundwater may contact mine waste at residual soil/bedrock interface. Shallow alluvial groundwater mitigated by dicalcium silicate and magnesium hydroxide in residual soil/bedrock. |
| Groundwater Discharge from Shallow Bedrock to Camanche Reservoir, Q5 | 0.12 | Contacts mine waste and naturally acidifying bedrock |
| Upland Watershed Inflow (Surface water and shallow alluvial groundwater), Q6 | 150.7 | Surface water does not contact mine waste, but contains background metal loading. |

### Table 9
### Estimated Monthly Flows, Post-Restoration (acre-feet/month)
### Second Interim Effectiveness Monitoring Report, July 1999
### Penn Mine Environmental Restoratiojn Project

| Month | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 |
|---|---|---|---|---|---|---|
| January | 19.79 | 1.02 | 15.52 | 33.27 | 0.01 | 27.99 |
| February | 18.09 | 1.02 | 14.18 | 30.50 | 0.01 | 25.59 |
| March | 17.05 | 1.02 | 13.37 | 28.82 | 0.01 | 24.12 |
| April | 9.39 | 1.02 | 7.33 | 16.36 | 0.01 | 13.28 |
| May | 4.26 | 1.02 | 3.28 | 8.02 | 0.01 | 6.03 |
| June | 1.34 | 1.02 | 0.98 | 3.26 | 0.01 | 1.89 |
| July | 0.24 | 1.02 | 0.11 | 1.48 | 0.01 | 0.35 |
| August | 0.33 | 1.02 | 0.18 | 1.62 | 0.01 | 0.46 |
| September | 1.19 | 1.02 | 0.86 | 3.02 | 0.01 | 1.68 |
| October | 6.17 | 1.02 | 4.79 | 11.12 | 0.01 | 8.73 |
| November | 12.17 | 1.02 | 9.52 | 20.88 | 0.01 | 17.22 |
| December | 16.51 | 1.02 | 12.94 | 27.94 | 0.01 | 23.36 |
| Totals (acre-feet/year | 106.53 | 12.24 | 83.06 | 186.29 | 0.12 | 150.70 |

## Table 11
## Estimated Nominal Pore Water Characterstics in Mine Run and Hinckley Run
## Second Interim Effectiveness Monitoring Report, July 1999
## Penn Mine Environmental Restoration Project

| Parameter | Mine Run | Hinckley Run |
|---|---|---|
| Aluminum, mg/L (1) | <276 | 2,360 |
| Cadmium, mg/L | <6 | <11 |
| Copper, mg/L | 72 | 4,140 |
| Nickel, mg/L | <33 | <14.5 |
| Zinc, mg/L | 162 | 2,170 |
| pH (estimated) | 2.33 | 1.75 |

Notes:

(1) mg/L = milligrams per liter

# Table 12
# Pre-Restoration Water Budget and Metal Loads
## Second Interim Effectiveness Monitoring Report, July 1999
## Penn Mine Environmental Restoration Project

| Component | Flow Ac - ft/yr | Copper Mass (lbs/yr) | Zinc Mass (lbs/yr) |
|---|---|---|---|
| Inflow from direct precipitation, Q1 | 106.56 | 0.00 | 0.00 |
| Groundwater inflow from shallow bedrock, and Mine Shaft 4 seepage, Q2 | 43.50 | 1,583 | 4,514 |
| Evapotranspiration, Q3 | 94.00 | 0.00 | 0.00 |
| Surface water and shallow alluvial groundwater discharge to Camanche Reservoir, Q4 | 56.20 | 19,378 | 39,930 |
| Groundwater discharge from shallow bedrock to Camanche Reservoir, Q5 | 0.12 | 4.89 | 71.76 |
| Upland watershed inflow (surface water and shallow alluvial groundwater), Q6 (1) | 0.00 | 0.00 | 0.00 |
| Total estimated discharge to Camanche Reservoir (Q4 + Q5) | 56.32 | 19,383 | 40,002 |

Notes:

(1) Q6 is diverted around site in pre-restoration condition

# Table 13
# Post-Restoration Water Budget and Metal Loads
# Second Interim Effectiveness Monitoring Report, July 1999
# Penn Mine Environmental Restoration Project

| Component | Flow (Ac - ft/yr) | Copper Mass (lbs/yr) | Zinc Mass (lbs/yr) |
|---|---|---|---|
| Inflow from direct precipitation, Q1 | 106.56 | 0.00 | 0.00 |
| Groundwater inflow from shallow bedrock, and Mine Shaft 4 seepage after plug installation, Q2 | 12.20 | 52.00 | 158.38 |
| Evapotranspiration, Q3 | 83.07 | 0.00 | 0.00 |
| Surface water and shallow alluvial groundwater discharge to Camanche Reservoir, Q4 | 186.30 | 117.30 | 348.30 |
| Groundwater discharge from shallow bedrock to Camanche Reservoir, Q5 | 0.12 | 4.89 | 71.76 |
| Upland watershed inflow (surface water and shallow alluvial groundwater), Q6 | 150.70 | 48.92 | 151.60 |
| Total estimated discharge to Camanche Reservoir (Q4 + Q5) | 186.42 | 122.2 | 420.1 |

# Table 14
# Soil Amendment Summary
# Second Interim Effectiveness Monitoring Report, July 1999
# Penn Mine Environmental Restoration Project

| Potential Amendment | Characteristics Pertinent to Penn Mine Site | Recommended for use at Penn Mine |
|---|---|---|
| *Limestone Family* | | |
| Limestone (calcium carbonate) | Dissolves in acid and releases $CO_2$<br>Keeps pH of aqueous phase less than 5.0 to 6.0 until $CO_2$ is released, thereby allowing metals to remain in solution at higher concentrations. | No |
| Dolomite (calcium magnesium carbonate) | | No |
| Cement kiln dust | Could produce drainage of high pH leading to undesireable precipitates. | No |
| Limestone (calcium carbonate) | | No |
| *Phosphate rock*<br>(calcium phosphate, ferric phosphate) | Inhibits acid formation in pyrite deposits by precepitating ferric iron. Can encapsulate pyritic minerals, stopping acid formation. | Yes (to supress formation of new acidity) |
| *Magnesium hydroxide and magnesium oxide* | Elevates pH to about 9.0, regardless of amount applied | Yes (to raise pH of runoff high enough to precipatate metals) |
| *Dicalcium silicate* | Maintains a pH of about 11 regardless of amount applied. Neutralizing capacity is about 85 to 90 percent that of limestone on a weight-equivalent basis | Yes (to immobilize metals in residual soil and bedrock and neutralize pore water in shallow bedrock) |

## Table 15
## Failure Mode Analysis Summary
## Second Interim Monitoring Report, July 1999
## Penn Mine Environmental Restoration Project

| Mode of Failure | Effects of Failure | Severity of Effects | Probability of Occurrence | Potential Preventive or Corrective Measures |
|---|---|---|---|---|
| High Metal Concentration | | | | |
| 1. Active acid formation on steep side slopes | Excessive consumption of soil amendment material; potential adverse effects during low flow from Pardee Dam | Low to moderate during Pardee low flow | Low to moderate | Grout acid - generating zone with grout containing pulverized phosphate rock. |
| 2. Localized seeps or springs are flowing | Excessive consumption of soil amendment material; potential adverse effects during low flow from Pardee Dam | Low to moderate during Pardee low flow | Moderate | Reapply passive agent such as magnesium hydroxide along the drainage route |
| 3. Diffuse flow contributing to poor water quality in stream channels. | Excessive consumption of soil amendment and stream channel treatment agent; potential adverse effects during low flow from Pardee Dam | Low to moderate during Pardee low flow | Moderate | Reapply passive agent such as magnesium hydroxide along the stream channel |
| 4. Shaft 4 plug leakage, bypassing, or failure | Rapid and excessive consumption of soil amendment and stream channel treatment agent | Moderate to serious during Pardee low flow | Low | Isolate leakage; apply large excess of pH-limiting alkali such as limestone or magnesium hydroxide; determine whether leakage can be corrected and what effect it has on the reservoir; confer with proper agencies and correct the situation as feasibility permits |
| Low pH Runoff | | | | |
| 5. Active acid formation on steep side slopes | Excessive consumption of soil amendment material; potential adverse effects during low flow from Pardee Dam | Low during low flow from Pardee Dam; negligible at high flow and runoff from site | Low to negligible | No action, periodic observation; if action is required; grout acid-generating zone with grout containing pulverized phosphate rock |

## Table 15
## Failure Mode Analysis Summary
## Second Interim Monitoring Report, July 1999
## Penn Mine Environmental Restoration Project

| Mode of Failure | Effects of Failure | Severity of Effects | Probability of Occurrence | Potential Preventive or Corrective Measures |
|---|---|---|---|---|
| <u>High pH Runoff</u> | | | | |
| 6. Site runoff from non-localized source at pH>9.0 to 9.3 | Creates localized high turbidity where runoff and Camanche Reservoir waters mix | Low to moderate (primarily aesthetic impairment) | Moderate to high during and immediately after site restoration; low to negligible later, including during low flow conditions | Sparge carbon dioxide into stilling well upstream of flume(s) at toe of drainage (stream) channels; wait for precipitates to form around alkaline amendment (dicalcium silicate), which will reduce the diffusion rate of alkali |
| 7. Top soil cover has washed off exposing dicalcium silicate-treated residual soil/bedrock surface | Creates localized high turbidity where runoff and Camanche Reservoir waters mix | Low to moderate (primarily aesthetic impairment) | Low to moderate until revegetation becomes established | Reapply soil cover and reseed; establish permanent drainage channel through washed-out zone; Sparge carbon dioxide into stilling well ahead of monitoring weir |
| <u>Nutrients Entering Camanche Reservoir</u> | | | | |
| 8. Excess acidity has neutralized amendment, dissolving phosphate rock | Leads to enhanced algal growth and die-off creating localized eutrophication | Low | Low to negligible | Locate, isolate, and treat source of excess acidity, if feasible; investigate integrity of stream channel amendments and of limestone channel (repair or replace if needed) |
| <u>Revegetation Impaired</u> | | | | |
| 9. Seeding and revegetation effort is ineffective | Top soil erosion; exposure and erosion of alkaline amendment and of phosphate rock | Low to moderate | Low to moderate | Examine affected area(s) for alkaline salt deposits, soil binding, or other evidence of impairment attributable to alkaline amendment (treat with soil penetrant and acidifier if needed); look for heavy metal oxide deposition or elevated dissolved solids (reapply alkali, reapply to top soil and reseed); look for surface water erosion (create a side channel if needed) |

## Table 16
## Mass Loading Estimates for Post-Restoration Conditions
## Second Interim Effectiveness Monitoring Report, July 1999
## Penn Mine Environmental Restoration Project

| Component | Average Flow Conditions | | | First Flush Conditions | | | Low Flow Conditions | | |
|---|---|---|---|---|---|---|---|---|---|
| | Flow (Ac - ft/yr) | Copper Mass (lbs/yr) | Zinc Mass (lbs/yr) | Flow (Ac - ft/yr) | Copper Mass (lbs/yr) | Zinc Mass (lbs/yr) | Flow (Ac - ft/yr) | Copper Mass (lbs/yr) | Zinc Mass (lbs/yr) |
| Inflow from direct precipitation, Q1 | 106.56 | 0.00 | 0.00 | 106.56 | 0.00 | 0.00 | 0.00 | N/A | N/A |
| Groundwater inflow from shallow bedrock, and Mine Shaft 4 plug seepage, Q2 | 12.20 | 52.00 | 158.38 | 12.20 | 52.18 | 153.38 | 12.20 | 52.18 | 153.38 |
| Evapotranspiration, Q3 | 83.07 | 0.00 | 0.00 | 83.07 | 0.00 | 0.00 | 0.00 | N/A | N/A |
| Surface water and shallow alluvial groundwater discharge to Camanche Reservoir, Q4 | 186.30 | 117.30 | 348.30 | 186.30 | 128.00 | 406.71 | 12.20 | 52.62 | 177.95 |
| Groundwater discharge from shallow bedrock to Camanche Reservoir, Q5 | 0.12 | 4.89 | 71.76 | 0.12 | 4.89 | 71.76 | 0.00 | N/A | N/A |
| Upland watershed inflow (surface water and shallow alluvial groundwater), Q6 | 150.70 | 0.00 | 0.00 | 150.70 | 60.62 | 210.14 | 0.00 | N/A | N/A |
| Total estimated discharge to Camanche Reservoir (Q4 + Q5) | 186.42 | 122.19 | 420.06 | 186.42 | 132.89 | 478.47 | 12.2 | 52.62 | 177.95 |

## Table 17
## Estimated Copper and Zinc Concentration Increases in Camanche Reservoi
## Second Interim Effectiveness Monitoring Report, July 1999
## Pre-Mining and Post-Restoration Conditions at Penn Mine

| Penn Mine Site Discharge Condition (flow, ac-ft/yr) | Pardee Dam Release Rate, cfs | Copper | Zinc |
|---|---|---|---|
| **Pre-Mining** (217.6.) | 5 | 0.0056 | 0.014 |
| | 50 | (6 x $10^{-4}$)[a] | 0.0014 |
| | 500 | (6 x $10^{-5}$) | (1.4 x $10^{-4}$) |
| **Post-Restoration** | | | |
| - Low Flow (12.3) | 5 | 0.005 | 0.018 |
| | 50 | (5 x $10^{-4}$) | 0.002 |
| | 500 | (5 x $10^{-5}$) | (2 x $10^{-4}$) |
| - Average Flow (186.3) | 5 | 0.011 | 0.028 |
| | 50 | 0.001 | 0.003 |
| | 500 | (1 x $10^{-4}$) | (3 x $10^{-4}$) |
| - First Flush (186.3) | 5 | 0.022 | 0.087 |
| | 50 | 0.002 | 0.009 |
| | 500 | (2 x 10-4) | (9 x 10-4) |

Notes:

[a] Values in perenthesis are below detection with routine anaytical methods commonly in use

# Figures

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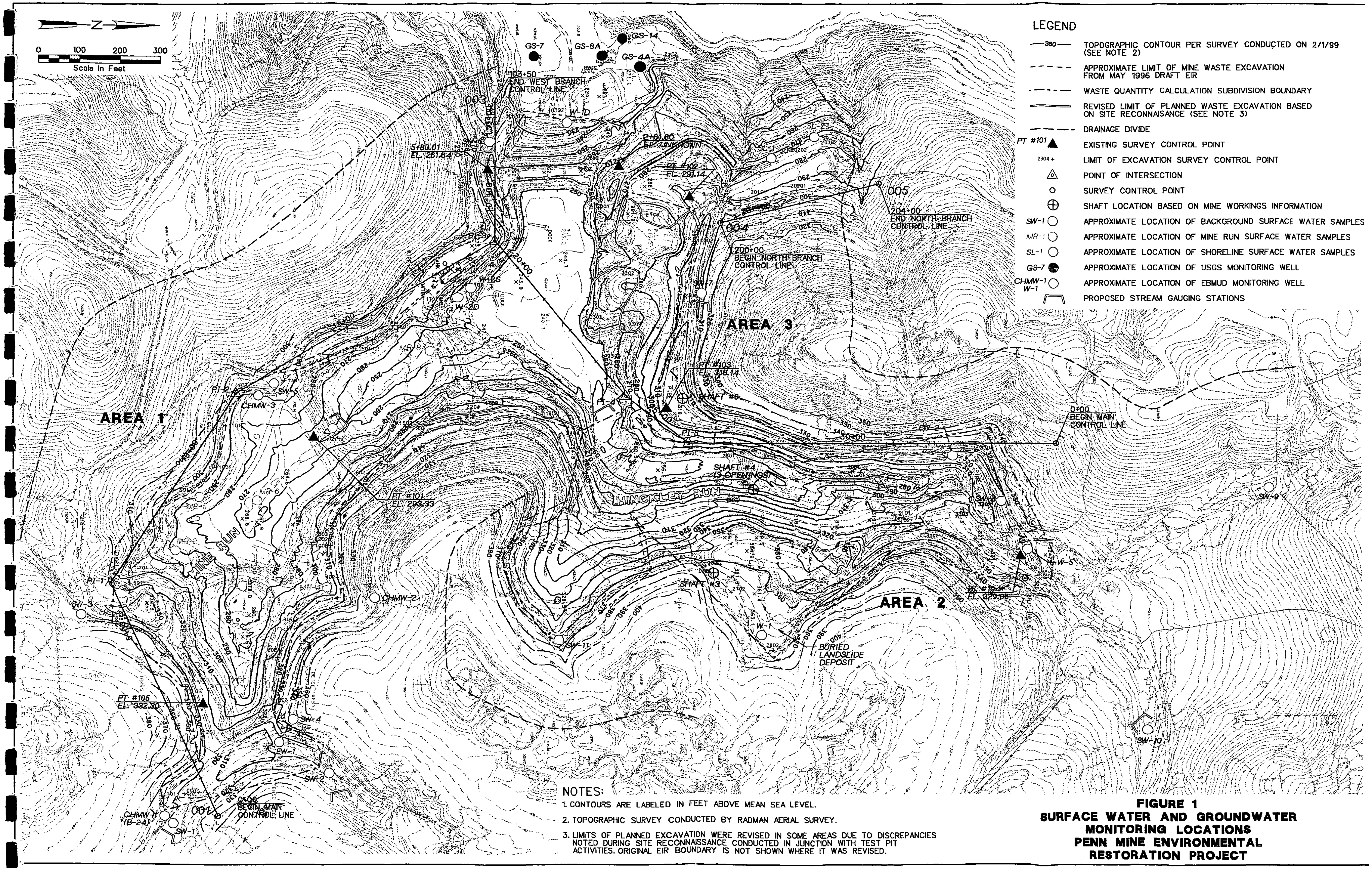


NOTES:

1. CONTOURS ARE LABELED IN FEET ABOVE MEAN SEA LEVEL.
2. TOPOGRAPHIC SURVEY CONDUCTED BY RADMAN AERIAL SURVEY.
3. LIMITS OF PLANNED EXCAVATION WERE REVISED IN SOME AREAS DUE TO DISCREPANCIES NOTED DURING SITE RECONNAISSANCE CONDUCTED IN JUNCTION WITH TEST PIT ACTIVITIES. ORIGINAL EIR BOUNDARY IS NOT SHOWN WHERE IT WAS REVISED.

**FIGURE 1**
**SURFACE WATER AND GROUNDWATER MONITORING LOCATIONS**
**PENN MINE ENVIRONMENTAL RESTORATION PROJECT**

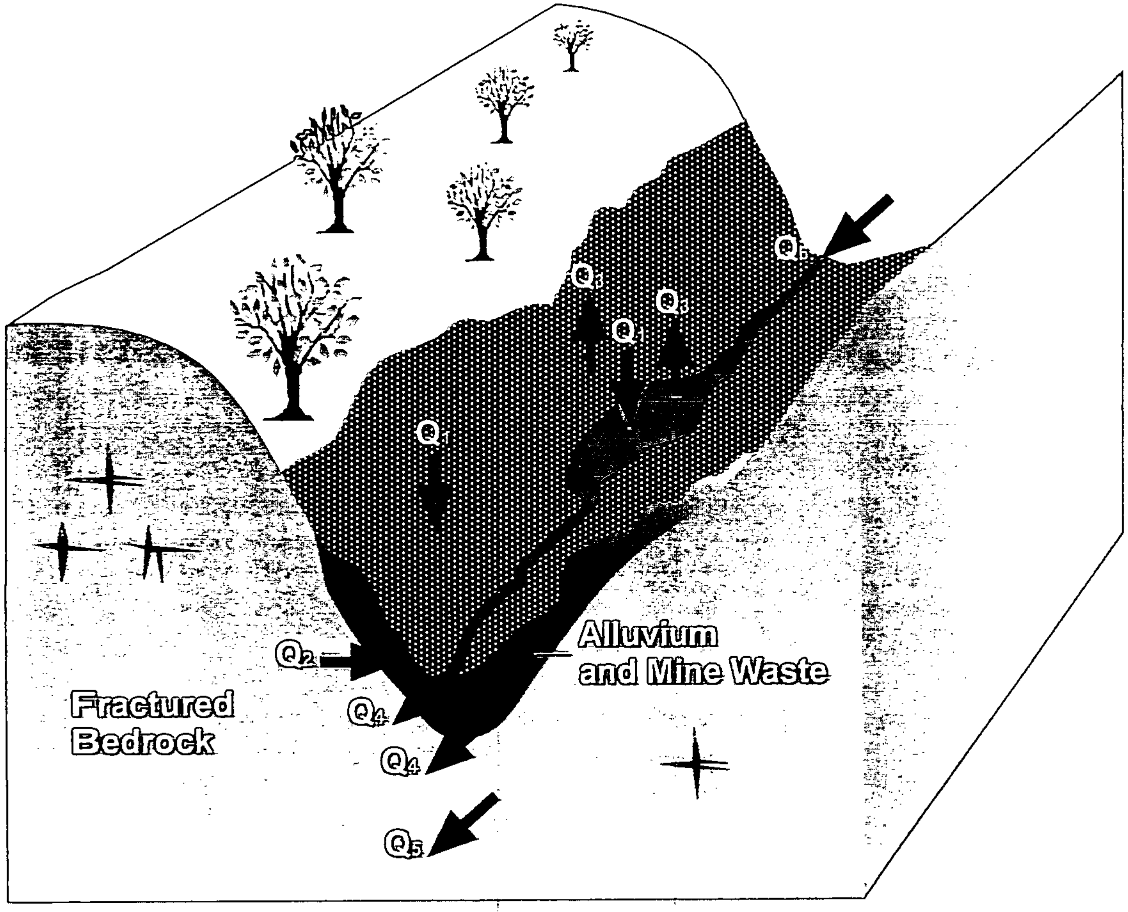


Figure 2
Pre-Restoration Conceptual Water Budget
Penn Mine Environmental Restoration Project

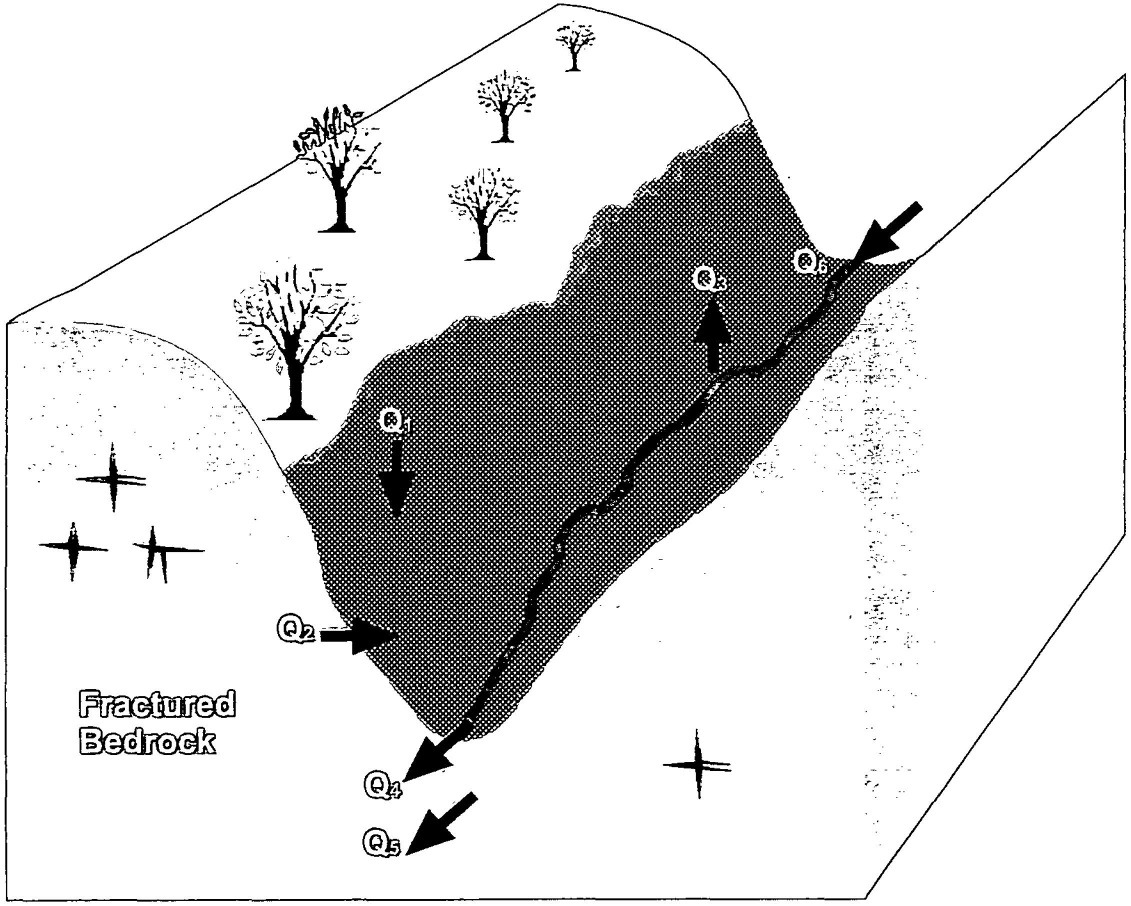


Figure 3
Restoration Period Conceptual Water Budget
Penn Mine Environmental Restoration Project

144069.08.45 • 144069.08.45 Restoration Period • 5/13/99 • mai • sfo

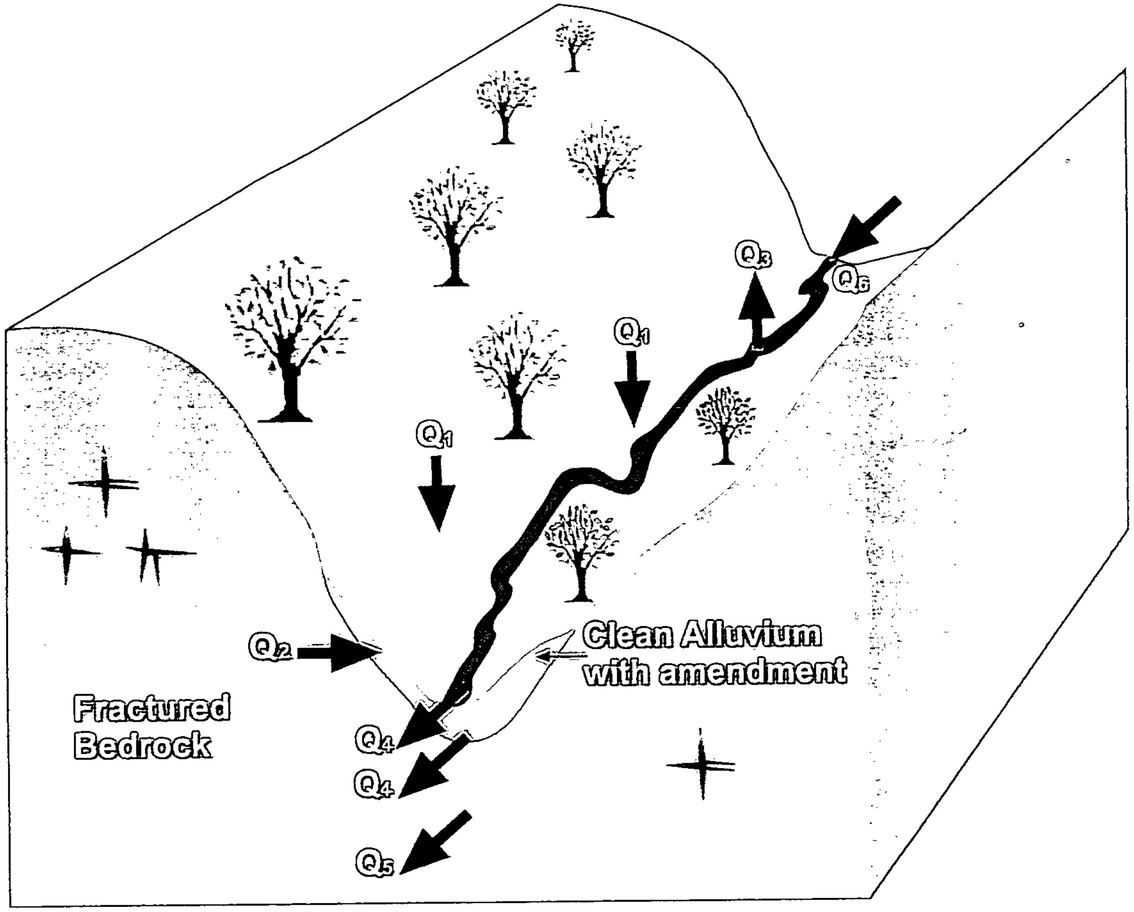


Figure 4
Post-Restoration Conceptual Water Budget
Penn Mine Environmental Restoration Project

# Appendix A

## Well Installation and Boring Logs

CH2MHILL

**PROJECT NUMBER** 144069.08.47

**WELL NUMBER** CHMW-2

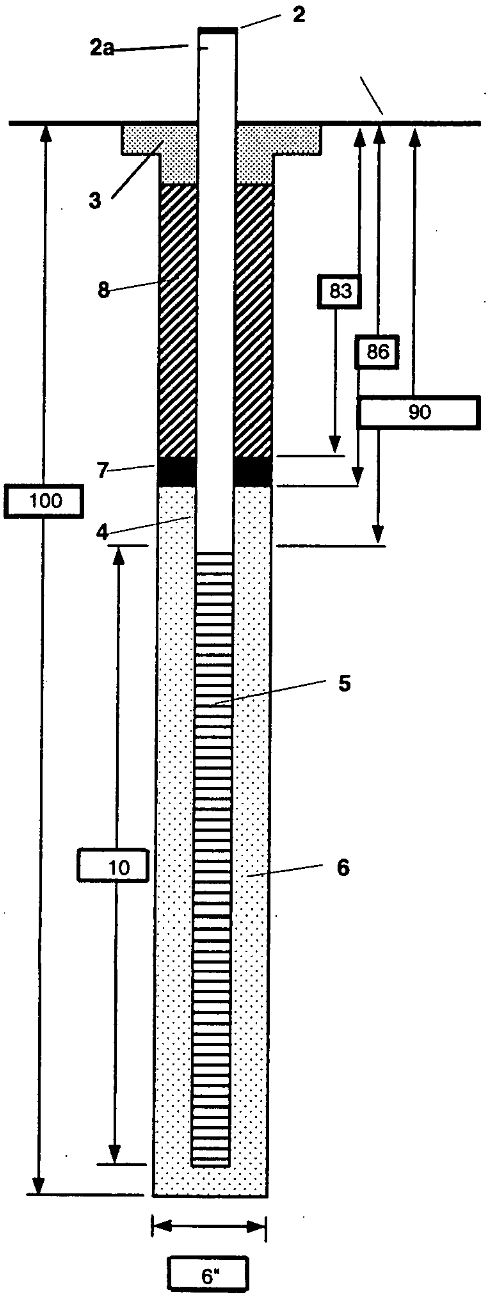
# WELL COMPLETION DIAGRAM

PROJECT Penn Mine Restoration Project LOCATION : Mine Run

DRILLING CONTRACT Hunt Drilling

DRILLING METHOD AND EQUIPMENT Air Percussion Casing Hammer Model TM-60

WATER LEVELS : START : END : LOGGER : M.Medina



1- Ground elevation at well

2- Top of casing elevation

3- Well head protection cover type 4" stove pipe

4- Dia./type of well casing 2-inch Schedule 40 PVC

5- Type/slot size of screen 0.01 inch

6- Type screen filter #2/12 sand

7- Type of seal Bentonite - Hole Plug - 3/8" chips
a) Quantity used

8- Grout neat cement
a) Method of placement tremie

Development method Surge and pump

Comments: Three centralizers used: one at the bottom of screen, one at top of screen, one near surface

**CH2MHILL**

| PROJECT NUMBER | WELL NUMBER |
|---|---|
| 144069.08.47 | CHMW-3 |

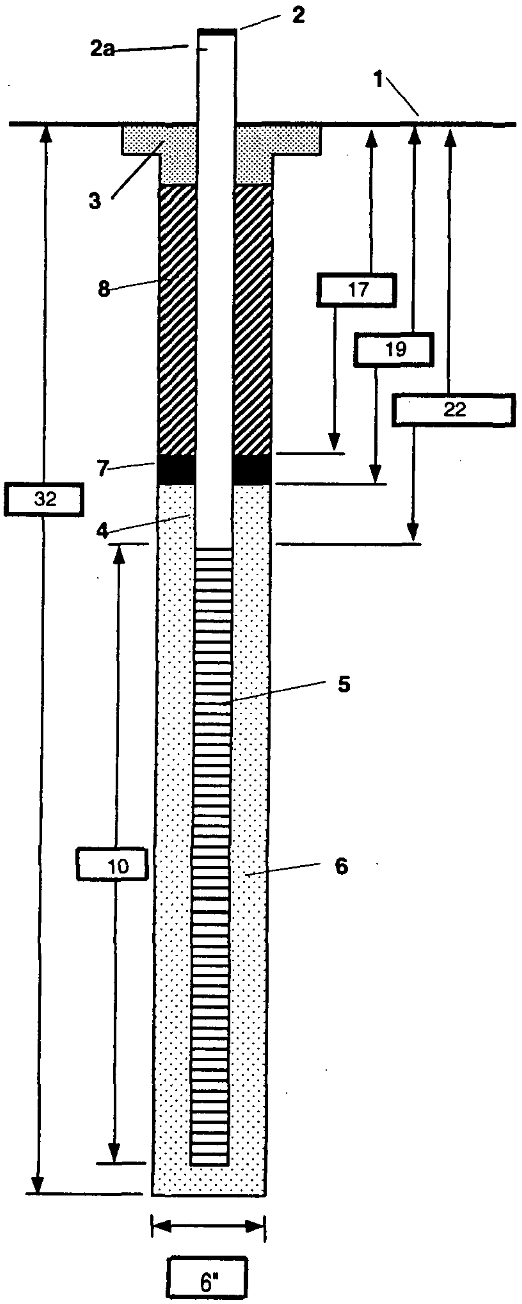
# WELL COMPLETION DIAGRAM

PROJECT Penn Mine Restoration Project LOCATION : Mine Run

DRILLING CONTRACT Hunt Drilling

DRILLING METHOD AND EQUIPMENT Air Percussion Casing Hammer Model TM-60

WATER LEVELS : START : END : LOGGER : M.Medina



1- Ground elevation at well

2- Top of casing elevation

3- Well head protection 4" stove pipe

4- Dia./type of well casing 2-inch Schedule 40 PVC

5- Type/slot size of screen 0.01 inch

6- Type screen filter #2/12 sand

7- Type of seal Bentonite - Hole Plug - 3/8" chips

8- Grout neat cement

a) Method of placement tremie

Development method Surge and pump

Comments: Centralizer used at bottom of screen

CH2MHILL

Project. Number: 144069.08.47

# SOIL BORING LOG

Project: Penn Mine

Drilling Contractor: Hunt Drilling

Drilling Method & Equipment: Air Percussion

Logger: M.Medina

| Depth Below Surface (FT) | Sample<br>Interval | Sample<br>Number and Type | Sample<br>Recovery (ft/ft) | Soil Description<br>Soil name, uscs group symbol, color, moisture content, relative density or consistency, soil structure, mineralogy | Comments<br>Depth of casing, drilling rate, drilling fluid loss, tests and instrumentation |
|---|---|---|---|---|---|
| Elevation: | | | | **Location: Mine Run** | **Boring No. CHMW-2** |
| Start: 9:35 | | | | Finish: 14:30 | Water Level: |
| | | | | | Sheet 4 of 4 |
| 90.0 | X | B | N/A | @ 90': cdark bluish gray (5PB, 4/1) | |
| 95.0 | X | B | N/A | | Driller estimates 3 gallons per minute production |
| 100.0 | X | B | N/A | **BORING TERMINATED AT 100 FEET BGS**<br>**BORING CONVERTED INTO MONITORING WELL** | |
| 105.0 | | | | | |
| 110.0 | | | | | |
| 115.0 | | | | | |
| 120.0 | | | | | |

CH2MHILL

Project. Number: 144069.08.47

# SOIL BORING LOG

Project: Penn Mine

Drilling Contractor: Hunt Drilling

Drilling Method & Equipment: Air Percussion

Logger: M.Medina

Elevation:

**Location: Mine Run**

**Boring No. CHMW-2**

Start: 9:35

Finish: 14:30

Water Level:

Sheet 1 of 4

| Depth Below Surface (FT) | Sample | | | Soil Description | Comments |
|---|---|---|---|---|---|
| | Interval | Number and Type | Recovery (ft/ft) | Soil name, uscs group symbol, color, moisture content, relative density or consistency, soil structure, mineralogy | Depth of casing, drilling rate, drilling fluid loss, tests and instrumentation |
| | | | | **SERICITE SCHIST,** light purplish brown, foliated, some soft clayey material between foliation, slightly greenish (possibly chlorite), some quartz fragment, dry | |
| 5.0 | X | B | N/A | | |
| 10.0 | X | B | N/A | | |
| 15.0 | X | B | N/A | | |
| 20.0 | X | B | N/A | **@ 20':** increase in purple color | |
| 25.0 | X | B | N/A | **@ 25':** yellowish (10YR, 7/6), increase in clay content | |
| 30.0 | X | B | N/A | | |

CH2MHILL

Project. Number: 144069.08.47

# SOIL BORING LOG

Project: Penn Mine

Drilling Contractor: Hunt Drilling

Drilling Method & Equipment: Air Percussion

Logger: M.Medina

Elevation:

**Location: Mine Run**

**Boring No. CHMW-2**

Start: 9:35

Finish: 14:30

Water Level:

Sheet 2 of 4

| Depth Below Surface (FT) | Sample |  |  | Soil Description | Comments |
|---|---|---|---|---|---|
|  | Interval | Number and Type | Recovery (ft/ft) | Soil name, uscs group symbol, color, moisture content, relative density or consistency, soil structure, mineralogy | Depth of casing, drilling rate, drilling fluid loss, tests and instrumentation |
| 30.0 | X | B | N/A | **@ 30'**: yellowish (10YR, 7/6), increase in clay content |  |
| 35.0 | X | B | N/A | **@ 35'**: very pale brown (10YR, 8/4) |  |
| 40.0 | X | B | N/A | **@ 40'**: 10% quartz |  |
| 45.0 | X | B | N/A | **@ 45': GREEN SCHIST;** light greenish gray (5GY,7/1), some sericite, chlorite, and quartz |  |
| 50.0 | X | B | N/A |  |  |
| 55.0 | X | B | N/A |  |  |
| 60.0 | X | B | N/A |  |  |

CH2MHILL

Project. Number: 144069.08.47

# SOIL BORING LOG

Project: Penn Mine

Drilling Contractor: Hunt Drilling

Drilling Method & Equipment: Air Percussion

Logger: M.Medina

Elevation:

**Location: Mine Run**

**Boring No. CHMW-2**

Start: 9:35

Finish: 14:30

Water Level:

Sheet 3 of 4

| Depth Below Surface (FT) | Sample | | | Soil Description | Comments |
|---|---|---|---|---|---|
| | Interval | Number and Type | Recovery (ft/ft) | Soil name, uscs group symbol, color, moisture content, relative density or consistency, soil structure, mineralogy | Depth of casing, drilling rate, drilling fluid loss, tests and instrumentation |
| 60.0 | X | B | N/A | **@ 60'**: light bluish gray (5B, 8/1), 70% quartz | |
| 65.0 | X | B | N/A | **@ 65'**: increase sericite | |
| 70.0 | X | B | N/A | | |
| 75.0 | X | B | N/A | **@ 75'**: bluish gray (10B, 6/1), 5-10% quartz | |
| 80.0 | X | B | N/A | **@ 80'**: dark bluish gray (5PB, 4/1), some pyrite | |
| 85.0 | X | B | N/A | **@ 85'**: trace pyrite | |
| | | | | | @ 87': First encountered groundwater |
| 90.0 | X | B | N/A | @ 90': no pyrite | |

CH2MHILL

Project. Number: 144069.08.47

# SOIL BORING LOG

Project: Penn Mine
Drilling Contractor: Hunt Drilling
Drilling Method & Equipment: Air Percussion
Logger: M.Medina

| Depth Below Surface (FT) | Sample | | | Soil Description | Comments |
|---|---|---|---|---|---|
| | Interval | Number and Type | Recovery (ft/ft) | Soil name, uscs group symbol, color, moisture content, relative density or consistency, soil structure, mineralogy | Depth of casing, drilling rate, drilling fluid loss, tests and instrumentation |
| Elevation: | | | | **Location:** | **Boring No. CHMW-3** |
| Start: 14:05 | | | | Finish: 14:30 | Water Level: |
| | | | | | Sheet 1 of 1 |
| | | | | **HIGHLY WEATHERED BEDROCK - METAVOLCANIC,** greenish gray (10Y, 6/1) with weathered dark reddish brown clay (5YR, 3/4), dry, 5-10% quartz, iron oxide staining, aphanitic textured | |
| 5.0 | X | | | **@ 5.':** less weathering, no iron oxide staining, greenish gray (10Y, 6/1), aphanitic textured | Quartz veins observed 30 feet northeast of boring within cut slope, approximately 7 feet bgs. Seep located at 15 feet bgs |
| 10.0 | X | | | **@ 10':** similar to above, trace quartz, aphanitic textured | |
| 15.0 | X | | | | |
| 20.0 | X | | | **@ 20': FRESH BEDROCK,** greenish gray (10GY, 5/1), aphanitic textured | @ 20': First encountered groundwater. |
| 25.0 | X | | | **@ 25':** greenish gray (5BG, 5/1) | |
| 30.0 | X | | | | |
| | | | | **BORING TERMINATED AT 32.0 FEET BGS**<br>**BORING CONVERTED INTO MONITORING WELL** | |
| 35.0 | | | | | |

# Appendix B

## Laboratory Reports

# Groundwater Samples

**CHROMALAB, INC.**
Environmental Services (SDB)

May 4, 1999 *Submission #:* 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 26, 1999

*re:* One sample for Miscellaneous Metals analysis.
*Method:* *EPA 3010A/3050A/6010A Nov 1990*

*Client Sample ID:* **W-2D**
*Spl#:* 238135 *Matrix:* WATER *Extracted:* April 30, 1999
*Sampled:* April 25, 1999 *Run#:* 18592 *Analyzed:* May 4, 1999

| **ANALYTE** | **RESULT (mg/L)** | **REPORTING LIMIT (mg/L)** | **BLANK RESULT (mg/L)** | **BLANK SPIKE (%)** | **DILUTION FACTOR** |
|---|---|---|---|---|---|
| COPPER | 0.0085 | 0.0050 | N.D. | 100 | 1 |
| IRON | N.D. | 0.10 | N.D. | 108 | 1 |
| ZINC | N.D. | 0.010 | N.D. | 102 | 1 |

Shafi Barekzai
Analyst

Eric Tam
Laboratory Director

**CHROMALAB, INC.**

Environmental Services (SDB)

May 4, 1999 *Submission #:* 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 26, 1999

*re:* One sample for Miscellaneous Metals analysis.
*Method:* *EPA 3010A/3050A/6010A Nov 1990*

*Client Sample ID:* **W-2S**
*Spl#:* 238136 *Matrix:* WATER *Extracted:* April 30, 1999
*Sampled:* April 25, 1999 *Run#:* 18592 *Analyzed:* May 4, 1999

| **ANALYTE** | **RESULT (mg/L)** | **REPORTING LIMIT (mg/L)** | **BLANK RESULT (mg/L)** | **BLANK SPIKE (%)** | **DILUTION FACTOR** |
|---|---|---|---|---|---|
| COPPER | 0.022 | 0.0050 | N.D. | 100 | 1 |
| IRON | N.D. | 0.10 | N.D. | 108 | 1 |
| ZINC | 0.38 | 0.010 | N.D. | 102 | 1 |

Shafi Barekzai
Analyst

Eric Tam
Laboratory Director

510-893-8205

# CHROMALAB, INC.

Environmental Services (SDB)

May 4, 1999 *Submission #:* 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 26, 1999

*re:* One sample for Miscellaneous Metals analysis.
*Method:* *EPA 3010A/3050A/6010A Nov 1990*

*Client Sample ID:* W-1
*Spl#:* 238137 *Matrix:* WATER *Extracted:* April 30, 1999
*Sampled:* April 25, 1999 *Run#:* 18592 *Analyzed:* May 4, 1999

| ANALYTE | RESULT (mg/L) | REPORTING LIMIT (mg/L) | BLANK RESULT (mg/L) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| COPPER | 0.10 | 0.0050 | N.D. | 100 | 1 |
| IRON | 29 | 0.10 | N.D. | 108 | 1 |
| ZINC | 0.14 | 0.010 | N.D. | 102 | 1 |

Shafi Barekzai
Analyst

Eric Tam
Laboratory Director

1220 Quarry Lane • Pleasanton, California 94566-4756
(925) 484-1919 • Facsimile (925) 484-1096
Federal ID #68-0140157

**CHROMALAB, INC.**

Environmental Services (SDB)

May 4, 1999 *Submission #:* 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 26, 1999

*re:* One sample for Miscellaneous Metals analysis.
*Method:* *EPA 3010A/3050A/6010A Nov 1990*

*Client Sample ID:* W-5
*Spl#:* 238138 *Matrix:* WATER *Extracted:* April 30, 1999
*Sampled:* April 25, 1999 *Run#:* 18592 *Analyzed:* May 4, 1999

| ANALYTE | RESULT (mg/L) | REPORTING LIMIT (mg/L) | BLANK RESULT (mg/L) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| COPPER | 0.11 | 0.0050 | N.D. | 100 | 1 |
| IRON | 0.76 | 0.10 | N.D. | 108 | 1 |
| ZINC | 0.84 | 0.010 | N.D. | 102 | 1 |

Shafi Barekzai
Analyst

Eric Tam
Laboratory Director

**CHROMALAB, INC.**

Environmental Services (SDB)

May 4, 1999 *Submission #:* 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 26, 1999

*re:* One sample for Miscellaneous Metals analysis.
*Method:* *EPA 3010A/3050A/6010A Nov 1990*

*Client Sample ID:* **CHMW-2**
*Spl#:* 238140 *Matrix:* WATER *Extracted:* April 30, 1999
*Sampled:* April 25, 1999 *Run#:* 18592 *Analyzed:* May 4, 1999

| **ANALYTE** | **RESULT (mg/L)** | **REPORTING LIMIT (mg/L)** | **BLANK RESULT (mg/L)** | **BLANK SPIKE (%)** | **DILUTION FACTOR** |
|---|---|---|---|---|---|
| COPPER | N.D. | 0.10 | N.D. | 100 | 20 |
| IRON | 130 | 2.0 | N.D. | 108 | 20 |
| ZINC | 110 | 0.20 | N.D. | 102 | 20 |

Shafi Barekzai
Analyst

Eric Tam
Laboratory Director

**CHROMALAB, INC.**

Environmental Services (SDB)

May 4, 1999 *Submission #:* 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 26, 1999

*re:* One sample for Miscellaneous Metals analysis.
*Method:* *EPA 3010A/3050A/6010A Nov 1990*

*Client Sample ID:* **CHMW-3**
*Spl#:* 238141 *Matrix:* WATER *Extracted:* April 30, 1999
*Sampled:* April 25, 1999 *Run#:* 18592 *Analyzed:* May 4, 1999

| ANALYTE | RESULT (mg/L) | REPORTING LIMIT (mg/L) | BLANK RESULT (mg/L) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| COPPER | 2.2 | 0.10 | N.D. | 100 | 20 |
| IRON | N.D. | 2.0 | N.D. | 108 | 20 |
| ZINC | 40 | 0.20 | N.D. | 102 | 20 |

Shafi Barekzai
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Eric Tam
Laboratory Director

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(925) 484-1919 • Facsimile (925) 484-1096
Federal ID #68-0140157

**CHROMALAB, INC.**
Environmental Services (SDB)

April 30, 1999 *Submission #:* 9904315

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 22, 1999

*re:* One sample for Miscellaneous Metals analysis.
*Method:* *EPA 3010A/3050A/6010A Nov 1990*

*Client Sample ID:* GS-7
*Spl#:* 237919 *Matrix:* WATER *Extracted:* April 26, 1999
*Sampled:* April 22, 1999 *Run#:* 18502 *Analyzed:* April 27, 1999

| ANALYTE | RESULT (mg/L) | REPORTING LIMIT (mg/L) | BLANK RESULT (mg/L) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| COPPER | 38 | 0.0050 | N.D. | 103 | 1 |
| IRON | 1.6 | 0.10 | N.D. | 99.4 | 1 |
| ZINC | 120 | 0.010 | N.D. | 106 | 1 |

Shafi Barekzai
Analyst

Michael Verona
Operations Manager

✓

**CHROMALAB, INC.**
Environmental Services (SDB)

April 30, 1999

*Submission #:* 9904315

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE
*Project#:* 10-467-01
*Received:* April 22, 1999

*re:* One sample for Miscellaneous Metals analysis.
*Method:* *EPA 3010A/3050A/6010A Nov 1990*

*Client Sample ID:* **GS8A**
*Spl#:* 237920
*Matrix:* WATER
*Extracted:* April 26, 1999
*Sampled:* April 22, 1999
*Run#:* 18502
*Analyzed:* April 27, 1999

| **ANALYTE** | **RESULT (mg/L)** | **REPORTING LIMIT (mg/L)** | **BLANK RESULT (mg/L)** | **BLANK SPIKE (%)** | **DILUTION FACTOR** |
|---|---|---|---|---|---|
| COPPER | 0.017 | 0.0050 | N.D. | 103 | 1 |
| IRON | 0.15 | 0.10 | N.D. | 99.4 | 1 |
| ZINC | 0.043 | 0.010 | N.D. | 106 | 1 |

Shafi Barekzai
Analyst

Michael Verona
Operations Manager

✓

**CHROMALAB, INC.**

Environmental Services (SDB)

April 30, 1999 *Submission #:* 9904315

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 22, 1999

*re:* One sample for Miscellaneous Metals analysis.
*Method: EPA 3010A/3050A/6010A Nov 1990*

*Client Sample ID:* **GS14**
*Spl#:* 237921 *Matrix:* WATER *Extracted:* April 26, 1999
*Sampled:* April 22, 1999 *Run#:* 18502 *Analyzed:* April 27, 1999

| **ANALYTE** | **RESULT (mg/L)** | **REPORTING LIMIT (mg/L)** | **BLANK RESULT (mg/L)** | **BLANK SPIKE (%)** | **DILUTION FACTOR** |
|---|---|---|---|---|---|
| COPPER | 42 | 0.0050 | N.D. | 103 | 1 |
| IRON | 40 | 0.10 | N.D. | 99.4 | 1 |
| ZINC | 140 | 0.010 | N.D. | 106 | 1 |

Shafi Barekzai
Analyst

Michael Verona
Operations Manager

510-893-8205 cc 04/30

M010 0.0C0405 JOHN 10:00

**CHROMALAB, INC.**

Environmental Services (SDB)

May 4, 1999

*Submission #:* 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE
*Project#:* 10-467-01
*Received:* April 26, 1999

*re:* One sample for Miscellaneous Metals analysis.
*Method:* *EPA 3010A/3050A/6010A Nov 1990*

*Client Sample ID:* G84A
*Spl#:* 238142
*Matrix:* WATER
*Extracted:* April 30, 1999
*Sampled:* April 25, 1999
*Run#:* 18592
*Analyzed:* May 4, 1999

| ANALYTE | RESULT (mg/L) | REPORTING LIMIT (mg/L) | BLANK RESULT (mg/L) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| COPPER | 0.12 | 0.10 | N.D. | 100 | 20 |
| IRON | N.D. | 2.0 | N.D. | 108 | 20 |
| ZINC | 17 | 0.20 | N.D. | 102 | 20 |

Shafi Barekzai
Analyst

Eric Tam
Laboratory Director

# CHROMALAB, INC.

Environmental Services (SDB)

May 4, 1999 *Submission #:* 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 26, 1999

*re:* One sample for Miscellaneous Metals analysis.
*Method:* *EPA 3010A/3050A/6010A Nov 1990*

*Client Sample ID:* **W1D**
*Spl#:* 238143 *Matrix:* WATER *Extracted:* April 30, 1999
*Sampled:* April 25, 1999 *Run#:* 18592 *Analyzed:* May 4, 1999

| ANALYTE | RESULT (mg/L) | REPORTING LIMIT (mg/L) | BLANK RESULT (mg/L) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| COPPER | 2.2 | 0.10 | N.D. | 100 | 20 |
| IRON | N.D. | 2.0 | N.D. | 108 | 20 |
| ZINC | 47 | 0.20 | N.D. | 102 | 20 |

Shafi Barekzai
Analyst

Eric Tam
Laboratory Director

**CHROMALAB, INC.**

Environmental Services (SDB)

May 4, 1999

**Submission #:** 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE

*Project#:* 10-467-01

*Received:* April 26, 1999

*re:* One sample for Miscellaneous Metals analysis.

*Method:* *EPA 3010A/3050A/6010A Nov 1990*

*Client Sample ID:* QC-2

*Spl#:* 238144 *Matrix:* WATER *Extracted:* April 30, 1999

*Sampled:* April 25, 1999 *Run#:* 18592 *Analyzed:* May 4, 1999

| ANALYTE | RESULT (mg/L) | REPORTING LIMIT (mg/L) | BLANK RESULT (mg/L) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| COPPER | N.D. | 0.0050 | N.D. | 100 | 1 |
| IRON | N.D. | 0.10 | N.D. | 108 | 1 |
| ZINC | N.D. | 0.010 | N.D. | 102 | 1 |

Shafi Barekzai
Analyst

Eric Tam
Laboratory Director

510-893-8205 cc 06/03

# CHROMALAB, INC.

Environmental Services (SDB)

May 4, 1999 *Submission #:* 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 26, 1999

*re:* One sample for Miscellaneous Metals analysis.
*Method:* *EPA 3010A/3050A/6010A Nov 1990*

*Client Sample ID:* QC-1
*Spl#:* 238139 *Matrix:* WATER *Extracted:* April 30, 1999
*Sampled:* April 25, 1999 *Run#:* 18592 *Analyzed:* May 4, 1999

| **ANALYTE** | **RESULT (mg/L)** | **REPORTING LIMIT (mg/L)** | **BLANK RESULT (mg/L)** | **BLANK SPIKE (%)** | **DILUTION FACTOR** |
|---|---|---|---|---|---|
| COPPER | 0.10 | 0.10 | N.D. | 100 | 20 |
| IRON | 130 | 2.0 | N.D. | 108 | 20 |
| ZINC | 110 | 0.20 | N.D. | 102 | 20 |

Shafi Barekzai
Analyst

Eric Tam
Laboratory Director

**CHROMALAB, INC.**
Environmental Services (SDB)

May 3, 1999 *Submission #:* 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 26, 1999

*re:* One sample for Soluble Miscellaneous Metals with Mercury analysis.
*Method:* *EPA 3005A/6010A/7470A Nov 1990*

*Client Sample ID:* W-2D
*Spl#:* 238145 *Matrix:* WATER *Extracted:* April 30, 1999
*Sampled:* April 25, 1999 *Run#:* 18576 *Analyzed:* April 30, 1999

| ANALYTE | RESULT (mg/L) | REPORTING LIMIT (mg/L) | BLANK RESULT (mg/L) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| COPPER | N.D. | 0.050 | N.D. | 99.6 | 10 |
| IRON | N.D. | 1.0 | N.D. | 113 | 10 |
| ZINC | N.D. | 0.10 | N.D. | 101 | 10 |

Christopher Arndt
Analyst

Michael Verona
Operations Manager

510-893-8205 GC 06/03

**CHROMALAB, INC.**

Environmental Services (SDB)

May 3, 1999 *Submission #:* 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 26, 1999

*re:* One sample for Soluble Miscellaneous Metals with Mercury analysis.
*Method:* *EPA 3005A/6010A/7470A Nov 1990*

*Client Sample ID:* **W-2S**
*Spl#:* 238146 *Matrix:* WATER *Extracted:* April 30, 1999
*Sampled:* April 25, 1999 *Run#:* 18576 *Analyzed:* April 30, 1999

| **ANALYTE** | **RESULT (mg/L)** | **REPORTING LIMIT (mg/L)** | **BLANK RESULT (mg/L)** | **BLANK SPIKE (%)** | **DILUTION FACTOR** |
|---|---|---|---|---|---|
| COPPER | 0.062 | 0.050 | N.D. | 99.6 | 10 |
| IRON | N.D. | 1.0 | N.D. | 113 | 10 |
| ZINC | 0.41 | 0.10 | N.D. | 101 | 10 |

Christopher Arndt
Analyst

Michael Verona
Operations Manager

510-893-8205 cc 05/03

M030 0:0C0405 JOHN 10::

**CHROMALAB, INC.**
Environmental Services (SDB)

May 3, 1999

*Submission #:* 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 26, 1999

*re:* One sample for Soluble Miscellaneous Metals with Mercury analysis.
*Method:* EPA 3005A/6010A/7470A Nov 1990

*Client Sample ID:* W-1
*Spl#:* 238147 *Matrix:* WATER *Extracted:* April 30, 1999
*Sampled:* April 25, 1999 *Run#:* 18576 *Analyzed:* April 30, 1999

| ANALYTE | RESULT (mg/L) | REPORTING LIMIT (mg/L) | BLANK RESULT (mg/L) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| COPPER | 0.10 | 0.050 | N.D. | 99.6 | 10 |
| IRON | 10 | 1.0 | N.D. | 113 | 10 |
| ZINC | N.D. | 0.10 | N.D. | 101 | 10 |

Christopher Arndt
Analyst

Michael Verona
Operations Manager

**CHROMALAB, INC.**
Environmental Services (SDB)

May 3, 1999 *Submission #:* 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 26, 1999

*re:* One sample for Soluble Miscellaneous Metals with Mercury analysis.
*Method:* *EPA 3005A/6010A/7470A Nov 1990*

*Client Sample ID:* **W-5**
*Spl#:* 238148 *Matrix:* WATER *Extracted:* April 30, 1999
*Sampled:* April 25, 1999 *Run#:* 18576 *Analyzed:* April 30, 1999

| ANALYTE | RESULT (mg/L) | REPORTING LIMIT (mg/L) | BLANK RESULT (mg/L) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| COPPER | 0.16 | 0.050 | N.D. | 99.6 | 10 |
| IRON | N.D. | 1.0 | N.D. | 113 | 10 |
| ZINC | 0.86 | 0.10 | N.D. | 101 | 10 |

Christopher Arndt
Analyst

Michael Verona
Operations Manager

**CHROMALAB, INC.**

Environmental Services (SDB)

May 3, 1999

Submission #: 9904340

CH2M HILL OAKLAND

Atten: Sam Brathwaite

*Project:* PENN MINE

*Project#:* 10-467-01

*Received:* April 26, 1999

*re:* One sample for Soluble Miscellaneous Metals with Mercury analysis.

*Method:* *EPA 3005A/6010A/7470A Nov 1990*

*Client Sample ID:* **CHMW-2**

*Spl#:* 238152

*Matrix:* WATER

*Extracted:* April 30, 1999

*Sampled:* April 25, 1999

*Run#:* 18576

*Analyzed:* April 30, 1999

| **ANALYTE** | **RESULT (mg/L)** | **REPORTING LIMIT (mg/L)** | **BLANK RESULT (mg/L)** | **BLANK SPIKE (%)** | **DILUTION FACTOR** |
|---|---|---|---|---|---|
| COPPER | 0.12 | 0.050 | N.D. | 99.6 | 10 |
| IRON | 140 | 1.0 | N.D. | 113 | 10 |
| ZINC | 120 | 0.10 | N.D. | 101 | 10 |

Christopher Arndt
Analyst

Michael Verona
Operations Manager

510-893-8205 GC 05/03

M030 0:000405 JOHN 10:34

**CHROMALAB, INC.**
Environmental Services (SDB)

May 3, 1999 *Submission #:* 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 26, 1999

*re:* One sample for Soluble Miscellaneous Metals with Mercury analysis.
*Method:* *EPA 3005A/6010A/7470A Nov 1990*

*Client Sample ID:* **CHMW-3**
*Spl#:* 238153 *Matrix:* WATER *Extracted:* April 30, 1999
*Sampled:* April 25, 1999 *Run#:* 18576 *Analyzed:* April 30, 1999

| **ANALYTE** | **RESULT (mg/L)** | **REPORTING LIMIT (mg/L)** | **BLANK RESULT (mg/L)** | **BLANK SPIKE (%)** | **DILUTION FACTOR** |
|---|---|---|---|---|---|
| COPPER | 2.3 | 0.050 | N.D. | 99.6 | 10 |
| IRON | N.D. | 1.0 | N.D. | 113 | 10 |
| ZINC | 39 | 0.10 | N.D. | 101 | 10 |

Christopher Arndt
Analyst

Michael Verona
Operations Manager

510-893-8205 cc 05/03

M030 0:000405 JOHN 10:34

# CHROMALAB, INC.

Environmental Services (SDB)

April 30, 1999 *Submission #:* 9904315

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 22, 1999

*re:* One sample for Soluble Miscellaneous Metals with Mercury analysis.
*Method:* *EPA 3005A/6010A/7470A Nov 1990*

*Client Sample ID:* **GS-7**
*Spl#:* 237922 *Matrix:* WATER *Extracted:* April 26, 1999
*Sampled:* April 22, 1999 *Run#:* 18484 *Analyzed:* April 26, 1999

| ANALYTE | RESULT (mg/L) | REPORTING LIMIT (mg/L) | BLANK RESULT (mg/L) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| COPPER | 37. | 0.0050 | 0.0098 | 101 | 1 |
| IRON | 1.8 | 0.10 | N.D. | 112 | 1 |
| ZINC | 120 | 0.010 | N.D. | 99.8 | 1 |

Christopher Arndt
Analyst

Michael Verona
Operations Manager

✓

**CHROMALAB, INC.**
Environmental Services (SDB)

April 30, 1999

*Submission #:* 9904315

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE
*Project#:* 10-467-01
*Received:* April 22, 1999

*re:* One sample for Soluble Miscellaneous Metals with Mercury analysis.
*Method:* *EPA 3005A/6010A/7470A Nov 1990*

*Client Sample ID:* **GS8A**
*Spl#:* 237923
*Matrix:* WATER
*Extracted:* April 26, 1999
*Sampled:* April 22, 1999
*Run#:* 18484
*Analyzed:* April 26, 1999

| ANALYTE | RESULT (mg/L) | REPORTING LIMIT (mg/L) | BLANK RESULT (mg/L) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| COPPER | 0.035 | 0.0050 | 0.0098 | 101 | 1 |
| IRON | N.D. | 0.10 | N.D. | 112 | 1 |
| ZINC | 0.084 | 0.010 | N.D. | 99.8 | 1 |

Christopher Arndt
Analyst

Michael Verona
Operations Manager

510-893-8205

**CHROMALAB, INC.**
Environmental Services (SDB)

April 30, 1999 *Submission #:* 9904315

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 22, 1999

*re:* One sample for Soluble Miscellaneous Metals with Mercury analysis.
*Method:* *EPA 3005A/6010A/7470A Nov 1990*

*Client Sample ID:* GS14
*Spl#:* 237924 *Matrix:* WATER *Extracted:* April 26, 1999
*Sampled:* April 22, 1999 *Run#:* 18484 *Analyzed:* April 26, 1999

| **ANALYTE** | **RESULT (mg/L)** | **REPORTING LIMIT (mg/L)** | **BLANK RESULT (mg/L)** | **BLANK SPIKE (%)** | **DILUTION FACTOR** |
|---|---|---|---|---|---|
| COPPER | 41 | 0.0050 | 0.0098 | 101 | 1 |
| IRON | 46 | 0.10 | N.D. | 112 | 1 |
| ZINC | 140 | 0.010 | N.D. | 99.8 | 1 |

Christopher Arndt
Analyst

Michael Verona
Operations Manager

**CHROMALAB, INC.**
Environmental Services (SDB)

May 3, 1999 *Submission #:* 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 26, 1999

*re:* One sample for Soluble Miscellaneous Metals with Mercury analysis.
*Method:* *EPA 3005A/6010A/7470A Nov 1990*

*Client Sample ID:* **GS4A**
*Spl#:* 238155 *Matrix:* WATER *Extracted:* April 30, 1999
*Sampled:* April 25, 1999 *Run#:* 18576 *Analyzed:* April 30, 1999

| **ANALYTE** | **RESULT (mg/L)** | **REPORTING LIMIT (mg/L)** | **BLANK RESULT (mg/L)** | **BLANK SPIKE (%)** | **DILUTION FACTOR** |
|---|---|---|---|---|---|
| COPPER | 0.15 | 0.050 | N.D. | 99.6 | 10 |
| IRON | N.D. | 1.0 | N.D. | 113 | 10 |
| ZINC | 15 | 0.10 | N.D. | 101 | 10 |

Christopher Arndt
Analyst

Michael Verona
Operations Manager

510-893-8205 GC 05103

M030 D:0C0405 JOHN 10:34

**CHROMALAB, INC.**
Environmental Services (SDB)

May 3, 1999 *Submission #:* 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 26, 1999

*re:* One sample for Soluble Miscellaneous Metals with Mercury analysis.
*Method:* *EPA 3005A/6010A/7470A Nov 1990*

*Client Sample ID:* **W1D**
*Spl#:* 238156 *Matrix:* WATER *Extracted:* April 30, 1999
*Sampled:* April 25, 1999 *Run#:* 18576 *Analyzed:* April 30, 1999

| ANALYTE | RESULT (mg/L) | REPORTING LIMIT (mg/L) | BLANK RESULT (mg/L) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| COPPER | 2.3 | 0.050 | N.D. | 99.6 | 10 |
| IRON | N.D. | 1.0 | N.D. | 113 | 10 |
| ZINC | 48 | 0.10 | N.D. | 101 | 10 |

Christopher Arndt
Analyst

Michael Verona
Operations Manager

**CHROMALAB, INC.**
Environmental Services (SDB)

May 3, 1999

*Submission #:* 9904340

CH2M HILL OAKLAND
*Atten:* Sam Brathwaite

*Project:* PENN MINE
*Received:* April 26, 1999

*Project#:* 10-467-01

*re:* One sample for Soluble Miscellaneous Metals with Mercury analysis.
*Method:* *EPA 3005A/6010A/7470A Nov 1990*

*Client Sample ID:* QC-1
*Spl#:* 238150
*Sampled:* April 25, 1999

*Matrix:* WATER
*Run#:* 18576

*Extracted:* April 30, 1999
*Analyzed:* April 30, 1999

| ANALYTE | RESULT (mg/L) | REPORTING LIMIT (mg/L) | BLANK RESULT (mg/L) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| COPPER | 0.14 | 0.050 | N.D. | 99.6 | 10 |
| IRON | 150 | 1.0 | N.D. | 113 | 10 |
| ZINC | 120 | 0.10 | N.D. | 101 | 10 |

Christopher Arndt
Analyst

Michael Verona
Operations Manager

**CHROMALAB, INC.**

Environmental Services (SDB)

May 3, 1999 *Submission #:* 9904340

CH2M HILL OAKLAND

*Atten:* Sam Brathwaite

*Project:* PENN MINE *Project#:* 10-467-01
*Received:* April 26, 1999

*re:* One sample for Soluble Miscellaneous Metals with Mercury analysis.
*Method:* *EPA 3005A/6010A/7470A Nov 1990*

*Client Sample ID:* **QC-2**
*Spl#:* 238157 *Matrix:* WATER *Extracted:* April 30, 1999
*Sampled:* April 25, 1999 *Run#:* 18576 *Analyzed:* April 30, 1999

| **ANALYTE** | **RESULT (mg/L)** | **REPORTING LIMIT (mg/L)** | **BLANK RESULT (mg/L)** | **BLANK SPIKE (%)** | **DILUTION FACTOR** |
|---|---|---|---|---|---|
| COPPER | 0.057 | 0.050 | N.D. | 99.6 | 10 |
| IRON | N.D. | 1.0 | N.D. | 113 | 10 |
| ZINC | N.D. | 0.10 | N.D. | 101 | 10 |

Christopher Arndt
Analyst

Michael Verona
Operations Manager

Sequoia
Analytical

680 Chesapeake Drive Redwood City, CA 94063 (650) 364-9600 FAX (650) 364-9233
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1551 Industrial Road San Carlos, CA 94070-4111 (650) 232-9600 FAX (650) 232-9612

Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566
Attention: Ken Wright

Client Proj. ID: 9904340
Lab Proj. ID: 9904A64

Received: 04/27/99
Reported: 05/05/99

## LABORATORY NARRATIVE

In order to properly interpret this report, it must be reproduced in its entirety. This report contains a total of 13 pages including the laboratory narrative, sample results, quality control, and related documents as required (cover page, COC, raw data, etc.).

SEQUOIA ANALYTICAL

oject Manager

Sequoia
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Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566

Attention: Ken Wright

Client Proj. ID: 9904340

Lab Proj. ID: 9904A64-01
Sample Descript: LIQUID,W-2D

Sampled: 04/25/99
Received: 04/27/99
Analyzed: see below

Reported: 05/05/99

## LABORATORY ANALYSIS

| Analyte | Units | Detection Limit | Method | Analyst | Date Analyzed | Sample Results |
|---|---|---|---|---|---|---|
| Alkalinity: Bicarbonate | mg CaCO3/L | 5.0 | SM 2320 | MYL | 05/03/99 | 350 |
| Sulfate | mg/L | 10 | EPA 300.0 | BE | 04/30/99 | 1700 |

alytes reported as N.D. were not present above the stated limit of detection.

**EQUOIA ANALYTICAL - ELAP #1210**

oject Manager

Please Note:
This sample was preserved in accordance with EPA approved preservation methods.

Sequoia
Analytical

| | | | |
|---|---|---|---|
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Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566

Attention: Ken Wright

Client Proj. ID: 9904340

Lab Proj. ID: 9904A64-02
Sample Descript: LIQUID,W-2S

Sampled: 04/25/99
Received: 04/27/99
Analyzed: see below

Reported: 05/05/99

## LABORATORY ANALYSIS

| Analyte | Units | Detection Limit | Method | Analyst | Date Analyzed | Sample Results |
|---|---|---|---|---|---|---|
| Alkalinity: Bicarbonate | mg CaCO3/L | 5.0 | SM 2320 | MYL | 05/03/99 | 280 |
| Sulfate | mg/L | 1.0 | EPA 300.0 | BE | 04/29/99 | 190 |

nalytes reported as N.D. were not present above the stated limit of detection.

**SEQUOIA ANALYTICAL** - ELAP #1210

roject Manager

Please Note:
This sample was preserved in accordance with EPA approved preservation methods.

Sequoia
Analytical

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Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566

Attention: Ken Wright

Client Proj. ID: 9904340
Lab Proj. ID: 9904A64-03
Sample Descript: LIQUID,W-1

Sampled: 04/25/99
Received: 04/27/99
Analyzed: see below
Reported: 05/05/99

## LABORATORY ANALYSIS

| Analyte | Units | Detection Limit | Method | Analyst | Date Analyzed | Sample Results |
|---|---|---|---|---|---|---|
| Alkalinity: Bicarbonate | mg CaCO3/L | 5.0 | SM 2320 | MYL | 05/03/99 | 64 |
| Sulfate | mg/L | 1.0 | EPA 300.0 | BE | 04/29/99 | 9.6 |

alytes reported as N.D. were not present above the stated limit of detection.

**EQUOIA ANALYTICAL** - ELAP #1210

oject Manager

Please Note:
This sample was preserved in accordance with EPA approved preservation methods.

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Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566

Attention: Ken Wright

Client Proj. ID: 9904340

Lab Proj. ID: 9904A64-04
Sample Descript: LIQUID,W-5

Sampled: 04/25/99
Received: 04/27/99
Analyzed: see below

Reported: 05/05/99

## LABORATORY ANALYSIS

| Analyte | Units | Detection Limit | Method | Analyst | Date Analyzed | Sample Results |
|---|---|---|---|---|---|---|
| **Alkalinity: Bicarbonate** | **mg CaCO3/L** | **5.0** | **SM 2320** | **MYL** | **05/03/99** | **66** |
| **Sulfate** | **mg/L** | **1.0** | **EPA 300.0** | **BE** | **04/29/99** | **20** |

nalytes reported as N.D. were not present above the stated limit of detection.

**SEQUOIA ANALYTICAL** - ELAP #1210

roject Manager

Please Note:
This sample was preserved in accordance with EPA approved preservation methods.

**Sequoia Analytical**

| | | | |
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Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566

Attention: Ken Wright

Client Proj. ID: 9904340
Lab Proj. ID: 9904A64-06
Sample Descript: LIQUID,CHMW-2

Sampled: 04/25/99
Received: 04/27/99
Analyzed: see below
Reported: 05/05/99

## LABORATORY ANALYSIS

| Analyte | Units | Detection Limit | Method | Analyst | Date Analyzed | Sample Results |
|---|---|---|---|---|---|---|
| Alkalinity: Bicarbonate | mg CaCO3/L | 5.0 | SM 2320 | MYL | 05/03/99 | N.D. |
| Sulfate | mg/L | 10 | EPA 300.0 | BE | 04/30/99 | 1400 |

nalytes reported as N.D. were not present above the stated limit of detection.

**SEQUOIA ANALYTICAL** - ELAP #1210

roject Manager

Please Note:
This sample was preserved in accordance with EPA approved preservation methods.

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Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566

Attention: Ken Wright

Client Proj. ID: 9904340

Lab Proj. ID: 9904A64-07
Sample Descript: LIQUID,CHMW-3

Sampled: 04/25/99
Received: 04/27/99
Analyzed: see below

Reported: 05/05/99

## LABORATORY ANALYSIS

| Analyte | Units | Detection Limit | Method | Analyst | Date Analyzed | Sample Results |
|---|---|---|---|---|---|---|
| Alkalinity: Bicarbonate | mg CaCO3/L | 5.0 | SM 2320 | MYL | 05/03/99 | 67 |
| Sulfate | mg/L | 100 | EPA 300.0 | BE | 04/30/99 | 3600 |

lytes reported as N.D. were not present above the stated limit of detection.

**EQUOIA ANALYTICAL • ELAP #1210**

oject Manager

Please Note:
This sample was preserved in accordance with EPA approved preservation methods.

Sequoia Analytical

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Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566

Attention: Ken Wright

Client Proj. ID: 9904340

Lab Proj. ID: 9904A64-08
Sample Descript: LIQUID,GS4A

Sampled: 04/25/99
Received: 04/27/99
Analyzed: see below

Reported: 05/05/99

## LABORATORY ANALYSIS

| Analyte | Units | Detection Limit | Method | Analyst | Date Analyzed | Sample Results |
|---|---|---|---|---|---|---|
| Alkalinity: Bicarbonate | mg CaCO3/L | 5.0 | SM 2320 | MYL | 05/03/99 | 110 |
| Sulfate | mg/L | 10 | EPA 300.0 | BE | 04/30/99 | 2100 |

nalytes reported as N.D. were not present above the stated limit of detection.

**EQUOIA ANALYTICAL** - ELAP #1210

oject Manager

Please Note:
This sample was preserved in accordance with EPA approved preservation methods.

**Sequoia Analytical**

| | | | |
|---|---|---|---|
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Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566

Attention: Ken Wright

Client Proj. ID: 9904340

Lab Proj. ID: 9904A64-09
Sample Descript: LIQUID,W1D

Sampled: 04/25/99
Received: 04/27/99
Analyzed: see below

Reported: 05/05/99

## LABORATORY ANALYSIS

| Analyte | Units | Detection Limit | Method | Analyst | Date Analyzed | Sample Results |
|---|---|---|---|---|---|---|
| Alkalinity: Bicarbonate | mg CaCO3/L | 5.0 | SM 2320 | MYL | 05/03/99 | 37 |
| Sulfate | mg/L | 10 | EPA 300.0 | BE | 04/30/98 | 1900 |

lytes reported as N.D. were not present above the stated limit of detection.

**EQUOIA ANALYTICAL** · ELAP #1210

ject Manager

Please Note:
This sample was preserved in accordance with EPA approved preservation methods

Sequoia
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1551 Industrial Road San Carlos, CA 94070-4111 (650) 232-9600 FAX (650) 232-9612

Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566

Attention: Ken Wright

Client Proj. ID: 9904340

Lab Proj. ID: 9904A64-05
Sample Descript: LIQUID,QC-1

Sampled: 04/25/99
Received: 04/27/99
Analyzed: see below

Reported: 05/05/99

## LABORATORY ANALYSIS

| Analyte | Units | Detection Limit | Method | Analyst | Date Analyzed | Sample Results |
|---|---|---|---|---|---|---|
| Alkalinity: Bicarbonate | mg CaCO3/L | 5.0 | SM 2320 | MYL | 05/03/99 | N.D. |
| Sulfate | mg/L | 10 | EPA 300.0 | BE | 04/30/99 | 1400 |

nalytes reported as N.D. were not present above the stated limit of detection.

**EQUOIA ANALYTICAL** - ELAP #1210

Please Note:
This sample was preserved in accordance with EPA approved preservation methods.

oject Manager

**Sequoia Analytical**

|  |  |  |  |
|---|---|---|---|
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| 1551 Industrial Road | San Carlos, CA 94070-4111 | (650) 232-9600 | FAX (650) 232-9612 |

Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566
Attention: Ken Wright

Client Project ID: 9904340

QC Sample Group: 9904A64-01 thru -09

Reported: May 5, 1999

## QUALITY CONTROL DATA REPORT

**Matrix:** Liquid
**Method:** EPA 310.2
**Analyst:** M.Lavrenko

**ANALYTE** Alkalinity

**QC Batch #:** IN0503993102FIA

**Sample No.:** 9904A63-1
**Date Prepared:** 5/3/99
**Date Analyzed:** 5/3/99
**Instrument I.D.#:** FIA

**Sample Conc., mg/L:** 55
**Conc. Spiked, mg/L:** 100

**Matrix Spike, mg/L:** 160
**% Recovery:** 101

**Matrix**
**pike Duplicate, mg/L:** 160
**% Recovery:** 105

**elative % Difference:** 3.9

**RPD Control Limits:** 0-20

---

**LCS Batch#:** LCS050399

**Date Prepared:** 5/3/99
**Date Analyzed:** 5/3/99
**Instrument I.D.#:** FIA

**Conc. Spiked, mg/L:** 200

**LCS Recovery, mg/L:** 200
**LCS % Recovery:** 100

**Percent Recovery Control Limits:**

|  |  |
|---|---|
| MS/MSD | 75-125 |
| LCS | 80-120 |

Quality Assurance Statement: All standard operating procedures and quality control requirements have been met.

Please Note:
The LCS is a control sample of known, interferent free matrix that is analyzed using the same reagents, preparation, and analytical methods employed for the samples. The matrix spike is an aliquot of sample fortified with known quantities of specific compounds and subjected to the entire analytical procedure. If the recovery of analytes from the matrix spike does not fall within specified control limits due to matrix interference, the LCS recovery is to be used to validate the batch.

**SEQUOIA ANALYTICAL**

Kayvan Kimyai
Project Manager

Sequoia Analytical
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Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566
Attention: Ken Wright

Client Project ID: 9904340

QC Sample Group: 9904A64-01 thru -09

Reported: May 5, 1999

## QUALITY CONTROL DATA REPORT

**Matrix:** Liquid
**Method:** EPA 300.0
**Analyst:** BE

| ANALYTE | Fluoride | Chloride | Nitrite | Bromide | Nitrate | Phosphate | Sulfate |
|---|---|---|---|---|---|---|---|
| QC Batch #: | IN0430993000ACA | | | | | | |
| Sample No.: | 9904A86-1C | | | | | | |
| Data Prepared: | 4/30/99 | 4/30/99 | 4/30/99 | 4/30/99 | 4/30/99 | 4/30/99 | 4/30/99 |
| Date Analyzed: | 4/30/99 | 4/30/99 | 4/30/99 | 4/30/99 | 4/30/99 | 4/30/99 | 4/30/99 |
| Instrument I.D.#: | INAC1 | INAC1 | INAC1 | INAC1 | INAC1 | INAC1 | INAC1 |
| Sample Conc., mg/L: | N.D. | 180 | 40 | N.D. | 520 | 56 | 120 |
| Conc. Spiked, mg/L: | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 |
| Matrix Spike, mg/L: | 1000 | 1100 | 970 | 920 | 1500 | 930 | 1000 |
| % Recovery: | 100.0 | 92 | 93 | 92 | 98 | 87 | 88 |
| Matrix Spike Duplicate, mg/L: | 1000 | 1100 | 960 | 910 | 1500 | 920 | 980 |
| % Recovery: | 100.0 | 92 | 92 | 91 | 98 | 86 | 86 |
| Relative % Difference: | 0.0 | 0.0 | 1.1 | 1.1 | 0.0 | 1.2 | 2.3 |
| RPD Control Limits: | 0-20 | 0-20 | 0-20 | 0-20 | 0-20 | 0-20 | 0-20 |

| LCS Batch#: | LCS0430993000ACA | | | | | | |
|---|---|---|---|---|---|---|---|
| Date Prepared: | 4/30/99 | 4/30/99 | 4/30/99 | 4/30/99 | 4/30/99 | 4/30/99 | 4/30/99 |
| Date Analyzed: | 4/30/99 | 4/30/99 | 4/30/99 | 4/30/99 | 4/30/99 | 4/30/99 | 4/30/99 |
| Instrument I.D.#: | INAC1 | INAC1 | INAC1 | INAC1 | INAC1 | INAC1 | INAC1 |
| Conc. Spiked, mg/L: | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| LCS Recovery, mg/L: | 11 | 9.7 | 10.0 | 9.5 | 9.8 | 9.5 | 9.8 |
| LCS % Recovery: | 109 | 97 | 100.0 | 95 | 98 | 95 | 98 |

**Percent Recovery Control Limits:**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| MS/MSD | 75-125 | 75-125 | 75-125 | 75-125 | 75-125 | 75-125 | 75-125 |
| LCS | 90-110 | 90-110 | 90-110 | 90-110 | 90-110 | 90-110 | 90-110 |

Quality Assurance Statement: All standard operating procedures and quality control requirements have been met.

Please Note:
The LCS is a control sample of known, interferent free matrix that is analyzed using the same reagents, preparation, and analytical methods employed for the samples. The matrix spike is an aliquot of sample fortified with known quantities of specific compounds and subjected to the entire analytical procedure. If the recovery of analytes from the matrix spike does not fall within specified control limits due to matrix interference, the LCS recovery is to be used to validate the batch.

SEQUOIA ANALYTICAL

Kayvan Kimyai
Project Manager

# CHROMALAB, INC.

Environmental Services (SDB) (DOHS 1094)

Lab: Sequoia

1220 Quarry Lane • Pleasanton, California 94566-4756
510/484-1919 • Facsimile 510/484-1096

## Sub-Contract
## Chain of Custody

DATE 4/27/99 PAGE 1 of 2

PROJ. MGR. Ken Wright
COMPANY
ADDRESS
9904344
SAMPLERS (SIGNATURE) (PHONE NO.)
(FAX NO.)

ANALYSIS REPORT

| SAMPLE I.D. | DATE | TIME | MATRIX | PRESRV. | Bicarbonate & Sulfate | | ChromaLab Reference or Submission Number(s) | NUMBER OF CONTAINERS |
|---|---|---|---|---|---|---|---|---|
| W-2D | 4/25/99 | | W | | X | 01 | 9904340 | 1 |
| W-2S | | | | | | 02 | | 1 |
| W-1 | | | | | | 03 | | 1 |
| W-5 | | | | | | 04 | | 1 |
| QC-1 | | | | | | 05 | | 1 |
| CHMW-2 | | | | | | 06 | | 1 |
| CHMW-3 | | | | | | 07 | | 1 |
| GS4A | | | | | | 08 | | 1 |
| W1D | | | | | | 09 | | 1 |

**PROJECT INFORMATION**

PROJECT NAME 9904340
PROJECT NUMBER
P.O. #

**SAMPLE RECEIPT**

| | |
|---|---|
| TOTAL NO. OF CONTAINERS | 10 |
| HEAD SPACE | |
| REC'D GOOD CONDITION/COLD | |
| CONFORMS TO RECORD | |

TAT [✓ STANDARD 5-DAY] 24 48 72 OTHER

SPECIAL INSTRUCTIONS/COMMENTS:

RELINQUISHED BY 1
(SIGNATURE) (TIME)
A Hardes (PRINTED NAME) 4/27/99 (DATE)
Chromalab (COMPANY)

RELINQUISHED BY 2
(SIGNATURE) (TIME)
(PRINTED NAME) (DATE)
(COMPANY)

RELINQUISHED BY 3
(SIGNATURE) (TIME)
(PRINTED NAME) (DATE)
(COMPANY)

RECEIVED BY 1
(SIGNATURE) (TIME)
A N Dewsley (PRINTED NAME) 1453 4-27 (DATE)
Sequoia (COMPANY)

RECEIVED BY 2
(SIGNATURE) (TIME)
(PRINTED NAME) (DATE)
(COMPANY)

RECEIVED BY (LABORATORY) 3
(SIGNATURE) 1629 (TIME)
Sequoia
E. C. Blanco (PRINTED NAME) 4-27-99 (DATE)
(LAB)

Sequoia
Analytical

| | | | |
|---|---|---|---|
| 680 Chesapeake Drive | Redwood City, CA 94063 | (650) 364-9600 | FAX (650) 364-9233 |
| 404 N. Wiget Lane | Walnut Creek, CA 94598 | (925) 988-9600 | FAX (925) 988-9673 |
| 819 Striker Avenue, Suite 8 | Sacramento, CA 95834 | (916) 921-9600 | FAX (916) 921-0100 |
| 1455 McDowell Blvd. North, Ste. D | Petaluma, CA 94954 | (707) 792-1865 | FAX (707) 792-0342 |
| 1551 Industrial Road | San Carlos, CA 94070-4111 | (650) 232-9600 | FAX (650) 232-9612 |

Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566
Attention: Ken Wright

Client Proj. ID: 45676
Lab Proj. ID: 9904979

Received: 04/24/99
Reported: 05/05/99

## LABORATORY NARRATIVE

In order to properly interpret this report, it must be reproduced in its entirety. This report contains a total of 7 pages including the laboratory narrative, sample results, quality control, and related documents as required (cover page, COC, raw data, etc.).

**SEQUOIA ANALYTICAL**

Project Manager

Sequoia
Analytical

680 Chesapeake Drive | Redwood City, CA 94063 | (650) 364-9600 | FAX (650) 364-9233
404 N. Wiget Lane | Walnut Creek, CA 94598 | (925) 988-9600 | FAX (925) 988-9673
819 Striker Avenue, Suite 8 | Sacramento, CA 95834 | (916) 921-9600 | FAX (916) 921-0100
1455 McDowell Blvd. North, Ste. D | Petaluma, CA 94954 | (707) 792-1865 | FAX (707) 792-0342
1551 Industrial Road | San Carlos, CA 94070-4111 | (650) 232-9600 | FAX (650) 232-9612

Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566

Attention: Ken Wright

Client Proj. ID: 45676

Lab Proj. ID: 9904979-01
Sample Descript: LIQUID,GS-7

Sampled: 04/22/99
Received: 04/24/99
Analyzed: see below

Reported: 05/05/99

## LABORATORY ANALYSIS

| Analyte | Units | Detection Limit | Method | Analyst | Date Analyzed | Sample Results |
|---|---|---|---|---|---|---|
| Alkalinity: Bicarbonate | mg CaCO3/L | 5.0 | SM 2320 | MYL | 04/30/99 | N.D. |
| **Sulfate** | **mg/L** | **10** | **EPA 300.0** | **BE** | **04/29/99** | **3000** |

Analytes reported as N.D. were not present above the stated limit of detection.

**SEQUOIA ANALYTICAL** - ELAP #1210

Please Note:
This sample was preserved in accordance with EPA approved preservation methods.

Project Manager

Sequoia Analytical

680 Chesapeake Drive Redwood City, CA 94063 (650) 364-9600 FAX (650) 364-9233
404 N. Wiget Lane Walnut Creek, CA 94598 (925) 988-9600 FAX (925) 988-9673
819 Striker Avenue, Suite 8 Sacramento, CA 95834 (916) 921-9600 FAX (916) 921-0100
1455 McDowell Blvd. North, Ste. D Petaluma, CA 94954 (707) 792-1865 FAX (707) 792-0342
1551 Industrial Road San Carlos, CA 94070-4111 (650) 232-9600 FAX (650) 232-9612

Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566

Attention: Ken Wright

Client Proj. ID: 45676

Lab Proj. ID: 9904979-02
Sample Descript: LIQUID,GS-8A

Sampled: 04/22/99
Received: 04/24/99
Analyzed: see below

Reported: 05/05/99

## LABORATORY ANALYSIS

| Analyte | Units | Detection Limit | Method | Analyst | Date Analyzed | Sample Results |
|---|---|---|---|---|---|---|
| Alkalinity: Bicarbonate | mg CaCO3/L | 5.0 | SM 2320 | MYL | 04/30/99 | 37 |
| Sulfate | mg/L | 1.0 | EPA 300.0 | BE | 04/28/99 | 200 |

nalytes reported as N.D. were not present above the stated limit of detection.

**EQUOIA ANALYTICAL** - ELAP #1210

roject Manager

Please Note:
This sample was preserved in accordance with EPA approved preservation methods.

Sequoia Analytical

680 Chesapeake Drive Redwood City, CA 94063 (650) 364-9600 FAX (650) 364-9233
404 N. Wiget Lane Walnut Creek, CA 94598 (925) 988-9600 FAX (925) 988-9673
819 Striker Avenue, Suite 8 Sacramento, CA 95834 (916) 921-9600 FAX (916) 921-0100
1455 McDowell Blvd. North, Ste. D Petaluma, CA 94954 (707) 792-1865 FAX (707) 792-0342
1551 Industrial Road San Carlos, CA 94070-4111 (650) 232-9600 FAX (650) 232-9612

Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566

Attention: Ken Wright

Client Proj. ID: 45676
Lab Proj. ID: 9904979-03
Sample Descript: LIQUID,GS-14

Sampled: 04/22/99
Received: 04/24/99
Analyzed: see below
Reported: 05/05/99

## LABORATORY ANALYSIS

| Analyte | Units | Detection Limit | Method | Analyst | Date Analyzed | Sample Results |
|---|---|---|---|---|---|---|
| Alkalinity: Bicarbonate | mg CaCO3/L | 5.0 | SM 2320 | MYL | 04/30/99 | 47 |
| Sulfate | mg/L | 100 | EPA 300.0 | BE | 04/30/99 | 3400 |

Analytes reported as N.D. were not present above the stated limit of detection.

**SEQUOIA ANALYTICAL** - ELAP #1210

Project Manager

Please Note:
This sample was preserved in accordance with EPA approved preservation methods.

Sequoia
Analytical

680 Chesapeake Drive Redwood City, CA 94063 (650) 364-9600 FAX (650) 364-9233
404 N. Wiget Lane Walnut Creek, CA 94598 (925) 988-9600 FAX (925) 988-9673
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1455 McDowell Blvd. North, Ste. D Petaluma, CA 94954 (707) 792-1865 FAX (707) 792-0342
1551 Industrial Road San Carlos, CA 94070-4111 (650) 232-9600 FAX (650) 232-9612

Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566
Attention: Ken Wright

Client Project ID: 45676

QC Sample Group: 9904979-01 thru -03

Reported: May 5, 1999

## QUALITY CONTROL DATA REPORT

**Matrix:** Liquid
**Method:** EPA 310.2
**Analyst:** M.Lavrenko

**ANALYTE** Alkalinity

**QC Batch #:** IN0430993102FIA

**Sample No.:** 9904979-1
**Date Prepared:** 4/30/99
**Date Analyzed:** 4/30/99
**Instrument I.D.#:** FIA

**Sample Conc., mg/L:**
**Conc. Spiked, mg/L:** 50

**Matrix Spike, mg/L:** 26
**% Recovery:** 51

**Matrix**
**pike Duplicate, mg/L:** 33
**% Recovery:** 65

**elative % Difference:** 24

**RPD Control Limits:** 0-20

---

**LCS Batch#:** LCS043099

**Date Prepared:** 4/30/99
**Date Analyzed:** 4/30/99
**Instrument I.D.#:** FIA

**Conc. Spiked, mg/L:** 200

**LCS Recovery, mg/L:** 200
**LCS % Recovery:** 102

**Percent Recovery Control Limits:**

| | |
|---|---|
| MS/MSD | 75-125 |
| LCS | 80-120 |

Quality Assurance Statement: All standard operating procedures and quality control requirements have been met.

**SEQUOIA ANALYTICAL**

Kayvan Kimyai
Project Manager

Please Note:
The LCS is a control sample of known, interferent free matrix that is analyzed using the same reagents, preparation, and analytical methods employed for the samples. The matrix spike is an aliquot of sample fortified with known quantities of specific compounds and subjected to the entire analytical procedure. If the recovery of analytes from the matrix spike does not fall within specified control limits due to matrix interference, the LCS recovery is to be used to validate the batch.

Sequoia Analytical

680 Chesapeake Drive Redwood City, CA 94063 (650) 364-9600 FAX (650) 364-9233
404 N. Wiget Lane Walnut Creek, CA 94598 (925) 988-9600 FAX (925) 988-9673
819 Striker Avenue, Suite 8 Sacramento, CA 95834 (916) 921-9600 FAX (916) 921-0100
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1551 Industrial Road San Carlos, CA 94070-4111 (650) 232-9600 FAX (650) 232-9612

Chromalab, Inc.
1220 Quarry Lane
Pleasanton, CA 94566
Attention: Ken Wright

Client Project ID: 45676

QC Sample Group: 9904979-01 thru -03

Reported: May 5, 1999

# QUALITY CONTROL DATA REPORT

**Matrix:** Liquid
**Method:** EPA 300.0
**Analyst:** BE

| **ANALYTE** | Fluoride | Chloride | Nitrite | Bromide | Nitrate | Phosphate | Sulfate |
|---|---|---|---|---|---|---|---|
| **QC Batch #:** | IN0429993000ACB | | | | | | |
| **Sample No.:** | 9904979-1A | | | | | | |
| **Date Prepared:** | 4/29/99 | 4/29/99 | 4/29/99 | 4/29/99 | 4/29/99 | 4/29/99 | 4/29/99 |
| **Date Analyzed:** | 4/29/99 | 4/29/99 | 4/29/99 | 4/29/99 | 4/29/99 | 4/29/99 | 4/29/99 |
| **Instrument I.D.#:** | INAC1 | INAC1 | INAC1 | INAC1 | INAC1 | INAC1 | INAC1 |
| **Sample Conc., mg/L:** | 5.1 | 60 | N.D. | N.D. | N.D. | N.D. | 3000 |
| **Conc. Spiked, mg/L:** | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 |
| **Matrix Spike, mg/L:** | 1000 | 910 | 950 | 900 | 910 | 680 | 4200 |
| **% Recovery:** | 99 | 85 | 95 | 90 | 91 | 68 | 120 |
| **Matrix Spike Duplicate, mg/L:** | 1000 | 920 | 950 | 900 | 920 | 710 | 4300 |
| **% Recovery:** | 99 | 86 | 95 | 90 | 92 | 71 | 130 |
| **Relative % Difference:** | 0.0 | 1.2 | 0.0 | 0.0 | 1.1 | 4.3 | 8.0 |
| **RPD Control Limits:** | 0-20 | 0-20 | 0-20 | 0-20 | 0-20 | 0-20 | 0-20 |
| **LCS Batch#:** | LCS0430993000ACB | | | | | | |
| **Date Prepared:** | 4/29/99 | 4/29/99 | 4/29/99 | 4/29/99 | 4/29/99 | 4/29/99 | 4/29/99 |
| **Date Analyzed:** | 4/29/99 | 4/29/99 | 4/29/99 | 4/29/99 | 4/29/99 | 4/29/99 | 4/29/99 |
| **Instrument I.D.#:** | INAC1 | INAC1 | INAC1 | INAC1 | INAC1 | INAC1 | INAC1 |
| **Conc. Spiked, mg/L:** | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| **LCS Recovery, mg/L:** | 10.0 | 9.1 | 9.5 | 9.0 | 9.1 | 8.4 | 9.1 |
| **LCS % Recovery:** | 100.0 | 91 | 95 | 90 | 91 | 84 | 91 |

**Percent Recovery Control Limits:**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| MS/MSD | 75-125 | 75-125 | 75-125 | 75-125 | 75-125 | 75-125 | 75-125 |
| LCS | 90-110 | 90-110 | 90-110 | 90-110 | 90-110 | 90-110 | 90-110 |

Quality Assurance Statement: All standard operating procedures and quality control requirements have been met.

Please Note:
The LCS is a control sample of known, interferent free matrix that is analyzed using the same reagents, preparation, and analytical methods employed for the samples. The matrix spike is an aliquot of sample fortified with known quantities of specific compounds and subjected to the entire analytical procedure. If the recovery of analytes from the matrix spike does not fall within specified control limits due to matrix interference, the LCS recovery is to be used to validate the batch.

**SEQUOIA ANALYTICAL**

Kayvan Kimyai
Project Manager

: 24 76

Sub Contract

# CHROMALAB, INC.

Environmental Services (SDB) (DOHS 1094)

1220 Quarry Lane • Pleasanton, California 94566-4756
510/484-1919 • Facsimile 510/484-1096

## Chain of Custody

DATE 4/22/99 PAGE 1 OF 1

PROJ MGR Ken Wright

COMPANY

ADDRESS 9904979

SAMPLERS (SIGNATURE)

(PHONE NO.)

(FAX NO.)

ANALYSIS REPORT

| | SAMPLE ID. | DATE | TIME | MATRIX | PRESERV. | Bicarbonate | Sulfate | ChromaLab Reference or Submission Number(s) | NUMBER OF CONTAINERS |
|---|---|---|---|---|---|---|---|---|---|
| 01 | GS-7 | 4/22/99 | | W | Vary | X | X | 45676 | 2 |
| 02 | GS8A | ↓ | | ↓ | ↓ | ↓ | ↓ | | 2 |
| 03 | GS14 | | | | | | | ↓ | 2 |

PROJECT INFORMATION

PROJECT NAME ~~990~~ 45676

PROJECT NUMBER

P.O. #

SAMPLE RECEIPT

| | |
|---|---|
| TOTAL NO. OF CONTAINERS | 6 |
| HEAD SPACE | |
| REC'D GOOD CONDITION/COLD | |
| CONFORMS TO RECORD | |

TAT [✓ STANDARD 5-DAY] 24 48 72 OTHER

SPECIAL INSTRUCTIONS/COMMENTS:

RELINQUISHED BY 1
A Pareles
(SIGNATURE) (TIME)
A. Pareles
(PRINTED NAME) (DATE)
(COMPANY)

RELINQUISHED BY 2
(SIGNATURE) (TIME)
(PRINTED NAME) (DATE)
(COMPANY)

RELINQUISHED BY 3
(SIGNATURE) (TIME)
(PRINTED NAME) (DATE)
(COMPANY)

RECEIVED BY 1
Noelle Lane 925
(SIGNATURE) (TIME)
Noelle Lane 4/24/99
(PRINTED NAME) (DATE)
Seq.
(COMPANY)

RECEIVED BY 2
(SIGNATURE) (TIME)
(PRINTED NAME) (DATE)
(COMPANY)

RECEIVED BY (LABORATORY) 3
(SIGNATURE) (TIME)
(PRINTED NAME) (DATE)
(LAB)

# Confirmation Samples

**CHROMALAB, INC.**

Environmental Services (SDB)

May 3, 1999 *Submission #:* 9904346

CH2M HILL OAKLAND

*Atten:* SAM BRATHWAITE

*Project:* PENN MINE *Project#:* 144069.08.52
*Received:* April 26, 1999

*re:* 4 samples for PERCENTAGE MOISTURE analysis.
*Method:* *EPA SW846 8000*

*Matrix:* SOLID *Extracted:* May 3, 1999
*Sampled:* April 25, 1999 *Run#:* 18618 *Analyzed:* May 3, 1999

| Spl# | CLIENT SPL ID | DRY WEIGHT PERCENT MOISTURE (%) | REPORTING LIMIT (%) | BLANK RESULT (%) | BLANK SPIKE (%) | DILUTION FACTOR | % MOISTURE |
|---|---|---|---|---|---|---|---|
| *239161* | HK-C3 | 6.02 | 0.1 | | -- | -- | 6.0 |
| *239163* | HK-C5 | 5.19 | 0.1 | | -- | -- | 5.2 |
| *239164* | HK-C8 | 18.4 | 0.1 | | -- | -- | 18.4 |
| *239166* | HK-C10 | 9.15 | 0.1 | | -- | -- | 9.2 |

Linda Atienza
Analyst

Joan Mullen for
Michael Verona
Operations Manager

# CHROMALAB, INC.

Environmental Services (SDB)

May 3, 1999 *Submission #:* 9904346

CH2M HILL OAKLAND

*Atten:* SAM BRATHWAITE

*Project:* PENN MINE *Project#:* 144069.08.52
*Received:* April 26, 1999

*re:* 4 samples for pH analysis.
*Method:* *9040/9045*

*Matrix:* SOIL *Extracted:* May 3, 1999
*Sampled:* April 25, 1999 *Run#:* 18615 *Analyzed:* May 3, 1999

| **Spl#** | **CLIENT SPL ID** | **pH (Units)** | **REPORTING LIMIT (Units)** | **BLANK RESULT (Units)** | **BLANK SPIKE (%)** | **DILUTION FACTOR** |
|---|---|---|---|---|---|---|
| *238189* | HK-C3 | 3.15 | 1-14 | 7.01 | -- | -- |
| *238191* | HK-C5 | 3.34 | 1-14 | 7.01 | -- | -- |
| *238194* | HK-C8 | 2.73 | 1-14 | 7.01 | -- | -- |
| *238196* | HK-C10 | 3.36 | 1-14 | 7.01 | -- | -- |

Linda Atienza
Analyst

Joan Mullenfor
Michael Verona
Operations Manager

**CHROMALAB, INC.**
Environmental Services (SDB)

May 4, 1999 *Submission #:* 9904346

CH2M HILL OAKLAND

*Atten:* SAM BRATHWAITE

*Project:* PENN MINE *Project#:* 144069.08.52
*Received:* April 26, 1999

*re:* One sample for Miscellaneous Metals analysis.
*Method:* *EPA 3010A/3050A/6010A Nov 1990*

*Client Sample ID:* **HK-C10**
*Spl#:* 238196 *Matrix:* SOIL *Extracted:* May 3, 1999
*Sampled:* April 25, 1999 *Run#:* 18600 *Analyzed:* May 4, 1999

| ANALYTE | RESULT (mg/Kg) | REPORTING LIMIT (mg/Kg) | BLANK RESULT (mg/Kg) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| ALUMINUM | 5500 | 250 | N.D. | 106 | 100 |
| CHROMIUM | N.D. | 100 | N.D. | 95.7 | 100 |
| COPPER | 11000 | 100 | N.D. | 100 | 100 |
| IRON | 22000 | 100 | N.D. | 107 | 100 |
| NICKEL | N.D. | 100 | N.D. | 95.1 | 100 |
| ZINC | 830 | 100 | N.D. | 97.2 | 100 |

Christopher Arndt
Analyst

Eric Tam
Laboratory Director

510-893-8205 GC 05/08

M010 0:QC0405 JOHN 15:04

**CHROMALAB, INC.**
Environmental Services (SDB)

May 4, 1999 *Submission #:* 9904346

CH2M HILL OAKLAND

*Atten:* SAM BRATHWAITE

*Project:* PENN MINE *Project#:* 144069.08.52
*Received:* April 26, 1999

*re:* One sample for Miscellaneous Metals analysis.
*Method:* *EPA 3010A/3050A/6010A Nov 1990*

*Client Sample ID:* **HK-C5**
*Spl#:* 238191 *Matrix:* SOIL *Extracted:* May 3, 1999
*Sampled:* April 25, 1999 *Run#:* 18600 *Analyzed:* May 4, 1999

| ANALYTE | RESULT (mg/Kg) | REPORTING LIMIT (mg/Kg) | BLANK RESULT (mg/Kg) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| ALUMINUM | 3800 | 250 | N.D. | 106 | 100 |
| CHROMIUM | N.D. | 100 | N.D. | 95.7 | 100 |
| COPPER | 6600 | 100 | N.D. | 100 | 100 |
| IRON | 200000 | 100 | N.D. | 107 | 100 |
| NICKEL | N.D. | 100 | N.D. | 95.1 | 100 |
| ZINC | 760 | 100 | N.D. | 97.2 | 100 |

Christopher Arndt
Analyst

Eric Tam
Laboratory Director

**CHROMALAB, INC.**
Environmental Services (SDB)

May 4, 1999 *Submission #:* 9904346

CH2M HILL OAKLAND

*Atten:* SAM BRATHWAITE

*Project:* PENN MINE *Project#:* 144069.08.52
*Received:* April 26, 1999

*re:* One sample for Miscellaneous Metals analysis.
*Method:* *EPA 3010A/3050A/6010A Nov 1990*

*Client Sample ID:* **HK-C3**
*Spl#:* 238189 *Matrix:* SOIL *Extracted:* May 3, 1999
*Sampled:* April 25, 1999 *Run#:* 18600 *Analyzed:* May 4, 1999

| ANALYTE | RESULT (mg/Kg) | REPORTING LIMIT (mg/Kg) | BLANK RESULT (mg/Kg) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| ALUMINUM | 9200 | 250 | N.D. | 106 | 100 |
| CADMIUM | N.D. | 50 | N.D. | 96.2 | 100 |
| COPPER | 1200 | 100 | N.D. | 100 | 100 |
| IRON | 55000 | 100 | N.D. | 107 | 100 |
| NICKEL | N.D. | 100 | N.D. | 95.1 | 100 |
| ZINC | 2400 | 100 | N.D. | 97.2 | 100 |

Christopher Arndt
Analyst

Eric Tam
Laboratory Director

1220 Quarry Lane • Pleasanton, California 94566-4756
(925) 484-1919 • Facsimile (925) 484-1096
Federal ID #68-0140157

**CHROMALAB, INC.**
Environmental Services (SDB)

May 4, 1999 *Submission #:* 9904346

CH2M HILL OAKLAND

*Atten:* SAM BRATHWAITE

*Project:* PENN MINE *Project#:* 144069.08.52
*Received:* April 26, 1999

*re:* One sample for Miscellaneous Metals analysis.
*Method:* *EPA 3010A/3050A/6010A Nov 1990*

*Client Sample ID:* **HK-C8**
*Spl#:* 238194 *Matrix:* SOIL *Extracted:* May 3, 1999
*Sampled:* April 25, 1999 *Run#:* 18600 *Analyzed:* May 4, 1999

| **ANALYTE** | **RESULT (mg/Kg)** | **REPORTING LIMIT (mg/Kg)** | **BLANK RESULT (mg/Kg)** | **BLANK SPIKE (%)** | **DILUTION FACTOR** |
|---|---|---|---|---|---|
| ALUMINUM | 14000 | 250 | N.D. | 106 | 100 |
| CHROMIUM | N.D. | 100 | N.D. | 95.7 | 100 |
| COPPER | 4800 | 100 | N.D. | 100 | 100 |
| IRON | 44000 | 100 | N.D. | 107 | 100 |
| NICKEL | N.D. | 100 | N.D. | 95.1 | 100 |
| ZINC | 5000 | 100 | N.D. | 97.2 | 100 |

Christopher Arndt
Analyst

Eric Tam
Laboratory Director

**CHROMALAB, INC.**
Environmental Services (SDB)

May 7, 1999 *Submission #:* 9904346

CH2M HILL OAKLAND

*Atten:* SAM BRATHWAITE

*Project:* PENN MINE *Project#:* 144069.08.52
*Received:* April 26, 1999

*re:* One sample for STLC Misc Metals with DI Water analysis.
*Method: CA WET3005A Mod/6010A/7470A Nov 1990*

*Client Sample ID:* **HK-C10**
*Spl#:* 239171 *Matrix:* SOIL *Extracted:* May 6, 1999
*Sampled:* April 25, 1999 *Run#:* 18688 *Analyzed:* May 7, 1999

| ANALYTE | RESULT (mg/L) | REPORTING LIMIT (mg/L) | BLANK RESULT (mg/L) | BLANK SPIKE (%) | DILUTION FACTOR |
|---|---|---|---|---|---|
| ALUMINUM | 72 | 10 | N.D. | 102 | 10 |
| CADMIUM | N.D. | 1.0 | N.D. | 103 | 10 |
| COPPER | 760 | 5.0 | N.D. | 102 | 10 |
| LEAD | N.D. | 5.0 | N.D. | 102 | 10 |
| NICKEL | N.D. | 5.0 | N.D. | 101 | 10 |
| ZINC | 76 | 5.0 | N.D. | 102 | 10 |

Shafi Barekzai
Analyst

Eric Tam
Laboratory Director

# CHROMALAB, INC.

Environmental Services (SDB)

May 7, 1999 *Submission #:* 9904346

CH2M HILL OAKLAND

*Atten:* SAM BRATHWAITE

*Project:* PENN MINE *Project#:* 144069.08.52
*Received:* April 26, 1999

*re:* One sample for STLC Misc Metals with DI Water analysis.
*Method:* *CA WET3005A Mod/6010A/7470A Nov 1990*

*Client Sample ID:* **HK-C8**
*Spl#:* 239170 *Matrix:* SOIL *Extracted:* May 6, 1999
*Sampled:* April 25, 1999 *Run#:* 18688 *Analyzed:* May 7, 1999

| **ANALYTE** | **RESULT (mg/L)** | **REPORTING LIMIT (mg/L)** | **BLANK RESULT (mg/L)** | **BLANK SPIKE (%)** | **DILUTION FACTOR** |
|---|---|---|---|---|---|
| ALUMINUM | 460 | 10 | N.D. | 102 | 10 |
| CADMIUM | 2.7 | 1.0 | N.D. | 103 | 10 |
| COPPER | 700 | 5.0 | N.D. | 102 | 10 |
| LEAD | N.D. | 5.0 | N.D. | 102 | 10 |
| NICKEL | N.D. | 5.0 | N.D. | 101 | 10 |
| ZINC | 580 | 5.0 | N.D. | 102 | 10 |

Shafi Barekzai
Analyst

Eric Tam
Laboratory Director

**CHROMALAB, INC.**

Environmental Services (SDB)

May 7, 1999 *Submission #:* 9904346

CH2M HILL OAKLAND

*Atten:* SAM BRATHWAITE

*Project:* PENN MINE *Project#:* 144069.08.52
*Received:* April 26, 1999

*re:* One sample for STLC Misc Metals with DI Water analysis.
*Method:* *CA WET3005A Mod/6010A/7470A Nov 1990*

*Client Sample ID:* **HK-C5**
*Spl#:* 239169 *Matrix:* SOIL *Extracted:* May 6, 1999
*Sampled:* April 25, 1999 *Run#:* 18688 *Analyzed:* May 7, 1999

| **ANALYTE** | **RESULT (mg/L)** | **REPORTING LIMIT (mg/L)** | **BLANK RESULT (mg/L)** | **BLANK SPIKE (%)** | **DILUTION FACTOR** |
|---|---|---|---|---|---|
| ALUMINUM | 150 | 1.0 | N.D. | 102 | 1 |
| CADMIUM | 0.13 | 0.10 | N.D. | 103 | 1 |
| COPPER | 100 | 0.50 | N.D. | 102 | 1 |
| LEAD | N.D. | 0.50 | N.D. | 102 | 1 |
| NICKEL | N.D. | 0.50 | N.D. | 101 | 1 |
| ZINC | 22 | 0.50 | N.D. | 102 | 1 |

Shafi Barekzai
Analyst

Eric Tam
Laboratory Director

**CHROMALAB, INC.**

Environmental Services (SDB)

May 7, 1999 *Submission #:* 9904346

CH2M HILL OAKLAND

*Atten:* SAM BRATHWAITE

*Project:* PENN MINE *Project#:* 144069.08.52
*Received:* April 26, 1999

*re:* One sample for STLC Misc Metals with DI Water analysis.
*Method:* *CA WET3005A Mod/6010A/7470A Nov 1990*

*Client Sample ID:* **HK-C3**
*Spl#:* 239168 *Matrix:* SOIL *Extracted:* May 6, 1999
*Sampled:* April 25, 1999 *Run#:* 18688 *Analyzed:* May 7, 1999

| **ANALYTE** | **RESULT (mg/L)** | **REPORTING LIMIT (mg/L)** | **BLANK RESULT (mg/L)** | **BLANK SPIKE (%)** | **DILUTION FACTOR** |
|---|---|---|---|---|---|
| ALUMINUM | 260 | 1.0 | N.D. | 102 | 1 |
| CADMIUM | 0.99 | 0.10 | N.D. | 103 | 1 |
| COPPER | 97 | 0.50 | N.D. | 102 | 1 |
| LEAD | N.D. | 0.50 | N.D. | 102 | 1 |
| NICKEL | 0.53 | 0.50 | N.D. | 101 | 1 |
| ZINC | 190 | 0.50 | N.D. | 102 | 1 |

Shafi Barekzai
Analyst

Eric Tam
Laboratory Director

# GeoAnalytical Laboratories, Inc.

1405 Kansas Avenue Modesto, CA 95351 Phone (209) 572-0900 Fax (209) 572-0916

## CERTIFICATE OF ANALYSIS

**Report #** **K123-01**

**Date:** 5/11/99

ChromaLab
1220 Quarry Lane
Pleasanton CA 94566

**Project:** 9904346

PO#

**Date Rec'd:** 5/03/99
**Date Started:** 5/03/99
**Date Completed:** 5/11/99

**Date Sampled:** 4/25/99
**Time:**
**Sampler:**

**Sample ID:** HK-C3
**Lab ID:** K21555

| Method | MDL | Analyte | Results | Units |
|---|---|---|---|---|
| 3.2.1 | NA | Potential Acidity | 54.1 | meq $H^+$/100g |
| 3.2.1 | NA | Neutralizaton Potential | 35.5 | * |
| 3.2.1 | 0.001 | Sulfur | 0.93 | % |

*tons $CaCo_3$ equivalent to 1000 tons material

Ramiro Salgado
Chemist

Certification # 1157

Donna Keller
Donna Keller
Laboratory Director

# GeoAnalytical Laboratories, Inc.

1405 Kansas Avenue Modesto, CA 95351 Phone (209) 572-0900 Fax (209) 572-0916

## CERTIFICATE OF ANALYSIS

**Report #** **K123-01**

**Date:** 5/11/99

ChromaLab
1220 Quarry Lane
Pleasanton CA 94566

**Project:** 9904346

PO#

**Date Rec'd:** 5/03/99
**Date Started:** 5/03/99
**Date Completed:** 5/11/99

**Date Sampled:** 4/25/99
**Time:**
**Sampler:**

**Sample ID:** HK-C5
**Lab ID:** K21556

| Method | MDL | Analyte | Results | Units |
|---|---|---|---|---|
| 3.2.1 | NA | Potential Acidity | 41.5 | meq $H^+$/100g |
| 3.2.1 | NA | Neutralizaton Potential | 12.5 | * |
| 3.2.1 | 0.001 | Sulfur | 0.69 | % |

*tons $CaCo_3$ equivalent to 1000 tons material

Ramiro Salgado
Chemist

Certification # 1157

Donna Keller

Donna Keller
Laboratory Director

# GeoAnalytical Laboratories, Inc.

1405 Kansas Avenue Modesto, CA 95351 Phone (209) 572-0900 Fax (209) 572-0916

## CERTIFICATE OF ANALYSIS

**Report #** K123-01

**Date:** 5/11/99

ChromaLab
1220 Quarry Lane
Pleasanton CA 94566

**Project:** 9904346

PO#

**Date Rec'd:** 5/03/99
**Date Started:** 5/03/99
**Date Completed:** 5/11/99

**Date Sampled:** 4/25/99
**Time:**
**Sampler:**

**Sample ID:** HK-C8
**Lab ID:** K21557

| Method | MDL | Analyte | Results | Units |
|---|---|---|---|---|
| 3.2.1 | NA | Potential Acidity | 103 | meq $H^+$/100g |
| 3.2.1 | NA | Neutralizaton Potential | 95.3 | * |
| 3.2.1 | 0.001 | Sulfur | 1.84 | % |

*tons $CaCo_3$ equivalent to 1000 tons material

Ramiro Salgado
Chemist

Certification # 1157

Donna Keller
Laboratory Director

# GeoAnalytical Laboratories, Inc.

1405 Kansas Avenue Modesto, CA 95351 Phone (209) 572-0900 Fax (209) 572-0916

## CERTIFICATE OF ANALYSIS

**Report #** **K123-01**

**Date:** 5/11/99

ChromaLab
1220 Quarry Lane
Pleasanton CA 94566

**Project:** 9904346

PO#

**Date Rec'd:** 5/03/99
**Date Started:** 5/03/99
**Date Completed:** 5/11/99

**Date Sampled:** 4/25/99
**Time:**
**Sampler:**

**Sample ID:** HK-C10
**Lab ID:** K21558

| Method | MDL | Analyte | Results | Units |
|---|---|---|---|---|
| 3.2.1 | NA | Potential Acidity | 44.5 | meq $H^+$/100g |
| 3.2.1 | NA | Neutralizaton Potential | 20.1 | * |
| 3.2.1 | 0.001 | Sulfur | 0.75 | % |

*tons $CaCo_3$ equivalent to 1000 tons material

Ramiro Salgado
Chemist

Certification # 1157

Donna Keller
Donna Keller
Laboratory Director

**GeoAnalytical Laboratories, Inc.**
1405 Kansas Avenue Modesto, CA 95351 Phone (209) 572-0900 Fax (209) 572-0916

**Report#** K123-01

## QC REPORT

Chromalab
1220 Quarry Lane
Pleasanton CA 94566

**Dates Analyzed** 5/4/99

| **Analyte** | **Batch #** | **Method** | **Original** | **Duplicate** | **RPD** | **Blank** |
|---|---|---|---|---|---|---|
| Potential Acidity | I00913 | 3.2.1 | 44.5 | 45.25 | 1.7 | ND |
| Neutralizaton Potential | I01048 | 3.2.1 | 95.3 | 97.5 | 2.3 | ND |
| Sulfur | I01049 | 3.2.1 | 0.75 | 0.76 | 1.3 | ND |

*tons $CaCo_3$ equivalent to 1000 tons material

Ramiro Salgado
Chemist

Certification # 1157

Donna Keller

Donna Keller
Laboratory Director

[redacted]

Lab: [redacted]

**CHROMALAB, INC.**

Environmental Services (SDB) (DOHS 1094)

1220 Quarry Lane • Pleasanton, California 94566-4756
510/484-1919 • Facsimile 510/484-1096

# Sub-Contract
# Chain of Custody

DATE 4/30/99 PAGE 1 of 1

PROJ MGR Ken Wright

COMPANY

ADDRESS

SAMPLERS (SIGNATURE) (PHONE NO.)

(FAX NO.)

**ANALYSIS REPORT**

| SAMPLE ID. | DATE | TIME | MATRIX | PRESERV. | Net Acidity | Acid-base Accounting | | ChromaLab Reference or Submission Number(s) 9904346 | NUMBER OF CONTAINERS |
|---|---|---|---|---|---|---|---|---|---|
| HK-C3 | 4/25/99 | | Soil | N | X | X | K21555 | ~~990443~~ | 1 |
| HK-C5 | ↓ | | ↓ | ↓ | ↓ | ↓ | K21556 | 9904346 | 1 |
| HK-C8 | | | | | | | K21557 | ↓ | 1 |
| HK-C10 | | | | | | | K21558 | | 1 |

**PROJECT INFORMATION**

PROJECT NAME 9904346

PROJECT NUMBER

P.O. #

**SAMPLE RECEIPT**

TOTAL NO. OF CONTAINERS

HEAD SPACE

REC'D GOOD CONDITION/COLD

CONFORMS TO RECORD

TAT [✓ STANDARD 5-DAY] 24 48 72 OTHER

SPECIAL INSTRUCTIONS/COMMENTS

**RELINQUISHED BY 1**

(SIGNATURE) APareds (TIME)

(PRINTED NAME) A. Paredes (DATE) 4/30/99

(COMPANY) Chromalab

**RELINQUISHED BY 2**

(SIGNATURE) (TIME)

(PRINTED NAME) (DATE)

(COMPANY)

**RELINQUISHED BY 3**

(SIGNATURE) (TIME)

(PRINTED NAME) (DATE)

(COMPANY)

**RECEIVED BY 1**

(SIGNATURE) Joel V (TIME) 8:45am

(PRINTED NAME) Joel Virgen (DATE) 5/3/99

(COMPANY) GeoAnalytical Labs

**RECEIVED BY 2**

(SIGNATURE) (TIME)

(PRINTED NAME) (DATE)

(COMPANY)

**RECEIVED BY (LABORATORY) 3**

(SIGNATURE) (TIME)

(PRINTED NAME) (DATE)

(LAB)

**MEMORANDUM** **CH2MHILL**

# Laboratory Analysis

**TO:** Afsaneh Solimpor

**COPIES:** Bill Ingles
Jim Mavis

**FROM:** Sam Brathwaite

**DATE:** May 3, 1999

Per our conversation, this memo confirms that the following total and soluble metal analyses shall be performed on samples HK-C3, HK-C5, HK-C8, and HK-C10:

| Total Metals | Soluble |
|---|---|
| Aluminum | Aluminum |
| Cadmium | Cadmium |
| Copper | Copper |
| Iron | Lead |
| Nickel | Nickel |
| Zinc | Zinc |

Note that the total and soluble metals shall be analyzed using EPA Method 6010.

Please call if you have any question.

Post-it® Fax Note 7671

| | |
|---|---|
| Date 5/4/99 | # of pages ▶ 1 |
| To Afsaneh Solimpor | From Sam Brathwaite |
| Co./Dept. CHROMALAB | Co. CH2m Hill |
| Phone # 925/484-1919 | Phone # 510/251-2888 |
| Fax # 925/484-1096 | Fax # 510/622-9137 |

[redacted]

3458187 2181

TLC

# CHAIN OF CUSTODY RECORD AND AGREEMENT TO PERFORM SERVICES

Project #: 139.08.52
Purchase Order #:
Project: PENN MINE
Company Name: CH2M HILL

☐ LGN
One Innovation Drive, Suite C
Alachua, FL 32615
(904) 462-3050 FAX (904) 462-1370

☐ LRD
Caterpillar Road
Redding, CA 96003-1412
(916) 244-5227 FAX (916) 244-4109

☐ LMG
2567 Fairlane Drive
Montgomery, AL 36116-1622
(334) 271-2440 FAX (334) 271-3428

☐ LXW
Canviro Analytical Laboratories, Inc.
50 Bathurst, Unit 12
Waterloo, Ontario, Canada N2V
(519) 747-2575 FAX (519) 747-3806

Lab use:
Lab:
Page of
Client:
Price Source: A P Q S
Acct Code:
Test Group:
Project Code:
Ack. Gen.:
LIMS Ver:
Login:
Mult.:
COC Review:

Project Manager or Contact & Phone #: SAM BRATHWAITE
Report Copy to:
Requested Completion Date: Standard TAT
Site ID:
Sample Disposal: Dispose ☐ Return ☐

| Sampling Date | Sampling Time | Type COMP | Type GRAB | Matrix WATER | Matrix SOIL | CLIENT SAMPLE ID (9 CHARACTERS) | QC ID (3 CHAR) | # OF CONTAINERS | pH EPA method [illegible] | Total metals | Soluble Metals | Net Acidity | Acid-base Accounting | Moisture Content | | | | SAMPLE REMARKS | LAB 1 ID | LAB 2 ID |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4/23 | 10:40 | | | | | HK-C1 | | | | | | | | | | | | | | |
| ↓ | 11:30 | | | | | HK-C2 | | | | | | | | | | | | | | |
| | 12:0 | | | | | HK-C3 | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | |
| | 12:30 | | | | | HK-C4 | | | | | | | | | | | | | | |
| | 12:45 | | | | | HK-C5 | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | |
| | 13:05 | | | | | HK-C6 | | | | | | | | | | | | | | |
| | 13:35 | | | | | HK-C7 | | | | | | | | | | | | | | |
| | 13:50 | | | | | HK-C8 | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | |
| | 14:00 | | | | | HK-C9 | | | | | | | | | | | | | | |
| ↓ | 14:10 | | | | | HK-C10 | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | |

SUBM #: 9904346 REP: GC
PRIORITY: 2
DUE: 05/05/99
REF #:45715

Sampled By & Title (Please sign and print name): Sam Brathwaite Date/Time: 4/26/99 / 1100
Relinquished By (Please sign and print name): Sam Brathwaite Date/Time:
Received By (Please sign and print name): R. Marer Date/Time: 4-26-99 1300
Relinquished By (Please sign and print name): R. Marer Date/Time: 4-26-99 1600
Received By (Please sign and print name): Date/Time: 4/26/99 1644
Relinquished By (Please sign and print name): Date/Time:
Received By (Please sign and print name): Date/Time:
Shipped Via: UPS Fed-Ex Other
Shipping #:

HAZWRAP/NESSA: Y N
EDATA: Y N
QC LEVEL 1 2 3 OTHER
pH
Ice
Custody Seal
Temp

Batch Remarks: ~~The~~ Analyses to be performed will be provided at a later date.

Instructions and Agreement Provisions on Reverse Side

DISTRIBUTION: Original - LAB, Yellow - LAB, Pink - Client
REV 5/95 LAB FORM 340

04/29/99 THU 16:47 FAX 510 893 8205 CHROMALAB, INC.

APR.-29'99(THU) 10:22 CH2M HILL TEL:510 484 1096

**CHROMALAB**

Change request received by:

Date Requested: 05/03/99

## SAMPLE STATUS CHANGE FORM

| Submission# | Client Samp.ID | Old Status Description | Description of Changes | Requested by (Client's name) |
|---|---|---|---|---|
| 9904346 | B1318189<br>B1318190 | HK-C3<br>HKC5<br>HKC8<br>HKC10 | Add STLC Misc Metals | |
| 9904346 | | | change due date 05/03/99 to 05/04/99 | |
| | | | | |
| | | | | |
| | | | | |

Changes were done in lims by(login): Cri On: / /

CC: __ Lab.Director __ Dept.manager __ Analyst __ Proj.Manager

**CHROMALAB** Change request received by: AS Date Requested: 5 / 4 / 9

# SAMPLE STATUS CHANGE FORM

| Submission# | Client Samp.ID | Old Status Description | Description of Changes | Requested by (Client's name) |
|---|---|---|---|---|
| 9904346 | HK-C3<br>HK-C5<br>HK-C8<br>HK-C10 | STLC | STLC DI H2O (AL, Cd, Cu, Pb, Ni, Zn)<br>239/68, 69, 70, 71 | CH2M-HILL |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Changes were done in lims by(login):_____________ On:____/____/____

CC: ___ Lab.Director ___ Dept.manager ___ Analyst ___Proj.Manager

QAL ITY ANALYTICAL
ORATORIES, INC.

45719

# CHAIN OF CUSTODY RECORD AND AGREEMENT TO PERFORM SERVICES

**Project #** 144069.08.52

**Purchase Order #**

**Project Name** PENN MINE

**Company Name** CH2M HILL

**Project Manager or Contact & Phone #** SAM BRATHWAITE

**Report Copy to:**

**Requested Completion Date:** Standard TAT

**Site ID**

**Sample Disposal:** Dispose ☐ Return ☐

☐ **LGN**
One Innovation Drive, Suite C
Alachua, FL 32615-9586
(904) 462-3050 FAX (904) 462-1670

☐ **LRD**
5090 Caterpillar Road
Redding, CA 96003-1412
(916) 244-5227 FAX (916) 244-4109

☐ **LMG**
2567 Fairlane Drive
Montgomery, AL 36116-1622
(334) 271-2440 FAX (334) 271-3428

☐ **LKW**
Canviro Analytical Laboratories, Inc.
50 Bathurst, Unit 12
Waterloo, Ontario, Canada N2V 2C5
(519) 747-2575 FAX (519) 747-3806

**THIS AREA FOR LAB USE ONLY**

| | | | |
|---|---|---|---|
| Lab # | | Page | of |
| Client Service | | Price Source A P Q S | |
| Acct Code | | Test Group | |
| Project Code | | Ack. Gen. | |
| LIMS Ver | | Login | Mult. |
| COC Review | | | |

**ANALYSES REQUESTED**

| Sampling Date | Sampling Time | Type COMP | Type GRAB | Matrix WATER | Matrix SOIL | CLIENT SAMPLE ID (9 CHARACTERS) | QC ID (3 CHAR) | # OF CONTAINERS | pH EPA method 9045 | Total metals | Soluble Metals | Net Acidity | Acid-base Accounting | Moisture Content | | | | SAMPLE REMARKS | LAB 1 ID | LAB 2 ID |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4/25 | 10:40 | | | | | HK-C1 | | | | | | | | | | | | | | |
| | 11:30 | | | | | HK-C2 | | | | | | | | | | | | | | |
| | 12:0 | | | | | HK-C3 | | | | | | | | | | | | | | |
| | 12:30 | | | | | HK-C4 | | | | | | | | | | | | | | |
| | 12:45 | | | | | HK-C5 | | | | | | | | | | | | | | |
| | 13:05 | | | | | HK-C6 | | | | | | | | | | | | | | |
| | 13:35 | | | | | HK-C7 | | | | | | | | | | | | | | |
| | 13:50 | | | | | HK-C8 | | | | | | | | | | | | | | |
| | 14:00 | | | | | HK-C9 | | | | | | | | | | | | | | |
| | 14:10 | | | | | HK-C10 | | | | | | | | | | | | | | |

SUBM #: 9904346 REP: GC
CLIENT: CH2
DUE: 05/03/99
REF #:45719

**Sampled By & Title** (Please sign and print name) Sam BRATHWAITE **Date/Time** 4/26/99/1100

**Relinquished By** (Please sign and print name) Sam Brathwaite. **Date/Time**

**Received By** (Please sign and print name) B. Moran **Date/Time** 1300 4-26-99

**Relinquished By** (Please sign and print name) B Moran **Date/Time** 1644 4-26-99

**Received By** (Please sign and print name) AWeeks **Date/Time** 4/26/99 1644

**Relinquished By** (Please sign and print name) **Date/Time**

**Received By** (Please sign and print name) **Date/Time**

**Shipped Via** UPS Fed-Ex Other

**Shipping #**

| | | |
|---|---|---|
| HAZWRAP/NESSA: | Y | N |
| EDATA: | Y | N |
| QC LEVEL 1 2 3 OTHER | | |
| pH | Ice | |
| Custody Seal | Temp | |

**Batch Remarks:** ~~THE~~ ANALYSES TO be performed will be provided AT A Later date.

*Instructions and Agreement Provisions on Reverse Side*

*DISTRIBUTION: Original - LAB, Yellow - LAB, Pink - Client*

REV 5/95 LAB FORM 340

# Appendix C

## Precipitation Data

## Table C-1
## Comparison of Precipitation at Pardee Dam, New Hogan Lake, and Onsite
## (in inches)
## Penn Mine Environmental Restoration Project

| Day | Pardee Dam Station | New Hogan Lake Station | Onsite Weather Station | Day | Pardee Dam Station | New Hogan Lake Station | Onsite Weather Station |
|---|---|---|---|---|---|---|---|
| 1-Mar-99 | 0.00 | 0.00 | NA | 1-Apr-99 | 0.00 | 0.00 | 0.00 |
| 2-Mar-99 | 0.08 | 0.80 | NA | 2-Apr-99 | 0.00 | 0.00 | 0.00 |
| 3-Mar-99 | 0.00 | 0.04 | NA | 3-Apr-99 | 0.00 | 0.07 | 0.00 |
| 4-Mar-99 | 0.00 | 0.00 | NA | 4-Apr-99 | 0.00 | 0.00 | 0.00 |
| 5-Mar-99 | 0.00 | 0.00 | NA | 5-Apr-99 | 0.00 | 0.53 | 0.46 |
| 6-Mar-99 | 0.00 | 0.00 | NA | 6-Apr-99 | 0.02 | 0.00 | 0.02 |
| 7-Mar-99 | 0.00 | 0.00 | NA | 7-Apr-99 | 0.02 | 0.02 | 0.00 |
| 8-Mar-99 | 0.32 | 0.25 | NA | 8-Apr-99 | 0.00 | 0.52 | 0.36 |
| 9-Mar-99 | 0.00 | 0.00 | NA | 9-Apr-99 | NA | NA | 0.00 |
| 10-Mar-99 | 0.00 | 0.00 | NA | 10-Apr-99 | NA | NA | 0.08 |
| 11-Mar-99 | 0.00 | 0.00 | 0.00 | 11-Apr-99 | NA | NA | 0.02 |
| 12-Mar-99 | 0.00 | 0.00 | 0.03 | 12-Apr-99 | NA | NA | 0.00 |
| 13-Mar-99 | 0.00 | 0.00 | 0.00 | 13-Apr-99 | NA | NA | 0.00 |
| 14-Mar-99 | 0.00 | 0.00 | 0.00 | 14-Apr-99 | NA | NA | 0.00 |
| 15-Mar-99 | 0.00 | 0.00 | 0.00 | 15-Apr-99 | NA | NA | NA |
| 16-Mar-99 | 0.00 | 0.00 | 0.00 | 16-Apr-99 | NA | NA | NA |
| 17-Mar-99 | NA | 0.00 | 0.00 | 17-Apr-99 | NA | NA | NA |
| 18-Mar-99 | 0.00 | 0.00 | 0.00 | 18-Apr-99 | NA | NA | NA |
| 19-Mar-99 | 0.33 | 0.35 | 0.11 | 19-Apr-99 | NA | NA | NA |
| 20-Mar-99 | 0.03 | 0.03 | 0.23 | 20-Apr-99 | NA | NA | 0.00 |
| 21-Mar-99 | 0.00 | 0.01 | 0.02 | 21-Apr-99 | NA | NA | 0.00 |
| 22-Mar-99 | 0.00 | 0.02 | 0.01 | 22-Apr-99 | NA | NA | 0.00 |
| 23-Mar-99 | 0.00 | 0.06 | 0.02 | 23-Apr-99 | NA | NA | 0.00 |
| 24-Mar-99 | 0.00 | 0.02 | 0.00 | 24-Apr-99 | NA | NA | 0.00 |
| 25-Mar-99 | 0.00 | 0.00 | 0.01 | 25-Apr-99 | NA | NA | 0.00 |
| 26-Mar-99 | 0.00 | 0.00 | 0.00 | 26-Apr-99 | NA | NA | 0.00 |
| 27-Mar-99 | 0.00 | 0.00 | NA | 27-Apr-99 | NA | NA | 0.00 |
| 28-Mar-99 | 0.00 | 0.00 | NA | 28-Apr-99 | NA | NA | 0.00 |
| 29-Mar-99 | 0.00 | 0.00 | NA | 29-Apr-99 | NA | NA | 0.00 |
| 30-Mar-99 | 0.00 | 0.49 | NA | 30-Apr-99 | NA | NA | 0.00 |
| 31-Mar-99 | 0.00 | 0.00 | 0.00 | | | | |

Notes:

NA = not available

Source of Data: Pardee Dam and New Hogan Lake Station data from Department of Water Resources' California Data Exchange Center (cdec);
Onsite data from Penn Mine weather station datalogger.

## Table C-2
## 1999 Cumulative Precipitation, Pardee Dam and New Hogan Lake Stations
## (in inches)
## Penn Mine Environmental Restoration Project

| Day | Pardee Dam Station | New Hogan Lake Station | Day | Pardee Dam Station | New Hogan Lake Station | Day | Pardee Dam Station | New Hogan Lake Station |
|---|---|---|---|---|---|---|---|---|
| 1-Jan-99 | 0 | 0 | 1-Feb-99 | 3.36 | 2.64 | 4-Mar-99 | 9.07 | 8.99 |
| 2-Jan-99 | 0 | 0 | 2-Feb-99 | 3.36 | 2.64 | 5-Mar-99 | 9.07 | 8.99 |
| 3-Jan-99 | 0 | 0 | 3-Feb-99 | 3.36 | 2.64 | 6-Mar-99 | 9.07 | 8.99 |
| 4-Jan-99 | 0 | 0 | 4-Feb-99 | 3.36 | 2.64 | 7-Mar-99 | 9.39 | 8.99 |
| 5-Jan-99 | 0 | 0 | 5-Feb-99 | 3.36 | 2.64 | 8-Mar-99 | 9.39 | 9.24 |
| 6-Jan-99 | 0 | 0 | 6-Feb-99 | 4.01 | 3.17 | 9-Mar-99 | 9.39 | 9.24 |
| 7-Jan-99 | 0 | 0 | 7-Feb-99 | 4.81 | 4.12 | 10-Mar-99 | 9.39 | 9.24 |
| 8-Jan-99 | 0 | 0 | 8-Feb-99 | 5.95 | 4.78 | 11-Mar-99 | 9.39 | 9.24 |
| 9-Jan-99 | 0 | 0 | 9-Feb-99 | 6.99 | 6.03 | 12-Mar-99 | 9.39 | 9.24 |
| 10-Jan-99 | 0 | 0 | 10-Feb-99 | 6.99 | 6.03 | 13-Mar-99 | 9.39 | 9.24 |
| 11-Jan-99 | 0 | 0 | 11-Feb-99 | 6.99 | 6.03 | 14-Mar-99 | 9.39 | 9.24 |
| 12-Jan-99 | 0 | 0 | 12-Feb-99 | 6.99 | 6.03 | 15-Mar-99 | 9.39 | 9.24 |
| 13-Jan-99 | 0 | 0 | 13-Feb-99 | 7.06 | 6.09 | 16-Mar-99 | 9.39 | 9.24 |
| 14-Jan-99 | 0 | 0 | 14-Feb-99 | 7.06 | 6.09 | 17-Mar-99 | 9.39 | 9.24 |
| 15-Jan-99 | 0.84 | 0.13 | 15-Feb-99 | 7.06 | 6.09 | 18-Mar-99 | 9.39 | 9.24 |
| 16-Jan-99 | 0.92 | 0.13 | 16-Feb-99 | 7.78 | 6.64 | 19-Mar-99 | 9.72 | 9.59 |
| 17-Jan-99 | 1.35 | 0.13 | 17-Feb-99 | 7.78 | 6.64 | 20-Mar-99 | 9.72 | 9.62 |
| 18-Jan-99 | 1.35 | 0.13 | 18-Feb-99 | 7.78 | 6.99 | 21-Mar-99 | 9.72 | 9.63 |
| 19-Jan-99 | 2.07 | 1.38 | 19-Feb-99 | 7.78 | 6.99 | 22-Mar-99 | 9.72 | 9.65 |
| 20-Jan-99 | 2.07 | 1.38 | 20-Feb-99 | 8.75 | 8.1 | 23-Mar-99 | 9.72 | 9.71 |
| 21-Jan-99 | 2.08 | 1.68 | 21-Feb-99 | 8.75 | 8.13 | 24-Mar-99 | 9.72 | 9.73 |
| 22-Jan-99 | 2.09 | 1.68 | 22-Feb-99 | 8.75 | 8.13 | 25-Mar-99 | 9.72 | 9.73 |
| 23-Jan-99 | 2.55 | 2.05 | 23-Feb-99 | 8.75 | 8.13 | 26-Mar-99 | 9.72 | 9.73 |
| 24-Jan-99 | 2.55 | 2.05 | 24-Feb-99 | 8.99 | 8.13 | 27-Mar-99 | 9.72 | 9.73 |
| 25-Jan-99 | 2.75 | 2.07 | 25-Feb-99 | 8.99 | 8.15 | 28-Mar-99 | 9.72 | 9.73 |
| 26-Jan-99 | 2.75 | 2.26 | 26-Feb-99 | 8.99 | 8.15 | 29-Mar-99 | 9.72 | 9.73 |
| 27-Jan-99 | 2.75 | 2.39 | 27-Feb-99 | 8.99 | 8.15 | 30-Mar-99 | 9.72 | 10.22 |
| 28-Jan-99 | 2.75 | 2.39 | 28-Feb-99 | 8.99 | 8.15 | 31-Mar-99 | 9.72 | 10.22 |
| 29-Jan-99 | 2.75 | 2.39 | 1-Mar-99 | 8.99 | 8.15 | 1-Apr-99 | 9.72 | 10.22 |
| 30-Jan-99 | 3.18 | 2.39 | 2-Mar-99 | 9.07 | 8.95 | 2-Apr-99 | 9.72 | 10.22 |
| 31-Jan-99 | 3.36 | 2.39 | 3-Mar-99 | 9.07 | 8.99 | 3-Apr-99 | 9.72 | 10.29 |

# Table C-2
# 1999 Cumulative Precipitation, Pardee Dam and New Hogan Lake Stations
# (in inches)
# Penn Mine Environmental Restoration Project

| Day | Pardee Dam Station | New Hogan Lake Station | Day | Pardee Dam Station | New Hogan Lake Station | Day | Pardee Dam Station | New Hogan Lake Station |
|---|---|---|---|---|---|---|---|---|
| 4-Apr-99 | 9.72 | 10.29 | | | | | | |
| 5-Apr-99 | 9.72 | 10.82 | | | | | | |
| 6-Apr-99 | 9.74 | 10.82 | | | | | | |
| 7-Apr-99 | 9.76 | 10.84 | | | | | | |
| 8-Apr-99 | 9.76 | 11.36 | | | | | | |
| 9-Apr-99 | 9.76 | 11.36 | | | | | | |
| 10-Apr-99 | 9.76 | 11.36 | | | | | | |
| 11-Apr-99 | 9.76 | 11.36 | | | | | | |
| 12-Apr-99 | 9.76 | 11.36 | | | | | | |
| 13-Apr-99 | 9.76 | 11.36 | | | | | | |
| 14-Apr-99 | 9.76 | 11.36 | | | | | | |
| 15-Apr-99 | 9.76 | 11.36 | | | | | | |
| 16-Apr-99 | 9.76 | 11.36 | | | | | | |
| 17-Apr-99 | 9.76 | 11.36 | | | | | | |
| 18-Apr-99 | 9.76 | 11.36 | | | | | | |
| 19-Apr-99 | 9.76 | 11.36 | | | | | | |
| 20-Apr-99 | 9.76 | 11.36 | | | | | | |
| 21-Apr-99 | 9.76 | 11.36 | | | | | | |
| 22-Apr-99 | 9.76 | 11.36 | | | | | | |
| 23-Apr-99 | 9.76 | 11.36 | | | | | | |
| 24-Apr-99 | 9.76 | 11.36 | | | | | | |
| 25-Apr-99 | 9.76 | 11.36 | | | | | | |
| 26-Apr-99 | 9.76 | 11.36 | | | | | | |
| 27-Apr-99 | 9.76 | 11.36 | | | | | | |
| 28-Apr-99 | 9.76 | 11.36 | | | | | | |
| 29-Apr-99 | 9.76 | 11.36 | | | | | | |
| 30-Apr-99 | 9.76 | 11.36 | | | | | | |

Source of Data: Pardee Dam and New Hogan Lake Station data from Department of Water Resources' California Data Exchange Center (cdec)

Note: cdec data entered as "--" was considered as zero for calculating cumulative precipitation

California Department of Water Resources Division of Flood Management

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# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District

*Current data as of Thursday at 17:23:33*

Select a sensor name for a plot of recent data. **Note: Reservoir Flows are daily averages.**

| Date | RES ELE<br>*FEET* | STORAGE<br>*AF* | RES CHG<br>*AF* | OUTFLOW<br>*CFS* | PPT INC<br>*INCHES* | INFLOW<br>*CFS* |
|---|---|---|---|---|---|---|
| Earlier | | | | | | |
| 1999 03/19 | -- | -- | -- | -- | 0.33 | 1252 |
| 1999 03/20 | 559.79 | 180960 | -- | 1508 | 0.03 | 1394 |
| 1999 03/21 | 559.64 | 180640 | -320.00 | 1501 | 0.00 | 1354 |
| 1999 03/22 | 559.39 | 180120 | -520.00 | 1511 | 0.00 | 1246 |
| 1999 03/23 | -- | 179510 | -610.00 | -- | 0.00 | 1215 |
| 1999 03/24 | 558.83 | 178950 | -560.00 | 1527 | 0.00 | 1237 |
| 1999 03/25 | 558.54 | 178350 | -600.00 | 1537 | 0.00 | 1229 |
| 1999 03/26 | 558.21 | 177660 | -690.00 | 1536 | 0.00 | 1187 |
| 1999 03/27 | 557.90 | 177020 | -640.00 | 1539 | 0.00 | 1217 |
| 1999 03/28 | 557.62 | 176440 | -580.00 | 1540 | 0.00 | 1249 |
| 1999 03/29 | 557.30 | 175780 | -660.00 | 1550 | 0.00 | 1224 |
| 1999 03/30 | 556.93 | 175030 | -750.00 | 1562 | 0.00 | 1160 |
| 1999 03/31 | 556.55 | 174230 | -800.00 | 1559 | 0.00 | 1162 |
| 1999 04/01 | 556.08 | 173270 | -960.00 | 1574 | 0.00 | 1094 |

Later | Latest

Warning! This data is preliminary and subject to revision.

Show PAR Map | Plot PAR Data | 1 Month PAR Data | Real-Time PAR Data

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District

*Current data as of Thursday at 17:29:25*

Select a sensor name for a plot of recent data. **Note: Reservoir Flows are daily averages.**

| Date | RES ELE<br>*FEET* | STORAGE<br>*AF* | RES CHG<br>*AF* | OUTFLOW<br>*CFS* | PPT INC<br>*INCHES* | INFLOW<br>*CFS* |
|---|---|---|---|---|---|---|
| Earlier | | | | | | |
| 1999 04/02 | 555.57 | 172230 | -1040 | 1598 | 0.00 | 1068 |
| 1999 04/03 | 555.07 | 171210 | -1020 | 1585 | 0.00 | 1113 |
| 1999 04/04 | 554.61 | 170280 | -930.00 | 1584 | 0.00 | 1081 |
| 1999 04/05 | 554.11 | 169280 | -1000 | 1587 | 0.00 | 1084 |
| 1999 04/06 | 553.62 | 168300 | -980.00 | 1592 | 0.02 | 1096 |
| 1999 04/07 | 553.09 | 167230 | -1070 | 1582 | 0.02 | 1047 |
| 1999 04/08 | 552.67 | 166400 | -830.00 | 1583 | 0.00 | 1156 |
| 1999 04/09 | 552.02 | 165080 | -1320 | 1597 | -- | 958.00 |
| 1999 04/10 | 551.40 | 163880 | -1200 | 1596 | -- | 955.00 |
| 1999 04/11 | 550.79 | 162660 | -1220 | 1554 | -- | 966.00 |
| 1999 04/12 | 550.93 | 162960 | 300.00 | 903.00 | -- | 1034 |
| 1999 04/13 | 551.18 | 163450 | 490.00 | 900.00 | -- | 1143 |
| 1999 04/14 | 551.61 | 164300 | 850.00 | 923.00 | -- | 1314 |
| 1999 04/15 | 552.27 | 165600 | 1300 | 916.00 | -- | 1551 |

Later | Latest

Warning! This data is preliminary and subject to revision.

Show PAR Map | Plot PAR Data | 1 Month PAR Data | Real-Time PAR Data

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District

*Current data as of Thursday at 17:22:30*

Select a sensor name for a plot of recent data. **Note: Reservoir Flows are daily averages.**

| Date | RES ELE *FEET* | STORAGE *AF* | RES CHG *AF* | OUTFLOW *CFS* | PPT INC *INCHES* | INFLOW *CFS* |
|---|---|---|---|---|---|---|
| Earlier | | | | | | |
| 1999 04/16 | 552.84 | 166740 | 1140 | 1068 | -- | 1614 |
| 1999 04/17 | 552.97 | 167000 | 260.00 | 1427 | -- | 1551 |
| 1999 04/18 | 553.21 | 167470 | 470.00 | 1550 | -- | 1785 |
| 1999 04/19 | -- | -- | -- | -- | -- | -- |
| 1999 04/20 | 553.66 | 168380 | -- | 1601 | -- | 1856 |
| 1999 04/21 | 553.80 | 168640 | 260.00 | 1633 | -- | 1776 |
| 1999 04/22 | 553.83 | 168710 | 70.00 | 1633 | -- | 1667 |
| 1999 04/23 | 553.81 | 168680 | -30.00 | 1621 | -- | 1623 |
| 1999 04/24 | 553.76 | 168580 | -100.00 | 1617 | -- | 1561 |
| 1999 04/25 | 553.54 | 168140 | -440.00 | 1626 | -- | 1400 |
| 1999 04/26 | 553.53 | 168120 | -20.00 | -- | -- | -- |
| 1999 04/27 | 553.46 | 167950 | -170.00 | 1637 | -- | 1556 |
| 1999 04/28 | 553.53 | 168120 | 170.00 | 1628 | -- | 1699 |
| 1999 04/29 | 553.35 | 167750 | -370.00 | 1620 | -- | 1443 |

Later | Latest

Warning! This data is preliminary and subject to revision.

Show PAR Map | Plot PAR Data | 1 Month PAR Data | Real-Time PAR Data

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District

*Current data as of Thursday at 17:21:58*

Select a sensor name for a plot of recent data. **Note: Reservoir Flows are daily averages.**

| Date | RES ELE *FEET* | STORAGE *AF* | RES CHG *AF* | OUTFLOW *CFS* | PPT INC *INCHES* | INFLOW *CFS* |
|---|---|---|---|---|---|---|
| Earlier | | | | | | |
| 1999 04/30 | 553.10 | 167250 | -500.00 | 1644 | -- | 1397 |
| 1999 05/01 | 552.89 | 166860 | -390.00 | 1650 | -- | 1448 |
| 1999 05/02 | 552.85 | 166760 | -100.00 | 1661 | -- | 1581 |
| 1999 05/03 | 553.08 | 167210 | 450.00 | 1644 | 0.04 | 1876 |
| 1999 05/04 | 553.01 | 167080 | -130.00 | 1652 | 0.00 | 1583 |
| 1999 05/05 | 552.89 | 166840 | -240.00 | 1655 | 0.00 | 1531 |
| 1999 05/06 | 552.69 | 166440 | -400.00 | 1652 | 0.00 | 1456 |
| 1999 05/07 | 552.46 | 165980 | -460.00 | 1666 | 0.00 | 1415 |
| 1999 05/08 | -- | -- | -- | 1649 | 0.00 | 1416 |
| 1999 05/09 | -- | -- | -- | 1646 | 0.00 | 1512 |
| 1999 05/10 | -- | -- | -- | 1643 | 0.00 | 1458 |
| 1999 05/11 | 551.54 | 164160 | -- | 1652 | 0.00 | 1265 |
| 1999 05/12 | 551.37 | 163820 | -340.00 | 1668 | 0.00 | 1483 |
| 1999 05/13 | -- | -- | -- | -- | -- | -- |

Later | Latest

Warning! This data is preliminary and subject to revision.

Show PAR Map | Plot PAR Data | 1 Month PAR Data | Real-Time PAR Data

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

California Data Exchange Center Mail to Webmaster

# NEW HOGAN LAKE *(NHG)*

Elevation: 554' · CALAVERAS R basin · Operator: US Army Corps of Engineers

*Current data as of Thursday at 11:49:29*

Select a sensor name for a plot of recent data. **Note: Reservoir Flows are daily averages.**

| Date | RES ELE<br>*FEET* | FNF<br>*CFS* | STORAGE<br>*AF* | RES CHG<br>*AF* | OUTFLOW<br>*CFS* | TEMP MX<br>*DEG F* | TEMP MN<br>*DEG F* | PPT INC<br>*INCHES* | INFLOW<br>*CFS* |
|---|---|---|---|---|---|---|---|---|---|
| Earlier | | | | | | | | | |
| 1998 12/25 | 676.56 | 50.00 | 182953 | -125.00 | 109.00 | 46.00 | 23.00 | 0.00 | 33.00 |
| 1998 12/26 | 676.54 | 80.00 | 182891 | -62.00 | -- | -- | -- | -- | -- |
| 1998 12/27 | 676.49 | 36.00 | 182735 | -156.00 | -- | -- | -- | -- | -- |
| 1998 12/28 | 676.46 | 50.00 | 182642 | -93.00 | 109.00 | 56.00 | 27.00 | 0.00 | 30.00 |
| 1998 12/29 | 676.44 | 74.00 | 182580 | -62.00 | 109.00 | 60.00 | 29.00 | 0.00 | 68.00 |
| 1998 12/30 | 676.40 | 47.00 | 182455 | -125.00 | 104.00 | 59.00 | 31.00 | 0.00 | 74.00 |
| 1998 12/31 | -- | 42.00 | -- | -- | 104.00 | 55.00 | 33.00 | 0.00 | 47.00 |
| 1999 01/01 | 676.34 | 72.00 | 182269 | -- | 102.00 | -- | -- | -- | 40.00 |
| 1999 01/02 | 676.32 | 69.00 | 182206 | -63.00 | 98.00 | -- | -- | -- | 68.00 |
| 1999 01/03 | 676.27 | 22.00 | 182051 | -155.00 | 98.00 | -- | -- | -- | 67.00 |
| 1999 01/04 | 676.25 | 69.00 | 181989 | -62.00 | 98.00 | 47.00 | 25.00 | 0.00 | 22.00 |
| 1999 01/05 | 676.21 | 36.00 | 181865 | -124.00 | 98.00 | 50.00 | 25.00 | 0.00 | 69.00 |
| 1999 01/06 | 676.18 | 52.00 | 181771 | -94.00 | 98.00 | 42.00 | 27.00 | 0.00 | 36.00 |
| 1999 01/07 | 676.15 | 51.00 | 181678 | -93.00 | 98.00 | 43.00 | 28.00 | 0.00 | 52.00 |
| 1999 01/08 | 676.12 | 50.00 | 181585 | -93.00 | 98.00 | 39.00 | 32.00 | 0.00 | 51.00 |

Later | Latest

Warning! This data is preliminary and subject to revision.

Show NHG Map | Plot NHG Data | 1 Month NHG Data | Real-Time NHG Data

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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# NEW HOGAN LAKE *(NHG)*

Elevation: 554' · CALAVERAS R basin · Operator: US Army Corps of Engineers

*Current data as of Thursday at 11:50:55*

Select a sensor name for a plot of recent data. **Note: Reservoir Flows are daily averages.**

| Date | RES ELE<br>*FEET* | FNF<br>*CFS* | STORAGE<br>*AF* | RES CHG<br>*AF* | OUTFLOW<br>*CFS* | TEMP MX<br>*DEG F* | TEMP MN<br>*DEG F* | PPT INC<br>*INCHES* | INFLOW<br>*CFS* |
|---|---|---|---|---|---|---|---|---|---|
| Earlier | | | | | | | | | |
| 1999 01/08 | 676.12 | 50.00 | 181585 | -93.00 | 98.00 | 39.00 | 32.00 | 0.00 | 51.00 |
| 1999 01/09 | 676.08 | 35.00 | 181461 | -124.00 | 98.00 | -- | -- | -- | 51.00 |
| 1999 01/10 | 676.04 | 35.00 | 181337 | -124.00 | 98.00 | -- | -- | -- | 35.00 |
| 1999 01/11 | 676.02 | 71.00 | 181275 | -62.00 | 98.00 | 45.00 | 26.00 | 0.00 | 35.00 |
| 1999 01/12 | 675.99 | 55.00 | 181182 | -93.00 | 99.00 | 55.00 | 26.00 | 0.00 | 71.00 |
| 1999 01/13 | 675.95 | 42.00 | 181058 | -124.00 | 100.00 | 50.00 | 25.00 | 0.00 | 56.00 |
| 1999 01/14 | 675.93 | 72.00 | 180996 | -62.00 | 101.00 | 56.00 | 32.00 | 0.00 | 42.00 |
| 1999 01/15 | 675.99 | 197.00 | 181182 | 186.00 | 101.00 | 55.00 | 39.00 | 0.13 | 72.00 |
| 1999 01/16 | 676.00 | 175.00 | 181213 | 31.00 | -- | -- | -- | -- | -- |
| 1999 01/17 | 676.03 | 151.00 | 181306 | 93.00 | -- | -- | -- | -- | -- |
| 1999 01/18 | 676.34 | 588.00 | 182269 | 963.00 | -- | -- | -- | -- | -- |
| 1999 01/19 | 676.35 | 2397 | 182300 | 31.00 | 101.00 | 56.00 | 52.00 | 1.25 | 151.00 |
| 1999 01/20 | 679.62 | 3460 | 192622 | 10322 | 104.00 | -- | -- | -- | 2397 |
| 1999 01/21 | 679.52 | 1877 | 192302 | -320.00 | 527.00 | 55.00 | 42.00 | 0.30 | 3460 |
| 1999 01/22 | 678.29 | 982.00 | 188386 | -3916 | 2035 | 58.00 | 39.00 | 0.00 | 1877 |

Later | Latest

Warning! This data is preliminary and subject to revision.

Show NHG Map | Plot NHG Data | 1 Month NHG Data | Real-Time NHG Data

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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California Data Exchange Center Mail to Webmaster

**California Department of Water Resources** **Division of Flood Management**

# NEW HOGAN LAKE *(NHG)*

Elevation: 554' · CALAVERAS R basin · Operator: US Army Corps of Engineers

*Current data as of Thursday at 11:51:36*

Select a sensor name for a plot of recent data. **Note: Reservoir Flows are daily averages.**

Earlier

| Date | RES ELE<br>FEET | FNF<br>CFS | STORAGE<br>AF | RES CHG<br>AF | OUTFLOW<br>CFS | TEMP MX<br>DEG F | TEMP MN<br>DEG F | PPT INC<br>INCHES | INFLOW<br>CFS |
|---|---|---|---|---|---|---|---|---|---|
| 1999 01/22 | 678.29 | 982.00 | 188386 | -3916 | 2035 | 58.00 | 39.00 | 0.00 | 1877 |
| 1999 01/23 | 677.62 | 1930 | 186272 | -2114 | 2952 | 58.00 | 46.00 | 0.37 | 982.00 |
| 1999 01/24 | 676.67 | 1479 | 183296 | -2976 | 2993 | -- | -- | -- | 1930 |
| 1999 01/25 | 675.87 | 763.00 | 180810 | -2486 | 2993 | 53.00 | 33.00 | 0.02 | 1930 |
| 1999 01/26 | 675.67 | 570.00 | 180192 | -618.00 | 2012 | 49.00 | 38.00 | 0.19 | 763.00 |
| 1999 01/27 | 675.56 | 448.00 | 179852 | -340.00 | 877.00 | 52.00 | 28.00 | 0.13 | 570.00 |
| 1999 01/28 | 675.61 | 323.00 | 180006 | 154.00 | 619.00 | 52.00 | 29.00 | 0.00 | 453.00 |
| 1999 01/29 | 675.72 | 259.00 | 180346 | 340.00 | 245.00 | 58.00 | 35.00 | 0.00 | 328.00 |
| 1999 01/30 | -- | 211.00 | -- | -- | 83.00 | 60.00 | 32.00 | 0.00 | 259.00 |
| 1999 01/31 | -- | 796.00 | -- | -- | -- | -- | -- | -- | -- |
| 1999 02/01 | 676.63 | 736.00 | 183171 | -- | 103.00 | 48.00 | 31.00 | 0.25 | 792.00 |
| 1999 02/02 | 676.84 | 440.00 | 183827 | 656.00 | 104.00 | 54.00 | 33.00 | 0.00 | 440.00 |
| 1999 02/03 | 676.98 | 329.00 | 184264 | 437.00 | 104.00 | 61.00 | 34.00 | 0.00 | 329.00 |
| 1999 02/04 | 677.09 | 280.00 | 184609 | 345.00 | 104.00 | 56.00 | 30.00 | 0.00 | 280.00 |
| 1999 02/05 | 677.17 | 238.00 | 184859 | 250.00 | 104.00 | 60.00 | 32.00 | 0.00 | 238.00 |

Later | Latest

Warning! This data is preliminary and subject to revision.

Show NHG Map | Plot NHG Data | 1 Month NHG Data | Real-Time NHG Data

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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# NEW HOGAN LAKE *(NHG)*

Elevation: 554' · CALAVERAS R basin · Operator: US Army Corps of Engineers

*Current data as of Thursday at 11:52:04*

Select a sensor name for a plot of recent data. **Note: Reservoir Flows are daily averages.**

Earlier

| Date | RES ELE<br>*FEET* | FNF<br>*CFS* | STORAGE<br>*AF* | RES CHG<br>*AF* | OUTFLOW<br>*CFS* | TEMP MX<br>*DEG F* | TEMP MN<br>*DEG F* | PPT INC<br>*INCHES* | INFLOW<br>*CFS* |
|---|---|---|---|---|---|---|---|---|---|
| 1999 02/05 | 677.17 | 238.00 | 184859 | 250.00 | 104.00 | 60.00 | 32.00 | 0.00 | 238.00 |
| 1999 02/06 | -- | 260.00 | -- | -- | 102.00 | 53.00 | 49.00 | 0.53 | 260.00 |
| 1999 02/07 | -- | 4530 | -- | -- | 110.00 | 55.00 | 48.00 | 0.95 | 4530 |
| 1999 02/08 | 682.08 | 3905 | 200593 | -- | 550.00 | 57.00 | 52.00 | 0.66 | 3905 |
| 1999 02/09 | 686.78 | 9084 | 216317 | 15724 | 1147 | 54.00 | 26.00 | 1.25 | 9084 |
| 1999 02/10 | 686.97 | 2942 | 216966 | 649.00 | 2609 | 52.00 | 28.00 | 0.00 | 2942 |
| 1999 02/11 | 685.63 | 1617 | 212409 | -4557 | 3908 | 59.00 | 31.00 | 0.00 | 1617 |
| 1999 02/12 | 684.00 | 1176 | 206937 | -5472 | 3930 | 59.00 | 34.00 | 0.00 | 1176 |
| 1999 02/13 | 682.23 | 942.00 | 201085 | -5852 | 3887 | 62.00 | 38.00 | 0.06 | 942.00 |
| 1999 02/14 | 680.32 | 793.00 | 194872 | -6213 | 3921 | 57.00 | 35.00 | 0.00 | 793.00 |
| 1999 02/15 | 678.29 | 714.00 | 188386 | -6486 | 3978 | 58.00 | 37.00 | 0.00 | 714.00 |
| 1999 02/16 | 677.28 | 700.00 | 185204 | -3182 | 2304 | 55.00 | 46.00 | 0.55 | 700.00 |
| 1999 02/17 | 678.45 | 2385 | 188893 | 3689 | 523.00 | -- | -- | -- | 2385 |
| 1999 02/18 | -- | 1375 | -- | -- | 699.00 | 58.00 | 34.00 | 0.35 | 1375 |
| 1999 02/19 | -- | 1297 | -- | -- | 1000 | 62.00 | 35.00 | 0.00 | 1297 |

Later | Latest

Warning! This data is preliminary and subject to revision.

Show NHG Map | Plot NHG Data | 1 Month NHG Data | Real-Time NHG Data

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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**California Department of Water Resources** **Division of Flood Management**

# NEW HOGAN LAKE *(NHG)*

Elevation: 554' · CALAVERAS R basin · Operator: US Army Corps of Engineers

*Current data as of Thursday at 11:52:39*

Select a sensor name for a plot of recent data. **Note: Reservoir Flows are daily averages.**

| Date | RES ELE<br>*FEET* | FNF<br>*CFS* | STORAGE<br>*AF* | RES CHG<br>*AF* | OUTFLOW<br>*CFS* | TEMP MX<br>*DEG F* | TEMP MN<br>*DEG F* | PPT INC<br>*INCHES* | INFLOW<br>*CFS* |
|---|---|---|---|---|---|---|---|---|---|
| Earlier | | | | | | | | | |
| 1999 02/19 | -- | 1297 | -- | -- | 1000 | 62.00 | 35.00 | 0.00 | 1297 |
| 1999 02/20 | 679.11 | 1102 | 190992 | -- | 1001 | 55.00 | 35.00 | 1.11 | 1102 |
| 1999 02/21 | 680.25 | 2860 | 194647 | 3655 | 1014 | 56.00 | 36.00 | 0.03 | 2860 |
| 1999 02/22 | 680.58 | 1550 | 195712 | 1065 | 1010 | 60.00 | 35.00 | 0.00 | 1550 |
| 1999 02/23 | 680.63 | 1099 | 195874 | 162.00 | 1009 | 64.00 | 36.00 | 0.00 | 1099 |
| 1999 02/24 | 680.54 | 871.00 | 195583 | -291.00 | 1010 | -- | -- | -- | 871.00 |
| 1999 02/25 | 680.54 | 1017 | 195583 | 0.00 | 1009 | 59.00 | 31.00 | 0.02 | 1017 |
| 1999 02/26 | -- | 868.00 | -- | -- | 1009 | 60.00 | 31.00 | 0.00 | 868.00 |
| 1999 02/27 | 680.27 | 725.00 | 194711 | -- | 1009 | 66.00 | 41.00 | 0.00 | 725.00 |
| 1999 02/28 | 680.03 | 626.00 | 193939 | -772.00 | 1008 | 70.00 | 47.00 | 0.00 | 625.00 |
| 1999 03/01 | 679.68 | 439.00 | 192815 | -1124 | 996.00 | 67.00 | 38.00 | 0.00 | 439.00 |
| 1999 03/02 | -- | 483.00 | -- | -- | 1004 | 73.00 | 44.00 | 0.80 | 483.00 |
| 1999 03/03 | -- | 1013 | -- | -- | 1007 | 55.00 | 30.00 | 0.04 | 1013 |
| 1999 03/04 | 679.33 | 745.00 | 191694 | -- | 768.00 | 58.00 | 31.00 | 0.00 | 745.00 |
| 1999 03/05 | 679.47 | 600.00 | 192142 | 448.00 | 366.00 | 59.00 | 34.00 | 0.00 | 600.00 |

Later | Latest

Warning! This data is preliminary and subject to revision.

Show NHG Map | Plot NHG Data | 1 Month NHG Data | Real-Time NHG Data

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

California Data Exchange Center Mail to Webmaster

**California Department of Water Resources** · **Division of Flood Management**

Current River Conditions · Snowpack Status · River Stages/Flows · Reservoir Data/Reports · Satellite Images · Station Information
Data Query Tools · Precipitation/Snow · River/Tide Forecasts · Water Supply · Weather Forecasts · Text Reports

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# NEW HOGAN LAKE *(NHG)*

Elevation: 554' · CALAVERAS R basin · Operator: US Army Corps of Engineers

*Current data as of Thursday at 11:53:17*

Select a sensor name for a plot of recent data. **Note: Reservoir Flows are daily averages.**

Earlier

| Date | RES ELE<br>*FEET* | FNF<br>*CFS* | STORAGE<br>*AF* | RES CHG<br>*AF* | OUTFLOW<br>*CFS* | TEMP MX<br>*DEG F* | TEMP MN<br>*DEG F* | PPT INC<br>*INCHES* | INFLOW<br>*CFS* |
|---|---|---|---|---|---|---|---|---|---|
| 1999 03/05 | 679.47 | 600.00 | 192142 | 448.00 | 366.00 | 59.00 | 34.00 | 0.00 | 600.00 |
| 1999 03/06 | -- | 490.00 | -- | -- | 98.00 | 58.00 | 29.00 | 0.00 | 490.00 |
| 1999 03/07 | 679.92 | 447.00 | 193585 | -- | 98.00 | 61.00 | 31.00 | 0.00 | 448.00 |
| 1999 03/08 | 680.11 | 413.00 | 194196 | 611.00 | 100.00 | 56.00 | 40.00 | 0.25 | 413.00 |
| 1999 03/09 | 680.44 | 645.00 | 195260 | 1064 | 101.00 | 56.00 | 31.00 | 0.00 | 645.00 |
| 1999 03/10 | 680.73 | 580.00 | 196197 | 937.00 | 101.00 | 54.00 | 36.00 | 0.00 | 580.00 |
| 1999 03/11 | 680.96 | 488.00 | 196942 | 745.00 | 101.00 | 62.00 | 31.00 | 0.00 | 488.00 |
| 1999 03/12 | 681.16 | 438.00 | 197591 | 649.00 | 101.00 | 65.00 | 38.00 | 0.00 | 438.00 |
| 1999 03/13 | 681.32 | 375.00 | 198112 | 521.00 | 101.00 | 68.00 | 36.00 | 0.00 | 375.00 |
| 1999 03/14 | -- | 490.00 | -- | -- | 101.00 | 60.00 | 43.00 | 0.00 | 485.00 |
| 1999 03/15 | 681.70 | 354.00 | 199350 | 489.00 | 101.00 | 61.00 | 44.00 | 0.00 | 354.00 |
| 1999 03/16 | 681.84 | 334.00 | 199808 | 458.00 | 101.00 | 55.00 | 35.00 | 0.00 | 334.00 |
| 1999 03/17 | 681.96 | 308.00 | 200200 | 392.00 | 103.00 | 64.00 | 35.00 | 0.00 | 308.00 |
| 1999 03/18 | 682.07 | 299.00 | 200560 | 360.00 | 107.00 | 66.00 | 38.00 | 0.00 | 299.00 |
| 1999 03/19 | -- | 269.00 | -- | -- | 109.00 | 67.00 | 41.00 | 0.35 | 269.00 |

Later | Latest

Warning! This data is preliminary and subject to revision.

Show NHG Map | Plot NHG Data | 1 Month NHG Data | Real-Time NHG Data

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

# NEW HOGAN LAKE *(NHG)*

Elevation: 554' · CALAVERAS R basin · Operator: US Army Corps of Engineers

*Current data as of Thursday at 11:53:50*

Select a sensor name for a plot of recent data. **Note: Reservoir Flows are daily averages.**

| Date | RES ELE<br>*FEET* | FNF<br>*CFS* | STORAGE<br>*AF* | RES CHG<br>*AF* | OUTFLOW<br>*CFS* | TEMP MX<br>*DEG F* | TEMP MN<br>*DEG F* | PPT INC<br>*INCHES* | INFLOW<br>*CFS* |
|---|---|---|---|---|---|---|---|---|---|
| Earlier | | | | | | | | | |
| 1999 03/19 | -- | 269.00 | -- | -- | 109.00 | 67.00 | 41.00 | 0.35 | 269.00 |
| 1999 03/20 | 682.30 | 349.00 | 201314 | -- | 109.00 | 63.00 | 38.00 | 0.03 | 349.00 |
| 1999 03/21 | 682.42 | 318.00 | 201709 | 395.00 | 110.00 | 65.00 | 35.00 | 0.01 | 318.00 |
| 1999 03/22 | 682.50 | 255.00 | 201972 | 263.00 | 111.00 | 64.00 | 47.00 | 0.02 | 255.00 |
| 1999 03/23 | 682.60 | 284.00 | 202300 | 328.00 | 111.00 | 63.00 | 42.00 | 0.06 | 284.00 |
| 1999 03/24 | 682.68 | 254.00 | 202564 | 264.00 | 111.00 | 68.00 | 48.00 | 0.02 | 254.00 |
| 1999 03/25 | 682.76 | 259.00 | 202828 | 264.00 | 111.00 | 70.00 | 41.00 | 0.00 | 259.00 |
| 1999 03/26 | 682.78 | 211.00 | 202894 | 66.00 | 164.00 | 67.00 | 33.00 | 0.00 | 211.00 |
| 1999 03/27 | 682.79 | 232.00 | 202926 | 32.00 | 200.00 | 64.00 | 31.00 | 0.00 | 232.00 |
| 1999 03/28 | 682.78 | 194.00 | 202894 | -32.00 | 195.00 | 64.00 | 30.00 | 0.00 | 209.00 |
| 1999 03/29 | 682.79 | 201.00 | 202926 | 32.00 | 194.00 | 62.00 | 32.00 | 0.00 | 201.00 |
| 1999 03/30 | 682.78 | 199.00 | 202894 | -32.00 | 202.00 | 59.00 | 33.00 | 0.49 | 199.00 |
| 1999 03/31 | 682.82 | 310.00 | 203025 | 131.00 | 216.00 | 56.00 | 30.00 | 0.00 | 310.00 |
| 1999 04/01 | 682.84 | 244.00 | 203091 | 66.00 | 213.00 | 62.00 | 30.00 | 0.00 | 244.00 |
| 1999 04/02 | 682.83 | 211.00 | 203058 | -33.00 | 214.00 | 66.00 | 39.00 | 0.00 | 211.00 |

Later | Latest

Warning! This data is preliminary and subject to revision.

Show NHG Map | Plot NHG Data | 1 Month NHG Data | Real-Time NHG Data

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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California Data Exchange Center Mail to Webmaster

# NEW HOGAN LAKE *(NHG)*

Elevation: 554' · CALAVERAS R basin · Operator: US Army Corps of Engineers

*Current data as of Thursday at 11:54:24*

Select a sensor name for a plot of recent data. **Note: Reservoir Flows are daily averages.**

| Date | RES ELE<br>*FEET* | FNF<br>*CFS* | STORAGE<br>*AF* | RES CHG<br>*AF* | OUTFLOW<br>*CFS* | TEMP MX<br>*DEG F* | TEMP MN<br>*DEG F* | PPT INC<br>*INCHES* | INFLOW<br>*CFS* |
|---|---|---|---|---|---|---|---|---|---|
| Earlier | | | | | | | | | |
| 1999 04/02 | 682.83 | 211.00 | 203058 | -33.00 | 214.00 | 66.00 | 39.00 | 0.00 | 211.00 |
| 1999 04/03 | 682.81 | 194.00 | 202992 | -66.00 | 214.00 | 58.00 | 28.00 | 0.07 | 194.00 |
| 1999 04/04 | 682.80 | 210.00 | 202959 | -33.00 | 214.00 | 62.00 | 29.00 | 0.00 | 210.00 |
| 1999 04/05 | 682.85 | 298.00 | 203124 | 165.00 | 214.00 | 46.00 | 36.00 | 0.53 | 298.00 |
| 1999 04/06 | 683.01 | 486.00 | 203653 | 529.00 | 214.00 | 56.00 | 39.00 | 0.00 | 486.00 |
| 1999 04/07 | 683.11 | 386.00 | 203983 | 330.00 | 214.00 | 49.00 | 45.00 | 0.02 | 386.00 |
| 1999 04/08 | 683.38 | 670.00 | 204877 | 894.00 | 215.00 | 50.00 | 28.00 | 0.52 | 670.00 |
| 1999 04/09 | -- | 779.00 | 205972 | -- | -- | -- | -- | -- | -- |
| 1999 04/10 | 683.96 | 645.00 | 206804 | -- | -- | -- | -- | -- | -- |
| 1999 04/11 | -- | 602.00 | 207738 | -- | -- | -- | -- | -- | -- |
| 1999 04/12 | 684.50 | 535.00 | 208607 | -- | -- | -- | -- | -- | -- |
| 1999 04/13 | 684.72 | 469.00 | 209344 | 737.00 | -- | -- | -- | -- | -- |
| 1999 04/14 | 684.91 | 430.00 | 209982 | 638.00 | -- | -- | -- | -- | -- |
| 1999 04/15 | 685.06 | 387.00 | 210486 | 504.00 | -- | -- | -- | -- | -- |
| 1999 04/16 | 685.19 | 385.00 | 210924 | 438.00 | -- | -- | -- | -- | -- |

Later | Latest

Warning! This data is preliminary and subject to revision.

Show NHG Map | Plot NHG Data | 1 Month NHG Data | Real-Time NHG Data

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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California Data Exchange Center Mail to Webmaster

**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

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# NEW HOGAN LAKE *(NHG)*

Elevation: 554' · CALAVERAS R basin · Operator: US Army Corps of Engineers

*Current data as of Thursday at 11:54:57*

Select a sensor name for a plot of recent data. **Note: Reservoir Flows are daily averages.**

| Date | RES ELE<br>*FEET* | FNF<br>*CFS* | STORAGE<br>*AF* | RES CHG<br>*AF* | OUTFLOW<br>*CFS* | TEMP MX<br>*DEG F* | TEMP MN<br>*DEG F* | PPT INC<br>*INCHES* | INFLOW<br>*CFS* |
|---|---|---|---|---|---|---|---|---|---|
| Earlier | | | | | | | | | |
| 1999 04/16 | 685.19 | 385.00 | 210924 | 438.00 | -- | -- | -- | -- | -- |
| 1999 04/17 | 685.29 | 347.00 | 211261 | 337.00 | -- | -- | -- | -- | -- |
| 1999 04/18 | 685.38 | 316.00 | 211565 | 304.00 | -- | -- | -- | -- | -- |
| 1999 04/19 | 685.46 | 301.00 | 211835 | 270.00 | -- | -- | -- | -- | -- |
| 1999 04/20 | 685.51 | 264.00 | 212003 | 168.00 | -- | -- | -- | -- | -- |
| 1999 04/21 | 685.53 | 268.00 | 212071 | 68.00 | -- | -- | -- | -- | -- |
| 1999 04/22 | 685.51 | 222.00 | 212003 | -68.00 | -- | -- | -- | -- | -- |
| 1999 04/23 | 685.50 | 255.00 | 211970 | -33.00 | -- | -- | -- | -- | -- |
| 1999 04/24 | 685.46 | 200.00 | 211835 | -135.00 | -- | -- | -- | -- | -- |
| 1999 04/25 | 685.44 | 214.00 | 211767 | -68.00 | -- | -- | -- | -- | -- |
| 1999 04/26 | 685.42 | 196.00 | 211699 | -68.00 | -- | -- | -- | -- | -- |
| 1999 04/27 | 685.40 | 185.00 | 211632 | -67.00 | -- | -- | -- | -- | -- |
| 1999 04/28 | 685.38 | 163.00 | 211565 | -67.00 | -- | -- | -- | -- | -- |
| 1999 04/29 | -- | 172.00 | -- | -- | -- | -- | -- | -- | -- |
| 1999 04/30 | 685.34 | 196.00 | 211430 | -- | -- | -- | -- | -- | -- |

Later | Latest

Warning! This data is preliminary and subject to revision.

Show NHG Map | Plot NHG Data | 1 Month NHG Data | Real-Time NHG Data

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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# Appendix D

## Releases from Pardee Dam

**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data; Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

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# PARDEE

Map of surrounding area

| | | | |
|---|---|---|---|
| **Station ID** | PAR | **Elevation** | 568' ft |
| **River Basin** | MOKELUMNE R | **County** | CALAVERAS |
| **Hydrologic Area** | SAN JOAQUIN RIVER REGION | **Nearby City** | VALLEY SPRINGS |
| **Latitude** | 38.2500°N | **Longitude** | 120.8500°W |
| **Operator** | East Bay Municipal Utility District | **Data Collection** | DATA EXCHANGE |

The following data types are available online. Select one of the links below to retrieve recent data.

| | | |
|---|---|---|
| **CHANGE IN STORAGE**, af | (daily) | From 10/01/1995 to present. |
| **INCREMENTAL PRECIP**, inches | (daily) | From 10/01/1995 to present. |
| **RESERVOIR ELEVATION**, feet | (daily) | From 10/01/1995 to present. |
| **RESERVOIR INFLOW**, cfs | (daily) | From 10/01/1995 to present. |
| **RESERVOIR OUTFLOW**, cfs | (daily) | From 10/01/1995 to present. |
| **RESERVOIR STORAGE**, af | (daily) | From 10/01/1995 to present. |
| **ACCUMULATED PRECIP**, inches | (hourly) | From 10/06/1997 to present. |
| **RESERVOIR ELEVATION**, feet | (hourly) | From 01/01/1997 to present. |
| **RESERVOIR INFLOW**, cfs | (hourly) | From 01/01/1997 to present. |
| **RESERVOIR OUTFLOW**, cfs | (hourly) | From 01/01/1997 to present. |
| **RESERVOIR STORAGE**, af | (hourly) | From 01/01/1997 to present. |
| **RESERVOIR STORAGE**, af | (monthly) | From 12/01/1945 to present. |

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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**California Data Exchange Center** **Mail to Webmaster**

**California Department of Water Resources** **Division of Flood Management**

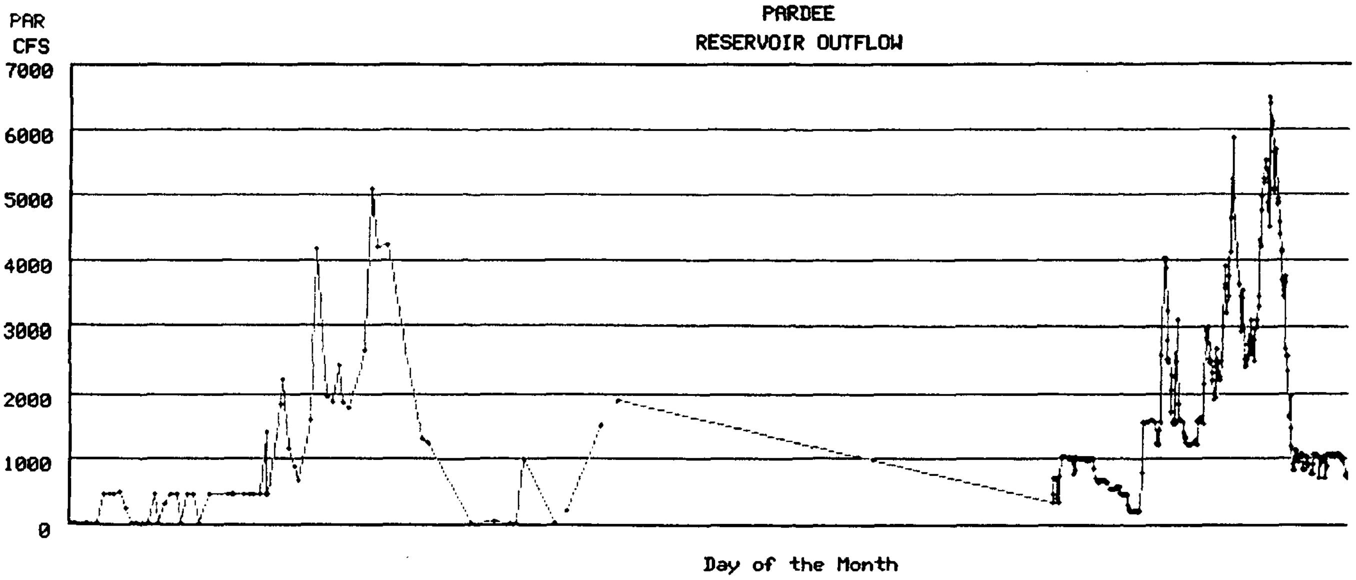
Current River Conditions | Snowpack Status | River Stages Flows | Reservoir Data Reports | Satellite Images | Station Information

Data Query Tools | Precipitation Snow | River Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 11:16:58*



Data from 05/06/1994 00:00 through 05/06/1999 00:00 · Duration: 1826days
Max of period: 6483 · Min of period: -9999

Show data | Plot earlier | Plot later

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

**California Data Exchange Center** **Mail to Webmaster**

LAST 5 YRS

**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

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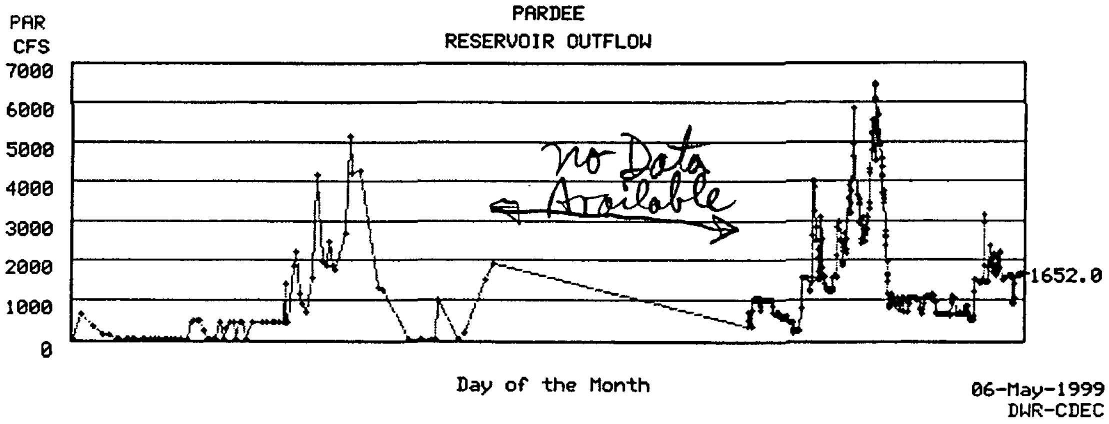
# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 14:15:26*



Data from 12/31/1989 00:00 through 05/06/1999 00:00 · Duration: 3413days
Max of period: 6483 · Min of period: -9999

Show data | Plot earlier | Plot later

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Real-Time Data | Group of Real-Time Stations | Daily Data | Group of Daily Stations
Monthly Data | Historical Data | Custom Graph Plotter | Text Reports

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**California Data Exchange Center** **Mail to Webmaster**

LAST 10 YEA

**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

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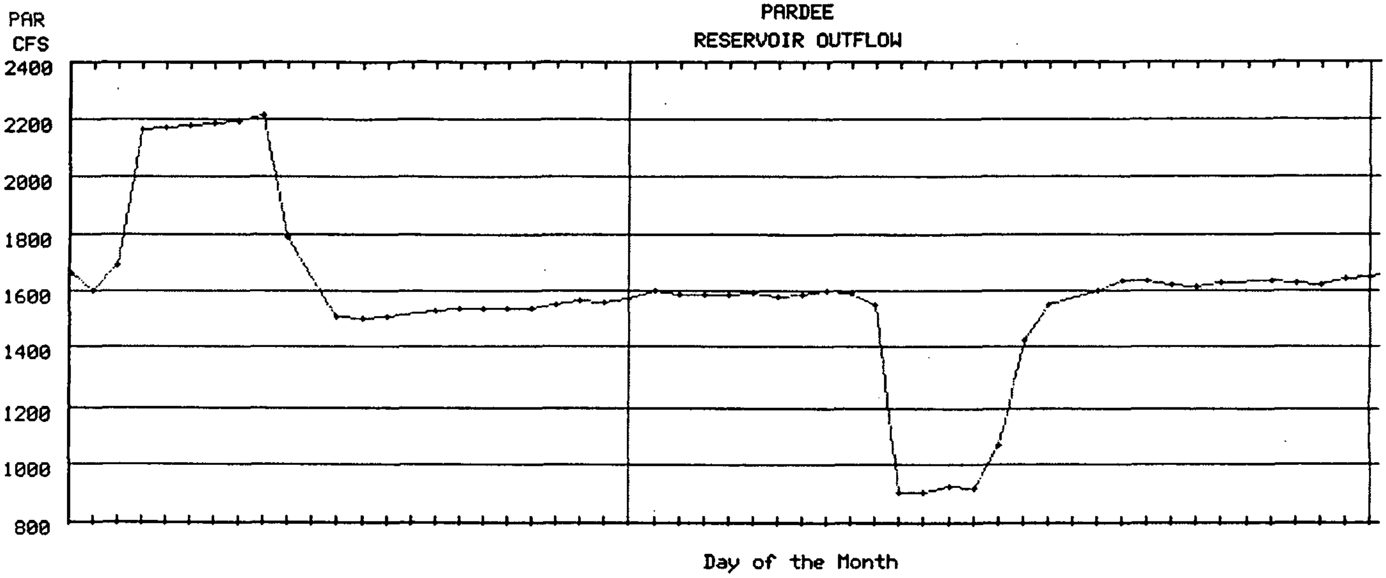
# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District

*Query executed Friday, 05/07/1999 11:09 PDT*



From 60 days ago to now

Daily PAR data| Real-Time PAR data

Warning! This has not been reviewed for accuracy. Graphics produced using gd

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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**California Data Exchange Center** **Mail to Webmaster**

LAST 60 DAY

**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

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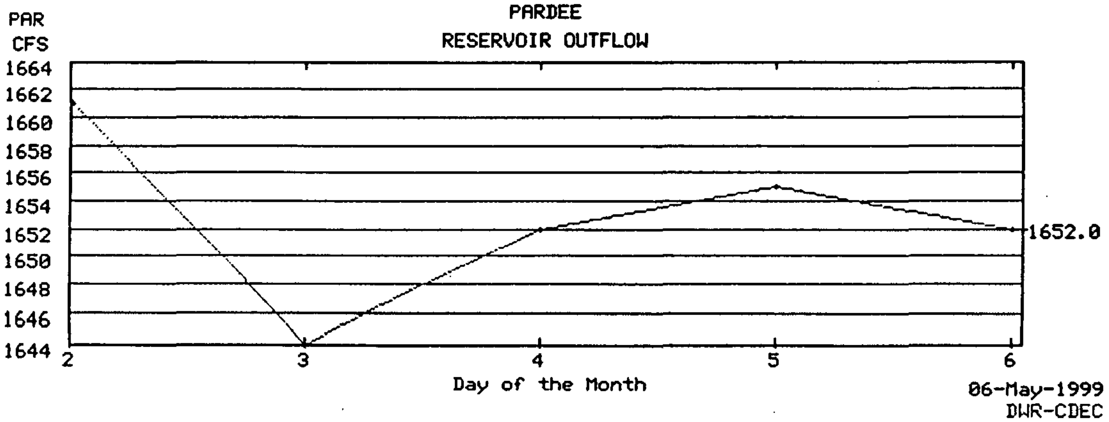
# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 13:45:01*



Data from 05/01/1999 00:00 through 05/06/1999 00:00 · Duration: 5days
Max of period: 1661 · Min of period: 1644

Show data | Plot earlier | Plot later

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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**California Data Exchange Center** **Mail to Webmaster**

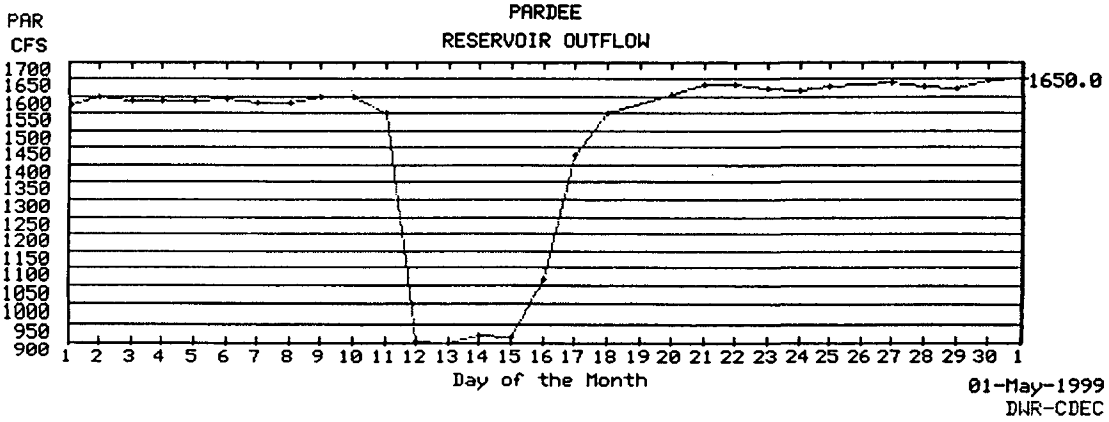
MAY-99

**California Department of Water Resources** **Division of Flood Management**

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 13:47:12*



Data from 03/31/1999 00:00 through 05/01/1999 00:00 · Duration: 31days
Max of period: 1650 · Min of period: 900

Show data | Plot earlier | Plot later

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

APR-99

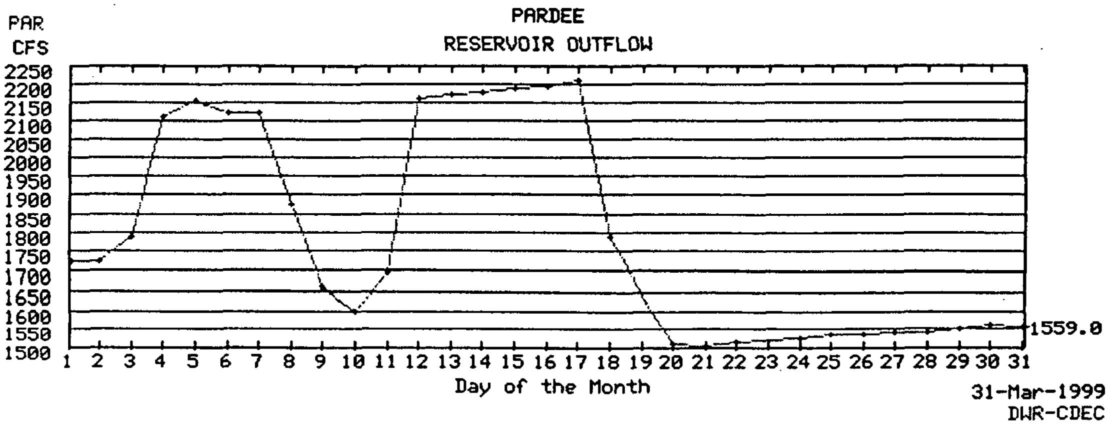
**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 13:47:50*



Data from 02/28/1999 00:00 through 03/31/1999 00:00 · Duration: 31days
Max of period: 2211 · Min of period: 1501

Show data | Plot earlier | Plot later

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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**California Data Exchange Center** **Mail to Webmaster**

MAR-99

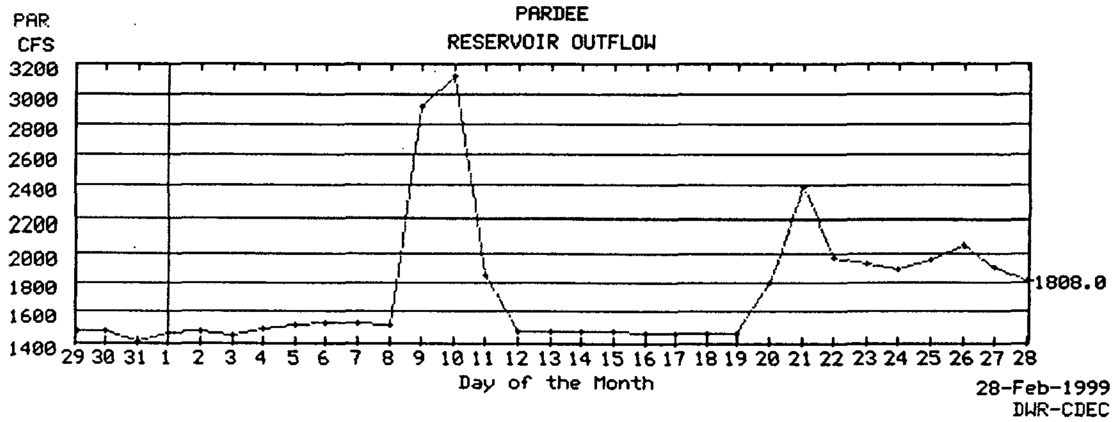
**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 13:48:11*



Data from 01/28/1999 00:00 through 02/28/1999 00:00 · Duration: 31days
Max of period: 3118 · Min of period: 1404

Show data | Plot earlier | Plot later

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

**California Data Exchange Center** **Mail to Webmaster**

FEB-99

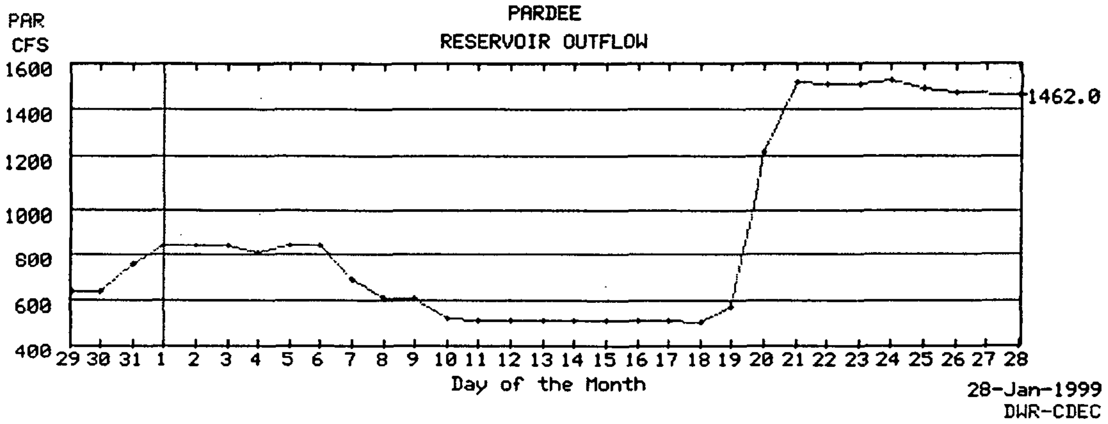
**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 13:49:21*



Data from 12/28/1998 00:00 through 01/28/1999 00:00 · Duration: 31days
Max of period: 1522 · Min of period: 505

Show data | Plot earlier | Plot later

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

**California Data Exchange Center** **Mail to Webmaster**

JAN-99

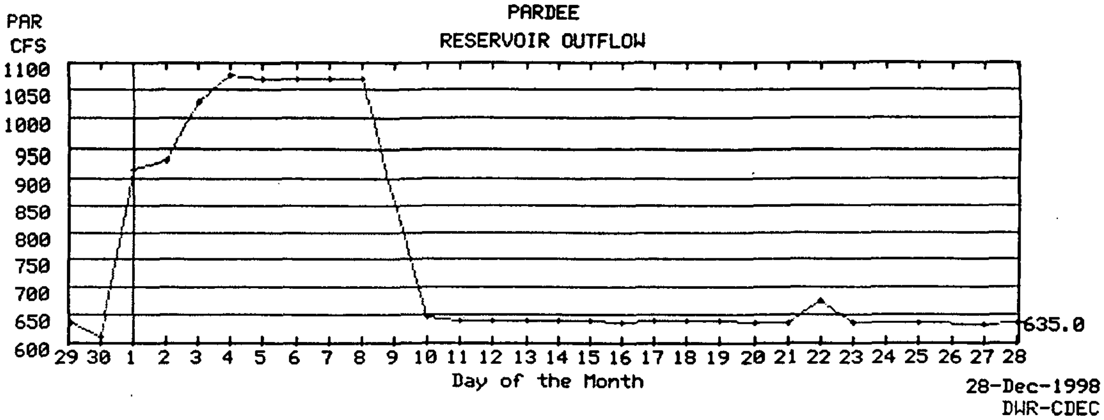
**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 13:51:40*



Data from 11/28/1998 00:00 through 12/28/1998 00:00 · Duration: 30days
Max of period: 1075 · Min of period: 609

Show data | Plot earlier | Plot later

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

**California Data Exchange Center** **Mail to Webmaster**

DEC-98

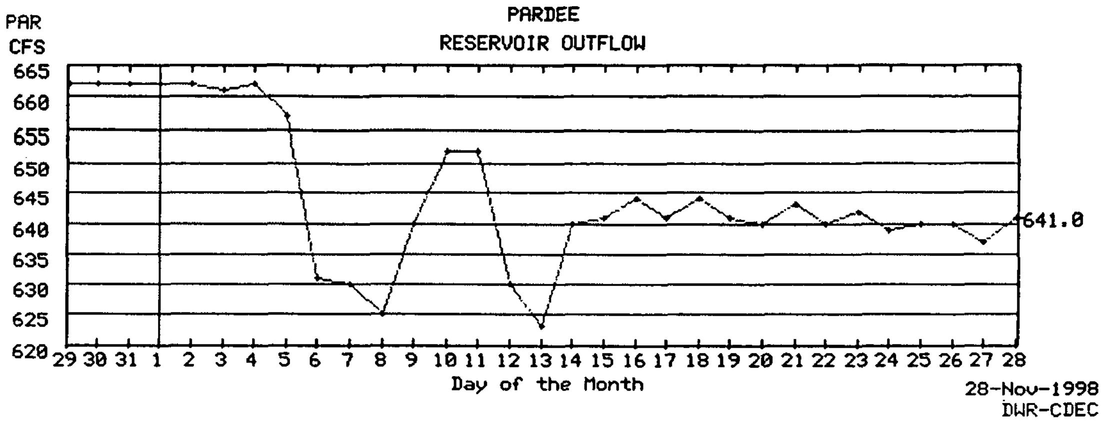
**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 13:52:05*



Data from 10/28/1998 00:00 through 11/28/1998 00:00 · Duration: 31days
Max of period: 711 · Min of period: 623

Show data | Plot earlier | Plot later

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

Nov - 98

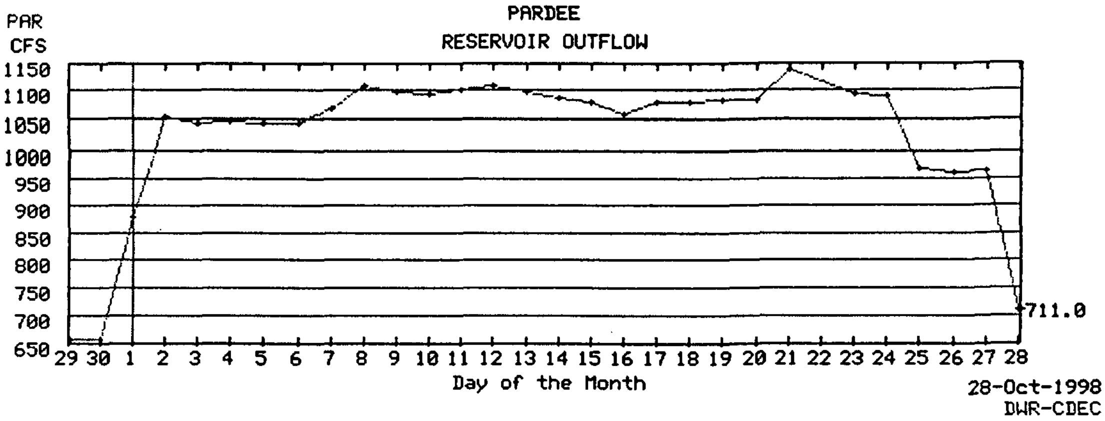
**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 13:52:27*



Data from 09/28/1998 00:00 through 10/28/1998 00:00 · Duration: 30days
Max of period: 1138 · Min of period: 656

Show data | Plot earlier | Plot later

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

**California Data Exchange Center** **Mail to Webmaster**

OCT-98

**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

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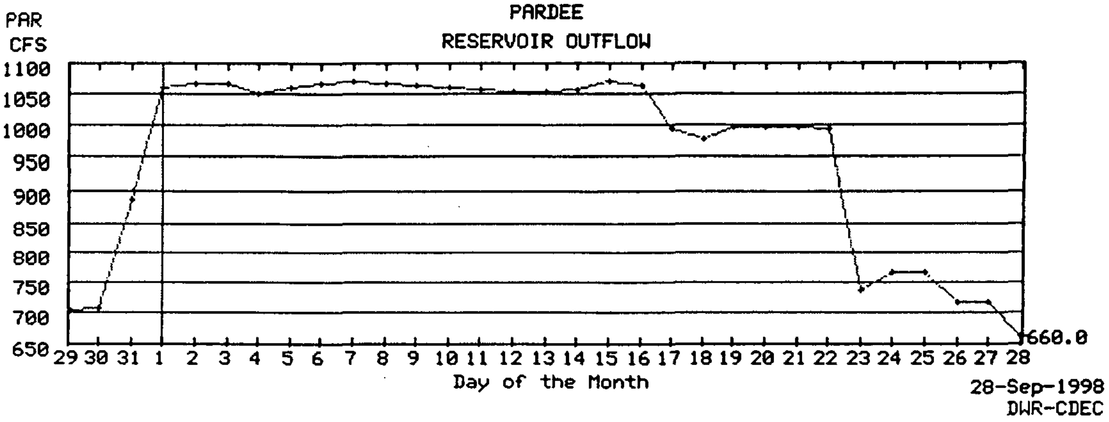
# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 13:57:28*



Data from 08/28/1998 00:00 through 09/28/1998 00:00 · Duration: 31days
Max of period: 1070 · Min of period: 660

Show data | Plot earlier | Plot later

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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**California Data Exchange Center** **Mail to Webmaster**

SEP-

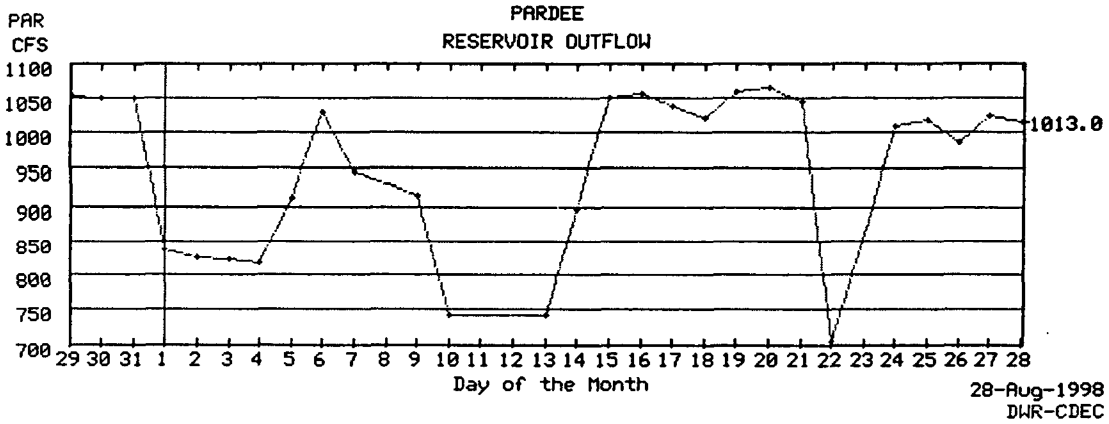
**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 13:57:53*



Data from 07/28/1998 00:00 through 08/28/1998 00:00 · Duration: 31days
Max of period: 1064 · Min of period: 705

Show data | Plot earlier | Plot later

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

AUG-98

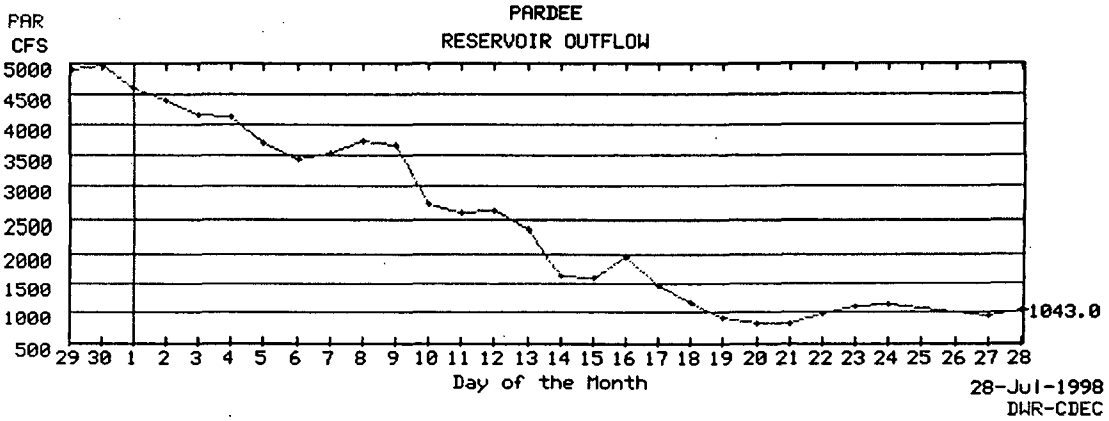
**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 13:58:39*



Data from 06/28/1998 00:00 through 07/28/1998 00:00 · Duration: 30days
Max of period: 4951 · Min of period: 804

Show data | Plot earlier | Plot later

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

JUL-98

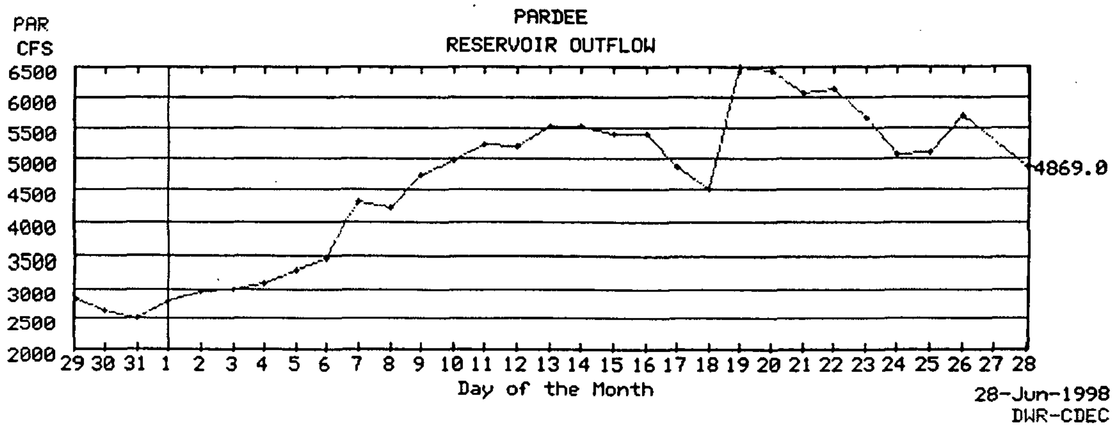
**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 13:59:16*



Data from 05/28/1998 00:00 through 06/28/1998 00:00 · Duration: 31days
Max of period: 6483 · Min of period: 2499

Show data | Plot earlier | Plot later

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

**California Data Exchange Center** **Mail to Webmaster**

JUN-98

**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

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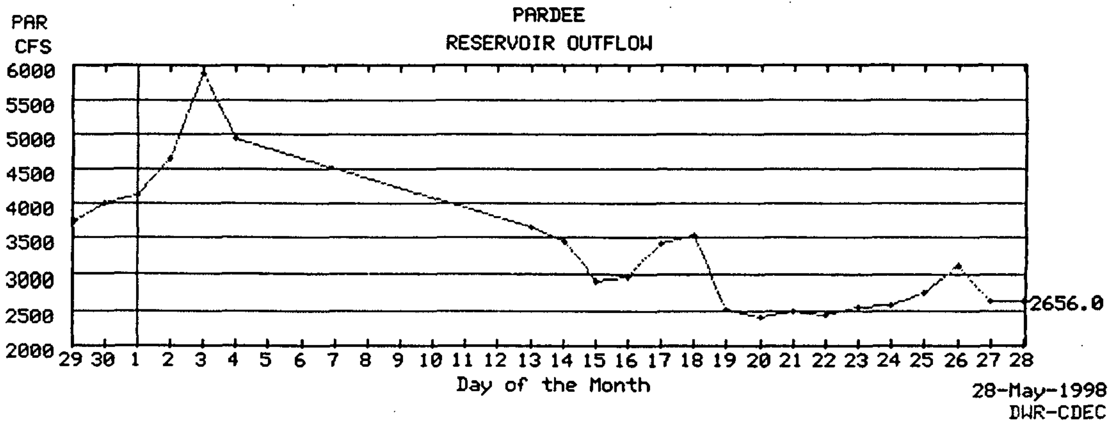
# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 13:59:30*



Data from 04/28/1998 00:00 through 05/28/1998 00:00 · Duration: 30days
Max of period: 5870 · Min of period: 2429

Show data | Plot earlier | Plot later

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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**California Data Exchange Center** **Mail to Webmaster**

MAY-98

**California Department of Water Resources** **Division of Flood Management**

Current River Conditions · Snowpack Status · River Stages/Flows · Reservoir Data/Reports · Satellite Images · Station Information
Data Query Tools · Precipitation/Snow · River/Tide Forecasts · Water Supply · Weather Forecasts · Text Reports

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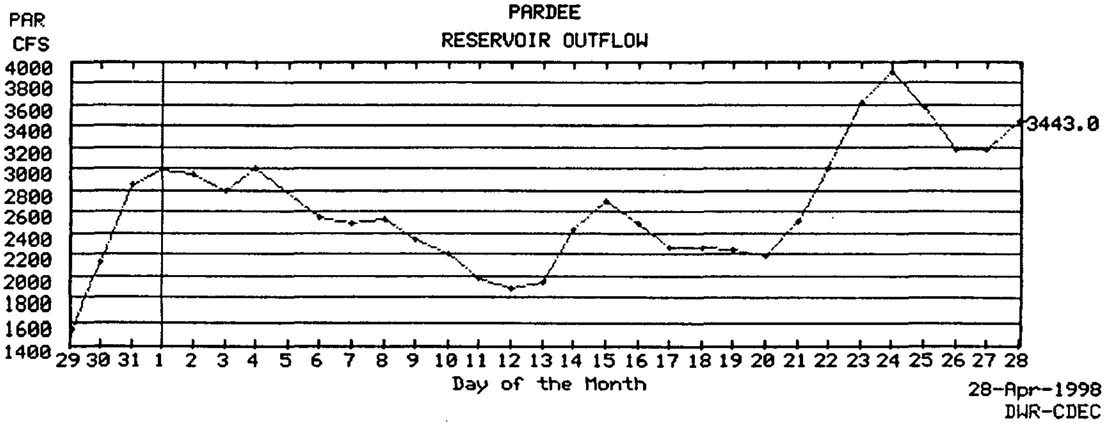
# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 13:59:48*



Data from 03/28/1998 00:00 through 04/28/1998 00:00 · Duration: 31days
Max of period: 3897 · Min of period: 1540

Show data | Plot earlier | Plot later

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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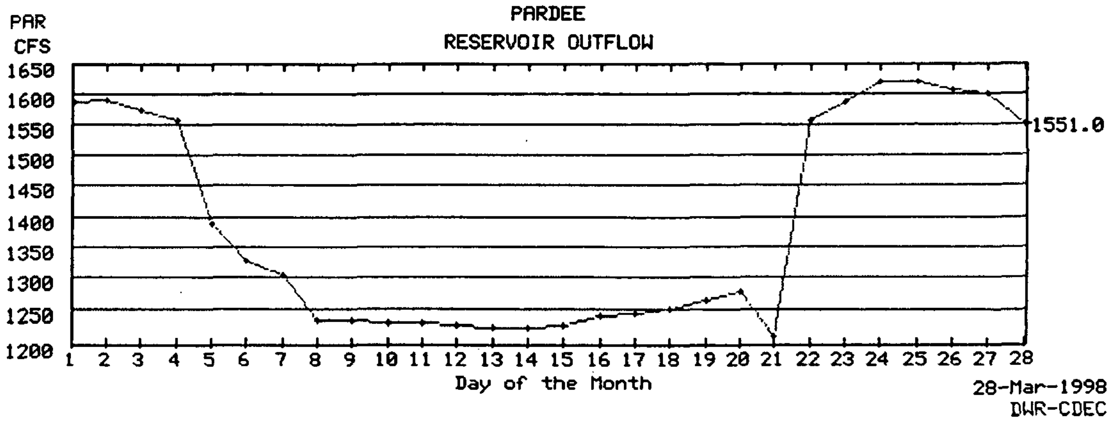
**California Data Exchange Center** **Mail to Webmaster**

APR-98

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 14:00:00*



Data from 02/28/1998 00:00 through 03/28/1998 00:00 · Duration: 28days
Max of period: 1620 · Min of period: 1213

Show data | Plot earlier | Plot later

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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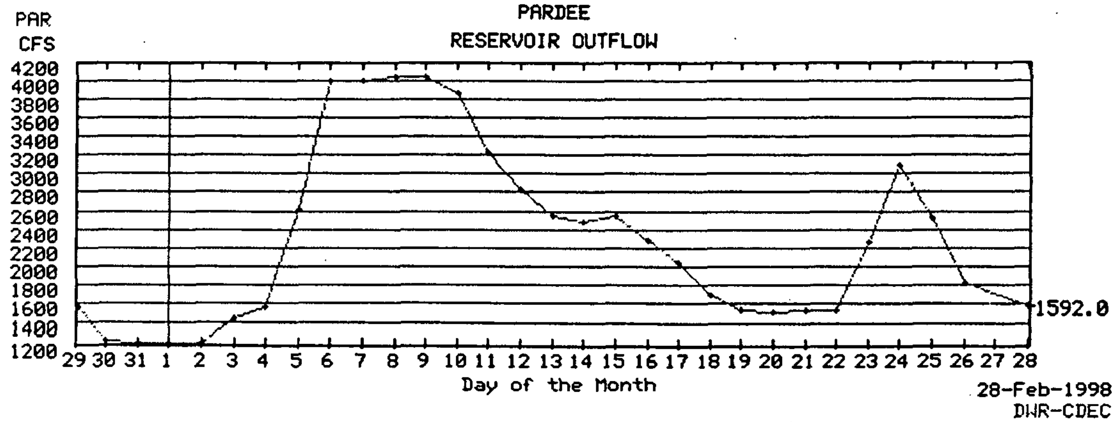
**California Data Exchange Center** **Mail to Webmaster**

MAR-98

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 14:01:15*



Data from 01/28/1998 00:00 through 02/28/1998 00:00 · Duration: 31days
Max of period: 4035 · Min of period: 1218

Show data | Plot earlier | Plot later

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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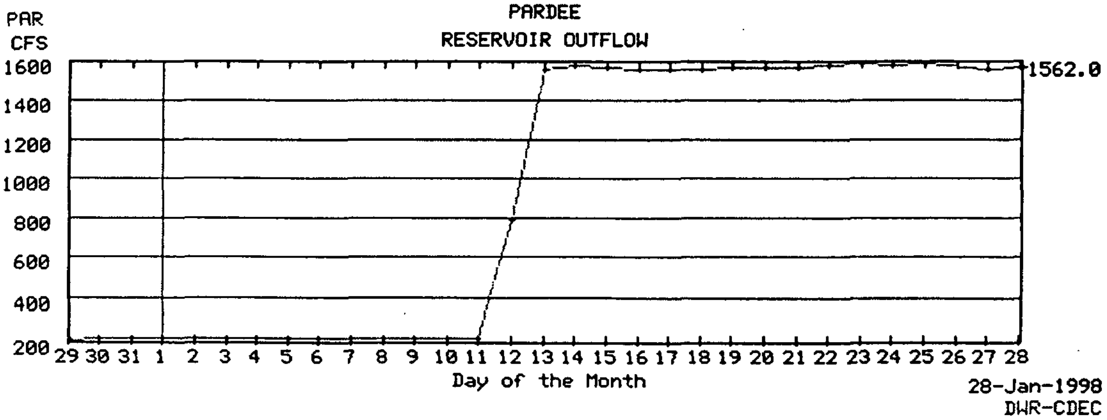
FEB-98

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 14:04:12*



Data from 12/28/1997 00:00 through 01/28/1998 00:00 · Duration: 31days
Max of period: 1580 · Min of period: 201

Show data | Plot earlier | Plot later

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

JAN-9

**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

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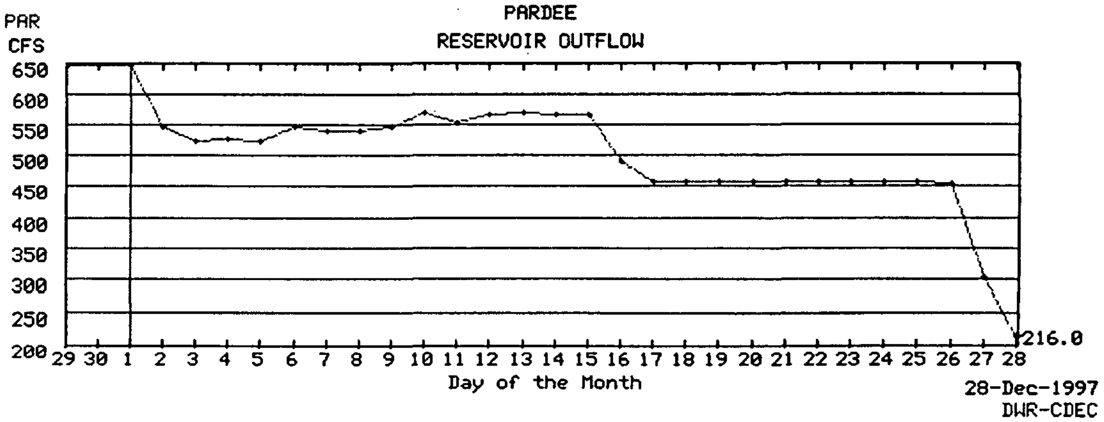
# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 14:04:42*



Data from 11/28/1997 00:00 through 12/28/1997 00:00 · Duration: 30days
Max of period: 645 · Min of period: 216

Show data | Plot earlier | Plot later

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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**California Data Exchange Center** **Mail to Webmaster**

DEC-9

**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

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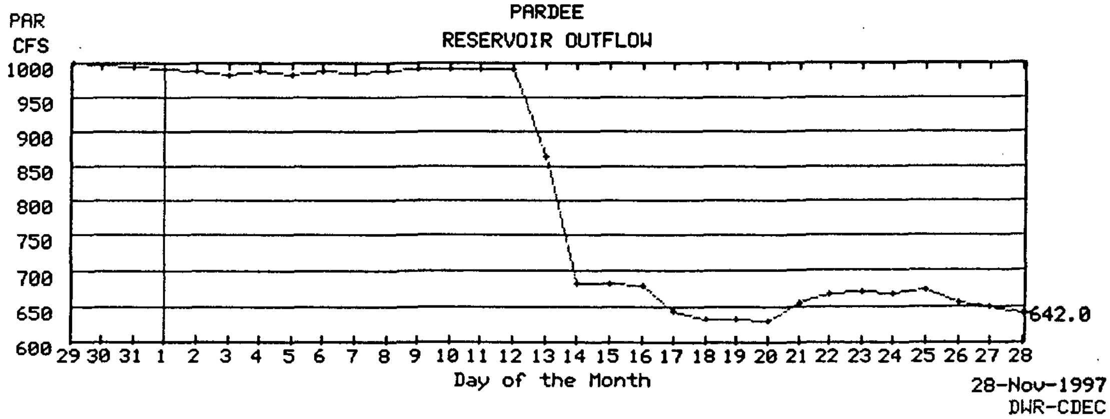
# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 14:06:26*



Data from 10/28/1997 00:00 through 11/28/1997 00:00 · Duration: 31days
Max of period: 998 · Min of period: 631

Show data | Plot earlier | Plot later

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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**California Data Exchange Center** **Mail to Webmaster**

NOV-97

**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

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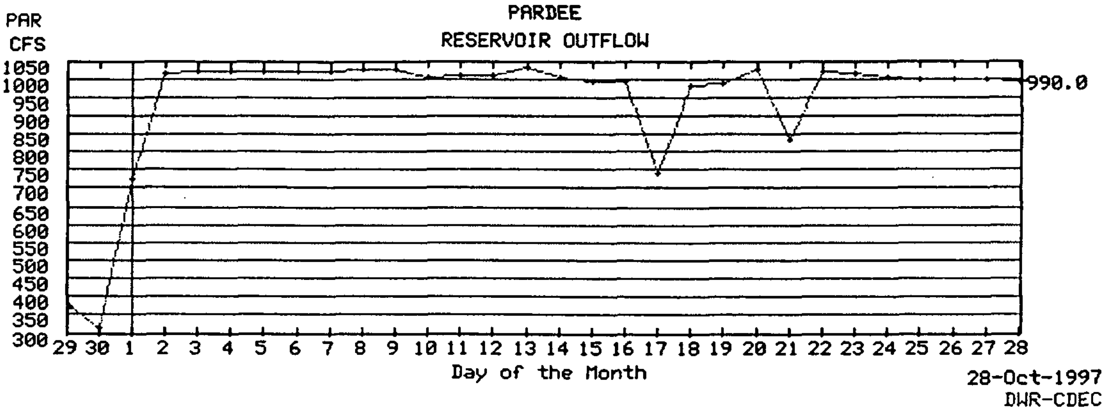
# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 14:10:43*



Data from 09/28/1997 00:00 through 10/28/1997 00:00 · Duration: 30days
Max of period: 1030 · Min of period: 315

Show data | Plot earlier | Plot later

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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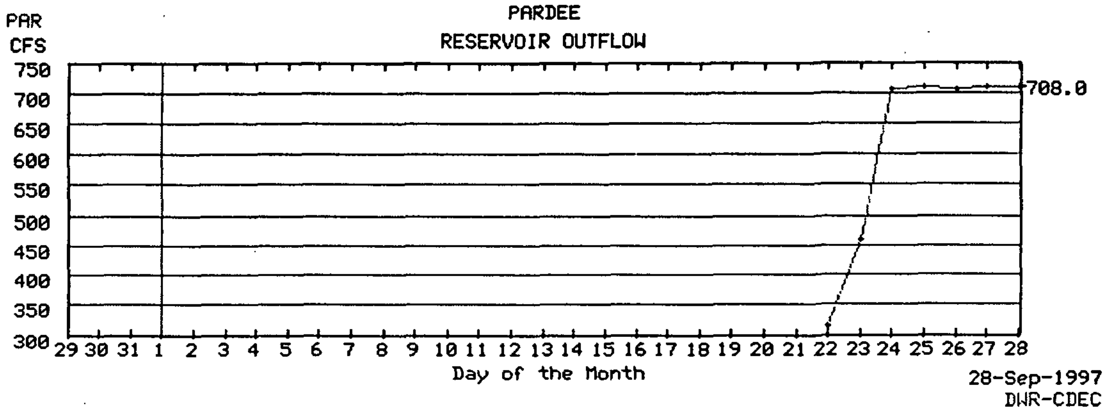
**California Data Exchange Center** **Mail to Webmaster**

OCT-9

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 14:11:07*



Data from 08/28/1997 00:00 through 09/28/1997 00:00 · Duration: 31days
Max of period: 708 · Min of period: 315

Show data | Plot earlier | Plot later

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

SEP-9

**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

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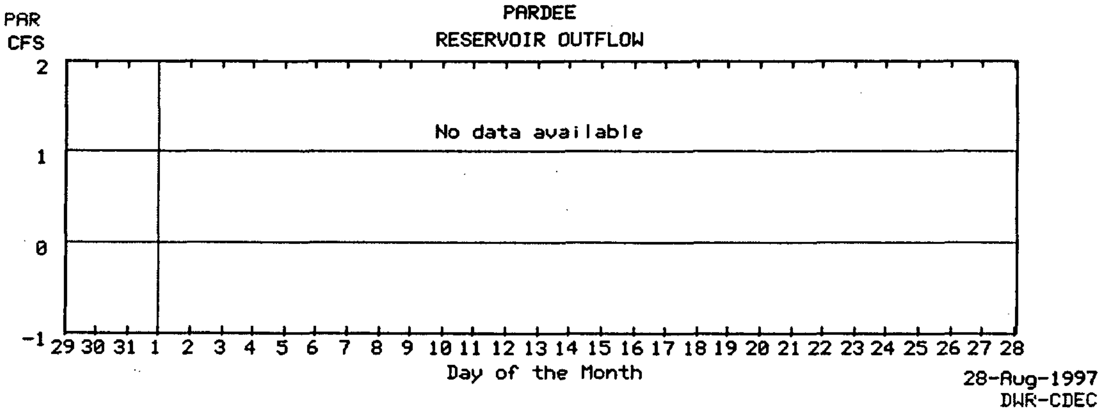
# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 14:12:46*



Data from 07/28/1997 00:00 through 08/28/1997 00:00 · Duration: 31days
Max of period: · Min of period:

Show data | Plot earlier | Plot later

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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AUG-9

**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

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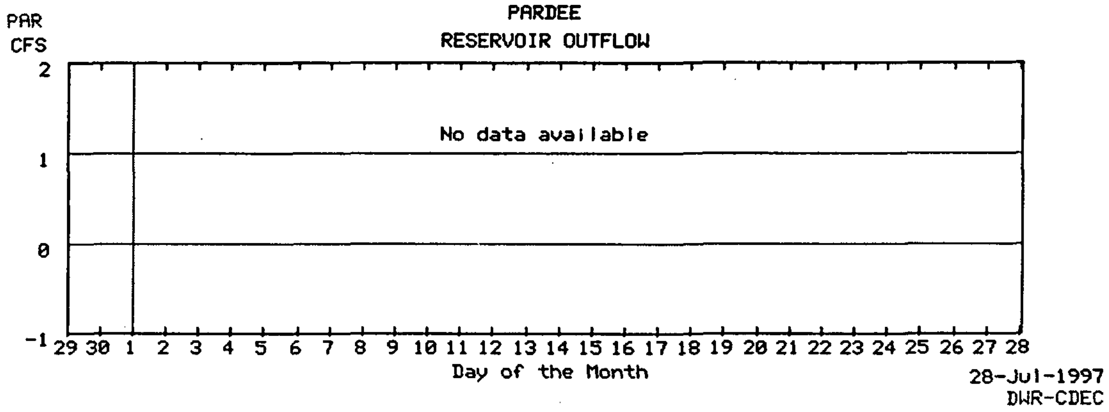
# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 14:13:00*



Data from 06/28/1997 00:00 through 07/28/1997 00:00 · Duration: 30days
Max of period: · Min of period:

Show data | Plot earlier | Plot later

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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**California Data Exchange Center** **Mail to Webmaster**

JUL-9

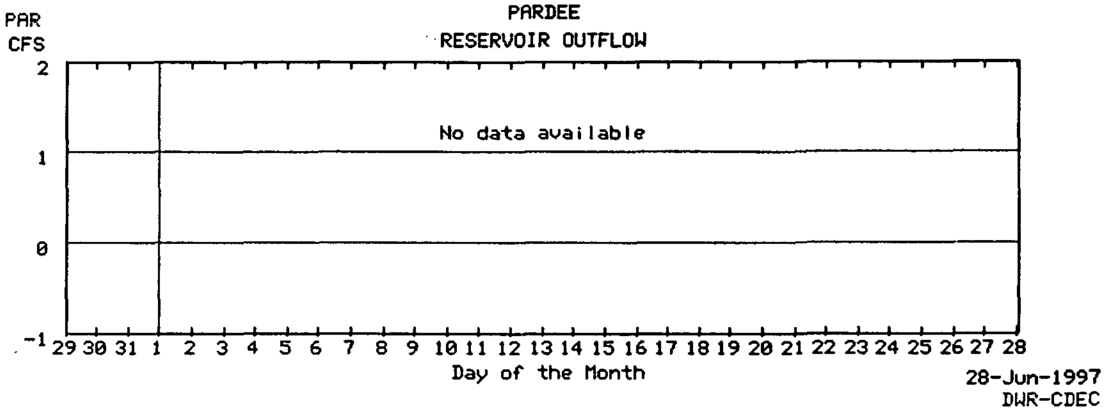
**California Department of Water Resources** **Division of Flood Management**

Current River Conditions | Snowpack Status | River Stages/Flows | Reservoir Data/Reports | Satellite Images | Station Information
Data Query Tools | Precipitation/Snow | River/Tide Forecasts | Water Supply | Weather Forecasts | Text Reports

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 14:13:33*



Data from 05/28/1997 00:00 through 06/28/1997 00:00 · Duration: 31days
Max of period: · Min of period:

Show data | Plot earlier | Plot later

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

**California Data Exchange Center** **Mail to Webmaster**

JUN-

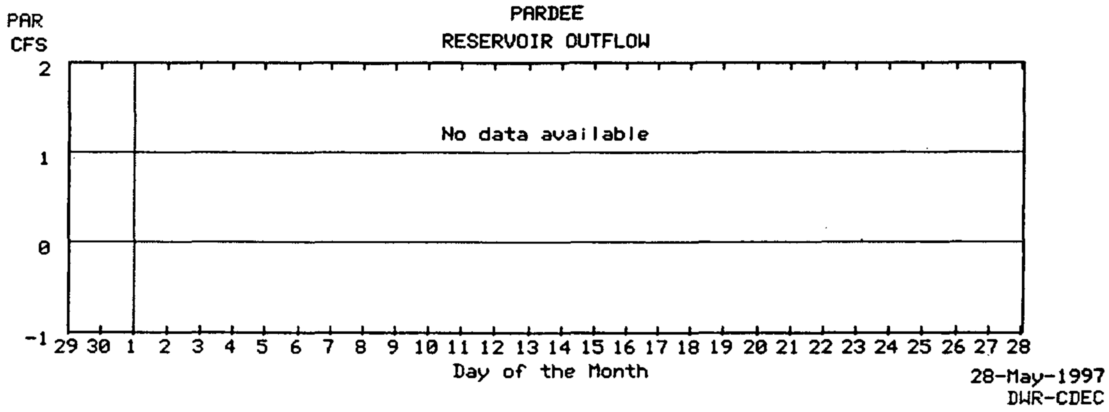
**California Department of Water Resources** **Division of Flood Management**

Current River Conditions · Snowpack Status · River Stages/Flows · Reservoir Data/Reports · Satellite Images · Station Information
Data Query Tools · Precipitation/Snow · River/Tide Forecasts · Water Supply · Weather Forecasts · Text Reports

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 14:42:14*



Data from 04/28/1997 00:00 through 05/28/1997 00:00 · Duration: 30days
Max of period: · Min of period:

Show data | Plot earlier | Plot later

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*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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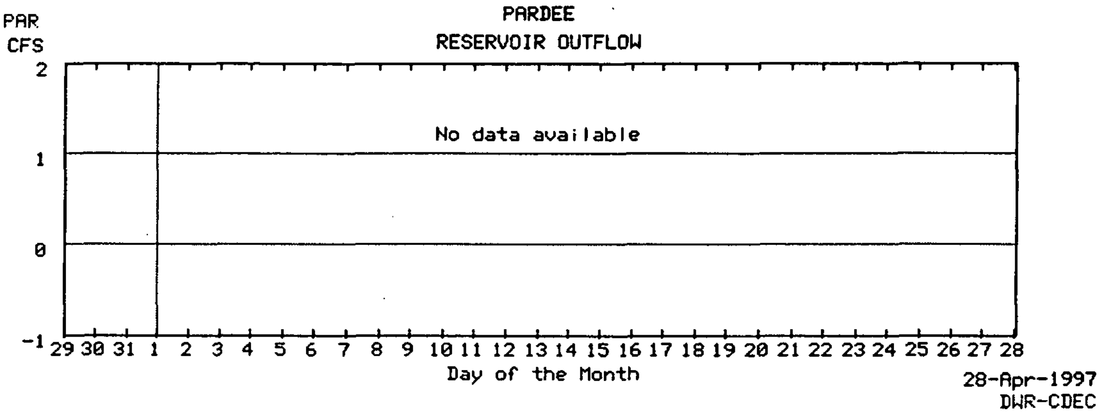
**California Data Exchange Center** **Mail to Webmaster**

MAY-97

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District
Sensor ID number *3396*

*Plot generated Friday at 14:42:37*



Data from 03/28/1997 00:00 through 04/28/1997 00:00 · Duration: 31days
Max of period: · Min of period:

Show data | Plot earlier | Plot later

*Real-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

APR-9

California Department of Water Resources Division of Flood Management

Current River Conditions · Snowpack Status · River Stages/Flows · Reservoir Data/Reports · Satellite Images · Station Information
Data Query Tools · Precipitation/Snow · River/Tide Forecasts · Water Supply · Weather Forecasts · Text Reports

# PARDEE *(PAR)*

Elevation: 568' · MOKELUMNE R basin · Operator: East Bay Municipal Utility District

## RESERVOIR OUTFLOW (3396)

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| 02/25/1999 | 1956.00 cfs |
| 02/26/1999 | 2056.00 cfs |
| 02/27/1999 | 1908.00 cfs |
| 02/28/1999 | 1808.00 cfs |
| 03/01/1999 | 1721.00 cfs |
| 03/02/1999 | 1723.00 cfs |
| 03/03/1999 | 1789.00 cfs |
| 03/04/1999 | 2110.00 cfs |
| 03/05/1999 | 2152.00 cfs |
| 03/06/1999 | 2124.00 cfs |
| 03/07/1999 | 2122.00 cfs |
| 03/08/1999 | 1873.00 cfs |
| 03/09/1999 | 1664.00 cfs |
| 03/10/1999 | 1601.00 cfs |
| 03/11/1999 | 1692.00 cfs |
| 03/12/1999 | 2161.00 cfs |
| 03/13/1999 | 2169.00 cfs |
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| 03/18/1999 | 1789.00 cfs |
| 03/19/1999 | -- |
| 03/20/1999 | 1508.00 cfs |
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| 03/22/1999 | 1511.00 cfs |
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| 03/24/1999 | 1527.00 cfs |
| 03/25/1999 | 1537.00 cfs |
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| 03/27/1999 | 1539.00 cfs |
| 03/28/1999 | 1540.00 cfs |
| 03/29/1999 | 1550.00 cfs |
| 03/30/1999 | 1562.00 cfs |
| 03/31/1999 | 1559.00 cfs |
| 04/01/1999 | 1574.00 cfs |
| 04/02/1999 | 1598.00 cfs |
| 04/03/1999 | 1585.00 cfs |
| 04/04/1999 | 1584.00 cfs |
| 04/05/1999 | 1587.00 cfs |
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| 04/07/1999 | 1582.00 cfs |
| 04/08/1999 | 1583.00 cfs |

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9    1597.00 cfs
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      916.00 cfs
     1068.00 cfs
9    1427.00 cfs
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     1652.00 cfs
     1655.00 cfs
9    1652.00 cfs
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not been reviewed for accuracy.

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*-Time Data* | *Group of Real-Time Stations* | *Daily Data* | *Group of Daily Stations*
*Monthly Data* | *Historical Data* | *Custom Graph Plotter* | *Text Reports*

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**ata Exchange Center** **Mail to Webmaster**

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# Appendix E

## Pre-, During-, and Post–Restoration Site Water Budget

# APPENDIX E

## Pre-, During-, and Post-Restoration Site Water Budget

Three water budgets have been produced for the Penn Mine Site: the first water budget describes pre-restoration conditions, the second water budget describes the site during restoration, and the third water budget estimates post-restoration conditions. These water budgets are largely based on calculations performed by CH2M Hill for the *Interim Effectiveness Monitoring Report* (CH2M Hill, 1999b).

For consistency, the six water budget components described in *Addendum 3, Monitoring and Evaluation of Stage II Site Activities* (CH2M Hill, 1999a) and the *Interim Effectiveness Monitoring Report* (CH2M Hill, 1999b) are used in the current water budgets. The six water budget components include three components of inflow into the Penn Mine Site, and three components of outflow from the Penn Mine Site. The six components of the water balance are listed in Table 1.

Figures 1 through 3 display conceptual block diagrams of each water budget component for pre-restoration, restoration, and post-restoration periods. Flow quantities for each of the components during each period are estimated below.

### Pre-Restoration Period

### Inflow from Direct Precipitation, $Q_1$

Inflow from direct precipitation is calculated as the product of the average precipitation and the area of the Penn Mine Site. The average precipitation measured at the Camp Pardee rain gauge is 21.17 inches per year (California Department of Water Resources web site, 1999). The area of the Penn Mine site is 60.4 acres (Golder Associates, 1996). The resulting direct precipitation is calculated as:

$$Q_1 = 21.17\ inches\ x \frac{1\ foot}{12\ inches} x\ 60.4\ acres$$

$$Q_1 = 106.56\ acre - feet / year$$

### Groundwater Inflow from Shallow Bedrock, $Q_2$

The largest quantity of groundwater inflow from shallow bedrock appears to originate from Mine Shaft 4 in the Hinkley Run. Estimates of the annual average flow from Mine Shaft 4 suggested average flows of approximately 20 gallons per minute, or 32.3 acre-feet per year (CH2M Hill, 1999a).

Davy (1992, Appendix 2) estimated flow from the Hinkley Creek spring at 2 gallons per minute, or 3.2 acre-feet per year. Additional, minor seeps are shown on recent site drawings by CH2M HILL. Five seeps are mapped in the Mine Run. Assuming each seep contributes approximately 0.5 gallons per minute, and an equivalent number of seeps occur in the Hinkley Run, these seeps add 5 gallons per minute to the inflow from shallow bedrock.

The total shallow bedrock inflow is the sum of the Mine Shaft 4 flow, the Hinkley Creek spring flow, and the flow from seeps. These components total 27 gallons per minute, or 43.5 acre-feet per year.

### Evapotranspiration, $Q_3$

Evapotranspiration comprises evaporation from surface water bodies and transpiration through plants. Table 4.11 in the Draft EIR lists the pre-restoration evaporation as 27.77 acre-feet per year.

Estimates of Transpiration are not explicitly calculated for the pre-restoration water balance, but are accounted for in calculations for $Q_4$, below.

### Surface Water and Shallow Alluvial Groundwater Discharge to Camanche Reservoir, $Q_4$

The shallow water and shallow alluvial groundwater discharge to Camanche Reservoir consists of all the inflows into the surface water and shallow alluvial groundwater systems, less the evapotranspiration and flow into the bedrock.

Inflows include direct precipitation of 106.56 acre-feet per year, and flow from bedrock of 43.5 acre-feet per year. Pond evaporation is estimated to be 27.77 acre-feet per year. Golder Associates (1996) estimated that that 44% of the water falling on the Penn Mine Site is lost to evaporation, evapotranspiration, unsaturated storage, or bedrock outflow before reaching the ponds. Changes in unsaturated storage are assumed to be zero for purposes of these calculations. As discussed in the following section, bedrock outflow is estimated to be approximately 0.12 acre-feet per year. Assuming the entire bedrock outflow originates from the rainfall on the site, the amount of rainfall that does not reach the surface water or shallow alluvium is equal to the loss factor applied to the sum of direct precipitation ($Q_1$) and flow from bedrock ($Q_2$), less the bedrock outflow ($Q_5$):

$$Loss = 0.44 \times (Q_1 + Q_2 - Q_5)$$

$$Loss = 0.44 * (106.56 + 43.5 - 0.12)$$

$$Loss = 66.0\ acre - feet\,/\,year$$

Therefore, the surface water and shallow alluvial groundwater discharge to Camanche Reservoir, $Q_4$, is equal to all inflows ($Q_1$ and $Q_2$), less the other outflows (losses, pond evaporation, bedrock outflow):

$$Q_4 = Q_1 + Q_2 - Loss - Pond\ Evaporation - Bedrock$$

$$Q_4 = 106.56 + 43.5 - 66.0 - 27.77 - 0.12$$

$$Q_4 = 56.2\ acre - feet\,/\,year$$

### Groundwater Discharge from Shallow Bedrock to Camanche Reservoir, $Q_5$

Alpers, Hamlin, and Hunerlach (1999) estimated that the flow beneath Mine Run Dam with pH less than 5 is between 7 feet$^3$/day and 14 feet$^3$/day (.06 to 0.12 acre-feet/year). Golder Associates (1996) performed a statistical analysis of likely discharge rates, using a lognormally distributed conductivity distribution and a uniform groundwater gradient distribution. The flow rate corresponding to the 50% exceedence probability for the mean permeability was approximately 13.37 feet$^3$/day. Based on these two estimates, an outflow of 14 feet$^3$ per day (0.12 acre-feet/year) was chosen for the pre-restoration period.

### Upland Watershed Inflow (Surface water and shallow alluvial groundwater), $Q_6$

Upland watershed inflows are diverted around the Penn Mine Site by the Hinkley Run and Mine Run diversions. Therefore, $Q_6$ is set to zero for the pre-restoration period.

### Pre-Restoration Totals

Total flows for each pre-restoration water budget component is presented in Table 2.

## Restoration Period

### Inflow from Direct Precipitation, $Q_1$

Restoration activities have no influence on the inflow from direct precipitation. Therefore, $Q_1$ for the restoration period is set to the same amount as for the pre-restoration period, 106.56 acre-feet per year.

### Groundwater Inflow from Shallow Bedrock, $Q_2$

The removal of waste material in the vicinity of Mine Shaft 4 during restoration has resulted in an observed increase in flow from the adit. Recent observations of flow from Mine Shaft 4 suggest that the annual average flow rate may be closer to 60 gallons per minute, or 96.8 acre-feet per year (EBMUD, personal communication, 1999a).

The Mine Shaft 4 flow added to the estimated flow from seeps and springs described for the Pre-Restoration condition totals 67 gallons per minute or 108.1 acre-feet per year.

### Evapotranspiration, $Q_3$

Evapotranspiration comprises evaporation from surface water bodies and transpiration through plants. On average, the pond surface area during restoration is approximately 3 acres (EBMUD, personal communication, 1999b). Table 4.11 of the Draft EIR shows that the average pre-restoration evapotranspiration rate was 27.77 acre-feet per year (Golder, 1996) over an assumed pond area of 6.32 acres (Davy, 1992). This yields an average annual evaporation rate of 4.39 feet per year. Applying this evaporation rate to the restoration pond area of 3 acres yields a volumetric evaporation rate of 13.2 acre-feet per year.

Vegetation is stripped from the site during restoration. Therefore the transpiration during restoration is set to zero.

### Surface Water and Shallow Alluvial Groundwater Discharge to Camanche Reservoir, $Q_4$

The surface water and shallow alluvial groundwater discharge to Camanche Reservoir consists of all the inflows into the surface water and shallow alluvial groundwater systems, less the evapotranspiration and flow into the bedrock.

Inflows include direct precipitation of 106.56 acre-feet per year, and flow from bedrock of 108.1 acre-feet per year. Pond evaporation is estimated to be 13.2 acre-feet per year. Because the site has been stripped of vegetation, soil, and mine waste, there is little evaporation or evapotranspiration outside of Mine Run Dam Reservoir. The loss of rainwater prior to ponds is set to zero.

Therefore, the surface water and shallow alluvial groundwater discharge to Camanche Reservoir is equal to all inflows ($Q_1$ and $Q_2$), less the other outflows (pond evaporation and bedrock outflow):

$$Q_4 = Q_1 + Q_2 - Pond\ Evaporation - Q_5$$

$$Q_4 = 106.56 + 108.1 - 13.2 - 0.12$$

$$Q_4 = 201.3\ acre - feet / year$$

### Groundwater Discharge from Shallow Bedrock to Camanche Reservoir, $Q_5$

Restoration activities have no influence on the discharge from shallow bedrock into Camanche Reservoir. Therefore, $Q_5$ for the restoration period is set to the same amount as for the pre-restoration period. Using the flows estimated by Alpers, Hamlin, and Hunerlach (1999), and bedrock discharges beneath Mine Run Dam estimated by statistical analysis (Golder, 1996), $Q_5$ is set to 14 feet$^3$/day, or 0.12 acre-feet/year.

### Upland Watershed Inflow (Surface water and shallow alluvial groundwater), $Q_6$

During restoration, the upland watershed inflows continue to be diverted around the Penn Mine Site by the Hinkley Run and Mine Run diversions. Therefore, $Q_6$ is set to zero for the restoration period.

### Restoration Totals

Total flows for each restoration period water budget component is presented in Table 3.

## Post-Restoration Period

### Inflow from Direct Precipitation, $Q_1$

Restoration activities have no influence on the inflow from direct precipitation. Therefore, $Q_1$ for the post-restoration period is set to the same amount as for the pre-restoration period, 106.56 acre-feet per year.

### Groundwater Inflow from Shallow Bedrock, $Q_2$

Restoration activities have no influence on the groundwater inflow from the shallow bedrock. However, plugging Shaft No. 4 will reduce the overall flow rate by an amount that depends on the effectiveness of the plug. It is assumed that the plug will reduce flow from the Penn Mine workings to 1 percent of the current 60 gallons per minute, or to 0.97 acre-foot per year. Therefore, $Q_2$ for the post-restoration period equals the amount of groundwater flowing through shallow bedrock, plus the leakage from the plugged mine workings, or 12.2 acre-feet per year.

### Evapotranspiration, $Q_3$

Evapotranspiration comprises evaporation from surface water bodies and transpiration through plants. Ponds will be removed from the site after restoration, therefore the pond evaporation is set to zero.

Evapotranspiration through plants is calculated below as a result of the $Q_4$ calculations. The estimated evapotranspiration is 83.07 acre-feet per year.

### Surface Water and Shallow Alluvial Groundwater Discharge to Camanche Reservoir, $Q_4$

The post-restoration surface water and shallow alluvial groundwater that discharges to Camanche Reservoir includes runoff from direct precipitation, shallow alluvial groundwater flow from direct precipitation, groundwater flowing into and through the shallow alluvium from shallow bedrock, and surface water flowing onto and through the Penn Mine site. Each of these sources will be treated below

#### *Surface Water and Shallow Alluvial Groundwater from Direct Precipitation*

The surface water flows are estimated by subtracting deep percolation and evapotranspiration from precipitation. Grundski's rule (Turner, 1985) is applied to estimate post-restoration losses to combined evapotranspiration and deep percolation at the site. Grundski's rule estimates the amount of precipitation lost to evapotranspiration and deep percolation can be estimated with the following equation:

$$L = P - 0.01P^2$$

Where L is the water lost to evapotranspiration and deep percolation, and P is precipitation in inches. Applying Grundski's rule to the average precipitation of 21.17 inches yields:

$$L = 21.17 - 0.01*(21.17)^2$$

$$L = 16.69\ inches$$

Over the entire 60.4 acres, the losses to evapotranspiration and deep percolation are

$$L = 16.69\ inches\ x \frac{1\ foot}{12\ inches} x\ 60.4\ acres$$

$$L = 84.01\ acre - feet\ /\ year$$

The surface water outflow due to direct precipitation is therefore 106.56 acre-feet per year minus 84.01 acre-feet per year, or 22.55 acre-feet per year.

A portion of the 84.01 acre-feet will flow into Camanche Reservoir as shallow alluvial groundwater flow. The amount of shallow alluvial groundwater flowing into Camanche Reservoir can be estimated with Darcy's Law, as described above. Assuming the groundwater gradient in the shallow alluvium is similar to the groundwater gradient in the fractured bedrock beneath Mine Run Dam, a groundwater gradient of 0.14 is used to calculate shallow alluvial groundwater fluxes (Alpers, Hamlin, and Hunerlach, 1999). The width of the shallow alluvium is assumed to be 100 feet, the same width used by Alpers, Hamlin, and Hunerlach (1999) to calculate the flux of groundwater through shallow bedrock into Camanche Reservoir. The average soil depth is 1 foot (H.T. Harvey & Associates, 1999). A representative hydraulic conductivity was estimated from slug tests conducted by Davy (1992). Of the five slug tests reported, four intercepted alluvial or granular material. The geometric mean of hydraulic conductivities for these four tests is approximately 8 feet per day. This value was used for the shallow groundwater flow calculations. Although this conductivity may be higher than the conductivity of soils used for revegitation, it serves as a reasonable estimate of the soil permeability.

Combining the parameter estimates above, the shallow alluvial groundwater flow into Camanche Reservoir is

$$Q = KiA$$

$$Q = 8*0.14*100*1$$

$$\begin{aligned} Q &= 112\ feet^3\ /\ day \\ &= 0.94\ acre - feet\ /\ year \end{aligned}$$

Assuming all except the 0.94 acre-feet of groundwater flowing into Camanche Reservoir is lost through evapotranspiration:

$$Evapotranspiration = 84.01 - 0.94$$

$$Evapotranspiration = 83.07\ acre - feet / year$$

### *Groundwater Flowing into Shallow Alluvium from Shallow Bedrock*

Groundwater flowing into shallow alluvium from shallow bedrock is calculated above, as $Q_2$. Assuming all of this groundwater leaves the Penn Mine site as surface water or shallow alluvial groundwater, this accounts for 12.2 acre-feet of water that leaves the site as surface water or shallow alluvial groundwater.

### *Water Flowing onto the Penn Mine Site*

Surface water from upland areas is currently diverted around the Penn Mine Site by the Hinkley Run and Mine Run diversions. Estimates of post-restoration water flowing onto the Penn Mine Site from upland areas is presented below, in the calculations for water balance term $Q_6$. These calculations show that the anticipated surface water flow onto and through the site is 150.7 acre-feet per year.

### *Total Surface Water and Shallow Alluvial Groundwater Discharge to Camanche Reservoir*

The total surface water and shallow alluvial groundwater discharge to Camanche Reservoir is the sum of the runoff from direct precipitation, shallow alluvial groundwater flow from direct precipitation, shallow alluvial groundwater from shallow bedrock, and water flowing onto and through the Penn Mine site, less water discharging through shallow bedrock.

$$Q_4 = 22.55 + 0.94 + 12.2 + 150.7 - 0.12$$

$$Q_4 = 186.3\ acre - feet / year$$

## Groundwater Discharge from Shallow Bedrock to Camanche Reservoir, $Q_5$

Restoration activities have no influence on the discharge from shallow bedrock into Camanche Reservoir. Therefore, $Q_5$ for the post-restoration period is set to the same amount as for the pre-restoration period. Using the flows estimated by Alpers, Hamlin, and Hunerlach (1999), and bedrock discharges beneath Mine Run Dam estimated by statistical analysis (Golder, 1996), $Q_5$ is set to 14 feet$^3$/day, or 0.12 acre-feet/year.

## Upland Watershed Inflow (Surface water and shallow alluvial groundwater), $Q_6$

Currently, upland watershed inflows are diverted around the Penn Mine Site by the Hinkley Run and Mine Run diversions. These diversions will be removed during restoration. As shown above, the anticipated losses to evapotranspiration and shallow groundwater flow for the site, and areas around the site, are 16.69 inches out of 21.17 inches of rainfall. Therefore, 4.48 inches of rainfall contribute directly to runoff.

The entire watershed covers 464 acres, of which 403.6 lie outside the Hinkley Run and Mine Run diversions. The total annual runoff from these 403.6 acres can be calculated by applying the previously calculated 4.48 inches of runoff:

$$Q_6 = 403.6\ acres \times 4.48\ inches \times \frac{1\ foot}{12\ inches}$$

$$Q_6 = 150.7\ acre - feet / year$$

### Post-Restoration Totals

Total flows for each post -restoration period water budget component is presented in Table 4.

### Seasonal Post-Restoration Totals

To differentiate between potential wet season and dry season metals loading to Camanche Reservoir, the annual water budget for the post-remediation period has been divided into monthly average water budgets. The analysis of the annual water budget described above was applied to monthly average rainfall data. Results of this analysis are shown on Table 5.

## References

Alpers, C.N., S.N. Hamlin, and M.P. Hunerlach, 1999, *Hydrogeology and Geochemistry of Acid Mine Drainage in Ground Water in the Vicinity of Penn Mine and Camanche Reservoir, Calaveras County, California: Summary Report, 1993-95, Water Resources Investigations Report 96-4287. Sacramento, CA.*

CH2M Hill, 1999a, *Addendum 3, Monitoring and Evaluation of Stage II Site Activities, Penn Mine Environmental Remediation.*

CH2M Hill, 1999b, *Interim Effectiveness Monitoring Report, Penn Mine Environmental Remediation.*

Davy Environmental, 1992, *Site Characterization Report, Penn Mine, Calaveras County, California.*

East Bay Municipal Utilities District, 1999a, *Personal communication with Ms Eileen Fanelli.*

East Bay Municipal Utilities District, 1999b, *Personal communication with Ms Eileen Fanelli.*

Golder Associates, 1996, *Draft Environmental Impact Report for the Penn Mine Site Long-Term Solution Project.*

Turner, M.T., 1985, *Water Loss from Forest and Range Lands in California. Chaparral Ecosystems Research: Meeting and Field Conference, University of California, Santa Barbara.*

## Table 1
## PENN MINE SITE WATER BUDGET COMPONENTS

| COMPONENT | DESIGNATION (FROM CH2M HILL, 1999a) |
|---|---|
| **Inflows** | |
| Inflow from Direct Precipitation | $Q_1$ |
| Groundwater Inflow from Shallow Bedrock and Shaft No. 4 | $Q_2$ |
| Upland Watershed Inflow (Surface water and shallow alluvial groundwater) | $Q_6$ |
| **Outflows** | |
| Evapotranspiration | $Q_3$ |
| Surface Water and Shallow Alluvial Groundwater Discharge to Camanche Reservoir | $Q_4$ |
| Groundwater Discharge from Shallow Bedrock to Camanche Reservoir | $Q_5$ |

## Table 2
## PENN MINE SITE PRE-RESTORATION WATER BUDGET

| COMPONENT | FLOW (AC-FT/YR.) | Comments |
|---|---|---|
| Inflow from Direct Precipitation, $Q_1$ | 106.56 | Has not contacted mine waste |
| Groundwater Inflow from Shallow Bedrock and Shaft No. 4, $Q_2$ | 43.5 | Acidified from contact with natural bedrock |
| Evapotranspiration, $Q_3$ | 94 | Carries no metals or acidity off site. |
| Surface Water and Shallow Alluvial Groundwater Discharge to Camanche Reservoir, $Q_4$ | 56.2 | Contacts mine waste |
| Groundwater Discharge from Shallow Bedrock to Camanche Reservoir, $Q_5$ | 0.12 | Contacts mine waste and naturally acidifying bedrock |
| Upland Watershed Inflow (Surface water and shallow alluvial groundwater), $Q_6$ | 0 | All intercepted by diversion structures |

## Table 3
## PENN MINE SITE RESTORATION PERIOD WATER BUDGET

| COMPONENT | FLOW (AC-FT/YR.) | Comments |
|---|---|---|
| Inflow from Direct Precipitation, $Q_1$ | 106.56 | Has not contacted mine waste |
| Groundwater Inflow from Shallow Bedrock and Shaft No. 4, $Q_2$ | 108.1 | Acidified from contact with natural bedrock |
| Evapotranspiration, $Q_3$ | 13.2 Evaporation | Carries no metals or acidity off site. |
| Surface Water and Shallow Alluvial Groundwater Discharge to Camanche Reservoir, $Q_4$ | 201.3 | Contacts mine waste |
| Groundwater Discharge from Shallow Bedrock to Camanche Reservoir, $Q_5$ | 0.12 | Contacts mine waste and naturally acidifying bedrock |
| Upland Watershed Inflow (Surface water and shallow alluvial groundwater), $Q_6$ | 0 | All intercepted by diversion structures |

## Table 4
## PENN MINE SITE POST-RESTORATION WATER BUDGET

| COMPONENT | FLOW (AC-FT/YR.) | Comments |
|---|---|---|
| Inflow from Direct Precipitation, $Q_1$ | 106.56 | Has not contacted mine waste |
| Groundwater Inflow from Shallow Bedrock, and Shaft Plug Seepage, $Q_2$ | 12.2 | Acidified from contact with natural bedrock. Treated with ammendments in alluvium. Shaft No. 4 plug is 99 percent effective. |
| Evapotranspiration, $Q_3$ | 0 Evaporation<br>83.07 Transpiration | Carries no metals or acidity off site. |
| Surface Water and Shallow Alluvial Groundwater Discharge to Camanche Reservoir, $Q_4$ | 186.3 | Surface water does not contact mine waste. Shallow alluvial groundwater may contact mine waste at alluvium/bedrock interface. Shallow alluvial groundwater treated by CKE in alluvium. |
| Groundwater Discharge from Shallow Bedrock to Camanche Reservoir, $Q_5$ | 0.12 | Contacts mine waste and naturally acidifying bedrock |
| Upland Watershed Inflow (Surface water and shallow alluvial groundwater), $Q_6$ | 150.7 | Surface water does not contact mine waste. |

## Table 5
## ESTIMATED MONTHLY FLOWS, POST RESTORATION
## (Acre-feet/month)

| | $Q_1$ | $Q_2$ | $Q_3$ | $Q_4$ | $Q_5$ | $Q_6$ |
|---|---|---|---|---|---|---|
| **January** | 19.79 | 1.02 | 15.52 | 33.27 | 0.01 | 27.99 |
| **February** | 18.09 | 1.02 | 14.18 | 30.50 | 0.01 | 25.59 |
| **March** | 17.05 | 1.02 | 13.37 | 28.82 | 0.01 | 24.12 |
| **April** | 9.39 | 1.02 | 7.33 | 16.36 | 0.01 | 13.28 |
| **May** | 4.26 | 1.02 | 3.28 | 8.02 | 0.01 | 6.03 |
| **June** | 1.34 | 1.02 | 0.98 | 3.26 | 0.01 | 1.89 |
| **July** | 0.24 | 1.02 | 0.11 | 1.48 | 0.01 | 0.35 |
| **August** | 0.33 | 1.02 | 0.18 | 1.62 | 0.01 | 0.46 |
| **September** | 1.19 | 1.02 | 0.86 | 3.02 | 0.01 | 1.68 |
| **October** | 6.17 | 1.02 | 4.79 | 11.12 | 0.01 | 8.73 |
| **November** | 12.17 | 1.02 | 9.52 | 20.88 | 0.01 | 17.22 |
| **December** | 16.51 | 1.02 | 12.94 | 27.94 | 0.01 | 23.36 |
| **Totals** | 106.54 | 12.20 | 83.05 | 186.28 | 0.12 | 150.70 |

# Appendix F

## Design Basis Memorandum

DRAFT

**TECHNICAL MEMORANDUM** **CH2MHILL**

# Penn Mine Design Basis Memorandum for Mitigation of Residual Acidity and Acid Generating Capacity

| | |
|---|---|
| **PREPARED FOR:** | Penn Mine Project File |
| **PREPARED BY:** | Jim Mavis/SEA |
| **COPIES:** | Bill Ingles/SFO<br>Sam Brathwaite/SFO<br>Eileen Fanelli/EBMUD |
| **DATE:** | June 25, 1999 - Rev. B |

Design of restoration for the Penn Mine site is in progress concurrently with the characterization of the exposed surfaces remaining after excavation of the mine-derived waste. To expedite the design, a brief summary of the basis for the design has been prepared, and a preliminary list of known constraints identified. Specific features are incorporated into the design to address the known and anticipated considerations and constraints.

As site characterization information becomes available to the project stakeholders, additional constraints have been suggested. Consequently, this design basis memorandum provides a benchmark of the current stage of the design project, and the basis for design will need to be revisited periodically.

## Design Basis

The basis for designing a site restoration plan is the identification and implementation of Best Management Practices (BMPs) for mines with sulfide ores and sulfide residues. BMPs are not explicitly prescribed; they are identified, developed, and adapted on a site-specific basis.

BMPs for Penn Mine consist of the following:

- Excavating the sulfide-bearing mine waste from Mine Run and Hinckley Run, and placing it in a secure onsite landfill
- Neutralizing the residual acidity in the alluvium and channel side slopes exposed by the removal of mine waste
- Grading site to establish drainage channels through Mine and Hinckley Runs
- Placing top soil over the alluvium and seeding the top soil to prevent erosion and support establishment of native species
- Removing the diversion dam and channels around Mine and Hinckley Runs
- Removing the dam at the base of the Mine Run-Hinckley Run confluence

- Developing and implementing a monitoring plan for the site and for Camanche Reservoir

The ideal outcome would be to return the site to pre-mining conditions; however, there is no unequivocal method for establishing what the pre-mining conditions consisted of. Nonetheless, pre-mining conditions would include water quality within the mine site, terrestrial habitat, and conditions downstream in the Mokelumne River.

Downstream conditions in the Mokelumne have been irreversibly altered by controlled releases from Pardee Dam that may occur independently of immediate precipitation events at the Penn Mine site. This prevents strict reestablishment of pre-mining conditions within Camanche Reservoir.

## Additional Considerations and Constraints

The BMPs provided broad guidelines for designing the site restoration program. Dialog with stakeholders and PAC members has led to the identification of additional considerations and constraints that need to be addressed. The factors that have been identified to date are summarized below:

- The amount of "soil" amendment material that can be applied to Mine Run and Hinckley Run is constrained by the amount of alluvium remaining after waste excavation. (Application of extra "soil" amendment in selected areas may be needed to provide a sufficient inventory to neutralize localized zones of higher-than-average acidity, and permanently immobilize metals.)
- Application of excess "soil" amendment material must not cause excessively alkaline conditions to occur in the receiving body (Camanche Reservoir), either as a direct detriment to aquatic organisms or by causing aesthetically unacceptable precipitation. (It is considered to be adequately protective if the pH does not exceed ~9.0 at the point of release into Camanche Reservoir. Magnesium hydroxide may be a candidate neutralization agent in selected locations because its upper pH limit is ~9.0. Dicalcium silicate, with an upper pH limit of ~11 may also be effective in constraining the pH of water leaving the restored site. Cement kiln dust with an upper pH limit of 12 to 12.5 poses a greater risk to excessive site runoff pH than dicalcium silicate.)
- Sufficient "soil" amendment needs to be applied that acidic drainage from the site will be neutralized as long as acid and metals are being released. (Periodic amendment re-application in the stream channels to maintain an effluent pH greater than 8.5 would be part of site maintenance.)
- The steep side slopes need to be restored. These slopes may have been affected by contact with mine waste. (Magnesium hydroxide blended with wood cellulose fiber and tackifier can be applied by spraying onto the side slopes to neutralize any residual acidity prior to hydroseeding.)
- Exposed fine-grained pyrite may generate acidity that remobilizes precipitated metals. (Application of phosphate would suppress acid formation and could precipitate heavy metals that come into contact with the phosphate amendment. A phosphate rock-containing grout could be prepared and applied to steeply inclined, pyrite-containing

walls to prevent acid formation. The phosphate will suppress further acid formation, thereby protecting the cement binder.)

- Active application of chemical agents to flowing streams would be viewed as "treatment," and therefore the treated streams would be point sources, subject to regulation. (All "soil" amendments need to have long-term effectiveness, yet not create short-term over-treatment that would make the neutralized runoff from the site detrimental to the receiving stream, Camanche Reservoir. Passive, limited solubility amendments such as limestone, dolomite, magnesium hydroxide, and dicalcium silicate placed in zones away from the stream beds would meet this requirement.)

The foregoing considerations (and some additional ones) place semi-quantifiable constraints on the design. The combination of geotechnical and geochemical factors permits only approximate predictions the effectiveness of the soil amendment portion of restoration. These limitations need to be presented to all the stakeholders in order that the implied risks and their mitigations, which are being addressed through technical and non-technical means, are acceptable.

## Specific Design Features

### pH Range of Site Runoff

The preceding conditions and constraints were used to develop an overall conceptual design for subgrade restoration, and control over acidic runoff and metal release from the site. The two principle metals of concern are copper and zinc. Both metals would have sufficiently low solubilities that metal release could be prevented if the pH of runoff from the site were between 8.5 and ~12.0. Below pH ~8.5, the solubilities of both metals rise, and above pH ~12, the solubility of zinc also rises.

A preliminary analysis shows that at a pH of ~9.0 to 9.5, the alkaline compounds calcium carbonate and (over pH ~10.5) magnesium hydroxide could precipitate in Camanche Reservoir. Aesthetic concerns and localized impairment of aquatic life preclude discharges of runoff with too high a pH. Taking into account the (small) buffering capacity (bicarbonate content) of water in Camanche Reservoir, the upper limit for pH of water entering the Reservoir from the Penn Mine site should not exceed 9.5.

The design pH range of water from the Penn Mine site, therefore should be within 8.5 and 9.5.

### Site Amendment Materials

A number of soil pH amendment materials are available for use at sites such as Penn Mine. Several common amendments produce a pH that is far outside the range that has been stipulated for the Penn Mine site.

Limestone and dolomite neutralize acidity, but both produce a liquid stream with a pH typically between 5.0 and 6.0 because carbon dioxide is not efficiently released to the atmosphere in subgrade applications. This is too low a pH to immobilize copper and zinc and produce site runoff that resembles pre-mining runoff. Consequently, neither limestone or dolomite is well-suited as the primary amendment.

Calcined lime (calcium oxide and calcium hydroxide) and cement kiln dust create an excessively high pH, up to 12.5. This is unfavorable because of the potential for zinc dissolution and the potential for high pH runoff into Camanche Reservoir. In addition, the pozzolanic properties of cement kiln dust are not a necessary factor in the site restoration goals. Consequently, calcined lime and cement kiln dust are not recommended as primary amendments.

Dicalcium silicate has 85 to 90 percent the neutralizing capacity of limestone (on a dry weight-comparable basis), has a limiting pH of ~11.0, and exhibits some pozzolanic properties when used with calcined lime. With its lower pH, dicalcium silicate imparts only ~3 percent of the soluble alkali content to water coming into contact with it that cement kiln dust or calcined lime would impart. Its lower pH, lower solubility, low cost, and reduced potential for unfavorable secondary impacts makes it a candidate for use as an amendment for alluvium and fractured bedrock, provided areas where it is used are covered by topsoil, and runoff will not directly enter Camanche Reservoir without mixing with more pH-neutral runoff.

Phosphate rock is not typically used as a neutralizing agent on acid drainage sites. However, phosphate rock stops acid production by reacting with ferric iron and by encapsulating pyrite, isolating it from oxygen and water. Phosphate rock can be applied sparingly on the site to suppress active acid formation, and could be co-distributed with dicalcium silicate to limit the potential for inadvertent release of phosphate to Camanche Reservoir. Any soluble phosphate that may form when the phosphate rock reacts with acid would precipitate as iron, aluminum, or any of several other metals that form insoluble phosphates. Application of a small quantity of phosphate rock, co-distributed with dicalcium silicate, is recommended to suppress acid formation by pyrite that was exposed during waste removal.

Magnesium hydroxide can neutralize acidic drainage and will form a soluble sulfate salt, irrespective of the sulfate concentration in solution. For this reason, it has a greater potential to form "salt blooms" that form on soil surfaces through capillary transport and evaporation. Magnesium hydroxide can raise the pH of water to a maximum of 9.0, irrespective of how much is applied, with any excess remaining insoluble until the pH falls below 9.0. It is proposed to treat the sub-floor of the stream beds in Mine and Hinckley Runs with magnesium hydroxide to neutralize acidic pore water that flows into the stream channel from the subsurface fractured zone. Placed in this location, magnesium hydroxide would not cause salt blooms in areas undergoing revegetation, but would provide long-term *in situ* neutralization of upwelling shallow groundwater.

Magnesium hydroxide can be also be applied to the side slopes of Mine Run and Hinckley Run to neutralize residual acidity that may remain from contact with the mine waste. The magnesium hydroxide would be applied as a dilute slurry and held in place with a tackifier similar to those used in hydroseeding.

Limestone is recommended as a secondary neutralization material for lining stream channels and for constructing a channel lining system below the confluence of Mine and Hinckley Runs. Used in this manner, limestone provides a safeguard against sudden release of highly acidic runoff and impart some "buffering capacity" (bicarbonate) to the site runoff which will protect against excessive pH excursions.