4.0 ANALYSIS OF PUMPING

Following calibration and sensitivity analyses the model was used for future predictions of the potential impacts of 40 years of plant pumping at the maximum annual pumping rate of 3,000 gpm (4,850 ac-ft/yr). The locations of the pumping wells are shown on Figure 33. Each of the model runs described below is the result of three model calculations: a steady state (non-pumping) case to provide initial conditions, a transient model run with pumping, and a transient model run without pumping. The non-pumping results were subtracted from the pumping results in order to arrive at predicted changes due solely to pumping and to remove any model-generated errors over the course of 100 and, in one case, 200 years of transient calculations.

4.1 PREDICTED DRAWDOWNS

The results for the base case are shown on Figures 34 through 36a. The predicted drawdowns in the volcanic (lower) aquifer show an almost uniform drop in water levels of about 85 ft. In the middle aquifer (Figure 33), a general zone of small drawdowns (less than 4 ft) is predicted as a result of 40 years of pumping. This zone is centered above the pumping area and extends outward in areas where the lakebed clay thins. In the upper aquifer (Figure 36), a small zone of less than 0.5 ft predicted drawdown is shown after 40 years of pumping. In summary, a base-case model using a specific yield of 11 percent shows that predicted drawdowns as a result of 40 years of pumping range from less than 0.5 ft (upper aquifer) to less than 4 ft (middle aquifer) to 85 ft (volcanic aquifer). The predicted area of maximum potential drawdown in the upper aquifer is in the vicinity of the Denton well and Banegas Ranch well No. 2. This is the section of river where the lakebed clay is mapped by USGS as being absent. The predicted effects on river flow and river underflow are discussed in Section 4.2.

The sensitivity cases were also used to predict an envelope of potential predicted impacts. The worst realistic case was the 4 x 10^{-5} ft/d aquitard conductivity case with higher rates of recharge to the volcanic aquifer, because this case leads to the greatest predicted drawdowns in the upper and middle aquifers. Volcanic, middle, and upper aquifer predicted drawdowns for this case are shown on Figures 37 through 39. A drawdown of less than 1 ft in the upper aquifer is predicted in this high aquitard conductivity case. It should be noted that high recharge rates (2.7 times the average rate) were applied in this case in order to maintain the observed vertical head gradients between aquifers.

The best feasible case was the 1 x 10^{-6} ft/d aquitard conductivity case, because this case leads to the least predicted drawdowns in all aquifers. The predicted groundwater level drawdown from the project in this case was approximately 65 ft in the lower (volcanic) aquifer, less than 0.5 ft in the middle aquifer, and less than 0.1 ft in the upper aquifer.

Predicted drawdowns over time for the base and sensitivity cases are shown on Figures 40 through 42. The most sensitive parameter tested is aquitard conductivity. Potential impacts of less than 1 ft drawdown in the upper aquifer are predicted to occur after 20 or 30 years of pumping. The volcanic aquifer is predicted to take about 130 years for 90 percent recovery to pre-pumping heads.

4.2 PREDICTED FLOW RATES INTO THE RIVER ALLUVIUM

Groundwater flow rates to the river alluvium were predicted for the base and sensitivity cases. It was predicted that drops in flows to the marsh, gorge and, to a small degree, to evapotranspiration outside the marsh, due to project pumping, would occur (refer to Table 9). The potential decrease in flows is predicted to occur gradually over the period of pumping. Both the response and recovery times were predicted to be very slow.

TABLE 9
PREDICTED FLOW RATES IN THE RIVER ALLUVIUM[a]
AT YEAR 40

Flow Rates	Base Case		Realistic Worst Case: Aquitard conductivity of $4x10^{-5}$ ft/d		Less Evaporative Marsh		7% specific yield case		15% specific yield case		Best Case: Aquitard conductivity of $1x10^{-6}$ ft/d	
	(gpm)	(ac-ft/yr)	(gpm)	(ac-ft/yr)	(gpm)	(ac-ft/yr)	(gpm)	(ac-ft/yr)	(gpm)	(ac-ft/yr)	(gpm)	(ac-ft/yr)
Underflow Through Gorge (Davidson, 1973)	496	800			496	800						
Flow Rate in Big Sandy River 1 mile downstream of Gorge (BLM measurement)	2,034	3,280			2,034	3,280						
Rate of Evaporation, and Evapotranspiration at Marsh (Table 1)	1,893	3,053			1,893	3,053						
Predicted Groundwater Flow Rate under Non-Pumping Conditions												
Flow Rate into Marsh	5,733	9,247	6,175	9,960	1,311	2,115	5,734	9,248	5,732	9,245	5,139	8,289
Flow Rate Through Granite Gorge	965	1,556	997	1,608	2,208	3,561	965	1,557	965	1,557	922	1,487
Flow Rate to Evapotranspiration	8,795	14,185	8,732	14,084	8,660	13,968	8,795	14,185	8,796	14,187	8,258	13,319
Predicted Groundwater Flow Rate After 40 years of Pumping												
Flow Rate into Marsh	5,600	9,032	5,901	9,518	1,258	2,029	5,543	8,940	5,629	9,079	5,134	8,280
Flow Rate Through Granite Gorge	954	1,539	976	1,574	2,152	3,471	949	1,531	956	1,542	922	1,486
Flow Rate to Evapotranspiration	8,785	14,169	8,711	14,050	8,635	13,927	8,781	14,163	8,787	14,172	8,256	13,316
Combined Change in Flow Rate to Marsh, to Evapotranspiration, and Through Gorge	155	248	317	510	135	217	222	356	122	196	8	13

[a] Storativity of 1×10^{-6} ft^{-1} used in all cases.

It was concluded from these results that:

- the base case and less-evaporative marsh cases bracket the (imprecise) data for outflows from the Big Sandy basin at the south end of the valley.

- alternate marsh scenarios predict a redistribution of flows between the gorge and the marsh, but do not significantly change the predicted overall drop in flow rates in the southern end of the valley

The overall predicted drop in flow rates to the river alluvium includes drops in evapotranspiration, drops in flow to the marsh, and drops in outflow through the gorge. These predicted drops in flow vary from zero to a maximum as a result of 40 years of pumping, as shown in Table 10. For the worst realistic case, overall groundwater flow to the alluvium flow is predicted to drop by up to 1 percent (371 gpm or 598 ac-ft/yr) by year 70.

TABLE 10
PREDICTED DROP IN FLOW RATES TO THE RIVER ALLUVIUM OVER TIME

Time Since Pumping Began (Years)	Predicted Drop in Flow Rate to River Alluvium			
	Base Case		Realistic Worst Case: Aquitard conductivity of $4x10^{-5}$ ft/d	
	(gpm)	(ac-ft/yr)	(gpm)	(ac-ft/yr)
0	0	0	0	0
10	32	52	60	97
20	72	116	145	234
30	112	181	230	371
40 (pumping stops)	155	248	317	510
50	168	271	350	564
60	170	274	365	589
70	166	268	371	598
80	161	260	371	598
90	155	250	371	598
100	151	244	371	598