APPENDIX F

Groundwater Modeling Technical Memorandum

Documentation of Groundwater Model

Groundwater Model

The primary tool used to evaluate potential impacts on groundwater was a groundwater flow and solute transport model developed by San Benito County Water District and San Benito County. The model was first developed and documented in 2002 (Yates and Zhang 2001) but has evolved since then, including modifications implemented specifically to better evaluate impacts of the wastewater project. The model is regional in extent, covering the entire San Benito County part of the Gilroy-Hollister groundwater basin. The groundwater flow component of the model uses the MODFLOW2000 computer program developed by the U. S. Geological Survey (Harbaugh and others, 2000). Groundwater salinity is simulated using the solute transport program MT3DMS (Zheng and Wang, 1999), which functions as an extension to MODFLOW2000. Numerous spreadsheets, geographic information system (GIS) maps and Fortran utility programs were also developed to prepare input data sets for the models and to extract and display selected simulation results.

The finite-difference model grid includes five layers to enable simulation of vertical differences in groundwater levels and salt concentration. Grid cells are 250 x 250 feet near the DWTP and IWTP and increase to 1000 x 1000 feet in the rest of the basin. **Figure A-1** shows the the extent of the model and the finite-difference grid used in the model to simulate water levels at discrete points across the basin. The model has continued to evolve since 2001 as new information becomes available and to improve its capabilities. This includes modifications specifically implemented for the wastewater project. Modifications implemented since 2001 include:

- The grid spacing was decreased in the vicinity of the DWTP and IWTP in order to provide greater detail in simulated water table mounding beneath the percolation ponds.
- The model was divided into five layers in order to represent vertical differences in water levels and salinity. The upper surface of the top layer (layer 1) was shaped to parallel the relatively low water table surface at the start of the calibration period. This helps prevent layer 1 cells from going dry when simulated water levels fall below the bottom elevation of layer 1.
- The original calibration period was January 1993 to September 2000. This was extended through September 2003. The model uses quarterly time intervals for transient simulations.
- The active part of the flow domain was expanded to include the Lomerias Muertas/Flint Hills area and the Hollister Hills area that projects north from near San Justo Reservoir. Subsurface permeability is lower in these hilly areas than in the valley floor areas, but they are all part of a single, continuous groundwater flow system. The original model had excluded these areas. They were added to the model in order to explore potential impacts on the groundwater contaminant

plume at the former Whittaker ordnance facility and on groundwater flow and salinity near the proposed Flint Hills sprayfield site.

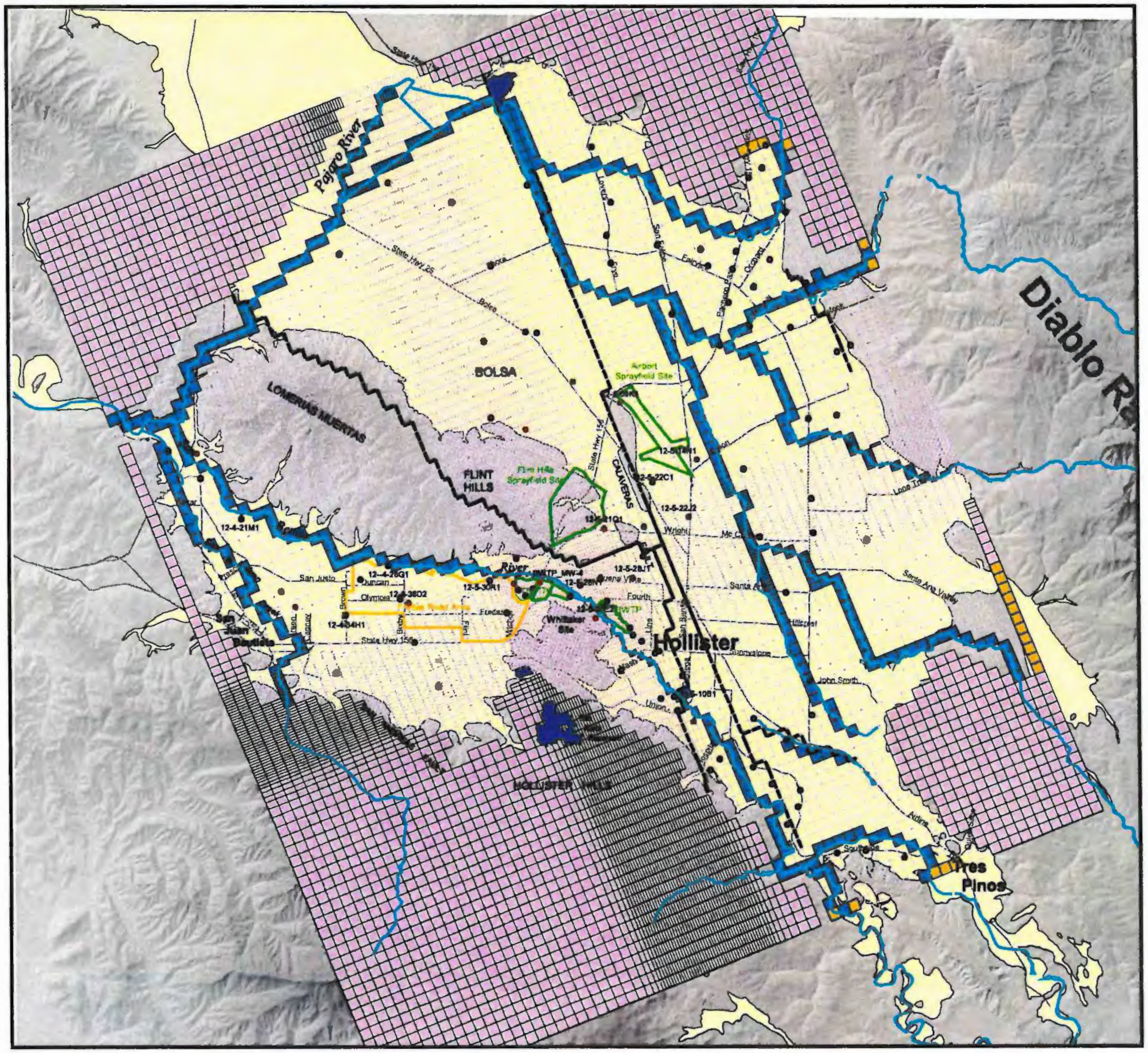
- The simulation of salt loading was completely revised to include separate loads from individual sources (stream percolation; wastwater percolation; recharge from rainfall and irrigation water, etc.) and to simulate loads on a transient basis. Salt loading by deep percolation of infiltrated rainfall and irrigation water was converted to a spatially variable input by calibrating a "background mass load" based on local groundwater salinity and irrigation water salinity. The background mass load represents all sources of dissolved solids in the deep percolation other than irrigation water (gypsum, fertilizers, atmospheric deposition, and dissolution of soil minerals) and was calibrated so that simulated deep percolation salinity equaled shallow groundwater salinity. Shallow groundwater salinity was set equal to the average of ten shallow wells in the San Juan Valley (2,330 mg/l) because spatial variability and lack of data in other parts of the basin precluded regional contouring of shallow groundwater salinity. However, measured TDS concentrations in shallow wells near the DWTP, IWTP and airport were included as localized areas of detail.
- Recharge zones for future simulations were revised to conform with the 2002 land use survey completed by the California Department of Water Resources and to include separate zones for wastewater disposal and reuse areas. The model calibration period was simulated using the 1997 land use survey.
- The recharge preprocessor was modified to account for recharge on peripheral hills that are not included in the active part of the model flow domain.
- Mathematical functions relating stream depth, width and dissolved-solids concentration to stream flow were greatly improved based on new field data collected by SBCWD in 2004.
- The MODPATH extension to the MODFLOW model code was implemented to simulate the Whittaker contaminant plume path
- The ZONEBUDGET extension to MODFLOW was implemented to obtain water budget information for subregions of the model flow domain.
- Inflow to the basin through alluvium along creeks (Pacheco Creek, Arroyo de las Viboras, Arroyo Dos Picachos, Tres Pinos Creek and the San Benito River was represented by general-head boundaries. Inflow beneath the Pajaro River from the Llagas area was similarly represented. The conductance terms for these inflows were calibrated to obtain reasonable inflow rates comparable to the estimated inflows in water budgets developed for SBCWD annual groundwater reports.
- The model was completely recalibrated. This included redefining zones of hydraulic conductivity and storativity, adjusting their parameter values, adjusting the locations and conductances of faults, and adjusting streambed permeability. Shallow wells were added to the calibration data set to support calibration of vertical hydraulic conductivity.

Hydrographs of simulated and measured water levels at 16 of the 106 well locations used for model calibration are shown in **Figure A-2**. These are wells located in areas that would be affected by the wastwater project, and their locations are labeled in **Figure A-1**.

The model uses quarterly stress periods and was calibrated to measured groundwater levels and stream-aquifer fluxes during 1993-2003. Calibration of the flow component of the model is good in all subbasins.

The ability of the solute transport component of the model to correctly simulate existing TDS concentration at any point in the basin is limited. Salinity data are fairly sparse, especially for shallow aquifers. Available data show considerable spatial variability geographically and with depth. Because of this variability, contoured initial concentrations for deep aquifers (model layers two through five) are not highly reliable except near the measurement wells. There were too few points to allow regional contouring of salinity in shallow aquifers (model layer 1), Instead, an initial concentration equal to the average of all available measurements was used in all parts of the basin except areas near the DWTP, IWTP and airport, for which one or more measured values were available. The solute transport model also simplifies water quality processes by lumping all salt loads other than irrigation water into a single background mass load term that was calibrated using an assumption that existing shallow groundwater salinity is in equilibrium with recharge salinity. Because of these simplifying assumptions, the solute transport component of the model is primarily useful for comparing relative differences among alternatives rather than predicting absolute TDS concentrations.

Figure A-1. Model Grid, Boundary Conditions and Calibration Well Locations



Finite-difference grid

No-flow (inactive) cells

Stream cells

General-head boundary cells

Faults

12-5-9M1 Location of well used for calibration (Well name or number shown for wells with hydrographs)

N

0 2 4 Miles

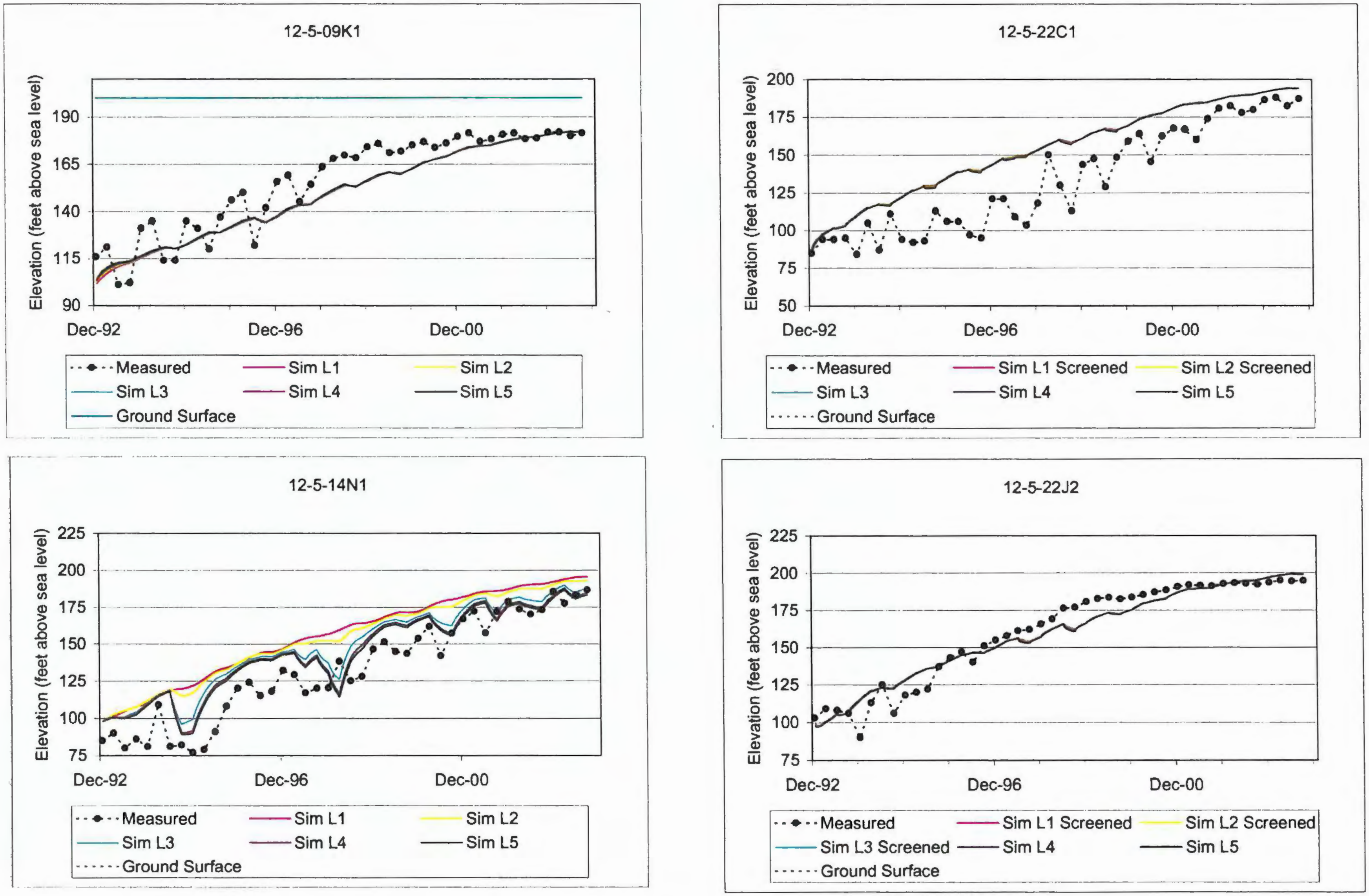


Figure A-2. Simulated and Measured Groundwater Levels for the 1993-2003 Calibration Simulation at Selected Locations Potentially Affected by the Proposed Project

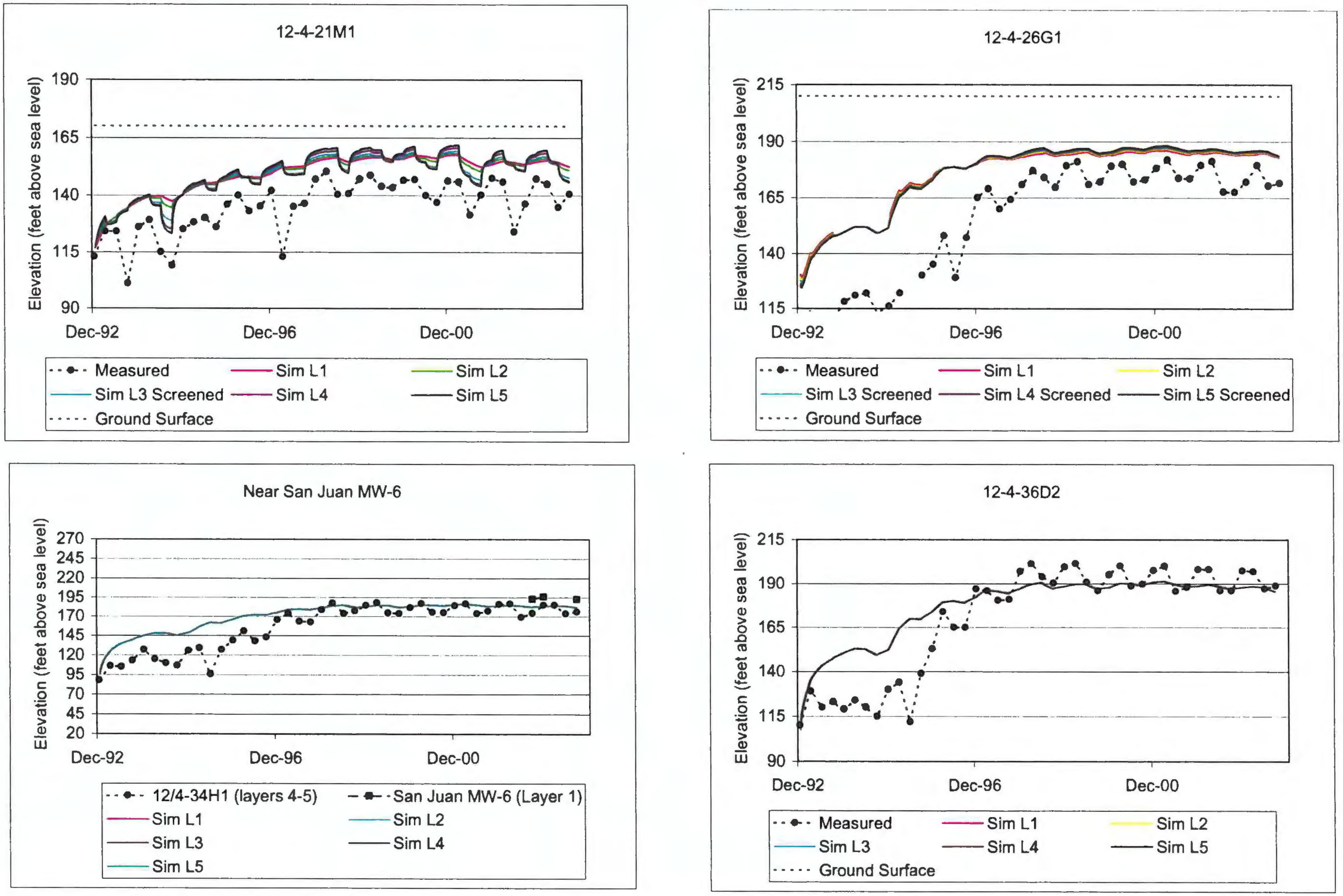


Figure A-2 — continued

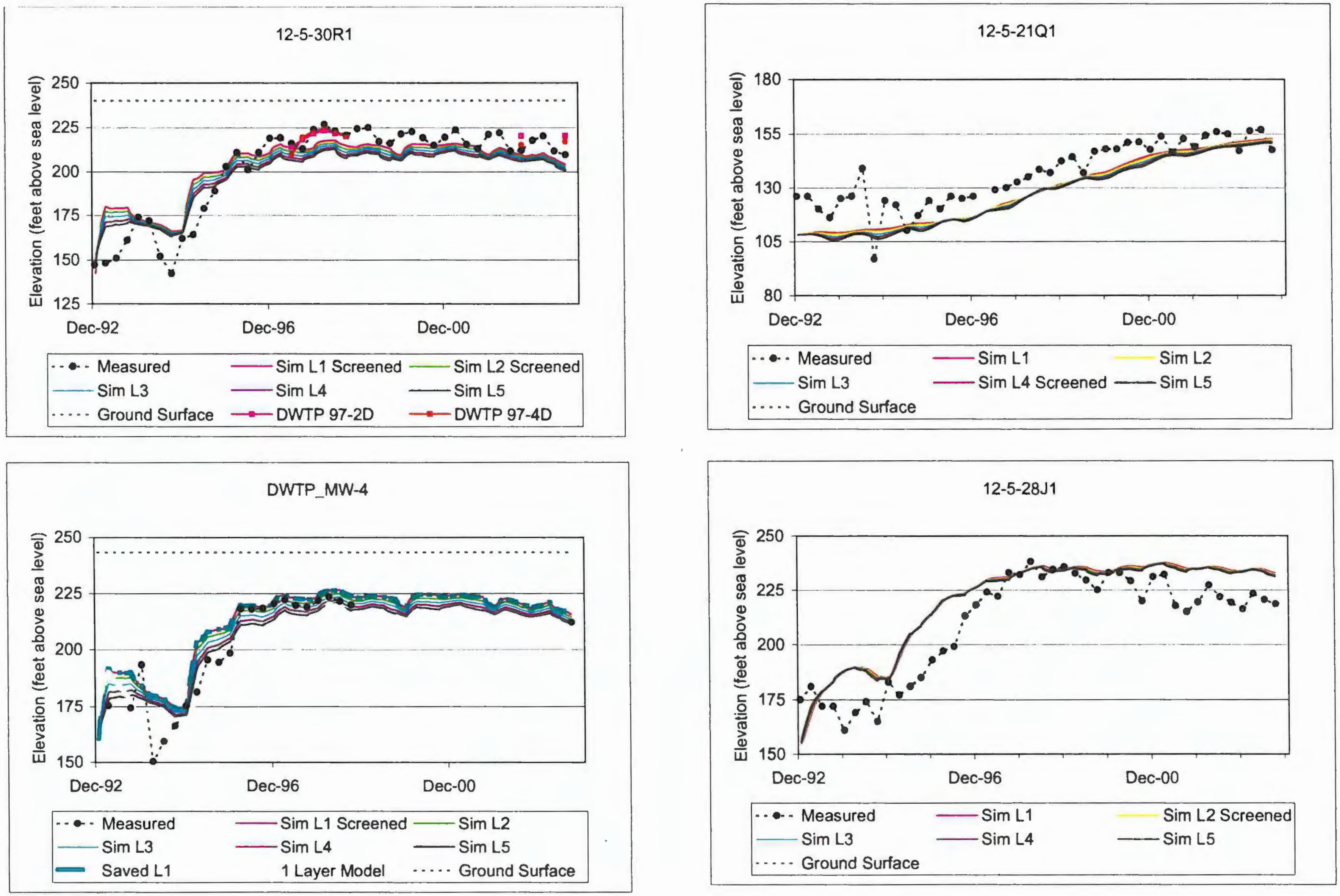
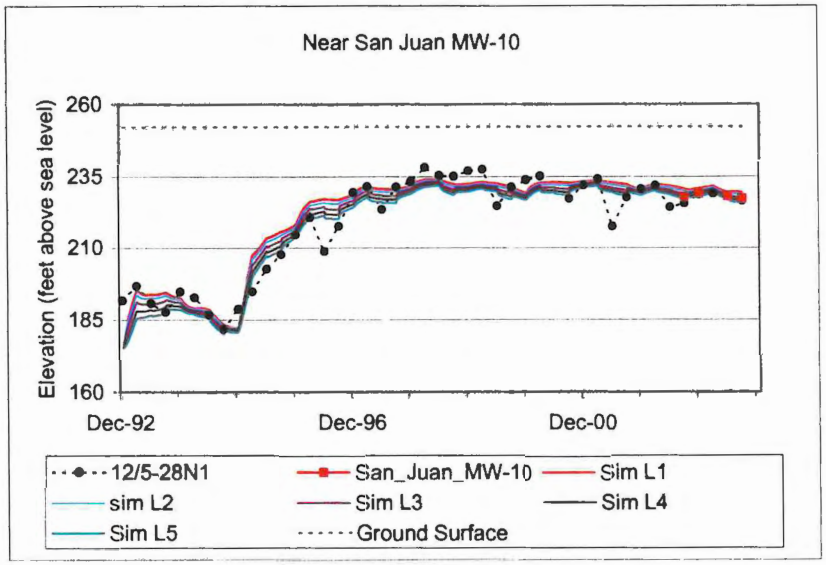
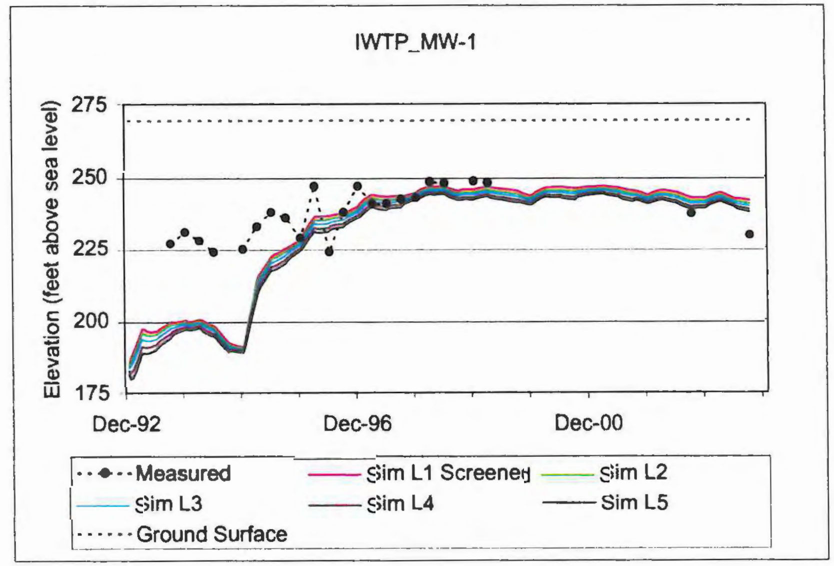
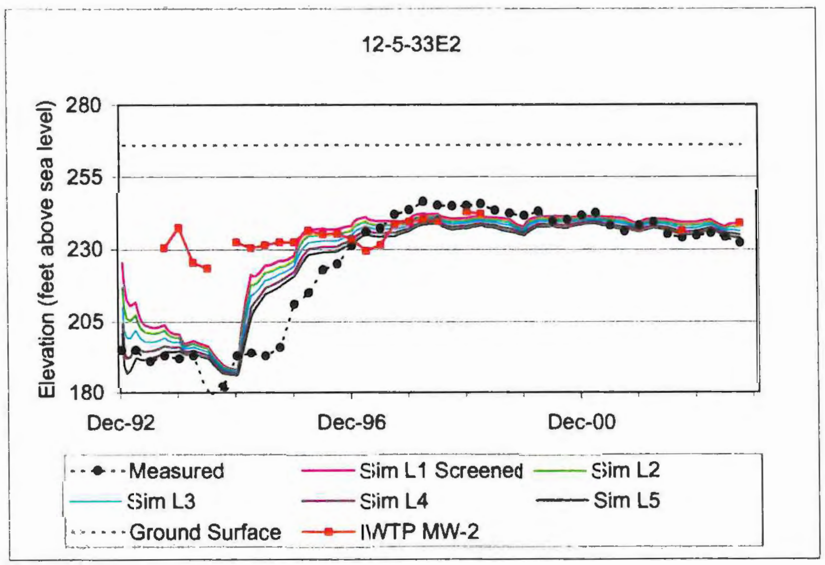


Figure A-2 -- continued







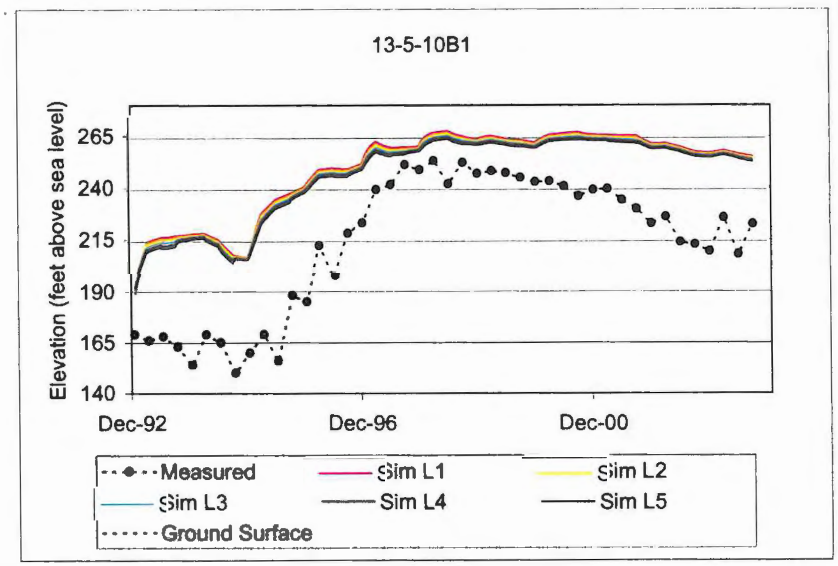


Figure A-2 — continued

Table 1 Annual Wastewater Percolation, Recycling and Disposal Volumes, 2008-2023

Year	Total Effluent Flow (ac-ft/yr)	IWTP Percolation (ac-ft/yr)	Recycled for Irrigation (ac-ft/yr)	DWTP Percolation (ac-ft/yr)	Sprayfield Disposal								
					Location:	Airport		Airport		Flint Hills		Total	
					Method:	Sprayfield		Turf		Sprayfield			
					Rate (in/yr):	50		36		50			
					Area (ac):	161		73		762			
					Capacity (af/yr):	671		219		3,175		4,065	
						(af/yr)	(% of cap)	(af/yr)	(% of cap)	(af/yr)	(% of cap)	(af/yr)	(% of cap)
2008	3,327	750	0	2,240		253	38%	83	38%	0	0%	336	8%
2009	3,416	750	0	2,240		321	48%	105	48%	0	0%	426	10%
2010	3,517	750	0	2,240		397	59%	130	59%	0	0%	526	13%
2011	3,607	750	0	2,240		464	69%	152	69%	0	0%	616	15%
2012	3,708	750	0	2,240		540	81%	176	81%	0	0%	717	18%
2013	3,820	750	0	2,240		625	93%	204	93%	0	0%	829	20%
2014	3,932	750	336	2,240		456	68%	149	68%	0	0%	605	15%
2015	4,033	672	672	2,240		338	50%	110	50%	0	0%	448	11%
2016	4,156	123	2,016	2,016		0	0%	0	0%	0	0%	0	0%
2017	4,268	0	3,136	1,131		0	0%	0	0%	0	0%	0	0%
2018	4,391	0	3,551	840		0	0%	0	0%	0	0%	0	0%
2019	4,503	0	3,663	840		0	0%	0	0%	0	0%	0	0%
2020	4,637	0	3,797	840		0	0%	0	0%	0	0%	0	0%
2021	4,772	0	3,932	840		0	0%	0	0%	0	0%	0	0%
2022	4,895	0	4,055	840		0	0%	0	0%	0	0%	0	0%
2023	5,041	0	4,201	840		0	0%	0	0%	0	0%	0	0%

Table 2. Changes in Basinwide Salt Load Sources Affected by the Proposed Project

Salt Load Source	Existing			Phase I			Phase II		
	ac-ft/yr	mg/l[3,4]	tons/yr	ac-ft/yr[5]	mg/l[3,4]	tons/yr	ac-ft/yr	mg/l[6]	tons/yr
Effluent percolation at DWTP and IWTP	3,000	1,250	5,100	3,000	1,250	5,100	800	600	700
Evaporative concentration at airport sprayfield	n.a.	n.a.	0	500	1,250	800	0	n.a.	0
Evaporative concentration of urban irrigation[1,2]	4,000	780	4,200	4,100	780	4,300	5,000	300	2,000
Evaporative concentration of agricultural irrigation in Freitas Road area	3,800	900	4,600	3,800	900	4,600	3,800	600	3,100
Evaporative concentration of agricultural irrigation in urbanizing areas[7]	1,800	800	2,000	900	800	1,000	0	n.a.	0
TOTAL			15,900			15,800			5,800

Notes:

[1] Approximately 55% of urban water use is for irrigation, based on a comparison of wastewater generation and total water use. City of Hollister projects total urban area water use to equal 8,122 ac-ft/yr in 2008 ("existing"), 8,383 ac-ft/yr in 2013, and 11,840 ac-ft/yr in 2023. Average Phase I use was assumed to equal the average of the 2008 and 2013 projections, and average Phase II water use was the average of 2013 and 2023 projections.

[2] Irrigation efficiency assumed to be 90% for urban and agricultural irrigation. For irrigated areas, the salt load equals the salt content of 90% of the applied irrigation water, which is the volume shown in the "ac-ft/yr" columns.

[3] The TDS concentration of municipal supply water is a weighted average of City of Hollister and SCWD measurements in 2004.

[4] The TDS concentration of agricultural irrigation water is an approximate average of measured TDS in wells near the respective irrigated areas.

[5] The airport sprayfield volue is the average annual volume during Phase I. Annual volumes range from 336 to 829 ac-ft/yr.

[6] Demineralization is assumed to achieve a municipal supply salinity of 300 mg/l as the means of achieving an average wastewater salinity of 600 mg/l.

[7] A total of 1,992 acres of irrigated agricultural land is expected to become urbanized by 2020, according to the City of Hollister general plan. Half of the conversion was assumed to be completed by the end of phase I.