MEMORANDUM

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Date:	October 17, 2008
To:	Jeff Cattaneo and Harry Blohm, SBCWD Steve Wittry, City of Hollister Bryan Yamaoka, Sunnyslope CWD Holly Kennedy, HDR Inc. Marc Nakamoto, RMC Water and Environment
From:	Gus Yates, consulting hydrologist
Cc:	
Subject:	HUAWWMP: Groundwater Impacts of Revised Alternative 3B—Highlights of Preliminary Simulation Results

This memorandum summarizes key findings of preliminary simulations of revised Alternative 3B for the Hollister Urban Area Water and Wastewater Master Plan. This alternative is a "limited demineralization" option in which demineralization of the municipal water supply for the City of Hollister and Sunnyslope County Water District would be implemented in phases, beginning with selected wells in approximately 2015.

Summary

Under revised Alternative 3B, municipal pumping would be concentrated in a small area on the east side of the San Benito River in the general vicinity of Enterprise Road and the Ridgemark Golf Course. This concentration of pumping resulted in larger simulated water-level declines during droughts. Simulated water levels remained higher than the lowest historical water levels, which typically occurred during 1981-1994. However, hydrographs of simulated water levels at numerous locations exhibited a declining trend near the end of the 30-year simulation period. This suggests that the new municipal pumping regime might not be sustainable, or that water levels would decline before stabilizing at a lower level that compensates for the increased pumping intensity. An extended simulation would be needed to further investigate this issue. From a management standpoint, the problem could probably be eliminated by reoperation of releases from Hernandez Reservoir or by shifting some municipal production to the north-central part of Hollister.

Water levels were higher under revised Alternative 3B in locations where municipal pumping decreased. This includes the area around Hollister municipal airport, where water levels under existing conditions are already shallow enough to cause potential drainage and liquefaction problems. Although revised Alternative 3B raised water levels by only 1-2 feet, the impact could be significant.

The proposed municipal pumping regime for revised Alternative 3B would increase percolation from the San Benito River, thereby diminishing river flows along the entire

reach downstream of Tres Pinos Creek. The largest effect occurred during high flow-flow periods for several years following a major drought (1987-1992 hydrology). The maximum increase in percolation relative to existing conditions was 53 cfs. At certain times and locations, increased percolation decreased the flow to zero.

The reach impacted by flow depletion—between Bird Creek and the Pajaro River—is not designated as critical habitat for steelhead trout, but reaches upstream and downstream are. On all of the dates when flow depletion decreased the flow to zero at any point along the river, flow was already discontinuous between Bird Creek and the Pajaro River. Therefore, flow depletion resulting from revised Alternative 3B would probably not adversely affect steelhead migration.

The impacts of revised Alternative 3B on groundwater salinity stem primarily from changes in irrigation salinity and wastewater percolation. The beneficial effect of demineralization on the urban irrigation supply led to decreases of several hundred milligrams per liter in shallow groundwater salinity throughout developed parts of the Hollister and SSCWD service areas. Decreases of up to 700 mg/L occurred beneath wastewater percolation ponds. Groundwater salinity increased at Riverside Park and the south end of the airport, where recycled water would become the sole source of irrigation water applied to previously nonirrigated soils. The increase of 500-900 mg/L in groundwater salinity at Riverside Park was the same result produced by previous simulations for the City's LTWMP SEIR. The increase at the airport was much smaller, however, because the recycled water would be blended with CVP water to a salinity of 700 mg/L and would be applied to a smaller area. The maximum simulated increase barely exceeded 100 mg/L and was limited to a small area at the southern end of the airport. The impact dissipated completely by the end of the simulation.

Groundwater salinity also increased beneath cropland that was newly irrigated or where recycled water replaced CVP water as a source of irrigation supply. In those areas, simulated groundwater salinity increased by as much as 700 mg/L over existing conditions. Although the areas designated for recycled water use were different, the magnitude of the increases were similar to the results of previous simulations completed for the City's LTWMP SEIR.

Assumptions for Revised Alternative 3B

The simulations incorporate the most current assumptions regarding water and wastewater projects that the City and SSCWD expect to implement. Previous versions of the City's wastewater project were simulated in 2006 and 2007 for the LTWMP EIR and SEIR, and several variations of SSCWD's project were simulated earlier this year. Many of the assumptions and data sets used for those previous efforts are also used in the current simulations. New and important assumptions for the current simulations include the following:

- SSCWD is assumed to implement Scenario 4A of its LTWMP. Two new municipal supply wells would be drilled along Southside Road near Enterprise Road, and a third would be drilled near Well #8 in the golf course area. Municipal supply wells would be centrally softened and/or demineralized. Wastewater percolation would continue at the Ridgemark I facility, but not Ridgemark II. Recycled water would be used for part of the irrigation supply for Ridgemark Golf Course, replacing CVP water.

- The City of Hollister is assumed to implement a variation of Alternative G from the LTWMP SEIR. A limited amount of domestic effluent would continue to be percolated at the DWTP, and transfers to the IWTP would be phased out. Recycled water would be used to irrigate Riverside Park and—during Phase I—a downsized set of fields at the southern tip and southwestern corner of the airport.

- A new feature of the City's project is the planned dilution of recycled water with CVP water during Phase I, bringing the TDS concentration down to 700 mg/L. This blended water will be delivered for irrigation use on fields in the Wright Road and Buena Vista Road area, in addition to the fields at the airport.

- Demineralization of the first set of City and SSCWD wells is assumed to begin in 2015 (year 8 of the simulation), bringing the wastewater TDS down to an average of 600 mg/L. Additional wells would be demineralized by 2023. Pumping volumes were increased to reflect the assumed 85% recovery efficiency of the demineralization process.

- Production from City and SSCWD wells would be coordinated and initially focused on a few wells in order to minimize the near-term capital costs of installing demineralization facilities.

- Between 2015 and 2023, the reuse area for recycled water from the DWTP would expand eastward incrementally along the Wright-McCloskey Road corridor. By 2017, it would expand to include fields east of Fairview Road (south of McCloskey Road), and by 2021 it would include additional fields east of Fairview Road (north of McCloskey Road).

Annual values of water use, wastewater percolation, wastewater recycling, and water quality assumed for the 30-year simulation period are shown in **Table 1** for the City and SSCWD.

Most of the impacts of revised Alternative 3B on groundwater levels and quality were expected to be similar to those revealed by previous simulations, because many of the project components have changed only slightly. A new and potentially large impact could result from concentrating municipal groundwater production at a handful of wells in the vicinity of Enterprise Road and the Ridgemark Golf Course. This could result in much larger cumulative water level declines during droughts and increased percolation losses along the San Benito River.

Effects on Groundwater Levels

Simulated impacts of revised Alternative 3B on groundwater levels are shown in the water-level contour maps on **Figure 1**. The maps show contours of the difference in simulated water level in model layer 1 (top layer) under revised Alternative 3B compared to a continuation of existing conditions. The largest difference occurs during droughts, when CVP deliveries are curtailed and groundwater recharge from rainfall and stream percolation is diminished. The upper plot shows the simulated water-level difference corresponding to December 1990 hydrologic conditions (the end of a multi-year drought). The red hues indicate areas where water levels would be higher than under existing conditions. This occurs in the Wright Road area, where recycled water would substitute for groundwater. The increase in water level (slightly over 10 feet) is small relative to the depth to the water table (about 100 feet) and would have no adverse impacts.

The blue hues indicate areas where water levels would be lower than under existing conditions. The largest decrease would be approximately 40 feet near the proposed SSCWD well #13 in the Ridgemark development. Two factors contribute to the large simulated drawdown in that area. First, the area is southeast of the intersection of the Calaveras Fault (which approximately follows Southside Road) and the Tres Pinos Fault (which approximately follows Enterprise Road and Highway 25). The faults partially isolate that region from the recharge capacity of the San Benito River, so that an increase in pumping results in a larger amount of drawdown than for wells closer to the river. Second, total groundwater withdrawals in the southeast quadrant would increase by a factor of nearly three following the addition of SSCWD well #13 in that area, slight increases in production at wells #5 and #8, and additional production to allow for the recovery efficiency of demineralization,.

Increased production from municipal wells along the east side of the river between Hospital and Nash Roads lowered simulated water levels by 14-20 feet in that region under drought conditions. The localized water-level declines beneath the DWTP and IWTP were the result of decreased percolation.

The general pattern of water-level differences under wet conditions (March 1998 hydrology) was similar to the pattern for dry conditions, but the changes were more moderate. The increase in water levels along Wright Road was less than 10 feet, and the decrease in the Ridgemark area was about 36 feet.

Figure 2 is a map showing the locations of the hydrographs of simulated water levels that are plotted in **Figure 3**. The map also indicates the areas where recycled water was assumed to be used for irrigation. Each of the 20 hydrographs is labeled with the ground surface elevation and—where available—the minimum historical water level at that location or at a nearby well monitored by SBCWD. The cumulative water-level decline during years 13-18 of the simulation (corresponding to the 1987-1992 drought) was larger in the Southside Road and Ridgemark areas than it was in simulations of earlier HUAWWMP alternatives because revised Alternative 3B concentrates municipal pumping in that area. Although the drought drawdowns were large, the minimum simulated water levels remained 20-190 feet higher than historical minimum water levels at all locations.

Simulated water levels recovered after the drought, but many of them were declining considerably faster than under existing conditions during the last 5 years of the simulation. Water use was constant during that part of the simulation, and rainfall (corresponding to water years 1999-2004) was close to the long-term average. The declining trends could indicate that the amount of municipal pumping was locally unsustainable. It is possible, however, that the long-term declines would eventually have stabilized at a lower level that induced stream and river recharge over a sufficiently large area to balance the average annual water budget. Additional analysis would be needed to resolve that question.

Water levels were higher under revised Alternative 3B in locations where municipal pumping decreased. This included the area around Hollister municipal airport, where water levels under existing conditions were already shallow enough to cause potential drainage and liquefaction problems (see hydrographs 16 and 19). Although revised Alternative 3B raised water levels by only 1-2 feet, the impact could be significant.

Effects on River Flow and Recharge

The municipal groundwater pumping regime under revised Alternative 3B would increase percolation losses along the San Benito River for three reasons: overall pumping would increase due to population growth, pumping would be relatively concentrated in wells near the river, and total production would increase an additional 15% to allow for the recovery efficiency of the demineralization process. The increase in simulated percolation was greatest during high flows following a prolonged drought, when it reached a maximum of 53 cfs. **Figure 4** shows hydrographs of simulated flows near Flint Road under existing conditions (orange lines) and under revised Alternative 3B (blue lines). The lower plot shows the same data as the upper plot but with an expanded Y scale to reveal more detail in the low-flow range. Flow depletion was greater in the latter half of the simulation, when municipal pumping was larger. At high flows, the depletion was a fairly small percentage of flow, but at certain times and locations it reduced the flow to zero.

The effects of flow depletion accumulated in the downstream direction, which is evident in profile plots of flow along the length of the river. The upper plot in **Figure 5** shows flow profiles in year 21 of the simulation (February 1995 hydrology), which was the date of the maximum rate of flow depletion. Because flows were high at that time, depletion amounted to less than 10% of the flow at any point along the river. Later that year (November 1995, shown in the lower plot), the depletion rate had dwindled to 14 cfs, but it amounted to as much as 78% of the flow in the river.

Flow depletion could potentially cause adverse impacts on fish. The species most likely to raise regulatory concerns is steelhead trout. The National Marine Fisheries Service included a number of stream reaches in San Benito County as part of the critical habitat for the south central coast steelhead population (Federal Register 70FR52573). These reaches included Bird Creek and all of the San Benito River upstream of Bird Creek (which enters the river 0.5 mile downstream of Tres Pinos Creek), and the Pajaro River above and below the confluence with the San Benito River. Fortunately, the impacts of the project on San Benito River flows are almost entirely limited to the reach that is not included in the critical habitat designation: from Bird Creek down to the Pajaro River. However, this reach serves as a migration corridor for steelhead farther upstream, and flow depletion could potentially shorten the migration season. An examination of simulation results revealed that on all the dates when revised Alternative 3B decreased flow to zero at any point along the river, flow was already discontinuous. That is, fish passage between the Bird Creek confluence and the Pajaro River was already impossible. Thus, this preliminary evaluation of stream depletion suggests that impacts on steelhead are probably negligible.

Effects on Groundwater Salinity

Figure 6 shows contours of the difference in simulated groundwater salinity between revised Alternative 3B and existing conditions. The upper plot shows the differences at the end of Phase I (2015), when demineralization was assumed to come on-line. Small changes in salinity had begun to develop at various locations for different reasons. Near Wright Road, Simulated salinity in model layer 1 had increased by more than 300 mg/L because the average salinity of irrigation water increased in areas where CVP water (300 mg/L of total dissolved solids) was replaced with recycled water (initially blended to 700 mg/L). Newly irrigated areas at the south end of the airport, east of Fairview Road, and northeast of the intersection of Fairview Road and Highway 25 had begun to accumulate salt in model layer 1, although the increases were all less than 300 mg/L. At Riverside Park near the IWTP, new irrigation with recycled water increased layer 1 salinity by up to 900 mg/L. Eliminating percolation at the Ridgemark II facility caused local groundwater salinity to drop by up to 500 mg/L. Replacing groundwater with recycled water as the source of irrigation supply in the Wright Road/Buena Vista Road area began decreasing layer1salinity, by as much as 100 mg/L.

The subsequent 23 years under Phase II introduced further changes in groundwater salinity (lower plot in **Figure 6**). The slight decrease in salinity throughout the urban area resulted from landscape irrigation with demineralized municipal supply water. The decrease of over 300 mg/L in the Wright Road/Buena Vista Road area resulted from replacing groundwater with recycled water for irrigation. The decreases of 500-700 mg/L beneath the DWTP and Ridgemark I wastewater percolation ponds resulted from the decrease in effluent salinity following demineralization of the municipal groundwater supply. In newly irrigated areas and areas where the average salinity of the irrigation sources increased, shallow groundwater salinity increased. These increases were generally in the 100-500 mg/L range.

Hydrographs of groundwater salinity in model layers 1-3 at selected locations are shown in **Figure 7**. The upper row of plots shows the evolution of salinity in model layers 1, 2 and 3 during the 30-year simulation of existing conditions. The lower row of plots shows salinity during the simulation of revised Alternative 3B. The patterns vary by location, depending on local hydrology and the timing of project implementation. For example, groundwater salinity beneath the Ridgemark I ponds (hydrograph 1) remained at existing levels until demineralization was implemented in year 8 of the simulation, whereupon it dropped rapidly in layer 1, followed by similar decreases in layers 2 and 3. In contrast, salinity beneath the Ridgemark II ponds (hydrograph 3) began gradually returning to the background concentration starting in year 1 of the simulation, when percolation was assumed to be discontinued.

At Riverside Park (hydrograph 8), salinity increased from 1,000 to 2,000 mg/L over a few years under revised Alternative 3B, but the concentration stabilized and was eventually diluted by an influx of river recharge during the first high flow event following the drought that occurred in years 13-18 of the simulation.

Near Wright and Buena Vista Roads (hydrographs 14 and 15), the decrease in irrigation water salinity when recycled water replaced caused a steady decrease in layer 1 salinity throughout the simulation. The effect had propagated down to layer 2 after about 12 years but had not begun to affect layer 3 by the end of the simulation.

At the airport, the only area proposed for irrigation with recycled water under revised Alternative 3B is two fields near the south end of the airport. Both fields are nonirrigated under existing conditions, and irrigation with recycled water during the first 7 years of the simulation gradually increased groundwater salinity in layer 1 (hydrograph 16). Salinity gradually returned to the background concentration during the remainder of the simulation. At the end of 30 years, salinity was very slightly lower than under existing conditions because of landscape irrigation with demineralized water on newly urbanized adjoining parcels.

The decrease in groundwater salinity near the intersection of Southside Road and Enterprise Road (hydrograph 17) was principally the result of converting groundwater-irrigated cropland to residential landscaping irrigated with demineralized water. A possible contributing factor is the diluting effect of additional river recharge induced by the increase in municipal pumping in that area.

Table 1. Overview of Annual Model Input Data for Hydrology, Land Use, Water Use and Wastewater Disposal during the 30-Year Simulation Period

		Source of Hydrologic Conditions			Municipal Water Supply				City of Hollister Wastewater Disposal									SSCWD Wastewater Disposal			
					Water Use (ac-ft/yr)						Percolation		Offsite Recycling								
															Cropland						
Simulation Elapsed Time (years)	Simulated Water Year	Water Year	Year Type[1]	Land Use	CVP[2]	Groundwater	Total	Average TDS[3] (mg/L)	Total Flow[4] (ac-ft/yr)	Average TDS (mg/L)	IWTP (ac-ft/yr)	DWTP (ac-ft/yr)	Riverside Park (ac-ft/yr)	Airport (ac-ft/yr)	Recycled Water (ac-ft/yr)	Dilution Water[5] (ac-ft/yr)	Total (ac-ft/yr)	Total Flow[6] (ac-ft/yr)	Average TDS (mg/L)	Perco-lation (ac-ft/yr)	Recycled Water (ac-ft/yr)
1	2008	1975	Normal (+)	Existing	**2,240**	**5,122**	7,362	**615**	**3,064**	1,204	840	2,207	16	0	0	0	1	**239**	1774	**239**	0
2	2009	1976	Normal (-)	Existing	2,464	5,106	7,570	**615**	3,157	1,204	840	2,207	110	0	0	0	0	248	1774	248	0
3	2010	1977	Dry	2010	2,688	5,090	7,779	**615**	3,250	1,204	840	2,207	157	23	23	29	52	257	1774	257	0
4	2011	1978	Wet	2010	2,912	5,075	7,987	**615**	3,344	1,204	840	2,207	157	70	69	87	156	266	1774	266	0
5	2012	1979	Normal (+)	2010	3,136	5,059	8,195	**615**	3,437	1,204	840	2,207	157	116	116	146	263	275	1774	275	0
6	2013	1980	Normal (+)	2010	**3,360**	**5,043**	8,403	**615**	**3,529**	1,204	840	2,207	157	163	162	204	366	284	1774	284	0
7	2014	1981	Normal (-)	2010	3,360	5,442	8,802	**615**	**3,636**	1,204	840	2,207	157	216	215	271	487	293	1774	293	0
8	2015	1982	Wet	2015	3,360	5,840	9,201	**289**	3,753	600	672	2,207	157	0	717	0	717	302	600	**131**	171
9	2016	1983	Wet	2015	3,360	6,239	9,599	282	3,870	600	123	2,016	157	0	1,574	0	1,574	311	600	131	180
10	2017	1984	Normal (-)	2015	3,360	6,637	9,998	275	3,987	600	0	1,131	157	0	2,699	0	2,699	320	600	131	189
11	2018	1985	Normal (-)	2015	3,360	7,036	10,396	268	4,104	600	0	840	157	0	3,107	0	3,107	329	600	131	198
12	2019	1986	Wet	2015	3,360	7,435	10,795	262	4,221	600	0	840	157	0	3,224	0	3,224	338	600	131	207
13	2020	1987	Dry	2020	3,360	7,833	11,194	255	4,338	600	0	840	157	0	3,341	0	3,341	347	600	131	216
14	2021	1988	Dry	2020	3,360	8,232	11,592	248	4,454	600	0	840	157	0	3,457	0	3,457	356	600	131	225
15	2022	1989	Normal (-)	2020	3,360	8,630	11,991	241	4,571	600	0	840	157	0	3,574	0	3,574	365	600	131	234
16	2023	1990	Dry	2020	3,360	**9,029**	12,389	**234**	**4,687**	600	0	840	157	0	3,690	0	3,690	374	600	131	243
17	2024	1991	Normal (-)	2020	3,360	9,029	12,389	234	4,687	600	0	840	157	0	3,690	0	3,690	383	600	131	252
18	2025	1992	Normal	2020	3,360	9,029	12,389	234	4,687	600	0	840	157	0	3,690	0	3,690	**392**	600	131	261
19	2026	1993	Normal (+)	2020	3,360	9,029	12,389	234	4,687	600	0	840	157	0	3,690	0	3,690	392	600	131	261
20	2027	1994	Dry	2020	3,360	9,029	12,389	234	4,687	600	0	840	157	0	3,690	0	3,690	392	600	131	261
21	2028	1995	Wet	2020	3,360	9,029	12,389	234	4,687	600	0	840	157	0	3,690	0	3,690	392	600	131	261
22	2029	1996	Normal (+)	2020	3,360	9,029	12,389	234	4,687	600	0	840	157	0	3,690	0	3,690	392	600	131	261
23	2030	1997	Normal (+)	2020	3,360	9,029	12,389	234	4,687	600	0	840	157	0	3,690	0	3,690	392	600	131	261
24	2031	1998	Wet	2020	3,360	9,029	12,389	234	4,687	600	0	840	157	0	3,690	0	3,690	392	600	131	261
25	2032	1999	Normal (-)	2020	3,360	9,029	12,389	234	4,687	600	0	840	157	0	3,690	0	3,690	392	600	131	261
26	2033	2000	Normal	2020	3,360	9,029	12,389	234	4,687	600	0	840	157	0	3,690	0	3,690	392	600	131	261
27	2034	2001	Normal	2020	3,360	9,029	12,389	234	4,687	600	0	840	157	0	3,690	0	3,690	392	600	131	261
28	2035	2002	Normal (+)	2020	3,360	9,029	12,389	234	4,687	600	0	840	157	0	3,690	0	3,690	392	600	131	261
29	2036	2003	Normal	2020	3,360	9,029	12,389	234	4,687	600	0	840	157	0	3,690	0	3,690	392	600	131	261
30	2037	2004	Normal	2020	3,360	9,029	12,389	234	4,687	600	0	840	157	0	3,690	0	3,690	392	600	131	261

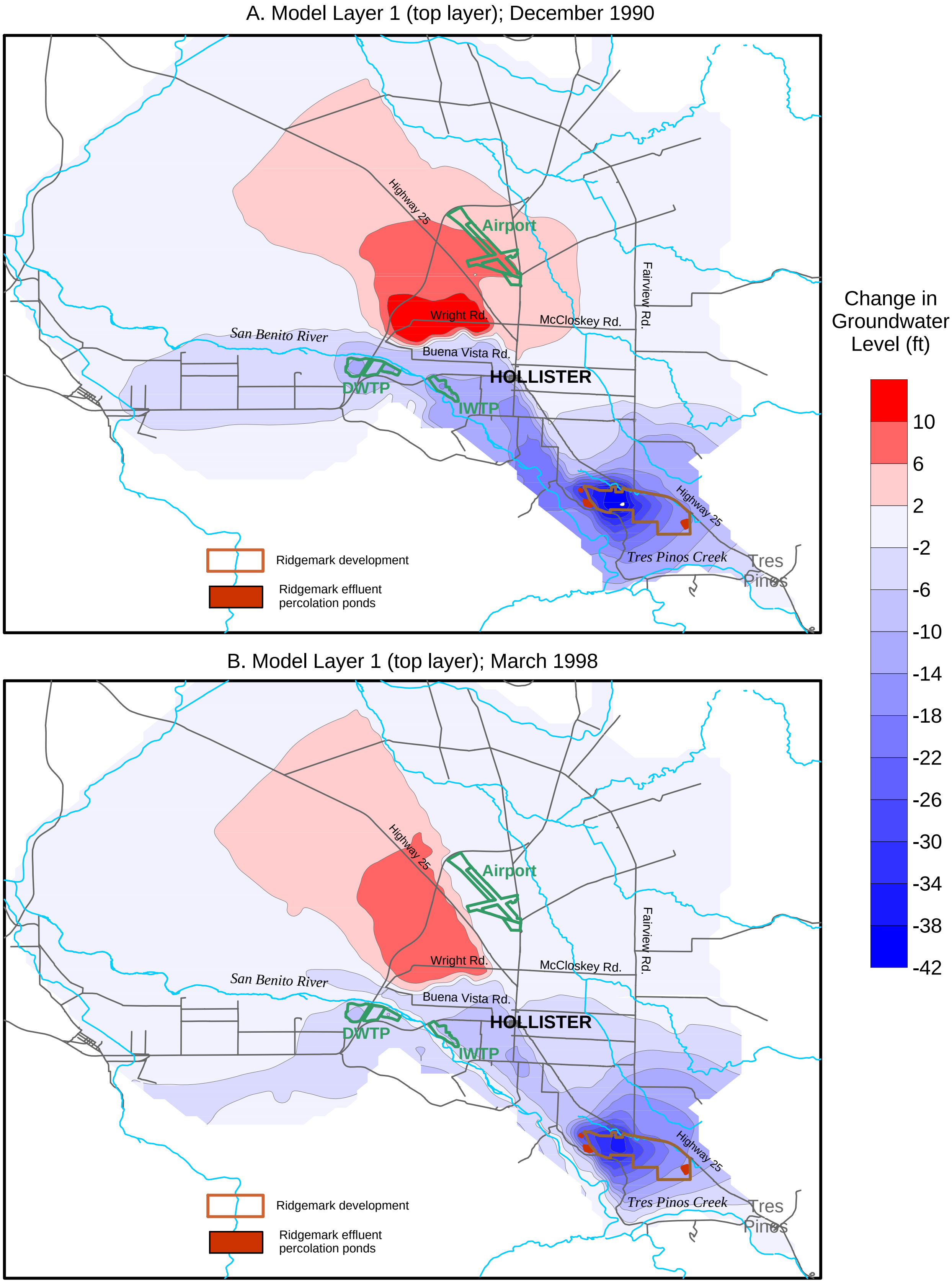
[1] Year types reflect annual rainfall as percentage of the 1875-2005 average: 0-20% = Dry, 21-40% = below normal [normal (-)], 41-60% = normal, 61-80% = above normal [normal (+)], and 81-100% = wet

[2] Assumes Lessalt water treatment plant capacity increases from 1.4 mgd in 2005 to 3.0 mgd in 2013 as a result of plant improvements. This interpolation equals 2.0 mgd (2,240 ac-ft/yr) in 2008.

[3] Municipal supply TDS is assumed to remain at the existing concentration until 2015, when demineralization could commence at selected wells. Additional demineralization would be phased in by 2023. Bold numbers are the assumed values, the other years have interpolated values.

[4] Wastewater generation values in bold are from the City of Hollister's Long-Term Wastewater Management Plan Subsequent EIR (Analytical Environmental Services, February 2008), minus the SSCWD wastewater flows that were assumed in the SEIR to flow to the DWTP. Other years have interpolated values.

[5] In the early years of the project, the City of Hollister's recycled water for crop irrigation is diluted with CVP water to achieve a blended TDS of 700 mg/L.



Note: water-level change is with respect to existing conditions

Figure 1. Contours of Simulated Change in Groundwater Elevation in Model Layer 1 under Dry (December 1990) and Wet (March 1998) Conditions for Revised HUAWWMP Alternative 3B

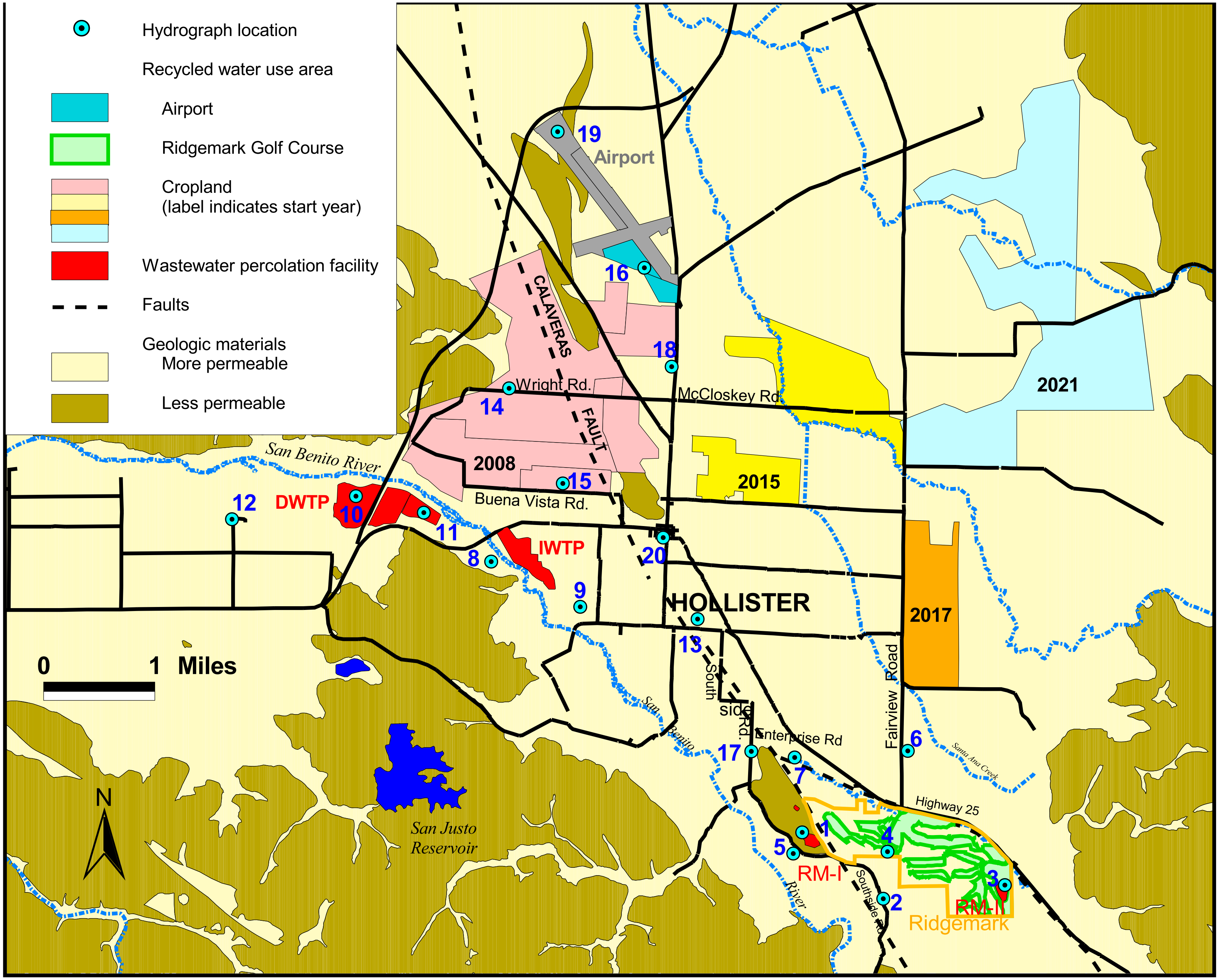
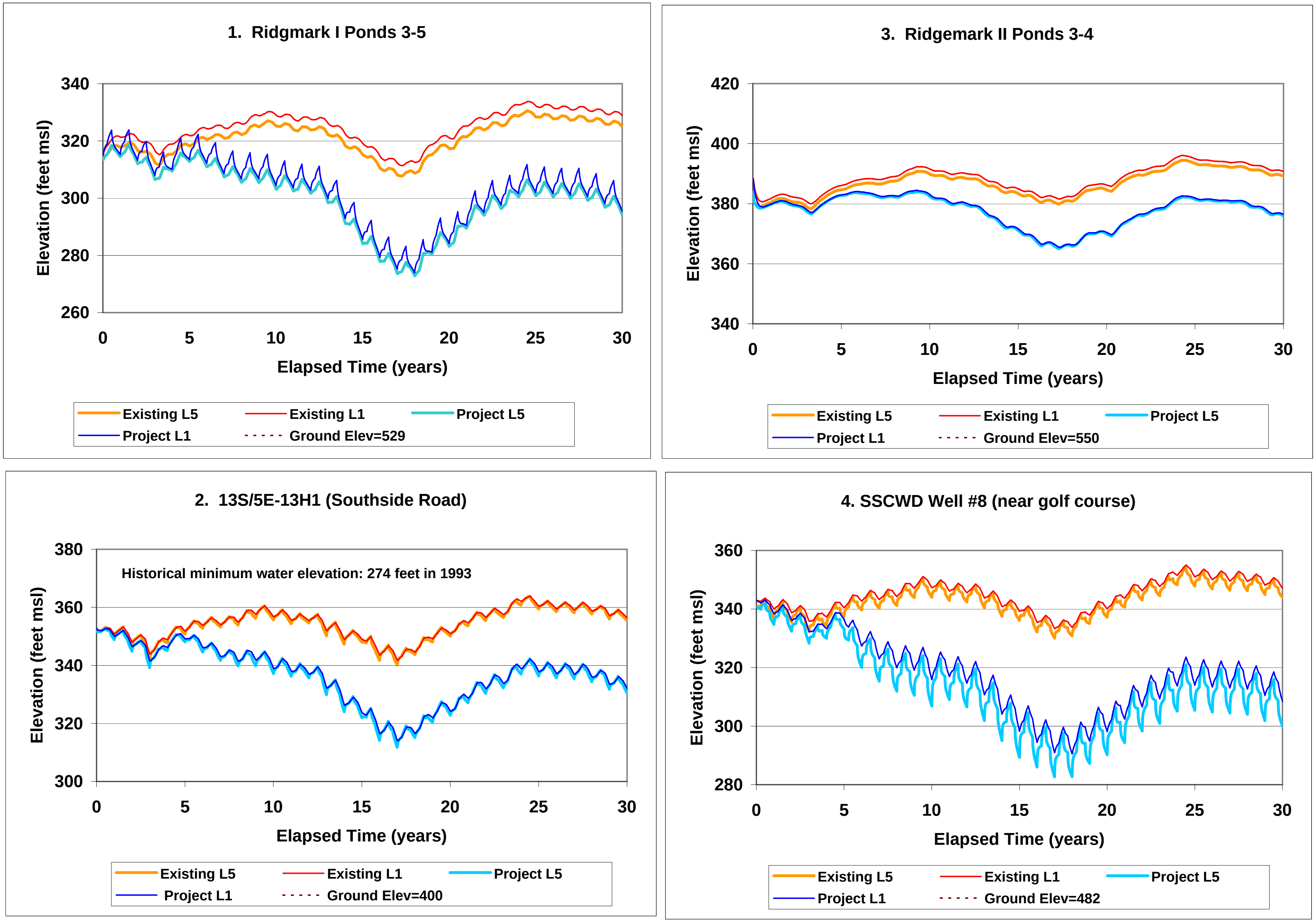
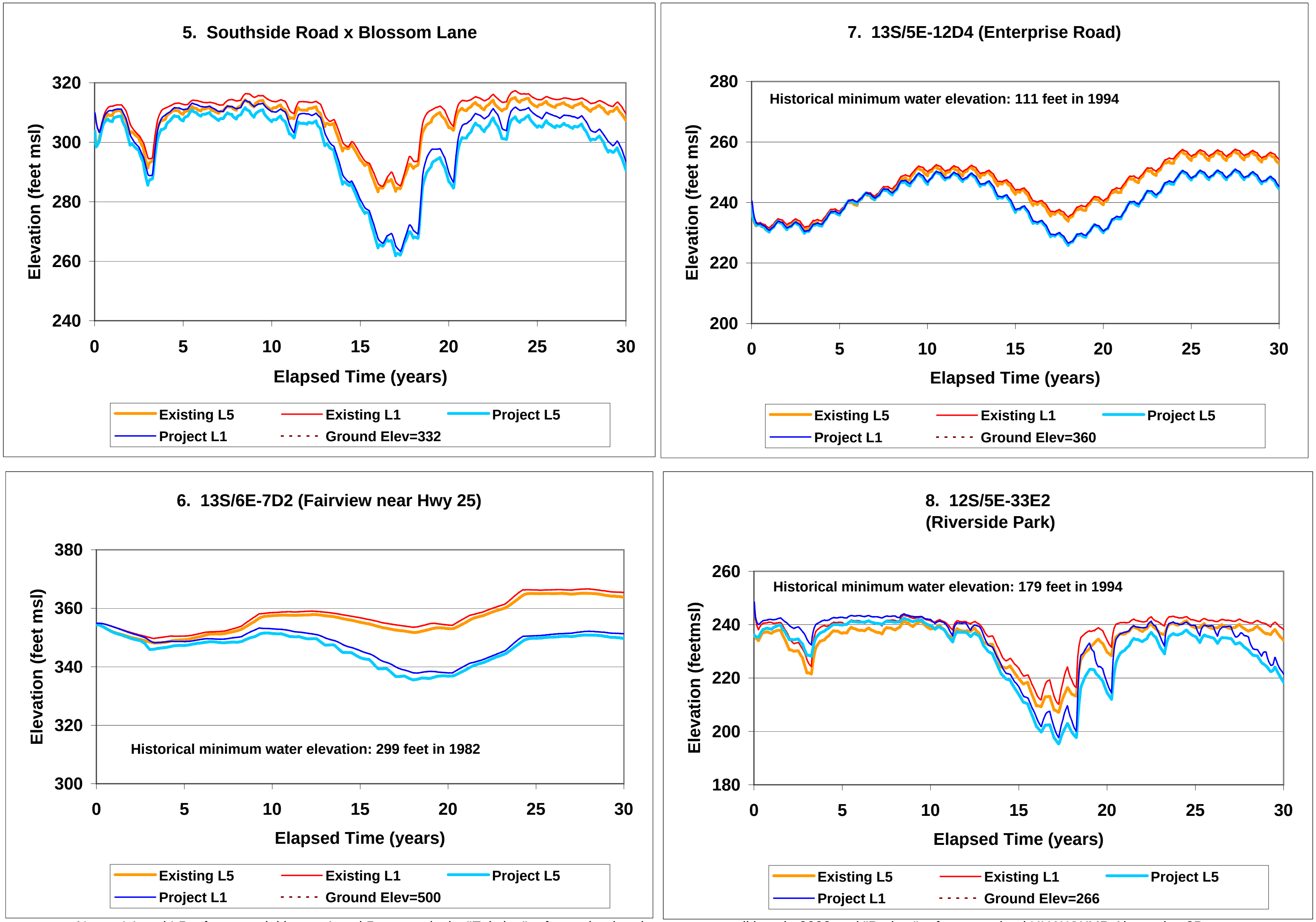


Figure 2. Locations of Hydrographs and Potential Recycled Water Use Areas



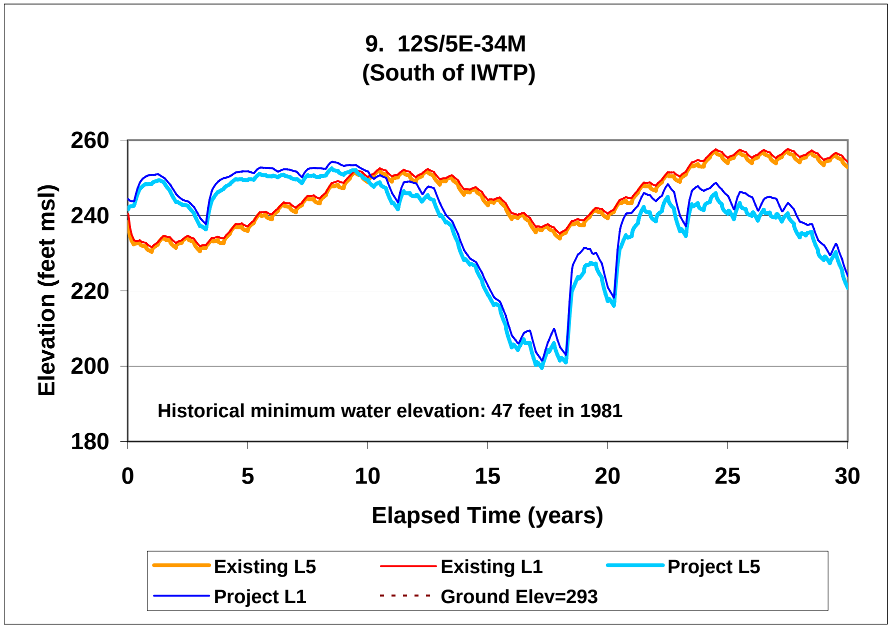
Notes: L1 and L5 refer to model layers 1 and 5, respectively. "Existing" refers to land and water use conditions in 2008 and "Project" refers to revised HUAWWMP Alternative 3B.

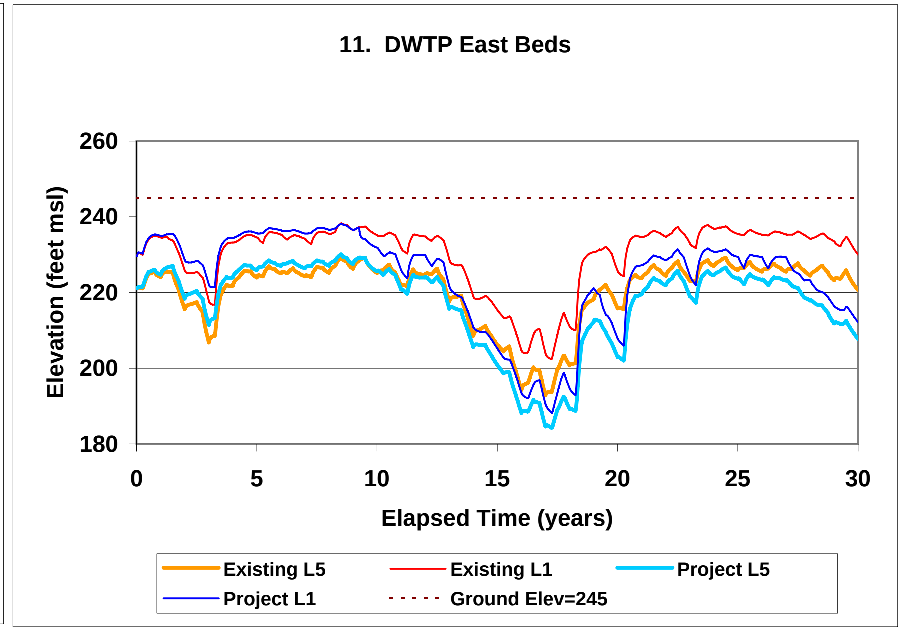
Figure 3. Hydrographs of Simulated Groundwater Levels under Revised HUAWWMP Alternative 3B Compared with Existing Conditions

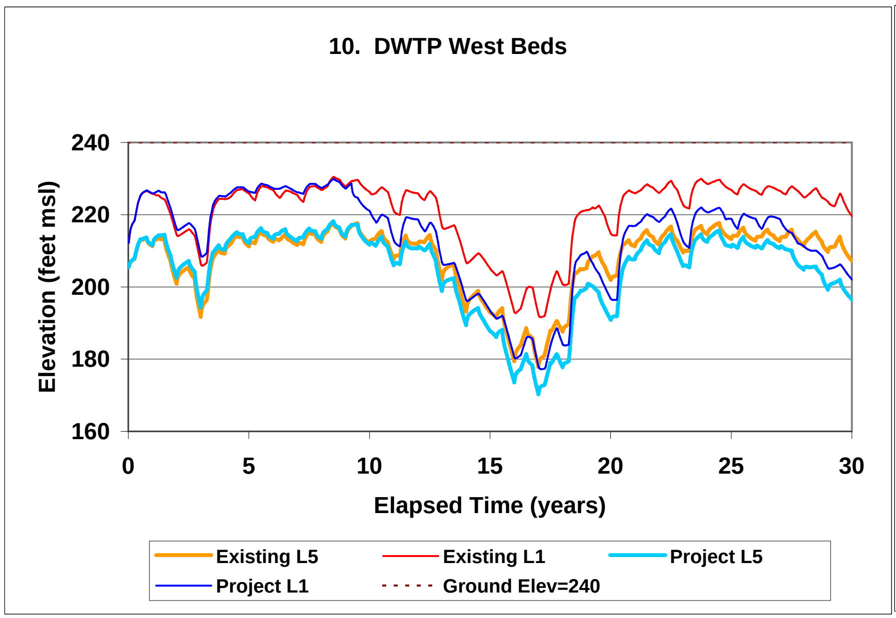


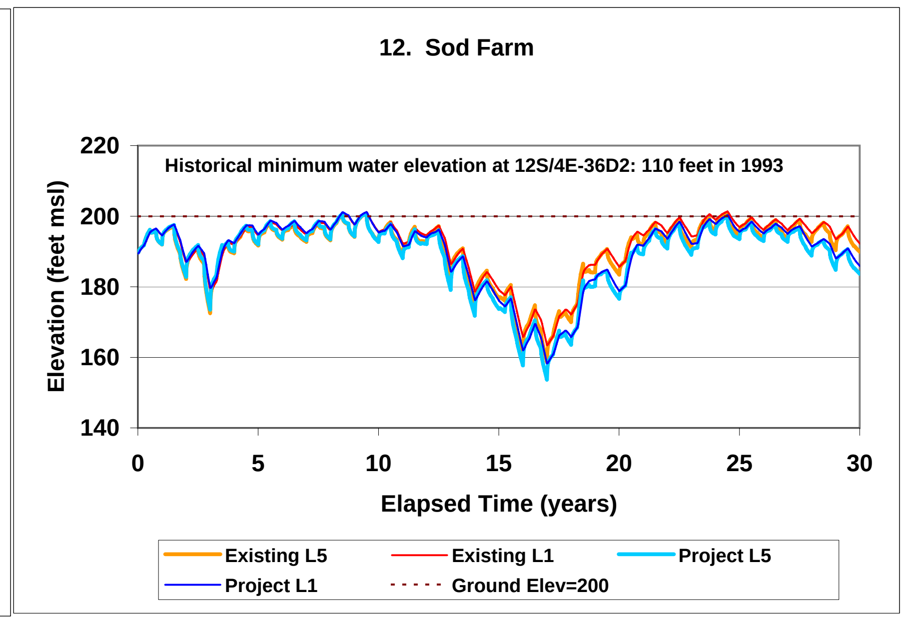
Notes: L1 and L5 refer to model layers 1 and 5, respectively. "Existing" refers to land and water use conditions in 2008 and "Project" refers to revised HUAWWMP Alternative 3B.

Figure 3—continued









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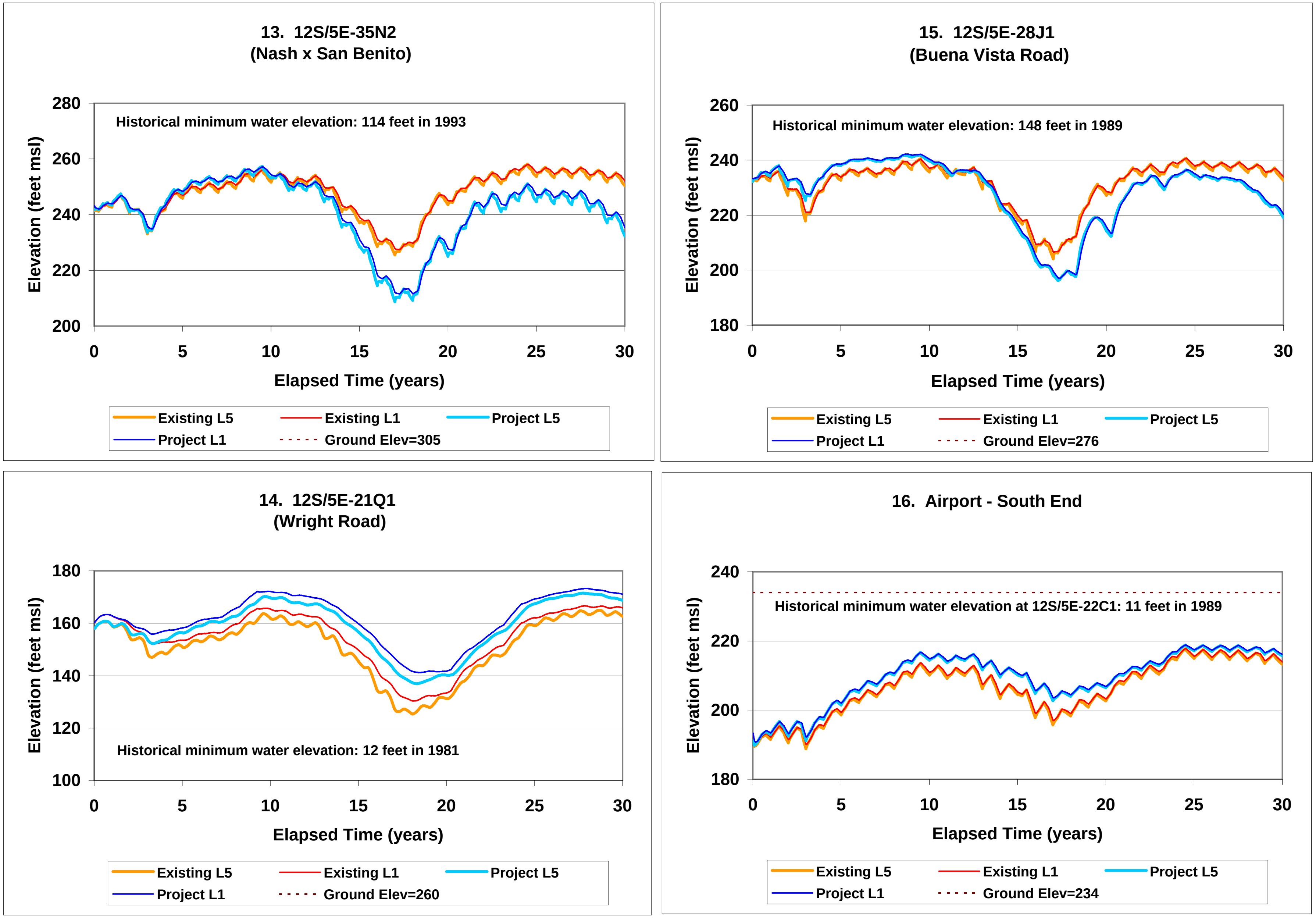

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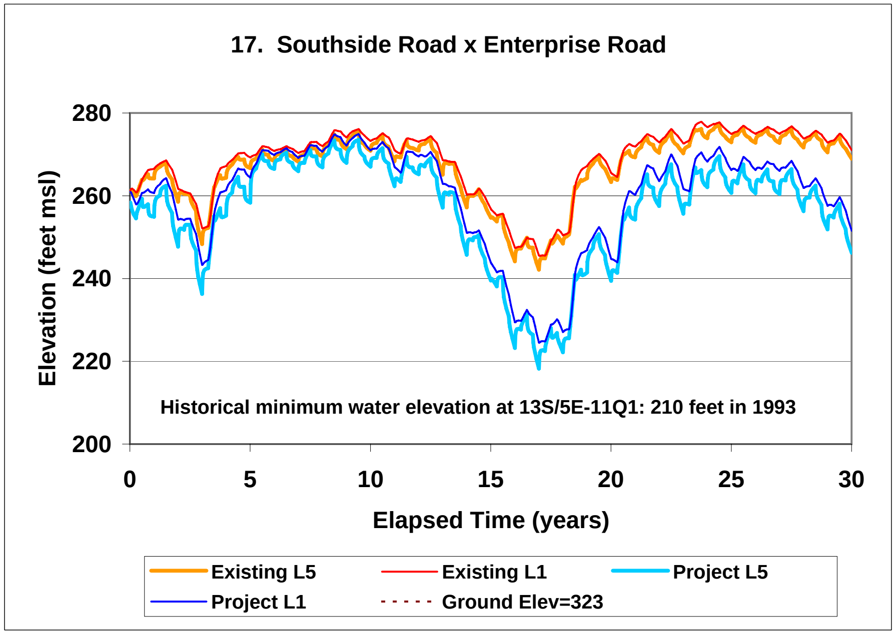
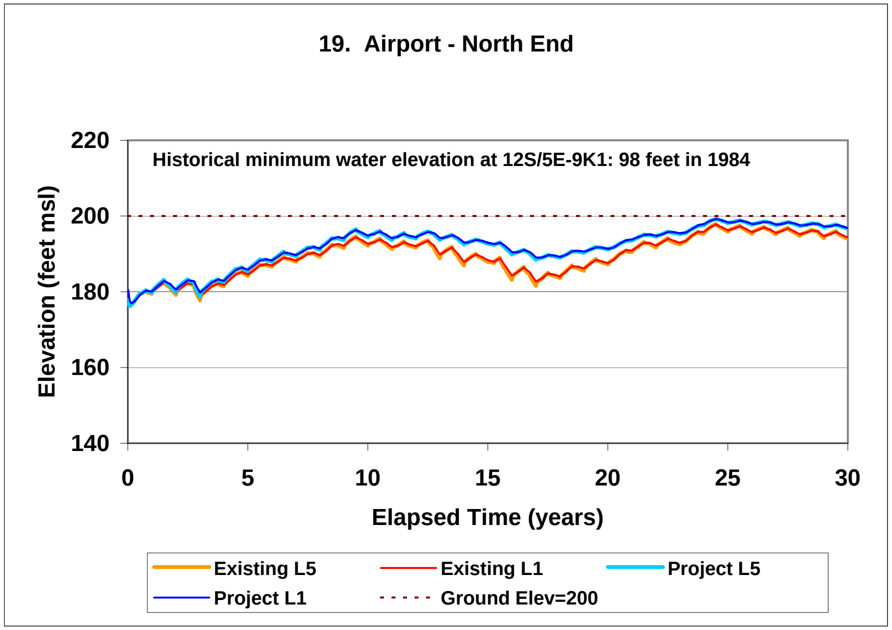
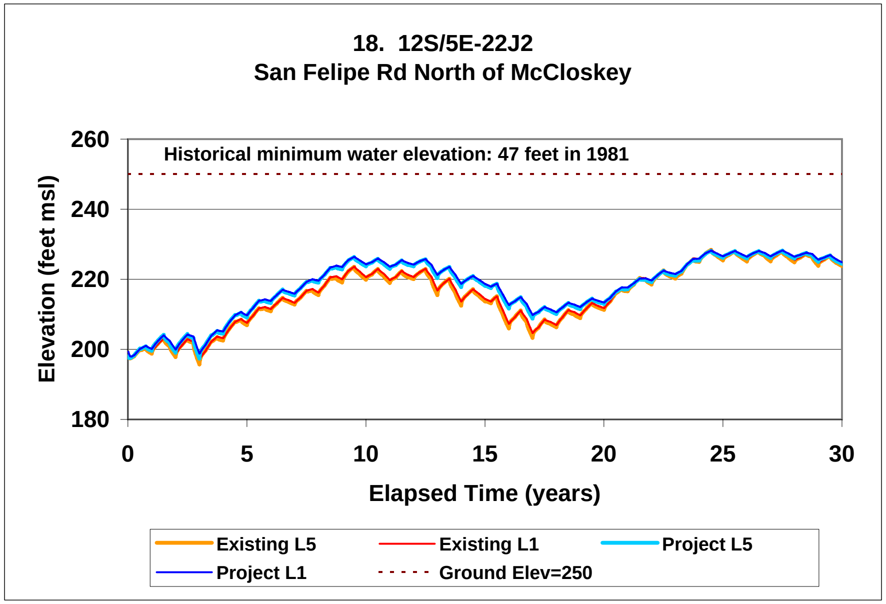






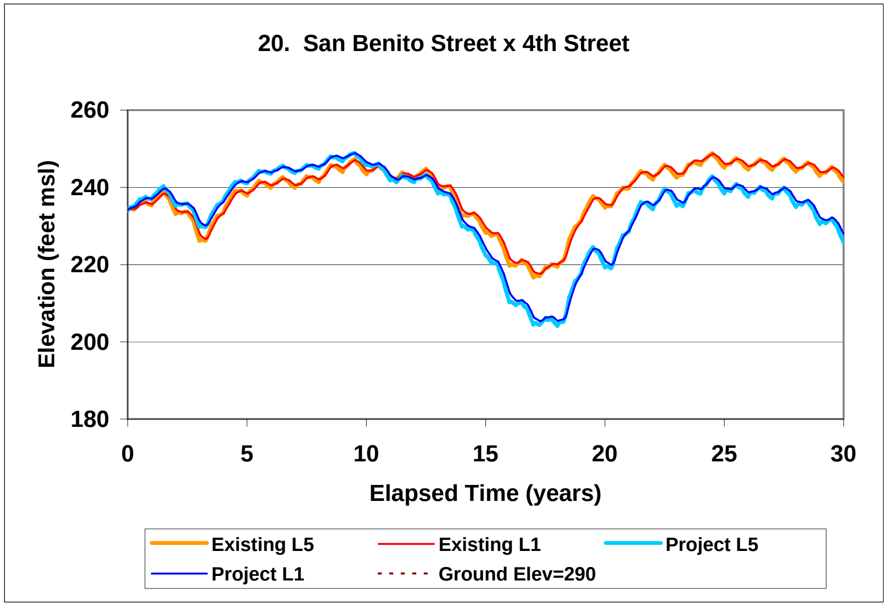
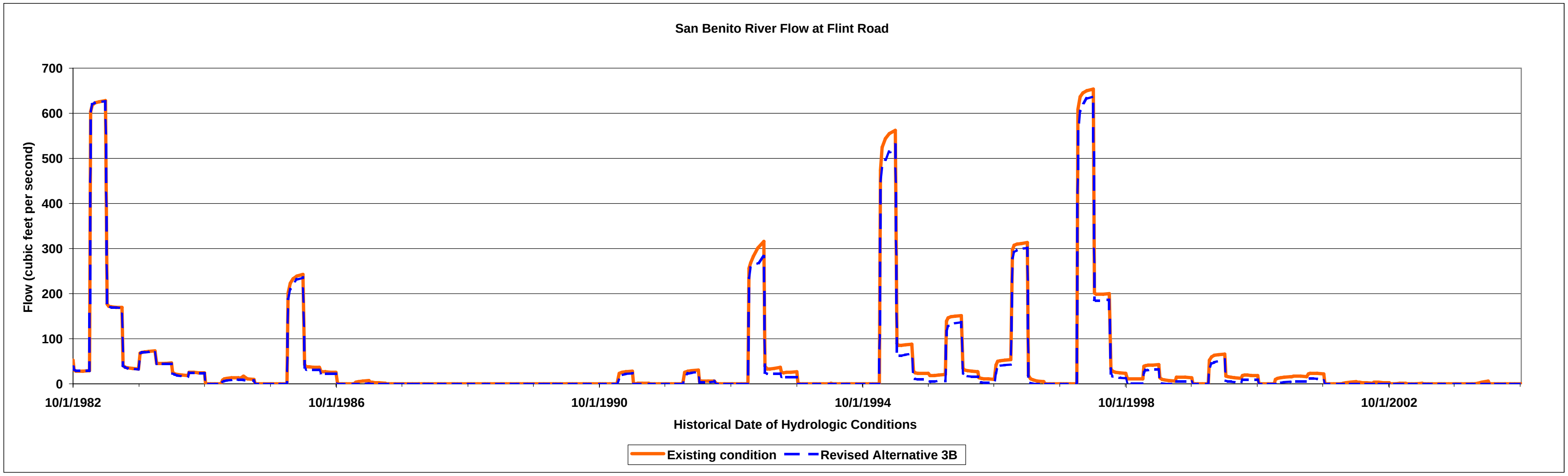


Figure 3—continued



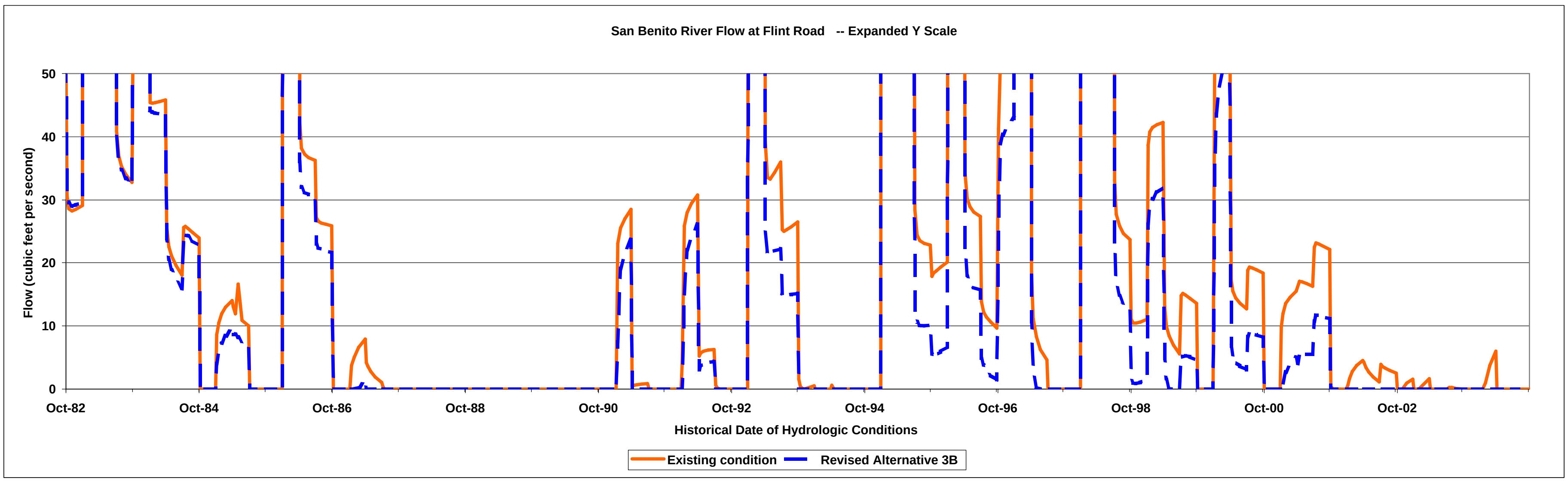
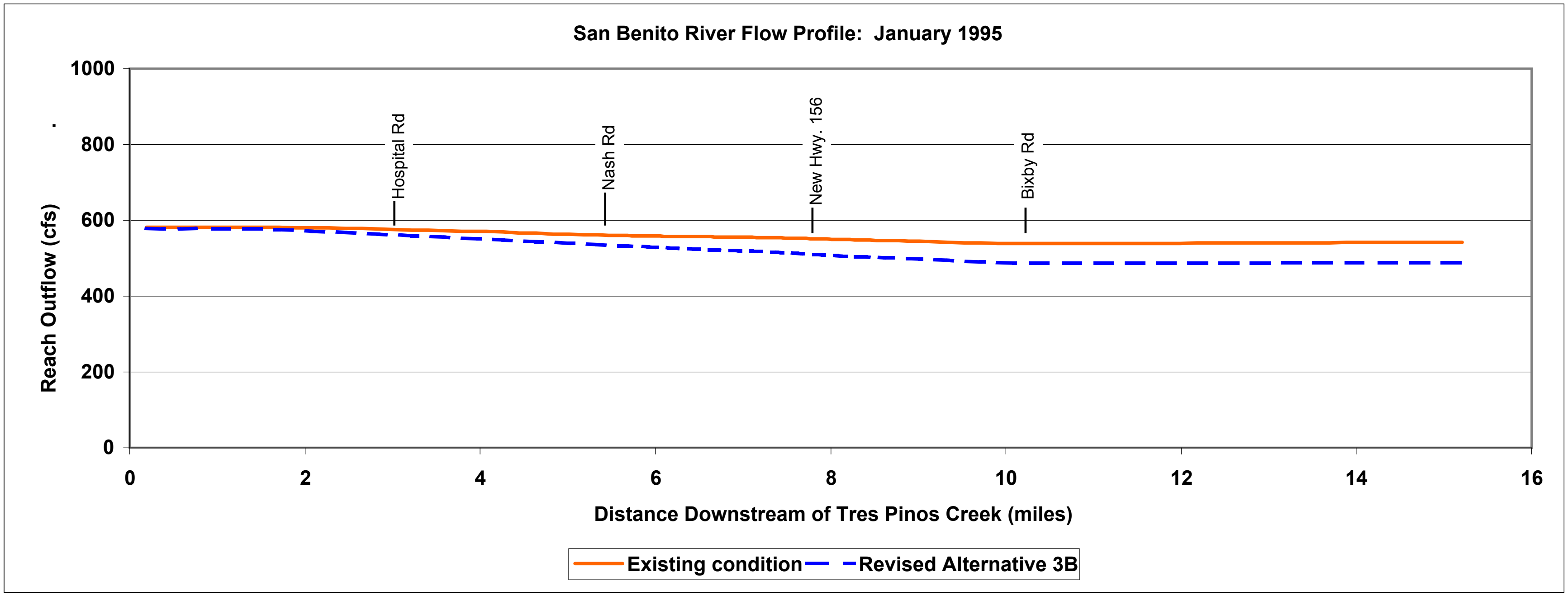


Figure 4. Hydrographs of Simulated Flow in the San Benito River at Flint Road under Existing Conditions and Revised Alternative 3E



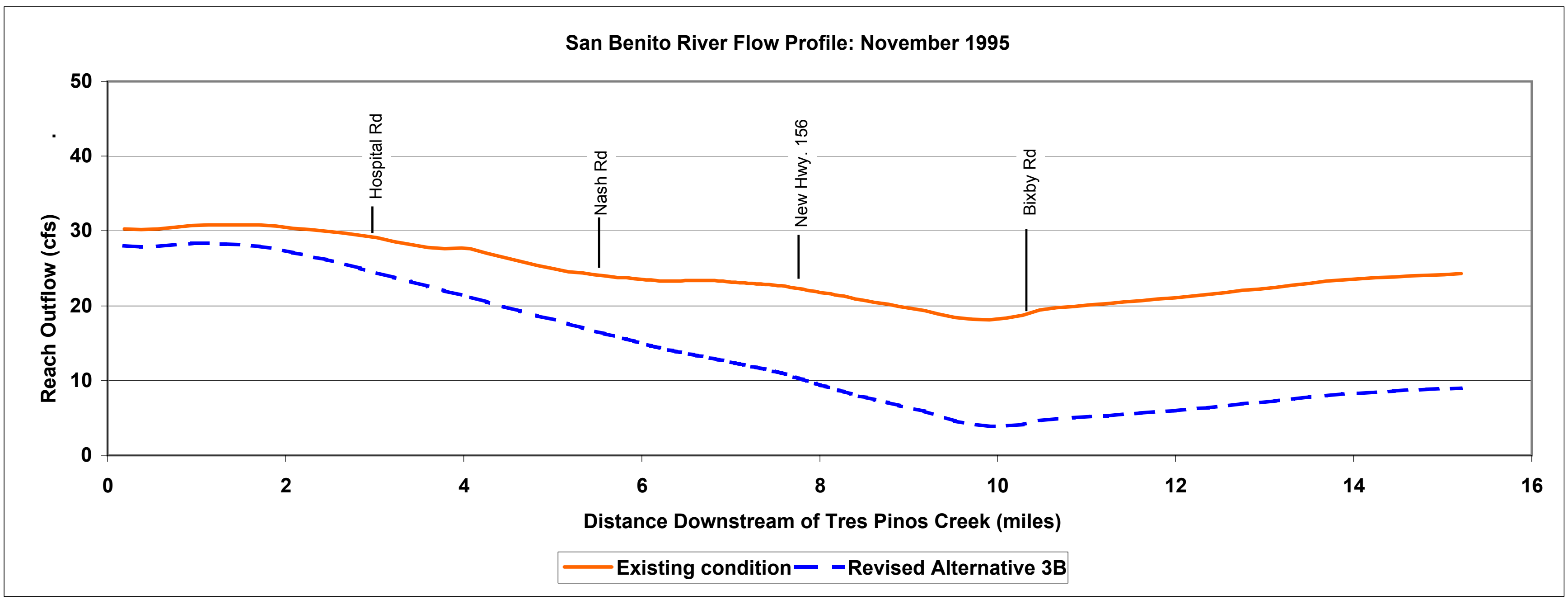
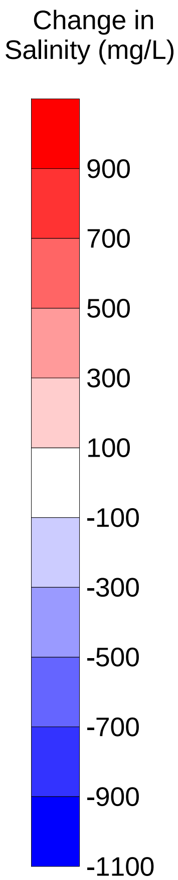
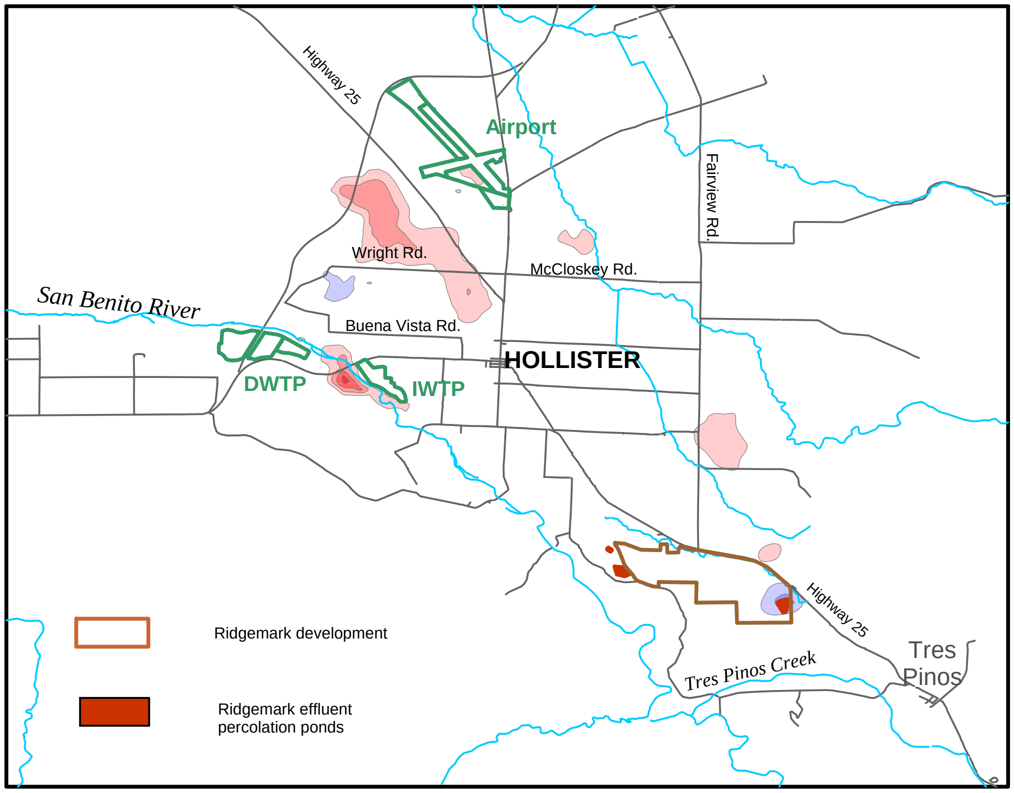
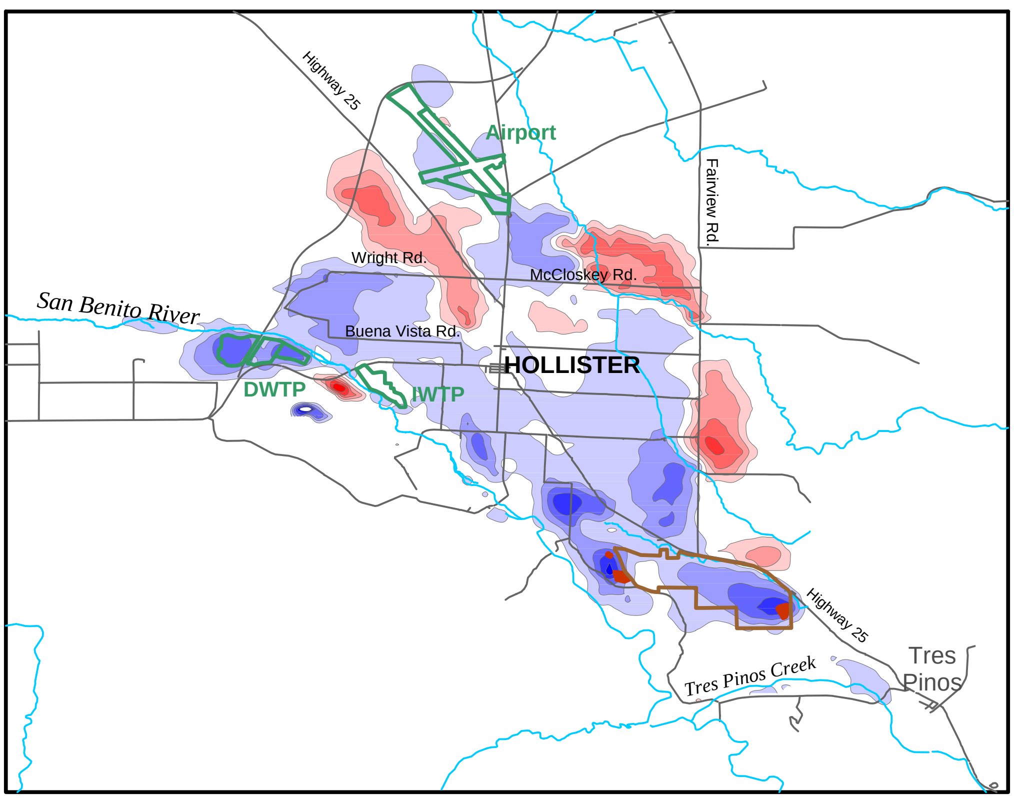


Figure 5. Profiles of Simulated Flow along the San Benito River under Existing Conditions and Revised Alternative 3B, with February and November 1995 Hydrology





Contours of change in simulated Layer 1 salinity from existing conditions to
to future project conditions (revised Alternative 3B) in year 7 of the simulation



Contours of change in simulated Layer 1 salinity from existing conditions to
future project conditions (revised Alternative 3B) in year 30 of the simulation

Figure 6. Effects of HUAWWMP Revised Alternative 3B on Groundwater Salinity in Model Layer 1

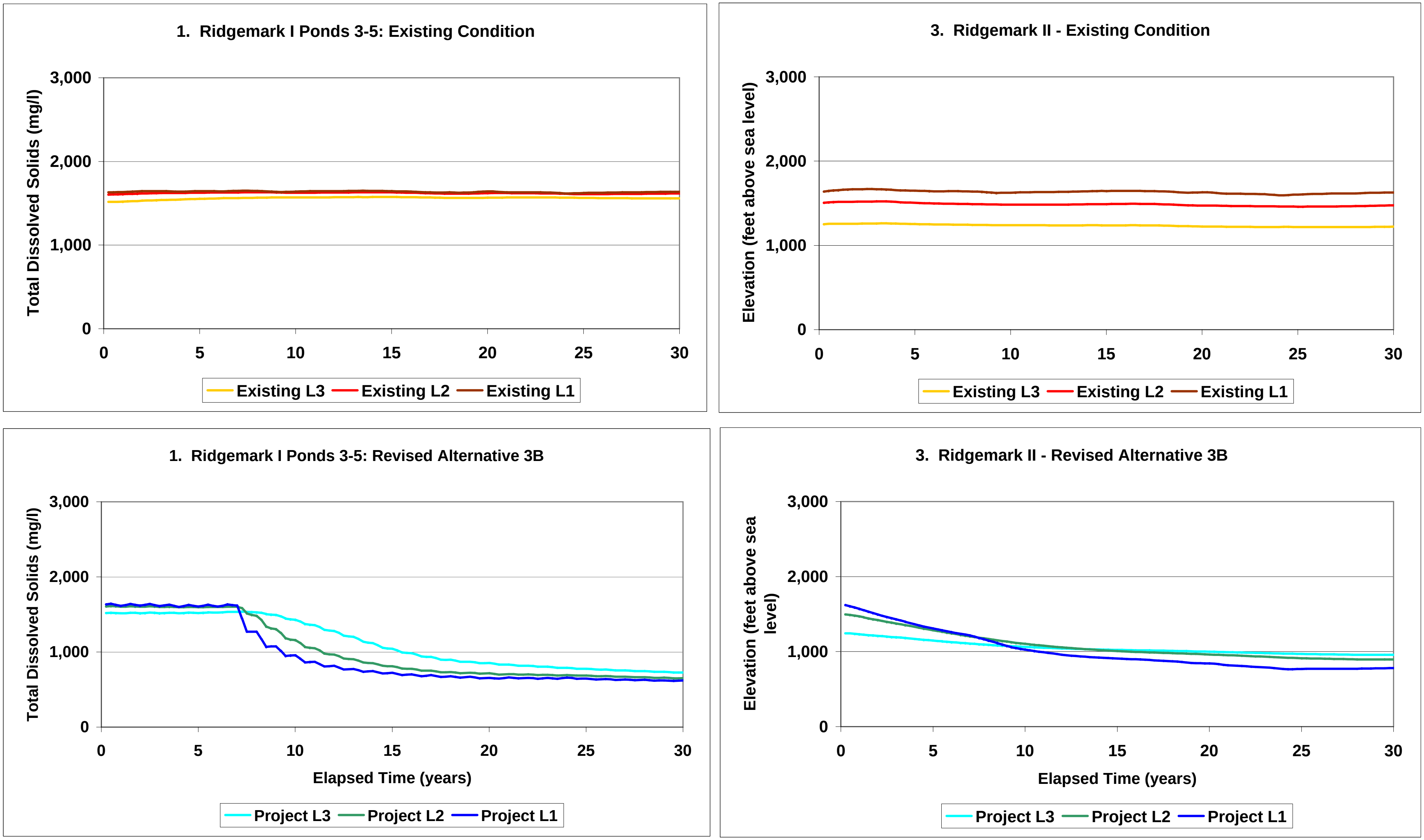
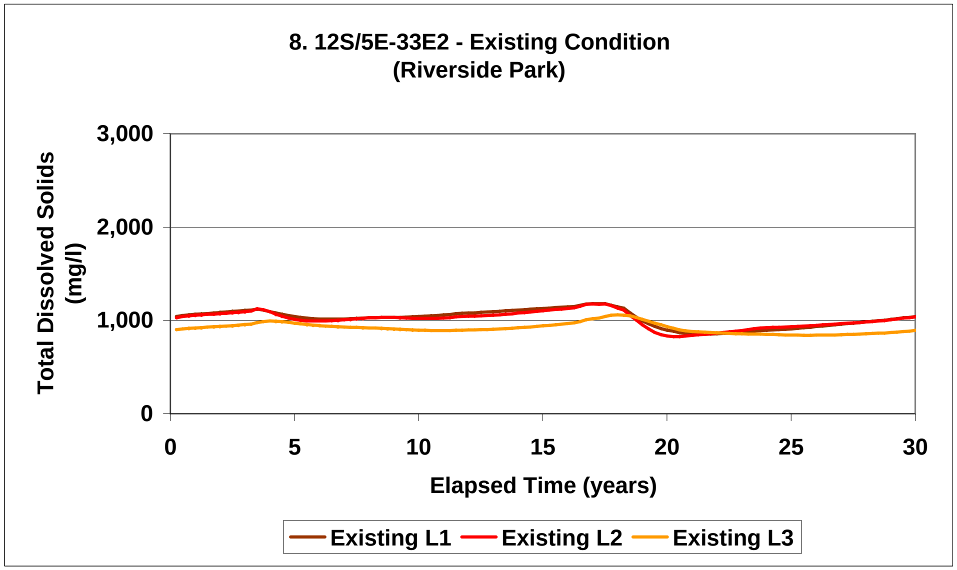
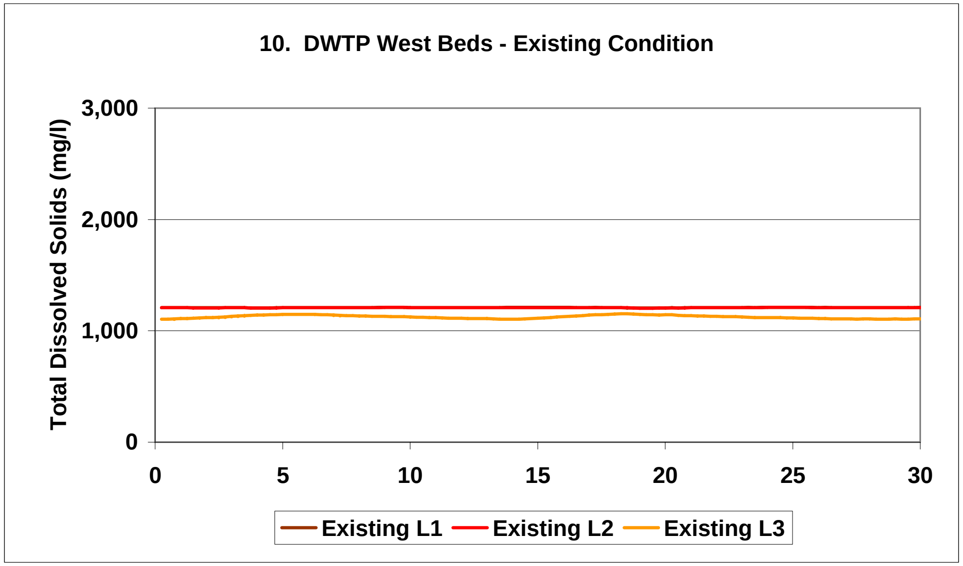
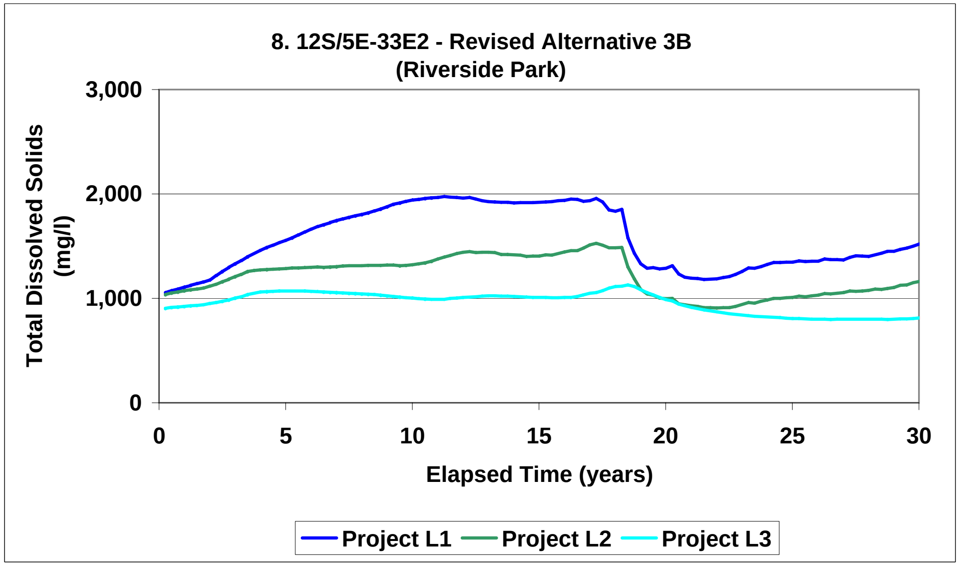
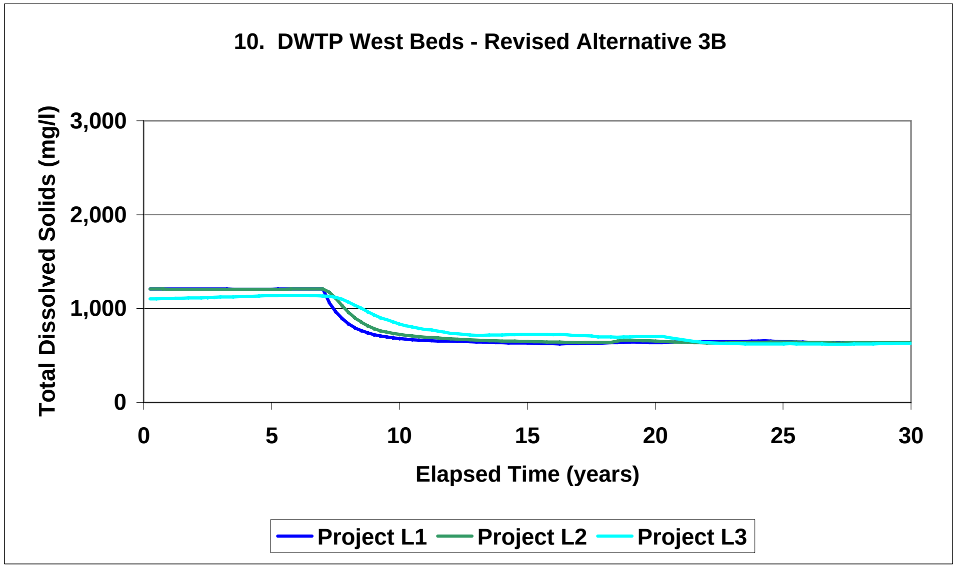


Figure 7. Hydrographs of Groundwater Salinity at Selected Wells under Existing Conditions and Revised Alternative 3B









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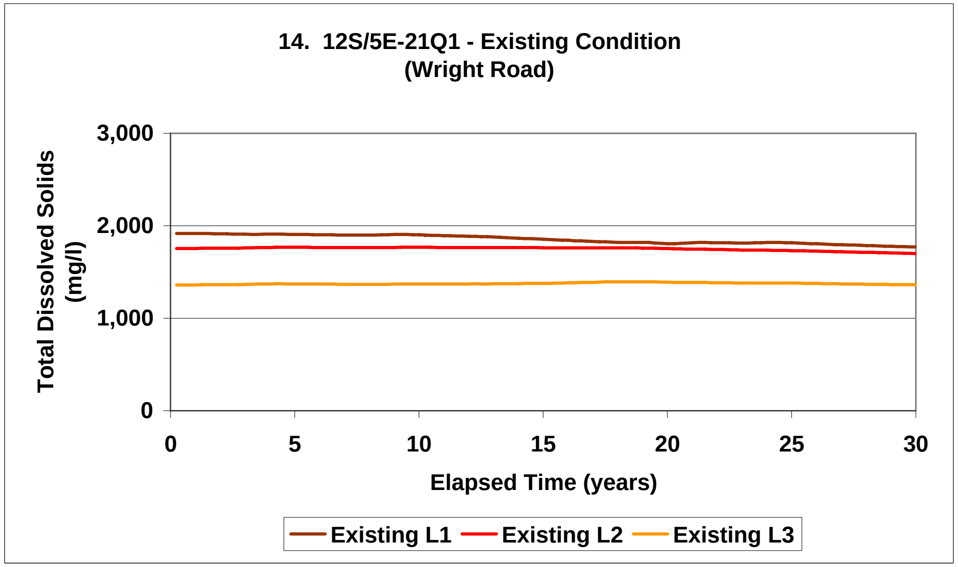
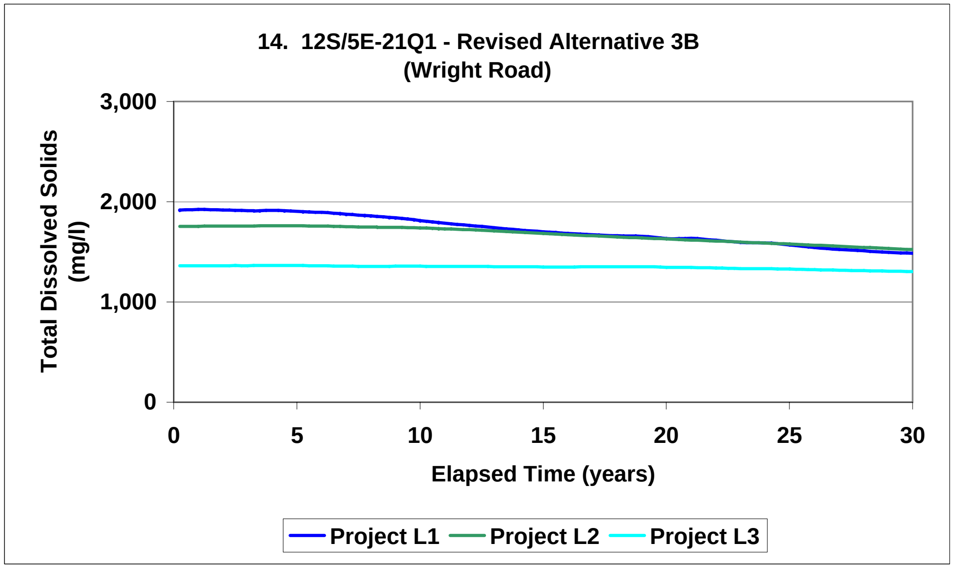




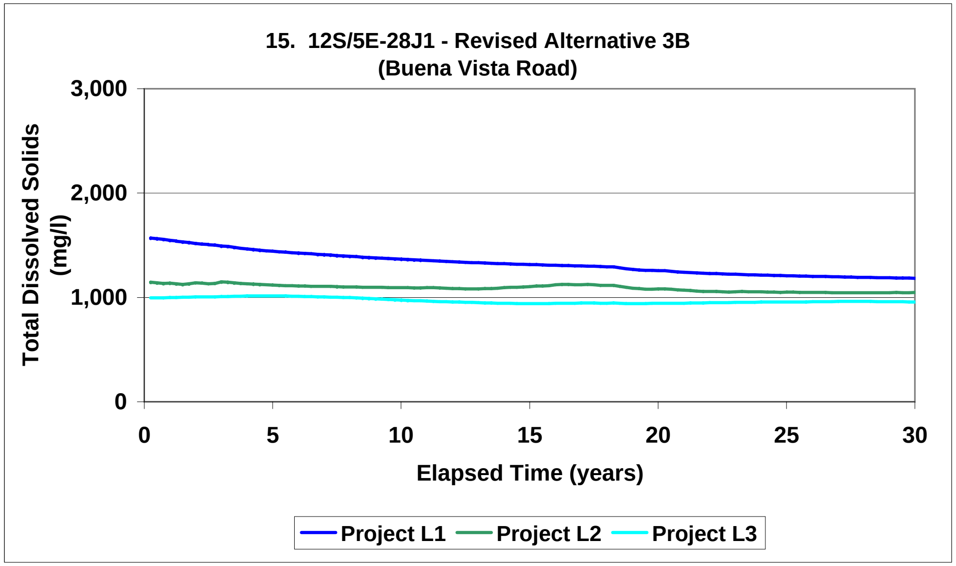
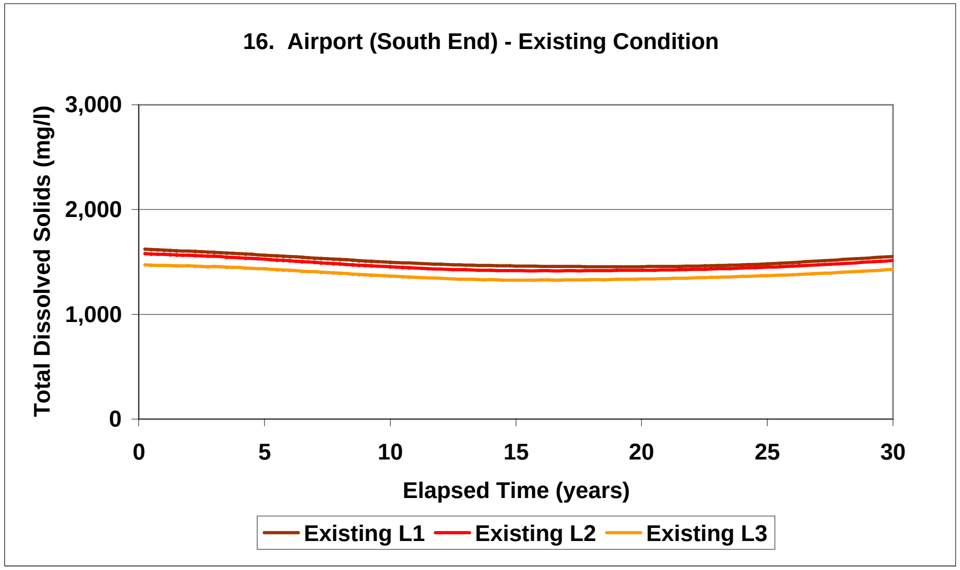
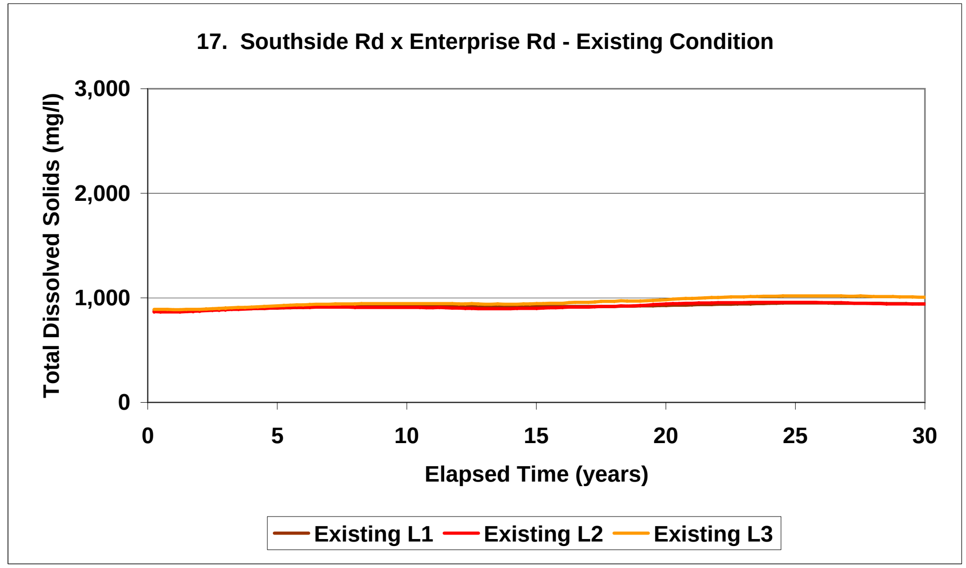
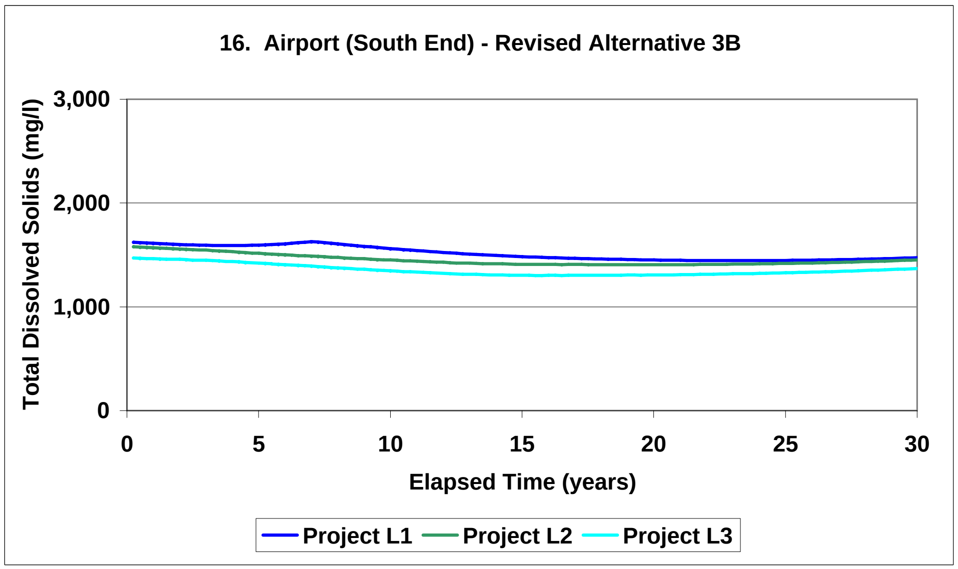


Figure 7—continued







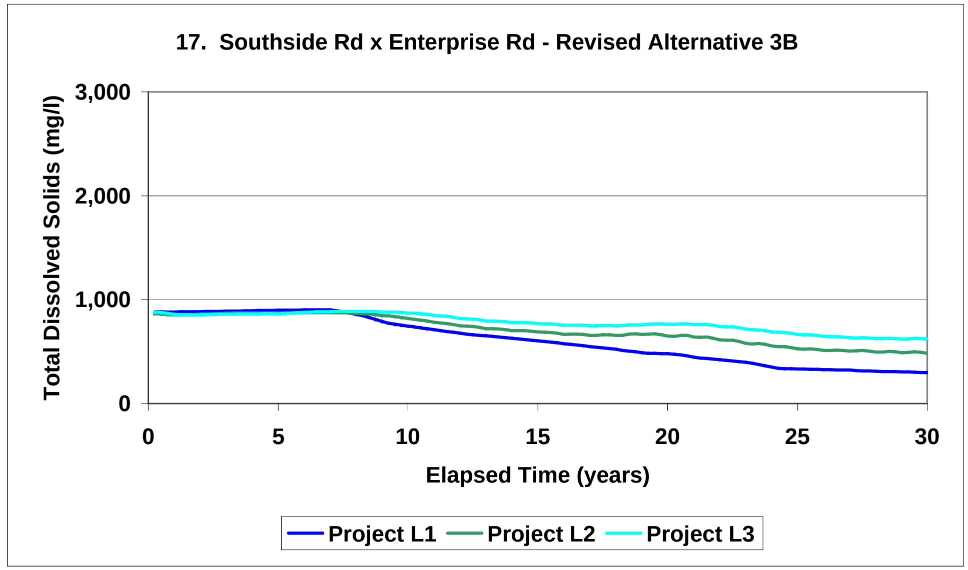


Figure 7—continued

MEMORANDUM

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DATE: 11 December 2006

TO: John Gregg and Jeff Cattaneo, SBCWD
Harry Blohm, HUAWWMP Project Coordinator
Steve Wittry, City of Hollister
Kevin Kennedy and Bob Ellis, HDR Engineering

FROM: Gus Yates, Consulting Hydrologist

SUBJECT: Hollister Urban Area Water and Wastewater Master Plan: Groundwater Model Simulation Results for Alternatives 2A, 3A, 4A and 4B

This memorandum documents the inputs and results for simulations of HUWWWMP Alternatives 2A, 3A, 4A and 4B using the regional groundwater model of northern San Benito County developed by SBCWD in cooperation with other local agencies. The simulated water level and water quality impacts of these alternatives should help the project management team develop a “preferred” alternative that may combine elements from two or more of the alternatives.

The conclusions and recommendations resulting from the modeling analysis are presented first, as they will be of interest to everyone. Those sections are followed by a thorough discussion of assumptions and results for each of the four alternatives. That information should contain the answers to many specific questions you may have.

Conclusions

- In subbasins where there are surface streams with large percolation capacities, increases in pumping are absorbed up to a point by increased percolation from the stream and/or decreased groundwater discharge to the stream. The San Juan, Hollister West, Tres Pinos and Pacheco subbasins are in this category.

- In subbasins not hydraulically connected to large overlying streams (Hollister East and Bolsa Southeast), the opportunity to increase pumping without inducing overdraft is more limited and approximately equals the present rate of long-term storage increase (if any).

- Even in subbasins with creeks or rivers, too much pumping can overwhelm the capacity to induce additional recharge and result in long-term overdraft. This happened in the simulations of Alternatives 4A and 4B.

- Overdraft can be avoided for those alternatives by decreasing the average annual pumping rate of the demineralization or export wellfield. In the case of Alternative 4A (demineralization wellfield in the San Juan Valley), the simulation made the subbasin water budget more negative than the existing budget by 5,785 ac-ft/yr (4,385 ac-ft/yr increase in pumping combined with a 1,400 ac-ft/yr decrease in percolation at the DWTP), and resulted in overdraft. A previous simulation with only a 3,000 ac-ft/yr negative shift in the water budget was sustainable.

- The recharge capacity of surface waterways is most prominent following droughts, when it accelerates the recovery of groundwater levels and restores them to their former high levels.

- Minimum simulated water levels during droughts under all alternatives are substantially higher than minimum historical water levels, except for Alternative 4B which had water levels similar to the historical minimums in the Lovers Lane area. Thus, the lowering of deep groundwater levels is not significantly adverse.

- Changes in groundwater salinity are more strongly influenced by changes in land use and wastewater disposal than by changes in pumping. Because the former changes are the same under all alternatives, changes in simulated shallow groundwater salinity are similar for all of the alternatives.

- Irrigation of formerly nonirrigated land always increases the volume and salinity of recharge, regardless of the irrigation source.

- For an irrigated area, the impact of an alternative on shallow groundwater salinity can be estimated directly from the change in average salinity of the irrigation water.

- Increases in groundwater withdrawals cause compensating changes in head-dependent flows, especially seepage to and from streams. Consequently, impacts on water levels are reversible and tend to wax and wane from dry to wet periods.

- In contrast, impacts on water quality are generally cumulative and increase throughout the simulation. Most would continue to increase if the simulation were extended beyond 30 years.

- A general assessment of water-level impacts of the alternatives is indicated in the table below. It is based on the following logic:

    - Moderate, temporary decreases in deep water levels are not significantly adverse, especially if the minimum levels during droughts are higher than minimum historical water levels.
    - Decreases in shallow water levels are beneficial (and increases are adverse) in areas with shallow groundwater problems.
    - Large decreases in shallow water levels near gaining reaches of creeks and rivers adversely affect aquatic and riparian habitat by decreasing the volume and/or duration of baseflow and potentially dewatering the root zone of phreatophytic vegetation.

Alternative	Deep Water Levels	Shallow Water Levels	Habitat
1B	LTS	LTS (beneficial)	Possible dewatering of wetlands in the San Benito River channel near Hospital Road during droughts
3A	LTS	LTS	Likely dewatering of wetlands in the San Benito River channel near Hospital Road during droughts
4A	Overdraft of San Juan subbasin at the simulated pumping rate	Large beneficial decrease in western San Juan Valley	Possible adverse impacts on riparian and aquatic habitats along the lower reaches of San Juan Creek and the San Benito River during droughts.
4B	Overdraft of Lovers Lane area at the simulated pumping rate	Large beneficial decrease in the Lovers Lane area	Likely adverse impact on riparian and aquatic habitats along the lower reaches of Tequisquita Slough and Pacheco Creek in most years.

- Water quality impacts tend to be more localized than water level impacts because they propogate at the speed of groundwater flow. Water level impacts propogate by pressure effects that spread much farther and more rapidly.

Recommendations

Selecting a preferred alternative requires consideration of cost, permitting and infrastructure issues in addition to the groundwater quantity and quality issues that are the focus of this memorandum. Without getting into cost details, some alternatives lend themselves to partial or incremental implementation more than others simply based on the fixed amount of infrastructure required to implement them. Depending on the magnitude of those fixed costs, there is a minimum degree of implementation that is economically feasible for each alternative. For example, adjusting pumping rates at existing municipal wells can easily be done incrementally, and the cost of adding a new municipal well is relatively small compared to other facilities envisioned by the alternatives. Alternative 4B probably has the largest fixed costs because it requires construction of a wellfield along Lovers Lane, a second treatment plant for municipal use of CVP water, and a diversion facility and desalination plant for use by PVWMA near Watsonville. A relatively large average annual pumping and transfer rate would be needed to justify the capital outlay for those facilities. This coarse level of relative costs was considered in developing recommendations.

If simplicity of implementation and minimization of impacts on water levels and water quality are the top priorities, Alternative 1B is recommended. The primary drawbacks or limitations to this alternative are that it provides no relief of shallow groundwater problems and it does not create an opportunity to obtain funding by selling CVP water to an out-of-county contractor. Note that a key element of Alternative 1B—delivering recycled water to CVP users in the San Juan Valley—is actually included in all of the alternatives because it is the preferred wastewater management option for 2023.

If addressing shallow groundwater problems in the western San Juan Valley and/or the Lovers Lane area is included as an objective, Alternatives 4A and 4B offer the greatest benefits. However, the pumping rates simulated for these alternatives exceeded the local sustainable yield of the groundwater system. In the case of the San Juan Valley wellfield (Alternative 4A), at least four options could easily be implemented to eliminate the overdraft problem while still achieving a beneficial decrease in shallow groundwater elevation:

1. scale back the size of the alternative by combining it with another alternative,
2. delivering some recycled water to groundwater users in the Freitas Road area, which helps rebalance the water budget by decreasing groundwater withdrawals,
3. shift some of the demineralization pumping to new or existing wells in other subbasins, or
4. resume the historical practice of managing Hernandez Reservoir percolation releases to augment recharge in the San Juan subbasin.

Fewer options are available for minimizing the overdraft impact of Alternative 4B. As simulated, the Lovers Lane wellfield appeared to engage all of the head-dependent sources of additional recharge in that region. It is unclear whether spreading the wellfield out over a larger area—such as farther south and east along Tequisquita Slough—would be capable of intercepting enough additional streamflow to balance the groundwater budget. A more dispersed wellfield would also be more expensive to construct. The amount of pumping for this alternative could simply be reduced if the alternative were combined with another alternative, but below some threshold, it would no longer be cost-effective to implement a scaled-down project.

Alternative 3A has the advantage of bringing the water budget for the Hollister East subbasin closer into balance. The budget under existing conditions is slightly positive, which means that shallow groundwater conditions could continue creeping southward into areas near the airport slated for future development.

If generating additional funding opportunities is a top priority, Alternatives 3A and 4A have the advantage of freeing up CVP supply that could be sold to another (out-of-county) CVP contractor.

A project configuration that appears favorable with respect to water levels, cost, funding opportunities, and riparian/aquatic impacts is to combine Alternatives 3A and 4A. This would divide the desalination supply between a new wellfield in the San Juan Valley and exsiting and new municipal wells in the Hollister urban area. The water budget of the San Juan subbasin would be maintained in dynamic balance by adjusting the percentage of municipal supply obtained from the San Juan Valley wellfield and by reoperating Hernandez Reservoir to increase percolation in the San Juan subbasin. The advantages of this alternative include:

- Lowering of shallow groundwater levels in the western part of the San Juan Valley,
- Preventing the encroachment of shallow groundwater conditions into the area near the airport if pumping is increased at existing Hollister Well #3 or a new municipal well south of the airport,
- Flexibility to maintain balanced water budgets in the San Juan and Hollister East subbasins,
- The opportunity to obtain funding for project implementation by marketing the CVP water presently used by San Juan Valley farmers who would switch to recycled water,
- Low-cost use of local water resources through reoperation of Hernandez Reservoir,
- Moderate new infrastructure costs (probably more expensive than 1B or 3A but less expensive than 4B).

Additional application of the groundwater model is recommended for one or more of the following purposes:

1. Throuugh trial and error, identify the maximum increase in groundwater pumping that can be sustained in the San Juan and Hollister East subbasins,
2. Simulate reoperation of Hernandez Reservoir and its effectiveness in rebalancing the water budget in the San Juan subbasin,
3. After a preferred alternative has beed defined, simulate the gradual implementataion of that alternative between 2008 and 2023, along with concurrent gradual transitions in land use and wastewater disposal/recycling.

Global Assumptions for All Simulations

Two minor improvements were made to the model for this round of simulations to enhance the detail and accuracy of results. The golf course in the Ridgemark development was delineated as a recharge zone separate from the surrounding residential area. Also, leaks from the municipal water distribution system were included as a source of recharge. Appendix C of the September 2006 draft of the HUAWWMP reported that unaccounted for water in the City of Hollister and Sunnyslope CWD systems averages 11% of total annual production. It was assumed for these simulations that the pipe leak component of unaccounted for water amounts to 8% of annual production.

Existing conditions (the no-project alternative) and each of the four project alternatives were simulated for a 30-year hydrologic period under urban land use conditions expected to be present in 2023. Details regarding these future conditions that apply to all of the simulations include the following:

1. Land use, water use and wastewater disposal/recycling patterns were constant throughout the 30-year simulation period. This is standard practice for alternatives analysis because it indicates how each alternative would perform in the long run,

independent of gradual changes in other variables that affect the groundwater system.
2. The simulated hydrologic period was water years 1975-2004, which is the same period recently used to simulate wastewater management alternatives.
3. Initial water levels and groundwater TDS concentrations were the same for all simulations and represent conditions in 2005.

Reference Simulation: Existing Conditions

Each of the alternatives was compared with a reference simulation that represented a continuation of existing conditions. Assumptions incorporated in the reference simulation included the following:

1. Recharge is based on land use patterns in 2005 as depicted in the December 2005 update of the City of Hollister general plan. Urban areas are the developed areas not covered by colored polygons in the map shown in **Figure 1**. The polygons are agricultural and uncultivated lands that are expected to be developed at various times in the future as indicated in the legend.
2. Effluent percolation at the DWTP remains at its current level of 1.9 mgd, or 2,128 ac-ft/yr after adjusting for evaporation losses. Percolation at the IWTP also continues at the current rate of 0.77 mgd (443 ac-ft/yr) after evaporation losses plus 800 ac-ft/yr of cannery wastewater and stormwater.
3. Wastewater disposal sprayfields are not included because their operation will have been discontinued by 2023.
4. The Lessalt water treatment plant produces 2,375 ac-ft/yr of water, which was the actual amount of water treated in 2005.
5. Total municipal water use equals measured use in 2005, which was 7,965 ac-ft/yr.
6. Municipal groundwater production equals total use minus Lessalt production: 7,965 – 2,375 = 5,590 ac-ft/yr.
7. Municipal groundwater production iis allocated among wells in proportion to their actual use in 2005.
8. The total dissolved solids (TDS) concentration in the municipal water supply equals the flow-weighted average of CVP TDS (300 mg/l) and local groundwater TDS (varies by well). The municipal supply TDS affects the calculated salinity of groundwater recharge beneath irrigated landscaping in the urban area.
9. The TDS concentration of municipal wastewater equals its current average of 1,250 mg/l of TDS

Results of the simulation of existing conditions reveal basic characteristics of the groundwater flow system that help guide the interpretation of alternative simulations. **Figure 2** shows the locations of wells, wellfields, wastewater disposal areas and other features used to represent the alternatives or mentioned in the discussion of simulation results. The two magenta circles indicate the locations of hypothetical wellfields assumed in the simulations of Alternatives 4A and 4B.

The general pattern of groundwater flow under existing conditions is indicated by the two contour maps shown in **Figure 3**. The upper graph shows groundwater elevation in model layer 5 (the lowermost layer) and is representative of water levels in aquifers tapped by water supply wells. Starting in the Tres Pinos subbasin at the southeast corner of the map, groundwater flow bifurcates into northward flow east of the Calaveras Fault and flow parallel to the San Benito River west of the fault. This latter flow generally follows the gradient of the river through the Hollister West subbasin and then westward through the San Juan Valley, although there is an additional northward component of flow in that subbasin from recharge south of the river. The northward flow from the Tres Pinos subbasin passes between the Calaveras Fault and a zone of low hydraulic conductivity roughly located between San Felipe, Fairview, Fallon and Santa Ana Roads. There is a large east-to-west water-level drop across the Calaveras Fault to pumping depressions in the Bolsa Southeast and Bolsa subbasins. There is a similar steep drop from the Hollister West subbasin northward into the Bolsa Southeast subbasin across a fault or anticline extending east from the Flint Hills to the Calaveras Fault. In the northeast part of the basin, groundwater flows west from the foothills and tributary creek valleys of Pacheco Creek, Arroyo de las Viboras, Arroyo Dos Picachos and Santa Ana Creek. Groundwater that is not captured by wells seeps into the lower reaches of those creeks, collecting in San Felipe Lake and crossing the Calaveras Fault as flow in Miller Canal. In addition to this surface pathway, some groundwater presumably leaks through the fault plane in the subsurface.

In terms of impacts, decreases in deep aquifer water levels are generally undesirable because they increase pumping costs and potentially cause well pumps to break suction, corrosion of the well screen, or cavitation damage to pump bowls.

For water levels in shallow aquifers, a rise in water levels is of greater concern than a decline because shallow groundwater already creates soil drainage problems in parts of the basin. The lower map in **Figure 3** shows the simulated depth to groundwater in model layer 1 in a wet year (1998 hydrology) under existing conditions. The red shading hues indicate areas where the simulated water table is less than 10 feet below the ground surface. This includes two areas where field data confirm that drainage problems and flowing wells already occur: the western part of the San Juan Valley and the Lovers Lane area. Simulation results near the other areas on the map with red shading are less certain because they have not been confirmed with field data under conditions as wet as 1998. Many of them also occur in areas where data were unavailable for model calibration. In particular, the shallow groundwater areas along the southern edge of the San Juan Valley and the toe of the foothills east of Fairview Road between Comstock and Santa Ana Roads could result from hydraulic conductivity values that are too low in those parts of the model. Hydraulic conductivity is the variable used to represent the permeability of basin deposits. Similarly, the patch of shallow groundwater between Fallon and Santa Ana Roads results from a zone of very low hydraulic conductivity selected for calibration to deep water levels. During wet periods, however, this zone causes excessively high simulated water levels in shallow aquifers. It should be reevaulated during future calibration improvements.

Simulated changes in groundwater levels over time under existing conditions are illustrated in **Figure 4**. These selected hydrographs demonstrate how certain model parameters influence water levels in different parts of the basin. The upper-left hydrograph of water levels in the Freitas Road area in the San Juan Valley represents a typical pattern. Water levels decline during droughts and then recover to their former level, with no net long-term increase or decrease. Hydrologic conditions corresponding to the 1976-1977 drought occur in years 2-3 of the simulation, and conditions corresponding to the 1987-1992 drought occur in years 13-18. The minimum water levels during these simulated droughts are not nearly as low as minimum historical water levels because CVP imports now keep the basin in a relatively full condition and diminish the amount of groundwater pumping during droughts. Typical of most parts of the basin, vertical water-level gradients are small; that is, water levels in all model layers are essentially the same. A different water-level signature is evident in the Lovers Lane area, where the stabilizing effects of Pacheco Creek and San Felipe Lake minimize the seasonal and year-to-year variations in layer 1 water levels. Seasonal fluctuations are relatively large in model layer 5 because of the high degree of aquifer confinement in that part of the basin and because all of the irrigation supply in that area comes from groundwater, which causes large seasonal pulses of pumping.

High rates of recharge at the ground surface tend to elevate layer 1 water levels relative to layer 5, such as occurs near the DWTP percolation ponds (lower left hydrograph). In the Hollister East subbasin, which includes the area east of the Calaveras Fault between the Airline Highway and approximately Fallon Road, hydrographs have a long-term upward trend. This is the one subbasin where recovery from historical overdraft is still in progress, and continuation of existing conditions will eventually lead to water levels that are slightly higher than they were in 2005.

Groundwater movement can also be depicted as velocity vectors or particle traces. Vectors indicate the direction and rate of groundwater flow at a particular point in time and space. Examples are the vectors shown in **Figure 5**, which are for model layer 1 under existing conditions and hydrology corresponding to September 2004. A blue arrow is shown for each cell in the model, and the size of the arrow is proportional to flow rate. The percolation ponds at the DWTP and IWTP are ringed by arrows radiating outward. There are also high rates of flow along the sand and gravels deposits in the river channel. Particle traces show the cumulative movement of a sample water particle from the beginning to the end of the 30-year simulation. Examples are indicated by the red lines, which originate from a series of points along the hillside below the Whittaker contamination plume. The traces show that groundwater percolating down the hillslope becomes entrained in the regional flow direction as soon as it enters the alluvial valley floor area.

On a regional scale, groundwater quality tends to change very slowly because the mass of solutes in the basin is large relative to the inputs and outputs. **Figure 6** shows contours of simulated TDS concentration in model layers 1 and 5 at the end of the 30-year simulation of existing conditions. The most obvious pattern is that layer 1 salinity is considerably higher than layer 5 salinity, consistent with field data and with the assumed initial conditions for the simulation. Elevated salinity in layer 1 results primarily from historical evaporative concentration of applied irrigation water, but also from wastewater percolation and the direct application of soluble materials such as gypsum and fertilizers to the ground surface. Recharge from creeks and the San Benito River is relatively dilute and creates bands of low-TDS groundwater along the losing reaches of those waterways. Groundwater salinity in layer 5 resembles the initial condition, which was obtained by gridding and smoothing measured TDS concentrations at the points indicated on the lower map. A pattern that particularly influences the interpretation of simulated alternatives is the southeast-to-northwest salinity gradient in the San Juan Valley.

Changes in simulated groundwater salinity over time under existing conditions are shown in **Figure 7** for several locations. The large changes that occur in layer 2 are partly the result of the assumed concentrations at the start of the simulation. The initial salinity in layer 1 was assumed to equal average measured TDS concentration in agricultural drains and shallow monitoring wells. The initial salinity in layers 2-5 was assumed to equal the contoured salinity in water supply wells, which is consistently much lower than in drains and shallow wells. This created a large difference in salinity between layers 1 and 2 at the start of the simulation. As recharge percolates downward from layer 1 to layer 2, the simulated concentration in layer 2 climbs fairly rapidly. Data are not available to confirm the accuracy of the simulated rate of increase in layer 2. The layers in the model are also fairly thick for precise simulation of solute transport. These issues limit the ability of the model to simulate salinity accurately, and results should be interpreted accordingly. Because these underlying issues affect all of the simulations more or less equally, simulated differences in concentration are more accurate than the absolute concentrations for any individual simulation. A reasonable assessment of model accuracy is that it can differentiate between large increases, small increases, small decreases and large decreases in salinity that would result from implementation of the alternatives.

Trends in simulated layer 1 salinity—such as in the timeseries plot for the north end of the airport—indicate locations where the assumed initial concentration was slightly inconsistent with simulated recharge salinity.

Global Assumptions for All Alternatives

1. Urban lands in the Hollister area include agricultural areas expected to become urbanized by 2020. These are the polygons in categories 1 through 3 in **Figure 1**.
2. Half of the nonirrigated grassland in Zone 6 east of Fairview Road between Lone Tree Lane and Highway 25 becomes irrigated. The assumed irrigation supply is CVP water in normal and wet years, supplemented with groundwater in dry years.
3. Municipal water use equals the projected use for 2023: 11,840 ac-ft/yr for COH plus Sunnyslope CWD
4. The Lessalt water treatment plant operates at its full capacity of 3.0 mgd year-round, for an annual total of 3,361 ac-ft/yr. This exceeds recent historical operation, which ranged from 1,777 to 2,375 ac-ft/yr during 2004-2006.
5. Shortages in CVP supply in dry years are made up by increased groundwater use.
6. Agricultural and urban water use for irrigation vary from year to year based on rainfall and ET conditions. The foregoing numbers are average annual values.
7. Average municipal water supply TDS = 265 mg/l.
8. All municipal groundwater is demineralized in order to meet the municipal hardness objective of 120 mg/l as $CaCO_3$ and the wastewater salinity target of 600 mg/l. This means that all alternatives include demineralization, not just Alternatives 3A and 4A.
9. Demineralization efficiency is 85%. Gross groundwater pumping therefore equals the target supply divided by 0.85 (or multiplied by 1.18).
10. Wastewater generation is Steve Wittry's estimate for 2023: 4.5 mgd = 5,041 ac-ft/yr.

11. Wastewater disposal is per Phase II of the proposed wastewater project:
    a. IWTP percolation = 800 ac-ft/yr of stormwater runoff and cannery wastewater only; no domestic effluent
    b. DWTP percolation = 840 ac-ft/yr (0.75 mgd)
    c. Recycling = 4,200 ac-ft/yr (3.75 mgd)
    d. No sprayfields
    e. Watsewater average TDS = 600 mg/l
12. The flow-weighted average TDS concentration of irrigation water for CVP users in the San Juan Valley changes as follows:
    a. Existing: (38% GW)(900 mg/l)+(62% CVP)(300 mg/l) = 528 mg/l
    b. Alt. 1B: (38% GW)(900 mg/l)+(24% CVP)(300 mg/l)+(38% RW)(600 mg/l) = 642 mg/l.

Alternative 1B: Exchange Recycled Water for Agricultural CVP Water within Zone 6

Assumptions

- Recycled water is delivered to agricultural users in the San Juan Valley (Subsystem 10) in exchange for an equal amount of their present CVP use.
- The amount exchanged is the projected supply of recycled water in 2023, or 4,200 ac-ft/yr.
- The agricultural CVP water is exchanged for M&I CVP water on a one-to-one basis.
- A new water treatment plant is operated in parallel to the Lessalt plant to process the additional CVP water for municipal use.
- The existing and new CVP municipal supplies are used as a relatively constant, year-round base supply. Municipal groundwater pumping is therefore concentrated in the dry season relative to the existing seasonal pumping distribution.
- Municipal groundwater pumping increases in dry years to compensate for shortfalls in CVP M&I deliveries.
- Net municipal groundwater production equals total demand minus municipal CVP use, and gross groundwater production equals net production divided by the demineralization process efficiency:
    - Total demand = 11,840 ac-ft/yr
    - Lessalt production = 3 mgd year-round = 3,361 ac-ft/yr
    - New treatment plant production = 4,200 ac-ft/yr (=3.75 mgd)
    - Net groundwater production = 11,840-3,361-4,200 = 4,279 ac-ft/yr
    - Gross groundwater production = 4,279/0.85 = 5,033 ac-ft/yr
- Groundwater pumping is allocated among municipal wells in the same proportions as occurred in 2005.

Results

<u>Hydrographs</u>

With respect to groundwater quantity, Alternative 1B results in a net decrease in groundwater pumping. The exchange of 4,200 ac-ft/yr of recycled water for CVP M&I plus increased direct purchase of CVP M&I water for the Lessalt plant more than meet the approximately 4,000 ac-ft/yr of increased water demand. Even after increasing groundwater pumping to allow for demineralization process losses, gross municipal pumping decreases from 5,590 to 5,033 ac-ft/yr. However, pumping is greater than under existing conditions during droughts, because groundwater compensates for shortages in the CVP supply, which increases under this alternative.

Figure 8 shows the effects of Alternative 1B on groundwater levels over time. The red and orange lines in each plot are the simulated water levels in model layers 1 and 5 under existing conditions. These are displayed to facilitate comparison with the results for layers 1 and 5 under alternative conditions (the dark and light blue lines, respectively). The decrease in percolation at the DWTP has a negligible effect on water levels in normal-wet years because there is a compensating increase in river recharge. During droughts, river flow is insufficient to compensate. This causes Alternative 1B water levels to temporarily fall as much as 10 feet below existing levels. Water levels are still far higher than minimum levels experienced during the past 20 years, however.

The cessation of percolation at the DWTP west beds causes layer 1 water levels to collapse down to the layer 5 water levels, which are up to 10 feet lower than under existing conditions during drought periods. In the Hollister West subbasin, increased pumping during droughts causes water levels to temporarily decline during droughts, but increased river recharge quickly refills the deficit. Near Sunnyslope Well #8, the increased seasonality of municipal pumping increases the amplitude of seasonal water-level fluctuations. Water levels are generally lower by 5-20 feet because of the absence of Ridgemark WWTP percolation and (during droughts) increased nearby agricultural and municipal pumping.

Minor changes in water levels resulting from urbanization can be seen in the hydrographs near the airport and northern Hollister. These are caused by changes in recharge and discontinued use of irrigation wells. Alternative 1B has essentially no effect on water levels near Lovers Lane and Pacheco Creek.

<u>Water-Level Contours</u>

Figure 9 provides a more complete view of the magnitude and extent of water-level changes when they are greatest. In the case of layer 5, the maximum decrease relative to existing conditions is during droughts (upper plot). The decrease is largest in the Hollister West subbasin, where municipal pumping is concentrated. The maximum decrease is approximately 23 feet, but water levels are still much higher than their historical minimums.

In the case of layer 1, the maximum increase in water levels is during a wet year such as 1998 (lower plot). Alternative 1B has a negligible effect on the extent of areas with shallow groundwater problems, as can be seen by comparing **Figure 9** with **Figure 3**.

<u>Groundwater Budgets</u>

Groundwater budgets for the Hollister East subbasin under existing conditions and the four simulated alternatives are shown in **Figure 10**. Each group of bars represents an inflow or outflow item in the water budget, and the bar colors correspond to the alternatives.

Alternative 1B has little effect on the water budget for this subbasin because changes in municipal pumping and wastewater percolation are mostly in other subbasins and because the net effect of urbanization on recharge and pumping is small.

Groundwater Salinity Contours

Changes in groundwater salinity for all alternatives are complex because they reflect changes in water supply sources, water supply TDS, wastewater percolation rates and TDS, and land use. Model layer 1 is the first layer to be affected by these changes, and the cumulative impact of Alternative 1B on layer 1 salinity is shown in **Figure 11**. The upper plot shows the difference in simulated salinity between Alternative 1B and existing conditions after 30 years. The broad area of increased salinity in the central and western part of the San Juan Valley is the area where approximately half of existing CVP use for irrigation would be replaced with recycled water, increasing the flow-weighted average irrigation water salinity by 114 mg/l. This increase is amplified by the process of evaporative concentration, resulting in a net increase in layer 1 salinity of 100-300 mg/l. The increase in salinity east of Fairview Road results from converting nonirrigated land to irrigated land, which increases recharge salinity even if CVP water is the primary source of irrigation supply. A small spot of increased salinity next to Santa Ana Creek south of Fallon Road similarly results from an assumption that the park planned for that area will be groundwater-irrigated turf, replacing cropland irrigated with a combination of CVP water and groundwater.

Most of the urban area experiences a decrease in shallow groundwater salinity because the TDS concentration of municipal supply water would decrease by 400-500 mg/l. This reduces the salinity of recharge from irrigated landscaping and from leaks in the water distribution system. Layer 1 salinity decreases at the DWTP because the TDS concentration of the remaining wastewater percolation is smaller than under existing conditions. The concentration of water percolated at the IWTP would remain approximately the same as under existing conditions, so there is little change in shallow groundwater salinity.

Groundwater Salinity Timeseries

The rate of change in groundwater salinity under Alternative 1B can be seen for selected locations in the TDS timeseries plots in **Figure 12**. The upper plot in each pair shows the TDS concentrations in model layers 1 through 3 as they evolve during the simulation of existing conditions. The lower plot shows the corresponding trends under Alternative 1B. The slight increase in irrigation salinity where recycled water is used in the western San Juan Valley appears as a very gradual rise in layer 1 salinity. Groundwater salinity in all three layers beneath the DWTP equilibrates within a few years to the decrease in percolation and in wastewater TDS.

Sunnyslope Well #7 is in an area where shallow groundwater salinity improves as a result of the decrease in municipal supply TDS (and possibly also the elimination of percolation at the Ridgemark WWTP). Because this well is a production well, vertical mixing of groundwater is relatively fast, and all three layers respond within a few years to the change in salinity conditions. By the end of the simulation, TDS in layers 1 and 5 are lower by about 400 and 200 mg/l, respectively. A similar but slightly smaller effect can be seen in the timeseries plot for a location in northern Hollister.

Alternative 3A: Demineralize Wells in Urban Area

Assumptions

- Net groundwater use equals total 2023 water demand minus Lessalt production, and gross groundwater production equals net production divided by 85% efficiency:
  - Total demand = 11,840 ac-ft/yr
  - Lessalt production = 3 mgd year-round = 3,361 ac-ft/yr
  - Net groundwater production = 11,840-3,361 = 8,479 ac-ft/yr
  - Gross groundwater production = 8,479/0.85 = 9,975 ac-ft/yr
- To meet increased municipal pumping demand, the City of Hollister has a new 900 gpm well south of the airport and Sunnyslope CWD has a new 700 gpm well along the southern edge of the Ridgemark development. This allows the pumping demand to be met without operating any well more than 50% of the time on an annual basis.
- Annual production is allocated among existing and new municipal wells in proportion to their pumping rates in gallons per minute (Note: this is the only alternative with this pumping distribution; all others follow the 2005 distribution)

Results

<u>Hydrographs</u>

The pattern of water-level impacts of Alternative 3A is similar to the pattern for Alternative 1B, but the impacts are larger. Future increases in municipal water demand under Alternative 3A are supplied by groundwater, which—combined with the additional increment needed for demineralization—increases municipal groundwater pumping by 4,385 ac-ft/yr. Most of this increase occurs in the Hollister West subbasin. The hydrographs in **Figure 13** show the effects of Alternative 3A during the course of the 30-year simulation period at selected locations.

Hydrographs in the San Juan Valley (Lucy Brown Lane and DWTP west bed hydrographs) are essentially the same as under Alternative 1B. The small decrease in water levels during droughts stems primarily from decreased DWTP percolation. Near municipal wells in the Hollister West and Tres Pinos subbasins (Sunnyslope #8 and Hollister #5 hydrographs) the larger amount of municipal pumping results in lower water levels. Water levels are 12-20 feet lower at Sunnyslope #8 and 5-22 feet lower at Hollister #5, with the larger changes occurring during droughts. Increased percolation from the San Benito River keeps the declines near this well relatively small during normal-wet years and causes a speedy water-level recovery following a drought. Even during droughts, however, the simulated water levels under Alternative 3A are much higher than minimum historical water levels that occurred during 1975-1995.

Increased municipal pumping from wells in the Hollister East subbasin lowers water levels by up to 12 feet as far north as McCloskey Road (hydrograph 12-5-22J2), but the impact diminishes to less than 5 feet at the north end of the airport. This subbasin is not strongly coupled to a surface stream, so the difference persists through wet and dry periods. Farther north, water levels near Lovers Lane and Pacheco Creek are unaffected.

Water-Level Contours

Contour maps provide a clearer picture of the distribution of simulated water-level impacts. The upper map in **Figure 14** shows the maximum effect of Alternative 3A on deep groundwater levels, which occurs after several years of drought (1990 conditions). Water levels are lower by 12-24 feet throughout most of the Hollister West subbasin, where much of the municipal groundwater pumping is concentrated. Decreases of more than 3 feet are present throughout the Hollister urban area and most of the San Juan Valley, with larger drawdowns present near individual municipal wells with substantial increases in pumping. The particularly large drawdown cone near Hollister Well #3 on Fallon Road near San Felipe Road results from the low permeability of basin deposits imposed in that area during model calibration .

The lower map in **Figure 14** shows the simulated depth to water in model layer 1 in March 1998, which was when most simulated hydrographs reached their highest point. The extent of shallow groundwater (red shading) is essentially identical to the pattern under existing conditions at the west end of the San Juan Valley (Figure 3). The shallow groundwater area north of Hollister (near Highway 156 and Santa Ana Creek) is pushed back perhaps 2,000 feet. The shallow groundwater area along the south edge of the San Juan Valley is smaller, but its presence in the simulation of existing conditions may be an artifact of calibration uncertainty and needs to be confirmed with field data.

Water Budgets

Simulated average annual groundwater budgets are shown in **Figure 15** for the Hollister West subbasin, which is the subbasin most heavily impacted by this alternative. The budget changes imposed under Alternative 3A are the decrease in percolation at the IWTP and the increase in pumping at municipal wells. The system responded to this change in stress in several ways, the largest of which was an increase in percolation from the San Benito River. There were also smaller changes in groundwater inflow and outflow. Flows to and from groundwater storage both increased by similar amounts, essentially canceling each other out.

Groundwater Salinity Contours

The effects of Alternative 3A on the distribution of groundwater salinity in layer 1 are shown in **Figure 16**. The contours in the upper graph show the cumulative difference in TDS concentration between existing conditions and Alternative 3A after 30 years of operation. The numerous changes in the urban area are very similar to the simulated changes for Alternative 1B (**Figure 11**) and can be traced to land use changes and the decrease in TDS concentration of municipal supply water and wastewater. Similarly, the slight increase in layer 1 salinity in the central and western part of the San Juan Valley results from the increase in average irrigation water salinity when recycled water is substituted for CVP water.

The lower map in Figure 16 shows contours of TDS concentration in model layer 1 at the end of the 30-year simulation. It demonstrates that the changes in concentration displayed in the upper plot are fairly small relative to ambient concentrations, but that they could become significant over long periods of time.

<u>Groundwater Salinity Timeseries</u>
Groundwater salinity timeseries plots for Alternative 3A are shown in **Figure 17**. Salinity trends are are almost identical to those for Alternative 1B throughout the basin (see **Figure 12**). Changes in groundwater salinity are driven more by recharge than pumping, and recharge was the same for both alternatives.

Alternative 4A: Demineralize Wells in the San Juan Valley

Assumptions

- Net groundwater use equals total 2023 water demand minus Lessalt production:
  - Total demand = 11,840 ac-ft/yr
  - Lessalt production = 3 mgd year-round = 3,361 ac-ft/yr
  - Net groundwater production = 11,840-3,361 = 8,479 ac-ft/yr
- Existing municipal wells pump at their 2005 rates, but because the water is demineralized, the net production is only 85% as large as under existing conditions:
  - Existing municipal well production = 5,590 ac-ft/yr
  - Net production after demineralization = (5,590)(0.85) = 4,752 ac-ft/yr
- The net groundwater production from new demineralization wells in the San Juan Valley equals total net groundwater demand minus net groundwater produced from existing wells. This is adjusted to gross pumping assuming 85% recovery efficiency of the demineralization process:
  - Net production from San Juan wellfield = 8,479 – 4,752 = 3,727 ac-ft/yr
  - Gross pumping at San Juan wellfield = 3,727/0.85 = 4,385 ac-ft/yr
- The demineralization wellfield consists of 6 deep wells located along Highway 156 between Lucy Brown Lane and Bixby Road. The annual production corresponds to a continuous pumping rate of 453 gpm at each well.

Results

<u>Hydrographs</u>

Figures 18a and 18b show hydrographs of simulated water levels in model layers 1 and 5 under Alternative 4A. Water levels near the demineralization wellfield (hydrograph 12S/4E-34H1) are lower by about 7 feet during wet periods and 24 feet during droughts. More importantly, the hydrograph has a long-term declining trend as indicated by the trend lines spanning the 1981-1995 hydrologic period (representative of long-term average conditions). This trend confirms that a gross production rate of 4,385 ac-ft/yr at the wellfield combined with a 1,400 ac-ft/yr decrease in percolation at the DWTP is more than the river can offset through increased percolation and decreased groundwater outflow. Previous simulations with a decrease of only 3,000 ac-ft/yr in the subbasin water budget did not result in declining hydrographs, indicating that the smaller pumping rate was within the sustainable yield of the subbasin. At the east end of the San Juan subbasin (near the DWTP), layer 5 water levels are 5-25 feet lower than under existing conditions. However, they fully recover after droughts, indicating that the overdraft around the demineralization wellfield does not extend this far east.

In and north of the Hollister urban area (**Figure 18b**), water levels under Alternative 4A are similar to those for existing contitions and Alternative 1B because there is little change in pumping at existing municipal wells. Changes in recharge and agricultural pumping associated with urbanization of agricultural lands result in minor water-level changes of little significance.

Water-Level Contours

The large pumping trough created by the demineralization wellfield under Alternative 4A is the dominant feature of the water-level contour map in the upper plot of **Figure 19**. These contours show the maximum difference in layer 5 water levels between this alternative and existing conditions, which occurs after several years of drought. Water levels at the demineralization wellfield are approximately 24 feet lower than under existing conditions, and water levels are more than 12 feet lower throughout almost the entire San Juan subbasin.

The patch of slightly increased water levels near the airport results from the cessation of pumping at an irrigation well retired due to urban expansion. The areas of lowered water levels along Fairview Road north of Highway 156 are the result of pumping at wells supplying newly irrigated lands east of Fairview. The effects of those wells are apparent primarily during droughts, as the irrigation supply was assumed to be CVP water most of the time.

A benefit of the demineralization pumping is that it decreases the magnitude and extent of shallow groundwater problems in the western part of the San Juan Valley, as can be seen by comparing the pink area in the lower plot on **Figure 19** with the corresponding plot on **Figure 3**. The eastern edge of the area where simulated water levels are less than 10 feet below the ground surface retreats from near Lucy Brown Lane to near Prescott Road. The western edge remains near Anzar Road.

Water Budgets

The simulated groundwater budget for the San Juan subbasin under Alternative 4A is shown in **Figure 20** and confirms that a demineralization pumping rate of 4,385 ac-ft/yr exceeds the sustainable yield of the San Juan subbasin unless other compensating actions are implemented. Under Alternative 4A, percolation at the DWTP would decrease by 1,400 ac-ft/yr while groundwater pumping would increase by 4,385 ac-ft/yr, for a combined negative shift in the groundwater budget of 5,785 ac-ft/yr. The groundwater flow system responds with compensating changes in all head-dependent flow terms. The largest responses are increases in percolation from the San Benito River and decreases in groundwater outflow into the river, which together offset 80% of the imposed stress. Inflow from groundwater storage and outflow to groundwater storage both increase, but not by equal amounts. The net result is an average annual depletion of groundwater storage of 1,870 ac-ft/yr. This is consistent with the long-term declining trends in the simulated hydrographs. Neither the water levels nor the water budget appear to equilibrate at a new sustainable condition by the end of the simulation, so it must be concluded that the simulated demineralization pumping rate would result in groundwater overdraft.

There are numerous options for avoiding the simulated overdraft while still obtaining sufficient demineralization supplies. These include:

- Deliver some or all of the recycled water to groundwater users in the Freitas Road area instead of delivering all of it to CVP users. This could re-balance the water budget by decreasing agricultural groundwater pumping.
- Obtain some of the future demineralization supply from wells in the Hollister West or East subbasins. Existing municipal wells in those subbasins will need to be demineralized anyway to meet water quality objectives. New municipal supply wells could presumably be installed in multiple subbasins to distribute the pumping stress more broadly and avoid overdraft. The wells could all be tied into the same demineralization infrastructure.
- Reinstate the historic operation of Hernandez Reservoir, which included percolation releases that flowed all the way into the San Juan subbasin to supply recharge in that area. This would create a positive shift in the San Juan subbasin water budget and help offset some of the demineralization pumping.

Groundwater Salinity Contours

Changes in layer 1 groundwater salinity under Alternative 4A are shown in the upper plot in **Figure 21**.Changes in the urban area and near the DWTP and IWTP stem from land use changes and are roughly the same as for Alternatives 1B and 3A (see **Figures 11 and 16**). The increase in salinity in the central and western parts of the San Juan Valley is larger, however. The change in irrigation and recharge salinity in this area resulting from the substitution of recycled water for CVP water is the same for all simulations. The larger simulated concentration under Alternative 4A results from a decrease in simulated layer 1 thickness. The decrease in water levels decreases the saturated thickness of layer 1. Consequently, recharge is mixed into a smaller volume of ambient groundwater, resulting in a higher concentration. Thus, the difference between simulations in this case is an artifact of model layering. The conceptual model to keep in mind is that relatively salty recharge water arrives at the top of the groundwater system (the water table) and in most areas percolates downward in response to vertical gradients created by water supply wells, blending with ambient groundwater en route.

The lower plot in **Figure 21** shows the simulated TDS concentration in layer 1 at the end of the 30-year simulation. Except for the aforementioned change in part of the San Juan Valley, the salinity pattern is essentially identical to the pattern for the other alternatives.

Groundwater Salinity Timeseries

Trends in simulated groundwater salinity under Alternative 4A are shown in **Figure 22**. In the central and western parts of the San Juan Valley (MW-5 timeseries plot), simulated layer 1 TDS increases at a slightly faster rate throughout the simulation than under Alternatives 1B or 3A because of the smaller saturated layer thickness (see

Figures 12 and 17). This effect propogates downward and slightly affects layer 2. This alternative is also slightly different near existing municipal wells, which are assumed to pump at their 2005 rates with no increase to allow for demineralization inefficiency. As a result, the turnover rate of groundwater near the wells is not quite as large as under Alternatives 1B and 3A, so groundwater salinity in layers 1 and 2 does not decrease quite as quickly.

Alternative 4B: Exchange Pacheco/Bolsa Groundwater for PVWMA CVP Water

Assumptions

- The amount of CVP water transferred from PVWMA averages 4,440 ac-ft/yr.
- A new treatment plant operates in parallel with the Lessalt plant to process the increased supply of CVP M&I water (4,440 ac-ft/yr = 3.96 mgd).
- An equal amount of groundwater is delivered to PVWMA in exchange for the CVP water. The groundwater is pumped from new wells in the Lovers Lane area and discharged into Pacheco Creek, from where it flows via Miller Canal and the Pajaro River to a diversion point near Watsonville.
- The export wellfield consists of 12 wells spaced 600 feet apart along Lovers Lane between Pacheco Creek and Shore Road.
- The amount of groundwater exported to PVWMA allows for conveyance losses and demineralization by PVWMA after rediversion near Watsonville:
    - Net amount delivered to PVWMA = 4,440 ac-ft/yr
    - Conveyance losses during delivery: 15%
    - Demineralization efficiency of PVWMA plant: 85%.
    - Gross groundwater pumping: (4,440)/0.85/0.85 = 6,145 ac-ft/yr.
- Net groundwater use at COH and Sunnyslope CWD wells equals total 2023 water demand minus Lessalt production and minus new CVP use. Local groundwater is demineralized at 85% efficiency, resulting in the following gross groundwater production:
    - Total demand = 11,840 ac-ft/yr
    - Lessalt production = 3 mgd year-round = 3,361 ac-ft/yr
    - New CVP supply from PVWMA: 4,440 ac-ft/yr
    - Net groundwater production = 11,840-3,361-4,440 = 4,039 ac-ft/yr
    - Gross groundwater production = 4,039/0.85 = 4,752 ac-ft/yr
- The existing and new CVP municipal supplies are used as a relatively constant, year-round base supply. Municipal groundwater pumping is therefore concentrated in the dry season relative to the existing seasonal pumping distribution.
- Annual production is allocated among municipal wells in the same proportions as occurred in 2005.

Results

Hydrographs

The effects of Alternative 4B on groundwater levels in the San Juan subbasin and the Hollister urban area are shown in **Figure 23** and are very similar to the effects under Alternative 1B (**Figure 8**). Both alternatives involve a supplemental supply of CVP water that—together with the existing Lessalt supply—create a year-round base supply approximately equal to total municipal demand in winter. Groundwater is used to supply additional municipal demand during the dry season and to compensate for cutbacks in CVP M&I allocations during droughts. Water levels are 5-10 feet lower in the San Juan Valley during droughts but recover to existing levels within a few years afterward. Water levels near municipal wells in the urban area are 2-12 feet lower, excluding the larger dry-season drawdown caused by the more seasonal distribution of pumping. Water levels near the Lovers Lane wellfield are lower by 40 feet during droughts and do not recover to pre-drought levels afterward. The long-term declining trend in the hydrographs for layers 1 and 5 reveals that the simulated pumping rate exceeds the sustainable yield of that part of the basin. The simulation converts Tequisquita Slough and the lower end of Pacheco Creek from gaining to losing streams, but that shift is insufficient to compensate for the increase in pumping. The overdraft extends upstream as far as well 11-5-26N2 (midway between San Felipe Road and Highway 156 (see trend line in hydrograph plot) but no farther south than the north end of the airport.

<u>Water-Level Contours</u>

The prominent impact of Alternative 4B is the large pumping trough created by the wellfield along Lovers Lane. The maximum drawdown in layer 5 relative to existing conditions occurs at the end of a drought, and is shown in the upper plot in **Figure 24**. Drawdown is 30-40 feet throughout the Lovers Lane-San Felipe Lake area east of the Calaveras Fault. Drought drawdown diminishes to less than 8-10 feet south and east of Highway 156.

The large decline in water levels near the wellfield is beneficial with respect to shallow groundwater problems. The extent of the area in which simulated layer 1 water levels in a wet year are less than 10 feet below the ground surface is only about 10% as large as under existing conditions (compare the red-shaded areas near Lovers Lane with the corresponding part of the lower plot in **Figure 3**).

The lowering of shallow groundwater levels and the depletion of dry-season baseflow along the lower reaches of Pacheco Creek and Tequisquita Slough are large enough that they would likely have an adverse impact on riparian and aquatic habitats. No analysis was attempted to link the changes in streamflow and water table elevation to corresponding changes in ecological integrity or populations of particular species.

<u>Groundwater Budgets</u>

The pumping stress created by the Lovers Lane wellfield stands out in the water budget bar chart shown in **Figure 25**. The budget is for the northern part of the Hollister Valley, bounded by the Calaveras Fault on the west, Comstock Road and the Highway 156 bypass on the south, and the toe of the foothills on the north and east. The wellfield more than doubles the existing amount of groundwater pumping in that region. All head-dependent flow items respond to this stress. The largest responses are increased percolation from streams and decreased percolation to streams, which together compensate for 77% of the increase in pumping. The simulated increase in groundwater inflow may exceed what would actually occur because it represents underflow through alluvium where the Pacheco Creek and Arroyo de las Viboras drainages enter the valley. In practice, the increase in underflow would be limited to the amount of additional stream percolation that could be induced by lowered groundwater levels along the reach just outside the model boundary.

Finally, flows to and from storage also both respond to the pumping stress, but not equally. Inflow from storage increases more than outflow to storage, which means there is a net storage depletion on an average annual basis. This is consistent with the long-term declining trend in water levels near the wellfield, and it confirms that the simulated wellfield pumping rate exceeds the sustainable yield of this part of the basin.

<u>Groundwater Salinity Contours</u>

Alternative 4B reverses the predominant direction of groundwater-surface water exchange along the lower reaches of Pacheco Creek and Tequisquita Slough. These reaches convert from predominantly gaining to predominantly losing streams. The result is an influx of relatively fresh groundwater into shallow aquifers, which creates bands of decreased groundwater salinity along the creek channels, as shown in **Figure 26**. The patch of slightly elevated layer 1 salinity south of Tequisquita Slough between San Felipe Road and Frye Lane results from the more rapid northward movement of an existing zone of higher groundwater salinity under the influence of the Lovers Lane pumping trough.

Groundwater salinity changes in the San Juan Valley and Hollister urban area stem from land use changes and wastewater recycling and are approximately the same as under other alternatives.

<u>Groundwater Salinity Timeseries</u>

Figure 27 shows simulated trends in groundwater salinity under Alternative 4B. Note that a slightly different set of wells was selected to illustrate the effects of this alternative, because salinity trends in the San Juan Valley and Hollister urban area were essentially the same as under Alternatives 1B and 3A (Figures 12 and 17). The Lovers Lane wellfield induces percolation from lower Pacheco Creek and Tequisquita Slough and accelerates the downward movement of shallow groundwater to model layers 3-5. The results are:

- a slight decrease in layer 1 groundwater salinity that quickly equilibrates to the new flow regime, and
- much more rapid increases in layer 2 and 3 salinity, as layers 1-3 all converge toward a single TDS concentration.

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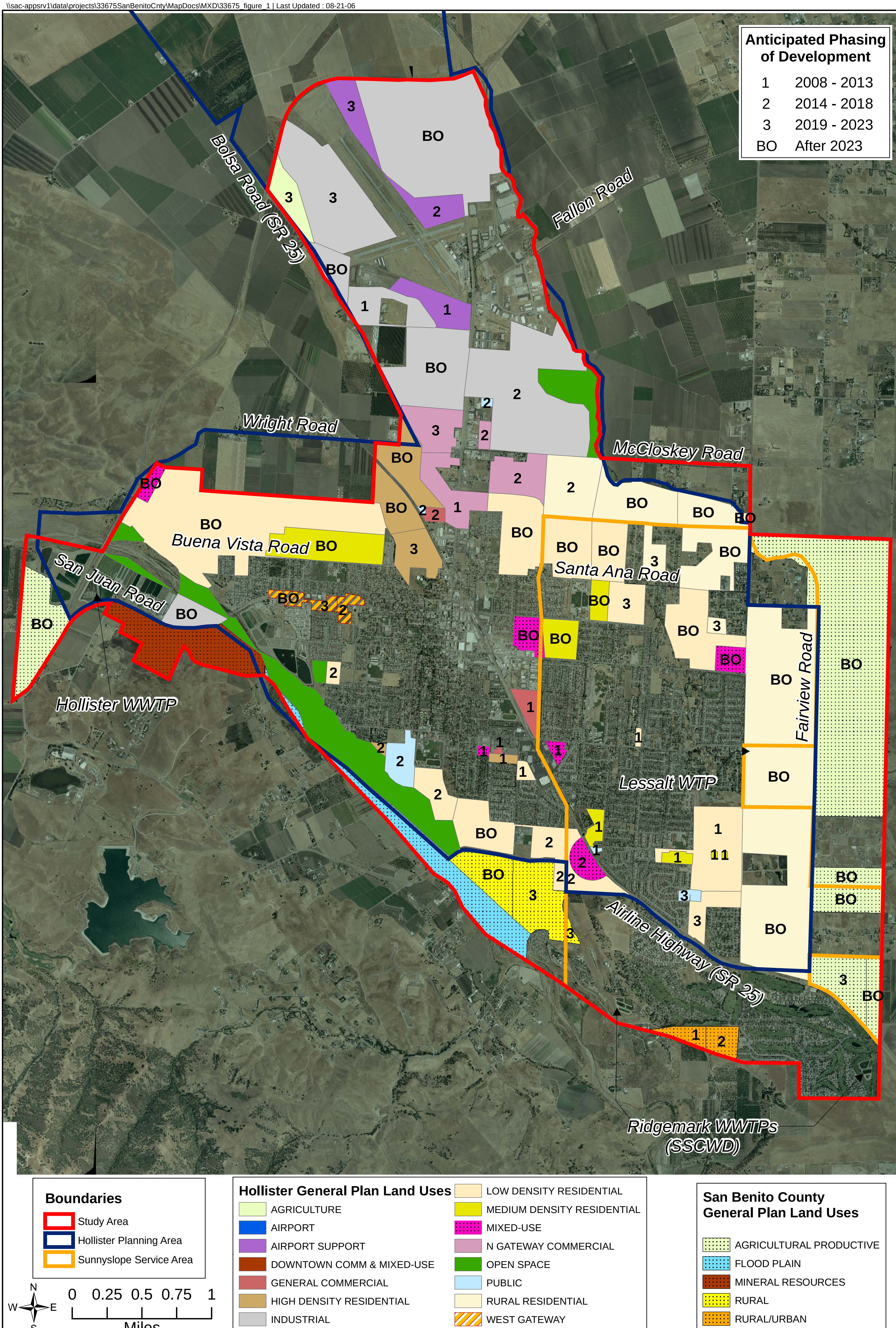


Future Land Uses

FIGURE 1

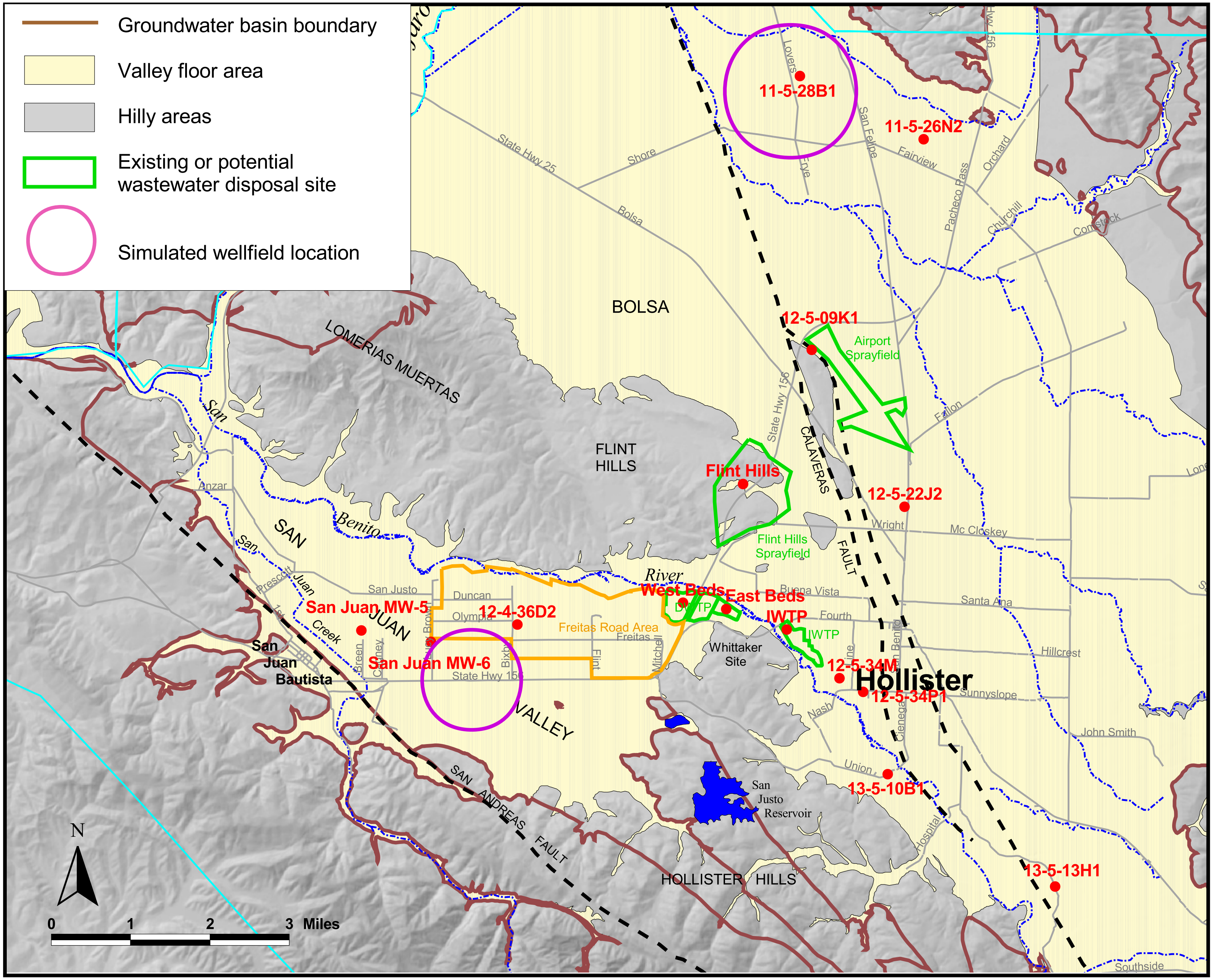
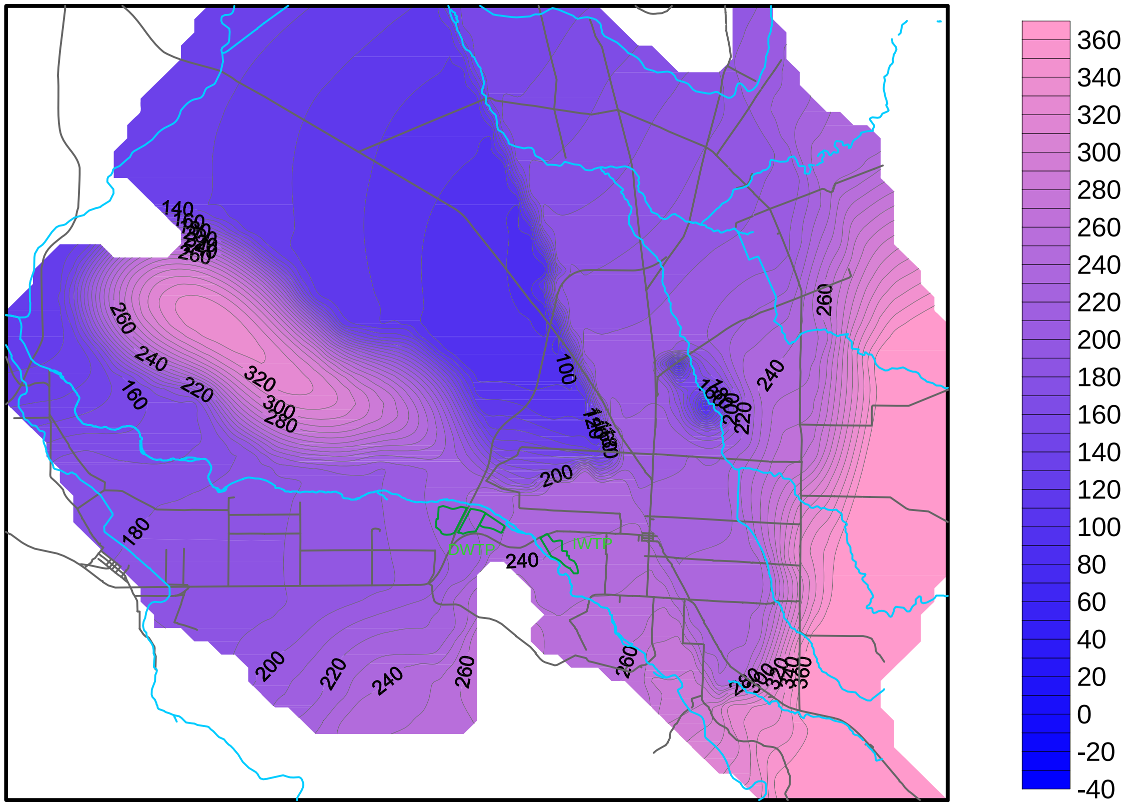
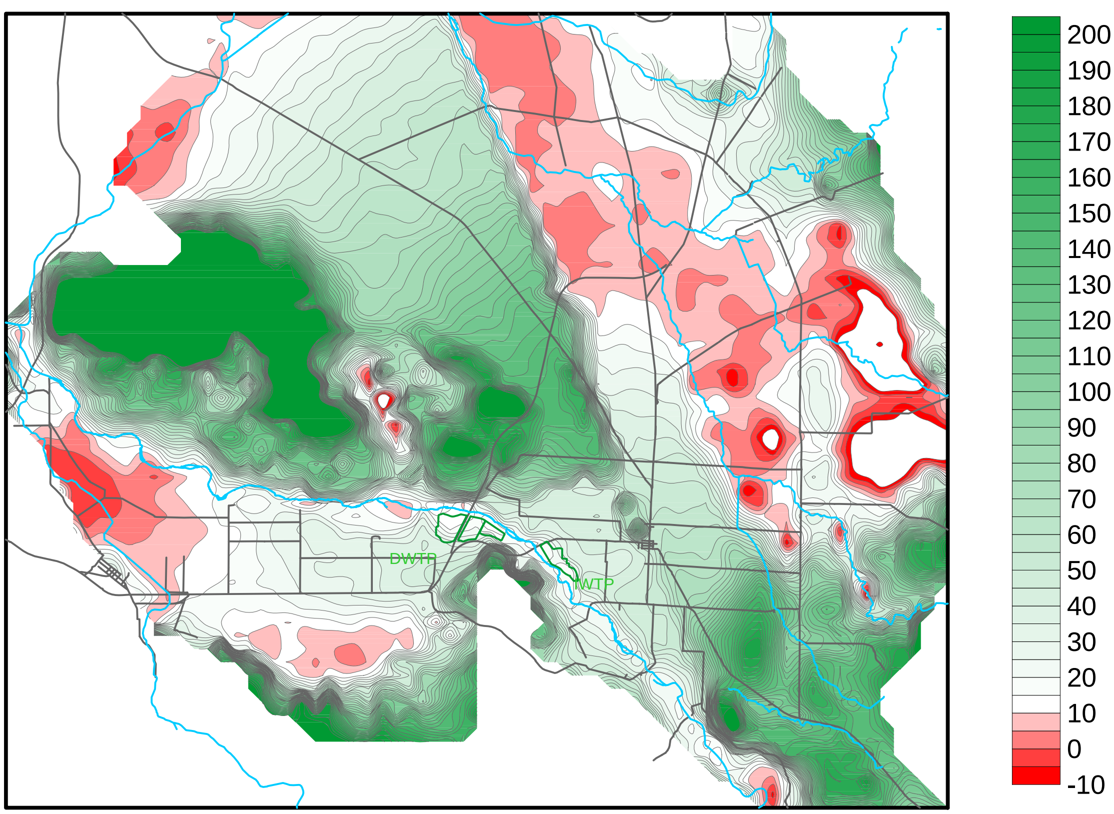


Figure 2. Locations of Wells, Wellfields, and Wastewater Disposal Areas Featured in the Evaluation of Alternatives



A. Simulated Groundwater Elevation in Deep Aquifers (Model Layer 5)



B. Simulated Depth to Groundwater in Shallow Aquifers (Model Layer 1)

Figure 3. Simulated Water Levels in Shallow and Deep Aquifers under Existing Conditions in a Wet Year (1998)

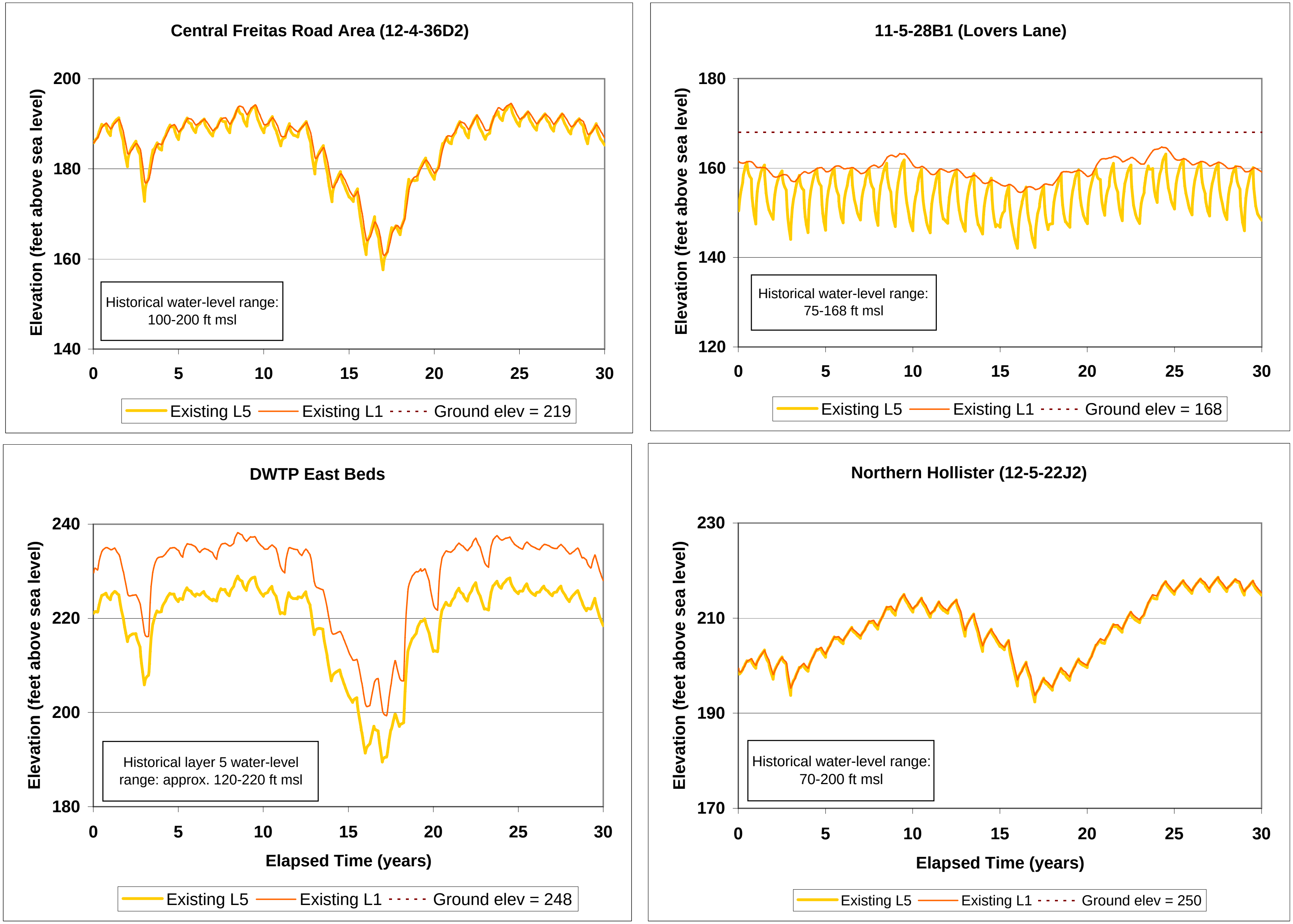


Figure 4. Hydrographs of Simulated Groundwater Elevation at Selected Locations under Existing Conditions

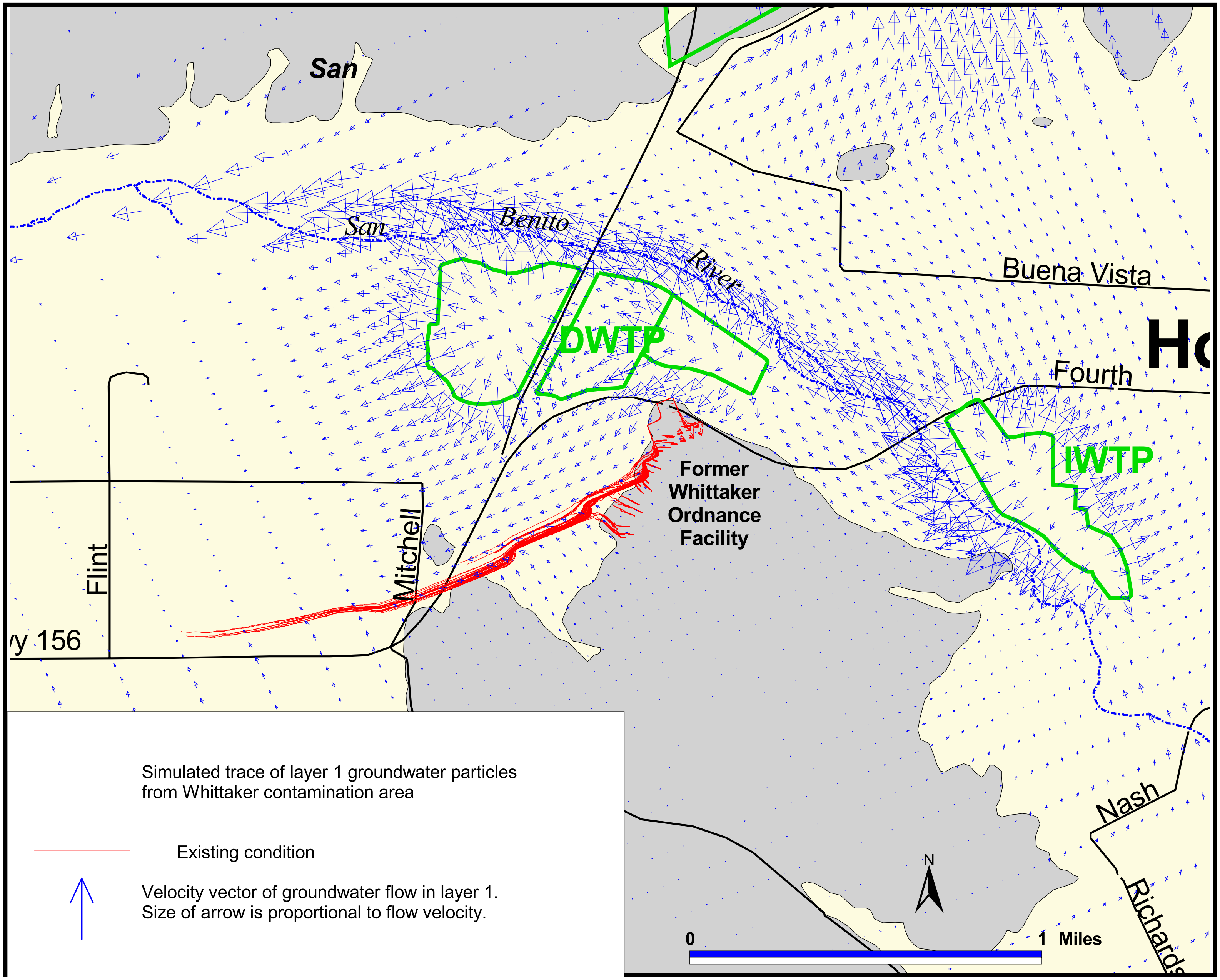
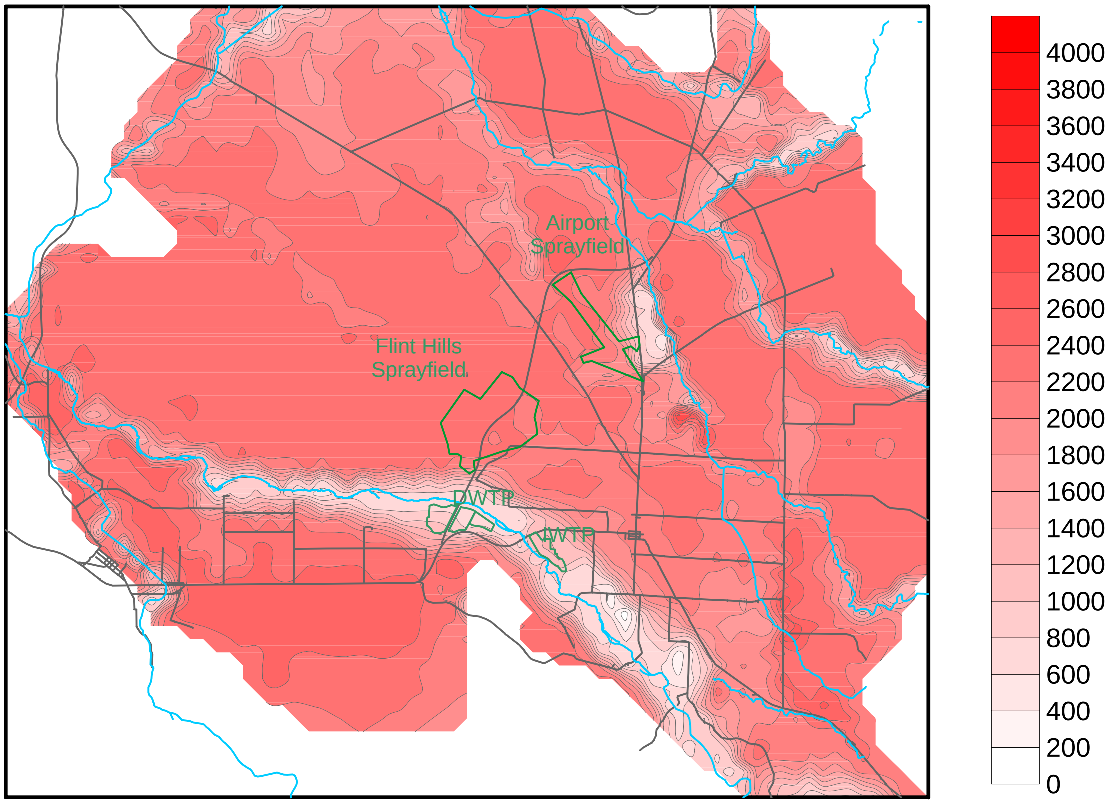
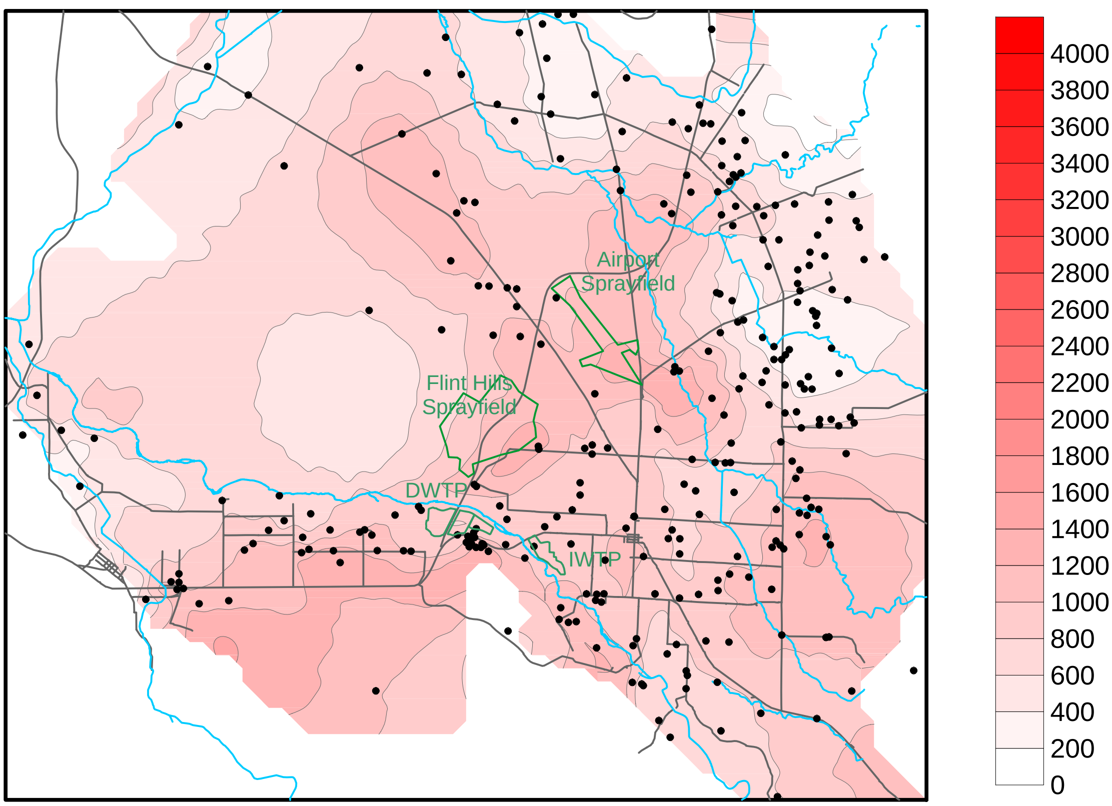


Figure 5. Simulated Groundwater Velocity Vectors and Path of Whittaker Contamination Plume after 30 Years under Existing Conditions



A. Groundwater TDS Concentration in Model Layer 1



B. Groundwater TDS Concentration in Model Layer 5

Figure 6. Simulated Concentrations of TDS in Shallow and Deep Aquifers after 30 Years under Existing Conditions

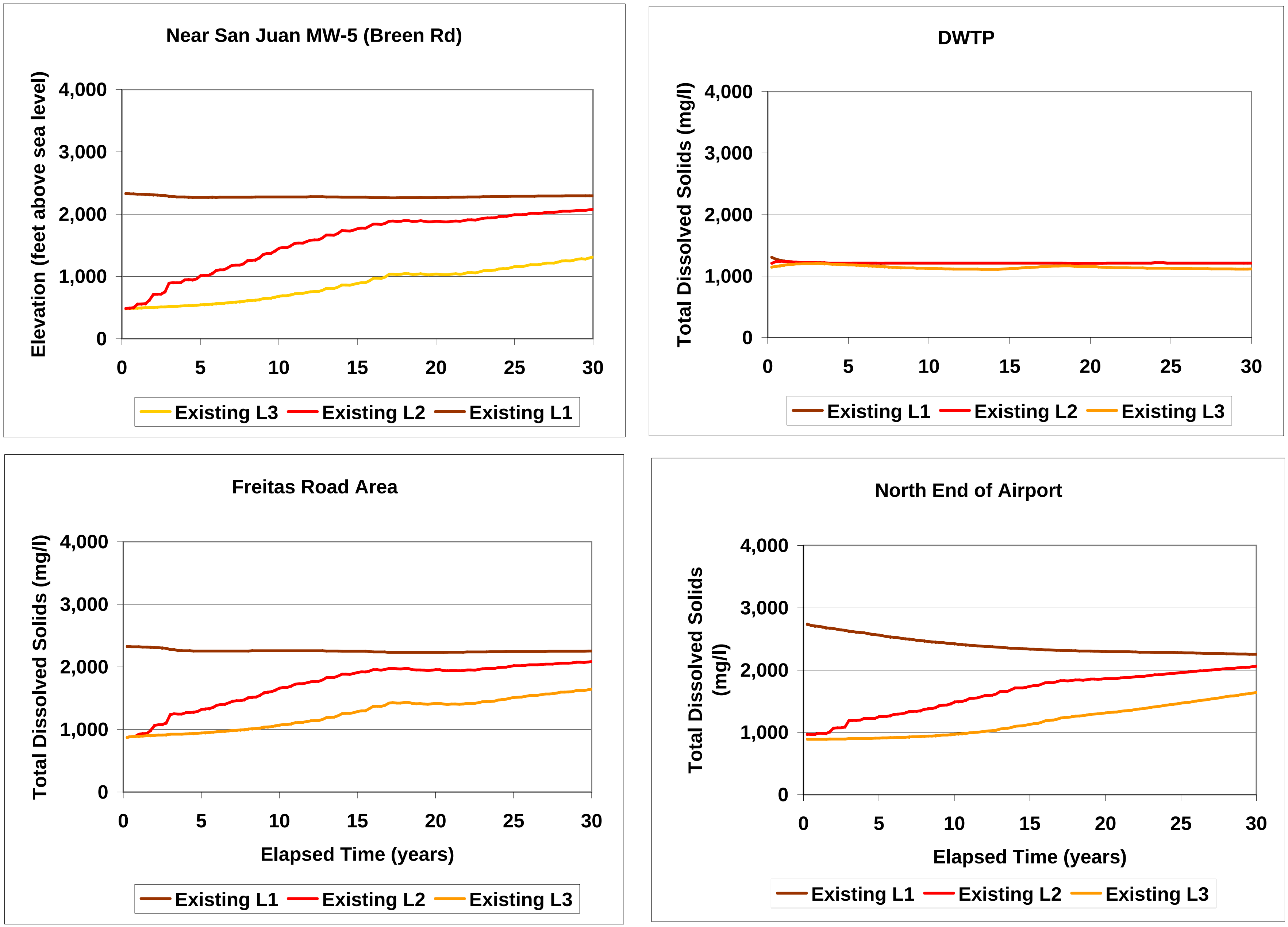


Figure 7. Simulated Timeseries of Groundwater Salinity in Model Layers 1-3 at Selected Locations under Existing Conditions

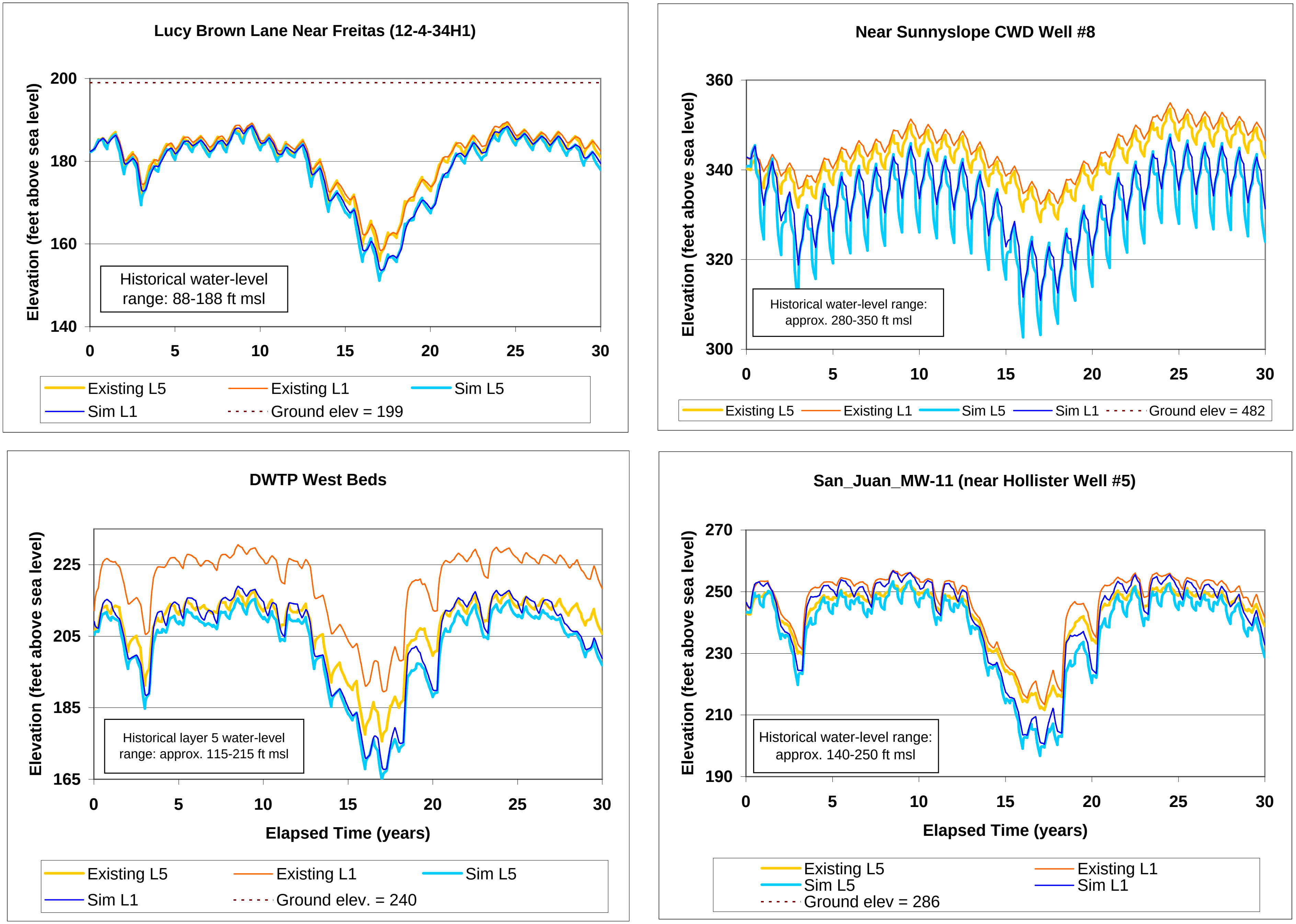


Figure 8. Hydrographs of Simulated Groundwater Elevation at Selected Locations under Alternative 1B

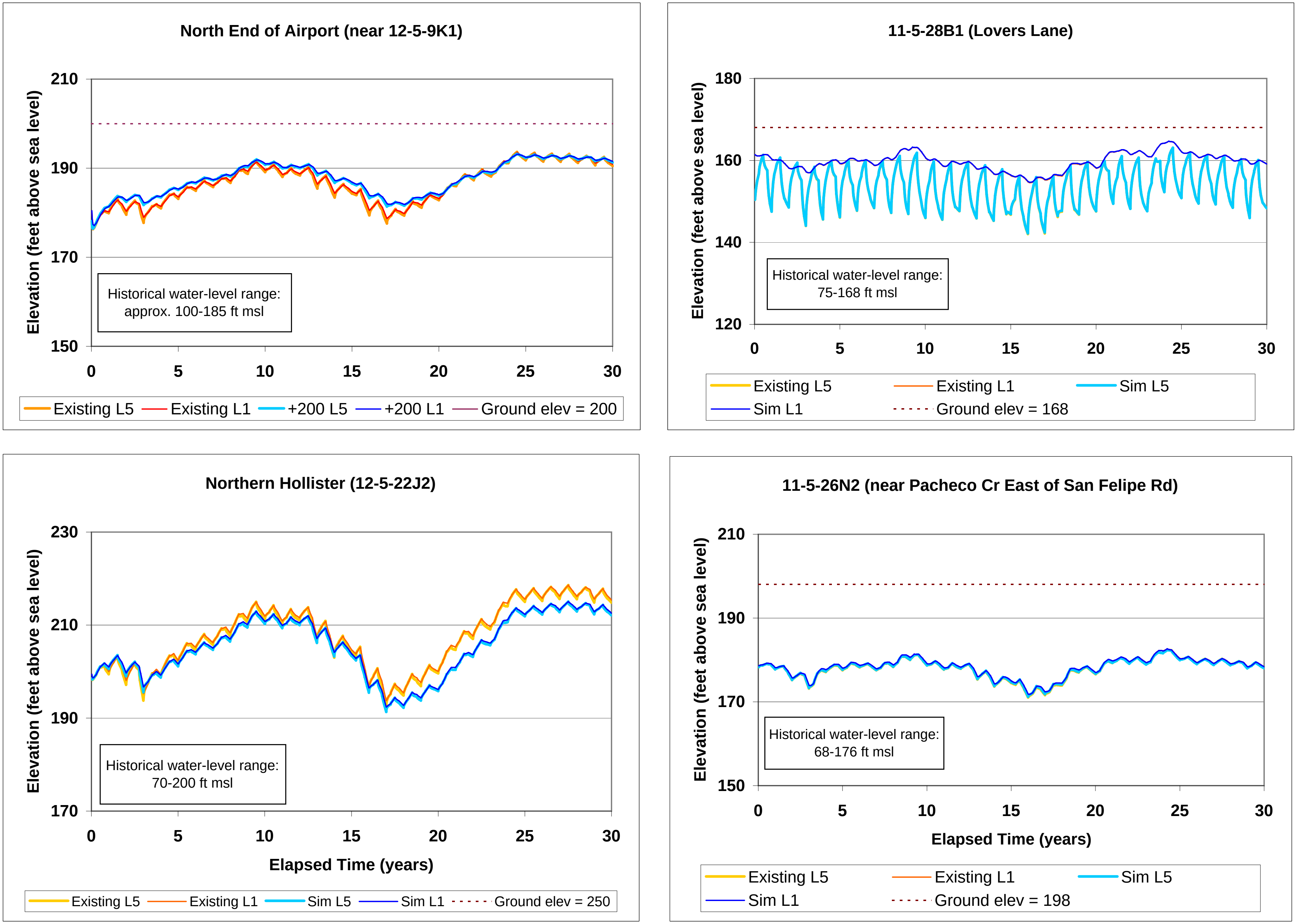
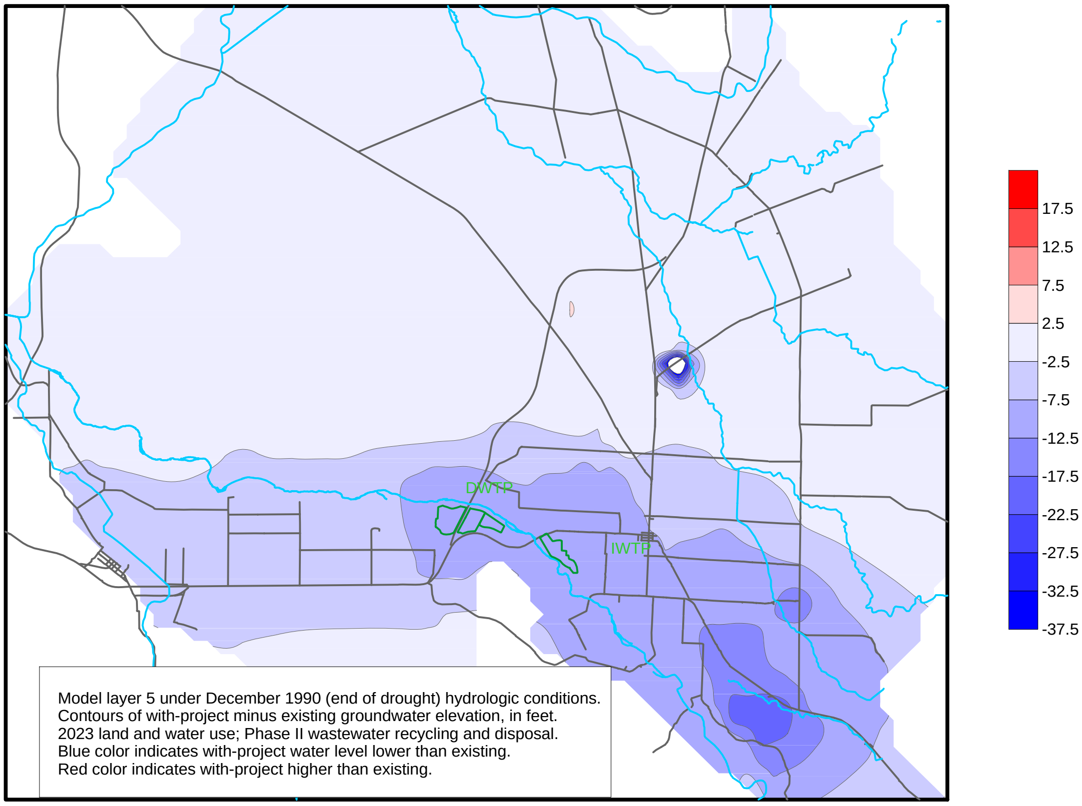
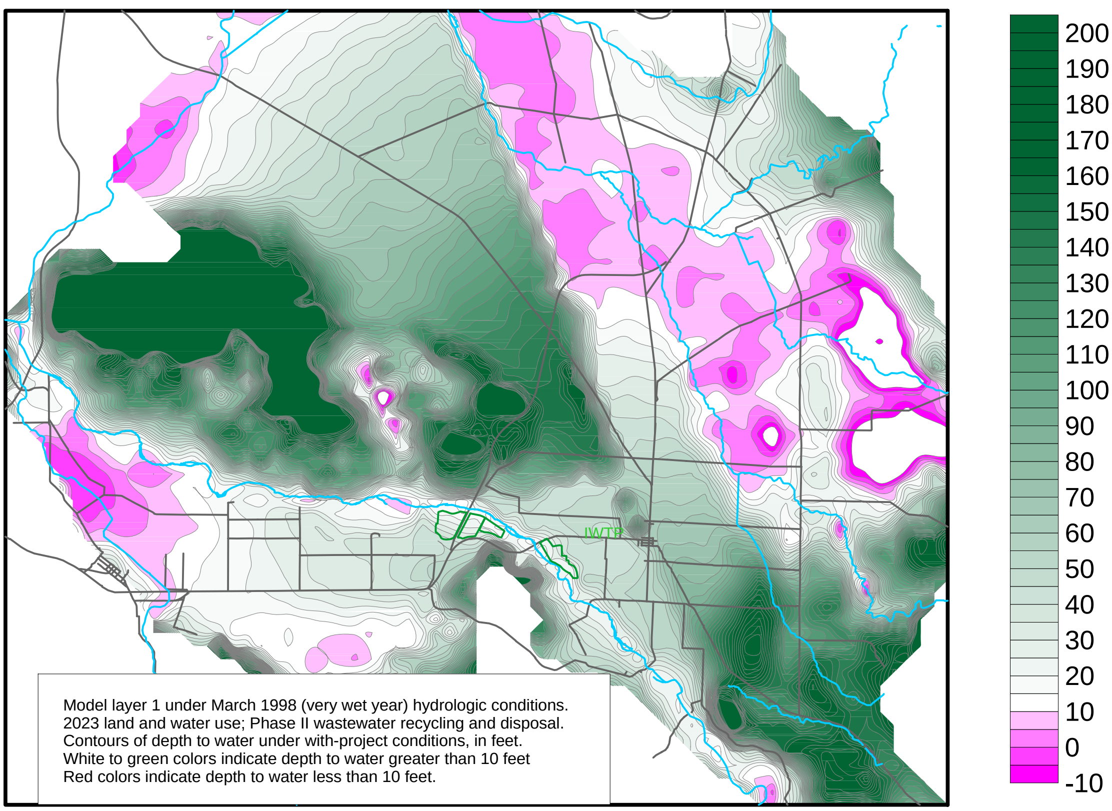


Figure 8 — continued

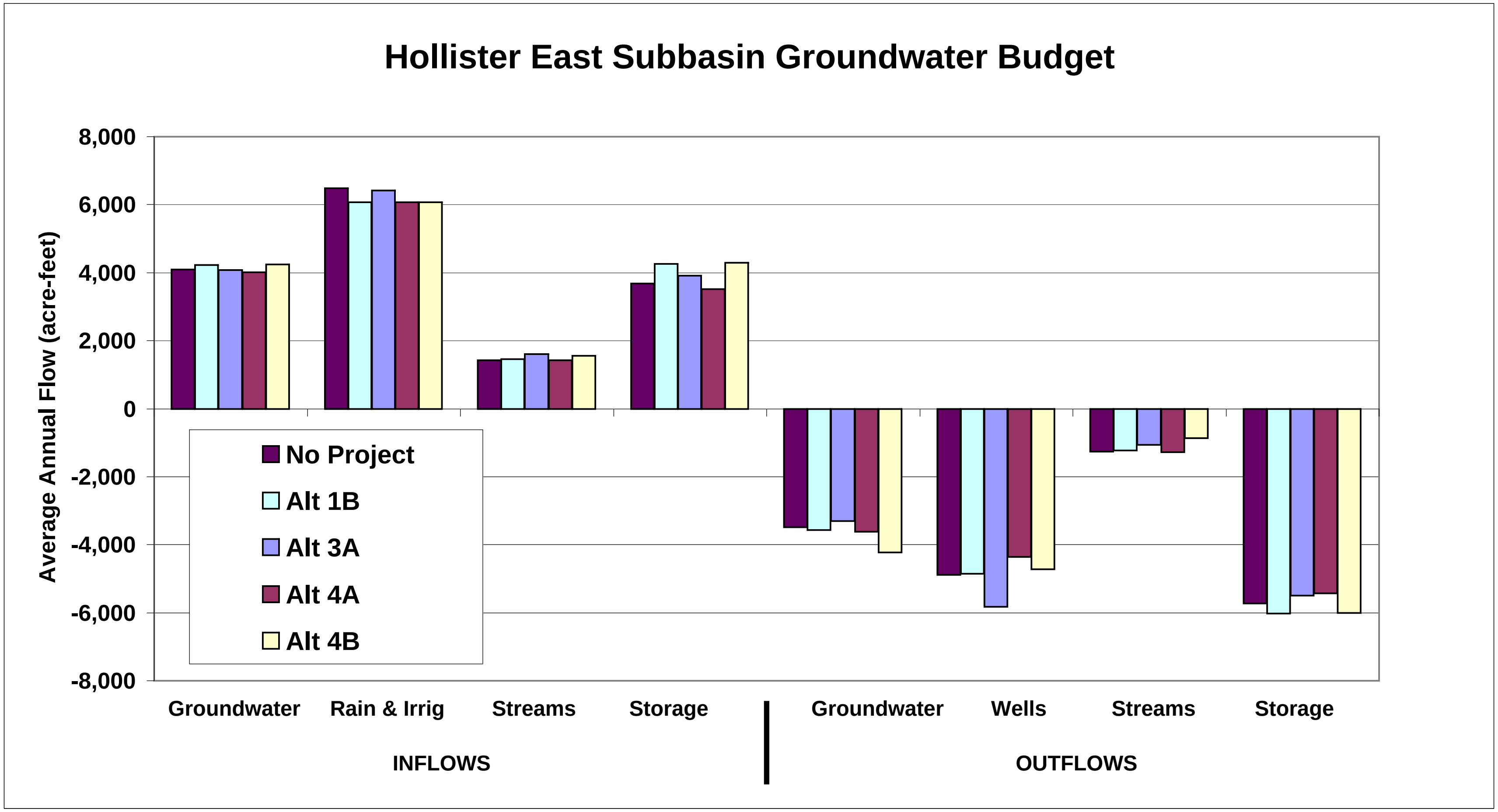


A. Maximum Change in Water Level in Deep Aquifers from Existing Conditions to Alternative 1B



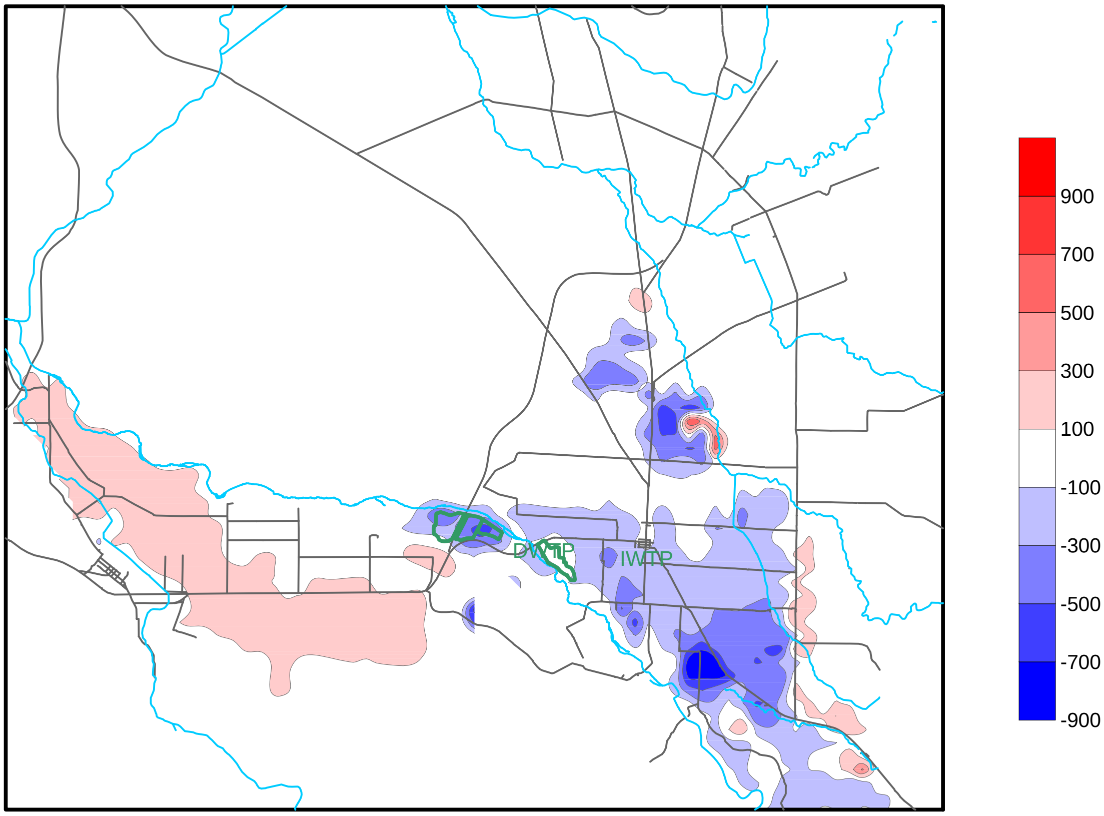
B. Minimum Depth to Groundwater in Shallow Aquifers under Alternative 1B

Figure 9. Effects of Alternative 1B on Deep and Shallow Groundwater Levels under 2023 Conditions

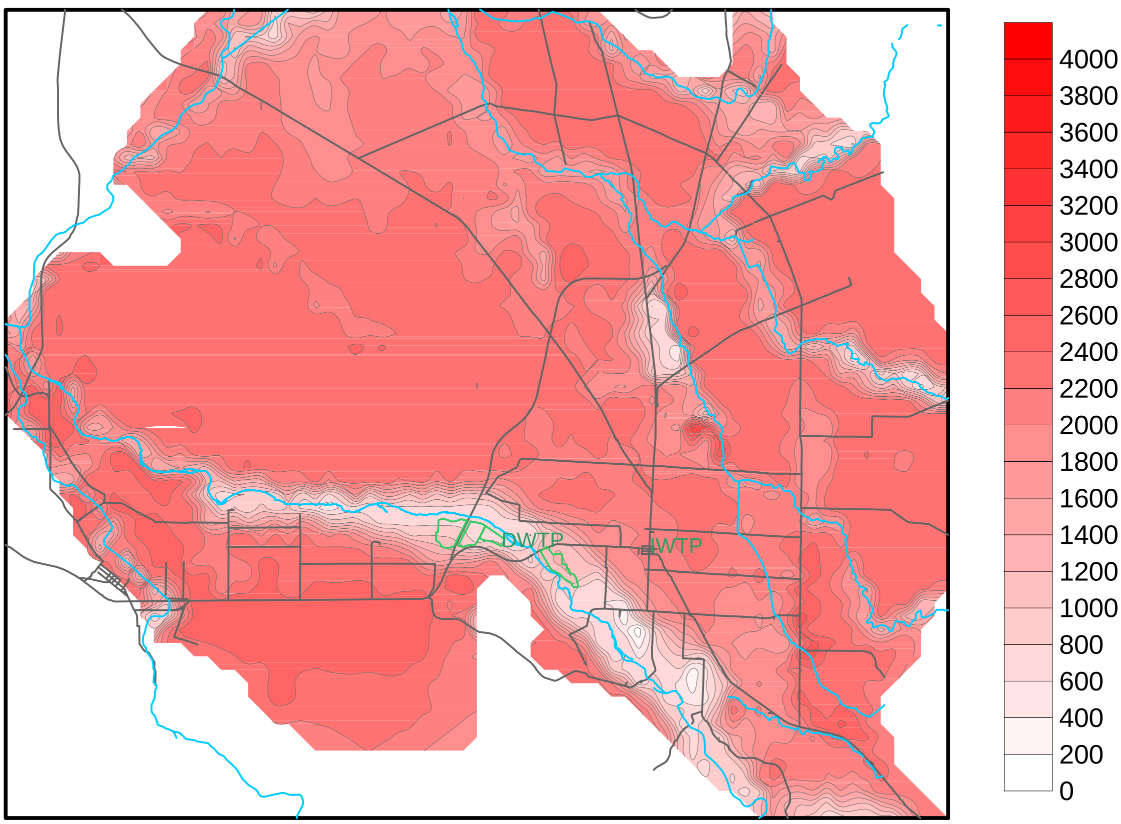


Note: budgets are averaged over years 7-21 of each simulation, corresponding to hydrologic conditions during water years 1981-1995.

Figure 10. Comparison of Average Annual Water Budgets under Existing (No-Project) Conditions and HUAWWMP Alternative Conditions



A. Change in Groundwater TDS Concentration in Model Layer 1



B. Groundwater TDS Concentration in Model Layer 1

Figure 11. Effects of 30 Years of Alternative 1B on Shallow Groundwater Salinity under 2023 Conditions

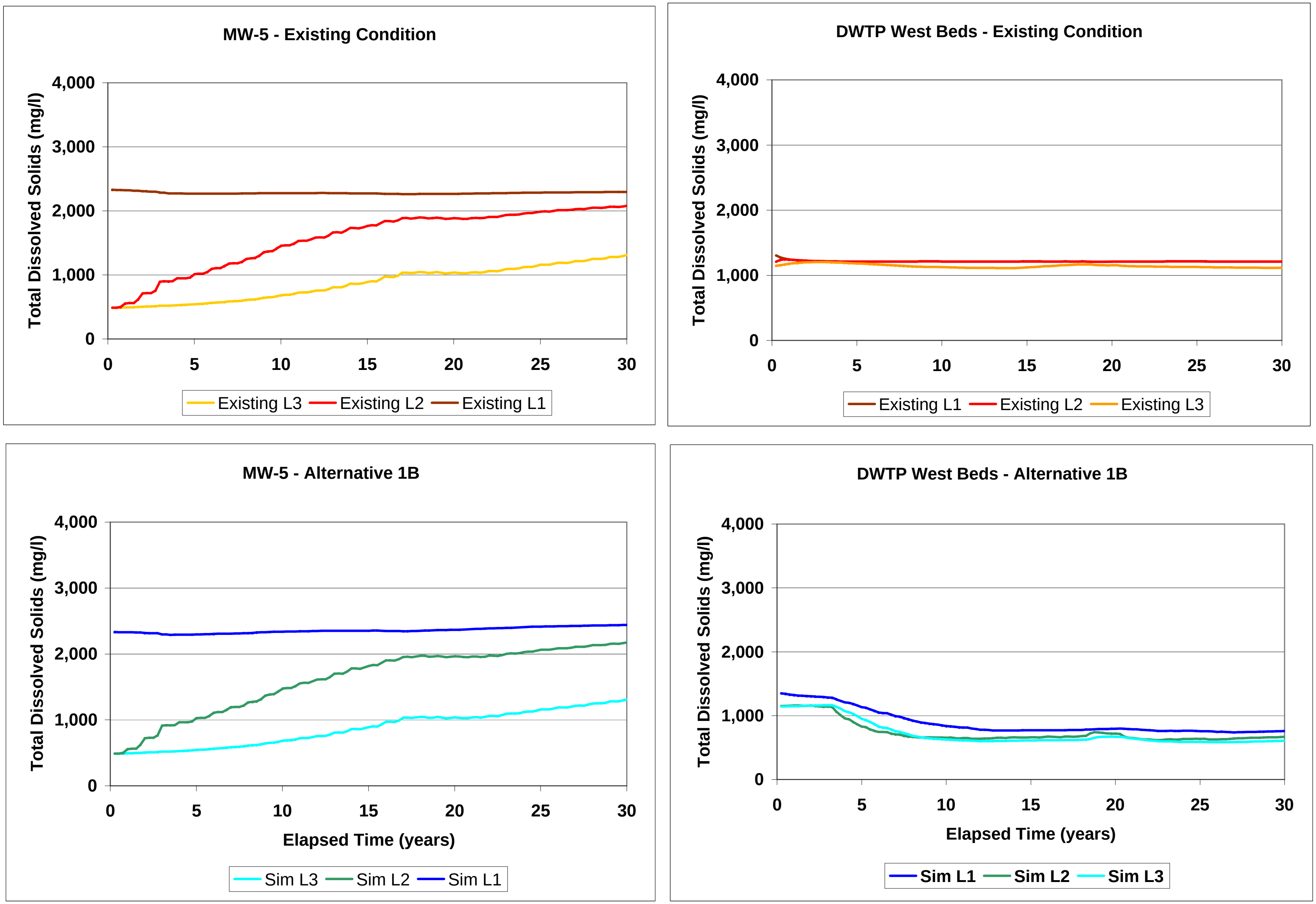
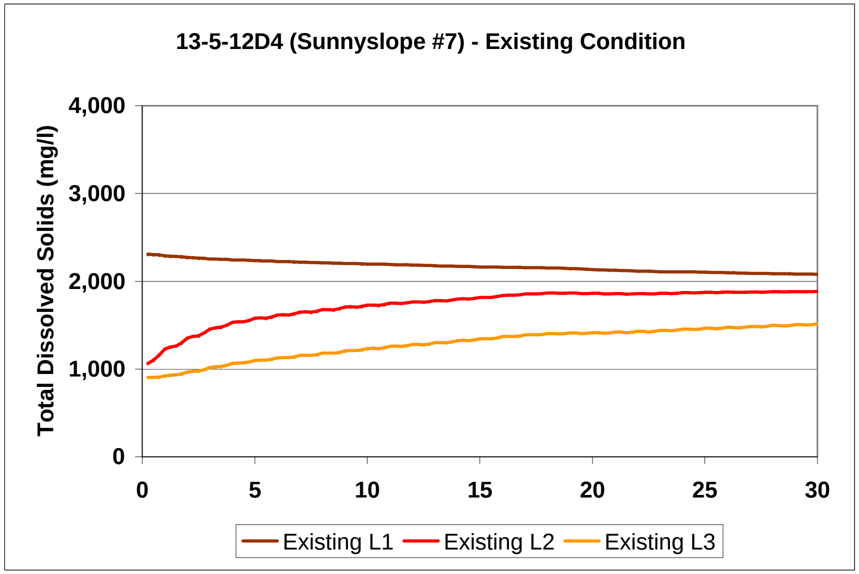
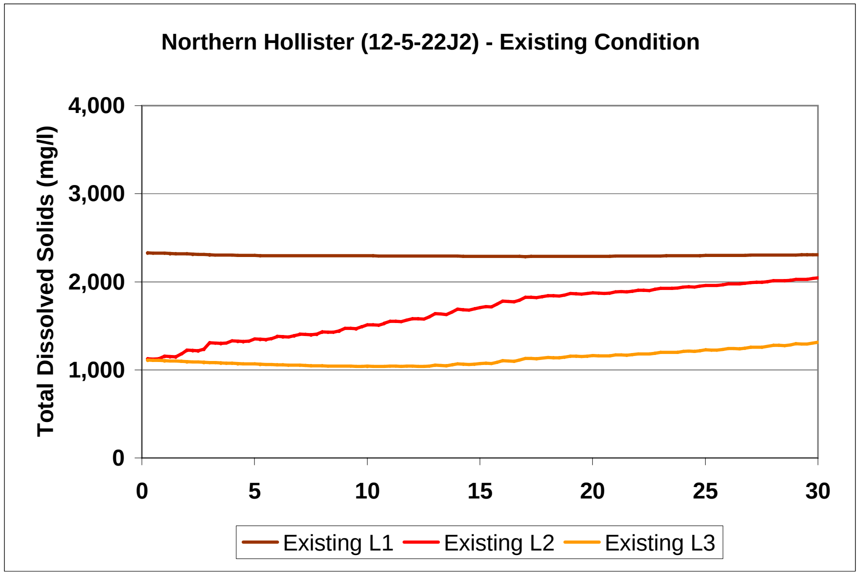
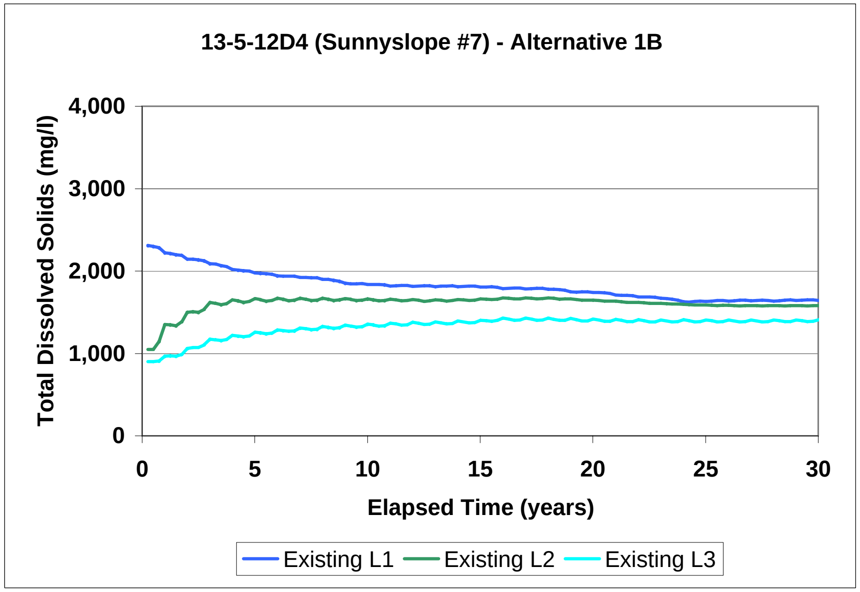


Figure 12. Effects of Alternative 1B on Trends in Groundwater Salinity in Model Layers 1-3







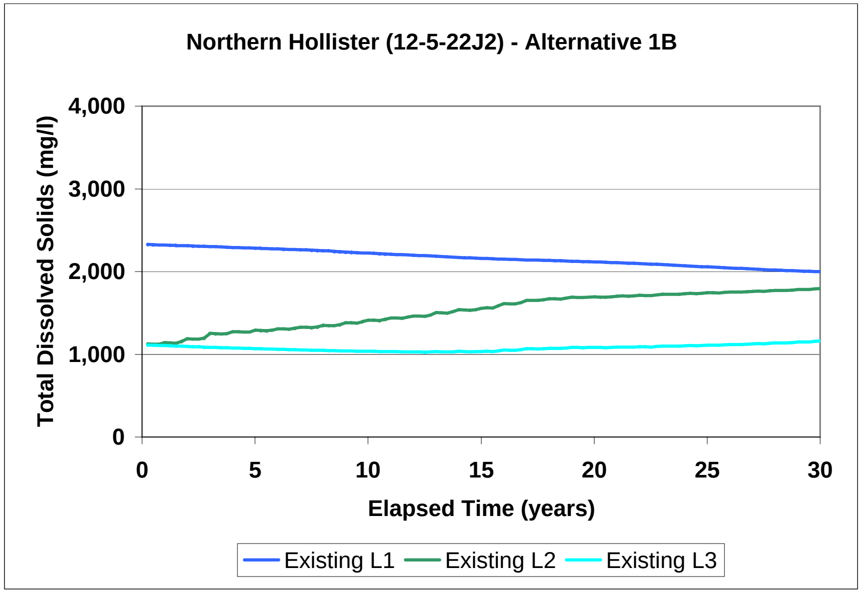


Figure 12 — continued

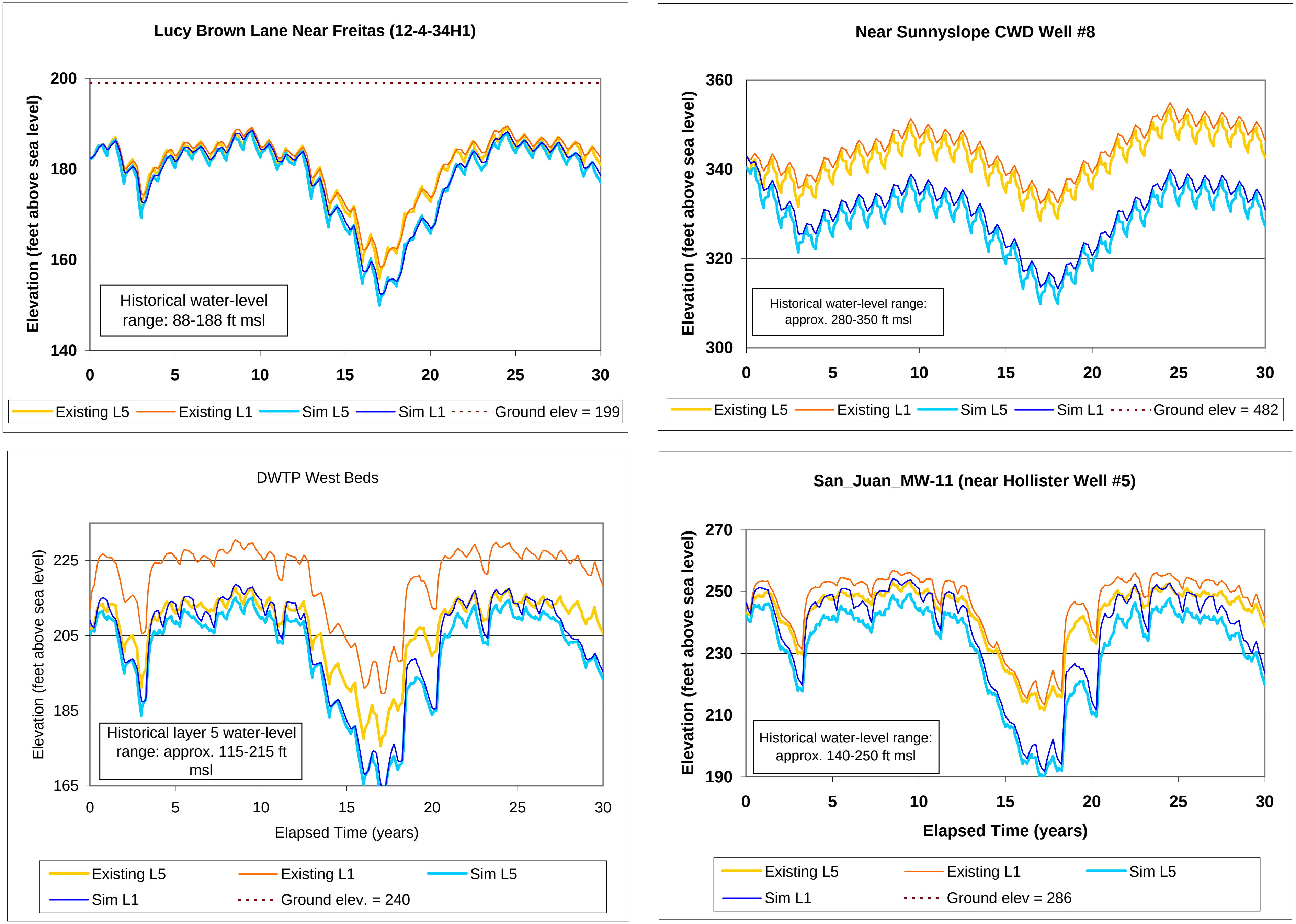
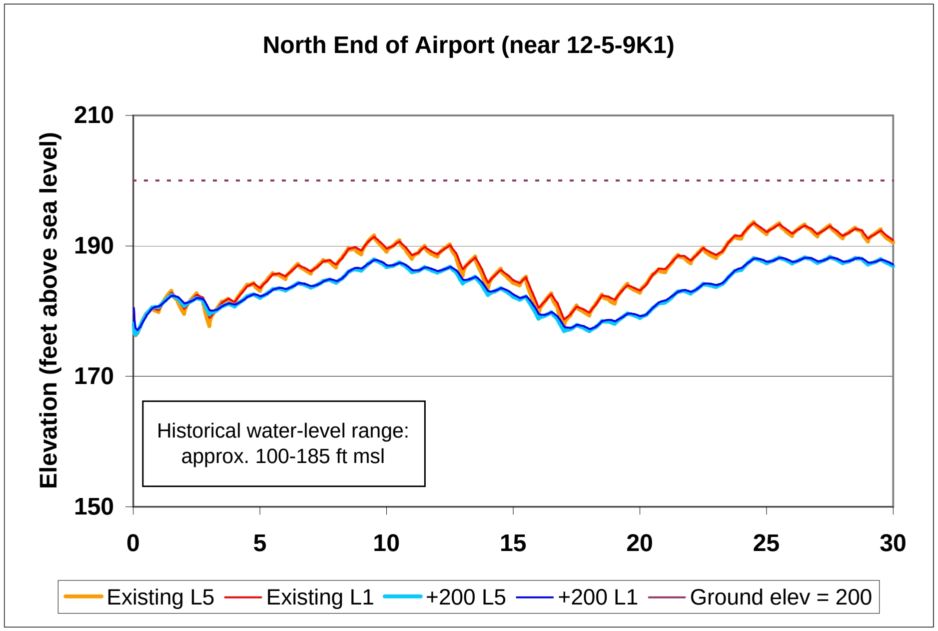
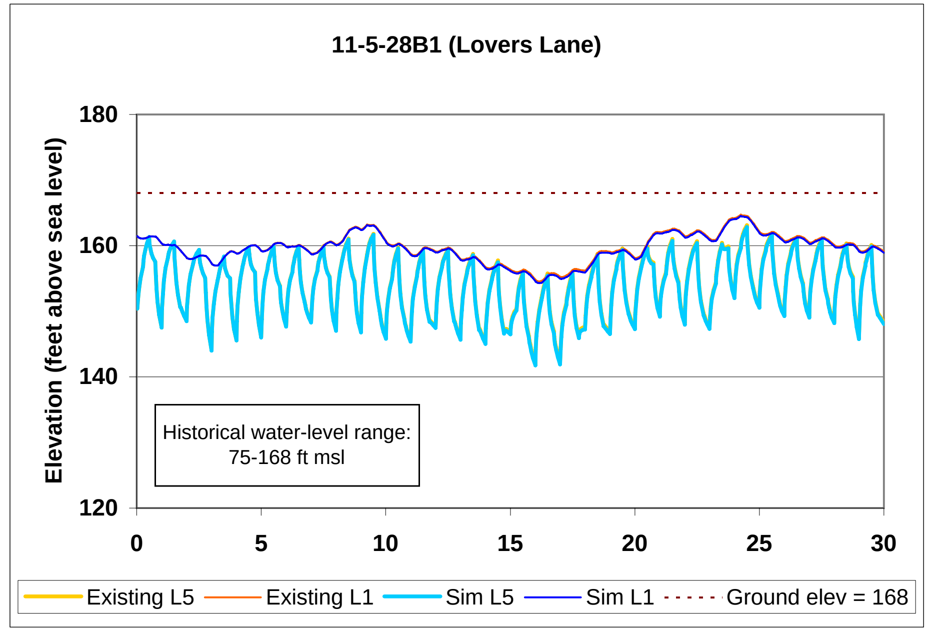
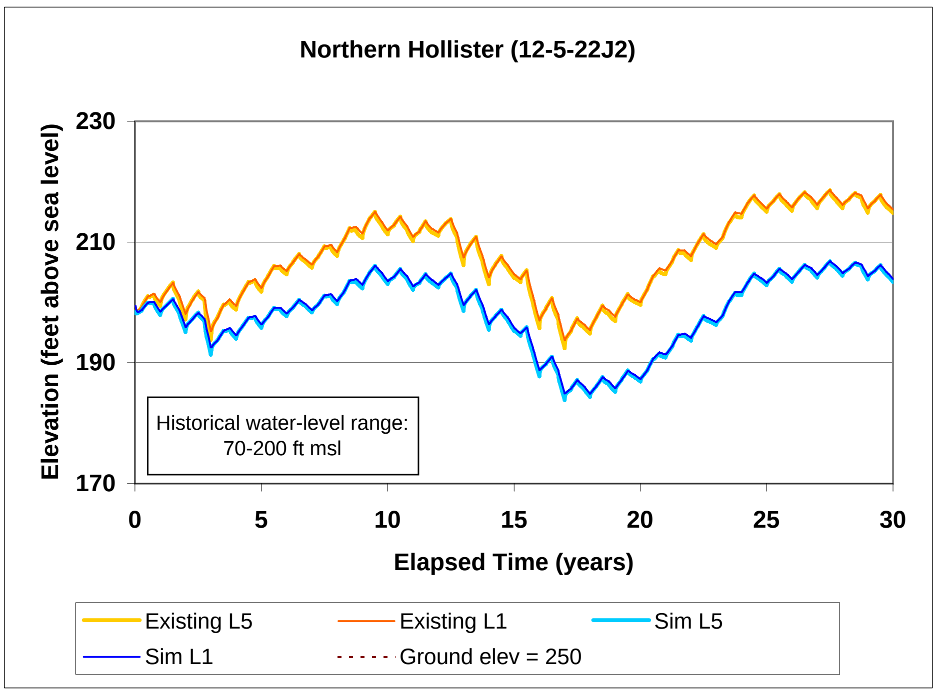


Figure 13. Hydrographs of Simulated Groundwater Elevation at Selected Locations under Alternative 3A







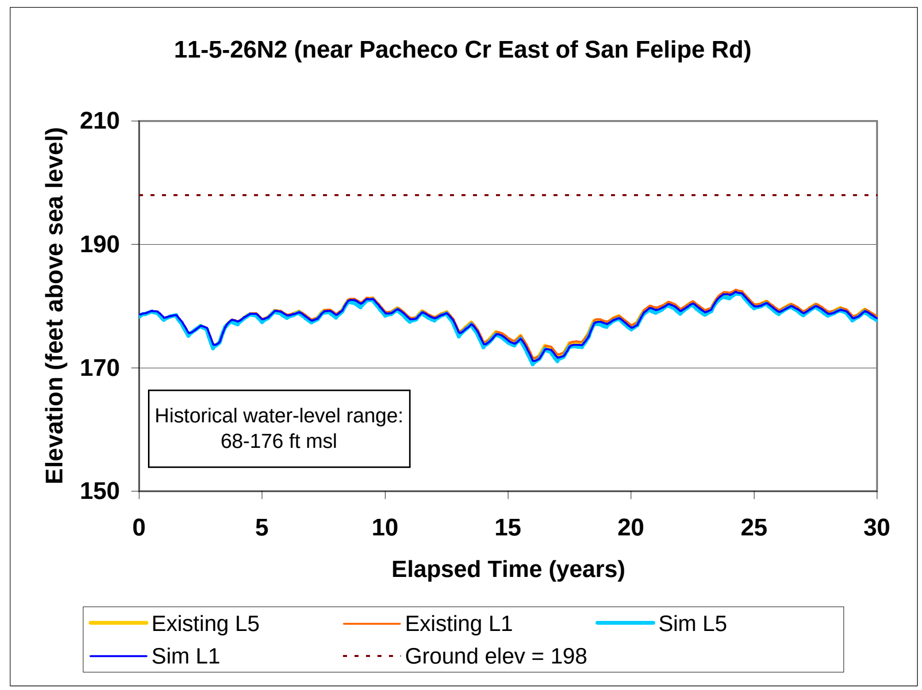
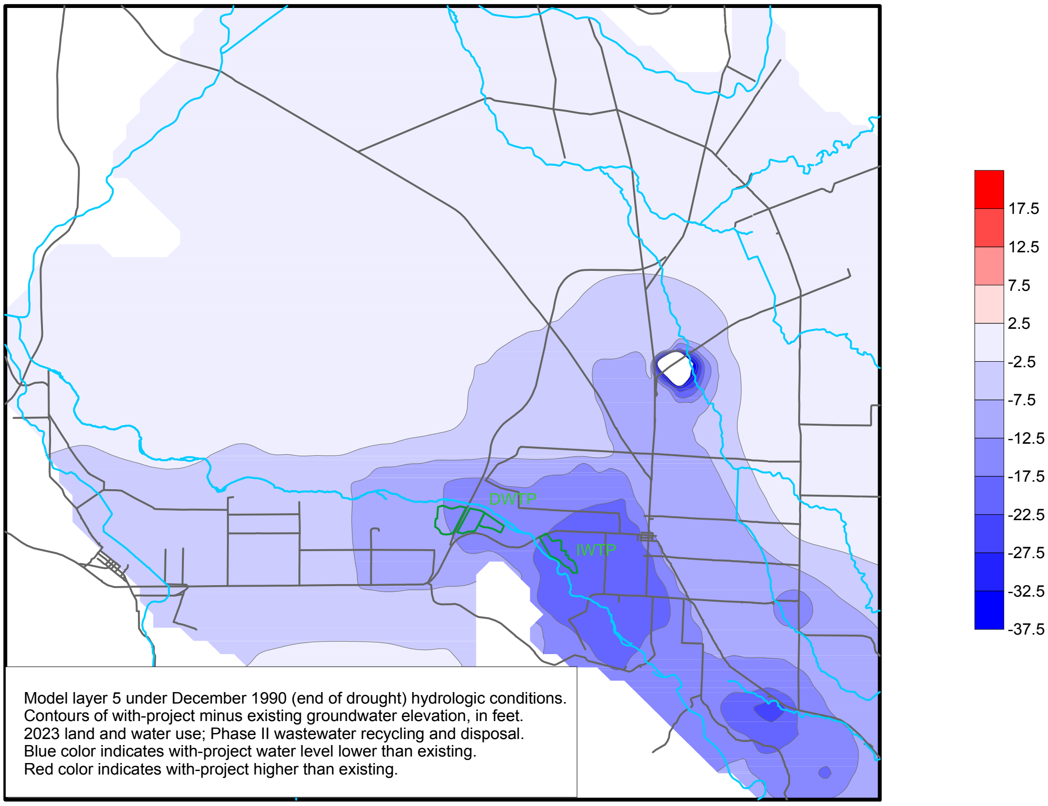
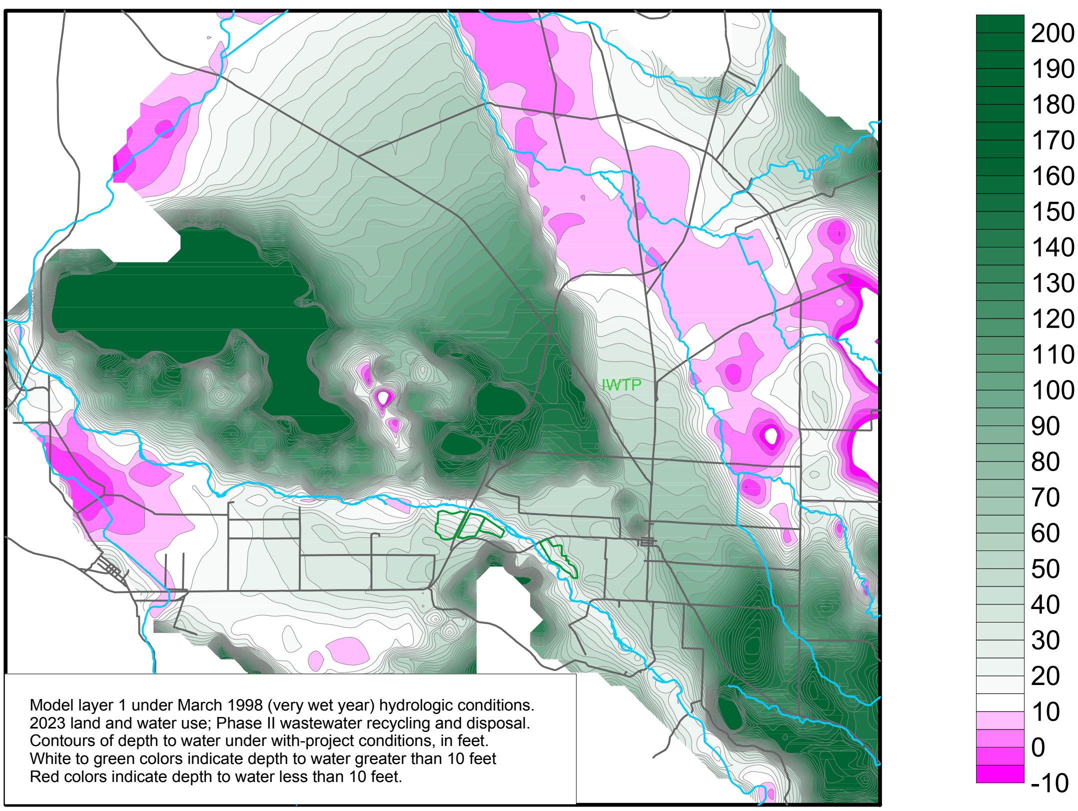


Figure 13 — continued

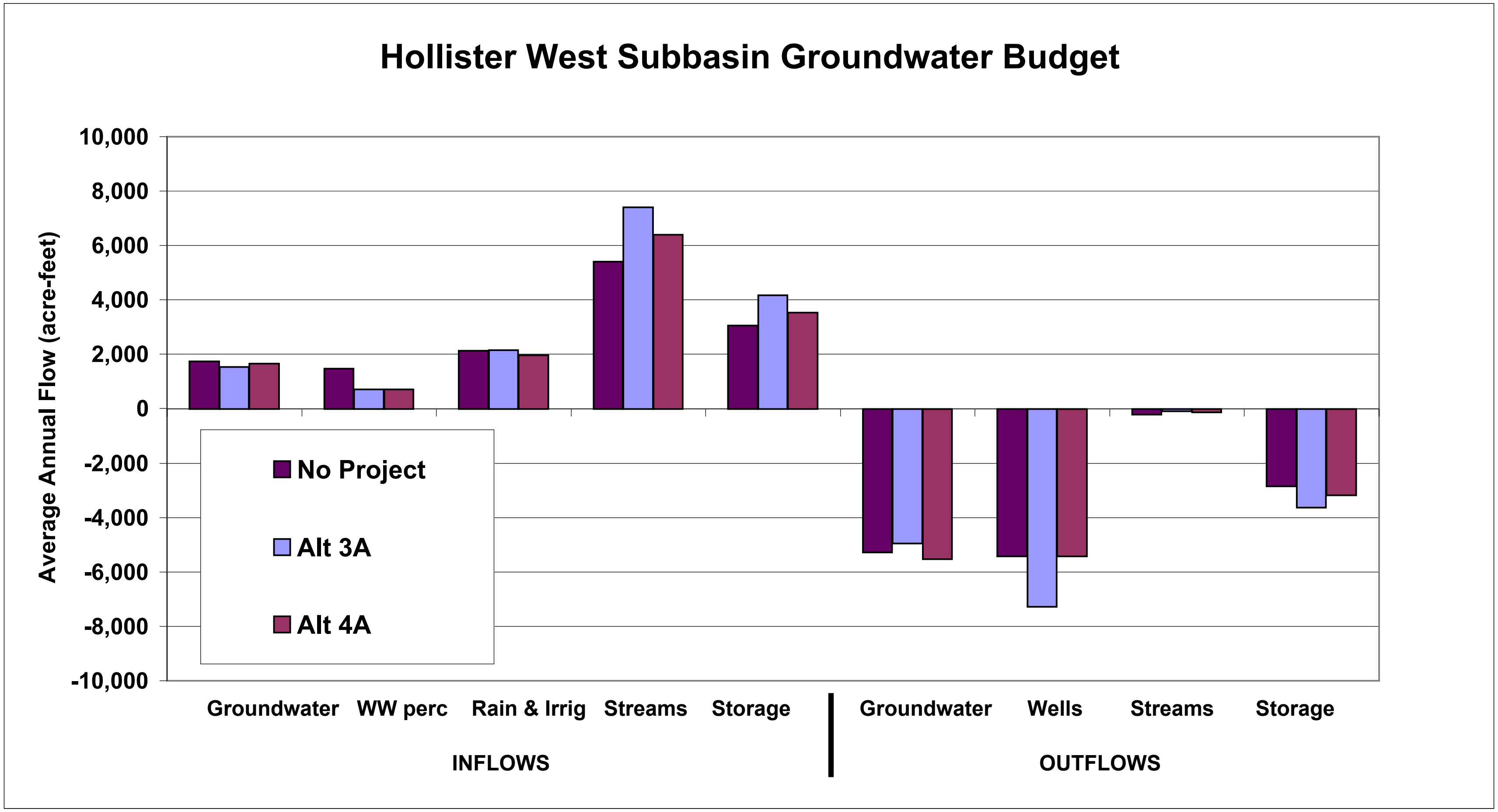


A. Maximum Change in Water Level in Deep Aquifers from Existing Conditions to Alternative 3A



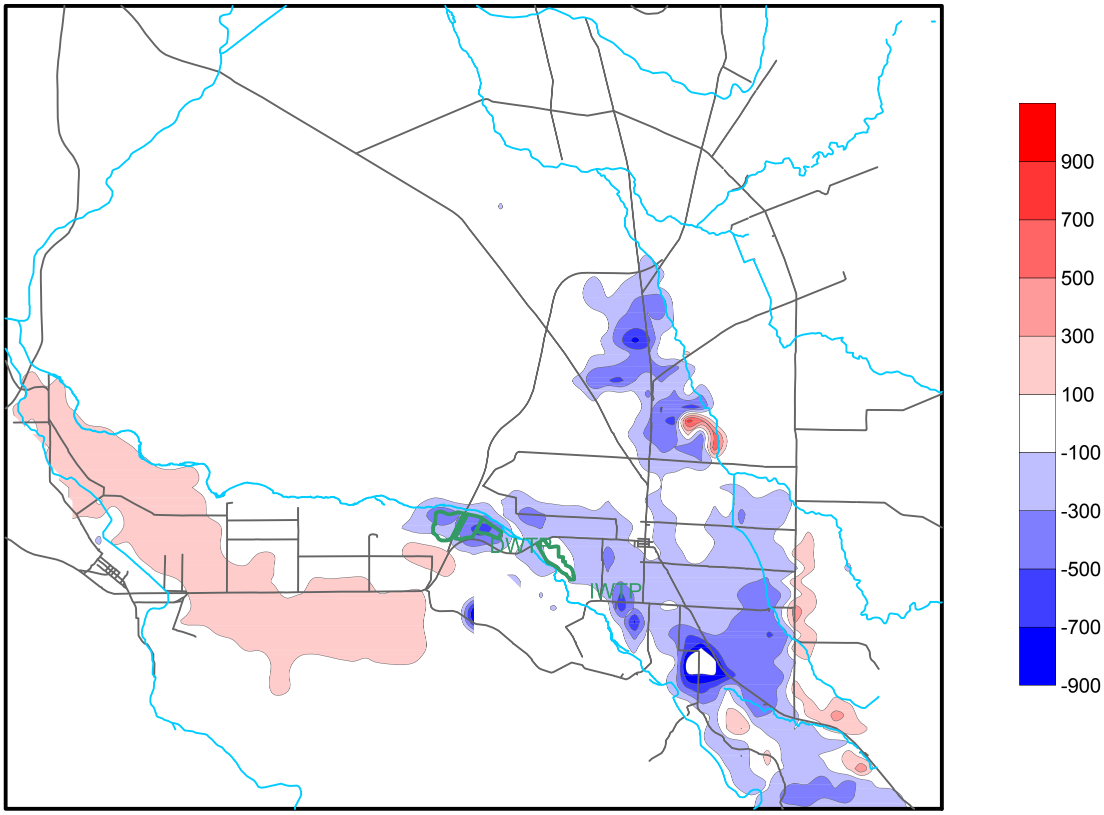
B. Minimum Depth to Groundwater in Shallow Aquifers under Alternative 3A

Figure 14. Effects of Alternative 3A on Deep and Shallow Groundwater Levels under 2023 Conditions

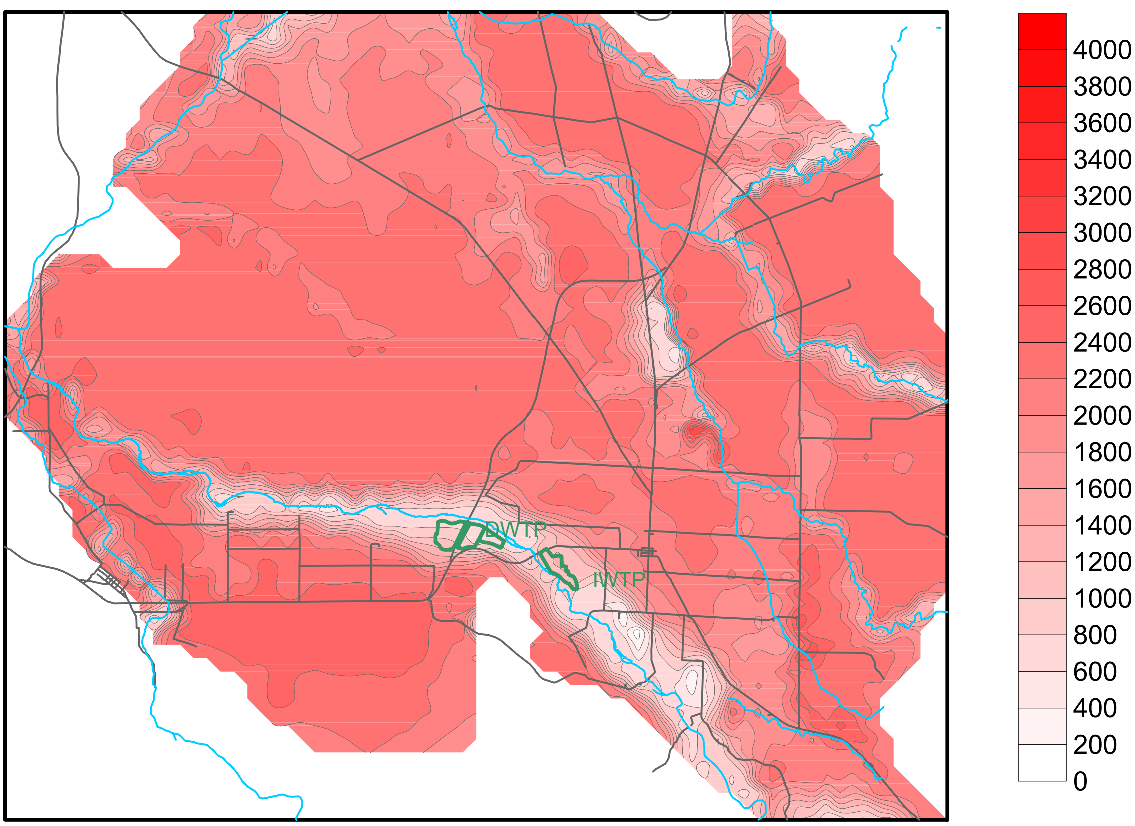


Note: budgets are averaged over years 7-21 of each simulation, corresponding to hydrologic conditions during water years 1981-1995.

Figure 15. Comparison of Average Annual Water Budgets in the Hollister West Subbasin under Existing and With-Project Conditions



A. Change in Groundwater TDS Concentration in Model Layer 1



B. Groundwater TDS Concentration in Model Layer 1

Figure 16. Effects of 30 Years of Alternative 3A on Shallow Groundwater Salinity under 2023 Conditions

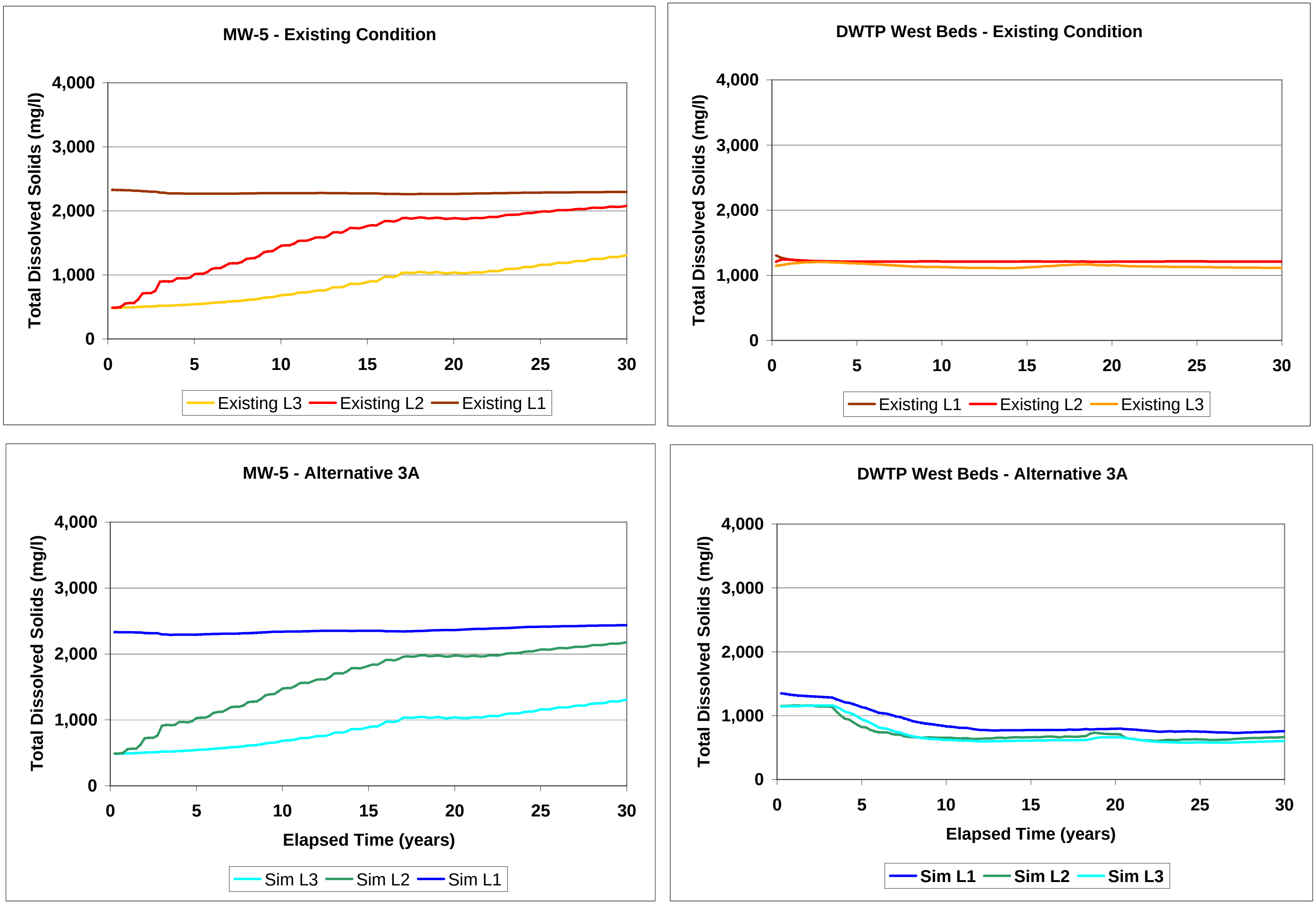
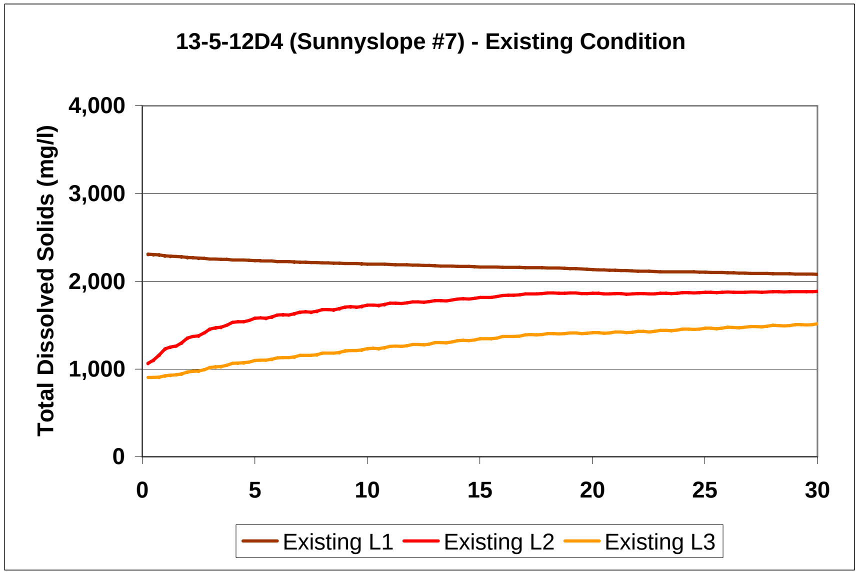
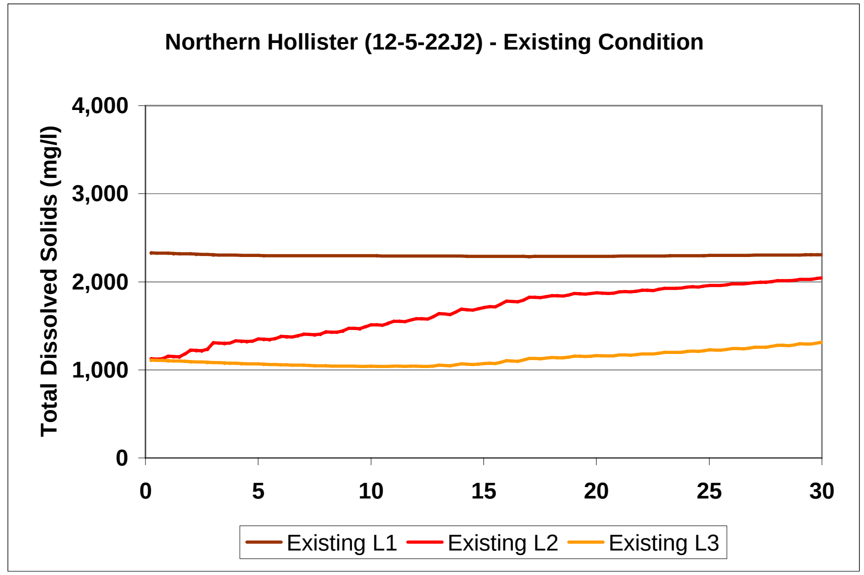
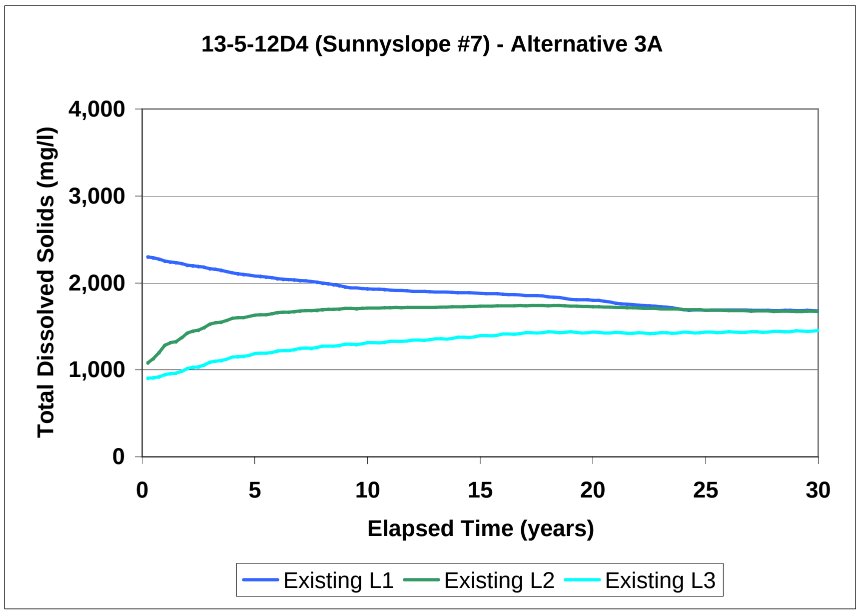


Figure 17. Effects of Alternative 3A on Trends in Groundwater Salinity in Model Layers 1-3







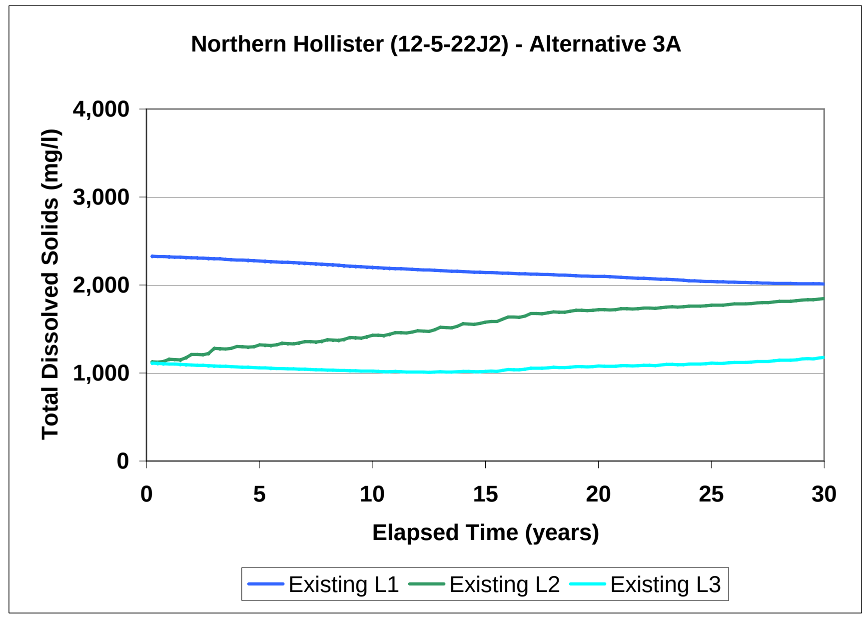


Figure 17 — continued

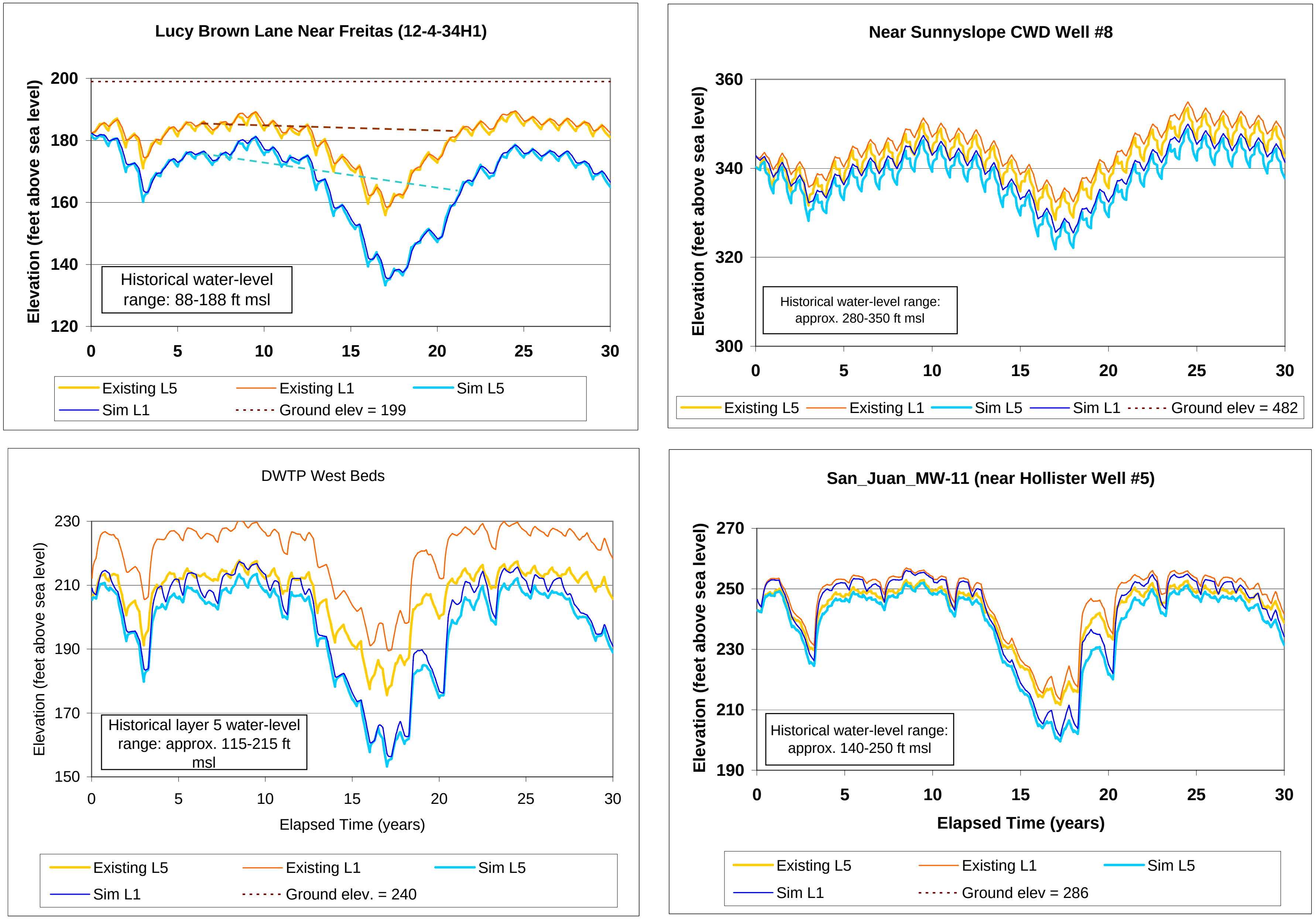


Figure 18. Hydrographs of Simulated Groundwater Elevation at Selected Locations under Alternative 4A

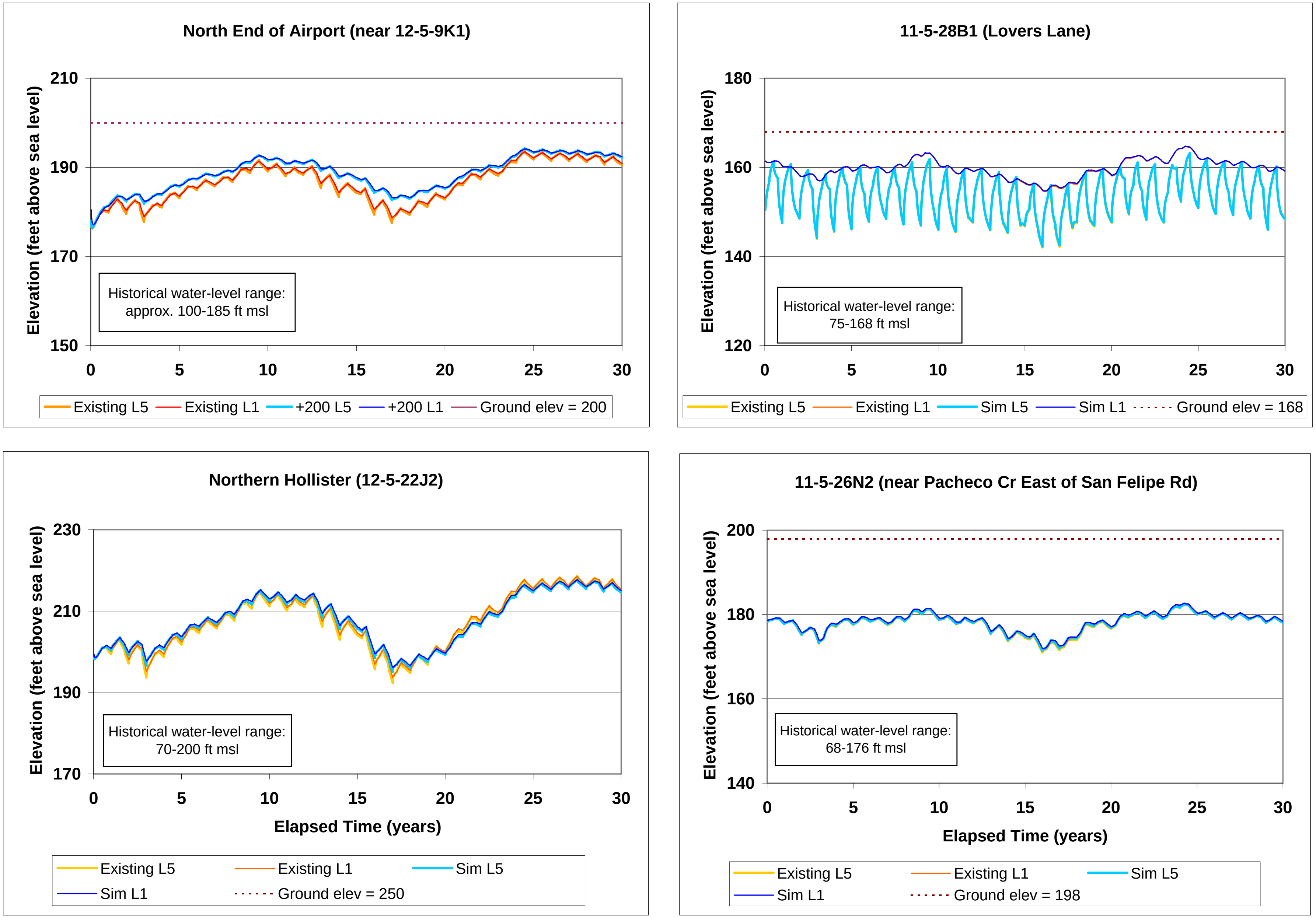
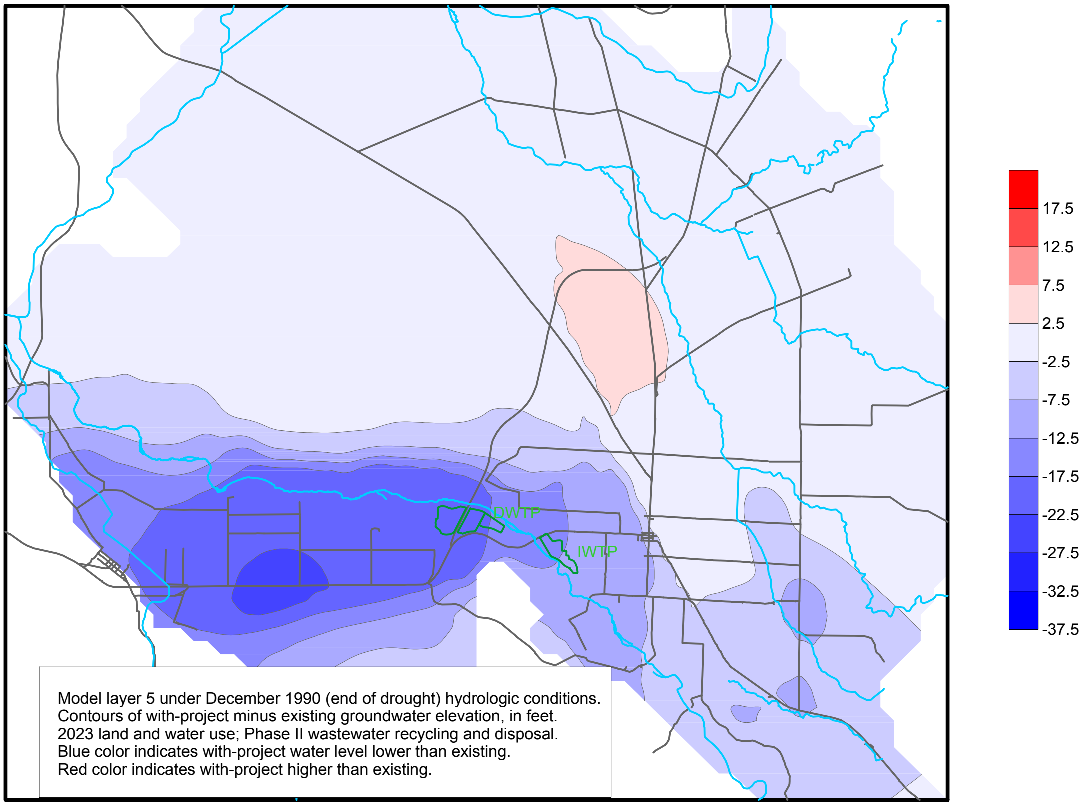
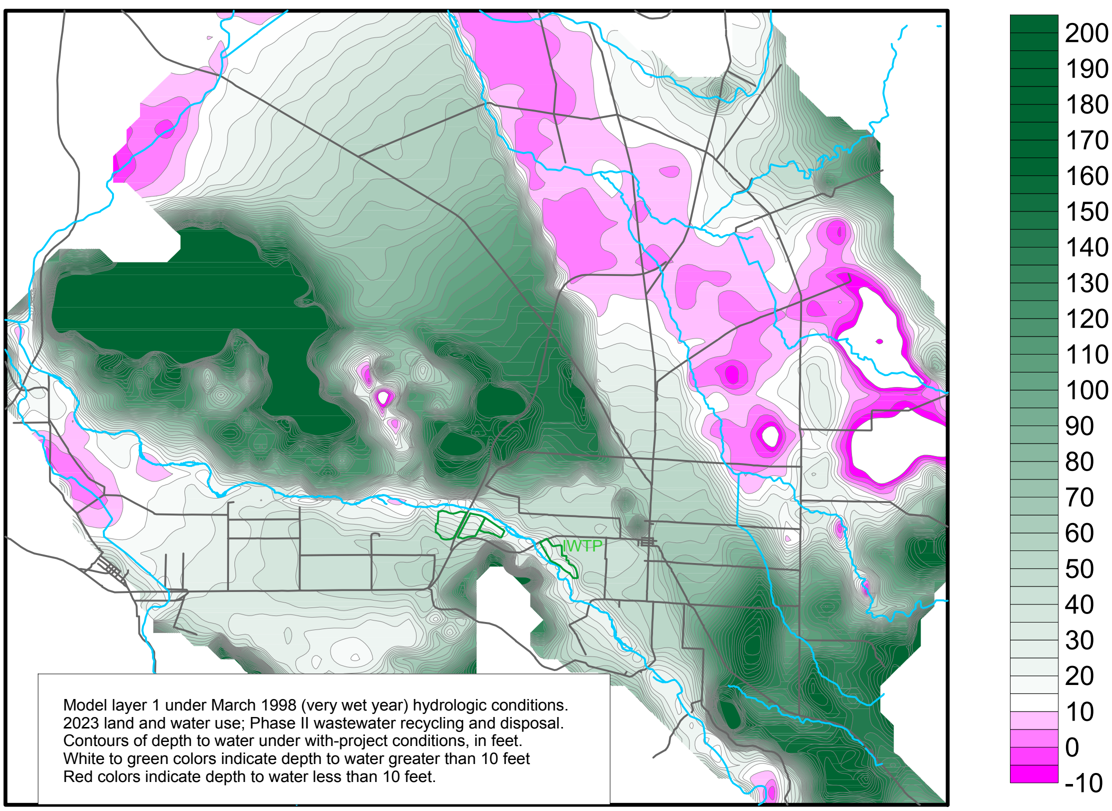


Figure 18 — continued

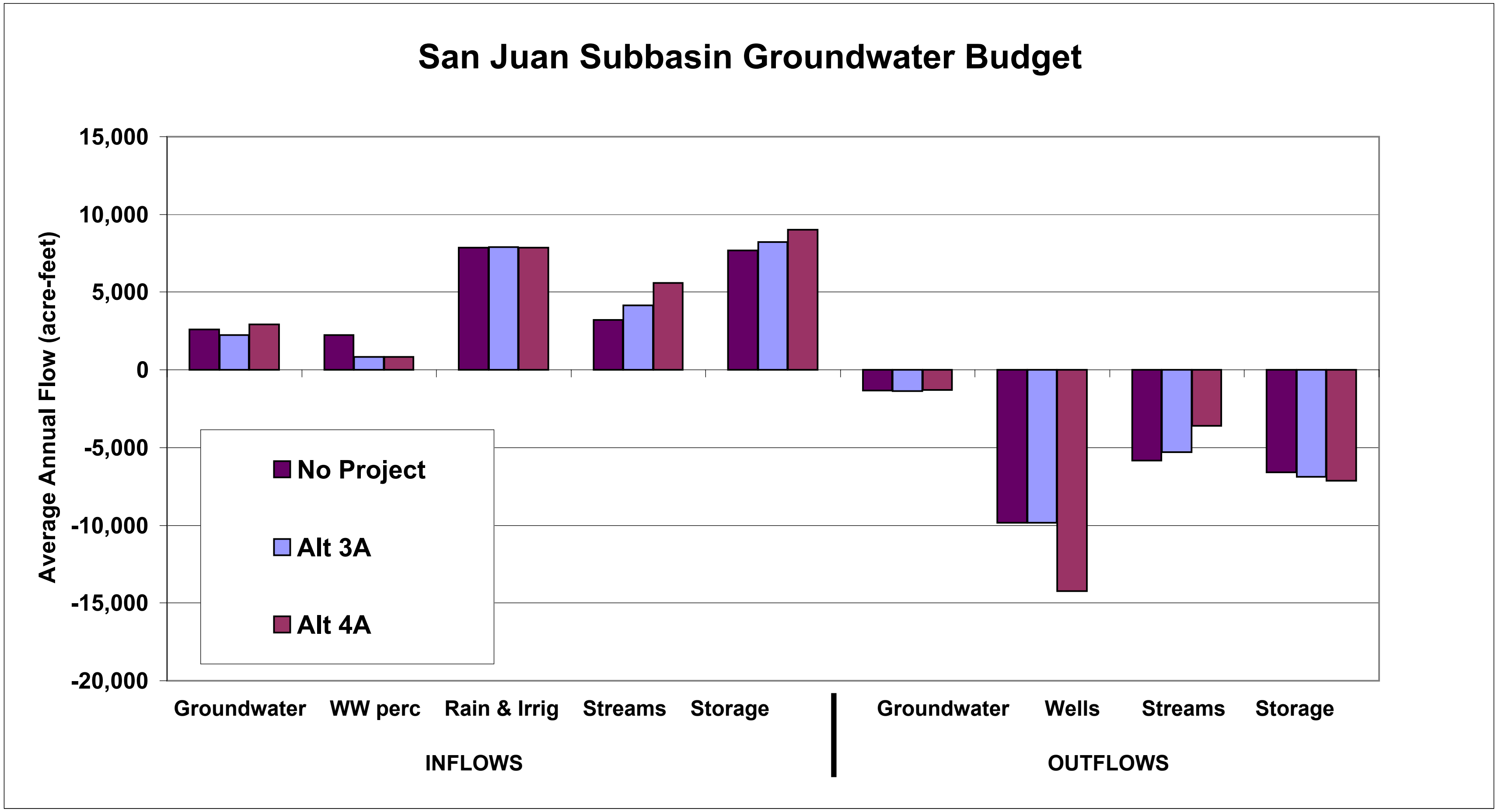


A. Maximum Change in Water Level in Deep Aquifers from Existing Conditions to Alternative 4A



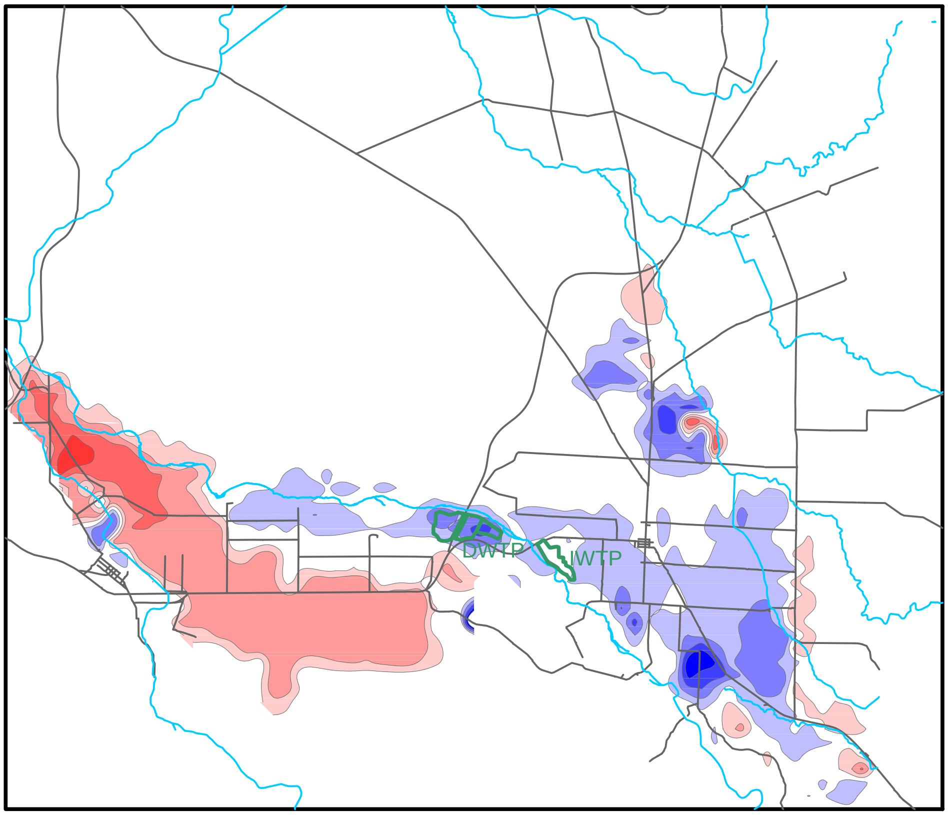
B. Minimum Depth to Groundwater in Shallow Aquifers under Alternative 4A

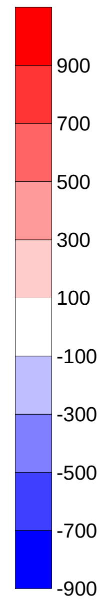
Figure 19. Effects of Alternative 4A on Deep and Shallow Groundwater Levels under 2023 Conditions



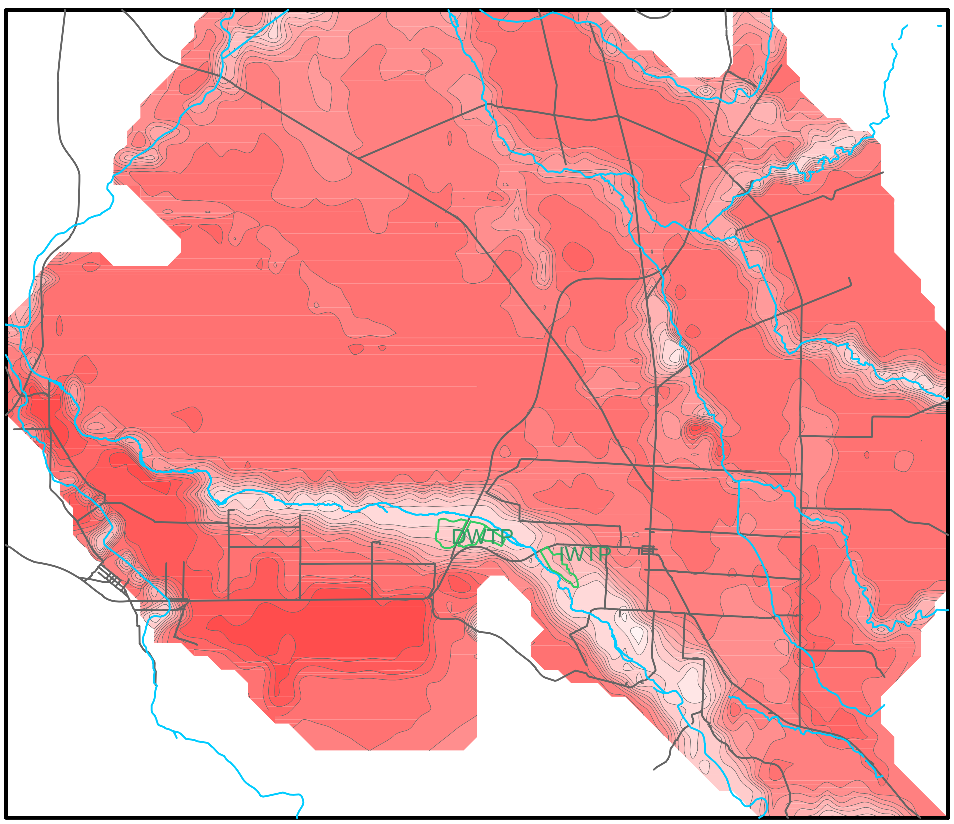
Note: budgets are averaged over years 7-21 of each simulation, corresponding to hydrologic conditions during water years 1981-1995.

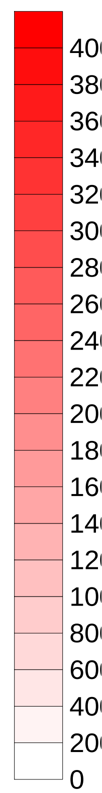
Figure 20. Comparison of Average Annual Water Budgets for the San Juan Subbasin under Existing and With-Project Conditions





A. Change in Groundwater TDS Concentration in Model Layer 1





B. Groundwater TDS Concentration in Model Layer 1

Figure 21. Effects of 30 Years of Alternative 4A on Shallow Groundwater Salinity under 2023 Conditions

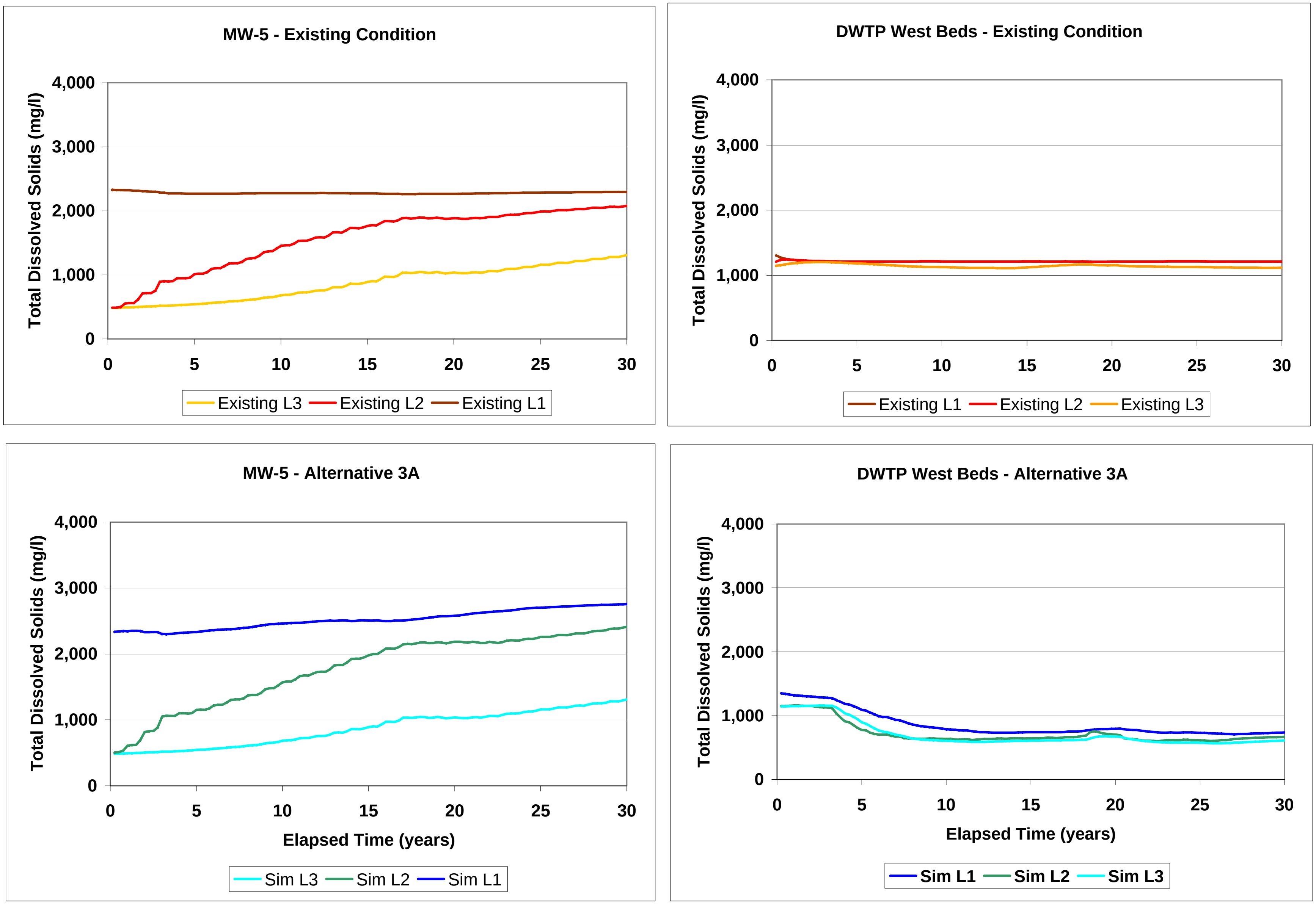
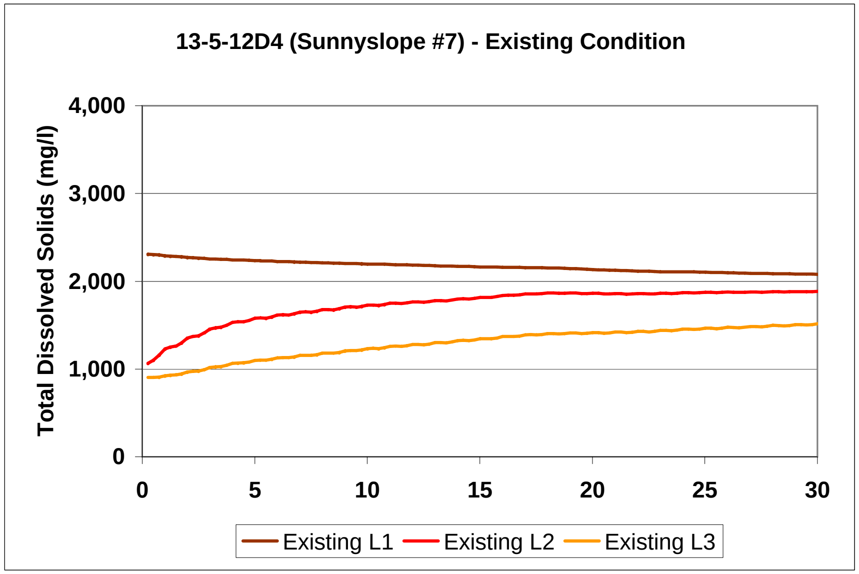
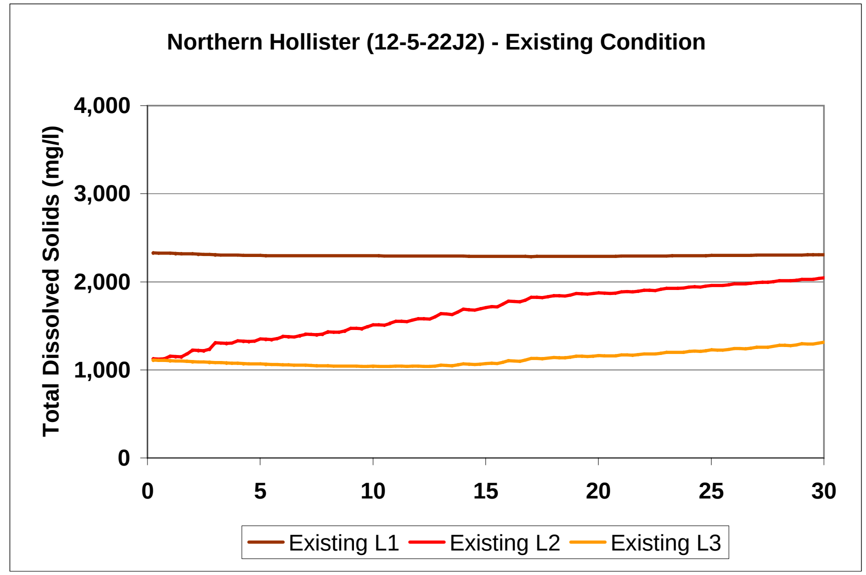
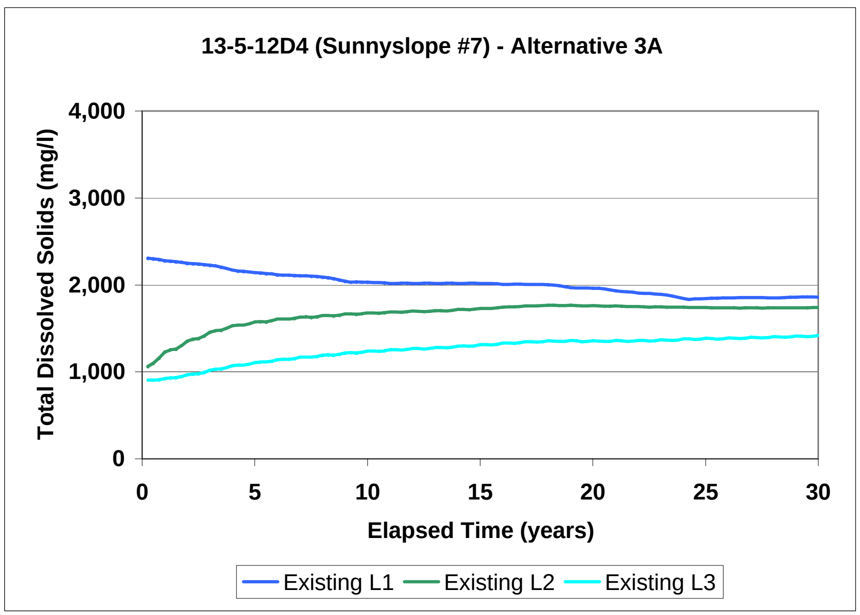


Figure 22. Effects of Alternative 4A on Trends in Groundwater Salinity in Model Layers 1-3







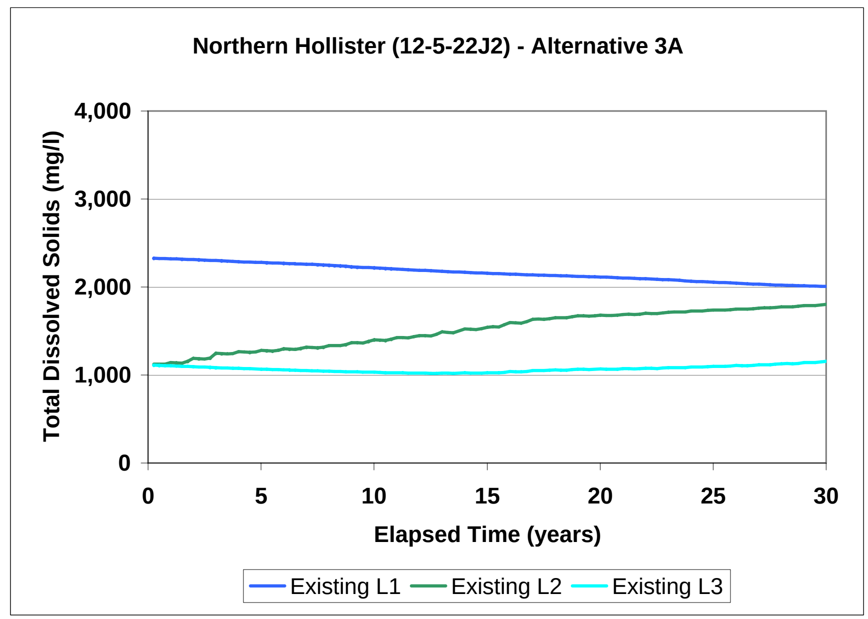


Figure 22 — continued

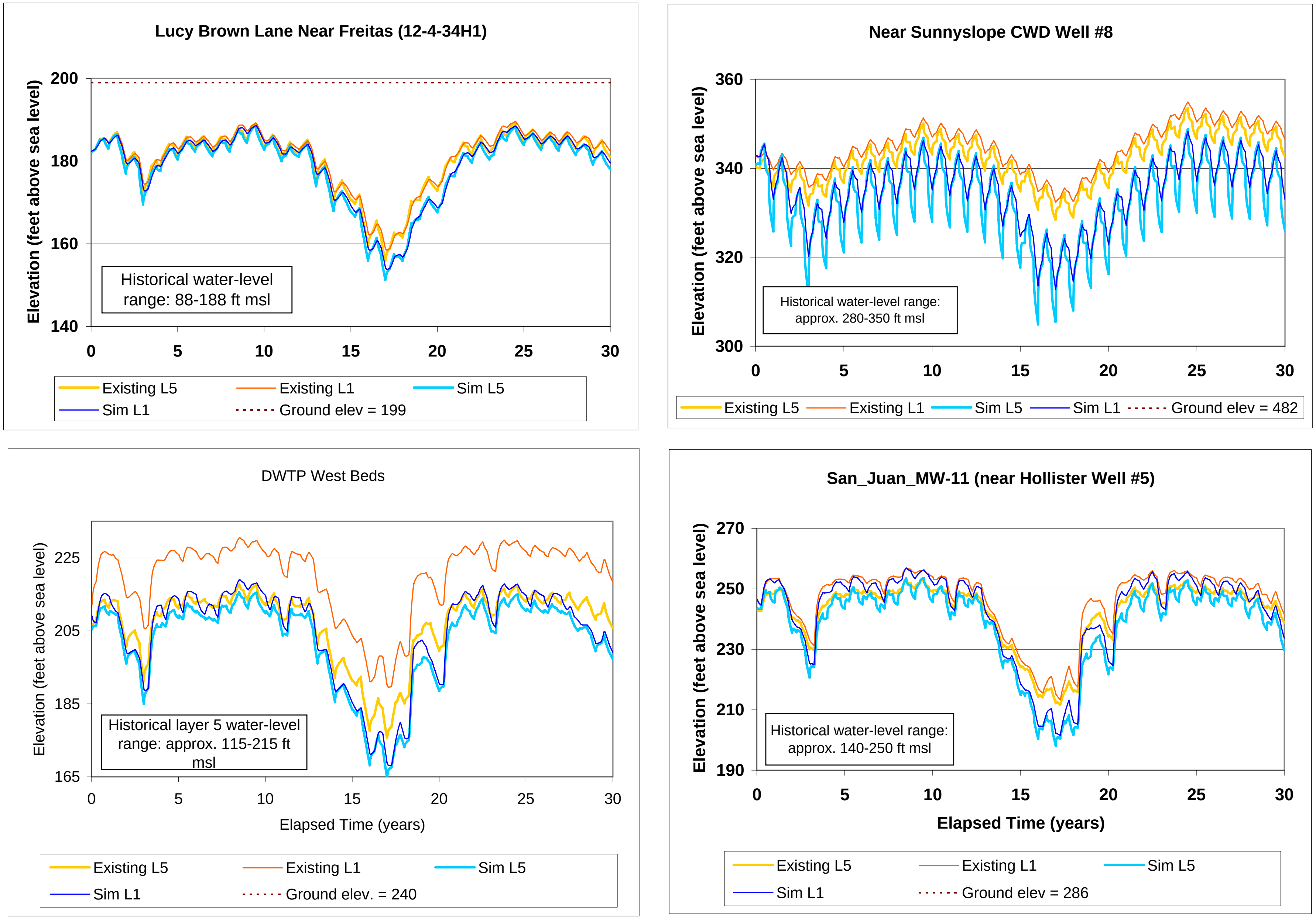


Figure 23. Hydrographs of Simulated Groundwater Elevation at Selected Locations under Alternative 4B

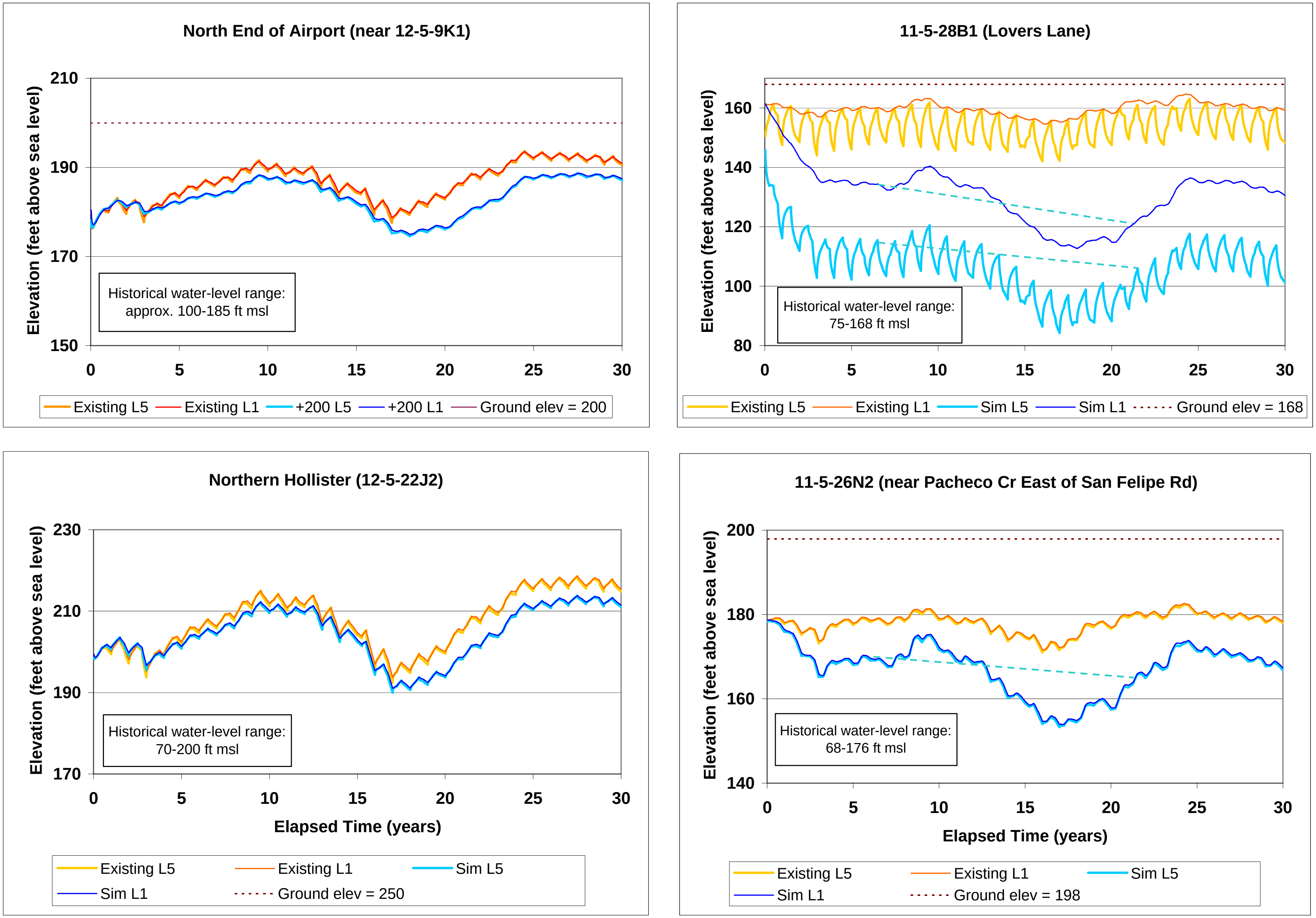
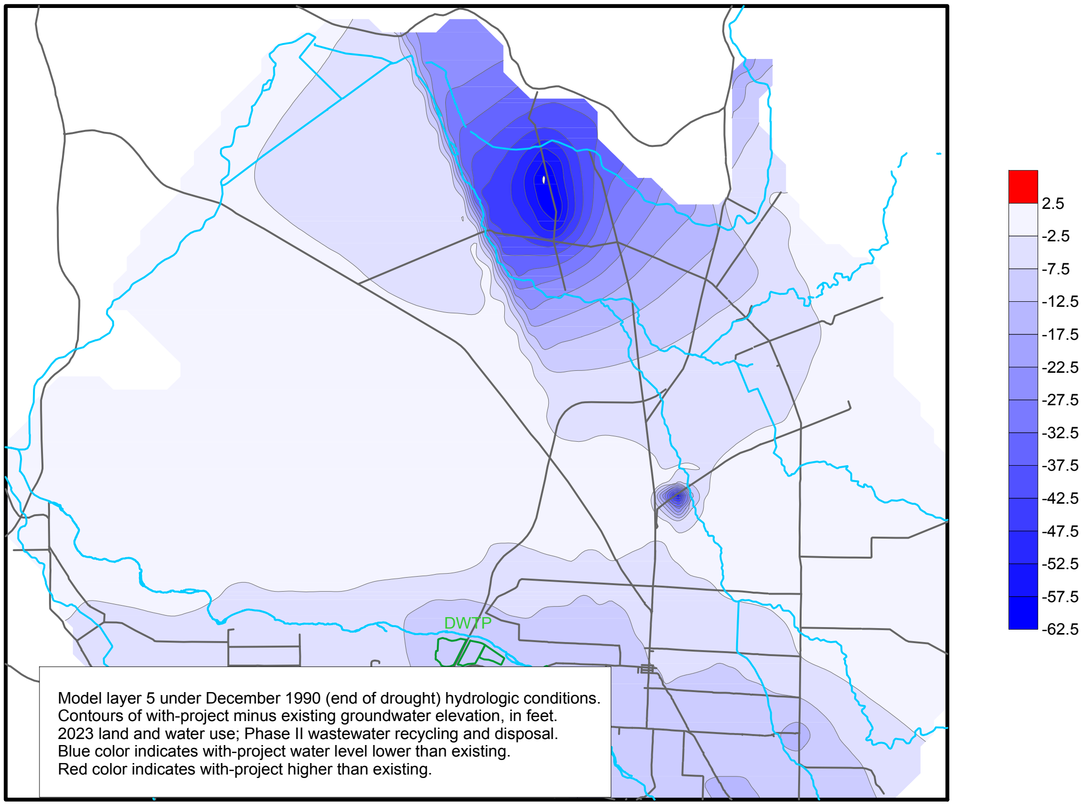
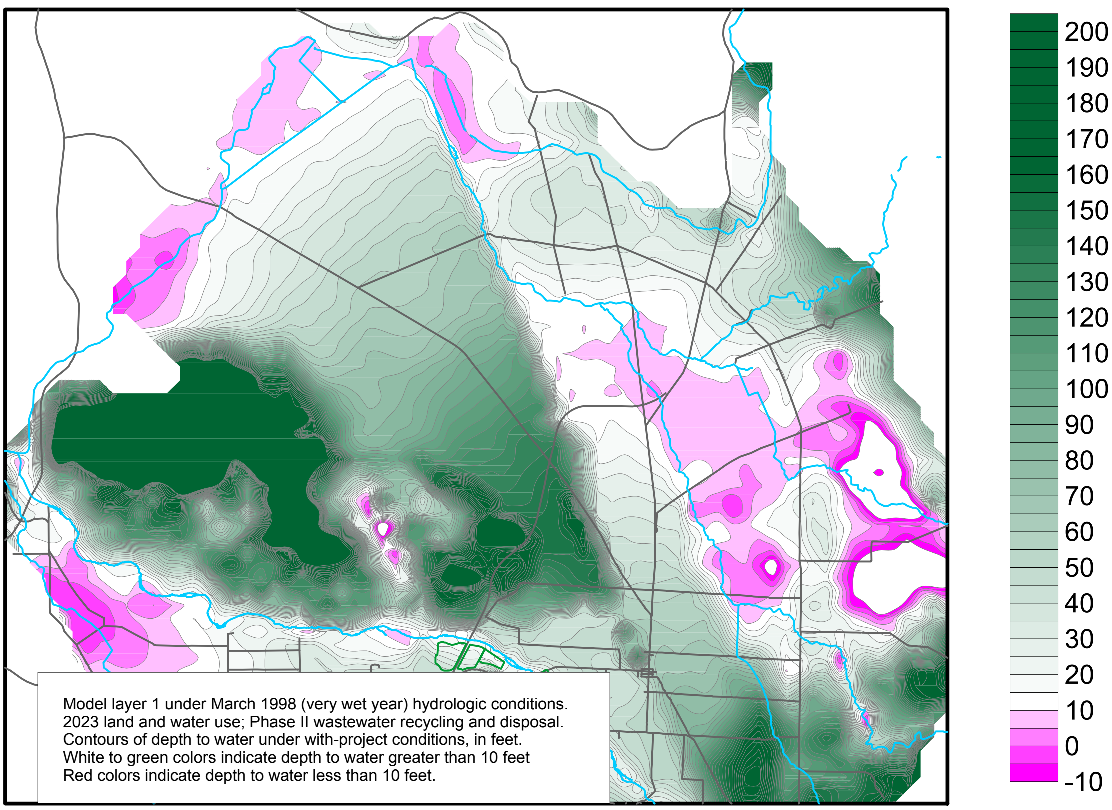


Figure 23 — continued

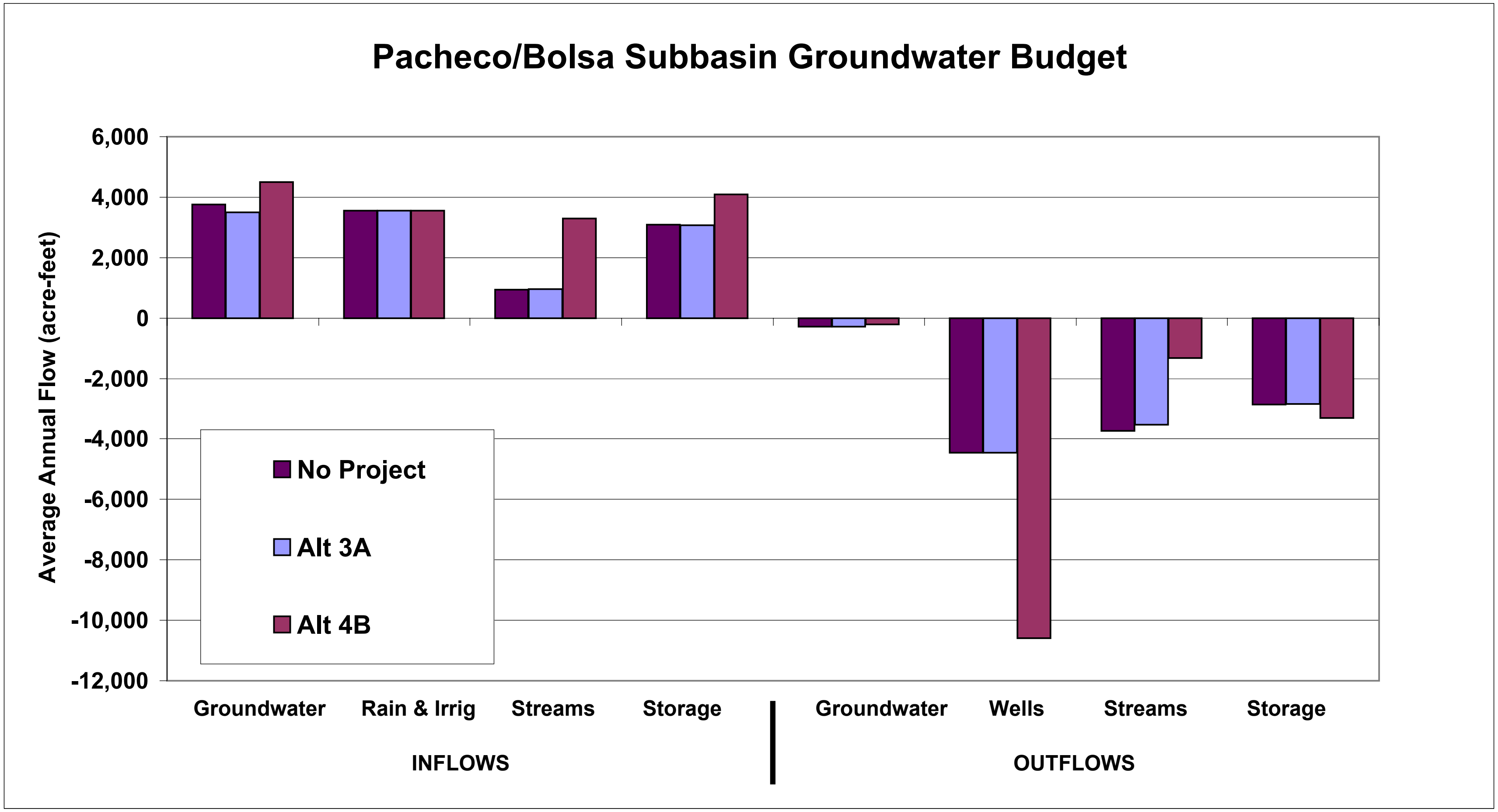


A. Maximum Change in Water Level in Deep Aquifers from Existing Conditions to Alternative 4B



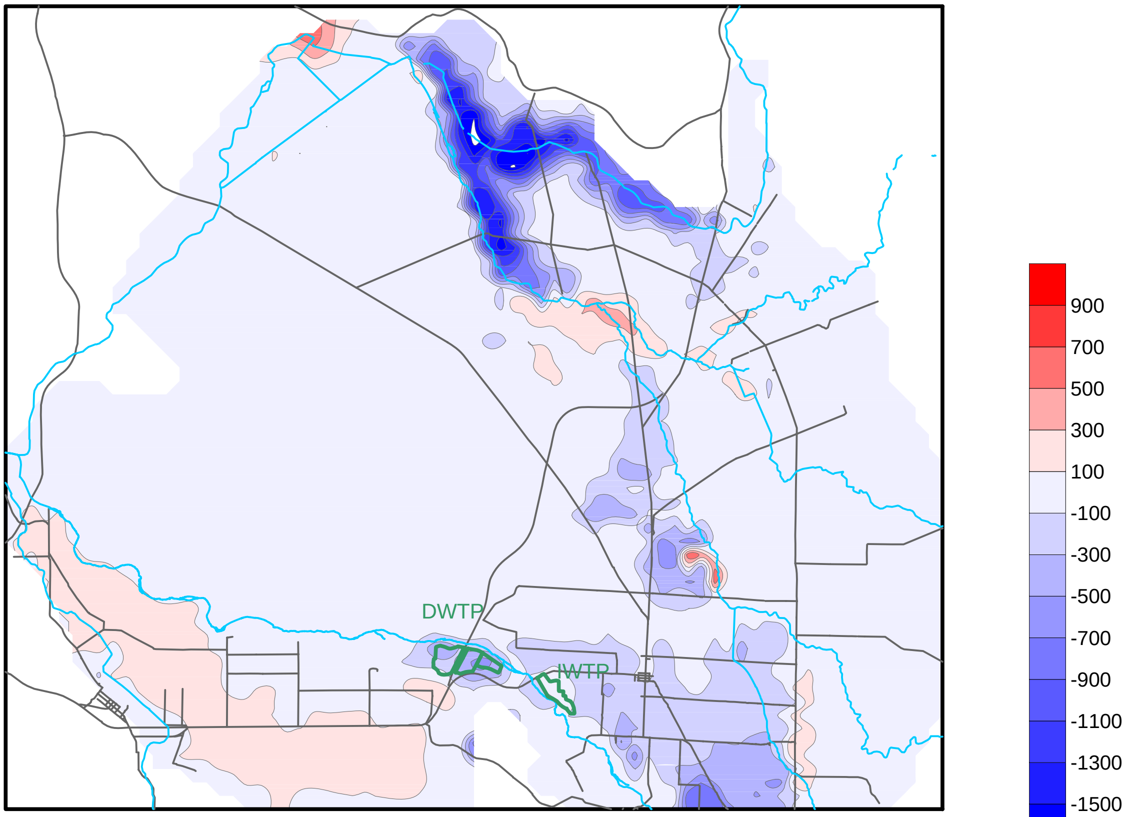
B. Minimum Depth to Groundwater in Shallow Aquifers under Alternative 4B

Figure 24. Effects of Alternative 4B on Deep and Shallow Groundwater Levels under 2023 Conditions

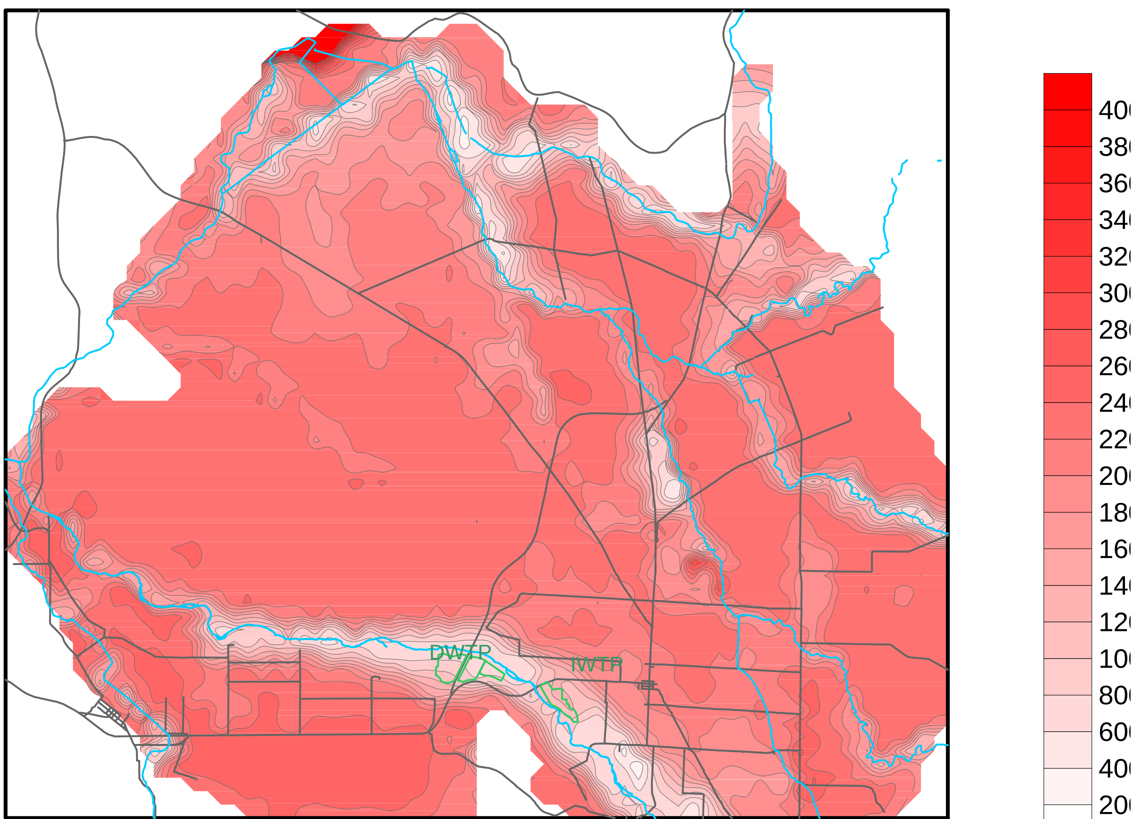


Note: budgets are averaged over years 7-21 of each simulation, corresponding to hydrologic conditions during water years 1981-1995.

Figure 25. Comparison of Average Annual Water Budgets for the Pacheco-Bolsa Area East of the Calaveras Fault under Existing and With-Project Conditions



A. Change in Groundwater TDS Concentration in Model Layer 1



B. Groundwater TDS Concentration in Model Layer 1

Figure 26. Effects of 30 Years of Alternative 4B on Shallow Groundwater Salinity under 2023 Conditions

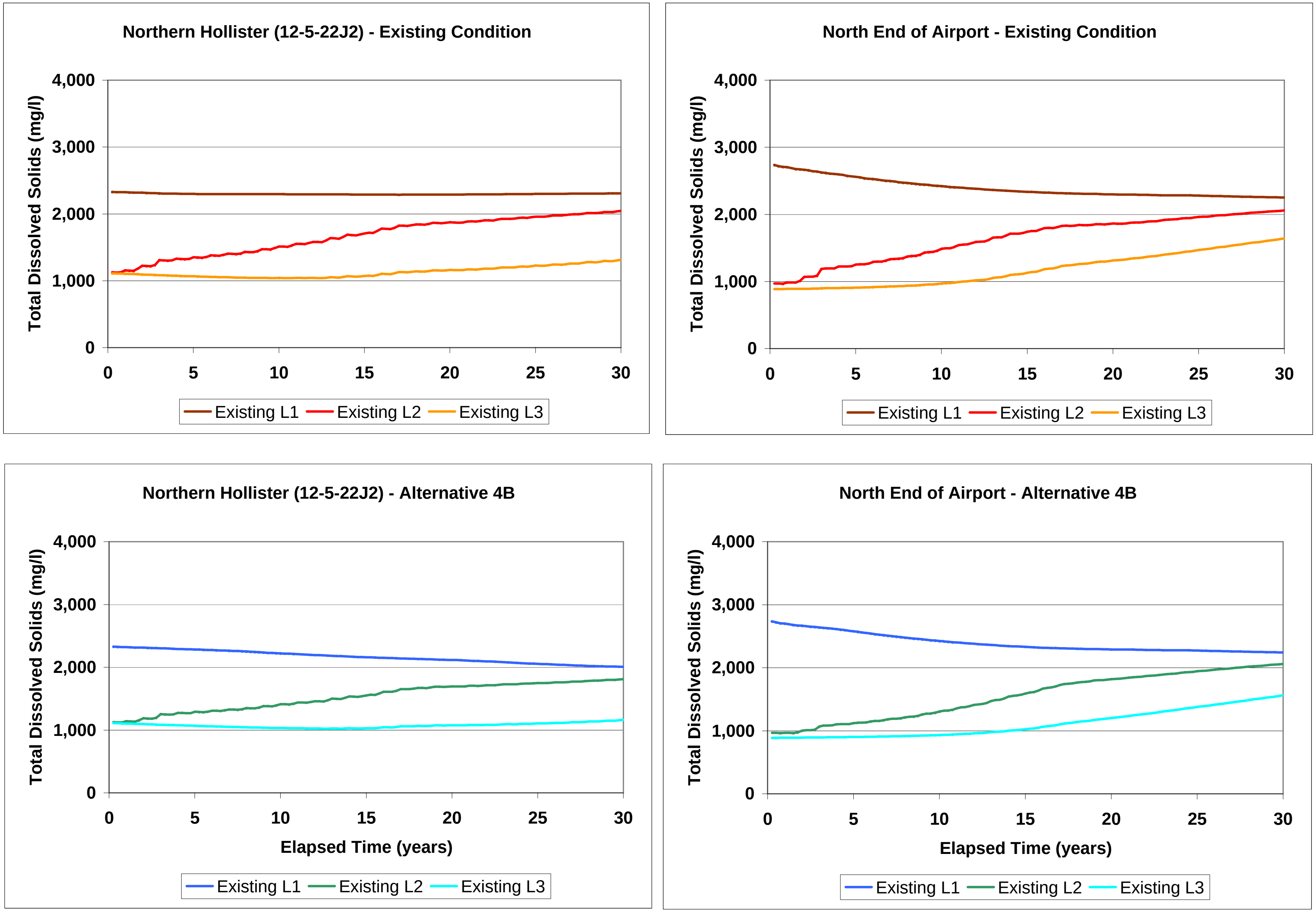


Figure 27. Effects of Alternative 4B on Trends in Groundwater Salinity in Model Layers 1-3

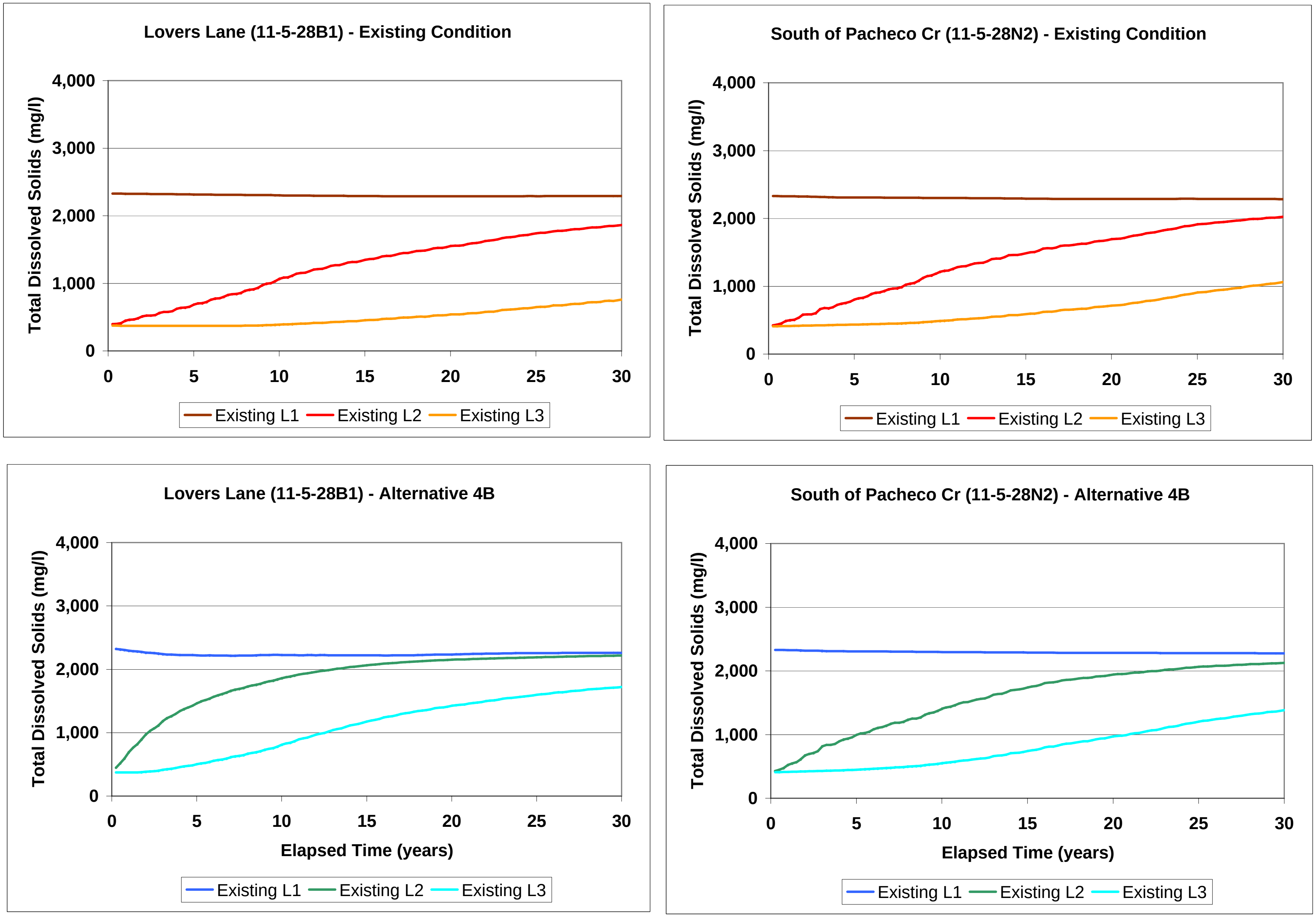


Figure 27 — continued

MEMORANDUM

Gus Yates, PG, CHg, Consulting Hydrologist • 1809 California Street, Berkeley, CA 94703
tel/fax 510-849-4412 • gusyates@earthlink.net

DATE: 3 January 2007

TO: John Gregg and Jeff Cattaneo, SBCWD
Harry Blohm, HUAWWMP Project Coordinator
Steve Wittry, City of Hollister
Kevin Kennedy and Bob Ellis, HDR Engineering

FROM: Gus Yates, Consulting Hydrologist

SUBJECT: Hollister Urban Area Water and Wastewater Master Plan: Assumptions Regarding Land Use Changes for Recent and Upcoming Groundwater Model Simulations

At our HUAWWMP team meeting on December 1, 2006, I agreed to provide additional details regarding land use changes included in my recent simulations of HUAWWMP alternatives, so that we could jointly agree on the best assumptions to use for upcoming simulations of the "preferred" alternative. This memorandum explains exactly how the model currently includes each of the parcels identified for future urbanization in the City of Hollister general plan. It also describes the locations of agricultural lands that were not irrigated as of 2002, so that we can specify reasonable locations for assumed future expansion of irrigated agriculture.

My recent simulations of Alternatives 2A, 3A, 4A and 4B (see my memo dated December 11, 2006) showed their long-term impacts under future conditions, but did not include the gradual changes in land use, water use, wastewater disposal and water quality expected to occur between now and 2023. In other words, the simulations "jumped ahead" to 2023 conditions. This approach simplified the preparation of the data sets and the interpretation of results. I assume that for upcoming simulations of a "preferred alternative", I will return to the fully transient simulation of the gradual changes during 2005-2023 that I used for the recent wastewater EIR.

Urbanization Identified in City of Hollister General Plan

The recent update to the City of Hollister's general plan identified land use changes expected over the next 20 years at a very detailed, parcel-by-parcel level. **Figure 1** is a copy of the map showing the parcels where land use changes are expected, indicating the future land use and approximate date of conversion. I assumed that by 2023 all conversions in groups 1, 2 and 3 would be complete and that none of the conversions in the buildout (BO) group had occurred. For the upcoming fully-transient simulations, I will assume that parcels in groups 1, 2 and 3 convert in 2010, 2015 and 2020, respectively, consistent with my assumption for the wastewater EIR. **Figure 2** shows the land use changes and dates at a general level. It also shows, for your reference, the locations of retired irrigation wells, new municipal wells and new irrigation wells that I assumed in the wastewater EIR simulations and will assume for the upcoming preferred-alternative simulation.

Figure 3 is an index map of the urbanizing parcels shown in **Figure 1**, but uniquely labeled for discussion purposes. All of the BO parcels are labeled “X” and were assumed to remain in their existing land use for all simulations. Small parcels (less than about 5 acres) are labeled “Y” and were too small to accurately represent with the current model grid. Most of them are infill parcels that were included in the Hollister urban zone in the simulation of existing conditions (that is, they were implicitly assumed to be urbanized already).

All of the other urbanizing parcels in **Figure 3** are numbered sequentially, and their respective existing and future land use characteristics are listed in **Table 1**. The recharge zone number refers to geographic areas in the model where recharge from rainfall and irrigation is uniform and distinct enough from adjacent areas to warrant simulating separately. These zones are refinements of zones I delineated years ago on the basis of soil type, crop type and irrigation status. I subdivided many of those zones for the wastewater EIR and HUAWWMP projects to increase the spatial detail of land use in the sprayfields and urban areas. The “land use” columns in the table are very brief descriptions of the assumed land use. I did not include a column indicating soil type, which does not change with urbanization. However, differences in soil type explain why zones with the same crop type can have different recharge rates.

Table 1 also lists my assumptions regarding the source of irrigation water for each zone, which affects the calculated salinity of deep percolation. In urban areas, the irrigation supply for irrigated landscaping is assumed to be the municipal supply. Under future conditions, I assume that the municipal supply for all alternatives consists of a combination of CVP water and demineralized groundwater with a blended TDS of 265 mg/l. For existing land uses, I based the percentages of groundwater and CVP water for the municipal supply based on recent Lessalt and municipal well production. The percentages for agricultural zones are based on water use data from the District’s billing database, averaged by subbasin. The table also lists the average annual irrigation rate and groundwater recharge rate for each zone. In urban areas, the irrigation rate applies to the irrigated percentage of the zone only, whereas the groundwater recharge rate is the area-weighted average for the entire zone.

An additional assumption in the soil-moisture-budget and recharge calculations that the HUAWWMP team might want to review regards recharge from impervious area runoff. In urban areas, a percentage of the runoff from impervious areas is assumed to flow to adjacent pervious soils, where it infiltrates and immediately percolates through the root zone to become recharge. That is, evapotranspiration (ET) by vegetation in the runoff collection areas is assumed to be met by the rainfall landing on those areas, so no ET losses are subtracted from the runoff. The remaining impervious runoff is assumed to be lost as surface outflow via storm drains and ditches to nearby creeks and rivers. The percentage of each land use area assumed to be covered by impervious surfaces is listed in **Table 2**, along with the percentage of impervious runoff assumed to become groundwater recharge.

Table 2. Parameters for Estimating Recharge from Impervious Area Runoff

Land Use	Percent Impervious	Percent of Impervious Runoff that Becomes Recharge
Rural residential	15	50
Medium-density residential	35	20
Commercial/industrial	80	10
Airport runways	40	50

Figure 4 shows how land use zones are assigned to cells in the model grid. The grid spacing is finer (250 x 250 feet) near the DWTP and IWTP and coarser in other areas (up to 1000 x 1000 feet), as is evident by the size of the rectilinear stair-steps in the zone boundaries. The maximum cell size has an area of 23 acres, which is why some small parcels are difficult to simulated individually. The zone labels correspond to the entries in the "model recharge zone" column on **Table 1**.

Future Expansion of Irrigated Lands

The only future expansion of irrigated lands included in my recent simulations of HUAWWMP alternatives was the strip along the east side of Fairview Road between Santa Ana Valley Road and the Airline Highway, which is labeled as zone 35 in **Figure 4**. John Gregg and Jeff Cattaneo have already indicated that this zone should be farther north. More importantly, they also requested that the simulations include a general expansion of irrigated area in other parts of the basin, consistent with the groundwater management plan (GMP). That plan estimated that irrigated cropland in the northern part of San Benito County would increase by approximately 17,000 acres from the amount irrigated in 2002 (approximately 36,000 acres). We need to agree on the assumed locations of the newly irrigated lands.

Figure 5 shows nonirrigated lands as mapped by the California Department of Water Resources in its most recent land use survey (2002). I have grouped the nonirrigated cropland parcels into various geographic categories, and the total nonirrigated area in each category is listed in **Table 3**. I also showed parcels with access to the CVP distribution system but that presently do not use that source of supply ("blind flange" parcels). These parcels amount to a small fraction of the total basin area, and most of them are in areas mapped as irrigated (presumably by groundwater). There were approximately 10,600 acres of nonirrigated land within Zone 6 in 2002, mostly clustered north of the airport and in the foothills east of Fairview Road. An additional 9,200 acres of nonirrigated land were present in the Bolsa area. Together, those two categories of nonirrigated lands would meet the irrigation expansion anticipated in the GMP. However, some of those nonirrigated lands will become urbanized instead. Also, it is reasonably likely that some of the irrigation expansion will occur in the Paicines and Tres Pinos Creek Valley areas. We need to jointly identify 17,000 acres of nonirrigated land assumed to become irrigated in simulations of future conditions.

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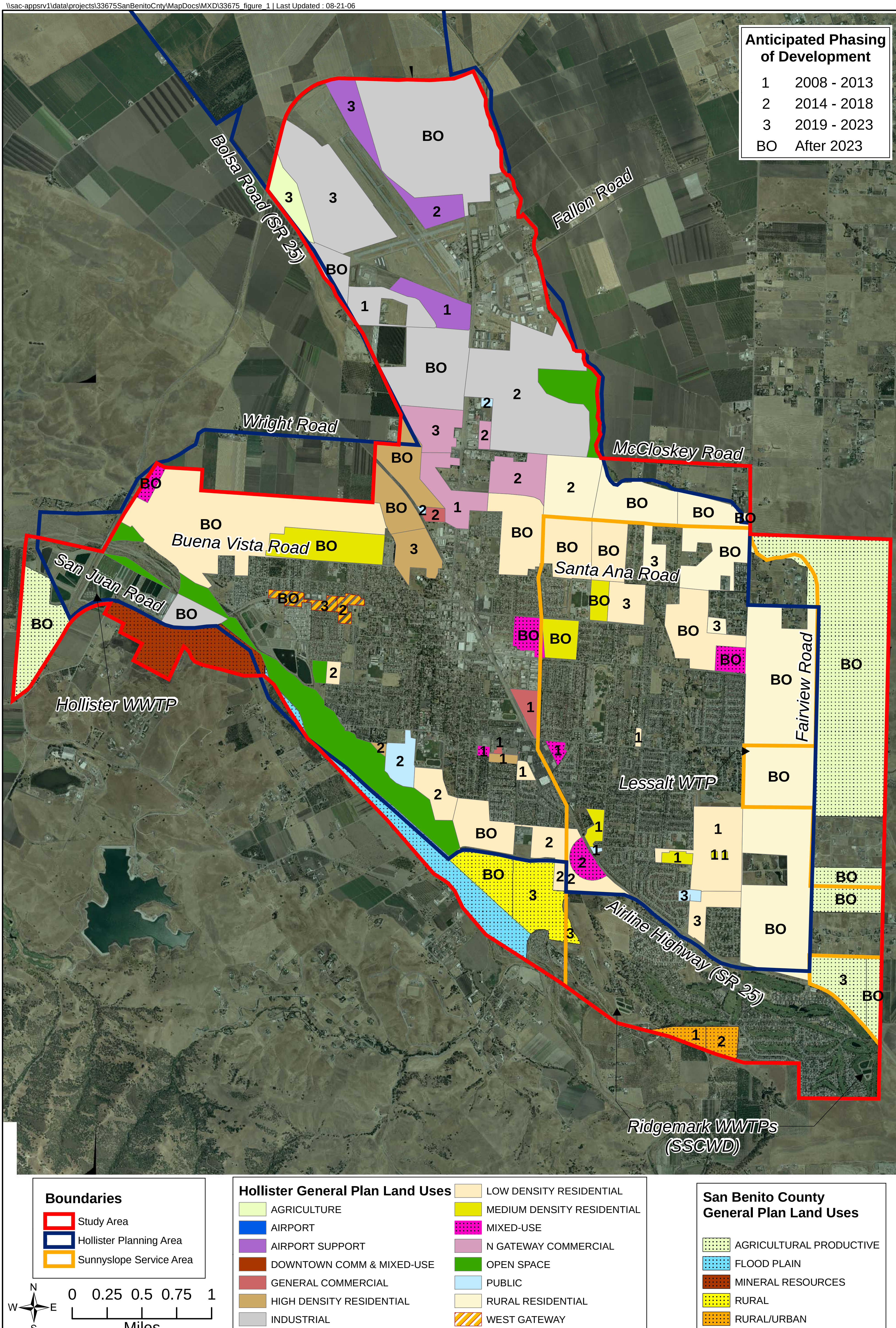

Future Land Uses

FIGURE 1

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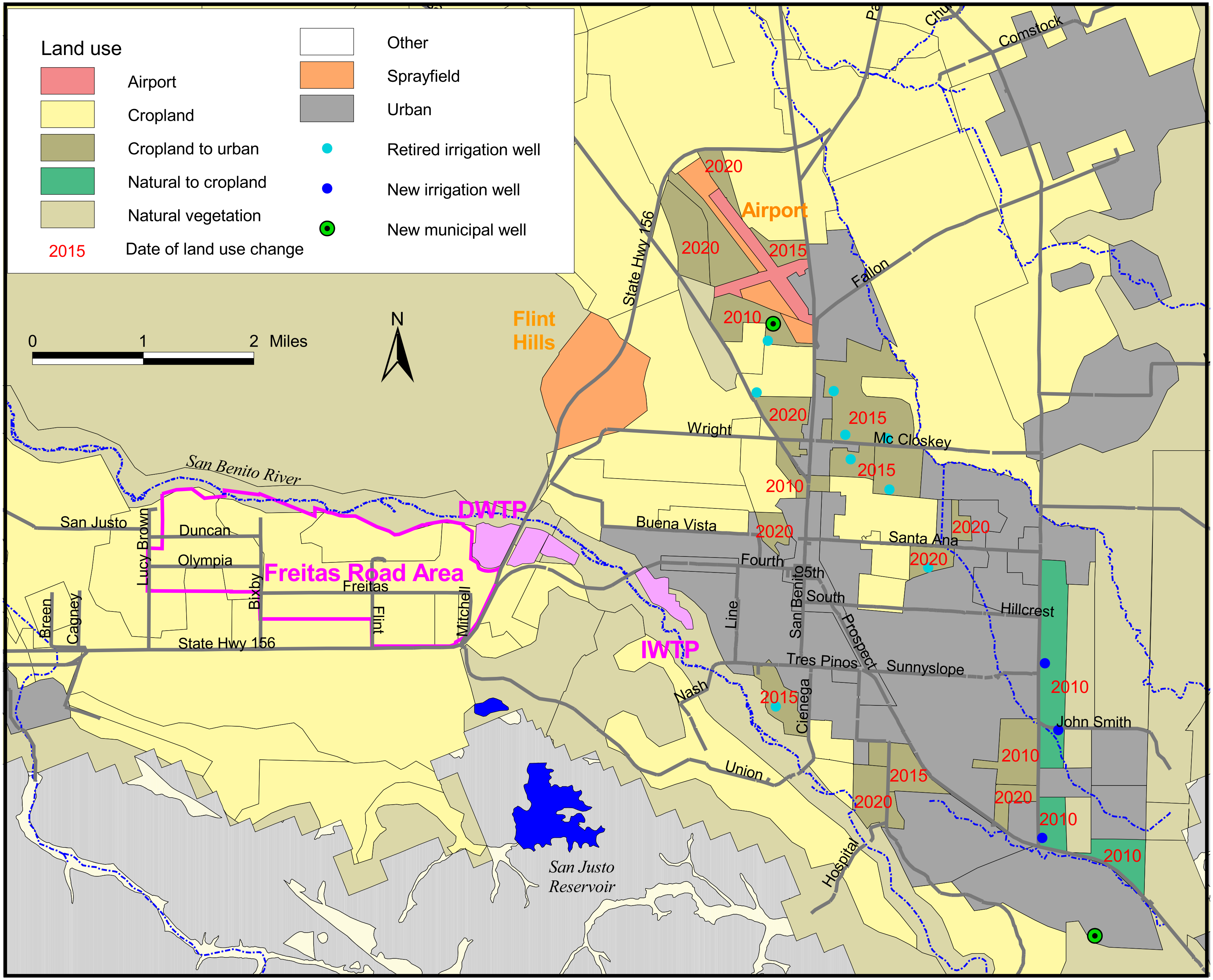


Figure 2. General Changes in Land Use and Groundwater Pumping from 2005 to 2023

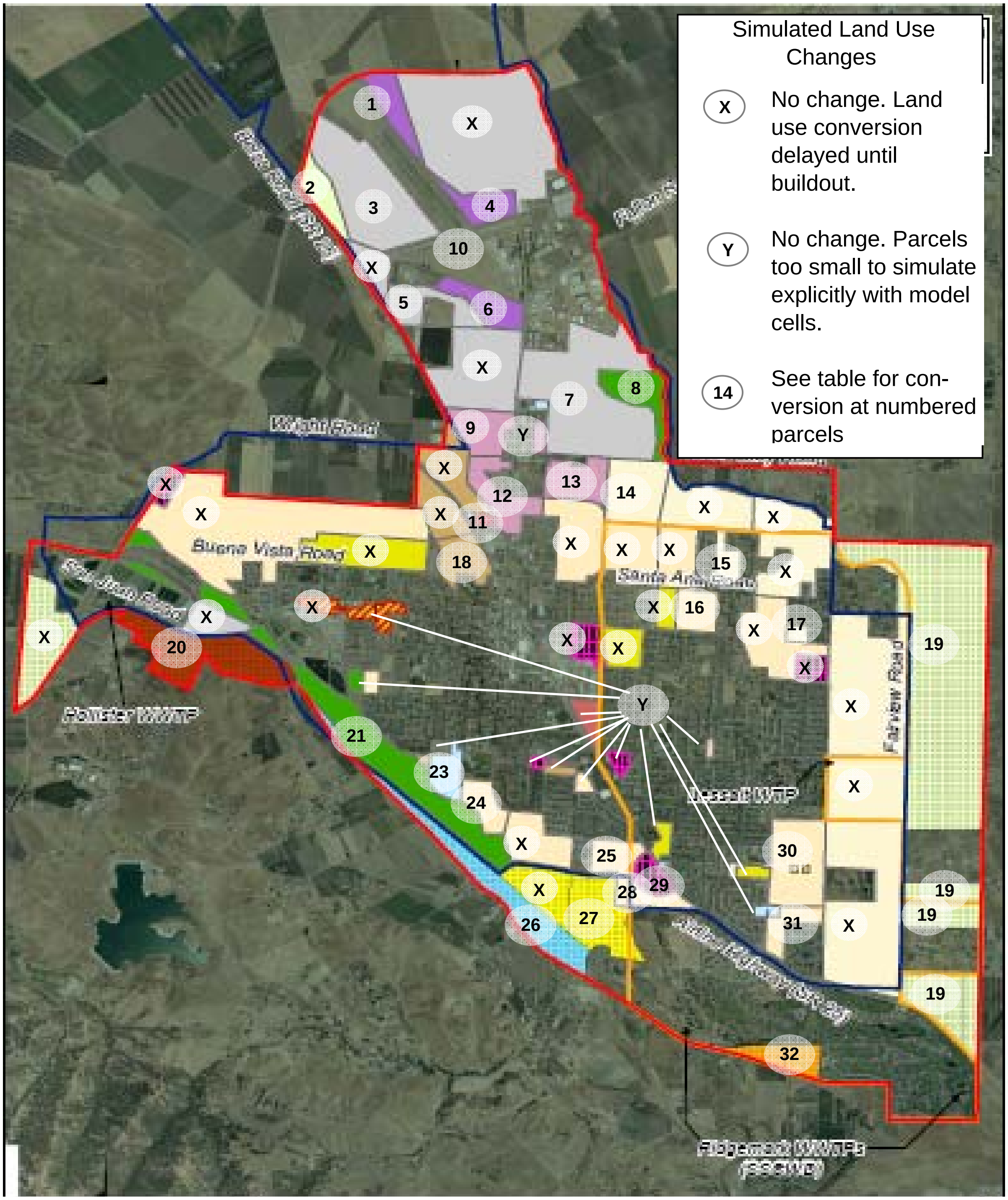


Figure 3. Index Map for Land Use Changes by Parcel

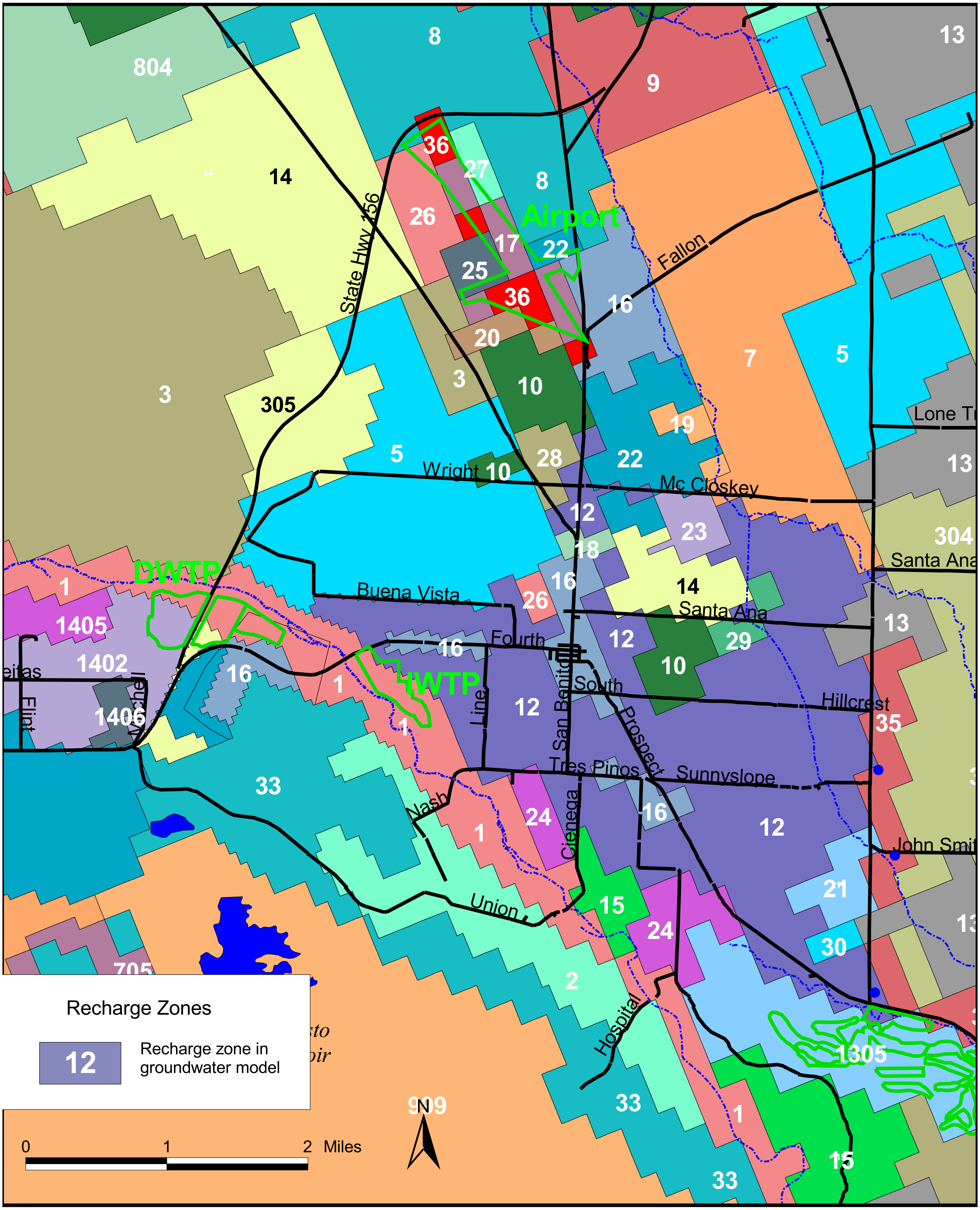
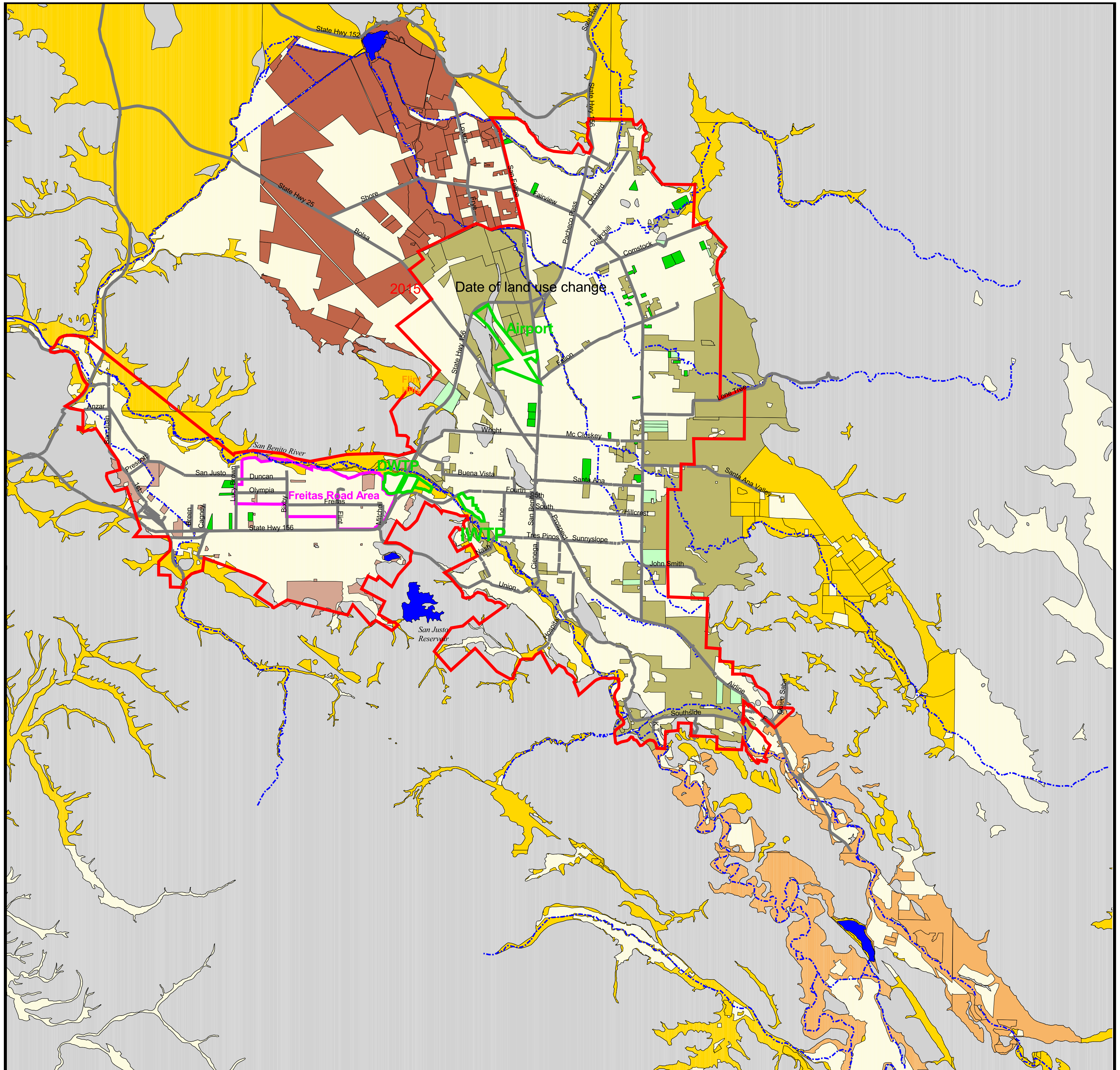


Figure 4. Recharge Zones and Zone Numbers in Groundwater Model

Figure 5. Nonirrigated Cropland Surveyed by DWR in 2002



Zone 6 boundary

Nonirrigated cropland in 2002

- Bolsa
- Excluded
- Other Zone 6
- Paicines & TP Cr Vly
- San Juan

Blind flange parcels

- Irrigated
- Nonirrigated

N

0 2 4 6 8 Miles

Table 1. Parcel-Level land Use Changes Reflected in Groundwater Model Recharge Zones

Parcel Map ID (Fig. 3)	Model Recharge Zone (Fig. 4)	Existing Condition (2005)					Future Condition (2023)				
		Land Use	Irrigation Supply (percent)		Irrigation (in/yr)	Groundwater Recharge (in/yr)	Land Use	Irrigation Supply (percent)		Irrigation (in/yr)	Groundwater Recharge (in/yr)
			Groundwater	CVP/Demin				Groundwater	CVP/Demin		
1	27	Nonirrigated grain or field crop	0%	0%	0.0	0.6	Commercial/Industrial	0%	100%	1.7	3.0
2	14	Truck crops	72%	28%	13.2	6.1	Truck crops	72%	28%	13.2	6.1
3	25	Truck crops	29%	71%	13.5	5.8	Commercial/Industrial	0%	100%	1.7	3.0
3	26	Grassland	16%	84%	0.0	2.4	Commercial/Industrial	0%	100%	1.7	3.0
4	22	Truck crops and pasture	30%	70%	15.1	3.5	Commercial/Industrial	0%	100%	1.7	3.0
5	20	Truck crops and pasture	30%	70%	15.1	3.5	Commercial/Industrial	0%	100%	1.7	3.0
6	20	Truck crops and pasture	30%	70%	15.1	3.5	Commercial/Industrial	0%	100%	1.7	3.0
7	22	Truck crops and pasture	30%	70%	15.1	3.5	Commercial/Industrial	0%	100%	1.7	3.0
8	19	Truck crops	72%	28%	13.2	6.1	Park: irrigated turf	100%	0%	37.1	6.5
9	28	Truck crops with some grain/field crops	29%	71%	13.5	5.8	Commercial/Industrial	0%	100%	1.7	3.0
10	17	Airport: nonirrigated runway turf strips	0%	0%	0.0	4.1	Airport: nonirrigated runway turf strips	0%	0%	0.0	4.1
10	36	Airport: Nonirrigated grain or field crop	0%	0%	0.0	0.6	Airport: Nonirrigated grain or field crop	0%	0%	0.0	0.6
11	18	Truck crops with some grain/field crops	29%	71%	13.5	5.8	Commercial/Industrial	0%	100%	1.7	3.0
12	18	Truck crops with some grain/field crops	29%	71%	13.5	5.8	Commercial/Industrial	0%	100%	1.7	3.0
13	22	Truck crops and pasture	30%	70%	15.1	3.5	Commercial/Industrial	0%	100%	1.7	3.0
14	23	Truck crops and pasture	30%	70%	15.1	3.5	Rural residential	74%	26%	8.5	3.3
15	29	Truck crops and pasture	30%	70%	15.1	3.5	Commercial/Industrial	0%	100%	1.7	3.0
16	29	Truck crops and pasture	30%	70%	15.1	3.5	Commercial/Industrial	0%	100%	1.7	3.0
18	26	Grassland	0%	0%	0.0	2.4	Commercial/Industrial	0%	100%	1.7	3.0
19	35	Grassland	0%	0%	0.0	2.4	Truck crops	19%	81%	10.9	3.4
20	1	Natural vegetation and nonirrigated pasture	0%	0%	0.0	5.2	Natural vegetation and nonirrigated pasture	0%	0%	0.0	5.2
21	1	Natural vegetation and nonirrigated pasture	0%	0%	0.0	5.2	Natural vegetation and nonirrigated pasture	0%	0%	0.0	5.2
23	24	Orchard	100%	0%	12.6	2.9	Medium density residential	0%	100%	6.8	4.1
24	24	Orchard	100%	0%	12.6	2.9	Medium density residential	0%	100%	6.8	4.1
25	24	Orchard	100%	0%	12.6	2.9	Medium density residential	0%	100%	6.8	4.1
26	1	Natural vegetation and nonirrigated pasture	0%	0%	0.0	5.2	Natural vegetation and nonirrigated pasture	0%	0%	0.0	5.2
27	24	Orchard	100%	0%	12.6	2.9	Medium density residential	0%	100%	6.8	4.1
28	24	Orchard	100%	0%	12.6	2.9	Medium density residential	0%	100%	6.8	4.1
29	24	Orchard	100%	0%	12.6	2.9	Medium density residential	0%	100%	6.8	4.1
30	21	Truck crops and orchard	45%	55%	13.1	5.0	Medium density residential	0%	100%	6.8	4.1
31	30	Truck crops with some grain/field crops	72%	28%	13.2	6.1	Medium density residential	0%	100%	6.8	4.1
32	1305	Ridgemark residential and golf course	50%	50%	18.0	5.0	Ridgemark residential and golf course	21%	79%	18.0	5.0

Table 3. Nonirrigated Lands in and Near the Groundwater Basin

Location	Area (acres)
Inside Zone 6	
San Juan Valley	
Blind flange parcels	67
Other parcels	920
Other Zone 6	
Blind flange parcels	967
Other parcels	8,621
Total Zone 6	10,575
Outside Zone 6	
Bolsa subbasin	9,220
Other in-basin valley floor	3,941
Paicines and Tres Pinos Creek Valley	8,493
Total	21,654
Excluded	
Santa Clara County	19,854
San Benito County	15,589

Notes:

Land use delineation from California Department of Water Resources survey in 2002.

Within San Benito County nonirrigated lands not considered likely to become irrigated were excluded. These lands include river and creek channels mapped as "riparian", lands outside the Gilroy-Hollister groundwater basin, and small, isolated upland patches of cropland.