7 Fate and Transport Analysis

The fate and transport analysis for the SNMP provides a tool that will be used to assess the effect of salt and nutrient loadings on average concentrations on each subarea with salt and nutrient water quality objectives. The effect loadings have on the average concentration in the subarea depends on flows into the subarea and other existing loadings.

Section 9 includes a comparison of effects of additional loadings on subarea concentrations to assimilative capacity for salt and nutrients in each subarea. Subareas have assimilative capacity where average concentrations for the salt and nutrient constituents (TDS, chlorides, and nitrates as N) are less than the subarea's water quality objectives. Assimilative capacity in these subareas is the difference between the average concentration for the salt and nutrient constituent and the water quality objective. Additional loadings will use up assimilative capacity. The mass balance model will be used to evaluate additional loadings from proposed future projects based on the percentage of assimilative capacity used by the loadings. The mass balance model can also be used to evaluate impacts of management measures based on how reductions in existing loadings changes assimilative capacity

7.1 MASS BALANCE SPREADSHEET MODEL

The mass balance model is implemented in a series of spreadsheets. The mass balance model treats each hydrostratigraphic unit in each subarea as a single mixing cell. Inputs to the mass balance model are time series of hydrologic/hydrogeologic inflows and outflows for 1996-2012, as well as salt concentrations and loadings. The model calculates the subarea groundwater concentration for each year based on the estimated annual flows and loadings and the previous year's concentration. Estimated flows are adjusted to maintain a balance between inflows and outflows each year.

7.1.1 Mixing Cell Concentration Calculation

Part of the model calculation of the mixing cell concentration is the steady state concentration. This is the steady state concentration if loadings and flows do not change over the long term. It is essentially the loadings divided by the inflow as in the following equation where $C_{t=\infty}$ is the steady state concentration in the subarea mixing cell, C_i is salt or nutrient concentration of any inflow and Q is inflow:

$$C_{t=\infty} = \frac{\sum_{i=1}^{n} C_i Q_i}{\sum_{i=1}^{n} Q_i}$$

Only the inflows and loadings are considered in the calculation because the assumption for the mixing cell concentration is total outflows equal total inflows and discharge of salts are based on the concentration in the subarea mixing cell.

The steady state concentration is modeled for annual inflows and loadings each year but how close the concentration approaches the steady state concentration in the year depends on the residence time for mass in the subarea mixing cell, which is the water volume in the subarea mixing cell divided by the flow through the subarea mixing cell. The following equation is used to calculate transient concentrations C(t) where V is the water volume, t is the time interval of 1 year, and C_o is the subarea mixing cell concentration from the previous year:

$$C(t) = C_{t=\infty} + (C_o - C_{t=\infty})e^{-\frac{\sum_{i=1}^{n} Q_i}{V}t}$$

Data used in the assimilative capacity analysis did not have well depth information so estimated existing water quality represents both the UAS and the LAS. To be conservative, concentrations are modeled based on the volume of the UAS instead of the combined volume of the UAS and LAS.

7.1.2 Subarea Mixing Cell Volume Calculation

The change in subarea mixing cell concentration from year to year depends on size of the subarea volume. The subarea volumes for the UAS and the LAS were calculated based on the regional groundwater model updated in 2006 (HydroMetrics LLC, 2006). In the model, the Piru, Fillmore, and Santa Paula basins have three layers with layers 1 and 2 defining the UAS and layer 3 defining the LAS. In the Oxnard Forebay and Mound basins, there are only two layers with layer 1 defining the UAS and layer 2 defining the LAS.

The volumes are calculated based on average heads for the Forward run of the regional groundwater model. Total saturated volumes of the model layers are multiplied by an estimate of porosity. Porosity of 0.35 is used for the UAS and 0.1 for the LAS based on calibrated values in the Upper Santa Clara River Chloride TMDL GSWIM model (CH2M Hill, 2008). Only UAS volumes (**Table 7-1**) are used to evaluate assimilative capacity with the mass balance model.

Table 7-1 Estimated Water Volumes for Upper Aquifer System by Subarea

Subarea	Volume (AF)
Upper Piru Below Lake Piru	6,700
Lower Piru East of Piru Creek	270,000
Lower Piru West of Piru Creek	580,000
Fillmore Pole Creek Fan	600,000
Fillmore South of Santa Clara River	930,000
Fillmore Remaining	980,000
Santa Paula East of Peck Road	610,000
Santa Paula West of Peck Road	1,500,000
Oxnard Forebay	830,000
Mound	2,300,000

7.1.3 Initial Concentrations

The initial concentrations used in the mass balance model for each subarea are set so that median concentrations in the results match the average existing concentrations estimated for each subarea in the assimilative capacity analysis.[1] The assimilative capacity analysis does not distinguish between the UAS and the LAS based on lack of available well depth information so the initial concentrations are applied to both the UAS and the LAS.

In the Piru basin, for the Upper Area below Lake Piru subarea, there are no data to estimate average existing concentrations. Initial concentrations for this subarea are selected so that the overall trend in the results from 1996-2008 is steady. After 2008, the water balance changed as the Piru spreading grounds was no longer used to add managed recharge to the subarea

7.2 DISCUSSION OF OVERALL MODEL RESULTS

The analysis of historic groundwater quality data trends (**Subsection 4.3**) shows that there is no observed overall trend in average concentrations for basins and subareas except for a decreasing chloride trend in the Oxnard Forebay. However, the model results for some subareas show a trend. This is primarily due to the steady state concentration that would result from the loads and inflows being different from the estimated average existing concentrations for a subarea. This reflects uncertainty in both the estimates of existing groundwater quality and the inflows and loadings. The model results generally show variation over the 1996-2012 period that are within a likely error range of the estimated water quality concentration. The model results show groundwater quality could change over time based on the best available estimates of loadings and flow. Modeled concentrations generally show little response to variations in hydrologic conditions.

Table 7-2 summarizes the groundwater concentration results modeled for the 1996-2012 period and compares it to the existing groundwater quality based on 1996-2012 data.

[1] Median concentrations for years 1996 through 2012 for each well and constituent were calculated and plotted on maps. From the spatial distribution of median concentrations, zones of similar water quality were hand delineated. Concentrations for all the wells located within each zone of the subarea or basin were averaged to provide an overall average concentration for the zone. The acreage of the zone between contours, and its average concentrations were used to estimate an area weighted average concentration for each subarea/basin.

Table 7-2 Summary of Groundwater Concentrations Modeled for 1996-2012 and Existing Groundwater Quality Based on 1996-2012 Data

Mixing Model Average Loadings for Piru Basin - Upper Area below Lake Piru							
		TDS		**Chloride**		**Nitrate as N**	
	Inflow (AFY)	**Concentration (mg/L)**	**Load (lbs/d)**	**Concentration (mg/L)**	**Load (lbs/d)**	**Concentration (mg/L)**	**Load (lbs/d)**
Non Land Use Surface Flows							
Managed Recharge	1,150	650	5,590	40	300	0.5	4
Precipitation	20	10	2	0.1	0	0.1	0
Mountain Front Recharge	140	10	10	0.1	0	0.1	0
Land Use Surface Flows							
Agricultural Irrigation with Surface Water	360	2,070	5,540	150	400	30	80
Agricultural Irrigation with Groundwater	50	3,140	1,280	200	80	40	15
Septic Systems	2	1,260	16	160	2	40	0
Inflow Totals1							
Non Land Use Surface Flows	1,320		5,600		300		4
Land Use Surface Flows	420		6,830		490		100
Total Inflows and Loads	1,730		12,430		790		100
Outflows	**Outlow (AFY)**		**Flux (lbs/d)**		**Flux (lbs/d)**		**Flux (lbs/d)**
Groundwater Flows							
Piru - Lower Area East of Piru Creek	-1,300		-8,640		-510		-60
Lower Aquifer (Piru Upper)	-260		-1,710		-100		-11
Groundwater Production	-180		-1,290		-80		-10
Total Outflows and Loads	-1,740		-11,640		-690		-81
Note: Data may include rounding error							

7.3 DISCUSSION OF RESULTS BY SUBAREA/BASIN

Groundwater concentrations modeled with the mass balance model by subarea or basin for the UAS are summarized below. Concentrations are modeled based on the volume of the UAS instead of the combined volume of the UAS and LAS in order to be conservative. For each subarea or basin, a table and four figures are displayed. The table shows average flows, concentrations, and loads for different sources of TDS, chloride, and nitrate-N. There is a figure that shows estimated annual flows by year. The figures show estimated annual loads and modeled groundwater concentrations by year. There is one figure each for TDS, chloride, and nitrate-N loads and concentrations.

7.3.1 Piru Basin – Upper Area Below Lake Piru

In this subarea, the main non-land use based inflow and loads are from the managed aquifer recharge at the Piru spreading grounds and the main land use based load is agricultural irrigation with surface water **(Table 7-3**). Groundwater concentrations of TDS and chloride are higher than surface water concentrations because concentrations in infiltrating irrigation water are higher than in source water as it is assumed that none of the salts are taken up by plants as water demand is met. The load for nitrates from fertilizers in the agricultural irrigation results in concentrations that are substantially higher than surface water concentrations.

After water year 2008, water was not recharged to the Piru spreading grounds resulting in no managed aquifer recharge inflow (**Figure 7-1**). After 2008, inflows are reduced to 25% of the inflows from 1996-2008 and loadings are dominated by agricultural irrigation. Groundwater concentrations based on these annual loads and smaller inflows for the later period raise concentrations for TDS, chloride, and nitrate-N due to higher concentrations in infiltration of agricultural irrigation than the source water. The modeled annual groundwater concentrations for TDS (**Figure 7-2**), chloride (**Figure 7-3**), and nitrate-N (**Figure 7-4)** show increases in concentrations during years with little to no managed aquifer recharge. The percentage change in these years is greatest for nitrate-N. Based on the estimated loadings for this subarea after water year 2008, modeled groundwater concentrations rise to and above the water quality objectives for TDS (1,100 mg/L) and nitrate-N (10 mg/L) by 2012. Modeled concentrations for chloride remain below the water quality objective for chloride (200 mg/L). However, existing groundwater concentrations for this subarea have not been calculated due to a lack of data and the availability of assimilative capacity cannot be assessed.

Table 7-3 Mass Balance Model Average Loads for Piru Basin – Upper Area below Lake Piru

		TDS		Chloride		Nitrate as N	
	Inflow (AFY)	**Concentration (mg/L)**	**Load (lbs/d)**	**Concentration (mg/L)**	**Load (lbs/d)**	**Concentration (mg/L)**	**Load (lbs/d)**
Non Land Use Surface Flows							
Managed Recharge	1,150	650	5,590	40	300	0.5	4
Precipitation	20	10	2	0.1	0	0.1	0
Mountain Front Recharge	140	10	10	0.1	0	0.1	0
Land Use Surface Flows							
Agricultural Irrigation with Surface Water	360	2,070	5,540	150	400	30	80
Agricultural Irrigation with Groundwater	50	3,140	1,280	200	80	40	15
Septic Systems	2	1,260	16	160	2	40	0
Inflow Totals[1]							
Non Land Use Surface Flows	1,320		5,600		300		4
Land Use Surface Flows	420		6,830		490		100
Total Inflows and Loads	1,730		12,430		790		100
Outflows	**Outlow (AFY)**		**Flux (lbs/d)**		**Flux (lbs/d)**		**Flux (lbs/d)**
Groundwater Flows							
Piru - Lower Area East of Piru Creek	-1,300		-8,640		-510		-60
Lower Aquifer (Piru Upper)	-260		-1,710		-100		-11
Groundwater Production	-180		-1,290		-80		-10
Total Outflows and Loads	-1,740		-11,640		-690		-81

[1] May include rounding error

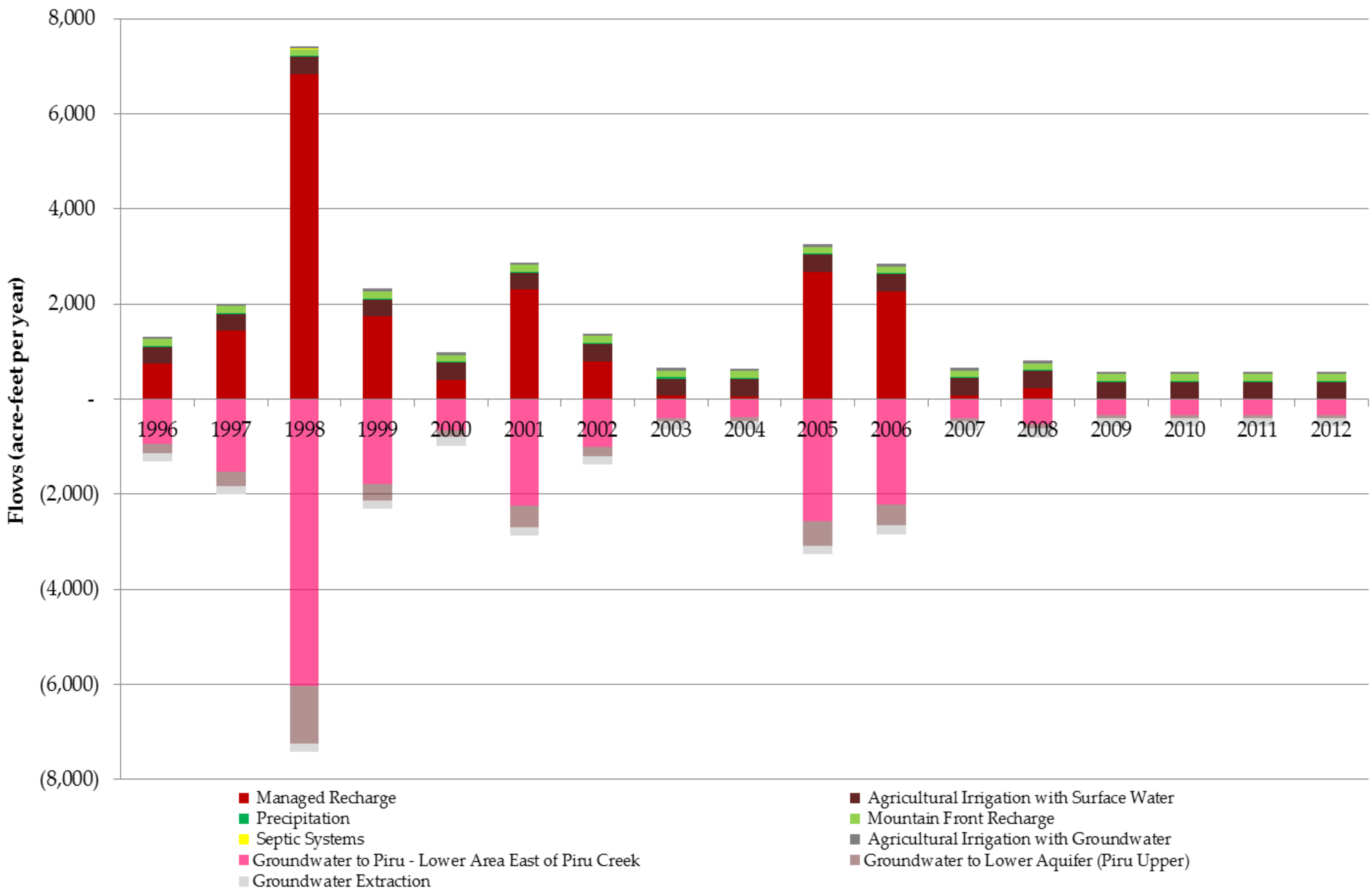

Figure 7-1 Modeled Annual Inflows and Outflows for Piru Basin – Upper Area

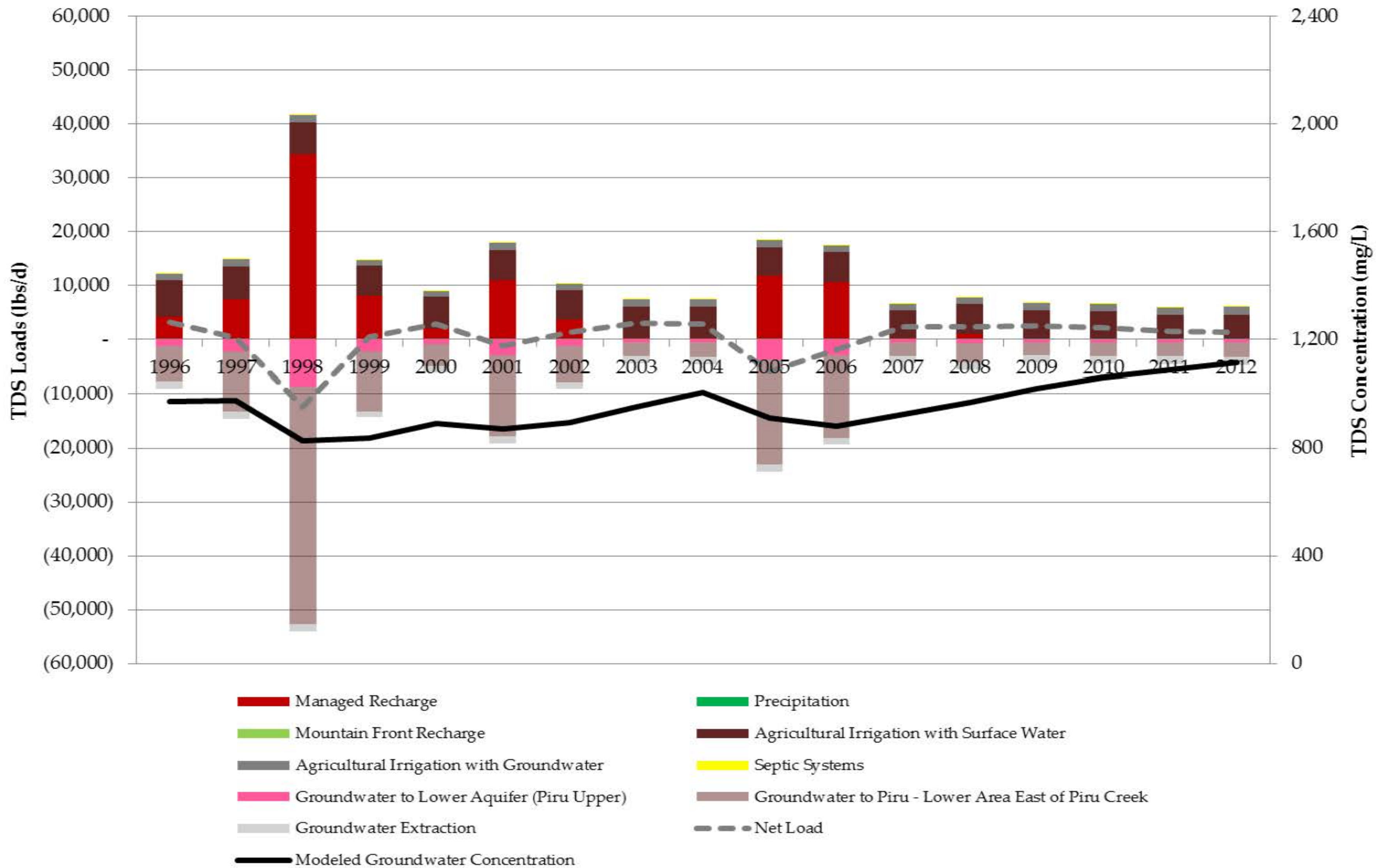

Figure 7-2 Modeled Annual TDS Loads and Concentrations in Groundwater for Piru Basin – Upper Area below Lake Piru

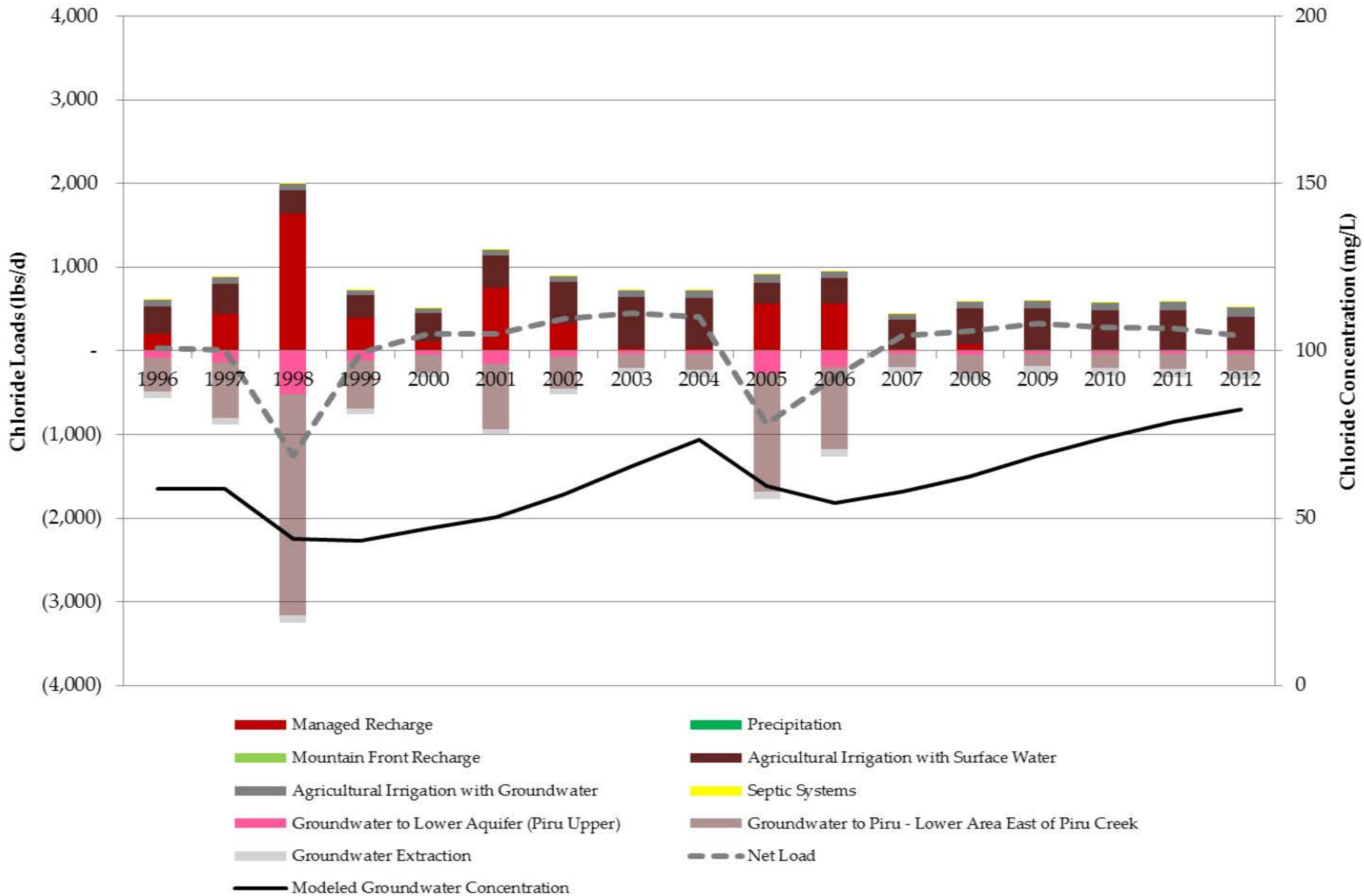

Figure 7-3 Modeled Annual Chloride Loads and Concentrations in Groundwater for Piru Basin – Upper Area below Lake Piru

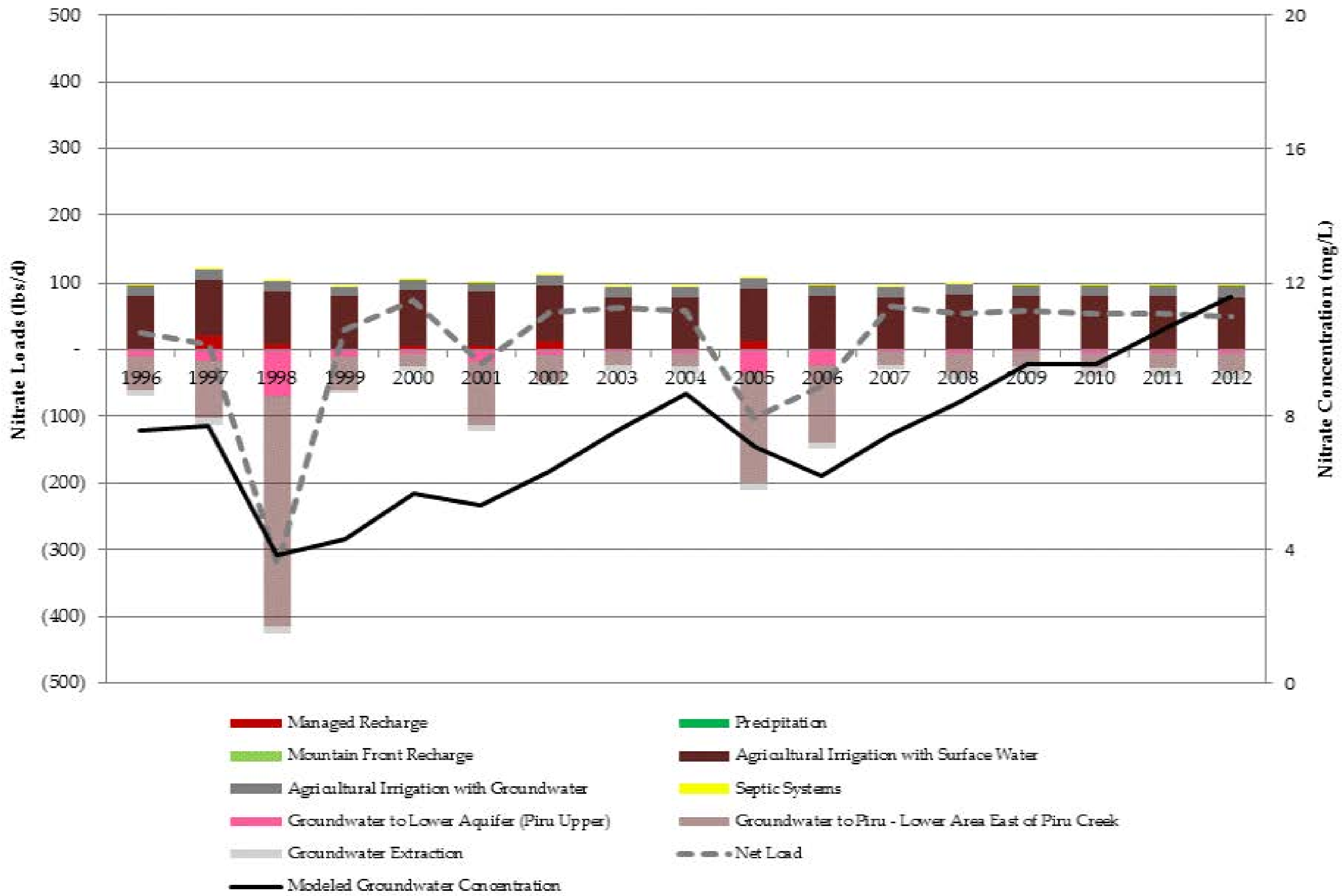

Figure 7-4 Modeled Annual Nitrate-N Loads and Concentrations in Groundwater for Piru Basin – Upper Area below Lake Piru

7.3.2 Piru Basin – Lower Area East of Piru Creek

In this subarea, the main non-land use based inflow and loads are from streambed percolation from the SCR and Piru Creek (**Figure 7-5**). The main land use based loads are agricultural irrigation with surface water and groundwater. The high percentage of overall inflow from streambed percolation results in groundwater concentrations for TDS and chloride calculated as similar to surface water concentrations. The nitrate-N load from fertilizer results in nitrate-N concentrations higher than surface water quality, however the large amount of streambed percolation results in calculated groundwater concentrations closer to surface water quality than irrigation infiltration water quality (**Table 7-4**).

The mass balance model shows that existing loads in this subarea result in concentrations in groundwater (**Table 7-2)** that are below water quality objectives for TDS (2,500 mg/L), chloride (200 mg/L) and nitrate-N (10 mg/L). The model results are consistent with the finding that the subarea has assimilative capacity for all three constituents based on groundwater quality data.

The modeled concentrations for TDS (**Table 7-6)** are similar to the estimated existing concentration for the subarea. The modeled concentrations for chloride (**Figure 7-5)** and nitrate-N (**Figure 7-8**) are in groundwater show a trend that increases concentrations above the estimated existing concentration for the subarea. For chloride, this is due to the dominant inflow of stream percolation having a chloride concentration greater than the estimated existing concentration for the subarea. The high nitrate-N modeled result may be due to estimates of relatively high use of fertilizer in irrigation water in the subarea. Existing nitrate-N concentrations are estimated to be higher in the lower area of Piru basin west of Piru Creek subarea than east of Piru Creek, but fertilizer use is lower west of Piru Creek where the largest irrigated area grows oranges versus east of Piru Creek where the largest irrigated area grows row crops. Modeled annual TDS concentrations in the subarea show little variation in response to hydrologic conditions (**Figure 7-6**). Modeled chloride (**Figure 7-7**) and nitrate-N (**Figure 7-8**) show small variations in response to hydrologic conditions over the water years 1996-2012.

Table 7-4 Mass Balance Model Average Loads for Piru Basin – Lower Area East of Piru Creek

	Inflow (AFY)	TDS Concentration (mg/L)	TDS Load (lbs/d)	Chloride Concentration (mg/L)	Chloride Load (lbs/d)	Nitrate as N Concentration (mg/L)	Nitrate as N Load (lbs/d)
Groundwater Flows							
Upper Santa Clara River Underflow	360	970	2,580	120	320	3.4	9
Piru - Upper Area below Lake Piru	1,300	940	9,070	60	560	7.0	70
Non Land Use Surface Flows							
Santa Clara River and Tributaries	34,540	940	240,680	120	30,410	2.2	560
Precipitation	580	10	40	0.1	0	0.1	0
Mountain Front Recharge	990	10	70	0.1	1	0.1	1
Land Use Surface Flows							
Agricultural Irrigation with Surface Water	550	3,120	12,700	400	1,630	30	130
Agricultural Irrigation with Groundwater	1,120	3,340	27,890	310	2,590	30	270
Septic Systems	5	1,260	50	160	7	40	2
Inflow Totals[1]							
Groundwater Flows	1,650		11,650		880		80
Non Land Use Surface Flows	36,110		240,790		30,410		560
Land Use Surface Flows	1,670		40,630		4,230		390
Total Inflows and Loads	39,430		293,070		35,530		1,030
Outflows	**Outlow (AFY)**		**Flux (lbs/d)**		**Flux (lbs/d)**		**Flux (lbs/d)**
Groundwater Flows							
Lower Aquifer (Piru East)	-26,170		-195,210		-22,880		-510
Piru - Lower Area West of Piru Creek	-11,290		-84,190		-9,860		-220
Groundwater Production	-1,980		-14,760		-1,730		-40
Total Outflows and Loads	-39,440		-294,160		-34,470		-770

[1] May include rounding error

Figure 7-5 Modeled Annual Inflows and Outflows for Piru Basin – Lower Area East of Piru Creek

Figure 7-6 Modeled Annual TDS Loads and Concentrations in Groundwater for Piru Basin – Lower Area East of Piru Creek

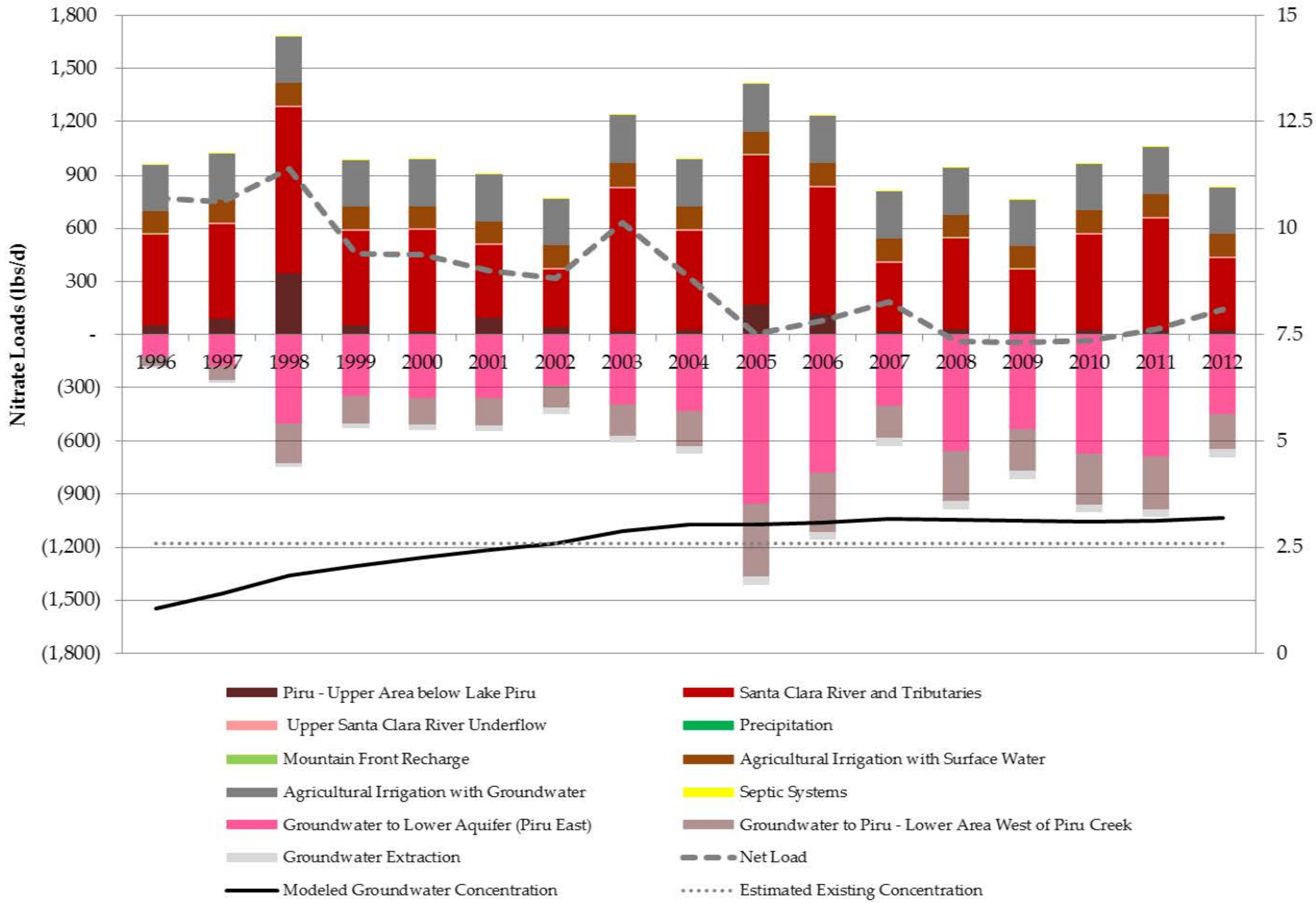

Figure 7-7 Modeled Annual Chloride Loads and Concentrations in Groundwater for Piru Basin – Lower Area East of Piru Creek

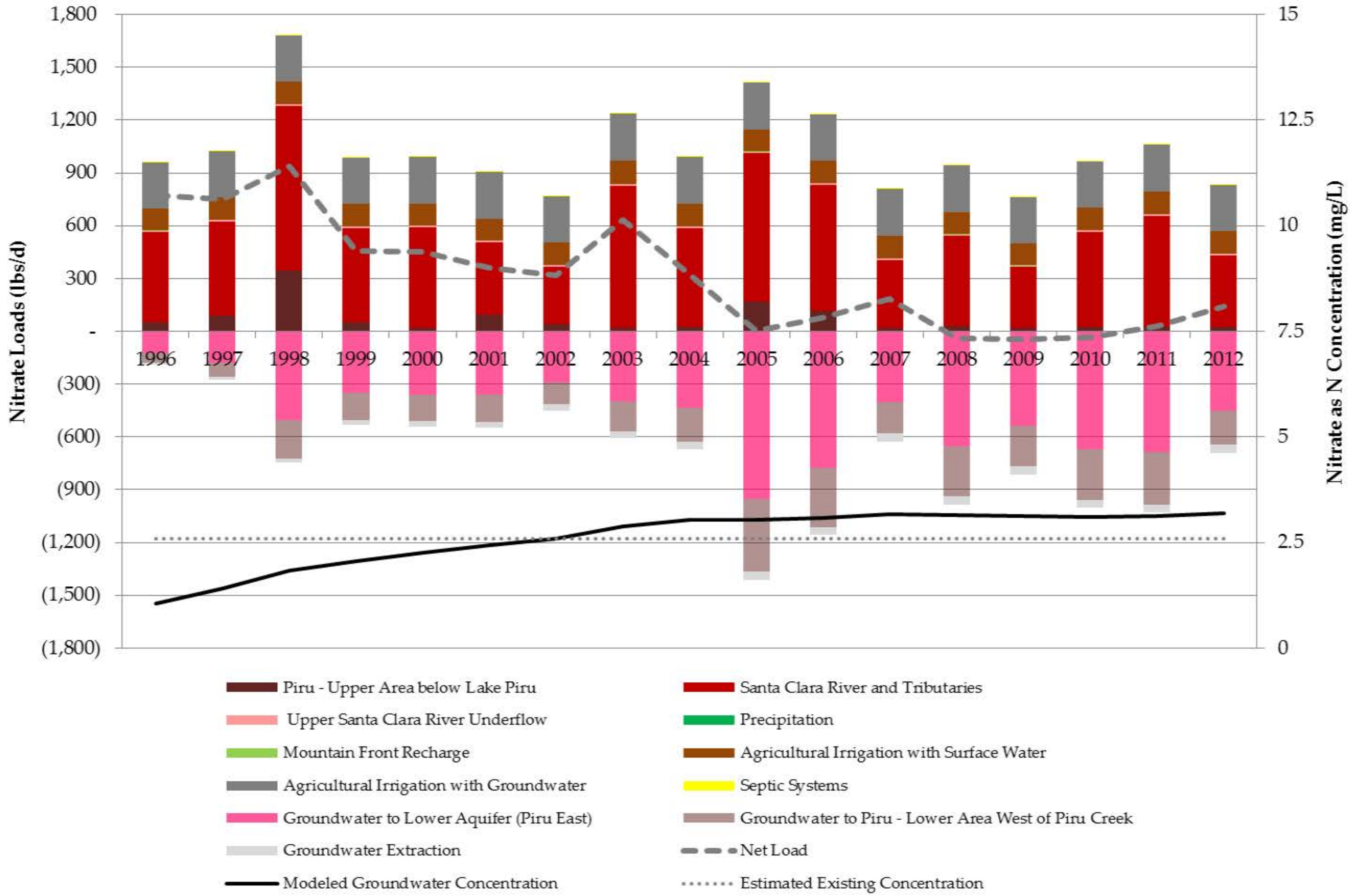

Figure 7-8 Modeled Annual Nitrate-N Loads and Concentrations in Groundwater for Piru Basin – Lower Area East of Piru Creek

7.3.3 Piru Basin – Lower Area West of Piru Creek

In this subarea, the main non-land use based inflow and loads are from streambed percolation from the SCR and Piru Creek, but there is also a large amount of underflow from the subarea east of Piru Creek (**Figure 7-9**). The main land use based load is agricultural irrigation with groundwater (**Table 7-5**). The high percentage of overall inflow from streambed percolation results in groundwater concentrations for TDS and chloride modeled as similar to surface water concentrations. The nitrate-N load from fertilizer results in modeled nitrate-N concentrations higher than surface water quality, however the large amount of streambed percolation results in calculated groundwater concentrations closer to surface water quality than irrigation infiltration water quality

The mass balance model shows that existing loads in this subarea result in modeled concentrations in groundwater (**Table 7-2**) that are below water quality objectives for TDS (1,200 mg/L), chloride (100 mg/L) and nitrate-N (10 mg/L). This is consistent with the finding that the subarea has assimilative capacity for all three constituents based on groundwater quality data.

The modeled concentrations for TDS are similar to the estimated existing concentration for the subarea (**Figure 7-10**). The modeled concentrations for chloride show a trend that increases concentrations above the estimated existing concentration for the subarea (**Figure 7-11**). This is due to the high concentration of chloride in groundwater flowing from the subarea east of Piru Creek. The modeled concentrations for nitrate-N in groundwater show a trend that decreases concentrations below the estimated existing concentration for the subarea (**Figure 7-12**). The decreasing nitrate-N modeled result may be due to estimates of relatively low use of fertilizer in irrigation water in the subarea. Existing nitrate-N concentrations are estimated to be higher in the lower area of Piru basin west of Piru Creek subarea than east of Piru Creek, but fertilizer use is lower west of Piru Creek where the largest irrigated area grows oranges versus east of the Piru Creek where the largest irrigated area grows row crops.

Modeled annual concentrations in the subarea show little variation in response to hydrologic conditions over the water years 1996-2012.

Table 7-5 Mass Balance Model Loads and Steady State Concentrations for Piru Basin – Lower Area West of Piru Creek

	Inflow (AFY)	TDS Concentration (mg/L)	TDS Load (lbs/d)	Chloride Concentration (mg/L)	Chloride Load (lbs/d)	Nitrate as N Concentration (mg/L)	Nitrate as N Load (lbs/d)
Groundwater Flows							
Piru - Lower Area East of Piru Creek	11,290	1,000	84,310	120	9,850	2.5	210
Non Land Use Surface Flows							
Santa Clara River and Tributaries	26,130	880	171,590	70	12,890	1.1	210
Precipitation	1,390	10	100	0.1	1	0.1	1
Mountain Front Recharge	1,490	10	110	0.1	1	0.1	1
Land Use Surface Flows							
Agricultural Irrigation with Surface Water	330	2,970	7,360	230	560	15	40
Agricultural Irrigation with Groundwater	1,590	3,340	39,520	220	2,620	18	210
Wastewater Treatment Percolation Ponds	210	1,260	1,950	160	250	1.0	2
Septic Systems	60	1,260	540	160	70	40	17
Inflow Totals[1]							
Groundwater Flows	11,290		84,310		9,850		210
Non Land Use Surface Flows	29,000		171,810		12,890		210
Land Use Surface Flows	2,220		49,360		3,510		260
Total Inflows and Loads	42,510		305,480		26,250		680
Outflows	**Outlow (AFY)**		**Flux (lbs/d)**		**Flux (lbs/d)**		**Flux (lbs/d)**
Groundwater Flows							
Lower Aquifer (Piru West)	-22,990		-171,230		-11,550		-620
Fillmore - Pole Creek Fan Area	-6,730		-50,160		-3,380		-180
Fillmore - South Side of Santa Clara River	-3,750		-27,930		-1,880		-100
Seepage to Santa Clara River	-1,990		-14,880		-1,000		-50
Groundwater Production	-7,050		-52,490		-3,550		-190
Total Outflows and Loads	-42,510		-316,690		-21,360		-1,140

[1] May include rounding error

Figure 7-9 Modeled Annual Inflows and Outflows for Piru Basin – Lower Area West of Piru Creek

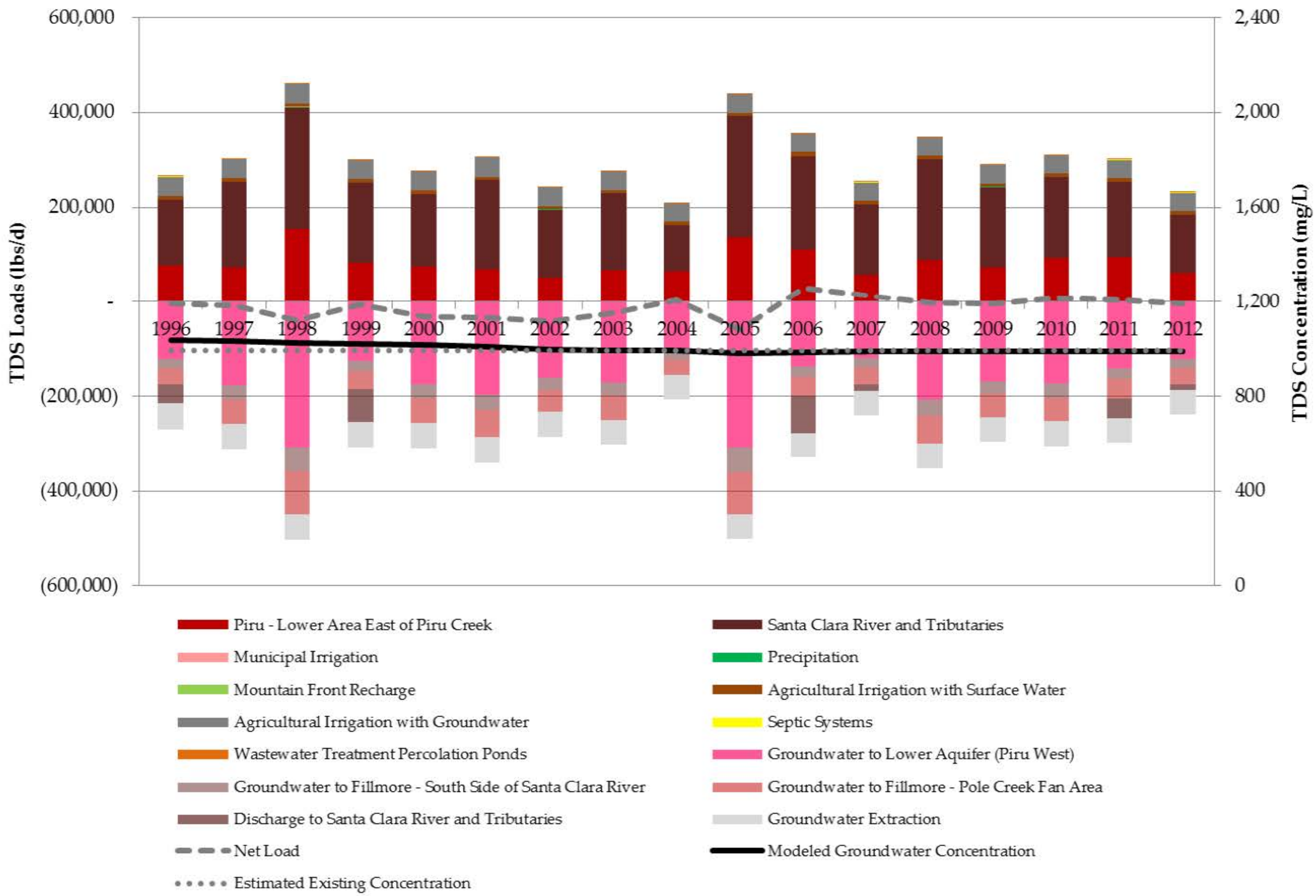

Figure 7-10 Modeled Annual TDS Loads and Concentrations in Groundwater for Piru Basin – Lower Area West of Piru Creek

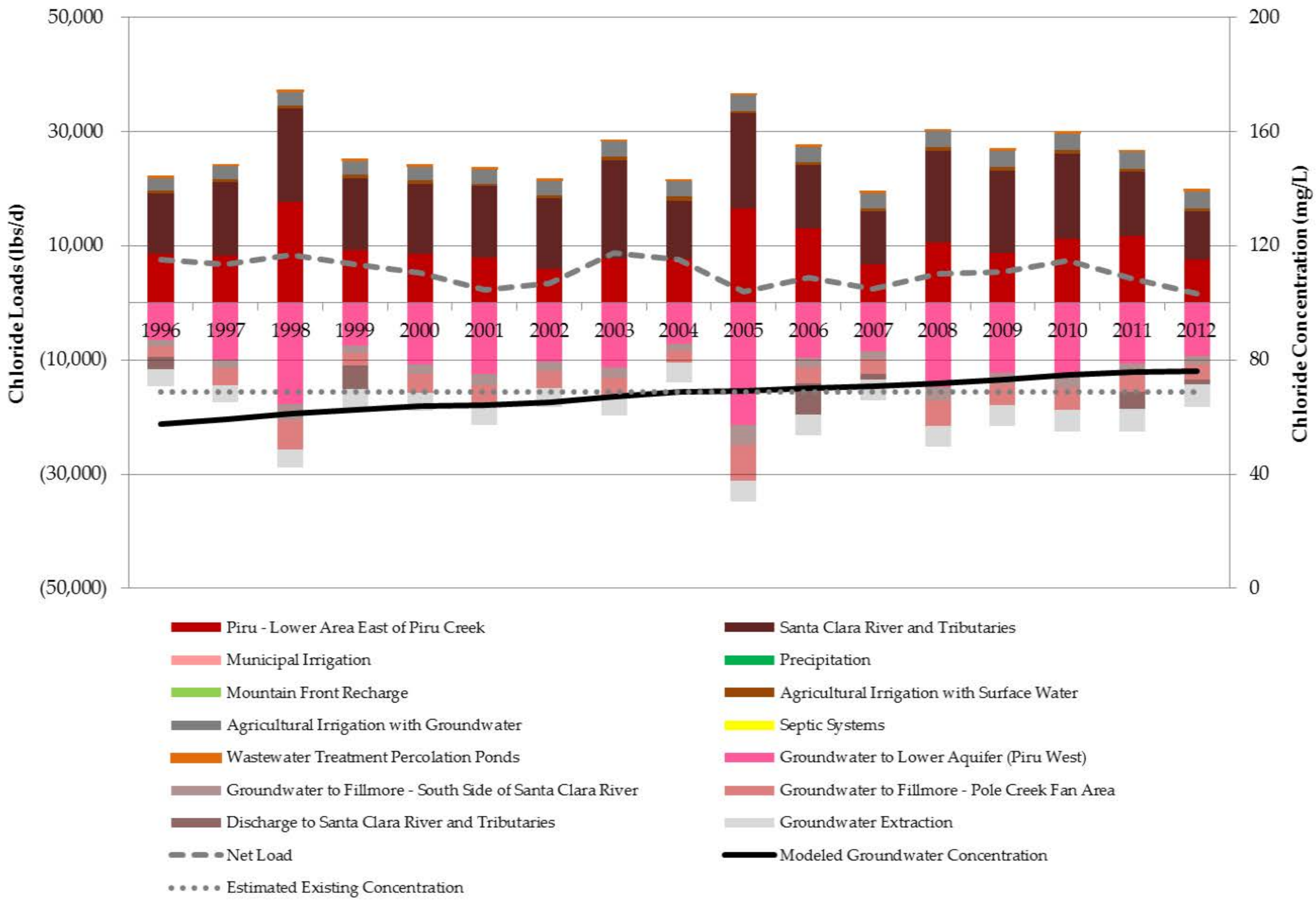

Figure 7-11 Modeled Annual Chloride Loads and Concentrations in Groundwater for Piru Basin – Lower Area West of Piru Creek

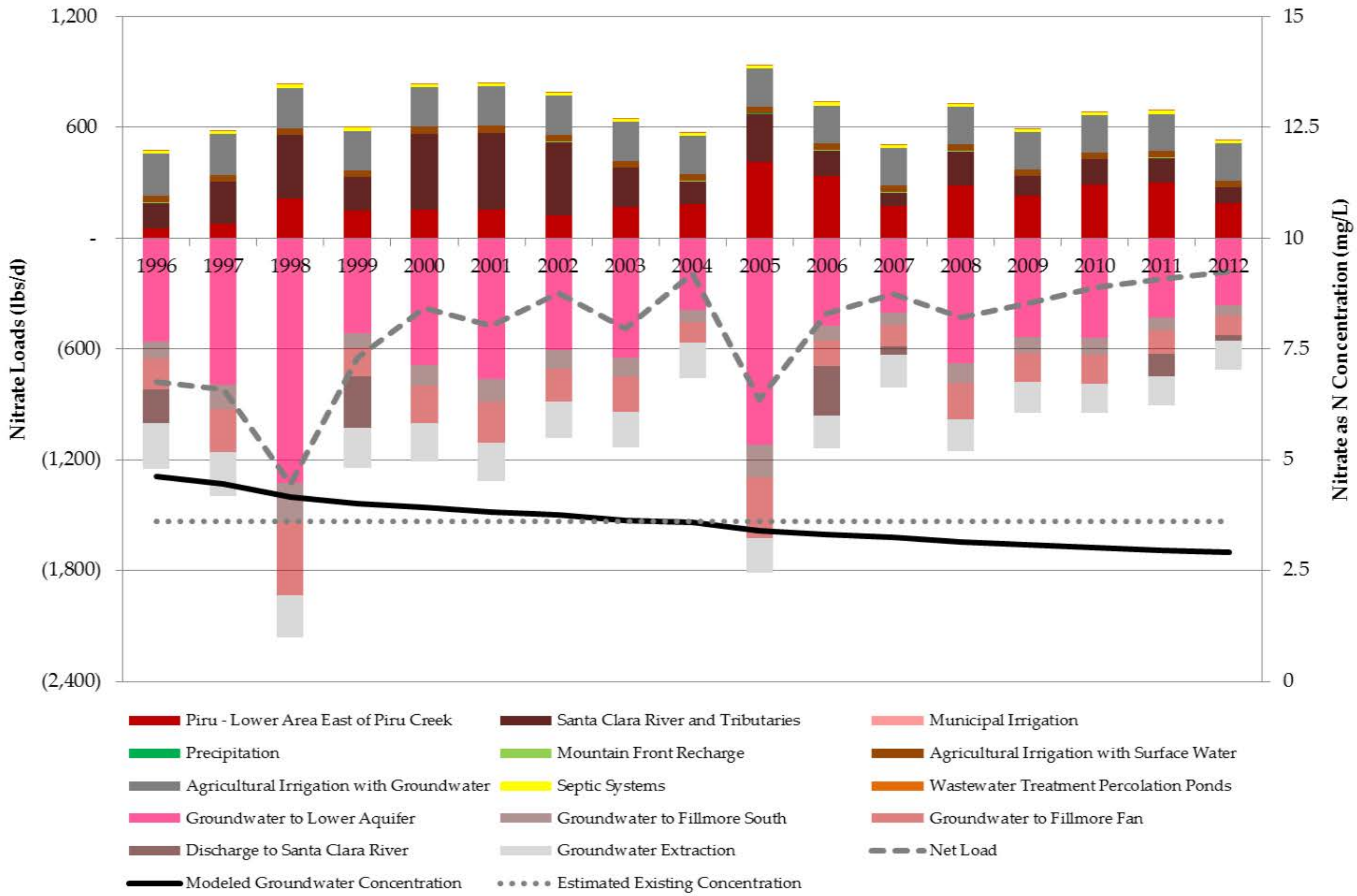

Figure 7-12 Modeled Annual Nitrate-N Loads and Concentrations in Groundwater for Piru Basin – Lower Area West of Piru Creek

7.3.4 Fillmore Basin – Pole Creek Fan Area

In this subarea, the largest non-land use based groundwater inflow and load is from streambed percolation from the SCR and Pole Creek, but there are also large amounts of underflow from the Piru basin to the west and from the LAS (**Figure 7-13**). The large amount of underflow from the LAS is consistent with rising groundwater discharging to the Santa Clara River in this subarea. The main land use based loads are wastewater percolation ponds, agricultural irrigation, and municipal irrigation. Streambed percolation is the largest inflow and is estimated to have concentrations that dilute calculated groundwater concentrations for all three constituents (**Table 7-6**).

The mass balance model shows that existing loads in this subarea result in modeled concentrations in groundwater (**Table 7-2**) that are below water quality objectives for TDS (2,000 mg/L), chloride (100 mg/L) and nitrate-N (10 mg/L). This is consistent with the finding that the subarea has assimilative capacity for all three constituents based on groundwater quality data.

The modeled concentrations for TDS (**Figure 7-14**), chloride (**Figure 7-15**) and nitrate-N (**Figure 7-16**) are similar to the estimated existing concentrations for the subarea. Modeled annual concentrations in the subarea show little variation in response to hydrologic conditions.

Table 7-6 Mass Balance Model Average Loads and Steady State Concentrations for Fillmore Basin – Pole Creek Fan Area

		TDS		Chloride		Nitrate as N	
	Inflow (AFY)	**Concentration (mg/L)**	**Load (lbs/d)**	**Concentration (mg/L)**	**Load (lbs/d)**	**Concentration (mg/L)**	**Load (lbs/d)**
Groundwater Flows							
Piru - Lower Area West of Piru Creek	6,730	1,000	50,350	70	3,320	3.7	190
Lower Aquifer (Fillmore Fan)	15,590	1,090	125,970	60	7,260	3.2	370
Non Land Use Surface Flows							
Santa Clara River and Tributaries	3,540	930	24,530	60	1,480	2.4	60
Precipitation	1,830	10	140	0.1	1	0.1	1
Mountain Front Recharge	170	10	13	0.1	0	0.1	0
Land Use Surface Flows							
Municipal Irrigation	190	1,670	2,320	80	110	4.7	7
Agricultural Irrigation with Groundwater	930	3,660	25,340	200	1,350	12.9	90
Wastewater Treatment Percolation Ponds	1,040	1,190	9,200	100	770	3.4	30
Septic Systems	30	1,190	240	100	20	40.0	8
Inflow Totals[1]							
Groundwater Flows	22,320		176,320		10,580		560
Non Land Use Surface Flows	5,540		24,680		1,480		70
Land Use Surface Flows	2,180		37,090		2,250		130
Total Inflows and Loads	30,040		238,090		14,310		750
Outflows	**Outlow (AFY)**		**Flux (lbs/d)**		**Flux (lbs/d)**		**Flux (lbs/d)**
Groundwater Flows							
Fillmore - South Side of Santa Clara River	-10,040		-82,050		-4,390		-210
Fillmore - Remaining Northwest	-9,030		-73,810		-3,950		-190
Groundwater Production	-10,970		-89,630		-4,810		-230
Total Outflows and Loads	-30,040		-245,490		-13,150		-630

[1] May include rounding error

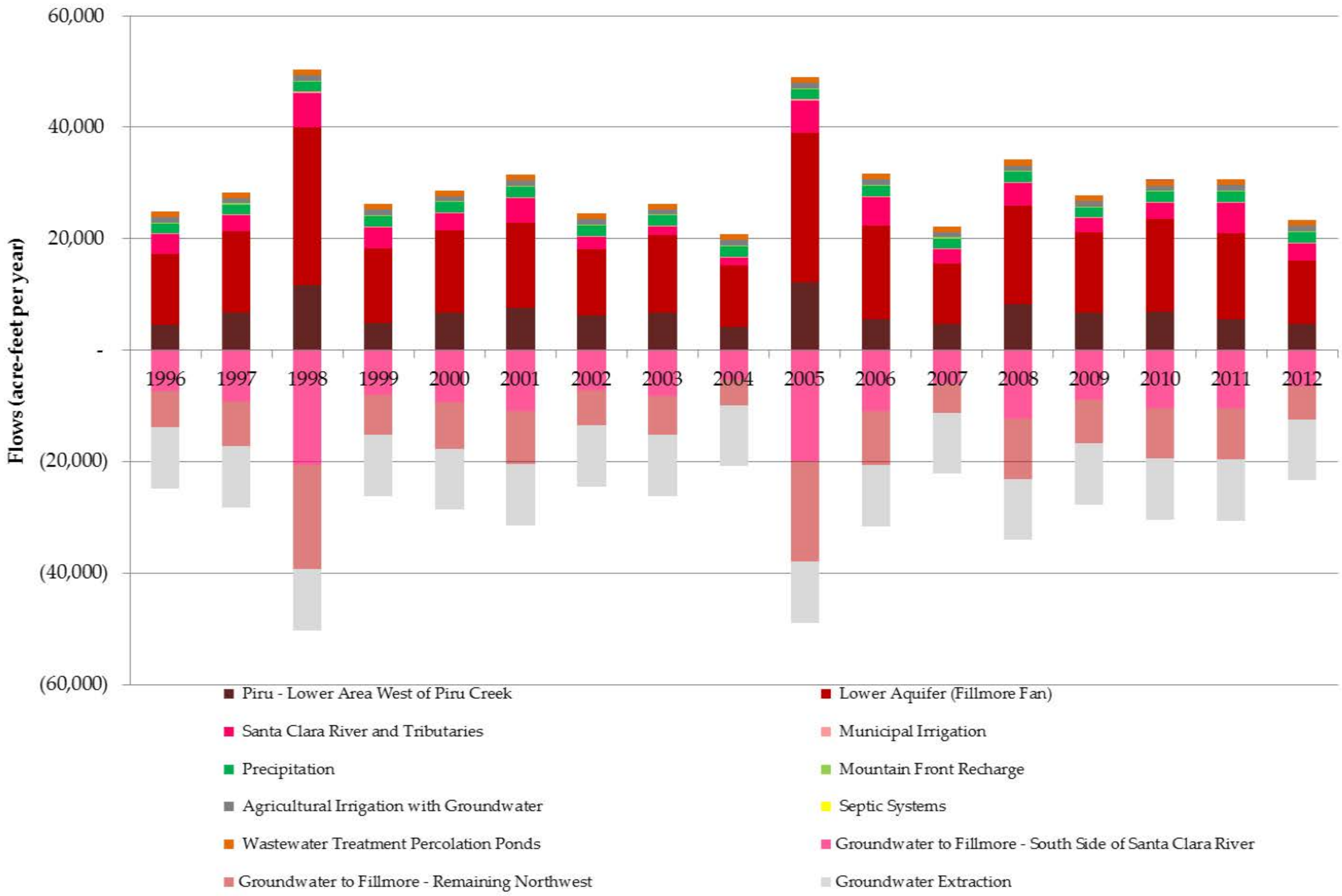

Figure 7-13 Modeled Annual Inflows and Outflows for the Fillmore Basin – Pole Creek Fan Area

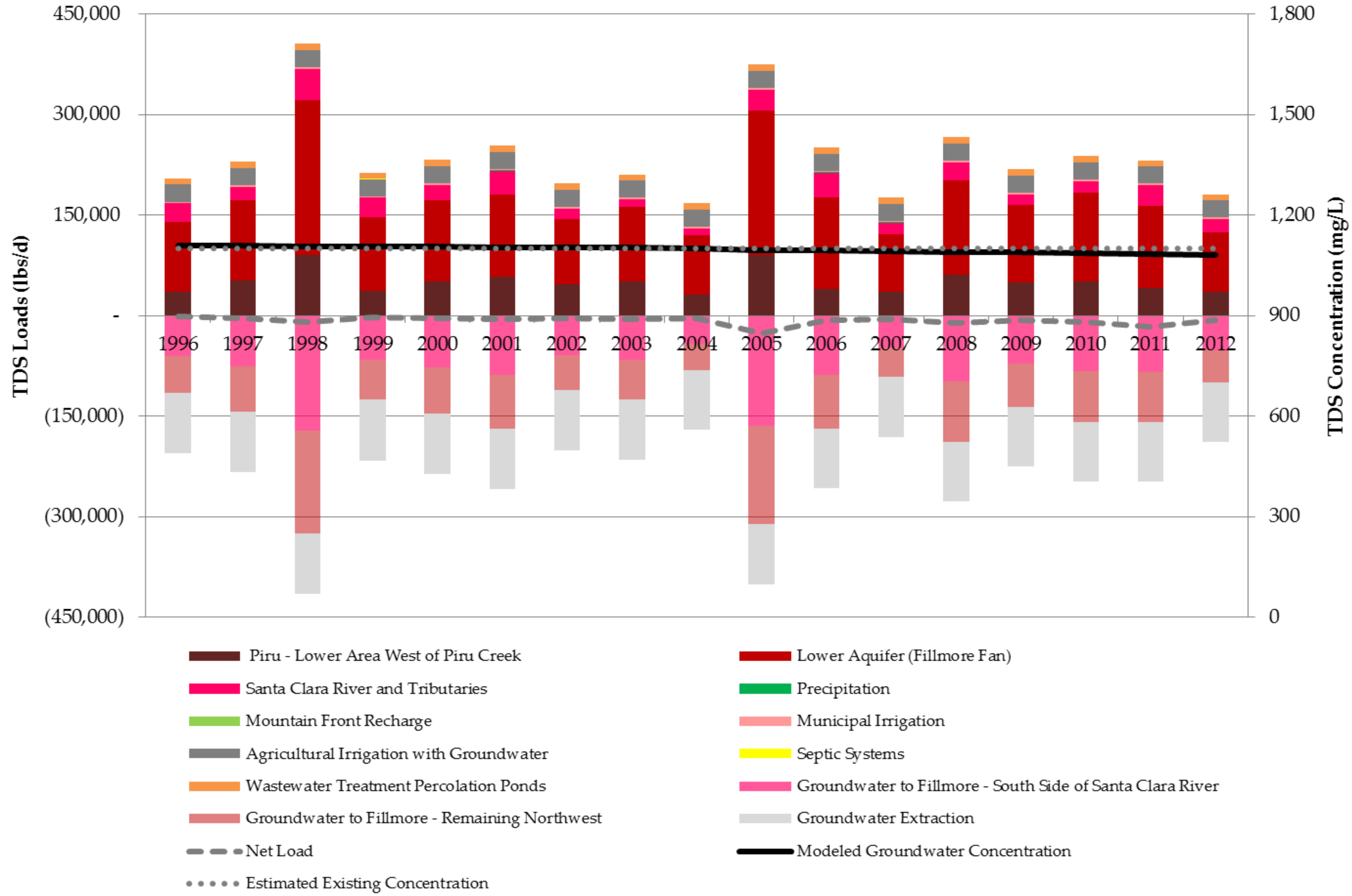

Figure 7-14 Modeled Annual TDS Loads and Concentrations in Groundwater for Fillmore Basin – Pole Creek Fan Area

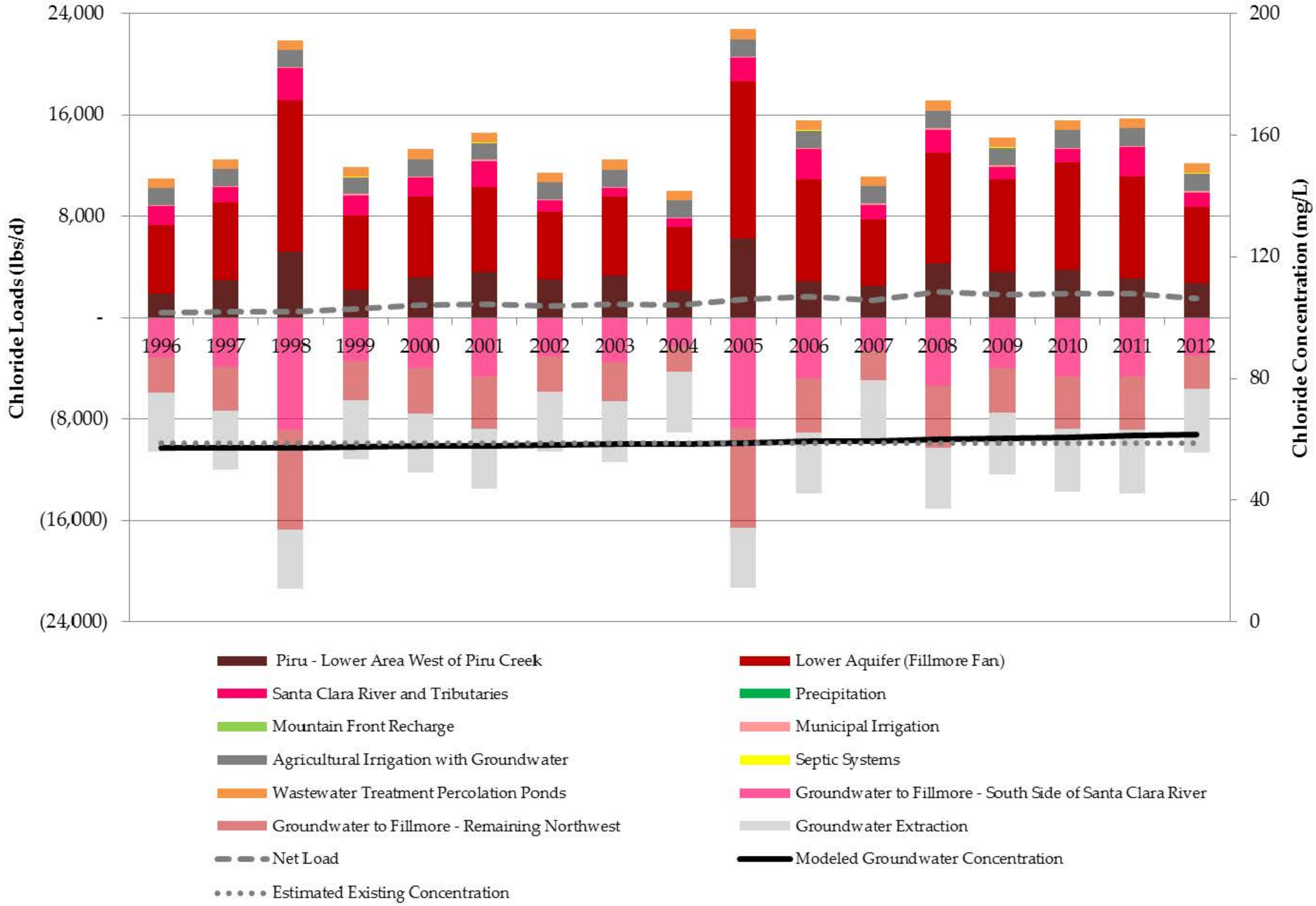

Figure 7-15 Modeled Annual Chloride Loads and Concentrations in Groundwater for Fillmore Basin – Pole Creek Fan Area Creek

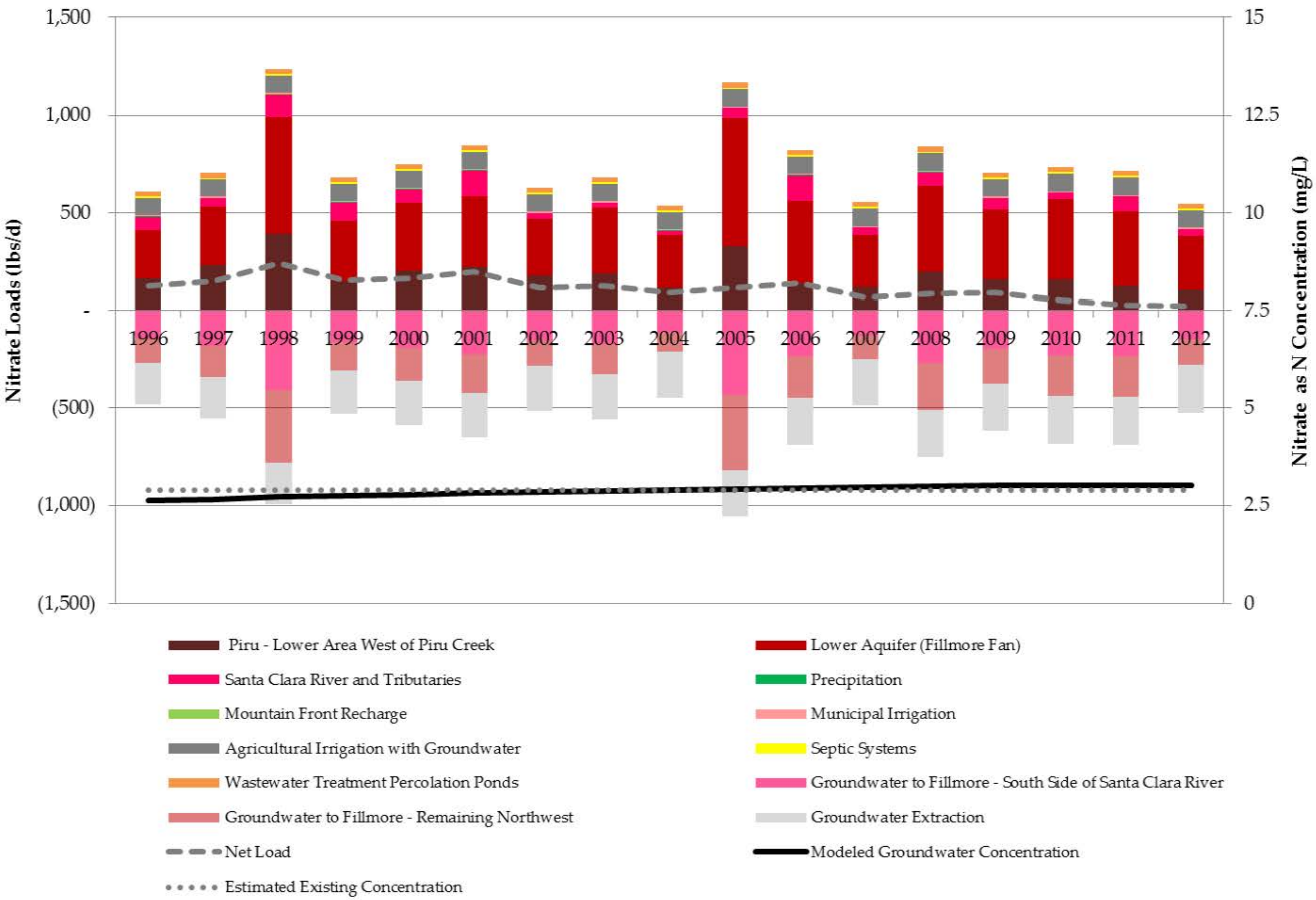

Figure 7-16 Modeled Annual Nitrate-N Loads and Concentrations in Groundwater for Fillmore Basin – Pole Creek Fan Area

7.3.5 Fillmore Basin – South of Santa Clara River

In this subarea, the largest non-land use based inflow and load is from underflow from the Pole Creek Fan Area, but there are also large amounts of underflow from Piru Basin and the LAS as well as streambed percolation from the SCR (**Figure 7-17**). The large amount of underflow from the LAS is consistent with rising groundwater discharging to the Santa Clara River in this subarea. The main land use based load is agricultural irrigation with groundwater (**Table 7-7**).

The mass balance model shows that existing loads in this subarea result in modeled concentrations in groundwater that are below water quality objectives for TDS (1,500 mg/L), chloride (100 mg/L) and nitrate-N (10 mg/L). This is consistent with the finding that the subarea has assimilative capacity for all three constituents based on groundwater quality data.

The modeled concentrations for TDS (**Figure 7-18**), chloride (**Figure 7-19**), and nitrate-N (**Figure 7-20**) are similar to the estimated existing concentrations for the subarea. Modeled annual concentrations in the subarea show little variation in response to hydrologic conditions.

Table 7-7. Mass Balance Model Average Loads and Steady State Concentrations for Fillmore Basin – South of Santa Clara River

		TDS		Chloride		Nitrate as N	
	Inflow (AFY)	**Concentration (mg/L)**	**Load (lbs/d)**	**Concentration (mg/L)**	**Load (lbs/d)**	**Concentration (mg/L)**	**Load (lbs/d)**
<u>Groundwater Flows</u>							
Piru - Lower Area West of Piru Creek	3,750	1,000	28,040	70	1,850	3.7	100
Lower Aquifer (Fillmore South)	4,740	1,340	47,290	70	2,570	5.2	190
Fillmore - Pole Creek Fan Area	10,040	1,100	82,200	60	4,370	2.8	210
<u>Non Land Use Surface Flows</u>							
Santa Clara River and Tributaries	3,100	930	21,490	60	1,300	2.4	60
Precipitation	2,910	10	220	0.1	2	0.1	2
Mountain Front Recharge	1,820	10	140	0.1	1	0.1	1
<u>Land Use Surface Flows</u>							
Municipal Irrigation	40	1,670	440	80	20	4.7	1
Agricultural Irrigation with Groundwater	3,390	4,690	118,540	250	6,240	30.0	640
Recycled Water	50	4,960	1,910	970	370	8.0	3
Septic Systems	70	1,190	610	100	50	40.0	20
<u>Inflow Totals</u>[1]							
Groundwater Flows	18,530		157,530		8,800		500
Non Land Use Surface Flows	7,820		21,850		1,300		60
Land Use Surface Flows	3,550		121,500		6,690		660
Total Inflows and Loads	29,900		300,870		16,790		1,230
Outflows	**Outlow (AFY)**		**Flux (lbs/d)**		**Flux (lbs/d)**		**Flux (lbs/d)**
<u>Groundwater Flows</u>							
Fillmore - Remaining Northwest	-8,120		-85,050		-4,490		-340
Santa Paula - East of Peck Road	-3,260		-34,090		-1,800		-140
Seepage to Santa Clara River	-7,210		-75,470		-3,980		-300
Groundwater Production	-11,310		-118,400		-6,250		-470
Total Outflows and Loads	-29,900		-313,010		-16,520		-1,250

[1] May include rounding error

Figure 7-17 Modeled Annual Inflows and Outflows for Fillmore Basin – South of the Santa Clara River

Figure 7-18 Modeled Annual TDS Loads and Concentrations in Groundwater for Fillmore Basin – South of Santa Clara River

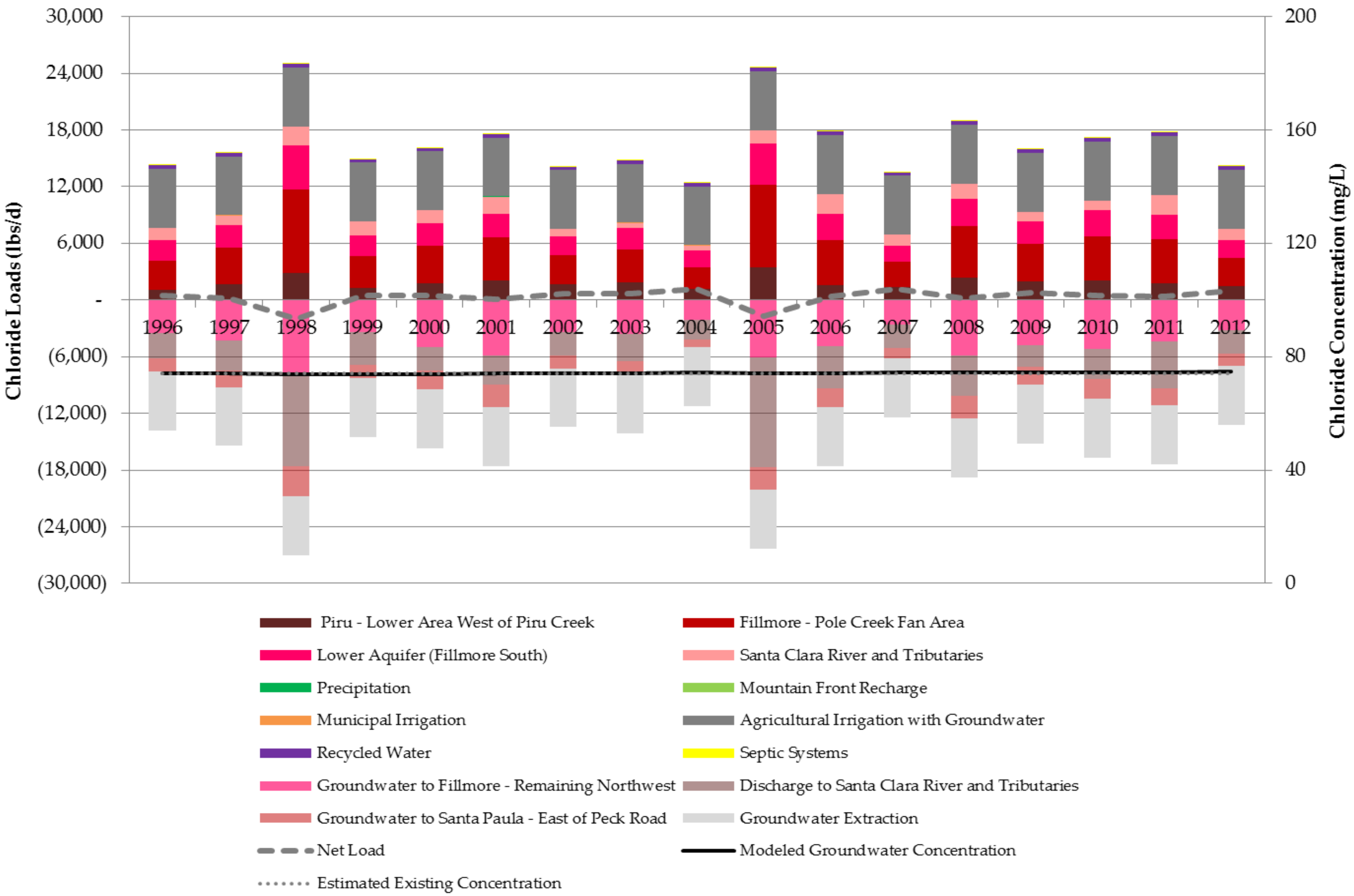

Figure 7-19 Modeled Annual Chloride Loads and Concentrations in Groundwater for Fillmore Basin – South of Santa Clara River

Figure 7-20 Modeled Annual Nitrate-N Loads and Concentrations in Groundwater for Fillmore Basin – South of Santa Clara River

7.3.6 Fillmore Basin – Remaining Area

In this subarea, the largest non-land use based inflow and load is from underflow from the other two Fillmore basin subareas and the LAS but there are also large amounts from streambed percolation from the Sespe Creek (**Figure 7-21**). The large amount of underflow from the LAS is consistent with rising groundwater discharging to the Santa Clara River in this subarea. The main land use based load is agricultural irrigation from groundwater (**Table 7-8**).

The mass balance model shows that existing loads in this subarea result in modeled concentrations in groundwater (**Table7-2**) that are below water quality objectives for TDS (1,000 mg/L) and nitrate-N (10 mg/L). This is consistent with the finding that the subarea has assimilative capacity for these two constituents based on groundwater quality data. However, the mass balance model shows that existing chloride loads result in modeled concentrations in groundwater approaching the water quality objective for chloride (50 mg/L), while the average subarea concentration based on groundwater quality data is just below the water quality objective.

The modeled concentrations for TDS (**Figure 7-22**) and chloride (**Figure 7-23**) in groundwater show a trend that increases concentrations above the estimated existing concentration for the subarea. The modeled steady state concentrations for nitrate-N are similar to the estimated existing concentration. Modeled annual concentrations in the subarea show little variation in response to hydrologic conditions.

Table 7-8 Mass Balance Model Average Loads and Steady State Concentrations for Fillmore Basin – Remaining Area

		TDS		Chloride		Nitrate as N	
	Inflow (AFY)	Concentration (mg/L)	Load (lbs/d)	Concentration (mg/L)	Load (lbs/d)	Concentration (mg/L)	Load (lbs/d)
Groundwater Flows							
Fillmore - Pole Creek Fan Area	9,030	1,100	73,950	60	3,940	2.8	190
Fillmore - South Side of Santa Clara River	8,120	1,410	85,200	70	4,490	5.6	340
Lower Aquifer (Fillmore Northwest)	3,870	830	23,930	40	1,230	6.0	170
Non Land Use Surface Flows							
Santa Clara River and Tributaries	5,830	630	27,540	50	2,240	0.2	9
Precipitation	4,430	10	330	0.1	3	0.1	3
Mountain Front Recharge	1,540	10	110	0.1	1	0.1	1
Land Use Surface Flows							
Agricultural Irrigation with Groundwater	5,160	2,780	106,780	140	5,510	30	1,220
Septic Systems	110	1,190	970	100	80	40	30
Inflow Totals[1]							
Groundwater Flows	21,030		183,080		9,650		700
Non Land Use Surface Flows	11,800		27,980		2,240		14
Land Use Surface Flows	5,300		108,120		5,610		1,260
Total Inflows and Loads	38,130		319,180		17,500		1,970
Outflows	**Outlow (AFY)**		**Flux (lbs/d)**		**Flux (lbs/d)**		**Flux (lbs/d)**
Groundwater Flows							
Santa Paula - East of Peck Road	-13,730		-86,460		-4,480		-680
Seepage to Santa Clara River	-7,210		-45,280		-2,340		-360
Groundwater Production	-17,190		-108,210		-5,600		-860
Total Outflows and Loads	-38,130		-239,950		-12,420		-1,900

[1] May include rounding error

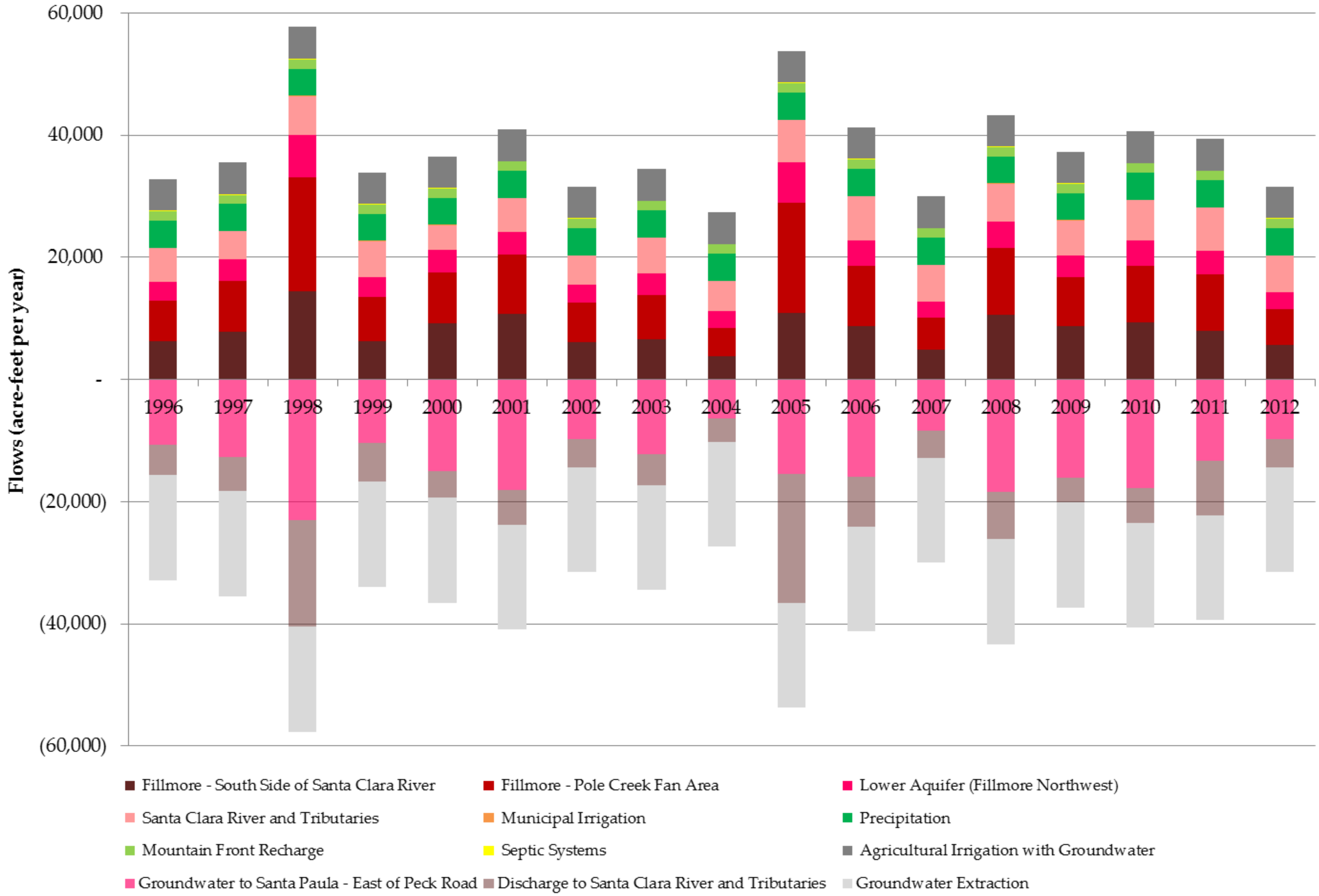

Figure 7-21 Modeled Annual Inflows and Outflows for Fillmore Basin – Remaining Area

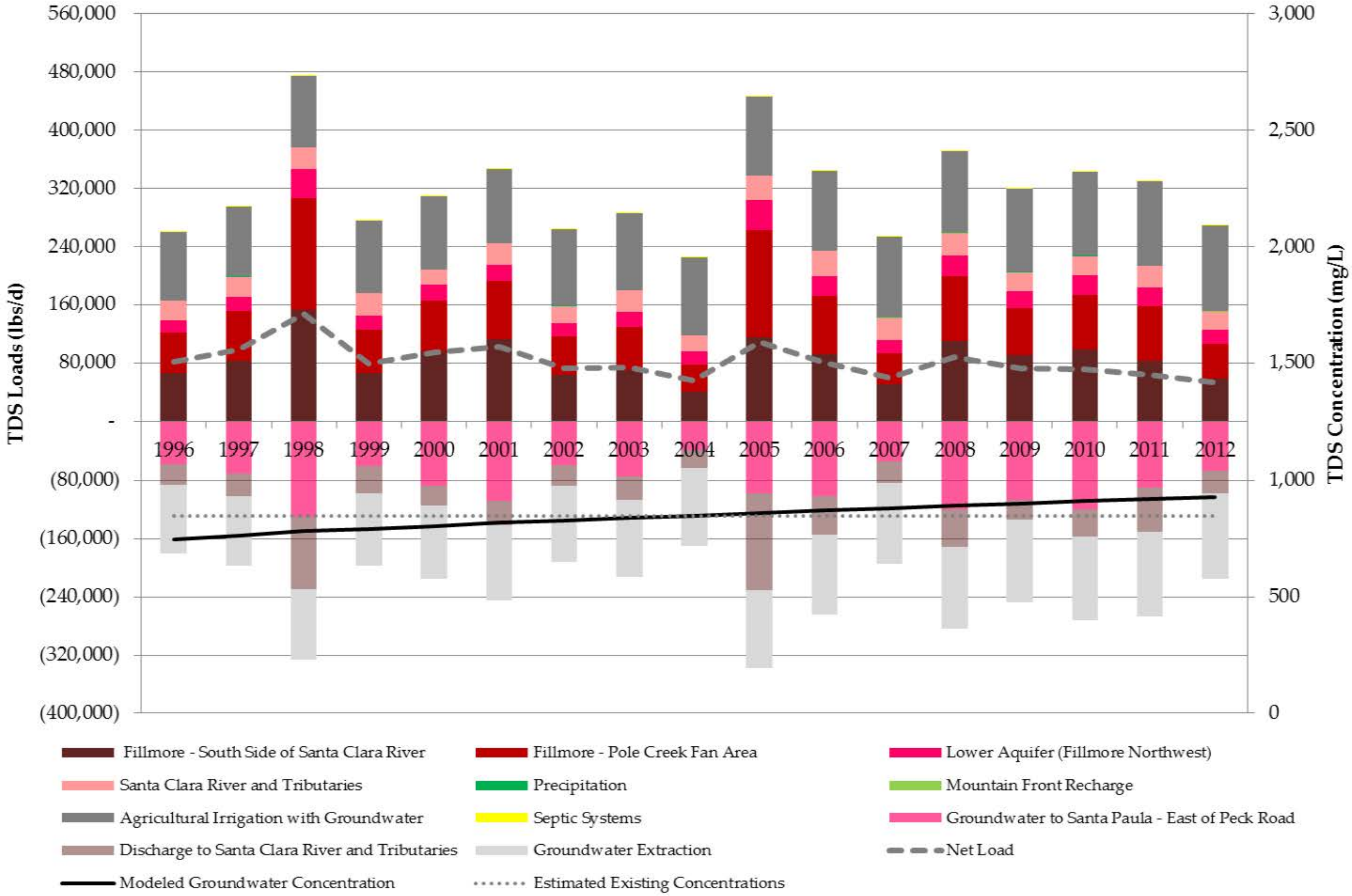

Figure 7-22 Modeled Annual TDS Loads and Concentrations in Groundwater for Fillmore Basin – Remaining Area

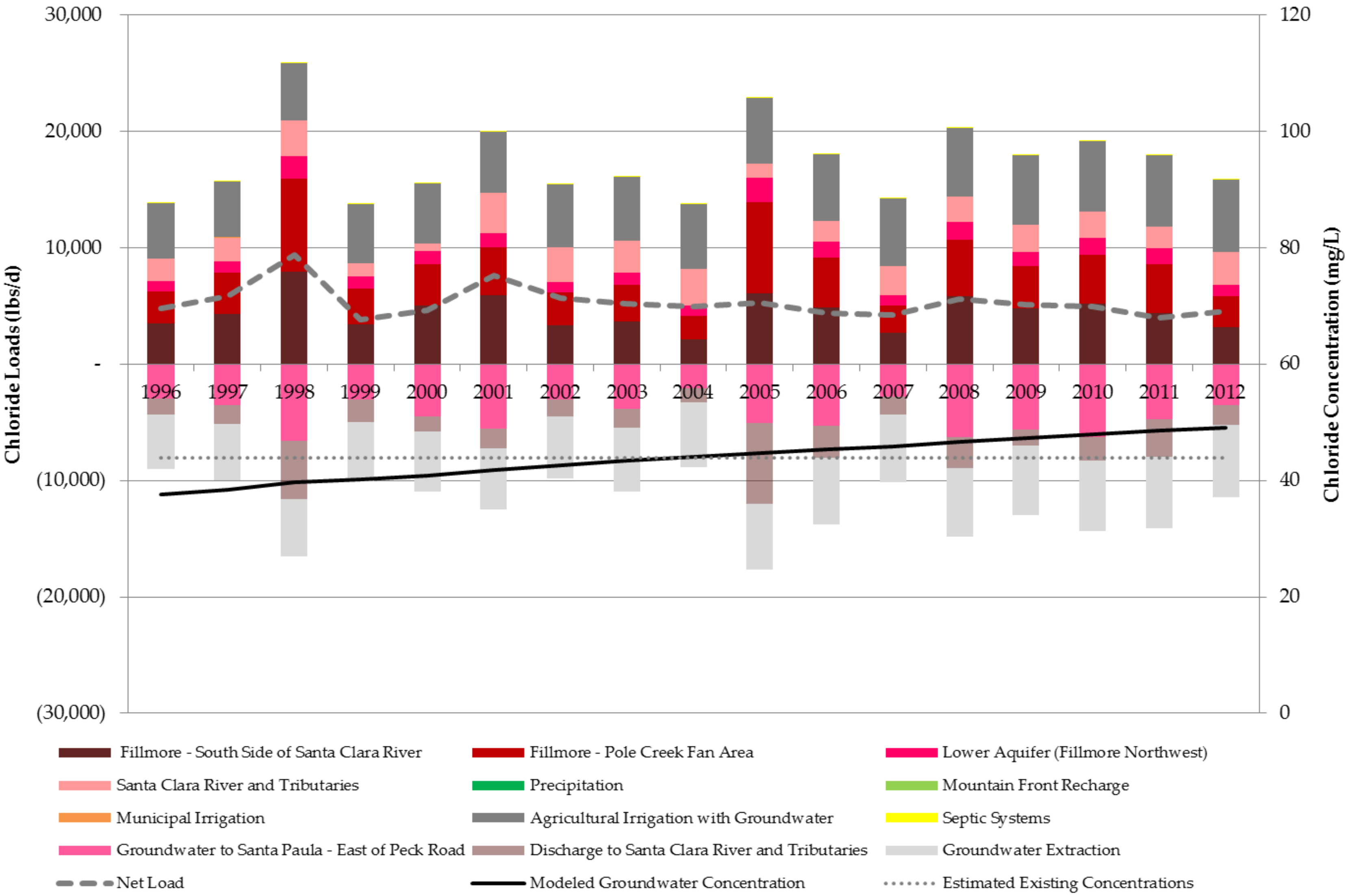

Figure 7-23 Modeled Annual Chloride Loads and Concentrations in Groundwater for Fillmore Basin – Remaining Area

Figure 7-24 Modeled Annual Nitrate-N Loads and Concentrations in Groundwater for Fillmore Basin – Remaining Area

7.3.7 Santa Paula Basin – East of Peck Road

In this subarea, the largest non-land use based inflow and load is from underflow from the Fillmore basin (**Figure 7-25**). The main land use based loads are agricultural irrigation from groundwater and municipal irrigation (**Table 7-9**).

The mass balance model shows that existing loads in this subarea result in modeled concentrations in groundwater (**Table7-2**) that are below water quality objectives for TDS (1,200 mg/L), chloride (100 mg/L) and nitrate-N (10 mg/L). This is consistent with the finding that the subarea has assimilative capacity for all three constituents based on groundwater quality data.

The modeled concentrations for TDS (**Figure 7-26**) and chloride (**Figure 7-27**) are similar to the estimated existing concentration for the subarea. The modeled concentrations for nitrate-N in groundwater show a trend that increases concentrations above the estimated existing concentration for the subarea. This is due to the higher nitrate-N concentrations in groundwater flowing from the Fillmore basin, the largest inflow into the subarea. The high calculated concentration for nitrate-N is also related to the high fertilizer loads assumed for avocados, the crop with the most acreage in the subarea.

Modeled annual concentrations in the subarea show little variation in response to hydrologic conditions.

Table 7-9 Average Loads and Steady State Concentrations for Santa Paula Basin – East of Peck Road

	Inflow (AFY)	TDS Concentration (mg/L)	TDS Load (lbs/d)	Chloride Concentration (mg/L)	Chloride Load (lbs/d)	Nitrate as N Concentration (mg/L)	Nitrate as N Load (lbs/d)
Groundwater Flows							
Fillmore - Remaining Northwest	13,730	830	85,250	40	4,400	6.7	680
Fillmore - South Side of Santa Clara River	3,260	1,410	34,150	70	1,800	5.6	140
Lower Aquifer (Santa Paula East)	2,560	950	18,010	40	760	4.9	90
Non Land Use Surface Flows							
Santa Clara River and Tributaries	1,370	680	6,950	30	310	1.0	10
Precipitation	2,530	10	190	0.1	2	0.1	2
Mountain Front Recharge	2,070	10	150	0.1	2	0.1	2
Land Use Surface Flows							
Municipal Irrigation	390	1,840	5,280	80	240	7.2	20
Agricultural Irrigation with Surface Water	90	2,010	1,410	100	70	30	20
Agricultural Irrigation with Groundwater	1,210	3,190	28,880	130	1,180	40	330
Septic Systems	60	1,270	520	110	40	40	16
Inflow Totals[1]							
Groundwater Flows	19,540		137,410		6,960		910
Non Land Use Surface Flows	5,970		7,300		310		13
Land Use Surface Flows	1,750		36,090		1,530		390
Total Inflows and Loads	27,260		180,790		8,800		1,310
Outflows	**Outlow (AFY)**		**Flux (lbs/d)**		**Flux (lbs/d)**		**Flux (lbs/d)**
Groundwater Flows							
Santa Paula - West of Peck Road	-16,650		-118,430		-4,880		-620
Groundwater Production	-10,620		-75,530		-3,110		-390
Total Outflows and Loads	-27,270		-193,960		-7,990		-1,010

[1] May include rounding error

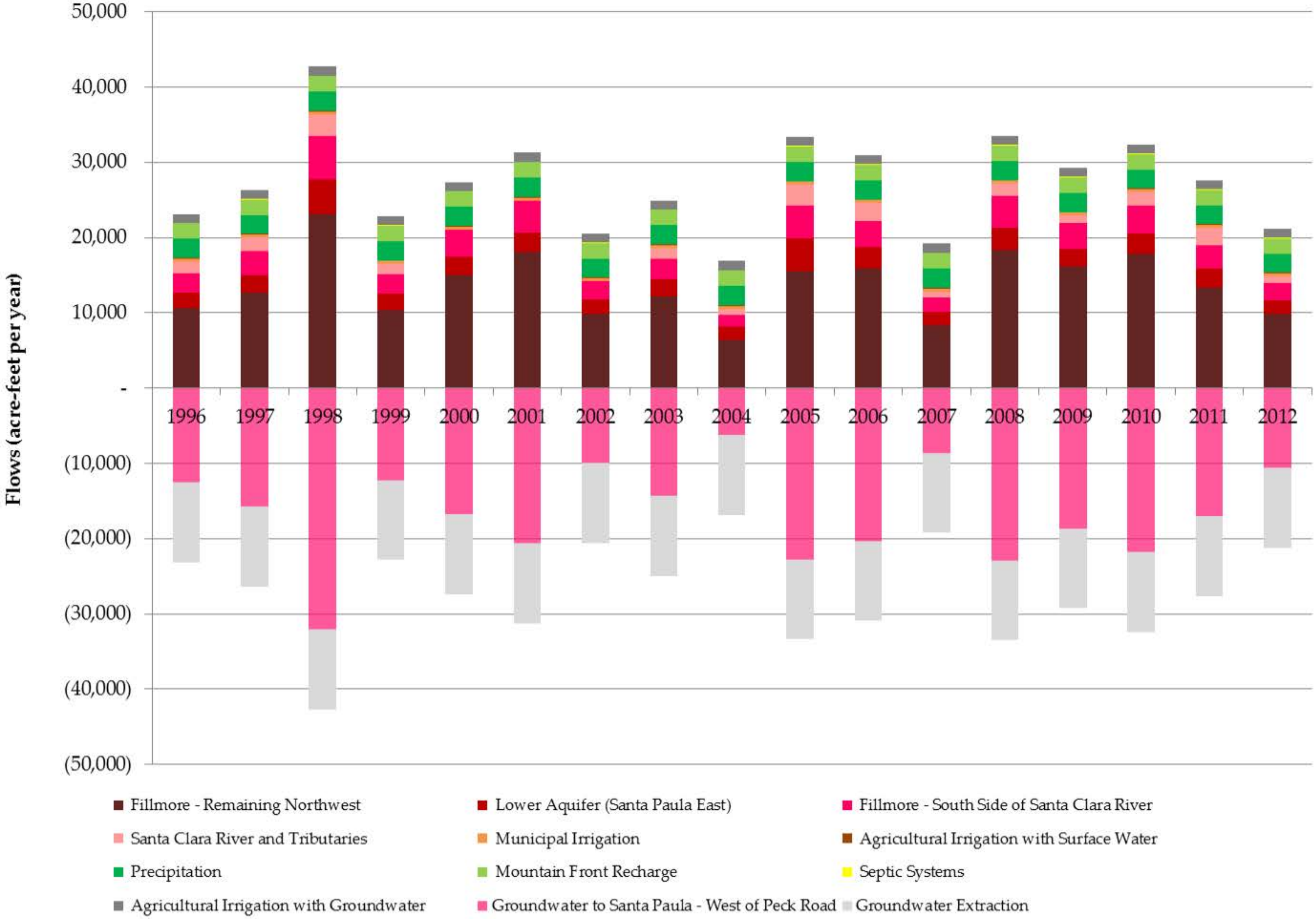

Figure 7-25 Modeled Annual Inflows and Outflows for Santa Paula Basin – East of Peck Road

Figure 7-26 Modeled Annual TDS Loads and Concentrations in Groundwater for Santa Paula Basin – East of Peck Road

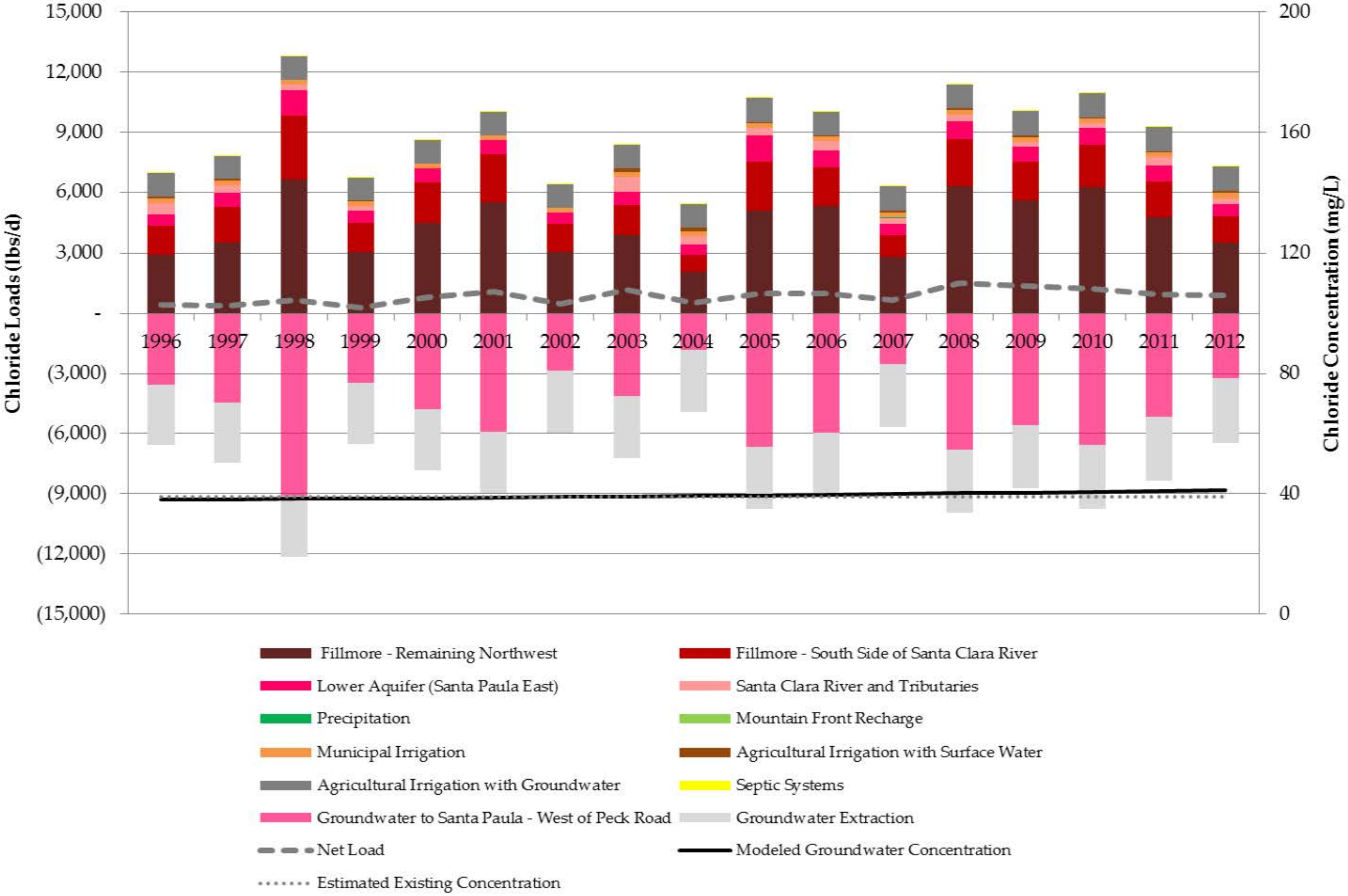

Figure 7-27 Modeled Annual Chloride Loads and Concentrations in Groundwater for Santa Paula Basin – East of Peck Road Area

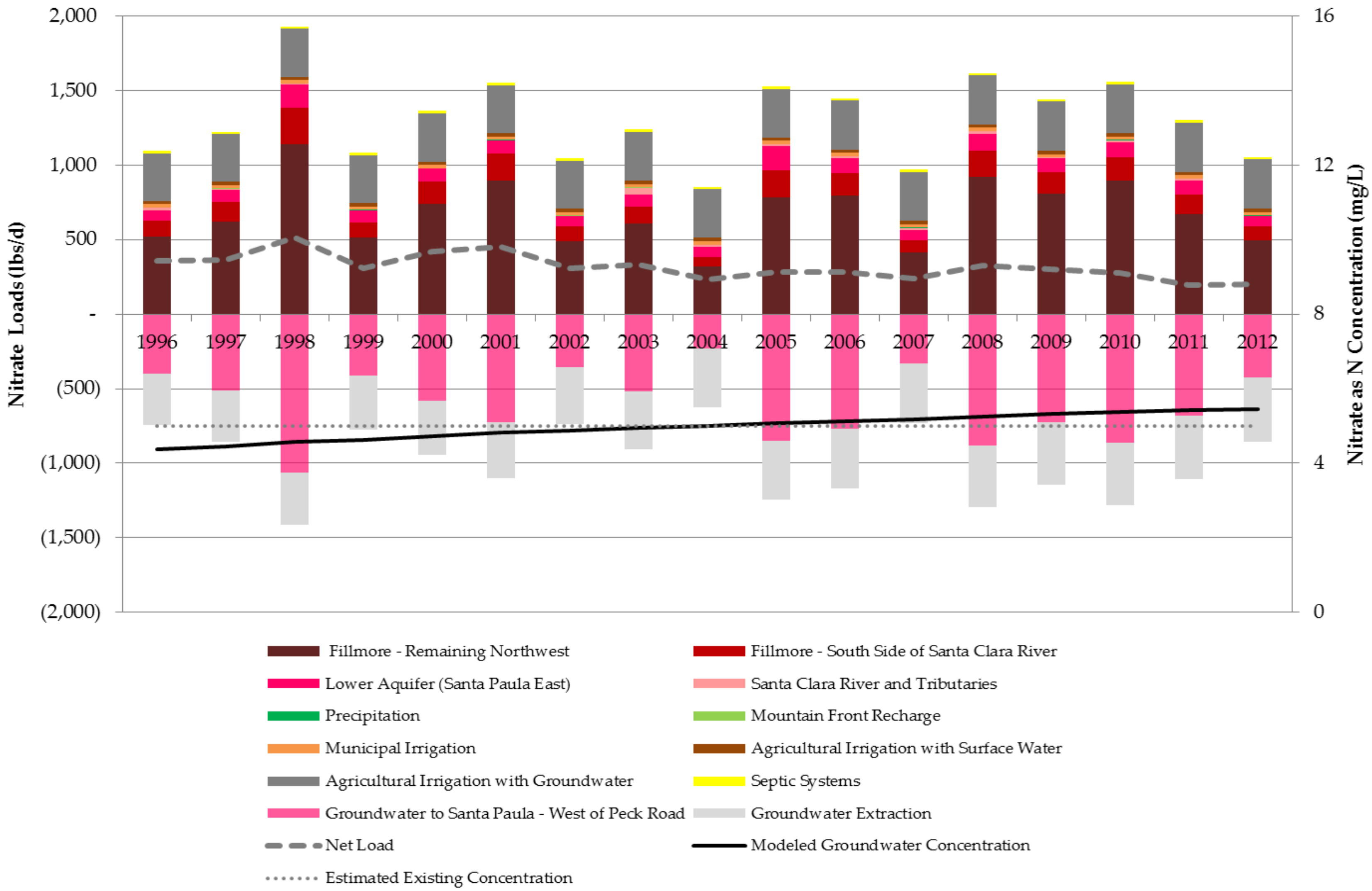

Figure 7-28 Modeled Annual Nitrate-N Loads and Concentrations in Groundwater for Santa Paula Basin – East of Peck Road Area

7.3.8 Santa Paula Basin – West of Peck Road

In this subarea, the largest non-land use based inflow and load is from underflow from Santa Paula basin's east of Peck Road subarea (**Figure 7-29**). The main land use based loads are agricultural irrigation from groundwater and wastewater treatment percolation plants (**Table 7-10**).

The mass balance model shows that existing loads in this subarea result in modeled concentrations in groundwater (**Table7-2**) that are below water quality objectives for TDS (2,000 mg/L), chloride (110 mg/L), and nitrate (10 mg/L). This is consistent with the finding that the subarea has assimilative capacity based on groundwater quality data.

The average modeled steady state concentrations for TDS and chloride are similar to the estimated existing concentrations for the subareas. The modeled concentrations for nitrate-N in groundwater show a trend that increases concentrations above the estimated existing concentration for the subarea. Nitrate-N concentrations in underflow from east of Peck Road subarea are higher than existing concentrations in this subarea. Increasing concentrations modeled for nitrate-N are also related to the high fertilizer loads assumed for avocados, the crop with the 2^{nd} most acreage in the subarea behind lemons.

Modeled annual concentrations in the subarea show little variation in response to hydrologic conditions.

Table 7-10 Average Loads and Steady State Concentrations for Santa Paula Basin – West of Peck Road

	Inflow (AFY)	TDS Concentration (mg/L)	TDS Load (lbs/d)	Chloride Concentration (mg/L)	Chloride Load (lbs/d)	Nitrate as N Concentration (mg/L)	Nitrate as N Load (lbs/d)
Groundwater Flows							
Santa Paula - East of Peck Road	16,650	960	118,830	40	4,860	4.9	610
Non Land Use Surface Flows							
Precipitation	6,240	10	460	0.1	5	0.1	5
Mountain Front Recharge	1,530	10	110	0.1	1	0.1	1
Land Use Surface Flows							
Municipal Irrigation	570	1,840	7,800	80	350	7.2	30
Agricultural Irrigation with Groundwater	6,100	4,300	195,210	260	11,950	30	1,350
Wastewater Treatment Percolation Ponds	2,230	1,300	21,690	150	2,550	6.7	110
Septic Systems	120	1,270	1,130	110	90	40	40
Inflow Totals[1]							
Groundwater Flows	16,650		118,830		4,860		610
Non Land Use Surface Flows	7,770		580		6		6
Land Use Surface Flows	9,030		225,830		14,950		1,530
Total Inflows and Loads	33,440		345,250		19,810		2,140
Outflows	**Outlow (AFY)**		**Flux (lbs/d)**		**Flux (lbs/d)**		**Flux (lbs/d)**
Groundwater Flows							
Oxnard Forebay	-8,090		-86,870		-5,840		-120
Lower Aquifer (Santa Paula West)	-7,110		-76,300		-5,130		-110
Mound	-1,010		-10,870		-730		-16
Seepage to Santa Clara River	-3,460		-37,240		-2,530		-40
Groundwater Production	-13,770		-147,970		-9,970		-200
Total Outflows and Loads	-33,440		-359,250		-24,200		-486

[1] May include rounding error

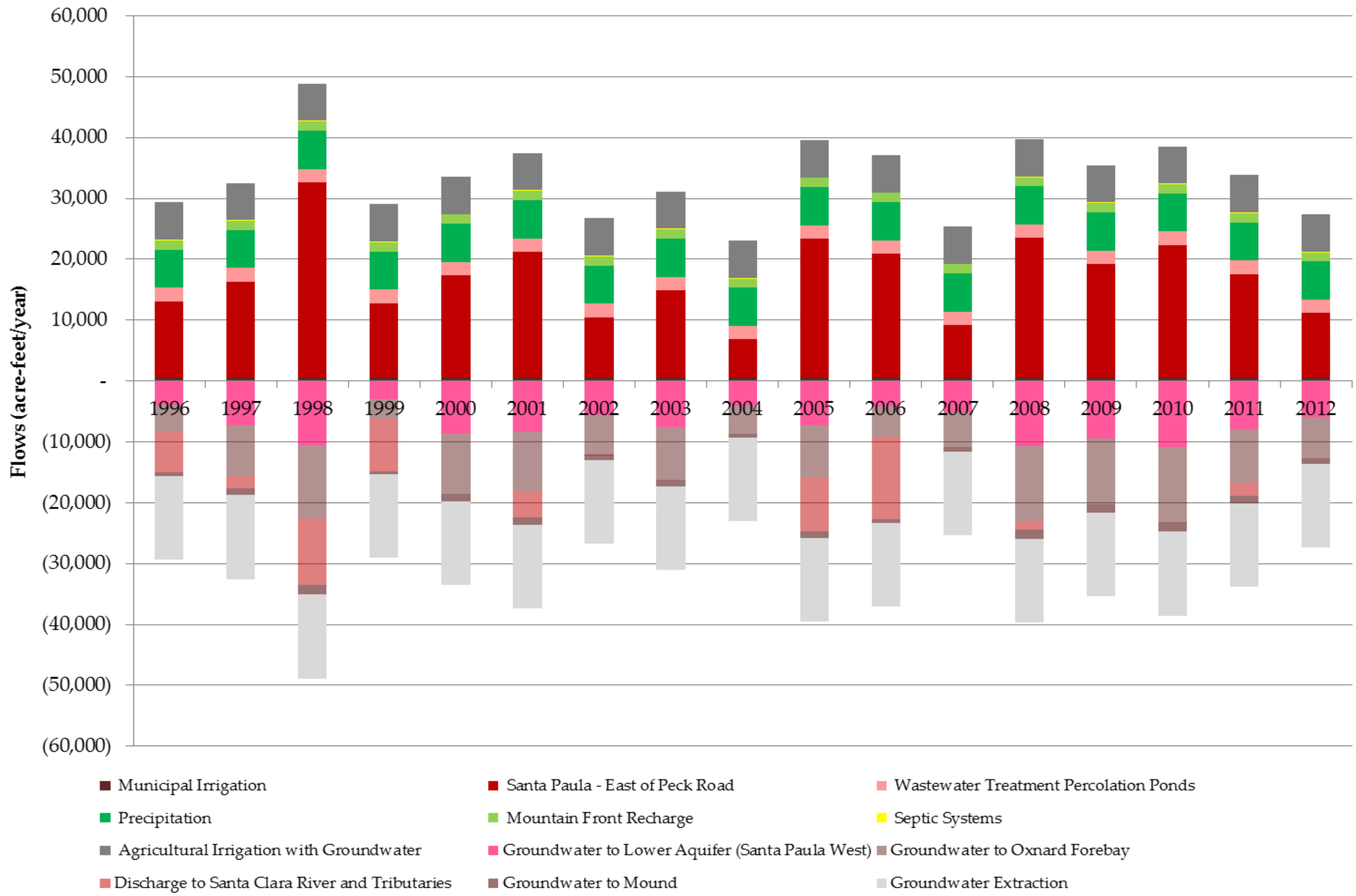

Figure 7-29 Modeled Annual Inflows and Outflows for Santa Paula Basin – West of Peck Road

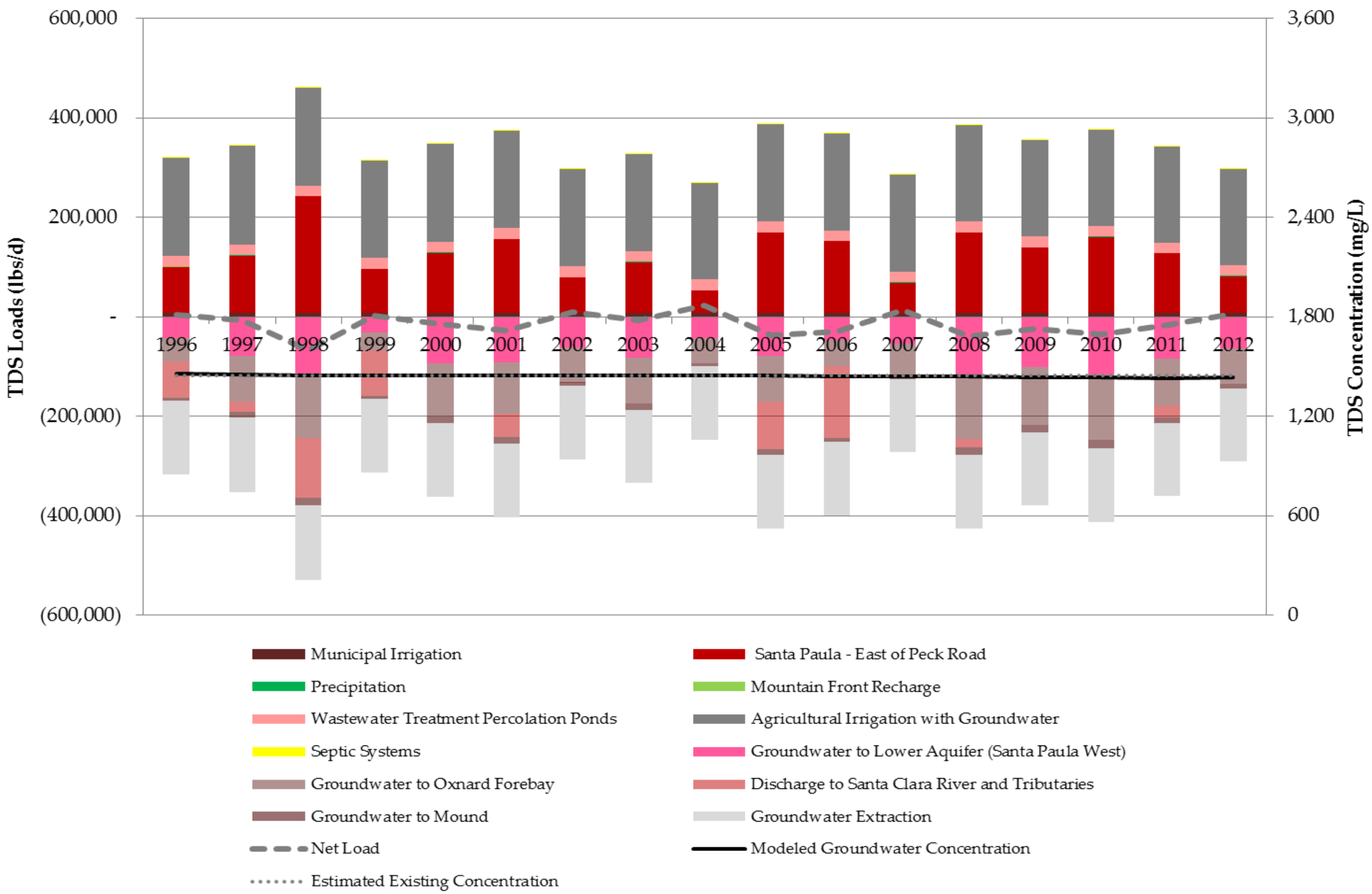

Figure 7-30 Modeled Annual TDS Loads and Concentrations in Groundwater for Santa Paula Basin – West of Peck Road

Figure 7-31 Modeled Annual Chloride Loads and Concentrations in Groundwater for Santa Paula Basin – West of Peck Road

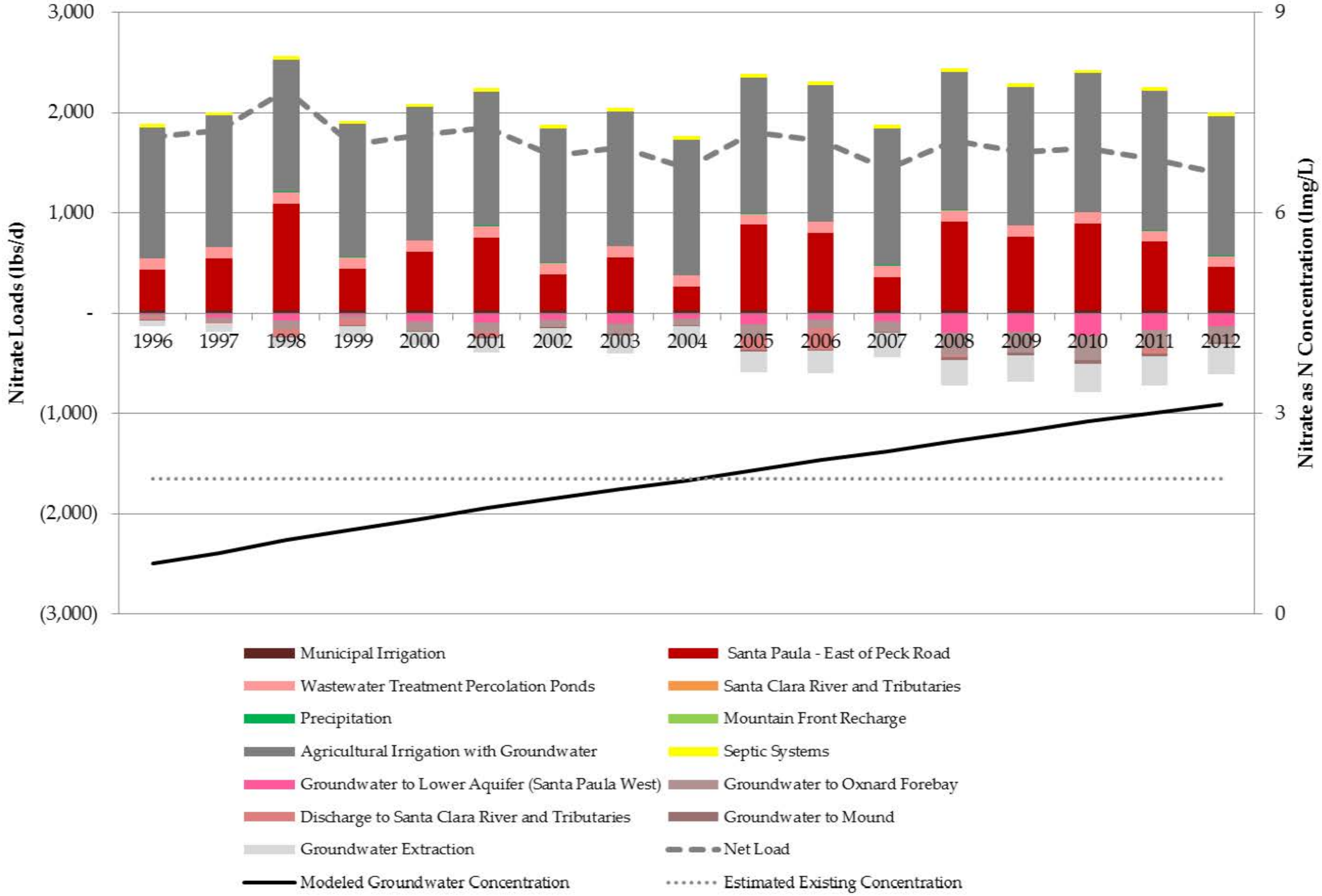

Figure 7-32 Modeled Annual Nitrate-N Loads and Concentrations in Groundwater for Santa Paula Basin – West of Peck Road

7.3.9 Oxnard Forebay Basin

In this basin, the largest non-land use based inflow and load is from managed aquifer recharge of SCR flow diverted at the Freeman diversion and recharged at the Saticoy, El Rio and Noble recharge basins by UWCD (**Figure 7-33**). The main land use based load is agricultural irrigation from groundwater. The high percentage of overall inflow from percolation results in modeled groundwater concentrations for TDS and chloride calculated as similar to surface water concentrations. The nitrate-N load from fertilizer results in modeled concentrations for nitrate-N higher than surface water quality but the large amount of managed aquifer recharge results in modeled groundwater concentrations closer to surface water quality than irrigation infiltration water quality (**Table 7-11)**.

The mass balance model shows that existing loads in this subarea result in modeled concentrations in groundwater **(Table7-2)** that are below water quality objectives for TDS (1,200 mg/L), chloride (150 mg/L) and nitrate-N (10 mg/L). This is consistent with the finding that the subarea has assimilative capacity for all three constituents based on groundwater quality data.

The modeled concentrations for TDS (**Figure 7-34**) and chloride (**Figure 7-35**) are similar to the estimated existing concentrations for the subareas. The modeled steady state concentrations for nitrate-N (**Figure 7-36**) in groundwater show a trend that decreases concentrations below the estimated existing concentration for the subarea. Infiltration concentrations for nitrate-N are relatively high to account for fertilization of strawberries, the crop with the most acreage in the subarea. It is possible that irrigation inflows are underestimated for the area.

Modeled annual concentrations in the subarea show little variation in response to hydrologic conditions. There have been observations of nitrate concentrations increasing for time periods of less a few months or less with little managed aquifer recharge. The mass balance modeled likely does not show that variation because there is enough managed aquifer recharge each year so that calculated annual concentrations for the basin do not increase substantially from year to year.

Table 7-11 Average Loads and Steady State Concentrations for Oxnard Forebay Basin

	Inflow (AFY)	TDS Concentration (mg/L)	TDS Load (lbs/d)	Chloride Concentration (mg/L)	Chloride Load (lbs/d)	Nitrate as N Concentration (mg/L)	Nitrate as N Load (lbs/d)
Groundwater Flows							
Santa Paula - West of Peck Road	8,090	1,440	86,980	100	5,870	1.9	110
Non Land Use Surface Flows							
Santa Clara River and Tributaries	9,710	1,050	75,600	60	4,180	1.1	80
Managed Recharge	54,880	1,080	439,510	60	23,460	1.3	510
Precipitation	3,310	10	250	0.1	2	0.1	2
Mountain Front Recharge	2,070	10	150	0.1	2	0.1	2
Land Use Surface Flows							
Municipal Irrigation	1,230	0	0	0	0	0.0	0
Agricultural Irrigation with Groundwater	2,090	3,590	55,800	190	2,950	16	250
Septic Systems	18	1,200	160	100	14	40	5
Inflow Totals[1]							
Groundwater Flows	8,090		86,980		5,870		110
Non Land Use Surface Flows	69,960		515,510		27,640		600
Land Use Surface Flows	3,450		57,520		3,080		260
Total Inflows and Loads	81,500		660,010		36,600		970
Outflows	**Outlow (AFY)**		**Flux (lbs/d)**		**Flux (lbs/d)**		**Flux (lbs/d)**
Groundwater Flows							
Oxnard Plain	-35,370		-283,850		-15,080		-1,210
Mound	-20,160		-161,320		-8,540		-710
Lower Aquifer (Oxnard Forebay)	-19,020		-152,160		-8,060		-670
Groundwater Production	-6,960		-55,850		-2,970		-240
Total Outflows and Loads	-81,510		-653,180		-34,650		-2,830

[1] May include rounding error

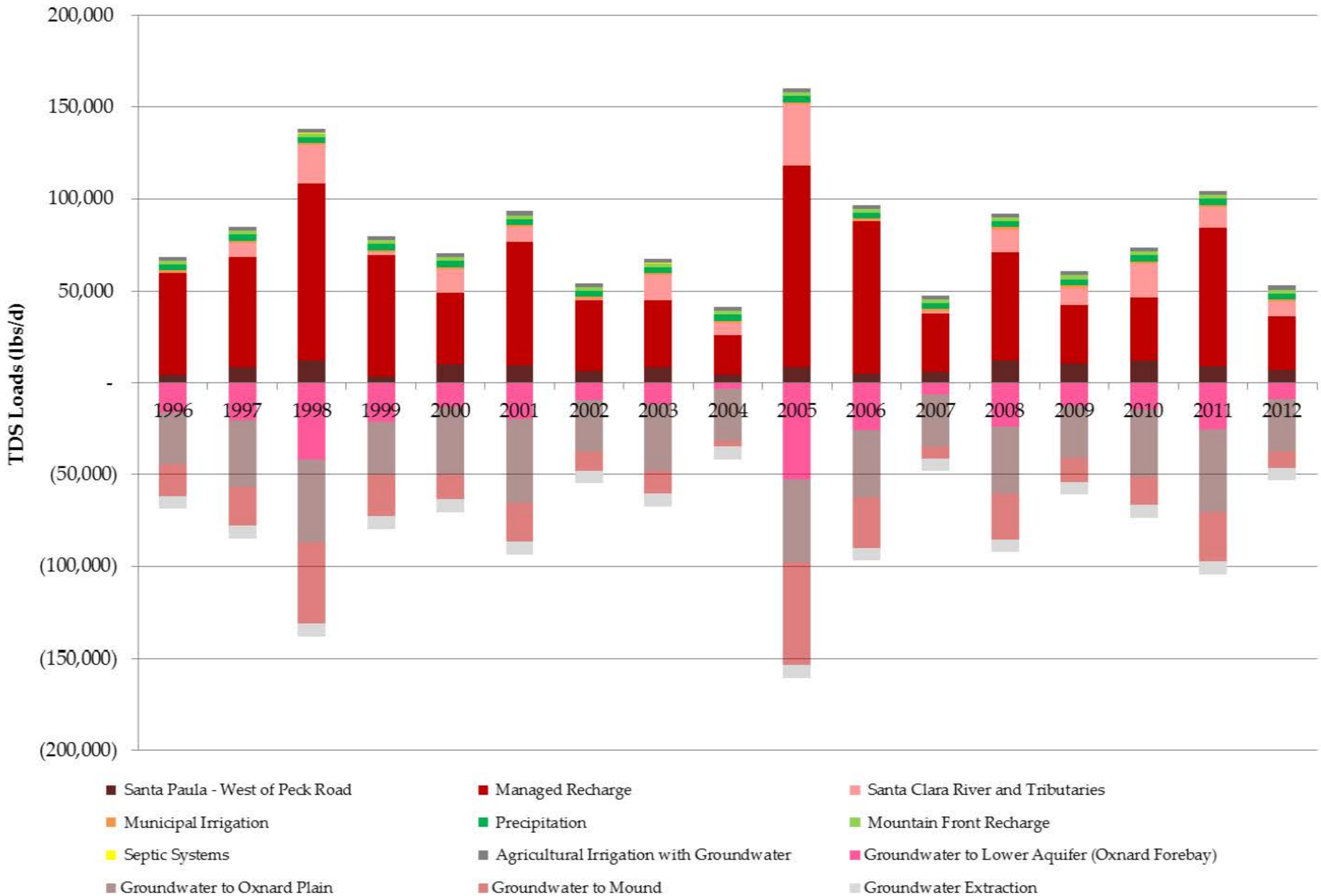

Figure 7-33 Modeled Annual Inflows and Outflows for Oxnard Forebay Basin

Figure 7-34 Modeled Annual TDS Loads and Concentrations in Groundwater for Oxnard Forebay Basin

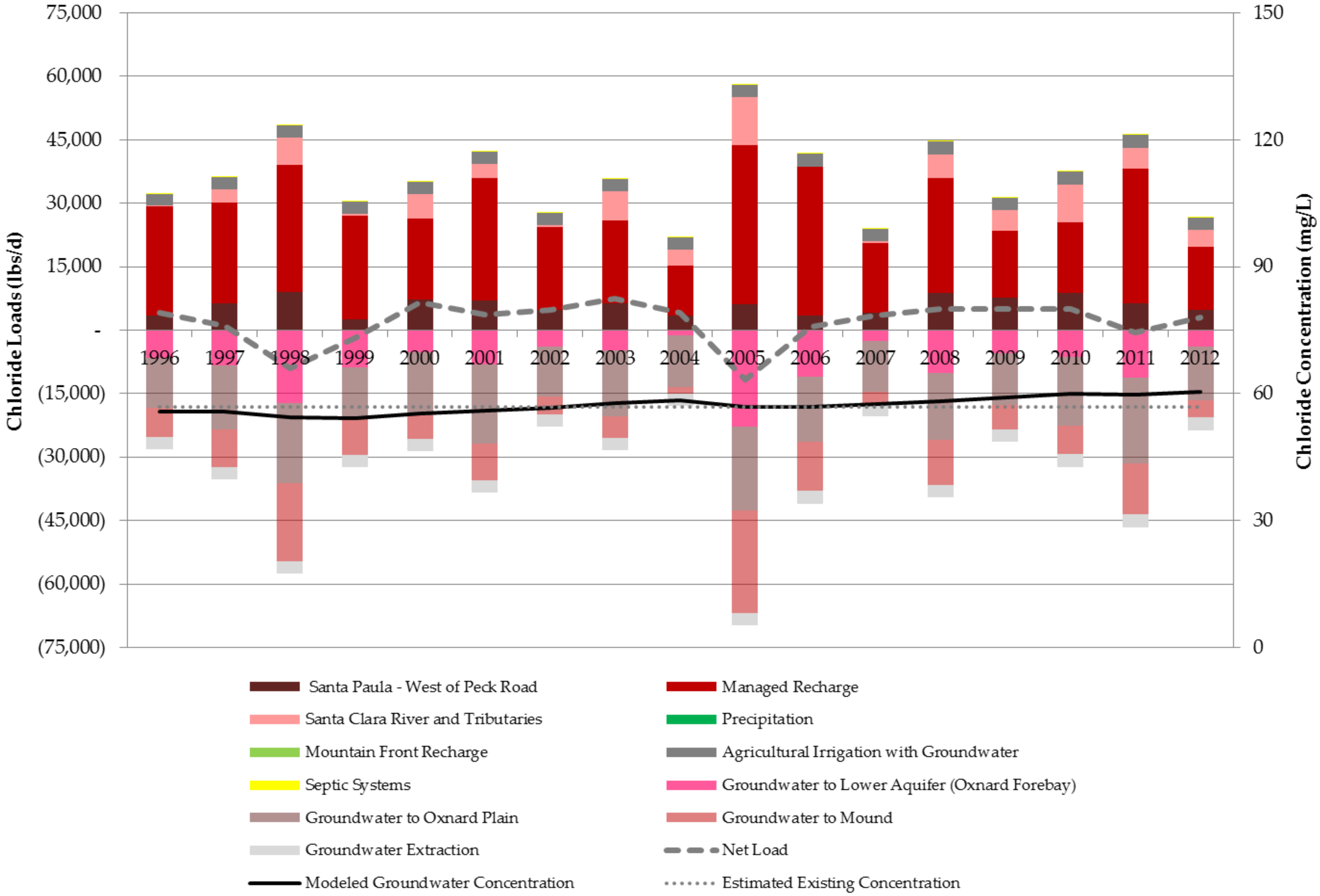

Figure 7-35 Modeled Annual Chloride Loads and Concentrations in Groundwater for Oxnard Forebay Basin

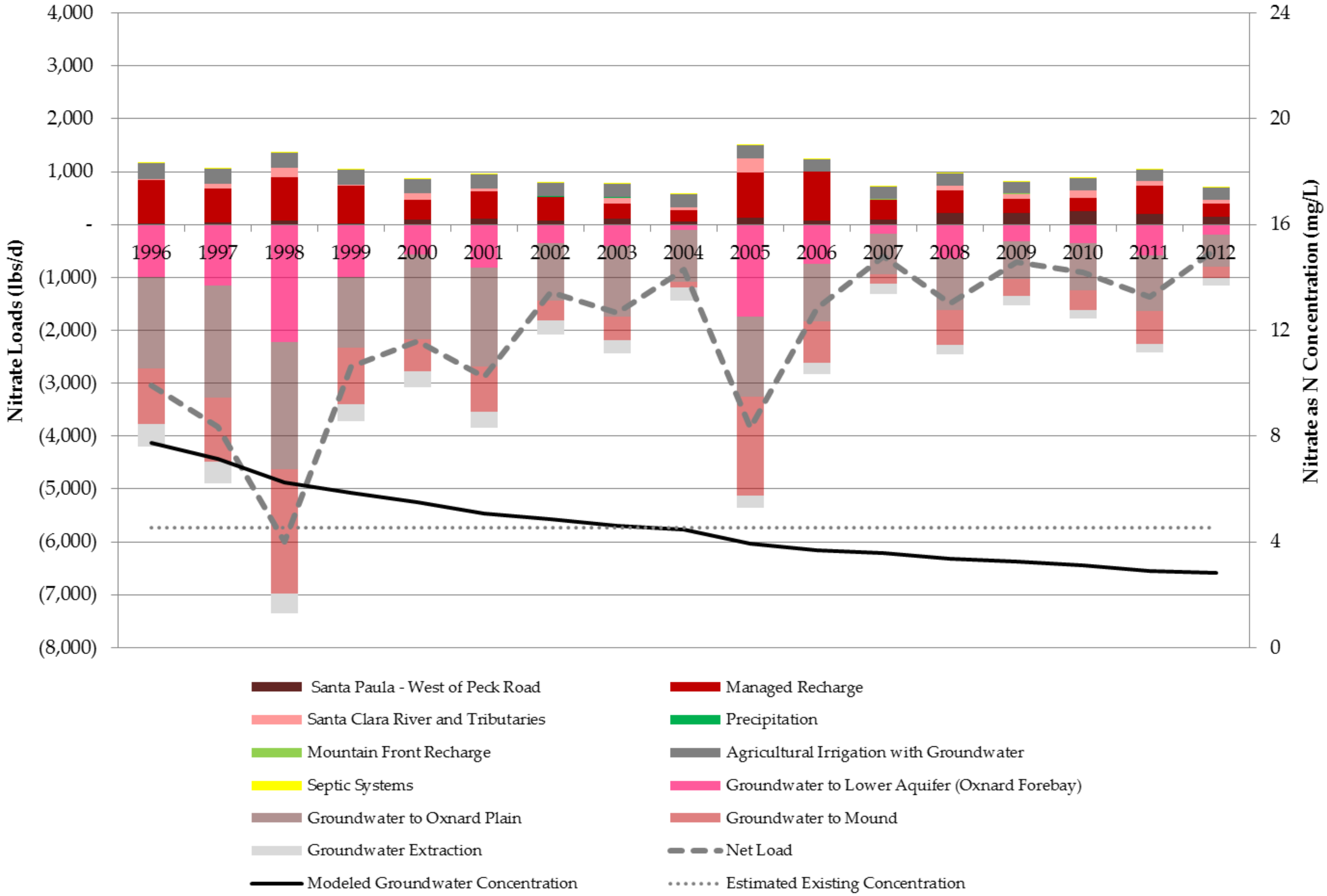

Figure 7-36 Modeled Annual Nitrate-N Loads and Concentrations in Groundwater for Oxnard Forebay Basin

7.3.10 Mound Basin

In this basin, the largest non-land use based inflow and load is underflow from the Oxnard Forebay basin (**Figure 7-37**). The main land use based loads are municipal irrigation and agricultural irrigation from groundwater (**Table 7-12**).

The mass balance model shows that existing loads in this subarea result in modeled concentrations in groundwater that are above water quality objectives for TDS (1,200 mg/L), but below water quality objectives for chloride (150 mg/L) and nitrate-N (10 mg/L). This is consistent with the finding that the subarea has assimilative capacity for chloride and nitrate-N but not TDS based on groundwater quality data.

The modeled concentrations for TDS (**Figure 7-38**), chloride (**Figure 7-39**), and nitrate-N (**Figure 7-40**) are similar to the estimated existing concentrations for the subarea.

In the Mound basin, the small amount of inflow relative to groundwater volume results in stable concentrations even if there are net loads as estimated for TDS and nitrate-N. It is possible that existing concentrations represent historical conditions as opposed to more recent inflows and loads. Additionally, the presence of a perched zone of poor quality water over a confined basin likely results in a small influence of surface loading in the Mound basin on water quality in the deeper confined aquifers used for groundwater production.

As discussed above, the distribution of inflow into the Mound basin is controversial. While output from the regional groundwater model used for the mass balance model indicates the largest inflow is underflow from the Oxnard Forebay basin, the City of Ventura has concluded that the primary inflow is underflow from the Santa Paula basin. If the alternate flow distribution is assumed, concentrations for TDS and chloride would be greater than presented in **Table 7-12** because TDS and chloride concentrations are higher in the Santa Paula basin than the Oxnard Forebay basin. However, concentrations would also be stable assuming the alternate flow distribution because total inflow would still be small relative to groundwater volume.

Table 7-12 Average Loads and Steady State Concentrations for Mound Basin

		TDS		Chloride		Nitrate as N	
	Inflow (AFY)	Concentration (mg/L)	Load (lbs/d)	Concentration (mg/L)	Load (lbs/d)	Concentration (mg/L)	Load (lbs/d)
Groundwater Flows							
Santa Paula - West of Peck Road	1,010	1,440	10,890	100	730	1.9	14
Oxnard Forebay	20,160	1,080	162,040	60	8,560	5.1	770
Non Land Use Surface Flows							
Precipitation	80	10	6	0.1	0	0.1	0
Mountain Front Recharge	1,410	10	100	0.1	1	0.1	1
Land Use Surface Flows							
Municipal Irrigation	2,630	2,570	50,240	130	2,580	3.6	70
Agricultural Irrigation with Groundwater	1,380	4,090	42,170	250	2,610	30	300
Recycled Water	100	4,960	3,640	970	710	8.0	6
Septic Systems	18	1,490	200	290	40	40	5
Inflow Totals1							
Groundwater Flows	21,170		172,930		9,290		780
Non Land Use Surface Flows	1,490		110		1		1
Land Use Surface Flows	4,130		96,250		5,940		390
Total Inflows and Loads	26,790		269,290		15,230		1,170
Outflows	**Outlow (AFY)**		**Flux (lbs/d)**		**Flux (lbs/d)**		**Flux (lbs/d)**
Groundwater Flows							
Lower Aquifer (Mound)	-18,100		-165,460		-10,230		-530
Oxnard Plain	-2,650		-24,210		-1,500		-80
Coast	-2,260		-20,630		-1,280		-70
Groundwater Production	-3,790		-34,700		-2,140		-110
Total Outflows and Loads	-26,800		-245,000		-15,150		-790

[1] May include rounding error

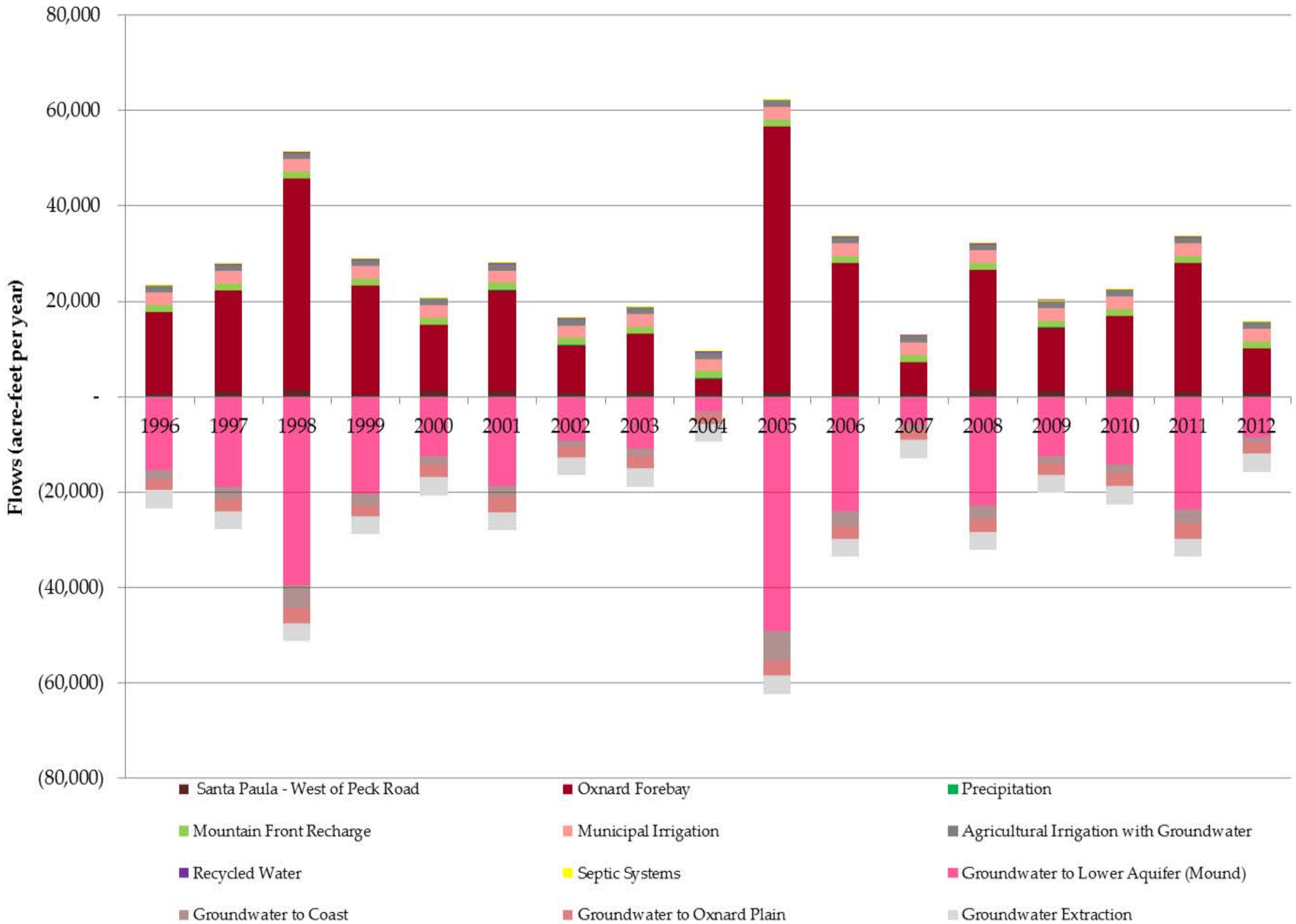

Figure 7-37 Modeled Annual Inflows and Outflows for Mound Basin

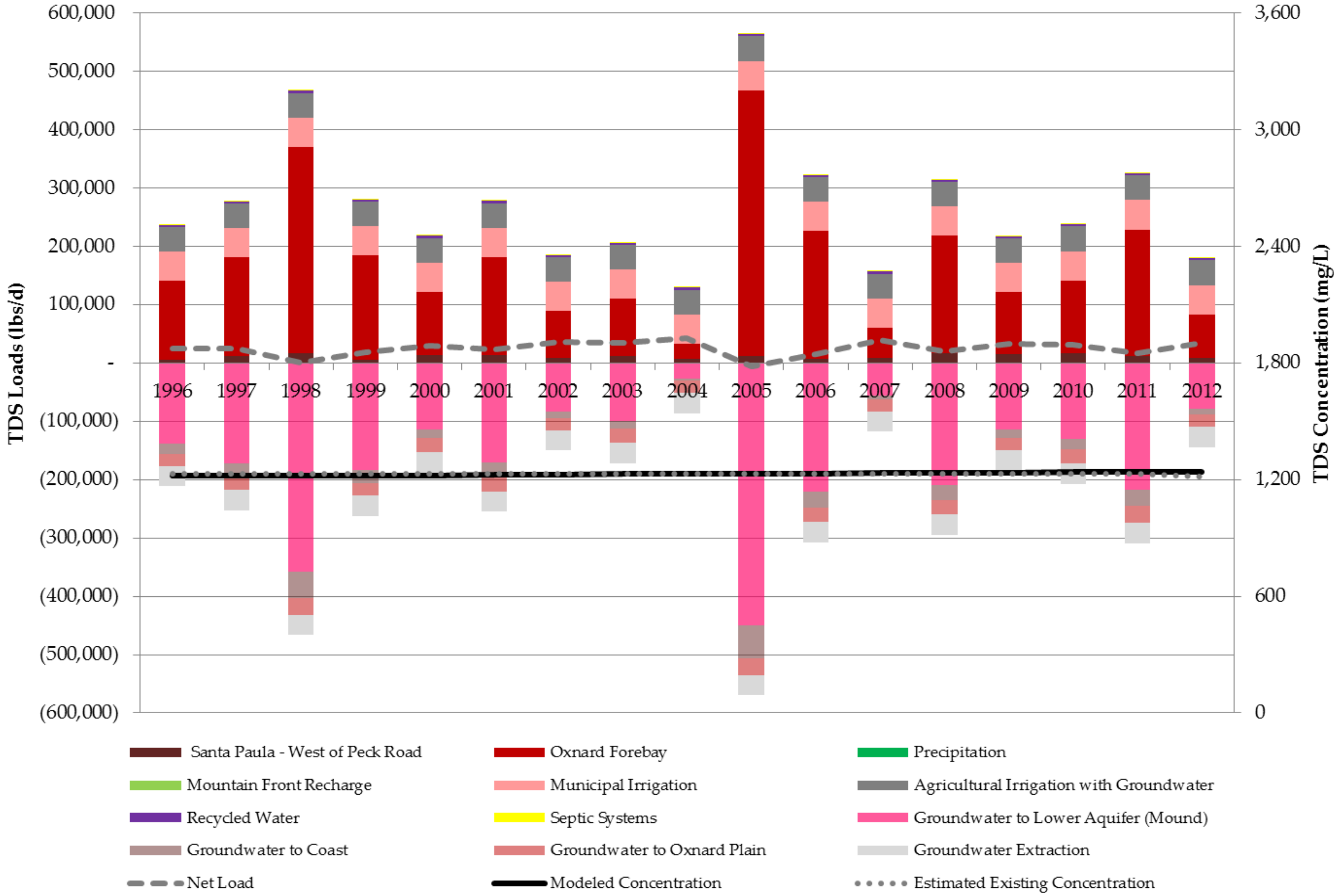

Figure 7-38 Modeled Annual TDS Loads and Concentrations in Groundwater for Mound Basin

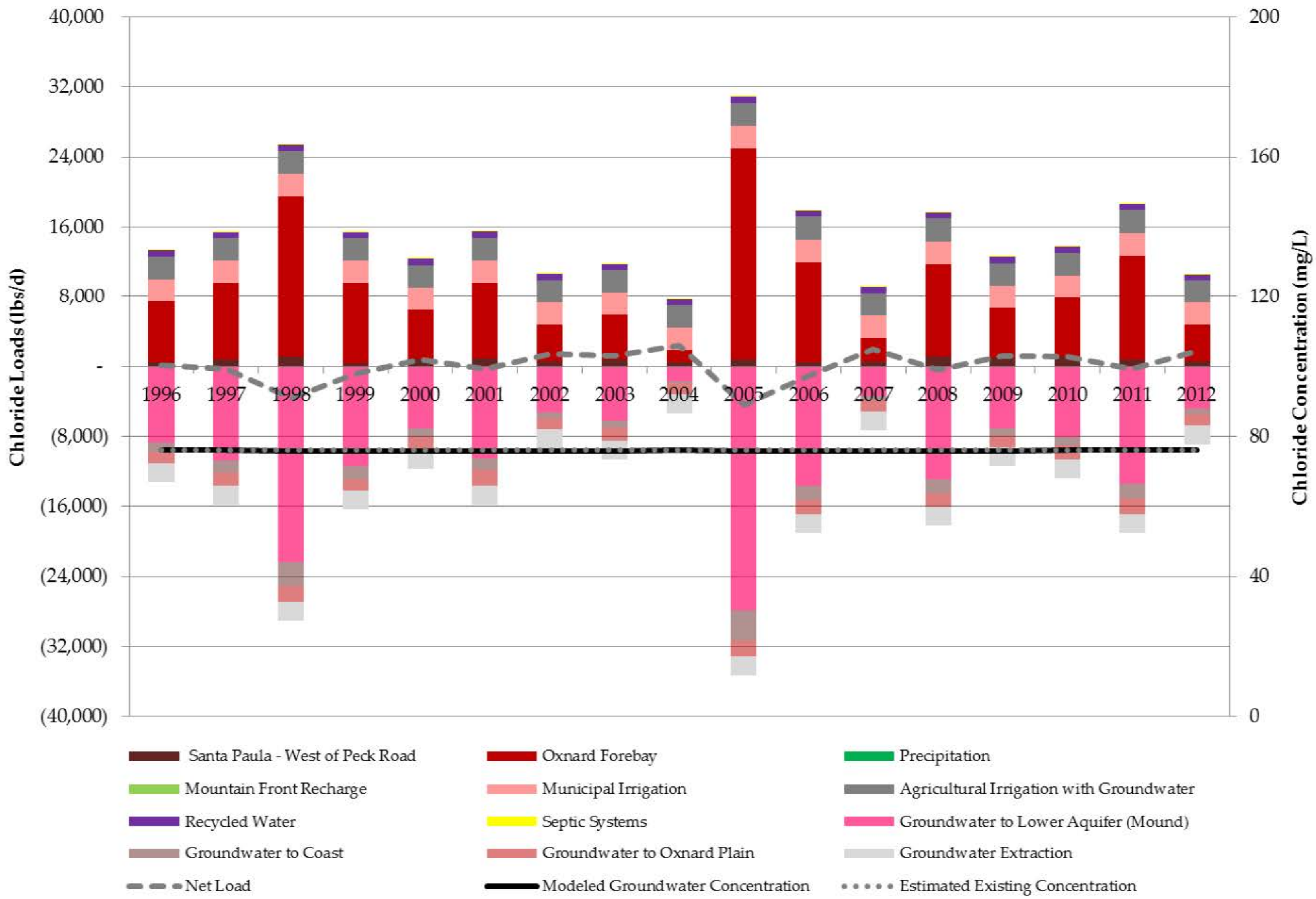

Figure 7-39 Modeled Annual Chloride Loads and Concentrations in Groundwater for Mound Basin

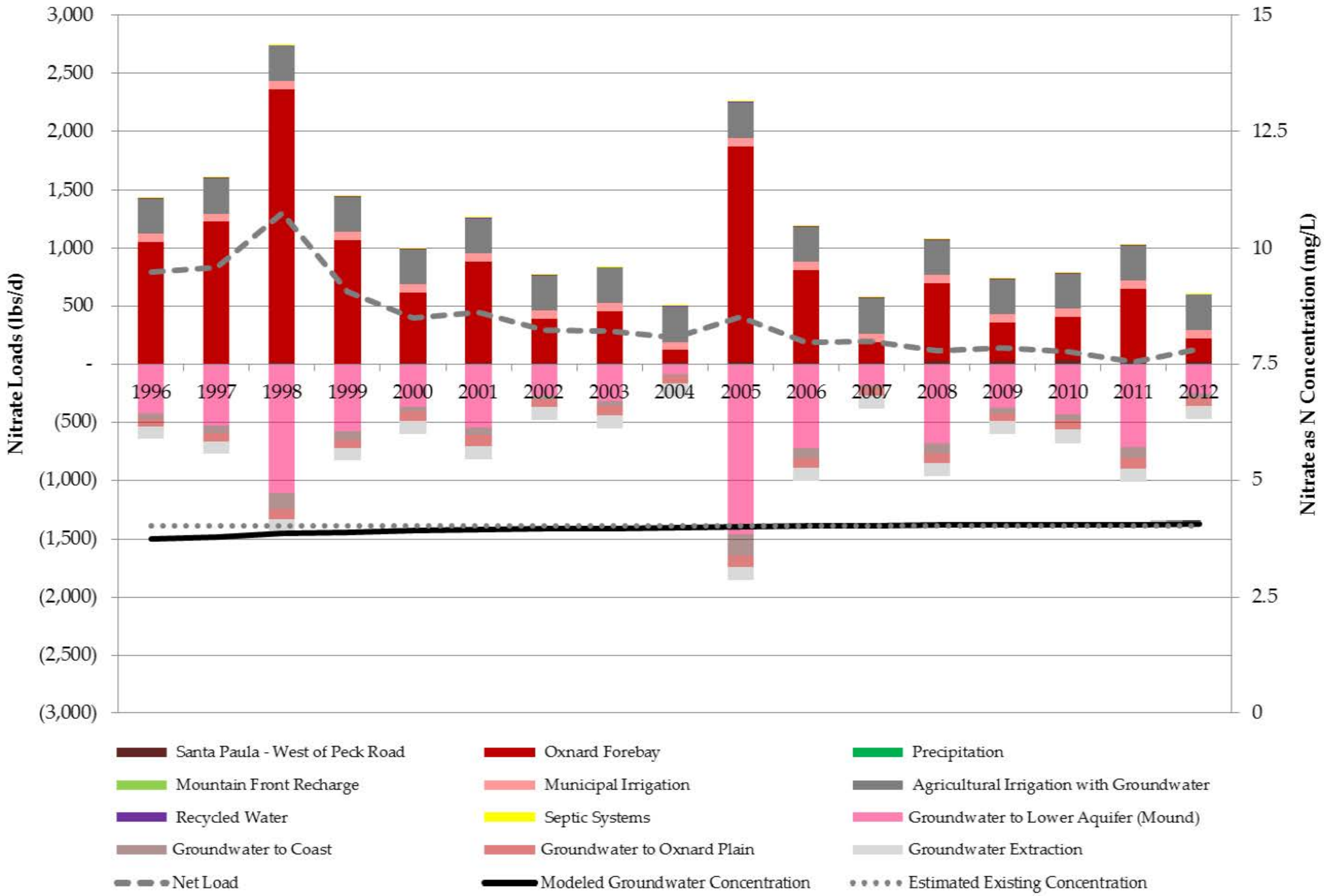

Figure 7-40 Modeled Annual Nitrate-N Loads and Concentrations in Groundwater for Mound Basin

7.4 USE OF MASS BALANCE SPREADSHEET MODEL TO ESTIMATE THRESHOLD LOADINGS FOR AVAILABLE ASSIMILATIVE CAPACITY

As described in **Section 9**, projects will be evaluated based on the amount of available assimilative capacity that will be used up by the projects or group of projects. The thresholds that are used to evaluate whether projects require additional management measures are 10% of available assimilative capacity for a single project and 20% of available assimilative capacity for a group of projects. The mass balance spreadsheet is used to calculate the additional load in a subarea that will use up threshold percentage of available assimilative capacity so that projected loads from projects can be evaluated.

7.4.1 Methodology

The mass balance model is set up to repeat the 1996-2012 hydrology to evaluate future loadings. The initial concentrations are set at the existing concentrations estimated for the subarea in **Section 4**. A loading is added to the model for the subarea so that 20% of available assimilative capacity as estimated in **Section 5** is used up by the end of the 17-year period. This loading represents the threshold for evaluating a group of projects. Half of this loading represents the threshold for evaluating a single project. No flow is added to the model along with the additional loading so this is a conservative estimate of the effect of the additional load on subarea groundwater concentrations.

Besides the additional loading to estimate threshold loading, the loadings or flows in the subarea are the same as the 1996-2012 model with one exception discussed below. The baseline concentrations are based on the 1996-2012 results so the baseline concentrations change over time and may use up or increase assimilative capacity without additional loadings. For evaluating threshold loading, the loadings or flows in upgradient subareas are assumed to be the same as the 1996-2012 model so the effect of additional projects in upgradient subareas are not considered.

The exception to using the 1996-2012 model setup for all loadings and flows besides the threshold loading is the chloride concentration used for recharge in the Santa Clara River percolation reaches from Newhall to Torrey Road and from Torrey Road to Cavin Road in the Piru basin. These concentrations are expected to change with reduced chloride concentrations in the Santa Clara River as a result of the Upper Santa Clara River chloride TMDL. Chloride concentrations projected from the Groundwater Surface Water Interaction Model for the Santa Clara River after the chloride TMDL is fully implemented are used to estimate recharge concentrations for these percolation reaches. There is typically a dry gap towards the west of these percolation reaches so downstream concentrations of surface water recharge are not changed based on the Upper Santa Clara River chloride TMDL.

7.4.2 Effect of Future Changes to Flows and Loadings

Future conditions may differ from existing conditions independent of new projects that add salt and nutrient loadings. Changes in future conditions that are most likely to change mass balance calculations relate to flows from surface water, wastewater and recycled water discharges, and irrigation practices. The largest source of water to most subareas is surface water, either percolation from streams or managed recharge. Concentrations in surface water are generally lower than concentration in groundwater so surface water inflows generally have a diluting effect. Changes in management of surface water flows in the LSCR could change the spatial distribution of surface water inflows and therefore the spatial distribution of groundwater concentrations.

The largest land-use based loading of salts and nutrients is irrigation. Changes in irrigation volumes will change the loading and result in different modeled groundwater concentrations. For nitrates, the fertilizer load is the major load source so changes in fertilizer practices would result in changes to modeled groundwater concentrations.

There are three potential future changes to the water balance from the 1996-2012 period. First, the Piru spreading grounds ceased operation in 2009 and are not expected to be used in the future. Therefore, the managed recharge modeled in the subarea of the Piru basin below Lake Piru for 1996-2008 is not expected to occur. However, loads to use up additional assimilative capacity are not calculated for this subarea because there are no data to estimate existing groundwater quality. In addition, the effect of this change is not evaluated downstream because most Piru Creek flows recharge in the Piru basin so the flow and load is added to the lower subareas of the Piru basin as surface water recharge instead of groundwater. The total flow and load into those subareas should not change much.

There is the potential for a reduction in flows in the Santa Clara River due to the Upper Santa Clara River chloride TMDL with new wastewater treatment processes implemented in Los Angeles County. However, the flows projected after the chloride TMDL is fully implemented are similar to the modeled flows used for most years in the1996-2012 time frame. Therefore, the use of the 1996-2012 water balance is a good approximation of future conditions.

Additionally, the Newhall Ranch development may result in additional flows due to the potential for a new wastewater treatment plant discharge. It is currently anticipated that all of the water from the Newhall Ranch wastewater treatment plant will be recycled or discharged to land and will not increase flows to the receiving water.

7.5 ESTIMATED THRESHOLD LOADING RESULTS

Table 7-13 shows the preliminary results for threshold loads that use up 20% of available assimilative capacity in each subarea.[2] These results are based on existing water quality of the SCR as it crosses into Ventura County. The results will be updated based on projected water quality after the Upper Santa Clara River chloride TMDL is fully implemented. The lower chloride concentrations projected for the Upper Santa Clara River chloride TMDL will increase the 20% threshold loads for chloride in all subareas except for the Piru basin Upper Area below Lake Piru. The lower chloride concentrations for Santa Clara River recharge in the Piru basin will affect downgradient subareas.

Table 7-13 shows 20% threshold loads of zero for chloride in the Piru basin – lower area west of Piru Creek and for TDS and chloride in the Fillmore basin – remaining northwest area. There is available assimilative capacity for these constituents in these subareas, but the mass balance spreadsheet shows 20% of the available assimilative capacity being used up by estimated

[2] Preliminary results are provided so that RWQCB can review methodology and planned documentation.

existing loads in the 17-year period. There is no assimilative capacity for TDS in the Mound basin so the threshold load is zero for TDS in that basin.

Table 7-13 Threshold Loads Using Up 20% of Available Assimilative Capacity Estimated by Mass Balance Model

Basin	Subarea	TDS				Chloride				Nitrate-N			
		WQO (mg/L)	Existing Quality (mg/L)	20% Available Assimilative Capacity Concentration (mg/L)	20% Threshold Load based on 17-Yr Trend (lbs/d)	WQO (mg/L)	Existing Quality (mg/L)	20% Available Assimilative Capacity Concentration (mg/L)	20% Threshold Load based on 17-Yr Trend (lbs/d)	WQO (mg/L)	Existing Quality (mg/L)	20% Available Assimilative Capacity Concentration (mg/L)	20% Threshold Load based on 17-Yr Trend (lbs/d)
Piru	Upper Area below Lake Piru	1,100	No data	NA	NA	200	No data	NA	NA	10	No data	NA	NA
	Lower Area East of Piru Creek	2,500	1,000	1300	96,000	200	118	134	14,100	10	2.6	4.1	230
	Lower Area West of Piru Creek	1,200	992	1034	26,000	100	69	75	1,100	10	3.6	4.9	970
Fillmore	Pole Creek Fan Area	2,000	1,101	1281	83,000	100	59	67	1,000	10	2.9	4.3	480
	South Side of Santa Clara River	1,500	1,411	1429	26,000	100	74	79	1,900	10	5.6	6.5	510
	Remaining Fillmore	1,000	846	877	0	50	44	45	0	10	6.7	7.3	300
Santa Paula	East of Peck Road	1,200	953	1002	22,000	100	39	51	3,000	10	5.0	6.0	60
	West of Peck Road	2,000	1,444	1555	106,000	110	97	99	6,300	10	2.0	3.6	0
Oxnard Forebay		1,200	1,077	1102	20,000	150	57	75	11,000	10	4.5	5.6	2,490
Mound		1,200	1,230	1224	0	150	76	91	16,300	10	4.0	5.2	1,270

7.5.1 Piru Basin – Lower Area East of Piru Creek

Figure 7-41 shows the additional loading of 96,000 lbs/d TDS that results in TDS concentrations increasing to 300 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show no trend over time.

Figure 7-42 shows the additional loading of 14,100 lbs/d chloride that results in chloride concentrations increasing to 16 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show a significant decrease over time increasing the available assimilative capacity.

Figure 7-43 shows the additional loading of 230 lbs/d nitrate-N that results in nitrate-N concentrations increasing to 1.5 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show an increase over time decreasing the available assimilative capacity.

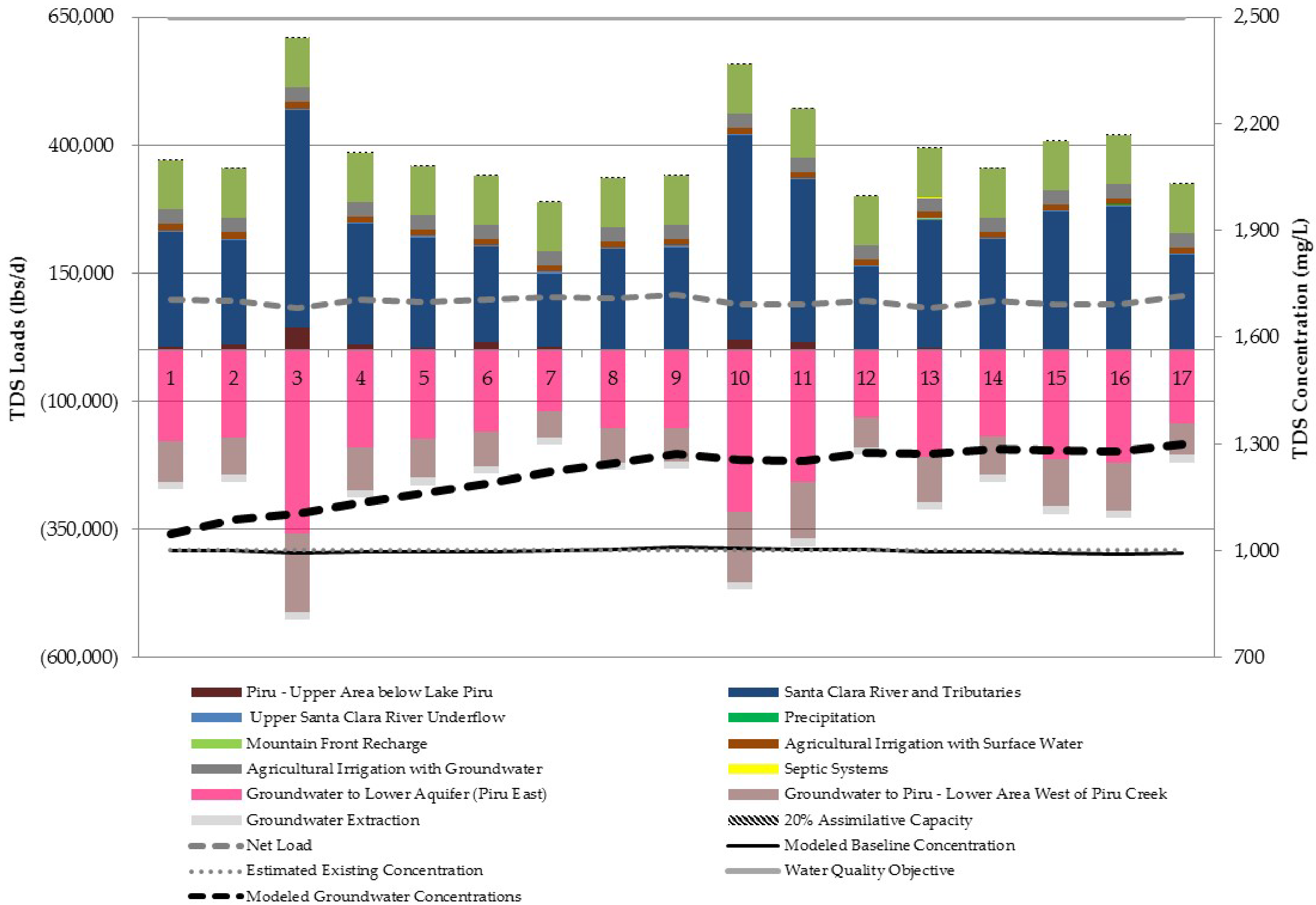

Figure 7-41 Modeled TDS 20% Threshold Load and Annual Concentrations for Piru Basin – Lower Area East of Piru Creek

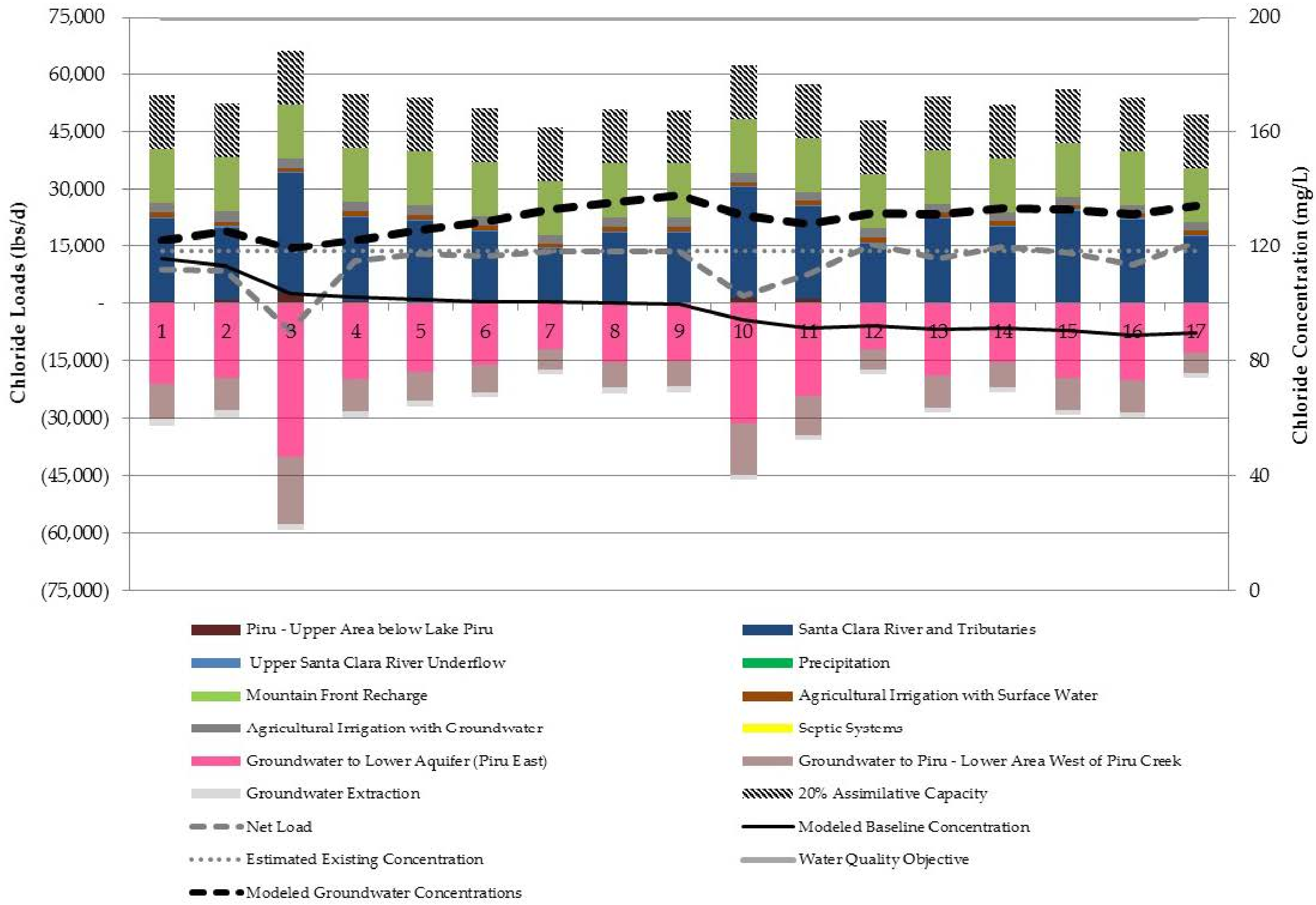

Figure 7-42 Modeled Chloride 20% Threshold Load and Annual Concentrations for Piru Basin – Lower Area East of Piru Creek

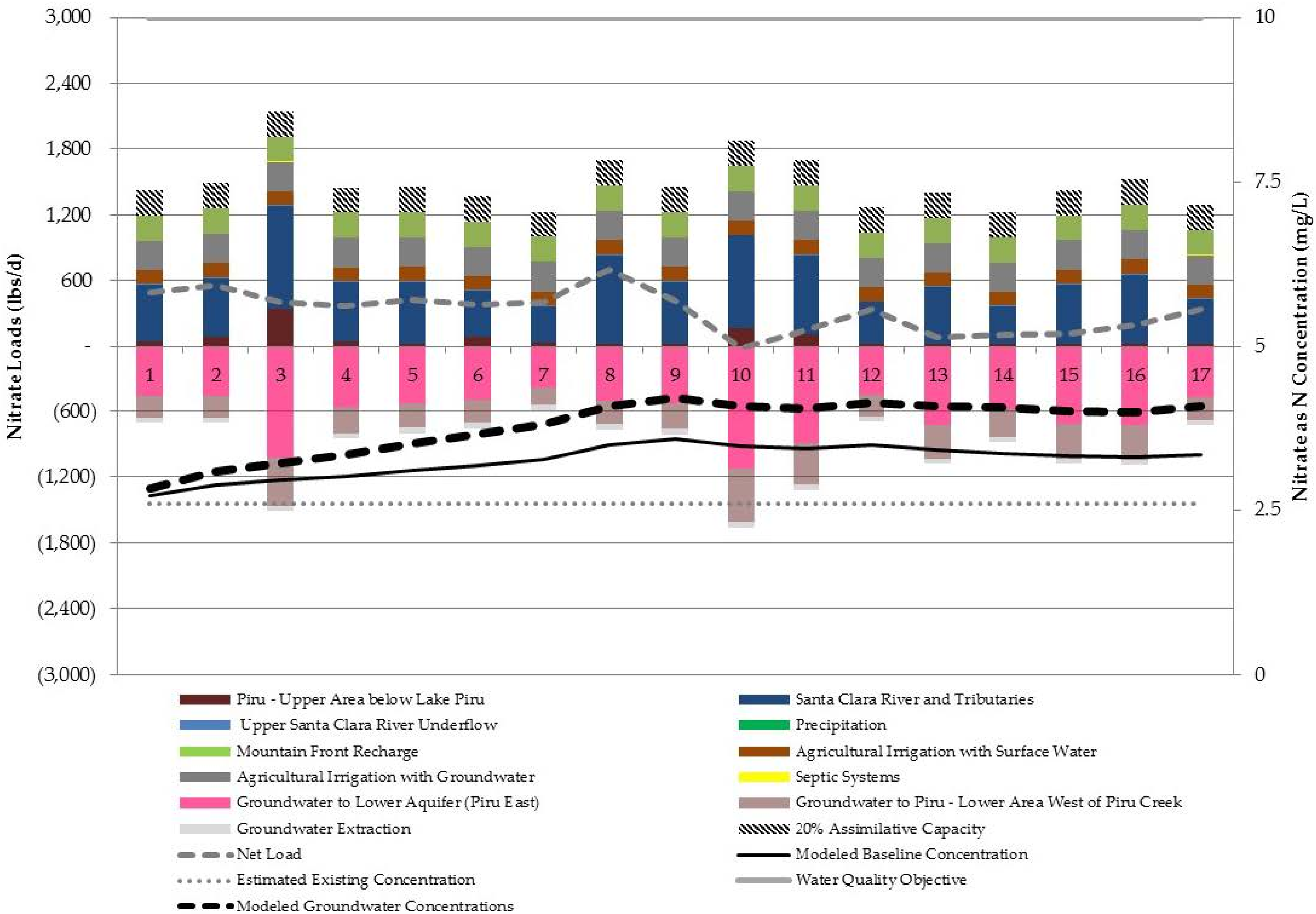

Figure 7-43 Modeled Nitrate 20% Threshold Load and Annual Concentrations for Piru Basin – Lower Area East of Piru Creek

7.5.2 Piru Basin – Lower Area West of Piru Creek

Table 7-44 shows the additional loading of 26,000 lbs/d TDS that results in TDS concentrations increasing to 42 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads decrease over time increasing the available assimilative capacity.

Figure 7-45 shows the additional loading of 1100 lbs/d chloride that results in chloride concentrations increasing to 6 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show a slight increase over time decreasing the available assimilative capacity.

Figure 7-46 shows the additional loading of 970 lbs/d nitrate-N that results in nitrate-N concentrations increasing to 1.3 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads decrease over time increasing the available assimilative capacity.

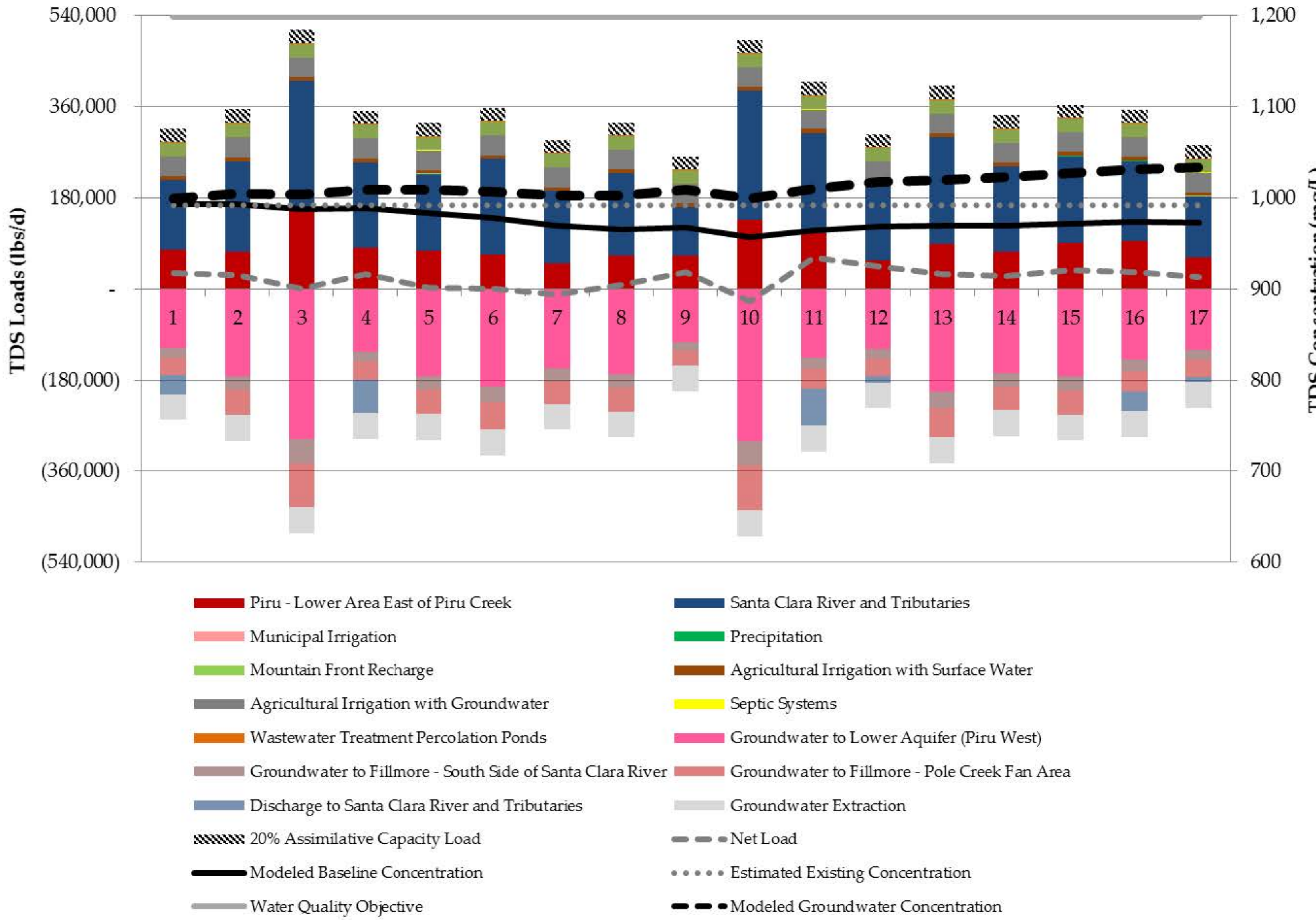

Figure 7-44 Modeled TDS 20% Threshold Load and Annual Concentrations for Piru Basin – Lower Area West of Piru Creek

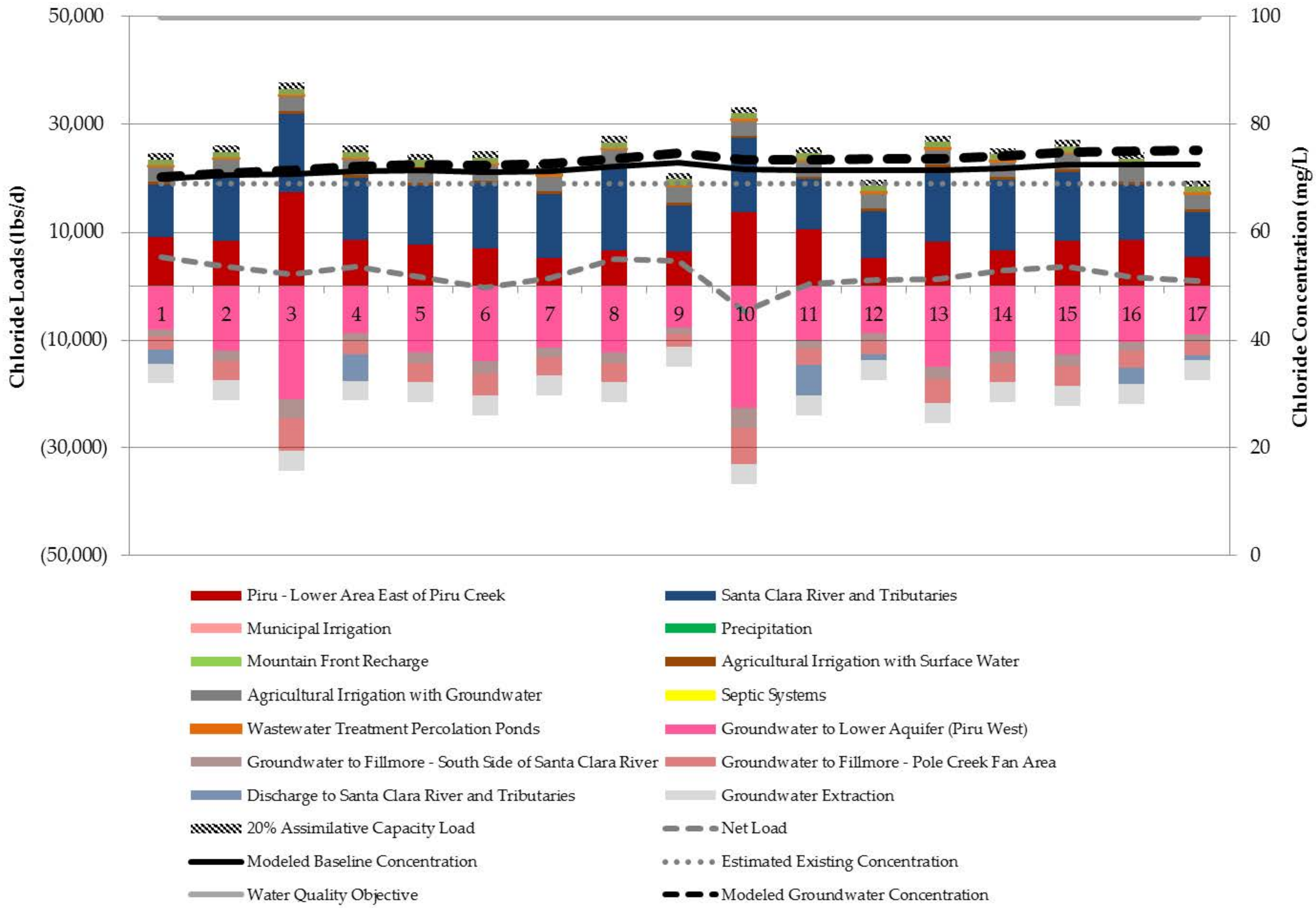

Figure 7-45 Modeled Chloride 20% Threshold Load and Annual Concentrations for Piru Basin – Lower Area West of Piru Creek

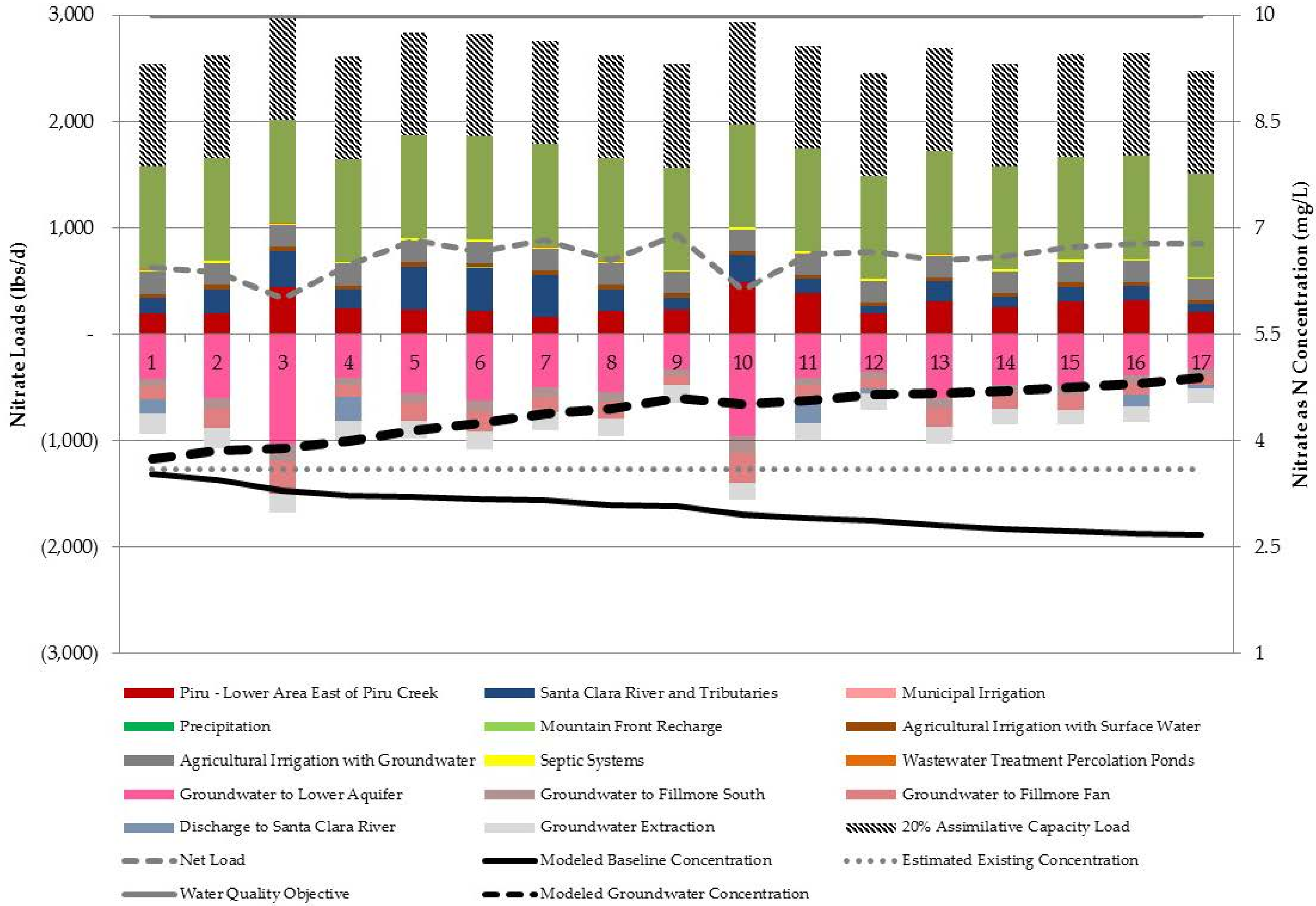

Figure 7-46 Modeled Nitrate 20% Threshold Load and Annual Concentrations for Piru Basin – Lower Area West of Piru Creek

7.5.3 Fillmore Basin – Pole Creek Fan Area

Figure 7-53shows the additional loading of 83,000 lbs/d TDS that results in TDS concentrations increasing to 180 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show a slight decrease over time increasing the available assimilative capacity.

Figure 7-54 shows the additional loading of 1,000 lbs/d chloride that results in chloride concentrations increasing to 8 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show a slight increase over time decreasing the available assimilative capacity.

Figure 7-49 shows the additional loading of 480 lbs/d nitrate-N that results in nitrate-N concentrations increasing to 1.4 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show a slight increase over time decreasing the available assimilative capacity.

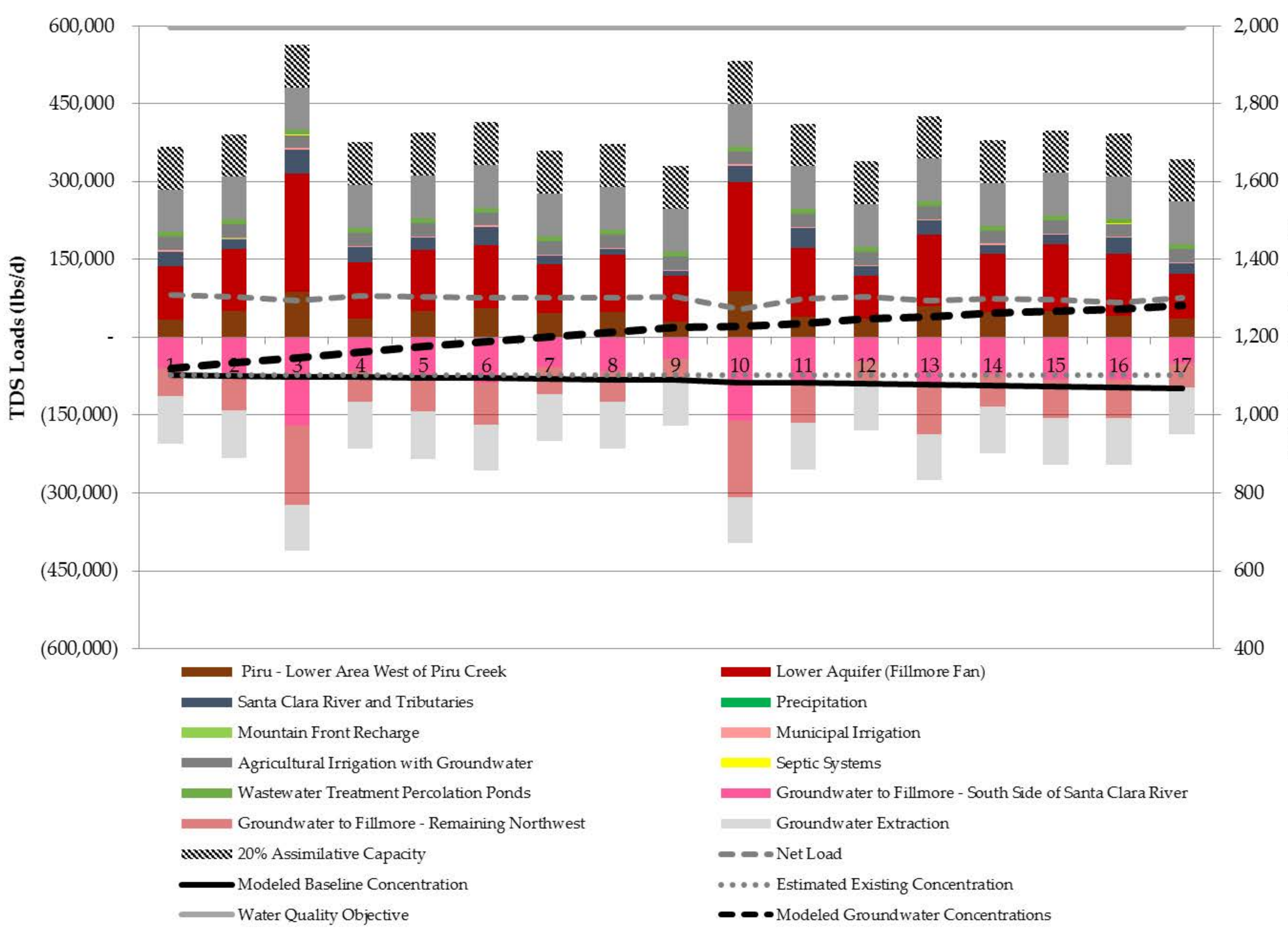

Figure 7-47 Modeled TDS 20% Threshold Load and Annual Concentrations for Fillmore Basin – Pole Creek Fan Area

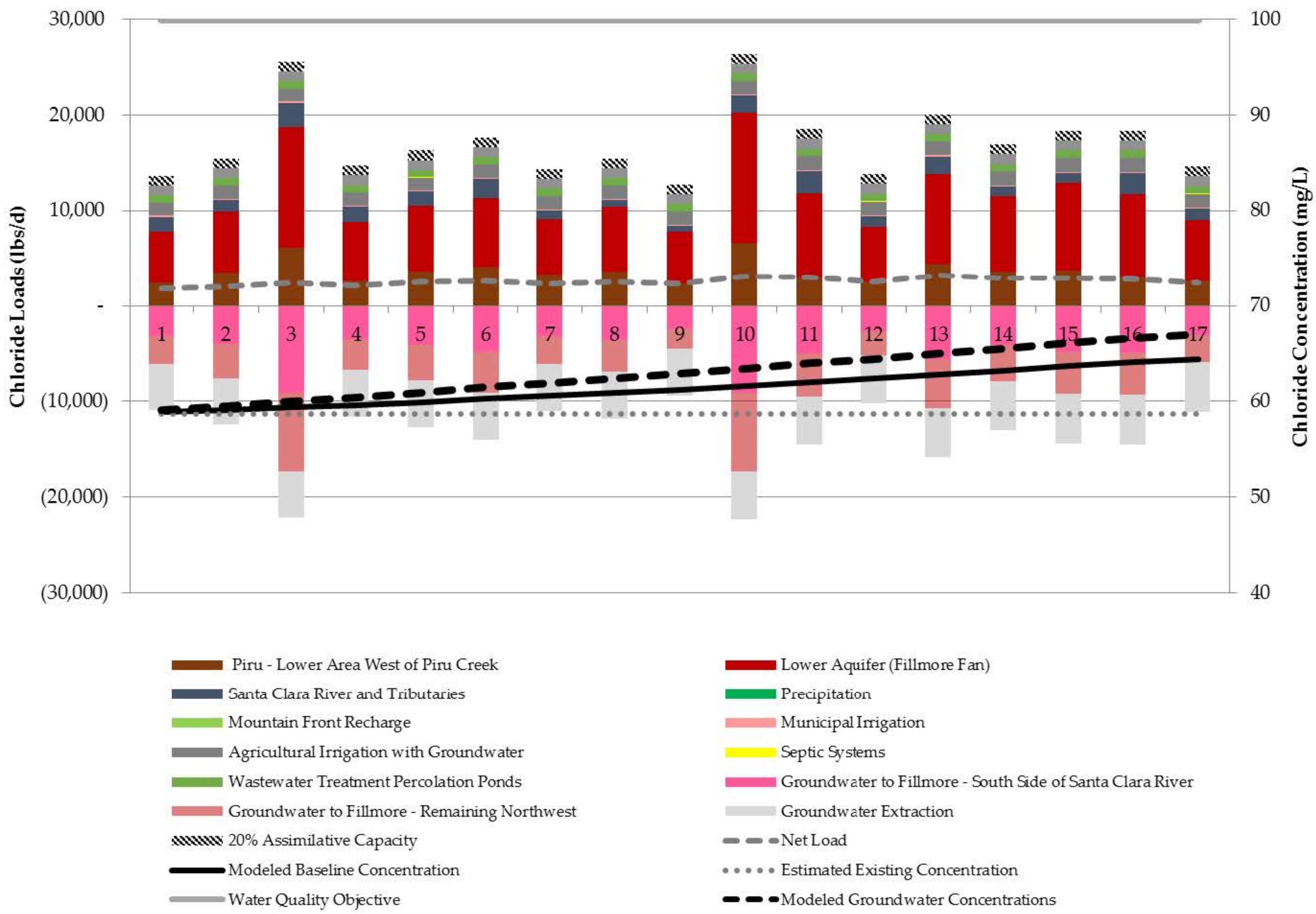

Figure 7-48 Modeled Chloride 20% Threshold Load and Annual Concentrations for Fillmore Basin - Pole Creek Fan Area

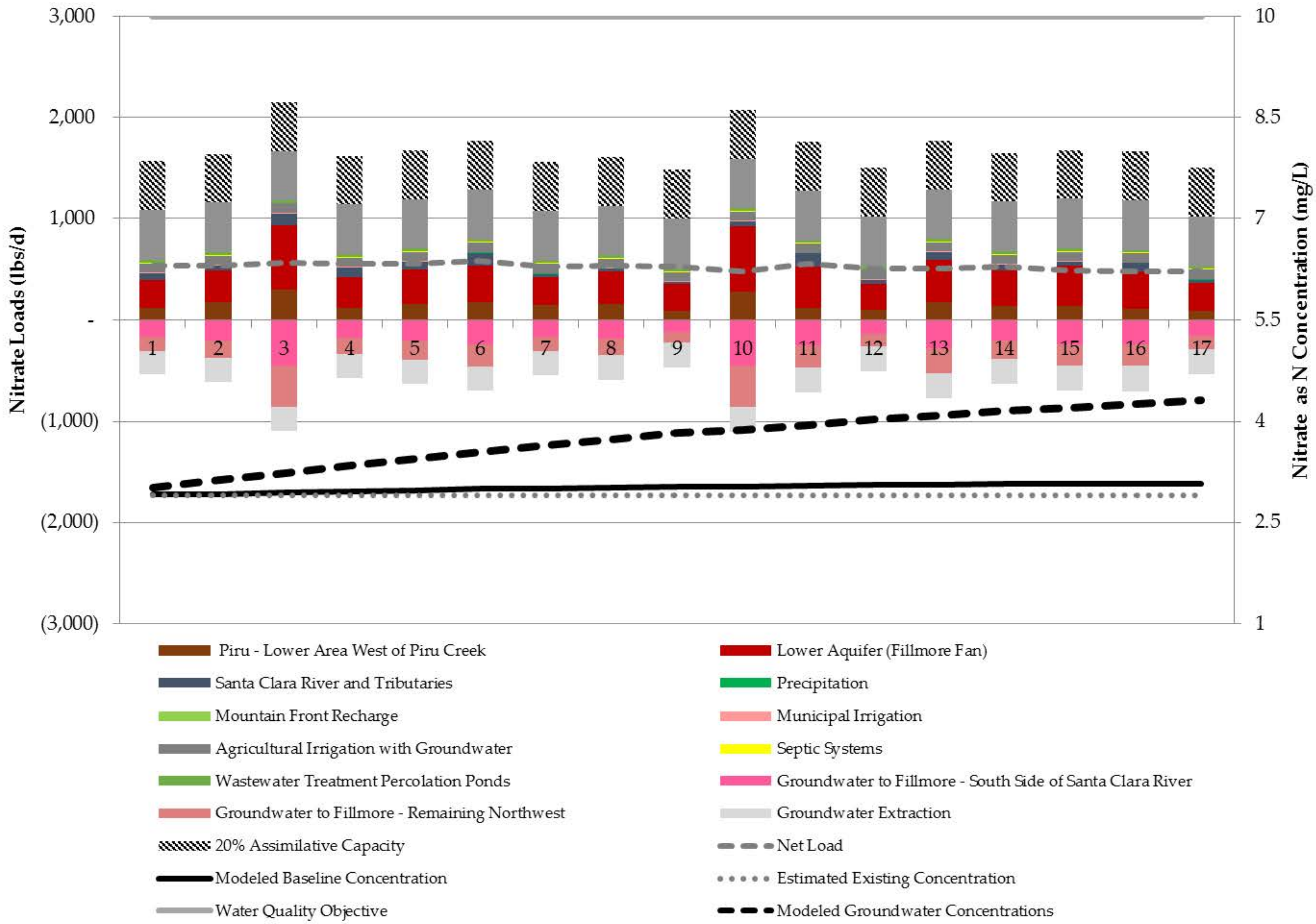

Figure 7-49 Modeled Nitrate 20% Threshold Load and Annual Concentrations for Fillmore Basin – Pole Creek Fan Area

7.5.4 Fillmore Basin – South of Santa Clara River

Table 7-50 shows the additional loading of 26,000 lbs/d TDS that results in TDS concentrations increasing to 18 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show a decrease over time increasing the available assimilative capacity.

Figure 7-51 shows the additional loading of 1,900 lbs/d chloride that results in chloride concentrations increasing to 5 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show a slight increase over time decreasing the available assimilative capacity.

Figure 7-52 shows the additional loading of 510 lbs/d nitrate-N that results in nitrate-N concentrations increasing to 0.9 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show no trend over time.

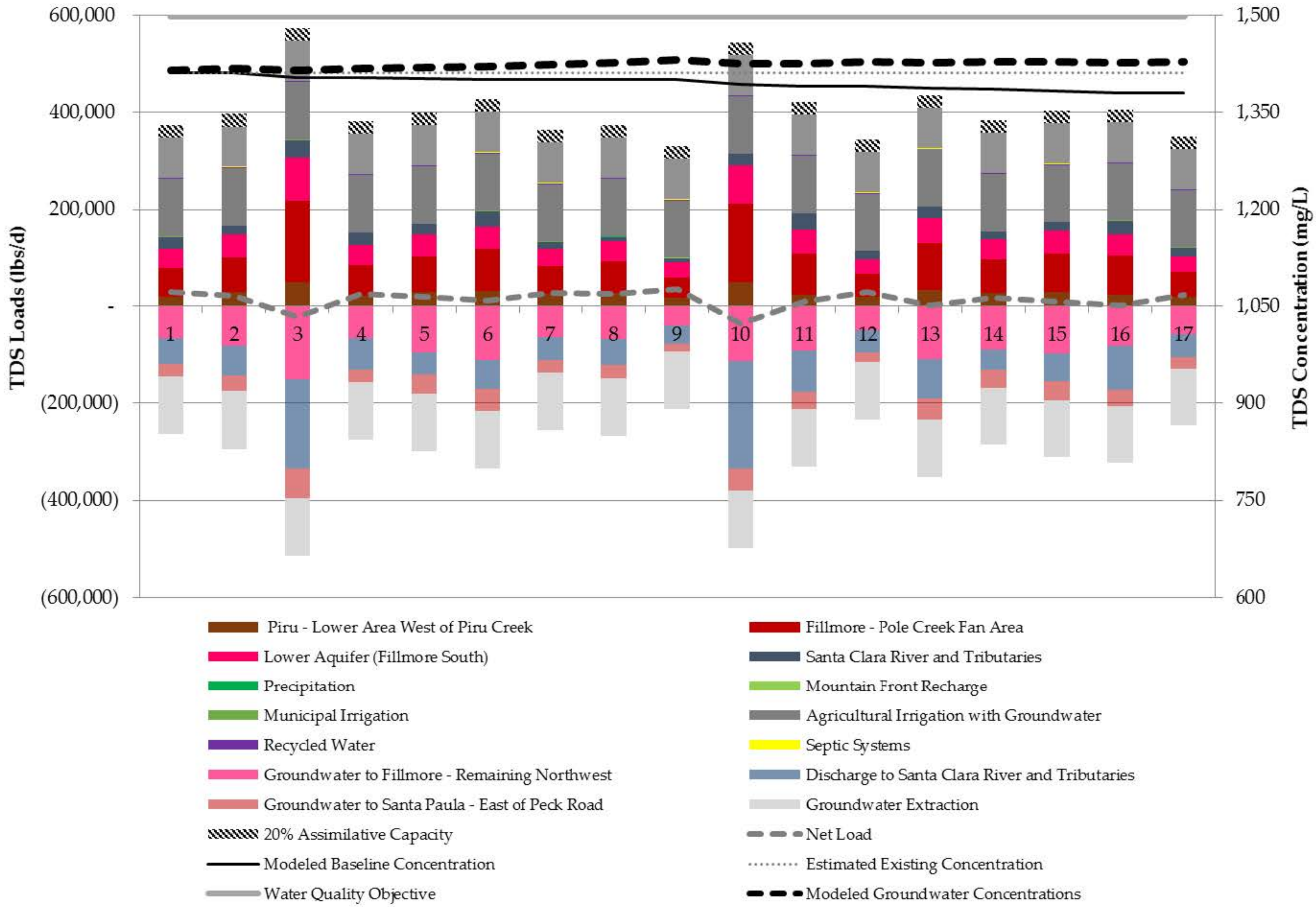

Figure 7-50- Modeled TDS 20% Threshold Load and Annual Concentrations for Fillmore Basin – South of Santa Clara River

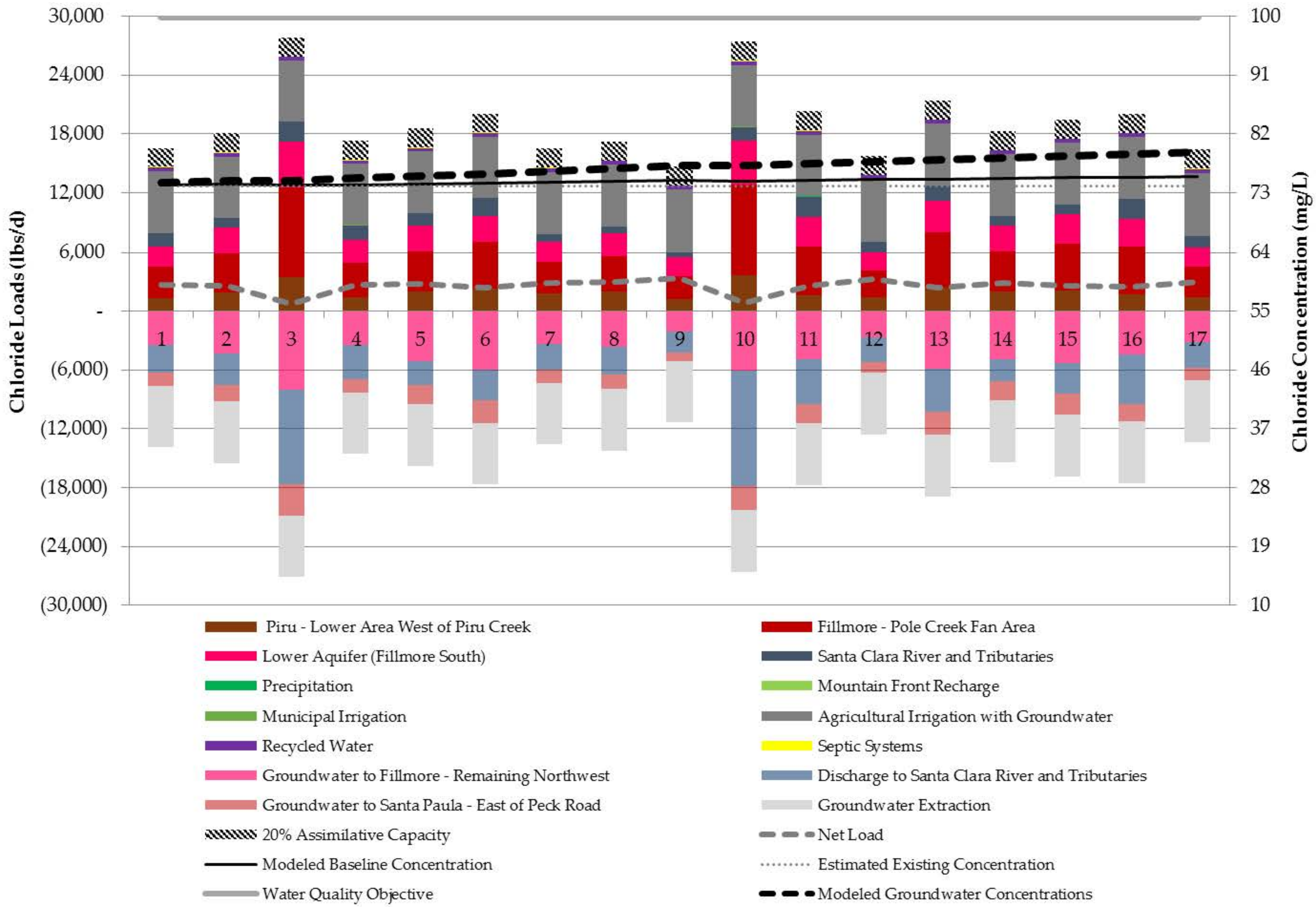

Figure 7-51- Modeled Chloride 20% Threshold Load and Annual Concentrations for Fillmore Basin – South of Santa Clara River

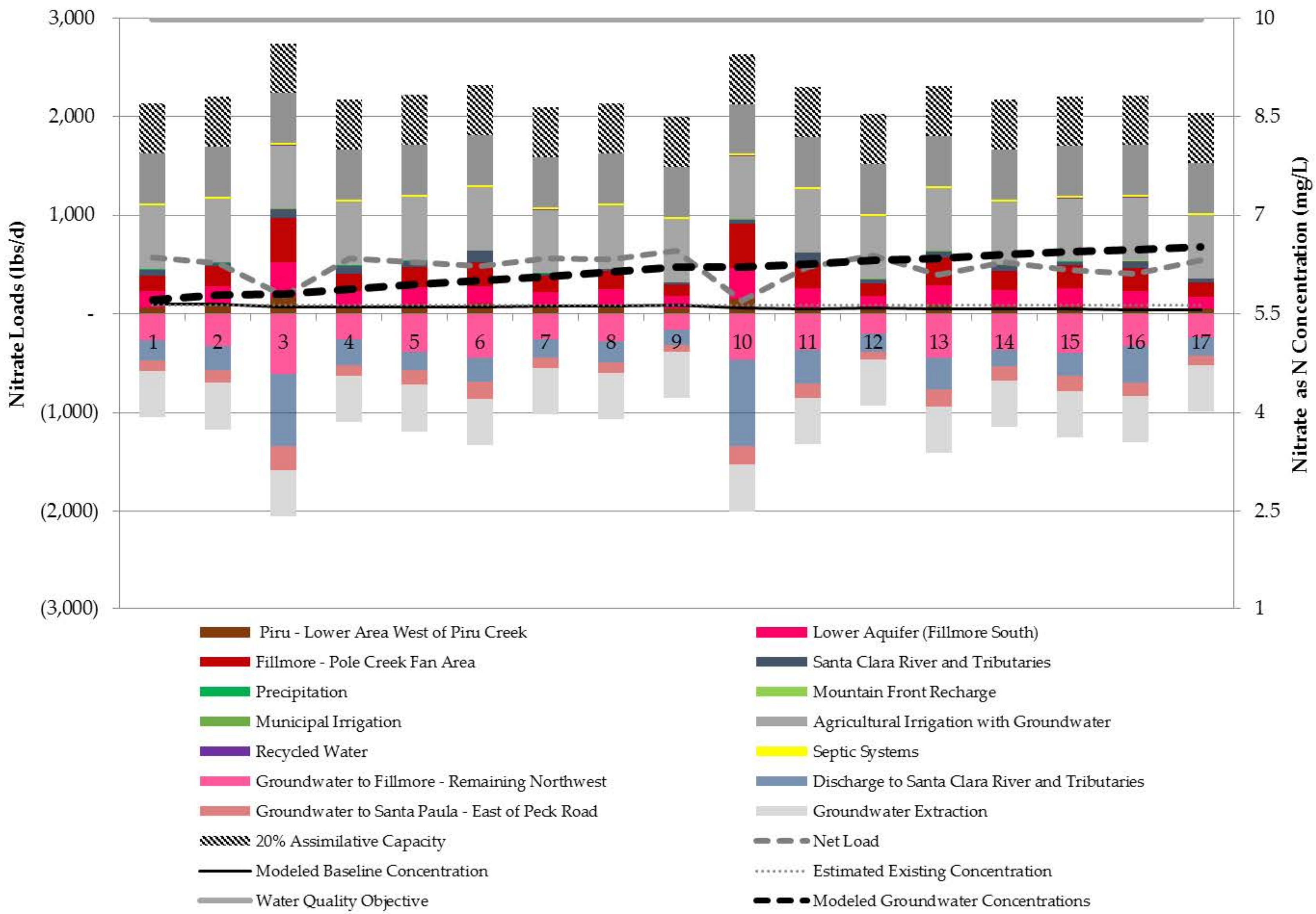

Figure 7-52 Modeled Nitrate 20% Threshold Load and Annual Concentrations for Fillmore Basin – South of Santa Clara River

7.5.5 Fillmore Basin – Remaining Area

Figure 7-53 shows no additional loading since the baseline TDS concentrations increasing to the water quality objective. Modeled baseline concentrations based on estimated existing loads increase over time, decreasing available assimilative capacity until the water quality objective is exceeded and assimilative capacity is no longer available.

Figure 7-54 shows no additional loading since the baseline chloride concentrations increasing to higher than the water quality objective. Modeled baseline concentrations based on estimated existing loads increase over time, decreasing available assimilative capacity until the water quality objective is exceeded and assimilative capacity is no longer available.

Figure 7-55 shows the additional loading of 300 lbs/d nitrate-N that results in nitrate-N concentrations increasing to 0.7 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show a slight increase over time decreasing the available assimilative capacity.

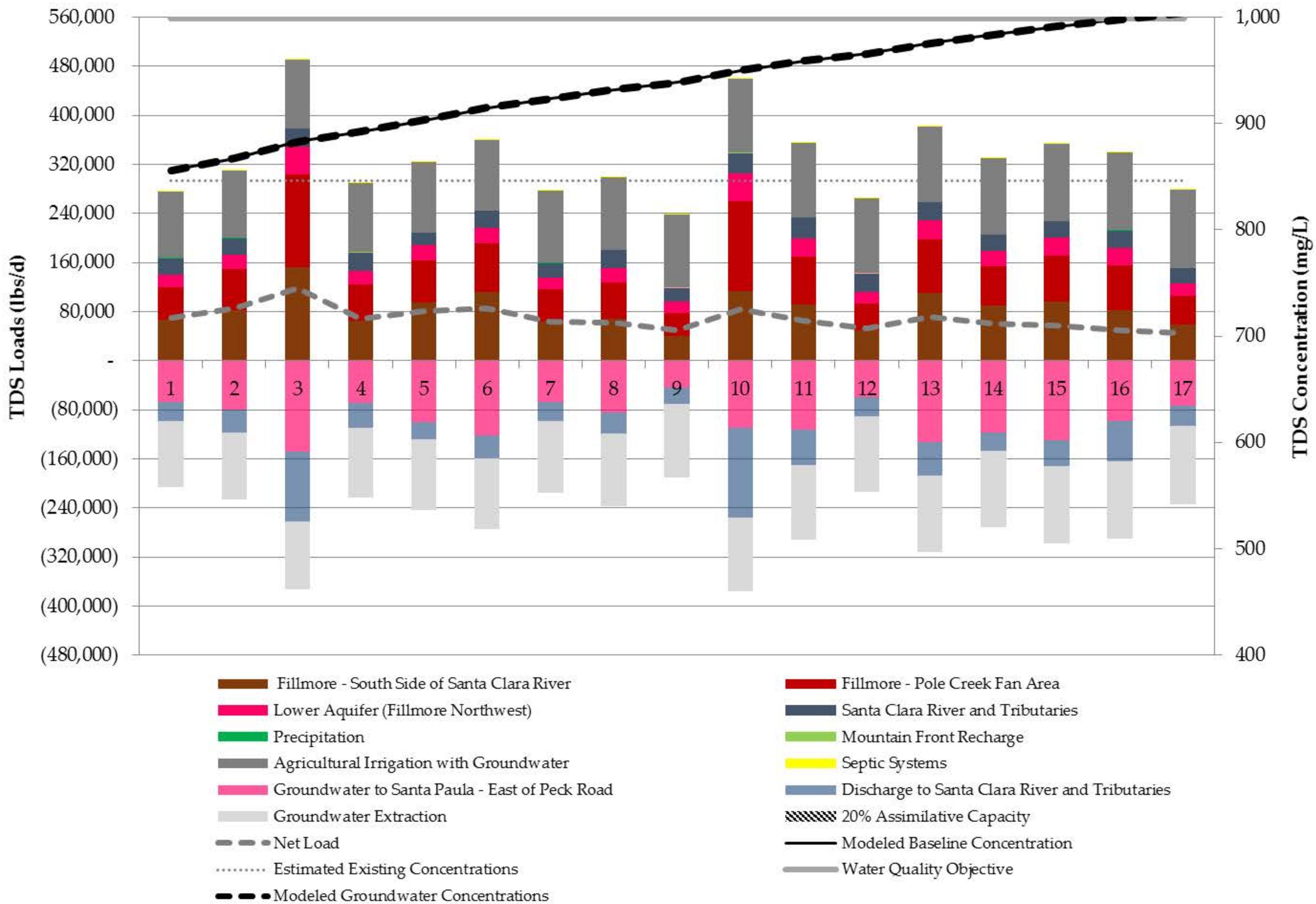

Figure 7-53 Modeled TDS 20% Threshold Load and Annual Concentrations for Fillmore Basin – Remaining Area

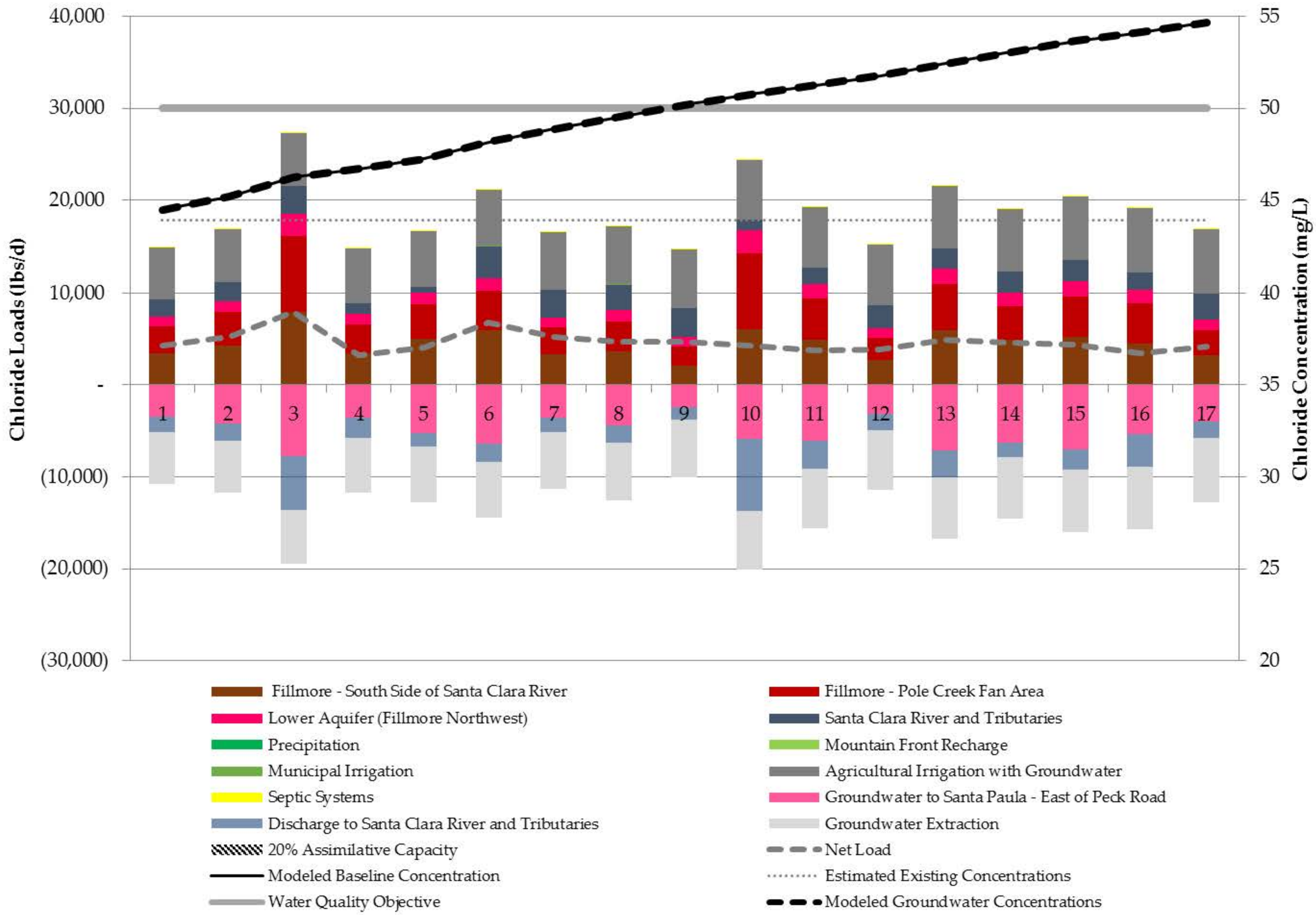

Figure 7-54 Modeled Chloride 20% Threshold Load and Annual Concentrations for Fillmore Basin – Remaining Area

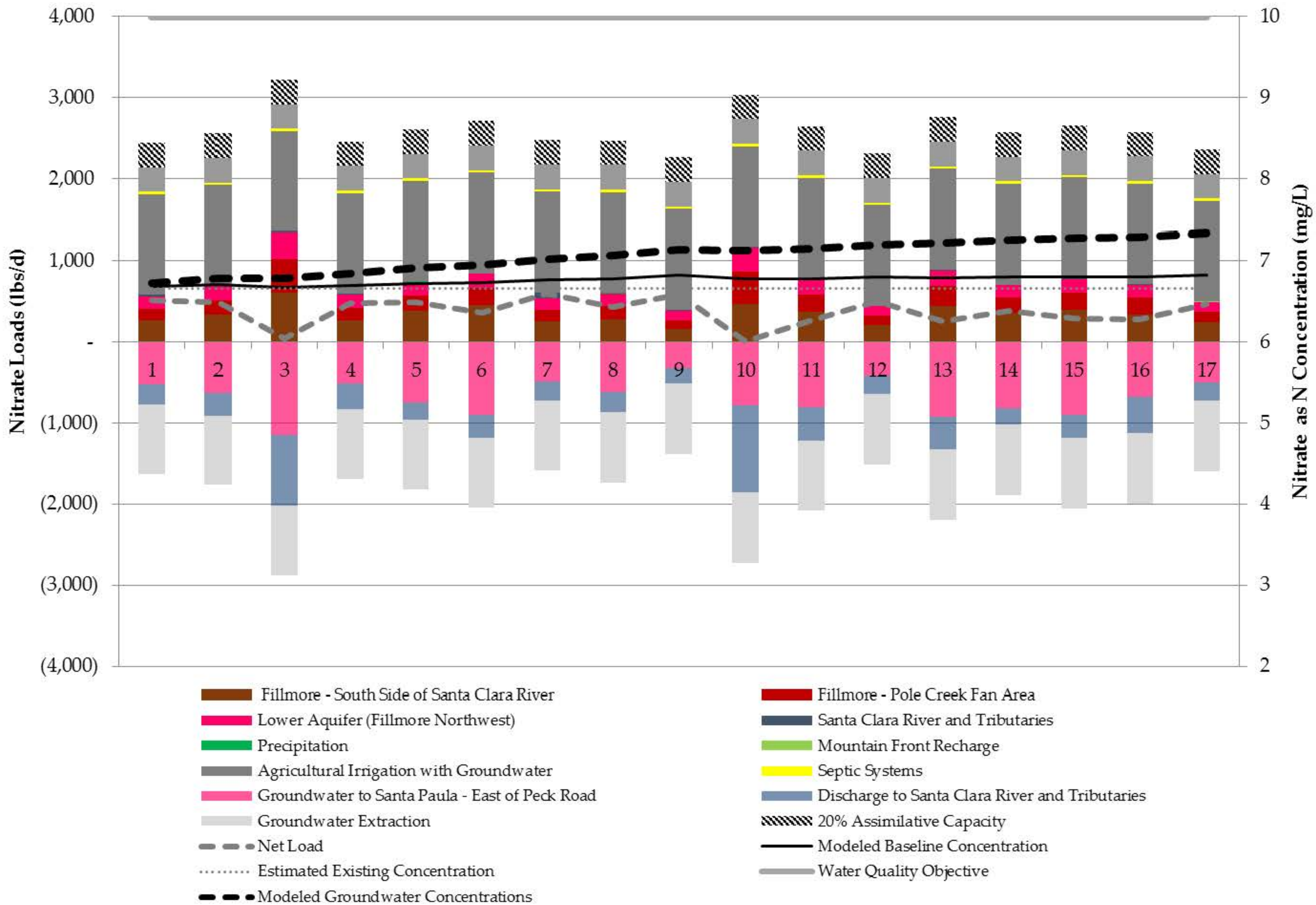

Figure 7-55 Modeled Nitrate 20% Threshold Load and Annual Concentrations for Fillmore Basin – Remaining Area

1.1.1 Santa Paula Basin – East of Peck Road

Figure 7-56 shows the additional loading of 22,000 lbs/d TDS that results in TDS concentrations increasing to 49 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show a slight decrease over time increasing the available assimilative capacity.

Figure 7-57 shows the additional loading of 3,000 lbs/d chloride that results in chloride concentrations increasing to 12 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show an increase over time decreasing the available assimilative capacity.

Figure 7-61 shows the additional loading of 60 lbs/d nitrate-N that results in nitrate-N concentrations increasing to 1 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show an increase over time decreasing the available assimilative capacity.

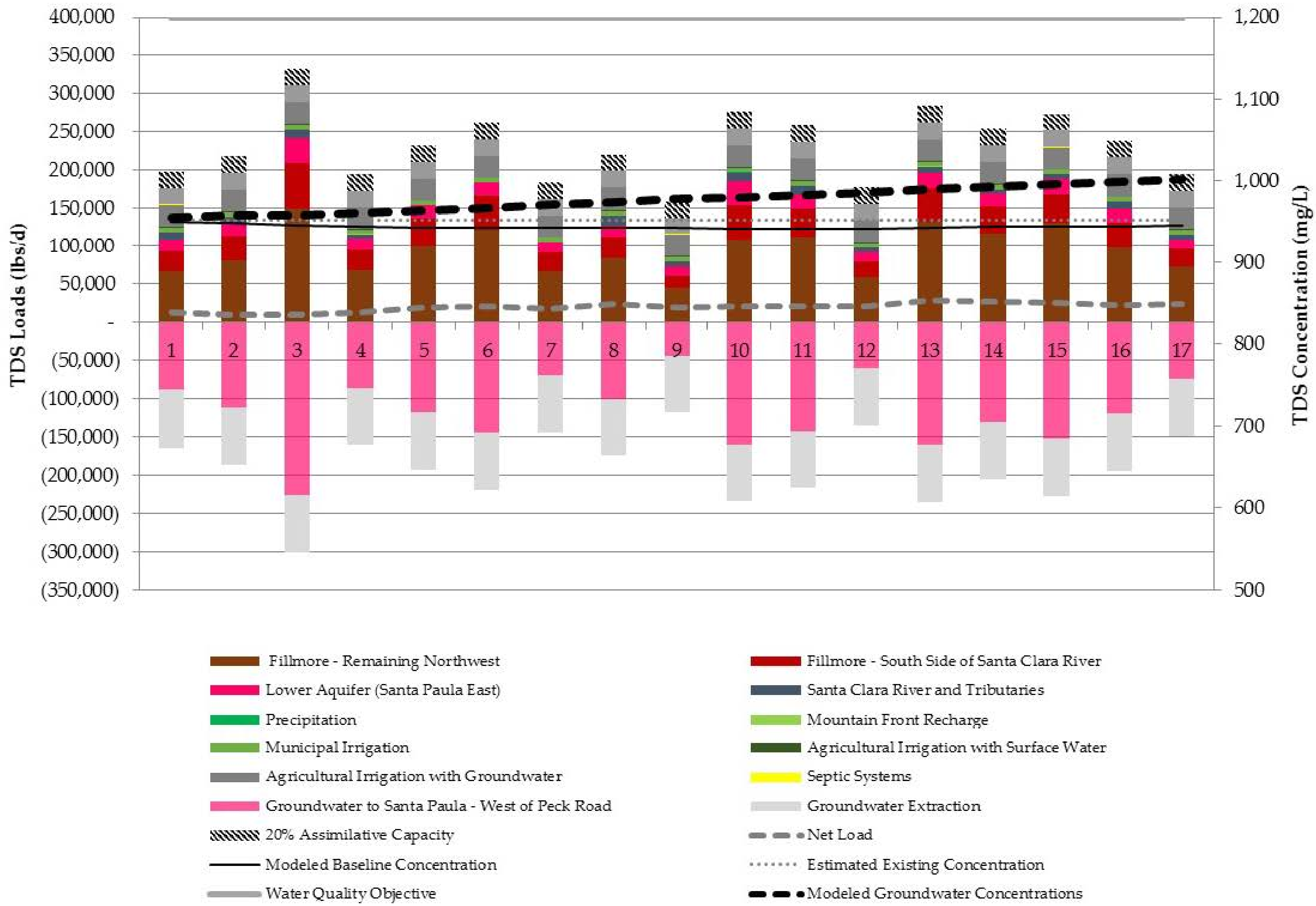

Figure 7-56 Modeled TDS 20% Threshold Load and Annual Concentrations for Santa Paula Basin – East of Peck Road

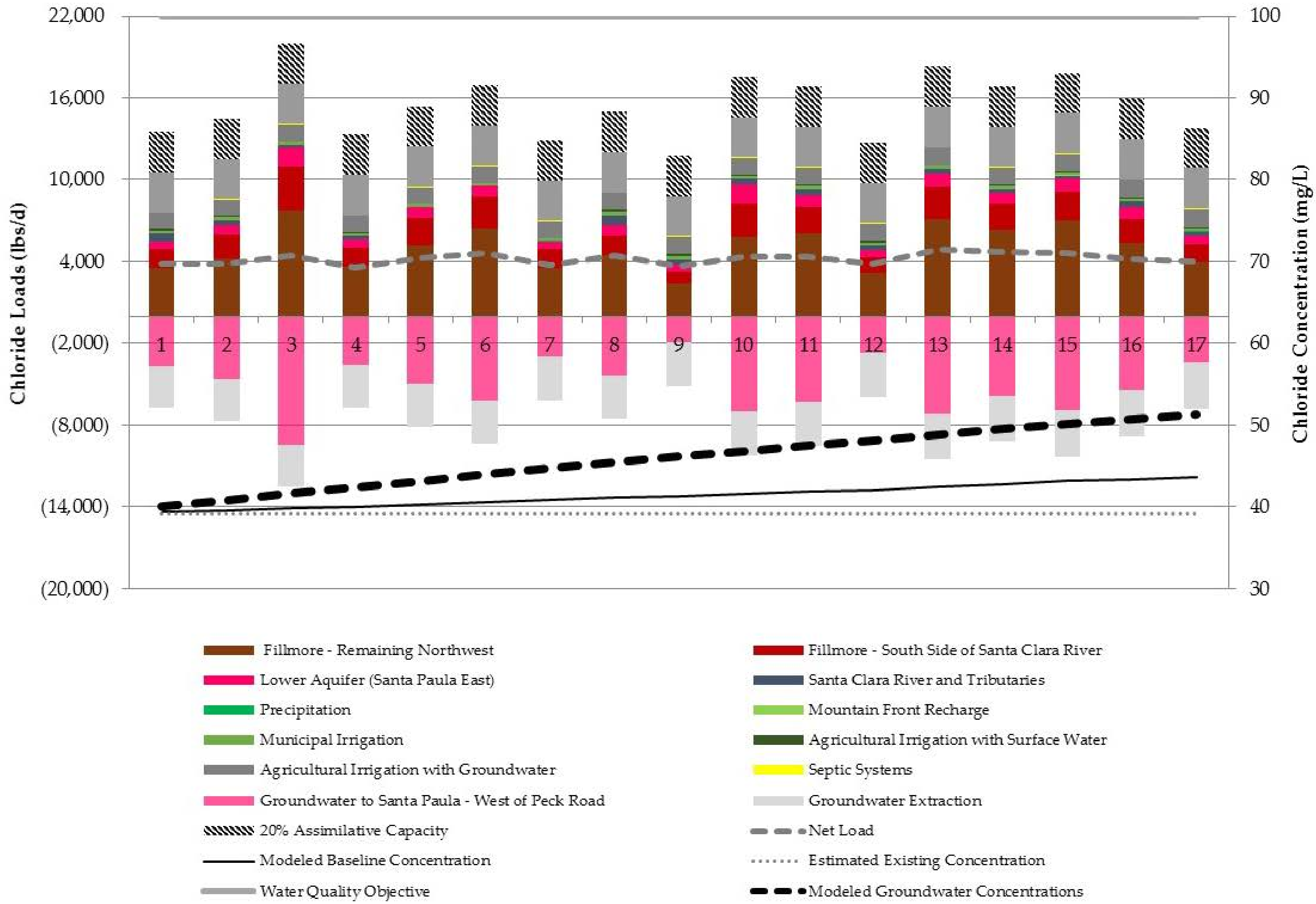

Figure 7-57 Modeled Chloride 20% Threshold Load and Annual Concentrations for Santa Paula Basin – East of Peck Road

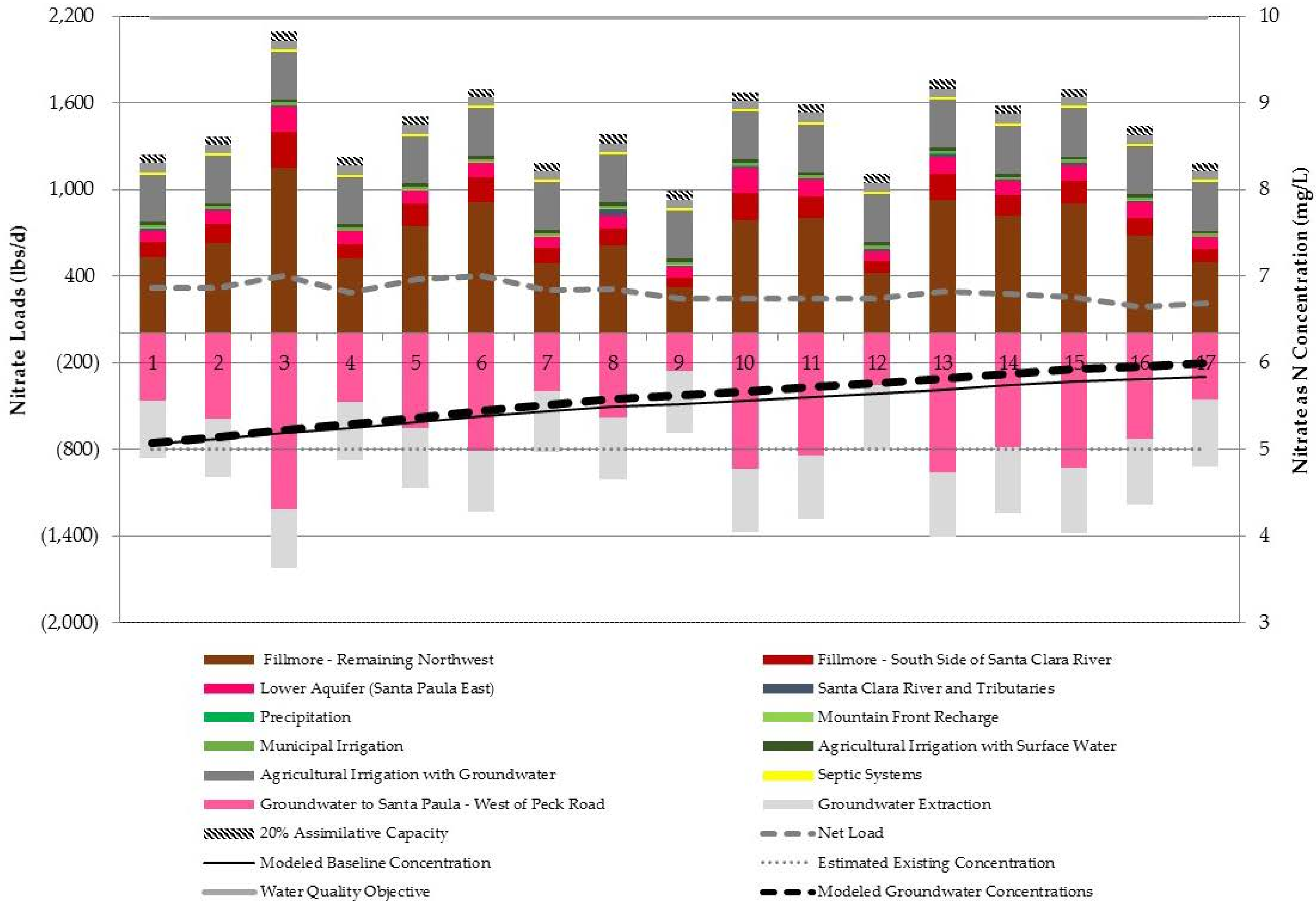

Figure 7-58 Modeled Nitrate 20% Threshold Load and Annual Concentrations for Santa Paula Basin – East of Peck Road

7.5.6 Santa Paula Basin – West of Peck Road

Figure 7-59 shows the additional loading of 106,000 lbs/d TDS that results in TDS concentrations increasing to 111 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show a slight decrease over time increasing the available assimilative capacity.

Figure 7-60 shows the additional loading of 6,300 lbs/d chloride that results in chloride concentrations increasing to 2 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show a decrease over time increasing the available assimilative capacity.

Figure 7-61 shows no additional loading since the baseline nitrate-N concentrations increase more than 2 mg/L above existing concentrations using up more than 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads increase over time, decreasing available assimilative capacity more than 20%.

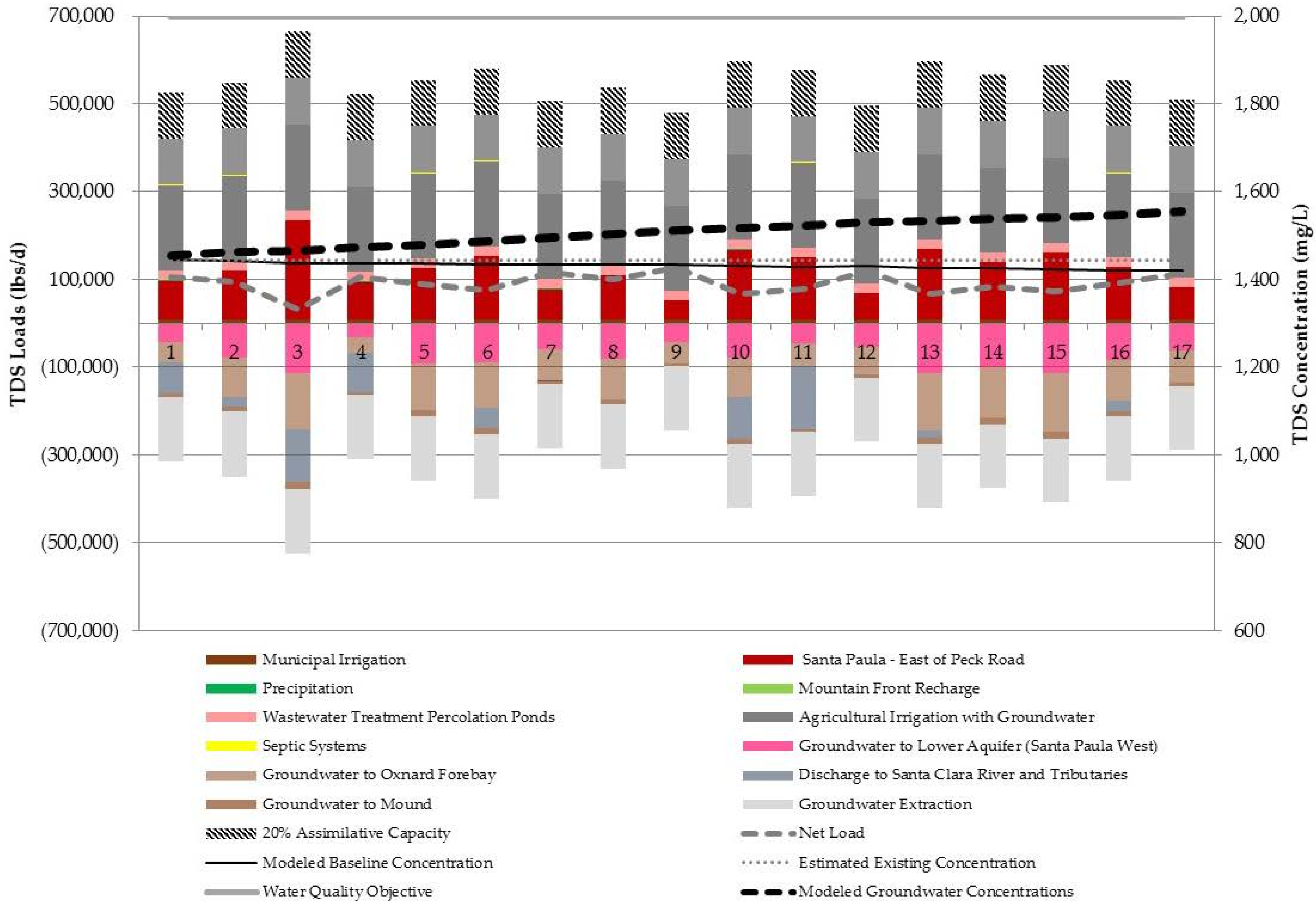

Figure 7-59 Modeled TDS 20% Threshold Load and Annual Concentrations for Santa Paula Basin – West of Peck Road

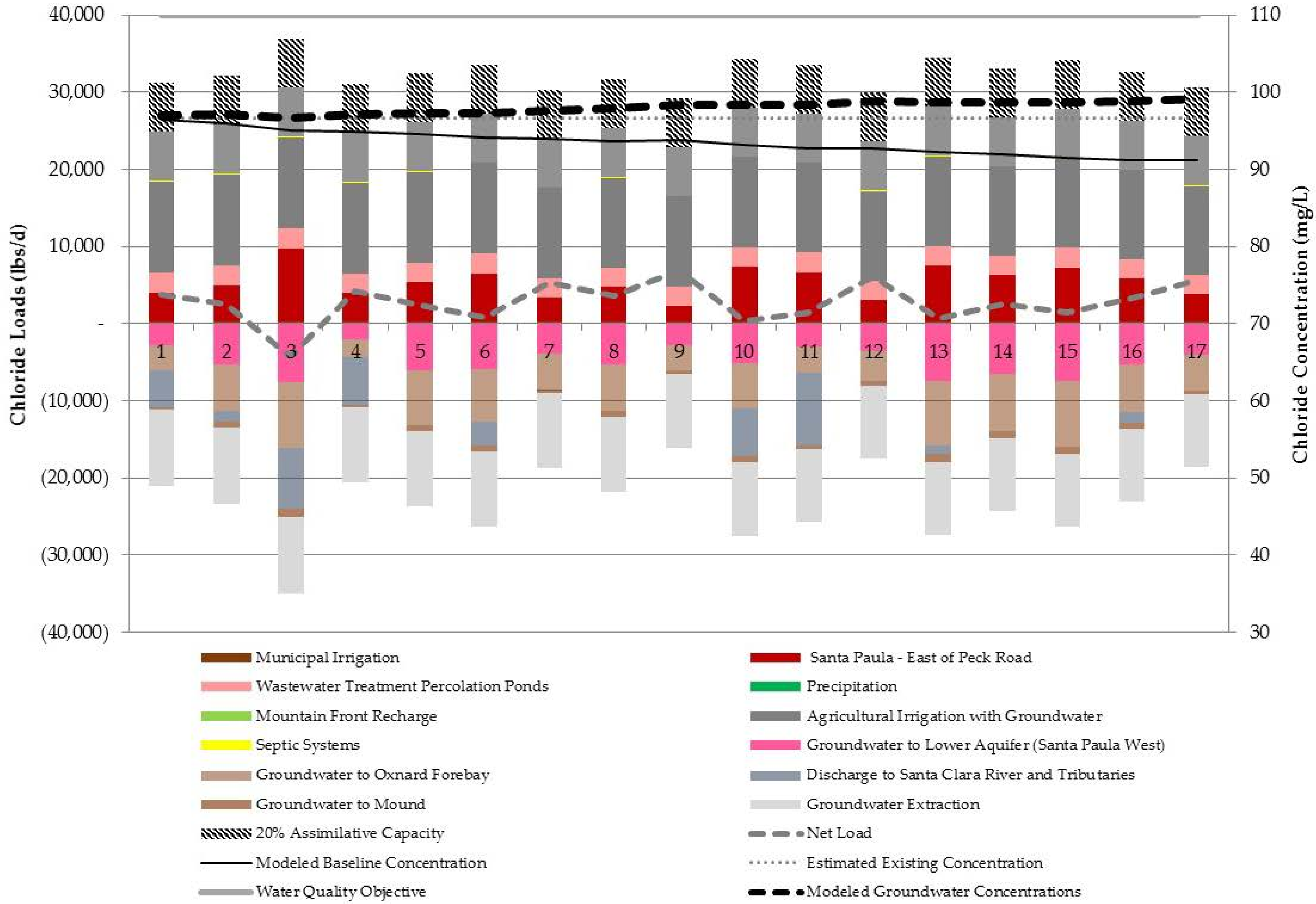

Figure 7-60 Modeled Chloride 20% Threshold Load and Annual Concentrations for Santa Paula Basin – West of Peck Road

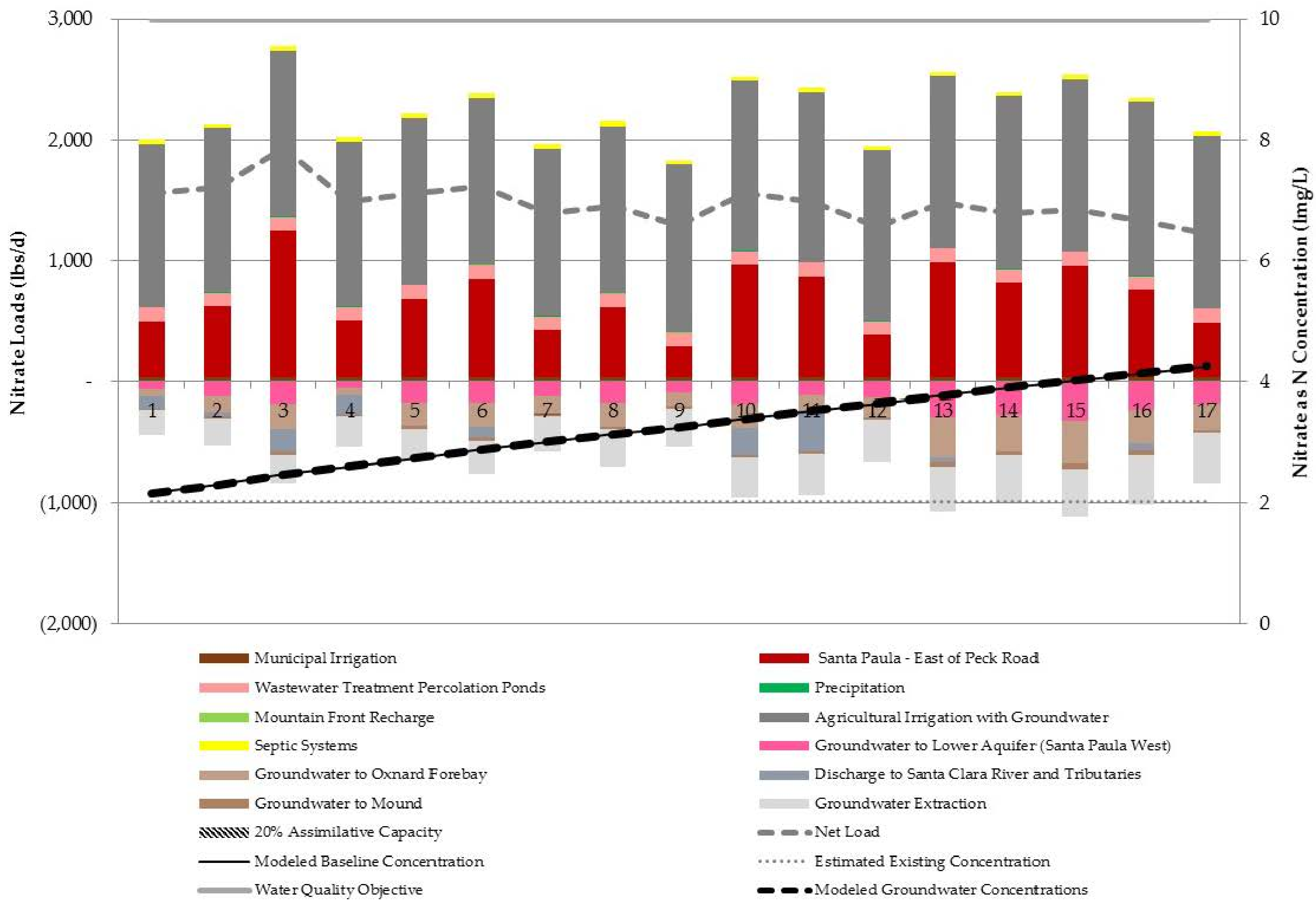

Figure 7-61 Modeled Nitrate 20% Threshold Load and Annual Concentrations for Santa Paula Basin – West of Peck Road

7.5.7 Oxnard Forebay Basin

Figure 7-62 shows the additional loading of 20,000 lbs/d TDS that results in TDS concentrations increasing to 25 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show a slight decrease over time increasing the available assimilative capacity.

Figure 7-63 shows the additional loading of 11,000 lbs/d chloride that results in chloride concentrations increasing to 18 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show a slight increase over time decreasing the available assimilative capacity.

Figure 7-64 shows the additional loading of 2,490 lbs/d nitrate-N that results in nitrate-N concentrations increasing to 0.9 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show a decrease over time increasing the available assimilative capacity.

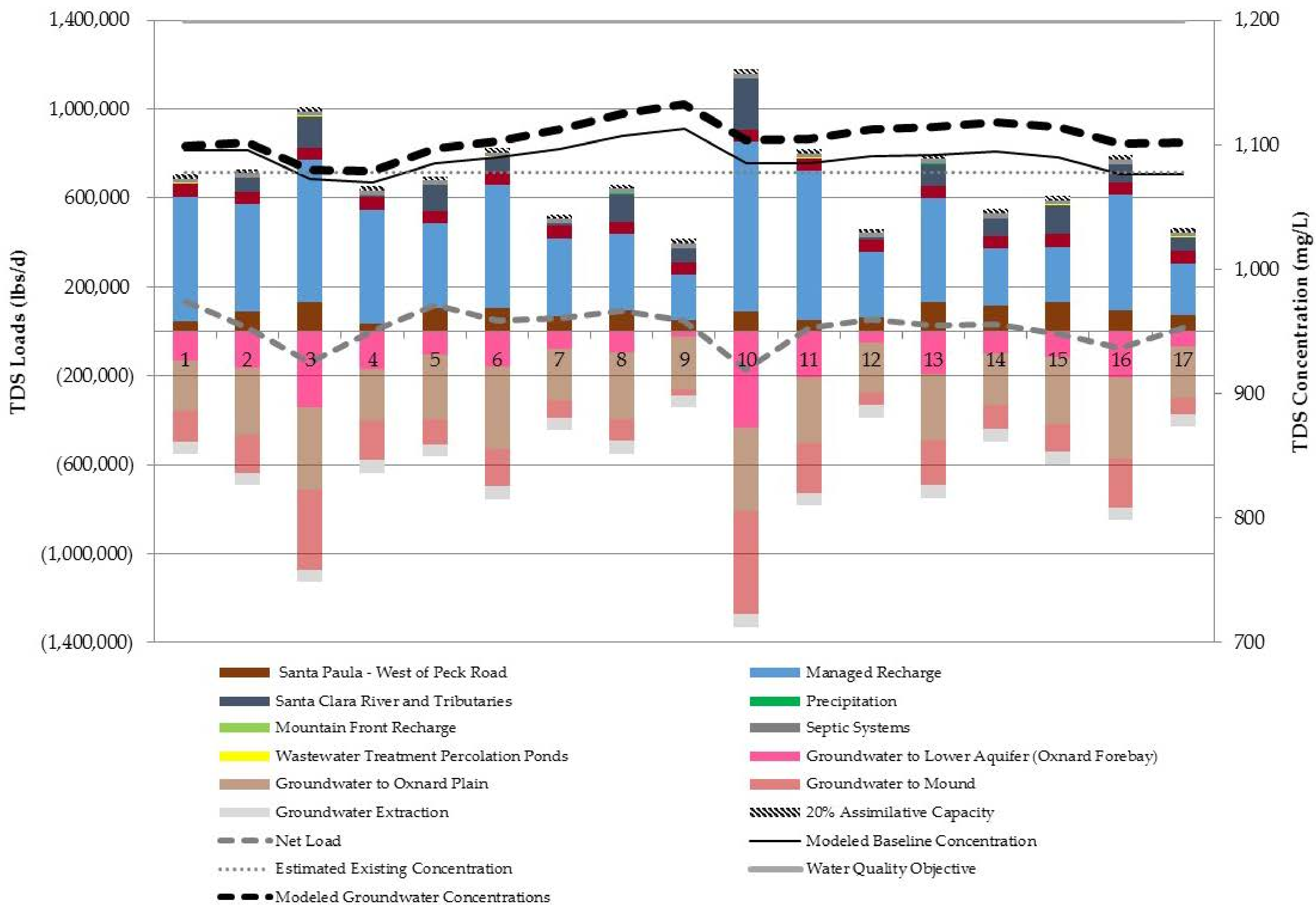

Figure 7-62 Modeled TDS 20% Threshold Load and Annual Concentrations for Oxnard Forebay Basin

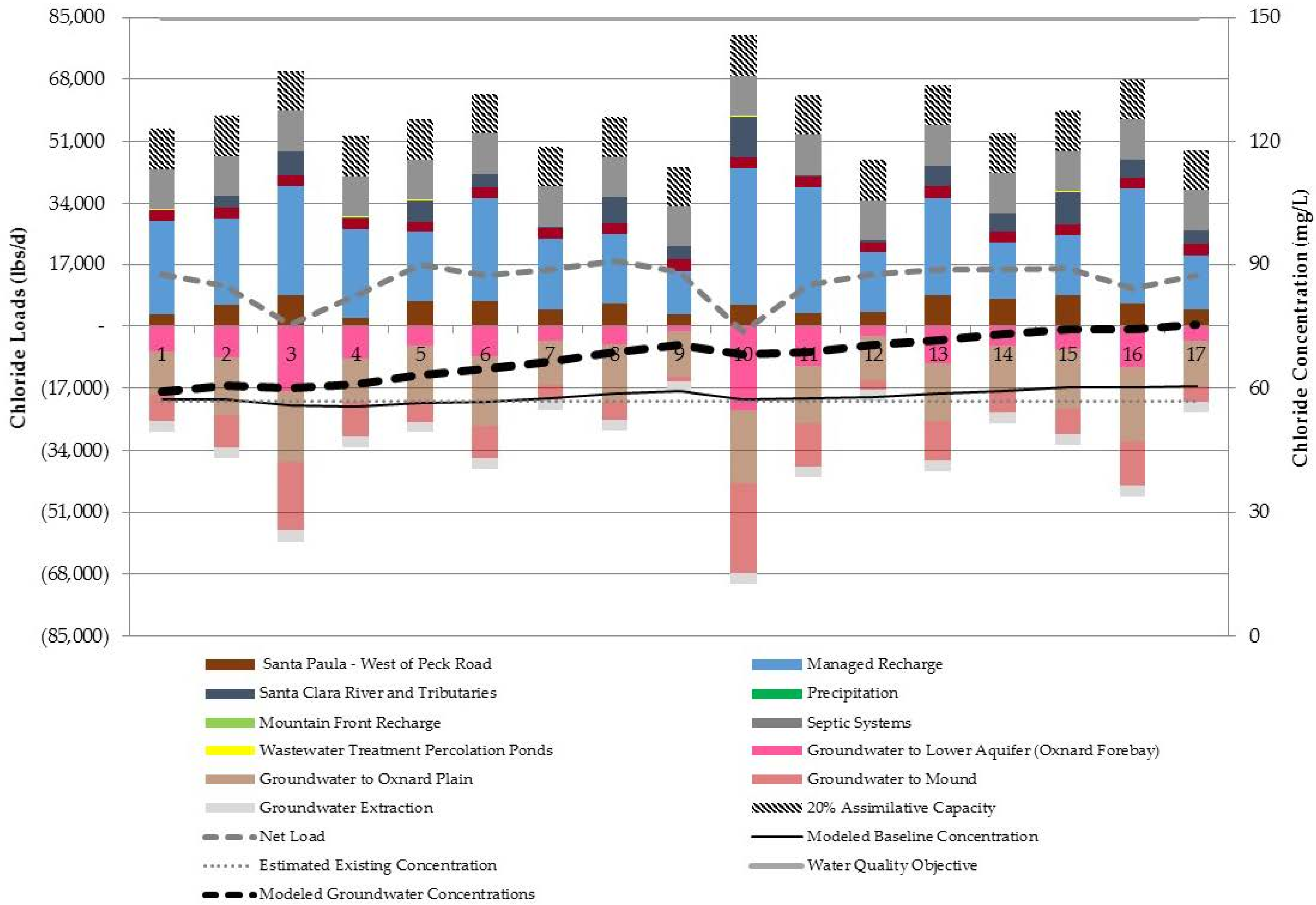

Figure 7-63 Modeled Chloride 20% Threshold Load and Annual Concentrations for Oxnard Forebay Basin

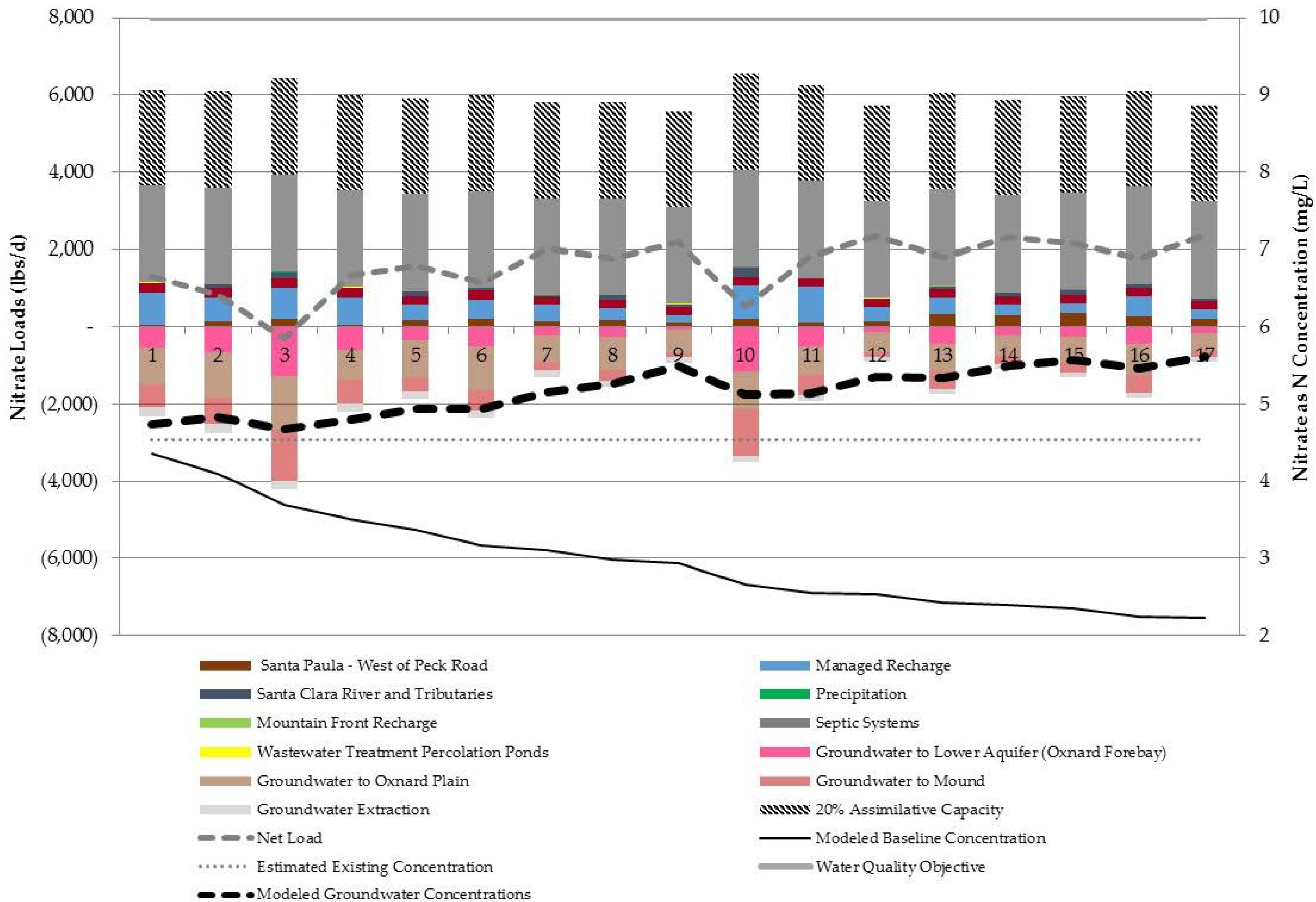

Figure 7-64 Modeled Nitrate 20% Threshold Load and Annual Concentrations for Oxnard Forebay Basin

7.5.8 Mound Basin

Figure 7-65 shows no additional loading since the estimated existing TDS concentration is higher than the water quality objective. Modeled baseline concentrations based on estimated existing loads show a slight increase over time.

Figure 7-66 shows the additional loading of 16,300 lbs/d chloride that results in chloride concentrations increasing to 15 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show no trend over time.

Figure 7-67 shows the additional loading of 1,270 lbs/d chloride that results in chloride concentrations increasing to 1.2 mg/L above existing concentrations using up 20% available assimilative capacity. Modeled baseline concentrations based on estimated existing loads show no trend over time.

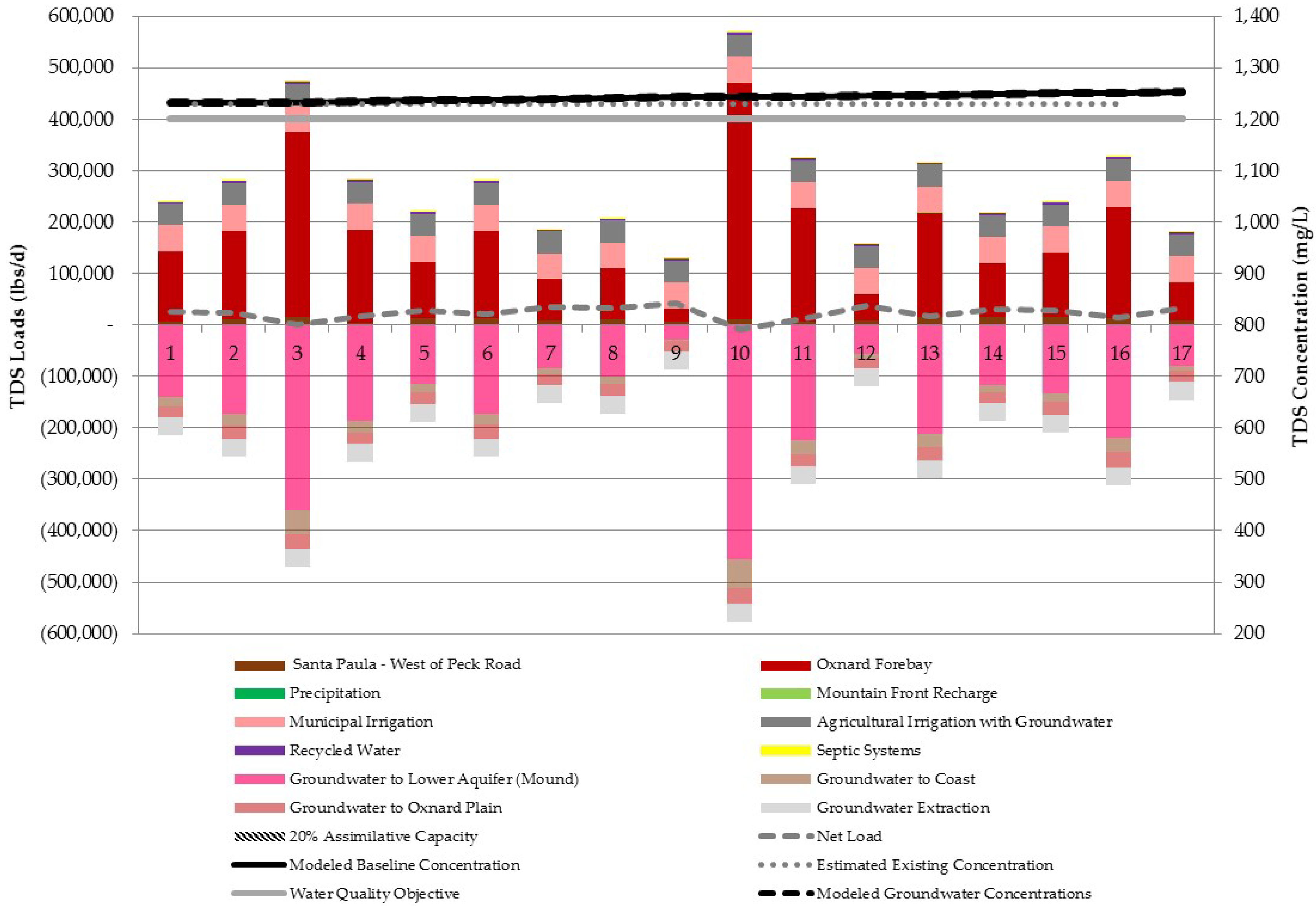

Figure 7-65 Modeled TDS 20% Threshold Load and Annual Concentrations for Mound Basin

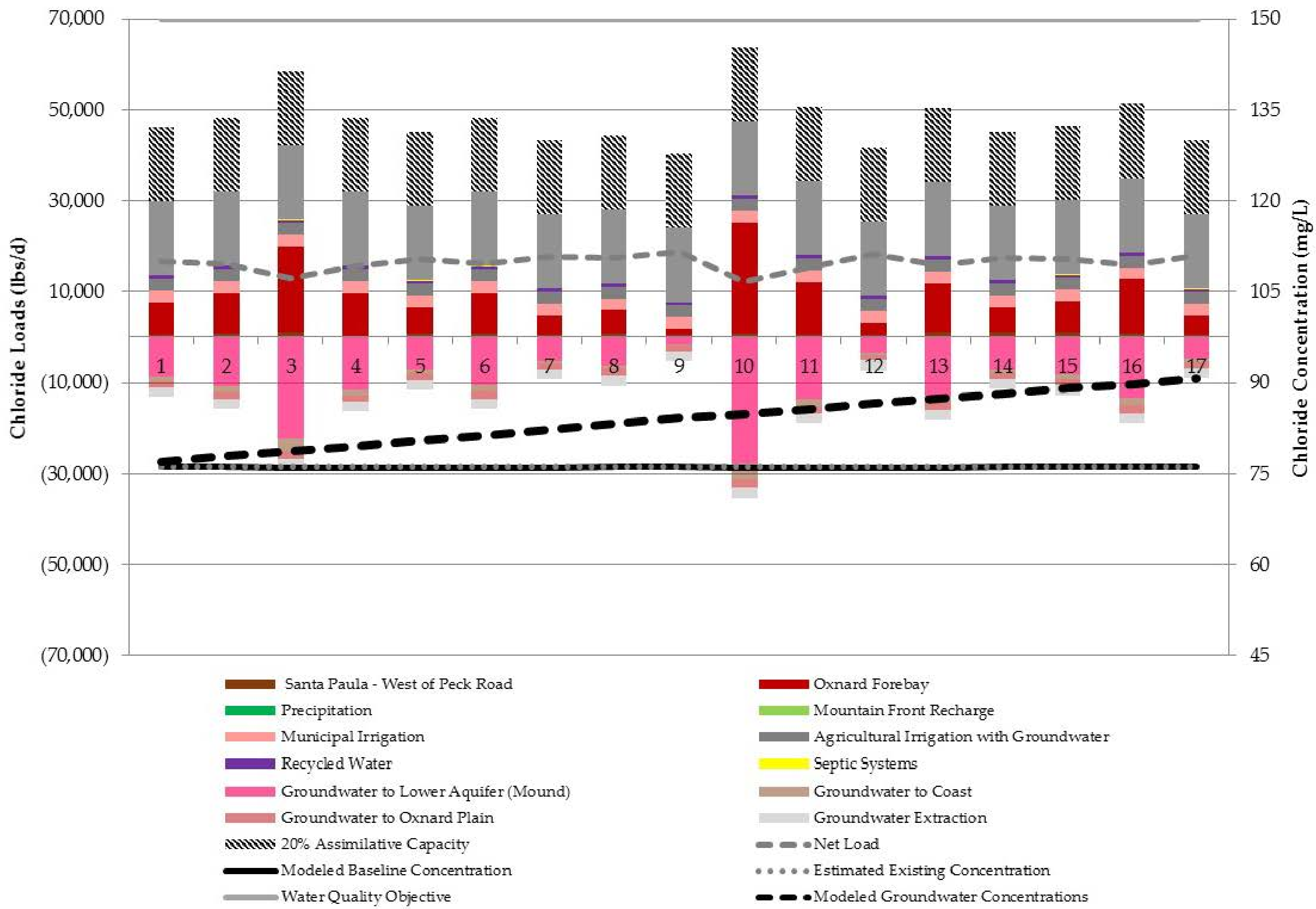

Figure 7-66 Modeled Chloride 20% Threshold Load and Annual Concentrations for Mound Basin

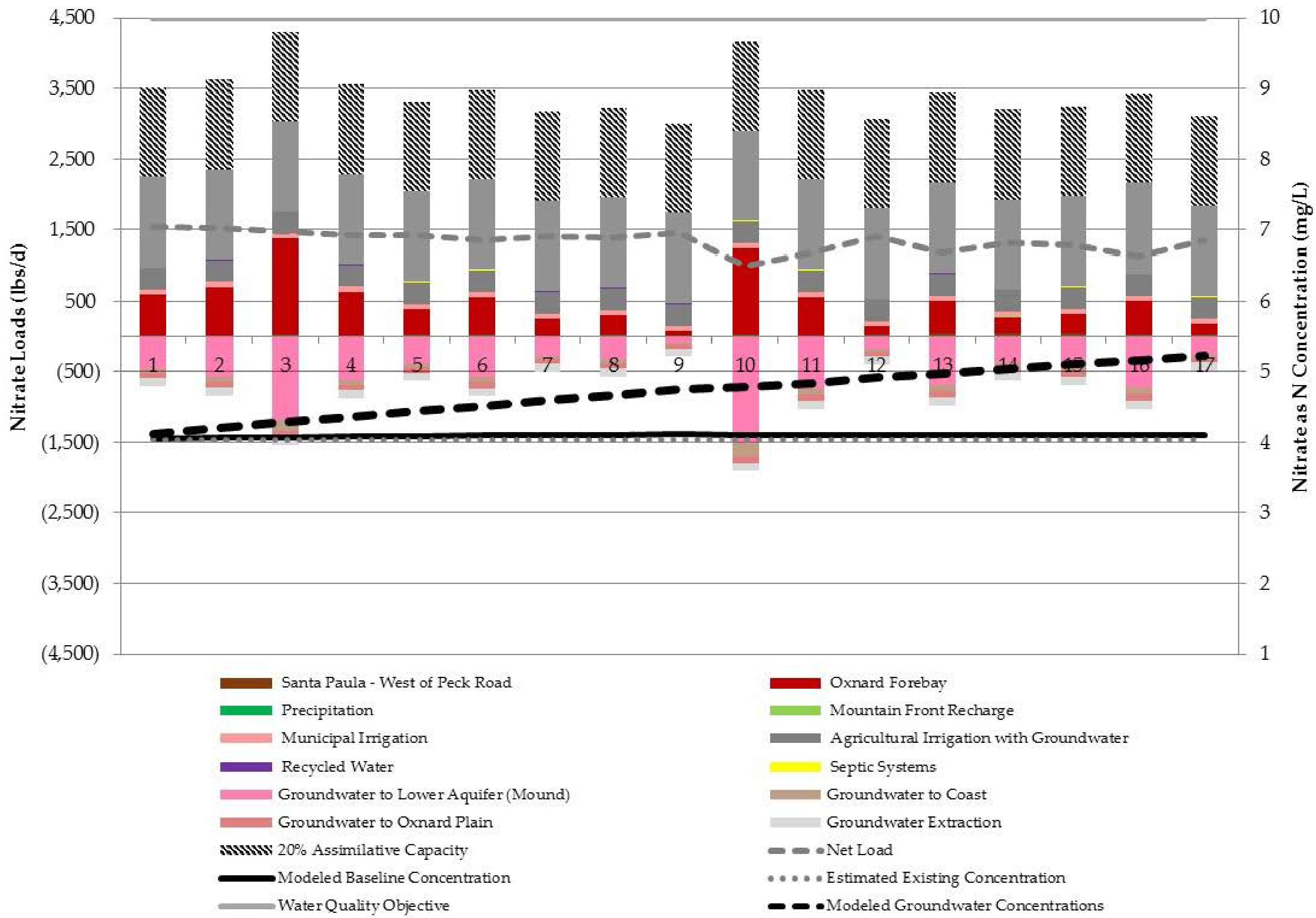

Figure 7-67 Modeled Nitrate 20% Threshold Load and Annual Concentrations for Mound Basin