4.2 Previous South Lake Tahoe/Stateline Investigations

4.2.1 UC Davis Thesis (Woodling 1987)

Woodling conducted a study from January 1986 until February 1987 to characterize the geologic, hydrology, hydraulic and hydrochemical conditions in the South Lake Tahoe groundwater basin. The information was then used to assess the magnitude and distribution of the groundwater and nutrient fluxes to Lake Tahoe. The study area was chosen because there was a large base of available data. In addition to using existing information, Woodling also collected water samples and aquifer tests as part of his fieldwork. Computer simulation was then used to approximate the flow regime.

Woodling determined that a steady-state flow model could approximate the South Lake Tahoe groundwater basin. Although current studies suggest that South Lake Tahoe has a multiple aquifer system, Woodling's study reported that the aquifer was unconfined based on the specific yield and hydrochemical evidence of the distribution of chemical constituents. Woodling determined the transmissivity was highest at the lakeshore near the center of the valley. The concentrations of nitrate-nitrogen in the groundwater were much higher than in the streams or lake. Soluble reactive phosphorous concentrations of groundwater were only slightly higher than in streams and the lake. Woodling's numerical simulation indicated that interflow from the surrounding granitic bedrock is important, and piezometric data suggested that lake water influx to the basin may be possible over a limited area of shoreline.

Woodling determined annual discharge of groundwater to Lake Tahoe in the study area encompassing Trout Creek and Upper Truckee watersheds is 1.7×10^6 cubic meters (1,375 acre-feet). The nitrate and soluble reactive phosphorus loading from groundwater was 152.6 kg/yr (336.4 lb/yr) and 26.6 kg/yr (58.6 lb/yr), respectively. This accounted for only 4.6 percent and 1.8 percent of the nitrate and soluble reactive phosphorus loads from the watershed, respectively. Woodling also determined that the high nutrient concentrations of groundwater at the sediment-lake interface may be important in the biological processes of Lake Tahoe.

4.2.2 UC Davis Institute of Ecology Study (Loeb 1987)

Loeb studied the Upper Truckee and Trout Creek watersheds in the mid 1980s with the objectives of determining the degree of nutrient contamination of the groundwater, quantifying the amount of water and associated nutrients entering Lake Tahoe via groundwater, assessing the impact of groundwater inflow on the growth rate of algae in Lake Tahoe, and outlining mitigation measures to prevent further degradation of groundwater quality.

Groundwater sampling indicated that deeper wells had a much lower nitrate-nitrogen concentration than shallow wells in the Trout Creek watershed. Loeb determined that nitrate enters the aquifer from the land surface and does not mix well into the large reservoir of water deep in the aquifer. In addition, a majority of the highest nitrate concentration wells were near the shore. The range of nitrate-nitrogen concentrations were 0.006 – 2.548 mg/L and 0.023 –

1.528 mg/L for Upper Truckee and Trout Creek, respectively. Loeb found that the overall average nitrate-nitrogen concentration for the wells in the Upper Truckee watershed was 0.466 mg/L while phosphorus was found in low to medium concentrations averaging 0.018 mg/L.

The gradient that Loeb observed in the South Lake Tahoe groundwater basin was 0.0028. Transmissivity was taken from earlier studies and further testing was conducted during his study. Loeb determined the distribution of transmissivity correlated closely with sediment thickness. It was found to be highest near the lake in the vicinity of Tahoe Keys and decreased toward the rock boundaries on the east and west. The average transmissivity was 346 m^2/day (3,724 ft^2/day).

Loeb observed a large pumping depression near the confluence of Heavenly Valley Creek and Trout Creek extending north into the Al Tahoe area. Loeb considered the possibility of lake water entering the subsurface due to groundwater pumping, but found that it was not conclusive from the groundwater level data alone.

Using the hydraulic data from his study, Loeb determined that the Upper Truckee and Trout Creek watersheds discharged 1.71 x 10^6 m^3/year (1,386 acre-feet/year) of water into Lake Tahoe. Using the nutrient values from the groundwater monitoring network, Loeb estimated groundwater loaded 153 - 799 kg (337 – 1,761 lb) of nitrate-nitrogen per year into Lake Tahoe representing 5 - 20 percent of the total dissolved inorganic nitrogen loading of Lake Tahoe from this area. Annual loading of 27 kg (60 lb) soluble reactive phosphorus was discharged from the South Lake Tahoe watersheds Loeb studied, which represented 2 percent of the watershed's total loading of soluble reactive phosphorus (SRP).

Loeb recommended mitigation measures to deal with the groundwater nutrient loading to Lake Tahoe. He emphasized the need for educating the local community on how to protect the lake, and that fertilizer use should be held to a minimum and sewer systems should be routinely checked for exfiltration points. He also recommended that the water quality agencies require all public and private water systems to grant permission for water quality sampling for environmental health twice a year. Another suggestion was to restrict land disturbance and sustain a monitoring program to evaluate the trends and provide better information.

4.2.3 DRI Near Shore Clarity Study (Taylor 2002)

Results from Taylor's monitoring, conducted along the south shore for July 2002, show elevated turbidity near Tahoe Keys, the outlet of the Upper Truckee River and Trout Creek, near Al Tahoe and Bijou Creek. The chlorophyll results are highest near Tahoe Keys and the Upper Truckee River. Moderate concentrations were observed near Bijou Creek.

4.2.4 Other Investigations

The USGS maintains the most extensive groundwater monitoring network in the South Lake Tahoe/Stateline area. This is mostly due to the extensive basin and groundwater wells available for monitoring. The South Tahoe Public Utility District operates the largest groundwater municipal supply system in the basin. Groundwater supplies 100 percent of the drinking water for the region. The California Tahoe Conservancy, El Dorado County Department of Transportation and local golf courses also provide localized groundwater monitoring networks. These latter systems are typically built for monitoring water quality rather than public supply of drinking water. El Dorado County Environmental Management, the California DHS and Nevada Bureau of Health Protection Services also retain limited nutrient data relevant to public drinking water standards. The well construction information for regional wells with nutrient monitoring data is provided in Table 4-2.

Table 4-2. South Lake Tahoe/Stateline Area Well Construction Information

Site No.	Elevation ft above msl	Depth of Well meters	(ft)
Emerald Bay to Taylor Creek			
027	--	114	(373)
041	6235	30	(100)
058	--	14	(45)
059	--	59	(195)
066	--	12	(38)
Subregion 1			
043	6235	--	--
055	6253.58	--	--
056	6240	8	(25)
057	6240	8	(25)
053	6235	7	(24)
054	6235	7	(24)
051	6235	--	--
052	6235	--	--
047	6235	11	(35)
048	6235	11	(35)
Subregion 2			
076	--	--	--
081	--	--	--
084	6280.92	--	--
087	6276.89	41	(135)
086	6270	--	--
083	--	41	(135)
085	6278	79	(260)
050	6230	104	(341)
Subregion 3			
042	6255	123	(405)
049	6268.33	--	--
039	6255.37	--	--
034	6250	--	--
044	--	23	(77)

Site No.	Elevation ft above msl	Depth of Well meters	(ft)
045	6260	38	(125)
Subregion 4			
046	--	--	--
032	--	--	--
040	--	--	--
031	6235	25	(82)
030	--	--	--
028	--	32	(104)
037	--	35	(115)
024	--	--	--
025	--	--	--
026	6235	43	(142)
029	6250	40	(130)
033	--	46	(150)
036	--	31	(102)
038	--	30	(98)
035	--	34	(110)
023	--	--	--
021	--	25	(82)
013	6239.48	55	(180)
022	--	--	--
014	6237.88	--	--
020	--	21	(70)
011	6240	76	(250)
016	6230	76	(248)
019	6260	--	--
018	--	--	--
005	--	--	--
008	--	30	(100)
015	--	--	--
006	--	23	(76)
009	--	21	(70)
010	--	--	--
007	--	--	--
012	--	--	--
Stateline			
197	6235	18	(58)
200	6230	3	(9)
199	6230	3	(11)
201	6230	3	(9)
003	6230	2	(6)
202	6240	4	(13)

Site No.	Elevation ft above msl	Depth of Well meters	(ft)
001	6235	2	(8)
002	6235	3	(10)
004	6245	7	(23)
188	6275	61	(200)
193	6260	8	(25)
198	6360	5	(18)
186	6320	2	(8)
219	6335	--	--

Notes:
1. The source agency code associated with each site number can be found in Appendix A.
2. -- indicates the elevation or well depth is unknown.
3. Data obtained from USGS, LRWQC, CTC, TRPA, El Dorado EM, STPUD, Nevada BHPS, California DHS, California DWR, and Nevada DWR.

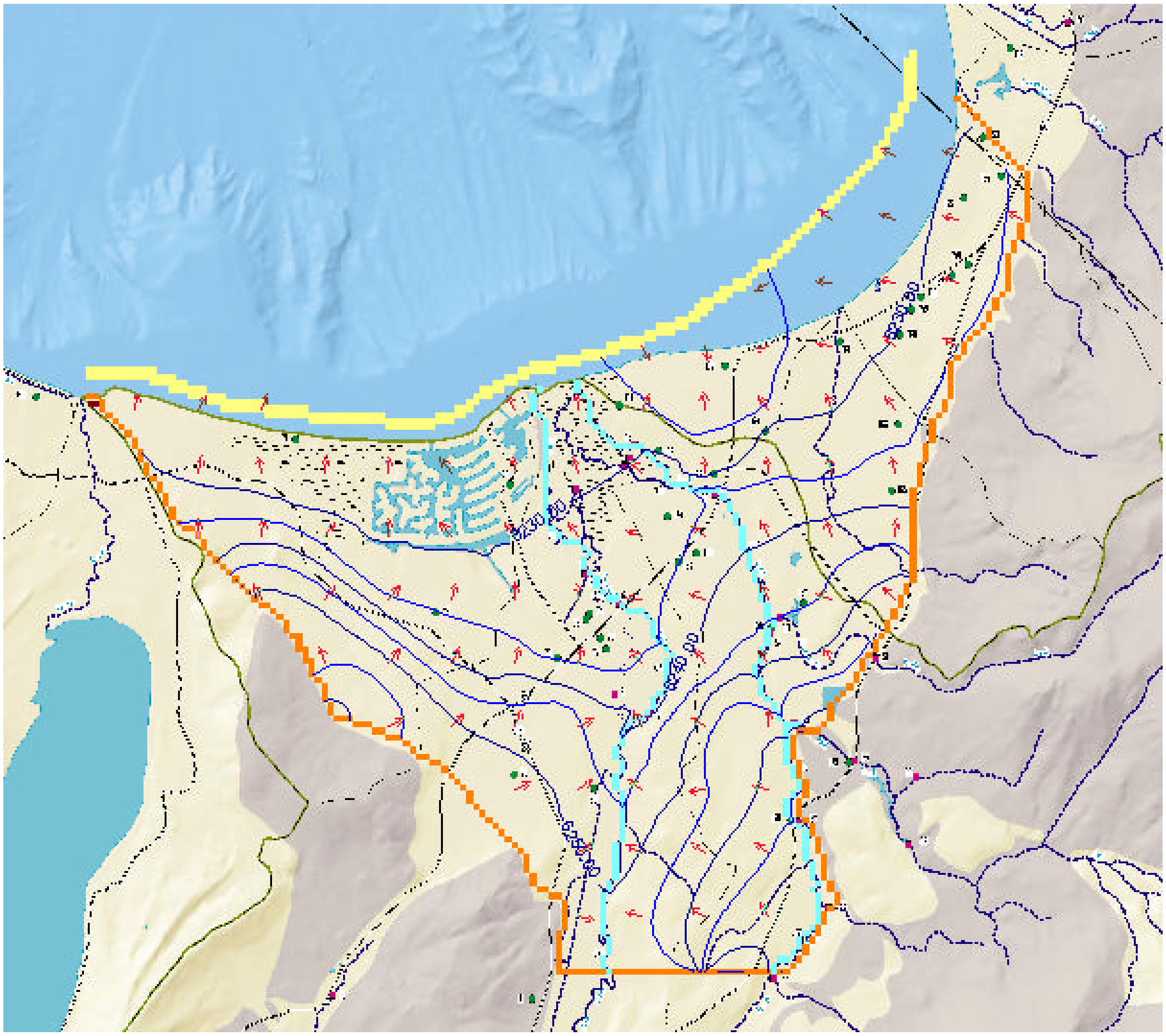
Monitoring data available from agencies date back to 1980. Monitoring of some wells still continues as part of the USGS basin-wide monitoring network and local groundwater monitoring networks. This data is collected to monitor both environmental and public health. See Section 4.3 for a detailed description of the nutrient data.

Groundwater elevations have been recorded periodically as well. These elevations were used in the numerical model for calibration in addition to stream gage elevation data. See Appendix B for a comprehensive report of the groundwater modeling effort.

4.3 Nutrient Concentrations

Groundwater wells are spread throughout the area from Christmas Valley to the Lake shore. The groundwater that is likely to discharge directly to the lake is within 1,500 meters (4,921 ft) of the shoreline. Additionally, groundwater located within 2,000 meters (6,562 ft) directly south of the Tahoe Keys is likely to discharge into the Keys and subsequently into Lake Tahoe. Figure 4-7 shows the flow lines and groundwater contours in the model area. To the south and east of Tahoe Keys, the groundwater tends to travel towards the Upper Truckee River and Trout Creek (Fenske 2003). Because of the extensive monitoring system, this discussion will focus on the wells within the area where groundwater likely discharges directly to the Lake.

Figure 4-7. South Lake Tahoe Model Area Groundwater Contours and Flow Lines



Notes:
1. Figure obtained from Fenske (2003)

LRWQCB requires groundwater monitoring at Bijou golf course to establish baseline conditions in early spring, monitor the effects of chemicals applied during the summer season and determine the residual effects once the active season has ceased. LRWQCB also requires the golf course to build a database adequate to provide effective feedback for golf course chemical and irrigation management with respect to environmental protection (LRWQCB 2000b). To build the database, LRWQCB has required that groundwater be monitored on a monthly basis. The golf course is required to sample groundwater for dissolved chemical constituents passing through a 0.45 micron filter. The nutrient constituents requiring analysis are dissolved Kjeldahl Nitrogen, dissolved nitrite plus nitrate, and dissolved orthophosphorus and total dissolved phosphorus. TRPA also requires Edgewood Golf Course to collect groundwater samples. Edgewood golf course is required to sample groundwater quality to assure that the fertilizer management plan will meet the water quality thresholds. The sample testing focuses on nutrients representative of types of fertilizers used on the property. Three groundwater sites are monitored on a monthly basis, and the samples are tested for nitrate plus nitrite, ammonia, and total phosphorus.

USGS has been collecting samples periodically for many years. These wells are sampled as part of a Tahoe basin-wide monitoring program. The USGS typically tests for dissolved ammonia, dissolved Kjeldahl nitrogen, dissolved nitrate plus nitrite, dissolved orthophosphorus, and total dissolved phosphorus. The specific analytical profiles per well may vary.

The California DHS, Nevada BHPS, STPUD and El Dorado County EM require sampling for nitrate and nitrite in drinking water wells. These samples have been added to the larger data set to combine as much nutrient chemistry collected in the basin as possible.

The average concentrations and top of open interval for wells located near the lake are included in Table 4-3 through Table 4-8. The top of open interval represents the depth below ground surface that groundwater can freely enter the well (e.g. top of screen or bottom of casing in fractured rock). The well locations and land use in each are shown in Figure 4-8 through Figure 4-13.

4.3.1 Emerald Bay to Taylor Creek Nutrient Concentrations

The wells and land use in the area are depicted in Figure 4-8. Well 041 is the only well that has been monitored for all applicable forms of dissolved nitrogen and phosphorus. Well 041 has been sampled since 1995. Wells 027, 058, 059 and 066 have only been sampled to monitor drinking water standard compliance which includes only total nitrate and nitrite testing.

The dissolved ammonia + organic nitrogen concentrations for well 041 range from 0.001 mg/L to 0.09 mg/L, averaging 0.045 mg/L. The dissolved nitrate concentrations, which include nitrite, range from 0.034 mg/L to 0.064 mg/L with an average of 0.051 mg/L. This results in an average total dissolved nitrogen concentration of 0.096 mg/L. The average total nitrate concentrations found in wells 027, 058, 059 and 066 range from 0.012 mg/L to 0.4584 mg/L. Lower concentrations of nitrogen are found in well 041. This may be indicative of denitrification, which occurs as the groundwater travels towards the lake, or the difference in dissolved versus total nitrogen concentrations. Table 4-3 includes the dissolved nitrogen concentrations for well 041.

Orthophosphorus concentrations for well 041 range from 0.022 mg/L to 0.085 mg/L, averaging 0.071 mg/L. The range of total dissolved phosphorus is 0.06 mg/L to 0.101 mg/L, averaging 0.085 mg/L. No phosphorus concentrations have been measured in the other wells in the area. Table 4-3 includes the dissolved phosphorus concentrations for well 041.

Well 041 is well placed to represent the downgradient conditions for the area. It is likely an accurate reflection of the majority of the groundwater discharging across this area (Figure 4-8).

Table 4-3. Emerald Bay to Taylor Creek Average Nutrient Concentrations (mg/L)

	Well ID
Constituent	041
Ammonia + Organic	0.045
Nitrate	0.051
Total Nitrogen	0.096
Orthophosphorus	0.071
Total Phosphorus	0.085
Top of Open Interval (ft bgs)	70

Notes:
1. All concentrations reported are dissolved.
2. Data obtained from USGS.
3. Top of Open Interval with a -- indicates the open interval is unknown. A < indicates less than the total depth of the well.
4. na – not analyzed
5. Total Nitrogen is calculated for those wells with both ammonia + organic and nitrate concentrations
6. Nitrate concentrations include nitrite.