9.0 LAKE TAHOE BASIN-WIDE GROUNDWATER NUTRIENT LOADING

9.1 Basin-Wide Data Gaps

Systematic groundwater investigations should be conducted throughout the basin, especially in the more populated parts and where they coincide with sedimentary fill basins. Investigations should be designed to define vertical and horizontal variations in flow, mixing among various zones, and interaction with surface water and the lake shore zone. These factors are pertinent for better understanding available resources and for defining management strategies for protecting those resources. Geochemical analyses should be performed to adequately define variations among shallow, intermediate and deep aquifer systems and to determine groundwater evolution trends as water travels from the mountain slopes to the lake. Geologic and geophysical evaluations should be conducted to more accurately define aquifer parameters, water basin boundaries and the importance of confining horizons. Much controversy exists about the extent and continuity of fine-grained horizons in South Lake Tahoe. Such units should be adequately defined there and in other parts of the basin.

Survey data for the wells and stream gage stations, for the most part, has not been collected. This is a minor activity that could greatly improve the loading calculations by providing better data for more accurate gradients. Groundwater level data should be obtained for all wells during sample collection. This too would provide a more complete data set to determine accurate gradients in the basin.

A consistent set of nutrients monitored would provide a more complete dataset for evaluation. Specifically, additional organic nitrogen and total phosphorus testing would provide a more complete dataset.

9.2 Error Analysis

The accuracy of the groundwater discharge and nutrient loading estimates are a function of the input parameter data quality. The data set is limited for the basin, thereby reducing the level of accuracy in the estimates. Unfortunately, the lack of data also hinders the assessment of accuracy. The discussion of errors is qualitative.

Groundwater level measurements are accurate from 0.03 m to 6 m (0.1 foot to 20 feet). This broad range of accuracy is due to only a handful of wells with survey data. The vertical coordinates of the remainder of wells has been estimated by topographic maps, inducing an error of one half a contour interval. In addition, the horizontal accuracy of the wells is poor because of the lack of survey data. These factors combined limit the accuracy of the hydraulic gradients estimated.

Hydraulic conductivity estimates were based primarily on drillers' well logs. The literature was also searched for better descriptions of the geology. The poor quality of drillers' reports and lack of sufficient geological investigations produces errors associated with these

estimates. This is probably the largest source of error in most parts of the basin. The aquifer area also suffers from the lack of geological investigations. The depth to bedrock and potential confining layers are also inferred from drillers' well logs. The well logs tend to be inconsistent, introducing error into the estimates of geological parameters. The lack of data from fracture flow is also a problem. There is a potential to have significant flows from the fractured bedrock that is not evaluated.

The accuracy of the chemical analysis is likely the most accurate. The groundwater samples are representative of the aquifer chemistry to the extent collection and analytical methods are valid. The extrapolation of the groundwater chemistry to other part of the basin based on land use, average or downgradient estimates can induce error. Similar land uses may not be directly comparable throughout the basin. A good example of this is residential land use. There are neighborhoods in the basin with manicured lawns and other with natural vegetation. These two types of neighborhoods may have drastically different groundwater loading associated with them. This type of information was not available, and therefore was not considered in the estimated land use averages. In addition, many of the wells are screened in the deep aquifer. The analytical results may not accurately reflect the upper aquifer which likely contains the highest levels of nutrients.

9.3 Overall Loading to Lake Tahoe

A regional groundwater discharge and loading estimates were conducted throughout the basin. These values produce a new estimate of groundwater discharge and nutrient loading to Lake Tahoe. Each of the areas have unique characteristics which warrant regional nutrient loading estimates. These values can then be combined to evaluate the overall estimates of nutrient loading to Lake Tahoe. Table 9-1 summarizes the range and most reasonable estimates of nutrient loading in each area.

Table 9-1. Range of Nutrient Loading to Lake Tahoe by Region

Constituent		Region										Total Groundwater Loading to Lake Tahoe	Total Groundwater Loading to Lake Tahoe (Murphy et al. 2000)
		South Lake Tahoe/Stateline											
		Emerald Bay to Taylor Creek	Subregion 1	Subregion 2	Subregion 3	Subregion 4	Stateline	Incline Village	Tahoe Vista/ Kings Beach	Tahoe City/ West Shore	East Shore		
Total Dissolved Nitrogen (kg/year)	Minimum	24	68	298	1	372	371	62	6,363	2,313	3,063	12,935	
	Maximum	261	519	1,284	71	1,300	1,154	19,535	14,998	48,755	6,151	94,028	
	Estimate	142	364	778	39	486	650	4,189	9,667	28,327	6,151	50,800	60,000
Total Dissolved Phosphorus (kg/year)	Minimum	21	8	21	0	29	12	9	723	1,380	79	2,282	
	Maximum	229	37	193	11	103	30	1,123	2,205	7,564	150	11,645	
	Estimate	125	26	143	6	86	30	768	1,099	4,395	140	6,800	4,000

The estimated total nitrogen and total phosphorus loading to Lake Tahoe from groundwater is 50,900 and 6,800 kg (112,215 and 14,991 lbs) per year, respectively. This is similar to the 60,000 and 4,000 kg reported in the U.S. Forest Service Watershed Assessment. This constitutes 12% and 15% of the annual nitrogen and phosphorus loading to Lake Tahoe, which is similar to Thodal's estimates of 15% nitrogen and 10% phosphorus loading annually.