CHAPTER 8

Nutrient Loading and the Trophic State of the Main Valley Lakes.

8.1 GENERAL

The classic terms of Oligotrophic, mesotrophic and eutrophic are useful for describing the character of lakes, but they do not allow quantitative comparisons to be made. The rate at which nutrients enter a lake allows for direct comparison among lakes from widely scattered geographical regions and provides a more quantitative basis for evaluating the trophic state of lakes (Vollenweider, 1969).

The total phosphorus load to each Okanagan main valley lake was considered the most reliable indicator of current trophic state, for there was a strong relationship between the concentrations of total phosphorus in lake water at spring overturn and the amount of chlorophyll-a. in the photic zone in mid-summer (Figure 8.1). This relationship of phosphorus load to lake primary productivity will, in most cases, extend to alt trophic levels.

While total phosphorus load is a reliable trophic state indicator, gathering valid data to use is by no means a simple task. The large volume of most of the main valley lakes and the comparatively short length of the study period further hampered the collection of precise data. The extreme variations of tributary streamflows from year to year in the basin make any single years' data questionable, if long term mean values are to be used in planning. This is particularly the case in Okanagan Lake where values may vary by a factor of several times annually (see Technical Supplement IV).

Several different approaches were used to gain an indication of phosphorus loading rates to the main valley lakes. Actual field measurements were obtained during the period 1969 to 1972. The length of time the various sources were monitored varied. Streams and outfalls, the two major sources, were monitored continuously. These data are presented in Table 8.1. A second method used was based on theoretical soil characteristics and population-dependent-phosphorus-export (Vollenweider, 1969), to calculate the total phosphorus loads to all main valley lakes except Vaseux. As a check on this method, the chemical nutrient data of Clarke and Alcock (1968) were used to compute loads. A comparison of these data and other research data is summarized in Table 8.2.

The data from actual measurement and that calculated according to Vollenweider's criteria were computed on an areal basis (gTP/m^2) for the years of data and plotted as a function of lake mean depth over water residence time (Figure 8.2). This provides a basis for determining the current trophic state of the Okanagan main valley lakes.

TABLE 8.1

MAJOR NUTRIENT LOADINGS TO THE MAIN VALLEY LAKES

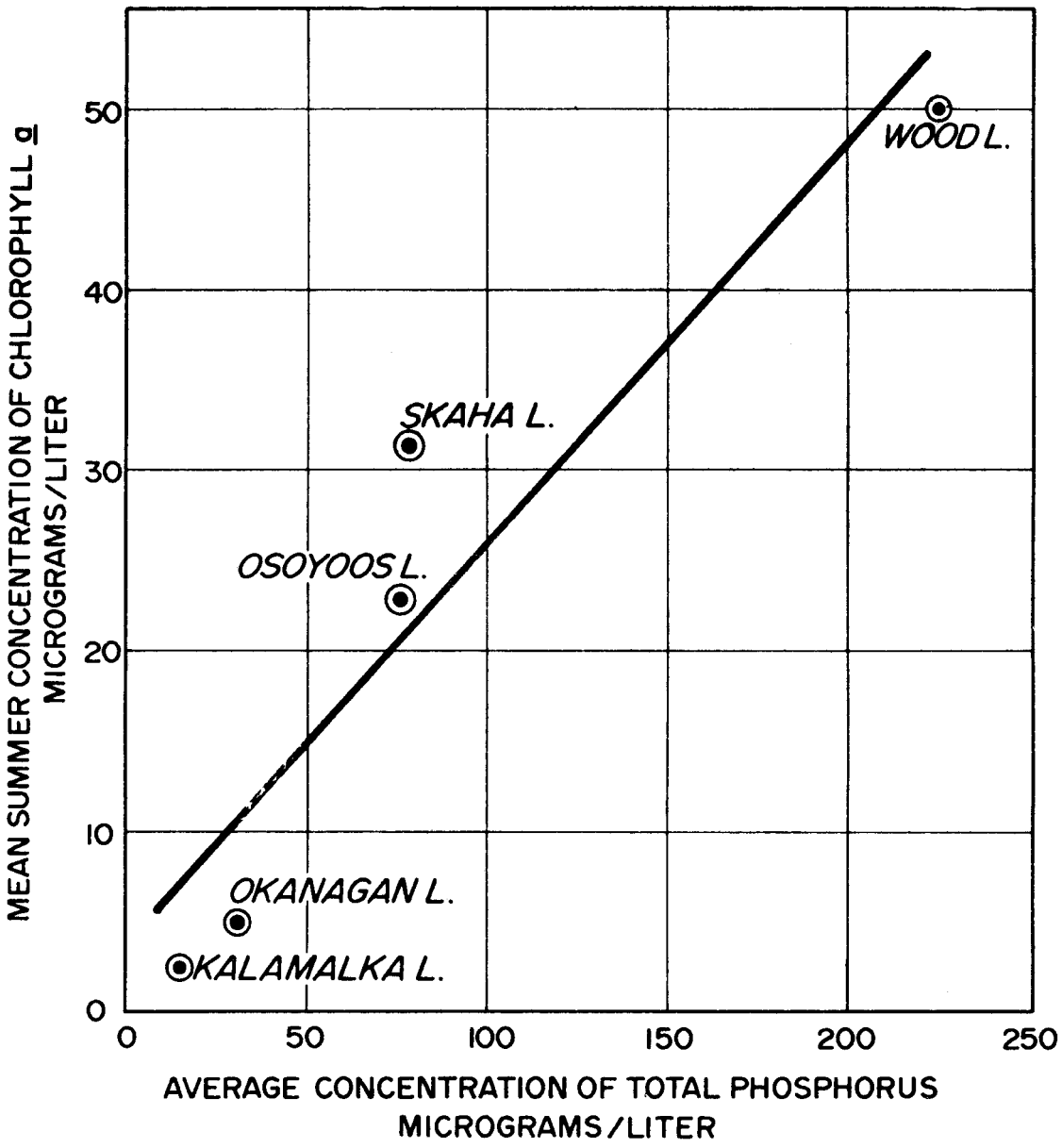
	ESTIMATED ANNUAL INPUT OF TOTAL PHOSPHORUS INTO THE MAIN VALLEY LAKES -1971							
	ANNUAL LOCAL WATERSHED LOADINGS - POUNDS PER YEAR 1969-1971							
LAKE	TRIBUTARY[2] STREAMS	MUNICIPAL TREATMENT PLANTS	DUSTFALL AND PRECIPITATION	GROUNDWATER SEPTIC TANKS	OTHER SOURCES*1	SUBTOTAL	CONTRIBUTED FROM UPSTREAM LAKE OUTFLOW (lb/yr)	TOTAL LOADING TO LAKE (lb/Yr)
WOOD	800	-	140	1,660	720	3,320	-	3,320
KALAMALKA	3,600	-	600	940	40	5,180	-	5,180
OKANAGAN North	19,480	39,680	5,900	1,560	920			
OKANAGAN Central	29,800	42,480	4,960	4,840	2,620	185,720	1,600	187,320
OKANAGAN South	18,600	-	8,740	4,660	1,480			
SKAHA	4,200	28,900	1,660	2,600	500	37,860	10,600	48,460
VASEUX	260	-	40	280	120	700	18,800	19,500
OSOYOOS (Canada)	800	4,060	980	8,560	980	15,380	22,140	37,520
SUB TOTALS	77,540	115,120	23,020	25,100	7,380	248,160	53,140	301,300

*1 Includes Industrial Outfalls, Storm Sewers, and Groundwater from Agricultural Land and Natural Sources.

*2 Includes Natural and Diffuse Loadings to streams from Agriculture and Septic Tank Sources

	ESTIMATED ANNUAL INPUT OF TOTAL NITROGEN INTO MAIN VALLEY LAKES - 1971								
	ANNUAL LOCAL WATERSHED LOADINGS - POUNDS PER YEAR (MEAN VALUES)								
LAKE	TRIBUTARY*[2] STREAMS	MUNICIPAL TREATMENT PLANTS	DUSTFALL AND PRECIPITATION	GROUNDWATER SEPTIC TANKS	AGRICULTURE	OTHER*[3] SOURCES	SUBTOTALS	CONTRIBUTED FROM UPSTREAM LAKE OUTFLOW (lb/Yr)	TOTAL LOADING TO LAKE (lb/Yr)
WOOD	20,000	-	3,800	17,160	9,860	3,760	54,580	-	54,580
KALAMALKA	79,000	-	9,200	10,220	4,340	940	103,700	-	103,700
OKANAGAN North	87,820	86,720	48,600	18,160	12,560	4,880			
OKANAGAN Central	322,400	119,000	56,800	55,600	43,980	12,960	1,142,760	40,400	1,183,160
OKANAGAN South	86,000	-	65,400	56,200	36,520	29,160			
SKAHA	22,200	112,180	22,600	27,560	15,480	7,640	207,660	181,600	389,260
VASEUX	9,600	-	3,600	2,980	4,920	2,220	23,320	268,800	292,120
OSOYOOS (Canada	1,720	8,100	6,000	86,400	64,600	17,580	184,400	317,800	502,200
SUB TOTALS	628,740	326,000	216,000	274,280	192,260	78,800	1,716,420	808,600	2,525,020

*3 Includes Industrial Outfalls, Storm Sewers, and Groundwater from Natural Sources.



RELATION BETWEEN CHLOROPHYLL CONCENTRATION AND TOTAL PHOSPHORUS CONTENT OF WATER FROM THE OKANAGAN MAIN VALLEY LAKES.

Figure 8.1

TABLE 8.2

VALUES OF THE TOTAL PHOSPHORUS LOADINGS TO THE OKANAGAN LAKES AND OTHER PARAMETERS OF IMPORTANCE IN THE CALCULATION OF THE TOTAL LOAD.[*1]

LAKE	WATER RESIDENCE TIME	TOTAL PHOSPHORUS LOAD (Kilograms per year) 1969	1970	1971	TOTAL PHOSPHORUS LOAD (g/m^2 Lake Surface/Year) 1969	1970	1971	TOTAL PHOSPHORUS LOAD FROM LAKE ABOVE (gm/m^2 per year)	PERCENT RETENTION OF PHOSPHORUS IN THE LAKE IN RELATION TO PHOSPHORUS LOAD
OSOYOOS	0.5[a]	19,366[d]	12,700[f]	45,359[f]	2.0[d]	1.28	4.50	1.56[d]	--
	1.0[c]	25,176[e]	12,200[g]	16,900[g]	2.6[e]	1.23	1.71		
		AVERAGE: 21,950			AVERAGE: 2.22				
VASEUX	0.15[b]	9,710[h]	5,443[f]	10,886[f]	1.86[h]	1.05	2.09	1.84[h]	12[h]
		AVERAGE: 8,680			AVERAGE: 1.67				
SKAHA	1.2[a]	27,430[d]	16,329[f]	22,679[f]	1.4[d]	0.81	1.13	0.33	65
	1.0[c]	43,104[e]	13,400[g]	15,400[g]	2.2[e]	0.66	0.76		
			14,700			0.73			
		AVERAGE: 21,863			AVERAGE: 1.09				
OKANAGAN	57.0[a]	129,610[d]	162,386[f]	421,840[f]	0.38[d]	0.47	1.22	0.0	95
	60.0[c]	133,021[e]	49,000[g]	235,000[g]	0.39[e]	0.14	0.68		
		AVERAGE: 188,476			AVERAGE: 0.54				
KALAMALKA	100.0[a]	8,288[e]	890[g]	3,220[g]	0.32[e]	0.034	0.12	0.02	90
	115-71[i]		745[g]	2,610[g]		0.028	0.10		
		AVERAGE: 2,625			AVERAGE: 0.10				
WOOD	30-100[a]	4,650[e]	145[g]	602[g]	0.50[e]	0.015	0.065	0.01	90
	20-109[i]								
		AVERAGE: 1,805			AVERAGE: 0.19				
WOOD/KALAMALKA Combined			6,350[f]	9,072[f]		0.18	0.25		
		AVERAGE: 7,711			AVERAGE: 0.21				

[a] Lerman, 1972
[b] Stockner, unpublished data
[c] Stockner-Koshinsky, unpublished data
[d] Patalas, 1972 (data of Clarke and Alcock, 1968)
[e] Patalas, 1972 (Vollenweider criteria)
[f] Corrigan, 1972
[g] Lerman, 1972; Streams and outfalls only
[h] Stockner, unpublished data- assumes 9,600 from Skaha (Patalas, 1972), and 110 from Shuttleworth (Corrigan, 1972
[i] Stockner-Koshinsky, Wood/Kalamalka Report

[*1]

NOTE: The estimates shown in the above table, particularly that of Corrigan, Lerman, Stockner and Koshinsky, was based on early data interpretation, much of which was later revised. (See Table 8.1 and Technical Supplement IV).

In all cases (Figure 8.2) the values calculated are higher than those estimated from study measurements. It is suggested that in this regard a conservative approach, which means considering the maximums as perhaps a high extreme, is most appropriate. With this attitude in mind, all the main valley lakes are receiving phosphorus at excessive levels. Even using the lower estimates, all main valley lakes - with the possible exception of Kalamalka Lake - are receiving phosphorus inputs at or near dangerous levels, thus unnaturally speeding the process of eutrophication.

8.2 NUTRIENT SOURCES

8.2.1 Osoyoos Lake

Almost 60 percent of the total annual phosphorus load comes from the Okanagan River which drains Skaha and Vaseux Lakes above. Only about 30-35% of the river load comes from Skaha or Vaseux Lakes, while the remainder apparently comes from surface and sub-surface agricultural return flows and from septic tanks located near the river. The Oliver Sewage Treatment Plant contributes about 1,500 to 2,000 kg/year to Osoyoos Lake. Present evidence indicates that the remainder comes from sub-surface flows from agricultural lands and septic tank fields surrounding the lake. Hence, a large part of the load to Osoyoos Lake is from sources which are difficult to control.

8.2.2 Vaseux Lake

The average total phosphorus load comes from the Okanagan River which drains Skaha Lake above. Any reduction of phosphorus load in Skaha Lake will accordingly reduce loads to Vaseux Lake, and as such represents the only feasible means of nutrient control for this lake.

8.2.3 Skaha Lake

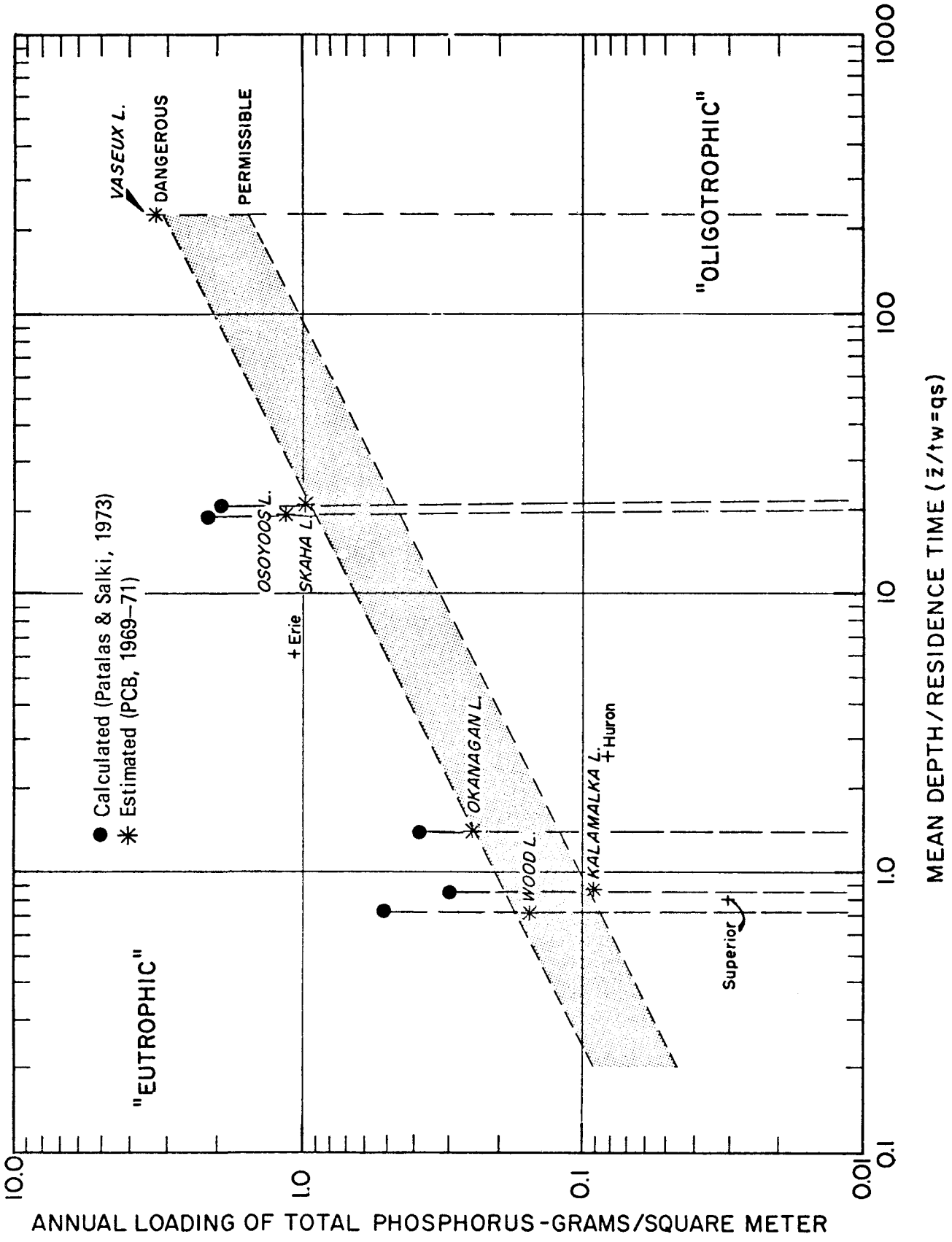
The average annual total phosphorus load to Skaha Lake is about 22,000 kg/year About 60 percent of this total comes from the Penticton Sewage Treatment Plant and the remainder from the Okanagan River draining Okanagan Lake, and from other surface and sub-surface flows to the south of the City of Penticton.

8.2.4 Okanagan Lake

The average annual phosphorus load to Okanagan Lake is 85,000 kg/year. About 45% of this total is attributable to sewage treatment plant effluent; 35% to tributary streams draining a variety of landuse regions; and the balance to septic tanks (6%), dustfall and precipitation (10%), and other sources (3%).

8.2.5 Kalamalka Lake

The average annual load to Kalamalka Lake is about 2,500 kg/year. No industrial or municipal outfalls enter this lake. The majority of the phosphorus



THE ANNUAL TOTAL PHOSPHORUS LOAD TO THE MAIN VALLEY LAKES OF THE OKANAGAN BASIN, 1969-1971. Figure 8.2

load is from Coldstream Creek and sub-surface return flows. About 20% of the total phosphorus load comes from Wood Lake, which has a small inflow to the lake in the south basin.

8.2.6 Wood Lake

The average annual load to Wood Lake is about 1,500 kg/year. Recent estimates indicate that about 25% of this total comes from Vernon Creek, while the remainder comes from sub-surface return flows from septic tanks (50%) and from agricultural lands (20%), which represent the predominant landuse practice on the watershed. Two fruit packing plants with outfalls discharging to the lake also contribute a small amount of phosphorus to this lake.