THE EFFECTS OF THE MINISTRY OF FORESTS AIR TANKER BASE ON LAKE KATHLYN WATER QUALITY

by

Dawn Remington

Waste Management Branch
Northern Region
Skeena Zone

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C O N T E N T S

1. INTRODUCTION

Water quality testing by the Waste Management Branch (WMB) indicates that runoff of nutrient-rich fire retardant from the Ministry of Forests (MOF) Air Tanker Base at the Smithers Airport into nearby Lake Kathlyn is causing deterioration of the lake water quality and nuisance algae blooms. Lake Kathlyn and its outflow stream provide the domestic water supply for 52 residences and it has a public beach which is a popular water sport recreation area. This report will summarize the rather lengthy history of the problem and present recent water quality and biological data. The purpose is to demonstrate that better containment of the retardant is necessary and that the deteriorating condition of the lake necessitates immediate action.

2. HISTORY

The purpose of this section is to illustrate that extremely large volumes of nutrient-rich effluent have been discharged from the air tanker base for at least 15 years, and that numerous studies have shown that the effluent is entering nearby Lake Kathlyn.

Air tanker planes have been loaded with chemical fire retardant at the Smithers Airport since 1960. As early as 1970 complaints were received of nuisance weed growths in Lake Kathlyn downslope from the tanker base. At that time, fire retardant which spilled during mixing and loading into the tanker planes was simply washed into a small pond which drained into a ditch and thus the lake. The fire retardant used then was Firetrol 100, ammonium sulphate $(NH_4)_2SO_4$ (also expressed as its fertilizer value of 21-0-0). The retardant is colored red with iron oxide and usually has a clay thickener and a corrosion inhibitor. Lake Kathlyn was found to be mildly eutrophic and to have a "nuisance" aquatic weed growth in 1974 (Baillie and Buchanan, 1974).

A broken water line in 1975 caused flushing of a large volume of red retardant-laden water into the lake, raising public complaint and prompting government investigation. At that time the northern portion of the airport runway drained into Lake Kathlyn as well. Urea, $(NH_2)_2CO$, (34-0-0) which was applied at an average rate of 9000 kg (10 tons) per winter as a de-icing agent, was identified as a second possible source of nutrient pollution to the lake. Hawthorne (1976) found extremely high nitrogen levels in ditch water from both the runways and the tanker base. The nutrient concentrations in the airport ditches are compared to Upper Kathlyn Creek, a tributary to Lake Kathlyn and nearby Glacier and Simpson Creeks in Table 1. The average total nitrogen level found in the airport ditches was 21.1 mg/L compared to 0.06 mg/L average in the other streams (an increase of 350 times). Nutrient levels in lake water adjacent to the airport and on the other side of the lake (control site) are shown in Table 2. Also shown are nutrient levels at the lake center in 1973-74. Total nitrogen levels in the lake at the airport averaged 0.878 mg/L or 2 times the average of 0.357 mg/L found elsewhere. Recommendations were made by the Pollution Control Board (PCB) to the Ministry of Transporation for runway drainage changes and to the B.C. Ministry of Forests for modifications to the air tanker base in order to prevent further nutrient addition to the lake. The resulting airport drainage patterns are shown in Figure 1.

TABLE 1
NUTRIENT CONCENTRATIONS IN AIRPORT DITCHES AND NEARBY STREAMS (1973-1976)

Date	Location and Site Number	Nitrogen Total mg/L	Nitrite/ Nitrate mg/L	Phosphorus ug/L*
18 Nov 75	tanker base ditch #5144996	32.5	6.5	234
24 Mar 76	"	12	1.35	378
3 May 76	"	23	5.1	199
18 Nov 75	runway ditch #5144997	30	6.5	163
23 Mar 76	"	8	1.22	255
13 Aug 73	upper Kathlyn Creek	0.11	0.05	100
14 Aug 73	Simpson Creek	0.03	L0.02	5
14 Aug 73	Glacier Creek	0.04	0.04	--

* Note that nitrogen levels are given in mg/L (parts per million) and phosphorus levels are given in ug/L (parts per billion)

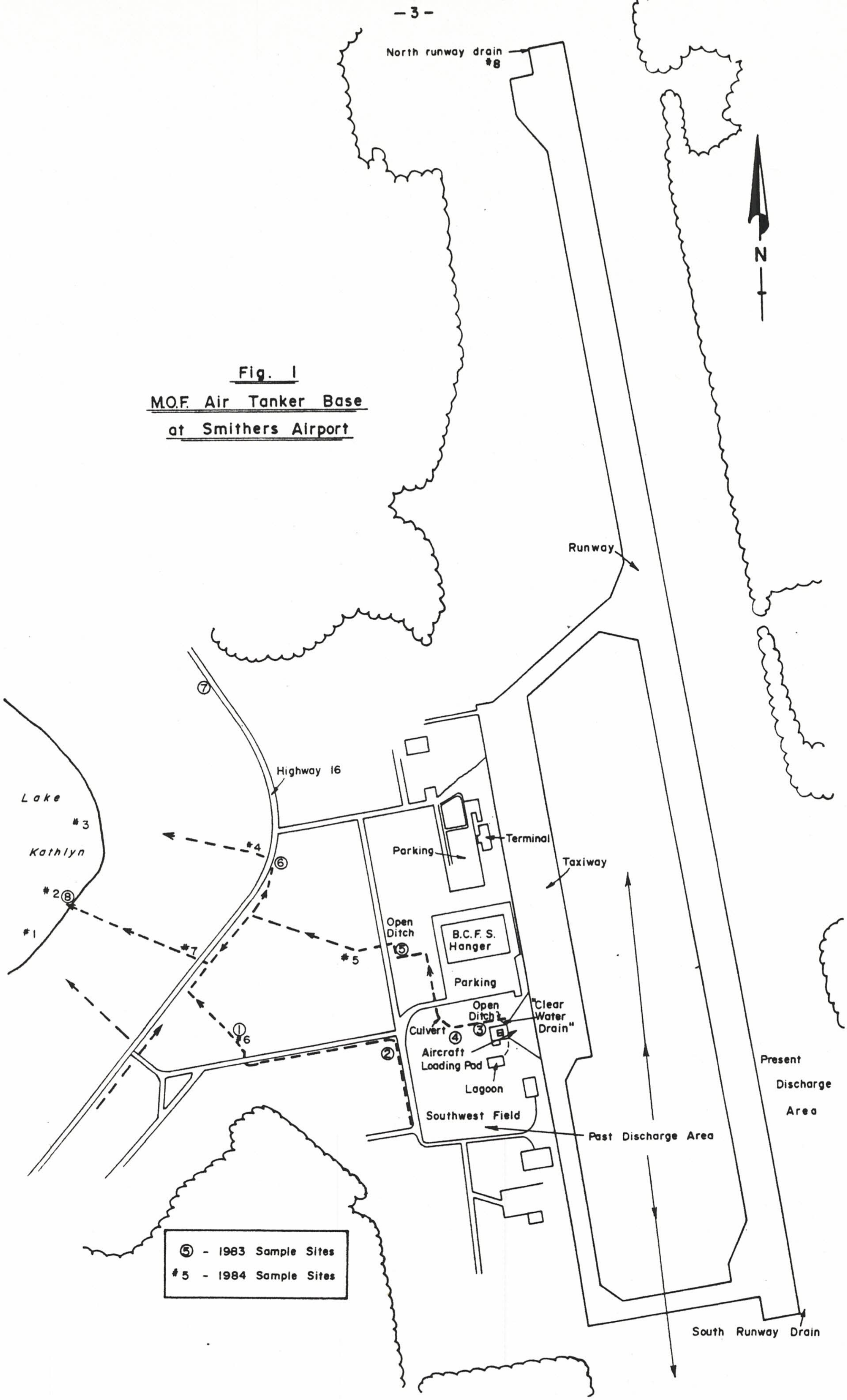

Fig. 1
M.O.F. Air Tanker Base
at Smithers Airport

TABLE 2

LAKE KATHLYN NUTRIENT CONCENTRATIONS AT AIRPORT AND CONTROL SITES

(1974-1976)

Date	Location and Site Number	Nitrogen Total mg/L	Nitrite/ Nitrate mg/L	Phosphorus ug/L
18 Nov 75	lake at airport #5144998	0.845	0.43	18
23 Mar 76	"	0.86	0.10	67
20 Apr 76	"	0.929	0.05	10
18 Nov 75	N/W lake (control) #5144999	0.35	0.02	12
23 Mar 76	"	0.48	0.17	22
20 Apr 76	"	0.50	L0.02	48
13 Aug 73	Lake Kathlyn northwest basin	0.24	L0.02	9
13 May 74	"	0.46	0.05	22
22 Jul 74	"	0.11	L0.02	10

A reconstruction of the airport runways was being carried out and the Ministry of Transport agreed to alter the perimeter drainage for the runways so that a diversion to the Bulkley River could be made at a later date. This diversion has never been completed, however, the north half of the runway drainage was diverted into a large swamp to the north of the airport. The south half of the runway has always drained towards the Bulkley River.

Modifications to the tanker base were completed in 1977 (see Figure 2). The retardant storage tanks were moved from the runway and curbing installed so that spillage and washdown water is captured in a drain which empties either into an earth lagoon or into the "clearwater" ditch which drains into the lake. Valves at either end of the drain determine the direction of water flow. Presumably the flow is directed into the lagoon for the entire fire season, however exceptionally heavy precipitation may require opening of the clearwater drain valve to avoid overfilling the lagoon.

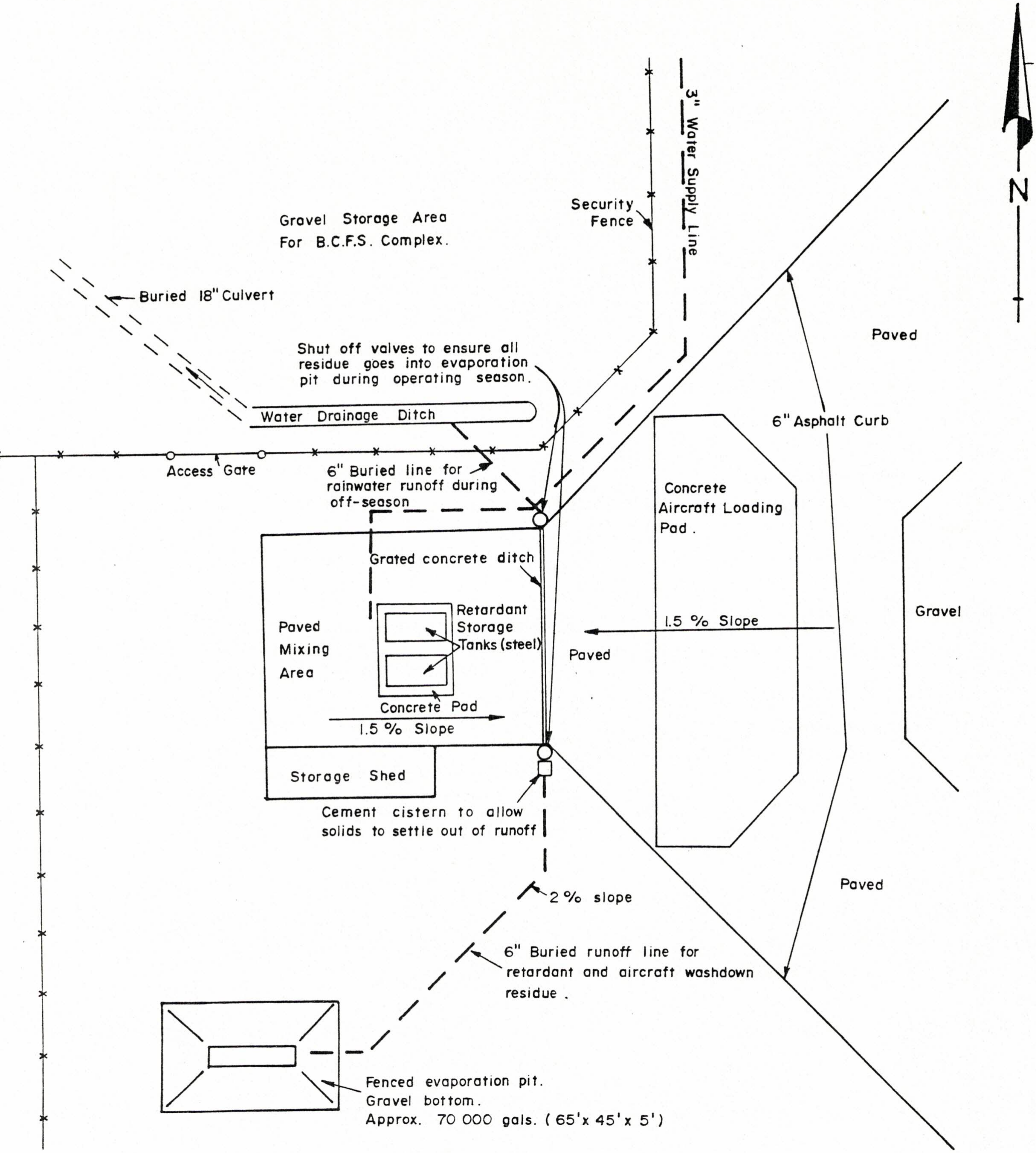

Fig.2 MOF Air Tanker Base

At the start-up of the new facility in June, 1977 the MOF was advised to pump 25.46 m^3 (5600 gal) of red retardant-laden water standing in the clearwater drain ditch into the newly constructed lagoon. It quickly become apparent that evaporation would not sufficiently empty the lagoon and it was lowered periodically by pumping the effluent onto the adjacent fields. Apparently, the lagoon had been constructed about half the volume shown in the PCB application, but was subsequently upgraded by the addition of berms. Eventually a decision was made to pump the excess effluent into a tank truck and spray it on airport fields. The assumption was that the effluent (fertilizer) would be totally taken up by the grass and would not find its way into the lake.

The field at the south end of the runway was shown as the disposal area in the WMB permit issued in 1978. Later reports indicate that the grass infield between the runways was primarily used. The volumes of effluent sprayed onto airport fields are shown in Table 3. The average characteristics of the effluent (1978) were as follows:

Nitrogen, Total	1144 mg/L (1.1 kg/m^3)
Phosphorus	922 mg/L (.9 kg/m^3)
Specific Conductance	8420 umhos/cm

(Specific conductance is a good indicator of the amount of solids dissolved in the water.)

The large phosphorus component of the effluent is apparently a by-product of fertilizer manufacture. The volume of effluent applied to airport fields in 1979, for instance, would have contained approximately 207 kg (456 lbs) nitrogen and 170 kg (375 lbs) of phosphorus.

In approximately 1980, the MOF began using the high phosphorus fire retardants Phos-chek, $(NH_4)_2HPO_4$, (ortho 21-53-0), and Firetrol 931, $(NH_4)_2HPO_4$, (Poly N 10-34-0 liquid fertilizer). Since about 1982 only Firetrol 931 has been used. The ammonium polyphosphate in Firetrol

931 is manufactured primarily for use as a liquid fertilizer because the phosphorus, as well as the nitrogen, is water soluble. The polyphosphorus reverts to highly soluble orthophosphate which is the most readily usable form of phosphorus for plant nutrition. It is also the most serious form of phosphorus in terms of lake pollution (Wetzel, 1975).

TABLE 3
MINISTRY OF FORESTS AIR TANKER BASE EFFLUENT DISCHARGE

Year	Discharge (m^3)	Volume (gals)	Retardant Used	Location of Discharge
1960 to 1977	---	---	---	washed directly into holding pond and drain ditch
1978	50.01	11,000	Firetrol 100 $(NH_4)_2SO_4$ 21-0-0	storage lagoon constructed, effluent sprayed on southwest field and runway fields
1979	188.6	41,500		
1980	not reported		Firetrol 100 and Phoschek $(NH_4)_2HPO_4$ 21-53-0	tanker truck disposal onto runway infield and field south of runway or used by local farmers
1981	used by local farmers			
1982	100.1 m^3	22,020	Firetrol 931 $(NH_4)_2HPO_4$ 10-34-0 liquid fertilizer	
1983 (Apr)	unauthorized discharge, volume unknown			sprayed directly onto southwest field
1983 (rem)	90.92	20,000		tanker truck disposal east of runway
1984	590.85	130,000		
1985	851.03	187,200		

Intensive biological and water quality monitoring of Lake Kathlyn was carried out in 1982 at the request of the Regional District (Boyd, et al. 1984). A comparison of nutrient concentrations in the main inflow streams to the lake again showed high nutrient concentrations in the airport drainage ditches. Not only were nitrogen concentrations elevated, but phosphorus concentrations were 30 times greater than controls and orthophosphate concentrations were nearly 200 times greater than the controls (see Table 4). The extremely high concentration of orthophosphate confirms that the source of the nutrients was the new polyphosphate fire retardant.

TABLE 4

NUTRIENT CONCENTRATIONS IN LAKE KATHLYN INFLOW STREAMS (1982)

Date	Location and Site Number	Nitrogen Total mg/L	Nitrite/ Nitrate mg/L	Phosphorus ug/L	Ortho-Phosphate ug/L
12 May 82	Airport ditch #1131037	2.1	0.68	1,610	1,420
12 May 82	NW inflow #1131035	0.67	L0.02	42	12
12 May 82	NE inflow #1131040	1.16	0.03	89	10
12 May 82	West inflow #1131038	0.48	0.06	26	L3

In April, 1983 there had apparently been a misunderstanding between WMB and MOF personnel and an unauthorized lowering of the lagoon was carried out, with the effluent being sprayed directly onto the field to the southwest of the tanker base. The resultant early green-up of the grass is visible in the photograph on frontispiece. The nutrient concentrations found in the lagoon (Feb/83) prior to the discharge were as follows:

Nitrogen, total	2,521 mg/L (2.5 kg/m^3)
Phosphorus, total	3,440 mg/L (3.4 kg/m^3)
Specific Conductance	14,800 umhos/cm

The effluent contains a much higher phosphorus concentration as the result of the change to a high phosphorus retardant. For example, the volume of effluent discharged in 1982 would have contained 250 kg (551 lbs) nitrogen and 340 kg (750 lbs) phosphorus.

WMB testing subsequent to the unauthorized discharge revealed extraordinarily high nitrogen and phosphorus levels in both the clearwater drain ditch and the southwest field ditch water (Table 5). The lake water near the inflow of the airport ditches contained a correspondingly high nutrient concentration particularly of phosphorus (806 ug/L compared to 19 ug/L in the lake northwest basin). Clearly, an unacceptable amount of nutrients were entering the lake from the tanker base clearwater drain and from land disposal of effluent within the watershed. The MOF air tanker base permit was revised June, 1983 to allow discharge only to the area east of the runway (which slopes toward the Bulkley River). The volumes which have been discharged east of the runway are also shown in Table 3.

TABLE 5
NUTRIENT CONCENTRATIONS IN AIRPORT DITCHES AND LAKE KATHLYN (1983)

Date	Location and Site Number	Nitrogen Total mg/L	Nitrite/ Nitrate mg/L	Phosphorus ug/L
14 Apr 83	Clearwater drain site #3	58.7	18.7	261,000
14 Apr 83	Clearwater drain site #5	1.41	0.49	5,080
14 Apr 83	Terminal road ditch site #6	0.51	L0.02	178
14 Apr 83	SW field site #4	193.36	0.36	24,100
14 Apr 83	SW field ditch site #2	0.53	L0.02	312
14 Apr 83	SW field ditch site #1	1.7	0.04	91
14 Apr 83	Lake Kathlyn site #8	1.49	0.30	806
18 Apr 83	Lake Kathlyn northwest basin	0.37	0.04	19

Water quality monitoring carried out in 1984 and 1985 reveals continued nutrient loading in the tanker base runoff despite the revised land discharge location (east of the runway). Nutrient levels found in the ditch water and in runoff flowing out on to the lake ice are shown in Table 6. Unfortunately, only one water sample was taken in 1985, but it indicates continued nutrient loading in the runoff water from the tanker base.

Several possible paths of nutrient movement from the tanker base into the runoff water are as follows:

1. Incomplete washdown of the tanker loading pad prior to opening the clearwater drain valve. The lagoon may not be of sufficient size to accept large washdown volumes or, for that matter, sudden heavy precipitation onto the loading pad.

2. Seepage from the unlined lagoon into groundwater and thus into the drain ditches.

3. Surface runoff of the effluent discharged onto the airport fields. The discharge of effluent onto the southwest field in April 1983, appears to have caused the exceptionally high nutrient concentrations in the runoff that year.

4. Groundwater movement of the nutrients discharged onto airport fields over many years. The runway infield, for example, was repeatedly used as a disposal site from 1978 to 1982.

5. Leaching of nutrients from sediments previously deposited in the ditches. Soil samples taken from the sides and bottoms of the ditches (1984) were inconclusive, however, except for one extremely high orthophosphate concentration in the bottom of the lower field ditch, site #7 (94 ug/g dry compared to an average of 1.1 ug/g at the other sites).

TABLE 6

NUTRIENT CONCENTRATIONS IN AIRPORT DITCHES (1984-1985)

Date	Location and Site Number	Nitrogen Total mg/L	Nitrite/ Nitrate mg/L	Phosphorus ug/L	Ortho-Phosphate ug/L
8 Feb 84	Clearwater ditch site #5	3.79	0.35	395	
2 Mar 84	"	2.22	0.12	460	176
8 Feb 84	Terminal road ditch site #4	3.13	0.10	1,330	
2 Mar 84	"	2.18	0.06	400	97
8 Feb 84	SW field ditch site #6	1.47	0.10	365	
2 Mar 84	"	3.40	0.04	1,150	288
8 Feb 84	Lower field ditch site #7	2.21	0.21	456	
2 Mar 84	"	2.9	0.10	872	301
6 May 85	"	1.65	0.40	282	219
8 Feb 84	Lake Kathlyn site #1*	1.21	0.07	313	
2 Mar 84	"	1.78	0.02	536	190
8 Feb 84	Lake Kathlyn site #2*	2.34	0.21	545	
2 Mar 84	"	2.91	0.15	759	266
8 Feb 84	Lake Kathlyn site #3*	2.57	0.18	595	
2 Mar 84	"	2.49	0.30	442	55
8 Feb 84	North runway ditch site #8	247.8**	17.8	71	

* runoff water flowing out over lake ice

** high nitrogen, low phosphorus concentrations indicate the presence of urea,— used as a runway de-icing agent

3. LAKE KATHLYN WATER QUALITY

Lake Kathlyn is a shallow water body with a relatively low-flushing rate (0.9/yr), making it especially susceptible to eutrophication caused by anthropogenic nutrient loading. The major complaint received from lakeside residents is that algae blooms with unpleasant tastes and odors have increased over the years. Several residents have described their water supply as smelling and tasting like dead fish (Dec, 1985) and are obtaining their drinking water elsewhere. The nutrient loading from the air tanker base will be discussed mainly in terms of the nuisance algae problem.

3.1 Effect of Air Tanker Base Effluent

Nitrogen, phosphorus and sulphate have been entering Lake Kathlyn in the airport runoff since the start of air tanker fire fighting in the early 1960's. All of these are important nutrients to phytoplankton (free-floating algae) and rooted aquatic plants. However, it has been shown that phosphorus is almost always the limiting nutrient for algal growth in lakes and that removal of the phosphorus loading from the watershed is the most effective way to reverse the trend toward eutrophication and undesirable algae growth (Welch, 1980). The most reactive form of phosphorus for algae nutrition is orthophosphate. Orthophosphate is found in very low concentrations in natural waters and almost always makes up les than 5% of the total phosphorus concentration (Wetzel, 1975).

The average phosphorus concentration in water entering Lake Kathlyn from the air tanker base 1982 - 85 was 927 ug/L. This is almost 200 times that of the other inflows (average 52 ug/L). Orthophosphate made up 86% of the total phosphate in the tanker base effluent tested in May, 1984 (330 mg/L orthophosphate, 384 mg/L phosphorus). The average orthophosphate concentration in the airport ditch water 1984/85 was 216 ug/L or 34% of the total phosphorus (634 ug/L). In other words, the limiting nutrient for algae growth is being added in 200 times normal concentrations and in a biologically very active form.

A detailed analysis of phosphorus loading from septic tanks around Lake Kathlyn was completed by Boyd et al in 1982. An estimated 28 kg/yr enters the lake via septic effluent. The amount estimated entering the lake in an average precipiation year from the airport-tanker base watershed was 250 kg/yr. There are no other major nutrient sources to the lake. Neither the airport grounds or the cultivated field between the airport and the lake have received chemical fertilizers in the past five years.

3.2 Water Quality Criteria for Phosphorus and Algae

The recommended water quality criteria for drinking water for lakes in B.C. is a total phosphorus concentration not exceeding 10 ug/L (at spring overturn). This criteria was established to ensure that algae would not exceed acceptable limits (Nordin, 1985). Algae blooms may occur with phosphorus concentrations as low as 20 ug/L (Follows, 1982). A water quality objective for total phosphorus of 15 ug/L at spring overturn has been recommended for Lake Kathlyn. This concentration would be expected to reduce the mean summer chlorophyll *a* concentration to 4 ug/L, the recommended objective for Lake Kathlyn (Boyd et al, 1984). Phosphorus concentrations in Lake Kathlyn in 1973/74 and 1982-85 are shown in Table 7. The average spring overturn phosphorus concentration from 1982-85 was 24 ug/L.

Chlorophyll *a* is a measurement of phytoplankton productivity. The chlorophyll *a* concentrations varied (1982-85) from a low of 2.6 to a high of 38 ug/L. This extremely high chlorophyll *a* concentration occurred in July, 1983. A large phosphorus discharge is known to have occurred from the tanker base in April, 1983. The high chlorophyll *a* concentration is indicative of the intensity of the blue-green algae bloom which occurred that summer. A lake is generally considered eutrophic with a chlorophyll *a* concentration higher than 5 (Nordin, 1985).

3.3 Nuisance Algae

Phosphorus added to a lake is rapidly incorporated into the planktonic algae. Subsequent increased levels of photosynthesis can continue until the next least abundant major nutrient, nitrogen, becomes limiting. Algae unable to fix nitrogen from the atmosphere are excluded and the blue-green algae with nitrogen-fixing capabilities predominate. Blue-green algae contain gas vacuoles causing them to clump near the surface giving a scummy appearance. Many blue-green algae also produce objectionable tastes and odours and in dense blooms may be toxic. The trend toward predominance of blue-green algae as lake eutrophication increases is the factor most objectionable to the public (Palmer, 1977). Many of the algae genera which are common in Lake Kathlyn recently are considered to be indicators of the eutrophic state of a lake, i.e. Anabaena, Aphanizomenon, Microcystis, Coelosphaerium (Welch, 1980).

The relative concentrations of the five major algal groups sampled in Lake Kathlyn are shown in Figure 3. The percentage of blue-green algae in the Aug. 13, 1973 sample was 6.5%. When next sampled 10 years later, blue-green algae had increased to 61.4% (July 27, 1982) and 98% (July 27, 1983) of the samples. The density of the phytoplankton (cells/ml) appears to have increased, as well. A surface sample taken in 1973 contained 820 cells/ml compared with a surface sample taken July 27, 1983 of 9,343 cells/ml and a sample taken September 12, 1984 of 7,743 cells/ml. (Because different sampling methods were used, it is not possible to compare the densities of all the samples).

Typically there is a seasonal succession of species in the phytoplankton. Usually diatoms dominate in the spring, greens in summer, blue-green algae in late summer and possibly diatoms again in the autumn. However as eutrophication increases there is a tendency for blue-green algae to dominate for a greater part of the season. This trend is observed in the May 6, 1985 sample in which blue-green algae already make up 73.8% of the sample.

Odor and taste characteristics of some of the algae commonly found in Lake Kathlyn are listed in Table 8. In addition to the unpleasant tastes and odors produced by nuisance algae, some may be toxic when in great concentrations. There are many records of acute and often fatal poisoning of livestock where the animals had been drinking from ponds containing dense blue-green algae blooms. Health authorities in Saskatchewan have warned persons against swimming in water containing a bloom of blue-green algae. Contact types of dermatitis and symptoms of hay fever, as well as gastroenteritis have been reported to be caused by blue-green algae (particularly Anabaena and Anacystis) (Palmer, 1977).

4. CONCLUSIONS

The amount of fertilizer effluent applied to the airport fields has probably not exceeded guidelines for intensive agriculture. A similar spray irrigation disposal method is being used at the Dease Lake airport which is far from any watercourses. However, there are numerous examples of lake eutrophication caused by runoff of fertilizer from croplands and even suburban lawns (Wetzel, 1975). Lake Kathlyn is a shallow water body with a low flushing rate and surrounded by residences. In this situation the fire retardant from the MOF air tanker base has contributed an unacceptably high nutrient load to the lake, causing a proliferation of nuisance algae and deterioration of drinking water quality.

5. RECOMMENDATIONS

Since the main movement of nutrients appears to be during spring runoff, it is imperative that containment be undertaken this spring (1986) and continued as long as necessary.

1) Sump pumps should be installed at the start of spring freshet at three sites; the open clearwater drain ditch outside the tanker base fence (site #3-83), the clearwater drain at the first road culvert (site #5-83), and the road culvert at the bottom of the

southwest field. The water should be pumped up and into the airport south runway drain (and thus be diverted towards the Bulkley River) or out of the Lake Kathlyn watershed.

2) Enlarge and line the lagoon with an impervious liner such as hypalon. The sludge at the bottom of the present lagoon and all contaminated soil surrounding it should be removed from the Lake Kathlyn watershed.

3) Complete the diversion of the airport north runway drainage system (begun ten years ago) so that it drains toward the Bulkley River.

4) Monitor the effectiveness of the above containment actions by frequent water quality sampling of remaining runoff water. (It may prove necessary to install sump pumps at the highway culverts also).

5) Install piezometers at three or more sites on the lakeshore (near the three ditches) to monitor water quality of the groundwater entering the lake.

TABLE 7

LAKE KATHLYN MAJOR NUTRIENTS (NORTHWEST BASIN)

Date	Depth m	pH units	Sp. Cond. umhos/cm	Temp °C	Nitrogen Total mg/L	Nitrite/ Nitrate mg/L	Phosphorus Total ug/L	Ortho- Phosphate ug/L	Chlorophyll a ug/L
13 Aug 73	0	7.5	44	19.1	0.24	L0.02	9	L3	
	8	6.6	60	9.6	0.53	L0.02	71	23	
13 May 74	1	7.2	52	7.3	0.46	0.05	22	L3	
	8	7.0	51	6.2	0.47	0.08	26	3	
22 Jul 74	1	7.4	45	17.3	0.11	L0.02	10	L3	
	8	6.6	56	9.8	0.55	0.02	26	7	
11 May 82	1		61	8			25		5.9
	8		62	4.7			19		
22 Jul 82	1				0.25	L0.02	43	4	3
	9				0.65	0.02	66	4	
8 Sep 82	0.5			17	0.32	L0.02	14	L3	M2.6
	10			9.8	1.58	L0.02	337	L3	
18 Apr 83	1	7	58		0.37	0.04	19	4	
27 Jul 83	0 & 2 (avg)				0.27	L0.02	11	5	2.4
	5				0.69	L0.02	34	7	M38
12 Apr 84	0	6.8	61	5	0.43	L0.02	27	L3	M22
18 Jul 84	1	7.8	58	18.6	0.32	L0.02	17	L3	M2.6
	8	7.0	69	11.4	0.72	L0.02	107	34	
12 Sep 84	1	7.2	52	13.8		L0.02	20	L3	7.3
	8	7.1	63	12.3		L0.02	21	L3	
6 May 85	1	7.6	66	7	0.43	L0.02	24	3	M9.3
	9.5	7.3	64	5	0.39	L0.02	32	4	
16 Jul 85	1	7.7	56	19.9	0.31	L0.02	13	L3	
	9	6.6	69	9.7	0.52	L0.02	26	L3	

Fig. 3

Phytoplankton (% of sample) and Chlorophyll a Concentrations in Lake Kathlyn

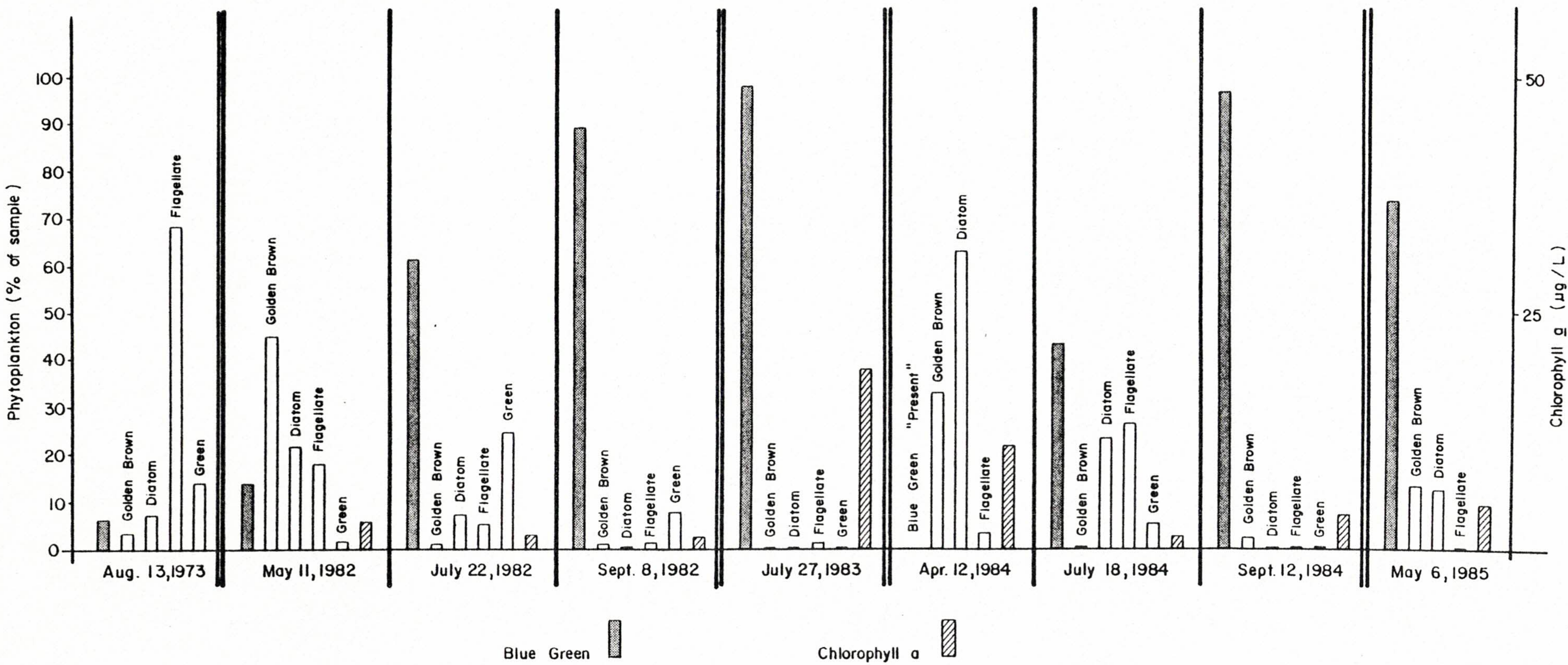

TABLE 8

ODOR AND TASTE CHARACTERISTICS OF SOME ALGAE

COMMONLY FOUND IN LAKE KATHLYN

Algal Genus	Algal Group	Taste and Odor When Algae Concentrations Are: Moderate	Abundant
Anacystis	blue-green	grassy, sweet	septic - toxic
Anabaena	blue-green	grassy, nasturtium, musty	septic - toxic
Aphanizomenon	blue-green	grassy, nasturtium, musty	septic - toxic
Gomphosphaeria	blue-green	grassy, sweet	grassy - toxic
Dinobryon	golden-brown	violet	fishy, slick
Malbmonas	golden-brown	violet	fishy
Synura	golden-brown	cucumber, muskmelon, spicy	fishy, bitter, dry metallic, slick
Asterionella	diatom	geranium, spicy	fishy
Cyclotella	diatom	geranium	fishy
Melosira	diatom	geranium	musty, slick
Tabellaria	diatom	geranium	fishy

(Palmer, 1977)

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