plankton 8
fish C

A REPORT ON MORRIS LAKE AND BOLGER BOG

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Morris Lake is a small round shaped lake on the northern edge of Notre Dame's property in Land O'Lakes, Wisconsin. Water flows northwest into Morris Lake from Ward Lake. Morris Lake then empties out into Tenderfoot Creek. The lake is about seven to eight meters deep with a few deeper spots in the middle. The characteristics of Morris are those of a eutrophic lake. There is a small volume to surface area ratio, a gradual slope into the lake, much vegetation along the shores, a large fish population, and much plankton.

The terrain of the area is level with a forest of mixed hardwoods and conifers surrounding the area. Thick vegetation consisting of bushes and small trees surround the lake. Lily pads extend outward from the shore in several places. There is little sphagnum moss growing at the shore line. The vegetation along the shore is a haven for many Northern Pike. A few Yellow Perch are also found. The abundance of the pike and the large size of the perch make Morris a good fishing lake.

Morris Lake displayed a definite thermocline(figs. 1&2). It had not completely turned over yet. This is further indicated by the presence of H_2S. Both the smell test and the Alka-Seltzer test gave positive results. The latter gave a score of two on a five point maximum scale.

The chemical data on Morris Lake is consistent(fig. 1).

The acidity is fairly high at 150 mg/l. The pH is 6.4. As should be expected the alkalinity is very low, 15 mg/l for the epilimnion and less than 10 mg/l for the hypolimnionl The reason the Morris lake has such a low alkalinity is that the bedrock of the region is granite, not limestone. Limestone provides a large buffering capacity to lakes. Without this buffering capacity, the lakes of the area have become more acidic than basic.

The hardness of Morris is also low. Calcium and magnesium ions are most commonly present in the form of bicarbonates. Such bicarbonates either do not exist in large amounts, or are neutralized, as indicated bythe low alkalinity and high acidity.

The specific conductance of Morris Lake does not seem to agree with the rest of the data. It is a little high, especially in the hypolimnion. W. Einsele found that ferrous iron and phosphorous can combine in thehypolimnion of eutrophic lakes to form an insoluble ferric phosphate.[1] This ferric phosphate is precipitated at times when oxygen in introduced. Morris has a very large thermocline which indicates that some stirring of the epilimnion and hypolimnion has occurred. This would introduce oxygen into the hypolimnion and set off the reaction mentioned. ∴ ↓ cond. This would explain the large specific conductance in the lake, the larger specific conductance in the hypolimnion than in the epilimnion, and the larger amount of total phosphorous in the hypolimnion thar in the epilimnion.

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[1]Franz Ruttner, Fundamentals of Limnology (Toronto: Univ. of Toronto Press, 1975),p.91

The partial turnover of the thermocline would also affect the nitrogen cycle of the lake. Ammonia is the chief product from the decomposition that occurs in the hypolimnion. As soon as oxygen is introduced, nitrifying bacteria convert the ammonia into nitrate. This is percolated through the soil into the water. This would in part explain the larger amount of nitrate nitrogen in the hypolimnion than in the epilimnion.

The increase of nitrogen and phosphorous in the hypolimnion than in the epilimnion is also due to the amount of flora and fauna. The nitrogen and phosphorous are taken up by the phytoplankton, some zooplankton, and the macrophytes of the epilimnion. Since light does not penetrate as deep as the hypolimnion, and since it is a largely anaerobic zone, such life does not exist there.

The color reading for the hypolimnion is much higher than for the epilimnion. This is due to a larger amount of silt, humus, and metal ions in the hypolimnion than in the epilimnion. The color reading is not greatly affected by centrifugation, however. The true color is not significantly less than the apparent color. The lake must also contain soluble ions, humic acids, and particles which are not greatly affected by centrifugation.

The Secchi disk reading for Morris was 1.15 meters. It was taken under windy, rainy conditions. The light penetration of the lake is at least 2.5 meters, then. As a direct result of the light penetration, there are several green algae in the lake. These photosynthesizing microphyta are dependent on the light før energy production. In return, they form the basis for the food chain in the lake. Other microphyta include blue-green algae, dinoflagellates, and diatoms. These phytoplankton are the primary producers of the lake. They make up the first trophic level of the biomass pyramid.[2] The most abundant genera of microphyta during the day are Dinobryon, Tabellaria, and Asterionella(data sheet 1). Other genera found were Oscillatoria, Scenedesmus, Gonium, and Ceratium. The most abundant genera at night are also Dinobryon, Tabellaria, and Asterionella(data sheet 2). Other genera found were Spirogyra, Ceratium, Navicula, and Synedra.

The amount of phytoplankton at the surface at night is greater than during the day. If light is too strong, it can have an inhibiting effect on the plankton. Also, photosynthetic microphytes migrate to the surface at night for the process of dark photosynthesis. The air-water interface is where the greatest oxygen supply is present in the water.

The primary consumers of the lake are the zooplankton. They make up the second trophic level.[3] The most abundant zooplankton during the day were the genera Keratella and Asplanchna of the Rotifera family(data sheet 3). There were more Keratella than Asplanchna since Keratella are a source of food for Asplanchna. Asplanchna could be considered a secondary consumer but is still a part of the second trophic level. Also found in the Rotifer family was an Asplanchnopus. The only other zooplankton present were members of the family Copepoda. These included the genera

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[2] W. D. Russell-Hunter, Aquatic Productivity (New York: MacMillan Publishing Co., Inc., 1970),p.24

[3] Ibid.

Eucylclops, Paracyclops, and Ectocyclops.

The amount of Copepoda remained unchanged in the night sample (data sheet 4). A Daphnia was also found at night. A marked contrast occurred within the Rotifer family. A sudden increase in the amount of Keratella and especially Asplanchnopus occurred. With the increase in phytoplankton at night, and being grazing animals, this increase is to be expected. Also, it is safer to feed at night. The predatory Asplanchna is less of a threat in the dark of night.

Bolger Bog is a very large kettle bog on the eastern side of Notre Dame's property. Unlike Morris Lake, Bolger Bog is a seepage body of water. It has no streams flowing into or out of it. It lies in the bottom of a valley of mostly coniferous trees. A large Sphagnum mat extends three to six meters from the shore. It is a quaking bog. On the bog mat are several specimens of pitcher plants, sundew, Labrador tea, leather leaf, bog cranberry, and tamarack pine. On the shore are several spruce and fir trees. The only large fish in Bolger are suckers and shiners. Several small species of fish that live under the bog mat include Mud Minnows, Bluntnose Minnows, Northern Red Belly Dace, and Brook Stickleback.

Although only four meters deep, Bolger displays a clear thermocline(figs. 1 & 2). Like Morris Lake, Bolger Bog has not turned over. Although H_2S was smelt, the Alka-Seltzer test was negative. This is due to the oxidation of the sample before it was tested.

The chemical data of Bolger is also consistent. The acidity is high at 160-170 mg/l while the pH is 5.4. Bolger is far more acidic than Morris. This is due to the large amount of decaying matter that releases humic acids. The decomposition also releases CO_2 which decreases the pH.[4] Bogs are unique in that they often contain sulphur bacteria that can produce traces of free H_2SO_4. The sphagnum moss is specially adapted to bog existence. The membrane of sphagnum is capable of adsorbing bases, such as calcium ions, from dissolved salts.[5] Free acids are then released into the water. This acts as a buffer for the plant as well as releasing more acid into the environment.

As a result the alkalinity is low. This is also due to the lack of any buffering capacity because of the granite bedrock. Likewise the hardness is low. As in Morris Lake, the calcium is greater than the magnesium. This is common in most lakes. Some lakes in northeastern Wisconsin, however, have a higher magnesium content than calcium.[6] This is due to a layer of magnesium limestone in the drainage basin. This does not apply to the Land O'Lakes region where the bedrock is all granite.

Just like Morris, Bolger has a high specific conductance. The specific conductance is especially higher in the hypolimnion than in the epilimnion. When CO_2 containing water comes in contact with ferrous iron, a ferrous bicarbonate results and goes into solution.[7] These conditions exist in the hypolimnion of Bolger where no oxygen is present. This would explain the greater alkalinity and specific conductance of the hypolimnion

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[4] Ruttner, p.223

[5] Ibid., p.224

[6] G. Evelyn Hutchinson, A Treatise on Limnology (New York: John Wiley and Sons, Inc., 1975),vol. I, no. 2, p.556

[7] Ruttner, p.83

than of the epilimnion. Formation of such ferrous bicarbonates is also favored by the presence of decaying humus. Decomposing organic matter is effective in reducing the ferric form of iron to the ferrous form. A low pH also promotes the formation of ferrous bicarbonates. At a lower pH, the absence of oxygen is less critical for the solubility of the ferrous compound. At a higher pH, the presence of oxygen is more likely to precipitate out the iron in a ferric form. Morris Lake, with a pH of 6.4 is at the threshold of the critical pH value of 6.5.[8] Bolger Bog at 5.4, is well within the critical pH range.

Another important difference between the two bodies of water is their drainage system. Water flows through Morris. Any soluble metals in Morris likewise flow through. Bolger Bog has no drainage system. Being at the bottom of a coniferous valley, it accumulates all that enter into it. Any metal particles from the atmosphere or the floor of the forest are reduced by the humic content of the lake and gradually become incorporated as insoluble compounds.

The amount of nitrate nitrogen in the hypolimnion is greater than in the epilimnion in Bolger as in Morris. In Morris this could be explained by the partial turnover of the thermocline. This is not the case in Bolger. There is a sudden, sharp thermocline, that indicates no mixing at all between the epilimnion and the hypolimnion. No oxygen can penetrate the hypolimnion. Ammonia released from the decaying organisms at the bottom is oxidized into nitrate. Without oxygen in the hypolimnion, there should be very little nitrate, if any at all. If a turnover had

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[8] Ibid., p.84

occurred, the results would be consistent. However, the presence of a hydrogen sulfide smell, and the bog's location in the bottom of a sheltered valley, seem to preclude the possibility of a turnover. The only other explaination is that oxidized nitrates are washed into the bog from the coniferous forest and the atmosphere. These nitrates are then trapped in the hypolimnion or assimilated in the epilimnion by the zooplankton, phytoplankton, and macrophytes. This would explain the lower nitrate content in the epilimnion than the hypolimnion.

If Bolger has so much iron in it, than like Morris, the ferrous forms should react with the phosphorous in the lake to form the insoluble ferric phosphorous compounds in the hypolimnion. This does not appear to happen however. The total phosphorous content of the epilimnion is greater than the hypolimnion of Bolger. No oxygen mixed with the hypolimnion to oxidize the ferrous form of iron into the ferric compound of phosphate.

The color of Bolger is much darker than Morris. Since Bolger is a seepage body of water and is sheltered from winds, it is less likely that its color is due to turbidity. Since centrifugation settles out metals, phytoplankton, and silt and humus particles, the cause of Bolger's color can be determined. The difference between the apparent and true color is quite large in the hypolimnion. This would suggest that much of the color could be due to the humic matter on the bottom of the bog. If Bolger has a higher metal, specifically iron, content in its hypolimnion than Morris, then the difference between apparent and true color should be greater in Bolger than in Morris. The results confirm this idea. The larger difference is due to the metal ions in Bolger settling out during centrifugation.

That Bolger has a greater metal content is also shown by the greater specific conductance in Bolger's hypolimnion than in Morris'. Bolger also has greater amounts of calcium and magnesium ions than Morris. Bolger has less phosphorous than Morris so the color difference in Bolger is less dependent on the amount of microphytes. This is also seen by the few microphytes that exist in Bolger.

The Secchi disk reading on Bolger Bog was 0.75 meters. It was taken on a sunny, windless day. The reading, then, is a good indication of the light penetration of the bog. The light penetration is 1.5 meters deep. This is deep for a body of water only four meters deep. There was much Dinobryon found in the daytime sample(data sheet 5). More than in Morris. Nitrogen and phosphorous are limiting nutrients. The amount of epilimnion phosphorous is comparable between the two bodies of water. Bolger, however had seven times as much nitrate in its epilimnion. This could account for the increased amount of Dinobryon. Also found during the day were some Anacystis and Ceratium.

At night, the amount of Dinobryon decreased as did the total amount of phytoplankton(data sheet 6). Normally, less phytoplankton would be expected during the day. With such a high color as Bolger has, the effects of light inhibition are minimal if existent at all. Another explation lies in the fact that two different people analyzed the results. The differences in sampling, experience, proficiency, or counting procedure could account for the results. For example, one person might have made exact counts while the other only made rough estimates. The only other phytoplankton found in the night sample was a Ceratium and an Asterionella.

The most common zooplankton found in the day sample were Keratella(data sheet 7). As in Morris, the predatory Asplanchna was also found in relatively less numbers. The only other zooplankton found was a specimen of Diaptomus. A very similar amount of Keratella and Asplanchna were found in the night sample (data sheet 8). In addition, many members of the Copepoda family were found. If not for the distinct drop in the amount of phytoplankton, this would be expected. It is possible that there is nannoplankton present that was not caught in the Wisconsin net. The nannoplankton would provide food for the zooplankton. This would explain the sudden appearance of Cyclops, Senecella, and Canthocampus. Also, since these are members of the second trophic level, they could be escaping members of the third trophic level by feeding at night.

Like Morris Lake, Bolger Bog has many of the characteristics of a eutrophic lake. It has a high surface to volume ratio, a rich accumulation of decaying organisms, and a thermocline with an anaerobic hypolimnion. Bolger Bog even looks like a lake. Bolger Bog appears to be one step beyond a lake. It is a dystrophic body of water. Characteristically it has brown colored water, a high concentration of acidic organic materials, deposits of unrotted vegetation on the bottom, a comparatively small amount of zooplankton and phytoplankton, and no large populations of big fish. The only large fish are suckers and shiners. The rest are small grazing fish that are members of the second or third trophic level. While the pike in Morris represented the fifth and final trophic level of the lake, the suckers of Bolger can at best be considered in the fourth trophic level.

The few Yellow Perch in Morris average nine to thirteen inches in length. With so many predatory Northern Pike in the lake, few perch survive. Those that do survive beyond a certain length are too big to be preyed upon. Thus, the only perch in Morris are large ones.

The pike of Morris average seventeen to twentythree inches and are five to six years old. Pike at that age are usually much larger. Since there are plenty of nutrients in the lake, something else must be stunting their growth. The lake is clearly overpopulated with pike. This has also resulted in reduced weights. Scale examinations show very small growth patterns for the first four to five years. Low weights and slow growth have resulted from overcrowding and intense competition for food. The fifth and sixth year markings on the fish are larger. This indicates better living conditions in the past few years, most likely less overcrowding. The "catch it and keep it" practice of fishing should probably be continued for only a few more years. Eventually the lake will be able to return to a natural ecological balance. Even if Morris is to remain a good fishing lake, this practice should continue. It will give the pike a chance to grow beyond the legal limit and make the fishing more competitive.

Except for the few shiners and suckers, Bolger Bog is of no use as a fishing spot. It should be allowed to continue its evolutionary process without the interference of man, Scientific studies, however, should be continued since Bolger presents such a unique educational opportunity.

Figure 1

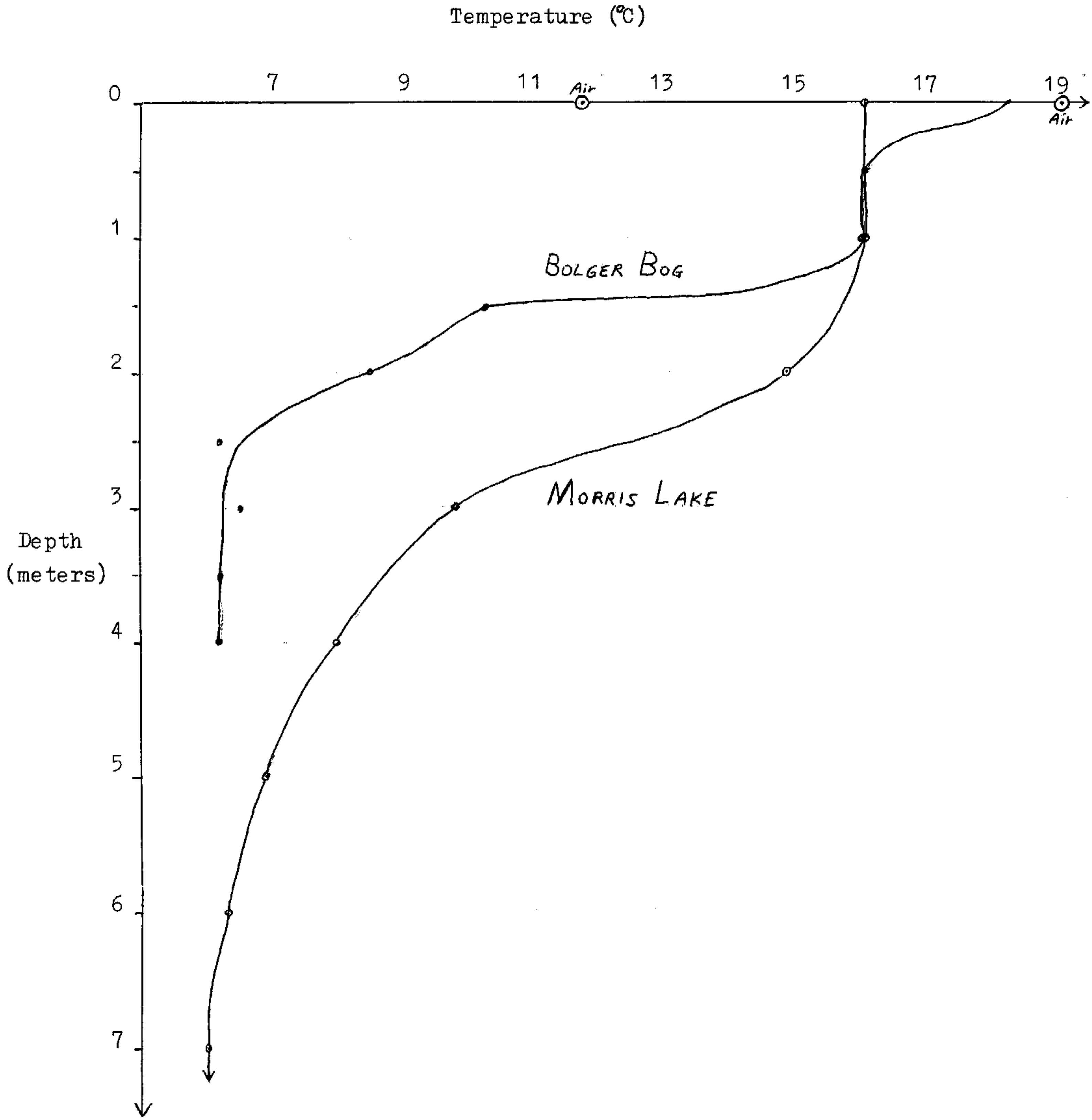
Temperature (°C)
7
9
11
13
15
17
19
Air
Air
0
1
2
3
4
5
6
7
Depth (meters)
Bolger Bog
Morris Lake

Figure 2

Depth (meters)	Temperature (°C)	
	Morris	Bolger
Air	11.7	19.0
Surface	16.0	18.2
0.5	---	16.0
1.0	16.0	16.0
1.5	---	10.2
2.0	14.8	8.5
2.5	---	6.2
3.0	9.8	6.5
3.5	---	6.2
4.0	8.0	bottom
5.0	6.9	
6.0	6.3	
7.0	6.0	

Figure 3

TEST	Morris Lake EPI.	Morris Lake HYPO.	Bolger Bog EPI.	Bolger Bog HYPO.
Acidity				
Methyl	0.0 mg/l	0.0 mg/l	0.0mg/l	0.0 mg/l
Phenophthalein	150 mg/l	150 mg/l	170 mg/l	160 mg/l
Alkalinity	15 mg/l	10 mg/l	10 mg/l	55 mg/l
Color				
Apparent	120.0	275.5	255.0	315.0
True	110.0	255.0	323.5	177.5
Specific Conductance	93 μmhos/cm	115 μmhos/cm	44 μmhos/cm	132 μmhos/cm
Hardness				
Calcium	30.0 mg/l	32.5 mg/l	13.0 mg/l	43.0 mg/l
Magnesium	13.0 mg/l	17.5 mg/l	9.0 mg/l	20.0 mg/l
Total	43.0 mg/l	50.0 mg/l	22.0 mg/l	63.0 mg/l
Nitrate Nitrogen	.10 mg/l .44 mg/l	.60 mg/l .50 mg/l	.70 mg/l	1.30 mg/l
Total Phosphate	.55 mg/l .50 mg/l	.94 mg/l .80 mg/l	.48 mg/l	.30 mg/l
pH	6.4		5.4	
Secchi Disk	1.15 meters		0.75 meters	
H_2S	positive (2)		positive (0)	

Data Sheet 1

PHYTOPLANKTON COUNT DATA

Sample No. Morris Lake A.M. Date Analyzed 6/14-15/79

Analyzed By B. Bret Volume Filtered ______ ML

ORGANISM		TALLY	C/ML	TOTALS
Total coccoid blue-green algae per ml.				
Oscillatoria		/		
Total filamentous blue-green algae				
Total coccoid green algae				
Total filamentous green algae				
Dinobryon		~~////~~ //		
Scenedesmus		/		
Gonium		/		
Total green flagellates				
Ceratium		/		
Total other pigmented flagellates				

Centrics		c/ml

Pennates		c/ml

Diatoms

	Centric	Melos.	Other	c/ml
Shells				
Live				
Total live centric				
Pennate shells				
Live Pennates				
Total live pennate				
TOTAL LIVE ALGAE (c/ml)				

-OVER-

Data Sheet 2

PHYTOPLANKTON COUNT DATA

Sample No. Morris Lake P.M. Date Analyzed 6/14

Analyzed By B. Bret Volume Filtered ______ ML

ORGANISM		TALLY	C/ML	TOTALS
Total coccoid blue-green algae per ml.				
Total filamentous blue-green algae				
Total coccoid green algae				
Spirogyra		/		
Total filamentous green algae				
Dinobryon		~~卌~~ ~~卌~~ //		
Total green flagellates				
Certium		//		
Total other pigmented flagellates				

Centrics		c/ml

Pennates		c/ml

Diatoms

	Centric	Melos.	Other	c/ml
Shells				
Live				
Total live centric				
Pennate shells				
Live Pennates				
Total live pennate				
TOTAL LIVE ALGAE (c/ml)				

- OVER -

Data Sheet 3

ZOOPLANKTON COUNT DATA

Sample No. Morris Lake A.M. Date Analyzed 6/14-15/79

Analyzed by B. Bret Sample Volume ____ ML

ORGANISM	TALLY	C/LITER
Rotifera		
Keratella	~~||||~~ ~~||||~~ |||	
Brachionus		
Polyarthra		
Synchaeta		
Trichocera		
Asplanchna	~~||||~~ ~~||||~~	
Asplanchnopus	|	

Total Rotifers per liter ____

Cladocera		
Bosmina		
Daphnia		
Moina		
Ceriodaphnia		

Copepoda		
Nauplii		
Cyclops & related genera Eucyclops, Paracyclops Ectocyclops	~~||||~~ ~~||||~~ ~~||||~~	
Diaptomus		

Total Crustacea per liter ____

Nematodes (per liter)	
Other Invertebrates (per liter)	

Data Sheet 4

ZOOPLANKTON COUNT DATA

Sample No. *Morris Lake PM* Date Analyzed *6/14*

Analyzed by *B. Bird* Sample Volume ______ ML

ORGANISM	TALLY	C/LITER
Rotifera		
Keratella	*卌 卌 卌 III*	
Brachionus		
Polyarthra		
Synchaeta		
Trichocera		
Asplanchnopus	*卌 卌 卌*	
Asplanchna	*卌*	

Total Rotifers per liter ______

Cladocera		
Bosmina		
Daphnia	*/*	
Moina		
Ceriodaphnia		

Copepoda		
Nauplii		
Cyclops & related genera	*卌 卌 卌*	
Diaptomus		

Total Crustacea per liter ______

Nematodes (per liter)	
Other Invertebrates (per liter)	

Data Sheet 5

PHYTOPLANKTON COUNT DATA

Sample No. Bolger Bog AM   Date Analyzed 6/14/79

Analyzed By SKolber   Volume Filtered ______ ML

ORGANISM		TALLY	C/ML	TOTALS
Anacystis		////		
Total coccoid blue-green algae per ml.				
Total filamentous blue-green algae				
Total coccoid green algae				
Total filamentous green algae				
Dinobryon		~~////~~ ~~////~~ ~~////~~ ~~////~~ ~~////~~ /		
Total green flagellates				
Ceratium		//		
Total other pigmented flagellates				

Centrics		c/ml
Pennates		**c/ml**

Diatoms

	Centric	Melos.	Other	c/ml
Shells				
Live				
Total live centric				
Pennate shells				
Live Pennates				
Total live pennate				
TOTAL LIVE ALGAE (c/ml)				

Data Sheet 6

PHYTOPLANKTON COUNT DATA

Sample No. Bolger Bog P.M. Date Analyzed 5/14/79

Analyzed By R Richards Volume Filtered ______ ML

ORGANISM		TALLY	C/ML	TOTALS
Total coccoid blue-green algae per ml.				
Total filamentous blue-green algae				
Total coccoid green algae				
Total filamentous green algae				
Dinobryon		~~||||~~ ||||		
Ceratium		/		
Total green flagellates				
Total other pigmented flagellates				

Centrics		c/ml

Pennates		c/ml

Diatoms

	Centric Melos.	Other	c/ml
Shells			
Live			

Total live centric

Pennate shells

Live Pennates

Total live pennate

TOTAL LIVE ALGAE (c/ml)

Data Sheet 7

ZOOPLANKTON COUNT DATA

Sample No. Bolger Bay AM Date Analyzed 6/14/79

Analyzed by S Kolber Sample Volume ______ ML

ORGANISM	TALLY	C/LITER
Rotifera		
Keratella	𝍸 /	
Brachionus		
Polyarthra		
Synchaeta		
Trichocera		
Asplanchna	/	

Total Rotifers per liter

Cladocera		
Bosmina		
Daphnia		
Moina		
Ceriodaphnia		

Copepoda		
Nauplii		
Cyclops & related genera		
Diaptomus	/	

Total Crustacea per liter

Nematodes (per liter)	
Other Invertebrates (per liter)	

Data Sheet 8

ZOOPLANKTON COUNT DATA

Sample No. Bolger Bog PM Date Analyzed 6/14/79

Analyzed by R.Richards Sample Volume ______ ML

ORGANISM	TALLY	C/LITER
Rotifera		
Keratella	𝍸	
Brachionus		
Polyarthra		
Synchaeta		
Trichocera		
Asplanchna	/	

Total Rotifers per liter

Cladocera		
Bosmina		
Daphnia		
Moina		
Ceriodaphnia		

Copepoda		
Nauplii		
Cyclops & related genera	𝍸 //	
Diaptomus		
Senecella (calanoides)	𝍸 ////	
Canthocampus	///	

Total Crustacea per liter

Nematodes (per liter)	
Other Invertebrates (per liter)	

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