Water Chemical Confines of *Odonata*

(Dragonflies and Damselflies)

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Abstract

Water quality has long been tested to find correlations between the organisms found there and the characteristics of the site. Water characteristic tests such as conductivity, surface oxygen, surface temperature, alkalinity and the like have been used to find parameters for indicator organisms like Odonata (Dragonflies and Damselflies). These organisms can give valuable information to aquatic ecologists about the quality of the waters and surrounding environment in which they were found. In this experiment, collections of Odonata larvae and adults from ten different sites on the U.N.D.E.R.C. property, in Northern Wisconsin and the Upper Peninsula of Michigan, were made during the beginning of June and the beginning of July 1997. A battery of water chemistry tests were also run on the sites to determine the characteristics of each site. From the data collected, correlations between the water characteristics and Odonate larvae, and parameters in which the larvae could be found, were set .

Two organisms highly associated with water quality are the dragonflies and the damselflies. These two types of insects belong to the order Odonata. Odonata are one of the few groups of aquatic insects in which non-specific, or common, names have been liberally applied to species (McCafferty, 1981). Most names are based either on characteristics of the adults, or transliterations of the Latinized scientific names. The common name for all insects of the order Odonata is *dragonfly* (Ward and Whipple 1959). The French word demoiselle, from which *damselfly* may have originated, also applies to all Odonata. Both types of insects are characterized by two pairs of elongate, multi-veined wings which do not lie flat against the body. In the sub-order *Zygoptera,* the wings are held together and above the body, while in the sub-order *Anisoptera,* the wings are held outstretched from the body. Insects of the order Odonata mate for life and are often seen flying in tandem (mating position) with the male on top holding onto the back of the female's head. Eggs are deposited into water or onto floating vegetation and

will hatch only when in the presence of water (Merritt and Cummins 1978). The duration of the larval development is highly dependent on both water temperature and food availability. The predatory larvae, called nymphs, crawl along the bottom of ponds and streams capturing minute creatures by means of a long protrusible underlip. Dragonfly nymphs respire through a rectal chamber which pumps water in and out as though they were jet propelled (Lehmkuhl, 1979). Damselfly nymphs respire by means of three leaf-like gills which protrude from the posterior end of their body. These gills also serve as undulatory organs to provide movement for the nymphs.

Dragonflies are about 1 to 3 ½ inches long and have large, stout, membranous wings. These wings are constantly held out from the body - even during times of rest (Hausman, 1950). Their speed and agility when flying excels even that of swallows and hawks as they capture their prey while in flight. Adult damselflies are about the same length as dragonflies though they are more slender and delicate than dragonflies. They have thin gauzy wings which can be folded back, but are still held above the body when the insect is not in flight (Hausman, 1950). Damselflies are more colorful, graceful, and flitting than dragonflies, hence their name. Both types of flies are found along margins of ponds and streams in which their nymphs dwell.

Members of this Order have long been used as an "Indicator Species;" meaning their larvae are usually only found in areas with specialized water characteristics. In order to determine these parameters, a number of sites with varying qualities must be sampled. This experiment sampled ten sites of differing water qualities for Odonata. These parameters, set by the water characteristics, provide valuable information which can then be used to determine the specific ranges in which the Odonata genera of Northern Wisconsin and Michigan are found in their natural environment.

I will be noting the associations between the organisms in these specific areas. The organisms I will be studying are the dragonflies and damselflies. It is my null hypothesis that there will not be variances in the species and numbers of dragonflies and damselflies found in the different lake and stream sites due to specialized water quality and environment.

Materials and Methods

To allow for a continuation of a previous study, ten different lake and streams were chosen and sampled for the presence of Odonata. The sites included Bay Lake, Bergner Lake, Brown Creek (pool area), Kickapoo Lake, Mullahy Lake, Nansen Lake, Raspberry Lake, Tenderfoot Lake, Tenderfoot Creek (riffle area), and Ward lake. All of the sites were located on the University of Notre Dame Environmental Research Center property - situated on the boarder of Wisconsin and the Upper Peninsula of Michigan. Each site varied in size, depth, temperature, oxygen concentration, surrounding vegetation, acidity, alkalinity, color, light and conductivity.

Water Chemistry Tests

The first part of this project involved characterizing every site by means of a battery of water chemistry tests. The eight tests run on each site included temperature and oxygen profiles, pH, conductivity, light, color, alkalinity and sulfide. The tests were carried out, and water samples were collected, using a boat or raft in the deepest part of the site. A meter was used to measure temperature, oxygen, pH and conductivity. Light was measured using a Secchi Disc. Water samples were recovered at one half the Secchi depth and just below the surface by means of a VanDorn Sampler. These water samples were collected in clean glass jars, labeled,

immediately refrigerated and processed for color, alkalinity, and sulfide within 12 hours. Tests for color, alkalinity, and sulfide were run according to the HACH protocols found in the HACH Water Analysis Handbook. Each site was tested twice - once during each of the two sampling periods (beginning of June and beginning of July).

Each of the tests were used to check for the presence of a certain water characteristic. The conductivity test was used to gauge the flow of electrons in the water. The electron flow increased as the temperature of the water increased. Since conductance is the reciprocal of resistance, the higher the amount of electrons in the water, the greater the resistance and therefore, the lower the conductance. The hydrogen sulfide (H_2S) test gauged the amount of hydrogen sulfide in the water. If no reduction of sulfate to sulfide was noted, one could be sure that the redox potential was > .1 volt, and anaerobic conditions were not occurring. The dissolved oxygen tested for the amount and distribution of O_2 within the water column. Four types of O_2 versus depth curves could be seen from the results of this test: orthograde, clinograde, positive heterograde and negative heterograde. Orthograde curves are nearly straight due to uniform distribution of oxygen during the spring turnover. Clinograde curves are vertical due to the extreme drain of oxygen, by dead and dying organic matter, in the hypolimnion waters which occurs during summer stratification. Positive heterograde curves show a maximum amount of oxygen within the thermocline due to low turbulence and oxygen produced by photosynthesis exceeding that used in respiration. Negative heterograde curves show a minimum amount of oxygen within the thermocline due to increased respiration by excessive amounts of migrating animals, and water masses with low oxygen concentrations becoming interpositioned between layers of well oxygenated water (Cole 1975). The Secchi Disc depths reflected the depth of light

penetration. Color was determined using the Forel-Ule scale of colors which tested for the amounts of suspended organic material in the water. Sites with high amounts of suspended materials indicated good areas to find Odonata larvae due to increased nutrients and sediment - both conditions necessary for proper larval development. As stated by Cole in 1975, the amounts of suspended organic materials also affected the light intensities which provoked certain swimming patterns for migrating animals that possibly served as food sources for Odonate larvae. The surface temperature was measured to be sure the sites had stratified and the top meter of water was warming due to the sun's light and heat. The pH was measured to determine the hydrogen-ion concentration within the water. This number determined limits for pollution, and which type of organisms could grow most efficiently in this environment. The alkalinity of the water was measured by the amounts of bicarbonates, formed from carbon dioxide molecules, found in the water and how they moved in and out of solution.

Insect Sampling

The second part of the project consisted of sampling the sites for Odonata. The littoral zone of each site was sampled for 2 hours (first collection period) and 1.5 hours (second collection period) using dip nets, kick nets, and mesh nets. Depending on the state of the edges of the site, sampling was done either by foot or from a boat or raft. Waders were used if the perimeter was solid enough; otherwise, boats or inflatable rafts were employed. Depending on the size of each site and littoral zone, different types of substrate were also sampled. Larger lakes has less littoral zone sampled while smaller lakes had more littoral zone sampled. Every Odonata nymph collected was placed in a labeled glass jar containing 85% ethanol. Adult Odonata were caught in mesh nets then placed in plastic baggies with wings flattened and flight

muscles broken. These were labeled and frozen until pinned and dried. The sites were sampled twice with each collection period lasting three or four days. This was to ensure similar species would be found in the same stages of their life cycles.

Identification of Insects

The final part of the project was to identify the collected insects. Dissecting microscopes and various keys (Needham and Westfall, Hilsenhoff) were used to identify specimens to the genus level (nymphs) and species level (adults). After identification the nymphs were placed in separate, numbered vials containing 85% ethanol and a label stating the site, date it was found, and name of the organism. The identified adults were placed in dry-boxes with numbered labels stating the site, date it was found, and name of the organism.

Results

The parameters for the ten sites were laid out as seen by the results of the water chemistry tests shown in Table 1. All the sites were found to be within the neutral range - +/- 1 of pH 7.0. Bergner Lake was the most acidic at 6.0, and Nansen Lake registered as the most basic site at 8.0. Conductivity varied greatly among the ten sites. Tenderfoot Lake was the least conductive at 7.9 mhos while Ward Lake was the most conductive at 144.5 mhos. The Secchi depths had a brief range which varied from 1.30m in Mullahy Lake to 3.70m in Bay Lake. Despite such a short range in Secchi depths, the color varied greatly among the sites. Bay Lake was the clearest with only 13.50PtCo and Nansen Lake was the darkest at 137.50PtCo - this data coincided with the Secchi depth readings. Alkalinity was detected only during the second sampling period, and only

in seven of the sites. The sites which gave readings were all of rather low alkalinity with Nansen Lake the least alkaline at 10.5mEq/L and Ward Lake the most alkaline at 58.0mEq/L. The surface temperatures steadily increased as the summer progressed with the first sampling period having readings between 19.0 ^{0}C and 23.0 ^{O}C, and the second sampling period giving warmer temperatures between 23.5 ^{0}Cand 29.5 ^{O}C. The surface O_2 varied between 4.60mg/L and 10.50mg/L. The average water chemistry measurements are all shown in Table 2. The oxygen and temperature readings for each site are shown in Appendixes I-X.

Odonata were found and recovered from all ten sites. During the first sampling period, the Families collected included: Aeshnidae, Calopterygidae, Corduliidae, Gomphidae, Libellulidae, Coenagrionidae and Lestidae. The distribution of the species in the collection is shown in Table 3. The most abundant, and diverse, site was Ward Lake with 100 insects, in 17 species, collected from 12 different genera. The another diverse site was Nansen Lake with 49 insects, in 16 species, from 14 genera. Raspberry Lake was also rather diverse with 13 genera and 43 insects recovered, in 17 species. Bergner and Mullahy Lakes both contributed 11 genera from 29 and 89 insects, in 14 and 17 species, respectively. Kickapoo Lake gave 7 genera from 28 insects, in10 species. Bay and Tenderfoot Lakes both recovered 6 genera from 16 and 12 insects, in 7 and 8 species, respectively. One of the least diverse sites was Tenderfoot Creek which only recovered 16 insects, in 6 species, from 5 genera. The least diverse site was Brown Creek which, while it resulted in 7 genera in 8 species, only 16 insects were recovered.

The Macromiidae were only found during the second sampling period, along with all the previously mentioned families from the first sampling period. The difference in the distribution of the insects between the first and second sampling periods can be seen in Tables 4 and 5.

Adult Odonata were recovered during both sampling periods from every site except Bergner Lake. The majority of the insects were collected from Tenderfoot Lake during the second sampling period. The distribution and species of these Odonata are shown in Table 6.

Discussion

With regards to the species of Odonata found, a few notable trends were seen from the results of the water chemistry tests. These trends were seen in the Calopterygidae, Gomphidae, Lestidae and Macromiidae Families. The insects of the Calopterygidae Family were found only in brown Creek. In addition, mostly *Zygoptera* larvae were recovered from Brown Creek. An explanation for this trend would be centered around the amounts of O_2 also found in Brown Creek's waters. *Zygoptera* are often found in sites with lower oxygen amounts due to the presence of caudal lamellae which enable greater respiration. *Anisoptera* larvae do not have caudal lamellae and, therefore, cannot respire as well in waters with low oxygen concentrations. The Calopterygidae were also selective for sites less than 50 acres and water temperatures of 23^0C (Tables 8 and 16).

The Gomphidae Family was selective for sites with brief surface oxygen ranges (6.6mg/L - 9.35mg/l) and surface temperature ranges (22.5^0C - 24.85^0C). Despite these specialized parameters, the Gomphidae larvae were found in Brown Creek, Tenderfoot Creek and Tenderfoot Lake - three vastly differing sites.

The Lestidae Family was found in only Bay and Mullahy Lakes. It was specialized for sites with less than 150 acres, surface oxygen concentrations between 8.95mg/L and 9.2mg/L, and surface temperatures between 21.75^0C and 22^0C. As these larvae are also *Zygoptera*, the

bodies of cooler, better oxygenates water were more suited to their respiratory needs.

The Macromiidae larvae were recovered from Ward and Bergner Lakes. The Family appeared to be selective for smaller sites - both sites were less than 50 acres. The Macromiidae were also selective for high surface oxygen concentrations (8.8mg/L - 10.5mg/L) and higher surface temperatures (24^0C - 25.75^0C). Since most water with high oxygen concentrations is cooler, these two pieces of data seem to contradict each other, though not to any extremes.

The rest of the families appeared to be generalists with regard to water characteristics. As a generalized statement, the Odonate larvae were found in sites with vastly variable water characteristics. Since few obvious trends were noted in the Families Aeshnidae, Corduliidae, Libellulidae and Coenagrionidae, it is likely that the variation, in species found at each site, was due to the vast fluctuations in the water characteristics.

The data collected on the Family Aeshnidae revealed no particular correlations between the water chemistry and the species of larvae found. These insects appeared to be unaffected by variations in any of the tests besides alkalinity. *A. vinosa* occurred within a small range for alkalinities; between 10.5mEq/L and 36mEq/L. *A. eremita* was found in 6 of the sites while *A. verticalis* was found only in Raspberry, and *A. junius* was found only in Nansen. *A. vinosa* and *A. janata* were both found in 3 sites. Kickapoo did not recover any Aeshnid larvae, possibly due to the vast number of fish.

In the Family Corduliidae correlations between sites and water chemistry could be detected as the species were present in all types of sites. *C. shurtleffi*, *C. libera*, *C. regina* and *C. proxima* were generalists and present in most sites while *C. yamaskanensis* occurred only in Raspberry. *C. cingulata* was present in Mullahy and Nansen - two of the darkest lakes. This

finding could suggest color was a confine for this species (Table 9).

The Family Coenagrionidae was also present in a wide range of water qualities (Tables 7-16). Two unknown species were recovered in Bergner, while another was found in Ward. *C. basidens* occurred only in Kickapoo, *C. divagans* occurred solely in Raspberry. *C. civile* occupied a narrow alkalinity range of 36 - 39.5mEq/L. *C. saucium*, *C. cyathigerum*, *C. ebrium*, *C. hageni*, *C. vesperum* and *C. gracilis* were found across the sites so no correlations could be determined for these species. *C. irene* was found in a short range of very darkly colored water (79.83 - 134.88PtCo). This data could suggest a parameter for this species.

No correlations could be determined for the adult Odonata collected due to the small numbers recovered from each site and the large numbers recovered from Tenderfoot Lake. As a flying organism, the insects were found all over the property.

Conclusion

Among the eight families of Odonata found at the ten sites, only the Calopterygidae Gomphidae, Lestidae and Macromiidae were found to have correlations between water characteristics and species distribution. The Calopterygidae were selective for small, cool water sites. The Gomphidae were selective for brief ranges of surface oxygen and temperature. The Lestidae were selective found only in Bay and Mullahy Lakes - also sites with high concentrations of oxygen and cooler water temperatures. The Macromiidae were recovered in only two sites that had higher surface oxygen concentrations and higher surface temperatures. The rest of the families were generalists with regard to water characteristics and no parameters could be determined. Likewise, the adult Odonata collected were also determined to be

generalists for water qualities as they were found everywhere.

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Literature Cited

Borror DJ, White RE. 1970. A field guide to the insects of America north of Mexico. Houghton Mifflin Co. Boston. 404p.

Coker RE. 1953. Steams lakes ponds. The Univ of N Carolina Press. Chapel Hill. 327p.

Cole GA. 1975. Textbook of limnology. The C.V. Mosby Co. Saint Louis. 283p.

Hausman LS. 1950. Beginner's guide to freshwater life. G.P. Putnam's Sons, N.Y. 128p.

Hilsenhoff WL. 1975. Aquatic insects of Wisconsin. Generic keys and notes on biology, ecology and distribution. Tech. Bulletin. Wisc Dept Nat Resources No.89. 53p.

Klots AB, Klots EB. 1972. Insects of North America. Doubleday and Co., Inc. N.Y. 250p.

Lehmkuhl, DM. 1979. How to know the aquatic insects. Wm. C. Brown Company Pub 168p.

Merritt RW, Cummins KW. 1978. An introduction to the aquatic insects of North America. Kendall/Hunt Pub Co. Iowa. 441p.

McCafferty WP. 1981. Aquatic entomology. Sci Books Int. Boston. 448p.

Needham JG, Westfall MJ. 1954. Dragonflies of N America. Univ of California Press. Berkeley and Los Angeles/Cambridge Univ Press. London. 615p.

Ward HB, Whipple GC. 1959. Fresh water biology. 2nd ed. John Wiley and Sons, Inc. 1248p.

Table 1. Water Chemistry Data

Site Name	Per	Date	Cond	Secchi	pH	Color	Surf 02	Surf temp	alkalinity
Raspberry	1	1-Jun-97	11.4	2.6	7.1	37.25	9.35	20	0
Bergner	1	1-Jun-97	10.7	2.2	6.6	70	10.5	22	0
Mullahy	1	2-Jun-97	86	1.6	7.9	80.25	8.95	20	0
Ward	1	2-Jun	135.4	2.7	8.1	58	8.8	23	0
Kickapoo	1	2-Jun-97	42.4	1.4	7.8	90	8.9	22.5	0
Nansen	1	3-Jun-97	27.1		8.4	137.5	4.6	20.1	0
Tenderfoot Ck	1	3-Jun-97	77.5		8	69.5	8.15	21.7	0
Brown Ck	1	3-Jun-97	78.8		7.8	104	6.6	22	0
Bay	1	4-Jun-97	14.7	3.7	7.9	13.5	9.2	19	0
Tenderfoot	1	4-Jun-97	76.7	2.7	8	36.5	9.35	20	0
Raspberry	2	29-Jun-97	11.3	2.7	7.3	35	4.75	24	0
Bergner	2	29-Jun-97	11.6	2.2	6	54.75	3.8	29.5	0
Kickapoo	2	29-Jun-97	73.6	1.6	7.6	66	5.3	25.5	39.5
Brown Ck	2	29-Jun-97	105.4		7.1	76.5	2	25	47
Mullahy	2	30-Jun-97	110.3	1.3	7.6	79.4	5.3	23.5	36
Ward	2	30-Jun-97	144.5	2.25	7.6	56.5	4	25	58
Bay	2	30-Jun-97	14.8	3.4	7.6	16	4.6	25	0
Nansen	2	1-Jul-97	31.6	1.4	7	132.25	4.6	24	10.5
Tenderfoot Lk	2	1-Jul-97	84.3	3.5	7.9	43.5	3.4	25	33.5
Tenderfoot Ck	2	1-Jul-97	95.5		7.6	71	2.6	28	38

Table 2. Averages of Water Chemistry Data

Site Name	Per	Date	Cond	Secchi	pH	Color	Surf 02	Surf temp	alkalinity
Raspberry	1	1-Jun-97	11.35	2.65	7.3	36.13	9.35	22	0
Bergner	1	1-Jun-97	11.15	2.2	6	62.38	10.5	25.75	0
Mullahy	1	2-Jun-97	98.15	1.45	7.6	79.83	8.95	21.75	36
Ward	1	2-Jun	139.95	2.48	7.6	57.25	8.8	24	58
Kickapoo	1	2-Jun-97	58	1.5	7.6	78	8.9	24	39.5
Nansen	1	3-Jun-97	29.35	1.4	7	134.88	4.6	22.05	10.5
Tenderfoot Ck	1	3-Jun-97	86.5	0	7.6	70.25	8.15	24.85	38
Brown Ck	1	3-Jun-97	92.1	0	7.1	90.25	6.6	23.5	47
Bay	1	4-Jun-97	14.75	3.55	7.6	14.75	9.2	22	0
Tenderfoot	1	4-Jun-97	80.5	3.1	7.9	40	9.35	22.5	33.5

Table 3. Total Odonata Collected (1-4 June and 29 June-1 July 1997)

Name	Bay	Bergner	Brown Ck.	Kickapoo	Mullahy	Nansen	Raspberry	Tenderfoot Ck.	Tenderfoot Lk.	Ward
A. Aeshnidae Aeschna eremita	1	1	1		9				1	2
A. Aeshnidae Aeschna verticalis							1			
A. Aeshnidae Anax junius						1				
A. Aeshnidae Basiaeschna janata			1				1	1		
A. Aeshnidae Boyeria vinosa					2	1			1	
A. Corduliidae Cordulia shurtleffi		3		6	1	3	1			6
A. Corduliidae Dorocordulia libera	2	3					1	1		
A. Corduliidae Epitheca princeps				1	1	1	1		1	2
A. Corduliidae Epitheca regina		1		3	2		3		4	6
A. Corduliidae Neurocordulia molesta	3						2			
A. Corduliidae Neurocordulia yamaskanensis							1			
A. Corduliidae Somatochlora cingulata					1	2				
A. Gomphidae Gomphus borealis			1						1	
A. Gomphidae Hagenius brevistylus								1		
A. Gomphidae Ophiogomphus anomalus								11		
A. Gomphidae Ophiogomphus occidentis								1		
A. Gomphidae Stylurus amnicola									1	
A. Libellulidae Celithemis elisa				1	5	2	3			1
A. Libellulidae Celithemis eponina					4	2	2			4
A. Libellulidae Ladona julia						2	1			5
A. Libellulidae Leucorrhinia frigida				2	11	1	5			2
A. Libellulidae Leucorrhinia proxima		1								7
A. Libellulidae Libellula incesta		1								
A. Libellulidae Libellula luctuosa										1
A. Libellulidae Pachydiplax longipennis					1	3				
A. Libellulidae Perithemis tenera				1			1			
A. Libellulidae Plathemis lydia						3				
A. Libellulidae Sympetrum vicinum				1		1				1
A. Macromiidae Didymops transversa		1								2
Z. Calopterygidae Calopteryx aequabilis			2							
Z. Calopterygidae Calopteryx maculata			2							
Z. Coenagrionidae Amphiagrion saucium			2			5				
Z. Coenagrionidae Coenagrion spp1		1								
Z. Coenagrionidae Enallagma basidens				6						
Z. Coenagrionidae Enallagma civile				4	4					
Z. Coenagrionidae Enallagma cyathigerum		4				1				7
Z. Coenagrionidae Enallagma divagans							4			
Z. Coenagrionidae Enallagma ebrium		1		3	12	12	13			24
Z. Coenagrionidae Enallagma hageni	2				15				1	
Z. Coenagrionidae Enallagma spp1										2
Z. Coenagrionidae Enallagma spp2										
Z. Coenagrionidae Enallagma vesperum		1	1				2		2	17
Z. C. Ischnura/Anomalagrion spp1		6								
Z. Coenagrionidae Nehalennia gracilis		1	1		14		1	1		10
Z. Coenagrionidae Nehalennia irene					2	9				
Z. Coenagrionidae Nehalennia spp1		4								
Z. Lestidae Archilestes grandis	1									
Z. Lestidae Lestes dryas					3					
Z. Lestidae Lestes eurinus	5									
Z. Lestidae Lestes inaequalis	2									
Z. Lestidae Lestes unguiculatus					1					
Total Anisoptera	6	11	3	15	37	22	23	15	9	40
Total Zygoptera	10	18	8	13	52	27	20	1	3	60
Total Odonata	16	29	11	28	89	49	43	16	12	100
Total Genera	6	11	7	7	11	14	13	5	6	12

Table 4. First Sampling Collection
(1-4 June 1997)

Name	Bay	Bergner	Brown Ck.	Kickapoo	Mullahy	Nansen	Raspberry	Tenderfoot Ck.	Tenderfoot Lk.	Ward
A. Aeshnidae Aeschna eremita	1				2					2
A. Aeshnidae Aeschna verticalis							1			
A. Aeshnidae Anax junius						1				
A. Aeshnidae Boyeria vinosa									1	
A. Corduliidae Cordulia shurtleffi		1		3	1	3	1			3
A. Corduliidae Dorocordulia libera	2	3					1	1		
A. Corduliidae Epitheca regina		1		3	2		3		4	6
A. Corduliidae Epitheca princeps						1	1			1
A. Corduliidae Neurocordulia molesta	3						1			
A. Corduliidae Somatochlora cingulata					1	2				
A. Gomphidae Ophiogomphus anomalus								11		
A. Gomphidae Stylurus amnicola									1	
A. Libellulidae Ladona julia							1			5
A. Libellulidae Leucorrhinia frigida				2	11	1	5			
A. Libellulidae Leucorrhinia proxima										7
A. Libellulidae Pachydiplax longipennis					1					
A. Libellulidae Perithemis tenera				1			1			
A. Libellulidae Plathemis lydia						3				
A. Libellulidae Sympetrum vicinum				1		1				
Z. Calopterygidae Calopteryx aequabilis			2							
Z. Calopterygidae Calopteryx maculata			1							
Z. Coenagrionidae Amphiagrion saucium						5				
Z. Coenagrionidae Coenagrion spp1		1								
Z. Coenagrionidae Enallagma basidens				6						
Z. Coenagrionidae Enallagma civile				4	2					
Z. Coenagrionidae Enallagma cyathigerum		4				1				7
Z. Coenagrionidae Enallagma ebrium				3	7	11	10			16
Z. Coenagrionidae Enallagma divagans							4			
Z. Coenagrionidae Enallagma hageni	2				15				1	
Z. Coenagrionidae Enallagma vesperum										17
Z. Coenagrionidae Enallagma spp1										2
Z. C. Ischnura/Anomalagrion spp1		6								
Z. Coenagrionidae Nehalennia gracilis					12		1			8
Z. Coenagrionidae Nehalennia irene						9				
Z. Coenagrionidae Nehalennia spp1		4								
Z. Lestidae Archilestes grandis	1									
Z. Lestidae Lestes eurinus	5									
Z. Lestidae Lestes inaequalis	2									
Total Anisoptera	6	5	0	10	18	12	15	12	6	24
Total Zygoptera	10	15	3	13	36	26	15	0	1	50
Total Odonata	16	20	3	23	54	38	30	12	7	74

Table 5. Second Sampling Collection
(29 June - 1 July 1997)

Name	Bay	Bergner	Brown Ck.	Kickapoo	Mullahy	Nansen	Raspberry	Tenderfoot Ck.	Tenderfoot Lk.	Ward
A. Aeshnidae Aeschna eremita		1	1		7				1	
A. Aeshnidae Aeschna verticalis										
A. Asehnidae Anax junius										
A. Aeshnidae Basiaeschna janata			1				1	1		
A. Aeshnidae Boyeria vinosa					2	1				3
A. Corduliidae Cordulia shurtleffi		2		3						1
A. Corduliidae Epitheca regina										
A. Corduliidae Epitheca princeps				1	1				1	1
A. Corduliidae Neurocordulia molesta							1			
A. Corduliidae Neurocordulia yamaskanensis							1			
A. Corduliidae Somatochlora cingulata										
A. Gomphidae Gomphus borealis			1						1	
A. Gomphidae Hagenius brevistylus								1		
A. Gomphidae Ophiogomphus occidentis								1		
A. Libellulidae Celithemis elisa				1	5	2	3			1
A. Libellulidae Celithemis eponina					4	2	2			4
A. Libellulidae Ladona julia						2				
A. Libellulidae Leucorrhinia frigida										2
A. Libellulidae Leucorrhinia proxima		1								
A. Libellulidae Libellula incesta		1								
A. Libellulidae Libellula luctuosa										1
A. Libellulidae Pachydiplax longipennis						3				
A. Libellulidae Sympetrum vicinum										1
A. Macromiidae Didymops transversa		1								2
Z. Calopterygidae Calopteryx aequabilis										
Z. Calopterygidae Calopteryx maculata			1							
Z. Coenagrionidae Amphiagrion saucium			2							
Z. Coenagrionidae Enallagma basidens										
Z. Coenagrionidae Enallagma civile					2					
Z. Coenagrionidae Enallagma cyathigerum										
Z. Coenagrionidae Enallagma ebrium		1			5	1	3			8
Z. Coenagrionidae Enallagma divagans										
Z. Coenagrionidae Enallagma hageni										
Z. Coenagrionidae Enallagma vesperum		1	1				2		2	
Z. Coenagrionidae Enallagma spp1										
Z. Coenagrionidae Nehalennia gracilis		1	1		2			1		2
Z. Coenagrionidae Nehalennia irene					2					
Z. Coenagrionidae Nehalennia spp1										
Z. Lestidae Lestes dryas					3					
Z. Lestidae Lestes unguiculatus					1					
Total Anisoptera	0	6	3	5	19	10	8	3	3	16
Total Zygoptera	0	3	5	0	16	1	5	1	2	10
Total Odonata	0	9	8	5	35	11	13	4	5	26

Table 6. Adult Odonate Collection
(Summer 1997)

Name	Site	Date Collected	# Collected
A. Aeshnidae Gomphaeschna furcillata	Brown Creek	29-Jun-97	1
A. Corduliidae Cordulia shurtleffi	Tenderfoot Lake	14-Jun-97	1
A. Corduliidae Epitheca cynosura	Bay	30-Jun-97	2
A. Corduliidae Epitheca cynosura	Tenderfoot Lake	1-Jul-97	1
A. Corduliidae Epitheca spinigera	Tenderfoot Creek	3-Jun-97	1
A. Corduliidae Epitheca spinigera	Tenderfoot Lake	14-Jun-97	2
A. Corduliidae Epitheca spinigera	Kickapoo	29-Jun-97	4
A. Corduliidae Epitheca spinigera	Mullahy	30-Jun-97	2
A. Corduliidae Epitheca spinigera	Bay	30-Jun-97	1
A. Corduliidae Epitheca spinigera	Tenderfoot Lake	1-Jul-97	1
A. Corduliidae Plathemis lydia	Brown Creek	29-Jun-97	1
A. Gomphidae Gomphus exilis	Bay	30-Jun-97	1
A. Gomphidae Gomphus exilis	Tenderfoot Lake	1-Jul-97	1
A. Gomphidae Gomphus spicatus	Ward	30-Jun-97	1
A. Libellulidae Celithemis elisa	Bay	30-Jun-97	2
A. Libellulidae Dorocordulia libera	Tenderfoot Lake	14-Jun-97	2
A. Libellulidae Ladona julia	Tenderfoot Lake	17-Jun-97	1
A. Libellulidae Ladona julia	Tenderfoot Lake	20-Jun-97	1
A. Libellulidae Ladona julia	Raspberry	29-Jun-97	2
A. Libellulidae Ladona julia	Mullahy	30-Jun-97	1
A. Libellulidae Ladona julia	Ward	30-Jun-97	2
A. Libellulidae Leucorrhinia frigida	Mullahy	30-Jun-97	1
A. Libellulidae Leucorrhinia frigida	Ward	30-Jun-97	3
A. Libellulidae Leucorrhinia frigida	Nansen	1-Jul-97	2
A. Libellulidae Libella pulchella	Brown Creek	29-Jun-97	1
A. Libellulidae Libella pulchella	Tenderfoot Lake	1-Jul-97	1
A. Libellulidae Plathemis lydia	Tenderfoot Lake	18-Jun-97	1
A. Libellulidae Sympetrum atripes	Kickapoo	16-Jun-97	1
A. Petaluridae Tachopteryx thoreyi	Tenderfoot Creek	23-Jun-97	1
A. Petaluridae Tachopteryx thoreyi	Raspberry	29-Jun-97	1
A. Petaluridae Tachopteryx thoreyi	Tenderfoot Lake	1-Jul-97	2
Z. Calopterygidae Calopteryx aequabilis	Brown Creek	29-Jun-97	2
Z. Calopterygidae Calopteryx aequabilis	Brown Creek	29-Jun-97	1
Z. Calopterygidae Calopteryx maculata	Tenderfoot Creek	1-Jul-97	3
Z. Calopterygidae Calopteryx maculata	Tenderfoot Lake	1-Jul-97	1
Z. Lestidae Lestes	Ward	30-Jun-97	2

Table 7. Sites Ranked by Alkalinity (mEq/L)

	Alkalinity	0	0	0	10.5	33.5	36	38	39.5	47	58
Site Name	Bay	Bergner	Raspberry	Nansen	TFt. Lake	Mullahy	TFt. Creek	Kickapoo	Brown Ck.	Ward
Family/spp										
Aeshnidae/eremita	x	x			x	x			x	x
Aeshnidae/verticalis			x							
Aeshnidae/janata			x				x		x	
Aeshnidae/junius				x						
Aeshnidae/vinosa				x	x	x				
Corduliidae/shurtleffi		x	x	x		x		x		x
Corduliidae/libera	x	x	x				x			
Corduliidae/princeps			x	x	x	x		x		x
Corduliidae/regina		x	x		x	x		x		x
Corduliidae/molesta	x		x							
Corduliidae/yamaskanensis			x							
Coduliidae/cingulata				x		x				
Gomphidae/borealis					x				x	
Gomphidae/brevistylus							x			
Gomphidae/anomalus							x			
Gomphidae/occidentis							x			
Gomphidae/amnicola					x					
Libellulidae/elisa			x	x		x		x		x
Libellulidae/eponina			x	x		x				x
Libellulidae/julia			x	x						x
Libellulidae/triglda			x	x		x		x		x
Libellulidae/proxima		x								x
Libellulidae/incesta		x								
Libellulidae/luctuosa										x
Libellulidae/longipennis				x		x				
Libellulidae/tenera			x					x		
Libellulidae/lydia				x						
Libellulidae/vicinum				x				x		x
Macromiidae/transversa		x								x
Calopterygidae/aequabilis									x	
Calopterygidae/maculata									x	
Coenagrionidae/saucium				x					x	
Coenagrionidae/spp1		x								
Coenagrionidae/basidens								x		
Coenagrionidae/civile						x		x		
Coenagrionidae/cyathigerum		x		x						x
Coenagrionidae/divagans			x							
Coenagrionidae/ebrium		x	x	x		x		x		x
Coenagrionidae/hageni	x				x	x				
Coenagrionidae/spp1										x
Coenagrionidae/spp2										
Coenagrionidae/vesperum		x	x		x				x	x
Coenagrionidae/spp1		x								
Coenagrionidae/gracilis		x	x			x	x		x	x
Coenagrionidae/irene				x		x				
Coenagrionidae/spp1										
Lestidae/grandis	x									
Lestidae/dryas						x				
Lestidae/eurinus	x									
Lestidae/inaequalis	x									
Lestidae/unguiculatus						x				

Table 8. Sites Ranked by Area (acres)

	Area (acre)	0	0	2.75	6.77	9.99	11.43	19.44	44.09	166.4	480
Site Name		TFt. Creek	Brown Ck.	Mullahy	Ward	Nansen	Raspberry	Kickapoo	Bergner	Bay	TFt. Lake
Family/spp											
Aeshnidae/eremita			x	x	x				x	x	x
Aeshnidae/verticalis							x				
Aeshnidae/janata		x	x				x				
Aeshnidae/junius						x					
Aeshnidae/vinosa				x		x					x
Corduliidae/shurtleffi				x	x	x	x	x	x		
Cordutiidae/libera		x					x		x	x	
Corduliidae/princeps				x	x	x	x	x			x
Corduliidae/regina				x	x		x	x	x		x
Corduliidae/molesta							x			x	
Cordulilidae/yamaskanensis							x				
Coduliidae/cingulata				x		x					
Gomphidae/borealis			x								x
Gomphidae/brevistylus		x									
Gomphidae/anomalus		x									
Gomphidae/occidentis		x									
Gomphidae/amnicola											x
Libellulidae/elisa				x	x	x	x	x			
Libellulidae/eponina				x	x	x	x				
Libellulidae/julia					x	x	x				
Libellulidae/frigida				x	x	x	x	x			
Libellulidae/proxima					x				x		
Libellulidae/incesta									x		
Libellulidae/luctuosa					x						
Libellulidae/longipennis				x		x					
Libellulidae/tenera							x	x			
Libellulidae/lydia						x					
Libellulidae/vicinum					x	x		x			
Macromiidae/transversa					x				x		
Calopterygidae/aequabilis			x								
Calopterygidae/maculata			x								
Coenagrionidae/saucium			x			x					
Coenagrionidae/spp1									x		
Coenagrionidae/basidens								x			
Coenagrionidae/civile				x				x			
Coenagrionidae/cyathigerum					x	x			x		
Coenagrionidae/divagans							x				
Coenagrionidae/ebrium				x	x	x	x	x	x		
Coenagrionidae/hageni				x						x	x
Coenagrionidae/spp1					x						
Coenagrionidae/spp2											
Coenagrionidae/vesperum			x		x		x		x		x
Coenagrionidae/spp1									x		
Coenagrionidae/gracilis		x	x	x	x		x		x		
Coenagrionidae/irene				x		x					
Coenagrionidae/spp1											
Lestidae/grandis										x	
Lestidae/dryas				x							
Lestidae/eurinus										x	
Lestidae/inaequalis										x	
Lestidae/unguiculatus				x							

Table 9. Sites Ranked by Color (PtCo)

Color (PtCo)	14.75	36.13	40	57.25	62.38	70.25	78	79.83	90.25	134.88
Site Name	Bay	Raspberry	TFl. Lake	Ward	Bergner	TFl. Creek	Kickapoo	Mullahy	Brown Ck.	Nansen
Family/spp										
Aeshnidae/eremita	x		x	x	x			x	x	
Aeshnidae/verticalis		x								
Aeshnidae/janata		x				x			x	
Aeshnidae/junius										x
Aeshnidae/vinosa			x					x		x
Corduliidae/shurtleffi		x		x	x		x	x		x
Corduliidae/libera	x	x			x	x				
Corduliidae/princeps		x	x	x			x	x		x
Corduliidae/regina		x	x	x	x		x	x		
Corduliidae/molesta	x	x								
Corduliidae/yamaskanensis		x								
Coduliidae/cingulata								x		x
Gomphidae/borealis			x						x	
Gomphidae/brevistylus						x				
Gomphidae/anomalus						x				
Gomphidae/occidentis						x				
Gomphidae/arnnicola			x							
Libellulidae/elisa		x		x			x	x		x
Libellulidae/eponina		x		x				x		x
Libellulidae/julia		x		x						x
Libellulidae/frigida		x		x			x	x		x
Libellulidae/proxima				x	x					
Libellulidae/incesta					x					
Libellulidae/luctuosa				x						
Libellulidae/longipennis								x		x
Libellulidae/tenera		x					x			
Libellulidae/lydia										x
Libellulidae/vicinum				x			x			x
Macromiidae/transversa				x	x					
Calopterygidae/aequabilis									x	
Calopterygidae/maculata									x	
Coenagrionidae/saucium									x	x
Coenagrionidae/spp1					x					
Coenagrionidae/basidens							x			
Coenagrionidae/civile							x	x		
Coenagrionidae/cyathigerum				x	x					x
Coenagrionidae/divagans		x								
Coenagrionidae/ebrium		x		x	x		x	x		x
Coenagrionidae/hageni	x		x					x		
Coenagrionidae/spp1				x						
Coenagrionidae/spp2										
Coenagrionidae/vesperum		x	x	x	x				x	
Coenagrionidae/spp1					x					
Coenagrionidae/gracilis		x		x	x	x		x	x	
Coenagrionidae/irene								x		x
Coenagrionidae/spp1										
Lestidae/grandis	x									
Lestidae/dryas								x		
Lestidae/eurinus	x									
Lestidae/inaequalis	x									
Lestidae/unguiculatus								x		

Table 10. Sites Ranked by Conductivity (umhos/cm)

Site Name	Conductivity	11.15 Bergner	11.35 Raspberry	14.75 Bay	29.35 Nansen	58 Kickapoo	80.5 Tft. Lake	86.5 Tft. Creek	92.1 Brown Ck.	98.15 Mullahy	139.95 Ward
Family/spp											
Aeshnidae/eremita		x		x			x		x	x	x
Aeshnidae/verticalis			x								
Aeshnidae/janata			x					x	x		
Aeshnidae/junius					x						
Aeshnidae/vinosa					x		x			x	
Cordulilidae/shurtleffi		x	x		x	x				x	x
Corduliidae/libera		x	x	x				x			
Corduliidae/princeps			x		x	x	x			x	x
Corduliidae/regina		x	x			x	x			x	x
Corduliidae/molesta			x	x							
Corduliidae/yamaskanensis			x								
Coduliidae/cingulata					x					x	
Gomphidae/borealis							x		x		
Gomphidae/brevistylus								x			
Gomphidae/anomalus								x			
Gomphidae/occidentis								x			
Gomphidae/amnicola							x				
Libellulidae/elisa			x		x	x				x	x
Libellulidae/eponina			x		x					x	x
Libellulidae/julia			x		x						x
Libellulidae/frigida			x		x	x				x	x
Libellulidae/proxima		x									x
Libellulidae/incesta		x									
Libellulidae/luctuosa											x
Libellulidae/longipennis					x					x	
Libellulidae/tenera			x			x					
Libellulidae/lydia					x						
Libellulidae/vicinum					x	x					x
Macromiidae/transversa		x									x
Calopterygidae/aequabilis									x		
Calopterygidae/maculata									x		
Coenagrionidae/saucium					x				x		
Coenagrionidae/spp1		x									
Coenagrionidae/basidens						x					
Coenagrionidae/civile						x				x	
Coenagrionidae/cyathigerum		x			x						x
Coenagrionidae/divagans			x								
Coenagrionidae/ebrium		x	x		x	x				x	x
Coenagrionidae/hageni				x			x			x	
Coenagrionidae/spp1											x
Coenagrionidae/spp2											
Coenagrionidae/vesperum		x	x				x		x		x
Coenagrionidae/spp1		x									
Coenagrionidae/gracilis		x	x					x	x	x	x
Coenagrionidae/irene					x					x	
Coenagrionidae/spp1											
Lestidae/grandis				x							
Lestidae/dryas										x	
Lestidae/eurinus				x							
Lestidae/inaequalis				x							
Lestidae/unguiculatus										x	

Table 11. Sites Ranked by Presence of Fish

Fish	0	1	1	1	1	2	2	2	2	2
Site Name	Nansen	TFt. Creek	Brown Ck.	Mullahy	Ward	Bergner	Raspberry	Bay	Kickapoo	TFt. Lake
Family/spp										
Aeshnidae/eremita			x	x	x	x		x		x
Aeshnidae/verticalis							x			
Aeshnidae/janata		x	x				x			
Aeshnidae/junius	x									
Aeshnidae/vinosa	x			x						x
Corduliidae/shurtleffi	x			x	x	x	x		x	
Corduliidae/libera		x				x	x	x		
Corduliidae/princeps	x			x	x		x		x	x
Corduliidae/regina				x	x	x	x		x	x
Corduliidae/molesta							x	x		
Cordulilidae/yamaskanensis							x			
Coduliidae/cingulata	x			x						
Gomphidae/borealis			x							x
Gomphidae/brevistylus		x								
Gomphidae/anomalus		x								
Gomphidae/occidentis		x								
Gomphidae/amnicola										x
Libellulidae/elisa	x			x	x		x		x	
Libellulidae/eponina	x			x	x		x			
Libellulidae/julia	x				x		x			
Libellulidae/frigida	x			x	x		x		x	
Libellulidae/proxima					x	x				
Libellulidae/incesta						x				
Libellulidae/luctuosa					x					
Libellulidae/longipennis	x			x						
Libellulidae/tenera							x		x	
Libellulidae/lydia	x									
Libellulidae/vicinum	x				x				x	
Macromiidae/transversa					x	x				
Calopterygidae/aequabilis			x							
Calopterygidae/maculata			x							
Coenagrionidae/saucium	x		x							
Coenagrionidae/spp1						x				
Coenagrionidae/basidens									x	
Coenagrionidae/civile				x					x	
Coenagrionidae/cyathigerum	x				x	x				
Coenagrionidae/divagans							x			
Coenagrionidae/ebrium	x			x	x	x	x		x	
Coenagrionidae/hageni				x				x		x
Coenagrionidae/spp1					x					
Coenagrionidae/spp2										
Coenagrionidae/vesperum			x		x	x	x			x
Coenagrionidae/spp1						x				
Coenagrionidae/gracilis		x	x	x	x	x	x			
Coenagrionidae/irene	x			x						
Coenagrionidae/spp1										
Lestidae/grandis								x		
Lestidae/dryas				x						
Lestidae/eurinus								x		
Lestidae/inaequalis								x		
Lestidae/unguiculatus				x						

Key: 0=no fish 1=some fish 2=many fish

Table 12. Sites Ranked by pH

pH	6	7	7.1	7.3	7.6	7.6	7.6	7.6	7.6	7.9
Site Name	Bergner	Nansen	Brown Ck.	Raspberry	TFt. Creek	Mullahy	Ward	Bay	Kickapoo	TFt. Lake
Family/spp										
Aeshnidae/eremita	x		x			x	x	x		x
Aeshnidae/verticalis				x						
Aeshnidae/janata			x	x	x					
Aeshnidae/junius		x								
Aeshnidae/vinosa		x				x				x
Corduliidae/shurtleffi	x	x		x		x	x		x	
Corduliidae/libera	x			x	x			x		
Corduliidae/princeps		x		x		x	x		x	x
Corduliidae/regina	x			x		x	x		x	x
Corduliidae/molesta				x				x		
Corduliidae/yamaskanensis				x						
Coduliidae/cingulata		x				x				
Gomphidae/borealis			x							x
Gomphidae/brevistylus					x					
Gomphidae/anomalus					x					
Gomphidae/occidentis					x					
Gomphidae/amnicola										x
Libellulidae/elisa		x		x		x	x		x	
Libellulidae/eponina		x		x		x	x			
Libellulidae/julia		x		x			x			
Libellulidae/frigida		x		x		x	x		x	
Libellulidae/proxima	x						x			
Libellulidae/incesta	x									
Libellulidae/luctuosa							x			
Libellulidae/longipennis		x				x				
Libellulidae/tenera				x					x	
Libellulidae/lydia		x								
Libellulidae/vicinum		x					x		x	
Macromiidae/transversa	x						x			
Calopterygidae/aequabilis			x							
Calopterygidae/maculata			x							
Coenagrionidae/saucium		x	x							
Coenagrionidae/spp1	x									
Coenagrionidae/basidens									x	
Coenagrionidae/civile						x			x	
Coenagrionidae/cyathigerum	x	x					x			
Coenagrionidae/divagans				x						
Coenagrionidae/ebrium	x	x		x		x	x		x	
Coenagrionidae/hageni						x		x		x
Coenagrionidae/spp1							x			
Coenagrionidae/spp2										
Coenagrionidae/vesperum	x		x	x			x			x
Coenagrionidae/spp1	x									
Coenagrionidae/gracilis	x		x	x	x	x	x			
Coenagrionidae/irene		x				x				
Coenagrionidae/spp1										
Lestidae/grandis								x		
Lestidae/dryas						x				
Lestidae/eurinus								x		
Lestidae/inaequalis								x		
Lestidae/unguiculatus						x				

Table 13. Sites Ranked by Secchi Disc Depth (m)

Secchi (m)	0	0	1.4	1.45	1.5	2.2	2.48	2.65	3.1	3.55
Site Name	Brown Ck.	TFt. Creek	Nansen	Mullahy	Kickapoo	Bergner	Ward	Raspberry	TFt. Lake	Bay
Family/spp										
Aeshnidae/eremita	x			x		x	x		x	x
Aeshnidae/verticalis								x		
Aeshnidae/janata	x	x						x		
Aeshnidae/junius			x							
Aeshnidae/vinosa			x	x					x	
Corduliidae/shurtleffi			x	x	x	x	x	x		
Corduliidae/libera		x				x		x		x
Corduliidae/princeps			x	x	x		x	x	x	
Corduliidae/regina				x	x	x	x	x	x	
Corduliidae/molesta								x		x
Corduliidae/yamaskanensis								x		
Coduliidae/cingulata			x	x						
Gomphidae/borealis	x								x	
Gomphidae/brevistylus		x								
Gomphidae/anomalus		x								
Gomphidae/occidentis		x								
Gomphidae/amnicola									x	
Libellulidae/elisa			x	x	x		x	x		
Libellulidae/eponina			x	x			x	x		
Libellulidae/julia			x				x	x		
Libellulidae/frigida			x	x	x		x	x		
Libellulidae/proxima						x	x			
Libellulidae/incesta						x				
Libellulidae/luctuosa							x			
Libellulidae/longipennis			x	x						
Libellulidae/tenera					x			x		
Libellulidae/lydia			x							
Libellulidae/vicinum			x		x		x			
Macromiidae/transversa						x	x			
Calopterygidae/aequabilis	x									
Calopterygidae/maculata	x									
Coenagrionidae/saucium	x		x							
Coenagrionidae/spp1						x				
Coenagrionidae/basidens					x					
Coenagrionidae/civile				x	x					
Coenagrionidae/cyathigerum			x			x	x			
Coenagrionidae/divagans								x		
Coenagrionidae/ebrium			x	x	x	x	x	x		
Coenagrionidae/hageni				x					x	x
Coenagrionidae/spp1							x			
Coenagrionidae/spp2										
Coenagrionidae/vesperum	x					x	x	x	x	
Coenagrionidae/spp1						x				
Coenagrionidae/gracilis	x	x		x		x	x	x		
Coenagrionidae/irene			x	x						
Coenagrionidae/spp1										
Lestidae/grandis										x
Lestidae/dryas				x						
Lestidae/eurinus										x
Lestidae/inaequalis										x
Lestidae/unguiculatus				x						

Table 14. Sites Ranked by Shore Development

	Shore Dev.	0	0	1.05	1.19	1.27	1.31	1.39	1.42	1.91	2.64
Site Name		Brown Ck.	TFt. Creek	Ward	Raspberry	Nansen	Kickapoo	Bergner	Mullahy	TFt. Lake	Bay
Family/spp											
Aeshnidae/eremita		x		x				x	x	x	x
Aeshnidae/verticalis					x						
Aeshnidae/janata		x	x		x						
Aeshnidae/junius						x					
Aeshnidae/vinosa						x			x	x	
Corduliidae/shurtleffi				x	x	x	x	x	x		
Corduliidae/libera			x		x			x			x
Corduliidae/princeps				x	x	x	x		x	x	
Corduliidae/regina				x	x		x	x	x	x	
Corduliidae/molesta					x						x
Corduliidae/yamaskanensis					x						
Cordulliidae/cingulata						x			x		
Gomphidae/borealis		x								x	
Gomphidae/brevistylus			x								
Gomphidae/anomalus			x								
Gomphidae/occidentis			x								
Gomphidae/amnicola										x	
Libellulidae/elisa				x	x	x	x		x		
Libellulidae/eponina				x	x	x			x		
Libellulidae/julia				x	x	x					
Libellulidae/frigida				x	x	x	x		x		
Libellulidae/proxima				x				x			
Libellulidae/incesta								x			
Libellulidae/luctuosa				x							
Libellulidae/longipennis						x			x		
Libellulidae/tenera					x		x				
Libellulidae/lydia						x					
Libellulidae/vicinum				x		x	x				
Macromiidae/transversa				x				x			
Calopterygidae/aequabilis		x									
Calopterygidae/maculata		x									
Coenagrionidae/saucium		x				x					
Coenagrionidae/spp1								x			
Coenagrionidae/basidens							x				
Coenagrionidae/civile							x		x		
Coenagrionidae/cyathigerum				x		x		x			
Coenagrionidae/divagans					x						
Coenagrionidae/ebrium				x	x	x	x	x	x		
Coenagrionidae/hageni									x	x	x
Coenagrionidae/spp1				x							
Coenagrionidae/spp2											
Coenagrionidae/vesperum		x		x	x			x		x	
Coenagrionidae/spp1								x			
Coenagrionidae/gracilis		x	x	x	x			x	x		
Coenagrionidae/irene						x			x		
Coenagrionidae/spp1											
Lestidae/grandis											x
Lestidae/dryas									x		
Lestidae/eurinus											x
Lestidae/inaequalis											x
Lestidae/unguiculatus									x		

Closer the value is to 1, the closer the site is to being a perfect circle.

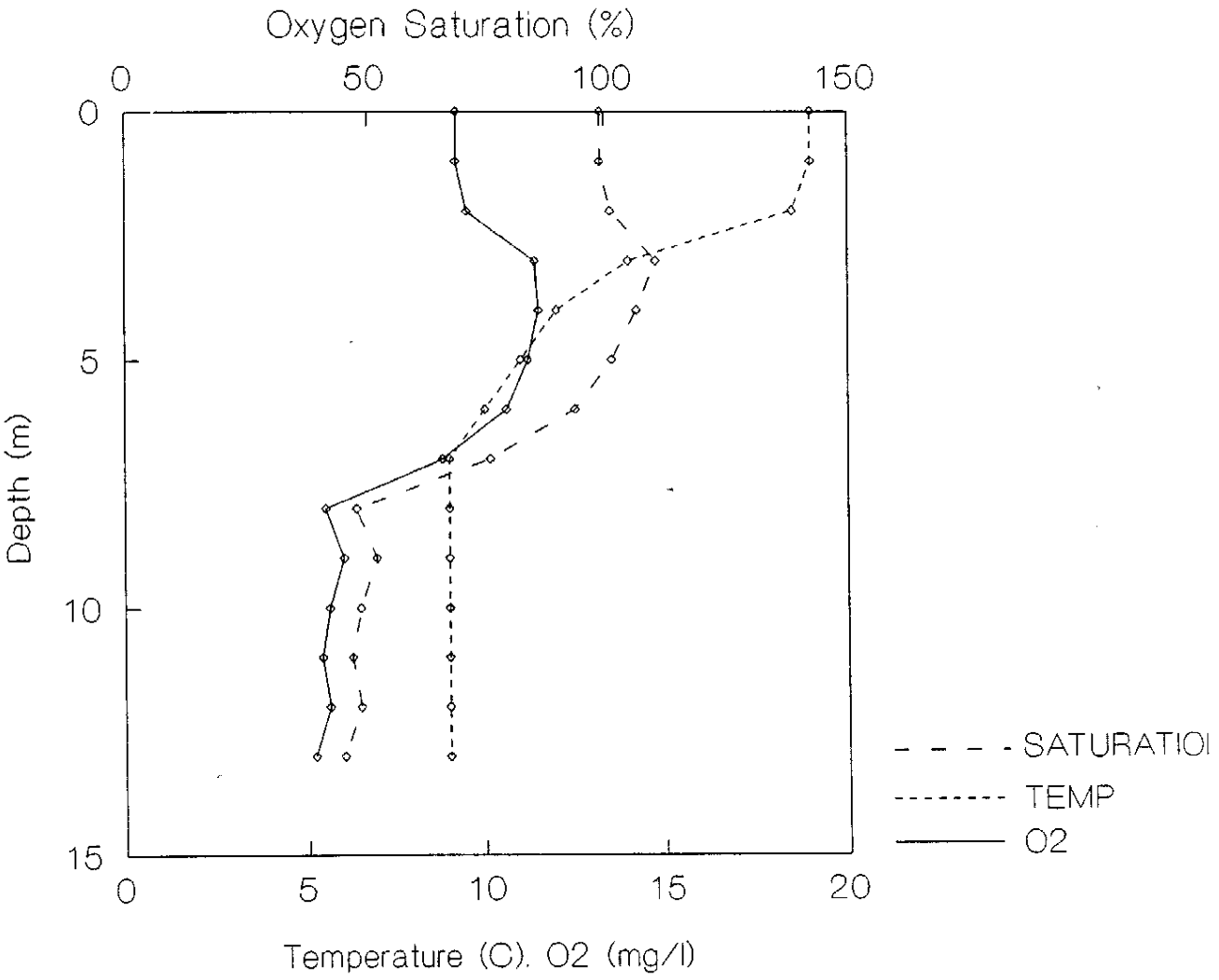
Table 15. Sites Ranked by Surface Oxygen (mg/L)

Surf. O2	4.6	6.6	8.15	8.8	8.9	8.95	9.2	9.35	9.35	10.5
Site Name	Nansen	Brown Ck.	TFt. Creek	Ward	Kickapoo	Mullahy	Bay	Raspberry	TFt. Lake	Bergner
Family/spp										
Aeshnidae/eremita		x		x		x	x		x	x
Aeshnidae/verticalis								x		
Aeshnidae/janata		x	x					x		
Aeshnidae/junius	x									
Aeshnidae/vinosa	x					x			x	
Corduliidae/shurtleffi	x			x	x	x		x		x
Corduliidae/libera			x				x	x		x
Corduliidae/princeps	x			x	x	x		x	x	
Corduliidae/regina				x	x	x		x	x	x
Corduliidae/molesta							x	x		
Corduliidae/yamaskanensis								x		
Coduliidae/cingulata	x					x				
Gomphidae/borealis		x							x	
Gomphidae/brevistylus			x							
Gomphidae/anomalus			x							
Gomphidae/occidentis			x							
Gomphidae/amnicola									x	
Libellulidae/elisa	x			x	x	x		x		
Libellulidae/eponina	x			x		x		x		
Libellulidae/julia	x			x				x		
Libellulidae/frigida	x			x	x	x		x		
Libellulidae/proxima				x						x
Libellulidae/incesta										x
Libellulidae/luctuosa				x						
Libellulidae/longipennis	x					x				
Libellulidae/tenera					x			x		
Libellulidae/lydia	x									
Libellulidae/vicinum	x			x	x					
Macromiidae/transversa				x						x
Calopterygidae/aequabilis		x								
Calopterygidae/maculata		x								
Coenagrionidae/saucium	x	x								
Coenagrionidae/spp1										x
Coenagrionidae/basidens					x					
Coenagrionidae/civile					x	x				
Coenagrionidae/cyathigerum	x			x						x
Coenagrionidae/divagans								x		
Coenagrionidae/ebrium	x			x	x	x		x		x
Coenagrionidae/hageni						x	x		x	
Coenagrionidae/spp1				x						
Coenagrionidae/spp2										
Coenagrionidae/vesperum		x		x				x	x	x
Coenagrionidae/spp1										x
Coenagrionidae/gracilis		x	x	x		x		x		x
Coenagrionidae/irene	x					x				
Coenagrionidae/spp1										
Lestidae/grandis							x			
Lestidae/dryas						x				
Lestidae/eurinus							x			
Lestidae/inaequalis							x			
Lestidae/unguiculatus						x				

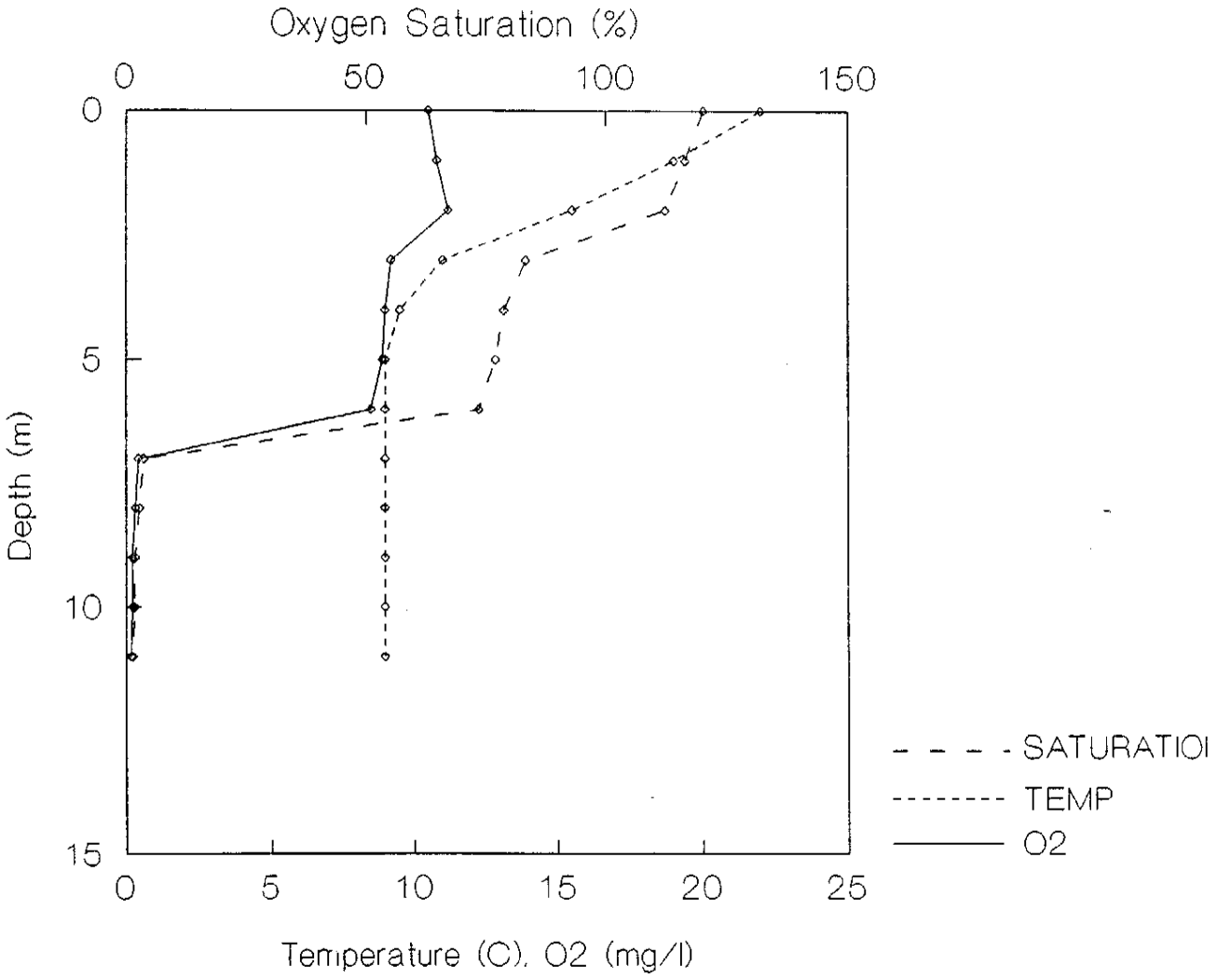
Table 16. Sites Ranked by Surface Temperature (oC)

	Surf. Temp.	21.75	22	22	22.05	22.5	23.5	24	24	24.85	25.75
Site Name		Mullahy	Bay	Raspberry	Nansen	TFt. Lake	Brown Ck.	Ward	Kickapoo	TFt. Creek	Bergner
Family/spp											
Aeshnidae/eremita		x	x			x	x	x			x
Aeshnidae/verticalis				x							
Aeshnidae/janata				x			x			x	
Aeshnidae/junius					x						
Aeshnidae/vinosa		x			x	x					
Corduliidae/shurtleffi		x		x	x			x	x		x
Corduliidae/libera			x	x						x	x
Corduliidae/princeps		x		x	x	x		x	x		
Corduliidae/regina		x		x		x		x	x		x
Corduliidae/molesta			x	x							
Corduliidae/yamaskanensis				x							
Coduliidae/cingulata		x			x						
Gomphidae/borealis						x	x				
Gomphidae/brevistylus										x	
Gomphidae/anomalus										x	
Gomphidae/occidentis										x	
Gomphidae/amnicola						x					
Libellulidae/elisa		x		x	x			x	x		
Libellulidae/eponina		x		x	x			x			
Libellulidae/julia				x	x			x			
Libellulidae/frigida		x		x	x			x	x		
Libellulidae/proxima								x			x
Libellulidae/incesta											x
Libellulidae/luctuosa								x			
Libellulidae/longipennis		x			x						
Libellulidae/tenera				x					x		
Libellulidae/lydia					x						
Libellulidae/vicinum					x			x	x		
Macromiidae/transversa								x			x
Calopterygidae/aequabilis							x				
Calopterygidae/maculata							x				
Coenagrionidae/saucium					x		x				
Coenagrionidae/spp1											x
Coenagrionidae/basidens									x		
Coenagrionidae/civile		x							x		
Coenagrionidae/cyathigerum					x			x			x
Coenagrionidae/divagans				x							
Coenagrionidae/ebrium		x		x	x			x	x		x
Coenagrionidae/hageni		x	x			x					
Coenagrionidae/spp1								x			
Coenagrionidae/spp2											
Coenagrionidae/vesperum				x		x	x	x			x
Coenagrionidae/spp1											x
Coenagrionidae/gracilis		x		x			x	x		x	x
Coenagrionidae/irene		x			x						
Coenagrionidae/spp1											
Lestidae/grandis			x								
Lestidae/dryas		x									
Lestidae/eurinus			x								
Lestidae/inaequalis			x								
Lestidae/unquiculatus		x									

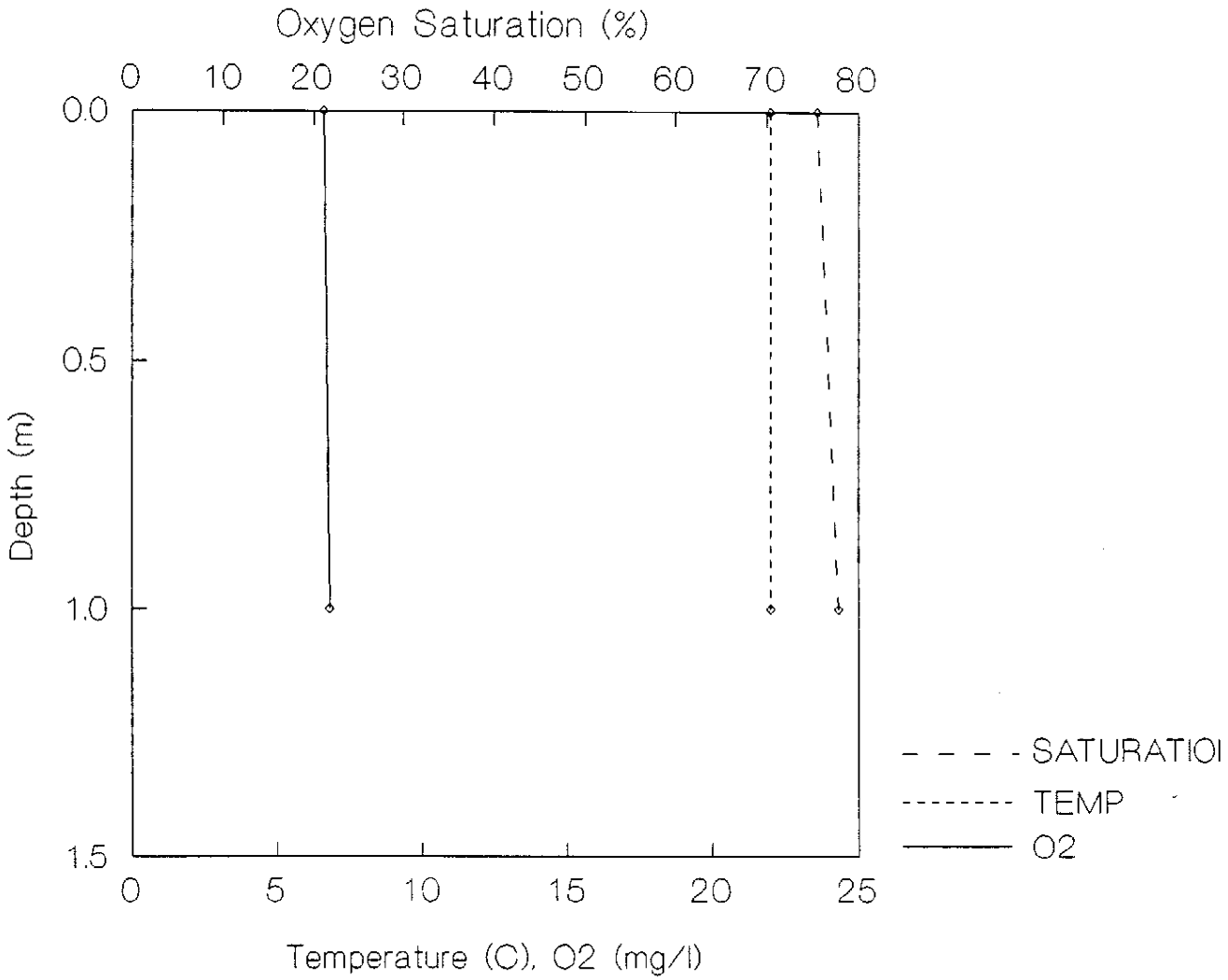
Appendix 1. % Surface oxygen, depth and temperature in Bay Lake



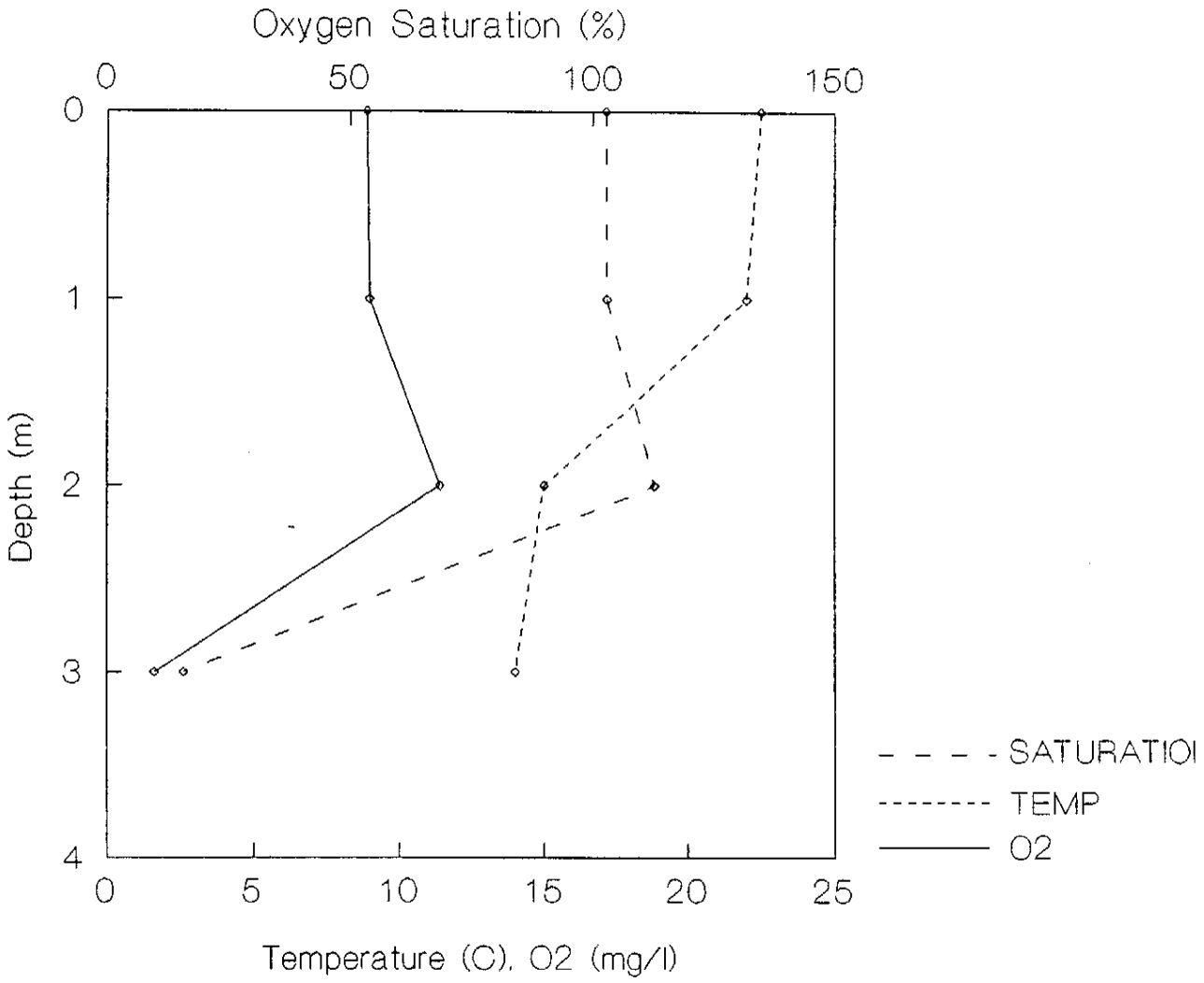
Appendix 2. % Surface oxygen, depth and temperature in Bergner Lake



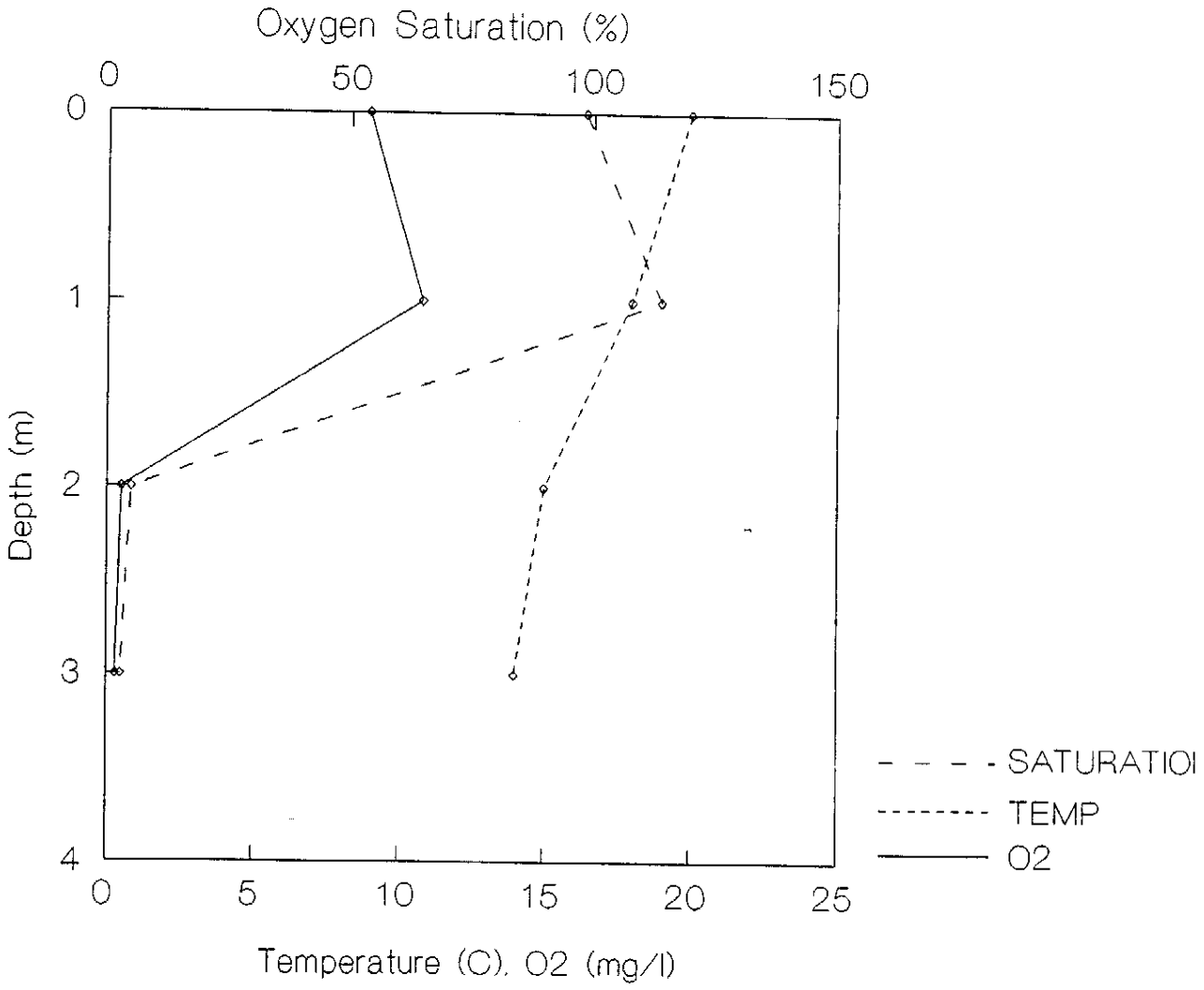
Appendix 3. % Surface oxygen, depth and temperature in Brown Creek



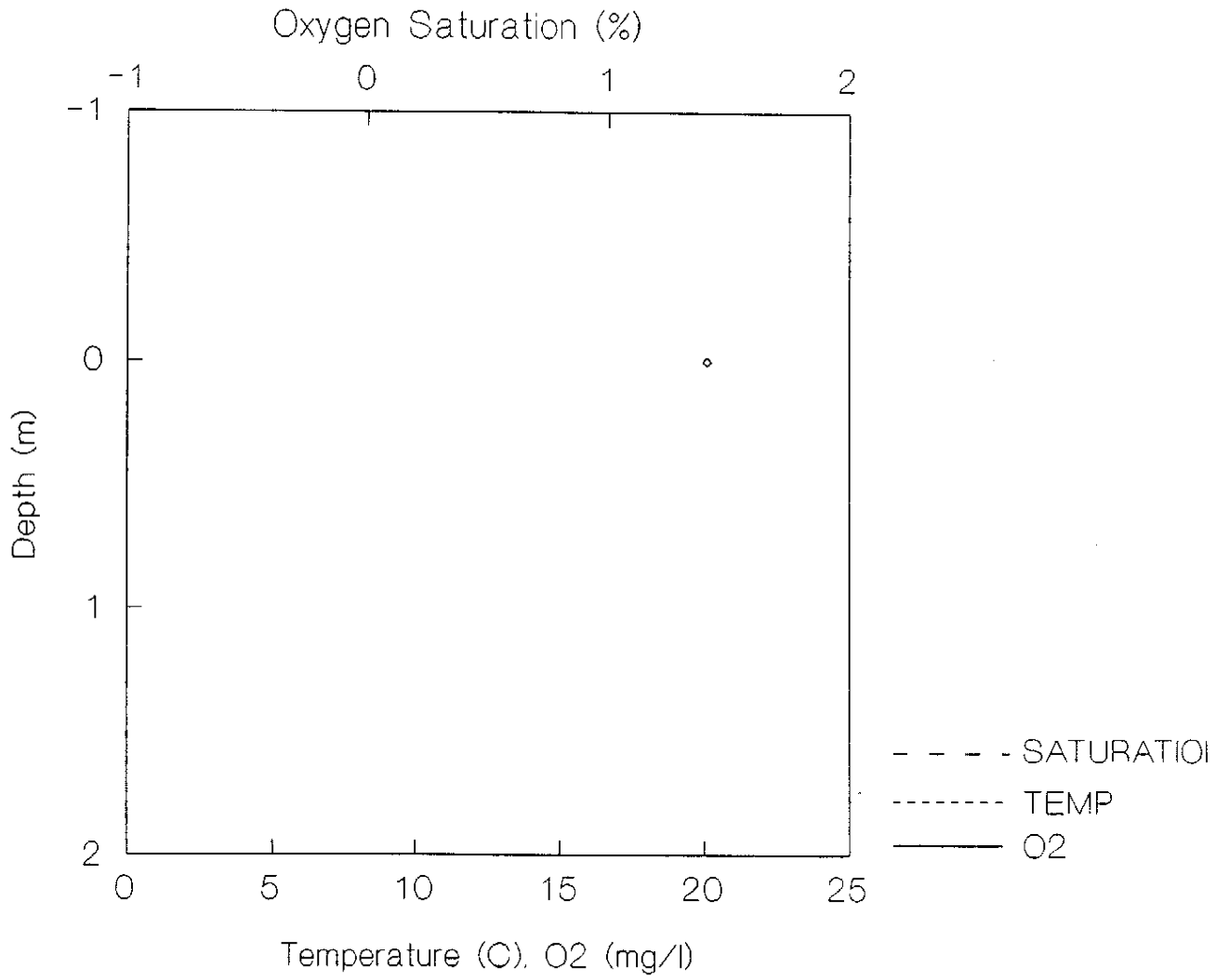
Appendix 4. % Surface oxygen, depth and temperature in Kickapoo Lake



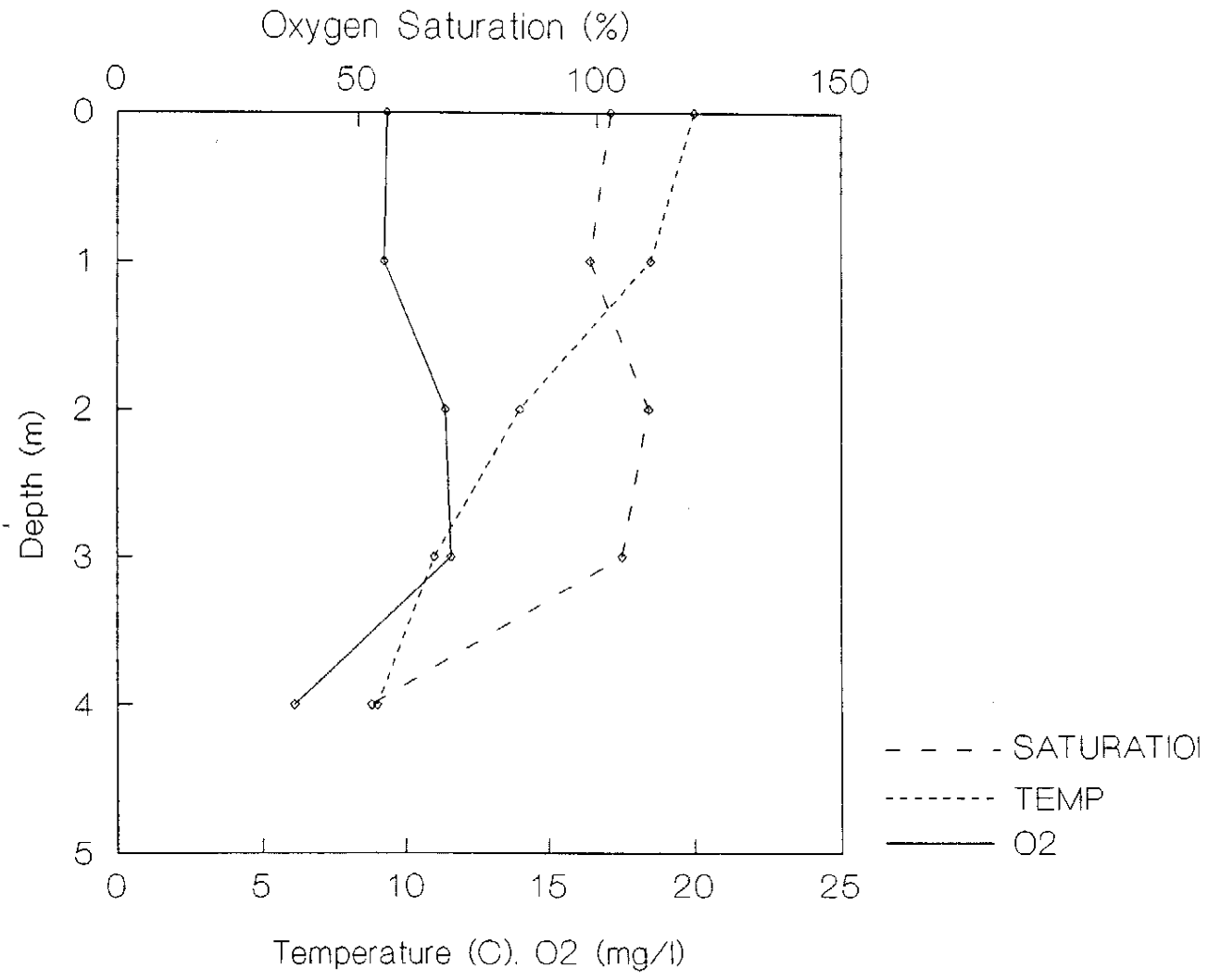
Appendix 5. % Surface oxygen, depth and temperature in Mullahy Lake



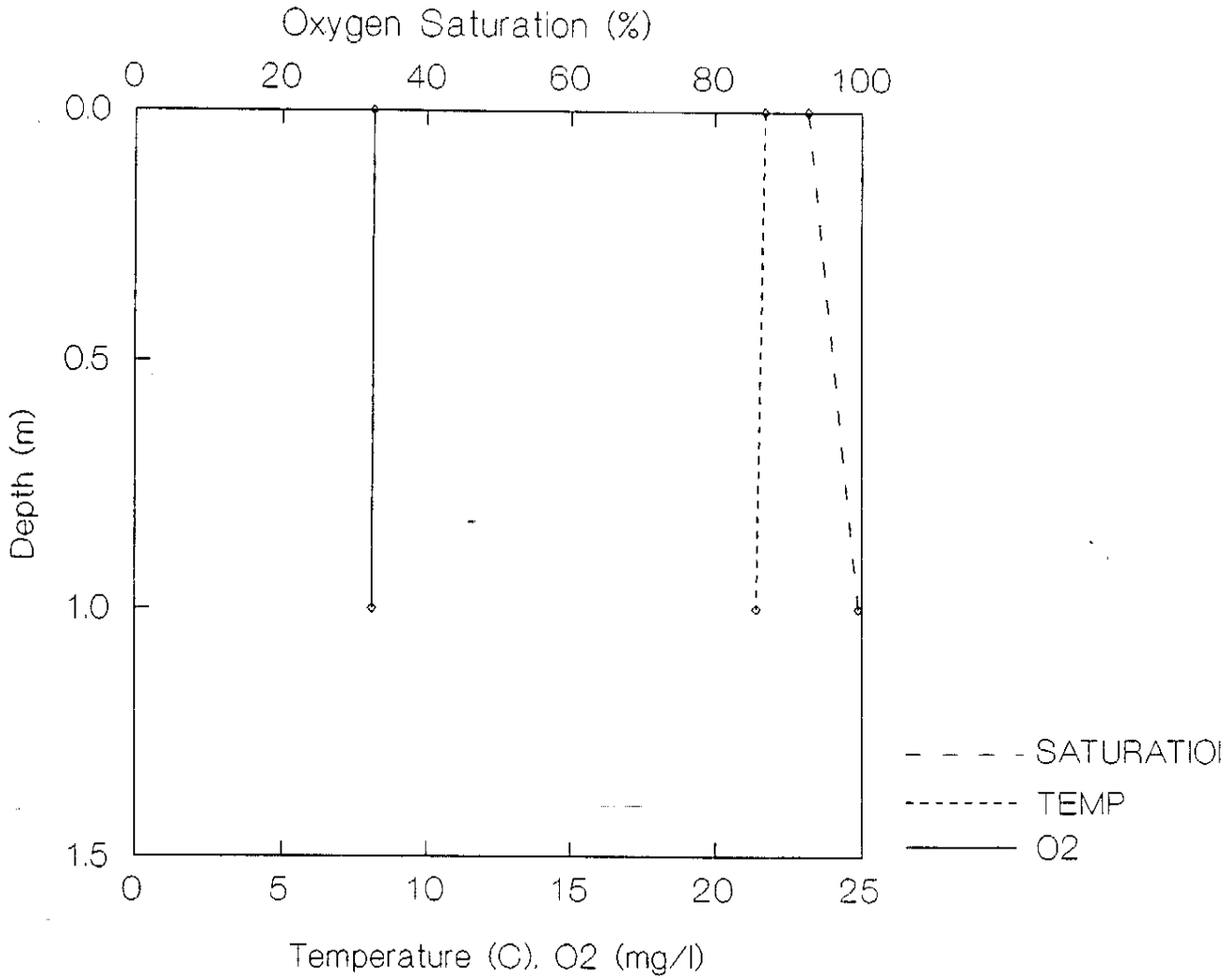
Appendix 6. % Surface oxygen, depth and temperature in Nansen Lake



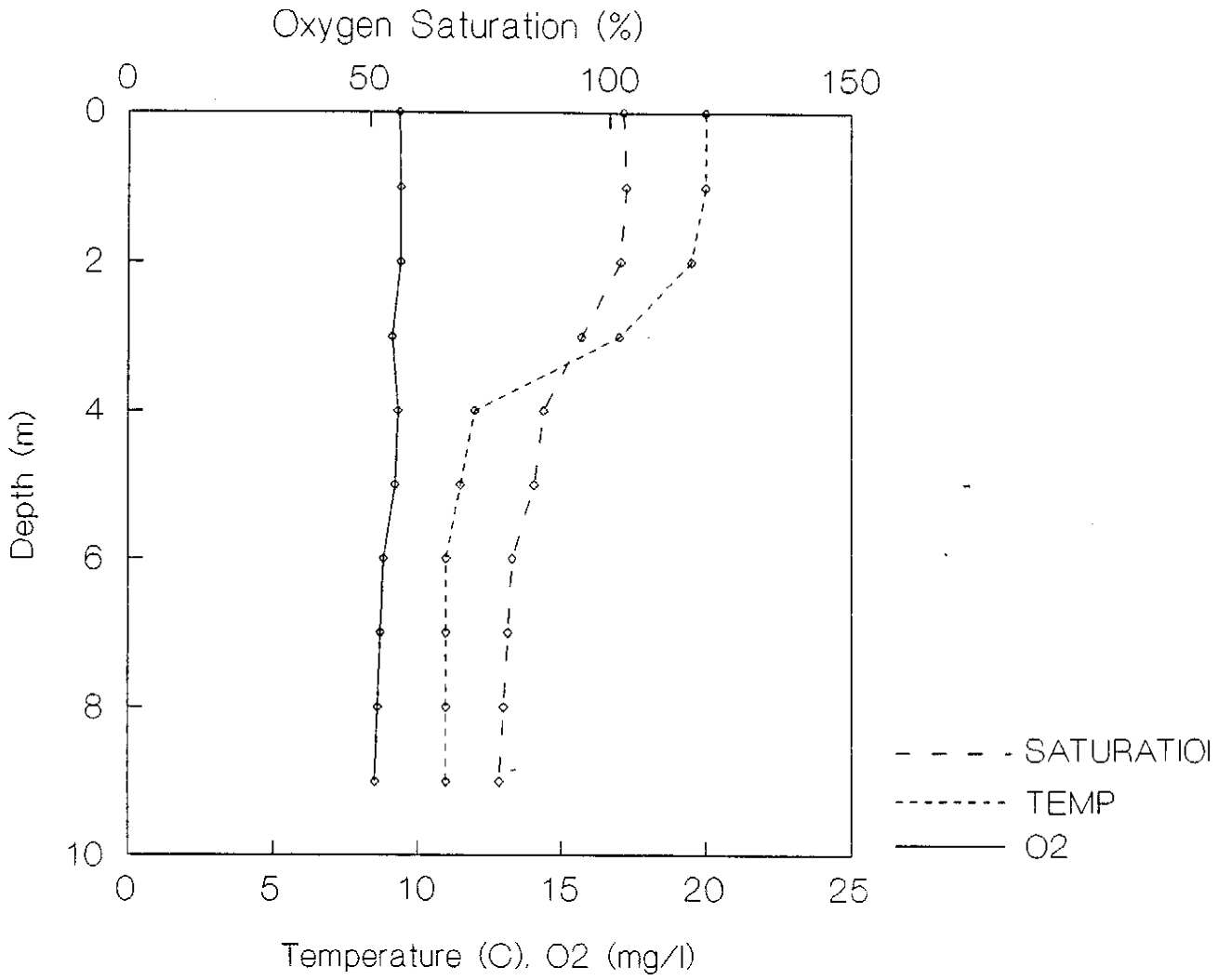
Appendix 7. % Surface oxygen, depth and temperature in Raspberry Lake



Appendix 8. % Surface oxygen, depth and temperature in Tenderfoot Creek



Appendix 9. % Surface oxygen, depth and temperature in Tenderfoot Lake



Appendix 10. % Surface oxygen, depth and temperature in Ward Lake