THAMES RIVER BASIN
WATER MANAGEMENT STUDY
TECHNICAL REPORT

BIOLOGICAL STUDIES
(1970-1973)

1976

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Ministry
of the
Environment

The Honourable
George A. Kerr, Q.C.,
Minister

Everett Biggs,
Deputy Minister

Biological Studies

Conducted
on the
THAMES RIVER BASIN

(1970-1973)

by
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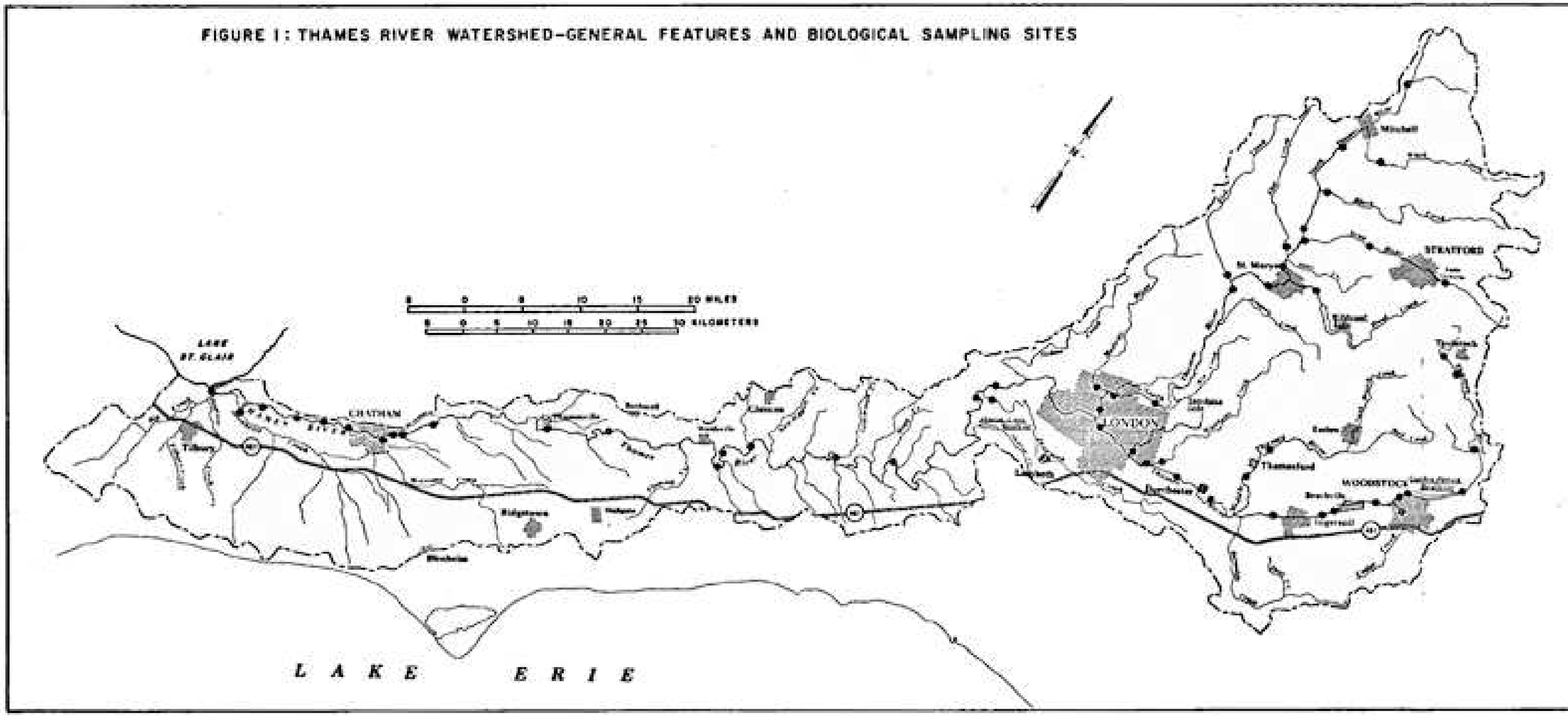
INTRODUCTION

A series of biological studies on the Thames River watershed were implemented to illustrate the effect of various water use practices on aquatic life and to recommend proper watershed management approaches designed to provide water of a satisfactory quality to support a healthy biotic system and to optimize water use. A detailed study of bottom-dwelling organisms was conducted at eighteen sites on the portion of the river flowing through London during the summer of 1970. In 1971, a survey of bottom fauna and fish populations was completed at 58 stations distributed throughout the entire watershed (Figure 1). Finally in 1973, a study of three flood control impoundments in the Upper Thames River basin was undertaken.

FISH

Fish populations were sampled qualitatively at nineteen sites on each of the North and South Thames sub-watersheds and at fourteen stations on the Lower Thames River during the summer of 1971. Owing to the variability in the physical nature of the river from upper to lower reaches, collection methods were not consistent. A representative sample of fish was obtained at each station by taking from one to three hauls with a 30-foot bag seine or a single haul using a 100-foot

FIGURE 1: THAMES RIVER WATERSHED–GENERAL FEATURES AND BIOLOGICAL SAMPLING SITES



bag seine in the lower reaches. For the most part, identification of fish to species was carried out at the time of collection and most specimens were returned to the stream. Samples of more difficult species were preserved and returned to the London Laboratory for identification.

RESULTS

In all, a total of 44 different species of fish including 10 game species were captured in the Thames River Basin. Smallmouth bass, rock bass, suckers and carp were gamefish common to the North, South and Lower Thames. The greatest variety of gamefish was restricted to the Lower Thames where artificial barriers did not interfere with the movement of populations between the lake and river environment. A number of species restricted in their distribution and considered somewhat rare in Ontario waters were collected during the survey. These included the sand darter, green-side darter and the least darter.

North Thames Watershed:

Table I of the Appendix indicates the number and species of fish collected from the North Thames River. A total of 26 species including five sports species were captured at 18 stations sampled (Figure 2). Smallmouth bass occurred at ten of the sites while other less popular gamefish (rock bass, bullheads, etc.) were found at an additional five locations. Size of fish increased with progress downstream.

From TN1 in the headwaters of the North Thames to TN4 just upstream from St. Marys, a total of only seven different species were captured in the mainstream. The population was not diversified (only four species per station) and numbers of fish per station were low partially the result of sampling difficulties at two stations. Although the widely distributed common shiner and white suckers dominated numbers at each location, smallmouth bass were present at three of the four stations.

Streams tributary to this stretch generally were characterized by a greater variety of fish and several species occurred only in the tributaries. Rockbass replaced smallmouth bass as the dominant gamefish. Greatest variety was exhibited on the Avon River upstream from Stratford where a population of over 200 individuals yielded a total of fourteen different species. Downstream from Stratford, variety was markedly reduced and sports species were rare or absent.

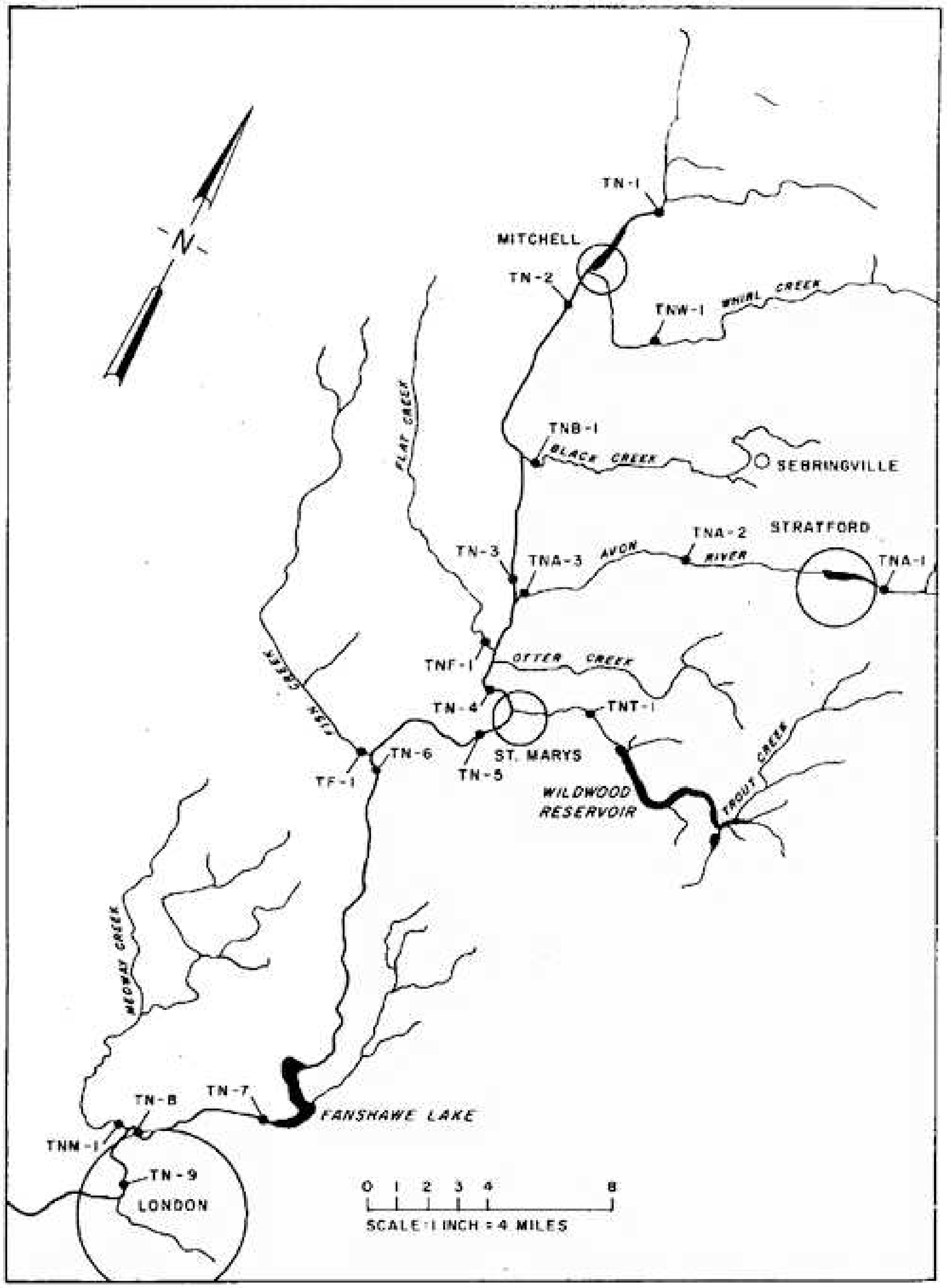


FIGURE 2: Biological Sampling Sites On The North Branch Of The Thames River (1971)

The Avon River above Stratford and Trout Creek below Wild-wood produced species such as the golden shiner, green-side darter and blacknose shiner found rarely elsewhere in the watershed.

An average of six species of fish per station were captured at the five sampling sites on the mainstream between St. Marys and the confluence of the North and South Thames in London. Generally, numbers of fish per station were depressed, but low flows and unfavourable bottom types at TN6 and TN7 were more likely responsible for the poor fishing returns than water quality impairment at these two locations. Common shiners constituted the majority of the fish populations at most stations although white suckers and smallmouth bass were most widely distributed occurring at each of the five stations sampled in this reach. As in the upper reach, fish populations in the tributary streams (Fish Creek, Medway Creek) contained species limited in their distribution including longnose dace, hog suckers and fantail darters.

Since 1969, a total of eight incidents involving the mortality of abnormal numbers of fish have been reported and investigated in the North Thames watershed. Table 1 documents the location, severity and causes of each fish kill investigated by the Biology Section.

TABLE 1: A summary of fish mortalities reported in the North Thames River basin from 1969 to 1973.

Water Body	Location	Severity	Cause
1969			
Trout Creek	Wildwood Lake	Moderate*	Natural
N. Thames R.	Brodhagen (Logan Twp.)	Moderate	Agricultural (Pesticides)
Wye Creek	Thorndale	Moderate	Dairy Wastes
Medway Creek	Hwy.22	Moderate	Agricultural (Fertilizer)
1970			
Black Creek	Sebringville	Moderate	Feed Mill Wastes
N. Thames (London)	Blackfriar's Bridge	Minor**	Chemicals washed to storm drain during fire
1971			
Avon River	above Stratford	Minor	Natural
Medway Creek	N.E. tributary	Moderate	Domestic and or Animal wastes
1972			
None Reported			
1973			
None Reported			

* 100-1000 individuals killed; ¼ - 1 mile stream affected.

** less than 100 individuals killed; limited stretch of river affected

Six of the mortalities were judged as moderately severe while two were regarded as minor. One half of the incidents were related to some facet of agribusiness and two were attributed to natural causes. Of the remaining mortalities, a minor incident was the result of herbicides being washed into a storm drain leading to the river during fire-fighting activities at a warehouse in London while the exact cause of the other was undetermined.

South Thames River:

A list of numbers and species of fish collected from the South Thames River is presented in Table II of the Appendix. Twenty-three species including seven gamefish were found at the 19 sampling sites (Figure 3). Two darters rather limited in their occurrence in Southwestern Ontario streams, were captured in the South Thames.

From Tavistock to Innerkip (TS1 to TS4), an average of eight species per station were collected. Populations which for the most part exceeded 100 individuals per station were dominated at each sampling site by common shiners. The population structure shifted from a variety of minnows and no sports species at TS1 and TS2 to limited minnow diversity and the occurrence of rock bass and smallmouth bass at stations TS3 and TS4.

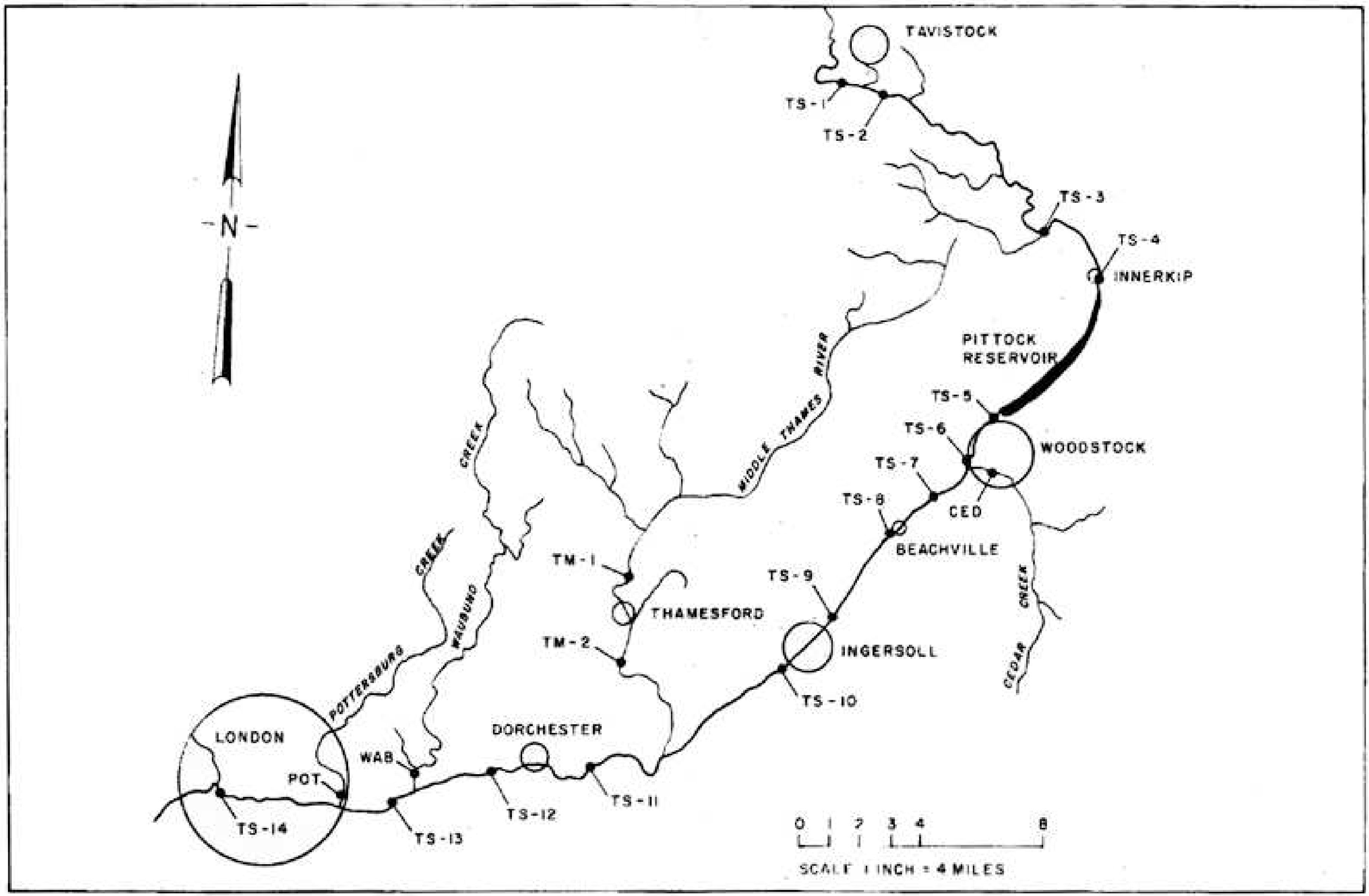


FIGURE 3: Biological Sampling Sites On The South Branch Of The Thames River (1971)

In the reach from the Pittock reservoir to Beachville, numbers of taxa per station averaged 7.5 at the four sites sampled (TS5 - TS8). Although game species such as rock bass, smallmouth bass and pike were well represented in the samples collected immediately below the reservoir at TS5, fish did not appear healthy and heavily-fungussed, two to three-inch brown bullheads and suckers were found dead or dying in large numbers.

The widely-distributed common shiner dominated populations through Woodstock at Stations TS6 and TS7 where a reduction in variety and the occasional capture of gamefish reflected impaired water quality. Despite difficult seining conditions at TS8 upstream from Beachville, an increase in variety to eleven species and the firm representation of sports fish in the population exemplified improved water quality at this point. Nine species including the rarely-found black-side darter were collected near the mouth of Cedar Creek, a tributary stream entering the South Thames in Woodstock.

From Beachville to the confluence of the North and South Thames in London, the average number of species per station was reduced to five, and numbers of fish per station seldom exceeded fifty. Smallmouth bass were not captured at any of the six stations sampled in this stretch of the mainstream. At TS9, and TS10 upstream and downstream of Ingersoll, respectively, low numbers of only three or four species of widely distributed coarse fish were found.

Sampling conditions were excellent and these poor results are attributed to impaired water quality. Diversity gradually increased with progress downstream but recovery of the population to upstream quality was incomplete at TS14 in London.

Upstream and downstream of Thamesford on the Middle Thames River, sports species including smallmouth bass collected below the town were represented in a fish association usually found in water of good quality. Although smallmouth bass were observed in Waubuno Creek, limited numbers and variety and several dead chub were found. Only the hardiest species were collected from Pottersburg Creek where the population was dominated by 500 common shiners.

From 1969 to 1973, a total of ten fish kills were investigated on the South Thames River. As illustrated in Table 2, three of the mortalities were attributed to natural causes and the cause of one was not conclusively diagnosed. Municipal-industrial and agribusiness discharges each were responsible for three incidents. Four of the fish kills were judged as severe according to the number of fish involved and the length of stream affected.

TABLE 2: A summary of fish mortalities reported in the South Thames River basin 1969 - 1973.

Water Body	Location	Severity	Cause
1969			
South Thames	Beachville	Moderate	Undetermined
South Thames	London	Severe	Municipal Wastes
1970			
None Reported			
1971			
S. Thames Trib.	Shakespeare	Severe	Agricultural (Pesticides & Fertilizer)
Pittock Reservoir	Woodstock	Moderate	Natural
South Thames	Ingersoll	Severe	Ind. Wastes
South Thames	Centreville	Severe	Ind. Wastes
S. Thames Trib.	E. of Woodstock	Moderate	Agricultural (Feedlot Run-Off)
1972			
Pittock Reservoir	Woodstock	Moderate	Natural
Waubuno Creek	N. Dorchester Township	Minor	Agricultural (Silage)
1973			
Shakespeare Pond	Shakespeare	Minor	Natural

Lower Thames River:

Numbers and species of fish collected at fourteen stations (Figure 4) on the Lower Thames River are presented in Table III of the Appendix.

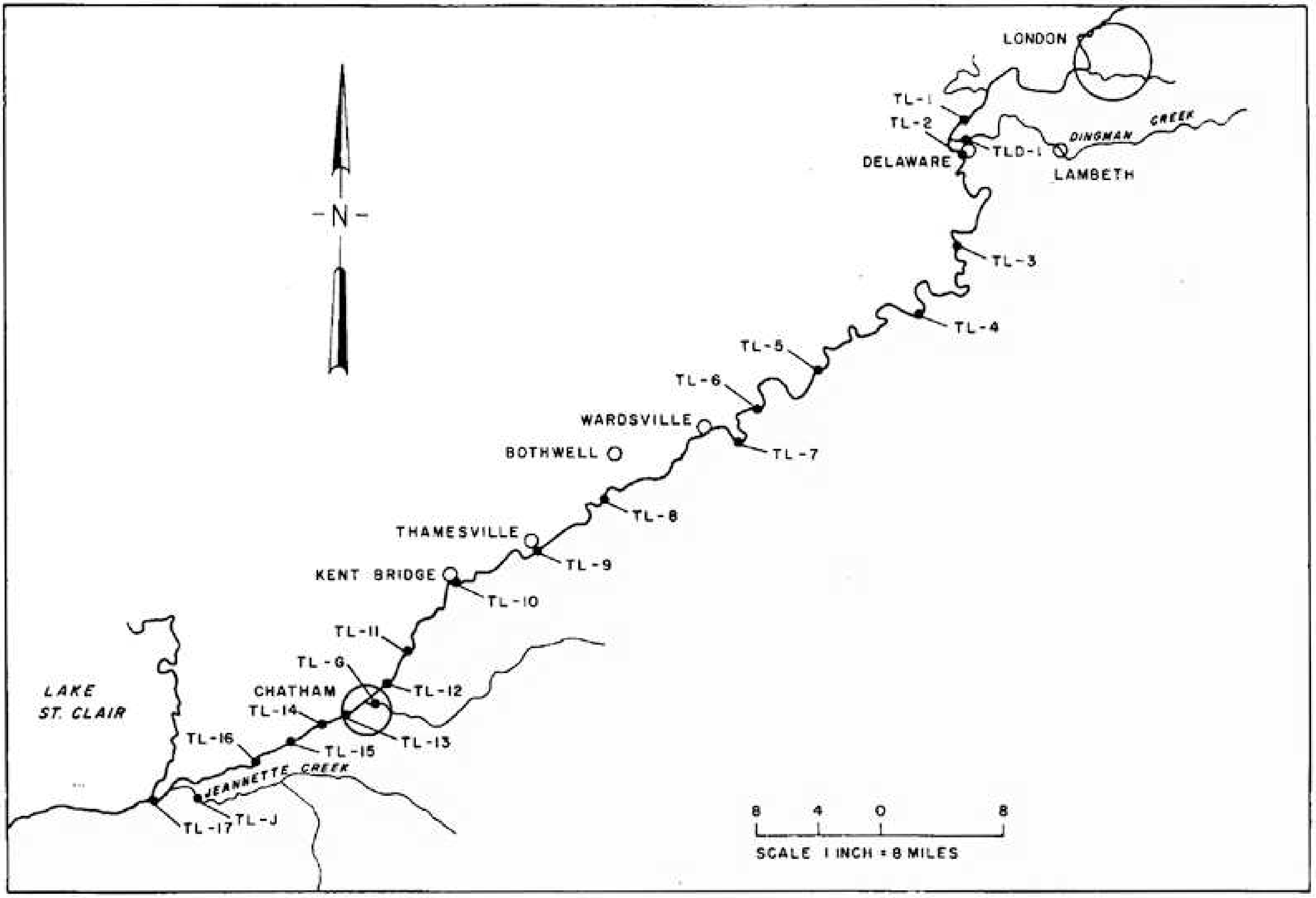


FIGURE 4: Biological Sampling Sites On The Lower Thames River (1971)

Twenty-five species of fish including ten sports species were taken during our sampling effort. Two additional sports species (yellow pickerel and pike) are common in the Lower Thames but were not collected because of the time of year and sampling difficulties.

From TL1 at Kilworth Bridge to TL3 at Muncey, variety and numbers of fish collected were suppressed but sampling was difficult in this swift, rocky stretch. It is interesting to note that young-of-the-year of two lake species -- the quillback carpsucker and the channel catfish--were found this far upstream, indicating an earlier spawning run. It is well known that in the spring, suckers and pickerel are involved in strong migrations to Kilworth Bridge about three miles from London.

From Bothwell (TL8) to Lake St. Clair, lake species became very common with gizzard shad dominating populations. Although conditions for seining at TL9 below the Hwy. 21 bridge were good, few fish were captured. From Kent Bridge downstream, the movement of lake species into the river resulted in a major increase in numbers of individuals.

The popularity of sports fishing in the Lower Thames should be pointed out. Smallmouth bass, largemouth bass, yellow pickerel, channel catfish, white bass, carp and yellow perch are common catches in the lower reaches. Upstream to the Komoka-Kilworth area, spawning runs of pickerel and suckers produce excellent angling in the spring. Recent introductions of chinook and cohoe salmon have increased the already broad spectrum of sports species available.

Three of four fish mortalities reported and investigated in the Lower Thames River Basin were regarded as severe and occurred on one stream - Dingman Creek. As indicated in Table 3, two of the incidents on Dingman Creek were related to agribusiness while the other was caused by plating wastes. A discharge of municipal and industrial wastes through a storm sewer in Chatham caused the other fish kill.

TABLE 3: A summary of fish kills reported in the Lower Thames River Basin from 1969 - 1973.

Water Body	Location	Severity	Cause
1969			
Dingman Creek	London	Severe	Plating Wastes
1970			
MacGregor Creek	Chatham	Moderate	Municipal -Industrial Wastes
1971			
Dingman Creek	Westminster Township	Severe	Agriculture (Silo Seepage)
1972			
Dingman Creek	London	Severe	Agriculture (Fertilizer Industry)
1973			
None Reported			

BOTTOM FAUNA

Among other factors, water quality strongly governs the distribution and abundance of aquatic organisms. Fish populations may respond to impaired water quality through acute mortality and complete elimination, a shift to more tolerant species or temporary avoidance until conditions return to normal. This latter mobility response often makes interpretation of water quality through the study of fish populations somewhat difficult and inconclusive.

For this reason, greater interpretive emphasis is placed on population studies of bottom dwelling animals. Bottom fauna organisms are virtually sessile; hence, the association collected at a specific location is representative of water quality at that sampling site. Since establishment of a strong population of bottom dwelling invertebrates may take several months, the study of this segment of the aquatic life system provides an indication of water quality over an extended time period. Thus, a comparison of variety and total numbers of bottom fauna organisms among strategically-located stations is an excellent tool to assess the quality of an aquatic environment. A clean-water association is usually characterized by a wide variety of species with no outstanding numerical abundance of one group. When subjected to toxic wastes or adverse environmental conditions, benthic associations become markedly depressed in both numbers and variety.

METHODS

The 1970 London survey was conducted during July at eighteen locations (Figure 5) situated between White's Bridge in the east and Fanshawe Dam in the north, to Delaware downstream from London. At most locations, three 1-square foot areas of stream bottom were sampled in a transect across the river using a Surber sampler. In addition, other habitats were sampled qualitatively at each station using a hand sieve. Where water depth precluded the use of a Surber sampler (e.g., Springbank Dam) bottom samplers were taken using a Ponar dredge.

The watershed survey of 1971 covered nineteen sites on each of the North and South Thames and twenty stations on the Lower Thames River (Figures 2, 3 and 4). At most collection sites, a 15-minute timed qualitative sample was taken on both sides of the river although Ponar dredge samples supplemented qualitative sampling in the deeper, slow- moving lower reaches.

In both 1970 and 1971, pertinent field observations such as the appearance and odour of the water and occurrence of aquatic weeds were documented. Invertebrate samples were preserved in 95% ethanol and returned to the London Laboratory for identification and examination.

London Survey:

Results of bottom fauna sampling in the London area may be found in Table IV of the Appendix.

At White's Bridge upstream from London on the South Thames, the presence of seven taxa of mayflies and four taxa of caddisfly larvae in a balanced and diverse bottom fauna population of 375 individuals per square foot indicated good water quality conditions. Sports-fishing at this reference location appeared to be popular. Diversity and numbers among the mayfly and caddisfly groups was markedly reduced downstream from the Highbury St. bridge, particularly in the north half of the river. However, the entire cross-section of the river was not effected nor were the less tolerant forms totally eliminated. Wastes from the Pottersburg sewage treatment plant were observed along the north shore at this site and the odour of the water was septic.

Severe interference with the bottom fauna association was evident downstream from the Vauxhaul sewage treatment plant. In all three samples, pollution-tolerant sludge-worms and midges dominated the 120 organisms per square foot and intolerant mayfly and caddisfly larvae occurred rarely. Roughly half the number of taxa collected at White's Bridge was found here. Septic conditions were further illustrated by the widespread occurrence of sewage fungus on the riverbed and reduced oxygen concentrations which were depressed to below 5 ppm. Neither number nor variety of

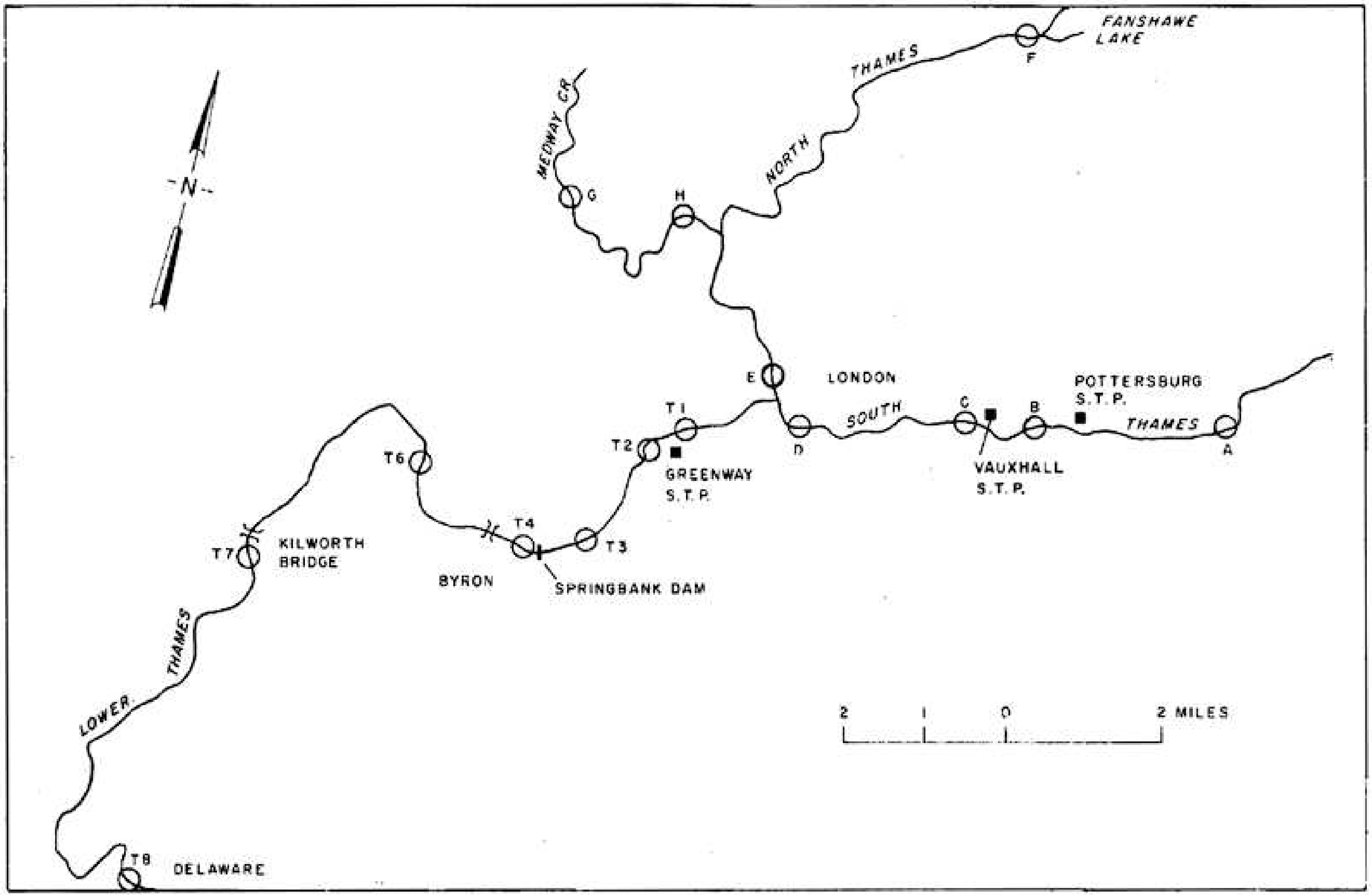


FIGURE 5: Biological Sampling Sites On The Thames River In The London Vicinity (1970)

organisms approached upstream reference levels on the South Thames as far downstream as its confluence with the North Thames. A distinct chemical odour was evident in the river at this point.

Immediately downstream from the stilling basin of the Fanshawe Dam, extremely enriched conditions were exemplified by high numbers of hydropsychid caddisfly larvae, midge larvae and flatworms which dominated the population of 800 individuals per square foot. These organisms were abundant likely the result of the continuous supply of food in the form of phytoplankton from the impoundment. Tolerant forms were virtually absent at this point on the North Thames. A strong representation of mayfly larvae in a somewhat smaller population of 300 bottom fauna organisms per square foot just upstream from the confluence of the North with the South branch indicated somewhat improved water quality. The benthic association at two sites on Medway Creek were diverse and quite similar although growth of *Cladophora* at the downstream site was heavy.

Upstream from the Greenway sewage treatment plant on the main Thames only three taxa of tolerant forms were found in the population of 200 organisms per square foot dredged from the silt-gravel bottom. At two locations sampled in the backwaters of the Springbank Dam downstream from the Greenway plant, toxic conditions were illustrated by the severe reduction in numbers per square foot to 15 and 33 and presence of only the most tolerant forms. At Station T3 immediately upstream from the dam, water at the 18-foot mark contained only 3 ppm dissolved oxygen.

Downstream from the Springbank Dam, organic enrichment was illustrated by the high numbers of caddisfly, midge and blackfly larvae in population which exceeded 725 organisms per square foot. Intolerant forms were found rarely at this point where active decomposition appeared to have started. The water gave off a septic odour and rocks were slippery with a soapy film.

Variety of organisms remained somewhat depressed to the Kilworth Bridge although mayfly larvae gradually become reestablished at this point. Although the Oxford sewage treatment facility appeared to discourage active decomposition as indicated by the reduction in the bottom fauna population to 300 organisms per square foot, the effect was localized and numbers of organisms at Kilworth returned to the 600-700 individuals per square foot density found upstream at the Springbank Dam. Short algae scums were evident from Oxford Street to the Kilworth Bridge.

The high numbers of caddisfly, midge and blackfly larvae which constituted the majority of the 600 organisms per square foot population at Delaware indicated that organic decomposition prevailed to this point. However, the increase in variety to 20 different organisms found and the firm reestablishment in the association of tree genera of mayflies indicated improved water quality conditions. *Cladophora* and aquatic vegetation growth was heavier at this point. The bottom fauna association typical of the good water quality found at White's Bridge on the South Thames was not duplicated as far downstream from London to Muncey.

North Thames River:

From the eighteen sites sampled on the North Thames watershed, a total of 63 different macroinvertebrate taxa was found. This figure which represents an extremely wide variety of organisms included diverse mayfly and caddis-fly populations. Results are provided in Table V (Appendix).

Upstream from Mitchell, the bottom fauna association contained a good variety of pollution-intolerant mayflies, but the small population collected in the 15-minute qualitative sampling (29 organisms) suggested intermittent streamflow. Similar numbers (26 organisms) were found downstream from the town and, aside from a significant reduction in the variety of mayflies collected, diversity above and below Mitchell was virtually identical suggesting that critical streamflows rather than inputs from Mitchell were responsible for the stunted population. Although waste discharges from Mitchell did not seriously affect bottom fauna associations, bluegreen algae scums were prevalent downstream from the municipality. Variety and numbers of organisms increased gradually with progress downstream to the junction of the North Thames with the Avon River and growth of aquatic vegetation occurred in minor proportions to this point. At TN3, the ponded area near the bridge was utilized by local children for swimming.

Immediately upstream from St. Marys, a substantial increase in mayfly and caddisfly variety highlighted increased diversity and numbers to 24 and 121, respectively, in the bottom fauna association. This excellent diversity and the simultaneous occurrence of more prolific aquatic vegetation growth indicated well-aerated, nutrient-rich waters.

A major increase in the bottom fauna population to over 400 individuals coupled with a dramatic decrease in pollution-intolerant mayflies and caddisflies reflected the effect of organic enrichment from St. Marys on aquatic life. Luxurious filamentous algae growth indicated nutrient-enriched waters. A return to the benthic community of mayflies, an increase in variety of organisms to 26 and a decrease in numbers of organisms to 123 signalled major recovery at the Hwy. 7 bridge. Black ferric sulphide deposits on the bottoms of rocks encompassed by sediments which settled out noticeably in this stretch indicated anaerobic conditions at the mud-water interface.

Nutrient-enriched water was illustrated by prolific growths of *Cladophora* on shoreline rocks and bluegreen algae on bottom rocks immediately downstream from the Fanshawe Dam. Mayfly and caddisfly larvae were almost totally eliminated from the bottom fauna community and facultative flatworms, midge and *Physa* snails dominated the population.

Greatest degradation of water quality on the North Thames was reflected by the bottom fauna association collected just upstream from the Richmond Street Bridge in London. Only six different types of organisms - mostly pollution tolerant midges and leeches - were found in a population of almost 400 individuals indicating organically-enriched conditions. Blackened rocks suggested anaerobic conditions in bottom waters. The river gave off a sewage odour at this point. An increase in variety to 15 including both mayfly and caddisfly larvae and a reduction in numbers of organisms to 60 illustrated that the river had recovered significantly at Blackfriar's Bridge just upstream of the confluence of the North and South Thames. Weed growth covered approximately 85% of the riverbed at this point.

Samples were collected only near the mouth of most major streams tributary to the North Thames although the Avon River was sampled at three sites. A good variety of benthic animals (greater than 20 taxa) and normal numbers (about 100 organisms) were found at the mouths of Fish, Flat, and Medway Creeks, although the nutrient- rich symptom of heavy *Cladophora* growth found in 1970 on Medway Creek was confirmed in the 1971 survey. In populations collected from these three creeks, mayfly and caddisfly larvae were well represented indicating that water quality was not seriously impaired. Extremely low flows were discharging from Flat Creek and during drought conditions, water quality could rapidly change at this location.

Low numbers of organisms collected from Black and Whirl Creeks suggested intermittent streamflow although intolerant forms were well established in the population found in Black Creek. Facultative or tolerant forms dominated the population of 125 macroinvertebrates downstream from the Wildwood Dam. Intolerant mayflies and caddisflies were rarely found, likely the result of the low dissolved oxygen concentration of 3.5 ppm recorded at 11 a.m. at this station. Anaerobic reservoir water discharged by low-levels valves at the dam was likely responsible for the depressed levels of oxygen.

On the Avon River below Stratford, intolerant forms were virtually nonexistent and populations approached 300 organisms indicating organically enriched water quality. Considerable but incomplete recovery was evident at the mouth of the Avon, but high numbers of tolerant or facultative forms prevailed. The presence of high nutrient burden in the Avon was exemplified by heavy growths of aquatic vegetation from Stratford to its junction with the North Thames.

South Thames River:

A total of 60 taxa of bottom-dwelling macroinvertebrates were collected from the 19 sampling points on the South Thames watershed. The bulk of this variety was found at only three stations on the mainstream and at two tributary streams. Results are provided in Table VI (Appendix) Upstream from Tavistock, the bottom fauna association was varied but the population was dominated by facultative forms and very little variety was encountered in the intolerant mayfly and caddisfly groups.

This symptom of subtly impaired water quality prevailed downstream from Tavistock where variety was slightly decreased and facultative forms more greatly dominated somewhat higher numbers. Floating bluegreen algae matts were observed at this point. Low flows and minor inputs of domestic and agricultural wastes are likely responsible for these results. Cattle were observed drinking from the stream in the

Tavistock vicinity.

A greater variety of mayfly and caddisfly larvae in well-balanced bottom fauna populations and an increase in overall variety to 24 different organisms at Innerkip signalled an improvement in water quality to that point. *Cladophora* and aquatic weed growth prevailed from Tavistock to Innerkip where the substrate was suitable.

The faunal association immediately downstream from the Pittock reservoir in Woodstock reflected sudden water quality impairment. Only 13 different taxa were found in the population of 160 organisms which were mainly pollutant-tolerant sludgeworms and midges. Growth of aquatic weeds and *Cladophora* was heavy. The heavy deposition of silt below the dam likely accounted for the density of sludgeworms and midges in the population. A further decrease in variety of organisms to 12, the complete elimination of intolerant mayfly and caddisfly larvae, and the increase in numbers of organisms (mostly sludgeworms) to 350 illustrated the response of the benthic community to organic enrichment from Woodstock.

Water was black and an odour characteristic of wastes from the textile industry accompanied the sewage smell given off by the river. Nutrient-rich water was exemplified by the heavy growth of bluegreen algae on the river bottom. Serious impairment of water quality by the organic load from Woodstock extended to-station TS7, half-way between Woodstock and Beachville. Intolerant forms were still absent from the bottom fauna population which increased to over 500 individuals. About 80% of the organisms found were sludgeworms which thrived in the large quantities of silt which settled out in this area. A textile odour still emanated from the water and aquatic vegetation or *Cladophora* (substrate permitting) covered 50% of the bottom.

At Beachville, some recovery was evident as the population dropped to 100 organisms and variety increased from 10 at TS7 to 14. Sludgeworms made up an insignificant portion of the population although mayflies and caddisflies were found rarely. *Cladophora* covered about 35% of the bottom which received a major solids burden from siltation.

Immediately upstream from Ingersoll, a further increase in different types of bottom fauna organisms to 17 was in part, the result of the return of mayfly and caddis-fly larvae to the association. Aquatic weeds, *Cladophora* and bluegreen algae growth covered about 50% of the riverbed. This recovery upstream from Ingersoll appeared to be shortlived as over 650 organisms (mostly tolerant slugeworms and midge larvae) were found immediately downstream from Ingersoll. This dense population plus the presence of a few mayflies indicated an organically polluted but well aerated riffle. The growth of *Cladophora* or any suitable substrate was evidence of nutrient-rich water.

Downstream from the Highway 73 bridge, variety in the benthic community increased to 19 including six different genera of mayflies illustrating water of good quality. Recovery appeared complete judging by a reduction in numbers of organisms to 90 and the balanced nature of the bottom fauna association. Nutrient concentrations were still adequate to support moderate growth of aquatic vegetation and *Cladophora.*

Although 25 different types of bottom fauna organisms were found downstream from Dorchester at the Highway 74 bridge, a higher population (300 organisms) and an imbalanced community illustrated minor organic enrichment. The high variety and presence of good numbers of mayflies indicated that concentrations of dissolved oxygen were not critically affected by the organic burden under survey flow conditions. The presence of solid refuse in the river and heavy *Cladophora* growth rendered this stretch aesthetically unpleasing.

The effect of inputs from Dorchester was neutralized at White's bridge upstream from London since variety remained high (23 different taxa) and the population was halved. The presence once again of six mayfly genera in a balanced community indicated that water was of good quality for desirable fish food organisms. Heavy *Cladophora* growth prevailed. Near the mouth of the South Thames, toxic conditions were exemplified by a major reduction in variety to ten different forms in a relatively small population. Intolerant organisms were found rarely and facultative or tolerant midges constituted over 75% of the population. Aquatic vegetation cover was heavy. River water gave off a septic odour.

Water in major streams tributary to the South Thames was either of excellent or very poor quality. Balanced populations with extremely varied mayfly and caddisfly representation reflected the excellent water quality in the Middle Thames River both upstream and downstream from Thamesford. Aquatic vegetation was present at both sampling sites although bottom cover was limited to only 40% downstream from the town. Balanced populations including a good variety of intolerant bottom fauna organisms were also found at the mouth of Waubuno Creek. Solid litter cluttering the streambottom detracted from the good water quality found at this site.

In contrast, only 12 individuals of six different types were found at the mouth of Cedar Creek in Woodstock. Low levels of dissolved oxygen (1 ppm) certainly contributed to the limited scope of aquatic life which typified toxic wastes. Bedsprings and other refuse littered the bottom.

Similar garbage was found at the mouth of Pottersburg Creek where the bottom fauna association suggested a major burden of organic wastes. Virtually all of the 375 organisms collected were tolerant midges or sludgeworms. Only four additional types of organisms were found. An oily film covered the surface and a septic odour emanated from the creek.

Lower Thames River:

A total of 55 different bottom fauna organisms was found on the Lower Thames with the greatest variety concentrated in the upper half of the watercourse from London to Thamesville(Table VII - Appendix).

At Kilworth Bridge below London, a total of 200 organisms - mainly facultative forms - were collected. An unusually high number of pollution-tolerant leeches were found although the presence of two of the hardier mayfly genera among the 20 taxa found, indicated that dissolved oxygen concentrations in riffle areas at this point were not severely depressed. Growth of aquatic vegetation was sparse. Benthic macroinvertebrate populations continued to be dominated by facultative forms to Delaware where mayflies were found rarely. However, assimilation of much of the organic burden of the river causing the community imbalance upstream was illustrated by a decrease in the population to 120 organisms. The virtual elimination of mayflies at Delaware is attributed to a reduction in dissolved oxygen to critical concentrations during darkness as a result of respiration of aquatic vegetation which totally covered the riverbed at this point. At Muncey, considerable recovery was reflected by the presence of six different mayfly genera in the bottom fauna community. A balanced population including a wide variety of mayfly larvae and productive clam beds indicated good water quality at Melbourne.

Number of taxa found at Tate's Bridge was reduced to eight and the population to 60. However, the presence of the mayfly genera including two burrowing species (*Ephoron* and *Hexagenia*) suggested that rather than an acutely toxic waste input, subtle physical factors such as silt deposition was responsible for the limited diversity. Similarly, at the Woodgreen Bridge, qualitative sampling in an even flow area because of the absence of a riffle is the most likely explanation for the abnormally unproductive benthic community found. Intolerant mayflies and large clams persisted here.

The collection once again of a wide variety of mayfly larvae among the 20 different forms represented in the balanced bottom fauna association found at Big Bend reflected the good water quality which prevailed in the stretch between Muncey and Wardsville. Population imbalance as illustrated by a preponderance of the widely distributed caddisfly *Cheumatopsyche* among the 250 organisms was indicative of organically enriched water downstream from Bothwell. The continuing presence of mayflies and unionid clams in the association suggests that dissolved oxygen concentrations do not fall to critical levels.

At Thamesville, increased variety in the mayfly segment of the bottom fauna association and a more diverse caddisfly population, signalled significant recovery although blackfly larvae dominated numbers. From Muncey to Thamesville, water was turbid from a heavy silt burden, likely accounting for the lack of prolific growth in aquatic vegetation observed in this stretch.

From Kent Bridge to Lake St. Clair, a deepening of the river to 10 or 15 feet necessitated the implementation of dredging techniques to complement shoreline qualitative sampling. This change is partially responsible for a major shift in the types of organisms collected in the lower reaches compared to those found at stations upstream from Kent Bridge. At the three stations from Kent Bridge to Chatham (TL10-12) number of taxa found varied from six at TL12 to ten at TL11.

Numbers per square meter ranged from 30 at TL10 where the north half of the riverbed was shale to 180 at TL11 where sediments were more amenable to bottom-dwelling animals. At each of these stations intolerant forms such as mayfly larvae or unionid clams were found.

Within Chatham in the stretch of river parallelling the K-Mart Plaza, full dredges containing a fine organic detritus yielded a solitary midge indicative of sterile conditions at that point. Impairment was further illustrated downstream from the Chatham sewage treatment facility where only tolerant midges and sludgeworms constituted the entire population of 80 organisms per square meter. Both dredges taken were filled with organic, oozy sediments which gave off a septic odour. An oil slick observed while sampling was traced to a storm drain on the south side of the river downstream from the sewage treatment plant.

Although decomposition appeared more active at the Paincourt Road judging by higher numbers of worms and midges, bottom fauna populations from this point to Lake St. Clair were basically unproductive. Bottom type in this stretch could best be described as an oozy slurry. This impermanent substrate, continuous dredging and dyking activities plus reversible flows in the lower reaches combine to produce an unstable benthic environment - the most probable reason for such depressed bottom fauna associations.

Samples were collected at the mouths of four streams tributary to the Lower Thames. Spring's Creek just upstream from Kilworth appeared to be of good quality by the occurrence of intolerant stoneflies, mayflies and fishflies in the small population of 40 organisms. Facultative forms dominated the bottom fauna community at the mouth of Dingman Creek near Delaware. Below the Princess Street bridge in Chatham, water quality of the McGregor Creek appeared impaired as indicated by the limited population of benthic animals, the presence of garbage on the streambed and by the sewage odour which emanated from the water. Similar limitations to those which prevailed in the main Thames below Chatham applies to Jeannett's Creek where the bottom fauna population was also unproductive.

RESERVOIR STUDIES

To define water quality in major flood control impoundments to the Thames River watershed, limnological studies were conducted on Fanshawe, Wildwood and Pittock reservoirs during the summer of 1973. In addition, the investigations were intended to aid in the formulation of a reservoir management approach which would optimize use.

Reservoir Descriptions

All of the dams are operated by the Upper Thames Valley Conservation Authority and are multipurpose in their use. Wildwood and Fanshawe reservoirs are located near St. Marys and London, respectively, on the North Thames watershed. The Gordon Pittock Dam is situated on the South Thames at Woodstock. Both Fanshawe and Pittock reservoirs regulate flows from rich agricultural drainage areas which, in combination with upstream industrial and municipal sources, accounts for the high fertility of impounded waters.

Wildwood Dam is situated in a deep valley created by a glacial meltwater stream and dams Trout Creek - a tributary of the North Thames. The lack of significant industrial or municipal nutrient inputs upstream and the relatively unproductive farmland through which the creek flows accounts for the lower fertility of Wildwood Lake. Pertinent physical data for each reservoir are presented in Table 4.

Table 4: Physical information at normal operating levels for three flood control reservoirs situated in the Upper Thames watershed.

	FANSHAWE	WILDWOOD	PITTOCK
Surface Areas(acres)	645	960	610
Volume (acre feet)	10,033	14,480	4,750
Depth - average (feet)	15.5	15.0	7.8
- maximum			
Drainage Area (sq. mi.)	560	54.6	93.5
First operating year	1953	1965	1967
Mode of discharge	Surface or low-level	Surface or low-level	Surface or low-level

Methods

Routine Monitoring:

At each impoundment, a close surveillance of phytoplankton populations and water quality with depth was maintained from mid-June through late August. With co-operation of personnel from the Upper Thames River Valley Conservation Authority, phytoplankton and chlorophyll samples were collected weekly through a column of water approximating the depth of significant light penetration. Appropriate preservative was added to each sample which then was forwarded to the MOE Laboratory in Toronto for analysis.

Once every two weeks at three sites on Fanshawe Lake three on Wildwood Lake and at two sites on Pittock reservoir, dissolved oxygen and temperature determinations were conducted at five-foot intervals with depth. At each station on each reservoir, two 32-ounce water samples were collected at the surface and five feet above the bottom. Parameters tested included BOD, nitrogen, phosphorus, pH and iron. Weather records were obtained from the London Weather Office.

Experimental:

In 1965, Johnson & Berst documented the effect of low-level discharge on the summer temperature and oxygen content of water in Fanshawe reservoir. The bottom-draw was shown to break thermal stratification making the impoundment virtually homothermous and to significantly reduce the volume of hypolimnetic water which was either low in or totally depleted of dissolved oxygen. Because of the positive implications to both fish culture and the control of chronic algae blooms by maintaining aerobic bottom waters, partial low-level discharge was employed during the summer of I973. Effects of the discharge, both on water quality and phytoplankton populations of the reservoir as monitored routinely and on downstream water quality immediately following discharge were investigated. Monitoring downstream was conducted at two-hour intervals in the spillway, at the Clarke Road bridge and at the Highbury Avenue bridge on the day preceding and on the first day of discharge. On July 17, the reservoir manager initiated low-level discharge at a rate of 40 cfs. This rate was emitted continuously throughout the summer through the low-level valves; the balance of flow was surface-drawn.

Results

Routine Monitoring:

Results of biological, physical and chemical data are presented in Tables VIII to X of the Appendix and illustrated in Figures 6 and 7 of the text.

Biological:

Compared to other Southwestern Ontario waters commonly used for recreational pursuits (Lake Huron at Grand Bend), average standing stocks of phytoplankton in all reservoirs were high (Table 5).

Table 5: Mean, maximum and minimum standing stocks of phytoplankton in five bodies of water in South-Western Ontario. (June to September 1973).

Water Body	Standing Stock (a.s.u./mL.)	
	Mean	Range
Lake Huron (Grand Bend)	202	4 - 625
Western Lake Erie (Ruthven)	3,723	1,670 - 8,059
Wildwood Reservoir	1,946	320 - 3,861
Fanshawe Reservoir	3,395	632 - 9,875
Pittock Reservoir	6,238	465 - 14,026

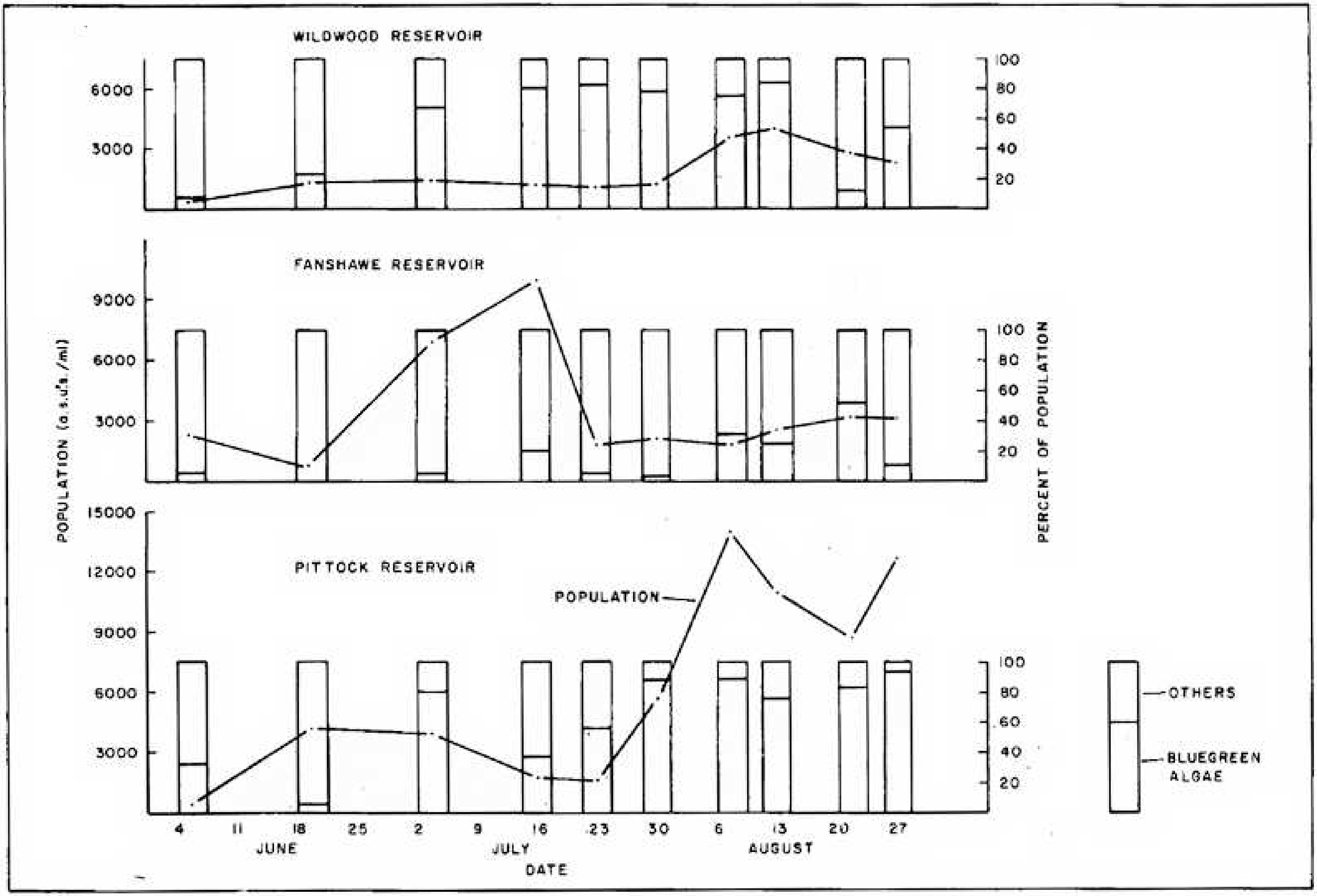


FIGURE 6: Numbers And Types Of Phytoplankton In Samples Collected From Three Reservoirs On The Upper Thames Watershed During The Summer Of 1973

The mean of algae counts on samples taken weekly from western Lake Erie at the Union water plant (M.O.E. data) was similar to the standing stock at Fanshawe which averaged 3,395 a.s.u./mL. Average counts at Pittock (6,238 a.s.u./mL) were almost double those from western Lake Erie. Samples from Grand Bend and Union were collected from intakes extending offshore rather than from a column through the entire photic zone and counts would be expected to be somewhat lower for this reason. However, both intakes are situated in relatively shallow nearshore waters which are well mixed and quantitative disparities resulting from differences in collection approaches would not be expected to be substantial.

Among reservoirs, mean populations varied from a low of 1,946 a.s.u./mL in Wildwood to a high of 6,238 a.s.u./mL at Pittock. As indicated in Table 6, chlorophyll a and water visibility data (as measured by the secchi disc) bear out this ranking. Waters from Wildwood were about twice as clear as Fanshawe and Pittock waters and average levels of chlorophyll a (4.5 µgm/L) were substantially lower. Mean chlorophyll a concentrations in Fanshawe Lake and Gordon Pittock reservoir were 9.6 and 18.4 µgm/L respectively.

While standing stocks at Wildwood and Pittock attained maximum levels in the first two weeks in August, populations were at their highest in Fanshawe during the first two weeks of July. From July 23 through the end of August, phytoplankton populations at Fanshawe were numerically similar to or less than those at Wildwood. In the same six-week period, algae counts at Pittock were at least double those of either of the other reservoirs and achieved a high of 14,000 a.s.u./mL.

Table 6: Chlorophyll a concentrations and secchi disc readings at three reservoirs in the Upper Thames River basin. (June - September 1973)

Reservoir	Secchi Disc (ft.)		Chlorophyll a (µgm/L)	
	Mean	Range	Mean	Range
Wildwood	6.1	3.5 - 10.5	4.5	(1.5 - 7.2)
Fanshawe	3.2	1.5 - 5.0	9.6	(4.6 - 15.5)
Pittock	3.1	2.0 - 5.5	18.4	(7.4 - 34.0)

Qualitatively, phytoplankton associations in both Wildwood and Pittock reservoirs again were similar while those in Fanshawe Dam did not follow the same pattern of development. Bluegreen forms (usually associated with eutrophic conditions) constituted over 75 percent of the phytoplankton population in 6 of I0 samplings at Pittock and 5 of 10 samplings at Wildwood.

Only once did bluegreen algae comprise 50 percent of the standing stock in Fanshawe. When populations attained "bloom" proportions on August 2 at Wildwood and Pittock, the bluegreen *Aphanizomenon* dominated. Population increases in Pittock later in August were the result of proliferations of the bluegreens *Anabaena* and *Microcystis. Aphanizomenon*, documented as the dominant in a "bloom" in 1972 at Fanshawe was not found in the summer of 1973 and green algal forms (particularly *Scenedesmus*) constituted over half the population on July 16 when the standing stock at Fanshawe peaked.

When algae counts were conducted, the presence and rough numbers of zooplankton organisms were documented. It is significant to note that for the most part, zooplankton populations found in samples from Fanshawe far exceeded those from other reservoirs. The grazing of these zooplankters upon algae populations in the reservoir would partially explain the lower phytoplankton numbers in Fanshawe during the summer of 1973.

Chemical

Results of chemical data collected from each reservoir are presented in Table 7 and Figure 7 illustrates dissolved oxygen and temperature profiles for Fanshawe Lake.

Fanshawe Lake (Figure 7) exhibited the lowest concentrations of dissolved oxygen and areas low in oxygen were distributed most extensively in this reservoir. Levels fell to below 2 mg/L at the 20 - 25 foot mark from July 3 to the end of August. The most extensive distribution of waters low in dissolved oxygen occurred on July 23 when it

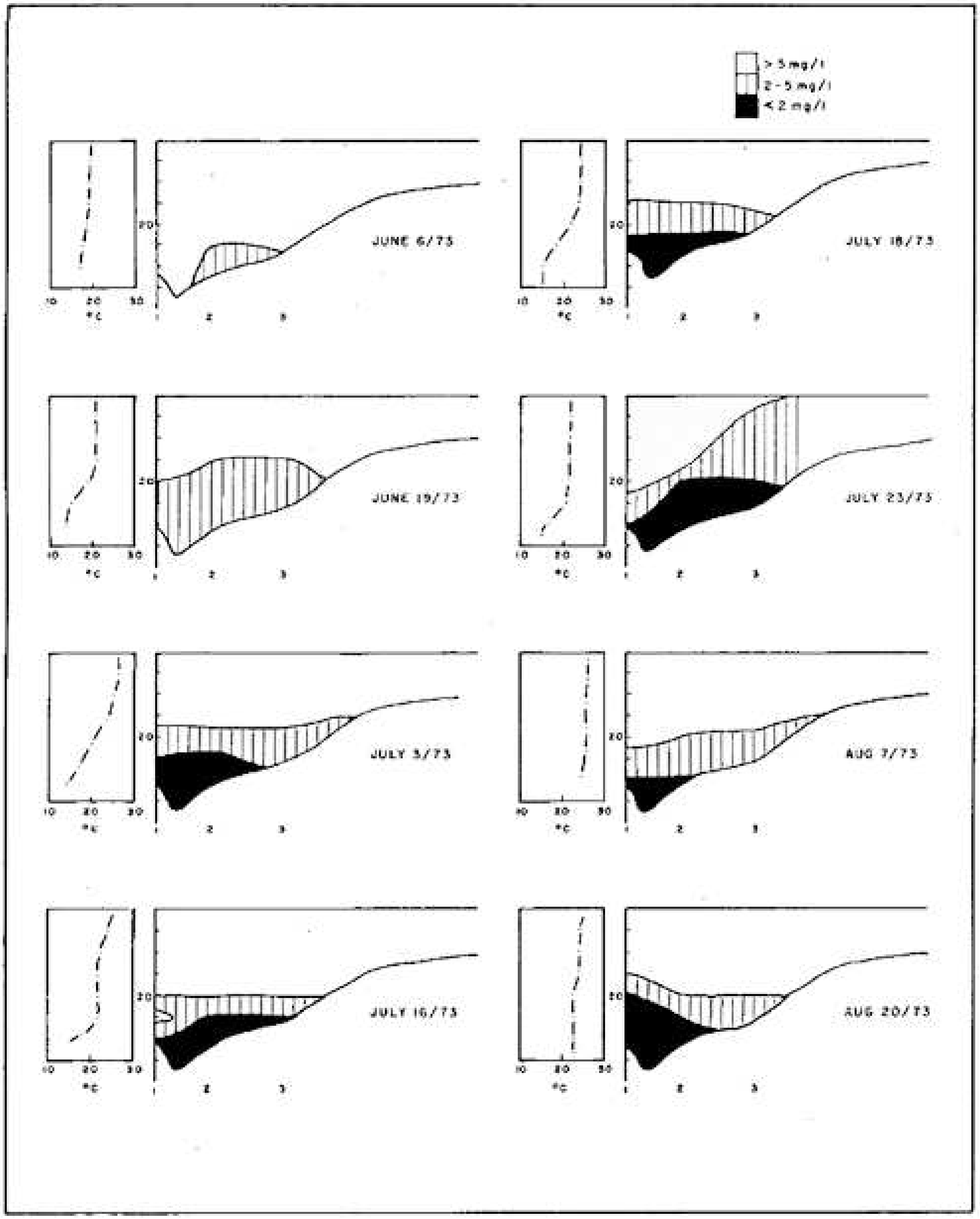


FIGURE 7: Dissolved Oxygen Concentrations And Temperatures With Depth At Three Stations On Fanshawe Lake (June - Sept, 1973)

appeared that about half of the reservoir water contained 5 ppm or less dissolved oxygen. Fanshawe was partially stratified thermally from June 19 to July 23. Dissolved oxygen levels did not fall below 2 ppm in Wildwood Lake and for most of the year were satisfactory for warm water fish. It is significant to note that thermal stratification did not occur during the study period. Only once in bottom waters did dissolved oxygen concentrations fall below 5 ppm in Pittock Lake. As in Wildwood Lake, the Pittock reservoir was homothermous throughout the summer of 1973.

In all reservoirs, the organic nature of both surface and bottom waters was similar although average levels of BOD among reservoirs varied considerably. Average concentrations were highest in Fanshawe (4.5 ppm) and lowest in Wildwood (1.7 ppm). In all three reservoirs, concentrations of ammonia and total phosphorus were higher in bottom waters than near the surface and for both parameters, Fanshawe again exhibited the highest averages and Wildwood the lowest.

The average total phosphorus concentrations in surface waters at Fanshawe and Pittock (82 ppb and 61 ppb respectively) were substantially higher than the average at Wildwood (31 ppb). Average iron concentrations in Fanshawe and Pittock reservoirs were similar and significantly higher than those from Wildwood.

TABLE 7: Average concentrations of various physical and chemical parameters in surface and bottom waters of three flood control reservoirs in the Upper Thames River watershed (June - September 1973).

- All results except temperature in mg/L.

RESERVOIR	PARAMETER												
	BOD		NH_3		pH		Tot. P		Sol. P		Fe		Temp.
	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	°C
Wildwood Surface	1.6	0.5-2.2	0.03	.01-.06	8.14	7.8-8.4	0.031	.016-.066	0.004	.001-.009	0.058	.05-.10	22.8
Bottom	1.8	1.0-3.4	0.13	.03-.31	7.84	7.2-8.1	0.048	.020-.096	0.007	.001-.028	0.32	.05-1.5	21.2
Fanshawe Surface	4.9	1.6-15	0.14	.01-.30	8.22	7.7-8.6	0.082	.045-.220	0.009	.002-.034	0.19	.05-.55	23.8
Bottom	4.1	1.2-8.5	0.83	.11-2.4	7.56	7.3-8.0	0.161	.033-.360	0.038	.004-.130	1.2	.10-3.4	18.5
Pittock Surface	3.1	1.0-6.0	0.08	.01-.22	8.12	7.6-8.3	0.061	.030-.110	0.011	.001-.039	0.31	.10-3.0	23.0
Bottom	3.4	0.8-7.0	0.20	.08-.34	7.97	7.5-8.9	0.123	.032-.340	0.011	.001-.060	1.3	.20-4.0	22.2

Physical:

Flushing rates were estimated from mean influent streamflow for July and August 1973 and anticipated operating levels outlined in the Manual of Operations for each reservoir. The calculated rates for the summer of 1973 ranged from a low of 50 days at Fanshawe to a high of 250 days at Wildwood. Displacement of the total volume of water at Pittock would take approximately 60 days.

Average surface water temperatures were highest in Fanshawe reservoir (23.8°C) and essentially the same in Pittock and Wildwood (23.0°C and 22.8°C respectively). Bottom waters were warmest on the average in Pittock reservoir (22.2°C) and coolest in Fanshawe (18.5°C). Maximum surface water temperatures were attained in early July on Fanshawe (27°C), mid-July on Wildwood (25°C) and in early August on Pittock (25.5°C).

Table 8: Monthly meteorological summary May through August 1972-73 (London Airport)

	1972				1973			
	M	J	J	A	M	J	J	A
Duration of bright sunshine (hours)	252	205	244	220	139	231	261	236
Mean daily temperature	57	60	68	66	52	67	70	70
Precipitation	above normal				above normal			

From June through August, average daily air temperatures were higher in 1973 than in I972 although the mean for May was lower. Hours of sunlight records indicated a 7 to I2% increase over the previous year for the months of June, July and August and a 45% decrease during May.

Experimental:

Results of biological, chemical and physical data collected before and after the July 17 initiation of partial bottom-draw at Fanshawe are illustrated in Figures 6 and 7 and presented in Table 9.

Biological:

Standing stocks of phytoplankton increased from June 19 to July 16. Green algae replaced flagellates as dominant towards the end of this period. On July 23, following bottom-draw, algae counts decreased to roughly 1/6 of the numbers reported in the previous week. Counts remained at most ⅓ of the July 16 levels for the rest of the summer.

Chemical-Physical:

Effects of bottom-draw on reservoir quality are illustrated in Figure 7 of the text. Immediate effects on the river downstream from the dam are presented in Table 9

Table 9: Average temperatures and concentrations of various chemical parameters immediately before and following the initiation of low - level discharge at three locations downstream from the Fanshawe Dam.

	Spillway		Clark Road		Highbury	
PARAMETER	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.
D.O.	8.6	8.3	8.3	8.7	8.0	8.1
Temp.(°C)	24.8	22.1	24.9	23.7	24.9	25.4
BOD	7.0	5.3	6.9	5.2	5.2	4.9
NH_3	0.05	0.31	0.05	0.21	0.02	0.08
TKN	1.5	1.5	1.4	1.4	1.2	1.2
NO_2	0.06	0.05	0.05	0.05	0.05	0.06
NO_3	1.0	0.95	1.0	1.0	1.0	1.0
Tot. P	0.14	0.13	0.14	0.14	0.14	0.13
Sol. P	0.003	0.005	0.003	0.005	0.003	0.005
Fe	0.23	0.28	0.30	0.27	0.35	0.24
Cl	20	19	20	19	20	20
pH	8.2	8.1	8.2	8.2	8.2	8.2

of the text.

Within the reservoir, the change to a partial bottom-draw appeared to have little effect on bottom water chemistry during the six weeks it was monitored. Increases in levels of total phosphorus and decrease in total inorganic nitrogen concentrations in bottom waters later in the summer were typical not only of Fanshawe but of the other Upper Thames reservoirs. Three weeks following initiation of the low-level discharge regime, de-stratification appeared complete and the reservoir was virtually homothermous for most of the month of August.

Related to the gradual increase in bottom water temperatures was a subtle elevation in BOD concentrations in deeper waters.

Downstream from the reservoir, the most obvious water quality alterations following bottom-draw involved an approximate 3°C drop in water temperature and a sixfold increase in ammonia concentrations to roughly 0.4 ppm in the stilling basin of the dam. Effects on water temperature and ammonia levels were detectable as far downstream as the Highbury Avenue bridge. Levels of the remaining parameters monitored including dissolved oxygen, BOD and phosphorous did not appear effected by the discharge of bottom water.

Discussion

Although many of the results of the 1973 studies were largely as anticipated, a few inconsistencies were apparent.

Despite their differences in phosphorus levels and phytoplankton abundance, Wildwood and Pittock reservoirs exhibited unexpected similarities during the summer of 1973. Bluegreen forms dominated phytoplankton populations in both impoundments throughout July and August. Algae numbers peaked during the same week in August and both supported bluegreen algae blooms of differing intensity during the summer.

The severe and repeated blooms on Pittock as compared to Wildwood were likely the result of the comparatively high fertility of its waters and the fact that its shallow, unstratified nature and exposure to prevailing winds make more nutrients dissolved in the water available for blooms.

Pittock and to a greater extent, Wildwood are characterized by low flushing rates which probably contribute to their vulnerability for bloom incidents. Even though Wildwood waters are significantly less fertile, the extremely long flushing time during summer storage makes the reservoir more susceptible to phytoplankton blooms. The oxygen regime of both reservoirs was satisfactory for warm - water biota throughout most of the summer and neither Pittock nor Wildwood became thermally stratified. Under such conditions, phosphorus recycling from sediments and attendant algae blooms would not be expected.

These latter observations were those anticipated at Fanshawe but not totally achieved. It was apparent that a bottom discharge of 40 cfs. was adequate to alter thermal stratification at Fanshawe but inadequate to significantly improve dissolved oxygen levels in bottom waters. At Wildwood, the 40 cfs. bottom discharge far exceeded average incoming summer flows and more profoundly affected thermal stratification and oxygenation of reservoir waters. The east-west orientation and shallow depth of Pittock are major factors preventing the establishment of distinct thermal layers and decreasing oxygen levels with depth.

The failure to significantly increase dissolved oxygen levels and to reduce phosphorus concentrations in bottom waters at Fanshawe and at the same time avoid blue-green bloom conditions indicated that other factors contributed to the stimulation of algae problems. Fanshawe, with an estimated flushing rate of 50 days, was the only impoundment which could be totally flushed during July and August and this fact may have significantly affected algae growth.

Ridley (1970) indicated that rising water temperatures, shallow depth and reduction of water velocity are physical factors increasing primary production. He further stated that some bluegreen algae will not proliferate rapidly above or below a certain level of turbulence. Similarly, Wirth & Dunst (I967) documented that circulation of a body of water is often effective in suppressing blue-green algal growth. It is likely then that the faster flushing rate and/or an altered current regime following bottom-draw contributed to conditions which discouraged bluegreen blooms.

In an effort to explain the occurrence of a heavy bloom in the summer of 1972 based solely on altered flushing rates, influent and effluent flow data for Fanshawe was compared for July and August of 1972 and 73. If flushing rates alone exerted major control over bluegreen blooms, one would anticipate that blooms would be more liekly to occur when flows leaving the dam were less than those entering, essentially reducing normal summer streamflow below the dam. Such was not the case at Fanshawe.

In both July and August 1972, effluent flows substantially exceeded influent flows; however, in the summer of 1973, there was a decrease in average exit flows compared to those entering the dam. Bottom-draw was not being utilized in 1972 and one could conclude, albeit on insufficient evidence, that this operational mode was responsible for the improvement in 1973. It must be emphasized that average monthly flow information was used for a very general assessment of cause-and-affect relationships between flow and algae production. A more detailed weekly analysis of entry and exit flows may prove informative.

It is interesting to note that in Fanshawe, pH decreased significantly with depth-typical of eutrophic water bodies of moderate depth. A lower pH is associated with increased CO_2 availability which, according to Shapiro (I972) favours the development of green algal forms over the bluegreens. The bluegreen forms more effectively utilize CO_2 at low concentrations and tend to dominate algal associations in waters of elevated pH.

Surface currents through the contiguous thermal density gradient established with bottom draw at Fanshawe may have exposed the phytoplankton population to a continuous supply of free CO_2 available in deeper waters.

It would appear that many variables contribute to the production of troublesome phytoplankton levels in Upper Thames reservoirs. In this study, the initiation of bottom-draw corresponded with a decrease in algal numbers and prevented a bluegreen 'bloom'. Phosphorus recycling may have been reduced although natural background nutrient levels appeared to be adequate to support, algae growth. It is more likely that the prevention of the bluegreen 'bloom' was associated with physical factors and/or CO_2 availability.

Summary and Recommendations

Although this study achieved the objective of documenting water quality in the three Upper Thames reservoirs, conclusions which can be drawn from the low-level discharge experiment are limited. Concerning water quality, it was found that:

1. Pittock reservoir appeared to be the most productive among dams as reflected by high phytoplankton populations, limited light penetration and elevated chlorophyll a levels.

   Fanshawe, which supported phytoplankton numbers equivalent to those found in western Lake Erie was next productive while Wildwood was the least productive impoundment.

2. Pittock and Fanshawe were notably enriched by algae-stimulating phosphorus while Wildwood was at least ½ as fertile. In all reservoirs, levels of total phosphorus in bottom waters were roughly twice as high as those in surface waters.

3. Fanshawe Lake exhibited the lowest concentrations of dissolved oxygen and areas low in oxygen were distributed most extensively in this reservoir. Adequate dissolved oxygen levels existed in Pittock and Wildwood reservoirs throughout most of the summer of 1973. Both Pittock and Wildwood were isothermous all summer and Fanshawe became isothermous following initiation of bottom-draw.

4. Bluegreen algae blooms occurred in minor proportions on Wildwood and in major proportions on Pittock. Phytoplankton numbers did not assume bloom conditions in Fanshawe Lake. It is thought that a significant variable influencing the development of phytoplankton problems is the flushing rate of the reservoir.

The bottom-draw experiment at Fanshawe yielded the following information:

1. Algae populations dropped significantly following the initiation of partial low-level discharge and remained low for the rest of the summer.

2. The change to a partial bottom-draw appeared to have little effect on water chemistry within the reservoir during the six weeks it was monitored. However, the impoundment did become destratified thermally in three weeks.

3. Discharge of bottom water had little effect on water quality downstream from the Fanshawe reservoir.

Based on these findings the following recommendations are made:

1. A discharge at a rate of 15 cfs as assigned for flow augmentation purposes should be maintained through low-level tubes at the Gordon Pittock Dam. Bottom-draw should be continued at Fanshawe but the discharge rate should be increased to 60 cfs. The total low-level discharge operation at Wildwood appears satisfactory. This operating approach

should commence no later than the end of June.

2. Every effort must be made to reduce the amount of phosphorus entering the reservoirs.

3. Any steps which could be taken to increase flushing rates during the summer storage period should be instituted. For example, a close surveillance should be kept on influent and exit flows to avoid periods of protracted stagnation. Where possible, exit flows should equal or exceed influent flows to maximize flushing rates and to prevent increases in nutrient concentration through evaporation of reservoir waters.

4. Studies should be initiated to monitor the relative availability of free CO_2 and its relation to phytoplankton occurrence in each of the three reservoirs during the summer growth period.

Acknowledgements

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APPENDIX

Tabulation of Biological Data

Table I: Numbers and species of fish collected from 18 stations on the North Thames River and some tributary streams (July 1971).

	TN 1	TNW 1	TN 2	TNB 1	TN 3	TNA 1	TNA 2	TNA 3	TNF 1	TN 4	TNT 1	TN 5	TF 1	TN 6	TN 7	TN 8	TNM 1	TN 9
Hornyhead chub		2						11	11		1							
Creek chub	1	1				28	39											
Brassy minnow		1				12												
Fathead minnow						38	30											
Bluntnose minnow						22	1	6										
Rosyface shiner			9	15	53			5									7	100
Common shiner	20	18	7	20	40	67	9	65	23	20	15	7	200		P	15	35	200
Blacknose shiner											8							
Golden shiner						5					35							
Longnose dace																	1	
Blacknose dace						14	60											
Redhorse sucker												13	2					
White sucker	P	2	30	P	1	7			1	1	1	5	1	2	P	2	1	1
Hog sucker				P									1					
Brook stickleback							1											
Fantail darter						4											1	
Rainbow darter											1							
Least darter						1												
Johnny darter		1				40						1				1		5
Greenside darter						1												
Blackside darter						2												
Rock bass		2				3		1	5			5	2	1	P	2		
Pumpkinseed			1							1		12	1	P				
Smallmouth bass	1		3	P						5		5	2	2	P	2		1
Brown bullhead																2		
Carp			1					1				1			P	P		6
Total Taxa/Station	4	7	6	5	3	14	6	6	4	4	6	8	7	4	5	7	5	6
Total Taxa 26																		
No. of fish/Station	22	27	51	35	94	244	140	89	40	27	61	49	209	5	P	24	45	313

Table II: Numbers and species of fish collected from 19 stations on the South Thames River and tributaries (summer, 1971).

	TS 1	TS 2	TS 3	TS 4	TS 5	TS 6	CED 1	TS 7	TS 8	TS 9	TS 10	TM 1	TM 2	TS 11	TS 12	WAB 1	TS 13	POT 1	TS 14
Hornyhead chub	1	15	1	3			1		12	2		4	1	3	4	7	2	4	
Creek chub	49	55					6	1	20			1		1		2		4	
Brassy minnow	1																		
Fathead minnow	21	8					1												
Bluntnose minnow	12	17				3	4		22										4
Rosyface shiner									1		1			10					6
Common shiner	250	150	20	100	P	50	46	90	120	30	35	23	25	20	50	29	30	500	200
Blacknose dace	25	38																	
Redhorse sucker												4			1				
White sucker	1		3	21	40	1	154	6	8	1	1		25		7			8	4
Hog sucker			2	2								1	3						
Brook stickleback	8	2																	
Johnny darter	11				P		4		4						1				3
Greenside darter								2											
Blackside darter				1			1												
Yellow perch									2										
Rock bass			P	1	2	2			2				6		9	3	4		1
Pumpkinseed			P	4		20	2	1	2			1	P				3		
Smallmouth bass			P	3	7								6			2			
Brown bullhead					P			1											
Northern pike					2														
Goldfish																		2	
Carp					3				1	2					6		3		3
Total Taxa/Station	10	7	7	8	8	5	9	6	11	4	3	6	7	4	7	5	5	5	7
Total Taxa 23																			
No.of Fish/Station	379	285	26	135	54	76	219	101	194	35	37	34	66	34	88	43	42	518	221

Table III : Numbers and species of fish collected from 14 stations on the Lower Thames River (summer,1971).

	TL 1	TLD 1	TL 2	TL 3	TL 5	TL 8	TL 9	TL 10	TL 12	TL 13	TL 14	TL 16	TL J	TL 17
Bluntnose minnow					5	7								
Common shiner		52			9									
Spotfin shiner	2		30		20									
Spottail shiner					6		6	2	10	12	60	28		31
White sucker			33	6	5	3			2	3	1	1		
Hog sucker		1	1			1								
Johnny darter		2										2		
Sand darter	2		3		1									
Log perch					1								1	
Trout perch														2
Yellow perch														1
Rock bass					1				3					
Pumpkinseed														2
Bluegill													1	1
White bass							1	1	4	18	40	6	50	20
Smallmouth bass		2	9							1	1			
Largemouth bass												I		
Stonecat					4									
Channel catfish				5	5	1	2				3			
Bowfin														1
Quillback carpsucker	1		3	13	2	3		3			12	50		15
Gizzard shad						35	30	3	150	100	100	200	100	60
Mooneye									1					
Goldfish														3
Carp	P					1			6	15	1	1		3
Total Taxa/Station	4	4	6	3	11	7	4	4	7	6	8	8	4	11
Total Taxa 25														
No. fish/Station	5	51	79	24	59	51	39	9	176	149	21B	289	152	139

TABLE IV: Macroinvertebrates Collected At 17 Locations On The Thames River In The London Vicinity - Summer, 1970. (Numbers Per ft.^{2})

ORGANISMS	A	B	C	D	F	E	T1*	T2*	T3*	T4	T6	T7	T8	T9	G	H
STONEFLIES																
Acroneuria		1														
BAYFLIES																
Paetis	3				1	8				1	3	14	18	1	5	2
Caenis	2					1					P	P			P	3
Callibactis					P											
Heptagenia	1	2														
Potamanthus	1	1														
Pseudocleon	3															
Stenonema	2	1		1		2					1	1	4	1	P	1
Tricorythodes	25	9	1		1	1				P		1	8	1	P	1
CADDISFLI ES																
Athripsoles	3															
Cheumatopsyche	52	6	2	4	517	115				560	174	200	311	164	74	122
Chimera															P	1
Helicopsyche															P	
Hydropsyche	170	23	P	42	18	53				43	72	243	132	48	26	16
Hydroptilidae						1										
Macronemum	15															
Accedes																1
Psychomyin													1			
Priaenodes														1	P	
Unident. pupae	13	5		3	30	13				75	5	24	16	15	10	11
MEGALOPTERA																
Rialix			1	1		1									1	

TABLE IV: Macroinvertebrates Collected At 17 Locations On The Thames River in The London Vicinity - Summer, 1970. (Numbers Per $Ft.^2$) page 2.

ORGANISMS	A	B	C	D	F	E	T1*	T2*	T3*	T4	T6	T7	T8	T9	G	H
LEPIDOPTERA																
Nymphula																
ODONATA																
Aeshnidae										P						
Agrionidae															P	
Coenagrionidae	1	1	P	1		P				P					P	P
COLEOPTERA																
Elmidae	73	6	1	1										1	7	1
Dytiscidae				P												
Haliplidae				P											P	
Hydrophilidae				1		P							1		1	
Limnichidae															1	2
Pspheniidae	1	2	1			1							1		1	1
unident. adult.	23	5		1	1	5				p	1	1	4		10	5
D IPTERA																
Ceratopogonidae		P														
Chironomidae	13	14	35	35	117	86	204	13	33	49	53	184	48	11	12	30
Empididae		1			1						1		1			
Simuliidae		5		7	23	2				60	2	1	59			
HEMIPTERA																
Corixidae				P	P	1								P	P	P
Nepa						P										

TABLE IV: Macroinvertebrates Collected At 17 Locations On Tee Thames River in The London Vicinity - Summer, 1970. (Numbers Per Ft.2) page 3.

ORGANISMS	A	B	C	D	F	E	T1*	T2*	T3*	T4	T6	T7	T8	T9	G	H
MITES		1														P
AMPHIPODS																
Hyallela azteca	1	-P		P	P	P				P						P
ISOPODS																
Ascilus militaris					3	1										1
CRAYFISH																
Orconectes prop.	1	P	1	P	1	1				P	P	1		1	1	1
CLAMS																
Pisidium	1	P				P							1		p	
Sphaerium	3											P	1	1	P	
Unionidae													1	1		
SNAILS																
Amnicola	P															
Ferissia	1			1		4					7	P	2	1		
Goniobasis													1	1		
Gyraulus	P			1			2							1		
Helisoma				P												
Physa	P	P	1	5	P	1				P	2	P			1	1

TABLE IV: Macroinvertebrates Collected At 17 Locations On The Thames River in The London Vicinity - Summer, 1970. (Numbers Per Ft.^{2}) Page 4.

ORGANISMS	A	B	C	D	F	E	T1*	T2*	T3*	T4	T6	T7	T8	T9	G	H
FLATWORMS																
Planariidae	1		P	1	129	1				5	P	3	1	11	17	6
LEECHES																
Erpobdellidae	1		2	25		2				3	1	3	4	1	2	
Glossiphoniidae				P												
WORMS																
Lumbriculidae														1		
Naididae										1						
Tubificidae																
Unident.	P	1	75	9	1		7	2		1	2	2	1	1		P
Branchiura																
sowerbyi										1						
55																
No. TAXA	2	24	15	22	16	23	3	2	1	16	15	15	20	20	27	21
No. ORGANISMS	376	76	12	135	812	282	213	15	33	724	319	653	600	248	161	190

* Dredge Samples

Table V: Macroinvertebrates collected at 19 stations on the North Thames River and tributaries — summer, 1971.

	STATIONS																	
ORGANISMS	TN 1	TN 2	TN 3	TN 4	TN 5	TN 6	TN 7	TN 8	TN 9	TNW 1	TNBL	TNA 1	TNA 2	TNA 3	TNFL	TNT	TNF	TNM
STONEFLIES																		
Acroneuria									1		1							
MAYFLIES																		
Heptagenia																		1
Caenis	1			3			1		2	3		1		44	1	1	1	1
Baetis	5	1	1	10		3			1					1				1
Stenonema spp.	1		5	24		7		1	2		2			3	8		5	2
S.tripunctatum	1			1							8							
Tricorythodes			1	9	1	2											1	
Choroterpes											1							
Callibaetis												1						
CADDISFLIES																		
Cheumatopsyche	3	1	38	26	1	1	4		1				1	2	10	1	12	5
Hydropsyche		2	28	2	1	1			4		1		1		2		12	1
Pycnopsyche				2		1				6	29			1	1		1	
Triaenodes										1								
Accedes				1										4				
Chimarra	1	1	9	1													1	
Polycentropus				1														
Neophylax											1							
Macronemum																	5	
unident. pupa		1			1				6	1							3	1
MEGALOPTERA																		
Sialis				1														

Table V: continued

	STATIONS																	
	TN 1	TN 2	TN 3	TN 4	TN 5	TN 6	TN 7	TN 8	TN 9	TNW 1	TNBL	TNA 1	TNA 2	TNA 3	TNFL	TNT	TNF	TNM
LEPIDOPTERA																		
Pyralidae															1			
DAMSELFLIES																		
Coenagrionidae	1			1			1				1		6	3	6			1
Ischnura			1	1					1	2		1	5	3	1			
Enallagma			1		1	5			1	3							3	2
Hyponeura				2		2								1				
Hetaerina						1												
Chromagrion																	1	
Nehalennia																	1	
DRAGONFLIES																		
Gomphus confraternus						1					1							
Aeshna						1							6					
FLIES																		
Chironomidae	3	1	2		29	40	20	369	32	10	2	30	24	2	1	36	18	18
Dolichopodidae		1																
Ceratopogonidae														2				1
Palpomyia				1														
Simuliidae							2		4				164	1		8		4
Tabanidae																1		
unident. pupa					1	3	1	8	1			2	6		1			1

Table V - continued

	STATIONS																	
	TN 1	TN 2	TN 3	TN 4	TN 5	TN 6	TN 7	TN 8	TN 9	TNW 1	TNBL	TNA 1	TNA 2	TNA 3	TNFL	TNT	TNF	TNM
BUGS																		
Mesoveliidae	1	1				1				1					1	1		
Nepa														1				
Ranatra			1									1						
Corixidae			1			1	4			2		28	3	51	6	3		1
Gerridae				1	1		1		1		1		1					1
Macroveliidae					1													4
Veliidae																		4
Unidentified																		1
BEETLES																		
Adults	6	2	4	9	10	4		1	1	11	5	4	21	2	9	3	10	1
Hydrophilidae			1		1	1				1		1	10		1			1
Pspheniidae				2		1					1							
Elmidae					1	1					1						1	
Haliplidae						1											1	
Dytiscidae									1			5	10	1				1
Chrysomelidae											1							
AMPHIPODS																		
Hyalella azteca			1	15	4	9	12			2		1	2	29	3	3	5	1
ISOPODS																		
Asellus militaris				5	1		9						5		1			
CRAYFISH																		
Orconectes propinquus	3	4	2	1	1	4	4		1		3	2	1	3	3	2	3	
unident. immature	1				1		3									3		7

Table V: continued

	STATIONS																	
	TN 1	TN 2	TN 3	TN 4	TN 5	TN 6	TN 7	TN 8	TN 9	TNW 1	TNBL	TNA 1	TNA 2	TNA 3	TNFL	TNT	TNF	TNM
SNAILS																		
Physa	1	2		5	68	7	20	1	3	2	1	28	9	160	15	6	3	16
Lymnaea	1	2	1			2	1			1		1	11		3	1		1
Gyraulus							1			1			13					
Helisoma antrosum												27						
Helisoma campanulatam																1		
Amnicola																3	1	
CLANS																		
Sphaerium	1			1	1	1				2		36			1		5	1
Pisidium								1								1		
Unionidae												1					1	
FLATWORMS	4	8	1	4	322	21	33			1					4	53	2	
MITES				1							1	I	1	1	1	1	1	
LEECHES																		
Erpobdellidae	1	1			4	4		2					I	4				1
Glossiphoniidae												1		1				
Helobdella stagnalis						1		1										
WORMS																		
Tubificidae					1		1		P			2	2		1			1
NO. TAXA	15	12	16	24	17	26	16	6	15	15	17	18	19	20	20	16	22	25
NO. ORGANISMS	29	26	94	121	442	123	118	383	62	39	56	170	282	319	72	125	87	78

Table VI: Macroinvertebrates collected at 19 stations on the South Thames River and major tributaries (summer 1971).

	STATIONS																		
ORGANISMS	TS1	TS2	TS3	TS4	TS5	TS6	TS7	TS8	T59	TS10	TS11	TS12	TS13	TS14	TM1	TM2	CED.	WAU.	POT.
MAYFLIES																			
Baetis								1	5		7							1	
Caenis	6	11	7	8	11				1	1		35	8	2	2	3	1	11	
Callibaetis										3									
Centroptilum													1						
Cleon										1	1		1		1	1			
Ephemerella			1								1				1			1	
Hexagenia															1	3			
Isonychia											1				1				
Neocleon											1								
Potamanthus													1						
Pseudocleon										1		2						1	
Stenonema spp.			4	10					13		9	5	4	1	5	2		1	
S. tripunctatum			4	6															
Tricorythodes												1	2						
CADDISFLIES																			
Beraeidae															1				
Cheumatopsyche	1			3	3			1	5	1	1	4			1	6			
Helicopsyche																		1	
Hydropsyche		1		1							6	1	1	1	2			2	
Macronemum												1	15		1	10		1	
Oecetis	1			1							1				1			1	
Polycentropus				1															
Pycnopsyche			18	3											1	11		1	
Trianodes															1	1			
unident. pupae													1	4	1		1		

	TS1	TS2	TS3	TS4	TS5	TS6	TS7	TS8	TS9	TS10	TS11	TS12	TS13	TS14	TM1	TM2	CED.	WAU.	POT.
DAMSELFLIES																			
Agrion	3																		
Argia		1												1					
Coenagrionidae	1														2				
Enallagma	3	5	7	6	1	1	14	7	3	19	2	14	12	1	4	16	1	12	
Hyponeura													1	1		3			
Ishnura	2	7	1	3	7	6	10	8	1	15		2	4			4	1		
unident.						2	1	1			1		1			1		1	
DRAGONFLIES																			
Gomphidae	1		1																
Libellulidae	1	1		1		1													
LEPIDOPTERA																			
Elophila													2						
Paragyractis																		1	
HEMIPTERA																			
Corixidae	1			2		1	1		1			1							
Gerridae				1				1		1									
Nepidae												1							
TRUEFLIES																			
Ceratopogonidae				1	2								1			1			
Chironomidae	22	55	7	34	55	21	73	17	61	259	27	194	62	67	1	6	3	31	162
Simuliidae	5	1				1	2	15	10	1	4	1	1					3	
Tipulidae												1							
Ephydridae						1	1		1										1
unident. pupae	1	1	1	1	2	3	3	1		3	1	2	2		1		1	1	

	TS1	TS2	TS3	TS4	TS5	TS6	TS7	TS8	TS9	TS10	TS11	TS12	TS13	TS14	TM1	TM2	CED.	WAU.	POT.
BEETLES																			
Dytiscidae	1	1	3	1		1			2	2								1	
Elmidae			1									1	1		1	1		1	
Hydrophilidae				1						1						1			
Pspheniidae			1	2															
unident. adults	12	3	1	3	1	2			13	6	2	2	4	1	5	5		7	1
MITES					3				1			1		1		1		1	
AMPHIPODS																			
Hyallela azteca	12	22	5	10	10	1		12	2		3	10	13			1		2	
CRAYFISH																			
Orconectes propinquus	3	4	4	2	2		1	4	2	1		1	1	1	4	3	3	4	1
O. (immature)			4	9					1	3	1	1	1	1	7	1			
SNAILS																			
Amnicola											3	3	1		4	1			
Gyraulus	1			1	1					1		1							
Helisoma	1	1								1									
Lymnaea	1					2		1		2					1	1			
Physa	4	1	1	1	3	9	4	3		1	5	1	1		2	7		3	14
Valveta tricarinata												1							
CLAMS																			
Sphaerium	15	19						25			1	1	1		14	7	1	2	
Unionidae	1														1	1		1	
FLATWORMS				2	7		1	1	3		8	1	3		1			1	

	TS1	TS2	TS3	TS4	TS5	TS6	TS7	TS8	TS9	TS10	TS11	TS12	TS13	TS14	7241	TM2	CED.	WAU.	POT.
LEECHES																			
Erpobdellidae									1										1
Helobdella stagnalis																			
Placobdella				1															
unident.(immature)									1										
WORMS																			
Lumbriculidae	1														1				
Naididae														5					
Tubificidae		8		1	55	300	412	3	1	336		2	4		1				197
NO. TAXA	21	15	15	24	13	12	10	14	17	18	19	25	23	10	25	23	6	24	6
NO. ORGANISMS	100	142	71	115	163	352	523	101	128	658	86	291	150	87	70	98	12	96	377

Table VII: Macroinvertebrates collected at 20 stations on the lower Thames River and major tributaries (summer, 1971).

	STATIONS																				
ORGANISMS	TL 1	TL 2	TL 3	TL 4	TL 5	TL 6	TL 7	TL 8	TL 9	TL 10	TL 11	TL 12	TL 13	TL 14	TL 15	TL 16	TL 17	SPR.	MAC.	JEN.	DING.
STONEFLIES																					
Acroneuria																		1			
Neoperla							1														
MAYFLIES																					
Baetis	16		1		2		1	1	3									1			
Caenis	2								1		P							1			
Ephemerella			1																		
Ephoron			3	5	1	1			1												
Heptagenia									1												
Hexagenia					1																
Isonychia							1														
Paraleptophlebia																		1			
Potamanthus			4	1		1						20									
Stenonema			11	5	6	2	7	9	12									1			2
Tricorythodes		1	2	3	2		4	1	6	P											
unident.								1													
CADDISFLIES																					
Cheumatopsyche	59	15	8	70	39		25	184	34									2			14
Hydropsyche	6	2	1	2	7		2	1	1									5			3
Hydroptila									1												
Accedes			1			1															
Polycentropus						1															
unident. pupa	1			5			1		1												
MEGALOPTERA																					
Sialis																		1			

Table VII: - continued

	STATIONS																				
	TL 1	TL 2	TL 3	TL 4	TL 5	TL 6	TL 7	TL 8	TL 9	TL 10	TL 11	TL 12	TL 13	TL 14	TL 15	TL 16	TL 17	SPR.	MAC.	JEN.	DING.
DAMSELFLIES																					
Agrionidae						1															5
Anomalagrion												P									
Ishnura		1					1				P								P	3	1
DRAGONFLIES																					
Aeshnidae		1																			2
Libellulidae											P				P						
BUGS																					
Belastomatidae		1								P	P										
Corixidae	1		225	3	3	21	26		8	P	P	P		P	P				P		4
Gerridae	1	1																1			1
Mesoveliidae	2																				
Veliidae																		1			
COLEOPTERA																					
Dytiscidae	1		1																		
Elmidae	1	1	1				1	1													
Gyrinidae																				8	
Hydrophilidae	2						1														
Pspheniidae	1																				
TRUEFLIES																					
Chaoboridae															39				20		
Chironomidae	3	7	7	4		4	16	4	10	20	99	39	20	20	20	20	39	6	39		1
Culicinae																			p		
Simuliidae	1	3		1			4	30	135												
Tipulidae	1	1						1										1			1
unident. pupae			1	1			1				20				20			1			
Tabanidae																					1

Table VII: - continued

	STATIONS																				
	TL 1	TL 2	TL 3	TL 4	TL 5	TL 6	TL 7	TL 8	TL 9	TL 10	TL 11	TL 12	TL 13	TL 14	TL 15	TL 16	TL 17	SPR.	MAC.	JEN.	DING.
AMPHIPODS																					
Hyallela azteca	16	1				1	1			P						P	P		P	3	1
Gammarus fasciatus															P		p				
ISOPODS																					
Asellus militaris																	P		P		
CRAYFISH																					
Cambarus robustus																					
Orconectes propinquus		2				1	2		1									1			7
SNAILS																					
Bulimus																	P				
Goniobasis		5	1																		
Gyraulus																		1			1
Helisoma	1																				
Lymnaea																		1	P		1
Physa	78	12	3			1	1			P	P		P					10		5	19
CLAMS																					
Sphaerium		1		8		2	5	10	3		20	P		P	P		P				17
Unionidae				6		1		1			20										
FLATWORMS	4	67	22			4	6	1	1								P				
MITES													p		p						

Table VII: - continued

	STATIONS																				
	TL 1	TL 2	TL 3	TL 4	TL 5	TL 6	TL 7	TL 8	TL 9	TL 10	TL 11	TL 12	TL 13	TL 14	TL 15	TL 16	TL 17	SPR.	MAC.	JEN.	DING.
LEECHES																					
Erpobdellidae	9		1													P	P				
Helobdella																					
stagnalis	2	1																	P		
immature																			P		
WORMS																					
Tubificidae				1			1	1	1	10	20			69	118	59	P				
Lumbriculidae										1											
No. TAXA	20	18	17	12	8	14	20	14	16	8	10	6	3	4	8	4	9	16	9	6	17
NO. ORGANISMS	208	123	294	115	61	42	109	246	220	30*	179*	59*	20*	89*	197*	79*	39*	36	59*	27	81

* Dredge samples (numbers per M^2)

Table VIII: Plankton Analyses on Samples Collected from Fanshawe Lake, Summer 1973.

	6/6	19/6	3/7	16/7	23/7	30/7	7/8	13/8	21/8	27/8
Depth of Column (Ft.)	10	3	5	3	8	6	8	6	7	7
ORGANISMS										
Bluegreens										
Anabaena								5		69
Aphanothece							74		1276	
Chroococcus	4		270		38	15	438	588	355	131
Dactylococcopsis						8				
Merismopedia			P	1957			P	9		
Microcystis										106
unidentified bluegreen					26					
Flagellates										
Carteria							46	76	12	31
Chlamydomonas	2	2	472	141		63	2	7	13	20
Cryptomonas	1325	385	2632	751	357	1264	475	501	351	2157
Dinobryon	230									
Eudorina								158		
Euglena	32					26				
Mallomonas								47		
Peridinium		4	882							
Phacotus			42		23	41	18		77	
Pandorina	199							63		
Rhodomonas	100	11	146	560	49	76	3		1	123
Salpingoece										4
Trachelomonas		3		P	4	10	27	23	15	29
unident. chrysomonads	28	8	328	60		31	9	4	4	18

Table VIII: - continued

	6/16 10	19/6 3	3/7 5	16/7 3	23/7 8	30/7 6	7/8 8	13/8 6	21/8 7	27/8 7
Greens										
Ankistrodesmus	16	1	163	278	29	28	13	16	36	4
Characium							6	3	8	14
Chlorella	25			84	42					
Closterium		25		P	P	135		186		
Coelastrum	27	33	113	345		62	54	47		8
Cosmarium					78			P		
Crucigenia					393	47	97	103	23	11
Dictyosphaerium					6					
Elakatothrix							11			
Euastrum							15		84	
Gloeocystis		4		574	341		90		43	67
Kirchneriella				457	16					
Lagerheimia			28				6		P	
Oocystis		45	4	P		33	51	65	92	144
Pediastrum		107	71	P	42	73		16	532	5
Quadrigula								23		
Schroederia		1			2	8				
Scenedesmus	22	13	1389	2420	256	81	184	151	67	24
Selenastrum	11	3	128	109	27	19	5	10	2	2
Sphaerocystis						101		422		
Staurastrium						35			49	
Tetraedron		3		96	1		4	18	4	

Table VIII: -continued

	6/6	19/6	3/7	16/7	23/7	30/7	7/8	13/8	21/8	27/8
	10	3	5	3	8	6	8	6	7	7
Tetrastrum			42	241						
Treubaria						6				
Diatoms										
Achnanthes						3				
Cyclotella		6	88	1688	2	8				20
Nitzschia			72	P	11	10				
Stephanadiscus	183	5					100	24	28	48
Synedra				114		7			27	
Total Organisms (a.s.u's)	2204	632	6870	9875	1743	2190	1728	2569	3099	3035
Zooplankton	215/mL	16/mL	404/mL	204/mL	62/mL		246/mL	41/mL	31/mL	62/mL

Table IX: Plankton Analyses on Samples Collected from Wildwood Reservoir - Summer 1973

	6/6	19/6	4/7	17/7	23/7	30/7	7/8	13/8	21/8	23/8	27/8
Depth of Column (Ft.)	21	13	15	19	10	13	7	8	11	10	8
ORGANISMS											
Bluegreen											
Anabaena		205	23		3	8	39	134			
Aphanothece					35	272					
Aphanizomenon	26	93	769	1013	930	750	1808	2885	73	433	890
Chroococcus		3	146	42	5	22	18	140	84	191	35
Gomphosphaeria			3	5	20		238	P	82	744	183
Lyngbya							474				
Merismopedia							23	37	11	39	6
Microcystis									77		142
Stipitococcus								P			
Flagellates											
Carteria								116	67		16
Ceratium		P	140								
Chlamydomonas	1	2	3	3	2	7	5	6	18	2	32
Cryptolaux											6
Cryptomonas	37	75	17	53	20	86	70	69	45	106	224
Dinobryon				32			4	P			34
Euglena							15			32	
Katablepharis								5			
Ochromonas			2					8			
Pandorina									15		

Table IX: - continued

	6/6	19/6	40274	17/7	23/7	30/7	7/8	13/8	21/8	23/8	27/8
	21	13	15	19	10	13	7	8	11	10	8
Phacotus							62	100	19		
Rhodomonas	7	98	25	93	90	29	75	22	13	18	55
Trachelomonas										23	23
unident. Chrysomonads	2		2	5	35	43	75	49	19	10	28
Greens											
Actinastrum		10									
Ankistrodesmus		1	1					6	47		5
Characium											4
Chroococus											34
Closterium							6				
Coelastrum	4							24	68	78	20
Crucigenia			1				49	79	37	1	17
Elaktothrix		P									8
Gloeocystis		60	192	23					16	15	
Kirchneriella									49		
Lagerheimia									4		
Nephrocytium							18				
Oocystis		15	22	48	15	17	36	33	34	31	47
Scenedesmus	1			6	4	9	13	27	160	134	242
Schroederia	P	17				4	14				
Selenastrum				P	12	6	13	56	23	37	35
Sphaerocystis	3		57	2	37	70	204				

Table IX: — continued

	6/6 21	19/6 13	4/7 15	17/7 19	23/7 10	30/7 13	7/8 7	13/8 8	21/ 8 11	23/8 10	27/8 8
Tetraedron					1				12		2
Treubaria								6	9		10
Diatoms											
Attheya											83
Cyclotella						1	8			35	
Cymbella					1						
Fragilaria	239	791						P	995	75	
Melosira		5					82	P		P	
Nitzschia							12		22		
Stephanodiscus								15	21	32	13
Synedra	P	6					28	44	863	10	75
Total (a.s.u's/mL)	320	1381	1403	1325	1210	1324	3389	3861	2874	2046	2269
Zoo plankton	3/mL	8/mL	15/mL				8/mL			31/mL	

Note: Bloom observed Aug. 2 (*Lyngbya, Aphanizomenon, Anabaena, Synura*)

TABLE X: Plankton Analyses On Samples Collected From Pittock Reservoir - Summer 1973

	DATE										
	6/6	19/6	4/7	17/7	23/7	30/7	7/B	13/8	21/8	22/8	27/8
Depth of Column(ft)	11	5	11	7	7	5	5	4	5	4	4
ORGANISMS											
Bluegreens											
Anabaena	18						18	240	5876	1469	8965
Aphanothece					23						
Aphanizomenon	21	130	2250	548	630	3835	11906	7889	168	89	276
Chroococcus	98		41	146	194		103	85	74	6	374
Coelosphaerium									349		
Dactylococcus,									15		
Gomphosphaeria						29		53	178	291	15
Merismopedia		53	1033		24	88	607	17	4		
Microcystis						1261		148	580	1131	1489
Oscillatoria										208	672
Flagellates											
Carteria								24	28		15
Chlamydomonas	6	50	2	2	25		12	14	28	10	3
Cryptomonas	69	185	278	168	55	27	95	270	653	563	455
Dinobryon								13			
Euglena								265	35		
Katablepharis							1	9			
Mallomonas									56		
Ochromonas										4	
Pandorina						24					
Peridinium						49			45		
Phacotus					71		63	193	208		
Phacus										15	

	DATE										
	6/6	19/6	4/7	17/7	23/7	30/7	30/7	13/8	21/8	22/8	27/8
Depth of Column(ft)	11	5	11	7	7	5	5	4	5	4	4
Rhodomonas	3		21	484	111	76	30	28	3		
Trachelomonas									6	12	
Unident. *Chrysomonads*	4	29		3	32	7	28	31	5		
Greens											
Ankistrodesmus		3					15	11	4		
Botryococcus				90							
Characium			37	95				6	3	14	
Closterium							39	81	26	44	146
Coelastrum	10	110	18		47		15	100	44	4	
Cosmarium					47						
Crucigenia	5	73	24	65	58	84	99	56	36	6	5
Elaktothrix											19
Euastrum			39	39							
Gloeocystis	12		19	21			35				
Golenkia				6							
Lagerheimia	8								2		
Micractinium								39			
Oocystis	73	3023	138	53	10	67	73	445	165	129	106
Pediastrum	26	452		74		135	615	644		47	
Quadrigula	11										
Scenedesmus	73	262	3	16	25	107	131	122	31	36	
Schroederia	4	20			42	9		10			
Selenastrum		2		3	3	2	9				
Sphaerocystis		25				28			12		
Staurastrum	5									18	26
Tetraedron	3	5					26				

	DATE										
	6/6	19/6	4/7	17/7	23/7	30/7	30/7	7/8	21/8	22/8	2718
Depth of column (ft)	11	5	11	7	7	5	5	4	5	4	4
Diatoms											
Asterionella			233				13	181			
Cyclotella	10				9						
Melosira				53	127				65		
Stephanodiscus				7			93				
Total (A.S.U.'s/mL	465	4422	4136	1867	1533	5828	14026	10974	8699	4096	12,566
Zooplankton	10/mL	64/mL					62/mL	31/mL			123/mL