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BENTHIC REPORT
FOR THE
GRAND RIVER VALLEY

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INTRODUCTION

Biological determinations of water quality have been increasingly used as a measure of water quality rather than chemical determinations. Aquatic invertebrates are very sensitive to changes in their habitat, whether these changes are physical or Chemical. The biological method is often capable of detecting minute gradual changes that would escape notice by chemical methods.

Chemical analysis of the water quality gives an accurate picture of the chemical pollutants that are present in the water at the particular moment that the sample was taken. However, if this is an isolated chemical analysis of this particular stream, the results may not represent normal conditions of the stream.

The invertebrate fauna of a stream not only represents present chemical conditions but also changes in water quality that have occurred in the past. Once a biologist is familiar with a stream, minor changes of water quality are revealed to him by replacement of species by other closely related species or by the gradual disappearance of some species. An overnight chemical discharge may go unnoticed by the chemist but is strikingly apparent to the biologist by the sudden absence of some organisms. By working upstream until these organisms are found, he can pinpoint the position of the chemical overload. This could be monitored chemically only by a great number of tests if the discharge had been noticed in the first place.

The studies outlined in this report are G.R.C.A.'s first attempt at detailed biological surveys. The areas chosen for study were picked to determine the effects of reservoirs on the downstream fauna and water quality. This in turn will allow us to predict changes made by future reservoirs.

Invertebrates were collected by kicking a given area of stream bottom into a fine mesh net. During months when the water was open, additional invertebrates were collected by hand-picking them off rocks for a given period of time. All fish were collected using seining techniques.

The kick sampling technique was chosen for a number of reasons, The basic equipment is cheap and easy to construct. Samples are very easy to collect in the field, taking only a few minutes. Results are not strictly quantitative, that is, they do not give the accurate number of organisms present, but results from one area can be validly compared to results from different areas. In recent years, it has been found that the more laborious and tedious methods of collection seldom give much more accurate results. The kick sampling technique is very good for collecting smaller organisms but some of the larger ones are capable of swimming around the face of the net. This is the reason why collectors also hand-picked invertebrates as they tend to collect only larger specimens which would likely be overlooked by using only the net.

Invertebrates were separated from the debris in the sample by the addition of a solution of saturated calcium chloride. This increases the density of the water, causing most of the lighter organisms to float. This eliminates much of the work but the sample still has to be hand picked for molluscs, caddisfly cases and other heavier organisms.

Almost all species of aquatic invertebrates have very narrow environmental tolerances. In recent years, it has been discovered that most species exhibiting wide tolerances are in fact several closely related species or even entire families of organisms. By learning a species preference for water temperature, dissolved oxygen concentration, substrate type and water flow, its presence or absence in an unknown stream delineates the past and present water quality of that stream. Of course, this involves a great deal of research on each species before. one is able to categorize a stream by its invertebrate population.

Many invertebrates are characteristic of enriched waters and their relative abundance to the other organisms is a measure of the degree of pollution. However, it is not safe to use just one organism as a measure of organic enrichment because a multitude of causes may be interacting to produce this result. These causes would be missed by using only one or two types of invertebrates as indicators and a completely erroneous conclusion could be reached.

In Chapter V, we have attempted to illustrate the gradations occurring in benthic communities according to stream flow and water Quality. It should be understood that this is merely a guideline and does not take into account many other factors such as water temperature, stream size, water turbidity and many other variables that are considered when doing an actual benthic study. This Chart is constantly being revised as more literature is reviewed and more data collected.

After this year's experience, we are now capable of completing a stream survey in a few weeks. This will give us an accurate picture of water quality in these areas with all variables being included, even past stream history. This can be repeated any year to determine changes that have occurred.

1. BELWOOD

A station was set up above and below the reservoir in much the same areas as reported by Spence and Hynes (1971a). These stations were chosen so that we could continue their study. As this was G.R.C.A.'s first attempt at a benthic study, comparison between our results and those of Spence and Hynes proved invaluable at the start of the survey.

Results obtained from Belwood and Conestogo reservoirs help to delineate the effects that impoundments have on invertebrate and fish populations and will help us to predict what will happen when reservoirs are constructed in future.

1. Description of Sampling Areas

Station one, above the reservoir, was fast to moderate in flow. Water depth varied from approximately 5 cm. to over 2 metres, depending on the season and recent precipitation. The study area was primarily bedrock covered in some areas with large cobblestones. Riffles contained smaller rocks while some areas were covered with very coarse gravel. Most of the loose substrate was coated with marl.

The physical properties of the station below the reservoir were very similar to those of the station above, differing mainly in the lack of marl on the rock. Mosses and diatoms covered the substrate in lieu of the marl, forming communities. Water flow was rapid at all times. Depth fluctuated only slightly with the seasons and was unaffected by precipitation. This station corresponds to station three of Spence and Hynes (1971a).

2. Discussion of Results

Tables of results are given in Appendix I.

Marked differences occur both in invertebrate and fish population structures above and below the dam. A total of seventy invertebrate species and fifteen fish species were collected above the impoundment, while only forty-eight invertebrate species and twelve fish species were collected below the dam.

Triclads, or flatworms, were six times as common below the dam than above. Temperature is often a limiting factor for species of flatworms (Hynes; 1970), with many triclads being cold stenotherms (Pennak, 1953). The majority of triclad species are restricted to waters where the oxygen concentration does not fall below 70%

(Pennak, 1953). The water below the dam is almost always constantly oxygen saturated while there is very little daily fluctuation in water temperature with temperatures being much cooler below the dam than above. This probably explains the higher concentrations of flatworms below the dam, but they should have been identified to species to be certain.

There were relatively few differences in the leech populations above and below the reservoir. The two species of *Erpobdella* were dominant at each station. This is one leech that demands high oxygen concentrations and is rarely found in water that suffers oxygen depletion (Hynes, 1970). They are also able to move in rapidly flowing water so that below the impoundment would be an ideal habitat for them. Two other leech species were found to be rare above the dam.

No real differences were found in snail populations between the two stations. Spence and Hynes, (1971a), reported *Ferrissia* as being absent above the dam but one was found by G.R.C.A. indicating that it is rare above the dam.

Clams were common above the dam and rare below it. This is probably due to a combination of several factors such as lack of suitable substrate higher turbidities in late summer and fall, the abundance of mosses and diatoms, or lack of available hosts.

Differences in mayfly populations were pronounced, with eighteen species being found above the reservoir and only nine below. *Heptagenia* nymphs were reasonably common above the reservoir and absent below. This mayfly normally replaces *Stenonema* species in areas of bedrock, (Leonard, 1965), but as it is a filter-type feeder one would expect to find more of them below the impoundment than above. Their absence below the reservoir cannot be explained at this point. Spence and Hynes, (1971a), did not find any of these mayflies above the impoundment either. On one occasion, seventeen specimens of *Cinygma* were captured above the reservoir with this being the only record of them in this area.

This was probably an isolated population from a microhabitat but further samplings may reveal otherwise. Seven species of *Stenonema* were found above the reservoir. This genus of mayfly is common to clean streams flowing through glacial drift, and the number of species present increases with increasing water temperature range (Ide,1935). Six species were found below the dam, with *Stenonema tripunctatum* being the only one present in significant numbers. This species has the highest tolerances to extremes in water temperature and quality, and so is the last remaining mayfly of the genus *Stenonema* present when the water undergoes serious changes in quality (Leonard, 1965, Spence and Hynes 1971a). Five years ago, when Spence and Hynes, (1971a), studied the Belwood area they found that *S. tripunctatum* was the only species of this genus present.

From G.R.C.A. data it would appear that the *Stenonema* species have recovered somewhat since their study. *Pseudocloeon, Centroptilum, Paraleptophlebia moerens, P. mollis, Ephemarella* bicolor and *E. deficiens* were present above the dam and absent below. Absence of these species is probably due to changes in water temperature or water velocity which make the habitat generally unsuitable for these species. For example, *Ephemerella deficiens* does not occur in midstream, (Coleman and Hynes, 1970), but normally inhabits detritus and marginal vegetation. (Allen and Edmunds, 1963). Due to the increased water velocity below the dam, there is very little detritus along the river's edge so that there is no suitable habitat present for *Ephemerella deficiens*.

The most significant difference in the two invertebrate populations is the complete absence of stoneflies below the dam. Above the reservoir *Acroneuria* sp. , *Paragnetina media,* and *Phasganophora capitata* were very common, while five specimens of *Amphinemura delosa* were collected. Spence and Hynes, (1971a), also found specimens of *Allocapnia pygmaea* and *Taeniopteryx maura* above the reservoir. They explained the absence of stone flies below the reservoir to the lack of available oxygen as a result of the heavy respiratory demands of the aquatic plants present. However, dissolved oxygen tests done by G.R.C.A. (1971) and O.W.R.C. (1970, 1971) indicate continuous high oxygen concentrations in the water below the reservoir. Even if a microlayer of oxygen depletion did occur larger forms of stoneflies should be able to avoid this layer. Another explanation may be that this area is not really unsuitable for stoneflies but is unavailable to them.

During dam construction, high turbidities and silt would result in decimation of the stonefly populations. Stoneflies were probably only present down the river as far as Fergus or Elora as the river is slow and silty through this area and often attains high temperatures. Adult stoneflies have very limited powers of flight with many of them merely walking to their breeding site. Coleman and Hynes, (1970), report that *Allocapnia pygmaea* walks away from the stream to breed while *Taeniopteryx nivalis* spawned soon after emergence without leaving the general vicinity of the stream. The lack of stoneflies in this area may thus be due to their poor range as adults. It would be interesting to check these theories by introducing stoneflies below the dam to see if they could survive.

Differences in caddisfly populations can not really be dealt with due to the lack of suitable keys for their identification to the species level. As was found by Spence and Hynes, (1971a), the vast majority of caddisflies found below the impoundment were free-living or net spinning types while the population structure was much more varied upstream.

Several differences are apparent in the species of flies present at the two stations. Over three times as many chironomid or midge larvae were caught below the dam than above. This is probably because of the. growth of mosses which allows them better attachment to the substrate and a better supply of food. *Antocha* was much more abundant above the reservoir than below. This genus generally lives in swiftly flowing water and feeds on algae, (Johannsen, 1937). It would so natural to expect more below the reservoir. However, this insect prefers gravelly areas and the lack of gravel below the dam may explain their scarcity. Over two-thirds of the specimens caught above the dam were caught in one sample so that this probably represents an isolated colony. Black fly larvae were more numerous below the impoundment than above. These insects prefer fast flowing, to torrential water so that they are normally common below dams.

The water penny beetle larvae, *Psephenus* and *Ectopria,* were comparatively scarce below the dam. Spence and Hynes found neither of these at their station immediately below the dam while, they reappeared further downstream. It would appear that they prefer moderate to rapid water flow, but are swept downstream if the water velocity is exceptional. In the riffle beetle family, G.R.C.A. found that *Stenelmis* was over twice as abundant as *Optioservus* above the reservoir, while *Optioservus* was much more common than *Stenelmis* below the reservoir and was the dominant form of beetle. More information on the biology of these two Elmid beetles is necessary before we can postulate reasons for these differences.

Results of seining for fish above and below the impoundment are given in Appendix I. These results show considerable changes since 1960 when Spence and Hynes (1971b), completed their fish census of these two areas. At this time. they found that four minnow species which required higher water temperatures were absent below the reservoir and present above it. In 1971, G.R.C.A. found that three of those species are now present below the dam namely the hornyhead chub, the spotfin shiner and the bluntnose minnow. The river chub is still absent from this reach of the river. Hornyhead chub are rare with only seven specimens being caught, all but the two one year olds were fry. These three species of fish are still very uncommon suggesting that there are concentrated populations of these species further downstream, which disperse upstream in years that the water temperatures are sufficiently high. The presence of hornyhead chub fry below the dam indicates that the water does become sufficiently warm some years to allow successful spawning of all four of these minnow species.

These four species are usually distributed south of the 17.8°C isotherm. (Spence and Hynes, 1971b). During 1971, this water temperature was reached by July 6 and remained above it until the end of September (G.R.C.A., 1971). Fish distribution below the reservoir undoubtedly varies each year depending on the temperature of the water.

One carp was caught below the reservoir indicating that this rather undesirable species has spread up the river to the base of the dam. G.R.C.A's 1970 Fish Census indicates carp have spread into the Belwood Lake also. Above the reservoir is generally unsuitable habitat for this fish so it is unlikely that it will ascend further up the Grand River.

Blacknose dace did not show up in G.R.C.A.'s samples below the dam, while they were present when Spence and Hynes sampled. This may be another example of annual variation due to water temperature.

The only two longnose dace collected above the reservoir were found dead indicating that this is very marginal habitat for this species.

Both the Iowa darter and barred fantail were common above the reservoir and rare to absent below. Both of these prefer slow moving riffles while the barred fantail prefers very slow water, even living in lakes. The absence of still water below the dam explains the lack of darters.

3. <u>Summary and Recommendations</u>

a) Benthic studies conducted by the Grand River Conservation Authority and Spence and Hynes (1971a, 1971b), indicated that the water flowing into Belwood reservoir was of excellent quality.

b) These same studies indicated fewer invertebrate and fish species present below Belwood reservoir than in the river entering the reservoir. The absence of most invertebrates below the reservoir was due to habitat preference. That is, species that did not normally live in cooler, fast-flowing water were absent.

c) Both studies found stoneflies ware absent below the reservoir and common above it. Spence and Hynes attributed their absence to oxygen depletion between the bottom and water interfaces due to the heavy nightly respiratory demands of the algae present.

Water quality studies conducted by G.R.C.A. (1971) and O.W.R.C. (1970, 1971), indicated that dissolved oxygen concentrations were always sufficient even at night-time. A map of low oxygen concentrations compiled by G.R.C.A. (1971a) indicates that oxygen concentrations became much lower above the reservoir than below. When stoneflies occur occasionally in Canagagigue Creek where dissolved oxygen concentrations consistently drop as low as two to four ppm at night, the absence of stoneflies below Belwood cannot be attributed to low dissolved oxygen concentrations.

G.R.C.A. proposes that stoneflies were eradicated by heavy silting and water turbidity during construction of the dam. It is probable that stoneflies were only present downstream as far as Fergus where they would be eliminated by the lack of suitable habitat and by the chemical overloading that occurs at this point. Adult stoneflies are very poor fliers, with many species merely walking to their breeding site. It is considered possible that the absence of stoneflies below the dam may be because they have been unable to fly the great distance necessary to re-colonize this area as the nearest streams supporting stoneflies are over a mile from the dam. This theory will be tested by introducing caged stoneflies below the reservoir to see if they are capable of surviving.

d) When Spence and Hynes (1971a) conducted their benthic study five years ago, they discovered only one species of the mayfly *Stenonema*. It is known that the wider the range in water temperature, the more species of *Stenonema* will be present. The lack of a balanced community of *Stenonema* species was explained by the temperature lag occurring below the reservoir.

In 1971, G.R.C.A. discovered six species of the mayfly *Stenonema* below the dam. During the summer the water temperature below the dam reached a high of 24°C compared with 25.5°C above the reservoir. it is postulated that the number of species of *Stenonema* present, and also those of various other invertebrates may vary from year to year depending on the high water temperature reached that year.

e) Spence and Hynes, (1971b), found that four species of minnows that were common above the reservoir were absent below due to the colder water temperatures. Three of these species were found much further downstream.

These same three species were found in limited numbers below the dam in 1971 by G.R.C.A. Fry were found of the species having the lowest temperature threshold indicating that all of these species were capable of spawning that year.

Fish species present each year also depends on the high water temperatures reached in that particular year.

f) Invertebrate and fish populations below the reservoir are limited only by physical environmental factors rather than chemical ones. Populations affected only by substrate type, water chemistry and water flow would remain stable from year to year. Populations of those organisms affected primarily by temperature may fluctuate annually depending or the high water temperature reached below the reservoir.

Actual chemical water quality below the reservoir is virtually the same as the inflowing streams.

g) The study of invertebrate and fish populations above and below Belwood reservoir will be continued until a full year has been spent on the project. This will give us a definite interval of time for comparison in future years, while the usage of an entire year covers all possible life cycles that may occur.

II CONESTOGO

1. Description of Sampling Areas

Three stations were set up in order to determine the effects of the Conestogo impoundment on the water quality, invertebrate and fish populations of the Conestoga River.

Station one is above the village of Drayton behind the Arena. The river at this point becomes very narrow and shallow in the summer. The sampling area consisted of two small moderately flowing riffles flowing into a large clay bottomed pool which retained a depth of a metre in places even during drought. The river at this point is subject to severe flooding in the spring.

Station two is on Spring creek at the first bridge above the lake. The creek at this point is spring fed. The width is normally only 15 to 30 cm. but it extends to approximately six metres below the bridge. The bottom is completely covered with fine silt or sand which is several feet deep in places. Depth varies from zero to a meter. The stream was dry from October 5, 1971, until January 1972. The creek is filled with aquatic vegetation while the whole surface is covered with duckweed during the summer. Due to the nature of the substrate, only one kick sample was taken at this point. Instead of collecting invertebrates by hand, they were caught in the seine while we were seining for fish.

Station three was located approximately one hundred yards below the outflow of the reservoir. At this point, the river is roughly 12 meters wide and 1.5 to 2 meters deep. The bottom is composed entirely of larger sized stones and rocks, This station was poorly chosen as the stream gradient was very steep and the current fast so that the collector could venture only a few feet from the shore. In times of high water, samples were taken that were actually dry land only a few days previously. Since January 1972, the station has been moved downstream to a point whore it is possible to sample in midstream. The reservoir was drained in the fall of 1971. This resulted in the flow being considerably reduced after the month of December.

2. Discussion of Results

Results obtained from the benthic and fish collections are shown in Appendix II. Forty-four invertebrate species were caught in six samplings at Drayton, twenty-eight species in three samplings in the Spring Creek, and twenty-six species in five samplings below the dam.

Flatworms were common in the main river above and below the reservoir, but absent in the Spring Creek as they prefer a stony bottom. The same applies to the roundworms of the family Naididae which prefer sheltered places in stony streams (Hynes 1970). The availability of stones explains why they are common below the reservoir, scarce in Drayton and absent in Spring Creek.

Differences in leech populations can be correlated to differences in substrate types and dissolved oxygen concentrations. Leeches were rare at Drayton with only one *Erpobdella octoculata* being caught. The clay bottom at Drayton is generally unsuitable for leeches as they prefer either stony bottoms or mud. The one species caught demands high oxygen concentrations (Hynes 1970), indicating that the water normally has acceptable oxygen contents.

Below the dam four leeches of two species were captured. Again, lack of mud and small stones is probably the reason why leeches were uncommon. In the Spring Creek, twelve leeches of four species were caught. Their abundance is due to the muddy substrate. Two of these species are able to tolerate oxygen depletion which occurred in late fall, However, the commonest leech was *Erpobdella octoculata.* This leech has dependent respiration so that it requires high oxygen concentrations. It also has a life cycle of two or three years so that it is probably that this stream did not normally dry up for this period of time.

Records from the gauge station at this point indicate that the stream normally dries up each year but usually for a shorter period of time than during 1971. The main feeder spring for this creek is located approximately one quarter of a mile downstream from the sampling area. Organisms appearing at the sampling spot would either have to migrate upstream when water flow was sufficient or remain in an egg or cyst-type condition during dry seasons.

Mollusc populations also varied among the sampling areas Below the reservoir, five species of molluscs were found with *Physa* and *Ferrissia* being the commonest. *Physa* is normally commonest in running waters. Below the reservoir there is also a continuous supply of detritus flowing from the lake so that conditions are perfect for this snail below the reservoir. *Ferrissia* is a snail which prefers fast currents and is often the only species present in the outflows of large reservoirs.

Four species of molluscs were found in Spring Creek where they were extremely abundant on the luxuriant vegetation. At Drayton, three species were found but they were very uncommon. This is probably due to the general lack of detritus and shoreline vegetation.

Differences in mayfly populations were extreme. At Drayton, 223 mayflies representing fourteen species were caught. Four species of mayflies comprised almost half of the sample, These types are ones that burrow in mud: *Ephemera simulans, Caenis, Tricorythodes* and *Paraleptophlebia. Paraleptophlebia* normally inhabits only water that has a minimum of organic matter so that its scarcity is an indication of mild enrichment. The remainder of the species caught are indicative of slower flowing yet fairly clear streams. The mayfly population of the Conestogo River at Drayton is typical of a slower moving warm stream that is only very slightly organically enriched.

Below the dam only 110 mayflies representing four species were caught. These were all burrowing mayflies. The lack of mayflies of the genus *Stenonema* is probably due to the lack of samples taken in the centre of the river but this will be borne out in future samples. Lack of *Stenonema* may also be due to the fact that the water is cooler and quite fast flowing at this point. Mayflies that are unable to burrow are probably swept away by the rapid current. One *Paraleptophiebia* was present showing that the river was still relatively pure.

In Spring Creek, *Caenis* was the only species of mayfly present. In most temporary streams, mayflies are completely absent (Burks, 1953). However, Berner (1950) found *Callibaetis* and *Caenis* in intermittent streams in Florida.

Hynes and Williams, (1962), found that *Caenis* developed much faster than other mayflies while Sloan (1956) found that *Caenis* and *Callibaetis* tolerated lower oxygen concentrations than other mayflies. Their fast development and to for low oxygen explains the presence of *Caenis* in this stream.

Differences among the dragonfly populations were apparent. Spring Creek contained four species of damselfly and dragonfly species which normally burrow in the mud or climb on aquatic vegetation. Both of these conditions are optimum in Spring Creek which explains their abundance. Pennak (1953) states that most damselflies have two generations per year but, that some of the larger dragonflies, particularly of the family Aeschnidae, may require up to four years to develop.

Aeschna was common in the sampling area so that it must migrate with the falling water level or perhaps there is sufficient ground water at depth that it can survive drought by burrowing deep into the substratum. Dragonflies and damselflies were not important members of the invertebrate populations above and below the reservoir in the main river. One specimen of the damselfly *Ischnura* was caught at each station while ono dragonfly of the genus *Paltothemis* was caught below the dam. This latter dragonfly occurred also in Spring Creek. Ward and Whipple, (1966) state that members of its family do not burrow. It has a robust body form so it is difficult to explain how it would withstand the current below the dam and also be present in Spring Creek and withstand the drought.

Stoneflies were sparsely represented at each station. Five specimens of *Acroneuria* (? *lycorias*) were collected from Drayton, one specimen of *Phasganophora capitata* from Spring Creek, and one specimen of *Taeniopteryx parvulus* was found below the reservoir. None of these stations exhibited balanced populations of stoneflies which indicates slight organic enrichment of the water with phosphorus and nitrogen. Occurrence of stoneflies below the reservoir indicates that there is no build-up of nutrients within the reservoir.

True bugs were very prevalent in the aquatic vegetation in Spring Creek. They were rare to absent at the other stations due to fast water currents and general lack of vegetation.

Caddisflies were very common in Drayton but represented only seven genera. Three of these genera formed approximately 88 percent of the caddisfly population. These are free-living, net spinning species which were caught primarily in the riffle areas. The general low populations of case building caddisflies in the pool areas is probably due to the clay bottom. Shifting of the clay substrate could smother many of the less mobile caddisflies.

Below the reservoir, only eight caddisflies of four genera were caught. All but one were case-bearing caddisflies instead of the expected net spinners. *Neophylax* has a case which is weighted on each side with a longitudinal stone so that it can withstand more current than most case dwelling caddisflies. *Orchotrichia* lives in a fine silken case which is attached firmly to the substrate with silk. General rarity of Hydropsychidae larvae cannot as yet be explained unless it is the lack of samples taken near the centre of the river.

One specimen of caddisfly *Cheumatopsyche* was found in Spring Creek. This genus has previously been found inhabiting intermittent streams where it is one of the first to re-colonize after drought.

Midge larvae or chironomids were common to all three stations, being most abundant in the mud of Spring Creek. Flies of the Family Tabanidae, the horse-flies, were common in Spring Creek and absent at the other stations. These insect larvae prefer muddy-bottomed streams of moderate flow (Johannsen 1937), so that the habitats available at Drayton and, below the dam are generally unsuitable for this family of flies.

Three genera of craneflies were found at Drayton while none were found at either of the other stations. *Limnobia* is an uncommon genus which is found in organic mud at the edges of streams. *Elliptera* is another uncommon cranefly which is found in delicate silken tubes beneath moss or algae in a moderately flowing stream, (Johannsen, 1937).

Antocha is the most common cranefly. It prefers riffles and needs a high concentration of dissolved oxygen as it has no spiracles. Spring creek is unsuitable for this fly as the bottom is muddy, the dissolved oxygen content is often low and the stream dries up. Their absence below the dam is probably due to the lack of suitable spawning area above the sampling station. It is probable that they occur a few hundred yards downstream.

The robber fly, *Atherix variegata,* was collected at Drayton and in Spring Creek after termination of the drought. The eggs of this fly are laid on twigs overhanging the river. The absence of *Atherix* below the dam is probably because there are no trees between the dam and the sampling. area.

Beetles were fairly well represented at Drayton, especially by the riffle beetles and water pennies. A total of six species were caught at Drayton.

Five beetle species were present in Spring Creek. Two of these were the riffle beetles *Stenelmis* and *Optioservus*. These beetles are able to respire in both air and water while the larvae or able to burrow into the substrate and obtain enough air from the damp soil (Hynes 1958). One specimen of the water penny, *Paephenus,* was collected. This is unusual as the water pennies generally prefer fast flowing water. However, they are found in lakes along the shores where there is sufficient wave action. There may be a similar microhabitat in Spring Creek.

The Dytiscidae, or tiger -beetles, and Curculionidae, or weevils, that were found here are capable of breathing air. In fact, they must resurface for air in order to survive so that they are normally present in slow flowing streams where there is an abundance of vegetation. They are also capable fliers so that they could follow the stream downwards when it dried up.

One riffle beetle and one tiger beetle were the only beetles caught below the dam. The waterpennies are probably unable to withstand the severe current but should be found further downstream. Spence and Hynes (1971a) found no water pennies directly below Shand Dam but they were common a few hundred yards downstream.

Variations in fish population structures also occurred among the three stations.

Hog suckers were present at Drayton only. This fish is generally distributed in the riffles of cooler, clear streams with stony bottoms. Its absence in Spring Creek is because of the muddy bottom and slow flow. Below the reservoir, several hundred northern shorthead redhorses were caught with the electrofisher. The lack of hog suckers below the reservoir may be because of competition with the redhorses.

Hornyhead chub were present at Drayton and below the dam. They are never found in muddy, silt-bottomed or stagnant streams, (Carlander, 1969), pointing up why they were not found in Spring Creek. As this is one of the minnows with the most southern range, (Spence and Hynes, 1971b), its presence below the dam indicates that the temperature lag below the reservoir is not severe enough to affect minnow populations. There is also a deep quiet pond-like area adjacent to the main river which would warm up faster than the main river and thus provide water of temperatures suitable for breeding.

Redbelly Dace were found only in Spring Creek. This is a fish which prefers bog ponds and slow-moving creeks. Spawning is done among filamentous aquatic plants and algae is the main food (Carlander, 1969). Fast currents and lack of vegetation at the other two stations explain its absence there.

Rosyface Shiners were very common in Drayton, rare below the dam and absent in Spring Creek. This shiner inhabits clear, swift streams and spawning occurs in gravel only at a temperature over 21°C (Carlander, 1969). Their scarcity below the reservoir is probably because of the high water temperature required for breeding.

Fathead minnows were absent from Drayton. This is probably because they do very poorly in competition with other minnow species, (Carlander, 1969) and common shiners, rosyface shiners and bluntnose minnows were present.

Smallmouth bass were absent from Spring Creek due to the lack of available gravel. They were common, both above and below the reservoir, with some large specimens being collected below the reservoir with the electrofisher.

Brook sticklebacks were extremely abundant among the vegetation in Spring Creek. One was caught below the dam. This was probably one of an isolated population in the inlet area off the main river.

Fourteen species of fish were caught below the dam while twelve species were caught at Drayton and Spring creek. A total of sixteen species were caught.

3 Summary and Recommendations

a) Benthic and fish population studies of the Conestogo River at Drayton indicated that the water quality in this area is not quite pristine but slightly enriched with nitrogen and phosphorus. The diverse invertebrate population structure indicated that this section of the river has not been exposed to any chemical overloads.

b) Studies of Spring Creek showed that the water in this creek was of very good quality, although there is an excess of nitrogen and phosphorus. This also gave valuable information on invertebrates that were able to live in an intermittent stream.

c) The scarcity of invertebrates below the dam can be attributed to the natural restrictions put on the organisms due to the physical nature of the environment. Thus only organisms that could stand extremely fast flowing water that was cooler than normal were present. The current was strong enough that there was very little to no mud available so that burrowing species of invertebrates were limited to those that readily burrowed under stones. Very few invertebrates can withstand the extreme velocity of this water so that the majority of invertebrates collected here were of the burrowing type.

The presence of stoneflies indicated that organic enrichment was slight and that the reservoir did not appreciably build up dissolved nutrient contents. Cooler or delayed high water temperatures below the reservoir did not seem to affect fish populations.

In general, the dam did not appreciably change water chemistry. Invertebrates present were those that could withstand or avoid fast currents and it is undoubtedly true that the invertebrate fauna becomes much more varied as one progresses downstream from the dam. The dam had almost no effect on the fish population structure, with more species being caught below the dam than at Drayton.

d) The studies of the invertebrate and fish populations at Drayton, in Spring creek and below the Conestogo Dam should be continued until a full year of sampling has been completed and then collections will be terminated.

III. PROPOSED GUELPH DAMSITE

1. Description of Sampling Areas

Station one, above the damsite, is located on the Guelph-Eramosa Township Line approximately two and a half miles north of Highway 24. Even when the proposed reservoir is filled to capacity, this stretch of the river will not be flooded. The river at this point is fast flowing over a cobblestone bottom with riffle areas having smaller gravel. The substrate becomes slightly covered with marl but not to the extent that the bottom above Belwood reservoir does. A series of small islands results in small silty areas on their downstream end. Aquatic vegetation is sparse but some does occur along the stream margins. Depth varies from a few centimeters to 60 cm in the pools during summer flows.

Station three below the damsite, is located on Woodlawn Avenue in Guelph. At this point the river is just entering Guelph and has not yet been subjected to any outflows. This station is located approximately one mile downstream from the present proposed damsite. Immediately below the station is the Speed dam, a small overflow reservoir that does not quite reach back to sampling area even during flood conditions. The entire sampling region is shallow ranging op almost 30 cm in depth during low flows. Water velocity is fairly rapid over a cobblestone bottom. An outcrop of the shore results in an eddy creating a silty-bottomed, slow-flowing region that is about 2½ meters wide and 6 meters long. Mosses and some submergent aquatic plants grow in this area while the substrate of the main river is virtually plantless. Marl encrustations are uncommon and slight.

2. Discussion of Results

Both stations exhibited an excellent diversity of invertebrate species with seventy-seven species being collected above the damsite and eighty below. Results are given in Appendix III.

Differences between the two stations are slight with booth having invertebrate populations typical of a fast-flowing pristine stream. Station three had three more species as it also has a mud bottom habitat but invertebrates were almost twice as numerous above the damsite.

Neither of the stations exhibited a significant leech population. They were absent above the damsite and only one specimen was taken below. This is due to the general lack of slow moving water and muddy areas.

Snails and clams were plentiful at both stations indicating a well balanced mollusc population.

A total of twenty-six mayfly species was caught, with twenty-four being present above the damsite and twenty-five below the damsite. The large numbers of mayflies and mayfly species are indicative of very good water quality.

Six species of stoneflies are present at the station above the damsite while only three species were found below the damsite. The absence of these three species below the damsite shows that the river has been enriched with nitrogen and phosphorus somewhere between the two stations. The river passes through much pasture and croplands so that the input of nutrients is unquestionably due to agricultural practices.

Each station had one species of dobsonfly. *Chauliodes* was found only above the damsite. This species requires well aerated waters where it generally lives under stones. (Hynes, 1970). *Sialis* was present below the damsite. This dobsonfly burrows into mud arid detritus, preferring a substrate that is covered with vegetation (Ward and Whipple, 1966).

Two species of aquatic caterpillars were found. *Cataclysta* was common to both stations while one specimen of *Nymphula* was collected below the damsite. *Nymphula* is generally found in ponds that are overgrown with aquatic vegetation. It lays its eggs on the underside of floating vegetation and attaches its case to vegetation (Pennak, 1953). Lack of vegetation and still water explains its absence above the damsite while its occurrence below the damsite may be due to its proximity to the Speed dam.

Of twelve genera of caddisflies, eleven were found below the damsite and ten above it. Differences in caddisfly populations between the two stations were due to genera that were scarce at each station. That is, no *Pynopsyche* or *Chimarra* were caught above the damsite but only one of each were caught below the damsite. One small difference between the stations is that the proportion of case-living caddisflies to free-living caddisflies was slightly higher below the damsite than above. This is because of the slightly slower water velocity below the damsite and the influence of the pond-like eddy.

Fly populations were similar at each station with the same organisms being present throughout the river. *Antocha* was much more common above the damsite. It prefers fast-flowing well aerated water. The flow below the damsite is normally fast enough, but dissolved oxygen concentrations occasionally become somewhat lowered during some of the hotter nights. *Atherix variegata* was also more common above the damsite. The adult of this species lays its eggs on overhanging tree limbs so that the abundance of trees above the damsite probably explains the abundance of larvae.

The beetle populations were similarly composed of riffle beetles and water penny beetles. *Optioservus* was eight times as common above the damsite as *Stenelmis* and only three times as common below the damsite. It was noted both by Spence and Hynes (1971a) and G.R.C.A. that *Optioservus* was dominant below Belwood reservoir and *Stenelmis* above. Perhaps this is an indication that *Optioservus* is better adapted to withstand fast currents than *Stenelmis*. The other riffle beetle, *Dubiraphia* was much commoner below the damsite. This may also be due to current preference as they have also been found in the Bay of Quinte. (Johnson and Brinkhurst, 1971).

Two genera of the family Haliplidae and one of the family Dytiscidae of the beetles were present below the damsite. Both of these families live in areas sheltered from the current and need some vegetation for laying of eggs and feeding Ward and Whipple, 1966; Pennak, 1953).

A total of nineteen fish species were caught with sixteen of them being found below the damsite and fifteen above. Pearl dace were common below the damsite and absent above. These fish are common only in bogs, ponds or lakes, (Hubbs and Lagler 1964), and so must have originated in the Speed dam a few hundred yards downstream. Great Lakes Longnose Dace were caught only above the damsite. These fish prefer cooler water with currents over 0.5 m/sec and depths less than 0.3 m (Carlander, 1969). Two redbelly dace were caught above the dam and none below. These fish prefer still water containing vegetation so that their absence below the damsite is probably due to competition with ether minnow species such as the pearl dace. Three central mudminnows were caught below the damsite. These fish are normally found in pools with muddy bottoms (Hobbs and Lagler, 1964), so that their presence below the damsite may be due to fish wandering upstream from the Speed dam. The absence of smallmouth bass above the damsite cannot readily be explained. Probably upon completion of the dam, they will inhabit this area. Green sunfish were captured below the damsite. This is a rare fish in Ontario where it prefers sluggish creeks and small ponds (Hubbs and Lagler, 1964). One mottled sculpin was caught above the damsite. This fish prefers cooler creeks and is often found in association with brook trout (Hubbs and Lagler, 1964).

Thus, differences in the fish populations were due primarily to current velocity and water temperatures.

3. Summary, Recommendations and Predictions

a) Benthic and fish populations above the damsite were typical of a cooler, fast-flowing stream of pristine water quality.

b) Populations below the damsite showed that the current here was less than above the damsite. The average annual temperature of the water at this point, was slightly higher, and the decrease in the number of Stonefly species showed that the river became slightly enriched between the two stations due to agricultural practices. In other words, the river at this point is almost pristine, moderate in flow and attains slightly higher temperatures during the summer months than above the damsite.

c) Upon flooding, the station above the reservoir will he unchanged, except that smallmouth bass may be present.

d) During construction of the dam several, changes will be made on the river. Summer water temperature will increase as clearing progresses. Silting of the river may occur which may or may not affect stonefly populations at the station below the damsite If silting is very severe, the entire bottom fauna will be affected by the change in substrate. However, it is very doubtful that silting will be this extensive. Upon completion of the reservoir, the average annual temperature will decrease below what it is presently and water flow will be increased during summer months. Water quality will be excellent, possibly better than at present. If initial silting was not too severe the invertebrate and fish populations below the damsite may be very similar to that of the station. above the damsite at present. The entire stretch of river between the proposed dam and the Speed dam will become suitable for rainbow trout. It will probably take at least five years for the benthic communities below the reservoir to become stabilized and there will undoubtedly be annual fluctuations because of varying water temperatures depending on releases from the reservoir.

e) Studies of the fish and invertebrate populations above and below the damsite will be continued for as many years as deemed necessary.

f) A year-long biological study of two creeks that will flow into the new Guelph reservoir has already been initiated. This will be to ascertain what quality of water the new reservoir will be receiving and how these two creeks can be further developed.

g) A station has been set up on the Speed River in Guelph immediately above the inflow of the Eramosa River. This area will be sampled to detect improvements that the impoundment makes on the river after it has received several industrial outfalls.

h) In addition to continuing the regular sampling, an instantaneous biological survey will be done on the Speed River. This can be repeated after completion of the reservoir to determine the effects the dam has had on the whole Speed River system.

IV. PROPOSED WOOLWICH DAMSITE

1. Description of Sampling Areas

Station one is located a few yards downstream from the Floradale community park and above the outfall of the Floradale mill. This is approximately one hundred and fifty yards below the Floradale mill pond. Canagagigue Creek is less than 3 metres wide at the sampling area with depth ranging from approximately 15 to 60 cm during summer flow. Current is very variable depending on precipitation but is for the most part moderate in velocity with areas of higher velocity. In spring and during periods of very heavy precipitation, the creek becomes very turbid with a lot of silt deposited in the quieter stretches. The bottom contains some gravelly areas but is mostly silt covered with large boulders being present. There is one riffle area where the stones are swept free of silt.

From station one the creek travels about a mile and a half through wooded terrain before it reaches station two at the first bridge below Floradale. In this distance it receives a small spring creek which is only 25 cm in width at its mouth.

The creek at station two is roughly the same width but has a much more gravelly substrate with fewer silty areas. The study area is a gravelly riffle flowing into a pool which is about 100 cm deep at the deepest point.

2. Discussion of Results

Sixty-three species of invertebrates were collected from below the damsite while fifty-two were collected at Floradale. Lists of invertebrates and fish caught are given in Appendix IV.

There was a distinct difference in the leech populations of the two areas. In Floradale, they were much more numerous but only of three species. Five species were found below the damsite. The three species found in Floradale flourished in the muddy substrate while they were scarcer below due to the limited areas of silt. *Erpobdella octoculata* was present below the damsite. This leech needs well aerated water (Hynes, 1970), and it was shown by G.R.C.A. (1971), that station one averaged lower in dissolved oxygen concentrations than did station two. Also present below the damsite was *Glossiphonia complanata* which lives under stones in rapid water (Hynes, 1970).

Nine specimens of *Daphnia,* the water flea, were found at station one. These had no doubt been washed out of the Floradale mill pond.

Snails and clams were well represented at both stations with few real differences being found in the populations. Of interest is the occurrence of the snail *Viviparus* in the Floradale pond. It is extremely abundant in the pond where it attains a diameter of almost two inches. A few isolated specimens were found downstream, probably being washed over the dam.

There was a considerable difference in the structure of the two mayfly populations. Mayflies were more common below the damsite where there were fourteen species compared to eight in Floradale. One specimen of *Ephemera varia* was collected below the damsite. Detection of this mayfly is very difficult by use of a net. Due to its large size of over two inches, it is capable of swimming around the kick-net. The one specimen captured was caught by hand when observed swimming through the water.

The main difference in mayfly populations between the two stations was the number of species of *Stenonema* present. Below the damsite, there were eight species and only four in Floradale. Mayflies of this genus inhabit crevices and the undersides of rocks, (Pennak, 1953). The extreme silting in Floradale fills in crevices and covers rocks so that there is little habitat available for those mayflies.

A total of three specimens, representing two species of stoneflies at the two stations, indicate that the stream is overloaded with nutrients at this point. True bugs were common indicating high productions of aquatic vegetation in the stream.

Caddisflies were abundant at each station with ten genera being represented below the damsite and eight in Floradale. Free living forms comprised most of the population in Floradale and approximately two thirds of the population below the damsite. Caddisflies were more common in Floradale due to heavy concentrations of the net-spinning Hydropsychidae in the swift riffles below the mill dam.

Flies were common below the damsite and extremely abundant in Floradale. In the silt in Floradale, midge larvae were very common, forming almost a third of the number of organisms caught. Blackflies were even more common comprising over forty percent of the year’s sample. The flies taken at Floradale throughout the year formed 76.8% of the entire sample. Below the damsite, midge larvae also formed a third of the sample but blackflies were uncommon being only 4 percent of the entire year's sample. Two winged flies made up a total of 41%, of all the organisms collected below the damsite. The difference in fly numbers is due solely to the slower water velocity below the damsite so that there were few blackfly larvae present. The cranefly *Antocha* was absent in Floradale due to the lack of available stones and because oxygen concentrations were often low.

Of the nine species of beetles caught, eight were found below the damsite and six in Floradale. In the riffle beetle populations, *Optioservus* was more common than *Stenelmis* in Floradale while they were equally represented below the damsite. Once again, this implies the *Optioservus* is better at withstanding or avoiding high water velocities.

The water penny beetles were common below the damsite and rare in Floradale. This further suggests that these beetle larvae are swept away by fast currents. The lack of available stones may also have been a factor resulting in their scarcity in Floradale.

The fish populations of the two stations were very similar. A total of fifteen species wore caught with thirteen being represented below the damsite and twelve in Floradale. Longnose dace were present in Floradale and absent downstream due to their preference for fast-flowing water. Bluntnose minnows were absent in Floradale but only three specimens were caught below the damsite so that their presence there on one occasion may be spurious. One brown bullhead was caught below the damsite while one stonecat was caught in Floradale. Neither of these catfish species were abundant enough to be significant. Brock sticklebacks were scarce in the quieter sections downstream and absent from the rapid stretches of water in Floradale.

3. <u>Summary, Recommendations and Predictions</u>

a) Canagagigue Greek in Floradale is organically enriched and often suffers oxygen depletion. The Floradale mill dam acts as a catchbasin for the silt which runs off the upper part of this creek's watershed. During periods of extreme waterflow, much silt is washed over the dam and is deposited within the first few hundred yards downstream. As a result, the aquatic fauna is restricted to those that are capable of surviving in swift turbid water or that can burrow into the silt to avoid the current. Although the number of species was considerably less in Floradale there were approximately three times as many organisms. Those were composed mostly of blackfly larvae in the fast flowing areas and midge larvae in the deposited silt.

b) By the time the creek reaches the first bridge below Floradale, the current is much reduced and most of the silt has been deposited further upstream. The water is better aerated and slightly cooler due to the shade of the forest it passes through and to the influence of a small spring creek.

The bottom has some silty areas but for the most part is stony with alternating riffles and pools. The diversity of habitat and very slightly improved water quality allow a greater number of species to live in this area. Due to the more numerous species and competition among these species, none of these forms become dominant as occurs in Floradale. Thus a much more healthy and balanced fauna occurs below the damsite than in Floradale. However, since the water quality even here is slightly impaired, the species diversity cannot compare to that of the upper Speed or Grand Rivers.

c) Once the reservoir is flooded, the station at Floradale will be under water when the reservoir is at its maximum holding capacity. The creek at this point will become increasingly silty. Benthic organisms will be limited to those that live in mud and are equally at home in flowing and still water. The bottom fauna will probably be almost entirely midge larvae as was found by Paterson and Fernando (1970). Leeches, clams and roundworms will be present and an occasional specimen of the mayfly *Caenis* may be found. The main effect the reservoir will have on the invertebrates of this station is to eliminate the large blackfly population and replace it with more midge larvae.

d) The fish population of the new reservoir will be primarily white suckers, common shiners, creek chub and rock bass. Largemouth or smallmouth bass are being considered for stocking purposes.

e) The station below the damsite will be affected by a slight increase in temperature as there will be no shading trees present, by silting, during periods of high flow and by consistently fast currents. The invertebrate fauna population of this station will become similar to that of station one at the present with the majority of the invertebrate biomass being made up of blackflies. Fish species present will be similar to those now present in Floradale. The effects of the dam on the invertebrate and fish populations of the creek will be minimal. The major result will be an increased flow throughout the summer months. The high concentrations of blackfly and midge larvae below the reservoir will only extend a short ways downstream as in Floradale, while populations further downstream to the town of Elmira will be virtually unaffected.

f) A station has been set up below the town of Elmira. Presently the stream here is highly polluted with a very poor benthic population. Summer stream flow augmentation should improve water quality in this region.

g) Sampling will continue at these three stations for at least one year after completion of the reservoir in order to test our theories and the effectiveness of the reservoir in improving water quality downstream of Elmira.

V. INITIAL CLASSIFICATION OF INVERTEBRATE POPULATIONS BY THE LIMITATIONS OF WATER QUALITY

Introduction

This chapter is an attempt to illustrate the striking variations occurring in benthic communities according to stream flow and water quality. This is only a guideline as it does not take into account many factors such as water temperature, stream size, water turbidity, water chemistry and many other variables. As more literature is reviewed and more data analyzed, this chart will constantly be revised and updated.

The following is a legend of the symbols used in the chart.

O - none present.

R - rare; one or two show up per year.

S - scarce; one or two every second or third sample.

C - common; always present in each sample according, to its life cycle.

A - abundant; extremely common in all samples.

D - dominant; comprise 50% or more of the sample.

INITIAL CLASSIFICATION OF INVERTEBRATE, POPULATIONS BY THE LIMITATIONS OF WATER QUALITY.

TYPES OF STREAMS > ORGANISM	Fast Flowing Pristine Stream	Slow Flowing Pristine Stream	Fast Flowing Mildly Polluted Stream	Slow Flowing Mildly Polluted Stream	Fast Flowing Highly Polluted Stream	Slow Flowing Highly Polluted Stream
TRICLADIDA (Flat worm)	C	S	C	S	O	O
OLIGOCHAETA (Round Worm)						
Aquatic Forms	C	R	S	O	C	O
Terrestrial Forms	O	O	O	C	O	C
HIRUDINEA (leeches)						
Erpobdella octoculata	C	C	R	O	C	O
E. punctata	S	R	R	O	O	O
Glossiphoria complanata	S	S	S	C	C	A
Helobdella stagnalis	R	R	C	C	C	A
AMPHIPODA (Scuds, Sideswimmer)						
Hyalella azteca	R	C	O	R	O	O
DECAPODA (crayfish)						
Orconectes	C	C	C	C	O	O
Camparus	S	S	S	S	O	O
MOLLUSCA (Clams)						
Physa	C	C	C	C	S	S
Sphaerium	A	C	C	R	R	R
Gyraulus	C	C	C	C	O	O
Ferrissia	C	C	C	S	S	O
Lymnaea	R	R	R	S	O	O
Pisidium	S	C	S	C	O	O
Alasmidarea	S	S	S	S	O	R
Viviparus	R	S	R	S	O	O

INITIAL CLASSIFICATION OF INVERTEBRATE POPULATIONS BY THE LIMITATIONS OF WATER QUALITY

TYPES OF STREAMS > / ORGANISM	Fast Flowing Pristine Stream	Slow Flowing Pristine Stream	Fast Flowing Mildly Polluted Stream	Slow Flowing Mildly Polluted Stream	Fast Flowing Highly Polluted Stream	Slow Flowing Highly Polluted Stream
TUBIFICIDAE (sludgeworms)	O	O	O	R	S	D (50%)
EPHEMEROPTERA (mayflies)						
S. gildersleevei	C	C	S	O	O	O
S. nepotellum	C	S	R	O	O	O
Stenonema fuscum	C	S	R	O	O	O
S. tripunctatum	C	A	C	S	O	O
S. pulchellum	C	C	R	O	O	O
S. heterotarsale	C	S	S	O	O	O
S. canadens	C	C	R	O	O	O
S. pudicum	C	S	R	O	O	O
Tricorythodes	S	S	R	R	O	O
Ephemerella aurivilli	R	R	O	O	O	O
E. bicolor	C	S	S	S	O	O
E. deficiens	C	S	R	R	O	O
Ephemera simulans	R	S	R	S	O	O
E. varia	O	R	R	R	O	O
Paraleptophlebia mollis	C	S	R	R	O	O
P. moerens	C	S	O	C	O	O
P. adoptiva	C	S	O	O	O	O
Leptophlebia cupida	C	C	O	O	O	O
Habrophlebiodes	R	R	O	O	O	O
Heptagenia	S	R	O	O	O	O
Caenis	S	A	R	A	R	R
Baetis	C	C	C	S	O	O
Centroptilum	S	R	O	O	O	O
Ephoron	O	S	O	S	O	O
Cloeon	S	R	O	O	O	O

INITIAL CLASSIFICATION OF INVERTEBRATE POPULATIONS BY THE LIMITATIONS OF WATER QUALITY

TYPES OF STREAMS > ORGANISM	Fast Flowing Pristine Stream	Slow Flowing Pristine Stream	Fast Flowing Mildly Polluted Stream	Slow Flowing Mildly Polluted Stream	Fast Flowing Highly Polluted Stream	Slow Flowing Highly Polluted Stream
ODONATA (damselflies)						
Argia	S	S	S	O	O	O
Agrion	S	S	O	O	O	O
Ischnura	S	C	S	O	O	O
Enallagma	R	S	S	O	R	O
(dragonflies)						
Aeschnidae	R	S	R	S	O	O
Libellulidae	R	S	R	S	O	O
Gomphidae	R	S	R	S	O	O
PLECOPTERA (stoneflies)						
Phasganophora capitata	C	S	O	O	O	O
Paragnetina media	C	S	O	O	O	O
Acroneuria	S	S	O	O	O	O
Taeniopteryx	S	R	O	O	O	O
Brachyptera	S	R	O	O	O	O
Alloperla	S	R	O	O	O	O
Chloroperla	S	R	O	O	O	O
Nemoura	S	R	O	O	O	O
HEMIPTERA (bugs)						
Belostoma	C	R	O	R	O	O
Corixidae	R	C	R	C	R	C
Ranata	R	S	R	O	S	O
NEUROPTERA (dobson flies)						
Sialis	R	S	R	R	S	R
Chauliodes	S	R	R	O	S	O

INITIAL CLASSIFICATION OF INVERTEBRATE POPULATIONS BY THE LIMITATIONS OF WATER QUALITY

TYPES OF STREAMS > ORGANISM	Fast Flowing Pristine Stream	Slow Flowing Pristine Stream	Fast Flowing Mildly Polluted Stream	Slow Flowing Mildly Polluted Stream	Fast Flowing Highly Polluted Stream	Slow Flowing Highly Polluted Stream
LEPIDOPTERA (aquatic caterpillars)						
Cataclysta	R	S	R	R	S	R
Nymphula	S	R	R	O	S	O
TRICOPTERA (caddis flies)						
Cheumatopsyche	C	C	C	R	R	O
Hydropsyche	C	S	C	R	R	O
Helicopsyche	C	C	C	S	O	O
Leptocella	R	S	O	O	O	O
Rhyacophila	C	S	C	R	O	O
Chimarra	R	R	R	O	O	O
Limnephilus	R	S	O	R	O	O
DIPTERA (flies)						
Chironomidae	R	A	R	D	R	D(80%)
Ceratopogonidae	R	S	R	C	R	C
Atherix variegata	S	S	S	S	O	O
Simuliidae	C	R	S	O	O	O
Antocha	C	S	R	O	O	O
Tabanidae	S	S	S	S	S	O
Chrysops	R	S	R	S	O	O
Dixinae	O	O	O	S	O	S
Ephyridae	O	O	O	O	O	C
COLEOPTERA (beetles)						
Ectopria	C	R	S	O	O	O
Psephenus	C	R	S	O	O	O
Helodidae	C	C	S	O	R	O
Dubiraphia	S	S	S	C	R	O
Stenelmis	C	S	S	S	R	O
Optioservus	C	S	S	S	R	O
Dytiscidae	R	S	R	S	O	O
Haliplidae	R	S	R	S	O	O

DISCUSSION OF ENTIRE BENTHIC PROJECT

This project was very successful from G.R.C.A.'s viewpoint. It pointed out that benthic studies were essential to the complete understanding of water quality, as well as making a start at explaining changes in water quality above and below a reservoir.

Water quality studies conducted by OWRC (1970, 1971) and G.R.C.A. (1971) showed that the water being discharged from Conestogo and Belwood reservoirs was of superior quality. Benthic studies at Conestogo showed no appreciable buildup of nutrients within the reservoir so that water quality below the reservoir was similar to that of the water entering the reservoir. Absence of stoneflies below Belwood suggested that water became very slightly enriched within the impoundment or that stoneflies had been eliminated during construction of the dam and had been unable to re-establish themselves due to their poor abilities of flight. The distribution of invertebrates below the reservoirs seemed to be delineated by physical rather than chemical properties such as water velocity and temperature. In addition, the studies of these two large reservoirs will enable us to predict changes in benthic and fish communities of future reservoirs. A full year's sampling of these stations will give us a unit that we can compare in future to determine any slight changes that may have taken place.

Studies of the proposed Guelph reservoir served to give valuable background knowledge of this area and will enable us to monitor changes that occur during the construction of a major reservoir. In addition, it indicated the diversity of fauna that can be expected in a pristine aquatic environment, thus serving as a yardstick for classifying other streams in the watershed.

The benthic communities of the proposed Woolwich reservoir showed what a great effect the addition of phosphorus, nitrogen and silt have on an invertebrate population. In addition, samples here demonstrated that the extreme effects below a small overflow-type dam, that is, the Floradale mill pond, extend for a very short stretch downstream with the stream quickly reverting to normal. The reservoir will eliminate a mile of stream but water quality of the stream between the dam and Elmira will remain much the same, while water quality below the town of Elmira will be greatly improved. Thus, removal of a mile of stream results in improved water quality plus excellent waterfowl and warm water sports fish habitat where none previously existed.

These studies proved very beneficial but are limited in that they take a year to complete. For a reservoir or proposed reservoir, twelve monthly samplings are the best means to determine water quality. However, for streams and rivers that are not going to be drastically altered, a new approach is planned. Simultaneous samples will be taken at strategic points throughout the stream to determine water quality, benthic and fish populations. Depending on the size of the region being tested, field work can be completed in one to two weeks. This will give us a definite comparison among sampling areas as variables such as date, time of day, air and water temperatures will be eliminated. In addition, these samplings can be repeated in future years at the same calendar date to monitor subtle changes that have taken place.

By the same token, intensive sampling will be done once or twice a year above and below Belwood and Conestogo reservoirs. This will entail sampling every type of habitat in order to ascertain what species of invertebrates and fish are present. Results from these studies will tell us if any subtle changes in writer quality have taken place since the last sampling period.

The same type of intensive sampling should be done in Canagagigue Creek as it enters Elmira, in the Conestogo River near Glen Allen and in the Grand River above Fergus. The station above Elmira will tell us to what extent the Town of Elmira affects Canagagigue Creek and how the water quality immediately above Elmira is comparable to that below Floradale. The stations at Glen Allen and Fergus will tell us how far down the rivers the effects of the cooler, faster water flowing from the major impoundments are reflected in benthic populations.

The major problem encountered in this study was the lack of full-time qualified personnel. Summer students each had to be taught techniques and they were not employed long enough to be of any real service. Part-time assistants do not have the necessary dedication to do the job properly as do the full-time staff. Also, compilation of data during the winter is the most complicated step of analysis when qualified personnel familiar with procedures are necessary.

Emphasis should be made on hiring permanent staff members rather than part-time labour. A few full time members presently working on this project know all the sampling are and techniques and are capable of identifying fish to species. All of them recognize invertebrate groups, while one of them, a marine biologist, is now able to key invertebrates to the species level. One of these men is easily worth a dozen summer students.

More reference books and technical, keys are desperately needed. Many of the scientific works that we are using as guides are now outdated. File cards recording data on each species of invertebrate and fish found in the area are kept. These files are constantly being added to and revised as we review more of the voluminous literature available. As these files grow, so does our proficiency in interpreting benthic communities.

REFERENCES

Allen, R.K. and G.F. Edmunds, Jr. 1963. A revision of the Genus *Ephemerella* (Ephemeroptera: Ephemerellidae) VI. The subgenus *Serratella* in North America. Ann. Entomol Soc. Amer. 56: 583 -600.

Berner , Lewis, 1950. The mayflies of Florida. Univ. Florida Stud., Biol . Ser. 4 (4) : 270 pp.

Burks , B. D. 1953. The mayflies or Ephemeroptera of Illinois. Bull. Ill. Nat, Hist, Surv. 26(1): 1-236.

Carlander, Kenneth D. 1969. Handbook of Freshwater Fishery Biology. Volume I. The Iowa State University Press, Ames, Iowa.

Claassen, Peter W. 1931. Plecoptera Nymphs of America (North of Mexico). The Thomas Say Foundation, Springfield and Baltimore, 193 pp.

Coleman, M.J., and H.B.N. Hynes. The life histories of some Plecoptera and Ephemeroptera in a southern Ontario stream. Can. J. Zool. 48: 1333-1339.

Davies, Ronald W. 1971. A key to the freshwater Hirudinoidea of Canada. J. Fish Res. Bd. Canada 28: 543-552.

Grand River Conservation Authority, 1970 Annual Report. Forestry & Wildlife Branch.

Grand River Conservation Authority, 1971 Water Quality Report.

Grand River Conservation Authority 1971. 1971 Fish Report for the Grand River Valley.

Hubbs, Carl L., and Karl F. Lagler, 1964. Fishes of the Great Lakes Region, Ann Arbor, The University of Michigan Press, 202 pp.

Hynes, H.B.N. 1958. The effect of drought on the fauna of a small mountain stream in Wales. Verh, int. Verein. theor. angew. Limnol. 13: 826-35.

Hynes, H.B.N. 1970, The Ecology of Running Waters, University of Toronto Press. 555 pp.

Hynes, H.B.N and T.R. Willliams, 1962. The effect of DDT on the fauna of a Central African stream, Ann. trop. Med. Parasit. 56: 78-91.

Ide, F.P, 1935. The effect of temperature on the distribution of the mayfly fauna of a stream. Univ. Toronto Studies, Biol. Series. 39: 1-76.

Johannsen, O.A. 1937. Aquatic Diptera, Reprinted in 1969 by Entomological Reprint Specialists, 369 pp.

Johnson, M.G., and R.O. Brinkhurst. 1971. Associations and species diversity in benthic macroinvertebrates of Bay of Quinte and Lake Ontario. J. Fish Res. Bd. Canada 28z 1683-1697.

Leonard, Justin W. 1965. Environmental Requirements of Ephemeroptera. *In:* Tarzwall, C. M. Biological Problems in Water Pollution. Publ. Health. Serv. 999-WP-25, pp, 110-117.

Needham, James G., J.H. Traver, and Yin-Chi Hsu. 1935. The Biology of Mayflies with a Systematic Account of North American Species. Comstock. Publishing Co., Inc., 759 pp.

Ontario Water Resources Commission. 1970 Water Quality Monitoring Data.

Ontario Water Resources Commission, 1973 Water Quality Monitoring Data.

Paterson, C.G., and C.H. Fernando, 1970, Benthic fauna colonization of a. new reservoir with particular reference to the Chironomidae. J. Fish. Res. Bd. Canada, 27: 213-232.

Pennak, Robert W. 1953. Fresh-Water Invertebrates of the United States. The Ronald Press Company, New York. 769 pp.

Sloan, W.C. 1956. The distribution of aquatic insects in two Florida streams. Ecology, 37. 81-98.

Spence, J. and H.B.N. Hynes. 1971a. Differences in benthos upstream and downstream of an impoundment, J. Fish. Res. Bd. Canada 28: 35-43.

Spence, J. A. and H. B. N. Hynes. 1971b. Differences in fish populations upstream and downstream of a mainstream impoundment. J. Fish Ed. Canada 28: 45-46.

Ward, Henry B., and C. C Whipple. *ed*. W.T. Edmondson. 1966. Fresh-Water Biology. Second Edition John Wiley and Sons, Inc., New York. 1248 pp.

APPENDIX I

TABLES OF RESULTS FROM BELWOOD

1971 BENTHIC DATA COLLECTED FROM BELWOOD

Organism	Above Reservoir	Below Reservoir
Order Tricladida	19	128
Oligochaeta	10	22
Hirundinoidea		
Erpobdella octoculata	14	26
E. punctata	1	5
Placobdella	1	-
Helobdella stagnalis	1	-
Amphipoda		
Hyalella azteca	2	5
Decapoda		
Orconectes	2	12
Cyclopoida	1	-
Gastropoda		
Lymnaea	5	3
Ferrissia	1	4
Physa	2	23
Gyraulus	15	5
Pelecypoda		
Sphaerium	11	-
Pisidium	22	3
Alasmidonta	1	-
Acari	49	4

1971 BENTHIC DATA COLLECTED FROM BELWOOD

Organism	Above Reservoir	Below Reservoir
Order Ephemeroptera		
Cinygma	17	-
Heptagenia	12	-
Stenonema canadens	16	5
S. fuscum	91	1
S. gildersleevei	18	5
S. heterotarsale	21	11
S. nepotellum	12	-
S. pulchellum	27	3
S. tripunctatum	6	28
Caenis	5	1
Tricorythodes	24	20
Baetis spp	68	25
Pseudocloeon	7	-
Centroptilum	20	-
Paraleptophlebia moerens	7	-
P. mollis	2	-
Ephemerella bicolor	26	-
E. deficiens	17	-
Number of mayflies	396	99
Number of mayfly species	18	9
Total of 18 species		
Order Odonata		
Argia	69	-
Ischnura	1	-
Aeschna	-	1
Order Plecoptera		
Acroneuria	14	-
Paragnetina media	31	-
Phasganophora capitata	38	-
Amphinemura delosa	5	_

1971 BENTHIC DATA COLLECTED FROM BELWOOD

Organism	Above Reservoir	Below Reservoir
Order Hemiptera		
Mesovelia	1	-
Gerris	-	2
Ranata	-	1
Order Neuroptera		
Sialis	2	2
Chauliodes	4	-
Order Lepidoptera		
Cataclysta	81	-
Order Tricoptera		
Hydropsyche	353	140
Cheumatopsyche	213	241
Rhyacophila	184	134
Limnephilus	44	3
Chimarra	2	-
Neophylax	1	5
Oecetis	2	-
Helicopsyche	104	64
Athripsodes	4	5
Orchotrichia	10	4
Leptocella	12	1
Number of caddisflies	927	597
Number of caddisfly species	11	9
Total of 11 species		
Order Diptera		
Chironomidae	294	1,038
Ceratopogonidae	10	-
Antocha	241	28
Atherix variegata	2	2
Prosimulium	5	-
Simulium vittatum	-	40
Total number of flies	552	1,108

1971 BENTHIC DATA COLLECTED FROM BELWOOD

Organism	Above Reservoir	Below Reservoir
Order Coleoptera		
Helodidae imagines	101	8
Elmidae imagines	5	2
Dubiraphia	6	4
Stenelmis	369	15
Optioservus	162	280
Psephenus	38	1
Ectopria	63	1
Ptilodactylidae: *Anchytarsus*	1	-
Curculionidae	1	-
Dytiscidae: *Bidessus*	-	1
Hydrophilidae: *Hydrobius* larva	-	1
Helodidae: *Elodes* larva	-	1
Number of beetles	746	314
Number of beetle species	9	10
Total number of species	70	48
Total number of organisms	3,026	2,364
Grand Total of 77 species		
Number of times sampled	8	8

FISH COLLECTED FROM BELWOOD, 1971

Species	Above Reservoir	Below Reservoir
Catostomidae		
Common White Sucker	80	54
Cyprinidae		
Carp	-	1
Northern Creek Chub	58	20
Northern Pearl Dace	-	1
Hornyhead Chub	96	7
River Chub	109	-
Blacknose Dace	6	-
Longnose Dace	2	-
Redbelly Dace	-	4
Common Shiner	858	26
Spotfin Shiner	56	16
Bluntnose Minnow	37	11
Ictaluridae		
Brown Bullhead	1	
Percidae		
Yellow Perch	139	500
Iowa Darter	61	2
Barred Fantail	24	-
Centrarchidae		
Rock Bass	3	-
Cottidae		
Mottled Sculpin	1	12
Total number of fish	1,531	654
Total of 17 species		

APPENDIX II

TABLES OF RESULTS FROM CONESTOGO

1971 BENTHIC DATA COLLECTED FROM CONESTOGO

Organism	Drayton	Spring Creek	Below Dam
Order Tricladida	26	-	14
Oligochaeta	2	-	28
Hirundinoidea			
Erpobdella octoculata	1	7	-
Erpobdella punctata	-	1	3
Helobdella stagnalis		2	-
Glossiphonia complanata	-	2	-
Batracobdella paludesa	-	-	1
Amphipoda			
Hyalella azteca	2	2	37
Decapoda			
Orconectes	1	1	24
Gastropoda			
Physa	6	7	40
Gyraulus	1	65	1
Lymnaea	-	1	1
Ferrissia	-	-	33
Pelecypoda			
Sphaerium	1	3	3
Acari	2	-	-

1971 BENTHIC DATA COLLECTED FROM CONESTOGO

Organism	Drayton	Spring Creek	Below Dam
Order Ephemeroptera			
Ephemera simulans	1	-	9
Caenis	98	5	98
Tricorythodes	4	-	2
Paraleptophlebia mollis	-	-	1
P. ontario	1	-	-
Baetis	21	-	-
Cloeon	5	-	-
Ephemerella needhami	2	-	-
E. bicolor	3	-	-
Stenonema gildersleevei	16		-
S. fuscum	4	-	-
S. heterotarsale	34	-	-
S. nepotellum	10	-	-
S. pulchellum	14	-	-
S. tripunctatum	10	-	-
Number of mayflies	223	5	110
Number of mayfly species	14	1	4
Total of 15 species			
Order Odonata			
Ischnura	1	1	1
Agrion	-	2	-
Aeschna	-	3	-
Paltothemis	-	1	1
Order Plecoptera			
Acroneuria	5	-	-
Phasganophora capitata	-	1	-
Taeniopteryx parvulus	-	-	1

1971 BENTHIC DATA COLLECTED FROM CONESTOGO

Organism	Drayton	Spring Creek	Below Dam
Order Hemiptera			
Corixidae	-	136	-
Ranata	-	8	-
Belostoma	-	1	-
Notonecta	-	7	2
Order Neuroptera			
Sialis	1	-	-
Order Lepidoptera			
Cataclysta	1	-	-
Order Tricoptera			
Hydropsyche	129	-	1
Cheumatopsyche	154	1	-
Helicopsyche	12	-	-
Rhyacophila	110	-	-
Oecetis	1	-	-
Athripsodes	6	-	-
Orchotrichia	35	-	4
Limnephilus	-	-	2
Neophylax	-	-	1
Number of caddisflies	447	1	8
Number of caddisfly species	7	1	4
Total of 9 species			
Order Diptera			
Chironomidae	521	971	283
Chrysops	-	2	-
Limnobia larvae	3	-	-
Elliptera pupa	1	-	-
Antocha	26	-	-
Atherix variegata	2	-	-
Number of flies	553	973	283
Number of fly species	5	2	1
Total of 6 species			

1971 BENTHIC DATA COLLECTED FROM CONESTOGO

Organism	Drayton	Spring Creek	Below Dam
Order Coleoptera			
Stenelmis	13	4	-
Optioservus	4	1	-
Dubiraphia	-	-	1
Ectopria	26	-	-
Psephenus	13	1	-
Peltodytes	1	-	-
Helodidae imagines	9	-	-
Dytiscidae imago	-	1	1
Curculionidae: *Stenopelmus*	-	1	-
Number of beetles	66	8	2
Number of beetle species	6	5	2
Total of 9 species			
Total number of species	44	28	26
Total number of organisms	1,339	1,238	593
Grand total of 67 species			
Number of times sampled	6	3	5

FISH COLLECTED FROM CONESTOGO, 1971

Species	Drayton	Spring Creek	Below Dam
Catostomidae			
Common White Sucker	19	11	6
Northern Hog Sucker	31	-	0
Cyprinidae			
Northern Creek Chub	11	37	3
Hornyhead Chub	3	-	14
River Chub	48	41	39
Redbelly Dace	-	12	-
Rosyface Shiner	215	-	1
Common Shiner	336	14	129
Northern Fathead Minnow	-	29	13
Bluntnose Minnow	36	18	25
Ictaluridae			
Northern Brown Bullhead	2	1	27
Percidae			
Iowa Darter	8	135	13
Barred Fantail	-	12	3
Centrarchidae			
Smallmouth Bass	7		5
Rock Bass	6	3	2
Gasterosteidae			
Brook Stickleback	-	300	1
Number of species caught	12	12	14
Number of fish caught	752	633	282

APPENDIX III

TABLES OF RESULTS FROM GUELPH

1971 BENTHIC DATA COLLECTED FROM GUELPH

Organism	Above Dam	Below Damsite
Order Tricladida	13	8
Oligochaeta	8	-
Hirundinoidae		
Glossiphonia heteroclita	-	-
Isopoda		
Asellus	-	1
terrestrial forms	2	-
Amphipoda		
Hyalella azteca	19	20
Decapoda		
Orconectes	5	9
Cambarus	-	1
Cyclopoida	1	-
Acari	-	5
Gastropoda		
Gyraulus	9	16
Ferrissia	6	16
Physa	7	9
Lymnaea	1	8
Pelecypoda		
Alasmidonta	3	-
Sphaerium	75	3
Pisidium	9	2
Order Collembola		
Isotomurus palustris	1	1

1971 BENTHIC DATA COLLECTED FROM GUELPH

Organism	Above Dam	Below Damsite
Order Ephemeroptera		
Ephemera simulans	18	6
Ephoron	2	8
Heptagenia	13	3
Stenonema canadens	1	1
S. fuscum	17	2
S. gildersleevei	10	3
S. heterotarsale	3	9
S. nepotellum	51	23
S. pudicum	3	7
S. pulchellum	23	23
S. tripunctatum	8	8
Leptophiebia	-	3
Paraleptophiebia moerens	41	6
P. mollis	7	1
Habrophlebiodes	-	1
Ephemerella aurivilli	13	4
E. bicolor	17	4
E. deficiens	19	12
S. needhami	3	2
E. temporalis	1	-
Caenis	72	96
Tricorythodes	13	12
Centroptilum	7	1
Baetis	13	15
Cloeon	10	6
Pseudocloeon	5	3
Number of mayflies	370	268
Number of mayfly species	24	25
Total of 26 species		

1971 BENTHIC DATA COLLECTED FROM GUELPH

Organism	Above Dam	Below Damsite
Order Odonata		
Zygoptera		
Agrion	6	3
Enallagma	-	-
Ischnura	3	26
Argia	6	7
Anisoptera		
Aeschna	1	1
Erpetogomphus	1	-
Orthemis	-	1
Number of dragonflies	17	41
Number of dragonfly species	5	6
Total of 7 species		
Order Plecoptera		
Acroneuria (? lycorias)	2	5
Aeroneuria sp.	2	-
Paragnetina. media	17	17
Phasganophora capitata	11	4
Brachyptera glacialis	1	-
Nemoura (Ostrocerca) truncata	3	-
Number of stoneflies	36	26
Number of stonefly species	6	3
Total of 6 species		
Order Hemiptera		
Corixidae	1	11
Order Neuroptera		
Chauliodes	1	-
Sialis	-	7

1971 BENTHIC DATA COLLECTED FROM GUELPH 1971

	Above Dam	Below Damsite
Order Lepidoptera		
Cataclysta	14	19
Nymphula	-	1
Order Tricoptera		
Cheumatopsyche	276	194
Hydropsyche	398	115
Hydropsychidae pupae	7	1
Orchotrichia	6	1
Hydroptilidae	5	1
Helicopsyche	328	260
Rhyacophila	49	28
Chimarra	-	1
Limnephilus	13	28
Leptocella	3	8
Athripsodes	4	-
Neophylax	1	14
Oecetis	1	8
Pycnopsyche	-	1
Number of caddisflies	1,091	660
Number of caddisfly species	12	13
Total of 14 species		
Order Diptera		
Chironomidae	926	708
Ceratopogonidae	9	1
Chryops	1	1
Eriocera	2	1
Antocha	597	85
Atherix variegata	36	8
Number of flies	1,571	804
Number of fly species	6	6
Total of 6 species		

1971 BENTHIC DATA COLLECTED PROM GUELPH

Organism	Above Dam	Below Damsite
Order Coleoptera		
Stenelmis	48	27
Optioservus	407	99
Dubiraphia	5	13
Psphenus	50	52
Ectopria	43	16
Haliplus	-	1
Bidessus	-	1
Peltodytes imago	-	1
Dryopidae imago	1	-
Helodidae imagines	15	28
Total number of beetles	569	243
Number of beetle species	7	9
Total of 10 species		
Number of samples taken	8	8
Total number of organisms	3829	2170
Total number of species	77	80
Grand total of 82 species		

FISH COLLECTED FROM GUELPH, 1971

Organism	Above Dam	Below Damsite
Catostomidae		
Common White Sucker	17	103
Northern Hog Sucker	32	40
Cyprinidae		
Northern Creek Chub	93	65
Northern Pearl Dace	-	52
Hornyhead Chub	200	438
River Chub	97	338
Western Blacknose Dace	91	56
Great Lakes Longnose Dace	8	-
Northern Redbelly Dace	2	-
Common Shiner	371	2059
Bluntnose Minnow	3	127
Umbridae		
Central Mudminnow	-	
Percidae		
Iowa Darter	2	6
Barred Fantail	1	4
Centrarchidae		
Northern Smallmouth Bass	-	10
Green Sunfish	-	31
Northern Rock Bass	1	12
Cottidae		
Mottled Sculpin	1	-
Gasterosteidae		
Brook Stickleback	3	26
Number of fish caught	922	3370
Humber of species caught	15	16
Total of19 species		

APPENDIX IV

TABLES OF RESULTS FROM WOOLWICH

1971 BENTHIC DATA COLLECTED FROM WOOLWICH

Organism	Floradale	Below Damsite
Order Tricladida	35	3
Oligochaeta	29	12
Hirundinoidea		
Helobdella stagnalis	25	1
H. triserialis	2	3
Erpobdella punctata	5	4
E. octoculata	-	3
Glossiphonia complanata	-	2
Amphipoda		
Hyalella azteca	24	33
Decapoda		
Orconectes	11	16
Cladocera		
Daphnia	9	0
Acari	2	6
Gastropoda		
Physa	84	54
Gyraulus	13	3
Ferrissia	23	41
Lymnaea	1	2
Vivipara	1	1
Pelecypoda		
Sphaerium	433	261
Pisidium	52	5
Alasmidonta	1	3

1971 BENTHIC DATA COLLECTED FROM WOOLWICH

Organism	Floradale	BELOW Damsite
Order Ephemeroptera		
Ephemera simulans	1	1
E. varia	-	1
Stenonema canauens	7	7
S. gildersleavei	33	97
S. heterotarsale	5	52
S. fuscum		2
S. nepotellum	-	1
S. pudicum	-	2
S. pulchellum	-	9
S. tripunctatum	6	54
Caenis	180	294
Tricorythodes	1	1
Baetis	-	6
Cloeon	2	1
Total number of mayflies	240	528
number of mayfly species total of14 species	18	14
Order Odonata		
Agrion	-	3
Ischnura	18	19
Dromogomphus	1	-
Order Plecoptera		
Chloroperla cydippe	2	-
Acroneuria	-	1
Order Hemiptera		
Corixidae	34	3
Ranata	2	1
Belostoma	-	1
Gerris	1	-

1971 BENTHIC DATA COLLECTED FROM WOOLWICH

Organism	Floradale	Below Damsite
Order Neuroptera		
Sialis	2	24
Order Tricoptere		
Cheumatopsyche	410	75
Hydropsyche	80	132
Rhyacophila	7	35
Orchotrichia	10	8
Hydroptilidae pupae	8	
Helicopsyche	5	103
Limnephilus	27	23
Athripsodes	4	2
Leptocella	1	1
Chimarra	-	3
Neophylax	-	8
number of caddisflies	554	394
number of caddisflies species total of10 species	8	10
Order Diptera		
Chironomidae	2,316	978
Ceratopogonidae	1	4
Simulium vittatum	3,300	45
Antocha	-	21
Atherix variegata	22	4
Dixa	2	
Chrysops	1	
Hemerodromia rogatoris pupa	-	1
number of flies	5,642	1,053
number of fly species total of 8 species	6	6

1971 BENTHIC DATA COLLECTED FROM WOOLWICH

Organism	Floradale	Below Damsite
Order Coleoptera		
Stenelmis	7	14
Optioservus	16	15
Dubiraphia	2	1
Ectopria	5	27
Psephenus	-	6
Peltodytes	14	2
Haliplus	1	-
Bidessus	-	1
Helodidae imagines	-	18
Number of beetles	45	84
number of beetle species	6	8
total of number of species - 9		
number of times sampled	10	10
total number of organisms	7,341	2,564
total number of species grand total of species - 70	52	63

FISH COLLECTED FROM WOOLWICH, 1971

Species	Floradale	Below Damsite
Catostomidae		
Common White Sucker	9	10
Northern Hog Sucker	5	14
Cyprinidae		
Northern Creek Chub	27	47
Hornyhead Chub	393	231
River Chub	83	87
Western Blacknose Dace	18	13
Great Lakes Longnose Dace	8	-
Common Shiner	588	688
Bluntnose Minnow	-	3
Ictaluridae		
Northern Brown Bullhead	-	1
Stonecat	1	-
Percidae		
Iowa Darter	4	7
Barred Fantail	4	2
Centrarchidae		
Northern Rock Bass	32	4
Gasterosteidae		
Brook Stickleback	-	6
Number of fish caught	1,172	1,113
Number of species caught	12	13
Total of 15 species		

APPENDIX V

GLOSSARY OF TERMS

GLOSSARY

apneustic -	having no spiracles. The spiracles are in effect gills that allow the organism to breathe in damp air or water. Aquatic organisms without gills or spiracles need well-oxygenated water in order to survive.
Erpobdella -	a genus of leeches or bloodsuckers
free-living -	not in a shell or case but exposed to the environment.
fry-	a fish that is less than one year old.
invertebrate -	any animal not having a backbone or bony spine.
isotherm -	a line on a mop which joins areas having equal temperatures.
marl -	also called travertine. Deposits of calcium carbonate which are laid down on the bottom of a stream. Deposition is usually associated with photosynthesis of algae or mosses
Naididae -	a family of roundworms.
net-spinning caddisflies -	several genera of free-living caddisflies live in rapid water. To obtain food, they make a funnel-shaped silken net facing upstream which traps drifting invertebrates.
pristine -	pure
riffle -	an area of stream that is fast-flowing over a stony bottom.
stenotherm -	unable to adjust to temperature changes.

ENGLISH EQUIVALENTS OF LATIN TERMINOLOGY

Order Tricladida -	flatworms
Oligochaeta -	round worms - exclusive of sludge worms in this study
Hirudinoidea -	leeches or bloodsuckers
Amphipoda -	side-swimmers, scuds, freshwater shrimps
Decapoda-	crayfish
Isopoda -	sow bugs, water lice
Cyclopoida -	water fleas
Acari -	water mites
Gastropoda -	snails
Pelecypoda -	clams
Collembola -	spring-tails
Ephemeroptera -	mayflies
Odonata -	dragonflies and damselflies
Plecoptera -	stoneflies
Hemiptera -	true bugs
Neuroptera -	dobsonflies and alderflies
Lepidoptera -	moths and butterflies
Tricoptera -	caddisflies
Diptera -	two-winged flies
Coleoptera -	beetles

Catostomidae -	suckers and redhorses
Cyprinidae -	minnows, shiners, carp, goldfish, chubs, dace
Ictaluridae -	catfish
Umbridae -	mudminnows
Percidae -	perch, darters
Centrarchidae -	sunfish including smallmouth bass
Cottidae -	sculpins
Gasterosteidae -	sticklebacks