Benthic Macroinvertebrate Fauna
of the Robert S. Kerr Reservoir Below Lake Tenkiller
Adjacent to the Effluent Outfall of the
Sequoyah UF_6 Facility, Kerr-McGee Nuclear Corporation,
Gore, Oklahoma,

October 1980 to December 1981

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INTRODUCTION

License SUB-1010 Condition 15, issued by the U.S. Nuclear Regulatory Commission for the Kerr-McGee Nuclear Corporation Sequoyah UF_6 Facility requires semi-annual sampling of benthic macroinvertebrate organisms at upstream and downstream locations from the facility outfall. Kerr-McGee Nuclear Corporation undertook an intensive initial monitoring program from October 1978 to December 1979. A total of five sampling periods occurred during this time, with eight sampling locations analyzed. The area studied was adjacent to the Sequoyah uranium hexaflouride (UF_6) conversion facility which discharges an effluent in the lower reaches of the Illinois River/arm of Robert S. Kerr (RSK) Reservoir in Southeast Oklahoma. In this initial study by Dorris and Russell[1] of the effects of the Sequoyah facility effluent, a change in the community structure did occur but was not reflected by a decrease in species diversity. At the mouth of the effluent stream and adjacent to it in the Illinois River/arm of the (RSK) Reservoir, species diversity was elevated, numbers of individuals were reduced and numbers of species were not significantly changed. Wilhm and Dorris[2] hypothesize that species diversity (Shannon-Weiner function, H) may be used to determine the effect of a pollutant on a community (see Appendix A). Pollution is postulated to reduce the value of the diversity index. However, results obtained from the initial study of the Sequoyah effluent stream did not fit this hypothesis.

In other studies[3,4] of the effects of a thermal effluent on estuarine and freshwater communities similar findings have been observed. Nauman and Cory[3] found an increase in the diversity of epifauna in the effluent of a steam electric plant. Logan and Maurer[4] showed an unusually high diversity existing in a thermal effluent at the mouth of a discharge canal. These findings suggest that environmental change (i.e., thermal pollution) may not always be associated with a decrease in species diversity.

Kerr-McGee has continued the monitoring program. From July of 1980 to December of 1981 the benthic macroinvertebrate population was sampled semi-annually at locations indicated on Figure 2. Continued monitoring results demonstrate the species diversity index has remained higher in the effluent stream than in the (RSK) Reservoir sampling stations. These continued monitoring results confirm earlier findings, and support the conclusion that the Sequoyah facility effluent stream exhibits no appreciable adverse effect on the (RSK) Reservoir benthic macroinvertebrate community. Moreover, the effluent stream itself supports a stable low fluctuating benthic macroinvertebrate community.

Study Area

The Illinois River flows into the upper reaches of the Robert S. Kerr Reservoir (Fig. 1). The water level in the lowest region of the Illinois River discharges into the RSK Reservoir, and remains constant under the influence of the lock and dam system of the Arkansas River. The Sequoyah Facility is located on the east bank of the upper reaches of the RSK Reservoir approximately 4.8 km south-southeast of Gore, Oklahoma. Process water is pumped into the plant from Tenkiller Reservoir (located on the Illinois River approximately 16 km above the confluence of the RSK Reservoir and Illinois Rivers) and discharges into an effluent stream at a rate of 3 mgd. The effluent stream empties into the RSK Reservoir about 0.8 km downstream from the plant. The mouth of the effluent stream is approximately 1.6 km from the confluence of the Illinois and Arkansas Rivers. The main volume of water in the effluent stream is contributed by the Sequoyah Facility.

Three sites of investigation in the Illinois River arm of the RSK Reservoir were chosen (Fig. 2). The upstream station is approximately 426 m upstream from the plant effluent outfall and the downstream station is approximately 426 m downstream from the effluent outfall. These stations correspond to transects #6 and #1 previously evaluated (Dorris and Russel[1]). The effluent mouth station is at the confluence of the effluent stream and the Illinois River arm.

Materials and Methods

Four Hester Dendy multiplate artifical samplers were suspended approximately 1.5 m from the bottom at each station. Conventional samplers are typically attached to rafts or floats and are visible and subject to vandalism. To avoid vandalism, samplers were submerged by concrete blocks but suspended off the bottom by means of a styrofoam float (Fig. 3). Replicate block assemblies were located at each station to ensure successful recovery of at least one block assembly (four Hester Dendys). Samplers were left in place a minimum of six weeks. Semi-annual sampling began July of 1980 and ended December of 1981. A total of four sampling periods occurred during this time: July 19 - September 6, 1980; October 25 - December 6, 1980; March 28, - May 9, 1981; and October 24 - December 5, 1981.

Each Hester Dendy sampler was made of seven masonite plates 7.5 cm square separated by masonite spacers 2.5 cm square, mounted on an eye-bolt (Fig. 2). The plates were separated by the 0.3 cm thick spacers to provide varying widths of separation as follows: 3 single spacers, 2 double spacers, 1 triple spacer. The masonite hardboard surface facing up, alternated smooth and rough for the seven plates allowing maximum variation in habitat possible for each sampler. Total surface area of the sampler was 640 cm^2.

When retrieved, the samplers were raised to the surface slowly to avoid dislodging the organisms and immediately placed into a submerged container. Samplers were iced and [illegible]ted to the laboratory in an ice chest.

The samplers were disassembled and washed in a U.S. Standard No. 30 sieve, preserved in 0.2 percent Rose Bengal-10 percent formalin, sorted under a dissecting scope, counted and recorded as numbers/sampler. Organisms were identified to species whenever possible. Mean species diversity ($\bar{d}$) was measured by the Shannon equation:

$$\bar{d} = - \sum_{i=1}^{s} (n_i \quad) \log_2 (n_i/n)$$

when n_i = number of individuals of the i^{th} species, (for the purpose of computing diversity, the highest taxonomic classification of each different individual was considered as a species), n = total number of individuals. Mean diversity was determined by pooling numbers of species and individuals collected from four Hester Dendy samplers (one float assembly).

Results

Physical

Increasing salinity gradient from the downstream station to near the effluent mouth during the fall indicates encroachment of the saltier Arkansas River water into the lower reaches of the Illinois River Channel (Fig. 4). Dorris and Russel[1] found that due to the salinity differences of the two water bodies, layering of the two water masses occurred with the Arkansas River water underlying the Illinois River during the colder season. This condition can change from day to day. Power generation upstream at Tenkiller Lake results in a pulse of water which tends to push the Arkansas River water downstream; afterwards encroachment of the Arkansas River returns. The benthic fauna in the lower reaches of the Illinois River arm of the RSK Reservoir (downstream station) are subjected to intermittent changes in salinity as a consequence of this phenomena.

Temperature

In the lower reaches of the Illinois River arm, water temperature normally fluctuates annually, seasonally and diurnally in response to the amount of electrical power produced at the power station, (Table 1). The control stations are subject to this fluctuating temperature, with the downstream station also influenced by the warmer pulsating Arkansas River water. The temperature variations measured by the Sequoyah Facility at the outfall are shown in Fig. 5. This data is from a continuous recorder, and each point of the graph represents the average of the month. The vertical bars represent the maximum temperature for that month. Hawkes[5] states that thermal discharges have no effects on the benthic invertebrates when the temperature does not exceed 30°C. Based on the temperature recorded at the Sequoyah Facility outfall, temperatures never approached levels that would have deleterious effects on the benthic population. Further, the effluent stream exhibits little temperature influence on the lower Illinois River arm of the RSK Reservoir (Table 1).

Species and Individuals

Corresponding seasonal data from the initial monitoring program 1978-1979 and all of the semi-annual periods (1980-1981) are provided on Figures 6,7, and 8.

A consistent pattern of species diversity, number of species and number of individuals was recorded at the three stations monitored from 1978-1981. For the monitoring period 1980-1981, there is a similarity in the species richness at all stations and lower numbers of individuals at the effluent mouth station (Table 2, Fig. 6, 7). The number of individuals is generally higher at the upstream station (599 to 2163) and the downstream station (962 to 1825) than at the effluent mouth station (310 to 477). The number of species is consistently higher at the effluent station (24 to 37), lower at the downstream station (18 to 36) and the upstream station (18 to 37) (Fig. 6). Lower number of species and individuals occurs at the three stations in the fall of 1980. The highest number of species occurred at all stations in the fall of 1981.

Consistent trends between both the Illinois River arm stations (upstream and downstream stations) can be seen from the fall of 1980 to the fall of 1981. Low numbers of species occur (fall of 1980, spring of 1981) as well as high numbers of individuals (fall of 1981) for both upstream and downstream Illinois River arm stations. This suggests that the condition(s) which influence the occurrence of species and numbers in time are similar for both the upstream and downstream River stations.

The effluent mouth station shows a consistently higher number of species and lower number of individuals than the Illinois River arm (Fig. 6,7). The water present at the effluent mouth station varies little in its quality, producing a more stable, non-fluctuating community as measured by the low variation of number of individuals through time.

A checklist of the species found at each station appears in Table 3 (monitoring period, 1980-1981). The 1980 Summer sampling period showed a dominance by the aquatic worms Nais sp., Dero sp., and the chironomids (aquatic flies): Glyptotendipes sp., Glyptotendipes senelis, Rheotanytarsus sp. and Cladotanytarsus sp. for the upstream and effluent mouth stations. These species dominate the respective stations but the numbers vary widely between stations. During the 1980 Fall sampling period, the chironomid Glyptotendipes sp. dominates at all three stations, with the largest number occurring at the downstream station. The chironomid Cladotanytarsus sp.

dominates at the upstream station is nearly absent at the downstream station and is represented in low numbers at the effluent mouth.

The spring 1981 sampling period showed the coelenterata Hydra sp. dominating the downstream station, nearly absent at the effluent mouth and reduced in numbers at the upstream station. The dominant species for the effluent mouth station was the aquatic worm Nais sp. which was slightly reduced in numbers at the downstream station and nearly absent at the upstream station. The chironomid Glyptotendipes sp. dominated the upstream station, showed reduced numbers at the downstream station and was very low in numbers at the effluent mouth.

The fall 1981 sampling period showed the aquatic worm Stylaria lacustris dominating at the downstream station, greatly reduced at the upstream station and nearly absent at the effluent mouth station. The damselfly nymph Argia sp. was dominant at the effluent mouth but absent at the other stations. The fall 1981 sampling period was represented by no single species dominating at the upstream and effluent mouth stations. However, the highest number of species occurred at this time at all stations.

Fig. 8 shows the dominance of the chironomid group and its percentage to the total community at each station for the four sampling periods. The aquatic worms predominantly make up the remaining portion of the population. The trend in the percentage of the chironomids with time is similar at all three stations. Thus, although total numbers of individuals varies, the seasonal succession and relative abundance as a percentage of the chironomids occurs similarly for all stations. This suggests that the succession or seasonal pattern (life cycle-occurrence and emergence of one species, replaced by another species of chironomid through time) and proportion of chironomids to the total community is similar at all three stations.

Diversity

In all sampling, diversity index ($\bar{d}$) increases from the upstream station to the effluent mouth and drops at the downstream station (Fig. 9). Diversity is always highest at the effluent mouth station except in fall of 1980 (2.16 to 4.16) and attains the highest value in the fall of 1981 (4.16). The other two stations exhibit their highest diversity also in the fall of 1981.

The upstream station and the downstream station have their lowest diversity in the spring of 1981 and fall of 1980, respectively. The diversity index at the downstream station is consistently the lowest of any of the stations and may be a reflection of the salinity gradient exhibited by the presence of the Arkansas River water in this area. The dissimilarity of the diversity index value at the effluent mouth with the Illinois River arm stations is mainly due to lower numbers of individuals and more eveness in species distribution. This eveness in species distribution for the effluent mouth station results in the higher diversity index values.

Discussion and Conclusion

Data from this study is similar with others[3,4,5] in that an area of high diversity may exist in areas such as those associated with a thermal effluent. Warinner and Brehmer[5] found this area of elevated diversity only in the winter, while both the present study and Logan and Maurer[4] and Nauman and Cory[3] found it throughout the year. The Sequoyah Facility effluent stream investigation reflected that higher diversity was associated with eveness of distribution among species present.

If criteria other than diversity are used, the community at the mouth of the Sequoyah Facility effluent is not similar to these other studies. Warinner and Brehmer[5] reported that the number of species present in the effluent in the winter was only one-half of the number present in the remote control stations. Nauman and Cory[3] noted no differences in species composition but found higher production in the effluent cooling canal than the intake canal. Logan and Maurer's[4] investigation showed differences in species composition, an increase in relative numbers of a pollution indicator organism, and reduction in species number and in the total number of organism in the effluent. In the present investigation of Sequoyah Facility effluent differences in species composition was negligible, pollution indicator organisms were not apparent, and no reduction in specie numbers occurred. The only apparent difference between effluent and Illinois River arm stations was a lower value in the total number of organisms at the effluent mouth.

Moreover, the highest diversity and eveness of distribution corresponded to that of higher numbers of species and lowest numbers of individuals recorded at the mouth of the effluent stream.

A higher diversity index has also been associated with moderate amounts of pollution. Harrel and Dorris[9] recorded differences in diversity associated with the influx of oil-field brines in an intermittent stream. The addition of moderate amounts of oil-field brine was associated with a high diversity community composed of many types of species.

Logan and Maurer[4] hypothesize an explanation for their observed negative association between the environmental change and the value of a diversity index. Their hypothesis is based on large temperature variations that might exist in the effluent stream brought about by storms and periods of plant shutdown. If a large portion of the community at a location is destroyed during the temperature changes, the ensuing periods of stable conditions are periods of recolonization. Their assumption is that communities in this area are characterized as being pioneer communities and because no species has gained dominance through interaction, diversity may be unusually high in pioneer communities[6]. This explanation cannot account for the results in the present study based upon no clear evidence of sudden temperature variations in the Sequoyah Facility effluent and the fact that no species are present that could be characterized as pioneer species.

One possible explanation for the higher diversity at the Sequoyah Facility effluent mouth is the physical effect of siltation. A greater amount of silt on samplers from the effluent mouth station than the Illinois River arm stations has been observed during several monitoring periods. The effluent streams close proximity to an agricultural field and dirt roads in the confines of the Sequoyah Facility could be the source of the silt during storm runoff.

The effects of siltation to the aquatic environment have been studied. Sprules[10] studied the effects of a beaver dam on the insect fauna of a trout stream. He found that increased sandy silt reduced the total number of insects emerging in that area. This implied that total number of individuals were reduced in the area where siltation occurred.

Given the nature of the sampling device (Hester Dendy) similar phenomena would occur at the Sequoyah Facility effluent mouth if available space for the benthic macroinvertebrate colonization was reduced on the samplers by the presence of more silt at the Sequoyah Facility effluent mouth. The diversity index would compute a high value when low numbers of individuals and high numbers of species are entered. The silt phenomena on the samplers could explain the trends witnessed at the Sequoyah Facility effluent mouth.

It could be concluded that based upon these findings the Sequoyah Facility effluent mouth is the more stable, least fluctuating environment than the Illinois River arm stations (upstream, downstream). Hawkes[7] states that detectable changes in benthic communities at a given station in a river, with time and under the same flow regime, indicate changes in water quality. The effluent mouth station exhibited the least detectable change in benthic communities with time. The upstream station showed the greatest fluctuation with time in the benthic community, possibly due to the influence of a deep storage reservoir effect in the river system below the lake. Young, Kent, and Whiteside[8] found the communities downstream of a deep storage reservoir had wide seasonal fluctuations in diversity due primarily to changes in the dominance of certain taxa. They indicated that benthic communities living below a reservoir were subject to periods of environmental stress based on the effects of thermal stratification of a reservoir.

The communities at the downstream station could also be characterized as highly fluctuating with time possibly reflecting the changes in water quality. The fluctuating salinity gradient found in this area due to its close proximity to the high saline water of the Arkansas River could impose environmental stress on the benthic community. This station showed a high variation in numbers through time and the lowest diversity of the studied area.

In conclusion, based upon results from the monitoring program in the lower reaches of the Illinois River arm of the RSK Reservoir, the Sequoyah Facility effluent has no detrimental effect on the benthic community. The environmental stresses indicated earlier appear to have more of an impact on the benthic comunity in the lower reaches of the Illinois River than the Sequoyah Facility effluent. The mouth of the Sequoyah Facility effluent stream supports a stable, low fluctuating benthic community made up of many species and of high diversity while the Illinois River arm stations (upstream and downstream) benthic communities are highly fluctuating in numbers, of lower diversity and possibly reflect the influence of a greater number of environmental stresses.

Summary

The benthic macroinvertebrate communities in the Illinois River arm of the Robert S. Kerr Reservoir and the Sequoyah Facility effluent mouth were studied from 1978 through 1981 resulting in the following conclusions:

1. The species composition at the three stations are in general, similar.
2. A difference in species diversity was evident, species diversity index was frequently higher at the Sequoyah Facility effluent mouth.
3. Total number of individuals was consistently lower at the Sequoyah Facility effluent mouth.
4. Chironomid insect percentage of the total community was similar through time at the three stations--Illinois River arm stations (upstream, downstream) and Sequoyah Facility effluent mouth.
5. A salinity gradient occurred in the area of the Illinois River arm of the RSK Reservoir (downstream station) due to its close proximity to the Arkansas River.
6. The lower reaches of the Illinois arm of the RSK Reservoir are under the influence of the Tenkiller hydroelectric Reservoir.
7. The Sequoyah Facility effluent mouth is under the influence of siltation during periods of storm runoff.
8. The Sequoyah Facility effluent mouth station represents the more stable least fluctuating benthic community based upon evaluation of numbers of species, numbers of individuals and species diversity than the Illinois River arm stations (upstream. downstream) through time.

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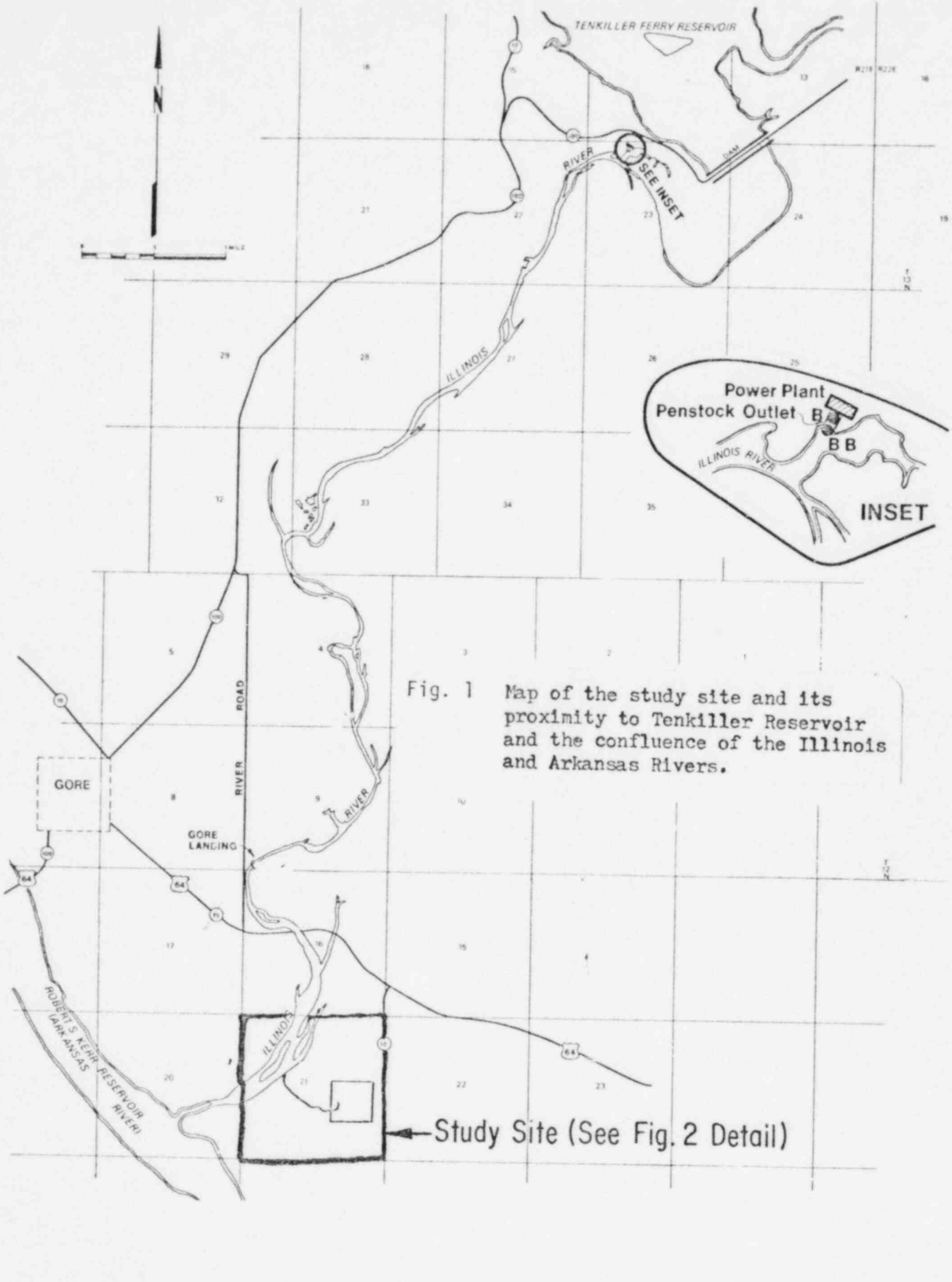

Fig. 1 Map of the study site and its proximity to Tenkiller Reservoir and the confluence of the Illinois and Arkansas Rivers.

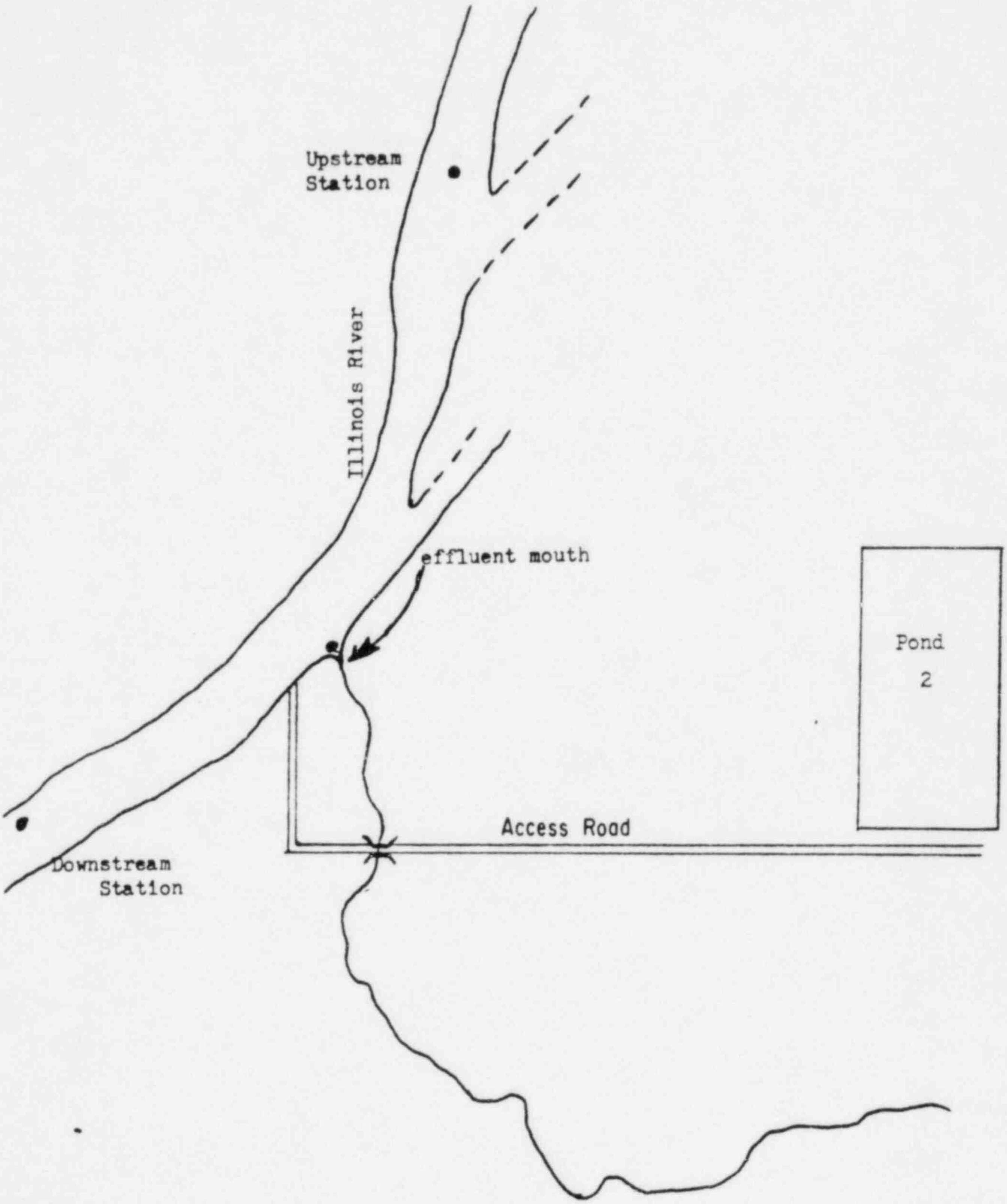

Fig. 2 Biological monitoring sites in the lower reaches of the Illinois River adjacent to plant facility outfall for the semi-annual monitoring program.

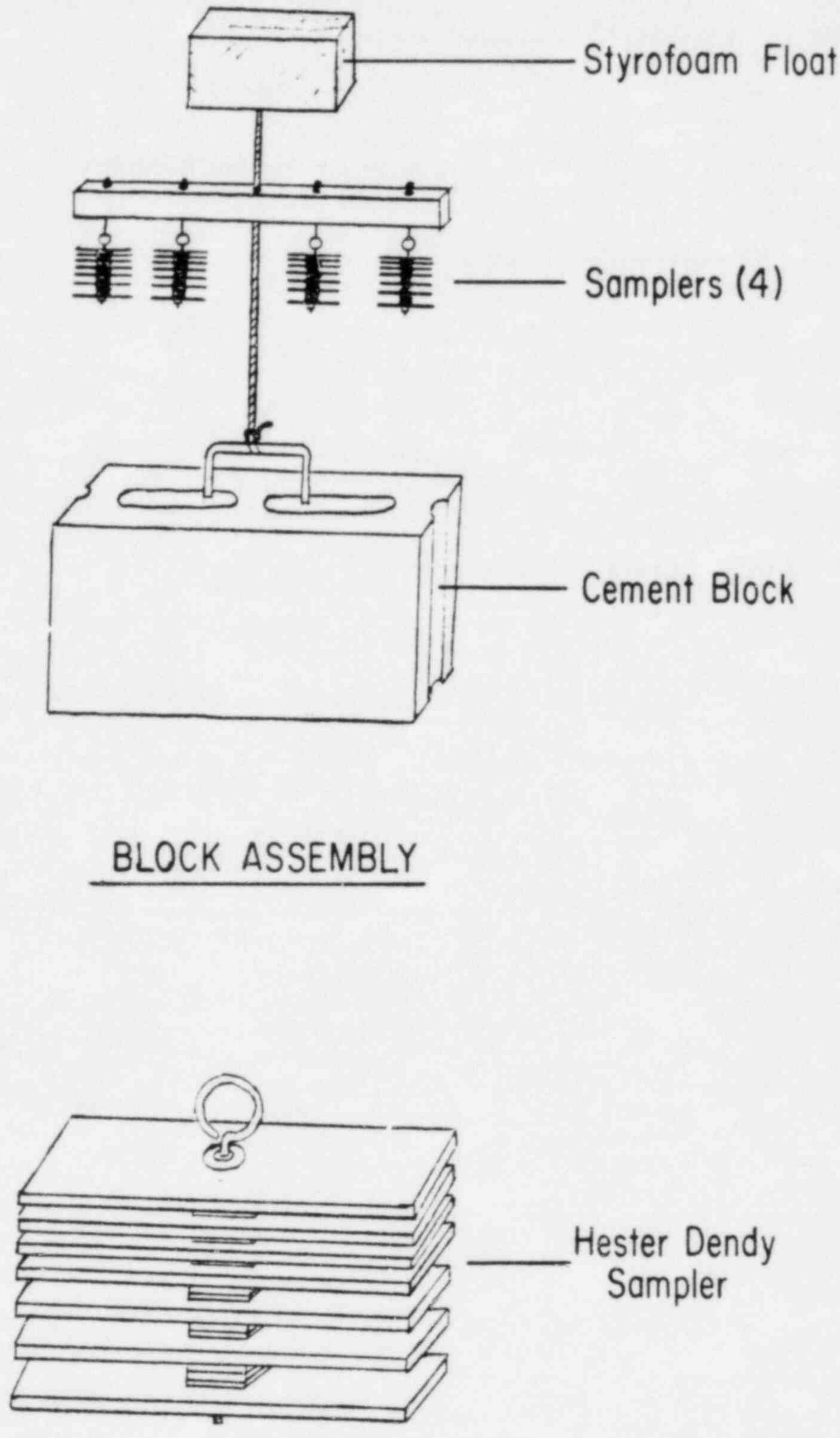

Fig. 3 **Modified Hester Dendy sampler, and sampler float assembly.**

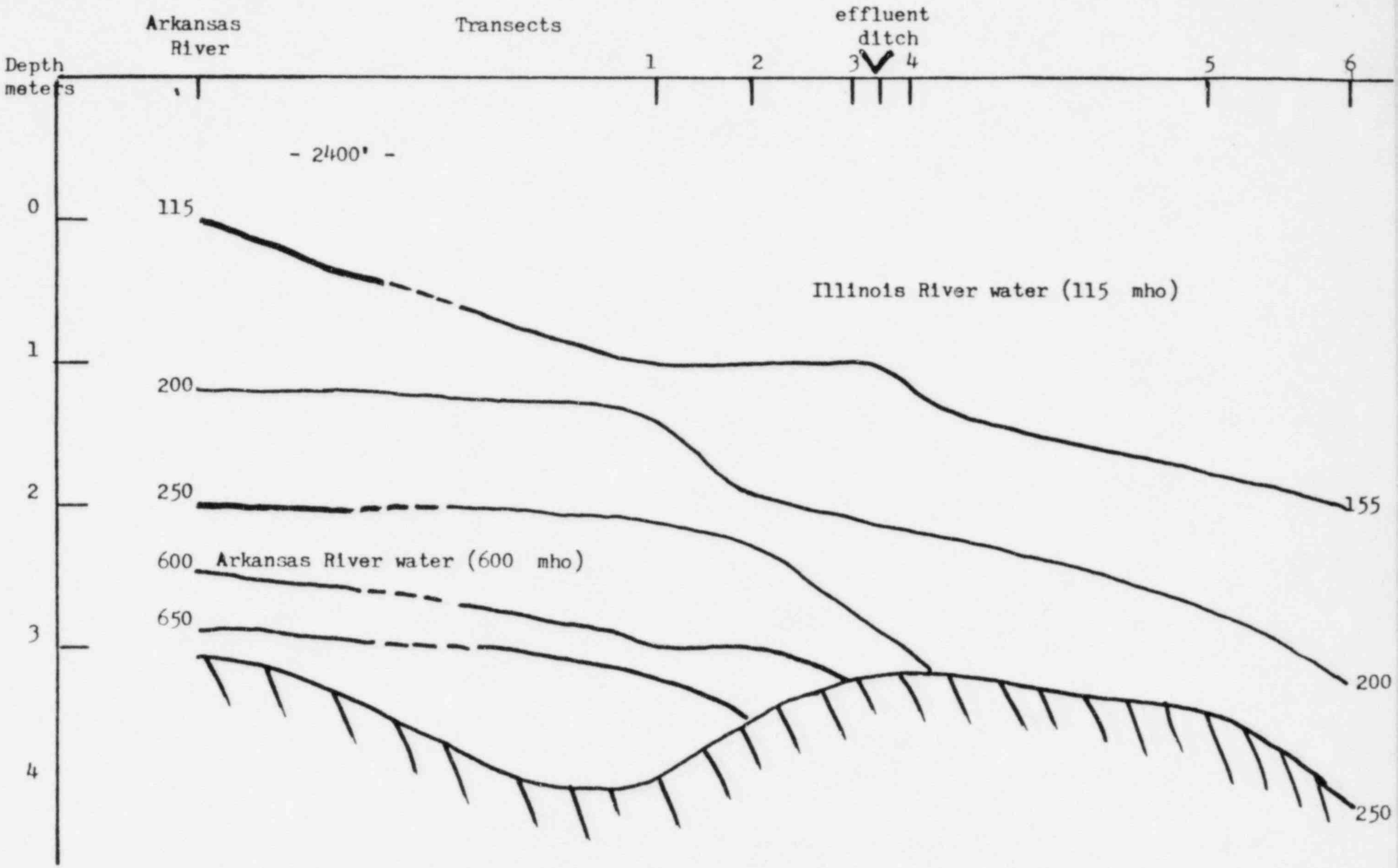

Fig. 4 Conductivity (mho), Illinois River, 10 December, 1978 (1" = 400')

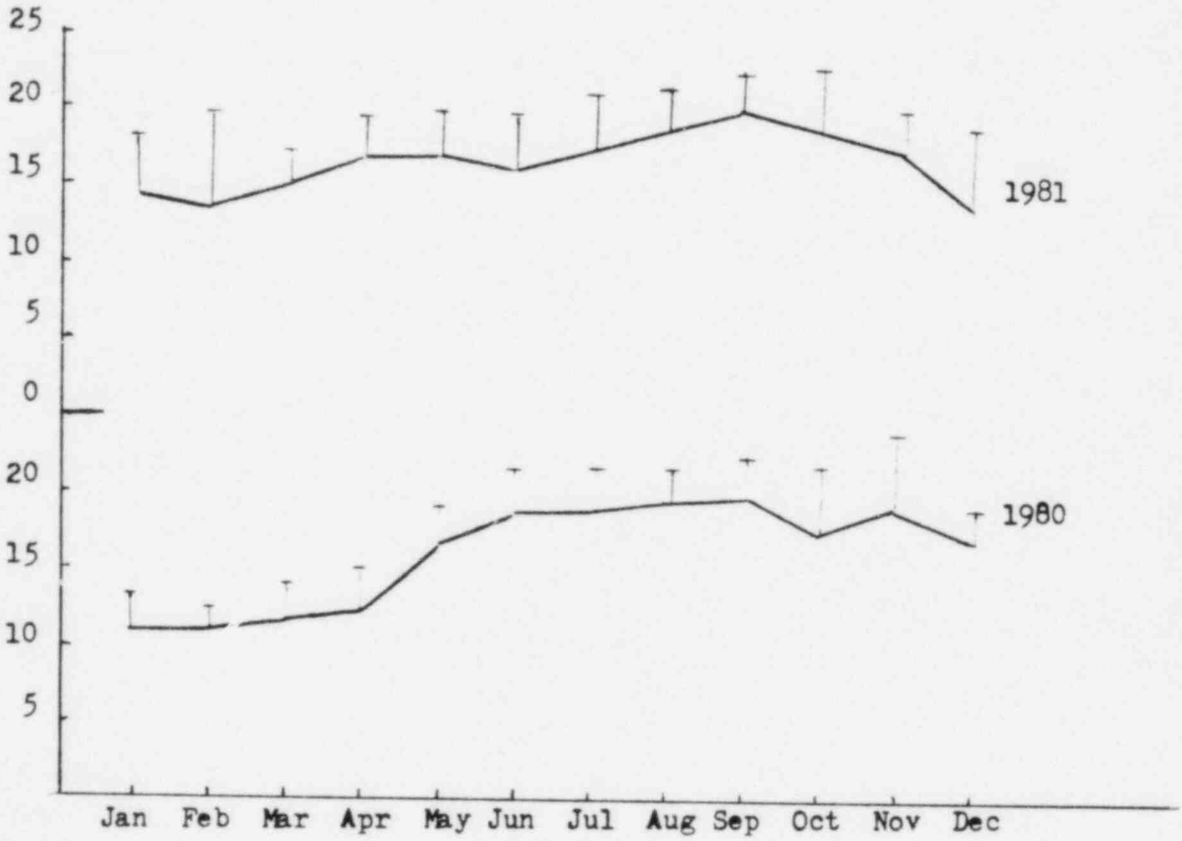

Fig. 5 Temperature (°C) for the Sequoyah Facility Outfall, Period 1980 and 1981. Vertical bars show monthly maximum temperature.

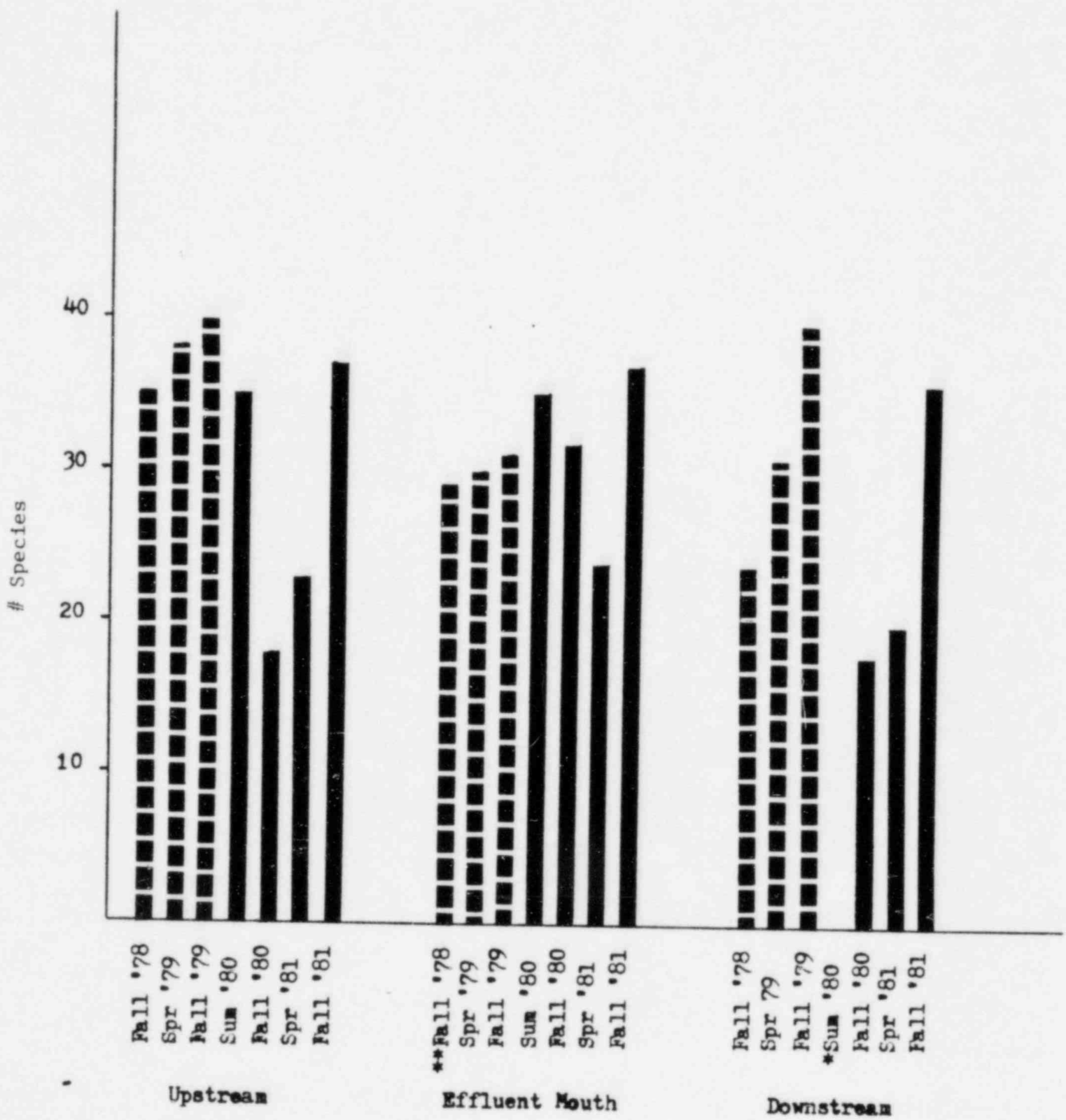

Fig. 6. Number of species pooled at Stations in Illinois River. The dash line represents select data from the 1978 and 1979 initial program. The solid line represents the data of the 1980 and 1981 semi-annual monitoring program.

* Station Vandalized.

** A spill occurred in the effluent stream during the fall 1978.

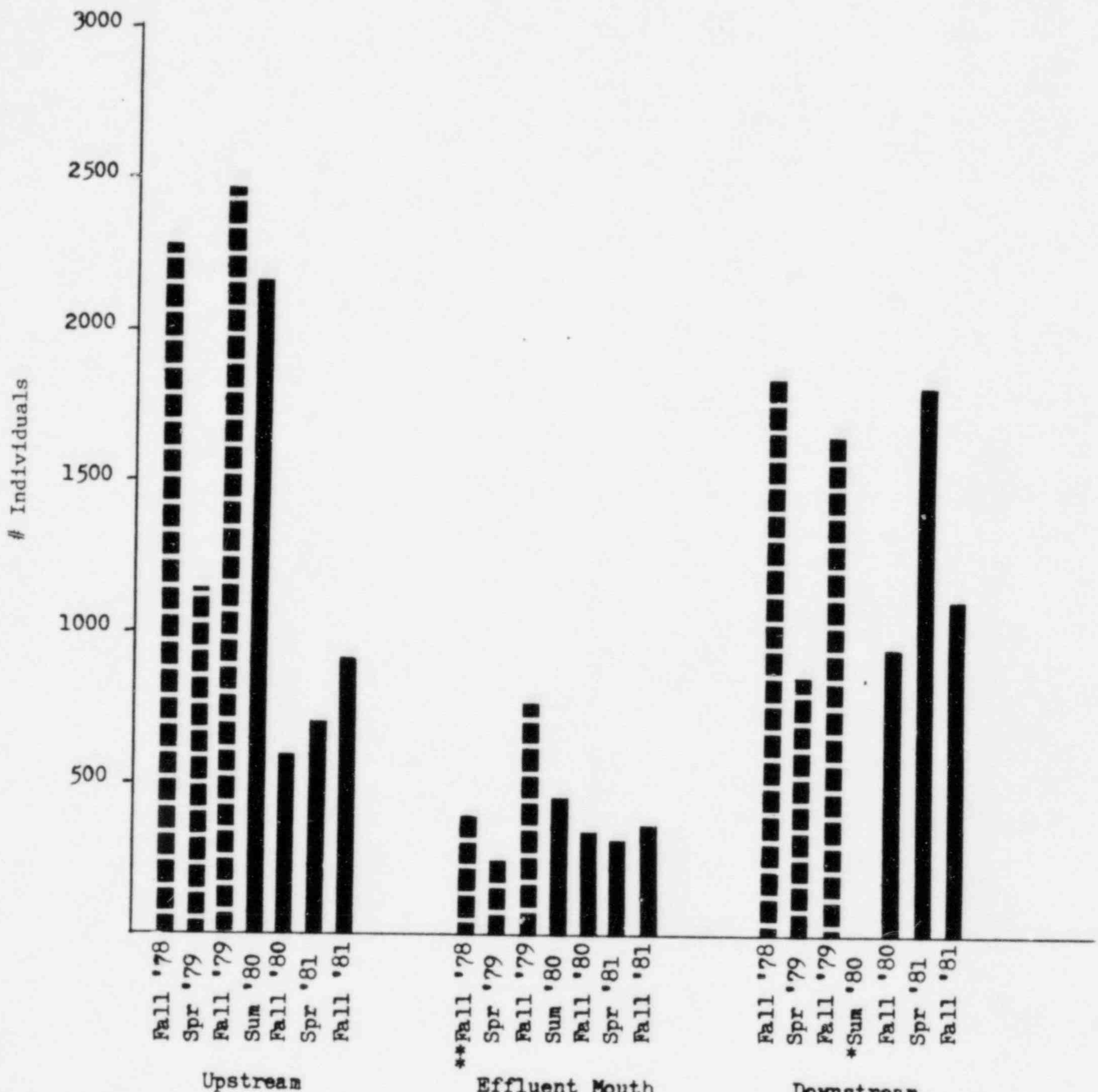

Fig. 7. Density of the pooled benthic macroinvertebrates at Stations in the Illinois River. The dash line represents select data from the 1978 and 1979 initial program. The solid line represents the data of the 1980 and 1981 semi-annual monitoring program.

* Station Vandalized.

** A spill occurred in the effluent stream during the fall 1978.

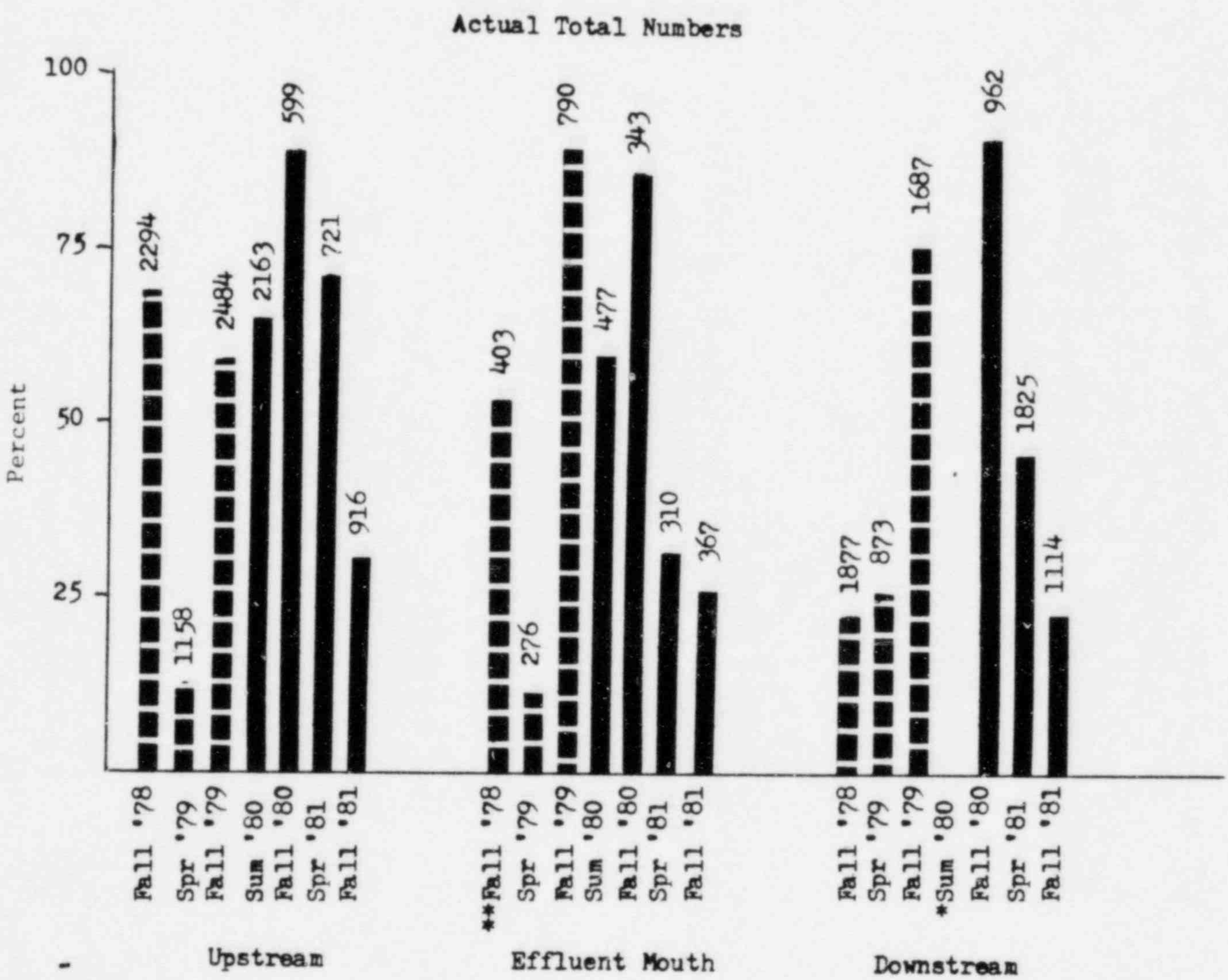

Fig. 8. Percent of the family chironomidae to total community at Stations in Illinois River. The dash line represents select data from the 1978 and 1979 initial program. The solid line represents the data of the 1980 and 1981 semi-annual monitoring program.

* Station Vandalized.

** A spill occurred in the effluent stream during the fall 1978.

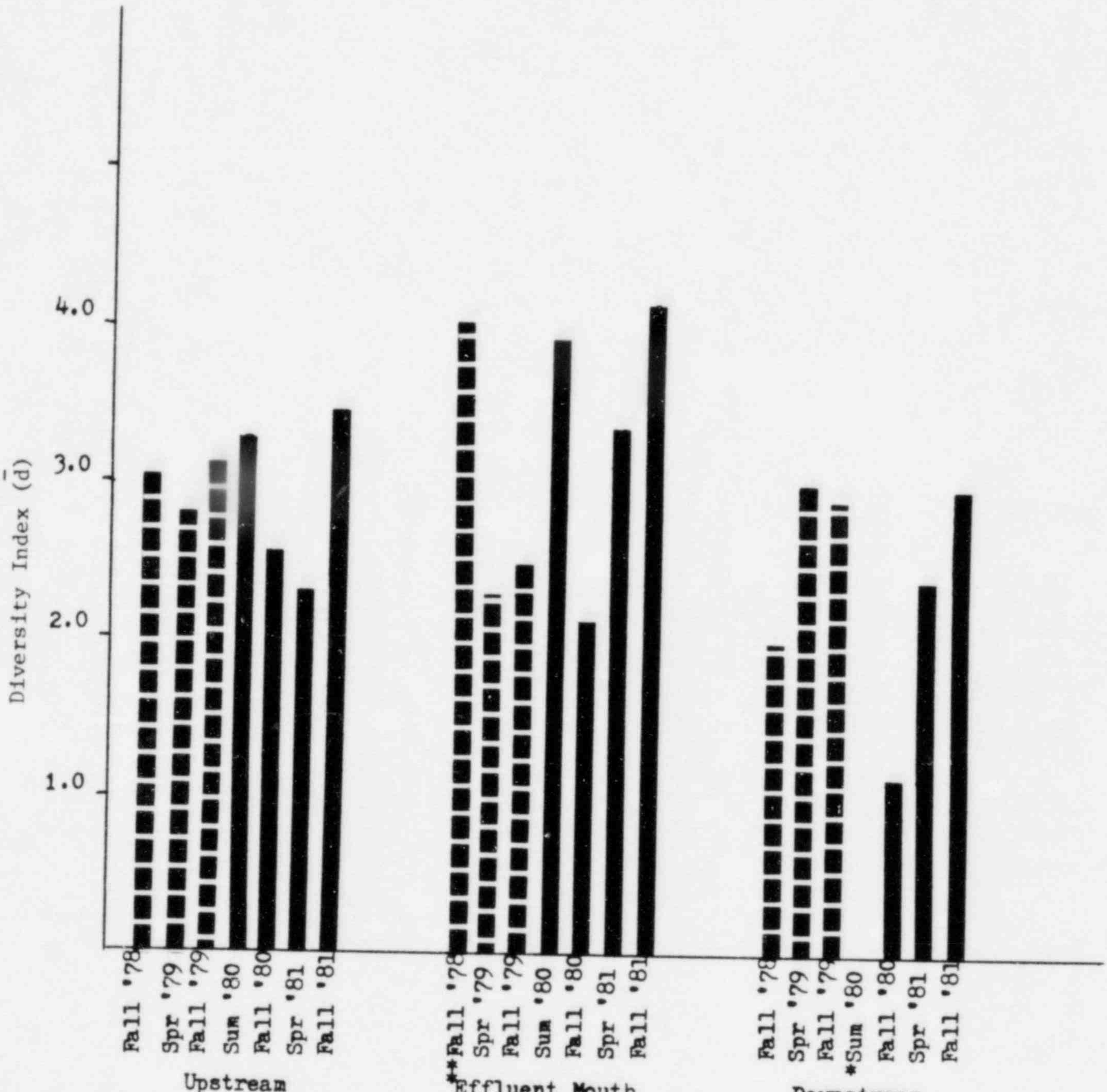

Fig. 9. Diversity index ($\bar{d}$) pooled from Stations in Illinois River. The dash line represents select data from the 1978 and 1979 initial program. The solid line represents the data of the 1980 and 1981 semi-annual monitoring program.

* Station Vandalized.

** A spill occurred in the effluent stream during the fall 1978.

	Bridge Highway 64 °F	150 Yds. Below Effluent Ditch °F
1973		
April	55	55
May	63	63
June	67	67
July	73	75
August	71	71
September	71	70
October	70	70
November	60	60
December	54	53
1974		
January	44	43
February	43	43
March	49	49
April	55	55
May	59	59
June	65	65
July	70	69
August	71	71
October	67	67
November	59	59
December	52	51
1975		
January	46	46
February	43	43
March	44	44
April	50	50
May	55	55
June	57	57
July	61	61
August	69	68
September	65	65
October	65	65

Table 1. Temperature in Illinois River below Tenkiller Reservoir, April 1973 to October 1975 (Kerr-McGee Nuclear Corporation).

Table 2. Summary of Community Parameters from Hester Dendy Samplers for three sampling periods of the initial study (78-79) and all the semi-annual sampling (80-81)

*Vandalized Station ** A spill occurred during Fall 1978

Parameters Measured

	Upstream	Stations Effluent Mouth	Downstream
Number of Individuals			
Fall '78**	2294	403	1877
Spring '79	1158	276	873
Fall '79	24[illegible]4	790	1687
Summer '80	2163	477	*
Fall '80	599	343	962
Spring '81	721	310	1825
Fall '81	916	367	1114
Number of Species			
Fall '78**	35	29	24
Spring '79	38	30	31
Fall '79	40	31	40
Summer '80	35	35	*
Fall '80	18	32	18
Spring '81	23	24	20
Fall '81	37	37	36
Diversity Index ($\bar{d}$)			
Fall '78**	3.09	4.08	2.00
Spring '79	2.80	2.28	3.03
Fall '79	3.11	2.52	2.85
Summer '80	3.27	3.94	*
Fall '80	2.58	2.16	1.14
Spring '81	2.32	3.37	2.40
Fall '81	3.45	4.16	2.98

Table 3. Occurrence of Species Collected from July 1980 to December 1981 at all Stations.

Species	Stations
Coelenterata	
Hydra sp.	U, EM, D
Turbellaria	
Unidentified sp.	U, EM, D
Nematoda	
Unidentified sp.	EM, D
Oligochaeta	
Nais sp.	U, EM, D
Nais barbota	D
Stylaria lacustris	U, EM, D
Stylaris fossularis	U, D
Dero sp.	U, EM, D
Chaetogaster sp.	U, EM, D
Slavina appendiculata	U, EM, D
Pristina sp.	U
Aulophorus furcatus	U, EM
Amphipoda	
Hyalella azteca	U, EM, D
Gammarus sp.	EM
Isopoda	
Lirceus sp.	EM
Decapoda	
Unidentified sp.	U, EM, D
Ephemeroptera	
Leptophlebia sp.	U, D
Stenacron sp.	U, EM, D
Stenonema sp.	U, EM, D
Caenis sp.	U, EM, D
Centroptilium sp.	U
Trichoptera	
Hydroptilia sp.	U, EM
Cyrnellus sp.	U, EM, D
Agraylea sp.	U, EM, D
Orthotrichia sp.	U, EM
Coleoptera	
Dubiraphia sp.	EM
Dineutus sp.	EM
Unidentified Elmidae	U
Oreodytes sp.	EM
Deronectes sp.	EM
Odonata	
Enallagma sp.	U, EM, D
Argia sp.	EM, D
Zoniagrion sp.	EM, D
Neuroptera	
Sialis sp.	U, EM, D

Species	Stations
Chironomidae	
Ablabesmyia janta	EM, D
Ablabesmyia mallochi	U, EM, D
Ablabesmyia ornata	EM
Chironomus sp.	U, EM, D
Cladotanytarsus sp.	U, EM, D
Conchapelopia sp.	EM, D
Cricotopus sp. B	U, EM
Cricotopus sp. C	U, EM, D
Cricotopus sp. D	U, EM, D
Cricotopus sp. F	U, EM, D
Cryptochironomus sp.	EM
Dicrotendipes modestus	U, EM, D
Dicrotendipes nervosus	U, EM, D
Einfeldia sp.	U, EM, D
Endochironomus sp.	U, EM, D
Eukiefferiella sp.	EM
Glyptotendipes sp.	U, EM, D
Glyptotendipes senelis	U, EM, D
Labrundinia sp.	EM
Micropsectra sp.	U, EM, D
Microtendipes sp.	U
Parachironomus sp.	U, EM, D
Paratendipes sp.	U
Polypedilum sp.	U, EM, D
Potthastia sp.	U, EM, D
Procladius sp.	U, EM, D
Psectrocladius sp. B	U, EM, D
Rheotanytarsus sp.	U, EM, D
Tanytarsus sp.	U, EM, D
Tribelos sp.	U, EM
Trissocladius sp.	U, EM, D
Mollusca	
Unidentified planorbidae Planorbidae	U
Ferrissia sp.	U, EM, D

Total species numbers
U-51
EM-58
D-46

U - Upstream Station
EM - Effluent Mouth Station
D - Downstream Station

Appendix A - Calculation of mean species diversity ($\bar{d}$ = d-bar)

Wilhm and Dorris[2] hypothesize that species diversity (Shannon-Weiner function, $\bar{d}$) may be used to determine the effect of a pollutant on a community. Pollution is postulated to reduce the value of the diversity index. There are three basic assumptions to this hypothesis:

A. A change in an environmental parameter (pollutant) causes a change in commmunity structure.
B. A change in community structure causes a change in diversity.
C. The nature of the change in diversity is such that increasing amounts of environmental change (or pollution concentration) result in decreasing diversity.

In consequence of this, diversity indices act as a tool providing objective, numerical measures of the effects of variations in quality of the environment on aquatic communities. Relatively undisturbed aquatic environments support benthic macroinvertebrate communities having large number of individuals with no species present in overwhelming abundance. If the species in such a community are ranked in order of numerical abundance, relatively few species will have large number of individuals, and large numbers of species will be represented by a few individuals. Environmental stresses tend to reduce diversity by creating situations that are unsuitable for some species, or that give other species some competitive advantage. Species diversity has two components:

-- richness of species, and
-- distribution of individuals among species.

Indices of diversity based on information theory include both of these components. The diversity equation specified by the Oklahoma Water Resources Board is:

$$\bar{d} = -\sum_{i=1}^{s} (n_i/n)\log_2(n_i/n)$$

where s is the total number of species (taxa) in the sample, n_i is the number of individuals per species, and n is the total number of individuals in the sample.