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THERMAL DISCHARGE AND ITS EFFECT ON MACROINVERTEBRATES AND PERIPHYTON IN THE WABASH AND WHITE RIVERS, INDIANA

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THERMAL DISCHARGE AND ITS EFFECT ON MACROINVERTEBRATES AND PERIPHYTON IN THE WABASH AND WHITE RIVERS, INDIANA

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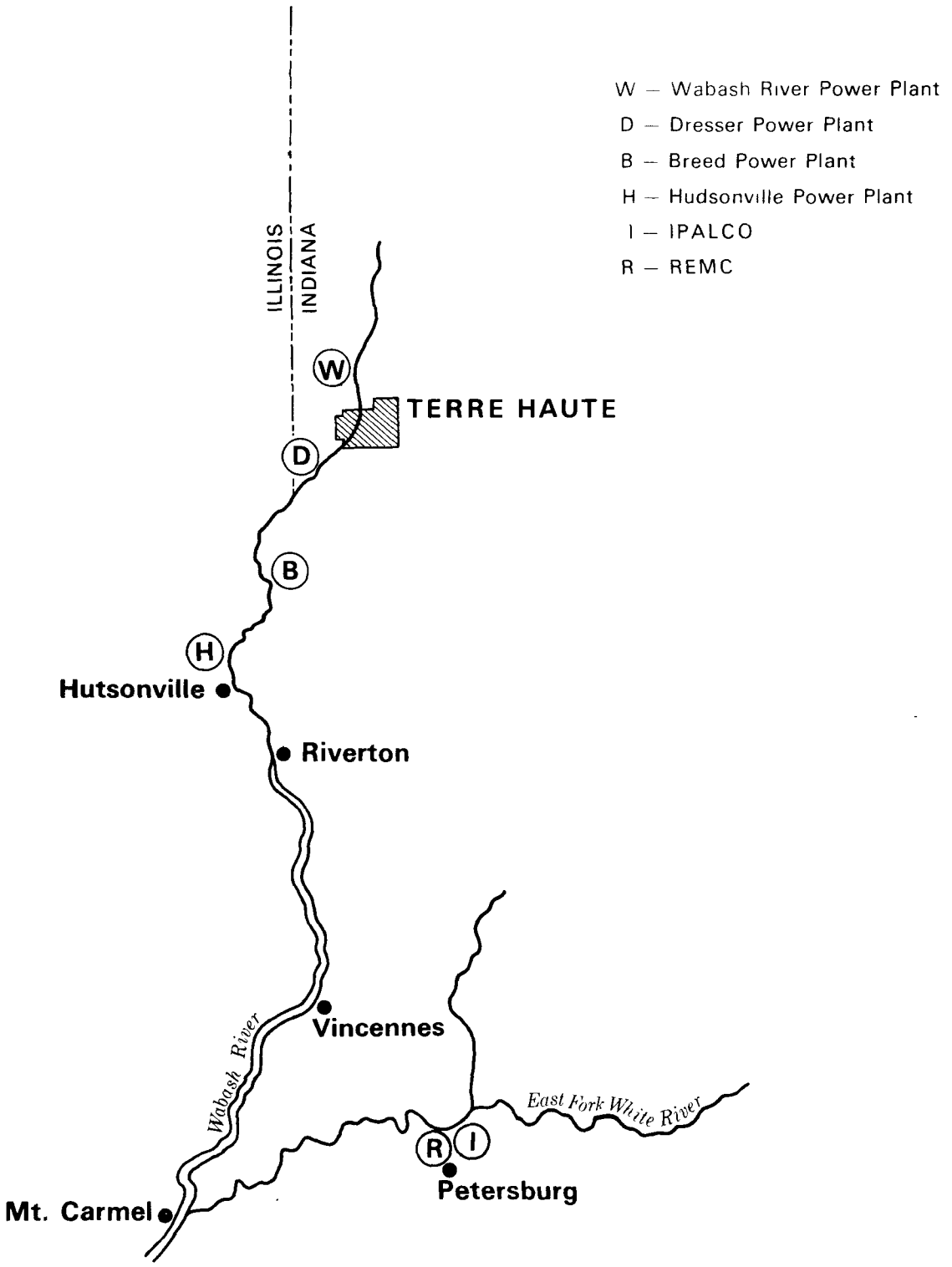

STATION LOCATION MAP

Scale 1 Inch = 16 Miles

INTRODUCTION

In April 1967, the Biology Unit of the Evansville Field Station (now the Indiana District Office) began a preliminary survey of water temperatures and macroinvertebrates in the vicinity of the newly constructed fossil-fuel electric power generating plant operated by the Indianapolis Power and Light Company (IPALCO), and the then soon to be constructed Rural Electric Cooperative Power Plant operated by Hoosier Energy (REMC). Both Plants are located on the White River at Petersburg, Indiana. The study was directed toward establishment of basic information concerning water temperatures and composition of macroinvertebrate fauna and their distribution near the Plant sites before and after operation. In 1970 and 1971, the study was expanded to include periphyton (attached algae).

In July 1970, another survey was begun on the Wabash River in the vicinity of the Wabash River, Dresser, Breed, and Hutsonville Power Plants. The data obtained included temperature, macroinvertebrate and periphyton.

METHODS AND PROCEDURES

Temperatures - The temperatures were obtained near the surface of the water in both the Wabash and White Rivers. During summer flow periods these rivers are relatively shallow, and preliminary temperature data showed there was little or no temperature difference from the surface to the bottom. Temperatures were taken at the sample site during each sampling period using a dial hand thermometer and a YSI Model 51 or 54 oxygen meter which also determines temperature. In addition, maximum and minimum recording thermometers were installed at selected locations to determine the wide range of temperatures over a 4 to 6 week interval. In 1971, a Ryan continuous recording thermograph was used in the Wabash River approximately 0.75 miles downstream of the Wabash River Power Plant. The time intervals and temperature data are shown in Tables I through XIII, and Figures 1,2,3,6 and 7.

Macroinvertebrate sampling - Macroinvertebrate organisms were collected from sampling sites upstream and downstream of the Power Plants by means of artificial substrates which included rock-filled baskets or multiple-plate samplers. The samplers were installed on overhanging trees or logs projecting from the water, or from floats anchored to the bottom of the river. The exposure period was approximately six weeks at which time the organisms were collected and returned to the laboratory for identification. All samples were preserved in 75% isopropyl alcohol treated with Rose Bengal dye, a material used to stain the organisms in order to facilitate sorting.

The macroinvertebrate data were reported in terms of percent of total population at each power plant for each sampling date. For example, where three samples were collected: (1) upstream, (2) in the cooling water discharge, and (3) downstream of a particular Power Plant on a given date, the percent of the total population was determined for each of the three locations with the sum total of the three equaling 100%.

These data are shown in Figures 10 through 16, and 18 through 21.

Periphyton sampling - Periphyton were collected on glass microscope slides using a wood-float periphyton sampler designed and constructed at the Evansville Office.[1] After 4 to 6 weeks exposure the slides were collected and preserved in 120 ml of 5% formalin solution. In the laboratory all counts and enumerations were done using the Sedgwick-Rafter method as described in the 13th Edition of Standard Methods.

The periphyton data were reported in terms of percent of total population as described in the previous section under macroinvertebrate sampling (Figures 4,5,8,9, and 17).

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[1] Anderson, Max A. and Silas L. Paulson. A Simple and Inexpensive Wood-Float Periphyton Sampler. The Progressive Fish-Culturist, 34(4), 1972.

SUMMARY AND CONCLUSIONS

Wabash River

Temperature, macroinvertebrate and periphyton data were collected at four Power Plants. These were: (1) Wabash River, (2) Dresser, (3) Breed, and (4) Hutsonville.

Of these four, the Wabash River Plant upstream of Terre Haute, Indiana is considered the most important contributor to increassed temperatures within the Wabash River. Temperatures here were in excess of the 5°F rise above the ambient limit as described in Indiana's Water Quality Criteria Proposed Regulation SPC 1R-2 (Appendix) on ten different occasions at a distance of between 0.25 and 1.5 miles downstream of the Plant (Figure 1). Temperature increases ranged from 3 to 7°F as far downstream as the Dresser Plant, a distance of 14 miles. Twenty two degrees Fahrenheit was the maximum ΔT temperature for all four Power Plants, and occurred in the cooling water discharge at the Wabash River Power Plant on November 22, 1971.

The macroinvertebrates collected in the vicinity of the Wabash River Power Plant in 1970 showed an increase in the total population at the 0.5 mile downstream station in comparison to the upstream station. No samples were taken from the cooling water discharge canal during 1970. Macroinvertebrates collected in 1971 showed a significant decrease in numbers in the discharge canal as compared with the numbers collected in the river, but with little or no change in the taxa; the macroinvertebrates at the 0.5 mile downstream

station were similar in composition to the upstream control station. No significant change in the macroinvertebrate population was observed at the other three Power Plants.

The majority of periphyton data were collected in 1971 from the Wabash River Plant Site. The ΔT temperatures at this plant did not appear to exceed the tolerance limits for most periphyton. There was, in fact, a marked increase in the population in the area of the discharge canal and at the 0.5 mile downstream station with the undesirable blue-green algae being the most abundant. This increase seems to be directly related to the hot water coming from the Power Plant, and was far more pronounced at this Plant than at any of the other three.

The significance of this increase in the periphyton population has not been determined as far as its total impact on the river is concerned, nor can it be said that such an increase will occur consistently over the years. However, if this condition is indeed consistent, then it seems reasonable to conclude that such an increase, especially in the blue-green algae would, over a period of time, accelerate eutrophication and subsequently degrade the present quality of aquatic life.

A total of 54 periphyton genera were identified in the vicinity of the Wabash River Power Plant, of which only one was significantly affected by the hot discharge water. This was the diatom Cocconeis which was greatly reduced in numbers in the cooling water discharge as compared to the control station.

Little or no periphyton population increase was noted downstream of the three smallar Plants (Dresser, Breed, and Hutsonville), nor was there evidence that periphyton were killed due to the cooling water discharge at these plants.

Flow data are shown in Table XV.

White River

Temperature determinitations, and macroinvertebrate and periphyton sampling was conducted at two power plants. These were: (1) Indianapolis Power and Light Company (IPALCO), and (2) Hoosier Energy Division Petersburg Power Plant (REMC).

At IPALCO the downstream temperature measured in September 1967 through September 1971 exceeded the 5°F rise above ambient on four different occasions, and exceeded the maximum monthly limit on one occasion. At REMC the downstream temperatures taken in 1970 and 1971 exceeded the 5°F above ambient limit on ten different occasions, and the maximum monthly limit on six different occasions (Figures 6 and 7).

High temperatures were recorded as far downstream as 1.25 miles below the REMC Plant. Maximum and minimum thermometer data showed a 12°F rise in the water temperature above ambient at this location. The ambient temperature throughout the study was the temperature recorded upstream of the IPALCO Plant.

The macroinvertebrate population varied rather significantly from the control station upstream of the IPALCO Plant to the farthest downstream station, 1.25 miles below the REMC Plant. A decline in the total population was noted immediatly downstream of both Power Plants during most of the sampling periods. The most abrupt decline occurred in the REMC cooling water discharge in August of 1970 and August and

October 1971 when the condenser cooling water temperature was generally highest. The temperature range which affected the population most was between 95 to 99°F.

The next downstream station was some 100 yards below REMC's discharge. Here the macroinvertebrate population increased significantly over that recorded at the control station. This increase occurred during all sampling periods, and is attributed to the moderately fast moving and well aerated river water mixing with the warmer discharge water. This had a tendency to increase both the desirable and undesirable periphyton groups and subsequently the macroinvertebrates, since many utilize certain periphyton as a basic food source. Beyond the 100 yard station to the last downstream station, 1.25 miles below the REMC Plant the macroinvertebrate population gradually declined to a level comparable to that which existed at the control station.

Periphyton data were collected in August and October 1970 and again in August, September and October 1971. During these sampling periods the blue-green algae were by far the most abundant, followed by diatoms and green algae. The blue-green population increased significantly downstream of the REMC Plant where water temperatures were generally highest from the combined discharges of both the IPALCO and REMC Power Plants.

The blue-green algae, if in large enough numbers tend to severely degrade the water quality of an area. They are generally undesirable as a food source for aquatic macroinvertebrates and fishes, and contribute in large measure to objectionable tastes and odors in drinking

water, especially during the warmer parts of the year. Many also produce toxic substances which can result in mortality of fish and other aquatic organisms.

A more intense investigation will need to be conducted below the REMC Plant before it can be determined to what degree, if any, the increased blue-green population is adversely affecting both the water quality and aquatic life within this reach of the river. This is an area of concern, and should not be overlooked.

DISCUSSION
WABASH RIVER

Wabash River Power Plant - The Wabash River Power Plant is located on the west bank of the Wabash River near Terre Haute, Indiana at river mile 208.0 (STORET miles used). This plant is owned and operated by the Public Service Company of Indiana, Inc. and has a generating capacity of 970 MW. The plant began operation in 1953, and was the largest electrical generating plant on the Wabash River at the time this study was made; its capacity has since been exceeded by the Cayuga Plant.

Temperature - Temperatures were taken in the vicinity of the Wabash River Power Plant during the summers of 1970 and 1971 (Tables II and VI). These data show the river temperatures at no time exceeded the maximum monthly limits as described in Indiana's Water Quality Criteria Proposed Regulation SPC 1R-2 (Appendix). However, there were recorded during ten different sampling periods temperatures that exceeded the 5°F rise above the ambient temperature (the 5°F rise is also a part of the SPC 1R-2 regulation). Ambient in this case refers to the temperature upstream of the Power Plant.

The Wabash River Power Plant is 14 river miles upstream of the Dresser Power Plant. A comparison of ambient river temperatures upstream of the Wabash River Plant with temperatures 0.25 miles upstream of the Dresser Plant showed that on four different sampling dates the temperature of the river upstream of the Dresser Plant was 3 to 7°F warmer than it was above the Wabash River Plant. These temperature increases occurred in July and August 1970, and September and October 1971. Temperature data collected during October 1970, and July and

August 1971 showed no increase (Figures 2 and 3). From these data it appears that elevated temperatures below the Wabash River Power Plant do not always return to ambient levels within a short distance from the discharge, but rather at times travels for many miles downstream, far in excess of any acceptable mixing zone.

Macroinvertebrates - During the 1970 sampling season, macroinvertebrates were collected from rock-filled basket samplers located 0.25 miles upstream and 0.5 miles downstream of the Wabash River Power Plant in August and October. In September and October 1971, samples were collected on multiple-plate samplers at the same locations with an additional station in the cooling water discharge.

A review of the 1970 data (Figure 18) showed 16 taxa at the upstream station and 12 at the downstream station in the August samples, and 12 taxa upstream and 13 downstream of the Power Plant in October. Except for one midge genus, the four taxa that were absent at the downstream station in August were not among the groups that make up the bulk of the Wabash River's macroinvertebrate population. Their absence was probably not due to the power plant discharge, but rather, they were not collected on the artificial substrate samplers because of their sparse population in the river.

The total number of macroinvertebrates collected from the Wabash River Power Plant in 1970 for both August and October was much higher at the downstream station. Five genera including Rheotanytarsus, Polypedilum, Hydropsyche, Potamyia, and Baetis were responsible for the bulk of the increase. These genera are common in the Wabash River, and are usually found in large numbers. It cannot be determined at this

time if this increase is directly related to the Power Plant discharge, or if it is due to other factors, since a similar increase did not occur in the 1971 sampling.

A review of the 1971 macroinvertebrate data (Figure 19) shows 15 taxa were collected from the Wabash River Power Plant Site at the upstream station, 15 taxa in the condenser cooling water discharge, and 10 taxa at the downstream station during September's sampling; while 12, 12 and 11 taxa respectively were collected in October. Of the total number of macroinvertebrates collected in September, 38% occurred upstream of the Power Plant, 28% in the cooling water discharge, and 34% at the downstream station. From samples collected in October, 51% of the macroinvertebrates occurred upstream, 9% in the cooling water discharge and 40% at the downstream station.

In order to determine the effect of the cooling water on the macroinvertebrates passing through the condenser, multiple-plate samplers were placed well within the discharge canal. The influence of the hot water did not seem to affect the total taxa, but there was a marked reduction in the total number of at least five genera, which included Rheotanytarsus, Hydropsyche, Potamyia, Tricorythodes, and Baetis.

At the next downstream station 0.5 miles below the Wabash River Power Plant, the heated water did not seem to adversely affect the macroinvertebrate population. At this location the kinds and numbers of organisms were nearly similar to those collected at the upstream control station.

Periphyton - The Wabash River, a characteristically eutrophic river, maintains a significant periphyton population (attached algae). The groups most commonly represented, in order of abundance, are the blue-greens, greens and diatoms.

The most complete set of periphyton data was gathered at the Wabash River Power Plant site in 1971. These data were collected from three locations: (1) 0.25 miles upstream of the Power Plant, (2) within the cooling water discharge canal, and (3) 0.5 miles downstream of the Power Plant. A total of 54 genera were identified from these three stations, of which only one was significantly affected by the hot discharge water. This was the diatom Cocconeis, which is generally considered to be rather intolerant of adverse environmental conditions, and was likely killed passing through the cooling water condenser.

The ΔT temperatures created by the Wabash River Power Plant did not appear to exceed the tolerance limits for most periphyton. There was, in fact, a marked increase in the periphyton population in the area of the discharge canal and at the 0.5 mile downstream station (Figure 4). This increase seems to result from the hot water coming from the Power Plant, and was far more pronounced at this Plant than at any of the other three (Dresser, Breed and Hutsonville).

The significance of this increase, particularly among the blue-green algae, in relation to the total impact on the Wabash River has not yet been determined. However, any influence which stimulates the growth of additional algae in the river is only adding to an already oxygen-saturated environment (Appendix).

Dresser Power Plant - The Dresser Power Plant, located downstream of Terre Haute, Indiana at river mile 193.5 is owned and operated by the Public Services Company of Indiana, Inc. This Plant has a generating capacity of 220 MW and discharges its cooling water into the Wabash River from the west bank.

Temperature - Temperatures were taken 0.25 miles upstream; in the heated water discharge; and 0.5 miles downstream of the Power Plant during the summer of 1970 and 1971. Indiana's proposed maximum monthly temperature limit was never exceeded at the downstream river station, nor was there a violation of the $5^{o}F$ rise above the ambient temperature in the river. These data are shown in Tables III and VII.

Macroinvertebrates - The 1971 data was the most complete set of data collected at this station. Samples were obtained in August and September from stations 0.25 miles upstream and 0.5 miles downstream of the Power Plant (Figure 19). The macroinvertebrate population at these sampling sites varied rather extensively from one sampling period to the other. During August, the total number of organisms collected at the downstream station was much larger than at the upstream station, but with fewer taxa. During September's sampling, conditions were just the opposite, with fewer total numbers but with more taxa being collected at the downstream station. The temperature difference between the upstream and downstream stations for both months of sampling was $4^{o}F$.

Periphyton - From all periphyton samples collected during 1970 and 1971 at the Dresser Power Plant, 50% of the population at the 0.25 mile upstream station consisted of blue-greens, 24% greens, and 26% diatoms;

for the same time period the station 0.5 miles downstream of the Plant was 75% blue-greens, 14% greens, and 11% diatoms. The increase in blue-greens at the downstream station is not necessarily due to the heated water coming from the Power Plant, but rather is likely due to poor sampling results at the control station. On one occasion the periphyton sampler, at the control station, was covered with sticks, leaves and other debris; on another, the sampler was left almost on the bottom of the river in a shallow eddy due to a substantial drop in the water level. Here the sampler was subjected to heavy silting which greatly inhibited the growth of the periphyton. This condition did not occur at the downstream station since the sampler was attached to a fallen tree in a deeper part of the river. No data were gathered from the cooling water discharge.

From these data it does not appear that the Dresser Power Plant is adversely affecting the river's macroinvertebrate and periphyton population.

Breed Power Plant - The Breed Power Plant is owned by the Indiana and Michigan Electric Company. It is located at river mile 172.8 on the Wabash River and has a generating capacity of 450 MW. The Plant began operation in July 1960 and since that time has operated on a somewhat intermittent basis. There were occasions during the 1970 and 1971 sampling periods when crews from the Evansville Office were at the plant site only to discover it was not operating.

Temperature - The Plant is located on the east bank of the Wabash River, and during the times of operation there was a distinct warm water plume that followed along this bank for some two to three miles downstream. The Plant was in operation during three of the six visits

that were made. These were in October 1970, September 1971 and October 1971. On two of these visits the downstream river temperature at a distance of 0.5 miles exceeded the 5°F rise above ambient (Appendix I), but was below the maximum monthly limits (Tables IV and VIII).

Macroinvertebrates - Data collected during August, September and October 1971 are considered here (Figure 20). The Power Plant was not operating when the August samples were collected; it was in operation in September and October, however. During August, 59% of the total macroinvertebrate population was collected from the upstream station, and 41% from the 0.5 mile station downstream; the total taxa for this period was 8 and 12 respectively. In September and October, samples were collected from the cooling water discharge plume as well as at the 0.25 mile upstream and 0.5 mile downstream stations. The population distribution for September was 29% upstream, 51% in the plume and 20% downstream; the total taxa was 11, 11, and 12. For October, the population distribution was 20% upstream, 57% in the plume and 23% downstream, and 12, 9, and 10 taxa. The higher population in the plume was due to an increase in the more tolerant genera of midges and caddisflies. This, coupled with the relatively uniform distribution of taxa at each station indicates the water temperatures were being tolerated by the macroinvertebrate larvae collected in the vicinity of this Power Plant.

Periphyton - Data collected during the 1970 and 1971 sampling seasons are summarized here. A substantial number of blue-green algae were collected, with the majority occuring at the upstream station (92%) and in the discharge canal (93%). At the downstream station 0.5 miles from the Power Plant the blue-green population was less (83%). The green algae and diatoms were far less abundant at all three sampling stations with 6% and 2% respectively recorded upstream, 3% and 4% in the plume, and 15% and 2% downstream. Due to the intermittent discharge it can not be determined if the Power Plant is adversely affecting the periphyton population, however, because of the relatively high downstream temperatures recorded at the time the plant was operating, it is believed that this could be a potential problem area and should be investigated further.

Hutsonville Power Plant - This Power Plant is located at river mile 161.6 on the Wabash River, 2 miles north of Hutsonville, Illinois, and has a generating capacity of some 200 MW. Sampling was conducted in July, August and October, 1970 and July, August, September and October, 1971.

Temperature - Data gathered during the summer and fall of 1970 and 1971 showed no temperature violation at the downstream river station, 0.5 miles below the cooling water discharge. During the majority of visits to the Plant Site the temperature at the 0.5 mile station was the same as the upstream control station. The maximum river temperature recorded was 86°F on September 10, 1971. This occurred 0.5 miles downstream of the Power Plant. The highest ΔT temperature during the study was 11°F (Table IX).

Macroinvertebrates - Samples were collected in August and October 1970 (Figure 18); and in August, September and October 1971 (Figure 21) at locations 0.25 miles upstream and 0.5 miles downstream of the Power Plant. All samples collected in both 1970 and 1971 showed a decrease in the total macroinvertebrate population at the downstream station. This decrease is not believed to be related to water temperatures, since no temperature violation was recorded at this station during the study period. The reason for the decrease in the organisms is not known at this time.

Periphyton - No significant change was noted in the periphyton population upstream and downstream of the Power Plant from data collected during 1970 and 1971 to indicate that any damage occurred as a result of the Plant's operation. The concentration of blue-green algae for both sampling years combined was nearly identical, with 83% recorded at the upstream control station and 85% at the 0.5 mile downstream station. The green algae increased by 4% at the downstream station, while the diatoms were reduced by 6%. These differences were probably due to a natural population fluctuation rather than temperature-caused fluctuations since the temperatures at the 0.5 mile station were nearly always identical to the control station.

Indianapolis Power and Light Company (IPALCO) - The Indianapolis Power and Light Company generating station is a 732 MW plant located on the White River near Petersburg, Indiana at river mile 50.0. Two units are in operation at the present time. The first unit began operation in June 1967; the second unit became operational in 1969. Construction of a new 450 MW unit is planned for 1977. This unit will be equipped with off-stream cooling.

Temperature - Temperature data were first collected in April 1967, two months prior to the operation of the first unit (Table X). A noticeable increase in the water temperature downstream of the Power Plant was first observed in September 1967 when a 6°F temperature rise above ambient was recorded. From this date through September 1971, the water temperature exceeded Indiana's 5°F rise above ambient limit on four different occasions. These data are shown in Figure 6.

On one occasion the temperature downstream of IPALCO exceeded the maximum monthly limit. This occurred on July 24, 1968 when the temperature reached 93°F (Figure 7).

Macroinvertebrates - The first series of macroinvertebrate samples was collected from artificial substrates in April 1967 prior to the time the Power Plant went into operation. The results of the sampling showed a significant reduction in the macroinvertebrate population approximately 0.25 miles downstream of the Power Plant as compared to the upstream station. A similar condition occurred in June 1967 at the same location.

A logical explanation seems to be that the bulldozing activity near the downstream station during this time created an additional silt load in the river which hampered the attachment and growth of macroinvertebrates.

The distribution and composition of macroinvertebrates collected after the Plant went into operation was highly irregular. In some instances the numbers declined downstream of the Plant's cooling water discharge canal, while at other times there was a noticeable increase. Because of this irregular population pattern it was difficult to determine if the cooling water discharge adversely affected these organisms.

Periphyton - Periphyton sampling began in August and October, 1970 (Figure 8). Samples were obtained from stations located 0.25 miles upstream and 0.25 miles downstream of the Power Plant. The results of these data showed an increase in the periphyton population at the downstream station during both sampling periods. The temperature difference was not great between the two sampling stations; in August a $3^{\circ}F$ rise downstream was noted, and in October there was a $2^{\circ}F$ rise.

Periphyton samples were also collected in August, September and October, 1971 (Figure 9). Again, an overall increase at the downstream station was observed. Water temperatures were $7^{\circ}F$ higher at the downstream station during August and September and $4^{\circ}F$ higher in October. No periphyton data were obtained downstream of IPALCO in October.

On a number of sampling runs it was noted that a foam-like substance entered the river from the IPALCO Plant cooling water discharge. This was most evident during the hot summer months and was very unsightly, especially across the river where it had accumulated along the north shore.

Hoosier Energy Division Petersburg Power Plant (REMC) - This 232 MW Plant is located 0.8 miles downstream, and on the same side of the river as the Indianapolis Power and Light Company's Plant at river mile 49.2. The Plant began operation in 1970, and presently has two 116 MW units on line.

Temperature - Temperatures were taken at various locations downstream of the Hoosier Energy Plant in August and October 1970 and August, September and October 1971 (Table XII). On ten different occasions during these sampling periods the temperature exceeded the 5°F above ambient limit, and on six occasions the maximum monthly limit was exceeded (Figures 6 and 7). Delta T temperatures in the condenser cooling water canal ranged from 14 to 20°F; the maximum temperature occurred in September 1971.

The farthest downstream station where temperatures were recorded was at Indiana Highway 61 bridge, 1.25 miles below the Hoosier Energy Plant. Maximum and minimum thermometer data showed a 12°F rise in the water temperature at the Highway 61 bridge as compared to the ambient temperatures upstream of IPALCO's Plant. This occurred during the period of August 21 to October 16, 1970. A 10°F rise was recorded during the period of July 21 to August 20, 1971 at the same location.

Macroinvertebrates - Macroinvertebrate data were collected in August and October 1970, and August, September and October 1971 using artificial substrate samplers. Samples were taken in the cooling water discharge plume and at various downstream points to Highway 61 bridge. Figures 10 through 14 show the distribution of the macroinvertebrate population

upstream and downstream of both Power Plants, and the relationship of the population to the water temperatures taken at the time the samples were collected.

A reduction in the total population was noted in the cooling water discharge in August of 1970 and 1971, and October 1971. This reduction was not evident in the October 1970 and September 1971 samples. The next downstream station was in the river proper some 300 feet below REMC. Here the macroinvertebrate population increased sharply. This is believed due to a significant increase in the periphyton at the same location, which provided an abundant food source for the macroinvertebrates. On one occasion the increase at this station was over 10 times greater than what was recorded at the control station. Beyond the 300 foot station the macroinvertebrate population decreased until at the Highway 61 bridge, 1.25 miles below the REMC Plant, it was nearly comparable in numbers to the control station.

The macroinvertebrate taxa below the REMC Plant varied from station to station. On two occassions (August and September 1971) fewer taxa were collected from the cooling water discharge than at any other station during these months of sampling (Figures 12 and 13). At other times the taxa in the cooling water discharge was generally comparable to the other sampling stations. Entrainment damage occurs most during the hot summer months when the cooling water temperature is highest. The temperature range which affected the population most during this study was between 95 to 99°F (temperatures were not recorded above 99°F). Figure 16 shows the distribution of macroinvertebrates collected at various temperature ranges.

Periphyton - The blue-greens were the most abundant periphyton in the Lower White River, followed by diatoms and greens. Periphyton counts during the two years of collection ranged from 7,000 to 200,000 cells/ mm^2, and included from 9 to 17 different taxa. Of the kinds collected, four genera were adversely affected by the cooling water discharge. They were Pediastrum, Cocconeis, Gomphonema and Melosira. During all sampling periods these algae were either absent or greatly reduced in numbers immediatly downstream of REMC's discharge as compared to the upstream control station.

Two series of periphyton samples were obtained in 1970 and three in 1971. During both years, with the exception of the above named genera, the population increased downstream of the Hoosier Energy Plant (REMC) and on two occasions was extremely abundant. This was in August 1970 and October 1971 where 65 and 80 percent of the population was collected at the downstream station (Figures 8 and 9).

Figure 17 is a compilation of the periphyton collected at IPALCO and REMC Power Plants during 1970 and 1971. These data show the influence the heated water has on the blue-green population in terms of increased productivity. This is a point of concern since blue-green algae are the most undesirable algae in the river, and are utilized far less frequently than any other type as a food source by fish and other aquatic organisms. In addition, large numbers of these algae cause undesirable tastes in drinking water, as well as produce a foul odor which develops from products of decomposition as the algae begin to die off. They also influence the dissolved oxygen-carbon dioxide

balance in the river which, under favorable environmental conditions, can result in a supersaturated state.

If the blue-green algae continue to increase as a result of higher water temperatures downstream of the IPALCO and REMC Power Plants, it seems that the overall result can only lead to progressively poorer biological conditions in the future.

APPENDIX

TABLE I

WABASH RIVER THERMAL POLLUTION STUDY
TEMPERATURE DATA

STATION	DATE	MAXIMUM TEMP °F	MINIMUM TEMP °F
MAXIMUM AND MINIMUM THERMOMETER DATA			
Wabash River Power Plant			
Cooling water discharge	7/14/71 to 7/20/71	106	84
Cooling water discharge	7/20/71 to 8/11/71	104	70
Cooling water discharge	8/11/71 to 8/24/71	98	80
0.25 mi. upstream	8/24/71 to 9/2/71	82	72
Cooling water discharge	" " "	100	78
0.25 mi. upstream	9/2/71 to 9/8/71	80	78
Cooling water discharge	" " "	100	86
0.25 mi upstream	9/8/71 to 9/28/71	80	64
Cooling water discharge	" " "	98	70
0.25 mi. upstream	9/28/71 to 10/6/71	68	62
Cooling water discharge	" " "	92	64
CONTINUOUS RECORDING THERMOGRAPH DATA			
0.75 mi. downstream	7/14/71 to 7/16/71	79	77
0.75 mi. downstream	7/20/71 to 7/21/71	77	74
0.75 mi. downstream	9/2/71 to 9/9/71	88	79
0.75 mi. downstream	9/9/71 to 9/26/71	81	64
0.75 mi. downstream	9/28/71 to 10/11/71	75	59

TABLE I (CONTINUED)

WABASH RIVER THERMAL POLLUTION STUDY
TEMPERATURE DATA

STATION	DATE	MAXIMUM TEMP °F	MINIMUM TEMP °F
	MAXIMUM AND MINIMUM THERMOMETER DATA		
Dresser Power Plant			
0.5 mi. downstream	7/14/71 to 8/11/71	107	74
0.5 mi. downstream	8/11/71 to 9/9/71	86	72
0.5 mi. downstream	9/9/71 to 10/6/71	78	68
Breed Power Plant			
0.5 mi. downstream	7/15/71 to 8/12/71	102	66
0.5 mi. downstream	8/12/71 to 9/10/71	105	82
0.5 mi. downstream	9/10/71 to 10/7/71	70	68
Hutsonville Power Plant			
0.5 mi. downstream	7/15/71 to 8/12/71	82	72
0.5 mi. downstream	8/12/71 to 9/10/71	88	80
0.5 mi. downstream	9/10/71 to 10/7/71	82	68

Note - Maximum and Minimum thermometers and thermographs were used in 1971 only.

TABLE II

WABASH RIVER THERMAL POLLUTION STUDY
WABASH RIVER POWER PLANT TEMPERATURE DATA

1970

Station Location	Date	Ambient Temp °F	Sampling Sta. Temp °F	ΔT Temp °F
0.25 mi. upstream	7/8/70	72	72	0
Cooling water discharge	"	72	88	16
0.25 mi. downstream	"	72	82	10
0.5 mi. downstream	"	72	79	7
0.75 mi. downstream	"	72	79	7
1.5 mi. downstream	"	72	77	5
0.25 mi. upstream	8/18/70	79	79	0
Cooling water discharge	"	79	No temp. data	
0.5 mi. downstream	"	79	88	9
0.75 mi. downstream	"	79	88	9
1.5 mi. downstream	"	79	86	7
0.25 mi. upstream	10/8/70	66	66	0
Cooling water discharge	"	66	77	11
0.25 mi. downstream	"	66	75	9
0.5 mi. downstream	"	66	66	0

TABLE III

WABASH RIVER THERMAL POLLUTION STUDY
DRESSER POWER PLANT TEMPERATURE DATA

1970

Station Location	Date	Ambient Temp °F	Sampling Sta. Temp °F	△T Temp °F
0.25 mi. upstream	7/8/70	79	79	0
Cooling water discharge	"	79	88	9
0.1 mi. downstream	"	79	82	3
0.75 mi. downstream	"	79	79	0
0.25 mi. upstream	8/18/70	84	84	0
Cooling water discharge	"	84	91	7
0.1 mi. downstream	"	84	88	4
0.75 mi. downstream	"	84	88	4
1.75 mi. downstream	"	84	88	4
0.25 mi. upstream	10/8/70	66	66	0
Cooling water discharge	"	66	77	11
0.1 mi. downstream	"	66	70	4
0.75 mi. downstream	"	66	66	0

TABLE IV

WABASH RIVER THERMAL POLLUTION STUDY
BREED POWER PLANT TEMPERATURE DATA

1970

Station Location	Date	Ambient Temp °F	Sampling Sta. Temp °F	Δ T Temp °F
0.25 mi. upstream	7/9/70	75	75	0
0.5 mi. downstream	"	75	75	0
0.25 mi. upstream	10/9/70	66	66	0
Cooling water discharge	"	66	77	11
0.25 mi. downstream	"	66	75	9
0.5 mi. downstream	"	66	70	4

TABLE V

WABASH RIVER THERMAL POLLUTION STUDY
HUTSONVILLE POWER PLANT TEMPERATURE DATA

1970

Station Location	Date	Ambient Temp °F	Sampling Sta. Temp °F	Δ T Temp °F
0.25 mi. upstream	7/9/70	77	77	0
Cooling water discharge	"	77	84	7
0.5 mi. downstream	"	77	77	0
0.25 mi. upstream	8/17/70	81	81	0
Cooling water discharge	"	81	86	5
0.5 mi. downstream	"	81	81	0
0.25 mi. upstream	10/9/70	66	66	0
Cooling water discharge	"	66	75	9
0.5 mi. downstream	"	66	68	1

TABLE VI

WABASH RIVER THERMAL POLLUTION STUDY
WABASH RIVER POWER PLANT TEMPERATURE DATA

1971

Station Location	Date	Ambient Temp °F	Sampling Sta. Temp °F	△ T Temp °F
0.25 mi. upstream	7/14/71	77	77	0
Cooling water discharge	7/14/71	77	88	11
0.5 mi. downstream	7/14/71	77	79	2
0.25 mi. upstream	7/20/71	74	74	0
Cooling water discharge	7/20/71	74	86	12
0.5 mi. downstream	7/20/71	74	75	1
0.25 mi. upstream	8/11/71	84	84	0
Cooling water discharge	8/11/71	84	93	9
0.5 mi. downstream	8/11/71	84	88	4
0.25 mi. upstream	8/24/71	77	77	0
Cooling water discharge	8/24/71	77	90	13
0.5 mi. downstream	8/24/71	77	81	4
0.25 mi. upstream	9/2/71	79	79	0
Cooling water discharge	9/2/71	79	97	18
0.5 mi. downstream	9/2/71	79	86	7
0.25 mi. upstream	9/8/71	79	79	0
Cooling water discharge	9/8/71	79	95	16
0.5 mi. downstream	9/8/71	79	82	3

TABLE VI (CONTINUED)

WABASH RIVER THERMAL POLLUTION STUDY
WABASH RIVER POWER PLANT TEMPERATURE DATA

1971

Station Location	Date	Ambient Temp °F	Sampling Sta. Temp °F	ΔT Temp °F
0.25 mi. upstream	9/28/71	68	68	0
Cooling water discharge	9/28/71	68	88	20
0.5 mi. downstream	9/28/71	68	77	9
0.25 mi. upstream	10/6/71	66	66	0
Cooling water discharge	10/6/71	66	79	13
0.5 mi. downstream	10/6/71	66	70	4
0.25 mi. upstream	11/22/71	39	39	0
Cooling water discharge	11/22/71	39	61	22
0.5 mi. downstream	11/22/71	39	46	7

TABLE VII

WABASH RIVER THERMAL POLLUTION STUDY
DRESSER POWER PLANT TEMPERATURE DATA

1971

Station Location	Date	Ambient Temp °F	Sampling Sta. Temp °F	Δ T Temp °F
0.25 mi. upstream	7/14/71	77	77	0
Cooling water discharge	"	77	88	11
0.5 mi. downstream	"	77	79	2
0.25 mi. upstream	8/11/71	84	84	0
Cooling water discharge	"	84	104	20
0.5 mi. downstream	"	84	88	4
0.25 mi. upstream	9/9/71	82	82	0
Cooling water discharge	"	82	91	9
0.5 mi. downstream	"	82	86	4
0.25 mi. upstream	10/6/71	72	72	0
Cooling water discharge	"	72	84	12
0.5 mi. downstream	"	72	72	0

TABLE VIII

WABASH RIVER THERMAL POLLUTION STUDY
BREED POWER PLANT TEMPERATURE DATA

1971

Station Location	Date	Ambient Temp °F	Sampling Sta. Temp °F	ΔT Temp °F
0.25 mi. upstream	7/15/71	79	79	0
Cooling water discharge	"	79	79	0
0.5 mi. downstream	"	79	79	0
0.25 mi. upstream	8/12/71	81	81	0
Cooling water discharge	"	81	82	1
0.5 mi. downstream	"	81	82	1
0.25 mi. upstream	9/10/71	82	82	0
Cooling water discharge	"	82	93	11
0.5 mi. downstream	"	82	88	6
0.25 mi. upstream	10/7/71	64	64	0
Cooling water discharge	"	64	77	13
0.5 mi. downstream	"	64	75	11

TABLE IX

WABASH RIVER THERMAL POLLUTION STUDY
HUTSONVILLE POWER PLANT TEMPERATURE DATA

1971

Station Location	Date	Ambient Temp °F	Sampling Sta. Temp °F	ΔT Temp °F
0.25 mi. upstream	7/15/71	79	79	0
Cooling water discharge	"	79	84	5
0.5 mi. downstream	"	79	79	0
0.25 mi. upstream	8/12/71	82	82	0
Cooling water discharge	"	82	93	11
0.5 mi. downstream	"	82	82	0
0.25 mi. upstream	9/10/71	84	84	0
Cooling water discharge	"	84	91	7
0.5 mi. downstream	"	84	86	2
0.25 mi. upstream	10/7/71	68	68	0
Cooling water discharge	"	68	75	9
0.5 mi. downstream	"	68	68	0

TABLE X

WHITE RIVER THERMAL POLLUTION STUDY
IPALCO POWER PLANT*

1967-1968

Station Location	Date	Ambient Temp °F	Sampling Sta. Temp °F	△T Temp °F
0.25 mi. upstream	4/18/67	61	61	0
0.25 mi. downstream	4/18/67	61	63	2
0.25 mi. upstream	7/28/67	80	80	0
0.25 mi. downstream	7/28/67	80	81	1
0.25 mi. upstream	9/29/67	57	57	0
0.25 mi. downstream	9/29/67	57	63	6
0.25 mi. upstream	7/24/68	84	84	0
0.25 mi. downstream	7/24/68	84	93	9

* IPALCO became operational in June 1967.

TABLE XI

WHITE RIVER THERMAL POLLUTION STUDY
IPALCO AND REMC POWER PLANTS
1970 - 1971

STATION	DATE	MAXIMUM TEMP °F	MINIMUM TEMP °F
MAXIMUM AND MINIMUM THERMOMETER DATA			
0.25 mi. upstream of IPALCO	8/21/70 to 10/16/70	78	no data
At REMC water intake	8/21/70 to 10/16/70	88	54
1.25 mi downstream of REMC at Hwy 61 bridge	8/21/70 to 10/16/70	90	52
0.25 mi. upstream of IPALCO	7/21/71 to 8/20/71	80	74
1.25 mi downstream of REMC at Hwy 61 bridge	7/21/71 to 8/20/71	90	75
1.25 mi. downstream of REMC at Hwy 61 bridge	8/20/71 to 9/27/71	90	72
1.25 mi. downstream of REMC at Hwy 61 bridge	9/27/71 to 10/27/71	84	68

TABLE XII

WHITE RIVER THERMAL POLLUTION STUDY
IPALCO AND REMC POWER PLANTS

1970-1971

Station Location	Date	Ambient Temp °F	Sampling Sta. Temp °F	ΔT Temp °F
0.25 mi. upstream of IPALCO	8/21/70	81	81	0
0.25 mi. downstream of IPALCO	8/21/70	81	84	3
Cooling water discharge-REMC	8/19/70	81	99	18
750 ft. downstream of REMC	8/19/70	81	95	14
1.25 mi. downstream of REMC at Hwy. 61 Bridge	8/19/70	81	88	7
0.25 mi. upstream of IPALCO	10/16/70	59	59	0
0.25 mi. downstream of IPALCO	10/16/70	59	62	3
Cooling water discharge-REMC	10/16/70	59	77	18
450 ft. downstream of REMC	10/16/70	59	65	6
1.25 mi. downstream of REMC at Hwy. 61 Bridge	10/16/70	59	59	0
0.25 mi. upstream of IPALCO	8/20/71	79	79	0
0.25 mi. downstream of IPALCO	8/20/71	79	86	7
Cooling water discharge-REMC	8/20/71	79	95	16
0.5 mi. downstream of REMC	8/20/71	79	88	9
1.25 mi. downstream-Hwy. 61 Bridge	8/20/71	79	88	9
0.25 mi. upstream of IPALCO	9/27/71	68	68	0
0.25 mi. downstream of IPALCO	9/27/71	68	75	7
Cooling water discharge-REMC	9/27/71	68	88	20
300 ft. downstream of REMC	9/27/71	68	82	14
0.5 mi. downstream of REMC	9/27/71	68	81	13
1.25 mi. downstream-Hwy. 61 Bridge	9/27/71	68	77	9

TABLE XII (CONTINUED)

WHITE RIVER THERMAL POLLUTION STUDY
IPALCO AND REMC POWER PLANTS

1970-1971

Station Location	Date	Ambient Temp °F	Sampling Sta. Temp °F	△T Temp °F
0.25 mi. upstream of IPALCO	10/27/71	65	65	0
0.25 mi. downstream of IPALCO	10/27/71	65	69	4
Cooling water discharge-REMC	10/27/71	65	79	14
300 ft. below REMC	10/27/71	65	71	6
0.5 mi. downstream of REMC	10/27/71	65	71	6
1.25 mi. downstream-Hwy. 61 Bridge	10/27/71	65	70	5

TABLE XIII

WHITE RIVER TEMPERATURE EXTREMES 1964 - 1970

Petersburg, Indiana U.S.G.S. Gaging Station Thermograph

Water Year	Maximum Temp. °F	Date	Minimum Temp. °F	Date
June 1964 - Sept. 1965	87°	8/4/64	32°	12/22/64 2/7/65
Oct. 1965 - Sept. 1966	88°	7/14 & 15	32°	Several Days Jan. & Feb.
Oct. 1966 - Sept. 1967	84°	7/26-28 8/2 & 3	35°	Dec. 30-Jan. 3, Jan.18-20
Oct. 1967 - Sept. 1968	84°	7/21-27 8/9, 10, 8/21-26	36°	Jan. 2-15, 24-28, Feb. 10-21
Oct. 1968 - Sept. 1969	84°	7/5-9, 7/17-21	34°	1/4-13
Oct. 1969 - Sept. 1970	90°	8/18-21	36°	Jan. 8, 19-22, Feb. 5-9

TABLE XIV

FLOW DATA

Wabash River at Terre Haute, Indiana

Sample Collection Date	Flow (cfs)	Monthly mean (cfs)
8 July, 1970	4,660	4,764
9 July, 1970	4,360	4,764
17 August, 1970	3,380	5,219
18 August, 1970	3,180	5,219
8 October, 1970	4,900	6,509
9 October, 1970	5,130	6,509
4 July, 1971	3,800	6,351
14 July, 1971	11,200	6,351
15 July, 1971	9,370	6,351
11 August, 1971	2,600	2,803
12 August, 1971	3,100	2,803
24 August, 1971	2,050	2,803
2 September, 1971	1,900	3,796
8 September, 1971	3,960	3,796
9 September, 1971	5,430	3,796
10 September, 1971	5,610	3,796
28 September, 1971		
6 October, 1971	No data	No data
7 October, 1971	No data	No data
22 November, 1971	No data	No data

TABLE XV

FLOW DATA

White River at Petersburg, Indiana

Sample Collection Date	Flow (cfs)	Monthly Mean (cfs)
18 April, 1967	13,100	16,990
28 July, 1967	2,950	2,918
29 September, 1967	1,140	1,298
24 July, 1968	4,570	5,994
19 August, 1970	2,090	2,957
21 August, 1970	2,860	2,957
16 October, 1970	3,720	2,430
1 December, 1970	3,300	5,655
2 December, 1970	3,180	5,655
3 December, 1970	3,100	5,655
4 December, 1970	3,000	5,655
20 August, 1971	2,050	3,200
20 September, 1971	2,020	2,387
27 September, 1971	2,780	2,387
10 October, 1971	No data	No data
27 October, 1971	No data	No data

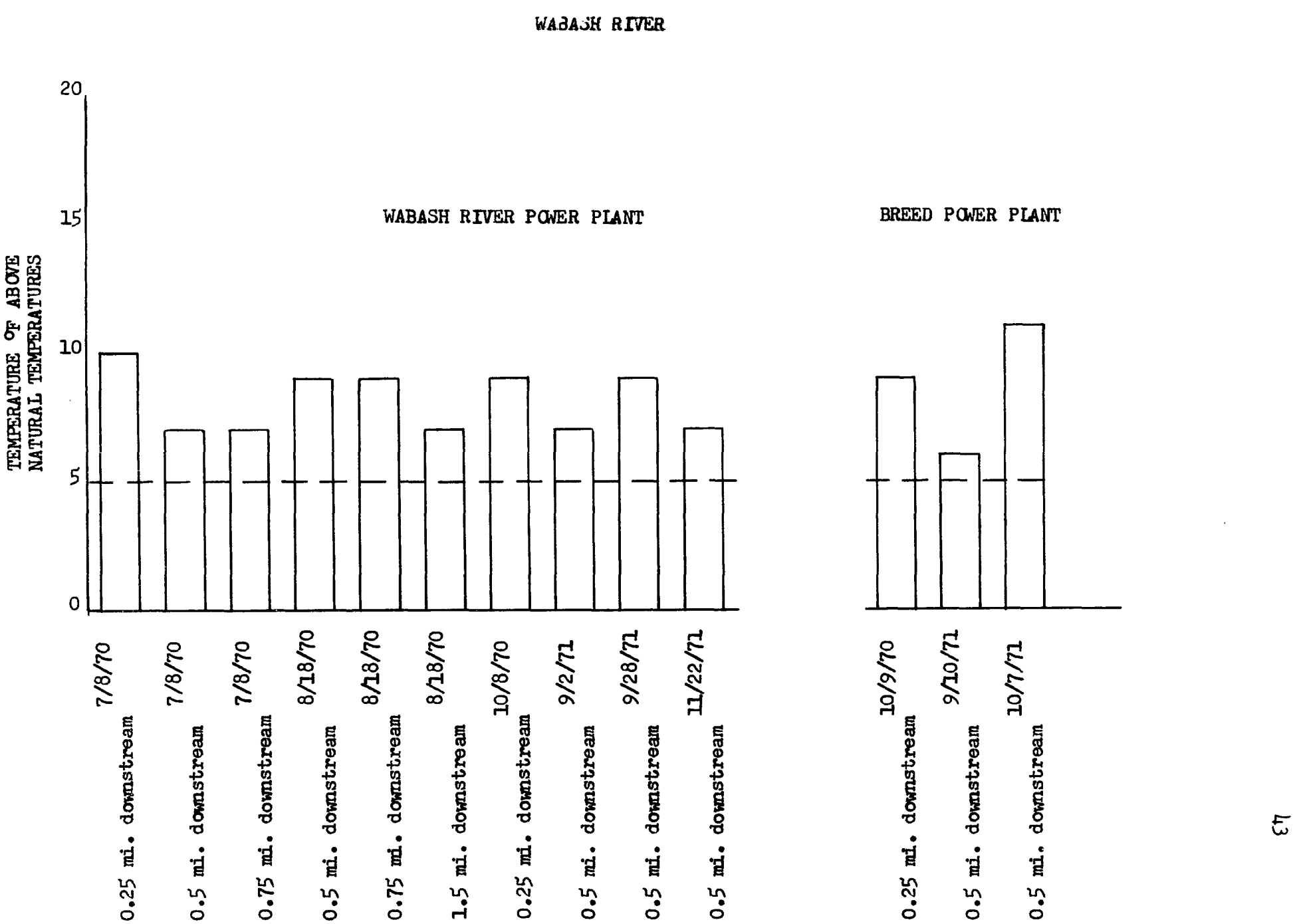


Figure 1 Data showing sampling periods where temperatures in the river exceeded the 5°F rise above natural temperatures (upstream temperatures) as described in Indiana's Proposed Regulation SPC 1R-2

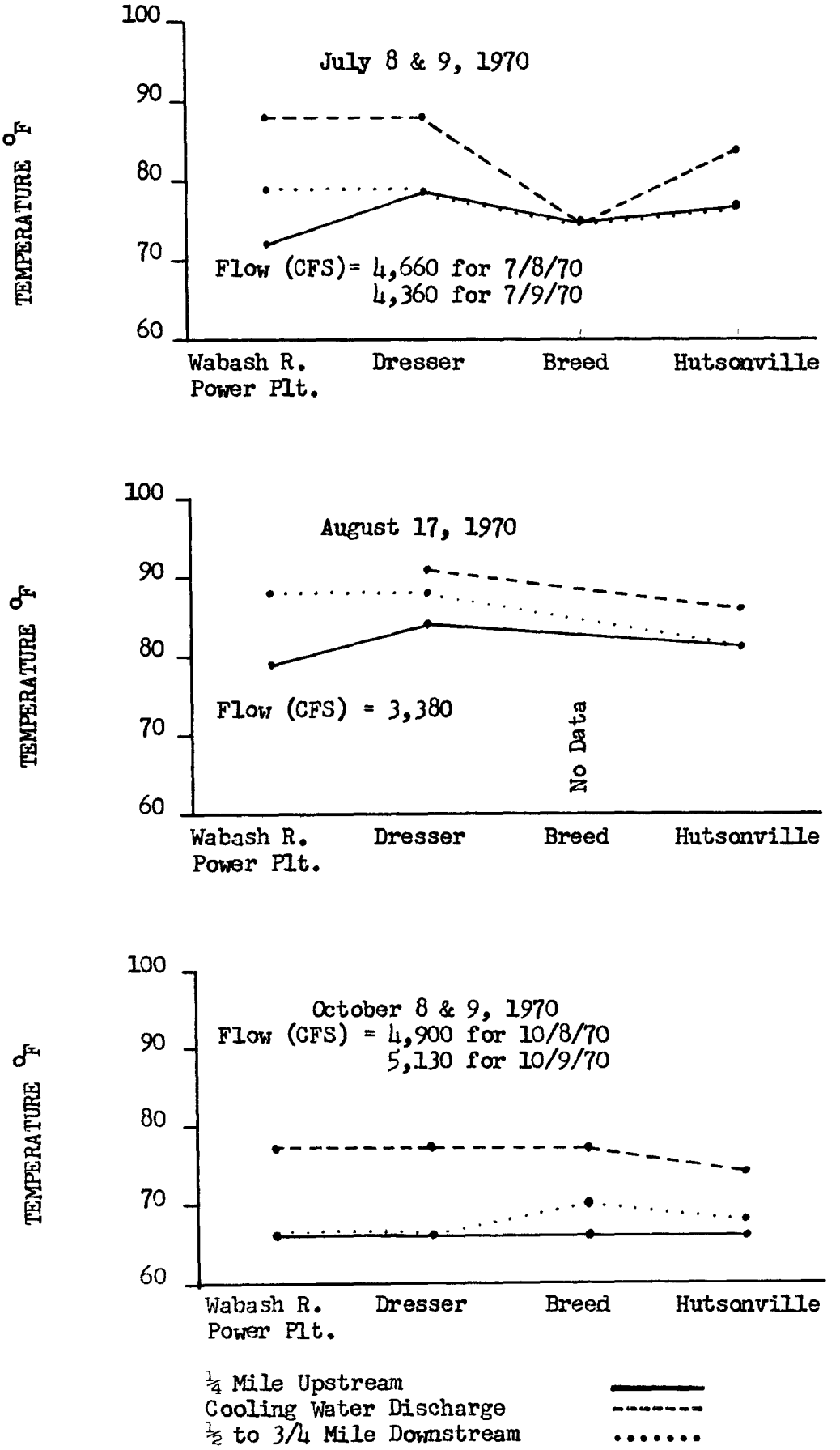


Figure 2 Temperature Data From Wabash River for July, August, and October, 1970

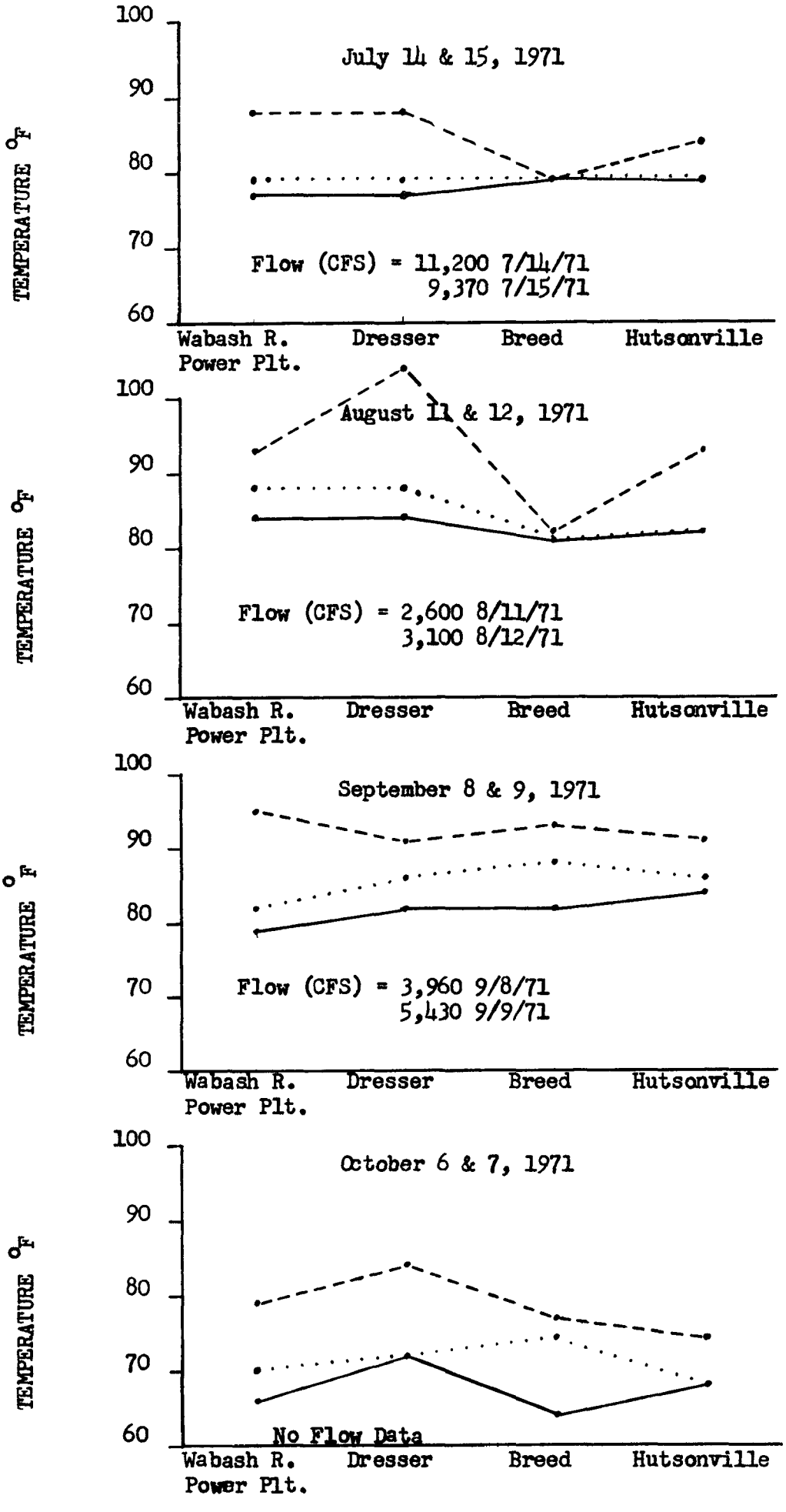


Figure 3 Temperature Data from Wabash River for 1971

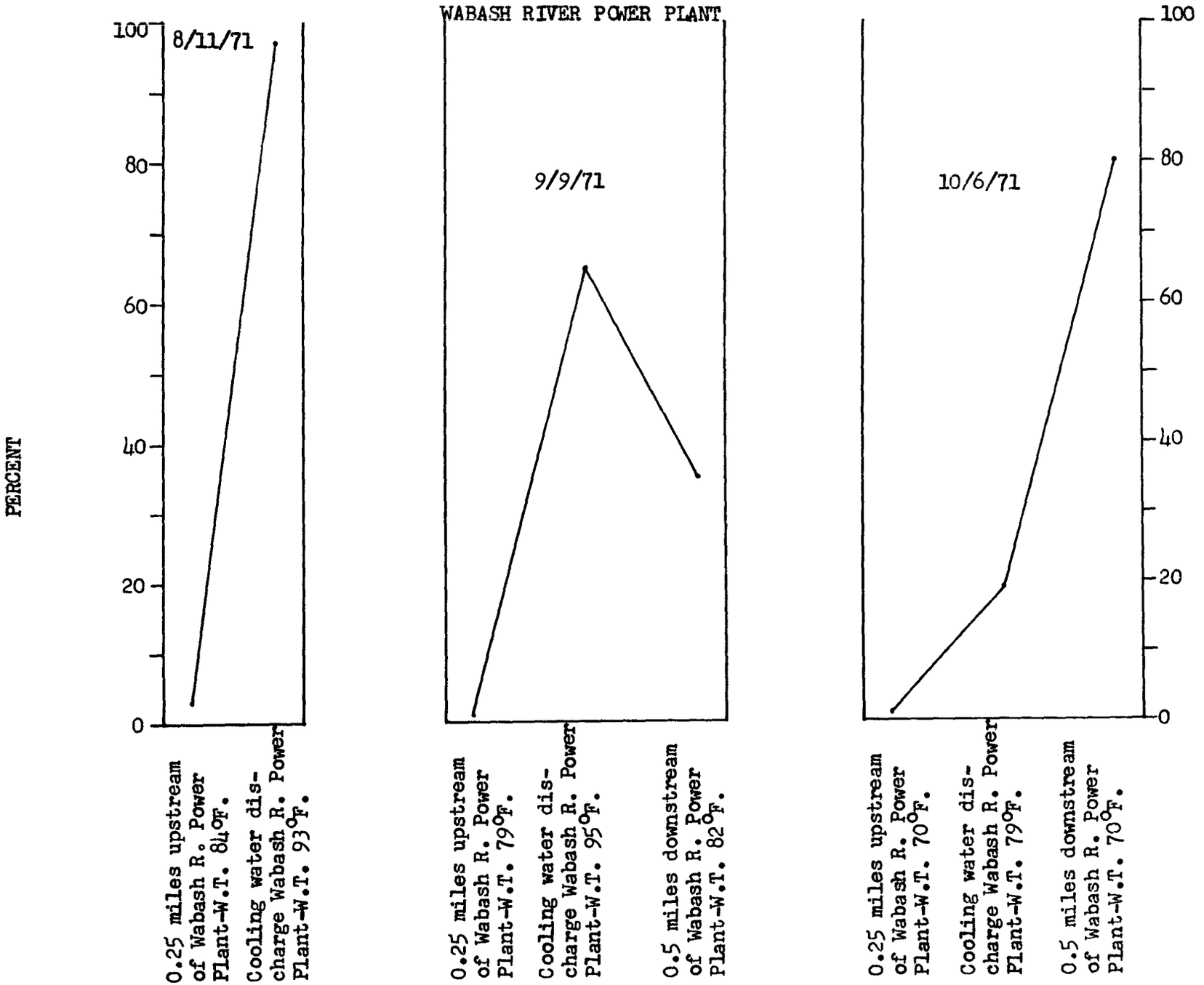


Figure 4 Periphyton data showing total population by percent upstream, in cooling water discharge, and downstream of the Wabash River Power Plant - 1971.
Direction of Flow ⟶

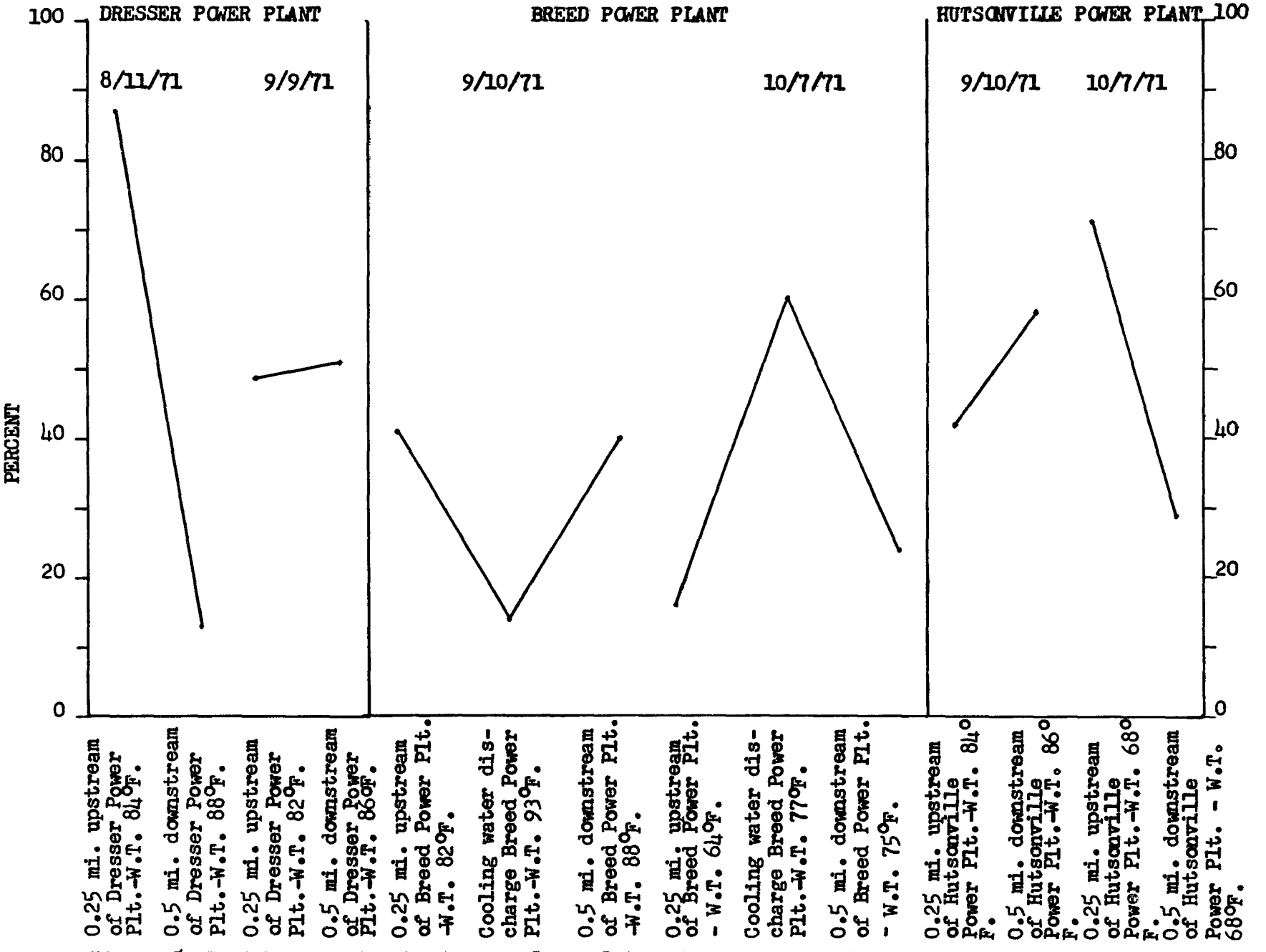


Figure 5 Periphyton data showing total population by percent at Dresser, Breed and Hutsonville Power Plants - 1971.

Direction of Flow ——————→

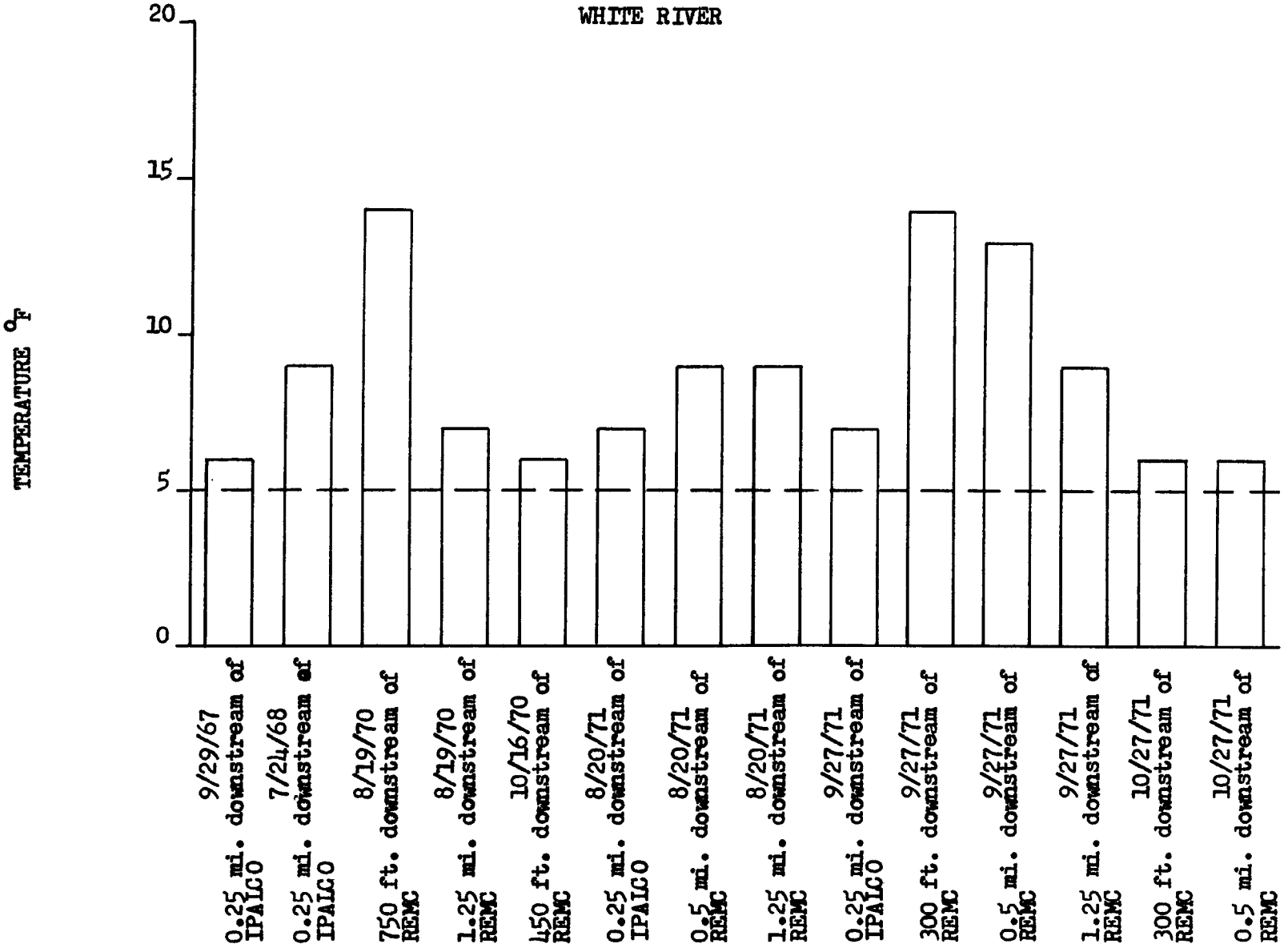


Figure 6 Data showing sampling periods where temperatures in the river exceeded the 5°F rise above natural temperatures (upstream temperatures) as described in Indiana's Proposed Regulation SPC 1R-2.

WHITE RIVER

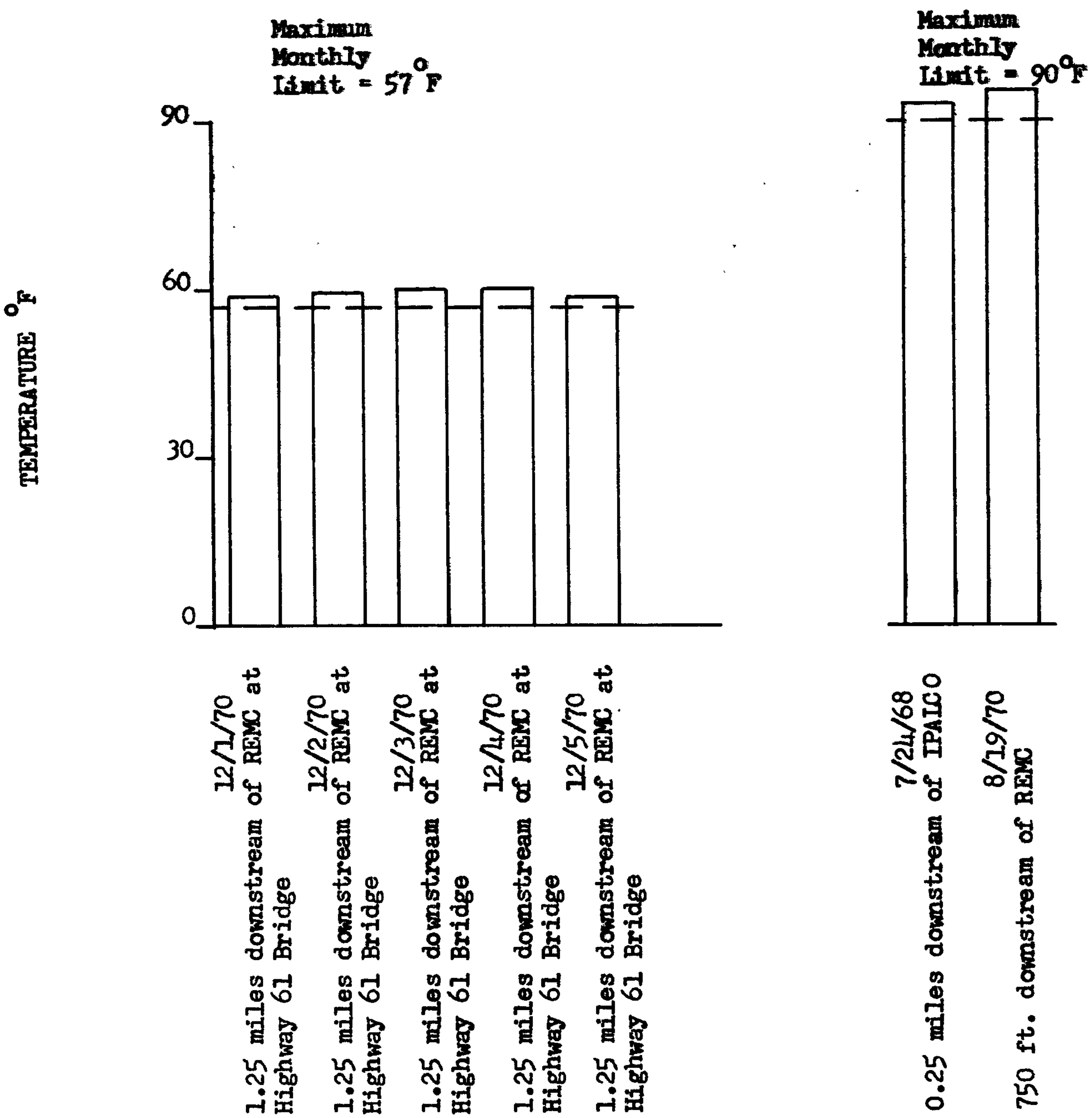


Figure 7 Data showing periods where temperatures in the river exceeded the maximum monthly limits as described in Indiana's proposed regulation SPC 1R-2

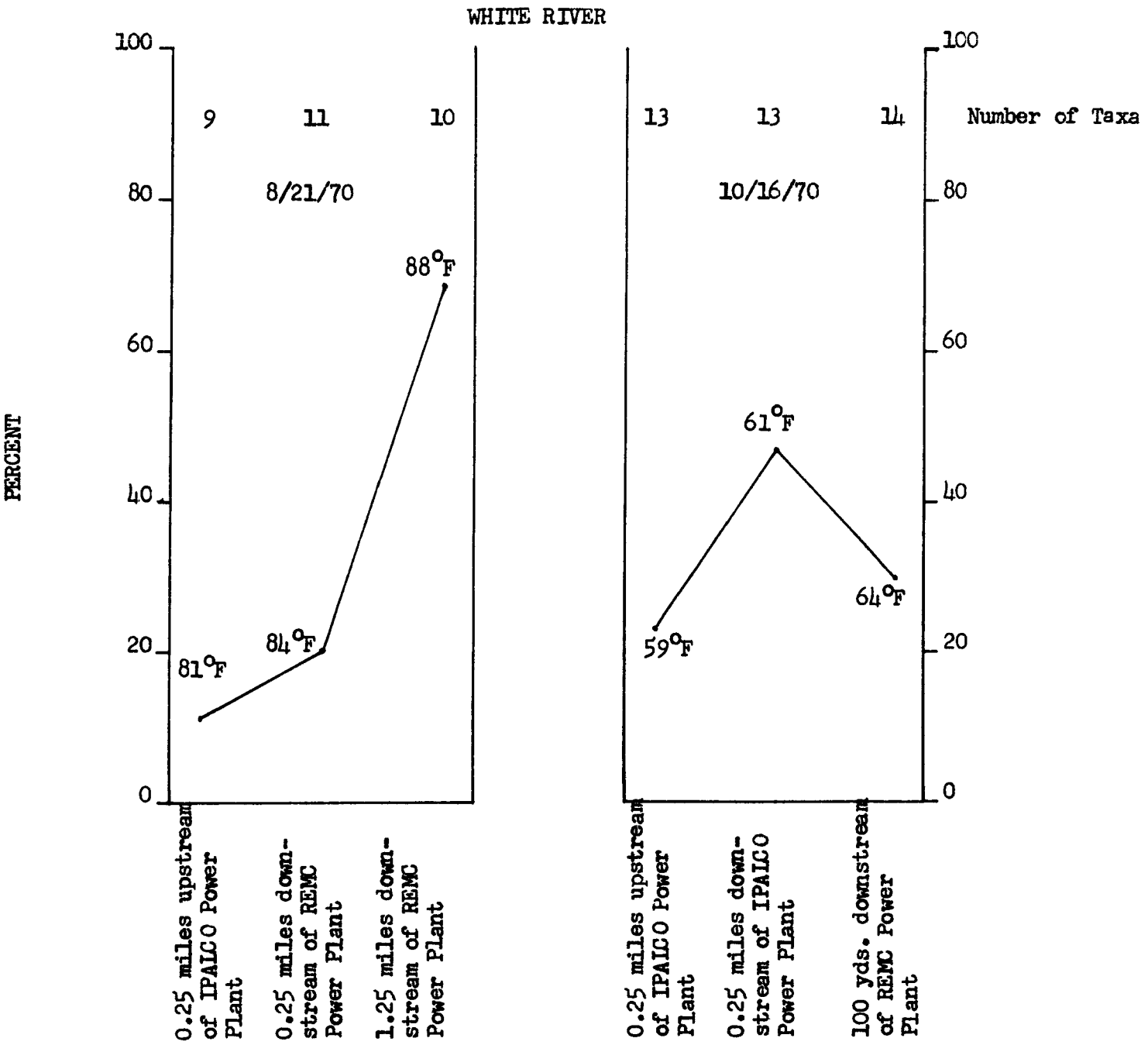


Figure 8 Periphyton Data showing total population by percent upstream and downstream of the IPALCO and REMC Power Plants near Petersburg, Indiana - 1970

Direction of Flow ⟶

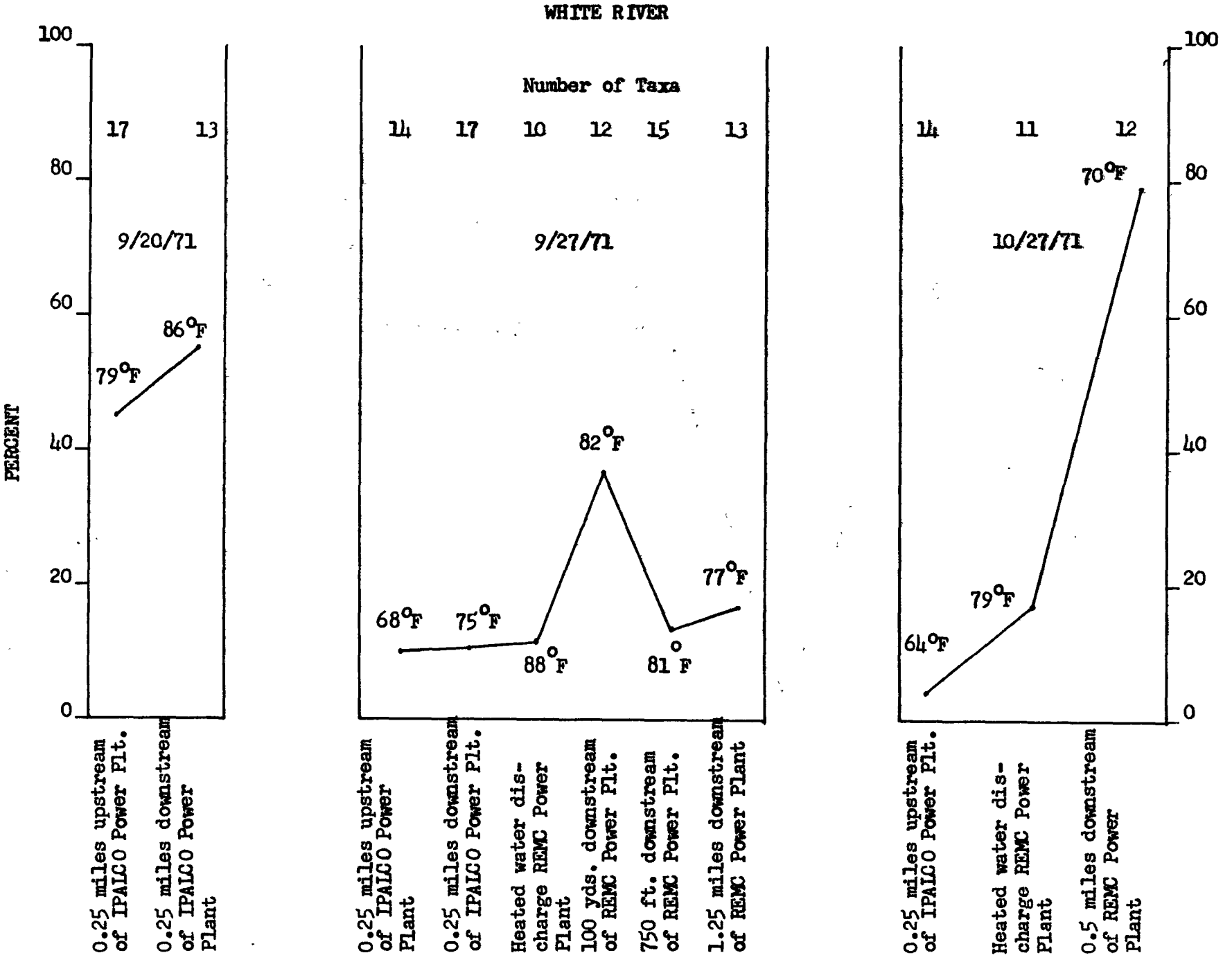


Figure 9 Periphyton data showing total population by percent upstream, in heated water discharge, and downstream of the IPALCO and REMC Power Plants near Petersburg, Indiana - 1971

Direction of Flow ——————→

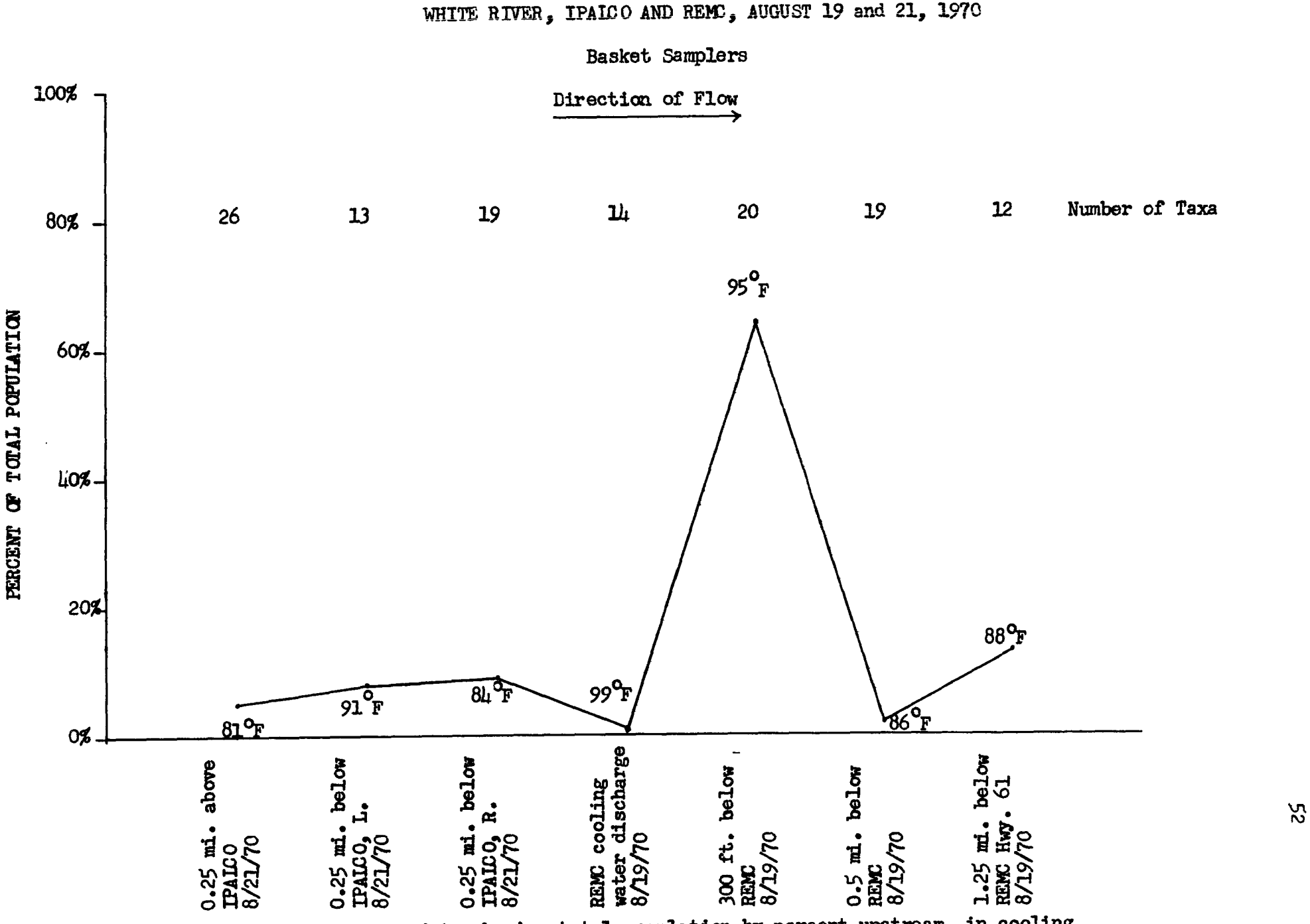


Figure 10 Macroinvertebrate data showing total population by percent upstream, in cooling water discharge, and downstream of the IPALCO and REMC Power Plants near Petersburg, Indiana.

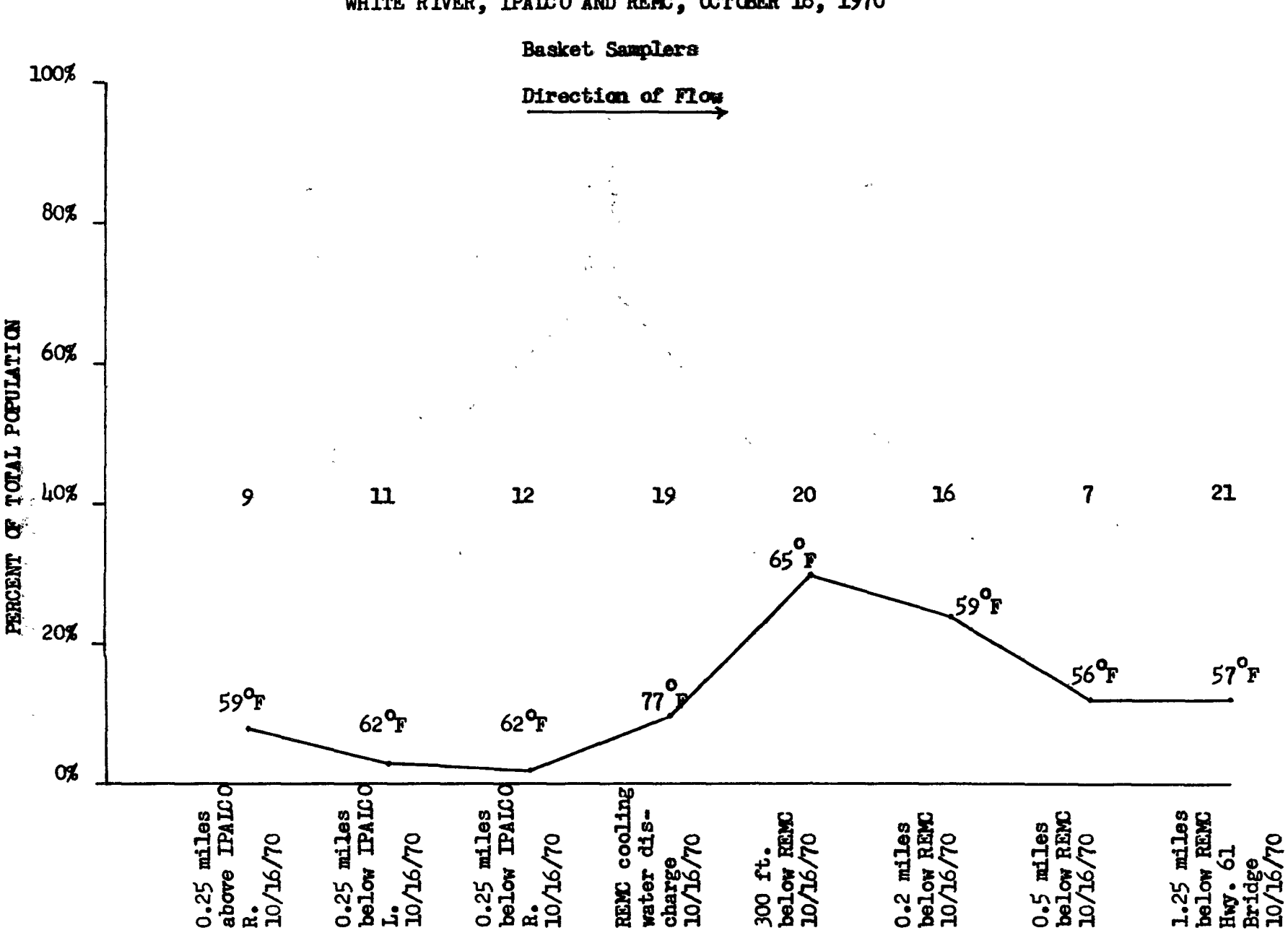


Figure 11 Macroinvertebrate data showing total population by percent upstream, in cooling water discharge, and downstream of the IPALCO and REMC Power Plants near Petersburg, Indiana.

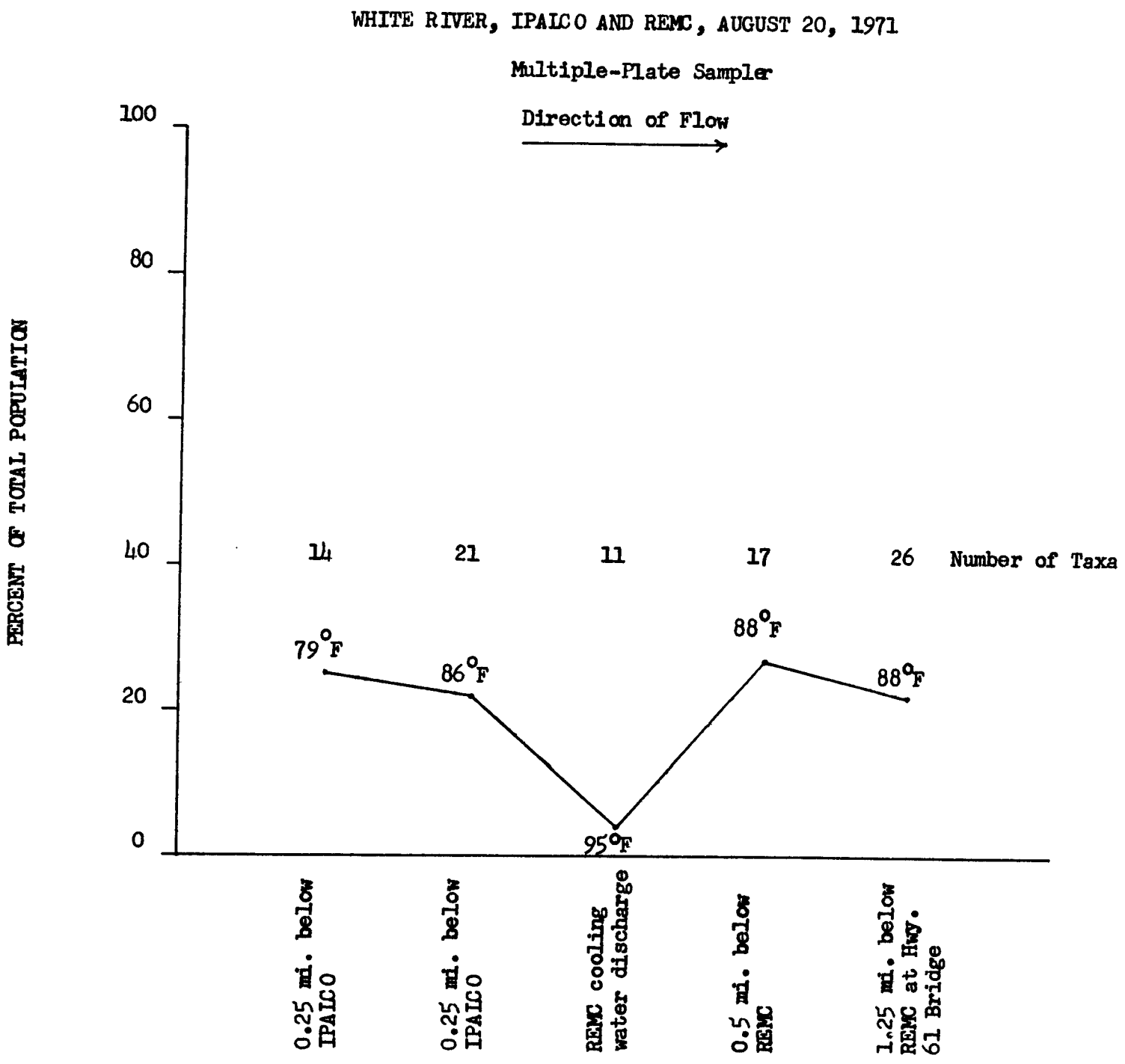


Figure 12 Macroinvertebrate data showing total population by percent upstream, in cooling water discharge, and downstream of the IPALCO and REMC Power Plants near Petersburg, Indiana.

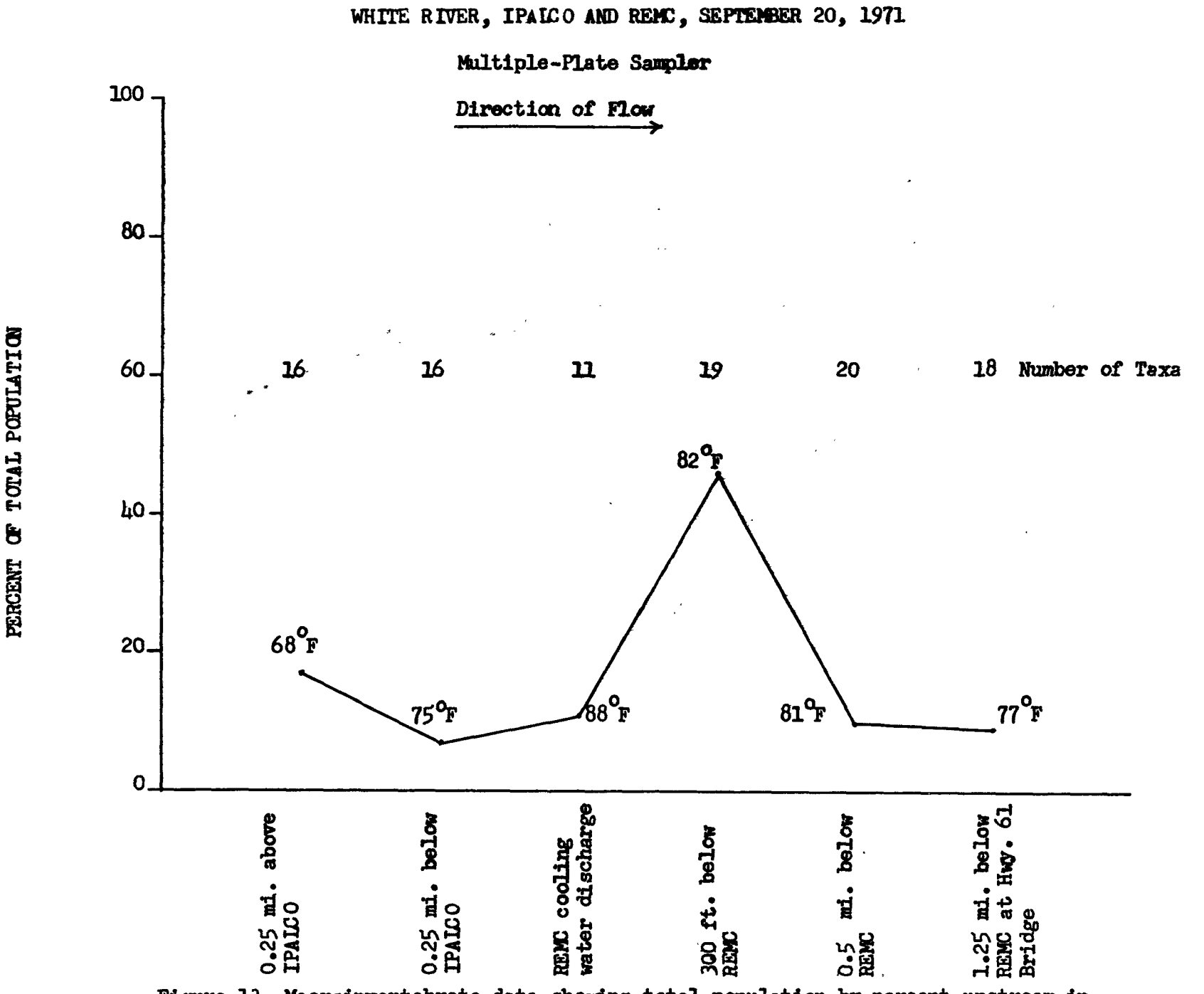


Figure 13 Macroinvertebrate data showing total population by percent upstream in cooling water discharge, and downstream of the IPALCO and REMC Power Plants near Petersburg, Indiana.

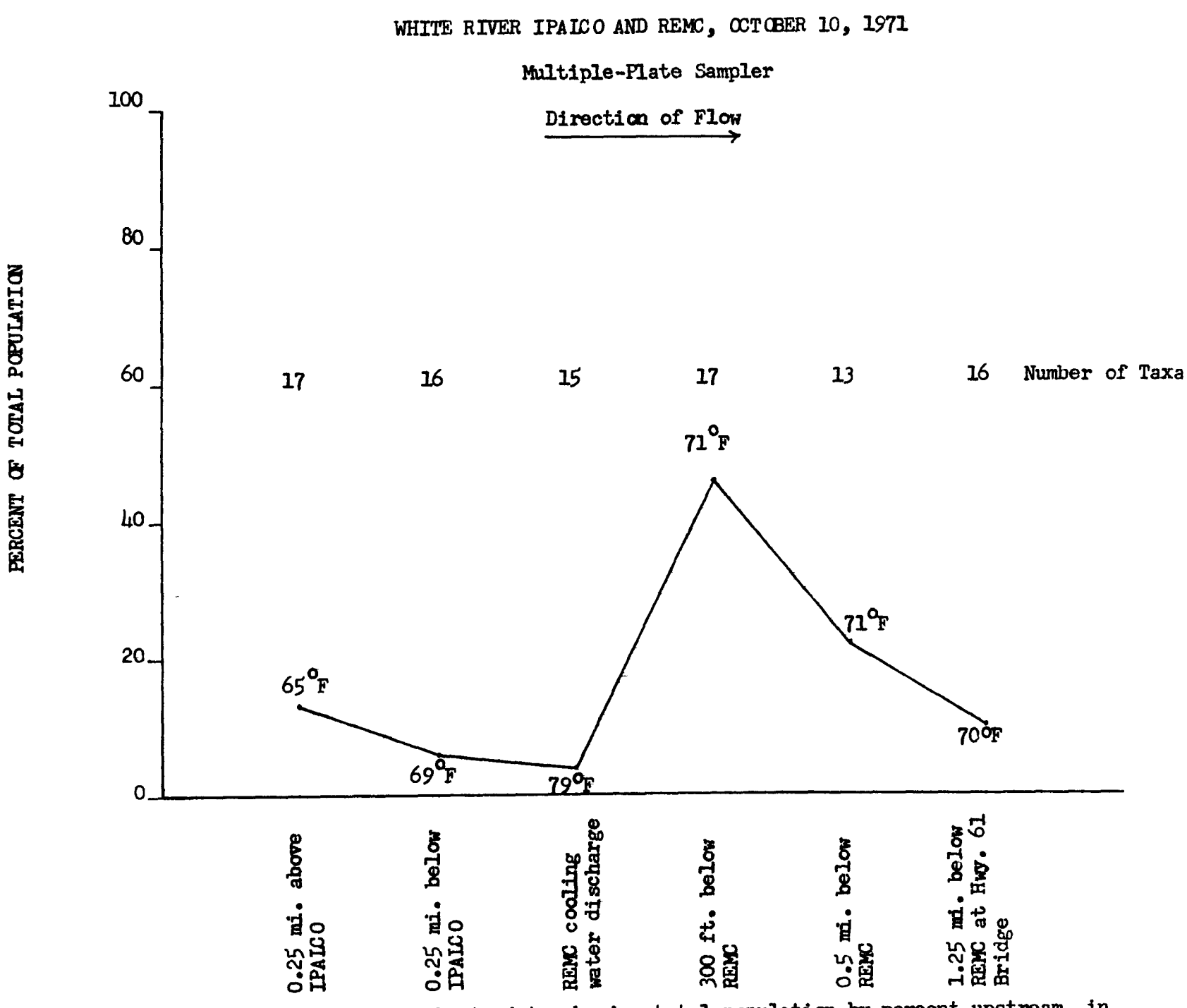


Figure 14 Macroinvertebrate data showing total population by percent upstream, in cooling water discharge, and downstream of the IPALCO and REMC Power Plants near Petersburg, Indiana.

Figure 15

DISTRIBUTION OF BENTHIC TAXA AT DIFFERENT TEMP. RANGES

WABASH RIVER

TEMP. RANGE °F

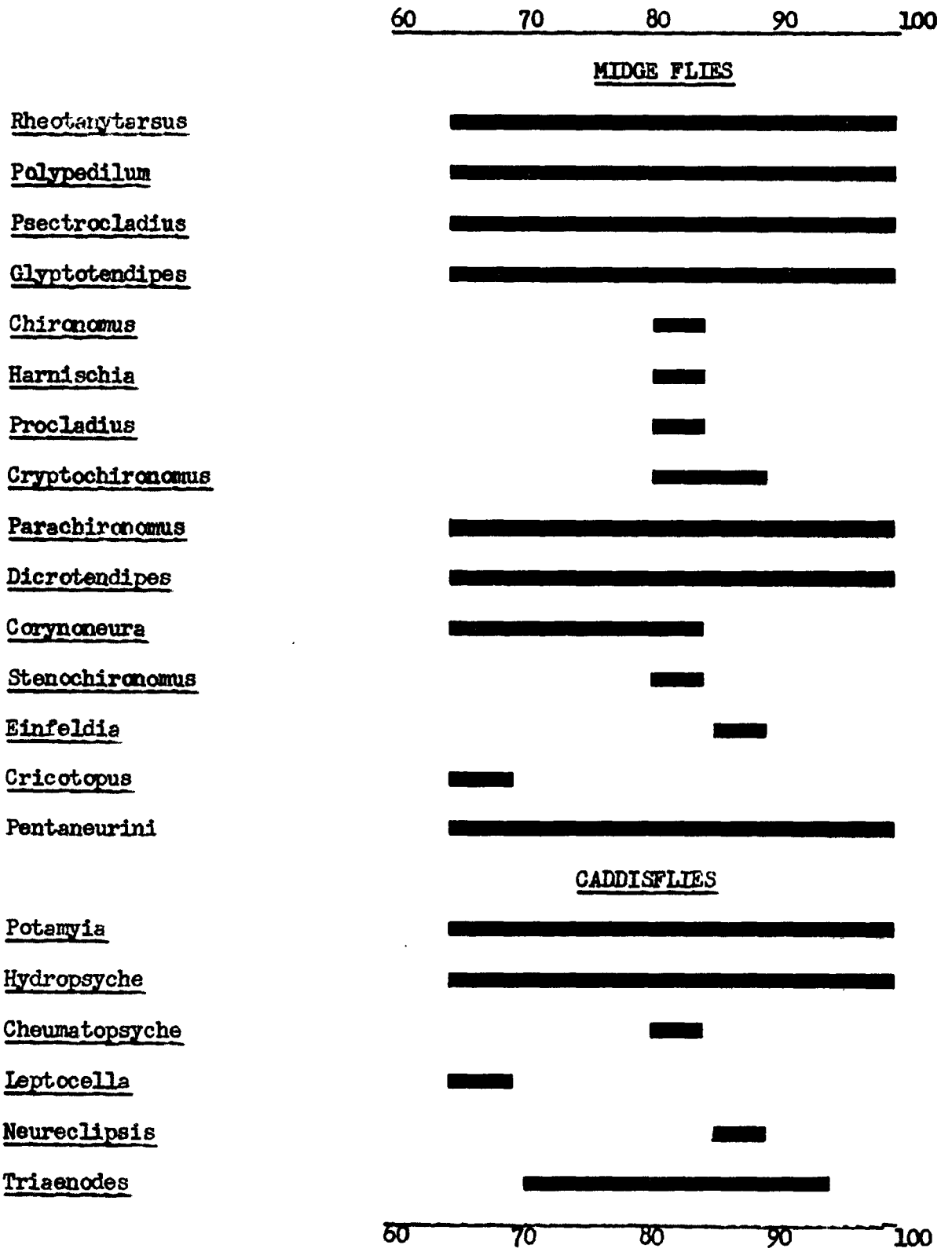


Figure 15
WABASH RIVER (Continued)

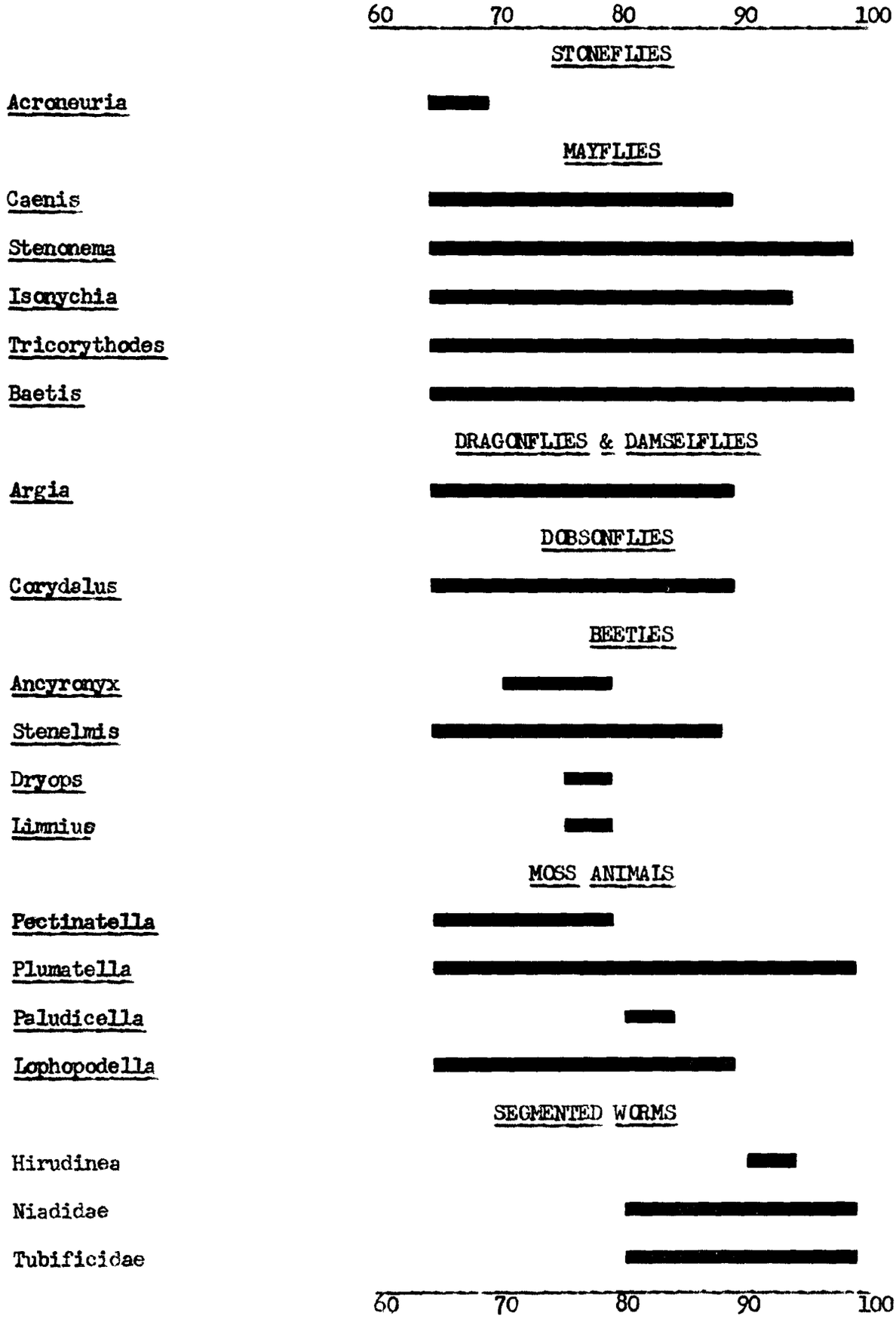


Figure 16

DISTRIBUTION OF BENTHIC TAXA AT DIFFERENT TEMPERATURE RANGES
WHITE RIVER, PETERSBURG, INDIANA

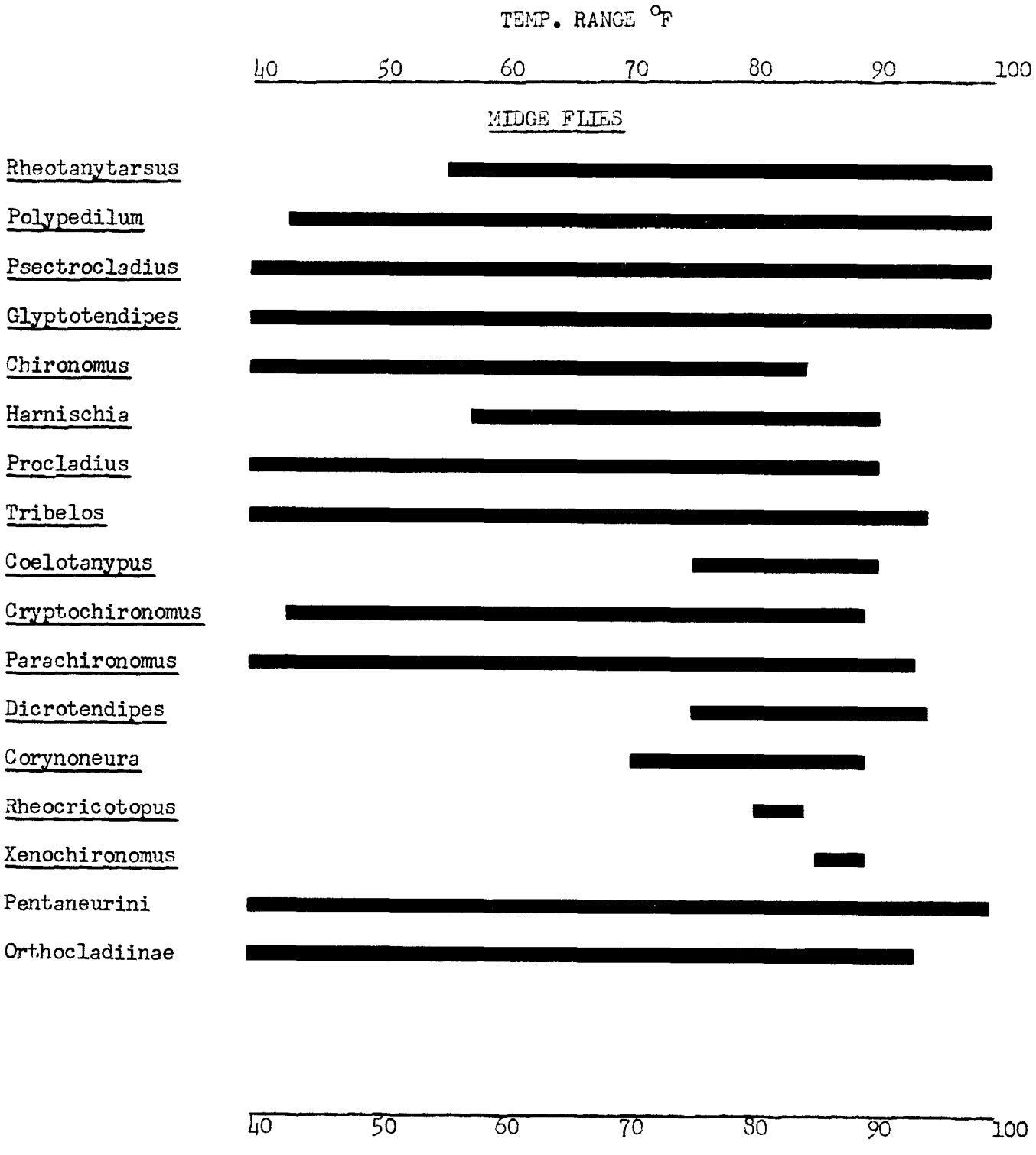
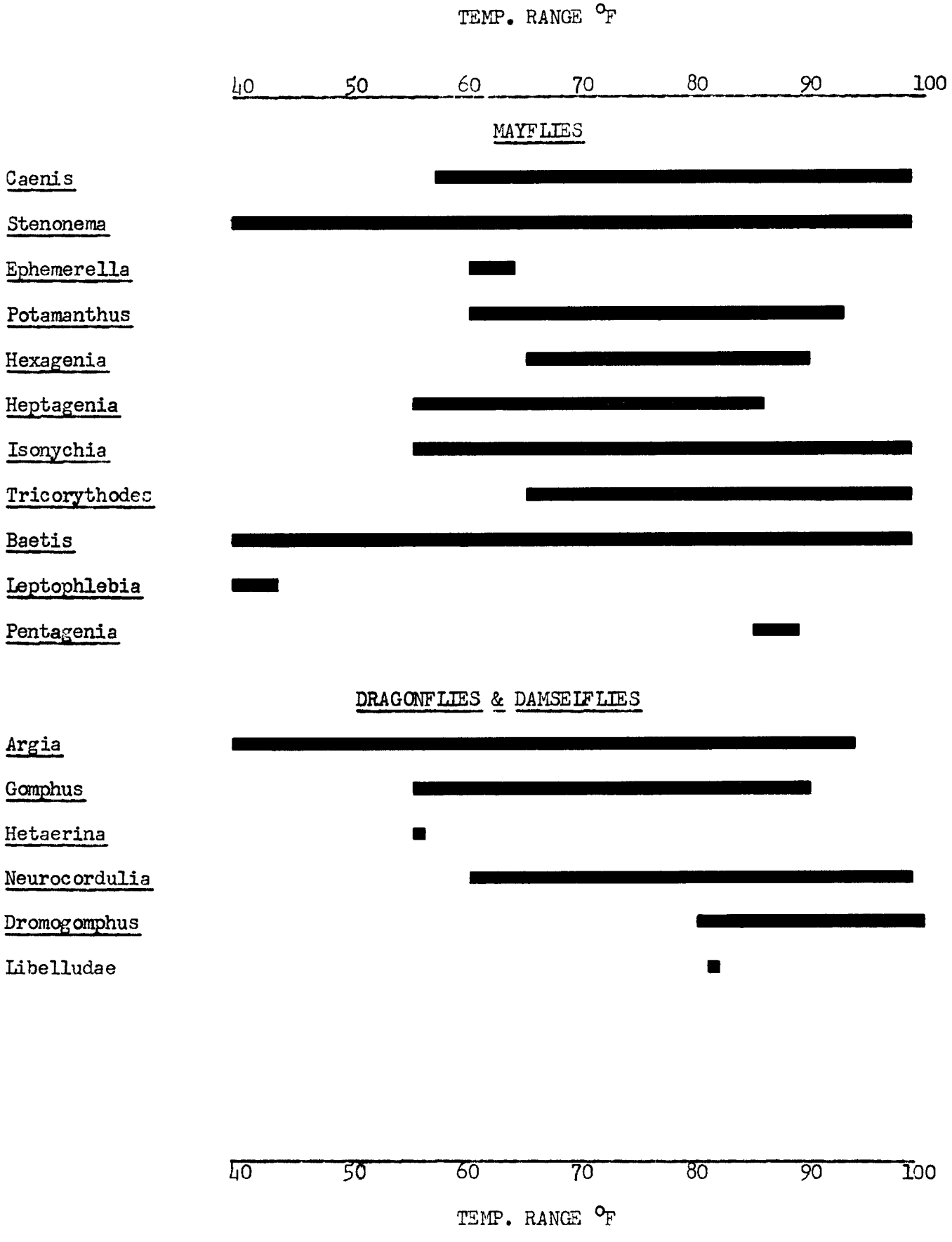


Figure 16 Continued

Figure 16 Continued



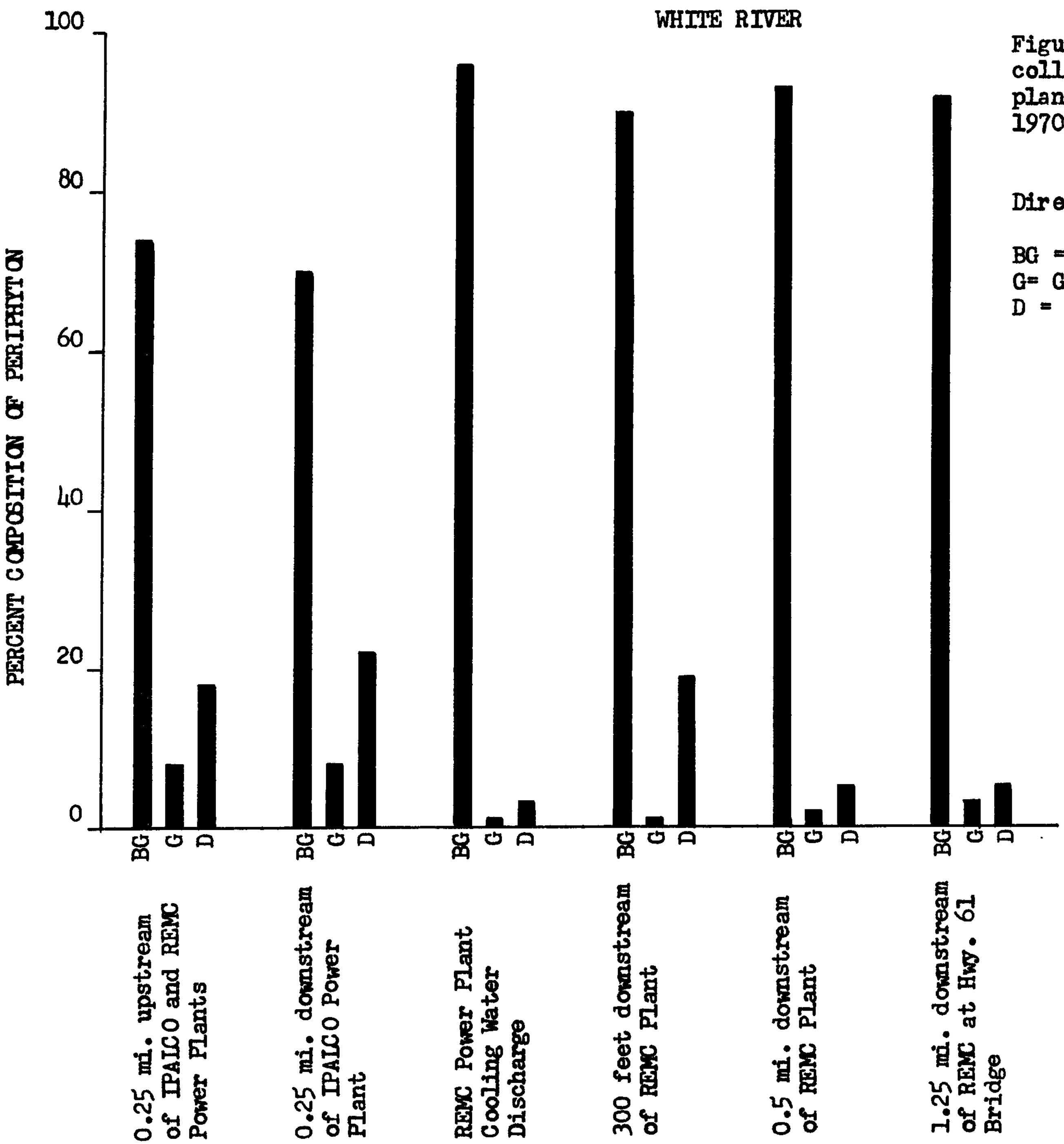


Figure 17 - White River periphyton data collected at IPALCO and REMC power plants near Petersburg, Indiana 1970 and 1971

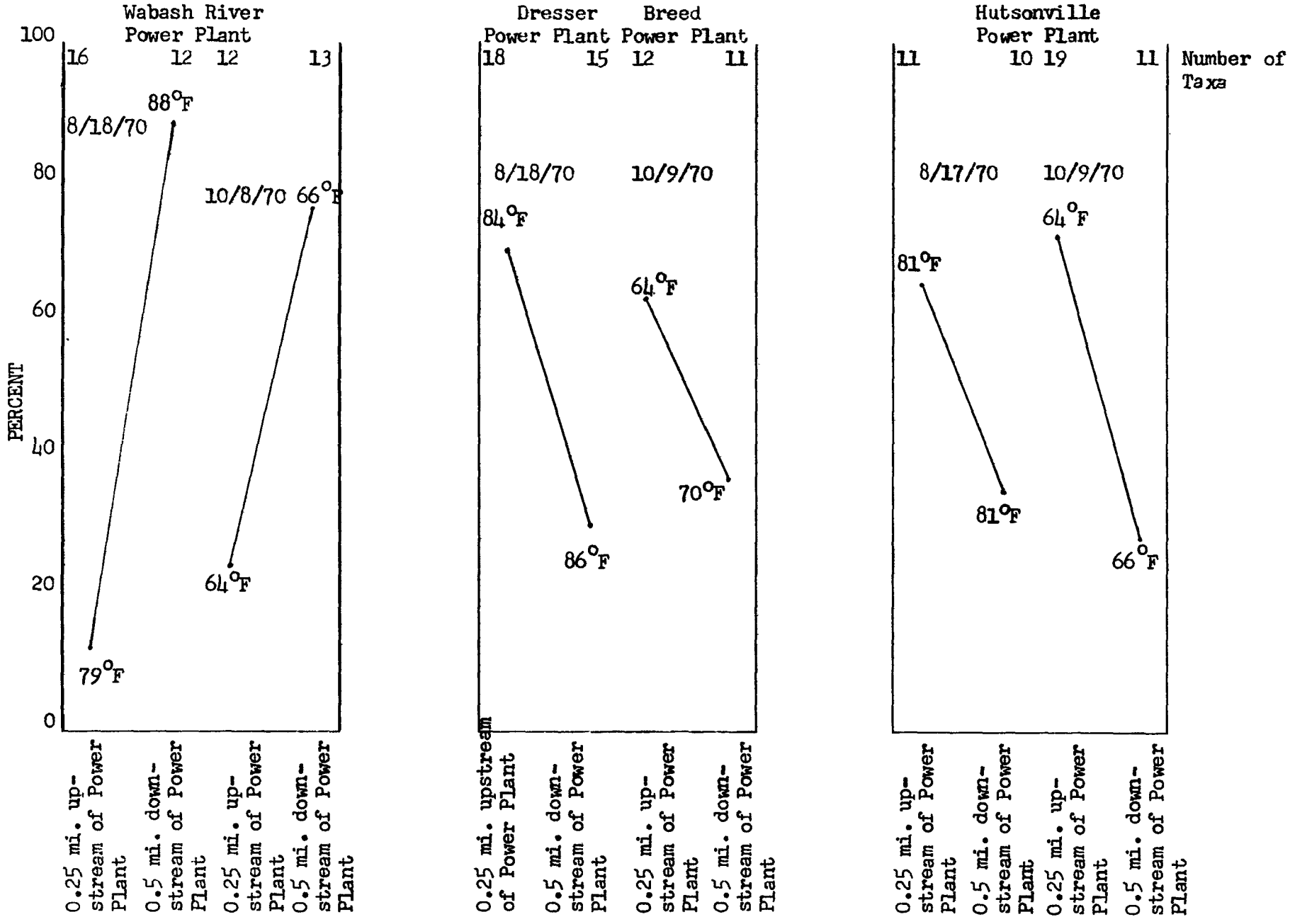


Figure 18 Macroinvertebrate data showing total population by percent upstream and downstream of Wabash River, Dresser, Breed, and Hutsonville Power Plants - 1970

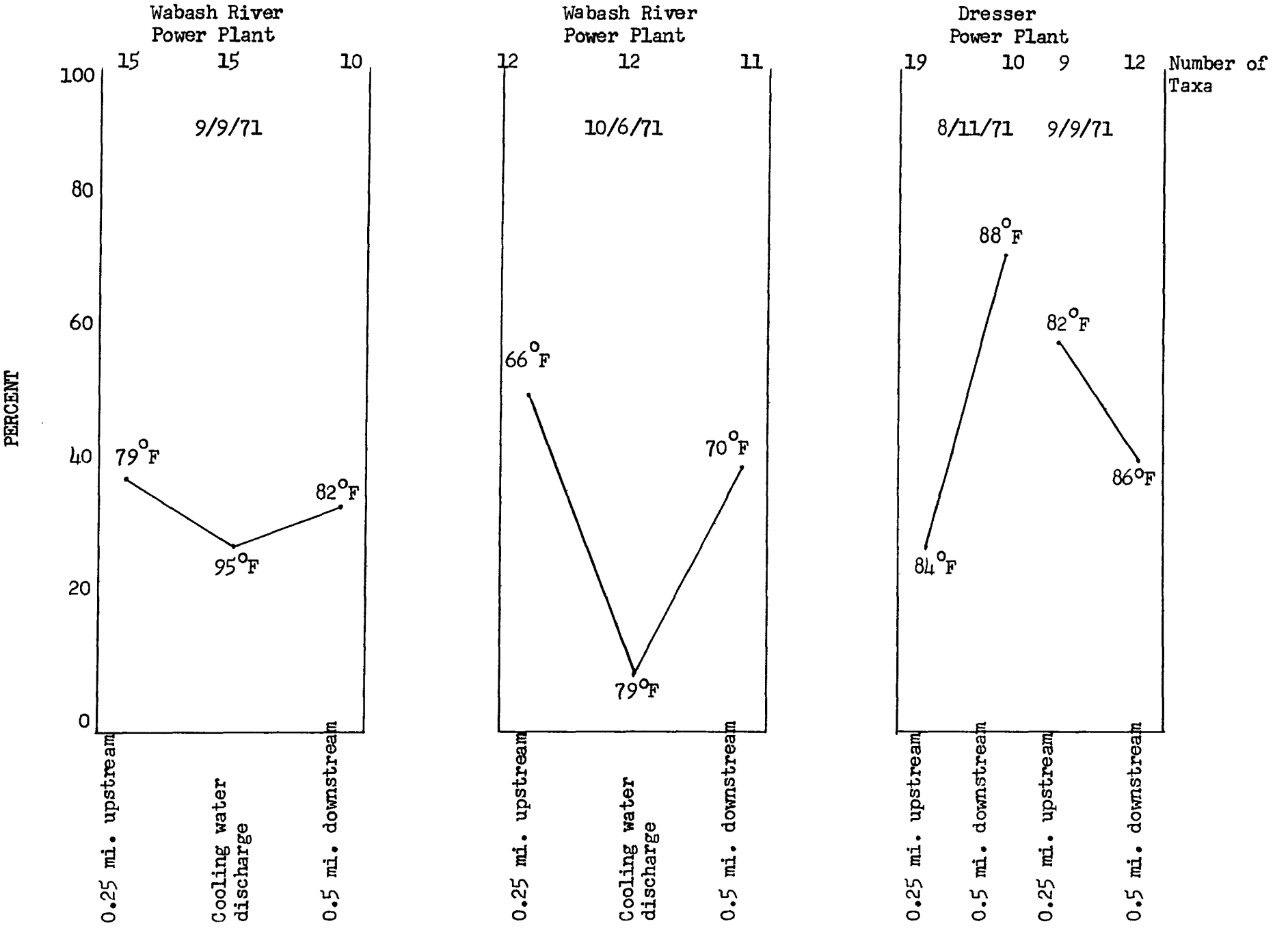


Figure 19 Macroinvertebrate data showing total population by percent upstream and downstream of Wabash River and Dresser Power Plants - 1971

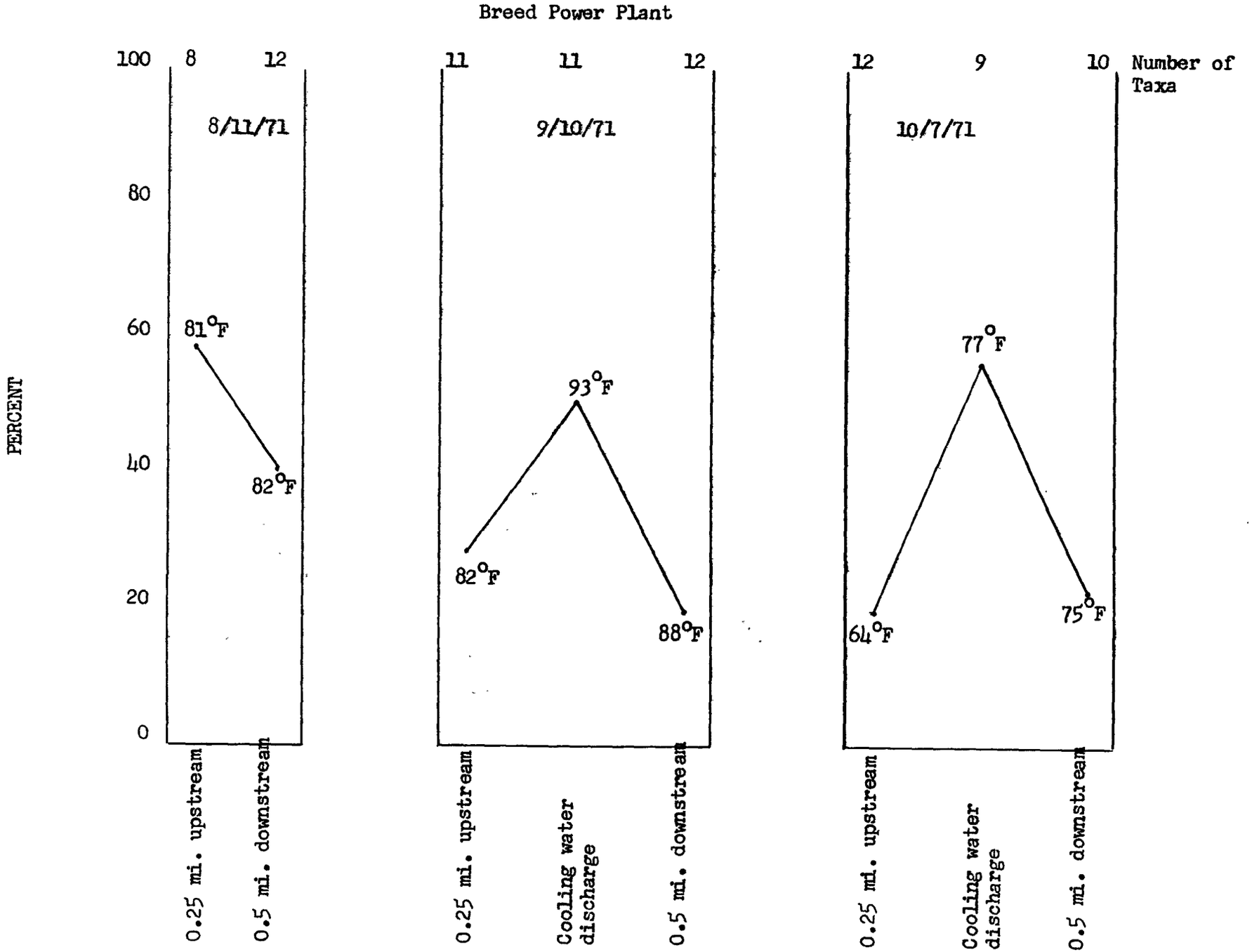


Figure 20 Macroinvertebrate data showing total population by percent upstream, in cooling water discharge and downstream of Breed Power Plant - 1971

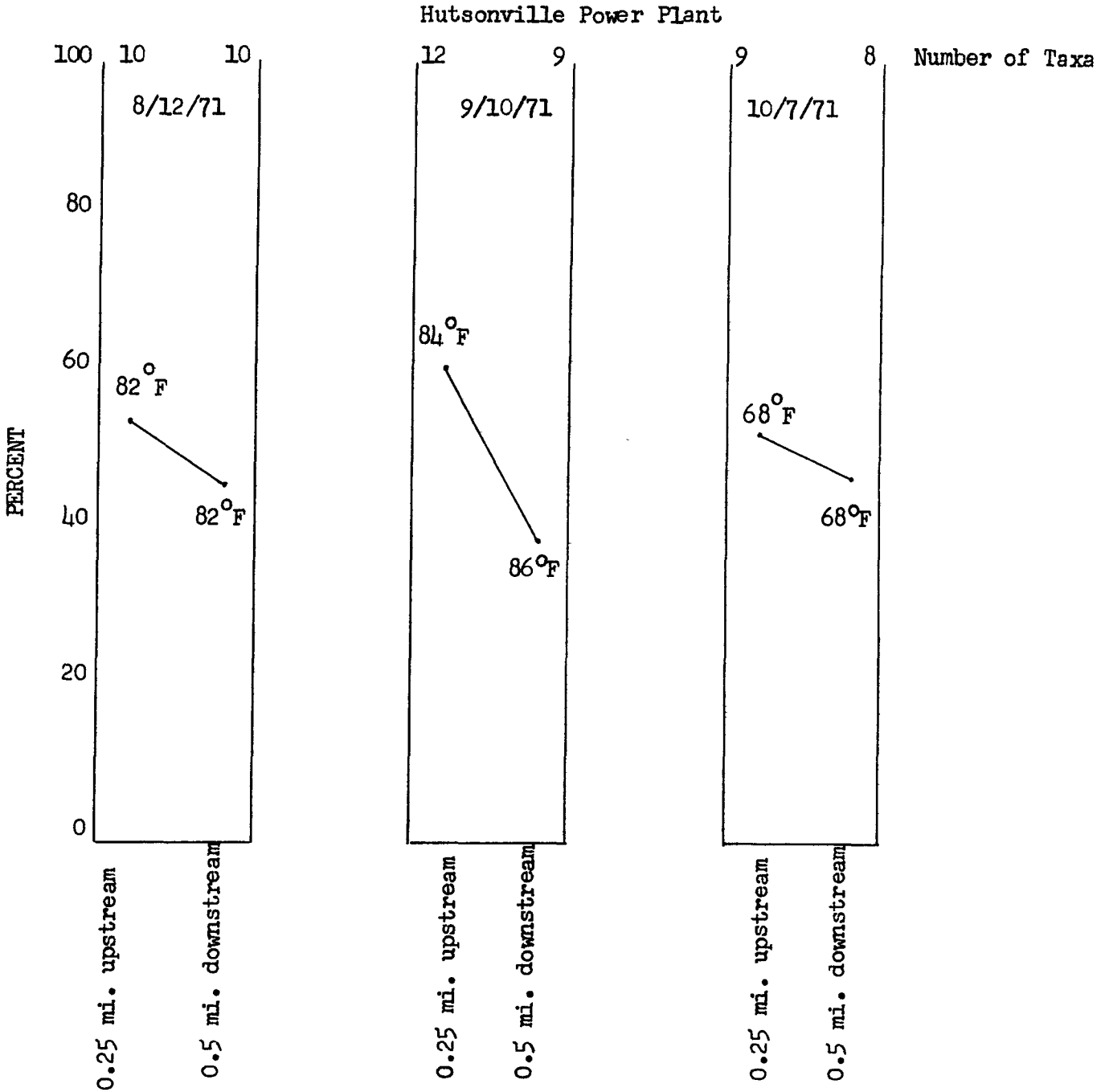


Figure 21 Macroinvertebrate data showing total population by percent upstream and downstream of Hutsonville Power Plant - 1971

REGULATION SPC 1R-2_

WATER QUALITY STANDARDS

FOR WATERS OF INDIANA

MINIMUM CONDITIONS APPLICABLE TO ALL WATERS AT ALL PLACES AND AT ALL TIMES

1. Free from substances attributable to municipal, industrial, agricultural or other discharges that will settle to form putrescent or otherwise objectionable deposits.

2. Free from floating debris, oil, scum, and other floating materials attributable to municipal, industrial, agricultural or other discharges in amounts sufficient to be unsightly or deleterious.

3. Free from materials attributable to municipal, industrial, agricultural or other discharges producing color, odor or other conditions in such degree as to create a nuisance.

4. Free from substances attributable to municipal, industrial, agricultural or other discharges in concentrations or combinations which are toxic or harmful to human, animal, plant or aquatic life.

S T R E A M - Q U A L I T Y C R I T E R I A

FOR PUBLIC WATER SUPPLY AND FOOD PROCESSING INDUSTRY

The following criteria are for evaluation of stream quality at the point at which water is withdrawn for treatment and distribution as a potable supply:

1. Bacteria: Coliform group not to exceed 5,000 per 100 ml as a monthly-average value (either MPN or MF count); nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 20,000 per 100 ml in more than five percent of such samples.

2. Threshold-odor number: Taste and odor producing substances, other than naturally occurring, shall not interfere with the production of a finished water by conventional treatment consisting of coagulation, sedimentation, filtration and chlorination. The threshold odor number of the finished water must be three or less.

3. Dissolved solids: Other than from naturally occurring sources not to exceed 500 mg/l as a monthly-average value, nor exceed 750 mg/l at any time. Values of specific conductance of 800 and 1,200 micromhos/cm (at 25°C.) may be considered equivalent to dissolved-solids concentrations of 500 and 750 mg/l.

4. Radioactive substances: Water supplies shall be approved without further consideration of other sources of radioactivity intake of Radium-226 and Strontium-90 when the water contains these substances in amounts not exceeding 3 and 10 picocuries per liter, respectively. In the known absence of Strontium-90 and alpha emitters, the water supply is acceptable when the gross beta concentrations do not exceed 1,000 picocuries per liter.

5. Chemical constituents: Not to exceed the following specified concentrations at any time:

Constituent	Concentration (mg/l)
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium (Hexavalent)	0.05

Constituent	Concentration (mg/l)
Cyanide	0.025
Fluoride	1.0
Lead	.0.05
Selenium	0.01
Silver	0.05

FOR INDUSTRIAL WATER SUPPLY

The following criteria are applicable to stream water at the point at which the water is withdrawn for use (either with or without treatment) for industrial cooling and processing:

1. Dissolved oxygen: Not less than 2.0 mg/l as a daily-average value, nor less than 1.0 mg/l at any time.

2. pH: Not less than 5.0 nor greater than 9.0 at any time.

3. Temperature: Not to exceed 95°F. at any time.

4. Dissolved solids: Other than from naturally occurring sources not to exceed 750 mg/l as a monthly-average value, nor exceed 1,000 mg/l at any time. Values of specific conductance of 1,200 and 1,600 micromhos/cm (at 25°C.) may be considered equivalent to dissolved solids concentrations of 750 and 1,000 mg/l.

FOR AQUATIC LIFE

The following criteria are for evaluation of conditions for the maintenance of a well-balanced, warm-water fish population. They are applicable at any point in the stream except for areas immediately adjacent to outfalls. In such areas cognizance will be given to opportunities for the admixture of waste effluents with the receiving water:

1. Dissolved oxygen: Concentrations shall average at least 5.0 mg/l per calendar day and shall not be less than 4.0 mg/l at any time or any place outside the mixing zone.

2. pH: No values below 6.0 nor above 8.5, except daily fluctuations which exceed pH 8.5 and are correlated with photosynthetic activity, may be tolerated. However, any sudden drop below 6.0 or sudden rise above 8.5 not related to photosynthesis indicates abnormal conditions which should be investigated immediately.

3. Temperature:

Warm Water Species

a. There shall be no abnormal temperature changes that may affect aquatic life unless caused by natural conditions.

b. The normal daily and seasonal temperature fluctuations that existed before the addition of heat due to other than natural causes shall be maintained.

c. The maximum temperature rise at any time or place above natural temperatures shall not exceed 5°F. In addition, the water temperature shall not exceed the maximum limits indicated in the following table:

	Ohio River Main Stem	St. Joseph River Tributary to Lake Michigan	Other Indiana Streams
January	50	50	50
February	50	50	50
March	60	55	60
April	70	65	70
May	80	75	80
June	87	85	90

	Ohio River Main Stem	St. Joseph River Tributary to Lake Michigan	Other Indiana Streams
July	89	85	90
August	89	85	90
September	87	85	90
October	78	70	78
November	70	60	70
December	57	50	57

Cold Water Species

a. In trout and salmon streams where natural reproduction is to be protected, no heat shall be added.

b. In put-and-take streams, temperature shall not exceed 65°F. or a 5°F. rise above natural, whichever is less.

4. Toxic substances: Not to exceed one-tenth of the 96-hour median tolerance limit obtained from continuous flow bioassays where the dilution water and toxicant are continuously renewed, except that other application factors may be used in specific cases when justified on the basis of available evidence and approved by the appropriate regulatory agencies.

5. Taste and odor: There shall be no substances which impart unpalatable flavor to food fish, or result in noticeable offensive odors in the vicinity of the water.

6. Trout streams: In addition, the following criteria are applicable to those waters designated for put-and-take trout fishing:

a. Dissolved oxygen: Concentrations shall not be less than 6.0 mg/l at any time or any place. Spawning areas (during the spawning season) shall be protected by a minimum DO concentration of 7.0 mg/l.

FOR RECREATION

The following criteria are for evaluation of conditions at any point in waters designated to be used for recreational purposes:

1. Whole body contact: The fecal coliform content (either MPN or MF count) shall not exceed 200 per 100 ml as a monthly geometric mean based on not less than five samples per month; nor exceed 400 per 100 ml in more than ten percent of all samples taken during a month. The months of April through October, inclusive, are designated as the recreational season.

2. Partial body contact: The fecal coliform content (either MPN or MF count) shall not exceed a geometric mean of 1,000 per 100 ml, nor exceed 2,000 per 100 ml in more than ten percent of the samples.

FOR AGRICULTURAL OR STOCK WATERING

Criteria are the same as those shown for minimum conditions applicable to all waters at all places and at all times.

NOTE 1: Unless otherwise specified, the term average as used herein means an arithmetical average.

NOTE 2: The analytical procedures used as methods of analyses to determine the chemical, bacteriological, biological, and radiological quality of waters samples shall be in accordance with the latest edition of Standards Methods for the Examination of Water and Wastewater or other methods approved by the Indiana Stream Pollution Control Board and the Environmental Protection Agency, Water Quality Office.

A Preliminary Study of the Taste and Odor Problems In Grand Lake, Ohio and the Wabash River, Indiana

Note - The following two pages are excerpts from this report

By
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Federal Water Pollution Control Administration
U. S. Department of the Interior
Ohio Basin Region
Lower Ohio Basin Office
Evansville, Indiana
October 1969

Chemical Data - Wabash River, Indiana and Grand Lake, Ohio

Table 15 (Cont'd)

Sta. No.	Station Description and Sampling Date	Nitrate Nitrogen Mg/l	Ammonia Nitrogen Mg/l	Total Kjel. Nitrogen Mg/l	Total Phos. Mg/l	Total Soluble Phos. Mg/l	Soluble Ortho-Phos.-P Mg/l	Susp. Solids Mg/l	Susp. Vol. Solids Mg/l	Field DO Mg/l	Water Temp. °C.	Field pH	Field Cond. umhos@25° C.	Turb. J.U.
W-71	Wabash River Clinton, Indiana													
	November 17, 1967	1.4	--	1.0	0.22	0.16	0.14	12	?	10.0	5	7.8	750	14
	December 28, 1967	4.4	--	--	0.38	0.083	0.077	230	32	12.0	0	8.0	380	190
	February 20, 1968	4.1	--	0.6	0.20	0.088	0.083	55	7	--	0	--	--	43
	March 26, 1968	4.9	0.09	--	0.17	0.105	0.090	32	7	--	--	--	--	22
	April 16, 1968	4.1	0.04	1.1	0.18	--	0.10	32	--	9.4	14	8.2	540	22
	May 7, 1968	1.1	0.05	1.4	0.22	--	0.076	--	--	8.4	18	8.1	470	30
	June 11, 1968	4.4	0.08	--	0.19	--	0.069	--	--	--	26	7.0	520	30
W-61	Wabash River Terre Haute, Indiana													
	November 22, 1967	0.95	--	1.0	0.19	0.12	0.11	13	3	11.0	6	7.0	900	12
	December 28, 1967	4.3	--	--	0.40	0.071	0.075	240	26	12.5	0	8.1	380	210
	March 7, 1968	3.1	0.16	1.6	0.21	0.11	0.10	9	1	--	0	--	--	13
	March 25, 1968	5.0	0.10	--	0.13	0.091	0.078	39	7	--	--	--	--	20
	April 18, 1968	4.0	0.05	1.0	0.18	--	0.083	46	--	9.7	14	8.9	550	19
	May 9, 1968	1.1	0.19	1.2	0.19	--	0.042	--	--	9.2	18	8.1	500	29
	May 21, 1968	4.3	0.20	2.2	0.36	--	0.079	250	--	--	--	--	--	220
	June 11, 1968	4.1	0.17	1.8	0.18	--	0.060	--	--	--	27	7.7	550	24
W-45	Wabash River Merom, Indiana													
	November 22, 1967	1.3	--	1.6	0.23	0.16	0.15	34	9	10.0	8	7.7	775	14
	January 3, 1968	4.1	--	--	0.21	0.071	0.072	54	3	10.5	0	7.9	480	80
	March 7, 1968	1.1	0.15	--	0.13	0.042	0.027	18	1.5	--	0	--	--	24
	March 25, 1968	3.3	0.16	--	0.16	0.070	0.050	40	8	--	--	--	--	34
	April 18, 1968	0.78	0.04	--	0.24	--	0.044	85	--	10.4	15	7.8	430	63
	May 10, 1968	1.0	0.04	3.8	0.28	--	0.047	--	--	9.3	18	7.4	480	100
	June 10, 1968	4.3	--	--	0.23	--	0.074	--	--	--	27	7.2	520	45

Summary of Chemical Data - Wabash River, Indiana and Grand Lake, Ohio

Table 14 (Cont'd)
November 1967 Thru June 1968

Sta. No.	Station Description		Nitrate Nitrogen Mg/l	Ammonia Nitrogen Mg/l	Total Kjel. Nitrogen Mg/l	Total Phos. Mg/l	Total Soluble Phos. Mg/l	Soluble Ortho-Phos.-P Mg/l	Susp. Solids Mg/l	Susp. Vol. Solids Mg/l	Field DO Mg/l	Water Temp. °C.	Field pH	Field Cond. umhos/cm @25°C.	Turb. J.U.
W-71	Wabash River Clinton, Ind.	Max.	4.9	0.09	1.4	0.38	0.16	0.14	230	32	12.0	26	8.2	750	190
		Min.	1.1	0.04	0.6	0.17	0.083	0.069	12	2	8.4	0	7.0	380	14
		Avg.	3.5	0.065	1.02	0.22	0.11	0.09	72.2	12	9.95	10.5	--	532	50
W-61	Wabash River Terre Haute, Ind.	Max.	5.0	0.20	2.2	0.40	0.12	0.11	250	26	12.5	27	8.9	900	220
		Min.	0.95	0.05	1.0	0.18	0.071	0.042	9	1	9.2	0	7.0	380	12
		Avg.	3.35	0.14	1.46	0.24	0.098	0.078	99.5	9.25	10.6	11	--	576	68
W-45	Wabash River Merom, Ind.	Max.	4.3	0.16	3.8	0.28	0.16	0.15	85	9	10.5	27	7.9	775	100
		Min.	0.78	0.04	1.6	0.13	0.042	0.027	18	1	9.3	0	7.2	430	14
		Avg.	2.3	--	2.7	0.21	0.086	0.066	46.2	6.7	10.1	11.3	--	537	51
W-33	Wabash River Vincennes, Ind.	Max.	4.7	0.16	4.0	0.23	0.11	0.10	88	9	12.5	26	8.3	775	99
		Min.	1.0	0.04	1.6	0.15	0.056	0.045	8	1	9.3	0	7.4	470	13
		Avg.	3.3	--	2.8	0.19	0.073	0.07	42.1	5	10.8	11.3	--	561	38
W-19	Wabash River Mt. Carmel, Illinois	Max.	4.2	0.35	3.	0.31	0.15	0.15	130	16	13.0	25	8.1	760	190
		Min.	0.76	0.05	0.9	0.20	0.069	0.050	42	1	9.3	0	7.0	300	25
		Avg.	2.7	0.13	1.8	0.23	0.97	0.082	74.1	11.75	11.0	10.8	--	492	62
W-10	Wabash River New Harmony, Indiana	Max.	3.9	0.10	2.2	0.31	0.17	0.16	140	19	13.5	26	8.1	750	140
		Min.	0.86	0.03	1.3	0.14	0.062	0.048	15	1	9.2	0	7.2	430	20
		Avg.	2.45	0.07	--	0.22	0.096	0.078	60.3	10.5	11.6	10.8	--	516	55