AN ECOLOGICAL SURVEY OF A
SOUTHERN MICHIGAN TROUT STREAM

THESIS FOR THE DEGREE OF M. S.
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RAYMOND E. REILLY

1963

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ABSTRACT

This study was an attempt to relate historical records to ecological factors influencing productivity of McCoy Creek. Information about the stream's past history was compared to present conditions. The study area was divided into nine units and morphometric data including pool locations and water types were determined for each unit. Where possible, this information was given as the percentage of composition for each unit. Complete data were obtained for the distribution of substrata, and permanent and non-permanent stream cover. This was expressed as the percentage of coverage per unit. Physical data were correlated with biological information obtained from electrofishing, seining, bottom fauna sampling and the relationship between ground water and spawning beds. A questionnaire was used to obtain additional information about the fish population. The main limiting factors appeared to be: a deficiency in available trout spawning facilities, inadequate food production during the critical portion of the year, and lack of protective shelter for adult trout. These deficiencies were compounded by the deleterious effects of man's activities. Recommendations for management are also discussed.

Approved

AN ECOLOGICAL SURVEY OF A SOUTHERN MICHIGAN TROUT STREAM

By

Raymond E. Reilly

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INTRODUCTION

Much trout stream research and survey work has been conducted in northern Michigan. But there exist in southwestern[1] Michigan twenty streams, for which, in many cases, only casual surveys have been conducted to evaluate their suitability as trout habitat (Vondett--personal communication).

Some trout populations and food studies have been carried on for the southern Michigan streams of Augusta and Portage Creeks, Kalamazoo County; Dowagiac Creek, Cass County; and Silver Creek, Allegan County. McCoy Creek however, is one of the trout streams receiving only a casual survey.

According to Smedley (1938), a survey of early records does not indicate brook trout (Salvelinus fontanalis) as being native to the Lower Peninsula of Michigan. In 1879 the first plantings were made in this peninsula. They were in southern Michigan; Berrien County was included (specific locations are not known).

An early report (8) states that brook trout occurred in McCoy Creek at least since 1920.

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Visual evidence of the man-made environmental changes are easily noted by any experienced observer. What then is the stream's present biological and physical condition regarding trout habitat? Can accelerated degradation of the environment be demonstrated? If so, what has been man's influence? If a wide disparity exists between the present and former environment, is it feasible to attempt stream restoration? These questions form the structure of this thesis. The approach for this study was to: 1) Attempt a reconstruction of the stream's past history. 2) Survey the stream's present physical and biological condition, discussing their ecological significance. 3) Prepare suggestions, based on all segments of the study, for improved management of the stream.

Description of the Study Area

Location

McCoy Creek is located in southwestern Michigan's Berrien County. It has headwaters at the Indiana-Michigan state line. The stream flows in a northeasterly direction through sections 21, 16, 9, 4, and 3 in Bertrand Township, and sections 34, 35, and 25. Buchanan Township; Town 8 and 7, south, respectively; Range 18 west. It empties into the St. Joseph River, which flows into Lake Michigan. Figure 1 represents the stream's relative location in the area.

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The county has a mean annual precipitation of 33 inches, usually evenly distributed throughout the year. The average snowfall is 51.6 inches, more than one-half occurring in January and February (Kerr et al., 1927). The mean maximum for July is 72° and the mean minimum for January is 26° (U. S. Weather Bureau, 1961).

Geological Description of the Area

Lane (1907), in his summary of the geology of southern Michigan states that the western portion of Berrien County is underlain by Antrim shale formed during the Devonian period. The surface features of the area were formed almost wholly by deposition from the Lake Michigan lobe of the late Wisconsin glacier, and by shore features of the waters impounded by the melting glaciers. Glacial outwash aprons of gravelly and loam soils are characteristically distributed between moraines which have been formed on a north-south pattern.

Soil and Land Description

The major portion of the stream flows through land types characterized by a gently rolling plain dotted with numerous, relatively deep basins which are features of glacial origin. A large percentage of the steeper slopes still remain in forest. Much of the peat and muck retain a cover

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a cover of trees, shrubs and herbaceous vegetation. The cleared land has been used for general farm crops and pasture (Veatch, 1934).

The total watershed estimated from a 1927, United States Geological Topographical Survey map and delineated on Figure 1, consists of approximately 15 square miles.

The following description of the area's six main soil types were obtained from Kerr et al. (1927), Soil Survey of Berrien County.

The muck soils are nearly typical in composition except nearer the stream where they may contain a larger content of silt clay or marl than is common.

The Plainfield sand and sandy loam both are reported to have good to excessive underdrainage. The rainfall is largely absorbed and carried away through the substrata of sand and gravel. Drainageways were reported to occur only at wide intervals.

Fox loam and sandy loam have unweathered substrata composed of calcareous rocks, gravel, and beds of sand, respectively. The clay in the loam's B layer results in soil coherence, allowing good but not excessive absorption and drainage. Both soils are capable of retaining a good supply of moisture. Springs are commonly associated with the sandy loam.

The survey also mentions Bellefontaine sandy loam, occurring in the steeper slopes, having good underdrainage.

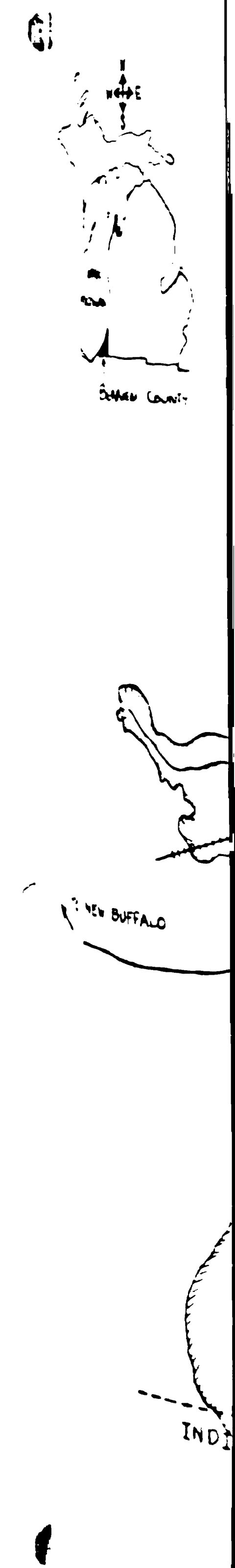
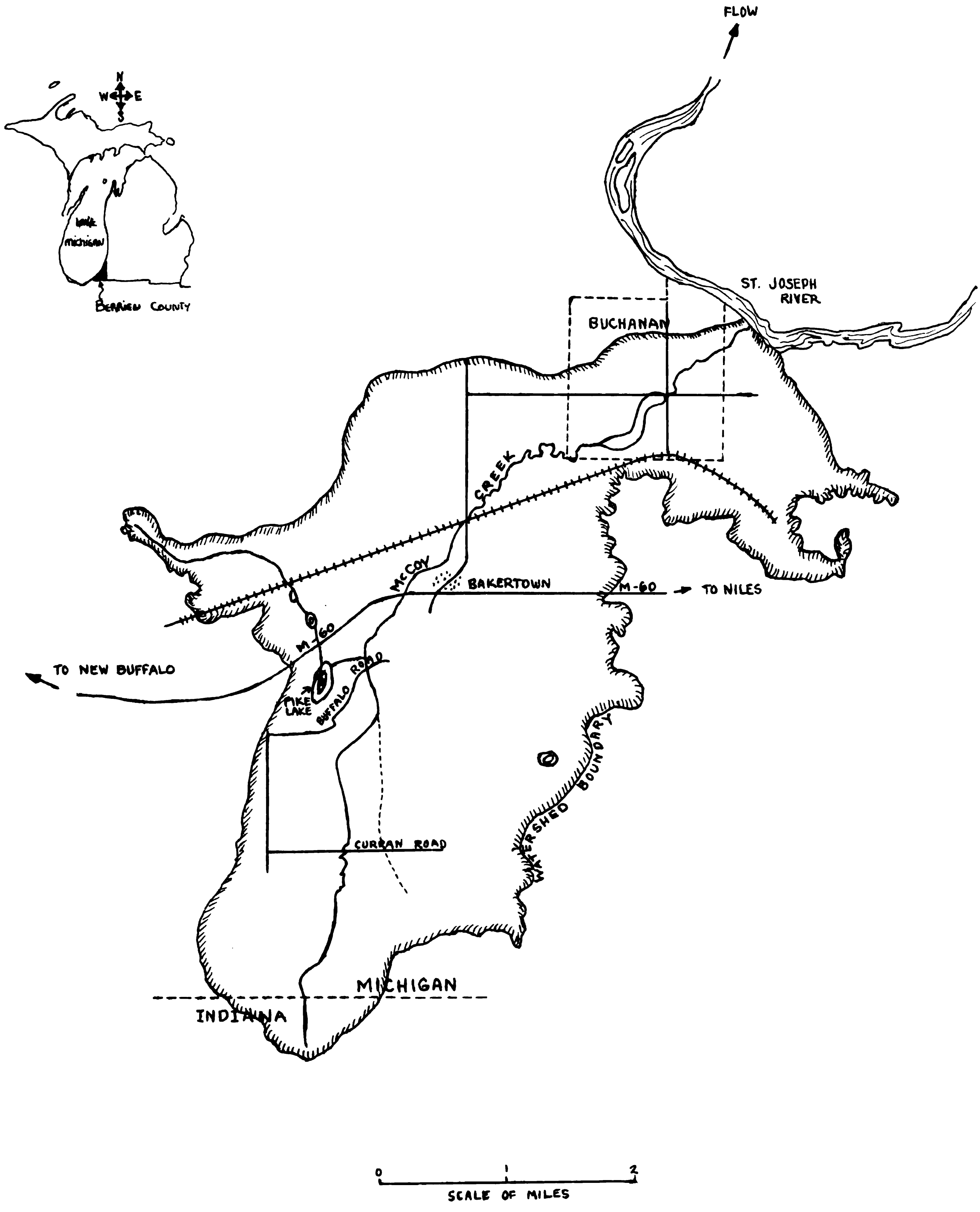


Figure 1

Map of McCoy Creek showing watershed boundary and relationship to surrounding area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Its substrate is composed primarily of unassorted gravelly and stony glacial drift with much limestone. Much of the hilly portions of the study area are composed of these soils.

The Miami silt loam is composed of a silty loam graduating after three feet in depth into heavy unweathered till. This parent till is calcareous but the top and subsoil is generally leached of its lime. The drainage is good; the subsoil allowing absorption and distribution of moisture without accumulation of excessive amounts.

History of the Study Area

Introduction

Historical data were obtained from two public agencies and utilizing verbal information from eleven individuals. These individuals have had close contact with the stream through long-time area residency and/or consistent stream fishing over a period of from five to forty-five years. Their information was compared for accuracy by cross-checking their data for agreement on certain points. Most informants admitted knowing only about specific sections of the stream. Only one person (8) offered information regarding certain conditions of the whole stream.

Most queries were directed at obtaining information regarding the altered stream sections. It appears that these changes had the greatest effect on the overall stream cl

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stream character and therefore should be the most significant historically and biologically.

The Berrien County Drain Commission provided data concerning the dates of drainage and cleaning activities. The County Highway Department gave information regarding the bridge and road work on M-60.

<u>Stream Alterations</u>

Prior to 1894 most of McCoy Creek followed its natural stream course. The exceptions to this were the location of a millpond in section 3 covering approximately 20 acres,[2] and an excavated mill race location within the city of Buchanan. It is not known how long prior to 1894 the section 3 millpond existed but it appeared on a deed as early as 1847.

In 1894 a group of local residents owning property through which the stream flowed, petitioned the Berrien County Drain Commission to straighten and dredge the stream commencing from Curran Road (which bisects section 16 in an east-west direction) downstream to the point of junction of the New York Central Railroad grade and the Bakertown-Buchanan road. This was a total of 19,014 feet.[3] The portion of the stream dredged was to be known as the Bakertown Drain. It was to be maintained by direct tax

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[2] Atlas Plate Book of Berrien County, 1929.

[3] Berrien County Drain Commission Report, 1897.

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assessment of the landowners through whose land the stream flowed. It is interesting to note that the petition was first rejected because the Commission felt no one would benefit from the dredging.

The most marked change in the stream's course resulted from dredging the portion from Curran Road to Buffalo Road (in section 9). The newly straightened section between these two points had a length of approximately 8,000 feet,[4] in contrast with the original stream's length (between the same two locations) of about 14,000 feet. The work from Buffalo Road to the termination of the drain work, consisted primarily of dredging and widening the existing stream's course. The channel, after dredging, had a surface width of approximately 25 feet maximum, to 14 feet minimum, compared to the original surface width of from 12 feet maximum to 5 feet minimum.

It is impossible to determine what effect the dredging had on the standing crop and carrying capacity of the stream, since no such records are available.

Data from dredging operations in Indiana (Murray, 1938) stated that the immediate results were quite striking with a tendency to decrease both the numbers and kinds of organisms present. Rees (1959) in a Washington salmon

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[4] This and all other distances, unless otherwise specified, are based on measurements from an aerial photo map; scale 1:660, obtained with the use of a map measure.

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stream study, found a 97 percent reduction in bottom fauna immediately after dredging and a reduced level for 5 months. After 10 months the stream's bottom fauna had recovered completely. No data is given regarding the quantitative or qualitative changes in the substrata which might have influenced their overall results.

From 1894 to 1930 the "drain" remained untouched. Hand dug side ditches were excavated in sections 9 and 16, in an attempt to drain the muck bottom lands for agricultural use. The ditches were few in number, small in size and not maintained (5). However, they undoubtedly contributed some siltation to the stream.

By 1930 part of the stream's dredged portion, according to information from residents (1, 2, 5, 8, 11) again developed many characteristics of its former course.

Informants state that upstream from Buffalo Road, the stream's substrata and banks were composed of muck and marl (1, 2, 3, 8). There were many large holes extending horizontally into the bank where trout sought refuge (8). The mode of formation of these holes is unknown.

It was reported (1, 2, 8) that the stream bottom from Buffalo Road downstream to the present state highway M-60, consisted mostly of gravel with some sand and silt edges. Several hundred feet of stream, flowing at right angles to the slope of a usually plowed hillside, had relatively more sand than other portions immediately upstream. It was sugges

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was suggested (1) that the frequent erosion of the hillside contributed to the deposition of sand.

From the present M-60 to the railroad grade, the water course was described as follows (4, 5, 8, 11). The channel was much deeper and somewhat winding. Each informant attempted to verify their conclusion on the basis of the water level then and now related to some physical structure still present in the stream; or water depth versus hip-boot height. This greater reported volume may help account for the deep holes and undercut banks described as formerly existing.

The substrate was composed primarily of medium-sized gravel mixed with some sand. Little silt occurred along the edges. There were occasional patches of watercress.

The creek's channel downstream from the railroad grade to about the west edge of the city limits of Buchanan remained untouched.

Approximately 7900 feet (stream measurement from map) east of the west edge of the city, the stream divides its flow. The original channel flows southeast and the other, called the mill race, flows east-northeast. Both, flowing underground in culverts, again join under the city of Buchanan and emerge as one from the Portage Road culvert. The mill race was established about 1820 to provide a mill, located in Buchanan, waterpower. The race has been cleaned out by hand and dredged periodically over the years.

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From the point at which the stream emerges until it flows into the St. Joseph River, only two alterations have taken place; both at an early date on Clark Equipment Company's property. A few hundred feet downstream from Portage Road, a small pond of about one acre in size and six feet deep had been created. A dam controls its water level. At the east edge of Clark's property, another dam is located creating a cascade with approximately 10-15 feet of fall. Part of the water enters the factory just above the dam, is used for industrial purposes and then discharged further downstream.

In 1930 the Drain Commission was authorized to re-dredge the stream from the railroad grade upstream to approximately the present M-60 highway. This was a distance of about 5,600 feet. This cleaning removed the undercut banks, natural holes, stumps and logs (11). However, it only slightly modified the width of the stream.

In 1932 significant road and bridge construction was undertaken approximately 4,600 feet upstream from the Bakertown-Buchanan Road. A heavy duty concrete bridge was built as part of M-60, across McCoy Creek. Large quantities of sand and gravel were hauled in to build a roadbed approaching the bridge. This bed is about 15 feet above the surface of the creek and surrounding low land. In order to situate the building forms etc., large quantities of sand and gravel were pumped from the stream bed; the

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sand residue being deposited in and along the stream (4). It appears that the thick sand deposits in the stream from the bridge to approximately 2,400 feet downstream are a result of the combined construction activities, and slower current.

In 1935 additional work was done by the WPA on the creek upstream from M-60 to Buffalo Road. This work consisted of removing logs, cutting brush and removing stream bends that had reformed in the creek (1, 4, 9).

The mill race was dredged by dragline in 1941. As mentioned, this race had been hand-cleaned many times prior to 1941. A water diversion structure (now defunct) was located where the mill race and main channel separate. This device regulated the amount of water entering the mill race.

Two observers (8, 11) noted the main branch was formerly (prior to dredging) a very fast flowing stretch of water. Due to its velocity and depth, wading was hazardous. Undercut banks were common. The bottom type was primarily medium to large gravel, scattered with large rocks. The water area was heavily shaded by long and dense overhanging sedge.

The bottom is now primarily sand. The undercut banks are gone. The swiftness and volume of water has been greatly reduced. Whether the dredging of the mill race and abandonment of the water diversion structure were entirely

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In 1936 the Pike Lake outlet flowing into the creek approximately 600 feet downstream from Buffalo Road, was dredged and straightened. The original outlet flowed into the stream and must have carried a fair volume of water driven by a velocity great enough to scour a good sized pool at the point of junction with the creek. This pool was used as a swimming location (1). The bottom was firm and the water approximately 4 feet deep and cold. Almost immediately after this outlet was dredged, the pool became unsuitable for swimming due to the deposition of muck and silt dislodged during the dredging. The wider outlet, now having less velocity, apparently could not keep the pool scoured out.

According to the Drain Commission's records, scattered work was done on the stream during 1941 and 1942. It is not known where this work was carried out.

A small one-quarter acre pond was dug within the last 15 years, 3,200 feet westerly from the mill race separation. It is fed by a diversion channel leading from the creek into the pond. The outlet goes back into the creek a short way down from the pond's inlet.

Only minor scattered cleaning work has occurred on the main stream since 1942.

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Approximately 11 years ago, a portion of the stream and a small pond was dredged out about one-quarter mile upstream from the Bakertown-Buchanan Road. According to the landowner (7), the dragline operator commented on the extremely thick layer of gravel occurring about 3 feet below the present muck substrate. There is insufficient data to definitely say that this gravel was the stream's original substrate and the 3 feet of muck is a result of recent erosional deposition.

In 1955 an agricultural venture was initiated on the muck lands between Curran and Buffalo Roads. This was an attempt to drain the land for use in a corn growing program by dredging a network of side ditches at angles to the main channel. The work between 1955 and 1960 accounted for approximately 5 lineal miles of ditches being dug. This program was a failure and abandoned by 1960. Some interest in a similar project has been revived by new landowners.

According to a local resident (8) who has fished this section of the stream for about 30 years, all the former hollowed out holes extending horizontally into the banks silted in. This area's bottom,banks, and pools are now so heavily silted over that navigating the stream by canoe, in many stretches, is very difficult or impossible. Its character is now that of a ditch more than a stream.

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Physical Characteristics

Objectives

A survey of the published literature revealed no previous work of an intensive nature having been completed for McCoy Creek. A prime objective then was a thorough analysis of the stream's physical characteristics.

The stream survey included: 1) ascertaining its length, average width and depth. 2) Sketching in detail the geographical course of the stream. 3) Mapping in all significant characteristics such as location and abundance of large beds of aquatic vegetation, and in the case of water cress, its water surface area coverage; location of bank cover and its degree of stream shading; logs, stream debris, undercut banks; pools--their approximate water surface area and depth, and types of substrate. 3) Randomly selecting stations throughout the stream's length.

The data to be collected at each station included: stream velocity, width, depth, and substrate types. Some of these stations were to be later used as collection points to obtain water for chemical analysis, bottom fauna samples and minnow samples.

Methods

The major portion of this survey extended from mid-October to the first of November, 1961. Certain phases continued into the summer of 1962.

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A convenient permanent station site was selected and a depth gauge installed in mid-stream. Readings were taken daily; the water depth recorded in tenths of a foot. Air and water temperature were recorded morning and late afternoon at the same location. Water temperatures were taken from the bank, with the thermometer held several inches below the surface of the water. Further details will be given and discussed under the topic of "temperatures."

For convenience of reference during the course of this dissertation, a discussion of the division of the stream into sections will be given at this point rather than later.

The stream was divided into sections based on visual and measured differences noted in the stream's character. Nine sections were defined. Table 1 gives their geographical points of demarcation, the length of each section and the dominant characteristics used to identify them. Their relationship to the stream is shown in Figure 2.

The survey was accomplished by wading the stream's length except for the following areas: upstream from the Buffalo Road bridge to the headwaters. A canoe was used where practical, and the remainder was surveyed by walking the stream's bank. Downstream from the Buchanan sewage plant to the St. Joseph reservoir the bank was traversed. In these areas stream depth was recorded only in larger pools.

Table 1

Geographical features demarcating stream sections

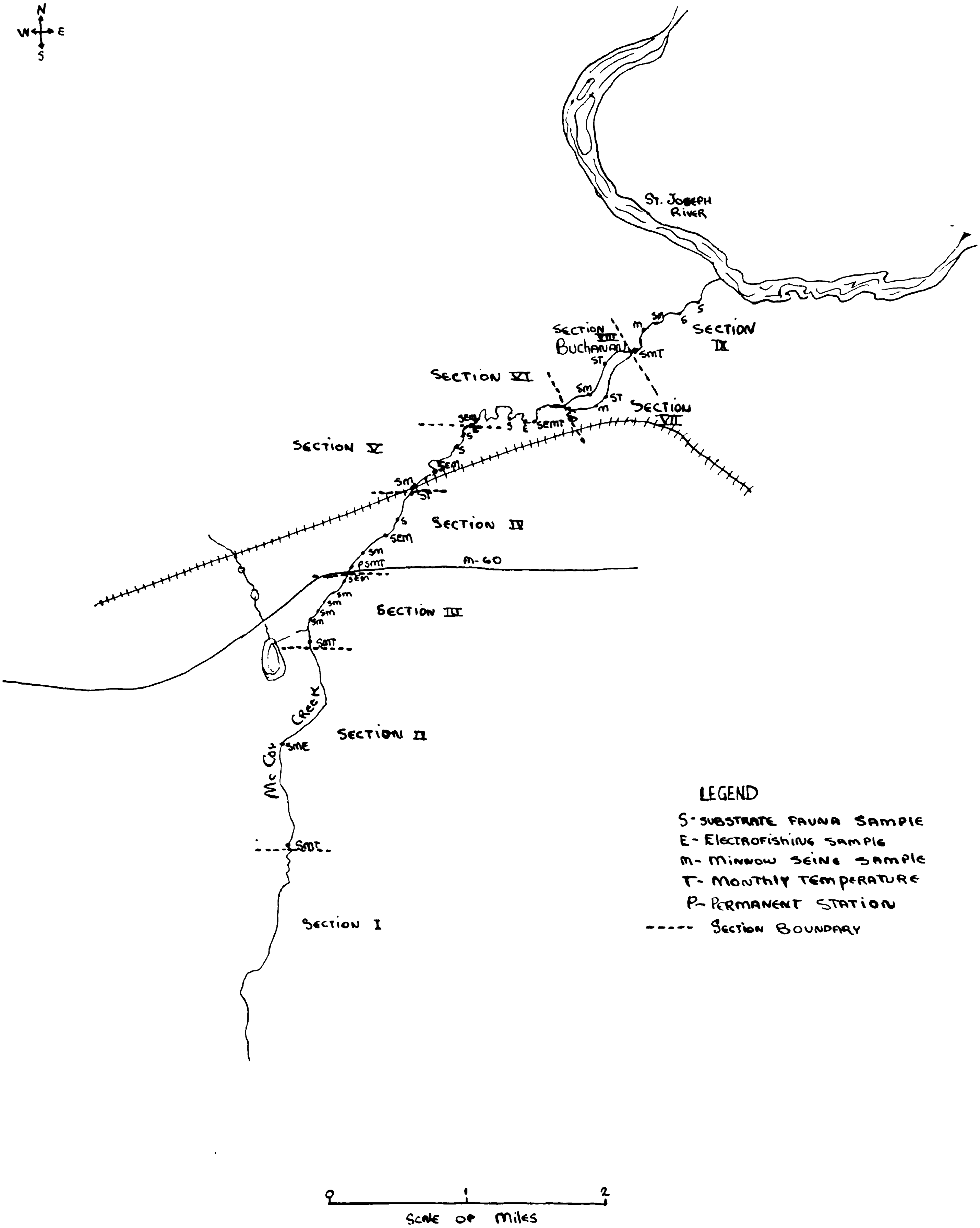
Section	Figure no.	Approximate length (in feet)	Geographical marks of delineation	Distinguishing characteristics
I	1	6100	From headwaters to Curran Road	Very narrow--brushy--winding partly in natural state
II	2	7900	Curran Road to Buffalo Road bridge	Resembles drainage ditch. Mucky bottom. Limited shrub and sedge cover
III	4	4300	Buffalo Road to M-60	Medium amount of water shading. Resembles a natural stream course
IV	5	4600	M-60 to Bakertown-Buchanan Road (at railroad grade)	Little water shading. Straight flow--few pools. Resembles drainage ditch. Dense growth of aquatic plants
V	7	6300	Buchanan-Bakertown Road to 200 feet upstream from Andrew's wooden bridge	Original winding stream. Large amount of water shading. Silt edges, narrow channel
VI	9	7800	Wooden bridge to Mill Race--main branch division	Original winding stream. Medium amount of water shading. Wide channel but narrow through water cress beds

Section	Figure	Approximate length	Geographical marks	Distinguishing characteristics

Section	Figure no.	Approximate length (in feet)	Geographical marks of delineation	Distinguishing characteristics
VII	11	4200	Main branch to Days Avenue	Original stream (?) Winding--medium amount of water shading in upper portion. Narrow width. Rapid flow through lower stretch
VIII	12	3000	Mill Race to Chippewa Avenue	Resembles narrow canal. Little water shading. Silt bottom
IX	13	6600	Portage Avenue to St. Joseph River	Although not too homogeneous physically most of section has been subject to industrial and/or sewage pollution. Steep gradient. Shading by canopy of large trees

Figure 2

Map of McCoy Creek showing sectional subdivision locations and various sample site locations


N
W
E
S
St. Joseph River
Section VIII
Buchanan
Section IX
Section VI
Section VII
Section V
Section IV
M-60
Section III
McCoy Creek
Section II
Section I
LEGEND
S - Substrate fauna sample
E - Electrofishing sample
m - Minnow seine sample
T - Monthly temperature
P - Permanent station
----- Section boundary
0
1
2
Scale of Miles

Figure

Figur

Plate I

Figure 1. Section I. Natural portion of creek upstream from Curran Road.

Figure 2. Curran Road looking east. Hump in road indicates presence of underground springs.

Figure

Figure 4

Plate II

Figure 3. Section II. Dredged portion of creek downstream from Curran Road.

Figure 4. Section III. Upstream view near Station 8.

Figure 5

Figure 6

Plate III

Figure 5. Section IV. Looking downstream towards permanent station.

Figure 6. Section IV. End of "Bakertown Drain." Downstream view from Station 13.

Figure 7.

Figure 8.

Plate IV

Figure 7. Section V. Shows stream emerging from under dense shrubbery.

Figure 8. Section V. One of the more "open" portions of this section.

Figure 9. Se
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Plate V

Figure 9. Section VI. Looking upstream toward Station 17.

Figure 10. Section VI. Looking downstream near Station 17. Note dense mats of water cress. Dotted lines indicate approximate extent of ice coverage.

Figure

Figure

Plate VI

Figure 11. Section VII. View downstream near Station 19. Dotted lines indicate approximate extent of ice coverage.

Figure 12. Mill Race--Section VIII. This section completely frozen over during part of winter.

Figure 13

Figure 14.

Plate VII

JAN 1963

Figure 13. Section IX. Upstream view through Clark's property.

JAN 1963

Figure 14. Section IX. Upstream view through Clark's property.

Figure 15.

Plate VIII

JAN 1963

Figure 15. Section IX. Downstream view through Clark's property. Dotted lines indicate approximate extent of ice coverage.

A description of the methods used to measure the stream's physical characteristics, and discussions of each, follows.

Length

See footnote 4, page 8.

Width

This measurement was made at the selected stations only from solid bank to bank. Readings were recorded to the nearest one-half foot. Beds of water cress were included as part of the stream since they were growing in the water. A total of 27 measurements were taken. The average widths per section is summarized in Table 2.

Results and Discussion.--Widths in Sections II, III, and IV show the results of earlier dredgings. They are much greater than would normally be expected compared to relative widths in adjoining upstream and downstream sections. It appears that this stream width change has decreased the stream's velocity from that which would have occurred had it not been widened.

Depth

Measurements were taken frequently while wading the stream in:

a) the main channel and/or the center of the stream.

b) all pools.

c) s

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Table 2

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The depth was also recorded at each station for the stream center and at each edge.

All measurements were made with a yardstick, to the nearest inch. In the case of stream edges, only the clear water flowing over the semi-solid silt was measured. In those sections not waded, depth was recorded only at the selected stations.

Results and Discussion.--Analysis of the data in Table 2 shows a noticeable difference in depth in section V compared to other adjoining sections. The data suggests that the bank cover has acted as a stabilizing agent. The stream basin in this section is therefore subject to greater scouring action (in the main channel) than adjacent sections.

Field data show this data section to have the greatest depth variation between the main channel and the edges. The channel was approximately 31 to 34 inches throughout much of its length but usually only 3-4 feet wide. The remainder was quite heavily silted bringing the depth average down considerably. How much of this silt was present prior to "recent" dredging activities can only be guessed.[6]

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5 Edge defined here to mean the approximate mid-point between center and bank.

6 The stream was randomly divided into units; one to many units composed a section. Within each unit

Table 2

Summarization of certain physical characteristics of McCoy Creek, by section

Sections	Section length feet	Average width feet	Average depth inches	Substrata--percent composition average/section					
				Silt %	Sand-silt %	Sand %	Sand and fine gravel %	Medium gravel %	Small rocks %
I	6100	2.5	5	20	80	--	--	--	--
II	7900	10.0	10	78	14	--	8	--	--
III	4300	15.0	15	27	62	--	5	7	--
IV	4600	18.0	14	15	44	18	19	4	--
V	6300	13.0	24	73	4	T	22	T	T
VI	7800	17.5	19	35	14	6	23	18	4
VII	4200	14.0	11	23	--	7	40	18	13
VIII	3000	14.5	13	48	30	--	22	--	--
IX	6600	17.5	21	10	35	--	25	5	25
Total	50,800			33	32	4	18	8	5

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Substrata

Results and Discussion.--The bottom character was determined visually and by the degree of abrasiveness felt by scouring the bottom with the foot. The types mapped were: silt; sand and silt mixture (usually stratified with the sand overlaying the silt); sand--usually some mineral silt intermingled; sand--gravel mixture--usually fine gravel but some medium-sized gravel intermingled--always a large proportion of sand; medium-sized gravel--mostly occurring with an admixture of sand; small rocks--normally little sand intermixed.

Due to the turbidity of the water below the Buchanan sewage plant, the bottom types were not mapped except at three points.

Table 2 shows that silt composes 33 percent of the total different types of substrata (25 percent loose silt[7]). A mixture of sand-silt makes up 32 percent, sand 4 percent, a sand-gravel mixture 18 percent, medium-sized gravel 8 percent and small rocks 5 percent.

---

certain physical characteristics (e.g., water types, water cress beds, etc.) were mapped as to their approximate area of water coverage. This was based on their visually estimated width from the bank towards the stream's center, times the lineal distance they occurred in a stream's unit. Areas of physical characteristics per unit were combined to compute their percent occurrence for a total stream section.

[7]Loose silt refers to silt not forming soil media for watercress beds.

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Velocity

Current was measured in midstream at 27 stations using a light plastic float attached to a 5 foot length of nylon line, .01 in diameter. The length of time to extend the line's full 5 feet was measured by stopwatch. A series of 3 trials were made and the results averaged. The surface velocity was computed by dividing the average time in seconds into the distance traversed by the float. Table 3 summarizes the data for the different sections.

Results and Discussion.--Only two sections had a moderately swift (approximately 1-1.5 feet per second) average velocity. A two foot per second average velocity for Section IX could be considered swift water. Three sections (I, III, IV) were moderately slow and two (II and III) averaged slow water. The headwater section was not checked. Much of the dense shrub cover in Section V lies on the water's surface along the stream's sides. This causes a current speed-up by channeling most of the water down the center of the stream.

Volume

This was determined, using the Robins and Crawford (1954) method, as outlined by Lagler (1956). This data was collected at 7 locations near the geographical terminal point of the sections designated in Table 4.

Table 3

Velocity of water flow

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Flow in CFS	Sections I	II	III	IV	V	VI	VII	VIII	IX
	Average velocity--feet/second								
Less than .5		X						X	
.5 - .9	X		X	X					
1 - 1.4					X		X		
1.5 - 1.9						X			
2+									X

Table 4

Volume of water flow

By section, in cubic feet/second

CFS	Section I	II	III	IV	V	VII	VII	VIII	IX
	Not measured	Not measured	3.3	5.0	7.3	11.0	6.0	4.4	17.0

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Gradient

A topographical map (U. S. Geological Survey) with a contour interval of 20 feet was used to determine the gradient of the stream. It should be noted that the rate of stream fall is not necessarily uniform between mapped contour intervals. This is especially true for Section VII and the lower part of Section VI.

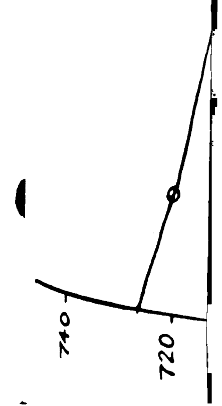
Results and Discussion.--A longitudinal section of the stream is pictured in Figure 3. This illustrates that the gradient for the upper 84 percent of the stream's course is quite uniform, averaging 1.2 feet of fall per one thousand feet of stream length. The average gradient increases sharply for the remaining 16 percent of the stream's course; the gradient being 5.9 feet per one thousand.

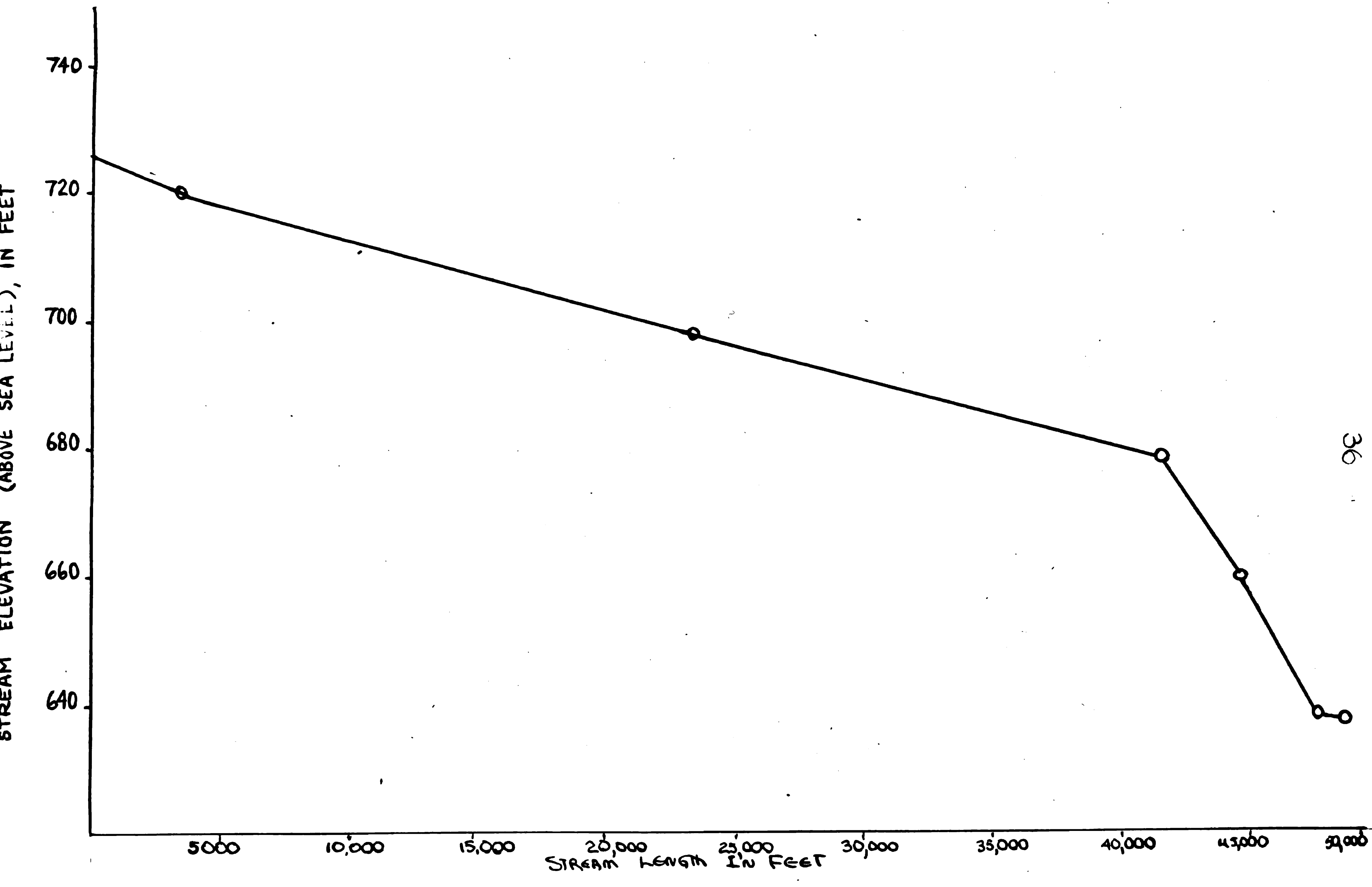
Allen's (1951) reference to Huet's (1946) work stated that in Belgium, waters with a gradient greater than 3 feet per one thousand are predominantly occupied by trout. Grayling and chub also occur in gradients less than 6.5 feet per one thousand. He further mentions trout being a dominant species in streams having gradients as low as 1.5 feet per one thousand. Between this and a .75 feet per one thousand trout occur in only small numbers.

Allen (1951) summarizing Hobbs and Huet's work reports that with increasing volume a decreasing gradient is required to produce a given velocity. It is the velocity

Figure 3

Longitudinal profile of McCoy Creek




STREAM ELEVATION (ABOVE SEA LEVEL), IN FEET
740
720
700
680
660
640
5000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000
STREAM LENGTH IN FEET

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produced by gradient or a gradient-volume relationship that is the important factor.

Analyzing McCoy Creek first on gradient alone, it appears as though the last 16 percent (plus one-half of Section VII) of the stream shows proper gradient (and therefore velocity) specifically suited for trout adaptation. The upper reaches appear suitable for trout but the environment will hold a greater variety and abundance of fish competitors than one of higher gradients.

No known technique is available for reconciling volume and gradient data so as to arrive at a common velocity factor as an end result.

According to Huet (1959) European's stream profile and a cross section of their valley can be used to delineate biological zones.

The cross section of the McCoy Creek valley can be divided into four zones. The first zone extended from the headwaters, downstream approximately 29,000 feet (60 percent of the stream's length). It is a relatively flat mile-wide valley, part of a prairie soil area of northern Indiana. Approximately one-half mile to the east of the stream lies a series of forested ridges 100-160 feet above the stream plain. These hills are parallel to the general direction of stream flow towards the St. Joseph River [type 3].

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The second zone extends approximately 12,000 feet (25 percent of the stream's length). Closing in of the hills to the southeast and formation of hills on the northwest side reduces the valley to only one-fourth mile in width. The current in this stretch increases noticeably [type 2]. In the third zone, the stream is enclosed by very steep banks 10-20 feet high [type 1A].

The last zone winds through a narrow (300 feet wide) valley completely surrounded by the now converged bordering hills [type 1C].

Table 5 summarizes the survey's results obtained for the previously discussed topics.

The anomaly here is that the upper reaches are quieter waters than the lower stretches. This appears the reverse of conditions for most trout streams. Unfortunately, Section IX, which assays physically to be more typically trout water, is the section which is frequently exposed to treated sewage and industrial discharges.

Stream Cover

Permanent cover was considered to be primarily beds of aquatic vegetation and bank shrubs.

Water cress (Nasturtium officinale) was the predominant aquatic plant. During the survey all cress beds were mapped. Their stream surface area coverage was estimated by pacing their length and estimating their

Table 5

Stream gradient and cross section types

Gradient stream fa in thousa of feet
Valley ty cross section

	Section								
	I	II	III	IV	V	VI	VII	VIII	IX
Gradient stream fall in thousands of feet	1.4	1.0	1.0	1.0	1.0	1.1	1.1	1.1	5.9
Valley type cross section		Type 3				Type 2			Type 1A & 1C

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approximate width. Their coverage in percent of each section was noted.

Other aquatic vegetation which afforded cover in the order of their observed abundance and frequency: Vallisineria americana; Potamogeton pusillus; Anacharis canadensis: Potamogeton spp.; Nymphea odorata; Podostementum spp., and Chara.

Location and abundance of these vegetation beds were marked. Criterion of abundance was based on the general method in part from Lagler (1956); abundant-growing in a dense distribution on the stream's substrate, common-growing in scattered dense patches in the stream; sparse-seldom observed in a stretch of stream.

Bank shrubs extending over the stream which would offer shade were located on the survey map. Their extent of stream shading, in percent, for each section was estimated by previously outlined methods.

Temporary cover included brush piles, debris, undercut banks and logs. All such types of cover were mapped as to location.

These results are summarized in Table 6.

Results and Discussion.--Only in Sections I and V were there high percentages of shrub shading (vegetation in leaf). These two sections represented the "original stream." Most of Section III was well lined with trees providing "unmeasured" shading.

Table 6

Percentage of cover based on total stream length and cover

Sections	Cover					
	Permanent			Non-permanent		
	At peak of vegetation growth			Number		
	Bank shrubs %	Water cress %	Aquatic vegetation beds	Brush	Logs	Undercut banks

Sections	Cover					
	Permanent			Non-permanent		
	At peak of vegetation growth			Number		
	Bank shrubs %	Water cress %	Aquatic vegetation beds %	Brush %	Logs %	Undercut banks %
I	75	10	Not tallied	Not tallied		
II	20	20	"	"		
III	35	8	Common throughout	7	14	5 small
IV	6	22	Abundant	3	9	None
V	90	Less than 5%	Sparse	*	2	4 medium
VI	30	40	Common in some areas	6	15	3
VII	25	16	Sparse	--	3	4
VIII	5	5	Common	--	1	--
IX	7	Less than 5%	Not observable	1	11	4

* Limbs of shrubs interlacing on water surface; has similar effect as surface debris.

** Heavily wooded bottom land providing much shading, not measured.

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The cress and shrubs in Sections I, V and VI cover over 70 percent of the water surface.

Much of Section VI flowing through Buchanan is kept pruned. Some of the banks along its course are lined with 3-6 foot high wooden and concrete retaining walls which inhibit shrub growth. Section VIII is almost devoid of bank cover. Although Section IX is a natural stream section, the bank shrubs on Clark's property are kept pruned. Below the sewage plant, large trees form a dense canopy excluding much light and light-requiring shrubs.

The aquatic vegetation beds in Section IV were commonly distributed at the time of the initial stream survey (November). However luxuriant growths covered the stream's substrate during the months from May through mid-September. Sections III, VI and VIII had sparsely distributed beds of vegetation for 3 seasons but had common distribution throughout the stream for the period from May through mid-September. In the rapid water portions of Section VI, little vegetative growth was noted during any season.

Temporary cover occurred sporadically throughout the stream in small amounts. Section III provided this type of cover most frequently.

The importance of cover to trout is well understood. Boussu (1954) found that removing brush cover along a small st

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small stream resulted in a decrease in the numbers of fish, even though the fish in the control section increased in numbers. Similar results were observed with removal of under-cut banks. In the same study, aquatic vegetation (mainly water cress) was cited to be primarily of value to fingerlings. This cover had no apparent effect on the abundance of legal-sized fish: bank cover's effect on temperature will be discussed in another section.

Water Types

Variations in the character of the water were tabulated. Descriptions of these types are in terms commonly used by fishermen and biologists (in part, Allen, 1956).

Pools--water depth at least 20 inches and 8-10 inches deeper than that of the main channel. Current sometimes turbulent, usually slight.

Flats--Generally smooth flowing water of moderate to slight current--less depth than pools.

Run--Moderate to rapid current and fairly deep, flow usually turbulent. Uncluttered water area usually of less than average width.

Riffles--Shallow water with a rapid current and usually a broken flow.

Cascades--Water in which a steep gradient combined with a bed of stones or rocks produces a very rapid, broken flow, often with white water.

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These water types were mapped during part of the regular survey.

Table 7 summarizes the data by sections.

Results and Discussion.--In the dredged Sections (II, III, IV, VIII) flats predominate; riffles are very infrequent as are runs (except for a small area of Section III).

The abundance of runs in Section V has already been described on page 31.

The flats in Section IX are a result of relatively deep, fairly straight stretches. The lack of stream narrowing obstructions and relatively uniform width also help account for this condition in a section with a high gradient factor.

The data suggests a correlation between water types and substrata. The sections with the greatest percentage of substrate in medium gravel and rocks have the greatest percentage of riffles (Sections VI, VII, IX). Those sections with the highest percentage of silt and sand, were composed primarily of the "flat" water type (Sections II, III, IV, VIII). Section V seems to be an exception. This is due to the large areas of relatively still water under the shrubs which allow accumulation of silt. This is comparable to the semi-solid build-up of silt in the cress beds. In the active stream flow channel, little silt is present.

Table 7

Water types (in percent), based on total stream length and area

Sections
I
II
III
IV
V
VI
VII
VIII
IX
Average percent total s

Sections	Water types			
	Flats %	Runs %	Riffles %	Cascades %
I	Not completely recorded			
II	100	--	--	--
III	82	15	3	--
IV	93	6	1	--
V	28	72	--	--
VI	27	56	17	--
VII	10	35	55	--
VIII	95	3	2	--
IX	54	10	24	12
Average in percent for total stream	51	39	10	.5

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Considering the entire stream, the data indicated flats are the predominant water type, followed by runs; riffles being the least frequent.

Pools

Data obtained for pools were mapped according to location, depth and approximate water surface area coverage. This was accomplished by measuring the various depths throughout the pool and their approximate maximum width, surface shape, and length. Their area was then computed. The total number of pools per section was also tabulated as well as the amount of their overhead cover. The instrument of pool formation was noted if observable.

Results and Discussion.--Analysis of the summarized data in Tables 8 and 9 show a low density of pools per unit of stream length and area. Section V contains the greatest number of pools (30). This section had an approximate pool-stream surface area ratio of 1:27. The average individual pool surface area was 113 square feet.

In an evaluation study of stream improvement devices Shetter et al. (1946) lists statistics from a 1600 foot section of "improved" stream. The 29 pools had a total area of 5,720 square feet and an average individual pool surface area of 238 square feet. Its pool-stream area ratio was 1:5.2. Better fish yields and increased brook trout numbers were attributable to a greater survival of

Table 8

Pool survey indicating their abundance, probable mode of formation, and relative abundance of shading.

Sections	Number of pools	Pools with overhead cover %	Pool formation			
			Shrubs %	Curve %	Lower debris %	Other
I				Not tabulated		
II				Not tabulated		
III	20	98	30	10	60	--
IV	9	85	45	22	23	9
V	30	88	22	60	11	7
VI	23	72	16	56	19	9
VII	4	75	25	--	50	25
VIII	0			None		
IX	15	7	--	55	45	--

Table 9

Morphometric pool data

Sectio
I
II
III
IV
V
VI
VII
VIII
IX

Sections	Average depth in inches	Approximate pool surface area in sq. ft.	Pool/stream area ratio
I		Not tabulated	
II		Not tabulated	
III	26	1,000	1:65
IV	22	400	1:207
V	34	3,400	1:24
VI	32	1,800	1:75
VII	24	130	1:452
VIII		None	
IX	38	1,800	1:64

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young trout. These results were apparently from quantitative and qualitative improvements.

The remainder of the stream had few pools and, except for Sections VI and IX, they were generally smaller in depth and area.

These results could be expected since the "flat" water type and low stream velocity are not conducive to pool formation.

Temperatures

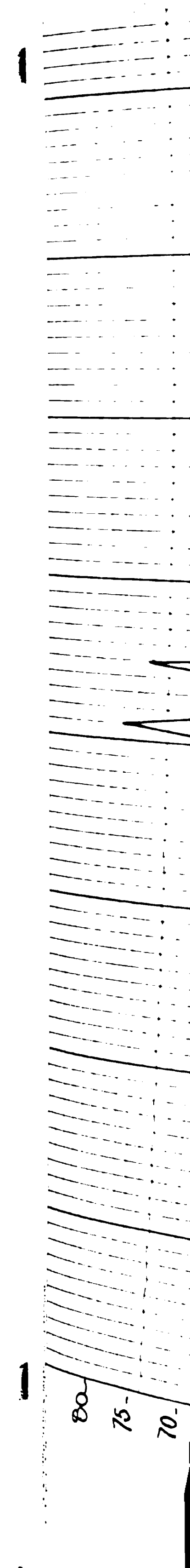
Temperatures were recorded daily and monthly at the permanent station and monthly at six other stations. Daily readings were recorded at approximately 7-8:00 A.M. and 5-6:00 P.M. All readings were made with a glass thermometer, mercury type, graduated in degrees F° (see page 15). Figures 4 through 12 present the daily changes recorded for the months of October, 1961 through part of June, 1962. These temperatures do not necessarily denote daily maximum or minimum temperatures. Since water temperatures lag somewhat behind that of air, they would more nearly indicate maximum and minimum water temperatures. No adjustment was made for seasonal changes in the length of day and its effect on recordings for these specific times.

Monthly temperature data were collected during the latter one-third of the month in the afternoon, at the

Figure 4

Daily water and air temperatures for October, 1961

permanent station



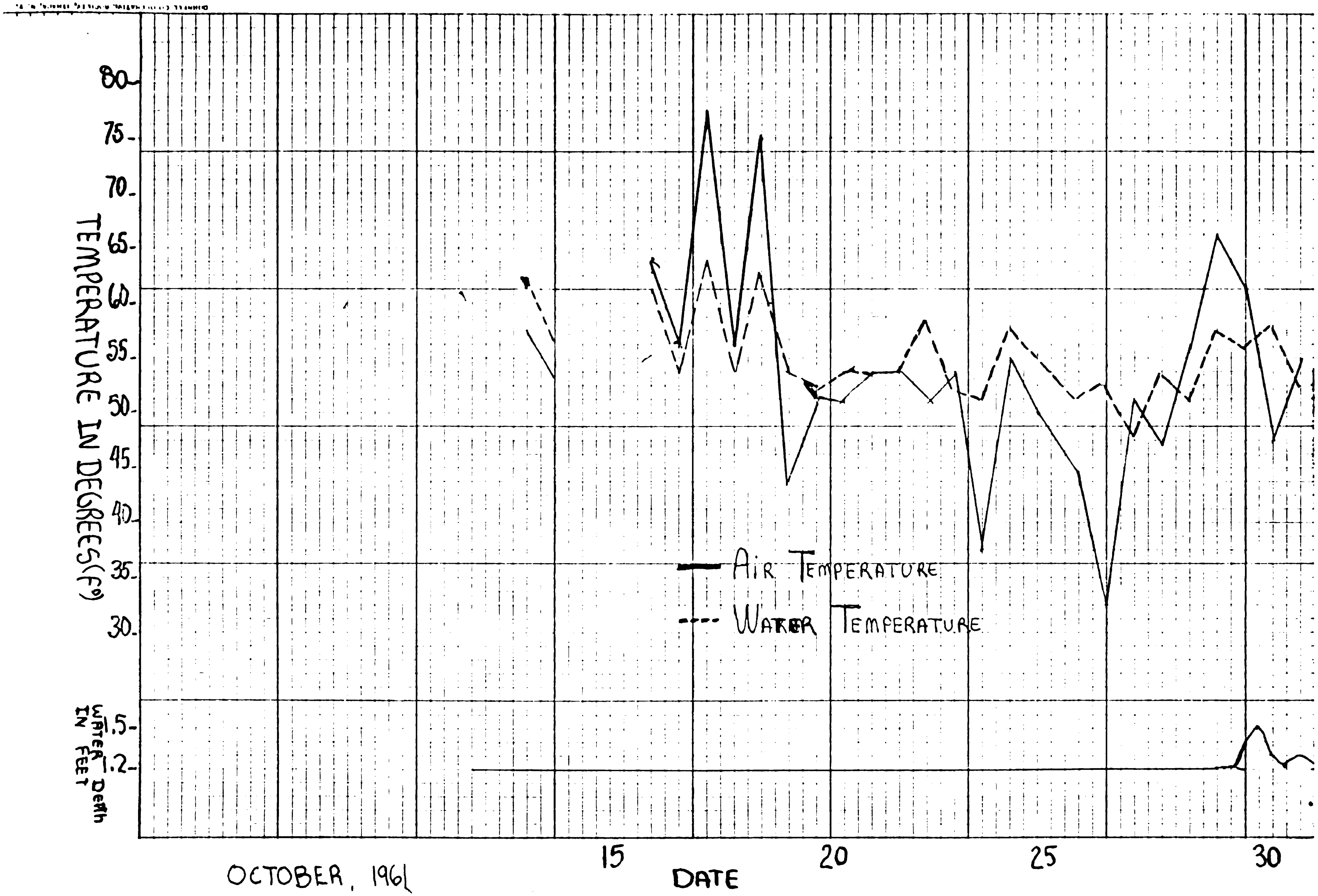

80
75
70
65
60
55
50
45
40
35
30
TEMPERATURE IN DEGREES (F°)
1.5
1.2
WATER DEPTH IN FEET
AIR TEMPERATURE
WATER TEMPERATURE
15
20
25
30
DATE
OCTOBER, 1961

Figure 5

Daily water and air temperatures for November, 1961

permanent station

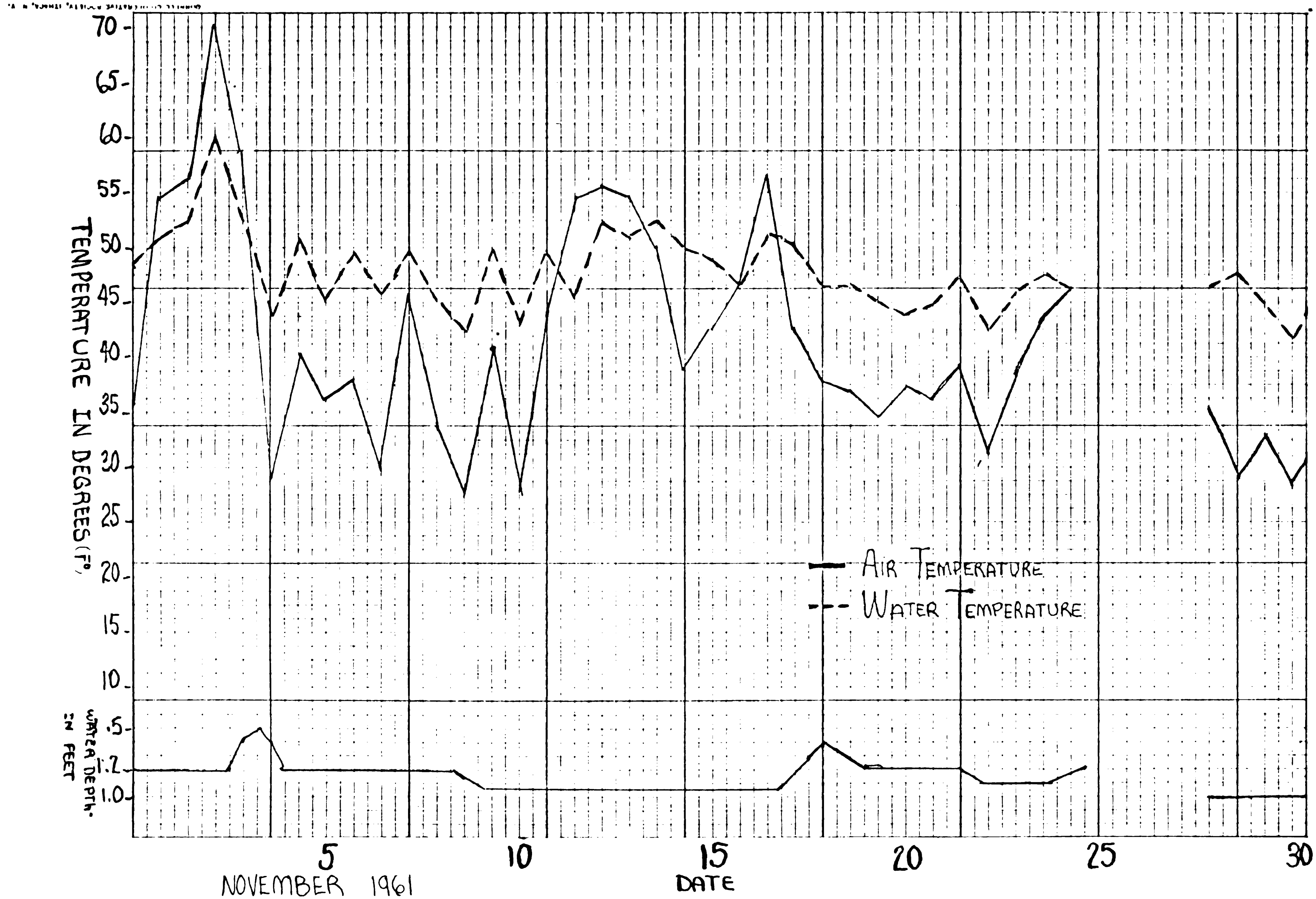
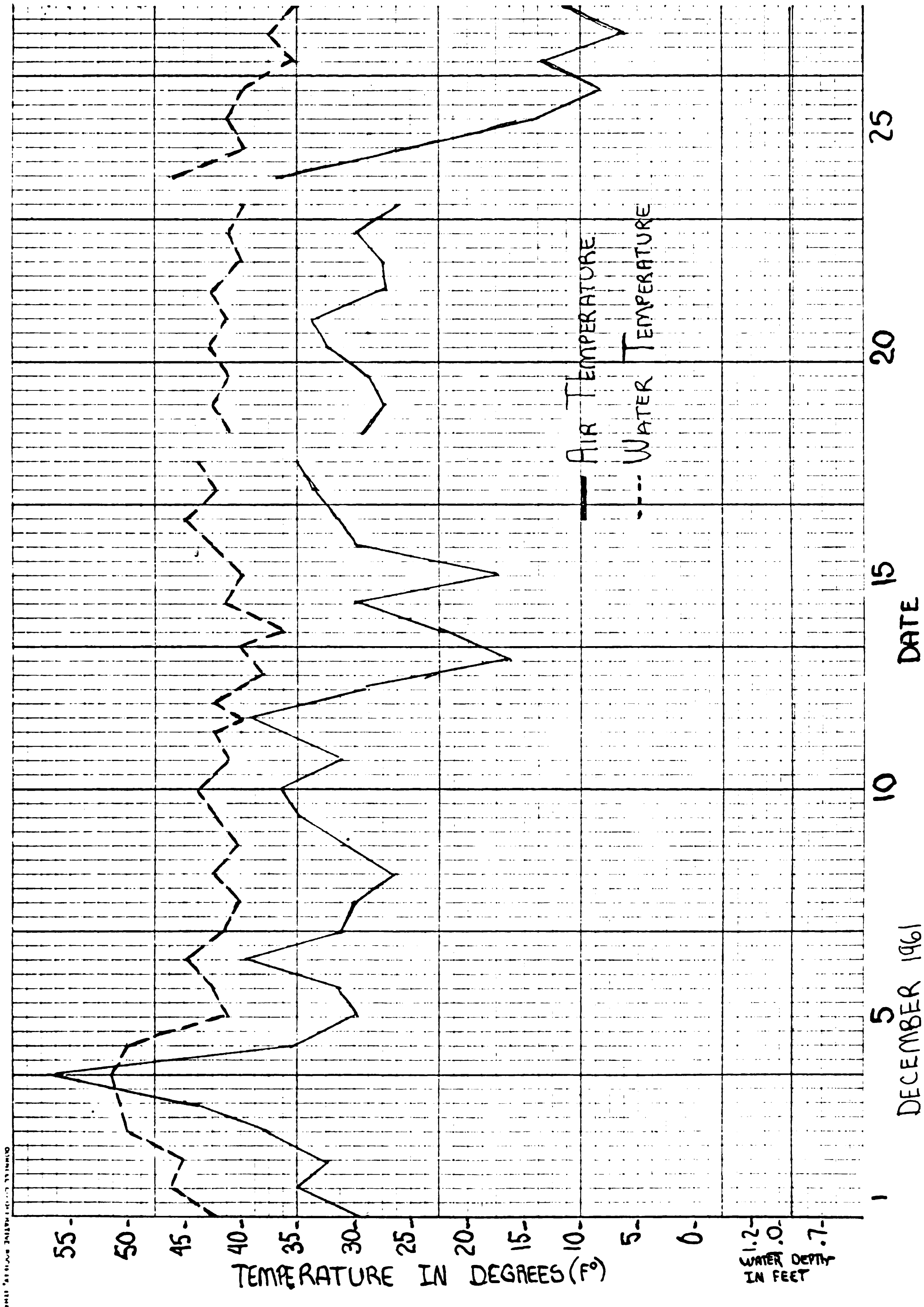

TEMPERATURE IN DEGREES (F°)
70
65
60
55
50
45
40
35
30
25
20
15
10
.5
1.2
1.0
WATER DEPTH IN FEET
AIR TEMPERATURE
WATER TEMPERATURE
5
10
15
20
25
30
NOVEMBER 1961
DATE

Figure 6

Daily water and air temperatures for December, 1961

permanent station

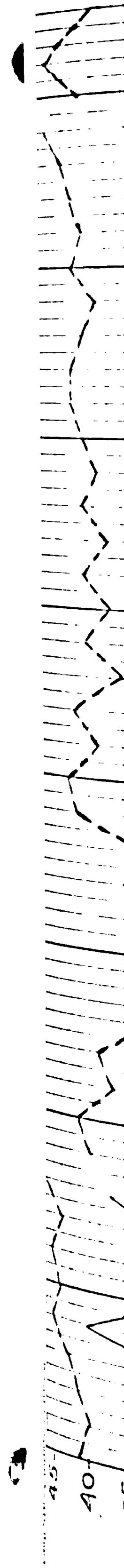


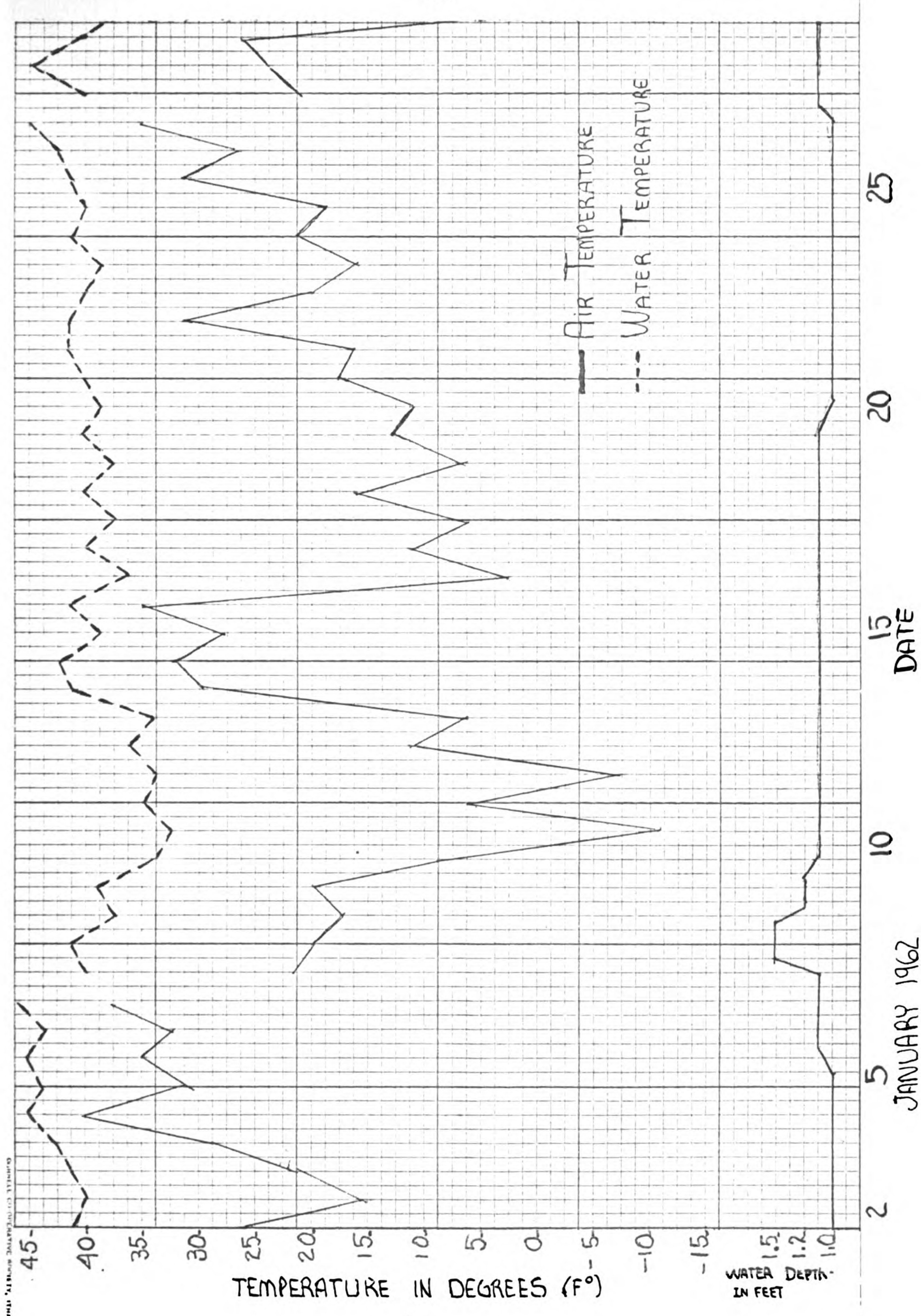
55-
50-
45-
40-
35-
30-
25-
20-
15-
10-
5-
0-
1.2-
1.0-
.7-
TEMPERATURE IN DEGREES (F°)
WATER DEPTH IN FEET
1
5
10
15
20
25
DECEMBER 1961
DATE
AIR TEMPERATURE
WATER TEMPERATURE

Figure 7

Daily water and air temperatures for January, 1962

permanent station





Air Temperature
Water Temperature
45-
40-
35-
30-
25-
20-
15-
10-
5-
0
-5
-10
-15
1.5
1.2
1.0
TEMPERATURE IN DEGREES (F°)
WATER DEPTH IN FEET
2
5
10
15
20
25
DATE
JANUARY 1962

Figure 8

Daily water and air temperatures for February, 1962

permanent station

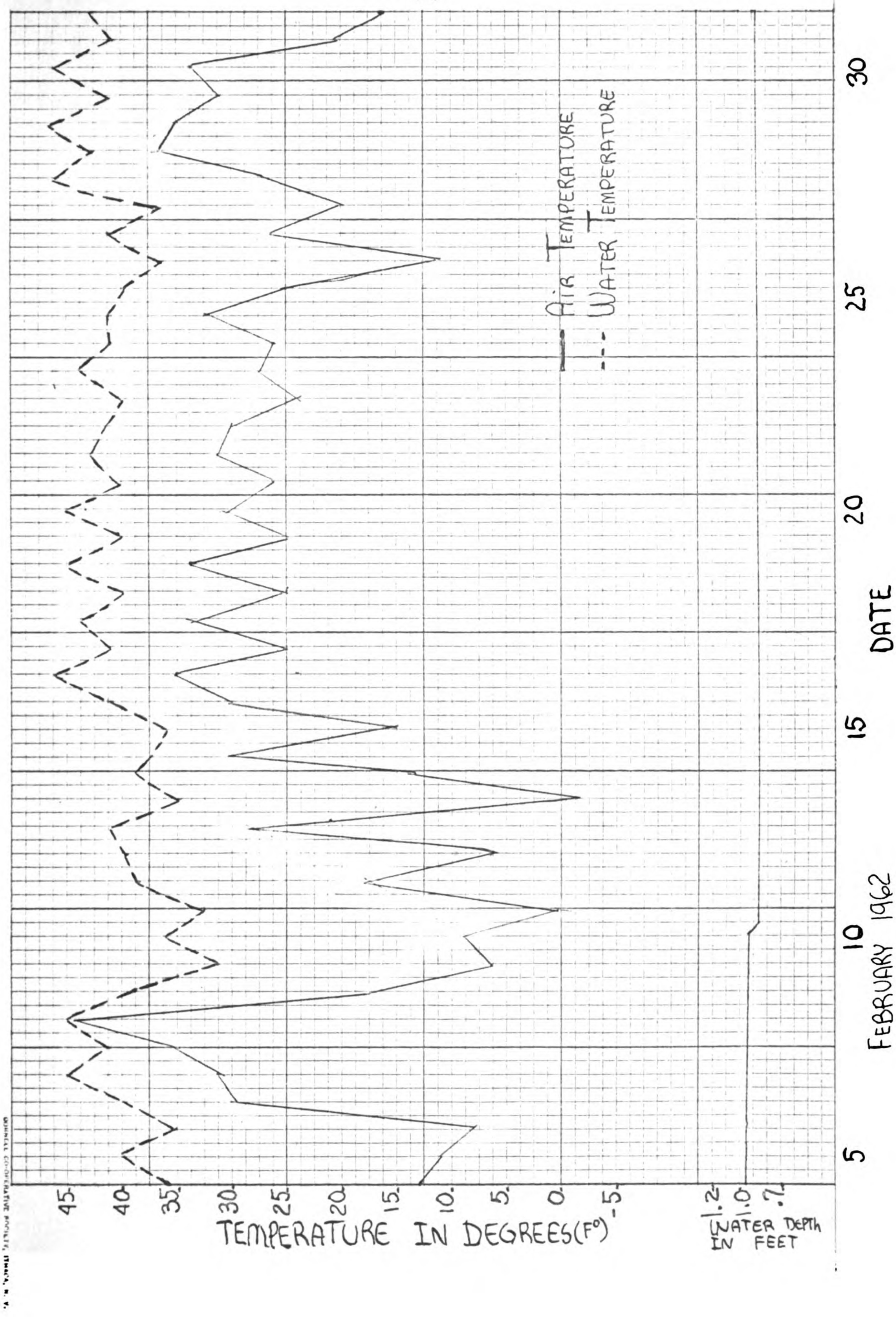

Air Temperature
Water Temperature
DATE
FEBRUARY 1962
5
10
15
20
25
30
45
40
35
30
25
20
15
10
5
0
-5
TEMPERATURE IN DEGREES(F°)
1.2
1.0
.7
WATER DEPTH IN FEET

Figure 9

Daily water and air temperatures for March, 1962
permanent station

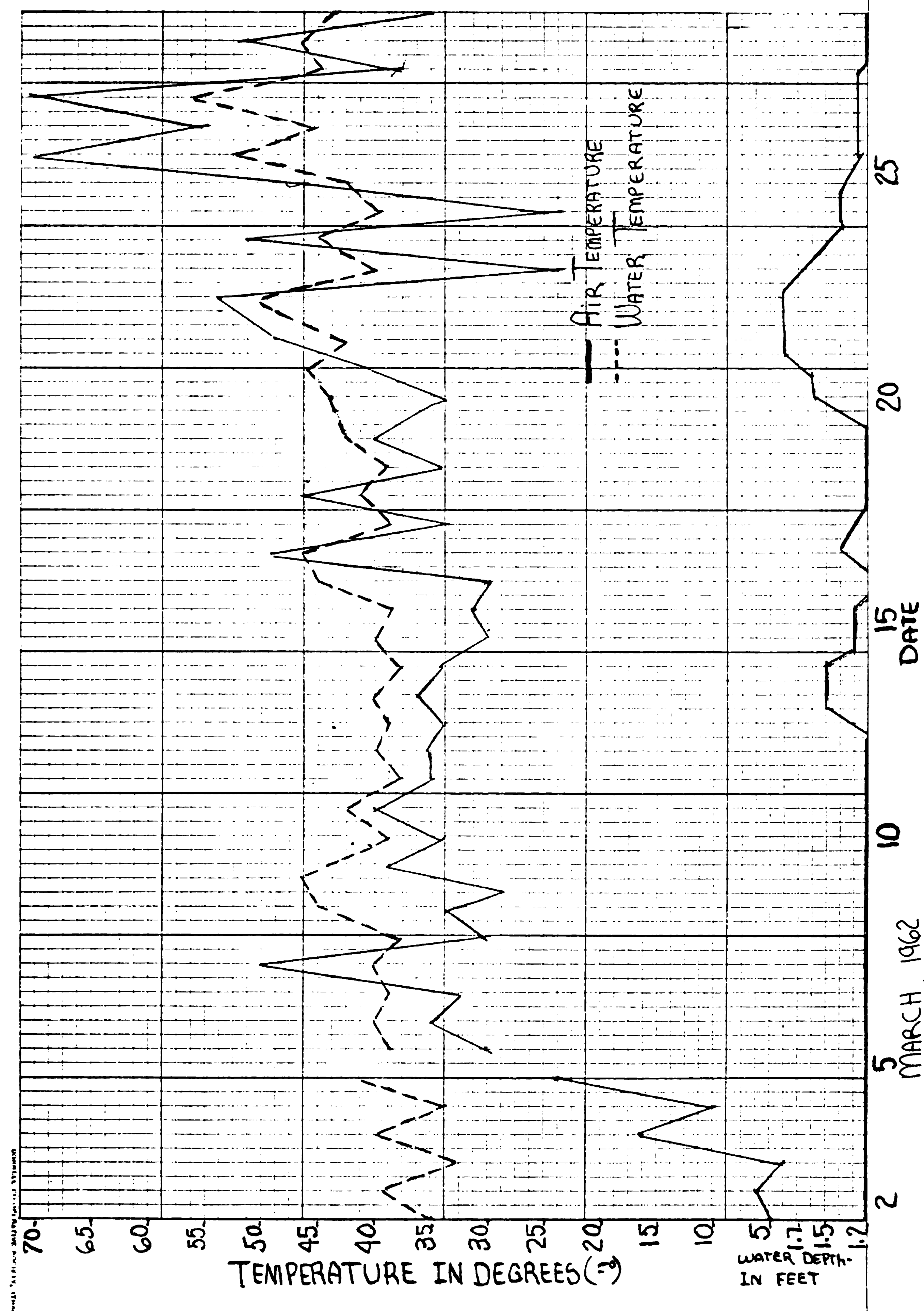

AIR TEMPERATURE
WATER TEMPERATURE
2
5
MARCH 1962
10
15
DATE
20
25
70-
65
60
55
50
45
40
35
30
25
20
15
10
5
1.7
1.5
1.2
TEMPERATURE IN DEGREES
WATER DEPTH IN FEET

Figure 10

Daily water and air temperatures for April, 1962
permanent station

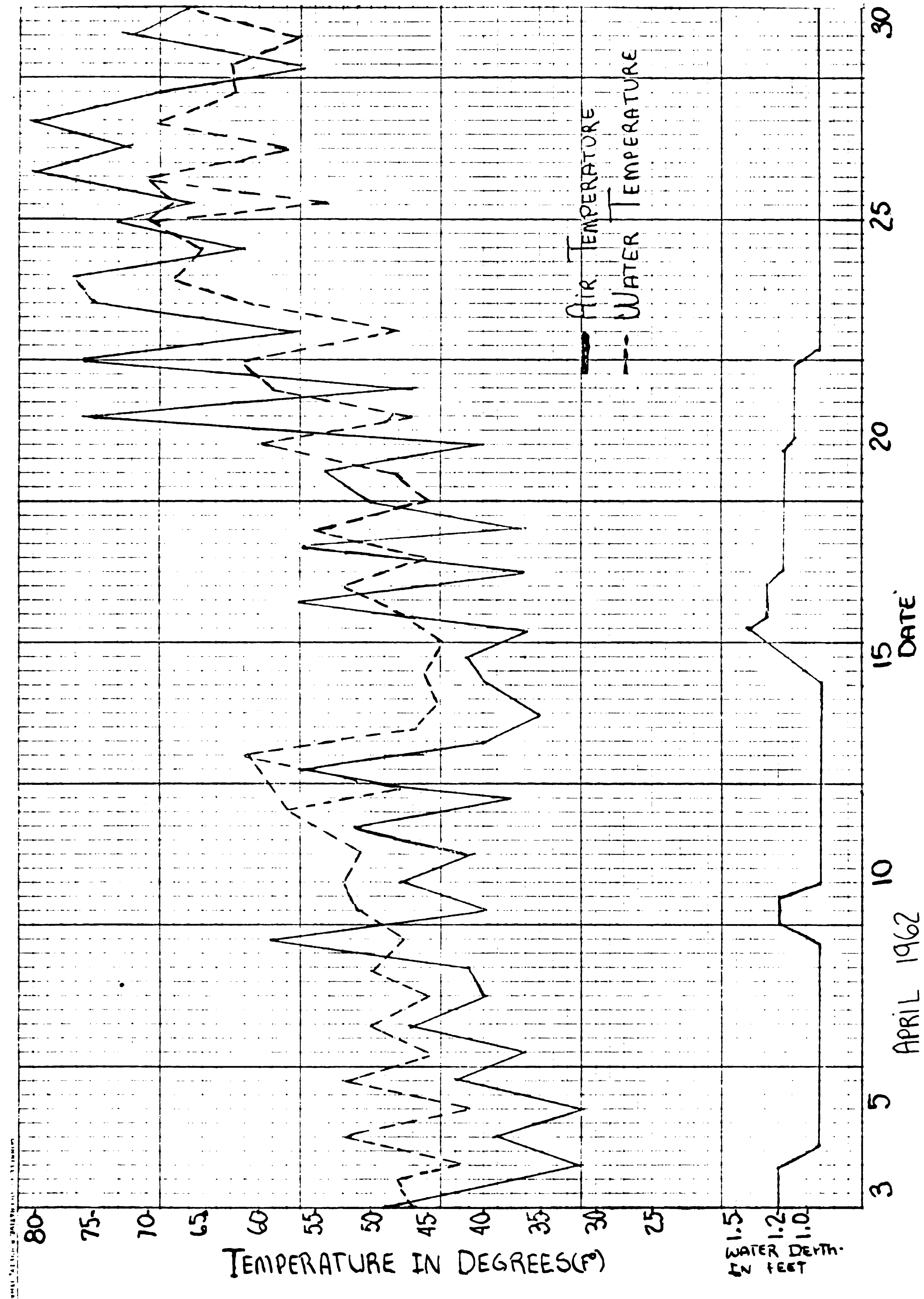
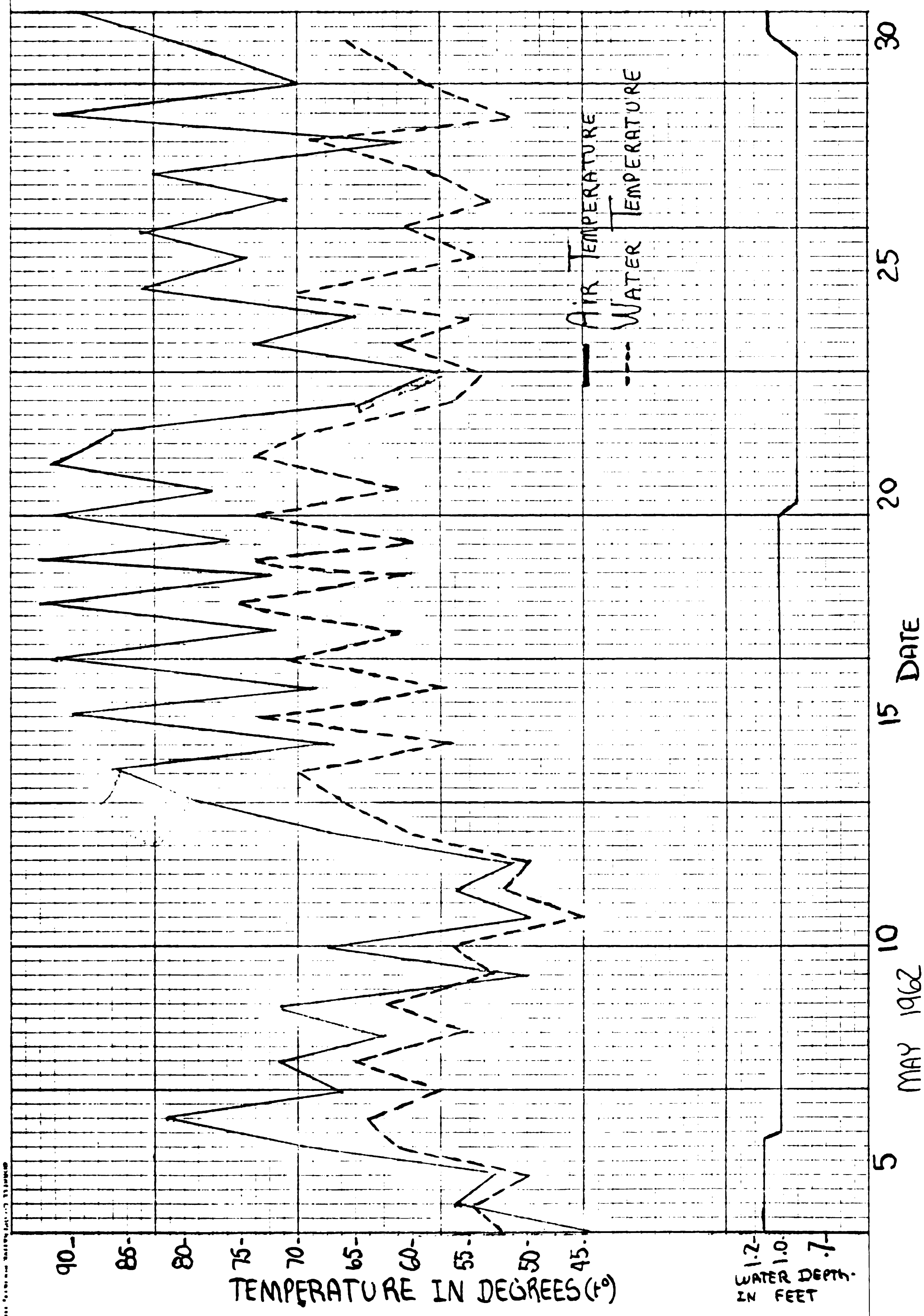

Air Temperature
Water Temperature
Date
April 1962
Temperature in Degrees (F°)
Water Depth in Feet

Figure 11

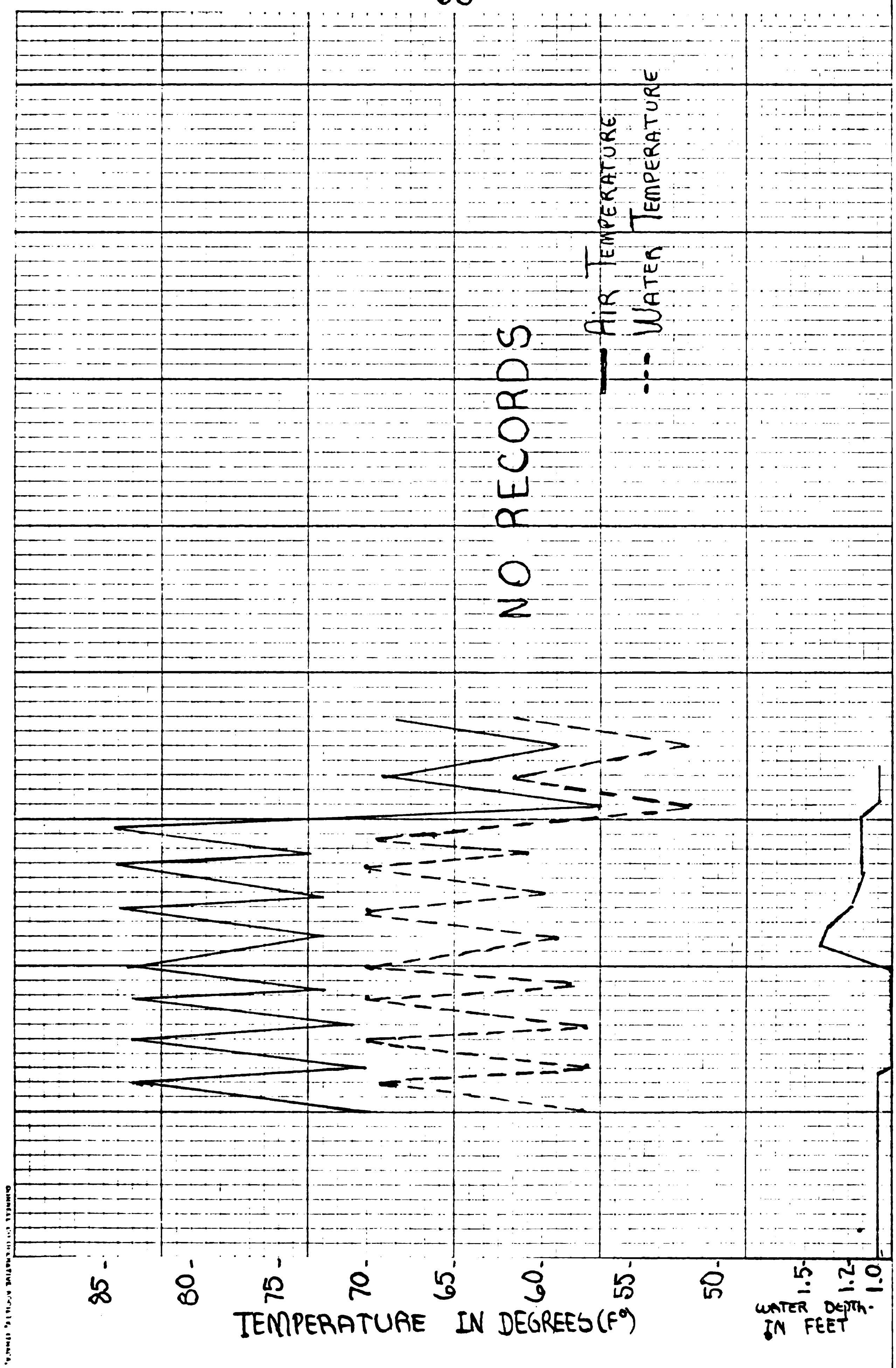
Daily water and air temperatures for May, 1962
permanent station



AIR TEMPERATURE
WATER TEMPERATURE
90
85
80
75
70
65
60
55
50
45
TEMPERATURE IN DEGREES (F°)
1.2
1.0
.7
WATER DEPTH IN FEET
5
10
15
20
25
30
DATE
MAY 1962

Figure 12

Daily water and air temperatures for June, 1962 permanent station


NO RECORDS
Air Temperature
Water Temperature
DATE
5
10
15
June 1962
85
80
75
70
65
60
55
50
1.5
1.2
1.0
TEMPERATURE IN DEGREES (F°)
WATER DEPTH IN FEET

stations designated in Fig. 2. If possible, days were selected on which the air temperature was above or below normal. It was postulated that the moderating effect of ground water could then be detected more readily. Figure 13 illustrates graphically the data collected monthly for the 7 stations.

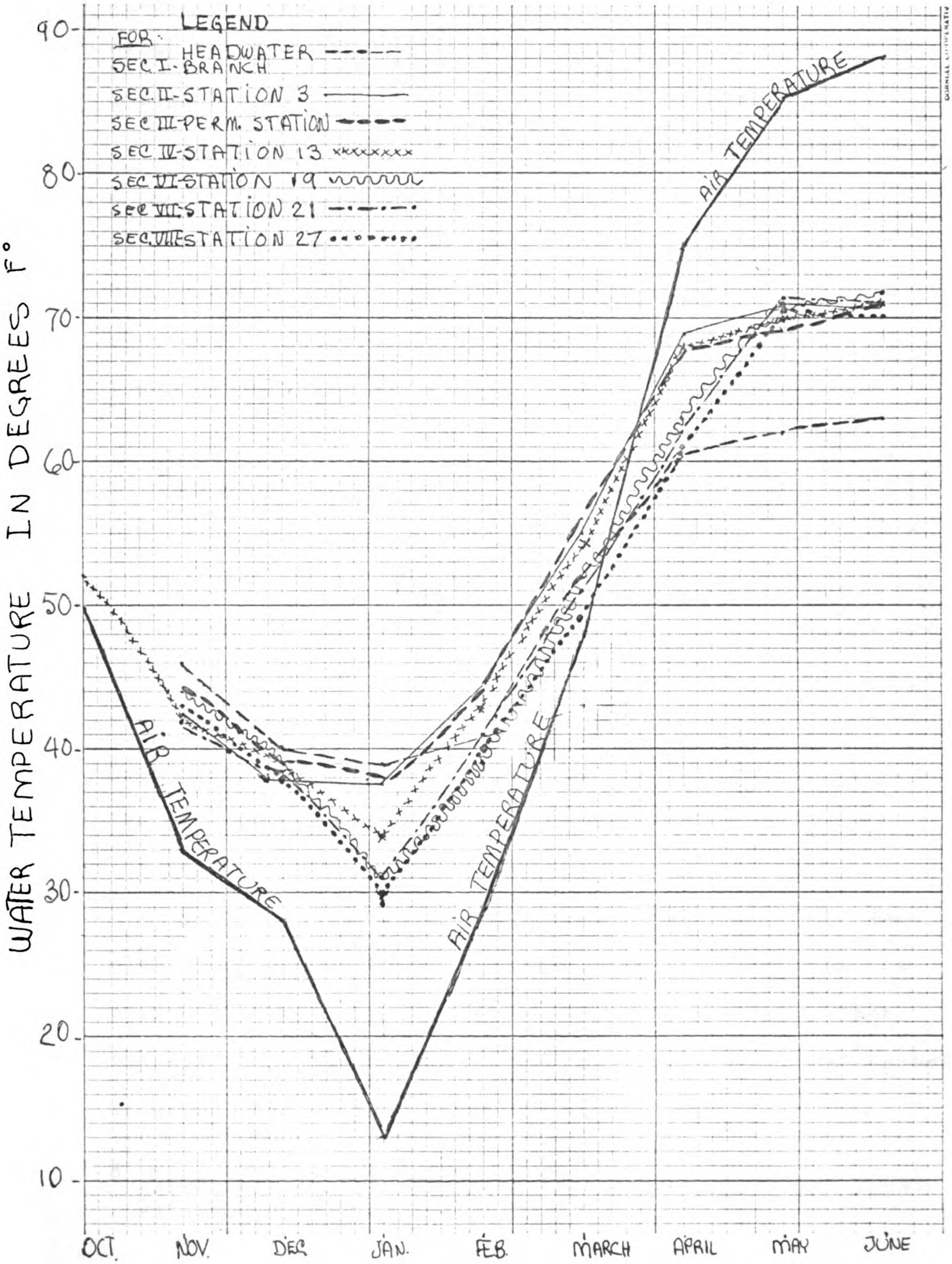
Results and Discussion.--There seems to be only general agreement in the literature regarding habitable temperature for brook and brown trout (*Salmo trutta*). Embody (1921) stated that brook trout prefer waters with maximum temperature of no greater than 70°F., optimum for growth being equal to or less than 70°F. They will tolerate 75°F. water under certain O_2 and CO_2 conditions. At 83° heavy mortality occurs and produces a deleterious delayed action effect on the remaining population. Brasch *et al.* (1958) summarize the literature, stating that exposure to temperature above 78° for more than a few hours will kill brook trout. Fry (1947), states that increased temperature above 66° results in decreasing brook trout activity; this activity declines until lethal temperatures are reached. He found that brook trout could withstand 77° temperatures.

It is recognized that brown trout will tolerate and thrive in warmer water than brook trout. Embody (1921) refers to optimum temperature as equal to or less than 75°, but growing in waters which reach 80°F. Needham (1938)

Figure 13

Monthly air and water temperatures

from seven stations


LEGEND
FOR:
SEC. I - HEADWATER BRANCH
SEC. II - STATION 3
SEC. III - PERM. STATION
SEC. IV - STATION 13
SEC. VI - STATION 19
SEC. VII - STATION 21
SEC. VIII - STATION 27
AIR TEMPERATURE
WATER TEMPERATURE IN DEGREES F°
90
80
70
60
50
40
30
20
10
OCT.
NOV.
DEC.
JAN.
FEB.
MARCH
APRIL
MAY
JUNE

also found the 75-80° range suitable for the growth of brown trout. He gives 81°F. as the maximum safely tolerated temperature.

An examination of the daily air and water temperature data for the permanent station, shows a generalized pattern on warm days. When the recorded air temperatures were between 75-81°, the water temperature did not rise above 69°. When the daily air temperatures exceeded 82° the water temperature rose over 70° but on the hottest[8] days, the water temperature did not exceed 75°. The morning water temperatures following the previous day's high air temperature always declined to 55-65°. The warm months then, showed an approximate 12° difference between afternoon air and water temperature; the water temperature not surpassing 75°. Two spot checks in late August, during high air temperatures (90-95°F.) showed a water temperature no higher than the same reached during 90° weather in May. The minimum water temperature during this period also corresponded with those during May.

The significance of these high, late summer air temperatures appears to be that the water does not store up much heat energy as the summer season progresses. This suggests that the influx of cool ground water is sufficient to offset stored heat energy in the stream.

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[8] Eight days in May, recorded with afternoon temperatures reaching 85-94°.

While the air temperatures in January varied considerably for different periods of the month (a 51^{o} variation), the water temperature only fluctuated 13^{o}. The lowest water temperature reading was recorded at 33^{o} on a day when the air was -12^{o}.

Monthly winter water temperatures for different stations, showed a gradual decrease in temperature as the stream flowed towards its mouth. Stream-edge ice increased in area downstream from the permanent station, reducing the main channel to a 2-3 foot width. These lowered downstream water temperatures and increasing ice coverage might be correlated with minimal ground water activity. More seepage apparently is present upstream from the permanent station, thus preventing stream-edge ice from forming and maintaining a higher winter water temperature.

Except for the headwater area, the water temperatures during the warmer months show slightly cooler temperature downstream than those of upstream stations. No definite explanation can be given for this apparent anomaly of summer-winter temperature reversal. However, one factor may be that diffuse ground water supplies are only active as they diffuse from shallow surface seepage. When the ground freezes, this seepage stops until a general spring thaw takes place.

The lower stream sections may be retaining their coolness, in part due to better shade conditions. Table 10

Table 10

A comparison between water temperature gradients and water shading gradients have been computed using Section I as the base. A + number indicates the number of degrees higher the water temperature is compared to that found in Section I. Temperatures are from stations located near the end of the Section listed.

Section	Percentage of water surface area shaded when:		Monthly water temperature gradients					
	Shrubs leafless	Shrubs leafed	February	March	April	May	June	August
I	10	85	0	0	0	0	0	0
II	20	40	+1	+6	+8	+11	+12	+7
III*	8	43	0	+2	+8	+10	+10	+7
IV	6	38	+1	+3	+8	+11	+10	+8
V	5	95	--	--	--	--	--	--
VI	40	70	-2	0	+3	+10	+8	+7
VII	16	41	-2	0	+3	+9	+8	+7
VIII**	5	10	-3	0	+3	+9	+8	+8

* This section lined by trees.

** Temperatures obtained approximately 725 feet from end of Section VI.

compares monthly water temperatures with shade development. The headwater branch is arbitrarily given a zero value against which other water temperatures are compared. The difference between the base (0) and the recorded temperatures is the temperature gradient. These gradient values are the highest for Sections II and III, decreasing with increasing length of stream. Comparing these gradients with the percent of water shaded and/or covered, two things are suggested: 1) that the stream shading helps suppress maximum daytime water temperature; 2) the greater the degree of water shading, the slower is the seasonal rise in water temperature. By August, the stream's water temperatures reacted quite uniformly to high air temperature except for Section I.

This data suggests the importance of stream shading to water temperature.

Examination of the temperature data for McCoy Creek indicates tolerable temperatures exist for both brook and brown trout. During the hotter days, brook trout may congregate in the vicinity of spring water sources (Brasch et al., 1958), deeper pools and possibly in cress beds. Spot checks showed these beds to be about 5-6° cooler than the main stream. Brown trout should find the stream's temperature suitable for a high physiological rate of activity. Temperatures are higher than ideal for brook trout.

Water Analysis

A routine water analysis for various chemical properties was conducted during December, 1961. Samples were collected at eight stations and tested for dissolved oxygen, free carbon dioxide, phenolphthalein, and methyl orange alkalinity.

The oxygen content was determined by use of Alsterberg's modification of the Winkler method, described in the tenth edition of "Standard Methods for the Examination of Water and Sewage" (1955, pp. 250-251). The free carbon dioxide content was analyzed by the methods described by Lagler (1956).

A summarization of the data is presented in Table 11.

Results and Discussion.--The stream was found to be nearly saturated with dissolved oxygen at the stations sampled.

Carbon dioxide content varied between 5 and 9 ppm. with the exception of the water taken from the last sampling station; here it was 14 ppm.

The then partially treated sewage, discharged near the last sampling station, may have had some effect on the oxygen and carbon dioxide content further downstream where oxidation of the residue would be taking place. At this site a somewhat oily, grey discharge was being circulated into the stream from Clark's factory. This discharge apparently did not affect the oxygen supply but may have been in part responsible for a higher carbon dioxide content.

Table 11

Summarized data for chemical analysis of the water

Station no.	Date 1961	Air temperature degrees	H_2O temperature degrees	O_2 ppm	O_2 Saturation %	CO_2 ppm	Total alkalinity phth ppm	Total alkalinity M-O alkalinity ($CaCO_3$) ppm	Total alkalinity Total ppm
2	12/22	31	44	10	82	7.0	0.0	41	41
3	12/22	33	41	12	93	--	0.0	41	41
9	12/23	26	39	12	90	5.0	0.0	38	38
13	12/23	29	39	13.5	99	7.0	0.0	40	40
22	12/26	33	39	13.2	100	9.0	0.0	45	45
23*	12/26	35	40	13.3	100	8.0	0.0	31	31
24	12/26	35	40	14.2	100	9.0	0.0	35	35
27**	12/26	35 snow	45	13.5	100+	14.0	0.0	38	38
									Ave. 42

* Some type effluent being discharged into stream--no apparent change in water color.

** Water temperature raised here due to effluents from factory and sewage water (warm). Water color grey.

The total average alkalinity content (42 ppm.) approached the minimal average values (45 ppm.-200 ppm.) for waters in mid-continental United States (Ellis et al., 1948). This relatively low alkalinity value may have some biological significance. Taft and Shapovalov's (1935) general findings indicated that a stream's richness in bottom fish foods are generally correlated with high alkalinity reading. Armitage (1958) concluded that for the Yellowstone River, $CaCO_3$ alkalinity appeared to be the main factor in determining total quantity of stream organisms.

This topic of productivity will be discussed in the next section.

Biological Conditions

Objectives

A survey of the stream for biological information included: analysis of the stream's bottom fauna productivity in relation to the substrate and aquatic vegetation; obtaining data regarding the fish population, past and present conditions; surveying the stream's potential spawning ground areas and their relation to ground water. No sampling of the stream's plankton was undertaken.

Bottom Fauna

The objective of this phase of the project was to obtain an overall picture of the stream's production of benthic macroorganisms, especially the insects. Further comparative analysis of these data would aid in determining the ecological condition of the stream.

Although total agreement is lacking, late fall and early winter appears to be one of the periods of greatest immature aquatic insect abundance (Maciolek and Needham, 1951; Ellis and Gowing, 1957; Armitage, 1958; Needham, 1938). The samples for this study were collected during mid-November, 1961.

Needham and Usinger (1956) demonstrated that for one riffle, 2 or 3 samples were sufficient to be reasonably certain of obtaining representatives of the principal groups of bottom organisms present. From this, it appeared that the samples from the 27 randomly located stations would contain representatives of the primary groups present in the stream substrata.

Using a Surber sampler and the method described by Welsh (1948), 49 bottom samples were collected. Unless the substrata appeared very homogeneous, two samples were taken at each station, as suggested by Lagler (1956); one each from the center and west (or north) side of the stream. The material collected was washed in the stream while still in the net of the sampler. It was then placed in a jar, labelled, and later refrigerated for future use.

When the material was to be sorted, it was emptied into a large, bright aluminum-bottomed pan, then flooded with a sugar solution. This modified floatation method is described by Anderson (1959). All insect fauna and crustaceans were removed and placed in a 5 percent formalin solution containing borax. Most mollusk shells were empty, therefore, none were enumerated.

Two separate samples of each of the four common types of aquatic vegetation were collected. One substrate sample also contained mostly _Odostemum_ _ceratophyllum_.[9] Approximately a one-half square foot area of vegetation was uprooted and bottled for each sample. Later, the plants were washed thoroughly over cheesecloth which served as a net to catch falling organisms.

Identification of all fauna was accomplished with the aid of Pennak's "Fresh Water Invertebrates of the United States" (1959). The insect identifications were checked by Dr. G. Guyer of Michigan State University.

A synoptic list of all organisms collected and recorded is presented in Table 12.

Results and Discussion.--The data collected from sample analysis showed Tendipedidae (Diptera) to be the most numerous insect type collected. _Cylloepus_ (Coleoptera) was the second most numerous insect while _Hydropsyche_

---

[9] The substrate sample was taken on a flat rock. This plant comprised most of the material sampled.

Table 12

Synoptic list of bottom fauna collected

Station	1	2	3		4		5		6		7		8		9		10		11	
Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Oligochaeta				2																
Aeolosomatidae		1	1			4			1							7	2			
Niadidae			1						1			1			1	1				
Lumbriculidae																				
Tubificidae																				
Hirudinea																				
Asellus																				
Hyalella																				
Gammarus	4			1			1	2							2	5		6	1	2
Ephemeroptera				1																2
Baetis																1				
Ameletus		1														1				
Paraleptophlebia																1				
Blasturus																				
Ephemera																				
Hexagenia																				
Stenonema																				
Iron																				
Ishnura						1														
Somatochlora																				1
Corixidae						1						1		1						
Belostomatidae																				
Sialis									1			5								5
Rhyacophila																				
Glossosoma																				
Hydropsyche				2						6			3	3		47		4		31
Limnephilus	2			1									1		2	3				
Pycnopsyche																				1
Oligostomis																1				
Ptilostomis																				
Neotrichia																				
Smicridea				2																

Station	12		13	14		15		16		17	18		19		20	21	
Sample	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Oligochaeta																	
Aeolosomatidae									8								
Niadidae						2	1		2	2				7			
Lumbriculidae										1		2	2	1		1	
Tubificidae																	
Hirudinea	2	1												3			
Asellus								2				1		2		1	
Hyalella									1			1	1				
Gammarus		1				3	5	2			2				2	9	8
Ephemeroptera																	
Baetis																	
Ameletus																	
Paraleptophlebia																	
Blasturus																	
Ephemera														3		1	
Hexagenia														5			
Stenonema							2										
Iron																	
Ishnura																	
Somatochlora																	
Corixidae														6			
Belostomatidae			1														
Sialis																	
Rhyacophila											1		1				
Glossosoma													1				
Hydropsyche							2				21		8				
Limnephilus						1	1						2				
Pycnopsyche												1				1	
Oligostomis																	
Ptilostomis																	
Neotrichia																	
Smicridea																	

Station	22		23		24		25	26	27							
Sample	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53
Oligochaeta										1						
Aeolosomatidae																
Niadidae				35	5	6	1	4	13	1	2		3			
Lumbriculidae																
Tubificidae							*									
Hirudinea								2		2	3			2		
Asellus				1						173					8	17
Hyalella								1		212	87					
Gammarus	3	1	1	1				5	1	17	28				43	39
Ephemeroptera												1				
Baetis										1		1				
Ameletus															2	1
Paraleptophlebia										4	1				1	
Blasturus										1						
Ephemera								5								
Hexagenia															2	3
Stenonema										4				18	2	7
Iron							1									
Ishnura										34	7					
Somatochlora							1				1					
Corixidae										9						
Belostomatidae																
Sialis											4					
Rhyacophila										1						
Glossosoma										2	1					
Hydropsyche								2				5		50		4
Limnephilus										4	4	1				
Pycnopsyche															8	4
Oligostomis																
Ptilostomis															1	
Neotrichia															1	
Smicridea																

* 45,000.

Station	1	2	3		4		5		6		7		8		9		10		11	
Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Coleoptera																				
Cylloepus					1										3	2				1
Helichus																				
Throscinus															1					
Haliplus			2																	
Helodidae																		2		
Galerucella																				
Diptera																				
Tipulidae	3																			
Pseudolimnophila																				
Limonia																1				
Antocha																				
Pedicia																				
Maruina																1				
Simuliidae				5										2		2				
Tendipedidae	2			2		4	2	1	4			7		5		26	10	4		12
Ceratopogonidae																1				
Stratiomyiidae																				1
Tabanus	1																			1
Chrysops														2		1		2		
Anthomyiidae																				
Ephydridae																				

Station	12		13	14		15		16		17	18		19		20	21	
Sample	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Coleoptera													2				
Cylloepus							2				36	16	14	4		75	2
Helichus											4		1				
Throscinus																1	
Haliplus																	
Helodidae																	
Galerucella																	
Diptera																	
Tipulidae						2	1			3		4					
Pseudolimnophila		1															
Limonia	1																
Antocha																1	
Pedicia																	
Maruina																	
Simuliidae													2				
Tendipedidae		1	6	11		11	21	5	11	43	96	260	7	45			
Ceratopogonidae														1			
Stratiomyiidae																	
Tabanus																	
Chrysops	1											1					
Anthomyiidae												1		1			
Ephydridae																1	

(Tricoptera) ranked third. Samples containing crustaceans indicated Asellus (Asellidae), Hyalella (Talitridae) and Gammarus (Gammaridae) to be the most common forms (listed in order of occurred frequency) in the collections.

In Table 13, the amount of substrate types (in percent)[10] for the whole stream is compared with the proportion of substrate types (in percent) for all samples. This comparison indicates that loose silt and sand-silt types were undersampled. Sand and fine gravel-sand mixtures were oversampled. Medium and small rocks were sampled slightly disproportionately to the stream's substrata composition.

Judging from the conclusions of Needham and Usinger's (1956) riffle study, statistically significant productivity data for McCoy Creek's substrata probably would not be obtained from 49 samples. However, a food grade scale (Lagler, 1956) was used to arrive at some basis for comparative substrata and vegetation productivity.

Figure 14 compares the bottom type of each sample with its calculated food grade rating. Each bar, representing the degree of food scale rating is divided into the total number of organisms tallied and their volume (in cc.). Data from Figure 14 is further broken down for comparison

---

[10] From Table 2.

Table 13

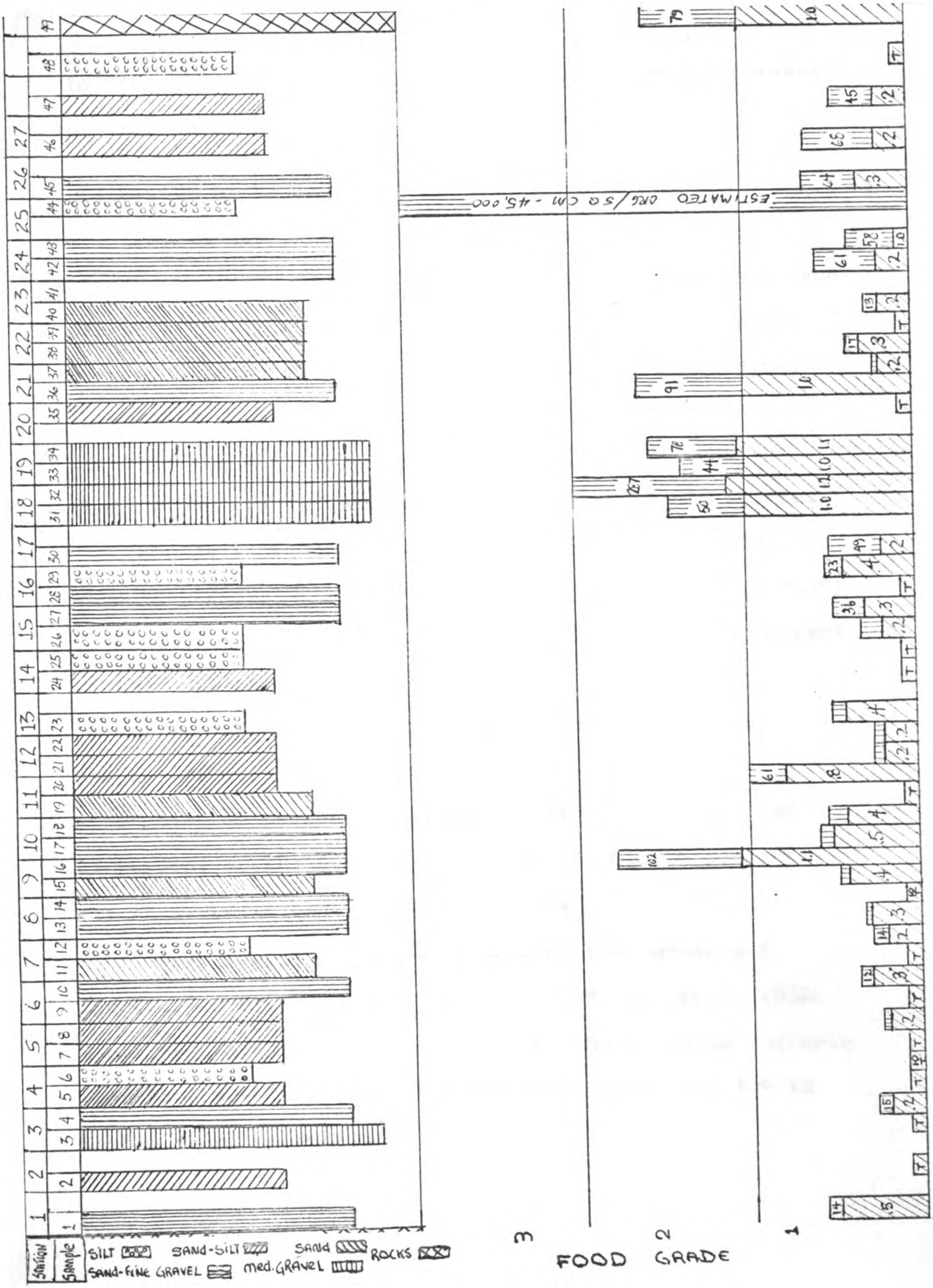
Percentage comparisons of the stream's total substrata composition with samples from different substratum

	Loose silt*	Sand-silt	Sand	Sand-fine gravel	Medium gravel	Small rocks
Composition of stream's substrate--in percent	25	32	4	18	8	5
Composition of substrata samples--in percent	16	25	16	28	12	2

* Silt not in water cress beds.

Figure 14

Substrate samples in relation to food grades. Vertical bars in the food grade scale are divided into: bottom half--volume of the sample (in cc.); top half--the number of organisms collected per sample. Vertical substrate bars represent the principle soil type of each sample.



STATION
SAMPLE
SILT
SAND-SILT
SAND
ROCKS
SAND-FINE GRAVEL
med. GRAVEL
ESTIMATED ORG/SQ CM - 45,000
3
2
1
FOOD GRADE

in Table 14. This table indicates the number and percent of samples by bottom type, in each food grade.

Discussion of Productivity

Pennak and Van Gerper (1947) found that gravel yielded two and one-half times more bottom fauna than sand per unit area. Shetter et al. (1946) noted that as the current exposed additional gravel bottom in the stream, the bottom fauna population eventually increased in quantity and quality. Morofsky et al. (1949) mentions similar results as does Tarzwell (1937) from his studies.

Analysis of the data suggests results concurring with the literature regarding general productivity. Sixty-seven percent of the medium gravel samples and 100 percent of the rock samples were in grade II.

Silt represented 16 percent of the total substrate samples of which 12 percent of the silt type was in grade III, 88 percent in grade I. Sand-silt comprised 25 percent of the substrate samples of which 8 percent was in grade II and 92 percent in grade I.

These results tend to agree with the summarized findings of other workers (Murray, 1938; Tarzwell, 1938; Tebo, Jr., 1955; Cordone and Kelley, 1961), which indicate that sand and inorganic silt substrata were very low in bottom fauna productivity.

Table 14

Number and percent of samples by bottom and vegetation types in each food grade

Type of substrate or vegetation sampled	Total samples differentiated (by percent) into substrate types	Total number and percent of substrate samples in the different food grades		
		Food Grade III	Food Grade II	Food Grade I
Silt	16	(1) - 12%	--	(7) - 88%
Sand/silt	25	--	(1) - 8%	(11) - 92%
Sand	16	--	--	(8) -100%
Sand and gravel(fine)	28	--	(2) - 14%	(12) - 86%
Medium gravel	12	--	(4) - 67%	(2) - 33%
Small rocks	2	--	(1) - 100%	--
Total number and percent in each food grade for all substrata		(1) - 2%	(8) - 17%	(40) - 81%
Nasturtium officinale	Common--all seasons locally	(1) - 50%	(1) - 50%	--
Anacharis canadensis	Sparse--all seasons generally	--	(2) - 100%	--
Vallisneria americana	Abundant locally--summer Common locally--3 seasons	--	--	--
Potamogeton pusillus	Abundant locally--summer Sparse generally--3 seasons	--	--	--

The one silt sample in grade III contained a very high estimated[11] number of Oligochaetes. It was collected from substrate in water subject to industrial and sewage wastes and far enough from the waste discharge source to allow the material to decompose. Goodnight and Whitley (1960) state that it is thought that Oligochaetes may serve as indicators of pollution.

Two percent of all samples were in food grade III, 17 percent in grade II, and 81 percent in grade I. This data suggest low substrate fauna productivity.[12]

An analysis of the vegetation sampled suggests their importance for harboring aquatic fauna. Data recorded in Table 14 show the 2 cress samples in grades III and II respectively. Both Anacharis samples were in grade II. Vallisneria and Potamogeton pusillus did not yield any organisms in November. However, visual inspection in June of these two submerged species, as well as two other species of Potamogeton not present in November, showed large numbers of clinging Simulidae larva and cases. This food adds measurably to the total summer's standing crop in the stream.

The presence of a few species of stream vegetation

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11 Number of organisms in one square in. counted and total organisms estimated on this basis for the rest of the sample.

12 From Fig. 14; 87 percent of total stream substrata in sand mixtures or silt.

during the months of June through mid-September is very noticeable. However, except for cress and Anacharis, the volume of vegetation declined drastically during the months from mid-September through May. As noted, Anacharis is scarce at any season. Water cress, however, begins extending their growth during April and reach maximum growth in July, which they maintain until approximately October. The beds then decline gradually until a low point is reached around the first of April.

The limited data collected suggests agreement with Lagler's (1956) summary of Needham's (1930) work, indicating a seven times greater productivity for stream bottoms supporting vegetation than substrata barren of rooted plants. It must be remembered however, that comparable productivity of vegetation and substrate in this study is difficult since the quantities sampled are not comparable.

It appears as though aquatic fauna samples for McCoy Creek would best be obtained in early spring prior to hatches.

Bottom Fauna and Velocity

Both Rees (1959) and Curry (1954) found that the principal factors affecting the distribution of insects in a stream appeared to be current and bottom type. Rees found Diptera to predominate in slow sandy bottom areas; Coleoptera preferred gravel, Ephemeroptera, Plecoptera and

Tricoptera, swift flow and gravel bottom. His data does not include possible variances in substrate preferability based on insect generic differences. Curry's work with Tendipedidae found individual species were restricted by current and bottom types.

The data in Figure 5 portrays the relationship of velocity and substrate to insect numbers classified by order. The predominant insect genera comprising these orders are listed on page 81. Based on these predominating genera, the greatest number of Tendipedidae (Diptera) and Hydropsyche (Tricoptera) were found in gravel substrate and slow water. Cylloepus (Coleoptera) was common in both gravel and sand--fine gravel mixture, appearing to show a preference for moderately fast water. Seventy-eight percent of all samples (38 out of 49) were from slow or moderately slow water (this water type comprised most of the stream--12 percent (6) from moderately fast water, and 10 percent (5) from fast water.[13]

Six and three-tenths times as many samples were taken from slow water as from moderately fast water. For a better comparison, assume the insects will be taken from the moderate velocity water in the same proportion as the actual sampling. Then 38 samples from water of moderate velocity might yield approximately 6.3 times the numbers already presented or:

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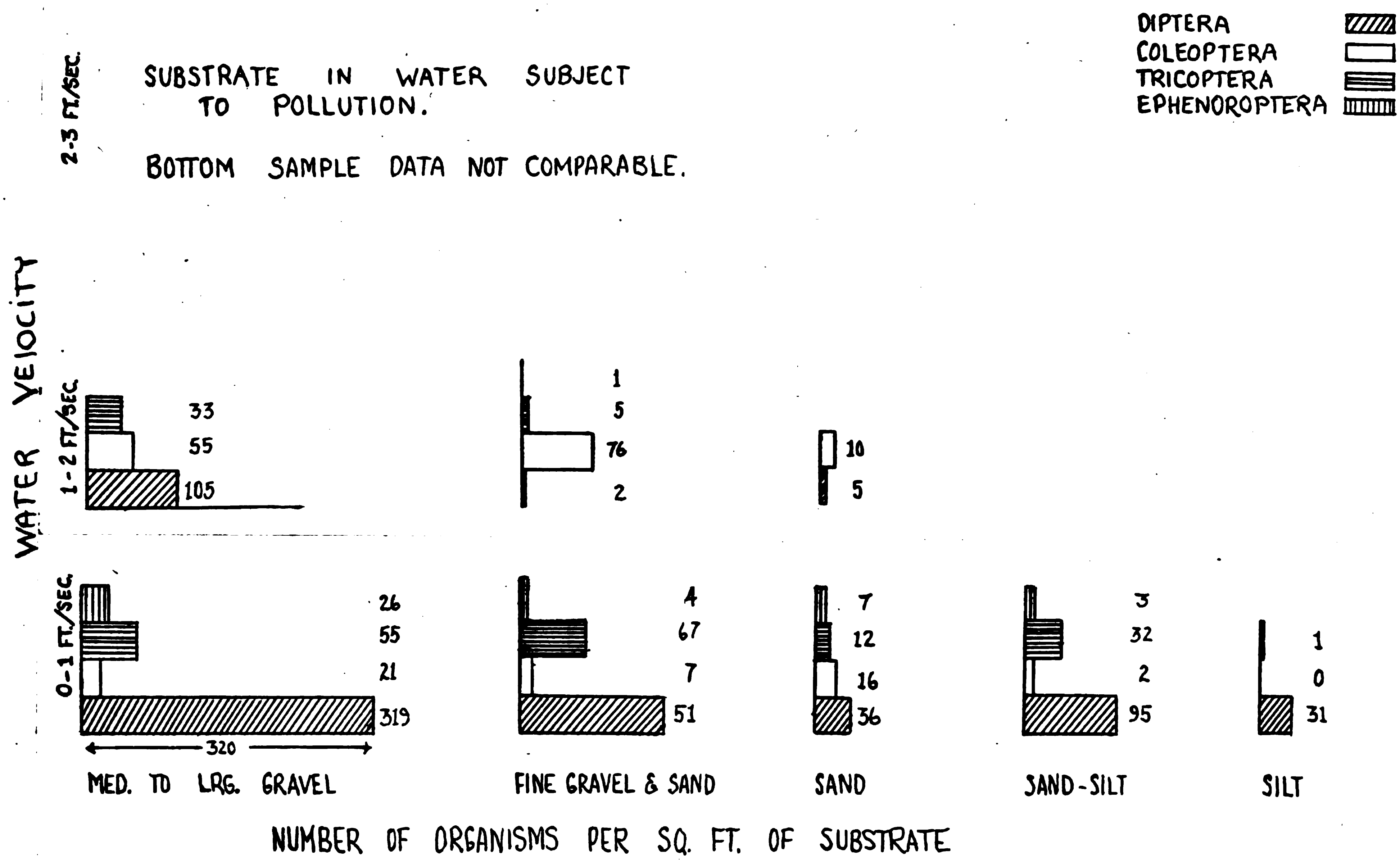
[13] From water subject to pollution.

Figure 15

Velocity and bottom type relationship to insect numbers--by genera



SUBSTRATE IN WATER SUBJECT TO POLLUTION.
BOTTOM SAMPLE DATA NOT COMPARABLE.
DIPTERA
COLEOPTERA
TRICOPTERA
EPHENOROPTERA
WATER VELOCITY
2-3 FT./SEC.
1-2 FT./SEC.
0-1 FT./SEC.
33
55
105
1
5
76
2
10
5
26
55
21
319
320
4
67
7
51
7
12
16
36
3
32
2
95
1
0
31
MED. TO LRG. GRAVEL
FINE GRAVEL & SAND
SAND
SAND-SILT
SILT
NUMBER OF ORGANISMS PER SQ. FT. OF SUBSTRATE

662	Diptera	vs. 319	for	slow	water	in	gravel	
13	"	vs. 151	"	"	"	"	gravel-sand	
32	"	vs. 36	"	"	"	"	sand	
347	Coleoptera	vs. 21	for	slow	water	in	gravel	
479	"	vs. 7	"	"	"	"	gravel-sand	
65	"	vs. 16	"	"	"	"	sand	
227	Tricoptera	vs. 55	"	"	"	"	gravel	
32	"	vs. 67	"	"	"	"	gravel-sand	
0	"	vs. 12	"	"	"	"	sand	

The actual numbers have no significance except to show the trend of environmental preference by the insects concerned.

Trout Food Preferences

Another method of evaluating the food value of a stream is to consider its faunal production in terms of preferred trout foods. Although no stomach analysis data were collected, it appeared that a comparison of preferred trout foods with a sampling of invertebrate fauna from McCoy Creek might be a useful evaluation tool.

Judging from stomach analysis data, Morofsky (1934) found brown trout to prefer Tricoptera and Ephemeroptera. These two orders were also the most commonly distributed groups in the study area. Ellis and Gowing (1957) stated that where plentiful, crustaceans and mollusks also seem quite important in a northern Michigan stream. Brook

trout in a southern Michigan stream also showed this food preference (Morofsky, 1934) as did larger browns in an English study area (Frost, 1939), Shetter et al. (1946) quoting Leonard's findings stated that apparently certain species of Tricoptera, Tendipedidae and Hyalella (Talitridae) were favored by brook trout in Hunt Creek, Michigan. A western United States rainbow (Salmo gairdnerii) and brown trout study (Maciolek and Needham, 1951) indicated the importance of Tendipedidae; being preferred even though low sometimes in availability.

Although sampling data based on a food scale rating indicate low food production values for McCoy Creek, two out of three most common insect types sampled seem to be good trout foods. The same type fauna (Asellus and Hyalella) harbored by some of the vegetation in the study stream appeared to be readily eaten by trout in other Michigan stream studies. Since water cress, anacharis and other aquatic vegetation seemed to provide habitat for a greater population than did most other substrates, any change in the volume of vegetation present in the stream may play an important part in affecting the stream's faunal population.

Fishing

Verbal information from the previously-mentioned cooperators aided in obtaining a generalized relationship between trout fishing success and changes in stream characteristics.

Originally, it was reported that the stream offered good trout fishing throughout most of its entire length (6, 8, 11). However the area flowing downstream through and beyond Clark's property has been and still is, subject to industrial wastes and to a lesser extent sewage discharge. This waste has ruined all aesthetic values of fishing in these areas and may have been responsible for a lower catch (8).

Stream conditions were different prior to 1935 than those existing now, and have been previously described.

Prior to 1900, bluegills (Lepomis spp.) and bass (Micropterus spp.) were caught in the stream below the mill pond (Section III) dam (9). Reports from the years after 1925 indicated that the most abundant trout species caught were rainbow and brown trout (2, 5, 11). Brook trout were taken from certain areas throughout the stream but more commonly upstream from M-60 (8). Limits of 15 rainbow trout per day were caught frequently (3, 8, 11). Summer fishing, using grasshoppers as bait, was very good (5, 11). Fish size varied in the catch from less than 7 inches to an occasional 16-18 inch brown or rainbow trout (3, 8, 11). It was the consensus of the cooperators that undersized trout of any species had not been caught for 15-20 years

(5,8). However, very little fishing has been done by any of these people in recent years. All informants (3, 5, 8, 11) emphasized the fact that fishing was very good in earlier years.

As physical changes in the stream occurred, smaller catches became the usual. Fishing interest waned. Prior to 1954 the sections north of M-60 still provided fair catches of brook trout (8). As this stretch became silted in from ditching operations, the fish yield--and fishing interest, declined.

The area from the railroad grade downstream to the city limits of Buchanan may still hold a fair population of fish with some large trout (5, 8). Much of this area is almost impossible to fish in any fashion due to shrub tangles covering the stream.

Of the "non-game" fish, suckers were the most abundant, especially during the spring. Presumably they entered through the Pike Lake drain, spawning in the creek. Horny head chubs and grass pickerel were frequently caught (5, 8, 11).

Although the major fishing effort is apparently directed towards catching trout, other species are sought. As in former years, suckers can be found in the creek during the spring. At this time they seem to be present in catchable numbers and sought by younger fishermen. Bass can be taken in a small dredged-out connecting pool

Plate IX

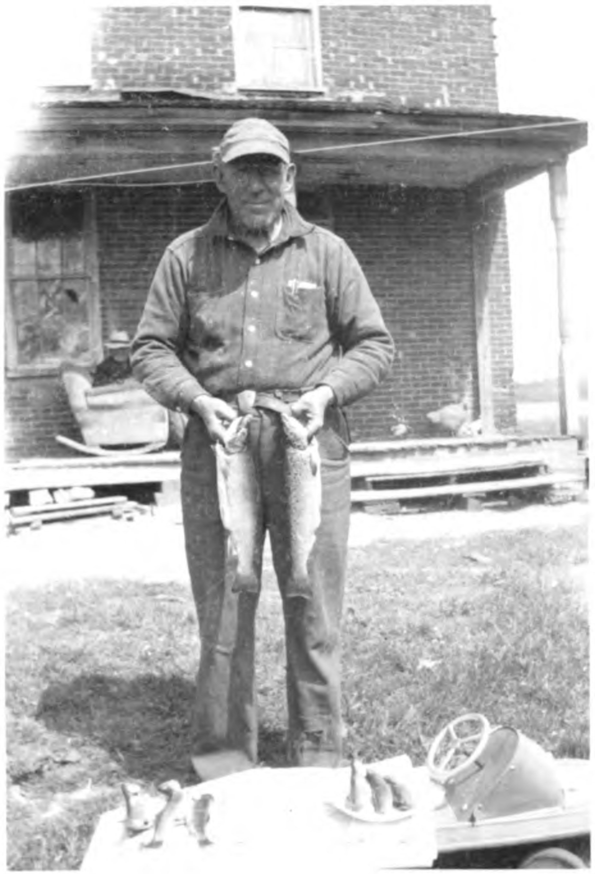


Fig. 16. Trout caught in 1942. The two largest trout are rainbow (left) and brown (right).

Fig. 17. Trout caught in 1947.

McCoy Creek Trout Catches

Plate X

Fig. 18. Trout caught in 1954 from McCoy Creek.

one-fourth mile upstream from the Bakertown-Buchanan Road bridge. These bass are only in evidence during a certain time in the spring. This may correspond to their spawning period. Other warm water fish may be present in the two ponds in Buchanan

McCoy Creek has been stocked[14] with trout by the Conservation Department as early as 1934. Since 1948, the department has, as policy, managed McCoy Creek as a trout stream. Table 15 lists all trout stocked since 1948. A total of 1,000 legal size (7 inch) rainbow and 14,400 legal-sized brook trout have been planted--no rainbow stocked since 1955. In 1959, 20,000 brook trout fry were released as well as the larger fish. These additional small fish represented utilization of a hatchery over-production situation. The 1961-62 program called for two plants of 300 each; one just prior to the opening of the season and the second during May. Each plant was divided equally between the Buffalo Road bridge site and the Bakertown-Buchanan Road bridge site. Fish size in the first plant was between 8 and 9 inches; those of the second plant were slightly smaller. All were over minimum legal size. None of the fish were marked for future identification.

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[14] All information regarding stocking was obtained from communications with Henry J. Vondett, Michigan Department of Conservation.

Table 15

Record of trout plantings for McCoy Creek

1948-1962

Date	Brook trout	Size	Rainbow trout	Size
1948	400	Legal	--	--
1949	700	Legal	200	Legal
1950	900	Legal	--	--
1951	1,200	Legal	100	Legal
1952	1,300	Legal	100	Legal
1953	900	Legal	400	Legal
1954	1,200	Legal	100	Legal
1955	1,200	Legal	100	Legal
1956	600	Legal	--	--
1957	600	Legal	--	--
1958	1,200	Legal	--	--
1959	1,200	Legal	--	--
	20,000	Fry		
1960	1,200	Legal	--	--
1961	600	Legal	--	--
1962	600	Legal	--	--

To provide some data regarding a general index to fishing pressure, species and size of the fish harvested, a fisherman questionnaire form was prepared. A sample form is duplicated below.

Date ____________________
Time spent fishing ____________________
Number of legal size trout caught ________
Size of trout: 7-10 in. 11-14 in. 15-20 in.
(check one or more)
Number of sub-legal size trout caught and released ____________________
Kinds of fish: Brook trout Brown trout
(Check one or more) Sucker Chub Other

Four easily accessible locations were posted with stream-side signs soliciting information regarding fishing results. Questionnaire forms were located in metal containers along with a pencil, at each station. It was requested that upon termination of fishing, a form be completed and deposited in the box provided (Figure 19).

Due to limitations of time, no attempt was made to contact fishermen personally for interviews or to check on the percentage of fishermen actually complying with the request.

The general prankster who completes questionnaires fallaciously introduces errors. Forms obviously of this type were discarded. Data from the station in Buchanan were primarily of this type.

Plate XI

Fig. 19. Set-up for soliciting information from fishermen.

Undoubtedly, some data were inaccurate due to inadequate knowledge of fish identification.

Some data were "missed" due to an absence of some piece of equipment from the station. All stations were checked frequently to reduce occurrence of this situation. It was almost impossible to keep the Buchanan station constantly supplied with materials. After the second week of the trout season, no more attempts were made to keep this station "active."

Unfortunately the wooden box at the Bakertown-Buchanan bridge site was destroyed by vandalism. All data were lost.

Results.--The author resided within observation distance from the M-60 station and drove by the Bakertown-Buchanan bridge[15] daily. Comparing the observed amount of fishing activity with the total number of returned questionnaires, it appears that many fishermen did not comply with posted requests. Of the 39 usable forms returned, 95 percent of the 36 fishermen indicated they had some success. It is highly doubtful if this high success ratio can be projected to all McCoy Creek fishermen. Needham (1947) reports that over 80 percent of the fish taken in any given watershed are taken by less than twenty-five percent of the anglers. This would tend to corroborate the author's personal observations of high use, but few returns.

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[15] By visual observation, the most heavily used fishing site.

Shetter (1951) stated that streams with concentrations of large adult trout will receive the greater part of their angling pressure and the greater part of the season's total catch will be removed during the first four weeks of the trout season. Morofsky et al. (1949) found in a southern Michigan study that 144 of the total 180 brook trout reportedly taken for the season, were reportedly taken on the opening day. This evidence tends to explain the marked decrease of fishermen visually noted using the stream after the second week. Fishermen were visually observed to concentrate at the two fish release sites. Cooper (1952) noted similar results stating that planted areas attracted about three times as much fishing as unplanted sections.

Analyzing the data obtained and summarized in Table 16 a total of 82 legal sized trout were reported to have been caught. Ninety-four and five-tenths percent of these were brook trout and 6 percent were brown trout. Eighty-nine and five-tenths percent of the brook trout were of the size planted (7-10 inches). The next size group represented 10.5% of the reported catch. This class could be survivors of last year's plant, extra large fish of the 1962 plant, or another age class from natural reproduction. Since no brown trout had been stocked in recent years, those of legal size reportedly caught must have been the result of natural spawning.

Table 16

Summarization of catch data from fishermen questionnaires

Station	Number of trout reported caught						
	Brook				Brown		
	Sub-legal	7-10 in.	11-14 in.	Total catch	7-10 in.	11-14 in.	Total catch
Buchanan picnic area		3	--	3	--	--	--
Bakertown-Buchanan bridge site				Destroyed			
M-60	2	30	4	34	1		1
Buffalo Road bridge	10	36	4	40	3	1	4
Totals	12	69	8	77	4	1	5
Percent of total catch for species				94			6

Unfortunately, the sub-legal size trout were not listed as to species. Other fish listed as caught were chubs, suckers, and mud pickerel mentioned in the order of descending frequency.

Discussion.--Under "normal" population conditions, it could be expected that bait fishermen would be catching trout other than just "keepers." Shetter and Leonard (1942) published results from a brook trout population study from a limited area indicating[16]: 2.3 percent were 7 inches or more in length, 22 percent between 4 inches and 6 7/8 inches; and 75.7 percent were less than 4 inches. Schuck's (1945) findings for brown trout showed approximately 56 percent of the fish in age class 0; 23 percent for I; 11 percent for II; 6 percent for III; 2 percent for IV and 1 percent for V. This information suggests that data obtained for McCoy Creek's trout population shows it to be primarily an artificial one. Assuming the sub-legal length trout reported were trout and not chubs, only 14 percent of the total catch was sub-legal, while 86 percent was legal. It must also be considered that the hook size would tend to eliminate catching some of the smaller fish.[17] Generally

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[16] The authors stated that for their study it was impossible to predict accurately the ages of the various elements of the brook trout population from their total length.

[17] Problems of Trout Management, Michigan Department of Conservation, Fish Division Pamphlet No. 13, 1954.

though, it appears that the native population is materially augmented by the planted trout.

Assuming all sub-legal trout were brown trout (they evidently spawn in the creek), they would represent 70 percent of the total brown trout catch reported. Sizes 7-10 inches, 24 percent; and sizes 11-14 inches, 6 percent. This seems to be more in line with data presented from the literature. On this basis, the McCoy Creek native population might be considered following a somewhat general and standard pattern, but one of very low productivity.

Electrofishing

The purpose of this phase of study was to obtain samples of the stream's larger-sized resident fish population, arriving at some indication of their abundance. Estimates of the total population by species were beyond the scope of this project.

Six areas were selected for sampling: one each in Section II through V; two areas for Section VI, and the largest and deepest pool in the stream (also in Section VI). The areas in each section were chosen for their accessibility as well as being representative of each section.[18] The work was carried out in December, 1961.

A pair of hand-held electrodes each connected to 100 feet of insulated wire leading from the generator,

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[18] The pool being an exception.

served as the "shockers." A portable 500 w, 110 v, 60 cycle AC generator provided the power. By locating the generator midway in the section to be worked, it was possible to shock a total stretch 200 feet long. A blocking net was anchored across the stream 200 feet upstream from the intended starting point. The 100 foot leads were stretched out on the bank prior to entering the stream to reduce the chance of scaring the quary.

Two men worked in the electrodes upstream towards the net. They strived to cover the entire stream without allowing fish to swim out and around the effective "charged" area. The distance between the electrodes varied. Where pools were encountered, a narrower but more intense electric field was desired. In clear, clean-edged, shallow stretches, a wide field sufficed. One man followed, netting the fish. Very few fish that were observed to have been stunned, were lost. No estimate is available of how many unobserved stunned fish were missed. No attempt was made to net all the smaller fish, but a note was made regarding their observed frequency of occurrence.

Approximately 1,250 feet of stream were shocked. This represented about a 2 percent sample of the total stream's length.

A summary of the results is tabulated in Table 17.

Results and Discussion.--Electrofishing using an AC generator (500 w, 110 v capacity) has proven valuable for

Table 17

Results of electrofishing--by sections.
Ratio of stream worked to total area
of stream comprising each section

Stream section	Area shocked (see Figure 2)	Water temp. degrees	Air temp. degrees	Fish species over 5 inches in length: Mud pickerel	White sucker	Horny-head chub	No. creek chub	Fish known to have escaped
II	From under Frame's bridge, station upstream 200 feet	42	23	2	2		3	3
III	50 feet downstream of station 8	40	23	5	1			
IV	From Cemetery Road's cement bridge, 200 feet upstream	40	22	3			2	
V	Station 14, 200 feet upstream	38	17	2		1		1
VIa	From first pool downstream of Andrew's wooden bridge, 200 feet upstream--to bridge	39	18	3	1	1		1 (sunfish)

Stream section	Area shocked (see Figure 2)	Water temp. degrees	Air temp. degrees	Fish species over 5 inches in length: Mud pickerel	White sucker	Horny-head chub	No. creek chub	Fish known to have escaped
VIb	40 feet upstream from station 19, 200 feet upstream	37	17	2			2	
VIc	Large pool between stations 18 and 19	37	17	--	--	--	--	--
VII, IX, VIII	Not sampled, frozen over							

* Smaller fish noted in order of observed frequency of occurrence. Dace, sculpin (minnows?), darter.

fish capture. Its efficiency is variable, being more successful in turning up the larger fish (Shetter et al., 1946; Cooper, 1951; Pratt, 1951; Benson et al., 1959). Larimore (1961) studying a warm water stream in Illinois found its efficiency to vary with the behavior, habitat and morphological characteristics of each fish species. Pratt's (1951) work on two southern Michigan trout streams with AC and DC generators also indicated species variation in relation to ease of capture. Trout listed in apparent order of difficulty of capture were brown, rainbow, and brook trout, the brook trout showing the best capture rate--100 percent.[19] Shetter et al. (1946) working with brook trout in the Pigeon River obtained excellent results; efficiency of capture averaged 96.7 percent, varying with the size of the fish. Benson et al. (1959) found no significant difference in recovery rates between brown and rainbow trout. It might be conjectured that warier browns moved upstream out of the area in greater numbers, since no blocking net was used. Cooper (1951) publishing on two year's data regarding brook and brown trout shocking recovery, indicates no significant difference between species in the rate of recovery.

The collector's ability to see and collect fish, the weather and water conditions can vary the computed

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[19] Very small sample.

effectiveness of the shocker and data obtained (Shetter et al., 1954; Larrimore, 1961).

Considering the reported efficiency the most significant results were negative--no trout! Since 600 legal brook trout were planted during 1961 and they may be somewhat easier to capture, it was assumed that some would have been taken. The absence of trout from the catch suggests several things: 1) a high percentage of fish planted are caught by fishermen soon after planting. Lemmien et al. (1957) published a recovery rate of 66 percent for rainbows in a southern Michigan stream. Cooper (1951) showed a 64 percent recovery rate for brook trout and 67 percent for rainbow trout in the Pigeon River. Cooper (1953) also found a 59.5 percent return in the same stream for 1951. He stated that rainbow trout planted in Michigan during the angling season at accessible points should give a return in excess of 67 percent. This seemingly would be applicable in McCoy Creek where the initial angling pressure is heavy and the plants are made just prior to and during the open season. However some recovery rates in southern Michigan streams (Shetter, 1947) showed much lower percentages; 17 percent for rainbow trout and 12 percent for brown trout. 2) A high rate of mortality for planted fish has been thoroughly demonstrated in the literature. It seems reasonable to believe that assuming 30-40 percent[20]

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[20] Based on Cooper's estimated 67 percent return.

of the trout planted escaped the fisherman, a large number of these would have succumbed by December. With only a 2 percent sample shocked, the probability of taking any of these seems slight.

Another explanation may be:

3) An absence of native brook trout and brown trout in the sections sampled. Section V was very difficult to sample effectively. This section, however, appears to contain certain characteristics of a more favorable trout environment.

4) The trout moving out of the colder waters into warmer sections. "Typical" samples were shocked however, in upstream warmer-water sections without results.

5) Still another explanation for not recovering any trout is an inherent sampling error, i.e., although trout were present in the large sections sampled, none were in the units shocked.

Mud pickerel (Esox americanus), were recovered in all sections, appearing to be the most universally distributed and abundant fish in the stream. This concurred with the opinion formulated by the author from fish observed during survey trips. Other fish listed in order of frequency of capture were: Northern Creek chub (Semotilus atromaculatus), white sucker (Catostomus commersonnii) and horny-head chub (Nocomis biguttatus). One sunfish (Lepomis spp.) was captured, but lost.

Dace and sculpin (<u>Cottus bairdii</u>) were the most frequently observed smaller fish associates.

It appears that the trout population in McCoy Creek consists largely of planted brook trout. After these trout are caught or succumb naturally, the creek's trout population will be very low. What trout that may exist might be located in the more inaccessible regions of the stream.

In general, the data suggest an overall fish population composed of few species and low numbers.

<u>Minnow Seining</u>

Various workers have described the significance of the presence or absence of smaller non-game fish. These forage fish assist in designating the ecological environment of a stream. They also serve as forage for the larger, carnivorous fish. Conversely they compete with the same carnivorous game fish for the stream's food organisms. Because of this competition the best brook trout streams would be those which contain only trout and no forage fish. Brook trout make very satisfactory growth on bottom organisms without foraging on smaller non-game fish. Certain cold water associates such as Northern Mudder and Miller's Thumb are thought to be destructive to trout fry (Murray, 1938).

Collecting took place on June 13 and 14, 1962. The seining was done at certain previously located sampling stations which represented visually different habitats (see Figure 2).

A six foot by four foot Common Sense minnow seine was used having a 0.125 inch square mesh. Two men, each handling one of the seine's two poles, made 3 to 4 sweeps approximately 6 feet long along the stream's bottom. All individual sweep samples were collected and placed in separate jars. Later, living material was transferred to jars containing a 5 percent formalin (with borax) solution. Identification took place at a later date.

Data recorded at each sampling site included bottom type; air and water temperatures; water depth; number of sweeps at each location; approximate velocity (using velocity data for stations obtained at time of November survey).

Table 18 summarizes the data collected.

Results and Discussion.--Data of Table 18 indicates the spp. in order of abundance to be:

	Number
*Rhyinicthys attratulus a.	37
*Cyprinidae larvae	23
Catastomidae larvae	16
Etheostoma caeruleum	11
*Pimephales notatus n.	10
Cottus bairdii b.	6
Cottidae larvae	2

	Number
Etheostoma nigrum n.	3
Etheostoma blennoides	1
*Etheostoma microperca	1
Semotilus atromaculatus a.	1
*Esox americanus v.	1

Summarizing from Troutman (1957) all of the species in this list (except those marked with an asterisk) typically occur in streams with a steady flow, medium gradient and clear, unpolluted water having sand and mixed gravel bottoms. Pimephales is reported to tolerate a wide variety of silt bottomed degraded habitats. Etheostoma microperca is more typically a species of low gradient streams with silt bottoms. Esox americanus is characteristically found in clear, densely vegetated streams whose bottoms are composed chiefly of organic debris. This latter species because of its size and ability to elude the seine probably represents an accidental capture.

Figure 16 portrays the relative productiveness of the seining. As the graph indicates, there is a general correlation between the number of fish captured per sweep, the percentage of seining sweeps producing fish and the type of substrate. Since the stream is composed predominately of sands and silts, the data suggest environments not conducive to high potential populations of forage fish.

Table 18

Minnow seine data

Obtained June 13 and 14, 1962

Section	Station	Substrate	Productive sweep/ total number	Air temp. degrees	Water temp. degrees	Approx. velocity	Water depth in.	No. and species: Fish	No. Crayfish
II	1	Sand-silt	1/4	72	57	Mod. slow	5-7	2 *Rhynichthys attratulus* a.	
	2	Sand-silt	0/2	74	63	Slow	16	Nothing	
III	3	Med-fine gravel	5/7	75	63	Mod. swift	10	6 *Rhynichthys attratulus* a. 4 *Etheostoma caerulum*	
	upstream of 4	Sand-silt	1/1	75	65	Slow	15	1 *Etheostoma microperca*	
	4	Sand-silt	0/2	75	65	Slow	15	Nothing	
	upstream of 5	Sand	1/1	75	65	Mod. slow	--	1 *Cottus bairdii* b.	
	5	Sand-silt	0/4	75	65	Mod. slow	10	Nothing	
	6	Sand	2/3	--	--	Mod. swift	13	1 *Esox americanus* v.	
	7	Med-fine gravel	1/2	74	69	Mod. swift	11	1 *Rhynichthys attratulus* a. 1 *Etheostoma caerulum*	

Section	Station	Substrate	Productive sweep/ total number	Air temp. degrees	Water temp. degrees	Approx. velocity	Water depth in.	No. and species Fish	No. Crayfish
IV	9 Perm. station	Sand-fine gravel	4/5	74	69	Mod. swift	14	1 _Etheostoma nigrum_ n. 1 _Etheostoma caerulum_ 1 _Cottus bairdii_ b.	1
	10	Sand-fine gravel	2/5	74	69	Mod. swift	14	1 Unidentified larva 10 _Pimephales notatus_ n.	
	11	Sand	1/4	76	59	Mod. slow	8	6 Cyprinidae larvae	
V	Between 11-12	Sand	1/4	76	59	Mod. slow	14	2 Catostomidae larvae	
	Between 13-14	Med-fine gravel	4/9	73	57	Mod. swift	16	1 _Cottus bairdii_ b. 2 _Etheostoma caeruleum_	5
	14	Sand-silt	1/1	73	57	Mod. swift	15	2 Cyprinidae larvae	5
VI	17	Sand-fine gravel	2/4	71	55	Mod. swift	23	1 _Etheostoma nigrum_ n. 1 _Etheostoma blennoides_	1
	17	Water cress	1/1	71	55	--	18	3 _Etheostoma caerulum_	

Section	Station	Substrate	Productive sweep/ total number	Air temp. degrees	Water temp. degrees	Approx. velocity	Water depth in.	No. and species Fish	No. Crayfish
VI (cont'd)	upstream of 19	Med-fine gravel		76	62	Swift	8	1 *Cottus bairdii* b. 1 *Semotilus atromaculatus* a. 19 *Rhynichthys attratulus* a.	1
	19	Med-fine gravel	1/3	76	62	Swift	33	9 Catastomidae larvae	
VII	Between 20-21	Large gravel and rocks						9 *Rhynichthus attratulus* a. 1 *Cottus bairdii* b.	4
VIII	23	Lg. rocks embedded in sand	2/4	69	65	Swift		10 Nothing	
	27	Sand-silt	2/3	70	65	Med-slow	11	1 *Cottus bairdii* b. 1 *Etheostoma nigrum* n.	
IX	22	Sand-fine gravel	2/4	69	65	Mod. swift	16	2 Cottidae larvae 1 Catostomidae larvae	1
	Between 22-23	Rocks-sand	1/4	68	65	Mod. swift	15-24	15 Cyprinidae larvae	3

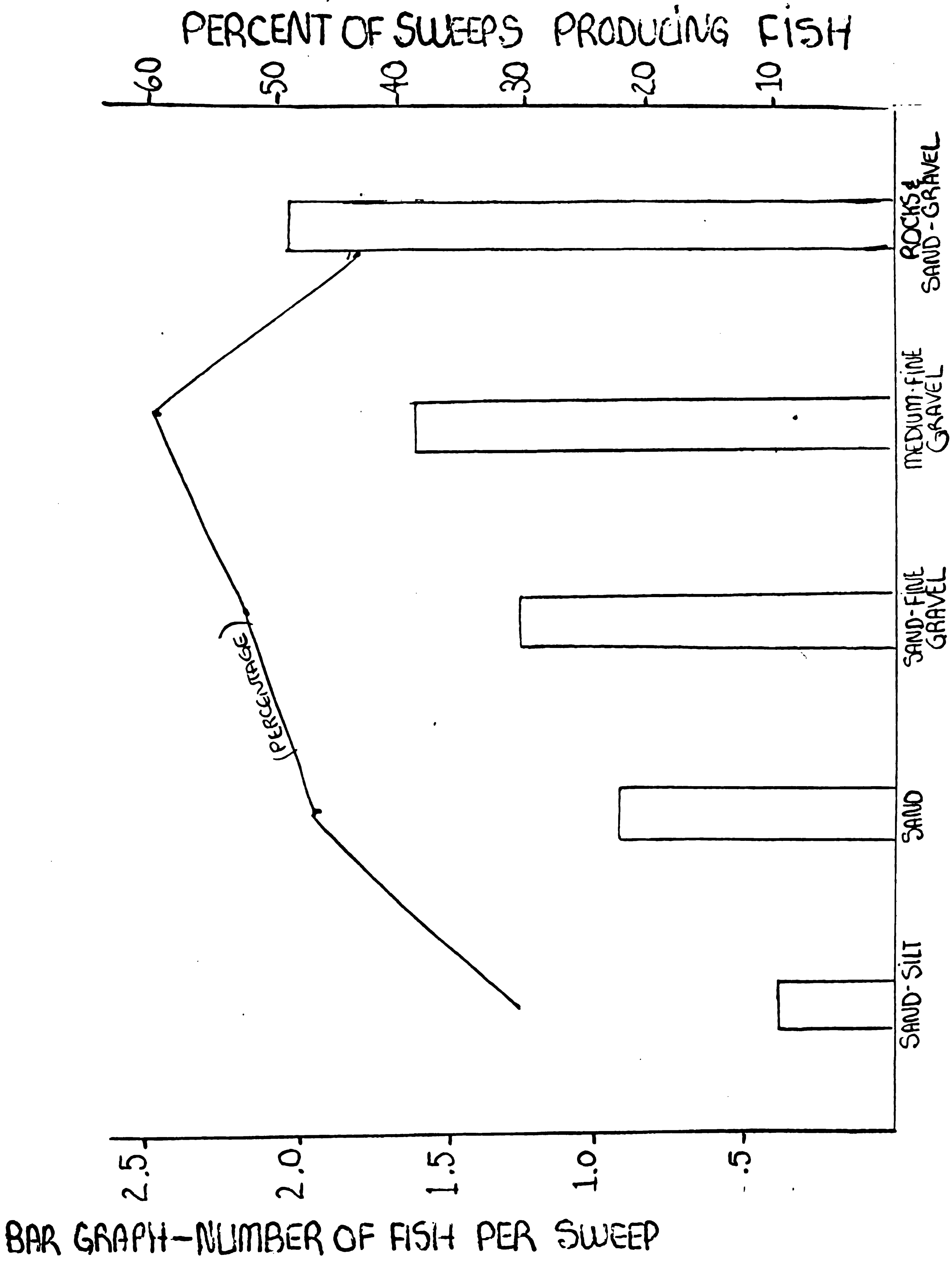
PERCENT OF SWEEPS PRODUCING FISH
60
50
40
30
20
10
ROCKS & SAND-GRAVEL
MEDIUM-FINE GRAVEL
SAND-FINE GRAVEL
SAND
SAND-SILT
(PERCENTAGE)
2.5
2.0
1.5
1.0
.5
BAR GRAPH—NUMBER OF FISH PER SWEEP

Figure 16

Relationship of seining productivity to substrate.

Hallum (1958) and Cooper (1952) list some species typically associated with trout in streams such as Rhynichthys atratulus, Semotilus atromaculatus, Catastomidae and Cottus bairdii. All of these occur in McCoy Creek. Some Percidae (Ethestoma spp.) are also evident in the stream's gravel riffle area.

As previously stated it is generally agreed that high quality trout stream habitat usually has a high trout/forage fish ratio. Invasion by Percidae has been stated (Gutsell, 1929) as an indication of declining trout habitat.

McCoy Creek has a low trout/forage fish ratio and Percidae inhabiting the gravel riffles. It is therefore postulated that this trout/forage fish ratio suggests a marginal trout stream environment. Those trout that do exist have to face considerable competition in the various stream habitats, i.e., water cress beds--fingerling predation by Esox; food competition in gravel riffles by Ethestoma spp., and in sand, silt and gravel bottoms with the other array of fish.

Possibly with environmental improvement favoring higher trout populations, their competing fish might become forage for an increasing trout population and therefore become more limited in their distribution and abundance. Shetter et al. (1946) noted that after stream improvement work had been in part completed on the river, brook trout and sculpins increased in numbers; the trout had a corresponding increase in weight and rate of survival. The associated minnow population failed to increase in weight per fish and showed only a slight increase in numbers.

Ground Water and Spawning

A study by Benson (1953) indicated that ground water seepage influenced trout populations in the Pigeon River by controlling the location of brook and brown trout redds. Population estimates indicated that trout abundance was correlated with the number of redds per area.

Recent investigations have indicated that for salmon spawn to hatch (Wickett, 1954) and the embryos to develop successfully (Shumway,[21] 1960; Silver,[22] 1960; Coble, 1961) certain stream bed conditions regarding oxygen and velocity of ground water percolation must be met. These conditions seem even more important in the case of brook trout than brown trout.

Various workers (Pollard, 1955; Terhune, 1958; Gangmark, 1958) were prompted to develop apparatus and techniques to measure the velocity and oxygen content of the stream bed. Although these techniques provide more

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[21] Unpublished M.S. thesis.

[22] *Ibid*.

refined data, it was not within the scope of this survey to utilize these methods.

Using the general survey methods of Benson (1953), e.g., winter water temperature, surface ice cover, summer water temperature, and gravel substrata temperature, areas with ground water seepage were located.

Winter and summer water temperatures have been discussed more fully in an earlier section of this dissertation. In general, only the main feeder stream definitely showed evidence from seasonal temperatures, of significant amounts of ground water influence. However, because the substrata in this section seemed unsuitable for brown and possibly brook trout spawning, no further investigations were conducted in this section.

Most of the stream was observed frequently throughout the winter months. Dates of stream ice formation and its coverage was noted and are depicted in Figures 9 through 14.

Only on the coldest mornings were there evidences of stream-edge ice upstream from station 12. The ice cover formed at places of reduced water current (cress beds) and around protruding stream brush, bushes and logs.

Below station 12 stream-edge ice was more noticeable. During the coldest periods Section V had an ice-free channel (2-3 feet wide) but an ice layer frozen to the interlacing branches on the water's surface. Section VI had an ice-free channel 2-3 feet wide. The ice was covered with 8-10 inches of snow except during parts of February. A few isolated areas in this section contained no ice and were noted for future inspection.

Section VII retained a 2-3 foot open channel with conditions similar to those in Section VI--but there were no areas of "open water."

Section VIII was solidly frozen for most of its length during the most of January and February. Section IX had some edge ice present. Industrial and sewage effluents discharged into the stream apparently warmed the water enough to prevent ice formation except for short periods of time.

Extent of ice cover did provide general information about where not to look for ground water seepage.

Since all gravel areas (potential spawning areas) had been mapped, a check of the substrata temperatures in these locations was undertaken. Special attention was given to those stream portions which had little or no ice cover during the winter.

A battery operated thermometer on which were connected 2 wire electrodes was used to take substrata temperatures. One electrode was attached to a sharp stick, then probed 2-3 inches into the substrate; the resulting temperature was recorded. The second electrode was kept in the stream to record general water temperature compared with that of the substratum. Tabulation of the survey's results are given in Table 19.

Of the gravel beds present in Section III, only one stretch approximately 75 feet long, downstream from station 7 (see Figure 2) was there ground water seepage through the substrata. The soil temperatures here were 50° compared to 66° stream temperature. Many stream bank water seepages were noted, but these seeps were flowing directly into the stream's surface water and not entering by way of the substratum.

Three substrata water seepage areas were located in Section VI between stations 18 and 19. All three were in the ice-free areas noted during the winter survey and located in the south banks and substrata. These seeps varied in bottom surface area coverage from 120 square feet to 350 square feet. All seeps percolated through gravel of various sizes intermixed with varying amounts of sand. The water depth over the seepages varied between 5 to 12 inches of medium surface velocity. The substrate in the seepage beds was noticeably more loosely packed compared to other gravel beds having no ground water activity. Table 19 summarizes the morphometry of the ground water areas located.

According to previously mentioned investigations, seepage through the stream substratum is a very important ecological factor affecting trout populations. Apparently

Table 19

Locations of ground water areas graphically located in Figure 3

Section	Location of seepage	Square feet of coverage	Water depth in.	Substratum	Water temp. degrees	Sub-strata temp. degrees
I	No gravel beds--not checked					
II	No gravel beds--not checked					
III	Between stations 7 and 8; east bank. Immediately upstream from large downed elm tree	60-75 long 2-3 wide 350 sq.ft.	10-12	Med.gravel sand mixture	66	50
IV	None located					
V	Not checked due to lack of gravel beds and appropriate water depth					
VI	Between stations 17 and 18. All on south bank curves	1)20-30 long 4-5 wide 150 sq.ft.	8-10	Large gravel some sand	62	52
		2)40-50 long 8-10 wide 410 sq.ft.	5-10	Med.& fine gravel mixed with sand	62	52
		3)30-35 long 6-7 wide 203 sq.ft.	8-12	Med.& fine gravel mixed with sand	62	52
VII	Not checked--no evidences of spring water activity during winter survey					
VIII	Not checked--no evidences of spring water activity during winter survey					
IX	Not checked--affected by sewage and industrial pollution					

from earlier years' fishing, many more trout were caught in McCoy Creek, including those of sub-legal size. If the stream formerly produced a native trout fisheries a decline in suitable spawning areas may be a major factor in a decreased trout population. Reduced spawning areas may have been a result of a heavy build-up of additional substrate from erosion etc., a decrease in the ground water seepage, and/or a combination of both. The problem of erosion and siltation in the stream has already been discussed. To fully investigate the second hypothesis would require investigations beyond the scope of this project. However, we can examine some ground water facts and local records and opinions.

Spring fed streams receive their water supply primarily from the ground water zone known as the zone of saturation (Ackerman et al., 1955). This zone is at the surface level in some lakes, ponds and swamps acting as ground water storage units, feeding streams continually. It is "recharged" from precipitation percolating into the ground. These interactions are part of the hydrologic cycle.

The rate of seepage into the streams is determined in part by the hydrostatic pressure (pressure caused by the weight of water above). With proper geological conditions existing, sufficient pressure occasionally occurs to cause the water to rise in a well above the land surface creating a flowing or artesian well (Ackerman, 1955). Elementary physics indicates that this pressure which feeds water to wells and ground seepages or to turbines at a dam site can be reduced, if the stored water (zone of saturation in the case of wells and seeps) is exploited faster than it is replaced.

How much do we know about water conservation and hydrology? Harrold (1954) states that ". . . our stockpile of data for meeting water conservation planning needs is distressingly inadequate." Thomas' (1955) views regarding this lack of information are ". . . that hydrologists can see no farther underground than other people."

Information regarding spring activity, well flow, stream flow, and general water conditions were solicited from the aforementioned local residents. Of those who felt qualified to answer, all mentioned a reduction in the total volume of stream flow. Many specific incidents were cited, e.g., present stream level (already discussed in an earlier section); reduced frequency of spring floods (3, 4); disappearance of swimming holes (11). Former flowing springs in close proximity to the creek have ceased to exist (1, 3, 4, 9). These springs according to information received, had a very strong, large flow of water during all seasons. Much of the now ditched muck land was covered by water, cattails and sedge. Now the same area supports a stand of cherry trees, grey dogwood and some crab apple trees (2).

Results and Discussion.--Where has the water gone? Examination of the population statistics for the town of Buchanan[23] shows a 36 percent increase in population from 1930 to 1960. Added water demands come from an enlarged Clark Equipment factory and the addition of several "new" factories. On the McCoy Creek watershed in Buchanan Township, an 80 percent increase in home numbers[24] has occurred since 1930; an approximate 114 percent increase has occurred in Bertrand Township.

Two local well drillers (12, 13) who have been connected with the business for 15 to 20 years provided some additional information which is summarized below.

1) Spring water activity has decreased.
2) Wells in close proximity to McCoy Creek are still supplying water at 25-30 feet.
3) Wells along the north part of the watershed are about 60 feet deep and fairly stable.
4) Periodically they are called to redrill old drilled wells because they have gone dry.

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[23] City water is pumped from deep wells near the stream.

[24] Figures determined by comparing the number of houses indicated on a 1927 U.S. Geological Survey map with those now present on a 1960 aerial photograph. Results expressed in percent.

5) It was their opinion that very few hand-dug wells were still producing. Most of them have had to be drilled deeper.

Undoubtedly, increased tiling of farm lands adjacent to the creek has added to the reduction of hydrostatic pressure as has ditching activities.

From the preceding data it appears that the ground water supplies in the vicinity of the creek, seem adequate for human consumption. The data suggest however, that hydrostatic pressure in the watershed has been reduced. This pressure (or head), has been stated by Pollard,(1955), to be very important in determining the velocity of the ground water seepage, along with permeability of the gravel. Reduction in the stream's substrate permeability has already been demonstrated to be a logical aftermath of the erosion & siltation of former and recent years. Reduction in water head could also account for lack of pressure to force ground water through the stream's substrata. This in turn might explain an increase in stream temperature, a reduced stream depth, and a decrease in suitable trout spawning areas.

Limiting Factors

The foregoing data presented and their discussions suggest certain seemingly outstanding deficiencies in the stream's ecology. 1) A shortage of adequate spawning areas. 2) Inadequate production of bottom fauna determined from a food scale rating. 3) Low density of adequate adult trout shelter. Pools present are generally small in surface area and only sporadically distributed.

Suggestions for Management

Arranged in the suggested order of completion.

Environmental Improvement

Headwater Management.--It should be quite obvious to the reader that little can be accomplished to improve McCoy Creek for trout unless the lands in the headwater area are stabilized. Of prime concern are the bottom lands (Sections 16 and 19) from which much spring water emanates--and is the major source of siltation. The following discussion will concentrate on this area.

The author suggests several possibilities:

1) Through joint cooperation between the State Department of Agriculture and one of the State Conservation agencies, these bottom lands might be put into a soil bank trust or lease predicated on a long term management basis. Only after reaching a mutual agreement between the land owner, department, and the administering conservation agency, could these lands be put back into production. This should insure future safeguards against a recreation of the siltation problem once costly improvement measures are completed to "restore" the stream.

2) Elimination of the open ditches by installation of a network of tile drains. According to the local Soil Conservation agent, tiling would provide a more effective drainage system, discharging only relatively clear, cold water onto the stream. To accomplish this, some arrangement might be worked out through one of the conservation agencies, department, and local landowners.

3) A multi-purpose recreation area might be developed. The area would have to be purchased or leased on a long-term basis to assure proper management. The area is ideally suited for the establishment of a managed water fowl marsh. One water control structure would be needed near Buffalo Road. Only a limited amount of diking would be necessary because of the nearly ideal surrounding terrain. This area, administered by the Conservation Department could provide a fine water fowl nesting area. If desired, regulated (or open-to-the-public) shooting would create excellent local interest and recreational opportunities.

This arrangement would undoubtedly raise the water temperature of the stream. This increase, due to a readjustment of the stream's heat budget, could be approximated by computation. This increase could be offset, in part, by tapping the spring water under the large mounds scattered through the marsh. The water has varying amounts of vertical pressure which could conceivably be capped and controlled.

Literature has already been discussed concerning optimum and maximum water temperatures for brown trout. Near optimum water temperatures for brown trout could be maintained by installation of stream improvement devices.

The many cress beds now present are valuable for trout fingerling cover. Shelter for adult trout is greatly needed. Properly located stream improvement structures should increase the number of pools, undercut banks, etc.

Increasing Production of Bottom Fauna.--1) The preponderance of silts and sands forming the substrata appears to offer an inhospitable environment for most aquatic fauna. It is the author's opinion that to assure water velocity of sufficient swiftness to maintain an unsilted bottom, the total stream width in Sections II, III, and IV should be reduced 3-4 feet and 5 feet respectively.

2) Addition of rocks on the scoured bottom could create riffle areas and in general, a more suitable habitat for bottom fauna. Gravel size similar to that used along railroad grades should prove adequate.[25]

Creation of Spawning Areas.--Various workers (Needham, 1961; Stuart, 1953; Webster, 1962) have demonstrated the possibility of creating artificially attractive trout spawning situations. Further field application of these

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[25] Figure 12, results of sample 49.

methods may provide the necessary additional spawning grounds in McCoy Creek which now appear to be very limited in their distribution. Investigations by the author using field tiling systems to simulate ground water upwelling through the substrata are being contemplated.

Trout Populations

Recommendations for management of the game fish populations would vary with the methods used to stabilize the watershed. If the present water temperature is maintained, or decreased through various measures outlined, a native brook trout fisheries along with improved brown trout conditions, might be developed. If the water temperature permitted only brown trout inhabitation, pre-season and early season stocking with brook trout would provide fast but short-lived sport for the first two weeks. The brown trout would provide a good native population testing the skill of the trout fisherman and providing him with a good residual population which contained older and larger fish.

An alternate to the trout management program would be a serious evaluation of the stream for northern small mouth bass (*Micropterus dolomieu*) occupancy.

SUMMARY

Investigation of an eleven mile long stream (McCoy Creek) in southwestern Michigan was prompted by the scarcity of trout stream information available for this portion of the state.

The stream's past history was compiled with the aid of two public agencies and eleven selected local residents. Historical information indicates major dredging occurred in 1897; other significant bridge construction and dredging work was carried out in the mid-thirties and early forties.

All survey and map work was completed by wading or canoeing in the stream, and walking the bank. The stream was divided into nine sections and morphometric data were compiled for each section. Little attention was given the last section due to the water's constant exposure to industrial and sewage wastes.

The substrata were composed primarily of silt and a sand-silt combination. Other types in their order of abundance: sand-fine gravel, sand, medium gravel, and small rocks. Medium gravel and rock harbored the most bottom fauna; silt and sand-silts were the least productive. Water cress and Anacharais yielded good samples of fauna--primarily crustaceans. Vallisneria and *Potamogeton pusillus* harbored a rich fauna in the summer

only. Tendipedidae, Cylloepus and Hydropsyche were the most common insect types found in the samples. This stream appears to be low in aquatic fauna production.

Most of the stream was composed of moderately slow water (under one foot per second). The fastest water (over two feet per second) was in the lower one-sixth of the stream.

The gradient averaged 1.2 feet per 1,000 feet for upper 84 percent of the stream's course; 59 feet per 1,000 feet for the lower 16 percent.

Water shading by bank shrubs was fairly good, ranging from very little (Section IV) to almost 100 percent coverage (Section V). Shading apparently had some effect on water temperature during certain warmer months.

Water cress was fairly well distributed and sporadically plentiful. Most other aquatic plants varied in abundance with the seasons.

Very few logs, undercut banks or stream debris, were present.

The predominant water type for the stream was flats, and much less common runs and riffles. The stream-pool area ratio was very poor.

Results from fishermen's questionnaires indicated the catch to consist primarily of brook trout, 7-10 inches long, and some slightly larger. A few 7-14 inch brown trout were reported. A small number of sub-legal sized trout were reportedly caught. The native trout population appears to be composed of brown trout with a low population density.

A sampling of 2 percent of the stream by electrofishing returned no trout. Mud pickerel was the most common fish with a few horny-head chubs and white suckers recovered.

Seining results indicate a correlation between forage fish abundance and distribution with substrate type. The trout/forage fish ratio appears to indicate an unfavorable competition situation for the trout. The species of forage fish inhabiting the stream suggests it to be one of marginal value for trout.

Crayfish appeared to be quite abundant in the sand and gravel substrata.

Only 4 substratum seepage areas were located. Their importance to trout spawning was discussed. A general reduction in hydrostatic pressure in the creek's watershed seems to have occurred over the years. This reduction was evaluated in terms of increases in rural and urban populations.

The major limiting factors appeared to be: 1) a shortage of adequate spawning facilities. 2) Low aquatic fauna production. 3) Lack of shelter for adult trout.

LIST OF INFORMANTS

Names of Informants**	Length of residence yrs.	Fished stream consistently Yes*	No
1. Coleman, John	50		X
2. Ferguson, Ivan	66	1925-1940 Buffalo Road to M-60	
3. Frame, William, Sr.	80		X
4. Haas, Walter	55		X
5. Hanover, Roscoe	40	1928-1955 M-60 to city limits	
6. Hassinger, Victor	18		X
7. Kingery, William	20		X
8. Klasner, Floyd	40		X
9. Redden, John	81	1920-1961 1. Entire stream 2. More recently upstream from M-60	
10. Reinholdt, Lawrence	25		X
11. Rohl, Edward	43	1928-1930 1. M-60 to RR grade 2. Inside city's limits	
12. Ferris, Carl	Well driller		
13. Schutze, Fred J.	Well driller		

* Includes years in which the stream fished most consistently and the area of the stream most utilized.

** All currently residing in area except William Frame, Sr. who died in January, 1962.

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