The Relationship of Current and the Amount of Detritus to the Invertebrate Populations of Little Carp Creek

A Student Research Project
for Bio 585 Ecology of Streams

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July-August 1990

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ABSTRACT:

Little Carp Creek is a small, cold, spring fed, sand bottom, oligotrophic stream flowing into Burt Lake, Michigan. Using sediment size sorting screens, drying and Muffle ovens, Gurley meter and other equipment, data was obtained to allow an exploration of depth, current, sediment sizes, detritus, nutrients and the benthic invertebrates of Little Carp Creek. The small amount of detritus was determined to be the limiting factor in the distribution and concentration of benthic invertebrates in Little Carp Creek.

Key Words:

Benthic, Invertebrates, Benthic Invertebrates, Nematoda, Amphipoda, Gammarus, Chironomid, Pisidium, Physa, Limnephilus, Hirudinea, Detritus, Sediments, Substrate, Sand, Silt, Ash Free Dry Mass (AFDM), Little Carp Creek, University of Michigan Biological Station (UMBS), Oligotrophic, Streams, Spring-fed, Current, Gurley meter.

INTRODUCTION

Introduction to Little Carp Creek:

Little Carp Creek (LCC) is a small, cold, clearwater stream beginning in the Gorge as a series of spring fed streamlets and emptying into Burt Lake about 1 3/4 miles downstream to the south. The water in LCC seeps from South Fishtail Bay, Douglas Lake through glacial till for 1 mile, emerging through springs in the sandy soil. Sand is the dominant substrate the entire 1 3/4 mile length of the stream. There is some silt along the shore on inside curves and in backwater areas created by many logs or fallen trees. Some pebbles and granules are present in riffle areas. LCC is shallow, <30 cm deep in most areas.

The temperature of LCC remains very constant (11 -13°C) summer 1990, July 9-August 2. This is to be expected since it is a spring fed stream which is shaded its entire length.

No fish are obvious to an observer standing on the bank, although there appears to be some cover in the form of logs and undercut banks. Very little vegetation grows in the creek or along the edges; there are only occasional beds of Chara (stonewort) or Nasturtium (watercress) and these are few and far between. There is very little insect life apparent in the stream, only water striders (Gerridae - Hemiptera) being visible in any numbers. In general, LCC would seem to have a relatively low productivity.

Discussion of the Research Project:

The assumption or hypothesis is that a coorelation between substrate size and composition to the invertebrate populations in those substrates will be found. If a coorelation is found, it will be analyzed mathematically and graphically and several diversity indexes will be applied.

Little Carp Creek was chosen for study because it was felt that there would be few variables affecting the population diversity of the benthic invertebrates. As a spring fed stream, the water supply and quality should be very constant. Round, (15), in The Biology of Algae, states that springs may in fact be a more constant environment than more stable bodies of water such as large lakes. LCC has no tributaries after the 7 or so spring fed streamlets come together in the Gorge to form the stream. LCC flows through a White Cedar swamp habitat over a glacial outwash sand bed. The only other source of water apart from the springs in the Gorge is precipitation in the form of runoff and spring meltwater. The basic physical and chemical factors of the stream remain very constant according to other researchers (Tables 1, 2, 3). It is worth noting the stability of the ecosystem with regard to these parameters, the length of LCC and also with regard to the seasons.

Purpose:

To determine if there is a relationship between:

1. Depth and Current
2. Current and Sediment sizes
3. Current and Amount of Detritus
4. Current and Invertebrate populations
5. Sediment sizes and Invertebrate populations
6. Detritus and Invertebrate populations
7. Nutrient factors and Invertebrates

Materials:

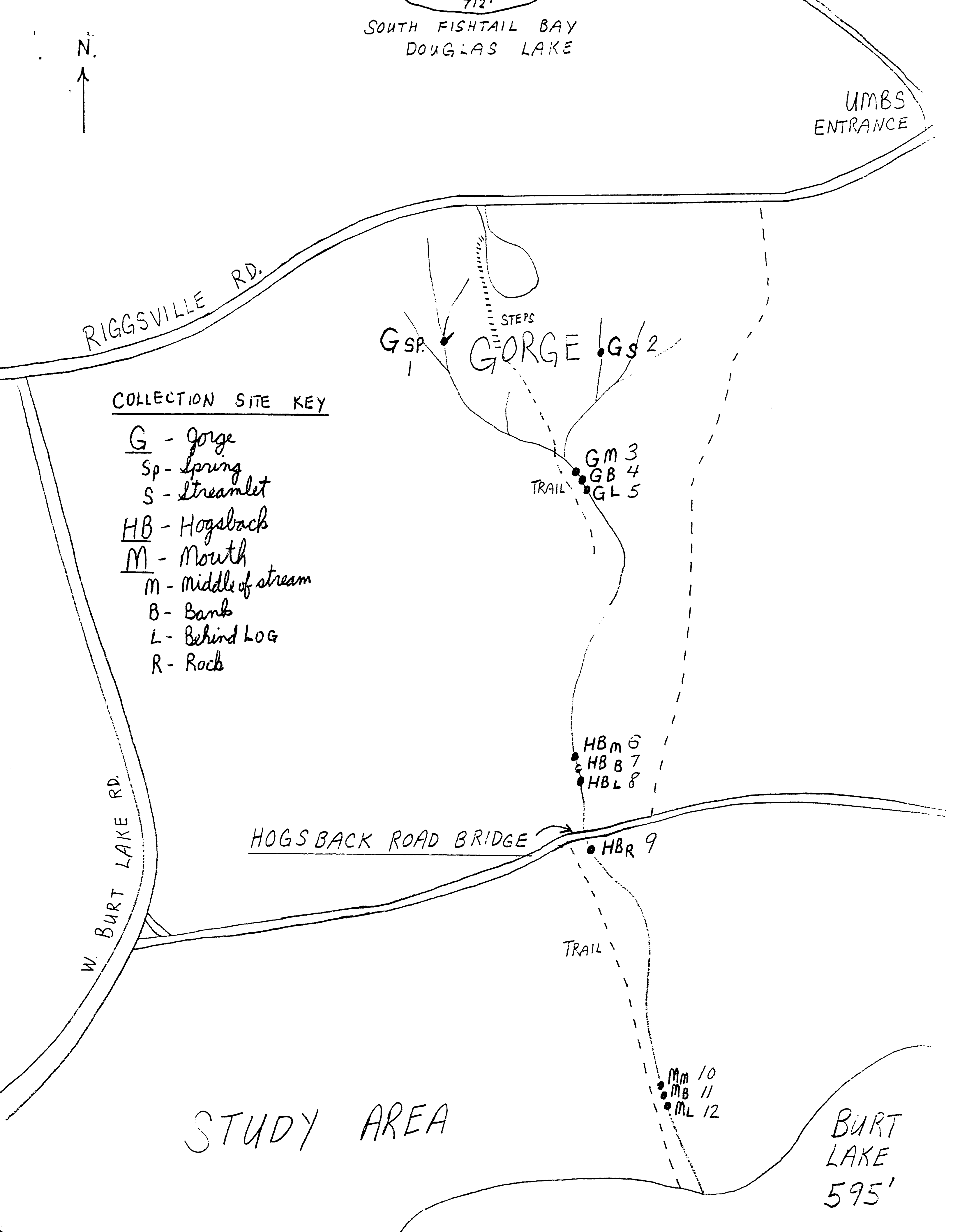
In Field	In Laboratory
Thermometer	Complete set of of Substrate sorting screens:
pH meter	(2mm, 1mm, 500um, 250um,125um, 63um
Conductivity meter	funnel
Pygmy Gurley meter	graduated cylinders
stop watch	forceps
meter stick	magnifying lens
small plastic ball	disecting scope and various keys
pails	Mettler balance
Substrate screen pan	aluminum dishes for drying samples
PCV Pipe (7.6 cm dia)	drying oven
	Ash free dry mass Muffle ovens

METHODS

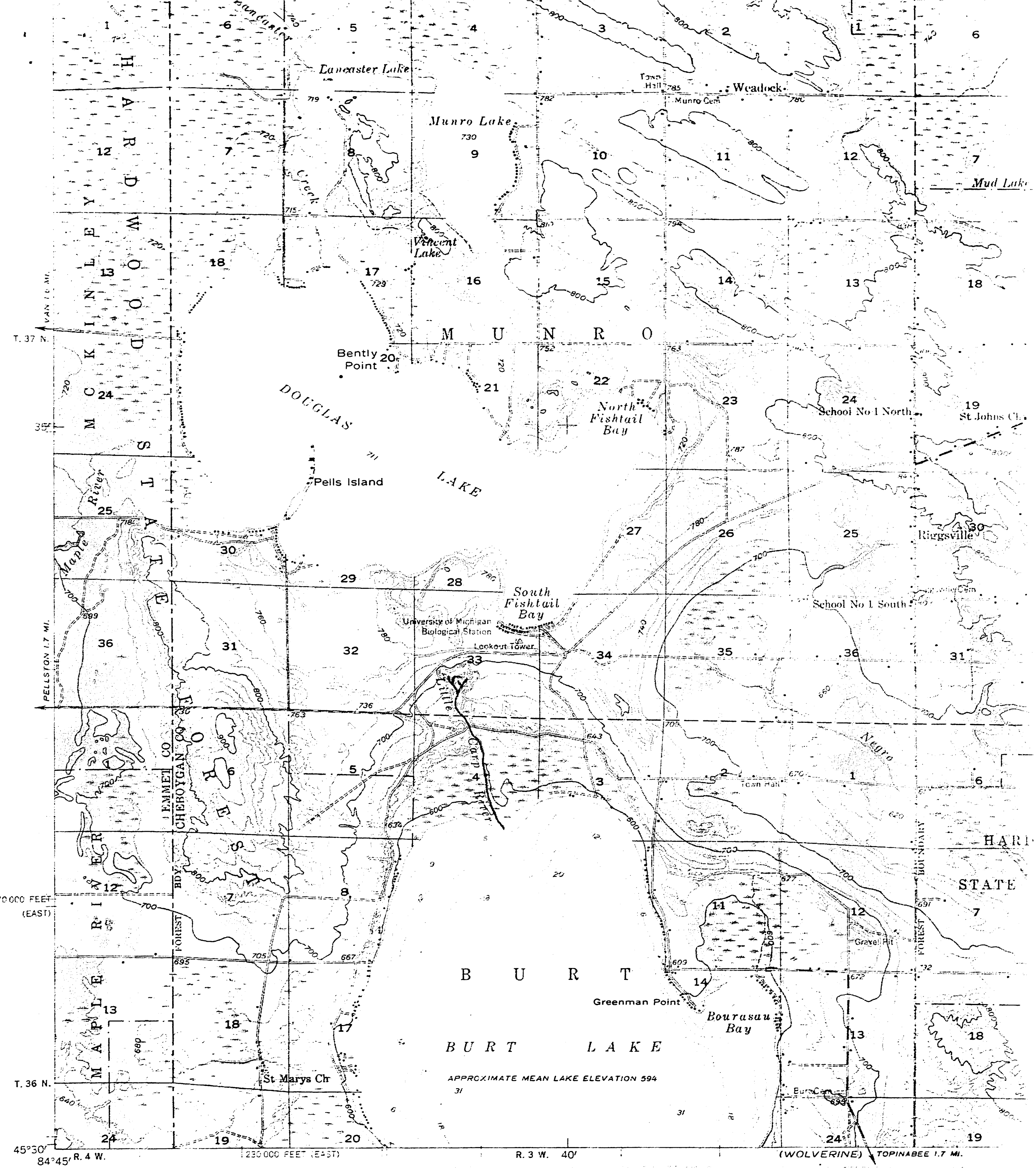
Study Area:

Tweleve sampling sites were selected in LCC for data and substrate samples. 5 in the Gorge (G), 4 near Hogsback Road bridge (HB) and 3 near the mouth of the stream (M). In each of the 3 regions of the stream a substrate sample was taken from the thalweg, from behind a log where the current had been altered and from near the bank where both depth and current were considerably less. An additional sample was taken near Hogsback Road bridge between two 20 cm rocks that had some green filamentous algae growth. Two additional substrate samples were taken in the Gorge, one from a streamlet, another from a spring itself. Following is a list of the sampling sites: (Sites are also indicated on map.)

1	G Sp	Gorge Spring - leaf and wood detritus over sand
2	G S	Gorge Streamlet - 10 m after emerging from a spring with gravel and some wood detritus mixed with sand
3	G M	Gorge, middle of stream in thalweg after convergence of streamlets, sand
4	G B	Gorge bank, grannules, sand silt, slow current
5	G L	Gorge behind log, sand
6	HB M	Hogsback, 100 m upstream from bridge in thalweg, sand
7	HB B	Hogsback, 100 m upstream from bridge near bank, 1/2 sand, 1/2 silt
8	HB L	Hogsback, 100 m upstream from bridgel behind log
9	HB R	Hogsback, 10 m downstream from bridge, between 2 rocks, sand and gravel
10	M M	Mouth, 100 m upstream from Burt Lake, sand
11	M B	Mouth, 100 m upstream from Burt Lake along bank; sand, detritus, silt
12	M L	Mouth, 100 m upstream from Burt Lake behind log, sand



712'
SOUTH FISHTAIL BAY
DOUGLAS LAKE
N.
UMBS
ENTRANCE
RIGGSVILLE RD.
STEPS
G SP. 1
GORGE
G S 2
COLLECTION SITE KEY
G - Gorge
Sp - Spring
S - Streamlet
HB - Hogsback
M - Mouth
m - middle of stream
B - Bank
L - Behind LOG
R - Rock
GM 3
GB 4
TRAIL
GL 5
HBm 6
HB B 7
HB L 8
HOGSBACK ROAD BRIDGE
HB R 9
W. BURT LAKE RD.
TRAIL
Mm 10
MB 11
ML 12
STUDY AREA
BURT
LAKE
595'



Mapped, edited, and published by the Geological Survey

SCALE 1:62500

1 ½ 0 1 2 3 4 MILES

3000 0 3000 6000 9000 12000 15000 18000 21000 FEET

1 .5 0 1 2 3 4 5 KILOMETERS

TRUE NORTH

MAGNETIC NORTH

4°

APPROXIMATE MEAN DECLINATION, 1957

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS 594 FEET
FOR BURT LAKE, 593 FEET FOR MULLETT LAKE, AND 579 FEET FOR STRAITS OF MACKINAC

MICHIGAN

QUADRANGLE LOCATION

Methods:

At each sampling site the following field data was taken: date, time, initial description of substrate, depth, water temperature, pH, conductivity, and current velocity. Whenever possible 2 methods were used: a direct method with a hollow plastic ball, meter stick and stop watch (3-10 trials) and 3-5 readings with a Pygmy Gurley meter at 3 different depths - 2 cm below surgface, .6 depth and 2 cm above substrate. A substrate sample was taken at each collection site to a depth of about 5 cm.

Upon returning to UMBS, each substrate sample was filtered through sediment size sorting screens and examined thoroughly and carefully for any invertebrates >63 um, the smallest filter screen mesh size. Invertebrates were identified. Each sediment size subsample was measured in graduated cylinders after it was allowed to settle.

A subsample of each sediment size was then put in a drying oven until all moisture was removed (usually 24+ hours at 100 °C). A careful weighing of each sample before and after it was then placed in a Muffle oven for 6+ hours at 550 °C allowed calculation of ash free dry mass (AFDM) and thus the proportions of inorganic and organic matter in each sample size.

Data was recorded, a summary of the substrate written and calculations of invertebrates per meter squared made.

The following graphs were prepared and analyzed:

1. .Depth vs Current
2. Sediment size vs Current
3. % Detritus vs Current
4. Total Invertebrate Concentration vs Current
5. Total Invertebrate Concentration vs Sediment size
6. Total Invertebrate Concentration vs % Detritus
7. Conductivity vs position in stream

Calculations of the Invertebrate diversity at each site were made using Simpson's Diversity Index.

Water chemistry, plant, algae, invertebrate and fish data were obtained from 3 previous UMBS student research papers and compared to the data obtained in this study.

RESULTS

Summary Table of
Abiotic and Biotic Results

Substrate Summary and
Benthic Invertebrates Found
for all Sample Sites

Graphs

1. Depth vs Current
2. Sediment Size as a function of Current
3. % Organic Detritus vs Current
4. Invertebrate Concentration vs Current
5. Invertebrate Concentration as a function of Sediment Size
6. Invertebrate Concentration as a function of % Organic Detritus
7. Conductivity vs Position in LCC

DATE 19..	TIME	SITE	DEPTH (cm)	TEMP. (°C)	pH	CONDUCTIVITY	VELOCITY cm/sec: DIRECT METHOD BALL	VELOCITY cm/sec: PYGMY GURLEY METER	SUBSTRATE SUMMARY	% ORGANIC DETRITUS	INVERTEBRATES COLLECTED	INVERTS PER m^2	COMMENTS
7/27	9AM	1 GSP	2	11	11.2	290	10	S .6 B X	83% SAND	8.3	1 Chironomid	222	8.3% organic detritus was leaf, wood on surface too large pieces for Inverts. 1 Chironomid in sand
7/24	2pm	2 GS	3	12	10.2	290	X	S 21 .6 B	37% granules/gravel 55% SAND	7.1	0	0	7.1% organic detritus was wood size of gravel - not small enough for Inverts
7/24	3pm	3 GM	13	12	11.3	280	29	S 23 .6 20 B 17	90% SAND 9.4% SILT	est. <1	0	0	Not enough organic matter to serve as food for Inverts
7/27	9AM	4 GB	2	11.5	11.0	290	2	S .6 B X	30% granules 68% SAND	5.3	5 CLAMS Pisidium 7 Chironomids	2667	organic detritus was fine leaf litter - good food source for Clams and Chironomids
8/1	8AM	5 GL	10	12	11.0	280	10	S .6 B est <10 <10 <10	99% SAND	est <1	0	0	Not enough organic matter to serve as food for Inverts
7/20	2pm	6 HBm	27	13	9.4	290	36	S 34 .6 31 B 28	96% SAND	est. <1	0	0	Not enough organic matter to serve as food for Inverts
7/20	3pm	7 HBB	10	13	9.3	300	14.4	S 5.3 .6 5.8 B 5.3	49% SAND est 45% SILT + FPOM 6% shreded leaf litter	11.5	1 SNAIL PHYSA 22 CLAMS PISIDIUM 194 Nematodes 3 LEECHES 15 GAMMARUS 107 Chironomids 1 Caddis Fly Limnephilus	3576	Inverts .6g after AFDM .21% of organic matter 11.5% with CPOM + FPOM
8/1	10AM	8 HBL	16	13	?	290	27	S 21 .6 16 B 13	98% SAND	est <1	0	0	Not enough organic matter to serve as food for Inverts
7/29	9AM	9 HBR	22	12	11.5	290	53	S .6 B X	63% granules/gravel with 6% detritus 36% SAND	4.4	3 NEMATODES 1 GAMMARUS 2 Chironomids	1332	Not alot of detritus (4.4%), but enough for Inverts also good current to bring D.O. + FPOM!
7/27	2pm	10 Mm	17	13	11.5	250	37	S 34 .6 30 B 28	5% Bark, Twig, leaf 94% SAND	13.7	1 GAMMARUS	222	Although 13.7% detritus, it was chunks of bark, twigs, needles - not small enough for food source. Gammarus in sand.
7/27	3pm	11 MB	4	13	11.9	255	8	S .6 B X	17% LEAF, TWIG DETRITUS 65% SAND 12% SILT	17	2 CLAMS - PISIDIUM 5 GAMMARUS 20 Chironomids	6000	Good supply of CPOM at top and in sand, and FPOM in SILT!
7/27	4pm	12 ML	20	13	11.5	250	29	S 26 .6 21 B 18	95% SAND	2.3 AVE. 6.0	0	0	Not enough organic matter to serve as food for Inverts

All sample sites G, H3 and M combined

Substrate Summary:

Little Carp Creek Substrate is predominately sand with some granules and gravel in headwaters at Gorge, and just downstream from Hogsback Road bridge (most likely from the road). Some silt and detritus occurs along banks where the current is slow. The 12 substrate samples had an average of only 6 % organic detritus, and some of that was twigs, chunks of wood, and needles - hardly suitable as food for small invertebrates.

TOTAL Invertebrates Found: from 6 sample sites Invertebrates per M^2

P. Nematoda 197

P. Mollusca

C. Gastropoda 1 Physa

C. Pelecypoda 29 Pisidium

P. Annelida

C. Oligochaeta

C. Hirudinea 3

P. Arthropoda

C. Crustacea O. Amphipoda 22 Gammarus

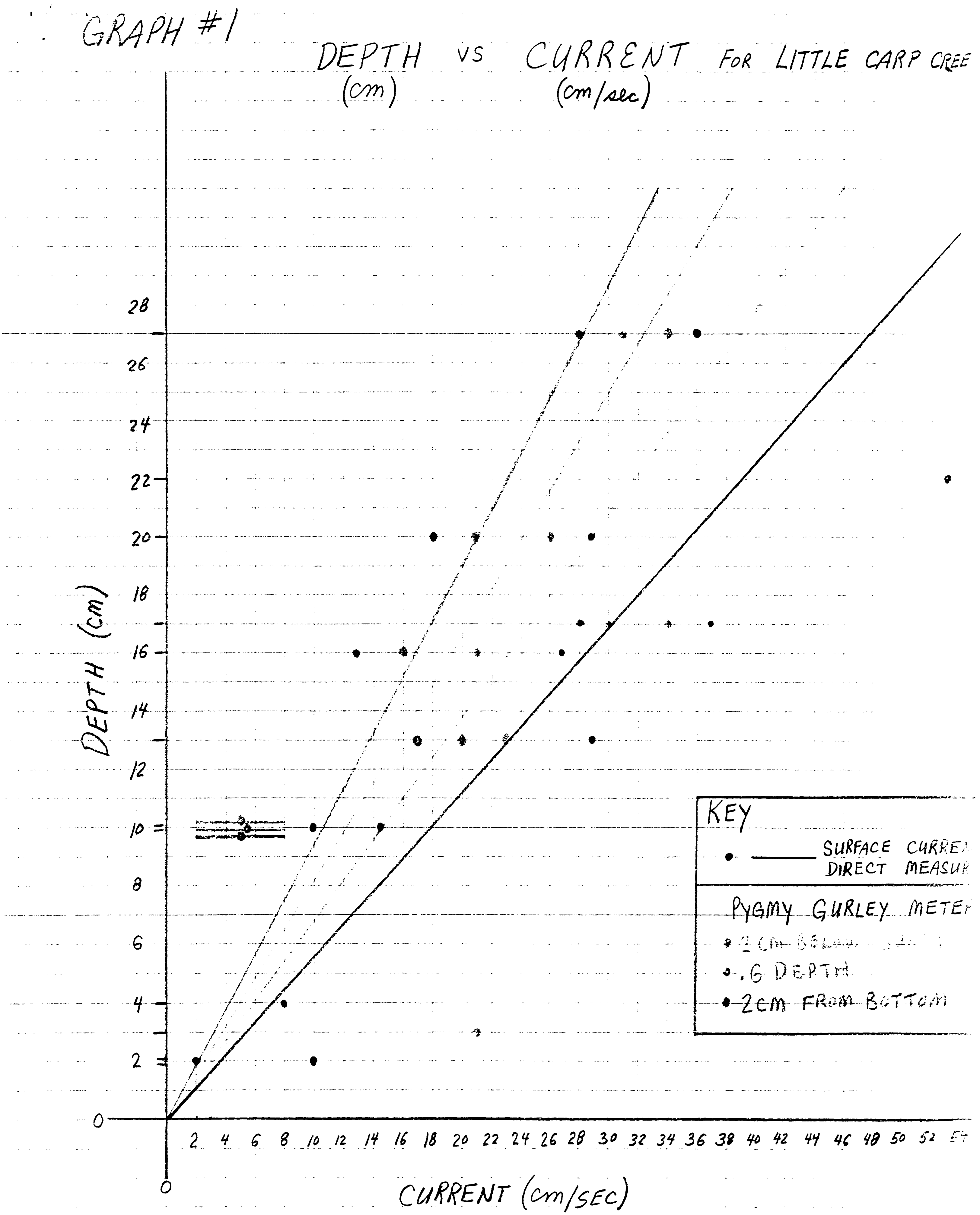
C. Insecta O. Plecoptera

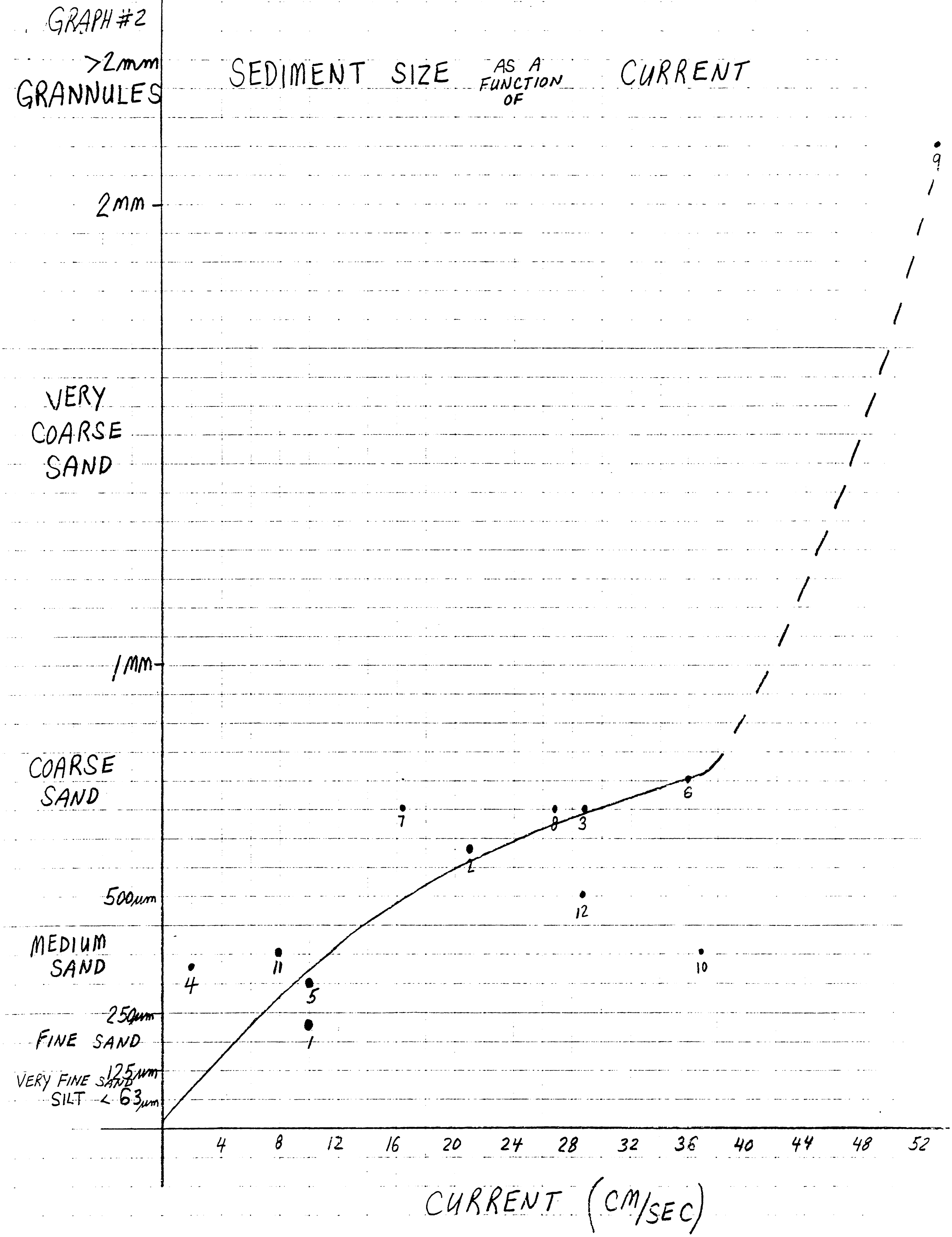
O. Trichoptera 1 Limnephilus

O. Diptera

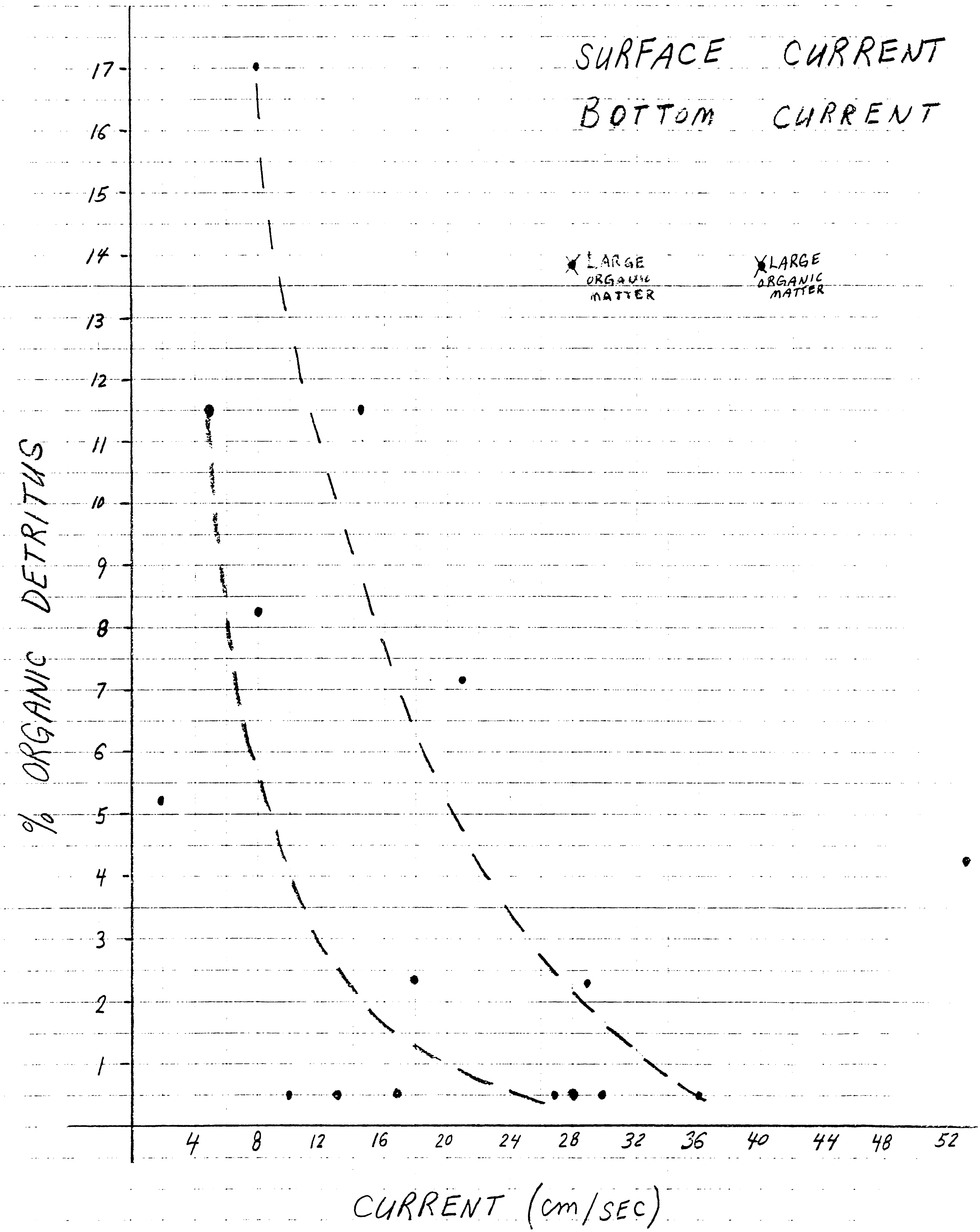
F. Chironomidae 130 Chironomids

TOTAL 383


GRAPH #1
DEPTH (cm) VS CURRENT (cm/sec) FOR LITTLE CARP CREE
DEPTH (cm)
CURRENT (cm/SEC)
KEY
SURFACE CURRE
DIRECT MEASUR
PYGMY GURLEY METE
.6 DEPTH
2cm FROM BOTTOM

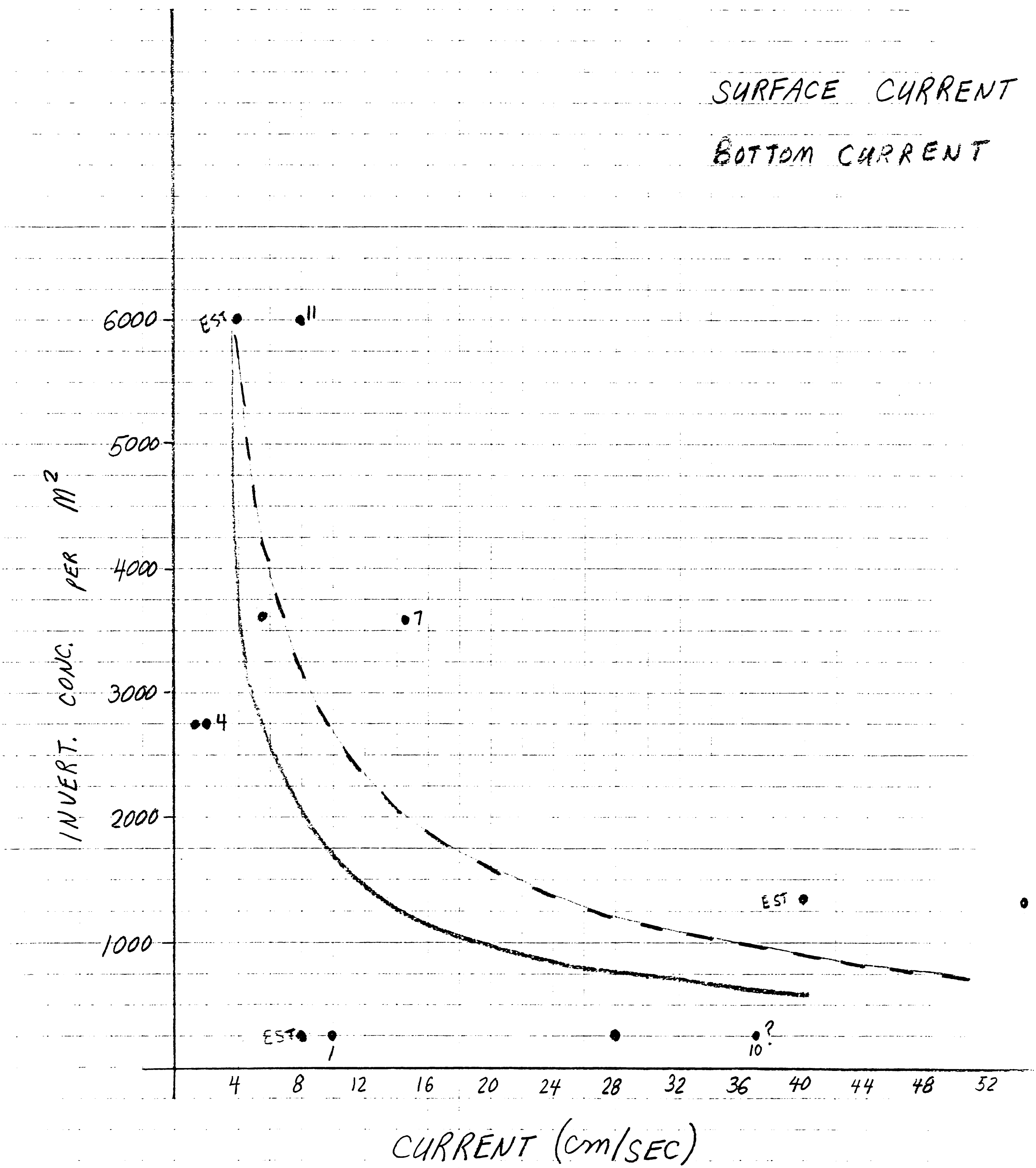

GRAPH #2
SEDIMENT SIZE AS A FUNCTION OF CURRENT
>2mm GRANNULES
2mm
VERY COARSE SAND
1MM
COARSE SAND
500µm
MEDIUM SAND
250µm
FINE SAND
125µm
VERY FINE SAND
SILT < 63µm
4
8
12
16
20
24
28
32
36
40
44
48
52
CURRENT (CM/SEC)
1
2
3
4
5
6
7
8
9
10
11
12

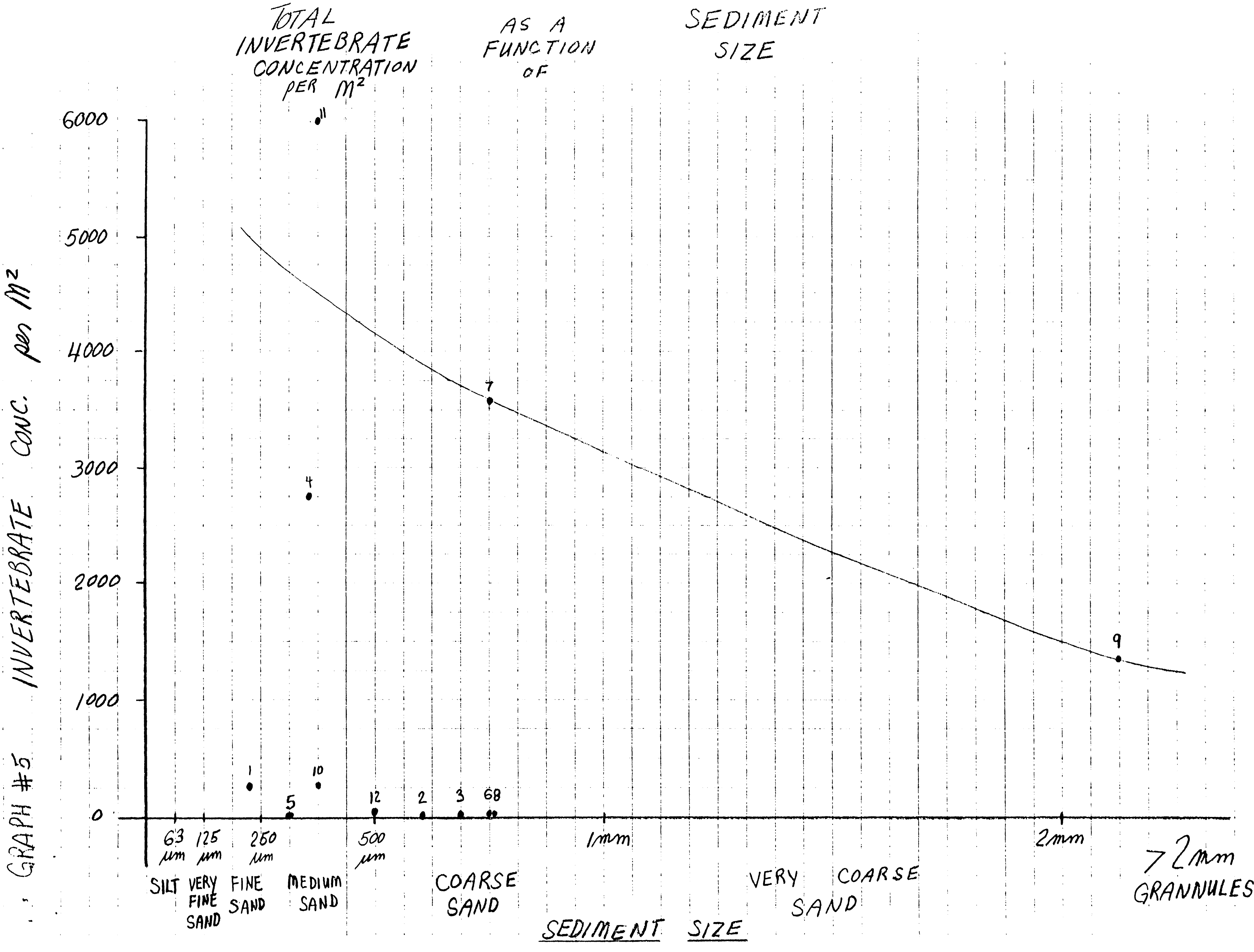
GRAPH #3 % ORGANIC DETRITUS VS CURRENT



GRAPH #4

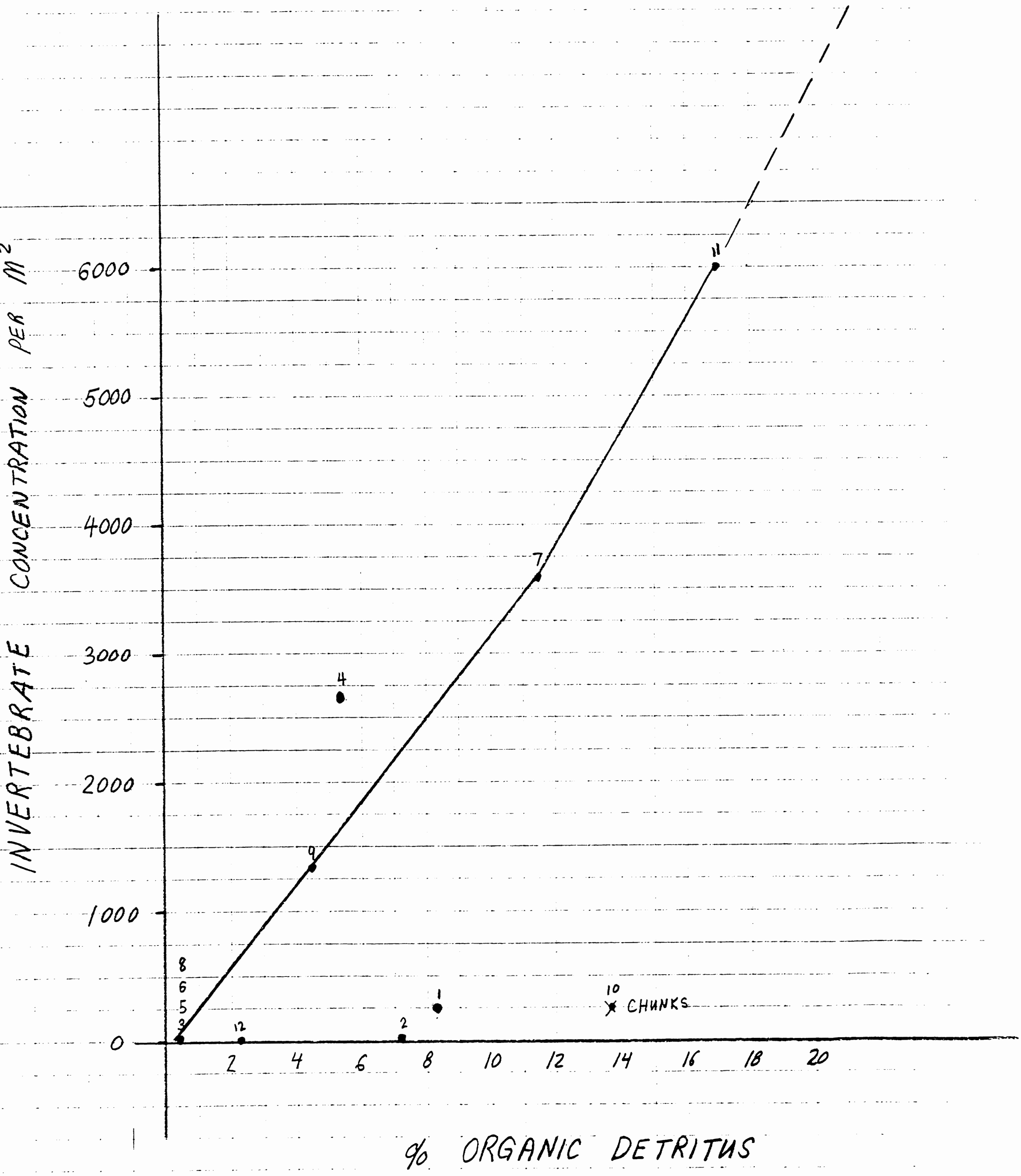
TOTAL INVERTEBRATE CONCENTRATION PER M^2 VS CURRENT cm/SEC



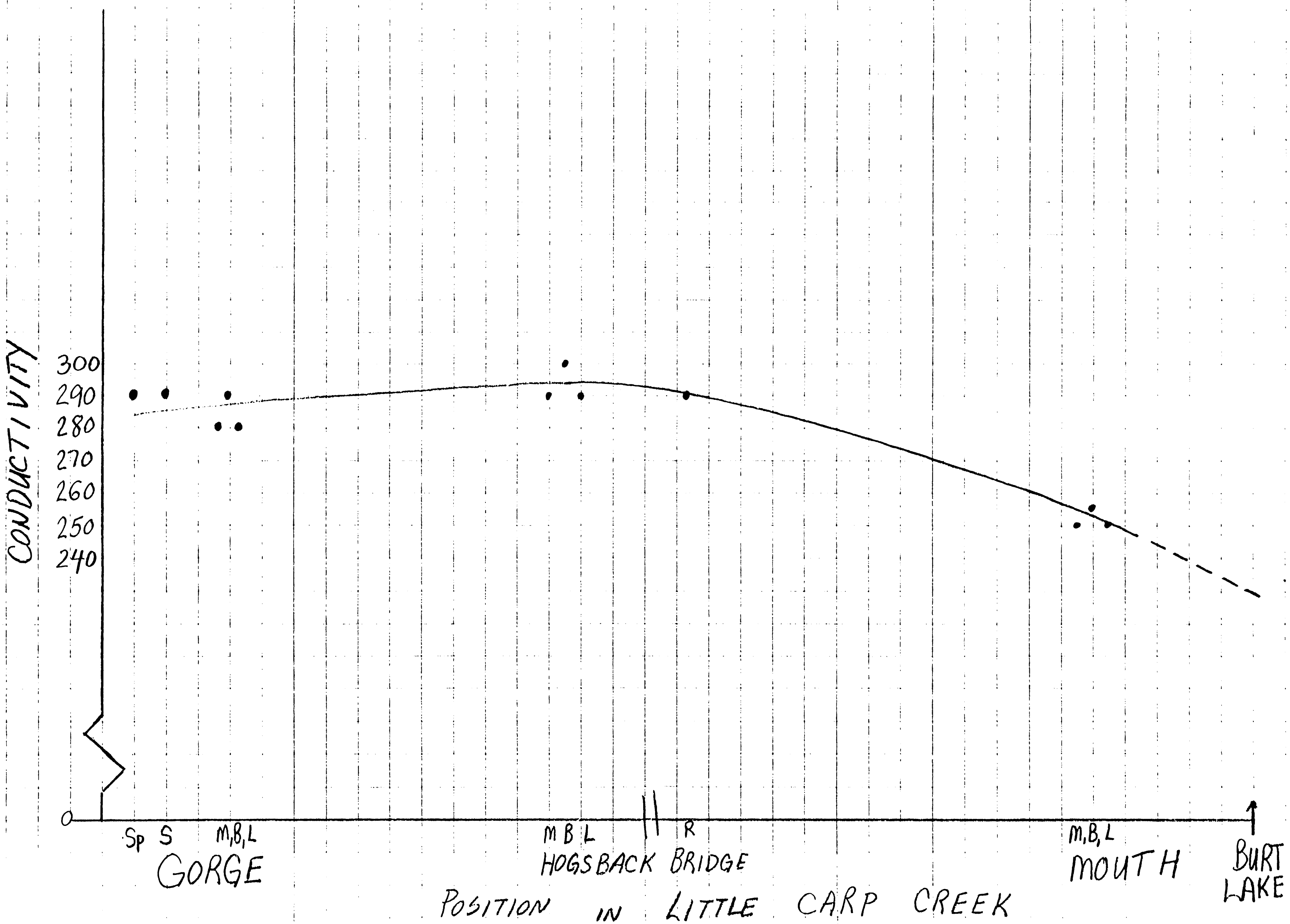

TOTAL INVERTEBRATE CONCENTRATION PER M²
AS A FUNCTION OF
SEDIMENT SIZE
INVERTEBRATE CONC. per M²
GRAPH #5
6000
5000
4000
3000
2000
1000
0
11
4
7
9
1
10
5
12
2
3
68
63 µm
125 µm
250 µm
500 µm
1mm
2mm
>2mm
SILT
VERY FINE SAND
FINE SAND
MEDIUM SAND
COARSE SAND
VERY COARSE SAND
GRANNULES
SEDIMENT SIZE

GRAPH # 6

TOTAL INVERTEBRATE CONCENTRATION PER M² AS A FUNCTION OF % ORGANIC DETRITUS



CONDUCTIVITY vs POSITION IN CARP CREEK



GRAPH #7

DISCUSSION

Diet Analysis of the Benthic Invertebrates of Little Carp Creek:

According to the River Continuum Concept by Ken Cummings, 1980, (4), most of the invertebrates of a 1st order stream like Little Carp Creek (LCC) should be Collectors/Gatherers/Filter Feeders or Shredders. Only a few Grazers and Predators should be present. The Production to Respiration ratio should be less than one ($P/R<1$). Since the stream is shaded, originates from springs and has a sand bottom with only 6% organic detritus, it can be classified as an oligotrophic stream. The small amount of detritus is overwhelmingly allochthonous, so indeed there must be more respiration than production. Even though LCC has a low concentration of invertebrates, in a Food and Energy Pyramid model, LCC has even less macrophytes and algae by comparison.

What do invertebrates of LCC feed on? According to Pennack, 1978, other various references, Dr. Jan Stevenson and Rich Schultz of the University of Louisville, here is an analysis of the diet of the invertebrates of LCC:

197 **Nematodes**: Nematodes are detritivores and feed as collector/gatherers. Some species only feed on dead plant material, some only on dead animal material, some both. A few are herbivorous, some even predaceous and of course there are well known parasitic forms.

"Nematodes are very ecologically and physiologically adaptable" (12). Nematodes are found in the top 5 cm of substrate (this researcher sampled to that depth), most in the top 2 cm. Nematodes can tolerate low $O2$ concentrations and only 2-10% oxygen saturation. They can even survive anaerobic conditions for several days to a few weeks. Nematode eggs are highly resistant and can remain viable for months without oxygen and after repeated freezing and thawing.

Nematode concentrations can exceed $100{,}000/m^2$ in some sediments. In the sand/silt of LCC near the banks, Nematode concentrations varied from $222/m^2$ to $2000/m^2$. They must be feeding on the Course Particulate Organic Matter (CPOM) in the detritus. They were found in the detritus, not in the sand.

130 **Chironomids** (Order Diptera, Class Insecta): Chironomids or midges are also detritivores and are classified as collectors. They too were found in the CPOM, not in the sand.

Chironomids can capitalize on any available food items and thrive under a variety of conditions. They also have a great reproductive capacity. They are abundant in many aquatic ecosystems and eat mainly detritus and algae.

29 **<u>Pisidium</u>** (Family Sphaeridae, Class Pelecypoda): Fresh water clams, including those in family Sphaeriidae are filter feeders. They eat Fine Particulate Organic Matter (FPOM) in the detritus that is dislodged from the substrate. According to Pennak 1978 (12), "Plankton forms only a minor element of the diet of Sphaeriidae. It has been found that some Sphaeriidae can remove FPOM as small as 1 um from the water with their siphons. Subsurface mud/silt Sphaeriids have a mechanism for suspending FPOM and bacteria in suspension momentarily, to be filtered out promptly and taken into the digestive tract. Silt particles injested are carried backward by ciliary action and expelled just before the inhalent <u>siphon</u>."

22 **<u>Gammarus</u>** (Class Amphipoda):Amphipods are usually collector/gatherers when found in detritus and sand. Some are shredders. Some are herbivores. According to Dr. Jan Stevenson, and Kerfoot (20), <u>Gammarus</u> will use <u>Nasturtium</u> as a food source. According to Pennak, 1978 (12) "Some Amphipods will occasionally attack live animals; but most are voracious feeders on dead plant and animal detritus."

Amphipods, including <u>Gammarus</u> are nocturnal. They react negatively to light and are found buried in the detritus or under debris during daylight. In the substrate filter screen pans, they would crawl or swim to the edge of the pan on the shaded side or burrough back into the sediment.

Amphipods need ecologically clear, unpolluted waters, including springs, spring brooks, streams, pools, ponds and lakes, so it is not surprising they would be found in the clean, cold spring-fed LCC. Amphipods are found in abundances above $10{,}000/m^2$ in clean, cold streams with lots of rooted vegetation. LCC has very little rooted vegetation. Concentrations of <u>Gammarus</u> in LCC were found to vary between $160/m^2$ and $1100/m^2$. Amphipods require alkaline water with abundant dissolved oxygen. Certainly LCC fits <u>Gammarus'</u> needs in these departments.

3 **Hirudinea** (Leeches): Leeches are detritivores, collectors/gatherers. The 3 found were small (about 1 cm) and were in the sample with the most silt and small sized detritus.

1 **Physa** (Class Gastropoda): The great majority of fresh water snails are herbivores and detritivores classified as grazers.

1 **Limnephilus** (Order Tricoptera): This caddis fly was probably a grazer.

Of the 383 Invertebrates collected in the substrate samples from LCC, 381 were collector/gatherers or filter feeders mainly of detritus. 2 were grazers.

Conclusions from Graphs and Data Analysis:

1. Depth and Current: a direct coorelation does exist between depth and current velocity (graph 1). 9 of 12 sample sites confirmed this pattern and the other 3 sites were close to the pattern. The faster currents in the thalweg erodes more sediments causing greater depths and the greater depth provides more water pressure which increases current.

2. Current: as discussed in Hynes 1970 (9) and many other stream textbooks, the surface and sub-surface current was always faster than the current at the bottom and the current at .6 depth was usually the mean current (graph 1 and Pygmy Gurley meter readings). This is to be expected as the current on the bottom experiences frictional forces from the sediments.

3. Pygmy Gurley Meter vs Direct measure: the Pygmy Gurley meter readings of current were consistantly less than direct measure currents computed by measuring the time a hollow plastic ball took to float with the current for 1 or 2 meters. The Pygmy Gurley meter readings averaged 87% of the direct measure readings. Therfore, readings with the Pygmy Gurley meters should be adjusted by a factor of 1.1494.

4. Pygmy Gurley Meter readings of Slow currents: at currents less than about 20 cm/sec or slow variable currents, the Pygmy Gurley meter is not reliable. At sample site 7, the current was 14.4 cm/sec as determined by the direct method; whereas, the Pygmy Gurley meter reported a current of only 5.3 cm/sec. Perhaps there is an initial force needed to get the Pygmy Gurley meter cups moving and start them up again in a variable current. Momentum is lost in a slow or variable current. To push the metal cups takes more force than to push a very light weight, hollow, plastic ball.

5. Sediment Size and Current: sediment size in the substrate of LCC did increase with faster currents, just as any textbook in geology or streams would state. However, size sorting of sediments is not as perfect as the textbooks lead us to believe. There was alot of variability in every one of the 12 substrate samples collected and filtered through the 6 sediment size filter screens. (Refer to each data sheet and graph 2 for confirmation of this conclusion.)

6. Detritus and Current: the amount of detritus decreases with an increase in current. (Refer to each data sheet and graph 3.) Since detritus is organic, it would have a lower specific gravity than inorganic sediments and thus be more easily moved by the current; so one would expect to find more detritus along the bank and in backwater or other slow current areas of a stream. The coorelation was best if one used data for bottom currents. (Red line on graph 3.)

7. Benthic Invertebrates and Current: the benthic invertebrate population concentration showed an inverse relationship with current; i.e., where the current was slower more benthic invertebrates were foumd. This of course would also relate to there being more detritus in the substrate samples where the current was slower; thus the benthic invertebrates which were all detritivores would have more food available there. There would also be less of a chance of being washed downstream in the more stable sediments where the current was slower. (Refer to data and graph 4.)

8. Benthic Invertebrates and Sediment Size: graph 5 indicates that more invertebrates were found in samples with smaller sediment size. This would be consistant with conclusions 6 and 7. However, there were several samples with no invertebrates found, so, conclusions 6, 7, and 9 are more valid.

9. Benthic Invertebrates and Detritus: there were greater concentrations of benthic invertebrates found where there was a greater amount of detritus (graph 6). This would certainly be expected since detritus is the food source for most or all of the benthic invertebrates collected. Sample site 10 had only 1 Gammarus, concentration = 222/m^2 and 13.7% organic matter. However, most of that detritus was chunks of bark, twigs and conifer needles - hardly small enough or nutrient rich enough for a substantial benthic invertebrate population.

10. Conductivity: the conductivity readings for LCC were relatively high, (average 290 in Gorge and Hogsback regions of stream, average 320+ from 1975-6 and 1985 data) indicating a substantial concentration of ions. These dissolved ions come from Douglas Lake and a mile of glacial till that the water in LCC must pass through in its journey from South Fishtail Bay, Douglas Lake to the springs in the Gorge. The conductivity at the bottom of South Fishtail Bay is 240. The conductivity in LCC at the mouth was 250, indicating ions being taken out of the water from Hogsback downstream. Perhaps algae and plants are absorbing them. (Refer to graph 7 and data from 3 previous UMBS student research papers 18, 16, 5.)

11. pH: pH readings were consistantly high (9.3-11.9) I suspect the pH meter used was not accurate. Jon Wendle, 1975 (18) showed values between 8 and 8.2. At any rate, the water in LCC is alkaline and probably very constant its entire 1 3/4 mile length.

12. D.O., Nutrients and Detritus: data from Kathy Schultz's Limnology research project in 1985 showed that LCC had high levels of O2 (8.6 Gorge, 9.2 Hogsback), high % O2 saturations (78%, 83%) and high NO2 concentrations (62.5, 75.0 mg/L). These high D.O. and nutrient concentrations would support much higher invertebrate opoulations than either Jon Wendle or this researcher found. The small amount detritus must therefore be the limiting factor in LCC.

13. Finding Benthic Invertebrates in your Substrate Samples: don't preserve samples until after they are searched for benthic invertebrates and pick samples as soon after collecting as possible. Animals were found by diluting small 50 ml substrate samples and watching for movement. Examples of invertebrates which were found mainly because of their movement: caddis fly - it was a stick that moved; little Amphids; leeches would have just looked like brown/black stick detritus; many small Chironomids and Nematodes which otherwise would have camouflaged with the sediment if they had not wiggled.

Future Research Possibilities:

1. More samples, more sample sites, samples at other times of the day and throughout the year would provide additional data which should be helpful to understanding the relationships between abiotic and biotic components of LCC.

2. Identifying organisms to species.

3. Inclusion of algae in the study of LCC.

4. Study other streams with similar abiotic components to see how similar the Benthic Invertebrates are.

5. Study other streams with a greater range of currents and sediments.

Diversity Calculations for Benthic Invertebrates of Little Carp Creek

Simpsons Diversity Index

$$D = 1 - \sum_{i=1}^{S} (P_i)^2$$

P_i = proportion of each type (Genus) of organism
S = number of types of organisms

$$= 1 - [(P_1)^2 + (P_2)^2 + (P_3)^2 + \text{etc to } (P_S)^2]$$

Sample site 4: $D_4 = 1 - [(\frac{5}{12})^2 + (\frac{7}{12})^2] = 1 - .1736 + .3403 = 1 - .514$

$\underline{D_4 = .486}$

Sample site 7: $D_7 = 1 - [(\frac{1}{343})^2 + (\frac{1}{343})^2 + (\frac{3}{343})^2 + (\frac{15}{343})^2 + (\frac{22}{343})^2 + (\frac{107}{343})^2 + (\frac{194}{343})^2]$
$= 1 - .0 + .0 + .0 + .0019 + .0041 + .0973 + .3199 = 1 - .4332$

$\underline{D_7 = .5768}$

Sample site 9: $D_9 = 1 - [(\frac{3}{6})^2 + (\frac{1}{6})^2 + (\frac{2}{6})^2] = .250 + .028 + .111 = .389$

$\underline{D_9 = .617}$

Sample sites 1, 10 $D_{1,10} = 1 - 1^2 = \underline{0}$

Sample site 11 $D_{11} = 1 - [(\frac{2}{27})^2 + (\frac{5}{27})^2 + (\frac{20}{27})^2] = .0055 + .0343 + .5487 = .588$

$\underline{D_{11} = .414}$

Total all Samples $D = 1 - [(\frac{197}{383})^2 + (\frac{1}{383})^2 + (\frac{29}{383})^2 + (\frac{3}{383})^2 + (\frac{22}{383})^2 + (\frac{1}{383})^2 + (\frac{130}{383})^2] =$

$D = 1 - (.2645 + 0 + .0057 + 0 + .0033 + 0 + .1152) = 1 - .3887$

$\underline{D = .6113}$

Interpretation of Simpson's Diversity Index:

D=0 is no diversity; D=1 is complete diversity, with every animal being a different species. The diversity of LCC benthic invertebrates varied from D=0 to D=.617. The diversity for the stream as a whole was .6113, and for the site 7 with the greatest number of invertebrates collected, the value was .577; so even though the production of LCC is low, its diversity is a respectable 60%.

Beck's Biotic Index Classes:

Class 1 (2 N_1) 1 Trichoptera
29 Pisidium clams
Class 2 (N_2) 22 Grammarus
Class 3 (0) 1 Physa
3 Hirudinea
197 Nematodes
130 Chironomids

Beck's Biotic Index

Sample 4 $B_4 = (2 \times 1) + 0 = 2$

Sample 7 $B_7 = (2 \times 2) + 1 = 5$

all other Samples $B = 0$

Total as 1 sample $B_T = (2 \times 2) + 1 = 5$

Interpretation of Beck's Biotic Index:

Index values range from 0-40. The lower the value, the greater the stress on the organisms, or the lower the productivity of the habitat. An index value of <10 usually indicates a polluted environment

Little Carp Creek has a Beck's Biotic Index value of only 5. Since LCC is not polluted, one can conclude from the low index value that LCC is a low productive stream, due to such a small amoun of detritus, and the cold spring water. It could be described as a oligotrophic stream.

Sequential Comparison Index (SCI)

An SCI was not calculated for LCC because 2 sample sites had only 1 organism, and sample site 7 had 343 organisms - too much variation for an accurate SCI. SCI is only valid for sample sites with fewer than 250 specimens.

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