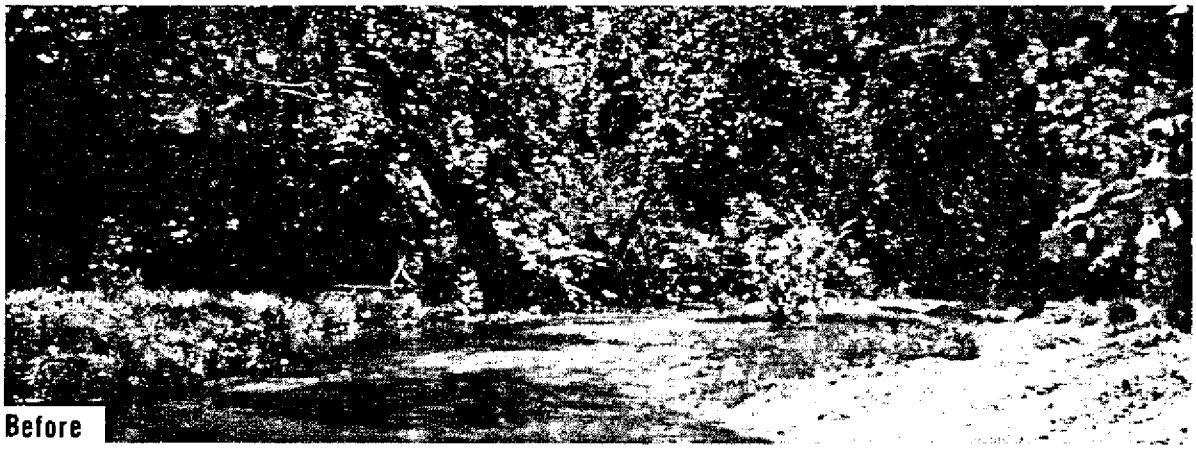
THE EFFECTS OF A CHANNEL RELOCATION PROJECT ON THE ECOSYSTEM OF LITTLE SUGAR CREEK

Benton County, Arkansas

FHWA/AR-80/002842



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16. Abstract

The widening of U.S. 71 in Northwest Arkansas required that the Arkansas State Highway and Transportation Department relocate a portion of the channel of the Little Sugar Creek. A channel relocation project, in which careful channel construction and provisions for habitat were an integral part of the plan; was carried out and the effects monitored. It was discovered that the planned channel relocation had little total effect on any parameter studied. The creek apparently recovered very rapidly and repopulation of the systems inhabitants was nearly total. This type of channel construction, rather than channelization, is recommended for environmentally sensitive projects where a stream alteration is unavoidable.

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TABLE OF CONTENTS

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ABSTRACT

The widening of U.S. 71 in Northwest Arkansas required that the Arkansas State Highway and Transportation Department relocate a portion of the channel of the Little Sugar Creek. A channel relocation project, in which careful channel construction and provisions for habitat were an integral part of the plan; was carried out and the effects monitored. It was discovered that the planned channel relocation had little total effect on any parameter studied. The creek apparently recovered very rapidly and repopulation of the systems inhabitants was nearly total. This type of channel construction, rather than channelization, is recommended for environmentally sensitive projects where a stream alteration is unavoidable.

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INTRODUCTION

Little Sugar Creek is a tributary of Elk River, Missouri, and drains a large area west, northwest, north, and northeast of Bentonville. The headwaters are in the region enclosed by Blansett, Rich, Humphrey, and Radcliff Mountains in the northeast area of Benton County (Branner, 1891). From its headwaters the stream flows through a narrow valley bordered on the north and south at frequent intervals by steep limestone bluffs. The creek has a general west course for 15 miles and then flows north-northwest to the Missouri border. The rock strata found along the course of Little Sugar Creek are predominantly limestone bluffs and chert with some sandstone and shale. Major tributaries to Little Sugar Creek are Spanker Creek, McKissick Creek, Tanyard Creek, and Pinion Creek. The latter tributary is dry except when spring rains cause a minor flow (Van Kirk, 1962).

The widening of 7.5 miles of the two-lane U.S. 71, beginning at Bella Vista and ending at the Missouri State Line, necessitated the relocation of the stream channel of the Little Sugar Creek for 700 feet at one point and 2,200 feet in another. The former channel of the creek was utilized as much as possible. In identifying the environmental impacts of the widening, it became apparent that there was not sufficient room for the roadway between the existing scenic bluffs on one side and Little Sugar Creek on the other.

The limestone bluffs are considered to be of both archeological and aesthetic significance. Aboriginal natives used the overhanging bluffs for shelter and as semi-permanent residences. Artifacts from this occupation have been found beneath the bluffs and studied by

the Arkansas Archeological Survey.

In conjunction with the U.S. Department of the Interior, Arkansas Game and Fish Commission and residents of Bella Vista, it was decided that Little Sugar Creek could be relocated in such a manner that the impact to its ecosystem would be minimized and that this would be more desirable than destroying the limestone bluffs.

After deciding that the channel of Little Sugar Creek would be relocated, plans were made to create habitat in the new creek channel to alleviate as many of the destructive effects of stream moving as possible. Some of the methods used included the incorporation of meanders to maintain stream length and add some flow diversity, the planting of trees to assist in reclaiming lost streamside vegetation, he placing of a digger log to replace and maintain a pool and the moving of some large boulders fron the old channel to the new one to provide some similar characteristics of the old channel in the constructed channel.

Past studies on artifically induced channel alterations indicate that the effects of the alteration depend on the type and amount of change in the stream structure that is induced by the type of channelization utilized. Channelization not only affects the life in the area of the stream that is channelized, but also the upstream and downstream ecosystems (Patrick, 1973). For these reasons and others, stream alterations are a popular source of controversy.

The parameters studied for this project were water chemistry (pH, conductivity, dissolved oxygen, temperature, turbidity, NO_3, SiO_2, alkalinity, suspended solids and PO_4), algae, invertebrates, streamside vegetation, fish and mammals.

ALGAL STUDIES
(Periphyton and Phytoplankton)

The purpose of this section is to contribute to our knowledge of the periphyton (attached) and planktonic (free-floating) algal community of Sugar Creek which runs through Bella Vista, Arkansas. This investigation is concerned with an area of just above Lake Bella Vista to a point just below the last site of channel relocation. The study consisted of qualitative seasonal collections taken between June 3, 1975 and May 1, 1977. Samples were collected above, below and at major sites of construction throughout the investigation.

Site Description

Station 1-clear, slow moving water with a pebble-small stone basin. The stream is bounded by a pasture on one side and un unmanaged meadow on the opposite side.

Station 2-is located below the Lake Bella Vista Dam overflow. This station is characterized by jagged rocks, with swift, often turbid water present. The stream is bounded by the roadside on the west and by a meadow on the east.

Station 3-originally was a slow moving pool. During the construction project this area was changed to a raceway which extended from Station 2 to Station 4. The stream bottom was composed chiefly of small stones and pebbles. The banks consist of a highway retainer wall to the west and a meadow to the east.

Station 4-construction altered this station from a moderately deep pool to a shallow pebble bottom raceway. There appears to be a good deal of disturbance in this area caused by campers (wading, etc.).

The stream is banked by campgrounds to the east and by the highway to the west.

Station 5-is a deep slow moving organically rich pool. This station is shaded throughout the summer. Leaf litter is commonly found in this area throughout the year. Trees and other vegetation are present on the banks in this area with the highway to the west and the campgrounds to the east.

Station 6-is located just below the site of the new bridge on Highway 71. The stream characteristics appeared unstable at this station due to floods, construction in the area, and construction of the golf course adjacent to the area. This area was altered from a shaded deep pool to a wide shallow pool and a narrow raceway. The stream is composed of small stones and pebbles in this area. It is presently bounded by an established golf course to the north and a newly developed golf course to the south.

Station 7-is located at the initiation point of channel relocation. This station site is identical to McCraw (1974) Station SC-1. The riffle area is located below a long pool which extends upstream several hundred yards. The stream basin is composed of pebbles. The stream is banked by the golf course with a portion of the bank riprapped.

Station 8-has been altered considerably due to rock removal in the stream bed by Bella Vista workers. This station is identical to McCraw (1974) Station SC-3. This station is presently characterized by a wide riffle area which receives water from a pool that extends from the riffle area at Station 7. The station is banked on the east by the highway and on the west by the golf course. The stream bed

is composed of pebbles and small rock which is continually being removed by Bella Vista workmen.

Qualitative algal collections consisted of rock and vegetation scrapings and plankton tows. Samples were preserved and identified to the species level when possible. Diatoms were identified to the genus level due to the extensive time required for specific identification. Many other organisms such as Spirogyra, etc. require sexual stages for specific identification. Still others can be forms unidentifiable due to lack of sufficient numbers, senescent cells or environmental growth forms. Samples were collected from each station from June 3, 1975 to May 1, 1977. Emphasis was placed on Stations 7 and 8 where major construction of rechannelization took place. The abbreviated distance span of the project limited the variability observed between any two pools or riffle areas.

In general, the algal genera observed were present before and after construction, without an observed shift in community composition directly due to the construction project. There were changes from station to station during any one sample date due to the nature of the station, i.e. pool or riffle. A shift in community structure was observed at those stations where the stream bed characteristics changed during the 3 year sampling regime. This shift was in part due to construction but flooding played a role in these shifts also. This is not to imply that the stream quality was altered, but rather that a shift in stream bed characteristics occurred, as one might expect. This same sort of shift can be observed in natural situations during

times of floods and low flow.

A large percentage of the periphyton present consisted of diatoms. Some attached green algae were noted, but their numbers and diversity were considerably less than that of the diatom community. A limited number of blue-green algae were also present in the periphyton community. The rheoplanktonic portion of the algal community consisted chiefly of green algae and diatoms. A limited number of desmids and cryptomonad algae were also observed in the plankton. There was no attempt made at enumeration of the algae in this system due to the lack of a good quantative measurement for periphyton. Actual observations however, revealed that diatoms were the greatest in number and diversity of all groups present within the stream, with green and blue green algae of secondary importance. The number of genera of Bacillariophyceae was generally less than the chlorophyceae, but the specific diversity was greater among the Bacillariophyceae. The diatom genera were always commonly found on stones, but were particularly obvious during the winter and early spring months when large filaments of Melosira developed in small backwash areas. A species of Oscillatoria was generally observed in association with Melosira during those periods. The chlorophyceae were present during each collection but were most numerous, in relative terms, during the summer months. In the following tables the algal genera are listed by sample date, with Stations 7 and 8 included in each set. The flow characteristics of each station changed at least once throughout the duration of this project. For this reason, as well as the natural seasonal succession, it would be impossible to validly compare or contrast samples collected

at any one station throughout time. The point of the algal collections, rather, was to monitor and report on permanent community decimation or alteration due to construction practices.

Turbidity and accompanying decline in community abundance was occasionally observed, but prolonged effects were not evident. Community structure remained relatively stable.

The effects of construction activities appeared to be similar to those produced by flooding and natural changes in stream position. It is in the opinion of this investigator that seasonal effects played the greatest role in community structure, in both change and development.

June 3, 1975

Bacillariophyceae
- Navicula spp.
- Cymbella spp.
- Meridion spp.
- Diatoma spp.
- Cyclotella spp.
- Eunotia spp.
- Stauroneis spp.
- Nitzschiza spp.
- Surirella spp.
- Gomphonema sp.
- Frustulia spp.
- Synedra spp.
- Cocconeis spp.

Chlorophyceae
- Actinastrum sp.
- Scendedesmus armatus
- S. longus
- S. quadricuada
- S. dimorphus
- S. abundans
- Chlamydomonas spp.
- Pediastrum duplex
- Gongrosira sp.
- Spirogyra sp.
- Hydrodictyon sp.
- Ulothrix sp.
- Cladophora glomerata
- Rhizoclonium sp.
- Cosmarium spp.
- Closterium spp.

Cyanophyceae
- Oscillatoria spp.
- Spirulina sp.

Pyrrhophyceae
- Peridinium

July 28, 1975

Bacillariophyceae
- Navicula spp.
- Cymbella spp.
- Frustulia spp.
- Synedra spp.
- Eunotia spp.
- Meridion spp.
- Diatoma spp.
- Stauroneis spp.
- Gyrosigma sp.

Chlorophyceae
- Scenedesmus bijuga
- S. dimorphus
- S. abundans
- S. quadricauda
- Hydrodictyon sp.
- Spirogyra sp.
- Cosmarium spp.
- Closterium spp.
- Cladophora glomerata
- Rhizoclonium sp.
- Gloecystis sp.
- Gongrosira sp.
- Ankistrodesmus sp.

Cyanophyceae
- Oscillatoria spp.
- Microcystis sp.

September 8, 1975

Bacillariophyceae
- Navicula spp.
- Synedra spp.
- Frustulia spp.
- Eunotia spp.
- Diatoma spp.
- Meridion spp.
- Cyclotella spp.
- Cocconeis spp.
- Stauroneis spp.
- Gomphonema spp.
- Gyrosigma sp.

Chlorophyceae
- Ankistrodesmus sp.
- A. convulutus
- Scenedesmus abundans
- S. dimorphus
- S. longus
- S. Bijuga
- Spirogyra sp.
- Hydrodictyon sp.
- Rhizoclonium sp.
- Cladophora glomerata
- Ulothrix sp.
- Oedogonium sp.
- Actinastrum sp.
- Pediastrum tetras
- P. duplex
- Gloecystis ampla
- Cosmarium spp.
- Closterium sp.
- Gongrsira sp.

Cyanophyceae
- Nostoc sp.
- Oscillatoria spp.

Cryptophyceae
- Cryptomonas sp.

Euglenophyceae
- Trachelomonas sp.

January 30, 1976

Bacillariophyceae
- Navicula spp.
- Synedra spp.
- Surirella spp.
- Nitzschia spp.
- Cocconeis spp.
- Melosira granulata
- Melosira sp.
- Diatoma spp.
- Stauroneis spp.
- Cymbella spp.

Chlorophyceae
- Ulothrix sp.
- Cladophora glomerata
- Rhizoclonium sp.
- Oedogonium sp.
- Scenedesmus bijuga
- Pediastrum duplex
- P. simplex
- Staurastrum sp.
- Unidentified coccoid greens

Cyanophyceae
- Oscillatoria rubescens
- Oscillatoria sp.

Euglenophyceae
- Euglena sp.

Rhodophyceae
- Batrachospermum sp.

April 3, 1976

Bacillariophyceae
- Melosira granulata
- Melosira sp.
- Navicula spp.
- Stauroneis spp.
- Eunotia spp.
- Acnanthes spp.
- Cocconeis spp.
- Synedra spp.
- Frustulia spp.
- Diatoma spp.
- Meridion spp.
- Gomphonema spp.
- Cymbella spp.

Chlorophyceae
- Cladophora glomerata
- Rhizoclonium sp.
- Cosmarium spp.
- Closterium sp.
- Gloecapsa sp.
- Ulothrix sp.
- Oedogonium sp.
- Chaetophora sp.
- Pediastrum duplex
- P. simplex
- Scenedesmus bijuga
- S. dimorphus
- Calothrix sp.
- Stigeoclonium sp.

Cyanophyceae
- Nostoc sp.
- Oscillatoria rubescens
- Spirulina sp.

Pyrrhophyceae
- Peridinium sp.

Chrysophyceae
- Dinobryon divergens

June 27, 1976

Bacillariophyceae
- Navicula spp.
- Synedra spp.
- Cymbella spp.
- Cocconeis spp.
- Diatoma spp.
- Nitzschia spp.
- Surirella spp.
- Cyclotella spp.
- Frustulia spp.
- Meridion spp.
- Gomphonema spp.

Chlorophyceae
- Ankistrodesmus sp.
- A. convulutus
- A. longus
- Cladophora glomerata
- Rhizoclonium sp.
- Ulothrix sp.
- Oedogonium sp.
- Stigeoclonium sp.
- Cosmarium sp.
- Closterium sp.
- Spirogyra sp.
- Hydrodictvon sp.
- Gloecystis ampla
- Scenedesmus sp.
- S. abundans
- S. dimorphus
- S. quadricauda
- Pediastrum duplex
- P. simplex
- P. tetras
- Actinastrum sp.
- Sphaerocystis sp.

Cyanophyceae
- Oscillatoria spp.
- Spirulina sp.
- Arthrospira sp.
- Nostic sp.

Pyrrhophyceae
- Peridinium sp.

September 19, 1976

Bacillariophyceae
- Navicula spp.
- Synedra spp.
- Frustulia spp.
- Diatoma spp.
- Gomphonema spp.
- Meridion spp.
- Eunotia spp.
- Gyrosigma sp.
- Cymbella spp.

Chlorophyceae
- Closteriopsis sp.
- Scenedesmus bijuga
- S. abundans
- S. dimorphus
- Pediastrum duplex
- P. tetras
- Ulothrix sp.
- Oedogonium sp.
- Spirogyra sp.
- Hydrodictyon sp.
- Actinastrum sp.
- Cladophora glomerata
- Rhizoclonium sp.
- Stigeoclonium sp.
- Chaetophora sp.

Cyanophyceae
- Oscillatoria spp.
- Arthrospira sp.

Pyrrhophyceae
- Peridinium

Cryptophyceae
- Cryptomonas

December 19, 1976

Bacillariophyceae
- Melosira granulata
- Melosira sp.
- Navicula spp.
- Synedra spp.
- Cymbella spp.
- Cocconeis spp.
- Achnanthes spp.
- Surirella spp.
- Diatoma spp.
- Nitzschia spp.
- Eunotia spp.
- Frustulia spp.
- Cyclotella spp.

Chlorophyceae
- Pediastrum duplex
- P. tetras
- Cosmarium spp.
- Closterium spp.
- Scenedesmus abundans
- Chlamydomonas sp.
- Staurastrum sp.
- Staurodesmus sp.

Cyanophyceae
- Oscillatoria rubescens
- Oscillatoria sp.

Rhodophyceae
- Batrachospermum sp.

March 1, 1977

Bacillariophyceae
- Melosira glomerata
- Melosira spp.
- Navicula spp.
- Synedra spp.
- Stauroneis spp.
- Eunotia spp.
- Diatoma spp.
- Frustulia spp.
- Gomphonema spp.
- Gyrosigma sp.
- Acnanthes sp.
- Meridion spp.
- Cocconeis spp.
- Cymbella spp.
- Nitzschia spp.

Chlorophyceae
- Gloeocystis ampla
- Ankistrodesmus convultus
- Pediastrum duplex
- P. simplex
- P. tetras
- Cladophora glomerata
- Rhizoclonium sp.
- Ulothrix sp.
- Calothrix sp.
- Oedogonium sp.
- Chaetophora sp.
- Stigeoclonium sp.
- Scenedesmus dimorphus
- S. abundans
- Cosmarium spp.
- Closterium sp.

Cyanophyceae
- Oscillatoria spp.
- Arthrospira sp.
- Nostoc sp.

Chrysophyceae
- Dinobryon sp.

May 1, 1977

Bacillariophyceae
- Melosira spp.
- Navicula spp.
- Synedra spp.
- Nitzschia spp.
- Surirella spp.
- Cocconeis spp.
- Cymbella spp.
- Diatoma spp.
- Gomphonema spp.
- Frustulia spp.

Chlorophyceae
- Cladophora glomerata
- Cosmarium spp.
- Rhizoclonium spp.
- Oedogonium sp.
- Ulothrix sp.
- Spirogyra sp.
- Hydrodictyon sp.
- Scenedesmus quadricauda
- Gloeocapsa sp.
- Pediastrum tetras
- P. duplex
- Chaetophora sp.
- Stigeoclonium sp.
- Calothrix sp.

Pyrrhophyceae
- Peridinium sp.

INVERTEBRATE STUDIES
(Benthos)

The purpose of this section is to compare the benthic populations of Sugar Creek before and after channel relocation. The pre-channel relocation study was conducted by McCraw on April 25, 1974. The post-channel relocation study was conducted between May 26 and June 12, 1978. A partial collection was made on July 20, 1976. Only a few quantitative facts were obtained due to the limited number of samples.

Qualitative and quantitative methods used were identical to McCraw (1974). All specimens were killed and preserved in 70% alcohol. All organisms, with the exception of some chironominae, were returned to the laboratory for identification and enumeration. Stations SC-1 and SC-3 were sampled during the pre- and post-channel relocation investigations. In addition, Station SC-1 was sampled July 20, 1976. Station 6 (refer to chemistry and periphyton investigation) was included in the post-channel relocation study.

The pool and riffle quantitative samples are reported separately to demonstrate the differences observed between the two types of stream bed habitats that were analyzed in this abbreviated investigations.

Station SC-1. Results of this station are contained in Appendix A. McCraw found this station to be the richest of the two stations sampled during the pre-channel relocation investigation with an average of 65 organisms per square foot. In the post-channel relocation

study, 18 organisms per square foot were found in the riffle samples as compared to 34 organisms per square foot in the pool samples. The riffle samples were dominated by Ephemeroptera (68%) and Diptera (23%) as was the pool sample where Ephemeroptera comprised 61% of the total and Diptera 26%). McCraw found Emphemeroptera to comprise 51% of the total at this station without a subdominant.

Station SC-3. Results of this station are contained in Appendix B. McCraw found an average of 44 organisms per square foot at this station. In the post-channel relocation investigation, the riffle sampled yielded an average of 87 organisms per square foot with the pool sample reduced in numbers to an average of 25 organisms per square foot. In the riffle sample the benthic community was dominated by Diptera (54%) and contained subdominants in Ephemeroptera (28%) and Isopoda (13%). Isopoda (37%) and Diptera (36%) dominated the pool sample with Ephemeroptera (19%) present as a subdominant. This is contrasted to McCraw's study where 45% of the total were Ephemeroptera and Diptera contributed 28.5% of the total organisms.

Station 6. Results of this station are contained in Appendix C. This station was not included in the pre-channel relocation conducted by McCraw in 1974. This station is directly below the site of bridge construction on the main highway (U. S. 71). Only riffle samples were collected at this station. The pool area was too deep at this station for proper quantitative sampling. Ephemeroptera organisms contributed 61% of the total at this station with Trichoptera and Diptera contributing 13% and 9%, respectively.

Ephemeroptera was found to be dominant and the most diverse in the pre-channel relocation investigation. In the post-channel relocation study, Ephemeroptera occurred as co-dominants with Diptera and Isopoda. This shift in dominance is mot likely due to a time shift and consequently development and emergence of some organisms. Each of the 14 orders found in the initial study were found in the follow-up program with the exception of Hirudinea. The total organism count decreased at Station SC-1, where a large number of Ephemeroptera were found in the initial investigation. This decrease in total numbers could be attributed to emergence of Ephemeroptera prior to the follow-up program. The total number of organisms at Station SC-3 remained about the same in both collections if the sums of the pool and riffle samples are lumped and averaged.

Although it is difficult to compare investigations separated by a span of four years, the community structure observed by McCraw in 1974 prevailed in the present collection.

The benthic fauna as with the periphyton communities appeared to be affected for only a short term, i.e. less than one week, during periods of high turbidity due to rains or the opening of the flood gates on Lake Bella Vista. The benthic community, although not officially sampled, was observed during each algal collection. This was not a rigorous kick net collection but rather general observations made by picking stones from the stream bottom. From these collections it was noted that the orders found during intensive collections were also present when only casual observations were made.

APPENDIX A

Station SC-1-Qualatative
June 12, 1978

Decapoda
  Astacidae

Isopoda
  Asellidae
    Asellus sp.

Ephemeroptera
  Baetidae
    Baetis sp.
  Heptageniidae
    Stenonema sp.

Oligochaeta

Diptera
  Chironominae

Megaloptera
  Corydalidae
    Corydalus cornutus

Plecoptera
  Perlidae
    Perlesta sp.

Trichoptera
  Hydropsychidae
    Cheumatopsyche sp.
    Hydropsyche sp.

Gastropoda
  Ancylidae
    Ferrissia sp.

*Tendipidae=Chironominae

Station SC-1-Qualatative
July 20, 1976

Decapoda
  Astacidae

Isopoda
  Asellidae
    Asellus sp.

Ephemeroptera
  Heptageniidae
    Stenonema sp.

Diptera
  Chironominae

Coleoptera
  Psephenidae
    Psephenus sp.

Tricladida
  Planariidae
    Dugesia sp.

Trichoptera
  Hydropsychidae
    Hydropsyche sp.
    Cheumatopsyche sp.

Gastropoda
  Ancylidae
    Ferrissia sp.

APPENDIX B

Station SC-3-Qualatative
June 12, 1978

Decapoda
  Astacidae

Isopoda
  Asellidae
    Assellus sp.

Ephemeroptera
  Baetidae
    Baetis sp.
  Heptageniidae
    Stenonema sp.

Oligochaeta

Coleoptera
  Psephenidae
    Psephenus sp.
  Elmidae
    Stenelmis sp.

Megaloptera
  Corydalidae
    Corydalus cornutus

Trichoptera
  Rhyacophilidae
    Rhyacophila sp.
  Hydropsychidae
    Hydropsyche sp.
    Cheumatopsyche sp.

Diptera
  Chironominae

Hemiptera
  Gerridae
    Trepobates sp.

*Tendipidae=Chironominae

APPENDIX C

Riffle
Station 6-Quantatative
May 31, 1978

Decapoda	
Astacidae	1
Ephemeroptera	
Baetidae	
Baetis sp.	37
Heptageniidae	
Stenonema sp.	5
Isopoda	
Aselledae	
Asellus sp.	1
Oligochaeta	3
Tricladida	
Planariidae	
Dugesia sp.	4
Trichoptera	
Hydropsychidae	
Hydropsyche sp.	8
Rhyacophilidae	
Rhyacophila sp.	1
Diptera	
Chironominae	4
Simuliidae	2
Coleoptera	
Elmidae	
Stenelmis sp.	3
Total organisms	69
Mean	34.5
(2 Samples)	

*Tendipidae=Chironominae

Riffle
Station 6-Quantatativ
May 26, 1978

Ephemeroptera
- Baetidae
  - Baetis sp.
- Heptageniidae
  - Stenonema sp.

Diptera
- Simullidae
- Chironominae

Trichoptera
- Hydropsychidae
  - Hydropsyche sp.
  - Cheumatopsyche sp.

Plecoptera
- Early Instar

Oligochaeta

Tricladida
- Planariidae
  - Dugesia sp.

MAMMALIAN POPULATIONS

The purpose of this section is to describe population estimates of mammalian species and indicate what effect the channel relocation may have had on these populations. It was anticipated that the residing and transient mammals would be disrupted by direct destruction of habitat and peripheral effects of the construction operation.

The following assesses the actual effect of the project on the mammals at the construction site.

In order to maintain consistency, all procedures used in the original study were followed in the follow-up study. The three study plots used in the original study (Figure 1) were again used in this study. Plots 1 and 3 were essentially undisturbed by the construction; however, most of plot 2 was drastically altered.

Study plot 1 consists of oak, maple and sycamore overstory on an alluvial plain constituting the east bank of the creek. Area - 0.453 acres.

The northern portion (ca. 15-20%) of study plot 2 remained essentially the same--oak, hickory, walnut, maple, and sycamore overstory on a steep hillside (25°-55° slope). The remainder of plot 2 southward consists of various grasses growing sparsely on the chert and shale rip-rap. This plot constitutes the west bank of the stream. Area - 0.347 acres.

Study plot 3 consists of abandoned agricultural land with secondary growth of sumac, red cedar and persimmon as well as various grasses. Area - 0.174 acres.

Sherman live traps and National live traps (medium) were used. Small National traps were not used in the follow-up study as they did not yield any results in the original study (White and Tyler, 1977). The Sherman traps were baited with peanut butter and the National traps with apple slices and sardines. The capture efficiency of the traps were checked and were relocated if necessary. All mammals captured were weighed, sexed, tagged, and released.

Population estimates were made using the Lincoln-Peterson mark-recapture method, i.e. Population (P) = $\frac{xn}{y}$, where x equals the total captured each night, n equals the total previously marked and y equals the total recaptured each night. The population estimates were standardized to number per acre of equivalent habitat (White and Tyler, 1977). Squirrel populations were made using nest counts and again standardized as above.

All other data collected was qualitative. Plaster castings of footprints were made while some tracks were identified by direct observation when possible. In addition, visual sitings were noted. Also, identification by burrow and nest was made where possible.

Both the original study and the follow-up study were done in the late spring and early summer. The first study was done in 1975 and the follow-up was done in 1977.

Inventory of mammals documented during the initial collections (1975) at Little Sugar Creek near Bella Vista in Benton County, Ark.

METHOD OF DOCUMENTATION	SPECIES	COMMON NAME	STUDY PLOT REFERENCED
A. Captured in Live Traps:	Peromyscus maniculatus	Deer Mouse	1
	Peromyscus leucopus	White-footed Mouse	1,2
	Tamias striatus	Eastern Chipmunk	2
	Sigmodon hispidus	Hispid Cotton Rat	3
	Pitymys pinetorum	Pine Vole	1
	Procyon lotor	Raccoon	1,2
B. Observed during daylight hours:	Sciurus carolinensis	Eastern Gray Squirrel	2
	Sciurus niger	Fox Squirrel	2
	Marmota monax	Woodchuck or Groundhog	2
	Sylvalagus floridana	Eastern Cottontail	1,2,3
C. Plaster casting of footprints:	Odocoileus virginianus	White-tailed Deer	2
	Lynx rufus	Bobcat	2
	Canis latrans	Coyote	2
	Procyon lotor	Raccoon	2
	Sylvalagus floridana	Eastern Cottontail	2
D. Burrows, dens, and nests:	Scalopus aquaticus	Eastern Mole	1

Initial Population Estimates (1975) Based On Trapping Results
and the Relative Abundance of Species Present

STUDY PLOT	SPECIES CAPTURED	NUMBER CAPTURED	DIMENSION OF PLOT IN ACRES	MAMMAL NUMBER PER ACRE OF EQUIVALENT HABITAT
1	Peromyscus maniculatur	2	.453	4
1	Peromyscus leucopus	9	.453	11
1	Pitymys pinetorum	1	.453	2
2	Peromyscus leucopus	6	.347	12
2	Tamias striatus	7	.347	14
3	Sigmodon hispidus	7	.174	23
1,2	Procyon lotor	6	.800	8
2	Scirus niger*	16	.347	46

* Determined by nest count.

Inventory of mammals at Little Sugar Creek near Bella Vista
in Benton County, Arkansas (follow up study, 1977)

METHOD OF DOCUMENTATION	SPECIES	COMMON NAME	STUDY PLOT REFERENCED
A. Captured in live traps:	Peromyscus maniculatus	Deer Mouse	1,2
	Peromyscus leucopus	White-footed Mouse	1,2
	Tamias striatus	Eastern Chipmunk	1,2
	Sigmodon hispidus	Hispid Cotton Rat	1,2,3
	Procyon lotor	Raccoon	1,2
B. Observed during daylight hours:	Sciurus carolinensis	Eastern Gray Squirrel	2
	Sciurus niger	Fox Squirrel	2
	Marmota monax	Woodchuck or Groundhog	2
	Sylvalagus floridana	Eastern Cottontail	1,2,3
	Didelphis marsupialis	Opossum	3
C. Plaster casting & direct observation of footprints:	Odocoileus virginianus	White-tailed Deer	1
	Procyon lotor	Raccoon	1
	Sylvalagus floridana	Eastern Cottontail	1,3
D. Burrows, dens, and nests:	Castor canadensis	Beaver	1

Population estimates and relative abundance of mammal
Little Sugar Creek in Benton County, Arkansas (follow
study, 1977).

STUDY PLOT	SPECIES	POPULATION ESTIMATE	NUMBER PER ACRE EQUIVALENT HABITAT
1	Peromyscus maniculatus	6	12
1	P. leucopus	5	10
2	P. leucopus	10	28
1	Sigmodon hispidus	4	8
2	S. hispidus	6	16
3	S. hispidus	4	23
1	Tamias striatus	3	6
2	T. striatus	5	12
1&2	Procyon lotor	3	4

It would be expected that construction such as that undertaken in this project might result in drastic alteration or destruction of habitat and therefore dislocation of resident and transient mammalian species utilizing the area. This effect might particularly be expected in those areas where the construction actually occurred (study plot 2) and to a lesser extent in peripheral areas. However, upon comparison with the original study (White and Tyler, 1977) there appears to have been little if any effect on mammalian species in the area as a result of the highway project.

The variation in population estimates between the pre-construction and follow up investigation may simply be a manifestation of normal oscillations in population size due to natality and mortality, immigration and emmigration and normal reproductive cycling, etc. For example, the eastern chipmunk Tamias striatus breeds in April and again in late August and through most of September and has a 31 day gestation period (Burt and Grossenheider, 1976). Therefore the difference observed in the two studies may have resulted from normal reproductive cycling as the first litter of the year (normally 2-8 individuals) may not have appeared above ground as they usually don't until two-thirds grown. The deer mouse, Peromyscus maniculatus tends to congregate periodically and may not have been randomly dispersed throughout its range at that time, thereby effecting trapping results. The population density of the raccoon, Procyon lotor may vary from one per acre to one per 15 acres annually affecting trapping results. Therefore, any quantitative information on the raccoon from such a small area as that used

in this study must be scrutinized.

Viewed with these reservations, the data suggests that the construction project had probably little if any effect on the population size of the mammals found within the study area.

The qualitative data would also indicate that the construction project had little if any effect on the mammals in the area. With few exceptions, the mammalian species observed in the original study were again observed in the present study. Any discrepancies may simply be due to chance. For example, the fact that no pine voles, Pitymys pinetorum were observed or captured in the follow up study but were in the original study is not significant as only one was captured in the initial inventory.

The most noteworthy observation made in this study was the reutilization of study plot 2 which sustained the greatest alteration as a result of the highway construction. This area, once of the upland deciduous type is now covered with sparse vegetation - primarily grasses. However, all species reported to have inhabited this area prior to the construction again inhabit the area and in approximately the same numbers. The large rocks nearest the creek at the bottom of the steep hillside provide an excellent place for nests and burrows. All the species in this area are generalists with regard to habitat selection, nesting in forests and grasslands, rock burrows, tree stumps, etc. Therefore, this reutilization by these species is not surprising.

In addition, some species not previously reported in plot 2 were observed and captured in the present study i.e. Tamias striatus and Sigmodon hispidus. In fact, a rather large population of the latter

now inhabits study plot 2 (12 per acre of equivalent habitat).

Several observations made in the original study were not made in the follow-up study which are probably simply due to chance. There was no evidence of the presence of the coyote, Canis latrans, the eastern mole, Scalopus aquaticus and the pine vole, Pitymys pinetorum. However, the opossum, Didelphis marsupialis which was not observed in the original survey was sited in the follow-up inventory. Also the initial study, indicated den holes in the bank of the creek indicating the possible presence of the beaver, Castor canadensis. The evidence of habitat utilization and foraging by beavers was quite convincing and although not observed, a population of beavers in study plot 1 is highly probable.

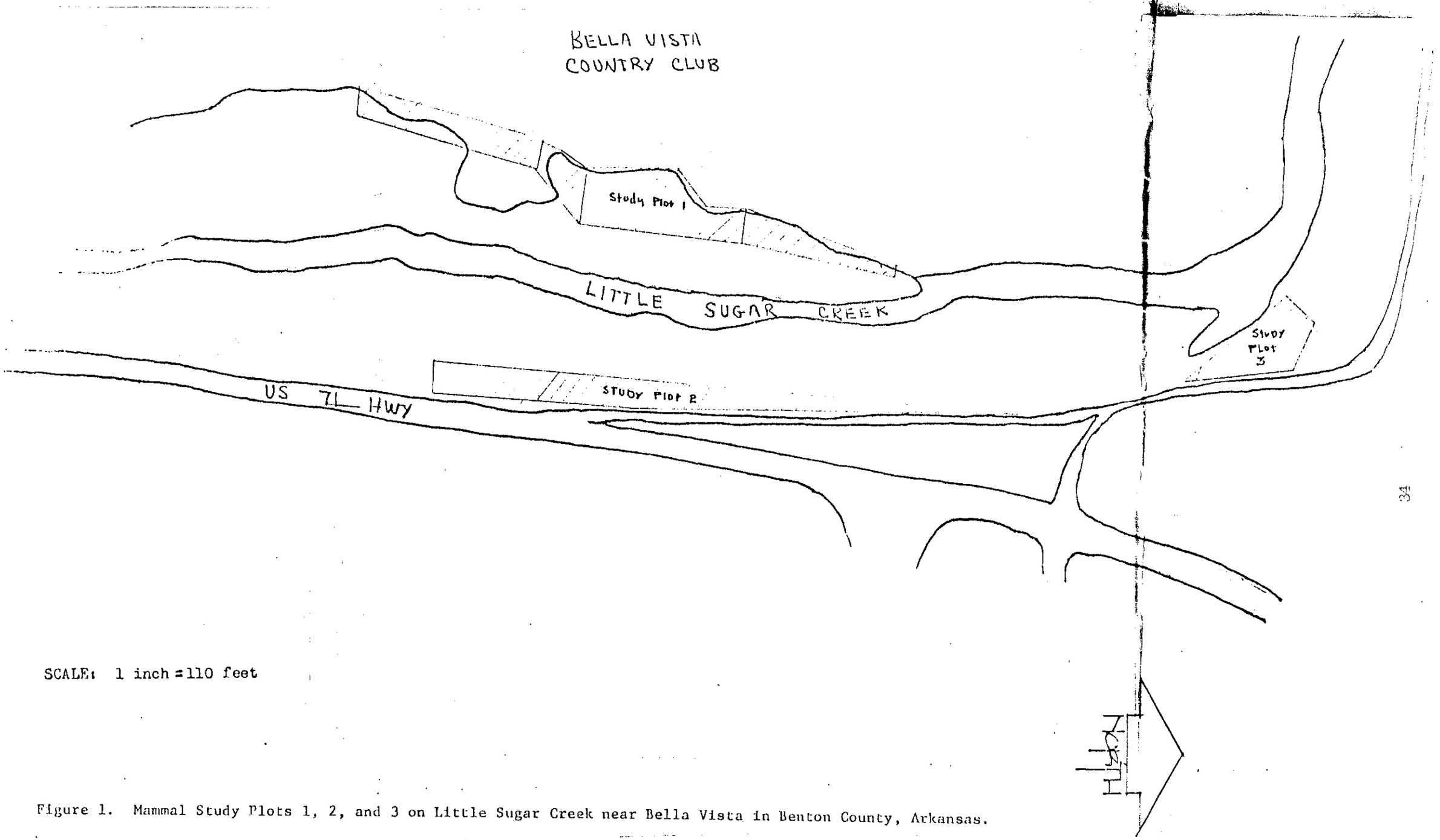


Figure 1. Mammal Study Plots 1, 2, and 3 on Little Sugar Creek near Bella Vista in Benton County, Arkansas.

VASCULAR PLANTS AND VEGETATION TYPES

The vegetation at all three relocation sites near Bella Vista is typical of most floodplain areas of small streams and moist uplands found elsewhere in the Ozarks of Arkansas as described by Turner (1935), Arend and Julander (1948), Bullington (1962), Dale and Fullerton (1963), Youree (1969), Dale (1974), and many others. These sites have been extensively disturbed by man and are not considered to represent unique ecosystems. Also, no rare or endangered species of plants were noted in any of these areas.

Vegetation analysis was accomplished in June, 1975 through the use of transects for trees (Phillips, 1959) and by means of the ocular tube method for understories (Dale and Fullerton, 1963). The data were then compiled by methods described by Phillips (1959), dominant and important secondary species determined, and vegetation types designated by number.

A follow up study was done in June and July of 1977. The vegetation types noted in the initial study were present in 1977. The amount of total vegetation had been reduced, but with planting done by the Highway and Transportation Department at all sites, some recovery is expected.

Many opinions exist as to criteria for designation of dominants and important secondary species, but for the purpose of this study, dominants are considered to be plants that are the most numerous, conspicuous, or largest plants in each stratum (overstory, woody understory, and forest floor or open space areas) that exert community control. Important secondary species are those that may dominate locally within any vegetation type, or are the most conspicuous, numerous, or

largest plants except the dominants.

Plant species present in each relocation site were collected periodically during the investigation and pressed, dried, and identified. These are deposited in the University of Arkansas Herbarium, Fayetteville, as voucher specimens.

Principal Vegetation Types (communities) of the Bella Vista Area. Overstory, woody understory and forest floor species of open areas that occur as dominants are indicated by number and important secondary species by letter in each vegetation type. Dash (---) indicates that no species occurred in the designated vegetation type as a dominant or important secondary species. Trees listed as woody understory are seedlings or small saplings.

Vegetation Types	Overstory	Woody Understory	Forest Floor or Open Areas
1.	---	---	1. Meadow fescue a. Johnson grass b. Kentucky blue grass c. Orchard grass d. Bermuda grass
2.	1. Bois d'arc 2. Sycamore	---	---
3.	1. Box elder 2. Swamp dogwood	1. Poison ivy a. sumac	a. Johnson grass
4.	1. Swamp dogwood	---	a. Virginia wild rye
5.	---	---	a. Johnson grass b. Kentucky blue grass c. Chickweed d. Meadow fescue e. Buffalo clover
6.	1. Sycamore 2. Green ash a. Box elder	1. American elm 2. Swamp dogwood 3. Red bud	1. Virginia wild rye a. Nodding fescue
7.	1. Northern red oak 2. Sycamore 3. Chinquapin oak a. White oak b. Green ash c. Black walnut	1. American elm 2. Swamp dogwood 3. Red bud	1. Johnson grass a. Water willow

- continued

Vegetation Types	Overstory	Woody Understory	Forest Floor or Open Areas
8.	1. Sycamore 2. Black willow a. American elm b. Green ash c. Ward's willow	---	a. Johnson grass b. Meadow fescue c. Water willow
9.	---	---	1. Meadow fescue a. Johnson grass b. Kentucky blue grass c. Buffalo clover d. Sedge
10.	---	---	1. Common plantain
11.	1. White oak a. Green ash b. Box elder c. Black cherry d. Sycamore e. American elm f. Hackberry g. Mockernut hickory	---	---
12.	1. Silver leaf maple 2. Box elder a. Black cherry b. Mockernut hickory	1. Green ash 2. American elm a. Hackberry b. Chinquapin oak c. Spice bush	1. Virginia wild rye a. Yellow ironweed
13.	1. Sycamore 2. American elm a. Black walnut	1. Box elder a. Pawpaw b. Persimmon c. Ohio buckeye d. Green ash	1. Virginia wild rye a. Stinging nettle b. Bear-foot
14.	1. American elm 2. Hackberry a. Green ash b. Hackberry	1. American elm 2. Hackberry a. Green ash b. Hackberry	1. Virginia wild rye

VASCULAR PLANTS

AT

RELOCATION SITE 1

SITE 1

ACANTHACEAE	Acanthus Family	
	Justicia americana (L.) Vahl	Water Willow
	Ruellia pedunculata Torr.	Wild Petunia
ACERACEAE	Maple Family	
	Acer negundo L.	Box Elder
	Acer saccharinum L.	Silver Maple
AMARANTHACEAE	Amaranth Family	
	Amaranthus sp.	Amaranth
BALSAMINACEAE	Touch-me-not Family	
	Impatiens capensis Meerb.	Spotted Touch-me-not
BIGNONIACEAE	Trumpet Creeper Family	
	Campsis radicans (L.) Seem.	Trumpet Creeper
CAMPANULACEAE	Bellflower Family	
	Triodanis perfoliata (L.) Nieuwl.	Venus' Looking Glass
CAPRIFOLIACEAE	Honeysuckle Family	
	Sambucus canadensis L.	Common Elderberry
	Symphoricarpos orbiculatus Moench	Coral Berry
	Viburnum prunifolium L.	Black Haw
CARYOPHYLLACEAE	Pink Family	
	Dianthus armeria L.	Deptford Pink
	Stellaria sp.	Chickweed
COMPOSITAE	Sunflower Family	
	Achillea millefolium L.	Common Milfoil
	Ambrosia artemisiifolia L.	Common Ragweed
	Ambrosia trifida L.	Horse Weed

Aster sagittifolius Wedemeyer	Aster
Aster sp.	Aster
Astranthium integrifolium (Michx.) Nutt.	Western Daisy
Chrysanthemum leucanthemum L.	Ox-eye Daisy
Erigeron philadelphicus L.	Philadelphia Fleabane
Lactuca serriola L.	Prickly Lettuce
Lactuca sp.	Wild Lettuce
Polymnia uvedalia L.	Bears-foot
Redbeckia laciniata L.	Wild Goldenglow
Silphium perfoliatum L.	Cup-plant
Silphium terebinthinaceum Jacq.	Prairie Dock
Solidago sp.	Goldenrod
Taraxacum officinale Wiggers	Common Dandelion
Verbesina alternifolia (L.) Britt.	Yellow Ironweed
Vernonia sp.	Ironweed
CONVOLVULACEAE Morning Glory Family	
Convolvulus sepium L.	Hedge Bindweed
CORNACEAE Dogwood Family	
Cornus drummondi Meyer	Rough-leaved Dogwood
CRUCIFERAE Mustard Family	
Barbarea vulgaris R. Br.	Yellow Rocket
Lepidium virginicum L.	Pepper Grass
Nasturtium officinale R. Br.	Water Cress
CUPRESSACEAE Cypress Family	
Juniperus virginiana L.	Red Cedar

CYPERACEAE Sedge Family	
Carex leavenworthii Dew.	Sedge
Cyperus sp.	Sedge
DIOSCOREACEAE Yam Family	
Dioscorea villosa L.	Wild Yam
FAGACEAE Beech Family	
Quercus muehlenbergii Engelm.	Chinquapin Oak
Quercus rubra L.	Northern Red Oak
GERANIACEAE Geranium Family	
Geranium maculatum L.	Wild Geranium
Geranium pusillum L.	Cranesbill
GRAMINEAE Grass Family	
Bromus racemosus L.	Hairy Chess
Cynodon dactylon (L.) Pers.	Bermuda Grass
Dactylis glomerata L.	Orchard Grass
Elymus virginicus L.	Wild Rye
Festuca elatior L.	Meadow Fescue
Festuca obtusa Biehler	Nodding Fescue
Panicum boscii Poir.	Panic-grass
Panicum sp.	Panic-grass
Poa pratensis L.	Kentucky Blue Grass
Sorghum halepense (L.) Pers.	Johnson Grass
Sphenopholis obtusata (Michx.) Scribn.	Wedge Grass
JUGLANDACEAE Walnut Family	
Carya tomentosa Nutt.	Mockernut Hickory
LABIATAE Mint Family	
Prunella vulgaris L.	Selfheal

LEGUMINOSAE Pea Family	
Cercis canadensis L.	Redbud
Desmodium sp.	Tick Trefoil
Gleditsia triacanthos Marsh.	Honey Locust
Melilotus sp.	Sweet Clover
Trifolium hybridum L. var. *pratense* Rabenh.	Alsike Clover
Trifolium reflexum L.	Buffalo Clover
Vicia sativa L.	Common Vetch
LILIACEAE Lily Family	
Allium canadense L.	Wild Garlic
Smilax bona-nox L.	Bullbrier
Smilax rotundifolia L.	Greenbrier
MORACEAE Mulberry Family	
Maclura pomifera (Raf.) Schneid.	Osage Orange
Morus rubra L.	Red Mulberry
NYCTAGINACEAE Four-o'clock Family	
Mirabilis nyctaginea (Michx.) Mac M.	Wild Four-o'clock
OLEACEAE Olive Family	
Fraxinus pennsylvanica Marsh.	Green Ash
ONAGRACEAE Evening Primrose Family	
Oenothera serrulata Nutt.	Evening Primrose
PASSIFLORACEAE Passion-flower Family	
Passiflora lutea L.	Passion-flower
PHYTOLACCACEAE Pokeweed Family	
Phytolacca americana L.	Pokeweed
POLEMONIACEAE Phlox Family	
Phlox divaricata L. var. *laphamii* Wood	Blue Phlox

PLANTAGINACEAE Plantain Family	
Plantago lanceolata L.	English Plantain
Plantago major L.	Common Plantain
PLATANACEAE Plane Tree Family	
Platanus occidentalis L.	Sycamore
POLYGONACEAE Buckwheat Family	
Polygonum sp.	Smartweed
Rumex altissimus Wood	Pale Dock
PRIMULACEAE Primrose Family	
Lysimachia nummularia L.	Moneywort
ROSACEAE Rose Family	
Geum sp.	Avens
Potentilla sp.	Five Finger
Prunus serotina Ehrh.	Black Cherry
Prunus sp.	Cherry
Rubus sp.	Blackberry
SALICACEAE Willow Family	
Populus deltoides Marsh.	Cottonwood
Salix caroliniana Michx.	Ward's Willow
Salix nigra Marsh.	Black Willow
SCROPHULARIACEAE Figwort Family	
Penstemon digitalis Nutt.	Beard-tougue
Verbascum blattaria L.	Moth Mullein
RUBIACEAE Madder Family	
Cephalanthus occidentalis L.	Buttonbush
Galium triflorum Michx.	Sweet-scented Bedstraw

	Sherardin arvensis L.	Field Madder
ULMACEAE	Elm Family	
	Celtis laevigata Willd.	Sugarberry
	Ulmus americana L.	American Elm
	Daucus carota L.	Queen Anne's Lace
	Sanicula canadensis L.	Black Snakeroot
	Thaspium barbinode (Michx.) Nutt.	Meadow Parsnip
	Thaspium trifoliatum (L.) Gray	Meadow Parsnip
URTICACEAE	Nettle Family	
	Boehmeria cylindrica (L.) Sw.	False Nettle
VALERIANACEAE	Valerian Family	
	Valerianella radiata (L.) Dufr.	Corn Salad
VERBENACEAE	Vervain Family	
	Lippia lanceolata Michx.	Fog Fruit
VIOLACEAE	Violet Family	
	Viola sp.	Violet
VITACEAE	Grape Family	
	Parthenocissus quinquefolia (L.) Planch.	Virginia Creeper
	Vitis vulpina L.	Winter Grape

VASCULAR PLANTS

AT

RELOCATION SITE 2

SITE 2

ALISMACEAE	Water Plantain Family	
	Sagittaria sp.	Arrowhead
ANNONACEAE	Custard Apple Family	
	Asimina triloba (L.) Dunal	Pawpaw
BETULACEAE	Birch Family	
	Ostrya virginiana (Mill.) K. Koch	Ironwood
BIGNONIACEAE	Trumpet Creeper Family	
	Campsis radicans (L.) Seem.	Trumpet Creeper
CAPRIFOLIACEAE	Honeysuckle Family	
	Lonicera flava Sims	Yellow Honeysuckle
	Viburnum prunifolium L.	Black Haw
	Viburnum rufidulum Raf.	Southern Black Haw
CARYOPHYLLACEAE	Pink Family	
	Saponaria officinalis L.	Bouncing Bet
CISTACEAE	Rockrose Family	
	Lechea tenuifolia Michx.	Pinweed
COMMELINACEAE	Spiderwort Family	
	Commelina communis L.	Day-flower
COMPOSITAE		
	Antennaria plantaginifolia (L.) Hook.	Pussy's Toes
	Aster patens Ait.	Spreading Aster
	Aster sagittifolius Wedemeyer	Aster
	Chichorium intybus L.	Common Chicory
	Eupatorium serotinum Michx.	Late Boneset
	Heliopsis helianthoides (L.) Sweet	Ox-eye

	Solidago sp.	Goldenrod
	Sonchus asper (L.) Hill	Spiny-leaved Sow Thistle
	Xanthium strumarium L.	Cocklebur
CONVOLVULACEAE	Morning Glory Family	
	Convolvulus sepium L.	Hedge Bindweed
CRUCIFERAE	Mustard Family	
	Lepidium virginicum L.	Pepper Grass
	Nasturtium officinale R. Br.	Water Cress
	Rorippa islandica (Oeder) Borbas	Marsh Yellow Cress
CYPERACEAE	Sedge Family	
	Carex tribuloides Wahlenb.	Sedge
	Scirpus atrovirens Willd.	Common Bulrush
DIOSCOREACEAE	Yam Family	
	Dioscorea villosa L.	Wild Yam
EBENACEAE	Ebony Family	
	Diospryros virginiana L.	Persimmon
ERICACEAE	Heath Family	
	Vaccinium stamineum L.	Deerberry
FAGACEAE	Beech Family	
	Quercus alba L.	White Oak
	Quercus muehlenbergii Engelm.	Chinquapin Oak
GRAMINEAE	Grass Family	
	Danthonia spicata (L.) Beauv.	Poverty Oat Grass
	Festuca elatior L.	Meadow Fescue
	Panicum boscii Poir.	Panic-grass
	Panicum sp.	Panic-grass
	Sorghum halepense (L.) Pers.	Johnson Grass

HYPERICACEAE	St. John's-wort Family	
	Hypericum sp.	St. John's-wort
IRIDACEAE	Iris Family	
	Sisyrinchium bermudiana L.	Bue-eyed Grass
JUNCACEAE	Rush Family	
	Juncus effusus L.	Soft Rush
JUGLANDACEAE	Walnut Family	
	Carya cordiformis (Wang.) K. Koch	Bitternut Hickory
	Juglans nigra L.	Black Walnut
LABIATAE	Mint Family	
	Prunella vulgaris L.	Selfheal
	Teucrium canadense L.	Woodsage
LAURACEAE	Laurel Family	
	Lindera benzoin (L.) Blume	Spice Bush
	Sassafras albidum (Nutt.) Nees	Sassafras
LEGUMINOSAE	Pea Family	
	Cercis canadensis L.	Redbud
	Desmodium sp.	Tick Trefoil
	Gleditsia triacanthos L.	Honey Locust
	Melilotus albus Desr.	White Sweet Clover
	Trifolium pratense L.	Red Clover
LILIACEAE	Lily Family	
	Polygonatum canaliculatum (Muhl.) Pursh	Solomon's Seal
MORACEAE	Mulberry Family	
	Maclura pomifera (Raf.) Schneid.	Osage Orange
	Morus rubra L.	Red Mulberry

NYCTAGINACEAE	Four-o'clock Family	
	Mirabilis nyctaginea (Michx.) Mac M.	Wild Four-o'clock
ONAGRACEAE	Evening Primrose Family	
	Oenothera speciosa Nutt.	White Evening Primrose
PAPAVERACEAE	Poppy Family	
	Papaver dubium L.	Blind Eyes
PLANTAGINACEAE	Plantain Family	
	Plantago major L.	Common Plantain
POLYGONACEAE	Buckwheat Family	
	Polygonum scandens L.	False Buckwheat
	Polygonum sp.	Smartweed
ROSACEAE	Rose Family	
	Amelanchier arborea (Michx. f.) Fern.	Shadbush
	Physocarpus opulifolius (L.) Maxim.	Ninebark
	Prunus serotina Ehrh.	Black Cherry
	Rosa setigera Michx.	Pasture Rose
	Rubus sp.	Blackberry
RUTACEAE	Rue Family	
	Ptelea trifoliata L.	Hop Tree
SCROPHULARIACEAE	Figwort Family	
	Gerardia grandiflora Benth.	Gerardia
	Penstemon tubaeflorus Nutt.	Beard-tongue
SOLANACEAE	Potato Family	
	Physalis sp.	Ground Cherry
STAPHYLEACEAE	Bladder-nut Family	
	Staphylea trifolia L.	American Bladder-nut

Arkansas
Game & Fish
Commission

STEVE N. WILSON, Director

NO. 2 NATURAL RESOURCES DR.
LITTLE ROCK, ARKANSAS 72205

Security Guard

Mr. Jim Gaither, Assistant Division Head of the Environmental Division, Arkansas Highway and Transportation Department, will stop by this building on Friday, June 26, 1981, between 6:30 a.m. and 7:00 a.m.

Please be watching for him during this period of time, in order that you can give him this stack of slides and information.

Thank you.

D. Baker
Director's Office

TILIACEAE	Linden Family	
	Tilia americana L.	Basswood
ULMACEAE	Elm Family	
	Ulmus alata Michx.	Winged Elm
	Ulmus americana L.	American Elm
UMBELLIFERAE	Parsley Family	
	Sanicula canadensis L.	Black Snakeroot
	Torilis japonica (Houtt.) DC.	Hedge Parsley
VITACEAE	Grape Family	
	Parthenocissus quinquefolia (L.) Planch.	Virginia Creeper
	Vitis vulpina L.	

VASCULAR PLANTS

AT

RELOCATION SITE 3

ANNONACEAE	Custard Apple Family	
	Asimina triloba (L.) Dunal	Pawpaw
ARISTOLOCHIACEAE	Birthwort Family	
	Asarum canadense L.	Wild Ginger
BALSAMINACEAE	Tough-me-not Family	
	Impatiens pallida Nutt.	Pale Touch-me-not
BETULACEAE	Birch Family	
	Corylus americana Walt.	Hazelnut
CAMPANULACEAE	Bellflower Family	
	Triodanis biflora (R.&P.) Greene	Venus' Looking Glass
CAPRIFOLIACEAE	Honeysuckle Family	
	Lonicera japonica Thunb.	Japanese Honeysuckle
	Viburnum prunifolium L.	Black Haw
	Viburnum rufidulum Raf.	Southern Black Haw
COMMELINACEAE	Spiderwort Family	
	Commelina erecta L.	Day-flower
COMPOSITAE	Sunflower Family	
	Astranthium integrifolium (Michx.) Nutt.	Western Daisy
	Bidens sp.	Beggar Ticks
	Chrysanthemum leucanthemum L.	Ox-eye Daisy
	Cichorium intybus L.	Common Chicory
	Heliopsis helianthoides (L.) Sweet	Ox-eye
	Solidago sp.	Goldenrod
	Verbesina alternifolia (L.) Britt.	Yellow Ironweed
CORNACEAE	Dogwood Family	
	Cornus obliqua Raf.	Swamp Dogwood
	Nyssa sylvatica Marsh	Black Gum

CRUCIFERAE	Mustard Family	
	Arabis laevigata (Muhl.) Poir.	Smooth Rock Cress
	Barbarea vulgaris R. Br.	Yellow Rocket
	Lepidium virginicum L.	Pepper Grass
	Thlaspi perfoliatum L.	Perfoliate Penny Cress
CYPERACEAE	Sedge Family	
	Carex gracilescens Steud.	Sedge
	Carex leavenworthii Dew.	Sedge
EBENACEAE	Ebony Family	
	Diospyros virginiana L.	Persimmon
EQUISETACEAE	Horsetail Family	
	Equisetum hyemale L.	Winter Scouring Rush
EUPHORBIACEAE	Spurge Family	
	Acalypha rhomboidea Raf.	Three-seeded Mercury
GERANIACEAE	Geranium Family	
	Geranium carolinianum L.	Cranesbill
GRAMINEAE	Grass Family	
	Bromus japonicus Thunb.	Japanese Chess
	Bromus racemosus L.	Hairy Chess
	Bromus tectorum L.	Downy Chess
	Dactylis glomerata L.	Orchard Grass
	Elymus virginicus L.	Wild Rye
	Festuca elatior L.	Meadow Fescue
	Festuca myuros L.	Fescue
	Festuca obtusa Biehler	Nodding Fescue
	Hordeum pusillum Nutt.	Little Barley
	Lolium multiflorum Lam.	Italian Rye Grass

Poa pratensis L.	Kentucky Blue Grass
Poa sylvestris A. Gray	Sylvan Blue Grass
HIPPOCASTANACEAE Horse Chestnut Family	
Aesculus glabra Willd.	Ohio Buckeye
LABIATAE Mint Family	
Lamium purpureum L.	Dead Nettle
Perilla frutescens (L.) Britt.	Beef-steak Plant
Teucrium canadense L.	Wood Sage
LAURACEAE Laurel Family	
Lindera benzoin (L.) Blume	Spice Bush
LEGUMINOSAE Pea Family	
Amorpha fruticosa L.	False Indigo
Gleditsia triacanthos L.	Honey Locust
Trifolium hybridum L. var. *praecox* Raben.	Alsike Clover
Trifolium procumbens L.	Large Hop Clover
Vicia sativa L.	Common Vetch
LILIACEAE Lily Family	
Allium canadense L.	Wild Garlic
MENISPERMACEAE Moonseed Family	
Cocculus carolinus (L.) DC.	Carolina Moonseed
NYCTAGINACEAE Four-o'clock Family	
Mirabilis nyctaginea (Michx.) Mac. M.	Wild Four-o'clock
OXALIDACEAE Wood Sorrel Family	
Oxalis dillenii Jacq.	Yellow Wood Sorrel
PASSIFLORACEAE Passion-flower Family	
Passiflora lutea L.	Passion-flower

POLYGONACEAE	Buckwheat Family	
	Polygonum persicaria L.	Lady's Thumb
	Polygonum scandens L.	False Buckwheat
	Polygonum sp.	Smartweed
	Rumex altissimus Wood	Pale Dock
	Rumex crispus L.	Sour Dock
RANUNCULACEAE	Buttercup Family	
	Cimicifuga racemosa (L.) Nutt.	Black Cohosh
	Ranunculus septentrionalis Poir.	Swamp Buttercup
ROSACEAE	Rose Family	
	Amelanchier arborea (Michx. f.) Fern.	Shadbush
	Geum canadense Jacq.	White Avens
	Prunus americana Marsh.	Wild Plum
	Rubus occidentalis L.	Black Raspberry
RUBIACEAE	Madder Family	
	Galium aparine L.	Cleavers
	Galium obtusum Bigel.	Bedstraw
	Galium triflorum Michx.	Sweet-scented Bedstraw
SALICACEAE	Willow Family	
	Salix caroliniana Michx.	Ward's Willow
SAPOTACEAE	Sapodilla Family	
	Bumelia lanuginosa (Michx.) Pers.	Chittem-wood
SCROPHULARIACEAE	Figwort Family	
	Veronica arvensis L.	Corn Speedwell
SOLANACEAE	Potato Family	
	Physalis pubescens L.	Ground Cherry
	Physalis sp.	Ground Cherry

ULMACEAE	Elm Family	
	Celtis occidentalis L.	Hackberry
	Ulmus americana L.	American Elm
UMBELLIFERAE	Parsley Family	
	Osmorhiza longistylis (Torr.) DC.	Anise Root
	Torilis japonica (Houtt.) DC.	Hedge Parsley
URTICACEAE	Nettle Family	
	Boehmeria cylindrata (L.) Sw.	False Nettle
	Laportea canadensis (L.) Guad.	Wood Nettle
VALERIANACEAE	Valerian Family	
	Valerianella radiata (L.) Dufr.	Corn Salad
VITACEAE	Grape Family	
	Vitis cinerea Engelm.	Grayback Grape
	Vitis vulpina L.	Winter Grape

FISH POPULATION CONFIGURATION

The purpose of this part of the study was to determine the re-establishment of a fish community after the channel relocation had taken place. Fish were collected on four occasions prior to construction, once in April, May, June, and July of 1975. The follow-up collections occured in March, April, June, and August of 1978. Sampling was done using a 20 foot seine and a backpack electroshocker.

The original creek channel was not disturbed during the construction of the new channel due to a bridge that was constructed to move equipment across the creek (see Conclusions and Discussion). After the new stream channel was constructed, water was allowed to backwash into the new channel. During this "ageing in" process, fish had access to the new channel as well as the original creek channel. On many occasions large numbers of fish were observed swimming in the quiet water of the new channel prior to the diversion of the stream.

A storm, which caused the creek to overflow its banks, washed out the earth dam that was preventing rapid water flow through the new channel on January 12, 1976, approximately seven months after the construction of this new channel. After this occurred the creek flowed through both the old and the new channels until June, 1976 when the old channel was filled for road construction.

By the time the old channel was filled in, the new channel had become established as an integral part of the creek and was being used by the fish in the area. This probably accounts for the near complete repopulation, in terms of configuration, demonstrated by the species list. Had fish been collected on a bi-weekly basis for one year before

and after the channel relocation, it is likely that the data would reflect total repopulation because of the small difference observed as a result of the eight collections.

Fishes Captured Before and After Channel Relocation

Cyprinidae	
Campostoma anomalum	stoneroller
Dionda nubila	Ozark minnow
Nocomis asper	redspot chub
Notropis pilsbryi	duskystripe shiner
Notropis rubellus	rosyface shiner
Phoxinus arythrogaster	southern redbelly dace
Semotilus astromaeulatus	creek chub
Catostomidae	
Catostomus commersoni	white sucker
Poeciliidae	
Gambusia affinis	mosquitofish
Centrarehidae	
Ambloplites rupestris	rock bass
Lepomis cyanellus	green sunfish
Lepomis macrochirus	bluegill
Micropterus salmoides	largemouth bass
Percidae	
Etheostoma blennioides	greenside darter
Etheostoma flabellare	fantail darter
Etheostoma punctulatum	stippled darter

Etheostoma spectabile	orangethroat darter
Etheostoma zonale	banded darter
Percina caprodes	logperch
Percina copelandi	channel darter

Cottidae

Cottus carolinae	banded sculpin

Fishes Collected Before Channel Relocation,
Not Collected After Channel Relocation

Cyprinidae

Notemigonus crysoleucas	golden shiner

Centrarchidae

Micropterus dolomieui	smallmouth bass

Fishes Collected After Channel Relocation
Not Collected Before Channel Relocation

Catostomidae

Moxostoma duquesnei	black redhorse
Moxostoma erythrurum	golden redhorse

WATER CHEMISTRY

In order to assess the effects of the channel relocation project on water quality, several parameters were studied at eight different locations including above the channel changes. Samples were taken every two weeks beginning in August of 1974 and continuing through July of 1977. The parameters studied were alkalinity, nitrate nitrogen, dissolved oxygen, pH, phosphate, silica, specific conductance, suspended solids, turbidity, and temperature.

The procedures used for the analyses were as follows:

Nitrate nitrogen, orthophosphate, and silica were measured according to procedures described in:

Standard Methods for the Examination of Water and Wastewater. American Public Health Association. 12 ed. 1965. 769 p.

Nitrate nitrogen: Perkin-Elmer dual beam UV-Vis spec. S. M. P. 200.

Orthophosphate: B & L Spec. 70. read absorbance at 705 nm. S. M. p. 234. Stannous Chloride Method.

Silica: B & L Spec. 70. read absorbance at 815 nm. S. M. p. 264. Colorimetric Heteropoly Blue Method.

Temp and DO: Yellow Springs Instruments Meter YSI tl. Calibrate meter by using modified Winkler Method of O_2 determination. Measurements taken in the field.

pH and Alkalinity: Corning pH meter. Reads pH directly. Titrate with sulfuric acid to pH 4.5 to determine alkalinity.

Turbidity: Hach 2100 A Turbidity instrument. Reads turbidity in NTU.

Suspended solids: Alternate method used of preweighing a glass fiber filter, drying it, and reweighing it. The difference in weight x 4(250 mls filtered) equals the milligrams of suspended solids/liter.

Conductivity: Direct reading conductivity meters were used throughout the study. Meters used were Hach DR-EL 2 with conductivity capability and a Yellow Springs YSI-33. (Hach instrument used until during first year only).

Alkalinity, which refers to the capability of water to neutralize acids, was apparently not affected by the channel relocation or the construction activity. A sharp drop between the 20th and 23rd months (figure 2) is likely due to heavy rains which caused increased flow through the creek during this time.

Nitrate nitrogen, which represents the most completely oxidized state of nitrogen commonly found in water, showed no significant change between stations (figure 3) or any effect of the channel relocation or construction. Fluctuations, instead, seemed to be seasonal. Increased levels of nitrate would have indicated biological wastes in the final stages of stabilization or possibly runoff from fertilized slopes.

Dissolved oxygen (figure 4) showed stability between stations and also indicated no effect of channel relocation and construction. Stations 1 and 2, which were upstream from the construction, generally showed equivalent readings to the remaining six stations. As anticipated the D.O. followed the gas laws and showed an inverse relationship with temperature.

pH, which expresses waters tendency to accept or donate protons (hydrogen ions) on a scale of 0 (very acidic) to 14 (very basic), tended to show seasonal variation (figure 5) and was apparently not effected by the project. The creek tended to be only slightly basic and fairly stable with a typical range of 7.4 to 8.0.

Phosphates often occur in natural waters and can enter a stream from fertilizer runoff or biological wastes and residues. A certain amount of phosphate is essential for stream life and is often the limiting nutrient for growth. Too much can produce eutrophication or

over-fertilization if large amounts of nitrates are present. The result would be a large growth of aquatic vegetation and the eventual lowering of the dissolved oxygen content of the stream due to the death and decay of the aquatic vegetation. The only station which showed any non-conformity (lower readings) indicating that the lake was the determining factor. Lake Bella Vista is a small recreational reservoir, whose level is controlled by a spillway dam, located just east of Highway 71 at Bella Vista. The condition of this small reservoir varies throughout the year and large algal blooms are seen frequently.

Silica, which normally exists as an oxide (SiO_2) or as a silicate (SiO_4^{2-} and SiO_3^{2-}), will be present in greater than normal amounts during times of increased runoff and in streams near new construction. No significant variances were noted between stations and due to the abundant use of erosion control and careful construction (see Conclusions and Discussion) no increase in silica was observed during construction (Figure 7).

Specific conductance is a measurement of the water's capacity for conveying an electrical current. Changes in conductivity can signal fluctuations in a stream purity and indicate a need for additional analysis. The various stations exhibited little difference throughout the project indicating that the channel relocation had little effect on conductivity (Figure 8). The difference in the data from the first ten months and the remainder is a result of the use of different instruments. A Hach field kit containing a conductivity meter was used initially and a Yellow Springs YSI-33 was used for the remainder of the project.

Suspended solids in water are measured to get an empirical

estimate of water quality by measuring the amount of suspended material present. As expected, construction in and around did cause temporary increases in suspended materials (Figure 9). Station 1, above Lake Bella Vista showed consistently lower concentrations indicating that the road construction and the activity by the Bella Vista maintenance people were causing the higher concentrations noted at Stations 2-8. Data from these stations indicated that the channel relocation project had little effect on suspended solids. Only during construction of the new channel was any increase noted at all.

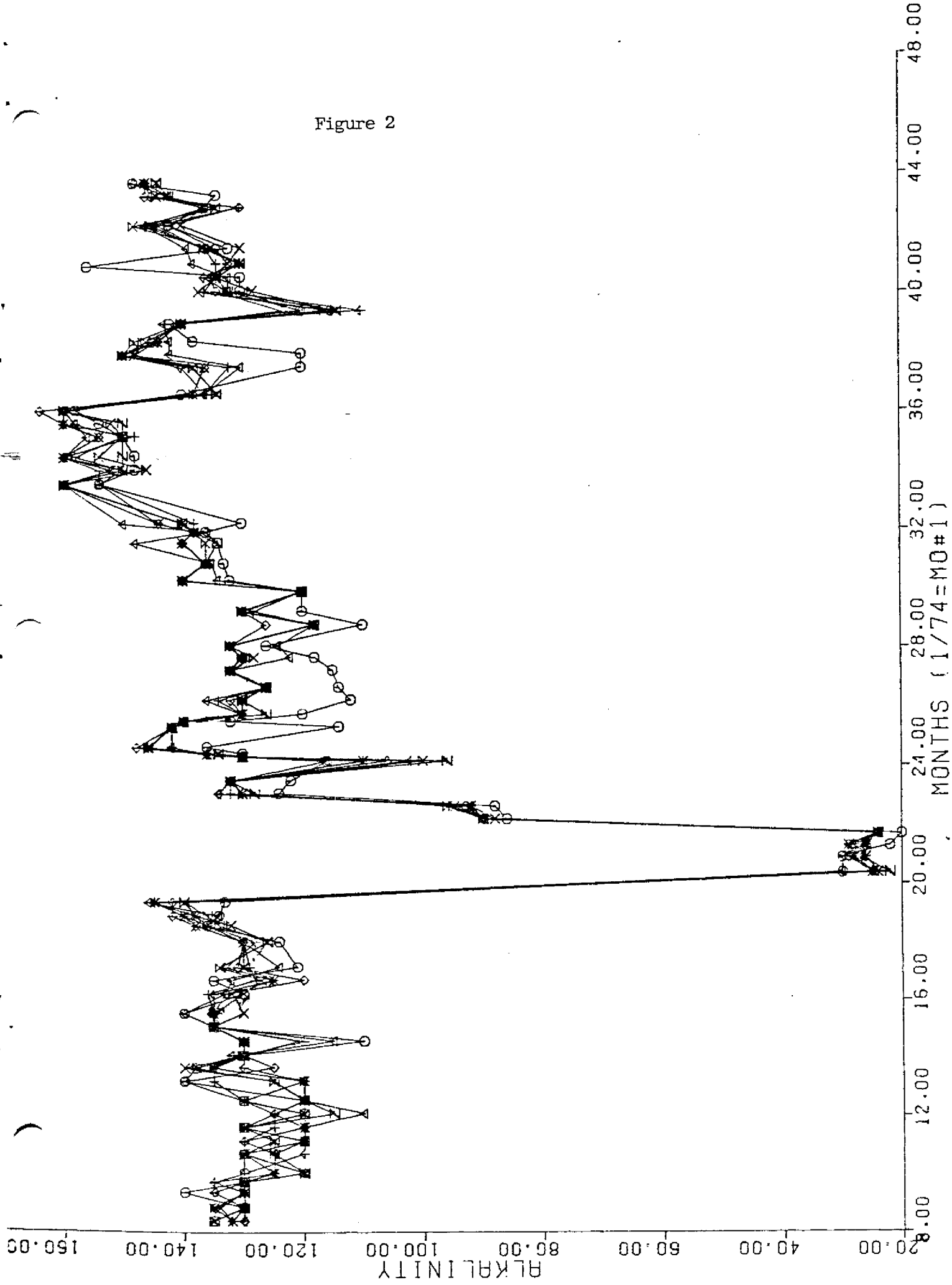
Turbidity indicates the amount of particulate matter present in water which affects the optical property of the water. Station 1 again was consistently lower in its values and the other stations remained fairly close. This also indicates that road construction and maintenance around Bella Vista were the contributing factors influencing the higher readings (Figure 10).

Temperature showed seasonal variances and almost no variation between stations (Figure 11). It has been reported that channelization projects where vegetation is cleared, the stream temperature will rise (Patrick, 1973). No evidence of a temperature rise corresponding to the channel relocation was noted. The careful attention given the existing vegetation during the new channel's construction seemed to have "paid off".

STATION #	SYMBOLS
1	⯃
2	△
3	+
4	×
5	◇
6	⯅
7	⧖
8	Z

LEGEND FOR FIGURES

Figure 2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100.00
120.00
140.00
160.00
MONTHS (1/74=MO#1)
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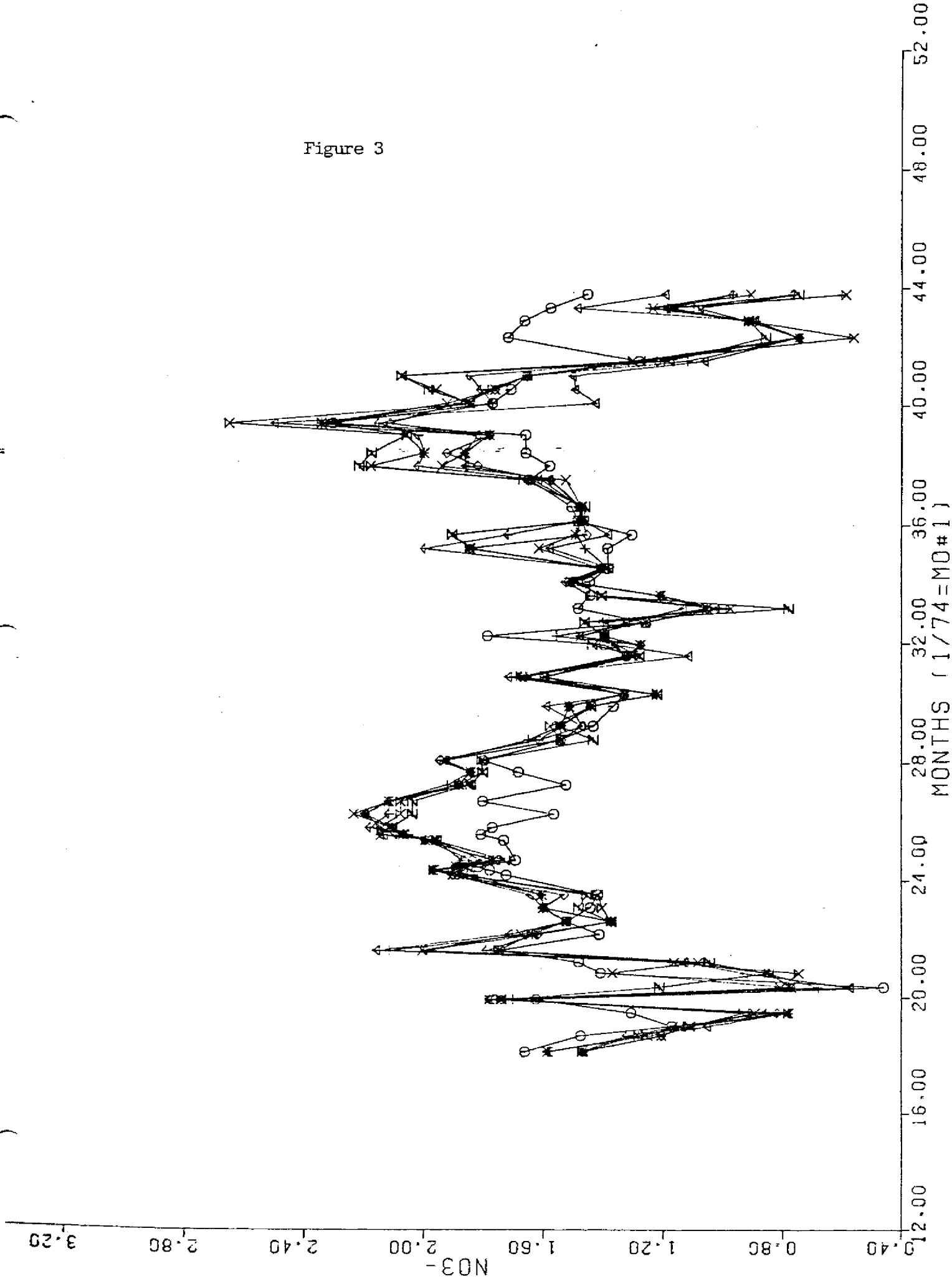
12.00
16.00
20.00
24.00
28.00
32.00
36.00
40.00
44.00
48.00

Figure 3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1.20
1.60
2.00
2.40
2.80
3.20
MONTHS (1/74=MO#1)
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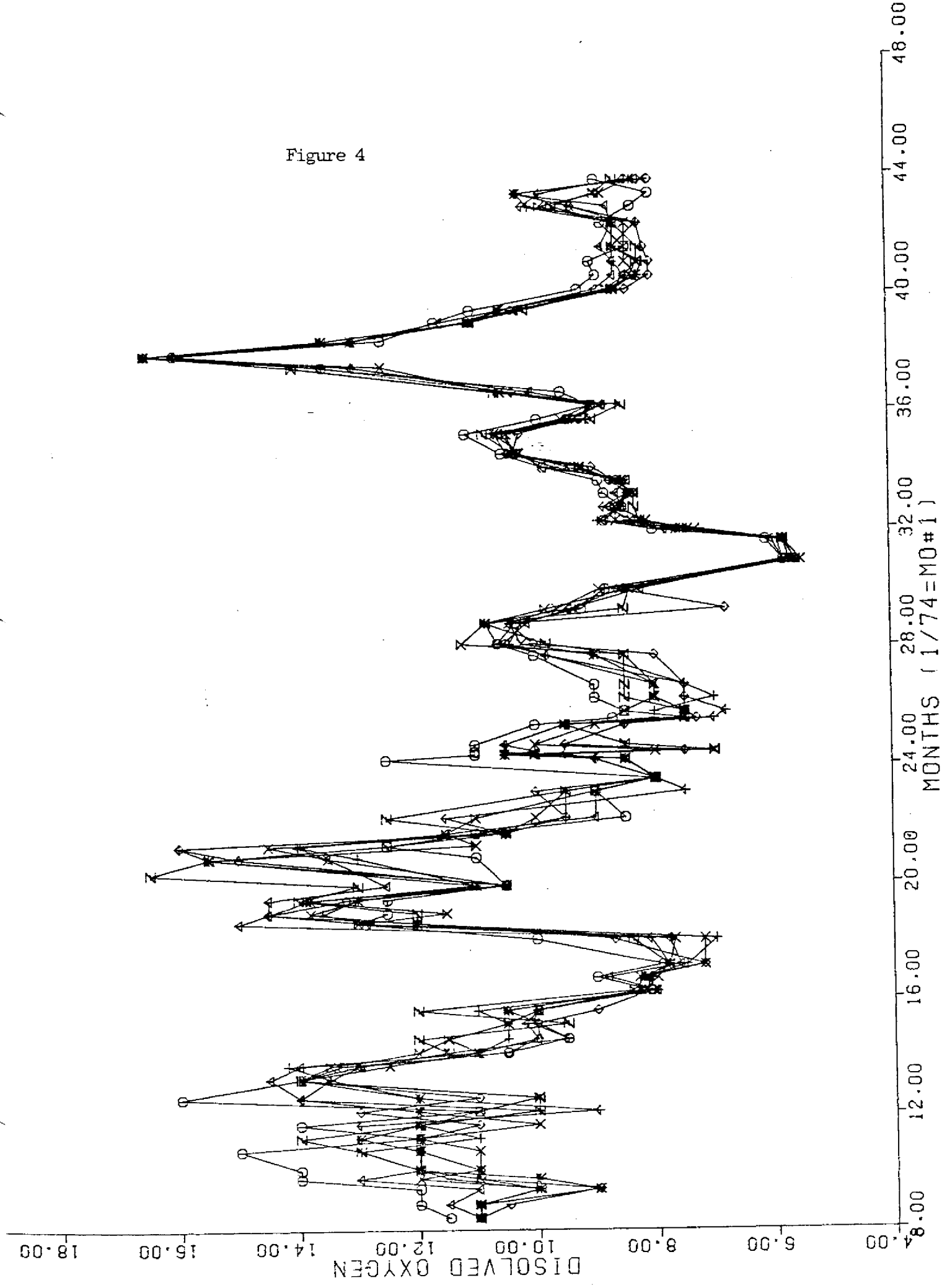
36.00
40.00
44.00
48.00
52.00

Figure 4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6.00
8.00
10.00
12.00
14.00
15.00
18.00
MONTHS (1/74=MO#1)
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32.00
36.00
40.00
44.00
48.00

Figure 5

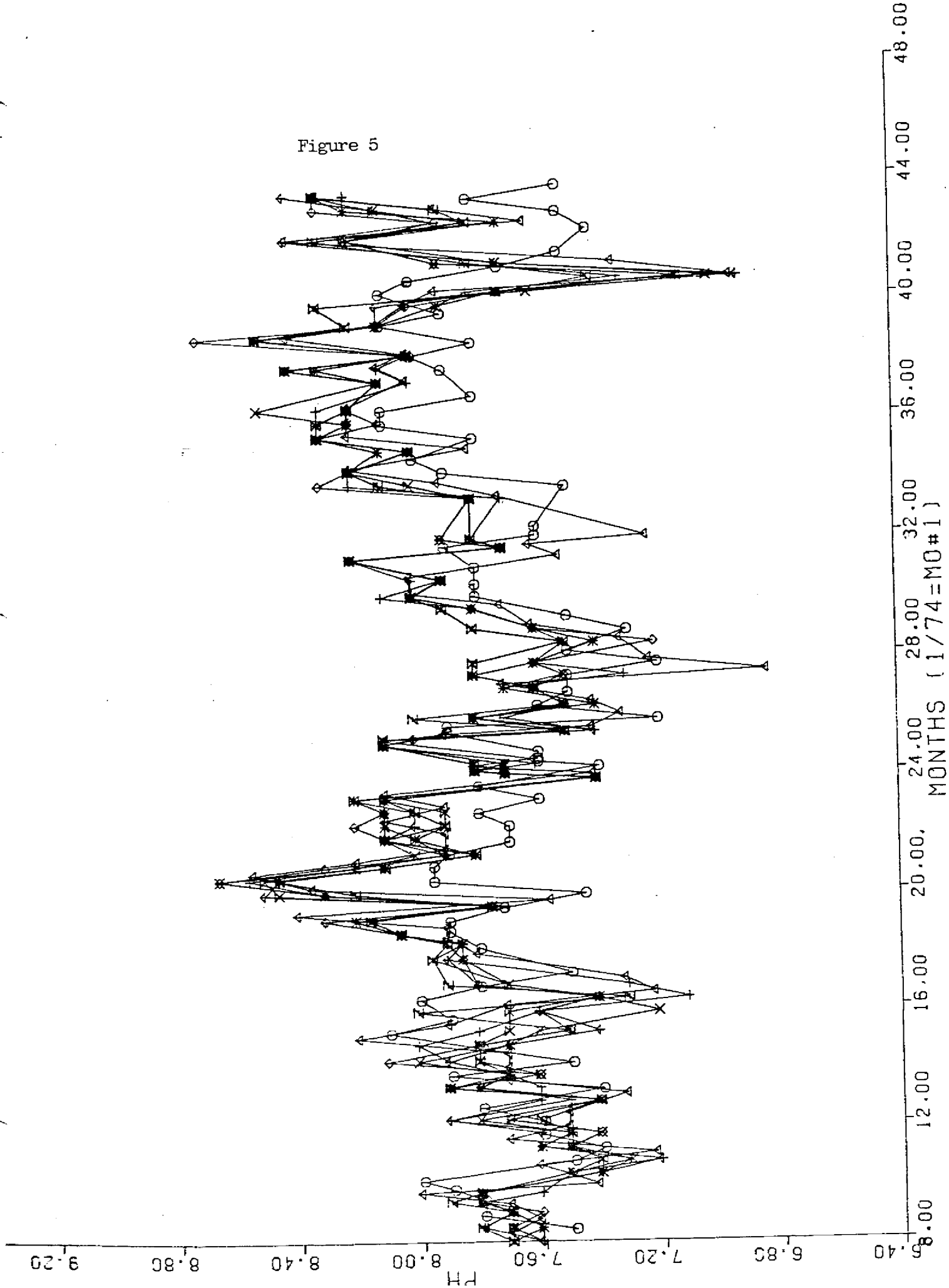
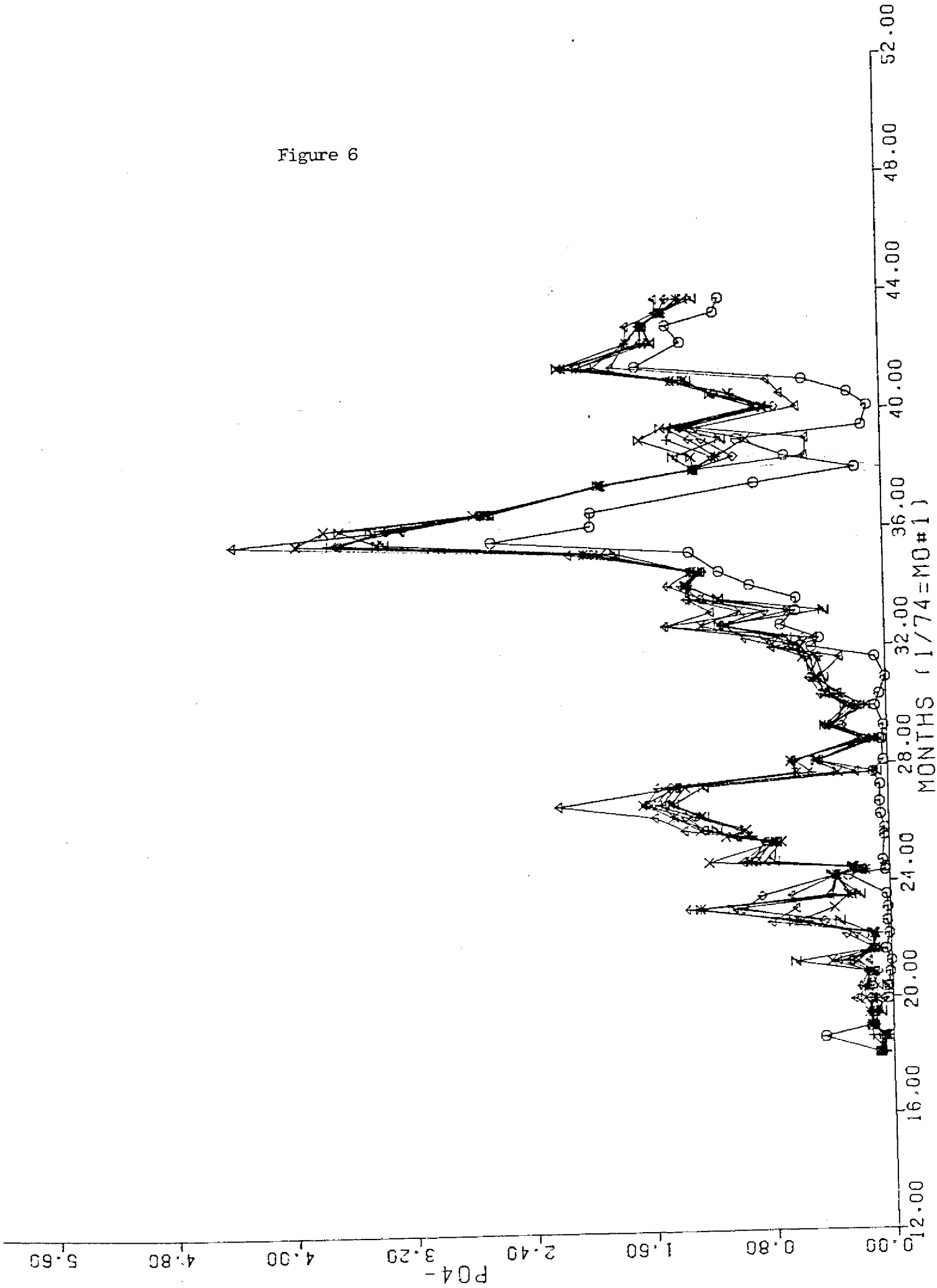

PH
9.20
8.80
8.40
8.00
7.60
7.20
6.80
6.40
MONTHS (1/74=MO#1)
8.00
12.00
16.00
20.00
24.00
28.00
32.00
36.00
40.00
44.00
48.00

Figure 6


PO4-
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0.80
1.60
2.40
3.20
4.00
4.80
5.60
MONTHS (1/74=MO#1)
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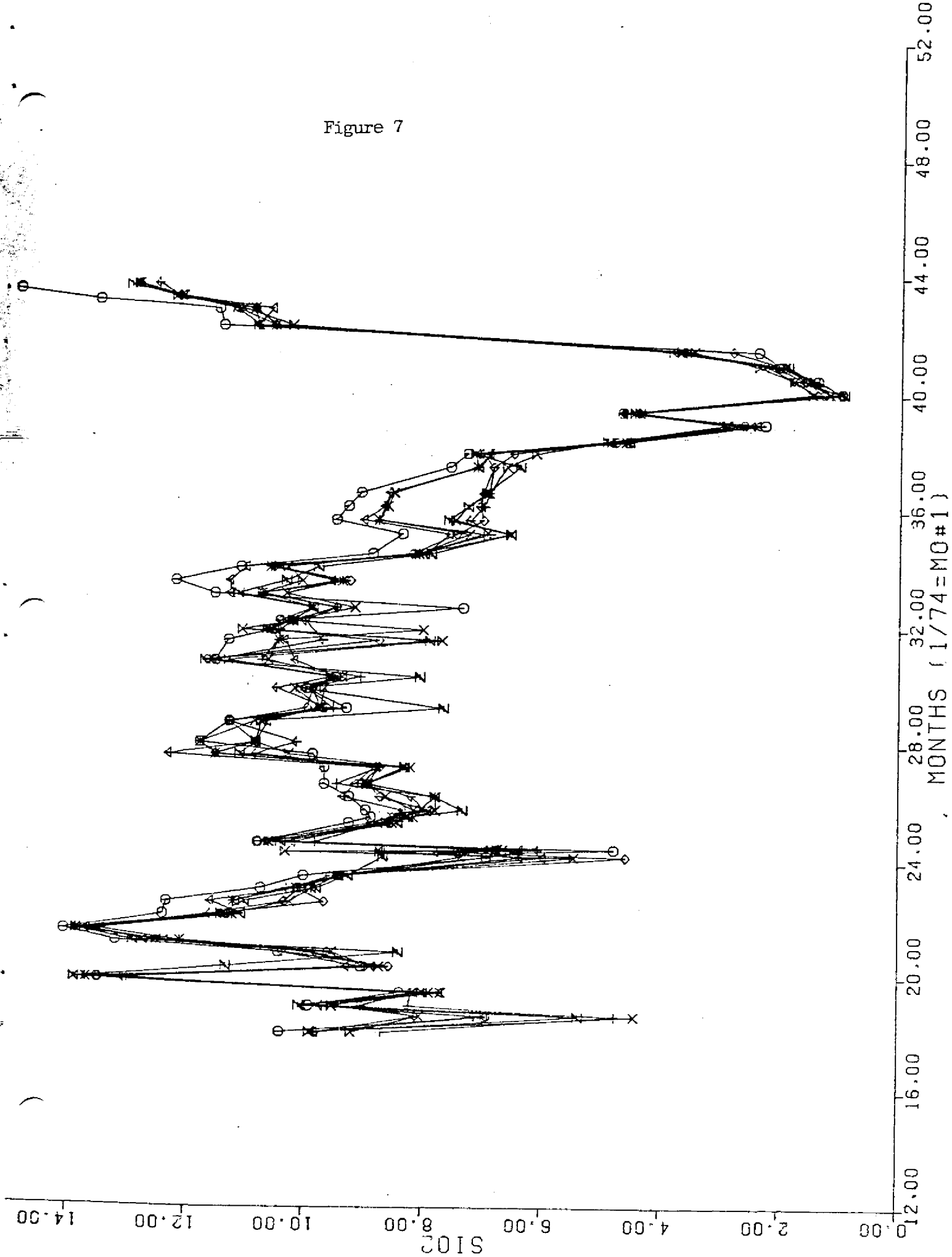
36.00
40.00
44.00
48.00
52.00

Figure 7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2.00
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6.00
8.00
10.00
12.00
14.00
MONTHS (1/74=MO#1)
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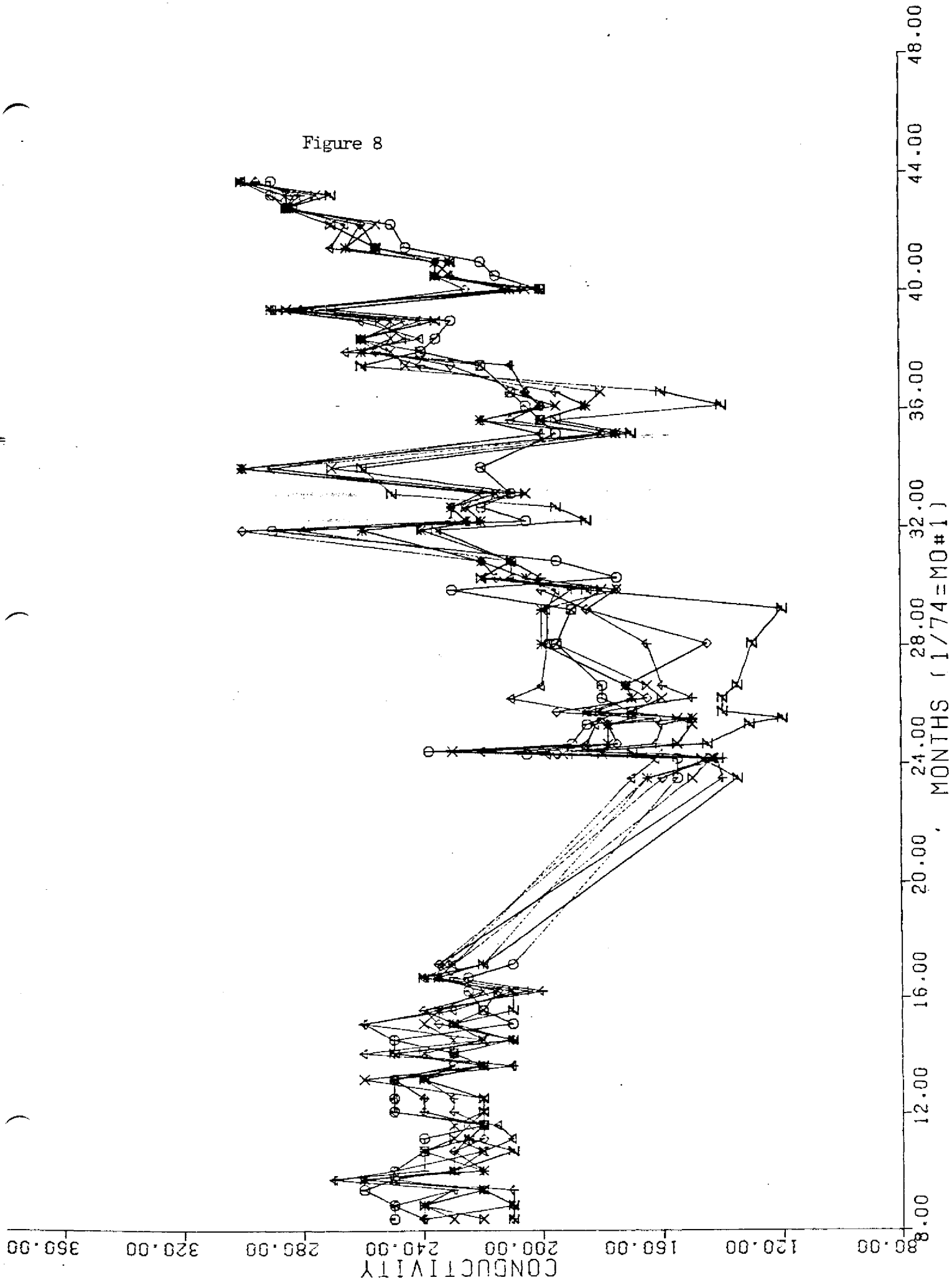
36.00
40.00
44.00
48.00
52.00

Figure 8


CONDUCTIVITY
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200.00
240.00
280.00
320.00
360.00
MONTHS (1/74=MO#1)
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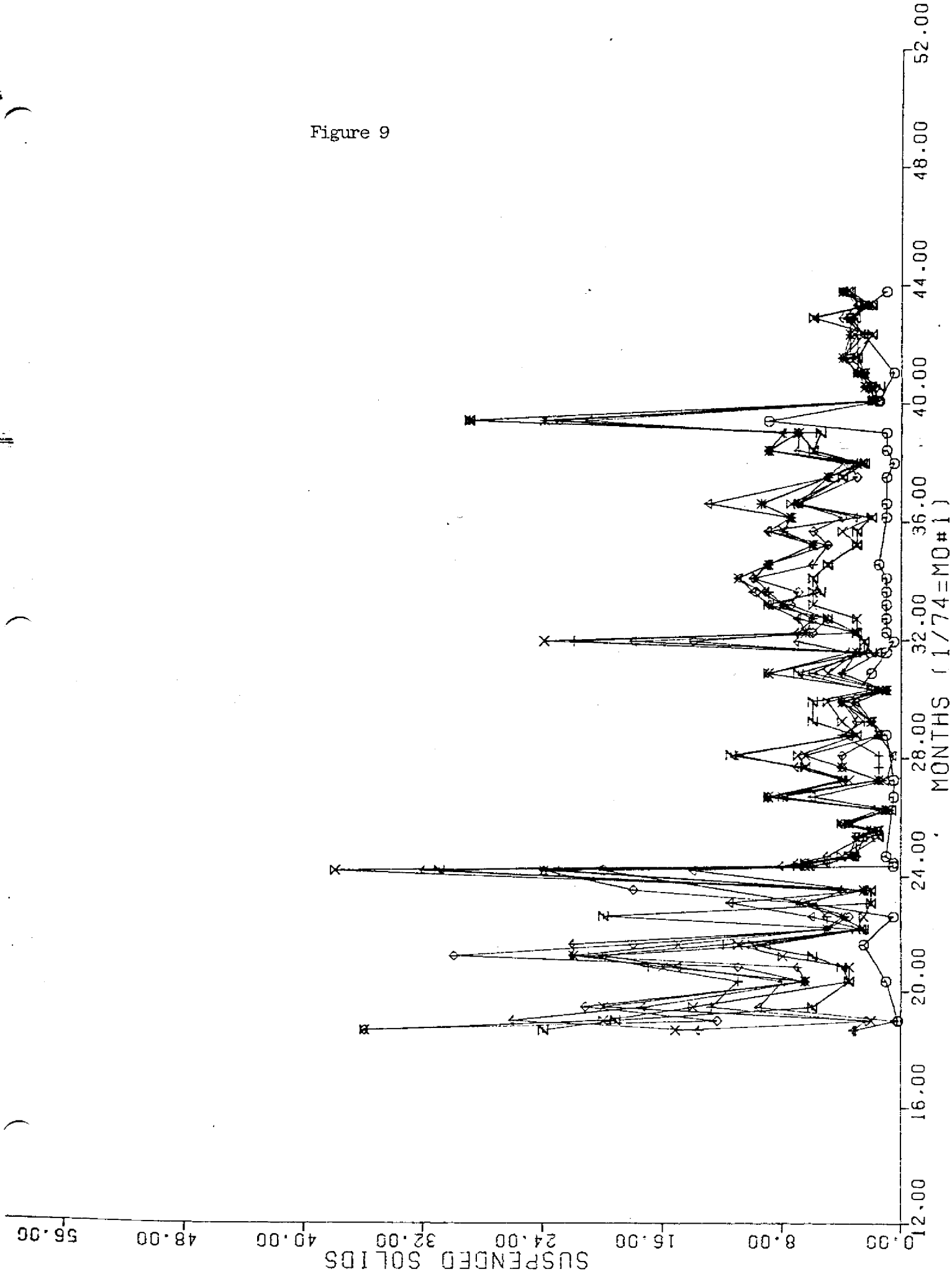
32.00
36.00
40.00
44.00
48.00

Figure 9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48.00
56.00
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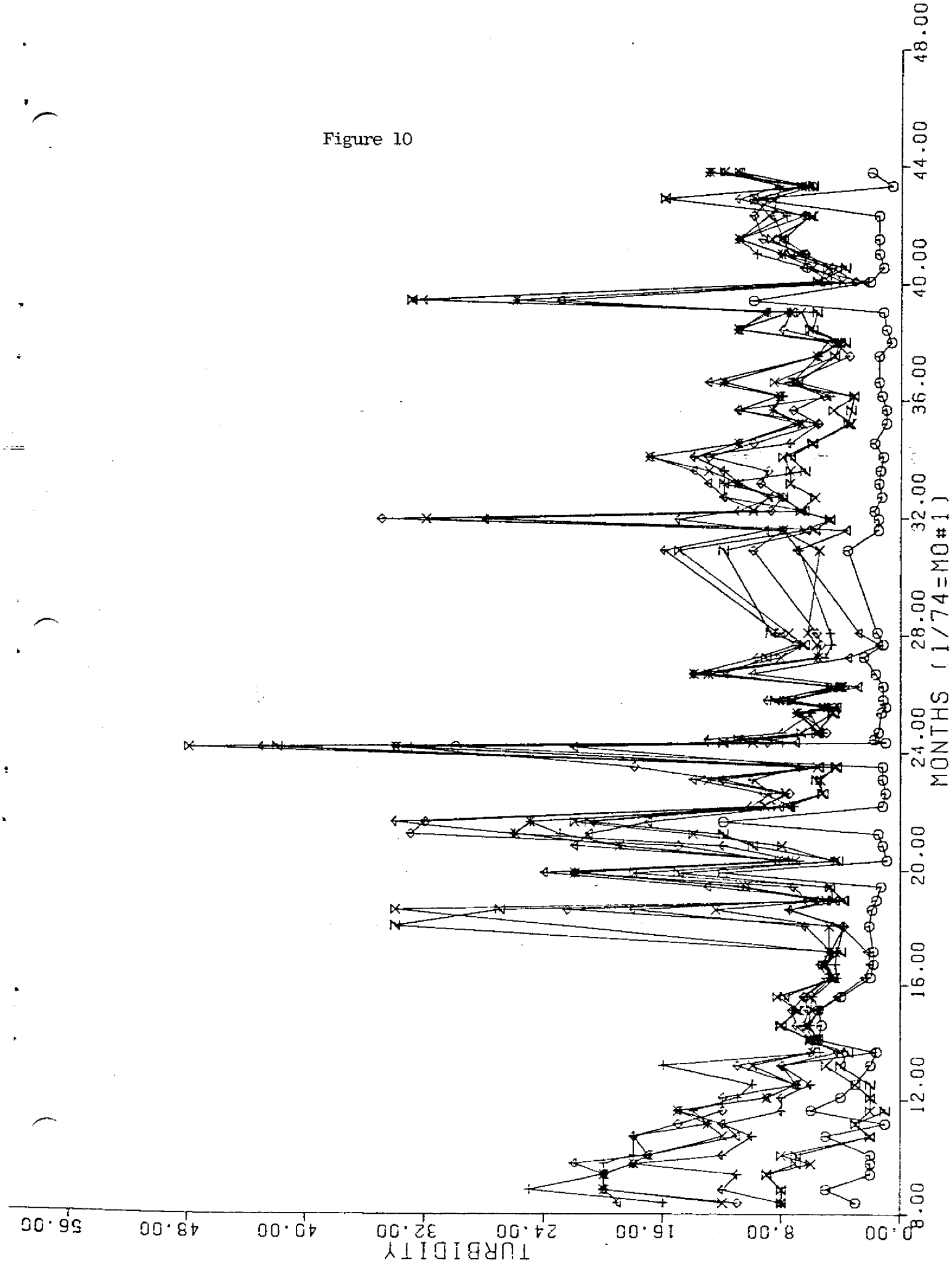
36.00
40.00
44.00
48.00
52.00

Figure 10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MONTHS (1/74=MO#1)
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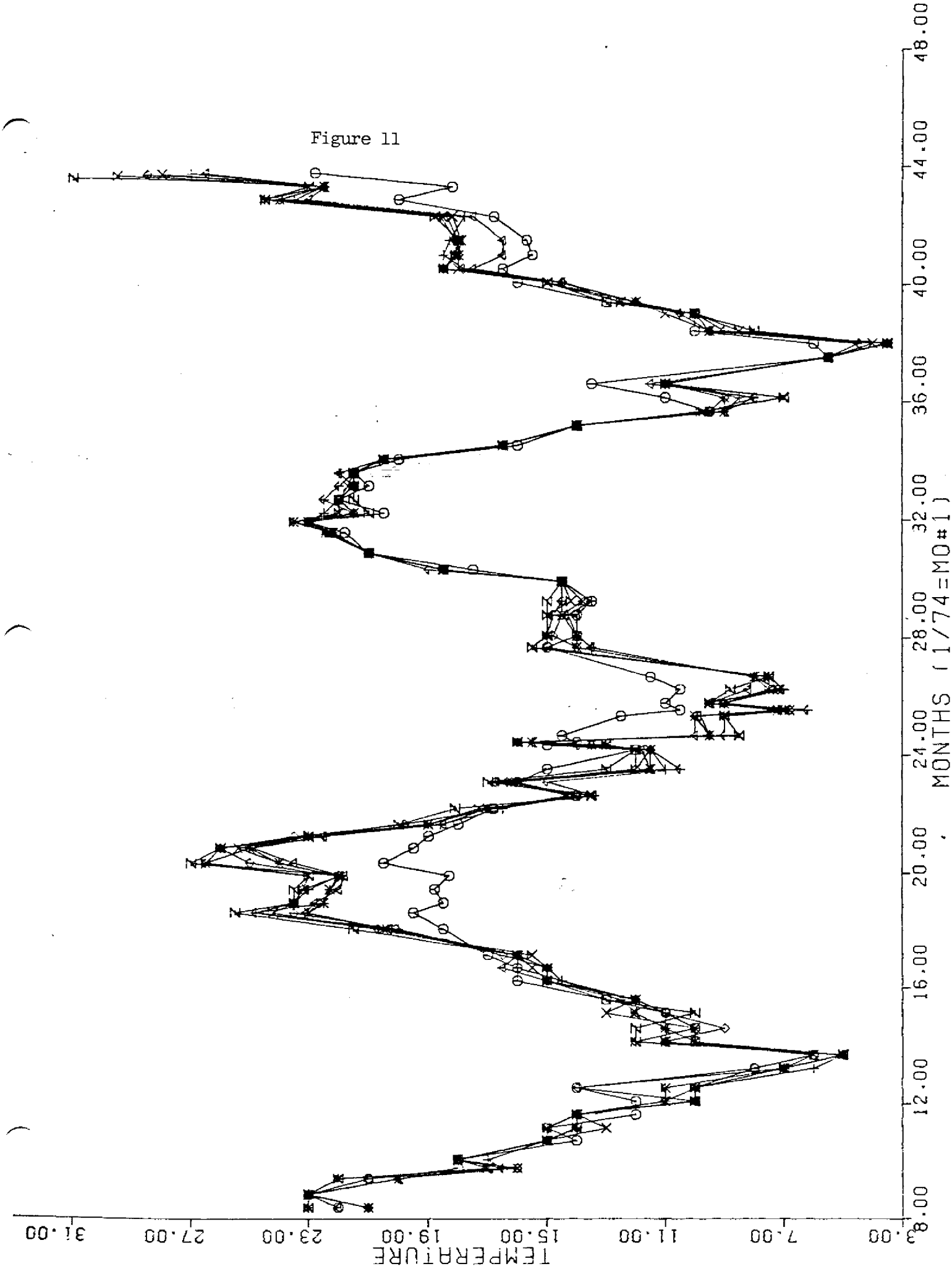
44.00
48.00

Figure 11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15.00
19.00
23.00
27.00
31.00
MONTHS (1/74=MO#1)
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12.00
16.00
20.00
24.00
28.00
32.00
36.00
40.00
44.00
48.00

CONCLUSIONS AND DISCUSSION

When the decision was made to move the channel of Little Sugar Creek, it was decided that some type of habitat replacement might soften the impact on the ecosystem and allow more rapid recovery of this system. The creek suffered problems, which affected the system, that were beyond the reach of the Arkansas Highway and Transportation Department.

Development along the creek banks included a camper parking area, a golf course, a driving range, and a recreation area. These areas all require regular maintenance and this activity includes fertilizing, some earthwork and dredging in the creek in an attempt to control flood problems, and obtain gravel. These factors must be kept in mind when considering the results of this project.

As a result of the activity along the creek, a system that was best for the prevailing conditions had developed. The areas of the creek immediately along the highway (the areas to be relocated) had been protected from total development by virtue of their proximity with the highway. These areas appeared to be "islands of nature" and any modifications needed to maintain the functioning of the ecosystem and not deteriorate the water quality.

A common and obvious trait of creeks and streams is that they rarely flow in a straight line. The meandering character of these streams provide them with a diversity of habitat, making it possible for many species of flora and fauna to exist. Bank stability and streamside vegetation also play important roles in habitat creation.

The portions of Little Sugar Creek that were being relocated

included two short meanders (totaling less than 700 feet) and one longer, relatively straight section of 2,200 feet. The alterations to the shorter sections simply involved replacing two narrow (approx. 20') meanders. New meanders were dug just outside the roadway fill area using a backhoe and a small bulldozer. The only vegetation that was taken was that which lay within the banks of the new creek channel. Because of the homogeneous substrate in the area, the character of the creek bed was not changed.

The long section presented more problems. This portion of the creek lay on the west side of the highway and contained only one gentle meander. Both banks were covered with dense vegetation for about 1500 feet. A golf green and a sand trap were located at the southwest portion of the channel to be relocated. In order to keep the channel the same length and to provide some diversity of flow to assist in system recovery, two meanders were incorporated in the new channel. The width and depth of the old channel were approximated in the new channel and large boulders which provided cover were transplanted to the new channel. Trees, of the same species located along the creek, were planted along the western bank in the area of the golf course to help replace some of the lost vegetation. A digger log was placed in the approximate location of a pool that existed in the old channel. This created and maintained another pool at an equivalent location in the newly constructed channel.

During construction of the new stream channel, a temporary bridge was constructed for the purpose of moving equipment across the channel without unnecessarily disturbing the creek's aquatic system by creating turbidity and increased sediment flow. The many trips that the

bulldozers and earth movers made across the creek had virtually no effect on water quality.

A Highway Department Maintenance Crew did the actual construction on the new creek channel. They were very careful to limit the movement of their equipment to the channel area so as not to destroy any surrounding habitat.

The new channel was dug leaving an earthen dam on the upstream portion. After digging the channel, the downstream side was opened allowing water to enter the new channel so that an "aging in" process could begin. As various communities began to become established, fish were observed using this new area on frequent occasions. Streamside vegetation began to emerge and by four months the area around the new channel began to appear to be an integral part of the creek's ecosystem.

A storm washed out the upstream dam during mid-winter and the creek flowed through both channels until the old channel was filled the next summer for road construction. The new channel was being utilized by most of the creek's inhabitants by this time and very little immediate effect was evident.

The most predominant immediate effect was the reduction of vegetation; however, most of the vegetation eliminated was not at the edge of the new channel. This allowed the development of many species of insects and reduced a possible negative effect on the overall productivity of the creek.

During the roadway construction many erosion control techniques were employed other than those commonly used. The most important of these were involved in the construction of bridge piers for a small

bridge over the creek. After construction of coffer dams, pumps were placed in the dams and hoses were connected to the pumps. These hoses were of a length which permitted the murky water seeping in the dam to be pumped to a small reservoir on the side of the embankment above the creek. As the water overflowed, this reservoir ran down the embankment through several rows of hay bales and then eventually back into the creek. The water returning to the creek was relatively clear and turbidity was kept to a minimum.

Mammals, fish, invertebrates, plant communities, algae, and water chemistry all seemed to suffer only temporary effects of the highway construction during the course of this study. The construction of a new creek channel appeared to have less total effect on the ecosystem than the highway construction or the maintenance activities of the Bella Vista community.

After the highway was completed, the relocated creek areas once again appeared to be "islands of nature" in a developed area. The apparent lack of permanent or even long-term impact on the ecosystem was likely due to the very careful attention given to the creek during new channel construction and highway construction.

By constructing a new channel to provide flow diversity and diverse habitat taking care to minimize impacts of construction, leaving as much vegetation as possible, and planting additional vegetation where construction has reduced the number of plants streamside, it has been possible to provide transportation progress without the destruction and sterilizing effects of common channelization. It can be possible to proceed with a project, highway, or otherwise if as much care and

attention are given to the surrounding ecosystem as is given to the plans for progress. Ruth Patrick stated in the Highway Research Board, Special Report 138, titled Effects of Channelization on the Aquatic Life of Streams, "If man is going to interfer and modify natural waterways, he should design his alterations to maintain the functioning of the aquatic ecosystem that makes possible the continuance of a stream's high water quality".

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