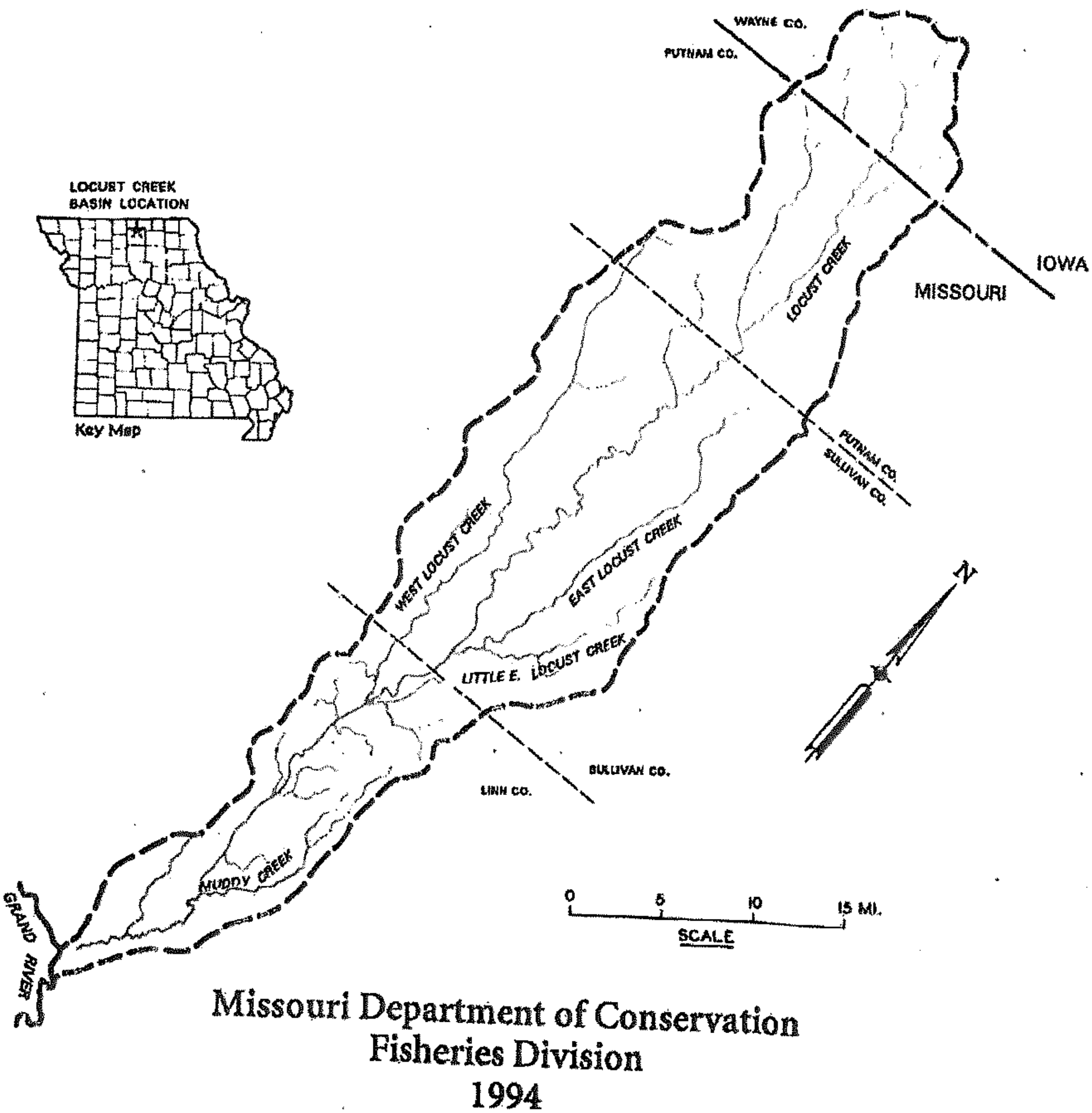
APPENDIX U

LOCUST CREEK BASIN MANAGEMENT PLAN

Locust Creek Basin

Management Plan



Missouri Department of Conservation
Fisheries Division
1994

STREAM MANAGEMENT PLAN
LOCUST CREEK BASIN

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EXECUTIVE SUMMARY

Locust Creek originates in Iowa and flows approximately 100 miles southward to its confluence with the Grand River in the northwest corner of Chariton County. Annual mean discharge for Locust Creek is 325 cubic feet per second (cfs) with a 7-day Q10 low flow of 0.7 cfs near Linneus, Missouri. Locust Creek drains 679 square miles and the basin lies in the Dissected Till Plains physiographic region. There are 26 streams fourth order and larger in the basin. Major tributaries to Locust Creek include East Locust Creek, West Locust Creek (South), Little East Locust Creek, Muddy Creek and Hickory Branch.

Land use is approximately 27% cropland, 47% grassland, 24% forest, and 2% urban or other uses. Excessive sediment is the major water quality problem in the basin. Point source pollution is generally not a problem, and no chronic fish kills have occurred in the basin.

Aquatic habitat conditions range from poor to good. Aquatic habitat problems are usually the result of channelization and excessive sediment. Two large reaches of Locust Creek have not been extensively channelized. The first is a 28.7 mile reach through Sullivan Co., which was recognized in the 1982 National Park Service Nationwide Rivers Inventory as being one the of the few remaining largely unchannelized reaches of stream in north Missouri. The second is a 17.4 mile reach from the confluence of

Locust Creek and Grand River to the northern boundary of Pershing State Park.

Fish communities are typical prairie fish assemblages dominated by cyprinids. A total of 37 fish species were collected in the basin, including two intolerant species: stonecat (*Noturus flavus*) and trout-perch (*Percopsis omiscomaycus*). The 1984-86 statewide telephone angler survey showed that 80-90% of all fishing trips in the Grand River basin were directed toward channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictis olivaris*), carp (*Cyprinus carpio*) and bullheads (*Ameiurus* sp.). Statewide fishing regulations apply to all streams within the basin.

Channel and flathead catfish will be the management emphasis species in the Locust Creek basin. The status of catfish and other fish populations will be evaluated by developing baseline fish community information. Project plans for catfish habitat improvement will be prepared and implemented. Objectives to improve habitat at a basin level involve reducing sedimentation by educating and assisting the public with stream corridor and watershed management techniques. This will reduce the amount of channelization and stream corridor timber clearing which cause a large portion of the sedimentation in the basin. Efforts will also be made to improve the public understanding of the ecological value and potential recreational use of the stream resource.

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BACKGROUND

Locust Creek originates in Iowa and flows southward approximately 100 miles through Putnam, Sullivan, and Linn counties in north central Missouri to its confluence with the Grand River near the northwest corner of Chariton County (Fig. 1A-C). Major tributaries are East Locust Creek and West Locust Creek (South) which join Locust Creek near the Sullivan/Linn County line. Other tributaries include Little East Locust Creek, which joins East Locust Creek near the Sullivan/Linn County line, and Muddy Creek and Hickory Branch, both of which enter immediately north of the Linn/Chariton County line.

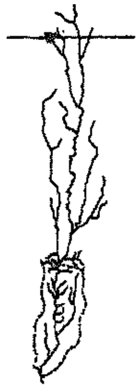
GEOMORPHOLOGY

Streams in the Locust Creek basin typically occupy broad, flat floodplains with small or imperceptible slopes. In some locations the channel is controlled by Pennsylvania sedimentary rock formations which cause the channel to be uncharacteristically straight. Along such reaches, habitat conditions are variable ranging from high diversity and good riffle/pool development to featureless channels with bedrock substrate.

Figure 1A.

Lower Locust Creek Drainage

Chariton-Linn Counties



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MILES
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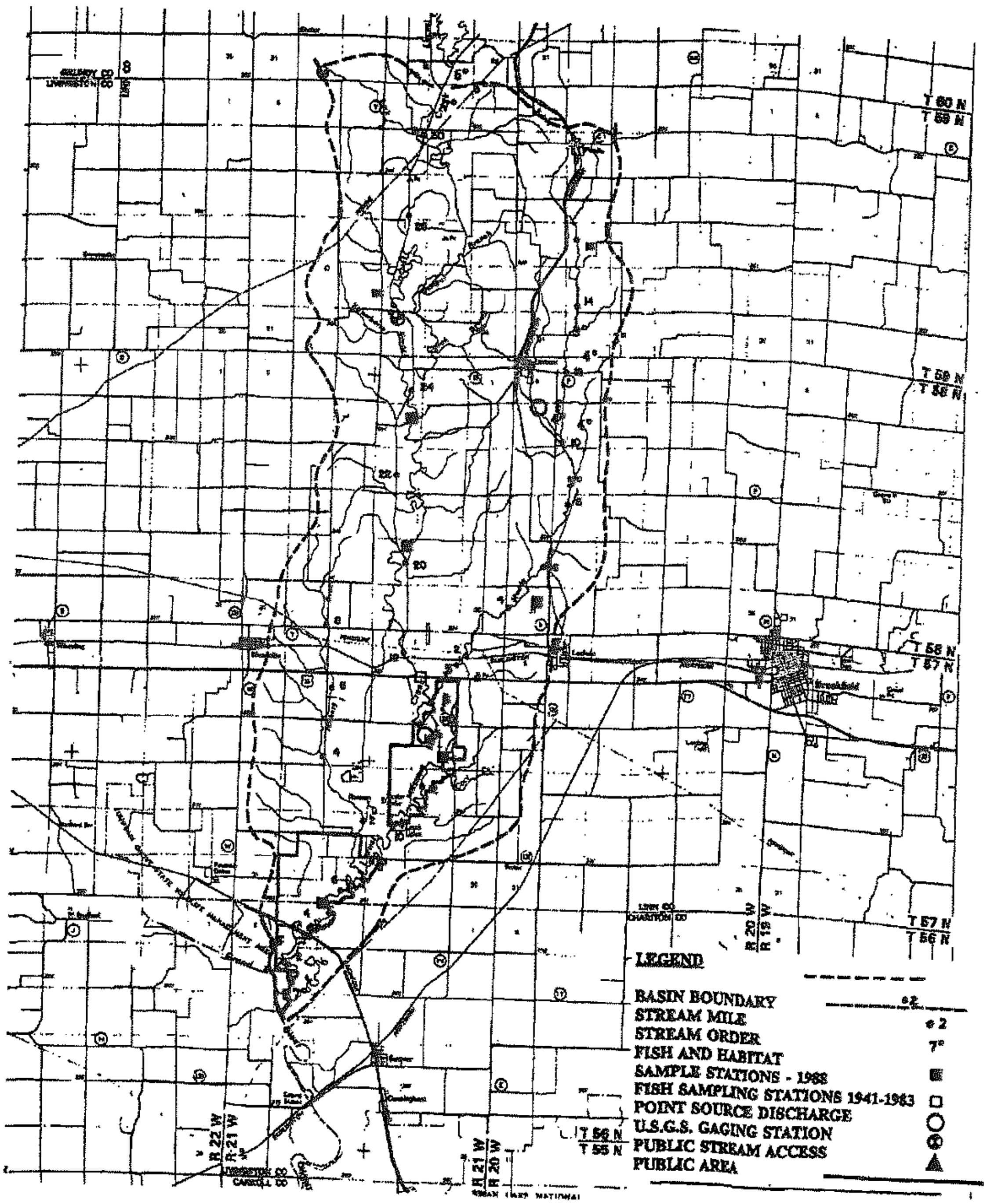
KILOMETERS



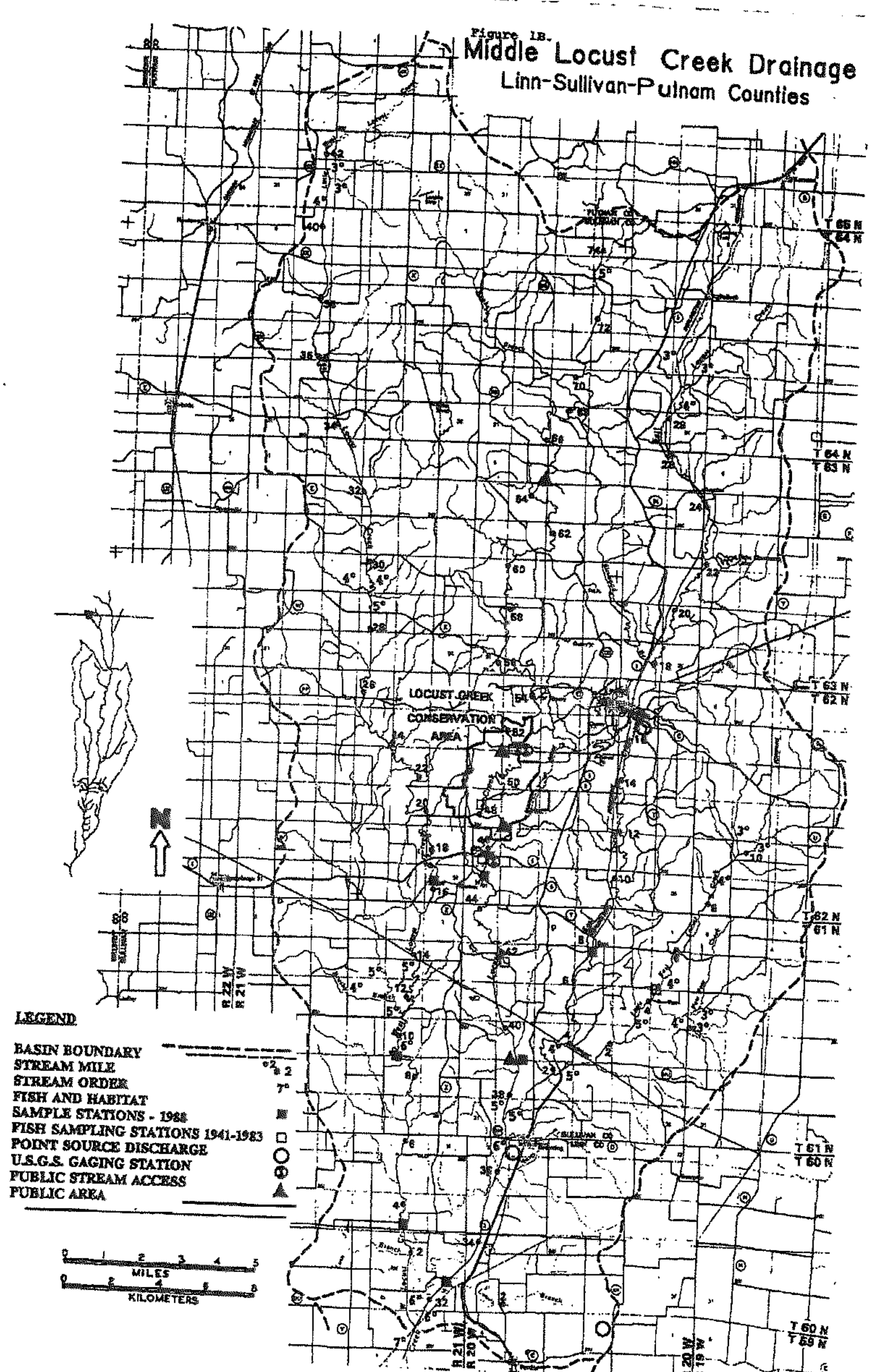


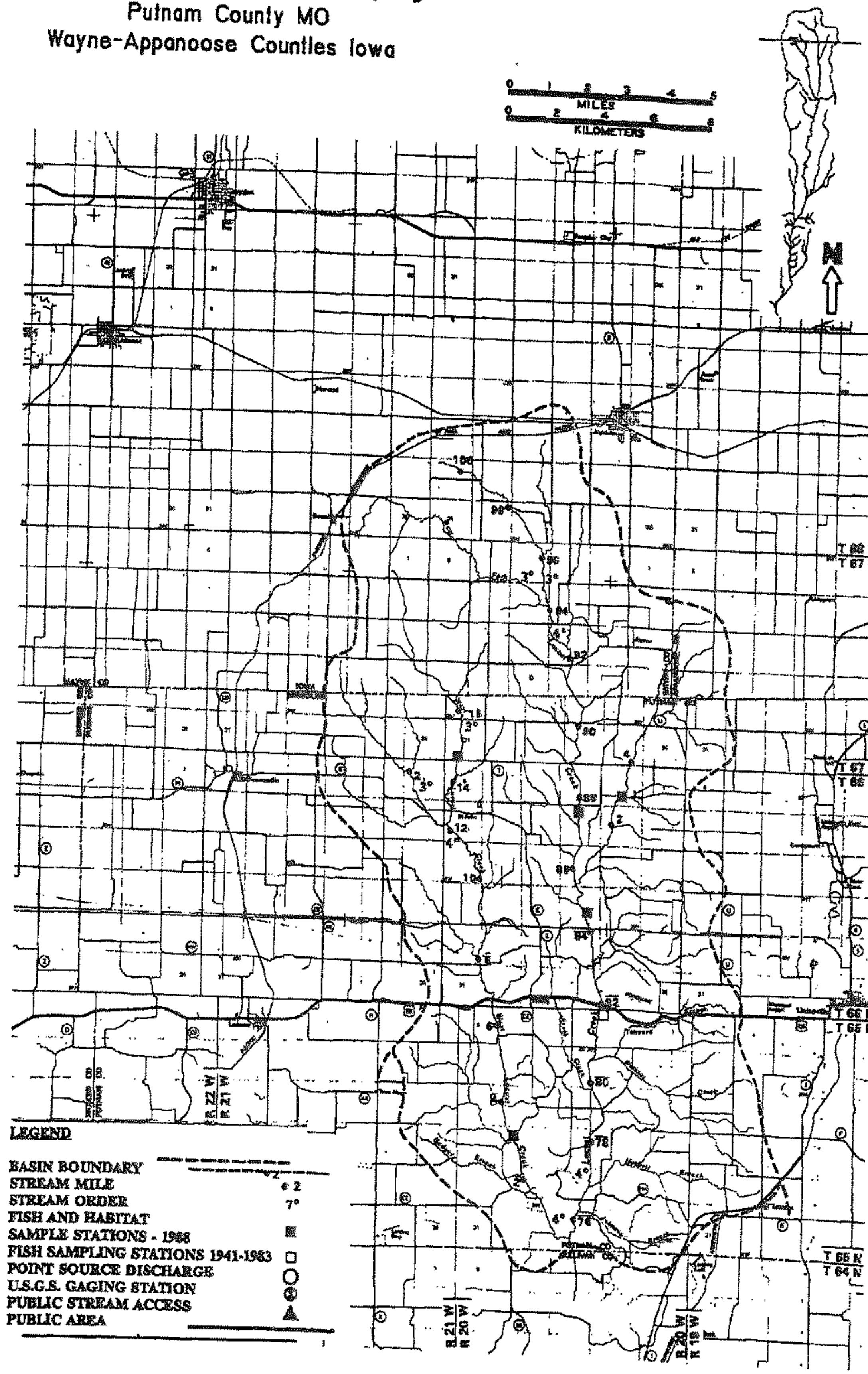
Figure 1B.
Middle Locust Creek Drainage
Linn-Sullivan-Putnam Counties
LOCUST CREEK CONSERVATION AREA
T 65 N
T 64 N
T 63 N
T 62 N
T 61 N
T 60 N
T 59 N
R 22 W
R 21 W
R 20 W
R 19 W
SULLIVAN CO
LINN CO
LEGEND
BASIN BOUNDARY
STREAM MILE
STREAM ORDER
FISH AND HABITAT
SAMPLE STATIONS - 1988
FISH SAMPLING STATIONS 1941-1983
POINT SOURCE DISCHARGE
U.S.G.S. GAGING STATION
PUBLIC STREAM ACCESS
PUBLIC AREA
MILES
KILOMETERS

Figure 1C.

Upper Locust Creek Drainage

Putnam County MO

Wayne-Appanoose Counties Iowa



Physiographic region/geology/soil type

The Locust Creek basin lies in the Dissected Till Plains physiographic region. This is a mix of hills and plains composed of glacial deposits on Pennsylvanian sedimentary rock. The till is predominately clay with some rock and gravel and is highly variable in depth, but generally less than 200 feet. Top soils of the basin consist of loess and drift 4-8 feet deep with transitional slopes containing both prairie- and forest- derived soils. Historically, prairie grasses were the native vegetation of the region and helped develop deep, organic-rich soils favorable for agricultural row crops. Predominant soils in the basin are grouped by parent material, slope and soil texture into soil associations (USDA 1982). Soils in the bottoms along Locust Creek, East Locust Creek and West Locust Creek (South) are typically a Kennebre-Nodaway-Colb-Zook association. Headwater regions and uplands have of a variety of soil associations with Weller-Keswick-Lindley-Mandeville and Pershing-Armstrong-Gora being dominant. These soil associations can generally be described as silty-clay loam and highly erodible, in part responsible for the turbid nature of streams in the basin.

Stream order

Stream orders were determined for all streams in the basin (Appendix 1A). For convenience, streams third order and larger were assigned a code number similar to Pflieger et al. (1981), but more digits were used to accommodate the many streams in the basin. Because of its numerous tributaries, Locust Creek was divided into three drainages (Upper, Middle and Lower).

Of the 100 tributaries to Locust Creek, 75 are third order, 20 are fourth order, four are fifth order and one is sixth order. Locust Creek is seventh order at its confluence with the Grand River. The sixth order tributary is West Locust Creek (South) which is largely in Sullivan County and should not be confused with the fourth order tributary, West Locust Creek (North) in Putnam County.

Appendices 1A and 1B provide the stream order, link magnitude, downstream link, and stream codes for streams 3rd order or larger.

Watershed area

Locust Creek basin is 678.6 mi^2, West Locust Creek (South; sixth order) is 134.6 mi^2; four fifth order streams average 39.8 mi^2 in watershed area (range 13.9 to 76.4 mi^2) and 20 fourth order streams average 8.4 mi^2 in watershed area (range 1.0 to 58.8 mi^2; Table 1). Watershed area appeared to correlate well with link magnitude (the number of first order segments above any given point on a channel; Osborne and Wiley 1992), though no statistical analysis was performed.

Table 1. Stream code, name, order, link magnitude, and watershed area for streams fourth order and larger in Locust Creek basin.

Stream Code	Name	Order	Link Magnitude	Watershed Area (mi^2)
52121000.000	Locust Creek	7	1734	678.6
52121410.000	West Locust Creek (S)	6	464	134.6
52121450.000	East Locust Creek	5	119	76.4
52121610.000	West Locust Creek (N)	4	92	58.8
52121451.000	L. East Locust Creek	5	75	40.2
52121140.000	Muddy Creek	5	203	28.7
52121110.000	Hickory Branch	4	69	22.3
52121560.000	Rooks Branch	4	40	21.9
52121411.400	Unnamed 31	5	143	13.9
52121451.200	Unnamed 54	4	20	11.8
52121430.000	Lowes Branch	4	39	10.2
52121111.000	Higgins Ditch	4	37	8.5
52121411.300	Unnamed 29	4	23	5.3
52121570.000	Unnamed 70	4	11	4.8
52121411.100	Linn Branch	4	32	4.6
52121411.410	Brushy Branch	4	26	4.1
52121148.000	Unnamed 13	4	26	3.9
52121412.200	Unnamed 41	4	43	3.9
52121360.000	Lick Branch	4	30	3.6
52121240.000	Unnamed 20	4	11	3.4
52121411.420	Unnamed 34	4	33	3.2
52121412.400	Unnamed 45	4	18	2.6
52121230.000	Unnamed 18	4	38	2.3
52121340.000	Unnamed 23	4	14	1.9
52121141.000	Unnamed 5	4	24	1.8
52121412.100	Unnamed 39	4	20	1.0

<u>Channel gradient</u>

Graphs of stream gradient help detect potentially unstable reaches and provide information useful in predicting habitat conditions. Appendix 2 contains gradient plots for fourth order and larger streams in the Locust Creek basin. Gradient plots are often not useful in detecting localized or minor problems because they do not show enough detail to reflect site specific conditions.

There was no observed relationship between gradient and habitat conditions in reaches sampled for fish and habitat (see Habitat Condition section), which may reflect a general trend toward physical stability approximately 70 years after the large-scale channelization undertaken in Linn County.

Average gradient was calculated for third order and larger reaches of mainstem Locust Creek, East Locust Creek and West Locust Creek (South; Table 2). Generally, these streams had a range of gradients: seventh order, 2 ft/mi; sixth order, 4-5 ft/mi; fifth order, 3-5 ft/mi; fourth order, 6-10 ft/mi; and third order, 10-18 ft/mi.

Table 2. Average gradient and percent slope for reaches third order and larger of Locust Creek, East Locust Creek, and West Locust Creek (South).

Stream name	Order	Average gradient (ft/mi)	Stream Miles	Percent slope
Locust Creek	7	2.09	31.1	0.040
Locust Creek	6	2.69	6.3	0.051
Locust Creek	5	3.22	37.9	0.061
Locust Creek	4	5.38	19.3	0.102
Locust Creek	3	6.99	1.4	0.132
East Locust Creek	5	3.09	1.9	0.058
East Locust Creek	4	5.53	27.6	0.105
East Locust Creek	3	10.06	3.4	0.190
West Locust Creek (South)	6	4.33	10.8	0.078
West Locust Creek (South)	5	4.00	18.0	0.076
West Locust Creek (South)	4	6.91	12.4	0.131
West Locust Creek (South)	3	10.18	1.1	0.193

These gradients may be higher than would normally be expected due to the extensive amount of channelization that occurred in the basin.

LAND USE

Recent land use

The basin is primarily rural; pasture and cropland is the dominant land use. Approximately 27% of the watershed north of Linn County is cropland, 47% is grassland, 24% is forested, and 2% is urban or other uses (SCS 1987b). These uses are comparable with the rest of the Grand River basin and probably with the rest of Locust Creek basin (USDA 1982). Land use on the uplands is 21% cropland, 53% grassland, 25% forested and 1% other. Most of the bottomland in the basin is cultivated (69%); 6% is grassland; 24% is forest; and 1% is under other uses. Approximately 5% of the bottoms are artificially drained with ditches, tiles, dikes, and pumps.

Lower Locust Creek has levees along much of its length because of high flood frequency and intensive bottomland row-crop farming. In contrast, few levees are located along streams north of the Linn/Sullivan County line where there is less bottomland area and less bottomland row-crop farming.

Soil conservation projects

The high percentage of land under pasture and cropland use, coupled with generally poor soil erosion control, has drastically increased the amount of sediment entering stream channels. Two soil conservation projects affecting Locust Creek watersheds north of Linn County are being implemented under the Watershed Protection and Flood Prevention Act, P.L. 83-566.

The Upper Locust Creek Watershed project (SCS 1987a) is designed to reduce flooding and improve soil conservation on 42,800 acres in Sullivan and Putnam Counties. The project consists of accelerated land treatment, five large floodwater detention impoundments, and 347 small floodwater detention and grade stabilization impoundments. The impoundments will reduce flooding on 26,900 (91%) of the 29,600 floodplain acres in the upper watershed. Land treatment program includes grade stabilization structures, grassed waterways or outlets, terraces, critical area planting, pasture and hay field planting, conservation tillage, conservation cropping systems, contour farming, tree planting, pasture and hay field management, livestock exclusion, and woodland improvement.

In June 1991, the Locust Creek Riparian Project, a 4-year supplement to the Upper Locust Creek Watershed Project, was approved for planning. This project was a cooperative effort between SCS and MDC and was funded by the U.S. Environmental Protection Agency. The riparian project sought to improve water quality and fish and wildlife habitat through riparian habitat protection and restoration on a 28 mile reach of Locust Creek in Sullivan County. Cattle exclusion, streambank stabilization, riparian corridor revegetation, conservation easements, and project monitoring were components of the project plan. At the time this basin plan was finalized, landowners showed little interest in the easements or stabilization projects.

Construction on the East Locust Creek watershed project started in spring 1988. This project will reduce erosion on 11,880 acres through land treatment and construction of 121 floodwater retention impoundments (SCS 1987b). The impoundments will reduce flooding on 8,800 acres (94%) of the 9,400 floodplain acres in the watershed.

Soil conservation projects planned for upper Locust Creek and East Locust Creek will reduce sediment delivered to stream by 70% (SCS 1987a and 1987b), thereby reducing excessive bedloads of sand that fill pools, embed riffles and create unstable, less productive substrate. Despite reduction of erosion within the basin, overall stream habitat conditions are expected to remain at present conditions due to the degree of channelization and intensive agriculture in the watershed (SCS 1987a). Improving aquatic habitat quality will require additional work, including reforesting riparian areas, increasing in-channel habitat diversity, and stabilizing streambed and streambank degradation.

The positive impacts of these projects could be offset by negative effects of increased clearing and cultivation of bottomlands, a possible result of increased flood protection provided by the PL-566 projects. In addition, the hydrologic impact of several hundred flood detention impoundments may create insufficient-flow problems unless the impoundments are modified to augment low flows.

Public areas

Several public areas are located in Locust Creek basin (Fig. 1A-C). Locust Creek Conservation Area (3,162 acres), Fountain Grove Conservation Area (6,714 acres) and Sears Community Lake (83 acres) are the three largest MDC-owned and -managed areas. Elmwood Lake near Milan is managed under MDC's Community Assistance Program (CAP). MDC stream access sites include Henry's Mill, Rocky Ford, and two sites on the Locust Creek Conservation Area. Fisheries Division has proposed one additional access site in Linn County near Linneus.

MDC owns approximately 14 miles of Locust Creek frontage, including 6.5 miles on Locust Creek Conservation Area, and 7.5 miles on one side of the channel at access sites and Fountain Grove Conservation Area. The Department of Natural Resources (DNR) owns approximately six miles of Locust Creek frontage in Pershing State Park.

Corps of Engineers jurisdiction

Waters of Locust Creek basin are under the Kansas City District Corps of Engineers (COE) regulatory jurisdiction. The upper boundaries of Phase I jurisdiction are: Locust Creek T66N, R20W, Sec. 35; West Locust Creek (South) T63N, R21W, Sec. 27; and East Locust Creek T62N, R20W, Sec. 2. These boundaries, however, were expanded by Federal Regulations 33 CFR 320-329 (1977) to include "the waters of the U.S." The entire length of all streams in the basin are within COE jurisdiction. Activities upstream of the point where median flow is less than five cfs are often covered by nationwide permits, although the COE may exercise discretionary authority over such activities.

HYDROLOGY

USGS gaging stations

The three U.S. Geological Survey (USGS) gaging stations that are or have been located in Locust Creek basin (Fig. 1A-C) are:

1) Wire-weight gage upgraded to water-stage recorder gage located at lat. 39°53′ long. 93°14′, in NE ¼ Sec. 34, T59N, R21W, at Linn County Highway bridge 3 miles northwest of Linneus, 5 miles downstream from the confluence of West Locust Creek (South) and Locust Creek, river mile 26.0; wire-weight gage period of record 1928-1956, water-stage recorder gage period of record 1956-1972.

2) Chain gage located at lat. 40°10;′ long. 93°11′ in SE ¼ Sec. 30 T62N, R20W, at bridge on State Highway 6, 0.3 miles east of Reger, Sullivan Co., river mile 45.85; period of record 1921-1933. Type A wire-weight gage

and crest stage gage at same location; period of record 1987-present.

3) Type A wire-weight gage located at lat. 40°11′, long. 93°10′, in NW ¼ Sec. 8 T62N, R20W, on county road bridge, 3.5 miles southwest of Milan, Sullivan Co., river mile 51.25; period of record 1987-1993.

In March 1990, a stage-discharge rating was developed by USGS for the gage at Reger for discharges up to 3,200 cfs. The relationship has been extrapolated to a discharge of 20,000 cfs. In March 1991, a provisional stage-discharge rating was developed by USGS for the gage near Milan. Unfortunately, the rating was not well supported above discharges of 300 cfs. The gage at Milan was discontinued in 1993 because channel changes during 1993 have made the stage-discharge rating obsolete and the gage inaccessible. The USGS will update and extend the rating for the gage at Reger when adequate stream flow occurs.

Permanent/intermittent streams

Precipitation in the area averages 36 inches annually with peak rainfall during May/June. As a result, Locust Creek, East Locust Creek and West Locust Creek (South) have permanent flow in reaches fifth order and larger (MDNR 1986a).

Stream flow

The only long-term flow data for the basin are for Locust Creek near Linneus (Table 3). Peak discharge generally occurs in June and annual mean discharge is 325 cfs with a 7-day Q10 low flow of 1.2 cfs for the period 1929-1965. This 7-day Q10 is similar to other streams of this size in the Dissected Till Plains region (Skelton 1970).

Table 3. Flow characteristics for Locust Creek near Linneus (river mile 26, 1928-1972).

Annual Mean Discharge	325 cfs
7-day Q10 Low flow	1.2 cfs
Slope Index $\frac{\text{7-day Q2}}{\text{7-day Q20}} = \frac{\text{6.1 cfs}}{\text{0.4 cfs}} = 15$	

A slope index (SI) of 15 (Table 3) is low compared to other streams within the Dissected Till Plains region of Missouri (average SI for 10 streams within the region was 25, ranging from nine on the Grand River at Gallatin, Missouri to 73 on the Platte River near Agency, Missouri). The low SI indicates relatively high variability in annual low flows and poor groundwater supply, further indication that there are low flow problems in the basin. Channelization and watershed modification contribute to the wide range of values for SI within this region of Missouri.

Under pre-settlement conditions, upper Locust Creek probably had significantly less channel capacity than lower Locust Creek. However, channel capacity (2,330 cfs) on lower Locust Creek, at river mile 22 (order 7), was similar to channel capacity on upper Locust Creek (river mile 73, order 5, 2,320 cfs; Table 4). The filling of the lower Locust Creek channel, and deepening and widening of middle and upper Locust Creek channels may be a result of channelization and poor land use practices. The increased channel capacity (7,020 cfs) of Locust Creek at river mile 46.0 is a result of channel widening for construction of the Highway 6 bridge.

Table 4. Bankfull discharge (cfs) and magnitude of flood (cfs) for various recurrence intervals (years) at seven sites in Locust Creek basin. Data for Locust Creek at river mile 26 are from Hauth (1974). Data for all other sites are from USDA (1982).

Stream	Basin Area mi^2	River Mile (approx)	Bank Full Discharge	Recurrence Interval 2	5	10	25	50	100
L.C.	588	22	2,330	--	--	--	--	--	29,630
L.C.	550	26	2,330	9,200	17,200	23,200	31,300	37,300	43,600
L.C.	243	46	7,020	--	--	--	--	--	18,120
L.C.	172	73	2,320	--	--	--	--	--	24,710
W.L.C.S.	118	6	2,590	--	--	--	--	--	14,700
W.L.C.S.	56	25	1,940	--	--	--	--	--	15,250
E.L.C.	75	8	1,790	--	--	--	--	--	12,830

Middle Locust Creek (river mile 31.2 to river mile 54.2) has variable out-of-bank discharge frequencies (from once per year to once every five or more years). Lower Locust Creek, where the stream is channelized and aggrading, experiences out-of-bank floods more frequently than once per year, reportedly as often as 13 times during a wet year (G. Seek, MDC, pers comm). This is supported by flow data from river mile 22.0 where a discharge with a two-year recurrence interval is four times bankfull discharge (Table 4). Upper Locust Creek also experiences frequent out-of-bank discharges (> one event/year).

Little information exists on flows required to provide sufficient fish habitat in warmwater streams. Consequently, it is difficult to interpret the effects of the altered flow regimes on the fish communities of Locust Creek basin. However, the "flashy" nature of flows, exacerbated by the effects of channelization and inadequate watershed management, reduces the stability of aquatic habitat and limits the quality of the fishery, especially in the headwaters.

Dam and hydropower influences

No dams exist on any of the major streams in Locust Creek basin. However, in the 1970s, there was an unsuccessful proposal to impound a large reach of Locust Creek in association with a proposed coal gasification plant near Milan (approximately river mile 46). In 1990, there was renewed interest in constructing the same 5,800 acre lake for water supply and recreation. This second attempt was also unsuccessful because the Locust Creek Lake Committee could not acquire sufficient funding to construct the reservoir. This lake would have inundated several miles of unchannelized stream and altered downstream flows. There is still local interest in creating a water supply and recreation lake near Milan.

WATER QUALITY AND USE

Beneficial use attainment

Streams within Locust Creek basin have only partial attainment of beneficial use as described by the Clean Water Act (P.L. 95-217). None of the streams within the basin are classified for whole-body contact, but Locust Creek is designated for drinking water supply.

Chemical quality/fish contamination and kills

Despite localized water quality problems, no chronic fish kill areas are known within the basin. Intermittent stream reaches with permanent pools may experience low dissolved oxygen concentrations during late summer. Low dissolved oxygen concentrations have been recorded downstream from the Milan sewage lagoon, but impacts on fish populations are not known. No fish kills were reported in the basin during the drought of 1988.

Annual fish flesh sampling reports (1980-1984) by the Environmental Protection Agency show whole fish standards for chlordane have been exceeded in the Grand River basin, although no advisory on fish consumption has been issued (MDNR 1986b). Contaminant analysis for Locust Creek conducted in 1990 by MDC showed that no FDA action limits were exceeded for channel catfish and carp. Chlordane and dieldrin were present above detection limits.

Low flows contribute to water quality problems within the basin by allowing pollutants (e.g. ammonia and raw sewage) and algae to accumulate to toxic concentrations. Low flows also cause stream temperatures to fluctuate widely. High water temperatures contribute to reduced dissolved oxygen concentrations, increasing the chances for fish kills. Watershed project impoundments planned for both East Locust Creek and upper Locust Creek, while reducing sedimentation, could potentially reduce base flows even further and increase water quality problems in the basin.

Ground water quality is generally poor due to high concentrations of total dissolved solids (500-10,000 ppm), total iron, and sulfates (MDNR 1986a).

<u>Water use</u>

Milan (Sullivan Co.) and Linneus (Linn Co.) obtain their water from reservoirs on smaller tributaries. Browning (Sullivan Co.) receives its water from a well near Locust Creek. No prolonged water withdrawals occur from streams in the basin; however, Unionville (Putnam Co.) uses Locust Creek for emergency water supply during drought.

Localized withdrawals by landowners occur during periods of severe drought, but the extent is unknown. Water quantity, from a municipal prospective, is not a major problem in the Locust Creek basin except during periods of severe drought.

Point-source pollution

Point-source pollution is not a major problem in the Locust Creek basin. There are no industrial or mining point-source discharges. In-active coal mines in Putnam and northern Sullivan counties could affect reaches through acid mine drainage if not reclaimed correctly; however, no acid mine drainage has been recorded (MDNR 1986a).

Three municipal point-source discharges from sewage treatment lagoons are located within the basin (Fig. 1A-C). One facility enters Locust Creek near Browning and another enters a small tributary to Muddy Creek near Linneus. Neither of these facilities is known to negatively impact the receiving streams. However, effluent from the Milan sewage treatment facility has adversely affected water clarity and dissolved oxygen concentrations in two miles of East Locust Creek (MDNR 1984). Additional pre-treatment of waste water beginning in 1988 from Banquet and Con-Agra industries in Milan has improved water quality in this reach.

Non-municipal point-source discharges include sewage lagoons located along Locust Creek in Pershing State Park and along Lowes Branch for Linn County R-1 school. One additional point source is a cattle waste facility in Putnam County along the headwaters of Unnamed stream 72 (MDNR 1984; Fig. 1A-C). Discharges from drinking water treatment plants are also located at Linneus and near Purdin (Linn County).

Nonpoint-source pollution

High turbidity and sediment load are the major water quality concerns within the basin (MDNR 1984). Excessive sediment fills pool habitat used by many fish species, resulting in a loss of habitat diversity and reduced quantity and integrity of aquatic life within the basin. Poor watershed management and stream channelization are the major causes of this nonpoint-source pollution.

The USDA (1982) estimated that nearly 100 million tons of sediment erode annually from the Grand River basin (which includes Locust Creek). Of this, sheet and rill erosion account for 88%, gully (6%), stream (3%), road and other (3%).

Gully erosion has a detrimental impact on the Locust Creek watershed. Based on detailed studies in the West Fork of Big Creek watershed located in the Grand River basin, gully erosion over a 100-year period was expected to erode 3% of the basin lands to a degree that they could not be used to generate an income, depreciate 25% of the land in the basin and produce 12% of all sediment from the basin (SCS 1987a). Locust Creek basin has similar land uses and soil types as the other sub-basins of the Grand River, and can be expected to experience similar land loss. For example, in the upper Locust Creek basin, an additional 11,900 acres (28% of the basin) is expected to be depreciated by the year 2010 as a result of gully erosion.

Other nonpoint-source pollution within the basin is primarily related to livestock waste. A large number of cattle in the basin are on pasture and, during the summer, many spend a large portion of time near or in streams. Animal waste runoff can increase organic and bacterial loading, turbidity, and can result in high concentrations of algae in the stream (MDNR 1984).

HABITAT CONDITION

Channel alterations

Mainstem Locust Creek was originally 123 miles in length. By 1979, only 51 miles remained unchannelized; 72 miles had either been eliminated (23 miles) or channelized (49 miles; MDNR 1986a). Most recent topographical maps (1964 to 1984) show Locust Creek to be 100 miles long; 46% (46 miles) of this length show evidence of past channelization (Appendix 1B). Most of the channelization has occurred north and south of Sullivan County. The extensive channelization south of Sullivan county was initiated "around 1918" (Lloyd Grafton, Locust Creek Drainage District, pers com). Recent channelization activities have been done by private landowners or local drainage districts.

Locust Creek basin has approximately 409 miles of streams third order and larger (Table 5). Sixth order reaches are more extensively channelized (71% of length) than third order reaches (11% of length).

Table 5. Total number of miles and percent of stream length channelized and unchannelized for reaches 3-7th order in Locust Creek basin.

Reach order	Stream miles	Channelized miles (%)	Unchannelized miles (%)
7	31.1	13.6(44)	17.5(56)
6	17.1	12.2(71)	4.9(29)
5	76.3	21.0(28)	55.3(72)
4	116.0	43.9(38)	72.1(62)
3	168.3	18.5(11)	149.8(89)
Total	408.8	109.2(27)	299.6(73)

The amount of channelization was variable for larger streams of Locust Creek basin (Table 6). Locust Creek, West Locust Creek (South), and West Locust Creek (North) were 37 to 52% channelized, whereas the other larger streams were less than 28% channelized.

Table 6. Percent of stream length channelized for major streams of Locust Creek basin. Stream miles and percentages are for reaches fourth order and larger.

Stream name	Stream order	Stream miles	Channelized miles (%)	Unchannelized miles (%)
L.C.	7	96.0	46.0(48)	50.0(52)
W.L.C.(S.)	6	42.3	15.6(37)	26.7(63)
Muddy Creek	5	16.6	3.5(21)	13.1(79)
Unnamed 31	5	8.0	0.5(6)	7.5(94)
E.L.C.	5	32.9	9.1(28)	23.8(72)
L.E.L.C.	5	10.6	2.1(20)	8.5(80)
W.L.C.(N.)	4	18.4	9.5(52)	8.9(48)

Unique habitats

Two largely unchannelized reaches of Locust Creek are considered unique. The first is a 28.7 mile segment beginning from the end of channelization in Sec. 8, T61N, R20W (river mile 42.1) to Sec. 28, T64N, R20W (river mile 70.8). This reach is recognized by the National Park Service in the 1982 Nationwide Rivers Inventory as having both State and National significance. The reach is described as having a "unique riffle-pool arrangement and maintains one of the last largely unchannelized, undisturbed landform features in northern Missouri exhibiting oxbow lakes; meanders; unimpeded flooding typical of natural prairie streams; one of the best examples of aquatic community types in the region; and diverse fish types including the unique stone cat (*Noturus flavus*)" [memo from Pat Graham (SCS) to Rich Wehnes (MDC), 1/12/84].

The second largely unchannelized reach of Locust Creek is a 17.4 mile segment beginning at the confluence of Locust Creek with the Grand River (river mile 0.0) and extending upstream to the northern most boundary of Pershing State Park (river mile 17.4). This reach, while presently aggrading, has well-established wooded corridors, abundant instream cover, and unique fish species, including trout-perch (*Percopsis omiscomaycus*) collected from Pershing State Park in 1988. The reach experiences frequent flooding (>1/yr) which has created a dispute between upstream landowners and the state park. Some landowners have suggested that DNR channelize Locust Creek through the state park to "help alleviate" flooding upstream. To date, no action has been taken by state or federal agencies to address the problem.

Improvement projects

Fish habitat improvement work was initiated in 1987 and continues at the Experimental Stream Management Area, located within Locust Creek Conservation Area near Milan. Habitat improvement projects installed and under evaluation include: cedar tree, hardwood tree, and willow pole revetments; cedar tree and rock gradient control structures; anchored rootwads; willow cuttings, stakes and post plantings; riparian tree planting, and gully erosion control structures. Other bank stabilization and in-stream habitat structures will be assessed.

Habitat assessment

Thirty randomly selected, one-half mile sites in Locust Creek basin were evaluated between September, 1983 and February, 1984 (Table 7) using Stream Habitat Evaluation Procedures (SHEP; Fajen and Wehnes 1981). Using this procedure, six parameters reflecting human impacts on a stream, are ranked and are then adjusted by four alteration functions (channel modifications, impoundments, water quality and stream bed conditions) to determine an index value of stream quality. Values can range from 0 (worst) to 10 (best). Scores for Locust Creek basin were low to moderate (0.3-5.7) due to poor watershed practices which have led to excessive bank erosion and channel sedimentation. Locust Creek had the highest average score of 4.37 (n=2), showing fair riffle-pool development, fair substrate diversity, and abundant snag cover. Although no trends were evident, tributaries had low average habitat values, generally due to streambank erosion problems and lack of woody riparian vegetation.

Table 7. Stream Habitat Evaluation Procedure (SHEP) results for Locust Creek basin (1983-1984).

Stream	Number of Sites	Weighted Average	Range
L.C.	2	4.37	2.7-4.5
W.L.C.(North)	11	3.62	0.9-5.7
E.L.C.	8	2.71	0.6-5.0
W.L.C.(South)	6	1.95	0.3-4.3
L.E.L.C.	3	1.05	0.7-1.3
Total	30	3.06	0.3-5.7

During early summer, 1988, another habitat survey of the basin was conducted to compare channelized vs. unchannelized reaches and reaches with wooded riparian corridor widths greater than, and less than, 100 feet. Using the most recent 7.5 minute topographical maps, representative sites along third order and larger streams were selected and placed in one of four habitat categories (CN,CW,UN,UW) based on whether the reach was channelized (C) or unchannelized (U), and had less than (N) or greater than (W) a 100-foot wide wooded corridor on both sides of the stream.

Streambank condition was generally fair to good at the 17 sites that were visited (Table 8; Fig. 1A-C; Appendix 3). Ten sites showed little or no erosion and had woody bank vegetation sufficient to maintain bank stability. Six of the 17 sites showed evidence of moderate erosion and bank sloughing during floods. Only one site lacked bank vegetation entirely and showed massive bank sloughing along the reach.

Instream cover was generally lacking at all sites, especially in third and fourth order streams. Only one of these streams had more than five submersed rootwads or logs in the sample reach. Sites in higher order streams also had limited instream cover, except for seventh order streams which had more than ten submersed logs in three of the four sites.

Average maximum pool depth was less than three feet for all sites. Drought conditions undoubtedly had a negative effect on this parameter. Pool depth averaged 2.0 feet at unchannelized sites and 1.2 feet at channelized sites. At sites with >100-foot wide wooded corridor, pool depth averaged 2.0 feet, and at sites with <100-foot wide wooded corridor, pool depth averaged 1.6 feet. Substrate composition was almost entirely sand/silt at all sites. Only four sites contained riffles, which were over 75% embedded.

Table 8. Sample sites of 1988 survey of Locust Creek basin stream fish communities and habitat.

Stream Name and Code	Order	River Mile	Location T.	R.	S.	Topographic Map	Habitat Category
Locust Creek	7	23.5	58N	21W	10	Laclede	CN
Locust Creek	7	20.5	58N	21W	27	Laclede	CW
Locust Creek	7	5.5	56N	21W	4	Fountain Grove	UN
Locust Creek	7	13.7	57N	21W	14	Laclede	UW
Locust Creek	6	32.6	60N	21W	36	Linneus	CN
West Locust Creek (South)	6	2.9	60N	21W	23	Browning	UN
West Locust Creek (South)	6	9.2	61N	21W	23	Browning	UW
Locust Creek	5	39.0	61N	20W	20	Browning	CN
West Locust Creek (South)	5	16.2	62N	21W	36	Milan West	CW
Locust Creek	5	45.4	62N	20W	31	Milan West	UN
Muddy Creek	5	4.9	58N	20W	31	Laclede	UW
West Locust Creek (North)	4	3.2	65N	20W	20	Pollock NW	CN
Locust Creek	4	86.7	66N	20W	10	St. John, MO-IA	CW
East Locust Creek	4	7.4	61N	20W	10	Browning	UN
Locust Creek	4	84.6	66N	20W	22	St. John, MO-IA	UN
West Locust Creek (North)	3	14.6	67N	20W	31	St. John, MO-IA	CN
Unnamed #76	3	3.0	66N	20W	2	Lk Thunderhead MO-IA	UN

Water quality was generally good (assessed visually), except for two sites which received organic pollution from cattle. Turbidity is a problem during normal flows; however, the low flows attributable to the 1988 drought lessened the influx of sediment to streams and allowed suspended sediment to settle.

Fish habitat conditions were poor at most sample sites. Excessive sand bedloads, probably from erosion of unstable channels and adjacent agricultural land, have filled in many pools, leaving very little stable substrate for spawning. Lack of instream woody cover may also be a factor limiting the balance and standing crop of fish communities. Woody debris helps create scour pools within channels, provides cover, and is an important substrate for invertebrate production.

A separate analysis was conducted to determine wooded riparian corridor widths throughout the basin (Tables 9-12). In general, most streams reaches in the basin (92%) lacked a wooded riparian corridor that was 100 feet wide or wider. A 100-foot wide wooded corridor was not acceptable to landowners probably because it was not compatible with row cropping and grazing activities in this basin.

Wooded riparian corridor widths generally increased as stream order increased (Table 12). The third and fourth order streams had the narrowest wooded riparian corridor widths; this may be attributable to clearing and farming corridors along streams that flood less frequently. Ranchers may have also cleared land to increase grazing acreage. The higher scores associated with larger streams were influenced by the wider wooded corridors found on state-owned land and the timber that lies between the stream channel and flood-control levees on privately owned land.

Table 9. Results of wooded riparian corridor assessment for Upper Locust Creek basin.

Stream Order	Stream Name	n Sites	Avg. Score*	Min. Score	Max. Score	n<100 ft Wide	%<100 ft Wide
4	Locust Creek	3	3.1	1.5	4.3	3	100
4	West Locust Creek (N)	2	0.2	0.1	0.3	2	100
3	West Locust Creek (N)	1	5.2	5.0	5.4	1	100
3	3rd Order Trib.'s	2	3.2	3.0	3.4	2	100
Summary	4th Order	5	1.9	0.1	4.3	5	100
	3rd Order	3	3.9	3.0	5.4	3	100
	Upper Basin	8	2.7	0.1	5.4	8	100

*Wooded Riparian Corridor Scoring System

Width (ft)	0	1-19	20-39	40-59	60-79	80-99	100+
Score	0	1	2	3	4	5	6

Table 10. Results of wooded riparian corridor assessment for Middle Locust Creek basin.

Stream Order	Stream Name	n Sites	Avg. Score*	Min. Score	Max. Score	n<100 ft Wide	%<100 ft Wide
6	West Locust Creek (S)	2	3.8	3.0	4.6	2	100
5	Locust Creek	8	4.1	2.8	5.7	8	100
5	West Locust Creek (S)	3	3.2	2.0	3.9	3	100
4	Little East Locust Creek	1	5.2	5.0	5.4	1	100
4	East Locust Creek	5	3.1	1.5	4.3	5	100
4	West Locust Creek (S)	3	2.0	0.6	3.4	3	100
3	East Locust Creek	1	2.4	1.8	3.0	1	100
3	West Locust Creek (S)	1	4.6	4.4	4.8	1	100
3	3rd Order Trib.'s	15	2.8	0.6	4.6	15	100
Summary	6th Order	2	3.8	3.0	4.6	2	100
	5th Order	11	3.9	2.0	5.7	11	100
	4th Order	9	3.0	0.6	5.4	9	100
	3rd Order	17	2.9	0.6	4.8	17	100
	Middle Basin	39	3.2	0.6	5.7	39	100

*Wooded Riparian Corridor Scoring System - See Preceding Table

Table 11. Results of wooded riparian corridor assessment for Lower Locust Creek basin.

Stream Order	Stream Name	n Sites	Avg. Score*	Min. Score	Max. Score	n< 100 ft Wide	%<100 ft Wide
7	Locust Creek	6	4.9	3.6	6.0	3	50
6	Locust Creek	1	4.3	3.8	4.8	1	100
5	Muddy Creek	2	5.5	4.9	6.0	1	50
4	Higgins Ditch	1	4.4	4.0	4.8	1	100
3	Muddy Creek	1	1.4	0.6	2.2	1	100
3	3rd Order Trib.'s	8	2.4	0.0	6.0	7	88
Summary	7th Order	6	4.9	3.6	6.0	3	50
	6th Order	1	4.3	3.8	4.8	1	100
	5th Order	2	5.5	4.9	6.0	1	50
	4th Order	1	4.4	4.0	4.8	1	100
	3th Order	9	2.3	0.0	6.0	8	89
	Lower Basin	19	3.7	0.0	6.0	14	74

*Wooded Riparian Corridor Scoring System

Width (ft)	0	1-19	20-39	40-59	60-79	80-99	100+
Score	0	1	2	3	4	5	6

Table 12. Results of wooded riparian corridor assessment for Locust Creek basin.

Stream Order	Stream Name	n Sites	Avg. Score*	n< 100 ft Wide	%< 100 ft Wide
7	Locust Creek Basin	6	4.9	3	50
6	Locust Creek Basin	3	4.0	3	100
5	Locust Creek Basin	13	4.1	12	92
4	Locust Creek Basin	15	2.7	15	100
3	Locust Creek Basin	29	2.8	28	97
Summary	Locust Creek Basin	66	3.3	61	92

*Wooded Riparian Corridor Scoring System

Width (ft)	0	1-19	20-39	40-59	60-79	80-99	100+
Score	0	1	2	3	4	5	6

STREAM BIOTA

Fish community

Forty-five species representing 11 families have a distribution range that includes Locust Creek basin (Pflieger 1975). This typical prairie fish community is dominated by cyprinids that can tolerate the widely fluctuating environmental conditions of northern Missouri streams. Thirty-seven species have been collected in Locust Creek basin (Table 13).

Table 13. Fish species with a distribution range which includes Locust Creek basin. Key to status: 1 = collected prior to 1945; 2 = collected between 1945-1988; 3 = collected during 1988

Common Name	Scientific Name	Status
Shortnose Gar	*Lepisosteus platostomus*	2,3
Longnose Gar	*Lepisosteus osseus*	2,3
Gizzard Shad	*Dorosoma cepedianum*	3
Goldeye	*Hiodon alosoides*	1,3
Mooneye	*Hiodon tergisus*	2
Northern Pike	*Esox lucius*	
Carp	*Cyprinus carpio*	2,3
Goldfish	*Carassius auratus*	
Golden Shiner	*Notemigonus crysoleucas*	1,3
Creek Chub	*Semotilus atromaculatus*	1,2,3
Silver Chub	*Macrhybopsis storeriana*	1
Speckled Chub	*Macrhybopsis aestivalis*	
Suckermouth Minnow	*Phenacobius mirabilis*	1,2,3
Emerald Shiner	*Notropis atherinoides*	
Redfin Shiner	*Lythrurus umbratilis*	3
Bigmouth Shiner	*Notropis dorsalis*	1,2,3
Red Shiner	*Cyprinella lutrensis*	1,2,3
Sand Shiner	*Notropis stramineus*	1,2,3
Western Silvery Minnow	*Hybognathus argyritis*	
Plains Minnow	*Hybognathus placitus*	1
Bluntnose Minnow	*Pimephales notatus*	1,2,3
Fathead Minnow	*Pimephales promelas*	1,3
Central Stoneroller	*Campostoma anomalum*	2,3
Bigmouth Buffalo	*Ictiobus cyprinellus*	3
Black Buffalo	*Ictiobus niger*	
Smallmouth Buffalo	*Ictiobus bubalus*	3
River Carpsucker	*Carpiodes carpio*	1,2,3
Quillback	*Carpiodes cyprinus*	1,3
White Sucker	*Catostomus commersoni*	1,3
Shorthead Redhorse	*Moxostoma macrolepidotum*	3
Black Bullhead	*Ameiurus melas*	1,2,3
Yellow Bullhead	*Ameiurus natalis*	2,3
Channel Catfish	*Ictalurus punctatus*	1,2,3
Stonecat	*Noturus flavus*	2
Flathead Catfish	*Pylodictis olivaris*	1,2,3
Trout-perch	*Percopsis omiscomaycus*	1,3
Largemouth Bass	*Micropterus salmoides*	1,2,3
Green Sunfish	*Lepomis cyanellus*	1,2,3
Orangespotted Sunfish	*Lepomis humilis*	1,2,3
Bluegill	*Lepomis macrochirus*	2,3
White Crappie	*Pomoxis annularis*	2,3
Black Crappie	*Pomoxis nigromaculatus*	
Walleye	*Stizostedion vitreum*	
Johnny Darter	*Etheostoma nigrum*	3
Freshwater Drum	*Aplodinotus grunniens*	2,3

Two species, silver chub (*Macrhybopsis storeriana*) and plains minnow (*Hybognathus placitus*), have not been collected since 1945; it is unknown whether inadequate sampling or extirpation caused by environmental change is responsible. No threatened or endangered species have been found in the basin. However, two intolerant species, stonecat and trout-perch, have been collected.

In the lower Grand River basin, which includes Locust Creek, fish distribution studies have shown that 3.5 to 5.0 percent of all fish species found in the basin early in this century have been either extirpated or greatly reduced in abundance; presumably as a result of increased turbidity and sediment deposition (MDNR 1984).

Thirty-three fish species were collected in the basin during 1988 (Table 14). Cyprinids dominated the community; eleven species composed 84% of the total number of individuals. Six species of catostomids, the second most common family, constituted 5% of the individuals. Omnivores dominated the trophic composition of the fish community; only two of 17 sites had fewer than 45% of the sample as omnivores. Piscivores comprised a very low percentage of the community at all sites.

Table 14. Percentage composition at each site and frequency of occurrence among all samples of species collected at 1988 Locust Creek basin sampling sites. Asterisk denotes less than one percent of collection.

Species	Site Name, Order and Habitat Condition																		
	L.C. 7 CN	L.C. 7 CW	L.C. 7 UN	L.C 7 UW	L.C. 6 CN	W.L.C.S. 6 UN	W.L.C.S. 6 UW	L.C. 5 CN	W.L.C.S. 5 CW	L.C. 5 UN	M.C. 5 UW	W.L.C.N. 4 CN	L.C. 4 CW	E.L.C 4 UN	L.C. 4 UN	W.L.C.N. 3 CN	N-N76 3 UN	Total Comp. (%)	Freq. Occur (%)
Longnose Gar	0	*	0	*	0	*	*	0	0	0	0	0	0	0	0	0	0	*	24
Shortnose Gar	*	2	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	*	18
Gizzard Shad	0	*	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	*	12
Goldeye	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	6
Bigmouth Shiner	27	0	*	2	22	*	5	0	8	8	2	52	28	46	42	57	61	20	88
Bluntnose Minnow	3	2	4	11	*	4	*	4	1	*	0	*	*	*	*	3	0	3	82
Carp	*	6	0	2	*	1	3	4	0	*	*	0	0	0	0	0	0	1	53
Creek Chub	*	0	0	*	1	*	1	5	9	2	14	36	33	18	10	3	29	8	88
Fathead Minnow	*	0	0	*	0	0	4	0	18	0	18	*	2	0	5	1	0	2	47
Golden Shiner	0	0	0	0	0	*	0	0	0	0	*	0	0	*	0	0	0	*	18
Red Shiner	56	62	80	50	63	35	21	45	43	60	17	3	12	22	27	2	0	40	94
Redfin Shiner	0	3	6	*	*	*	5	6	5	*	1	0	3	0	2	0	0	2	71
Sand Shiner	6	*	2	2	5	2	*	*	1	*	0	2	9	11	5	23	0	5	88
Stoneroller	0	0	0	*	0	0	0	2	*	*	0	5	8	*	*	2	0	1	53
Suckermouth Minnow	2	2	*	*	2	*	13	11	1	2	0	0	*	1	*	0	0	2	76
Bigmouth Buffalo	0	4	0	0	0	*	0	1	0	0	0	0	0	0	0	0	0	*	18
Quillback	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	*	6
River Carpsucker	1	7	2	12	2	11	6	9	*	5	0	0	*	1	*	0	0	4	76
Shorthead Redhorse	0	*	0	2	*	*	*	3	0	*	0	0	0	0	0	0	0	*	41
Smallmouth Buffalo	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	6
White Sucker	1	0	0	0	*	*	0	0	2	0	3	1	*	*	*	1	5	*	65
Black Bullhead	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	*	6
Channel Catfish	1	1	5	5	2	1	1	2	0	3	0	0	0	0	0	0	0	2	53
Flathead Catfish	*	*	0	*	0	*	*	*	0	*	0	0	0	0	0	0	0	*	41
Yellow Bullhead	*	0	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	*	18
Trout-Perch	0	0	0	*	0	5	13	0	4	0	0	0	0	0	*	0	0	1	29
Bluegill	0	0	0	*	0	*	0	0	0	0	0	0	0	0	0	0	0	*	12
Green Sunfish	2	3	0	2	*	2	3	3	2	*	37	*	0	*	*	0	0	2	76
Largemouth Bass	0	0	0	0	0	2	*	*	0	0	1	0	0	0	0	0	0	*	24
Orangespotted Sunfish	0	0	0	2	0	2	3	2	0	*	1	0	0	0	*	0	0	*	41
White Crappie	0	*	*	*	0	28	12	*	0	1	0	0	0	0	0	0	0	2	41
Johnny Darter	0	*	0	7	0	2	9	*	6	15	*	0	3	0	5	7	5	4	71
Freshwater Drum	0	1	0	*	0	*	0	*	0	*	0	0	0	0	0	0	0	*	35
Total No. of Individuals	1210	481	517	1926	1419	927	350	585	836	984	210	706	925	1350	844	489	38		

Red shiner *(Cyprinella lutrensis)* was the most abundant species (40% of all fish collected) and was found at all sites except one. Bigmouth shiner (*Notropis dorsalis*), the second most abundant species, was found at all sites except two. Other commonly collected species were creek chub (*Semotilus atromaculatus*), sand shiner (*Notropis stramineus*), bluntnose minnow (*Pimephales notatus*), suckermouth minnow (*Phenacobius mirabilis*), river carpsucker (*Carpiodes carpio*), green sunfish (*Lepomis cyanellus*), redfin shiner (*Lythrurus umbratilis*), and johnny darter (*Etheostoma nigrum*). One introduced species, carp (*Cyprinus carpio*), was captured at nine sites, all fifth order and above. Trout-perch, the only intolerant species captured, was found at five sites; at three of the sites, 30 or more individuals were collected. Another intolerant species, stonecat, has been collected previously in Locust Creek, but was not collected in 1988. Channel catfish (*Ictalurus punctatus*) and flathead catfish (*Pylodictis olivaris*) were collected in streams fifth order and larger; they comprised a low percentage of the total number of fish at most of these sites. However, these two species represented over five percent of the fishes collected at two unchannelized seventh order sites.

The abundance of tolerant and omnivorous fishes we saw in Locust Creek fish communities was the result of the extensive degradation of fish habitat in the basin. As Locust Creek habitat conditions became degraded, the proportion of intolerant species decreased and the proportion of tolerant species increased. Likewise, the proportion of omnivores increased because Locust Creek habitat degradation caused a decline in the macroinvertebrate food base, and the opportunistic habits of omnivorous fish made them more successful than specialized foragers.

Channelization had a consistent and dramatic negative impact on the fish community. This was generally true throughout the basin, except for Locust Creek at Rocky Ford Access which had a low water crossing that created a pool with water depths greater than the other channelized sites. Twenty species were collected at this site compared to an average of 13.6 species for channelized sites on fourth, fifth and sixth order streams in the basin. This site did not represent the typical habitat for a channelized reach of stream, but did show the effect of water depth on the diversity of the fish community despite other habitat conditions.

Channelization affected the trophic composition and species richness of Locust Creek basin fish communities. The average number of omnivorous species per site was 17% greater in channelized sites. Sites with the highest overall fish community diversity and highest sunfish diversity were unchannelized. In addition, four of the five sites where trout-perch were collected were unchannelized.

Abundance of channel and flathead catfish was inversely related to channelization. Higher average numbers of channel and flathead catfish longer than 11 inches were found at unchannelized sites, except in the relatively deep water upstream of the low water crossing at Rocky Ford Access. There were also higher average numbers of channel and flathead catfish of all sizes at unchannelized sites.

An inverse relationship existed between corridor width and the number of omnivores at a site. Sites with corridors less than 100 feet wide had, on average, 22% more omnivorous species per site. Species richness was lower at sites having narrow corridors. An average of 13 species were found in narrow corridor sites compared to an average of 16 species in wide corridor sites. Abundance of channel and flathead catfish was not affected by corridor width.

Fish stockings

Locust Creek was sampled near Pershing State Park in 1969. Carp and river carpsucker were the dominant species. At that time it was felt there was sufficient water clarity and available forage for survival of spotted bass (*Micropterus punctulatus*). However, no record of spotted bass being stocked exists (memo from J. Congdon to Fisheries, MDC 1969). Also during 1969, Representative Robert DeVoy of Brookfield requested that MDC review the possibility of a channel catfish put-and-take fishery in Locust Creek at Pershing State Park. This idea was rejected because of limited fish production facilities and the potential of fish moving out of the intensive fishing area. Approximately 86 largemouth bass (3-22 in long) were stocked in Locust Creek near Jo Shelby Lake on Fountain Grove Conservation Area (Linn Co.) in September, 1974 (note by G.D. Hickman 1974), but there are no recent survey records to indicate stocking results.

Sport fishing/harvest regulations

Although few data are available, the 1986 statewide angler survey shows catfish and carp as the primary sportfish sought by anglers in this basin (Steve Weithman, MDC, unpublished data). Sportfishing for centrarchids is limited because of low numbers due to poor habitat conditions.

Information on population dynamics of fish within streams of the basin is limited. Channel catfish collected from Locust Creek Wildlife Area in 1988 averaged 2.6, 5.0, and 9.0 inches at ages 1-3, respectively; data for succeeding years were insufficient to accurately describe growth. This growth is similar to that of channel catfish collected from the lower Salt River (Purkett 1958). The length frequency distribution of channel catfish from all 1988 Locust Creek basin sampling sites also shows peaks which correspond with age/growth information (Fig. 2). Samples contained few channel and flathead catfish longer than 16 inches (Fig. 2 and 3). More intensive sampling and creel data are required to determine the status of the fishery. Statewide limits and regulations apply in Locust Creek basin.

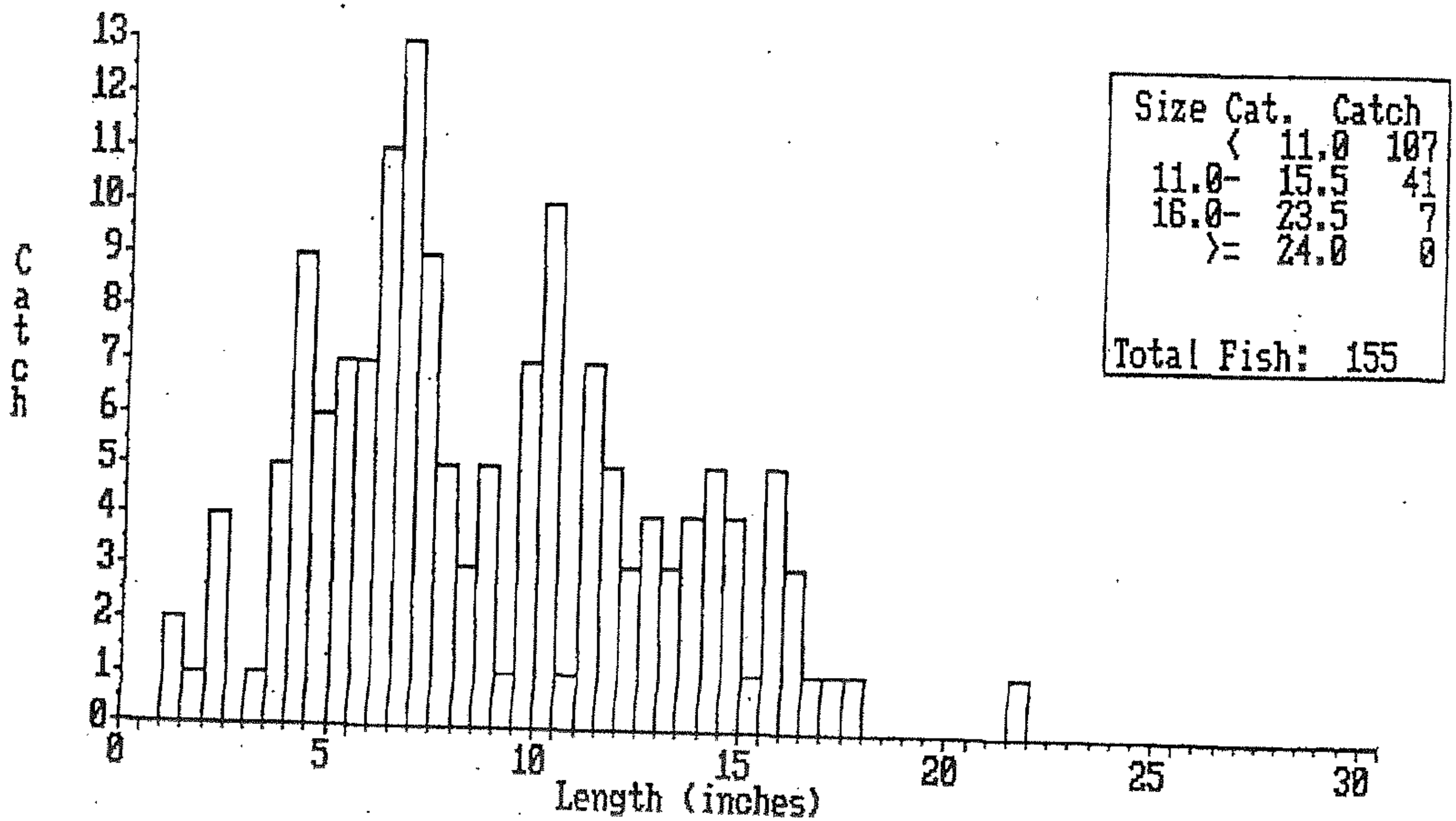


Figure 2. Length frequency of channel catfish collected from all 1988 Locust Creek basin sampling sites.

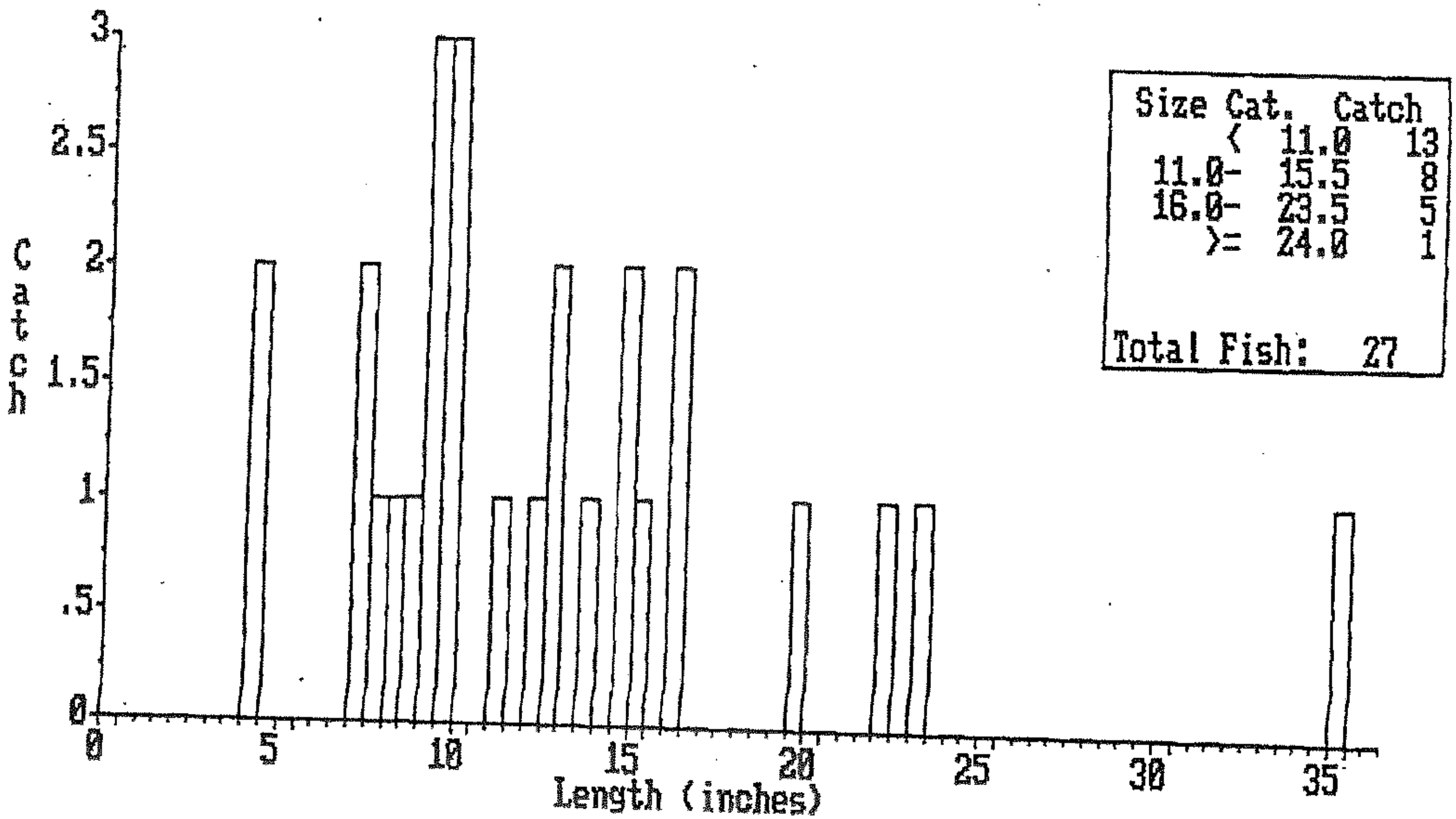


Figure 3.. Length frequency of flathead catfish collected from all 1988 Locust Creek basin sampling sites.

Aquatic invertebrates

MDC entered into a cooperative agreement with the Missouri Cooperative Fish and Wildlife Research Unit in 1988 to examine the aquatic macroinvertebrate fauna of selected central Missouri streams. This study resulted in a compilation of baseline data on aquatic invertebrate community structure and biomass in all major habitat types (Fantz 1993). One of the collection sites was on Locust Creek Conservation Area (Table 15). Results indicate that the average density and biomass of dominant taxa ranged from 441 to 712 individuals/m^2 and from 573 to 2274 mg/m^2, respectively (Table 16). Because of the greater biomass (mg/m^2) of aquatic invertebrates found in snag and riffle habitats, and because of the low percentage of availability of these habitats (<1.0% combined), it was concluded that an increase in these habitats would have a beneficial effect on invertebrate production in Locust Creek.

An extensive investigation of naiades has not been completed for Locust Creek basin. Oesch (1984) reported no mussels occurring within the basin. Excessive inputs of animal waste and silt were responsible for the extirpation of mussels from north-western and north-central Missouri streams (Oesch 1984).

Table 15. Qualitative description of aquatic invertebrate fauna in Locust Creek at the Locust Creek Conservation Area.

ORDER	FAMILY	GENUS
Diptera	Chironomidae	
	Simuliidae	Simulium
	Tipulidae	Pedicia
	Culicidae	
Trichoptera	Philopotamidae	Chimarra
	Hydropsychidae	Hydropsyche
Ephemeroptera	Heptageniidae	Stenonema
	Oligoneuriidae	Isonychia
	Caenidae	Caenis
	Ephemeridae	Hexagenia
	Baetidae	Baetis
Coleoptera	Staphylinidae	
	Elmidae	Stenelmis
	Noteridae	Notomicrus
	Dytiscidae	Dytiscus
Odonata	Gomphidae	Gomphus
	Coenagrionidae	Protallagma
Megaloptera	Sialidae	Sialis
Oligocheata		
Amphipoda		

Table 16. Average density and biomass of dominant taxa of aquatic invertebrates occurring in Locust Creek at the Locust Creek Conservation Area.

Habitat	Density (number/m^2)	Biomass (mg/m^2)
Riffle	441	2,274
Snag	712	1,312
Clay, Silt, Sand, Gravel	680	573

PROBLEMS AND OPPORTUNITIES

Fish Communities

One obstacle to managing Locust Creek fishes is the lack of information on what constitutes a healthy, stable community or population. The status of intolerant or unique species, and the overall integrity of fish communities in Locust Creek basin are relatively unknown.

Management emphasis for Locust Creek basin will incorporate angler preferences reflected in the statewide angler survey, while being realistic about the potential of aquatic habitat (improved or existing) in the basin. Although there may be potential for a better fishery, the limited information available suggests fish communities are currently dominated by species that tolerate sedimentation and other forms of habitat degradation. Few large catfish were collected, indicating a need for better habitat and/or improved sampling methods. Steps to improve habitat for large catfish should probably be initiated on MDC areas and then expanded as our knowledge grows.

Habitat

A major problem affecting the Locust Creek basin fishery is sediment. Degradation of aquatic habitats is exacerbated by channelization and corridor timber clearing. These activities reduce the amount of instream cover and pool and riffle habitat in streams.

Assisting private landowners with proper watershed, floodplain, and stream management represent the greatest opportunity to improve habitat in the basin. Efforts should concentrate on making information available to landowners, the public and other agencies regarding proper watershed management techniques and providing assistance to implement those techniques. Opportunities to protect unique areas, such as the unchannelized reaches, include easements under the PL-566 program and an expansion of MDC's Stream Stewardship Program.

Public

In addition to the lack of public understanding of proper stream management techniques, there is little public familiarity or appreciation with the potential for stream resource recreation in northern Missouri. Without public understanding and support for streams, any stream resource improvement will be short-term.

BASIN PLAN OBJECTIVES

Objectives for the Locust Creek basin plan are strategic and address the Missouri Department of Conservation Strategic Plan, Fisheries Division Operational Plan (FY 95-99), Stream Areas Program Plan, the Stream Access Acquisition Plan, and the fisheries-related problems and opportunities raised in the previous sections of this plan. Aquatic habitat (including water quality), biotic communities and recreational use are the three major areas addressed. All objectives and tasks are listed in order of priority under the appropriate category. Completion of these objectives will depend upon their status and priority in Fisheries Division operational plan, the availability of manpower and funds, and cooperation from other Divisions and agencies.

GOAL I: IMPROVE AQUATIC HABITAT CONDITIONS, INCLUDING WATER QUALITY AND QUANTITY, OF THE LOCUST CREEK BASIN TO MEET THE NEEDS OF NATIVE AQUATIC SPECIES WHILE ACCOMMODATING SOCIETY'S DEMANDS FOR WATER AND AGRICULTURAL PRODUCTION.

Status: Stream habitat values are low within the Locust Creek basin; streams suffer from non-point pollution. Poor watershed management practices, channelization and clearing of native riparian vegetation have led to excessive sand bedloads that embed riffles and fill deeper areas. Other problems are caused by sedimentation, turbidity and reduced discharges at low flows. Streambank condition was generally fair to good. Instream cover and depth were generally poor at most sites in the basin. Two unique, unchannelized reaches remain in the basin. Localized animal waste problems resulting from pasture runoff and livestock grazing in or near stream channels also occur. Point source problems are primarily sewage discharges. Fish habitat and water quality are degraded by low flows.

Objective 1.1: Water quality meeting state standards

Strategy: Full implementation of the Upper Locust Creek and East Locust Creek PL-566 watershed projects will reduce turbidity and sedimentation problems. Extension of the Upper Locust Creek project to include Linn and Chariton counties would decrease non-point pollution problems in the entire basin. While much of the observed low flow problem can be attributable to sampling during a drought, low flow problems are a legitimate concern. Integration of low flow augmentation features into PL-566 impoundments would help fish habitat and water quality.

Enforcement of existing state and federal water quality regulations will reduce the number of point and non-point water quality violations, especially those dealing with sewage effluents and runoff from livestock feed lots.

Increasing the awareness of landowners and youth about their roles in improving local water quality will generate more local interest in water quality problems and solutions. We assume that private land use is the main cause of major pollution problems in the basin. Grass roots education of landowners and youth will be necessary before water quality problems are seriously addressed.

*Include Linn and Chariton counties in the Upper Locust Creek PL-566 watershed project.

*Integrate low flow augmentation techniques into PL-566 impoundments.

*Review NPDES, 404 and other permits and recommend measures to protect aquatic communities and insure that low flow discharges are sufficient to dilute sewage and feed lot runoff.

*Assist appropriate regulatory agencies in detecting environmental violations such as improperly treated sewage discharge, livestock waste runoff, etc.

*Involve STREAM TEAMs in water quality monitoring and advocacy in the Locust Creek basin.

*Increase landowner and youth knowledge of point and non-point pollution problems and their solutions through workshops, lectures, and stream-oriented field trips.

*Incorporate water quality improvement techniques into educational materials used by local Vocational Agriculture instructors.

*Incorporate seining basin streams in the company of MDC fisheries biologists into Missouri Angler Program field trips.

*Promote the use of water quality improvement techniques through the popular and agricultural media in the basin.

Objective 1.2: On third order and larger streams, establish timbered riparian corridors meeting MDC stream guidelines; pools containing woody debris for instream cover; adequate low flow depths in a majority of pools in the basin; increased riffle/pool development; and all streambanks stable.

Strategy: Cooperation with landowners will be necessary to demonstrate economically feasible streambank, riparian and instream cover improvement on private lands. Advertising, promoting and providing technical assistance and incentives will encourage implementation of sound stream management practices. Improving stream habitat conditions on public lands can also be accomplished by installing improvement projects on MDC lands and those of other agencies through cooperative projects. Monitoring habitat conditions will better document adverse impacts of channelization and sedimentation and monitor the progress of recovery efforts. Regulatory remedies will help reduce impacts from stream development projects.

*Maintain and promote stream improvement demonstration projects on MDC areas and private lands.

*Promote stream management incentive programs through traditional and agricultural media.

*Regularly sponsor stream management workshops in the basin.

*Increase landowner awareness of MDC stream programs and the economic benefits of well-managed streams through SWCD and Farm Bureau cooperative programs at the county level.

*Provide organized and self guided tours of the Locust Creek experimental stream management area for landowners and government agencies.

*Monitor habitat conditions regularly using remote sensing, helicopter reconnaissance and channel morphology transects.

*Improve and maintain stream and riparian corridors on the Locust Creek and Fountain Grove Conservation areas, Henry's Mill and Rocky Ford accesses, and any new MDC areas acquired with stream frontage in the Locust Creek basin.

*Cooperate with DNR-State Parks on habitat improvement projects within Pershing State Park.

*Establish Special Area Land Treatment (SALT) or PL-566 watershed projects on selected watersheds to improve stream corridor management by cooperating with local agricultural agency programs and by offering stream incentive programs to assist in project implementation.

*Provide technical recommendations to all landowners requesting assistance and willing to establish and maintain a forested riparian corridor.

*Review all 404, dredging, bridge construction or other development projects for impacts to streams in the Locust Creek basin and recommend changes to maintain, improve or protect aquatic habitats.

*Encourage legislation to control stream channelization and limit riparian forest clearing.

*Encourage STREAM TEAMs to undertake specific stream improvement projects.

Objective 1.3: Unique Locust Creek basin aquatic habitats identified and protected from development or degradation.

Strategy: Acquisition and cooperation with other agencies and organizations can provide better management of unique areas. Two unchannelized reaches (a 28 mile reach in Sullivan County and a 17 mile reach from the Grand River confluence to Pershing State Park) will be emphasized.

*Place higher priority for technical services on landowners within these two reaches.

*Obtain protective easements for upstream unchannelized reaches through the Upper Locust Creek Watershed project.

*Protect lower unchannelized reach through acquisition, landowner easements and LCPs.

*Sample fish populations and assess habitat conditions or features within the basin to further define and delineate other unique habitats.

GOAL II: MAINTAIN ECOLOGICALLY BALANCED COMMUNITIES OF NATIVE AQUATIC ORGANISMS WHILE ACCOMMODATING ANGLER DEMANDS FOR QUALITY FISHING

Status: We collected 33 species of fish in the Locust Creek basin. The community is dominated by minnows representing typical prairie fishes that tolerate widely fluctuating environmental conditions. Sufficient sampling to assess the status of these populations has not been completed. Several insectivorous minnows as well as other fish and macroinvertebrates may serve as indicator species for water quality and habitat problems, but they too have not been assessed. Catfish and carp are most preferred by anglers in the Locust Creek basin. While no endangered species were found in the basin, two unique fish species -- stonecat and trout-perch-- have been collected.

Objective 2.1: Populations of channel and flathead catfish evaluated and maintained at sufficient quality to satisfy the angling public.

Strategy: Assess the current knowledge of ictalurid population parameters, habitat requirements, movements and management techniques available to improve ictalurid populations. Possible avenues to improve populations include harvest restrictions, habitat improvement, stocking and other methods.

*Develop standardized sampling procedures and monitor catfish population parameters and movements.

*Determine population objectives which balance the potential for good catfish populations with the desires of anglers.

*Improve catfish populations using regulations, stocking, habitat improvement and other methods.

*Determine angler harvest, species preference and fishing pressure and make recommendations to improve the quality of fishing.

Objective 2.2: Populations of native non-game fishes assessed and maintained at or above current levels in the basin.

Strategy: Regularly assess the status of fish communities, including unique species such as stonecat and trout-perch. We assume that the decline in the diversity and abundance of non-game fishes in the Grand River basin is largely related to land use changes over the last 100 years. Implementation of watershed projects, water quality improvements and stream habitat improvements will help reverse the decline in habitat quality, but progress is likely to be slow. Techniques to maintain or improve non-game fishes will depend on the species and the limiting factor(s). We also assume that other aquatic communities will improve as conditions for non-game fish improve.

*Develop standard sampling techniques for assessing fish communities, including the use of indicator species, and implement a monitoring program to track trends in species diversity and abundance.

*Protect or enhance fish species diversity and abundance, as well as stonecat and trout-perch populations using regulations, stocking, habitat improvement and other techniques.

GOAL III: INCREASE THE RECREATIONAL POTENTIAL OF THE AQUATIC RESOURCES IN THE LOCUST CREEK BASIN WITHOUT DEGRADING POPULATIONS OF NATIVE AQUATIC ORGANISMS

Status: The types and amount of public use (excluding fishing) of Locust Creek's streams have not been determined. Public access to streams is limited to five areas along 124 miles of floatable streams (5th order and larger). To date, no efforts have been made to publicize recreational opportunities in the basin.

Objective 3.1: Access sites, bank fishing areas and trails developed in sufficient numbers to accommodate public use.

Strategies: The Department strategic plan anticipates an increase in stream use because of an overall increase in the levels of fishing. We assume the demand for more fishing areas in the State will result in more stream anglers. We must also determine the level of public satisfaction with existing recreational opportunities and undertake acquisition and development projects to improve those opportunities.

*Conduct a recreational use survey in conjunction w[illegible] an angler survey to determine existing levels of, and satisfaction with, recreational opportunities in the b[illegible]sin.

*Acquire access sites or frontage on West Locust Cree[illegible] (South), East Locust Creek and the mainstem of Locust [illegible]k.

*Improve bank fishing and other stream based recreati[illegible]al opportunities on MDC lands in the basin.

Objective 3.2: All anglers and floaters have access to information on the stream recreational opportunities within the Locust Creek basin.

Strategy: We assume that few anglers in the Locust Creek basin know about stream recreational opportunities, but to document that proportion will unnecessarily divert activities of field personnel. Publicizing recreational opportunities in the basin will increase use and awareness of the resource's values.

*Annually release a general fishing and floating guide to the Locust Creek basin to the appropriate media outlets.

*Publicize Locust Creek fishing and other recreational use in local newspapers, radio and TV programs.

*Facilitate the adoption of Locust Creek by interested groups such as STREAM TEAMs.

*Produce one Missouri Conservationist article, one pamphlet or brochure and one "Missouri Outdoors" video promoting aquatic wildlife-based recreational opportunities in the Locust Creek basin.

*Include Locust Creek in future revisions of "Floating in North Missouri" and other float-oriented publications.

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Appendix 1A. Stream order, link magnitude, and downstream link classifications are provided for the mouth of each 3rd order and larger stream in Locust Creek basin.

Name	Maximum Order	Link Magnitude	Downstream Link
Locust Creek	7	1734	8
Hickory Branch	4	69	7
Higgins Ditch	4	37	4
Unnamed 1	3	5	4
Unnamed 2	3	10	4
Unnamed 3	3	17	7
Muddy Creek	5	203	7
Unnamed 5	4	24	5
Unnamed 6	3	6	4
Unnamed 7	3	6	5
Unnamed 8	3	8	5
Unnamed 9	3	4	5
Unnamed 10	3	9	5
Unnamed 11	3	11	5
Unnamed 12	3	11	5
Unnamed 13	4	26	5
Unnamed 14	3	4	4
Unnamed 15	3	7	4
Unnamed 16	3	15	7
Unnamed 17	3	5	7
Unnamed 18	4	38	7
Unnamed 19	3	19	4
Unnamed 20	4	11	7
Unnamed 21	3	7	4
Unnamed 22	3	14	7
Strawberry Branch	3	27	7
Couch Branch	3	21	7
Kemper Branch	3	25	7

Name	Maximum Order	Link Magnitude	Downstream Link
Unnamed 23	4	14	7
Unnamed 24	3	6	4
Unnamed 25	3	13	7
Lick Branch	4	30	7
Unnamed 26	3	13	4
West Locust Creek (South)	6	464	7
Linn Branch	4	32	6
Unnamed 27	3	11	4
Unnamed 28	3	5	6
Unnamed 29	4	23	6
Unnamed 30	3	14	4
Unnamed 31	5	143	6
Brushy Branch	4	26	5
Unnamed 32	3	4	4
Unnamed 33	3	4	4
Unnamed 34	4	33	5
Unnamed 35	3	4	4
Unnamed 36	3	6	4
Unnamed 37	3	38	4
Unnamed 38	3	9	4
Unnamed 39	4	20	5
Unnamed 40	3	8	4
Unnamed 41	4	43	5
Unnamed 42	3	9	4
Unnamed 43	3	14	4
Unnamed 44	3	23	5
Unnamed 45	4	18	5
Unnamed 46	3	6	4
Unnamed 47	3	12	4
Unnamed 48	3	9	4
Unnamed 49	3	11	4
Unnamed 50	3	5	6
Lowes Branch	4	39	6
Unnamed 51	3	12	4
Unnamed 52	3	11	4
Mairs Branch	3	12	6

Name	Maximum Order	Link Magnitude	Downstream Link
East Locust Creek	5	119	6
Little East Locust Creek	5	75	5
Unnamed 53	3	11	5
Unnamed 54	4	20	5
Unnamed 55	3	8	5
Unnamed 56	3	8	4
Unnamed 57	3	5	4
Unnamed 58	3	8	4
Unnamed 59	3	9	4
Unnamed 60	3	10	4
Elmwood Branch	3	10	4
Unnamed 61	3	4	4
Unnamed 62	3	8	4
West Locust Creek (North)	4	92	5
Unnamed 72	3	10	4
Unnamed 73	3	4	4
Unnamed 74	3	14	4
Unnamed 63	3	5	5
Unnamed 64	3	4	5
Unnamed 65	3	9	5
Unnamed 66	3	11	5
Unnamed 67	3	7	5
Rooks Branch	4	40	5
Unnamed 68	3	8	4
Unnamed 69	3	9	4
Unnamed 70	4	11	5
Unnamed 71	3	4	4
Johnson Branch	3	7	4
Hackett Branch	3	16	4
Brush Creek	3	4	4
Watkins Creek	3	26	4
Unnamed 75	3	6	4
Unnamed 76	3	32	4

Name	Maximum Order	Link Magnitude	Downstream Link
Unnamed 77	3	11	4
Unnamed 78	3	7	3
West Fork Locust Creek	3	19	4

Appendix 1B. Name and code number of third order and larger streams in Locust Creek basin and total mileage of each reach channelized or unchannelized. Other columns give county and location of downstream end of each reach, and stream watershed area (WA; mi^2). Streams without designated names were assigned a number and designated as "Unnamed #".

Stream Code	Stream Name	Order	County	T(N)	R(W)	S	WA	River Miles	Channelized	Unchannelized
52121000.000	Locust Creek	7	Charlton	56	21	17	678.6	0.0-31.1	13.6	17.5
52121000.000	Locust Creek	6	Linn	59	21	2		31.1-37.4	6.3	0.0
52121000.000	Locust Creek	5	Sullivan	61	20	32		37.4-75.3	13.2	24.7
52121000.000	Locust Creek	4	Putnam	65	20	34		75.3-94.6	12.9	6.4
52121000.000	Locust Creek	3	Wayne,IA	67	20	4		94.6-96.0	0.0	1.4
52121100.000	Locust Creek Sec 1	0	Charlton	56	21	17			0.0	0.0
52121110.000	Hickory Branch	4	Linn	57	21	33		0.0-0.2	0.0	2.2
52121110.000	Hickory Branch	3	Linn	57	21	28		2.2-9.0	0.3	6.5
52121111.000	Higgins Ditch	4	Linn	57	21	28		0.0-5.4	3.9	1.5
52121111.000	Higgins Ditch	3	Linn	58	21	34		5.4-7.1	0.0	1.7
52121111.100	Unnamed 1	3	Linn	57	21	3		0.0-0.1	0.0	0.1
52121111.200	Unnamed 2	3	Linn	58	21	34		0.0-0.3	0.0	0.3
52121120.000	Unnamed 3	3	Linn	57	21	23		0.0-2.4	0.0	2.4
52121130.000	Unnamed 4	3	Linn	57	21	14		0.0-0.3	0.1	0.3
52121140.000	Muddy Creek	5	Linn	57	21	11	28.7	0.0-10.2	2.0	8.2
52121140.000	Muddy Creek	4	Linn	58	20	17		10.2-13.2	1.2	1.8
52121140.000	Muddy Creek	3	Linn	59	20	32		13.2-16.6	0.3	3.1
52121141.000	Unnamed 5	4	Linn	57	21	1	1.8	0.0-0.6	0.0	0.6
52121141.000	Unnamed 5	3	Linn	57	21	12		0.6-1.8	0.0	1.2
52121141.100	Unnamed 6	3	Linn	57	21	12		0.0-0.5	0.0	0.5
52121142.000	Unnamed 7	3	Linn	58	20	31		0.0-0.5	0.0	0.5
52121143.000	Unnamed 8	3	Linn	58	20	31		0.0-1.0	0.0	1.0
52121144.000	Unnamed 9	3	Linn	58	20	29		0.0-0.1	0.0	0.1
52121145.000	Unnamed 10	3	Linn	58	20	29		0.0-1.6	0.0	1.6
52121146.000	Unnamed 11	3	Linn	58	20	29		0.0-0.3	0.0	0.3
52121147.000	Unnamed 12	3	Linn	58	20	17		0.0-0.3	0.0	0.3
52121148.000	Unnamed 13	4	Linn	58	20	17	3.9	0.0-0.8	0.0	0.8
52121148.000	Unnamed 13	3	Linn	58	20	7		0.8-2.7	0.4	1.5
52121148.100	Unnamed 14	3	Linn	58	20	7		0.0-0.3	0.0	0.3
52121149.000	Unnamed 15	3	Linn	59	20	32		0.0-0.2	0.0	0.2
52121200.000	Locust Creek Sec 2	0	Linn	57	21	11			0.0	0.0
52121210.000	Unnamed 16	3	Linn	58	21	35		0.0-3.9	1.1	2.8
52121220.000	Unnamed 17	3	Linn	58	21	26		0.0-0.1	0.1	0.0
52121230.000	Unnamed 18	4	Linn	58	21	22	2.3	0.0-0.3	0.0	0.3
52121230.000	Unnamed 18	3	Linn	58	21	22		0.3-4.8	0.8	3.7
52121231.000	Unnamed 19	3	Linn	58	21	22		0.0-4.2	0.3	3.9
52121240.000	Unnamed 20	4	Linn	58	21	22	3.4	0.0-0.3	0.3	0.0
52121240.000	Unnamed 20	3	Linn	58	21	22		0.3-1.3	0.7	0.3
52121241.000	Unnamed 21	3	Linn	58	21	22		0.0-0.1	0.1	0.0
52121250.000	Unnamed 22	3	Linn	58	21	10		0.0-2.5	0.0	2.5
52121300.000	Locust Creek Sec 3	0	Linn	58	21	10			0.0	0.0
52121310.000	Strawberry Branch	3	Linn	58	21	10		0.0-5.0	0.0	5.0
52121320.000	Couch Branch	3	Linn	58	21	2		0.0-2.3	0.0	2.3
52121330.000	Kemper Branch	3	Linn	59	21	35		0.0-5.7	0.6	5.1
52121340.000	Unnamed 23	4	Linn	59	21	27	1.9	0.0-0.6	0.0	0.6
52121340.000	Unnamed 23	3	Linn	59	21	22		0.6-0.9	0.0	0.3
52121341.000	Unnamed 24	3	Linn	59	21	22		0.0-0.6	0.0	0.6
52121350.000	Unnamed 25	3	Linn	59	21	11		0.0-3.1	1.4	1.7
52121360.000	Lick Branch	4	Linn	59	21	11	3.6	0.0-1.1	0.4	0.7
52121360.000	Lick Branch	3	Linn	59	21	10		1.1-2.9	0.0	1.8
52121361.000	Unnamed 26	3	Linn	59	21	10		0.0-1.2	0.0	1.2
52121400.000	Locust Creek Sec 4	0	Linn	59	21	2			0.0	0.0

Stream Code	Stream Name	Order	County	T(N)	R(W)	S	WA	River Miles	Channelized	Unchannelized
52121410.000	West Locust Creek (S)	6	Linn	59	21	2	134.6	0.0-10.8	5.9	4.9
52121410.000	West Locust Creek (S)	5	Sullivan	61	21	14		10.8-28.8	3.9	14.1
52121410.000	West Locust Creek (S)	4	Sullivan	63	21	22		28.8-41.2	4.9	7.5
52121410.000	West Locust Creek (S)	3	Putnam	65	21	32		41.2-42.3	0.9	0.2
52121411.000	West L.C. (S) Sect. 1	0	Linn	59	21	2			0.0	0.0
52121411.100	Linn Branch	4	Linn	60	21	26	4.6	0.0-2.2	0.8	1.4
52121411.100	Linn Branch	3	Linn	60	21	28		2.2-3.6	0.2	1.2
52121411.110	Unnamed 27	3	Linn	60	21	27		0.0-0.1	0.0	0.1
52121411.200	Unnamed 28	3	Linn	60	21	14		0.0-0.1	0.0	0.1
52121411.300	Unnamed 29	4	Sullivan	61	21	35	5.3	0.0-0.3	0.3	0.0
52121411.300	Unnamed 29	3	Sullivan	61	21	35		0.3-4.3	0.0	4.3
52121411.310	Unnamed 30	3	Sullivan	61	21	35		0.0-2.2	0.3	1.9
52121411.400	Unnamed 31	5	Sullivan	61	21	14	13.9	0.0-4.3	0.0	4.3
52121411.400	Unnamed 31	4	Sullivan	61	21	3		4.3-7.2	0.5	2.4
52121411.400	Unnamed 31	3	Sullivan	62	21	28		7.2-8.0	0.0	0.8
52121411.410	Brushy Branch	4	Sullivan	61	21	14	4.1	0.0-3.0	0.0	3.0
52121411.410	Brushy Branch	3	Sullivan	61	21	9		3.0-3.3	0.0	0.3
52121411.411	Unnamed 32	3	Sullivan	61	21	9		0.0-0.7	0.0	0.7
52121411.412	Unnamed 33	3	Sullivan	61	21	9		0.0-0.1	0.0	0.1
52121411.420	Unnamed 34	4	Sullivan	61	21	3	3.2	0.0-1.8	0.2	1.6
52121411.420	Unnamed 34	3	Sullivan	61	21	4		1.8-2.3	0.0	0.5
52121411.421	Unnamed 35	3	Sullivan	61	21	4		0.0-0.2	0.0	0.2
52121411.422	Unnamed 36	3	Sullivan	61	21	4		0.0-0.7	0.0	0.7
52121411.430	Unnamed 37	3	Sullivan	62	21	34	3.1	0.0-4.2	0.5	3.7
52121411.440	Unnamed 38	3	Sullivan	62	21	28		0.0-0.5	0.0	0.5
52121412.000	West L.C. (S) Sect. 2	0	Sullivan	62	21	28			0.0	0.0
52121412.100	Unnamed 39	4	Sullivan	62	21	10	1.0	0.0-1.0	0.0	1.0
52121412.100	Unnamed 39	3	Sullivan	62	21	10		1.0-2.0	0.0	1.0
52121412.110	Unnamed 40	3	Sullivan	62	21	9		0.0-0.4	0.0	0.4
52121412.200	Unnamed 41	4	Sullivan	62	21	3	3.9	0.0-2.7	0.4	2.3
52121412.200	Unnamed 41	3	Sullivan	63	21	32		2.7-3.8	0.0	1.1
52121412.210	Unnamed 42	3	Sullivan	62	21	4		0.0-0.6	0.0	0.6
52121412.220	Unnamed 43	3	Sullivan	63	21	32		0.0-0.6	0.3	0.6
52121412.300	Unnamed 44	3	Sullivan	63	21	34		0.0-2.0	0.0	2.0
52121412.400	Unnamed 45	4	Sullivan	63	21	22	2.6	0.0-1.2	0.3	0.9
52121412.400	Unnamed 45	3	Sullivan	63	21	21		1.0-2.5	0.0	1.3
52121412.410	Unnamed 46	3	Sullivan	63	21	21		0.0-0.1	0.0	0.1
52121412.500	Unnamed 47	3	Sullivan	63	21	10		0.0-2.4	0.0	2.4
52121412.600	Unnamed 48	3	Sullivan	63	21	4		0.0-0.9	0.0	0.9
52121412.700	Unnamed 49	3	Putnam	65	21	32		0.0-0.5	0.0	0.5
52121420.000	Unnamed 50	3	Linn	60	21	36		0.0-2.1	0.0	2.1
52121430.000	Lowes Branch	4	Linn	60	21	36	10.2	0.0-3.1	0.6	2.5
52121430.000	Lowes Branch	3	Linn	60	20	32		3.1-4.7	0.0	1.6
52121431.000	Unnamed 51	3	Linn	60	20	31		0.0-1.0	0.0	1.0
52121432.000	Unnamed 52	3	Linn	60	20	32		0.0-2.0	0.0	2.0
52121440.000	Mairs Branch	3	Linn	60	20	18		0.0-0.5	0.0	0.5
52121450.000	East Locust Creek	5	Sullivan	61	20	32	76.4	0.0-1.9	1.9	0.0
52121450.000	East Locust Creek	4	Sullivan	61	20	28		1.9-29.5	6.9	20.7
52121450.000	East Locust Creek	3	Sullivan	64	20	25		29.5-32.9	0.3	3.1
52121451.000	Little East Locust	5	Sullivan	61	20	28	40.2	0.0-4.0	0.0	4.0
52121451.000	Little East Locust	4	Sullivan	61	20	13		4.0-9.7	1.7	4.0
52121451.000	Little East Locust	3	Sullivan	62	19	29		9.7-10.6	0.4	0.5
52121451.100	Unnamed 53	3	Sullivan	61	20	22		0.0-1.1	0.0	1.1
52121451.200	Unnamed 54	4	Sullivan	61	20	13	11.8	0.0-1.4	0.0	1.4
52121451.200	Unnamed 54	3	Sullivan	61	20	13		1.4-1.9	0.0	0.5
52121451.210	Paw Paw Creek	2	Sullivan	61	20	13	5.7	0.0-4.8	0.0	4.8
52121451.220	Unnamed 55	3	Sullivan	61	20	13		0.0-2.4	0.0	2.4
52121451.300	Unnamed 56	3	Sullivan	62	19	29		0.0-2.2	1.6	0.6
52121452.000	Unnamed 57	3	Sullivan	61	20	3		0.0-0.8	0.0	0.8
52121453.000	Unnamed 58	3	Sullivan	62	20	34		0.0-1.5	0.0	1.5
52121454.000	Unnamed 59	3	Sullivan	62	20	26		0.0-1.7	0.4	1.3
52121455.000	Unnamed 60	3	Sullivan	62	20	2		0.0-1.3	0.1	1.2
52121456.000	Elmwood Branch	3	Sullivan	63	20	35		0.0-4.1	2.0	2.1

Stream Code	Stream Name	Order	County	T(N)	R(W)	S	WA	River Miles	Channelized	Unchannelized
52121457.000	Unnamed 61	3	Sullivan	63	20	24		0.0-1.2	0.0	1.2
52121458.000	Unnamed 62	3	Sullivan	64	20	25		0.0-4.1	0.0	4.1
52121500.000	Locust Creek Sec 5	0	Sullivan	61	20	32			0.0	0.0
52121510.000	Unnamed 63	3	Sullivan	62	20	20		0.0-0.7	0.0	0.7
52121520.000	Unnamed 64	3	Sullivan	62	20	4		0.0-0.2	0.0	0.2
52121530.000	Unnamed 65	3	Sullivan	62	20	4		0.0-2.2	0.0	2.2
52121540.000	Unnamed 66	3	Sullivan	63	20	17		0.0-2.2	0.0	2.2
52121550.000	Unnamed 67	3	Sullivan	64	20	33		0.0-1.3	0.0	1.3
52121560.000	Rocks Branch	4	Sullivan	64	20	28	21.9	0.0-4.6	0.0	4.6
52121560.000	Rocks Branch	3	Sullivan	64	21	12		4.6-7.3	0.0	2.7
52121561.000	Unnamed 68	3	Sullivan	64	20	19		0.0-0.9	0.0	0.9
52121562.000	Unnamed 69	3	Sullivan	64	21	12		0.0-1.4	0.8	0.6
52121570.000	Unnamed 70	4	Sullivan	64	20	10	4.8	0.0-0.2	0.0	0.2
52121570.000	Unnamed 70	3	Sullivan	64	20	10		0.2-1.1	0.0	0.9
52121571.000	Unnamed 71	3	Sullivan	64	20	10		0.0-1.3	0.0	1.3
52121600.000	Locust Creek Sec 6	0	Putnam	65	20	34			0.0	0.0
52121610.000	West L.C. (North)	4	Putnam	65	20	34	58.8	0.0-12.3	8.6	3.7
52121610.000	West L.C. (North)	3	Putnam	66	20	7		12.3-18.4	0.9	5.2
52121611.000	Unnamed 72	3	Putnam	65	20	20		0.0-1.4	0.5	0.9
52121612.000	Unnamed 73	3	Putnam	66	20	20		0.0-0.1	0.0	0.1
52121613.000	Unnamed 74	3	Putnam	66	20	7		0.0-2.0	0.3	1.7
52121620.000	Johnson Branch	3	Putnam	65	20	34		0.0-1.4	0.0	1.4
52121630.000	Hackett Branch	3	Putnam	65	20	27		0.0-1.9	0.4	1.5
52121640.000	Brush Creek	3	Putnam	65	20	22		0.0-0.4	0.4	0.0
52121650.000	Watkins Creek	3	Putnam	65	20	10		0.0-2.3	0.5	1.8
52121660.000	Unnamed 75	3	Putnam	66	20	27		0.0-1.7	0.0	1.7
52121670.000	Unnamed 76	3	Putnam	66	20	15		0.0-6.3	1.9	4.4
52121700.000	Locust Crk Sect. 7	0	Wayne IA	67	20	0			0.0	0.0
52121710.000	Unnamed 77	3	Wayne IA	67	20	15		0.0-2.8	0.0	2.8
52121720.000	West Fork L.C.	0	Wayne IA	67	20	9		0.0-4.8	0.0	4.8
52121730.000	Unnamed 78	3	Wayne IA	67	20	4		0.0-3.1	0.0	3.1

Appendix 2. Gradient profiles for fourth order and larger streams in Locust Creek basin. Gradient profiles include river miles for stream reaches third order and larger. Streams without a designated name were assigned a number and listed as "Unnamed #".

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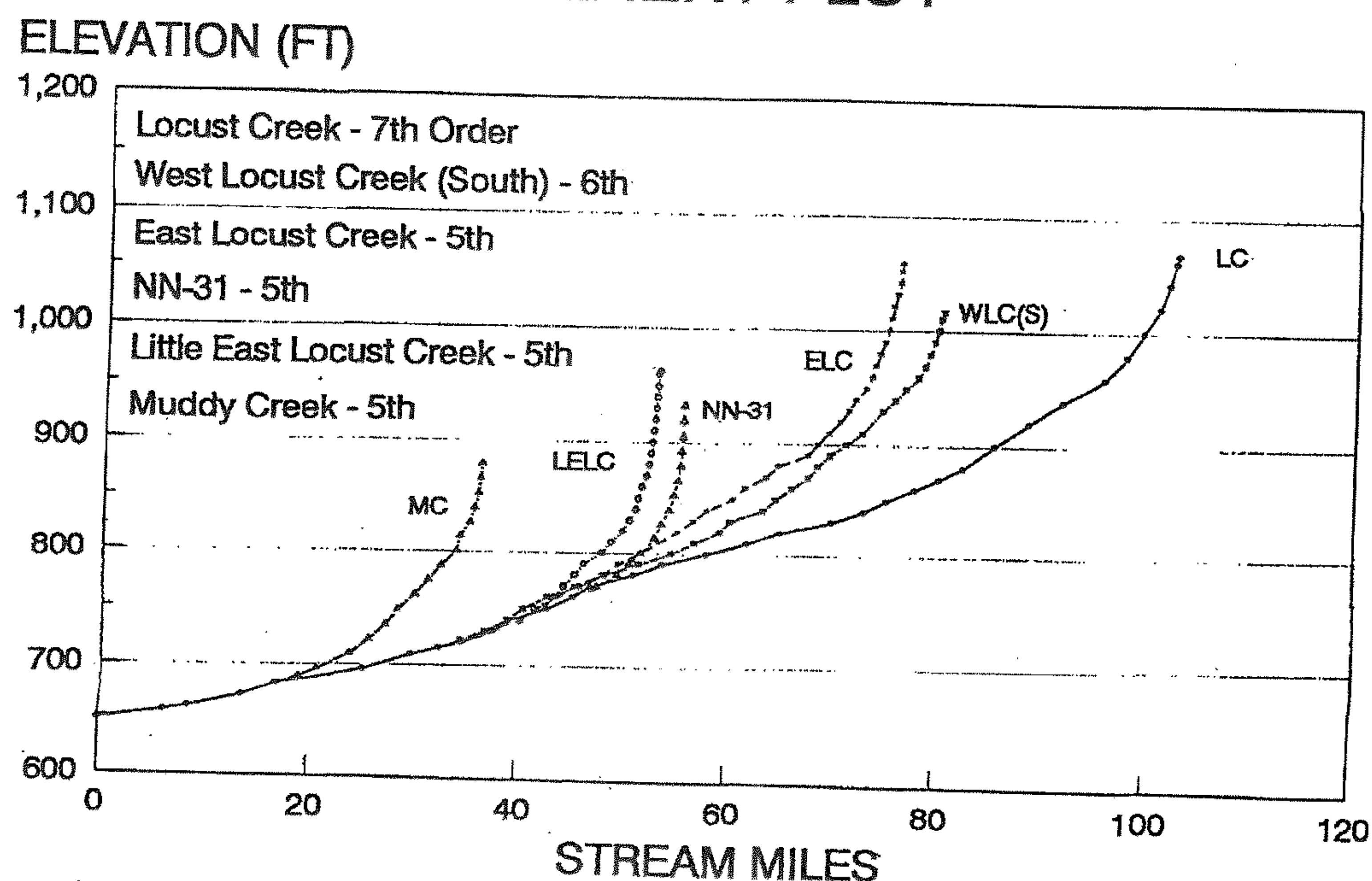

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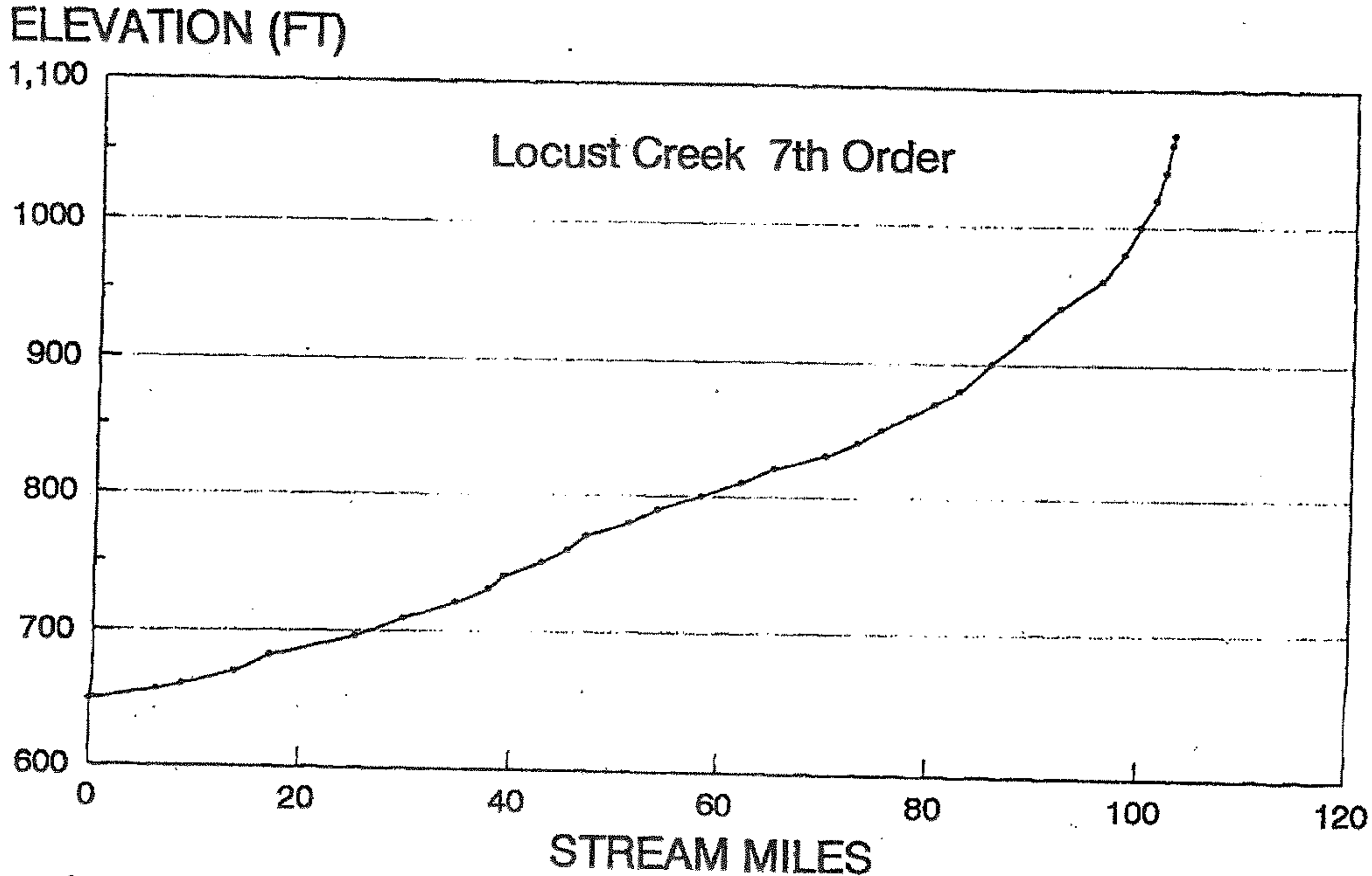

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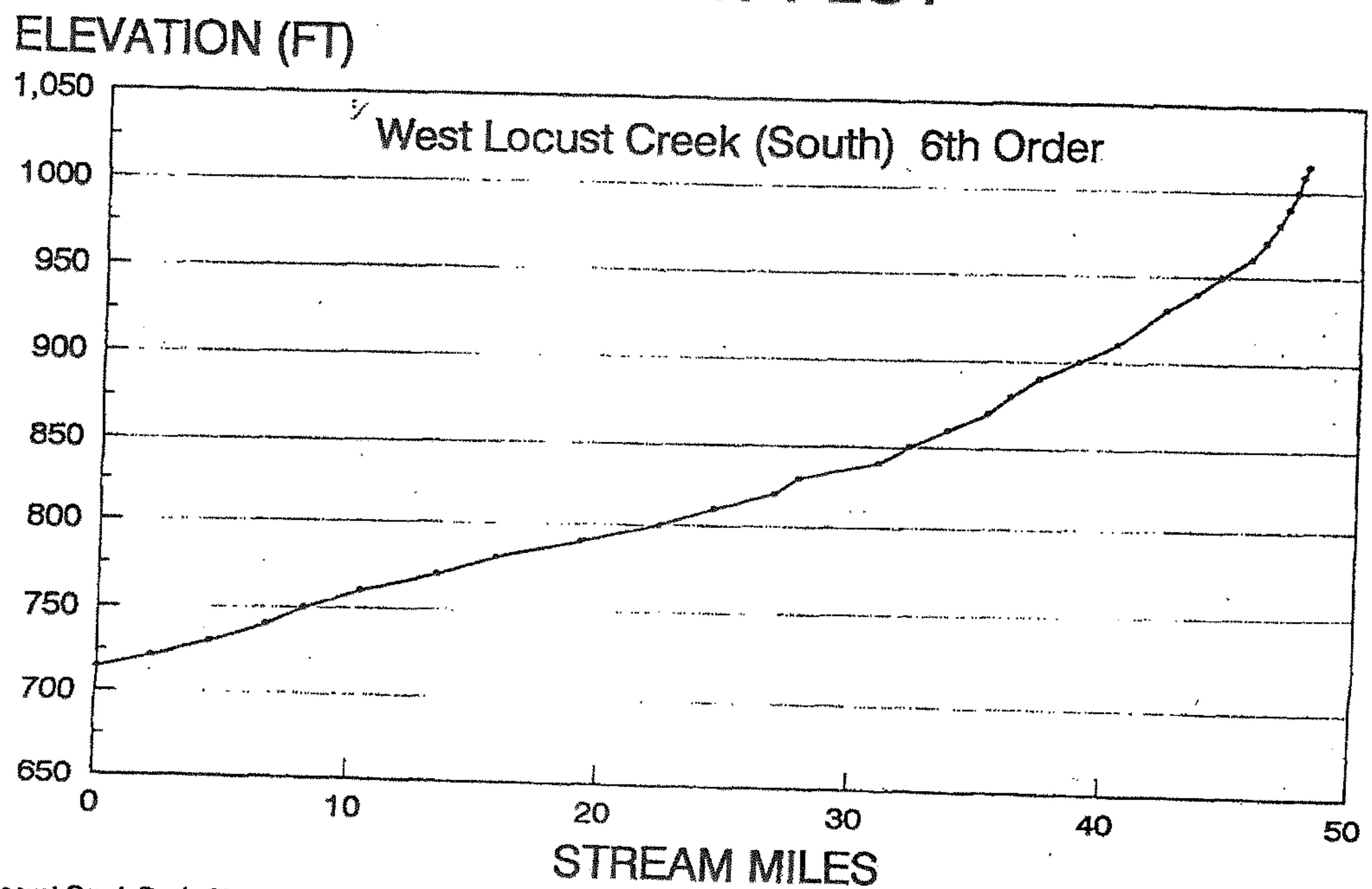

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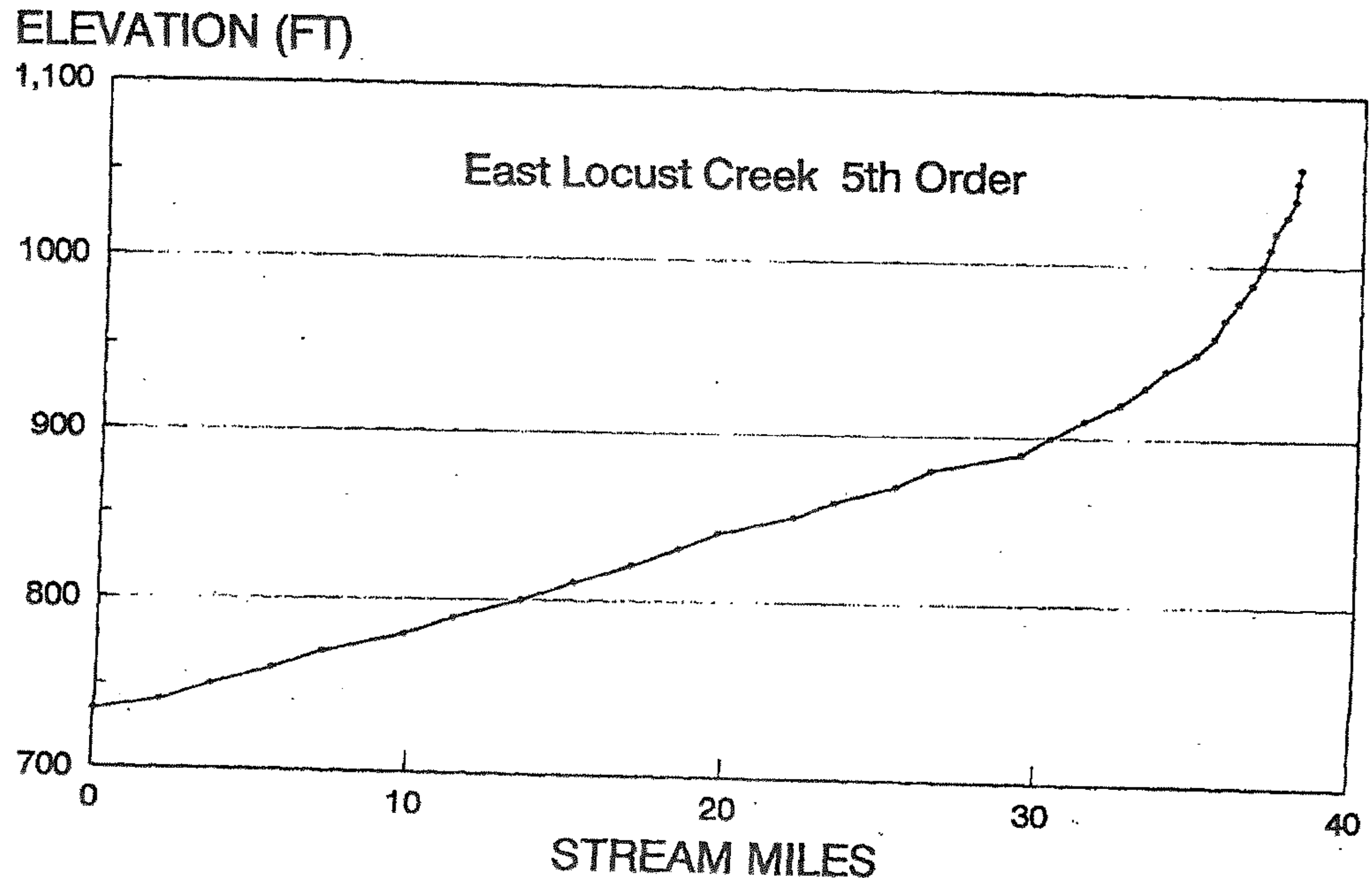
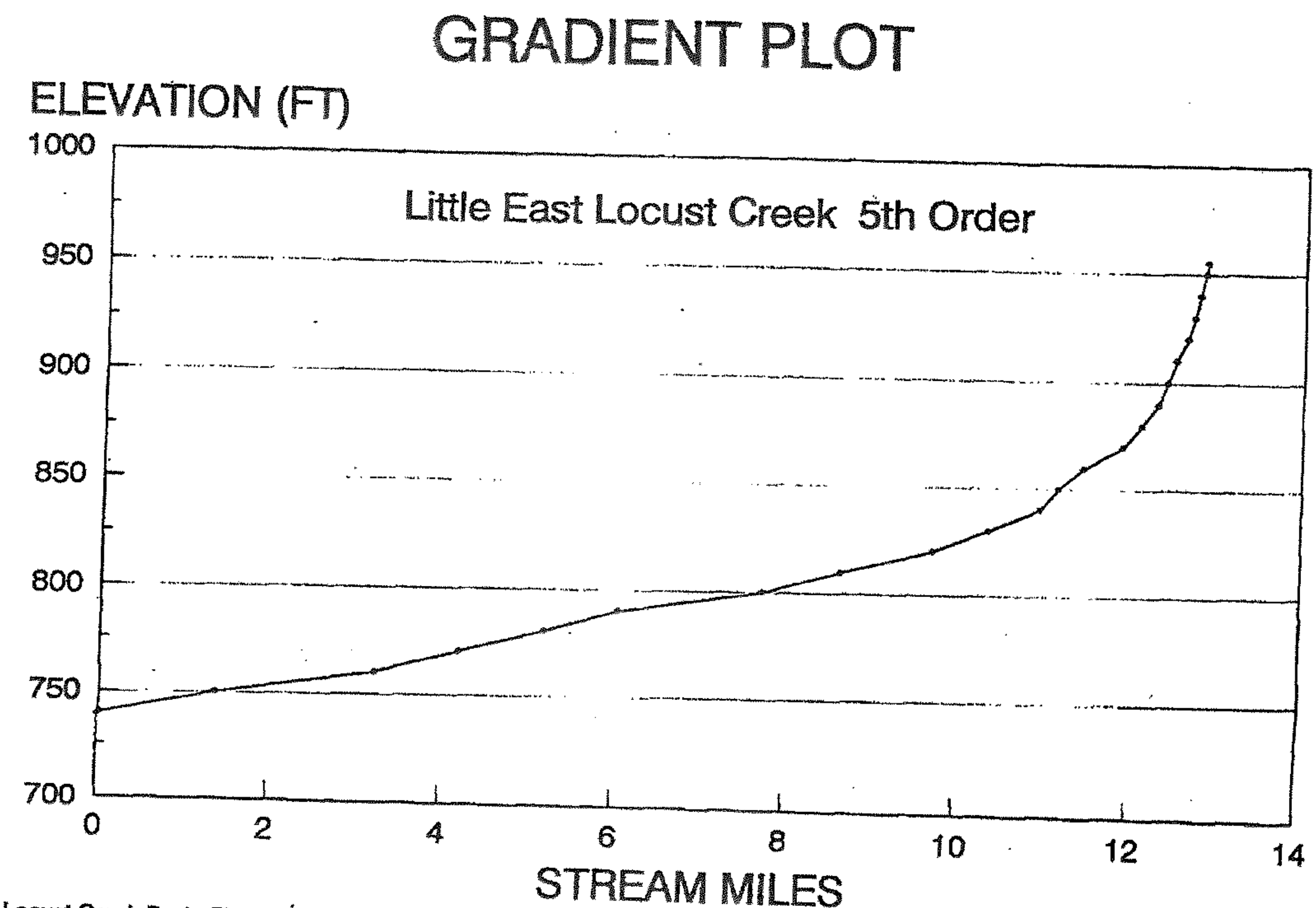


Locust Creek Basin Plan - 1991



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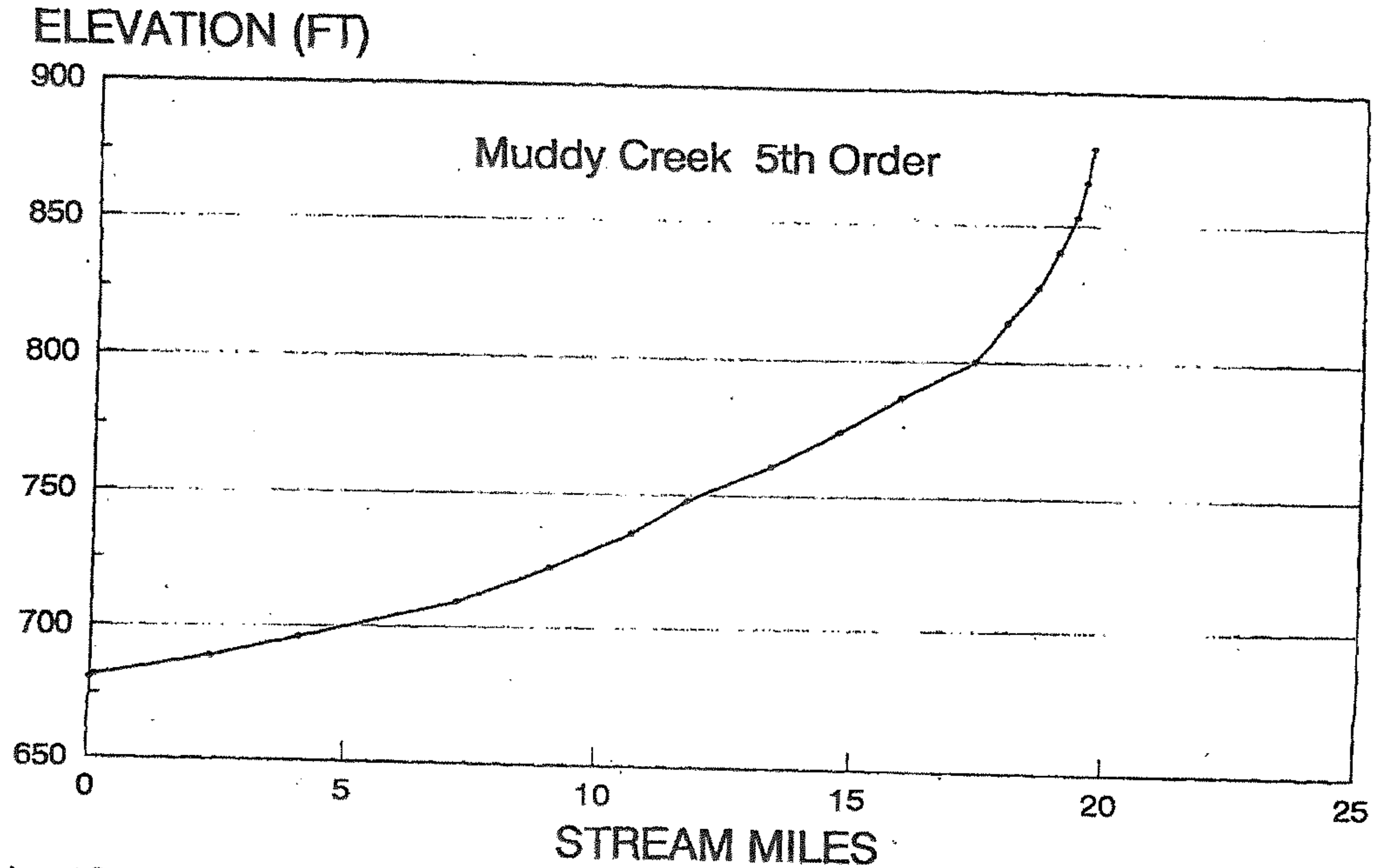

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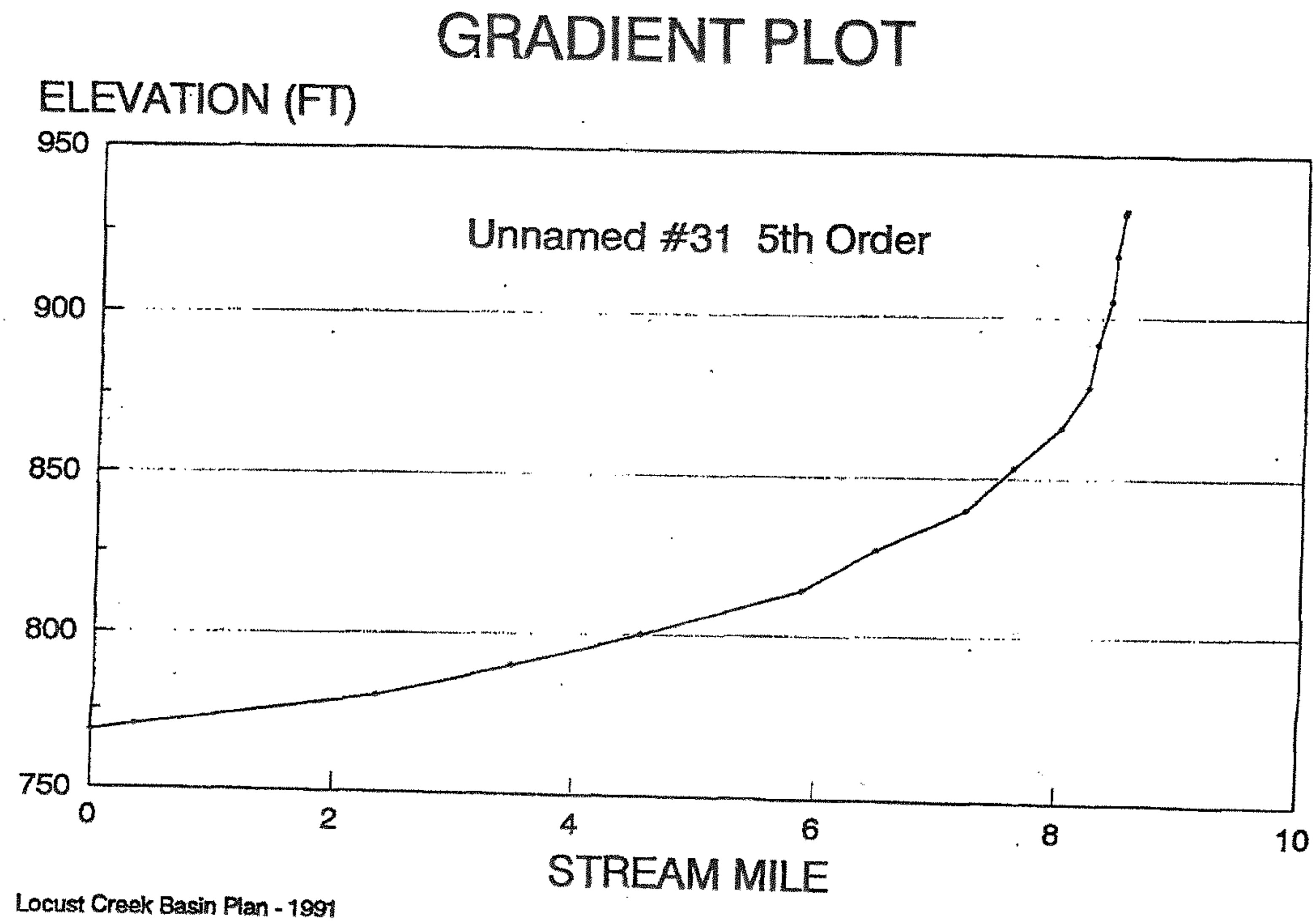
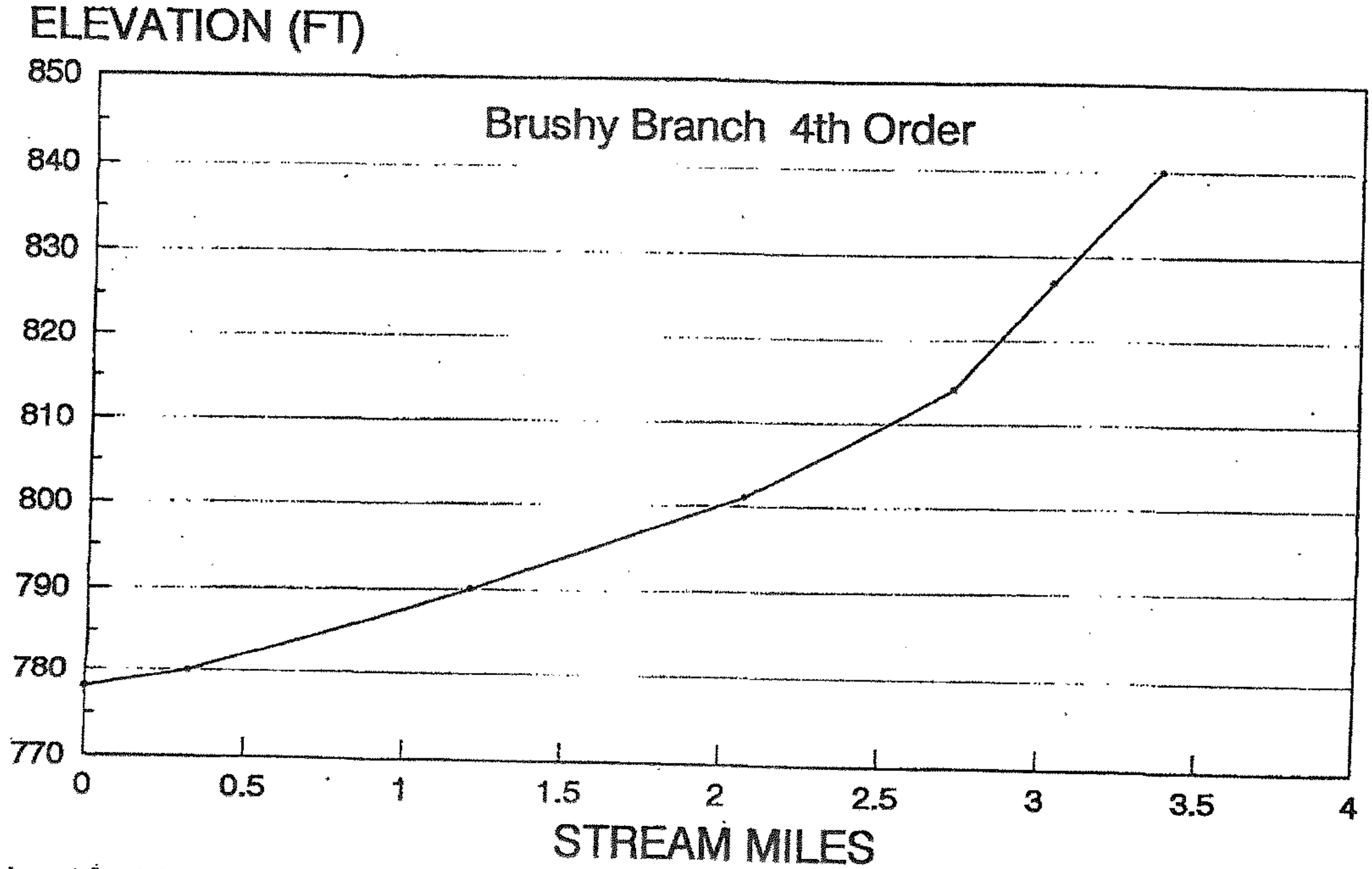

GRADIENT PLOT
ELEVATION (FT)
950
900
850
800
750
Unnamed #31 5th Order
0
2
4
6
8
10
STREAM MILE
Locust Creek Basin Plan - 1991

GRADIENT PLOT



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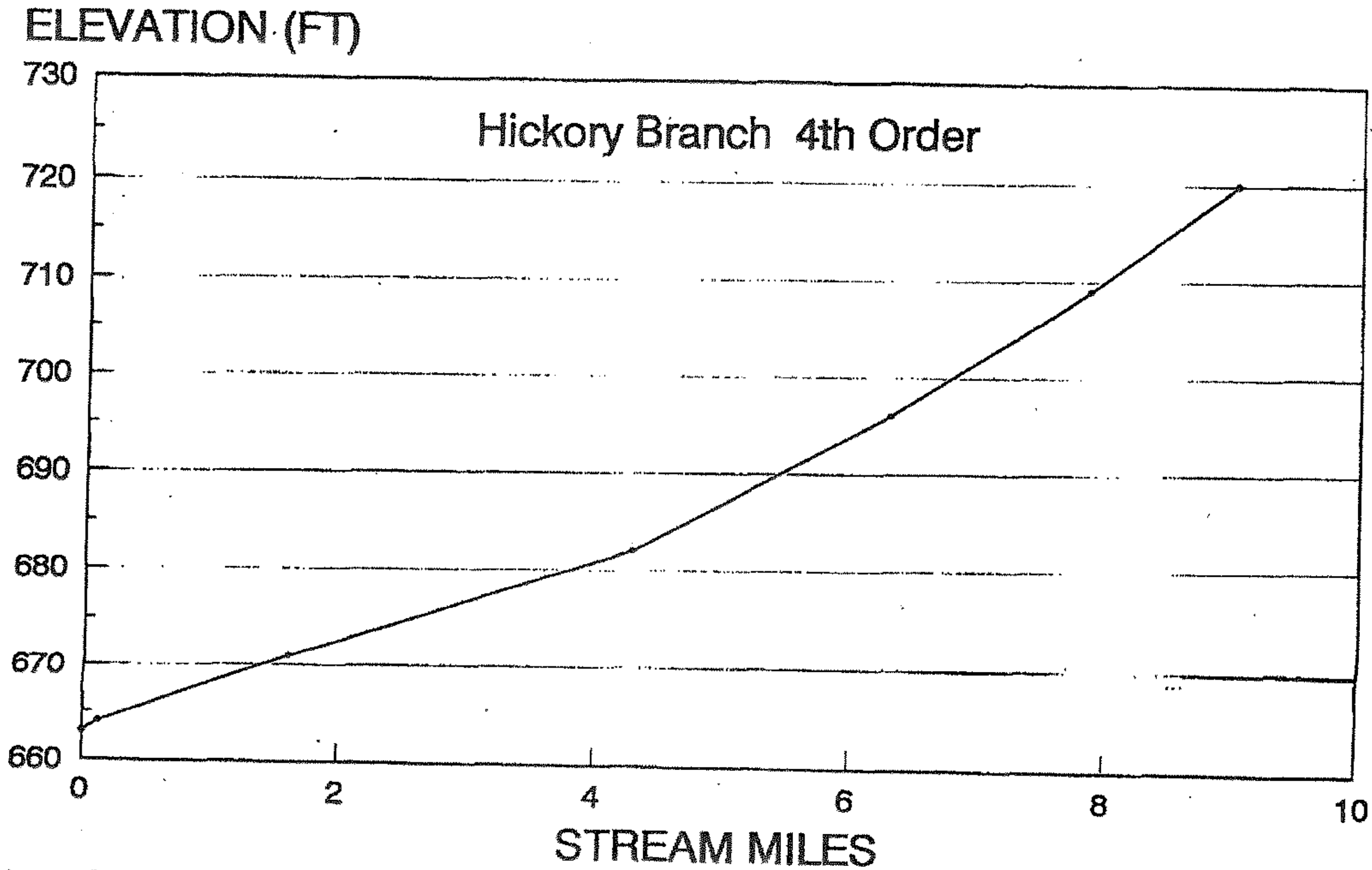

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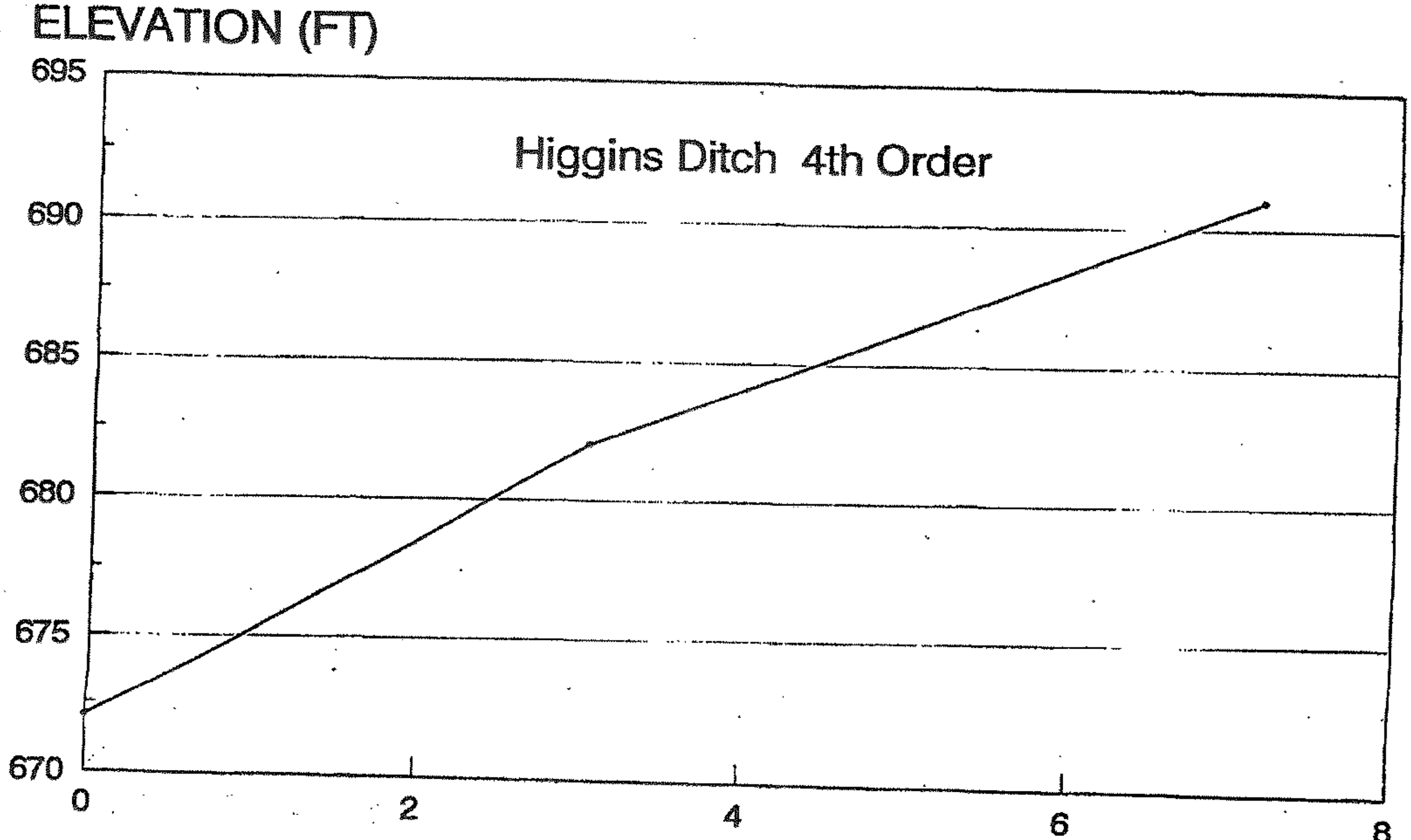

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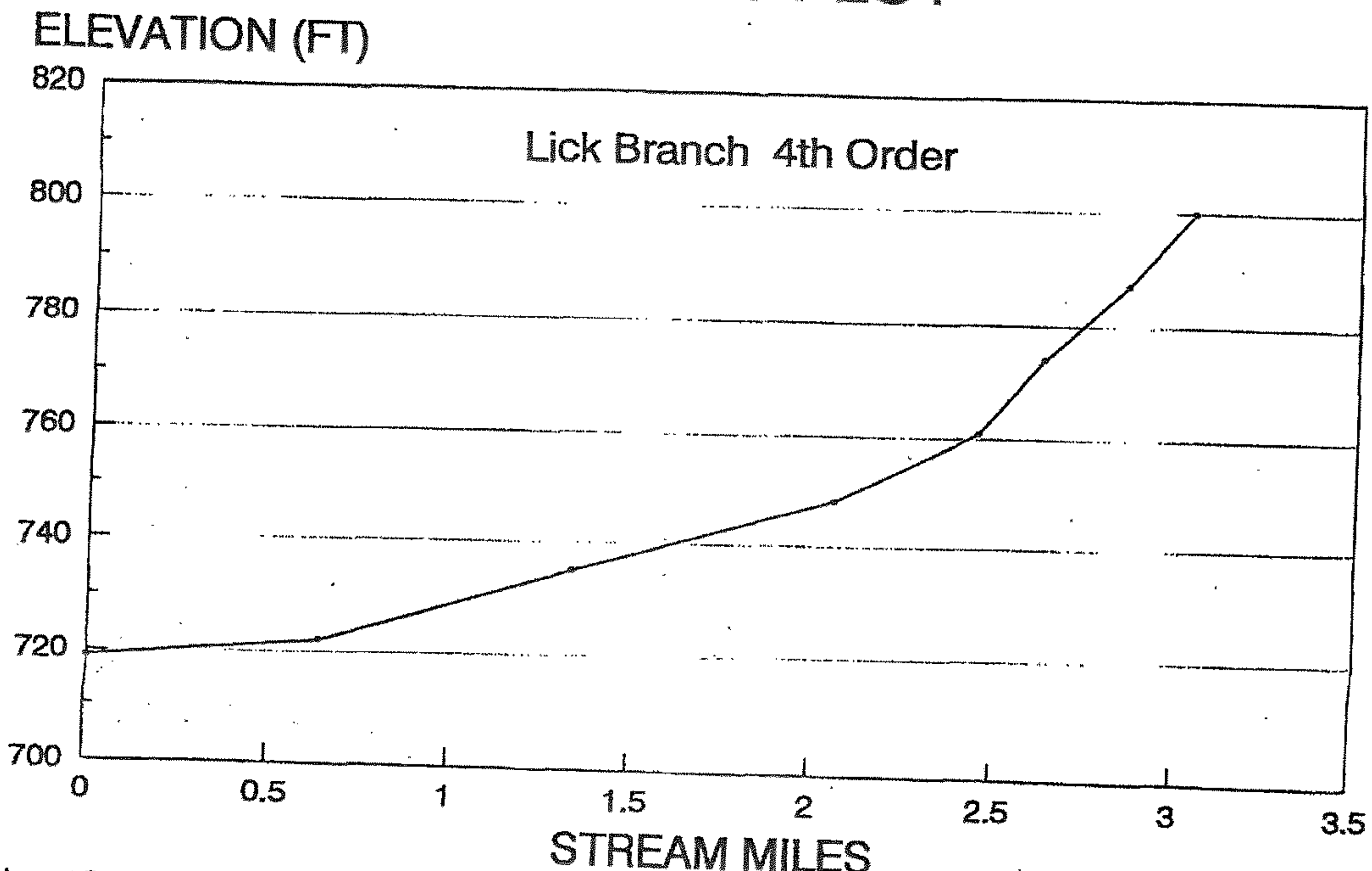

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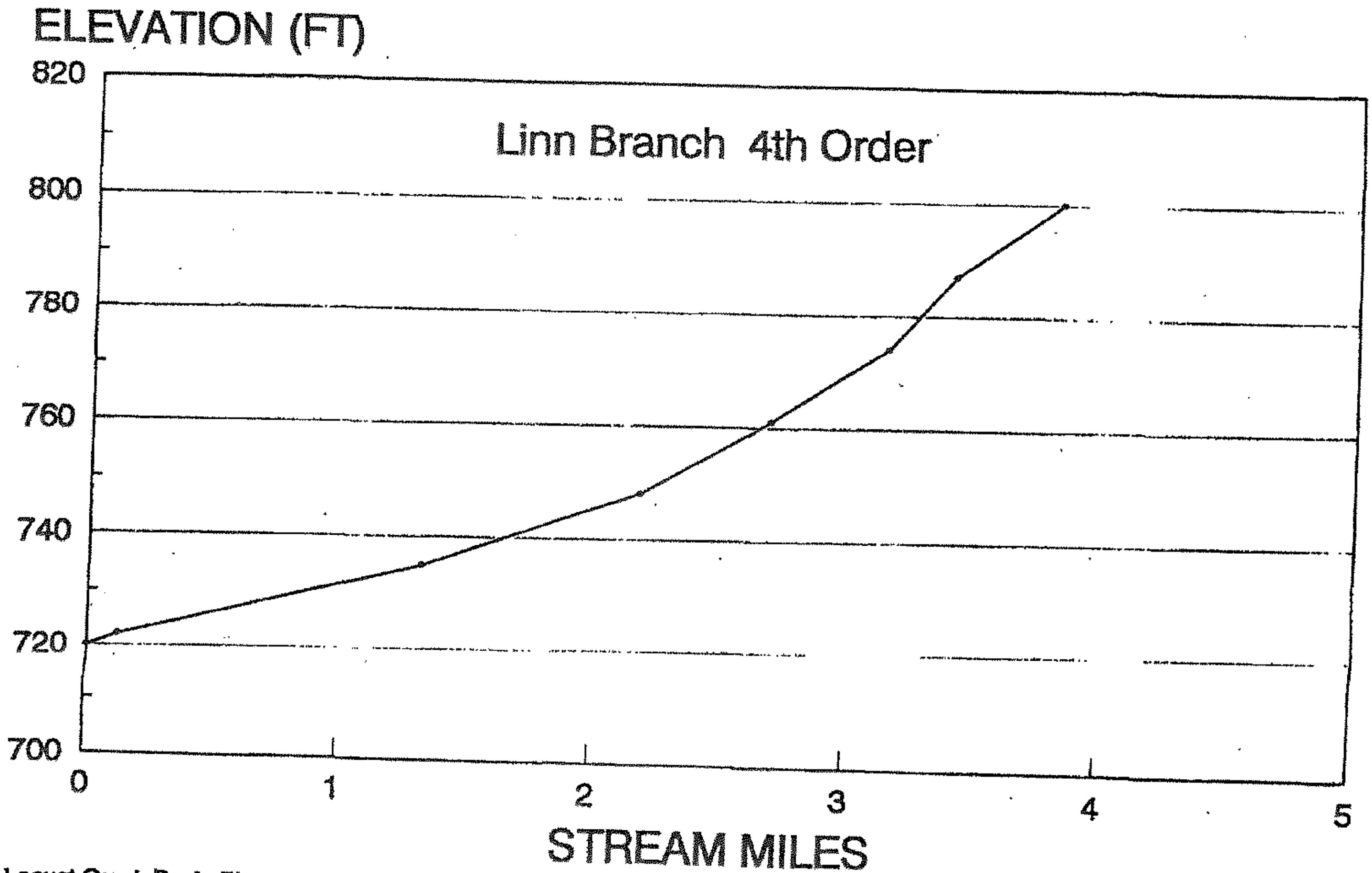

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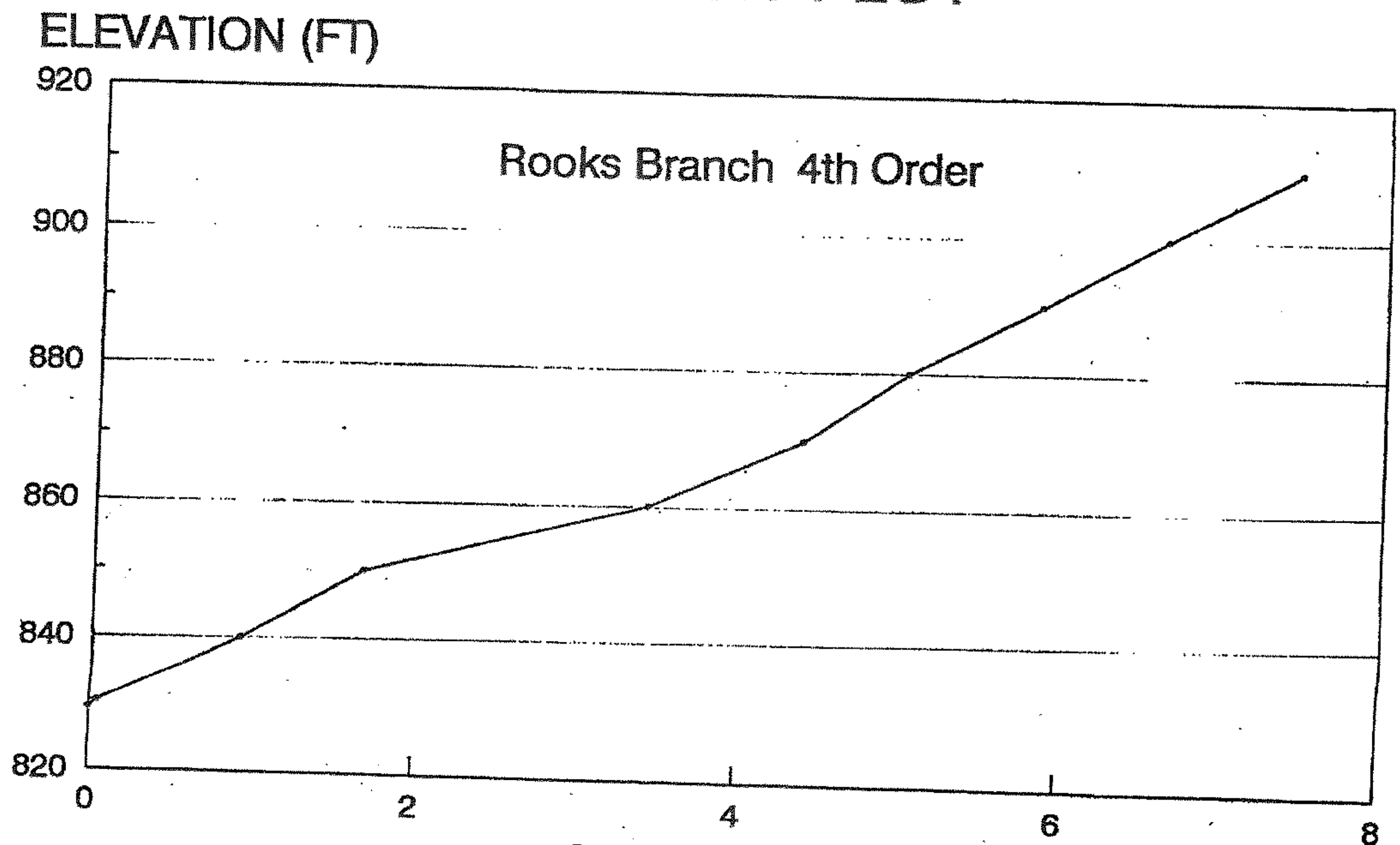

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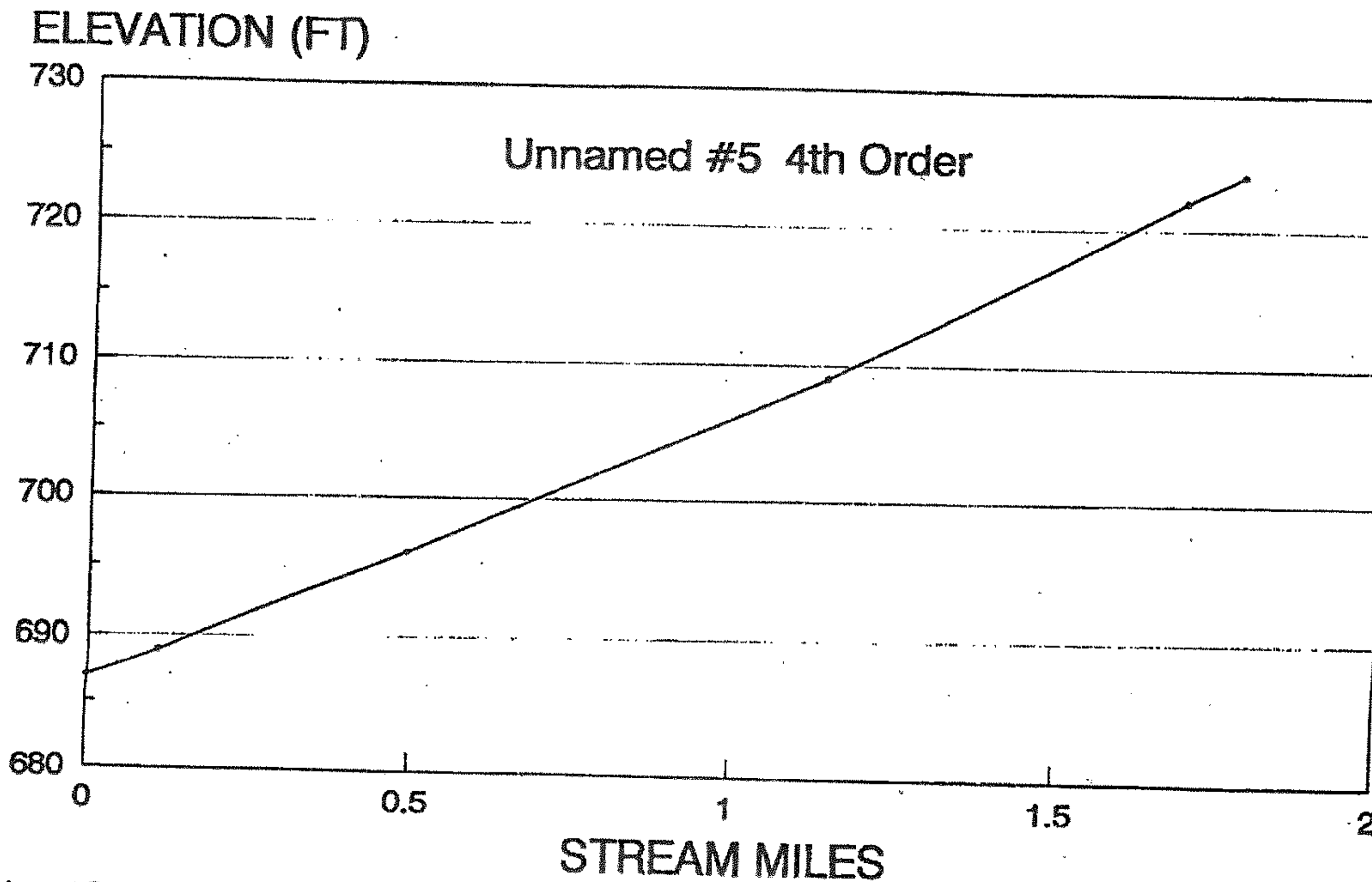

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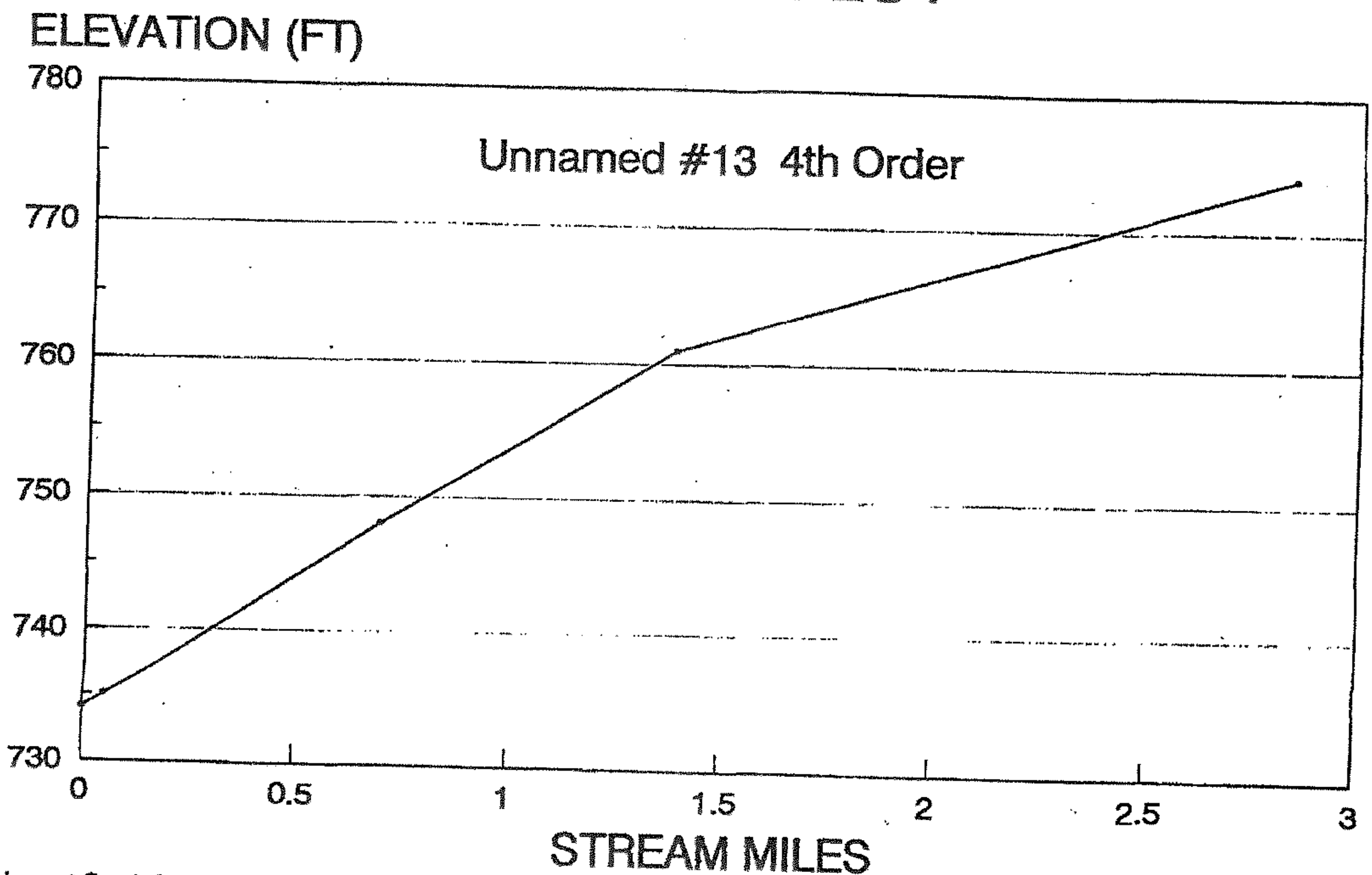

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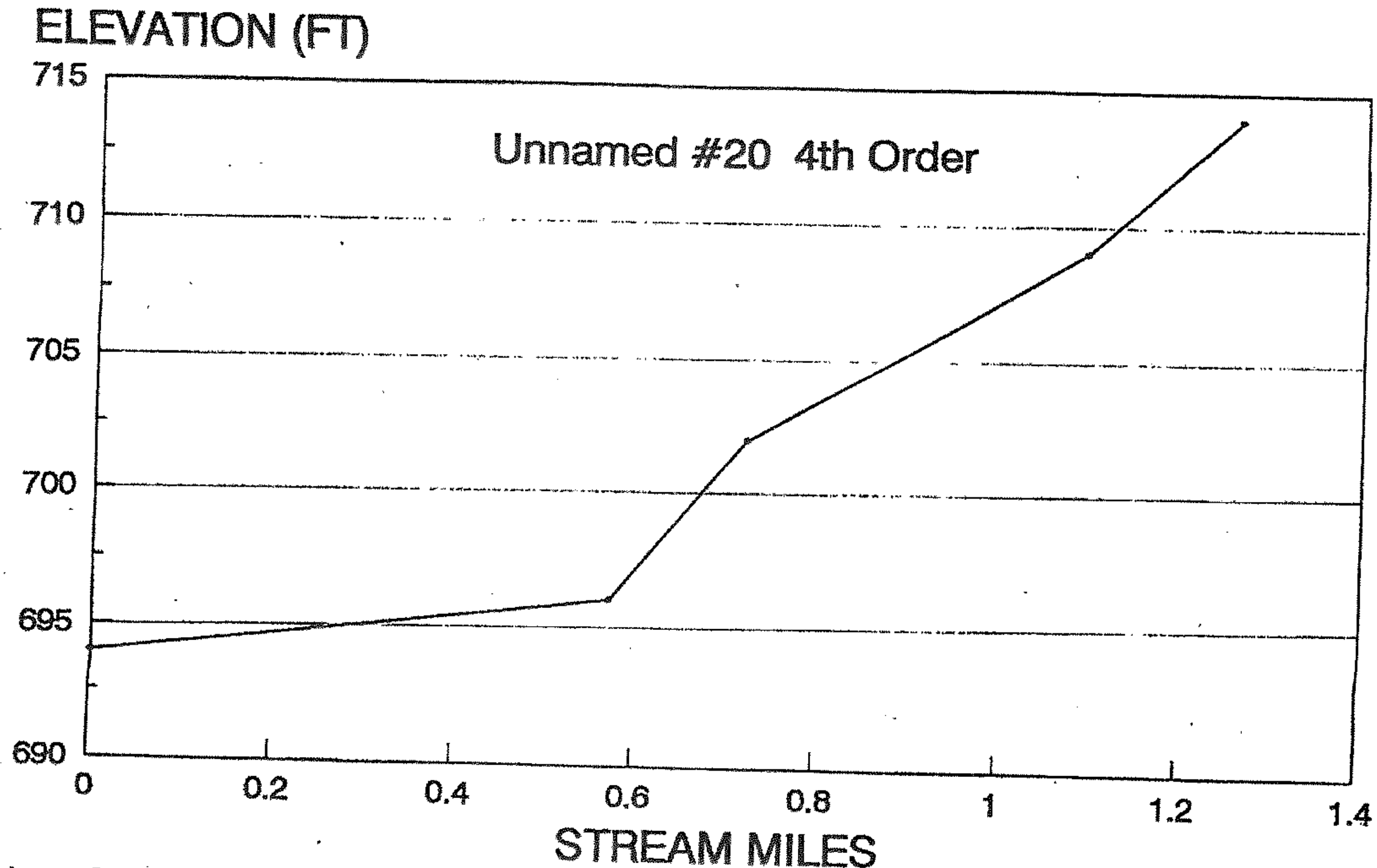

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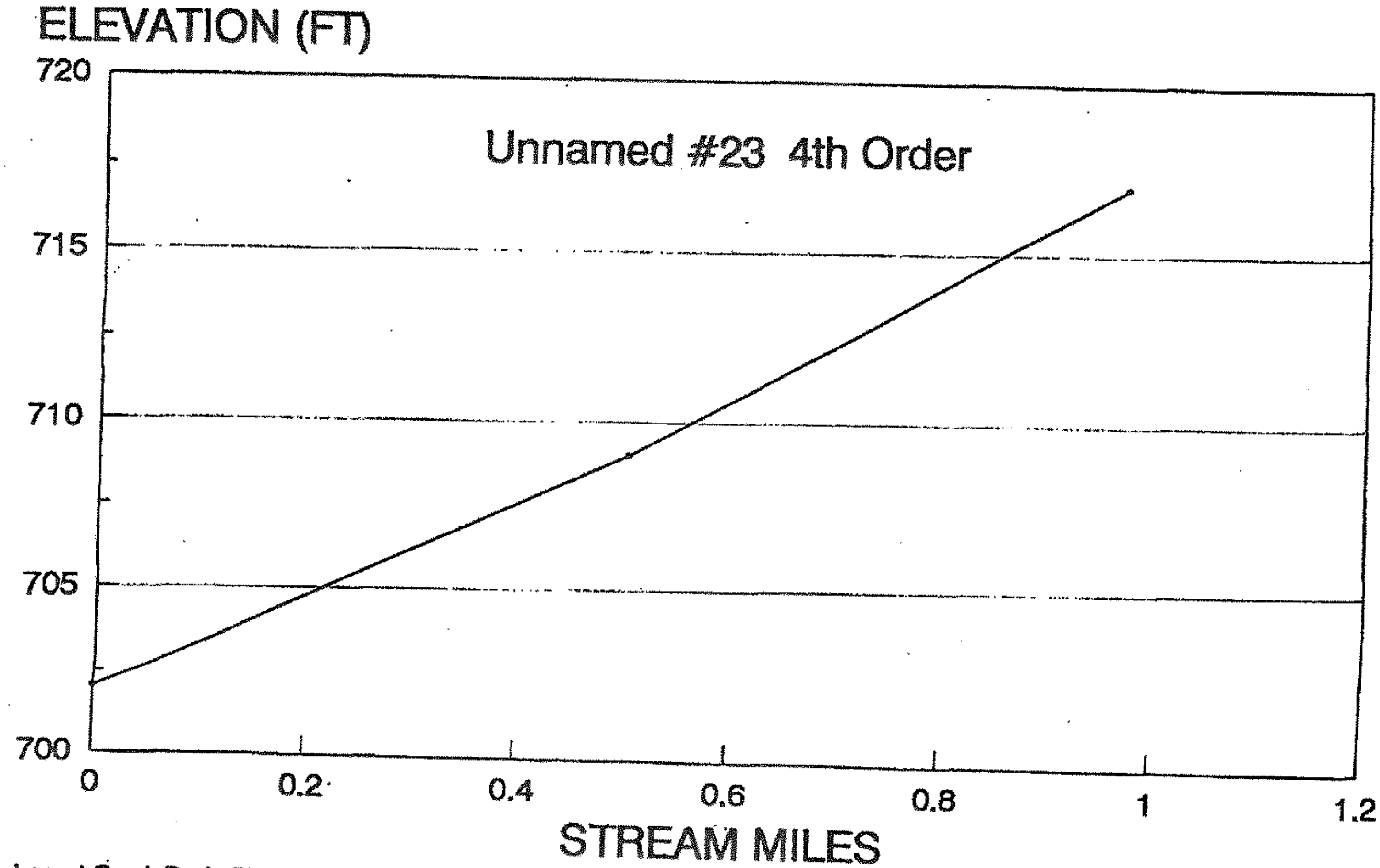

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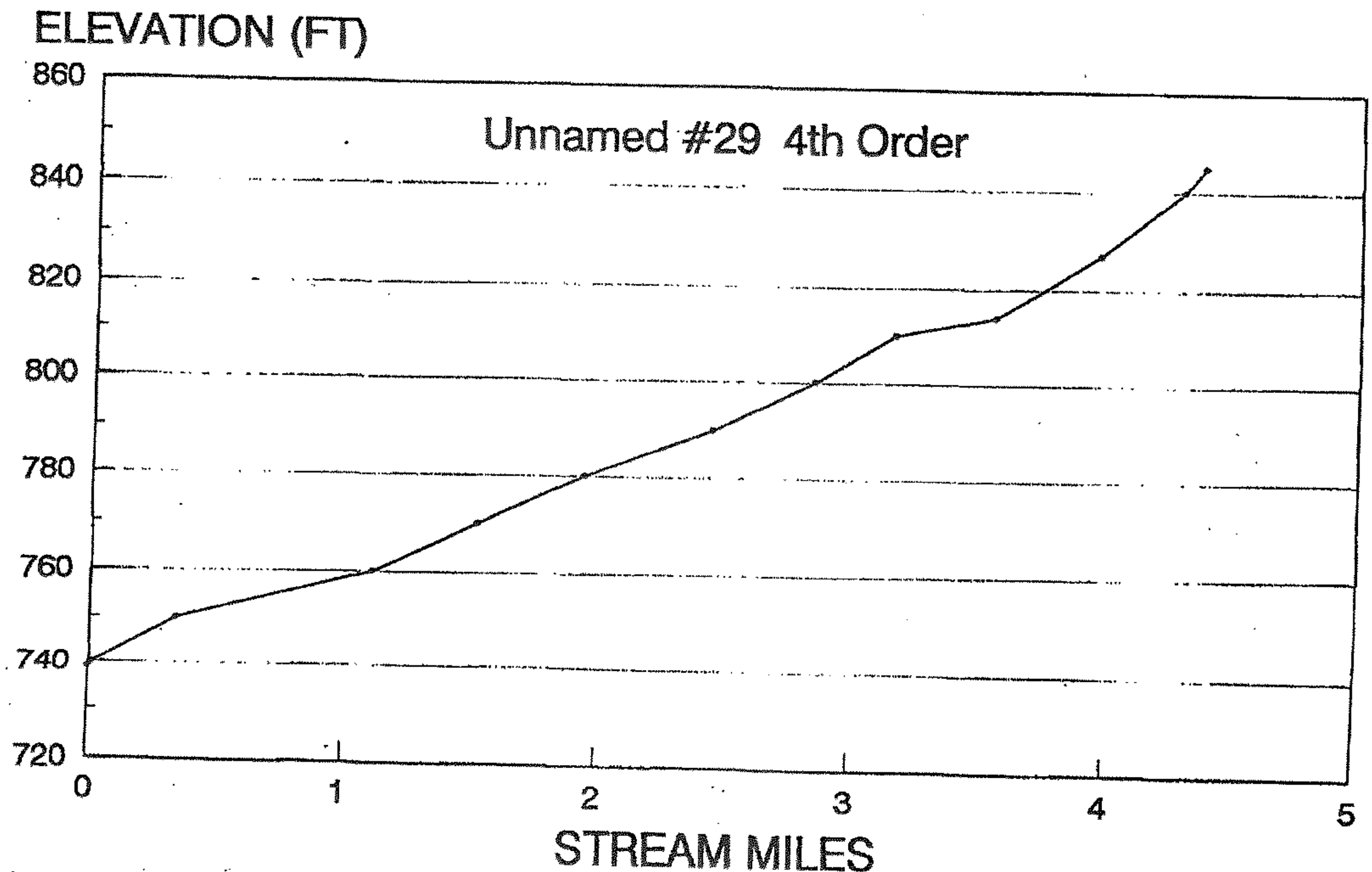

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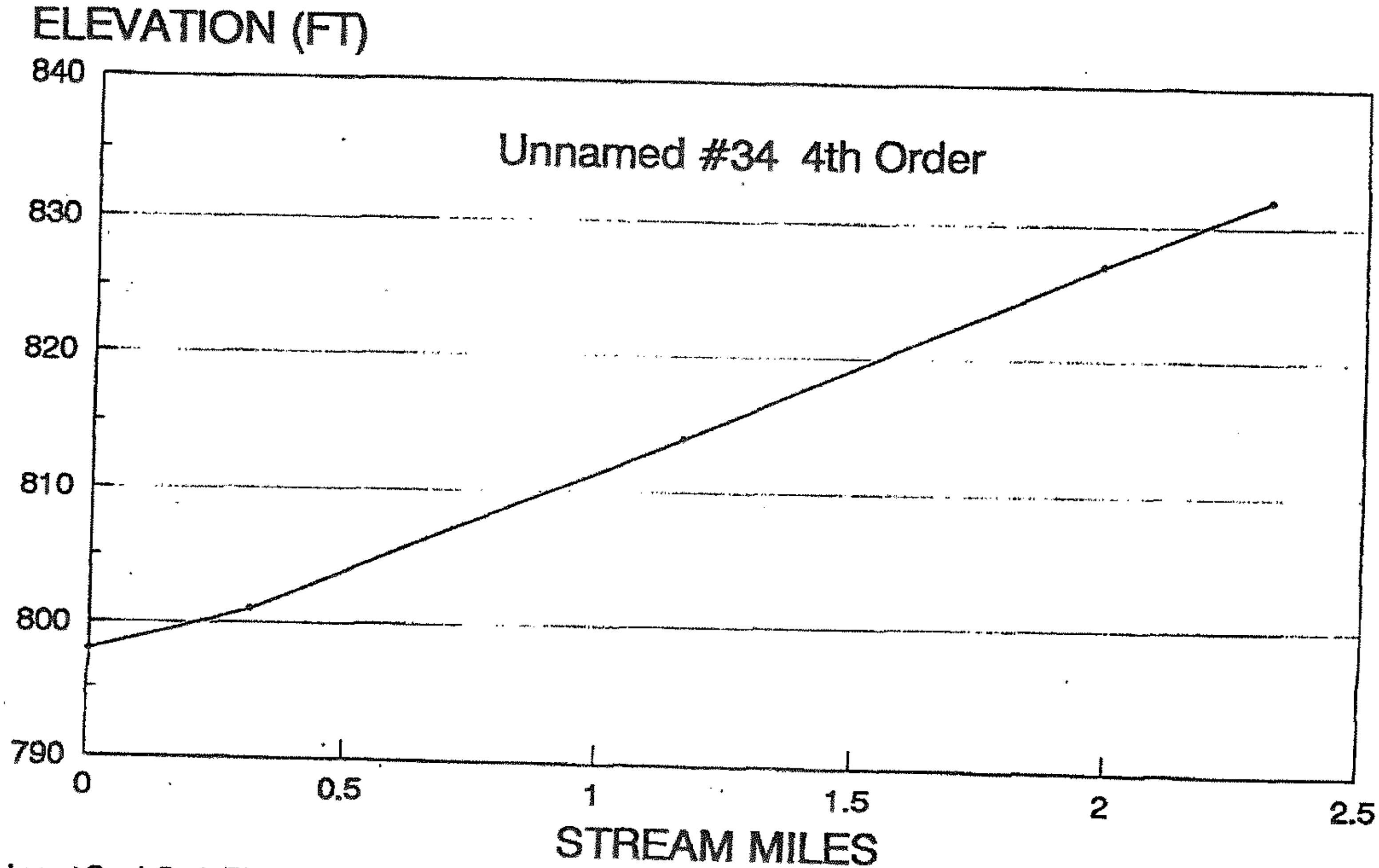

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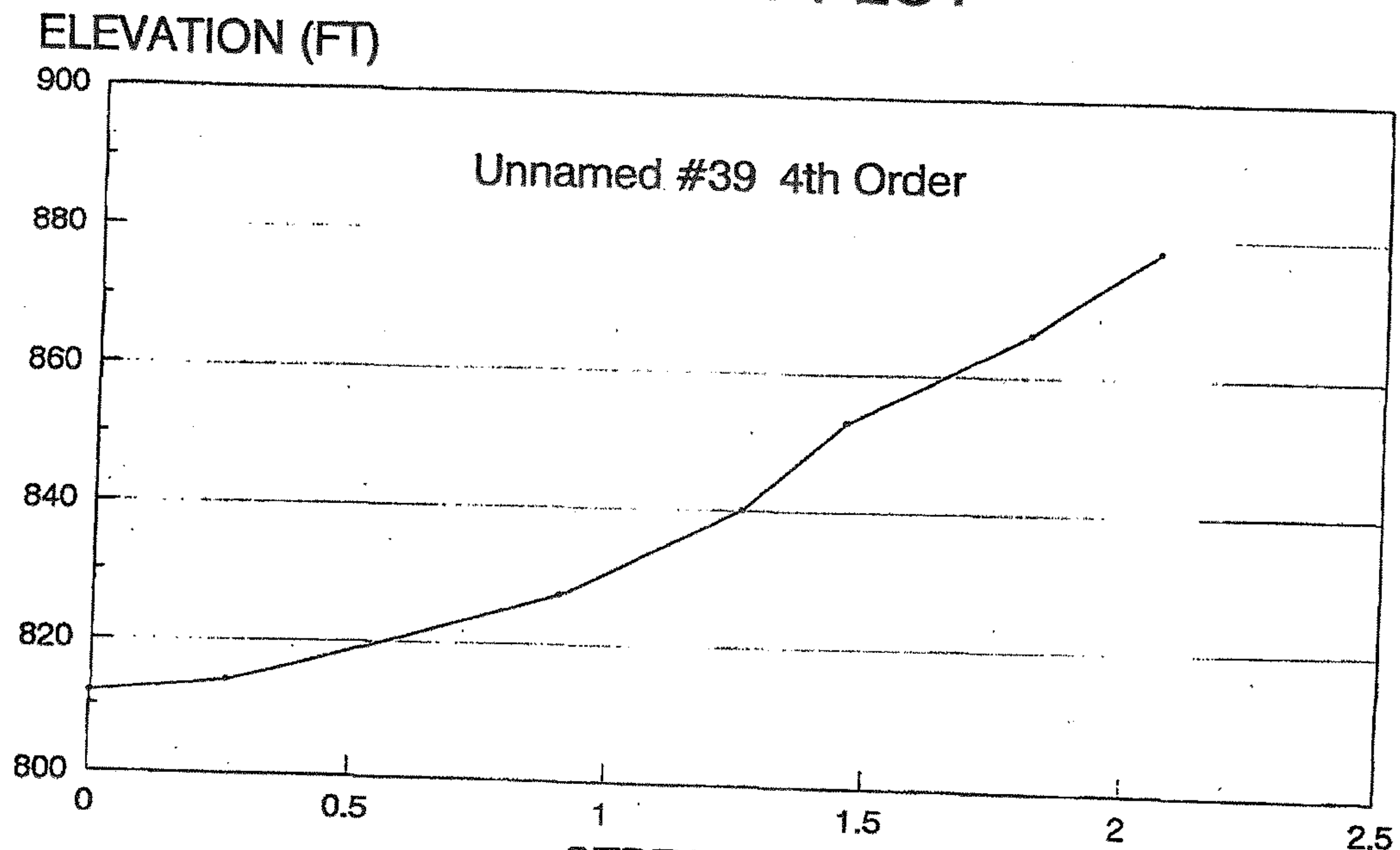

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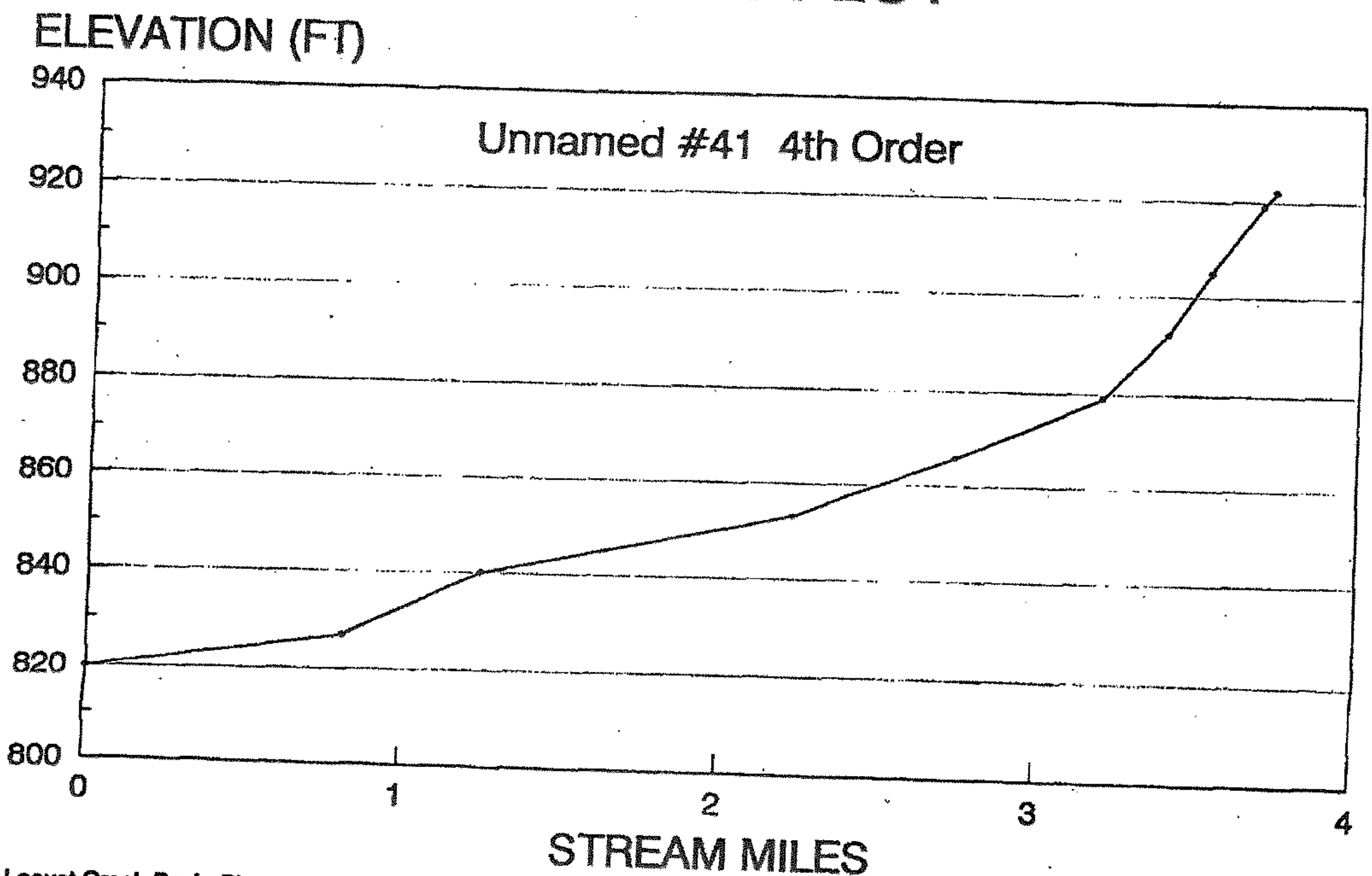

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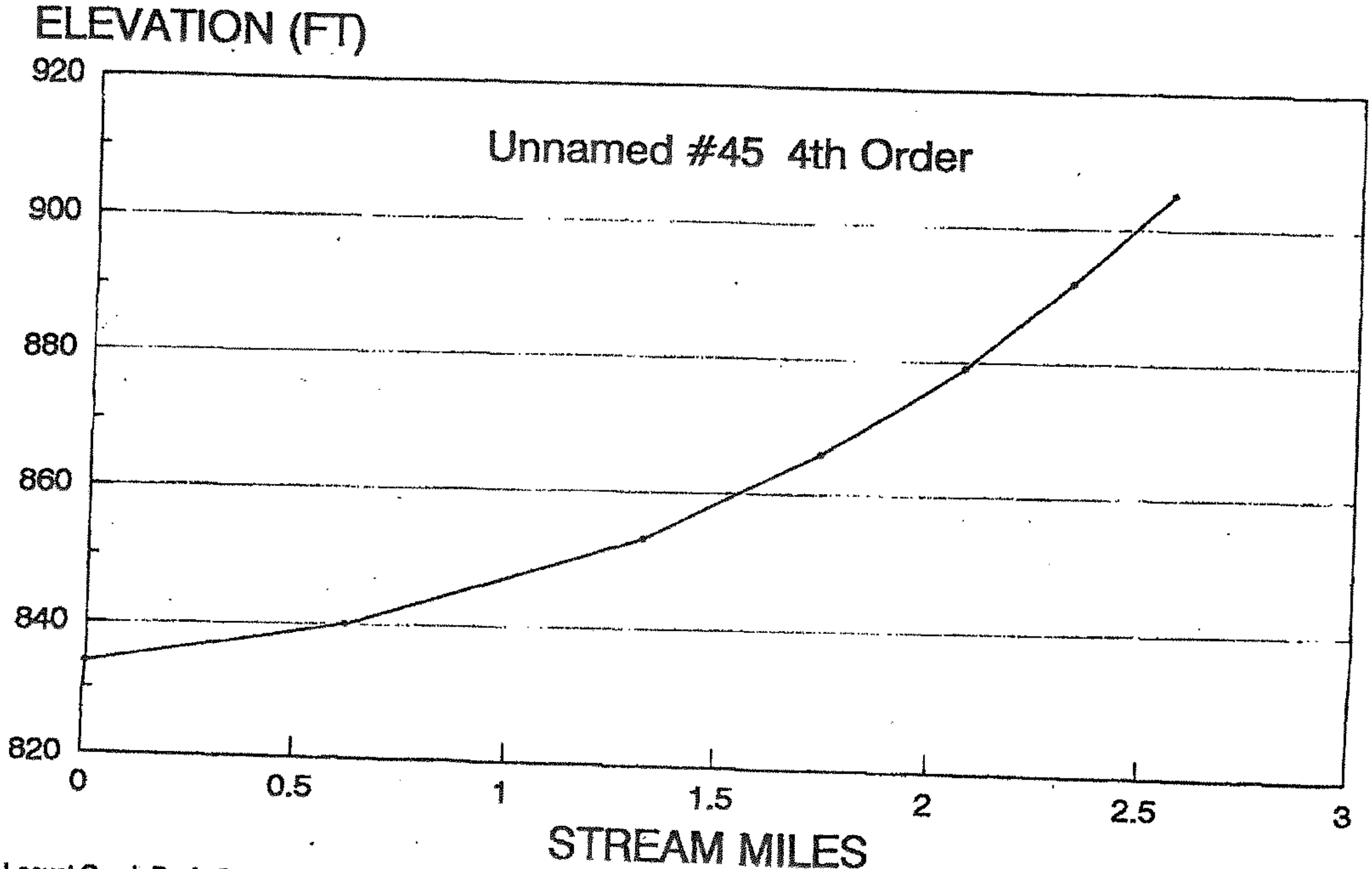

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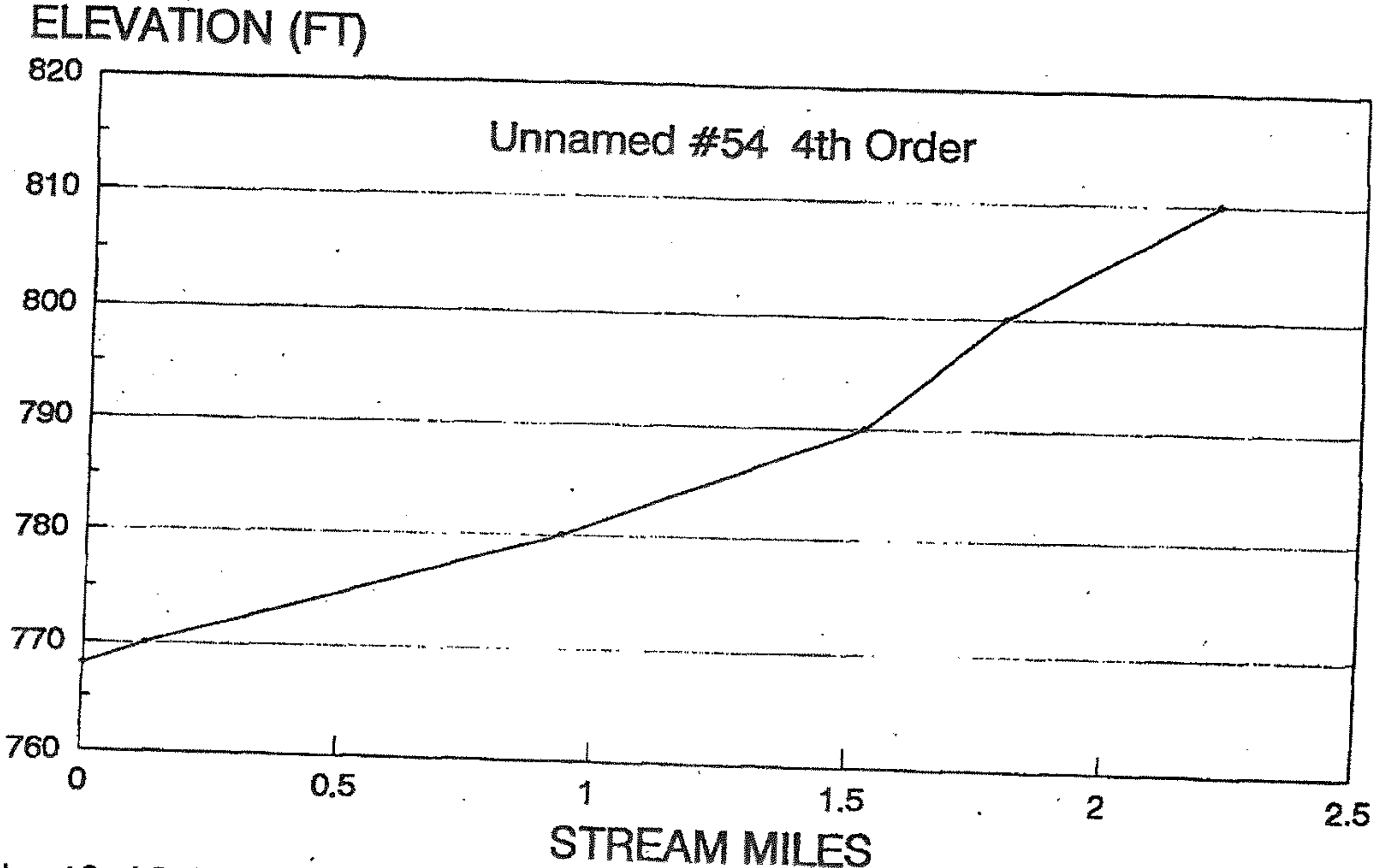

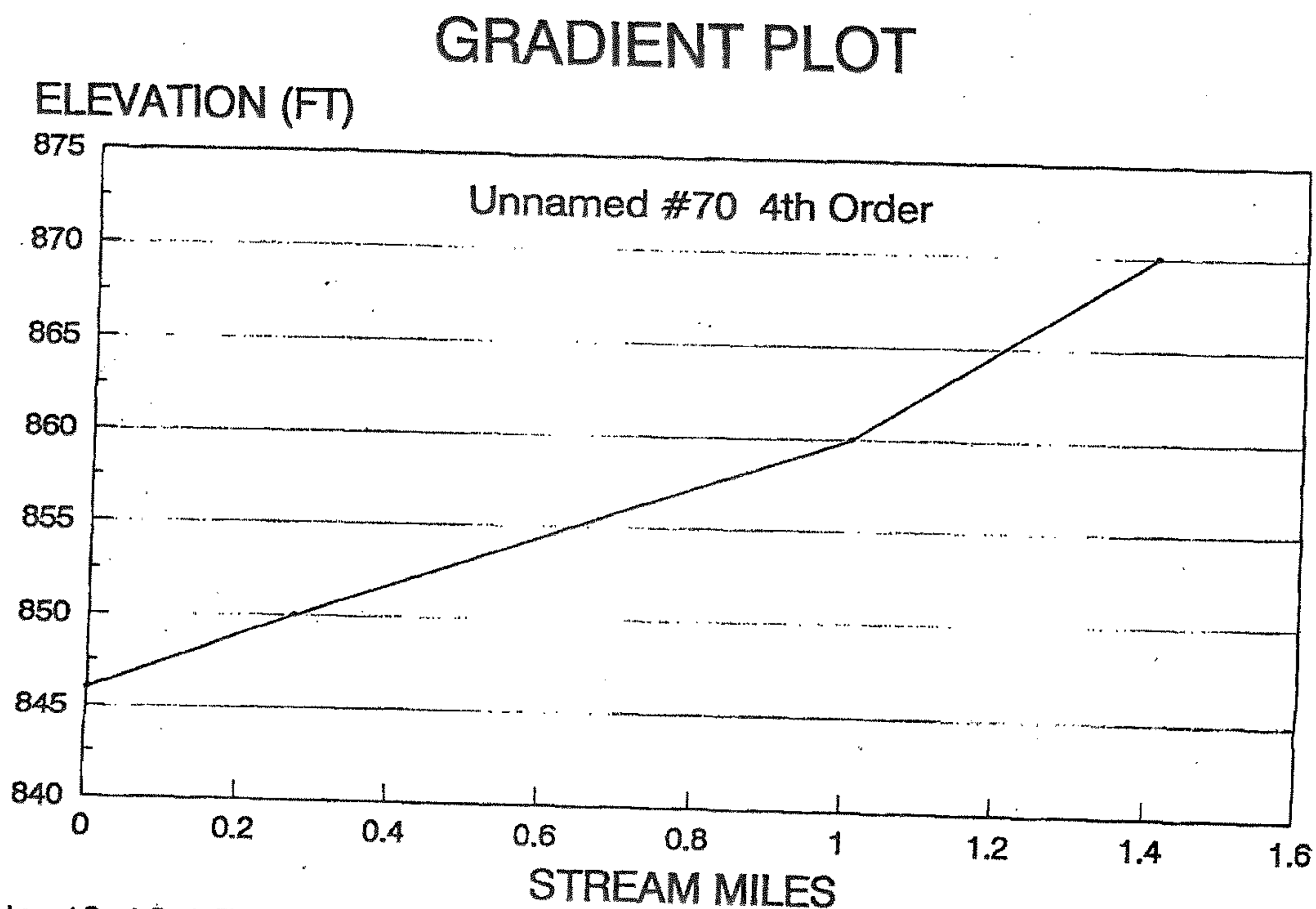

Locust Creek Basin Plan - 1991

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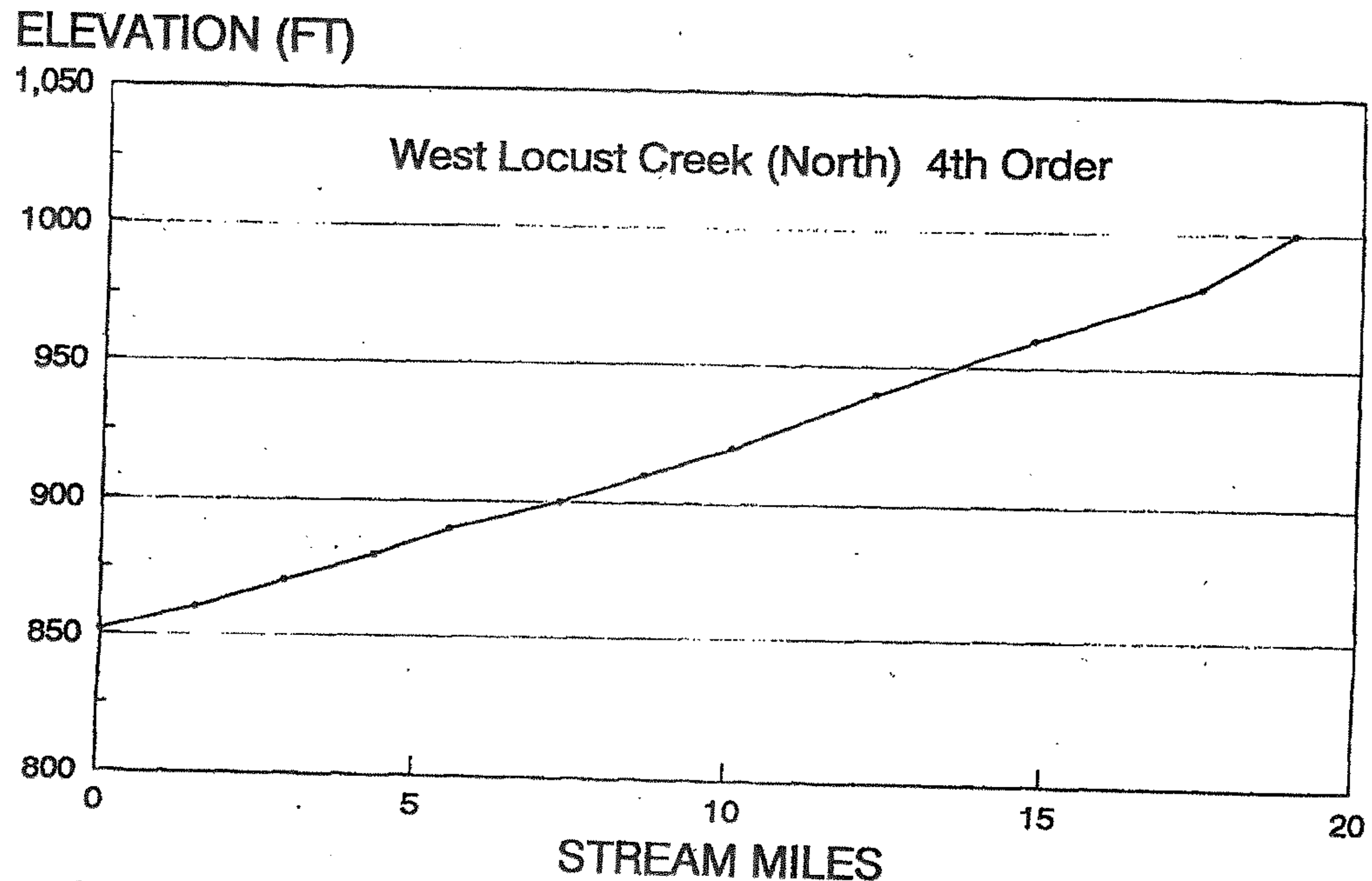

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Appendix 3. Habitat descriptions using SHAD for 1988 Locust Creek basin sampling sites. Letters represent a description of habitat parameter described on the following pages. Letters divided by a slash signify left/right bank descriptions. Abbreviation M.C. represents Muddy Creek. See habitat assessment portion of text for definitions of habitat categories (CN, CW, UN, UW) for sites.

	Site Name, Order, and Habitat Category																
SHAD Parameters	L.C. 7 CN	L.C. 7 CW	L.C. 7 UN	L.C 7 UW	L.C. 6 CN	W.L.C.S 6 UN	W.L.C.S 6 UW	L.C. 5 CN	W.L.C.S 5 CW	L.C. 5 UN	M.C. 5 UW	W.L.C.N 4 CN	L.C. 4 CW	E.L.C 4 UN	L.C. 4 UN	W.L.C.N 3 CN	N-N76 3 UN
Streambank Erosion	B	C	A/C	A	B	C	C	A	A	B	B	B	B	C	E	A	A
Streambank Protection	B	C	A/C	A	A	B	B	A	A	A	B	B	A	A/C	D	B	B
Width of Area	E	D/A	A/E	A	E	D	B	E	A	E/E	A	E	A	C	E	E	E
Minimum Corr. Width	D	D/A	A/D	A	E	E	B	C	A	D	A	D	A	D	E	C	D
Riparian Veg. Qual.	A	A	A/B	A	B	D	A	B	A	A	A	B	A	B/E	C	D	B
Riparian Land Use	B	A/C	A/C	A	C	C	A/B	B	A	C	A	C	A/C	B/C	C	C	A
Ave. Max Pool Depth	D	D	D	D	D	D	D	C	D	C	C	D	D	D	D	D	D
Instream Cover	C	A	A	A	C	C	B	B	B	C	C	C	C	B	C	C	C
Substrate Comp.	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Percent Embedded-ness	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
Water Quality	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Channel Alter-ations	C	B	A	A	C	A	B	C	B	A	A	B	B	A	A	B	A

Streambanks	A	B	C	D	E
Stream-bank Erosion	No unaccept-able erosion or bank caving; bank soil protected or soil type erosion resistant	Insignifi-cant small areas; mostly healed over; bank slightly eroding	Moderate in frequency and size; slumping and caving evident-erosion potential in all storm events; bank moderately eroding	Massive failings in isolated areas	Massive failings in most of the reach
Streambank Protection	Streambanks comprised of trees and shrubs indicative of a climax community; or otherwise controlled	Streambanks comprised of non-woody vegetation indicative of early stages of bank stabiliza-tion	Streambanks dominated by non-woody vegetation with sparse mature trees and shrubs insufficient to protect banks	Very sparse non-woody vegetation	None
Minimum Corridor Width	>100'	50'-100'	25'-50'	5'-25'	No corridor
Riparian Vegetation Quality	Riparian area composed of a dense stand of uneven aged trees and shrubs	Riparian area lacking trees; with thick shrubs and ground vegetation	Riparian area lacking trees and shrubs; but grass and weed cover with root systems capable of preventing flood scour	Riparian area bare of vegetation, used for row-crop production or with grass and weed cover having root systems incapable of preventing flood scour	
Riparian Land Use	Minimal Impact	Moderate Impact	Severe Impact		
Channel Condition					
Average Maximum Pool Depth	Order 1 - 3 4 - 5 $\geq$6	Average pool depth >3' >5' >10'	Average pool depth 1.5' - 3' 3' - 5' 5' - 10'	Average pool depth <1.5' <3' <5'	
Instream Cover	More than 60 root-wads, submerged logs or boulders >2' dia./mi	20-60 root-wads, submerged logs or boulders >2' dia./mi	1-20 rootwads, submerged logs or boulders >2' dia./mi	Reach has no instream cover	

Streambed Condition	A	B	C	D	E
Substrate Composition	% Boulder (≥ 12")	% Cobble (3"-11.9")	% Gravel (0.19"-2.9")	% Sand	% Silt
Embeddeness	>5%	5-25%	25-50%	50-75%	>75%
Water Quality	Water Quality rating based on observer's professional judgement				
Channel Alteration	No channelization; clearing or snagging; or channel paving	Channel alterations minor and impacts are minimal	Channel alterations are significant		