A SUMMARY OF WATER QUALITY FOR THE MENARD CREEK CORRIDOR UNIT, LANCE ROSIER UNIT AND LITTLE PINE ISLAND BAYOU CORRIDOR UNIT OF BIG THICKET NATIONAL PRESERVE, TEXAS 1975-1983

WATER RESOURCES REPORT NO. 86-8

WATER RESOURCES DIVISION
NATIONAL PARK SERVICE
COLORADO STATE UNIVERSITY
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by

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ABSTRACT

The Big Thicket National Preserve (BITH) in southeastern Texas contains diverse water resources, including the lower Neches River, several major streams and smaller tributaries, and extensive floodplain forest, baygall, and cypress sloughs. Present land-use activities within the watershed of BITH, such as oil and gas development, timber harvesting, and residential development, may adversely influence the quality of the water entering the preserve.

This report synthesizes available water quality information for three Management Units—the Menard Creek Corridor Unit, Lance Rosier Unit, and Little Pine Island Bayou Corridor Unit—in Big Thicket National Preserve. Water quality data in Pine Island Bayou upstream of BITH was also evaluated since Pine Island Bayou flows into the Little Pine Island Bayou Corridor Unit. It was observed that water quality in these units is moderately degraded. Elevated bacterial concentrations were frequently found in Menard Creek, Pine Island Bayou, and Little Pine Island Bayou. In addition, high specific conductance values and chloride concentrations were occasionally reported from stations located downstream from oil and gas operations.

Conditions observed during the 1970's and early 1980's can be established as a baseline to which results of current and future water quality monitoring may be compared. Physicochemical constituents, nutrient chemistry, bacteriological data, benthic macroinvertebrate diversity, and fish data were all considered in analyzing and establishing baseline conditions.

ACKNOWLEDGMENTS

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Finally, we would like to thank Doris Rust, who drafted the illustrations for this report and Sandy Wittler, who carefully typed the many drafts.

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INTRODUCTION

Big Thicket National Preserve (BITH) in southeastern Texas comprises 34,217 ha (84,550 acres) of mixed pine-hardwood forest, wetland pine savannah, floodplain hardwood forest, and cypress tupelo swamp. The preserve was set aside in 1974 in order to "assure the preservation, conservation, and protection of the natural, scenic, and recreational values of the Big Thicket area" (Public Law 93-439).

The preserve is composed of 12 distinct management units (Figure 1) located in portions of Hardin, Jasper, Jefferson, Liberty, Orange, Polk, and Tyler counties. The management units were selected to protect distinct areas that are representative of the ecological diversity of the Big Thicket region. The equally diverse water resources of the various units range from small tributaries to a major river. Developments within and surrounding the units influence the quality of water within the streams of the preserve.

The following land-use activities influence the water quality of BITH:

- oil and gas exploration and development in and adjacent to the preserve
- timber harvesting adjacent to several of the management units
- residential and recreational development, including subsequent production of sewage effluent along the periphery of the preserve

Elevated concentrations of suspended sediment, chlorides, coliform bacteria, nutrients, and turbidity in the water of the units downstream

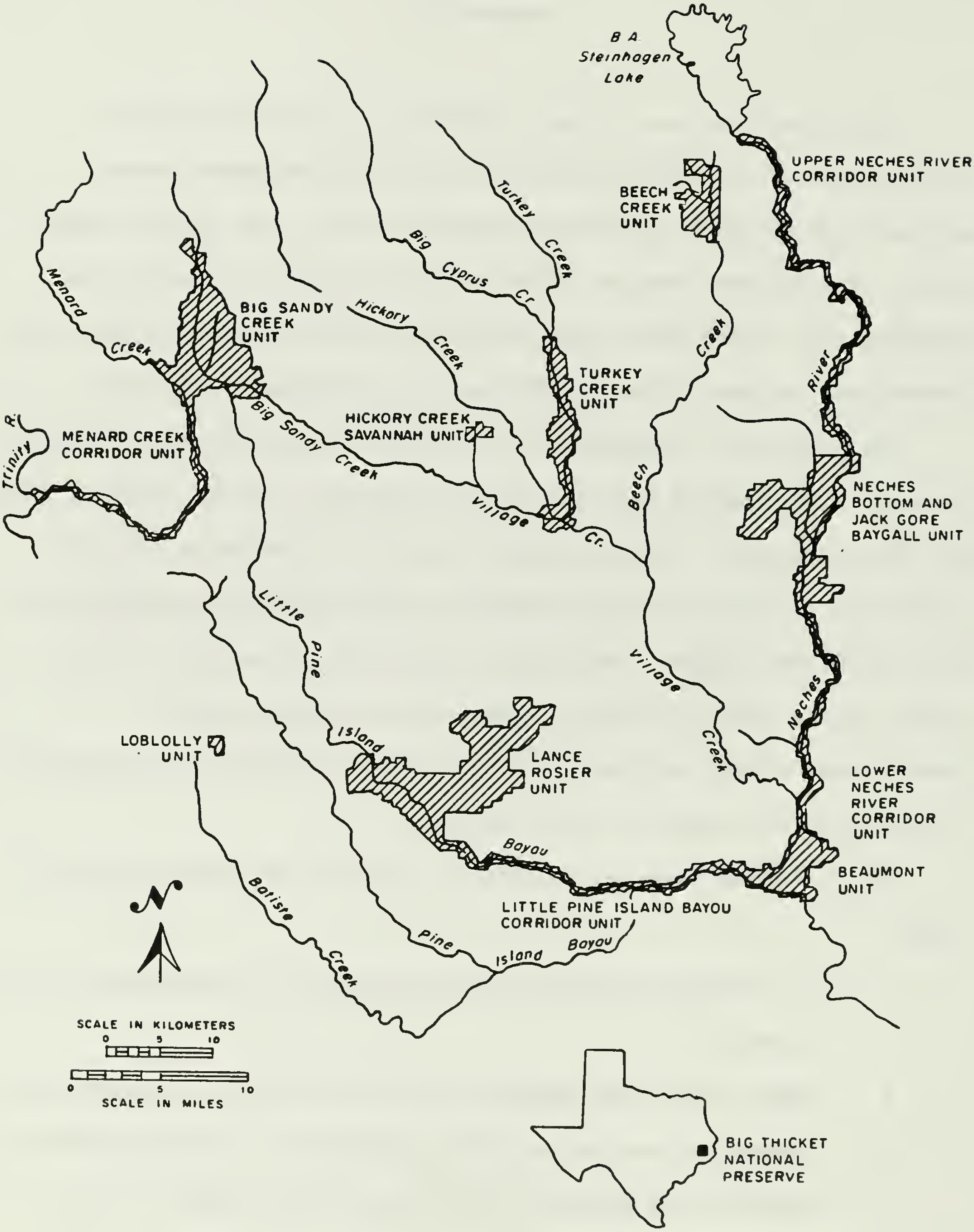


Figure 1. Management units of the Big Thicket National Preserve, Texas.

of these and other activities may lead to a subsequent decline in the ecological, aesthetic, and beneficial uses of the water.

To assess the effects of these activities on the water resources of BITH, a water quality monitoring program recommended by Flora (1984) was implemented by the Preserve staff in November of 1984. One of the components of this plan is the documentation and summarization of available water quality information gained from previous environmental studies in the preserve. Beginning in 1975, a number of water quality/aquatic biology studies were conducted in Big Thicket National Preserve by Dr. Richard Harrel and students from Lamar University (see Harrel and Watson, 1975; Harrel, 1976; Harrel, 1977; Kost, 1977; Darville, 1978; Harrel and Darville, 1978; Bass, 1979; Harrel and Bass, 1979; Harrel and Commander, 1980; Harrel and Newberry, 1981) with a number of other researchers providing specific information on regional hydrology, fish populations, and bacterial contamination.

Although of limited duration, these previous studies provide the resource management specialist with important information regarding the baseline water quality conditions in Big Thicket National Preserve during the 1970's and 1980's. Studies for the Big Sandy Creek, Beech Creek, and Turkey Creek management units of Big Thicket National Preserve were summarized in a report by Flora et al. (1985). Streams in these units displayed relatively good water quality.

This paper summarizes water quality conditions in the Menard Creek Corridor Unit, Little Pine Island Bayou Corridor Unit and Lance Rosier Unit within Big Thicket National Preserve. The streams in this report are impacted more seriously by the human activities mentioned previously.

Water quality information is presented for each of these three units individually, allowing a unit-by-unit comparison of data. Data from studies corresponding to a particular unit is summarized for each water quality parameter. Physicochemical water quality parameters considered in this report include water temperature, dissolved oxygen, pH, alkalinity, turbidity, color, specific conductance, chlorides and total iron. Nutrient chemistry data, includes orthophosphate, ammonium, and nitrate. When available discharge data is sufficient, relationships between water quality constituent concentration and discharge are discussed.

Biological data, including information on bacteriological contamination, macroinvertebrates, and fish populations are also included. No attempts are made to use population indices in the interpretation of the biological data unless this was done in the original study.

Physiography, Geology, and Climate

Big Thicket National Preserve is located on the geologically young coastal plain of southeast Texas. Surface formations were deposited by streams as alluvial plains and deltas during interglacial periods of the Pleistocene and Holocene epochs (USDI, 1976). The upper part of the preserve is hilly and well-drained and is separated by the Hockley scarp from the low, flat, and poorly drained areas of the lower preserve.

The oldest formations occur in the upper Big Thicket area and include the Willis formation, which was laid down in the Pliocene epoch. The youngest formations occur in the lower Big Thicket area and include the Bentley, Montgomery, and Beaumont formations.

Soil development generally reflects differences in geology and drainage conditions within the preserve. Soils are predominantly well-drained sandy loams in the upper BITH area, noncalcareous loams with iron oxide concretions in the central BITH area, and clayey and poorly drained soils in the lower BITH area (USDI, 1976).

Because the preserve is located within 75 miles of the upper Texas Coast and the prevailing winds are southeasterly, the climate is strongly influenced by maritime air masses brought in from the Gulf of Mexico. As a result, hurricanes, tropical storms, and thunderstorms are common. During the winter and spring months, the weather is affected by continental air masses entering the area that are driven by frontal cyclones moving west to east across the U.S. (Trenchard, 1977). The majority of the rainfall occurs in the spring and summer months. Summers in the preserve are generally warm and humid with abundant rainfall provided by thunderstorms. Frequent flooding along the Neches and Trinity Rivers and their major tributaries maintains the floodplain vegetation along the bottomlands of these streams and rivers.

MENARD CREEK CORRIDOR UNIT

General Description

The Menard Creek Corridor Unit comprises 1530 ha (3780 acres) in portions of Polk, Hardin, and Liberty counties of southeastern Texas (Figure 2). Menard Creek originates in central Polk county and flows approximately 77 kilometers (48 miles) before emptying into the Trinity River. Menard Creek enters the Menard Creek Corridor Unit of Big Thicket National Preserve upstream of State Highway 943. While all the other units of BITH drain into the Neches River, Menard Creek is the only major stream of Big Thicket National Preserve located within the Trinity River Basin.

The upper 30 kilometers (19 miles) of Menard Creek flows through private land, where land uses include residential development, and extensive timber harvesting. Likewise, private lands bordering the corridor unit include residential areas that use septic tank systems and timber harvesting areas. The timber harvesting method most commonly used in the region is clear cutting, where all the vegetation is removed. Greater sediment loads and higher flood peaks result from this practice. Another water quality concern is Schwab oil field, which is located within the Mill Creek drainage basin, a tributary of Menard Creek (Bass, 1979). At the time of publication, approximately ten pumping wells were in operation at Schwab oil field. To transmit the oil field products, three oil and gas pipelines pass through the Menard Creek Corridor Unit. The average gradient for Menard Creek is 1.3 m/km (2.6 ft/mile) from its headwaters to its confluence with the Trinity River.

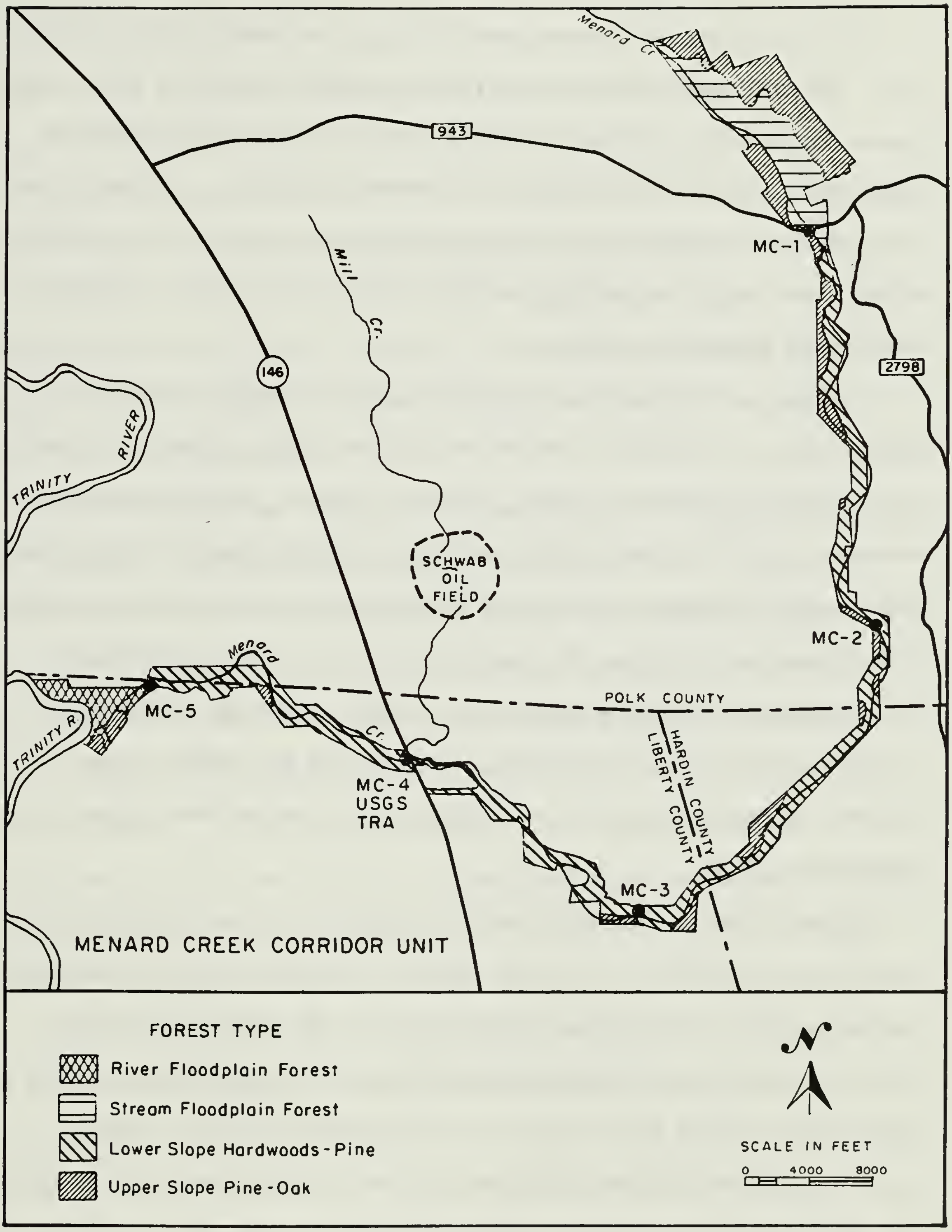


Figure 2. Vegetation map of Menard Creek Corridor Unit with historic sampling sites. Adapted from USDI (1976).

Of the sixteen soil types identified in the Menard Creek Corridor Unit, fifty six percent are classified as either Hatliff or Bibb sandy loams. These soils characteristically are located along bottomlands adjacent to stream channels and are frequently flooded. Although they have moderate to moderately rapid permeability, severe septic tank use restrictions exist for Hatliff and Bibb soils due to their continual wetness and flooding problems.

Located on the higher slopes and ridges of Menard Creek are the Bowie, Briley, and Rentzel series soils. The Briley loamy fine sands are found on 1-5 percent slopes, are well drained, and are moderately permeable. Both the Bowie fine sandy loam and the Rentzel loamy fine sand occupy 0-3 percent slopes and display moderately slow permeability. Severe restrictions exist for septic tank use for Bowie and Rentzel soils because of the slow percolation rates. Also, an impermeable plinthite layer found in Bowie fine sandy loams may inhibit water movement through these soils and can create a perched water table (Deshotels, 1978).

Figure 2 shows the four dominant vegetation types located in the Menard Creek Corridor Unit (USDI, 1976). Located along the streamsides in the northern part of the Corridor Unit is the stream floodplain forest. Beech and sweetgum dominate the overstory vegetation, which also includes black gum, basket oak, and loblolly pine as common species. The upper slope pine-oak forests grow on drier upper slopes and small ridge tops and are characteristically composed of red oak and both loblolly and shortleaf pines. The Menard Creek Corridor Unit's most abundant forest type is the lower slope hardwood-pine forest, which occupies gentle to steep slopes near streams. Beech, white oak, loblolly pine, and southern magnolia characterize the overstory in this forest type. Vegetation associations found near the confluence of Menard Creek with the Trinity River are the river floodplain forests. The following three categories of river floodplain forests are found on Menard Creek: 1) slough forests, characterized by cypress and water tupelo trees, 2) willow-oak flats, which support only willow and oaks in poorly drained areas, and 3) baygalls, which occur in poorly drained seepage areas and support osmunda and royal ferns as the dominant understory vegetation (USDI, 1976).

The U.S. Geological Survey (USGS) has been monitoring stream discharge and water quality on Menard Creek since 1965. Figure 2 locates USGS Station No. 08066300, which also corresponds to the water quality monitoring sites of the Trinity River Authority (TRA 800.003) and Bass (MC-4). Peak discharges occur during the early winter and spring months, while lower flows are generally present in the summer months (Figure 3). The month of March is relatively dry due to decreasing activity from both the winter frontal storm systems and the more intense summer rains, resulting in a pronounced dip in the annual hydrograph for Menard Creek (Tenchard, 1977).

Low- and high-flow periods were determined from the hydrograph data and used in this report to analyze discharge/water quality parameter relationships in two flow categories. The high-flow period is December through May, and the period of low flow extends from June through November. Although great variability exists, high-flow periods generally average above 125 cfs, while average discharge for the low flow months is generally well below 125 cfs.

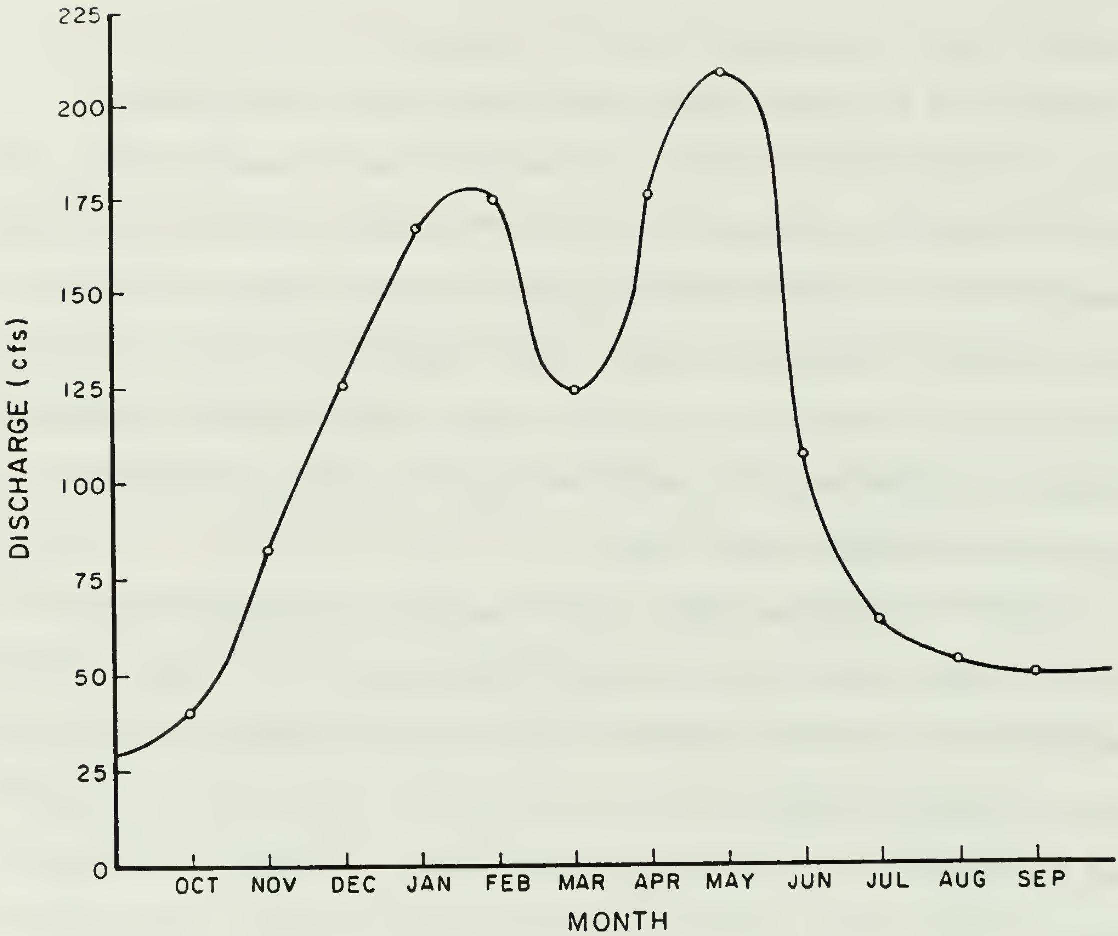


Figure 3. Average monthly discharge rates for USGS station 08066300 at Menard Creek (1965-1983).

The maximum daily discharge event (1965-1983) was 274 m^3/sec (9,660 ft^3/sec) and the minimum daily discharge for this period was 0.074 m^3/sec (2.6 ft^3/sec) (USGS, 1965-1983). Discharge and water quality parameters may be affected at station MC-4 by water flowing in from Mill Creek, which includes Schwab oil field within the Mill Creek drainage basin. Water quality parameters from station MC-5 may be influenced by water backing up from the Trinity River during low-flow periods (Harrel, 1976, 1977).

Previous Studies

Both the U.S. Geological Survey and the Trinity River Authority (TRA) have conducted regular surveys of water quality in Menard Creek. The USGS has monitored water discharge and physicochemical parameters in Menard Creek since 1965. The TRA records of water quality extend from July 1975 to April 1982. Both agencies sampled near the Hwy 146 bridge, which approximates the location of site MC-4 used by Harrel and his students.

Harrel established five sites on Menard Creek during his water quality reconnaissance studies in Big Thicket National Preserve (Harrel, 1976, 1977). These sites were subsequently used in the studies by Harrel and Darville (1978) and Bass (1979). Data from Harrel's five sites will be used to indicate longitudinal trends along Menard Creek, while TRA and USGS data will be used to look for long-term trends. Suttkus and Clemmer (1979) provided information on the fish populations within the unit. Site locations and stream-bottom substrate descriptions are given in Table 1. Specific sampling periods and the constituents sampled are given in Figure 4.

Water Quality Analysis

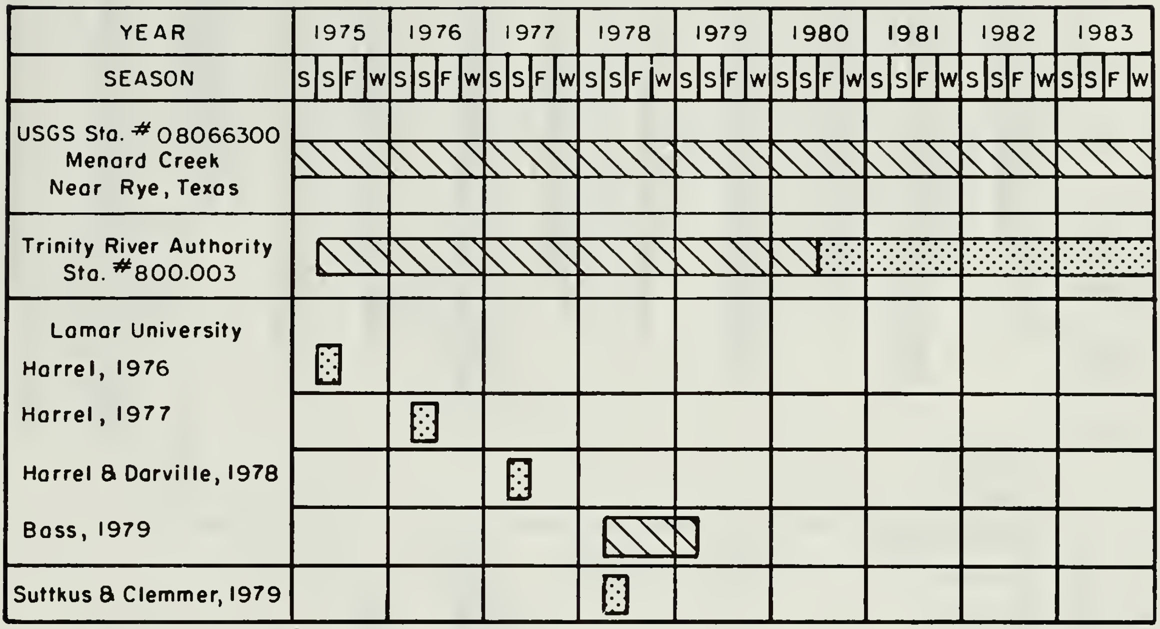
Physicochemical constituents. Water temperature, dissolved oxygen, pH, and alkalinity are consistent with levels expected in southeastern Texas surface waters and are similar to those observed in the Big Sandy Creek Unit adjacent to the Menard Creek Corridor Unit (Flora et al., 1985). Figure 5 depicts seasonal profiles of temperature and dissolved oxygen in Menard Creek. Water at sites MC-1, MC-3, and MC-4 appears

Table 1. Location and description of stream-bottom substrate at sampling sites in the Menard Creek Corridor Unit (from Bass, 1979).

Site	Location	Substrate
MC-1	on Menard Creek 30 m downstream from FR 943 Bridge west of Segno	gravel with same sand silt, and plant debris
MC-2	on Menard Creek 40 m downstream from bridge on Holly Grove Cemetary Road off FR 2798	sand and plant debris
MC-3	on Menard Creek 100 m downstream from bridge on Fuqua-Hoop 'N Holler Road off Hwy 105-787	sand and plant debris
MC-4	on Menard Creek under Hwy 146 bridge	coarse gravel with small particles of sand or silt
MC-5	on Menard Creek 30-50 m downstream from Hwy 2610 bridge	clay, gravel, sand, and silt

consistently warmer during the summer months than at the other two stations, but no other trends are apparent in either of the parameters.

Figures 6 and 7 show the range of pH and alkalinity values at each station observed during the study by Bass (1979). No seasonal trends were detected. Station MC-5, however, appears to have slightly higher pH and alkalinity values than the other stations. This might be attributed to the channel cutting into the more calcareous substrate nearer the Trinity River (Harrel, 1977). Median pH values at the five Menard Creek sampling sites vary from 5.5 (MC-2) to 6.1 (MC-5) (Figure 6). The low median value at MC-2 falls below the Texas state minimum standard of 6.0 pH units for section 0802. Alkalinity concentrations are also low, ranging from 5 mg/L to 27 mg/L. The lowest median concentration of 12 mg/L was recorded at MC-4. This station is



Parameters Measured

US Geological Survey (WATSTORE)
- Physicochemical Parameters

Trinity River Authority
- Physicochemical Parameters
- Bacteriological Parameters (occasionally)

Harrel, 1976
- Physicochemical Parameters

Harrel, 1977
- Physicochemical Parameters

Harrel and Darville, 1978
- Physicochemical Parameters
- Bacteriological Parameters
- Bass, 1979
- Physicochemical Parameters
- Bacteriological Parameters
- Macrobenthic Parameters (occasionally)

Suttkus and Clemmer, 1979
- Fish Survey

Menard Creek Corridor Units

- Monthly Samples
- Occasional Samples

Figure 4. Sampling periods and parameters measured in the Menard Creek Corridor unit.

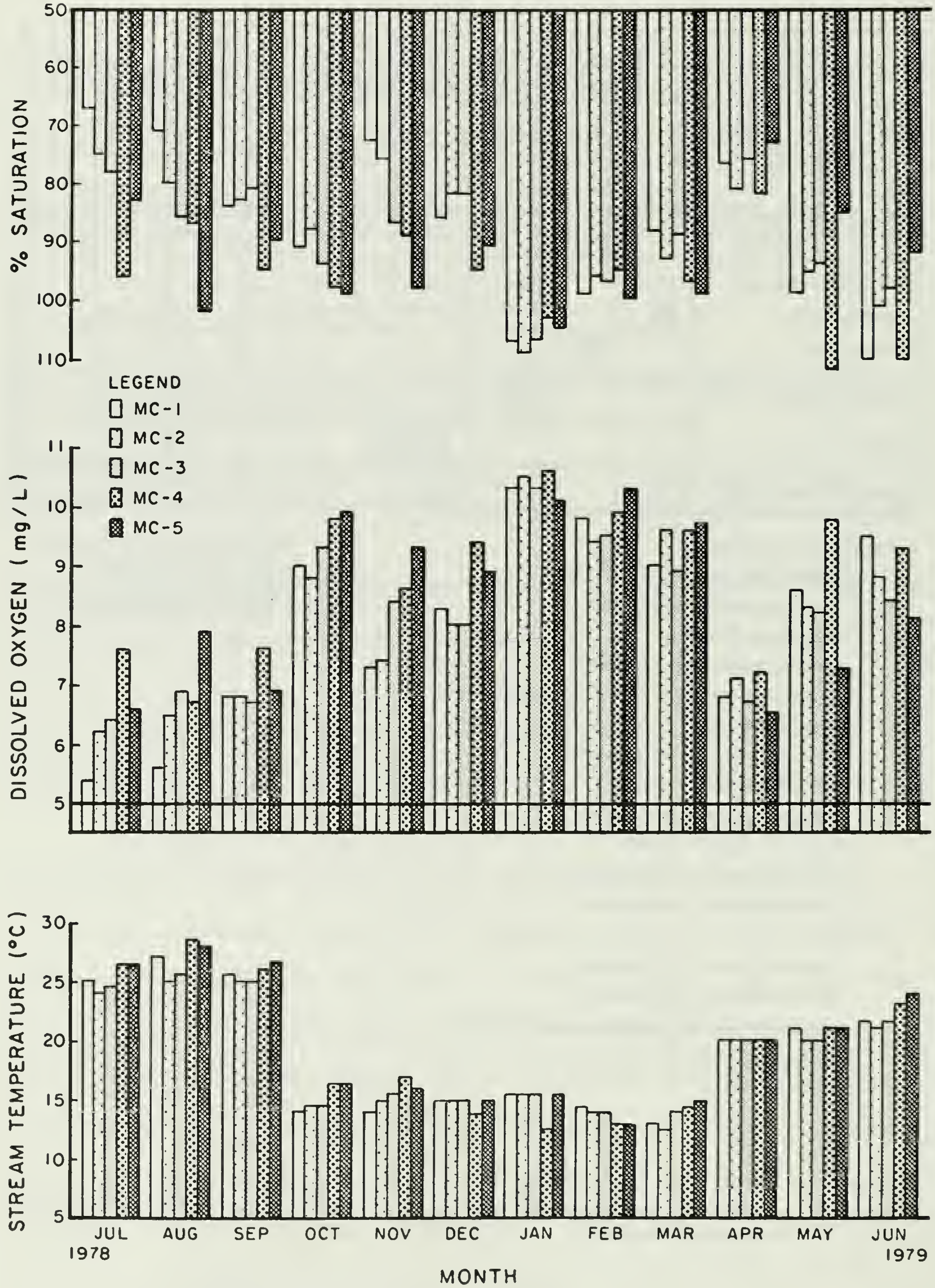


Figure 5. Seasonal profile of dissolved oxygen concentrations, percent oxygen saturations and stream temperatures (1978-1979) for the five sampling sites in the Menard Creek Corridor Unit. Data taken from Bass (1979). Heavy line denotes dissolved oxygen standard for segment 0802.

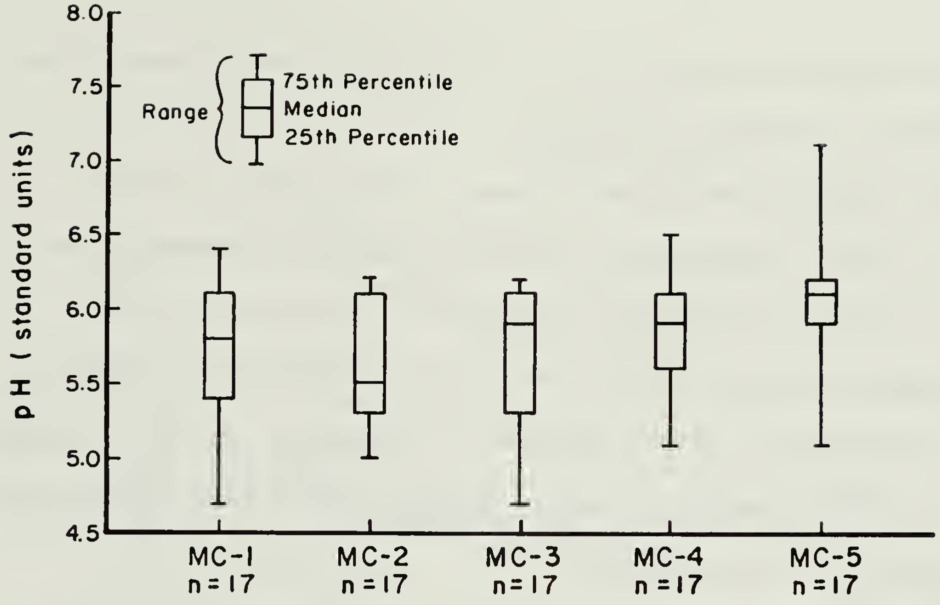


Figure 6. Median and range of pH levels for sampling sites in the Menard Creek Corridor Unit (1975-1979). Data taken from Harrel (1976, 1977), Harrel and Darville (1978), and Bass (1979).

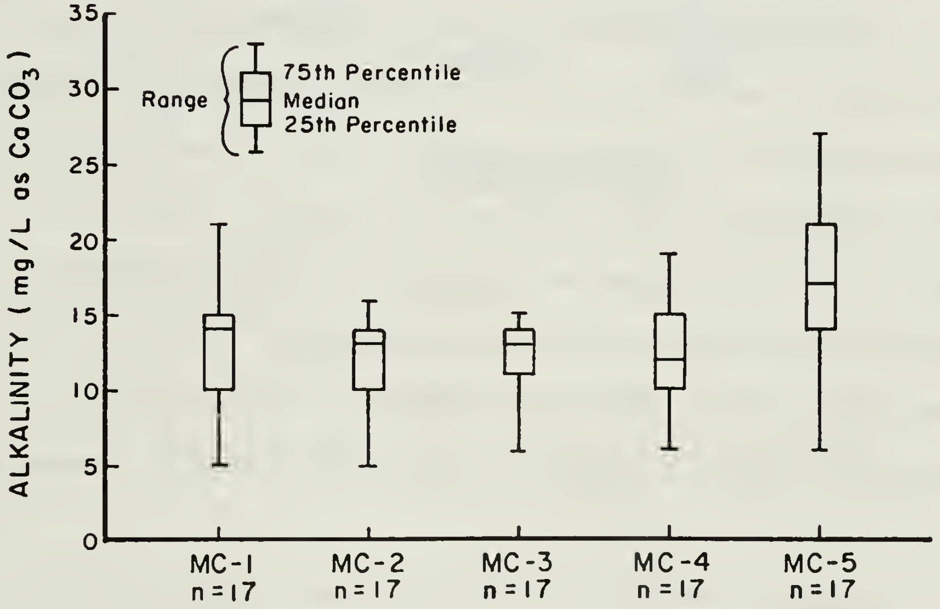


Figure 7. Median and range of alkalinity concentrations for sampling sites in the Menard Creek Corridor Unit (1975-1979). Data taken from Harrel (1976, 1977), Harrel and Darville (1978), and Bass (1979).

immediately downstream of the Mill Creek tributary, which drains the area containing the Schwab oil field.

Both turbidity and color of Menard Creek waters correlate strongly with flow, with higher turbidities and more intense color occurring during the higher flows (Figure 8). Turbidity values resembled those observed in the other units of the preserve and show no seasonal or downstream trends. Waters are moderately colored in Menard Creek ($\bar{x}$ = 163 color units), probably because of the large amounts of humic substances in these waters.

Although specific conductance and chloride concentrations at stations MC-1, MC-2, and MC-3 are lower than those observed at other sites in the preserve, concentrations greatly increased at stations MC-4 and MC-5 (Figures 9 and 10). A tributary that drains the Schwab oil field flows into Menard Creek downstream of station MC-3; brines from produced water impoundments may be leaching or overflowing into this tributary, thereby causing elevated chloride concentrations. Figure 11 shows that specific conductance values detected by Bass (1979) highly correlate with observed chloride levels (r^2 = 0.906), and this increase in chloride concentration might explain the increase in specific conductance. As would be expected, specific conductance and total dissolved solids (TDS) are also highly correlated (r^2 = 0.964) at MC-3. Using these relationships, total dissolved solids and chloride concentrations at these sites can be estimated from specific conductance readings.

Total iron concentrations in Menard Creek (Figure 12) were higher than commonly found ($\bar{x}$ = 1.36 mg/L), as aerated natural surface waters tend to have iron concentrations less than 0.5 mg/L (McNeely et

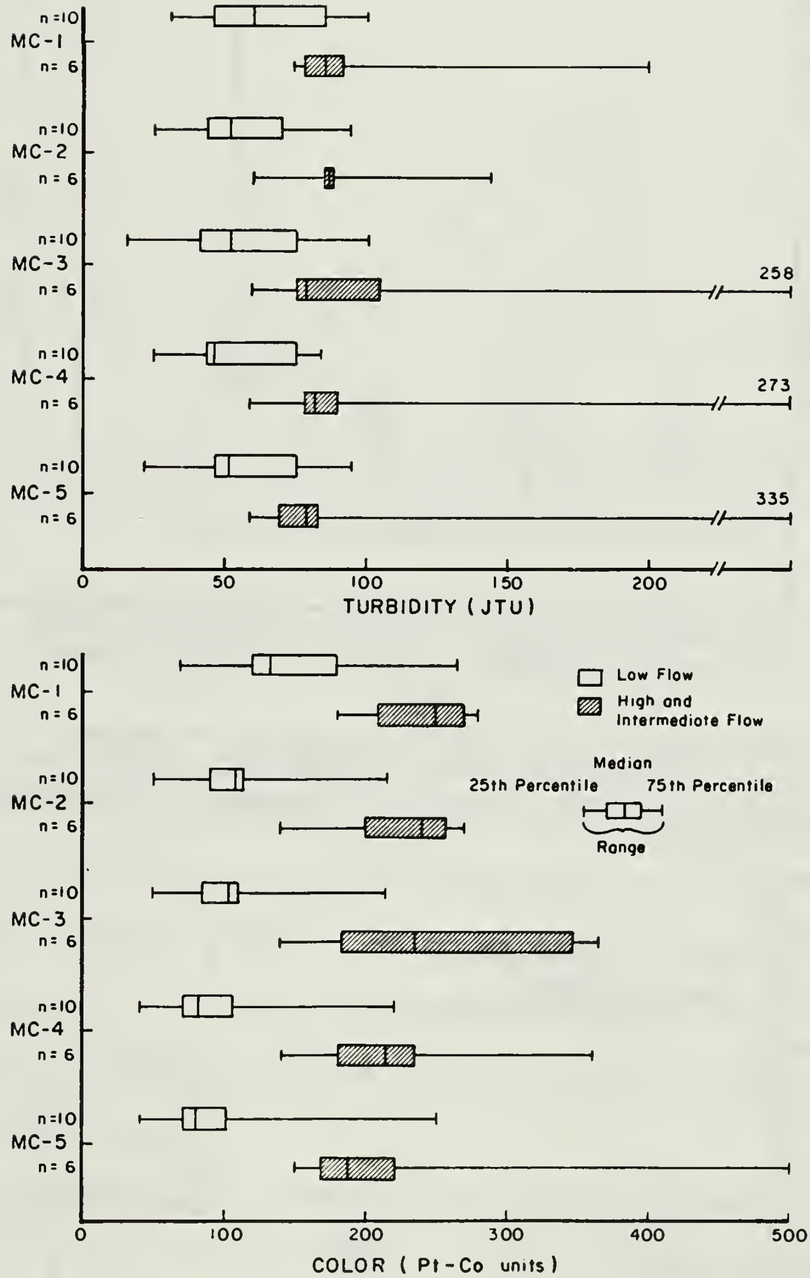


Figure 8. Low flow/high flow turbidity and color ranges for five sampling sites in the Menard Creek Corridor Unit (1975-1979). Data taken from Harrel (1976, 1977), Harrel and Darville (1978), and Bass (1979).

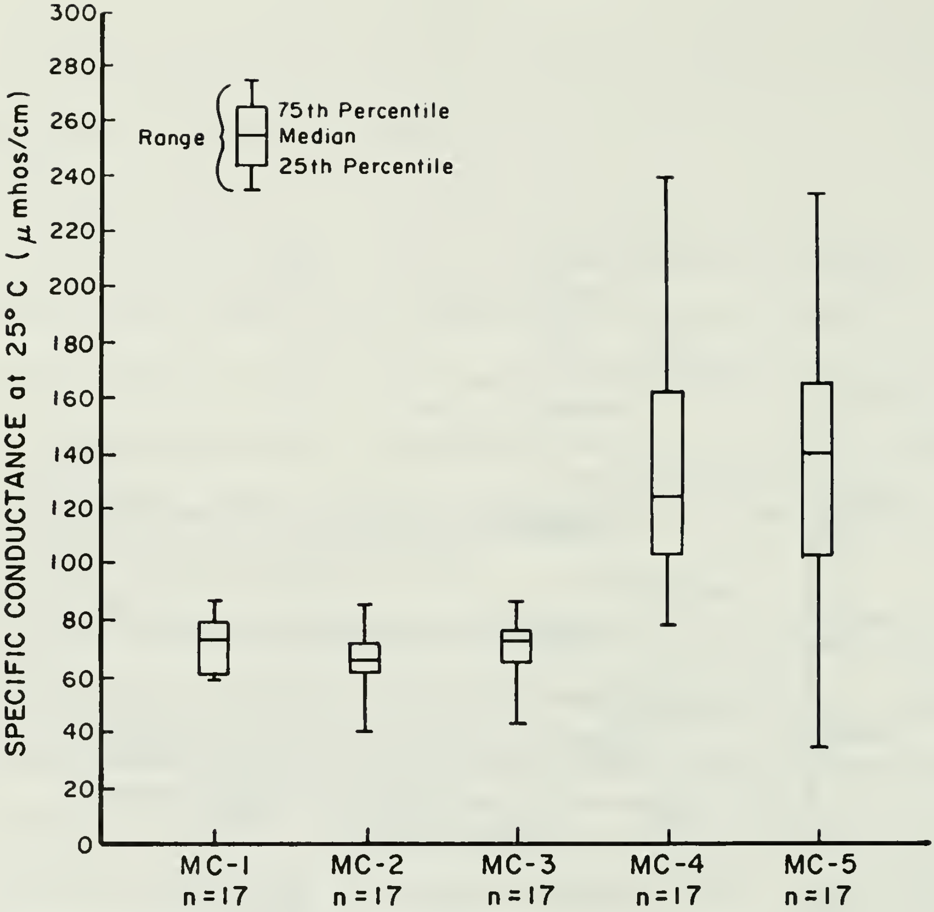


Figure 9. Median and range of specific conductance values for sampling sites in the Menard Creek Corridor Unit (1975-1979). Data taken from Harrel (1976, 1977), Harrel and Darville (1978), and Bass (1979).

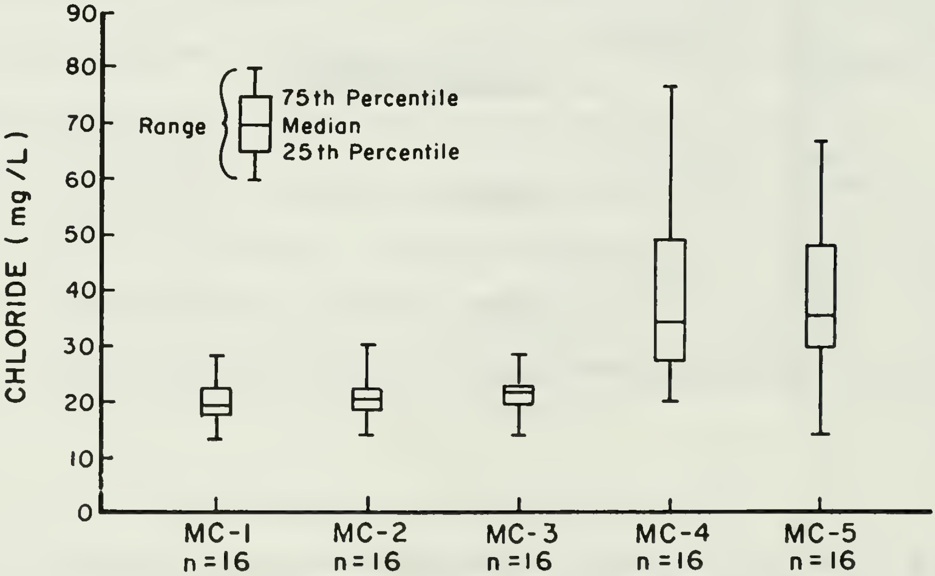


Figure 10. Median and range of chloride concentrations for sampling sites in the Menard Creek Corridor Unit (1975-1979). Data taken from Harrel (1976, 1977), Harrel and Darville (1978), and Bass (1979).

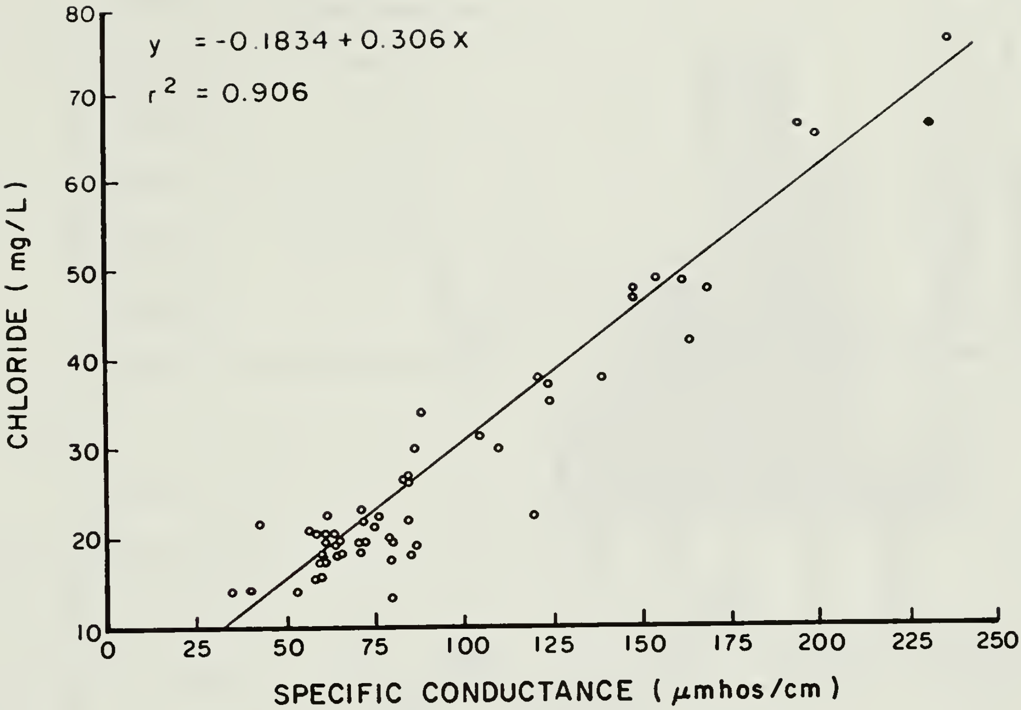


Figure 11. Relationship between chlorides and specific conductance values at USGS Station No. 08066300 (1975-1983).

al., 1979). However, iron concentrations can be affected by many factors, including a watershed's geology, soils, and ground-water chemistry. Data on total iron concentrations in the other Big Thicket units, while sketchy, indicate fairly high levels throughout the rest of the preserve as well. Although no conclusions can be made based on the available data, slightly elevated iron concentrations may be normal for the Big Thicket area.

Nutrient Chemistry. Although orthophosphate concentrations in Menard Creek are not as high as those observed in Big Sandy Creek, they are still higher than levels generally found in undisturbed watersheds of southeastern Texas (Flora et al., 1985). Mean concentrations for all five stations were similar, ranging from 0.28 mg/L at MC-5 to 0.41 mg/L at MC-4. As shown in Figure 13, orthophosphate concentrations at

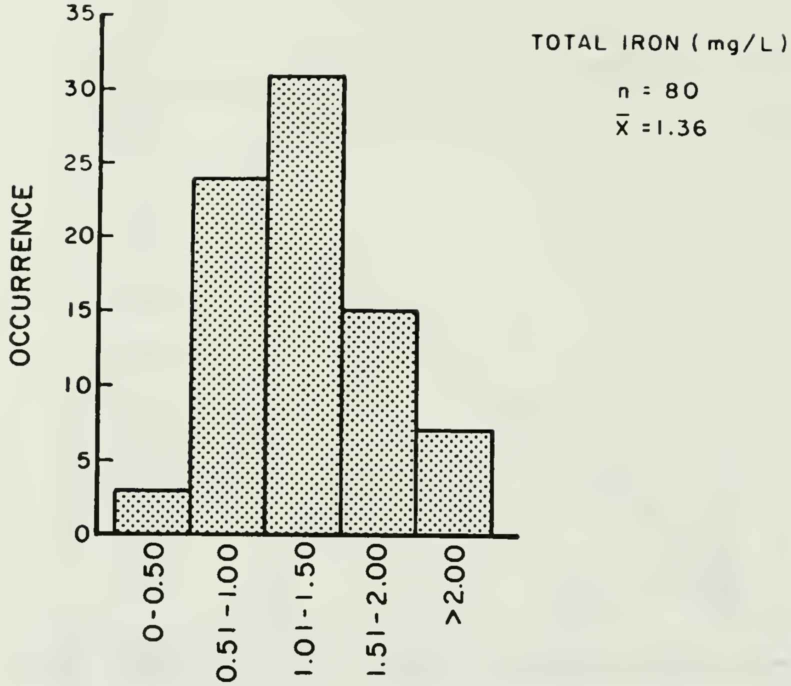


Figure 12. Frequency of occurrence of total iron concentrations for samples from the Menard Creek Corridor Unit (1975-1979). Data taken from Harrel (1976, 1977), Harrel and Darville (1978), and Bass (1979).

station MC-4 are greatest during high flow conditions in February. The greatest difference in orthophosphate concentrations between MC-1 and MC-4 occurred during the winter months, when values at MC-4 were sometimes double the values at MC-1.

Nitrate-nitrogen levels in Menard Creek, although higher than those in Big Sandy Creek, appear to be normal for the area ($\bar{x}$ of all stations combined = 0.005 mg/L). Nitrate concentrations seem to decrease with an increase in discharge (Figure 13), and are fairly consistent at all stations.

Ammonium-nitrogen concentrations reported by Bass (1979), although higher than normally found in many undisturbed watersheds, reflect those observed in other Big Thicket Units (Flora et al., 1985) ($\bar{x}$ of all

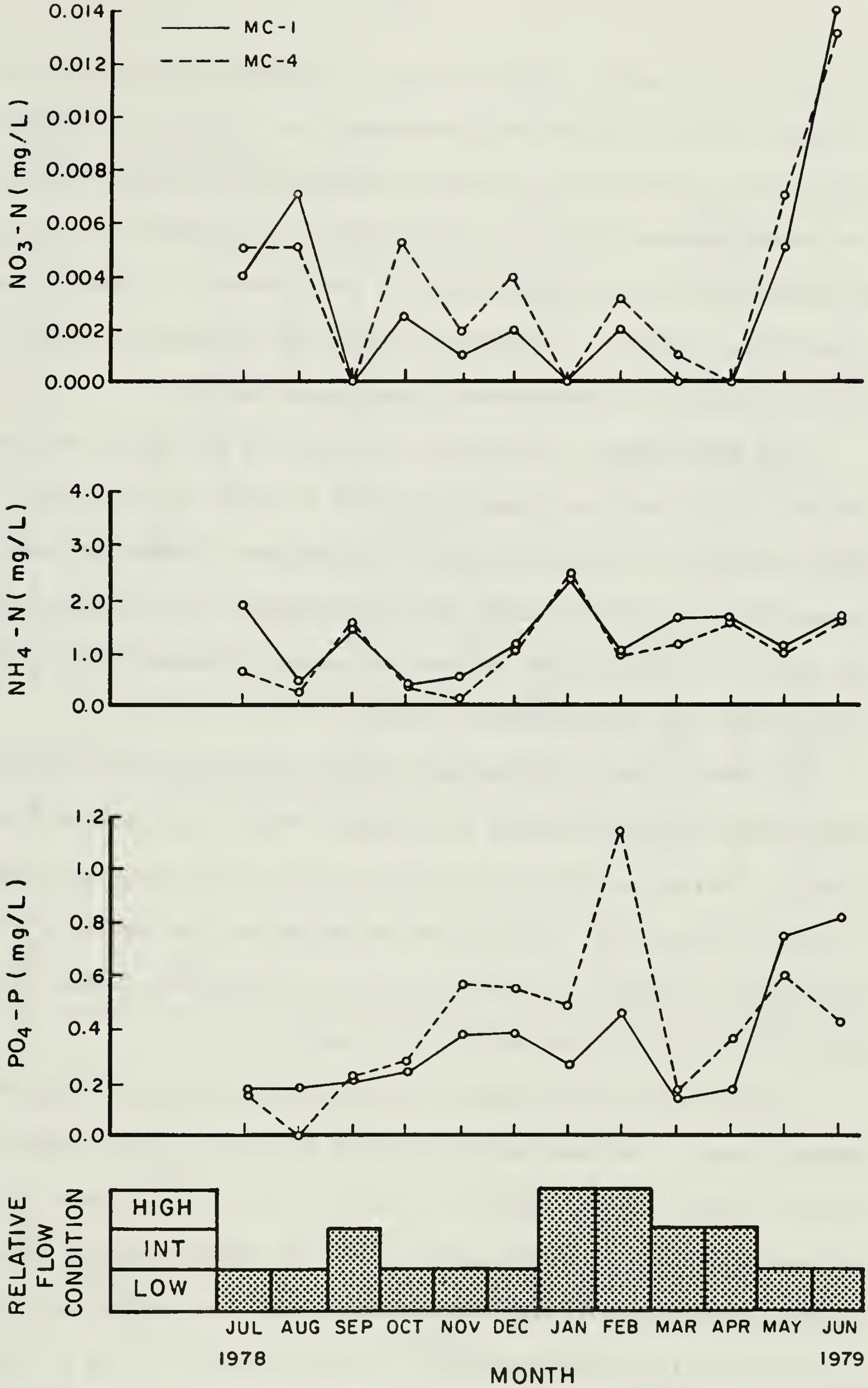


Figure 13. Seasonal relationship of discharge and NO_3-N, NH_4-N, and PO_4-P for two selected sampling sites in the Menard Creek Corridor Unit (1978-1979). Data taken from Bass (1979).

stations = 1.14 mg/L). Unlike nitrate, concentrations of ammonium-nitrogen tend to increase with increased flow (Figure 13), indicating that surface runoff may be influencing ammonium-nitrogen loading into the creek upstream of MC-1. Concentrations are similar at MC-4 and MC-1, indicating that ammonium is fairly conservative in these waters. No significant seasonal or downstream trends were noticed for either nitrate-nitrogen or ammonium-nitrogen concentrations.

Long-Term Trends. Using data collected by the USGS (1965-1983) and the TRA (n.d.) (data collected from 1975 to 1982) for site MC-4, physicochemical and nutrient concentrations were summarized over time. As mentioned previously, each year was divided into two flow regimes. The low-flow period begins in June and ends in November, while the high-flow period runs from December to May.

All mean values of dissolved oxygen concentrations are above the Texas state minimum standard for segment 0802 of the Trinity River, Tidal to Livingston Dam (Texas Department of Water Resources, 1981) of 5.0 mg/L (Figure 14). On only one occasion did a DO value fall below the minimum standard: in June of 1981, an individual sample yielded a dissolved oxygen concentration of 4.2 mg/L.

Figure 15 compares values of pH observed by the USGS and TRA in Menard Creek. The Texas state standard for pH in segment 0802 of the Trinity River allows a range of from 6.0 to 8.5. Both data sets have median values within this standard, with the USGS reporting a median reading of 6.3 and TRA reporting a median of 6.6. Occasionally pH values for this station drop below the lower limit of the standard (6.0), but Flora et al. (1985) have shown this also occurs infrequently in other streams of Big Thicket.

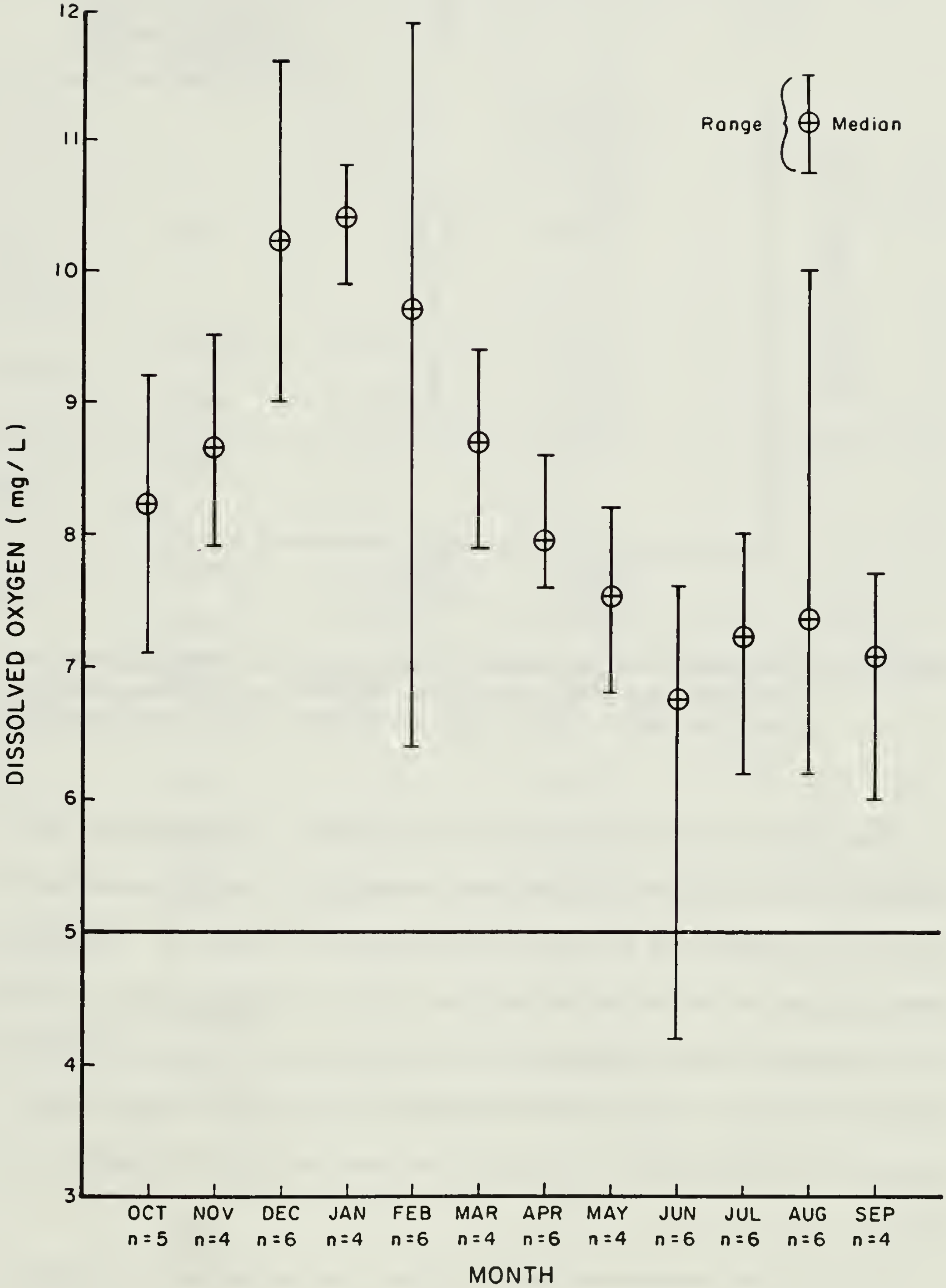


Figure 14. Seasonal profile of dissolved oxygen concentrations for the TRA sampling site in the Menard Creek Corridor Unit (1975-1982). Data taken from TRA (n.d.). Heavy line denotes disscLved oxygen standard for segment 0802.

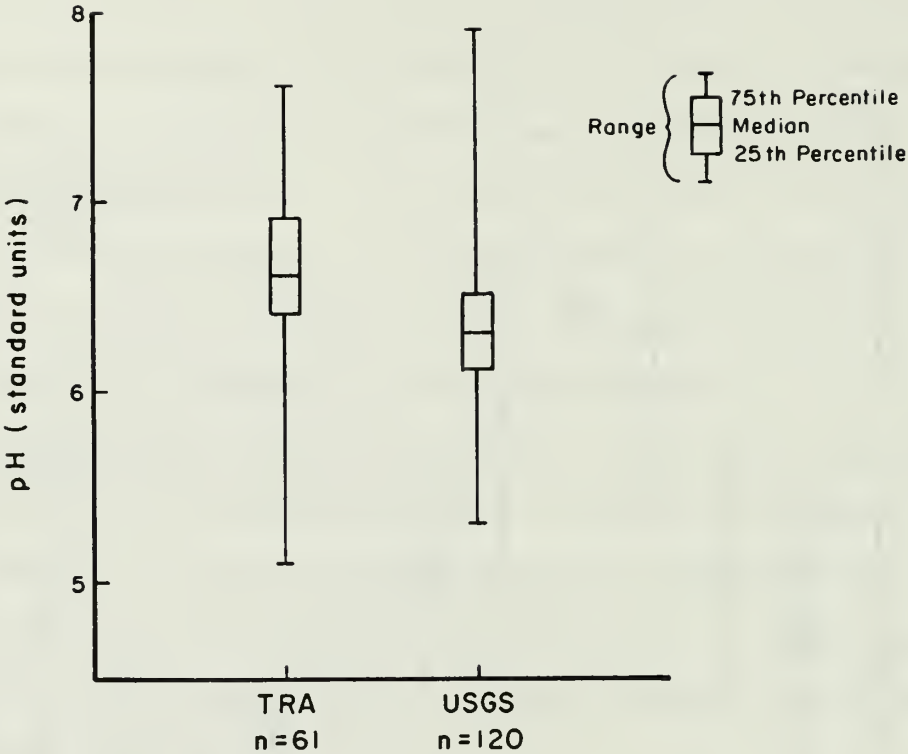


Figure 15. Comparison of pH values observed by the USGS Station No. 08066300 and TRA Station No. 800.003 in the Menard Creek Corridor Unit. Data taken from USGS (1965-1983) and TRA (n.d.).

Mean levels of total dissolved solids (TDS), conductivity, and hardness are all below state maximum standards, although occasional individual samples had very high concentrations (Table 2). Table 3 summarizes major cation concentrations found in Menard Creek. As might be anticipated, the cation concentrations decrease with an increase in stream discharge. Sodium concentrations seem slightly higher than expected, possibly due to contamination from oil field brines in the water.

Major anion concentrations are quite low throughout the Menard Creek Corridor Unit (Table 4). Chloride and alkalinity concentrations decreased from low- to high-flow periods while sulfate and fluorides increased. A report by Wright et al. (1957) noted that chlorides and

Table 2. Statistical information for total dissolved solids, specific conductance (at 25°C), and hardness for high- and low-flow periods in the Menard Creek Corridor Unit. Data taken from USGS (1965-1983) and TRA (n.d.).

Source and Flow Condition		Total Dissolved Solids (mg/L)	Specific Conductivity at 25°C (μmhos/cm)	Hardness (mg/L as $CaCO_3$)
USGS (1965-1983) Low flow	Mean	132.0	243.4	33.6
	N	73	76	76
	Std dev	104.4	213.4	24.8
	Range	34-579	49-1150	11-134
USGS (1965-1983) High flow	Mean	83.4	165.3	26.1
	N	74	79	79
	Std dev	46.3	111.2	13.0
	Range	37-275	50-557	11-72
TRA (1975-1982) Low flow	Mean	125.9	140.6	32.9
	N	31	31	26
	Std dev	41.3	60.6	40.2
	Range	72-229	48-288	8-200
TRA (1975-1982) High Flow	Mean	102.7	106.9	25.2
	N	27	30	28
	Std dev	21.9	36.5	18.4
	Range	25-131	30-172	1-86

Table 3. Statistical information for major cations for high- and low-flow periods in the Menard Creek Corridor Unit. Data taken from USGS (1965-1983).

Source and Flow Condition		Na (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)
USGS (1965-1983) Low flow	Mean	27.9	10.8	1.35	2.06
	N	52[1]	73	47[2]	73
	Std dev	30.11	7.84	0.46	1.13
	Range	4.9-165	3.4-44	0.7-3.3	0.6-6.2
USGS (1965-1983) High flow	Mean	16.4	7.3	1.13	1.56
	N	54[1]	75	47[2]	75
	Std dev	12.84	3.54	0.25	0.72
	Range	4.6-57.0	3.5-22.0	0.8-1.9	0.5-4.2

[1] No record for Sodium from 1970 through 1973.
[2] No record for Potassium from 1968, 1970 through 1973.

sulfates were often found in oil brines, and periods of increased rainfall and runoff from oil-producing areas could increase chloride and sulfate concentrations in the stream. Both sulfates and chlorides fall below the state maximum standards that are established for Trinity River Segment 0802 (chlorides not to exceed 125 mg/L and sulfates not to exceed 100 mg/L). During the early years of the USGS water quality studies, concentrations for many of the constituents were very high. These high concentrations may be explained by the recent enforcement of regulations regarding discharges from oil fields. A common practice up until the mid 1970s was to drain the oil brine pits into streams during flood events.

Fewer data exist for the nutrient concentrations shown in Table 5. Concentrations of nitrate-nitrogen (NO_3-N), ammonium-nitrogen (NH_4-N),

Table 4. Statistical information for major anions for high- and low-flow periods in the Menard Creek Corridor Unit. Data taken from USGS (1965-1983) and TRA (n.d.).

Source and Flow Condition		Cl (mg/L)	SO_4 (mg/L)	Alkalinity (mg/L as $CaCO_3$)	F (mg/L)
USGS (1965-1983) Low flow	Mean	62.6	3.66	10.2	0.04
	N	76	73	13[1]	69
	Std dev	64.0	3.65	3.42	0.05
	Range	9.2-345	0-8.5	2-15	0-0.2
USGS (1965-1983) High flow	Mean	38.7	4.15	8.8	0.06
	N	78	74	13[1]	69
	Std dev	33.78	2.40	2.52	0.08
	Range	7.5-160	0.2-9.8	3-12	0-0.4
TRA (1975-1982) Low flow	Mean	37.1	4.9	18.6	N/R
	N	31	18	31	N/R
	Std dev	18.71	3.28	19.6	N/R
	Range	12-89	1-12	10-120	N/R
TRA (1975-1982) High flow	Mean	25.8	11.5	12.2	N/R
	N	30	15	31	N/R
	Std dev	8.16	8.25	4.78	N/R
	Range	9.5-43.5	1-32	4-24	N/R

N/R - No Record
[1]Alkalinity recorded from 1981 through 1983.

Table 5. Statistical information for nutrient data for high- and low-flow periods in the Menard Creek Corridor Unit. Data taken from USGS (1965-1983) and TRA (n.d.).

Source and Flow Condition		NO_3-N (mg/L)	NH_4-N (mg/L)	PO_4-P (mg/L)
USGS (1965-1983) Low flow	Mean	0.2	N/R	N/R
	N	37[1]	N/R	N/R
	Std dev	0.37	N/R	N/R
	Range	0-1.3	N/R	N/R
USGS (1965-1983) High flow	Mean	0.19	N/R	N/R
	N	35[1]	N/R	N/R
	Std dev	0.21	N/R	N/R
	Range	0-0.9	N/R	N/R
TRA (1975-1982) Low flow	Mean	0.14	0.34	0.05
	N	28	28	27
	Std dev	0.20	0.23	0.17
	Range	0.03-1.1	0.03-0.7	0-0.9
TRA (1975-1982) High flow	Mean	0.17	0.33	0.04
	N	29	27	31
	Std dev	0.16	0.28	0.03
	Range	0.02-0.72	0.01-1.12	0.01-0.1

N/R - No Record
[1]Data recorded from 1965 through 1974.

and orthophosphate (PO_4-P) do not appear to respond to changes in discharge. The concentrations reported by TRA (n.d.) and USGS (1965-1983) were generally lower than those reported by Bass (1979).

Biological Sampling. Bacterial contamination appears to be a problem in Menard Creek. During 1978-1979, fecal coliform concentrations consistently exceeded state standards for contact recreation (Figure 16). State and federal EPA standards for fecal coliform bacteria state that coliform samples should not exceed a log mean of 200 colonies/100 ml based on a minimum of 5 samples taken over a 30-day peiod, nor should more than 10 percent of the total samples taken during a 30-day period exceed 400 colonies/100 ml (Texas Department of Water Resources, 1981 and U.S. Environmental Protection Agency, 1976).

Unlike the Big Thicket units previously reported (Flora et al., 1985), fecal coliform levels tended to be higher than fecal streptococci levels; the fecal coliform to fecal streptococcus ratio (FC/FS) averaged over 7.4 when all sites were combined. An FC/FS ratio greater than 4 suggests that the primary source of fecal bacteria is due to human contamination, while on FC/FS ratio less than 0.7 indicates animal wastes are the primary source of bacteria (Geldreich, 1966). Caution, however, must be exercised when using the FC/FS ratio. Due to die off rates of the streptococcus and coliform bacteria, the point of origin of the fecal contamination must be known in order to accurately employ the FC/FS ratio. Without knowing the source areas the results obtained from the FC/FS ratio may not be valid.

The highest numbers of fecal bacteria were seen after heavy rainfalls, indicating that surface runoff could be largely responsible for the high bacterial numbers. Inadequate septic absorption fields

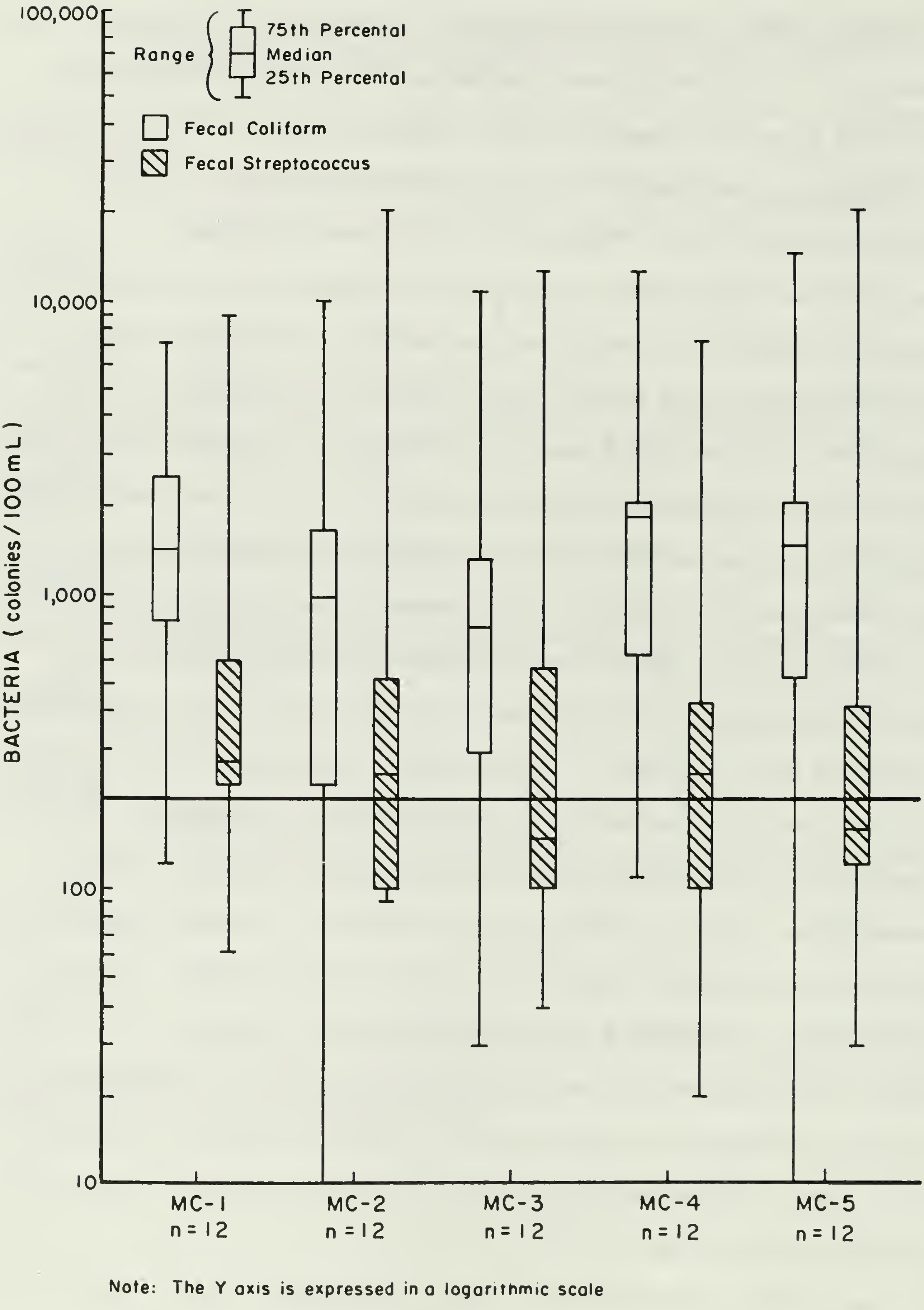


Figure 16. A profile of fecal coliform and fecal streptococcus bacterial counts for five sampling sites on the Menard Creek Corridor Unit (1978-1979). Data taken from Bass (1979). Heavy line denotes fecal coliform standard for contact recreation for segment 0802.

surrounding Menard Creek are a likely source of elevated bacterial levels in the creek. The slightly raised levels of ammonium-nitrogen also indicate septic field runoff. However, elevated levels of nitrate-nitrogen would be expected as well, and these were not observed.

A total of 125 taxa of macroinvertebrates were collected and identified from all sampling sites in the Menard Creek Corridor Unit. Annually, either the segmented worms (Oligochaeta) or the true flies (Diptera) dominated each station (Figure 17). On a seasonal basis, however, species diversity and composition were closely related to stream discharge. Diversity at all stations was lowest in March when water discharge had been high for the previous two months. High water flows probably supress diversity by scouring the streambed and by increasing turbidity and total suspended solids in the water (Bass, 1979).

Shannon-Weaver diversity values are lower for Menard Creek than for Big Sandy Creek or Beech Creek, but are slightly higher than Turkey Creek. Bass (1979), however, found that the macroinvertebrate populations of Menard Creek comprised large numbers of pollution-intolerant taxa and are similar to those of Beech Creek and Village Creek. This indicates that the lower diversity value for Menard Creek is more closely related to high discharge than to poor water quality.

Suttkus and Clemmer (1979) conducted one sampling in Menard Creek during their fish survey of the Big Thicket National Preserve. Of the twenty-nine species of fish collected, they found two species of sucker, ten species of minnow, two species of catfish, two species of killifish, one species of livebearers, eight species of sunfish, and four species of perch.

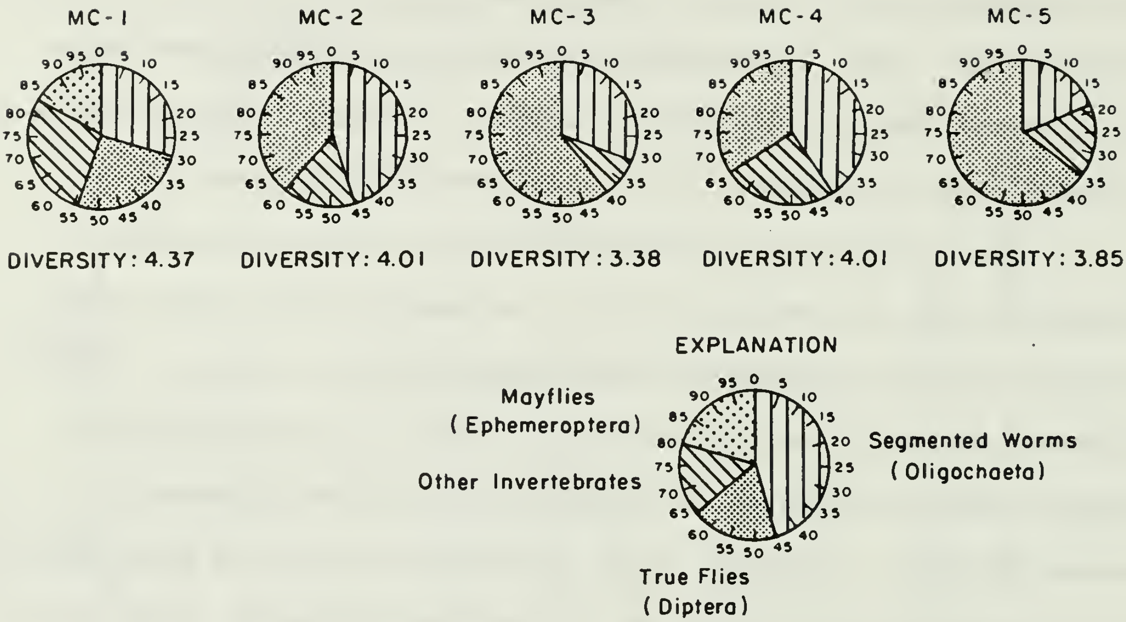


Figure 17. Annual percent distribution of aquatic macroinvertebrates and Shannon-Weaver diversity values for sampling sites in the Menard Creek Corridor Unit (1978-1979). Data taken from Bass (1979).

Conclusions

Most of the water quality parameters assessed in Menard Creek were well within the range considered to be normal for natural streams in southeastern Texas. Water temperatures are high in the summer, but lower than the maximum standard of 32.2°C (90°F) prescribed as a state standard for another local stream, Village Creek. Dissolved oxygen levels nearly always met the state standard of 5.0 mg/L and are high enough to support a diverse and healthy aquatic life, although increases in residential developments and the accompanying waste load may lead to future problems. Variability of oxygen levels is probably due to seasonal temperature variation rather than any significant organic pollution in Menard Creek.

Fairly low pH and alkalinity values can be expected in Menard Creek due to the somewhat acidic soils in the watershed and the influence of dissolved organic acids in the stream. The slight increase in pH and alkalinity at MC-5 can be attributed to changes in streambed geology. The moderately colored waters indicate the presence of organic acids leached from decomposing vegetation in the watershed, which in turn explains the increase in color after rainfall periods. Turbidity levels are normal for the area; higher levels during periods of high discharge probably result from concomitant increases in surface, road, and stream channel erosion during these times.

Although chloride concentrations determined by Bass (1979) never exceeded the state maximum standard (for Segment 0802) of 125 mg/L, the increases in chloride levels at MC-4 and MC-5 indicate that oil field brines from the Schwab oil field may be entering the tributary that flows into Menard Creek. The increase in specific conductance and sulfates at MC-4 also support this conclusion. Other cation and anion concentrations were not unusual for the area.

Nutrient concentrations generally lie within the range expected for undisturbed waters in southeastern Texas. However, the somewhat high ammonium-nitrogen levels may indicate a septic tank leachate problem, especially since higher concentrations correspond with increased stream flow and elevated fecal bacterial levels.

The diversity of the benthic macroinvertebrate and fish populations is less in Menard Creek than in the other streams of the Big Thicket National Preserve. Fish were sampled only once in this stream, so it is difficult to say whether the lower fish diversity is natural for this drainage or is a result of environmental stress.

As previously stated, the Shannon-Weaver diversity values in Menard Creek are somewhat lower than those reported for other units of the preserve. Since the benthic macroinvertebrate composition of Menard Creek contains large numbers of pollution-intolerant taxa, scouring of macrobenthos as they progress downstream, rather than poor water quality, may explain the lower diversity index. Diversity at the sites downstream of the oil field was not appreciably lower than diversity in the upstream sites.

LANCE ROSIER UNIT AND THE LITTLE PINE ISLAND BAYOU CORRIDOR UNIT

General Description

The Lance Rosier Unit and the Little Pine Island Bayou Corridor Unit encompass 10,570 ha (27,124 acres) of the Lower Big Thicket basin within Hardin County, Texas (Figure 18). The main stream draining these units is Little Pine Island Bayou, which begins in southeastern Polk county and flows in a southeasterly direction 74 km (46 miles) through Hardin county to its confluence with Pine Island Bayou. Near its headwaters, portions of two oil fields (Menard Creek oil field and Segno oil field) drain into Little Pine Island Bayou. Most of the watershed between the headwaters and the Lance Rosier Unit is used by the commercial forest products industries, with a few rural home sites and oil and gas production facilities dispersed throughout.

Sources of water quality impacts bordering the Little Pine Island Bayou Corridor Unit include small sewage treatment plants from both Pinewood Estates and Bevil Oaks developments, possible septic tank drainage from rural homes and communities, and oil and gas production facilities. Two active oil and gas production areas border the Lance Rosier and Little Pine Island Bayou Corridor Units. The Saratoga oil field, located adjacent to the northwest portion of the Lance Rosier Unit, contains about 175 active wells and has limited production facilities. A landmark created from the Saratoga oil fields is the "Salt Lake", which appeared as a result of storing oil brine materials and wastes in a natural depression. The Sour Lake oil field has approximately 150 shallow wells in operation with extensive oil storage

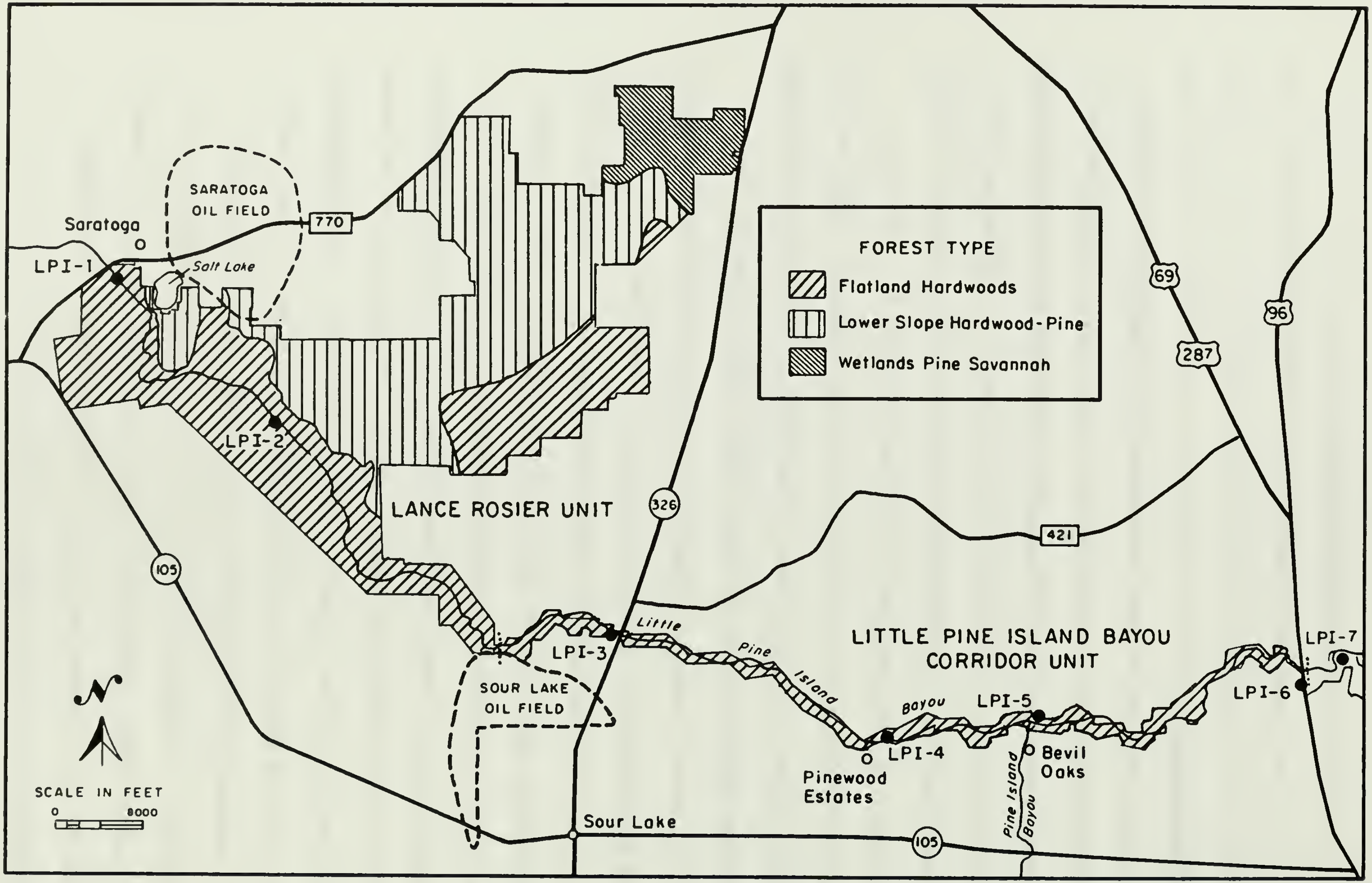


Figure 18. Vegetation types of the Lance Rosier and Little Pine Island Bayou Corridor Units, showing sampling sites established by Harrel (1976) and Darville (1978). Adapted from USDI (1976), and Harcombe and Marks (1979).

and production facilities. In addition to the oil and gas production areas, ten major oil and gas transmission lines transect the Lance Rosier and Little Pine Island Bayou Corridor Units.

The Little Pine Island Bayou Corridor Unit receives several small tributary streams before flowing into Pine Island Bayou. Several reports summarize water quality conditions for the entire Pine Island Bayou watershed (Adsit and Hagen, 1978; Lower Neches Valley Authority, 1983a,b; Commander, 1978). A subsequent section of this report will detail land uses and activities in the Pine Bayou watershed because of their influence on water quality in the downstream reaches of the Little Pine Island Bayou Corridor Unit.

Nineteen soil types can be found within the Lance Rosier and Little Pine Island Bayou Corridor Units, of which 57 percent belong to either the Sorter or Kirbyville soil series. The Sorter silt loams are characteristically deep, poorly drained, and have a slow permeability. Found primarily on upland flats in the Lance Rosier Unit, the Sorter soils have water tables 0.15 m to 0.76 m (0.5 to 2.5 ft) below the surface during wet periods. The formation of perched water tables in this soil type is a common occurrence. Because of frequent flooding and slow percolation rates, Sorter soils have severe restrictions for septic use.

Kirbyville fine sandy loams are moderately permeable soils found on gently sloping uplands in both the Lance Rosier and Little Pine Island Bayou Corridor Units. Wet-period water tables vary from 0.46 m to 0.76 m (1.5 to 2.5 ft) for the Kirbyville soils, which also exhibit a moderate percolation rate. Kirbyville soils also have severe restrictions for septic tank use, due mostly to their frequent wetness.

The remaining soils are predominantly sandy loams and clays, all of which have severe restrictions for sanitary facilities due to slow percolation rates and frequent wet periods (Deshotels, 1978).

Two vegetation types dominate the Lance Rosier Unit (Figure 18). The lower slope hardwood-pine forests are located in the northern and central aras of the Lance Rosier Unit and are composed of an open canopy of pine and hardwoods. The flatland hardwood forests do not have any pine in the overstory, but have a dense undergrowth of palmetto. This forest type is located primarily along streamsides in heavier clayey soils in the Lance Rosier Unit as well as the entire Little Pine Island Bayou Corridor Unit. A small section of wetland pine savannah forests, containing primarily oak and loblolly pine, are located in the higher regions of the Lance Rosier Unit (USDI, 1976; Harcombe and Marks, 1979).

Both Pine Island Bayou and Little Pine Island Bayou are slow moving streams with long, wide, and deep pools scattered throughout (Adsit and Hagen, 1978). Pine Island Bayou is a perenial stream while flow in Little Pine Island Bayou becomes intermittent during dry periods, isolating the deeper pools in the stream from flowing water. The average depth of Little Pine Island Bayou below State Highway (S.H.) 326 is 0.58 m (1.9 ft), with an average width of 3 m (10 ft). Pine Island Bayou below S.H. 326 has an average depth of 1.25 m (4.1 ft) and an average width of 15.2 m (50 ft) (Adsit and Hagen, 1978). Further downstream on Pine Island Bayou, the Lower Neches Valley Authority operates a pumping station to divert water for agricultural purposes. The pump is capable of diverting 936 cfs from the bayou, which can cause flow reversals in Pine Island Bayou during low-flow periods. The pump is operated from April 1 to September 30 during the peak rice-growing season (Adsit and Hagen, 1978). Salt-water barriers had been installed to prevent salt water from the Gulf of Mexico from moving upstream and being diverted by the pumping stations located in the lower reaches of Pine Island Bayou. The barriers have been removed and as of this writing no other structures have been installed.

Previous Studies and Applicable State Standards

Several water quality studies were conducted in the Pine Island Bayou watershed. During the summer of 1975, Harrel (1976) collected physicochemical data on Little Pine Island Bayou in the Lance Rosier Unit and physicochemical and biological information on Little Pine Island Bayou in the Little Pine Island Bayou Corridor Unit. The study objectives were to 1) determine locations for establishing water quality monitoring stations, 2) obtain base line water quality data, 3) locate existing or potential sites of water pollution and stress, and 4) develop recommendations for future investigations. Adsit and Hagen (1978) collected physicochemical and bacteriological data as well as macroinvertebrates in the Pine Island Bayou watershed three times during 1975 and 1976. Their purpose was to supply the Texas Water Quality Board with background information for establishing water quality management prescriptions. Harrel (1977) again sampled the Lance Rosier Unit during the summer and fall of 1976, expanding the physicochemical data base already established.

A more intensive monitoring program conducted from June 1977 to May 1978 by Darville (1978) yielded an extensive data base for the Lance Rosier and Little Pine Island Bayou Corridor Units. The physico-

Table 6. Location and description of stream-bottom substrate at sampling sites in the Lance Rosier and Little Pine Island Bayou Corridor Units (from Darville, 1978).

Site	Location	Substrate
LPI-1	on Little Pine Island Bayou from Highway 770 bridge near Saratoga	coarse and fine sand, silt, and large amounts of plant detritus
LPI-2	on Little Pine Island Bayou, near old wood bridge 90 m south of dirt road on Mary Smith land tract	coarse and fine sand, silt, and large amounts of plant detritus
LPI-3	on Little Pine Island Bayou 30 m upstream from highway 326 bridge	coarse and fine sand, silt, and large amounts of plant detritus
LPI-4	on Little Pine Island Bayou 30 m downstream from sewage treatment plant outfall	gravel and mud
LPI-5	on Pine Island Bayou 100 m downstream from confluence of Little Pine Island Bayou and Pine Island Bayou	fine sand, mud and clay
LPI-6	on Pine Island Bayou 200 m upstream from highway 96 bridge	fine sand, mud and clay
LPI-7	on Pine Island Bayou 100 m downstream from confluence of Village Slough with Pine Island Bayou	fine sand, mud and clay

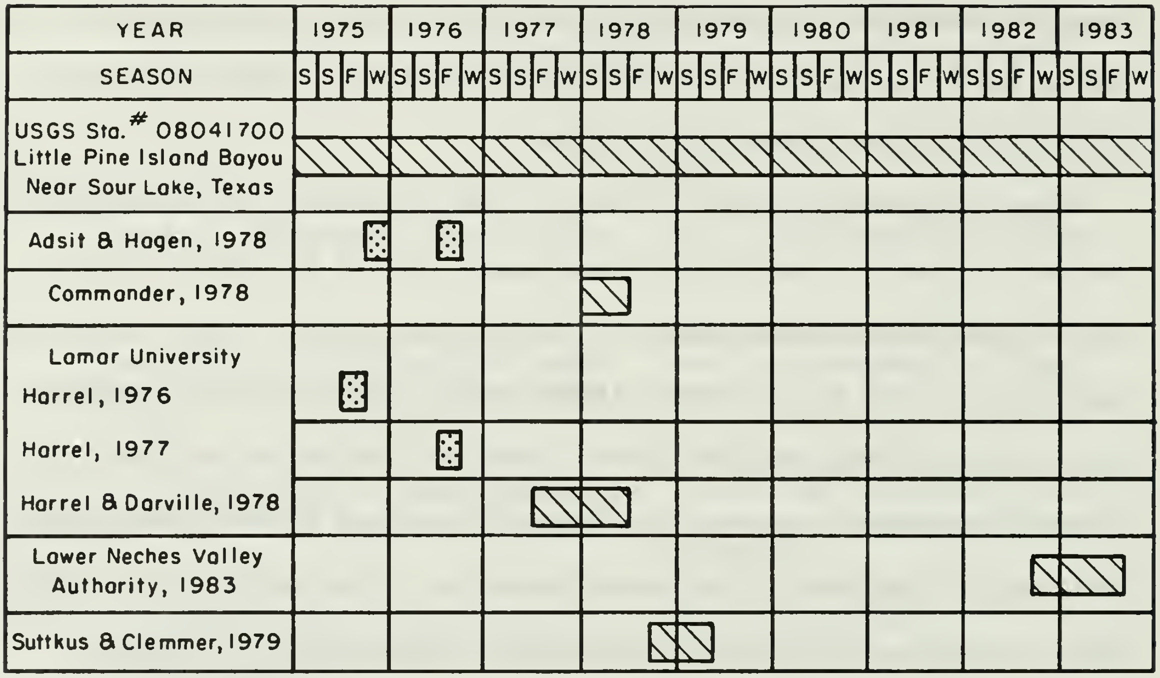
chemical and bacteriological data was collected to assess impacts on the study area from oil and gas operations, as well as sewage effluent from Pinewood Estates. Table 6 describes the sampling sites and the bottom substrate established by Darville's study.

Fecal coliform levels were recorded in January, February, April, and May of 1978 by Commander (1978). His study was designed to determine if fecal coliform levels in Stream Segment 0607 (the Pine Island Bayou drainage basin) remained below the state standard of 200 organisms/100 mL during high- and low-flow conditions. In his report, Commander attempts to identify the sources of fecal contamination. During the winter of 1978-1979, Suttkus and Clemmer (1979) completed their fish survey in Pine Island Bayou.

The Lower Neches Valley Authority (LNVA) measured physicochemical and bacteriological parameters from August 1982 to September 1983 in Pine Island Bayou (Stream Segment 0607) and summarized the results in two reports. The first report (LNVA, 1983a) documents and summarizes data characterizing nonpoint-source loads and estimates the land-use impacts from urban, agricultural, septic tank, oil field, and forested areas within the Pine Island Bayou watershed. The second report (LNVA, 1983b) furnishes additional information and analysis of dissolved oxygen, chlorides, and fecal coliform levels, and presents an alternative management strategy.

Additionally, the U.S. Geological Survey (USGS) has been monitoring water discharge and physicochemical parameters at one site in Pine Island Bayou, station No. 08041700, since 1968. Using the USGS data, Wells and Bourdon (1985) summarized statistical trends of selected water quality parameters collected at three stations including the Pine Island Bayou station. Although this monitoring station is not within the National Preserve, Pine Island Bayou does flow through BITH further downstream and will influence water quality in this region. Figure 19 presents the sampling periods and the parameters sampled in the Pine Island Bayou basin.

Specific water quality standards have been developed for Stream Segment 0607 of Pine Island Bayou (Texas Department of Water Resources, 1981) and are shown in Table 7. Although these standards do not apply



Parameters Measured

- U.S. Geological Survey (WATSTORE)
  - Physicochemical Parameters
- Adsit & Hagen, 1978
  - Physicochemical Parameters
  - Bacteriological Parameters
  - Sediment Analysis
  - Macrobenthic Parameters
- Commander, 1978
  - Bacteriological Parameters
- Harrel, 1976
  - Physicochemical Parameters
- Harrel, 1977
  - Physicochemical Parameters
- Darville, 1978
  - Physicochemical Parameters
  - Bacteriological Parameters
  - Macrobenthic Parameters (occasionally)
- Lower Neches Valley Authority, 1983 a,b
  - Physicochemical Parameters
  - Bacteriological Parameters
- Suttkus & Clemmer, 1979
  - Fish Survey

Little Pine Island Bayou Basin

Monthly Samples (or more often)

Occasional Samples

Figure 19. Sampling periods and parameters measured in the Lance Rosier and Little Pine Island Bayou Corridor Units.

Table 7. State water quality standards for Stream Segment 0607, Pine Island Bayou (from Texas Department of Water Resources, 1981).

Parameter	Standard
Chloride	150 mg/L
Sulfate	50 mg/L
Total dissolved solids	300 mg/L
pH	6.0 - 8.5
Fecal coliform	200 colonies/100 mL
Dissolved oxygen*	greater than 5.0 mg/L
Temperature	95°F

*Tributary streams must maintain a dissolved oxygen concentration of at least 2.0 mg/L at all times.

to Little Pine Island Bayou directly, they are an appropriate reference point in a regional water quality evaluation.

Pine Island Bayou Watershed

The majority of the Pine Island Bayou watershed is located outside of the preserve's boundaries. Within the Pine Island Bayou watershed, however, many land uses and activities occur that affect the quality of water flowing through the bayou. Because this water eventually flows into the Little Pine Island Bayou Corridor Unit and the Beaumont Unit of BITH, these activities are of concern.

Several sewage treatment facilities discharge wastes into the Pine Island Bayou basin. Major point-source dischargers who release effluent directly into Pine Island Bayou are the sewage treatment plants operated by the city of Sour Lake, the Bevil Oaks Municipal Utility District, and the Lumberton Municipal Utility District. Minor point-source dischargers on Pine Island Bayou are the West Hardin County Consolidated Independent School District, the Hardin-Jefferson Independent School

District, and the Saint Vincent de Paul Seminary sewage treatment plants (Adsit and Hagen, 1978; LNVA, 1983b).

The Lower Neches Valley Authority (1983b) has identified three point sources and 12 nonpoint sources on the tributaries of Pine Island Bayou. The point sources are the Hardin County Water Control and Improvement District (WCID) #1, Nome, and Daisetta sewage treatment plants. The 12 nonpoint sources include permits for septic tank use in the cities of Votaw, Thicket, Saratoga, and Hull; urban runoff from Pinewood Estates, Nome, Daisetta, China, and Lumberton; and three oil fields located near Daisetta, Saratoga, and Sour Lake. The sewage treatment facilities are not always effective: Adsit and Hagen (1978) noted the Hardin County WCID #1 treatment plant recorded 32 days in a one year period where effluent bypassed the system due to wet weather conditions.

Other potential nonpoint sources of pollution include erosion and sedimentation of tributaries and pesticide contamination in the drainage area from agricultural and silvicultural activities. In addition, a swine feedlot operation in Sour Lake discharges approximately 500 gallons/day of waste runoff into retention ponds. The liquid waste is allowed to evaporate in the ponds and also is used as fertilizer on pasture lands (Adsit and Hagen, 1978).

Three municipal landfills exist within the watershed, one of which is still active. The active landfill is located between the city of Daisetta and the community of Hull, and the inactive landfills are located one mile south of Votaw and in the Saratoga community. These landfills are expected to increase BOD, total nitrogen, total phosphorus, and total suspended solid loads into Pine Island Bayou (Commander, 1978).

Water Quality Analysis

On three occasions during Darville's (1978) study, isolated pools existed at two upstream stations on Little Pine Island Bayou. Because of the stagnant flow conditions in these pools, some water quality parameters reached extreme values. Biological activity and a concentrating effect due to evaporation contribute to the high values. These data were not considered representative of the water quality found in Little Pine Island Bayou and were not used in the statistical description of the various constituents. The isolated pools existed at sites LPI-1 and LPI-2 on July 17 and August 23, 1977 and also at site LPI-1 on October 15, 1977.

Physicochemical Constituents. Water temperatures of Little Pine Island Bayou follow the same seasonal patterns as other streams in Big Thicket (Flora et al., 1985). Figure 20 displays the seasonal variation in temperature reported by Darville (1978). Although temperatures increase during the summer months, the stream standard at 35°C (95°F) was not exceeded during Darville's study. Water temperatures generally increase downstream, which can be attributed to differences in shading, water volume, and time of sampling. A thermal stratification existed at sites LPI-6 and LPI-7 during the spring and summer months of 1977 and 1978 with a maximum difference between surface and bottom stream temperatures of 4°C at station 6 in April (Darville, 1978).

In Pine Island Bayou, DO concentrations periodically fall below the Texas State Water Quality standard of 5.0 mg/L, especially during the

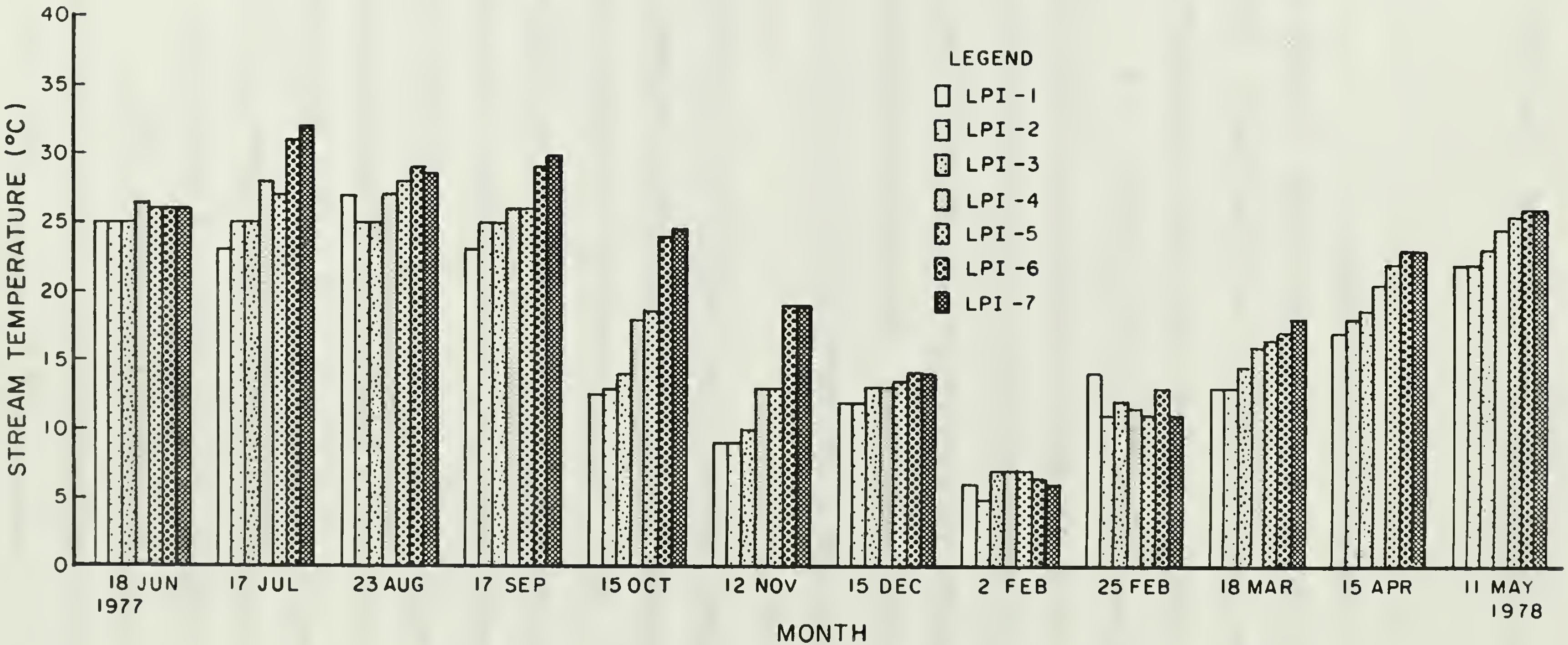


Figure 20. Seasonal profile of water temperatures (1977-1978) for the sampling sites in the Lance Rosier and Little Pine Island Bayou Corridor Units. Data taken from Darville (1978).

summer months (Figure 21). In summer, the lowest DO concentrations occurred under low flow conditions when small isolated pools formed at LPI-1 and when pools and thermal stratification conditions existed at LPI-6 and LPI-7 (Darville, 1978). The lower DO concentrations result from high stream temperatures, little rearation from turbulent mixing and, during low flow conditions, the lack of upstream replenishment of oxygen for oxygen-using organisms in the stream.

Dissolved oxygen was also monitored by the Lower Neches Valley Authority (1983a, 1983b), who report that DO concentrations are generally higher during wet weather periods than during dry periods. For tributaries of Pine Island Bayou, the Texas state minimum standard for DO is 2.0 mg/L, and a few DO concentrations were below this minimum at site LPI-1 on Little Pine Island Bayou. These values only occurred during summer months when isolated pools of water existed within the channel. A 4.0 mg/L concentration is considered the lowest value which will support a varied fish population, and at a station located upstream of LPI-1, 10 percent of the samples were below 4.0 mg/L (LNVA, 1983b). These values below 4.0 mg/L were also obtained during hot summer months under low flow conditions. Despite occasional DO violations, the LNVA generally considers the Pine Island Bayou Segment 0607 to meet Texas surface water quality standards for dissolved oxygen. Further, the LNVA states that all the low concentrations are caused by natural conditions such as low flow rates, high temperatures, lack of water turbulence for mixing, and a high oxygen demand of organic material (LNVA, 1983a).

Organic acids derived from tannins and lignins in the pine litter occur naturally in Little Pine Island Bayou and may account for the low pH values found in the stream (Figure 22). These pH values are often

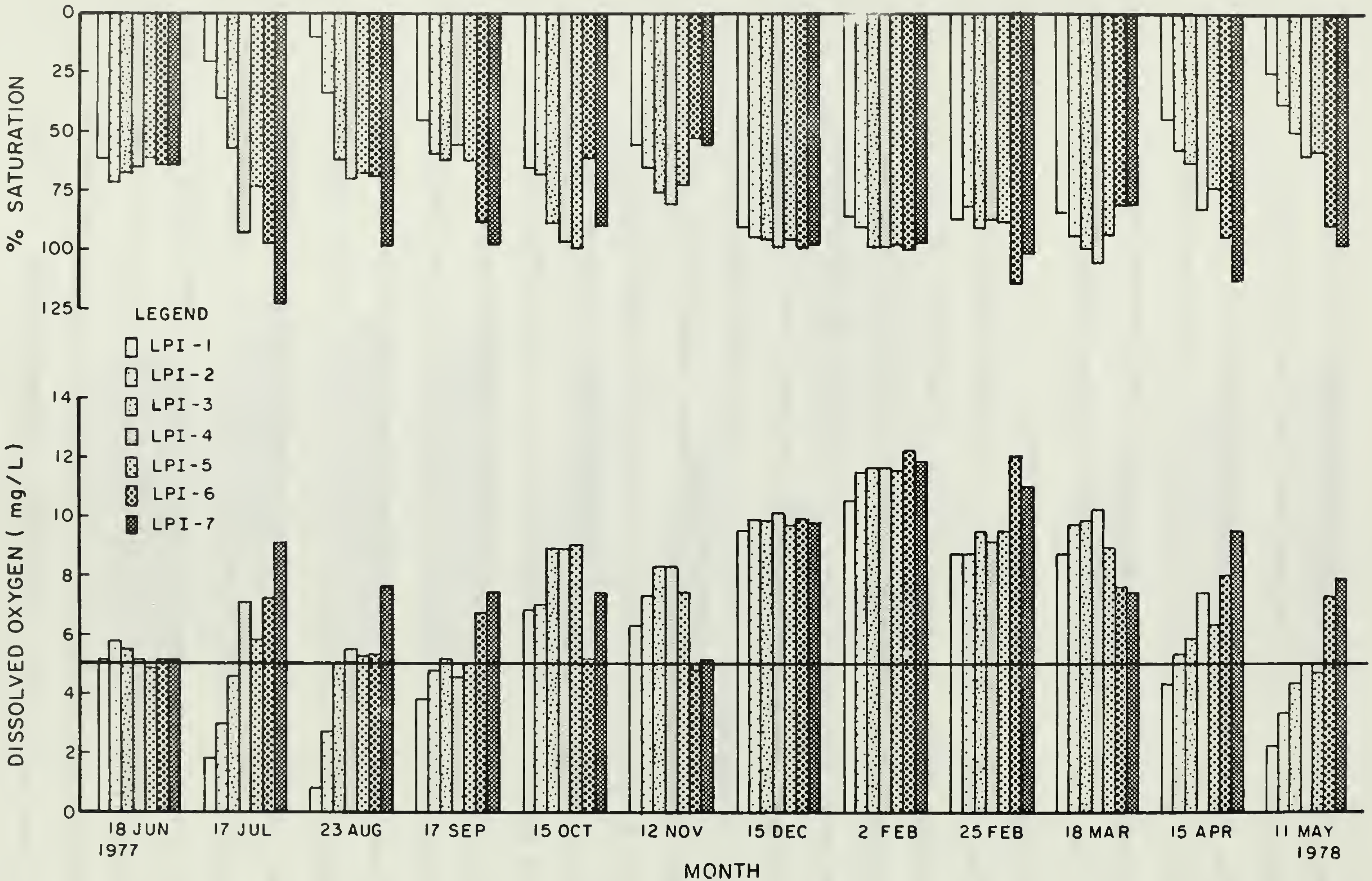


Figure 21. Seasonal profile of dissolved oxygen concentrations and percent oxygen saturations (1977-1978) for the sampling sites in the Lance Rosier and Little Pine Island Bayou Corridor Units. Data taken from Darville (1978). Heavy line denotes dissolved oxygen standard for segment 0607.

below the range of 6.0 - 8.5 standard units established by the Texas Department of Water Resources (1981).

Although alkalinity concentrations are low, they are slightly higher than other Big Thicket streams (Figure 23) (Flora et al., 1985). The Little Pine Island Bayou channel flows through a more calcareous Beaumont-derived soil formation, resulting in higher alkalinity concentrations (Watson, 1979). The highest alkalinity recordings are from site LPI-4, located directly downstream from the Pinewood Estates sewage treatment plant.

Turbidity and color values for little Pine Island Bayou are generally higher than in other streams in the Big Thicket region (Flora et al., 1985). During high flows, turbidity varied from 20 JTU at LPI-3 to over 395 JTU at sites LPI-5, LPI-6, and LPI-7 below the confluence of Pine Island Bayou (Figure 24). Higher turbidities were related to greater amounts of colloidal clays found naturally in the water from clayey soils. The influx of oil field brines at stations LPI-1, LPI-2, and LPI-3 and the sewage effluent at LPI-4 are throught to cause flocculation of clay particles, which reduces turbidity (Darville, 1978). Color values ranged from 30 to 600 color units (Figure 25), with the higher values from stations LPI-1, LPI-2, and LPI-3 due to dissolved organic materials from plant decomposition (Darville, 1978).

Darville (1978) reported conductivity values ranging from 20 μmhos/cm at LPI-7 to 3550 μmhos/cm at LPI-1 (Figure 26), and chloride concentrations measured at site LPI-1 ranged from 27.5 mg/L to 1440 mg/L (Figure 27). Elevated chloride concentrations at LPI-1 indicate that brines are entering the Lance Rosier Unit from the oil and gas production sites located in the headwater and upstream portions of

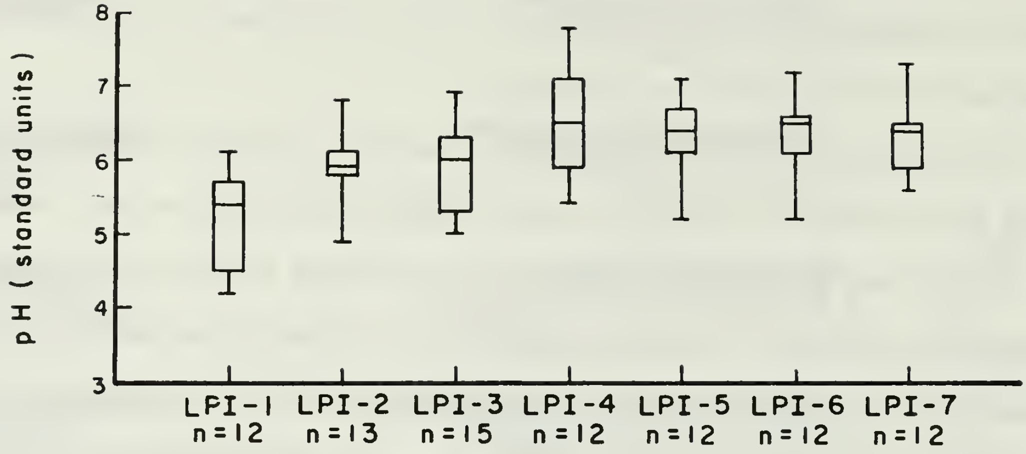


Figure 22. Median and range of pH levels for sampling sites in the Lance Rosier and Little Pine Island Bayou Corridor Units (1976-1978). Data taken from Harrel (1976, 1977) and Darville (1978).

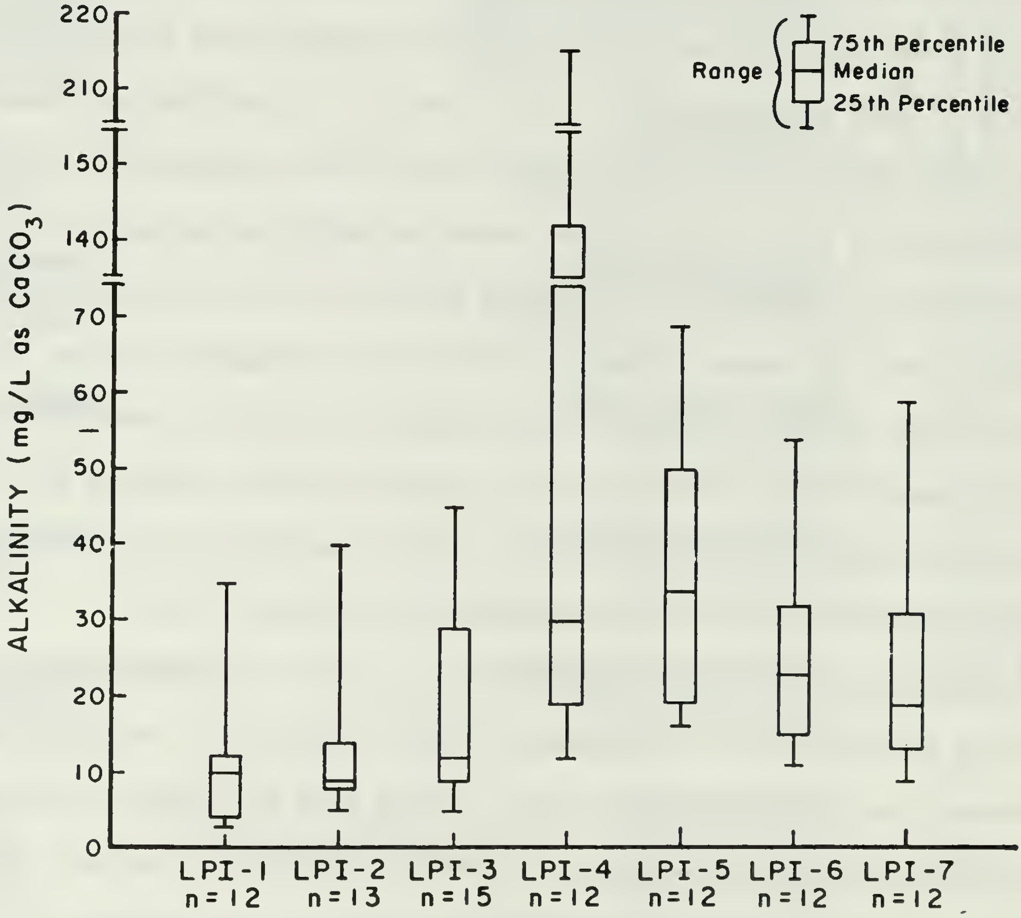


Figure 23. Median and range of alkalinity concentrations for sampling sites in the Lance Rosier and Little Pine Island Bayou Corridor Units (1975-1978). Data taken from Harrel (1976, 1977) and Darville (1978).

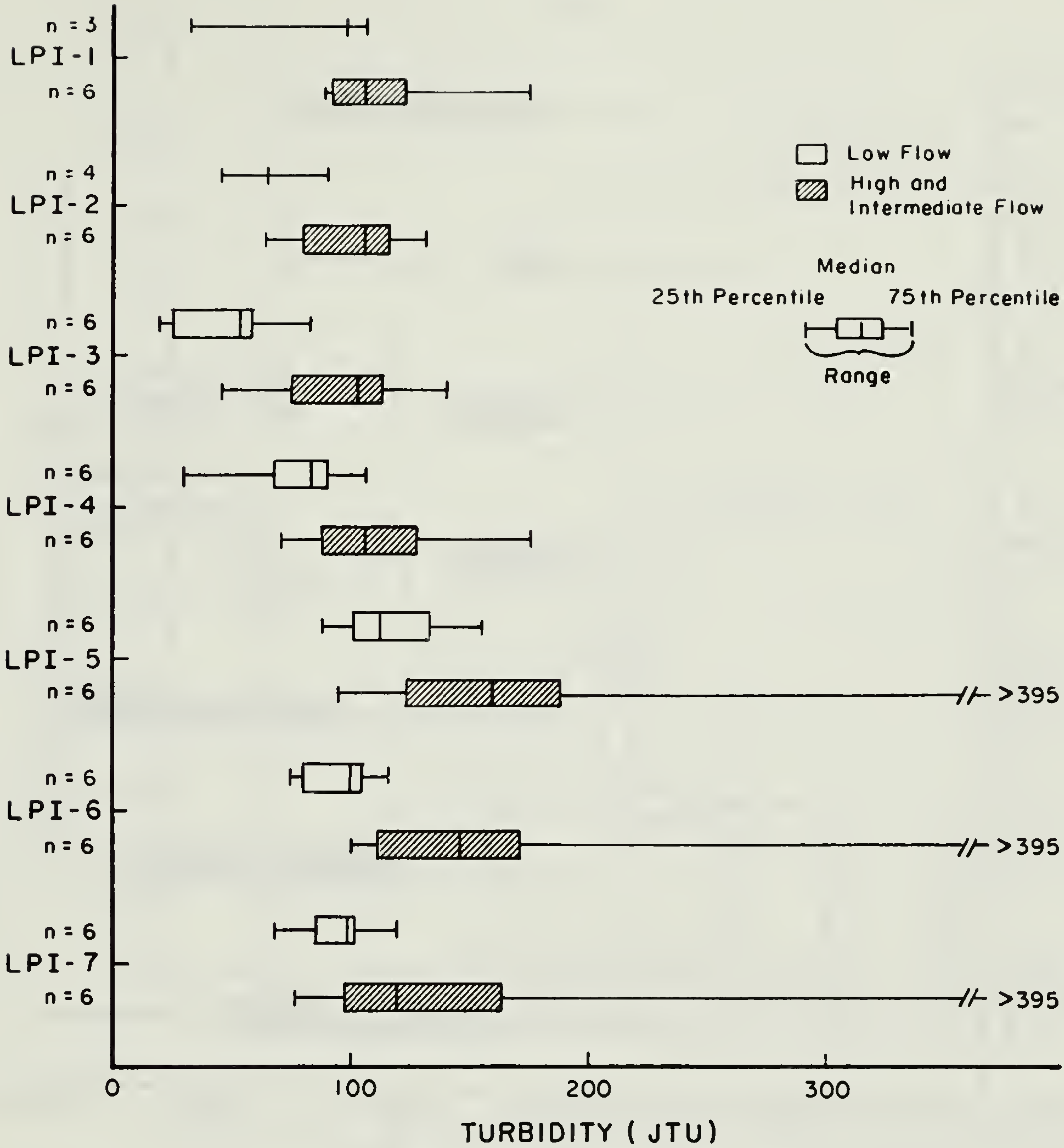


Figure 24. Low flow/high flow turbidity ranges for sampling sites in the Lance Rosier and Little Pine Island Bayou Corridor Units (1977-1978). Data taken from Darville (1978).

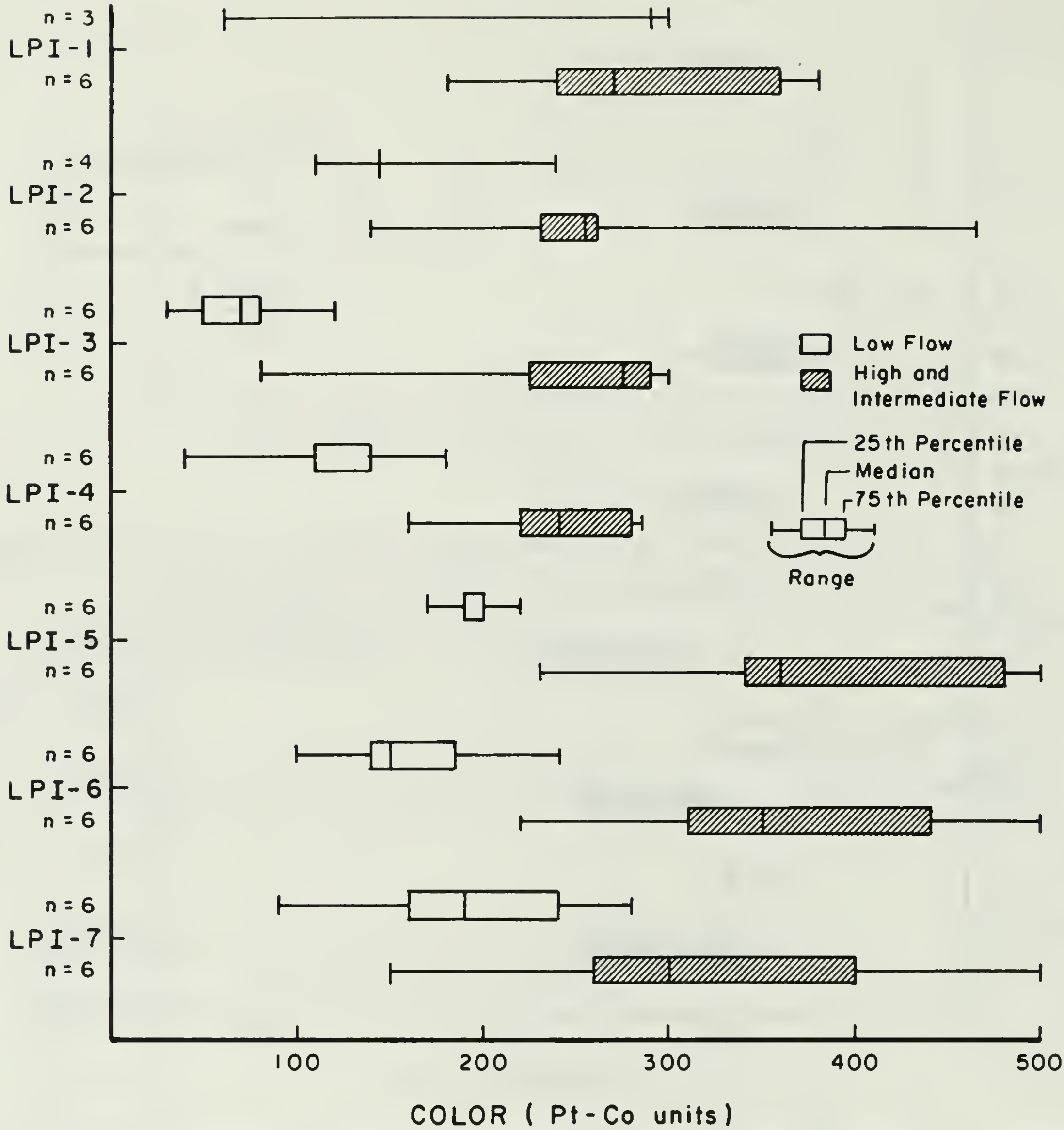


Figure 25. Low flow/high flow color ranges for sampling sites in the Lance Rosier and Little Pine Island Bayou Corridor Units (1977-1978). Data taken from Darville (1978).

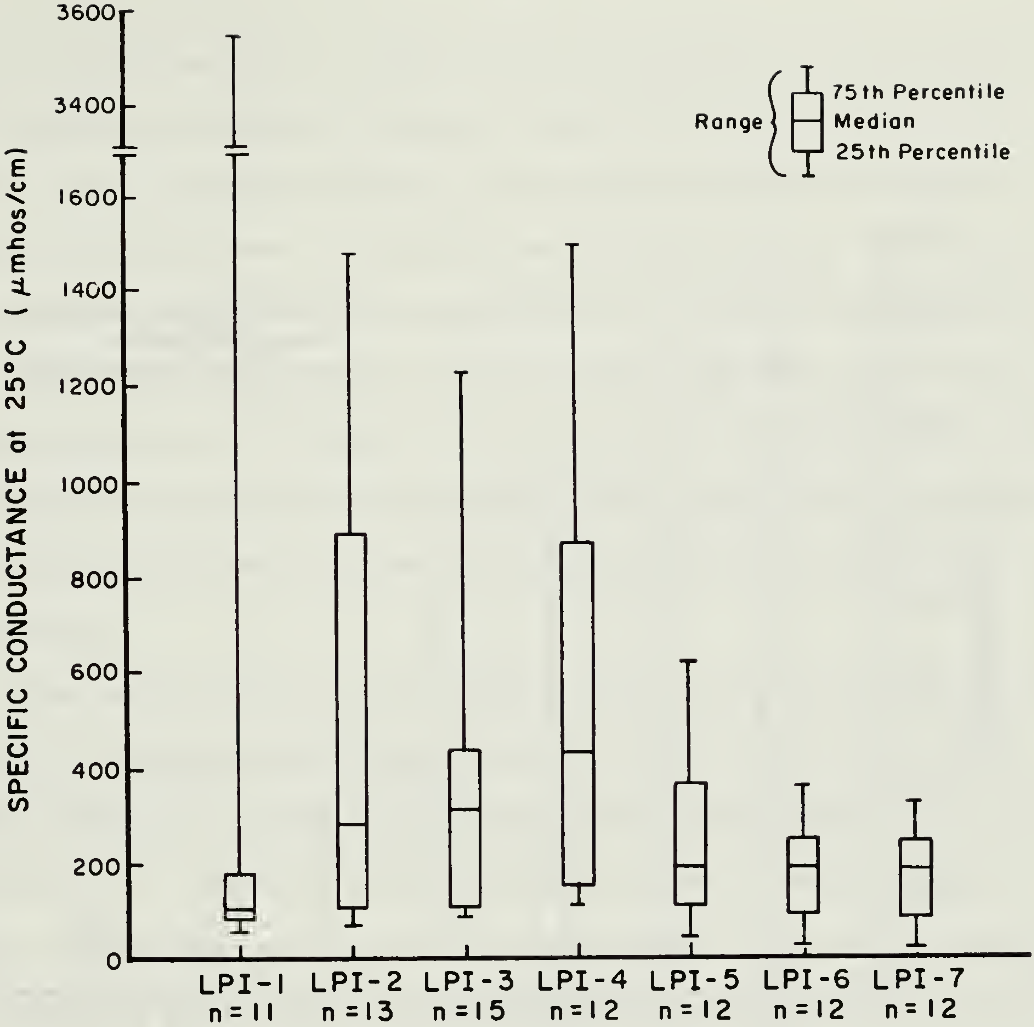


Figure 26. Median and range of specific conductance values for sampling sites in the Lance Rosier and Little Pine Bayou Corridor Units (1975-1978). Data taken from Darville (1978).

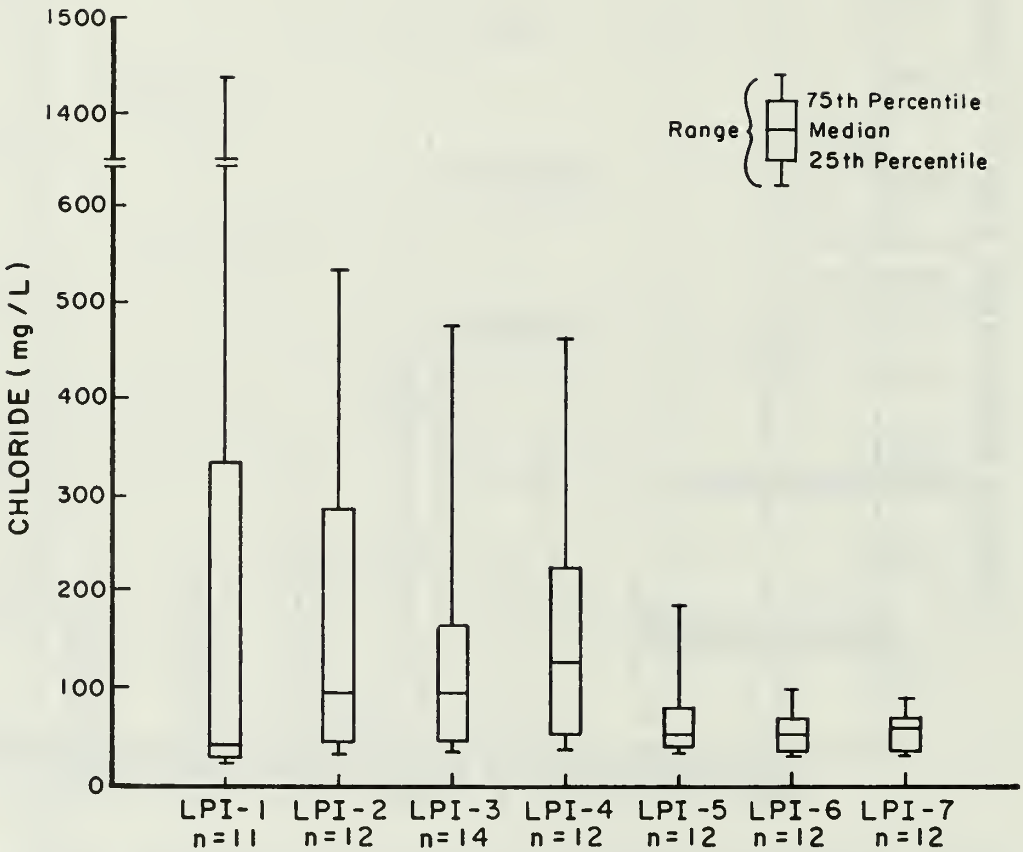


Figure 27. Median and range of chloride concentrations for sampling sites in the Lance Rosier and Little Pine Island Bayou Corridor Units (1975-1978). Data taken from Harrel (1976-1977) and Darville (1978).

Little Pine Island Bayou. High chloride concentrations at LPI-2 and LPI-3 can be attributed to seepage of brines from the Saratoga oil fields, while increased values at LPI-4 may result from the Pinewood Estates sewage effluent. Effluent from the Sour Lake oil field may also contribute to higher chloride concentrations at LPI-5 (Darville, 1978).

The Lower Neches Valley Authority (1983a) reported peak chloride concentrations above 150 mg/L at several stations on Little Pine Island Bayou and Pine Island Bayou during all weather conditions. Here also, the elevated chloride levels were attributed to oil-field related activities.

Iron concentrations in Little Pine Island Bayou were found to be similar to concentrations found in Menard Creek (Figure 28). These levels seem to be typical for the area and may result from any of the following: 1) increased metal solubility due to the water's acidic nature; 2) absorbed metal oxides or hydroxides on colloidal particles in the water; 3) iron present in plant debris; and 4) high iron solubility due to low oxygen levels near the stream bottom. Other metals detected in Little Pine Island Bayou include manganese and mercury (Adsit and Hagen, 1978). Manganese concentrations range from 50 μg/L to 750 μg/L within the corridor unit, with the peak value of 750 μg/L occurring at the confluence of Black Creek and Little Pine Island Bayou. A concentration of 1 μg/L of mercury was detected near site LPI-3 by Adsit and Hagen (1978); the source was unknown.

<u>Nutrient Chemistry</u>. Orthophosphate concentrations (Figure 29) found by Darville (1978) were higher in the Lance Rosier and Little Pine Island Bayou Corridor Units than those found in the Beech Creek or Turkey Creek Units. Site LPI-4 had the highest concentrations of

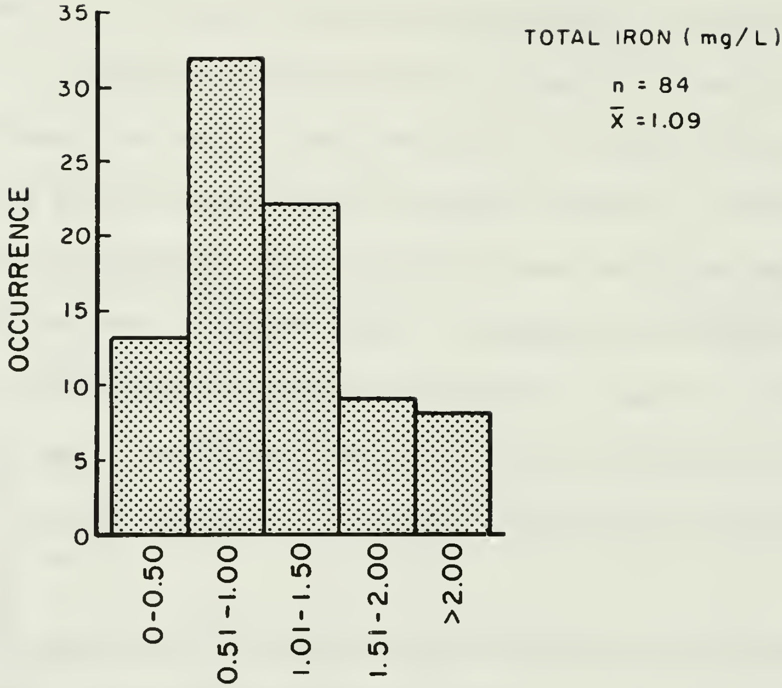


Figure 28. Frequency of occurrence of total iron concentrations for samples from the Lance Rosier and Little Pine Island Bayou Corridor Units (1975-1978). Data taken from Harrel (1975, 1976) and Darville (1978).

orthophosphates, which is thought to be the result of effluent from the Pinewood Estates sewage treatment plant (Darville, 1978). The LNVA (1983a) reports similar results, noting that higher concentrations of total phosphates occur downstream from agricultural and urban areas.

Darville (1978) reported that ammonium-nitrogen concentrations in Little Pine Island Bayou (Figure 30) were higher at LPI-1, where plant decay is considerable and oxygen concentrations are often low. The LNVA (1983a) study yielded similar results: the two sampling sites located furthest upstream in Little Pine Island Bayou had the highest ammonium-nitrogen concentrations during dry conditions. These two sites are the most heavily forested in the study area, and the higher levels of ammonium are probably due to nitrogen leaching from the forest litter into the bayou (Darville, 1978). Ammonium levels further downstream

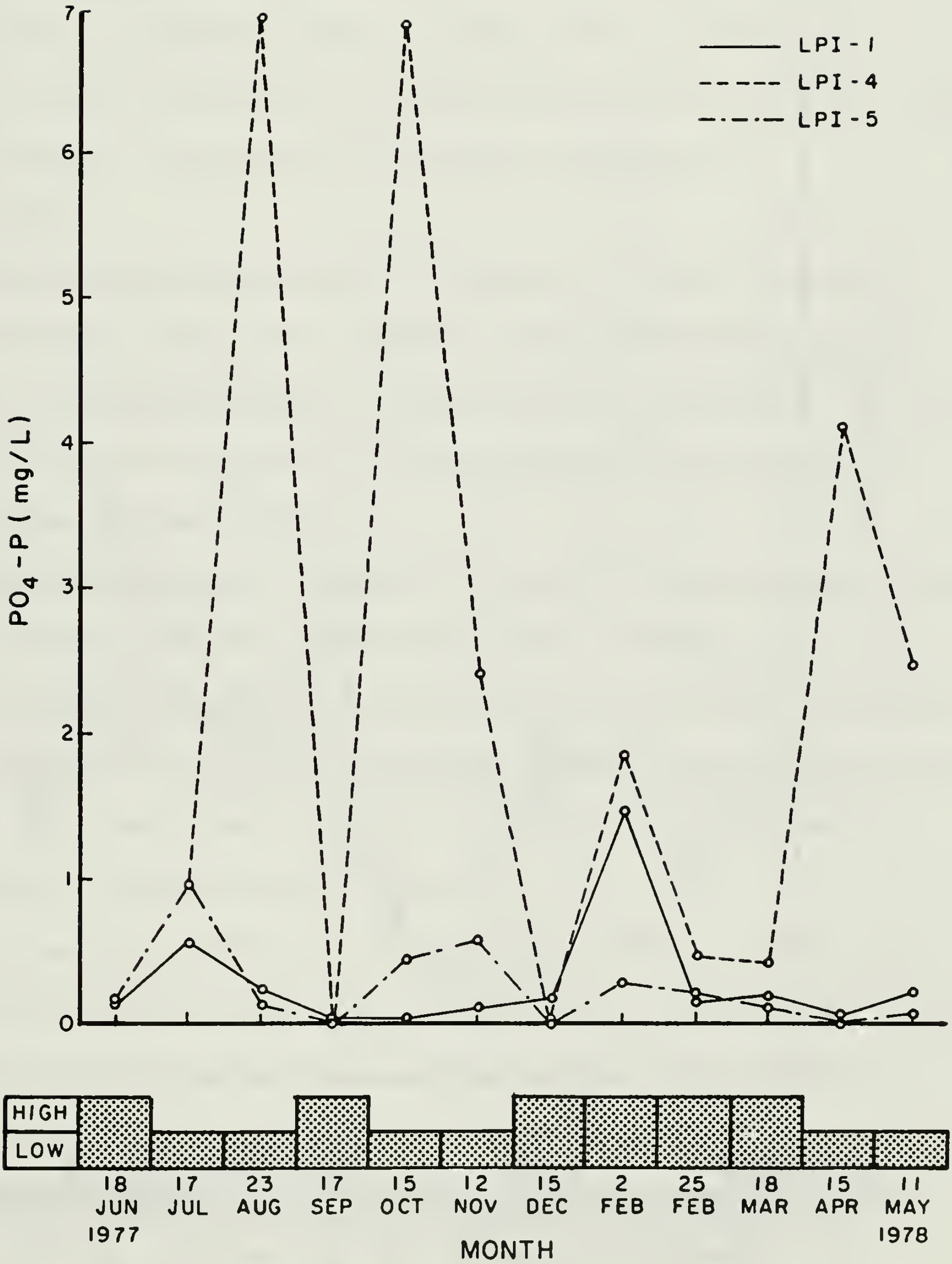


Figure 29. The seasonal relationship of PO_4-P with discharge for three selected sampling sites in the Lance Rosier and Little Pine Island Bayou Corridor Units (1977-1978). Data taken from Darville (1978).

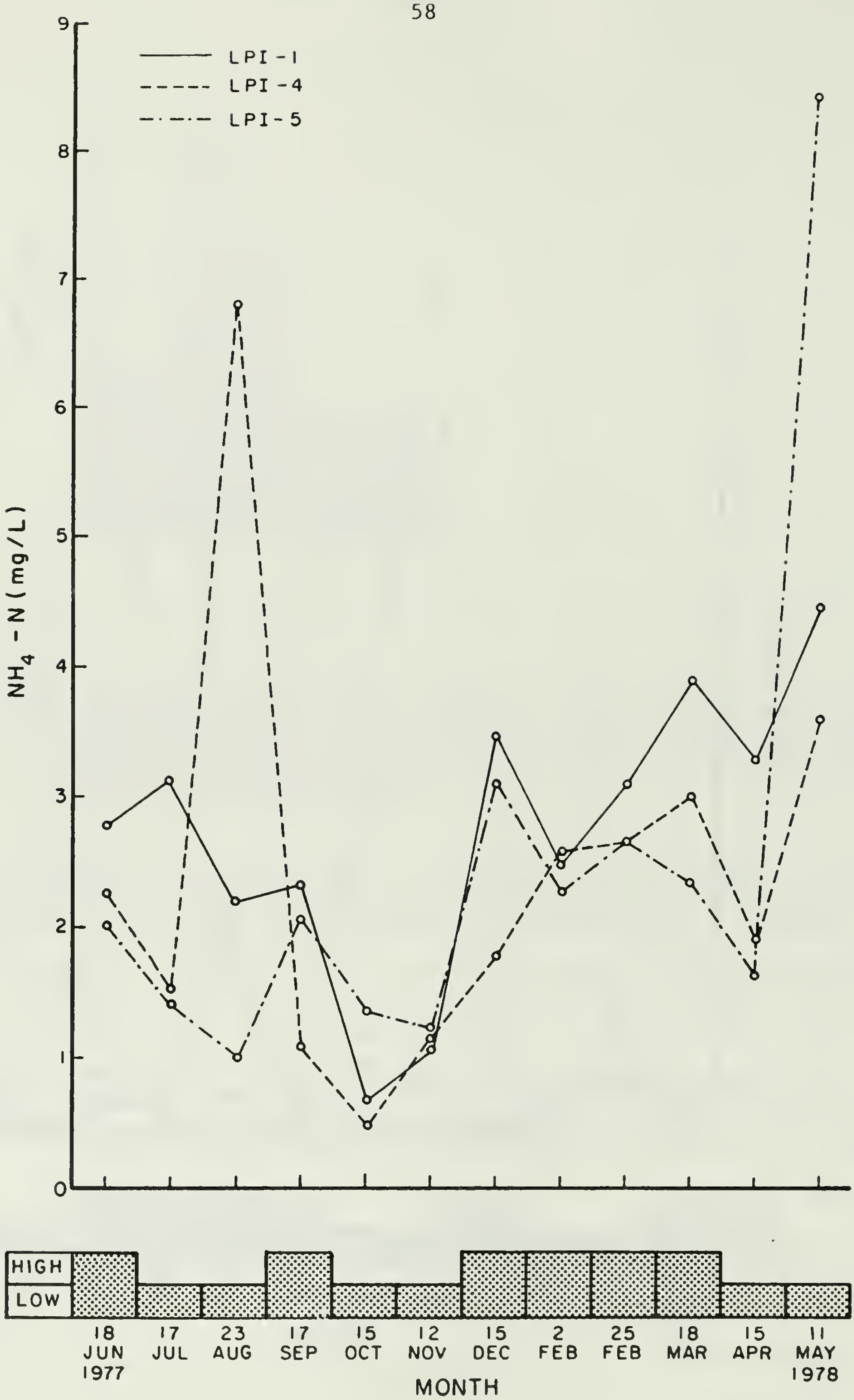


Figure 30. The seasonal relationship of NH_4-N with discharge for three selected sampling sites in the Lance Rosier and Little Pine Island Bayou Corridor Units (1977-1978). Data taken from Darville (1978).

fluctuated greatly at sites LPI-4 and LPI-5. Sewage effluent from Pinewood Estates is the most likely cause for the downstream variation. Septic tank seepage from the smaller residential areas into Little Pine Island Bayou was reported by Adsit and Hagen (1978). The seepage occurred because of saturated soil conditions due to high rainfall, poor natural drainage, high ground water tables, and poor soil characteristics.

Nitrate-nitrogen values were low (median = 0.8 mg/L) for Little Pine Island Bayou (Figure 31). During low flow conditions, Darville (1978) reported higher nitrate-nitrogen concentrations at LPI-4. Once again, this is most likely due to sewage effluent from the Pinewood Estates sewage treatment plant.

Biological Sampling. As shown in Figure 32, fecal bacterial levels tend to be high in the Pine Island Bayou basin. Only LPI-4 does not regularly exceed the Texas state maximum standard for contact recreation of 200 colonies/100 ml for fecal coliform bacteria. Low bacteria counts at this station most likely result from chlorination of the sewage treatment plant effluent (Darville, 1978).

Both Commander (1978) and Adsit and Hagen (1978) reported fecal coliform counts that correlated with stream flow. In Commander's study of bacterial levels in the Pine Island Bayou basin, fecal coliform stream standards were violated more often during wet weather periods than during dry weather (Commander, 1978). The portion of the Little Pine Island Bayou Corridor Unit that registered the highest fecal coliform counts is located downstream of a developed area (Lumberton) that depends primarily on septic systems for wastewater treatment. This

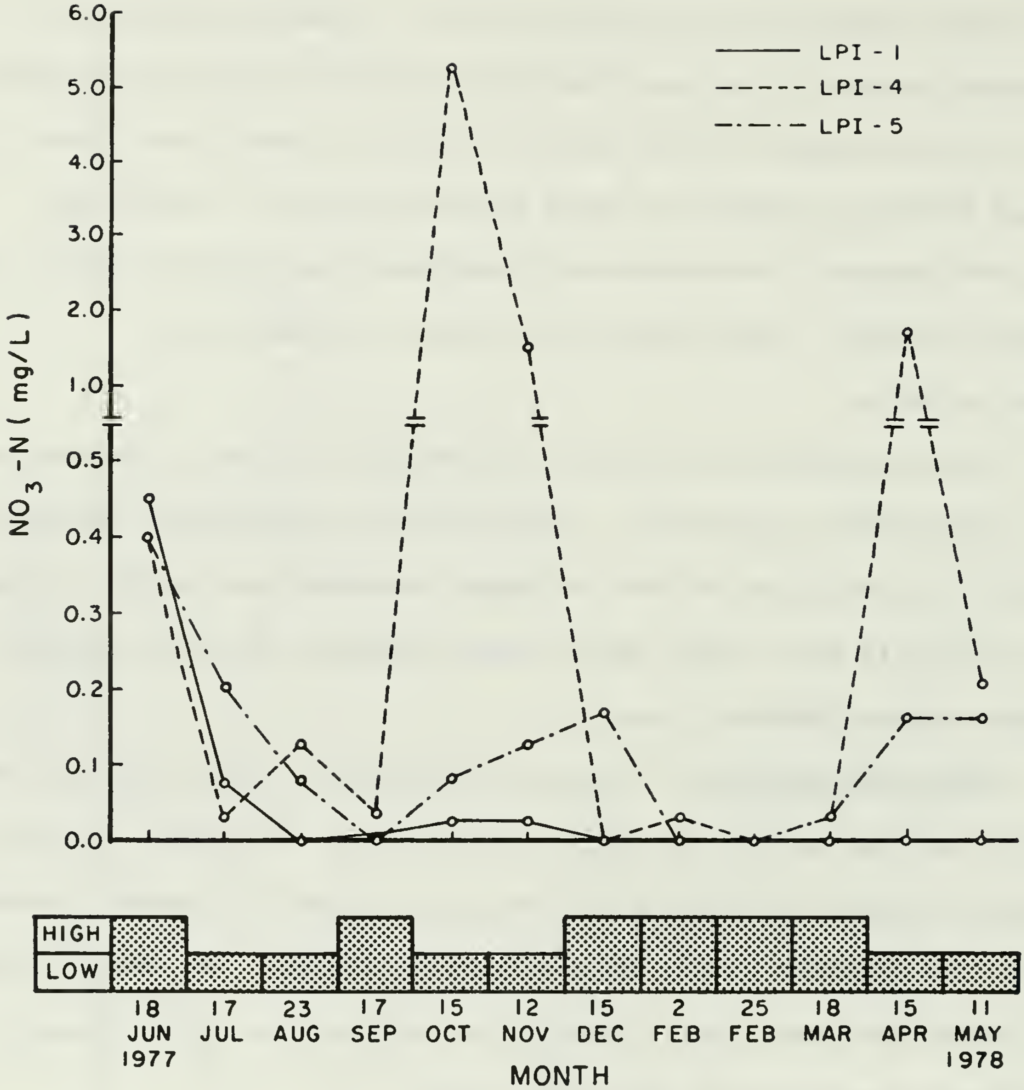


Figure 31. The seasonal relationships of NO_3-N with discharge for three selected sampling sites in the Lance Rosier and Little Pine Island Bayou Corridor Units (1977-1979). Data taken from Darville (1978).

indicates that seepage of septic tank effluent into the bayou is contributing to the observed bacterial contamination. Commander concluded that more fecal coliform loading to Pine Island Bayou comes from storm runoff carrying septic tank wastes than all wastewater treatment plants combined (Commander, 1978).

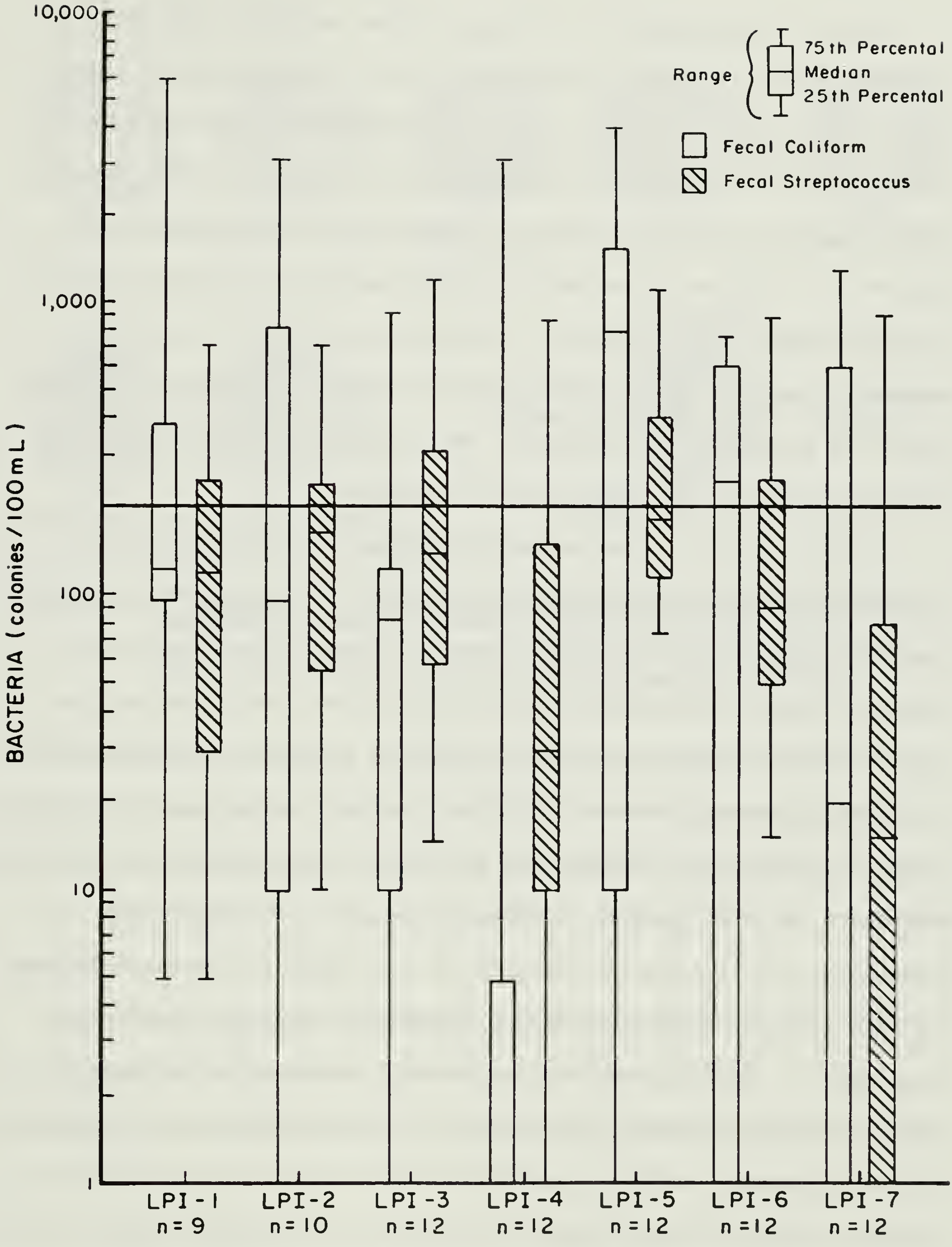


Figure 32. A profile of fecal coliform and fecal streptococcus bacterial counts for sampling sites in the Lance Rosier and Little Pine Island Bayou Corridor Units (1977-1978). Data taken from Darville (1978). Heavy line denotes fecal coliform standard for contact recreation for segment 0607.

The Lower Neches Valley Authority (1983a) estimates that most coliform loading into Pine Island Bayou comes from agriculture, forested lands, urban areas, and septic tanks. Of the four source areas, forested lands contribute the least bacteria, and septic tanks cause the highest bacterial counts. Slightly lower levels of coliforms were observed in locations where septic systems had been replaced by sewage treatment plants (LNVA, 1983a). In these areas, high counts are presumably due to storm runoff from heavily urbanized areas and from areas with scattered septic tanks. The LNVA reports that dry-weather coliform levels did not appear to be a problem.

Darville (1978) collected and identified 123 different taxa of macroinvertebrates in his year long study of the Lance Rosier and Little Pine Island Bayou Corridor Units. Figure 33 shows calculated annual diversity values and species composition for the seven sites sampled. Data on benthic macroinvertebrates collected by Adsit and Hagen (1978) generally agree with those of Darville. Neither study reports definite trends of increasing or decreasing diversity from upstream to downstream locations. In both studies, tolerant and facultative organisms predominate over intolerant organisms at the collection sites, although Darville found an intolerant mayfly (Hexagenia limbata) at all sites except LPI-4. In both studies, the authors conclude that diversity values and species composition indicate a moderately stressed community. The limiting factor in the Little Pine Island Bayou Corridor Unit community appeared to be high turbidity caused by colloidal clay in the drainage basin (Darville, 1978).

Seasonally, diversity levels fluctuated with flow. As in Menard Creek, heavy rains and flooding reduced population density by scouring

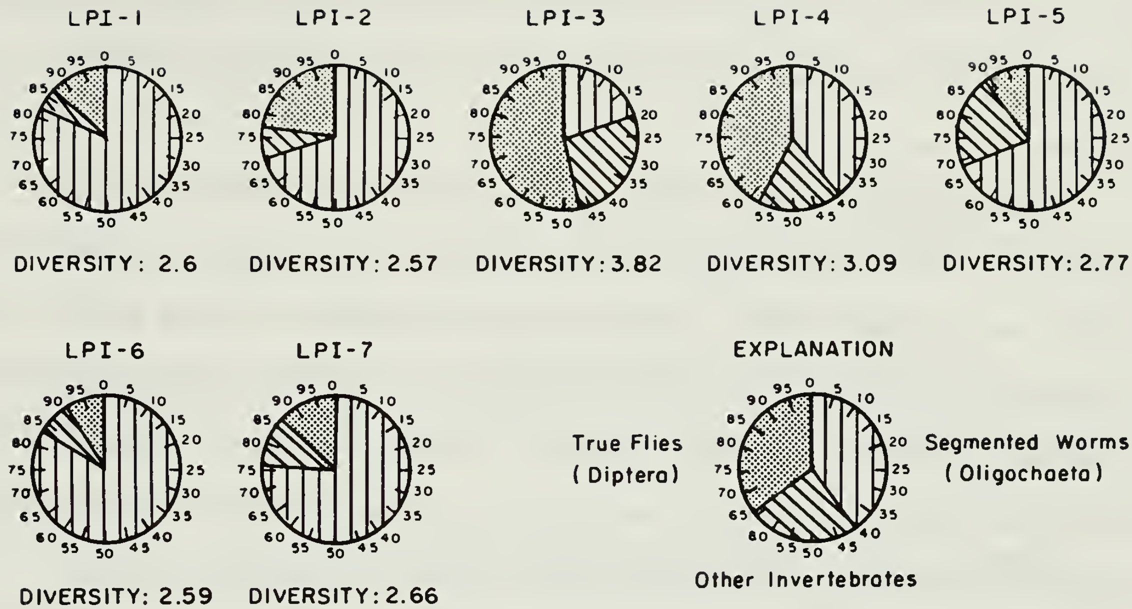


Figure 33. Annual percent distribution of aquatic macroinvertebrates and Shannon-Weaver diversity values for sampling sites in the Lance Rosier and Little Pine Island Bayou, Corridor Units (1977-1978). Data taken from Darville (1978).

the streambed and spreading the organisms over a greater area (Darville, 1978). Such scattering changes community structure; Lewis and Harrel (1978) found that increased discharge apparently favors oligochaetes and is more responsible for changes in community composition than other seasonal factors.

Fifty-six species of fish were identified in eighteen collections taken from Pine Island Bayou by Suttkus and Clemmer (1979). These included fourteen species of sunfish, thirteen species of minnows, six species of catfish, five species of darters, and four species of suckers. Also identified were three species of killifish, two species each of herrings and silversides, and one species each of pike, gar, lamprey, livebearer, pirateperch, bass, and drum. Species composition in the Pine Island-Little Pine Island Bayou relates to the intermittent flows observed in the upper reaches of Little Pine Island Bayou and the lack of gravel substrate in the sluggish downstream sections of both bayous (Suttkus and Clemmer, 1979).

Trend Analysis. Water quality records from the USGS Station No. 08041700 on Pine Island Bayou were analyzed for water quality trends (Wells and Bourdon, 1985). Sixteen years (1968-1984) of data were examined consisting of values for temperature, specific conductance, alkalinity, nitrate-nitrogen, hardness, calcium, magnesium, sodium, potassium, chloride, sulfate, and total dissolved solids. Of the parameters analyzed, slight decreasing trends were found for total alkalinity, dissolved calcium, dissolved magnesium and hardness, while a small increasing trend was observed for dissolved sulfate. No appreciable change occurred in the remaining parameters.

Conclusions

Many water quality parameters analyzed in the Lance Rosier Unit and Little Pine Island Bayou Corridor Unit are considered normal for the area. Warm water temperatures and sluggish flow characteristics contribute to a lack of mixing and a low reaeration rate and partially explain the lower dissolved oxygen concentrations. Another factor contributing to low DO concentrations is the presence of thermal stratification layers detected in Little Pine Island Bayou during the summer months.

Low pH values along with high turbidities and highly colored water also appear natural for Little Pine Island Bayou. Organic acids produced by large amounts of decomposing forest litter contribute to the low pH values. These organic acids also are partly responsible for the bayou's high color values. Clays from bottomland soils and the streambed are also suspended in the streams during higher flow periods, increasing turbidity values in the water.

Elevated values of conductivity and chlorides were observed in the bayou indicating that brines produced from oil field activities are reaching the stream. Monitoring of chlorides, sulfates, and conductivity should continue in order to detect increases in oil industry effluents as well as effluents from sewage treatment plants and runoff from agricultural areas.

Phosphorus concentrations will also increase when sewage effluent and runoff from urban and agricultural areas flow into Little Pine Island Bayou. The concentrations found in the bayou do not indicate excessively high concentrations of phosphates, except in areas immediately below sewage treatment effluent discharge. The highest orthophosphate concentrations detected in the bayou were at site LPI-4 and are thought to be caused by effluents from the Pinewood Estates sewage treatment plant. Nitrogen levels are generally low, except near areas where septic tanks and sewage treatment facilities drain into the bayou.

Ineffective septic tank absorption fields also are responsible for frequent violations for the state standards of fecal coliform counts. Coliform levels should decrease as the septic tanks are replaced by sewage treatment plants; however, coliform loading due to storm-water runoff from forest, agricultural, and urban areas may cause bacterial levels to continue to violate standard levels for contact recreation.

The Lance Rosier and Little Pine Island Bayou Corridor Units are characterized by an intermediate number of macrobiotic taxa, with diversity values indicating a moderately stressed benthic community. High turbidity due to colloidal clay in the water inhibits the presence of more species. Site LPI-4 exhibits lower diversity values due to increased turbidity and chlorination from the Pinewood Estates sewage treatment effluent.

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