HISTORICAL DATA REVIEW
ON
COW BAYOU TIDAL

Performed as part of the Tidal Stream Use Assessment
under TCEQ Contract No. 582-2-48657 (TPWD Contract No. 108287)

Cindy Contreras
Resource Protection Division
Texas Parks and Wildlife Department
Austin, Texas

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Introduction

This historical data review was performed as part of an assessment of aquatic life use attainability for three tidally-influenced streams in Texas. The work was performed by Texas Parks and Wildlife Department (TPWD) under contract with the Texas Commission on Environmental Quality (TCEQ). Funding for the contract is from the United States Environmental Protection Agency (USEPA). Under the contract, TPWD Resource Protection Division staff, led by the Water Quality and Coastal Studies Programs, will collect data on five tidal streams. This data will be used to determine the appropriate aquatic life use of three tidal streams, Cow Bayou Tidal, Tres Palacios Creek Tidal and Garcitas Creek Tidal.

Tidal streams serve as nursery grounds for many types of fish and shellfish, including important commercial and sport species. As tidal streams become healthier, the health of Texas bays and estuaries, and the Gulf of Mexico, will also improve.

Numerous tidal streams are included on the state's list of impaired waters. Inclusion on the list of impaired waters initiates the Total Maximum Daily Load (TMDL) process. As a first step in the TMDL process, it is necessary to assess the water body, and determine if the impairment is genuine, and if so, whether or not it is caused by pollutants. It is difficult to do this for tidal streams, because there is no generally accepted methodology for performing the assessment. The TCEQ and TPWD have jointly recognized the need for developing a methodology for assessing the health of tidal streams. The data collected as part of this project will ultimately be analyzed to make recommendations regarding aquatic life uses in use attainability analysis (UAA) reports for Cow Bayou Tidal, Tres Palacios Creek Tidal and Garcitas Creek Tidal.

The Tidal Streams Use Attainability Assessment project will be conducted through FY2006. In 2003 and 2004 TPWD staff will collect data about flow, physico-chemical parameters, fish, shellfish, benthic invertebrates, sediment, habitat, and water chemistry for Cow Bayou Tidal, Garcitas Creek Tidal, Tres Palacios Creek Tidal and two reference streams. In FY2005, TPWD staff will analyze data and prepare a methodology to assess the ecosystem health of Cow Bayou Tidal, Garcitas Creek Tidal, Tres Palacios Creek Tidal. In FY2006, staff will prepare aquatic life use attainability assessment reports.

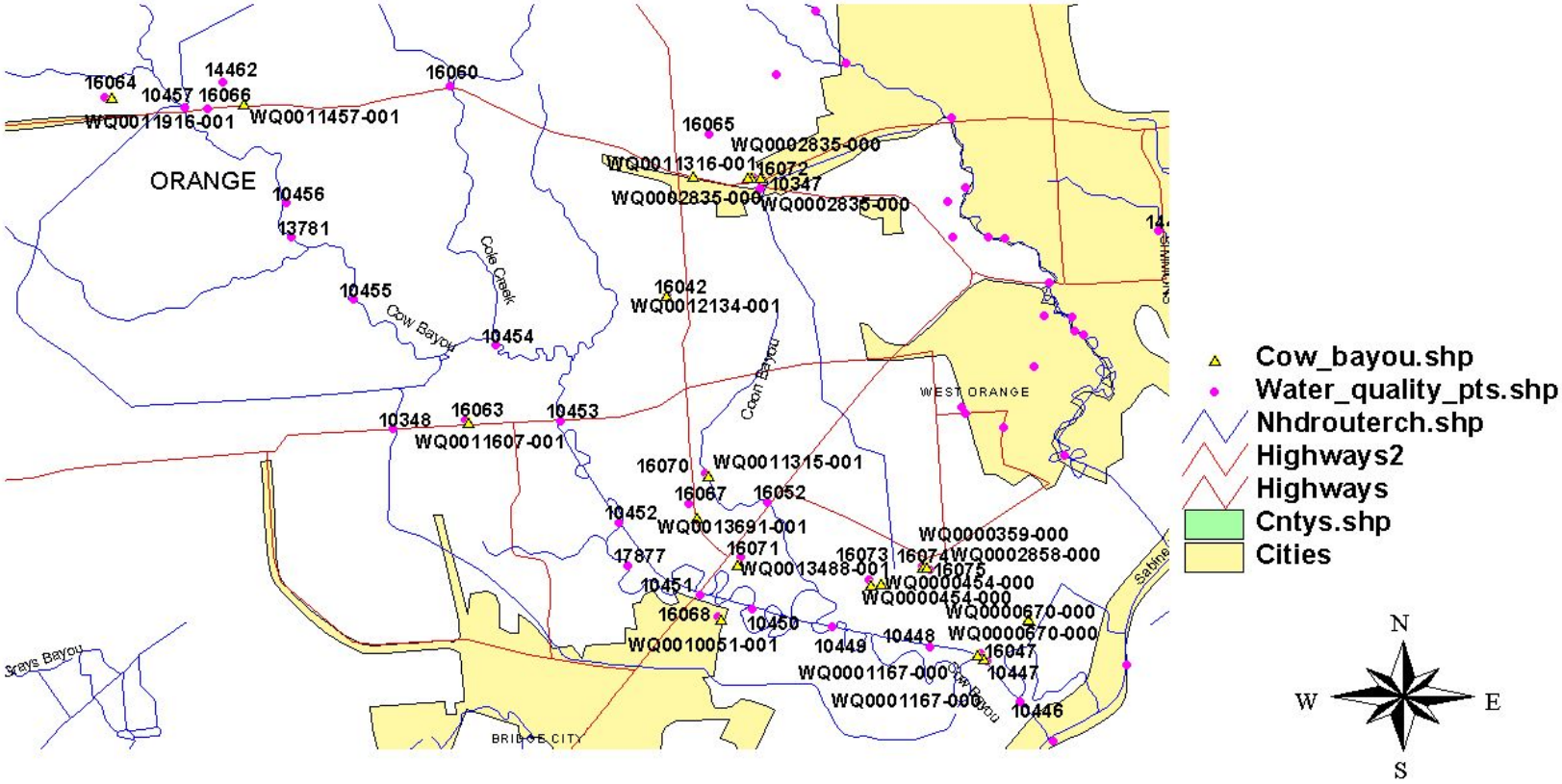
Site Description

Cow Bayou originates in Jasper County and flows southeast to its confluence with the Sabine River just upstream of Sabine Lake. The tidally-influenced portion, Cow Bayou Tidal, is defined by the Texas Surface Water Quality Standards (TSWQS) as Segment 0511, and is the subject of this review. Cow Bayou Tidal begins just upstream of IH-10 and ends at the confluence with the Sabine River. It lies mostly within the boundaries of Orange County. The lower part of Cow Bayou Tidal was channelized in the early 1950's for navigation, leaving numerous side channels and oxbows. The upper portion of its watershed is densely forested and relatively lightly populated. The lower portion is home to the communities of Bridge City and Orange. According to data from the TCEQ Regulatory Activities and Compliance System (TRACS), Segment 0511 receives wastewater at twenty outfalls representing fifteen facilities (Table 1, Figure 1). Note: permit number WQ0010808-001 is omitted from the map since the outfall is located in Jasper County far north of the study area. Four outfalls described as "sample" or "retention" were also not mapped, since presumably these are not discharged to surface water. The Orangefield oil field lies in the watershed of the stream .

Table 1. List of permitted outfalls for Segment 0511.

Permit No.	Category	Handling Method	Name of Permittee
WQ0000359-000	Industrial	Discharge	Chevron Phillips
WQ0000454-000	Industrial	Discharge	Bridgestone Firestone Inc.
WQ0000454-000	Industrial	Discharge	Bridgestone Firestone Inc.
WQ0000670-000	Industrial	Discharge	Honeywell Inter.
WQ0000670-000	Industrial	Discharge	Honeywell Inter.
WQ0001167-000	Industrial	Discharge	Bayer Corporation
WQ0001167-000	Industrial	Discharge	Bayer Corporation
WQ0002835-000	Industrial	Discharge	Texas Polymer Services
WQ0002835-000	Industrial	Discharge	Texas Polymer Services
WQ0002835-000	Industrial	Discharge	Texas Polymer Services
WQ0002858-000	Industrial	Discharge	PrintPack Inc.
WQ0002858-000	Industrial	Sample	PrintPack Inc.
WQ0010051-001	Public Domestic	Discharge	City of Bridge City
WQ0010051-001	Public Domestic	Sample	City of Bridge City
WQ0010808-001	Private Domestic	Discharge	Jasper Co. WCID #1
WQ0011315-001	Private Domestic	Discharge	Bayou Pines Park
WQ0011316-001	Private Domestic	Retention	Oak Leaf Mobile Home Park
WQ0011316-001	Private Domestic	Sample	Oak Leaf Mobile Home Park
WQ0011457-001	Private Domestic	Discharge	TxDOT/Orange Co. Comfort Station
WQ0011607-001	Public Domestic	Discharge	Orangefield ISD
WQ0011916-001	Private Domestic	Discharge	PCS Dev./Park View
WQ0012134-001	Public Domestic	Discharge	SRA #1
WQ0013488-001	Private Domestic	Discharge	Gulflander/Sunrise East Apts.
WQ0013691-001	Private Domestic	Discharge	Blacksher Dev./Waterwood Estates

Figure 1. Wastewater outfalls (yellow triangles) and SWQM stations (purple dots) on Cow Bayou Tidal



Water Quality Standards

Water quality standards include designated uses for a water body, specific numerical criteria for certain water quality parameters, and narrative criteria. The Texas Surface Water Quality Standards (TSWQS) are set by the TCEQ and approved by the USEPA. The TCEQ has established aquatic life uses and associated criteria for all waters of the state. The numeric criterion for dissolved oxygen is a surrogate or indirect measure of whether the aquatic life use is being maintained. Adequate dissolved oxygen is necessary for a healthy aquatic community. Most aquatic organisms become stressed if oxygen levels below about 2 mg/l persist for very long.

The designated uses for Cow Bayou Tidal, Segment 0511, are contact recreation and high aquatic life use (Texas Natural Resource Conservation Commission 2000b: 30 TAC §307.10(1)). The dissolved oxygen criteria for a tidal water body with a high aquatic life use are: daily average 4 mg/l, and daily minimum 3 mg/l (30 TAC §307.7(b)(3)(A)(i)). The daily average is evaluated as a minimum average across 24 hours. Since most data collected at fixed monitoring stations are instantaneous measurements, direct comparison to the 24-hour criteria is not possible. For Cow Bayou, 4.0 mg/l is used as the single measurement screening level to evaluate whether the high aquatic life use is being met (TNRCC, 1999). The dissolved oxygen criteria only apply in the "mixed surface layer," which in tidally-influenced water bodies is defined as "the portion of the water column from the surface to the depth at which the specific conductance is 6,000 umhos/cm greater than the specific conductance at the surface" (TNRCC, 1999). However, the TSWQS at 30 TAC 307.9(c)(3)(C) also specify that a composite sample from the mixed surface layer be used to determine standards attainment when stratification is caused by temperature (density stratification).

Review of Previous Studies

TCEQ's predecessor agencies conducted two intensive surveys of Cow Bayou Tidal, one in 1982 and one in 1986 (Kirkpatrick 1985, 1988). Data collection efforts focused on hydrology, field water quality measurements, and water chemistry (lab analyses for several parameters). Fourteen stations were sampled, twelve of which were within the designated boundaries of Cow Bayou Tidal (Segment 0511). One of the remaining stations was in Cow Bayou upstream of the tidal segment, and the other was in the Sabine River just below the confluence with Cow Bayou Tidal. No biological sampling was undertaken for either survey. Both surveys noted low dissolved oxygen levels in the upper portion of Cow Bayou Tidal (from IH-10 to just below the confluence with Cole Creek). The 1982 study attributed that condition to natural phenomena, namely the sluggish hydrology of the stream, since no major wastewater discharges occur in the upper portion of the bayou. The 1986 study found similar results, with low dissolved oxygen conditions present in approximately the same reach of stream. The 1986 study included measurements of primary productivity and sediment oxygen demand, made to better characterize the cause of the low dissolved oxygen. Results of the study indicated that sediment oxygen demand was highest and primary productivity was lowest in the area affected by low dissolved oxygen. The study's author concluded that these factors, in addition to the narrow sluggish configuration of the stream, were major contributors to low dissolved oxygen and all factors were attributable to natural conditions.

In 1987 TPWD River Studies staff conducted a fisheries use attainability study for Cow Bayou, in conjunction with a use attainability analysis being prepared by Texas Water Commission (predecessor to TCEQ) staff. Apparently the UAA was never completed, but the results of the fisheries survey are available in a River Studies report (Linam and Kleinsasser 1987). Four stations, all within the boundaries of Segment 0511, were sampled for habitat, field water quality parameters, and fish. Seining and gill netting were used to sample the fish community. Data tables summarizing the species and numbers samples are displayed in Appendix A at the end of this document. Results of the fish collections were evaluated using a number of methods, including the calculation of species diversity, index of similarity, and condition factor; and the evaluation of species richness, number of pollution intolerant species, proportion of the population comprised of pollution tolerant individuals, proportion of diseased fish, and trophic structure. Results were also compared to the Index of Biotic Integrity (IBI; Karr et al. 1986). The station furthest upstream (IH-10) was rated "good" based on Karr's IBI. The other three stations (Hwy. 87, Round Bunch Road, and Sabine River confluence) were all ranked "fair" to "good." The authors concluded that Cow Bayou Tidal holds the potential for a diverse and healthy fish community.

The Sabine River Authority conducted a special water quality study on Cow Bayou which was published in 1999. The study surveyed nine sites on Cow Bayou or its tributaries (including four sites upstream of tidal influence) and 15 wastewater treatment plant outfalls. Stream sites and some of the wastewater discharge sites were sampled quarterly for field water quality and water samples collected for lab analyses of several parameters. Field water quality and fecal coliform bacteria were measured weekly after each quarterly sampling event at those sites for a total of five consecutive weeks. Sampling was also conducted during significant rainfall events following spells of dry weather. Additional dissolved oxygen readings were taken at selected stream sites within two hours of sunrise and near midnight. Vertical salinity profiles were made at selected sites, and ambient toxicity samples were collected at three sites. Flow was measured at small tributaries to Cow Bayou. Black Bayou in Louisiana was used as a reference stream to which the water quality measurements were compared. A rapid bioassessment based on

fish collections was performed at three of the sites which are upstream of the tidally-influenced portion of Cow Bayou. Little Cow Creek (Newton County) was used as a reference stream for the rapid bioassessment.

Results from the dissolved oxygen measurements showed low dissolved oxygen conditions at one site in the upper portion of Cow Bayou Tidal (CB4 – FM 1442 north crossing). During rainfall events, additional sites in the upper portion of Cow Bayou Tidal exhibited low dissolved oxygen conditions. The report's authors attributed most of the oxygen problems to nonpoint source pollution "such as on-site septic systems and other human activities." Measurements taken near sunrise indicated very low dissolved oxygen conditions at a site further downstream (Round Bunch Road), where average dissolved oxygen values were generally not a problem.

The rapid bioassessment found that the fish community had an Index of Biotic Integrity between intermediate and limited (Karr et al. 1986). The report's authors stated, "The results from the main-stem indicate biological conditions are well below what should be present in the stream." Dissolved oxygen criteria were met during three out of four seasonal sampling events at only five of the nine sites sampled for the study. At one of the other four sites, the criterion was not met during any of the four sampling events. Separately, nine sites were sampled near sunrise to evaluate critical minimum values. The dissolved oxygen measurements ranged from 0.19 to 3.22 mg/l.

The introduction to the study states, "Tidal waterbodies typically have limited assimilative capacity, because of low flows and high dissolved solids. These conditions are made worse by the Subwatershed's high turbidity due to a heavy clay substrate and a large amount of detritus from the deciduous trees common in the area." The study's authors concluded that dissolved oxygen in Cow Bayou is naturally limited by the tidal nature of the system and turbidity, but is also being impacted negatively by point and nonpoint sources. In comparing the dissolved oxygen data to Black Bayou, they found that extreme lows in dissolved oxygen were not typically present there, even following rainfall events. There the mean value was 6.3 mg/l and was less than 4 mg/l only once out of 31 sampling events. The study's authors attribute much of the nonpoint source pollution in the Cow Bayou watershed to on-site wastewater treatment systems which they say are inadequate for the soil type and amount of rainfall in the area, and advocate a regional wastewater treatment system.

There is no historical SWQM data in the TRACS database on Lost River, the reference stream for Cow Bayou Tidal. Lost River has not been sampled by TPWD's River Studies Team.

Review of Water Quality Data

Water quality data from the Surface Water Quality Monitoring (SWQM) portion of TRACS was reviewed for the period of record. The focus was on dissolved oxygen measurements, since low oxygen is the reason this water body was suspected to be impaired. The data used in the assessment to list Cow Bayou Tidal as impaired for dissolved oxygen was also reviewed separately.

2000 303(d) Listing of Cow Bayou Tidal

Cow Bayou Tidal was listed in 2000 for not meeting the aquatic life use. The procedures for evaluating surface water data to determine whether uses and criteria were being met is described in "2000 Guidance for Screening and Assessing Texas Surface and Finished Water Quality Data." Under this guidance, dissolved oxygen data from the five-year period of record (1994 -1999) was compared to the criterion, to determine whether the aquatic life use was being met. Two types of data could be used to assess use support – instantaneous or routinely collected data and 24-hour or intensively collected data. With instantaneous data, at least nine values were required to evaluate whether the criterion was being met, with use being fully, partially, or not met based on the percentage of measurements not meeting the instantaneous screening level (4.0 mg/l in the case of Cow Bayou Tidal). With 24-hour data, at least five sets of measurements were required to evaluate whether the criterion was being met. Use attainment was evaluated based on the percentages of means and minimum values from those data sets which met the average and minimum criteria established under the TSWQS.

For the 2000 assessment, 208 dissolved oxygen measurements from four stations were evaluated; from upstream to downstream these were: station 10457 (IH 10), station 13781 (FM 1442 north crossing), station 10453 (FM 105), and station 10449 (FM 1442 downstream crossing/Round Bunch Road). See Figure 1 for locations of stations (purple dots). All were instantaneous measures of dissolved oxygen. Table 2 summarizes the results of the assessment.

Table 2. Summary of Dissolved Oxygen Data and Violations of Criteria Assessed for the 2000 Water Quality Inventory and 303(d) List.

Station ID	Mean D.O. (mg/l)	N	No. Violations	(%)
10457	4.0	23	12	52
13781	3.8	50	29	58
10453	4.3	71	31	44
10449	5.5	64	15	23

Unlike the Intensive Surveys of the 1980s, these data revealed low dissolved oxygen conditions throughout the water body (not just in the upstream portion). However there were higher percentages of violations of the criterion in the two upstream stations (52% and 58% of the measurements in 10457 and 13781, respectively), which are located in the part of Cow Bayou which historically has had low dissolved oxygen.

Cow Bayou was also assessed as not supporting the contact recreation use due to elevated fecal coliform densities, and only partially supporting general uses in the upper 14 miles of the segment, due to low pH values.

Summary of SWQM TRACS Historical Data

A raw data report of all SWQM data on Cow Bayou Tidal (Segment 0511) was obtained for the period of record ending with June 21, 2002. Over the period of record, water quality data has been collected at 13 different stations on Segment 0511. The two stations which have been most frequently monitored over time are Station ID 10449 (FM 1442 downstream crossing) and Station ID 10453 (FM 105). The data set begins in 1969 and monitoring took place somewhere on Segment 0511 at least once every year since then, and frequently on a monthly basis.

Mixed surface layer D.O. measurements

Since dissolved oxygen (D.O.) is the parameter of most concern for this study, an analysis was made of instantaneous D.O. measured at 0.3 meters or less from the surface (to approximate the mixed surface layer). Data collected between 5:00 and 9:00 a.m., which approximates the critical early morning period, was removed from the analysis. The mean D.O. for the remaining 439 measurements was 5.72 mg/l, and values ranged from 0.62 to 12.1 mg/l. Figure 2 shows the mean D.O. and standard deviations for these data by station. From FM 105 downstream D.O. values generally remain high. Upstream of FM 105 depressed D.O. can be seen. For all four stations between IH-10 and FM 105, the mean D.O. is below 4 mg/l. D.O. averages above 4 mg/l at all other stations.

Critical early morning

The data set contained only 34 measurements collected from 5:00 to 9:00 a.m. The mean of the 34 values was 4.32 mg/l, and the values ranged from 0.43 to 9.6 mg/l. Figure 3 depicts the mean (and standard deviations where more than one value was available) for these measurements at the various stations.

Vertical profiles

Summarizing vertical profile data can be difficult since data were collected at different depths each sampling trip, depending on the maximum depth at the sampling location that day. However, examining individual profiles of D.O. and specific conductivity generally shows an inverse relationship. Figure 4 depicts a profile at Station 10446, which is the TCEQ sampling station closest to the confluence with the Sabine River. The water column is well-mixed, and dissolved oxygen is stable throughout the water column. Figure 5 depicts temperature and dissolved oxygen for the same profile. Temperature remained constant throughout the water column. Figure 6 shows a profile at the same station, but when density stratification exists. Specific conductivity increases from around 6000 umhos/cm near the surface to over 17,000 umhos/cm at 5 meters depth. Over the same vertical distance, dissolved oxygen drops from 7 mg/l to near 4 mg/l. Figure 7 shows temperature, again very stable. Figures 8 and 9 show specific conductivity with dissolved oxygen, and temperature with dissolved oxygen, respectively, at Station 10453, about mid-way up the segment. Figures 10 and 11 show the same parameters for a different profile at the same station. In both profiles the water column does not exhibit density stratification, but shows a fairly dramatic decrease in dissolved oxygen as depth increases. In these cases it appears that there is some (probably short-term) stratification of dissolved oxygen. Decreased dissolved oxygen at depth could be due to a variety of factors, including increased photosynthetic oxygen production in the upper portion of the water, increased sediment oxygen demand adjacent to the bottom waters, or a combination of both. Figures 12, 13, 14, and 15 show similar graphs for two representative profiles at Station 13781, one of the farthest upstream stations. The water column appears fairly well-mixed, but a discernable inverse relationship

between specific conductivity and dissolved oxygen appears to exist. This would be typical of tidal streams, based on physical characteristics of surface water.

Dissolved Oxygen Measurements Over Time

Data from the mixed surface layer (measured at 0.3 meters or less from the surface) and collected anytime other than the critical early morning period (5:00 – 9:00 a.m.) were examined from the three stations which had the most measurements over time. These were Stations 10449 (246 measurements), 10453 (78), and 13781 (41). Mean D.O. was plotted over time for Station 10449 (Figure 16), Station 10453 (Figure 17), and Station 13781 (Figure 18).

Twenty-four Hour Data

The data set included three sampling events for 24-hour measurements of dissolved oxygen and other field parameters. Table 3 depicts the results of these events made at Station 13781.

Table 3. Summary of 24-hour measurements made on Cow Bayou Tidal, Station 13781.

Date	Depth (m)	Mean D.O. (mg/l)	Min. D.O. (mg/l)	Max. D.O. (mg/l)
5/18/2001	0.70	0.85	0.7	1.08
8/3/2001	1.00	1.21	1	1.81
8/29/2001	0.70	1.6	1.2	2.4

Effects of Nutrients, Suspended Solids, and TOC on Dissolved Oxygen

TRACS data were requested for sampling events where nutrients (ammonia, nitrate, phosphate), total suspended solids (TSS) and total organic carbon (TOC) were measured along with dissolved oxygen. A significant amount of these data were available for Station 10449. Each water quality parameter was charted versus dissolved oxygen. A Pearson correlation was run for each pair of variables, with the assumption that dissolved oxygen was the dependent variable.

Dissolved oxygen appeared to decline as TSS increased (Figure 19). This relationship was significant (see Table 4). Dissolved oxygen also decreased as TOC increased (Figure 20). There was no significant correlation between ammonia and dissolved oxygen (Figure 21). Dissolved oxygen decreased as phosphate increased (Figure 22). There was no significant relationship between nitrate and dissolved oxygen (Figure 23).

Table 4. Pearson correlations.

	TSS	TOC	NH4	PO4	NO3
Correlation coefficient (r)	- 0.269*	-0.227*	-0.108	-0.206*	0.056
Sample size	74	119	154	175	64

r : used to quantify the strength of the association between the variables. While positive r values indicate both increase together, negative r values indicate a negative relationship

*: p values < 0.05, hence one variable can be used to predict the other variable.

Figure 2. Mean Surface (<=0.3 m) Dissolved Oxygen Measurements for Period of Record By Station ID Number (Mean +/- Std. Dev.)

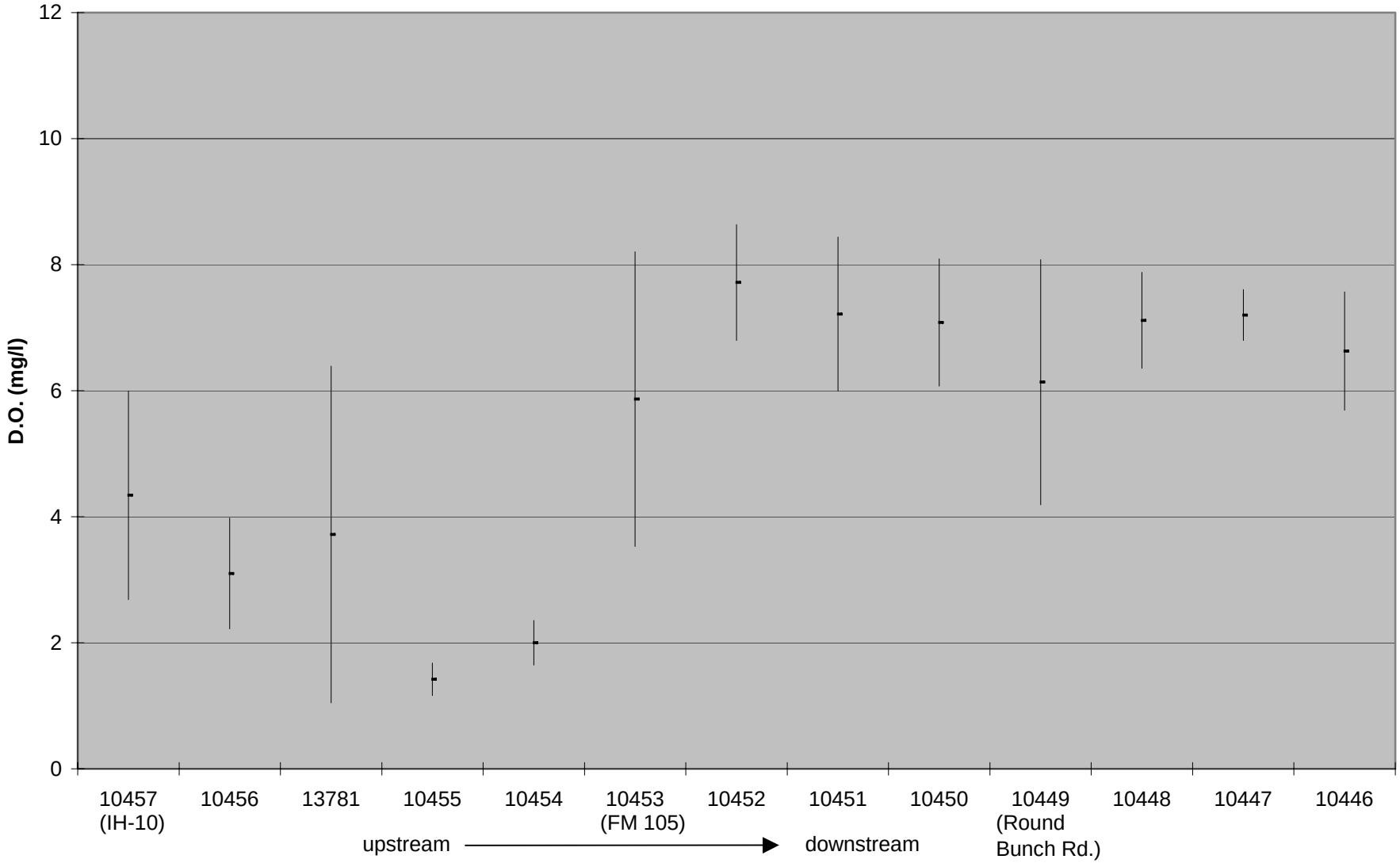


Figure 3. Mean Surface (<= 0.3 m) Dissolved Oxygen Measurements in Early Morning (5-9 a.m.) for Period of Record in Cow Bayou Tidal by Station ID Number (Mean +/- Std. Dev.) N = 34

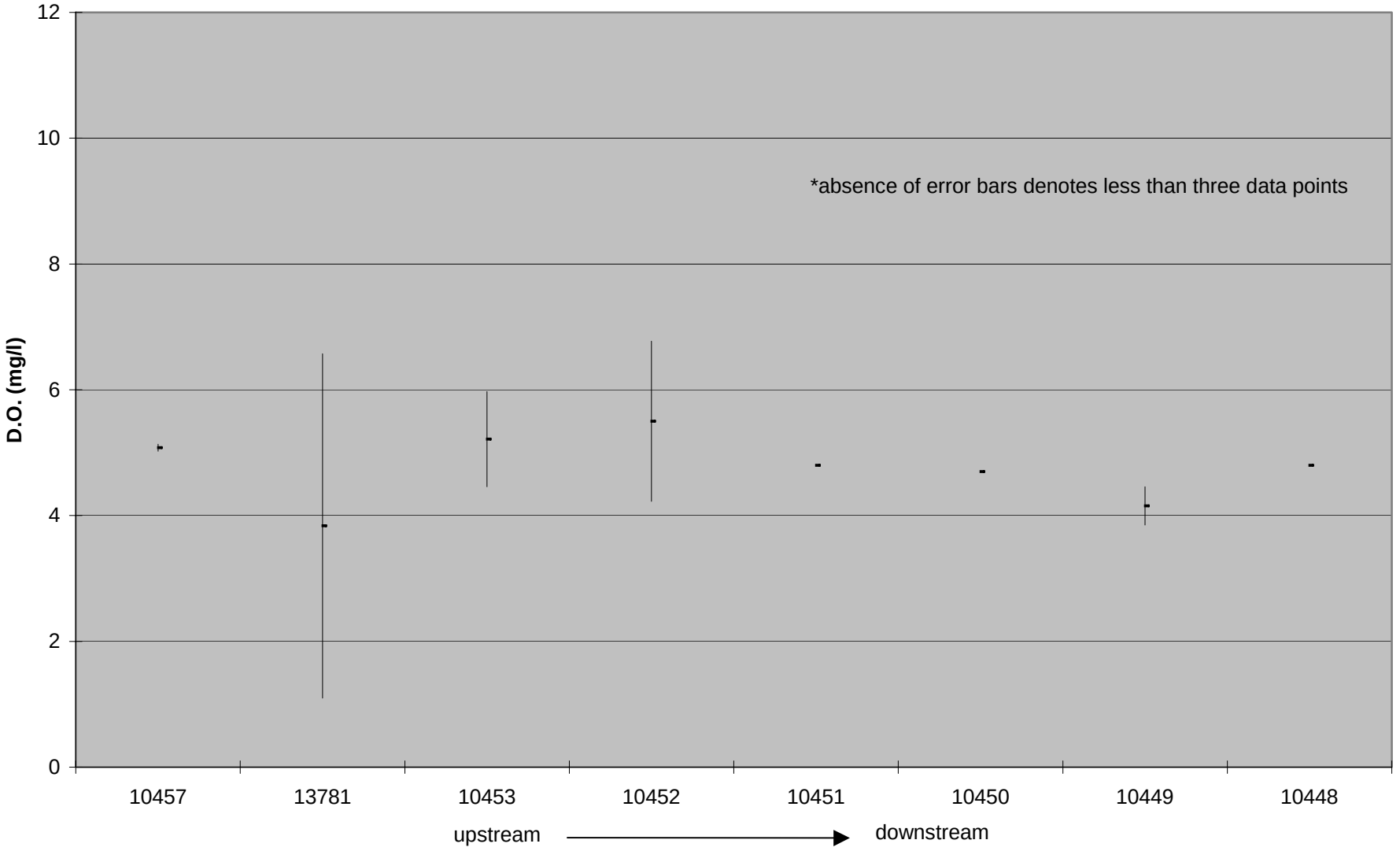


Figure 4. Cow Bayou Station 10446: Dissolved oxygen and conductivity on 9/10/86 at 4:56 p.m.

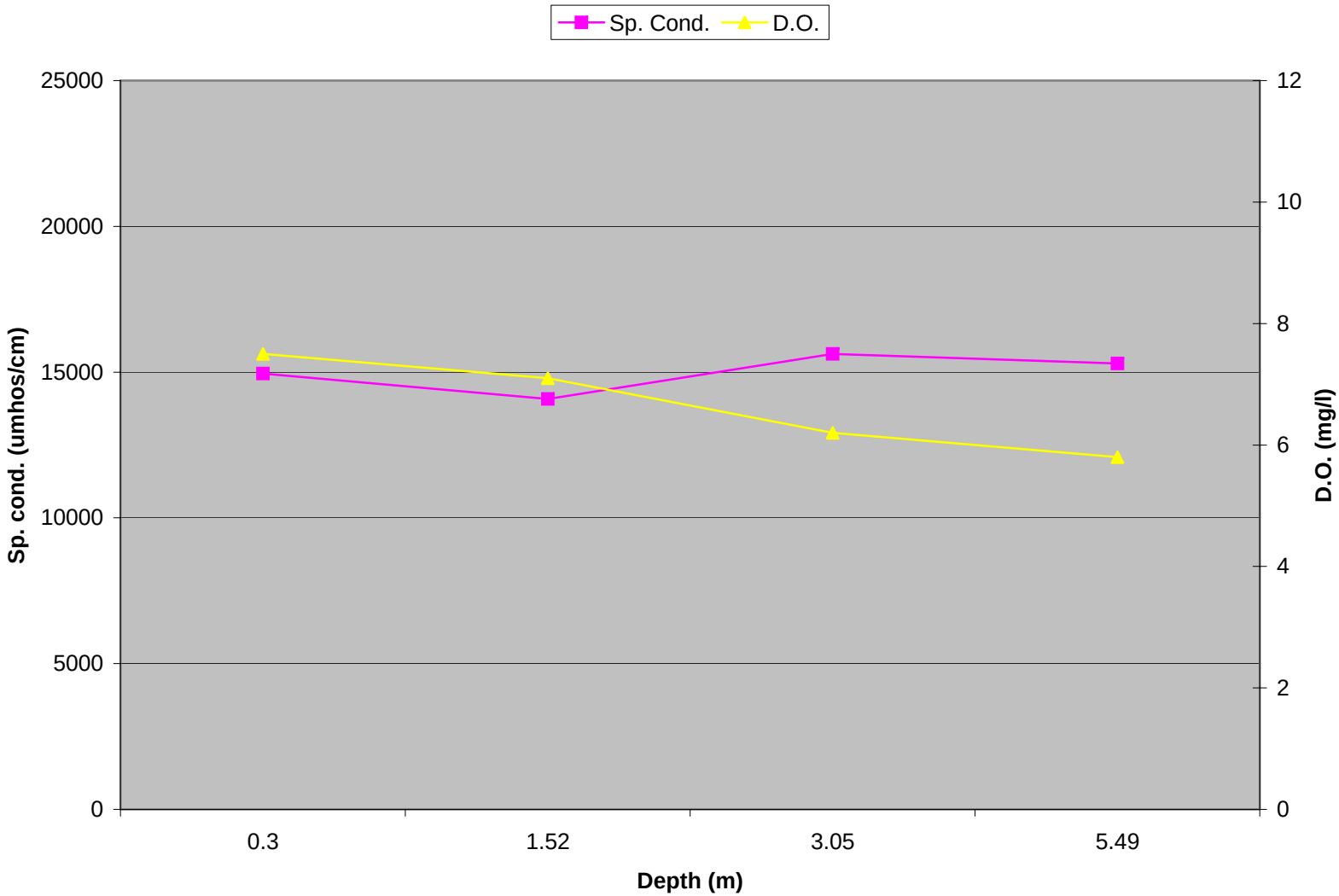


Figure 5. Cow Bayou Station 10446: Dissolved oxygen and temperature on 9/10/86 at 4:56 p.m.

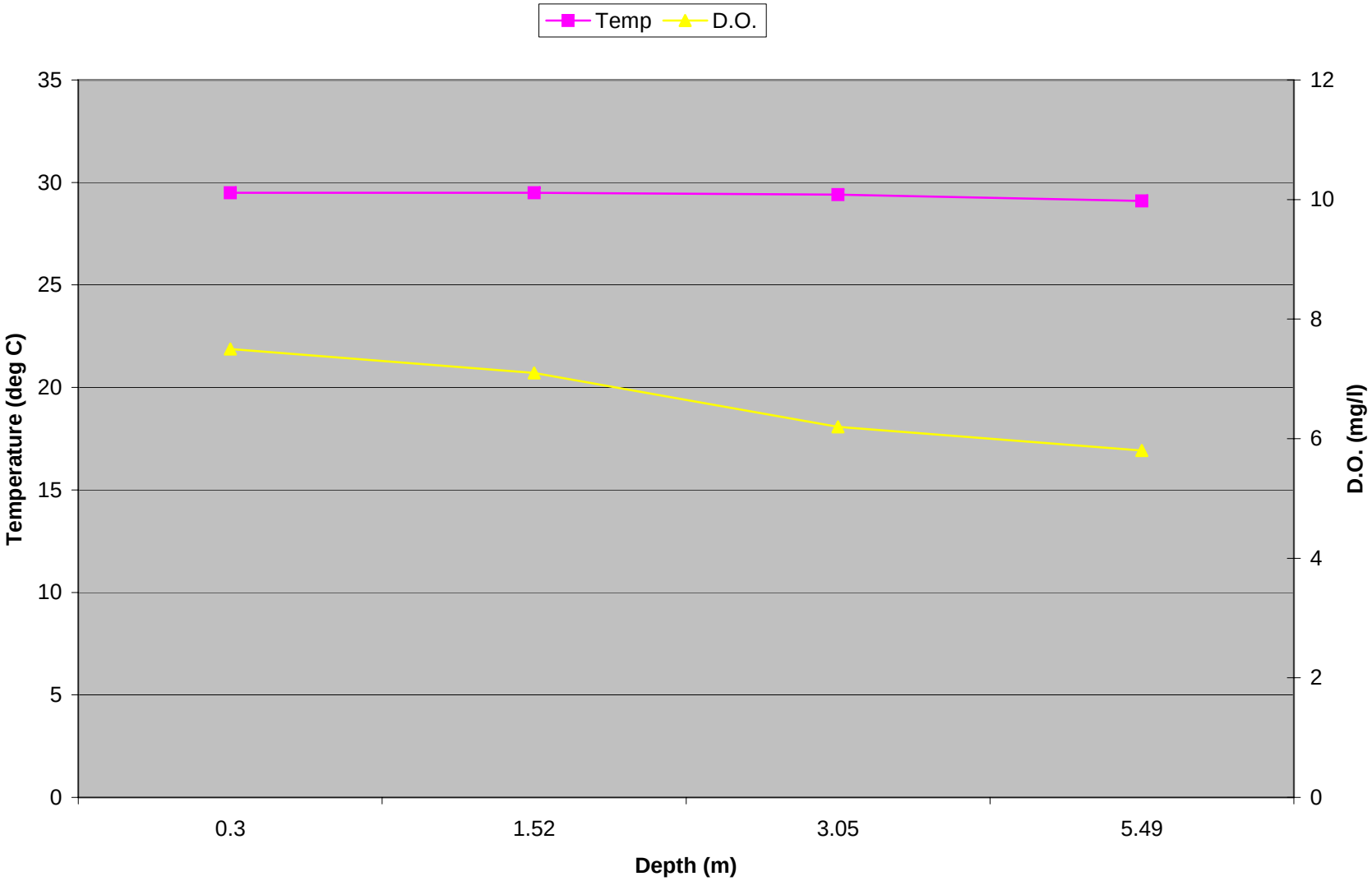


Figure 6. Cow Bayou Station 10446: Dissolved oxygen and conductivity on 8/31/82 at 4:42 p.m.

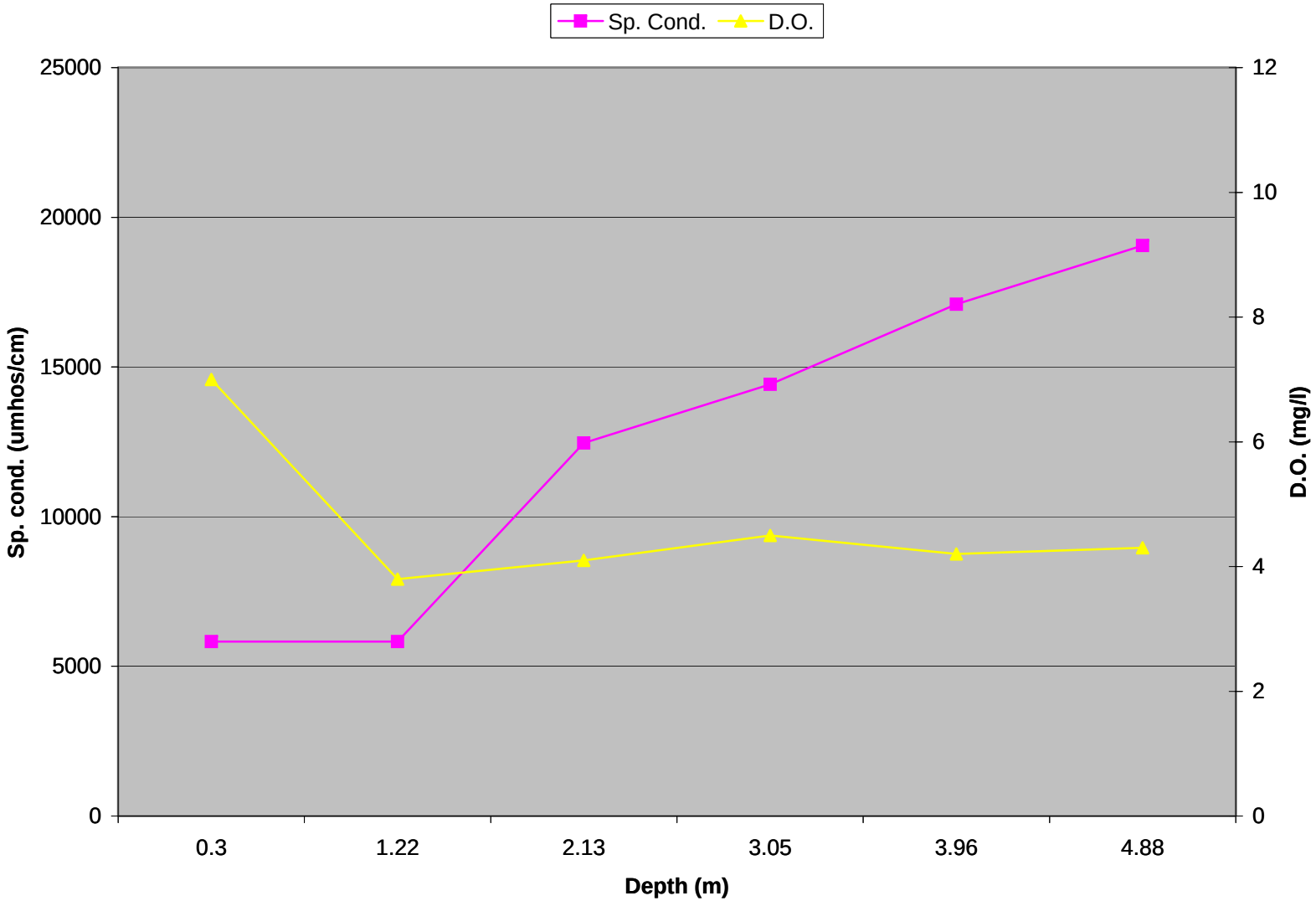


Figure 7. Cow Bayou Station 10446: Dissolved oxygen and temperature on 8/31/82 at 4:42 p.m.

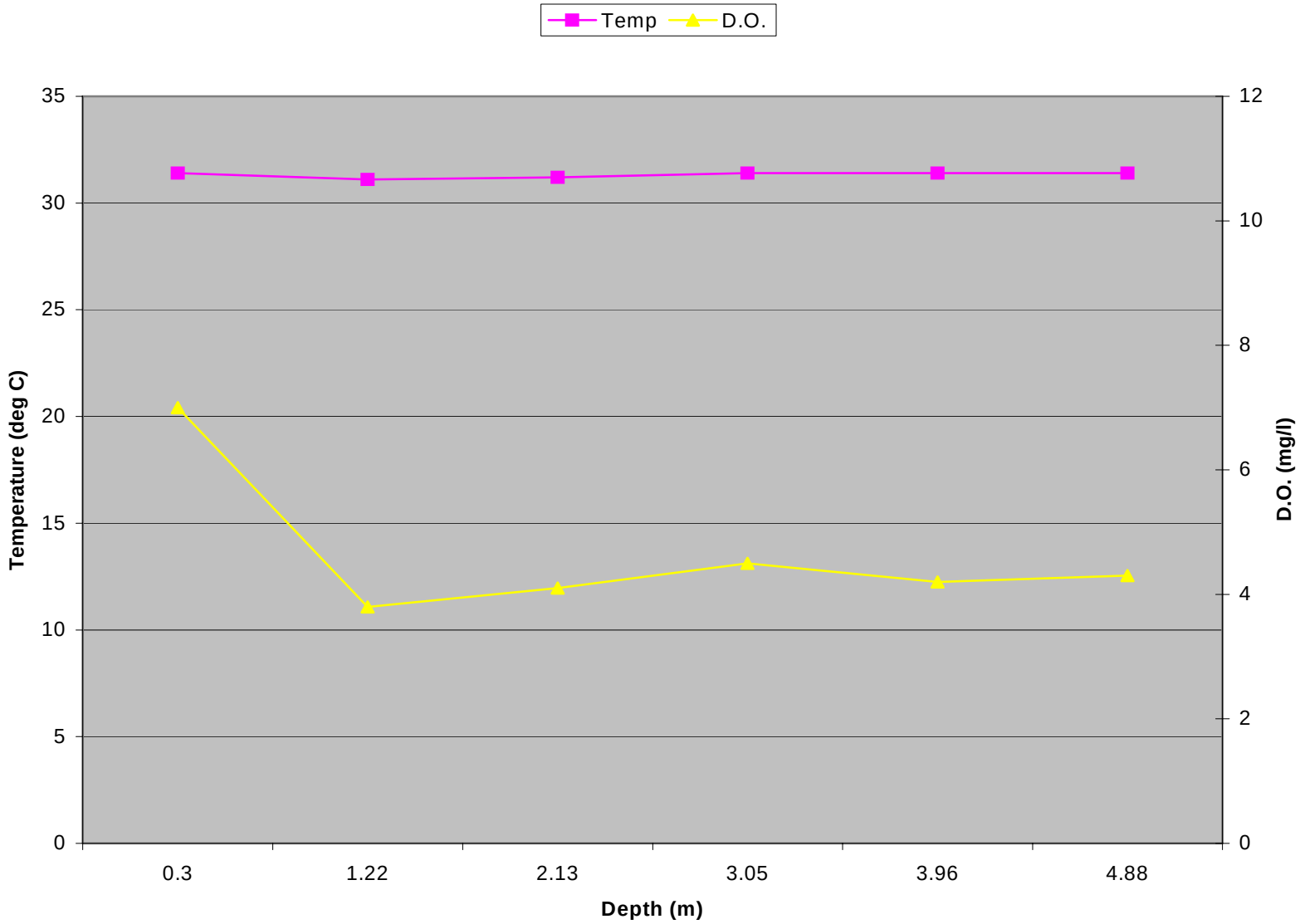


Figure 8. Cow Bayou Station 10453: Dissolved oxygen and conductivity on 11/15/84 at 1:23 p.m.

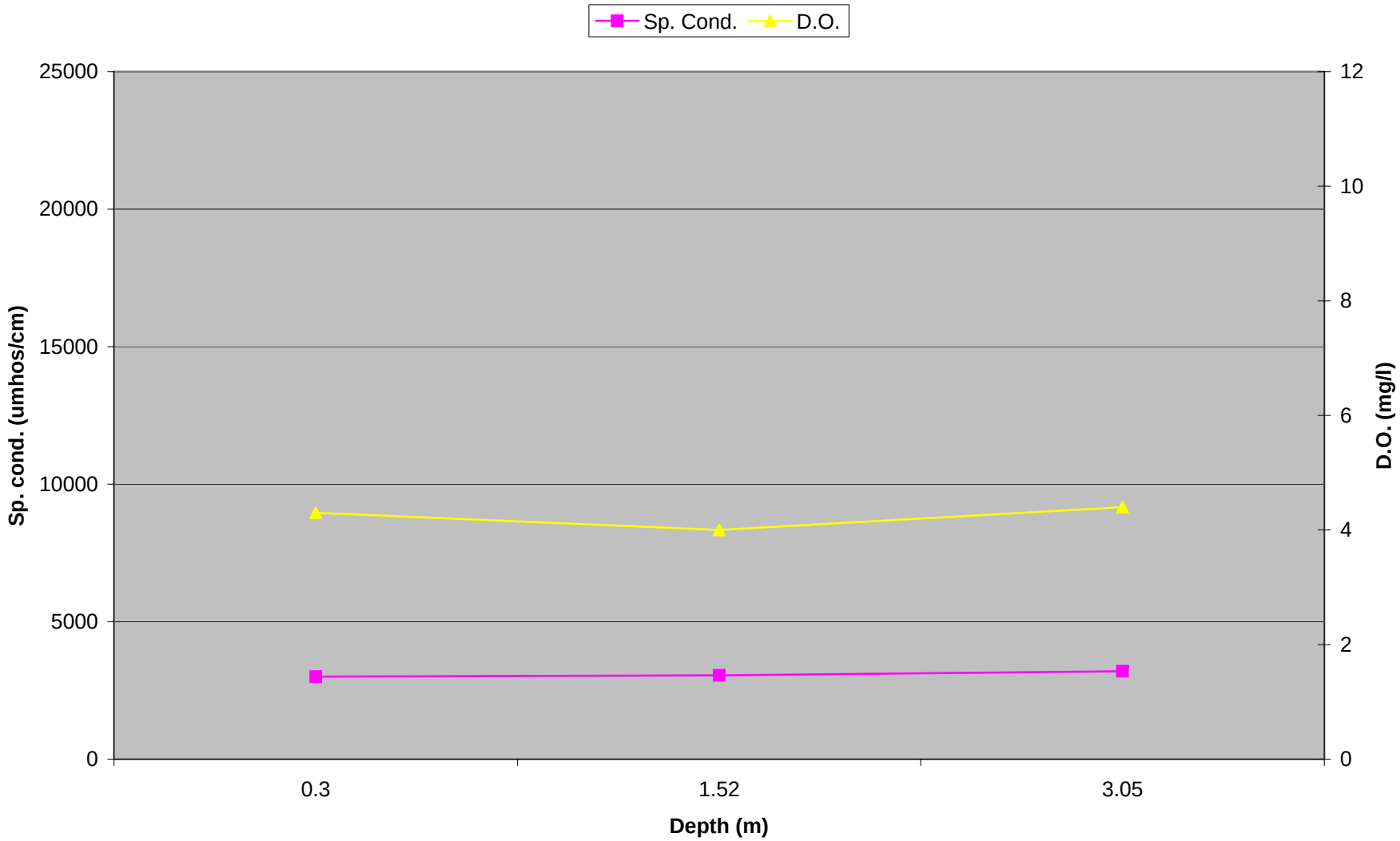


Figure 9. Cow Bayou Station 10453: Dissolved oxygen and temperature on 11/15/84 at 1:23 p.m.

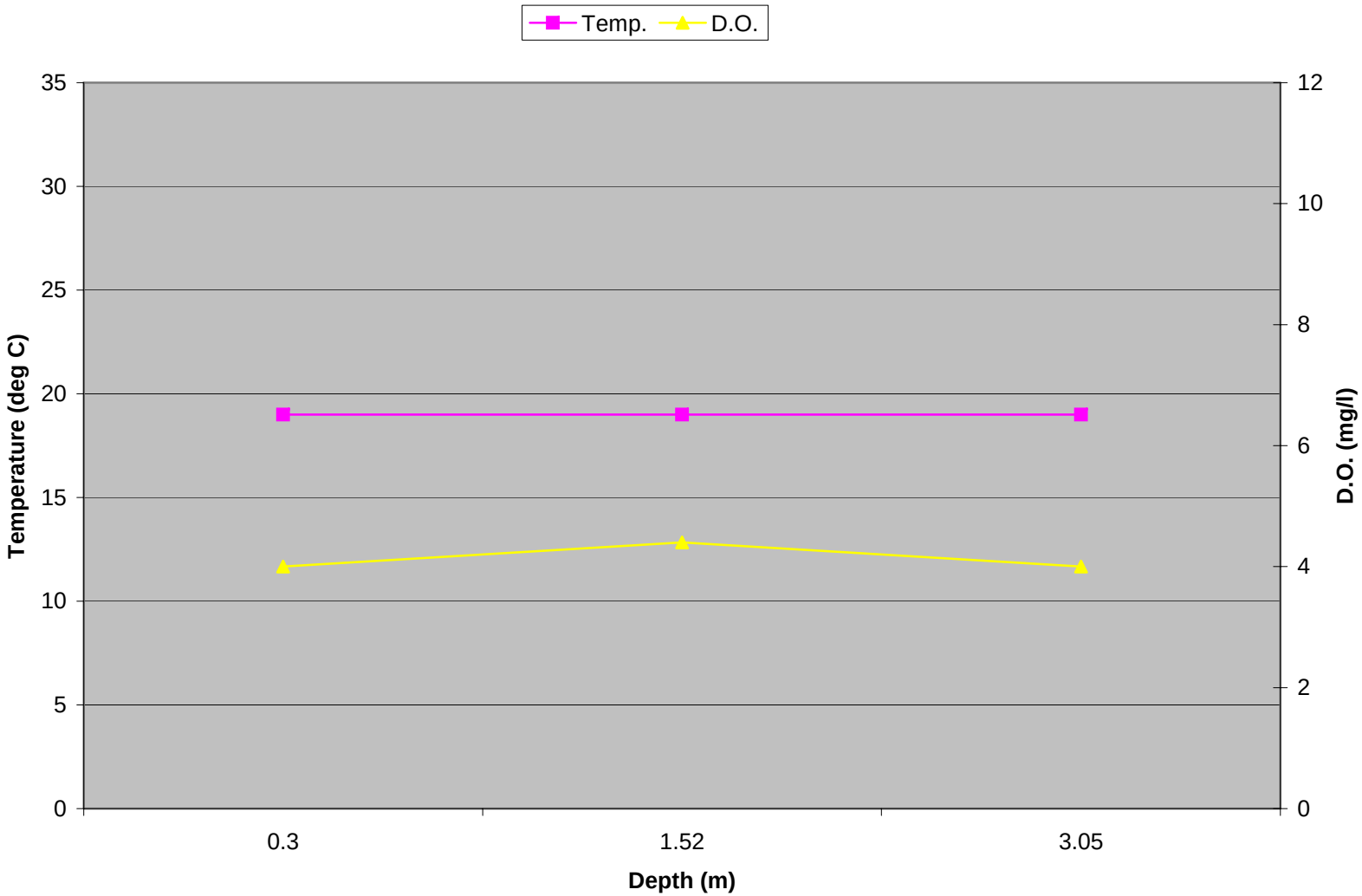


Figure 10. Cow Bayou Station 10453: Dissolved oxygen and conductivity on 11/14/83 at 1:50 p.m.

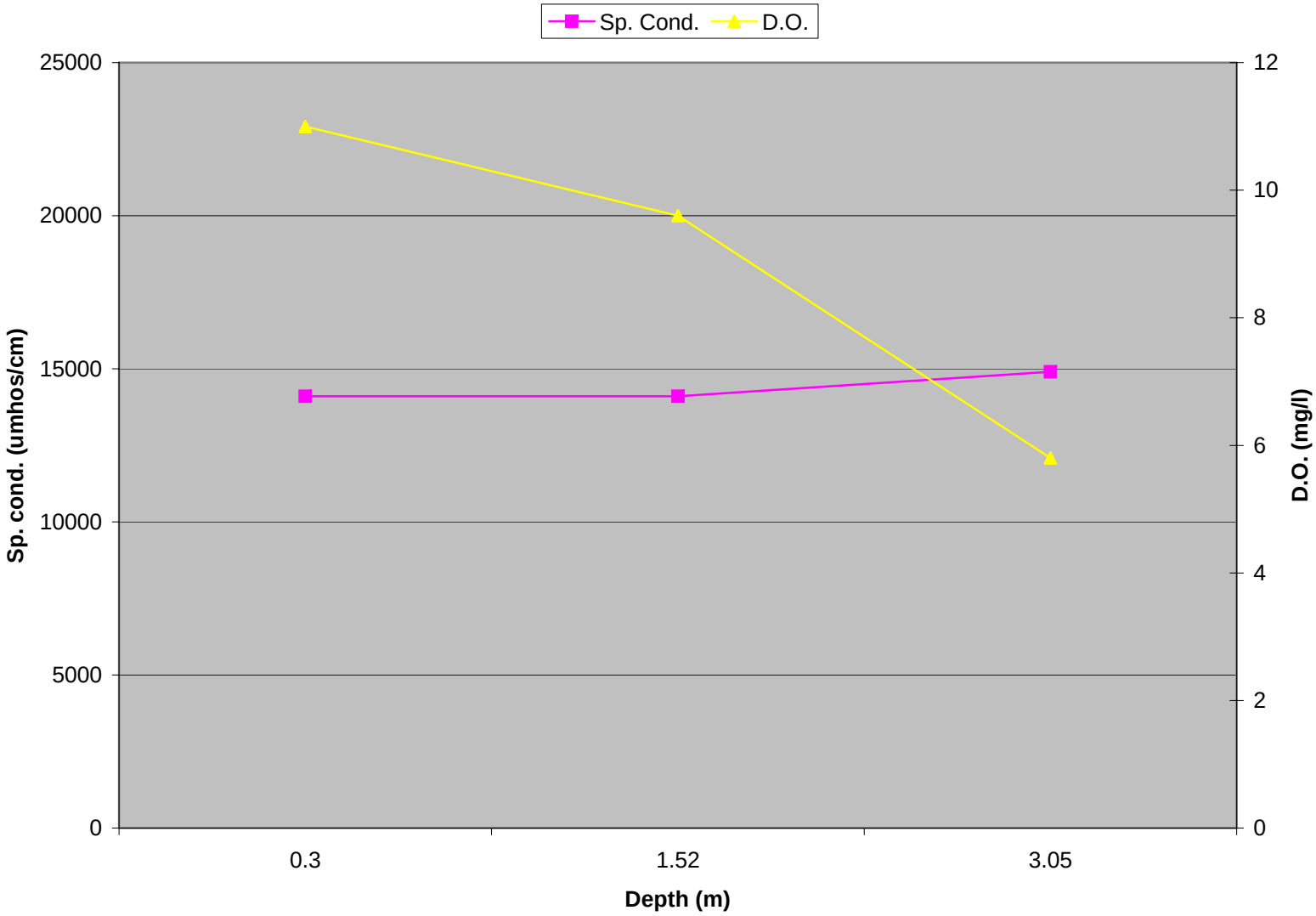


Figure 11. Cow Bayou Station 10453: Dissolved oxygen and temperature on 11/14/83 at 1:50 p.m.

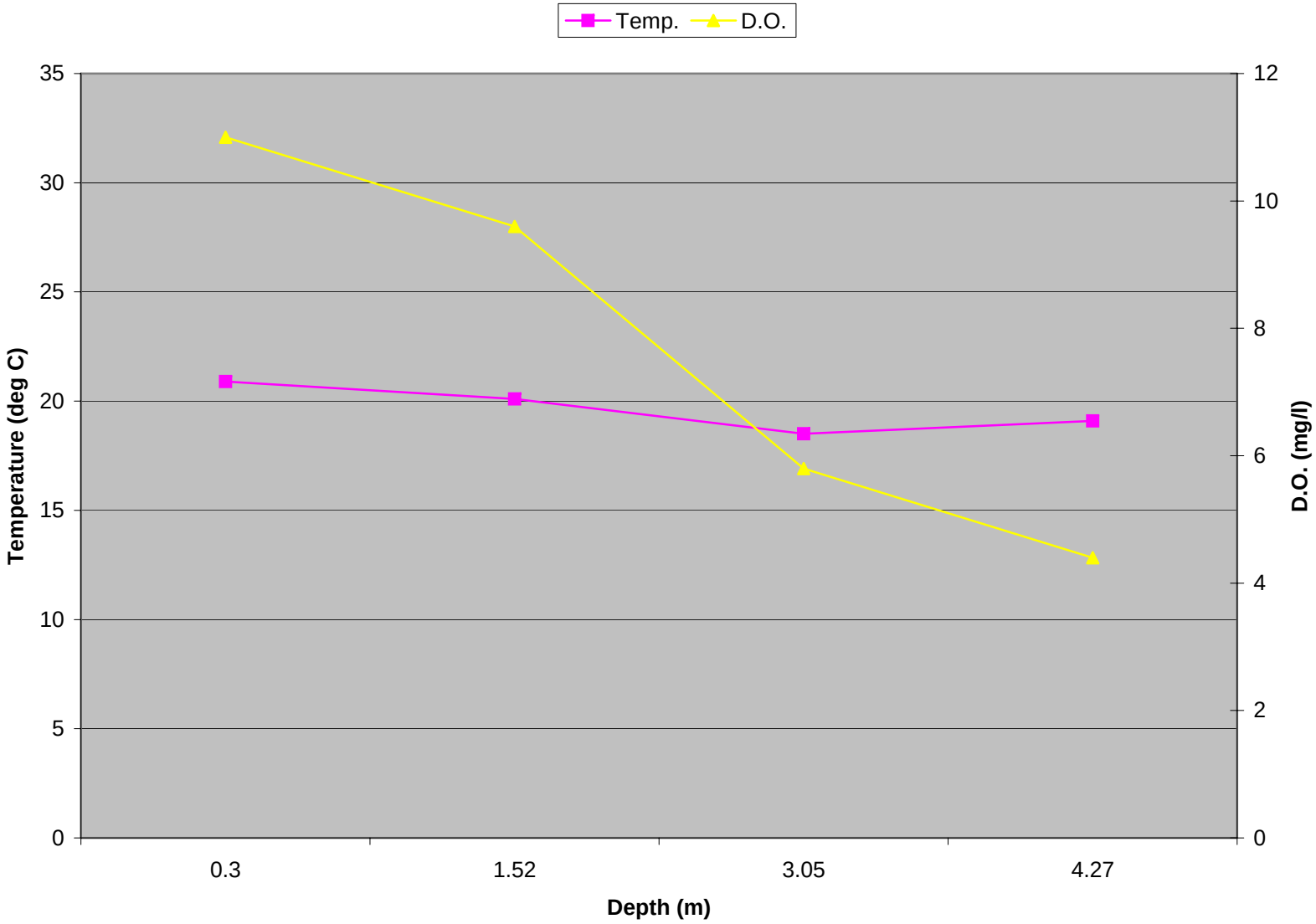


Figure 12. Cow Bayou Station 13781: Dissolved oxygen and conductivity on 9/23/93 at 11:20 a.m.

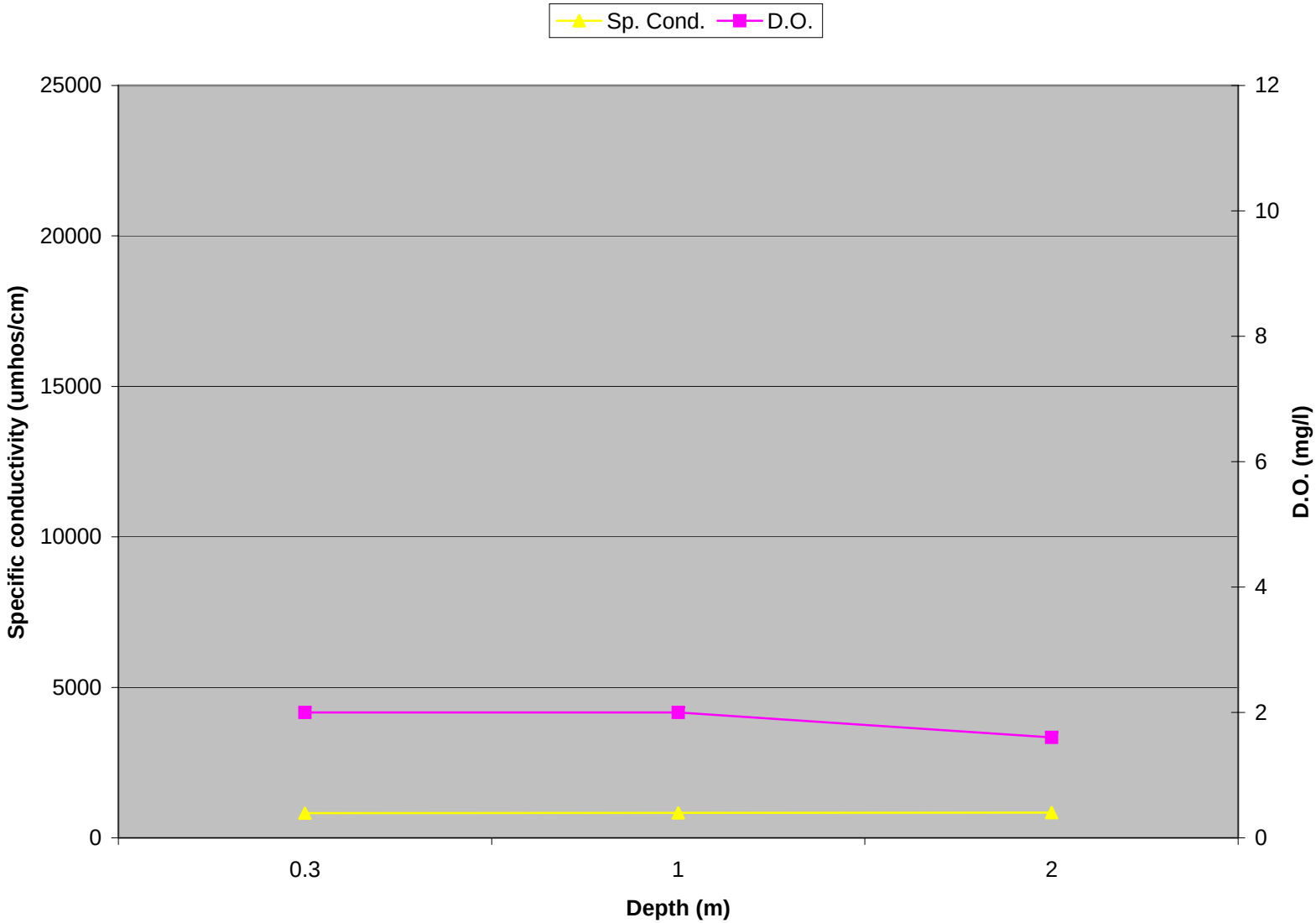


Figure 13. Cow Bayou Station 13781: Dissolved oxygen and temperature on 9/23/93 at 11:20 a.m.

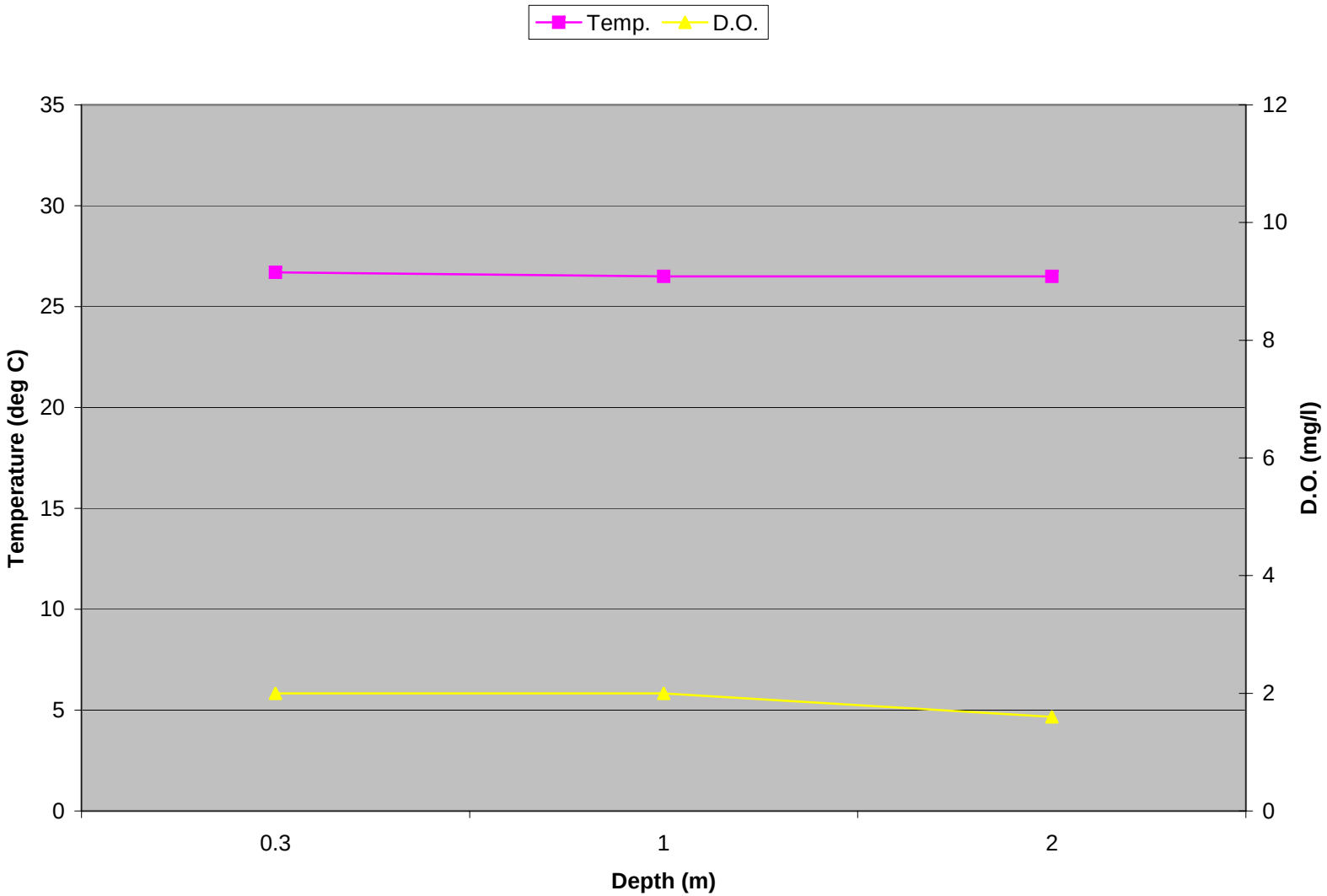


Figure 14. Cow Bayou Station 13781: Dissolved oxygen and conductivity on 11/9/98 at 8:19 a.m.

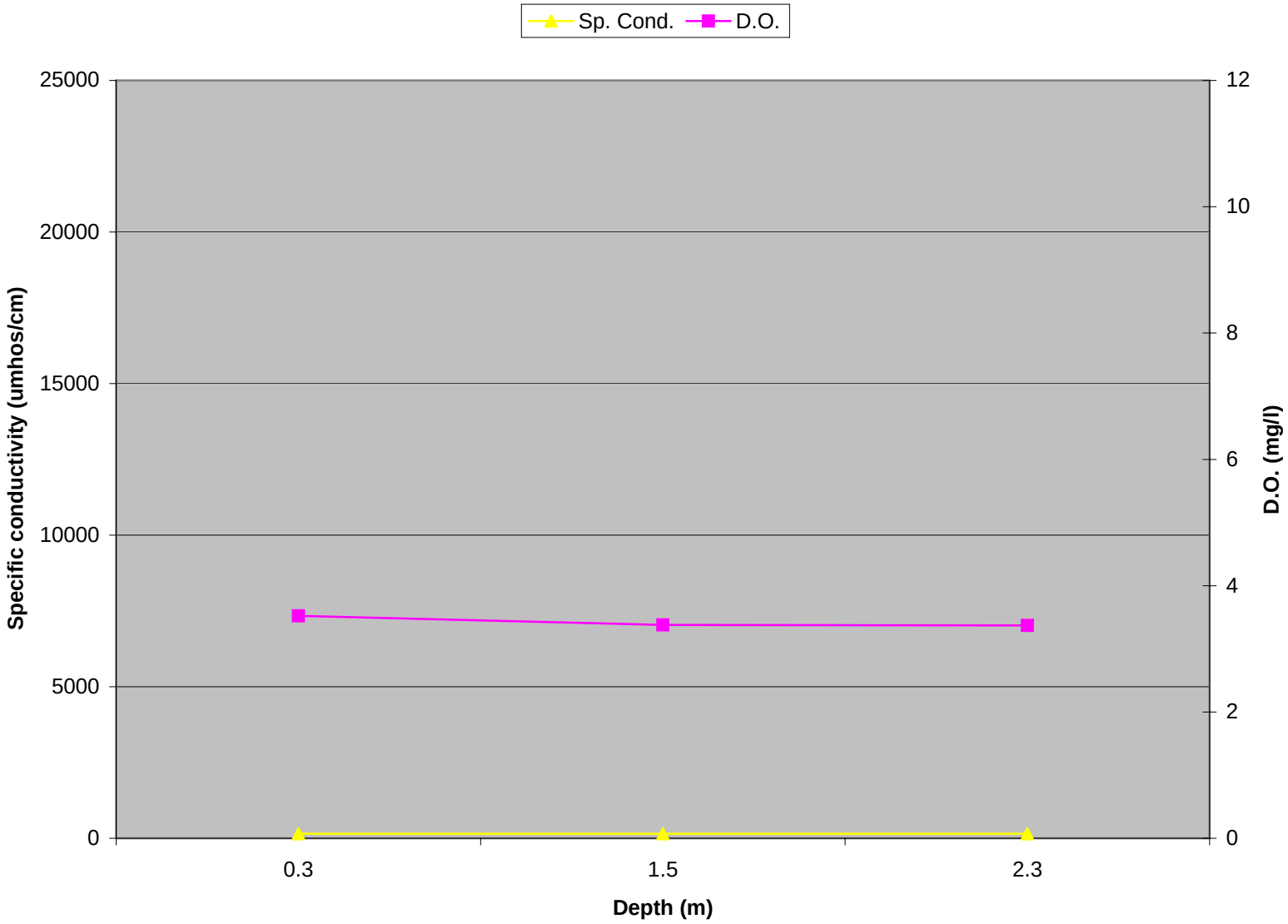


Figure 15. Cow Bayou Station 13781: Dissolved oxygen and temperature on 11/9/98 at 8:19 a.m.

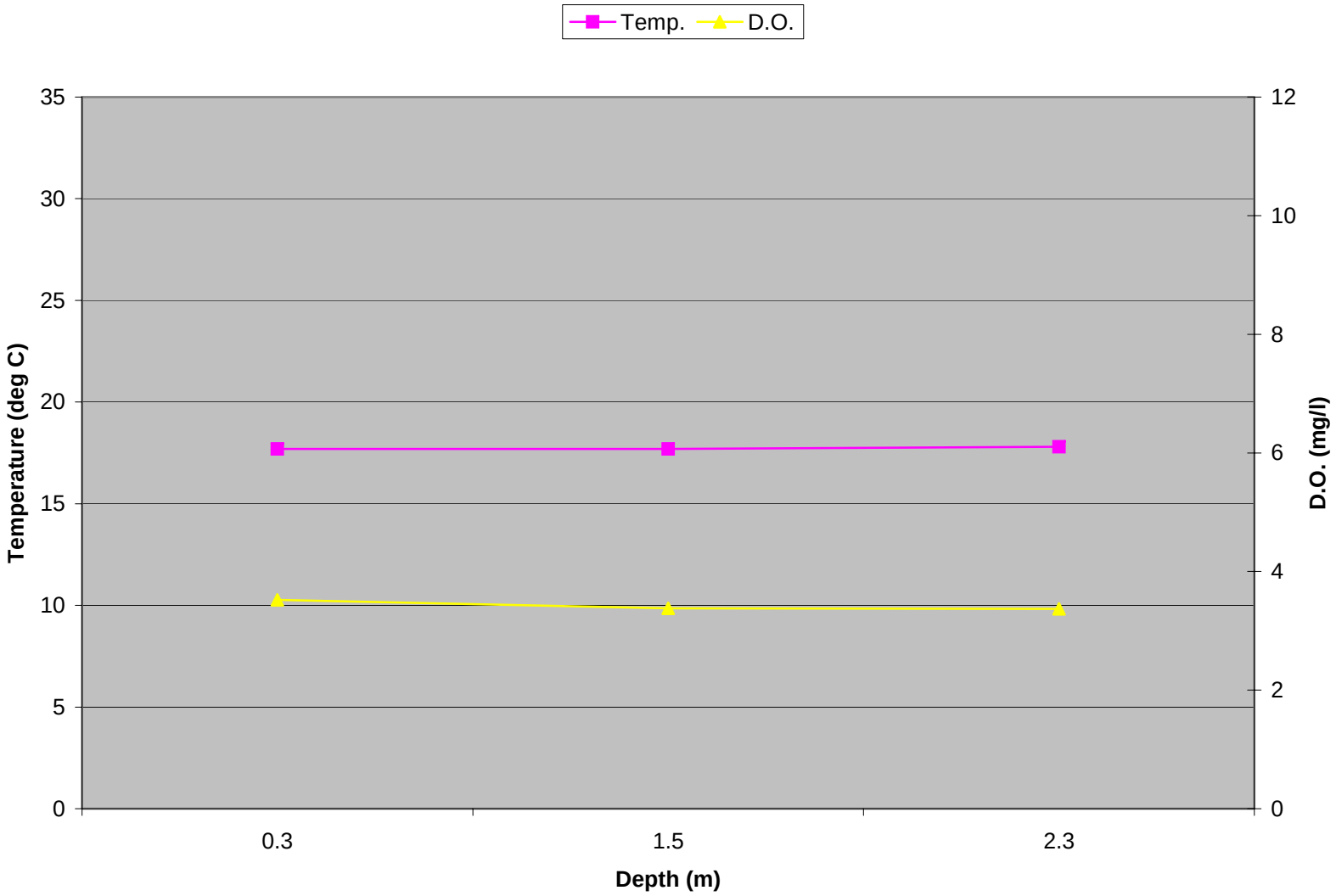


Figure 16. Mean Dissolved Oxygen at Cow Bayou Station 10449 (+/- Std. Dev.)
N = 246

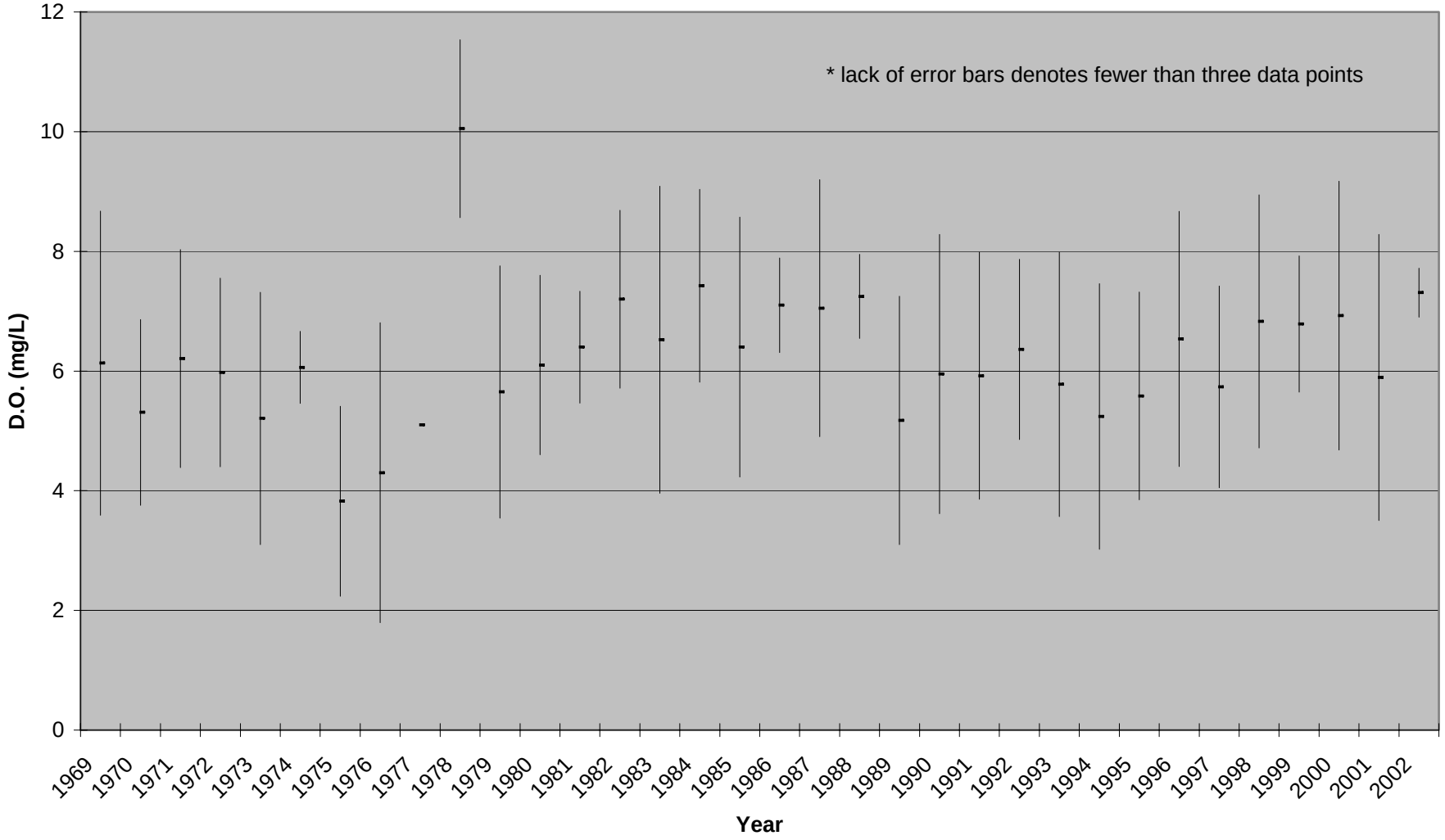


Figure 17. Mean Dissolved Oxygen at Cow Bayou Station 10453 (+/- Std. Dev.)
N = 78

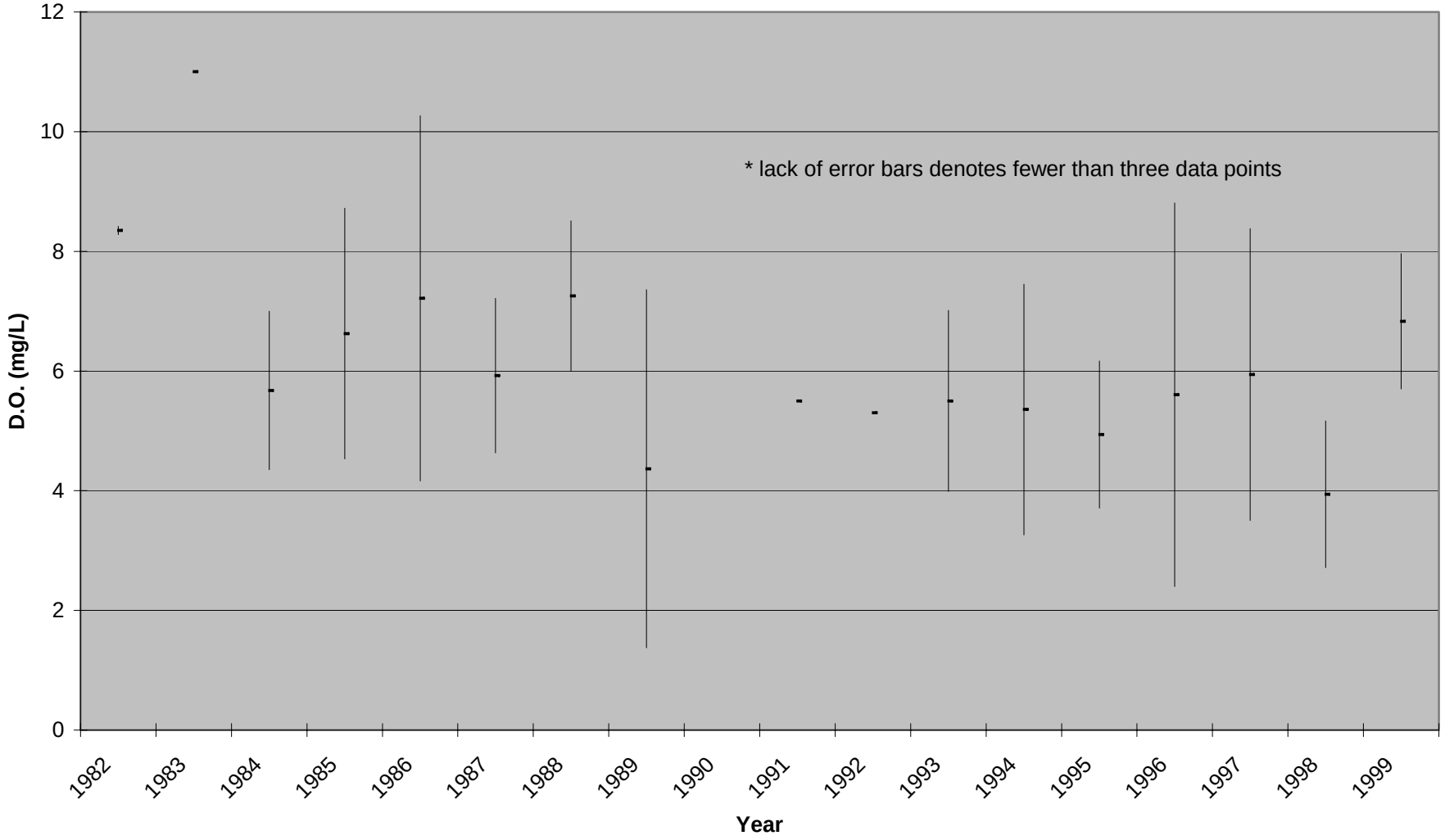


Figure 18. Mean Dissolved Oxygen at Cow Bayou Station 13781 (+/- Std. Dev.)
N = 41

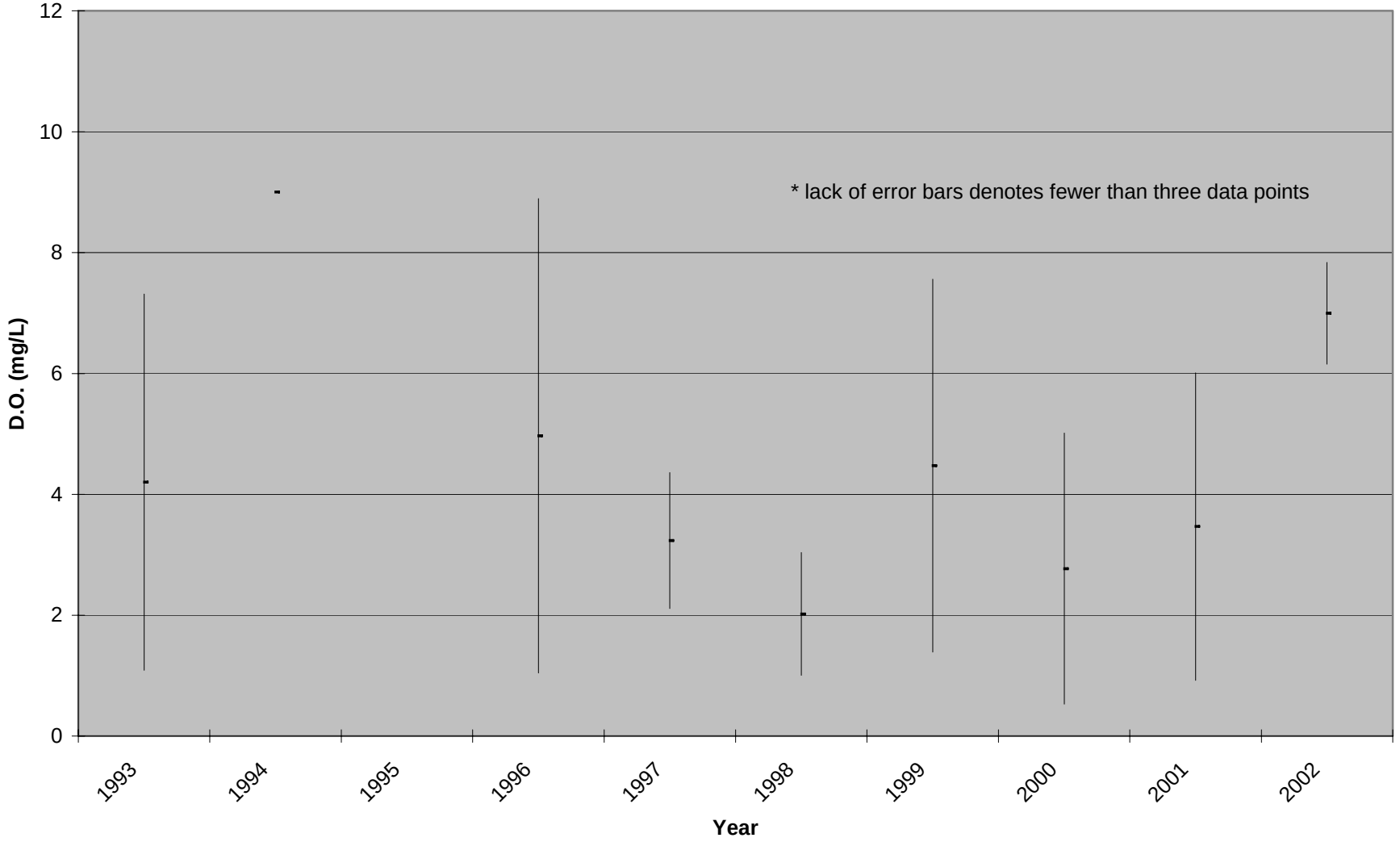


Figure 19. TSS vs. DO at Cow Bayou Station 10449

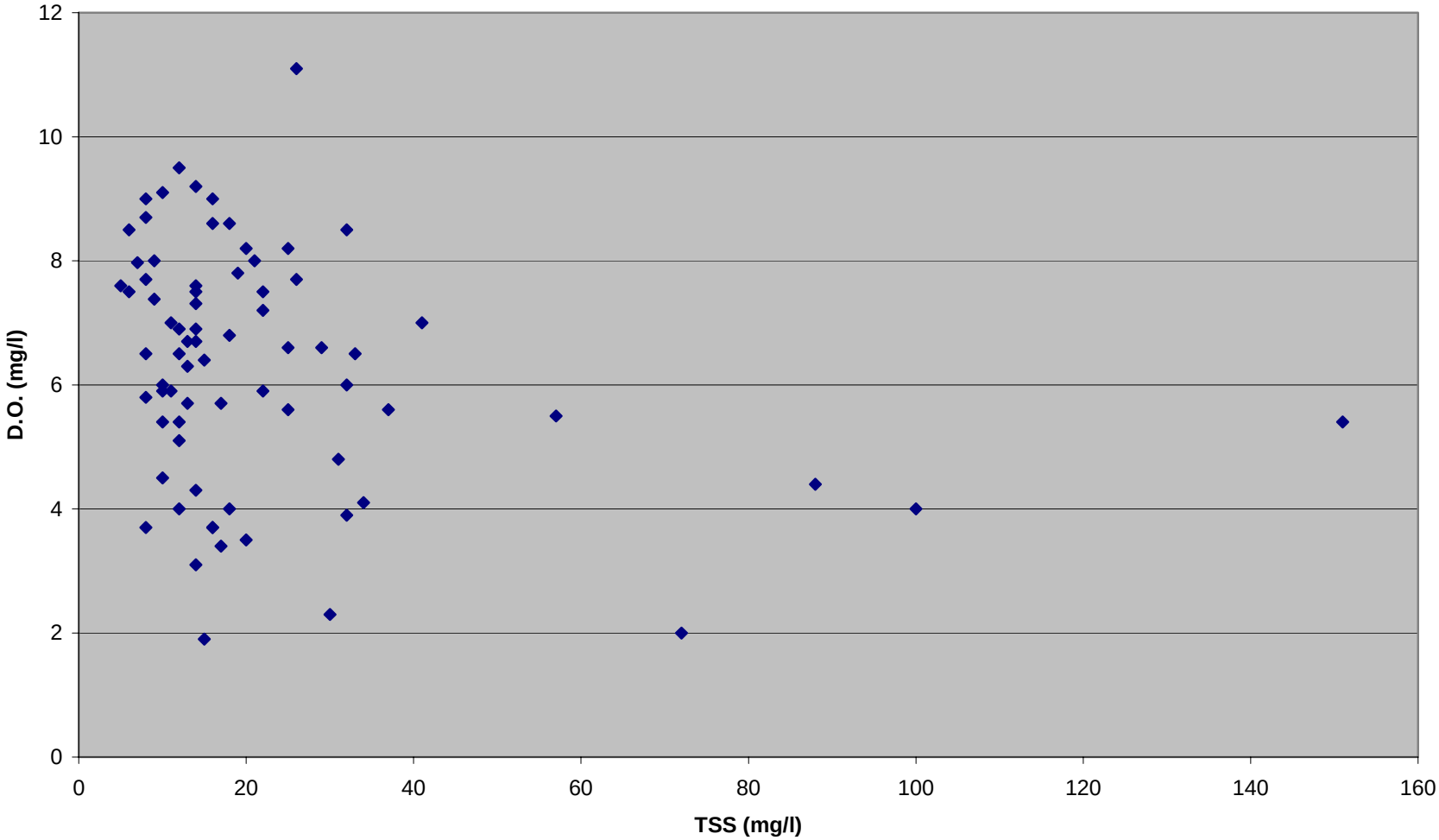


Figure 20. TOC vs DO on Cow Bayou Tidal Station10449

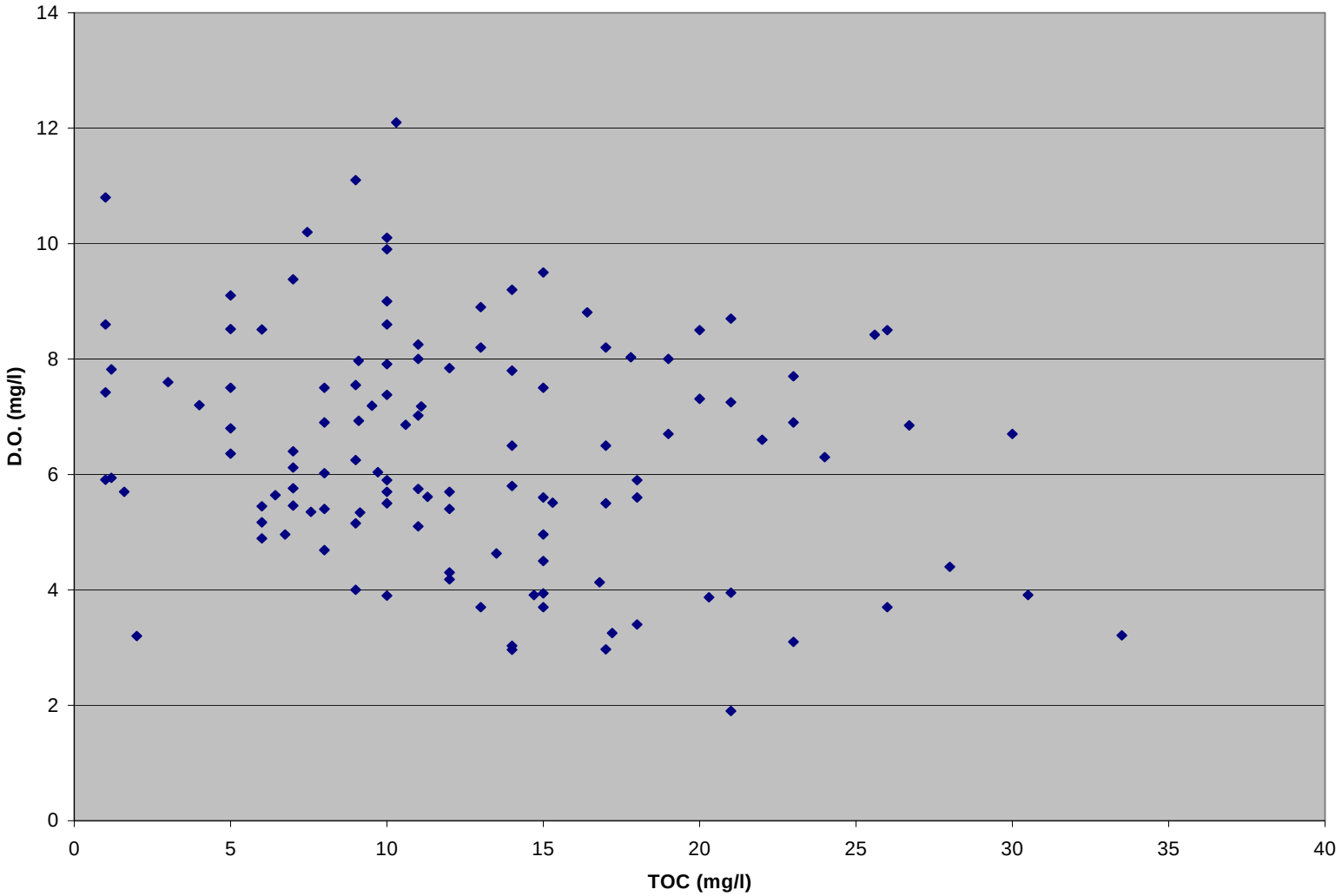


Figure 21. Ammonia vs. DO at Cow Bayou Tidal Station 10449

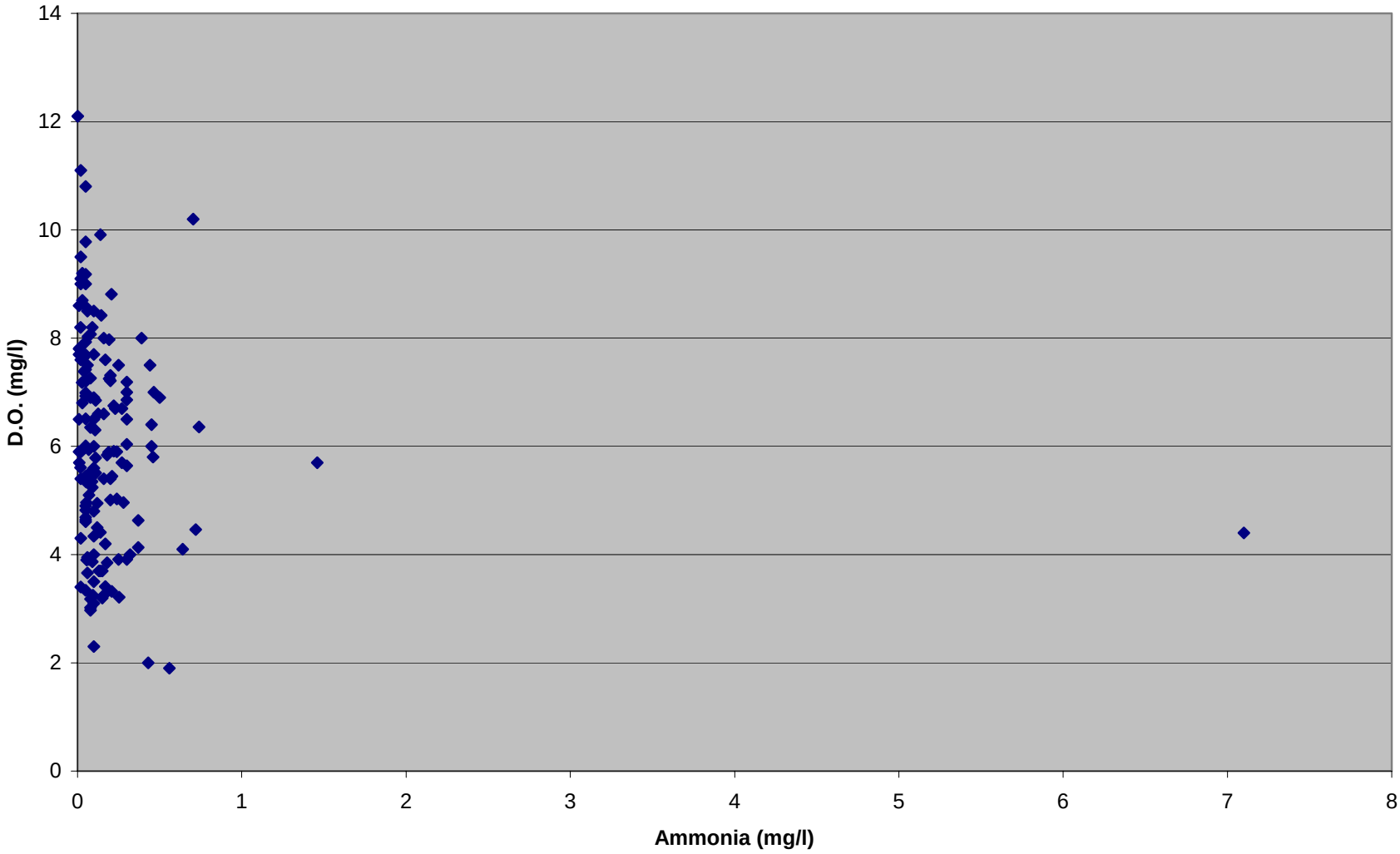


Figure 22. Phosphate vs. DO at Cow Bayou Tidal Station 10449

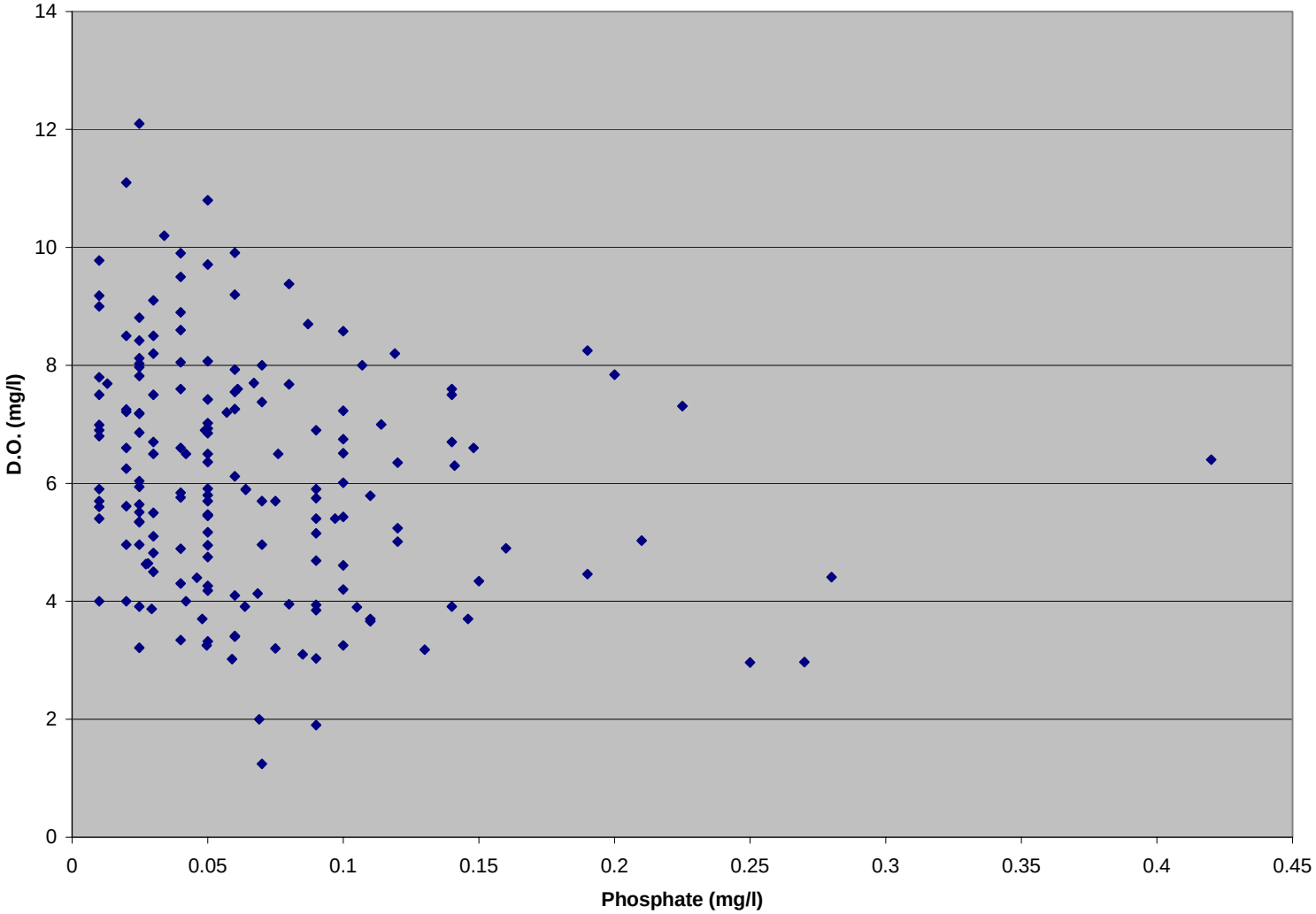
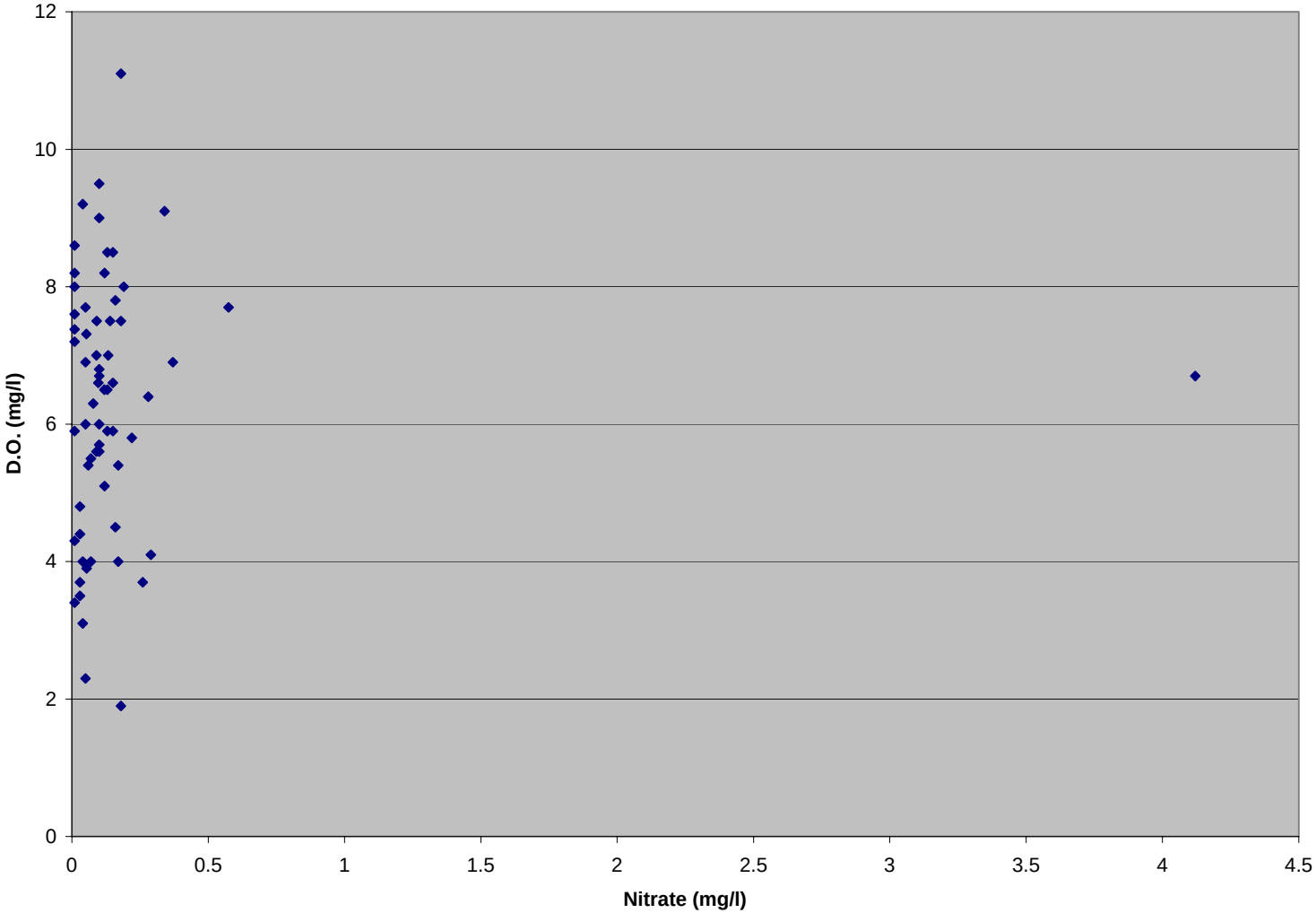


Figure 23. Nitrate vs. DO at Cow Bayou Tidal Station 10449



Conclusion

Intensive Surveys conducted in the 1980s on Cow Bayou determined that low dissolved oxygen conditions are typical in the stream at certain times of year. In the 1980s, low dissolved oxygen in the upper portion of Cow Bayou appeared to be primarily controlled by natural hydrological and environmental variables. A more recent water quality study done by Sabine River Authority attributed low dissolved oxygen conditions in different parts of the stream to point and nonpoint sources of pollution. Permitted wastewater discharges in Cow Bayou Tidal, are potential sources of pollutant loading to the stream. It is likely that low dissolved oxygen measurements at any given place and time on Cow Bayou may be due to natural or manmade factors or a combination of both.

Historical surface water quality data revealed that dissolved oxygen tends to be lower on the average, and more variable, in the upper end of the segment. Recent data used for listing the segment as impaired show a significant percentage of measurements below the water quality standards at all stations surveyed. Collection of 24-hour data at different times during the year would be of great use in understanding the oxygen dynamics of the system.

There is a relative paucity of biological data on Cow Bayou, considering all the years that water quality data have been collected. The studies reviewed for this report all employed techniques and assessment tools developed for use in freshwater systems. Using these assessment tools, the aquatic life community of the stream tended to be evaluated as less than optimal.

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APPENDIX A. Results of previous nekton sampling in Cow Bayou Tidal, data tables from TPWD sampling (Linam and Kleinsasser, 1987)

Table 2. Fishes collected by seine from Cow Bayou (July 1987).

Taxa	Common Name	IH-10	Hwy. 87	Round Bunch Road	Sabine River Confluence
Anchoa mitchilli	Bay anchovy		2	23	46
Brevoortia patronus	Gulf menhaden				3
Citharichthys spilopterus	Bay whiff				2
Etheostoma chlorosomum	Bluntnose darter	5			
Fundulus blairae	Blair's starhead topminnow	1			
Fundulus chrysotus	Golden topminnow	1	3		
Fundulus grandis	Gulf killifish				1
Fundulus notatus	Blackstripe topminnow	10			
Gambusia affinis	Mosquitofish	53	201		
Gobinellus boleosoma	Darter goby				29
Gobiosoma bosci	Naked goby			1	1
Leiostomus xanthurus	Spot				2
Lepomis macrochirus	Bluegill sunfish	12	11	11	
Lepomis microlophus	Redear sunfish	18	1	4	
Lepomis punctatus	Spotted sunfish		9	4	
Lepomis sp. (juvenile)	Sunfish		37	24	1
Lucania parva	Rainwater killifish		50	36	4
Menidia beryllina	Tidewater silverside		83	17	114
Microgobius gulosus	Clown goby			3	
Mugil cephalus	Striped mullet				5
Notropis emiliae	Pugnose minnow	19			
Percina sciera	Dusky darter	2			
Pimephales vigilax	Bullhead minnow	47	1		
Syngnathus scovelli	Gulf pipefish			13	3
Total # of individuals		168	398	136	211

Table 3. Fishes collected by gill net from Cow Bayou (July 1987).

Taxa	Common Name	IH-10	Hwy. 87	Round Bunch Road	Sabine River Confluence
Aplodinotus grunniens	Freshwater drum	1			
Dorosoma cepedianum	Gizzard shad	3		1	
Ictalurus furcatus	Blue catfish	1			
Ictalurus punctatus	Channel catfish	1	2	2	
Ictiobus bubalus	Smallmouth buffalo		1		
Leiostomus xanthurus	Spot			1	
Lepisosteus oculatus	Spotted gar	4	3	6	8
Lepisosteus spatula	Alligator gar				3
Micropogon undulatus	Croaker			1	
Micropterus salmoides	Largemouth bass		4	2	
Minytrema melanops	Spotted sucker	1			
Morone mississippiensis	Yellow bass		1	1	1
Mugil cephalus	Striped mullet				1
Paralichthys lethostigma	Southern flounder			1	
Pomoxis annularis	White crappie		1		
Pomoxis nigromaculatus	Black crappie	1	1	3	
Strongylura marina	Atlantic needlefish			1	