ANALYSIS OF WATER QUALITY DATA FOR EAST ELM, WEST ELM AND LORENCE CREEKS

Prepared for:

EDWARDS UNDERGROUND WATER DISTRICT
P.O. BOX 15830
San Antonio, Texas 78212

Prepared by:

WATER RESOURCES ASSOCIATES, INC.
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AUSTIN, TEXAS 78752

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1.0 INTRODUCTION

The Edwards Aquifer recharge zone near the City of San Antonio is experiencing continuing population growth and land development. Increased urbanization may be accompanied by changes in the character of stormwater runoff. This is a particular concern in the Edwards Aquifer recharge zone because stormwater runoff will eventually comprise a portion of the waters that recharge the aquifer. Little information is available at the present time to quantitatively define the relationship between urban stormwater runoff and ultimate effects upon aquifer recharge.

Demonstrating prudent foresight, the Edwards Underground Water District (EUWD), in conjunction with the U.S. Geological Survey (USGS), initiated a water quality sampling program on three small watersheds overlying the recharge zone near San Antonio in the mid-1970's. The water quality sampling program was conceived to demonstrate the effects of urbanization upon water quality, recognizing the potential impact upon aquifer recharge. The test watersheds and streams (East Elm, West Elm and Lorence Creeks) were selected to exhibit urbanization levels ranging from undeveloped to fully developed.

In December 1985, Water Resources Associates, Inc. (WRA) submitted a proposal to EUWD to study stormwater management techniques and their applicability to the San Antonio area. In June 1986, EUWD requested that WRA submit a proposal limited to an analysis of the water quality data available from the sampling program on East Elm, West Elm and Lorence Creeks. Water Resources Associates submitted its proposal on July 3, 1986, which was approved by EUWD. James Miertschin and Associates of Austin, Texas were subcontractors to WRA in completion of the study.

The objective of the study was to compile the data collected in the three watersheds and conduct a limited statistical analysis in order to determine if sufficient data are available with which to draw conclusions and, if so, if an effect of urbanization on runoff water quality is evident. Pursuant to the data analysis task, recommendations for continuation or modification of the sampling program were to be developed.

2.0 STUDY WATERSHEDS

Water quality data have been collected by the USGS since the mid-1970's on East Elm, West Elm and Lorence Creeks near the City of San Antonio, Texas. The study watersheds displayed varying levels of urbanization. In general, East Elm is an undeveloped watershed. The West Elm watershed was experiencing an intermediate level of development during the data collection period. The Lorence Creek watershed had a high level of development throughout the study. The developmental characteristics of each watershed were examined in order to quantify the level of urbanization.

2.1 URBANIZATION CHARACTERISTICS

Land use information in the study area was available in the form of aerial photographs and land use maps. Land use categories were delineated in detail from maps prepared by the City of San Antonio depicting 1981 urbanized conditions and were used as the basis for year-to-year comparison of land use. Land uses appearing in later aerial photographs or absent in earlier photographs were either added to or subtracted from the 1981 area totals.

Two sources of impervious cover estimates for selected land use categories were used to arrive at a consensus set of impervious cover estimates for development within the study watersheds. The two sources are identified and compared in Table 1. The data in Table 1 indicate general agreement in impervious cover estimates for various land use categories. The impervious cover estimates for residential development within the study watersheds were further substantiated from the 1983 aerial photography. Three test areas in residential developments were delineated and the impervious area in each was scaled from the aerial photographs. Percent impervious cover was then estimated from the areas covered by impervious surfaces (streets, driveways, sidewalks and structures) versus the total area considered. Impervious cover estimates for the three test areas selected were:

Residential Test Area	Density (Lots/Acres)	Impervious Cover (%)
Hollywood Park (North of Rua De Matta)	2.0	25
Hollywood Park (South of Rua De Matta)	1.0	17
Encino Park Unit 3	2.12	31

These estimates are generally consistent with the values and ranges in Table 1.

Tables 2 and 3 present the change in impervious cover over the period 1973-1983 for the Lorence and West Elm Creek watersheds. East Elm Creek remained undeveloped over the study period. In the watersheds experiencing urbanization the net increase in impervious cover (upstream of the gaging station sites) has been nominal. Impervious cover estimates for the study watersheds are summarized in Table 4.

2.2 SAMPLING PROGRAM

Each station was equipped with a Manning automatic sampler with a water level actuator. The sampler was programmed to fill several bottles when first activated and to sample at hourly intervals thereafter. A stage recorder and stilling well were provided at each site. In addition, a rain gauge and recorder were installed at each station. During each sampling event, USGS personnel were dispatched to the stations to collect and replace sample bottles and take manual flow readings. Sample collection commenced in May 1976 on East Elm and West Elm Creeks, and May 1980 on Lorence Creek.

3.0 DATA ANALYSIS AND DISCUSSION

The historical water quality data base consists of numerous storm event samples dating back to May 1976. For the samples collected, the USGS performed a variety of laboratory analyses. Statistical analyses were conducted in order to determine if the data displayed differences in water quality between watersheds with different levels of urbanization. For the present study, several key constituents were selected for statistical analysis: specific conductance, temperature, dissolved oxygen, five-day biochemical oxygen demand (BOD5), fecal coliform, fecal streptococcus, total dissolved solids, total suspended solids, total nitrogen, nitrate nitrogen, ammonia nitrogen, organic nitrogen, total phosphorus, total organic carbon and diazinon. The complete historical data base for the three sampling stations is contained in Appendix A. Typically, 30-50 data points were available for each constituent at each station.

Statistical parameters for the water quality data are summarized in Table 5. Arithmetic averages, standard deviations, ranges and flow-weighted averages for constituent concentrations are presented for each station separately and for all stations combined. As a general observation, the data indicate that mean concentration values for most of the constituents analyzed were highest at the Lorence Creek station. The average dissolved oxygen was lowest at the Lorence Creek site. Only total dissolved solids and diazinon concentrations showed a higher mean value at another site, West Elm Creek. Mean constituent concentrations at the West Elm Creek station were consistently higher than values at the East Elm site. Differences in concentration between stations could be attributable to several variables, including the degree of urbanization. For example, it is possible that the apparent differences between stations are primarily attributable to sampling vagaries rather than a significant difference in watershed characteristics.

The significance of the observed differences between station means was evaluated with a normal distribution test. Results are shown in Table 6. The test indicated that differences in mean concentration between Lorence Creek (the developed watershed) and West Elm Creek (the intermediately developed watershed) were generally not significant at a 5 percent level of significance. Only differences in BOD5, total nitrogen and total phosphorus showed a significant difference. Comparison of mean values between Lorence Creek and East Elm Creek (undeveloped watershed) showed significant differences for most of the constituents at a 5 percent level of significance. Therefore, the observed differences in concentration between the developed and undeveloped watershed are statistically significant. The differences may be attributable to the level of urbanization, but other variables could also contribute, such as soils, land cover, or the frequency and duration of stormwater runoff events.

Table 5 also presents a summary of the flow-weighted average constituent concentrations. On the basis of flow-weighted averages, highest constituent concentrations were generally associated with the West Elm Creek data. Fecal coliform, fecal streptococcus and total suspended solids concentrations were higher at the Lorence Creek station, in accordance with the arithmetic mean values. Comparison of flow-weighted average constituent concentrations between Lorence Creek and East Elm Creek did not show a consistent trend.

To illustrate typical observed trends in constituent concentration, example hydrographs and concentration profiles were plotted for storms occurring May 15, 1980 and May 20-21, 1983 (Appendix B). The plots indicate the difficulty associated with obtaining a complete record of the runoff hydrograph and accompanying concentrations during the storm event sampling program. In general, the data base includes several samples from numerous storm events, but typically does not provide detailed coverage of any particular runoff hydrograph.

Constituent concentrations in stormwater runoff often exhibit considerable fluctuation. Correlations between constituent levels and flow rates are evidenced in some areas. In many cases, the dilution afforded under high flow regimes results in relatively low instream concentrations of many constituents, compared to low flow conditions. Certain constituents may be present in higher concentrations at higher flow rates, particularly those derived from eroded sediment. Sampling data were examined for relationhips between flow rate and constituent concentration. Several mathematical expressions were examined as candidates for the correlations with streamflow:

$$y = a + bx$$
$$y = a \exp (bx)$$
$$y = a x b$$
$$y = a + b\log x$$

where y is the dependent variable, in this case constituent concentration, x is the dependent variable of discharge rate (or logarithm of the discharge), and a and b are constants. A computer was used to fit the most appropriate equation to the data. The analysis indicated goodness of fit for each relationship by calculation of the standard error. Best-fit relationships are presented in Table 7, 8 and 9. Plots of several relationships are displayed as examples in Appendix C. The plots indicate that inverse correlations between dissolved solids concentration and streamflow were evident at all three stations, with the best fit provided by the logarithmic function. Total phosphorus concentration displayed a positive correlation with flow rate, while BOD5 did not show a systematic trend. The calculated fits for all constituents were generally poor, indicating that the data do not exhibit strong correlations with discharge rate. This may be a consequence of the fact that the three test streams are ephemeral, flowing only in response to precipitation events. Thus, all samples collected were representative of stormwater runoff conditions, which precluded data characteristic of sustained base flow conditions that are common to many other studies.

4.0 SUMMARY

Water quality data collected on East Elm, West Elm and Lorence Creeks were compiled and analyzed. The watersheds of the three streams are characterized by different levels of urbanization. The East Elm watershed is largely undeveloped, while the Lorence Creek basin is almost completely urbanized as a residential area. The West Elm watershed represents an intermediate level of development.

Statistical analysis of the water quality data indicated that mean concentration values of most of the constituents were higher at the Lorence Creek station than at either the East Elm or West Elm sites. Further, mean concentration values at the West Elm station were higher than corresponding values at the East Elm station. The most apparent factor which may contribute to the observed differences in constituent concentrations is the level of urbanization in the test watersheds. However, additional factors could also contribute, such as physiographic variables and differences in the frequency and duration of stormwater runoff events. On the basis of flow-weighted average concentrations, West Elm Creek displayed the highest values, with no consistent difference evident between Lorence Creek and East Elm Creek.

Several mathematical relationships were examined to investigate correlations between constituent concentration and discharge rate for the three sampling stations. Only poor correlations were evident, indicating that concentrations are not a function of flow rate.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Based upon the analysis of available water quality data for East Elm, West Elm and Lorence Creeks conducted in the present study, the following conclusions were developed:

(1) The three study watersheds are characterized by different levels of urbanization with East Elm being undeveloped, Lorence highly urbanized and West Elm at an intermediate level of development.

(2) The highly urbanized Lorence Creek watershed generally displayed the highest arithmetic mean consituent concentrations of the three watersheds. West Elm Creek, with an intermediate level of development, generally exhibits higher arithmetic mean consitituent concentrations than the undeveloped East Elm Creek.

(3) West Elm Creek, with an intermediate level of development, generally displayed the highest flow-weighted average constituent concentrations of the three watersheds. Comparison of flow-weighted average constituent concentrations between Lorence Creek and East Elm Creek did not show a consistent trend.

(4) Constituent concentration data for the three study watersheds exhibited poor correlation with discharge rate, using several alternative mathematical relationships.

In summary, the data collected to date indicate a correspondence between urbanization and water quality constituent concentrations. However, the precise relationship is not completely straightforward, because results differ depending upon whether arithmetic or flow-weighted average concentrations are compared. Further, the data base exhibited significant differences between the two extant levels of urbanization in the test watersheds in mean concentrations of BOD5, total nitrogen and total phosphorus only. Expansion of the data base with additional samples could provide an opportunity for development of uniform trends. The following recommendations should be considered:

(1) The data collection program should be continued in its present form.

(2) After a substantial number of additional samples (on the order of 20) are collected, the data base should be updated and reanalyzed for a statistical comparison.

(3) A more detailed evaluation of hydrologic and physiographic characteristics of the three study watersheds should be conducted, in order to identify factors other than urbanization that may contribute to observed differences in constituent concentration. Typical characteristics would include slopes, land cover, soils, time of concentration, etc.

(4) A unit loading analysis for the study watersheds should be conducted. The objective would be to evaluate runoff loading rates on the basis of lb/acre/yr and lb/acre/in, which represents a common technique for evaluation of the effects of different levels of urbanization.

TABLES

TABLE 1
ESTIMATES OF IMPERVIOUS AREA FOR
LAND USE CATEGORIES

Land Use Category	Percent Impervious Area[1]	
	EPA[2]	SCS[3]
Residential		
Low density; acre lots	20	20
Medium density; 1/4 to 1/2 acre lots	40	25-38
High density; 1/8 acre lots	60	65
Multi-family	70	-
Paved areas	100	-
Commercial, highly developed	80	85
Industrial, highly developed	70	72
Commercial or industrial, moderately developed	50	-
Institutional, public	30	-
Open, undeveloped, with roads	8	-

[1] Impervious area includes street pavement, driveways, rooftops, parking lots, sidewalks and similar surfaces.

[2] Source: U.S. Environmental Protection Agency, "Areawide Assessment Procedures Manual, Volume I," EPA-600/5-76-014, July, 1976.

[3] Source: U.S. Department of Agriculture, "Urban Hydrology for Small Watersheds," Technical Release No. 55, Soil Conservation Service, January, 1975.

TABLE 2
LEVELS OF URBANIZATION
LORENCE CREEK
UPSTREAM OF USGS GAGE 08178620
(DRAINAGE AREA = 2648.3 ACRES)

Land Use Category[1]	Percent Impervious Cover	Year 1973	1977	1979	1981	1983
		Area (acres)				
Residential						
Dispersed	20	595.2	595.2	595.2	595.2	595.2
Subdivision	30	748.3	748.3	748.3	786.6	795.6
Mobile Homes	38	3.8	3.8	3.8	3.8	3.8
Commercial	85	9.6	9.6	9.6	9.6	9.6
Industrial	72	10.9	10.9	10.9	10.9	10.9
Services	85	8.9	8.9	8.9	10.9	10.9
Open Space, Agricultural, Vacant	8	1099.4	1099.4	1099.4	1059.1	1050.1
Street	98	172.2	172.2	172.2	172.2	172.2
Weighted Percent Impervious Cover		23.6	23.6	23.6	24.0	24.1

[1] Land use categories from City of San Antonio 1981 land use maps.

TABLE 3
LEVELS OF URBANIZATION
WEST ELM CREEK
UPSTREAM OF USGS GAGE 08178640
(DRAINAGE AREA = 1568 ACRES)

Land Use Category[1]	Percent Impervious Cover	Year 1973	1977	1979	1981	1983
		Area (acres)				
Residential Subdivision	30	0.0	0.0	0.0	147.8	305.9
Industrial	72	0.0	0.0	10.9	10.9	10.9
Open Space, Agricultural, Vacant	8	1520.6	1520.6	1509.7	1361.9	1203.8
Street	98	47.4	47.4	47.4	47.4	47.4
Weighted Percent Impervious Cover		10.7	10.7	11.2	13.2	15.5

[1] Land use categories from City of San Antonio 1981 land use maps.

TABLE 4
SUMMARY OF WEIGHTED PERCENT
IMPERVIOUS COVER UPSTREAM OF
THREE USGS GAGES NEAR
SAN ANTONIO, TEXAS

	Year 1973	1977	1979	1981	1983
Lorence Creek at Thousand Oaks Blvd. USGS Gage No. 08178620	23.6	23.6	23.6	24.0	24.1
West Elm Creek USGS Gage No. 08178640	10.7	10.7	11.2	13.2	15.5
East Elm Creek USGS Gage No. 08178645	8	8	8	8	8

TABLE 5
SUMMARY OF STATISTICAL PARAMETERS FOR HISTORICAL WATER QUALITY DATA SAN ANTONIO, TEXAS

DATE	TIME	STREAM-FLOW (CFS)	SPECIFIC CONDUCTANCE (UG/CM)	TEMP (DEG C)	DISSOLVED OXYGEN (MG/L)	BOD5 (MG/L)	FECAL COLIFORM (COLS/100ML)	FECAL STREP (COLS/100ML)	TOTAL DISSOLVED SOLIDS (MG/L)	TOTAL SUSPENDED SOLIDS (MG/L)	TOTAL NITROGEN (MG/L)	TOTAL NITRATE NITROGEN (MG/L)	TOTAL AMMONIA NITROGEN (MG/L)	TOTAL ORGANIC NITROGEN (MG/L)	TOTAL PHOSPHORUS (MG/L)	TOTAL ORGANIC CARBON (MG/L)	TOTAL DIAZINON (UG/L)
ALL STATIONS COMBINED																	
AVERAGE		48.14	117.99	19.75	8.26	3.95	31000.99	72290.82	77.56	357.94	2.44	0.51	0.12	1.75	0.24	19.10	0.13
FLOW-WEIGHTED AVERAGE			105.93			3.10	15775.06	24221.27	35.86	236.81	1.62	0.40	0.11	1.11	0.20	18.52	0.07
MAXIMUM		750.00	226.00	29.00	13.00	9.00	330000.00	410000.00	140.00	3650.00	18.00	4.72	0.95	14.00	0.85	120.00	1.30
MINIMUM		0.02	44.00	4.00	5.60	1.30	0.00	100.00	37.00	5.00	0.60	0.01	0.01	0.30	0.01	1.30	0.00
NUMBER OF DATA POINTS		128.00	141.00	75.00	71.00	121.00	102.00	98.00	75.00	115.00	115.00	118.00	119.00	116.00	119.00	112.00	58.00
STD. DEVIATION		101.59	33.06	3.96	1.30	1.52	39251.97	73067.53	19.55	603.34	2.42	0.63	0.11	2.03	0.19	14.57	0.27
LORENCE CREEK AT THOUSAND OAKS																	
AVERAGE		29.27	128.58	20.21	7.97	4.72	37609.38	97721.21	79.09	661.68	3.63	0.77	0.16	2.59	0.37	21.52	0.15
FLOW-WEIGHTED AVERAGE			103.38			2.15	20267.67	46376.55	32.98	374.23	1.23	0.33	0.11	0.75	0.21	13.44	0.09
MAXIMUM		534.00	226.00	29.00	12.00	8.50	130000.00	390000.00	140.00	3650.00	18.00	4.72	0.52	14.00	0.80	78.00	0.38
MINIMUM		0.07	70.00	4.00	5.80	2.70	2400.00	2400.00	55.00	15.00	1.20	0.10	0.03	0.73	0.14	8.10	0.01
NUMBER OF DATA POINTS		44.00	48.00	21.00	20.00	33.00	32.00	33.00	22.00	31.00	35.00	37.00	37.00	35.00	37.00	33.00	14.00
STD DEVIATION		82.09	26.95	4.98	1.36	1.44	31774.60	74964.97	17.18	879.39	3.64	0.90	0.10	3.14	0.18	13.25	0.12
WEST ELM CREEK																	
AVERAGE		51.57	122.12	19.10	8.56	3.83	34940.01	75050.00	83.72	399.94	2.21	0.49	0.12	1.57	0.23	20.50	0.21
FLOW-WEIGHTED AVERAGE			125.85			3.78	17793.23	20318.04	38.10	306.26	1.93	0.50	0.13	1.30	0.27	26.79	0.12
MAXIMUM		750.00	202.00	24.00	12.60	9.00	330000.00	410000.00	130.00	1760.00	7.50	2.73	0.95	7.00	0.85	120.00	1.30
MINIMUM		0.02	65.00	10.60	7.20	1.30	0.00	1000.00	51.00	12.00	0.60	0.01	0.01	0.30	0.02	1.30	0.00
NUMBER OF DATA POINTS		54.00	59.00	30.00	28.00	55.00	45.00	40.00	29.00	53.00	51.00	52.00	52.00	51.00	52.00	51.00	26.00
STD DEVIATION		120.06	35.18	3.62	1.17	1.67	50126.54	82963.31	20.97	492.00	1.53	0.46	0.14	1.31	0.17	17.86	0.36
EAST ELM CREEK																	
AVERAGE		69.65	95.29	20.17	8.15	3.38	15452.00	34044.00	68.71	42.39	1.42	0.24	0.07	1.07	0.08	13.69	.00
FLOW-WEIGHTED AVERAGE			80.94			2.79	10315.98	15767.57	34.63	59.53	1.47	0.30	0.07	1.08	0.09	10.63	0.10
MAXIMUM		280.00	154.00	26.00	13.00	5.20	54000.00	91000.00	100.00	137.00	3.30	0.70	0.19	2.90	0.27	27.00	0.02
MINIMUM		0.50	44.00	11.50	5.60	1.70	500.00	100.00	37.00	5.00	0.69	0.01	0.01	0.61	0.01	6.90	0.00
NUMBER OF DATA POINTS		30.00	34.00	24.00	23.00	33.00	25.00	25.00	24.00	31.00	29.00	29.00	30.00	30.00	30.00	28.00	18.00
STD DEVIATION		83.70	25.40	3.17	1.33	0.94	11990.57	25057.26	16.30	35.23	0.49	0.17	0.04	0.42	0.05	4.56	.00

TABLE 6
RESULTS OF TEST FOR SIGNIFICANCE OF THE DIFFERENCE IN MEANS USING THE NORMAL DISTRIBUTION TEST (5 PERCENT LEVEL OF SIGNIFICANCE)

	STREAM-FLOW (CFS)	SPECIFIC CONDUCTANCE (US/CM)	TEMP (DEG C)	DISSOLVED OXYGEN (MG/L)	BOD5 (MG/L)	FECAL COLIFORM (COLS/100ML)	STREP FECAL (COLS/100ML)	TOTAL DISSOLVED SOLIDS (MG/L)	FIXED SUSPENDED SOLIDS (MG/L)	VOLATILE SUSPENDED SOLIDS (MG/L)	TOTAL SUSPENDED SOLIDS (MG/L)	TOTAL NITROGEN (MG/L)	TOTAL NITRATE NITROGEN (MG/L)	TOTAL AMMONIA NITROGEN (MG/L)	TOTAL ORGANIC NITROGEN (MG/L)	TOTAL PHOSPHORUS (MG/L)	TOTAL ORGANIC CARBON (MG/L)	TOTAL DIAZINON (MG/L)
COMPARE LORENCE CREEK AT THOUSAND OAKS BLVD AND WEST ELM CREEK	NO	NO	NO	NO	YES	NO	NO	NO	NO	NO	NO	YES	NO	NO	NO	YES	NO	NO
COMPARE LORENCE CREEK AT THOUSAND OAKS BLVD AND EAST ELM CREEK	YES	YES	NO	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

YES = CONCLUDE THAT THE DIFFERENCE IN MEANS IS SIGNIFICANT AT A 5 PERCENT LEVEL OF SIGNIFICANCE

NO = CONCLUDE THAT THE DIFFERENCE IN MEANS IS NOT SIGNIFICANT AT A 5 PERCENT LEVEL OF SIGNIFICANCE

TABLE 7
SUMMARY OF REGRESSION ANALYSIS FOR SEVERAL REPRESENTATIVE CONSTITUENTS FOR LORENCE CREEK AT THOUSAND OAKS BLVD. UPSTREAM OF USGS GAGE 08178620
(x = streamflow)
(y = constituent)

BIOCHEMICAL OXYGEN DEMAND

Number of data points	29		
Mean of x data	20.3103	Stddev of x	37.6501
Mean of y data	4.6379	Stddev of y	1.5153

Equation	intercept	slope	stderr	r	r ** 2
Y = A + BX	4.62030	0.000066	1.543	0.02157	0.00047
Y = A + B log X	5.11433	-0.535226	1.505	-0.22198	0.04928
Y = A e**BX	4.37462	0.000460	1.560	0.05475	0.00300
Y = A X**B	4.69611	-0.030043	1.526	-0.13748	0.01890

TOTAL DISSOLVED SOLIDS

Number of data points	40		
Mean of x data	27.0650	Stddev of x	43.3747
Mean of y data	80.4500	Stddev of y	17.3987

Equation	intercept	slope	stderr	r	r ** 2
Y = A + BX	81.23206	-0.028896	17.580	-0.07204	0.00519
Y = A + B log X	88.40920	-7.647520	17.031	-0.25771	0.06642
Y = A e**BX	79.17361	-0.000139	17.672	-0.03075	0.00095
Y = A X**B	83.59626	-0.024251	17.186	-0.16699	0.02788

TOTAL SUSPENDED SOLIDS

Number of data points	27		
Mean of x data	21.3444	Stddev of x	38.8651
Mean of y data	619.3333	Stddev of y	951.3925

Equation	intercept	slope	stderr	r	r ** 2
Y = A + BX	551.35980	3.184600	961.908	0.13009	0.01692
Y = A + B log X	452.33984	180.554260	964.477	0.10878	0.01183
Y = A e**BX	158.20216	0.007900	1057.891	0.18977	0.03601
Y = A X**B	140.56717	0.134678	1064.760	0.10986	0.01207

TOTAL NITROGEN

Number of data points	31		
Mean of x data	19.9645	Stddev of x	36.5076
Mean of y data	3.8806	Stddev of y	3.8534

Equation	intercept	slope	stderr	r	r ** 2
Y = A + BX	4.29109	-0.020559	3.844	-0.19477	0.03794
Y = A + B log X	6.37984	-2.705863	3.623	-0.38155	0.14558
Y = A e**BX	3.12506	-0.003561	3.927	-0.18725	0.03506
Y = A X**B	4.35056	-0.188999	3.803	-0.34057	0.11599

TOTAL PHOSPHORUS

Number of data points	33		
Mean of x data	19.0364	Stddev of x	35.5442
Mean of y data	0.3909	Stddev of y	0.1797

Equation	intercept	slope	stderr	r	r ** 2
Y = A + BX	0.37718	0.000721	0.181	0.14269	0.02036
Y = A + B log X	0.34135	0.054649	0.180	0.16159	0.02611
Y = A e**BX	0.33652	0.002526	0.185	0.19514	0.03808
Y = A X**B	0.29849	0.080450	0.184	0.21394	0.04577

TABLE 8
SUMMARY OF REGRESSION ANALYSIS FOR SEVERAL REPRESENTATIVE CONSTITUENTS FOR WEST ELM CREEK UPSTREAM OF USGS GAGE 08178640
(x = streamflow)
(y = constituent)

BIOCHEMICAL OXYGEN DEMAND

Number of data points	46		
Mean of x data	58.5913	Stddev of x	130.1717
Mean of y data	3.8717	Stddev of y	1.4707

Equation	intercept	slope	stderr	r	r ** 2
Y = A + BX	3.86451	0.000123	1.487	0.01092	0.00012
Y = A + B log X	3.59020	0.254034	1.471	0.14991	0.02247
Y = A e**BX	3.61231	0.000096	1.508	0.03499	0.00122
Y = A X**B	3.36398	0.030112	1.491	0.16865	0.02844

TOTAL DISSOLVED SOLIDS

Number of data points	28		
Mean of x data	52.1571	Stddev of x	84.3997
Mean of y data	82.7857	Stddev of y	21.1193

Equation	intercept	slope	stderr	r	r ** 2
Y = A + BX	86.79691	-0.076906	20.480	-0.30734	0.09446
Y = A + B log X	98.55642	-12.759468	19.123	-0.45878	0.21048
Y = A e**BX	84.13472	-0.000911	20.576	-0.30025	0.09015
Y = A X**B	95.68238	-0.061085	19.202	-0.42260	0.17859

TOTAL SUSPENDED SOLIDS

Number of data points	45		
Mean of x data	60.0400	Stddev of x	131.3135
Mean of y data	300.1778	Stddev of y	381.5823

Equation	intercept	slope	stderr	r	r ** 2
Y = A + BX	296.86850	0.055118	385.924	0.01897	0.00036
Y = A + B log X	287.03424	11.734986	385.853	0.02703	0.00073
Y = A e**BX	108.07239	0.002086	428.592	0.18980	0.03602
Y = A X**B	84.05326	0.142352	425.442	0.19959	0.03984

TOTAL NITROGEN

Number of data points	52		
Mean of x data	53.5558	Stddev of x	123.1030
Mean of y data	7.4048	Stddev of y	31.1378

Equation	intercept	slope	stderr	r	r ** 2
Y = A + BX	4.85661	0.047580	30.886	0.18811	0.03538
Y = A + B log X	-1.77979	8.270329	30.696	0.21739	0.04726
Y = A e**BX	2.08995	0.001202	31.822	0.13917	0.01937
Y = A X**B	1.57138	0.136697	31.741	0.24232	0.05872

TOTAL PHOSPHORUS

Number of data points	46		
Mean of x data	58.6826	Stddev of x	130.0834
Mean of y data	0.2207	Stddev of y	0.1769

Equation	intercept	slope	stderr	r	r ** 2
Y = A + BX	0.20773	0.000219	0.177	0.16138	0.02605
Y = A + B log X	0.20608	0.013081	0.179	0.06434	0.00414
Y = A e**BX	0.15448	0.001384	0.185	0.23559	0.05550
Y = A X**B	0.13867	0.073880	0.186	0.19368	0.03751

TABLE 9
SUMMARY OF REGRESSION ANALYSIS FOR SEVERAL REPRESENTATIVE CONSTITUENTS FOR EAST ELM CREEK UPSTREAM OF USGS GAGE 08178645
(x = streamflow)
(y = constituent)

BIOCHEMICAL OXYGEN DEMAND

Number of data points	29		
Mean of x data	62.3966	Stddev of x	76.6256
Mean of y data	3.3793	Stddev of y	0.9447

Equation	intercept	slope	stderr	r	r ** 2
Y = A + BX	3.48798	-0.001742	0.952	-0.14126	0.01995
Y = A + B log X	3.34951	0.021615	0.962	0.01682	0.00028
Y = A e**BX	3.34647	-0.000495	0.963	-0.12765	0.01629
Y = A X**B	3.17469	0.006875	0.972	0.03919	0.00154

TOTAL DISSOLVED SOLIDS

Number of data points	21		
Mean of x data	58.7619	Stddev of x	67.5628
Mean of y data	66.5238	Stddev of y	15.9581

Equation	intercept	slope	stderr	r	r ** 2
Y = A + BX	72.78119	-0.106487	14.614	-0.45084	0.20326
Y = A + B log X	91.19524	-17.207024	11.850	-0.69007	0.47620
Y = A e**BX	71.20751	-0.001637	14.396	-0.44929	0.20186
Y = A X**B	93.29191	-0.110968	11.774	-0.66409	0.44102

TOTAL SUSPENDED SOLIDS

Number of data points	30		
Mean of x data	66.6500	Stddev of x	80.2971
Mean of y data	43.0000	Stddev of y	36.2577

Equation	intercept	slope	stderr	r	r ** 2
Y = A + BX	41.54004	0.021905	36.856	0.04851	0.00235
Y = A + B log X	32.06121	7.771473	36.432	0.15864	0.02517
Y = A e**BX	29.23532	0.000162	39.421	0.01389	0.00019
Y = A X**B	24.93426	0.052424	39.111	0.09560	0.00914

TOTAL NITROGEN

Number of data points	28		
Mean of x data	73.0536	Stddev of x	87.1994
Mean of y data	1.4214	Stddev of y	0.5094

Equation	intercept	slope	stderr	r	r ** 2
Y = A + BX	1.36361	0.000791	0.514	0.13547	0.01835
Y = A + B log X	1.24922	0.121309	0.510	0.18459	0.03407
Y = A e**BX	1.27323	0.000756	0.521	0.19714	0.03886
Y = A X**B	1.16646	0.043691	0.515	0.23323	0.05439

TOTAL PHOSPHORUS

Number of data points	29		
Mean of x data	71.3621	Stddev of x	86.1113
Mean of y data	0.0759	Stddev of y	0.0504

Equation	intercept	slope	stderr	r	r ** 2
Y = A + BX	0.06323	0.000177	0.049	0.30251	0.09151
Y = A + B log X	0.04070	0.024793	0.048	0.37453	0.14027
Y = A e**BX	0.05007	0.002952	0.051	0.36659	0.13439
Y = A X**B	0.03367	0.186047	0.049	0.47035	0.22123

APPENDICES

APPENDIX A

SUMMARY OF HISTORICAL WATER QUALITY DATA BY STATION

SUMMARY OF HISTORICAL WATER QUALITY DATA
LORENCE CREEK AT THOUSAND OAKS

DATE	TIME	STREAM-FLOW (CFS)	SPECIFIC CONDUCTANCE (US/CM)	TEMP (DEG C)	DISSOLVED OXYGEN (MG/L)	BOD5 (MG/L)	FECAL COLIFORM (COLS/100ML)	FECAL STREP (COLS/100ML)	TOTAL DISSOLVED SOLIDS (MG/L)	TOTAL SUSPENDED SOLIDS (MG/L)	TOTAL NITROGEN (MG/L)	TOTAL NITRATE NITROGEN (MG/L)	TOTAL AMMONIA NITROGEN (MG/L)	TOTAL ORGANIC NITROGEN (MG/L)	TOTAL PHOSPHORUS (MG/L)	TOTAL ORGANIC CARBON (MG/L)	TOTAL DIAZINON (UG/L)
MAY 15,1980	10.45	18.0	127	21.0	9.2	5.0	47000	97000	80	320	2.2	0.57	0.09	1.50	0.38		
MAY 15,1980	10.51	30.0	126	21.0	7.8	5.0	45000	83000	80	68	2.0	0.66	0.09	1.20	0.37	18.0	0.010
MAY 15,1980	11.30	31.0	126	21.0	7.6	3.7	26000	46600	86	69	1.6	0.51	0.06	1.00	0.25		
MAY 15,1980	12.45	7.0	125	21.0	7.2	3.0	5500	64000	77	43	1.2	0.35	0.03	0.83	0.22	15.0	0.090
MAY 15,1980	14.23	14.0	140	22.0	7.0	3.6	25000	61000	87	15	1.2	0.29	0.04	0.86	0.20		
OCT 16,1980	12.15	0.8	112				36500	68000		44	2.1	0.63	0.17	1.20	0.23	12.0	
OCT 18,1980	12.32	6.6	96	21.0	8.3	6.3	130000	64000	55	139		0.89	0.09		0.41	16.6	0.090
APR 23,1981	9.10	3.5	147				88000	170000			5.6	3.45	0.24	1.90	0.44		
APR 23,1981	10.30	26.0	151				44000	84000			4.8	2.77	0.16	1.80	0.43	8.1	
APR 23,1981	10.45	28.0	153														
APR 23,1981	11.00	25.0	150														
APR 23,1981	11.12	19.0	126	20.5	9.2												
APR 23,1981	11.15	19.0	154														
APR 23,1981	11.30	16.0	150														
MAY 29,1981	13.07	1.6	138			4.0	16000	190000	88	67	2.2	0.75	0.14	1.30	0.21	14.0	0.010
MAY 29,1981	13.25	7.8	133			4.6	47500	310000	85	36	2.3	0.74	0.13	1.40	0.31	19.0	0.030
MAY 29,1981	13.54	16.0	133			4.2	30000	390000	84	49	2.5	0.88	0.12	1.50	0.34	15.0	0.086
MAY 29,1981	14.24	11.0	114			3.0	16000	140000	72	53	2.0	0.63	0.11	1.20	0.24	12.0	
MAY 29,1981	15.24	4.2	114			3.6	14000	130000	72	19	1.7	0.42	0.11	1.10	0.22	10.0	0.210
MAR 23,1983	5.40	6.2	142			7.3	10000	40000		1000	3.5	0.28	0.18	2.90	0.70	33.0	
MAR 23,1983	9.37	2.5	127	10.5	10.0	3.0	6600	40000	77	114	2.0	0.53	0.15	1.20	0.22	13.0	
MAR 23,1983	10.05	3.4	128			3.1	2400	30000		162	2.0	0.53	0.12	1.30	0.21	13.0	
MAY 20,1983	14.46																
MAY 20,1983	14.47	4.2	163				35000	70000			7.5	0.44	0.22	6.70	0.50	29.0	
MAY 20,1983	14.54	5.6	175														
MAY 20,1983	15.02	6.1	169			6.4	25000	60000			8.2	0.45	0.20	7.40	0.80	26.0	
MAY 20,1983	15.09	5.8	151								5.6	0.24	0.32	4.00	0.70	26.0	
MAY 20,1983	15.17	5.3	142			6.4					5.9	0.32	0.24	5.20	0.70	20.0	
MAY 20,1983	15.24	5.1	131														
MAY 20,1983	15.32	4.8	125			6.3	9500	49500			15.0	0.24	0.20	14.00	0.60	26.0	
MAY 20,1983	15.39	4.2	121														
MAY 20,1983	16.30	2.8	112				11000	94000		972	4.4	0.10	0.34	3.70	0.60	34.0	
MAY 21,1983	10.40	150.0	128	18.0	8.5	6.2	41000	95000	84	154	2.4	0.54	0.26	1.50	0.50	15.0	0.250
SEP 3,1984	16.22	8.0	103			6.3	100000	94000		1150	2.0	0.38	0.06	1.40	0.52	18.0	0.060
SEP 3,1984	16.52	5.1	94			4.9	100000	80000	58	3650	1.4	0.40	0.04	0.86	0.31	28.0	
SEP 3,1984	17.22	3.8	96			4.9				1800							
SEP 3,1984	17.53	3.3	96	25.0	6.5	4.9	66000	40000	60	1800		0.38	0.05		0.30	20.0	0.040
JAN 14,1985	12.30	0.1	87	4.0	12.0	8.5		2400									
FEB 23,1985	10.00	0.8	226	16.5		2.7	13000	98000	140	180	18.0	4.72	0.18	13.00	0.22	17.0	
JUN 6,1985	13.35	50.0	119	22.0	8.3	3.6	50000	90000	79	2780	2.7	0.58	0.52	1.40	0.59	78.0	0.380
JUN 6,1985	14.09	150.0	103	22.0	8.3	4.0	54000	90000	71	1670	1.9	0.59	0.20	0.92	0.47	50.0	0.330
JUN 6,1985	16.25	10.0	150	29.0	7.4	3.9	14000	84000		158	3.1	0.94	0.14	2.00	0.33	12.0	
JUN 22,1985	12.50	10.0	159			3.1	20000	100000	100	46	1.7	0.77	0.07	0.83	0.24	23.0	
JUN 22,1985	13.12	534.0	70	25.5	6.9												
JUL 3,1985	17.00		84	21.0	8.2	5.0	80000	120000	56	1010	1.8	0.37	0.10	1.30	0.34	33.0	0.310
OCT 21,1985	12.45	15.0	138	20.0	7.6	3.0	6500	49500	80	224	1.6	0.54	0.13	0.87	0.14	14.0	0.150
MAY 26,1986	12.45		113	21.5	5.8	5.9			75	275	1.4	0.42	0.17	0.73	0.23	13.0	
MAY 27,1986	9.21		112	21.0	6.6	6.1				297	1.6	0.63	0.16	0.74	0.14	14.0	
MAY 27,1986	10.18		112	21.0	7.0	4.1				340	1.9	0.59	0.20	1.00	0.24	16.0	

SUMMARY OF HISTORICAL WATER QUALITY DATA
WEST ELM CREEK

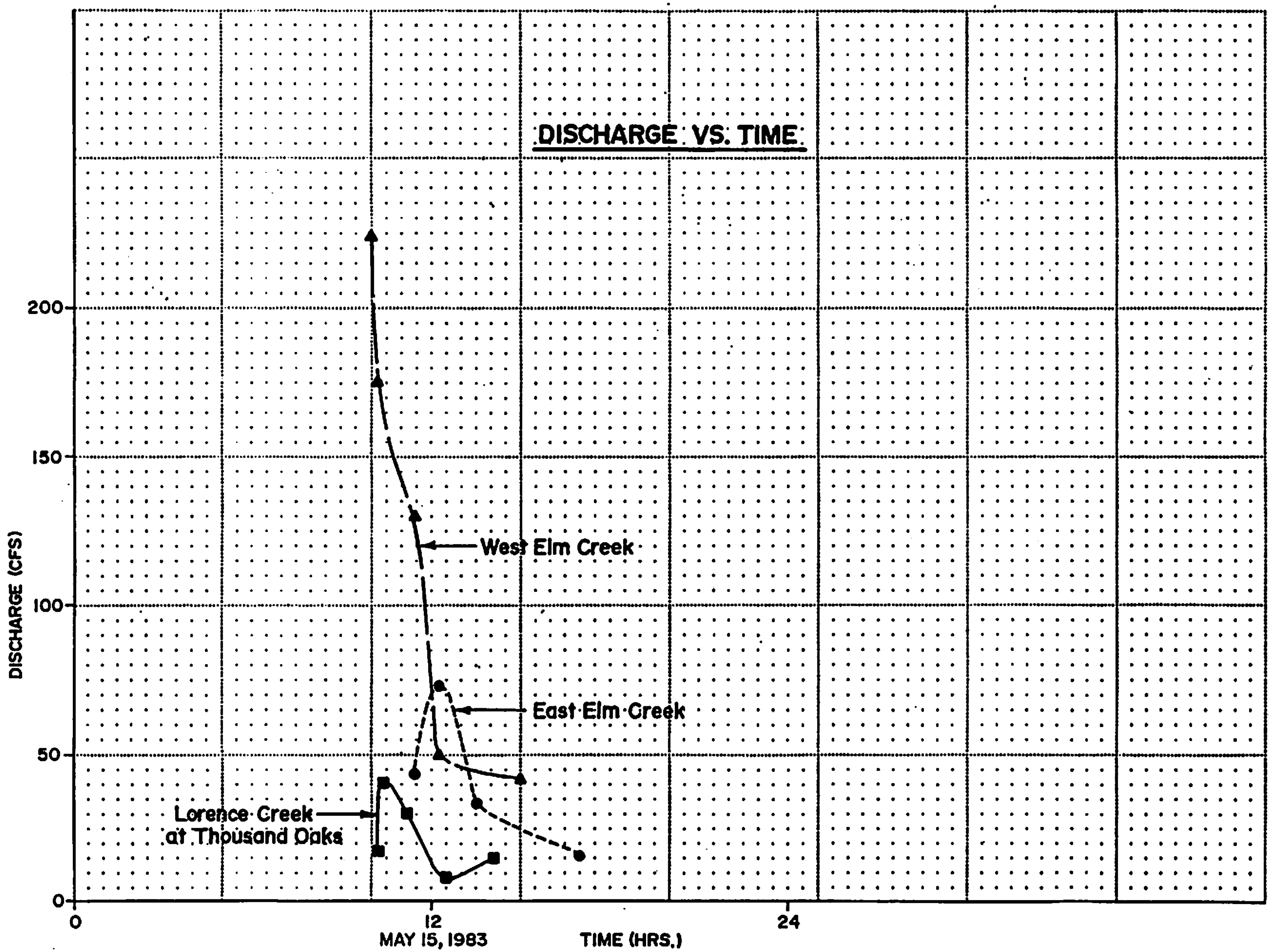
DATE	TIME	STREAM-FLOW (CFS)	SPECIFIC CONDUCTANCE (US/CM)	TEMP (DEG C)	DISSOLVED OXYGEN (MG/L)	BOD5 (MG/L)	FECAL COLIFORM (COLS/100ML)	FECAL STREP (COLS/100ML)	TOTAL DISSOLVED SOLIDS (MG/L)	TOTAL SUSPENDED SOLIDS (MG/L)	TOTAL NITROGEN (MG/L)	TOTAL NITRATE NITROGEN (MG/L)	TOTAL AMMONIA NITROGEN (MG/L)	TOTAL ORGANIC NITROGEN (MG/L)	TOTAL PHOSPHORUS (MG/L)	TOTAL ORGANIC CARBON (MG/L)	TOTAL DIAZINON (UG/L)
MAY 7,1976	8.45	101.0	119	18.0	9.3	4.3			79	134134	1.3	0.20	0.02	1.10	0.11	11.9	0.000
MAY 7,1976	10.10	24.0	141	18.0	9.0	3.5			93	33	0.9	0.11	0.01	6.75	0.09	12.0	0.000
JUL 6,1976	19.00	7.0	78	21.0	7.7	3.8			54	38	0.3	0.15	0.02	0.60	0.29	8.0	0.000
AUG 30,1976	17.20	7.0	84	22.0	7.7	4.2			65	290	1.3	0.30	0.03	0.97	0.09	11.0	0.010
APR 19,1977	23.15	13.0	106	19.5	7.4	3.5	52000	130000	75	40	1.0	0.07	0.06	0.83	0.17	7.9	0.000
NOV 1,1977	9.50	20.0	121	17.5	8.7	2.5	42000	41000	75	42	1.1	0.34	0.02	0.72	0.09	10.0	0.000
SEP 13,1978	10.54	28.0	156	23.0	7.9	2.3	39000	46000	100	42	0.8	0.02	0.04	0.74	0.06	1.2	0.000
SEP 13,1978	13.55	0.7	202	23.0	7.5	1.9	25000	34000	130	13	0.6	0.01	0.02	0.59	0.02	17.0	0.000
MAR 21,1979	6.35	1.2	166	16.0	12.6	2.9	40000	190000	100	61	0.8	0.04	0.03	0.70	0.04	14.0	0.000
JUN 1,1979	11.06	12.0	84	20.5	8.2	3.0	20000	29000	57	632	3.3	0.45	0.11	2.60	0.19	30.0	0.000
JUN 1,1979	13.31	32.0	122	20.5	7.2	2.6	13000	17000	71	24	1.7	0.65	0.05	0.89	0.09	13.0	0.000
MAY 15,1980	10.10	226.0	86	21.0	9.2	5.8	18500	26000	54	776		0.38	0.09		0.53	120.0	0.000
MAY 15,1980	10.30	174.0	86	21.0	9.0	6.4	23000	27000	53	239	3.7	0.40	0.13	3.20	0.32	40.0	0.000
MAY 15,1980	11.45	132.0	120	21.5	9.2	3.9	43000	41000	74	117	2.0	0.26	0.04	1.70	0.16	16.0	
MAY 15,1980	12.30	49.0	136	22.0	9.0	3.9	66000	80000	81	124	1.7	0.25	0.04	1.40	0.16	15.0	
MAY 15,1980	15.33	42.0	141	24.0	8.2	2.7	6000	16000	89	53	1.2	0.18	0.03	0.97	0.09	13.0	
OCT 18,1980	15.38	13.0	94	21.0	8.0	4.7	68000	11000	51	765	2.3	0.47	0.10	1.70	0.15	33.0	1.300
FEB 15,1983	2.10		74														
MAR 23,1983	3.22		79			4.4	4400	11000		1400	7.5	0.30	0.14	7.00	0.50	34.0	
MAR 23,1983	3.50	0.5	161			4.9	7400	10500		1160	4.7	1.24	0.12	3.30	0.60	40.0	
MAR 23,1983	4.20	1.0	169			4.2		18000		926	5.2	1.34	0.12	3.70	0.60	33.0	
MAR 23,1983	8.26	30.0	137	10.5	10.2	2.1	5000	16000	80	20	1.4	0.26	0.09	1.00	0.10	11.0	0.460
MAR 23,1983	9.12	19.0		10.0	10.4												
MAR 23,1983	9.32	15.0	147			2.2	7000	28000		14	1.1	0.17	0.10	0.80	0.07	12.0	
MAR 23,1983	14.02	0.2	166	13.0	9.6	2.4	3000	17000	98	16	1.6	0.17	0.13	1.30	0.06	13.6	
MAY 20,1983	0.07		74				10000	26000							0.20	37.0	0.005
MAY 20,1983	0.14		71			3.4				1570						33.0	
MAY 20,1983	0.20	.0	72			6.2				1760						37.0	
MAY 20,1983	0.26	.0	72			7.4				1620							
MAY 20,1983	13.54	20.0	65			7.7	20000	70000		1390	1.4	0.27	0.12	0.98	0.20	39.0	0.005
MAY 20,1983	16.12	58.0	114			4.4	43000	40000		34	1.3	0.37	0.15	1.20	0.12	15.0	
MAY 21,1983	11.35	39.0	133	18.5	8.7	3.2	25000	78000	96	13	1.5	0.27	0.10	1.10	0.07	15.0	
SEP 18,1983	17.35	10.0	120						73								0.350
SEP 18,1983	17.40	6.7	101			4.8	62000	43000			4.4	0.45	0.05	3.90	0.30	30.0	
SEP 18,1983	18.10	10.0	112			4.6	86000	36000			3.9	0.56	0.07	3.20	0.30	34.0	
SEP 18,1983	18.40	16.0	155				330000	130000									
DEC 30,1984	17.52	0.1	68	21.0	7.6	2.0				138	0.6	0.18	0.10	0.30	0.16	6.8	
DEC 31,1984	5.20	13.0															
DEC 31,1984	5.20	13.0	92			5.0	23500			94	0.6	0.07	0.13	0.37	0.17	8.3	0.180
DEC 31,1984	5.50	15.0	97			2.8	20000			202	0.9	0.17	0.11	0.59	0.21	8.6	0.230
DEC 31,1984	6.20	23.0	112			2.2	23400			1190	0.9	0.17	0.09	0.61	0.22	10.0	
DEC 31,1984	10.35	9.1	199	10.5	7.9	2.4	65000	240000	120	37	1.4	0.27	0.09	1.00	0.18	14.0	
FEB 23,1985	2.40	26.0	98			9.0	70000	115000		1020	3.9	0.45	0.50	2.90	0.85		0.150
FEB 23,1985	3.48	9.9	115			5.1	42000	170000		900	6.1	0.57	0.10	5.40		35.0	
FEB 23,1985	4.48	6.5	137			6.0	49000	215000	76	536	4.1	0.68	0.11	3.30	0.64		
FEB 23,1985	10.30	9.9	166	15.5		4.3	58000	125000		62	1.3	0.37	0.15	0.75	0.13		
FEB 23,1985	12.30	1.4	175	17.0		3.2	15500	175000	120	49	1.1	0.37	0.11	0.59	0.10	11.0	0.020
MAR 14,1985	4.49		112														
MAR 14,1985	4.49	5.7	112				60000	86000		83	1.9	0.76	0.18	0.92	0.26		
MAR 14,1985	4.49															8.2	1.200
MAR 14,1985	5.49		126														
MAR 14,1985	5.49	7.2	126			3.9	32000	74000		206	2.2	0.86	0.16	1.10	0.30		
MAR 14,1985	6.09	6.3	131	13.0	9.4	3.2	6500	50000	78	115	2.3	0.86	0.14	1.30	0.31	8.9	
JUN 5,1985	18.30	8.4	116			4.8											
JUN 5,1985	18.30									83	2.0	0.55	0.17	1.20	0.26	9.8	
JUN 6,1985	14.36	380.0	117	22.0	7.8	2.6	12000	19500	76	412	2.6	0.56	0.11	1.90	0.22	16.0	0.230
JUN 6,1985	16.20	62.0	147			3.6	0		90	186	2.1	0.75	0.11	1.20	0.15	14.0	
JUN 6,1985	17.20	26.0	176				0.5	42000	110	41	2.2	0.87	0.09	1.20	0.11	11.0	
JUN 22,1985	4.23	7.0	80			3.4	2000	1000		474	1.8	0.26	0.24	1.30	0.24	15.0	0.760
JUN 22,1985	5.23	290.0	125			3.9	16000			460	2.5	0.56	0.19	1.70	0.39	38.0	0.670
JUN 22,1985	6.20	750.0	157			3.5	3000			214	1.9	0.74	0.20	0.90	0.33	15.0	
MAY 26,1986	8.00									518	4.9	2.73	0.95	1.10	0.26	20.0	
MAY 26,1986	8.00					1.3											
MAY 26,1986	9.40		155			1.3											
MAY 26,1986	10.00					1.6				644	3.6	1.72	0.14	1.70	0.35	24.0	
MAY 26,1986	11.46	0.1		22.0	7.5	4.3				12	0.8	0.19	0.10	0.50	0.11	5.9	
MAY 27,1986	10.05			20.0	7.4	3.5	5000	410000		94	2.1	0.83	0.12	1.10	0.18	11.0	
JUN 4,1986	11.30		182	22.5	7.5	1.6	1500	8000	110								

SUMMARY OF HISTORICAL WATER QUALITY DATA
EAST ELM CREEK

DATE	TIME	STREAM-FLOW (CFS)	SPECIFIC CONDUCTANCE (US/CM)	TEMP (DEG C)	DISSOLVED OXYGEN (MG/L)	BOD5 (MG/L)	FECAL COLIFORM (COLS/100ML)	FECAL STREP (COLS/100ML)	TOTAL DISSOLVED SOLIDS (MG/L)	TOTAL SUSPENDED SOLIDS (MG/L)	TOTAL NITROGEN (MG/L)	TOTAL NITRATE NITROGEN (MG/L)	TOTAL AMMONIA NITROGEN (MG/L)	TOTAL ORGANIC NITROGEN (MG/L)	TOTAL PHOSPHORUS (MG/L)	TOTAL ORGANIC CARBON (MG/L)	TOTAL DIAZINON (UG/L)
MAY 7,1976	8.34	113.0	66	15.5	9.3	4.5			48	62	1.1	0.19	0.04	0.87	0.08	11.0	0.000
MAY 7,1976	10.20	47.0	95	15.5	8.6	3.7			69	21	1.3	0.15	0.04	1.10	0.06	8.3	0.000
MAY 7,1976	16.10	5.0	133	22.0	7.3	3.7			95	5	0.7	0.01	0.01	0.66	0.02	10.0	0.020
JUN 7,1976	20.31																0.000
JUL 6,1976	18.35	152.0	44	22.5	7.4	3.8			37	41	0.9	0.23	0.03	0.61	0.27	12.0	0.000
JUL 6,1976	20.31	20.0	78	23.0	7.1	4.6				17						8.0	0.000
APR 20,1977	10.10	52.0	99	19.0	5.6	2.7	2200	8000	78	31	1.2	0.02	0.01	1.20	0.04	7.8	0.000
NOV 1,1977	11.09	6.8	100	18.0	8.5	2.3	21000	8500	64	17	1.2	0.34	0.01	0.81	0.07	9.7	0.000
SEP 13,1978	9.45	130.0	85	22.5	8.4	1.9	15000	31000	62	51	1.1	0.04	0.05	1.00	0.04	6.9	0.000
SEP 13,1978	15.15	2.0	144	24.5	7.7	1.7	19000	14000	98	8	0.7	0.05	0.03	0.63	0.02	27.0	0.000
MAR 21,1979	8.30	8.0	138	17.0	13.0	2.3	4000	28000	86	30	0.9	0.03	0.06	0.74	0.02	9.6	0.000
JUN 1,1979	12.00	69.0	76	20.0	7.1	3.9	9000	33000	55	13	1.8	0.70	0.11	0.89	0.08	13.0	0.000
JUN 1,1979	14.17	47.0	91	20.5	7.0	3.0	9500	32000	63	6	1.5	0.47	0.04	0.92	0.08	13.0	0.000
MAY 15,1980	11.39	44.0	76	20.5	8.0	5.1	33000	60000	46	137	3.3	0.28	0.10	2.90	0.15	24.0	0.000
MAY 15,1980	11.51	103.0	73	20.5	9.1	4.3	54000	33000	51	99	1.7	0.25	0.09	1.30	0.13	19.0	0.000
MAY 15,1980	12.25	72.0	82	20.5	9.0	3.4	28000	28000	55	44	1.3	0.22	0.06	1.00	0.10	14.0	
MAY 15,1980	13.57	32.0	102	20.5	8.2	2.8	21000	27000	65	17	1.2	0.23	0.06	0.85	0.07	16.0	
MAY 15,1980	17.07	16.0	108	20.5	8.3	3.0	26000	11000	72	18	1.0	0.11	0.36	0.87	0.07	14.0	
MAR 23,1983	12.15	3.3	104	11.5	8.3	2.1	560	100	70	8	0.9	0.07	0.19	0.61	0.04	12.0	0.005
MAY 20,1983	17.23	0.5	81			4.4	26000	50000		37	1.7	0.17	0.15	1.30	0.11	14.0	0.005
MAY 20,1983	17.50	12.0	81			4.2	18000	93000		11	1.5	0.17	0.12	1.20	0.08	12.0	
MAY 20,1983	20.15	1.0	97	21.0		3.6	12000	54000		32	1.5	0.18	0.07	1.20	0.06	13.0	
MAY 21,1983	12.15	38.0	114	19.0	8.8	3.5	10000	29000	75	32	1.6	0.17	0.14	1.30	0.05	13.0	
FEB 23,1985	12.40	1.9	130	17.5	8.4	3.2	3100	80000	85	84	1.6	0.27	0.09	1.20	0.01	15.0	0.005
JUN 22,1985	5.07	12.0	79			5.2	26000	85000	55	51	1.9	0.28	0.07	1.50	0.08	13.0	
JUN 22,1985	6.07	250.0	72			3.5	16000	11000		70	2.0	0.46	0.08	1.40	0.09	20.0	
JUN 22,1985	7.04	280.0	96				11000	32000	68	56	1.4	0.18	0.06	1.10	0.08	16.0	
JUN 22,1985	10.53	24.0	143	24.5	7.3	3.0	3000	6000		8			0.03	0.87	0.03	17.0	
JUL 3,1985	16.10	46.0	60			3.9				130	1.7	0.38	0.10	1.20	0.12		
JUL 3,1985	17.10	260.0	82			2.5				54	1.6	0.28	0.08	1.20	0.08		
JUL 3,1985	18.10	242.0	80			2.2				100	1.5	0.57	0.11	0.79	0.07		
JUN 4,1986	6.00		80			4.6	6000	38000									
JUN 4,1986	7.00		87			3.9	5500	44000	69								
JUN 4,1986	9.30		110	22.0	7.7	3.3	7500	9500	83	24	1.4	0.38	0.09	0.91	0.06	15.0	
JUN 4,1986	14.35		154	26.0	7.4	1.8			100								

APPENDIX B

FLOW VS. CONCENTRATION PROFILES
FOR THE STORMS OF
MAY 15, 1980 AND MAY 20-21, 1983
FOR THE FOLLOWING CONSTITUENTS:
Q, BOD, TSS, TDS, TN AND TP

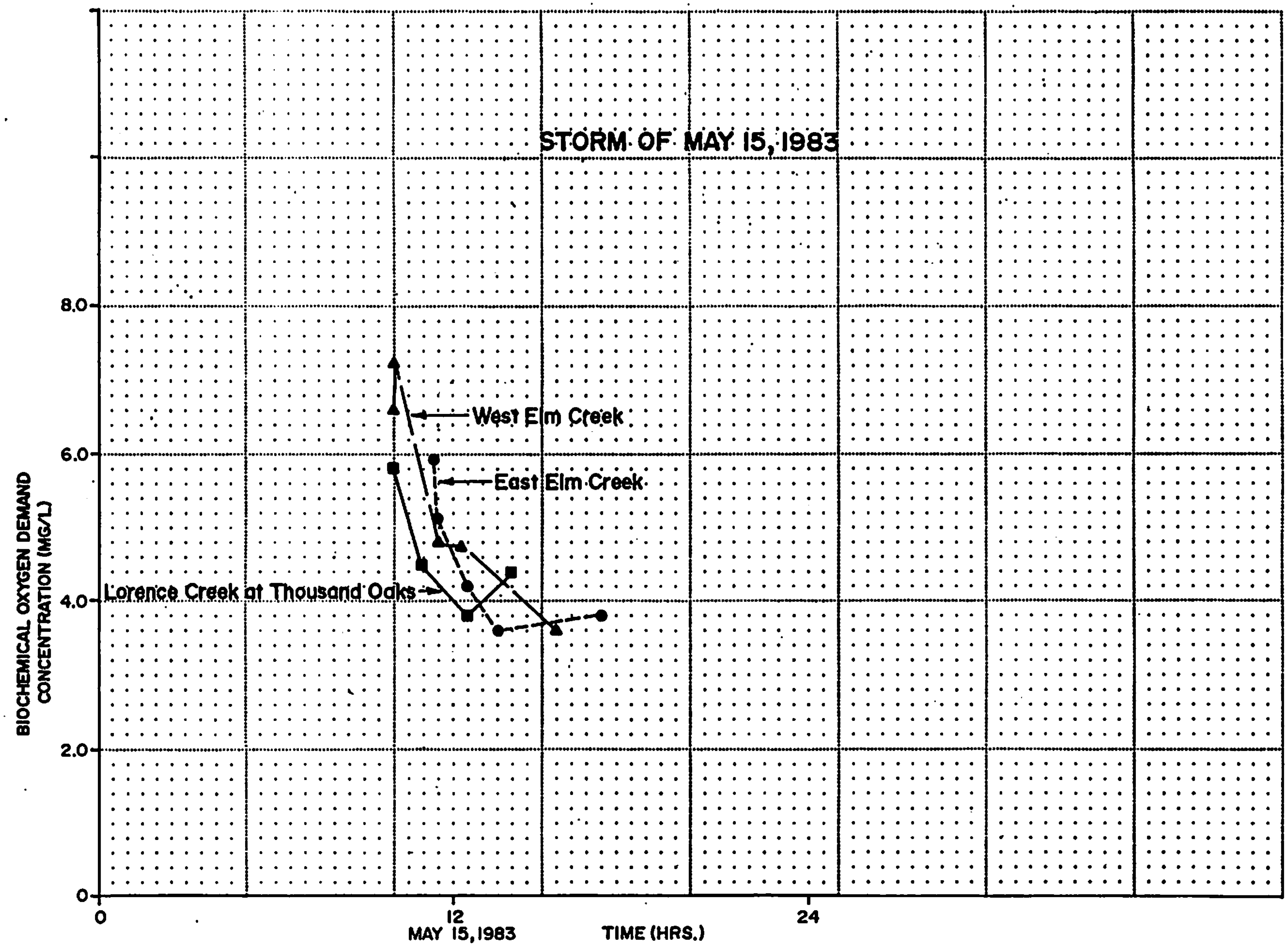


Water Resources Associates, Inc.

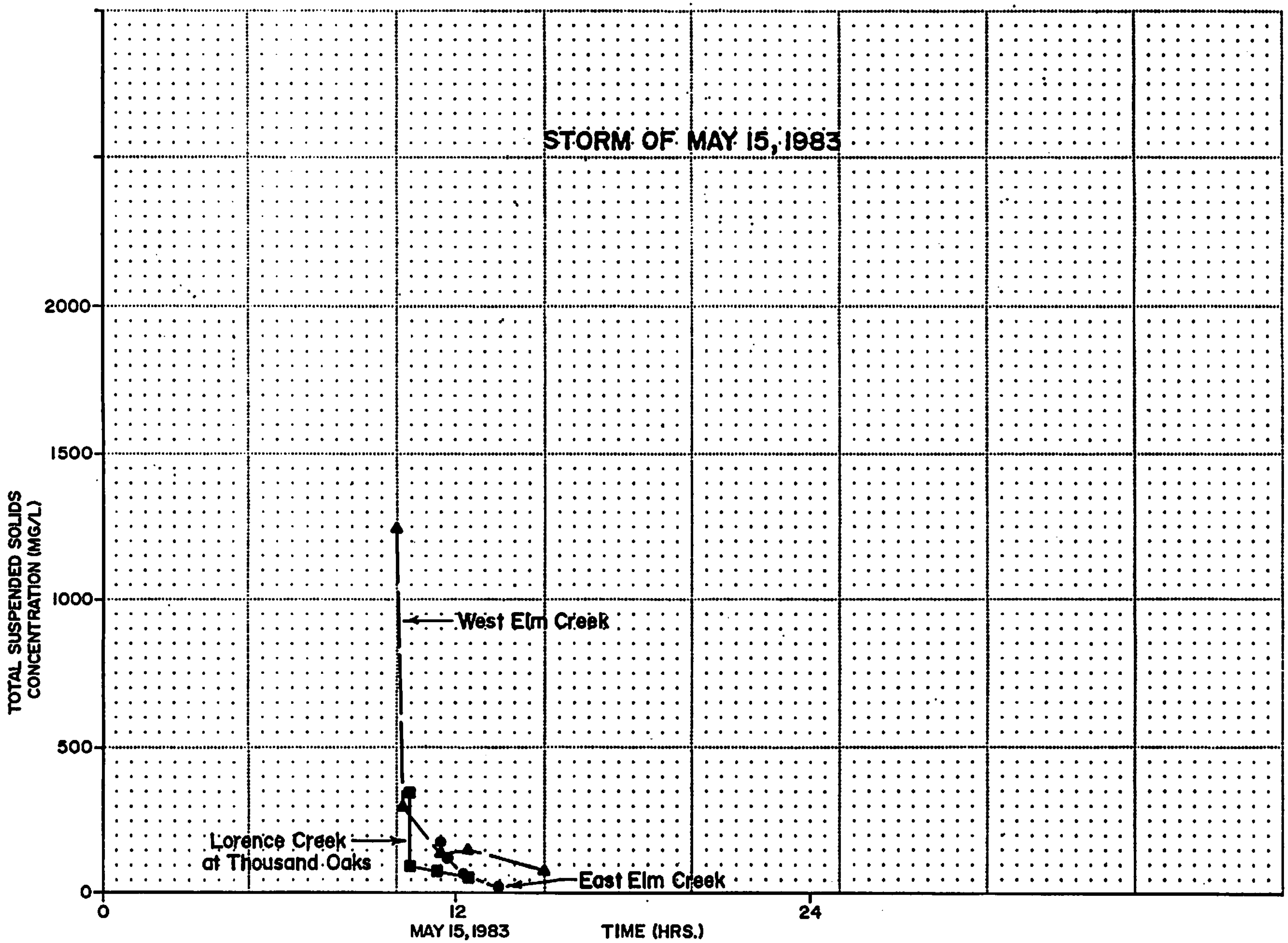
PROJECT NO. 08520550 DATE 8/29/86

MEASURED HYDROGRAPH
STORM OF MAY 15, 1983

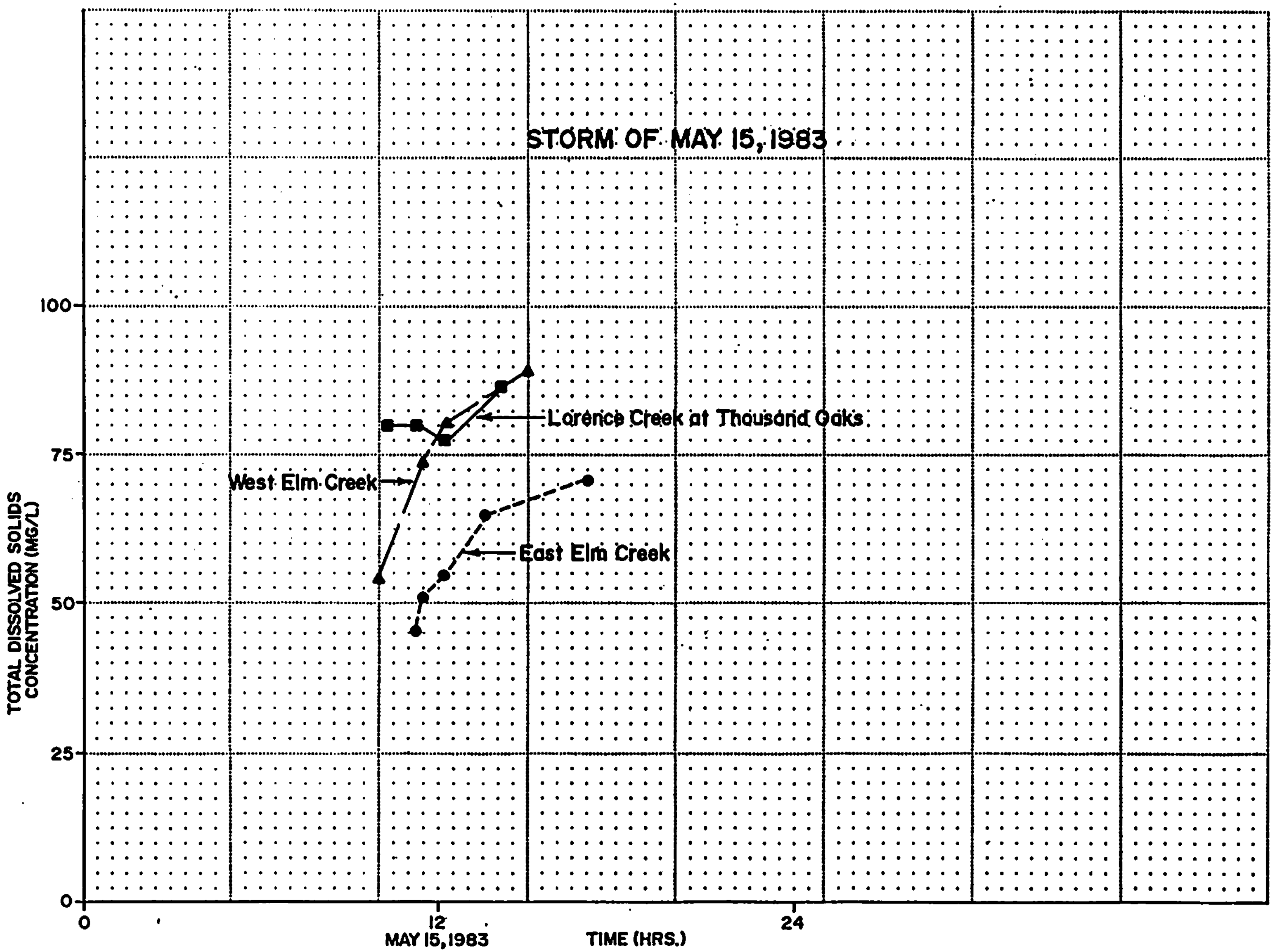
EDWARDS UNDERGROUND WATER DISTRICT
SAN ANTONIO, TEXAS



Water Resources Associates, Inc.	BOD CONCENTRATION VS. TIME
PROJECT NO. 08520550 DATE 8/29/86	EDWARDS UNDERGROUND WATER DISTRICT SAN ANTONIO, TEXAS



Water Resources Associates, Inc.	TOTAL SUSPENDED SOLIDS VS. TIME
PROJECT NO. 08520550 DATE 8/29/86	EDWARDS UNDERGROUND WATER DISTRICT SAN ANTONIO, TEXAS

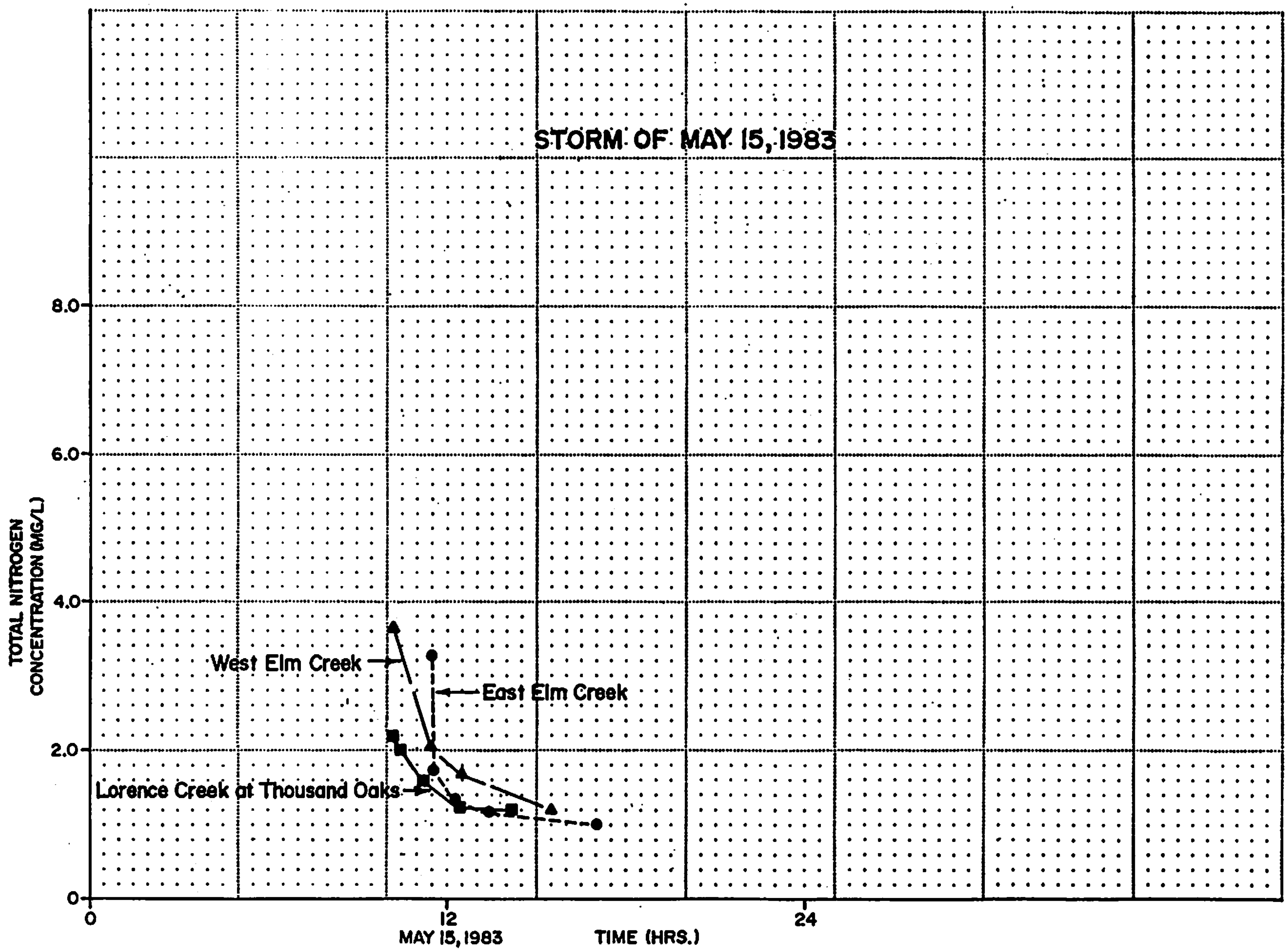


Water Resources Associates, Inc.

PROJECT NO. 08520550 DATE 8/29/86

TOTAL DISSOLVED SOLIDS VS. TIME

EDWARDS UNDERGROUND WATER DISTRICT
SAN ANTONIO, TEXAS

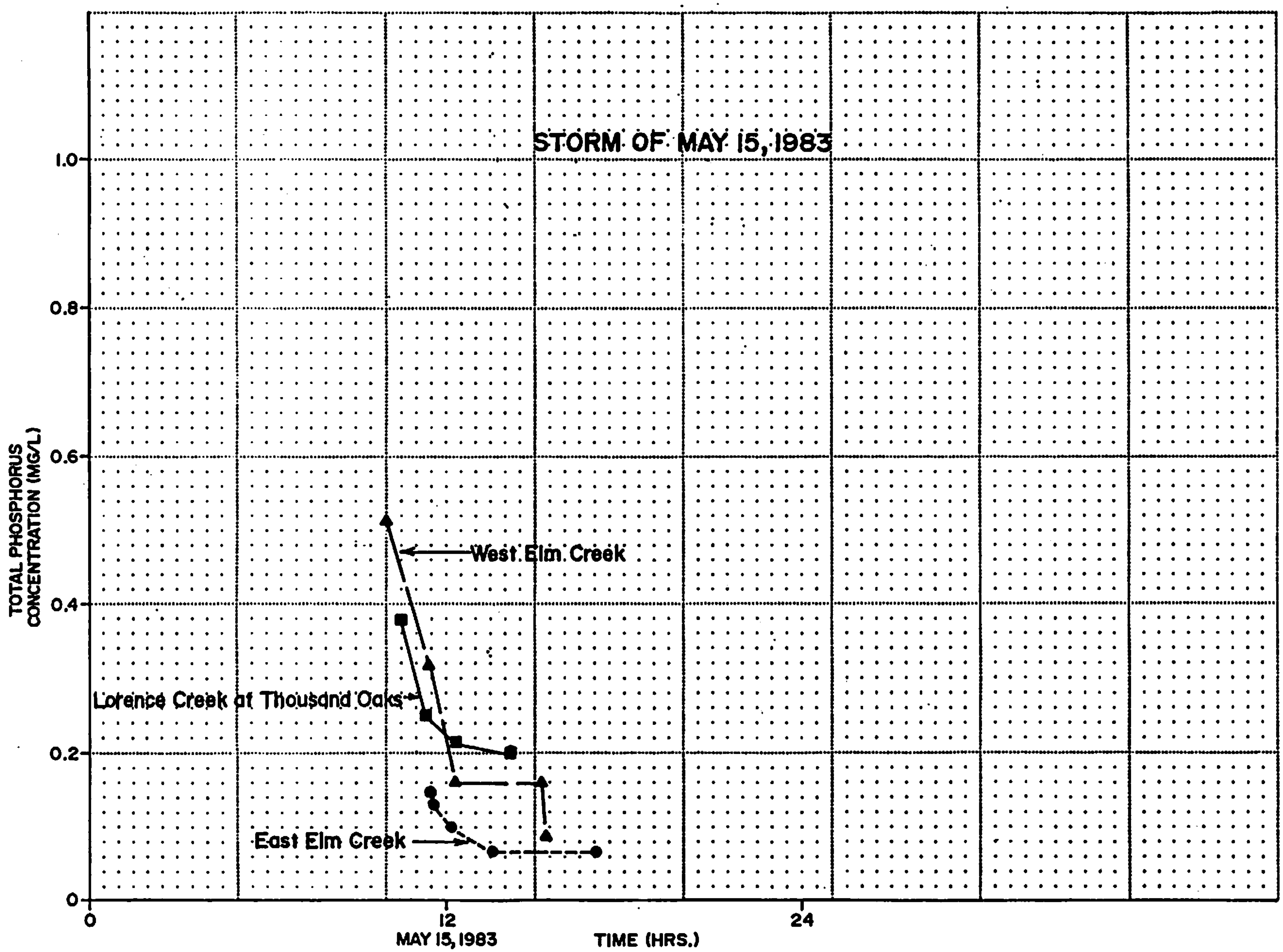


Water Resources Associates, Inc.

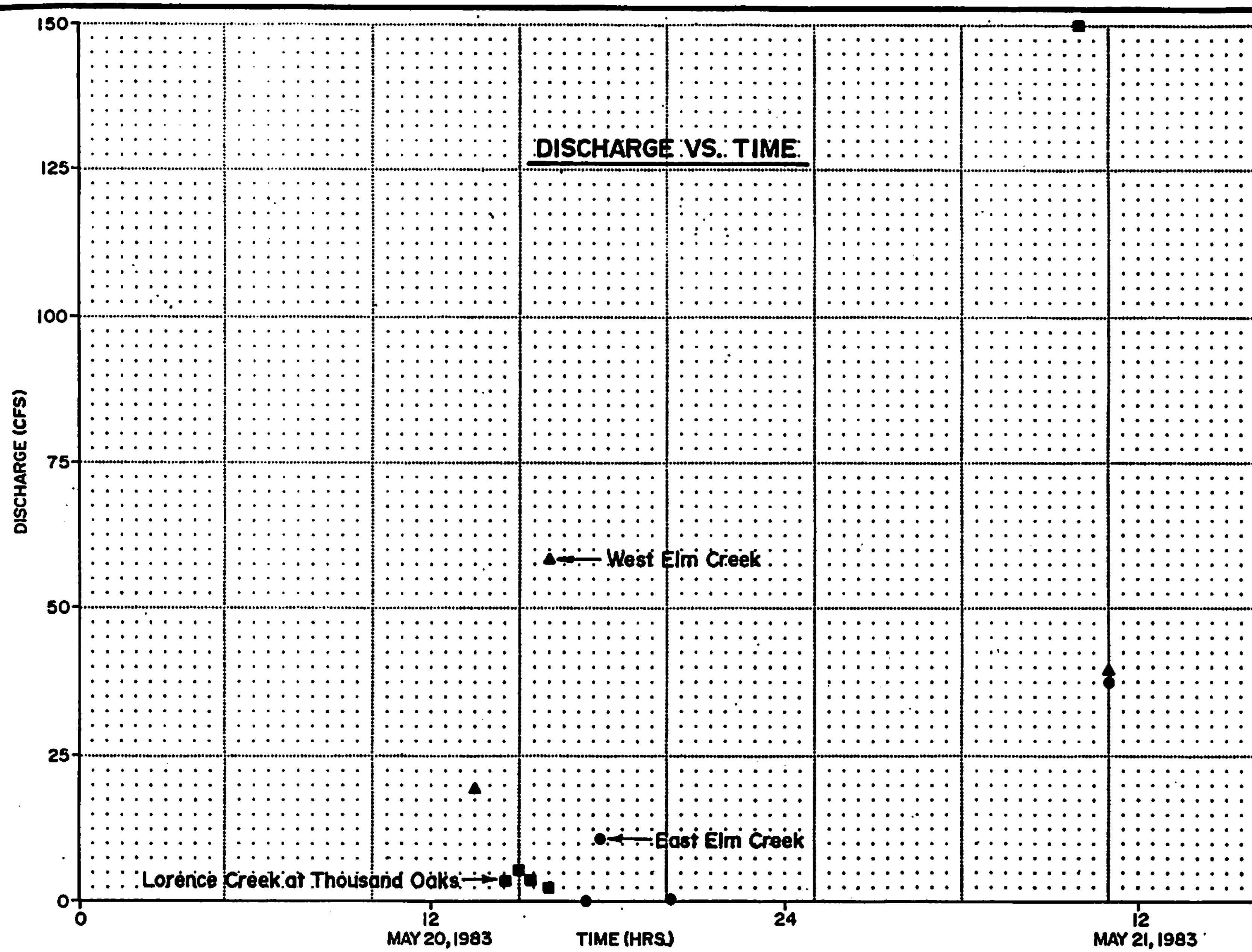
PROJECT NO. 08520550 DATE 8/29/86

TOTAL NITROGEN CONCENTRATION VS. TIME

EDWARDS UNDERGROUND WATER DISTRICT
SAN ANTONIO, TEXAS



Water Resources Associates, Inc.	TOTAL PHOSPHORUS CONCENTRATION VS. TIME
PROJECT NO. 08520550 DATE 8/29/86	EDWARDS UNDERGROUND WATER DISTRICT SAN ANTONIO, TEXAS

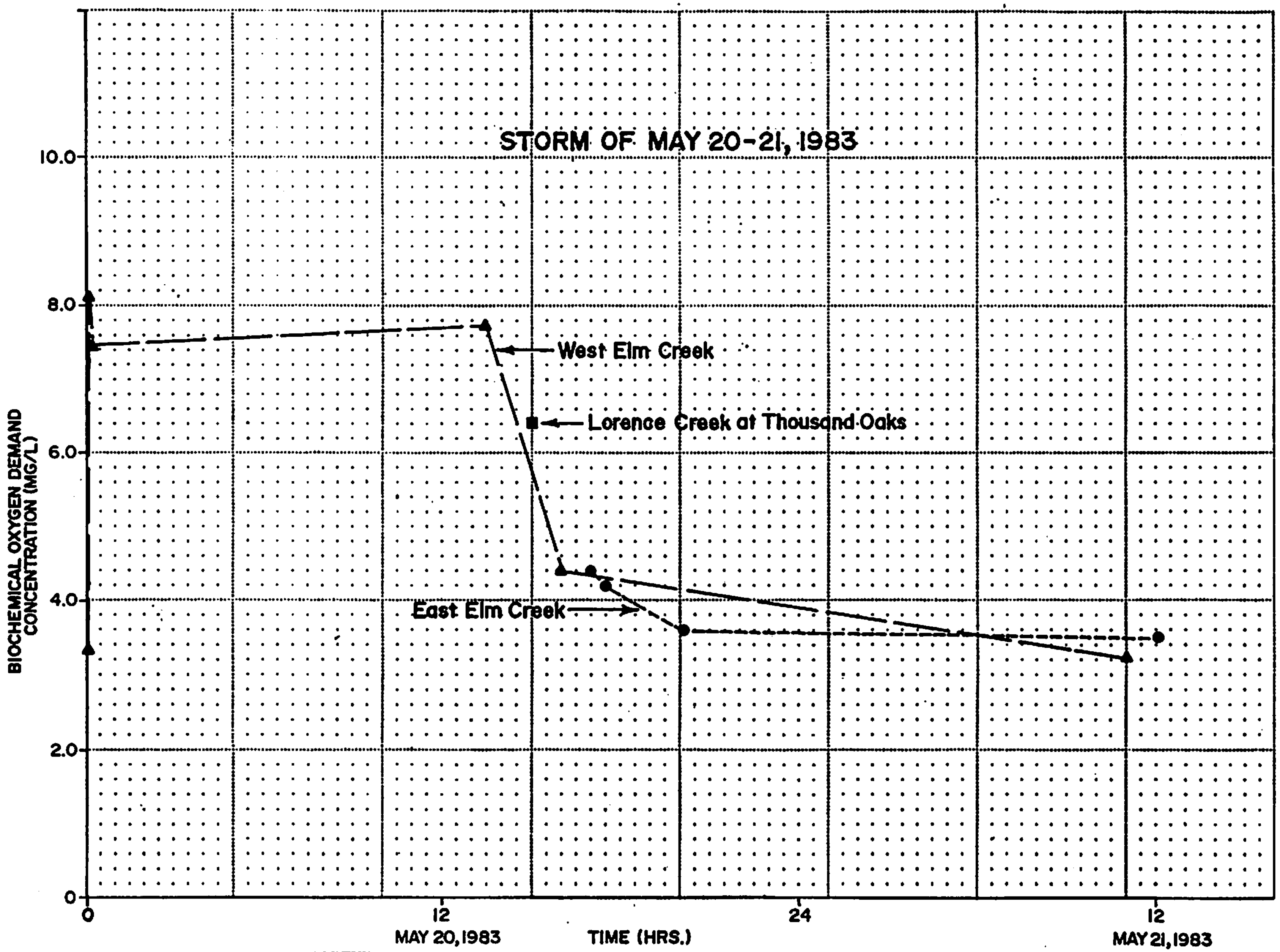


Water Resources Associates, Inc.

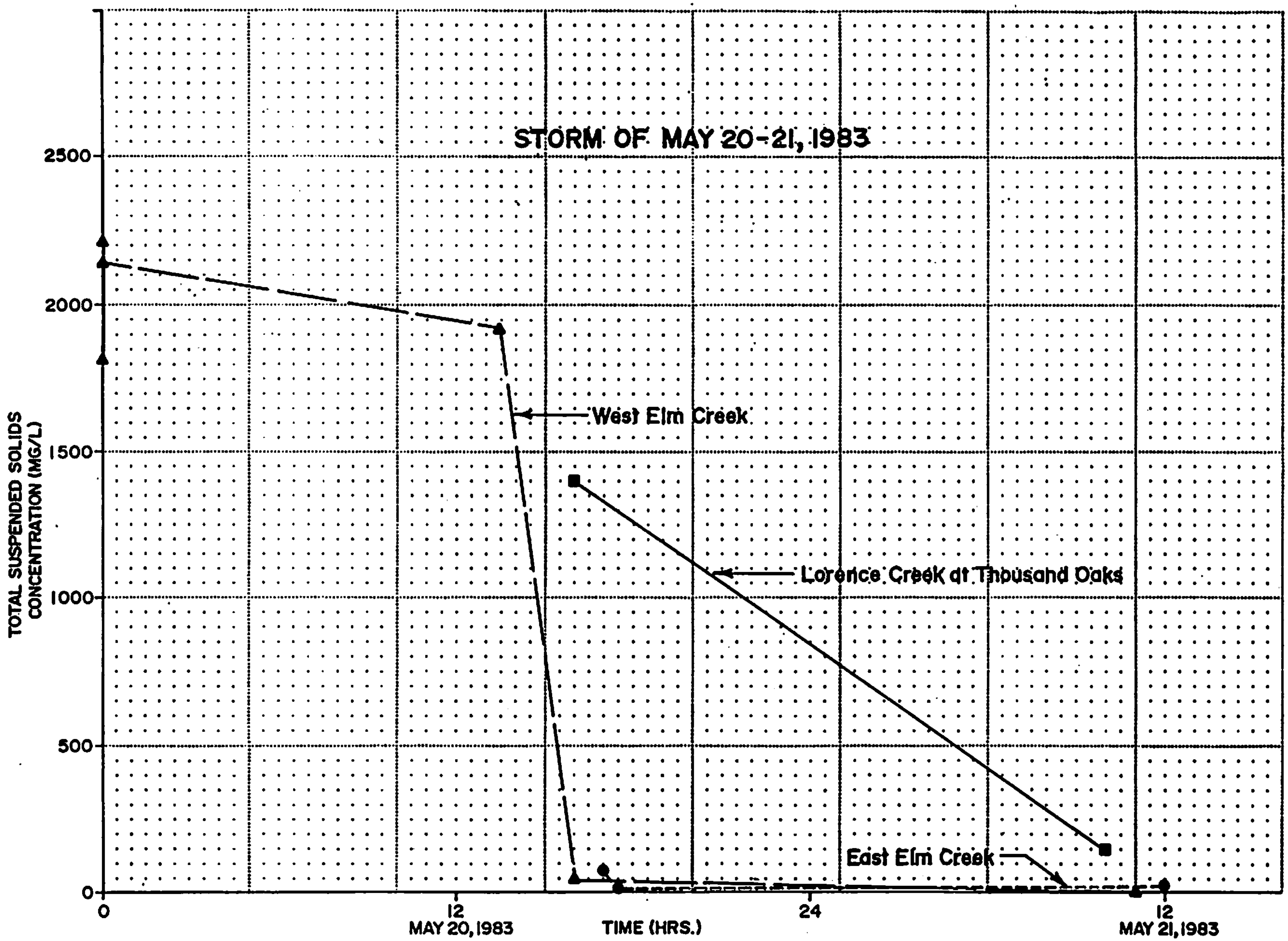
PROJECT NO. 08520550 DATE 8/29/86

MEASURED HYDROGRAPH
STORM OF MAY 20-21, 1983

EDWARDS UNDERGROUND WATER DISTRICT
SAN ANTONIO, TEXAS



Water Resources Associates, Inc.	BOD CONCENTRATION VS. TIME
PROJECT NO. 08520550 DATE 8/29/86	EDWARDS UNDERGROUND WATER DISTRICT SAN ANTONIO, TEXAS

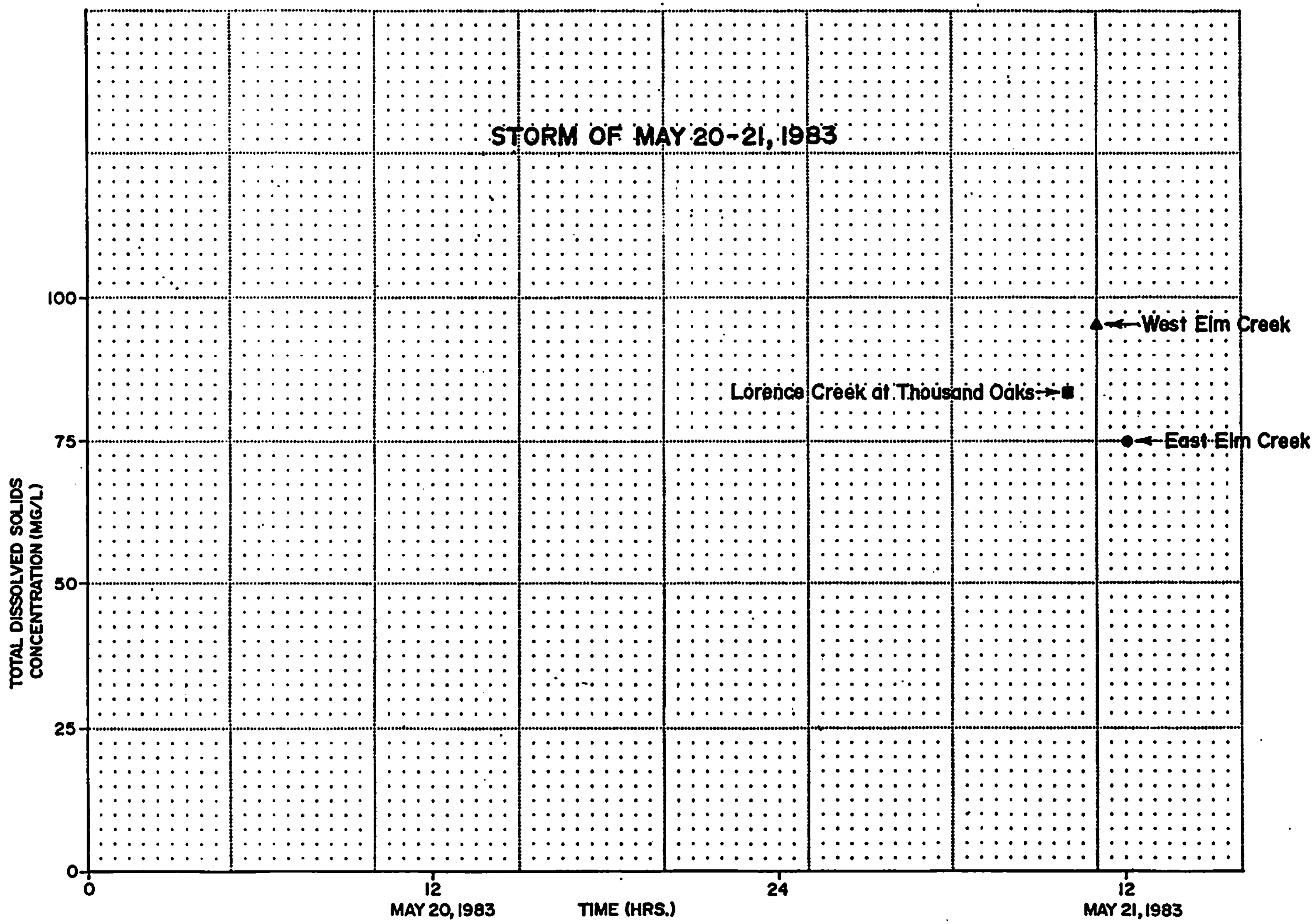


Water Resources Associates, Inc.

PROJECT NO. 08520550 | DATE 8/29/86

TOTAL SUSPENDED SOLIDS VS. TIME

EDWARDS UNDERGROUND WATER DISTRICT
SAN ANTONIO, TEXAS

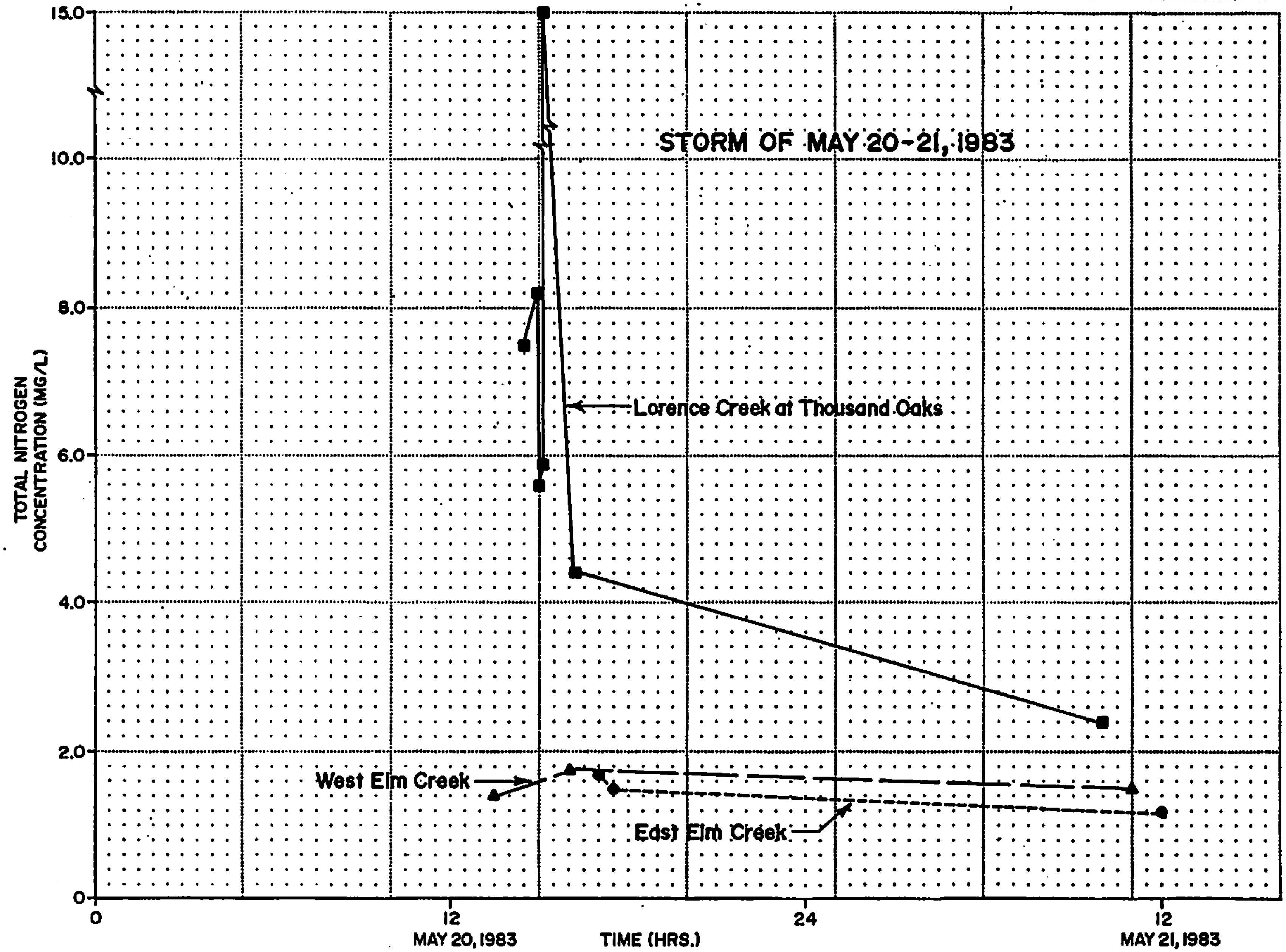


Water Resources Associates, Inc.

PROJECT NO. 08520550 DATE 8/29/86

TOTAL DISSOLVED SOLIDS VS. TIME

EDWARDS UNDERGROUND WATER DISTRICT
SAN ANTONIO, TEXAS

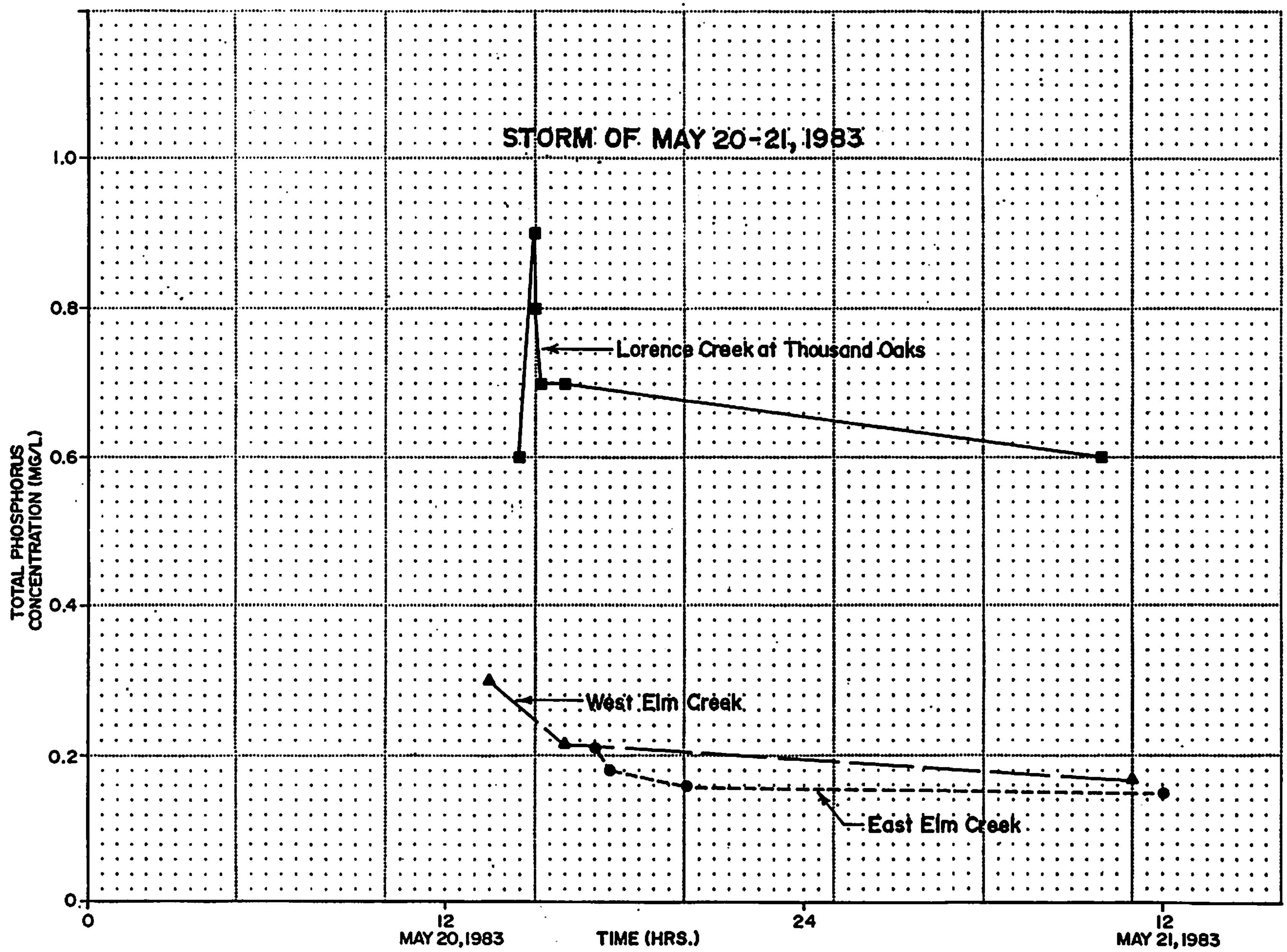


Water Resources Associates, Inc.

PROJECT NO. 08520550 DATE 8/29/86

TOTAL NITROGEN CONCENTRATION VS. TIME

EDWARDS UNDERGROUND WATER DISTRICT
SAN ANTONIO, TEXAS



Water Resources Associates, Inc.

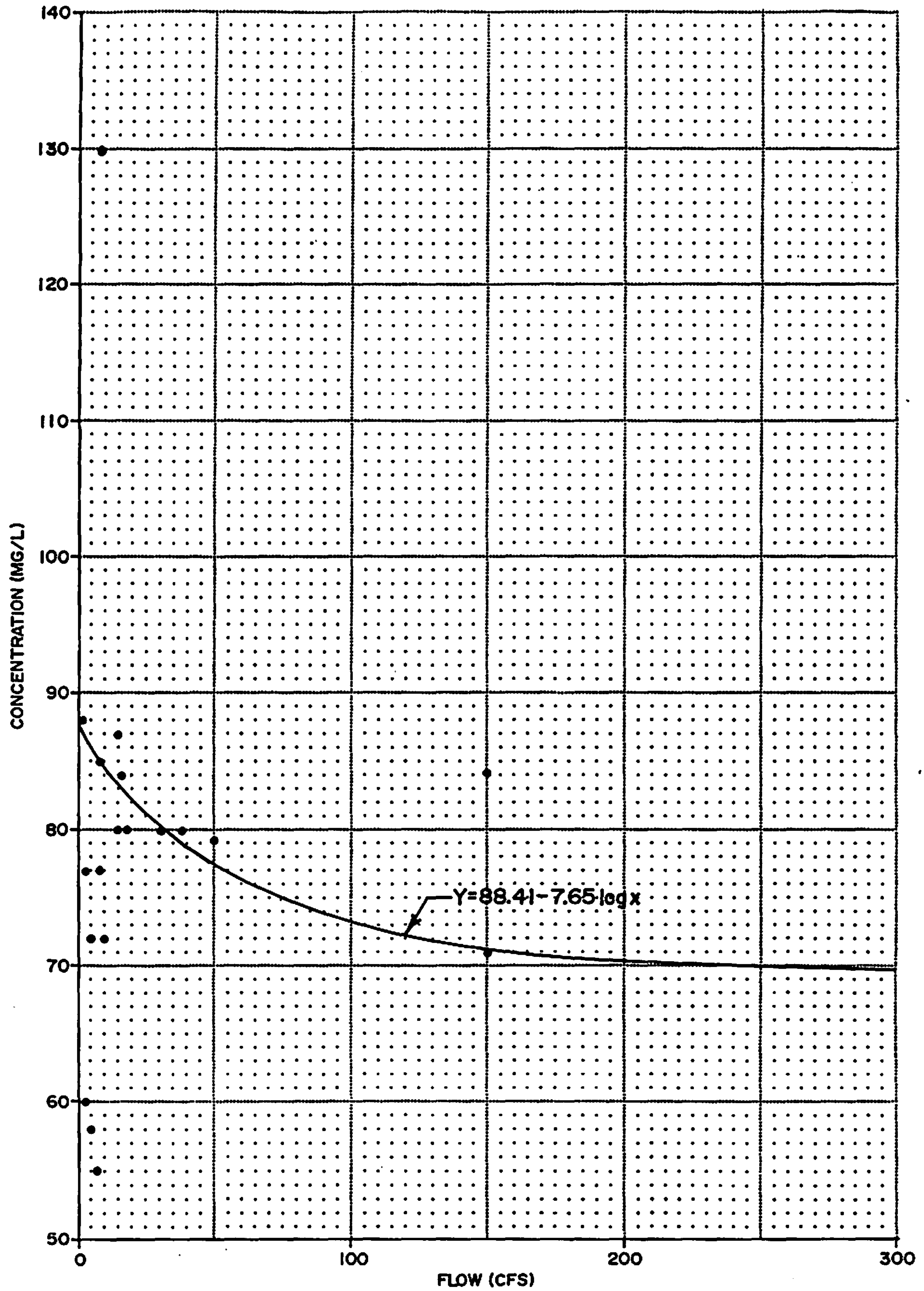
PROJECT NO. 08520550 | DATE 8/29/86

TOTAL PHOSPHORUS CONCENTRATION VS. TIME

EDWARDS UNDERGROUND WATER DISTRICT
SAN ANTONIO, TEXAS

APPENDIX C

FLOW VS. CONCENTRATION PLOTS FOR THREE REPRESENTATIVE CONSTITUENTS (TDS, TP, BOD5) FOR EACH STATION WITH THE LINE AND EQUATION REPRESENTING BEST-FIT



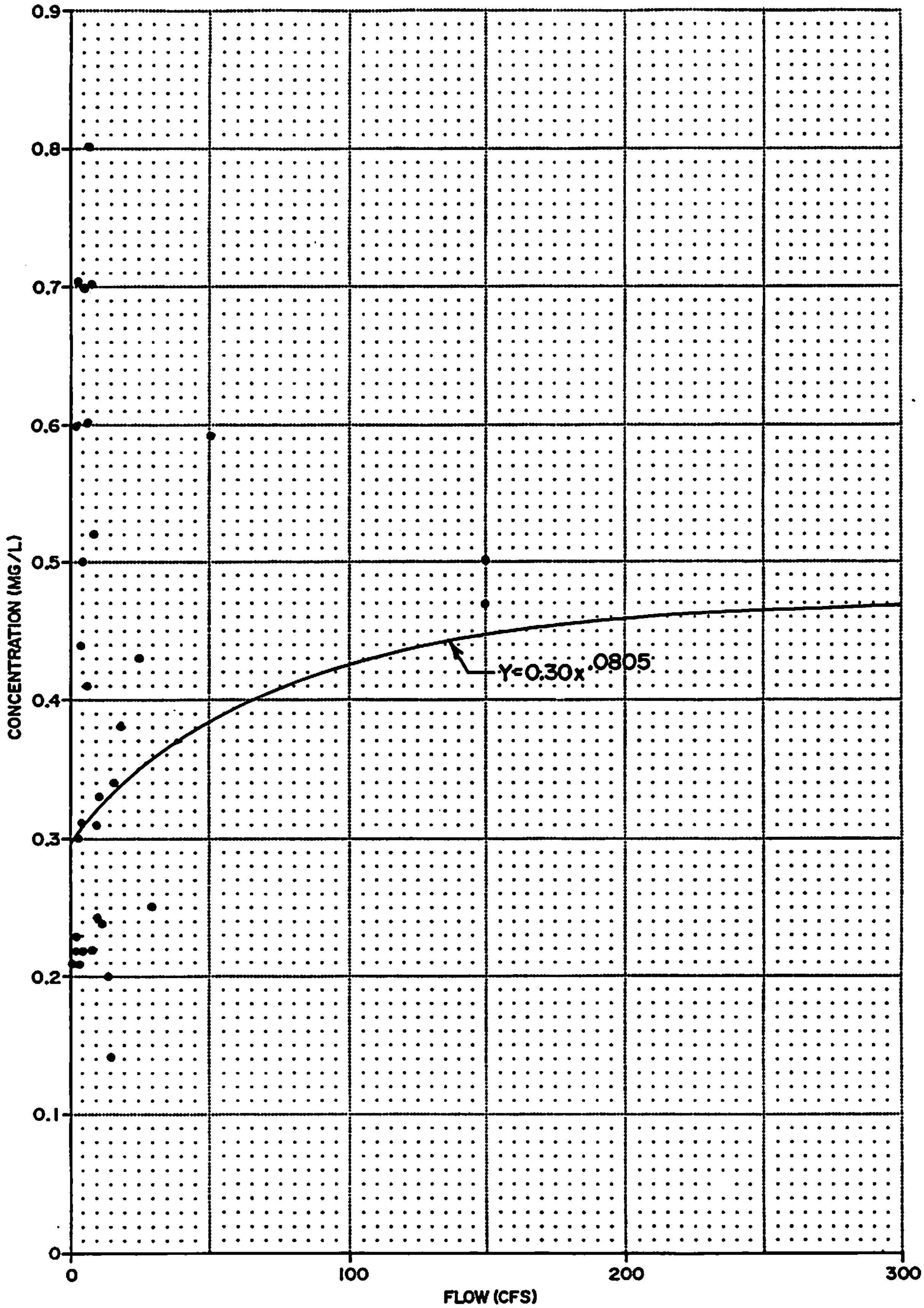
Water Resources Associates, Inc.

PROJECT NO. 08520550 DATE 8/29/86

TOTAL DISSOLVED SOLIDS

LORENCE CREEK AT THOUSAND OAKS

EDWARDS UNDERGROUND WATER DISTRICT
SAN ANTONIO, TEXAS



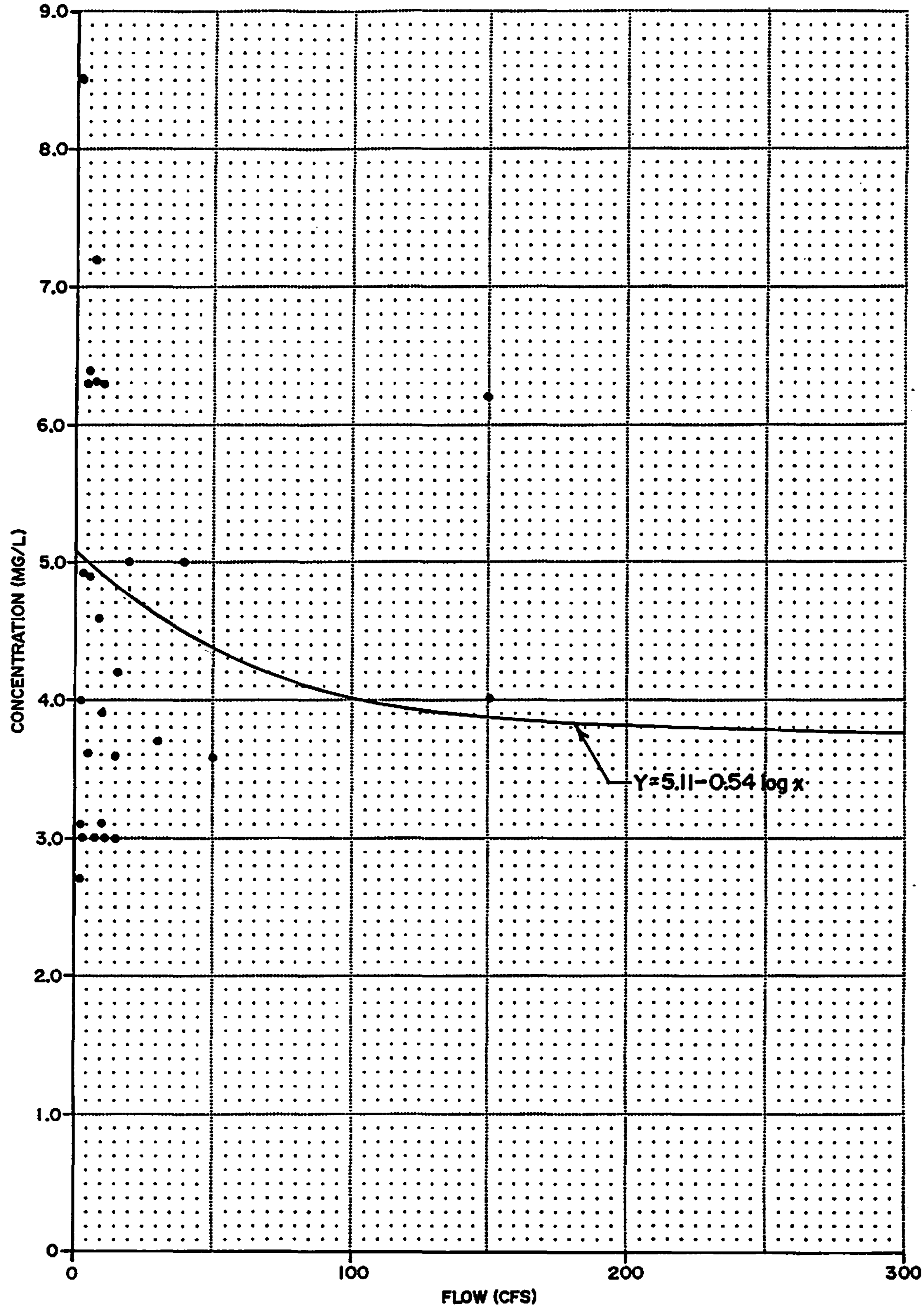
Water Resources Associates, Inc.

PROJECT NO. 08520550 | DATE 8/29/86

TOTAL PHOSPHORUS

LORENCE CREEK AT THOUSAND OAKS

EDWARDS UNDERGROUND WATER DISTRICT
SAN ANTONIO, TEXAS

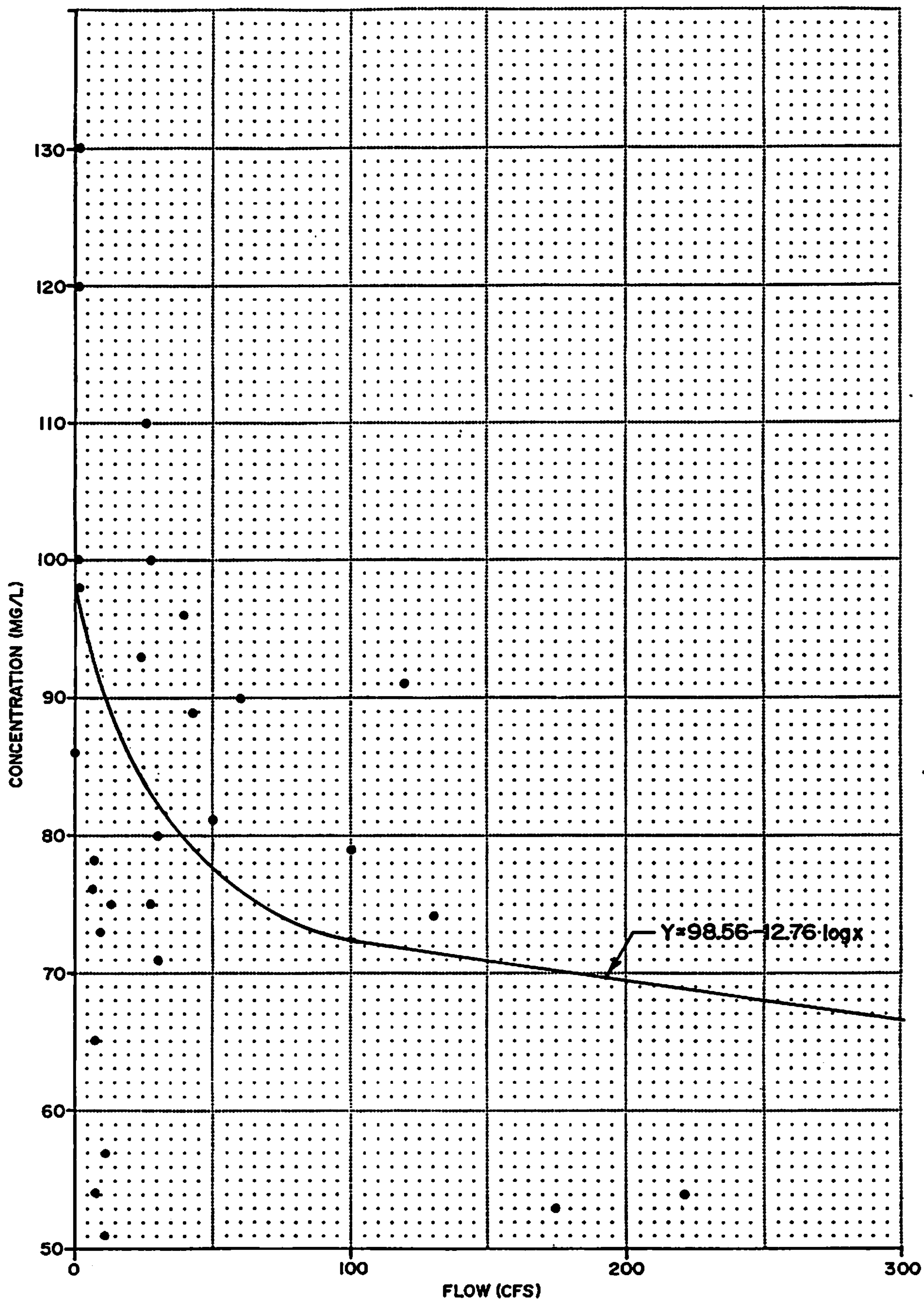


Water Resources Associates, Inc.

PROJECT NO. 08520550 DATE 8/29/86

BIOCHEMICAL OXYGEN DEMAND
LORENCE CREEK AT THOUSAND OAKS

EDWARDS UNDERGROUND WATER DISTRICT
SAN ANTONIO, TEXAS



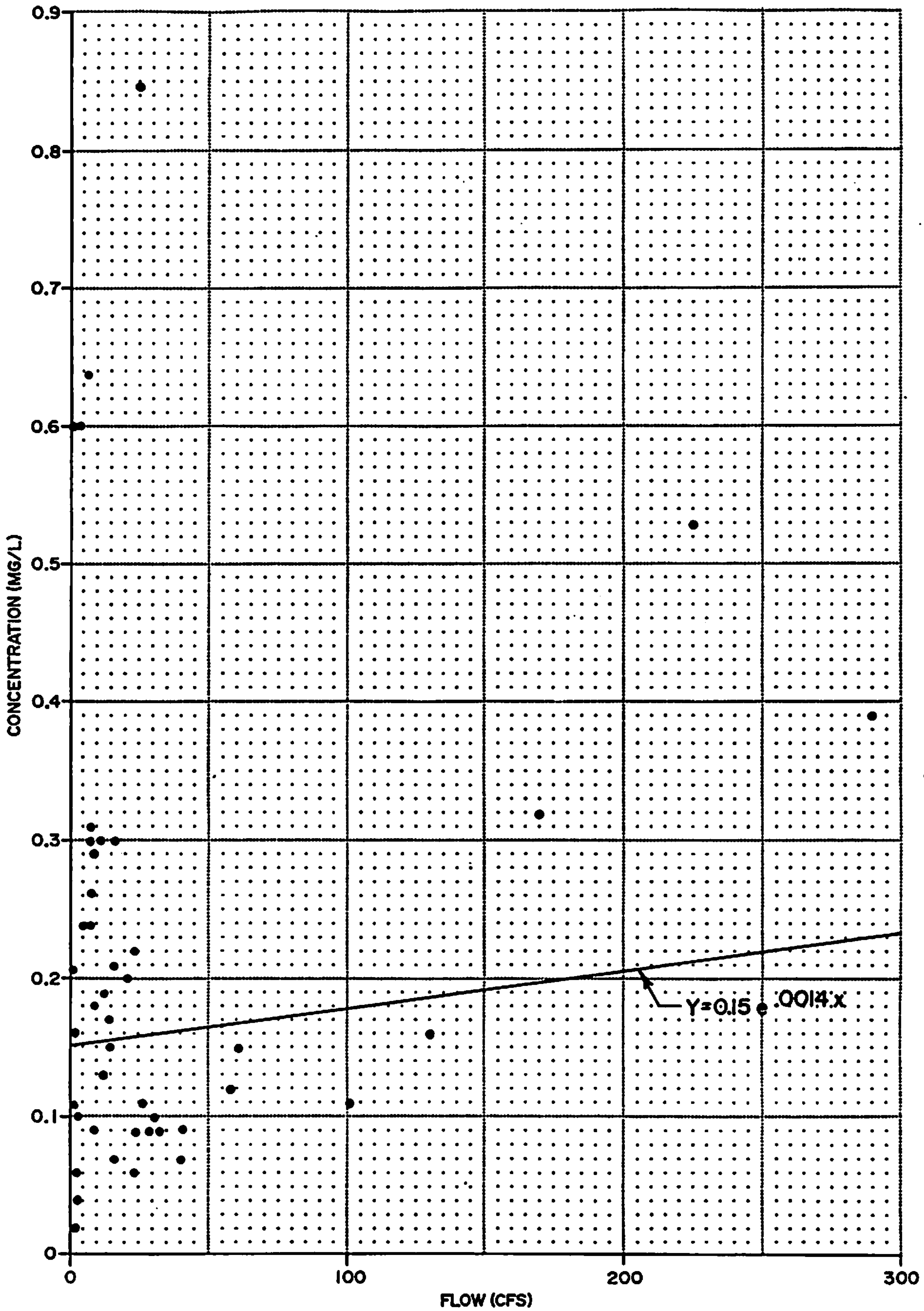
Water Resources Associates, Inc.

PROJECT NO. 08520550 DATE 8/29/86

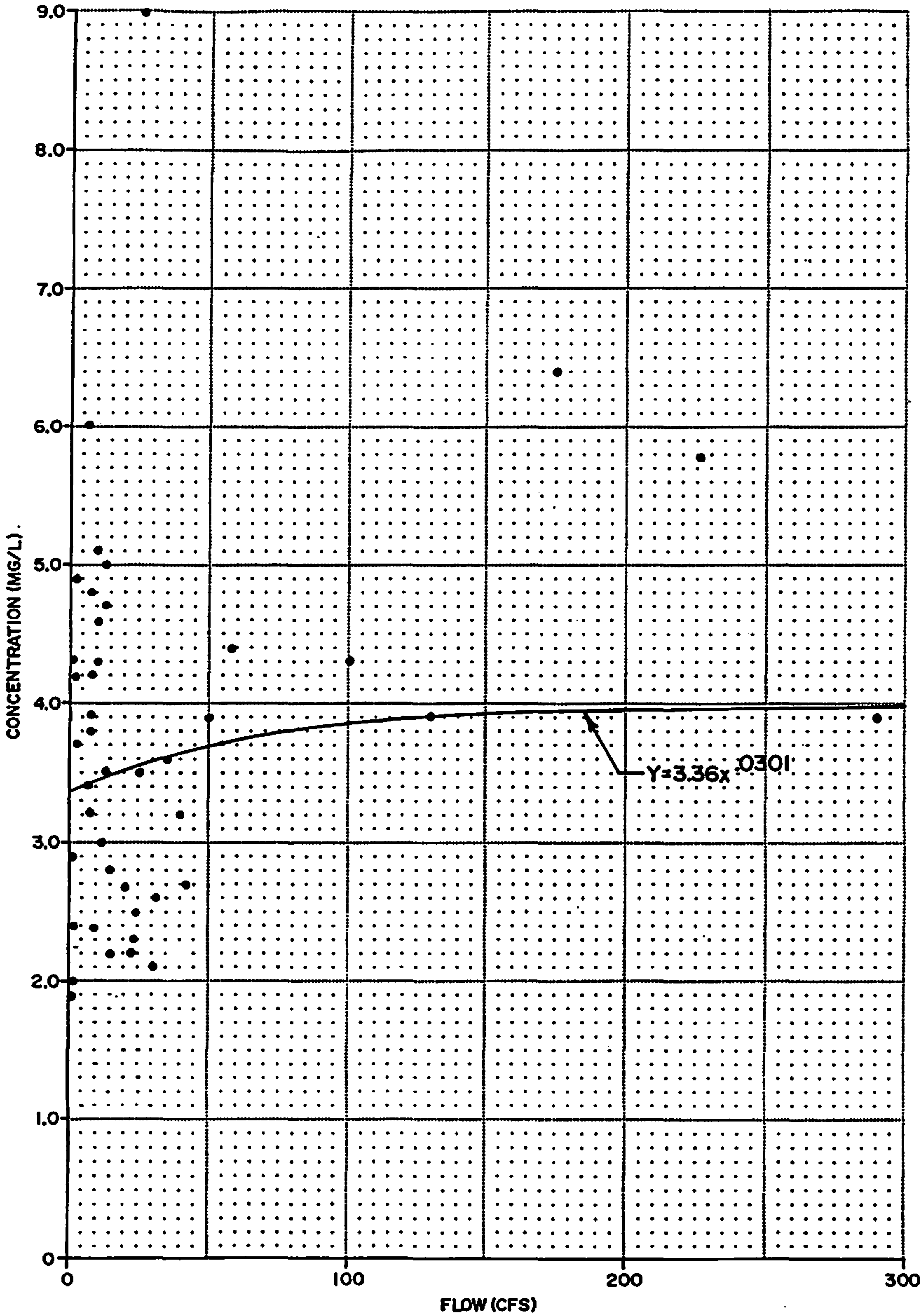
TOTAL DISSOLVED SOLIDS

WEST ELM CREEK

EDWARDS UNDERGROUND WATER DISTRICT
SAN ANTONIO, TEXAS



Water Resources Associates, Inc.	TOTAL PHOSPHORUS WEST ELM CREEK EDWARDS UNDERGROUND WATER DISTRICT SAN ANTONIO, TEXAS
PROJECT NO. 08520550 DATE 8/29/86	

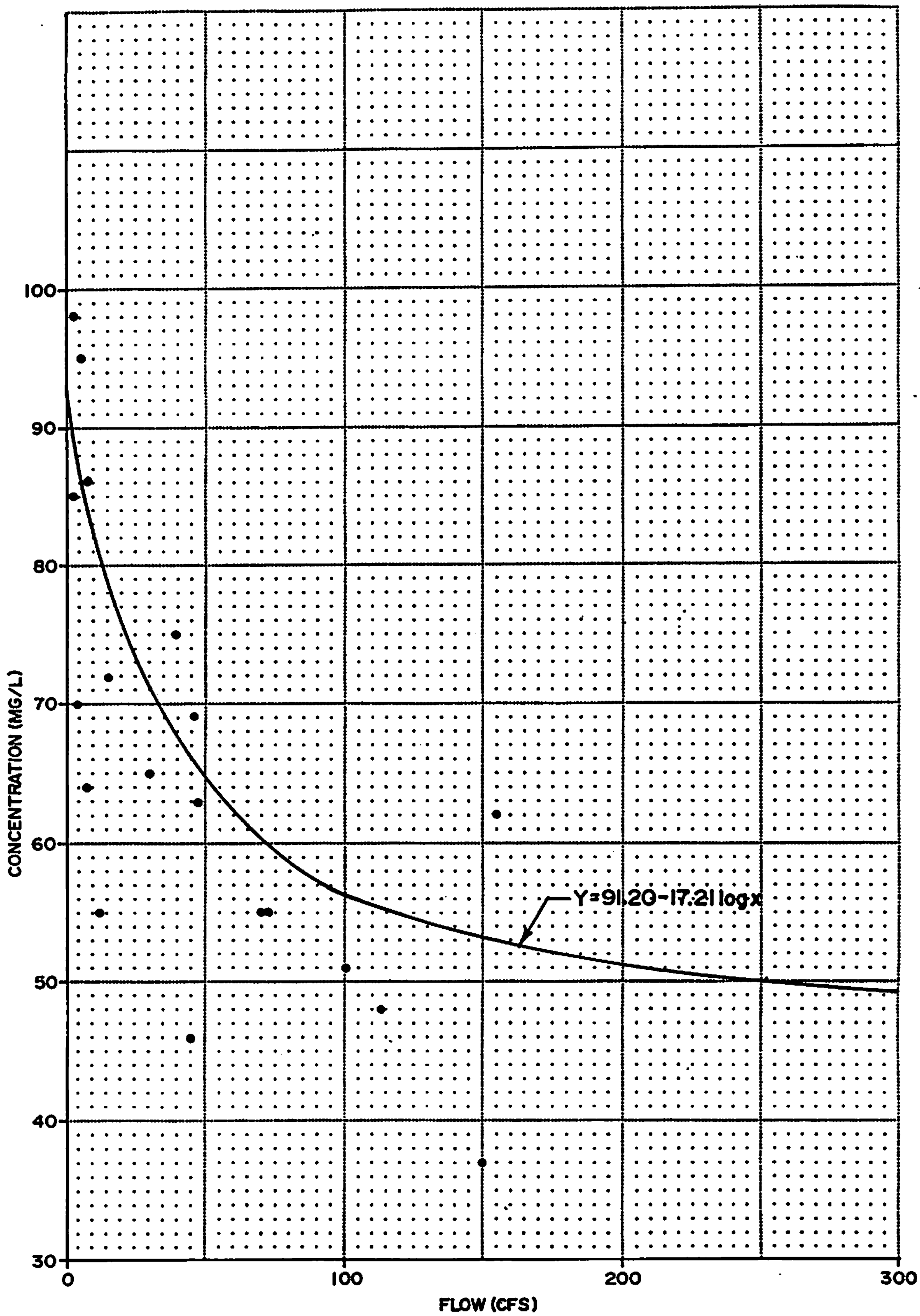


Water Resources Associates, Inc.

PROJECT NO. 08520550 | DATE 8/29/86

BIOCHEMICAL OXYGEN DEMAND
WEST ELM CREEK

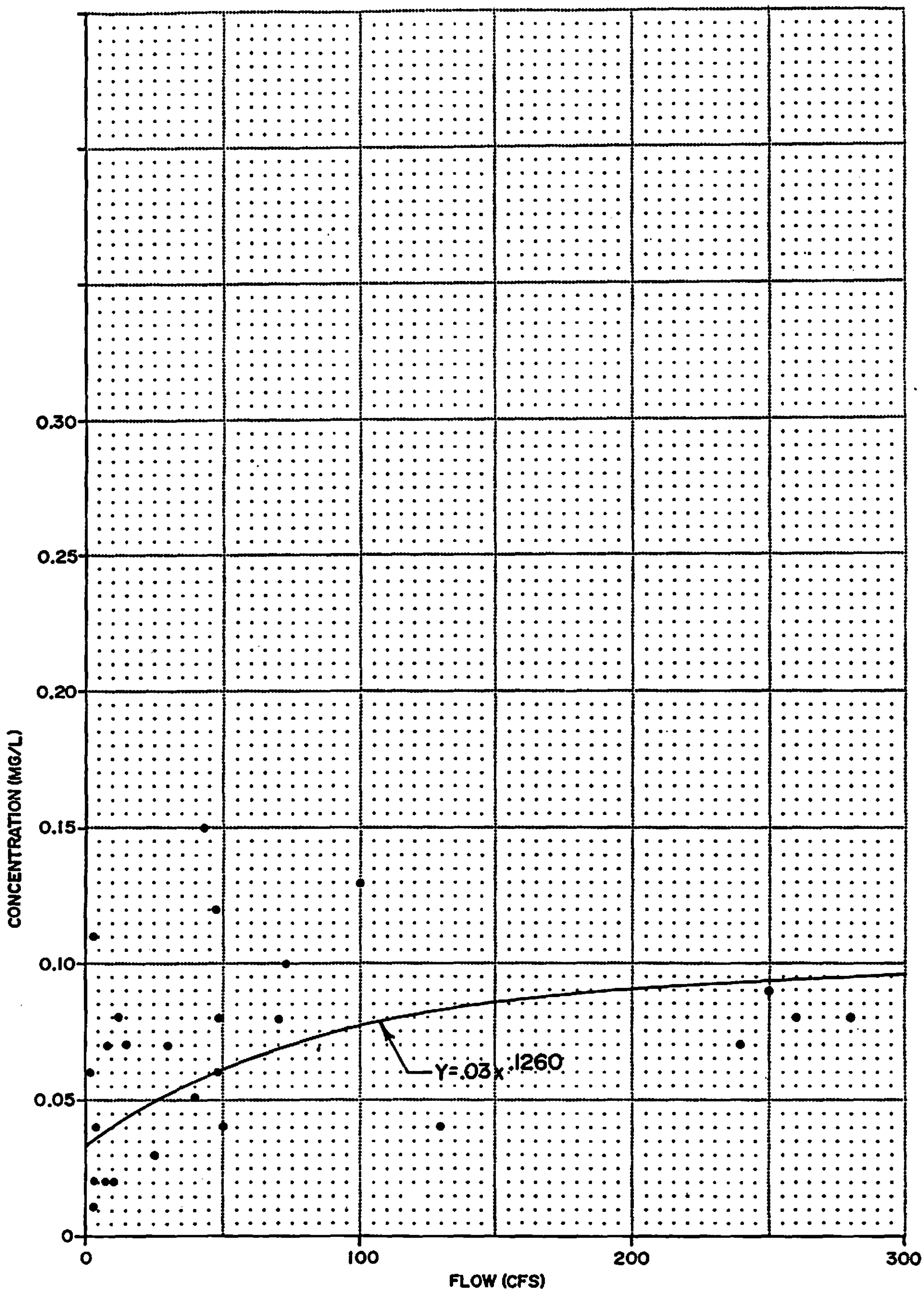
EDWARDS UNDERGROUND WATER DISTRICT
SAN ANTONIO, TEXAS



Water Resources Associates, Inc.

PROJECT NO. 08520550 DATE 8/29/86

TOTAL DISSOLVED SOLIDS
EAST ELM CREEK
EDWARDS UNDERGROUND WATER DISTRICT
SAN ANTONIO, TEXAS

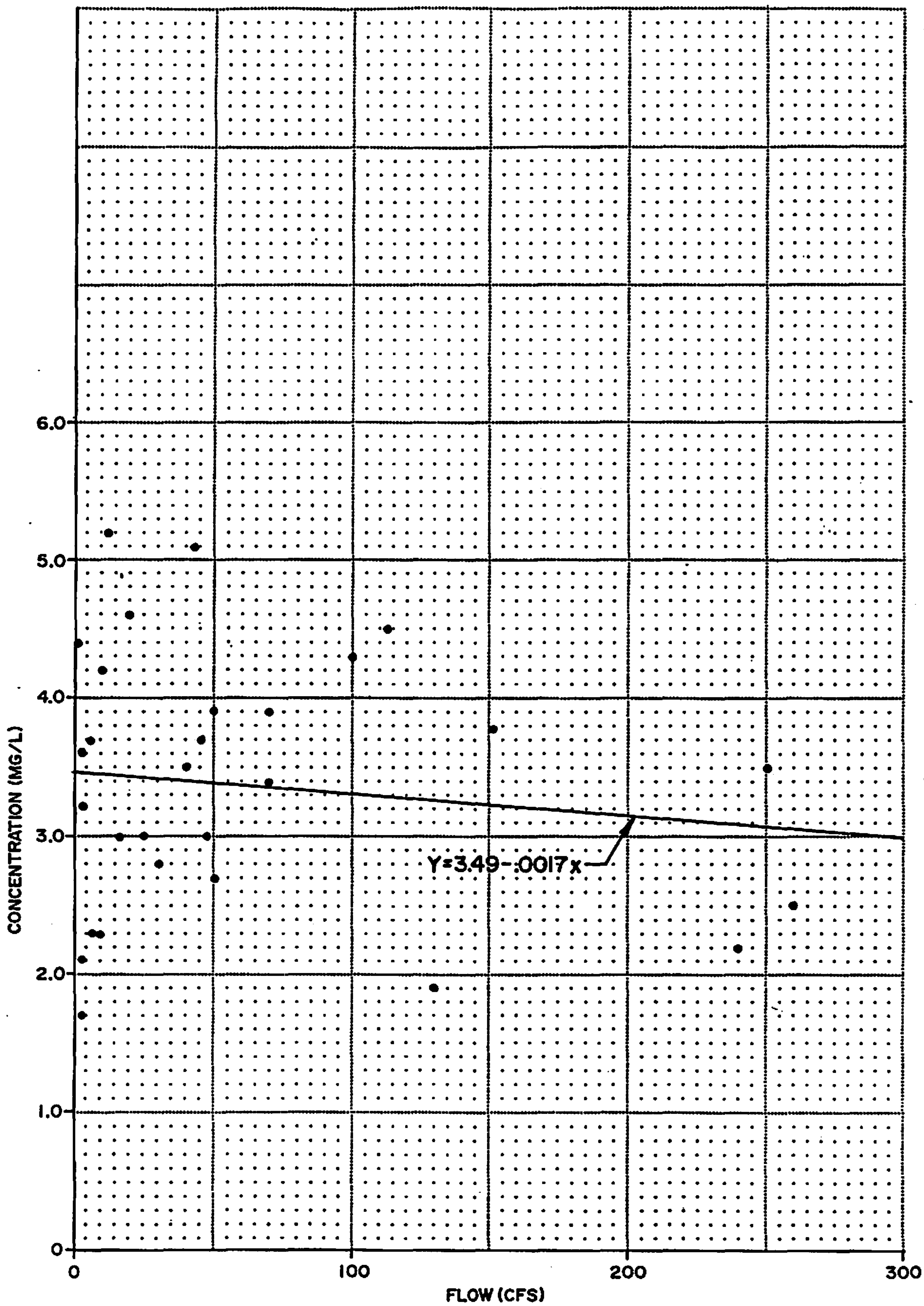


Water Resources Associates, Inc.

PROJECT NO. 08520550 DATE 8/29/86

TOTAL PHOSPHORUS
EAST ELM CREEK

EDWARDS UNDERGROUND WATER DISTRICT
SAN ANTONIO, TEXAS



Water Resources Associates, Inc.	**BIOCHEMICAL OXYGEN DEMAND** EAST ELM CREEK EDWARDS UNDERGROUND WATER DISTRICT SAN ANTONIO, TEXAS
PROJECT NO. 08520550 DATE 8/29/86	