BARTON SPRINGS WATER QUALITY TREND ANALYSIS

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Generally speaking, the water quality data for Barton Springs are insufficient for time series analysis. There are approximately seven years of data and there are only a few (1-3) measurements for five of the seven years. Nevertheless, the baseline water quality conditions of Barton Springs were studied using these data and the supplemental measurements collected at Barton Creek below the springs. During some dry weather periods, the water quality at Barton Springs can be considered equivalent to that of Barton Creek below the Springs. Table 1 and Figures 1-6 exhibit the mean, trend, frequency, and seasonal variation for biochemical oxygen demand (BOD), nitrate nitrogen (NO_3), total phosphorus (TP), total dissolved solids (TDS), and fecal coliform. Table 2 is a comparison of baseline water quality conditions between Barton Creek and Barton Springs.

Conclusions

1. There are no significant trends on the data of BOD, NO_3, TDS and fecal coliform (Figures 1-4). The coefficients of correlation between annual average concentrations and calendar years are not different from zero at 95% confidence level. The time trend on TP is significant at 95% confidence level (Figure 5). This trend is about 0.0018 mg/l increase per year compared to the mean value of 0.02 mg/l. No source has been identified for this increase. This level of phosphorous does not present the possibility of nuisance aquatic plant growth at Barton Springs pool or hazards to human health or aquatic species.

2. There is no significant seasonal variation in the data of TP, NO_3, TDS, and fecal coliform (Table 1). The differences of seasonal means are not different from zero at 95% confidence level. The BOD concentrations are higher during the spring and fall seasons. This result is heavily influenced by the BOD measurements of April and August 1984 which are several times higher than those of other years. No source has been identified for the significant increase of BOD in 1984.

3. As compared to Barton Creek, the Barton Springs water has higher concentrations in TDS and nitrogen compounds (including NO_2, NO_3, NH_3, and TKN), and has lower concentrations of dissolved oxygen and total organic carbon (TOC). This information is presented in Table 2.

4. The fecal coliform count of baseline conditions at Barton Springs is generally low. The geometric mean of sixty-three such measurements (measured during 1978-84) is 13 colonies/100 ml. Figure 6 is a

frequency plot of this data. Five of the sixty-three measurements collected in February and March 1982 exceed the State water quality standard limit[1] for contact recreation of 200 colonies/100 ml. This has been attributed to fractures in municipal sewer lines upstream from the springs during this period. The fractures were located by the City's Water and Wastewater Department.

5. There is a significant relationship existing between TDS and discharge at the springs (Figure 7). The regression of TDS on discharge is significant at 95% confidence level. The values of TDS decrease with the increase of spring discharge. There is no significant relationship existing between the other studied parameters and baseline spring discharge. The regression of BOD, NO_3, TP, or fecal coliform on discharge is insignificant.

6. It is recommended that baseline water quality sampling at Barton Springs be continued so that there will be sufficient data for definitive trend analysis. Additional data of at least six years would be required for this analysis. Currently, sampling for BOD, nutrients, bacteria, pesticides, and metals is scheduled six times yearly under the USGS/City Cooperative Monitoring Program[2]. This program also schedules sampling four times yearly for GC/MS volatile toxic organics analysis. Under another monitoring program supervised by the City's Office of Environmental Resource Management[3] (OERM), weekly samples for fecal coliform, streptococci, specific conductance, and pH are being collected. It is recommended that these sampling programs be continued indefinitely to provide a long term historical record of aquifer water quality.

7. It is also recommended that additional storm-event sampling at Barton Springs be conducted so that the effect of stormwater runoff on the Barton Springs water quality can be further studied. Few storm-event data has been collected at the Springs since the 1981-82 survey[3]. The net effect of urban development in the past three years on the quality of runoff water recharging the Edwards Aquifer has not been monitored during storm events.

Data Source and Previous Work

The data used in this study consists of the following:

1. Spring discharge and baseline water quality data for Barton Springs between 1978 and 1984[2].

2. Streamflow and baseline water quality data for Barton Creek below Barton Springs between 1975 and 1984[2].

3. Streamflow and baseline water quality for Barton Creek at Loop 360 and Highway 71 between 1977 and 1984[2].

4. Barton Springs discharge and baseline water quality data collected under an intensive survey during October 1981 - September 1982[4]. (These data are part of Item No. 1 above.)

5. The TDS concentration data collected prior to 1975, the beginning of the U.S. Geological Survey (USGS)/City of Austin Cooperative Monitoring Program (Table 3).

6. The fecal coliform concentration data collected by the Texas Water Quality Board prior to 1975[5].

Under the USGS/City of Austin Cooperative Monitoring Program[2], periodic water quality sampling has been conducted at Barton Springs since 1978, and at Barton Creek below Barton Springs since 1975. When there is no local runoff, the flow of Barton Creek below Barton Springs is composed of the spring discharge and Barton Creek streamflow bypassing the pool structure. If the creek upstream from the pool is dry, the flow of Barton Creek below Barton Springs consists of spring discharge only. It can be assumed that the water quality of Barton Creek below the springs is equivalent to that of Barton Springs when there is no flow in Barton Creek above the springs (such as Barton Creek at Loop 360 or Highway 71).

An intensive water quality survey[4] at Barton Springs was conducted during October 1981 - September 1982 by the USGS in cooperation with the City of Austin. A report analyzing the effect of stormwater runoff on Edwards Aquifer water quality was published in 1984. The report indicates that the concentrations of fecal coliform and fecal streptococcal bacteria in the water increase after stormwater runoff. The recharge during storm runoff resulted in significant decreases in specific conductance and NO_3 concentrations of the discharged groundwater. As a verification for the bacteria data obtained from the intensive survey, the OERM initiated a monitoring program for Barton springs. Based on the request of OERM, the Austin-Travis County Health Department[6] started a daily sampling for fecal coliform and fecal streptococci in February 1982. this sampling has been continued on weekly basis since 1983. On the other hand, the OERM has successively contracted with Aqualab, Inc., and Underground Resource Management, Inc., starting a new program[3] (1983-85). Under this program weekly samples at Barton Springs for fecal coliform, fecal streptococci, specific conductance, and pH are being collected.

Monitoring data from several sources, prior to the USGS/City of Austin Cooperative Monitoring Program, were compiled by Raymond Slade of the USGS as shown in Table 3. The Texas Water Quality Board[5] conducted a study of Barton Creek and Barton Springs. Approximately thirty-three non-storm event bacteria samples were collected from the major spring orifice during September 1973 - September 1974. This bacteria analysis indicates that groundwater discharged from the spring orifice contained low concentrations of fecal coliform bacteria.

10W01/20.a

REFERENCES

1. Texas Department of Water Resources (TDWR, or Texas Water Quality Board, before 1977). "Texas Water Quality Standards", Publication GP-3-1, reprinted February 1978.

2. U.S. Geological Survey (USGS). "Hydrologic Data for Urban Studies in the Austin, Texas Metropolitan Area", prepared in cooperation with the City of Austin and TDWR, 1975 - 1984.

3. City of Austin, Data Files for Barton Springs Monitoring Program (1983-85), compiled by the City's Office of Environmental Resource Management.

4. USGS. "Effects of Stormwater Runoff on Water Quality of the Edwards Aquifer Near Austin, Texas", prepared in cooperation with the City of Austin, Water Resources Investigations Report 84-4124, 1984.

5. Texas Water Quality Board, "Water Quality Evaluation of Barton Creek and Barton Springs", prepared by Steve Twidwell, Field Operations Division Special Report No. SR-6, 1976.

6. City of Austin. Data Files for Barton Spring (1982-85), compiled by the Environmental Health Services Division, Austin - Travis County Health Department.

10W01/20.a/ref

TABLE 1

BASELINE WATER QUALITY CONDITION OF BARTON SPRINGS

Parameter	Winter*	Spring	Summer	Fall	Mean**
BOD	0.30	0.50	0.60	0.20	0.35
TP	0.02	0.02	0.02	0.01	0.02
NO_3	1.20	1.30	1.30	1.20	1.30
TDS	354.00	341.00	342.00	352.00	346.00
Fecal Coliform	22.00	22.00	20.00	33.00	22.00

*Winter: Dec-Feb; Spring: Mar-May; Summer: Jun-Aug; Fall: Sep-Nov

**For fecal coliform the geometric mean was developed. Otherwise the arithmetic means were computed. Some data of Barton Creek below Barton Spring were used for computation as described in the text.

10W01/20.a/tbl

TABLE 2

COMPARISON OF BASELINE WATER QUALITY CONDITIONS BETWEEN BARTON CREEK AND BARTON SPRINGS

Source	Type of Mean	BOD*	TOC	DO	FCOL	TDS	NO_3	NH_3	TKN	TP
				Type of Parameters						
Barton Springs (1978-84)	**Arithmetic	0.4	1.6	6.5	152	348	1.33	.07	.61	.02
	Geometric	0.3	0.5	6.4	13	347	1.32	.05	.50	.02
Barton Creek below Barton Springs (1975-84)	Arithmetic	0.3	3.9	8.0	73	322	.98	.02	.43	.02
	Geometric	0.2	2.0	8.0	28	320	.84	.01	.12	.01
Barton Creek at Loop 360 (1977-84)	Arithmetic	0.4	3.6	9.6	21	235	.15	.03	.22	.01
	Geometric	0.4	2.9	9.6	14	235	.10	.02	.10	.01

*The unit of data values is colonies/100 ml for fecal coliform, and is mg/l for all other parameters.

**The values of BOD, FCOL, TDS, and NO_3 for Barton Spring are slightly different from that of Table 1 as no data of Barton Creek below Barton Spring were used for deriving the values.

10W01/20.a/t2

Table 3.--Water-quality analyses for Barton Springs prior to the beginning of the U.S. Geological Survey sampling program in 1978

(mg/L, milligrams per liter)

Sample date	Barton Springs discharge 1/ (ft^3/s)	Total dissolved solids (mg/L)	Specific conductance (micromhos)	pH field (units)	Hardness (mg/L as $CaCO_3$)	Calcium dissolved (mg/L as Ca)	Magnesium dissolved (mg/L as Mg)	Sodium dissolved (Na+K) 2/	Sodium dissolved (mg/L as Na)	Potassium dissolved (mg/L as K)	Bicarbonate (mg/L as HCO_3)	Sulfate dissolved (mg/L as SO_4)	Chloride dissolved (mg/L as Cl)	Fluoride dissolved (mg/L as F)	Silica dissolved (mg/L as SiO_2)	Iron dissolved (mg/L as Fe)	Boron dissolved (mg/L as B)	Nitrate dissolved (mg/L as NO_3)
Oct. 1903 3/	70	349	--	--	--	83	14	30	--	--	329	20	28	--	11	trace	--	--
Aug. 23, 1937 4/	32	405	--	--	309	87	22	36	--	--	329	56	42	--	--	--	--	5/
Sept. 7, 1937 4/	31	471	--	--	336	85	30	50	--	--	306	60	89	0.7	--	--	--	5/
Sept. 9, 1937 4/	31	342	--	--	318	83	27	10	--	--	318	28	31	.6	--	--	--	5/
Oct. 27, 1939 4/	16	407	--	--	312	79	28	37	--	--	305	38	71	.2	--	--	--	[illegible]/
Nov. 9, 1939 6/	12	399	--	--	338	73	38	26	--	--	311	41	68	--	--	--	--	5/
June 6, 1941 4/	100	321	--	7.7	282	80	20	7/4.1	--	--	302	16	18	--	10	0.04	--	1.[illegible]
Oct. 9, 1941 4/	55	350	--	7.7	320	92	22	7/3.2	--	--	323	22	25	.1	12	.02	--	4.[illegible]
June 10, 1948 4/	19	434	769	--	327	80	31	37	--	--	320	47	65	--	11	--	--	4.[illegible]
Jan. 18, 1955 3/	21	430	751	8.0	297	73	28	41.8	40	1.8	293	50	64	.3	12	.02	0.10	4.5
Aug. 13, 1965 3/	75	335	--	--	--	86	21	15	--	--	322	22	22	--	--	--	--	--
Apr. 22, 1971 9/	30	390	651	7.4	311	83	25	27	--	--	317	37	45	.2	11	--	--	6.5
Feb. 6, 1973 9/	69	319	555	7.8	282	82	19	12	--	--	298	25	22	.2	7	.02	.1	5.5

1/ Estimated (from periodic discharge measurements of Barton Springs)
2/ Calculated.
3/ Sample collected and analyzed by U.S. Geological Survey.
4/ From Arnow (1957).
5/ Nitrate value less than 20 mg/L.
6/ From George, Cumley, and Follett (1941).
7/ Reported as presented; probably erroneous.
8/ From St. Clair (1979).
9/ From Brune and Duffin (1983).

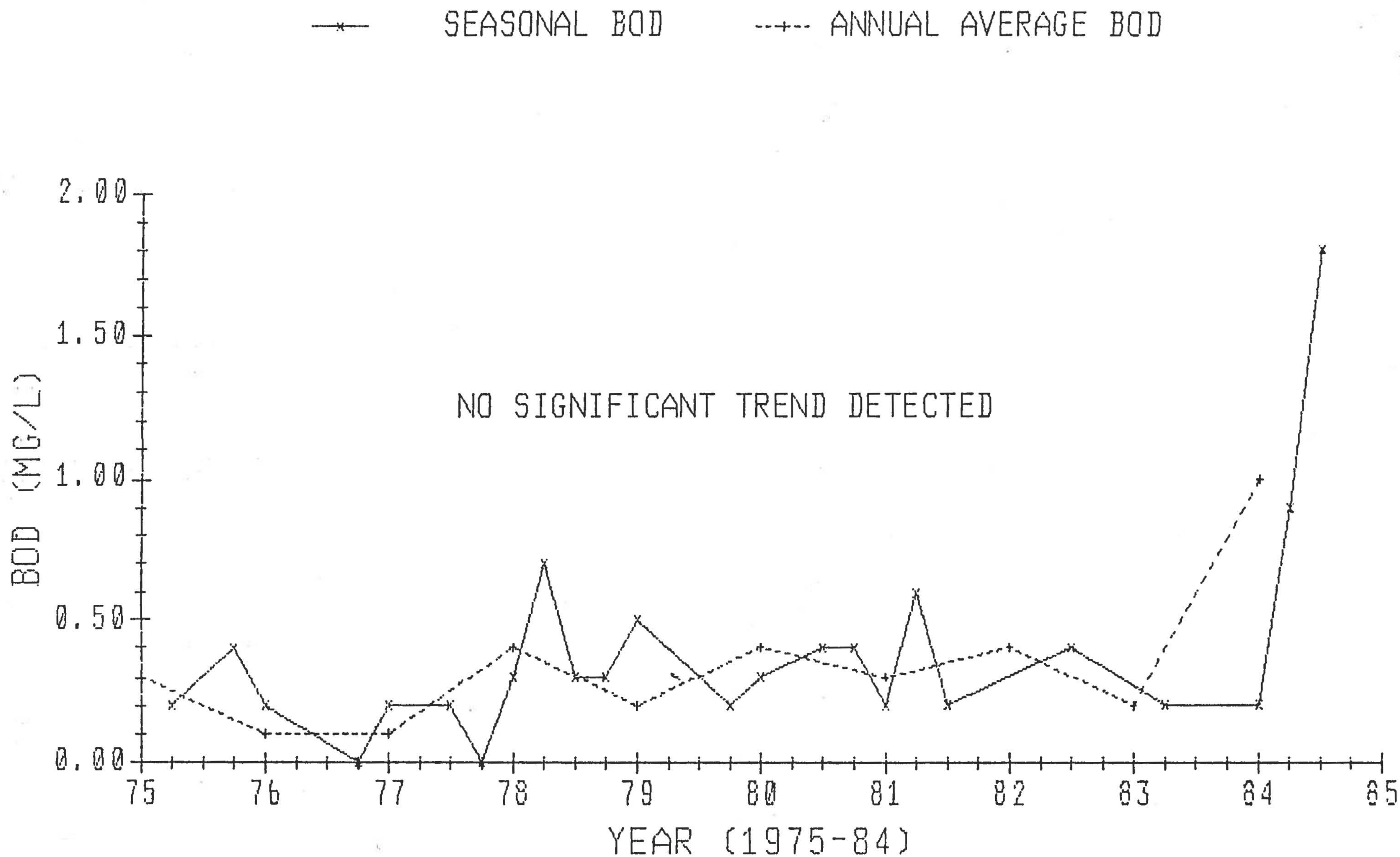

FIGURE 1. TREND ANALYSIS OF BOD CONCENTRATION DATA - HISTORICAL RECORD

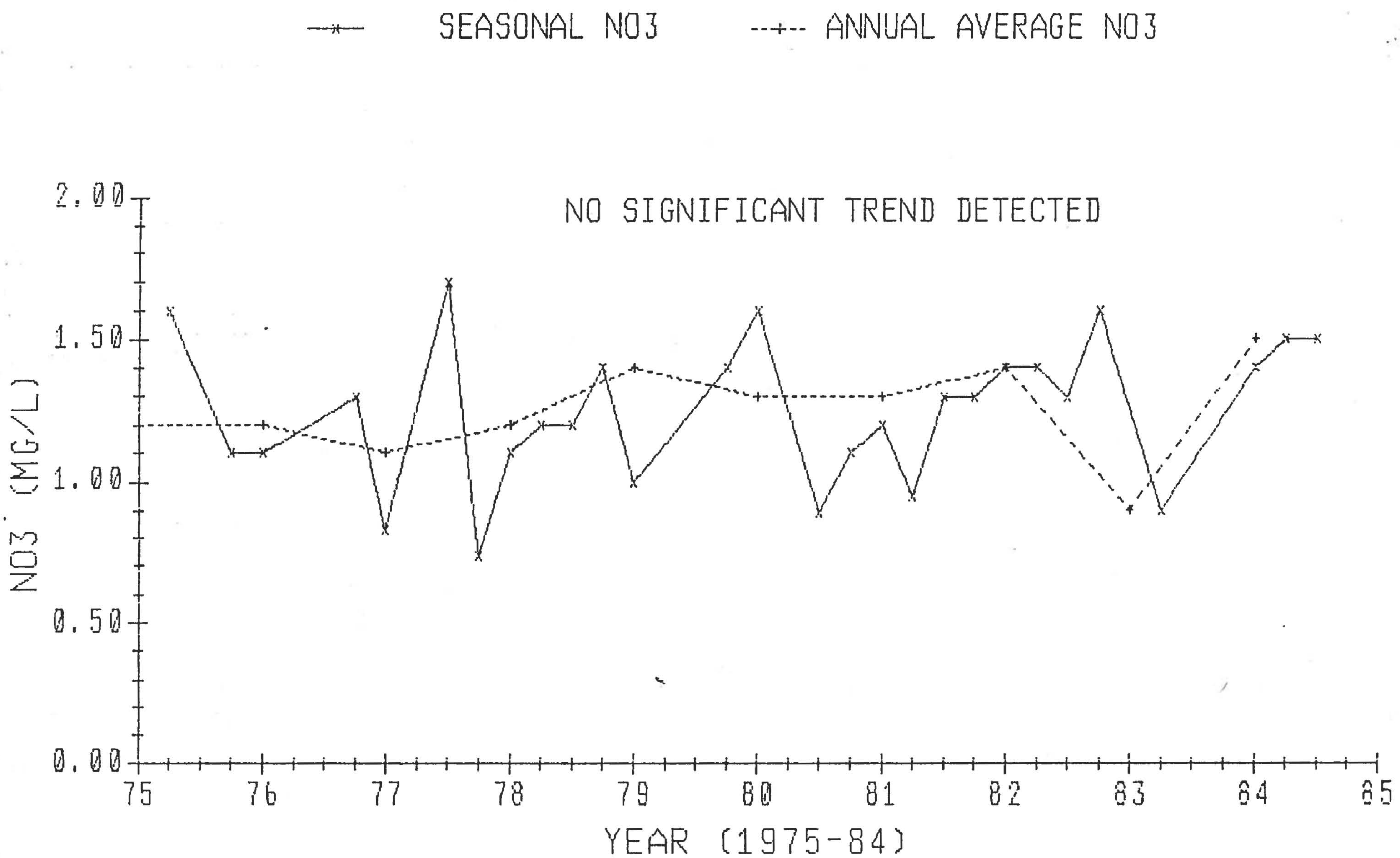

FIGURE 2. TREND ANALYSIS OF NO3 CONCENTRATION DATA - HISTORICAL RECORD

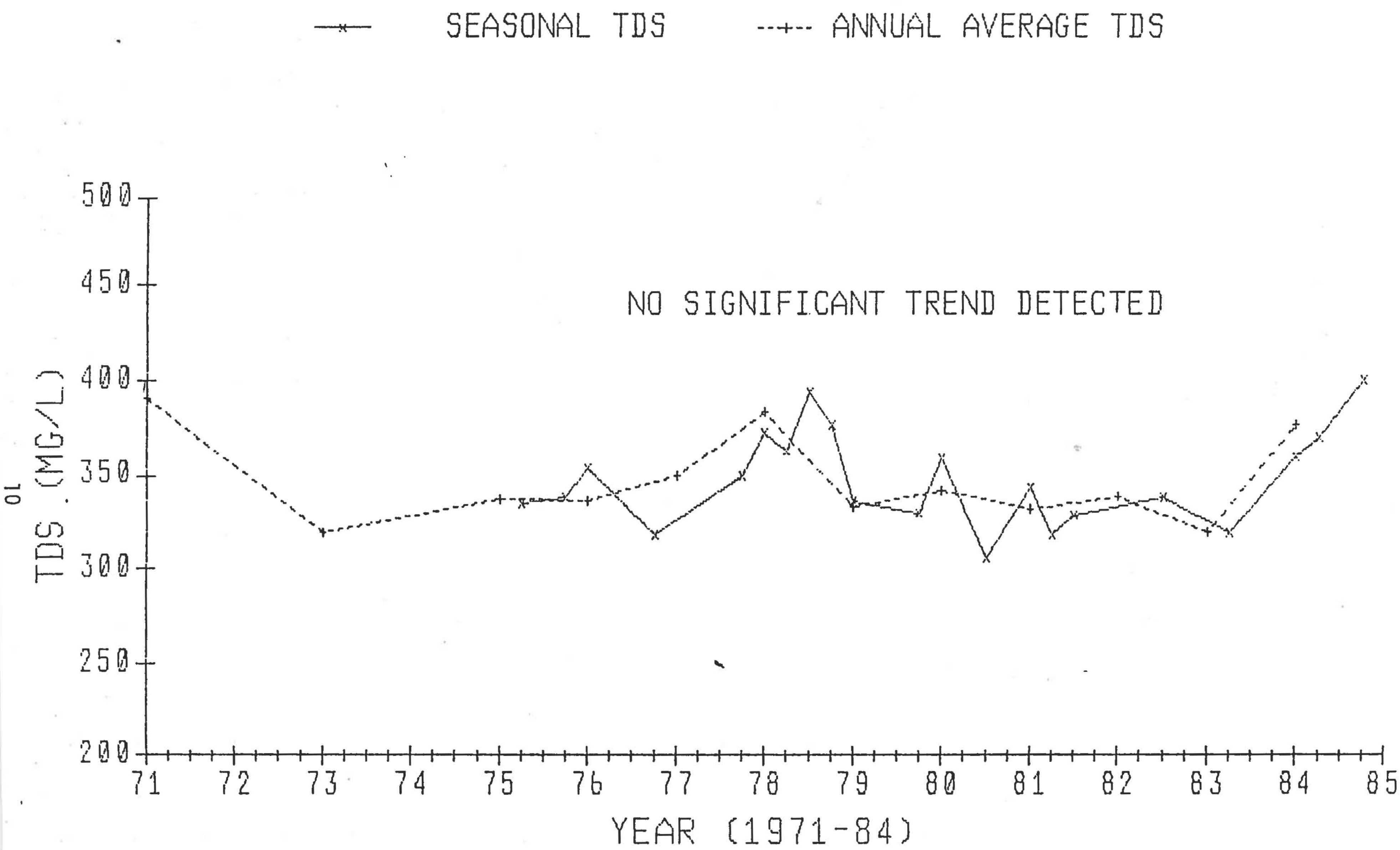

FIGURE 3. TREND ANALYSIS OF TDS CONCENTRATION DATA - HISTORICAL RECORD

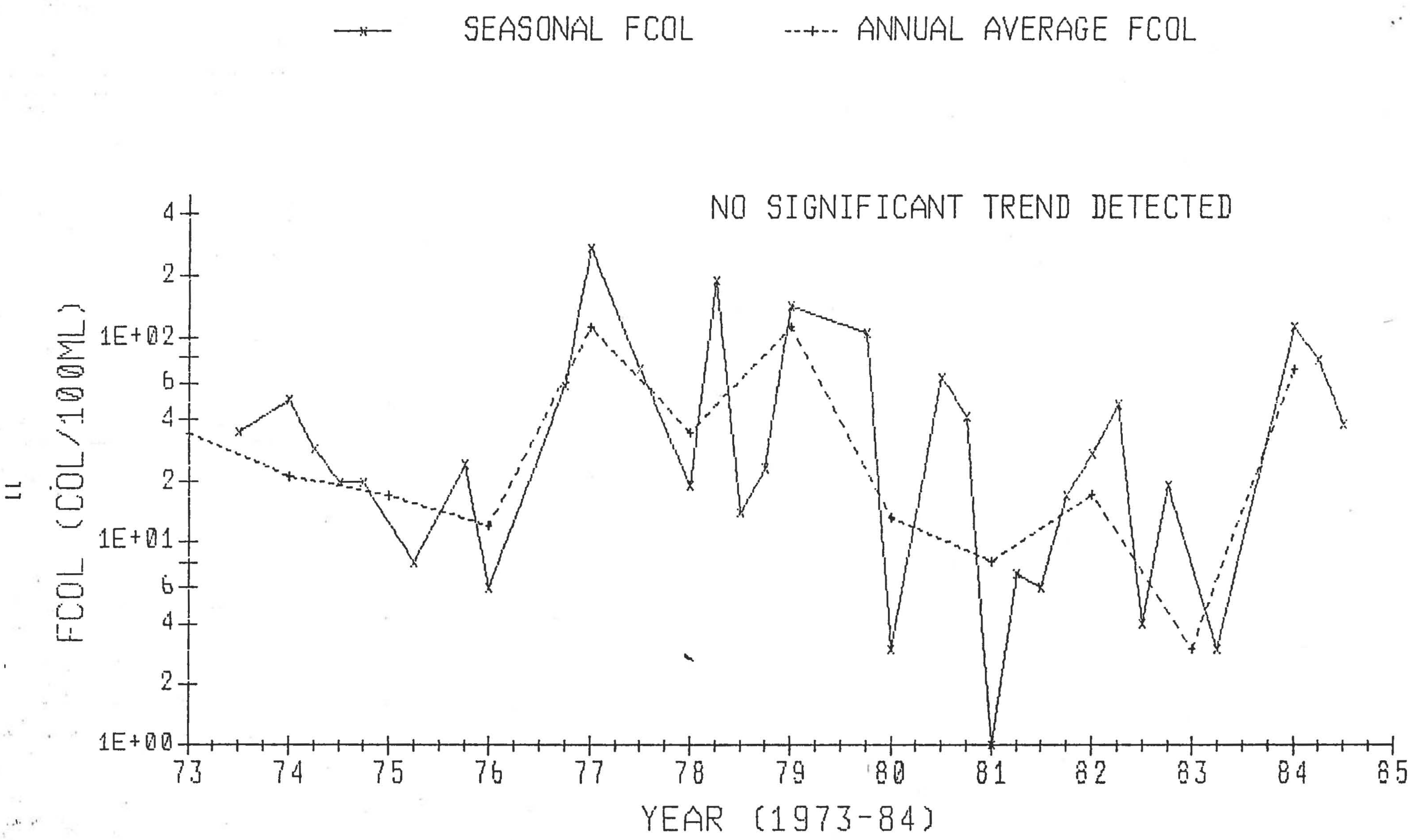

FIGURE 4. TREND ANALYSIS OF FECAL COLIFORM CONCENTRATION DATA - HISTORICAL RECORD

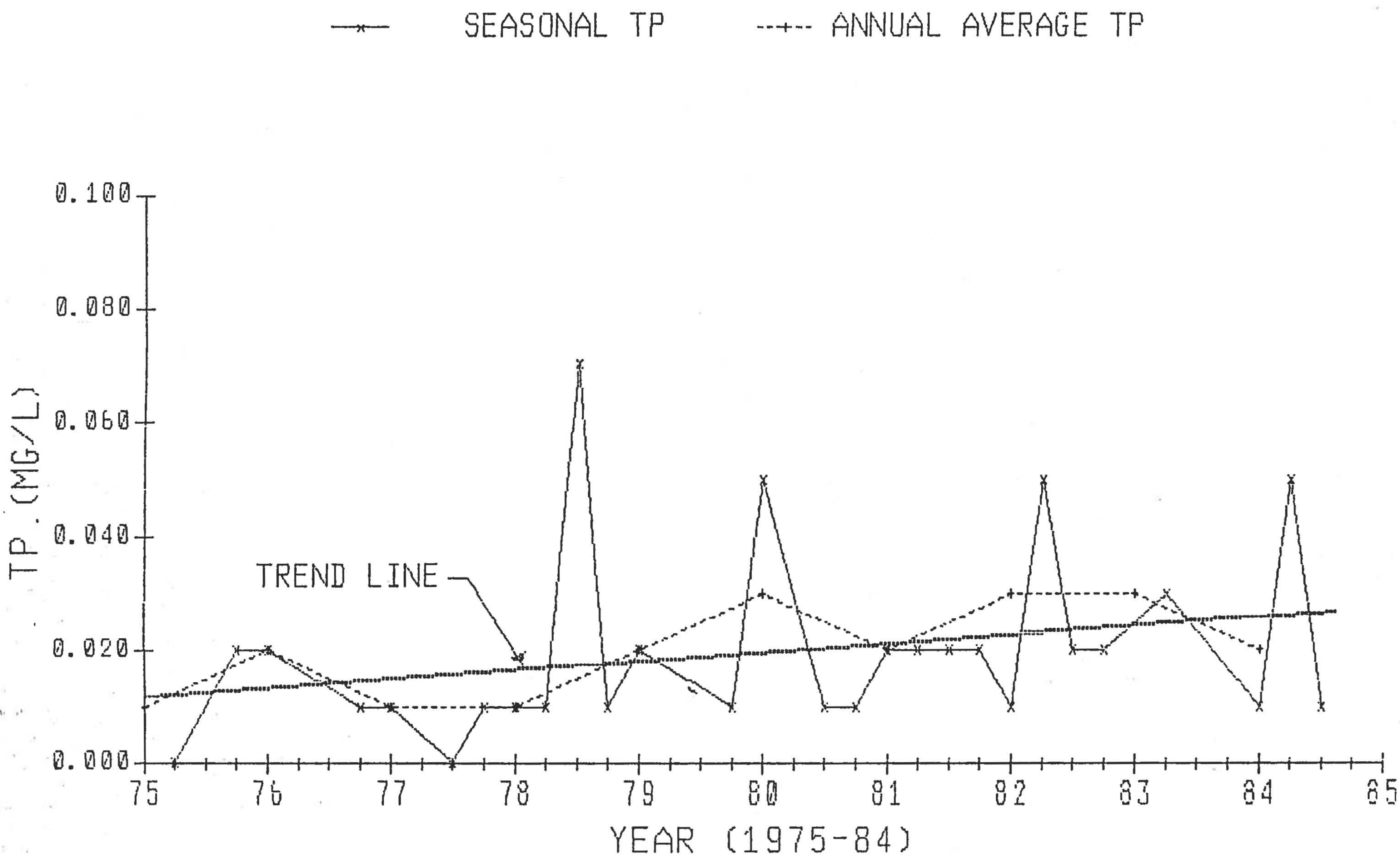

FIGURE 5. TREND ANALYSIS OF TP CONCENTRATION DATA - HISTORICAL RECORD

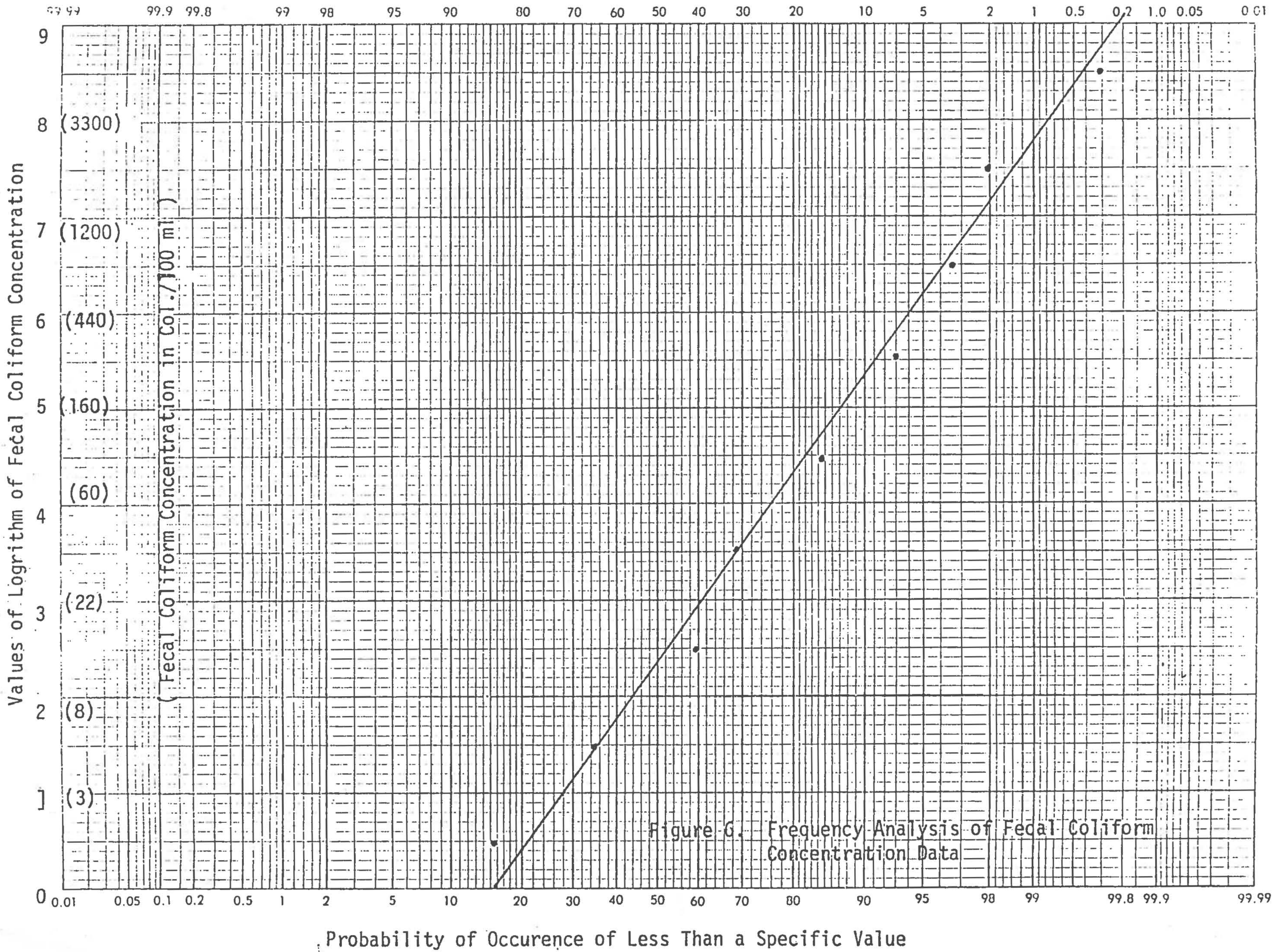

Figure G. Frequency Analysis of Fecal Coliform Concentration Data

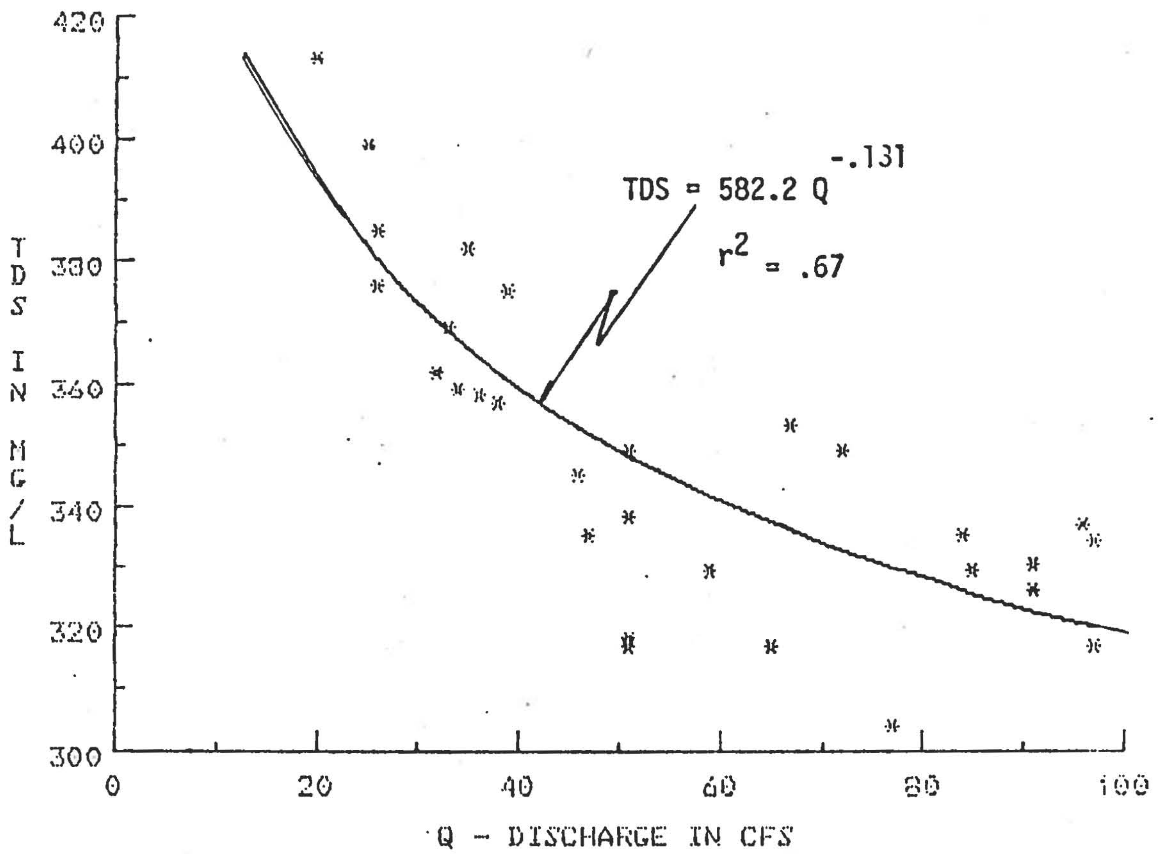

FIGURE 7 RELATIONSHIP OF TDS AND DISCHARGE