

INTENSIVE SURFACE WATER MONITORING SURVEY
FOR
SEGMENT NO. 1903 
MEDINA RIVER

REPORT NO. IMS-46

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TEXAS WATER QUALITY BOARD

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INTRODUCTION

DIRECTIVE

This intensive survey was accomplished in accordance with the Texas Water Quality Act, Section 21.257, as amended in 1973. The report is to be used in developing and maintaining the State Water Quality Strategy required by regulations published in 40 CFR 130.40 pursuant to Section 303(e) of the Federal Water Pollution Control Act as amended on October 18, 1972.

PURPOSE

The purpose of this intensive survey was to provide the Texas Water Quality Board with a valid information source:

- 1) to determine quantitative cause and effect relationships of water quality;
- 2) to obtain data for updating water quality management plans, setting effluent limits, and where appropriate, verifying the classifications of segments;
- 3) to set priorities for establishing or improving pollution controls; and
- 4) to determine any additional water quality management actions required.

SUMMARY

An intensive monitoring survey was conducted August 23-25, 1976 on Segment 1903 of the Medina River. The Medina River within Segment 1903 begins downstream of the Medina Diversion Reservoir and flows in a southeasterly direction approximately 72 miles through Medina and Bexar Counties to its confluence with the San Antonio River. In the upper portion of the segment the Medina River is characterized by clear water, swift velocity, steep banks, and a stream channel in which large pool and riffle areas predominate morphometry. The lower portion of the segment is deeper and slower moving and the water is more turbid. This survey included sampling stations in the main body of the Medina River throughout the segment, at selected locations on all significantly flowing tributaries, and at the major wastewater dischargers.

Municipal sewage treatment plants are the most common facilities from which wastewater is discharged to the segment. The City of San Antonio's Leon Creek Plant is the largest and discharged an effluent that contained 1455 lbs/day of BOD₅ and 4925 lbs/day of nutrient compounds (ammonia, nitrite, and nitrate nitrogen and ortho-phosphorus). The discharge from this plant actually enters Leon Creek (Segment 1906) approximately one mile upstream from its confluence with the Medina River.

A total of four flowing tributaries was sampled during this survey. Hydrological data collected from these tributaries indicated the majority of the inflow to the Medina River is supplied by Medio Creek and Leon Creek. The two remaining tributaries, Elm Creek and San Geronimo Creek, were small and contributed less than 3 cfs each.

Temperature and pH values varied from station to station within the Medina River, but none were in violation of the respective 90°F and 7-9 stream standards. The slightly alkaline pH values observed at all the Medina River stations may be partially explained by the underlying limestone formations. Total alkalinity values within the segment were high and, with the exception of one value from Medio Creek, were due totally to bicarbonates. Conductivity values in the Medina River generally increased downstream. This downstream increase is common in rivers, such as the Medina, that are utilized for irrigation.

The field dissolved oxygen data collected at the Medina River stations indicated generally good water quality conditions existed throughout much of Segment 1903. Mean dissolved oxygen levels remained above the 5.0 mg/l segment standard at all stations. The City of San Antonio's Leon Creek Sewage

Treatment Plant discharge, which enters the Medina River via Leon Creek immediately upstream from Station 16, caused a slight depression in dissolved oxygen levels. The carbonaceous and nitrogenous oxygen demand of this wastewater reduced the natural oxygen content from approximately 90 percent saturation to less than 80 percent saturation at Stations 17, 18, and 19 downstream. Station 17 had the lowest minimum dissolved oxygen level (4.9 mg/l) of any Medina River station sampled.

Levels of BOD₅ and ammonia nitrogen were higher downstream from the discharge of the Leon Creek Sewage Treatment Plant (Stations 16, 17, 18, and 19) than upstream. Ammonia nitrogen levels in this lower reach ranged from 0.2 mg/l to 0.7 mg/l. High nitrite nitrogen levels (above 0.5 mg/l) were also observed in the area between Stations 16 and 19. The presence of ammonia and nitrite nitrogen in such concentrations provides evidence that nitrification was occurring within this reach of the Medina River. Since nitrification is an oxygen consuming process, its occurrence may partially account for the slight depression in dissolved oxygen noted in the lower reach.

The same general area that had higher BOD₅ and ammonia nitrogen levels attributable to discharges of treated sewage effluents also had the highest phosphorus levels. Ortho and total phosphorus levels in the Medina River were less than 0.1 mg/l at Stations 1 through 14. Further downstream, at stations influenced by the Leon Creek Treatment Plant discharge, levels for both parameters exceeded 1 mg/l

Dissolved oxygen levels in the tributary streams were generally high. Only Medio Creek (Station 10) had dissolved oxygen levels that were considered low (less than 5 mg/l). This creek also had elevated levels of nutrient compounds (ammonia nitrogen and ortho-phosphorus). Flow in this tributary is dominated by the treated sewage effluents from five small plants located in the upper portion of the basin. Discharge from Medio Creek had no noticeable effects on the various field physico-chemical parameters from the Medina River.

The swift velocity and limestone bedrock underlying the Medina River within the segment are factors that combine to prohibit accumulation of sediment. For this reason, sediment samples were not collected for analysis of pesticides and heavy metals.

Chlorophyll a levels from the Medina River and tributary stations were generally below the detection limit (0.004 mg/l). Only Stations 10 (Medio Creek), 15 (Leon Creek), and 19 had detectable levels of chlorophyll a and they were only slightly above the detection limit.

Phytoplankton assemblages were generally diverse at most Medina River stations. Only diatoms and green algae were observed at Stations 1 through 14. Farther downstream in the area influenced by Leon Creek Treatment Plant discharge, the phytoplankton communities were less diverse and dominated by the pollution-tolerant blue-green alga, Aphanizomenon. The low standing crops, as estimated by numerical counts at all stations, correlated well with the chlorophyll a data and indicate that planktonic algae growth and proliferation was not stimulated anywhere within the segment. Apparently, the swift velocity of the Medina River prohibits a buildup of algal biomass.

Zooplankton occurrence and distribution within the segment was restricted to the three lowermost Medina River stations. The zooplankton communities were dominated by rotifers. Standing crop and diversity values were low, reflecting the low number of individuals and different taxa collected at each station. The restricted distribution of zooplankton correlates well with the area of the Medina River that is known to receive organic enrichment from the Leon Creek Sewage Treatment Plant.

Benthic macroinvertebrate communities within the segment were very diverse. A total of 70 different taxa of benthic organisms was encountered in the study. Composition of the benthos at the various Medina River stations indicated a definite relationship among organism type, diversity, and water quality. Community structure of the benthos from stations upstream from the influence of the Leon Creek Plant discharge was composed of a very high diversity of primarily clean water organisms considered intolerant to organic enrichment. The benthic macroinvertebrate communities downstream from the waste discharge were markedly different and characterized by pollution tolerant organisms. Diversity of the communities in this lower reach was lower, reflecting the fewer total individuals and smaller number of different taxa.

Fecal coliform bacteria levels were generally low throughout the segment. None of the stations sampled had fecal coliform densities that exceeded the segment standard of 200/100 ml. The Leon Creek Sewage Treatment Plant effluent did not contain fecal coliform bacteria.

WATER QUALITY PROBLEMS

Chemical and biological parameters evaluated during this survey indicate that excellent water quality conditions prevail throughout most of Segment 1903 of the Medina River. In the upper portion (65 miles) of the Segment, dissolved oxygen levels are generally near saturation, oxygen demanding materials and nutrient compounds are low in concentration, and biological communities are diverse and composed of organisms indicative of clean water.

The water quality conditions of the lower portion (7 miles) of the Medina River are influenced by the treated sewage discharge from the City of San Antonio's Leon Creek Plant. This discharge tends to reduce natural dissolved oxygen levels and increase the concentrations of nutrient compounds in the river. Biological communities sampled from similar habitats throughout the segment were less diverse and stable in the lower portion than those located farther upstream and were composed of organisms that favor organically enriched waters. Degradation of biological communities in the lower portion of the Medina River, as shown by this study, occurred even though the dissolved oxygen levels were in excess of the 5 mg/l stream standard. This indicates the waste discharge apparently contained constituents, other than those analyzed during this survey, that affected the aquatic organisms in the lower reach of the Medina River.

Additional studies of the Leon Creek Sewage Treatment Plant effluent and the lower portion of the Medina River will be conducted by the Special Studies Section. Parametric coverage during these studies will be expanded to include pesticides, metals, chlorine, chloramines and other suspected contaminants. Data from such monitoring efforts will indicate if these contaminants are routinely found in the waste discharge and the Medina River at levels considered toxic to aquatic organisms.

All of the existing water quality studies of the Medina River and San Antonio River were conducted during periods when Mitchell Lake was not discharging. Mitchell Lake is utilized by the City of San Antonio as an oxidation pond to treat domestic wastes which are diverted to the lake during mechanical or operational failures at the City's Rilling Road and Leon Creek Sewage Treatment Plants. The wastewater discharged from this lake typically has a BOD₅ in excess of 30 mg/l. A study of both river systems should be conducted by the Special Studies Section during a time when a discharge from Mitchell Lake is made. Existing information indicates that this discharge may further aggravate water quality problems associated with both river systems.

METHODS

Field and laboratory procedures used during this survey are described in Appendix A. The data were collected August 23-25, 1976, by the Special Studies Section, assisted by Texas Water Quality Board District 8. Laboratory analyses of water samples were conducted by the Texas Department of Health Resources, Chemistry Laboratory in Austin, Texas. Parametric coverage, sampling frequencies, and spatial relationships of sampling stations are consistent with the particular objectives of this survey and with known or suspected forms and variability of pollution occurring in the area.

DESCRIPTION OF SURVEY AREA

The Medina River within Segment 1903 begins downstream of the Medina Diversion Reservoir and flows in a southeasterly direction approximately 72 miles through Medina and Bexar Counties to its confluence with the San Antonio River. Natural stream flow within the segment is dependent upon the amount of water released from Medina Lake, and that discharged from numerous springs. In the upper portion of the segment, the Medina River is characterized by clear water, swift velocity, steep banks, and a stream channel in which large pool and riffle areas predominate morphometry. The lower portion of the Medina River is deeper, and slower moving, and the water is more turbid.

Leon Creek and Medio Creek are the two largest tributaries feeding the Medina River. Leon Creek is listed as a separate segment (1906) by the Texas Water Quality Board. Other tributaries of significance include San Geronimo Creek and Elm Creek.

The land adjacent to the Medina River is utilized extensively for cultivation of various agricultural crops. Many of the farming operations along the segment withdraw water from the Medina for irrigation purposes.

This survey included sampling stations in the mainstem of the Medina River and on each flowing tributary. Figure 1 is a map of the area which shows the locations of the sampling stations and Table 1 provides descriptions of their locations.

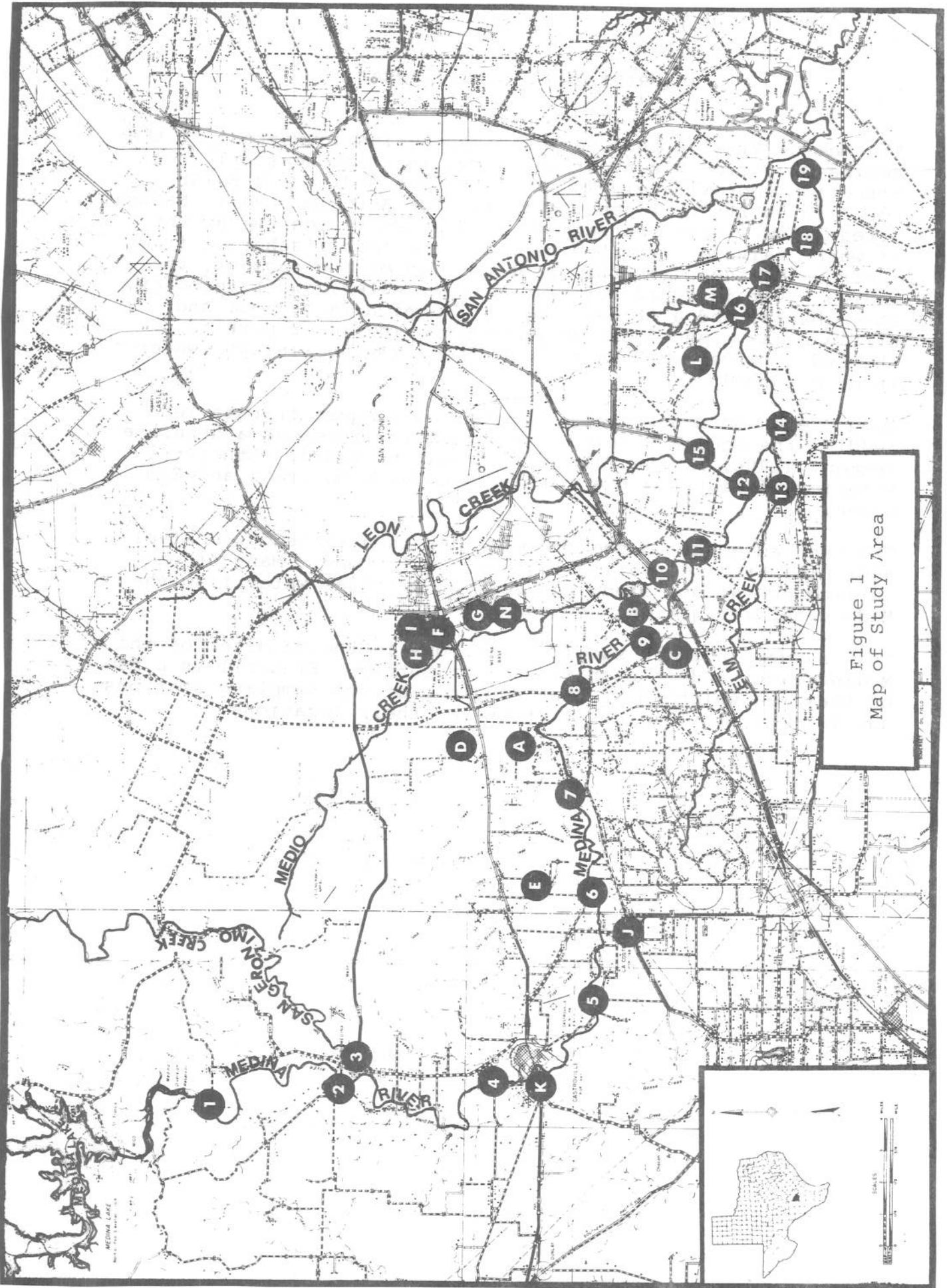


Table 1
Medina River Sampling Stations

Station Number	Location
1	River at county road 6 miles NW of Riomedina
2	River at county road 2 miles NW of Riomedina
3	San Geronimo Creek at FM 1937
4	River at county road 2 miles NW of Castroville
5	River at county road 2 miles SE of Castroville
6	River at county road 1 mile E of La Coste
7	River at county road 3 miles E of La Coste
8	River at FM 1604 near Macdonna
9	River at FM 2536 3 miles SE of Macdonna
10	Medio Creek at IH-30
11	River at county road 4 miles NE of Sommerset
12	River at SH 16
13	Elm Creek at SH 16
14	River at Applewhite Road
15	Leon Creek at SH 16
16	River at Cassin Road
17	River at US 281
18	River at FM 1937
19	River on private property 1/2 mile upstream from confluence with San Antonio River

WASTE SOURCES IN SURVEY AREA

POINT SOURCES

Table 2 contains a summary of all Texas Water Quality Board permitted wastewater dischargers in the survey area (see Figure 1 for locations). The values in Table 2 represent estimates of average quantities discharged and were obtained from Texas Water Quality Board self-reporting (1) and municipal return flow (2) data.

Sewage treatment plants are the most common facilities from which wastewater is discharged to this segment. Of the sewage treatment plants that discharge, the City of San Antonio's Leon Creek plant is the largest. The effluent from this facility actually enters Leon Creek (Segment 1906) approximately one mile above its confluence with the Medina River. Effluent discharged from the Leon Creek sewage treatment plant contained approximately 1455 lbs/day of BOD₅ and 4925 lbs/day of nutrient compounds (ammonia, nitrite, and nitrate nitrogen and ortho-phosphorus).

Medio Creek receives the permitted wastewater discharges from four small treatment plants (Bexar County WCID #16, Community Treatment-Medio Creek Plant, Community Treatment-Hunt Lane Plant, Lackland City Water Co.). In addition, a sewage treatment plant (Station N, Figure 1) that treats a portion of the domestic wastes generated at Lackland Air Force Base discharges to Medio Creek. Since this is a federal installation, no historical effluent data are available to the Texas Water Quality Board.

Table 2
Wastewater Dischargers

Map Code	Name	BOD ₅ lbs/day	Ortho- Phosphate lbs/day	Ammonia+nitrite+ nitrate nitrogen lbs/day
A	Luckey, E. G.	ND		
B	Mitchell, O. R. Ranch	ND		
C	Knowlton Milk Farms	ND		
D	Harlach, Harold R.	ND		
E	Melcher Brothers	ND		
F	Bexar County WCID #16	32.8	89.9	36.8
G	Lackland City Water Co.	31.1	53.9	30.7
H	Community Treatment Inc.	6.4	82.6	25.1
I	Community Treatment Inc.	8.2	27.0	9.6
J	Medina County WCID #1	ND		
K	City of Castroville STP	ND		
L	City of San Antonio, Leon Creek STP	1454.6	3139.0	1786.4
M	City of San Antonio, Mitchell Lake	ND		

ND - No discharge made from facilities during the survey.

All five of these plants serve various subdivisions in and around the Lackland Air Force Base complex located near Medio Creek.

The City of San Antonio also is allowed to periodically discharge wastewater from Mitchell Lake to Cottonmouth creek which enters the Medina River. Mitchell Lake is utilized by the City of San Antonio as an oxidation pond to treat domestic wastes which are diverted to the lake during mechanical or operational failures at the City of San Antonio's Rilling Road and Leon Creek Sewage Treatment Plants. Wastewater is also discharged to Mitchell Lake from the two plants following periods of heavy rainfall when excessive infiltration upsets operation. The City of San Antonio is permitted to discharge from Mitchell Lake only when the water level in the lake is high and the flow in the Medina River is sufficient to provide adequate dilution.

Approximately 18 discharges from Mitchell Lake have occurred since 1970. Average duration of these discharges is 4 days (range = 1-8 days) and average flow rate is 223 cubic feet per second (range 14-900 cfs). The water in the lake typically has a BOD₅ in excess of 30 mg/l. Water quality data were collected by the San Antonio River Authority from the Medina and San Antonio Rivers during most of these discharges. These data indicate that low dissolved oxygen levels (less than 5 mg/l) occurred in the San Antonio River during and following the time some of the discharges were made from Mitchell Lake. The dissolved oxygen levels in the river were lowest near Falls City and may have been caused by the Mitchell Lake effluent. (3)

The Texas Water Quality Board permit for Mitchell Lake has recently undergone revision. The new discharge guidelines contained in the permit issued in January 1977 are based on the water elevation in Mitchell Lake, the flow rate, water temperature, and existing dissolved oxygen levels in the Medina River. These guidelines were established from the modeling efforts and waste load evaluation conducted by the Texas Water Quality Board. Discharges made under the new guidelines should not cause violations of the Texas Water Quality Standards.

Two additional permit holders farther upstream also operate sewage treatment plants. The City of Castroville and Medina County WCID #1 utilize their treated effluents for irrigation purposes with no discharge made to the Medina River.

Two cattle feedlots, one swine feeding operation, and two dairies are also located along the segment. Wastewater is retained at these facilities and utilized for irrigation of adjacent farmland with no discharge made to the Medina River.

NON-POINT SOURCES

There exists the possibility that varying amounts of wastewater may enter the segment from non-point agricultural runoff since most of the land along the Medina River is utilized for cultivation of various farm crops. Additional sources such as irrigation tailwaters, nonconfined livestock operations, and malfunctioning rural septic tank systems have the potential for wastewater contribution to the segment.

Non-point source studies are to be conducted in the lower portion of the Medina River by the Alamo Area Council of Governments as part of 208 planning activities. When these studies are complete, the non-point source waste load contribution to Segment 1903 will be computed.

PRESENTATION OF DATA

The raw hydrological, physico-chemical, and biological data are available in the Texas Water Quality Board Central Office files.

HYDROLOGICAL

Hydrological data shown in Table 3 represent discharge measurements of the Medina River and tributary streams which were flowing at the time of the survey. Flow data from Stations 12 and 17 were taken from United States Geological Survey (USGS) records.

Table 3
Hydrological Data

Location	Station Number	Method	Time	Date	Discharge cfs
San Geronimo Creek	3	PM	0900	08/23/76	1.5
Medio Creek	10	PM	1730	08/23/76	11.2
Medina River	12	USGS	1400	08/23/76	100
Elm Creek	13	PM	1130	08/23/76	2.0
Leon Creek	15	PM	1600	08/23/76	7.4
Medina River	17	USGS	1200	08/23/76	126

PM - Pygmy Current Meter

The majority of inflow to the Medina River within the segment is supplied by Medio Creek and Leon Creek. The remaining tributaries are small and contributed less than 3 cfs each. All other tributaries feeding the Medina River were observed in a non-discharging condition or at a level considered not significant. The increase in flow in the Medina River between Stations 12 and 17 can be accounted for by the flow from Elm Creek, Leon Creek, and the effluent from the Leon Creek Sewage Treatment Plant which enter this reach.

FIELD MEASUREMENTS

Table 4 contains a summary of diurnal field measurements made at the appropriate Medina River stations on August 24, 1976. Tributary Stations 10 (Medio Creek) and 15 (Leon Creek) were also sampled on a diurnal basis. San Geronimo and Elm Creeks were sampled once.

Table 4
Medina River Stream Quality

Parameter	Station Number																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Temperature, °C	\bar{x}	25.9	25.4	28.5	25.6	26	26.1	26.2	25.7	25.5	27.8	25.8	25.8	25.8	25.5	28.9	26.1	26.2	26.1
	Range	23.7-27.5	24.6-26.2	*	24.6-26.6	25-26.8	24.9-27.2	24.8-27.7	25-26.5	24.6-26.3	26.3-29	24.8-26.6	24.9-26.5	*	24.8-26.5	27-30.5	24.5-27.5	24.8-27.5	24.8-27.5
pH	\bar{x}	7.9	7.9	7.8	8.1	8.1	7.8	7.9	7.9	7.8	8.1	8.0	8.1	8.0	7.9	7.3	7.9	7.9	7.8
	Range	7.8-8.0	7.9-8.0	*	8.0-8.2	8.0-8.2	7.8-7.8	7.8-7.9	7.8-7.9	7.8-7.85	8.1-8.2	7.9-8.0	*	7.95-8.0	7.8-7.9	7.1-7.6	7.9-8.1	7.8-8.0	7.7-7.9
Conductivity umhos/cm	\bar{x}	431	494	753	526	559	608	616	671	701	652	700	810	727	925	842	842	862	853
	Range	405-462	470-515	*	500-550	530-580	600-612	612-620	668-677	695-704	645-660	695-705	*	725-730	915-945	820-890	820-885	850-880	850-860
Dissolved Oxygen mg/l	\bar{x}	7.3	7.4	9.2	7.9	7.6	7.1	7.6	7.3	7.2	5.5	7.1	7.0	7.45	6.7	7.5	6.0	6.0	6.6
	Range	5.8-8.3	7.0-8.0	*	7.5-8.4	7.2-8.2	6.8-7.5	6.9-8.7	7.2-7.6	6.8-7.5	4.6-6.6	6.85-7.2	7-7.1	6.9-7.2	6.2-7.2	6.9-8.2	4.9-6.5	5.8-6.2	6.6-6.8
Dissolved Oxygen % Sat.	\bar{x}	88	89	117	95	87	87	93	89	87	70	87	91	87	81	96	73	73	80
	Range	67-104	84-99	*	90-103	86-101	81-92	82-107	86-93	82-92	56-84	86-91	*	86-89	75-88	88-105	58-81	70-78	80-85
P-Alkalinity	\bar{x}	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	Range	154-160	178-182	*	186-196	184-201	204-216	204-224	220-228	214-230	216-224	224-234	*	226-240	234-250	216-238	210-228	224-236	214-224
T-Alkalinity mg/l as CaCO ₃	\bar{x}	157	180	224	191	193	209	213	222	222	223	231	168	235	242	225	224	228	220
	Range	154-160	178-182	*	186-196	184-201	204-216	204-224	220-228	214-230	216-224	224-234	*	226-240	234-250	216-238	210-228	224-236	214-224

Temperature and pH values for Medina River and tributary stations, shown in Table 4, indicate some station to station variation, but none were in violation of the respective segment standards of 90°F and 7.0 - 9.0 standard pH units (4). The slightly alkaline pH values for all the Medina River stations may be partially explained by the underlying limestone formations. With the exception of Medio Creek, alkalinity within Segment 1903 was due totally to bicarbonates. The total alkalinity values for the Medina River stations were similar to those observed in the nearby San Antonio River (5) and indicate the river has excellent buffering capacity. Conductivity values in the Medina River generally increased downstream. Such downstream increases in conductivity are common in rivers, like the Medina, that are utilized for irrigation (6). Repeated irrigation and subsequent runoff tends to increase concentrations of salts in the Medina River Basin.

The field dissolved oxygen data collected at the Medina River stations indicated generally good water quality conditions existed throughout most of the segment. Mean dissolved oxygen levels remained above the 5.0 mg/l segment standard throughout the diurnal sampling period. The City of San Antonio's Leon Creek Sewage Treatment Plant discharge, which enters the Medina River via Leon Creek immediately upstream from Station 16, caused a slight depression in dissolved oxygen levels. The carbonaceous and nitrogenous oxygen demand of this wastewater reduced the natural oxygen content from approximately 90 percent saturation to less than 80 percent saturation at Stations 17, 18, and 19. Station 17 had the lowest minimum dissolved oxygen level (4.9 mg/l) of any Medina River station sampled during the survey.

Water quality data collected by the San Antonio River Authority in November, 1975 from the Medina River shows the same trend noted in the present study (7). According to their work, the Leon Creek Sewage Treatment Plant waste discharge was observed to reduce the oxygen content from a natural level of more than 90% dissolved oxygen saturation down to about 68% dissolved oxygen saturation in the lower portion of the river. The lowest dissolved oxygen level of 5.4 mg/l was observed at the U.S. 281 bridge location (Station 17 of this study).

Historical dissolved oxygen data collected by the Texas Water Quality Board at Station 17 (US 281) indicate a seasonal trend (Figure 2) (8). Dissolved oxygen levels at this station are generally lowest in the dry summer months when low flows in the river retard dilution of oxygen demanding material. Conversely, in the wetter winter months when the river flow is higher, adequate dilution and oxygenation are provided and dissolved oxygen levels remain near saturation. Although several of the historical dissolved oxygen levels approach the Texas Water Quality Standard of 5.0 mg/l, none fall below it.

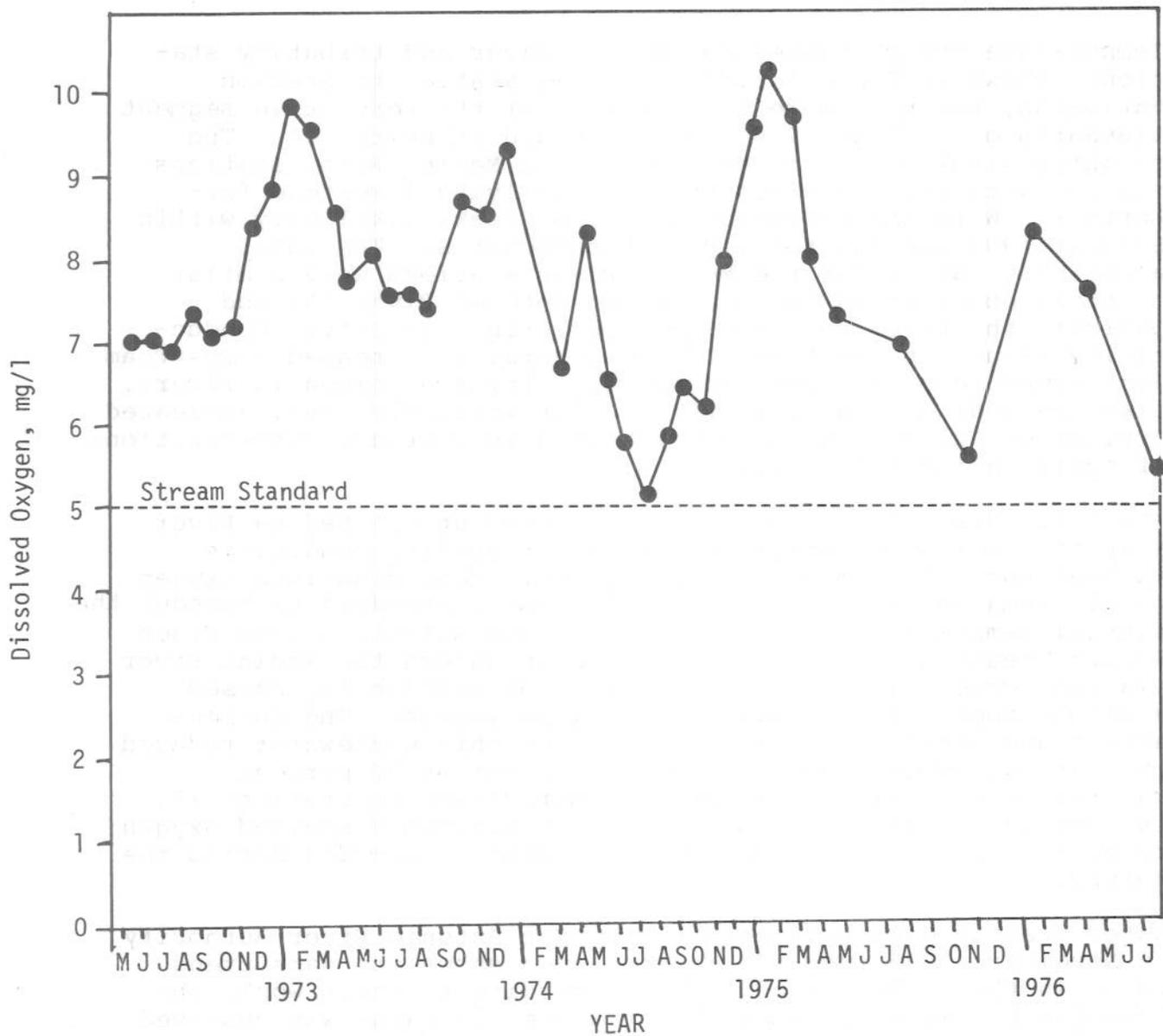


Figure 2. Dissolved oxygen data collected at Station 17 on the Medina River, May, 1972 through July, 1976.

Violations of the dissolved oxygen stream standard, although not shown in the present study or historical data, have occurred in the past. According to results of an earlier Intensive Monitoring Survey of the San Antonio River in which Station 17 of the Medina River was sampled during low flow conditions, the dissolved oxygen levels ranged between 3.6 mg/l and 4.0 mg/l during the 18-hour study (5).

Measured dissolved oxygen levels in the tributary streams are also shown in Table 4. Water quality characteristics of San Geronimo Creek, Medio Creek, Elm Creek, and Leon Creek upstream from the Leon Creek Sewage Treatment Plant discharge were generally good where sampled.

Medio Creek was sampled just upstream from its confluence with the Medina River. At this location, dissolved oxygen levels were generally lower than those observed in the Medina River and other tributaries. Medio Creek had the lowest minimum dissolved oxygen level (4.6 mg/l) measured during the survey. Flow in this creek is dominated by the treated sewage effluents from five small plants located in the upper portion of the basin. Medio Creek is dammed in the lower portion (2 miles upstream from Medina River confluence) to form a small reservoir with an estimated 30 day detention time (9). A recent water quality study of Medio Creek by Texas Water Quality Board District 8 personnel indicated that upstream from the reservoir, the stream is stressed from domination by treated sewage effluents (9). The stream in this reach typically has low dissolved oxygen levels, high BOD₅ levels, and is enriched with excessive nutrient compounds. The District 8 study indicated that the reservoir functions similar to an oxidation pond and that the creek downstream has generally good water quality. Water quality data collected from Medio Creek downstream from the reservoir in the District 8 study are parallel to data collected during this Intensive Monitoring Survey and indicate that the creek had recovered somewhat prior to its confluence with the Medina River. The Medio Creek discharge had no noticeable effects on the various field physico-chemical parameters from the Medina River downstream at Station 11.

Leon Creek at Station 15 had generally good water quality characteristics during this survey. Data collected on a previous Intensive Monitoring Survey of Leon Creek in July 1974 indicated poor water quality conditions (low dissolved oxygen, high BOD₅ and ammonia nitrogen levels, etc.) existed at the same location (10). Since the time of the earlier study, two small sewage treatment plants (Southwest Utilities, Inc., and Community Treatment, Inc.) have connected to the City of San Antonio's sewage collection system. Presumably, this reduction in organic load to Leon Creek has resulted in the improved water quality observed during this survey.

WATER ANALYSES

Laboratory analyses of diurnally composited water samples collected at the Medina River stations are shown in Table 5. Medio Creek, Leon Creek, and the Leon Creek Sewage Treatment Plant were also sampled on a diurnal basis. Grab water samples were collected for analyses from the two other tributaries.

Table 5
Laboratory Water Analyses

Parameter, mg/l	Station Number																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Chloride	14	17	46	19	22	24	25	32	36	39	44	46	77	49	87	65	65	68	--
Sulfate	44	44	34	45	51	49	48	57	60	51	75	76	152	82	123	85	87	91	--
O-Phosphorus	0.02	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1.06	0.08	0.08	0.05	0.07	0.15	1.05	1.03	1.08	1.16
T-Phosphorus	0.02	0.04	0.01	0.03	0.03	0.01	0.01	0.01	0.01	1.10	0.09	0.08	0.08	0.08	0.25	1.1	1.1	1.1	--
Ammonia Nitrogen	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	0.7	0.4	0.3	0.2
Nitrite Nitrogen	<0.02	<0.02	0.05	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.07	0.3	0.38	--
Nitrate Nitrogen	0.27	2.0	14.2	2.8	3.0	3.0	3.1	3.0	4.3	0.14	4.4	4.2	0.05	2.5	2.4	4.2	4.2	4.2	4.7
Kjeldahl Nitrogen	1.2	1.1	0.1	1.3	0.8	0.3	0.4	0.4	0.4	0.7	0.5	0.5	0.5	0.4	0.6	1.6	1.2	1.3	1.0
BOD ₅	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1	2	3	2	3
TOC	9	9	10	6	5	6	6	7	7	6	3	6	6	7	8	9	7	11	--
TSS	<10	10	13	20	25	20	15	21	18	20	25	19	33	21	26	30	24	25	--
FSS	<10	7	11	16	20	16	14	18	15	16	20	12	29	18	22	21	21	19	--
VSS	<10	3	2	4	5	4	1	3	3	4	5	7	4	3	4	9	3	6	--

Chloride and sulfate levels for all the Medina River stations were generally low and below the segment standard of 120 mg/l (annual averages) for both parameters (4). Levels for these two parameters, like the conductivity data, increased downstream from Station 1. Historical Texas Water Quality Board Stream Monitoring data indicate the observed downstream increase in chloride and sulfate levels is common, particularly during summertime conditions (8). In the Medina River, some of the added volume is return flow from irrigation which has an increased mineral content due to evaporation. Leon Creek, the Leon Creek Sewage Treatment Plant discharge, and Elm Creek also contributed significant quantities of sulfate and chloride to the Medina River.

Ortho-phosphorus levels were low (less than 0.02 mg/l) in the upper portion of the Medina River upstream from the influence of treated sewage effluents. Medio Creek which receives the treated sewage effluents from five small plants discharged water high in phosphorus (1.06 mg/l O-PO₄ and 1.1 mg/l T-PO₄) to the Medina River. This discharge increased phosphorus concentrations in the Medina River downstream at Stations 11, 12, and 14. The largest source of phosphorus input to the Medina River was the Leon Creek Sewage Treatment Plant effluent. This discharge contained high levels of ortho (5.8 mg/l) and total (6.0 mg/l) phosphorus. The highest phosphorus levels in the Medina River were observed at Stations 16, 17, 18, and 19, and were obviously influenced by the introduction of the treated sewage effluent from the City of San Antonio's Leon Creek plant via Leon Creek. The high levels observed at these lower four stations were considerably above the 0.9 mg/l ortho phosphorus level considered by Connell to cause excessive bio-growth and decay in Texas streams (11).

The same general areas that had high nutrient phosphorus loads attributable to discharges of treated sewage effluents also had high nitrogen levels. Since ammonia nitrogen is a common constituent of most treated municipal sewage effluents, its occurrence within the segment correlated well with areas that receive effluents. Ammonia nitrogen levels were low and not detectable in samples from Medina River Stations 1 through 14. Ammonia nitrogen concentration was highest at Station 16 (0.7 mg/l); however, Stations 17, 18, and 19 also had detectable levels. These ammonia nitrogen levels were obviously influenced by the Leon Creek Sewage Treatment Plant effluent which was high in ammonia (4.2 mg/l). The downstream gradual decrease in ammonia from Station 16 may be attributed to nitrification in the river. The oxidation of ammonia to nitrite and on to nitrate may partially explain the lower dissolved oxygen levels in the lower portion of the Medina River since nitrification is an oxygen consuming process.

The occurrence of nitrite nitrogen in the segment was restricted to the lower four stations. The presence of nitrite nitrogen indicates recent sewage pollution (12). These nitrite nitrogen levels may be attributed to nitrification of ammonia nitrogen in the treated sewage effluent which enters the river in this area.

Of the tributaries sampled, only Medio Creek (Station 10) contained a detectable level of ammonia nitrogen. This tributary receives the treated sewage effluents from five small plants. The presence of ammonia nitrogen in this creek suggests that nitrification was occurring and may partially account for the lower dissolved oxygen level observed at this station.

Nitrate nitrogen levels in the Medina River generally increased downstream from Station 1. Nitrate nitrogen levels in the river were apparently influenced by return flow from irrigation and from spring water sources. San Geronimo Creek (Station 3), a small spring fed stream, had the highest nitrate concentration (14.2 mg/l). High nitrate levels (above 4.0 mg/l) were observed at Medina River Stations 16, 17, 18, and 19 -- the area where nitrification was occurring. It is in this form that nitrogen is most easily assimilated by green plants rooted in the substrate or floating in the water (13).

Levels for BOD₅ throughout the segment were generally low. The introduction of the Leon Creek Plant's treated sewage effluent increased the BOD of the Medina River only slightly. Nonetheless, this slight increase in biochemical oxygen demand may partially explain the somewhat lower dissolved oxygen levels observed in this reach.

During an intensive monitoring survey of the San Antonio River in September, 1975, the Leon Creek Sewage Treatment Plant was discharging an effluent which contained high levels of oxygen demanding materials (NH₃-N of 18 mg/l and BOD₅ of 30 mg/l). The carbonaceous and nitrogenous oxygen demand of this effluent depressed dissolved oxygen levels in the lower portion of the Medina River below 4 mg/l throughout the study. During the present study, the Leon Creek Sewage Treatment Plant discharged an effluent containing much lower concentrations of ammonia nitrogen (4.2 mg/l) and BOD₅ (5 mg/l). This large decrease in load of oxygen demanding materials to the Medina River was partially responsible for the significant increase in dissolved oxygen levels noted between the studies.

SEDIMENT ANALYSES

The swift velocity and limestone bedrock underlying the Medina River within the segment are factors that combine to prohibit accumulation of sediment. The bottom of the stream channel at each sampling station consisted of solid rock or gravel. For this reason, sediment samples were not collected.

BIOLOGICAL

Chlorophyll a

Chlorophyll a analyses were utilized to provide an estimate of the relative amount of algal standing crop that was present at all stations sampled. Chlorophyll a levels from the Medina River and tributary stations were generally below the detection limit (Table 6). Only Stations 10 (Medio Creek), 15 (Leon Creek), and 19 had detectable levels of chlorophyll a and they were slightly above the detection limit. The chlorophyll a data indicate that planktonic algae growth and proliferation was not stimulated anywhere within the segment. Apparently, the swift velocity of the Medina River prohibits a buildup of algal biomass.

Table 6
Chlorophyll a Data

Station Number	Chlorophyll <u>a</u> , mg/l
1	<0.004
2	<0.004
3 San Geronimo Creek	<0.004
4	<0.004
5	<0.004
6	<0.004
7	<0.004
8	<0.004
9	<0.004
10 Medio Creek	0.007
11	<0.004
12	<0.004
13 Elm Creek	<0.004
14	<0.004
15 Leon Creek	0.006
16	<0.004
17	<0.004
18	<0.004
19	0.006

Phytoplankton

Phytoplankton assemblages were generally diverse at most Medina River stations (Table 7). A total of 11 taxa was encountered from samples collected between Stations 1 and 19. Diatoms were the only type of phytoplankton observed in samples from Stations 1, 4, and 6 in the extreme headwaters of the segment.

The phytoplankton communities at Stations 8, 11, and 14 were also dominated by various diatom taxa. Four diatom phytoplankters (Achnanthes, Synedra, Navicula, and Cymbella) were prevalent at most stream stations.

The phytoplankton communities downstream (Stations 16, 18, 19) from the City of San Antonio's Leon Creek Sewage Treatment Plant discharge, as shown by diversity index (\bar{d}) values, were less diverse than those upstream. Although various diatom genera were observed at these stations, Aphanizomenon dominated the communities. The distribution of this pollution-tolerant blue-green alga was restricted to the lower three stations. The discharge of treated sewage effluent high in nutrient compounds from the City of San Antonio's Leon Creek Plant apparently was responsible for the occurrence of this organism within this reach of the river.

Standing crop values were low at all stations and correlated well with chlorophyll a levels observed at the Medina River stations. Only Station 19 had a standing crop value over 200 individuals/ml.

Table 7
Phytoplankton Data

	Station Number								
	1	4	6	8	11	14	16	18	19
Total Number of Individuals/ml	91	117	169	130	143	143	143	182	260
Diversity Index (\bar{d})	2.5	2.5	2.5	2.5	2.5	2.5	1.8	1.8	2.0
Organisms									
CHLOROPHYTA (Green Algae)									
<u>Scenedesmus</u>				26	39	26			13
<u>Pandorina</u>					13				26
CHRYSOPHYTA (Diatoms)									
<u>Achnanthes</u>	26	13	13		13	13	13	13	13
<u>Synedra</u>	13	39	39	26	39	26	13	13	
<u>Navicula</u>	13	26	39	26	13	13	26		26
<u>Cymbella</u>	13	13	39	26	13	39	13	26	
<u>Ammonia</u>		26	26	13		26		26	
<u>Gomphonema</u>				13					
<u>Diatoma</u>					13				
<u>Pleurosigma</u>									13
CYANOPHYTA (Blue-green Algae)									
<u>Aphanizomenon</u>							91	104	91

In the upper portion of the segment where the water is very clear, phytoplankton growth and proliferation is apparently limited by very low concentrations of phosphorus (nitrate is abundant throughout the segment) and swift velocity of the river. Further downstream in the middle and lower portions of the segment where the water is influenced by treated sewage effluents, phosphorus and turbidity levels are much higher. Even though adequate nutrients are available, the turbidity and swift velocity of the Medina River apparently act together to limit accumulation of phytoplankton in these areas.

Zooplankton

Zooplankton occurrence and distribution was restricted to the three lowermost Medina River stations sampled (Table 8). Standing crop values for these three stations were low. Diversity within the zooplankton communities, as shown by diversity index values (\bar{d}), was low reflecting the small numbers of different taxa collected at each station.

The two genera of rotifers encountered during this study feed principally on periphyton, small plankton organisms, and detritus; however, they ingest all organic particles of appropriate size (14). Their restricted distribution correlates well with the area of the Medina River that is known to receive organic enrichment from the Leon Creek Sewage Treatment Plant.

Table 8
Zooplankton Data

Station Number	1	4	6	8	11	14	16	18	19
Standing Crop as Total Ind./Liter	0	0	0	0	0	0	37	157	36
Diversity Index (\bar{d})							1.21	1.13	1.52
Organisms as Ind./Liter									
ROTIFER									
<u>Keratella a</u>							24	114	17
<u>Keratella b</u>								3	
<u>Brachionus</u>							10	32	11
COPEPODA									
Immature copepods							3	8	8

Benthic Macroinvertebrates

A total of 70 different benthic macroinvertebrate taxa was identified from samples collected from similar habitats at the appropriate Medina River stations during this study (Table 9). This assemblage of benthic fauna from the Medina River is the most diverse of any Texas stream studied as part of the Intensive Surface Water Monitoring Survey Program to date (30 different streams have been studied under this program).

The results of the benthic macroinvertebrate identifications and counts from samples collected at the appropriate Medina River stations show a definite relationship among organism type, diversity, and water quality. Composition of the benthos consisted predominately of mayflies, caddisflies, dragonflies, dobsonflies, and clams at Stations 1 through 14 upstream from the influence of the City of San Antonio's Leon Creek Plant discharge. Such organisms are generally considered intolerant to organic enrichment (15). Diversity within the benthic macroinvertebrate communities of Stations 1 through 14 was generally high. Stations 1, 4, 5, and 11 had diversity index values (\bar{d}) above 3.0, which is the level considered indicative of clean water (16). Diversity at Station 14 was depressed by large numbers of Paraleptophlebia, a mayfly which is generally associated with clean water.

The community structure of the benthos observed from samples collected from Stations 16, 18, and 19, which were influenced by the City of San Antonio's treated sewage effluent, was markedly different from that upstream. At these downstream stations, the benthic macroinvertebrate communities were dominated by oligochaete worms and fly larvae which are considered pollution tolerant (15). The benthic communities at the three lowermost stations were characterized by fewer total individuals and number of different taxa than those located upstream. Many of the benthic fauna associated with the clean water upstream stations were virtually absent from those located in the lower portion of the river. Diversity index values were lower (2.0 - 2.2) and considered indicative of moderately polluted water (16).

Table 9
Benthic Macroinvertebrate Data

Station Number	1	4	6	8	11	14	16	18	19
Number of Taxa	25	24	25	13	19	10	8	7	6
Number of Individuals/ft ²	373	285	203	159	158	197	50	26	16
Diversity Index (\bar{d})	3.1	3.4	3.5	2.5	3.1	1.5	2.0	2.2	2.2
Organisms									
TURBELLARIA (Planarians)									
<u>Dugesia</u>	3	3	3						
NEMATODA (Roundworms)									
<u>Plectidae</u>							1		
OLIGOCHAETA (Aquatic earthworms)									
Oligochaeta A	1	3	2		2		13	3	7
Oligochaeta B							1		
<u>Tubificidae</u>		4							
EPHEMEROPTERA (Mayflies)									
<u>Isonychia</u>	42	22	8						
<u>Centroptilum</u>	16	24							
<u>Habrophelbiodes</u>	11	79		51					
<u>Caneis</u>	1								
<u>Paraleptophlebia</u>	3	4	69	58	9	132			
<u>Baetis</u>	6		15	2	1				
<u>Habrophlebia</u>		46	7		12	13			
<u>Emphemerella</u>			5						
<u>Choroterpes</u>				6					
<u>Heptagenia</u>				6					
<u>Leptohyphes</u>				1					
<u>Tricorythodes</u>					5				2
ODONATA (Dragonflies)									
<u>Nannothemis</u>	4								
<u>Agrion</u>	2		1						
Coenagrionidae	2	1							
<u>Gomphus</u>	1								
<u>Nannothemis bella</u>		2	1						
Libellulidae		1							
<u>Octogomphus</u>			1						
<u>Peltodytes</u>			1						
<u>Erythrodiplax</u>				2					
<u>Libellula</u>				1					
<u>Dromogomphus</u>									1
<u>Erythemis</u>					1				

Table 9 (Cont.)

Station Number	1	4	6	8	11	14	16	18	19
Organisms									
GASTROPODA (Snails)									
<u>Horatia nicra</u>			1						
<u>Cochliopa</u>			1						
<u>Hydrobia</u>			1						
<u>Amnicolidae</u>						3			
PELECYPODA (Clams)									
<u>Corbicula</u>	11	18	15	10	34	39			
<u>Atoperla</u>					1				
<u>Amblema</u>					1				
<u>Sphaerium</u>	2				2				

Bacteria

A summary of analyses for fecal coliform bacteria is shown in Table 10. The Texas Water Quality Board's permissible and desirable fecal coliform levels are based on not less than five samples collected over not more than 30 days (4). Since the data collected during this survey are based on grab samples, direct comparison of these data cannot be made with the Texas Water Quality Board Standards. However, none of the stations sampled had fecal coliform densities that exceeded the segment standard of 200/100 ml. The absence of fecal coliform bacteria in the effluent from the Leon Creek Sewage Treatment Plant indicates chlorine application was sufficient to be bactericidal.

Table 10
Fecal Coliform Data

Station Number	Fecal Coliform #/100 ml
1	5
2	25
3 San Geronimo Creek	15
4	100
5	50
6	90
7	95
8	40
9	70
10 Medio Creek	15
11	70
12	30
13 Elm Creek	180
14	20
15 Leon Creek	110
A Leon Creek STP	0
16	10
17	50
18	110
19	100

RELATED TEXAS WATER QUALITY BOARD ACTIVITIES

Several activities presently underway by the Texas Water Quality Board have direct influence on the protection of the water quality of this portion of the Medina River.

WASTE LOAD EVALUATION

A waste load evaluation was developed for the San Antonio River (Segment 1901) by the Modeling and Engineering Analyses Section of the Texas Water Quality Board on June 25, 1974. This evaluation also included water quality data from Segments 1906 (Leon Creek) and 1903 (Medina River). This evaluation was developed to show the relationships among various municipal and industrial organic loadings, stream assimilative capacity, and affect on stream standards of these three segments. This evaluation applies only to oxygen consuming substances being discharged from the various treatment plants and does not consider the effect of eutrophication caused by the introduction of nutrients. The waste load evaluation recommended that the City of San Antonio's three large plants should be required to provide a treatment process with the following effluent limits and monthly averages to assure compliance with the Texas Water Quality Standards:

$$\begin{aligned} \text{BOD}_5 &= 5 \text{ mg/l} \\ \text{NH}_3\text{-N} &= 3 \text{ mg/l} \end{aligned}$$

Based on these recommendations, the effluent requirements (BOD₅, TSS = 20 mg/l) of the existing discharge permit for the Leon Creek Plant have been changed to a BOD₅ and total suspended solids level of 5 mg/l and an ammonia nitrogen level of 3 mg/l. The permit indicates that these new requirements will become effective in November, 1977.

TWQB PERMITS AND REGISTRATIONS; NPDES PERMITS

All wastewater dischargers and confined feeding operations are required to have a permit or registration from the Texas Water Quality Board, as well as an NPDES Permit (National Pollutant Discharge Elimination System) Permit from the Environmental Protection Agency. These documents place restrictions on the quantity and quality of wastewater that can be released to the receiving stream.

COMPLIANCE MONITORING

Personnel from the Texas Water Quality Board District 8 Office in San Antonio will make periodic inspections of all waste sources

in the segment to confirm that the quality of effluent and retention facilities are in compliance with the Texas Water Quality Board Permits and the NPDES Permits.

STREAM MONITORING

Personnel from the Texas Water Quality Board District 8 Office will continue to monitor water quality of Segment 1903 at Station 17 and at US 90 in Castroville, on a quarterly basis. These are Texas Water Quality Board stream monitoring Stations 1903.01 and 1903.02, respectively.

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APPENDIX A

SEDIMENT ANALYSES

Field Measurements

Immediate Dissolved
Oxygen Demand (IDOD)

$$\text{mg/l IDOD} = \frac{D_0P - D_1}{P}$$

where D_0 = D.O. of original
dilution water

$$P = \frac{\text{dilution water used (ml)}}{\text{volume of BOD bottle (ml)}}$$

$$P = \frac{\text{amount of sample used (ml)}}{\text{volume of BOD bottle (ml)}}$$

D_1 = D.O. of diluted sample
15 min. after prepara-
tion using membrane
electrode method

Laboratory Analyses

Parameter

Method

Arsenic

Colorimetric

Mercury

Potassium permanganate
digestion followed by atomic
absorption(3).

All other metals

Atomic absorption(3).

Volatile Solids

Ignition in a muffle furnace.

COD

Dichromate reflux method.

Kjel-N

Micro-Kjeldahl digestion and
automated colorimetric method(2).

T- P_0_4

Ammonium molybdate(3).

Pesticides

Gas chromatographic method(4).

BACTERIOLOGICAL

Bacteriological samples are collected in sterilized glass bottles provided by the Texas Department of Health Resources and stored on ice until delivery to the laboratory or until cultures are set up by survey personnel (within 6 hours of collection). Bacteriological analyses are conducted by survey personnel or a suitable laboratory in the survey area.

<u>Parameter</u>	<u>Method</u>
Total Coliform	Membrane filter method(1)
Fecal Coliform	Membrane filter method(1)
Fecal Streptococci	Membrane filter method(1)

BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates are collected with a Surber sampler (1.0 ft.²) in riffle areas and with an Ekman dredge (0.25 ft.²) in pool areas. Samples are preserved in 10% formalin in the field and stained with Rose Bengal. They are later sorted according to taxa and counted in the laboratory.

Analysis of diversity is accomplished with a computer program adopted from Wilhm(5) for use on the Univac 1106 computer operated by the Texas Water Development Board. The program computes the diversity index, \bar{d} , for each sample using the following equation:

$$\bar{d} = - \sum_{i=1}^s (n_i/n) \log_2 (n_i/n)$$

where n = total number of organisms, n_i = number of individuals per taxon, s = number of taxa and \bar{d} = diversity.

The number of individuals per square foot is determined by dividing the total number of individuals by the area sampled.

PLANKTON

Phytoplankton

Phytoplankton samples in streams (which are usually vertically mixed) are collected beneath the water surface

in quart polyethylene containers. Sampling stations are generally located both upstream and downstream from pollution sources and care is taken to preclude confusing interferences such as contributions of plankton from reservoirs, from backwater areas, scouring of periphyton from the streambed, etc.

Phytoplankton samples from reservoirs are collected with a tube device in which sample collection is integrated from the surface to depth of the euphotic zone (3 times Secchi disc measurement). In cases where the euphotic zone depth is greater than the tube length, samples are collected with an appropriate water sampler at depths evenly spaced from the surface to the bottom of the euphotic zone. These samples are composited and stored in quart containers.

Phytoplankton samples collected during both stream and reservoir surveys are preserved in the field in a final concentration of 3 to 5 percent buffered formalin. The samples are returned to the laboratory and stored in the dark until microscopic examination is completed. Prior to examination, the samples are concentrated utilizing sedimentation chambers. Identification and enumeration of phytoplankton is conducted with an inverted microscope utilizing standard techniques. The diversity index (\bar{d}) is calculated as described previously.

Zooplankton

Zooplankton are concentrated at the site by either filtering a known volume of water through a No. 20 mesh standard Wisconsin plankton net or vertically towing the net a known distance. Concentrated samples are preserved in a final concentration of 5% formalin. The organisms are identified to the lowest taxonomic level possible and counts are made utilizing a Sedgwick-Rafter cell. Diversity is calculated as described previously.

NEKTON

Nekton samples are collected by the following methods(1):

- Common-sense minnow seine - 20' x 6' with 1/4" mesh
- Otter trawl - 12' with 1 3/16" outer mesh and 1/2" mesh liner
- Chemical fishing - rotenone

- Experimental gill nets - 125' x 8' (five 25' sections ranging in mesh size of 3/4" to 2 1/2")
- Electrofishing - backpack and boat units (both equipped with AC or DC selection). Boat unit is equipped with variable voltage pulsator.

These organisms are collected to determine: (1) species present, (2) relative and absolute abundance of each species, (3) size distribution, (4) condition, (5) success of reproduction, (6) incidence of disease and/or parasitism, (7) palatability, and/or (8) presence or accumulations of toxins.

Nekton collected for palatability are iced or frozen immediately. Samples collected for heavy metals analyses are placed in leak-proof plastic bags and placed on ice. Samples collected for pesticides analyses are wrapped in aluminum foil, placed in a water proof plastic bag and placed on ice.

As special instances dictate, specimens necessary for positive identification, parasite examination, etc., are preserved in 10% formalin containing 3 grams borax and 50 ml glycerin per liter. Specimens over 7.5 cm in length are slit at least one-third of the length of the body to enhance preservation of the internal organs. Other specimens are weighed and measured before being returned to the reservoir or stream.

ALGAL ASSAYS

The algal assay procedure was adapted from the "Algal Assay Procedure Bottle Test". (6) The water samples used for the algal assay are composite samples collected from the euphotic zone. They are stored in polyethylene containers on ice for transport to the laboratory.

Upon delivery the samples are autoclaved (15 psi, 250°F, 10 min./l). After autoclaving and cooling, they are allowed to equilibrate by bubbling air to restore the carbon dioxide lost during autoclaving.

The water is then distributed in 60 ml aliquots in 125 ml Erlenmeyer flasks. Appropriate amounts of sodium nitrate and potassium phosphate dibasic solutions are added separately or in combination to the test flasks to arrive at final concentrations of 0.005, 0.015, 0.050 mg P/l for

the phosphorus spikes, 0.075, 0.225, 0.750 mg N/l for the nitrogen spikes and 0.005 mg P/l + 0.075 mg N/l, 0.015 mg P/l + 0.225 mg N/l, 0.050 mg P/l + 0.750 mg N/l for the combined spikes. No nutrients are added to the control flasks.

Finally, all the flasks are seeded with a 7 day old culture of Selenastrum capricornutum to give a final concentration of 5×10^3 cells/ml. The stock culture of Selenastrum capricornutum obtained from the National Eutrophication Research Program, Corvallis, Oregon is maintained in the laboratory.

The cultures are incubated for 14 days in a reach-in incubator (Hotpack Corporation). The temperature is maintained at $24 \pm 2^\circ\text{C}$, and continuous, 400 ft.-c illumination is provided by 40 watt cool-white fluorescent lights.

After 14 days, the biomass dry weight is obtained by filtering the algal suspension through a prewashed tared Reeve Angel glass filter (AH-934). The filters are dried for 16 to 21 hours at 110°C then cooled in a dessicator and weighed.

PRODUCTIVITY/RESPIRATION

Two methods are utilized to estimate productivity and respiration in the study area. In areas where restricted flow produces natural or artificial ponding of sufficient depth, standard light bottle-dark bottle techniques are used. In flowing water the diurnal curve analysis described by Odum(7) is utilized.

Light Bottle-Dark Bottle Analyses

The light and dark bottle technique is used to measure net production and respiration in the euphotic zone of a lentic environment. The depth of the euphotic zone is considered to be three times the Secchi disc transparency ($3 \times Z_{sp}$). This region is subdivided into three sections. Duplicate light bottles (300 ml BOD bottles) and dark bottles (300 ml BOD bottles covered with electrical tape, wrapped in aluminum foil and enclosed in a plastic bag) are filled with water collected from the mid-point of each of the three vertical sections, placed on a horizontal metal rack and suspended from a flotation

platform to the mid-point of each vertical section. The platform is oriented in a north-south direction to minimize shading of the bottles. An additional BOD bottle is filled at each depth for determining initial dissolved oxygen concentrations (modified Winkler method). The bottles are allowed to incubate for a varying time interval, depending on the expected productivity of the waters. A minimum of four hours incubation is considered necessary.

The following equations are used to calculate respiration and photosynthesis:

- (1) For plankton community respiration (R), expressed as mg/l O₂/hour

$$R = \frac{D0_I - D0_{DB}}{\text{Hours incubated}}$$

where D0_I = initial dissolved oxygen concentration.

and D0_{DB} = average dissolved oxygen concentration of the duplicate dark bottles.

- (2) For plankton net photosynthesis (P_N), expressed as mg/l O₂/hour

$$P_N = \frac{D0_{LB} - D0_I}{\text{Hours incubated}}$$

where D0_{LB} = average dissolved oxygen concentration of the duplicate light bottles.

- (3) For plankton gross photosynthesis (P_G), expressed as mg/l O₂/hour

$$P_G = P_N + R$$

Conversions of respiration and photosynthesis may be accomplished by multiplying the depth of each of the three vertical zones (expressed in meters) by the measured dissolved oxygen levels expressed in grams/m³. These products are added and the result is expressed as grams O₂/m²/day by multiplying by the photoperiod. Conversions from oxygen to carbon may be accomplished by multiplying grams O₂ by 12/32.

Diurnal Curve Analyses

In situations where the stream is flowing, relatively shallow, and/or contains extensive rooted macrophytes, the diurnal curve analysis adopted from Odum(7) is utilized to determine productivity and respiration. Values for productivity and respiration in grams of oxygen per square meter per day are calculated with the aid of a Univac 1106 computer operated by the Texas Water Development Board. The program includes options which provide several methods for determination of diffusion rate constants as indicated in the program listing which follows. These options are: (a) calculations from raw data as described by Odum(7), Odum and Hoskin(8), Odum and Wilson(9), and Blain and McDonnel(10), (b) substitution into various published formulas for determination of K_2 , and (c) arbitrary selection of a value from tables of measured diffusion rates for similar streams.(11)

HYDROLOGICAL

Parameter

Flow Measurement

(1) Pygmy current meter (Weather Measure Corp. Model F583) (2) gage height readings at USGS gaging stations.

Time of Travel

Tracing of Rhodamine WT dye using a Turner Model 110 fluorometer.

Stream Cross-sections

Measure average width and average depth at each mainstream station. At least 4 cross-section measurements are made in the vicinity of each mainstream station.

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