WATER QUALITY SURVEY

OF

CARANCAHUA BAY

(SEGMENT 2456)

Field Data, Water Chemistry, and Metals and Pesticides in Water and Sediment

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ABSTRACT

An intensive survey of Carancahua Bay, Segment 2456, was conducted on September 23, 1982. High turbidities are common to Carancahua Bay due to wind and wave action stirring up silty riverine sediments from the upper reaches of this shallow system. The bay is also characterized by several distinct biotopes. Morphological features and compartmentalized circulation limit mixing of fresh and saline waters in the upper portion of the bay. Water and sediment quality were good during the survey and no violations of Texas Surface Water Quality Standards were detected. A review of ten years of routine monitoring data indicated no standards violations since May 1977. Prior to that time pH and coliform bacteria concentrations exceeded water quality standards several times.

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INTRODUCTION

Carancahua Bay is part of the Matagorda Bay system and an important natural resource with district ecotopes ranging from freshwater marsh to an open estuary. Extensive residential development is now taking place along the shoreline. Drainage and sewage influences are expected to occur. Public awareness and use, particularly sport fishing, are associated with this development. Routine monitoring of water quality has been limited to the upper part of the bay and is most characteristic of the brackish water biotope which is controlled by inflow from the main tributary, Carancahua Creek, This study was undertaken to characterize the present water quality throughout this system and to establish a baseline for future monitoring and enforcement activities.

SUMMARY

On September 23, 1982, an intensive survey was conducted on Carancahua Bay, Texas Department of Water Resources Segment 2456. Carancahua Bay is located within Calhoun and Jackson Counties near Palacios, Texas.

Carancahua Bay is a secondary bay off the Matagorda Bay system. It is a shallow bay with depths ranging between 2 and 6 feet (Table 1, Figure 1). The bay is usually very turbid in appearance due to wind and wave action stirring up silty riverine sediments from the upper portion of this shallow system. Carancahua Bay is characterized by several distinct biotopes. The upper portion of the bay, north of SH 35 bridge, is a brackish to freshwater marsh with low salinities, low species diversity and sand, silt and mud substrate. The main portion of the bay, south of the SH 35 boat ramp, is typical of the smaller secondary bay systems in Texas, influenced by the extent of freshwater inflows and tidal fluctuations. Substrate is sand and shell with diverse epifauna. Two saltwater marshes, Salt Lake and Redfish Lake, exist as tertiary bays off Carancahua Bay, east of Carancahua Pass into Matagorda Bay. Salt Lake and Redfish Lake are very shallow bays (generally 1 foot or less) with sand-shell substrate and numerous oyster reefs (Figure 2). Field data obtained from these two bays indicates good water quality (Table 2).

Uses of Carancahua Bay include, but are not limited to, disposal of municipal effluents, fishing, boating, propagation of fish and wildlife and aesthetics.

Current land uses around Carancahua Bay include cultivation of rice, grain and cotton; range and pasture land; small commercial and residential development; and production of oil and gas. Notably, approximately ½ of Carancahua Bay overlies a major oil and gas field. Although none were observed, brine water discharges may occur into Carancahua Bay from the numerous tank batteries along the shoreline.

Field data profiles were collected at 6 survey stations and water chemistry and sediment data were obtained at 2 locations, including routine monitoring station 2456.01 (Tables 2-6).

Currently, there is one Texas Department of Water Resources permitted discharge to Carancahua Bay. Sewage treatment facilities have been permitted for a small residential development at Port Alto. Anita's Resort Properties (WCO #12653-01) will be allowed to discharge .025 million gallons per day (MGD) (daily average), .050 MGD (daily maximum) with biochemical oxygen demand (BOD) and total suspended solids (TSS) limitations of 20 mg/l each, monthly average. Permit was effective February 14, 1983 although construction on the plant is not expected until mid-summer 1983.

No violations of Texas Surface Water Quality Standards were detected during this intensive survey.

A review of historical data covering the past 10 years of monitoring data from Carancahua Bay at SH 35 (2456.01) indicates a violation of stream standards has occurred. This violation was elevated pH (9.5 actual) during a plankton bloom and was accompanied by high dissolved oxygen concentration (15.3 mg/l). Historical data review also revealed that total coliform standard of 70/100 ml has been exceeded 4 times. The values were 600/100 ml, 300/100 ml, 110/100 ml and 400/100 ml. Sources for these elevated coliform concentrations have not been determined. No violation of coliform standards or other surface water quality standards has been detected since May 1977 (Table 7).

During this intensive survey, dissolved oxygen concentrations were good throughout the survey area. Dissolved oxygen concentrations in surface waters ranged from 7.2 mg/l to 9.7 mg/l. Dissolved oxygen concentrations in bottom waters ranged between 7.0 mg/l and 8.5 mg/l.

pH data from the survey indicated little difference between surface and bottom waters. During the survey pH values ranged between 7.3 and 8.5 in surface waters and 7.3 and 8.4 in bottom waters.

Water temperature data indicated no thermal stratification at any location sampled during the survey. Water temperatures ranged between 21.7°C and 25.1°C in surface waters and 22.9°C and 24.2°C in bottom waters.

Conductivity values for surface waters during the survey ranged between 18500 umhos/cm and 50100 umhos/cm. Conductivity values for bottom waters ranged between 31700 umhos/cm and 50300 umhos/cm. Conductivities in the Carancahua Bay system are controlled primarily by a combination

of freshwater inflow, tidal fluctuations and magnitudes, circulation patterns and morphological features of the system (Figure 3). The upper end of the bay, north of the SH 35 boat ramp, is more constricted than the open bay area, with several riverine curves which act to limit mixing in this transitional portion of the system.

Water chemistry data indicated good water quality in the surface waters during the survey. Ammonia, nitrate and nitrite nitrogen concentrations were all below limits of detection. Ortho-phosphorus concentrations were 0.01 mg/l and less. Total phosphorus was detected at a concentration of 0.18 mg/l at Station 1 and 0.06 mg/l at Station 4. Elevated chloride and sulfate concentrations at Station 4 are attributed to the influx of more saline waters into the system from Matagorda Bay.

A phytoplankton bloom was detected during the survey at Station 1. The bloom was characterized by elevated chlorophyll a concentration (0.03 mg/l), dissolved oxygen concentration (9.7 mg/l) and pH (8.5) as well as a greenish color to the water.

Bacteriological data obtained during the survey indicate total and fecal coliform concentrations of less than 10/100 ml at both sampling stations.

Carancahua Bay supports a diverse population of flora and fauna. There are large concentrations of freshwater clams, Rangia sp., in the upper portion of the bay and numerous live oyster reefs in the lower bay. Several commercial crabbers were observed running their trap lines during the period of this survey. Texas Parks and Wildlife Department includes Carancahua Bay in their Creel Census Surveys and has several routine netting stations in the bay to monitor nekton populations in the system.

Metals in water data indicate that concentrations of cadmium, copper, chromium, mercury, nickel, silver and zinc were at or below levels of detection at both sampling stations during the survey. Lead concentration was below detection level at Station 1 and manganese concentration was below detection level at Station 4. Concentrations of arsenic, barium, iron, lead and manganese at both stations were not excessive for healthy estuarine waters (Table 4).

From the survey, pesticide analyses of water samples from both sampling stations indicated concentrations of pesticides in Carancahua

Bay were below detection limits (Table 4). Analyses of sediment samples for pesticides indicated concentrations of pesticides in the sediments of Carancahua Bay were also below detection limits (Table 5).

Concentrations of heavy metals, oil and grease, volatile solids and total phosphorus in sediment samples collected at Stations 1 and 4 are not considered excessive (Table 6). Concentrations of arsenic, cadmium, copper, chromium, lead, mercury, nickel and zinc were all below the Environmental Protection Agency's screening criteria for open water disposal of dredged material. The review of past sediment data indicates an increase in concentrations of barium, oil and grease, and lead in Carancahua Bay sediments. This increase may be due, at least in part, to increased production of oil and gas in this area, and associated spills, discharges and other exploration and production activities.

CONCLUSIONS

Data collected during this survey indicate good water and sediment quality throughout the Carancahua Bay system. Carancahua Bay is a very turbid bay due to wind and wave action almost continuously stirring up silty riverine sediments from the upper reaches of this shallow system. The bay is characterized by several distinct biotopes: freshwater marsh, brackish marsh, salt marsh and open bay. The low to moderately saline upper reaches of the bay feature limited mixing of salt and freshwater. This is primarily due to the constricted and winding morphology of the upper bay and compartmentalized circulation patterns of the flooded stream meanders with reduced tidal influence progressing upstream from the open bay.

Wastewater discharge from sewage treatment facilities at Port Alto will impact a limited area of the bay near the outfall structure. Carancahua Bay along the Port Alto shoreline was closed to shellfish harvesting by the Texas Department of Health several years ago due to potential problems from septic tank facilities in the area.

Barium, lead and oil and grease concentrations in the sediments have increased over the past several years. The surveillance of sediment quality in Carancahua Bay will continue in order to evaluate trends in fluctuations of heavy metals and oil and grease in the system.

METHODS

Field and laboratory procedures used are described in Appendix A. Data were collected September 23, 1982 by Texas Department of Water Resources District 12 Public Waters Section personnel. Laboratory analyses of water and sediment samples exclusive of pesticides were conducted by the Corpus Christi-Nueces County Health Department laboratory. Pesticide analyses in water and sediment were conducted by the Texas Department of Health laboratory in Austin.

PRESENTATION OF DATA

TABLE 1

Carancahua Bay Survey
(9-23-82)

Station Description

Station	Location
1	Carancahua Bay at SH 35 bridge between Palacios and Port Lavaca
2	Carancahua Bay at ¼ mile off SH 35 boat ramp
3	Carancahua Bay off Port Alto
4	Carancahua Bay at mid-lower bay
5	Carancahua Bay in Carancahua Pass
6	Matagorda Bay at 1 mile off Carancahua Pass
A	Redfish Lake
B	Salt Lake

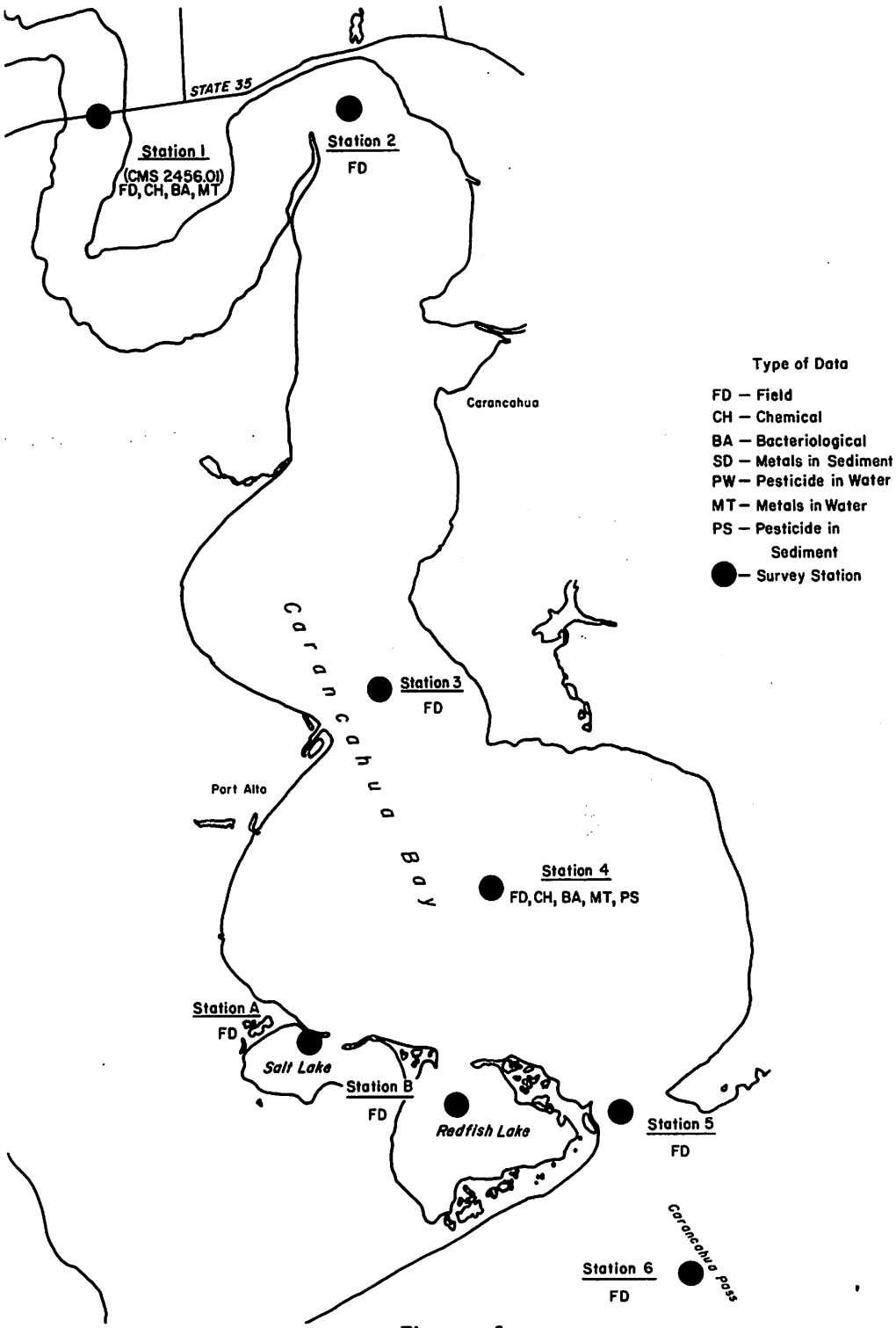

Figure 1
Map of Survey Area—
Carancahua Bay (2456.01)

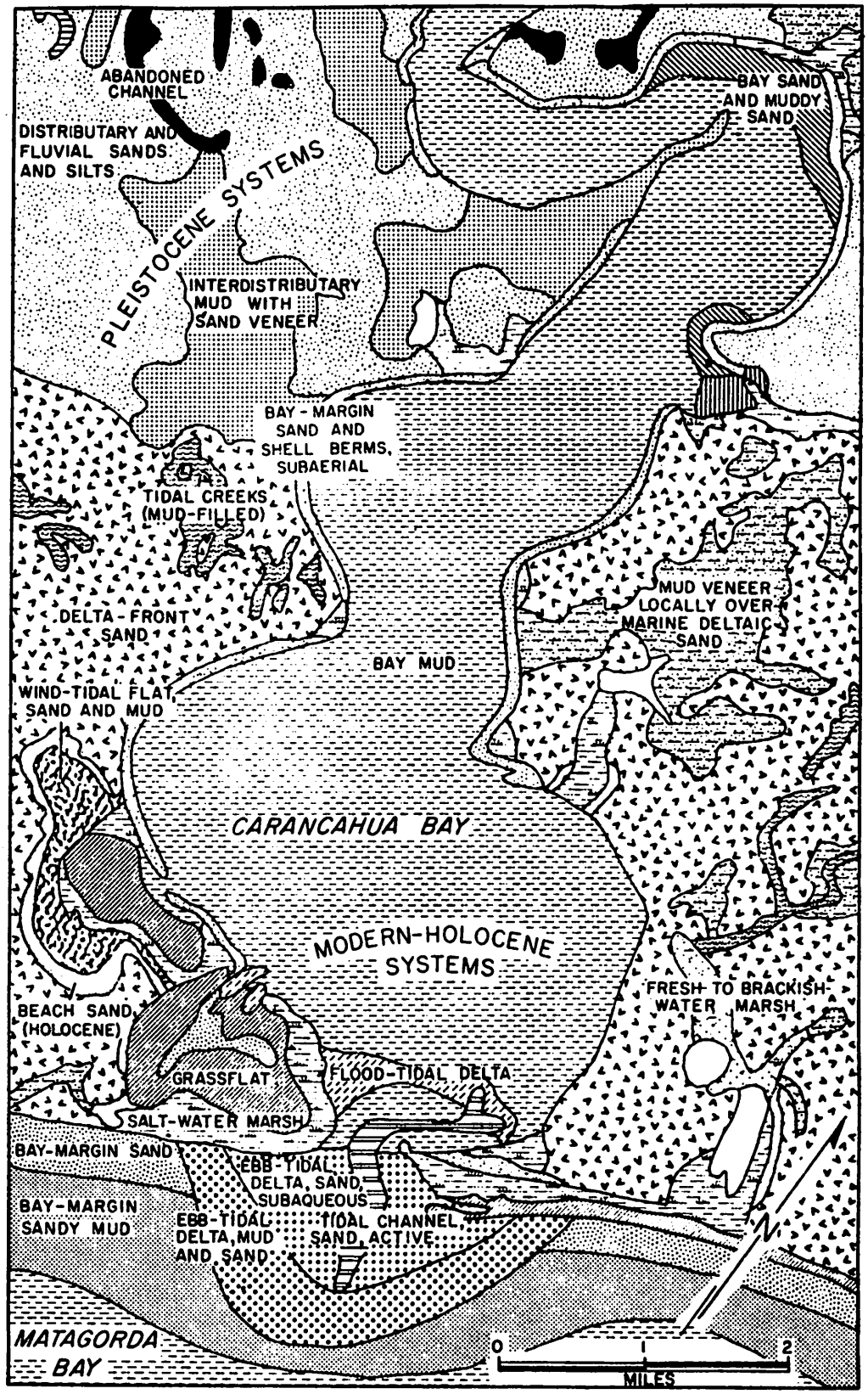

Figure 2. Modern bay-estuary facies, Carancahua Bay and northern Matagorda Bay. (From: McGowen, J. H. et al. 1976. Environmental Geologic Atlas of the Texas Coastal Zone - Port Lavaca Area. Univ. Texas, Bur. Econ. Geol. 107 p.)

TABLE 2

Carancahua Bay Survey
(9-23-82)

Field Data Profiles

Station	Depth (ft.)	Dissolved Oxygen (mg/l)	Temperature (°C)	pH	Conductivity (μmhos/cm)
1	1	9.7	25.1	8.5	18500
2	1	8.9	24.3	8.3	31200
	5	8.5	23.4	8.4	31700
3	1	7.9	23.9	8.0	40400
	5	7.2	22.9	8.0	43100
4	1	7.7	23.6	7.6	45800
	5	7.4	23.4	8.0	45900
	7	7.3	23.4	8.0	48100
5	1	7.9	24.3	7.8	50100
	5	7.1	24.2	7.4	50300
6	1	7.2	24.2	7.3	50000
	5	7.0	24.0	7.3	50100
A	1	7.7	21.7	7.7	43900
B	1	7.9	22.7	7.8	47900
TDWR Surface Water Quality Standards		≥5.0	≤35.0	6.5-9.0	

TABLE 3

Carancahua Bay Survey
(9-23-82)

Water Chemistry and Bacteriological Data

Parameter (mg/l, unless otherwise noted)	Station 1	Station 4	TDWR Surface Water Quality Standards
TSS	57	43	
VSS	25	--	
T-Phosphorus	0.18	0.06	
O-Phosphorus	<0.01	0.01	
Ammonia-N	<0.05	<0.05	
Nitrate-N	<0.03	<0.03	
Nitrite-N	<0.03	<0.03	
pH	8.6	8.4	
T-Alkalinity	212	156	
Conductivity (μmhos/cm)	17900	41400	
Chloride	5540	15300	
Sulfate	720	2300	
TOC	13	7	
Chlorophyll a	0.03	<0.005	
Pheophytin a	<0.005	<0.005	
Total Coliform (#/100 ml)	<10	<10	<70
Fecal Coliform (#/100 ml)	<10	<10	<70

-- no data

TABLE 4

Carancahua Bay Survey
(9-23-82)

Metals and Pesticide in Water

Type	Depth (ft.)	Parameter (µg/l)	Station 1 CMS 2456.01	Station 4
PW	1	2,4-D	<20	<20
PW	1	2,4,5-T	<5	<5
PW	1	Silvex	<5	<5
PW	1	Heptachlor	<0.02	<0.02
PW	1	H. Epoxide	<0.06	<0.06
PW	1	Lindane	<0.03	<0.03
PW	1	Malathion	<0.4	<0.4
PW	1	Methoxychlor	<0.5	<0.5
PW	1	Parathion	<0.25	<0.25
PW	1	PCB	<1	<1
MT	1	Arsenic	3	2
MT	1	Barium	285	100
MT	1	Cadmium	<5	<5
MT	1	Copper	<10	<10
MT	1	Chromium	<20	<20
MT	1	Iron	230	34
MT	1	Lead	<50	60
MT	1	Manganese	39	<10
MT	1	Mercury	<1	<1
MT	1	Nickel	<30	<30
MT	1	Silver	<10	<10
MT	1	Zinc	<5	5

PW - Pesticide in Water

MT - Metals in Water

TABLE 5

Carancahua Bay Survey
(9-23-82)

Pesticide in Sediment

Parameter (µg/kg)	Station 1 (CMS 2456.01) at SH 35	Station 2 Lower Bay
Aldrin	<0.5	<0.5
Chlordane	<3	<3
DDD	<3	<3
DDE	<1.5	<1.5
DDT	<3	<3
Diazinon	<5	<5
Dieldrin	<2	<2
Endrin	<3	<3
Heptachlor	<0.5	<0.5
Heptachlor Epoxide	<1	<1
Lindane	<1	<1
Methoxychlor	<10	<10
Methyl Parathion	<3	<3
Parathion	<3	<3
Toxaphene	<50	<50
PCB	<20	<20

TABLE 6

Carancahua Bay Survey
(9-23-82)

Sediment Data

Parameter (mg/kg)	Station 1 (CMS 2456.01) at SH 35	Station 4 Lower Bay	EPA Screening Criteria
Arsenic	<0.7	3.7	5.0
Barium	220	190	
Cadmium	<0.1	<0.1	2.0
Copper	5.9	8.2	50.0
Chromium	5.2	8.0	100.0
Lead	49	16	50.0
Mercury	<0.05	<0.05	1.0
Manganese	790	290	
Nickel	11	11	50.0
Silver	<0.5	<0.5	
Zinc	15	25	75.0
T-PO_4	220	220	
Volatile Solids	39800	56500	
Oil & Grease	340	700	

BAYS AND ESTUARIES

CARANCAHUA BAY
2456.0100 SH 35 BETWEEN PORT LAVACA AND PALACIOS
DISTRICT 12 COUNTY JACKSON USGS BASE 000000000 LAT / LONG 28 43 54 / 096 25 54

SAMPLE DATE	TIME	DEPTH (FT.)	SOURCE AGENCY	00300 DO MG/L	00400 PH SU	31501 TOT COLI MFIMENDO /100ML	00010 WATER TEMP CENT	00095 CNDUCTVY FIELD MICROMHO	00940 CHLORIDE CL MG/L	00945 SULFATE SO4 MG/L	00610 NH3-N TOTAL MG/L	00530 RESIDUE TOT NFLT MG/L
09/24/73	1630	1.0	TDWR	7.50	7.900		30.60	540.0				
10/17/73	1640	1.0	TDWR	7.00	8.100		23.30	20.0				
11/06/73	1030	1.0	TDWR	9.00	8.500	600.0*	19.70		52.0	14.0	.1000	54.0
12/31/73	1210	1.0	TDWR	10.10	7.750		11.70	5750.0				
01/29/74	1612	1.0	TDWR	9.00	7.850		17.80	570.0				
03/26/74	1536	1.0	TDWR	10.60	8.450		11.10	9300.0	2950.0	411.0	.1000	40.0
05/31/74	1320	1.0	TDWR	7.90	7.300		28.30	3000.0	1.0	198.0	.1000	44.0
06/20/74	1420	1.0	TDWR	7.30	8.220		30.00	850.0				
07/25/74	1120	1.0	TDWR	11.90	8.200		31.10	3200.0				
08/06/74	1300	1.0	TDWR	7.70	8.400		30.60	1200.0	307.0	46.0	.1000	61.0
09/26/74	1350	1.0	TDWR	8.70	8.300		21.90	1650.0				
10/31/74	1000	1.0	TDWR	7.70	8.300		26.10	15000.0				
11/19/74	1435	1.0	TDWR	7.50	7.550	.0	23.70	2380.0	680.0	98.0	.1000	168.0
12/18/74	1105	1.0	TDWR	9.10	7.800		13.30	2600.0				
01/20/75	1450	1.0	TDWR	11.30	8.300		12.20	2100.0				
02/24/75	1235	1.0	TDWR	11.00	8.230	24.0	11.70	9200.0	3473.0	400.0	.0000	192.0
03/24/75	1340	1.0	TDWR	8.90	7.900		22.20	18500.0				
04/28/75	1430	1.0	TDWR	7.70	8.200		25.60	21000.0				
05/06/75	1900	1.0	TDWR	6.20	8.400	.0	25.50	19000.0	6000.0	800.0	.3000	98.0
08/18/75	1710	1.0	TDWR	7.10	8.660		32.00	3700.0	980.0	319.0	.4200	318.0
11/04/75	1530	1.0	TDWR	8.40	8.300	.0	25.00	24000.0	7696.0	1099.0		50.0
02/02/76	1530	1.0	TDWR	7.80	8.400		16.30	20000.0	8330.0	1198.0		154.0
05/04/76	1630	1.0	TDWR	10.40	8.800		25.50	10000.0	2700.0	540.0	.0800	658.0
08/05/76	1430	1.0	TDWR	8.70	8.700	300.0*	34.00	2100.0	790.0	54.0	.0200	334.0
11/09/76	1815	1.0	TDWR	8.30	8.600	110.0*	20.00	24000.0	7900.0	1200.0 <	.030	36.0
02/15/77	1640	1.0	TDWR	15.30	9.500*		12.00	2350.0	570.0	110.0 <	.030	60.0
05/25/77	0920	1.0	TDWR	7.50	8.500	400.0*	25.00	6900.0	2000.0	380.0 <	.050	45.0
08/02/77	1917	1.0	TDWR	8.10	8.600	.0	31.50	3000.0	490.0	100.0 <	.050	164.0
10/04/77	1505	1.0	TDWR	8.50	8.70		25.50	16000.0	5460.0	1160.0 <	.050	26.0
01/24/78	1510	1.0	TDWR	12.0	7.850		8.50	1900.0	573.0	83.0	.230	100.0
04/26/78	1105	1.0	TDWR	9.60	8.850	2.0	21.00	10200.0	3110.0	460.0	.070	53.0
07/19/78	1615	1.0	TDWR	8.80	8.70		31.00	18200.0	3600.0	590.0 <	.050	340.0
10/18/78	1000	1.0	TDWR	8.60	8.50	.0	19.50	10900.0	3220.0	450.0 <	.050	41.0
12/05/78	1430	1.0	TDWR	9.50	8.50		16.80	4700.0	1300.0	160.0 <	.050	144.0
03/06/79	1715	1.0	TDWR	10.00	8.80	60.0	18.00	9300.0	2690.0	1100.0 <	.050	155.0
06/12/79	1930	1.0	TDWR	8.00	8.250		25.50	1300.0	288.0	39.0 <	.050	25.0
10/03/79	0950	1.0	TDWR	7.40	8.10		25.00	600.0	117.0	15.0 <	.050	36.0
12/04/79	1000	1.0	TDWR	10.20	8.150		11.00	11500.0	3520.0	513.0 <	.050	15.0

Table 7. Carancahua Bay
Station 2456.0100, 1973 to 1983

AN ASTERISK (*) DENOTES A MEASUREMENT THAT IS NOT WITHIN STANDARDS.

BAYS AND ESTUARIES

CARANCAHUA BAY
2456.0100 SH 35 BETWEEN PORT LAVACA AND PALACIOS
DISTRICT 12 COUNTY JACKSON USGS BASE 000000000 LAT / LONG 28 43 54 / 096 25 54

SAMPLE DATE	TIME	DEPTH (FT.)	SOURCE AGENCY	00300 DO MG/L	00400 PH SU	31501 TOT COLI MPNMENDO /100ML	00010 WATER TEMP CENT	00094 CNDUCTVY FIELD MICROMHO	00940 CHLORIDE CL MG/L	00945 SULFATE SO4 MG/L	00610 NH3-N TOTAL MG/L	00530 RESIDUE TOT NFLT MG/L
03/03/80	1740	1.0	TDWR	10.40	8.00		12.00	23890.0	7700.0	960.0	< .050	36.0
06/24/80	1610	1.0	TDWR	8.60	8.40		30.70	5800.0	1650.0	180.0	< .050	101.0
10/07/80	1730	1.0	TDWR	10.90	8.30		24.90	8140.0	2310.0	330.0	< .050	36.0
12/16/80	1830	1.0	TDWR	7.70	8.40		16.70	19580.0	6920.0	910.0	< .050	240.0
04/14/81	1355	1.0	TDWR	7.30	7.40 <	10.0	27.20	38800.0	10700.0	2000.0	< .050	42.0
06/02/81	1720	1.0	TDWR	5.00	7.850	120.0*	29.10	2640.0	670.0	100.0	.130	120.0
09/30/81	1623	1.0	TDWR	9.70	8.50		27.00	4800.0	1700.0	220.0	< .050	48.0
12/09/81	1530	1.0	TDWR	9.20	8.60	150.0*	23.0	6800.0	2040.0	255.0	< .050	112.0
03/23/82	1140	1.0	TDWR	8.70	8.60		19.30	7570.0	1990.0	300.0	< .050	74.0
06/07/82	2114	1.0	TDWR	7.60	8.850		27.50	3100.0	737.0	99.0	< .050	39.0
09/23/82	1452	1.0	TDWR	9.70	6.50 <	10.0	25.10	18500.0	5540.0	720.0	< .050	57.0
12/08/82	1408	1.0	TDWR	10.90	8.60		16.50	5920.0	1600.0	220.0	< .050	67.0

STATION SUMMARY

AVERAGE	8.9			22.4	8919.	2957.	469.	.079	115.
GEOMETRIC MEAN			61.						
MAXIMUM	15.3	9.50	600.	34.0	38800.	10700.	2000.	.420	658.
MINIMUM	5.0	7.30	0.	6.5	20.	1.	14.	.000	15.
NUMBER OF SAMPLES	50	50	11	50	49	38	38	36	38

SEGMENT STANDARDS

	DO MG/L	PH SU	TOT COLI MPNMENDO /100ML	WATER TEMP CENT	CNDUCTVY FIELD MICROMHO	CHLORIDE CL MG/L	SULFATE SO4 MG/L	NH3-N TOTAL MG/L	RESIDUE TOT NFLT MG/L
EFFECTIVE DATE: 10/01/67 DEPTH: 1.0 AGENCY: TDWR									
MAXIMUM		9.0		70.0		35.0			
MINIMUM	5.0	6.50							

Table 7. Continued

AN ASTERISK (*) DENOTES A MEASUREMENT THAT IS NOT WITHIN STANDARDS.

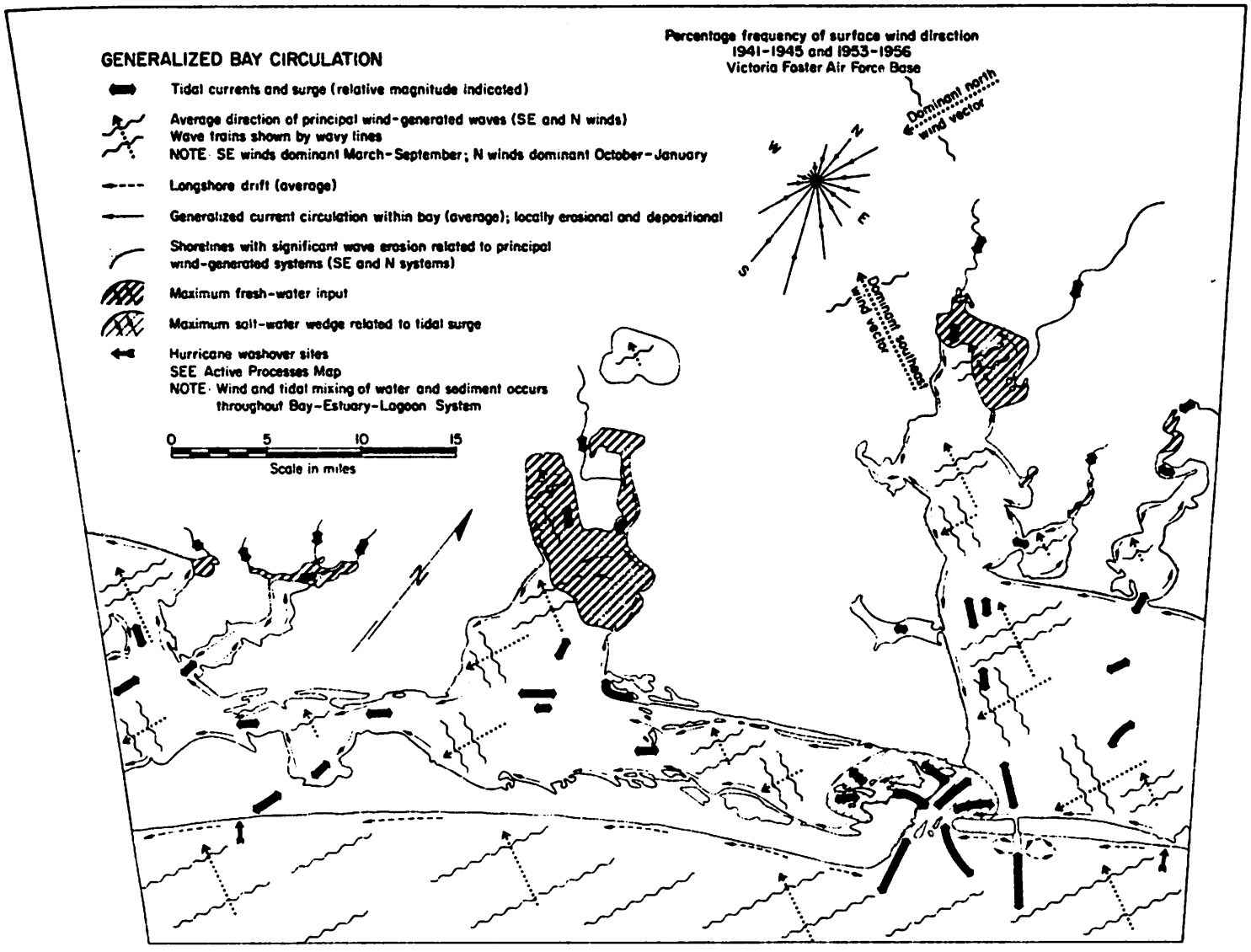

Figure 3. Circulation, waves, sediment transport, and other physical process, bay-estuary-lagoon and offshore systems, Port Lavaca map area. (From: McGowen, J. H. et al. 1976. Environmental Geologic Atlas of the Texas Coastal Zone - Port Lavaca Area. Univ. Texas, Bur. Econ. Geol. 107 p.)

APPENDIX A

FIELD AND LABORATORY PROCEDURES

The following methods are utilized for field and laboratory determinations of specified physical and chemical parameters. Unless otherwise indicated composite water samples are collected at each sampling station and stored in polyethylene containers on ice until delivery to the laboratory. Sediment samples are collected with a dredge or coring device, decanted, mixed, placed in appropriate containers (glass for pesticides analyses and plastic for metals analyses), and stored on ice until delivery to the laboratory. Laboratory chemical analyses are conducted by the Water Chemistry Laboratory of the Texas Department of Health unless otherwise noted.

WATER ANALYSES

Field Measurements

Parameter	Unit of Measure	Method
Temperature	°C	Hand mercury thermometer, Hydrolab Model 60 Surveyor, or Hydrolab 4041.
Dissolved Oxygen (DO)	mg/l	Azide modification of Winkler titration method, Hydrolab Model 60 Surveyor, or Hydrolab 4041.
pH	Standard Units	Hydrolab Model 60 Surveyor, Hydrolab 4041 or Sargent-Welch portable pH meter.
Conductivity	µmhos/cm	Hydrolab Model 60 Surveyor, Hydrolab 4041, or Hydrolab TC-2 conductivity meter
Phenolphthalein Alkalinity (P-Alk)	mg/l as $CaCO_3$	Titration with sulfuric acid using phenolphthalein indicator(1).
Total Alkalinity (T-Alk)	mg/l as $CaCO_3$	Titration with sulfuric acid acid using phenolphthalein and methyl red/bromcresol green indicators(1).
Chlorine Residual	mg/l	N,N-diethyl-p-phenylene-diamine (DPD) Ferrous Tetrimetric method(1).
Transparency	m or cm	Secchi disc

Laboratory Analyses

Parameter	Unit of Measure	Method
Five Day, Nitrogen Suppressed, Biochemical Oxygen Demand (BOD_5, N-Supp.)	mg/l	Membrane electrode method(1). Nitrogen Suppression using 2-chloro-6-(trichloromethyl)-pyridine (TCMP) method(2).
Five Day, Filtered, Nitrogen Suppressed, Biochemical Oxygen Demand (BOD_5, Filt., N-Supp.)	mg/l	Samples filtered with glass fiber filter. Analysis conducted on filtrate. Membrane electrode method(1). Nitrogen Suppression using TCMP method(2).
Twenty Day, Nitrogen Suppressed, Biochemical Oxygen Demand (BOD_{20}, N-Supp.)	mg/l	Membrane electrode method(1). Nitrogen Suppression using TCMP method(2).
Twenty Day, Filtered, Nitrogen Suppressed, Biochemical Oxygen Demand (BOD_{20}, Filt., (N-Supp.)	mg/l	Samples filtered with glass fiber filter. Analyses conducted on filtrate. Membrane electrode method(1). Nitrogen Suppression using TCMP method(2).
One through Seven Day, Nitrogen-Suppressed, Biochemical Oxygen Demand (BOD_{1-7}, N-Supp.)	mg/l	Membrane electrode method(1). Nitrogen Suppression using TCMP method(2).
Total Suspended Solids (TSS)	mg/l	Gooch crucibles and glass fiber disc(1).
Volatile Suspended Solids (VSS)	mg/l	Gooch crucibles and glass fiber disc(1).
Kjeldahl Nitrogen (Kjel-N)	mg/l as N	Micro-Kjeldahl digestion and automated colorimetric phenate method(3).
Ammonia Nitrogen (NH_3-N)	mg/l as N	Distillation and automated colorimetric phenate method(3).
Nitrite Nitrogen (NO_2-N)	mg/l as N	Colorimetric method(1).
Nitrate Nitrogen (NO_3-N)	mg/l as N	Automated cadmium reduction method(3).

Laboratory Analyses - Continued

Parameter	Unit of Measure	Method
Total Phosphorus (T-P)	mg/l as P	Persulfate digestion followed by ascorbic acid method(1).
Orthophosphorus (O-P)	mg/l as P	Ascorbic acid method(1).
Sulfate (SO_4)	mg/l	Turbidimetric method(1).
Chloride (Cl)	mg/l	Automated thiocyanate method(3).
Total Dissolved Solids (TDS)	mg/l	Evaporation at 180°C(3).
Total Organic Carbon (TOC)	mg/l	Beckman TOC analyzer
Conductivity	µmhos/cm	Wheatstone bridge utilizing 0.01 cell constant(1).
Chlorophyll a	µg/l	Trichromatic method(1).
Pheophytin a	µg/l	Pheophytin correction method(1).

SEDIMENT ANALYSIS

Parameter	Unit of Measure	Method
Arsenic (As)	mg/kg	Silver diethylidithcocarbonate method(3).
Mercury (Hg)	mg/kg	Potassium permanganate digestion followed by atomic absorption(3,4).
All other metals	mg/kg	Atomic absorption(3,4).
Volatile Solids	mg/kg	Ignition in a muffle furnace(3).
Chemical Oxygen Demand (COD)	mg/kg	Dichromate reflux method(3).
Kjeldahl Nitrogen (Kjel-N)	mg/kg	Micro-Kjeldahl digestion and automated colorimetric method(3).
Total Phosphorus (T-P)	mg/kg as P	Ammonium molybdate(3).
Pesticides	µg/kg	Gas chromatographic method(4,5).
Oil and Grease	mg/kg	Soxhlet extraction method(3).

BACTERIOLOGICAL

Bacteriological samples are collected in sterilized bottles to which 0.5 ml of sodium thiosulfate is added to dechlorinate the sample. Following collection, the samples are stored on ice until delivery to a 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.

Parameter	Unit of Measure	Method
Total Coliform	Number/100 ml	Membrane filter method(1)
Fecal Coliform	Number/100 ml	Membrane filter method(1)
Fecal Streptococci	Number/100 ml	Membrane filter method(1)