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WATER-DELIVERY STUDY

NUECES RIVER, TEXAS

Quantity and Quality, August 1963

By

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Prepared by the U.S. Geological Survey
in cooperation with the
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and the
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WATER-DELIVERY STUDY

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INTRODUCTION

This investigation was made by the U.S. Geological Survey under a cooperative agreement with the Lower Nueces River Water Supply District through the Texas Water Commission.

The purpose of the investigation was to determine gains or losses of flow and the changes in chemical quality of water in the Nueces River channel in the 35.0-mile reach from Lake Corpus Christi to Calallen Dam, during the period August 28-31, 1963, when the maximum daily water demand of 149 cfs (cubic feet per second) was being released from Lake Corpus Christi at a constant rate (Plate 1).

Water for domestic and municipal, irrigation, mining, and industrial use downstream is released from Lake Corpus Christi near Mathis and flows down the Nueces River channel into a channel lake formed by a dam at Calallen, 35 river miles downstream from Lake Corpus Christi. Water is pumped out of Calallen Lake by the city of Corpus Christi (two plants), Nueces County Water Control and Improvement District No. 3, Celanese Chemical Company, and Suntide Refining Company. Records for the stream-gaging station, Nueces River near Mathis, Tex., 0.6 mile downstream from Lake Corpus Christi, show that the flow was sustained at a constant rate 48 hours prior to and during the investigation, or, for the period August 26-31, 1963. No surface runoff occurred during the investigation and no general rains had fallen in the area for several months; therefore, soil moisture was low.

A temporary water-stage recorder was installed at Farm Road 666 crossing (mile 18.2) at Bluntzer, about midway of the study reach. Records show that the stage at this crossing fluctuated only ±0.01 foot during the investigation. The river was traversed by boat. Measurements of discharge and water temperature were made, and water samples were collected at near equal intervals (Plate 1). Tributaries and the river were inspected for seeps, diversions, return flow, and other unusual conditions that might affect streamflow.

A chemical-quality investigation was made August 31 on the downstream side of Calallen Dam. Specific conductance determinations were made and water samples collected in this tidal reach of the river.

Supplementary discharge and water temperature measurements were made and water samples collected on October 9-10, 1963, in two shorter reaches (mile 0 to 2.8 and 10.5 to 14.2) of the river to verify significant water losses recorded in these reaches in the August investigation (Table 4). For the verification, water was released from Lake Corpus Christi at a constant rate of 142 cfs for 48 hours prior to and during the investigation. There was no surface runoff during this period.

Supporting data not given in the text, tables, and figures are available in the files of the U.S. Geological Survey, Austin, Texas.

GENERAL GEOLOGY

The reach of the Nueces River investigated is in the southern part of the Texas Gulf Coastal Plain. Sedimentary beds of Pliocene and Pleistocene age form bands parallel with the coast and underlie this reach of the Nueces River Basin (Plate 2).

The Goliad Sand of Pliocene age underlies the upper 7 miles of the reach. The Goliad Sand is predominantly sand and gravel cemented with lime. High caliche banks occasionally border the river from Lake Corpus Christi to about 15 miles downstream. These caliche beds are common in the Goliad Sand and in the Lissie Formation. The Lissie Formation of Pleistocene age is composed mostly of sand and sandstone layers. The remainder of the 35-mile reach is underlain by the Beaumont Clay of Pleistocene age. The Beaumont Clay is principally a poorly-bedded calcareous clay containing thin beds of silt and fine sand.

The above information on general geology is principally from Wood, Gabrysch, and Marvin (1963, p. 29-30).

Quaternary alluvium of generally unknown lateral extent and depth is present along the river throughout the study reach. This study did not include the investigation of subsurface geology. However, a report by Ambursen Engineering Corporation and Reagan and McCaughan, Consulting Engineers (1954), contains the results of geologic investigations at three dam sites. (See Plates 3, 4, and 5.)

A report by Ambursen Engineering Corporation and Myers and Noyes and Associates (1952) states that :

> "The Nueces River flood plain is composed of alternating and non-continuous layers of sand, gravel, clay and silt. In general, the valley consists of a relatively impervious silt and clay stratum underlain by pervious material. The thickness of the impervious layer may vary from a few inches to fifteen feet and the thickness of the pervious material may vary from 80 to 160 feet, depending on the depth of the buried valley eroded by the River. The pervious material contains numerous thin strata of silt or clay which can best be described as lenticular as no correlation between borings can be made."

RESULTS OF INVESTIGATION

Results of the discharge measurements and chemical analyses of the water at points where data were collected in August are shown in Tables 1, 2, and 3 and on Plate 1. The results of the supplementary investigation in October are shown in Table 4. Discharge measurements, water temperature, and water samples for complete analyses were obtained at approximately 2-mile intervals from the stream-gaging station, 0.6 mile below Lake Corpus Christi, to near the upper end of Calallen Lake (Plate 1). Thirteen discharge measurements were made on the Nueces River between mile 0 and mile 25.8. In addition, water samples were collected at points between each measurement for chloride and specific conductance determinations (Table 3).

Between the site of the last discharge measurement and Calallen Dam (mile 34.4), the river was traversed by boat to check for diversions and return flow and to obtain water samples for chemical analysis. All tributaries were checked for flow, but no flow was found. Water samples were collected at about half-mile intervals through Calallen Lake. A profile of chloride and dissolved-solids concentrations and water discharge is shown on Figure 2.

Photographs were taken to show typical channel and vegetation conditions (Figure 1). In general, the banks are heavily wooded for a distance of several hundred yards on each side of the river, with lighter growths beyond. Aquatic growth was heavy in parts of the study reach. The results of the investigation are discussed by subdivision of the study reach. Each subdivision conforms with significant changes in discharge.

Reach From Mile 0 to Mile 2.8

Measured flow was 149 cfs at the stream-gaging station 0.6 mile below Lake Corpus Christi and was 141 cfs at mile 2.8, indicating a loss of 8 cfs. Streambed material in this reach is primarily sand and gravel. Banks are heavily wooded with many willow and live-oak trees and heavy underbrush. Some phreatophytes such as cattails were also observed. In this reach, as in the entire reach investigated, the river is characterized by long, deep pools with a small number of sand and gravel riffles. Average width of the river in this reach was about 60 feet. The Nueces River Valley below Lake Corpus Christi consists of alluvium. There probably is some interchange in surface and ground water throughout the reach. There was no visible evidence of diversion or inflow.

There was little change in the quality of the water in this reach (Figure 2). The chloride concentration varied from 72 to 74 ppm (parts per million).

Supplementary discharge measurements were made in this reach October 9-10 to substantiate the relatively large loss (9 cfs) found August 28. Rate of flow from Lake Corpus Christi was slightly less than during the August investigation (142 cfs compared to 149 cfs). Measurements were made and water samples collected at mile 0, mile 1.2, mile 2.0, and mile 2.8. Measured discharges were 142 cfs, 136 cfs, 141 cfs, and 141 cfs, respectively, indicating a loss of 6 cfs between the stream-gaging station and mile 1.2, and a gain of 5 cfs between mile 1.2 and mile 2.0. As in the August investigation, there was little change in water quality in this reach. The chloride concentrations of water samples collected are shown in Table 4. Heavy rain showers of up to 5 inches fell on some parts of this reach during September. This probably produced some recharge to

View looking upstream 1.2 miles below gage.

View looking upstream 2.0 miles below gage.

View looking downstream 2.0 miles below gage.

View looking upstream from Bluntzer Bridge, 18.2 miles below gage.

Figure 1.--Typical Views of Main Channel, Nueces River Between Stream-Gaging Station near Mathis, Texas, and Calallen Dam near Calallen, Texas. Photos taken October 9-10, 1963.

alluvial materials in portions of the flood plain and accounted for the lack of agreement in water loss found in the August and October investigations within this reach.

The major loss of streamflow in this reach is attributed to seepage into the alluvium. Further seepage into the underlying Goliad Sand is unlikely.

Reach From Mile 2.8 to Mile 10.8

Measurements of flow in this reach were made at mile 2.8, mile 4.5, mile 6.6, mile 8.7, and mile 10.8. Discharges at these sites were 141 cfs, 142 cfs, 142 cfs, 144 cfs, and 144 cfs, respectively, indicating a gradual gain of 3 cfs in this 8-mile reach, although some water must have been lost by evapotranspiration. Banks are heavily wooded, with many willow trees, and some portions of this reach contain heavy aquatic growth. Streambed material is primarily sand and gravel. Average river width in this reach was estimated to be 70 feet. There was no flow from the three tributaries in the reach. There was little change in water quality in this 8-mile reach (Figure 2).

Reach From Mile 10.8 to Mile 14.4

The three measurements of flow made in this reach in August indicate a loss of 9 cfs in 3.6 miles. At mile 10.8, measured flow was 144 cfs; at mile 13.4, measured flow was 137 cfs; and at mile 14.4, measured flow was 135 cfs. The largest apparent loss was 7 cfs between mile 10.8 and mile 13.4. No diversions were noted in this reach, and Sandy Hollow Creek, the only tributary, was not flowing. In general, both banks of the river are heavily wooded, with many willow trees. Streambed material is primarily sand and gravel, with some silt. No rock riffles are present. Average river width in this reach was about 75 feet. The quality of water did not change significantly (Figure 2).

Supplementary measurements near and within this reach were made on October 9-10 to substantiate the water loss found August 29. Measurements were made and water samples collected at mile 10.5, mile 11.7, and mile 14.2. Measured discharges were 143 cfs, 137 cfs, and 137 cfs, respectively, indicating a loss of 6 cfs. These measurements show that the significant loss from mile 10.8 to mile 14.4 found in August (7 cfs) also occurred in October. The samples collected showed no significant change in chemical quality. Sandy Hollow Creek had no flow.

A large pump powered by a 30-horsepower motor was found near the channel at approximately mile 11.2; however, it was not in operation at the time of the October supplementary investigation. It is not known whether or not this pump was operating during the August investigation.

The streamflow loss in this reach is probably due to seepage into the alluvium with little or no percolation into the tight underlying Lissie Formation.

Reach From Mile 14.4 to Mile 18.2

No appreciable change in flow was noted in this reach. Measurements were made at mile 14.4, mile 16.6, and mile 18.2, with resulting discharges of 135 cfs, 135 cfs, and 136 cfs, respectively. Water samples collected in the reach

showed little or no change in chemical quality (Figure 2). Both banks of the river are generally heavily wooded and aquatic growth was heavy in some portions of this reach. Streambed material in this reach was primarily sand and silt, except for approximately one-eighth of a mile in the vicinity of Farm Road 666 crossing at Bluntzer, where the bed was caliche. This was the only outcrop of consolidated material found in the channel during the investigation. No inflow or diversion was noted. Average width of the river was estimated as 75 feet.

Reach From Mile 18.2 to Mile 25.8

Mile 25.8 was the farthest downstream site on the river where a measurement of discharge was made. Measurements were made at mile 18.2, mile 20.2, mile 23.0, and at mile 25.8. Resulting discharges were 136 cfs, 133 cfs, 135 cfs, and 134 cfs, respectively, indicating no appreciable loss or gain in flow. Analyses of samples collected in this reach show water of near unifrom quality. Riverbed material in this reach was predominantly silt and sand, with no gravel. Average river width was estimated to be 85 feet. Vegetation in this reach is less dense than upstream, and at many points the riverbank is bare of trees. The low gradient, wide flood plain, and cutoff meanders are evidence that the Nueces River has changed its course in this reach in recent history.

Flow of Cayamon Creek, a tributary to the Nueces River, was estimated to be 0.22 cfs at Farm Road 666 crossing near Bluntzer; however, this flow did not reach the Nueces River as surface flow. The estimated flow, with a chloride concentration of 900 ppm, probably came from upstream gravel-washing operations. An analysis of the water sample collected from Cayamon Creek is shown in Table 2.

Reach From Mile 25.8 to Calallen Dam

No discharge measurements were made in this reach. Although measurements were planned, a shower on August 30 in Corpus Christi caused the city to reduce pumpage from Calallen Lake. With the reduction in pumping, the resevoir level rose, causing water to go into storage above the prospective measuring sites. Numerous small pumps with intakes in the river were noted at lake cabins along the riverbank. These pumps were not operating at the time of this investigation. From mile 30 to Calallen Dam, the right (south) bank is relatively high and the left bank is low. Visual inspection of the river indicates that if the river were to rise approximately 2 feet above the elevation on August 31, 1963, water would flow into the large, uninhabited lowlands on the left bank.

Measured discharge of the Robstown diversion ditch (used by Nueces County Water Control and Improvement District No. 3), was 29.0 cfs and the chloride concentration was 79 ppm. The city of Corpus Christi furnished records of diversion by the city, Celanese Chemical Company, Suntide Refining Company, and the Nueces County Water Control and Improvement District No. 3. These records indicate the following amounts of water were diverted from Calallen Lake during the investigation:

Date	Daily Diversion
Aug. 28, 1963	136 cfs
Aug. 29, 1963	139 cfs
Aug. 30, 1963	118 cfs
Aug. 31, 1963	93.2 cfs

Bihourly readings by the city of Corpus Christi of Calallen Lake level elevations indicated that the lake level ranged from a minimum elevation of 3.34 feet above gage datum at 12 noon on August 30, to a maximum of 4.52 feet above gage datum at 12 noon on August 31. Figure 3 illustrates range-in-stage of the lake and withdrawal rate during the period of investigation. Flow over the dam starts at 4.54 feet gage height.

Little change in the quality of the flow was noted until mile 33.2. The chloride concentration increased from 76 ppm at mile 32.0 (P-45), to 82 ppm at mile 33.2 (P-46), and continued to increase to Calallen Dam. A sample taken at mile 33.9, at the city of Corpus Christi pumping plant, had a chloride concentration of 92 ppm. The analysis of this sample (P-47) is shown in Table 2. The chloride concentration at Calallen Dam (P-48) was 101 ppm. Figure 4 shows a cross section of the river channel at the dam with chloride concentrations of the water at various depths and points in the cross section. There was no stratification.

Bay Side of Calallen Dam

After completing field studies above Calallen Dam, a limited investigation was made in the tidal reach of the river just below the dam. This bay-side investigation was completed at 11 a.m., August 31, before any of the lake water spilled over the dam. The stream depth was less than 4 feet except for a hole near the left bank just below the dam (Figure 5). Except for the water in this 18-foot hole, the chloride concentration of the water below the dam was only 218 ppm. This low-chloride concentration was probably due to dilution of tidal water by fresh water from prior accidental spills over the dam, and leakage through the dam. The water in the hole, apparently left by the ebb tide, had a chloride concentration of 10,000 ppm near the bottom.

COMPARISON WITH PREVIOUS INVESTIGATIONS

In 1948, the U.S. Geological Survey conducted a water-delivery investigation in this same reach (U.S. Geological Survey, 1950, p. 210; Texas Board Water Engineers, 1960, p. 179). Measurements were made April 20-22, 1948, starting at the stream-gaging station 0.6 mile below Lake Corpus Christi and ending at a point 25.5 river miles below the gage. Flow at the stream-gaging station during this investigation was 35.3 cfs.

In the 1948 investigation, a loss of 4.7 cfs occurred in the first mile of the reach. A loss of 1.8 cfs also was noted between mile 10.9 and mile 13.4.

In January 1960, the Texas State Department of Health made a salt water pollution survey of the Nueces River below Lake Corpus Christi (Craven, 1960). The chloride concentration of releases from Lake Corpus Christi increased 317 percent (17.7 ppm to 73.8 ppm) from Lake Corpus Christi to Calallen.

The principal sources of pollution noted by personnel of the Texas State Department of Health were brines produced by the oil and gas industry in the area and gravel washing operations with direct discharge to Cayamon Creek (Dismero Creek). Among other findings, the Texas State Department of Health reported that:

> "5. The combination of oilfield brines and chlorides from gravel washing operations amounts to approximately 14 tons per day. This tonnage of chlorides accounts for this average increase from 17.7 ppm chloride at Lake Corpus Christi to 73.8 ppm noted at the Calallen water intake."

Another investigation was made by the Texas State Department of Health in December 1961 and January 1962 (Classen, 1961). Samples for analyses were collected on several days at 12 sites in the lower Nueces River Basin. The primary purpose of this study was to note changes in the hardness characteristics of water of the reach and to locate sources of calcium-magnesium pollution, but other ions in solution were also determined. From Lake Corpus Christi to the Corpus Christi water-treatment plant at Calallen, the total hardness of the water increased 13.2 percent and the chloride concentration increased 86.1 percent. The total hardness of water showed an increase from 175 ppm at the head of the reach to 198 ppm at the bottom of the reach; chloride concentrations increased from 50 ppm to 93 ppm.

The report of the Texas State Department of Health concludes in part:

> "2. This increase in hardness is caused by the waste water from oil fields and gravel washing operations in the area, which seeps or is discharged into the river."

The changes in water quality found by the U.S. Geological Survey in the present investigation were very small by comparison with the results of the two investigations by the Department of Health. The chloride concentration in August 1963 increased 27.8 percent (from 72 to 92 ppm) from Lake Corpus Christi to the Corpus Christi pumping station at Calallen; the water hardness increased only 3.4 percent (from 147 to 152 ppm) in this reach.

Factors probably contributing to differences between the results of this study and the two previous ones by the Texas State Department of Health are as follows:

1. The release from Lake Corpus Christi was 149 cfs for this study as compared to an average flow of 91 cfs in January 1960 and 97 cfs in December 1961 and January 1962.

2. This investigation was made during a drought with temperatures 90°F or higher, while the two previous studies were conducted during the winter.

3. During this investigation there was no observed inflow into the Nueces River along the entire reach from tributary, spring, or seep.

WATER QUALITY AND USE

Water used on common carriers in interstate traffic must satisfy the standards published by the U.S. Public Health Service (1962). These standards are generally accepted as recommended limits for domestic and municipal water supplies. The recommended limits for chloride and sulfate are 250 ppm, and for total dissolved solids the recommended maximum is 500 ppm.

Chloride, sulfate and dissolved-solids concentrations of all river samples collected in the reach from Lake Corpus Christi to Calallen Dam were well below these recommended limits for public water supply. Based on the following table used by the U.S. Geological Survey in classifying water hardness by numerical ranges, the water (152 ppm hardness) in this reach is hard.

Hardness range (ppm)	Rating
0 - 60	Soft
61 - 120	Moderately hard
121 - 180	Hard
181 -	Very hard

The Nueces River water should be satisfactory for most industrial uses without extensive treatment. It may be desirable to soften the water for some processes. Hard water is particularly objectionable because of the formation of scale in containers where water is heated or evaporated.

In water used for irrigation, the total concentration of soluble salts and the sodium ion and its relative proportion to other ions are the most important characteristics in determining its quality. Based on standards of the U.S. Salinity Laboratory Staff (1954, p. 69-82), the Nueces River water would be classified as medium-salinity and low sodium. Periodic leaching of the soil from an average annual rainfall of over 30 inches in this study area should make the water entirely satisfactory for irrigation.

SUMMARY

During this investigation, a release of 149 cfs from Lake Corpus Christi resulted in a delivery of 134 cfs to the upper end of Lake Calallen. The largest losses were found in two reaches; from mile 0 to mile 2.8, and from mile 10.8 to mile 14.4. The loss in the reach from mile 0 to mile 2.8 was not entirely substantiated by supplemental measurements made in October. The loss from mile 10.8 to mile 14.4 was substantiated. The reach from mile 2.8 to mile 10.8 had a small but steady gain. The reach from mile 16.6 to mile 25.8 showed alternating small losses and gains. There were no tributary inflows. No unrecorded diversions of water from the river were noted.

During the August investigation, the water quality changed very little from Lake Corpus Christi to the head of Calallen Lake. Water quality is well within the limits recommended by the Public Health Service for public supply. There

was no evidence of ground-water inflow and little apparent effect on water quality from the local geology.

As shown on Figure 6, the change in chemical quality of water from mile 0 at the Mathis gage to mile 34.4 at Calallen Dam was minor. The small increase in total dissolved solids in Calallen Lake probably was due to evaporation, residual water from previous inflow, and local drainage into the lake.

The uniform quality of the Nueces River water released from Lake Corpus Christi during this study probably was due to the absence of tributary inflow in the study area. Runoff from drainage areas along this reach is of different quality than the Lake Corpus Christi water, and the quality of water in Calallen Lake must fluctuate with the percentage of tributary inflow and the area producing the runoff.

RECOMMENDATIONS FOR ADDITIONAL INVESTIGATIONS

The August 1963 reconnaissance study was made to determine where major changes in water quantity and quality occurred, and as a guide for planning additional investigations that might be needed. The following hydrologic studies are recommended.

1. An investigation of the ground water and geology, coordinated with a water-delivery study, is needed to determine why there are gains and losses in the study reach. The two reaches where largest losses occurred are characterized by wide alluvial flood plains. Aerial photographs show a wide flood plain covered with dense vegetation in the reach from mile 0.0 to 2.8. The river meanders through a similar flood plain in the reach from mile 10.8 to 13.4. The presence of these alluvial plains on the down-gradient side of the stream in the area of major water losses indicates that part of the loss is due to recharge of the alluvium from the river, but an investigation of subsurface geology and water-table gradients, coupled with river measurements, is needed to substantiate this probability.

2. Additional water-delivery studies are needed during periods of different climatic conditions.

3. An investigation in the tidal reach of the river from Calallen Dam to Nueces Bay is needed to determine the tidal effects on the quality and quantity of water below Calallen Dam.

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Table 1.--Summary of discharge measurements: Water-delivery investigation from Lake Corpus Christi to Calallen Dam, Texas, August 28-31, 1963

Site No. [a]	Date	Stream	River mile below gaging station [b]	Water Temp. (°F)	Discharge in cfs			Streambed material	Remarks
					Main stream	Tributary	Diversion		
1	1963 Aug. 28	Nueces River	0	87	149			Sand and gravel	Stream-gaging station No. 8-2110
2	28	Nueces River	2.8	87	141			Sand and gravel	
3	28	Nueces River	4.5	85	142			Sand and silt	
T-1	28	Six Mile Creek	4.6			0		-	At mouth
T-2	28	Bayou Creek	4.8			0		-	At mouth
4	28	Nueces River	6.6	89	142			Sand and silt	
T-3	28	Unnamed tributary	7.2			0		-	At mouth
5	29	Nueces River	8.7	85	144			Sand	
6	29	Nueces River	10.8		144			Silt and gravel	
T-4	29	Sandy Hollow Creek	12.6			0		-	At mouth
7	29	Nueces River	13.4	88	137			Sand and gravel	
8	29	Nueces River	14.4	85	135			Sand and gravel	
9	29	Nueces River	16.6	88	135			Sand and gravel	
10	29	Nueces River	18.2	85	136			Hard caliche	At Farm Road 666 bridge at Bluntzer
11	30	Nueces River	20.2	87	133			Sand and silt	
12	30	Nueces River	23.0	88	135			Sand and silt	
T-5A	30	Cayamon Creek	23.7			.22		Sandy loam	Discharge estimated at Farm Road 666 crossing; this water did not reach river.
T-5B	30	Cayamon Creek	23.7			0		-	At mouth
13	30	Nueces River	25.8	88	134			Sand and silt	
D-1	31	Diversion ditch	30.0				0	-	Many people have small pumps in this area.
T-6	31	Unnamed tributary	30.7			0		-	
T-7	31	Unnamed tributary	31.4			0		-	
D-2	31	Robstown Canal	32.7				29.0	Concrete	At Farm Road 624 entrance to Hazel Bazemore Park. Diverted at this rate 8½ hours per day.
T-8	31	Unnamed tributary	32.8			0		-	

[a] T means tributary; D means diversion.
[b] Gaging station: Nueces River near Mathis, Tex., 0.6 mile below Lake Corpus Christi.
Note: River mile shown for tributaries and diversions is mileage of main stream at mouth of tributary or point of diversion.

Table 2.--Chemical analyses: Water-delivery investigation from Lake Corpus Christi to Calallen Dam, Texas, August 28-31, 1963

[Results in parts per million except as indicated]

Site No.	River Mile[a]	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Dissolved solids: Parts per million	Dissolved solids: Tons per acre-foot	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
1	0	149	14	0.02	0.00	48	6.6	67	9.8	203	36	72	0.3	0.0	0.08	0.30	354	0.48	147	0	48	2.4	607	7.0
2	2.8	141	14	--	--	47	6.7	74		199	36	74	.3	.2	--	--	350	.48	145	0	53	2.7	607	7.1
3	4.3	142	15	--	--	48	6.8	73		203	37	72	.3	.2	--	--	352	.48	148	0	52	2.6	611	7.3
4	6.6	142	15	--	--	48	6.8	74		203	37	73	.3	.2	--	--	354	.48	148	0	52	2.6	609	7.2
5	8.7	144	15	--	--	48	6.8	72		200	37	72	.3	.2	--	--	349	.47	148	0	51	2.6	612	7.4
6	10.8	144	14	--	--	47	6.7	74		200	37	73	.3	.2	--	--	350	.48	145	0	53	2.7	606	7.4
7	13.4	137	15	--	--	46	7.1	73		199	37	75	.2	.2	--	--	354	.48	144	0	53	2.7	606	7.3
8	15.1	133	15	--	--	48	6.6	74		201	37	74	.3	.0	--	--	354	.48	147	0	52	2.7	610	7.3
9	16.6	135	15	--	--	48	6.8	74		202	37	74	.3	.0	--	--	354	.48	148	0	52	2.6	611	7.1
10	18.2	136	15	--	--	48	6.8	75		204	37	74	.4	.0	--	--	356	.48	148	0	52	2.7	614	7.1
11	20.2	133	15	--	--	48	6.8	75		204	37	74	.3	.0	--	--	356	.48	148	0	52	2.7	614	7.1
12	23.0	135	14	--	--	48	6.8	74		202	37	74	.3	.0	--	--	353	.48	148	0	52	2.6	611	7.4
13	25.8	134	14	.05	.00	43	7.4	70	10	188	38	76	.4	.0	.02	.30	351	.48	138	0	50	2.6	602	7.5
b P-47	33.9	--	15	--	.00	48	7.8	79	10	204	40	92	.4	.0	--	.30	392	.53	152	0	51	2.8	671	7.3
c P-48	34.4	--	14	--	--	55	7.5	83		190	46	101	.3	.0	--	--	400	.54	168	12	52	2.8	705	6.9
d T-5A	--	.22	46	--	--	79	54	638		208	348	900	1.2	.0	--	--	2,170	2.95	419	248	77	14	3,680	7.0

a Initial point is at gaging station, Nueces River near Mathis, 0.6 mile below Lake Corpus Christi.
b At City of Corpus Christi pumping plant.
c 200 feet upstream from Calallen Dam.
d Cayanon Creek at Farm Road 666 (this water did not reach the Nueces River).
Note: P-47 and P-48 are sites where quality-of-water samples were obtained without discharge measurements;
T-5A is a site on a tributary.

Table 3.--Chloride concentration, specific conductance, and temperature of water, Nueces River Basin below Lake Corpus Christi, August 28-31, 1963.

Site no.	Date	Time	River mile[a]	Chloride (ppm)	Specific conductance (micromhos)	Temperature (°F)
1	28	0920	0.0	72	607	87
P-1			.5	73	610	87
P-2			1.0	73	613	87
P-3			1.5	73	615	86
2	28	1200	2.8	74	607	87
P-4			3.3	73	609	87
P-5			3.8	74	611	87
P-6			4.3	73	613	87
3	28	1500	4.5	72	611	87
[b] T-1			4.6	74	617	86
[c] T-2			4.8	78	643	89
P-7			5.0	73	615	88
P-8			5.5	75	612	88
P-9			6.0	74	609	89
4	28	1600	6.6	73	609	89
P-10			7.1	74	615	89
[d] T-3			7.2	74	620	89
P-11			7.6	73	611	88
P-12			8.1	74	613	88
5	29	0735	8.7	72	612	85
P-13			9.2	74	605	86
P-14			9.7	73	606	86
P-15			10.2	74	605	85
6	29	0940	10.8	73	606	86
P-16			11.3	74	606	86
P-17			11.8	75	606	87
P-18			12.3	74	610	87
7	29	1130	13.4	75	606	88
P-19			13.9	75	611	88
8	29	1425	14.4	74	610	88
P-22			14.9	74	609	87

Table 3.--Chloride concentration, specific conductance, and temperature of water, Nueces River Basin below Lake Corpus Christi, August 28-31, 1963--Continued

Site no.	Date	Time	River mile[a]	Chloride (ppm)	Specific conductance (micromhos)	Temperature (°F)
P-23			15.4	74	608	88
P-24			15.9	74	608	87
9	29	1545	16.6	74	611	88
P-25			17.1	74	608	88
P-26			17.6	73	611	88
10	29	1700	18.2	74	614	88
P-28			19.3	75	614	86
P-29			19.7	74	612	86
P-30			20.1	74	607	86
11	30	1050	20.2	74	614	87
P-31			20.7	75	605	86
P-32			21.2	75	606	87
P-33			21.7	74	609	87
12	30	1250	23.0	74	613	88
P-34			23.5	75	616	88
[e] T-4	30	0700	--	900	3,680	--
[f] T-5			23.7	700	2,930	--
P-35			24.0	74	612	88
P-36			24.5	76	611	88
13	30	1620	25.8	76	602	88
P-37			26.3	76	606	88
P-38			26.8	75	612	88
P-39A			27.3	75	612	88
P-39B			27.8	74	614	88
P-40			28.3	76	611	85
P-41			29.0	76	611	85
P-42			29.7	76	611	85
P-43			30.4	76	614	87
P-44			31.0	76	622	86
P-45			32.0	76	621	87

Table 3.--Chloride concentration, specific conductance, and temperature of water, Nueces River Basin below Lake Corpus Christi, August 28-31, 1963--Continued

Site no.	Date	Time	River mile	Chloride (ppm)	Specific conductance (micromhos)	Temperature (°F)
[g] D-1			32.7	79	637	86
P-46			33.2	82	631	87
P-47	31	0915	33.9	92	673	87
P-48	31	0930	34.4	101	705	87

a Initial point is at gaging station, Nueces River near Mathis, 0.6 mile below Lake Corpus Christi.
b Six Mile Creek at mouth. Backwater from river.
c Bayou Creek at mouth. Backwater from river.
d Unnamed tributary at mile 7.2. Backwater from river.
e Cayamon Creek (Dismero Creek) at bridge on Farm Road 666.
f Cayamon Creek from pool near mouth.
g Robstown Canal at Farm Road 624.

Note: Sites denoted by P are those intermediate points where quality of water samples were obtained between discharge-measurement sites. Sites denoted by T are those for tributaries and those denoted by D are for diversions.

Table 4.--Summary of supplementary discharge measurements in river reaches between miles 0 to 2.8 and 10.5 to 14.2: Water-delivery investigation from Lake Corpus Christi to Calallen Dam, Texas, October 9-10, 1963

Date	River mile below gaging station[a]	Discharge (cfs)	Water temp. (°F)	Chlorides (ppm)	Streambed materials
1963 Oct. 9	0	142	77	68	Sand and gravel
9	1.2	136	77	68	Sand and silt
9	2.0	141	78	68	Do.
9	2.8	141	78	70	Sand and gravel
9	10.5	143	79	70	Gravel
9	11.7	137	79	72	Sand and gravel
10	14.2	137	76	70	Sand, gravel and silt

[a] Gaging station: Nueces River near Mathis, Tex., 0.6 mile below Lake Corpus Christi.

Note: There was no visible inflow to or diversion from the river in the two reaches shown in this table.

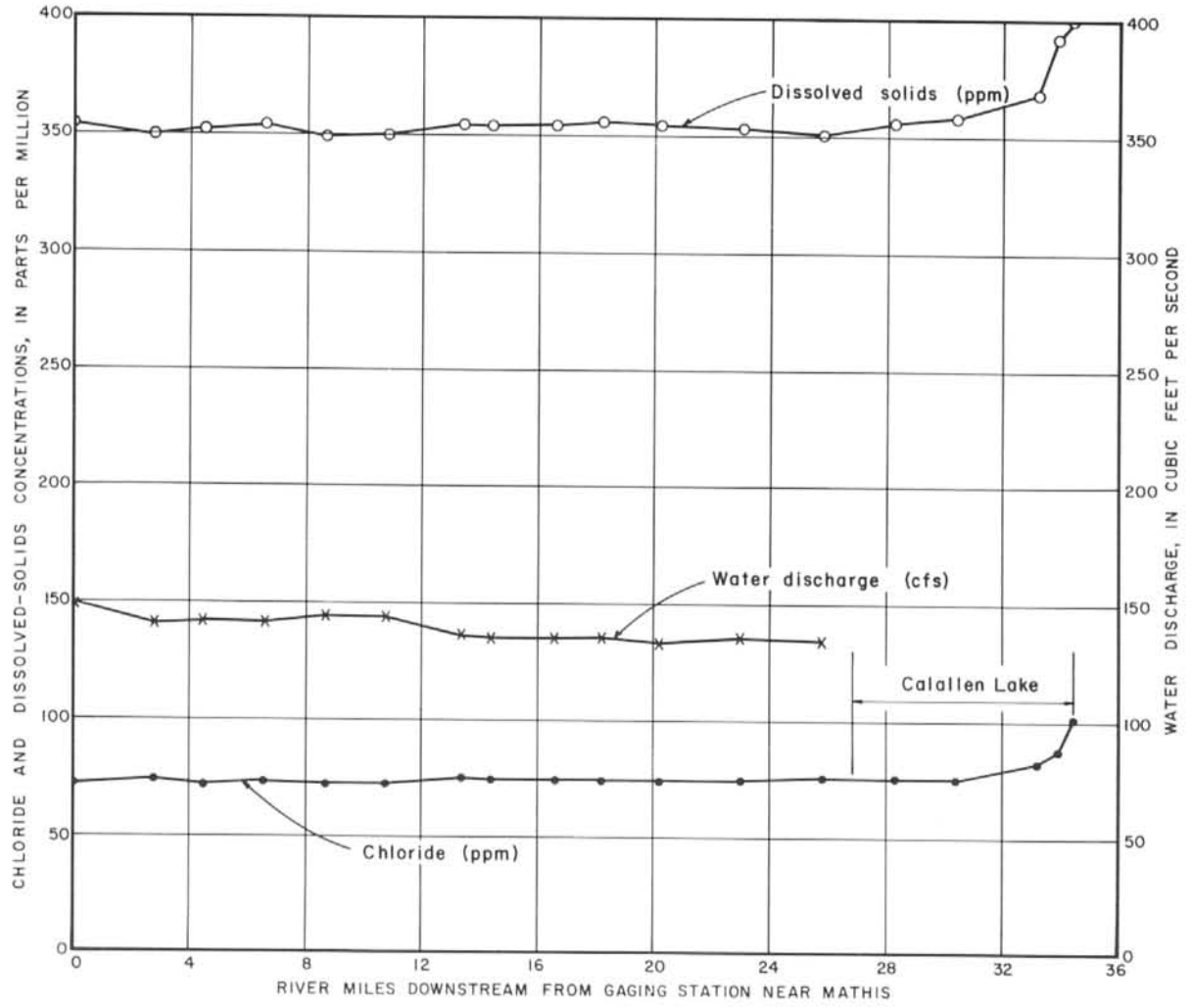

Figure 2

Chloride and Dissolved-Solids Concentrations and Water Discharge, Nueces River, August 28-31, 1963

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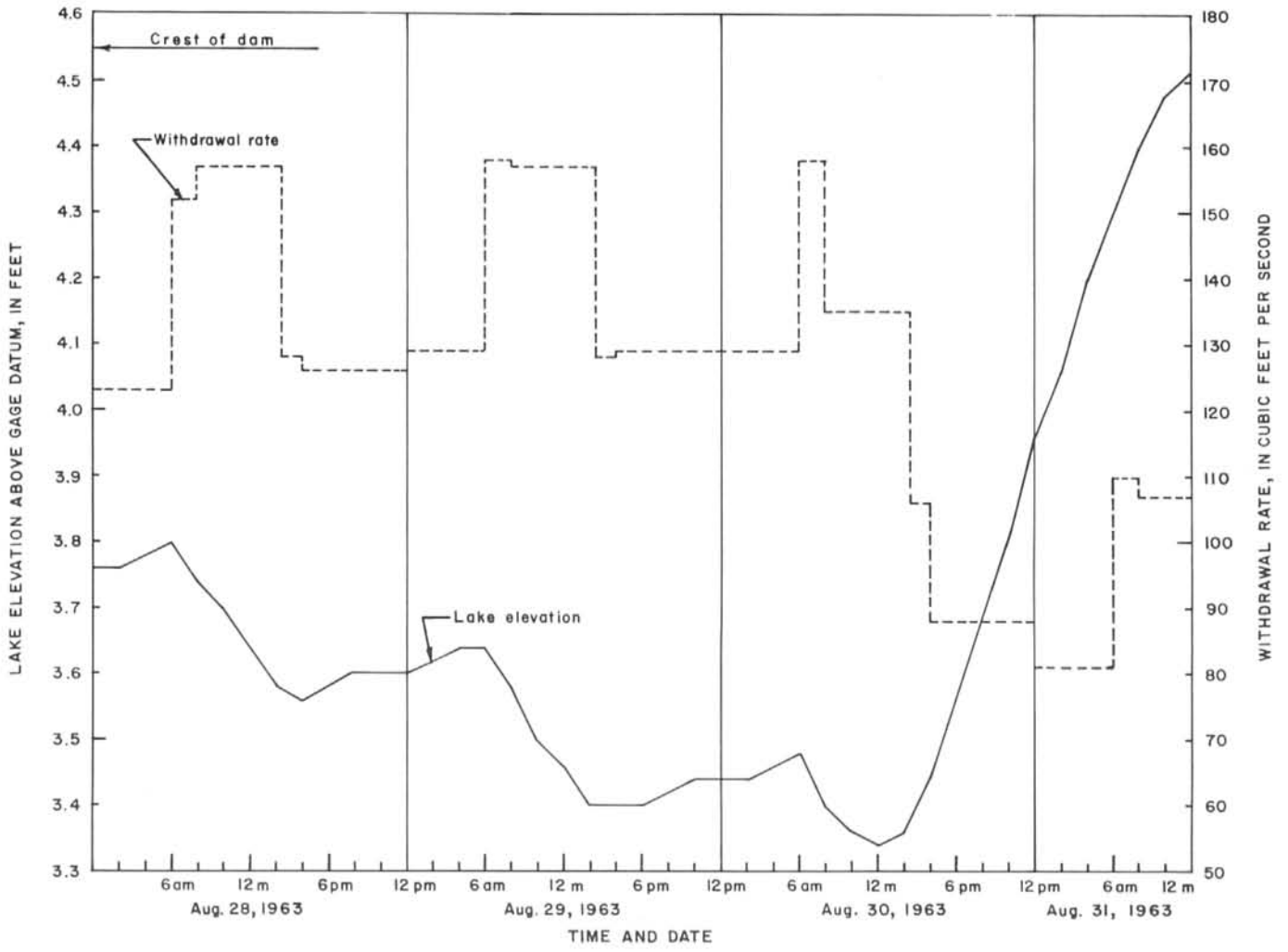

Figure 3

Profiles of Lake Elevation and Withdrawal Rate, Calallen Lake, August 28-31, 1963

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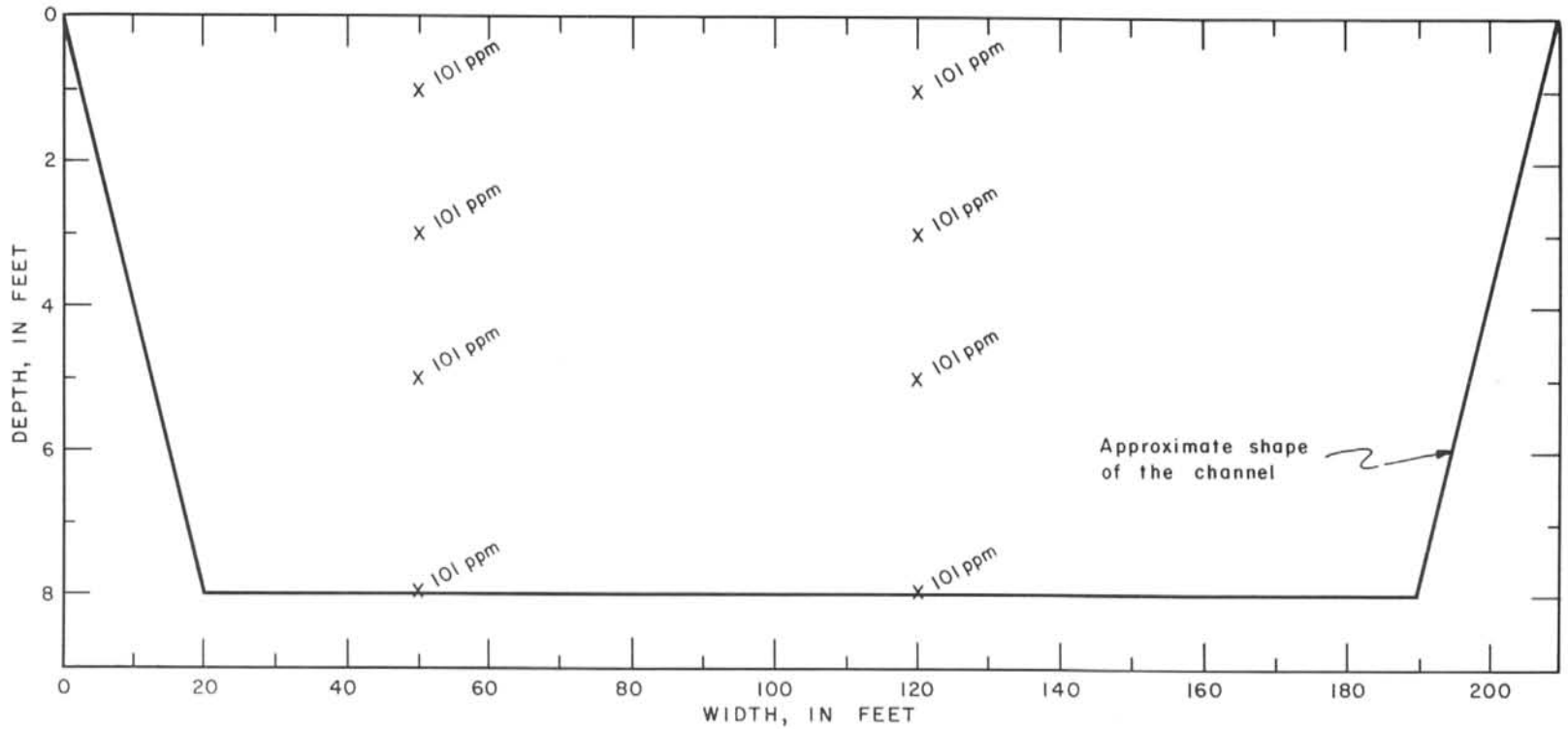

Figure 4

Cross Section Showing Chloride Concentrations, in Parts Per Million, in the Nueces River at Calallen Dam, August 31, 1963

U. S. Geological Survey in cooperation with the Texas Water Commission and the Lower Nueces River Water Supply District

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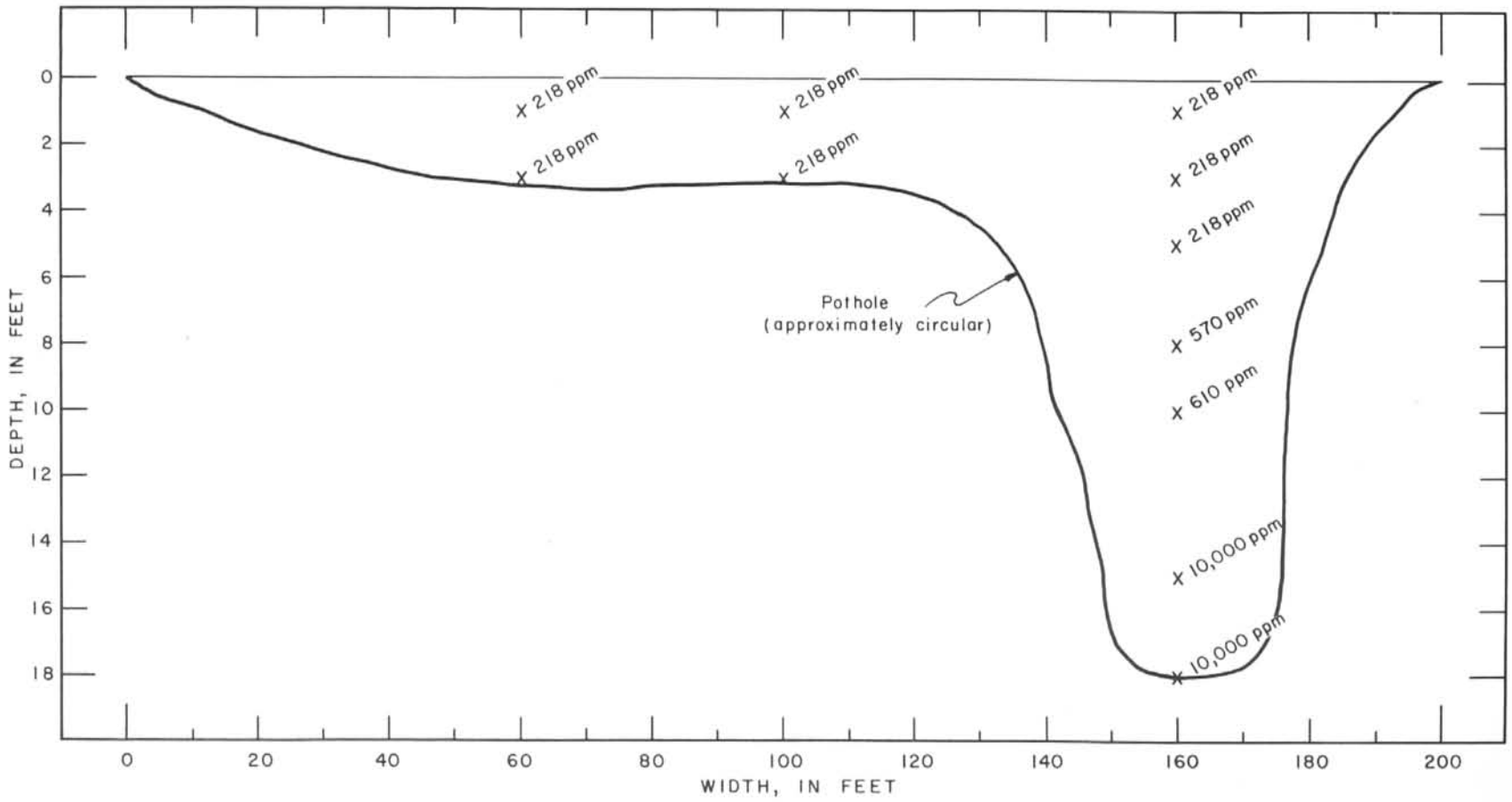

Figure 5

Cross Section Showing Chloride Concentrations, in Parts Per Million, in the Nueces River Below Calallen Dam, August 31, 1963

U.S. Geological Survey in cooperation with the Texas Water Commission and the Lower Nueces River Water Supply District

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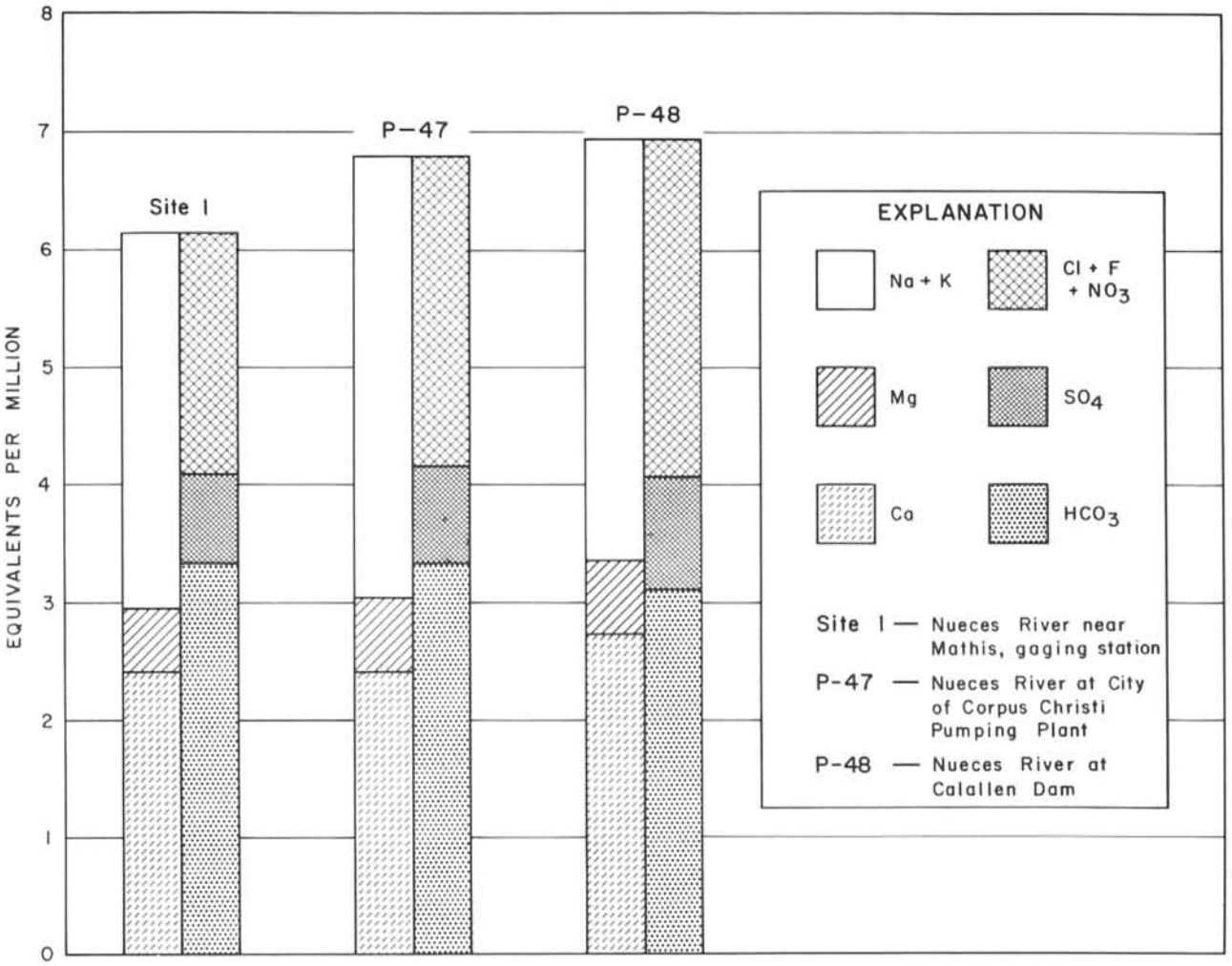

Figure 6

Chemical Analyses of Water of the Lower Nueces River, August 28-31, 1963

U.S. Geological Survey in cooperation with the Texas Water Commission and the Lower Nueces River Water Supply District

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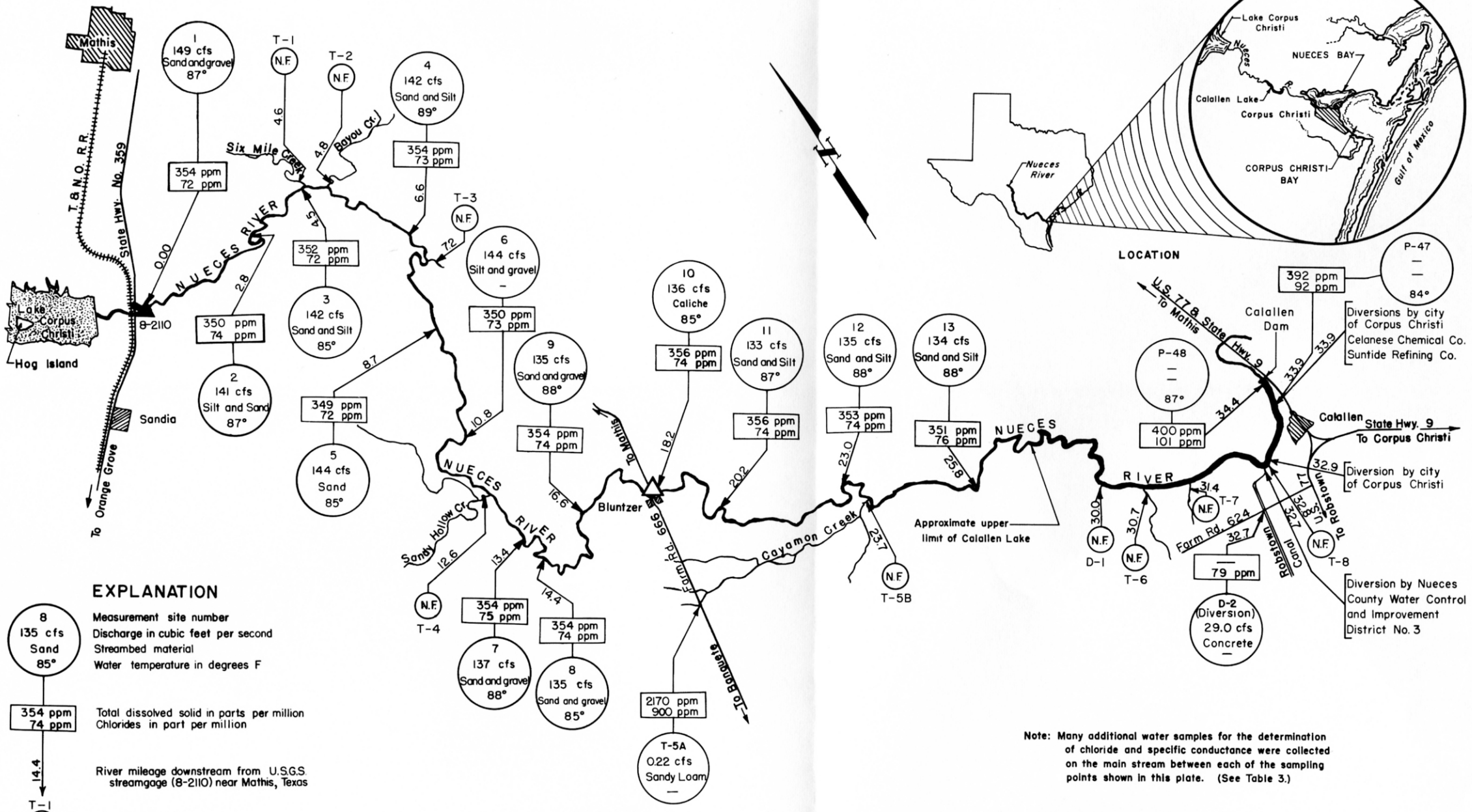

Plate 1

Map of Nueces River From Lake Corpus Christi to Calallen, Texas, Showing Locations of Discharge Measurements and Chemical-Quality Samples Obtained August 28-31, 1963

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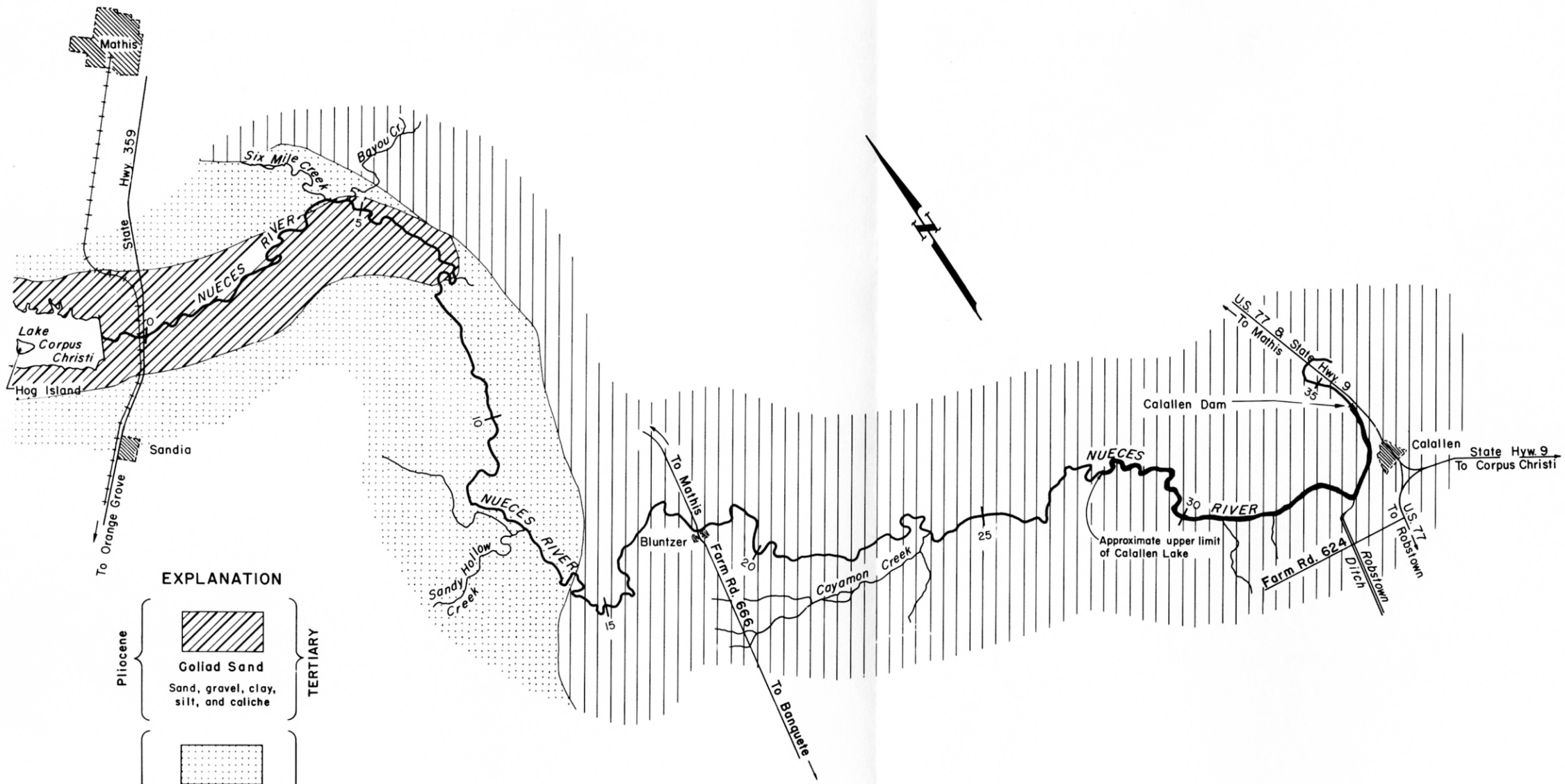
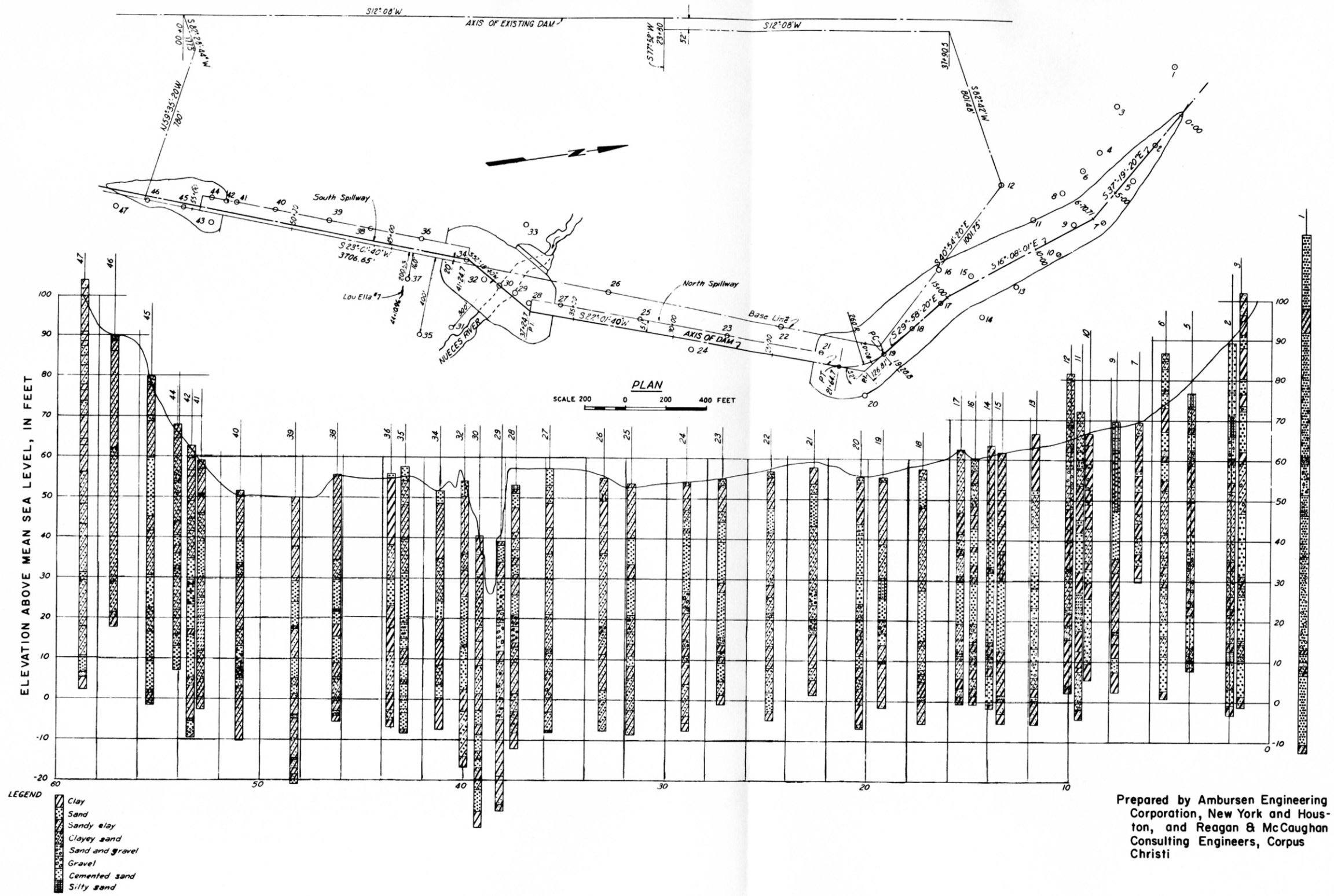


Plate 2

Geologic Map of Lower Nueces River

U.S. Geological Survey in cooperation with the Texas Water Commission and the Lower Nueces River Water Supply District



Prepared by Ambursen Engineering Corporation, New York and Houston, and Reagan & McCaughan Consulting Engineers, Corpus Christi

Plate 3

Cross Section of Nueces River Valley at Lake Corpus Christi

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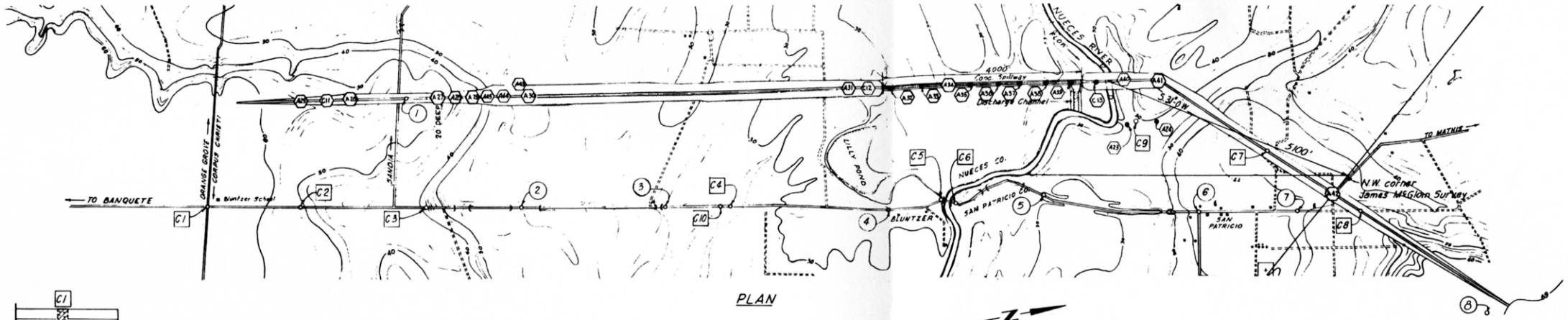
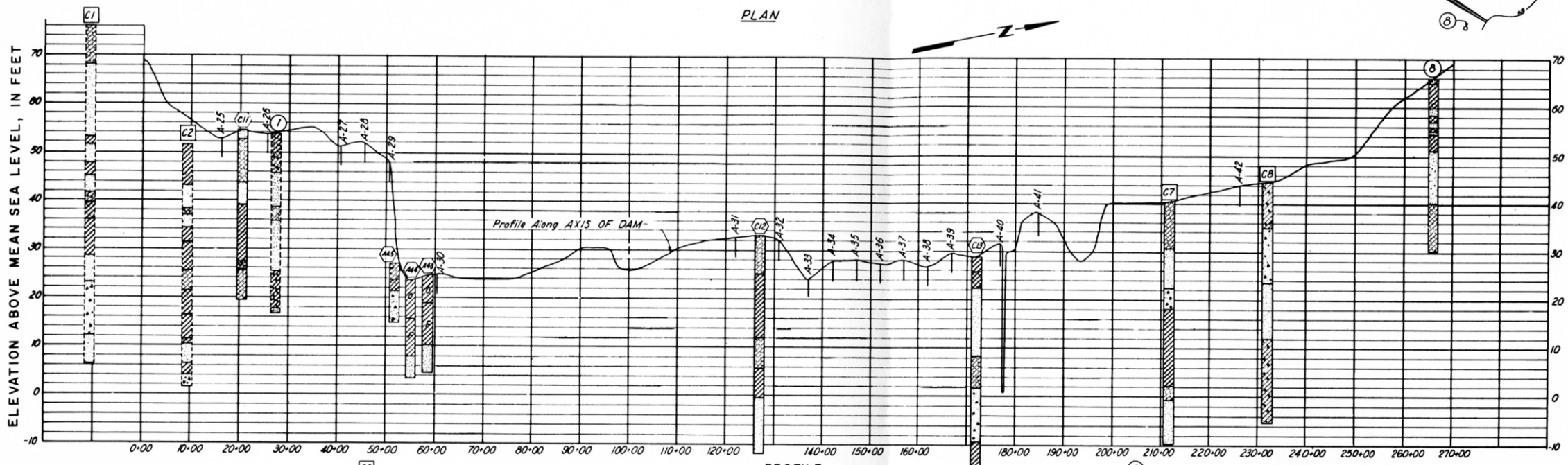
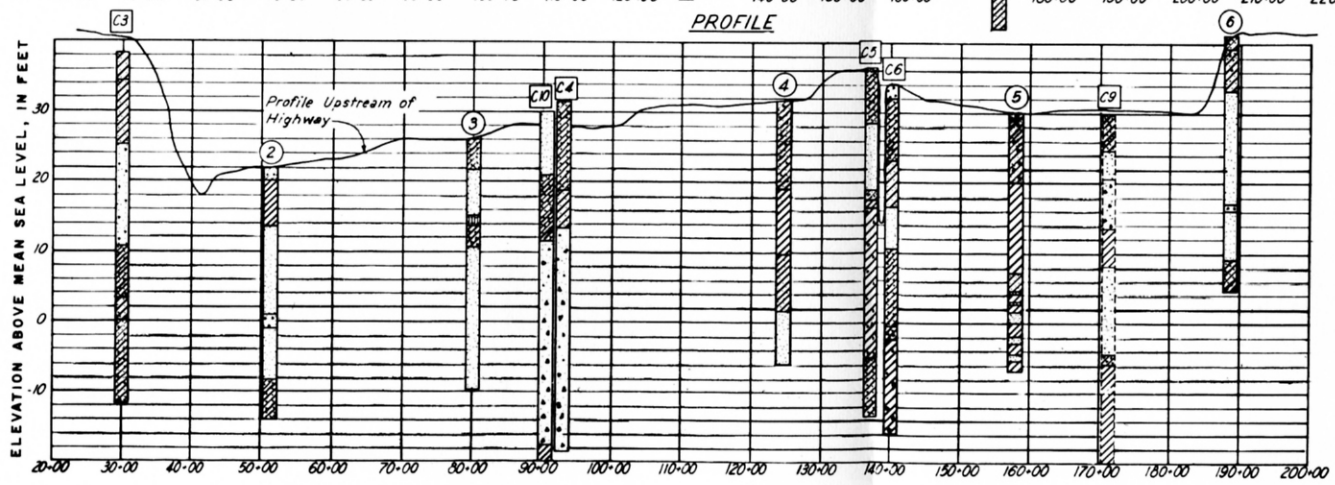


PLAN



PROFILE



F- Fat
O- Organic

Clay | Sand | Gravel

Sandy clay | Clayey sand | Sand and gravel

Clay and caliche | Silty sand | Sandy clay or clayey sand with gravel or caliche gravel

LEGEND

NOTES:

1. All core borings indicated thus ◯ were taken in February 1952 and all core borings indicated thus □ were taken in August 1954.
2. All auger and core borings indicated thus ⬡ were taken October 1954.
3. Logs of auger borings are tabulated in Appendix III of the Report.

SCALE 1000 0 1000 2000 FEET

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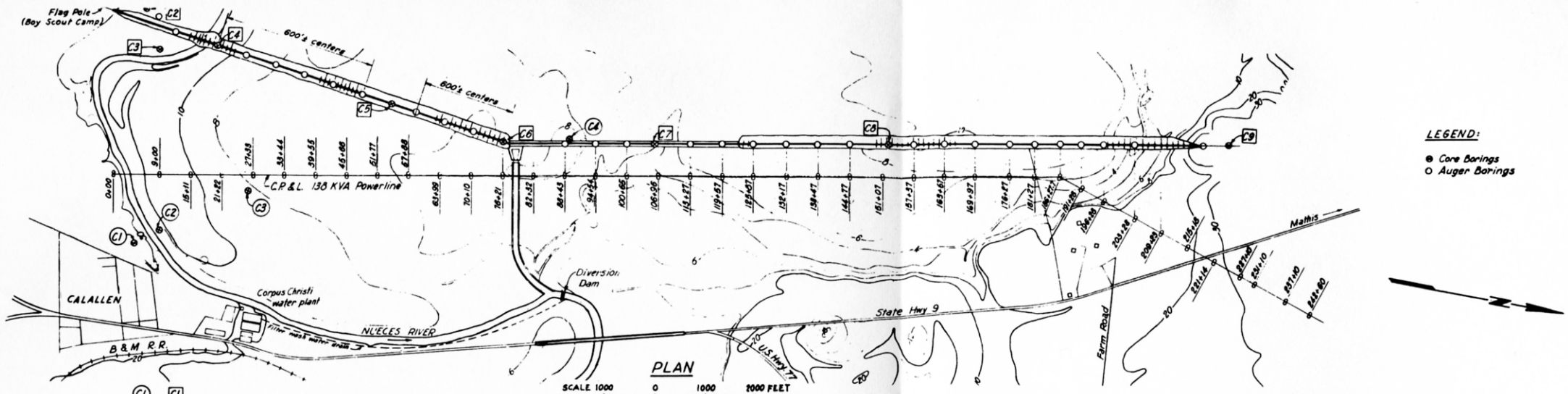
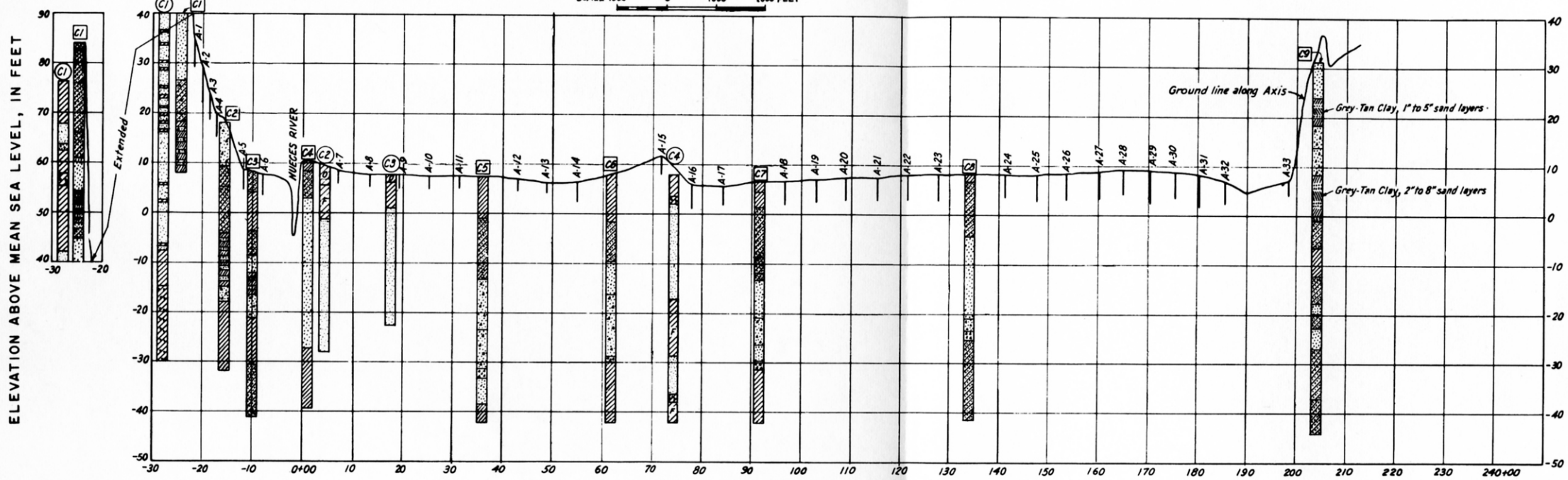
Plate 4

Cross Section of Nueces River Valley Near Bluntzer, Texas

U.S. Geological Survey in cooperation with the Texas Water Commission and the Lower Nueces River Water Supply District





"A" Indicates Auger Holes
"C" Indicates Core Holes

LEGEND

F-Fat O-Organic Clay
Sand
Gravel
Sandy clay
Clayey sand
Sand and gravel

NOTE:
1. All core borings indicated thus ◯ were taken in March 1952, and all core borings indicated thus □ were taken in August 1954.
2. All auger borings were taken in August 1954.
3. Logs of auger borings are tabulated in Appendix III of the Report.

Prepared by Ambursen Engineering Corporation, New York and Houston, and Reagan & McCaughan Consulting Engineers, Corpus Christi

Plate 5

Cross Section of Nueces River Valley Near Calallen, Texas

U.S. Geological Survey in cooperation with the Texas Water Commission and the Lower Nueces River Water Supply District