Memorandum Report No. 63-01

BRAZOS RIVER BASIN RESERVOIR STUDIES

PROGRESS REPORT, MAY 1962

Chemical Quality and Stratification of Belton, Whitney, and Possum Kingdom Reservoirs

By

H. B. Mendieta and
J. F. Blakey, Chemists
U. S. Geological Survey

Prepared by the U. S. Geological Survey
in cooperation with the Texas Water Commission
and the
Brazos River Authority

February 1963

TABLE OF CONTENTS

TABLES OF BASIC DATA

ILLUSTRATIONS

Plates

TABLE OF CONTENTS (Cont'd.)

BRAZOS RIVER BASIN RESERVOIR STUDIES

PROGRESS REPORT, MAY 1962

Chemical Quality and Stratification of Belton, Whitney, and Possum Kingdom Reservoirs

INTRODUCTION

The chemical quality of the water in the major reservoirs of the Brazos River Basin is being studied as a part of a basin-wide investigation by the U. S. Geological Survey in cooperation with the Brazos River Authority and the Texas Water Commission. Data obtained in the study will be applied to the problem of water-supply management and to the improvement of quality of water used for municipal and industrial supplies. The study began in September 1961 and will continue for three years, after which a final report will be prepared. This progress report gives the results of the reservoir studies made during the first 7 months of the program.

Reservoir studies in the basin will determine the dissolved-solids concentration at various locations and depths in the major reservoirs. Knowledge of the relation between dissolved-solids concentration and depth, during all seasons of the year, and under various conditions of stage, inflow, and discharge, will permit a better understanding of how density currents affect stratification and mixing of the reservoir water.

PREVIOUS INVESTIGATIONS

Evidence of stratification in Possum Kingdom Reservoir was noted in 1942 by W. W. Hastings while reviewing the chemical-quality data collected during the first 9 months of operation of the reservoir. Other investigators also have noted the evidence of stratification during the first year of operation. The serious effects of stratification in Possum Kingdom Reservoir were highlighted when the flood of 1957 failed to flush saline water having dissolved solids exceeding 1,000 parts per million from the bottom of the reservoir, even though the volume of flood water passing through the reservoir during 3 months of flood flow was more than three times the reservoir capacity. Though it is known that stratification existed in Possum Kingdom during the 1957 flood, there are no data indicating the thickness of the layer of saline water during the period of flood flow.

The ability to upgrade the quality of water in a reservoir by storing flood flows is severely curtailed when the saline water collected during low flows is not flushed out or is not mixed with the flood water.

A sampling program made by the U. S. Corps of Engineers (May to October 1956) showed stratification in Whitney Reservoir. Chloride concentrations were determined on samples taken from vertical profiles at the dam and at three stations upstream from the dam. Though this sampling was not sufficiently detailed to delineate the stratification, the changes in the patterns of layering and mixing could be determined.

At the time of the first monthly sampling in May 1956, the upper reaches of Whitney Reservoir held a large mass of good water (containing less than 250 parts per million of chloride). Chloride concentration of the water increased progressively toward the bottom and toward the dam. At the dam the maximum chloride concentration was 421 parts per million.

The June sampling showed that the saline water from the bottom of the reservoir had mixed with the water of better quality from the upper level, and for most of the reservoir the difference in the chloride concentration from top to bottom had decreased. At the same time a tongue of saline water from Possum Kingdom releases flowed along the bottom of the reservoir and slowly mixed with the water in storage.

In July the mixing of the saline inflow with the stored water was more pronounced. At this time the saline water advanced through the lake at an intermediate depth, between the upper and lower strata. In August the water in the deeper parts of the reservoir near the dam was completely mixed. A zone of water that was slightly more saline extended into the middle and upper reaches of the reservoir over the most saline water coming in from Possum Kingdom releases. By September the reservoir was almost completely mixed, and only in the extreme upper reaches was a slight stratification noticeable. The final sampling in October showed rather complete vertical mixing, and the upper reaches of the reservoir contained the best water.

The sampling in Whitney Reservoir during these months showed that stratification was extensive during some periods, that indistinct zones of salinity existed during other periods, and that almost complete mixing occurred at other times.

PRESENT STUDY

Methods of Investigation

The reservoir studies in the Brazos River Basin will consist of about nine conductivity and sampling surveys at Possum Kingdom and Whitney Reservoirs and about three at Waco, Proctor, and Belton Reservoirs during a 3-year period that began September 1, 1961. In addition, Waco, Proctor and Belton Reservoirs will be sampled four times each year, and releases from these reservoirs will be sampled also. Because the low-flow water entering Possum Kingdom and Whitney Reservoirs has a higher dissolved-solids concentration than most of the water in storage and, therefore, is more dense, stratification is expected to be more prevalent, and greater emphasis will be given to the study of these two reservoirs. Only minor stratification is expected at Waco, Proctor, and Belton Reservoirs because the dissolved-solids concentration of inflow water does not vary greatly from low to high flows. The sampling at these three reservoirs will give a more complete picture of the quality of the water available for blending in the lower Brazos River with the discharges from Possum Kingdom and Whitney Reservoirs.

Chemical analysis of selected water samples from vertical profiles provide the base for the study, and specific-conductance determinations are used to estimate the changes in water quality. Specific-conductance measurements are correlated with the chloride concentrations determined from samples collected during the survey. The chloride concentrations are used as an index of the dissolved-solids concentration because chloride is the main constituent of basin waters. Many of the load data for the basin are based on the chloride content.

The measurement of conductance and temperature through vertical profiles of reservoirs requires special equipment. A Solu-Bridge direct-reading conductivity meter with two conductivity cells and a thermistor thermometer on a 150-foot conductor cable was selected for the studies because of its portability and because of the speed with which the readings can be made (Plate 1A). The instrument compensates automatically for the effect of temperature variation on conductance. An additional thermistor thermometer probe is attached to the side of the conductivity cell for simultaneous temperature readings (Plate 1B). The thermistor probe has a very low constant or temperature lag, and readings may be made within a few seconds.

Water samples at selected depths in each vertical profile are collected with a Foerst sampler (Plate 2A). The Foerst sampler consists of a brass cylinder with rubber stoppers at both ends for trapping a sample. To obtain a sample after lowering the instrument to any desired depth, a brass weight or messenger is sent down the cable. The messenger activates a spring and the rubber stoppers cover the openings at the ends of the cylinder.

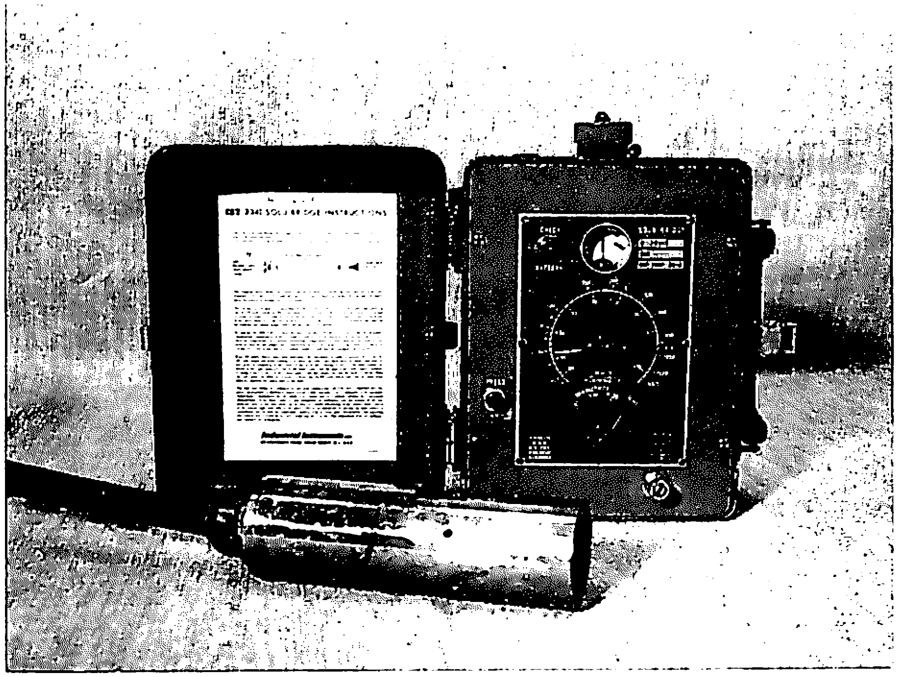
Cross bearings to landmarks in the area of each sampling station are used to relocate the points accurately and quickly. The deepest point along each sampling traverse, usually the old river channel, is located with the assistance of a light-weight transistorized depth sounder (Plate 2B).

Three classes of sampling stations are used: (1) stations that are aligned across the reservoir to determine the transverse as well as vertical salinity profiles, (2) intermediate sampling stations along the deepest part of the reservoir, and (3) stations on the principal tributaries.

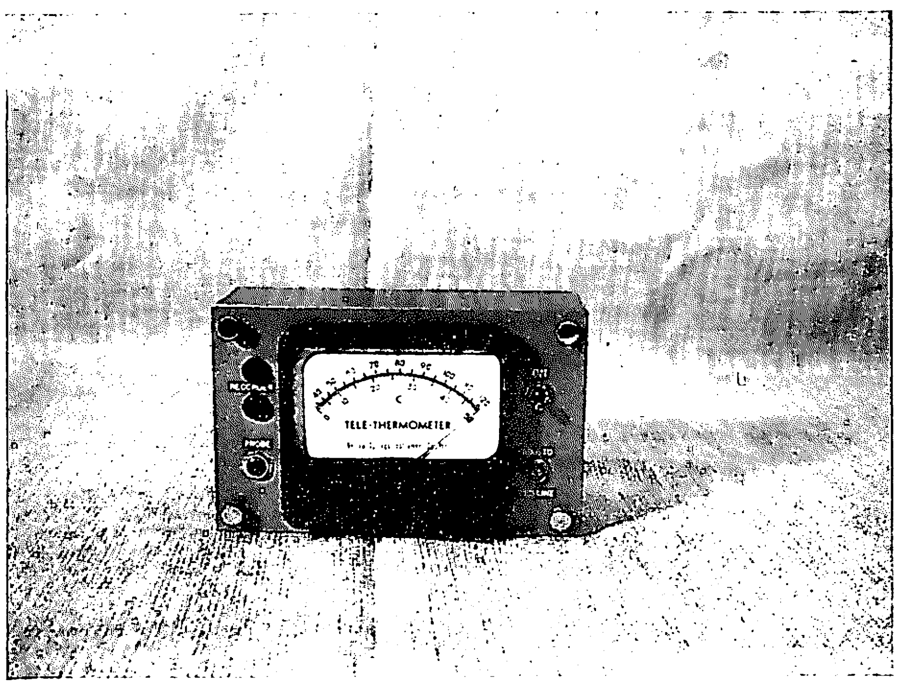
Belton Reservoir

The study on Belton Reservoir was made on October 25, 1961. On this date the reservoir had 211,000 acre-feet in storage at reservoir stage of 569 feet above mean sea level. Measurements were made through two or three vertical profiles along each of seven sampling traverses. Specific conductance and temperature determinations and the calculated chloride concentrations at all stations are tabulated in Table 1. Locations of the sampling points on Belton Reservoir are shown in Plate 3, and a longitudinal profile showing chloride concentrations is given in Plate 4.

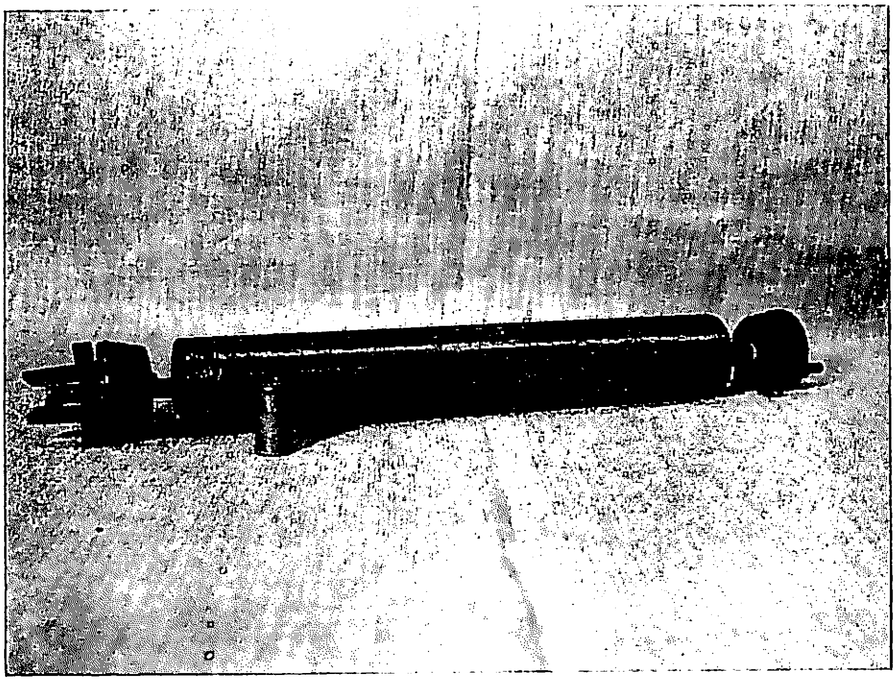
All conductance determinations and all the analyses of samples collected during the study indicated that the water was of excellent quality. Specific conductances ranged from 250 to 425 micromhos and water temperature ranged from 67.0 to 72.0°F. Chloride concentrations, calculated from the relation of specific conductance to chloride of samples taken during the study, ranged from 13 to 36 parts per million. The study showed that the water in the Cowhouse Creek arm of the reservoir contained higher concentrations of dissolved solids than the water in the Leon River arm. The chloride concentrations in Cowhouse Creek arm of the reservoir were about double those in the Leon River arm. The concentrations in the vertical profile at each sampling point were almost uniform except at line of sampling E, where the more concentrated water from Cowhouse



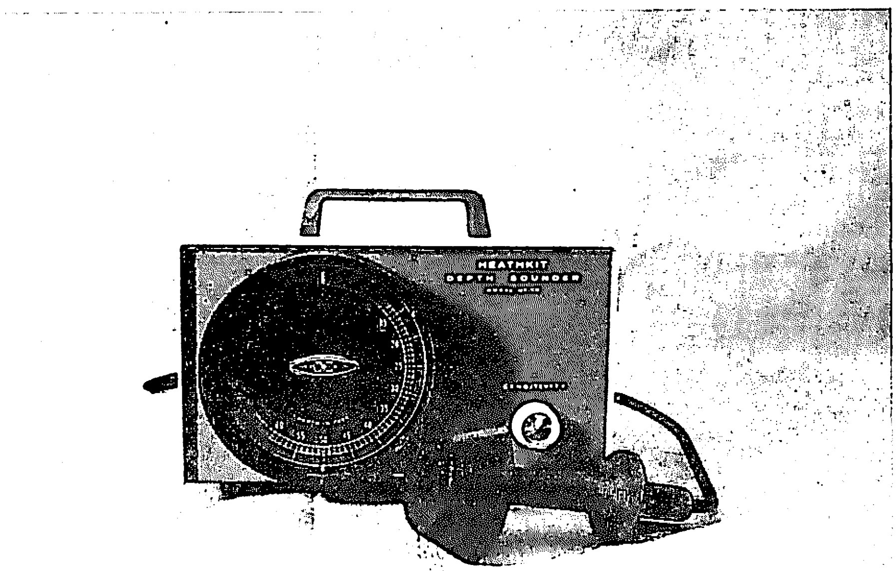
A. SOLU-BRIDGE DIRECT-READING CONDUCTIVITY METER AND CONDUCTIVITY CELL CASE WITH TWO CONDUCTIVITY CELLS AND TWO THERMISTOR TEMPERATURE PROBES



B. THERMISTOR TEMPERATURE RECORDER



A. FOERST DEPTH SAMPLER



B. SONIC DEPTH SOUNDER

Creek was overrunning the Leon River water, and at line of sampling G on the Leon River, where the more concentrated water was at the bottom. The temperature differential at all vertical profiles was 2°F or less except for the upper two traverses on the Leon River arm, where it was 2.5°F at line of sampling F and 4°F at line of sampling G.

The data for this single series indicate that stratification in Belton Reservoir is not likely to be a serious quality-of-water problem because all the reservoir water was of excellent quality.

Whitney Reservoir

A salinity survey of Whitney Reservoir was made on November 8-9, 1961, to determine the chemical quality and extent of stratification of the lake water during autumn. A second survey was made on March 6, 1962, at the end of the winter season when the reservoir water was coldest and maximum mixing could be expected. At the time of the first survey the reservoir had 387,000 acre-feet in storage at reservoir elevation of 520 feet above mean sea level, and for the second survey the storage was 372,000 acre-feet at elevation of 519 feet.

Specific conductance and temperature profiles were run at stations along three traverses of the reservoir, at seven other stations along the river channel, and at seven stations on tributary channels (Plate 5). These data and the calculated chloride concentrations at all stations are tabulated in Table 2. A longitudinal profile of the reservoir showing chloride concentrations (November 8 and 9, 1961) is given in Plate 6.

Specific conductances and analyses of selected samples show that most of the reservoir water was saline (containing more than 1,000 ppm dissolved solids). The water that was not saline was of only fair quality. Specific conductance ranged from 1,150 micromhos in the Nolands River channel to 2,390 micromhos near the dam. Chloride concentrations, calculated from the relation of specific conductance to chloride of samples taken during the study, ranged from 187 to 522 ppm. Temperatures ranged from 54.5 to 63.0°F. Temperature differentials at most stations were less than 1°F, and the maximum temperature difference for a single station was only 2.5°F.

Distinct stratification of the reservoir was not evident during this study except for a minor amount at line of sampling B, a transition zone where some mixing of water was occurring, and at P-12, in the Nolands River channel, where the more dilute river water was overrunning the reservoir water. Though there was no distinct stratification, there was considerable difference in the quality of the water in different areas of the reservoir, and the zones were fairly well defined. A zone extending from the dam to about 5 miles upstream had the most concentrated water with the chloride concentration in excess of 500 ppm. At the next two main channel stations upstream the chloride concentration ranged from 458 to 487 ppm. The upstream station had the lower concentration. At station P-6, 14.8 river miles upstream from the dam, the chloride concentration ranged from 364 to 368 ppm, the lowest along the main channel (Plate 6). Then the decreasing trend of chloride concentration reversed, and the chloride concentrations at the three uppermost stations increased to more than 400 ppm.

The quality of water in Whitney Reservoir during the late winter series of measurements on March 6, 1962, was characterized by its uniformity. Specific conductances, temperatures, and calculated chloride concentrations for all stations are tabulated in Table 3. The longitudinal profile of the reservoir showing chloride concentrations (March 6, 1962) is given in Plate 7.

At most stations the chloride concentration in the vertical profiles was virtually constant. At the three uppermost stations, the only stations along the main channel with any distinct stratification, the differences in concentration were minor. Concentrations at these three stations were similar to those in November 1961.

The water being discharged from the reservoir in March 1962 was less saline than that being discharged during November 1961. The decreased salinity of the outflow was the result of the almost complete mixing of the more concentrated water (specific conductance, 2,330 micromhos) found near the dam in November with the less concentrated water (specific conductance, 1,450 micromhos) from the middle reach of the reservoir.

Specific conductances determined in the field in March 1962 ranged from 1,750 to 2,250 micromhos. Chloride concentrations, calculated from the relation of specific conductance to chloride of samples taken during the study, ranged from 368 to 494 ppm. Temperatures ranged from 51.0 to 56.5°F. Temperature differentials at most stations were less than 2°F, and the maximum temperature difference at a single station was 3°F.

Possum Kingdom Reservoir

The study on Possum Kingdom Reservoir was made on March 8-10, 1962. During this period the storage in the reservoir was 548,000 acre-feet at reservoir elevation of 990 feet above mean sea level. Vertical profiles were run on 2 traverses of the reservoir, 15 stations on the river channel, and 6 additional stations on tributary channels (Plate 8). Specific conductances, temperatures, and the calculated chloride concentrations at all stations are tabulated in Table 4 and a longitudinal profile showing the chloride concentrations at stations on the old channel is shown in Plate 9.

All the water in the reservoir was found to be saline. Specific conductances ranged from 2,200 to 6,000 micromhos. Chloride concentrations, calculated from the relation of specific conductance to chloride of samples taken during the study, ranged from 470 to 1,680 ppm. The temperature ranged from 44 to 59.5°F, but only in the areas of deepest water did the temperature differential in a single vertical profile reach 4°F. Usually the differential from top to bottom at a station was less than 2°F.

The study showed that most of the stratification occurred near the dam, but at all stations, except the inflow stations in the upper reaches, salinity was greatest near the bottom. The inflow water was much more concentrated than the stored water, but mixing in the reservoir was rapid and uniform. In general, the upper 50 feet of water of the lake was uniform in quality.

TABLES OF BASIC DATA

Table 1.--Belton Reservoir sampling studies, October 25, 1961

Depth (ft.)	Temperature (°F)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
Sampling Point A-1			
3	71.0	410	34
10	71.0	410	34
20	71.0	410	34
30	71.0	410	34
40	71.0	410	34
50	70.5	410	34
60	70.5	410	34
70	70.5	410	34
Sampling Point A-2			
3	71.0	410	34
10	71.0	410	34
20	71.0	410	34
30	71.0	410	34
50	70.5	410	34
60	70.5	410	34
65	70.5	410	* 36
Sampling Point A-3			
3	71.0	410	34
10	71.0	410	34
20	71.0	410	34
30	71.0	410	34
50	70.5	410	34
70	71.0	410	34
75	71.0	425	36
80	71.0	425	* 36
Sampling Point B-1			
3	72.0	410	34
10	72.0	410	34
20	71.5	410	34
30	71.5	410	34
40	71.5	410	34
50	71.5	410	34
Sampling Point B-2			
3	72.0	410	34
10	72.0	420	35
20	72.0	420	35

* Laboratory analysis.

Table 1.--Belton Reservoir sampling studies, October 25, 1961--Continued

Depth (ft.)	Temperature (°F)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
Sampling Point B-3			
3	72.0	410	34
10	72.0	410	34
20	72.0	410	34
Sampling Point C-1			
3	71.5	400	33
10	71.5	400	33
20	71.5	400	33
25	71.5	400	33
30	71.5	400	33
34	71.5	400	33
Sampling Point C-2			
3	71.5	400	33
10	71.5	400	33
20	71.0	400	33
30	71.0	400	33
40	70.0	390	32
50	69.5	385	31
60	69.5	385	31
Sampling Point C-3			
3	71.5	400	33
10	71.5	400	33
20	71.5	400	33
30	71.0	400	33
Sampling Point D-1			
3	71.5	400	33
10	71.0	400	33
15	71.0	400	33
20	71.0	400	33
Sampling Point D-2			
3	71.0	400	33
10	71.0	400	33
20	71.0	400	33
30	71.0	395	32
40	69.5	400	33

Table 1.--Belton Reservoir sampling studies, October 25, 1961--Continued

Depth (ft.)	Temperature (F°)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
Sampling Point D-3			
3	71.5	400	33
10	71.5	400	33
15	71.5	400	33
Sampling Point E-1			
3	71.5	360	* 28
10	71.0	360	28
20	71.0	360	28
25	70.5	310	19
30	70.0	280	16
40	69.0	250	13
Sampling Point E-2			
3	71.0	360	28
10	71.0	360	28
20	70.5	310	19
30	70.0	270	15
40	70.0	250	13
50	69.5	250	13
60	69.5	250	* 13
70	69.5	250	13
80	69.5	250	13
Sampling Point F-1			
3	71.0	295	17
10	71.0	295	17
20	71.0	295	17
30	69.5	275	15
40	68.0	295	17
50	67.5	295	17
Sampling Point F-2			
3	71.0	295	17
10	71.0	295	17
15	70.5	295	17
Sampling Point G-1			
3	71.0	250	13
10	71.0	250	13
15	71.0	260	14
22	71.0	320	20

* Laboratory analysis.

Table 1.--Belton Reservoir sampling studies, October 25, 1961--Continued

Depth (ft.)	Temperature (°F)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
Sampling Point G-2			
3	71.0	260	14
10	70.5	260	14
20	70.0	280	16
25	68.0	320	20
30	67.5	320	20
35	67.0	325	20
40	67.0	330	21

Table 2.--Whitney Reservoir sampling studies, November 8-9, 1961

Depth (ft.)	Temperature (°F)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
Sampling Point A-1			
3	62.0	2,330	*518
10	61.5	2,330	518
20	61.5	2,330	518
30	61.5	2,330	518
40	61.5	2,330	518
50	61.5	2,330	518
60	61.5	2,330	518
70	61.0	2,330	518
80	60.5	2,330	*518
90	60.5	2,330	518
Sampling Point A-2			
3	62.0	2,330	518
10	62.0	2,330	518
20	62.0	2,330	518
30	62.0	2,330	518
35	62.0	2,330	518
Sampling Point A-3			
3	62.0	2,330	518
10	62.0	2,330	518
20	62.0	2,330	518
24	62.0	2,330	518
Sampling Point B-1			
3	62.0	2,330	518
10	62.0	2,330	518
20	62.0	2,330	518
25	62.0	2,330	518
Sampling Point B-2			
3	62.0	2,330	518
10	62.0	2,330	518
20	62.0	2,330	518
30	62.0	2,330	518
32	61.5	2,330	518
Sampling Point B-3			
3	63.0	2,330	518
10	63.0	2,330	518

(Continued on next page)

* Laboratory analysis.

Table 2.--Whitney Reservoir sampling studies, November 8-9, 1961--Continued

Depth (ft.)	Temperature (°F)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
	Sampling Point B-3--Continued		
20	63.0	2,330	518
30	63.0	2,330	518
40	63.0	2,330	518
50	63.0	2,330	518
60	63.0	2,330	518
70	61.5	2,330	518
80	61.5	2,220	478
90	61.5	2,220	478
	Sampling Point P-1		
3	62.0	2,330	518
10	62.0	2,300	500
20	62.0	2,300	500
30	61.5	2,300	500
40	61.5	2,300	500
50	61.5	2,300	500
60	61.5	2,300	500
	Sampling Point C-1		
3	61.5	2,250	487
10	61.5	2,230	482
20	61.0	2,230	482
30	61.0	2,230	482
32	61.0	2,230	482
	Sampling Point C-2		
3	61.5	2,250	487
10	61.5	2,250	487
20	61.5	2,250	487
30	61.0	2,250	487
40	61.0	2,250	487
50	60.5	2,250	487
60	60.5	2,250	487
67	60.5	2,200	473
	Sampling Point P-3		
3	61.0	2,120	*458
10	61.0	2,120	458
20	61.0	2,120	458
30	61.0	2,120	458
40	61.0	2,120	458
50	60.5	2,120	458
60	60.5	2,120	458
70	60.5	2,120	458

* Laboratory analysis.

Table 2.--Whitney Reservoir sampling studies, November 8-9, 1961--Continued

Depth (ft.)	Temperature (°F)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
Sampling Point P-5			
3	60.5	2,100	446
10	60.5	2,050	432
17	60.0	2,050	432
Sampling Point P-6			
3	60.0	1,820	368
10	60.0	1,820	368
20	60.0	1,820	368
30	60.0	1,820	368
40	59.5	1,800	364
50	59.5	1,800	364
60	59.5	1,800	364
Sampling Point P-7			
3	60.0	1,800	364
10	59.5	1,800	364
15	59.5	1,800	364
Sampling Point P-8			
3	58.0	1,250	214
10	56.5	1,200	200
15	56.0	1,210	203
20	56.0	1,280	222
Sampling Point F-1			
2	61.0	1,460	272
Sampling Point F-2			
3	60.5	1,450	269
10	60.0	1,450	269
20	59.0	1,480	277
25	59.0	1,490	280
30	58.5	1,490	280
35	58.5	1,490	280
40	58.5	1,500	282
44	58.5	1,500	282
Sampling Point P-10			
3	58.0	1,450	269
8	58.0	1,450	269
12	58.0	1,450	269

Table 2.--Whitney Reservoir sampling studies, November 8-9, 1961--Continued

Depth (ft.)	Temperature (°F)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
Sampling Point P-11			
3	60.5	2,190	*460
10	60.5	2,190	460
15	60.0	2,190	460
20	60.0	2,190	460
21	60.0	2,190	460
Sampling Point P-12			
3	58.0	1,160	*190
5	58.0	1,200	200
6	58.5	1,400	255
7	59.5	2,000	418
8	60.0	2,100	445
10	60.0	2,100	445
15	60.0	2,100	445
16	60.0	2,100	445
Sampling Point P-13			
3	58.0	2,200	473
10	58.0	2,200	473
15	56.0	2,200	473
20	56.0	2,200	473
25	55.5	2,200	473
28	55.5	2,200	473
Sampling Point P-14			
3	55.5	2,200	473
5	55.5	2,200	473
10	55.5	2,200	473
15	55.0	2,200	473
20	54.5	2,200	473
21	54.5	2,200	473

* Laboratory analysis.

Table 3.--Whitney Reservoir sampling studies, March 6, 1962

Depth (ft.)	Temperature (°F)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
Sampling Point A-1			
3	56.0	1,900	*395
10	55.0	1,900	395
20	54.5	1,900	395
30	54.5	1,900	395
40	54.5	1,900	395
50	54.5	1,900	395
60	54.5	1,900	395
70	54.5	1,900	395
80	54.5	1,900	395
90	54.5	1,900	*395
Sampling Point A-2			
3	56.0	1,900	395
10	55.0	1,900	395
20	54.5	1,900	395
30	54.5	1,900	395
35	54.5	1,900	395
Sampling Point A-3			
3	56.5	1,750	356
10	54.5	1,800	368
20	54.5	1,850	380
25	54.5	1,850	380
Sampling Point B-3			
3	55.5	1,900	395
10	54.5	1,900	395
20	54.5	1,900	395
30	54.0	1,900	395
40	54.0	1,900	395
50	54.0	1,900	395
60	54.0	1,900	395
70	54.0	1,900	395
80	54.0	1,900	395
84	54.0	1,900	395
Sampling Point B-2			
3	55	1,900	395
10	54.5	1,900	395
20	54.0	1,900	395
30	54.0	1,900	395
37	54.0	1,900	395

* Laboratory analysis.

Table 3.--Whitney Reservoir sampling studies, March 6, 1962--Continued

Depth (ft.)	Temperature (°F)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
Sampling Point B-1			
3	55.5	1,900	395
10	54.0	1,900	395
20	54.0	1,900	395
24	54.0	1,900	395
Sampling Point P-1			
3	55.0	1,900	395
10	54.0	1,900	395
20	53.5	1,900	395
30	53.5	1,900	395
40	53.0	1,900	395
50	53.5	1,900	395
57	53.5	1,900	395
Sampling Point C-1			
3	54.5	1,880	*390
10	54.0	1,880	390
20	54.0	1,880	390
31	54.0	1,880	390
Sampling Point C-2			
3	54.5	1,890	390
10	54.5	1,890	390
20	54.0	1,890	390
30	54.0	1,890	390
40	53.5	1,890	390
50	53.5	1,890	390
60	53.5	1,890	390
70	53.5	1,890	390
76	53.0	1,880	*392
Sampling Point C-3			
3	54.5	1,890	390
10	54.0	1,890	390
18	54.0	1,890	390
Sampling Point P-2			
3	55.0	1,890	390
10	54.0	1,890	390

(Continued on next page)

* Laboratory analysis.

Table 3.--Whitney Reservoir sampling studies, March 6, 1962--Continued

Depth (ft.)	Temperature (°F)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
	Sampling Point P-2--Continued		
20	53.5	1,890	390
30	53.0	1,890	390
40	53.0	1,890	390
50	53.0	1,890	390
52	53.0	1,890	390
	Sampling Point P-3		
3	54.5	1,890	390
10	54.0	1,890	390
20	53.0	1,890	390
30	53.0	1,890	390
40	53.0	1,890	390
50	53.0	1,890	390
60	53.0	1,890	390
70	53.0	1,890	390
	Sampling Point P-4		
3	54.5	1,820	370
10	54.0	1,820	370
20	53.5	1,820	370
30	53.5	1,820	370
36	53.5	1,820	370
	Sampling Point P-5		
3	55.5	1,800	*368
10	53.5	1,810	368
21	53.0	1,820	370
	Sampling Point D-1		
3	54.0	1,850	380
10	52.0	1,850	380
12	51.0	1,850	380
	Sampling Point D-2		
3	54.0	1,850	380
10	53.0	1,850	380
20	51.0	1,850	380
30	51.0	1,850	380
40	51.0	1,850	380
50	51.0	1,850	380
54	51.0	1,850	380

* Laboratory analysis.

Table 3.--Whitney Reservoir sampling studies, March 6, 1962--Continued

Depth (ft.)	Temperature (°F)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
Sampling Point D-3			
3	54.0	1,880	388
10	52.5	1,880	388
20	52.0	1,880	388
22	52.0	1,880	388
Sampling Point P-6			
3	55.0	1,850	380
10	54.0	1,850	380
20	52.0	1,850	380
30	52.0	1,850	380
40	52.0	1,850	380
50	52.0	1,850	380
60	52.0	1,850	380
62	52.0	1,850	380
Sampling Point P-7			
3	54.5	1,850	380
10	53.5	1,850	380
20	53.0	1,820	370
26	53.0	1,820	370
Sampling Point E-1			
3	53.0	1,880	388
10	52.0	1,880	388
20	52.0	1,880	388
30	52.0	1,880	388
32	52.0	1,880	388
Sampling Point F-2			
3	55.0	1,850	*372
10	54.5	1,850	372
20	54.0	1,850	372
30	52.0	1,850	372
40	52.0	1,850	372
44	51.0	1,850	372
Sampling Point P-10			
3	55.0	1,850	372
10	53.5	1,870	375
13	53.5	1,870	375

* Laboratory analysis.

Table 3.--Whitney Reservoir sampling studies, March 6, 1962--Continued

Depth (ft.)	Temperature (°F)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
Sampling Point P-11			
3	53.0	2,050	436
10	53.0	2,100	450
15	53.5	2,200	470
20	52.0	2,250	480
22	52.0	2,250	480
Sampling Point P-12			
3	53.5	1,900	394
8	53.5	2,150	466
10	53.5	2,150	466
15	53.5	2,200	470
18	53.5	2,250	480
Sampling Point P-13			
3	54.5	2,050	436
10	54.0	2,100	450
15	54.0	2,150	466
20	54.0	2,150	466
29	54.0	2,200	470
Sampling Point P-14			
3	53.5	2,270	*480
10	53.0	2,270	480
20	53.0	2,270	480

* Laboratory analysis.

Table 4.--Possum Kingdom Reservoir sampling studies, March 8-10, 1962

Depth (ft.)	Temperature (°F)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
Sampling Point A-1			
3	49.0	2,350	520
10	49.0	2,350	520
20	49.0	2,350	520
30	49.0	2,350	520
40	49.0	2,350	520
50	49.0	2,400	530
60	49.0	2,400	530
Sampling Point A-2			
3	49.0	2,350	*520
10	49.0	2,350	520
20	49.0	2,350	520
30	49.0	2,390	520
40	48.5	2,400	530
50	48.5	2,400	530
60	48.0	2,400	530
64	47.0	--	--
65	46.0	--	--
70	45.0	2,600	620
80	45.0	2,700	630
90	45.0	3,100	760
100	45.0	3,000	730
110	45.0	3,050	*740
Sampling Point P-1			
3	48.5	2,300	500
10	48.5	2,300	500
20	48.5	2,350	520
30	48.5	2,400	530
40	48.0	2,400	530
50	48.0	2,400	530
60	46.5	2,400	530
70	46.5	2,450	550
73	46.0	--	--
80	44.0	2,600	620
90	44.0	3,000	730
Sampling Point B-3			
3	49.0	2,300	500
10	48.5	2,300	500
20	48.5	2,350	520

(Continued on next page)

* Laboratory analysis.

Table 4.--Possum Kingdom Reservoir sampling studies, March 8-10, 1962--Continued

Depth (ft.)	Temperature (°F)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
Sampling Point B-3--Continued			
30	48.5	2,350	520
40	48.5	2,350	520
50	48.5	2,350	520
60	48.0	2,350	520
70	46.0	2,500	560
80	45.0	2,800	660
90	45	2,900	690
Sampling Point P-2			
3	49.5	2,300	500
10	49.5	2,300	500
20	49.5	2,300	500
30	49.0	2,300	500
40	48.0	2,300	500
50	48.0	2,300	500
60	48.0	2,300	500
70	47.0	2,400	530
75	47.0	2,500	560
80	46.0	2,600	620
Sampling Point P-3			
3	50.0	2,300	500
10	49.0	2,300	500
20	49.0	2,300	500
30	49.0	2,300	500
40	49.0	2,300	500
42	49.0	2,300	500
Sampling Point P-4			
3	50.0	2,300	500
10	50.0	2,300	500
20	49.5	2,300	500
30	49.0	2,300	500
40	48.0	2,300	500
50	47.0	2,300	500
60	46.0	2,300	500
70	46.0	2,500	560
74	46.0	2,500	560

Table 4.--Possum Kingdom Reservoir sampling studies, March 8-10, 1962--Continued

Depth (ft.)	Temperature (°F)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
Sampling Point C-1			
3	49.0	2,300	*500
10	49.0	2,300	500
20	49.0	2,300	500
30	48.0	2,300	500
40	47 5	2,300	500
50	47.0	2,300	500
60	47.0	2,400	530
69	47.0	2,450	550
Sampling Point P-5			
3	51.0	2,250	480
10	50.0	2,250	480
15	50.0	2,250	480
Sampling Point P-6			
3	50.0	2,300	500
10	49.0	2,300	500
20	49.0	2,300	500
30	49.0	2,300	500
40	48.0	2,300	500
50	48.0	2,400	530
60	48.0	2,500	560
63	48.0	2,900	690
Sampling Point P-7			
3	50.0	2,200	470
10	50.0	2,200	470
20	50.0	2,200	470
30	49.5	2,200	470
40	49.5	2,200	470
Sampling Point D-1			
3	50.0	2,300	500
10	50.0	2,300	500
20	50.0	2,300	500
30	49.0	2,300	500
40	49.0	2,300	500
50	49.0	2,300	500
60	48.0	2,500	560

* Laboratory analysis.

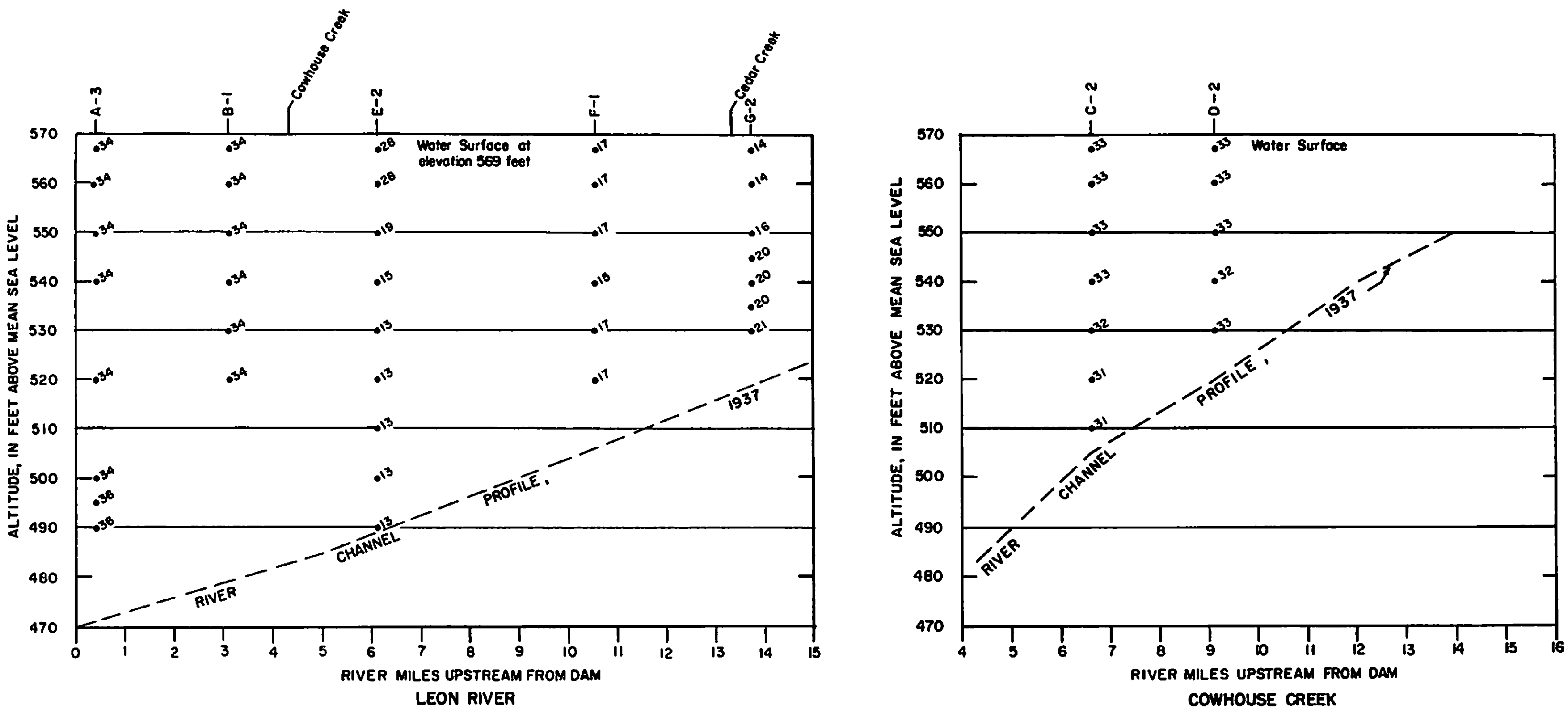
Table 4.--Possum Kingdom Reservoir sampling studies, March 8-10, 1962--Continued

Depth (ft.)	Temperature (°F)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
Sampling Point D-2			
3	50.0	2,300	500
10	50.0	2,300	500
20	50.0	2,300	500
30	49.0	2,300	500
40	49.0	2,300	500
50	48.0	2,350	520
57	47.5	2,500	560
Sampling Point P-8			
3	50.0	2,300	500
10	50.0	2,300	500
20	49.0	2,300	500
30	49.0	2,300	500
40	48.0	2,350	520
50	48.0	2,450	530
53	48.0	2,700	630
56	48.0	2,950	710
Sampling Point E-3			
3	50.0	2,350	520
10	49.5	2,350	520
20	49.5	2,350	520
30	49.5	2,350	520
40	49.5	2,400	520
50	49.0	2,650	610
Sampling Point F-2			
3	51.0	2,400	530
10	50.5	2,400	530
20	50.0	2,400	530
30	49.5	2,400	530
40	49.5	2,500	560
41	49.5	2,500	560
Sampling Point G-2			
3	52.0	2,450	550
10	51.0	2,450	550
20	50.5	2,450	550
30	50.5	2,600	620
32	50.0	2,650	610
34	50.0	2,700	630

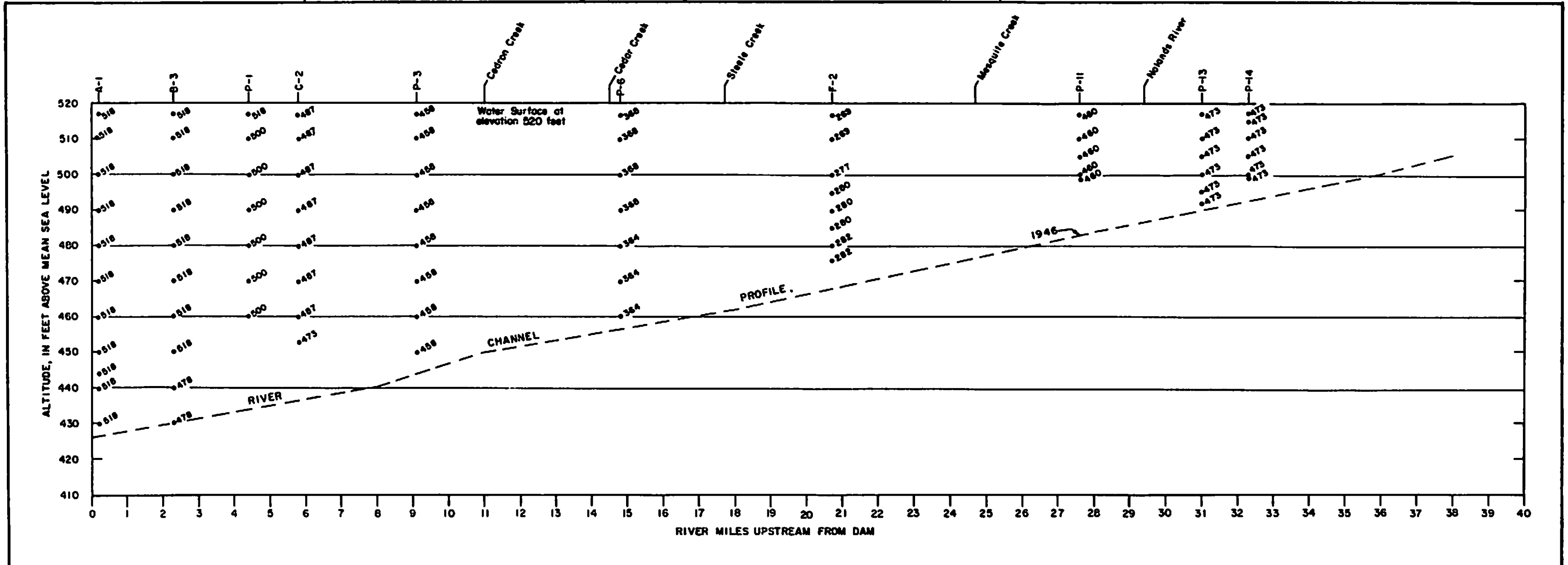
Table 4.--Possum Kingdom Reservoir sampling studies, March 8-10, 1962--Continued

Depth (ft.)	Temperature (°F)	Specific Conductance (micromhos)	Calculated Chloride (ppm)
Sampling Point H-1			
3	51.0	2,600	620
10	50.5	2,600	620
18	50.0	2,600	620
Sampling Point P-9			
3	52.0	2,600	* 620
10	52.0	2,600	620
20	51.0	2,600	620
26	50.0	2,600	620
Sampling Point P-10			
3	53.0	2,900	690
10	53.0	2,900	690
13	53.0	2,900	690
Sampling Point at Marker 156			
Top	55.5	3,300	820
3	55.5	3,300	820
9	55.5	3,400	850
Sampling Point at Marker 170			
Top	56.0	3,850	990
3	56.0	3,900	1,010
6	56.0	3,900	1,010
Sampling Point at Marker 178			
3	57.0	4,000	*1,080
6	57.0	4,000	1,080
Sampling Point P-11			
1	59.5	6,000	*1,680
3	59.5	6,000	1,680

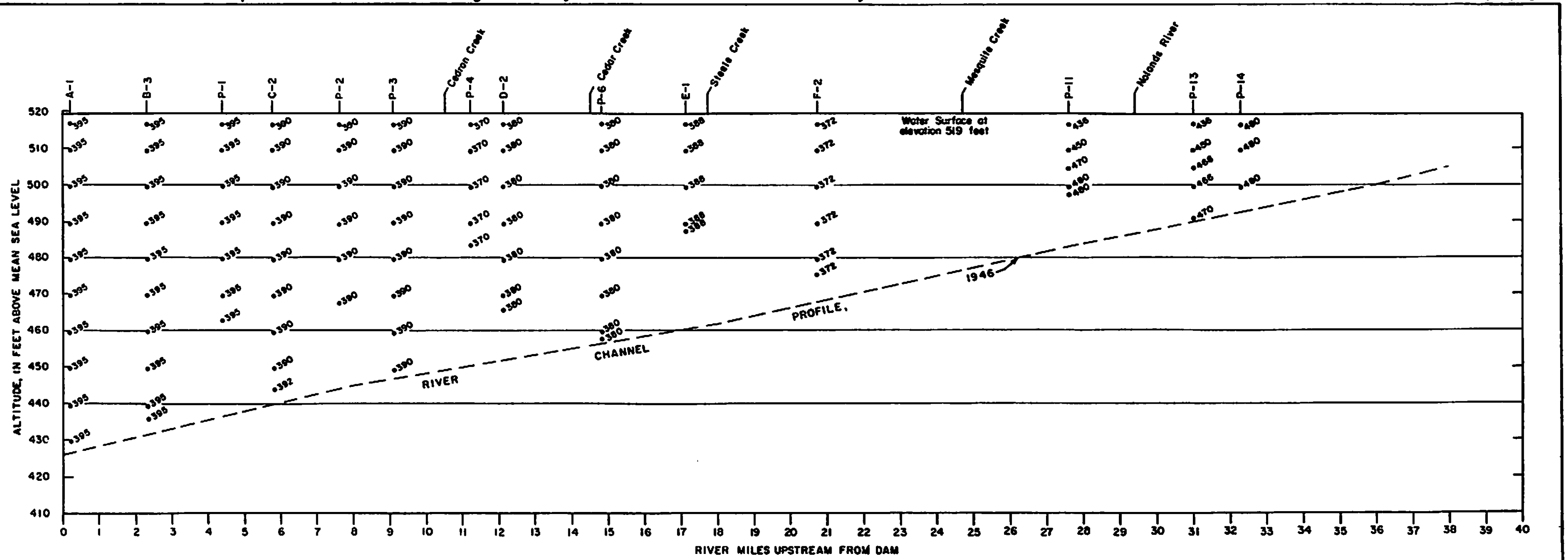
* Laboratory analysis.



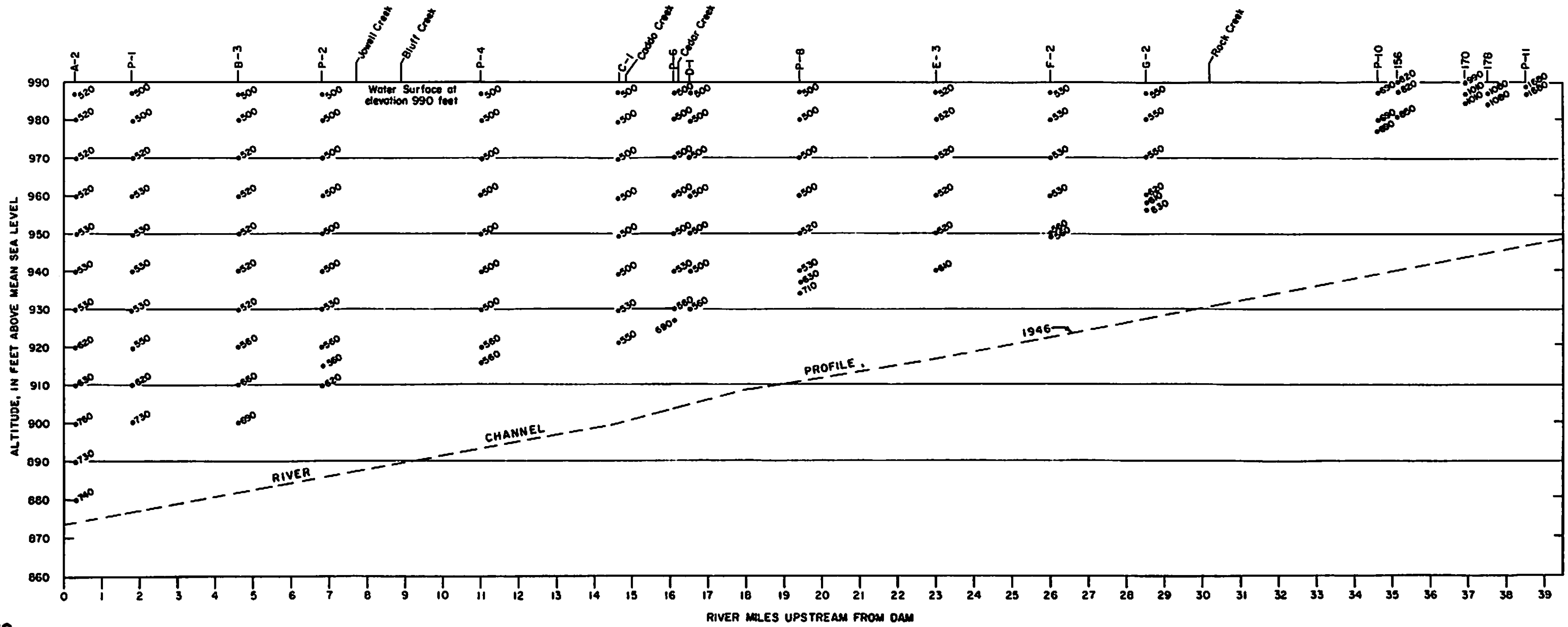
LONGITUDINAL PROFILE SHOWING CHLORIDE CONCENTRATIONS IN BELTON RESERVOIR, IN PARTS PER MILLION, OCTOBER 25, 1961



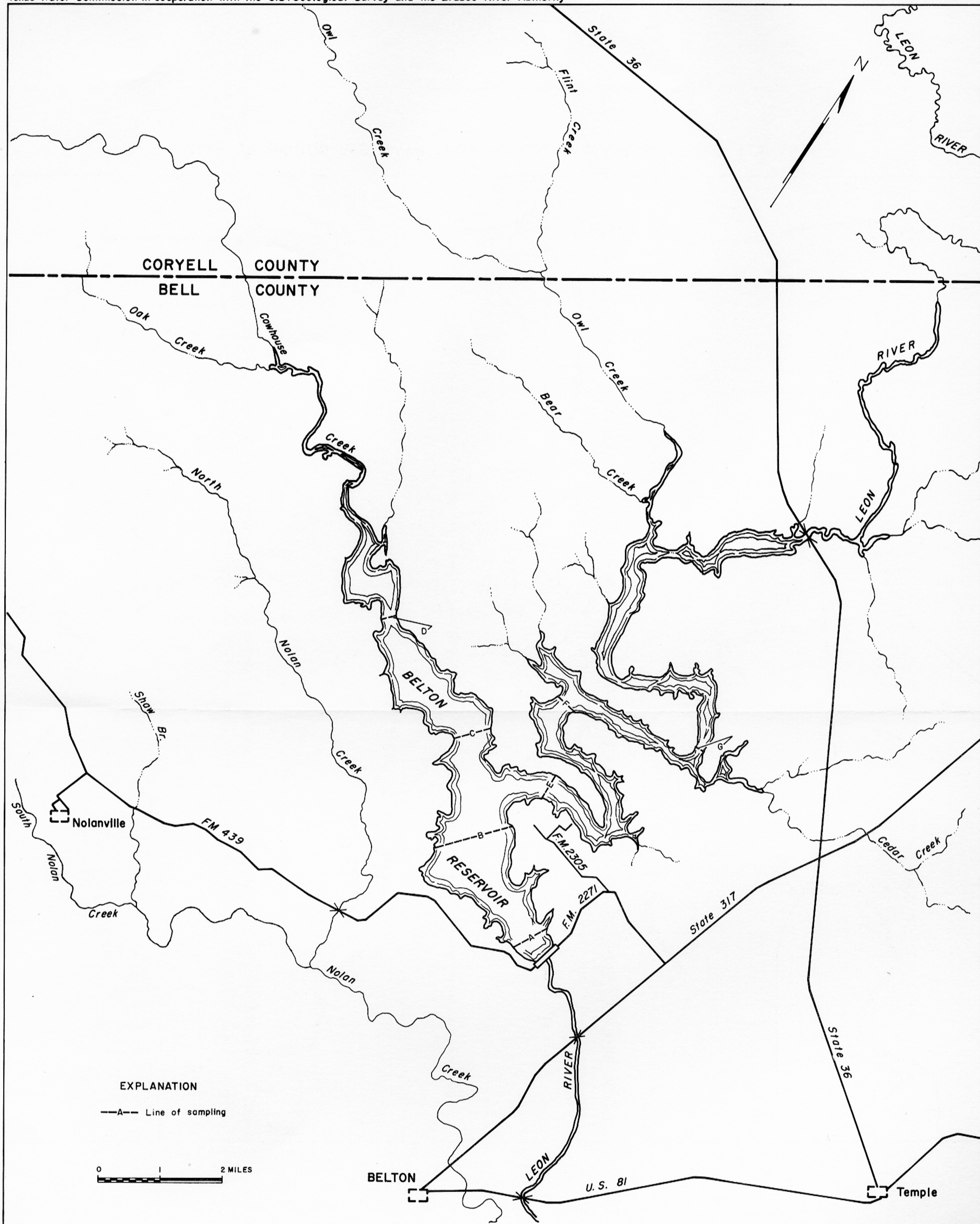
LONGITUDINAL PROFILE SHOWING CHLORIDE CONCENTRATIONS IN WHITNEY RESERVOIR, IN PARTS PER MILLION, NOVEMBER 8-9, 1961



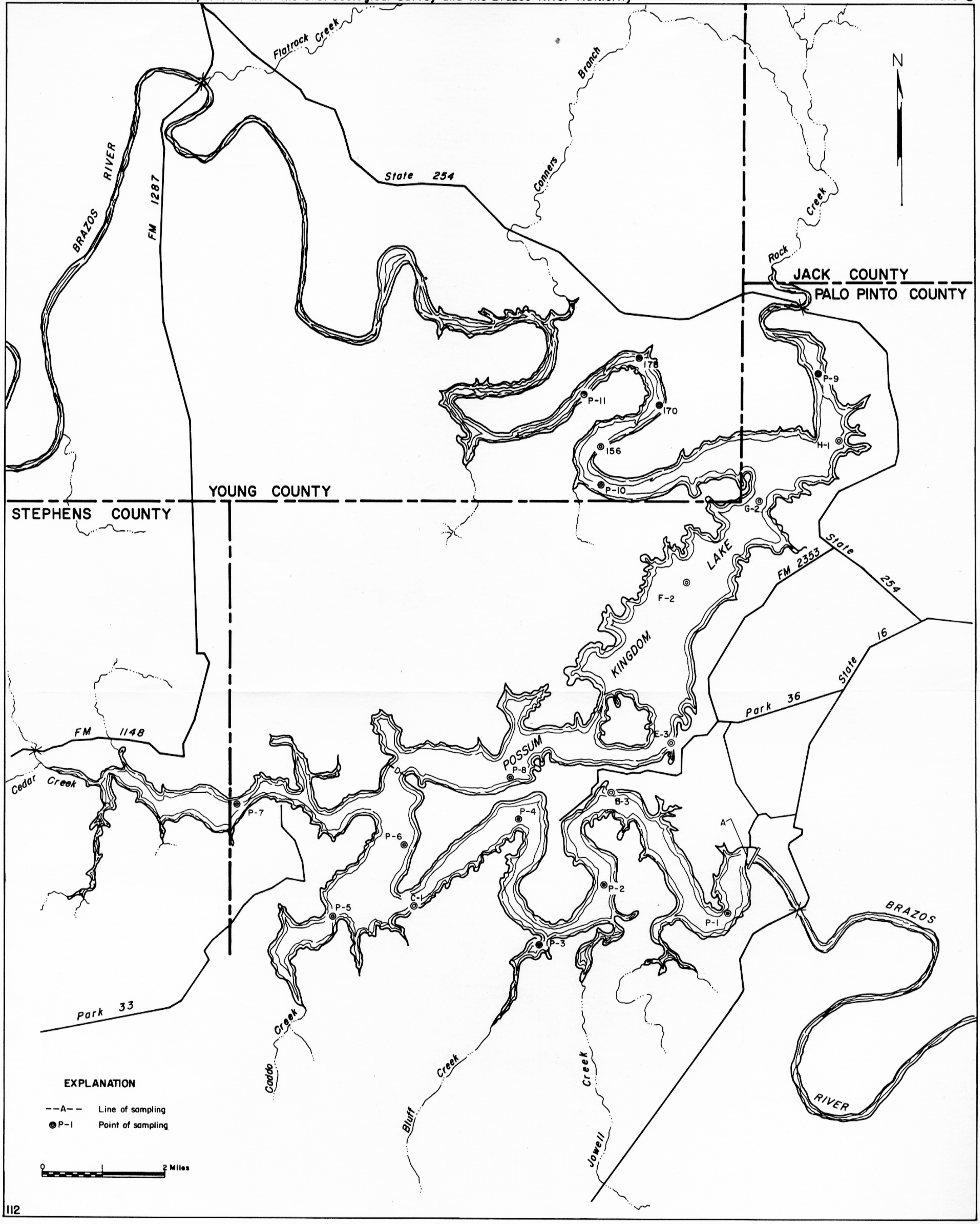
LONGITUDINAL PROFILE SHOWING CHLORIDE CONCENTRATIONS IN WHITNEY RESERVOIR, IN PARTS PER MILLION, MARCH 6, 1962



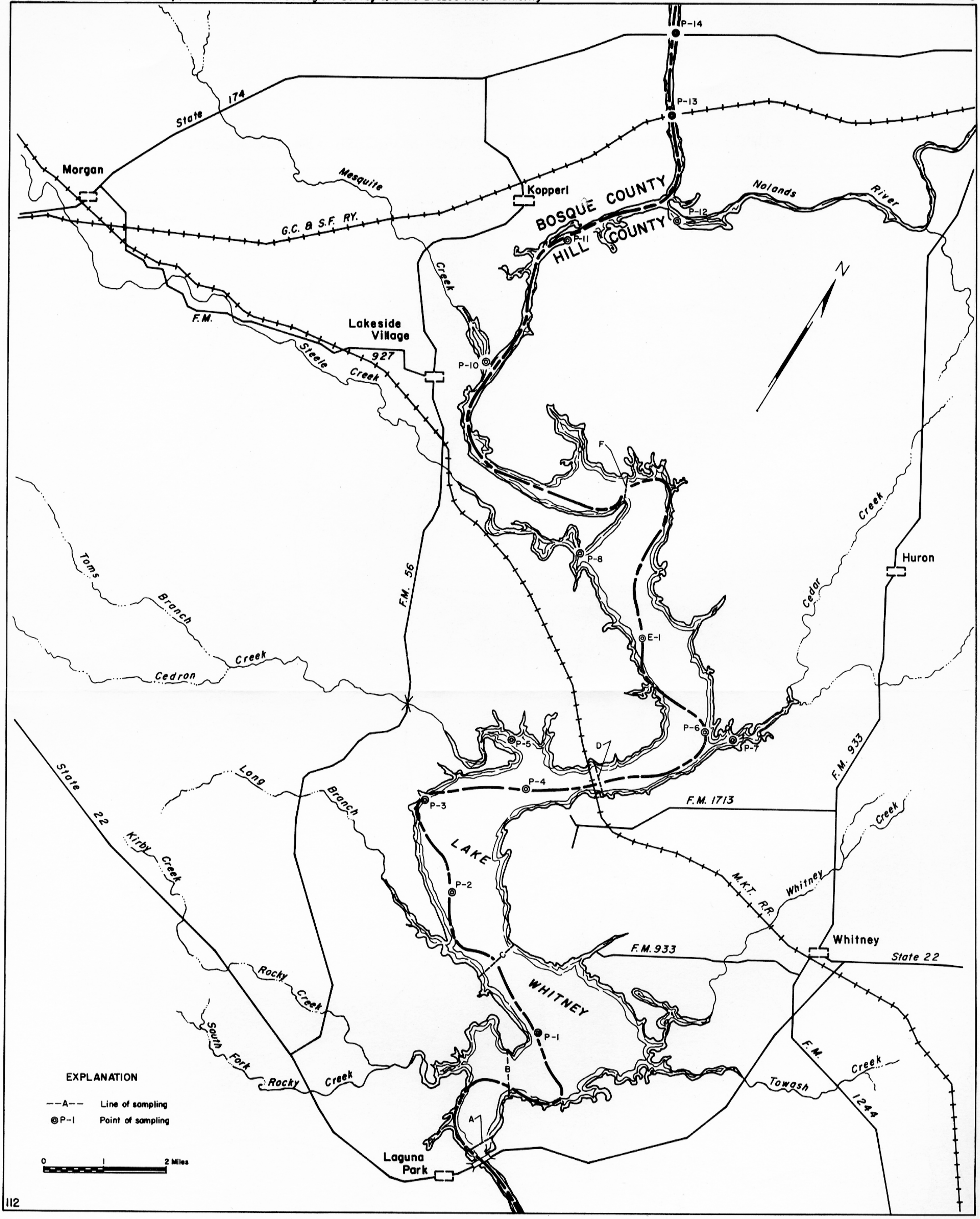
LONGITUDINAL PROFILE SHOWING CHLORIDE CONCENTRATIONS IN POSSUM KINGDOM RESERVOIR, IN PARTS PER MILLION, MARCH 8-10, 1962



MAP OF BELTON RESERVOIR SHOWING LOCATION OF SAMPLING POINTS



MAP OF POSSUM KINGDOM RESERVOIR SHOWING LOCATION OF SAMPLING POINTS



MAP OF WHITNEY RESERVOIR SHOWING LOCATION OF SAMPLING POINTS