WATER QUALITY, BIOLOGICAL AND HYDROGRAPHIC STUDY

B. K. ROBERTS CANAL

ALLIGATOR HARBOR, FLORIDA

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PROJECT PERSONNEL

Thomas Cavinder - Engineer
Delbert Hicks - Aquatic Biologist
Hoke Howard - Aquatic Biologist
Philip Murphy - Aquatic Biologist
Ted Vaughan - Engineer Technician

INTRODUCTION

During the period July 11-16, 1983, personnel of the Environmental Services Division (ESD), EPA, Region IV, conducted a water quality, biological and hydrographic study of the B. K. Roberts Canal adjoining Alligator Harbor near Panacea, Florida. The subject project is a relatively old (early 1970's) Section 10, River and Harbor Act, violation being handled by the Jacksonville District, Corps of Engineers (COE) and the U.S. Attorney's office. For a number of years, the Roberts Canal remained plugged and isolated from Alligator Harbor. However, the earther plug was breached at some time in the past and presently the cana is open to Alligator Harbor through a shallow connector channel. Resistance by the developer to reconstruct the plug resulted in initiation of legal action by the COE and Department of Justice. At their request, ESD personnel conducted the subject study to determine existing environmental conditions of the canal.

FINDINGS

1. B. K. Roberts Canal is separated from Alligator Harbor by a shoaled connector canal less than 1 foot deep at mean tidal stage. Shoaling at the mouth of the canal is expected to be a continuing problem due to prevailing seasonal winds and littoral drift.

2. Except for the shoaled areas of the connector canal, project depths ranged from about 4 to 7-1/2 feet at mean tide.

3. During the course of the study, water level fluctuations due to tide ranged from 4 feet to 2 feet. In general, tide level in the loop canal tracked closely with those of Alligator Har bor with inequities of only approximately a quarter (1/4) a foot at extreme low tide.

4. Due to positioning and elevation of the culverts relative to the canal loop, flood tides pass westerly through the culvert and ebb tides move easterly. Elevation of the culverts above the low water mark creates a no flow condition when water levels fall below -0.5 feet.

5. Release of a dye tracer to monitor canal flushing showed dispersal not to be uniform throughout the system. Four days after release, tracer concentrations in the western loop were 3 times greater than the concentration in the eastern loop. Overall, 50 percent of the tracer was released to Alligator Harbor within 44 hours, and 90 percent exchange was projected to occur in 140 hours.

6. Groundwater response to tides was rapid and its range was approximately 2/3 of the tidal range. Such rapid communicate between tidal and groundwater makes the use of septic tanks along the canal inadvisable.

7. Violation of water quality standards (4.0 mg/L minimum) was evident even at mid depth at interior canal Stations 3, 6 and 7 for a considerable part of the day. Under conditions where low tide coincides with much of the night time hours, more pronounced and extended violations are expected.

8. The canal was enriched with ammonia nitrogen concentrations ranging up to 0.35 mg/L. Ammonia concentrations in Alligator Harbor were 0.20 - 0.24 mg/L. Hydrogen sulfide (H_2S), an indicator of anaerobic metabolism, was present in bottom water (lower one foot) at all canal stations. Potentially toxic concentrations of H_2S were detected at several locations.

9. Chlorophyll _a_ concentrations ranged from 10.64 to 34.83 mg/m^3 in the canal while the bay concentrations ranged from 19.03 to 26.45 mg/m^3.

10. Light-dark bottle experiments yielded a P:R ratio ranging from 1.2 to 3.0, indicating an autotrophic water column in both the canal and bay.

11. Dissolved oxygen concentration at mid-depth monitoring stations were above State water quality standards during daylight hours reflecting photoynthetic oxygen production by the abundant phytoplankton community. Bottom water DO concentrations, however, were below the 4.0 mg/L minimum throughout the day at interior canal stations.

12. Benthic macroinvertebrate communities were sparce in the canal, limited in species richness, and confined primarily to shallow side slopes of the canal system. Conversely, the Alligator Harbor station exhibited a diverse and abundant assemblage of benthic macroinvertebrates.

13. Canal sediments featured an accumulation of finely divided organic material ranging from 10.5 to 14.5% of the total composition. Organic component of bay sediment was only 0.6% of total composition. Excessive amounts of finely divided matter such as in the canal are not conducive to development of diverse benthic macroinvertebrate communities.

OBJECTIVES

The primary task of the study was to characterize water quality, hydrology and biology of the B. K. Roberts Canal and adjacent waters (Alligator Harbor). To accomplish this task, specific objectives were as follows:

- o assess water quality of the B. K. Roberts Canal and adjacent waters through dissolved oxygen, temperature and salinity profiles and water chemistry sampling; identifying any water quality violations
- o characterize the surface and groundwater hydrology of the B. K. Roberts Canal
- o determine the flora and fauna of the B. K. Roberts Canal and Alligator Harbor
- o determine phytoplankton-chlorophyll _a_ levels of the B. K. Roberts Canal and Alligator Harbor
- o characterize sediment structure and chemistry of the B. K. Roberts Canal and Alligator Harbor.
- o assess water column metabolism via light/dark bottle experiments.

STUDY AREA AND STATION LOCATIONS

The B. K. Roberts Canal is located on the north side of highway 370 between the shoreline of Alligator Harbor and the highway (Figure 1). The canal, constructed in a loop configuration, is approximately 4500 feet long but is interrupted by a causeway with culverts near the eastern end of the looped waterway (Figure 2). A 400 feet long access channel perpendicular to the Alligator Harbor shoreline connects the canal to open water. Presently, only minimal residential development is directly associated with the canal although it does receive some use by local boats and water skiers. Five sampling stations were located in the loop canal with additional stations in the access channel and offshore in Alligator Harbor (Figure 2).

METHODS

For reasons of clarity, a brief discussion of methods used in the accomplishment of each task is included in the results section for each study task.

RESULTS

Project Depth

Project depths were determined by longitudinal and cross-sectional traces using a recording fathometer. Depths in the canal system varied from 7 1/2 feet to less than 1 foot at mean tidal stage (Figure 3). Considerable shoaling existed in the entrance channel and radiated into the loop system near its junction with the entrance channel. The junction as depicted in Figure 3 provides for a longitudinal division of the canal. The western leg of the canal between the junction and culverts measures approximately 3000 feet with the eastern leg approximating 1500 feet.

Water Levels

Water level recorders were placed in Alligator Harbor near the entrance of the canal from Alligator Bay and in the canal loop at the culverts. Water level range was approximately 4 feet on the first two days of the study and decreased to approximately 2 feet on the last day of the study (Figure 4).

In general, tide levels in the canal loop tracked closely those of Alligator Harbor. Inequities of approximately 0.25 feet were experienced during extreme low tides. As shown during these low water extremes, the loop canal system was not allowed to drain thoroughly due to shoaling in the entrance canal.

Flow Through Culverts

A current meter equipped with a recording strip chart was used to monitor flow through the culverts. Figure 5 depicts the flow direction through the culverts superimposed upon the water level record at the culverts. Notation "O" represents no flow, "W" represents flow to the west and "E" represents flow to the east. Due to the skewed configuration in respect to the placement of the culverts in the loop (Figure 2), flood waters passed westerly through the culverts and ebb waters passed easterly through the culverts. The culvert inverts were placed well above the low waters experience during the survey period, consequently no flow passed through the culverts when water levels fell below -0.5 feet (Figure 5).

Dye Tracer Study

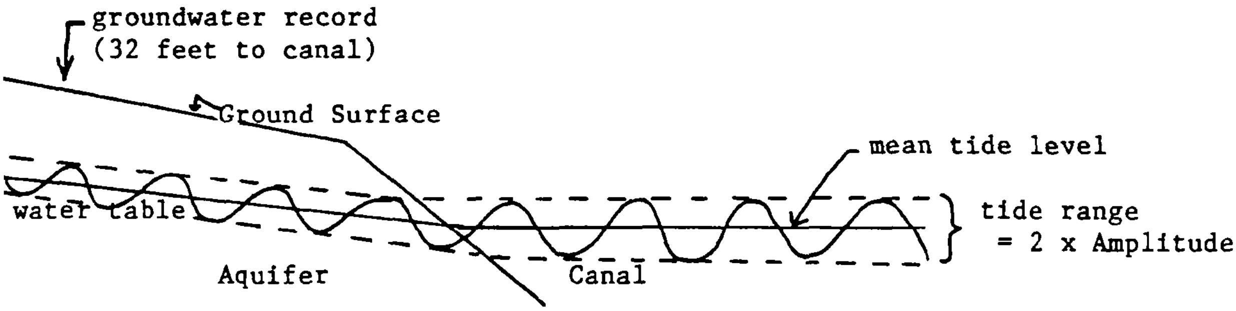
A tracer dye was released into the water column at Station 7 (see Figure 2) and monitored by means of automatic samplers and a fluorometer for a period of 4 days. The samplers were placed at Stations 2, 4, and 6 and were programmed to collect samples at hourly intervals. Results of the tracer study are given in Figures 6 and 7. As shown in Figure 6, the dye released into the western loop at Station 7 dispersed into the eastern loop and into Alligator Harbor by way of the culverts and entrance channel respectively. The spread of the dye cloud through the western leg of the loop, however, was not as effective. On 7/16/83, 4 days after the tracer release, tracer concentrations in the western loop remained 3 times those of the eastern loop (Figure 6).

A measure of the exchange rate between the loop canal and Alligator Harbor is shown in Figure 7. As shown, 50 percent of the tracer had been released to Alligator Harbor in 44 hours and 90 percent exchange was projected to occur at 140 hours.

Groundwater Dynamics

Dynamics of the groundwater levels in response to the tides were measured by means of an auger hole and a water level recorder. As shown in Figure 8, the groundwater response to the tides was rapid and its range was approximately 2/3 of the tidal range. Calculations on the following pages relate the dynamics of the groundwater response:

GROUNDWATER RESPONSE TO TIDE



Groundwater Response to tide

$$h_x = h_o \, e^{-x\sqrt{\pi \, s/t_o \, T}}$$

where h_x = groundwater amplitude at distance x from shore
h_o = tidal amplitude (ft)
x = distance from shore (ft)
s = aquifer storage coefficient
T = aquifer transmissibility gal/day/foot

for period of 1700 on 7/15/83 to 0300 on 7/16/83
groundwater range = 1.25 ft.
thus h_x = 0.63 ft.
tide range = 1.95 ft.
thus h_o = 0.98 ft.

and x = 32 ft. and t_o = 0.25 days

solving for S/T

$$0.63 = 0.98 \, e^{-32\sqrt{\pi \, s/0.25T}}$$

$$S/T = 1.52 \times 10^{-5}$$

Equates to a clean sand with a transmissibility of $\simeq$ 500 and a storage coef of 0.005

$$\text{time lag } (t_L) = x\sqrt{t_o \cdot s/4\pi T}$$

$$= 32\sqrt{\frac{0.25}{4\pi} \; 1.52 \times 10^{-5}}$$

$$= 0.018 \text{ days}$$

= 25 min. (ck's with record)

COMPUTE GROUNDWATER RESPONSE AT 100' FROM CANAL

Period of Record $\longrightarrow$ tide range = 2.5 ft.

thus h_o = 1.25 ft.

$$h_x = 1.25\, e^{-100 \sqrt{(\pi / 0.25\ (1.52 \times 10^{-5}}}$$

$= \underline{0.31}$ ft.

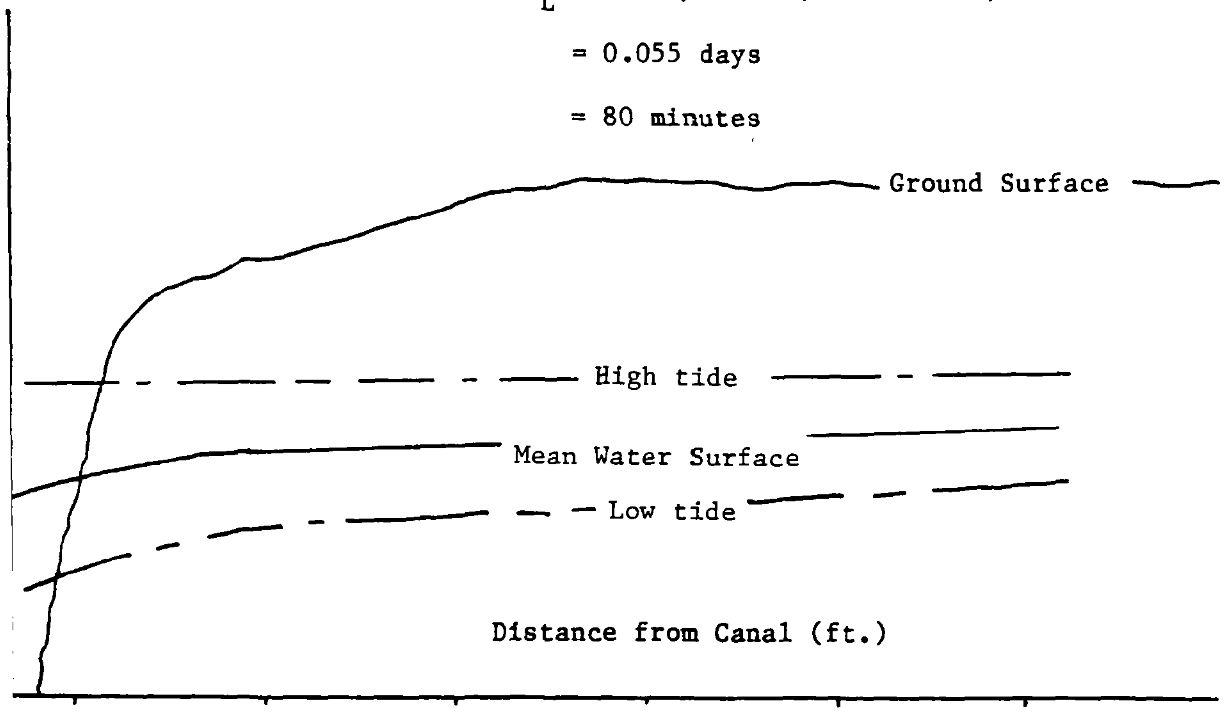
Groundwater range = 2 h_x = $\underline{0.62}$ ft.

time lag

$$t_L = 100 \sqrt{\frac{0.25}{4\ \pi}\ (1.52 \times 10^{-5})}$$

= 0.055 days

= 80 minutes



Dissolved Oxygen and Water Quality Standards

Continuous monitoring of dissolved oxygen concentrations and temperature was conducted over a 24-hour period at all canal and open water stations. Self-stirred dissolved oxygen probes connected to YSI Model 56 DO/temperature monitors were calibrated by the modified Winkler method immediately before and after each monitoring period and suspended near mid-depth throughout the diel period.

State of Florida water quality standards for Alligator Harbor and attendant waters require a minimum DO concentration from surface to bottom of 4.0 mg/L throughout the day (24-hour). Figure 9 depicts the daily record of DO concentrations at all stations for mid-depth except Station 2 where equipment problems negated accurate measurement. As revealed by these records, dissolved oxygen concentrations decreased with progression toward the interior of the canal and exhibited a pronounced decline during darkness. At Stations 3, 6 and 7 these trends resulted in violation of dissolved oxygen standards for a considerable time period. Review of surface to bottom profiles (Table 1) conducted at each station during high and low tide revealed the severely depressed dissolved oxygen concentrations in canal bottom waters near the culverts (Station 7).

Evident on all of the diel curves is the decline in DO concentrations with the onset of darkness (Figure 9). This is an expected response related to the respiration of phytoplankton and other biota resident in the water column and substrate in the absence of photosynthesis which does not occur at night.

At Stations 3, 6, and 7, the diel curves show a night time increase in dissolved oxygen during the period from about 2400 to 0600 hours (Figure 9). Such increases obviously cannot be related to photosynthetic oxygen production since darkness still prevails. Instead, explanation for such increases in this case is best defined through observation of the tidal traces (Figure 5) in conjunction with the diel DO curves. In short, as the dissolved oxygen was being metabolized during night-time of the specific study period, its decline was mediated by and temporarily elevated by oxygenated water from the harbor and surface layer being transferred to the probe zone by flood tide currents. On July 14-16, and between 2400 and 0600 hours, a flooding tide was in progress. Should the study be conducted during a period of the lunar tidal cycle when high tide does not directly correspond to darkness, (i.e. ebbing tide occurring during the maximum respiration period of 2400 to 0600 hours) then this "boost" or supplement of DO to the night-time DO regimen would not be available and concentrations at such a time would likely be even more suppressed and for a longer period of time than observed during the study period.

PHYTOPLANKTON-CHLOROPHYLL a

Water samples were collected from the B. K. Roberts canal and Alligator Harbor (Station 1) for chlorophyll a analysis. Samples were collected from the one-half (0.5) foot depth in Alligator Harbor, due to its shallow depths, and from one-half (0.5) foot and 3 foot depths in the B. K. Roberts canal. Filtering of the collected samples was accomplished in the field, and filter pads were stored in aluminum foil and placed on ice for return to the EPA lab for analysis. Chlorophyll a concentrations (Table 2) were similar at the B. K. Roberts canal and Alligator Harbor. Canal chlorophyll a concentrations ranged from 10.64 to 34.83 mg/m_3, while concentrations in Alligator Harbor were 19.03 and 26.45 mg/m^3. Chlorophyll a concentrations for the canal and Alligator Harbor samples were, with a couple of exceptions, higher than average concentrations of 17 mg/m^3 observed in Gulf inshore waters (Steidinger, 1973).

Water Column Metabolism

Assessment of the oxygen metabolism in the water column was accomplished through the deployment and incubation of light and dark bottles at depths totally integrating the water column. Associated with bottle deployment was the determination of light extinction (transmission) profiles with a marine photometer.

The oxygen metabolism of the phytoplankton community was reflected in gross primary production (GPP) and respiration (R) rates for the water column (Table 3) which translate into P:R ratios exceeding 2.0 at all stations except Station 7. Water column respiration at Stations 3 and 7 was substantially greater than other stations (Table 3). Stations 3 and 7 were associated with the culvert area of the canal.

Light Transmission

A submarine photometer was used to determine percent light transmission at all stations except 2 and 4. Light transmission data was utilized in determination of depths for light/dark bottle experiments and phytoplankton chlorophyll a sampling.

Light transmission was similar at all stations (Table 4) with the exception of Station 7, a canal dead-end site.

WATER CHEMISTRY

Water chemistry sampling was accomplished in conjunction with monitoring of dissolved oxygen, temperature and salinity (DST). Samples for water chemistry analyses (NH_3, NO_2-NO_3, TKN and T-P) were taken as close as possible to corresponding low and high slack tide. Samples were taken at mid-depth with a horizontal Van Dorn sampler unless dissolved oxygen, salinity, temperature (DST) profiles indicated stratification, in which case, stratified sampling of the water column was initiated. In addition, samples were collected near the water/mud interface for hydrogen sulfide analysis. Preservation and storage of samples followed the ESD SOP (standard operating procedures) manual protocol and chain-of-custody was maintained.

Results of water chemistry analyses show concentrations of NH_3, NO_2-NO_3, TKN and T-P in the canal water to be similar to the background station (BK-1) in Alligator Harbor (Table 5).

The most prevalent form of nitrogen was ammonia (NH_3-N) which ranged from 0.07 - 0.35 mg/L in canal waters and 0.20 to 0.24 mg/L in Alligator Harbor. Sources of ammonia for Alligator Harbor and the B. K. Roberts canal system can include surface drainage, domestic wastewater, recruitment from marine sediments, and export from submerged vegetation and tidal marshes which are prominent in the study area (Figure 10). Studies conducted on nitrogen, phosphorus and carbon flux in undisturbed Chesapeake Bay marshes (Axlerad, Moore and Bender, 1976) revealed that ammonia was exported from the marsh system in the spring and summer. Other studies by EPA personnel measured net fluxes of ammonia from marine sediments in Tampa Bay (Murphy, 1983). Similar sediment exchanges of ammonia have been reported by Boyten/ Kempler .

Total phosphorus (T-P) concentrations ranged from 0.06 to 0.08 mg/L at canal and Alligator Harbor waters, with the exception of a single concentration of 0.16 mg/L at Station BK-7.

The most salient chemical characteristic of the B. K. Roberts canal waters, other than DO dynamics is found in hydrogen sulfide (H_2S) concentrations which are a product of a reducing environment (Table 5). Undissociated H_2S at concentrations of 0.02 mg/L are toxic to aquatic life. At pH's common to the estuarine environment (7 to 8 units), the reported H_2S values of 1.2 and 4.6 mg/L would be considered toxic concentrations.

SEDIMENT CHEMISTRY AND PARTICLE SIZE

Replicate cores were collected with a 2-inch acrylic tube from the upper 10 cm of the bottom sediments at stations shown in Figure 2. Samples were labeled, placed in plastic storage bottles and kept on ice for return to the EPA lab in Athens, Georgia for processing. Analyses included chemical determination of TKN, NH_3, T-P and COD plus particle size assessment. Processing of the samples were in accordance with Divisional SOP's and QA protocol.

Sediment chemical analyses results reveal greater concentrations of NH_3, TKN, T-P, and COD in canal stations than in the background station (Station BK-1) (Table 6). For example, TKN values for the canal stations ranged from 1620 to 5720 mg/kg; whereas, the background station (BK-1) in Alligator Harbor yielded a TKN value of 126 mg/kg. Ammonia values were 6 to 26 times greater in the canal; total phosphorus values were 18 to 40 times greater in the canal, and COD values were 17 to 24 times greater in the canal. Past studies by EPA (1975) reported similar findings in regard to build-up of nutrients in canal sediments.

A concern with canal systems is the accumulation or "trapping" of finer sediments (silt, clay and finely divided organic matter) in the canal trough. Numerous studies by EPA have shown this to be the case. Liabilities of the trapping nature of the canals are twofold: (1) finer sediments are not conducive to establishment of a diverse macroinvertebrate community and (2) excessive organic matter creates added demands on the oxygen resources of the system.

Results of the sediment analysis from the B. K. Roberts canal stations clearly show greater percentages of fine sediments and organic matter present in bottom sediments when compared to the Alligator Harbor station (Figure 11). Silt and clay fractions constituted from 20% to 30% of the total dry weight of sediments from all canal stations while sediments from the background station contained less than 2.5% silt and clay. Organic content, another parameter indicative of the "trapping" nature of dead-end canals, ranged from 10.5-14.5% of sediment composition in the B. K. Roberts canals while organic content at the background station was only 0.6%.

BENTHIC MACROINVERTEBRATES

In conjunction with water quality studies, qualitative sampling for benthic macroinvertebrates was conducted at Stations 1, 3, 4, 5, 6 and 7. With the exclusion of the Alligator Harbor station (1), the remaining stations, located within the B. K. Roberts canal, were sampled at both the littoral area and the center trough. A variety of methods, including sweeps with a standard biological dip net, bottom grabs with a core sampler and visual inspection of available substrates constituted qualitative sampling efforts. A one-half (0.5) hour sampling effort was conducted at each habitat site. Samples were sieved with a U. S. Standard No. 30 sieve and stored in quart containers with 90% ETOH as the preservative. Chain-of-custody procedures were followed during sampling and processing as dictated by the Ecological Support Branch SOP (Standard Operating Procedures).

Results of benthic macroinvertebrate sampling were consistent with the findings of past studies conducted by EPA on man-made canal systems. The background station in Alligator Harbor (BK-1) possessed the greatest species richness with crustaceans, polychaetes and mollusks providing for a total of 11 taxa in the samples (Table 7). The benthic macroinvertebrate community, in terms of taxa present in the canal system was much diminished from that present in Alligator Harbor (Table 7). The littoral areas (sides) of the canals yielded a few more invertebrate taxa than did the center trough although still much less than the background station (Table 7). Three canal stations (3, 6 and 7) had no benthic macroinvertebrates in center trough collections (Table 7).

Substrate and water quality are known factors affecting the benthic macroinvertebrate community. Past studies of hydrological and biological characteristics of finger-fill canal systems (Trent, et. al, 1973; Taylor and Salomon, 1968; EPA, 1976; and Yokel, 1979) have indicated the limiting aspect of finely divided organic substrates on the benthic macroinvertebrate community. Silt and clay, in addition to organic matter, were much more prevalent in the B. K. Roberts canal system sediments than the background site (Figure 11). An additional liability associated with accumulation of organics and fine sediments is the excessive demands placed on the oxygen regime of the system. As can be seen upon examination of the dissolved oxygen, salinity and temperature profiles (Figure 9 and Table 1), near bottom concentrations of dissolved oxygen in the canal were depressed, especially the most landward stations. Excessive H_2S could also add to the impact on the macroinvertebrate community. Such conditions, coupled with poor substrate quality, are not conducive to establishment of a diverse benthic macroinvertebrate community. In a natural system, such as Alligator Harbor, tidal motion coupled to shallow depths provides adequate vertical mixing hence reducing the tendency for the accumulation of fine sediments and organic matter.

DISCUSSION

The B. K. Roberts Canal is a 4500 feet long loop canal, interrupted by culverts and a causeway, appended to a shallow bay, Alligator Harbor (Figures 1 and 2). Alligator Harbor is a designated State of Florida aquatic preserve. Aquatic preserve designation is dependent upon such factors as biological productivity, scientific importance, and aesthetics. Alligator Harbor meets all thes criteria. Since the B. K. Roberts Canal, in its unplugged status, is viewed as waters of the United States and, thus, an extension of Alligator Harbor, then it is reasonable to expect that the cana should be required to exhibit the same environmentally desirable qualities as the parent water. However, this is not the case.

Typical of many artificial canals, inhibited flushing of the B. K. Roberts Canal contributes largely to the decline in water quality and biological conditions. Shoaling at the entrance to the loop canal creates a sill effect as illustrated in Figure 3. The elevation of the culverts at the eastern end of the loop canal (Figure 3) creates a second barrier impairing flushing. The elevation of the culverts are such that at water levels less than -0.5 feet, no exchange occurs through the culverts.

Dissolved oxygen concentrations at Stations 3, 6 and 7 violate water quality standards (minimum 4.0 mg/L) for a considerable portion of the day as shown in Figure 9 and Table 1. Such violations are expected to be more pronounced and extended for longer periods of the day when low tides and maximum respiration (night-time) are more coincident. Associated with substandard DO concentrations are the respirational demands associated with the water column in conjunction with organically enriched sediment (a result of the trapping of finely divided organic material settling in the quiescent canal waters as well as the organic substrate through which the canal was constructed). The stratified nature of the water column, as depicted by the DO profiles (Table 1), illustrate the incomplete vertical mixing of the water column.

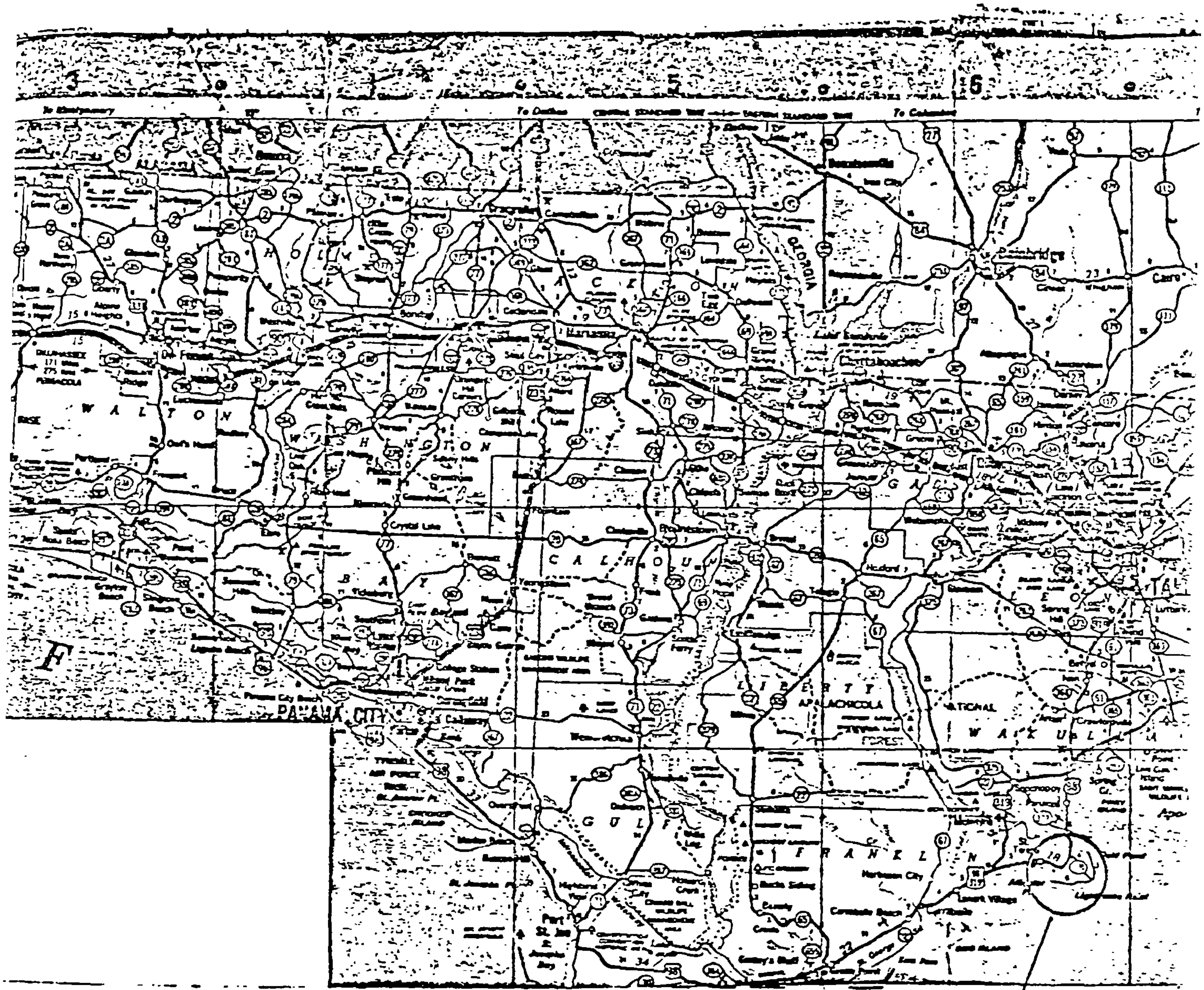
Initially, the enriched phytoplankton community in the canal system would appear to exert no liability upon the DO resource of the canal system since it produces more dissolved oxygen than it consumes over 24-hour period. However, the night-time respirational demand for oxygen by this enriched community in conjunction with such factors as (1) the continuous demand for oxygen by organically enriched sediments and (2) the inhibited exchange and/or vertical mixing of oxygen enhanced water from the bay (particularly at interior canal stations) all coincide to produce substandard dissolved oxygen concentrations for a considerable part of the day.

An indicator that resident conditions in the canal are probably even more adverse than observed in this short term study is the high concentrations of hydrogen sulfide (H_2S) (Table 5) found at the water/sediment interface of all canal stations and the relative absence of benthic macroinvertebrates in the canal bottom (Table 7). Hydrogen sulfide is produced and maintained only under anaerobic conditions (no oxygen). Concentrations at which H_2S was present in the canal are toxic to animal life, thus impairing the development of a quality macroinvertebrate community.

In contrast to the water quality and biological conditions in the canal are the conditions observed at Station BK-1, the background station in Alligator Harbor. No dissolved oxygen standard violations were encountered and the decline in DO at night-fall was not nearly as pronounced as at interior canal stations (Figure 9). The organic component of Station BK-1 sediment was only 0.6% compared to a range of 10.5% to 14.5% at canal stations. Chemical constituents and chlorophyll a concentrations were not markedly ıfferent between canal and bay stations, but the collective esult to the dissolved oxygen resource are more pronounced n the canal.

Comparison of hydrographic and chemical features are good ools for characterization of the B. K. Roberts Canal and the lligator Harbor station. As discussed above, in these regards, e canal is of inferior quality in comparison to the bay. However, the most important consideration is how all these water ality factors combine to produce value in terms of biological oductivity which is necessary to sustain important fish and ldlife. Here lies the most notable distinction between the nal and Alligator Harbor. Station BK-1, Alligator Harbor, exbited a diverse and balanced community of benthic macroinverteates (Table 7) comprised of 11 taxa. In contrast, the canal s dominated by worms (Polychaeta) limited primarily to side opes with three out of five stations being void of benthic ganisms in the center trough. Accordingly, the contributions estuarine food chains of the open bay compared to the canal e quite evident and contrasting. The bay station maximizes puts from primary production to sustain productivity to the condary level, producing a numerous and diverse assemblage of croinvertebrates to enter the food web. In contrast, the canal's gh levels of gross primary production in the water column is not anslated into support of secondary production since bottom water d sediment quality is not conducive to development of a diverse nthic community. The restricted flushing, trapping and accumution of fine organic material, and resultant anoxic conditions d sulfide production associated with the decomposition of this terial all serve to adversely limit biological productivity. As ated previously, these adverse conditions exist in the relative sence of development. With the rapid interaction of tide water th ground water adjacent to the canal, any insuing development companied by septic tanks or similar treatment would further compund the observed water quality problems through continued enrichnt of canal waters.

FIGURE 1.
GENERAL STUDY LOCATION, B. K. ROBERTS CANAL, JULY 1983.



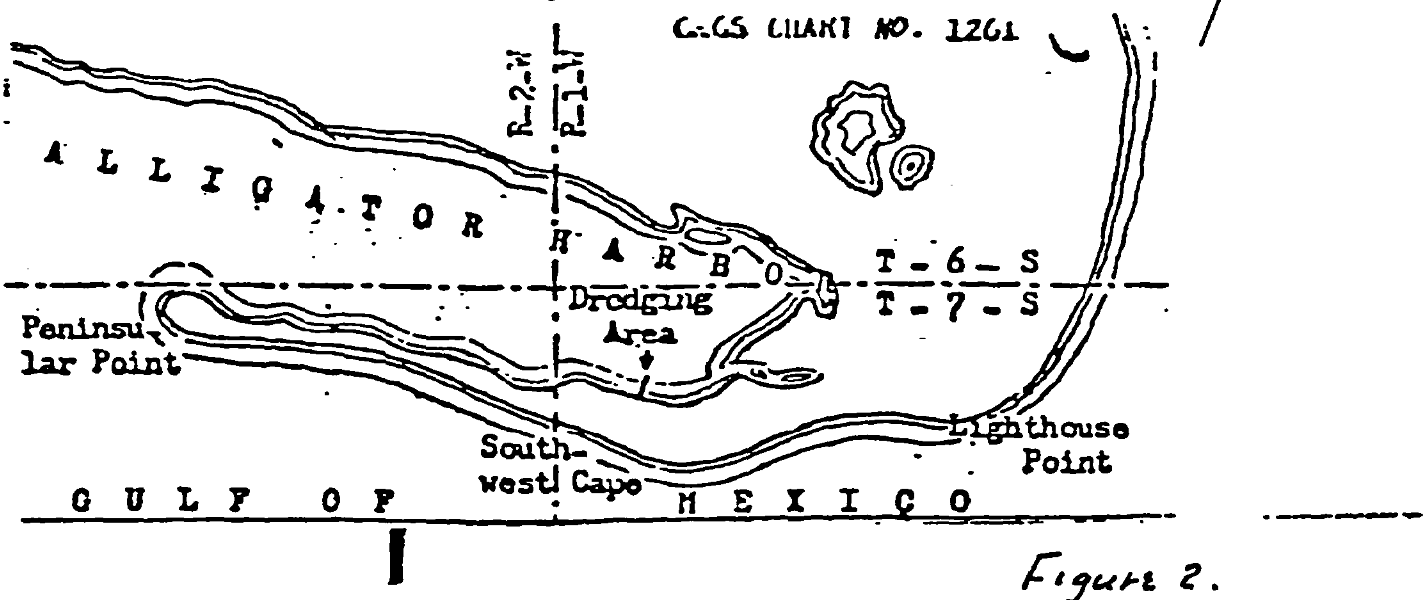


Figure 2.
B.K. Roberts Canal

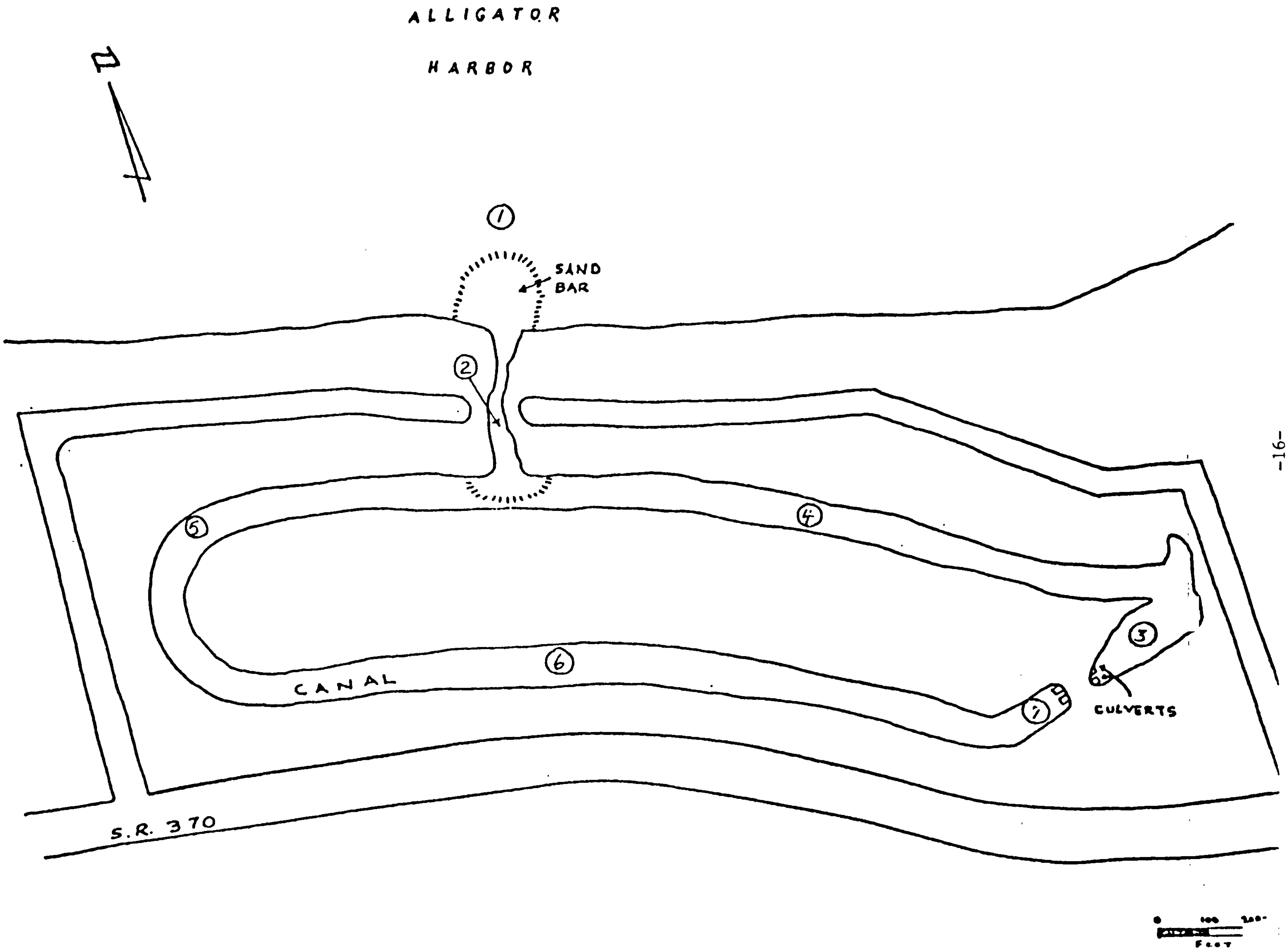
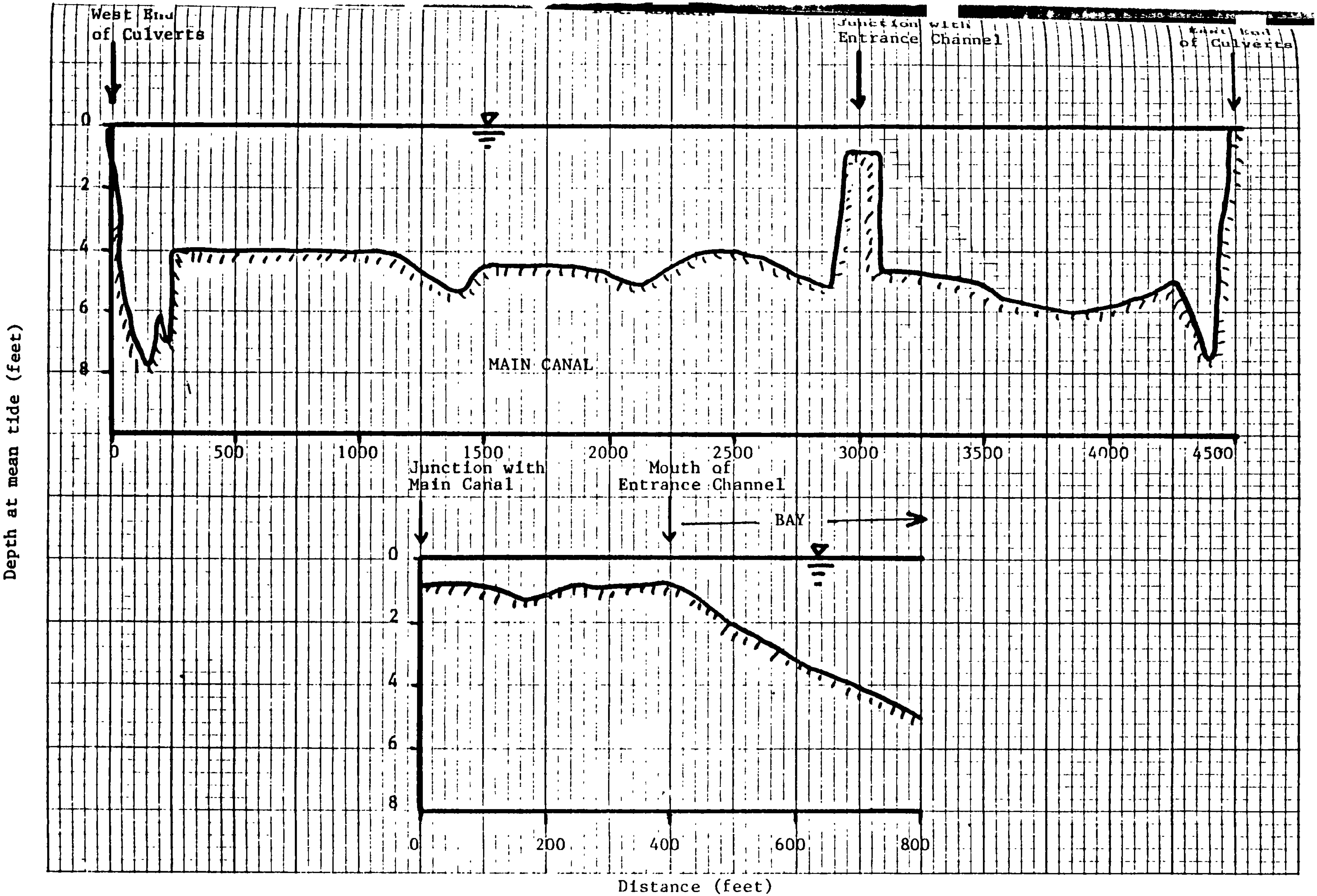
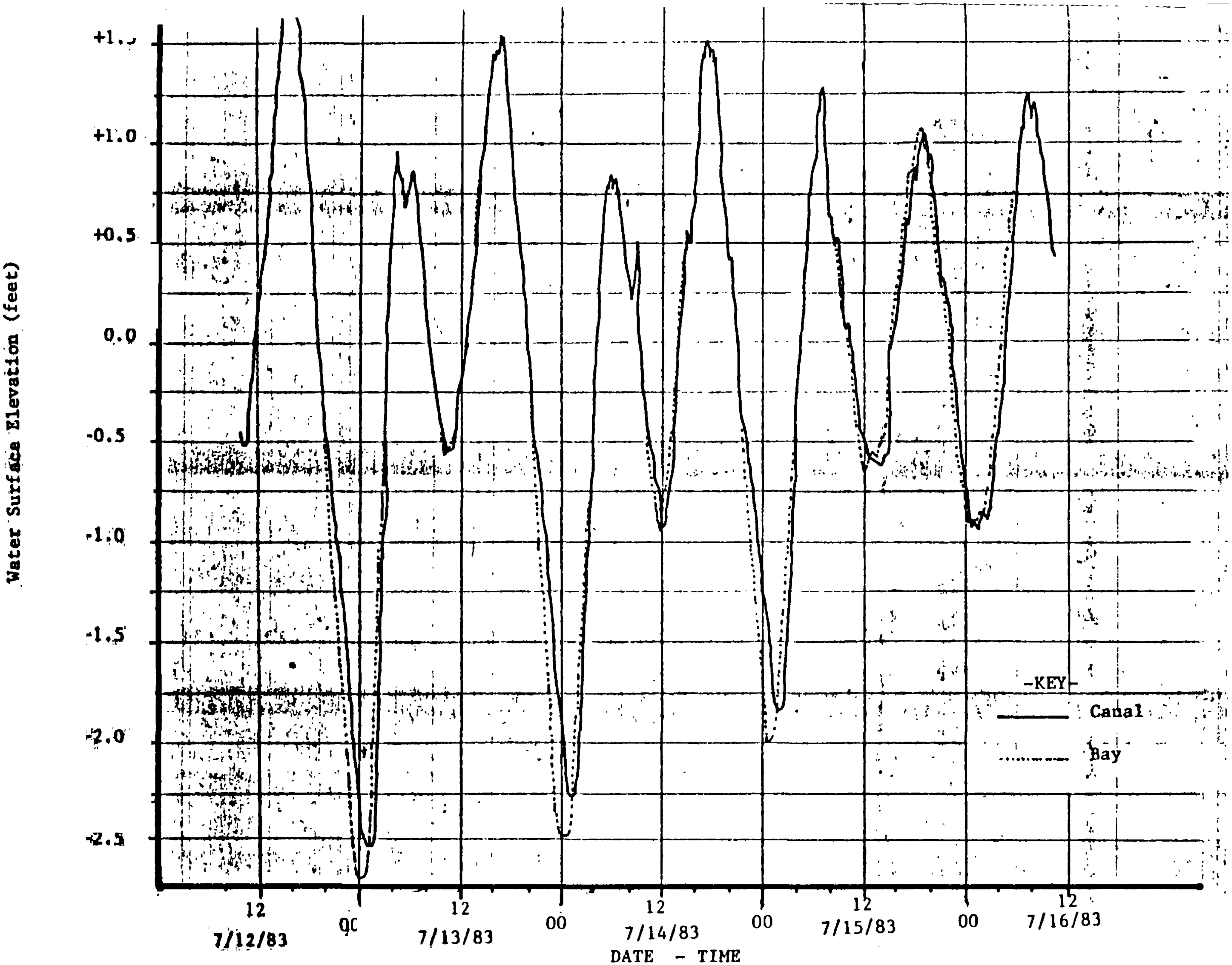


FIGURE 2.
STATION LOCATION AND CANAL CONFIGURATION, B. K. ROBERTS CANAL,
JULY 1983.


West End
of Culverts
Junction with
Entrance Channel
East End
of Culverts
0
2
4
6
8
MAIN CANAL
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Junction with
Main Canal
Mouth of
Entrance Channel
BAY
0
2
4
6
8
0
200
400
600
800
Depth at mean tide (feet)
Distance (feet)



Water Surface Elevation (feet)
+1.5
+1.0
+0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
12
7/12/83
00
12
7/13/83
00
12
7/14/83
00
12
7/15/83
00
12
7/16/83
DATE - TIME
-KEY-
Canal
Bay

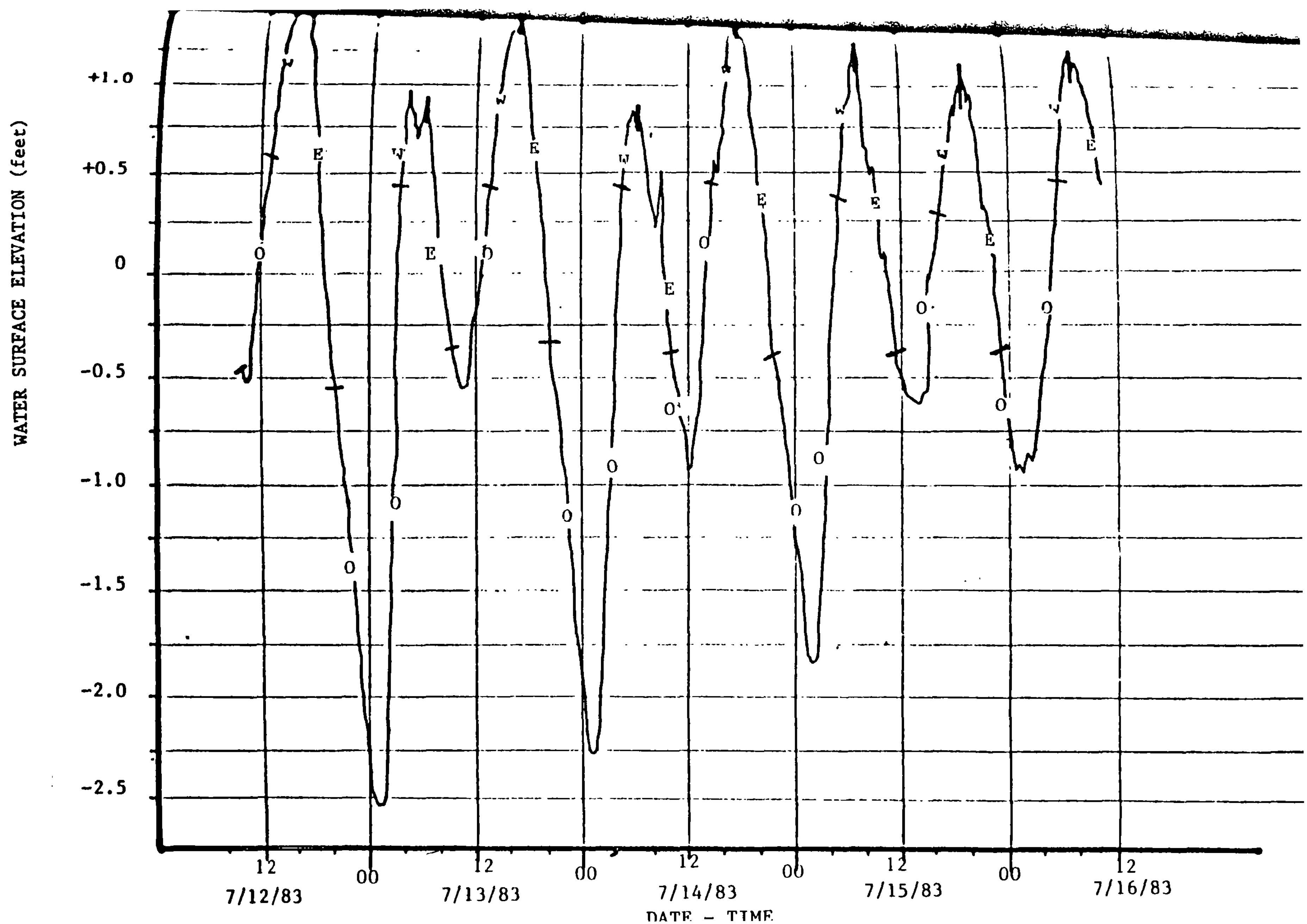

WATER SURFACE ELEVATION (feet)
+1.0
+0.5
0
-0.5
-1.0
-1.5
-2.0
-2.5
12
00
7/12/83
7/13/83
7/14/83
7/15/83
7/16/83
DATE - TIME

FIGURE 6
TRACER RESPONSE
B. K. ROBERTS

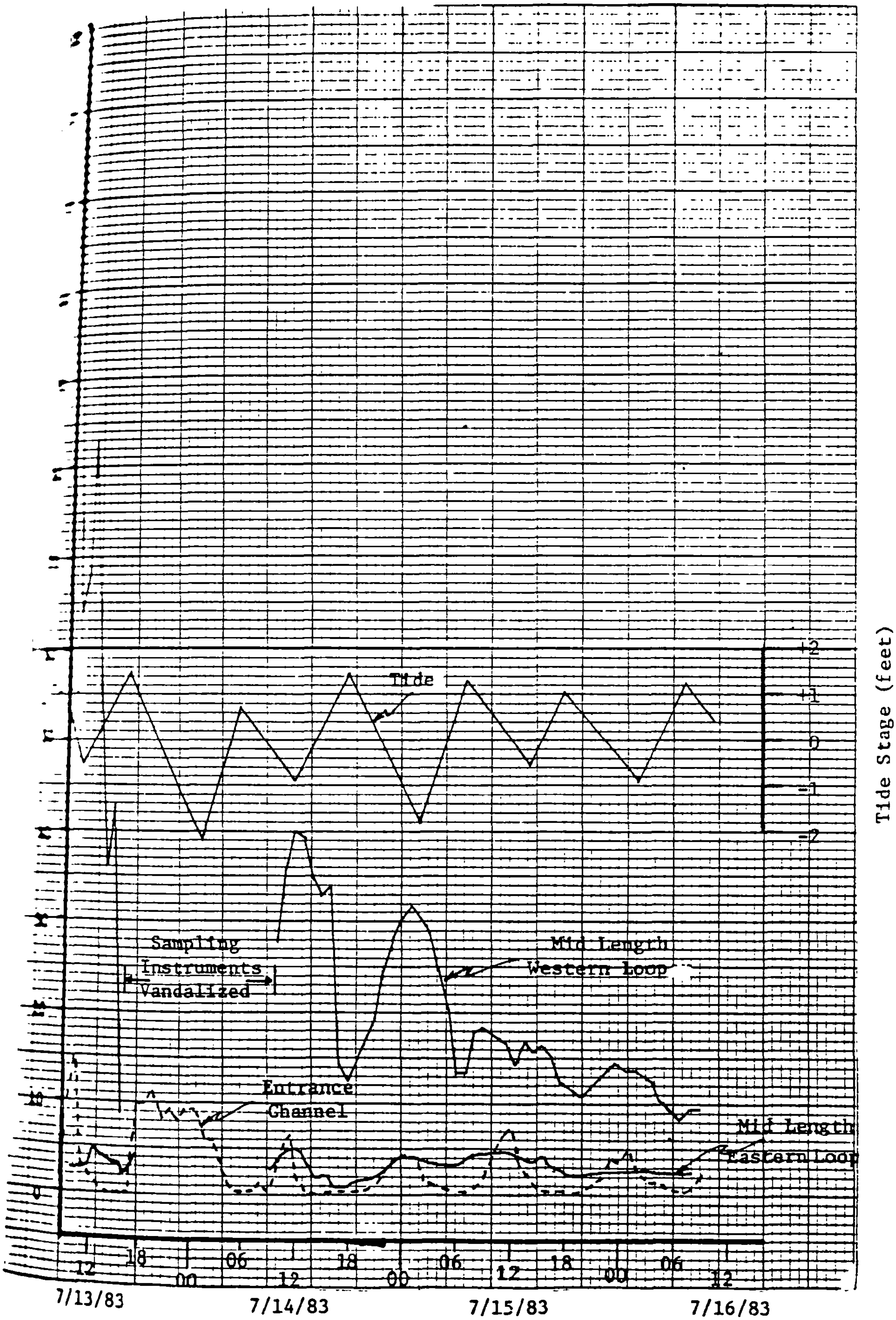
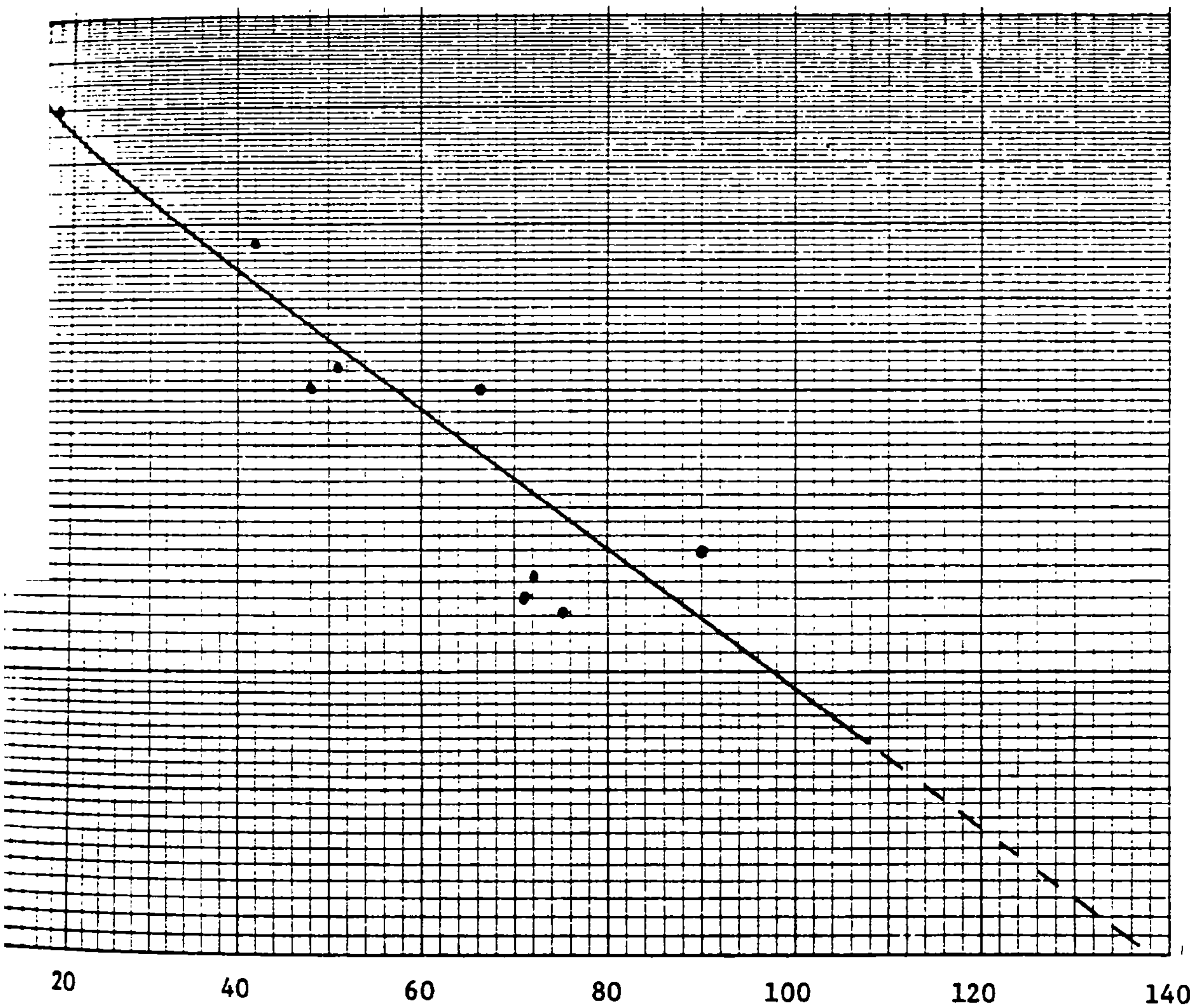


FIGURE 7
WATER EXCHANGE RATE
B. K. ROBERTS



Elapsed Time (Hours)

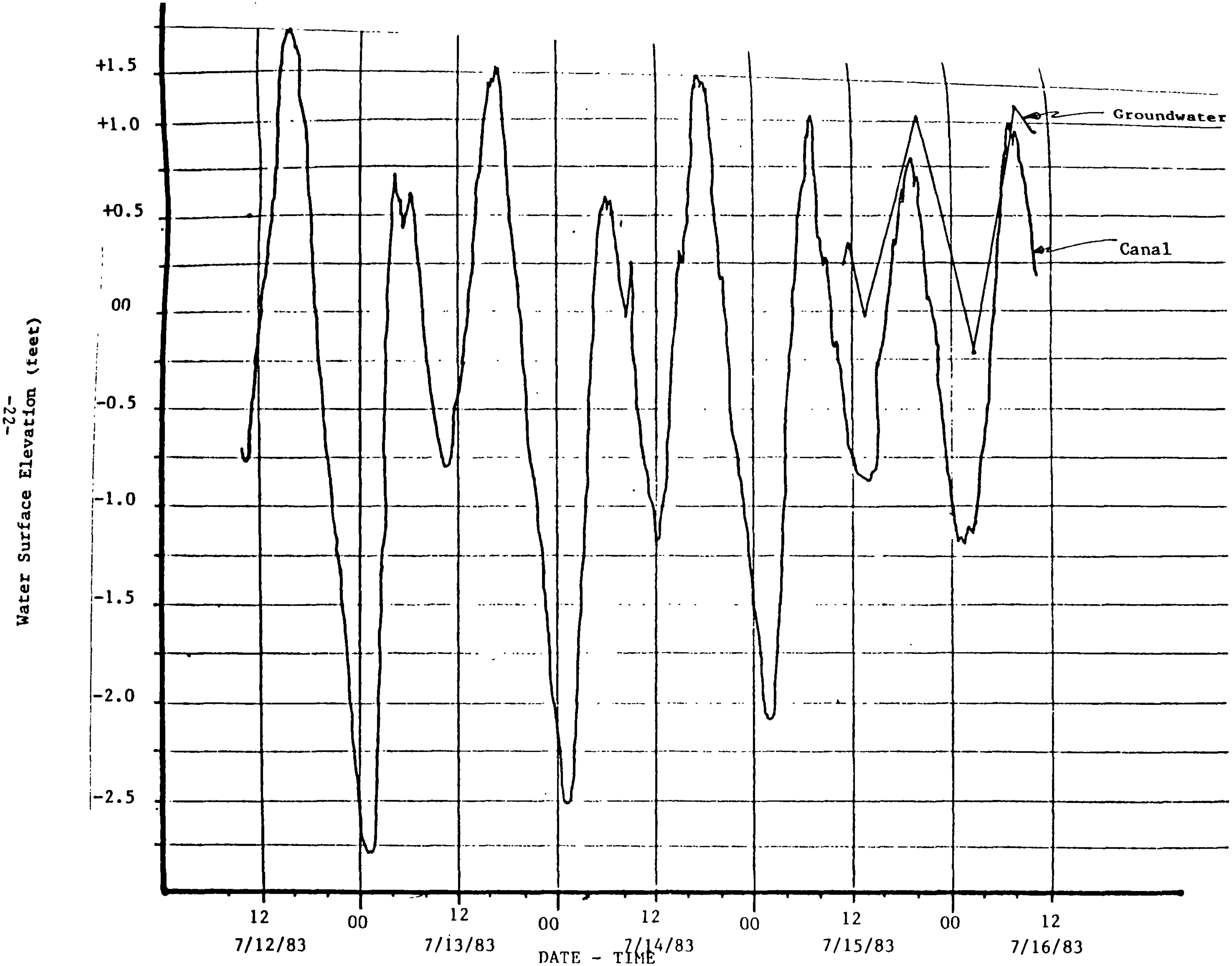

Water Surface Elevation (feet)
+1.5
+1.0
+0.5
00
-0.5
-1.0
-1.5
-2.0
-2.5
Groundwater
Canal
12
00
12
00
12
00
12
00
12
7/12/83
7/13/83
7/14/83
7/15/83
7/16/83
DATE - TIME

FIGURE 9.
MID DEPTH DIEL DISSOLVED OXYGEN CONCENTRATION,
B. K. ROBERTS CANAL, JULY 1983.

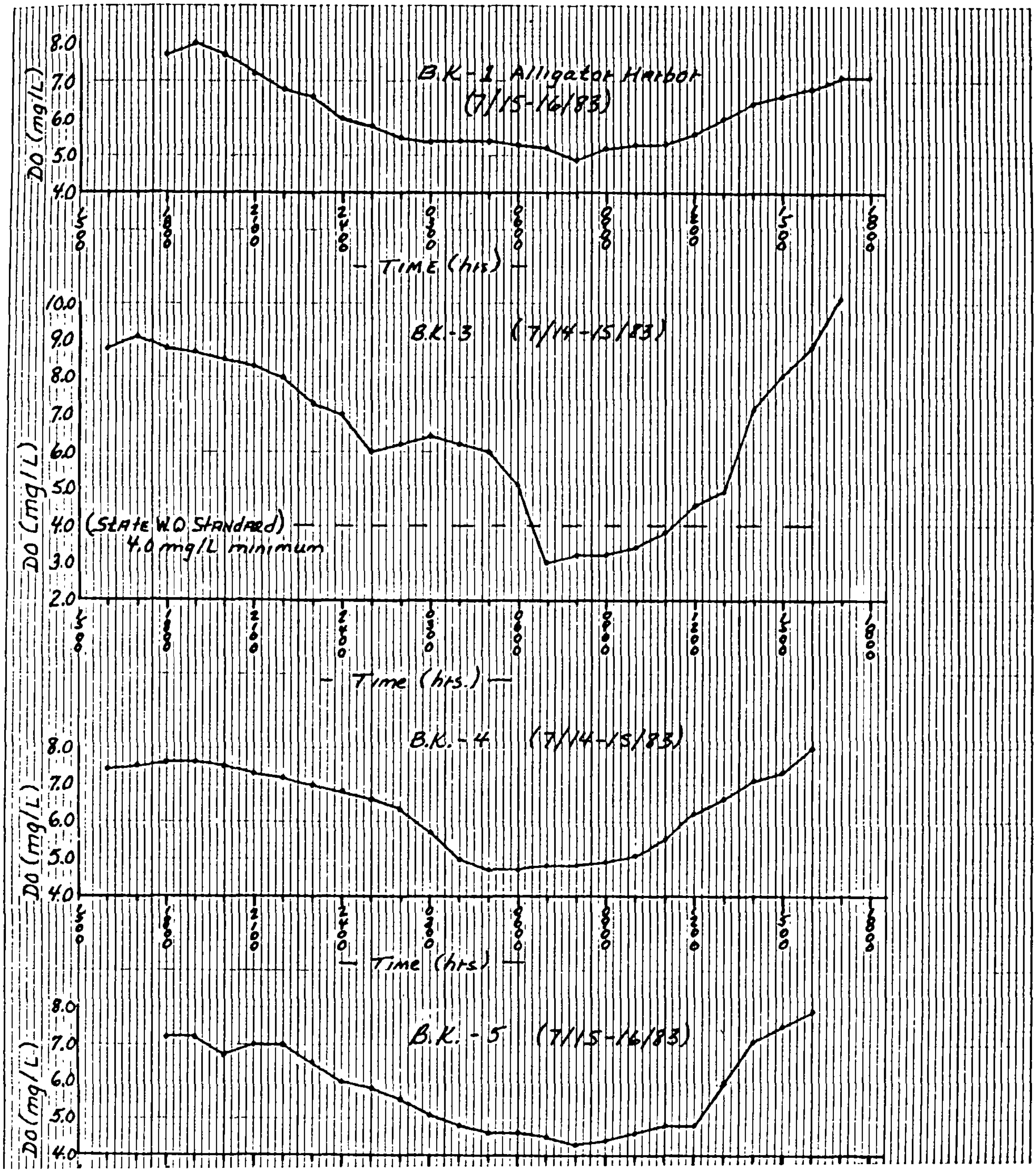


FIGURE 10
LOCATION MAP OF PROJECT AREA SHOWING EXTENT OF TIDAL MARSHES AND SUBMERGED VEGETATION (FROM NMFS, CIRC. 368)

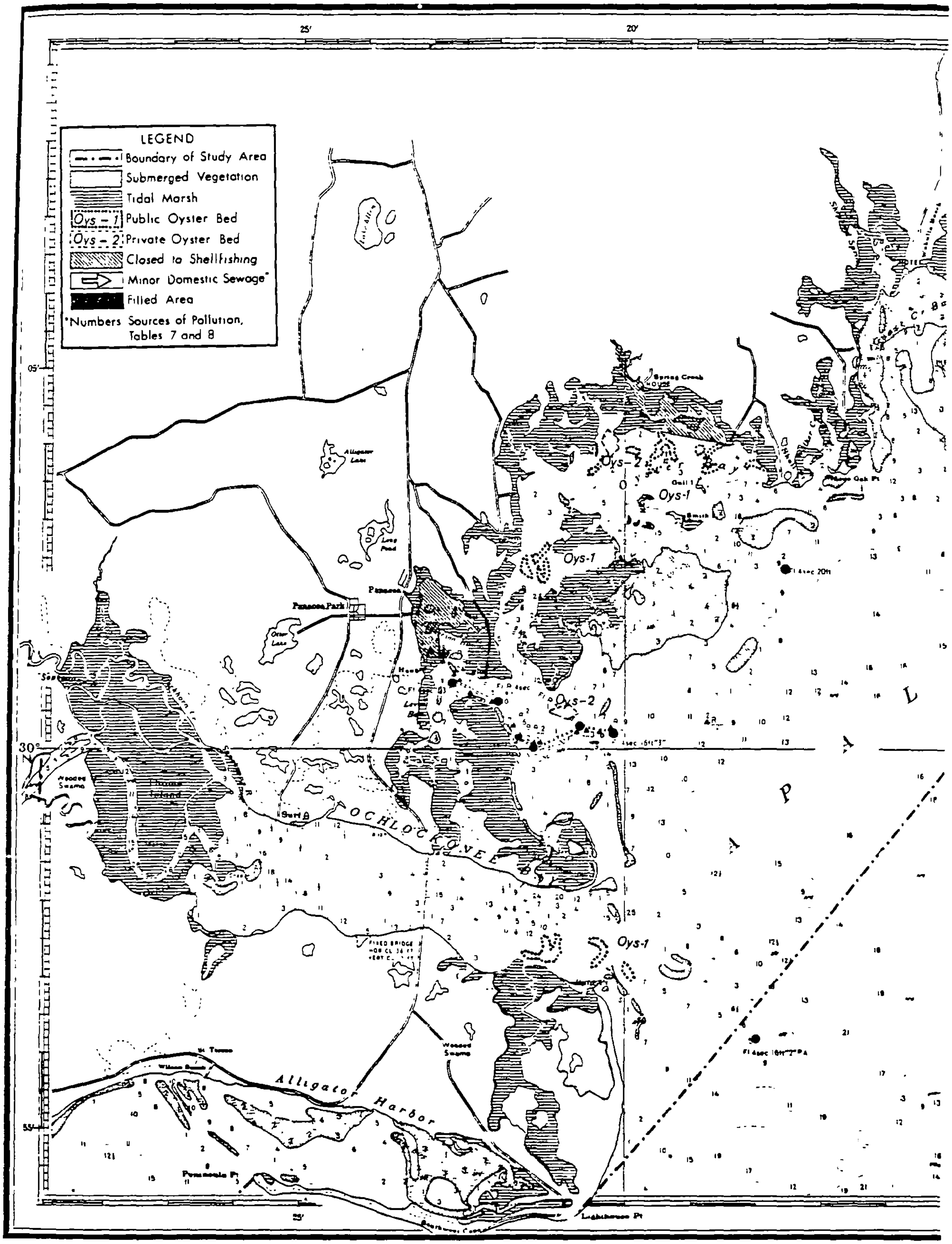
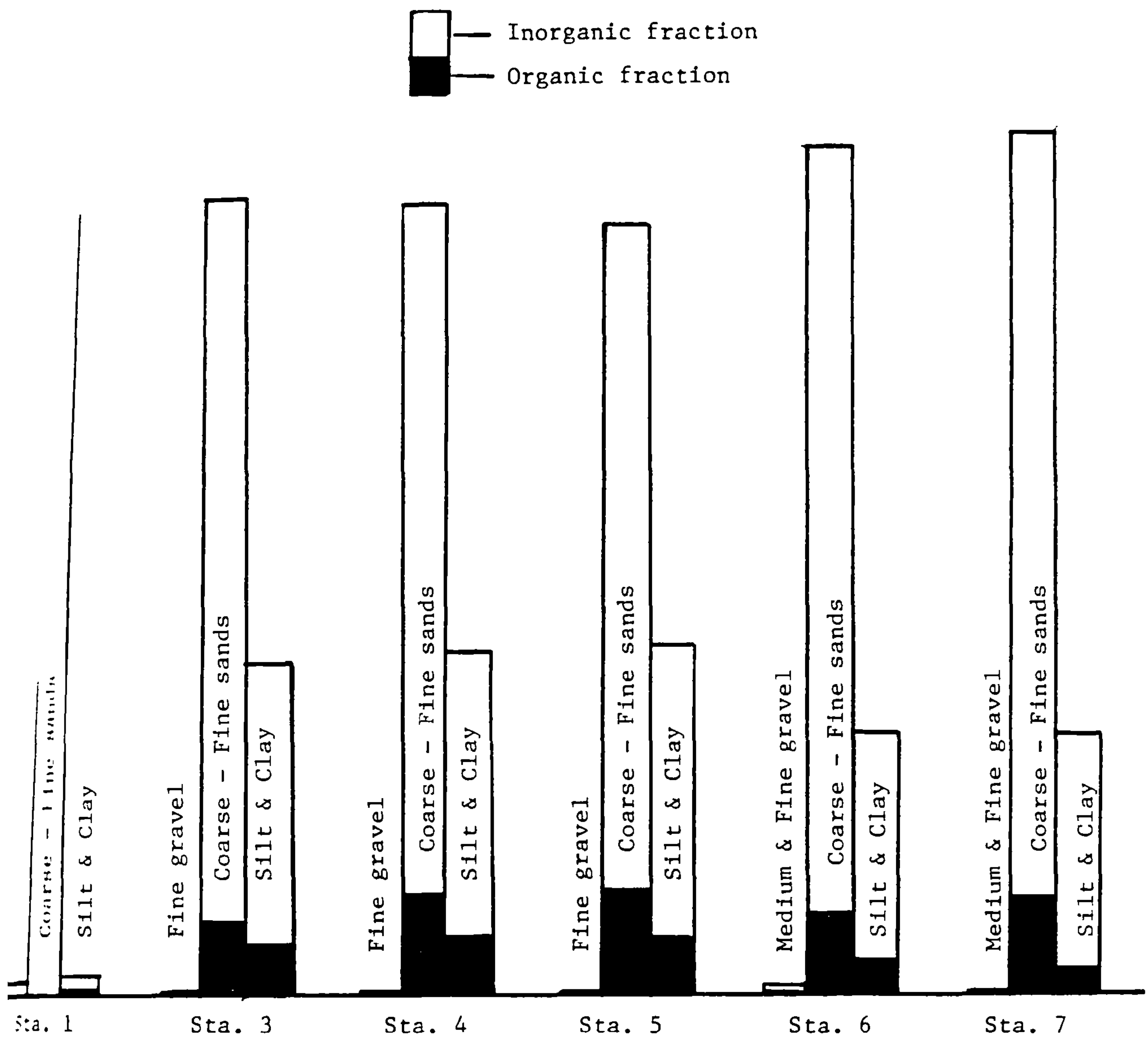
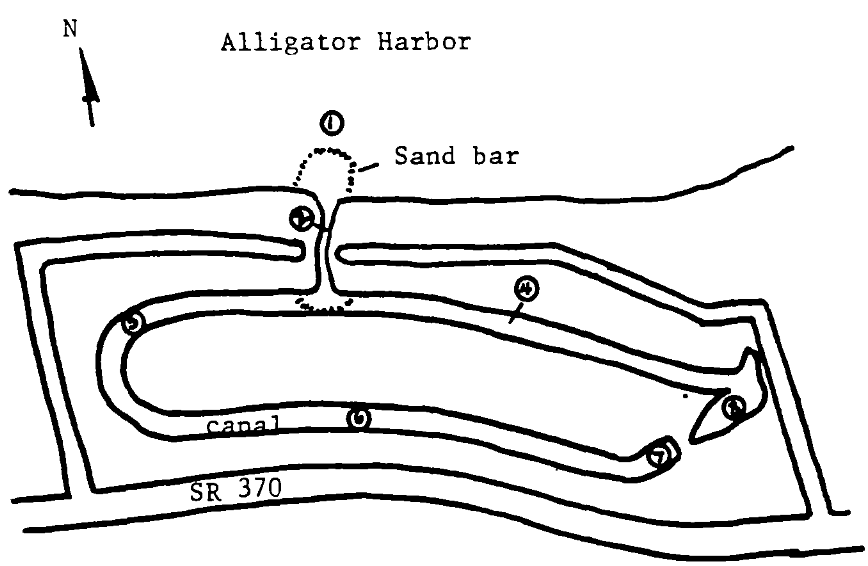


Figure 11. Sediment composition (%) of bottom sediments, B.K. Roberts canal study





STATION LOCALE

TABLE 1 . Summarization of Dissolved Oxygen, Salinity and Temperature Profiles, B. K. Roberts Canal and Alligator Harbor, July 1983.

STATION	DATE	TIME	DEPTH (ft)	SALINITY (ppt)	TEMP (°C)	D.O. mg/L
BK-7	7/14/83	1028	1	29.0	29.3	5.0
			2	29.0	29.3	4.9
			3	29.0	29.2	4.7
			4	29.0	29.2	4.3
			5	29.2	28.9	2.1
BK-7	7/14/83	1685	1	29.3	32.6	9.0
			2	29.4	32.4	8.9
			3	29.4	31.3	8.7
			4	29.3	30.4	6.7
			5	29.2	29.8	5.5
			6	29.3	29.5	4.8
			7	29.3	29.3	4.7
			8	29.3	28.8	0.8
BK-6	7/14/83	1040	1	29.1	29.3	5.8
			2	29.1	29.3	5.4
			3	29.4	29.0	3.9
BK-6	7/14/83	1710	1	29.5	32.5	8.7
			2	29.0	31.6	8.8
			3	29.7	30.7	8.0
			4	29.3	29.7	6.3
			5	29.4	29.5	4.2
BK-5	7/14/83	1048	1	29.3	29.1	4.9
			2	29.6	28.8	4.4
			3	29.6	28.8	3.6
BK-5	7/14/83	1718	1	30.1	32.0	7.5
			2	30.0	32.0	7.5
			3	30.0	32.0	7.5
			4	30.0	31.9	6.9
			5	29.8	30.6	5.4
			6	29.7	30.1	4.5
BK-4	7/14/83	1106	1	29.4	29.7	5.6
			2	29.5	29.3	5.0
			3	29.5	29.3	4.6
			4	29.6	29.2	3.8

Table 1 (continued)

STATION	DATE	TIME	DEPTH (ft)	SALINITY (ppt)	TEMP (°C)	D.O. mg/L
BK-4	7/14/83	1728	1	30.1	32.5	7.7
			2	30.1	32.4	7.8
			3	30.0	32.4	7.7
			4	29.4	32.2	7.7
			5	29.6	30.7	5.9
			6	29.6	29.5	4.5
			6 1/2	28.6	29.3	3.8
BK-3	7/14/83	1113	1	29.2	30.0	5.9
			2	29.3	29.7	5.5
			3	29.5	29.1	3.3
			4	29.6	29.1	2.4
			5	29.6	28.9	1.9
BK-3	7/14/83	1738	1	29.7	31.8	8.9
			2	29.5	31.4	9.1
			3	29.7	30.7	8.4
			4	29.7	30.4	8.3
			5	29.6	30.1	7.7
			6	29.8	29.3	4.0
			7	29.6	29.2	3.6
			7 1/2	29.2	29.1	1.9
K-2	7/14/83	1128	1	29.6	29.8	5.2
K-2	7/144/83	1804	1	30.1	31.4	7.2
			2	30.1	31.3	7.2
			3	30.0	31.3	7.1
-1	7/14/83	1136	1	29.9	29.3	5.6
			2	29.8	29.2	5.6
			3	29.8	29.1	5.6
-1	7/14/83	1755	1	30.0	31.2	7.2
			2	28.7	31.2	7.2
			3	30.0	31.1	7.1
			4	29.9	30.9	6.6

TABLE 2 . PHYTOPLANKTON - CHLOROPHYLL a CONCENTRATIONS (mg/m^3) FROM B. K. ROBERTS CANAL AND ALLIGATOR HARBOR. JULY 1983.

STATION	REPLICATE	DEPTH	CHL. a (mg/m^3)
1	1	1'	26.45
1	2	1'	19.03
3	1	1/2'	20.32
3	2	1/2'	10.64
3	1	3'	24.19
3	2	3'	30.32
4	1	1/2'	20.64
4	2	1/2'	19.67
4	1	3'	23.87
4	2	3'	29.03
5	1	1/2'	25.48
5	2	1/2'	20.32
5	1	3'	25.16
5	2	3'	32.25
6	1	1/2'	24.19
6	2	1/2'	26.12
6	1	3'	25.48
6	2	3'	34.83
7	1	1/2'	17.20
7	2	1/2'	27.41
7	1	3'	29.03
7	2	3'	23.22

TABLE 3 . Water Column Metabolism, B. K. Roberts Project, Alligator Harbor, Florida, July 1983.

Station	Net Primary Production NPP g $O_2/m^2/hr$	Respiration r g $O_2/m^2/hr$	Gross Primary Production GPP g $O_2/m^2/day$*	Respiration R g $O_2/m^2/day$**	Production: Respiration P:R Ration
1	0.42	0.10	6.76	2.40	2.82
3	1.09	0.32	18.33	7.68	2.39
5	0.72	0.16	11.44	3.84	2.98
6	0.58	0.14	9.36	3.36	2.79
7	0.85	0.43	16.64	10.32	1.61

*GPP day = 13 hr photoperiod

**R day = 24 hrs

TABLE 4. LIGHT TRANSMISSION, B. K. ROBERTS CANAL STUDY, JULY 1983.

STATION	DATE	TIME	DEPTH (FT)	% TRANSMISSION
1	7/15/83	1112	1	34
1	7/15/83	1112	2	11
3	7/15/83	1155	1	34
3	7/15/83	1155	2	18
3	7/15/83	1155	3	7
3	7/15/83	1155	4	4
3	7/15/83	1155	5	2
3	7/15/83	1155	6	1
5	7/15/83	1132	1	28
5	7/15/83	1132	2	17
5	7/15/83	1132	3	4
5	7/15/83	1132	4	3
6	7/15/83	1040	1	33
6	7/15/83	1040	2	19
6	7/15/83	1040	3	4
6	7/15/83	1040	4	2
7	7/15/83	0958	1	26
7	7/15/83	0958	2	8
7	7/15/83	0958	3	3
7	7/15/83	0958	4	1
7	7/15/83	0958	5	0.5
7	7/15/83	0958	6	0.3
7	7/15/83	0958	7	0.1

TABLE 5 . WATER CHEMISTRY DATA, B. K. ROBERTS CANAL STUDY, JULY 1983.

STATION	DATE	TIME	NH_3 mg/L	NO_2-NO_3 mg/L	TKN mg/L	T-P mg/L	TOC mg/L	Sulfides mg/L
BK-1 @ 2'	7/14/83	1137	0.20	0.05U*	0.36	0.07	14.0	
BK-1 @ 2'	7/14/83	1757	0.24	0.05U	0.24	0.06	0.8	
BK-2 @ 1'	7/14/83	1129	0.22	0.05U	0.23	0.07	14.0	
BK-2 @ 2'	7/14/83	1804	0.20	0.05U	0.35	0.07	1.2	
BK-3 @ 2-1/2'	7/14/83	1115	0.21	0.05U	0.21	0.08	13.0	
BK-3 @ 4'	7/14/83	1742	0.27	0.05U	0.32	0.07	2.3	
BK-3 @ 7-1/2'	7/14/83	1744	0.26	0.05U	0.26	0.07	14.0	
BK-4 @ 2'	7/14/83	1108	0.11	0.05U	0.28	0.06	15.0	
BK-4 @ 3'	7/14/83	1732	0.07	0.05U	0.10U	0.06	14.0	
BK-5 @ 1-1/2'	7/14/83	1050	0.07	0.05U	0.15	0.07	15.0	
BK-5 @ 3'	7/14/83	1723	0.07	0.05U	0.15	0.06	1.7	
BK-6 @ 1-1/2'	7/14/83	1042	0.23	0.05U	0.30	0.08	14.0	
BK-6 @ 3'	7/14/83	1710	0.07	0.05U	0.17	0.06	14.0	
BK-7 @ 2-1/2'	7/14/83	1030	0.25	0.05U	0.25	0.06	14.0	
BK-7 @ 3'	7/14/83	1700	0.22	0.05U	0.22	0.06	14.0	
BK-7 @ 8'	7/14/83	1700	0.35	0.05U	0.35	0.16	14.0	
BK-3 (bottom)	7/16/83	1415						1.20
BK-4 (bottom)	7/16/83	1355						0.14
BK-5 (bottom)	7/16/83	1345						0.07
BK-6 (bottom)	7/16/83	1325						0.10
BK-7 (bottom)	7/16/83	1450						4.55

*U = Material was analyzed for but not detected; the number is the minimum detection limit.

TABLE 6 . SEDIMENT CHEMISTRY DATA, B. K. ROBERTS CANAL STUDY, JULY 1983.

STATION	DATE	TIME	TKN mg/kg	NH_3 mg/kg	T-P mg/kg	COD mg/kg
BK-1	7/16/83	1405	129.0	15.0	10A*	2100
BK-3	7/16/83	1415	1620.0	183.0	270.0	36000
BK-4	7/16/83	1350	5300.0	400.0	400.0	38000
BK-5	7/16/83	1330	5720.0	321.0	380.0	38000
BK-6	7/16/83	1325	5495.0	95.0	180.0	51000
BK-7	7/16/83	1305	5378.0	278.0	300.0	38000

*A = average value

TABLE 7 . BENTHIC MACROINVERTEBRATES COLLECTED BY QUALITATIVE SAMPLING, B. K. ROBERTS CANAL AND ALLIGATOR HARBOR, PANACEA, FLORIDA, JULY 1983.

	Station BK-1 (Alligator Harbor)	Station BK-3 Side	Station BK-3 Center	Station BK-4 Side	Station BK-4 Center	Station BK- Side	Station BK- Center	Station BK-6 Side	Station BK-6 Center	Station BK-7 Side	Station BK-7 Center
Crustacea											
Corophium sp.										X	
Ampelisca sp.	X										
Mysidopsis bahia	X										
Palaemonetes pugio		X									
Penaeus sp.				X							
Tanaidacea (prob. *Leptochelia* sp.)				X							
Portunidae					X						
Polychaeta											
Glyceridae	X	X		X							
Questidae	X										
Paraonidae	X										
Spionidae	X				X	X	X			X	
Orbiniidae	X										
Terebellidae	X										
Ampharetidae		X		X							
Nereidae		X		X							
Bivalvia											
Mulinia lateralis	X										
Parastarte sp.	X										
Periploma sp.	X										
Holothuroidea								X			
TOTAL TAXA	11	4	0	5	2	1	1	1	0	1	0