PELICAN BAY DEVELOPMENT - AN ASSESSMENT OF THE POTENTIAL EFFECTS OF FILLING A 98-ACRE (39.7 ha) TRACT OF MANGROVE FOREST

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by

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SUMMARY AND CONCLUSION

Personnel of the Surveillance and Analysis Division conducted a brief field survey to characterize some hydrographic, topographic and vegetative features of a 98 acre (39.7 ha) tract of mangrove forest associated with Upper Clam Bay near Naples, Florida. The applicant (Coral Ridge - Collier Properties, Inc.) has applied for a Section 404 permit to fill the subject tract of mangroves for the purpose of completing a residential development. The survey was conducted from 9-13 July, 1979. Following are salient findings of the survey and review of data provided by the applicant.

1. Maximum tidal elevations during the study period were comparable to 5 percent of the highest tides recorded during the most recent 19 years tidal epoch. Tidal inundation of the mangrove community in the study site was limited to 30-40 percent of the forested area. This area was primarily associated with the black mangroves along the western side of Upper Clam Bay and the mangroves fronting a small tidal creek extending north of the bay.

2. Freshwater drainage, both surface and subsurface flow, appears as the primary mechanism for the delivery of detrital material to the estuary. Free litter accumulation in some areas of the forest suggest an active mechanism for detrital export and in situ decomposition despite the absence of benefits derived from routine tidal inundation. Approximately 30-40 percent of the detrital budget of Upper Clam Bay appears to be derived from its surrounding watershed and associated mangrove forests. The contribution appears comparable to the detrital yields of other important mainland mangrove areas such as Fahkahatchee Bay of the Ten Thousand Islands.

3. Consultants for the applicant provided a conservative estimate of the quantity of detritus derived from mangrove areas and an over-estimate of the organic carbon input from areas outside the Upper Clam Bay

watershed. The applicant, based on these estimates, concluded that the proposed filling activity will result in an insignificant loss in the organic carbon supply to Upper Clam Bay.

4. Recalculation of carbon inputs based on more appropriate literature values for water budget data increases significantly the estimate of detrital input values for the watershed of Upper Clam Bay and associated indigenous mangroves.

5. Filling of 98 acres (39.7 ha) of the Upper Clam Bay mangroves would decrease productivity of the area by approximately 29 percent, in terms of carbon subsidies to Upper Clam Bay.

INTRODUCTION

Collier Properties, Inc. proposes the filling of 98 acres (39.7 ha) of mangrove forest and marshland in conjunction with the Pelican Bay development in Collier County, Florida. The total development spans 2104 acres (851.5 ha) of property which includes 1312 acres (531 ha) of uplands and 792 acres (321 ha) of wetlands, beach and water. The 98 acres (39.7 ha) of proposed fill area and approximately 570 acres (230.7 ha) of estuarine wetlands to be preserved lie adjacent to the Gulf of Mexico and is part of a major lagoon system.

To facilitate a complete review of the proposed filling action as described in the public notice, the Director of the Enforcement Division requested personnel of the Surveillance and Analysis Division to conduct a survey of selected hydrological and biological features and other data associated with the proposed fill site. The field survey was completed during the period of 9-12 July 1979. Following are the results of the field effort and the evaluation of salient data provided by the applicant (Heald, et al., 1978).

STUDY AREA

As illustrated in Figure 1, the general study site is identified by the cross-hatched area shown in the northwest portion of the map. Vegetation in the fill area included mainly mangroves with marsh areas along the eastern edge. A general vegetational map (Figure 2) was provided by the applicant.

Sampling efforts focused primarily on the mangrove areas of the fill site because of their predominance and interaction with tidal exchange and freshwater drainage, a key topic in the applicant's assessment of the area's ecology.

HYDROGRAPHIC SURVEY

Transect lines, identified as A, B, and C (Figure 3), were established by standard engineering techniques to provide horizontal and vertical control. Water level recorders were referenced to National Geodetic Vertical Datum (NGVD) and placed at three locations: (1) the finger canal just north of Vanderbilt Beach Road, (2) the edge of a small lake south of Vanderbilt Beach Road, and (3) a tidal creek which extended north to northwest from Upper Clam Bay (Figure 3). The recorder sites were selected for the purpose of describing tidal dynamics and the extent of inundation of the mangrove forest segment of the proposed fill area.

The finger canal was part of an extensive residential waterway system which ultimately joined the Gulf of Mexico via Wiggins Pass. The lake appeared to be a tidal body that had been cut off from the Wiggins Pass system upon construction of the Vanderbilt Beach Road.

Changes in water levels during the two days of monitoring are shown in Figure 4 for the three staging stations. Water level responses due to tidal affects were not observed at the small lake. However, modest and strong effects were recorded at the creek and finger canal stations, respectively. Maximum tidal amplitudes recorded at the finger canal station (2.6 ft NGVD) exceeded 95 percent of all high tides during the most recent 19 year tidal epoch. Water levels in the creek attained a maximum elevation of 1.25 feet NGVD which flooded the forest floor for a distance of about 100-200 feet north of the tidal creek. Ground surface elevations of 1.20 to 1.50 feet NGVD

(Figure 3) as well as a natural berm along the creek bank (1.30 ft NGVD) deterred tidal inundation of more distant elevations. The berm abutting the tidal creek was generally at an elevation greater than 1.25 feet (the maximum tide heighth recorded in the creek); however, breaches in the berm and water transport through the porous peat substrate provided for the observed inundation.

Tidal overwash of some areas in the western sector of the proposed fill site was apparent during the survey period. A walk-through along an east-west line near township T48S (Figure 1) provided an opportunity to observe the forest floor inundated with marine water. The transect extended from the western edge of Upper Clam Bay through a black mangrove forest to near the beach line. At the time of the walk-through, tidal water was breaching a few low spots along the natural berm flanking the western edge of Upper Clam Bay.

Water transport of nutrients including organic carbon from the mangrove area of Upper Clam Bay appears linked to two mechanisms both of which are dependent primarily on freshwater drainage. Subsurface movement of water through the peat strata of the forest floor would provide a route for the transport of dissolved nutrients to the shallow groundwater system and then to the creek and bay systems. Secondly, storm events which provide intensive rainfall could saturate and inundate the forest floor by exceeding the rate of soil percolation; hence, the rainfall is impounded until a sufficient hydraulic head forces surface water flow to collection channels such as the creek shown in Figure 3 and then to the bay. Both transport mechanisms have been identified and verified in the report by Heald, et al., 1978.

The freshwater transport mechanism provides added advantages over those usually attributed to a tidal-driven mechanism. Results from an on-going EPA-sponsored research project at Rookery Bay indicates that freshwater increases the leaching rate of soluble compounds from mangrove litter, especially black mangrove leaves. The same consequence could be extended to mangrove peat. Furthermore, freshwater has proven to be a solvent which is superior to seawater for maintaining organic and inorganic compounds in the dissolved state. Snedaker, et al., 1977, provided an extensive discussion of this relationship which greatly aids in explaining the presence of extensive quantities of finely divided organic materials deposited on the bottom of the creek which penetrated the mangrove area north of

Upper Clam Bay. Other extensive deposits were also apparent along the near-shore reaches of the northern-most area of the upper bay. This form of carbon storage as well as the litter that is associated with the floor of the forest would have to be considered in extensive detail when developing an export model which describes the direct carbon output from mangrove litter. The pathway for flushing of the Clam Bay system remains primary with the existing pass to the Gulf. Construction activities associated with land development such as Seagate, Parkshore and Vanderbilt coupled with the intermittent closure of the pass decrease flushing of the system. Hence, large stores of organic material in the system appear unavoidable.

BIOLOGICAL SURVEY

As shown in Figure 3, plant association and ground elevations (NGVD) are reported for each station on the transect line.

To determine the relative structural maturity of the mangrove forest in the study area, a complexity index was determined for the area of station A-3 and in the manner described by Snedaker and Lugo, 1973. The index was derived from the calculated relationship between number of species present, maximum canopy height, tree abundance, and trunk basal area for a 0.1 ha of forest:

$$\text{Complexity Index} = \frac{(\Sigma \text{ Basal area})\ (\text{No. trees})\ (\text{max. Canopy heighth})\ (\text{No. species})}{1000}$$

Free litter accumulation on the forest floor was also measured at the site where the structural data was obtained. Gathering of litter was gathered from 10 quarter meter square quadrants. Each quadrant was spaced at a 5-meter interval along a transect line running east to west. In the lab, the loose litter samples were sorted into leaves and woody material, dried at 105°C, weighed, and reported in Table 1.

The western portion of the survey area was characterized as a mature black mangrove basin forest (Figure 2). Traditionally, this type of forest is associated with low areas where surface water is impounded over an extended period. The areas drain slowly because of the saturated peat substrate and the low topographic relief of the land. Furthermore, a slight, natural berm limits surface water exchange to a few points at the edge of the bay. In any case, long-term impoundment of saline water introduced via major high tides can lead to hypersaline conditions as evapotranspiration proceeds. In some instances, the community becomes stressed by excessive salt accumulation which inhibits or possibly terminates the growth of the mangroves. As reported by Heald, et al., 1978, hypersaline conditions occasionally occurred in the project site and may be responsible for an apparent low litter production rate in the black mangrove area west of Upper Clam Bay.

A mixed community of mangroves was featured in the area surveyed where higher land elevations prevailed (Figure 3). Coexisting with the mangroves were some Brazilian pepper and fern. Their presence most likely reflected the absence of salt effects and not necessarily a successional process. From the topographic features shown in Figure 3 and the water level record provided previously, tidal inundation of this area would be a rare event. However, the topography features a land surface slope to the west thus providing a gradient for the flow of surface and subsurface freshwater to the lower black mangrove basin and to the Upper Clam Bay lagoon. As shown in another case at Everglades City, horizontal movement of water through mangrove peat is virtually unrestricted by the substrate (Cavinder and Hicks, 1978). Consequently, subterranean and surface drainage pathways coupled to an active breakdown of the litter would aid in explaining the relatively low standing biomass of free litter at station A-3.

In the vicinity of station A-3, the average standing biomass of free litter was 901 gm dry wt/m^2 (Table 1). Of particular note is the reported abundance of wood in the litter samples which may reflect advanced maturity of the forest. Low wood fall can be associated with immature stands of mangroves. The accumulation of woody litter can also reflect the absence of recycling benefits from hurricanes (Pool, Lugo, and Snedaker, 1975). A complexity index of 70 for the forest at this location indicates a very mature state of growth (Lugo, personal communication).

For comparison, the following complexity indices of various mangrove forests are provided:

Location	Forest Type	
	Basin	Riverine
Rookery Bay, FL	61	
Everglades City, FL	39.7	
Puerto Rico		15.4
Mexico		73.2, 49.7
Florida		27.7
Costa Rica		10.3
Upper Pelican Bay	70	

When compared to other mangrove forests, the free litter estimates for station A-3 appeared low. At Rookery Bay, another mature basin forest, leaf accumulation on the forest floor averaged 559 gm dry wt/m^2 (leaves only) for a 2-year sampling period (Lugo and Snedaker, 1975). Compared to the Rookery Bay site, leaf accumulation at station A-3 was approximately 25 percent less. The Rookery Bay site was subject to tidal inundation from spring tides and major storm events during the wet season. For riverine and fringing mangroves in other areas of Florida, (Lugo and Snedaker, 1974), total free litter was reported to range from 2273 to 9841 gm dry wt/m^2. Cavinder and Hicks, 1978, reported an average free litter accumulation of 3704, 2709, and 800 gm dry wt/m^2 for different sites in a riverine community near Everglades City, Florida (Table 2). These latter data also demonstrate the need for extensive sampling because of the extremely patchy nature of litter distribution. In Lugo and Snedaker, 1975, the authors also referenced patchy distribution as a factor affecting variability.

The relatively low storage of litter at station A-3 of Upper Clam Bay suggests an active decomposition and export mechanism at work. The basis for this suggestion, however, requires the assumption that litter storage on the forest floor is at equilibrium with production.

An accurate estimate of free litter on the forest floor is essential if any meaningful assessment of the forest's detrital export system is attempted. Such data represents a measure of carbon storage which is a mediating factor on the export of carbon (detritus) to the estuary. All litter that falls to the forest floor is seldom caught up in an instantaneous export mechanism to the estuary. Lugo and Snedaker, 1975, reported that about 40 percent of the annual leaf fall in a mixed mangrove basin was exported directly with the remaining litter undergoing in situ decomposition. Exceptions to this view could be associated with fringing communities of mangroves and tidally overwashed islands. In these cases, much of the litter drop is subject immediately to a transport mechanism.

In Heald, et al., 1978, the authors provided an estimate of the detrital contribution of mangroves to Upper Clam Bay. However, in our view, the estimate was at best a conservative accounting because of the sampling and interpretive strategy employed. First, the method of sampling cannot provide a representative estimate of litter production. For each forest type, only two collection baskets were apparently employed. In each case, they were in close proximity to each other and serviced for 6 months from mid-May to mid-October, a period of 163 days. Such an effort would fail to account for spatial and temporal variations which are key features of such data. Month to month variation in litter production is clearly illustrated in Figure 5, which shows temporal patterns of litter fall at Rookery Bay. In Figure 5, we have added the mean daily litter production rate for the period of mid-May to mid-October for 1972 and 1973. Nearly a 40 percent variation between the 2 years occurred. The average for the 3-year period was 2.2 which is also the average of the two extremes used in the example. Dr. Snedaker of the University of Miami has over the past 7 years developed the most extensive record of litter production for mangrove forests in Florida and possibly the world. He reports that 20 collection baskets for each forest type operated over a two year period is a minimum effort for making meaningful assessments of litter production rates for any mangrove forest (personal communications).

Because of the restricted sampling efforts, the litter production rates provided in Heald, et al., 1978, should be viewed with caution when judging the representativeness of the data. This caution emerges with the conclusion of the authors that the litter production data reported for Upper Clam Bay are "roughly comparable" to published information. Reference data for this conclusion are found in Pool, Lugo, and Snedaker, 1975.

These investigators report the findings of a 3-year study of litter production for a mixed mangrove basin forest at Rookery Bay. In graphical form, these findings are illustrated in Figure 5. From this figure, daily, monthly, semi-annual and annual variations in production rates are clearly salient features of the 3-year record. For example, we have indicated in the figure the average daily production rate of 1.7 and 2.7 gm dry wt/m^2 for the May through October period of 1972 and 1973, respectively. For Upper Clam Bay, Heald, et al., 1978, report a daily average of 3.0 gm dry wt/m^2 for the May through October period of their study. By comparison, the estimate provided for Upper Clam Bay is from 10 to 43 percent greater than the values emphasized for Rookery Bay. Additionally, the reported litter production rate for Upper Clam Bay exceeds by 27 percent the average rate of 2.2 for Rookery Bay. Such an inflated value would have a reciprocal effect on the estimates provided in Heald, et al., 1978, regarding litter contributions from mangroves to Upper Clam Bay.

As determined in Heald, et al., 1978, the litter production of mangroves associated with Upper Clam Bay was 117,900 kg C for the study period (163 days). Carbon input to the Upper Clam Bay system from the mangrove area was also reported at 31,000 kg C during the same general study period; hence, the detrital load was equivalent to about 26 percent of the litter produced. Should the estimate of litter production (117,900 kg) be inflated by 27 percent, the detrital load to the bay could then be viewed as equivalent to 36 percent of the litter produced. This type of accounting only reflects the inadequacy of the sampling effort for assessing litter production. It remains an extremely superficial treatment of a very complex mechanism of litter production and its export. No considerations are extended to the affects of litter storage and litter turnover on carbon export to the estuary. The assessment provides only a hint to the possible sources of the carbon which fuels the detrital economy of the bay.

In Heald, et al., 1978, the authors provided a summary section which reports the carbon load to Upper Clam Bay at 95 metric tons for the 6 month study period. Of this total, they attributed 33 percent of the load originating with drainage from the watershed of Upper Clam Bay and associated mangrove areas and the remaining portion delivered with subterranean drainage from uplands outside the watershed. With the filling of 98 acres (39.7 ha), the contribution from the watershed and mangrove areas would potentially be diminished by about 22 percent of the total input of organic carbon to Upper Clam Bay. The applicant views this reduction as an insignificant loss to the productivity of the Clam Bay estuary. In our judgment, the basis of the applicant's conclusion lacks sufficient technical merit or precedence. Furthermore, the following discussion will provide a basis to view the filling of the 98 acres (39.7 ha) of mangroves as constituting even a greater loss than predicted from results reported in Heald, et al., 1976.

Approximately 71 million ft^3 of water entered Upper Clam Bay during the study period (Gee and Jenson, 1978). Potentially, rainfall could have contributed 68 million ft^3 to this total; however, 44 million ft^3 was transpired which diminished the rainfall contribution to 24 million ft^3 (Heald, et al., 1978). By deduction, the latter investigators hence reported that 47 million ft^3 originated from upland sources outside the watershed of Upper Clam Bay. Because the subsurface water supply contained organic matter, it would be viewed as a source of carbon to the bay. As proposed in Heald, et al., 1978, the upland source constituted at least 67 percent carbon subsidy to the bay.

Because transpiration (44 million ft^3) was sited as the principal consumptive use of rainfall, it constituted a major factor in the partitioning of the water budget. An over-estimate of transpiration tends to emphasize the importance of the subsidy from areas outside the watershed. Conversely, the lesser the transpiration losses, the greater is the drainage and carbon contributions from the mangrove areas and Upper Clam Bay watershed. The transpiration estimate was derived by Heald, et al., 1978, in the following manner.

Lugo and Snedaker, 1975, reported transpiration rates of 4194 and 2529 gm H_2O/m^2/day for fringe and basin mangroves, respectively. These values, when averaged, yield a mean of about 3400 gm H_2O/m^2/day. This value appeared as the estimate used to calculate transpiration for the mangroves and other vegetative areas of the Upper Clam Bay watershed. In view of the results presented in Carter, et al., 1973, the potential consumptive use of freshwater via transpiration appears as an over-estimate for the Upper Clam Bay watershed. From the latter work, the daily evapotranspiration rate for the Fahkahatchee Strand for the May through October period appeared near 2500 gm H_2O/m^2/day. As discussed next, the lower value of 2529 gm H_2O/m^2/day would have been more appropriate for estimating transpiration for the Upper Clam Bay watershed.

By averaging the two transpiration rates provided in Lugo and Snedaker, 1976, the resulting mean is weighted towards the higher value for fringing red mangroves. With the Upper Clam Bay system, the fringing red mangrove community constitutes less than 1 percent of the total acreage of the watershed. Secondly, no justifications are given in Heald, et al., 1978, for even considering the transpiration rates in Lugo and Snedaker as being applicable to upland regions such as pine flatwood and dwarf live oak communities which predominate the upland area of the watershed (Figure 2). Clearly a more conservative estimate of transpiration should have been used in partitioning the water budget for the Upper Clam Bay watershed. As shown next, a more conservative estmate of water losses via transpiration leads to a greater estimate of the carbon contribution originating from the watershed and associated mangroves.

Using the transpiration rate of 2529 gm H_2O/m^2/day (Lugo and Snedaker, 1975), water losses for the watershed would have amounted to 31 million ft^3 for the 6-month study period. With this accounting, the carbon subsidy to the bay of 64 metric tons from subterranean flow outside the watershed would be reduced by about 28 percent to 46 metric tons. In this assessment, the proportion of the total detrital load to Upper Clam Bay would be as follows:

	Contribution by Weight	
West/Northwest Mangrove Area	26.8	35%
East Mangrove Area	4.2	5%
Non-Mangrove	46.0	60%
	77.0 metric tons	100%

Combined, approximately 40 percent of the carbon budget of Upper Clam Bay can be traced to drainage from the mainland mangrove areas. From Carter, et al., about 48 percent of the organic carbon load to Fahkahatchee Bay was derived from mainland mangrove areas. In our judgment, the two export figures (40 and 48 percent) are comparable. Presently, the applicant proposes to fill approximately 72 percent of mangrove forests associated with Upper Clam Bay area and develop most of the remaining watershed. In effect, the detrital budget of Upper Clam Bay would be proportionally diminished to about 51.8 metric tons which constitute a reduction of 29 percent in potential productivity of the estuary. Greater losses can be expected if a more conservative estimate of transpiration is considered or the existing estimate of water inflow to the bay is reduced.

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Table 1

Free Litter Estimates g/m^2 Dry Weight
Pelican Bay Development, Collier County, Florida
July 1979

Sample No.	g dry wt/m^2		
	Leaves	Wood	Total
1	163.6	1114.8	1278.4
2	475.8	836.6	1312.4
3	171.6	265.4	437.0
4	380.2	634.9	1015.1
5	170.0	558.6	728.6
6	732.0	269.6	1001.6
7	350.8	256.6	607.4
8	882.5	92.3	974.8
9	508.4	156.5	664.9
10	524.4	468.6	993.0
Mean	435.9	465.4	901.3
Standard Deviation	242.0	325.0	286.0

Table 2

Free Litter Estimates gm/m^2, Dry Weight,
Everglades City, Florida
September 1978

Station A-13	Station B-15	Station B-19
5032	1872	312
5552	1684	1536
4068	1536	1588
2628	3356	396
3764	2552	664
2980	3828	292
2836	2464	1060
3668	3404	460
2344	2096	956
4168	4296	740
mean 3704 gm/m^2	mean 2709 gm/m^2	mean 800 gm/m^2
S.D. 1044.37 gm/m^2	S.D. 958 gm/^{2}	S.D. 478 gm/m^2

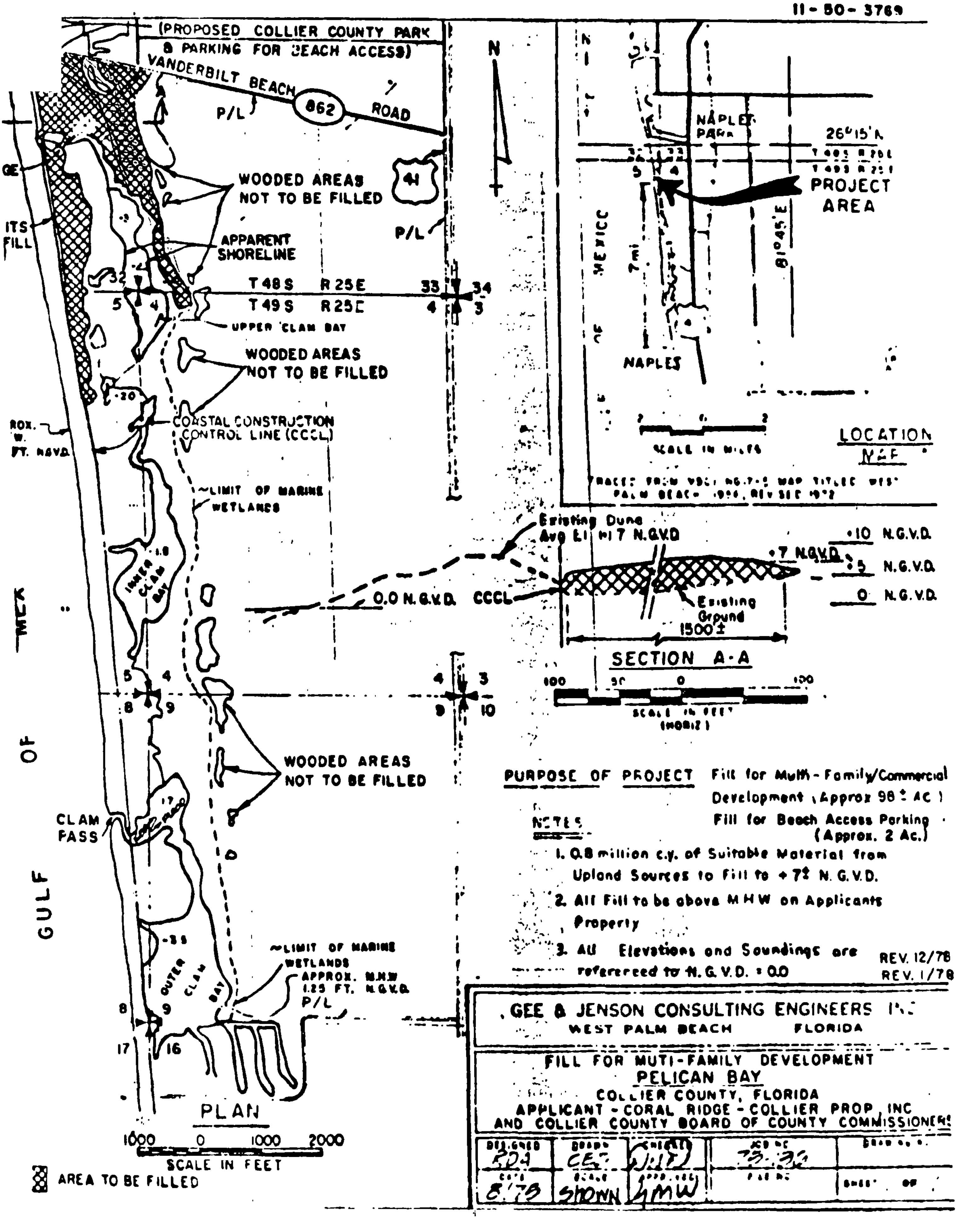


Figure 1. Proposed area to be filled for the
Pelican Bay project. Naples, Florida.

applicant. Naples, Florida.

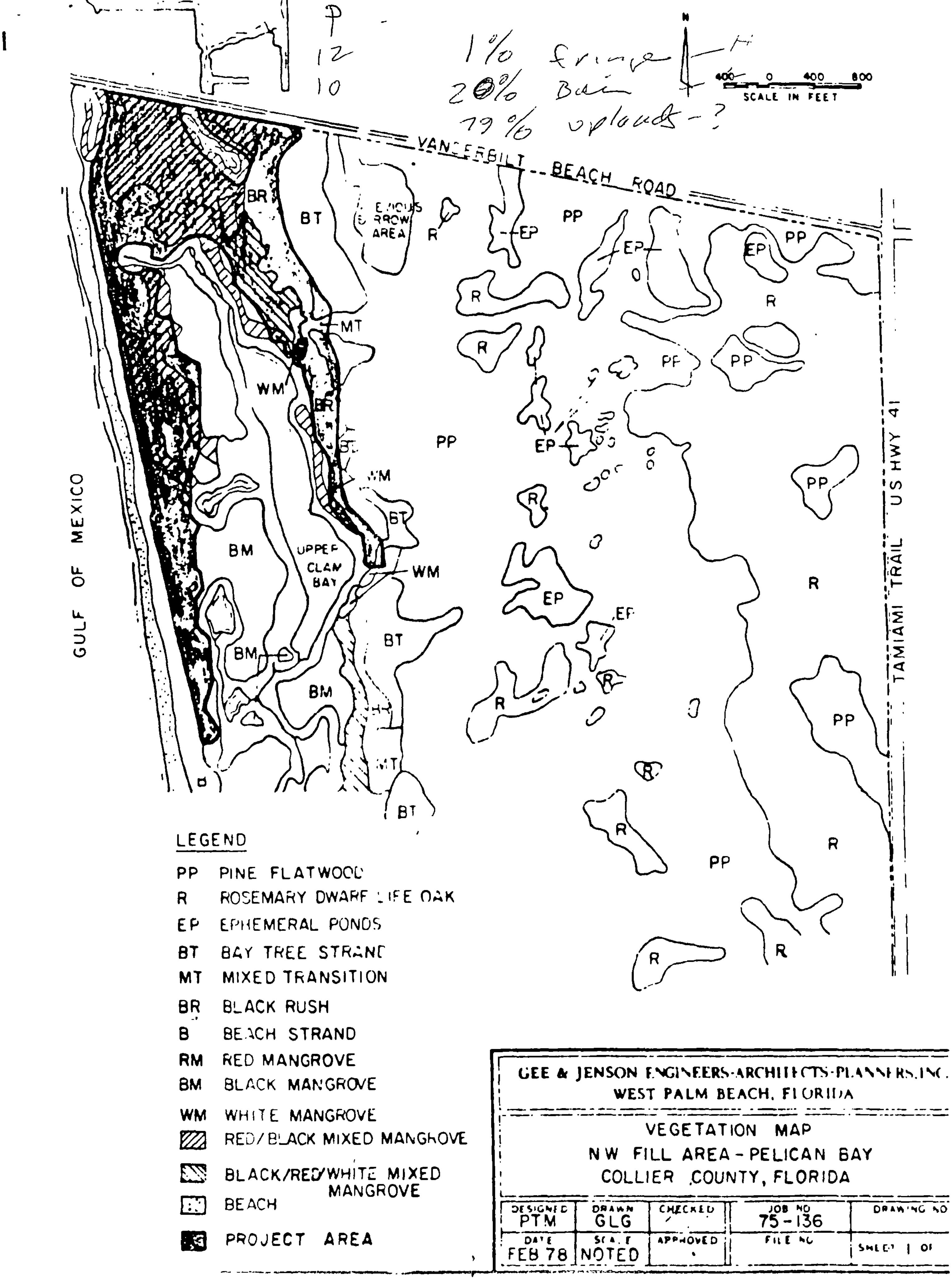
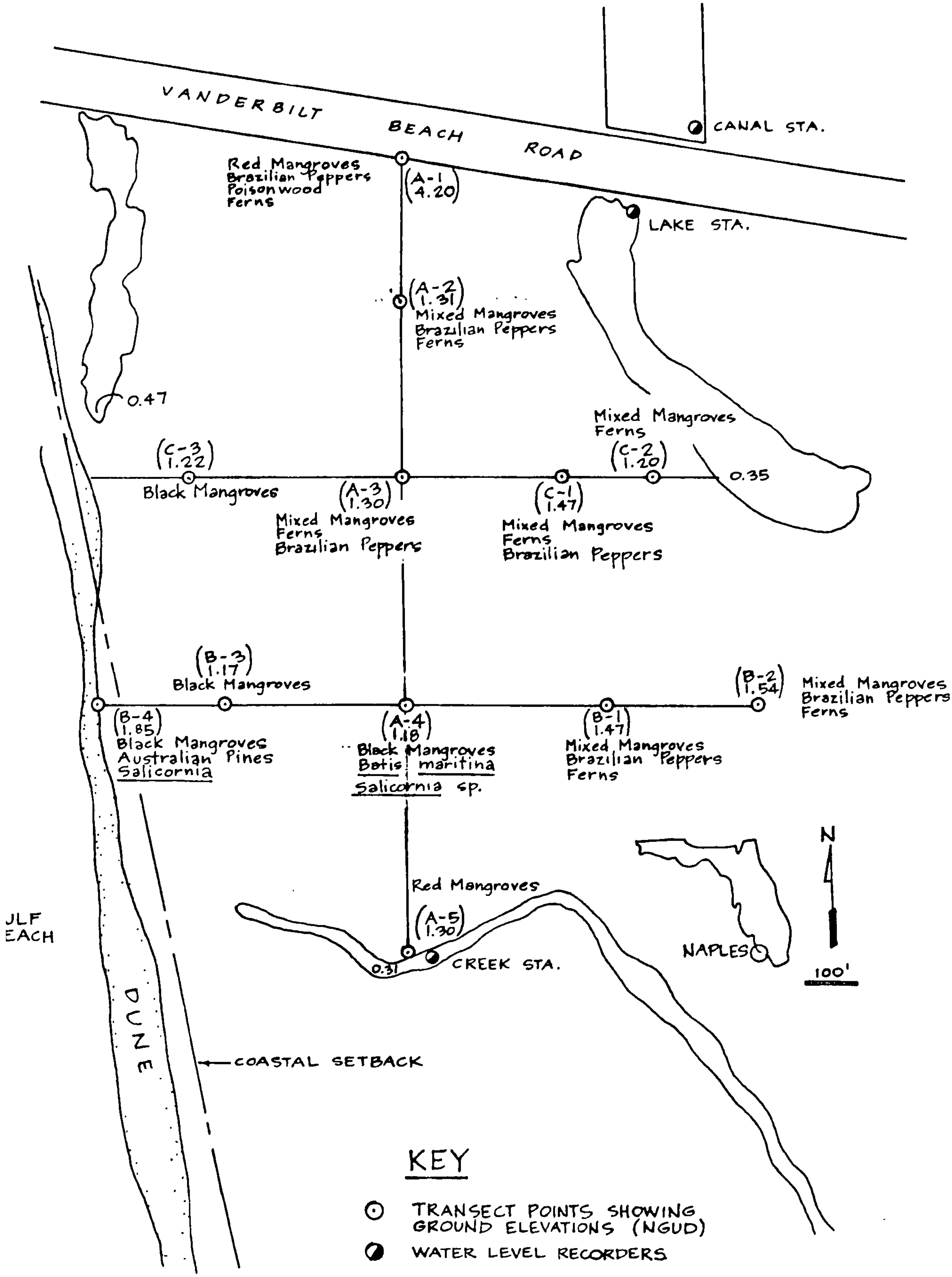


Figure 3. Study transects, with ground elevations (NGVD), locations of water level recorders, and sites for vegetational characterization. Upper Clam Bay, Naples, Florida. 1979.



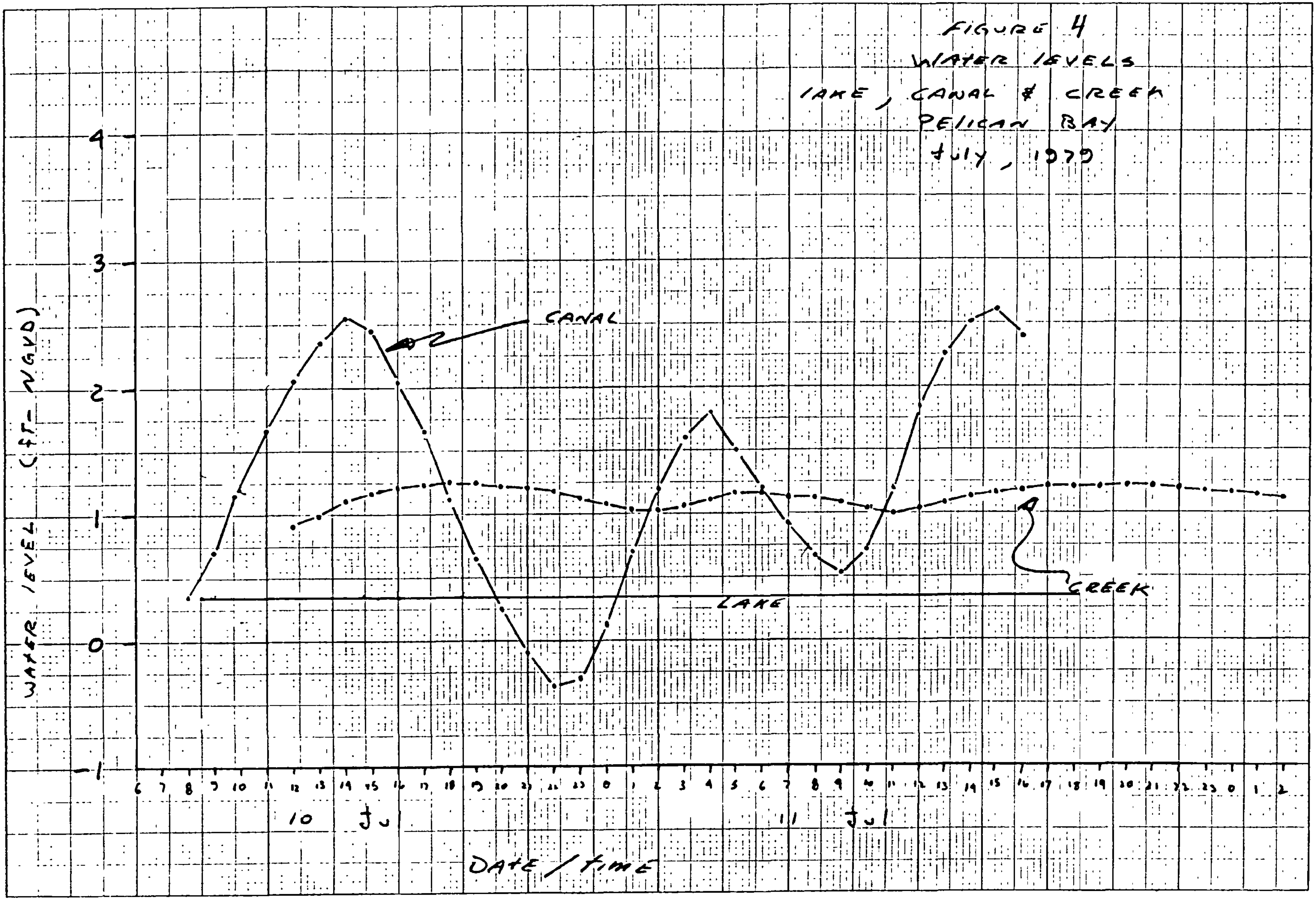
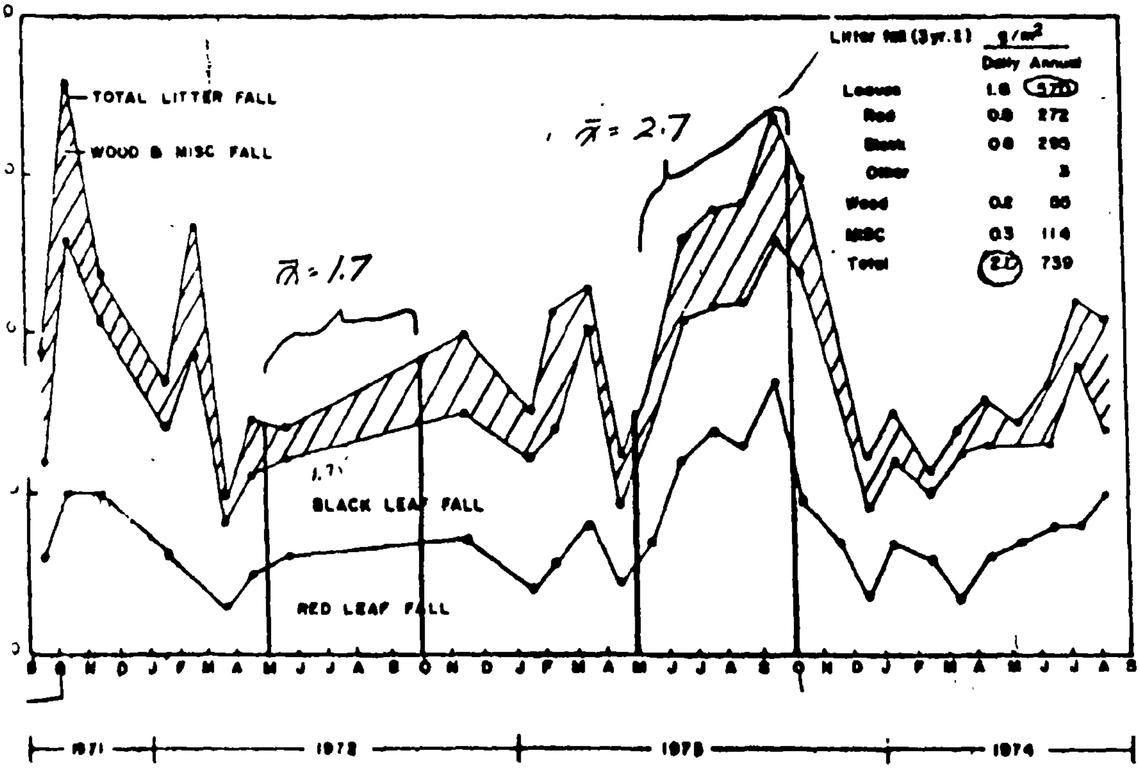


FIGURE 4
WATER LEVELS
LAKE, CANAL & CREEK
PELICAN BAY
JULY, 1979
CANAL
CREEK
LAKE
WATER LEVEL (FT - NGVD)
4
3
2
1
0
-1
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0 1 2
10 JUL
11 JUL
DATE / TIME

Figure 5. From Pool, Lugo, and Snedaker, 1976.
Emphasis added by this author.



Patterns of total litter-fall including leaf, wood, and miscellaneous fall for a basin mangrove at Rookery Bay, Florida. Data based on litter-fall collections from August 1971 to August 1974.