AN ECOLOGICAL RECONNAISSANCE OF
THE GRAND CANAL
SIESTA KEY, FLORIDA

Prepared for: Office of Coastal Zone Management
Environmental Services Department
County of Sarasota

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July 7, 1983

Mr. Robert Patten
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Dear Mr. Patten:

I am pleased to submit the enclosed report of our findings on the ecological status of the Grand Canal, Siesta Key. The report culminates nearly 300 hours of field and laboratory effort and should satisfy your immediate needs for preliminary information on the condition of the canal network.

Sincerely,

Ernest D. Estevez, Ph
Staff Scientist

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Enclosure

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Introduction

Mote Marine Laboratory (MML) was charged in May 1983 by the Sarasota County Office of Coastal Zone Management to perform an ecological reconnaissance of the Grand Canal, a network of waterways on the north end of Siesta Key, Florida. Tasks included:

1. Physical Reconnaissance: Field verification of aerial photography and County data on canal shape; drainage patterns and discharges to the canal: locations of culverts, bridges, and other structures; and mapping of fine sediment accumulations throughout the canal system.

2. Hydrographic Reconnaissance: Installation of ten temporary staff gauges and their observation over a complete semidiurnal tide: *in situ* measurements at gauge sites of temperature, salinity, dissolved oxygen and pH at surface, middle and bottom depths.

3. Biological Reconnaissance: Survey of epifauna and epiflora on intertidal substrata throughout the canal: quantitative grab samples at ten sites (1 sample/site) and analysis for density, species richness, and presence of pollution indicator species.

The objectives of the reconnaissance were threefold. First, certain aspects of past studies in the Grand Canal were to be revisited. Second, present ecological conditions in the canal were to be evaluated using new techniques. Third, a preliminary assessment was to be made of various mitigation actions proposed for the Grand Canal.

Problem Statement and Background

Although the environmental disadvantages of waterfront canals have been known for as long as their advantages to investors and developers, the first formal review and statement of the problem did not appear until 1972 (Barada and Partington, 1972). Two years later a report was released by New College professor J.B. Merrill and students C. deNarvaez, R. Foster, F.B. Ayer and E. Conner, entitled "Hydrography of the Grand Canal and Heron Lagoon Waterways, Siesta Key, Florida" in which many adverse environmental conditions were described for the Grand Canal. The report was based upon studies of hydrography, benthos, sedimentation and phytoplankton of the Grand Canal. Morrill et al. (1974) concluded:

> Of the two canal systems, the overall water quality and diversity of marine life is greater in the Heron Lagoon system than in the Grand Canal system. In the latter system sluggish tidal circulation and nutrient enrichment appear to be the primary causes of "undesirable" water quality conditions and the development of organically rich, soft bottom sediments and their communities of macro and micro-organisms. Neither canal system appears to constitute a health hazard at the present time. However, unless corrective measures are taken, waters in sections of the Grand Canal system will continue to deteriorate and ultimately influence the water quality and marine life in the adjoining areas of Roberts Bay.

The *New* College team recommended that in the Grand Canal:

o tidal flushing be increased by hydraulic interconnections if warranted by physical studies and allowed by regulatory agencies:

o shoreline vegetation be kept out of the waterways and that organic debris be manually removed;

o carbon and nitrogen in the SKUA wastewater plant effluent be decreased by 90 percent:

o pesticide and fertilizer applications to canal front lawns be avoided in the wet season:

o attempts be made to increase levels of dissolved oxygen near the canal bottom, perhaps by compressed air lines and water agitators;

o control of surface runoff be reduced by *new* construction standards <u>and</u> <u>also</u> by retrofitting of existing drainage systems;

o a long term ecological monitoring program be implemented.

Only one recommendation by Morrill et al. (1974) has been implemented to date. The SKUA facility now provides "tertiary" treatment wherein more than 80% and 90% of nitrogen and phosphorous (respectively) are being removed (Patten, 1982).

In January 1982 the Waterways and Canals Committee of the Siesta Key Association of Sarasota, Inc. called upon the Sarasota County Commission to recognize the adverse impacts to the canal of surface water discharges and, specifically, to

Provide an opening with a one-way valve, to allow tidal flow into the Grand Canal system from the Gulf of Mexico, thereby increasing tidal flushing,
and;
Adopt an ordinance requiring that canal shoreline vegetation be kept pruned so that waterflow and canal traffic are not impeded by submerged or hanging branchings.
(Loving, 1982)

Curiously, the Association did not request that stormwater controls be improved or that other recommendations by the New College team be implemented.

Later in 1982, coastal zone managers for Sarasota County responded to the Siesta Key Association's initiative. The County conducted a thorough survey and inventory of stormwater outlets discharging to the Grand Canal (Perry, 1982). Also, in a letter dated April 8, 1982, R. Patten posed several questions for which he desired answers before proceeding with mitigative or regulatory measures:

o What are the water quality parameters that now exist in the Grand Canal?

o How does water quality in the canal system correspond with ambient water quality in the receiving waters of Roberts Bay?

o What are the primary sources of nutrient loadings in the canal system?

o Specifically, what percentage of nutrient loading is caused by lawn fertilizer washed into the canal?

o What is the subterranean connection of the canal to the water table and rainfall?

These and related questions are central to management of the Grand Canal but could not be addressed quickly or inexpensively.

The following report was not concerned with any of these questions but rather addresses the ecological status of the Grand Canal and the management directions for new study that should be pursued to best advantage.

General Findings

The Grand Canal network of waterways can be divided into components named according to the system used by Merrill et al. (1974) and employed by Perry (1982). The nine areas also used in this report are named Bay Point, Waterside Wood,' Waterside East, Harmony, Waterside West, Sarasands, Siesta Manor, Palm Island and Siesta Isles (Figure 1). The canal network traverses moderate to high density neighborhoods and displays considerable variation with regard to shoreline type and condition, adjacent land use, and environmental quality.

Drainage

The Perry (1982) inventory of catch basins and stormwater outfalls is thorough and accurate (Figure 2). Our surveys of drainage structures were conducted from land and boat so numerous additional discharges were observed; however, none were inventoried since doing so would have required access to private property. In general, additional discharges other than seawall weep holes appear to include yard drainage-ways, swimming pool outlets, and parking lots or driveways abutting the canal. A culvert linking the Palm Island tidal pond to the Palm Island canal could also be considered a point of discharge,

Drainage on lands near the canal network is rapid. Lawn irrigation is intensive but no standing water was observed. Neighborhoods were visited during rainstorms and in most places were perfectly drained. After one rain the color of the lower canal near Midnight Pass Road became milky and a sheen was observed.

Bathymetry

A preliminary reconnaissance of the canal network confirmed the presence of a "primary circuit", or continuous loop central to all other canal segments. This primary circuit controls the hydrology of the entire network and, on the other hand, is affected by the cumulative impact of each segment's discharge and water quality. The primary circuit was surveyed June 3, 1983 at 1100 hours. Figure 3 and the accompanying chart in Figure 4 contain continuous depth records for the complete circuit, determined over a 30 minute period.

The transducer constant for the Sitex Clean Echo Fathometer employed in the survey was -0.4 ft. High tide for June 3 was 0923 hrs (+1.6 ft) and low tide after the survey was 1323 hrs (+1.4 ft) so fathometer data were corrected by 1.5 ft - 0.4 ft = 1.1 ft. Vertical bars on the fathometer charts indicate reference landmarks depicted in Figure 3. Depths in feet are shown at each reference point and at areas of notable relief.

Depths in the primary circuit ranged from 1.5 ft to 10.5 ft. The deepest water was found at the canal entrance; shallowest water in the primary circuit occurred at Mark 12 where the west end of Sarasands meets the south end of Siesta Manor. The cumulative mean depth for the primary circuit was 5.2 ft (s.d. 2.4 ft; N = 50). Merrill et al. (1974) gave average depths for 3 segments which can be compared to the present data:

	Average Depth (ft) Reported In:	
Segment	Merrill et al. 1974	This Study
Ocean Beach	5	3.0 (s.d.=1.1)
Sarasands	4-5	2.8 (s.d.=1.1)
Paradise Island (& Siesta Manor)	4-5	2.9 (s.d.=0.8)

This comparison suggests that infilling of the primary circuit may be proceeding at a very rapid rate, but better historical data should be sought to confirm this trend. More data on infilling will be presented in a subsequent section,

Shoaling and high points near the canal mouth (Mark 1) and a bathymetric rise near the Midnight Pass Road Bridge separate the lower canal into basins. Other parts of the primary circuit are not segmented in this manner; the usual condition is one of gradual, sloping relief. Water near bridges is shallower or deeper than between bridges and no consistent pattern was evident. Large debris and other potential obstacles to flow were detected by the fathometer in a few places but other objects (pile, branches, collapsed docks) were seen to be more numerous near to each bank.

Sedimentation

Morrill et al. (1974) and Perry (1982) commented briefly on sedimentation in the Grand Canal. In light of findings based upon our fathometric study and the known role of sediments in determining water quality, especially in canal systems, we conducted a survey to determine sediment thickness in the Grand Canal. A long metal probe connected to a staff gauge was manually thrust into the canal floor until resistance was met, usually by the underlying sand. Sedimentation was recorded as the thickness, in feet, of the accumulated fine, highly organic and often anaerobic material over the true canal floor. Data are presented for 24 representative sites in Figure 5. For the entire Grand Canal network, mean sedimentation was 0.9 ft (s.d. = 0.7 ft); the range was 0.1 ft to 2.7 ft. The high value of 2.7 ft was seen in the Palm Island segment. Mean sedimentation values for each canal segment are given below.

Segment	Mean Thickness (ft) of Fine, Organic Sediment
Entrance to SKUA	0.6 (s.d.=0.5)
Siesta Isles	1.1 (s.d.=0.7)
Palm Island	1.1 (s.d.=1.4)
Sarasands (& Siesta Manor)	0.8 (s.d.=0.4)
Paradise Island (to Ocean Beach)	0.5 (s.d.=0.7)

Close visual inspection of sediment from sites throughout the canal network did not provide much insight as to the origin of the accumulation, with one exception noted below. Sediments were dark, comprised largely of clay and silt sized particles, organic, and at times permeated with H_2S. Litter described by Morrill et al. (1974) as detritus was found everywhere in the canal network. Needed are analytical surveys of canal sediments designed to differentiate organic material produced by septage wastes from other sources, and to identify the relative amounts of petrogenic, pyrogenic and biogenic hydrocarbons.

One final comment is necessary in light of past discussions of sedimentation and new data for the Grand Canal. Fine organic matter is of course easily transported in the water column from its point of origin and is more likely to settle in quiet, depositional environments than elsewhere. Moreover, each canal segment is oriented uniquely relative to wind and proximity to Roberts Bay, and most are of significantly different ages. Some segments of the network may be continual sediment sinks, while others are net sources of material. Fine sediments are also reworked by storms, peak rainfall events, and boat traffic.

Benthic Fauna

Benthic (bottom-dwelling) infauna have been shown by numerous studies to be statistically useful indicators of long term water quality. Merrill et al. (1974) reported a gradient in diversity and density within the Grand Canal network with greatest richness in Roberts Bay. Their samples were taken by a bucket dredge of unspecified size, in August. The fauna were concentrated on a sieve with mesh openings of 1.58 mm. Another benthic survey was conducted in May 1983 as part of the present study. A petite ponar grab (area = 0.0225 m^2) was collected at each station in Figure 6. Samples were sieved on a 0.5 mm screen, relaxed in 10% MgCl, stained with rose bengal and fixed in formalin. Data are presented in Table 1.

Diversity ranged from 2 to 37 species (Figure 6). Fewest species (the polychaete *Streblospio benedicti* and the crustacean *Kaliapseudes*) were found in the Siesta Isles segment. The highest diversity was recorded from the Ocean Beach station between the Higel and Norma bridges. Mean diversitiy for all stations was 14 species.

The variance in diversity was high (s.d. = 70% mean) as a result of intrinsic variation and the lack of replication. Based on similar studies, the cumulative canal diversity (50 species) would probably have been increased by 10-20 percent with adequate replication but the dispersion of species between stations and their taxonomic distribution would not be significantly affected.

Density ranged from 311 - 63,327 organisms per square meter. Fewest individuals were collected in the Siesta Isles segment (Figure 7). The highest density was seen where Ocean Boulevard crosses the Paradise Island segment. The next highest density (59,727 individuals/m^2) occurred where diversity was highest, at Ocean Beach. Mean density for all stations was 22,468 individuals/m^2 (s.d. = 24,948). It is probable that replication would not reduce variance significantly in this case, e.g., the wide range of density data are indicative of existing conditions in the canal.

The species common to most stations (80 percent) was the opportunistic polychaete Capitella capitata, a well documented indicator of polluted and/or stressed marine environments. Capitella capitata accounted for about 20 percent of all individuals found at the average station. Three other species with 70 percent incidence across stations were the polychaete Streblospio benedicti and the tubiculous crustacea Corophium louisianum and Kaliapseudes sp. A. Overall, polychaetes contributed most to diversity (25 of 50 species), followed by crustaceans (13 species) and molluscs (6 species). Predominance of polychaetes is another indication of a typical polluted water community.

The similarity of benthic communities within the Grand Canal network was evaluated using a statistical coefficient known as Morisita's Index. The statistic compares the species and their numbers between pairs of stations. Table 2 presents the results of all pair-wise station comparisons. The index ranged from 0 (perfect dissimilarity) to 1.0 (the trivial case of a station being identical to itself). The fauna most like all others occurred where the Waterside Way segment meets the primary canal. In descending order or similarity came Stations G, I, C, J, D, B, E, and P, and finally A. It is interesting to note that stations with the most "highly similar" scores were between the bay and canal ends, and that the stations with very low similarities were at the Canal ends. Using Station J at the canal mouth for comparison reveals a similar pattern. In descending order of similarity to J are I, G, H, then after a large hiatus, F, E, C, and A with B and D. A statistical "break" in community structure occurs at the line shown in Figure 6, where stations farther up the canal are significantly more like one another and like the fauna of polluted waters.

Hydrology and Hydrography

The question of groundwater flux to the Grand Canal is worthy of discussion. Morrill et al. (1974) pointed to the surficial soils of the island as likely candidates for the rapid conveyance of groundwaters to the canal, and opined that such flux could transport nutrients and biocides to the canal. They found evidence for groundwater seepage at 7 sites throughout the canal, in the form of anomalous salinity gradients. The present study detected one additional anomalous gradient where Waterside East joins the primary circuit (Figure 8). More importantly in terms of its ecological impact, groundwater was observed flowing into the Grand Canal under the Higel Avenue bridge from a broken well. There, mineral salts have formed and are apparently incorporated into canal sediments. It is interesting to speculate whether this steady flow of well water is causally related to the very high diversity of benthic fauna found at a Station (I) only 100 ft away. The interaction of tubiculous infauna and groundwaters is particularly deserving of additional study in relation to environmental quality of the Grand Canal. Another worthy area of investigation concerns the oxygen content of groundwater, which frequently is very low. Ecological problems caused by benthic anoxia may be aggravated if flux rates are significant.

Circulation of canal waters has also been studied and debated. For the sake of clarity, currents will be used here to denote the vector displacement of water due to winds, tides, and other forces. Circulation will refer to the usual pattern of currents. Flushing and exchange will refer to the net replacement of water over time periods longer than a tidal cycle. Merrill et al. (1974) demonstrated the tidal current and pattern of circulation within the lower canal network, and concluded without reason that tidal exchanged occurred between the bay and a distant canal station. Data are lacking to compute actual flushing rates but the exchange potential can be estimated using existing information.

If the canal has a mean depth of 5 ft and a mean diurnal tide range of 2 ft, then 40 percent of its volume is affected with each such tide. This does not mean that an exchange of 40 percent has occurred because much of the water leaving the canal may reenter the network on the next flood tide. Nonetheless, water in Roberts Bay is of better quality than the Grand Canal, so even restricted exchange would benefit the lower canal system.

The relative importance of rainfall and runoff can also be evaluated roughly. The canal has a surface area of about 90 acres and a drainage basin of 530 acres (Merrill et al., 1974). If all of a year's rainfall reached the canal via runoff or as groundwater (assume that irrigation replaces evapotranspiration losses) and annual rainfall totals 54 inches (C. Dohme, SKUA, pers. comm.), the canal would be purged fivefold in one year. However, only about one percent of the canal's volume would be replaced by rainfall over the time period of one tidal cycle, and when intense rains deliver larger volumes to the canal the quality of the runoff (and groundwater) is probably detrimental.

Mean annual data for the SKUA treatment plant discharges show the effluent to be comparable in volume to rainfall. During the year ending May 1983, mean monthly discharges average 1.95 million gallons per day, or about one percent of the canal's volume. Better comparisons of treatment plant effluent and stormwater runoff must await data on the quality of each but it can be noted here that

(a) The STP effluent is discharged at a fixed place whereas runoff, and probably groundwater flux, occurs throughout the canal network.

(b) STP effluent is moved up-canal during flood tide and is continuous, whereas runoff is intermittent.

(c) STP effluent includes stormwater, where infiltration is great but septage and pet wastes may find their way into stormwater.

We examined tidal action in the Grand Canal network on June 2, 3, 21, and 24, 1983 for the singular purpose of determining whether the timing of tides differed between segments, or between the Canal network and either Roberts Bay or the Gulf of Mexico. Water elevations were recorded at numerous sites (Figure 9) over times bracketing high and low tides. Observations were first made from boats but travel was difficult due to low tides and speed restrictions. Later observations were made from land. Relative elevations were used since detailed surveys would be needed for referenced elevations.

Slack high water occurred in each canal segment at the same time or within 10 minutes of any other canal segment. At the time of slack low water in Palm Island or Siesta Isles no further fall in water levels at Midnight Pass Road were observed but an ebb current persisted and slack water at the canal mouth was delayed or foreshortened. These results should be confirmed with vertical reference data but suggest that little difference in tides exist between canal segments. If true, little opportunity may exist to improve internal circulation via the use of culverts or one way gates between segments.

Slack water on the Gulf beaches precedes slack water in the Grand Canal and Roberts Bay by an undetermined period. High tide occurred at the mouth of the Grand Canal before it occurred in Roberts Bay at the mouth of Phillippi Creek. No low tide data for these two areas were collected but slack low water must occur first at the Grand Canal. The seasonal discharge of Phillippi Creek may amplify differences in the time of slack low water but this could not be confirmed. The consequence of these findings relative to "flushing" of the Grand Canal by Bay or Gulf waters may be summarized as shown.

	Probable Direction of Flow	
Grand Canal Connected to:	Flooding & High Tide	Ebbing & Low Tide
Roberts Bay via Siesta Isles	From Canal to Bay?	From Bay to Canal
Gulf of Mexico via Sands Cove	From Gulf to Canal	From Canal to Bay

An important question answerable only by the mathematical analysis of better tide data is whether the water transported between the Gulf or Bay and the Grand Canal would be of sufficient quantity to improve canal conditions or justify the high capital costs likely to be involved.

About 200 measurements were made of temperature, salinity and dissolved oxygen over the period of 2 tides, at 10 stations throughout the canal network (Figure 9). Oxygen content was measured with a YSI Model 57 meter. Temperature and conductivity were measured with a Beckman SCT meter. Meters were calibrated at each station prior to use. Overall, dissolved oxygen ranged from 4.5 mg/l to supersaturation. The mean surface and bottom concentrations were 9.1 mg/l (s.d.=1.8) and 7.2 mg/l (s.d.=2.6). The difference of mean surface and bottom oxygen concentrations, 1.9 mg/l, was derived from observations made between 1100-1700 hrs on 2 days. These data suggest even greater gradients at night. Oxygen content varied between canal segments as shown.

	Dissolved Oxygen, mg/l	
	Mean*	Std. Deviation
Canal Mouth	6.2	0.9
Lower Grand Canal	6.5	1.4
Siesta Isles	8.9	0.9
Palm Island	8.6	2.6
Siesta Manor	12.9	0.9

*Surface, mid and bottom measurements combined.

Oxygen saturation in Siesta Manor and the relatively high variance in Palm Island implicate algal blooms in those canal segments.

Temperature and conductivity did not vary in any noteworthy manner. Water temperature ranged from 28.0-31.5°C and the greatest vertical difference was only 2.0°C. Conductivity ranged from 47.4 - 54.74 mmhos and the only significant vertical gradient was described earlier in connection with ground water discharge near Waterside East.

Intertidal Epibiota

The plants and animals growing in the intertidal zone are accurate indicators of water quality. Merrill et al. (1974) contrasted the diversity and abundance of fouling organisms in Heron Lagoon (a relatively clean waterway on Siesta Key) to the paucity of biota in the Grand Canal, where "only barnacles, oysters and mussels were found on sea walls above the Midnight Pass Road bridge". They also observed that, "From this bridge to the upper reaches of the canal system the relative abundance of these animals decreased becoming minimal in the Palm Island area".

Fourteen intertidal sites throughout the canal network were visited as part of the present study (Figure 10). The abundance and sizes of oysters, barnacles, sea-roaches, stone crabs, Florida crown conchs, mussels and tunicates were noted. The presence of plants was also recorded. Stations were rated using a scale based on barnacle and oyster density and size, and the presence of other organisms; a total score of 30 points was ideally possible (Table 3). Results are shown in Figure 10. It is extremely noteworthy that the station with highest score (22) was exceptional in that the canal shores were protected by riprap rather than seawall.

A gradient similar to that reported by Merrill et al. (1974) was noted in the present study, except that the sparsest fouling communities were found in Sarasands and Siesta Manor. The fauna of Siesta Isles was better developed than in Palm Island. Also, the fauna near stormwater outlets in the lower canal were better developed (e.g., larger, denser) than on walls removed from the outlet. A reverse pattern, or no trend relative to stormwater discharge, was seen in the upper canal.

Conclusions and Recommendations

1. The Grand Canal is a shallow waterway organized around a primary canal circuit with mean depth at low water of 5.2 ft.

2. Comparisons of past and present bathymetric data indicate rapid sedimentation but better historical data should be sought.

3. The existing widths and fetches of each canal segment define final equilibrium depths which will promote canal infilling to a point unsuitable for navigation.

4. Deepening of Palm Island, Siesta Isles, or other segments probably would aggravate water quality problems, but the removal of shoals near the canal mouth may improve circulation.

5. Technical studies of sediment transport, settling and composition in the Canal would be required to identify the sources of accumulating material. No evidence supports the conclusion that storm

drainage is the primary cause of canal sedimentation.

6. Bottom dwelling fauna in the canal are indicative of waters stressed by oxygen depletion and of fine grained, organically rich sediments. The fauna of the lower canal is more like the fauna of Roberts Bay than fauna in the upper canal segments.

7. Benthic fauna, particularly tube building crustaceans, may be an ecological indicator of ground water flux to the canal. Ground water may flow to the canal over most of its length.

8. Studies of groundwater flux to the canal are straightforward and should be given priority. If flux rates are significant, one remedy worthy of analysis is the replacement of seawalls with riprap.

9. The exchange of canal waters is promoted more by tides than rain or STP effluent, although heavy rains over short periods could overwhelm tidal effects. The water quality impact of tidal circulation is beneficial; that of STP effluent undetermined for canal segments above the discharge; and that of rainfall, detrimental.

10. The opportunity for improvement of circulation by connecting canal segments to one another may not be great. A better chance at forcing circulation exists in the connection of Roberts Bay or the Gulf of Mexico (or both) to the Grand Canal.

11. The decision to create new openings of the Grand Canal to other waters must be based upon the findings of a thorough hydrological study which treats, as a minimum:

a) tidal heights over a 30 day period;

b) cross sectional velocities at key canal and Bay/Gulf sites:

c) "head" computations and comparison to runoff or STP effluent volumes:

d) water quality considerations.

12. The impacts to beach sand transport of a new canal opening to the Gulf of Mexico must be evaluated if that alternative is pursued.

13. Shoreline productivity can be improved by the replacement of vertical seawalls with riprap. The use of natural grades planted in active vegetation is even better but opportunities for this technique are limited.

14. Controls on (a) the planting and maintenance of shoreline vegetation and (b) fertilizer applications should be developed and implemented as soon as possible. The retrofitting of stormwater drainage ways should also begin.

Acknowledgements

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Tables and Figures Available

upon request