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ISLAND RESOURCES FOUNDATION

Caribbean Headquarters
RED HOOK BOX 33, ST. THOMAS
U.S. VIRGIN ISLANDS 00802
(809) 775-6225

Washington, D.C. Office
1718 P STREET, N.W., SUITE T4
WASHINGTON, D.C. 20036
(202) 265-9712

MARINE ARCHAEOLOGICAL SURVEY

of

WEST INDIAN CO., LTD., PROPOSED DREDGE AREA
LONG BAY, ST. THOMAS
U.S. VIRGIN ISLANDS

Final Project Report

Date of Field Investigation: 25 July to 14 August, 1985

Date of Report: 6 September, 1985

Prepared for the
West Indian Co., Ltd.

by

Dr. Edward L. Towle, Project Director

VOLUME I OF TWO VOLUMES

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WICO LONG BAY DREDGE SITE MARINE ARCHAEOLOGICAL SURVEY

1.0 SUMMARY

In order to proceed with certain development plans for a portion of the Long Bay shoreline on the eastern perimeter of Charlotte Amalie harbor, St. Thomas, U.S. Virgin Islands, the West Indian Company, Ltd. requested permission from appropriate government authorities to dredge approximately 130,000 cubic yards of material from a 26 acre site in the central Long Bay area for use as fill. The effort would deepen the borrow area by approximately six feet. The Company prepared and submitted the necessary project plans and Environmental Impact Assessment (EIA) documents and, during 1984 and 85, obtained the customary permits from the U.S. Army Corps of Engineers (permit #84F-2218) and from the Virgin Islands Government (DCCA/DCZM permit #CZT-89-83W). (See Figure 1.)

However, the Army Corps of Engineers permit #84F-2218, under special condition II.B., required that prior to proceeding with the dredging phase of the project, the West Indian Company, Ltd. undertake "exploratory underwater archaeological investigations and a magnetometer study shall be performed..." for the purpose of determining whether or not the proposed dredge site included any historically valuable shipwreck sites that would be damaged or destroyed by the dredging process. The requirement for a "magnetometer study" was later modified to permit the implementation of a more appropriate and a more sophisticated electronic survey strategy employing a computer controlled sub-bottom electronic profiling system consisting of an EG&G Uniboom transducer/hydrophone array coupled to a strip chart recorder and Raytheon "Mini-Ranger" horizontal positioning control system.

1.0 (cont.)

The West Indian Company, Ltd. selected a local firm, the non-profit Island Resources Foundation (which had previously completed a marine archaeological survey of the Crown Bay and Gregerie Channel "dredging" area for the Virgin Islands Port Authority in 1984) to carry out the required work, and advance planning for the project was begun in 1985. Since much of the proposed 26 acre dredging area is located within a traditionally popular anchorage and mooring area for small boats utilizing the protected area of Long Bay, some delay in implementing the survey was experienced because the boats' owners or residents were reluctant to move and, in some cases, absentee owners of moored or anchored vessels were difficult to locate. However, with the help of DCCA's Enforcement Bureau, most of the boats had cleared the area by the 24th of July and mobilization of required equipment, vessels, barges and instrumentation was carried out between 25 and 28 July, utilizing a staging area and dock adjacent to Yacht Haven Marina provided by the West Indian Company, Ltd. Two professional survey engineers and 1,700 pounds of electronic survey equipment arrived on Monday, 29 July from Island Resources Foundation's survey phase sub-contractor, EG&G Oceanographic Services of Boston.

After one day of equipment assembly and testing, the first full week of on-site effort was devoted to completing 29 closely spaced survey transect lines gridding the 26 acre site. Geo-referencing (navigational control) was maintained as planned with the Raytheon Mini-Ranger III positioning system. An analysis of the sub-bottom profiling data printout sheets produced 37 potential sea-bed or sub-bottom targets. Five of these were dropped as being outside the proposed dredge area and five were

1.0 (cont.)

definitely identified as geologic anomalies, leaving a total of 27 sites to be explored and assessed. These 27 target sites were then relocated with the computer controlled Mini-Ranger and marked with steel rods on the sea-bed and also with numbered surface buoys.

As the electronic survey team sequentially established the exact positioning of the specific target sites ($\pm$2 meters), a second team of investigators working from a separate vessel, commenced a direct visual inspection of each site followed by deployment of a high pressure water jet probing system and, when appropriate, carried out an actual test excavation utilizing a diver-operated, four-inch air lift (driven by low pressure, high volume air compressors) situated on a barge and pumping into a second screening barge.

In checking the 27 target sites, 641 jet probe holes were driven in the harbor bottom to point of refusal, covering 1,034 square meters of sea-bed in the target area. Test excavations by air lift were conducted at twenty sites, and all promising sites and test holes were checked with a Fisher, Pulse 8, magnetic metal detector, sensitive to a depth of eight feet below the sensing head. All material lifted from the bottom to the surface was passed through a 1/4 inch mesh screen, and surprisingly only 28 miscellaneous (inconsequential) artifacts were recovered, although over forty tons of material was pumped and screened. The overall effort required 114 hours of diver bottom-time and 203 person-days (10 hour days), approximately four tons of equipment, two survey vessels, four small support craft, two barges, two vehicles and a 40 X 10 foot trailer for

1.0 (cont.)

gear storage at the base site. The full sequence of site inspection and data logging and rough mapping was completed on 11 August.

All findings were negative, and no historical shipwreck site or significant cluster of buried artifacts were confirmed within the target area. Most individual targets proved to be either buried or surface metallic debris, such as moorings, anchors, old chain, modern boat parts, abandoned engine blocks, transmissions, batteries, heads*, etc., or, alternatively, various sediment/coral interfaces or coral-rubble layers resulting from several previous extensive harbor dredging activities and/or sediment redistribution caused by recurring cruise ship and vessel propeller wash effects in the area over time.

From a marine archaeological perspective, there appears to be no valid reason why the West Indian Company, Ltd. cannot proceed to dredge the specified Long Bay area as scheduled. A dredge spoil discharge area monitoring and salvage strategy for artifacts delivered as part of the pumped sand/coral and water slurry at the shoreline settling ponds is recommended.

*Marine sanitation devices

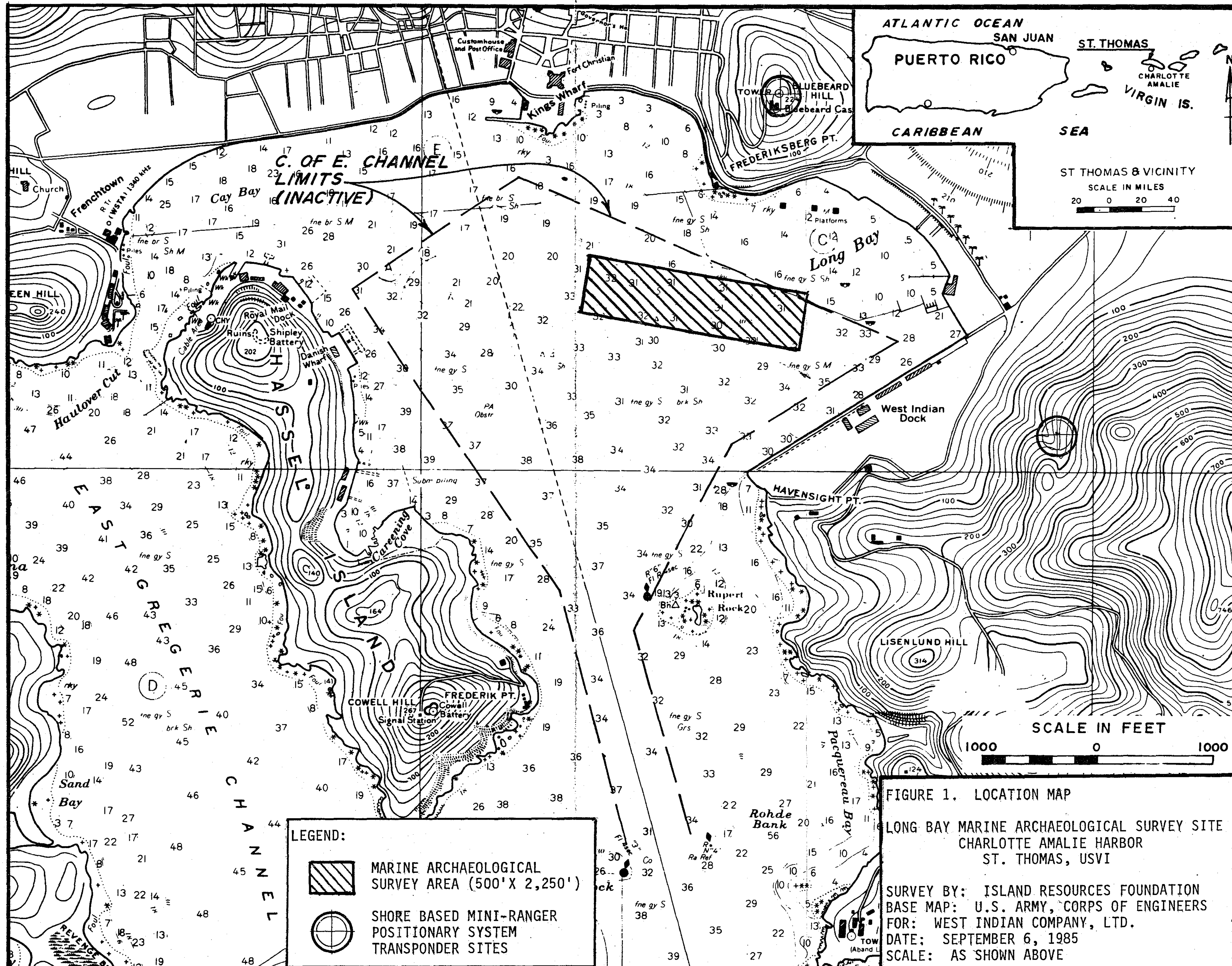

FIGURE 1. LOCATION MAP

LONG BAY MARINE ARCHAEOLOGICAL SURVEY SITE
CHARLOTTE AMALIE HARBOR
ST. THOMAS, USVI

SURVEY BY: ISLAND RESOURCES FOUNDATION
BASE MAP: U.S. ARMY, CORPS OF ENGINEERS
FOR: WEST INDIAN COMPANY, LTD.
DATE: SEPTEMBER 6, 1985
SCALE: AS SHOWN ABOVE

2.0 BACKGROUND INFORMATION

2.1 Introduction and Project Objectives

Beneath the shallow waters within the harbors and roadsteads and along the coastlines of all West Indian islands there lies a vast storehouse of shipwrecks and artifacts, an uninventoried, undeveloped marine resource with a story to tell the archaeologist/historian diver about man's activities, his daily life, his tools, vessels, commerce, migration, culture, trade and technology in centuries past. Covering a period of time spanning more than four centuries of Caribbean maritime history, these wrecks contain important artifacts, clues and information which, after careful excavation and proper treatment, will greatly assist our reconstruction, analysis and interpretation of the history and technology of the colonial era in the Caribbean. They are also of great interest to local and visiting sport divers.

The systematic process of exploration, discovery, excavation, identification, preservation and interpretation of historical materials from the sea-bed is called marine archaeology. It is a special field of inquiry subsumed by a much older, more traditional discipline called archaeology which Grahame Clark in 1939 defined as "the systematic study of antiquities as a means of reconstructing the past...." Another Englishman, Glynn Daniels, defined archaeology as "the study and practice of writing the history of man from material sources...."

But marine archaeology is relatively new - having emerged just since the early 1950's as a consequence of the development of

SCUBA diving technology which has enabled humans to work underwater with relative ease and safety with only a modicum of technical training and risk. In a non-formal, avocational sense, it has become a popular recreational aspect of diving and underwater photography. Marine archaeology as a discipline is, however, not only new but confronts a somewhat unique set of problems despite the apparent similarity to land archaeology in the case of excavation, analysis and interpretation techniques. What is it that is different?

In the first place, shipwreck sites are often very difficult to locate. Numerous shipwrecks have occurred in West Indian waters for which we have no site-specific documentation, either because none ever existed (i.e., the ship went down with no survivors to tell the tale) or such documentation has simply not yet been located in the numerous archives and manuscript repositories in the Western Hemisphere. Even when documents do exist, it is rare to find the exact shipwreck location specified - only a general statement such as "on Palliser's Reef" or "off Needham's Point", "at Pinney's beach", or "in Long Bay." See Table 1 for an example. Because wrecked ships break up, get spread about and buried in the sandy or muddy sediments or covered by corals over time, this makes them very difficult to locate, while artifacts encrusted with coralline algae are often very hard to identify. All of this means that searching for sites can be labor and time intensive and may require sophisticated electronic sensing instruments like

Table 1. Representative shipwreck list for the Eastern Harbor, Long Bay area, St. Thomas, U.S. Virgin Islands, for the period 1804 - 1837.

1804	George, British ship wrecked in Sandy Bay
1821	Commerce, English brig, stranded at Long Bay
Aug. 28, 1827	Alfred, English sloop, wrecked at Long Bay
1827	Bermuda, English brig wrecked at Long Bay
1827	Pochantas, American brig wrecked at Long Bay
1827	Randolph, American schooner wrecked at Long Bay
1827	Two Sons, American brig wrecked at Long Bay
1827	Ornen, Danish bark, wrecked on the rocks under Fredericksberg Hill
1827	Speculation, Ship of Hamburg, wrecked on the rocks under Fredericksberg Hill
1827	St. John's Packet, Danish sloop, wrecked on the rocks under Fredericksberg Hill
Aug. 28, 1837	Jolly Sailor, American schooner, driven ashore at Long Bay
1837	Le Bonne Mer, French brig, driven ashore under Mt. Gibson's Hill, east Harbor

Source: Mr. George Tyson, personal communications.

Note 1: The V.I. Planning Office has a master V.I. shipwreck file which has not as of this date been made available in printed format to the general public. DCCA does not have a file or reference copy of this list of shipwrecks which is far more comprehensive than the Towle, Marx and Albright inventory covering 1523-1825 as published in 1976 (2nd edition).

Note 2: Of the 21 listed shipwrecks for the hurricane of 1827 in Table 1 above, eight were in the Long Bay area but available data suggests all were driven ashore and wrecked along the shorelines. None are described as "sunk" or "foundered" in the harbor. This illustrates in part the primary reason for negative findings in the 26 acre study site.

proton magnetometers, side scan sonars, and mud-pingers, along with water jet probes, air lifts and submersible metal detectors.

For the average recreational diver, this situation also enhances both the sense of mystery about and excitement of discovery of a shipwreck site - which leads to a second reason why marine archaeology as a disciplined historical investigative process differs from both traditional history and archaeology.

Shipwreck sites (known and hypothetical) on the coastal shelf areas are (a) invisible to the non-diver, (b) unprotected by adequate legislation, control, or administrative processes, (c) generally uninventoried and unsupervised by appropriate government authorities and (d) a significant attraction for the hundreds, sometimes thousands, of tourist and resident recreational divers with a "finders-keepers" perspective, engaged in souvenir (artifact) hunting and on occasion surreptitious wreck exploration and salvage activities.

However, it is, more often than not, this veritable army of divers - these recreational/avocational enthusiasts and professional salvage divers - and not the few professionally trained marine archaeologists who discover most of the shipwrecks - and who therefore have the opportunity to scavenge them for souvenirs often doing considerable damage in the process.

A further difference between sea and land archaeology derives from the negative effects of salt water and marine organisms upon the artifacts themselves, which because of their often fragile, unstable physical and chemical state after a century or more of immersion, generally require careful, very specialized, often elaborate post-salvage preservation techniques in the field and in the laboratory before they can be stablilized for exhibit purposes. In most underwater sites, the actual recovery of artifacts consumes perhaps 20 percent of the marine archaeologist's field time compared with the balance of time for preserving, drawing, photographing, stabilizing, tagging, analysing and recording them.

Obviously, serious marine archaeology, like its terrestrial counterpart, involves a lot of hard work and sometimes the ubiquitous amateur wreck diver, souvenir/treasure hunter's activity is a problem. However, historic shipwrecks are important cultural resources, generally located on public land - namely, harbor bottoms and the nearshore shallower sea-bed shelves. As such, shipwrecks are a nonrenewable public resource and should be managed for the best interest of the community at large. They are a part of any island nation's cultural heritage and should not be exploited (like modern abandoned wrecked vessels) for private gain, although with proper training recreational divers can become bona fide participants in this exciting search for historical knowledge from shipwrecks and their associated artifacts. In fact, with a little calculated encouragement, education and guidance almost any diver, visitor or resident, novice or advanced, can make the critical transition from predatory souvenir hunter to volunteer conservationist and can contribute to the development of latent, local historical marine archaeological resources while simultaneously enjoying the experience of learning how to explore "history" under the sea. Managing this merger of public and private interests in an orderly systematic way often proves, however, to be a complex task of no mean proportions.

To accomplish this task of combining the interest of the state in protecting submerged sites along with the interest of sports divers in finding wreck sites and salvaging artifacts, a series of important steps must be taken to develop a resource management framework that is appropriate to the country specific situation.

The question of legislation needs to be dealt with carefully. Existing land oriented "antiquities" and development impact assessment and permitting procedures legislation and "wreck" laws in most Eastern Caribbean islands are generally inadequate. They rarely address in a comprehensive way the full spectrum of historic shipwreck site protection, marine archaeological search standards, site registry, salvage activities, "wreck" artifact ownership or disposition, tourist wreck diving and the cultural and educational aspects of marine archaeological end products - information, artifacts and experience.

The realization that shipwreck sites are important and are being destroyed by salvors and sport divers has led to legislation in countries that attempts to protect sites. In many this has been successful, mainly because the laws allow the participation of sport divers, set some historically valuable wrecks off-limits awaiting systematic archaeological excavation, and avoid an unenforceable "thou shalt not touch" stance.

However, poorly conceived unrealistic legislation tends to increase free lance, unprofessional souvenir and "treasure" hunting and the black market in artifacts by driving treasure hunters "underground." In the present circumstances, what they do is already out of sight "underwater." Legislation should strike a fair balance between two things:

1. The national or local interest in acquiring knowledge derived from historical shipwrecks and protecting the cultural patrimoney.
2. The grand adventurous spirit that sets men and women divers out in quest of them and the value to the area of recreational wreck diving as a tourist attraction.

What is needed is a reasonable set of laws and regulations which satisfy the diver, the marine archaeologist, the treasure salvor and the conscience that says knowledge and artifacts of historical value should not be lost or destroyed and which permit individuals to find shipwrecks, declare their finds, be licensed, and if competent, to excavate them properly, and receive a share of the artifacts (or their value) as partial recompense for the cost of search and salvage. Professional marine archaeologists should monitor this.

The administrative mechanisms by which marine archaeological sites are managed and developed are equally important. Who develops and maintains a centralized accessible inventory and maps collection? How are sites ranked as to potential historical significance or value? What is the definition of an historic site as opposed to a "modern" wreck open to all divers? How do "finders" register a wreck site and obtain a license to excavate it and under what conditions? Who monitors the activity and when? Who has title to what "artifacts" and what is an equitable division between the state and the diver/salvor? Where does the local museum system, the archives and the permitting system for development projects (public or private) fit in? How do they fit and work together? Who deals with the necessary conservatorial, preservation, custodial and exhibit aspects of artifacts removed from the sea-bed - whether accomplished formally by a professional marine archaeologist or less formally (but under a permit or license) by a non-professional sports diver or amateur marine archaeologists. In the Virgin Islands case, there are some unresolved jurisdictional and functional boundaries between the various federal and local agencies and offices concerned with marine archaeology. At the same time, there is no comprehensive territorial strategy as yet - but some key elements do exist as a result of both federal and local legislation and as a result of local initiative in both the V.I. Planning Office and the V.I. Department of Conservation and Cultural Affairs (Enforcement; Library, Museum and Archives and Coastal Zone Management). But lines of authority and clear assignments of responsibility are not, as yet, well defined - a situation exacerbated by both the absence of an integrated territorial plan and the presence of recurring unresolved federal/territorial "consistency" and concurrent jurisdiction and regulatory oversight problems. Many of these are not so much serious as they are confusing to the "developer" of any project seeking more precise "performance" guidelines and standards.

This report and the rather costly and technically elaborate search and survey methodology upon which it is based reflect this dilemma. The Island Resources Foundation had the "option" of selecting the appropriate strategy and technical methodology to fulfill the vague permit requirement of a "marine archaeological survey." It confronted the question of what level of precision, of detail, of assurety and of redundancy should or could be counterbalanced against questions of cost, risk, time and level of effort. Undoubtedly, a lower cost, less rigorous approach would probably have been acceptable. For this Long Bay site study it opted (as in the case of the Crown Bay magnetometer survey completed in 1984 for the V.I. Port Authority) to emphasize or utilize (a) the best available appropriate technology, (b) precision and redundant support systems and survey techniques, and (c) an intensive, large team, short time frame format for the project.

The justification for this approach derives from Island Resources Foundation's interest in experimentally introducing into the territory and the region new, best available methodologies and techniques of marine archaeological search, survey, and salvage tasks to establish cost figures for a truly professional, efficient, optimal strategy. Once we have such benchmarks and models, we (or anyone else) can seek ways to reduce costs, to simplify procedures, to eliminate redundancies and utilize more non-professional, less expensive, avocational divers, etc. without sacrificing quality. This can be accomplished over time by determining the "acceptable" (as opposed to experimentally high) levels of precision and acceptable risk taking (i.e., the risk of missing a site) while assuring a quality survey and assessment product serving the public interest.

Fortunately, the West Indian Company, Ltd. was willing to support this experimental strategy; in part, because, although it was more expensive, it was more efficient, more comprehensive and would produce more reliable findings.

However, one must not lose sight of the fact that the primary objectives of the recent Long Bay research effort was to determine whether or not the top six to eight foot layer of sedimentary and coral material in the 26 acre proposed dredge site or "borrow area" that would be removed or affected by dredging contained any culturally (historically) valuable or significant shipwrecks or clusters of artifacts. In the event of any positive indications regarding the presence of such culturally significant sites or objects, more detailed site investigations involving test excavations and magnetic surveys were to be employed to accomplish the second objective of the project - which was to evaluate any sites found. The third objective was to report all findings (positive or negative) and describe the methodologies used in the search, survey and assessment phases of the study.

2.2 The Environmental and Historical Setting

The Charlotte Amalie Harbor area contains 0.72 square miles (1.86 km^2) and includes three principal anchorages - Pacquereau Bay at the harbor entrance on the southeastern edge; Long Bay, the primary anchorage and docking area in the northeastern sector; and on the northwestern portion, the so-called Frenchtown anchorage. The largest marina, Yacht Haven, is located in Long Bay with 175 slips. A boat count taken in March 1981, showed 326 vessels that were either anchored, moored or docked in Long Bay. A 1983 count for the Long Bay area showed 175 docking slips, 141 of which were occupied plus 155 boats that were moored or anchored in the area immediately to the west of Yacht Haven and north of the West Indian Company, Ltd. dock (Wernicke and Towle, Vessel Waste Control Plan, March 1983). Freight and passenger vessels and larger yachts, naval vessels, research vessels, cruise ships, roll on/roll off cargo vessels, bulk cement and bulk fuel vessels all utilize Long Bay and, in particular, the 750 yard long dock owned and operated by the West Indian Company, Ltd.

The Department of Conservation and Cultural Affairs/Department of Natural Resources Management maintains eleven water quality stations in Charlotte Amalie harbor - three of which are located in the Long Bay anchorage area. The inner harbor environment, and especially Long Bay, is biologically stressed with low species abundance and diversity. In the early 1970's, the discharge of raw sewage through major outfalls from the Sugar Estate and Havensight area was terminated and since then there have been some slight decreases in turbidity (Secchi depth) and increases in dissolved oxygen at lower water depths.

The discharge of terrestrial pollutants from the urbanizing watershed surrounding Long Bay includes large quantities of clays and silts, vehicle parts and tires, waste oils from vehicles and service stations, septic tank seepage, effluent from broken sewers, cleaning fluids, municipal wastes, restaurant wash water, and general street debris -- all of which contribute significantly to the continual harbor pollution and result in a perpetual situation of marginal water quality. Additionally, the almost daily passage of larger vessels like cruise ships, tugs and cargo carriers repeatedly stir up the fine bottom sediments and redistribute massive amounts of bottom material, simultaneously keeping turbidity levels high and diminishing any significant recovery of the light sensitive benthic biota formerly present in the harbor.

General harbor currents are driven principally by the near-shore component of the North Equatorial Current and the wind driven waves, while tides are estimated to account for only a small fraction of the harbor water exchange, the tide prism being only 2.8 percent of the total harbor water volume. Surface currents enter the main harbor, sweep past Pacquereau Bay and follow a net counter-clockwise pattern through the harbor (Ragster, 1985).

During flood tides, harbor water exits through Haulover Cut (opened in 1864-65) between St. Thomas and Hassel Island, out into Gregerie Channel with a reversing flow on some ebb tides. Bottom currents tend to follow a reverse pattern to surface currents but are far more complex and variable. A more or less permanent eddy current exists in Long Bay itself, tending to entrain pollutants and sediments. The harbor is designated as "Class C" water under the Virgin Islands Water Quality Standards. Current velocities are generally low in the harbor and especially in the Long Bay area, ranging from 0.16 to 0.34 ft. per second (Ragster, 1985).

Furthermore, the almost daily arrival or departure of one or more cruise ship, cargo/container vessels in the Long Bay area results in extremely turbid water conditions with very low visibility throughout the water column from surface to sea-bed - a condition which persisted throughout this project except at the westerly end of the study site due south of King's Wharf.

The general history of Charlotte Amalie Harbor and its easterly Long Bay area has been reported by Tyson (1985), Ragster (1985), and to a degree in the various WICO consultant and project documents (Insular Environments, 1977; McComb, 1983; US/COE, 1977, 1979, 1981). There is, therefore, no need to review this long record of human activity and modification made in the study area. In all three dimensions, the Long Bay area bears little resemblance to its original shape and form - say in 1600.

In fact, not one linear foot of the original natural shoreline of Long Bay remains. For example, even the entire 1851 sea-land boundary has been subsequently obliterated by an additional continuous strip of filled land averaging approximately 100 yards in width. Similarly, the harbor bottom configuration has been substantially altered since about 1900 by two major dredging projects, one between 1912 and 1914 to provide fill for the present West Indian Company, Ltd. dock and another much larger scheme in 1935 in the central portion of Long Bay to provide fill for the Sugar Estate swamp and shoreline area. This latter dredging effort covered an area approximately one hundred acres, which, in the intervening fifty years since 1935, has gradually acquired a new upper layer or overburden of sand, silt and clay sediments varying from two to over six feet in depth. This more recent layer of material covers the more consolidated hard coral rubble layer left behind by the 1935 dredge (see Tyson, 1985; Ragster, 1985; and Appendix 1A to this report /Technical Data Supplement on jet probe and excavation findings/). This process of accelerated sediment deposition in the harbor, in company with the repeated bottom scouring and sediment resuspension and redeposition induced by large vessel (principally cruise ships) propeller wash, greatly complicates the task of understanding and interpreting sub-bottom profiling data obtained by any remote sensing technique (i.e., acoustic, electronic, magnetic or by jet probe). Any hypothetical "shipwreck" anomaly is intermixed with dozens of other anomalies caused by (a) buried modern objects or "trash", (b) buried older, geological features, or (c) man-made sediment and sediment/hard coral interfaces between differentiated strata which, in combination, significantly increase the number of "targets" and require costly air lift excavations for direct visual inspection and more precise (closer) magnetic field search and evaluation efforts.

3.0 RESEARCH DESIGN AND SURVEY METHODOLOGY

3.1 Antecedent Planning Considerations (January to June, 1985)

Early in 1985, the West Indian Company, Ltd. (WICO) advised the Island Resources Foundation (IRF) that under its U.S. Army Corps of Engineers Long Bay dredge and fill permit #84F-2218, a conditional clause required that an "exploratory underwater archaeological investigation and a magnetometer study shall be performed" prior to the commencement of any dredging activity. WICO requested that IRF develop a preliminary plan for undertaking this task and after an examination of the site, available maps and historical and contemporary documents pertaining to Long Bay and the Charlotte Amalie Harbor, IRF came to the conclusion (and reported to WICO on February 13, 1985) that while an underwater archaeological investigation could be done in a professionally acceptable, systematic fashion for the proposed marine dredging area in Long Bay, the required "magnetometer study" was not appropriate to prevailing circumstances in Long Bay. An alternative search and locate methodology should be employed.

Deploying a Geo-Metrics type marine magnetometer in the Long Bay study area would be difficult, if not impossible. There were too many anchored or moored boats, and too many currently-in-use or abandoned anchors and mooring systems (often with associated chain) in the survey area. The existing vessels anchored or moored in and surrounding the site set up confusing, non-optimum sets of magnetic fields and would prevent the accurate identification and marking of potential historic magnetic anomalies.

The magnetometer search methodology used for the Crown Bay Marine Archaeological Survey would simply not be appropriate in Long Bay. The Crown Bay survey area was essentially a channel with intermittent vessel traffic in the center, small-boat moorings and anchorages to the south and coastal engineering works to the north - it was, except for the southern edge of East and West Gregerie Channel, a busy but clear area, i.e., mostly open water. Secondly, it had never been a major anchorage and only in the twentieth century had significant levels of maritime, commercial or military usage.

In running transects, the magnetometer became almost useless every time the sensor was towed adjacent to the small-boat-anchorage area south of West Gregerie Channel. The problem is that when one reduces the magnetometer's sensitivity to eliminate a nearby vessel at anchor, say forty to sixty feet away in a horizontal direction, the instrument no longer is responsive to most other anomalies forty to sixty feet away in a vertical direction, namely, on the bottom or buried in the sediments. Secondly, scattered ferrous debris, closely spaced on the harbor bed result in the instrument "combining" (i.e., not discriminating) the separate magnetic field of the individual objects.

To deploy a magnetometer for optimum performance at Long Bay would have required the prior removal of most, if not all, vessels, anchors and ferrous moorings from the survey area, including those outside but on the perimeter of the study site. Even should this be feasible, the magnetometer would indicate an anomaly caused by a large abandoned and shallow buried mooring and chain while a smaller cultural artifact buried more deeply nearby is masked by the more intense magnetic field of the mooring and therefore goes undetected. Towed magnetometer sweep and survey strategies work extremely well in locating "isolated," widely dispersed ferrous targets in large areas but become increasingly marginal in smaller areas with numerous, closely spaced or adjacent ferrous "targets," both on the sea-bed and buried in the sediments.

As an alternative, IRF suggested a survey strategy deploying a sub-bottom profiling instrument, called a Uni-boom which uses a low-frequency, high-energy electric pulse and echo response which is "heard" by a hydrophone array and used to establish, in chart form, an outline profile of the sea-bed sediment layers <u>and</u> the general location of objects such as a shipwreck buried in the sediments. The exact location of these objects could then be pinpointed by water jet probing and inspected after an air lift excavation (following the methodology used at Crown Bay and described in detail in the antecedent marine archaeological survey plan accepted by the Virgin Islands Port Authority and the permitting agencies at the time). This sub-bottom electronic profiling approach uses the physical object as the "target" rather than the magnetic field of the target and therefore can be utilized even in and among a concentrated collection of randomly sized moored and anchored yachts. IRF recommended, therefore, that the two words "electronic survey" be substituted for "magnetometer study" in the permit conditions for the Long Bay project regarding the required antecedent underwater archaeological investigations.

The Uni-boom sub-bottom profiling system is manufactured by EG&G and Company of Boston, Massachusetts. It operates at 50 to 500 KHz and has a ten degree beam width. The pulse strength is 100 to 300 joules and consists of four elements -- energy unit-Model 234, Boomer-Model 230, hydrophone array-Model 265, and recorder - an EPC strip chart system. (See Figure 2 and Section 3.2.)

This would be supported for geo-referencing purposes by a Ratheon Mini-Ranger - a computerized electronic positioning system involving three shore-based transponder units and a master control/readout system placed on the survey vessel. (N.B. Visual fixes using shore-based surveyors transits from base stations would not work well because the numerous anchored vessels surrounding the survey area "break" the line of sight.)

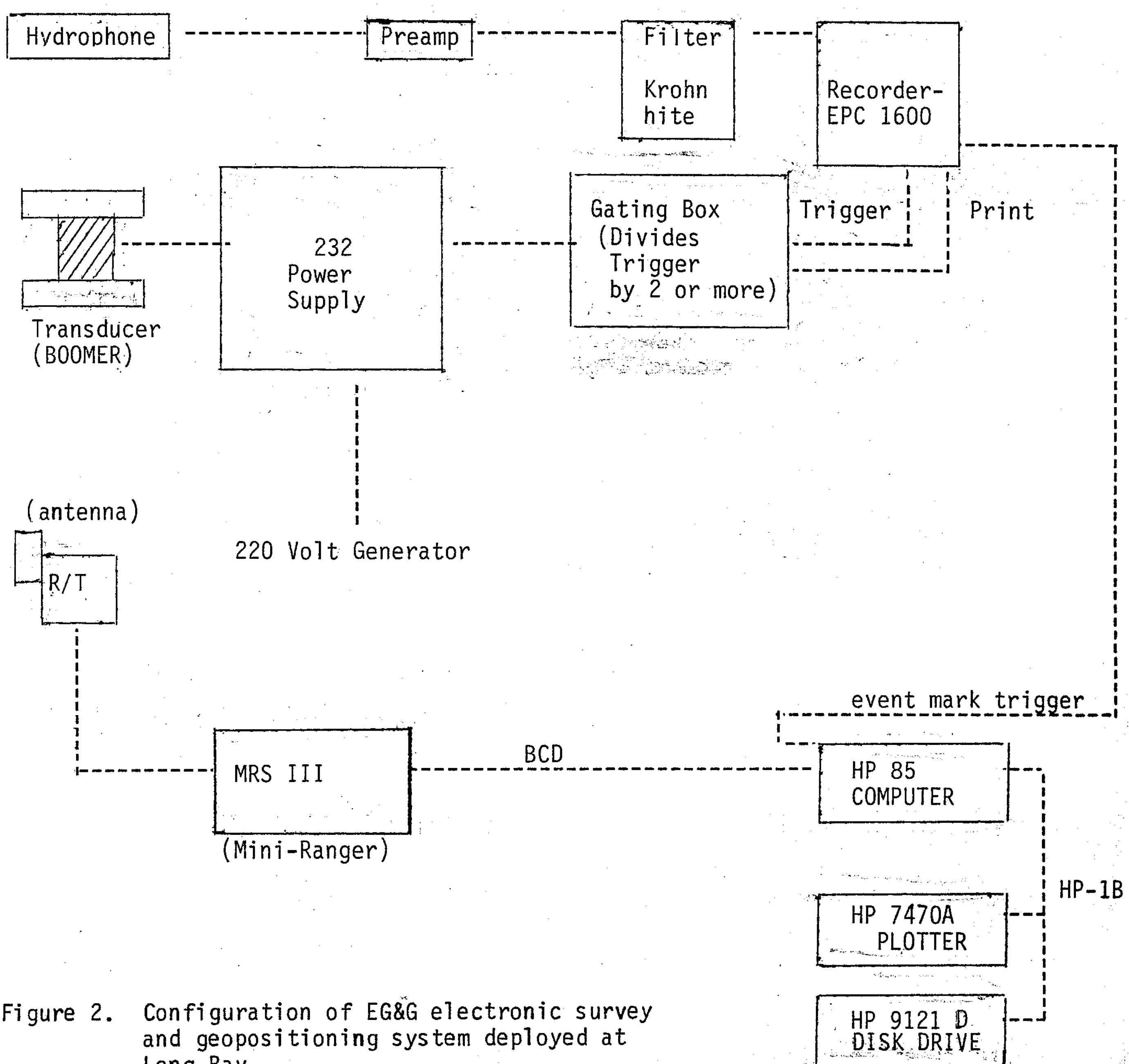

Figure 2. Configuration of EG&G electronic survey and geopositioning system deployed at Long Bay.

Island Resources Foundation
Marine Archeological Survey
Long Bay 8/85

Lastly, it is noted that a third alternative, a side-scan sonar survey strategy, was evaluated and discarded because of the presence of organic material in the sediments left over from the days of the public raw sewage marine outfall at the northern end of Sugar Estate beach, near where the present pumping station is located. Sonar signals will not easily penetrate organic laden sediments because of the microscopic air bubbles present.

The recommended survey methodology was accepted and details are provided in the next section.

It is noteworthy that at the time the contractor undertook the initial planning for the required WICO marine archaeological survey project at Long Bay, there were 37 boats moored or anchored within the 26 acre area scheduled to be dredged. Another 25 were situated just outside the site boundaries. It proved exceedingly difficult to track down the owners or managers of boats that were left unattended, and many of the boats with live-aboard owners or masters were extremely reluctant to move. Months went by and it was not until formal authority of the Virgin Islands Government, through the Enforcement Bureau of the Department of Conservation and Cultural Affairs, was brought to bear upon the problem that the final ten or twelve vessels still remaining in the study site finally moved out of the area in the 72 hour period preceeding the scheduled start date for the electronic survey. Needless to say, these circumstances made it difficult to schedule the exact start date for the project and to plan the exact sequence of running the survey transects. A copy of the official notices prepared and circulated by the DCCA is enclosed as Attachment #2 to this report.

3.2 Final Search Design, Instrumentation and Procedures

To conduct the sub-bottom profiling survey of the proposed dredge area, IRF proposed the use of an EG&G Uniboom Seismic Profiling System. The system included a Model 230-1 Uniboom pulse boomer, a Model 265 Hydrophone and a Model 234 Energy Source. Equipment specifications are provided as Attachment #3. The system interfaced to an EPC 1600 Recorder to provide high resolution single-line recording of the data. Using a single broad band acoustic pulse in the frequency range of 400 to 14000 Hz, the Uniboom System has a resolution approaching 1/2 foot and is capable of penetration of the marine bottom to 75 meters.

Horizontal control for the survey would be provided by a Motorola Mini-Ranger III Navigation System (J.B. Arnold and C. Clausen, 1975). The Mini-ranger provides range information from two shore-based transponders with an accuracy of ± 2 meters. Coupled to a HP-85 portable computer, the system calculates and displays x-y positions in the local grid system. In addition, an EG&G Navigation Software Package written for the HP-85 computer would graphically display the position of the survey boat in relation to a pre-selected trackline and provide updated numerical displays of distances off the line and to the start and end of any trackline. When using this system, navigation fixes with times and x-y coordinates are printed out on the HP-85 every six seconds and at 30 second intervals, corresponding event marks are printed across the sub-bottom records.

After each day of the survey, the IRF/EG&G team would post-plot the vessel tracklines on a base map and identify all sub-bottom targets for further investigations. Approximately twenty lines with 25-foot line spacings would be run to obtain full bottom coverage of the survey area. Additional cross-tie lines perpendicular to the initial survey tracks would be run if gaps in the bottom coverage exist. As bad navigation signals are often obtained when working in close proximity to sailboat masts, marker buoys would be set along the tracklines to verify adequate coverage and proper line spacings.

3.3 Proposed Target Site Assessment Methodology

The approach utilized by IRF at Crown Bay (Towle, 1984) was considered appropriate for Long Bay except for two modifications. The first involved utilizing more efficient circular (concentric) jet probe sweeps with one meter spacing--instead of an x (north/south) and y (east/west) axis grid with two meter spacing -- the objective being to overcome the low visibility problem by having the probe diver on a tether line and thereby speed up the probing process while also increasing its precision (more sampling points per square meter).

We assumed, correctly, we would have many more target sites to address. The second modification involved the proposed deployment of a metal detector (Fisher Pulse 8 Model) sensitive to eight feet (i.e., to below the proposed depth of the dredge cut).

In the event of preliminary positive findings at any given site, a major test excavation was planned to permit both IRF and V.I. Government archaeologists to inspect and evaluate the historical value or significance of the shipwreck or site and to determine the nature, scope and scheduling of subsequent salvage effort required. All artifacts recovered were to be transferred to the Government of the Virgin Islands (DCCA).

4.0 OPERATIONAL SUMMARY

4.1 Mobilization Phase

Between 24 and 29 July sub-contracts with EG&G of Boston (for electronic instrumentation and services) and with Pat Boatright, dba Deeper Cheaper of St. Thomas (for vessel, barge and diving services) were finalized and all personnel, diving equipment, search instrumentation, vessels, boats and barges were assembled on site at the Long Bay staging and small boat dock area provided by WICO. Flood lights for security were installed and a 10'X40" trailer was also provided by WICO for storage. IRF constructed a covered "workshop" area and all equipment was tested.

4.2 Electronic Survey Phase

The procedure outlined in Section 3.1 on project planning above was followed by IRF and its sub-contractor, EG&G. Using a 24' Bertram (with a 5KW, 220 volt AC portable generator on board) the EG&G engineers commenced the survey of the target area on 30 July with the equipment specified above (see Figure 2 for its configuration).

A total of thirty-seven (37) sites were initially identified by EG&G, utilizing the Uniboom system and methodology as described. Geo-positioning data for each site was accurately determined by deploying a Raytheon Mini-Ranger system also previously described.

The vertical scale on the sub-bottom profiling records was kept at eight milliseconds (ms) throughout the survey resulting in a time difference of 8 ms between scale lines. Assuming a velocity of 5,000 ft/second in water this translates into twenty feet between scale lines, slightly more in the near bottom sediments.

To achieve maximum resolution the power level was set as low as possible, 100 joules, to allow as fast a firing rate as possible. The maximum duty cycle of the 234 power source is 6 pops/second at 100 joules and, consequently, the firing rate used was one (1) pop every 160 ms. As the EPC recorder was set for 80 ms full scale, and thus providing trigger pulses every 80 ms, the gating box was used to divide the trigger rate by two to provide the 160 ms trigger rate for the 234 power source and to prevent the EPC recorder from printing noise during idle sweeps.

Exceptions were experimental lines 19 and 40 where the energy level was set for 200 joules and the firing rate was 320 ms. The scale on the EPC recorder was still maintained at 80 ms full scale, but the gating box was set to divide by 4.

The signal from the hydrophone was fed to a preamplifier with a gain of 10, then through the Krohnhite filter to the EPC recorder. After some experimentation with various filter settings the optimum appearedto be a low cut setting of 200 Hz and a high cut setting of 200 KHz (open). These settings were used during most of the survey.

The Motorola MRS III navigation sysyem was integrated with an HP 85A computer and HP 9121D disk drive and an HP 747A plotter. The EG&G software allowed for real time trackplots and the use of the CRT screen as a steering indicator, as well as for print out of x, y coordinates and for the recording on disk of raw MRS III data as well as x, y coordinates along with other necessary information. The navigation system automatically marked the sub-bottom profiles every thirty seconds allowing the navigation data to be correlated with the seismic data. The disk and the print outs also contain information regarding line numbers and fix numbers which refer to the hand-written line and fix numbers on the sub-bottom profiling records.

During each evening the day's strip recorder charts were analyzed, fixes plotted and targets identified and given priority ratings from 1 to 3 or as follows:

Priority 1: Targets of substantial size believed to be man-made objects.
Priority 2: Less prominent targets, some may be sediment anomalies.
Priority 3: Less than 50% probability of being man-made objects.
Priority 0: Almost certain to be geological features or sediment anomalies caused by dredging, etc.

Table 2 displays the results of this phase of the survey effort. Locations are given as x, y coordinates in the 1,000 ft. grid based on Puerto Rican coordinate system, Virgin Islands Extension. In the case of the x coordinates, the two most significant digits are omitted and for the y coordinates the most significant digit has been omitted.

Table 2. Electronic search data summary, Long Bay marine archaeological survey.

Target #	Priority	Line #	Fix #	Row X	Row Y	Corrected X	Corrected Y	Target Depth	Comments
1	1	1	102	23446	84605	23468	89605	2'-5'	Looks like small dense object or objects could be shallower, but offset North or South
2	1	1	177	22419	84831	22441	84826	2'-4'	Looks like small dense object (10' long?) Could be shallower, May be associated with target #6
3	3	1	205	21976	84946	21998	84941	0'	Probably geological (fault) or sediment migration
4	3	2	417 to 420	23395 23494	84666 84558	23373 23422	84671 84663	5'-7'	Looks like sediment anomalies but could be several fairly large objects - Shallower if offset horizontally
5	2	3	480	22977	84775	22999	84770	8'-10'	Probably sediment anomally, Could be solid object. Could be shallower and offset North or South
6	3	3	506	22457	84880	22479	84875	8'	Same comments as 5 above May be same object as target #2
7	2	5	839	23537	85083	23557	85081	1'-3'	Could be shallower if offset North or South up to 12 Ft. May also be sediment anomaly
8	3	5	950	21472	85386	21484	65420	0'-8'	Navig data poor, Sediment anomaly - probably caused by dredging
9	3	6	1104	22485	85290	22462	85294	2'-8'	Could be offset up to 12' North or South if shallower, May be sediment anomalies
10	2	8	1482 to 1484	22702 22730	85084 84989	22680 22718	85050	3'-4'	Navig data poor, May be shallower and offset horizontally. Could also be sediment anomaly. Appears to be part of target #11 and maybe #1

Table 2. (cont.)

Target #	Priority	Line #	Fix #	Row X	Row Y	Corrected X	Corrected Y	Target Depth	Comments
11	3	9	1635	22691	85055	22713	85052	3'-6'	Poor navig data. Could be shallower offset up to 15' North or South May be sediment anomaly. See target 10
12	3	9	1709	21362	85407	21466	85312	6'-8'	Poor navig data. Could be shallower and offset. May be sediment anomaly
13	3	9	1723	21221	85319	21243	85319	2'	Poor navig data. Possible horizontal offset to 12' Is probably sediment anomaly only
14	3	9	1703	21541	85318	21563	85318	5'	Poor nav data. Probably sediment anomaly
15	3	11	2099	21234	85182	21256	85177	3'-4'	Sediment anomaly due to dredging
16	2	12	2181	21571	85164	21549	85164	2'-3'	Could be shallower with offset North or South to 12', May be sediment anomaly only
17	3	12	2245	22504	84989	22482	84994	5'	Could be offset North or South if shallower
18	1	13	2347	23634	84901	23656	84900	0'	Looks like good size object, 10' or more in length
19	2	13	2405	22681	85020	22684	85015	2'-4'	Poor Navig data. Could be offset North or South up to 12'
20	3	13	2482	21366	85287	21388	85286	3'	Poor Navig data. Probably sediment anomaly due to dredging
21	2	14	2560	21436	85425	21414	85432	0'	
22	3	15	2796	22345	85258	22345	85250	1'	Poor Navig data, May be sediment feature
23	0	16	2848 to 2862	22430 22376	85397 85205	22932 22373	85411 85218	10' to 30'	

Table 2. (cont.)

Target #	Priority	Line #	Fix #	Row X	Row Y	Corrected X	Corrected Y	Target Depth	Comments
24	2	20	408- 409	21859	85483	21879	85483	0'-3'	Poor Navig data. May be sediment anomaly
25	2	22	729- to 734	23307 23221	84947 84906	23329 23243	84951 84923	5'-8'	Several scattered objects. May be offset North or South up to 25' if shallow.
26	3	22	793	22191	85128	22213	85115	2'-3'	Poor Navig data. Could be offset North or South up to 15'
27	3	22	834	21528	85297	21550	85292	3'-4'	Probably sediment anomaly only
28	0	26	1693	21441	85487	21463	85487	0	Poor Navig data
29	3	27	1847	22375	84919	22367	84932	0-40'	Possibly sediment anomaly only.
30	3	28	2144 to 2145	21536 21526	85171 85172	21556 21546	85171 85171	 4'	Probably sediment anomaly
31	0	29	2218 to 2221	21219 21267	85456 85495	21200 21247	85457 85444		Poor Navig data. Reef or sand bar
32	0	8	1365	21222	85445	21200	85405		Ledge
33	3	8	1420	21927	85243	21905	85248	8'-10'	Could be offset North or South if shallower
34	2	5	8795	22797	85185	21819	85180	3'-4'	Possible North/South offset if shallower
35	2	5	895	22505	85238	22527	85233	1'-2'	Possible North/South offset to 12' if shallower. This target is probably same object as target #36
36	3	27	1894	22998	84793	22976	84798	10'-12'	Could be offset 28' North or South if shallower. Probably same object as target #5

Table 2. (cont.)

Target #	Priority	Line #	Fix #	Row X	Row Y	Corrected X	Corrected Y	Target Depth	Comments
37	3	13	2407	22628	85039	22640	85030	13'	Could be offset up to 30' North or South if shallower

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Of the original 37 possible targets five (#7, 18, 23, 31 and 32) were dropped as lying outside the target area and five others (those with a zero rank as almost certain to be geological in orgin - see Table 2) were also dropped, leaving a target universe of 27 sites to be inspected in detail. (See Figure 3.)

Each of these targets was then relocated, one-by-one, using the Mini-Ranger positioning system and each site visually inspected and marked:

(a) At the sea-bed with a piece of 3' to 4' steel rod driven into the bottom with a sledge hammer.

(b) At the sea-bed with a second similar steel rod with a polypropylene line and numbered sea-surface marker float attached.

(c) A duplicate of (b) above but offset ten feet to the north of (b).

N.B. This was a precaution against accidental loss of the primary marker float due to night vessel and dinghy traffic.

4.3 Target/Site Assessment Phase

After a target site was relocated and marked on the bottom and on the surface, as indicated above, IRF deployed a second separate team of divers, boats, barges and support personnel to immediately carry out a sequence of inspection activities that included (a) a visual survey of the surface area at the bottom and (b) to undertake detailed sub-bottom investigations involving several sequential steps:

1. Insertion of a high-pressure water jet probe into the sea-bed bottom in a series of concentric circles around the hypothetical target site;

2. Excavation of an inspection hole (or holes) using an air lift at the most promising location as determined by the jet probe process; and

3. Conducting a magnetic sweep of the specific environs of the site and in the hole excavated by the air lift method using a Fisher Pulse 8 metal detector.

The data generated by these combined efforts was then assessed and used to determine whether or not the findings for that particular site were either negative or positive. When there were minor positive indications, a second and, in some cases, even a third test excavation was undertaken at a particular site using the four inch air lift with all of the excavated material being delivered by the air lift to the receiving screen on the barge for the collection and analysis of any objects that would indicate the presence of either a shipwreck in the area or even a cluster of culturally significant artifacts warranting a more serious and more intensive site-specific salvage archaeology strategy.

Jet Probe Phase: The high pressure jet probe strategy involved maintaining on the barge a standard three horsepower, centrifugal, high pressure water pump delivering water through a two inch hose through a reducer to a one inch I.D. ten foot galvanized pipe, which the diver on the bottom would deploy at one to two meter intervals on concentric circles (one meter spacing between circles) seeking the "point of refusal" to the water jet probe. This "depth" information was then relayed to the surface-support barge tender, with whom the diver could communicate through a microphone in either the Kirby Morgan helmets or Desco full-face masks which were utilized by this team. The azimuth of the diver on each of the concentric circles, and therefore the position of the hole, was determined on the support barge by taking angular measurements of the air bubble column. The diver on the bottom operated with a tether to the target's central marker which controlled the one meter spacing of each of the concentric circles that were utilized for the jet probe sampling pattern. The diver's air supply was provided by an eleven cubic foot per minute, 150 psi air compressor driven by a 5HP Briggs and Stratton engine. Duplicate backup systems for the Kirby Morgan masks, the Desco masks, the communications system, the water pump and the 150 psi air compressor on the barge were maintained at all times. Both low pressure air compressors fed into an accumulator tank through a standard "Y" connection and through an activated carbon and demoisturizing filter system, which was inserted in the supply line between the air compressor and the accumulator tank. The communication line between the barge and the diver was simply taped to the air supply line which was a standard 3/8 inch low pressure hose with standard quick disconnects.

Excavation Phase: Once the jet probe process was completed, a target site was selected for the air lift excavation and the air lift screening barge moved over the site. The air lift was powered by one of the eleven CFM low pressure air compressors and the diver was either supplied by the second compressor or was equipped to operate independently using standard SCUBA gear. The process required a second diver to tend the air lift pipe and a third person on the air lift screening barge to monitor the output of the air lift. The air lift was comprised of a combination of eight foot sections of four inch ID standard PVC pipe with flexible rubber couplings and stainless hose clamp fastenings, plus a section of four inch ID flexible hose connecting the air lift head with the riser pipe in order to give the diver slightly more maneuverability and eliminate the continual repositioning of the air lift screening barge on the surface.

Magnetic Survey Phase: Once the air lift excavation was completed (which in many cases meant reaching a sub-bottom layer of consolidated virtually impenetrable coral rubble left behind by the 1935 dredging operation), the Fisher Pulse 8 metal detector was deployed, both at the bottom and sides of the hole and around it, to determine if there were any metal objects within an eight foot range of its sensing head.

In each instance, therefore, the combination of investigation techniques utilized enabled the team to determine that there was no evidence of any shipwreck or significant unknown ferrous objects within the six to eight foot layer of sediments scheduled to be dredged by the West Indian Company, Ltd. at a later date. In most cases IRF's combination of jet probes, air lift and magnetic detection strategies determined that there was nothing of significance in the first ten feet of sedimentary material or sea-bed within the target areas covered by the jet probe strategy, and as documented in Appendix A to this report.

4.4 Staffing, Equipment and Logistical Support

The Long Bay project involved a "team" of fifteen persons with an institution breakdown as follows:

	No. of persons
IRF staff (prof. & tech.)	6
IRF contracted professionals	3
EG&G (sub-contract)	2
Deeper Cheaper (sub-contract)	4
	15

A complete list showing assignments and person days is shown in Table 3.

An inventory of major equipment items actually deployed at the site is displayed in Table 4 and represents a market value (not replacement cost) of approximately $300,000.00. About one half of the items were leased for the duration of the project (or in the case of EG&G's electronic survey and positioning system for the required days on a daily rate of approximately $500/day plus shipping transit-time charges).

Logistic support required two project vehicles, one full time driver, five VHF radios, one pickup truck (4 days), two major vessels (44' Odyssey and a 24' Bertram), two barges, and four small craft with outboards.

It is worth noting that the number of person days required to plan, prepare and mobilize (and to demobilize properly) represent about forty percent of the total spent in operating "field" days for the project. Despite our efforts to anticipate problems and to marshall needed spare parts, back-up systems, etc. on site, we still experienced twenty-one working hours of down time on target sites resulting from equipment failures. For example, the flex hose couplings on the four inch air lift pipes turned out to be too flexible and would "crimp". We had not had this problem at Crown Bay where we deployed a three inch system. The solution lies in using a heavier wire reinforced hose with greater wall thickness.

TABLE 3. Personnel deployment, Long Bay marine archaeological survey.

PERSONNEL DEPLOYED	TASK ASSIGNMENT/STATUS	NUMBER OF PERSON/DAYS
IRF Project Staff		
E. Towle	Project Director/ Marine Archaeologist	20
M. Walker	Asst. Project Director/ Marine Archaeologist	15
W. Wernicke	Engineer	3
W. Jones	Master Diver	22
A. Fredebaugh	Diver	9
G. Towle	Technician/Mechanic Shipwright	20
E. Trupp	Technician/Logistics	24
S. Tate/K. Finnerty	Secretary	16
A. Mowbray	Electronics Technician	6
EG&G Engineering Services (Sub-Contractor)		
A. Schanzle	Project Electronic Survey Engineer	6
H. Holm	Project Electronic Survey Engineer	6
Deeper Cheaper, Inc. (Diving Service/Barge and Vessel Sub-Contract)		
P. Boatright	Senior Diver	14
J. Fitzgerald	Diver	14
L. Magner	Diver	14
R. Simone	Support/Survey/Vessel Crew	14
TOTAL PERSON DAYS		203
Non-Staff Project Participants		
T. Linnio, DCCA, Asst. Territorial Archaeologist	V.I. Government Observer	3
R. Consolvo	Volunteer (Logistics Support)	4
C. Consolvo	IRF Observer	Provided Fisher, Pulse 8 Magnetic Metal Detector (on loan)
K. Damon	IRF Observer	

Table 4. Equipment list, Long Bay marine archaeological survey project.

Boats (survey and support craft)

24' Bertram (Thumper), diesel, leased from P. Boatright (dba Deeper Cheaper).

44' custom, steel diesel ketch (Odyssey) research vessel owned by Island Resources Foundation. Document #506779, Port of Registry-Miami, Florida, hailing port-Key Largo, Florida.

Small craft (4) Zodiac, Achilles, Avon and Whaler, each with outboard and spare engines.

Barges (work type)

Sea Slug - self-propelled, fiberglass pontoon type with deckhouse, 40HP, leased from P. Boatright (dba Deeper cheaper).

Air Lift Screen (8' x 10') work barge, owned by Island Resources Foundation.

Vehicles - two

Communications

VHF radios (5) One on Thumper, one on Odyssey and three portable, hand-held.

Diver/Surface - two systems; one set for Kirby Morgan helmets; one for IRF's Desco Full Face mask system.

CB System (two units - one each on Thumper and Odyssey)

Compressors

HP, Mako 14, 7CFM, 3,000 psi (on Odyssey) for SCUBA tank fills.

LP, (2) diaphragm type 11 CFM, each driven by 5HP Briggs and Stratton gasoline engines.

Water Pumps

B&S 2" 140 gpm, 3HP unit and associated 2" hose and jet probe.

Generators

5KW, AC, gasoline powered, portable
4KW, AC, (Onan) gasoline on Odyssey
3.5KW, Kohler, gasoline, portable
2.5KW, Homelight, gasoline, portable

Dive Gear

Kirby Morgan helmets (2) with communication
Desco Full Face masks (2) with communication
Air Supply Hose LP (200psi), 300' with quick disconnects, line filters (2), and accumulator tank
SCUBA tanks (14) and associated gear
Hookah regulator (backup) and 200' of hose
Tank pressure gauges (two)
Lift bags
Air Lift, 4" PVC with flexible couplings, 40' in length
Dive flags (3)

Table 4. (cont.)

Navigation Gear and Ground Tackle

Buoys (100)
Buoy line, 5,000' of ½" & ¼" polypropylene
Stakes, steel 48"x1/2" or 3/8" (re-bar) (80)
Surveyors flagging tape (vinyl)
Hand bearing compasses (two)
Anchors (11) 10 lb. to 45 lb. with associated chain and rodes.
Light table/drafting table (on site)
Fathometers (2)
Anemometers (1)

Electronic Survey Equipment (leased from EG&G, Boston)

EG&G Uniboom transducer (1) mounted on catamaran
EG&G Model 234 Power Source (1)
EG&G Model 262 Hydrophone (1)
Krohnhite filter model 3550 (1)
Preamplifier (home made) (1)
Gating Unit (1)
EPC model 1600 recorder (1)

Electronic Navigational/Horizontal Control Equipment

Motorola MRS III MiniRanger console
Motorola R/T unit (1)
Motorola transponders (2)
Additional transponders (2), available as back-up units
HP 85 computer with dual disk drive and plotter (1)
EG&G software (1 set)

Miscellaneous tools, first aid kits (3), portable flood lights, extension cords (8), fenders, coolers (4), hoses, clamps, specimen bags and containers, etc.

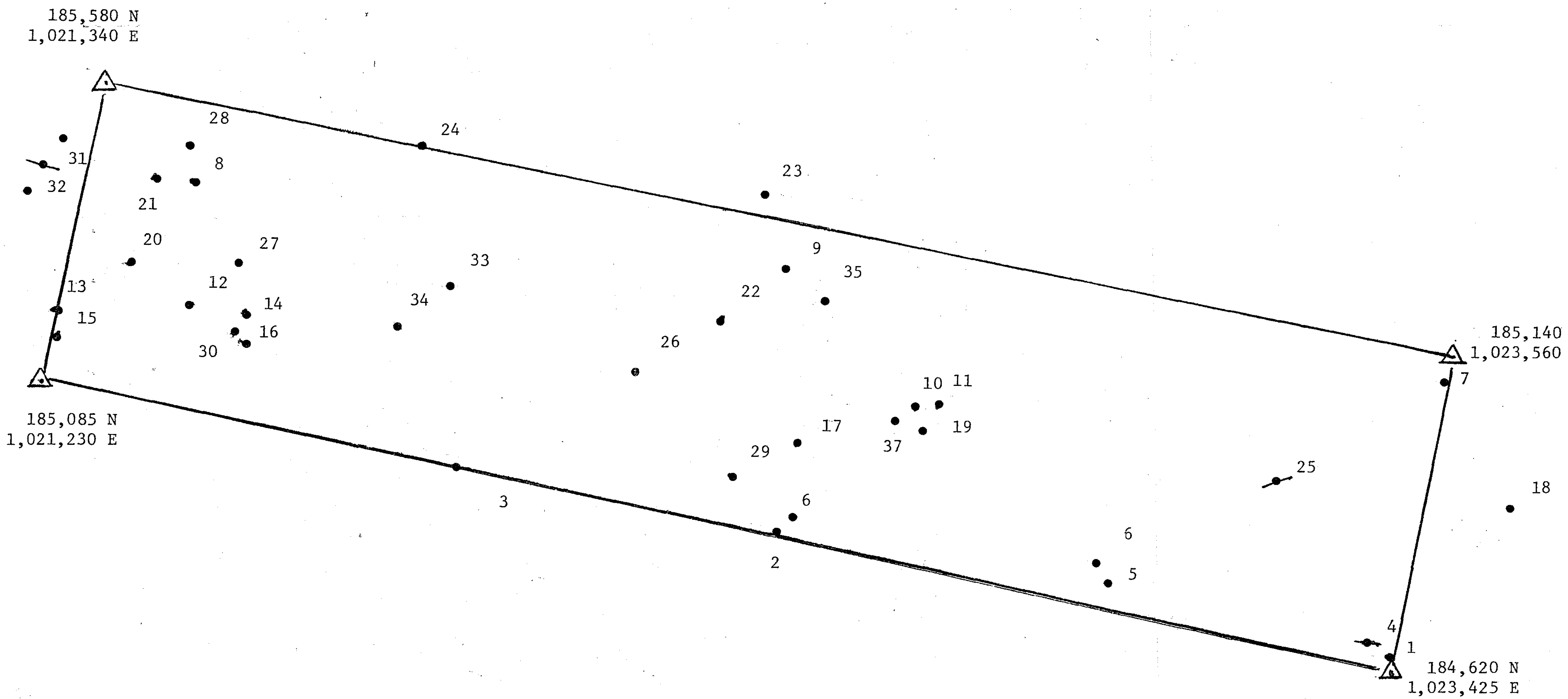

Figure 3.		by: ISLAND RESOURCES FOUNDATION
Target site identification map, Long Bay dredge area.	SCALE 1:24000 (1"=200')	DRAWN BY H. Holm, EG&G REVISED E. Towle, IRF
Based on U.S.Geological Survey, Topographic Sheet, Polyconic Projection, St. Thomas U.S.V.I.		
DATE 6 Sept,'85	APPROVED BY S. Tate	DRAWING NUMBER 85/Project #101

5.0 RESULTS AND CONCLUSIONS

5.1 Findings

Detailed findings, and a site "map" for each target site are presented in Appendix A (bound separately because it required a larger format). However, for the convenience of the reader, Table 5 combines elements of the survey data from Table 2 with site assessment and key findings from Appendix A. In our judgement, based on the evidence available, the 26 acre site to a sediment depth of approximately ten feet below the harbor bottom contains no shipwrecks, ship remains or cluster of artifacts with historical significance. We cannot say with any degree of certainty that the deeper sediments beneath this uppermost ten foot layer, i.e., deeper than forty feet from the water surface (MLW), do or do not contain one or more shipwreck sites but in all probability they do not.

Why was this 26 acre site so barren of both wreck sites and artifacts given the overwhelming evidence in the historical record of hundreds of "wrecked vessels" in the Long Bay and Charlotte Amalie harbor area - especially as a consequence of equally well documented periodic catastrophic hurricanes? The most logical explanation for the absence of shipwreck sites lies in (a) the nature of Long Bay and its relative shallowness, (b) its long history of consistent use as an anchorage, (c) its proximity to populated areas and (d) the fact that nearly all shipwrecks are caused by grounding along

Table 5. (cont.)

Target Site #	Priority from Electronic Data Analysis	Re-surveyed Marked and Buoyed	Jet Probes		Test Excavation	Finding	Notes:
			Number	Area, m²			
15	Low	no			none	none	geologic/sediment anomaly
16	Mid	yes	33	50	yes (1) (7 ft.)	negative	deep coral rubble layer (5 to 7') (See also site 30)
17	Low	yes	22	28	none	negative	negative mag. sweep (coral rubble 3-5')
18	High	yes			no	negative (mooring)	outside boundary, identifed visually as large mooring
19	Mid	yes	36	50	yes	negative	overlaps 10, 11 and 37, negative mag. sweep
20	Low	no			none	none	negative mag. sweep
21	Mid	yes				negative	U.S.C.G. mooring
22	Low	yes	37	64	yes (4) (@ 3-4')	negative	neg. mag. sweep, debris. Coral layer 4-6'
23	Nil	no					outside boundary
24	Mid	yes	37	64	yes (4)	negative	adjacent to old dredge cut ledge.
25	Mid	yes	39	56	yes (1) (@ 5')	negative	shell & coral (compacted) rubble layer negative mag.
26	Low	yes	25	78	yes (2)	negative	coral heads above sea bed, neg. mag. sweep
27	Low	no			no	negative	neg. mag. sweep
28	Nil	no			no	none	visual inspection neg. (chain assoc. with CG mooring)
29	Low	yes	25	28	yes (2)	negative	3 emergent coral heads on N/S axis, shell and coral layer consistent under

Table 5. (cont.)

Target Site #	Priority from Electronic Data Analysis	Re-surveyed Marked and Buoyed	Jet Probes		Test Excavation	Finding	Notes:
			Number	Area, m^2			
30	Low	no	none		no	negative	see 16, neg. mag. sweep
31	Nil	no					outside boundary
32	Nil	no					outside boundary
33	Low	yes	40	28	yes (1) (@ 6 ft.)	negative	grassy bottom, consolidated coral shell at 3 to 6'
34	Mid	yes	23	36	yes (2) (@ 5')	negative	no debris, coral & shell layer, variable, hard, neg. mag. sweep
35	Mid	yes	25	50	yes (1) (@ 5')	negative	neg. mag., hard packed sand
36	Low	yes				negative	same as Target #5 neg. mag. sweep
37	Low	yes				negative	same as Target #10

N.B. Neg. mag. = negative magnetic sweep of test airlift excavation hole or area using a Fisher Pulse 8 Underwater Metal Detector, (set for maximum distance/large mass reading of up to 8 feet from sensing head).

a shoreline - i.e., are driven ashore by storm action dragging their anchors or moorings under the force of combined effects of wind and wave action.

Ships in a harbor seldom "sink at anchor" or on a mooring. When they have, they (a) became hazards to navigation (i.e., to other vessel traffic) and were removed and (b) were easily salvaged or scavenged or both. If the sunken vessel could not be raised (i.e., floated off the bottom and towed elsewhere for repair or stripping), grappling hooks and often black powder (later dynamite) were used to break or blow them apart to make the salvaging of cannon, cargo, and ship's hardware easier. In the odd case of a catastrophic fire aboard a ship while at anchor, we do find (as in the case of the HMS Nymph, in Roadtown Harbor, Tortola) occasionally a "ships" remains in the "central" harbor and not along the shoreline. Even in this case - i.e., an uncontrollable fire - the usual result is an explosion of gun powder carried on board resulting in a dispersal of the ships fragmented remains over a large expanse of harbor bottom.

Lastly, and in conclusion, we see no valid reason, from a marine archaeological perspective, why the proposed WICO dredging of the 26 acre Long Bay site should not proceed. We do recommend a modest archaeological monitoring effort at the scheduled dredge spoil disposal/land-fill area to capture and retrieve possible miscellaneous artifacts of historical value pumped up from the borrow area.

5.2 Costs

It is instructive to compare the Long Bay marine archaeological survey costs ($69,000) with those for the Crown Bay study completed in two segments (1981 and 1984).

The Crown Bay Marine Archaeological Survey effort cost $38,000. for the preliminary (Tetra Tech) search effort (1981), and $48,000. for the magnetic anomalies site-relocation assessment effort (13 sites), but this second phase involved an additional hidden cost of approximately $10,000. as the VIPA provided various project support services (LADY PLEASANT with Captain and fuel for eight days @$500/day, a large rented trailer/van for on-site equipment storage for twenty days @$50/day, an on-site project office/communication center for thirty days ($500.), and two (2) shore-based transit operator/ surveyors with instruments for fixes (approximate cost - $3,500.), plus other incidental services of providing maps, shoreline georeference data, etc.

It is noted that the Crown Bay effort (Tetra Tech and IRF) cost a total of approximately $96,000 for thirty detected anomalies, or $3,200/anomaly (preliminary determination). The Island Resources Foundation relocating and assessment phase involved thirteen anomalies at $48,000. (plus $10K for Port Authority support), or a total of $58,000. for thirteen anomalies in the relocation assessment phase , or $4,460/anomaly. It was obviously not cost effective to perform the required work in two stages, as the second relocation task involves redundant costs.

In the case of the Long Bay effort just completed, with 37 sites located, 27 sites studied and 203 person days of effort covering 26 acres of harbor bottom (with turbid water conditions) the cost breakdown is as follows (with a total project cost of $69,000.):

37 total "detected" sites - $1,865./site
27 primary found and evaluated sites - $2,555./site
27 primary sites required 7.5 person days per site
It required 7.8 person days/acre of sea-bed studied
It cost $2,650./per acre
It cost $339./person/day (including support services, vessels, instruments, overhead, etc.)

Obviously, the Long Bay strategy, compared to Crown Bay, was more efficient even though it involved more sites and the search and survey instrumentation cost more than twice that at Crown Bay (which involved a magnetometer and shore-based "positioning" system). Furthermore, it was completed in less time but with greater precision, and at about half the unit cost per target as compared to the Crown Bay effort.

5.3 Acknowledgements

Several persons were extraordinarily helpful to the Long Bay project. Island Resources Foundation extends its appreciation especially to:

(a) Mr. Joe Sutton, Enforcement Bureau, DCCA - for assisting in the removal of yachts from the study site;

(b) Mr. Tom Linnio, Assistant Territorial Archaeologist, Bureau

of Libraries, Museums and Archives, DCCA - for both his three full days on site as an official observer and diver and for his constructive counsel;

(c) Mr. Charles Consolvo - for the loan of his brand new Fisher Pulse 8 Metal Detector;

(d) Mr. John Battles and Ms. Anna Clarke of WICO - for their efficient provision of technical and logistic support;

(e) Mr. Richard Consolvo - for donating several days time and the use of a pickup truck;

(f) Mr. Ken Damon of St. John - for his site visit and counsel on and evaluation of the electronic survey instrumentation and survey team performance.

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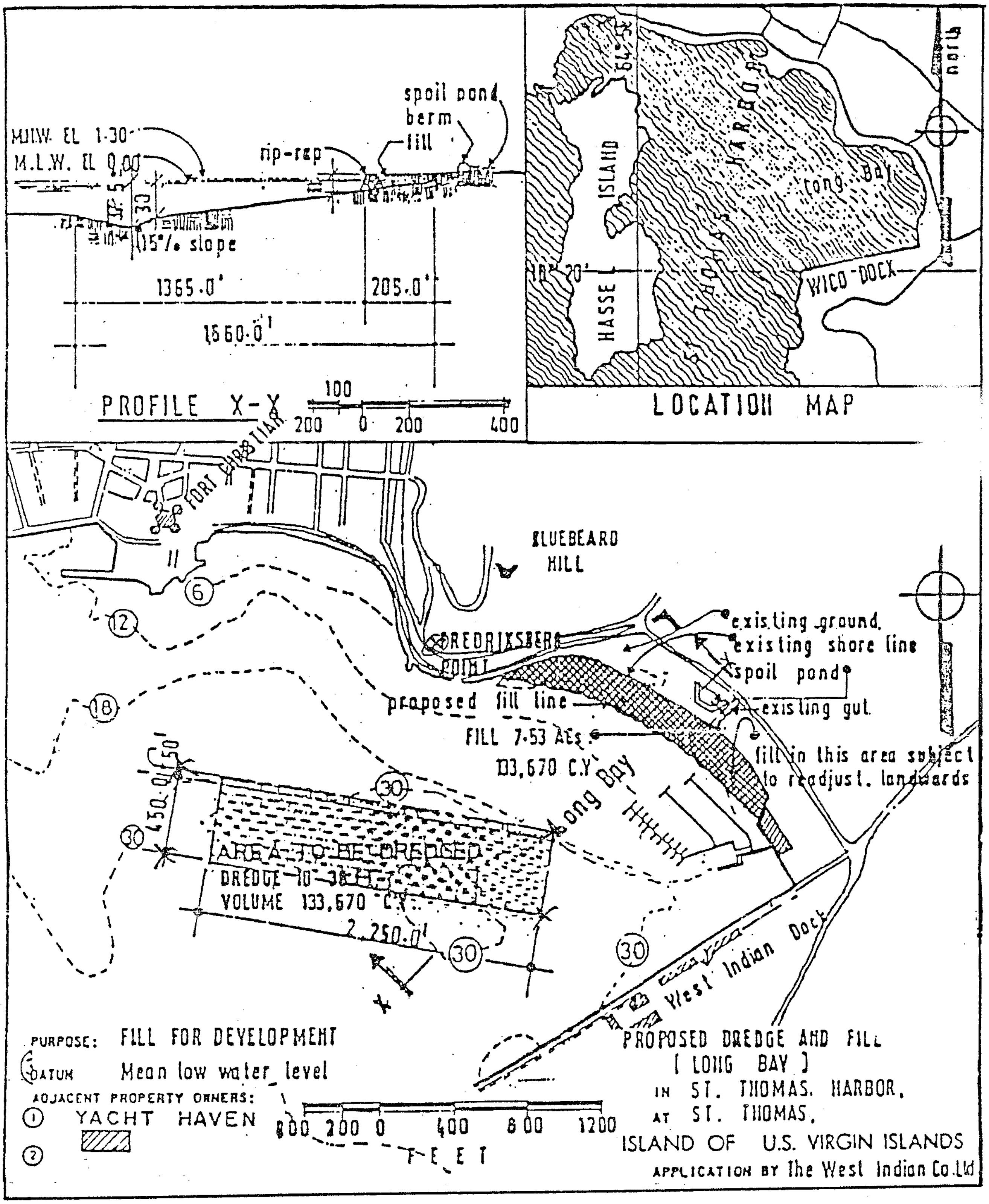
Attachment 1. Environmental assessment site specification map for proposed West Indian Co. dredging project.



Attachment 2. Notice from Department of Conservation and Cultural Affairs relative to removal of vessels from Long Bay study site.

DEPARTMENT OF CONSERVATION & CULTURAL AFFAIRS

WARNING

Department of Conservation and Cultural Affairs
P. O. BOX 4399
CHARLOTTE AMALIE, ST. THOMAS, V.I. 00801

June 25, 1985

MOORINGS PROHIBITED IN PORTIONS OF LONG BAY

An electronic survey followed by dredging a portion of Long Bay, St. Thomas, where some boaters are moored, is scheduled to begin on or about July 15, 1985, announced CZM Director Benjamin Nazario.

The West Indian Company, Ltd. has marked out an area approximately 2,250 ft. long running east to west; and 500 ft. wide running north to south. The corners and limits of this area are established with bright color spar buoys marked "DCCA".

Signs on floating buoys stating "Restricted Area; Area to be dredged; Mooring prohibited", will be used to demarcate the area to be surveyed and dredged.

Mooring within this area is restricted for the duration of this activity. Boaters are asked to relocate outside this area prior to July 15 and during the survey and dredge period which will last approximately six (6) months once work commences.

#######

RADIO ANNOUNCERS: Kindly make this announcement (1st and last paragraph) as frequently as possible. Thank you.

Attachment 3. Instrumentation specifications.

Model 230-1 UNIBOOM Unit Pulse Boomer

Pulse Character

Energy Level:	@ 100 watt-seconds	@ 200 watt-seconds	@ 300 watt-seconds
Duration:	0.2 milliseconds	0.2 milliseconds	0.2 milliseconds
Source Level:	95 db ref. 1 microbar at 1 meter	104 db ref. 1 microbar at 1 meter	107 db ref. 1 microbar at 1 meter
Spectrum:	700 Hz to 14 kHz	500 Hz to 10 kHz	400 Hz to 8 kHz
Repetition Rate:	6 pulses/second	4 pulses/second	2 pulses/second

Catamaran

Improved design features free flooding lower halves of floats for reduced buoyancy, increases inertia and less sensitivity to wave action.

Dimensions: 84 cm [W] x 59 cm [H] x 158 cm [L] [33" x 23" x 62"]
Weight: 90 kg [200 lbs.]
Cable Length: 40 meters [120 ft.]
Towing Speed: 2 to 8 knots

Model 234 Energy Source

Input Power Requirements:

Voltage:	115 ±15 VAC, 45 to 65 Hz	230 ±30 VAC, 45 to 65 Hz
Peak Current:	100 Amperes	50 Amperes
Average Current:	30 Amperes	15 Amperes
Average Power:	2.2 Kilowatts	2.2 Kilowatts

Trigger:

Pulse Amplitude: +5 to +15 volts into 700 ohms
Pulse Width: 5 to 500μs [50% points]
Rise Time: Less than 5μs
Manual Trigger also provided
Charging Voltage: 3.5 Kilovolts Nominal

Output Energy:

100 Joules Nominal [16μf Capacitor] — Maximum Discharge Rate 6 pps
200 Joules Nominal [32μf Capacitor] — Maximum Discharge Rate 4 pps
300 Joules Nominal [48μf Capacitor] — Maximum Discharge Rate 2 pps
Life Expectancy: 10 million discharges without component replacement at any output energy specified.

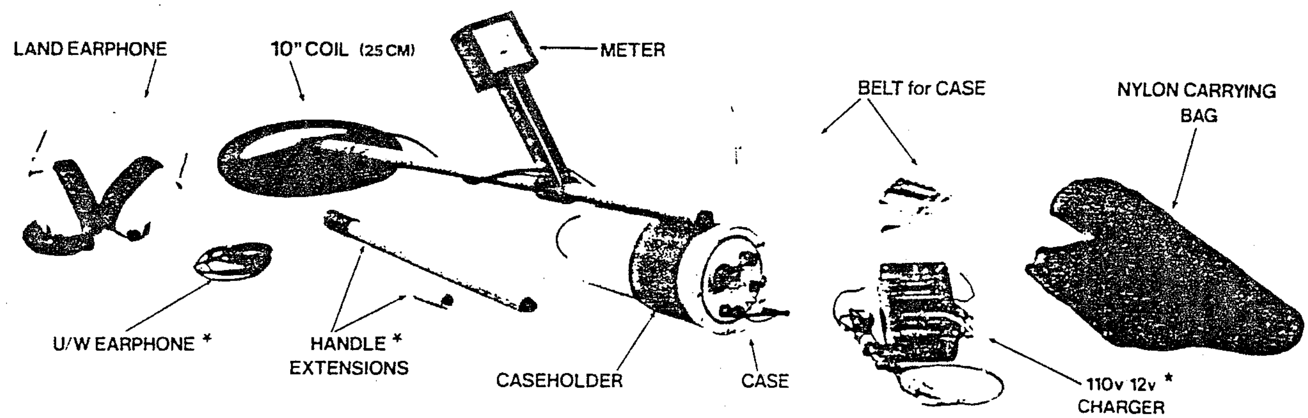
Dimensions: 51 cm [W] x 48 cm [H] x 56 cm [D] [20" x 19" x 22"]
Weight: 73 kg [160 lbs.]
Safety Features: •Cover Interlock • Dump Relay • Shunt Resistors • Circuit Breaker

Model 265 Hydrophone

Input Power:	9-volt battery	Active Section:	
Sensitivity:	−70 db/volt/microbar	Number of Elements:	8
		Length:	4.6 m [15 ft.]
Bandwidth:	100 Hz-10 kHz	Diameter:	25 mm [1"]
Maximum Tow Speed:	15 knots	Weight:	3.2 kg [7 lbs.] neutral buoyancy
Tow Depth:	0-30 meters [0-100 ft.]	Preamplifier:	
		Gain:	40 db
Output Connection:	BNC Connector	Output Impedance:	2k ohms
Tow Cable Length:	45 m [150 ft.]	Tail:	
Diameter:	1.25 cm [½"]	Length:	9.1 m [30 ft.]
Breaking Strength:	115 kg. [250 lbs.]	Diameter:	6 mm [¼"]

Fishers Underwater Pulse Detectors

For Underwater and Land Use



NOTE: PULSE 8 WITH ACCESSORIES SHOWN
★ PULSE 6 ACCESSORIES

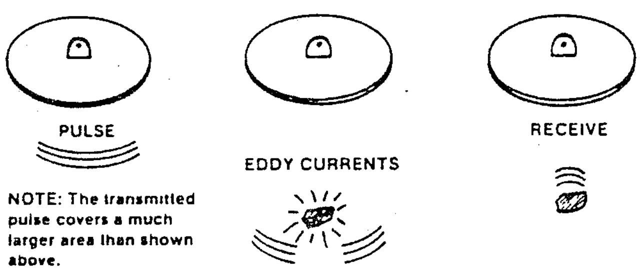
Pulse 6	$595.00
Pulse 8	$1200.00
Extra batt. pack for Pulse 6&8	$ 35.00

Boat Towed Pulse 10	$1900.00

PULSE DETECTORS   HOW THEY WORK

Conventional detectors (TR, BFO, inductance balance etc. — not including magnetometers) all radiate a continuous signal which is reflected back or whose frequency shifts, as a result of metal or minerals near the coil. Most quality detectors contain compensation networks in an effort to reduce the effect of minerals on the unit. At best, these networks reduce some of the minerals effect, but the units remain metal/mineral detectors. In large areas of the ocean floor the mineral concentration is so strong that it is very difficult to pick out metal targets from the strong mineral readings.

Pulse detectors operate by transmitting a continuous stream of high energy magnetic pulses (one hundred per second) from the coil. After each pulse is transmitted the unit then "listens" using the coil as the receiving antenna.



NOTE: The transmitted pulse covers a much larger area than shown above.

When a transmitted pulse hits a metal object, a magnetic field is induced in the object. This causes eddy currents to flow in the metal, which in turn generates a second magnetic field. This field is picked up by the coil, amplified and then displayed by the meter and heard in the earphone.

Our Pulse 6 and Pulse 8 detectors are identical in appearance. The main difference between the units is that the Pulse 8 is more sensitive and has more features. Once purchased, the Pulse 6 is upgradeable to a Pulse 8 any time in the future for the difference in price between the units.

PULSE SENSITIVITY

You can expect the following detection ranges whether buried in mud, coral, sand, dry or wet, fresh or salt water.

	Pulse 6	Pulse 8
• penny	6 in (15 cm)	12 in (30 cm)
• quarter	7 in (18 cm)	13 in (32 cm)
• 2" × 2" × 1/8" alum	10 in (25 cm)	15 in (38 cm)
• 4" × 4" × 1/8" alum	13 in (33 cm)	20 in (50 cm)
• 1 gal can	27 in (68 cm)	46 in (115 cm)
• larger targets to a maximum	6 ft (185 cm)	8+ ft (240+ cm)

WARRANTY

The PULSE 6 and 8 carry a full 2 year warranty from date of purchase.

FEATURES FOR PULSE 6

- upgradeable to a PULSE 8 at any time in the future
- single knob control
- very sensitive and stable
- detects both ferrous and non-ferrous metals
- detection indicated by both meter and earphone
- does not detect minerals
- underwater earphone fits under divers hood
- hand-held search coil with large easy to read meter on handle
- land extension handle which easily converts the unit to a perfectly balanced land detector
- "Battery Low" LED
- battery charger which operates from either 110vac or 12vdc (switch selectable). The charger connects to a plug on top of the underwater housing and recharges the ni-cad battery pack in 12-14 hrs.

ADDITIONAL FEATURES FOR PULSE 8

- considerably increased sensitivity and detection area
- sensitivity switch allowing pin pointing of targets
- meter indicates battery condition
- two sets of earphones, one for underwater and one for land use
- a belt case holder giving you the option of mounting the electronics case on your belt
- a nylon carrying bag for the detector and accessories

OPTIONS

Spare ni-cad battery pack — batteries are good for 5-6 hrs. of continuous use before requiring recharging (12-14 hrs.)

SPECIFICATIONS FOR PULSE 6 & PULSE 8

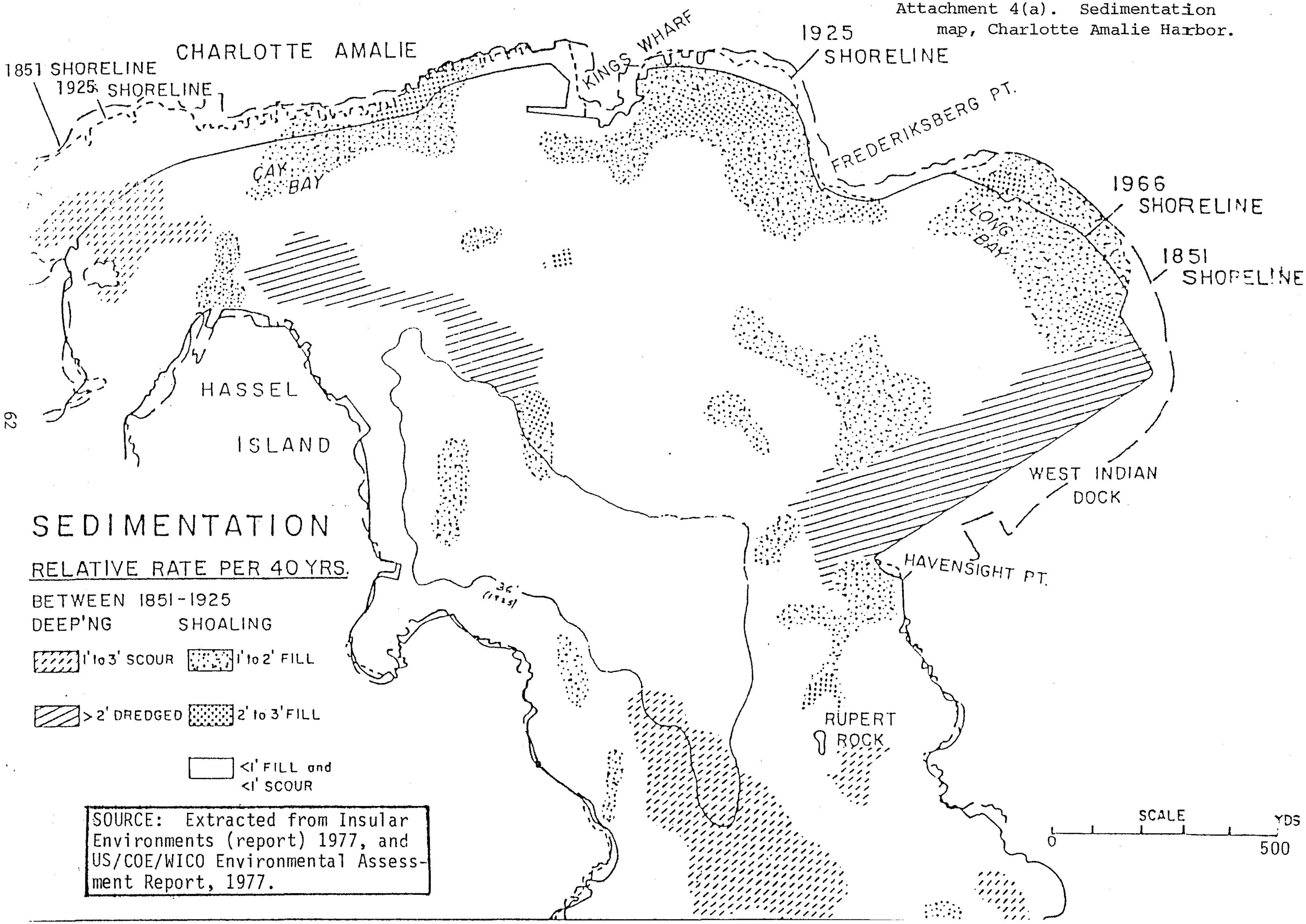
Coil:	
diameter	10 in. (25 cm)
weight (air)	20 oz. (.6 Kg)
(water)	10 oz. (.3 Kg)
material, color	epoxy, black
Case:	
diameter, length	3 • 8 ins (7 • 20 cm)
weight (air)	3 lbs (1.3 Kg)
(water)	4 oz (110 gr.)
material, color	epoxy, yellow
Handle:	
length from grip (U/W)	21 in (55 cm)
(land)	36 in (90 cm)

Attachment 3 (continued).

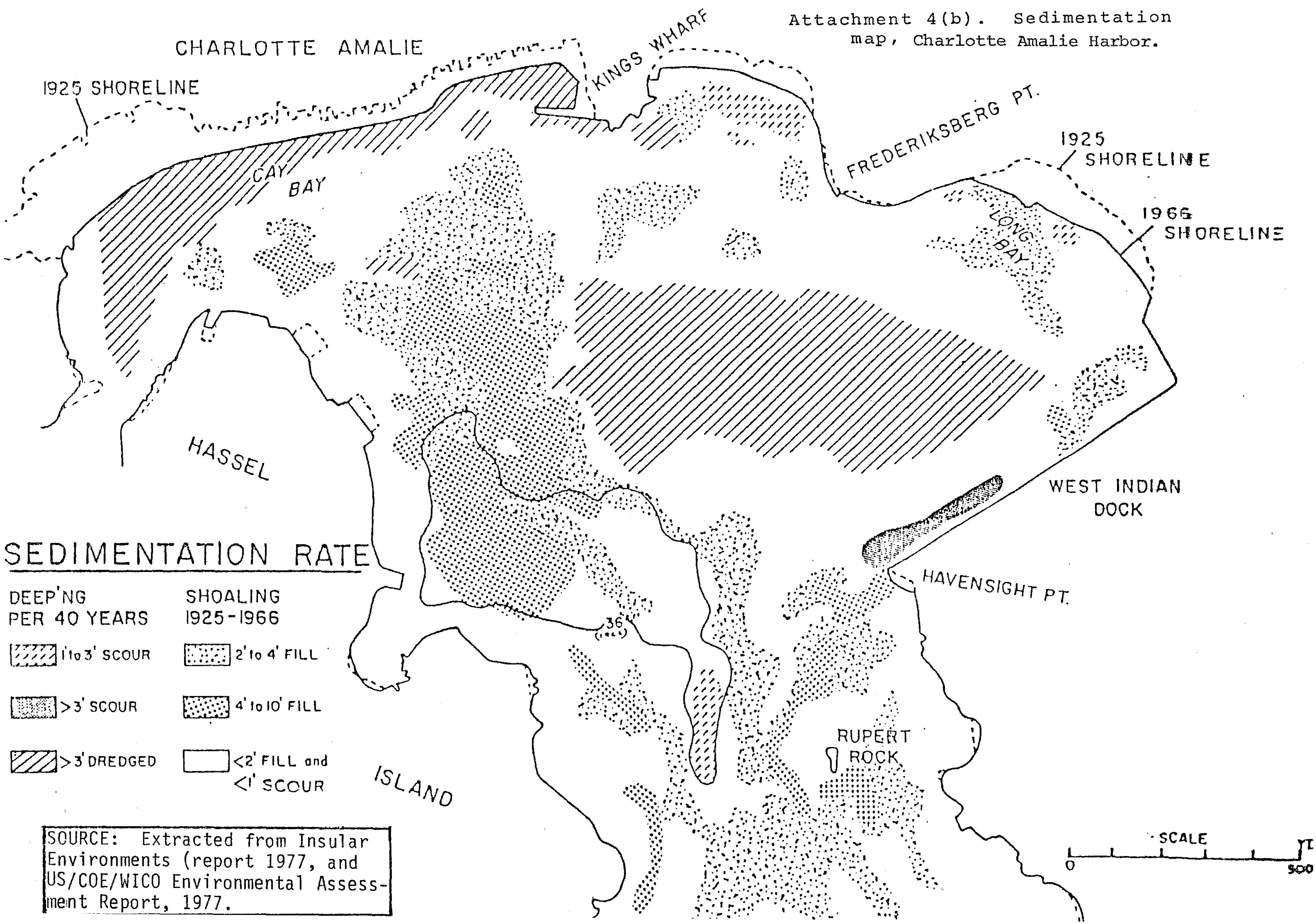
Mini-Ranger III Specifications

Frequency Range	5400 to 5600 MHz
Range (line of sight)	20 nautical miles (20–100 nm with available options).
Probable Range Error	3 m at 20 nautical miles
Coding	Four selectable codes utilizing pulse spacing
Range Readout Units	Meters, standard; Yards, optional; Feet, optional
Range Readout Selection	Channels A and B (Duel simultaneous readout)
Range Output to Peripherals	BCD, TTL, +8421 parallel
Operating Voltage	
Range Console	115/230 v, 50–400 Hz, 24–30 vdc (plug-in option)
Reference Stations	24–30 vdc
Antennas	
Mini-Ranger III	Omni-directional, 25° elevation
Reference Stations	13 dB Sector type, 75° azimuth, 15° elevation
Operating Temperature Ranges	
Range Console	0 to +50°C
Receiver–Transmitter	−40 to +60°C
Reference Stations	−54 to +71°C

Attachment 4(a). Sedimentation map, Charlotte Amalie Harbor.



Attachment 4(b). Sedimentation map, Charlotte Amalie Harbor.



SOURCE: Extracted from Insular Environments (report 1977, and US/COE/WICO Environmental Assessment Report, 1977.