Final Report

POSTDISPOSAL AREAL MAPPING OF SEDIMENT CHEMISTRY AT THE FORT PIERCE, FLORIDA ODMDS

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CONTENTS

APPENDICES

LIST OF FIGURES

List of Figures (continued)

LIST OF TABLES

1.0 INTRODUCTION

Ocean disposal of dredged materials can affect the environment of a disposal site by disrupting the benthic community and potentially causing long-term reduction of oxygen in the pore waters of the surficial sediments and the overlying water column. Dredged materials may also be transported by natural ocean processes into habitats adjacent to the disposal site. Because careful selection of a disposal site can minimize impact to sensitive areas, an Environmental Impact Statement is prepared to address these ecological considerations. Once a site is chosen for disposal of dredged materials, the Environmental Protection Agency (EPA), in conjunction with the United States Army Corps of Engineers (USACE), becomes responsible for managing and monitoring the disposal site and associated disposal activities. This responsibility is mandated under Section 102 of the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA). EPA Region IV is currently responsible for managing and monitoring 18 designated ocean dredged-material disposal sites (ODMDS). A critical component of the monitoring programs is the tracking of sediment and sediment movement patterns in and around the ODMDSs. Determining the transport and fate of deposited material is key to understanding the potential long-term effects of the dredged-material disposal and identifying where the effects may be manifested.

To assist in the monitoring of the Fort Pierce ODMDS, EPA Region IV uses a combined rapid seafloor sediment-sampling and analysis system, the GIMS/CS;, developed by the Center for Applied Isotope Studies at the University of Georgia (CAIS). The GIMS/CS; is made up of two component systems. The Gamma Isotope Mapping System (GIMS) uses a towed sled with a gamma radiation detection capability, and gathers seafloor radiation and bathymetric data for the interpretation of the chemical nature and distribution of seafloor sediments. The Continuous Sediment Sampling System (CS;) uses a sled-mounted submersible pump to collect and deliver a sediment slurry from the seafloor to the survey vessel, where it is processed and collected as a wafer sample on filter paper. The sediment samples collected are analyzed at the CAIS laboratory using x-ray fluorescence spectroscopy (XRF). The GIMS/CS; uses a single towed sled containing components of both systems, allowing their simultaneous operation. The GIMS/CS; enables the survey team to produce

near real-time maps of seafloor gamma radiation activity and bathymetry in and around the disposal site, and permits *in situ* evaluations of native sediments and dredged material.

Because EPA Region IV has routinely used the GIMS and CS; (or the combined GIMS/CS;) during ODMDS monitoring activities over the past several years, the operation of these systems and the subsequent analysis of collected samples has become routine. Therefore, the EPA has determined that one universal, comprehensive (19-point) Quality Assurance Project Plan (QAPjP) is applicable to all ODMDS surveys. This QAPjP (CAIS, 1995) should be referenced for detailed descriptions of the technical approaches, quality assurance, and quality control methods applied for the use of these systems.

2.0 OBJECTIVE

The primary objective of the sediment mapping survey was to systematically map the relative isotopic and elemental concentrations in and around the Fort Pierce ODMDS. A secondary objective of this study was to compare the data from the previous sediment mapping surveys and document any changes in the seafloor environment. Four previous sediment-mapping exercises (March 1992, June 1994, January 1997, and February 1998) have been completed at the Fort Pierce ODMDS and will be used as a historical background for the site (CAIS, 1992; CAIS, 1994; CAIS, 1997; and CAIS, 1998).

3.0 BACKGROUND

The Fort Pierce ODMDS was designated in 1993 following a long history of dredged material disposal in a nearby and overlapping region called the Ainterim@ disposal site (Figure 1). The interim site had been used for disposal of materials dredged from Fort Pierce Harbor between 1949 and 1991, with an estimated average of 21,200 cubic yards of material being deposited annually at the site (EPA, 1993). In January 1991, a video mapping survey conducted by the EPA at the interim disposal site indicated the presence of hard bottom communities near and

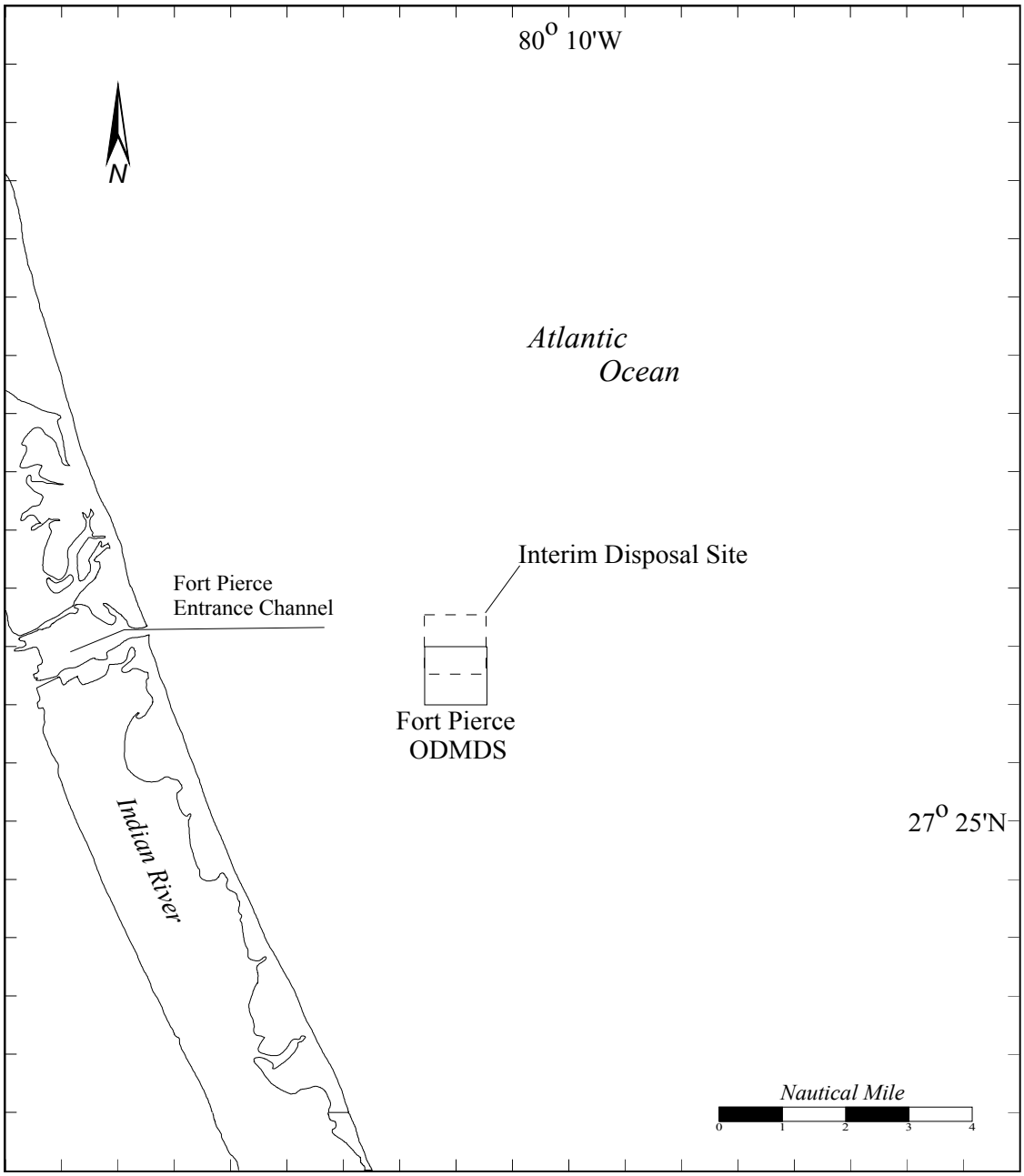


Figure 1. Fort Pierce ODMDS and the previously designated Interim Disposal Site.

within the northern site boundary, resulting in a shift of the proposed official ODMDS 0.5 nautical miles to the south. In March 1992, the CAIS conducted a baseline sediment mapping survey that encompassed both the interim and the proposed ODMDS site. With the exception of the hard bottom areas present in the interim site, the proposed ODMDS was found to consist primarily of medium to coarse-grained calcium carbonate sand sediments that exhibited relatively uniform elemental concentrations and gamma activity levels (CAIS, 1992). The U.S. EPA Region IV issued a final Environmental Impact Statement for the Fort Pierce ODMDS in July 1993 (EPA, 1993).

During the winter of 1993-94, approximately 77,400 cubic yards of material from Fort Pierce Harbor was deposited at the ODMDS. According to the EPA, the material was to have been deposited near the center of the newly designated ODMDS, in an area corresponding to the center of the southern boundary of the interim site (EPA communication, 1994). No further specifics on the disposal locations were provided, although a second CAIS mapping survey conducted in June 1994 provided a strong indication that the bulk of this material was actually dropped just north of the ODMDS boundary, in the northwest quadrant of the interim site (CAIS, 1994).

Between June and August 1995, the Fort Pierce harbor and entrance channel were dredged as part of a maintenance and deepening project. During the course of the project, approximately 724,000 cubic yards of dredged material were deposited at the Fort Pierce ODMDS. Of this material, it was estimated that 574,000 cubic yards of sediment were dredged from the harbor, and approximately 150,000 cubic yards was dredged from the entrance channel. The bulk of the harbor material was deposited along a north-south line near the western boundary of the ODMDS, although records show that several loads of dredged material were also deposited north of the ODMDS outside the site boundary (Figure 2). No specific drop locations were provided for the dredged material from the entrance channel.

A third sediment mapping survey was begun by CAIS at the ODMDS in November 1996 and completed in January 1997, following the Fort Pierce Harbor maintenance and

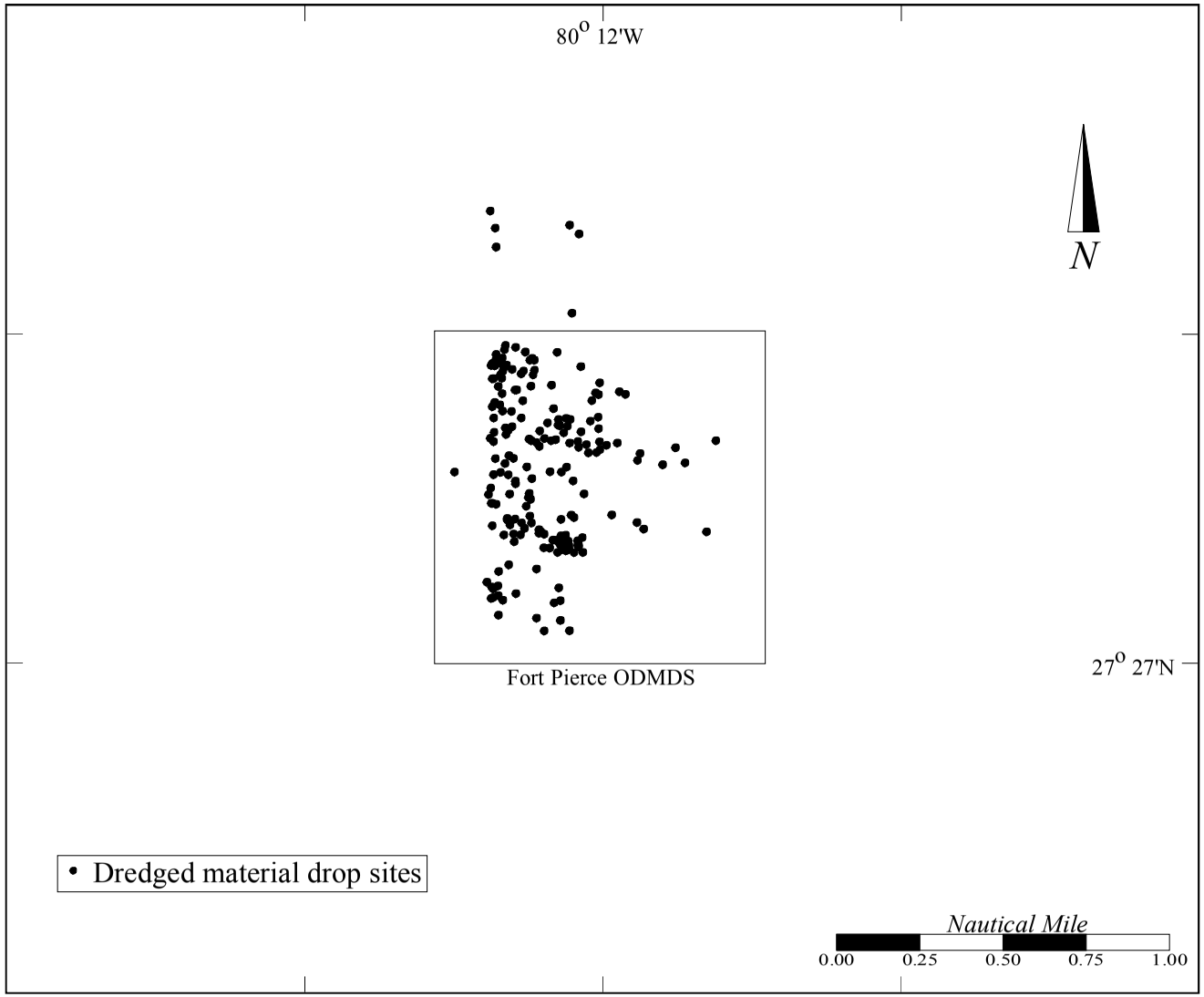


Figure 2. Dredged material deposited at the Fort Pierce ODMDS during 1995 disposal activities.

deepening project. The survey clearly indicated the presence of the deposited dredged material in association with the reported locations. A follow-up survey was conducted just over one year later in February 1998, which found that the deposited dredged material was still clearly visible within the ODMDS. However, there was distinctly less fine-grained sediment present at the site in February 1998 as compared to January 1997.

During August and September 2002, there were a total of 57 loads of dredged material transported to the ODMDS containing an estimated 143,000 cubic yards of sediment. Of this dredged material, approximately 40,000 cubic yards was silt and the remainder was fine- to medium-grained sand. The southeastern corner of the ODMDS was designated as the target area for disposal (Figure 3). The majority of the dredged material was deposited within the target area. However, there were several drops outside the target area, but within the ODMDS.

4.0 TECHNICAL APPROACH

The survey involved systematic mapping of the relative isotopic and elemental composition of seafloor sediments in and around the Fort Pierce ODMDS using the combined GIMS/CS; system. Table 1 lists the technical specifications for the GIMS and the CS; survey equipment. The GIMS/CS; survey data was used to generate a series of two- and three-dimensional maps for the target analytes listed in Table 2. Sediment grab samples were also collected and analyzed in the laboratory using an XRF spectrometer (for elemental content), a high purity germanium (HPGe) gamma spectrometer (for gamma radiation activity), and standard testing sieves (for particle size distribution). The target analytes and particle size classifications measured for the sediment grab samples are also listed in Table 2.

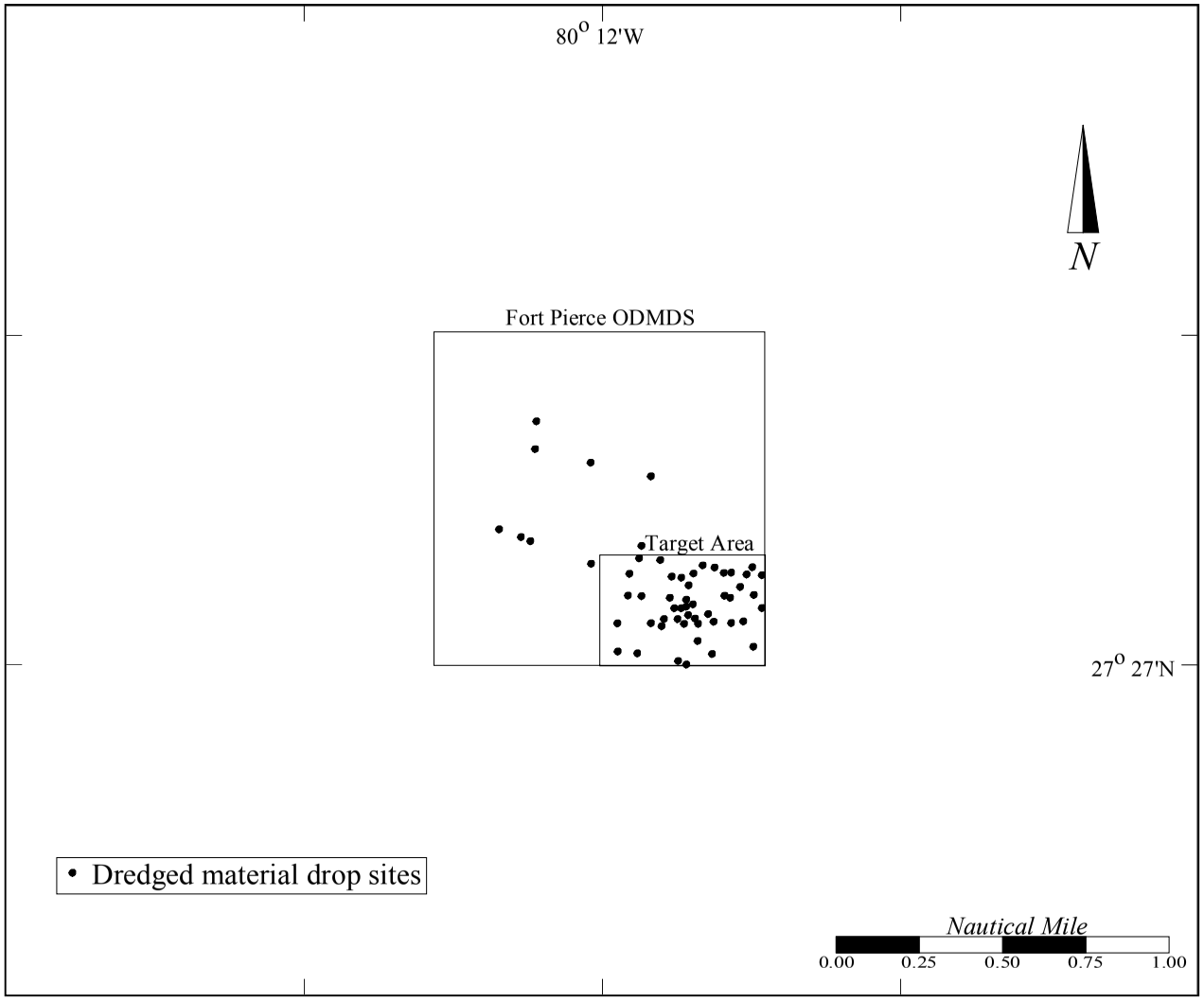


Figure 3. Dredged material drop sites at the Fort Pierce ODMDS during August and September, 2002.

Table 1. GIMS and CS; Technical Specifications

GIMS	
Data results	Counts per minute (cpm)
Format	Hard-copy printout
Sampling interval	60 s
Calibration standard	Monazite sand
Calibration results	Spectrum printout
Navigational method	Loran C and Differential Global Positioning System (DGPS)
Operating range	
Gamma signal depth	.25 cm
Reference	^{137}Cs
Reference channel	55
Resolution	. 8%
Gain	0-255
Preferred gain	50-220
Ship speed	2.5 to 3 kn
CS;	
Analytical method	XRF
Data results	Parts per million (ppm) Weight percent (wt%)
Format	Hard-copy printout
Sampling interval	305 m
Calibration test	NIST standards for XRF
Navigational method	Loran C and DGPS
Operating range	
Penetration (sled)	.2-10 cm
Ship speed	2.5 to 3 kn
Sample	Sediment pellet or wafer on glass fiber filter
Sample size	.31 mm
Sample weight	20-200 mg

Table 2. Analytes and Reporting Units According to Analytical Method

Analytical System	Analyte		Reporting Units
GIMS	^{40}K	Potassium	Counts per minute (cpm)
	^{214}Bi	Bismuth	
	^{208}Tl	Thallium	
	Total		
XRF (CS; filter and sediment grab)	Mg	Magnesium	Weight percent (wt%)
	Al	Aluminum	
	Si	Silicon	
	P	Phosphorus	
	Ca	Calcium	
	Fe	Iron	
	Ti	Titanium	
	K	Potassium	
	Sr	Strontium	Parts per million (ppm)
	Cr	Chromium	
	Mn	Manganese	
	Ni	Nickel	
	Cu	Copper	
	Zn	Zinc	
	Zr	Zirconium	
	Sn	Tin	
	Sb	Antimony	
	Ba	Barium	
	Pb	Lead	
HPGe (sediment grab)	^{238}U	Uranium	Picocuries per kilogram (pCi/kg)
	^{232}Th	Thorium	
	^{40}K	Potassium	
	^{7}Be	Beryllium	
	^{137}Cs	Cesium	
Particle size (sediment grab)	>1.000-mm	very coarse sand	Percent (%) by weight
	1.000-0.500-mm	coarse sand	
	0.500-0.250-mm	medium sand	
	0.250-0.125-mm	fine sand	
	0.125-0.062-mm	very fine sand	
	<0.062-mm	silt	

The survey was conducted aboard the EPA Ocean Survey Vessel *Peter W. Anderson* (OSV *Anderson*). The differential Global Positioning System (DGPS) aboard the survey vessel was used as the primary navigation system with the Loran/DGPS navigation system and fathometer components of the GIMS/CS; calibrated to this system.

4.1 GIMS/CS; Combined Survey System

The GIMS/CS; mapping system combines the components of the separate GIMS and CS; systems (described in sections 3.1.1 and 3.1.2) into a single towed sled that is connected by a set of umbilicals to shipboard systems for sample processing and data collection. The umbilical connectors include a tow cable, an armored signal cable, a power cable, and a sediment slurry transport hose. These components are configured in a cylindrical housing approximately 3.35-m in length and 28-cm in diameter, with the front section of the sled containing the GIMS components and the rear section containing the CS; submersible pump and its mesh housing. The GIMS/CS; sled is towed at speeds of 2.5 to 3 kn, and the data/sample collection systems of the GIMS and CS; are operated simultaneously.

4.1.1 Gamma Isotope Mapping System

The GIMS components aboard the towed sled include a 10.2 cm x 10.2 cm x 35.6 cm thallium-activated sodium iodide gamma radiation detector, a preamplifier, and a battery pack, all of which are connected by armored coaxial signal cable to a shipboard data acquisition system. The data acquisition system consists of an Exploranium GR-256 gamma spectrometer, an IBM notebook computer, a printer, a plotter, a fathometer, and a differential Northstar Model 8000 Loran/DGPS navigational unit.

The GIMS records seafloor ^{214}Bi, ^{208}Tl, ^{40}K, and total gamma activity radiation data in counts per minute for the selected isotopes. ^{214}Bi, ^{208}Tl, and ^{40}K are "pathfinder" elements that are indicative of the nature of seafloor sediments (Jones *et al*, 1988). For example, ^{214}Bi reflects the uranium content of phosphatic deposits often found in coastal regions, ^{208}Tl is associated with deposits of heavy minerals, and ^{40}K is often found in fine-grained clay

sediments. Total activity encompasses the complete spectrum of gamma radiation measured in the survey region, inclusive of (but not limited to) ^{214}Bi, ^{208}Tl, and ^{40}K. The GIMS is capable of measuring gamma radiation to a depth below the seafloor surface of approximately 25 cm, depending upon the intensity of the gamma-emitter energy and on the properties of the seafloor sediments (USDHEW, 1960).

Prior to deployment, the GIMS spectrometer is calibrated using a radioactive reference sample and the Loran/DGPS navigation system and fathometer are calibrated to the ship's systems. On the approach to the ODMDS survey area; the GIMS/CS; sled is lowered to the seafloor. The sled is towed at speeds of 2.5 to 3 kn along predetermined transects designated by EPA personnel.

The GIMS records latitude, longitude, water depth, and gamma activity data every 60 seconds. All data collected are stored on computer diskette, and a hard copy is produced for review during the survey. Survey transects are identified by time and location (latitude and longitude) and recorded in the logbook. A multi-color plot showing the ship's transects and the varying intensities of water depth, ^{214}Bi, ^{40}K, ^{208}Tl, and total gamma activity is produced in real time during the survey and is used as a visual aid to indicate changes in seafloor sediments.

Following the completion of survey transects, the GIMS sled is retrieved and a post-deployment calibration check is performed. Two- and three-dimensional gamma activity and bathymetry maps are immediately generated from survey data, with dredged sediments identified through the interpretation of the relative isotopic and bathymetric variations. The maps are also used to identify appropriate sites for the sediment grab sample collection that follows survey operations.

4.1.2 Continuous Sediment Sampling System

The CS^3 uses a positive displacement pump mounted aboard the GIMS/CS; towed sled to deliver a continuous slurry of surficial sediment and water to a shipboard sample processor. The continuous flow of slurry from the seafloor allows the collection of a unique sample from each selected station. However, it was determined prior to the survey that there would not be enough fine-grained surficial sediment present to actually collect CS; samples. Instead, the light intensity was monitored on the sediment slurry that was pumped from the seafloor. Monitoring the light intensity gave a real-time indication as to the amount of sediment suspended (slurry density) in the slurry transported to the CS; sample processor. The light readings were recorded along with station coordinates every 60 s during the survey. The light readings or slurry density were generally representative of the quantity of fine-grained sediment present on the seafloor with the low numbers indicating a greater concentration of fine-grained sediment and high numbers indicating sandy conditions. Two- and three-dimensional maps were generated from the light intensity data.

4.2 Sediment-Grab Sampling

Sediment grab samples are collected from the ODMDS to provide ground truth information for the GIMS and CS^3 slurry data, as well as to provide information for the identification of surface sediment types at the site. The navigation system aboard the OSV *Anderson* is used to position the vessel at each of the selected grab sampling locations. The sediment-grab device, supplied by the OSV *Anderson*, is cleaned and inspected prior to each deployment. The top 7.5 cm of sediment from each sediment grab sample is collected, stored in plastic bags, labeled according to site number, and immediately refrigerated. Following the completion of the survey, the samples are transported under refrigeration to the CAIS laboratory for analysis. Samples are divided into three portions, with one portion used to determine gamma radiation activity by HPGe spectroscopy (Section 4.3), one portion used to make a pellet sample for XRF analysis of elemental content (Section 4.4), and one portion used for particle size analysis (Section 4.5).

4.3 HPGe Gamma Radiation Analysis (Sediment-Grab Samples Only)

A portion of each sediment-grab sample is analyzed in the CAIS laboratory using an HPGe gamma radiation detector and pulse height-analyzer. A 1-kg portion of dried sample is ground to 3-mm or less particle size, packed into a tared 0.5-L Marinelli beaker, and weighed. The beaker is sealed with vinyl tape and stored for a minimum of 14 days before analysis to allow for the in-growth of the gamma-emitting U and Th daughter products. The sample is placed in a HPGe radiation detector for a counting time of 12,000 s. The results for ^{238}U, ^{232}Th, and ^{40}K are recorded and converted to picocuries per kilogram (pCi/kg). ^{238}U reflects the uranium content of phosphatic deposits often found in coastal regions, ^{232}Th is associated with heavy minerals deposits, and ^{40}K is often found in fine-grained clay sediments.

4.4 XRF Analysis (Sediment Grab-Samples)

The sediment-grab samples collected are analyzed for elemental content using XRF. To prepare the sediment-grab samples for XRF analysis, a representative subsample not exceeding 6 g is collected from each of the dried samples. Using an acid-washed mortar and pestle, the subsample is ground into coarse, sand-sized particles. The subsample is ground again with an acid-washed ball mill until at least 80% of the sample passes through a 230-mesh sieve. The ground subsample is then mixed with a cellulose binder and pressed into a pellet. The sediment-grab sample pellets are analyzed using standard CAIS procedures for XRF analysis. Calibration checks of the system are performed daily using NIST 8704 standard reference material.

4.5 Particle Size Analysis (Sediment Grab Samples Only)

A portion of the dried sediment from each of the sediment-grab samples is processed in the CAIS laboratory to determine the particle size distribution of the sample. U.S. Standard Testing sieves are used for separation of sediment. Percentages for each of the particle-size fractions listed in Table 1 are calculated and recorded in a laboratory notebook.

5.0 SURVEY

The sediment mapping survey began January 24, 2003, at 1845 h with the arrival of the CAIS crew at the Indian River Fruit Company dock in Fort Pierce, Florida. The CAIS survey equipment was loaded the following morning and installed onboard the OSV *Anderson*. The calibration check of the GIMS/CS; was completed by 0945 h while the vessel headed for the offshore disposal site shown in Figure 1. An initial calibration check of the GIMS utilizing ^{226}Ra was performed earlier at the CAIS facility prior to departure from Athens, Georgia. System calibration was confirmed by the comparison of the pulse height spectra of the ^{137}Cs peak as well as the ^{214}Bi, ^{208}Tl, and ^{40}K peaks.

Position agreement between the ship and GIMS/CS; DGPS units was verified on the way to the disposal site. The GIMS/CS; was deployed at 1310 h on the GIMS Station 001 (27E28.757'N and 80E13.101'W). The survey continued until GIMS Station 608 was reached (27E26.467'N and 80E12.951'W) at 0113 on January 26. The sled was retrieved from the seafloor by 0135 h.

The sediment-grab sampler supplied by the OSV *Anderson* was rigged for deployment off the stern following the completion of the GIMS/CS; survey. A total of four sediment-grab samples were collected at the ODMDS. The sample locations were chosen as a result of the isotopic and sediment slurry density data generated during the survey. The four sediment-grab stations were collected between 0713 h and 0800 h on January 26. The OSV *Anderson* returned to the Fort Pierce Port by 1000 h. The equipment was off loaded from the OSV *Anderson* by 1100 h.

6.0 RESULTS

The January 2003 GIMS/CS; survey at the Fort Pierce ODMDS encompassed an area of approximately 5.75 square miles and included more than 35 line miles of survey transects as shown in Figure 4. Data collection stations for bathymetric and gamma activity data, a total

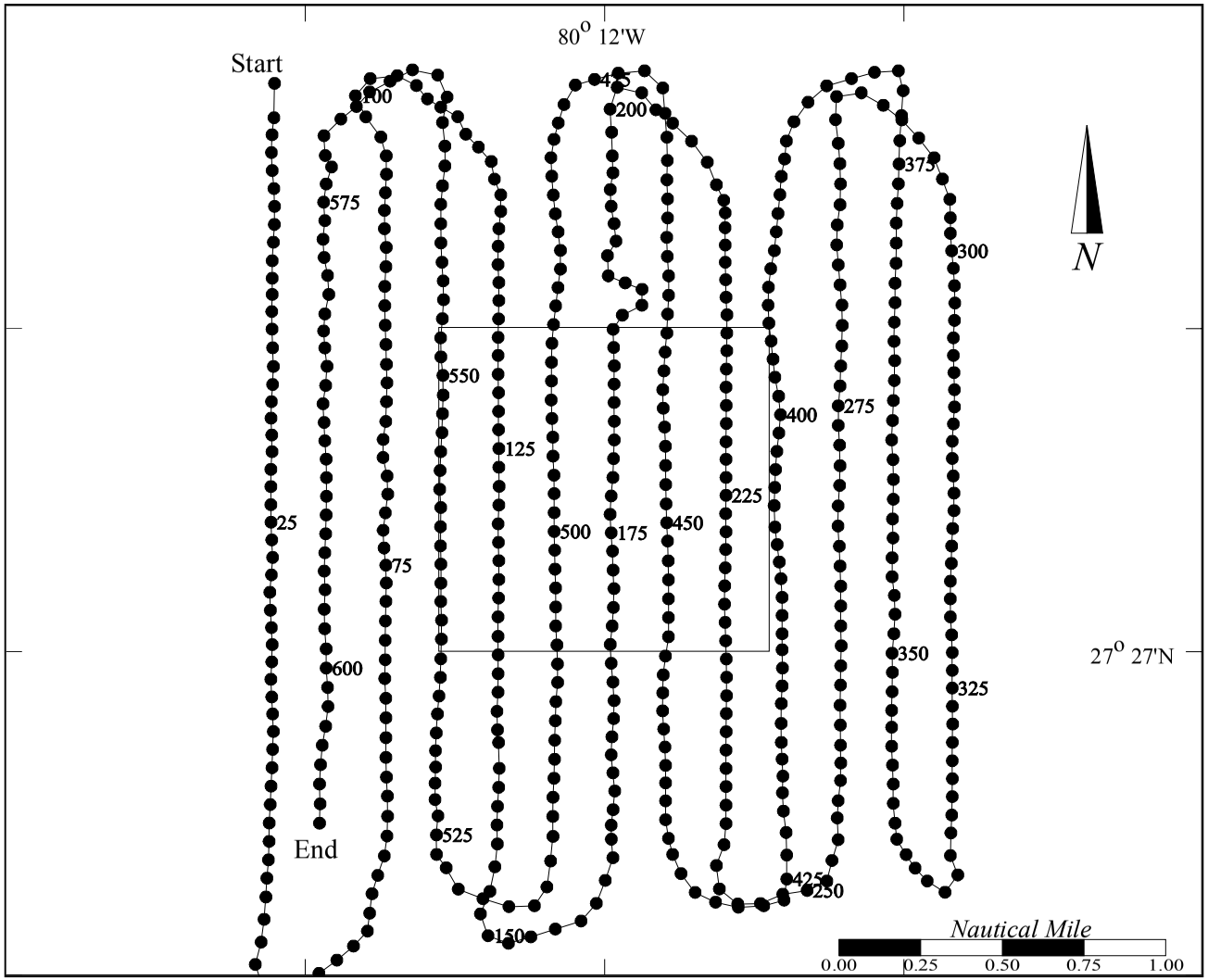


Figure 4. Ship's transects and GIMS stations for the Fort Pierce ODMDS.

of 608 stations, are indicated along the ship's transects. The location, water depth, sediment slurry density, and gamma activity measurements collected at each of these sampling stations are presented in Appendix A.

Figure 5 shows the bathymetric profile of the seafloor in the study area. Water depths range between 11 and 17 m (36 and 55 feet). The actual boundaries of the ODMDS have an easterly slope of approximately 2.4 m over one nautical mile. The January 2003 bathymetry indicated a slight ridge on the western half of the ODMDS oriented along a north-south axis. This ridge was shown in Figure 5 by consecutive bending of the contour lines, which indicated a very slight upward relief along the sloping seafloor. This ridge coincided with the location of the deposited dredged material identified at the ODMDS as early as January 1997 (CAIS, 1997). Figure 6 shows a comparison of the bathymetric data from March 1992 to January 2003. The most notable difference between the five maps, other than the ridge previously mentioned, was the apparent leveling or smoothing of the seafloor from January 1997 to February 1998 with little very little change from February 1998 to January 2003. The north-south contours representing Carpon Shoals on the western edge of the January 1997 bathymetric map is not shown in the February 1998 and January 2003 bathymetry because this area was not covered during the 1998 and 2003 sediment mapping surveys.

6.1 GIMS Survey

Figures 7(a) through (d) show the two- and three-dimensional gamma activity maps generated during the survey using the GIMS data. The ^{214}Bi gamma activity map (Figure 7(a)) did not provide any definitive indication of dredged material within the ODMDS, although this result was expected based on prior survey findings. In accordance with the previous surveys, ^{208}Tl (indicative of heavy mineral sands) and ^{40}K gamma activities (indicative of fine-grained clay particles often found in harbor and channel environments) provided the best indication of the location of the deposited dredged material. A well-defined area of enhanced ^{208}Tl and ^{40}K gamma activities are shown in Figures 7(b) and 7(c) in the southeastern corner of the ODMDS, clearly demonstrating where the most recent dredged material had been deposited.

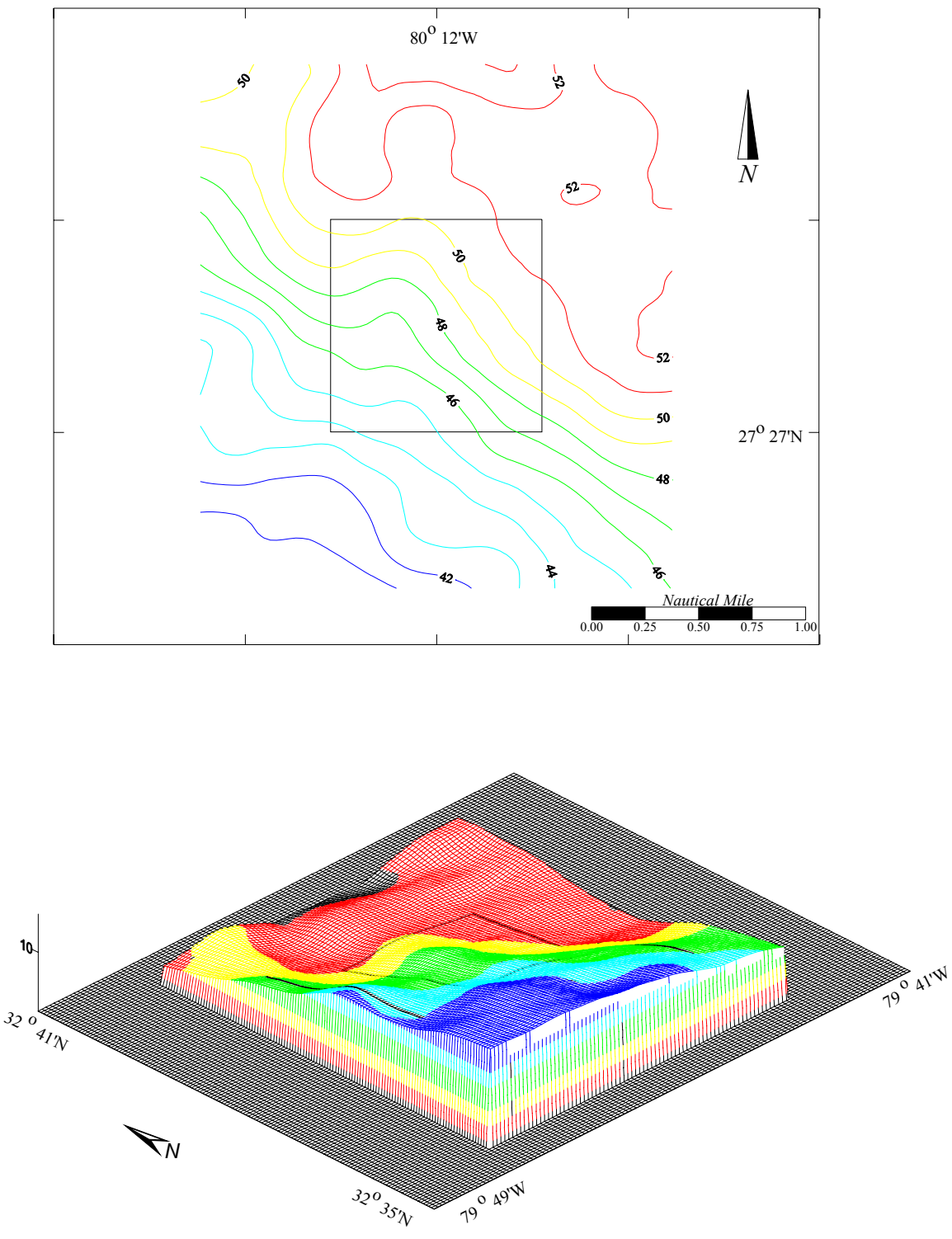


Figure 5. Contour map of water depth in feet (upper illustration) and bathymetric profile of the seafloor (lower illustration) for the Fort Pierce ODMDS.

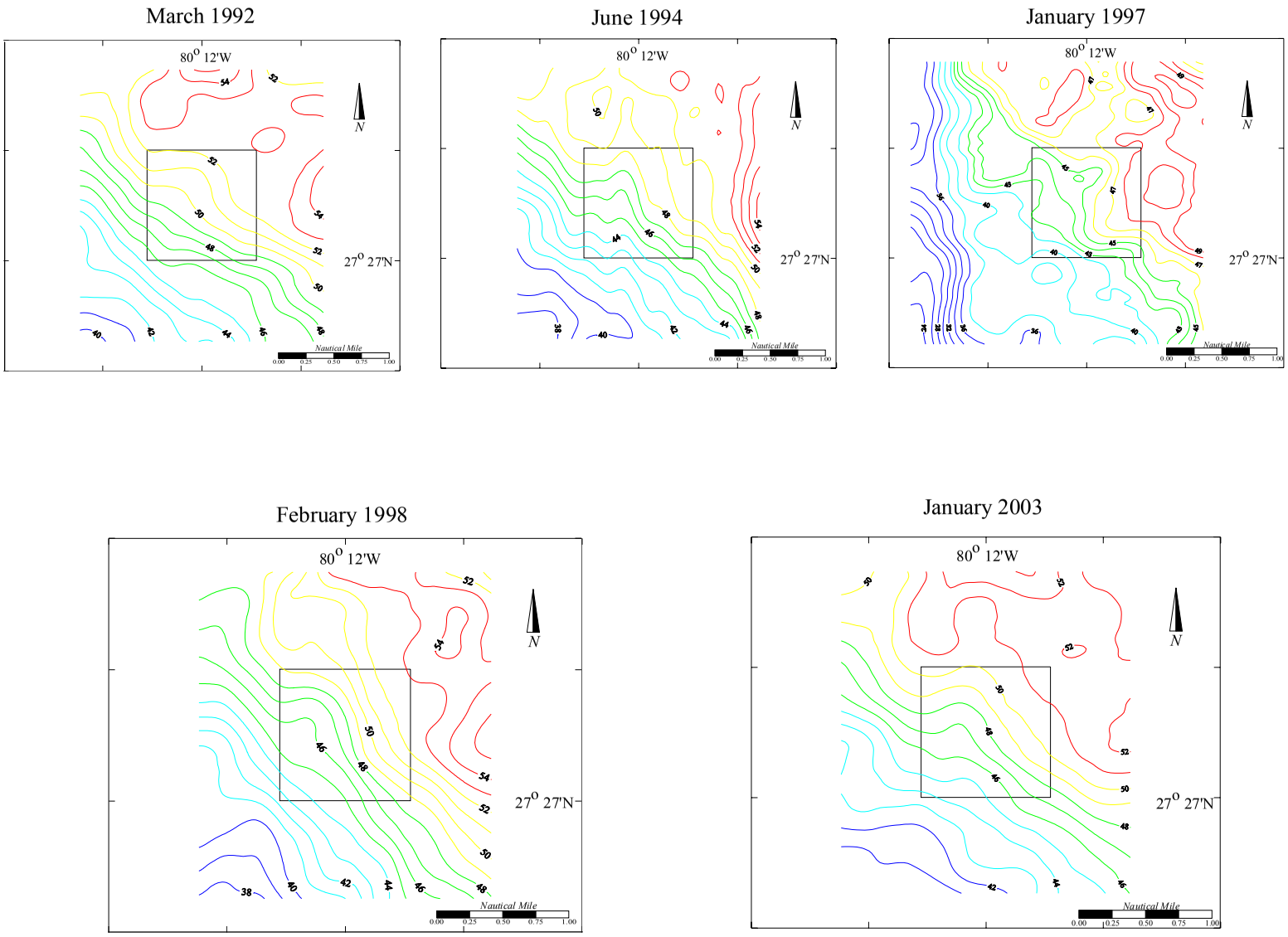


Figure 6. Seafloor bathymetry from March 1992 to January 2003 at the Fort Pierce ODMDS.

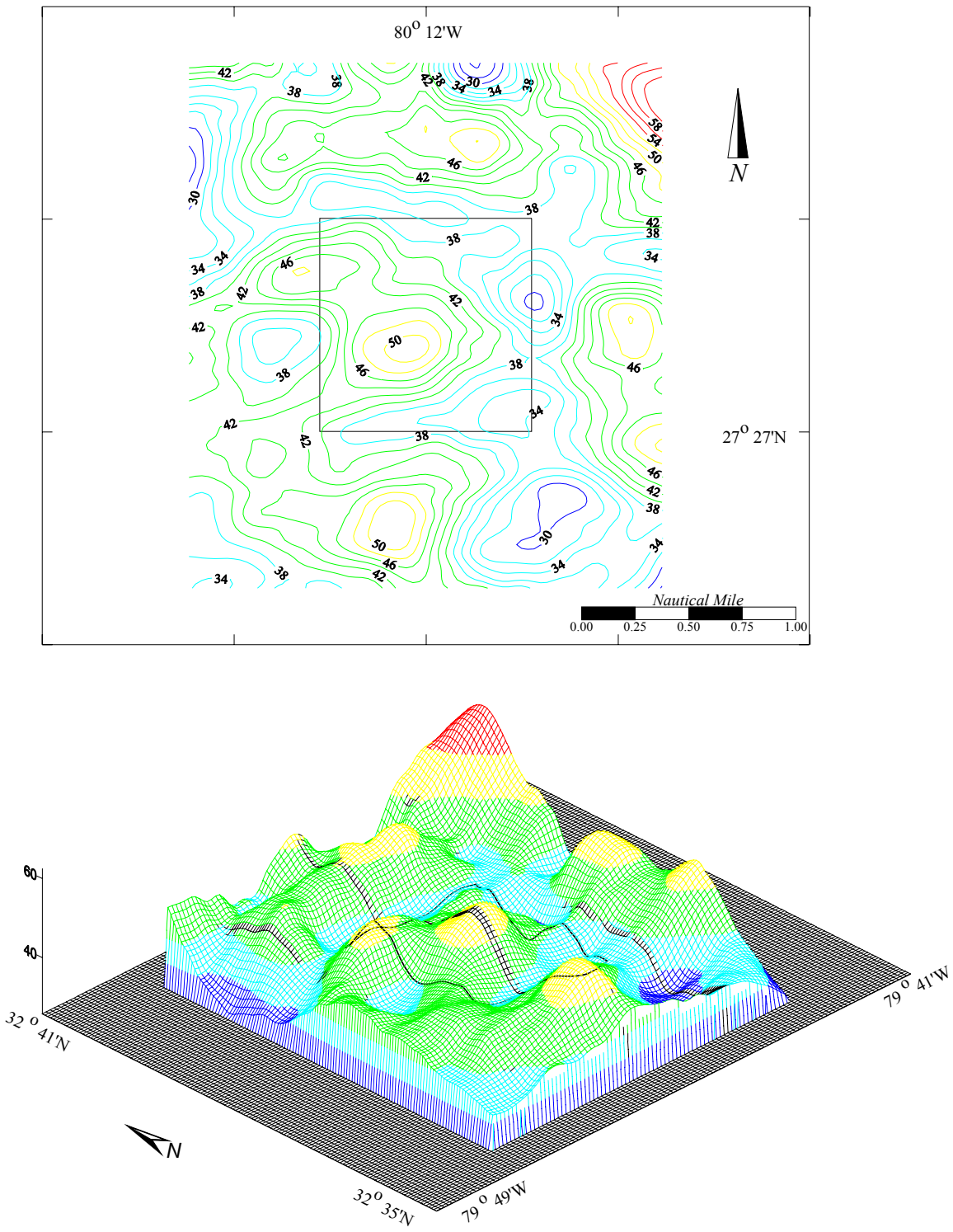


Figure 7. Contour map (upper illustration) and topographic profile (lower illustration) of gamma activity for the Fort Pierce ODMDS.

(a) ^{214}Bi activity.

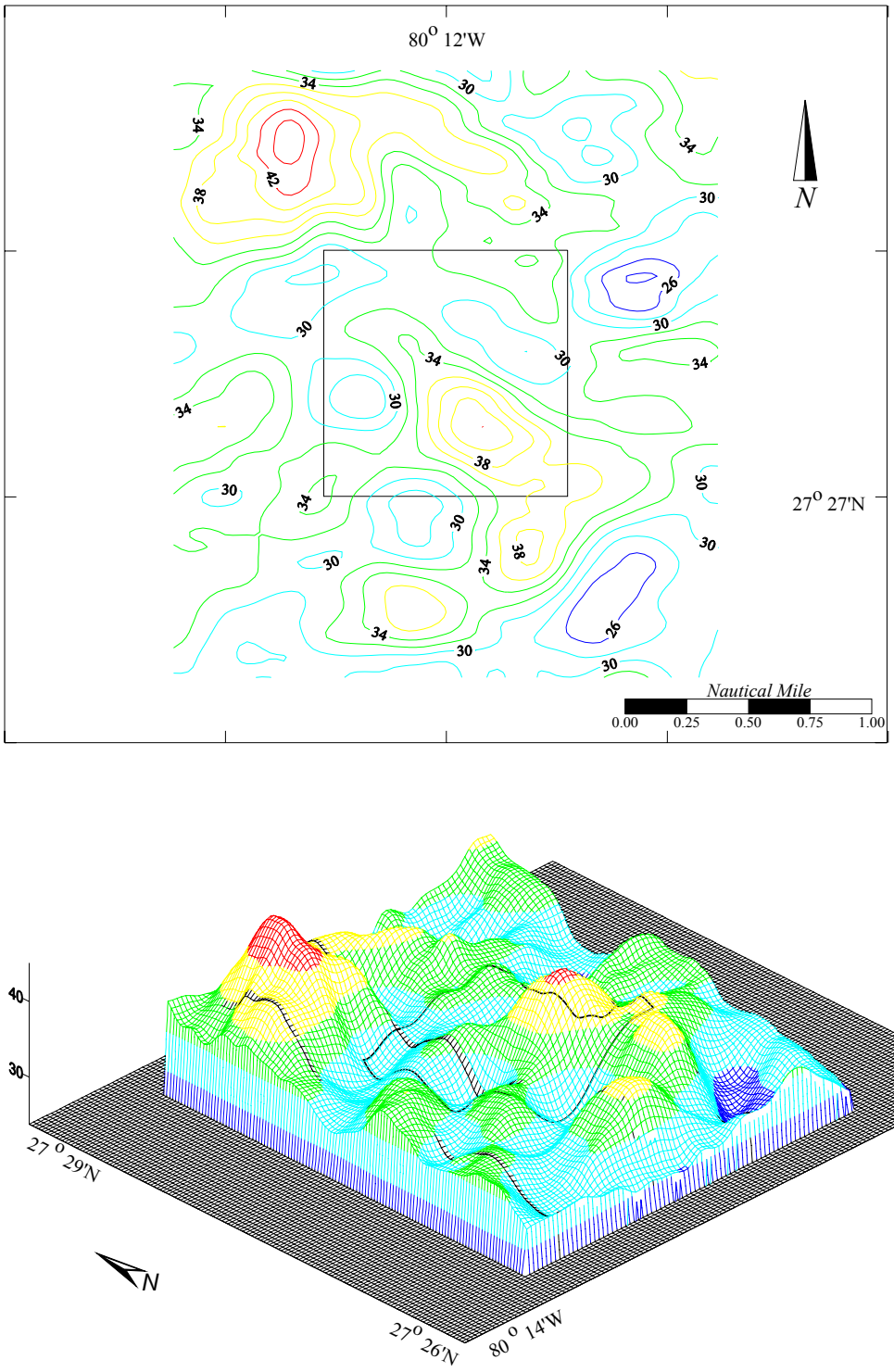


Figure 7. Contour map (upper illustration) and topographic profile (lower illustration) of gamma activity for the Fort Pierce ODMDS.

(b) ^{208}Tl activity.

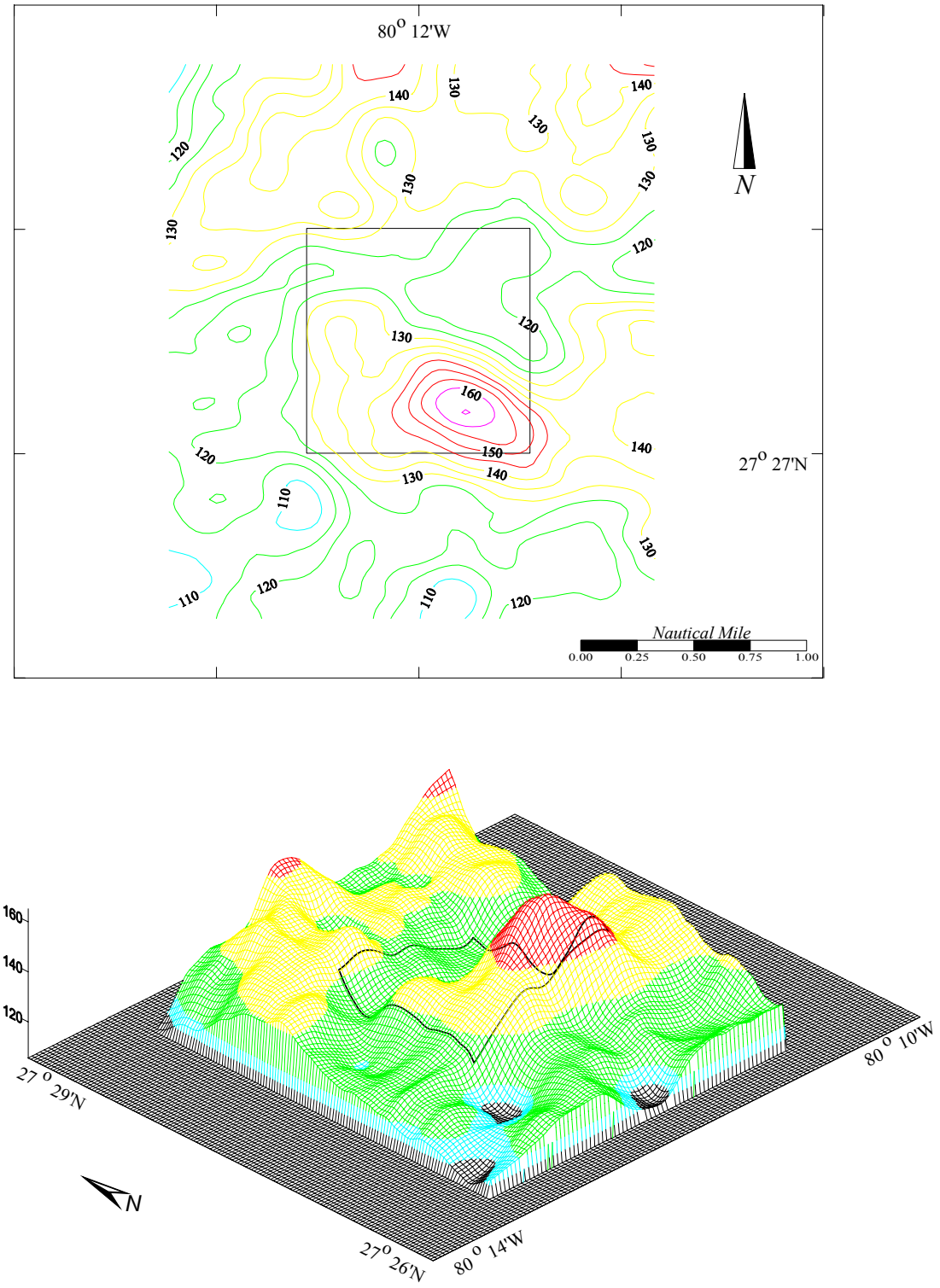


Figure 7. Contour map (upper illustration) and topographic profile (lower illustration) of gamma activity for the Fort Pierce ODMDS.

(c) ^{40}K activity.

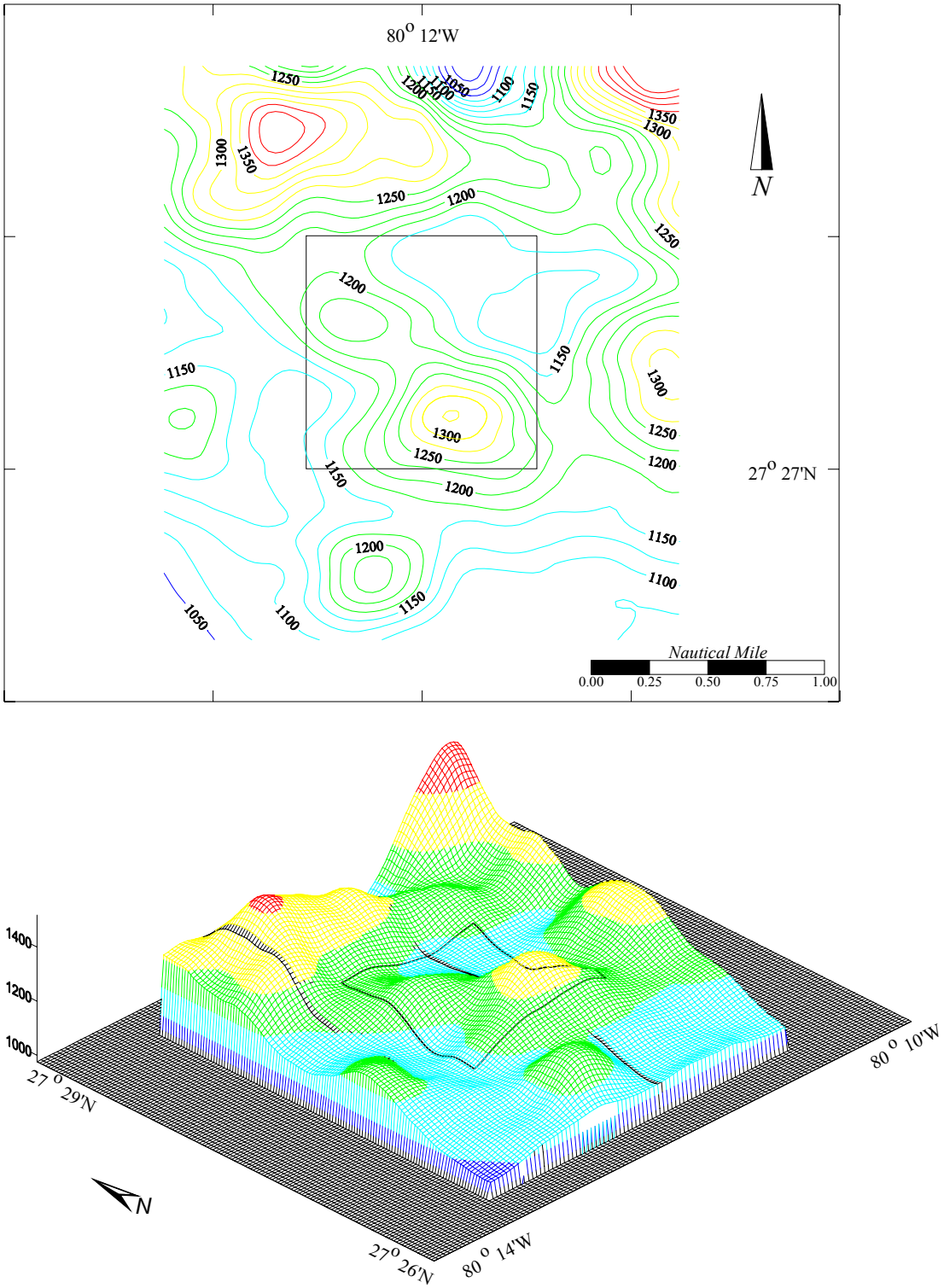


Figure 7. Contour map (upper illustration) and topographic profile (lower illustration) of gamma activity for the Fort Pierce ODMDS.

(d) Total activity.

No apparent trends of dredged material migrating from the ODMDS are visible in Figures 7(b) and 7(c). Figure 7(d), total gamma activity, corresponds well with Figures 7(b) and 7(c), reflecting the same points of interest as the ^{208}Tl and ^{40}K gamma activity maps.

The ^{208}Tl, ^{40}K and total gamma activity maps produced during the January 2003 survey are compared in Figures 8, 9, and 10 to historical gamma activity data collected at the Fort Pierce ODMDS. The March 1992 ^{208}Tl, ^{40}K and total gamma activity maps show no localized areas of activity within the ODMDS, although somewhat higher activity levels north and east of the site were noted. The June 1994 ^{208}Tl, ^{40}K and total gamma activity maps provided a clear indication that the material from the winter 1993-94 dredging operations was deposited in the northwestern corner of the interim site, which is north of the present site boundary. Likewise, the January 1997 ^{208}Tl, ^{40}K and total gamma activity maps clearly show the dredged material deposited as a result of the summer 1995 maintenance and deepening project in the Fort Pierce Harbor. The January 1997 maps also show the continued presence of the material deposited north of the site during the 1993-94 winter.

The maps compiled during the February 1998 survey did indicate a few changes from January 1997, but the body of dredged material was still clearly present within the ODMDS in approximately the same orientation. A slight decrease of 10 cpm ^{40}K gamma activity and the splitting of the dredged material deposit from one primary peak to two peaks were observed during the February 1998 survey. In addition to the decrease in ^{40}K gamma activity within the deposited dredged material, the surrounding ^{40}K gamma activity increased approximately 10 to 20 cpm. Another notable change in the ^{40}K gamma activity from January 1997 to February 1998 was the apparent loss of the well-defined ^{40}K anomaly located to the northwest of the ODMDS. In January 1997, this area was defined by approximately three loads of dredged material deposited outside the ODMDS. However, it was still defined by the ^{208}Tl gamma activity indicating that the silt and clay defined by the ^{40}K had diminished and the heavy mineral sand still remained. By February 1998, only traces of the silt and clay dredged material located to the northwest of the site were still present, but the heavy mineral sand represented by ^{208}Tl still remained.

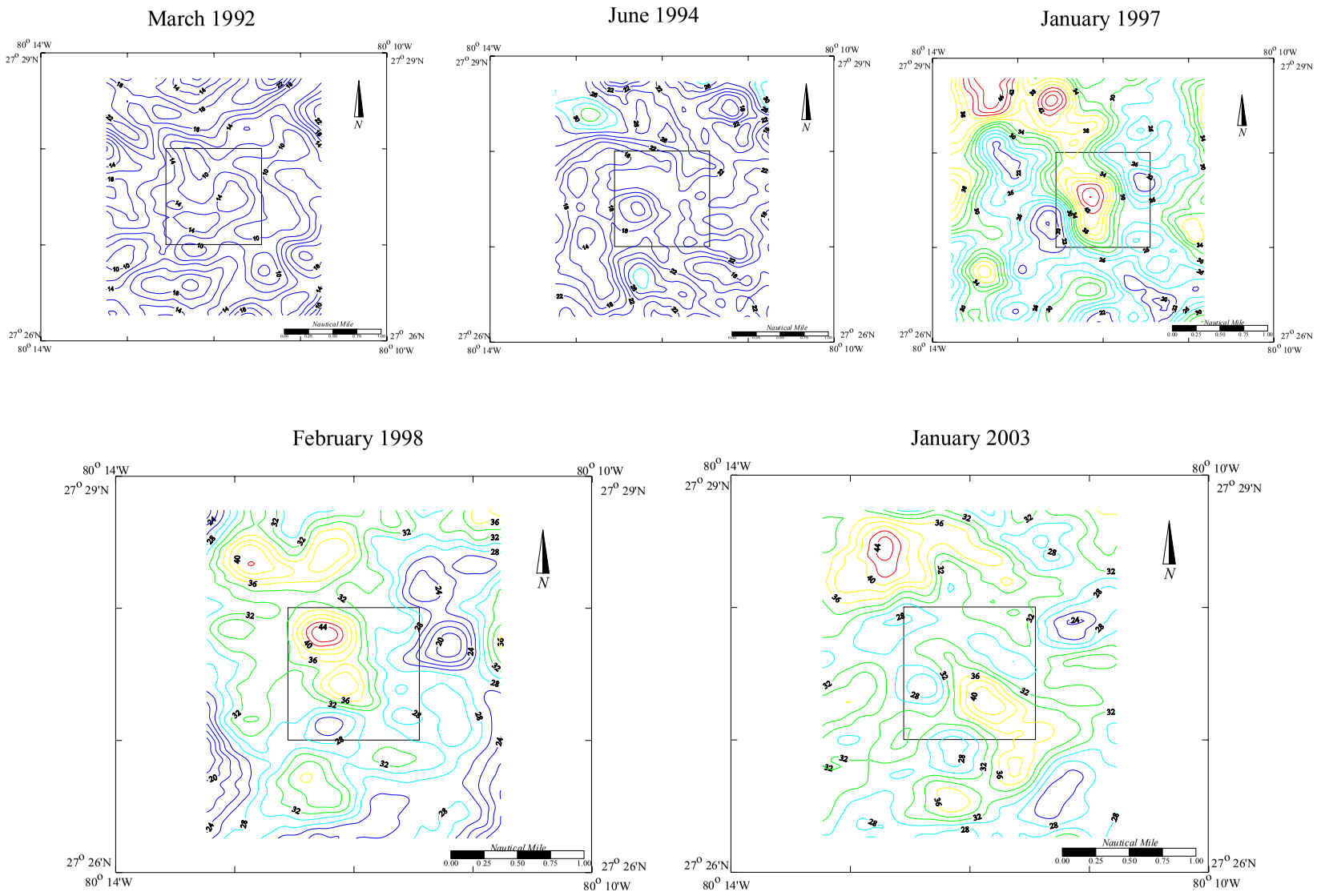


Figure 8. ^{208}Tl gamma activity from March 1992 to January 2003 for the Fort Pierce ODMDS.

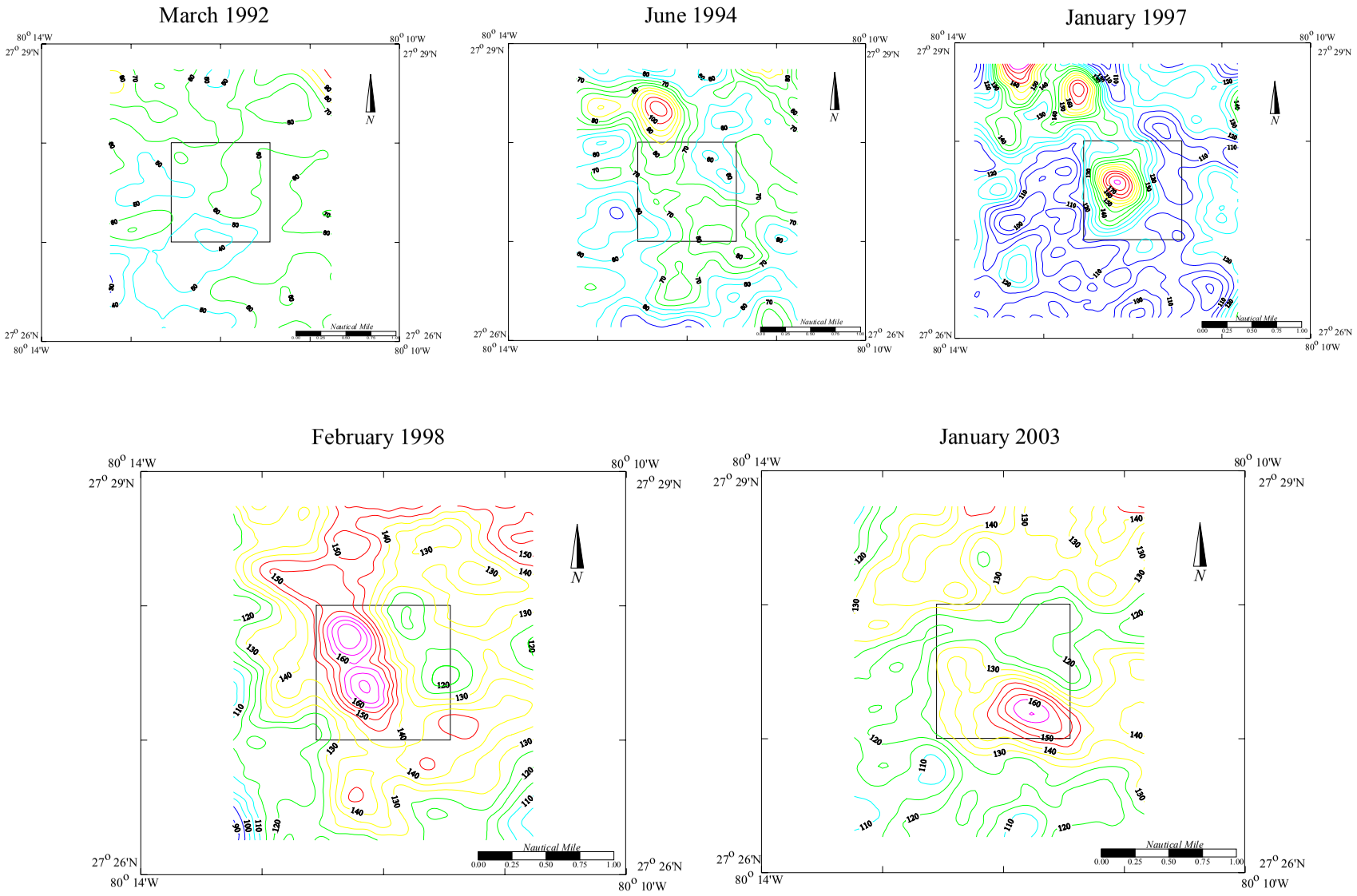


Figure 9. ^{40}K gamma activity from March 1992 to January 2003 for the Fort Pierce ODMDS.

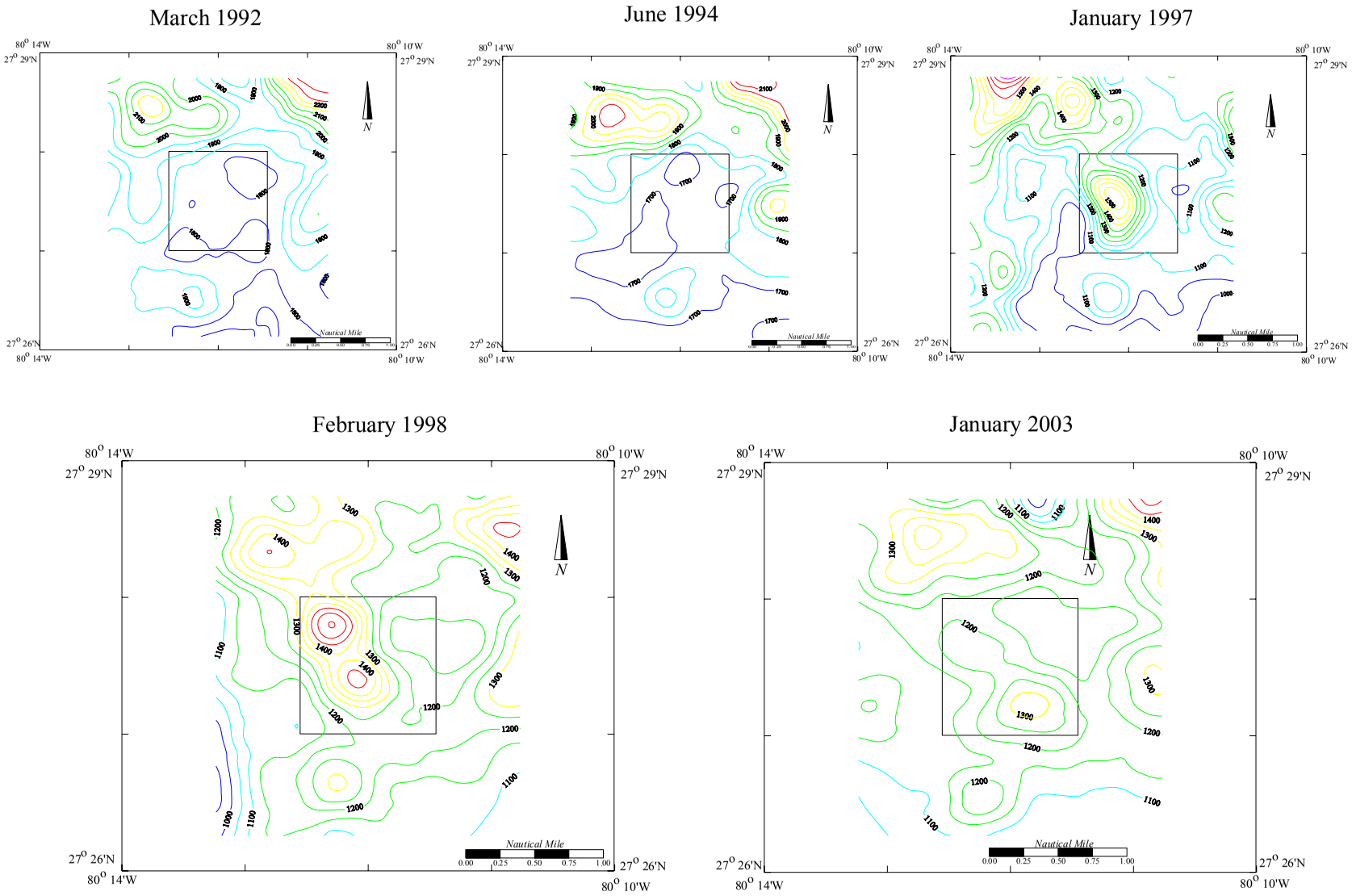


Figure 10. Total gamma activity from March 1992 to January 2003 for the Fort Pierce ODMDS.

In January 2003, the ^{208}Tl and ^{40}K gamma activity clearly showed the most recently deposited dredged material in the southeastern corner of the ODMDS. No evidence of dredged material had been found in this area prior to the January 2003 survey. A slight extension to the dredged material was shown to extend to the northwest. This extension coincides with the dredged material drops outside the target area (Figure 3) and and also the dredged material shown in both January 1997 and February 1998. This extension of gamma activity is most likely not related to migration of the main body of dredged material. The change of the ^{40}K gamma activity in and around the ODMDS and the diminishing anomaly to the northwest of the site most likely represents the dispersion of the fine-grained sediment at the ODMDS and the surrounding area.

The total gamma activity maps (Figure 10) also clearly define the deposited dredged material at the ODMDS in the same manner as the ^{208}Tl and ^{40}K gamma activity. However, the total gamma activity maps show that the area to the northwest of the site is returning to predisposal condition (1995 activities). The area to the northwest as defined by the January 2003 survey data compares closely with February 1998 and the June 1994 sediment mapping surveys which were completed prior to and after the 1995 harbor deepening project. The January 1997 sediment mapping survey was representative of the dredged material deposited at the site as part of the 1995 harbor-deepening project.

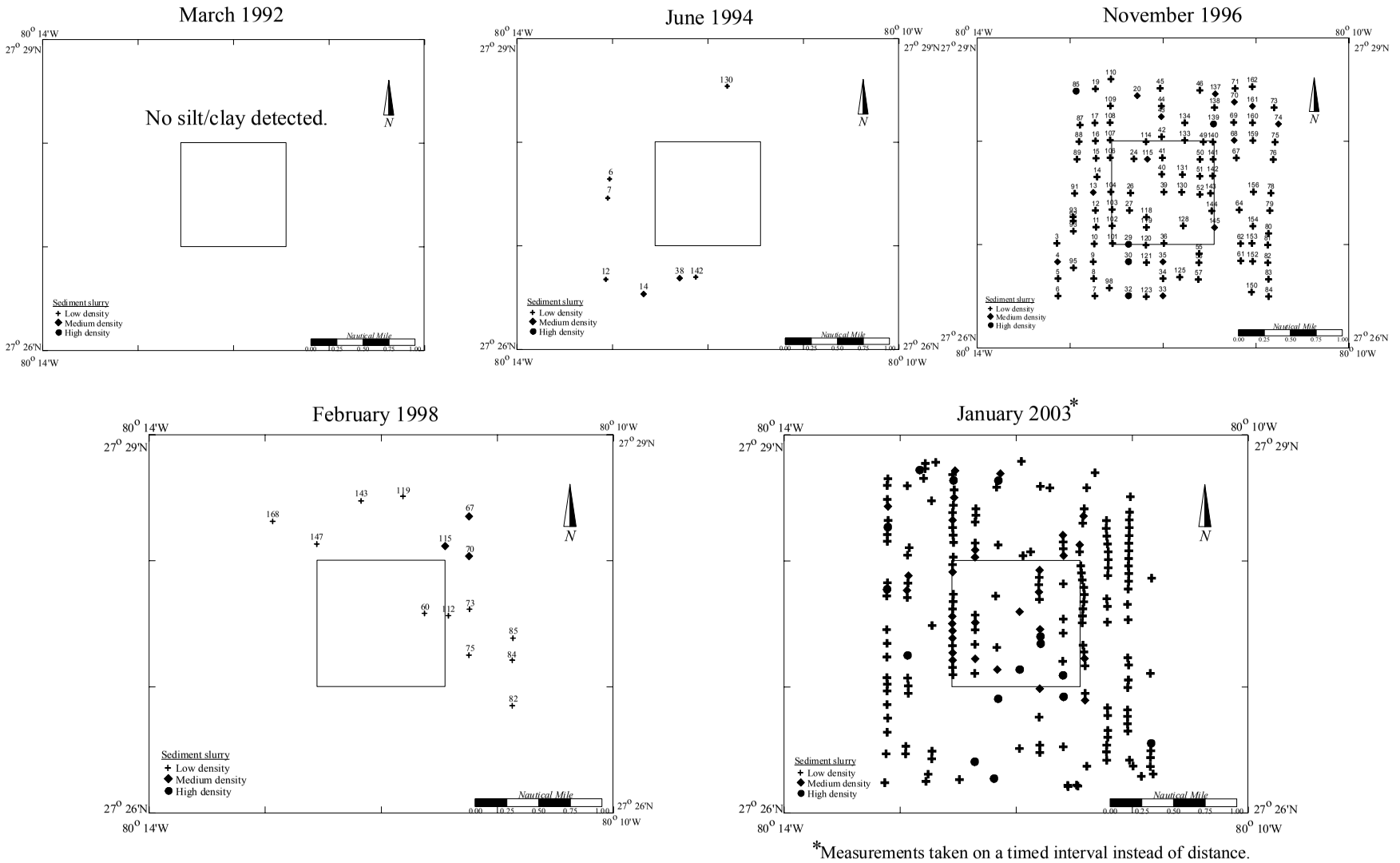
6.2 CS; Survey (Fine-Grained Sediment Sample Collection)

The only time prior to this survey that any significant quantities of fine-grained sediment was present at the Fort Pierce ODMDS was in November 1996 where approximately 69% of the site was covered with fine-grained sediment (CAIS, 1997). During the other sediment mapping surveys, only about 7% fine-grained sediment was encountered at the site. As a result, due to the past history of the absence of fine-grained sediment at the Fort Pierce ODMDS, it was decided not to utilize the CS; sediment sampler in January 2003. However, to make sure that no fine-grained sediment was overlooked by not attempting to collect CS; samples, a light intensity meter was utilized in place of the CS;. The light intensity was measured across a flow cell while the sediment slurry was pumped from the seafloor.

Readings from the meter were collected every 60 s and recorded according to position, depth, and gamma activity. The data from the light intensity measurements can be found in Appendix A along with the gamma activity data. Monitoring the sediment slurry has been routinely used at other ODMDS and has been found to provide a good quantitative evaluation of the amount of surficial fine-grained sediment on the seafloor. In order to compare the light intensity data with previous CS; sample collection, a value range was assigned to the light intensity data to represent approximate sediment slurry density. High density sediment slurry was given a range of 100 or less; medium density a range of 101 to 250; and low density a range of 251 to 500 with the remaining light intensity data representing where no CS; samples would have been collected.

Figure 11 shows the occurrence of the fine-grained sediment at the site over time. In March 1992, no fine-grained sediment was detected at the site. Later in June 1994, only a few CS; samples were collected, but after the 1995 disposal operation, a considerable number of samples were collected. Approximately one year later, in February 1998, the ODMDS had returned to only small amounts of fine-grained sediment present. As a result of the 2002 disposal operation, the ODMDS again had a detectable distribution of fine-grained sediment. However, it should be noted that there were only approximately fourteen locations where the sediment slurry density would have been considered high. The majority of the light readings indicated that there was only a dusting of fine-grained sediment in and around the ODMDS.

Figure 12 shows the contoured data representing the location of the fine-grained sediment (low numbers) and the sand (high numbers) on the seafloor surface. Most of the surveyed area contained only minimal quantities of surficial silt. However, there was one area that contained a higher percentage of silt that was located near the northeastern corner of the ODMDS. Contours of showing decreasing silt concentrations appeared to trail southward to overlap the disposal target area within the ODMDS. There was another small pocket of surficial silt along the western boundary of the ODMDS immediately adjacent to the remnants of the 1995 deepening dredged material at the site.



*Measurements taken on a timed interval instead of distance.

Figure 11. Sediment slurry data collected from March 1992 to February 1998 at the Fort Pierce ODMDS.

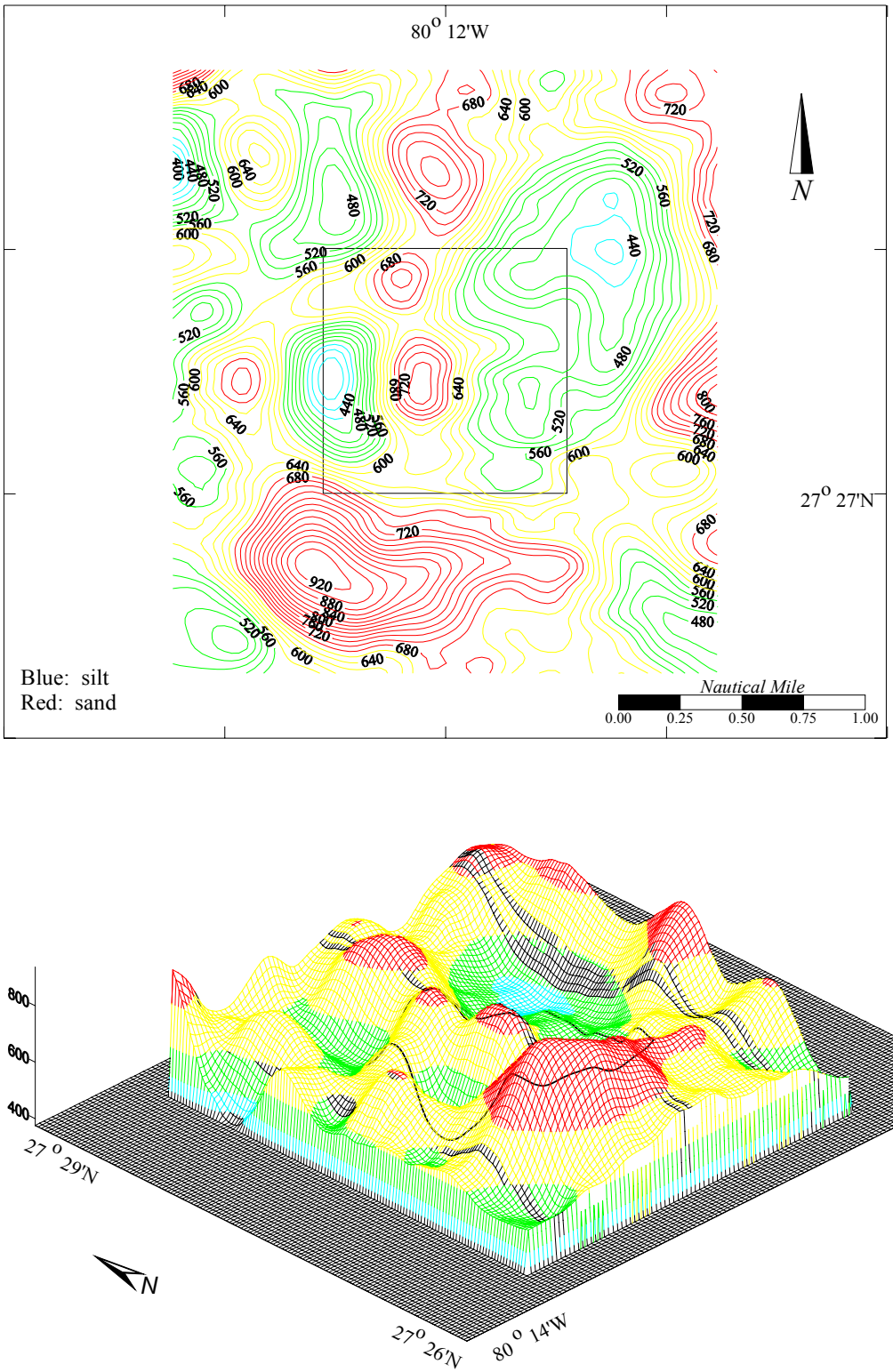


Figure 12. Contour map (upper illustration) and topographic profile (lower illustration) of sediment slurry density (light intensity) for the Fort Pierce ODMDS.

6.3 Bulk Sediment Sampling

In addition to the gamma activity and elemental concentration data collected, four bulk-quantity sediment samples were collected by CAIS in the vicinity of the Fort Pierce ODMDS using a sediment grab sampler supplied by the OSV *Anderson*. Figure 13 shows the location of the four sediment-grab samples collected at the site. Two were collected inside the ODMDS and two were collected outside the ODMDS. Table 3 lists the descriptions of the sediment-grab samples recorded at the time of collection.

Table 4 lists the results of the elemental and radiometric analyses for each of the sediment grab samples. Bar graphs show the particle size distribution (Figure 14) and the radiometric analysis (Figure 15) for the four sediment-grab samples. Sediment-grab samples 2 was located within the disposal target and sediment-grab Sample 3 was located within the general area of the dredged material drops outside the target area but within the ODMDS. Sample 3 was also located within the vicinity of the old dredged material deposited at the site during the deepening project of 1995. Sediment-grab Sample 4 was located near the dredged material placed in the old interim site and Sample 1 was located outside the ODMDS immediately east of the northeastern corner of the ODMDS.

Sediment-grab Sample 2 was predominantly medium grained sand (~49%) with approximately even distribution (~ 15%) of the coarse- to fine-grained sand sizes. There was only a trace of silt present in Sample 2. Sample 1 was highest in coarse-grained size fraction (~45%) with very course-grained particles (~30%) followed by ~20% of medium-grained sand. Samples 3 and 4 were nearly identical in the particle size distribution.

Sediment-grab Samples 2, 3, and 4 were all collected either in recent or relict dredged material disposal areas. As a result, there were not any major differences in their chemical or physical content. However, some differences were noted. For instance, Si was highest and Ca lowest in Samples 2 and 3. Both of these samples were collected in the vicinity of

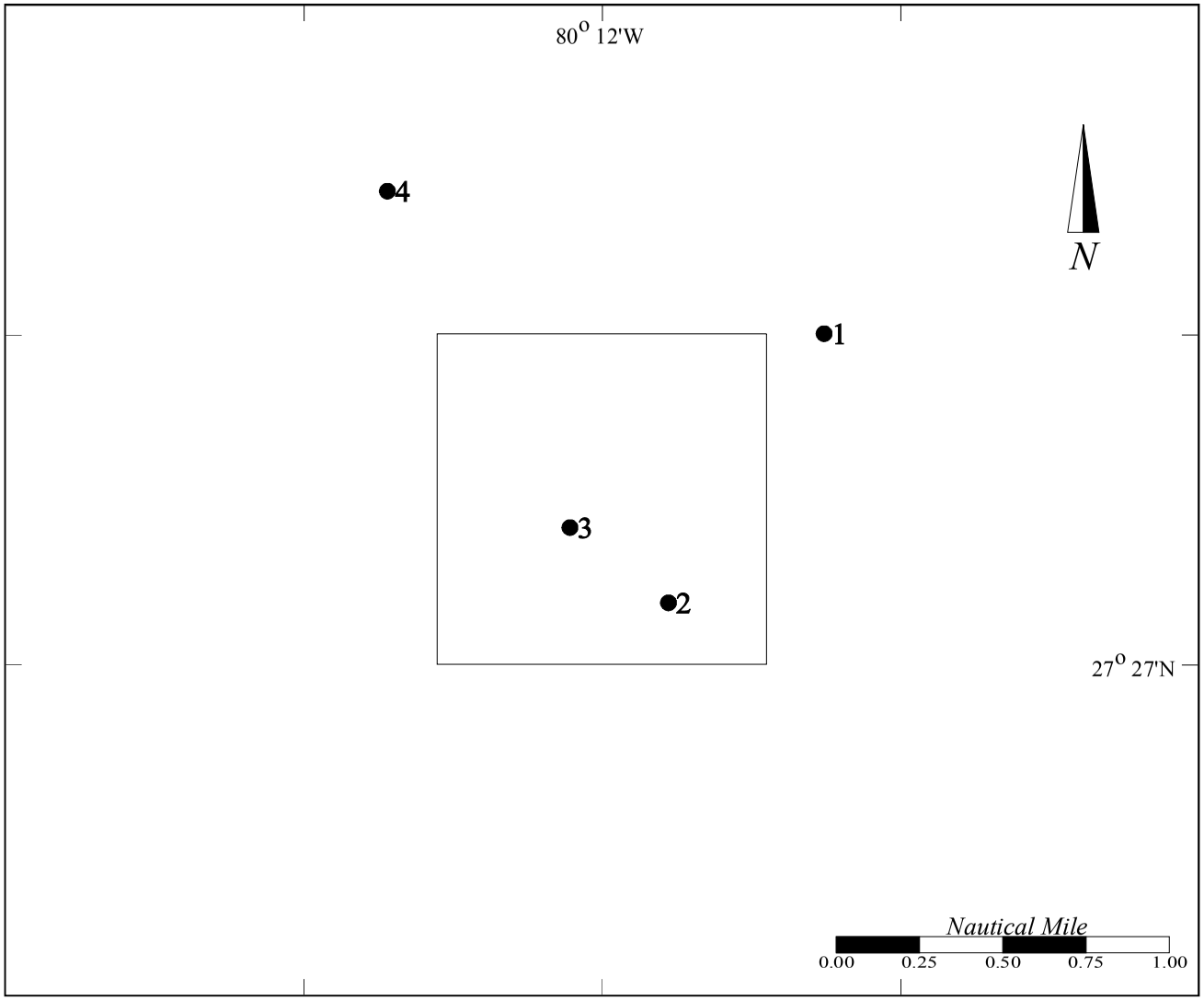


Figure 13. Sediment-grab sampling stations at the Fort Pierce ODMDS.

Table 3. Sediment-Grab Sample Descriptions

Sediment-grab Station	Description
1	Consisting mostly of medium- to coarse-grained sand with considerable quantities of shell hash and complete shells
2	Consisting mostly of coarse-grained sand with shell
3	Consisting mostly of coarse-grained sand with shell hash
4	Medium to coarse-grained sand with less shell hash than other samples and minor amounts of fine-grained sand

Table 4. Fort Pierce Sediment-Grab XRF and HPGe Analyses.

Station	1	2	3	4
Lat. N	27E28.002'	27E27.186'	27E27.414'	27E28.434'
Long. W	80E11.256'	80E11.778'	80E12.108'	80E12.720'
Element		wt%		
Mg	0.90	0.15	0.43	1.01
Al	0.53	0.50	0.61	0.60
Si	16.84	33.43	25.49	14.10
Ca	31.65	12.61	19.47	34.16
Fe	1.10	0.23	0.33	0.83
Ti	0.04	0.04	0.05	0.05
K	0.07	0.07	0.12	0.09
P	0.08	0.06	0.08	0.09
		ppm		
Zr	104	78	102	115
Cr	85	94	47	41
Mn	1000	1000	1000	1000
Ni	12	7	7	11
Cu	10	14	8	12
Zn	13	9	8	14
Sr	3109	778	1240	2904
Sn	<10	<10	<10	<10
Sb	<10	<10	<10	<10
Ba			16	8
Pb	<10	<10	<10	14
Radiometric		pCi/kg		
^{238}U	213	188	251	298
^{232}Th	916	1070	1673	2003
^{40}K	549	645	814	878
^{7}Be	38	N/D	N/D	N/D
^{7}Cs	N/D	N/D	N/D	N/D
		ratio		
U/Th	0.23	0.18	0.15	0.15
Th/K	1.67	1.66	2.06	2.28
U/K	0.39	0.29	0.31	0.34

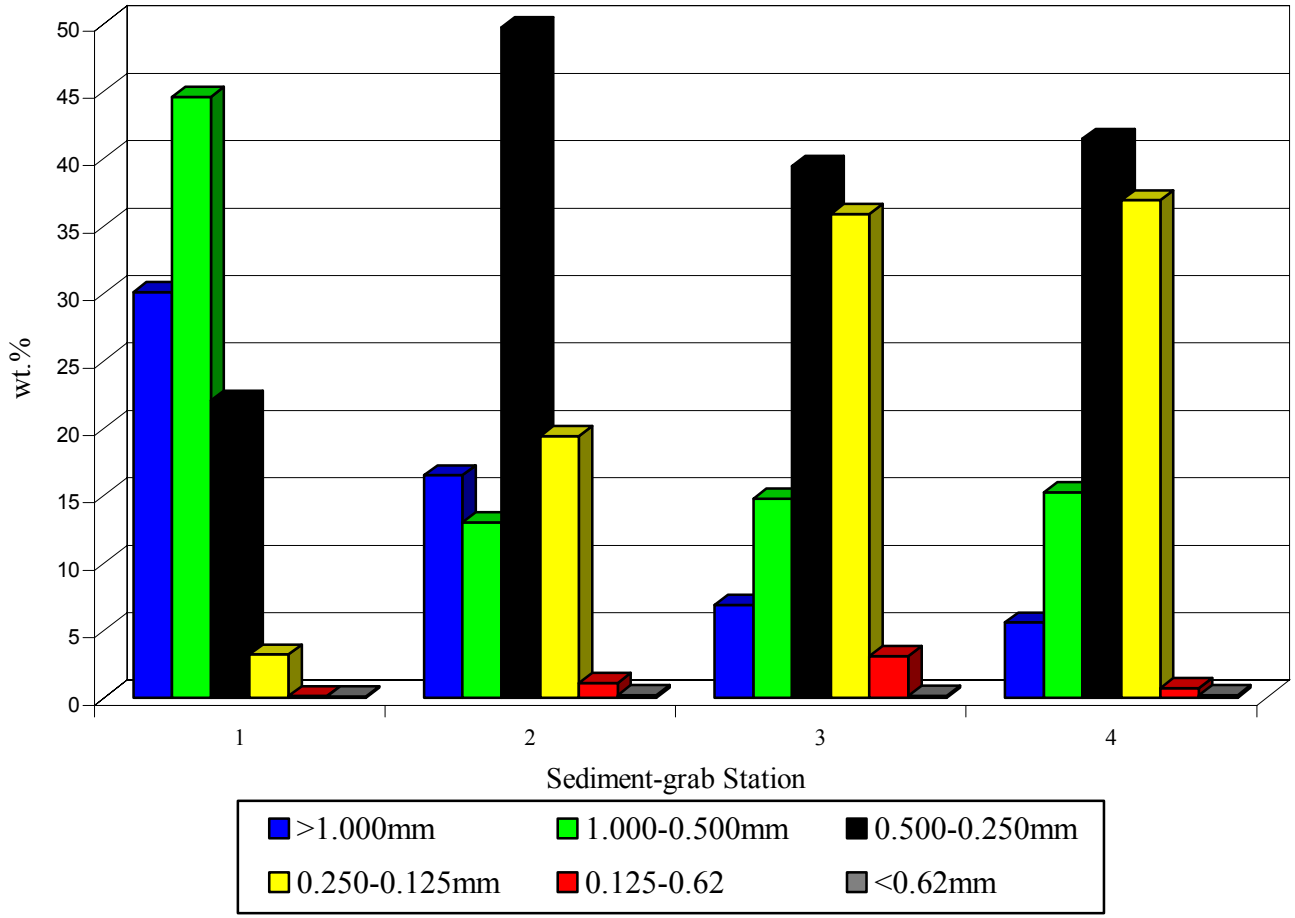


Figure 14. Fort Pierce ODMDS particle size analyses.

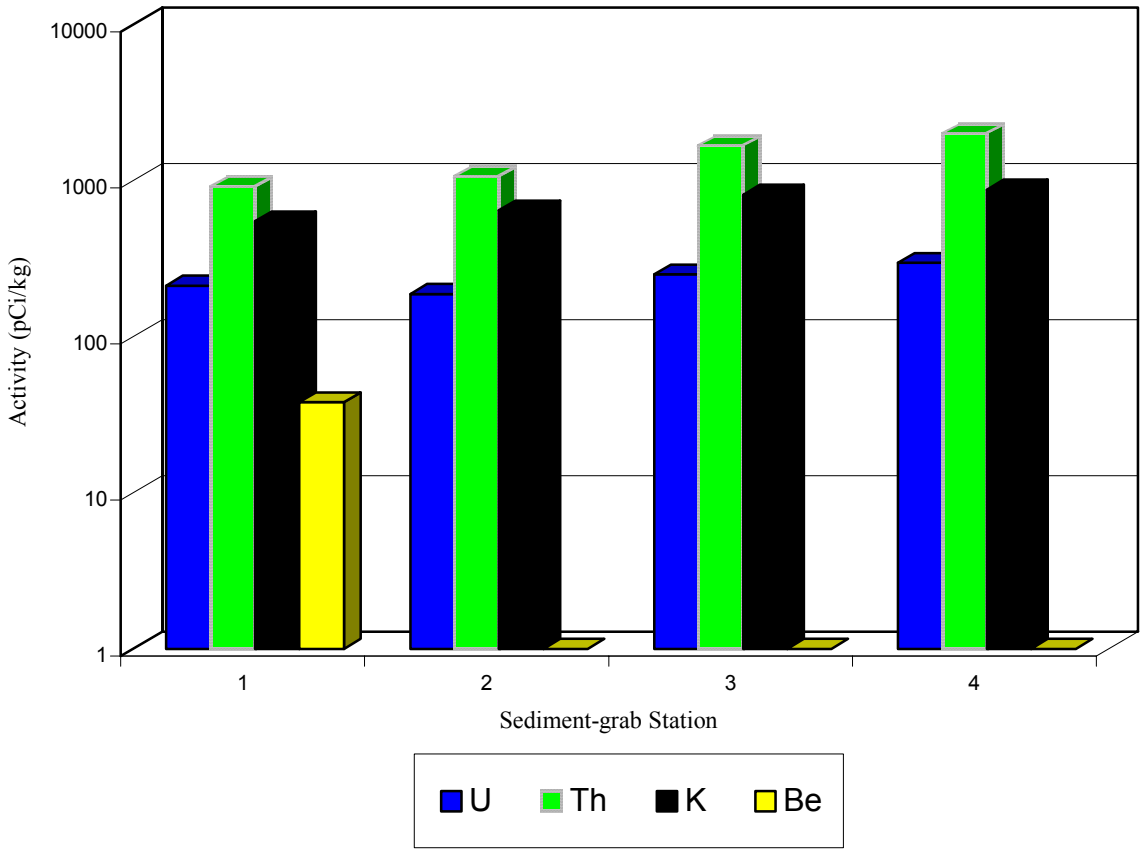


Figure 15. Fort Pierce ODMDS sediment-grab HPGE gamma analyses.

the most recent dredged material disposal at the ODMDS. The high Si most likely reflects the disposal of quartz sand at the ODMDS and the low Ca concentrations were representative of sand covering the relatively high shell hash typically found on the seafloor near the ODMDS.

Isotopically, all of the sediment-grab samples collected were very similar with the exception of Sample 1. U, Th, and K for Sample 1 were very similar to the other sediment-grab samples. However, ^{7}Be was also detected in Sample 1. ^{7}Be has been a good indicator of recent dredged material deposition at many ODMDSs sampled by CAIS (CAIS, 1995c; CAIS, 1996). It is concentrated in the surficial silt and clay particle size fraction of rivers and harbors where dredging commonly occurs. ^{7}Be has a short half-life of 53 days, which can be used to determine how recently fine-grained sediment had been deposited at a site. It is typically found in the marine environment, however, elevated ^{7}Be is not usually found in offshore environments unless it has been transported in quantity by anthropogenic processes including dredged material disposal. With the detection of ^{7}Be in Sample 1, it is possible that this sediment migrated from the target area after disposal. The sediment density map showed that the area that Sample 1 had been collected was one of the few areas within the surveyed area that did contain some silt. The contours also showed an apparent connection to the disposal target area within the ODMDS.

7.0 CONCLUSION

The ^{40}K and total gamma activities (Figures 9 and 10) best represent the historical distribution of the deposited dredged material at the Fort Pierce ODMDS. The dredged material deposited at the ODMDS has consistently had higher gamma activity than the surrounding seafloor allowing clear delineation of the dredged material within the survey area. The most recently deposited dredged material was clearly shown in the southeastern corner of the ODMDS. Several dredged material drops were placed outside the target area (Figure 3). This dredged material was identified by a northwestern extension of higher gamma activity leading from the target area into the western half of the ODMDS. The higher gamma activity in the western half of the ODMDS may also be supported by the

remnants of previously deposited dredged material as shown in January 1997 and February 1998.

The sediment slurry density distribution (Figure 12) showed that some of the silty dredged material deposited at the ODMDS might have migrated to the northeastern corner of the ODMDS after deposition. Sediment-grab Sample 1 was collected within this area, but only revealed trace amounts of silt. However, the gamma activity analyses completed on the sample indicated the presence of ^{7}Be, which is representative of relatively recent sediment from estuaries and harbors. Since Sample 1 did not indicate significant amounts of silt, the surficial fine-grained sediment represented by Figure 12 in the northeastern corner of the ODMDS is most likely present in thin layers and somewhat spotty.

8.0 SAMPLE CUSTODY AND RECORDS

All samples obtained as a result of the survey are stored at the CAIS building for at least one year after completion of the survey. The computer-generated maps are stored on computer diskette for a minimum of one year. A logbook was maintained during the survey, referencing major events, GIMS calibration spectra, and any other related data pertaining to the survey. Records of laboratory analysis have been stored in notebooks relating to the specific types of equipment used.

9.0 REFERENCES

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APPENDIX A

FORT PIERCE ODMDS SHIPBOARD DATA – GAMMA RADIATION

Appendix A. Fort Pierce Shipboard Data – Gamma Radiation

Station	Latitude (Deg. Min.)		Longitude (Deg. Min.)		Depth (ft)	K-40 (cpm)	Bi-214 (cpm)	Tl-208 (cpm)	Total (cpm)	Light (lux)
1	80	13.101	27	28.757	52	96	59	43	1255	1161
2	80	13.103	27	28.651	50	139	32	32	1391	258
3	80	13.109	27	28.598	50	86	10	21	1193	495
4	80	13.112	27	28.543	49	121	55	21	1242	599
5	80	13.109	27	28.487	50	133	12	45	1287	372
6	80	13.103	27	28.431	51	120	47	41	1230	128
7	80	13.101	27	28.376	49	95	19	22	1084	529
8	80	13.102	27	28.320	50	95	29	26	1177	488
9	80	13.105	27	28.265	48	112	24	49	1214	8
10	80	13.109	27	28.208	49	145	13	34	1186	312
11	80	13.109	27	28.154	47	167	42	45	1350	253
12	80	13.109	27	28.103	47	101	28	28	1271	594
13	80	13.111	27	28.051	46	113	29	28	1177	807
14	80	13.109	27	27.996	46	121	35	19	1040	971
15	80	13.108	27	27.938	47	135	22	51	1145	985
16	80	13.105	27	27.881	47	153	39	30	1069	986
17	80	13.108	27	27.825	47	126	28	36	1144	457
18	80	13.112	27	27.772	46	120	15	43	1115	31
19	80	13.113	27	27.721	47	169	48	20	1009	404
20	80	13.111	27	27.668	44	133	42	31	1165	608
21	80	13.109	27	27.617	46	97	35	30	1057	530
22	80	13.114	27	27.562	43	123	45	24	1081	628
23	80	13.114	27	27.509	43	112	27	26	1054	546
24	80	13.114	27	27.453	42	112	63	25	1116	340
25	80	13.113	27	27.398	41	121	27	27	1151	643
26	80	13.111	27	27.344	42	130	57	45	1168	371
27	80	13.108	27	27.290	42	84	52	17	1184	797
28	80	13.112	27	27.236	44	117	62	36	1303	467
29	80	13.117	27	27.182	44	133	18	67	1259	632
30	80	13.115	27	27.126	43	124	43	33	1255	678
31	80	13.112	27	27.073	42	110	53	9	1146	408
32	80	13.109	27	27.020	43	112	31	22	1080	364
33	80	13.111	27	26.966	43	78	32	33	1093	473
34	80	13.114	27	26.912	43	134	69	29	1222	861
35	80	13.111	27	26.858	43	97	30	48	1065	492
36	80	13.108	27	26.805	44	115	31	27	1083	819
37	80	13.105	27	26.751	41	119	40	32	1046	411
38	80	13.108	27	26.696	42	102	34	21	1036	651
39	80	13.109	27	26.639	41	161	42	39	1107	447
40	80	13.113	27	26.582	41	99	35	31	1028	516
41	80	13.115	27	26.525	39	104	32	51	1064	508
42	80	13.119	27	26.468	41	98	44	30	1026	396
43	80	13.120	27	26.411	42	81	44	27	1012	512
44	80	13.121	27	26.354	41	131	33	30	1060	572
45	80	13.127	27	26.297	39	99	29	33	1042	551
46	80	13.130	27	26.239	40	108	27	36	980	432
47	80	13.136	27	26.170	40	133	25	31	965	517
48	80	13.146	27	26.099	41	91	35	19	1058	540
49	80	13.166	27	26.030	40	117	48	27	1111	615
50	80	13.140	27	25.960	41	130	38	0	1046	560
51	80	13.067	27	25.928	40	97	50	42	1097	594
52	80	13.001	27	25.953	39	90	39	26	1003	705
53	80	12.953	27	26.003	38	146	29	44	1033	624
54	80	12.893	27	26.044	37	112	34	36	1063	842
55	80	12.838	27	26.087	39	121	57	25	1051	734

Appendix A. Fort Pierce Shipboard Data – Gamma Radiation

Station	Latitude (Deg. Min.)		Longitude (Deg. Min.)		Depth (ft)	K-40 (cpm)	Bi-214 (cpm)	Tl-208 (cpm)	Total (cpm)	Light (lux)
56	80	12.791	27	26.134	40	103	54	41	1036	548
57	80	12.784	27	26.189	42	118	46	31	1137	796
58	80	12.776	27	26.249	41	112	34	35	1018	495
59	80	12.757	27	26.306	40	101	33	33	1082	363
60	80	12.734	27	26.366	40	136	34	34	1120	619
61	80	12.725	27	26.428	42	121	17	7	1080	489
62	80	12.724	27	26.489	41	163	69	47	1073	294
63	80	12.724	27	26.551	43	70	44	40	1083	782
64	80	12.727	27	26.610	42	106	49	33	948	1113
65	80	12.729	27	26.671	40	115	57	36	1092	1090
66	80	12.729	27	26.732	42	120	67	19	1115	947
67	80	12.729	27	26.794	42	93	41	31	1185	832
68	80	12.730	27	26.854	41	88	33	37	1043	844
69	80	12.733	27	26.915	42	140	59	38	1102	841
70	80	12.731	27	26.973	44	65	52	32	1062	742
71	80	12.731	27	27.033	41	116	54	27	1067	721
72	80	12.731	27	27.093	45	104	35	38	1051	959
73	80	12.729	27	27.154	45	154	22	25	1021	991
74	80	12.728	27	27.211	43	121	42	32	1004	880
75	80	12.730	27	27.266	43	104	36	18	1085	704
76	80	12.736	27	27.319	45	85	36	35	1049	790
77	80	12.738	27	27.374	45	116	47	31	1082	607
78	80	12.731	27	27.428	44	109	17	31	1096	594
79	80	12.723	27	27.485	46	106	18	34	1108	346
80	80	12.725	27	27.542	47	90	34	41	1092	657
81	80	12.739	27	27.599	47	90	16	28	1031	772
82	80	12.738	27	27.655	47	111	50	28	1104	725
83	80	12.730	27	27.710	48	134	57	24	1109	678
84	80	12.727	27	27.772	48	149	78	21	1135	1007
85	80	12.725	27	27.830	49	96	38	37	1135	983
86	80	12.727	27	27.887	51	115	57	23	1131	761
87	80	12.729	27	27.949	49	120	10	26	1213	638
88	80	12.731	27	28.009	48	154	41	25	1139	605
89	80	12.733	27	28.069	49	113	13	22	1191	508
90	80	12.733	27	28.129	50	133	52	40	1150	592
91	80	12.729	27	28.189	51	119	45	23	1230	556
92	80	12.728	27	28.249	49	114	37	16	1353	659
93	80	12.734	27	28.307	49	153	17	27	1214	704
94	80	12.734	27	28.364	49	113	50	54	1322	723
95	80	12.731	27	28.418	50	108	75	50	1509	526
96	80	12.727	27	28.475	49	111	13	40	1437	496
97	80	12.728	27	28.532	50	147	52	57	1716	759
98	80	12.746	27	28.591	48	108	52	37	1266	691
99	80	12.796	27	28.653	48	117	18	32	1067	423
100	80	12.831	27	28.718	48	163	32	25	1236	9
101	80	12.781	27	28.772	50	151	53	28	1223	327
102	80	12.691	27	28.781	48	111	23	31	1251	361
103	80	12.628	27	28.750	47	98	26	42	1291	705
104	80	12.590	27	28.709	46	88	65	24	1184	579
105	80	12.545	27	28.683	50	146	45	40	1232	362
106	80	12.489	27	28.654	54	100	17	29	1171	610
107	80	12.462	27	28.600	53	139	47	43	1371	545

Appendix A. Fort Pierce Shipboard Data – Gamma Radiation

Station		Latitude (Deg. Min.)		Longitude (Deg. Min.)	Depth (ft)	K-40 (cpm)	Bi-214 (cpm)	Tl-208 (cpm)	Total (cpm)	Light (lux)
108	80	12.420	27	28.559	51	150	50	36	1390	679
109	80	12.377	27	28.515	54	123	34	31	1159	868
110	80	12.367	27	28.460	52	104	48	22	1307	626
111	80	12.346	27	28.412	50	109	39	38	1258	459
112	80	12.346	27	28.361	51	125	54	20	1071	330
113	80	12.352	27	28.307	51	90	55	33	1181	555
114	80	12.354	27	28.253	53	139	36	31	1211	585
115	80	12.355	27	28.196	51	150	16	28	1320	564
116	80	12.352	27	28.141	52	145	33	24	1154	304
117	80	12.352	27	28.085	51	154	30	41	1163	227
118	80	12.353	27	28.028	50	130	19	3	1213	177
119	80	12.354	27	27.971	51	156	36	31	1301	518
120	80	12.354	27	27.915	49	111	58	27	1118	826
121	80	12.354	27	27.857	50	102	52	45	1227	866
122	80	12.353	27	27.799	48	124	49	23	1187	767
123	80	12.353	27	27.742	47	103	33	37	1140	748
124	80	12.353	27	27.685	48	189	53	28	1271	528
125	80	12.352	27	27.626	49	153	39	48	1248	529
126	80	12.352	27	27.569	47	182	35	37	1487	253
127	80	12.350	27	27.509	46	138	51	46	1306	139
128	80	12.352	27	27.452	47	107	35	10	1116	551
129	80	12.354	27	27.394	46	119	44	28	1146	698
130	80	12.353	27	27.336	47	159	46	16	1021	309
131	80	12.352	27	27.280	45	157	18	36	1188	741
132	80	12.352	27	27.221	46	112	48	38	1099	117
133	80	12.353	27	27.164	45	143	48	34	1088	485
134	80	12.355	27	27.106	44	150	31	49	1193	426
135	80	12.355	27	27.046	44	149	50	32	1340	618
136	80	12.354	27	26.988	43	138	34	31	1164	744
137	80	12.354	27	26.930	43	160	14	22	1105	731
138	80	12.355	27	26.873	43	102	32	18	1082	501
139	80	12.358	27	26.813	42	128	63	39	1080	615
140	80	12.356	27	26.756	41	106	46	41	1145	571
141	80	12.353	27	26.717	43	83	35	23	1159	730
142	80	12.350	27	26.637	42	101	37	29	1161	1098
143	80	12.352	27	26.578	43	150	64	59	1321	696
144	80	12.356	27	26.519	42	118	68	32	1249	810
145	80	12.358	27	26.462	41	124	31	35	1146	808
146	80	12.356	27	26.403	43	108	52	15	1158	98
147	80	12.365	27	26.332	41	116	23	48	1256	801
148	80	12.382	27	26.256	41	129	37	46	1170	636
149	80	12.413	27	26.186	39	127	35	22	1041	508
150	80	12.388	27	26.119	40	163	19	17	1054	531
151	80	12.320	27	26.096	41	115	46	31	1094	591
152	80	12.245	27	26.116	40	78	63	14	1063	610
153	80	12.163	27	26.140	37	103	44	28	1136	880
154	80	12.077	27	26.165	39	117	26	46	1113	652
155	80	12.026	27	26.219	41	117	39	21	954	605
156	80	11.996	27	26.290	42	101	65	18	1091	873
157	80	11.971	27	26.360	43	74	40	20	1032	842
158	80	11.975	27	26.417	44	95	59	25	1044	558
159	80	11.976	27	26.461	44	109	28	43	1067	747

Appendix A. Fort Pierce Shipboard Data – Gamma Radiation

Station	Latitude (Deg. Min.)		Longitude (Deg. Min.)		Depth (ft)	K-40 (cpm)	Bi-214 (cpm)	Tl-208 (cpm)	Total (cpm)	Light (lux)
160	80	11.970	27	26.509	45	103	65	54	1175	405
161	80	11.965	27	26.567	45	85	48	50	1131	917
162	80	11.971	27	26.623	44	138	63	15	1117	877
163	80	11.977	27	26.679	44	109	37	16	1130	956
164	80	11.974	27	26.735	44	92	56	21	1156	1012
165	80	11.968	27	26.791	44	87	30	19	1179	954
166	80	11.966	27	26.846	44	120	43	43	1118	886
167	80	11.971	27	26.904	44	158	29	15	1147	801
168	80	11.976	27	26.962	45	128	35	21	1157	873
169	80	11.979	27	27.020	44	142	44	41	1164	513
170	80	11.973	27	27.077	46	199	33	38	1505	763
171	80	11.969	27	27.135	43	146	34	24	1261	14
172	80	11.967	27	27.193	44	170	40	50	1509	611
173	80	11.970	27	27.250	48	151	75	45	1237	631
174	80	11.972	27	27.309	46	130	46	52	1276	822
175	80	11.977	27	27.366	49	147	35	45	1221	824
176	80	11.980	27	27.423	47	114	35	44	1069	428
177	80	11.977	27	27.480	48	143	47	51	1209	1040
178	80	11.971	27	27.537	48	173	73	59	1331	961
179	80	11.968	27	27.595	49	125	33	34	1195	161
180	80	11.966	27	27.653	49	89	47	22	1214	598
181	80	11.966	27	27.711	50	111	25	25	1115	705
182	80	11.966	27	27.769	50	135	33	43	1148	733
183	80	11.966	27	27.826	51	113	36	28	1173	520
184	80	11.966	27	27.883	48	140	28	18	1143	523
185	80	11.968	27	27.940	49	121	21	53	1120	548
186	80	11.970	27	27.995	50	107	36	25	1021	608
187	80	11.939	27	28.040	52	85	18	24	1058	491
188	80	11.873	27	28.070	51	119	17	38	1101	388
189	80	11.873	27	28.120	51	137	34	24	1126	605
190	80	11.930	27	28.139	51	148	57	33	1151	828
191	80	11.986	27	28.161	50	105	37	15	1283	985
192	80	11.989	27	28.223	51	125	47	10	1318	907
193	80	11.960	27	28.268	52	125	77	48	1385	828
194	80	11.966	27	28.323	52	128	34	39	1243	855
195	80	11.977	27	28.376	52	93	25	44	1266	760
196	80	11.979	27	28.428	50	94	45	43	1263	505
197	80	11.971	27	28.480	51	133	37	38	1409	633
198	80	11.972	27	28.532	51	180	49	49	1433	724
199	80	11.975	27	28.606	50	110	50	13	1039	869
200	80	11.980	27	28.677	52	134	9	30	753	869
201	80	11.956	27	28.745	54	110	28	19	760	1237
202	80	11.874	27	28.727	54	106	2	11	638	761
203	80	11.827	27	28.675	52	111	29	37	1133	1354
204	80	11.771	27	28.634	52	113	29	35	1005	949
205	80	11.707	27	28.578	53	128	2	20	904	320
206	80	11.655	27	28.513	52	112	35	34	907	536
207	80	11.624	27	28.443	50	126	44	36	1161	883
208	80	11.600	27	28.395	52	165	72	6	1374	785
209	80	11.595	27	28.356	51	127	43	36	1391	748
210	80	11.596	27	28.310	51	82	60	51	1197	469
211	80	11.595	27	28.256	52	85	51	47	1125	698

Appendix A. Fort Pierce Shipboard Data – Gamma Radiation

Station	Latitude (Deg. Min.)		Longitude (Deg. Min.)		Depth (ft)	K-40 (cpm)	Bi-214 (cpm)	Tl-208 (cpm)	Total (cpm)	Light (lux)
212	80	11.595	27	28.203	50	150	56	31	1178	233
213	80	11.593	27	28.149	51	87	56	17	1165	372
214	80	11.593	27	28.095	50	130	35	31	1141	497
215	80	11.589	27	28.040	52	98	42	36	1183	242
216	80	11.590	27	27.984	51	62	46	36	1050	546
217	80	11.590	27	27.929	52	109	42	23	1083	542
218	80	11.591	27	27.872	51	118	27	31	1176	531
219	80	11.593	27	27.817	51	105	33	47	1174	469
220	80	11.591	27	27.760	50	141	43	34	1130	637
221	80	11.591	27	27.704	51	81	5	31	1010	828
222	80	11.593	27	27.647	50	116	15	35	1051	952
223	80	11.593	27	27.593	51	133	43	19	1121	510
224	80	11.593	27	27.537	49	110	40	39	1065	475
225	80	11.593	27	27.482	49	78	54	18	1063	866
226	80	11.593	27	27.425	50	100	47	12	1043	481
227	80	11.593	27	27.369	50	107	30	24	1139	639
228	80	11.593	27	27.314	50	132	10	29	1117	775
229	80	11.595	27	27.257	50	177	39	25	1226	702
230	80	11.597	27	27.202	48	145	56	51	1252	312
231	80	11.597	27	27.145	48	166	60	40	1279	716
232	80	11.596	27	27.089	47	191	22	38	1335	58
233	80	11.593	27	27.032	48	200	0	25	1285	953
234	80	11.591	27	26.975	47	159	31	57	1494	717
235	80	11.591	27	26.919	48	144	42	27	1082	19
236	80	11.591	27	26.862	46	133	30	40	1090	757
237	80	11.591	27	26.807	46	178	57	41	1180	1109
238	80	11.592	27	26.750	46	100	25	50	1105	620
239	80	11.593	27	26.693	45	112	35	40	1174	726
240	80	11.593	27	26.636	45	111	47	45	1170	898
241	80	11.593	27	26.581	44	150	10	26	1168	1031
242	80	11.593	27	26.523	43	115	44	41	1040	257
243	80	11.593	27	26.466	44	96	36	26	1063	703
244	80	11.599	27	26.401	42	106	28	14	1098	536
245	80	11.624	27	26.336	42	141	25	21	1071	839
246	80	11.615	27	26.264	41	125	13	47	1098	899
247	80	11.553	27	26.217	43	101	66	31	1071	409
248	80	11.477	27	26.219	43	129	35	20	1020	481
249	80	11.403	27	26.248	44	149	26	23	1043	610
250	80	11.321	27	26.259	45	105	39	36	1085	676
251	80	11.255	27	26.288	44	132	46	34	1116	831
252	80	11.238	27	26.352	46	103	5	8	1073	837
253	80	11.218	27	26.416	44	137	40	28	1120	281
254	80	11.221	27	26.483	45	108	12	16	1059	375
255	80	11.218	27	26.537	46	105	22	21	1032	484
256	80	11.210	27	26.599	45	91	30	14	1091	427
257	80	11.209	27	26.653	45	107	13	20	1125	390
258	80	11.210	27	26.708	46	122	37	16	1068	589
259	80	11.210	27	26.771	47	146	35	17	1050	448
260	80	11.211	27	26.832	48	130	16	19	1180	451
261	80	11.210	27	26.894	47	130	42	24	1094	578
262	80	11.209	27	26.954	48	148	80	49	1081	810
263	80	11.207	27	27.016	50	111	20	34	1123	838

Appendix A. Fort Pierce Shipboard Data – Gamma Radiation

Station		Latitude (Deg. Min.)		Longitude (Deg. Min.)	Depth (ft)	K-40 (cpm)	Bi-214 (cpm)	Tl-208 (cpm)	Total (cpm)	Light (lux)
264	80	11.209	27	27.077	49	119	30	49	1109	691
265	80	11.209	27	27.139	50	103	17	30	1124	604
266	80	11.209	27	27.201	50	150	43	43	1205	834
267	80	11.211	27	27.263	52	152	67	32	1143	840
268	80	11.214	27	27.325	51	130	35	41	1167	535
269	80	11.218	27	27.387	50	119	0	16	1054	506
270	80	11.218	27	27.449	52	154	30	18	1129	520
271	80	11.213	27	27.512	51	121	41	50	1083	373
272	80	11.211	27	27.574	51	97	48	46	1184	592
273	80	11.213	27	27.637	51	115	35	9	1121	383
274	80	11.217	27	27.698	51	139	24	31	1002	489
275	80	11.217	27	27.759	53	126	23	18	1060	535
276	80	11.212	27	27.820	50	124	31	12	1028	549
277	80	11.209	27	27.882	51	100	51	6	1135	490
278	80	11.206	27	27.944	51	136	39	32	1189	445
279	80	11.204	27	28.008	53	157	38	15	1110	463
280	80	11.205	27	28.071	53	161	33	46	1283	294
281	80	11.211	27	28.133	52	170	24	37	1199	363
282	80	11.217	27	28.195	52	137	43	34	1187	498
283	80	11.222	27	28.257	53	140	35	34	1152	387
284	80	11.221	27	28.319	50	115	29	35	1126	323
285	80	11.212	27	28.381	51	116	36	23	1202	551
286	80	11.210	27	28.445	51	170	72	15	1149	709
287	80	11.212	27	28.508	54	115	25	31	1045	1008
288	80	11.217	27	28.571	52	143	38	36	1029	759
289	80	11.227	27	28.645	49	160	75	8	1370	553
290	80	11.223	27	28.716	50	128	33	18	1073	689
291	80	11.140	27	28.727	50	129	70	21	1446	784
292	80	11.067	27	28.689	49	130	55	42	1605	1047
293	80	11.005	27	28.644	50	129	61	37	1722	869
294	80	10.948	27	28.588	52	153	66	43	1678	831
295	80	10.897	27	28.527	50	133	68	38	1307	995
296	80	10.869	27	28.461	53	96	55	24	1171	470
297	80	10.844	27	28.398	50	113	63	38	1229	303
298	80	10.842	27	28.341	51	130	42	40	1214	1071
299	80	10.842	27	28.292	53	163	67	34	1485	720
300	80	10.838	27	28.238	50	142	47	44	1437	1087
301	80	10.832	27	28.184	49	154	5	15	1146	972
302	80	10.829	27	28.130	50	85	70	23	1241	506
303	80	10.828	27	28.077	50	128	58	25	1568	713
304	80	10.829	27	28.023	53	158	75	22	1528	830
305	80	10.832	27	27.969	52	123	29	28	1228	894
306	80	10.832	27	27.915	51	98	28	48	1019	910
307	80	10.831	27	27.862	53	115	22	24	1185	404
308	80	10.829	27	27.809	52	110	14	24	1140	564
309	80	10.829	27	27.755	53	84	13	17	1130	752
310	80	10.832	27	27.703	52	130	51	49	1290	754
311	80	10.837	27	27.649	52	122	67	39	1155	644
312	80	10.837	27	27.596	52	146	36	29	1183	822
313	80	10.833	27	27.542	51	181	39	34	1472	628
314	80	10.831	27	27.488	54	159	44	38	1331	790
315	80	10.831	27	27.434	52	125	63	29	1214	1076

Appendix A. Fort Pierce Shipboard Data – Gamma Radiation

Station	Latitude (Deg. Min.)		Longitude (Deg. Min.)		Depth (ft)	K-40 (cpm)	Bi-214 (cpm)	Tl-208 (cpm)	Total (cpm)	Light (lux)
316	80	10.835	27	27.379	52	109	30	22	1320	1106
317	80	10.838	27	27.325	51	158	53	52	1386	1021
318	80	10.840	27	27.271	53	132	34	36	1233	793
319	80	10.842	27	27.216	52	149	40	36	1397	576
320	80	10.843	27	27.161	51	150	26	38	1386	599
321	80	10.842	27	27.106	50	121	32	21	1131	340
322	80	10.838	27	27.050	49	147	74	12	1146	611
323	80	10.837	27	26.995	50	126	43	21	1111	686
324	80	10.837	27	26.940	49	154	47	56	1228	590
325	80	10.837	27	26.885	47	139	68	41	1202	920
326	80	10.836	27	26.829	47	108	81	21	1150	664
327	80	10.835	27	26.774	49	159	28	18	1123	885
328	80	10.836	27	26.717	49	125	19	27	1120	814
329	80	10.837	27	26.660	47	127	64	51	1311	881
330	80	10.836	27	26.605	47	139	36	12	1142	720
331	80	10.837	27	26.549	46	163	31	29	1058	56
332	80	10.838	27	26.492	46	153	23	37	1032	464
333	80	10.841	27	26.437	48	90	34	15	1077	335
334	80	10.842	27	26.367	48	121	27	33	1062	496
335	80	10.818	27	26.307	46	116	32	29	1124	494
336	80	10.861	27	26.254	46	135	17	22	972	561
337	80	10.920	27	26.288	44	114	44	40	1045	471
338	80	10.960	27	26.328	44	123	48	33	1113	639
339	80	10.991	27	26.370	45	131	36	30	1128	421
340	80	11.021	27	26.417	46	109	50	32	1030	478
341	80	11.027	27	26.467	47	102	59	32	1059	597
342	80	11.033	27	26.528	45	100	38	29	1019	663
343	80	11.033	27	26.588	47	155	42	51	1145	569
344	80	11.036	27	26.647	47	118	21	27	1094	357
345	80	11.039	27	26.705	47	107	35	30	1192	372
346	80	11.039	27	26.764	47	117	36	28	1120	478
347	80	11.039	27	26.816	49	78	24	25	1167	499
348	80	11.038	27	26.874	49	133	50	30	1230	778
349	80	11.036	27	26.934	51	161	41	23	1210	686
350	80	11.037	27	26.993	50	142	30	43	1196	329
351	80	11.032	27	27.053	51	159	48	25	1164	370
352	80	11.027	27	27.114	51	122	42	37	1182	509
353	80	11.030	27	27.172	51	182	56	29	1412	331
354	80	11.037	27	27.230	52	172	61	29	1246	473
355	80	11.037	27	27.289	51	88	44	28	1130	920
356	80	11.035	27	27.350	50	152	58	34	1311	646
357	80	11.036	27	27.409	53	116	50	0	1307	613
358	80	11.033	27	27.470	54	168	81	48	1342	626
359	80	11.033	27	27.531	52	131	55	44	1372	472
360	80	11.035	27	27.592	51	138	58	41	1341	563
361	80	11.039	27	27.653	52	161	55	31	1330	373
362	80	11.036	27	27.713	50	157	49	43	1168	568
363	80	11.033	27	27.775	51	118	40	18	1220	441
364	80	11.030	27	27.837	51	69	17	30	1128	304
365	80	11.029	27	27.899	51	145	58	16	1058	399
366	80	11.031	27	27.958	50	142	47	36	1122	333
367	80	11.030	27	28.018	51	115	29	23	1117	377

Appendix A. Fort Pierce Shipboard Data – Gamma Radiation

Station		Latitude (Deg. Min.)		Longitude (Deg. Min.)	Depth (ft)	K-40 (cpm)	Bi-214 (cpm)	Tl-208 (cpm)	Total (cpm)	Light (lux)
368	80	11.027	27	28.078	51	117	48	23	1217	481
369	80	11.027	27	28.138	52	112	37	33	1043	408
370	80	11.024	27	28.200	51	116	39	34	1097	438
371	80	11.023	27	28.262	53	147	41	24	1170	485
372	80	11.024	27	28.324	51	131	37	24	1070	469
373	80	11.021	27	28.385	53	138	53	45	1238	492
374	80	11.016	27	28.446	53	155	51	34	1142	675
375	80	11.014	27	28.507	53	160	30	42	1278	422
376	80	11.012	27	28.579	54	177	38	37	1481	542
377	80	11.006	27	28.657	49	153	55	29	1395	510
378	80	11.000	27	28.734	49	122	63	20	1580	676
379	80	11.016	27	28.796	52	192	36	46	1603	637
380	80	11.096	27	28.791	53	129	46	49	1317	816
381	80	11.173	27	28.772	50	133	49	32	1235	743
382	80	11.256	27	28.749	52	122	53	35	1189	670
383	80	11.318	27	28.699	50	127	72	14	1348	259
384	80	11.366	27	28.638	54	130	28	35	1212	980
385	80	11.390	27	28.579	53	151	55	53	1507	310
386	80	11.396	27	28.523	54	113	28	17	1106	761
387	80	11.408	27	28.469	52	98	71	15	1258	571
388	80	11.412	27	28.412	50	149	28	38	1098	332
389	80	11.419	27	28.354	49	125	15	29	1229	223
390	80	11.425	27	28.297	51	159	27	17	1418	393
391	80	11.431	27	28.239	52	146	51	31	1280	726
392	80	11.443	27	28.183	52	115	54	27	1253	822
393	80	11.450	27	28.126	51	124	23	36	1207	174
394	80	11.452	27	28.070	53	113	40	46	1335	490
395	80	11.449	27	28.015	51	97	42	20	1159	563
396	80	11.442	27	27.959	51	140	25	34	1141	351
397	80	11.435	27	27.903	52	74	22	30	1046	441
398	80	11.429	27	27.847	51	129	41	52	1255	290
399	80	11.417	27	27.788	52	123	62	24	1155	370
400	80	11.410	27	27.731	51	137	32	35	1136	437
401	80	11.416	27	27.674	53	155	29	33	1132	495
402	80	11.423	27	27.618	51	136	19	49	1108	388
403	80	11.427	27	27.562	51	140	10	29	1178	353
404	80	11.429	27	27.506	50	86	21	24	1082	240
405	80	11.431	27	27.450	52	141	44	28	1176	512
406	80	11.429	27	27.384	51	99	49	55	1236	683
407	80	11.422	27	27.329	51	131	53	45	1351	346
408	80	11.414	27	27.275	48	101	34	29	1175	401
409	80	11.409	27	27.224	49	129	41	22	1121	205
410	80	11.405	27	27.166	50	161	16	30	1151	489
414	80	11.404	27	26.947	46	167	50	21	1277	407
415	80	11.405	27	26.892	47	141	45	40	1123	142
416	80	11.408	27	26.837	46	95	12	35	1158	931
417	80	11.408	27	26.776	45	151	19	46	1238	878
418	80	11.408	27	26.717	45	130	26	26	1211	855
419	80	11.405	27	26.666	45	104	43	28	1135	786
420	80	11.402	27	26.613	45	135	32	29	1051	505
421	80	11.404	27	26.561	46	136	17	15	1119	841
422	80	11.401	27	26.504	45	103	44	24	1068	960

Appendix A. Fort Pierce Shipboard Data – Gamma Radiation

Station	Latitude (Deg. Min.)		Longitude (Deg. Min.)		Depth (ft)	K-40 (cpm)	Bi-214 (cpm)	Tl-208 (cpm)	Total (cpm)	Light (lux)
423	80	11.392	27	26.438	45	138	31	32	1094	627
424	80	11.390	27	26.369	45	115	36	42	1102	439
425	80	11.390	27	26.294	44	130	44	20	1106	863
426	80	11.398	27	26.229	44	145	27	48	1096	567
427	80	11.466	27	26.212	44	105	48	26	1152	444
428	80	11.551	27	26.207	43	149	60	16	1090	491
429	80	11.627	27	26.223	44	106	47	27	1148	812
430	80	11.696	27	26.253	42	135	54	40	1141	522
431	80	11.743	27	26.311	42	96	17	30	1098	644
432	80	11.771	27	26.371	43	89	23	34	1089	663
433	80	11.785	27	26.420	43	119	28	41	1062	711
434	80	11.794	27	26.478	43	120	40	19	1075	461
435	80	11.794	27	26.536	44	135	12	32	1068	399
436	80	11.794	27	26.592	43	140	32	27	1120	781
437	80	11.794	27	26.646	42	135	46	28	1034	621
438	80	11.797	27	26.703	44	133	27	49	1082	618
439	80	11.801	27	26.759	45	95	60	35	1184	359
440	80	11.804	27	26.815	45	126	37	47	1242	733
441	80	11.804	27	26.870	45	111	71	31	1171	652
442	80	11.803	27	26.926	47	127	30	35	1238	757
443	80	11.795	27	26.984	46	124	36	31	1197	119
444	80	11.785	27	27.044	47	122	63	19	1169	824
445	80	11.785	27	27.104	46	133	9	43	1193	580
446	80	11.785	27	27.161	46	179	17	55	1324	553
447	80	11.785	27	27.220	49	153	39	21	1305	636
448	80	11.786	27	27.279	47	236	29	63	1652	609
449	80	11.788	27	27.340	48	202	63	51	1485	13
450	80	11.791	27	27.397	50	161	26	43	1392	41
451	80	11.792	27	27.455	50	133	51	35	1119	275
452	80	11.794	27	27.515	48	123	44	16	1146	538
453	80	11.794	27	27.574	51	114	51	23	1229	520
454	80	11.795	27	27.634	50	122	46	21	1126	539
455	80	11.798	27	27.693	52	106	26	28	1076	423
456	80	11.803	27	27.751	50	111	58	24	1122	167
457	80	11.804	27	27.809	51	115	41	37	1121	402
458	80	11.800	27	27.867	51	133	52	20	1174	381
459	80	11.796	27	27.925	50	133	77	36	1203	205
460	80	11.790	27	27.984	52	160	17	30	1086	624
461	80	11.788	27	28.043	50	126	24	46	1131	695
462	80	11.784	27	28.101	51	179	35	54	1148	643
463	80	11.784	27	28.161	52	134	16	17	1106	606
464	80	11.788	27	28.221	52	159	61	36	1308	550
465	80	11.791	27	28.280	51	168	35	60	1269	511
466	80	11.788	27	28.340	53	133	39	42	1221	648
467	80	11.788	27	28.399	49	160	61	12	1271	715
468	80	11.790	27	28.458	53	133	56	44	1235	583
469	80	11.788	27	28.518	51	129	79	25	1193	565
470	80	11.790	27	28.590	52	132	47	29	1183	412
471	80	11.797	27	28.664	53	156	40	20	1057	590
472	80	11.804	27	28.742	54	125	10	41	860	771
473	80	11.865	27	28.796	53	130	25	17	924	572
474	80	11.953	27	28.789	52	135	39	17	1040	500

Appendix A. Fort Pierce Shipboard Data – Gamma Radiation

Station		Latitude (Deg. Min.)		Longitude (Deg. Min.)	Depth (ft)	K-40 (cpm)	Bi-214 (cpm)	Tl-208 (cpm)	Total (cpm)	Light (lux)
475	80	12.032	27	28.769	54	125	51	18	1067	918
476	80	12.096	27	28.751	53	175	79	40	1401	901
477	80	12.134	27	28.691	53	218	58	56	1613	119
478	80	12.153	27	28.634	52	104	42	28	1249	12
479	80	12.167	27	28.583	51	148	27	47	1286	465
480	80	12.178	27	28.527	50	123	55	52	1412	904
481	80	12.175	27	28.469	50	191	53	39	1489	1022
482	80	12.170	27	28.411	49	130	45	36	1473	874
483	80	12.163	27	28.353	51	87	63	19	1264	923
484	80	12.154	27	28.297	49	142	53	25	1343	792
485	80	12.146	27	28.240	51	136	24	30	1268	866
486	80	12.146	27	28.182	52	141	60	42	1437	920
487	80	12.154	27	28.125	51	158	41	47	1301	353
488	80	12.161	27	28.068	50	97	39	40	1193	694
489	80	12.169	27	28.010	50	154	33	28	1166	955
490	80	12.174	27	27.952	49	153	26	36	1109	871
491	80	12.176	27	27.893	49	119	66	31	1105	1136
492	80	12.176	27	27.836	50	120	52	28	1146	753
493	80	12.176	27	27.777	48	126	44	29	1234	744
494	80	12.174	27	27.719	46	110	29	31	1191	285
495	80	12.172	27	27.662	46	117	50	35	1128	828
496	80	12.170	27	27.603	45	114	44	34	1315	913
497	80	12.167	27	27.544	48	119	56	29	1260	1028
498	80	12.167	27	27.487	45	123	59	19	1085	1257
499	80	12.167	27	27.428	47	125	47	29	1109	1127
500	80	12.167	27	27.370	46	110	57	18	1125	619
501	80	12.165	27	27.312	47	178	90	30	1421	490
502	80	12.164	27	27.253	45	122	60	25	1138	1138
503	80	12.162	27	27.195	44	148	33	30	1230	1088
504	80	12.161	27	27.136	46	128	27	34	1112	148
505	80	12.161	27	27.077	45	112	23	11	1148	984
506	80	12.158	27	27.019	46	143	32	28	1335	836
507	80	12.155	27	26.960	46	140	59	24	1325	688
508	80	12.155	27	26.903	45	146	42	16	1165	14
509	80	12.161	27	26.843	44	127	43	23	1078	709
510	80	12.163	27	26.784	44	147	48	57	1156	1066
511	80	12.165	27	26.724	43	120	57	26	1117	568
512	80	12.166	27	26.665	42	195	42	25	1246	997
513	80	12.167	27	26.606	43	147	59	48	1434	892
514	80	12.170	27	26.548	44	107	65	47	1320	966
515	80	12.172	27	26.488	42	157	54	58	1443	960
516	80	12.171	27	26.426	42	119	47	27	1188	906
517	80	12.179	27	26.350	42	157	45	21	1232	711
518	80	12.191	27	26.270	41	137	43	31	1048	35
519	80	12.233	27	26.212	42	118	46	19	1050	895
520	80	12.318	27	26.209	41	105	31	35	1038	943
521	80	12.404	27	26.234	41	102	20	4	1012	593
522	80	12.487	27	26.263	40	135	22	20	1045	380
523	80	12.527	27	26.329	40	123	57	27	1163	535
524	80	12.560	27	26.371	40	122	64	50	1159	1124
525	80	12.560	27	26.431	41	124	41	20	1065	1084
526	80	12.555	27	26.490	41	114	45	19	1064	1287

Appendix A. Fort Pierce Shipboard Data – Gamma Radiation

Station		Latitude (Deg. Min.)		Longitude (Deg. Min.)	Depth (ft)	K-40 (cpm)	Bi-214 (cpm)	Tl-208 (cpm)	Total (cpm)	Light (lux)
527	80	12.565	27	26.540	41	121	23	43	1129	833
528	80	12.565	27	26.591	40	118	37	34	1113	912
529	80	12.563	27	26.641	40	92	53	2	1085	1207
530	80	12.563	27	26.692	41	133	19	38	1153	1082
531	80	12.561	27	26.746	43	118	50	13	1205	995
532	80	12.557	27	26.805	43	82	36	38	1162	1269
533	80	12.551	27	26.861	43	106	30	27	1096	882
534	80	12.547	27	26.918	43	94	23	44	1067	966
535	80	12.545	27	26.976	44	114	53	52	1110	775
536	80	12.544	27	27.037	45	142	47	27	1139	851
537	80	12.543	27	27.095	46	141	40	28	1181	447
538	80	12.545	27	27.153	47	128	30	36	1187	422
539	80	12.545	27	27.210	47	97	71	38	1179	232
540	80	12.545	27	27.269	47	149	51	31	1121	144
541	80	12.547	27	27.326	47	131	47	27	1105	369
542	80	12.547	27	27.385	47	141	36	33	1090	160
543	80	12.545	27	27.444	48	151	24	19	1107	221
544	80	12.549	27	27.500	48	143	51	22	1149	187
545	80	12.548	27	27.559	49	132	66	19	1160	177
546	80	12.545	27	27.617	50	147	24	39	1323	302
547	80	12.542	27	27.676	48	110	70	21	1213	373
548	80	12.539	27	27.734	49	96	31	38	1280	408
549	80	12.538	27	27.792	50	114	57	34	1309	574
550	80	12.539	27	27.853	51	94	40	19	1136	625
551	80	12.545	27	27.910	50	123	39	33	1275	223
552	80	12.546	27	27.969	50	150	35	25	1190	342
553	80	12.541	27	28.028	52	139	54	20	1139	459
554	80	12.536	27	28.087	52	143	38	49	1166	736
555	80	12.538	27	28.145	52	153	26	49	1329	330
556	80	12.542	27	28.203	52	146	39	69	1343	414
557	80	12.545	27	28.263	53	136	45	52	1405	343
558	80	12.545	27	28.322	55	150	39	55	1422	227
559	80	12.545	27	28.382	53	182	83	50	1542	403
560	80	12.539	27	28.440	54	167	45	42	1514	387
561	80	12.532	27	28.501	54	195	0	36	1430	185
562	80	12.532	27	28.562	53	154	43	46	1478	496
563	80	12.539	27	28.636	53	184	35	51	1365	51
564	80	12.524	27	28.714	49	118	14	17	833	171
565	80	12.556	27	28.783	51	135	49	17	1082	1232
566	80	12.640	27	28.799	51	98	42	20	1055	1295
567	80	12.715	27	28.763	51	102	5	43	1104	1126
568	80	12.784	27	28.730	52	164	42	35	1287	292
569	80	12.827	27	28.685	51	161	71	59	1422	697
570	80	12.880	27	28.646	50	121	32	45	1401	777
571	80	12.937	27	28.595	50	129	51	33	1251	297
572	80	12.932	27	28.534	50	148	4	7	1188	643
573	80	12.911	27	28.498	50	151	57	62	1376	1185
574	80	12.929	27	28.445	48	162	32	41	1423	837
575	80	12.937	27	28.389	48	111	53	52	1351	849
576	80	12.933	27	28.332	49	172	56	28	1237	607
577	80	12.939	27	28.274	49	145	31	58	1376	1053
578	80	12.935	27	28.218	50	142	69	35	1466	910

Appendix A. Fort Pierce Shipboard Data – Gamma Radiation

Station		Latitude (Deg. Min.)		Longitude (Deg. Min.)	Depth (ft)	K-40 (cpm)	Bi-214 (cpm)	Tl-208 (cpm)	Total (cpm)	Light (lux)
579	80	12.924	27	28.162	50	208	60	48	1574	759
580	80	12.920	27	28.103	50	139	53	83	1583	262
581	80	12.933	27	28.043	51	121	40	30	1247	256
582	80	12.937	27	27.991	49	123	42	28	1253	546
583	80	12.933	27	27.938	49	154	44	33	1203	585
584	80	12.926	27	27.881	48	177	20	30	1178	148
585	80	12.931	27	27.822	47	146	53	35	1274	332
586	80	12.939	27	27.765	48	100	12	20	1168	237
587	80	12.936	27	27.707	48	116	41	31	1204	483
588	80	12.933	27	27.650	47	126	63	30	1246	629
589	80	12.929	27	27.594	46	119	54	33	1128	641
590	80	12.928	27	27.536	45	112	61	42	1168	882
591	80	12.928	27	27.479	45	139	20	42	1171	996
592	80	12.929	27	27.421	46	100	34	46	1216	1138
593	80	12.931	27	27.363	46	166	27	29	1290	923
594	80	12.933	27	27.304	46	143	37	50	1263	646
595	80	12.935	27	27.247	46	75	30	42	1053	86
596	80	12.932	27	27.190	46	127	39	36	1150	467
597	80	12.935	27	27.129	44	148	51	19	1220	689
598	80	12.934	27	27.069	45	124	26	38	1256	381
599	80	12.929	27	27.007	45	130	51	31	1156	524
600	80	12.929	27	26.947	44	164	39	24	1260	359
601	80	12.924	27	26.887	43	139	57	13	1186	517
602	80	12.922	27	26.828	44	135	35	49	1144	739
603	80	12.931	27	26.767	42	111	46	41	1138	636
604	80	12.941	27	26.708	43	137	31	27	1188	567
605	80	12.947	27	26.648	40	123	35	29	1113	655
606	80	12.951	27	26.588	42	107	41	29	1168	575
607	80	12.949	27	26.527	41	91	43	30	1104	387
608	80	12.951	27	26.467	41	125	35	13	1149	381

APPENDIX B

QUALITY ASSURANCE AND CONTROL

B.0 QUALITY ASSURANCE AND CONTROL

Several steps were taken to ensure that the systems used to perform the survey were operating properly at all times. The methods for the quality assurance and control were documented in the QAPjP (EPA 1991) for this project.

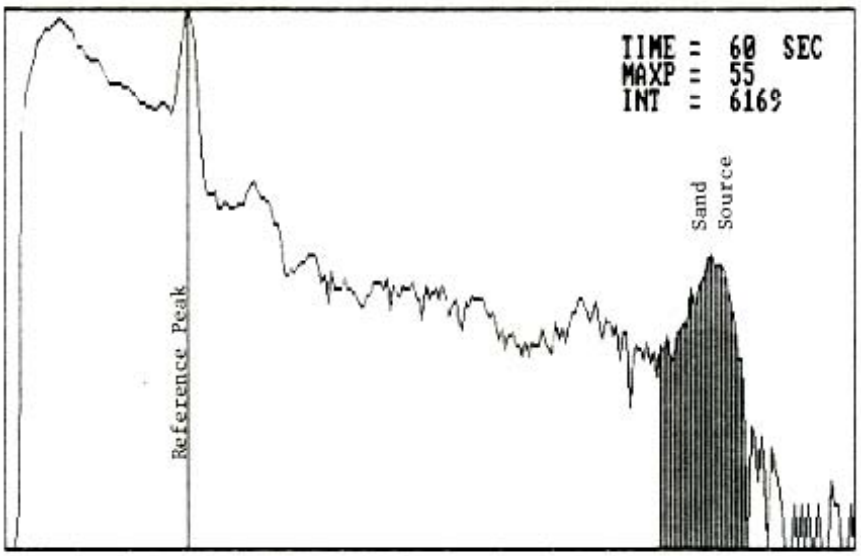
B.1 GIMS

To check the operating system of the GIMS, a CAIS monazite-sand (^{208}Tl) standard was used. A spectrum was printed on paper before and after the survey. The operator of the system reviews the spectrum to ensure that the operational peaks are in the proper settings. The operator also checks the system=s gain, reference channel, and resolution. Figure B-1 shows the two calibration spectra recorded before and after the GIMS portion of the survey.

B.2 XRF (Sediment-grab Samples)

A replicate sample analysis was performed for the standard NIST pellet. Table B-1 shows the results of the replicate analysis on the standard NIST 8704 pellet. All the analytes for the NIST 8704 pellet were within the expected precision and accuracy range.

Before Survey



After Survey

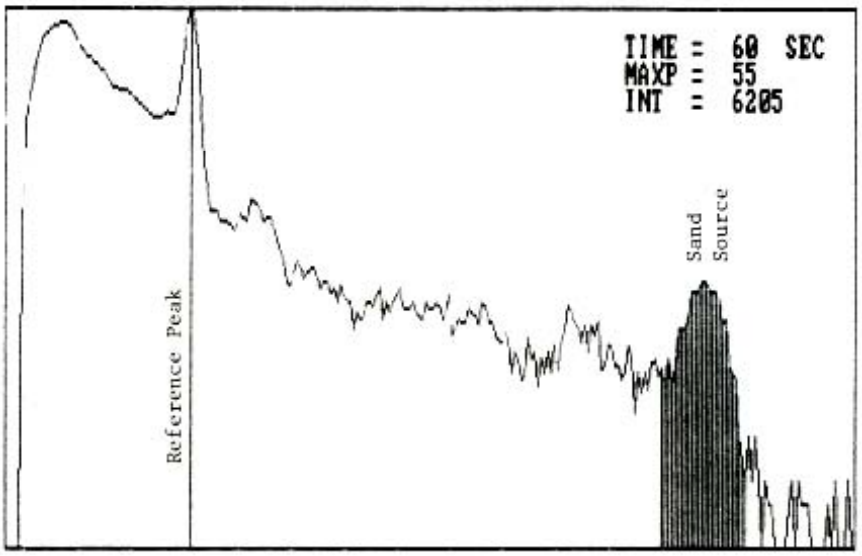


Figure B-1. Calibration spectra for GIMS.

Table B-1. XRF Data Quality Measurements for Pellets

System	Analyte	Precision[a]	Accuracy[b]	Precision[c]	Accuracy[c]
XRF	Al	"0.4%	"3.2%	"25%	"25%
wt%	Si	"0.2%	"2.4%	"25%	"25%
	S	"6.9%	"1.5%	"25%	"25%
	Fe	"0.1%	"0.8%	"25%	"25%
	Ca	"0.2%	"0.8%	"25%	"25%
	Mg	"4.2%	"3.7%	"25%	"25%
	Ti	"0.0%	"15.9%	"25%	"25%
ppm	Cr	"1.2%	"6.4%	"25%	"25%
	Mn	"2.1%	"7.1%	"25%	"25%
	Ni	"2.7%	"23.3%	"25%	"25%
	Cu	"1.0%	"4.9%	"25%	"25%
	Zn	"0.2%	"12.7%	"25%	"25%
	Zr	"0.3%	"0.1%	"25%	"25%
	Sr	"0.3%	"14.9%	"25%	"25%
	Ba	"1.2%	"3.6%	"25%	"25%
	Pb	"0.5%	"8.5%	"25%	"25%

[a]Relative standard deviation based on replicate analysis of NIST 8704 pellet.
[b]Difference from true value based on replicate analysis of NIST 8704 pellet.
[c]Acceptance/rejection values.

B.3 HPGe Detector

An EPA pitchblende standard was analyzed along with the six sediment-grab samples to monitor the operation of the HPGe detector. A replicate analysis of sediment-grab Sample 4 was performed in addition to the pitchblende sample. A background sample was also analyzed with the sediment-grab samples, and no detectable levels of gamma radiation were recorded. Table B-2 shows the results of the replicate analysis for sediment-grab Sample 4 and the EPA pitchblende standard.

Table B-2. HPGe Data Quality Measurements.

System	Analyte	Sample 4	Replicate 4	Precision
HPGe pCi/kg	^{238}U	298	289	"3%
	^{232}Th	2004	1953	"3%
	^{40}K	878	860	"2%

System	Analyte	Pitchblende	Replicate	Precision
HPGe pCi/kg	^{238}U	2968	3040	"2%