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MTADS MAPPING AND ORDNANCE INVESTIGATION AT THE FORMER FT. PIERCE AMPHIBIOUS BASE

VERO BEACH, FLORIDA, MARCH 1998

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EXECUTIVE SUMMARY

The *MTADS*, deployed with the magnetometer array, was used to conduct a survey at this site between January 19 - February 3, 1998 as a New Technology Evaluation. Approximately 150 acres of beach, between the shoreline and vegetation lines was surveyed, including over 15 miles of beachfront, primarily on North Hutchinson Island. Data was preprocessed on site to verify data integrity and determine the density and extent of buried OE contamination. Discussion between NRL and the USAESCH-CE led to a plan to identify a set of about 100 targets, representing a range of potential ordnance items and to dig these items to create an OE database that would have predictive value relative to the types and extent of contamination present along the shoreline.

Based upon guidance provided to NRL about required exclusion zone distances to inhabited properties, a group of 100 analyzed targets ranging in size from M-4 antitank mines to objects much too large to be 1000 lb bombs were chosen along a stretch of relatively heavily contaminated beach stretching for several miles from Round Island Park to the Avalon Park entrances in St Lucie county. These are the least inhabited areas of the beach that were surveyed.

NRL returned to NABFP in March of 1998 to way point and mark these selected targets for prosecution and remediation by USAESCH UXO personnel. After arrival on site, reconsideration of the required exclusion zones and distances limited digging of potential ordnance targets to items predicted to be smaller than or equivalent to an M6 AT mine. Even prosecuting of these relatively small items required establishing extensive beach access security forces and closing of the highway during digging operations. After completion of one week of digging these small targets, no ordnance targets were found along the limited stretch of beach.

At this point, target recovery switched to prosecution of targets considered to be too large to be discrete ordnance. These items were considered as likely beach access obstacles such as the horned sculleys which have previously been recovered at this site, particularly off shore. Switching the remediation to a non-UXO beach obstacle recovery operation for the St. Lucie County allowed the USAESCH UXO team to be released. Private UXO contractors, brought on site by NRL were then tasked with completing the target prosecution as a scrap clearance operation. Navy EOD personnel were present at the site throughout the two week duration of the remediation operations, should an ordnance item have been identified.

The 100 sample digs that were completed characterized the types of buried wastes that exist along this stretch of beach. Based upon the recovered targets, it is unlikely that significant ordnance contamination exists between Round Island Park to beyond the Avalon Park entrances to P.V. Martin's restaurant. Historical documentation indicates that this stretch of beach was used as a UDT training area primarily involving beach obstacles such as horned scullys. The larger targets recovered in this area are primarily railroad rails associated with the construction of beach obstacles. Very few of these were intact, many recoveries were associated with concrete rubble presumably resulting from destruction during training. Others were railroad rails, mostly lying horizontally, presumably having been pushed over by explosives or mechanical means. Smaller targets were primarily anthropic clutter or steel spikes or short sections of concrete reinforcing rod.

Our survey displays integrated into GIS overlays with modern aerial photographs show that north of Round Island parts of the beach are eroding. It is in this area that recent ordnance discoveries have been made. The five miles of beach south of Round Island are either similar to the way they existed 50 years ago or have accreted up to 1-2 feet of sand. Further to the south, approaching the Ft. Pierce Inlet much more

sand has accreted. We analyze many targets in this area that are currently buried 3-5 meters deep that were likely near surface items when they were emplaced in the early 1940's.

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1.0 BACKGROUND

1.1 Program Description and Sponsorship

Unexploded ordnance (UXO) is arguably the most serious and prevalent environmental problem currently facing DOD facility managers. Mitigation and remediation activities are often hindered by the fact that UXO is colocated with other environmental threats including ordnance explosives wastes (OEW), chemical wastes, and other toxic and hazardous materials. Not limited to active sites and test ranges, these problems also occur at DOD sites that are currently inactive, and in areas adjacent to military ranges that belong to the civilian sector or are under control of other government agencies. UXO mitigation and remediation problems assume even more compelling proportions when DOD lands are classified as Formerly Used Defense Sites (FUDS), or Base Realignment and Closure (BRAC) sites. Land on FUDS and BRAC sites must be evaluated and remediated as appropriate, and must be certified as suitable for the planned end use depending upon the pending disposition. Oversight and evaluation of these processes involves non-DOD agencies including EPA, state, county and local governments, and the civilian community.

The former Ft. Pierce Amphibious Base, Ft. Pierce, FL (NABFP) is such a site, *i.e.* it falls under the Department of Defense (DoD) Defense Environmental Restoration Program (DERP). Established in 1942 as an amphibious training base, a wide variety of operations involving both live and inert ordnance were conducted within the boundaries of the 19,000 acre facility. UXO remediation and site characterization activities have previously been carried out on portions of the former base. Uncertainty exists as to what residual UXO contamination remains at the facility, although intermittent discovery of ordnance items on the beach (particularly during construction activities), suggests that further site characterization is appropriate. Accordingly, in a cooperative effort with the U.S. Naval Research Laboratory (NRL), the U.S. Army Corps of Engineers (USACE) Jacksonville Division, in conjunction with the USAESCH, Huntsville requested that NRL conduct a geophysical survey of selected portions of the site using the Multi-Sensor Towed Array Detection System (*MTADS*). The capabilities of the NRL towed-array system are particularly suited for surveying and site characterization on the beaches of North and South Hutchinson Islands in areas associated with the NABFP.

1.2 MTADS Technology Description

The *MTADS* consists of a low magnetic signature tow vehicle that is used to tow either a passive magnetometer sensor array, or an active pulsed-induction sensor platform. These technologies have been described in detail. For the NABFP survey, the magnetometer platform was selected as the most appropriate sensor system. The magnetometer platform has eight cesium vapor total field magnetometers deployed as a horizontal array with 0.25 m separation. The position-over-ground is plotted using state-of-the-art Real-Time Kinematic (RTK, or on-the-fly) Global Positioning System (GPS) technology that also provides vehicle guidance during the survey. A Data Analysis System (DAS), developed by NRL, is used to locate, and categorize all military ordnance at its maximum probable self-burial depths. The *MTADS* provides high density data sets (>300,000 sensor data points per acre), and the GPS system provides positional accuracies to within six inches. The DAS provides tabulated target lists (x,y positions as global coordinates (latitude/longitude) or in local or State Plane coordinates. Estimates of target size and depth are provided,

based upon an ordnance model. In addition, the system generates false color maps which indicate the location and identification of targets. These images can be overlayed with other GIS information and photos. Targets can be way pointed using GPS at any time subsequent to the survey. Dig sheets provided to remediation crews provide x,y coordinates, target sizes and depths for prosecution of selected targets.

1.3 Objectives for the NABFP Survey

This Technology Evaluation effort involved the use of the *MTADS* to conduct a survey at selected NABFP sites. The beach, from the low tide shoreline to the vegetation line, was surveyed from the South Beach Park in Vero Beach, south to the Ft. Pierce Inlet. Sections of beach were also surveyed on South Hutchinson Island south of the Ft. Piece Inlet. A complete analysis and characterization of all targets (equivalent to or larger than an 8 in diameter, M-4 antitank mine) in the surveyed area have been carried out and are reported. Information is also provided in the form of digital target image maps suitable for GIS overlay. A partial remediation was carried out to provide information as to the type and range of ordnance present at the site. Finally, target reports are provided in the form of target tables identifying and characterizing all analyzed targets with coordinates suitable to support any future remediation operations.

1.4 MTADS Geophysical Study and Remediation

The time sequence of major events associated with the survey at the NABFP are summarized in Table 1.

2.0 SURVEY WORK PLAN

2.1 Historical Information

The former Ft. Pierce was established in 1942 as an amphibious training base, consisting of approximately 19,000 acres located on North and South Hutchinson Islands. In 1943, the Joint Army/Navy Experimental and Testing Board (JANET) was established. This activity took over much of North Hutchinson Island as a research and testing facility. This resulted in moving many of the training activities to the South Hutchinson Island. The Naval Research Unit was located on North Hutchinson Island, near Round Island. As the two islands were used for a diverse number of operations, the USACE has provided area designations indicating the location, extent, uses of various areas and has documented ordnance recovered in these various areas. A Work Plan supporting these activities ("WORK PLAN FOR ENGINEERING EVALUATION/COST ANALYSIS, FORMER FT. PIERCE AMPHIBIOUS BASE, FT. PIERCE, FLORIDA," November, 1994) was developed by the USACE which contained extensive information relative to prior land use in these areas. These identified sites are defined in Table 2.

The EECA Work Plan contains maps and outlines of the areas detailing their known uses, and the Final Report contains maps indicating the locations of recovered UXO. Ordnance items recovered at NABFP are cited in Table 3. Historical records document the use of additional ordnance in training activities on the base. These are given in Table 4. Figures 1 and 2 illustrate some of the ordnance items recovered and disposed of during the last 5 years. These items were discovered in the vicinity of Angler's Cove.

2.2 Site Visit

The *MTADS* survey was requested by the CEHNC and managed by Mr. Karl Blankinship from the Huntsville Headquarters. Activities at the NABFP fall under the Jacksonville District Regional Office of the Corps of Engineers. Mr. Robert Bridgers of this office has been the responsible interface with the citizens groups and local

political jurisdictions for operations associated with the former NABFP.

On 12-13 November 1997, Dr. J.R. McDonald, Mr. Karl Blankinship and Mr. Robert Bridgers met with

Table 1. Events that were part of the NABFP Site Characterization.

ACTIVITY	PARTICIPANTS	DATES
Site Visit	NRL, CEHNC, Jacksonville Region ACE, Indian River Co. Emergency Response Office	12-13 Nov., 1997
Survey Work Plan	NRL, CEHNC, Jacksonville ACE	22 Dec., 1997
POS Testing	NRL	15-19 Dec., 1997
GPS Control	NRL, Geometrics GPS, Hughes	5-8 Jan., 1998
MTADS Survey	NRL, CEHNC, Jacksonville ACE, Mayport EOD, Indian River & St. Lucie Co.	20-29 Jan., 1998
Remediation Work Plan	NRL, CEHNC, Jacksonville ACE	6 March 1998
UXO Operation	NRL, CEHNC, Jacksonville ACE	16-27 Mar., 1998
Scrap Recovery	NRL, CEHNC, Jacksonville ACE, Ordrem	

Table 2. Identified Operation Areas at the NABFP.

North Island:

Area	Identification	Extent
No. 1	The Engineering Board Area	4.4 miles (shoreline)
No. 2	The Naval Demolition Research Unit	1.1 miles (shoreline)
No. 3	Swamp Area Near Demolition Research Unit	0.0 miles (shoreline)
No. 4	Suspected Burial Site, New Sands Condominiums	1.1 miles (shoreline)
No. 5	Beach Obstacles, North Hutchinson Island	10.4 miles (shoreline)

South Island:

Area	Identification	Extent
No. 6	Artillery Range Bunkers	1.2 miles (shoreline)
No. 7	South Island Bombing Range	0.8 miles (shoreline)

Ft. Pierce Inlet:

Area	Identification	Extent
No. 8	Ocean Areas	Off shore

Table 3. Ordnance Items Recovered at Fort Pierce Amphibious Base.

Ordnance Item	Type	Status
Mine	M4, AT	Inert
Mine	M6, AT	Inert
Rocket, Demolition	7.2", MK5 Warhead w/MK3 Rocket Motor	Live
Mine	Japanese Type J1, contact fused	Inert
Bomb	GP, AN-M65A1, 1000 lb	Inert
Explosives	C-2, 1 ½ Blocks	Live
Bomb	Depth Charge, AN MK 17-M-1, 325 lbs (Torpex filled?)	Live
Rocket	Surface-to-Surface, 11.75" D, 120" L, 160 lb, (“Tiny Tim”)	Live

Table 4. Other Ordnance Items Tested at the NABFP

Ordnance Item	Type
Rocket	M8, 4.5"
Bomb	M30, 100 lbs
Reddy Fox	Metal tube, 10" D, up to 100' in length, filled with explosives
Bulk Explosives	20 lb Packs of Tetrytol

Figure 1. M6 Anti-tank mines recovered by Mayport EOD technicians in 1993 near Angler's Cove.

Mr. Doug Wright, Director, and Mr. John King, Emergency Management Coordinator of the Department of Emergency Services for Indian River County, Florida. Vero Beach and the northern portions of the former NABFP lie within Indian River County. The purpose of this meeting was to explore coordination of possible *MTADS* activities with the county officials, determine the need for permits and clearances and to explore the possibilities for logistics support which might be provided by the county.

Several County fire stations and Round Island Park were suggested as possible locations for headquarters support for *MTADS* survey operations. Fire Station #6 in South Vero Beach subsequently was chosen as a site for the *MTADS* survey support trailer and the remediation activities were supported by a headquarter's trailer that was set up behind the Fire House.

Figure 2. A live "Tiny Tim" Demolition Rocket recovered at Vero Beach in 1993.

Sites for vehicular access to the beach were also discussed. Access is very limited as most beach front is privately owned and in many places long stretches of beach lie within gated communities. We were shown areas where the county controlled access and places where this office could obtain permission for us to gain access over private property. We also discussed possibilities and restrictions on places where we could have first-order survey control established to support the *MTADS* navigation requirements.

A driving inspection was conducted of potential beach access points in Indian River and St. Lucie Counties. Several of these were through public parks controlled by the state. Some had clear access to the beach, many were set up only to accommodate foot traffic. A driving inspection of areas of the town of Ft. Pierce were also conducted south of the inlet. These areas are also of potential interest but appeared to be lower priority for immediate survey.

2.3 First-Order Control Points

As approximately 15 miles of shoreline were to be surveyed, it was necessary to establish several first-order navigational control points. NRL contracted with Mr. Doug

Richmond of GPS Geometrics to survey the required first order stations. Control Points FP1 through FP6 were established. The positions and identities are given in Table 4 and a full report of this operation is provided in the Survey Report.

Table 5. Locations of First-Order Navigational Control Points. Adjusted Coordinates NAD 83/90, NAVD88.

Station	Location/Identity	Latitude	Longitude	Ortho Height (m)	Height Above Ellipsoid (m)
FP 1	Turtle Cove	27°37'39.98613" N	080°21'00.88637" W	3.401	-24.314
FP 2	Angler's Cove	27°35'52.90561" N	080°19'55.61365" W	3.248	-24.447
FP 3	Round Island Park	27°33'42.52499" N	080°19'22.79461" W	3.041	-24.608
FP 4	Pepper Beach	27°29'45.99625" N	080°18'00.39964" W	2.440	-25.155
FP 5	Sea Turtle Beach/ Blind River	27°21'22.87897" N	080°14'29.92314" W	2.155	-25.422
FP 6	Normandy Beach	27°18'26.75488" N	080°13'13.13610" W	2.774	-24.827

order stations. Control Points FP1 through FP6 were established on 5-8 January 1997. The positions and identities are given in Table 5 and a report of this operation is provided in the Survey Report.

2.4 Historical Documents, Maps, and Photographs

NRL obtained 7.5 minute maps of the Ft. Pierce and Indrio quads from the U.S. Geological Survey. In addition to the U.S.G.S. maps, geo-referenced aerial photographs (NAD 83, 1 meter resolution, 1995) of the entire shoreline for the Ft. Pierce, Indrio, Eden and Riomar quads were obtained from the Florida Research and Environmental Analysis Center. These maps were used as the basis for the GIS overlays of *MTADS* survey data included in this document. These GIS overlays clearly show the location of detected targets with respect to the roads, buildings and structures in close proximity to the beach.

The 1994 USACE EECA Work Plan For the Ft. Pierce study provided historical information in support of this *MTADS* operation. It served as the master document to support our Demonstration Work Plan and SHERP. NRL drafted the *MTADS* Technology Demonstration Plan, Site Specific Work Plan and the Safety, Health, and Emergency Response Plan (SHERP) to support our survey demonstration and remediation operations. These documents were prepared in draft form in January 1998 for comment and approval and final versions were issued in March 1998.

2.5 Logistics Support Requirements

MTADS Survey

The base of operations for the survey portion of this effort was selected on the basis of ease of access to the beach, overnight security for the *MTADS* and support equipment, and access to power for the operation of the *MTADS* DAS and overnight battery charging. In addition, an office trailer was placed on site which required sufficient room to install. Fire Station #6 in Vero Beach was identified as the most appropriate location. Fire Captain Prime and Station Chief Charles Corbin, provided support for our operations during the survey. Figure 3 shows the office trailer located immediately behind the Fire Station. As with prior Technology Demonstrations, the *MTADS* equipment was trucked to the site. The truck served for local storage of support equipment and as a secure lockup at night. Power for the headquarters office trailer was brought by electrical cable from the Fire Station, eliminating the need for portable power generation. Figure 4 shows the layout for the *MTADS* data analysis workstations and support electronics. Radio

Figure 3. *MTADS* office trailer set up behind Fire Station No. 6 south of Vero Beach.

Figure 4. *MTADS* data analysis setup in the field office trailer.

communications systems were transported to the site by NRL in sufficient numbers to provide each individual involved in surveying continual voice communications. Because the long distances involved in the surveying operation, the radio's ranges were not sufficient to reach all personnel. Cellular telephones were maintained at the office trailer and either in the survey vehicle or with one of the personnel supporting the field survey.

Survey operations conducted on South Hutchinson Island were up to 15 miles away from the Fire Station #6 headquarters. Rather than relocating to the south island for a few day's work, arrangements were made to transport the *MTADS* field equipment by roll on/roll off trucks from Fire Station # 6 in the morning and return the equipment in the afternoon.

Target Remediation

The logistics support base for the target remediation operation was located on the ocean side of Round Island Park. This area was chosen because we had to have an explosives truck and magazine on site to support the operation. This part of the park is inside a fenced area with a locked gate. An office trailer and portable toilets were set up on the site, which served as the staging area for daily operations and safety briefings.

The prosecution of selected targets in close proximity to populated areas involved unique logistical requirements. Of particular concern was the high probability of civilian traffic along the beach during excavation of targets, and the need to establish and maintain exclusion zones in accordance with the guidelines defined by the Remediation Work Plan. Accordingly, NRL secured the services of a private security firm to provide uniformed personnel to establish and maintain the exclusion zone in accordance with these requirements. Security personnel were placed at strategic locations to prevent access to the site by pedestrians from either end of the secured beach area as well as access from residential areas and footpaths leading to the beach from parking areas.

Other logistical support requirements included the following:

- Trailer facilities for daily operational and safety briefings, and the storage of GPS equipment used for target way pointing;
- Provision of a backhoe and operator;
- Provision of explosives for use by CEHNC UXO

personnel;

- ❑ Construction of ordnance mock-ups for installation at the Blossom Point prove-out site;
- ❑ Radio communications for ten on-site personnel (including security); and
- ❑ Portable toilets at the office trailer.

the Blossom Point Prove-out site;

- Radio communications for ten on-site personnel (including security); and
- Portable toilets at the office trailer.

Figure 5 is a photograph of the office support trailer established in Round Island Park for the remediation operations. During the first week of target remediation a UXO dig team from CEHNC was in charge of prosecuting targets. During the second week of remediation the digging was declared to be a scrap recovery operation. The CEHNC UXO team returned to Huntsville and the Target prosecution was managed by a private UXO remediation firm, Ordrem, International.

Before beginning remediation operations on the NABFP our activities were coordinated with the EOD team, Mobile Unit #6, Naval Station Mayport, Mayport, FL. This is the military activity responsible for responding to ordnance discoveries at this site. This group has responded on numerous occasions to ordnance discoveries on this site and supported the ECCA activities on this site conducted by USACE in 1994. The EOD Mayport provided two support personnel on a standby basis to support the entire remediation operation.

3.0 ORDNANCE MODELS AND PROVE-OUT SITE

3.1 Ordnance Model Construction

Based on archival records that describe some of the ordnance items deployed at NABFP, NRL constructed several ordnance mock-ups for evaluation at the prove-out site located at NRL's Blossom Point facility. We fabricated ordnance models to simulate specific ordnance items that we had not previously encountered. Figure 6 is a photograph of these ordnance models. Simulant models include the M-4 and M-6 antitank mines, the Mk5, 7.2-inch rocket, the AN-M30A1, 100-lb. General Purpose (GP) bomb, and the AN-Mk17, 325-lb. depth bomb. The M8, 4.5-inch rockets are from NRL's inert ordnance inventory.

Figure 5. Office trailer set up near the ocean at Round Island Park.

Figure 6. Ordnance simulants prepared for evaluation prior to surveys at the NABFP.

3.2 Prove-out Site

The Naval Research Laboratory has assembled a comprehensive database of magnetic and electromagnetic ordnance signatures. Inert ordnance items include a wide range of munitions including 20 and 30 mm rounds, Mk 42 submunitions, antipersonnel ordnance, and a wide range of mortars, projectiles, rockets and bombs. Signatures have been collected at many depths orientations and inclinations.

Using this signature information, NRL has refined the Data Analysis System algorithms and our target analysistechniques to improve our ability to discriminate ordnance from scrap. Moreover, as research in the development of data fusion methods continues, additional ordnance items are evaluated to establish signature characteristics. Data sets collected at the prove-out sites at NRL's Chesapeake Bay Detachment and the Blossom Point facility are further augmented by the collection of ordnance and clutter signatures on demonstration sites where we have conducted simultaneous remediation operations. The ordnance signatures from the items described in Section 3.1 are added to this data base.

Figures 7 show a magnetic anomaly image created from the magnetometry survey of these ordnance simulants buried at the Blossom Point test site. The individual ordnance items, their depths (in inches), and their orientations are labeled beside each item in the figure. A small X denotes the geographical position of each item as it was surveyed when it was buried. Table 6 provides the printout of the *MTADS*

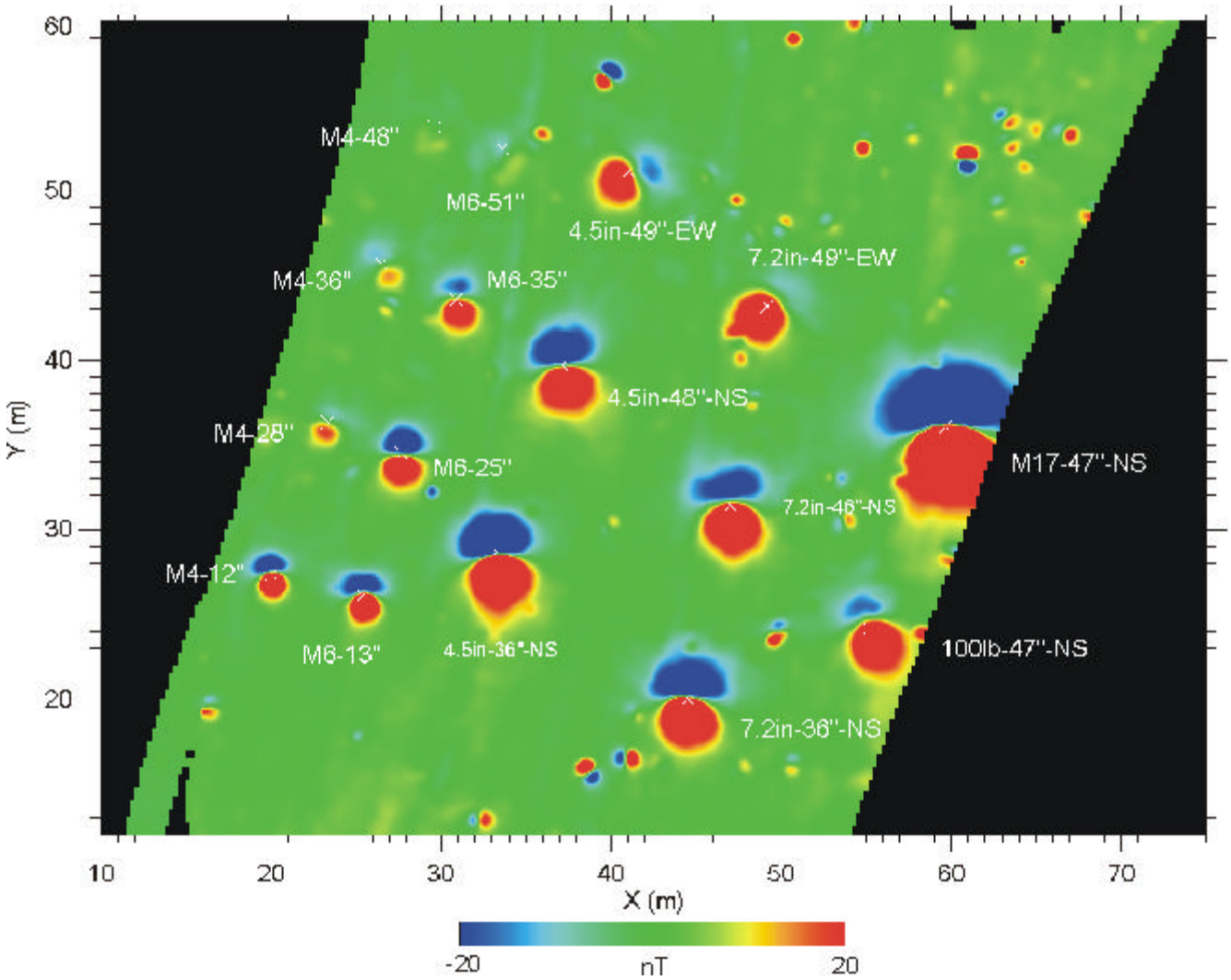

Figure 7. Magnetic anomaly image survey of the ordnance simulants at the Blossom Point Prove-out Site.

analysis of these ordnance items along with the ground truth information. Depending upon the depth and orientation of a given item the MTADS DAS converges to a range of fitted ordnance size estimations. The fitting algorithm reports the diameter of the target assuming an ordnance item with a length to diameter aspect ratio of 5. Because the mines are shaped like disks, the fit value does not relate well to the real dimensions of the target. Thus an M-4 AT mine is a predicted diameter of 8 or 9 cm and an M-6 mine has a predicted size of 9-12 cm. The predicted sizes of the 4.5 and 7.2 in rockets are similar to each other because their lengths are nearly the same and the shape of the 7.2 in rocket is very irregular.

Table 6. Target analysis of ordnance simulants buried at the Blossom Point Prove-out Site.

Ordnance	Depth (m)		Diameter (m)		Moment	Inclin.	Azim.	Fit	Local X	Local Y
	True	Fit	True	Fit	Fit	(Deg)	(Deg)	Quality	(m)	(m)
M4 AT Mine	0.43	0.31	0.20	0.08	0.3260	23	349	0.99	19.96	27.37
M4 AT Mine	0.81	0.64	0.20	0.08	0.2310	31	29	0.96	23.33	36.16
M4 AT Mine	1.02	0.64	0.20	0.09	0.3420	21	332	0.94	26.59	45.51
M4 AT Mine	1.55	0.64	0.20	0.08	0.2980	30	26	0.68	29.65	53.46
M6 AT Mine	0.42	0.32	0.32	0.10	0.4980	43	0	0.99	25.44	26.01
M6 AT Mine	0.73	0.63	0.32	0.12	0.8780	8	2	0.99	27.65	34.47
M6 AT Mine	1.02	0.9	0.32	0.11	0.7620	29	358	0.98	30.92	43.47
M6 AT Mine	1.33	1.3	0.32	0.09	0.4360	0	314	0.85	33.87	52.25
4.5 in. Rocket	1.05	0.92	0.11	0.20	4.2170	11	354	0.99	33.18	28.54
4.5 in. Rocket	1.34	1.22	0.11	0.18	2.9940	11	352	0.99	37.14	39.70
7.2 in. Rocket	1.38	1.24	0.18	0.16	1.5610	24	70	0.98	41.02	51.02
7.2 in. Rocket	1.14	0.92	0.18	0.18	3.4090	22	4	0.99	44.35	19.94
7.2 in. Rocket	1.42	1.18	0.18	0.18	3.3370	35	357	0.98	46.92	31.26
7.2 in. Rocket	1.51	1.26	0.18	0.16	2.0980	48	52	0.98	49.06	43.18
100 lb. Bomb	1.42	1.19	0.21	0.17	2.5510	47	337	0.99	55.12	24.03
M17 Depth Charge	1.55	1.21	0.38	0.32	17.3820	22	1	0.99	59.70	35.95

4.0 SURVEY OF NORTH HUTCHINSON ISLAND

4.1 Tide Charts and Satellite Availability

The 18 inch tides typical of this area at this time of the year have a significant affect on beach access. Particularly north of Round Island, the width of the beach at high tide is less than half that at low tide. There are areas near Angler's Cove where a vehicle cannot drive up the beach at high tide as the waves break onto private bulkheads. Our survey planning schedules were set up to allow surveying at the ocean's edge during low tide, thus providing the maximum survey coverage. Survey planning also took into account satellite availability. During this survey there were short periods each afternoon when navigation quality was not

sufficient to support operations. During these periods operations were suspended to allow downloading of data, changing of drivers, relocation of radio repeaters, etc. The starting times in the morning were adjusted to take advantage of the tide cycle when advantage could be gained.

4.2 Survey Layout

Surveying began at the Round Island Park, Figure 8, and proceeded to the south through Pepper Beach to the southern limit of the Island. The first order control point at Round Island Park was used to support operations until well south of the southern Avalon Park entrance. Up to 3 radio repeaters were used to relay position corrections to the survey vehicle. South of P.V. Martin's Restaurant the first order point was switched to the Pepper Beach control point. After completing surveying to the southern limit of the island at the Ft. Pierce Inlet operations were moved back to Round Island Park and surveying proceeded to the north. When repeater radio contact became weak, the base station was moved to Angler's Cove and subsequently to the Turtle Cove control point. Using this setup we surveyed to the northern limit of operations ending with the survey of South Beach Park adjacent to the 17th St. Causeway.

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4.3 *Survey Logs and Production Rates*

We found that surveying stretches of about 1km was most convenient and productive. To conduct data analysis and to create images for display and GIS overlays the individual survey files were broken up into 0.5 km segments with a 5 meter overlap at the north and south ends of each survey. Figure 9 shows a plot of the navigation tracks from an individual survey file taken on 21 January. The area is immediately north of the Round Island control point and covers two 0.5-kilometer survey areas (N1 and N2). This survey of 5 round trips took one hour and covered the beach from the vegetation line to the shore. On the following day, at dead low tide, two more round trips were surveyed along several kilometers of beach. These data were broken up and added to the individual 0.5 km files to create maximum survey

Figure 8. The *MTADS* vehicle is shown conducting a magnetometry survey south of Round Island Park.

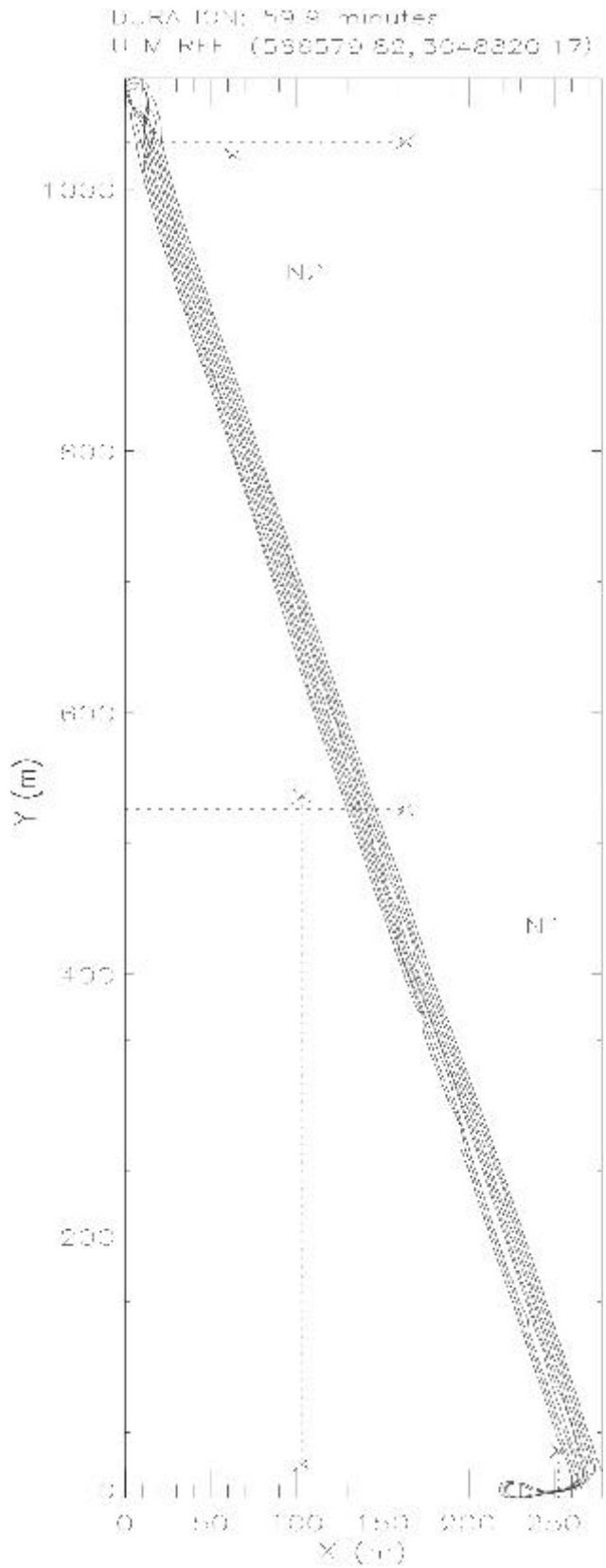

Figure 9. Plot of the survey tracks (course over ground) for a typical 1km survey setup.

coverage to the low tide shoreline.

Proceeding north from Round Island Park the survey files are numbered RIP-N1 through RIP-N17. Proceeding south from Round Island Park the survey files are numbered RIP-S1 through RIP-S20. Therefore, approximately 18.5 km of beach were surveyed between South Beach and the southern tip of the Island. The work was completed in 6 days of surveying between 21 and 27 January. The actual survey time was just under 25 hours. Assuming the average width of the survey is 30 meters, approximately 137 acres of beach was surveyed. This correlates with a survey rate of 5.5 acres/survey hour or about acres per day during the survey on North Hutchinson Island.

5.0 SURVEY ON SOUTH HUTCHINSON ISLAND

On 28 and 29 January the *MTADS* field survey equipment was transported using 2 roll-on roll-off trucks to South Hutchinson Island. On 28 January surveying began south of the Normandy Beach control point. Surveys were conducted in sectors S2 and S3 (beginning 0.5 km south of the control point and in sector N1 extending north from the Normandy Beach control point. On 29 January surveying began at the Turtle Beach control point and extended north for 1 km. Because equipment also had to be returned home using wreckers each day, the time available for surveying was limited. A total of 3.7 km of beach was surveyed on South Hutchinson Island during an actual 4.2 hours of data collection. The quality of data is not as high as that taken on North Hutchinson Island. Reasons contributing to this include: navigation data quality was limited by satellite access because of the closely-spaced high-rise buildings, obstacles on the beach (tree stumps and other objects which could not be traversed), uncooperative crowds on the beach, and difficulty coordinating survey times with the tides. In spite of these limitations, 3.7 km of beach was evaluated for buried objects and the data is of a quality to allow all buried objects to be reacquired and dug.

6.0 DATA REDUCTION AND TARGET ANALYSIS

6.1 Data Processing and Imaging

Survey data were returned to the headquarters trailer several times each day. If operations were suspended for an extended period, the reference data were also down loaded. The data were preprocessed on a continuing basis to allow verification of data fidelity, assembly of data into contiguous site files, and editing and correction of navigation and sensor reading errors. Because of the long narrow nature of the survey, it was immediately apparent that the data would have to be edited into site files that would allow visualization of the target information. As described before, survey data was edited to create 0.5 km long site maps. Individual survey plots of 0.5 km sections clearly display features and target information sufficient for planning remediation operations. These 0.5 km survey sections were also chosen for GIS overlay with aerial photography. These presentations are included as Appendix B. to this document. The 0.5 km images do not contain detailed information sufficient to support remediation operations. Therefore each 0.5 km site image was broken up into four 125-m long images. On these images unique target numbers are readable and target clusters are visually apparent to aid the dig teams. These images served as the dig images for each of the remediation teams.

6.2 Target Analysis

Sample target analyses were carried out while on site to verify the information seen in the images and to provide a general feeling for the sizes of the targets that appeared in

each of the high saturation target areas.

All detailed target analyses were conducted at NRL after the survey. Initial focus was on areas south of Round Island Park since it was presumed that remediation activities would initially focus on this sparsely populated stretch of beach. Target fits were continuously compared with the individual ordnance signatures taken at the NRL Prove-out site. Particular attention was given to locating small targets that might be M-4 AT mines. Targets clearly smaller than this limit were noted or disregarded. Many extremely large targets were analyzed and logged. Many of these with predicted diameters of >0.75 m clearly could not be individual ordnance items. As many of these gigantic targets were arranged in precise rows at very constant distances apart and at very similar depths there was considerable conjecture as to whether they were organized burials (perhaps many items on pallets) or whether they were precisely installed beach obstacles. This mystery remained until remediation began.

The complete analyzed target lists are presented in Appendix A. These are organized geographically from north to south and the targets analyzed on South Hutchinson Island are presented separately. The target tables exist as Microsoft Excel spread sheets that can be edited and re-sorted to support any planned operation in the future.

6.3 *GIS Overlays*

GIS overlays were prepared using Arc View software and the digitized aerial photographs described earlier. They are presented as 0.5 km *MTADS* survey images superimposed on the 1 meter resolution photographs. An example is shown in **Figure 10**. We have added some street names, some of the beach access points used and some of the landmark positions that we used to support and coordinate the survey. Individual houses, streets and other structures are clearly visible. Since these photographs were taken in 1995 some houses and condominiums have been built that are not shown on the GIS presentations. The metal and reinforced concrete bulkheads clearly appear on the *MTADS* magnetometry images, obscuring targets in the negative shadow. For analysis these images can be offset to allow analysis of individual targets not visible on these presentations.

The multistory condominiums and structures in St. Lucie County cast very dense negative magnetic anomalies across the beach. The larger structures, even on the west side of the highway are clearly magnetically visible. Targets can also be analyzed in these areas by off-setting the scale of the presentations.

7.0 PREPARATION FOR SAMPLE TARGET REMEDIATION

7.1 Remediation Work Plan

The survey plan called for the prosecution of small targets from the dig list before excavation of the larger and deeper targets. The initial dig lists were prepared beginning at Round Island Park and proceeding to the south. Extensive discussions with the structural and ordnance engineers at CEHNC established a 150 foot exclusion zone for digging ordnance items equivalent to or smaller than a 155 mm projectile. Larger exclusion zones were to apply to the larger items and there was discussion of bringing in protective works, such as the “Bud lites” which had recently been tested by the Corps and approved for use under certain circumstances.

We also brought 1000 sand bags to the site which could be filled and used as tamping if it was deemed prudent during an excavation or if an item had to be blown in place. There were designs and plans available for constructing a variety

of protective works to support the remediation operations. A backhoe was rented and an operator employed to support the remediation activities. Explosives, specified by CEHNC, were purchased from the Austin Powder Company. The explosives were delivered and stored in a portable magazine. The Austin Powder Company representative remained on site with the explosives during the remediation operation.

File Contains Data for PostScript Printers Only

Figure 10. GIS composite overlay of a 1-meter resolution false color IR photograph with an *MTADS* magnetic anomaly image map of the 0.5 km section RIP-N6.

portable magazine. The Austin Powder Company representative remained on site with the explosives during the remediation operation.

7.2 Site Selection and Target Selection

The survey sections RIP-N2, RIP-N1 and RIP-S1 through RIP-S6 span the border between Indian River and St. Lucie counties and are the least developed of the areas that we surveyed. Because of the exclusion zones required around targets to be dug, we chose these more remote areas for the sample remediations. Previous discoveries of UXO in recent years were made to the North of these sections in more populated areas. The EECA report infers that the RIP-N2 through RIP-S6 stretch of beach was used primarily as a UDT training area. Prior remediations in this area (both onshore and offshore) have included artifacts associated with beach obstacles. These eight, 0.5 km sections include both areas with very sparsely distributed buried targets and areas nearly saturated with large and deeply-buried targets. All targets in these sections were analyzed and the complete target tables are included in the Appendix A.

7.3 Dig Images and Dig Sheets

The scale on the 0.5 km GIS overlay maps (Figure 10) is too course to allow visualization and identification of individual targets. To aid the way pointing and remediation teams, each 0.5 km survey was broken up into four images. From these images individual targets can be visualized and target numbers can be read. These 125-meter long images are referred to as Dig Images. **Figure 11** is the magnetic anomaly image map of section RIP-S2 and **Figure 12** is the Dig Image RIP-S2a the north 125 meters of the section showing the individual targets labeled with their unique target numbers. The dig maps are identified by the Section designation (i.e. RIP-S2) and the image designation of a, b, c, or d (proceeding from North to South, in all cases).

These images are used by the way pointing and digging teams. They minimize the time spent walking between targets by allowing the way pointing team to start at one end of the image, and generally proceed through the area. In addition, the images allow the team to quickly identify the nearest target by number, and located it in the Trimble Data Collector (TDC) computer. The dig images allow the dig team to visually inspect the target signature, visualize nearby clutter that must be accounted for, and additionally they provide an awareness of other nearby targets so that care can be taken to leave them undisturbed.

The dig sheet for *MTADS* operations has been designed to assist the dig teams by providing target identification, location, depth and orientation information. The sheet contains a comment line with information from the target analyst which alerts the dig team to some unique feature of the target, or the presence of nearby clutter or other targets. The dig sheet also contains spaces to be filled out by the dig team, based on their observations, as well as a box to insert a sketch of the target.

8.0 REMEDIATION

8.1 UXO Recovery Operation

UXO remediation crews from CEHNC prepared to begin remediating targets on 17 March based upon target selections and dig lists prepared from analysis in Sections RIP-S3 and RIP-S4. The previously agreed upon exclusion zones of 150 ft (for ordnance up to and including 155mm) were declared invalid. An exclusion zone of 300 ft was declared on site for potential ordnance targets no larger than M6 AT mines. Except for targets 1 and 2 in RIP-S3 there are no homes within 300 ft. of any targets in these two sections. The dig lists were re-sorted for targets with predicted sizes

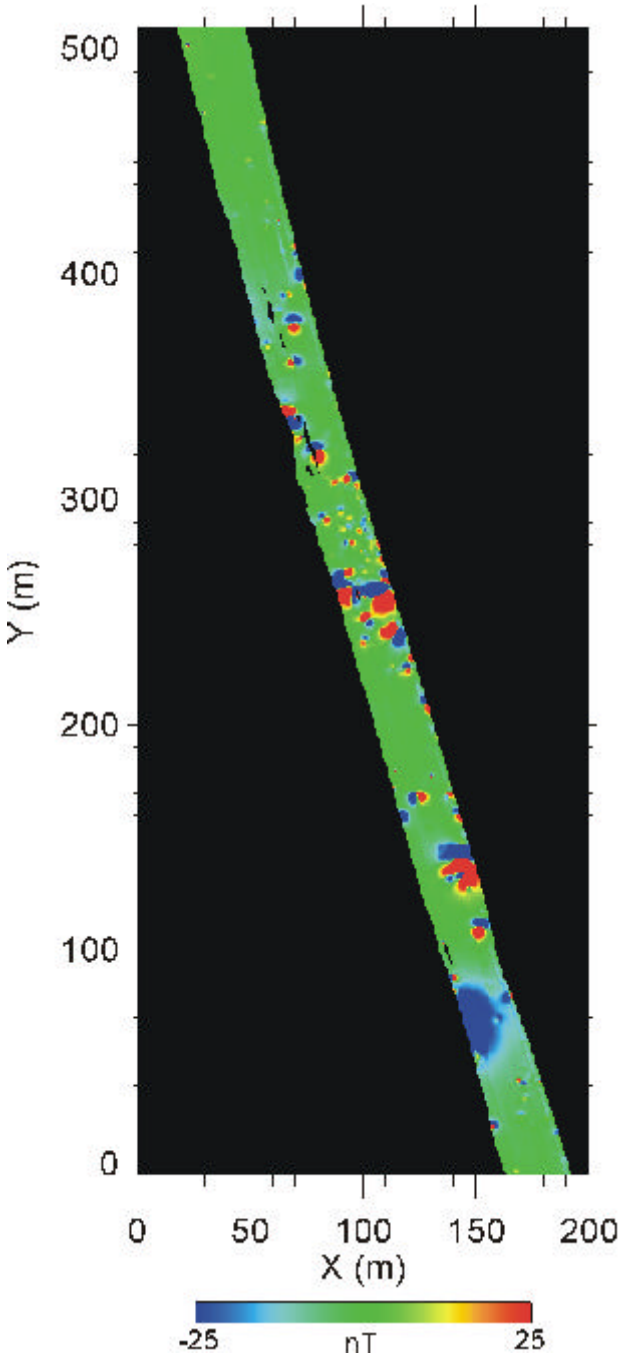

Figure 11. Magnetic anomaly image map of section RIP-S2.

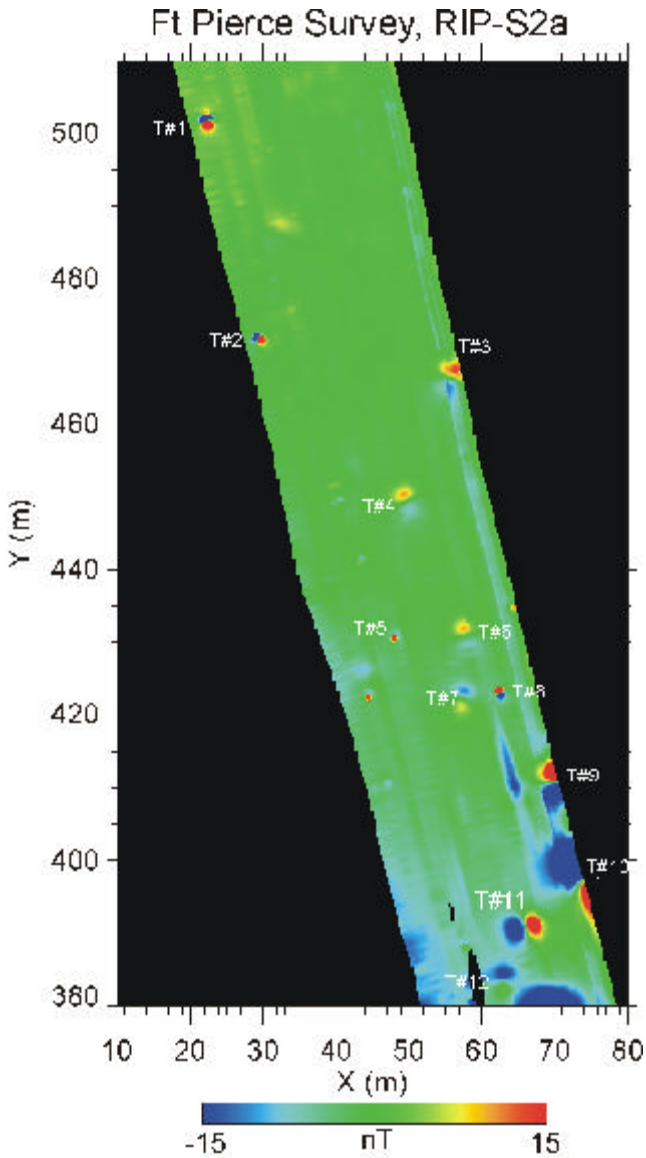

Figure 12. Dig Image showing targets selected from the north 125-meters of survey RIP-S2.

that include only M4 and M6 AT mines. About 20 targets were dug. No ordnance, or ordnance related items were discovered. This exhausted potential targets in this size range on these two sections.

On 18 March the target dig lists were again sorted for Section RIP-S4 to select larger targets for digging. An exclusion zone of 650 ft was declared. No homes fall within this zone for any targets in RIP-S4, however, digging targets required closing the highway. The St. Lucie Co. sheriff's department, working in conjunction with the private security

force hired as a support contractor, maintained the exclusion zone by blocking off the beach and closing the highway at the beginning of each digging operation. Using radios, the highway was re-opened immediately after the UXO crew exposed an individual target and declared it as not hazardous. The highway remained closed for periods of less than 5 minutes for each target prosecution. Approximately 15 of these larger targets were dug. No ordnance, or ordnance-related objects were discovered. The majority of the recovered targets were associated with World War II beach obstacles. This included scullys, reinforced concrete blocks and sections of rebar and railroad rail. At the end of the day on 18 March the UXO recovery operation was declared over and the UXO recovery crew from CEHNC returned home. Table 7 includes the target tables for these two sections sorted to display the targets remediated by CEHNC. Annotations have been added in the column labeled "CEHNC Comment" with information from the dig sheets to describe the targets recovered.

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8.2 Obstacle Removal Operation

On 20 March Ordrem, International., a private UXO service firm was brought on site to supervise digging operations. Ordrem, working in conjunction with support from the certified back hoe operator, the EOD team (on standby) from Naval Station Mayport, the Austin Powder Co. representative, and the project managers from CEHNC and NRL, began the obstacle recovery phase of the test remediation. During this operation, targets were dug from 19-27 March in sections RIP-S1 - RIP-S6. Digging began in sections S5 and S6 on targets sorted by size to select targets with predicted sizes too large to be single ordnance items. Many of these targets are at depths below sea level. Figure 13 is a photograph of the digging operation for one such target. Seawater, upwelling from below makes visualizing the target difficult and tends to make the walls of the hole unstable and subject to caving in. Some targets had to be abandoned for this reason. Figure 14 shows a 4-foot piece of rail being recovered and Figure 15 shows the likely origin of this type of target. The photograph is of a beach obstacle

Figure 13. Target recovery for an object below sea level in Section RIP-S3.

Figure 14. Recovery of a piece of railroad rail from a target in Section RIP-S3.

Figure 15. Picture (on the right) of a pyramid-shaped horned scully recovered at sea during a prior remediation.

Table 7. Targets dug in Sections RIP-S3 and RIP-S4 by the CEHNC UXO team.

Target ID	Local X (m)	Local Y (m)	Depth (m)	Size (m)	Inclin. (deg)	Azim. (deg)	Fit Quality	Analyst Comments	CEHNC Comment
S3-11	54.35	366.10	0.73	0.08	1	326	0.968	Size=M4, near veg line	18" Piece of Wire at 2.5'
S3-12	58.14	368.76	0.64	0.06	68	222	0.865	small for M4, weak fit	4'X4' Pallet, Near Surface
S3-13	72.34	367.71	1.13	0.07	1	101	0.849	Size= M4, deep, near surfline	Dug to 5', maybe target deeper
S3-15	68.97	354.26	1.80	0.14	8	174	0.899	Size= 4.5" Rocket, inverted,	Dug to 5', Nothing found
S3-34	132.90	163.54	0.80	0.13	0	293	0.985	large for M6, Dig?	Nothing Found
S3-35	120.52	160.89	0.32	0.06	19	338	0.983	Small for M4	2" diam pipe, length=?
S3-38	150.20	110.71	0.86	0.07	-11	316	0.884	Size=M4, poor fit	3"X4" piece of iron
S3-40	162.28	63.43	0.34	0.08	-2	41	0.980	small for M4	Nothing Found
S3-46	170.46	15.67	1.36	0.11	10	351	0.941	ize=M6, see T45 to the north	10' of Railroad Rail
S4-5	39.89	461.02	1.73	0.22	6	333	0.958	Size=M30, target at midbeach	Not Completed, Water
S4-6	46.97	458.03	0.24	0.12	18	360	0.970	Size=M6, target at 1 ft., Dig	Also Flg 4-97, 15.5' Railroad
S4-12	48.59	447.54	0.82	0.11	12	228	0.923	Size=M4-M6, in cluttered area	Nothing Found
S4-13	41.86	440.10	0.28	0.15	12	25	0.961	Size=4.5" Rocket, complex signal	Nothing Found
S4-14	35.77	439.02	0.20	0.10	-4	36	0.951	size=M6, at veg line	21"Steel Bar
S4-18	51.01	428.50	1.17	0.21	2	350	0.990	size=M30, near surf, in cluster	Not Completed, Water
S4-23	56.27	401.66	1.42	0.21	-2	1	0.970	Size=7.2" rocket, dig?	3/8" Rebar, 48" long
S4-24	60.31	397.09	1.10	0.28	0	140	0.967	inverted, very big, too near surf	Not Completed, Water
S4-28	64.50	384.58	0.84	0.21	-6	154	0.917	Size=7.2" rocket, inverted signal	No Comment Entered
S4-50	70.86	299.73	1.08	0.15	41	225	0.997	size=M30 in the veg line. Dig!	12" of Railroad Rail
S4-52	79.43	283.56	1.48	0.23	11	350	0.992	size=M30, DIG, see targ 53, 54	3/8" Rebar 3' long, 2 pieces
S4-53	77.67	278.15	0.92	0.22	-16	255	0.938	Size=M30, Dig, see targ 52, 54	15" Railroad Rail
S4-54	84.81	280.84	1.61	0.29	21	58	0.994	size=M17, DIG, see targ 52, 53	Scully, 3' X 4'
S4-57	99.46	258.15	1.00	0.12	6	51	0.970	size=M6, near the surf line	2' Railroad Rail
S4-59	90.53	249.08	1.91	0.13	-4	154	0.813	siae=M6, to deep to dig?	Concrete Block & Rail
S4-60	100.97	232.91	0.91	0.10	-17	157	0.869	size=M6, inverted signal, Dig?	3' of Cable
S4-64	98.78	227.50	0.72	0.30	-7	254	0.996	size=M6, inverted signal, Dig?	2.5' of cable
S4-68	93.24	223.98	0.98	0.25	11	310	0.990	size=M30, dig this	Scully, 2'X2', with rebar
S4-71	112.90	182.30	0.70	0.22	9	237	0.985	size=M30, inverted signal, mid beach	5' of Rebar
S4-72	106.88	174.48	1.12	0.27	-7	341	0.987	Size=M17, DIG?	2.5' Railroad Rail
S4-75	120.49	168.69	0.68	0.25	71	96	0.990	Size=M17 near shore, but shallow	Speaker Magnet (?)

called a horned scully; this target was recovered at sea in an earlier remediation operation. The railroad rail sections recovered during this operation likely originated from this and other types of beach obstacles. The fact that many of these targets are below sea level, and that they are often recovered with sections of rebar and concrete rubble, indicate that these targets were likely blown up by UDT teams during training operations. Blowing the obstacles likely left the rubble and rail sections at the bottom of craters below sea level. In fact, almost all rail sections were found lying nearly horizontal. **Table 8** presents the target tables for the five sections sorted to show the targets remediated during the obstacle removal operation.

9.0 SUMMARY

9.1 Remediation Results

The CEHNC and Ordrem UXO teams prosecuted 85 targets on a 3.5 km section of beach including Sections RIP-N1 to RIP-S6. The CEHNC recovery team concentrated on small, fairly shallow targets while the obstacle removal operation concentrated on large and intermediate sized targets. The *MTADS* analyst fit 464 targets in these seven sections that were as large or larger than M4 AT mines. Many of the analyzed targets were extremely large with predicted sizes much larger than 2000 lb GP bombs.

The 85 remediated targets represent >18% of the total targets identified. Nineteen of the digging operations failed to locate the specified target or were abandoned because water upwelling into the holes made their completion impossible. None of the recovered items were ordnance or ordnance-related materials. The vast majority of all recovered items are materials associated with beach obstacles, primarily the horned scullys. The most massive targets were arranged in precise lines at fixed distances apart as shown in Fig. 16. All dug targets recovered fragments of

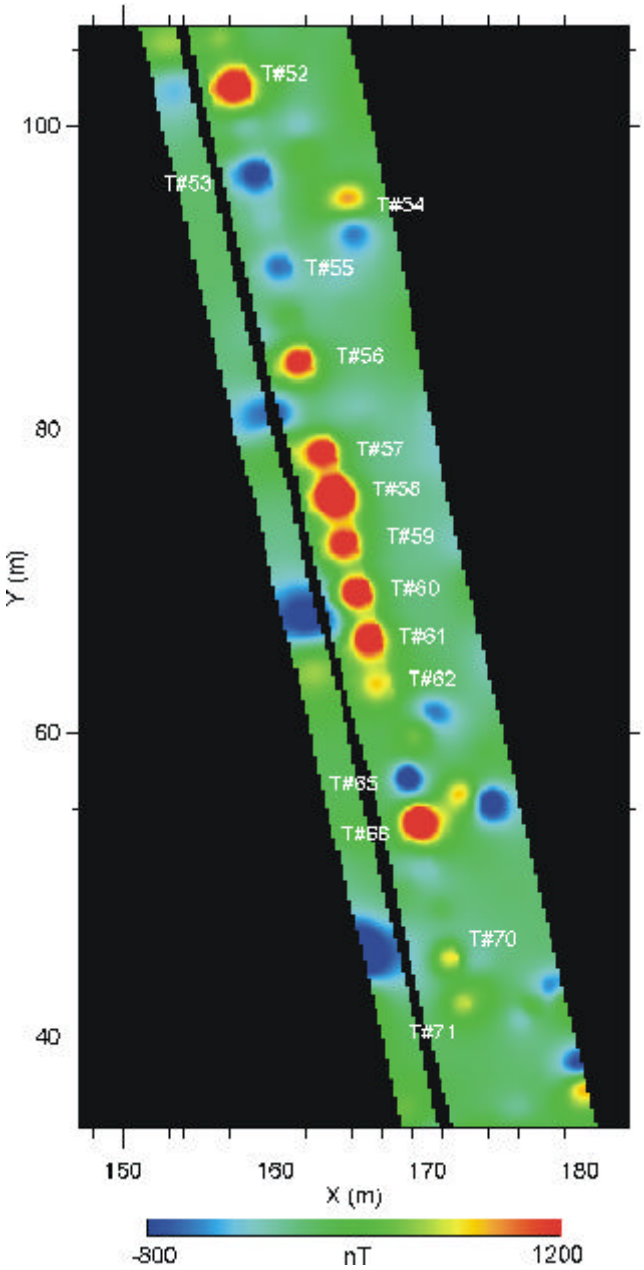

Figure 16. Magnetic anomaly image of a 35 meter long portion of RIP-S6 showing the layout of a row of beach obstacles.

the original beach obstacles indicating that they had been explosively destroyed. It is almost certain that the explosives used were satchel charges because if the targets had been destroyed by explosive ordnance, frag and ordnance scrap would have been recovered in our operations.

Table 8. Targets Prosecuted by the Target Recovery Team.

ID	Local X (m)	Local Y (m)	Depth (m)	Size (m)	Inclin. (Deg)	Azim. (Deg)	Fit Quality	Analyst Comments	Remediation Comments
N1-14	63.94	385.84	0.06	0.06	-2	3	0.997	small for M4, at surface	Nothing Found
N1-27	106.46	260.68	1.97	0.16	17	349	0.962	good target, deep	Shopping Cart at 4.5'
N1-28	111.32	245.12	2.57	0.24	3	246	0.964	great target size=Mk81, inverted signature	4' of Rebar at 8' deep
N1-35	123.18	195.20	2.21	0.19	4	355	0.973	Size=M30, clutter 1m WSW	3' of rebar at 6.5' deep
N1-44	144.70	88.60	2.41	0.36	0	16	0.996	size=Mk17, 2 clutter targs just W, DIG	2' railroad rail @6' deep
N1-56	166.55	24.86	0.70	0.12	0	328	0.996	size of M6 at 2 ft.	Nothing Found
N1-57	176.07	5.76	0.57	0.10	-1	34	0.990	M6 size, @1.5 ft near surf	Nothing Found
S1-16	27.56	(80.32)	1.93	0.18	3	340	0.986	Size=M30/Mk5, DIG	2' Rebar, & steel object @ 4'
S1-26	27.56	(80.32)	2.85	0.69	-4	138	0.977	very big, inverted signal DIG	8' & 5' Railroad rails
S1-31	27.56	(80.32)						jumbo target at surfline	Target abandoned, water in hole
S1-35	27.56	(80.32)	2.75	0.26	38	7	0.990	Size=Mk81, Dig	Nothing to 9' abandoned, water
S2-13	69.45	378.66	2.25	0.33	3	357	0.993	jumbo classic at 7 ft. DIG?	Nothing to 7' deep
S2-17	79.71	321.72	2.30	0.40	10	332	0.973	very big, note missed area	Nothing Found to 9.5'
S2-31	91.06	260.96	2.06	0.50	6	344	0.924	2 targets 1m apart E-W	7.5' of railroad rail @ 6' deep
S2-34	108.85	258.65	2.19	0.76	2	344	0.931	Great signal, size of a car, close to surf	8' of railroad rail @ 5.5' deep
S2-43	124.41	168.47	1.73	0.33	5	262	0.988	size=M17, inverted, DIG	2 pieces of 2" pipe
S2-46	144.55	140.94	2.40	0.97	7	7	0.946	size of a car	12' long railroad rail
S3-2	33.08	488.80	1.85	0.24	-4	80	0.990	large for 7.5", inverted, mid beach	5' of bent rebar @ 5.5' deep
S3-10	57.43	428.00	1.36	0.23	3	264	0.988	large for a 7.5", inverted signal	3' pof flat steel bar @ 4.5' deep
S3-23	98.62	277.55	1.08	0.16	8	1	0.993	size=M30, good target	2' of pipe @ 3.5' deep
S3-28	123.73	211.02						large target, at sea	engine block + parts
S3-34	132.90	163.54	0.80	0.13	0	293	0.985	large for M6, Dig?	3' of rebar @ 3.5' deep
S3-36	146.44	134.98	1.29	0.51	1	20	0.915	very big, very deep, near surf, in clutter	4'X4' scully with 6' of rail

ID	Local X (m)	Local Y (m)	Depth (m)	Size (m)	Inclin. (Deg)	Azim. (Deg)	Fit Quality	Analyst Comments	Remediation Comments
S3-46	170.46	15.67	1.36	0.11	10	351	0.941	see targ 45 to the N	tire/wheel + 8' long pipe @5' deep
S4-10	50.27	452.40	0.80	0.23	-2	326	0.993	Size=7.2" rocket, near surfline	2' of railroad rail = small stuff
S4-16	54.72	433.71	0.92	0.27	24	29	0.746	multiple targets	Scully parts with 2' rail
S4-27	53.78	381.55	1.63	0.40	0	175	0.970	too big for single ordnance	3.5' of railroad rail @ 5' deep
S4-34	72.04	362.25	0.91	0.58	-8	139	0.970	massive target near surf, small targets N & S	5' of railroad rail
S4-45	75.14	324.13	1.74	0.65	6	323	0.978	massive target, mid beach, dig?	8' of railroad rail
S4-73	114.91	171.59	0.84	0.37	-1	0	0.984	Size=M17, DIG	3.5' of railroad rail
S4-84	124.12	126.32	1.39	0.74	0	360	0.990	massive target at midbeach, DIG?	6' of railroad rail @ 4' deep
S4-97	147.03	44.39	1.15	0.28	3	353	0.993	Size=M17, near shore	3' of railroad rail
S5-17	115.73	271.31	1.83	0.72	-26	63	0.951	big target, much deep	11' long railroad rail 2 3' deep
S5-20	118.71	259.67	1.40	0.51	75	34	0.949	maybe wrong neg dipole	Rail vertical 10', cant recover
S5-40	142.10	167.97	1.57	0.61	29	31	0.938	2nd target 1.5m to SE	scully with rail, can't recover
S5-42	144.16	157.87	1.91	0.53	60	174	0.955	maybe 2 targets	4.5' rail + 12" steel object @ 7'
S5-52	157.18	102.46	1.91	0.62	47	194	0.858	poor fit, look 1m South and West	6.5' of railroad rail @ 5.5' deep
S5-58	163.95	75.86	1.38	0.54	80	144	0.975	#3 in a line of 7	railroad rail @ 5', cant recover
S5-60	164.80	69.32	1.35	0.48	38	246	0.987	# 5 in a line of 7	7' rail @ 6', cant recover
S5-64	162.24	65.11						very deep, partial signature	7' + 4' railroad rails
S6-2	27.54	(80.32)	1.87	0.67	21	33	0.904	complex target, burial pit?	9 pieces of railroad rail, 760lb.
S6-4	27.54	(80.32)	1.36	0.55	15	348	0.936	very large, similar to T1-3	6.5 & 3' railroad rails @ 5' deep
S6-5	27.54	(80.32)	2.40	1.03	3	26	0.915	same as T1	2 6-ft rails @ 5' deep
S6-18	27.54	(80.32)	1.76	0.41	61	120	0.800	massive, partial sig, in veg line, Dig?	3' & 4' rails/scully, recovered
S6-19	27.54	(80.32)	1.33	0.41	4	155	0.984	massive target	Rail in scully
S6-27	27.54	(80.32)	1.49	0.46	24	106	0.805	burial pit?	Several long pieces of rebar
S6-39	27.54	(80.32)	2.28	0.99	-9	62	0.935	massive burial	8' & 5' rails at 5' deep

ID	Local X (m)	Local Y (m)	Depth (m)	Size (m)	Inclin. (Deg)	Azim. (Deg)	Fit Quality	Analyst Comments	Remediation Comments
S6-40	27.54	(80.32)	2.30	0.85	-3	172	0.974	massive burial	6.5' railroad rail 7' deep
S6-46	27.54	(80.32)	2.40	0.54	19	338	0.992	pretty target, DIG?	7.5' railroad rail @ 6' deep
S6-50	27.54	(80.32)	2.37	0.45	7	335	0.967	big target in veg line, DIG?	6' railroad rail @ 8.5' deep
S6-58	27.54	(80.32)						burial pit?	Found Nothing to 12'
S6-63	27.54	(80.32)	2.05	0.20	15	176	0.981	midbeach, DIG?	5' rail @ 6' deep
S6-70	27.54	(80.31)	3.83	0.75	2	350	0.965	dig a biggie?	Found Nothing to 12'
S6-76	27.53	(80.31)	3.29	0.63	-7	148	0.972	massive, inverted sig	Found Nothing to 10'
S6-77	27.53	(80.31)	2.82	0.25	-5	182	0.968	inverted, M17 sized, DIG?	Found Nothing to 10

Our remediation efforts removed only a fraction of the identified targets. The survey also revealed partial magnetic signatures of many more targets beyond the shore line. The remaining targets, both on the beach and off shore represent a potential hazard to persons on the beach, and more likely to swimmers in and beyond the surf. However, it is unlikely that any of these objects constitute a UXO hazard.

The observations and conclusions stated in this section of the report apply only to the 7 km stretch of beach from 0.5 km North to 3.0 km south of the Round Island Park beach access. The UXO discovered over the past few years on the beach within the limits of our survey, (but outside the areas discussed above) suggest that investigation of target concentrations in other areas may be justified.

9.2 Survey Results, North Hutchinson Island

On North Hutchinson Island the survey effort was broken up into 37 0.5-kilometer sections. Analysis of the data identified a total of 1,665 magnetic anomalies. The smallest of these are of a size similar to M4 AT mines. The largest are much too massive to be single ordnance items. Based upon our observations in the previous section many of these items may be components of beach obstacles used in training. In several cases digging single *MTADS* targets revealed several closely-spaced objects. Therefore, the total number of items specified in our target tables may be significantly smaller than the actual number of buried items. This is particularly true in the most congested and cluttered areas. Simple inspection of the GIS overlay images reveals the locations of target clustering. We will briefly review the results of the survey as they apply to individual geographic areas. The following observations can be best understood by viewing the GIS overlays shown in Appendix B.

The northern limit of our survey extended just north of South Beach Park. RIP-N17 and RIP-N16 are relatively magnetically clean except for the area due east of E. Causeway Blvd. Massive anomalies at the point labeled Cable Crossing are probably due to structures associated with this or other utilities. The 5 sections from RIP-N15 through RIP-N11 are relatively clean with only 1 or 2 significant anomalies per section. This remains true into section RIP-N10 to about the point that Sea Grove Dr. intersects with Ocean Way. At this point the number of targets increases slowly. There were 39 small and medium sized targets picked in this section, mostly near the shore line.

In section RIP-N9 the number of targets begins to strongly increase and is at a very high level between Angler's Cove in RIP-N8 and Sea Grape Dr. in RIP-N7. In these two sections, which form Porpoise Point, we analyzed over 260 targets. These sections, centered at Porpoise Point, are where the majority of recently recovered UXO items have been found. See Figures 1 and 2.

The number of targets in RIP-N6 begins to diminish, but still remain at over 50 targets in the section, some of which are very large. By the point where Galleon Dr. intersects Reef Rd. the density of large targets has fallen to a minimum. The south half of RIP-N5 contains only relatively small shallow targets. There are only a small number of medium and large targets in RIP-N4 and RIP-N3. The density of targets reaches a minimum in RIP-N2 and remains low in RIP-N1. The total number of targets in RIP-N1 is 57, but the majority of them are small and are likely associated with clutter taken onto the beach from Round Island Park. The same observation holds for RIP-S1. Only 8 of the 39 targets are of significant size. Four of the larger targets were dug (see Table 8) and only rebar and railroad rails (from scullys) were found.

From RIP-S1 through RIP-S5 the density of targets continues to rise. The density of very large targets is at a maximum in the south half of RIP-S5 and the north half of

RIP-S6 (between the two turnouts for Avalon Park) and again begins to diminish to a minimum between the Ocean Harbour Boardwalk and PV Martin's Restaurant in RIP-S7. This is the area (RIP-S1 to RIP-S5) that we most intensely remediated. Our findings in these 7 sections were described earlier. Effectively, all dug targets revealed objects associated with beach obstacles. The most notable features in Section RIP-S8 occur just south of the Ocean Tower Condominiums Boardwalk. The analyst noted the features at midsection as possibly associated with a storm sewer outfall or some other utility.

Sections RIP-S9 through RIP-S12 are characterized by 10-30 targets each. In general, these targets are very large, similar in size to the concentrations of scully artifacts dug in Rip-S5 and RIP-S6. However, in this stretch of beach the targets are much deeper, from 2.5 to 5.5 meters below beach level. Most of the large targets are 2-4 meters below sea level. Additional targets clearly lie above the current vegetation line and beyond the current shore line.

Most of Section RIP-S12 and the northern 300 meters of RIP-S13 are relatively free of targets. A new clustering of targets is seen extending from the southern 200 meters of RIP-S13 to the mid point of RIP-S14. Most of the targets in this cluster are of intermediate size (0.15-0.25 m in apparent diameter). Again they are found at very deep levels (2-3.5 meters). Park Service officials claim that the beach on the southern end of the island has accreted up to 5 feet of sand over the past decade. This may explain, in part, the depth of the targets south of about RIP-S10. However, this observation would also indicate that the shore line may have been significantly further to the west when these objects were put in place. Regardless of the amount of sand that has accreted on the beach, the fact remains that most of the buried targets south of RIP-S7 are 2.5 to 4 meters below sea level.

Pepper Beach Park is shown in Sections RIP-S14 and RIP-S15. The beach is relatively clear of targets between the middle and the north lifeguard towers. Between the middle and south towers the beach is almost completely saturated with magnetic anomaly returns. Most are too dense and too large to analyze, however the targets that can be analyzed are 2.5-6.5 meters deep. The analyst classified the returns potentially as rubble. Indeed, the magnetic anomaly images resemble those we have measured over landfills that were filled with concrete rubble and other industrial wastes. The area containing these buried materials obviously extends above the current vegetation line and beyond the current shore line.

Between Pepper Beach Park and the inlet, three additional 300-500 meter long areas with similar very high concentrations of buried targets exist. They resemble the burials shown in RIP-S15. A 300 meter long concentration is seen in RIP-S16 in front of the three high rise condominiums. This group of targets do not appear to extend beyond the shore line, but are concentrated from midbeach to above the current vegetation line. The next concentration of large, deep, dense burials begins in RIP-S17 in front of the Ramada Inn and extends through 200 meters of RIP-S18. The next organized burials begin almost immediately south of this group at the midpoint of RIP-S18. This group of burials extends about 200 meters into RIP-S19 and ends abruptly at the point of the current sign for Ft. Pierce Inlet State Park. South of this point there are only sparse isolated targets of significant size.

9.3 Survey Results, South Hutchinson Island

The magnetic anomaly image GIS overlays for the surveys on South Hutchinson Island are also shown in Appendix B. These presentations, unlike those on North Hutchinson Island, are presented as 1 km survey images.

The northern-most survey is labeled Turtle Beach and extends north from the Sea Turtle Beach/Blind River first order control point (FP 5 in Table 5).

We analyzed 59 targets in this survey. Most targets are small to intermediate in size. Only two are large by the standards applied on North Hutchinson Island. All targets (except the largest target) are shallower than 1.5 m. There are no residences or other permanent structures on this stretch of beach. It would be relatively easy to remediate these targets and declare the section as clean.

The next survey to the south is labeled Normandy Beach, North 1. The southern limit of this 1-km survey is at the Normandy Beach first order control point. See Table 5 for the location of the control point. We analyzed 111 targets in this survey. Only one (NN1-35) is categorized as large by the standards applied on North Hutchinson Island. The targets are sparse and widely dispersed (except for a slight clustering at the northern limit of the survey). Almost all targets are at depths between 0.75 and 1.75 meters. Very few are the result of recent clutter. Although the island is very narrow and the road lies close to the beach there are no homes or other structures along this survey. It would be relatively easy to remediate and declare as clean.

The final survey begins at a point 1 km south of the Normandy Beach first-order control point and extends into the survey image labeled Normandy Beach South 3. The closely spaced high rise condominiums located very close to the beach, not only cast dense magnetic anomaly shadows across the beach, but made maintaining satellite navigation difficult. Constraints on available time did not allow us to adjust survey times to allow for favorable satellite positioning. Target analysis in Normandy Beach South 2 and 3 required constant offset adjustments to visualize the targets for analysis. We analyzed 92 targets in this survey. There are only 4 targets classified as large by standards applied on North Hutchinson Island. This is surprising given all the high rise construction that has taken place on this stretch of beach. The targets are relatively small and widely dispersed with no obvious clusters of buried items. As on the remainder of the surveys on South Hutchinson Island, the targets are mostly at depths of 0.75 to 1.75 meters. There is relatively little clutter from recent activities.

In total, we analyzed 262 targets in the 3 survey areas on South Hutchinson Island. This part of the island was purported to been used as a bombing range. We see no evidence of large target concentrations in any of the surveys that would be indicative of a bombing target. There are only about a half dozen targets large enough to be 250 lb GP (or larger) bombs, and these are widely dispersed. The target sizes and distributions are similar in all surveys. Sample remediation digs on the remote Turtle Beach or North 1 Surveys would likely establish the types of buried materials on the northern beaches on South Hutchinson Island.

10.0 SURVEY AND REMEDIATION COSTS

The site characterization and survey costs are summarized in Table 9 and the Sample Remediation costs are given in Table 10. Table 9 includes costs for preliminary site visits, costs for fabricating test ordnance, creating and surveying the Prove-out Site and for all data analysis and report writing and distribution costs. The sample remediation costs include only those items specifically related to the remediation. Data analysis, preparation of dig images, dig sheets, sorting and creation of files for loading into the way pointing equipment and project reporting are included in the survey costs. Not included in the remediation costs are expenses incurred by CEHNC for the remediation team that they had on site for three days. Additionally, the costs of having the EOD team from Naval

Station, Mayport on site as standby were borne outside of this effort.

There were some unusual costs associated with the survey phase of the operation. Since we had not previously had any experience with detection of mines, the costs associated with creation of the ordnance database for these items in the Prove-out phase of our study were significant. Because we had not had any prior experience operating equipment on the soft shifting beach sands, about a half day was lost in re-equipping the vehicle and making adjustments that would allow routine operation. Because of the risk associated with getting the equipment trapped in rising tides, we rented a four-wheel drive tractor and added an extra employee to act as back-up for vehicle rescue. About one full survey day was lost conducting equipment demonstrations, public relations interviews and press conferences. Finally, expense and lost time were associated in conducting the brief surveys on South Hutchinson Island which required equipment transportation to and from the site each day.

Given these caveats, the survey costs were quite reasonable. The costs per acre were a bit under $1,000. This includes creation of a permanent archival record for each target detected and creation of the permanent first-order survey control points that will enable the targets to be reliably reacquired at any time in the future.

In the sample remediation phase of our operation we recovered 85 targets. These recovered items represent a good statistical sample of the buried targets along this stretch of beach and have reasonably defined the probable risk associated with the remaining unrecovered targets. The costs of digging the targets is slightly over $800 per target and does not include the costs of the CEHNC dig team who were on site for 3 days of the two-week operation. Several factors contributed to the relatively high target recovery costs. We did not do an adequate job of defining the exclusion zone requirements associated with digging targets and incorporating this information into the remediation work plan. Resolving these issues on site cost a significant amount of lost time and the expense associated with redefining the remediation approach, recreating target dig lists, hiring a 10 person security team and coordinating efforts with law enforcement offices, and hiring and bringing in commercial UXO personnel on 2 day's notice.

In spite of the relative high cost per recovered target, we sampled a good cross-section of all the targets along this 3.5 kilometer section of beach in two counties. This information is probably sufficient to make final determinations about the need for future remediations along this section of beach. This information is valuable because this is one of relatively few undeveloped stretches of beach between Vero Beach and Ft. Pierce and is therefore likely to see significant construction in the near future.

Table 9. Ft. Pierce Site Characterization Costs.

SURVEY PREPARATION COSTS			
Test Plan		$4,000	
Logistics			
	Maps, Photos	$2,300	
	Misc. ODC's	$374	
	Labor (nova)	$1,000	
Geodetic Survey		$4,950	
Total Survey Preparation Costs			$12,624
PROVE-OUT COSTS			
Ordnance Mock Ups			
	Mines, Bombs, Rockets	$2,590	
	Installation	$1,000	
	Survey & Analysis	$1,500	
	Total Prove-out Costs		$5,090
SURVEY COSTS			
Mobilization/Demobilization			
	Truck/Trailer	$3,400	
	Labor/Driver (GEO)	$2,500	
	Total Equipment Mobilization Costs		$5,900
Logistics			
	Office Trailer	$955	
	Toilets	$300	
	Radios	$500	
	Tractor (Geo)	$1,300	
	Towing	$1,100	
	Misc. ODC's (GEO)	$2,100	
	Total Survey Logistics Costs		$6,255
Survey Support			
	Geocenters (labor travel, per diem)	$16,156	
	Hughes (labor, travel, per diem,ODC)	$11,800	
	AETC (labor, travel, per diem)	$18,200	
	Ordrem (labor travel, per diem)	$13,200	
	NRL (labor, travel, per diem)	$20,700	
	Total Survey Support Costs		$80,056
DATA ANALYSIS & REPORT PREPARATION			
	NRL (labor)	$18,000	
	Publication/Distribution	$3,500	
	Total Analysis and Report Costs		$21,500
TOTAL SITE CHARACTERIZATION AND SURVEY COSTS			**$131,425**

Table 10. Ft. Pierce Sample Remediation Costs.

Test Plan			$3,000	
Logistics				
	Office Trailer	$1,000		
	Toilets	$600		
	Radio lease	$500		
	Security	$6,300		
	Mobilization (equip. shipping)	$1,100		
	Backhoe	$1,553		
	Sandbags	$343		
	Nova (expediter)	$1,000		
	Total Remediation Logistics Costs		$12,396	
Remediation Support				
	CEHNC (labor, travel, per diem)	XX,XXX		
	Hughes (labor, travel, per diem)	$10,600		
	Ordrem (labor, travel, per diem)	$8,300		
	Explosives, Backhoe Operator	$11,500		
	Geocenters (labor, travel, per diem)	$5,100		
	NRL (labor, travel, per diem)	$18,200		
	Total Remediation Support Costs		$53,700	
TOTAL SAMPLE REMEDIATION COSTS				**$69,096**

APPENDIX A. TARGET TABLES FOR THE SURVEYS ON NORTH AND SOUTH HUTCHINSON ISLANDS.

APPENDIX B. GIS OVERLAYS OF THE *MTADS* SURVEYS WITH ORTHOGRAPHIC PHOTOGRAPHS OF THE VERO BEACH AND FT. PIERCE AREAS.