PROPOSED EXTENSION OF RUNWAY AT NORMAN MANLEY INTERNATIONAL AIRPORT

A RAPID ECOLOGICAL ASSESSMENT

Prepared for:
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Norman Manley International Airport
Palisadoes
Kingston

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Contents

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

Environmental Solutions Ltd. received a request for Proposal from the Airports Authority of Jamaica (AAJ) for a Rapid Ecological Assessment (REA) of an area of seafloor immediately adjoining the western end of the Norman Manley International Airport runway in Kingston (see Figure 1). The REA is required to satisfy permitting requirements for the National Environment and Planning Agency for the extension of the airport runway by up to 500 meters, using land-filling methods.

2.0 TERMS OF REFERENCE

A technical Terms of Reference for the REA was stipulated in the Request for Proposals document submitted by AAJ. The directives of the Terms of Reference are outlined below:

1. Comparison between historical and recent/current imagery/photography of the area at the end of runway 12 where the extension is to be executed.
2. Production of maps of the area showing the adjacent mangrove communities
3. Determination of the prevailing currents and circulation patterns within a 500m range of the footprint of the proposed reclamation
4. From a complete systematic design (500mx300m grid suggested) conduct stratified randomized quadrat sampling of the benthos to determine flora and fauna found on the substrate. Adopting the accepted one percent rule, use the grid of area to find a representative sample.
5. From the quadrat exploration determine the Seagrass coverage and status, as well as the presence of fishable resources. A species list shall be provided.
6. From the quadrat data determine the diversity (calculated) of the community within the 300mx300m footprint (substrate in fauna and seagrass epiphytes excluded)
7. From 10% of the 135 quadrats determine the substrate type, slope and geology.
8. Record observations while conducting the fieldwork (of mammals, reptiles, birds, etc.) within or near to the area of interest.
9. The Main Deliverable that is expected from this consultancy is a report documenting all of the above information, and giving appropriate meaningful analysis and commentary on the findings of the field work.

Figure 1 – Study Area Norman Manley International Airport (Box Highlighted in Red).

3.0 METHODS

The following methods were used to facilitate the information collection tasks outlined in the REA TORs:

3.1 AIR PHOTO INTERPRETATION AND INITIAL MAPPING

The following aerial imagery of the proposed development site was accessed:

1. Air Photographs of the Kingston Harbour area taken by the National Lands Agency in 1968 and 1991.
2. Google Earth[1] satellite images for the years 2009, 2006 and 2002.

These images were accessed so that air photo interpretation skills could be used to make spatial distinctions in benthic substrate/lifeforms and adjoining terrestrial lifeforms that could be resolved from the aerial images. Additionally, if there were any time-related changes that could be resolved from an analysis of images taken at different time periods, then this information would be incorporated into the study document. Finally, relevant images were inputted into a Geographical Information System[2] so that they could be referenced to JAD 2001, a known map projection/coordinate system[3] . Such referencing would enable measurements and general mapping to be done to support air photo interpretations made.

3.2 FIELD DATA COLLECTION

The orientation and distance intervals between each approach light set existing seaward of the NMIA runway were used as a guide for the layout of a grid network over the study area using GIS (see Figure 2 and table 1). Each grid was approximately 50 meters x 50 meters in dimensions and the coordinates for the intersection of each grid line were established and converted to Latitude-Longitude coordinates for up-loading into a hand-held GPS for navigation facilitation. All field data collected were referenced to an intersection point between imaginary grid lines established over the study area.

Boat-supported field data was collected within the study area over the period 12-17 of October, 2010, with data collection activities commencing at approximately 7:00 am and ending when daytime winds began to increase significantly (usually around 11:00 am).

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[1] www.earthgoogle.com
[2] www.mapmakerpro.com
[3] http://www.jamaicancaves.org/jad2001.htm

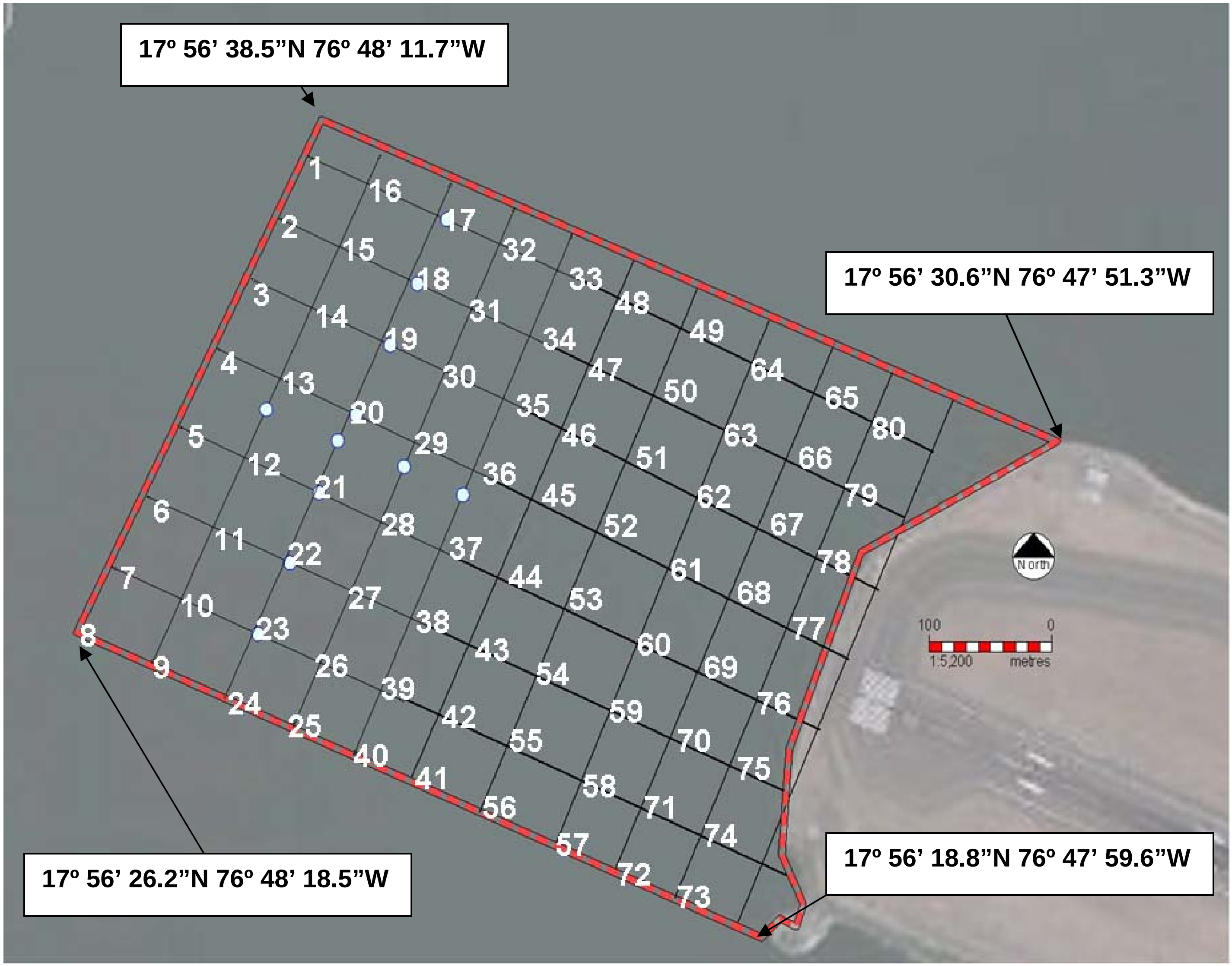

Figure 2: 50 meter x50 meter Grid Layout Utilized for Navigation over Study Area Grid Numbers Correspond with Table 1 Below.

Table 1: Latitude/Longitude Coordinates for Seafloor Sample Areas- NMIA		
Grid Intersection Number	Longitude	Latitude
1	76 48 12.0W	17 56 37.6N
2	76 48 12.8W	17 56 36.1N
3	76 48 13.7W	17 56 34.7N
4	76 48 14.6W	17 56 13.0N
5	76 48 15.7W	17 56 31.1N
6	76 48 16.6W	17 56 29.5N
7	76 48 17.5W	17 56 27.8N
8	76 48 18.3W	17 56 26.2N
9	76 48 16.4W	17 56 25.5N
10	76 48 15.6W	17 56 27.0N
11	76 48 14.6W	17 56 28.7N
12	76 48 13.9W	17 56 30.3N
13	76 48 12.7W	17 56 32.3N
14	76 48 12.0W	17 56 33.9N
15	76 48 11.1W	17 56 35.5N
16	76 48 10.4W	17 56 36.9N
17	76 48 8.4W	17 56 36.1N
18	76 48 9.3W	17 56 34.7N
19	76 48 10.0W	17 56 33.1N
20	76 48 10.8W	17 56 31.4N
21	76 48 11.8W	17 56 29.6N
22	76 48 12.6W	17 56 27.9N
23	76 48 13.6W	17 56 26.1N
24	76 48 14.3W	17 56 24.6N
25	76 48 12.4W	17 56 23.9N
26	76 48 11.6W	17 56 25.5N
27	76 48 10.8W	17 56 27.2N
28	76 48 10.0W	17 56 28.8N
29	76 48 9.1W	17 56 30.8N
30	76 48 6.9W	17 56 32.5N
31	76 48 7.5W	17 56 33.9N
32	76 48 6.7W	17 56 35.5N
33	76 48 5.1W	17 56 34.9N
34	76 48 5.9W	17 56 33.2N
35	76 48 6.7W	17 56 31.8N
36	76 48 7.5W	17 56 30.1N
37	76 48 8.4W	17 56 28.2N
38	76 48 9.2W	76 48 9.2W
39	76 48 10.0W	17 56 24.8N
40	76 48 10.7W	17 56 23.3N
41	76 48 9.2W	17 56 22.7N
42	76 48 8.5W	17 56 24.2N
43	76 48 7.6W	17 56 25.9N
44	76 48 6.9W	17 56 27.5N

Table 1: Latitude/Longitude Coordinates for Seafloor Sample Areas- NMIA		
Grid Intersection Number	Longitude	Latitude
45	76 48 5.9W	17 56 29.4N
46	76 48 5.0W	17 56 31.0N
47	76 48 4.2W	17 56 32.5N
48	76 48 3.4W	17 56 34.2N
49	76 48 1.7W	17 56 33.3N
50	76 48 2.5W	17 56 31.9N
51	76 48 3.2W	17 56 30.2N
52	76 48 4.0W	17 56 28.5N
53	76 48 5.0W	17 56 26.7N
54	76 48 5.8W	17 56 25.2N
55	76 48 6.6W	17 56 23.4N
56	76 48 7.2W	17 56 22.0N
57	76 48 5.1W	17 56 21.1N
58	76 48 4.5W	17 56 22.6N
59	76 48 3.6W	17 56 24.3N
60	76 48 3.1W	17 56 25.9N
61	76 48 2.1W	17 56 27.7N
62	76 48 1.3W	17 56 29.3N
63	76 48 0.6W	17 56 31.0N
64	76 47 59.7W	17 56 32.6N
65	76 47 57.9W	17 56 31.8N
66	76 47 58.9W	17 56 30.3N
67	76 47 59.6W	17 56 28.7N
68	76 48 0.4W	17 56 27.0N
69	76 48 1.3W	17 56 25.2N
70	76 48 2.0W	17 56 23.7N
71	76 48 2.8W	17 56 22.0N
72	76 48 3.5W	17 56 20.5N
73	76 48 1.7W	17 56 19.8N
74	76 48 1.1W	17 56 21.3N
75	76 48 0.4W	17 56 22.9N
76	76 47 59.7W	17 56 24.6N
77	76 47 58.8W	17 56 26.2N
78	76 47 58.0W	17 56 27.9N
79	76 47 57.2W	17 56 29.6N
80	76 47 56.4W	17 56 31.2N

Field data collection efforts were divided between the following areas:

3.2.1 Sea Current Measurements:

The foundation for sea current measurement was established with the examination of water current studies conducted within the Kingston Harbour, particularly, a paper published by Drs. Mona and Dale Webber and Doreen

Williams in 2003[4] (this paper is included as Appendix 1). In this study, density current actions (fresh and salt water interactions) were identified as being the main driving forces for the outer sections of the Harbour, including the main ship channel, while wind was identified as the main driving force for water movement within the inner harbor, including the study location.

Following the examination of the information outlined above, two types of sea current evaluation methods were employed to verify conformity with the information outlined in the data sets outlined above.

The first evaluation method was the collection of two sets of sea current measurements, which were obtained on the 13th of October, 2010 using a shallow water drogue (see Figure 3) deployed at two specific locations within the study area.

Figure 3: Shallow Water Drogue used for Current Tracking at NMIA

[4] http://www.ingentaconnect.com/content/umrsmas/bullmar/2003/00000073/00000002

Both drogues were set up to measure shallow water currents (less than 1m depth). Each drogue deployment was commenced from a fishing canoe, which was used as a support platform for the field surveys conducted.

The drogue was allowed to drift for 15 minute periods[5] at the end of which, the drogue was carefully approached by boat (so as not to disturb its movement with wake wash) and a position and time taken with a Global Positioning System. The positions and times of position taking were then plotted onto Google Earth imagery so that a spatial understanding of their movement could be obtained.

The second evaluation method was that of the examination of surface current movements as illustrated on time series Google Earth images of the area taken on the 14th of April, 2006 and the 10th of September, 2002. Wind speed and direction data was accessed from meteorological data archives found online at www.wunderground.com and used to support wave and water motion interpretations made from the Google images (tracks of fresh water lenses floating on the seawater were used as surface movement direction indicators).

3.2.2 Water Quality Sampling

Water samples were collected at three locations within the study area from the surface and at a depth of 1 meter above the seafloor. Water collected from depth was accessed through the use of a weighted 2 litre bottle, the stopper of which was tethered to the surface and pulled once the required depth was achieved.

Analysis for the following parameters was done:

1. Nitrates
2. Phosphates
3. Biochemical Oxygen Demand
4. Total Suspended Solids
5. Salinity
6. Temperature
7. Faecal Coliforms

In addition, water clarity data was obtained through the use of a Secchi Disk (see Figure 4) at all seafloor assessment locations.

[5] Intervals were chosen purely out of convenience since diving surveys were being conducted simultaneously.

Figure 4: Secchi Disk used for Water Turbidity Measurements at NMIA

3.2.3 Seafloor Substrate/Lifeform Analysis

The study site is 300m x 500m or 150,000m^2 in area. The unit of sampling used during the survey was a 1m x 1m PVC quadrat. The TORs submitted as guidance for the development of the REA spoke to the use of the "1% rule", meaning that the examination of 1% of the total seafloor area, or 1500 m^2 would be regarded as being representative of the entire site.

A 1m x 1m PVC quadrat was used as the sampling unit during the seafloor assessments. With a grid layout being established over the site with 80 specific intersection points for navigation, this meant that approximately 18 m^2 of seafloor would have to be examined at each intersection point in order to achieve the 1% rule.

Once a site was navigated to in the field (reference figure 2 and table 1), a tethered and weighted float was positioned at each GPS mark as a visual reference for a diver, who would descend the float line and visually (as well as photographically – where possible), assess the seafloor at the weighted anchor of the float.

The 1 meter quadrat was used in concert with a 30 meter tape measure and a diving compass to facilitate the assessment of approximately 18 m^2 of seafloor at each location. From these observation points, information on lifeforms and substrate character were obtained. Additionally, since previous marine experience had shown that marine supports for docks and moorings often provided support for benthic and pelagic marine life, the supports for the 7 sets of approach lights within the study area were examined for such life during the survey.

Further confirmation on substrate character and geology was obtained from a document titled, “Factual Report: Proposed RESA Extension for NMIA Runway” [6](see Appendix 2).

3.2.4 Seafloor Depth Measurements

Seafloor depths were measured at the locations outlined on Figure 2. Owing to a malfunction of a hand-held depth sounder obtained for depth measurements, depth soundings were taken using a combination of a weighted Fibreglass surveyor’s tape measure, which was dropped to the seafloor at each measurement site to facilitate measurement taking, and a metric depth gauge on the regulator of the assessing diver.

3.2.5 Supplemental Mapping

All data sets collected in the field were positioned using a Garmin Foretrex 101 Global Positioning System, with positions being obtained in latitude and Longitude. The Latitude and Longitude positions were then converted to Easting and Northing coordinates compatible with the JAD 2001 map reference system used in the GIS and overlaid onto georeferenced Google Earth images. The following layers were then produced:

1. Spatial distribution of substrate types and depths within the study area
2. Spatial distribution of water quality parameters within the study area
3. Spatial distribution of benthic and pelagic marine lifeform types within and adjoining the study area
4. Spatial distribution of terrestrial flora types found adjoining the study area

3.2.6 Limitations

The following study limitations have been outlined, since they represent limitations on the extent to which data could be collected or the accuracy of data collected:

1. Data collection was conducted between the hours of 0700hrs to 1100 hrs. This was done for two specific reasons. Firstly, day time wind conditions were calmest within this period – leading to more stable boating and diving conditions. Secondly, it was felt that the favourable horizontal surface visibility conditions at this

[6] Geotech Ltd Sept 2008

time would facilitate visual confirmation of the presence of the project work boat by the Airport Control tower.

2. Depths were taken using a plumb line as opposed to a sonar-based sounder (due to malfunction). Depths obtained may not be accurate, due to boat positioning and drift due to currents.
3. Subsurface visibility was extremely poor, particularly within a meter of the seafloor. Attempts at using image-capture techniques for data collection failed for the most part due to these conditions.
4. Night time observations were not made, due to safety considerations. Thus, marine fauna that may have been present within the study area during the night would not have been assessed. The collection of sea current data would have been affected by the lack of data collection during the night.
5. Further to point number 4, current movement occurring at night within the study area was inferred from wind speed and direction data obtained for the day in which currents were tracked.

4.0 RESULTS

Findings from both field and remote sensing interpretations are presented below:

4.1 AIR PHOTO INTERPRETATION AND INITIAL MAPPING

The 1968 and 1991 images obtained from the Lands Agency did not reveal much on analysis, due to turbidity conditions prevailing at the time of their capture. Where Google Earth images were concerned, only those captured in 2002 were clear enough to reveal seafloor conditions that could be used for spatial interpretation of seafloor substrate and lifeform conditions.

Figure 5 below describes in general terms the types of marine and terrestrial sessile lifeforms existing within and peripheral to the development site, as interpreted from aerial images.

4.2 FIELD DATA COLLECTION

4.2.1 Depth

Figure 6 illustrates depths measured within the study area. In general, the seafloor can be described as being of a low relief, i.e., without significant variations in contour. The seafloor of the study area gradually slopes from the northeast downwards towards its southwestern corner, with the shallowest depth measured within the area being 2.7 meters, while the deepest depth was 6.0 meters.

4.2.2 Seafloor Substrates

Diving inspections conducted within the study area revealed that the majority of the substrates observed were black sand typical of that seen on the dunes and beach areas on the southern side of the Palisadoes area, while the southern sections of the study area were dominated by thick layers of organic mud greater than 30 cm in depth, which most likely overlaid black sand sediments (see Figure 7). Mixed into the black sand sediments were abundant fragments of bivalve shells, which gave the initial appearance of white sands to the inspecting diver until a closer inspection was made (see Figures 8A-B).

Seafloor topography and substrate geology were consistent with the findings outlined in Appendix 2.

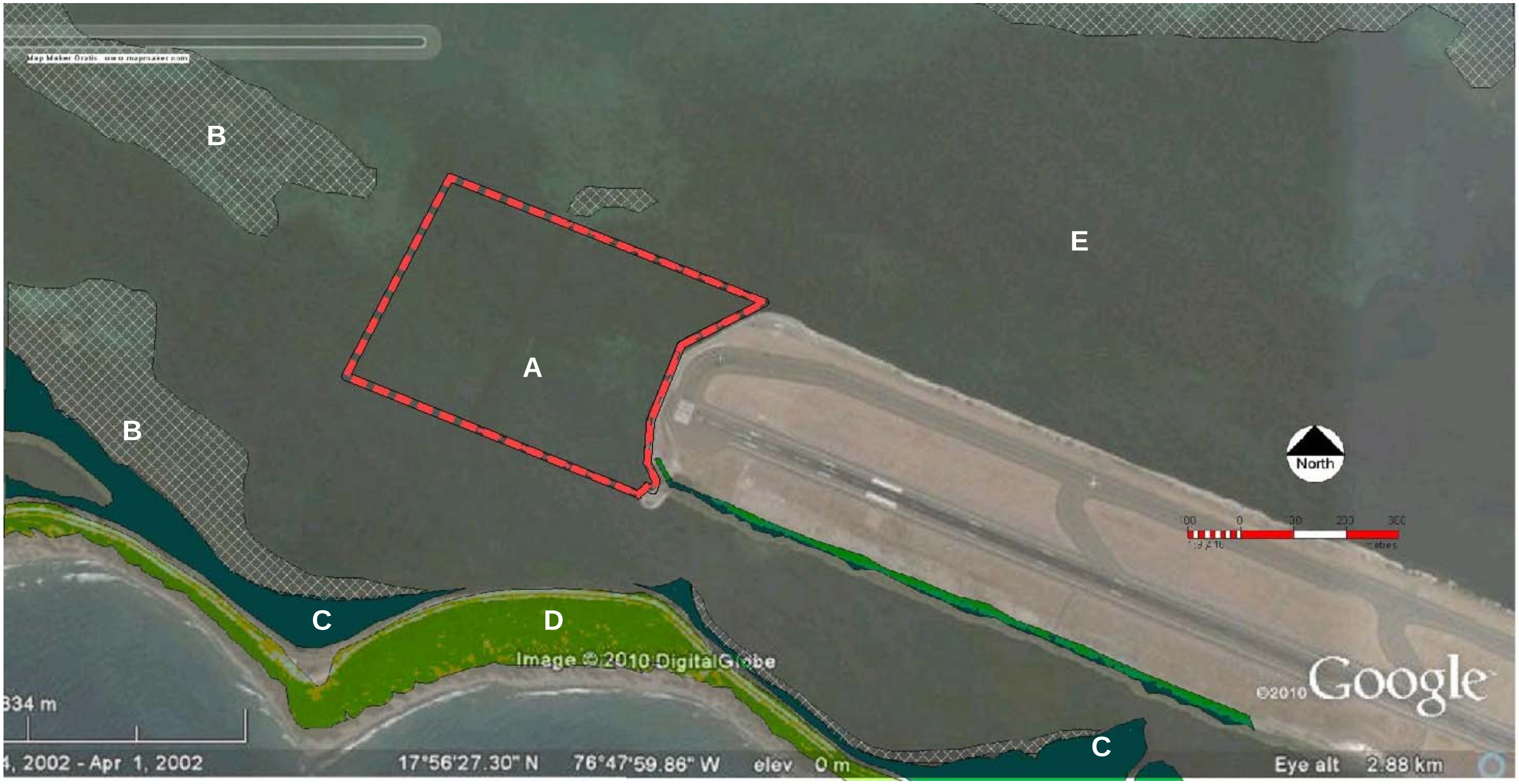

Figure 5: Google Earth Diagram of the NMIA Runway and Adjoining Areas Showing Sessile Marine and Terrestrial Lifeforms Present. A: Study Area, B: Seagrass Beds (Thalassia sp.) C: Mixed Mangrove Wetland Vegetation D: Sand Dune Vegetation E: Seafloor Sediments with Undetermined Biota.

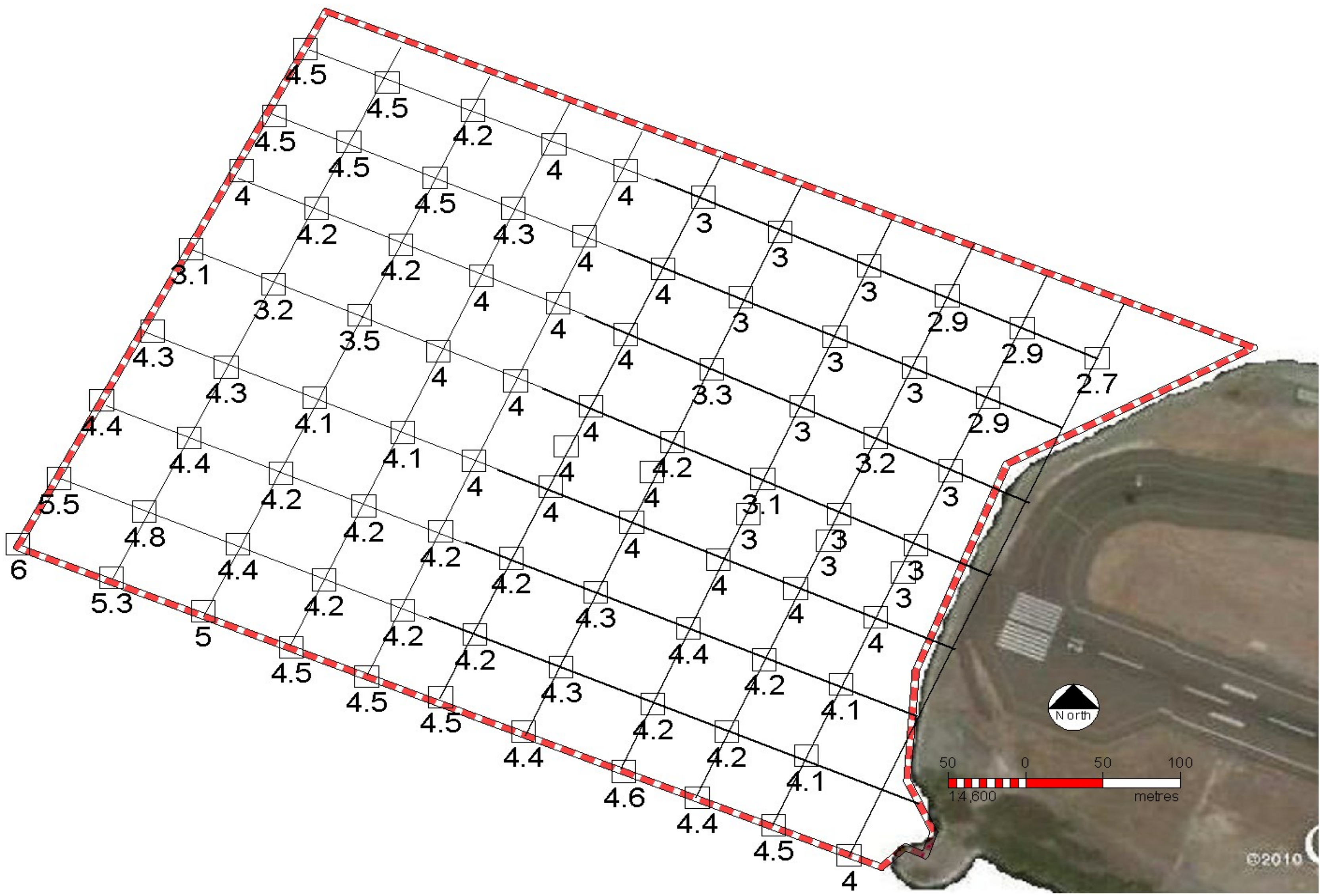

Figure 6: Depths Measured Within the NMIA Study Area (Depths in Meters).

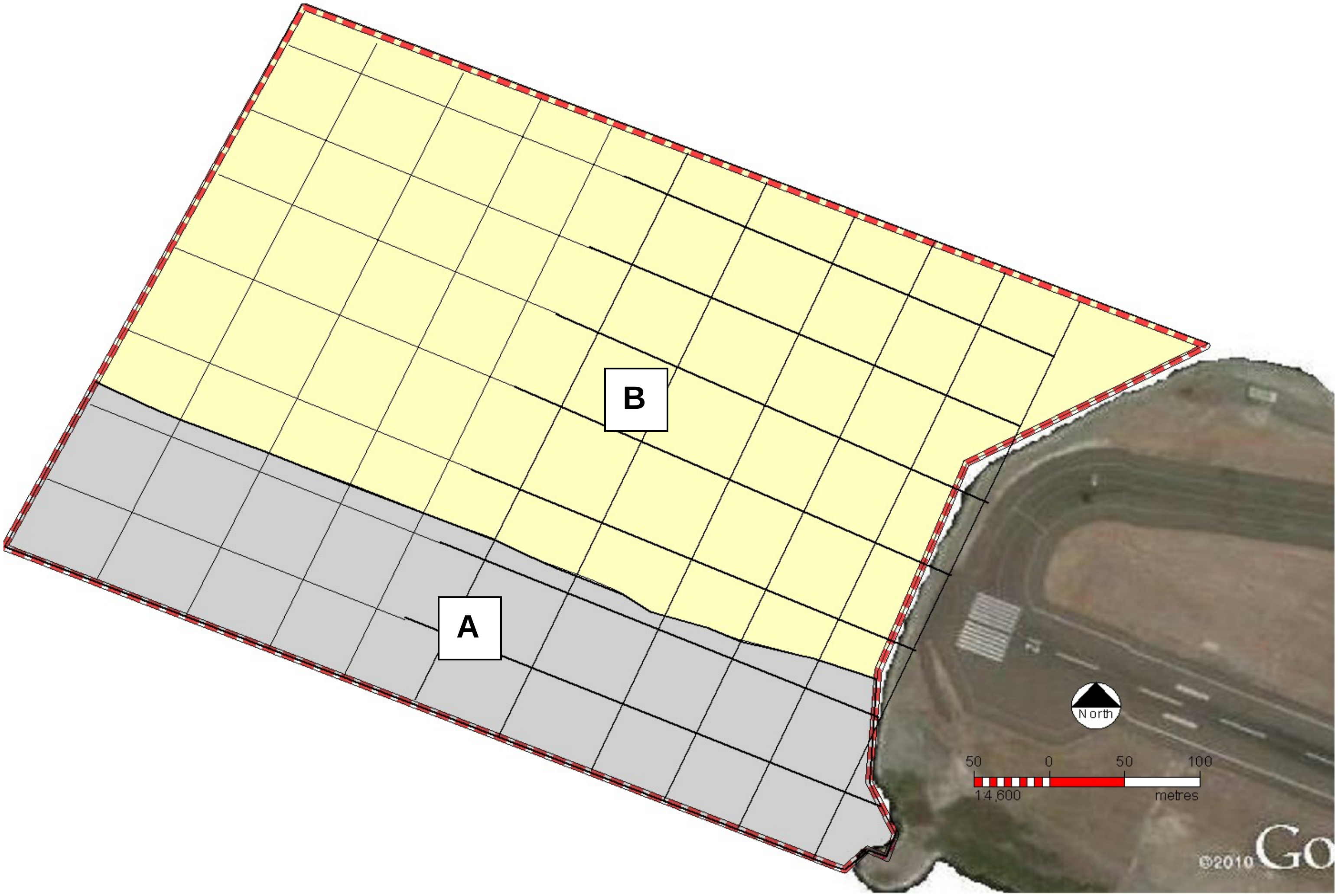

Figure 7: Spatial Distribution of Substrates Observed Within the NMIA Study Area - A: Organic Muds B: Black Sands. (Note, the boundary between both substrate types is not accurate)

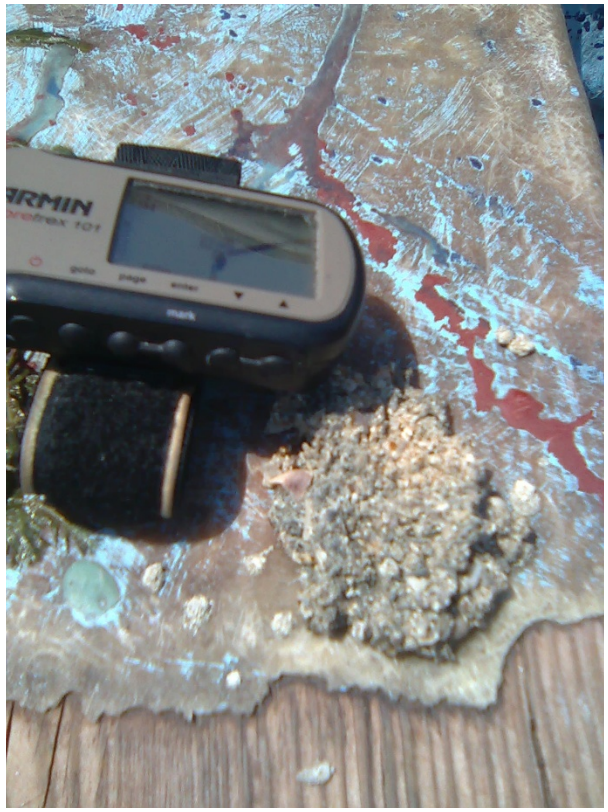

Figure 8A Black Sand Sample Obtained from Seafloor within Study Area

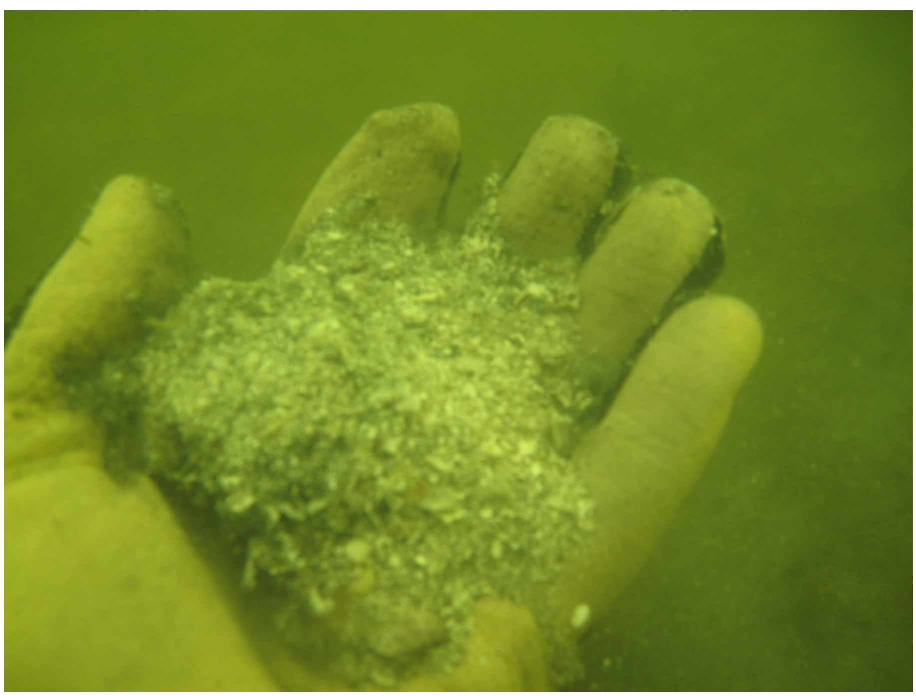

Figure 8B: Black Sand Seafloor Substrate with Bivalve Fragments, As Observed In Situ at the Study Area

4.2.4 Lifeform Analysis

4.2.4.1 Benthic Attached Lifeforms

None of the typical attached benthic lifeform features of importance, namely, corals and seagrass, were observed within the study area. The seafloor was largely devoid of any attached benthic lifeforms, with the exception of the northeastern section of the project area, which had 25-100% coverage of macro-algae, as measured within the 1m^2 PVC quadrats deployed for sampling. Figures 9A-C illustrate the algae observed in situ and after being sampled, while Figure 9D shows an approximate area of seafloor within the study area that was covered with macroalgae.

Three types of macroalgae were observed. These are listed below:

1. *Caulerpa mexicana*
2. *Caulerpa racemosa*
3. *Halimeda sp*

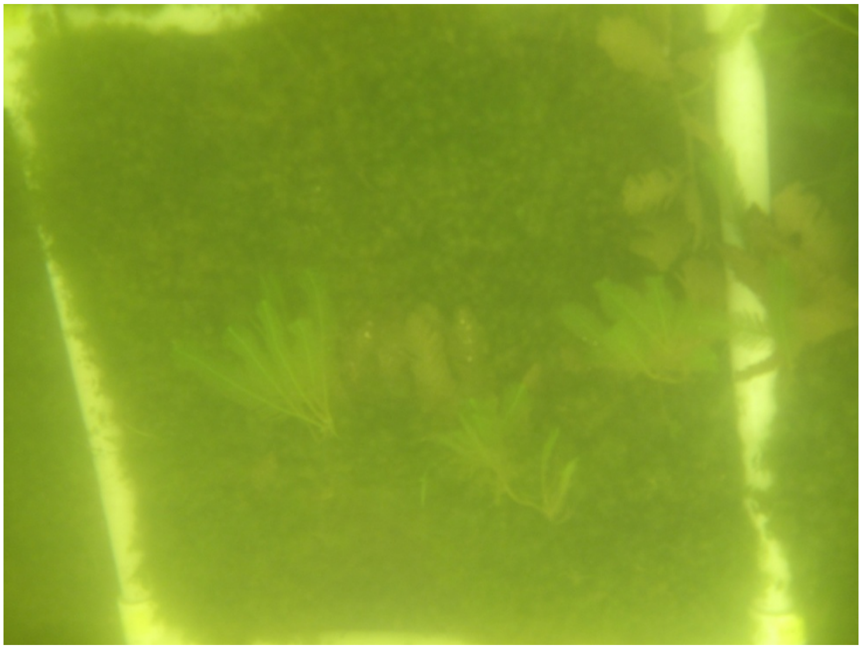

Figure 9A: *Caulerpa mexicana* and *Caulerpa racemosa* observed on the Seafloor Within the Study Area

Figure 9B: Sample of *Caulerpa mexicana* recovered from the Seafloor Within the Study Area

Figure 9C: Sample of *Halimeda sp* recovered from the Seafloor within the Study Area

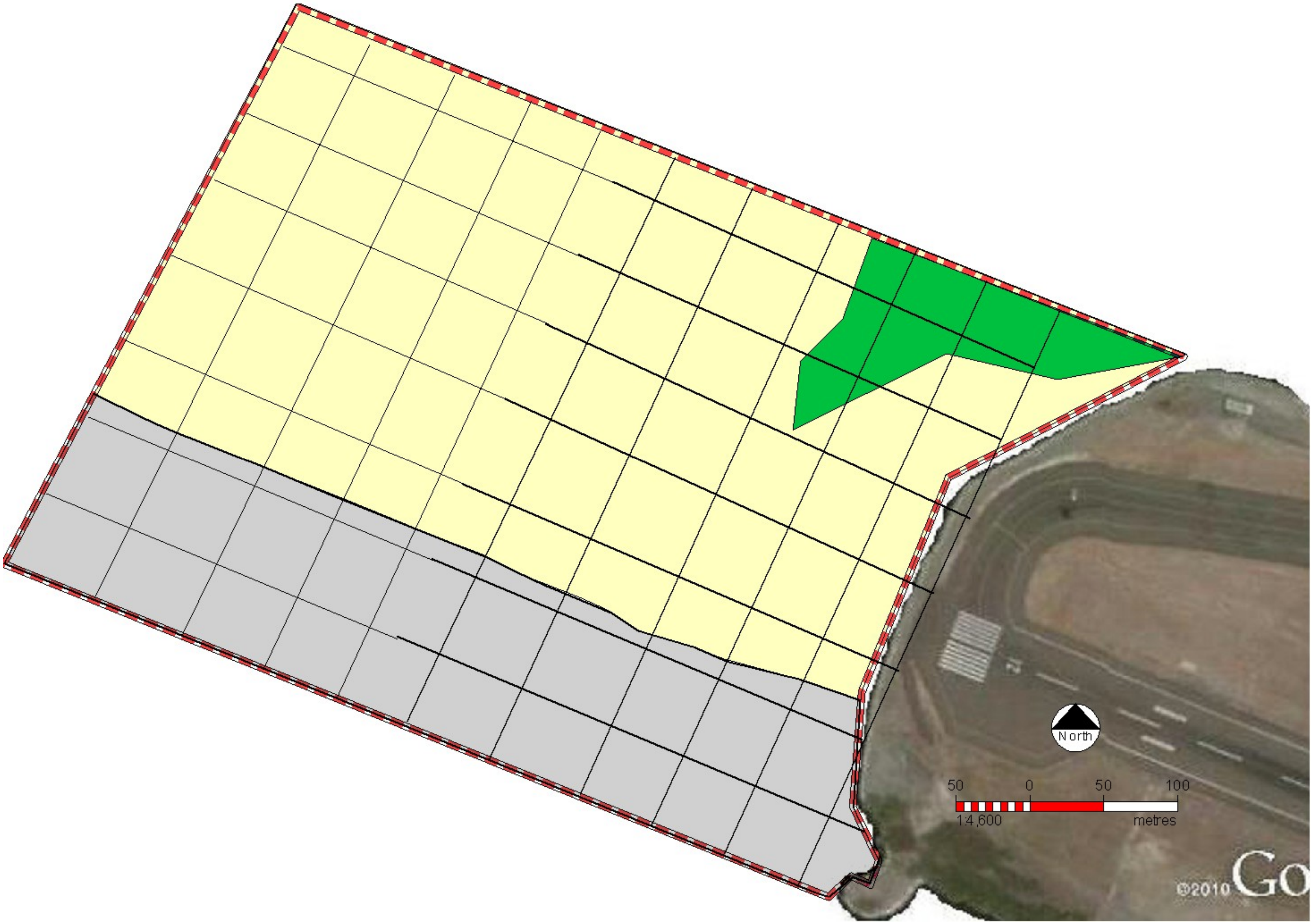

Figure 9D: Approximate Area of Seafloor Within Study Area Covered With Macroalgae (Defined in Green).

In addition to macroalgae observed on the seafloor within the study area, benthic sessile fauna – specifically the Large Ivory Barnacle (*Balanus eburneus*) Barnacles and a number of Red and Brown Sponges (none were identified), were observed on the metal I-Beams supporting the approach lights.

4.2.4.2 Benthic Mobile Lifeforms

It was apparent that the most abundant benthic mobile lifeform existing within the study area were bivalve gastropods. Numerous shell fragments were observed on the seafloor and mixed into the seafloor sediments during diving inspections conducted within the study area, as illustrated on Figure 10 below.

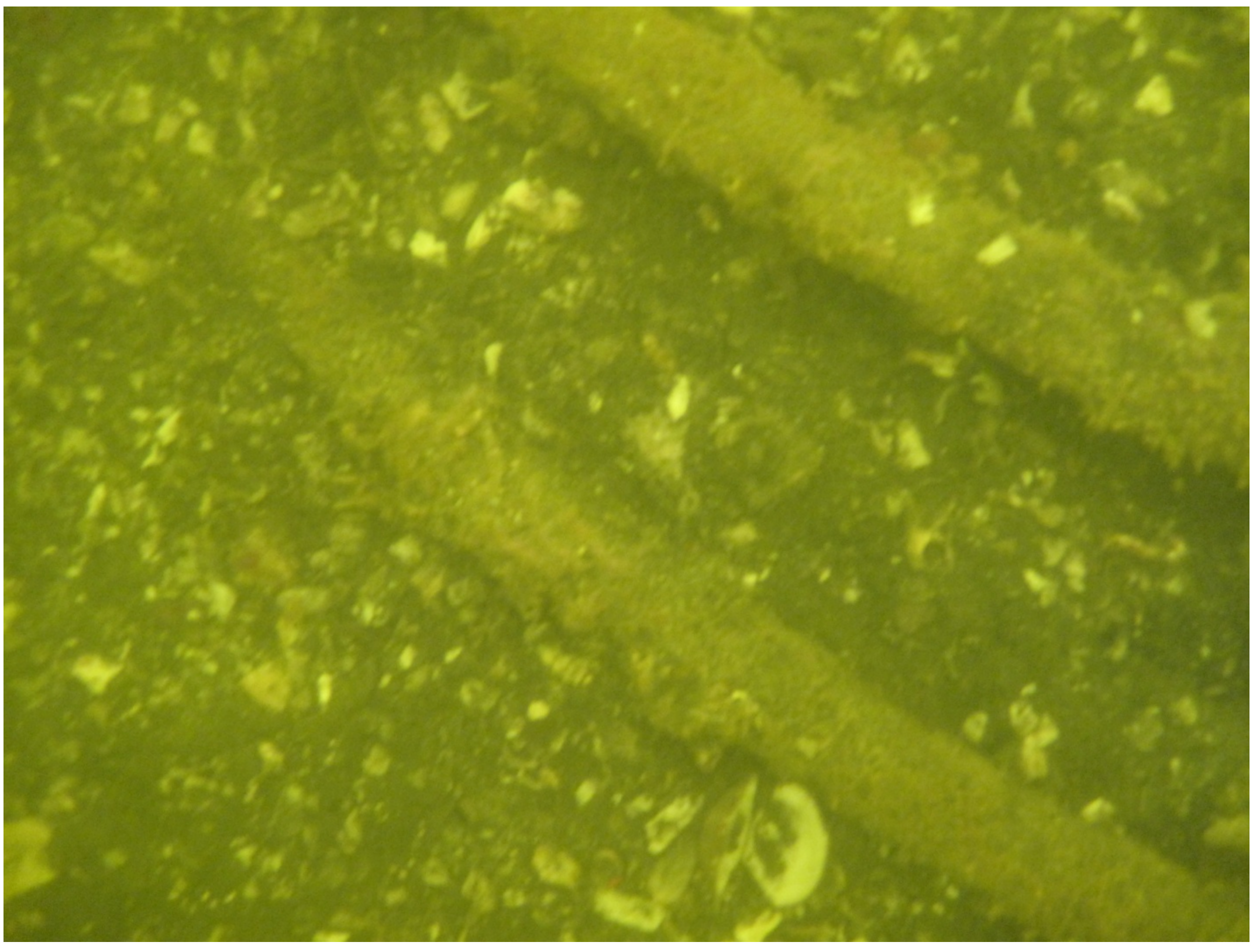

Figure 10: Bivalve Shell Fragments Observed Among Seafloor Sediments and Tree Roots on the Seafloor Within the Study Area.

Four bivalves were identified amongst the fragments observed within the study area. These are listed below:

1. *Anadara chemnitz*
2. *Martesia sp.*
3. *Brachiodontes exustus*
4. *Carditamera gracilis*

Broken shell casings of the Variegated (Green) Urchin ***Lytechinus variagatus*** were observed within the area indicated as bearing macroalgae on Figure 9D. Thus, it can be assumed that live examples could be found within this area.

4.2.4.3 Pelagic Lifeforms

No pelagic lifeforms were observed during the dives conducted over areas that could be defined as bearing seafloor sediments and muds in Figure 7. Neither was there any pelagic lifeforms observed over macroalgae-bearing seafloor areas outlined in Figure 9D (though this could have been as a consequence of poor visibility conditions present during the dives). The supports of the approach lights, on the other hand, appeared to act as Fish Aggregating Devices.

Two types of fish species were observed during inspections of the approach light supports. These are listed below:

1. Mangrove (Black) Snapper (*Lutjanus griseus*)
2. Four-Eye Butterfly Fish (*Chaetodon capistratus*)

Examples are illustrated on Figures 11A-B below:

Figure 11A: Example of Mangrove Snapper School Observed Around Supports for Approach Lights

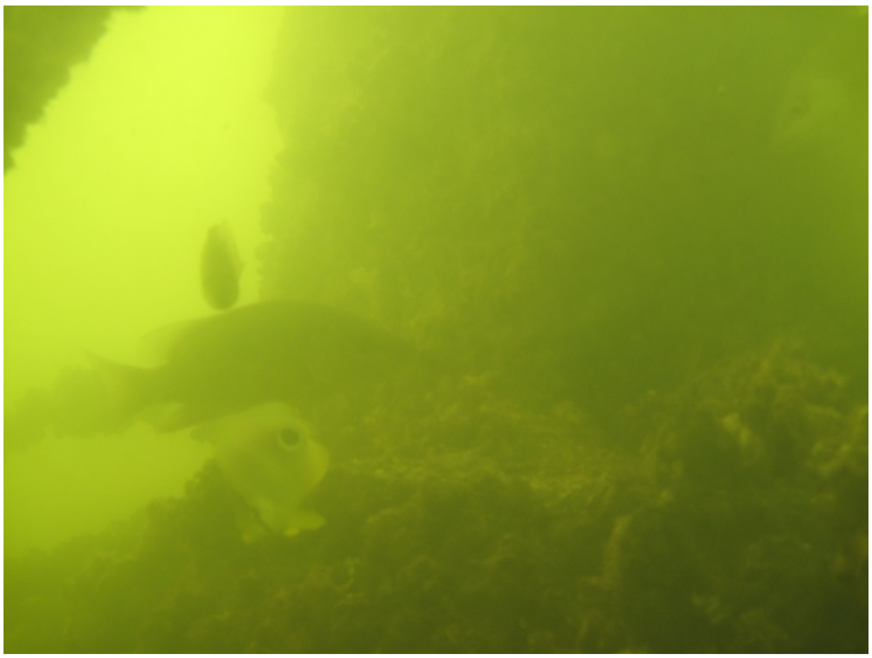

Figure 11B: Example of Solitary Four-eye Butterfly Fish Observed around Supports for Approach Lights

The Mangrove Snapper was the more abundant of the two fish types observed, with schools of up to 8 individuals being observed swimming around each of the supports examined.

Other than fish, the only other pelagic lifeform observed within the study area were jellyfish, specifically Dactylometra sp, which were seen in abundance near to the approach light supports within the study area (see Figure 11C).

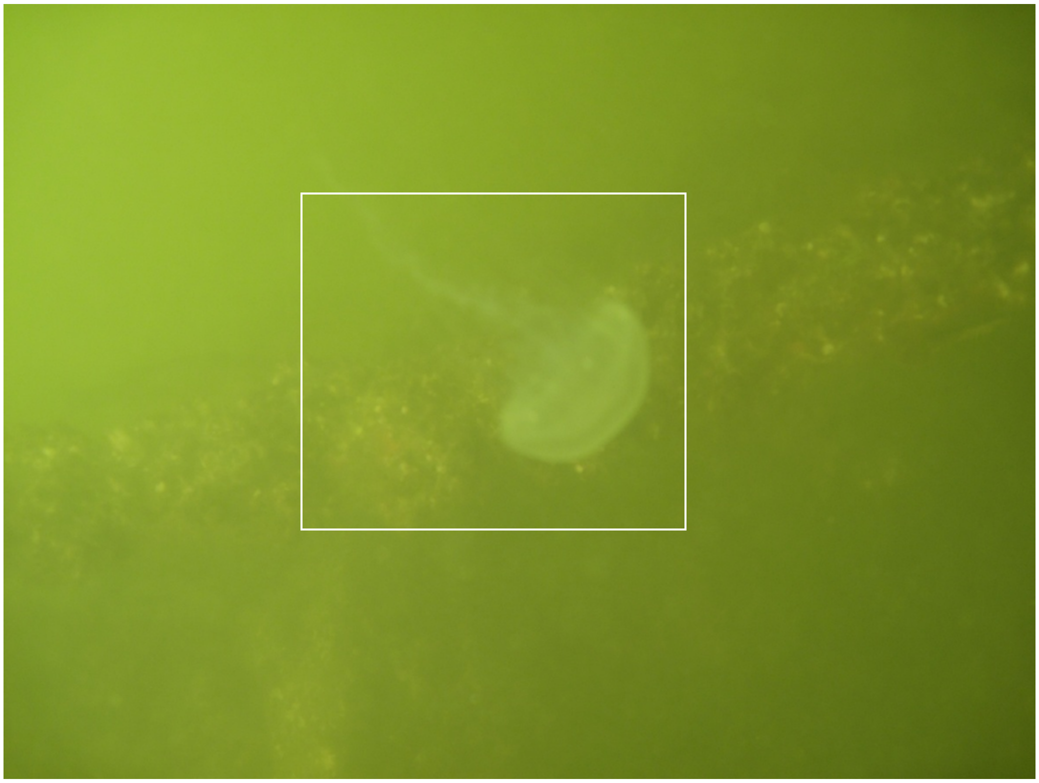

Figure 11C: Image of Dactylometra sp. Seen Amongst the Approach Light Supports within the Study Area.

4.2.4.4 Other Wildlife Observed

The Study area immediately adjoins the Port Royal Mangroves, an area that was designated under the Ramsar Convention (1971[7]) as a Ramsar site on April 22, 2005. The Information Sheet on Ramsar Wetlands for Port Royal[8] describes the Port Royal mangroves as having significant ecological importance due to fact that:

1. It provides a habitat for several endangered species of fauna, such as the West Indian Crocodile and three species of marine turtles.
2. It contributes to the biodiversity of the area in that it supports a large number of endemic species of marine fauna
3. It acts as a nursery habitat for a number of marine and avi-fauna species and, through this function, supports an important commercial fishery immediately offshore of the location.

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[7] http://www.ramsar.org
[8] http://www.wetlands.org/RSIS/_COP9Directory/Directory/ris/6JM002en.pdf

A detailed census of flora and fauna components existing within the areas peripheral to the study area was not done. However, a technical reference entitled The Biodiversity of Jamaican Mangrove Areas -Volume 7[9] (see Appendix 3) was used as a reference for the observation and identification of the following species observed during boat-based surveys conducted immediately adjoining the study area, within the confines of the area defined on Figure 1 above:

Marine Flora:

1. Turtle Grass – (*Thalassia testudinum*)

Marine Fauna:

1. Upside-Down Jellyfish (*Cassiopeia sp*)

Terrestrial Flora:

1. Red Mangroves (*Rhizophora mangle*)
2. Black Mangroves (*Avicennia germinans*)
3. White Mangroves (*Laguncularia racemosa*)
4. Button Mangroves (*Conocarpus erectus*)
5. Seaside Mahoe (*Thespesia populnea*)

Avi-Fauna:

1. Great Blue Heron (*Ardea Herodias*)
2. Brown Pelican (*Pelecanus occidentalis*)
3. Magnificent Frigate Bird (*Fregata sp*.)
4. Cattle Egret (*Bubulcus ibis*)

Terrestrial Fauna:

1. Fiddler Crab (*Uca sp*)
2. Mangrove Tree Crab (*Aratus pisoni*)

A detailed list of all flora and fauna observed within and peripheral to the study area is outlined in Appendix 4.

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[9] Written by Dr. Mona K Webber UWI Mona: dspace.mona.uwi.edu/.../Vol.7%20MANGROVE%20BIOTYPE%206-Common%20fauna.pdf -

4.2.5 Water Quality Analysis:

Both surface and seafloor water samples were collected at the sample stations illustrated on Figure 12A-B below, with parameters accompanying on Table 2. These sampling stations were proximate to the approach lights for the runway. Samples taken showed no significant freshwater influence (salinities varied between 30.1 -36.7ppt). Seawater temperatures varied predictably between surface and deep, with deep water samples being cooler.

All BOD samples were marginally in excess of the NEPA Marine Water Quality standards, with the exception of the nearshore surface sample point. Particularly high Faecal Coliform counts were obtained for two of three of the surface sample locations, with one marginally high result being observed for one deep sample.

All Nitrate samples were generally within the standards, however, two of the three deep samples (the most seaward) were not in compliance with the Marine Water Quality standards. Further, secchi disc readings suggested water turbidities that were particularly high.

No clear reasons could be given for the Phosphate and Faecal Coliform values observed. It is, however, suspected that the source of these parameters may have been droppings from birds roosting on the Approach lights. None were observed roosting at the time of the assessments; however, bird droppings were observed on the supports for the approach lights. It is likely that at sampling station AL4 the quantity of droppings was lower than at AL7.

Turbidity values suggested by the Secchi disc readings were probably indicative of the influence of recent flood events (Tropical Storm Nicole), with fallout of suspended materials in freshwater discharged from the Hunts Bay area, as well as the other Kingston gullies contributing visual occlusion.

4.2.6 Sea Current Measurements:

Figure 13A illustrates the direction in which surface currents measured within the study area moved during a 1 hour tracking period conducted on the 13th of October, 2010. This one hour period commenced at approximately 10:00 am. Currents generally progressed towards the northwest at a speed of approximately 10 cm/s. Prevailing wind direction and speed at the time of the tracking were from the Southeast at approximately 10 knots and surface currents tended to be moving in a direction consistent with the direction of the wind, confirming conformity with conclusions generated by Webber, Webber and Williams (2003).

Figures 13B-C illustrate the direction in which fresh water lenses observed floating on the sea on Google Earth images obtained for April 14 2006 and September 10, 2002 were moving at the time of capture. Wind directions, were deduced from wave crest and anchored vessel orientations visible on the Google earth images, as well as historical data obtained from www.wunderground.com. Fresh water lens movement appeared to be influenced by the direction of the prevailing wind, corresponding strongly with what was observed during drogue tracks done on the 13th of October, 2010. In the case of April 14, 2006, winds appeared to be easterly, while for September 10, 2002, the winds were from the south southeast (note – there was a disparity between the wind direction deduced from the September 2002 image and that represented on the wunderground.com graphics. The direction deduced from the image was used as the reference wind direction).

It is likely that the current movements generated at night would be influenced by the orientation of night winds. The wunderground.com graphics observed for October 13, 2010, April 14, 2006 and September 10, 2002 show winds originating out of the north to northwest during the night. This would generate currents moving southerly to south southeasterly during this period.

Temperature (Celsius)	30.5
Salinity (ppt)	32.5
Secchi Depth (m)	1
BOD (mg/L)	1.8
TSS (mg/L)	7.4
Nitrate as nitrogen (mg/L)	<0.3
Phosphate (mg/L)	0.03
Feacal Coliform (MPN/100mL)	920

Temperature (Celsius)	32.3
Salinity (ppt)	33.3
Secchi Depth (m)	1
BOD (mg/L)	2.4
TSS (mg/L)	9.0
Nitrate as nitrogen (mg/L)	<0.3
Phosphate (mg/L)	0.02
Feacal Coliform (MPN/100mL)	33

Temperature (Celsius)	32.0
Salinity (ppt)	36.7
Secchi Depth (m)	1
BOD (mg/L)	1.0
TSS (mg/L)	7.6
Nitrate as nitrogen (mg/L)	<0.3
Phosphate (mg/L)	0.03
Feacal Coliform (MPN/100mL)	350

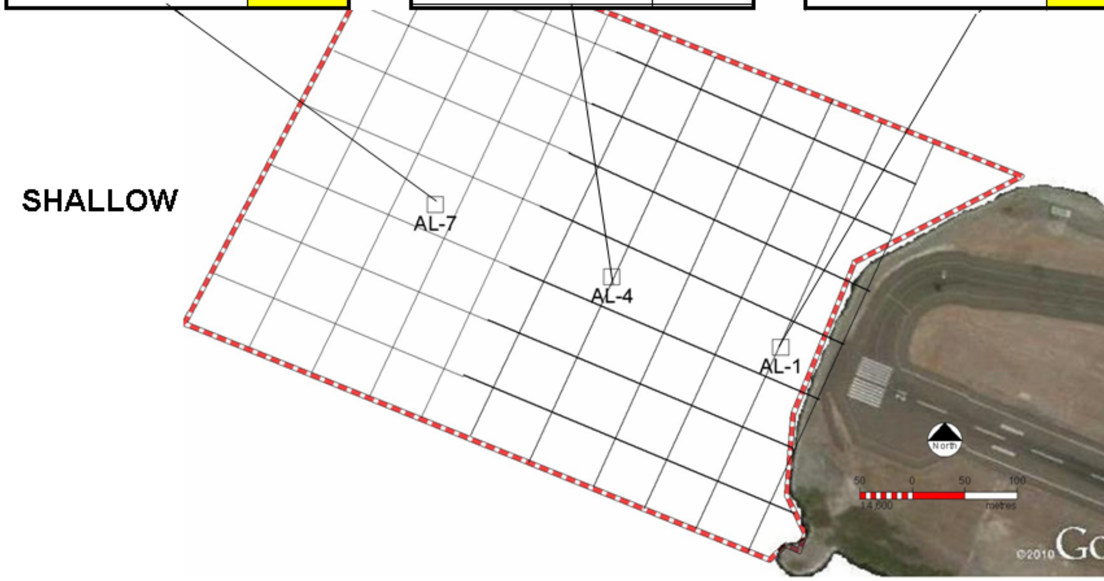

Figure 12A Water Quality Data for Surface Samples Taken Within Study Area (Yellow= Non-compliance with NEPA Marine Standards)

Temperature (Celsius)	30.1
Salinity (ppt)	33.8
Secchi Depth (m)	1
BOD (mg/L)	1.6
TSS (mg/L)	8.2
Nitrate as nitrogen (mg/L)	<0.3
Phosphate (mg/L)	0.11
Feacal Coliform (MPN/100mL)	70

Temperature (Celsius)	29.9
Salinity (ppt)	30.6
Secchi Depth (m)	1
BOD (mg/L)	2.0
TSS (mg/L)	8.6
Nitrate as nitrogen (mg/L)	<0.3
Phosphate (mg/L)	0.10
Feacal Coliform (MPN/100mL)	22

Temperature (Celsius)	30.2
Salinity (ppt)	33.0
Secchi Depth (m)	1
BOD (mg/L)	1.2
TSS (mg/L)	9.4
Nitrate as nitrogen (mg/L)	<0.3
Phosphate (mg/L)	0.02
Feacal Coliform (MPN/100mL)	33

DEEP

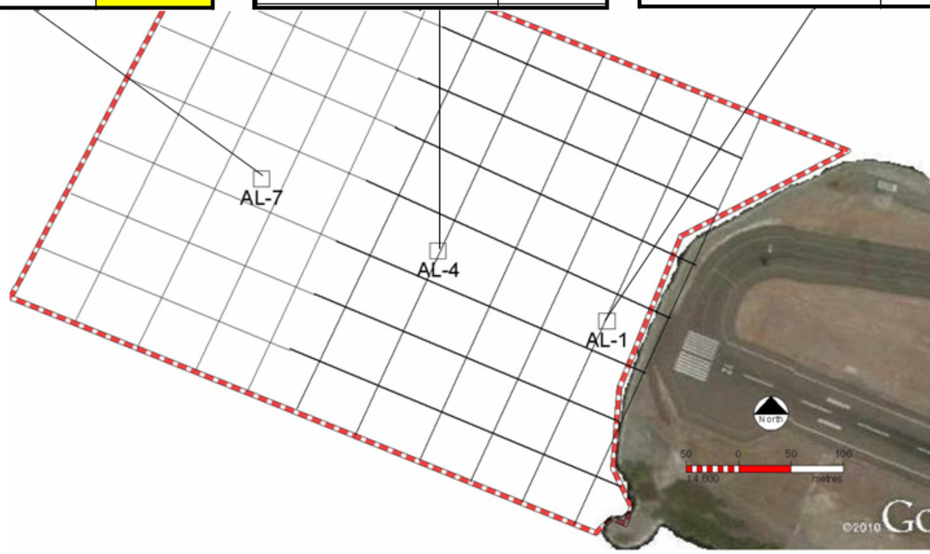

Figure 12B Water Quality Data for Bottom Samples Taken Within Study Area (Yellow = Non-compliance with NEPA Marine Standards

Table 2: Water Quality Parameters Measured Within the Study Area and Compared With NEPA Marine Standards(S=Surface, D=Deep)

PARAMETERS	SAMPLES						
	AL-#1S	AL-4S	AL-7S	AL-1D	AL-4D	AL-7D	NEPA Marine Standard
Temperature (Celsius)	32.0	32.3	30.5	30.2	29.9	30.1	-
Salinity (ppt)	36.7	33.3	32.5	33.0	30.6	33.8	-
Secchi Depth (m)	1	1	1	1	1	1	-
BOD (mg/L)	1.0	2.4	1.8	1.2	2.0	1.6	0.57-1.16
TSS (mg/L)	7.6	9.0	7.4	9.4	8.6	8.2	-
Nitrate as nitrogen (mg/L)	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.001-0.081
Phosphate (mg/L)	0.03	0.02	0.03	0.02	0.10	0.11	0.001-0.055
Faecal Coliform (MPN/100mL)	350	33	920	33	22	70	48-256

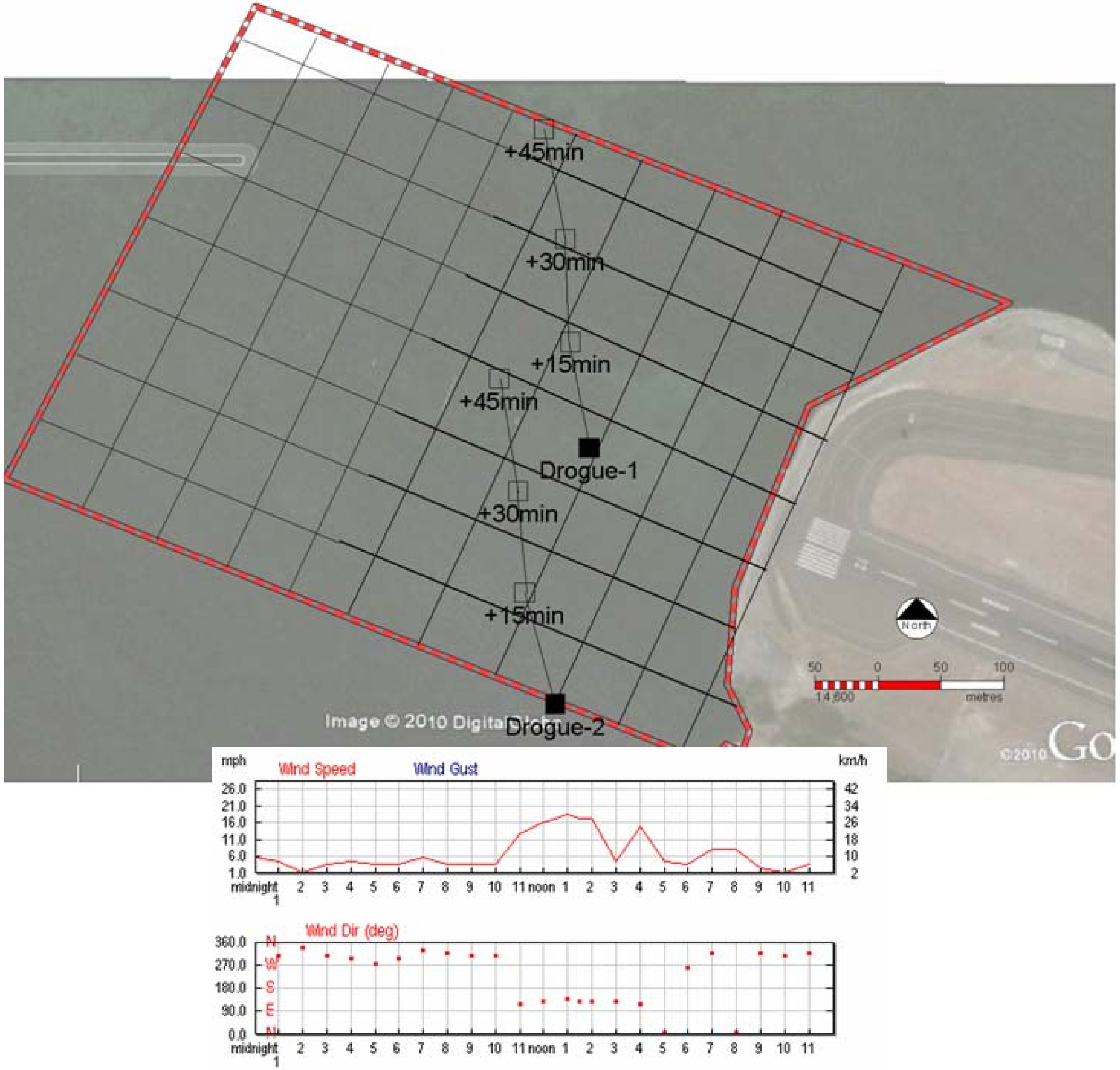

Figure 13A: Drogue Tracks for Currents Measured on October 13, 2010 Starting at 10:00am (Inset = Wind Data for 2010 Oct 13 obtained from www.wunderground.com)

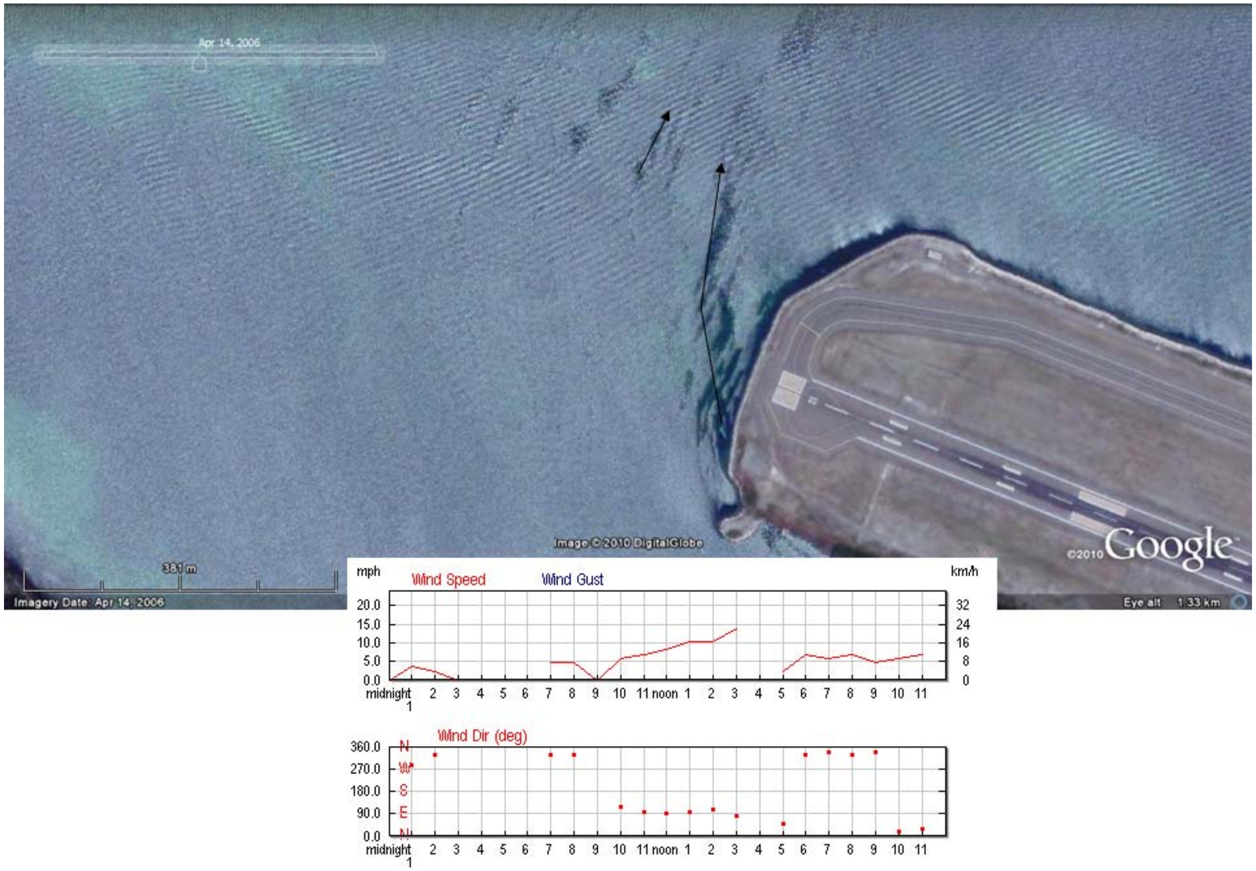

Figure 13A: Interpretation of Current Tracks from Fresh Water Lens Observed on Google Earth Images Dated April 14, 2006 (Inset = Wind Data for 2006 April 14 obtained from www.wunderground.com)

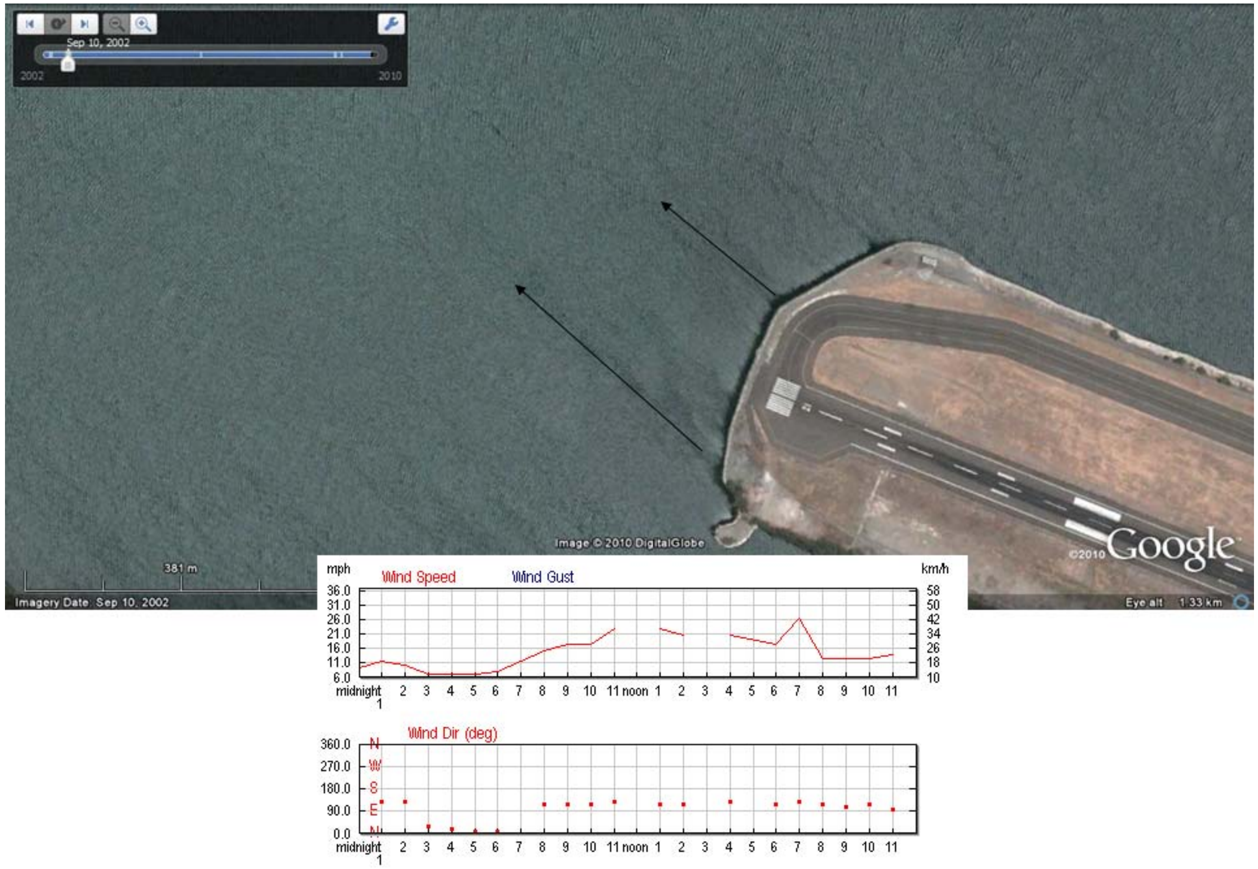

Figure 13B: Interpretation of Current Tracks from Fresh Water Lens Observed on Google Earth Images Dated September 10, 2002 (Inset = Wind Data for 2002 September 10 obtained from www.wunderground.com)

5.0 CONCLUSIONS

In summary, the following conclusions can be arrived at for the study area and its environs:

1. The Study area adjoins the Port Royal mangroves to the south, which have been identified as having important ecological features present within them and elements of this importance were observed during the REA
2. The seafloor within the Study area is comprised mainly of black sands of a land-based origin. These sediments appear to be covered with a layer of organic mud towards the southern boundary of the study area.
3. The Study area's seafloor and water column appear to be generally benign where marine life is concerned, with the exception of the presence of marine bivalves on or within the seafloor substrates, macroalgal growth and Sea Urchins towards the northeastern corner of the Study area.
4. No Seagrass beds or other important forms of benthic flora or fauna were observed within the study area. However, hard surfaces present within the study area, specifically, the supports for the approach lights, acted as a point of aggregation for sponges and a limited number of pelagic lifeforms – specifically the Mangrove Snapper.
5. Marine water quality in the vicinity of the approach lights may have been influenced by the presence of roosting birds, whose excrement may have resulted in localized contamination
6. Marine currents appeared to be influenced by the direction and intensity of the prevailing wind.

It is therefore unlikely that the act of landfilling within the footprint of the study area will have any significant impact on marine benthic or pelagic resources within this area. Peripheral areas, particularly the Port Royal mangroves to the south of the study area could, however, be put at risk, especially by the movement of suspended solids generated by the act of landfilling. These impacts would most likely occur at night, since the prevailing wind/current movement would be towards this area. Mitigations to be implemented for the proposed work must consider this possibility.

APPENDICES

APPENDIX 1: THE RELATIVE IMPORTANCE OF METEOROLOGICAL EVENTS, TIDAL ACTIVITY AND BATHYMETRY TO CIRCULATION AND MIXING IN KINGSTON HARBOUR, JAMAICA *DALE F. WEBBER, MONA K. WEBBER AND DOREEN D. WILLIAMS*

APPENDIX 2: FACTUAL REPORT AIRPORTS AUTHORITY OF JAMAICA PROPOSED RESA EXTENSION FOR NMIA RUNWAY, PALISADOES, KINGSTON, JAMAICA

APPENDIX 3: BIODIVERSITY OF JAMAICAN MANGROVE AREAS VOLUME 7, MANGROVE BIOTYPES VI: COMMON FAUNA BY MONA WEBBER (PH.D)

APPENDIX 4: FLORA AND FAUNA OBSERVED WITHIN AND PERIPHERAL TO THE NMIA STUDY AREA