REPORT

PROPOSED SEAGRASS RELOCATION AND REPLANTING AND CORAL RELOCATION METHODOLOGY

FIESTA JAMAICA LIMITED, HANOVER

Submitted to
NATIONAL ENVIRONMENT AND PLANNING AGENCY
10 Caledonia Avenue
Kingston 5

In collaboration with

JUNE 2006

REPORT

PROPOSED SEAGRASS RELOCATION AND REPLANTING AND CORAL RELOCATION METHODOLOGY

FIESTA JAMAICA LIMITED, HANOVER

Submitted to
NATIONAL ENVIRONMENT AND PLANNING AGENCY
10 Caledonia Avenue
Kingston 5

Submitted by
C.L. ENVIRONMENTAL
Town House 21
Perkins Estate
1 Perkins Boulevard
Kingston 19

JUNE 2006

TABLE OF CONTENTS

TABLE OF CONTENTS iii
LIST OF TABLES iv
LIST OF PLATES iv
LIST OF FIGURES iv
1.0 INTRODUCTION 1
2.0 METHODOLOGY 1
3.0 STUDY TEAM 4
4.0 RESULTS 5
4.1 TEMPERATURE 5
4.2 DISSOLVED OXYGEN 7
4.3 SALINITY 9
4.4 pH 11
4.5 TOTAL SUSPENDED SOLIDS 13
4.6 LIGHT EXTINCTION 15
4.7 NITRATES 15
4.8 ORTHO-PHOSPHATES 17
4.9 BIOCHEMICAL OXYGEN DEMAND 19
5.0 SEAGRASS BED AREA 21
5.1 DEPTH 23
5.2 SEDIMENT TYPES 23
5.3 SEAGRASS BED HEALTH 23
5.4 CURRENT REGIME 24
5.5 SWELL WAVES 26
6.0 REPLANTING METHODOLOGY 30
6.1 PREPARATION OF THE SITE 30
6.2 AT THE HARVESTING SITE 32
6.3 HARVESTING AND REPLANTING PERIODICITY 32
6.4 REPLANTING METHOD 33
6.5 MONITORING DURING REMOVAL 33
6.6 LOCATION OF REPLANTING 33
7.0 ALTERNATIVE 37
8.0 MONITORING OF REPLANTED MATS AND MERISTEMS 39
8.1 Contingencies 39
8.2 Designated Monitor 39
8.3 Reports 39
9.0 RELOCATION OF CORALS 41
10.0 REMOVAL AND RELOCATION OF OTHER MARINE FLORA AND FAUNA 43
11.0 CONCLUSIONS 43

LIST OF TABLES

Table 1 Water temperature by stations 5
Table 2 Dissolved oxygen levels by stations 7
Table 3 Salinity concentrations by stations.......... 9
Table 4 pH levels by stations 11
Table 5 Total suspended solids by stations 13
Table 6 Nitrate concentration by station 15
Table 7 Phosphate concentrations by stations.......... 17
Table 8 BOD levels by stations.......... 19
Table 9 Table depicted replanting locations and areas identified so far 35
Table 10 Example of the seagrass monitoring sheet.......... 40

LIST OF PLATES

Plate 1 Seagrass at the western end of the proposed Southern Beach 1 23
Plate 2 Seagrass at the western end of the proposed beach area.......... 23
Plate 3 Seagrass located in the central section of the proposed beach area.......... 23
Plate 4 Examples of seagrass beds located at the proposed Southern Beach 1 23
Plate 5 Examples of seagrass beds located at the proposed Southern Beach 2 24

LIST OF FIGURES

Figure 1 Beach locations 2
Figure 2 Map depicting temperature levels 6
Figure 3 Map depicting dissolved oxygen levels 8
Figure 4 Map depicting salinity concentrations 10
Figure 5 Map depicting pH levels 12
Figure 6 Map depicting total suspended solids 14
Figure 7 Map depicting nitrate concentrations.......... 16
Figure 8 Map depicting phosphate concentrations.......... 18
Figure 9 Map depicting BOD levels.......... 20
Figure 10 Map depicting seagrass bed locations 22
Figure 11 Currents measured (blue – surface drogues, green – sub surface drogues) .. 25
Figure 12 Swell waves from the north 26
Figure 13 Swell waves from the North East.......... 27
Figure 14 Swell waves from the North West 28
Figure 15 Swell waves from the West.......... 29
Figure 16 Example of turbidity screen (in red and black) enclosing the work area.. 31
Figure 17 Map depicting areas most suitable for replanting the reaped seagrass 34
Figure 18 Ideal replanting areas and areas that are currently bare 36
Figure 19 Diagram illustrating the Southern Beach 1 reduced to 40m seawards 38

1.0 INTRODUCTION

Fiesta Jamaica Limited is desirous of creating three (3) bathing beaches for their prospective guests when their hotel development is completed (Figure 1). Two areas that have been identified have seagrass growth on the seafloor.

This report was prepared at the request of Fiesta Jamaica Limited. It involves the mapping and assessment of the seagrass community within the proposed beach area and provides the guidelines and methodologies to be employed in the successful removal and replanting of the seagrass community.

2.0 METHODOLOGY

Physio-chemical data were collected at ten (10) locations within the bay.
The parameters collected were;

Temperature	Nitrates
Salinity	Ortho-Phosphates
Dissolved Oxygen	Total Suspended Solids
pH	Biochemical Oxygen Demand
Sediment Type	Currents
Waves	Depths
Light Extinction	

Temperature, salinity, dissolved oxygen and **pH** was collected *in situ* using a YSI 550 meter.

Nitrates, ortho-phosphates, total suspended solids and **biochemical oxygen demand** (BOD_5) determination were conducted on whole water samples collected subsurface. These samples were stored in a cooler and transported to the Environmental Technical and Analytical Services Ltd. for analyses.

BOD_5 was determined by the method in the – Standard Methods for the Examination of Water and Wastewater, 19^{th} Ed. American Public Health Association, American Water Works Association, Water environment federation. 1995. 1000pp.

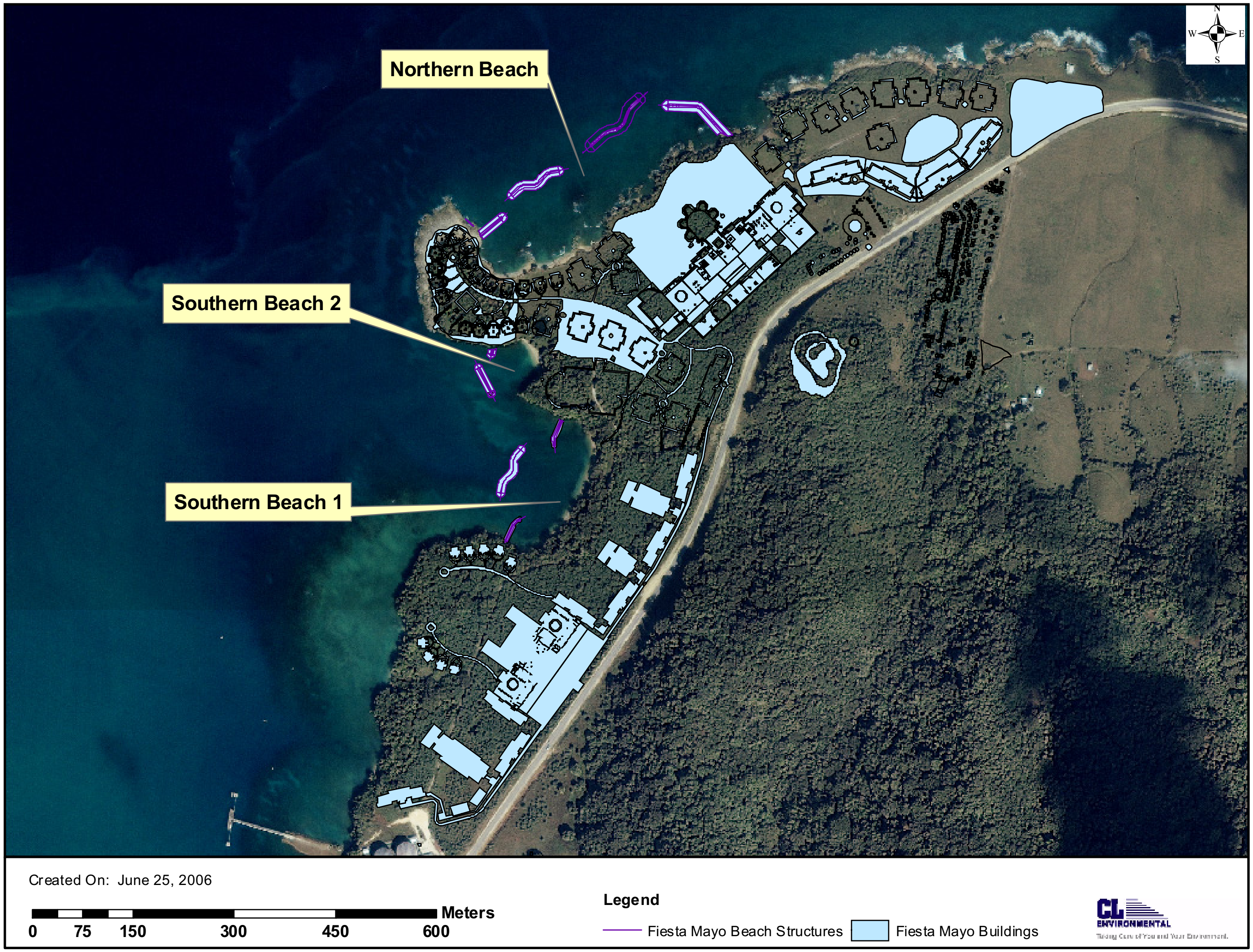


Figure 1 **Beach locations**

The **wave climate** within the Study Area was ascertained by investigating both the deepwater and near shore environment. This is broken down as follows;

1. Deepwater wave climate determined by:
    a. Deepwater hurricane waves determined by Extremal analysis of hurricanes passing within 500 kilometres of site.
    b. Swell and operational waves determined from 5 years historical wind data for Jamaica and hindcasting of wave climate using JONSWAP wave model, and
2. Near shore wave climate determined by refraction and diffraction modeling on bathymetry of site to determine wave height and direction close to shoreline

Currents around the site and offshore were determined using drogues during three sessions of drogue tracking. Winds for particular days (drogue tracking) were determined from the National DATA Buoy Center.

A hydrodynamic model was developed and calibrated for days for drogue tracking. The calibrated model was executed for <u>existing shoreline conditions and proposed shoreline configuration with structures in place</u>:

a. Easterly winds and NW winds (which are believed to be the worst wind directions for the southern beaches)
b. Slow, Average and Fast wind conditions

Currents for the surface and for mid-depth were extracted from the model.

Mapping – the maps were generated using the process of interpolation of the results of the parameters at the ten (10) stations. The number of stations and the proximity of these stations to each other within the area of interest provide an accurate characterisation of the area.

3.0 STUDY TEAM

Carlton Campbell (M.Phil) – Marine scientist

David Narinesingh - Oceanographer

Hugh Small (BSc), MPhil. Pending – Marine scientist Biologist

Najwa Barnes (BSc), MPhil. Pending – Environmental Scientist

Christopher Burgess (MSc., PE.) *et al.* of CEAC Solutions – Coastal Engineers

4.0 RESULTS

4.1 TEMPERATURE

Average temperature at the ten stations was 29.54 ^{o}C. Temperature levels ranged from a low of 29.02 ^{o}C (Station 9) to a high of 30.44 ^{o}C (Station 4) (Table 1). As expected, lower temperature levels were found at areas exposed to the open seas (oceanic water generally cooler). The highest temperature occurred at the northern coastline of Beach (Figure 2).

Table 1 Water temperature by stations

STATION NUMBER	TEMPERATURE (^{o}C)
1	29.27
2	29.88
3	29.23
4	30.44
5	29.65
6	29.76
7	29.66
8	29.10
9	29.02
10	29.35

The water temperatures recorded was expected in a tropical marine area influenced by the Trade Winds (≈27 –30 ^{o}C).

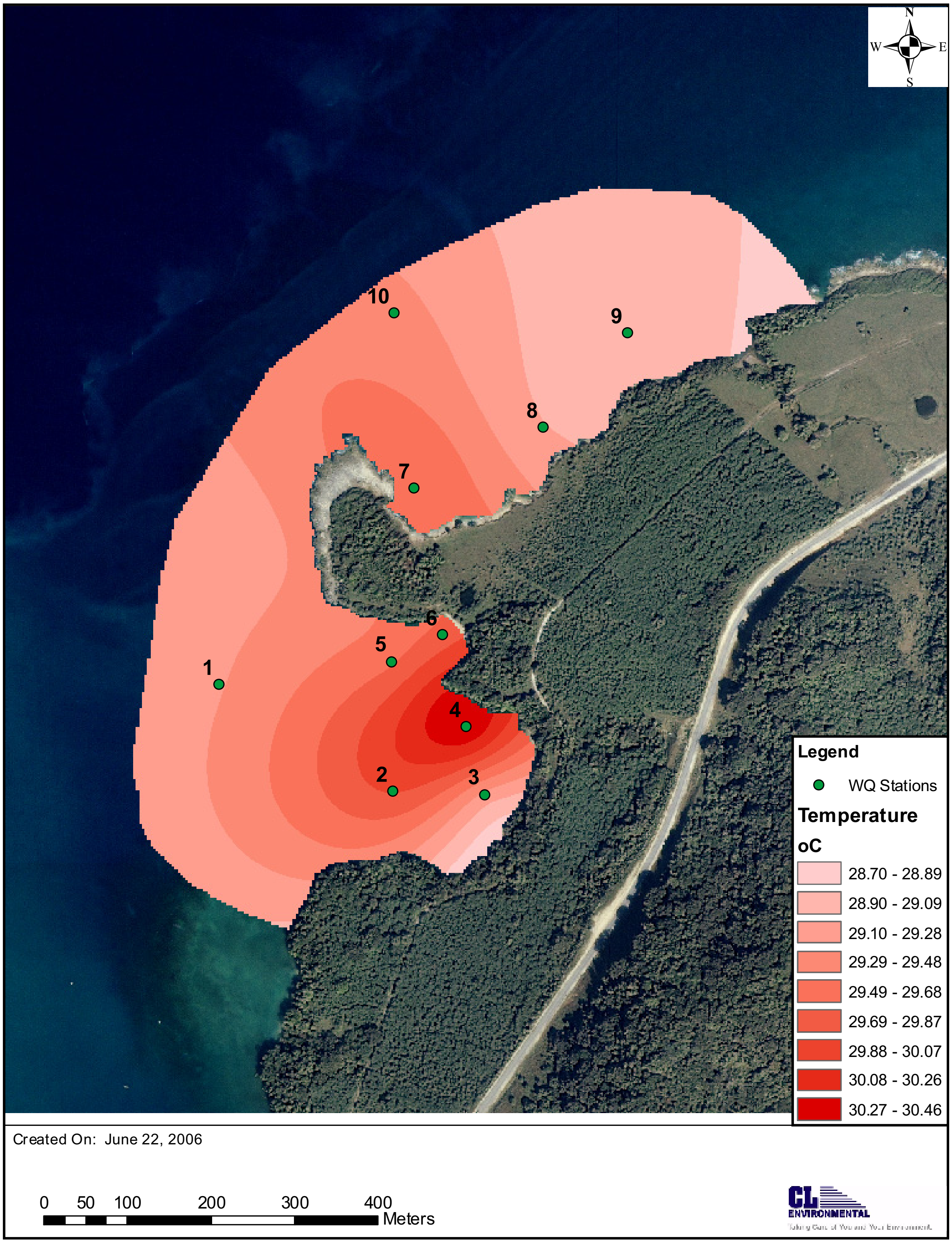


Figure 2 Map depicting temperature levels

4.2 DISSOLVED OXYGEN

Average dissolved oxygen concentrations recorded at the ten stations were 6.10 mg/l. Dissolved oxygen levels ranged from 4.77 mg/l (Station 1) to 7.79 mg/l (Station 7) (Table 2).

Table 2 Dissolved oxygen levels by stations

STATION NUMBER	DISSOLVED OXYGEN (mg/l)
1	4.77
2	5.49
3	5.83
4	6.71
5	6.06
6	6.30
7	7.79
8	6.00
9	6.06
10	5.98

From Figure 3 it is observed that lower dissolved oxygen levels were generally lower at the western sector. Within the Study Area, the highest dissolved oxygen concentrations occurred in proximity to the rocky shore. The breaking of waves on this shoreline could contribute to the higher dissolved oxygen at those stations in proximity.

Dissolved oxygen levels were all within acceptable levels (>4 mg/l) and above the level that would be considered detrimental to aquatic life (≤ 3 mg/l).

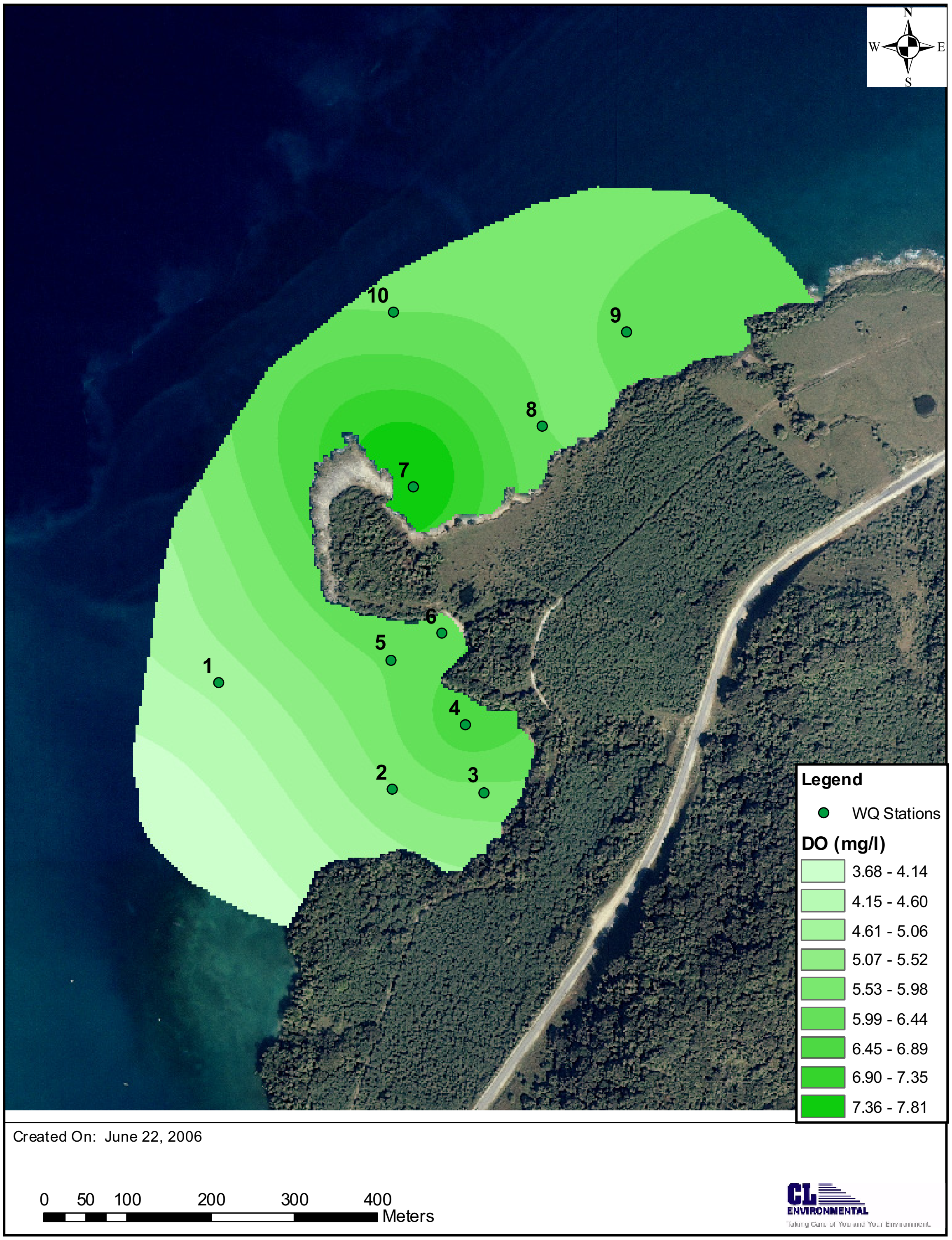


Figure 3 Map depicting dissolved oxygen levels

4.3 SALINITY

Average salinity levels recorded at the ten stations were 36.33 ‰. Salinity levels ranged from 36.28 ‰ (Station 8) to 36.37 ‰ (Station 3) (Table 3). Salinity levels were consistent with that considered marine (Figure 4).

Table 3 Salinity concentrations by stations

STATION NUMBER	SALINITY (‰)
1	36.34
2	36.32
3	36.37
4	36.31
5	36.36
6	36.35
7	36.34
8	36.28
9	36.38
10	36.29

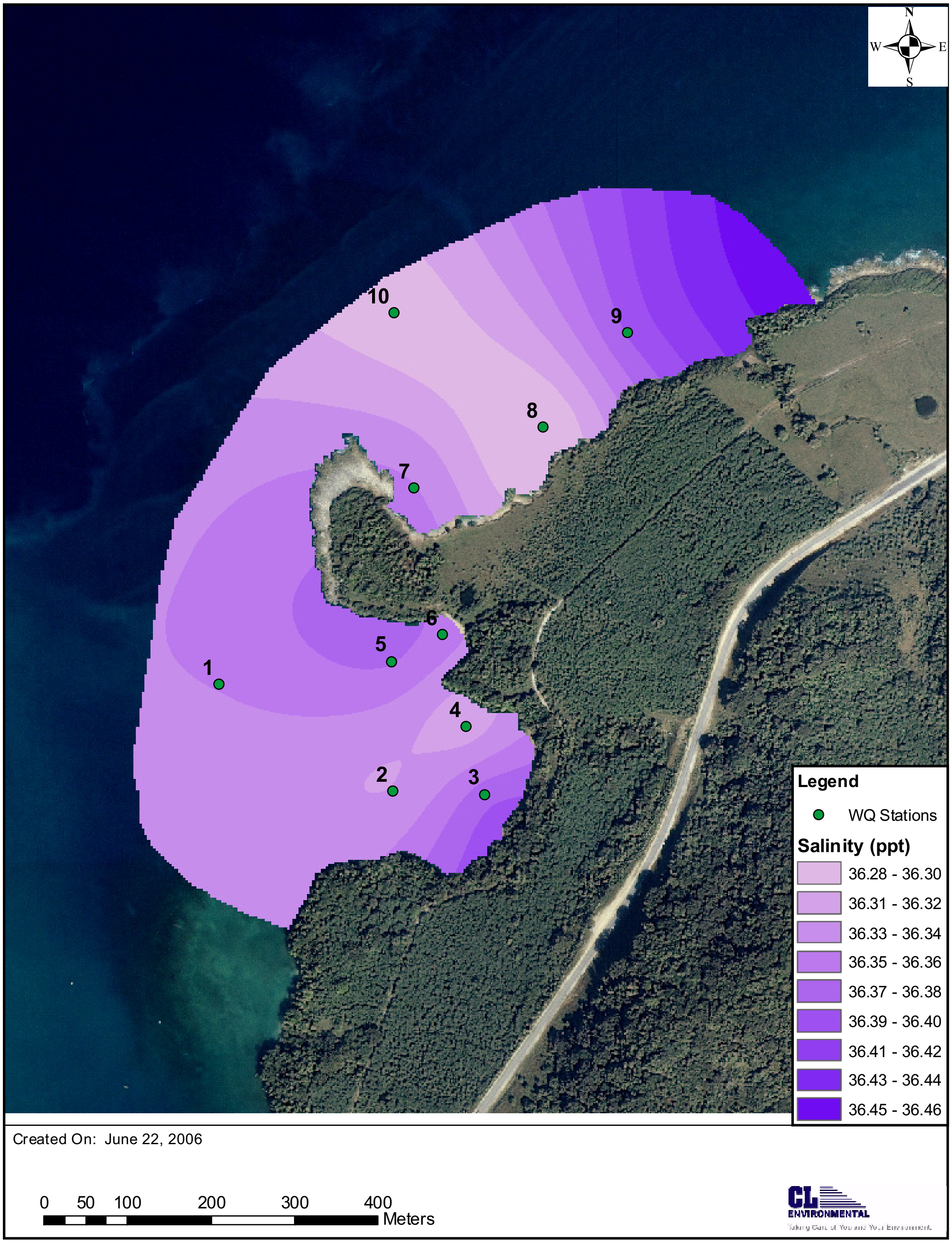


Figure 4 **Map depicting salinity concentrations**

4.4 pH

Average pH among the ten stations was 8.31 pH units. The levels ranged from 8.27 (Station 1) to 8.38 pH units (Station 7) (Table 4). In marine waters pH levels tend to range between 8-9 pH units.

Table 4 pH levels by stations

STATION NUMBER	pH
1	8.27
2	8.28
3	8.31
4	8.31
5	8.31
6	8.33
7	8.38
8	8.28
9	8.29
10	8.33

The highest pH levels (alkaline) were found along the rocky shore at the western end of Northern Beach (Figure 5). Higher pH normally indicates the possibility of photosynthesis changing the pH within the zone. The absence of obvious plant material suggests that the increased pH may be as a result of wave action acting on the ironshore rock coastline with the release of calcium carbonate which increases the alkalinity.

This is further supported by the fact that this area also experiences higher dissolved oxygen which may be a result of physical aeration of the water column from waves breaking on the rocky shoreline.

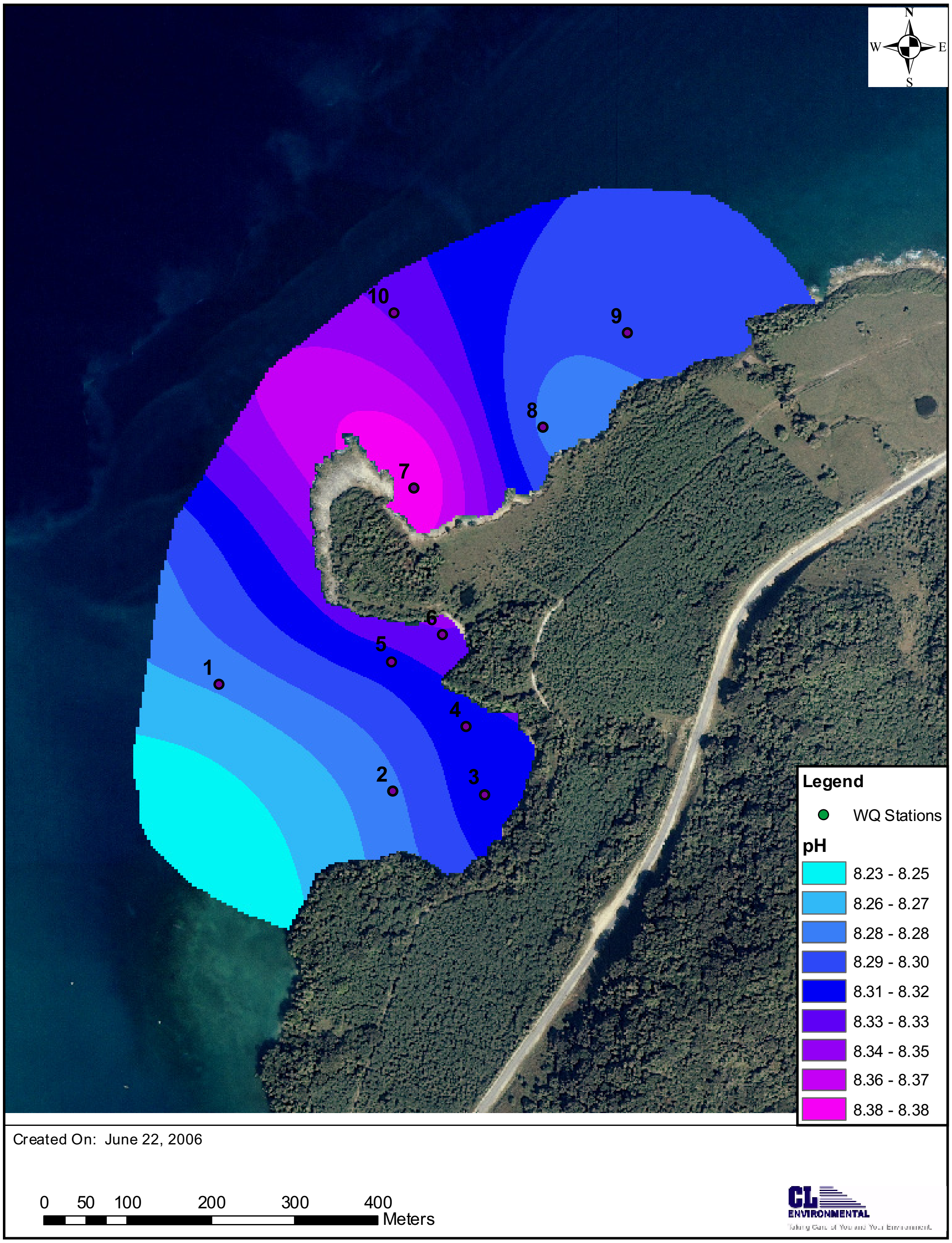


Figure 5 Map depicting pH levels

4.5 TOTAL SUSPENDED SOLIDS

Average total suspended solids concentration at the ten stations 133.39 mg/l. The lowest level occurred at Station 3 (113.34 mg/l) and the highest level at Station 4 (163.14 mg/l) (Table 5).

Table 5 Total suspended solids by stations

STATION NUMBER	TOTAL SUSPENDED SOLIDS (mg/l)
1	149.59
2	136.12
3	113.34
4	163.14
5	147.50
6	134.47
7	121.84
8	120.97
9	138.47
10	108.42

Total suspended solids concentration generally increases towards the coastline (Figure 6). The levels of total suspended solids were generally high.

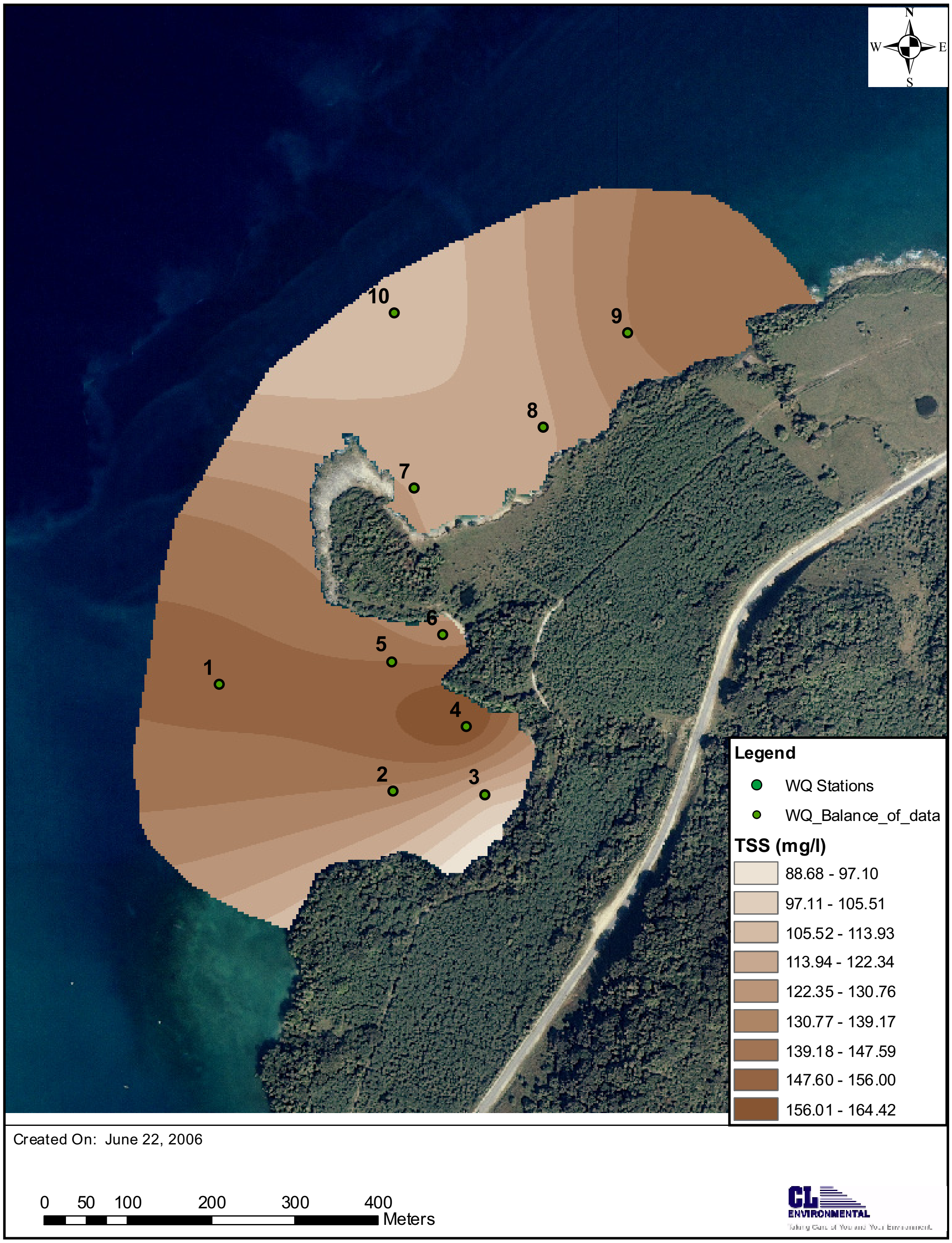


Figure 6 **Map depicting total suspended solids**

4.6 LIGHT EXTINCTION

At all stations where water quality and potential relocation sites are, visibility was to the bottom.

4.7 NITRATES

Average nitrate concentration for the ten stations was 0.78 mg/l. Concentration ranged from <0.76 mg/l to 0.88 mg/l (Stations 5 and 10) (Table 6).

Table 6 Nitrate concentration by station

STATION NUMBER	NITRATES (mg/l)
1	<0.76
2	<0.76
3	<0.76
4	<0.76
5	0.88
6	<0.76
7	<0.76
8	<0.76
9	<0.76
10	0.88

Possible sources of nitrate concentrations occur at Stations 5 and 10 (Figure 7). The nitrate concentrations within the Bay were all above the standard of 0.1 mg/l.

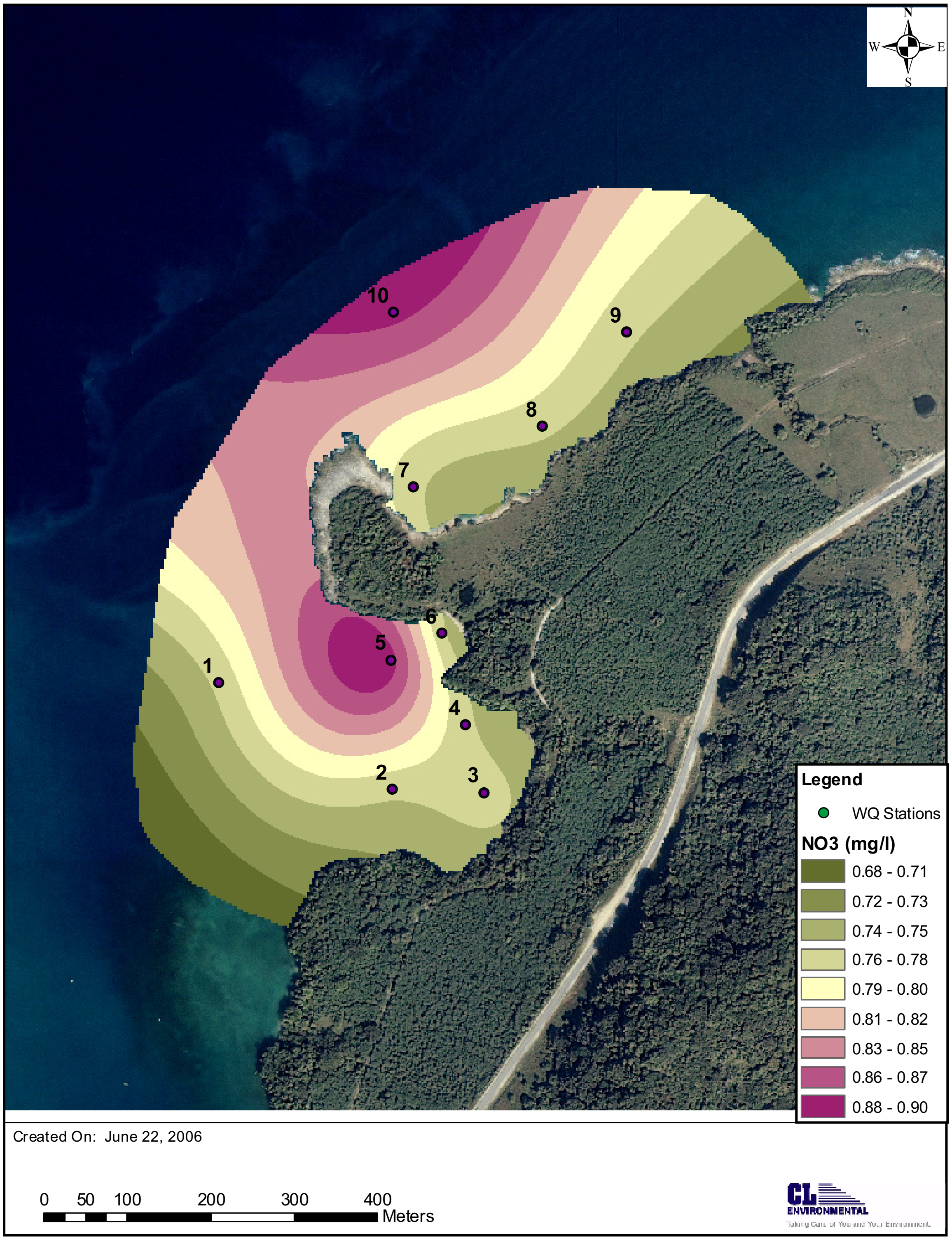


Figure 7 Map depicting nitrate concentrations

4.8 ORTHO-PHOSPHATES

Average phosphate concentration for the ten stations was 0.33 mg/l. Concentration ranged from <0.02 mg/l to 1.33 mg/l (Station 3) (Table 7).

Table 7 Phosphate concentrations by stations

STATION NUMBER	PHOSPHATES (mg/l)
1	0.27
2	0.75
3	1.33
4	0.61
5	0.23
6	<0.02
7	<0.02
8	<0.02
9	<0.02
10	<0.02

The coastline at Southern Beach 1 had the highest phosphate concentrations (Figure 8). This figure depicts the distribution of phosphates.

Phosphate concentrations within proximity to Southern Beach 1 were all above the standard of 0.01 mg/l.

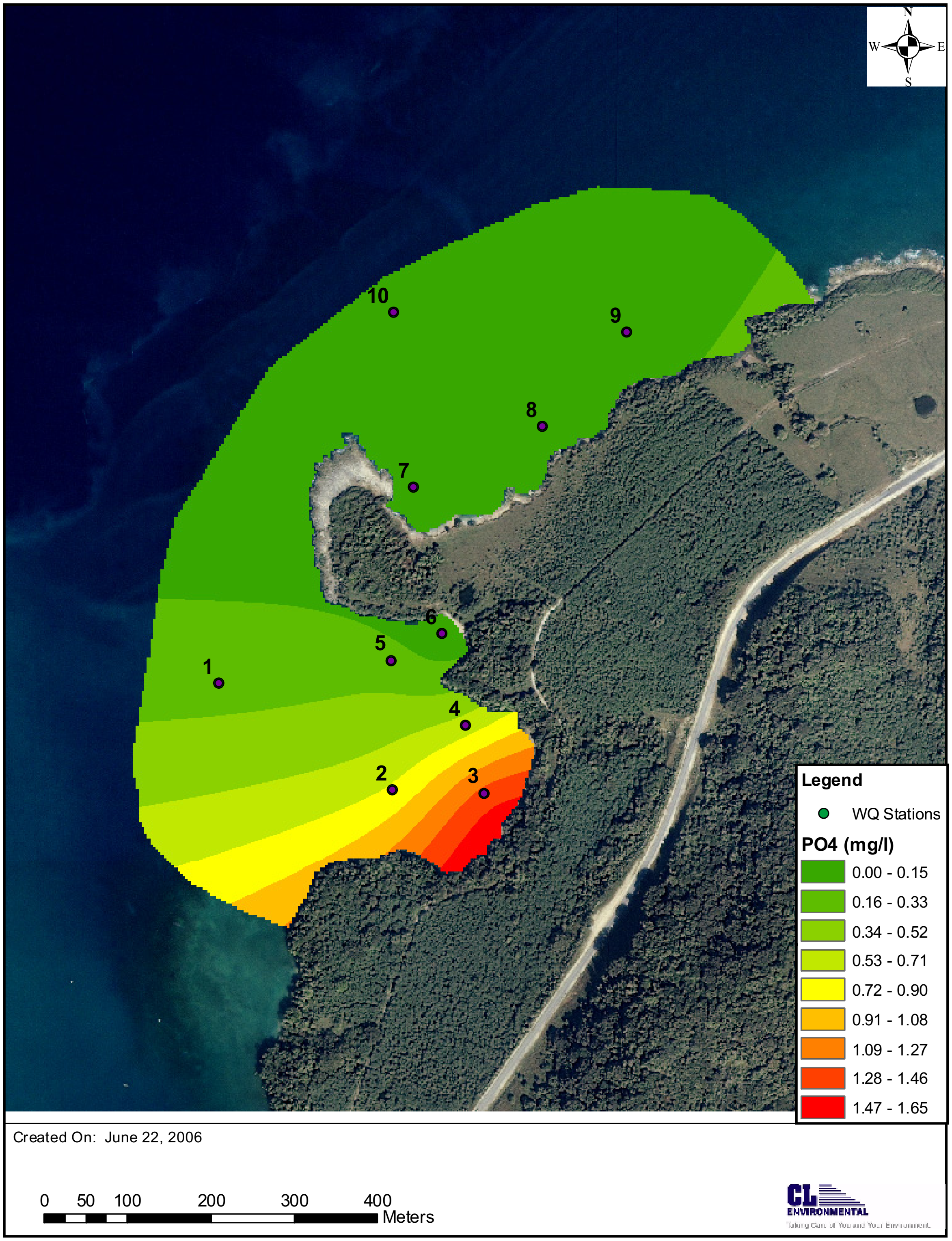


Figure 8 Map depicting phosphate concentrations

4.9 BIOCHEMICAL OXYGEN DEMAND

Average biochemical oxygen demand for the ten stations was 3.18 mg/l. The lowest level was at Station 10 (2.30 mg/l) and the highest at Station 1 (5.00 mg/l) (Table 8) (Figure 9).

Biological chemical oxygen demand is an empirical test used to estimate the relative oxygen requirements of wastewaters, effluents and polluted waters. It is used as an approximate measure of the amount of bio-chemically degradable organic matter present within a sample. Biological oxygen demand concentrations for all stations while within the required NEPA standard of 10 mg/l were somewhat elevated. This may be a result of the high total suspended solids within the water column.

Table 8 BOD levels by stations

STATION NUMBER	BIOCHEMICAL OXYGEN DEMAND (mg/l)
1	5.00
2	2.90
3	2.60
4	3.80
5	2.80
6	4.10
7	3.00
8	2.70
9	2.60
10	2.30

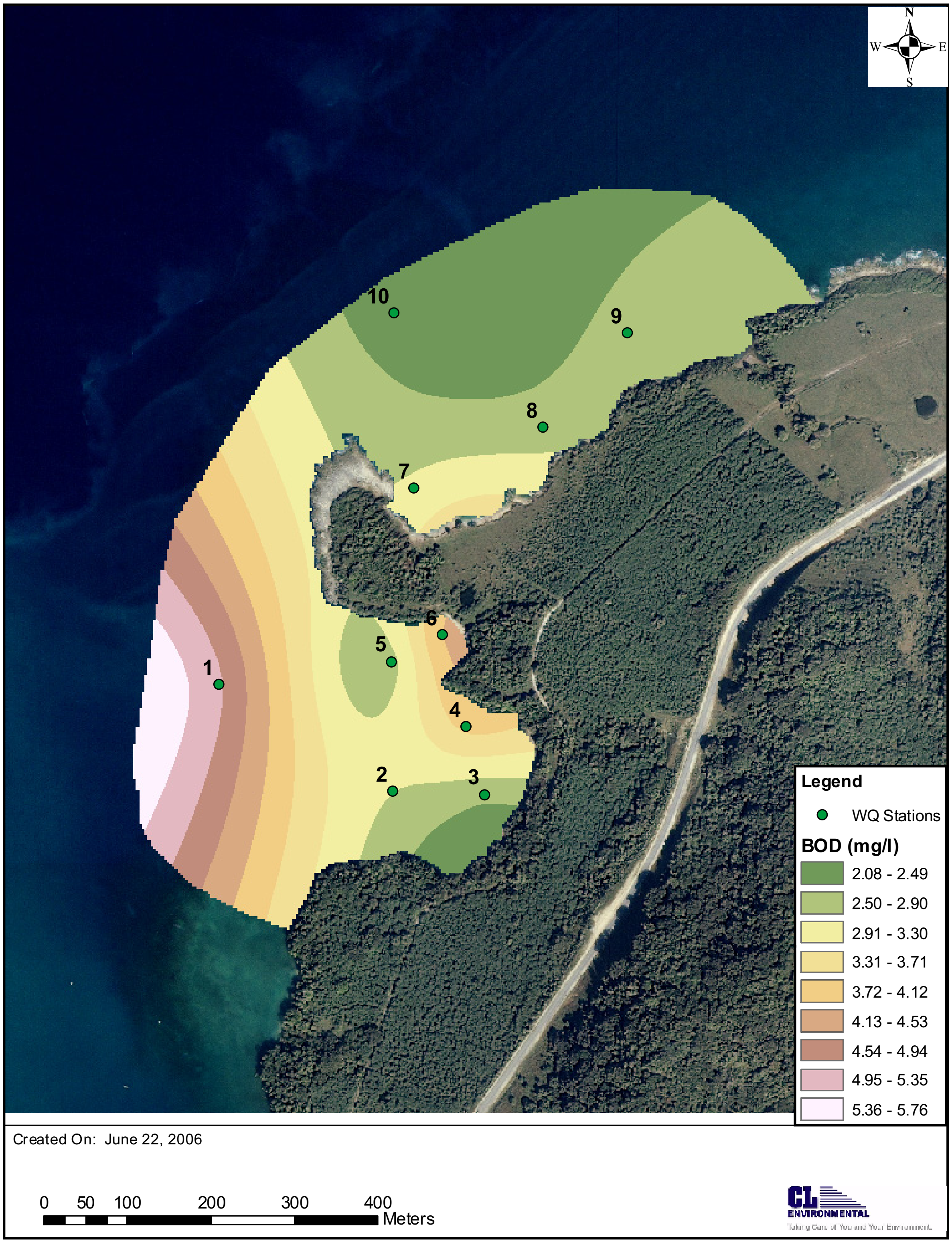


Figure 9 **Map depicting BOD levels**

5.0 SEAGRASS BED AREA

The area for seagrass removal applied for to NEPA is located approximately within one hundred and thirty metres (130 m) of the shoreline (Figure 10). The proposal involves the removal of approximately 8,449.84 m^2 (≈ 0.85 ha or ≈ 2.1 acres) of seagrass. Approximately 99% of this area is covered by *Thalassia testudinum* species with the balance being *Syringodium filiforme.*

5.1 SOUTHERN BEACH 1

The Southern Beach 1 had most of the seagrass with a total area of 8,066.66 m^2. Of this total, approximately 50 m^2 was *Syringodium filiforme.*

5.2 SOUTHERN BEACH 2

The area of Seagrass at the Southern Beach 2 was approximately 383.18 m^2 all of which was *Thalassia testudinum*.

5.3 NORTHERN BEACH

Seagrass beds in this area are virtually non-existent. This may be due to the rocky substrate and the high wave exposure at this beach. Any growth was sparse and was generally in poor health.

An alternative to this proposed plan is examined (Section 7.0). This alternative seeks to reduce the area of seagrass to be removed.

Figure 10 Map depicting seagrass bed locations

5.1 DEPTH

The seagrass beds within the area to be removed and replanted are found in an average water depths ranging from approximately 0.5m to approximately 4.7m.

5.2 SEDIMENT TYPES

Sediment types within the seagrass beds were noted. The sediments were mainly sand with some beds being established on hard coralline material

5.3 SEAGRASS BED HEALTH

The seagrass beds were generally in good health with some of the blades showing signs of grazing. The beds located at the Southern Beach 1 (Plate 4) were generally healthier than those at Southern Beach 2 although some beds at this beach were healthy.

Plate 4 Examples of seagrass beds located at the proposed Southern Beach 1

Plate 5 Examples of seagrass beds located at the proposed Southern Beach 2

5.4 CURRENT REGIME

No significant change was observed in the current velocities between the rising and falling tide measurements. Current velocities closest to the proposed beach area ranged from 0.5 to 2.0 cm/s, and flowed in a predominant westerly direction (Figure 11).

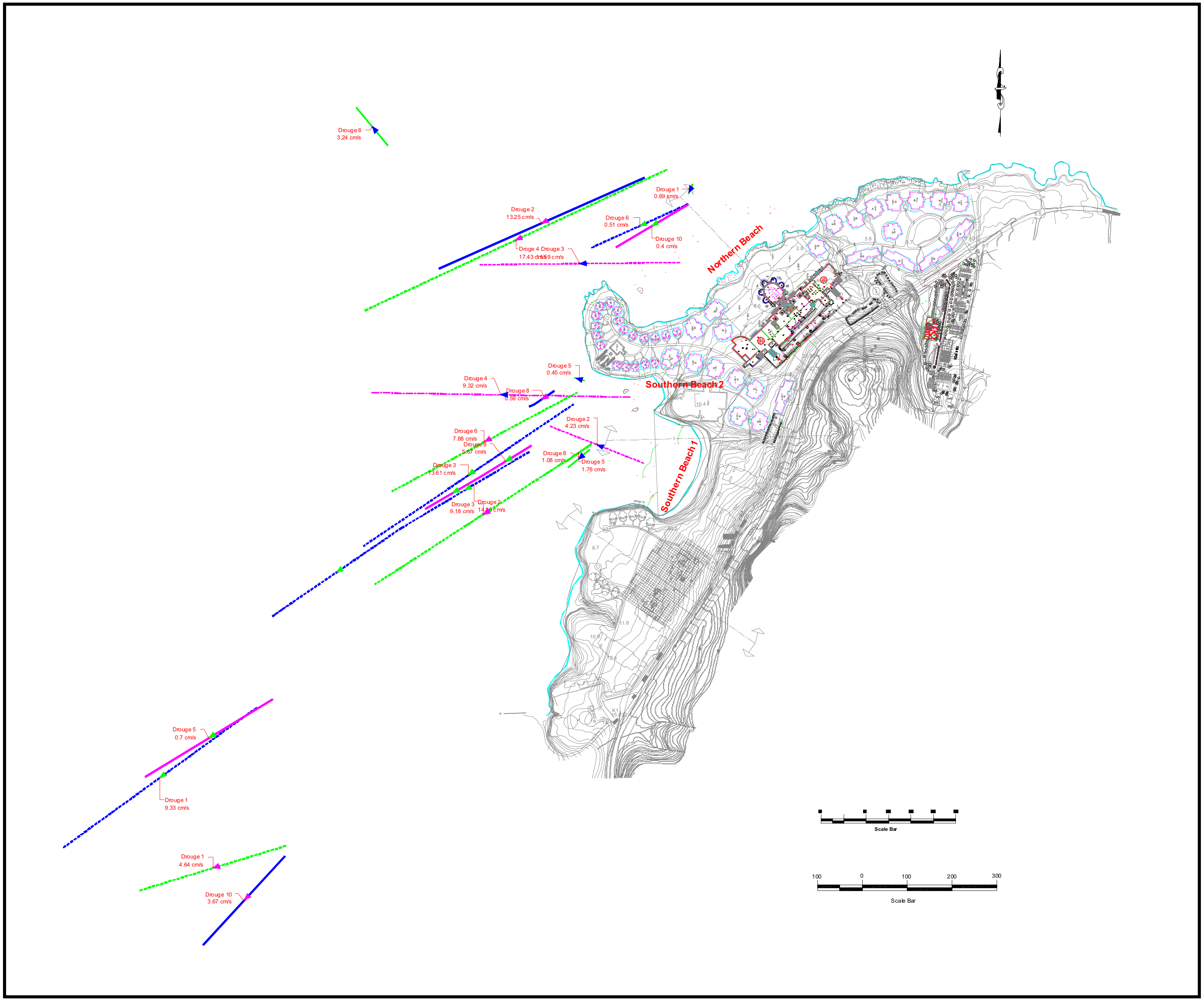


Figure 11 Currents measured (blue – surface drogues, green – sub surface drogues)

5.5 SWELL WAVES

Analysis was done on waves impacting on the three beaches (Southern Beach 1, Southern Beach 2 and Northern Beach) (Figures 12 – 15). Waves coming from four directions were analysed. These were from the North, North East, North West and West.

The results showed that Southern Beach 1 and 2 and proximity were impacted by the highest waves of below 1m coming from the West. Waves coming from the north were generally less than 0.4m, those from north east were generally less than 0.1m, and waves from the north west were generally less than 0.9m.

At the Northern Beach and proximity the highest waves of less than 2.5m were generally from the North East and North West. Waves from the west were generally less than 1m and those from the north were less than 1.9m.

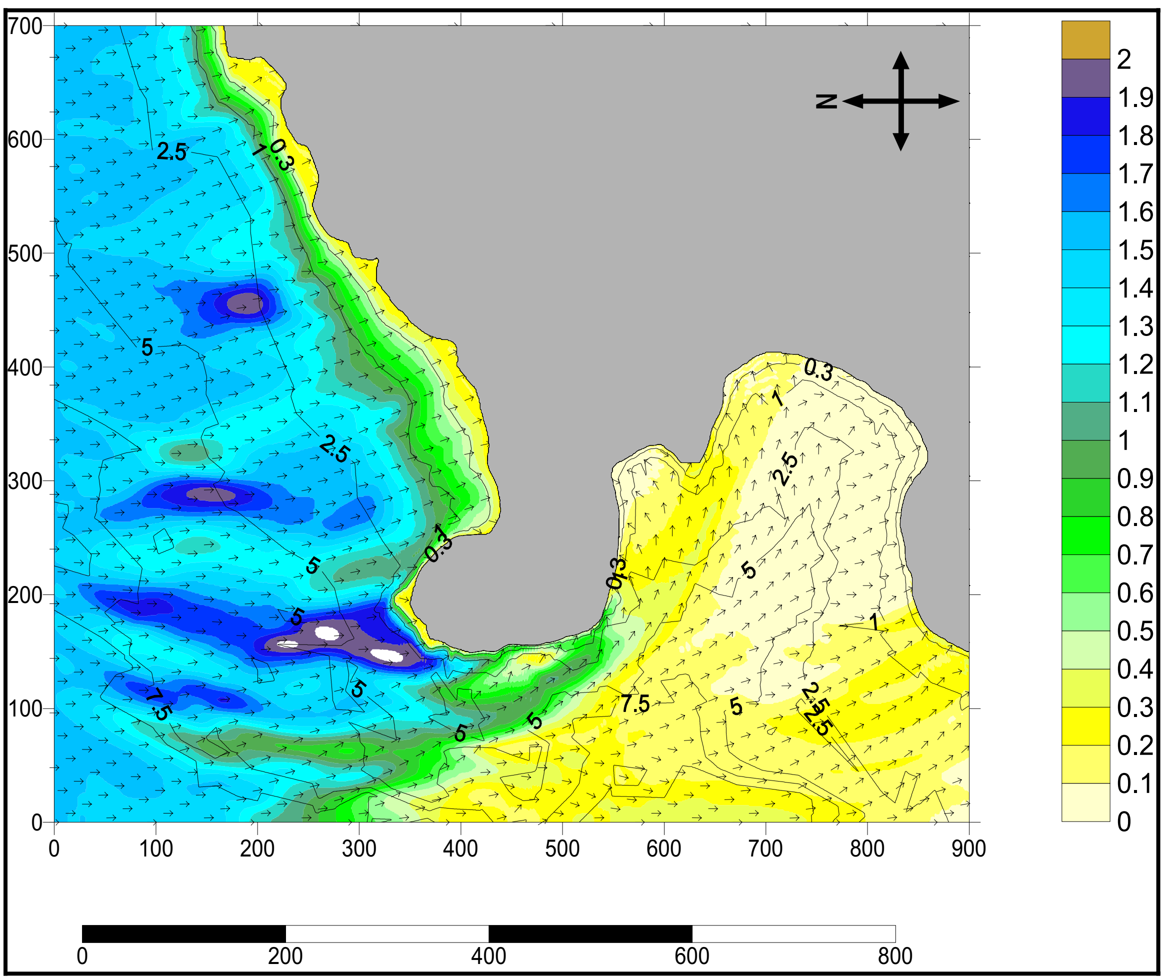


Figure 12 Swell waves from the north

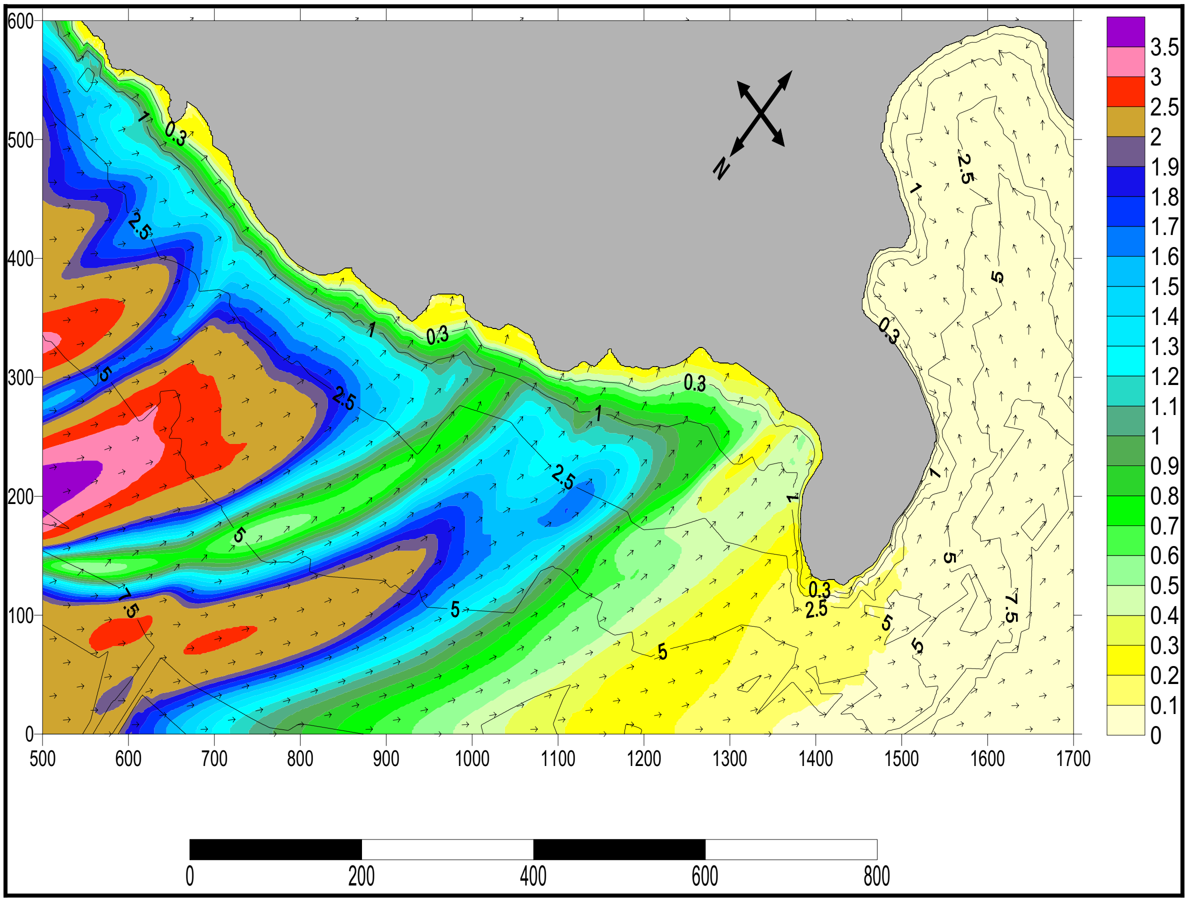


Figure 13 Swell waves from the North East

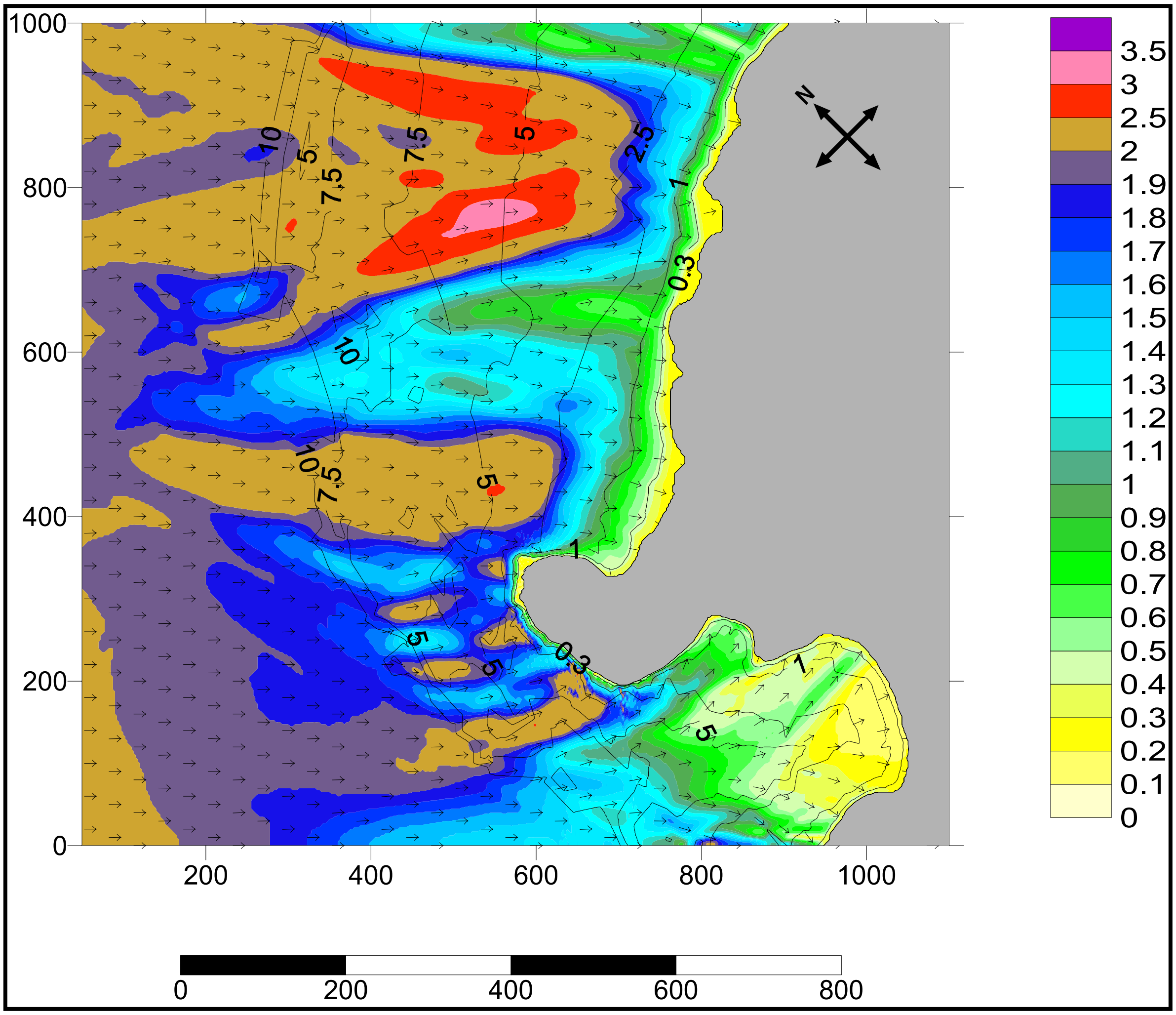


Figure 14 **Swell waves from the North West**

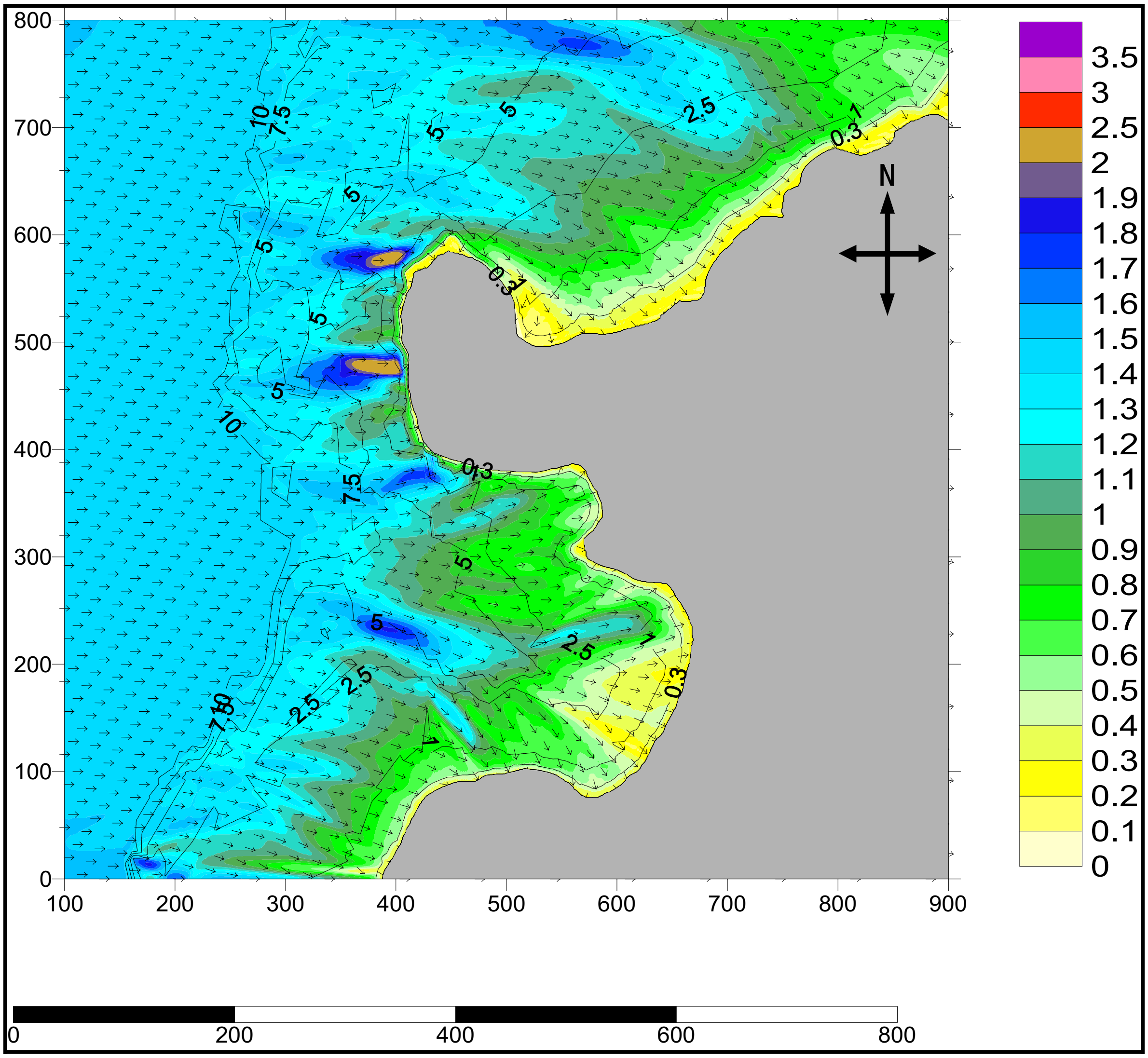


Figure 15 **Swell waves from the West**

6.0 REPLANTING METHODOLOGY

The Mat Method will be used to reap the seagrass for replanting. The proposed harvesting method is universal and in addition, all the seagrass to be harvested is *Thalassia testudinum* so there is no need for species specific harvesting methods.

The **Mat Method** which entails digging into manageable sections of the seagrass beds with shovels. The sections are removed with the rhizomes and soils attached and replanted in the designated relocation site. This method will not be species specific, as all the species will be transferred within the bed.

6.1 PREPARATION OF THE SITE

The area within which the removal will take place will be enclosed with **turbidity curtains** (screens). At the removal area the turbidity curtain will extend from the shoreline (Figure 16).

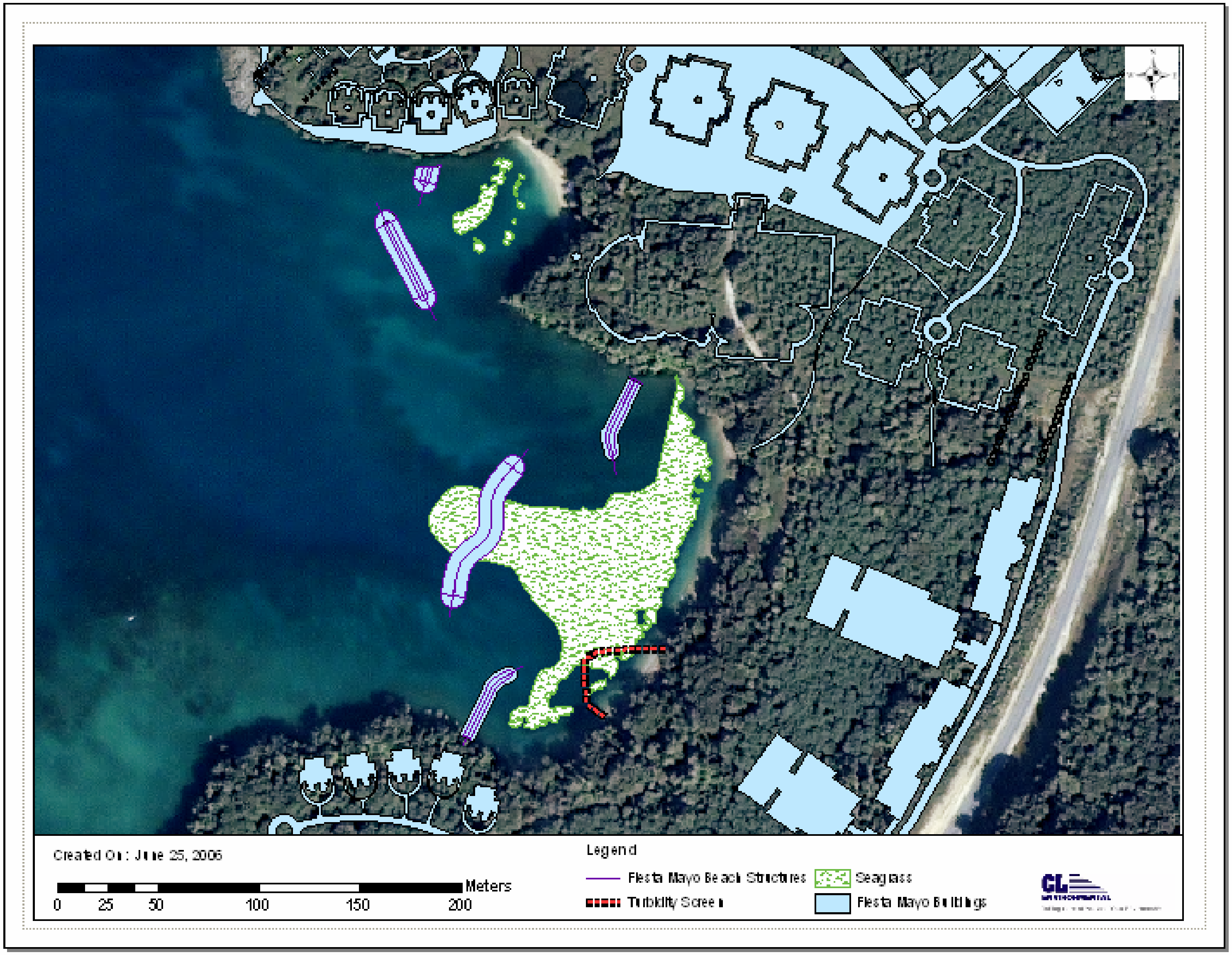


Figure 16 Example of turbidity screen (in red and black) enclosing the work area

6.2 AT THE HARVESTING SITE

The **Mat Method** entails manual digging. Shovels will be used to remove manageable sections (planting unit) of the seagrass bed with the rhizomes and sediments attached. Each **planting unit** (PU) is expected to be approximately **0.15 m^2** in area. The sections will be removed with the rhizomes and soils attached. These sections will be submerged at the harvesting site until they are needed for replanting but within the same day. Keeping the sections submerged at the harvesting site ensure that the leaves are covered with water thereby preventing desiccation, maintaining the same osmotic potential and temperature. Coupled with the fact that the quantities reaped per day will be limited to that, which can be replanted within the day. This with the method of keeping the seagrass sections before replanting will result in reduced seagrass plant stress.

In practice, Pus spacing typically ranges from 0.5 to 2.0m on center. More rapid coalescence of bottom coverage is achieved with higher planting density. The need for rapid coalescence will necessitate that the maximum number of Pus that can fit within the replanting area will be used.

The Pus will be placed on semi submerged rafts and transported to the replanting site.

6.3 HARVESTING AND REPLANTING PERIODICITY

This activity is slated to start immediately and will not be conducted during the period of the "northers" (a storm period during the months of December to January). The harvesting and replanting will be a daily event. It is anticipated that approximately **40 m^2** will be harvested and replanted per day. This is dependent on the distance to travel from the reaping site to the replanting site. At this anticipated rate, it will take approximately **two hundred and twelve (212) days** to remove and replant the approximately **8,449.84 m^2** of seagrass or approximately **one hundred and one (101) days** for the alternate **4,021.81 m^2**. This is dependent on weather conditions and other unforeseeable problems.

6.4 REPLANTING METHOD

The method of replanting is known as the **Staple Method**. The bed will be stabilised by "stapling" it to the ground with the use of U-shaped rebars.
For seagrass beds that are split in two (those growing through the bathing beach boundaries), the edges that are left exposed will be stabilised by using nylon mesh until the edges have consolidated.

All seagrass will be replanted using the "mat" method.

6.5 MONITORING DURING REMOVAL

Points along the turbidity curtain will be monitored to determine if turbidity is escaping and impacting the marine environment outside the isolated area. A turbidity of 10 Nephelometric Turbidity Units (NTU) above background outside (seaward) the turbidity curtain will be used to determine the point at which the seagrass removal processes should be halted and additional corrective and mitigative steps taken.

6.6 LOCATION OF REPLANTING

Conditions of total suspended solids, phosphates and light are the most important parameters when it comes to flourishing and growth of seagrass. These parameters in addition to substrate type where used with a GIS to determine the most suitable location(s) for replanting. The parameters used to determine the areas suitable are similar to those being experienced by the seagrass beds at Southern Beach 1and Southern Beach 2. These parameters were temperature <= 30.44 ^{o}C, total suspended solids <= 163.14 mg/l, ortho-phosphates >= 0.02 mg/l, nitrates >= 0.76 mg/l, Salinity >= 36.28 & Salinity <= 36.37and Biochemical Oxygen Demand <= 4.10.

The most suitable areas that were selected by this method are depicted in Figure 17.

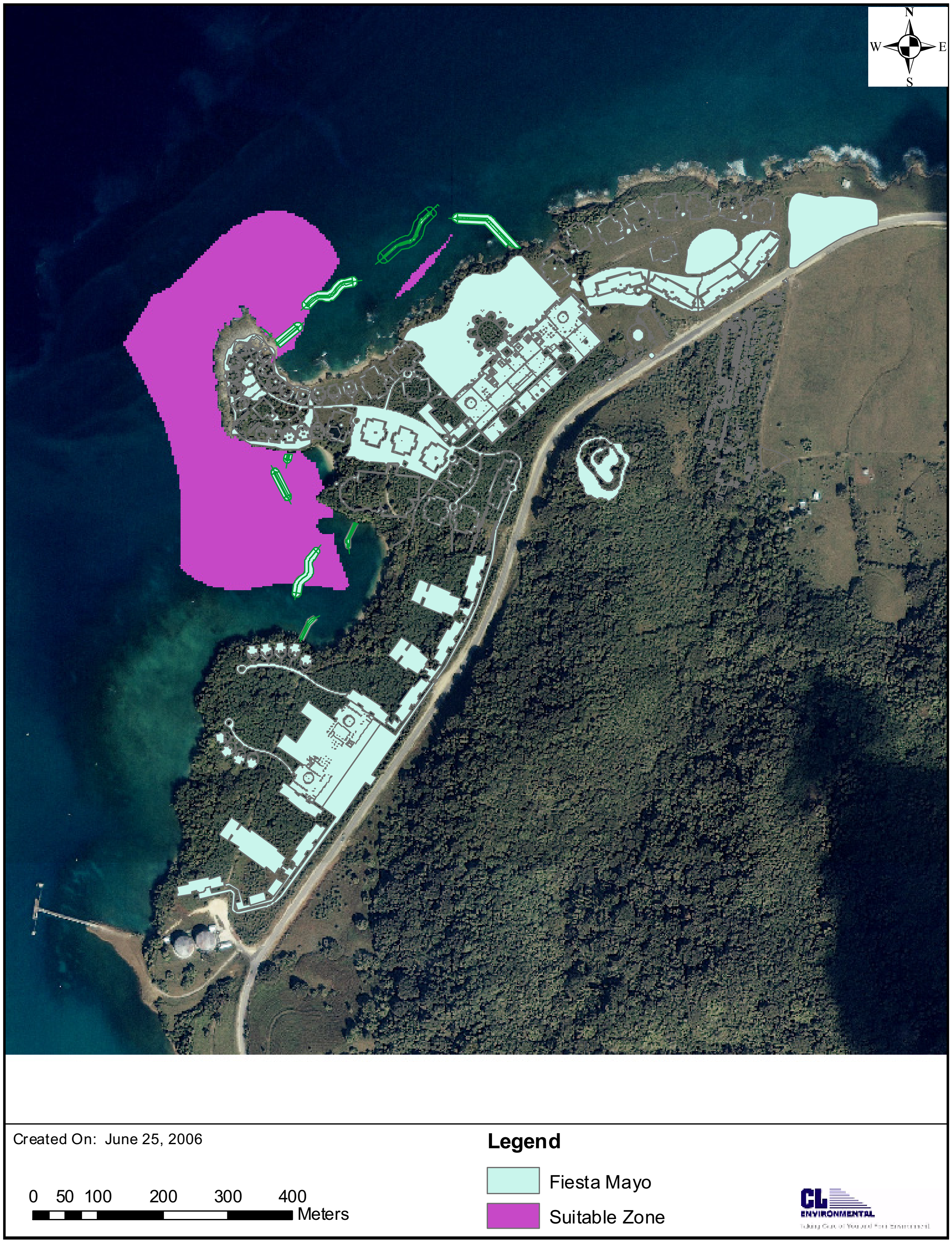


Figure 17 Map depicting areas most suitable for replanting the reaped seagrass

Figure 18 shows that only four of the identified space falls into the area considered suitable (in purple) for replanting. This space represents approximately 3,086.25 m^2. There are two spaces in proximity to the ideal location accounting for an additionally 122 m^2. There is also a space of 701.71m^2 located behind the submerged breakwater at Southern Beach 2. This space cannot be used due to its proximity to the breakwater and was not used in the calculation of free space.

The locations and areas of the potential replanting areas are listed in Jamaica 2001 Grid in Table 9 below. There are more replanting areas that were not mapped during this current exercise. These will have to be mapped before commencement of the Project.

Table 9 Table depicted replanting locations and areas identified so far

LOCATION	NORTHING	EASTING	AREA (m^2)
1	628031.50	700812.64	2,119.15
2	627996.43	700863.79	241.70
3	627917.52	700925.16	725.40
*4	628005.20	700705.97	77.72
*5	627994.97	700711.81	44.35
TOTAL			**3,208.32**

***These location falls outside of the area considered ideal for replanting**

The area to be removed is approximately 8,449.84 m^2 (≈ 0.85 ha).

.

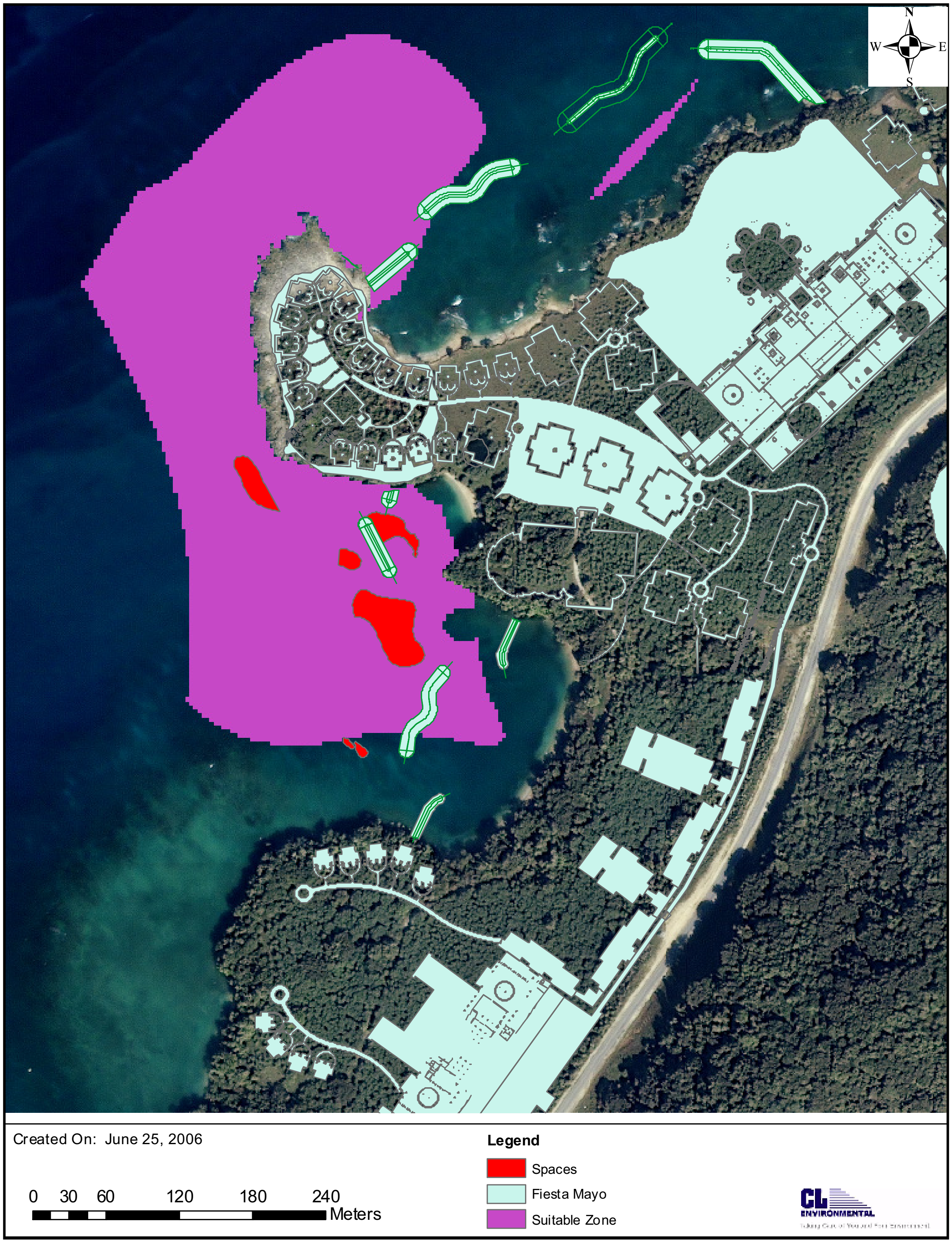


Figure 18 Ideal replanting areas and areas that are currently bare

7.0 ALTERNATIVE

This alternative involves reducing Southern Beach 1 seaward extent to a maximum of 40m. This measure would reduce the area of seagrass to be removed and replanted from Southern Beach 1to approximately 4,021.81 m^2 (≈ 0.41 ha or ≈ 1 acre) from approximately 8,069.89 m^2 and the total overall seagrass from approximately 8,449.84 m^2 to approximately 4,401.76 m^2 (Figure 19).

In addition, it would also reduce the number of corals that need to be relocated.

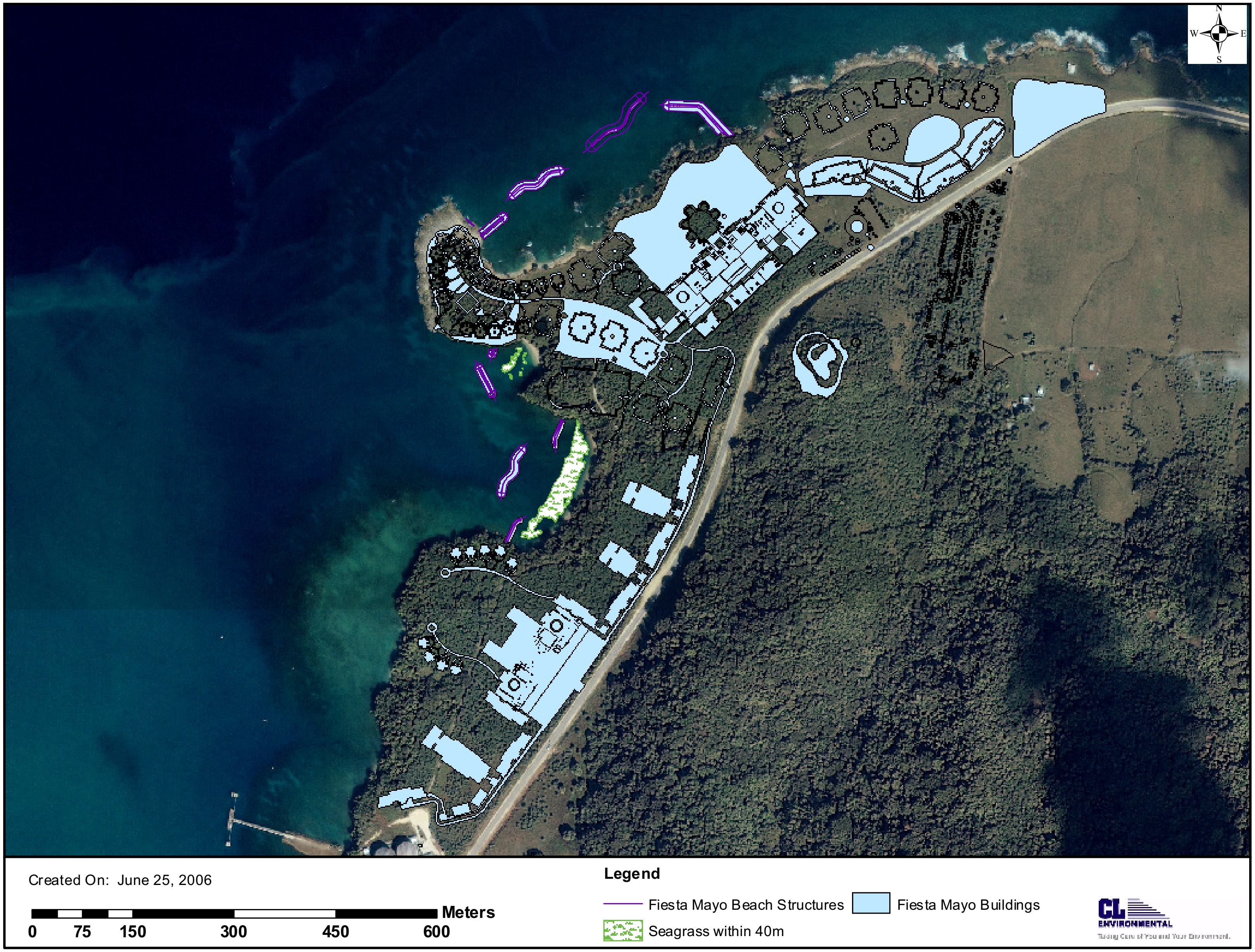


Figure 19 **Diagram illustrating the Southern Beach 1 reduced to 40m seawards**

8.0 MONITORING OF REPLANTED MATS AND MERISTEMS

The monitoring regime will be once per week for the first two (2) months, quarterly for the following twelve (12) months and biannually for the following thirty-six (36) months.

This monitoring will look at the condition and growth of the meristems survival, areal coverage and number of shoots per PU. Areal coverage and the number of shoots per PU will be assessed by using a quadrat. Other factors such as erosion and bioturbation impacts will also be assessed. Due to the large area, random sampling will be conducted. Additionally, video transects will be conducted. These will help in comparing and determining the health of the seagrass replanted.

In addition to self-monitoring it is recommended that the National Environment and Planning Agency or Agents conduct a monitoring exercise of their own.

8.1 Contingencies

If serious bioturbation occurs then the planted beds will be fenced to prevent fauna from accessing the seagrass bed until the bed is well established.

8.2 Designated Monitor

C.L. Environmental Co. Ltd.

8.3 Reports

As required by the Agency, reports will be submitted every two (2) weeks for the first two (2) months, quarterly for the following twelve (12) months and biannually for the next thirty- six (36) months.

The report format will include pictures and data in tabular form and will be rated. An example of the form that will be used is outlined in Table 10**.**

Table 10 Example of the seagrass monitoring sheet

Project: Fiesta Mayo Seagrass Replanting	**Date:**
Monitored By:	**Verified By:**

Monitoring Component		**Score** 1	2	3	4	5	**Remarks**
Seagrass PUs Conditions	Persistent survival						
	Areal coverage						
	Evidence of new growth						
	Coalescence occurring						
	Increase in animal abundance						
Physical conditions	Sediment stabilization						
	Lack of bioturbation						
	Lack of anthropogenic impact						

Scoring Key: 1 – Very Poor, 2 - Poor, 3 - Average, 4 - Good, 5- Excellent

9.0 RELOCATION OF CORALS

All coral found in the work area will be relocated. The following is the proposed methodology for coral relocation:

1. Donor site will be harvested on a grid pattern so as to limit lost time due to crossovers. This will also allow us to categorize and quantify specimen removal with correlation to depth, along with the Donor team having set goals on a daily basis. This will also aid the Relocation team with depth ranges for specific coral harvesting loads and provide the necessary information that will be required by NEPA as it relates to monitoring.

2. There will be three teams consisting of the: Donor Team, Transport Team and Relocation Team. The Relocation team will have the most members, the Donor Team slightly smaller and the Transport Team being few. The reason for the Relocation team being smaller than the Donor Team is to take into consideration the fact that it will take longer to plant the specimens than it will take to remove them.

3. Donor site divers will choose the specimens based on size, type, health, depth from which it was removed and ease of removal. Each, two man dive team, will have small hand tools such as crow bars, hammers, chisels, and scrapers to aid in removal. Most of the corals lie freely on the seafloor or are attached to coral rubble substrate that is wedged together in a mesh network. These items will be freed by hand with the aid of hand tools and placed in retrieval containers. Specimens that require mechanical removal will be dealt with on an item to item basis with the NEPA representative making the decision to remove or not. At no time will corals be removed from the water. If bad weather occurs, then the contractor will leave the full baskets on the seafloor at the transport.

4. The Relocation team will have the same two divers set up as the Donor team. They will assist in removal of the full units from the barge. Once divers have received a full retrieval unit for replanting then the divers will then replant the corals. Divers will take single full units to their allotted replanting site and commence unloading and replanting on an item by item basis. Replanting will be performed by:

a. Placement

b. Coral rubble wedging

c. Anchor pinning and

d. Marine epoxy adhesive.

Divers will decide which process to use depending on the type/shape and size of each specimen, location to existing corals (specifically antagonistic species) and the seafloor substrate, slope and current.

5. Urchins found in this area will also be collected and relocated.

10.0 REMOVAL AND RELOCATION OF OTHER MARINE FLORA AND FAUNA

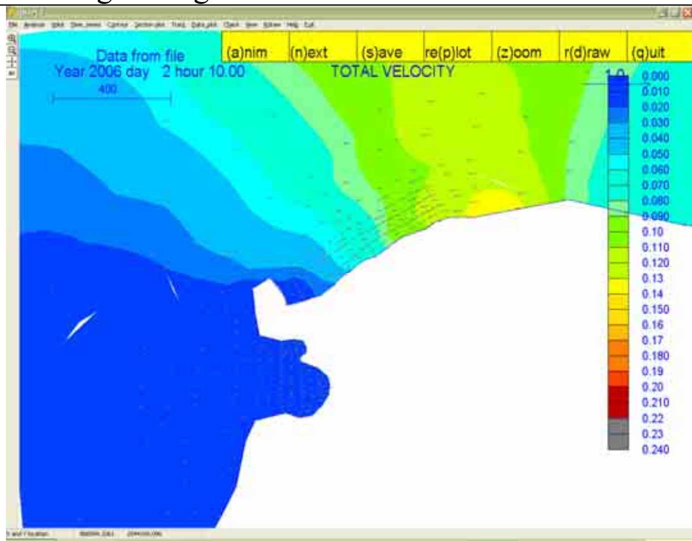
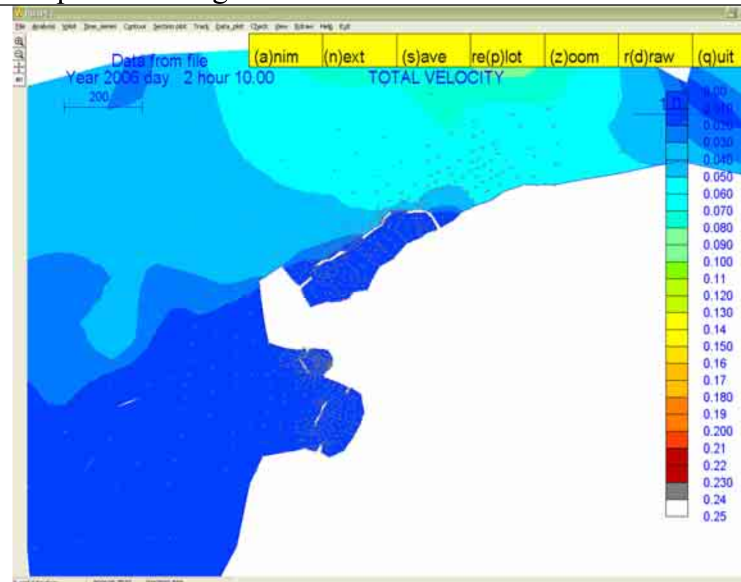
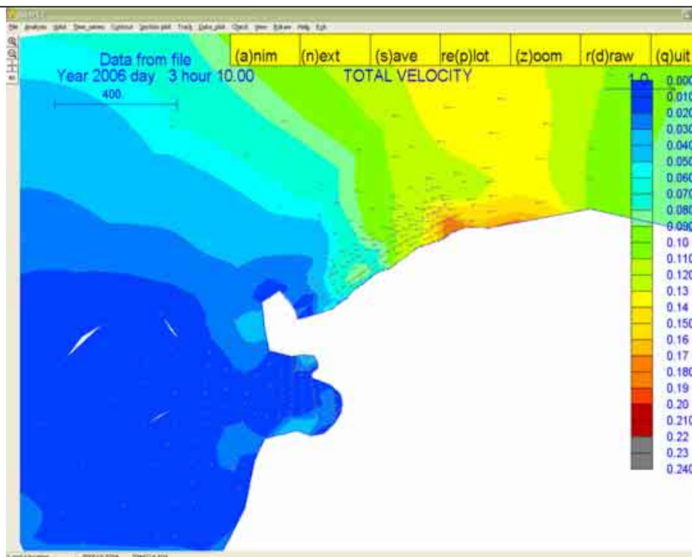
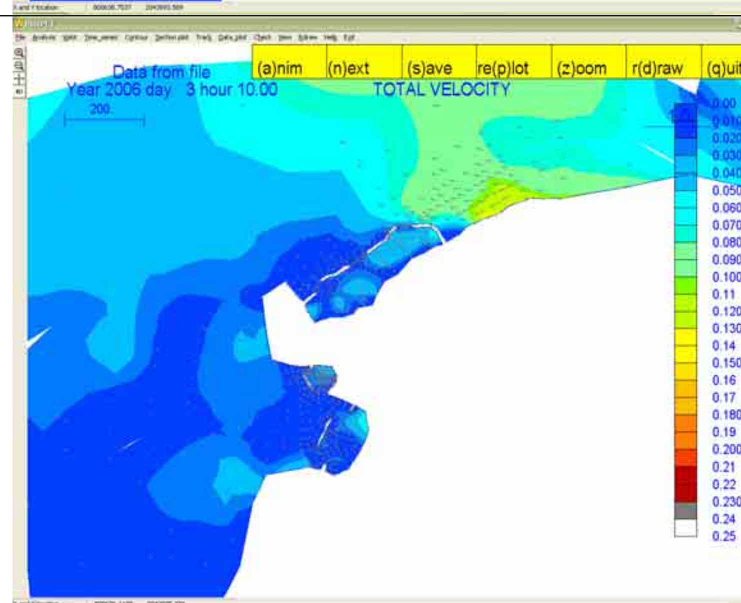
Any other sedentary or slow moving marine fauna and/or flora (e.g. *Diadema antillarum*) that require removal and relocating will be done in an approved method. These flora and fauna will be placed into a basket and moved immediately as they are encountered to areas outside of the harvesting and replanting area. The basket will be transported through the water so that the species remain submerged. There will be no holding time therefore reducing the potential of them becoming stressed.

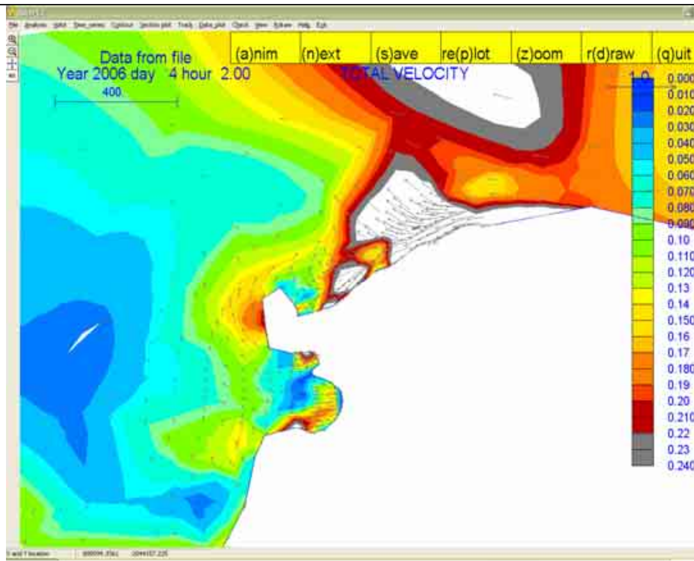
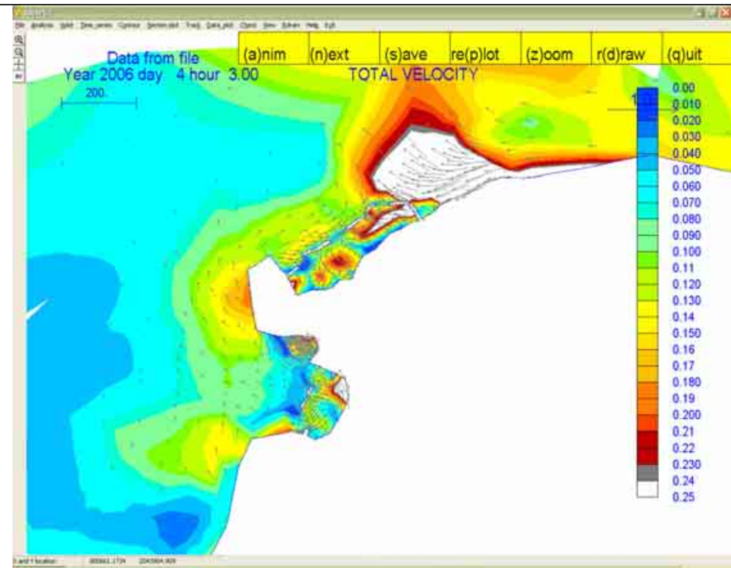
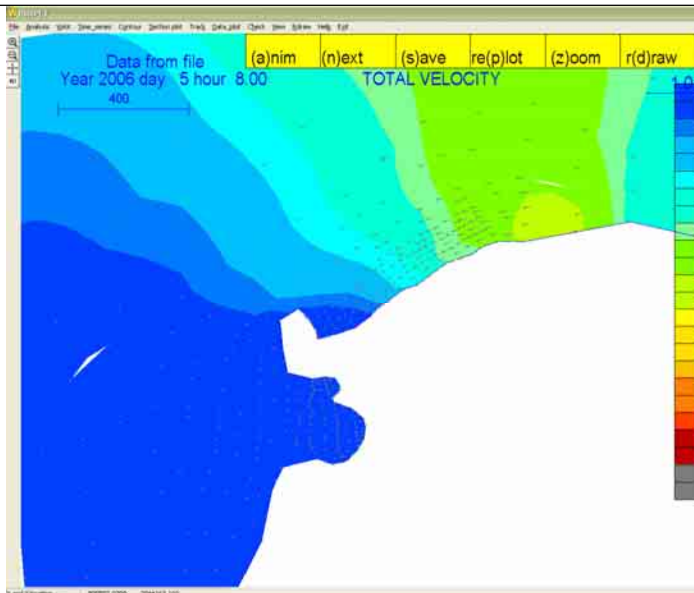
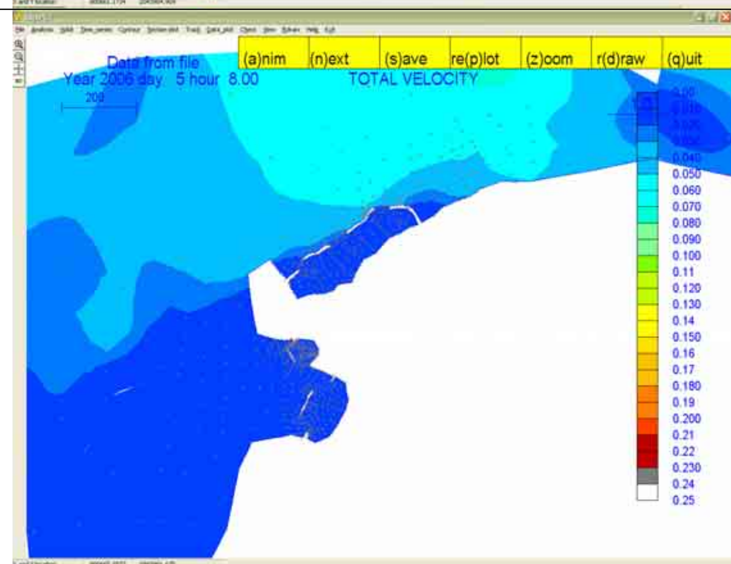
11.0 CONCLUSIONS

1. Approximately 8,449.84 m^2 (≈ 0.6 ha) of seagrass will be removed if the proposed beach plan is approval. The majority (≈ 99%) of this will be *Thalassia testudinum* –species.
2. If the alternative is approved, then less seagrass will be removed compared to the proposed beach plan. This would be a positive step, as less seagrass will have to be removed and replanted.
3. Approximately 3,086.25 m^2 of space was mapped in this exercise. However, there are additional spaces which were not mapped and will have to be done before the commencement of the Project.
4. All seagrass will be replanted using the mat method.

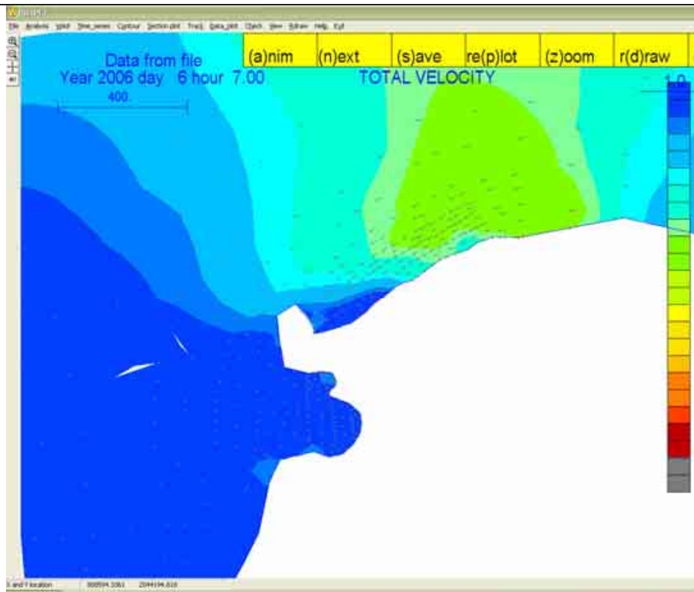
Appendix 1 Existing and Proposed Current Regime

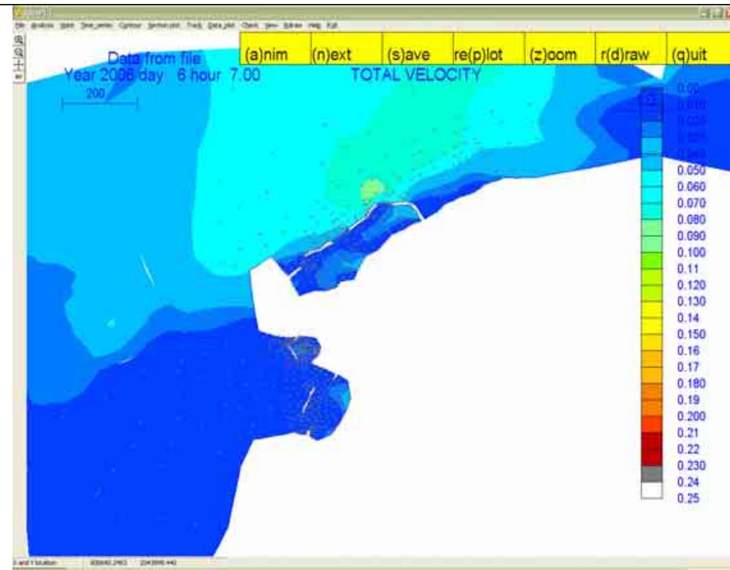
Surface Currents

<table>
<tr><td></td><td>Existing Configuration</td><td>Proposed Configuration</td></tr>
<tr><td>2.0 m/s
E Wind</td><td>
</td><td>
</td></tr>
<tr><td>5.0 m/s
E Wind</td><td>
</td><td>
</td></tr>
</table>

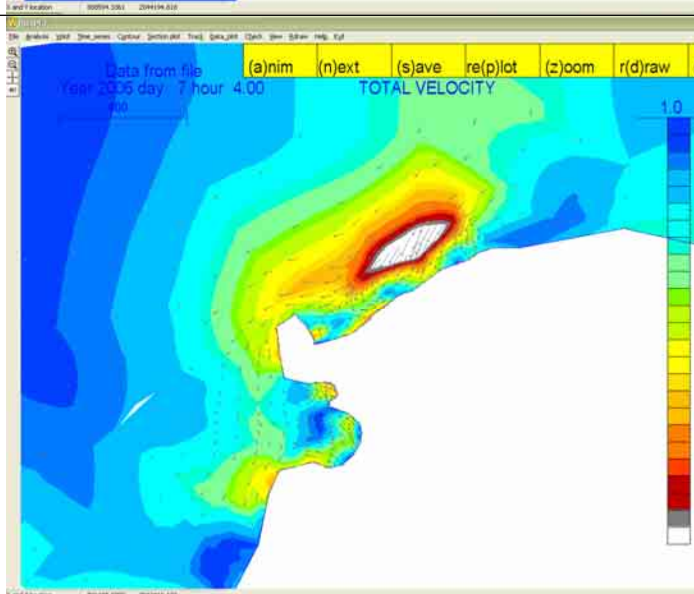
<table>
<tr>
<td>12.0 m/s E Wind</td>
<td>
</td>
<td>
</td>
</tr>
<tr>
<td>1.0 m/s NW Wind</td>
<td>
</td>
<td>
</td>
</tr>
</table>

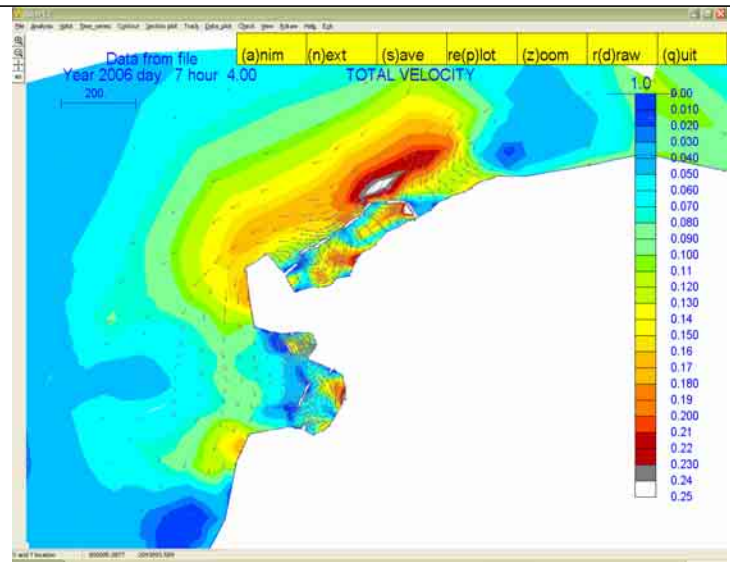
4.0 m/s NW Wind



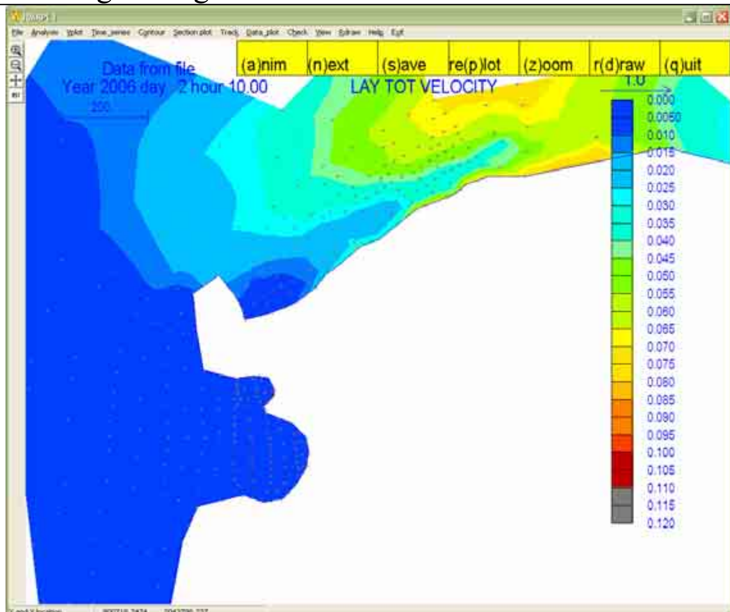
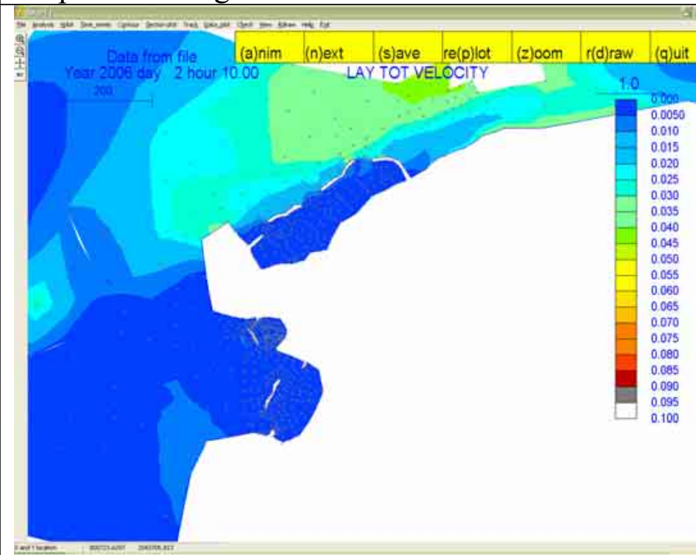
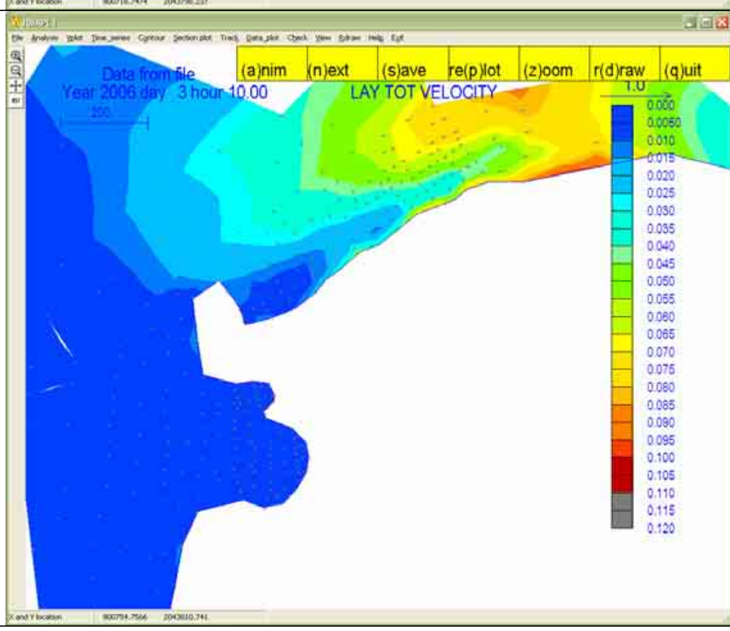
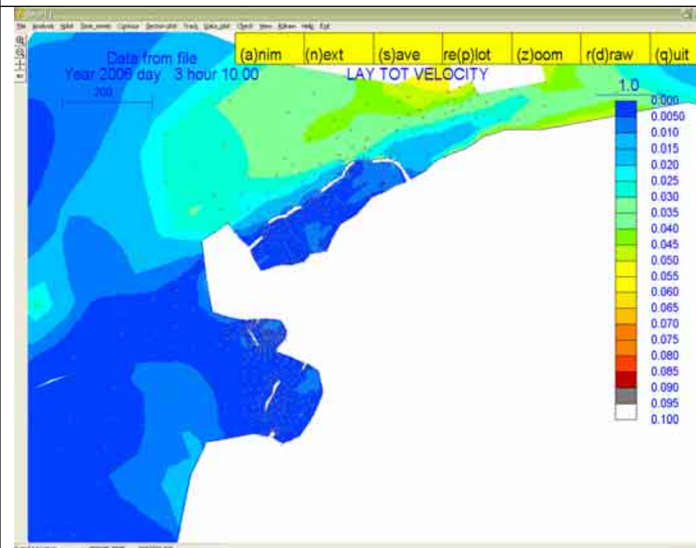


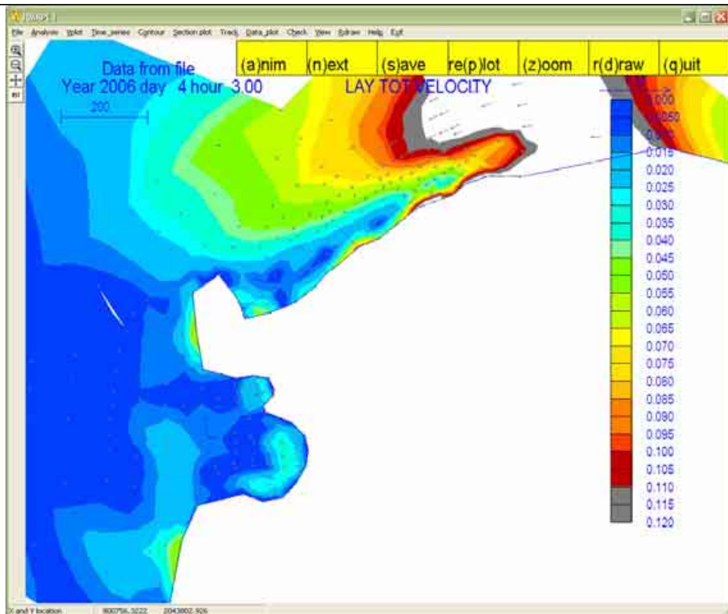
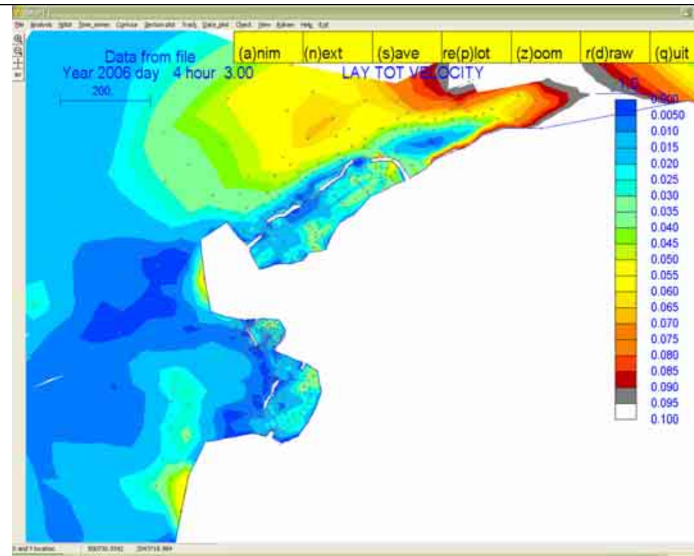
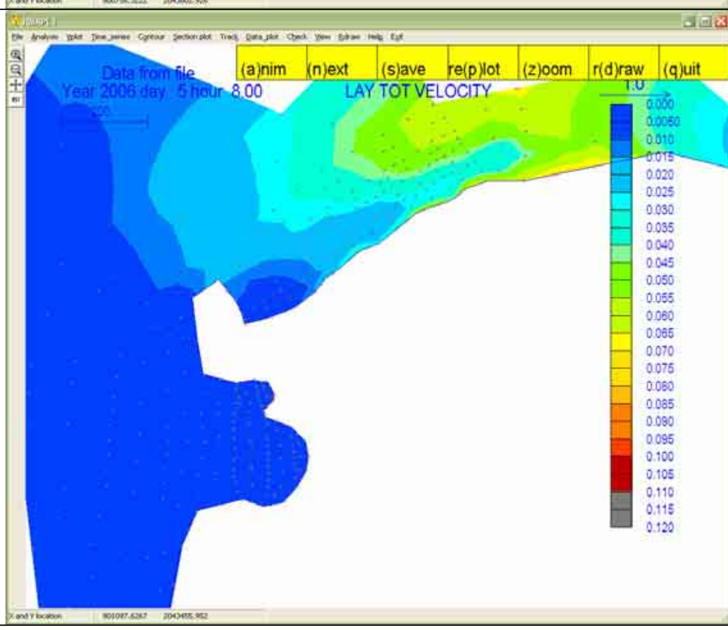
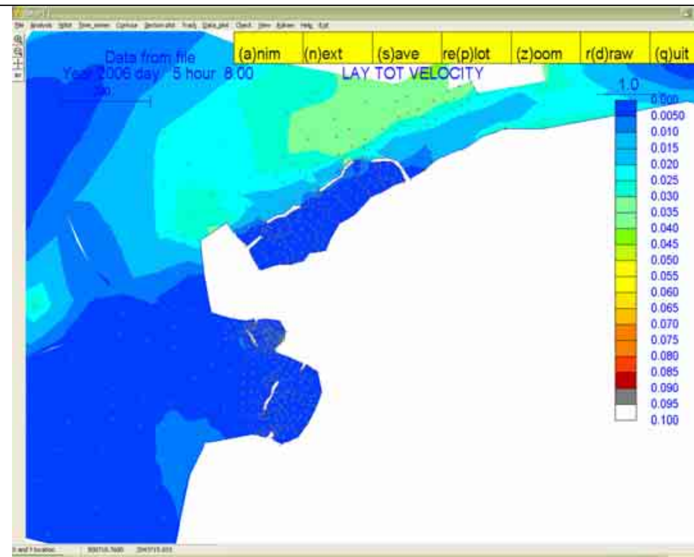
10.0 m/s NW Wind

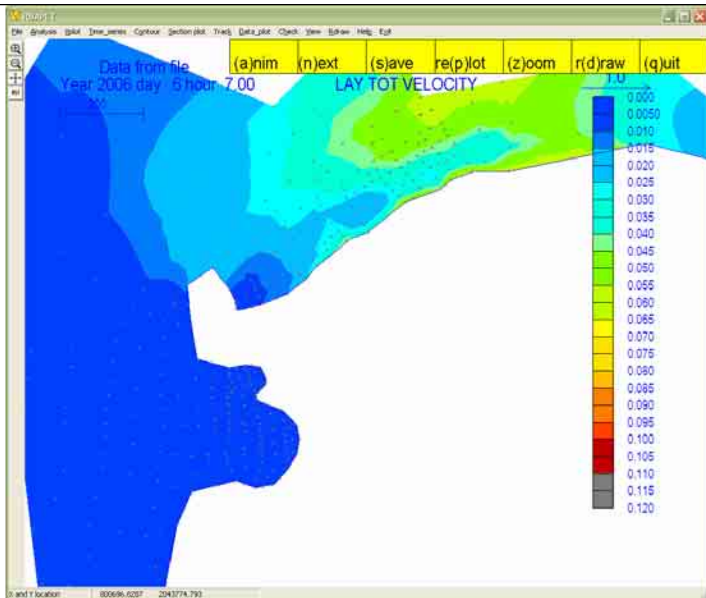
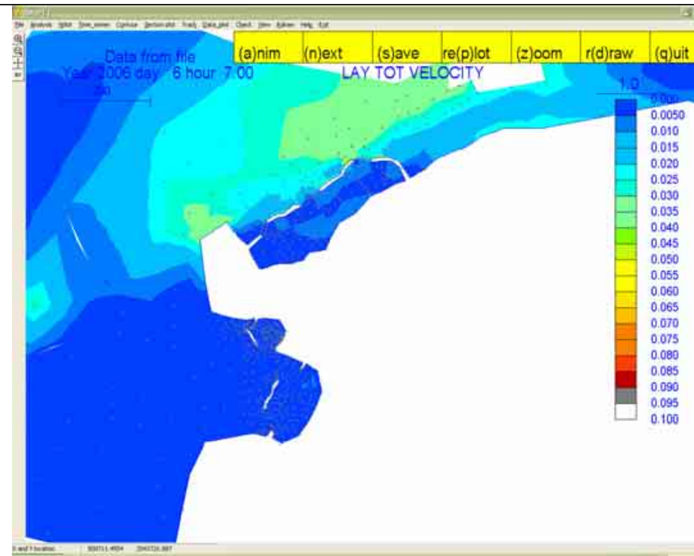
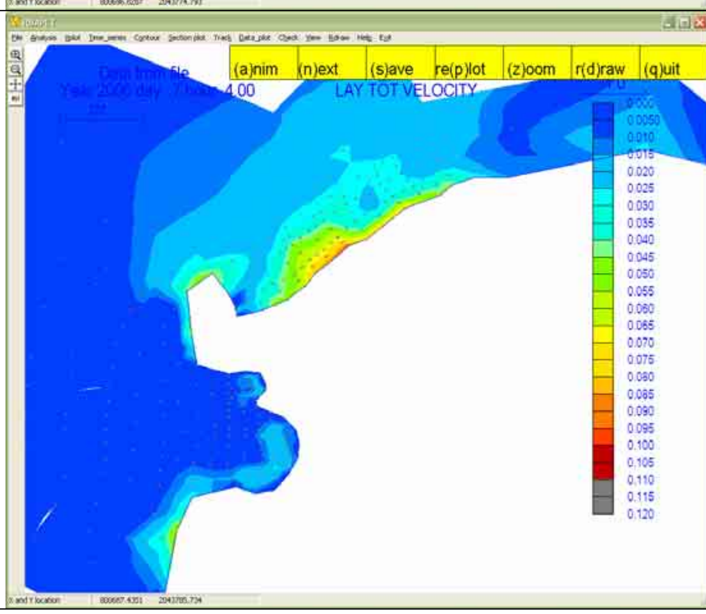
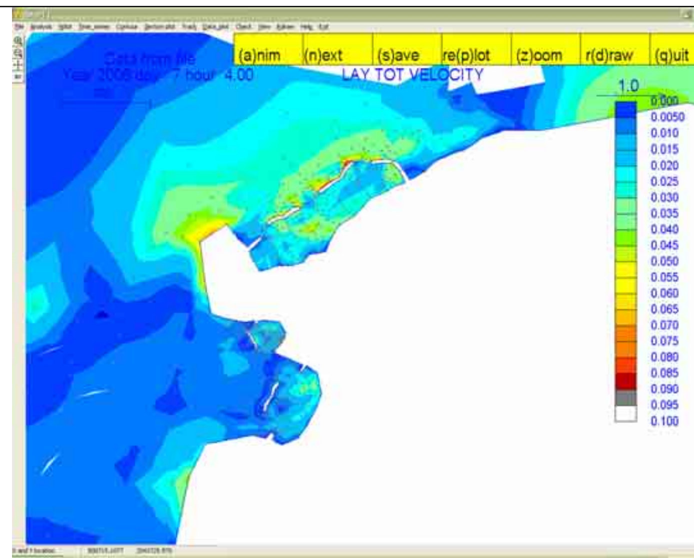




Sub-surface (mid-depths) currents

<table>
<tr><td></td><td>Existing Configuration</td><td>Proposed Configuration</td></tr>
<tr><td>2.0 m/s
E Wind</td><td>
</td><td>
</td></tr>
<tr><td>5.0 m/s
E Wind</td><td>
</td><td>
</td></tr>
</table>

12.0 m/s E Wind		
1.0 m/s NW Wind		

<table>
<tr>
<td>4.0 m/s
NW
Wind</td>
<td>
</td>
<td>
</td>
</tr>
<tr>
<td>10.0 m/s
NW
Wind</td>
<td>
</td>
<td>
</td>
</tr>
</table>