

**MINISTRY OF FOREIGN AFFAIRS,  
ENVIRONMENT, TRADE, LABOUR  
AND TOURISM,  
GOVERNMENT OF TUVALU**

**THE STUDY FOR  
ASSESSMENT OF ECOSYSTEM, COASTAL  
EROSION AND  
PROTECTION/REHABILITATION OF  
DAMAGED AREA IN TUVALU**

**FINAL REPORT  
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**JAPAN INTERNATIONAL COOPERATION AGENCY**

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**< Structure of Report >**

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Summary Report**

**Volume II  
Main Report**

**Volume III  
Supporting Report**

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**JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)**

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IN  
TUVALU**

**<FINAL REPORT>**

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# **PART III: FIELD SERVEY FOR FEASIBILITY STUDY**

## **Section 1: Supporting Report**

### **1. Topographic Survey**

## **1. Topographic Survey**

### **1.1 Topographic Survey in Southern Islets**

#### a) Overview of Topographic Survey in Southern Islets

The topographic survey in southern islets of Funafuti atoll was performed on the end of June 2010 during the feasibility study in the northern and southern parts of Funamanu and Falefatu islets, and the northern part of Mateika islet as shown in Figure 1.1, as a resource survey of gravels for the beach nourishment materials.

The survey was composed of the control point survey and the cross sectional survey with 10 meters pitch from ocean side to lagoon side, as well as the gravel classification and gravel volume calculation.

Table 1.1 shows the reference benchmarks, some of which were existing benchmarks and three of them were newly established in Funamanu and Falefatu islets.

**Table 1.1 Reference Benchmarks**

<b>Point ID</b>	<b>Easting</b>	<b>Northing</b>	<b>Condition</b>	<b>Given Elev. (m-CDL)</b>	<b>Location</b>	<b>Transfer from</b>	<b>Transfer Method</b>
TUVA3	741414.902	9056957.851	Existing	3.993	Fongafale		
UoH1	741434.577	9056953.506	Existing	3.781	Fongafale		
MAT01	731122.534	9048933.902	Existing	3.114	N-Mateika		
TP3A	732751.649	9050727.426	Existing	2.951	S-Falefatu		
TP3B	9051151.432	733098.160	New	3.316	N-Falefatu	TP3A	RTK
TP2A	9052485.595	734545.236	New	4.914	S-Funamanu	TUVA3	Static
TP2B	9052678.003	735084.725	New	4.748	N-Funamanu	TUVA3	Static

#### b) Result of Topographic Survey in Southern Islets

The results of the topographic survey in southern islets are shown in Figure 1.2 to Figure 1.6 for the northern and southern parts of Funamanu and Falefatu islets, and the northern part of Mateika islet as topographic plans.

More detailed results of the topographic survey in southern islets are shown in “Gravel Material Survey Data in Data Book”.





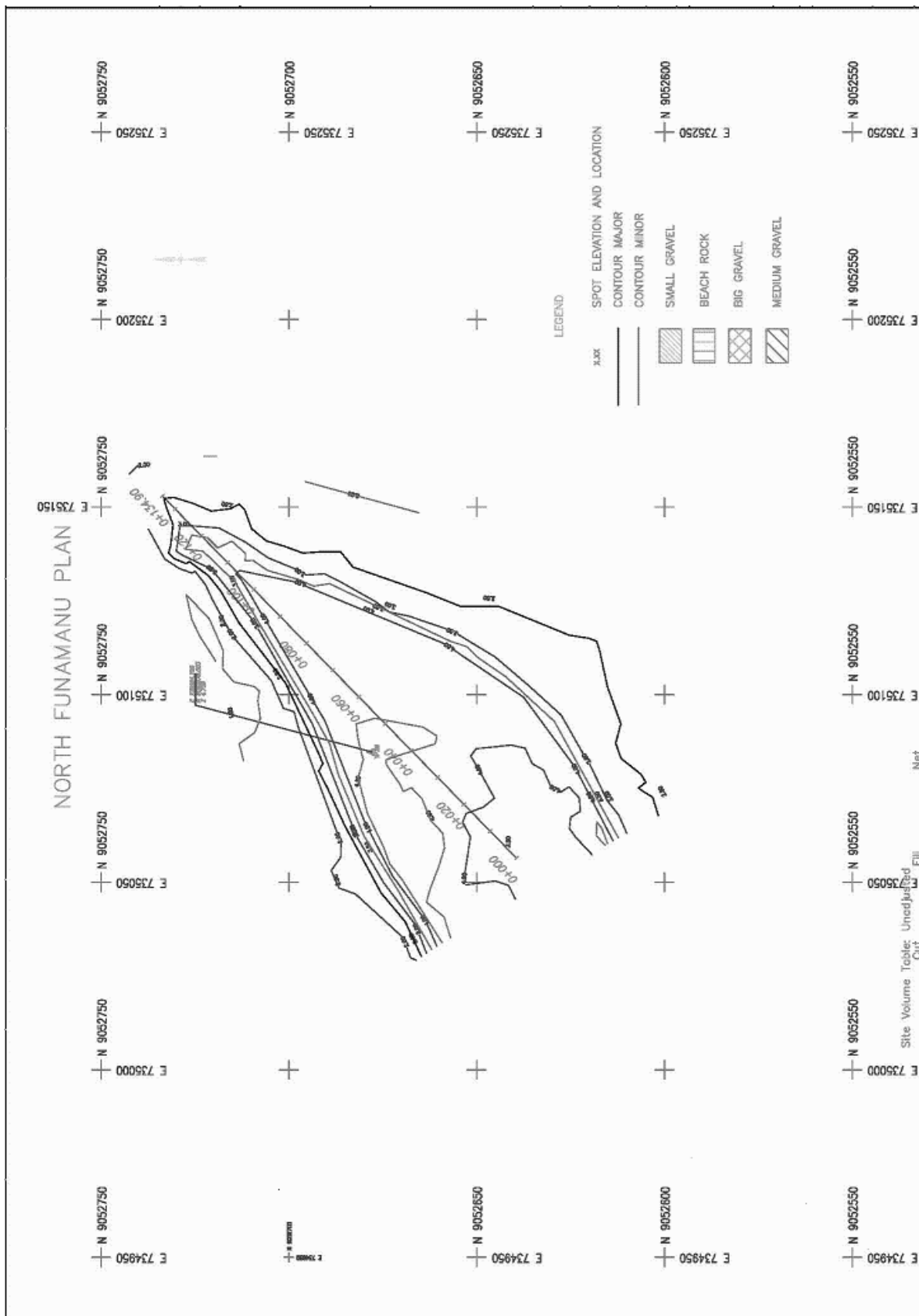
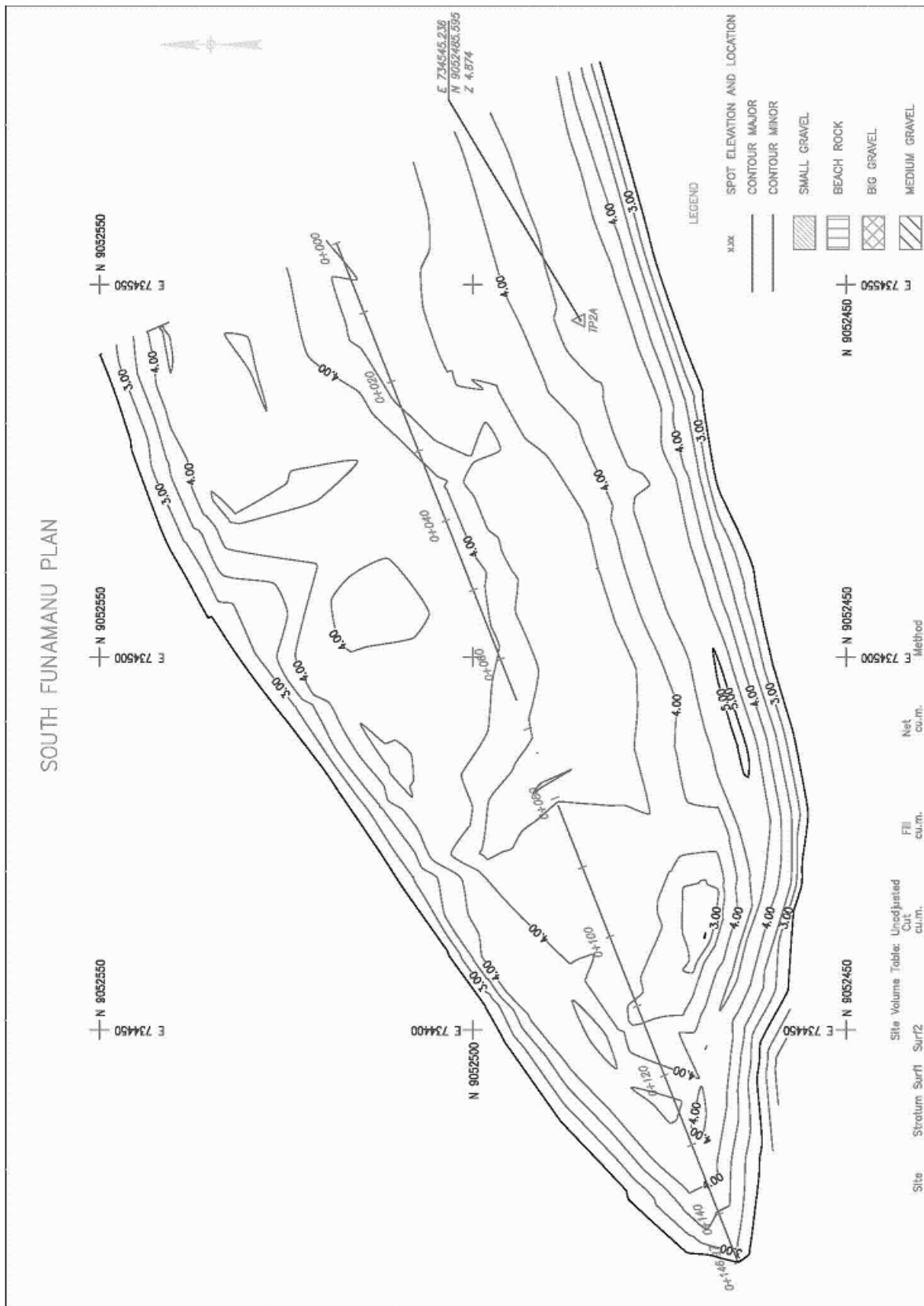


Figure 1.2 Topographic Map of Northern Part of Funamanu Islet





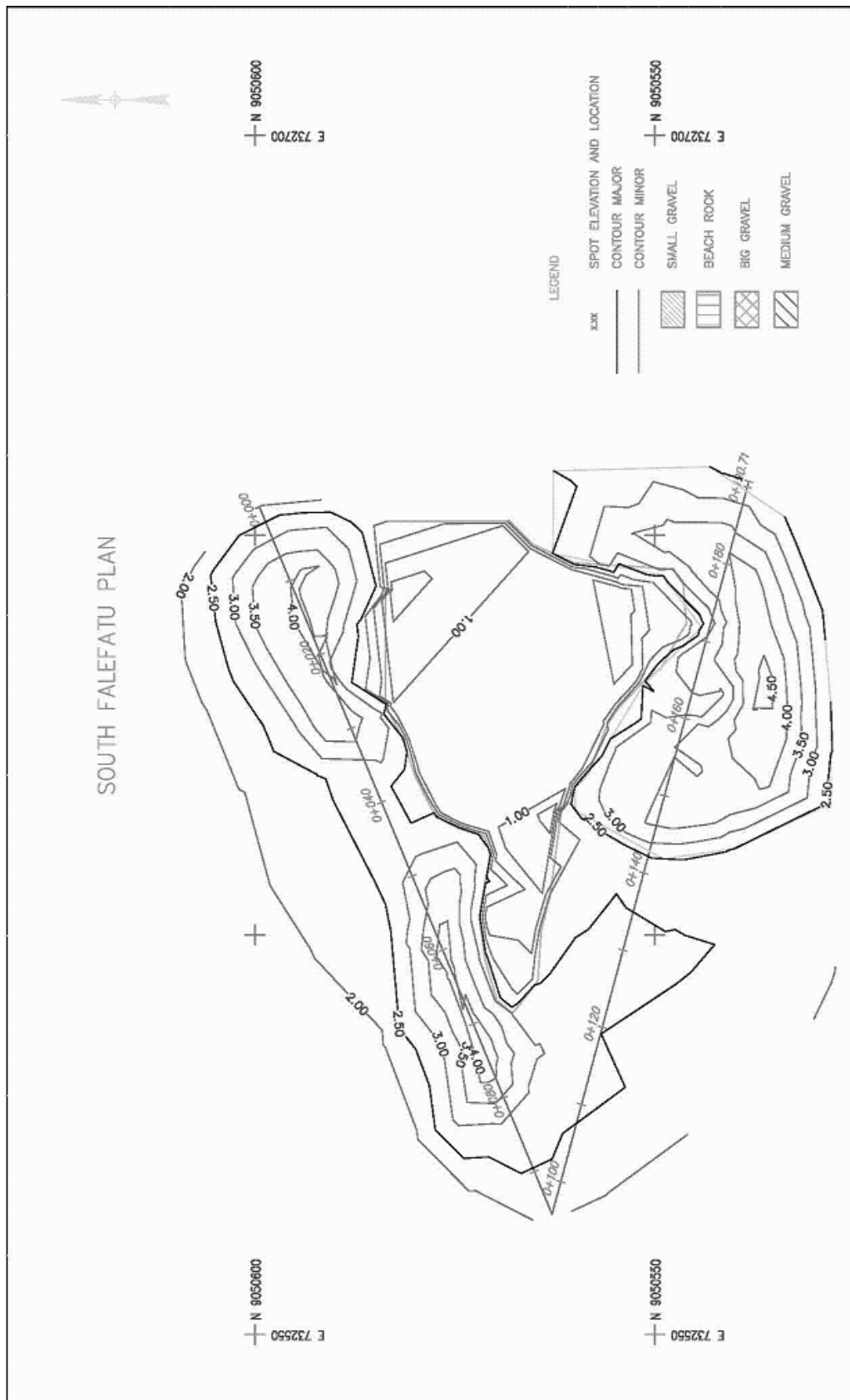


Figure 1.5 Topographic Map of Southern Part of Falefatu Islet

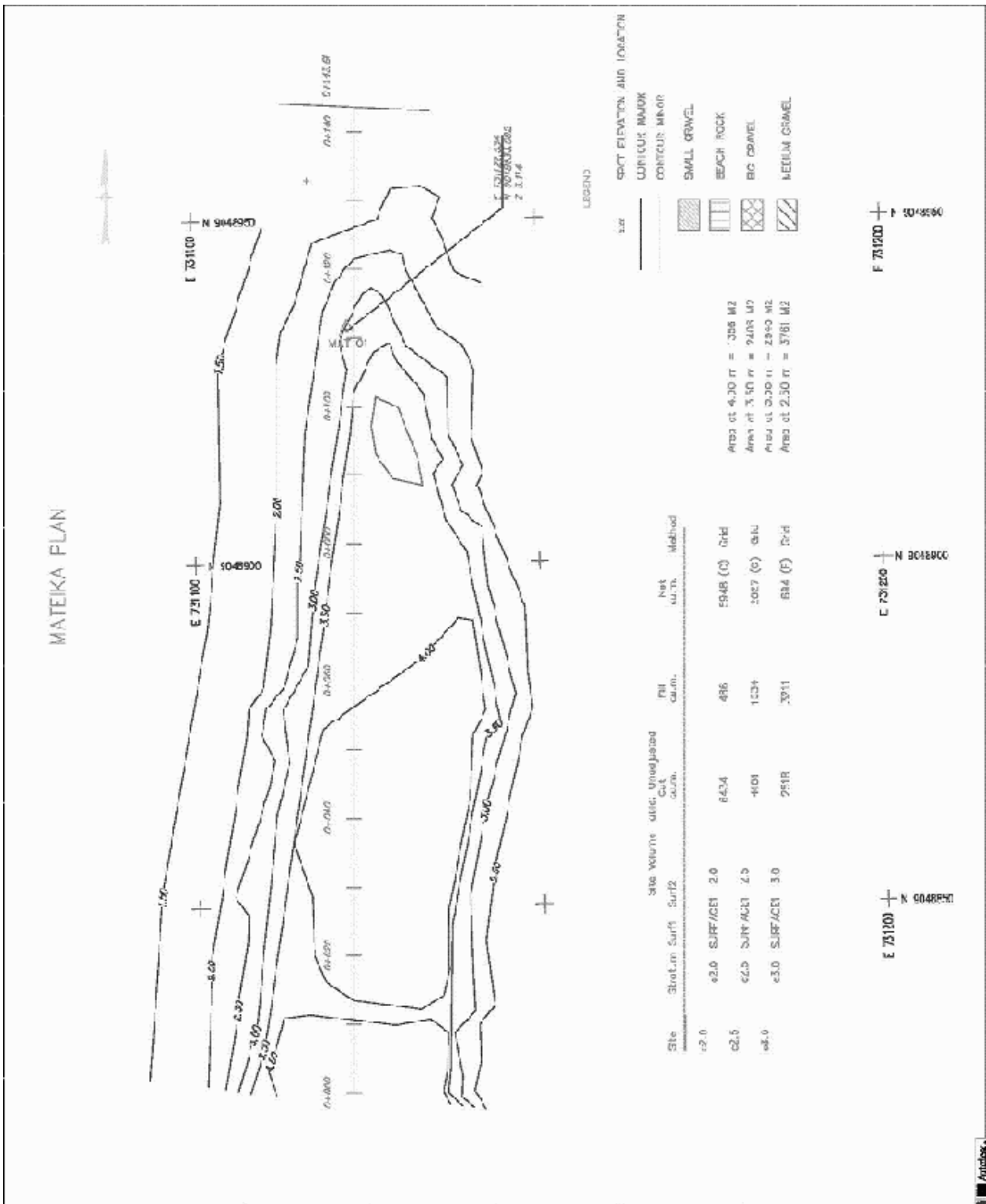


Figure 1.6 Topographic Map of Northern Part of Mateika Islet

## **2. Bathymetric Survey**

## **2. Bathymetric Survey**

### **2.1 Detailed Bathymetric Survey**

#### a) Overview of Detailed Bathymetric Survey

The detailed bathymetric survey covered the target zone for coastal protection measures as shown in Figure 2.1, which is 1.8 km length along the coastal line and an average distance of 200 m from the shoreline. The survey lines were spaced at 20 meters interval perpendicular to the shoreline and the total survey lines were 100 lines.

The bathymetric survey using an echo-sounder was performed from the shallowest shore, that survey vessel can get through, to the offshore survey boundary. In the shallow area that vessel could not get through, the beach topographic survey was done from the depth that operator can stand with equipment to the shore slope crest.

The positioning during the survey was performed by RTK GPS and observed soundings from the bathymetric survey were reduced to the Chart Datum using hourly sea level data from the tide gauge in Funafuti.

#### b) Result of Detailed Bathymetric Survey

The result of the detailed bathymetric survey in the target zone for coastal protection measures was compiled as a bathymetric map as shown in Figure 2.2 and a set of cross sections for each survey line for the calculation of required volume for gravel nourishment, which is provided in “Data Book” attached to this report.

The dialed bathymetric maps in the target zone for coastal protection measures are shown in Figure 2.5 to Figure 2.8.





**Figure 2.1** Location Map of Detailed Bathymetric Survey

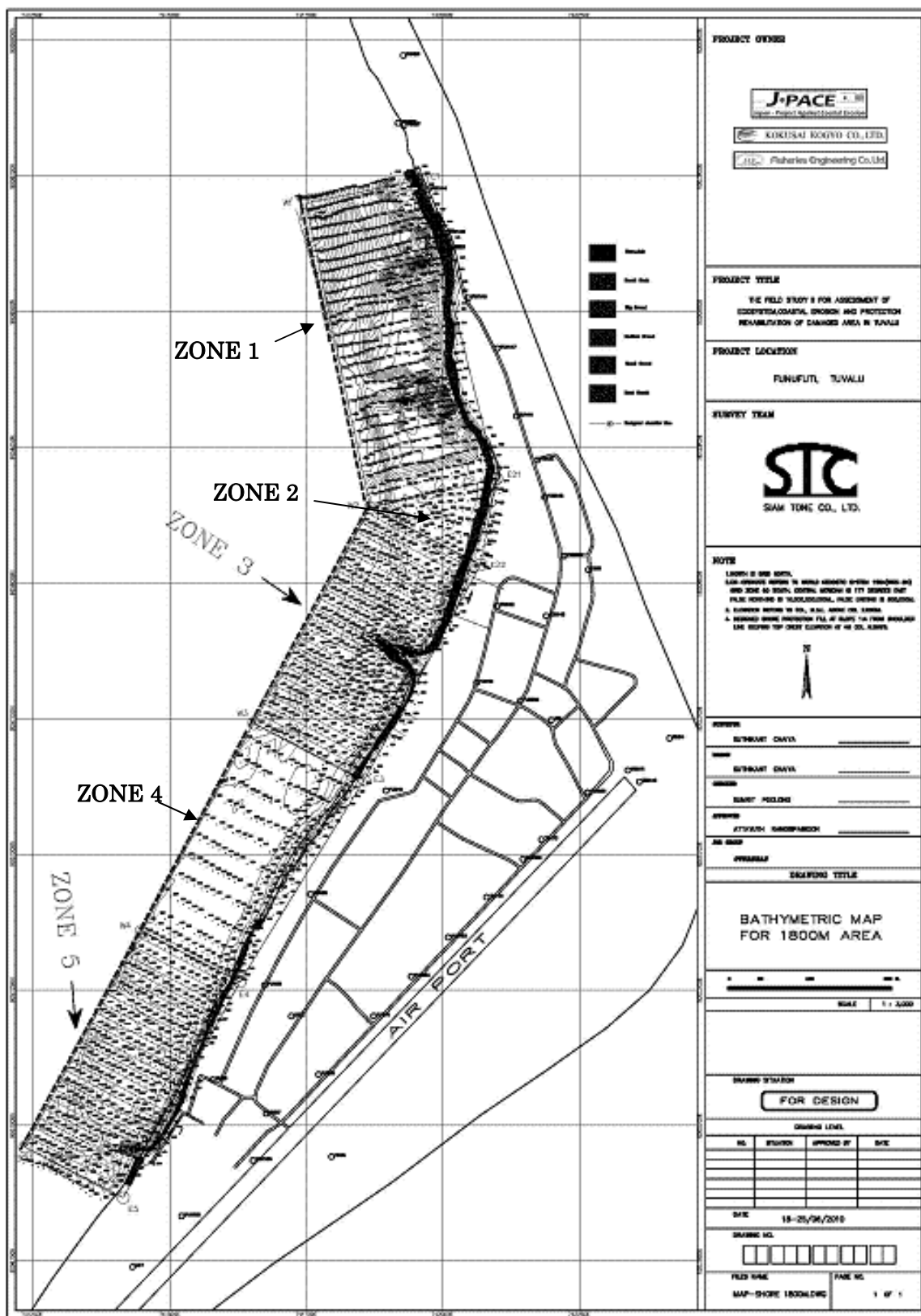


Figure 2.2 Bathymetric Map in Target Zone for Coastal Protection Measures

### **(3) Bathymetric Survey in Borrow Pits (Channels)**

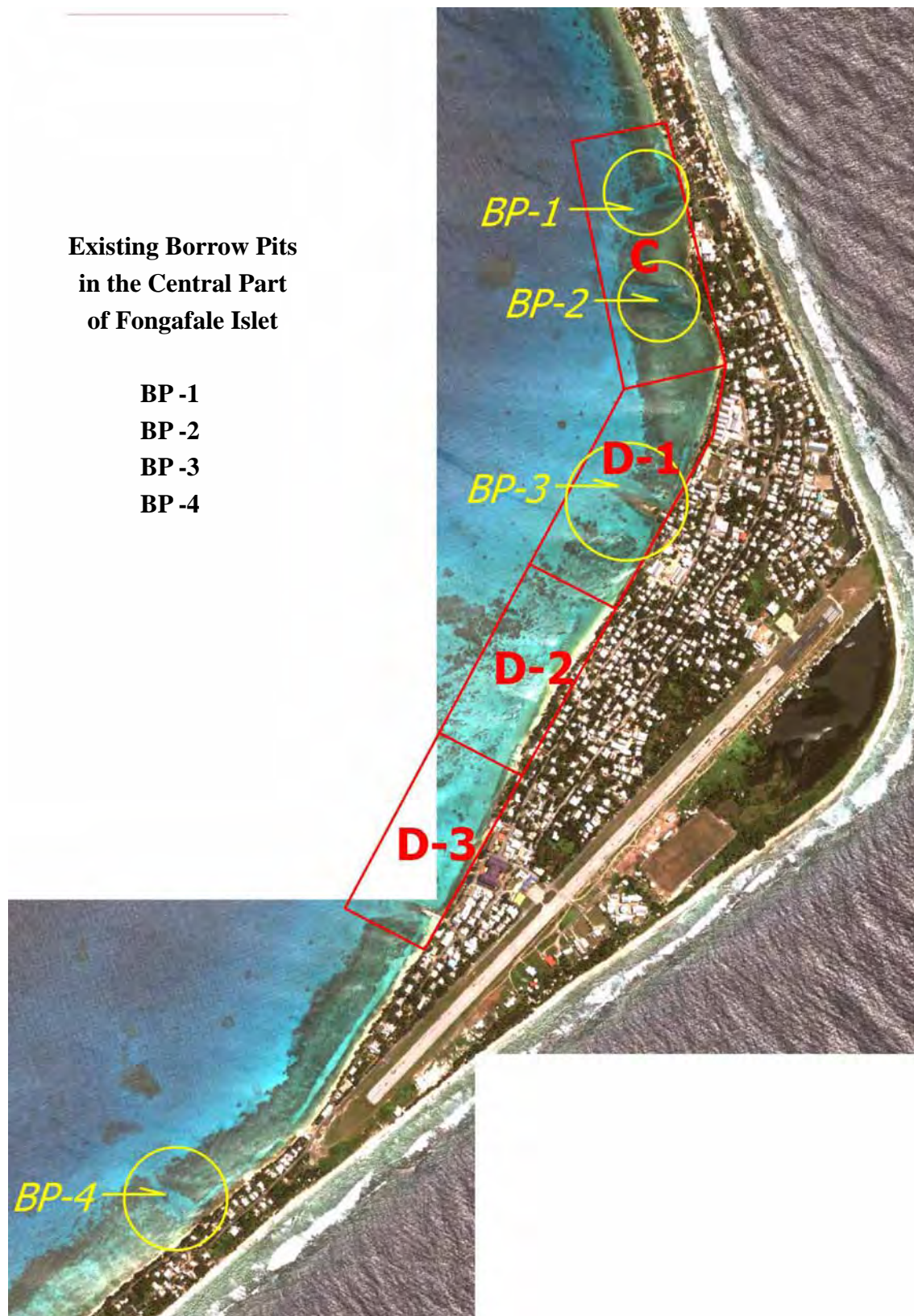
#### a) Overview of Bathymetric Survey in Borrow Pits

The detailed bathymetric survey for existing borrow pits (also called as “channels”); BP-1, BP-2, BP-3 and BP-4 as shown in Figure 2.3 was carried out in order to get an information of required volume for backfilling. The survey lines were spaced at 10 meters interval perpendicular to the shoreline.

#### b) Result of Bathymetric Survey in Borrow Pits

The result of the bathymetric survey in the borrow pits was compiled as a bathymetric map as shown in Figure 2.4 and a set of cross sections for each survey line for the calculation of required volume for backfilling, which is provided in “Data Book” attached to this report.

The dialed bathymetric maps in the target zone for coastal protection measures are shown in Figure 2.5 to Figure 2.8.



**Figure 2.3 Location Map of Borrow Pits in Target Zone**

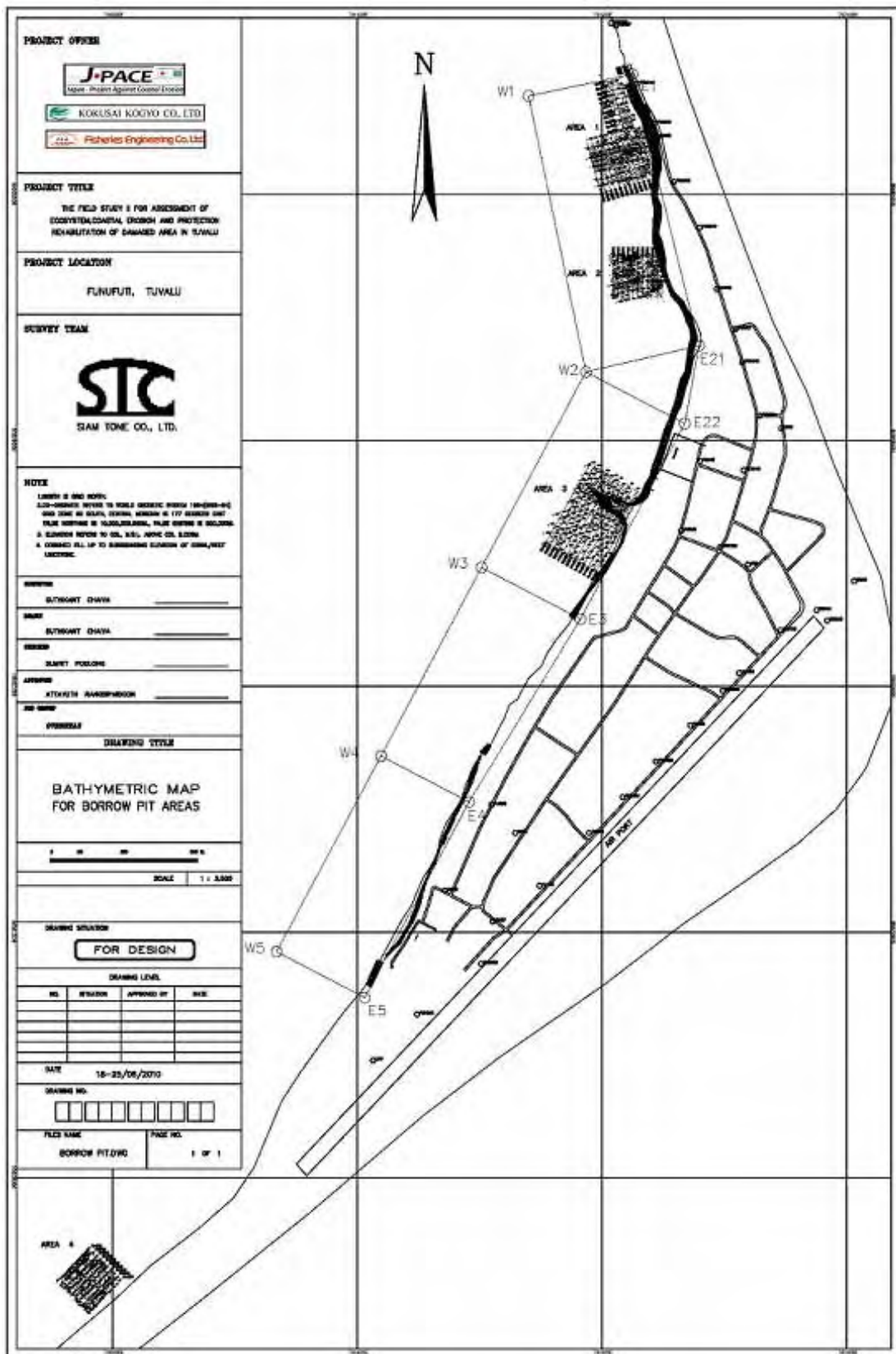


Figure 2.4 Bathymetric Map in Borrow Pit Areas

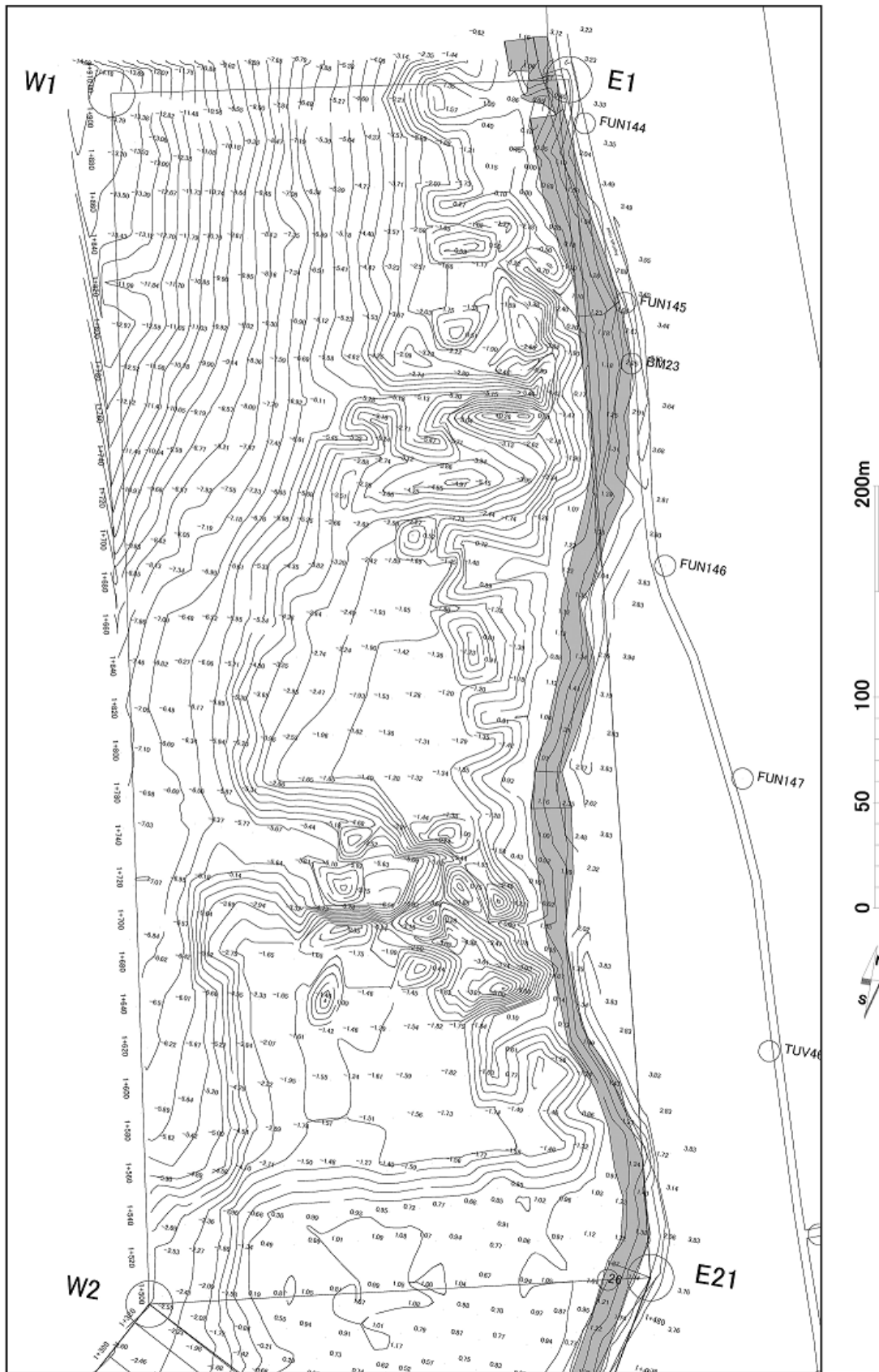


Figure 2.5 Detailed Bathymetric Map in Target Zone for Coastal Protection Measures  
(Zone - 1)

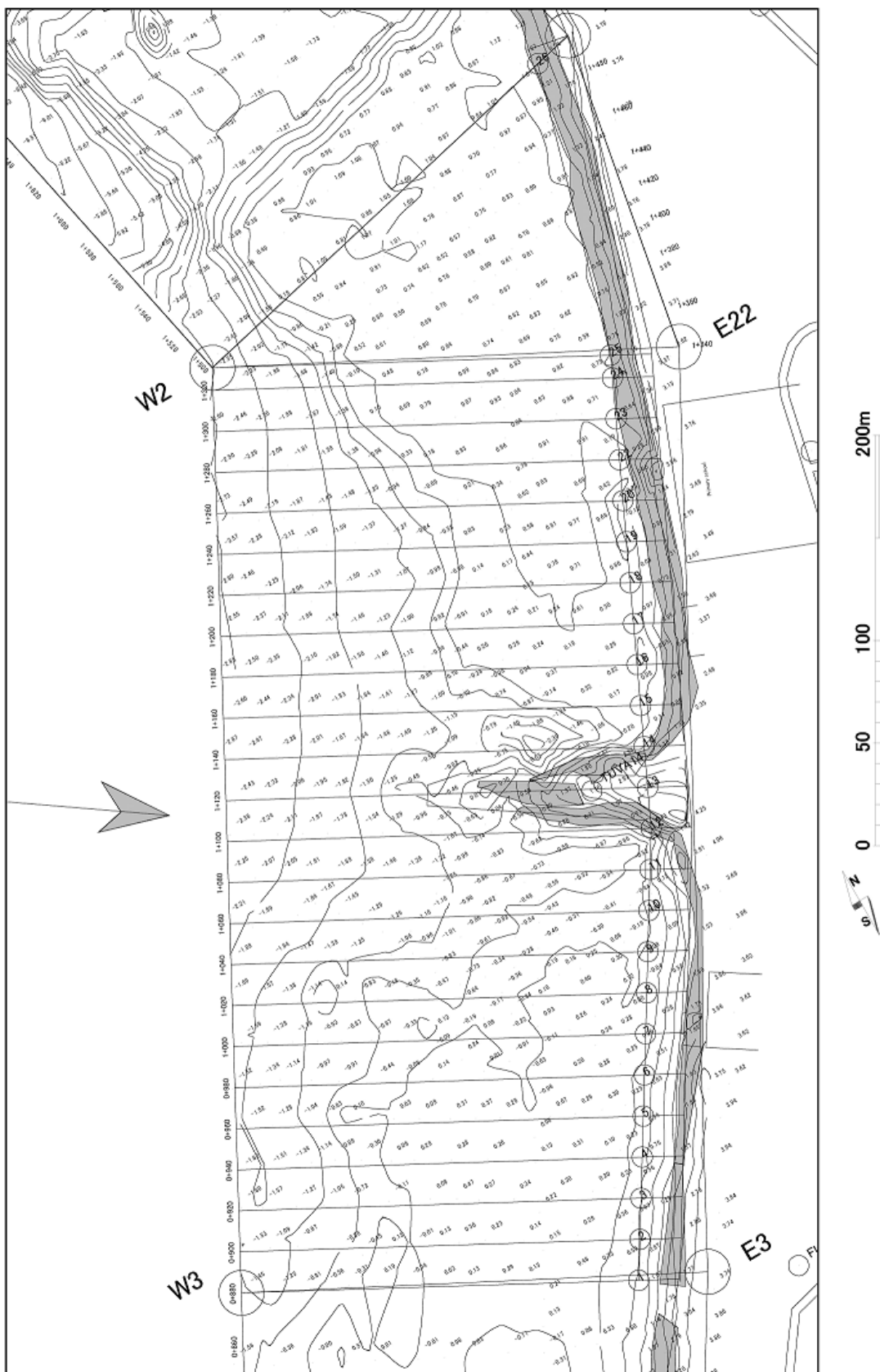


Figure 2.6 Detailed Bathymetric Map in Target Zone for Coastal Protection Measures (Zone - 2 & Zone - 3)

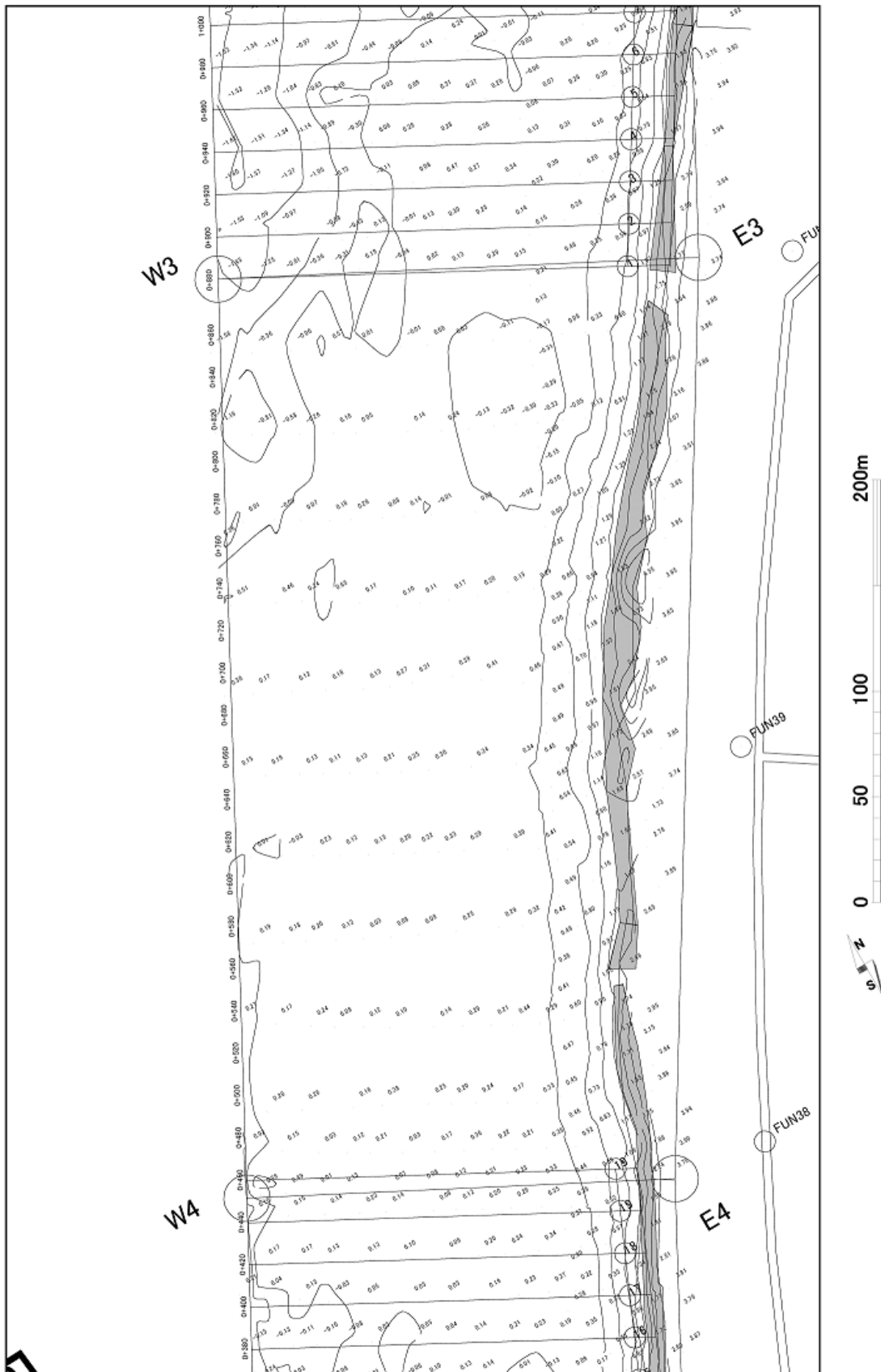


Figure 2.7 Detailed Bathymetric Map in Target Zone for Coastal Protection Measures  
(Zone - 4)



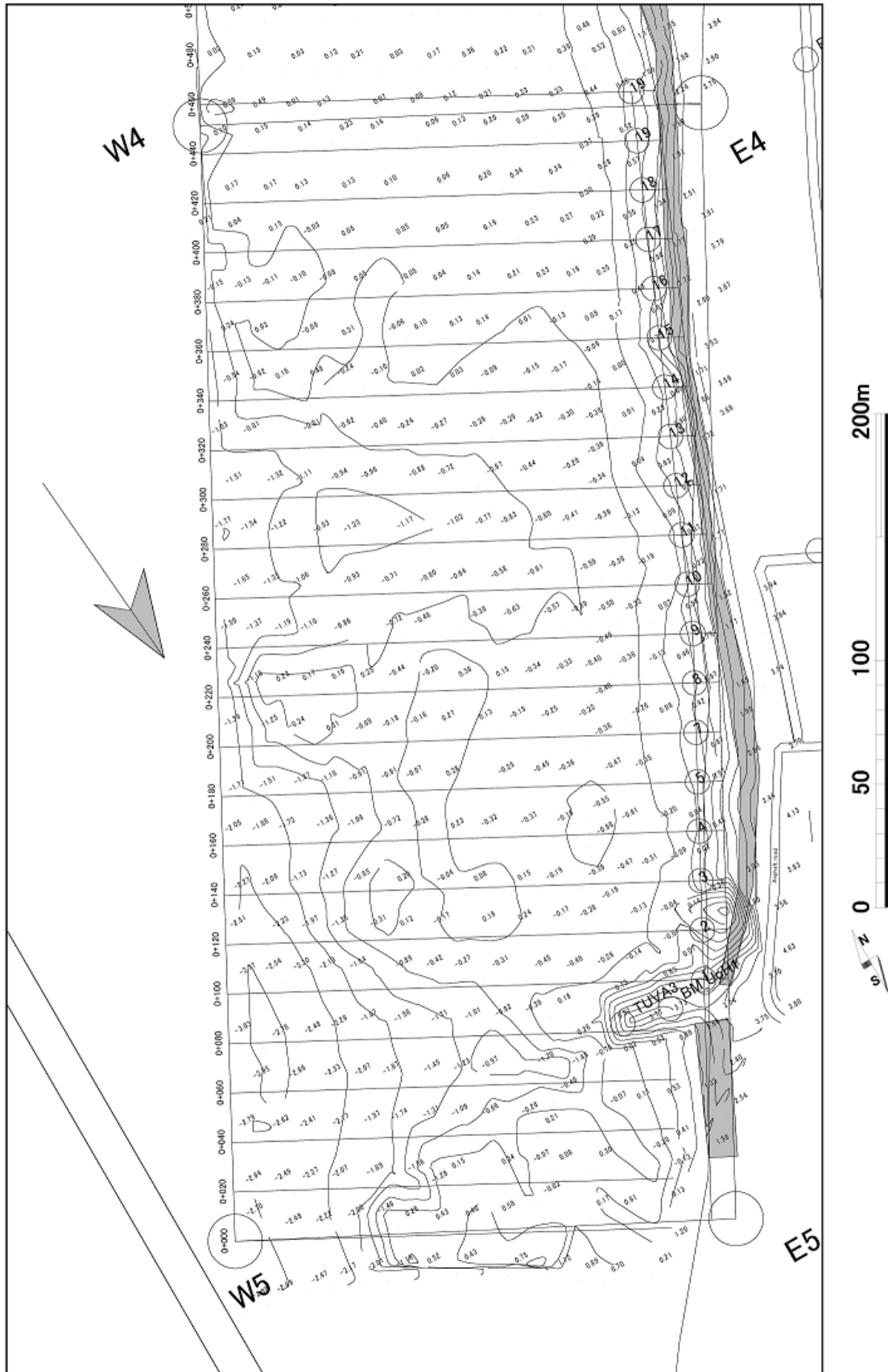


Figure 2.8 Detailed Bathymetric Map in Target Zone for Coastal Protection Measures  
(Zone - 5)

### **3. Gravel Resource Survey**

### **3. Gravel Resource Survey**

The gravel resources survey for the beach nourishment materials was conducted on June to July 2010 during the feasibility study on the southeastern islets of the Funafuti atoll and in the existing runway area of Fongafale islet.

#### **3.1 Gravel Resource Survey on Southern Islets**

The gravel resource survey in southern islets was performed in the northern and southern parts of Funamanu and Falefatu islets, and in the northern part of Mateika islet shown in Figure 3.1. The survey was composed of the gravel classification and gravel volume calculation as well as topographic survey.



**Figure 3.1 Location Map of Funamanu, Falefatu and Mateika Islets**

### **(1) Funamanu Islet**

The details for the topographic and gravel resource survey results in Funamanu islet are provided in “Data Book” attached to this report. The contents of the topographic and gravel resource survey in the Data Book are as follows;

- ① Topographic Map (North and South Funamanu Plans)
- ② Topographic Profile (North and South Funamanu Profiles)
- ③ Topographic Cross Section (North and South Funamanu Cross Sections)
- ④ Typical Gravel Materials (North and South Funamanu)

Figure 3.2 and Figure 3.3 show the field investigation result of typical gravel materials in the north part of Funamanu islet and in the south part of Funamanu islet, respectively.

The exploitable gravel volume in this islet for the beach nourishment will be discussed in the latter Chapter.

### **(2) Falefatu Islet**

The details for the topographic and gravel resource survey results in Falefatu islet are provided in “Data Book” attached to this report. The contents of the topographic and gravel resource survey in the Data Book are as follows;

- ① Topographic Map (North and South Falefatu Plans)
- ② Topographic Profile (North and South Falefatu Profiles)
- ③ Topographic Cross Section (North and South Falefatu Cross Sections)
- ④ Typical Gravel Materials (North and South Falefatu)

Figure 3.4 and Figure 3.5 show the field investigation result of typical gravel materials in the north part of Funamanu islet and in the south part of Falefatu islet, respectively.

The exploitable gravel volume in this islet for the beach nourishment will be discussed in the latter Chapter.

### **(3) Mateika Islet**

The details for the topographic and gravel resource survey results in Mateika islet are provided in “Data Book” attached to this report. The contents of the topographic and gravel resource survey in the Data Book are as follows;

- ① Topographic Map (North Mateika Plans)
- ② Topographic Profile (North and Mateika Profiles)
- ③ Topographic Cross Section (North Mateika Cross Sections)
- ④ Typical Gravel Materials (North Mateika)

Figure 3.6 shows the field investigation result of typical gravel materials in the north part of Mateika islet.

The exploitable gravel volume in this islet for the beach nourishment will be discussed in the latter Chapter.

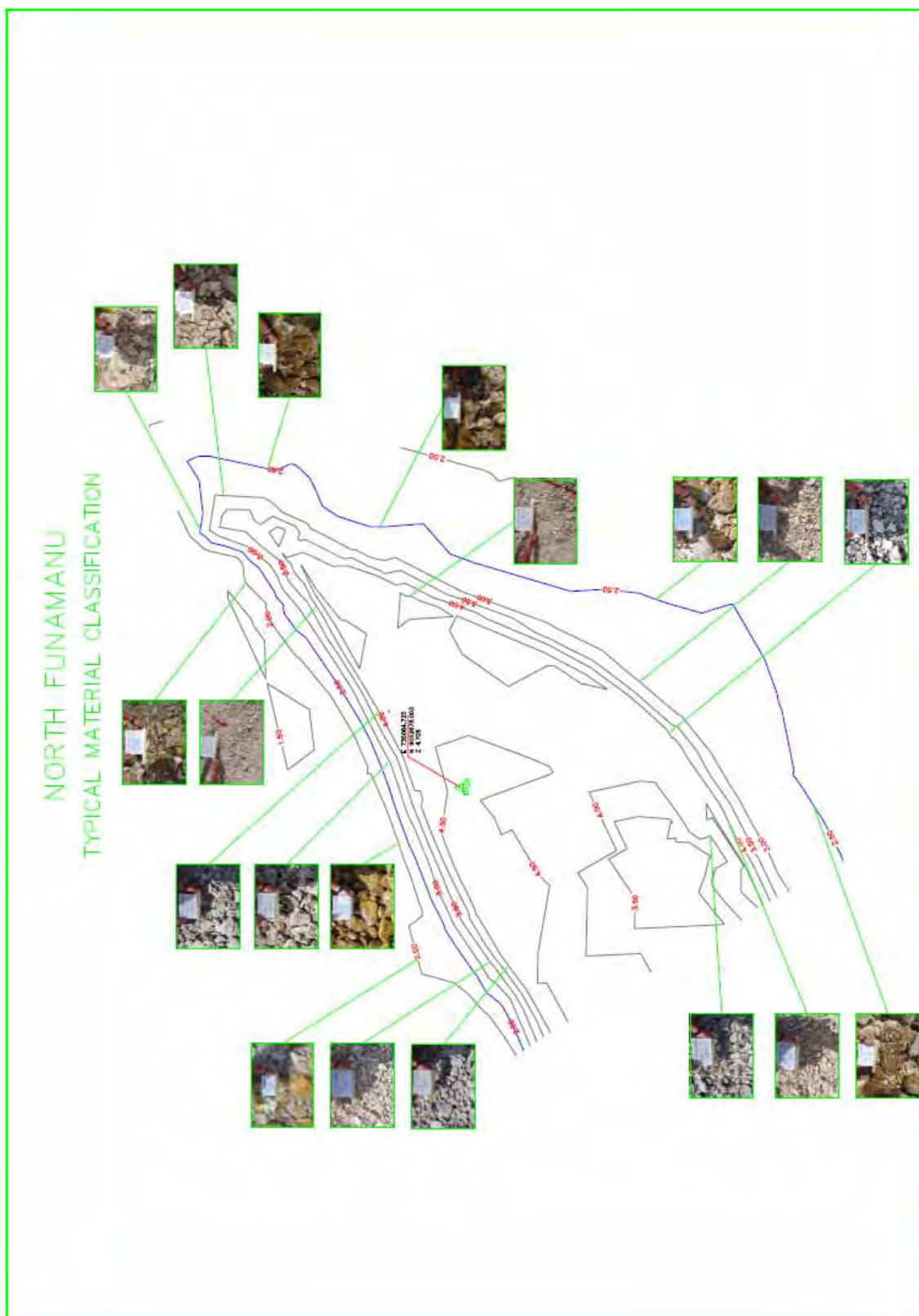


Figure 3.2 Typical Gravel Materials in Northern Part of Funamanu Islets

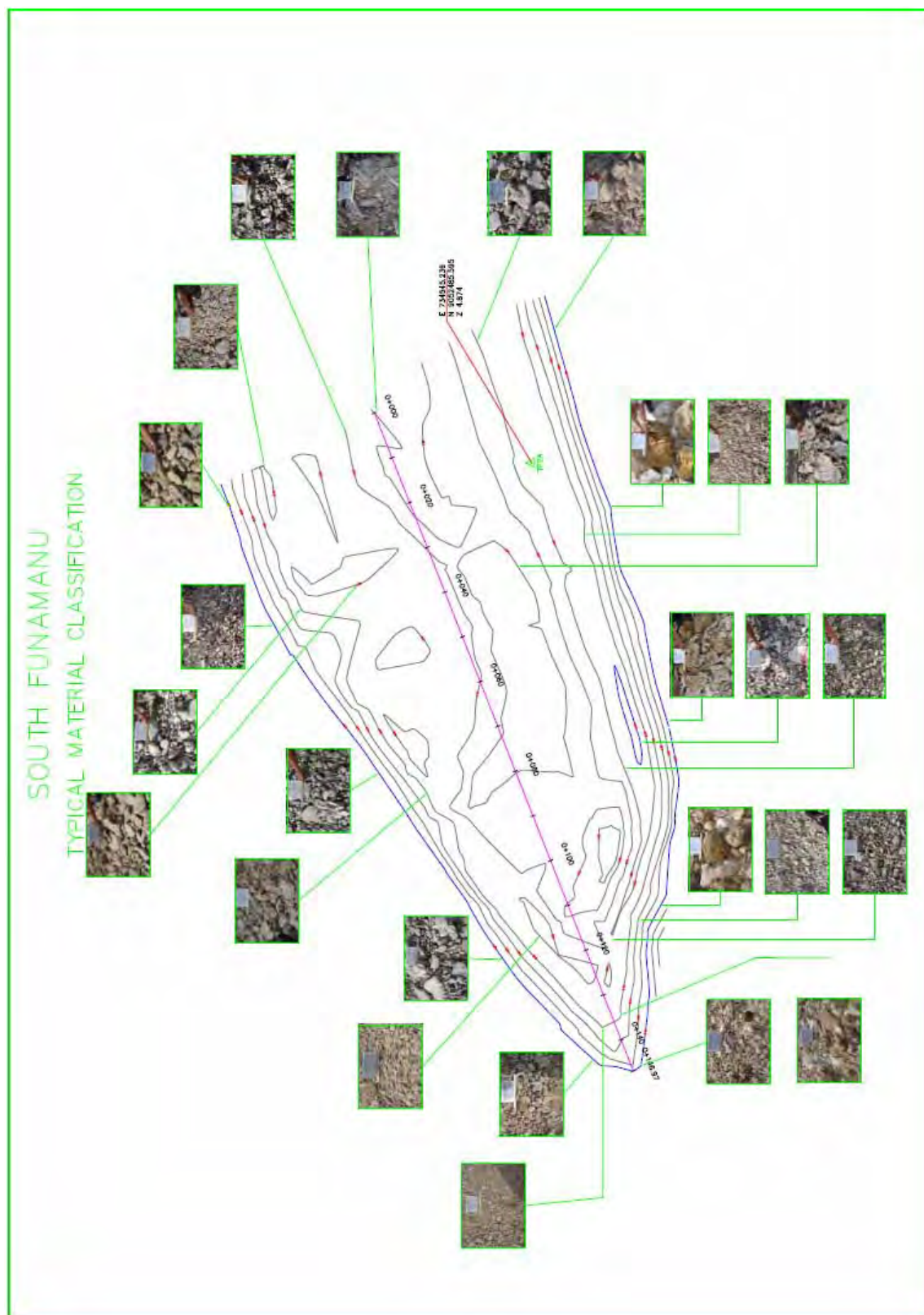


Figure 3.3 Typical Gravel Materials in Southern Part of Funamanu Islets

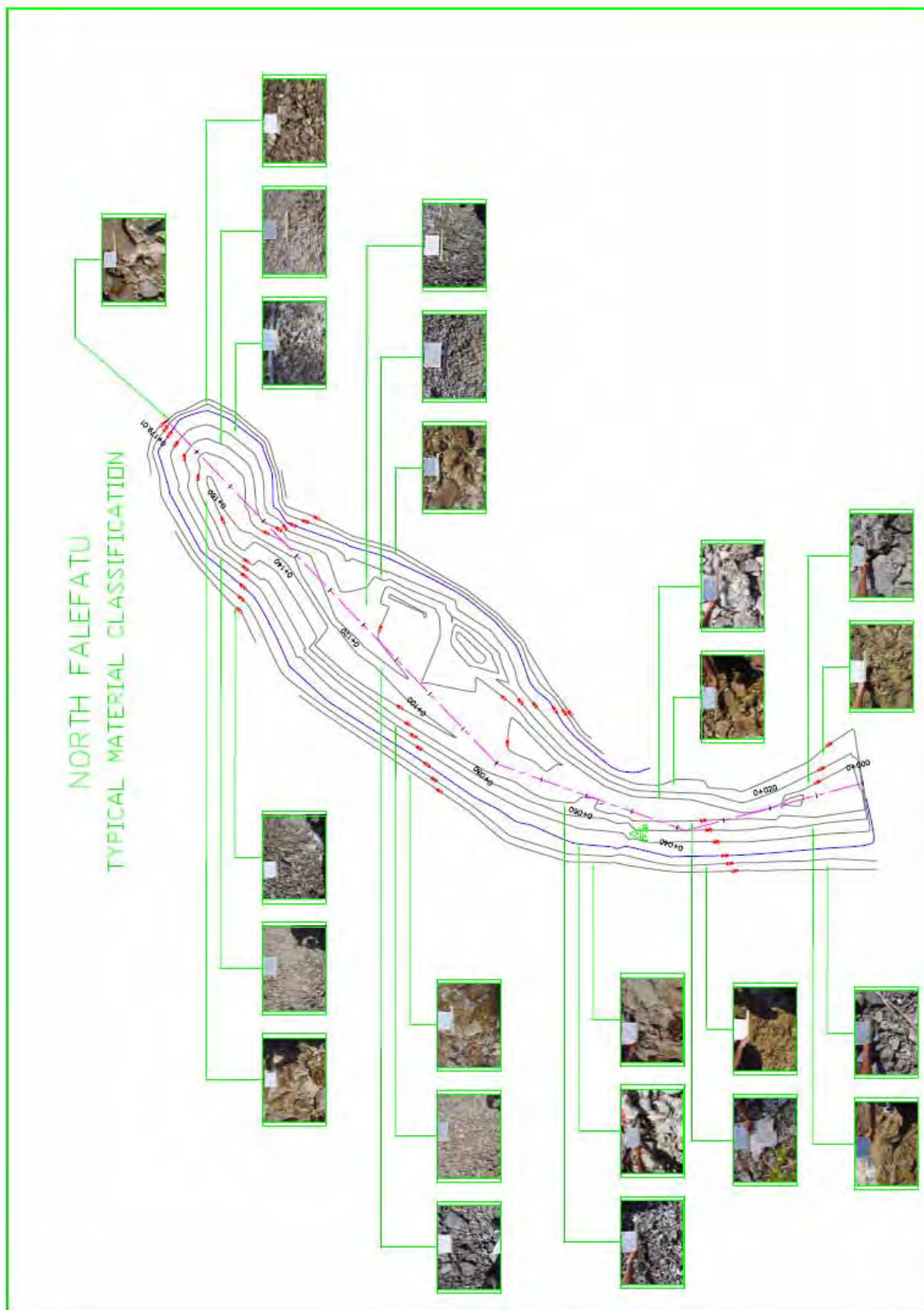


Figure 3.4 Typical Gravel Materials in Northern Part of Falefatu Islets



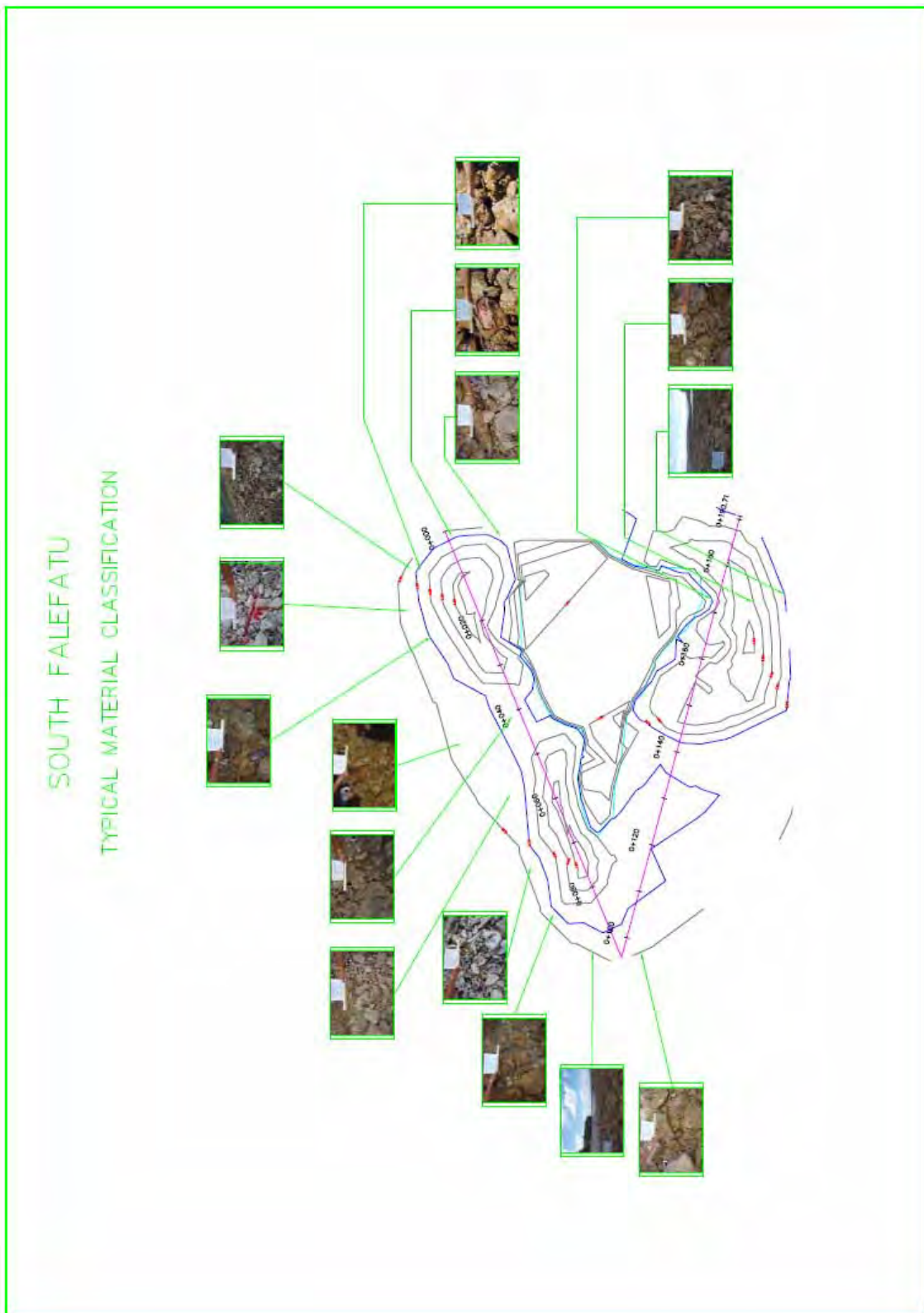


Figure 3.5 Typical Gravel Materials in Southern Part of Falefatu Islets

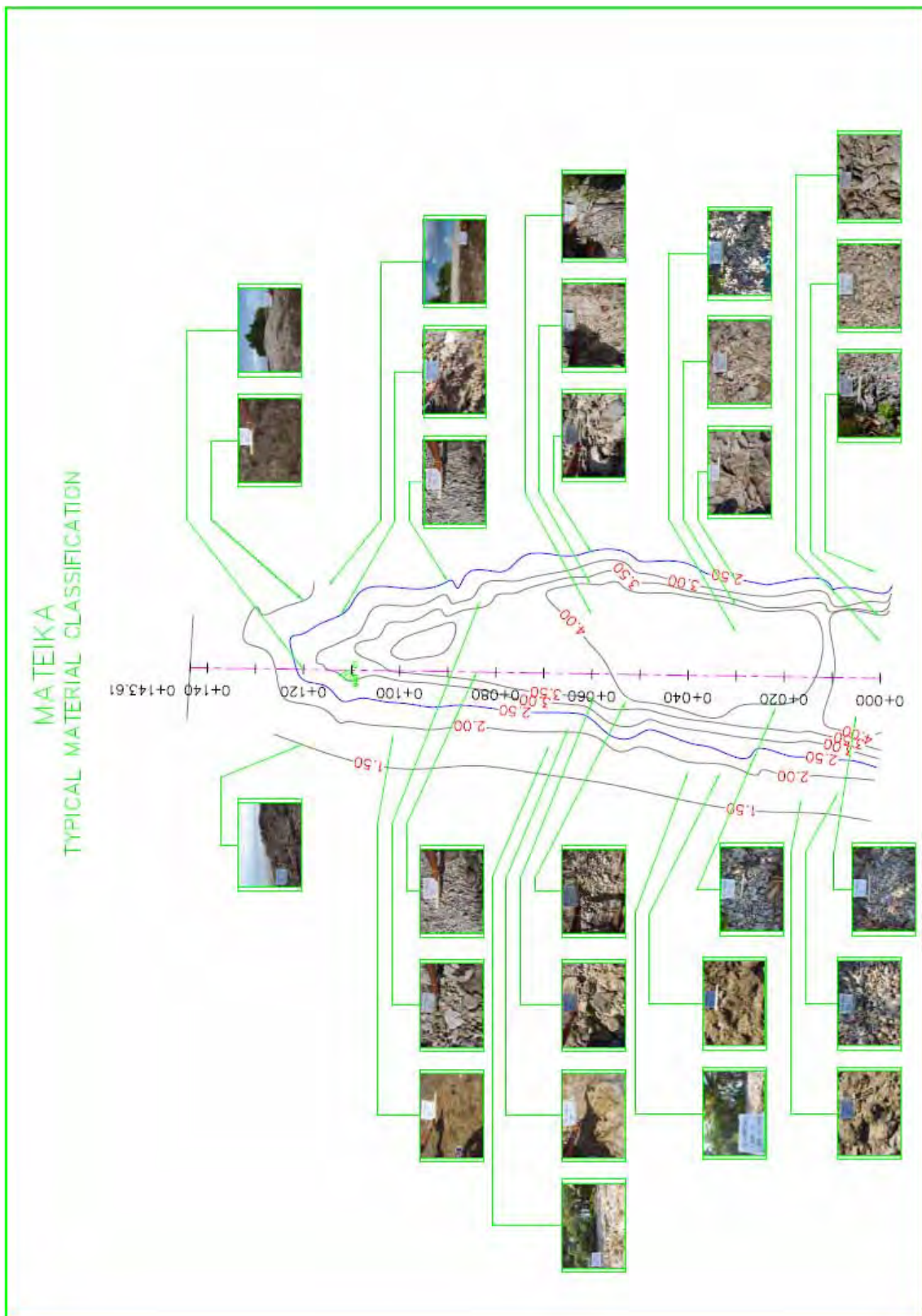


Figure 3.6 Typical Gravel Materials in Northern Part of Mateika Islets

## **3.2 Gravel Resource Survey on Fongafale Islets**

### **(1) Overview of Gravel Resource Survey**

The gravel resource survey along the existing runway in Fongafale islet was performed at eighteen (18) test pits in the ocean side of the safety zone beside the runway as shown in Figure 3.7. The test pits were excavated using an excavator at the size of one meter depth with one meter width and length in principle.

The gravel resource survey was composed of the test pit observation and gravel size distribution test at each pit, and the exploitable gravel volume for the beach nourishment was finally estimated.

### **(2) Result of Gravel Resource Survey**

Table 3.1 and Figure 3.8 show the detailed information such as locations, ground levels, underground water levels and sediments classification etc. at each test pit.

The results of the gravel size distribution test at each test pit are shown in Figure 3.9. This shows that the sediment materials in the study area is mainly composed of large gravels, larger than 2 cm diameter, and cobble with the occurrence percentage of more than 75 %.

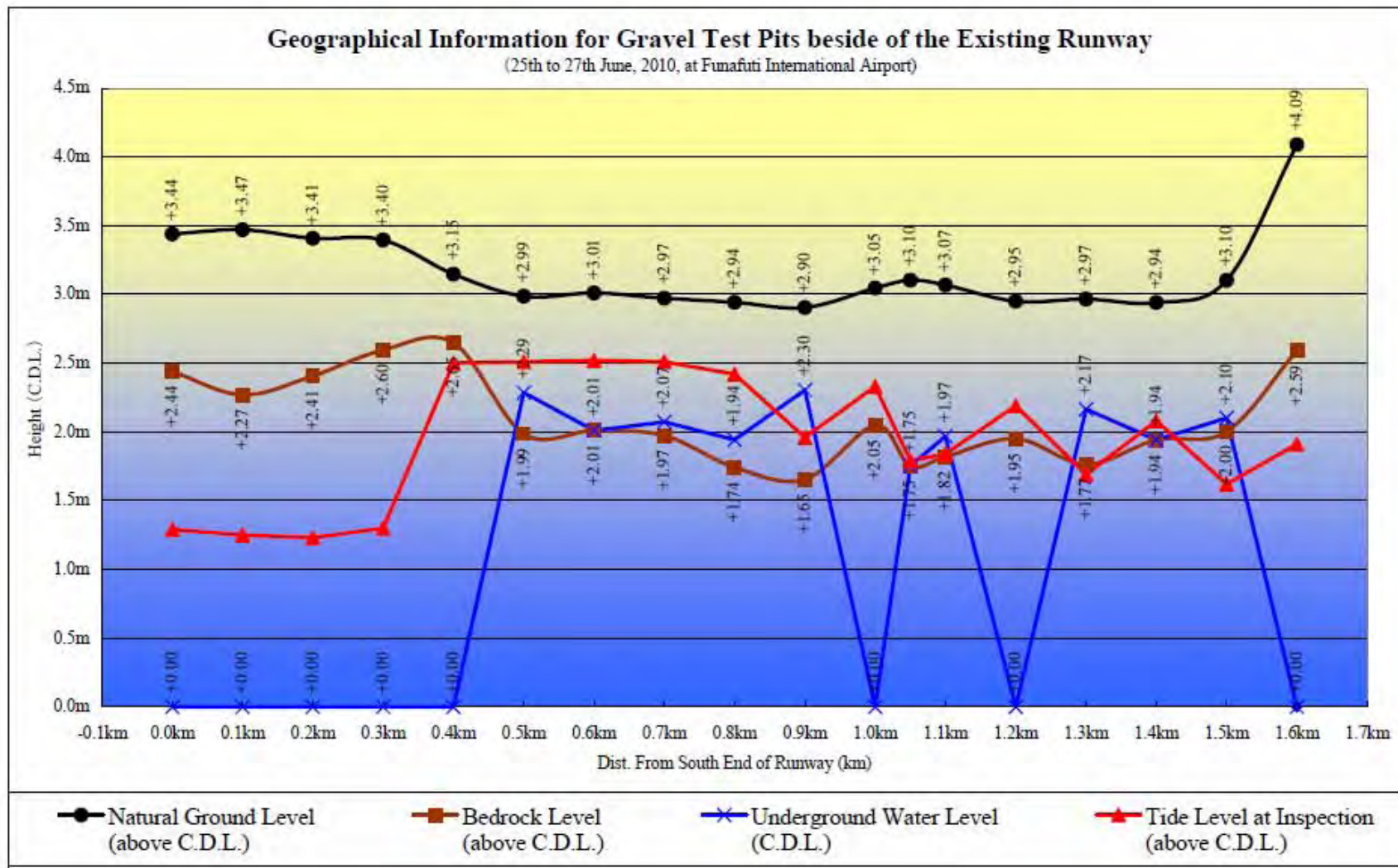


Figure 3.7 Location Map of Test Pits along Existing Runway

**Table 3.1 Detailed Information of Test Pits for Gravel Resource Survey along Existing Runway**

St.	Dist. From South End of Runway (km)	Easting	Northing	Natural Ground Level (above C.D.L.)	Depth (from N.G.L.)	Bedrock Level (above C.D.L.)	Underground Water Level (C.D.L.)	Classification	Remarks
P-13	1.600	742411.8796	9057672.1989	+4.09	-1.50	+2.59	Not observed	G	
P-12+	1.500	742343.2790	9057595.2910	+3.10	-1.10	+2.00	+2.10	G	Gravelly, Slight high U/G Water
P-12	1.400	742277.4945	9057524.0969	+2.94	-1.00	+1.94	+1.94	G	Gravelly, Slight high U/G Water
P-11+	1.300	742207.3849	9057453.0774	+2.97	-1.20	+1.77	+2.17	G	Gravelly, High U/G Water
P-11	1.200	742136.8308	9057380.3482	+2.95	-1.00	+1.95	Not observed	G	Gravelly, High U/G Water
P-10+	1.100	742067.9129	9057307.9960	+3.07	-1.25	+1.82	+1.97	S	No Gravel, High U/G water
P-10+0.5	1.050	742036.0473	9057276.0453	+3.10	-1.35	+1.75	+1.75	GS	Sand with Gravel, Low U/G water
P-10	1.000	741999.1026	9057236.3817	+3.05	-1.00	+2.05	Not observed	GS	Sand with Gravel, No U/G water
P-09+	0.900	741935.2287	9057160.3079	+2.90	-1.25	+1.65	+2.30	G	Gravelly, High U/G Water
P-09	0.800	741863.5388	9057087.6325	+2.94	-1.20	+1.74	+1.94	G	
P-08	0.700	741794.4500	9057014.7703	+2.97	-1.00	+1.97	+2.07	G	
P-07	0.600	741728.0656	9056940.8265	+3.01	-1.00	+2.01	+2.01	G	
P-06	0.500	741659.9577	9056868.6012	+2.99	-1.00	+1.99	+2.29	G	
P-05	0.400	741592.9891	9056795.6242	+3.15	-0.50	+2.65	Not observed	G	
P-04	0.300	741524.3872	9056721.0248	+3.40	-0.80	+2.60	Not observed	G	
P-03	0.200	741457.3948	9056647.7584	+3.41	-1.00	+2.41	Not observed	G	
P-02	0.100	741386.1791	9056576.9882	+3.47	-1.20	+2.27	Not observed	G	
P-01	0.000	741314.9658	9056506.3991	+3.44	-1.00	+2.44	Not observed	G	
Average				+3.16	-1.08	+2.09	+2.05		

Figure 3.8



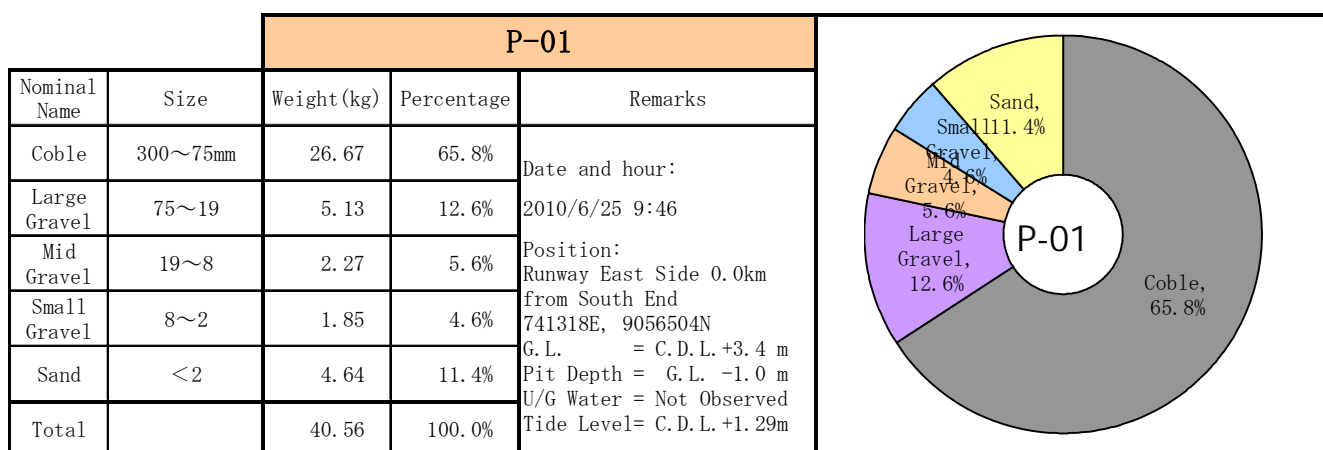
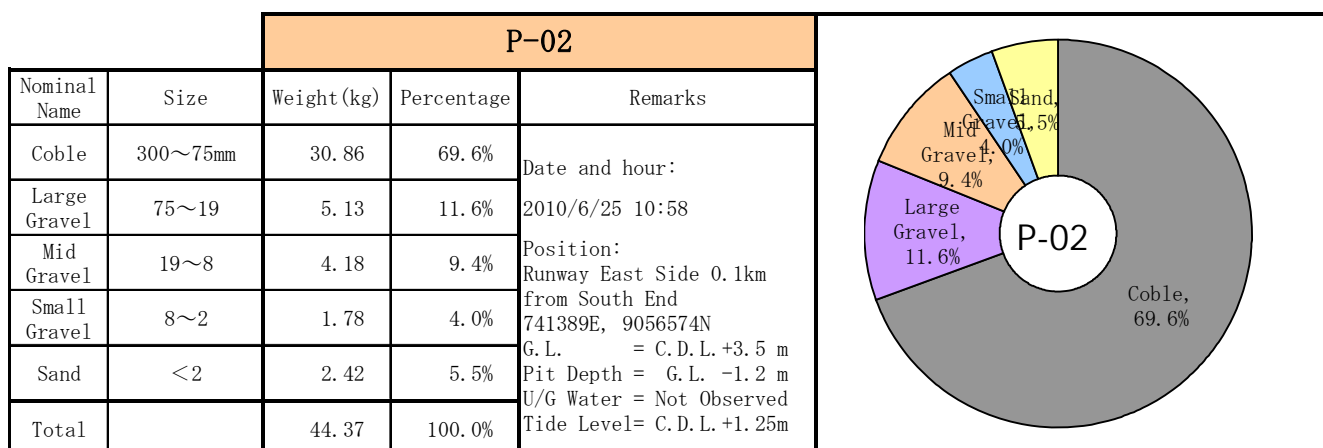
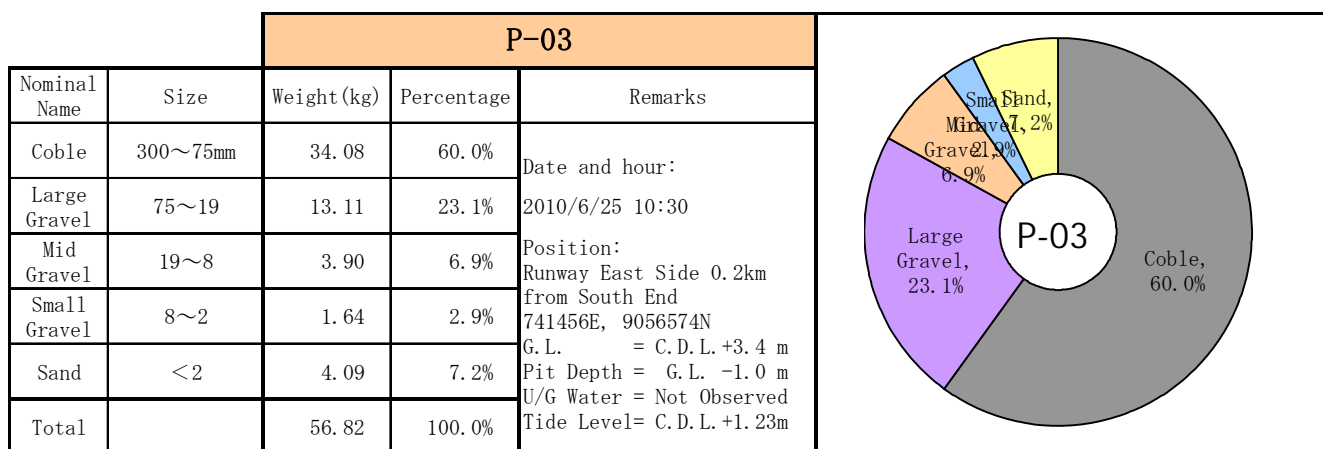


Figure 3.9(1) Gravel Particle Size of Test Pit Materials

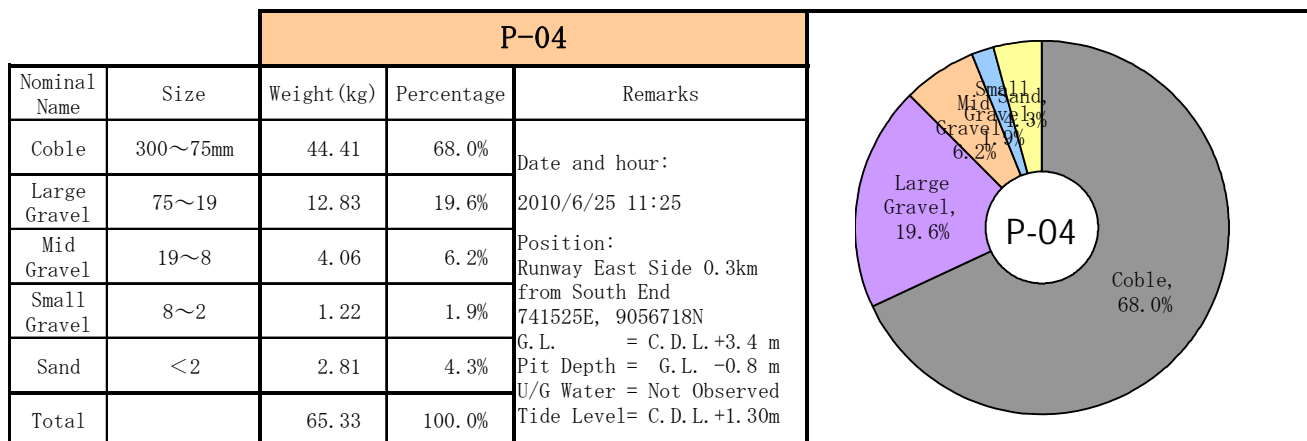
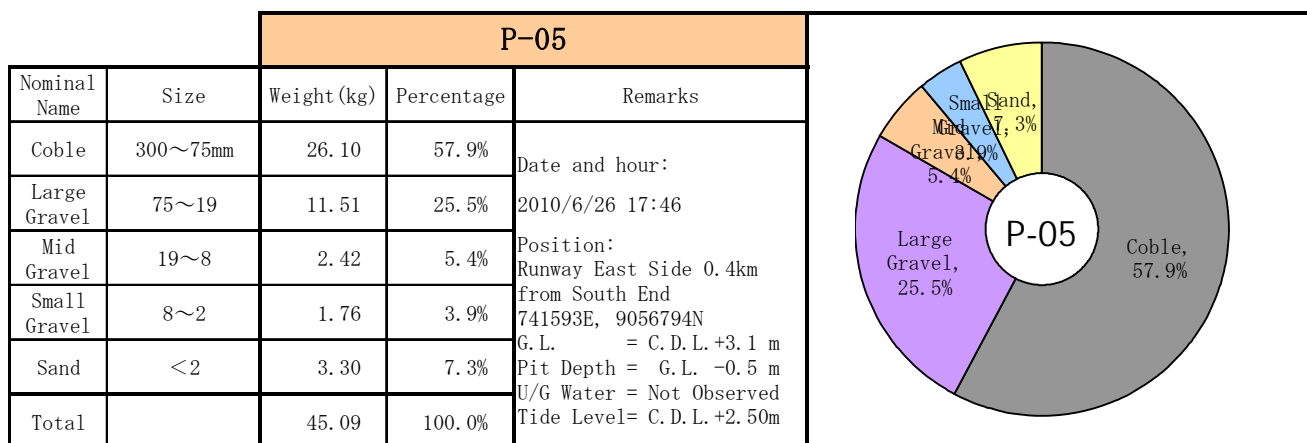
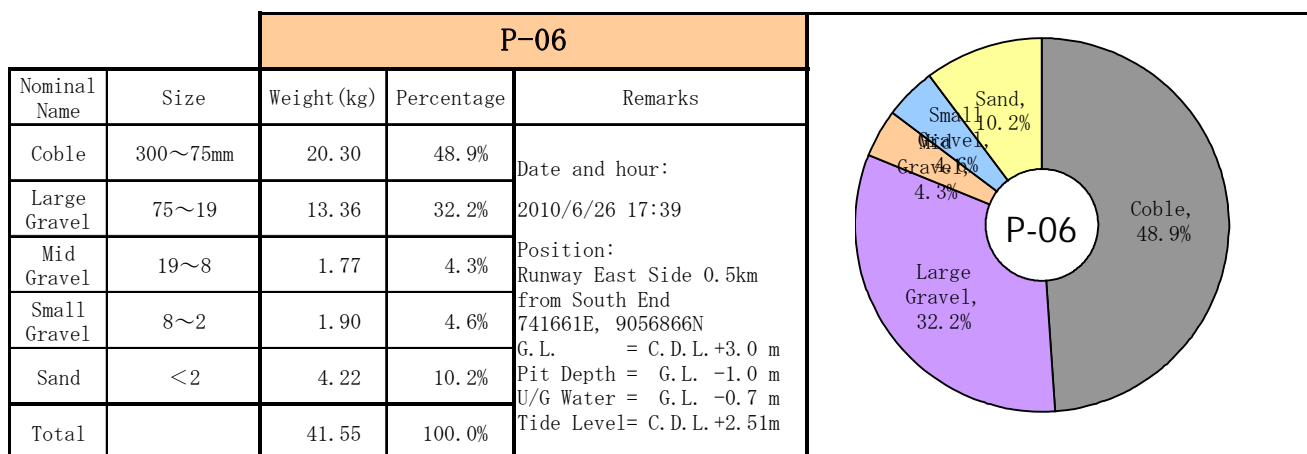


Figure 3.9(2) Gravel Particle Size of Test Pit Materials



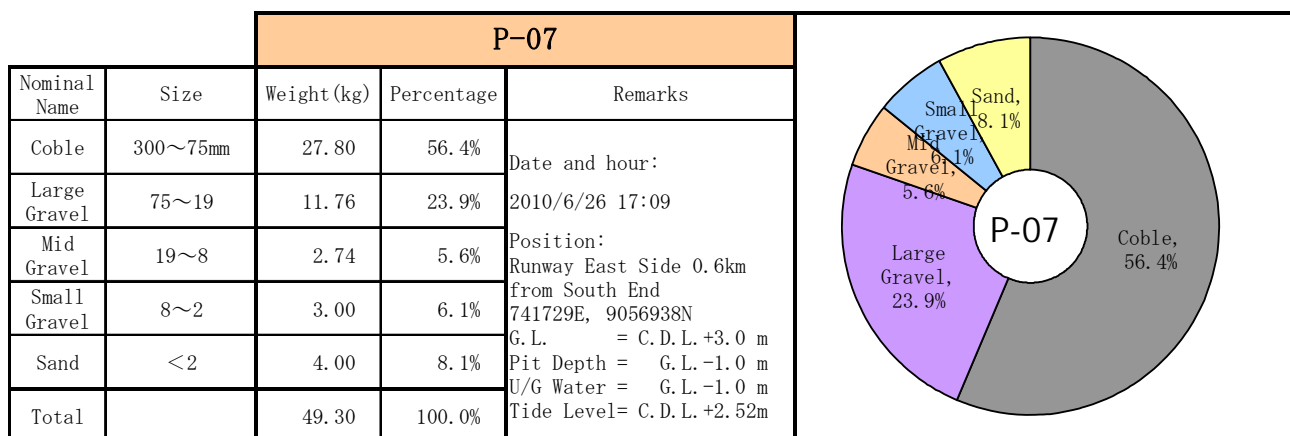
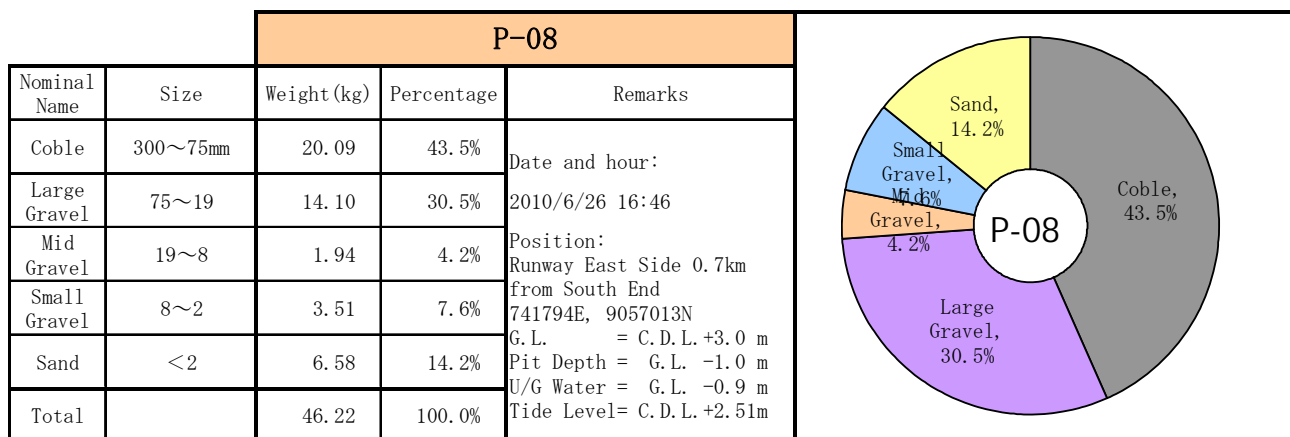
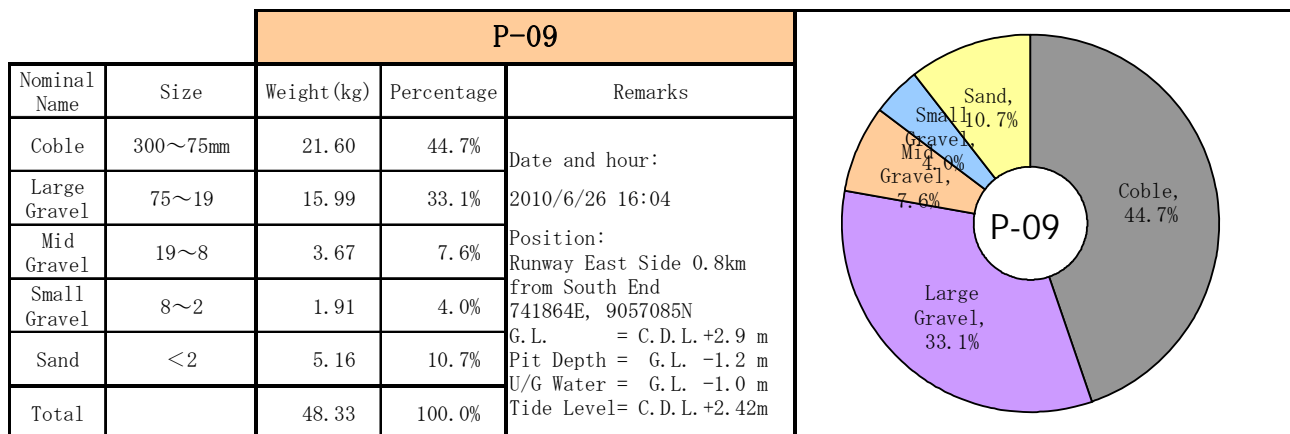


Figure 3.9(3) Gravel Particle Size of Test Pit Materials

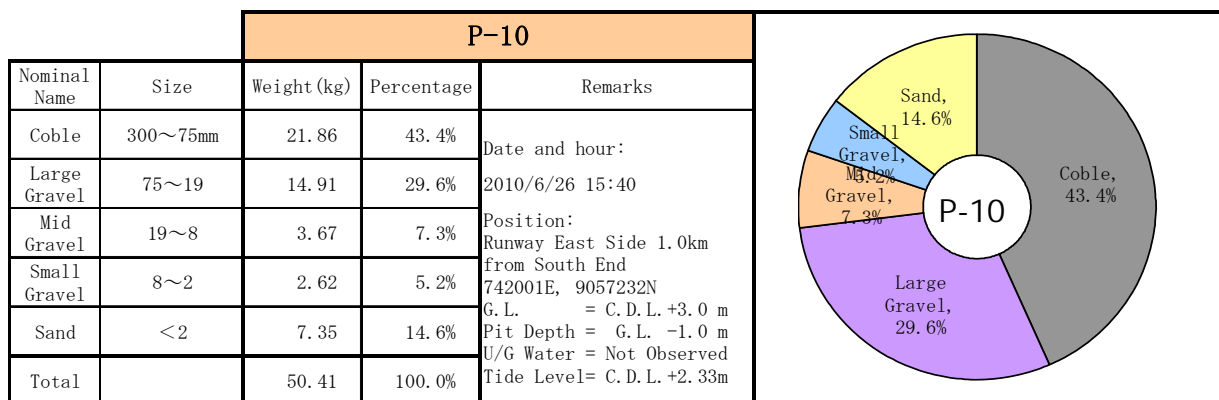
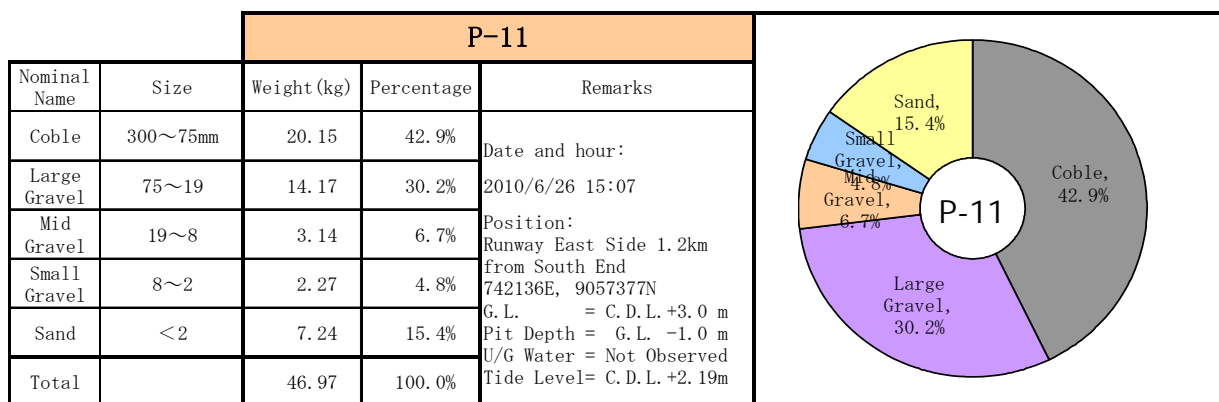
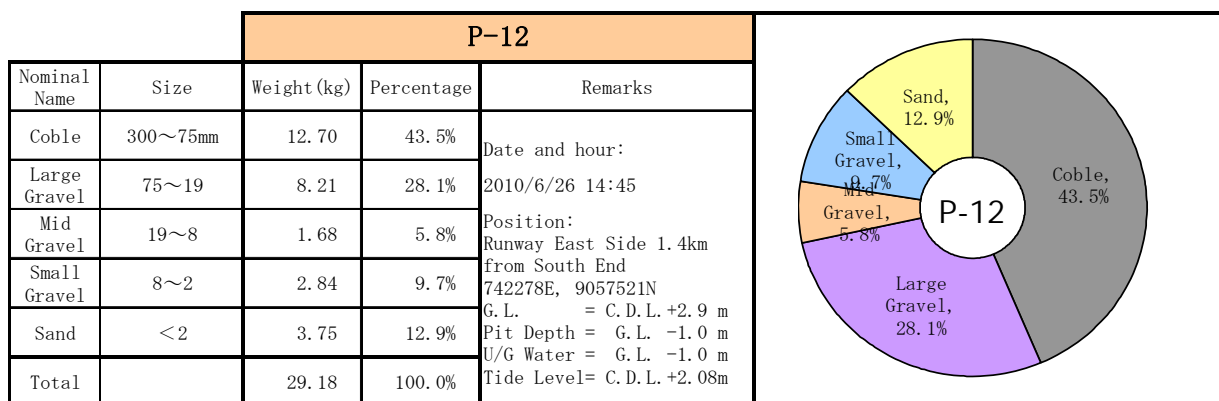
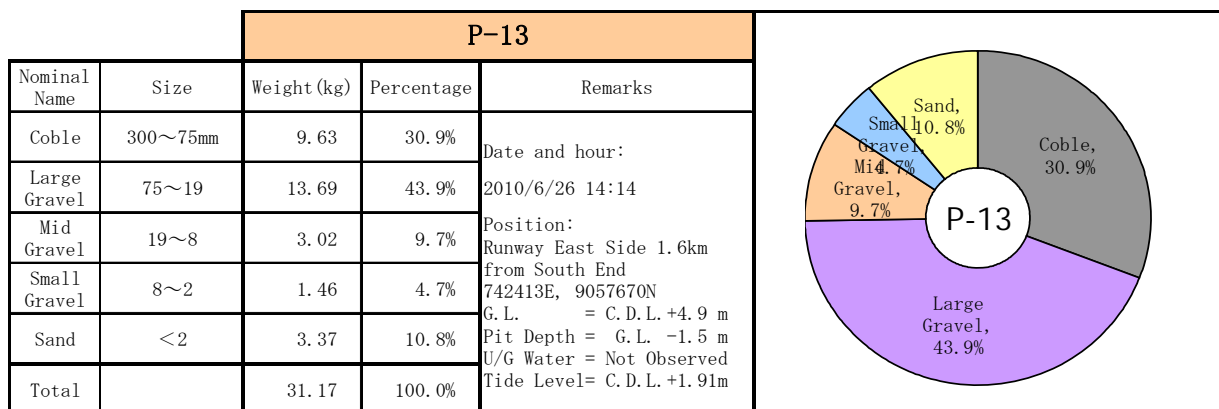


Figure 3.9(4) Gravel Particle Size of Test Pit Materials

## **4. Coastal Ecology Survey for Feasibility Study**

#### **4. Coastal Ecology Survey for Feasibility Study**

##### **4.1 Overview of Survey**

This survey conducted the following survey items.

1. Coastal Ecology Survey in the Target Zone for Coastal Protection Measures
2. Coastal Ecology Survey around South-Eastern Islets of Funafuti Lagoon

##### **4.1.1 Survey Area**

Survey area is shown in Figure 1.

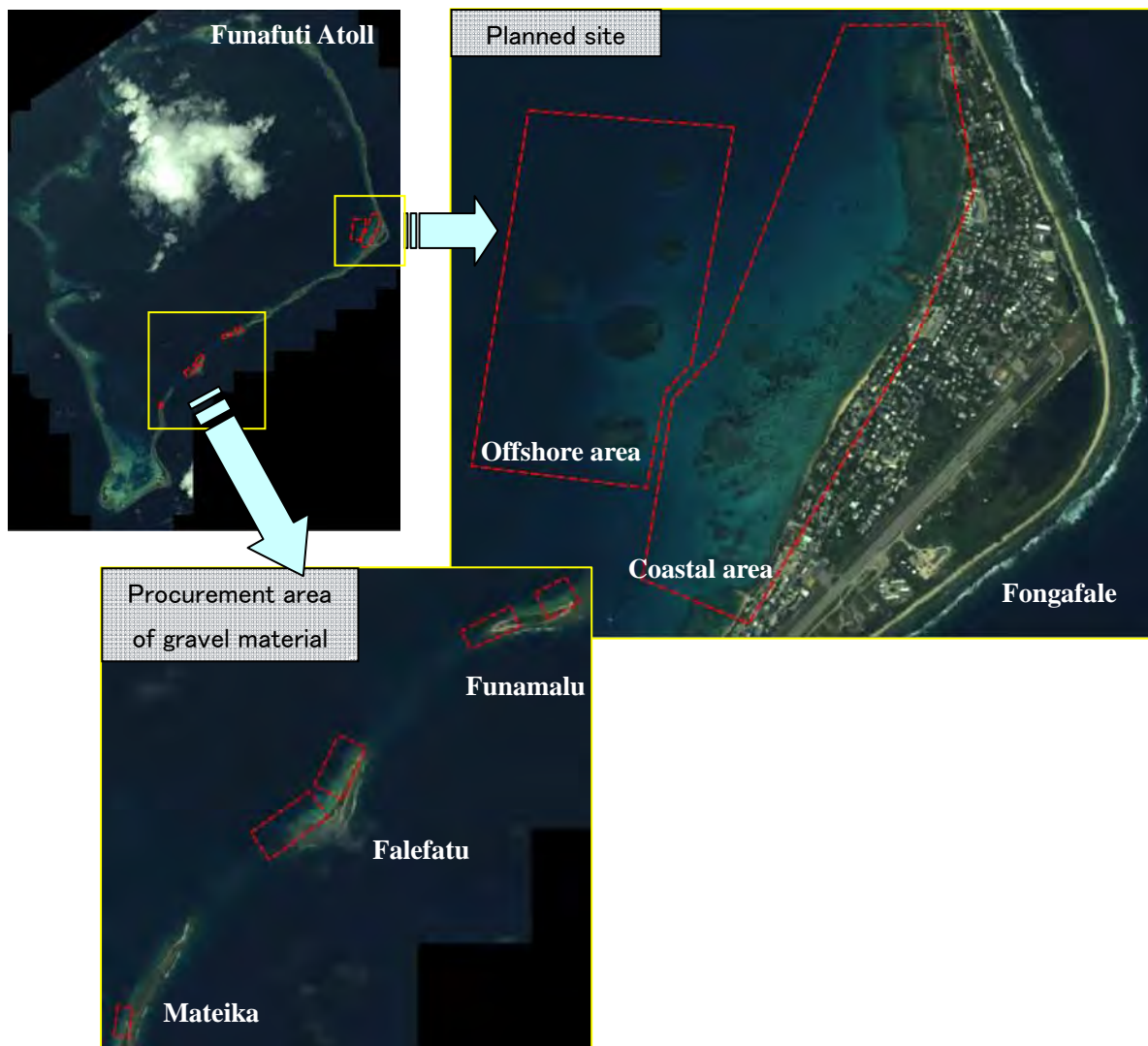


Figure 1 The location of coastal ecology survey for F/S

#### **4.1.2 Survey Duration**

20.07.2010 to 10.08.2010

#### **4.1.3 Survey Method**

Before the survey, field reconnaissance was carried out to understand the brief conditions of each survey point.. The positions of laying the survey lines were measured using a simple GPS (geographical coordinate system: WGS84).

In the coastal ecological survey, visual observation by divers (ecological research staff) was carried out as Figure 2 and Figure 3 in order to record the distribution (sectional distribution) of corals, fish, algae and bottom materials (rocks, coral pieces, foraminifers and shell pieces).



Figure 2 Line survey

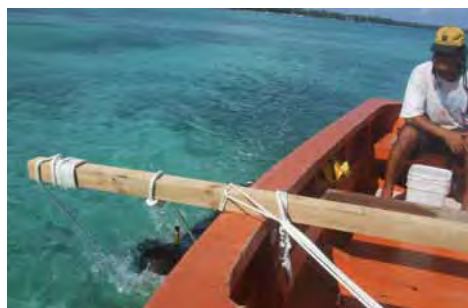


Figure 3 Manta-method

## 4.2 Results of Survey

### 4.2.1 Target Zone for Coastal Protection Measures

#### (1) Line Survey Results

##### 1) Location of Line Survey



Figure 4 Location of survey line (Red circles represent start and end of the line)

Table 1 Coordinate value of survey lines

		LAT	LNG
Fongafale 1	start	-8° 30' 45.7"	179° 11' 54.8"
	end	-8° 30' 44.5"	179° 11' 48.6"
Fongafale 2	start	-8° 30' 54.0"	179° 11' 56.0"
	end	-8° 30' 51.9"	179° 11' 49.8"
Fongafale 3	start	-8° 31' 12.4"	179° 11' 45.4"
	end	-8° 31' 08.6"	179° 11' 36.2"
Fongafale 4	start	-8° 31' 26.3"	179° 11' 38.5"
	end	-8° 31' 23.5"	179° 11' 29.1"
Fongafale 5	start	-8° 31' 08.1"	179° 11' 22.6"
	end	-8° 31' 03.4"	179° 11' 26.8"
Fongafale 6	start	-8° 31' 02.4"	179° 11' 52.0"
	end	-8° 30' 59.9"	179° 11' 47.7"

2) Profiles of Ecological Survey by Line Survey

Fongafale 1

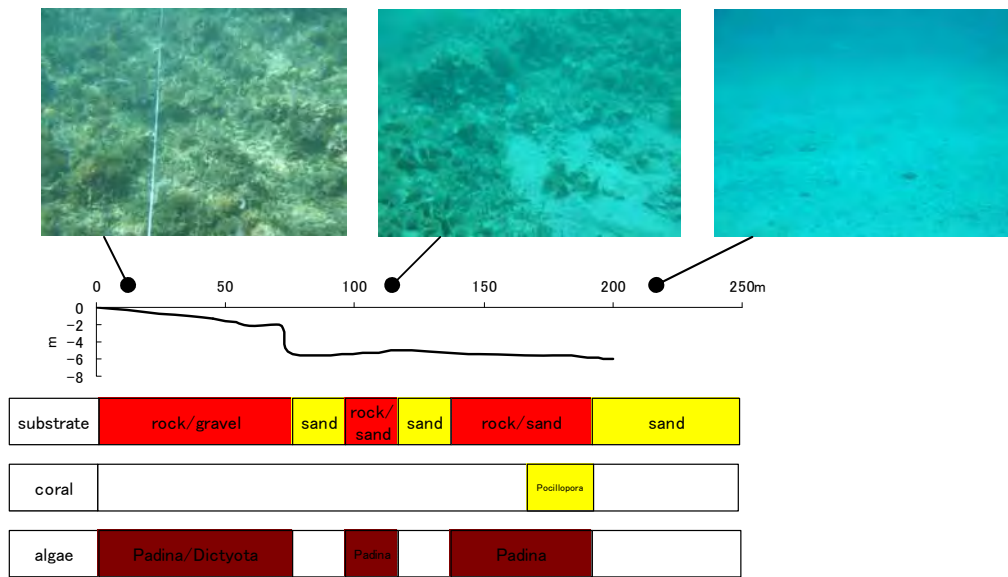


Figure 5 Profile in Fongafale 1 survey line

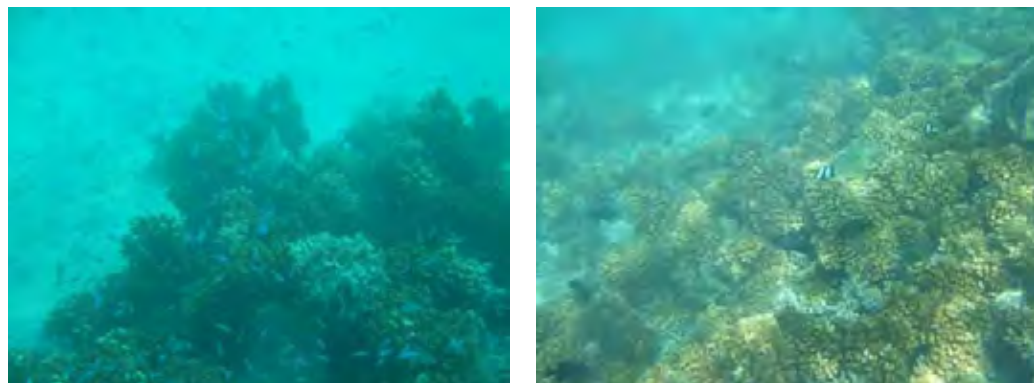


Figure 6 Confirmed Pocillopora zone in north of the Fongafare 1 line

Fongafale2

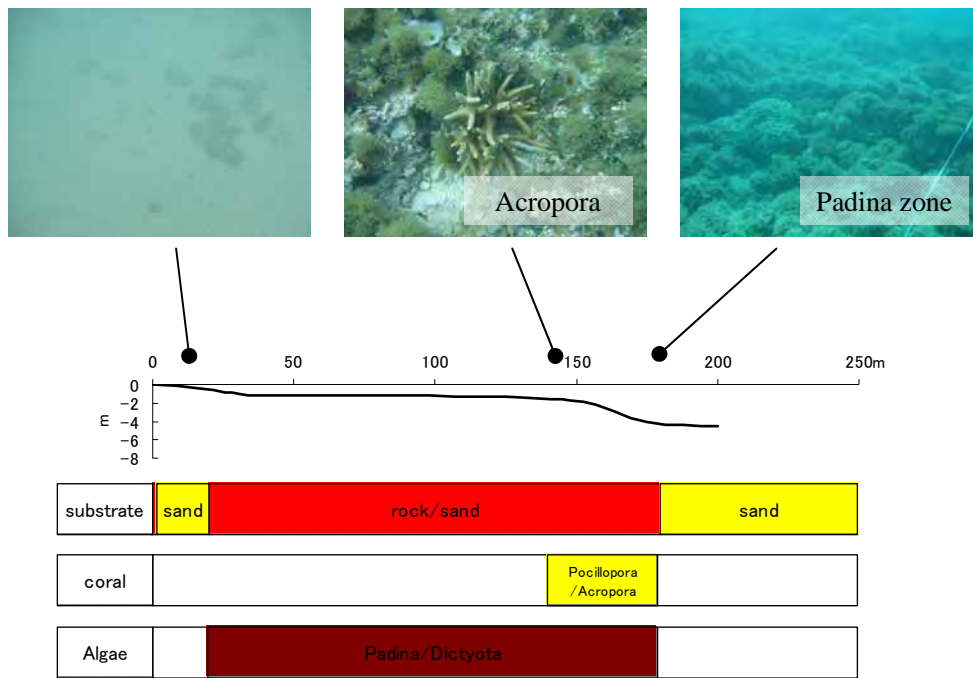


Figure 7 Profile in Fongafale 2 survey line

Fongafale3

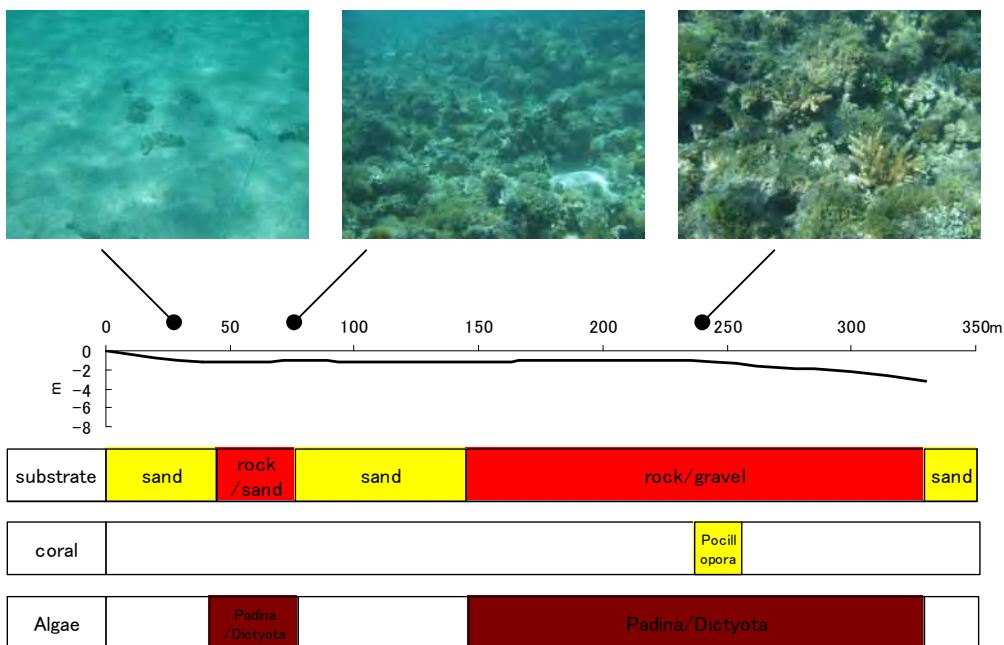


Figure 8 Profile in Fongafale 3 survey line



Fongafale4

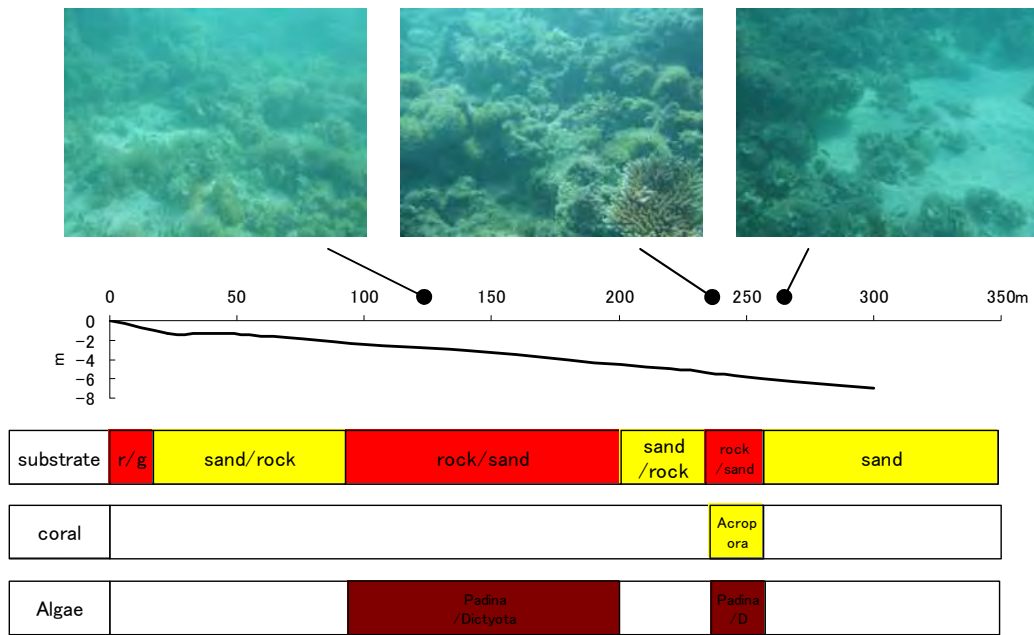


Figure 9 Profile in Fongafale 4 survey line

Fongafale5

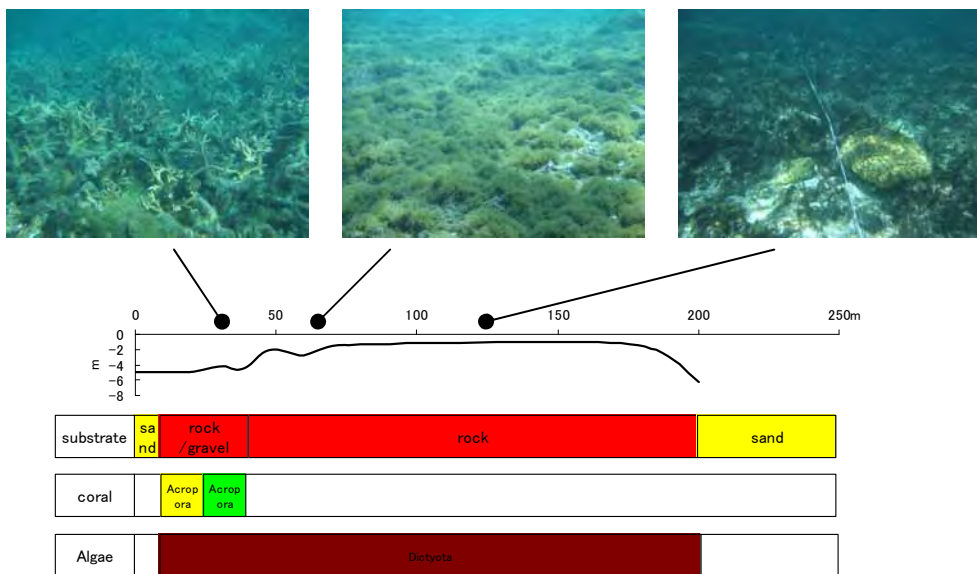


Figure 10 Profile in Fongafale 5 survey line

**Fongafale 6**

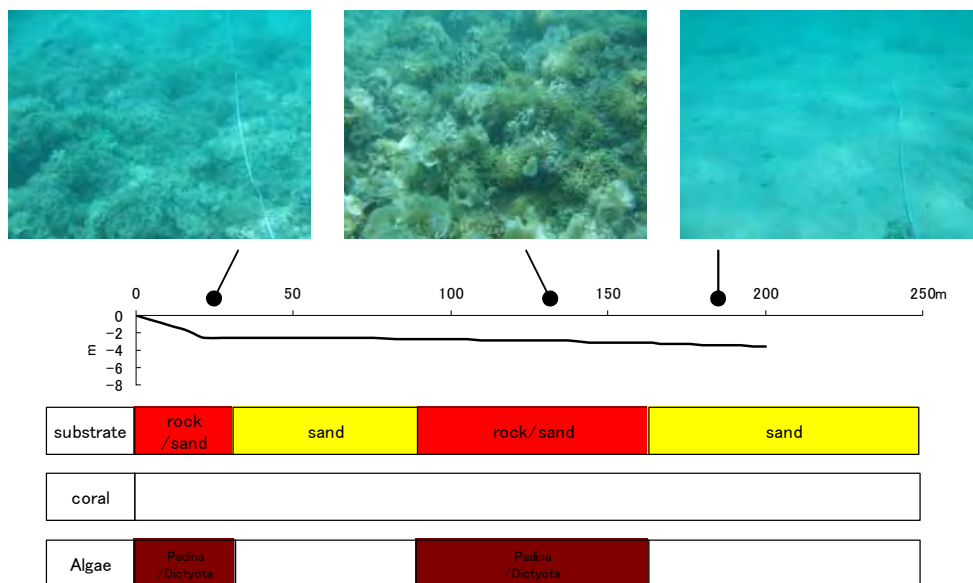


Figure 11 Profile in Fongafale 6 survey line

**3) Results of Fish Survey**

Table 2 Trend of the appearance of fish species

	Number of the appearance of fish species	Average number of fish speices per quadrat
Fongafale 1	47	10.5
Fongafale 2	43	7.4
Fongafale 3	46	9.2
Fongafale 4	49	7.3
Fongafale 5	59	11.7
Fongafale 6	48	8.3

Table 3-1 The results of observation about fish appearance in Funafuti 1

No.	Scientific name	No. of species	distance from shoreline(m)																					
			0	9	6	9	7	13	13	15	7	8	9	13	10	11	19	7	12	13	19	9		
1	Ophichthidae	SNAKE EELS																						
2	<i>Neoniphon sammara</i>	Bloodspot squirrelfish															r					rr		
3	<i>Myripristis</i> sp.	Soldierfishes																					r	rr
4	<i>Epinephelus merra</i>	Honeycomb grouper		rr					r	rr												rr		rr
5	<i>Cheilodipterus quinquelineatus</i>	Five-lined cardinalfish			r	r	rr									c	c	cc			r			r
6	<i>Apogon</i> sp.	Cardinalfishes				rr			rr															
7	<i>Lutjanus monostigma</i>	Onespot snapper		rr																				
8	<i>Lutjanus</i> sp.	Snappers			rr	rr																		r
9	<i>Caesio</i> spp.	Fusiliers																						r
10	<i>Pterocaesio trilineata</i>	Three-striped fusilier																						
11	<i>Monotaxis grandoculis</i>	Bigeye emperor							rr	rr	rr													
12	<i>Lethrinus ramak</i>																						rr	
13	<i>Lethrinus</i> sp.															rr	rr				r	r	r	rr
14	<i>Mulloidichthys flavolineatus</i>	Yellowstripe goatfish		rr													r					r		
15	<i>Parupeneus multifasciatus</i>	Multibarred goatfish							rr	rr	rr											rr		rr
16	<i>Parupeneus barberinus</i>	Dash-and-dot goatfish														rr	rr					rr		rr
17	<i>Chaetodon auriga</i>	Threadfin butterflyfish				rr			rr	rr	rr											rr		rr
18	<i>Chaetodon ephippium</i>	Saddled butterflyfish							rr															rr
19	<i>Chaetodon lunula</i>	Raccoon butterflyfish		rr																				
20	<i>Chaetodon vagabundus</i>	Vagabond butterflyfish								rr	rr													
21	<i>Chaetodon trifasciatus</i>	Redfin butterflyfish								rr							rr							rr
22	<i>Chromis viridis</i>	Blue-green chromis									cc				cc	cc	cc	cc	cc	cc				cc
23	<i>Dascyllus aruanus</i>	Humbug dascyllus									r				+	c	c	r	c			+	+	cc
24	<i>Chrysiptera biocellata</i>	Twospot demiselle		+																				
25	<i>Pomacentrus pavo</i>	Blue damsel				r	r			cc	rr										+	c		r
26	<i>Stegastes nigricans</i>	Dusky gregory							r	r	r													+
27	Pomacentridae	DAMSELFISHES		r	r	c	c	c	c	c	c		c	+	+	r	r	+	r	+	+	+	r	
28	<i>Stethojulis bandanensis</i>	Red-shoulder wrasse		rr	rr	rr			rr	rr						rr								
29	<i>Halichoeres trimaculatus</i>	Three-spot wrasse		r	r	r	r	r	+	+						r	r	r	r	r	r	r	+	+
30	<i>Cheilinus undulatus</i>	Humphead wrasse Napoleonfish						rr			rr													
31	<i>Cheilinus trilobatus</i>	Tripletail wrasse																					rr	
32	<i>Chlorurus sordidus</i>	Bullhead parrotfish					+	+	r	r							r				r	rr	rr	
33	<i>Scarus ghobban</i>	Bluebarred parrotfish																					r	
34	<i>Scarus</i> spp.	Parrotfishes					c	+	+	+					+	r	c	c	c	c	c	c	+	+
35	<i>Petroscirtes mitratus</i>	Floral fangblenny											rr											
36	<i>Oplonomus</i> spp.											r	r	r	r	r	r							
37	<i>Ctenogobiops feroculus</i>	Sandy prawn-goby																					rr	
38	<i>Vanderhorstia ambanoro</i>	Ambanoro prawn-goby											rr	rr								rr		
39	<i>Amblygobius nocturnus</i>	Nocturn goby										r						rr						
40	<i>Amblygobius phalaena</i>	Brown-barred goby		rr	rr	rr						c	r	+	+	r	r	+	+	+	r	r	r	
41	<i>Ptereleotris microlepis</i>	Pearly dartfish																						cc
42	<i>Zebrasoma veliferum</i>	Sailfin tang																						rr
43	<i>Ctenochaetus striatus</i>	Striped bristletooth							r	r	+									r			r	
44	<i>Acanthurus triostegus</i>	Convict surgeonfish											rr											
45	<i>Acanthurus</i> spp.	Surgeonfishes														rr	r				r	r	r	rr
46	<i>Pseudobalistes flavimarginatus</i>	Yellowmargin triggerfish																					rr	
47	<i>Rhinecanthus aculeatus</i>	Picassofish ; Humuhumu						rr									rr							

rr: 1~2N r: 3~10N +: 11~20N c: 21~50N cc: over 51N (N= number of individuals)

Table 3-2 The results of observation about fish appearance in Funafuti 2

No.	Scientific name	distance from shoreline(m)	0		50					100					150				200				
			No. of species		2	6	6	4	8	5	5	7	5	6	5	4	5	7	19	16	13	15	3
1	<i>Spratelloides</i> sp.	Blue sprat																					
2	<i>Neoniphon sammara</i>	Bloodspot squirrelfish															r	r					
3	<i>Myripristis</i> sp.	Soldierfishes																					+
4	Atherinidae	Silversides										cc											
5	<i>Epinephelus howlandi</i>	Blacksaddle grouper															rr						
6	<i>Epinephelus merra</i>	Honeycomb grouper														rr	rr	r	r	rr	rr		
7	<i>Cheilodipterus quinquelineatus</i>	Five-lined cardinalfish																					r
8	<i>Apogon</i> sp.	Cardinalfishes				rr																	
9	<i>Luftjanus fulvus</i>	Flametall snapper	rr	rr	rr	r	r	rr	rr	rr	r	rr	rr				rr	r	r	+		r	
10	<i>Pterocaesio trilineata</i>	Three-striped fusilier																					r
11	<i>Gnathodentex aureolineatus</i>	Yellowspot emperor																	+	c	+		
12	<i>Monotaxis grandoculis</i>	Bigeye emperor															rr	r			rr		
13	<i>Lethrinus harak</i>	Blackspot emperor			rr																		
14	<i>Lethrinus ramak</i>																	rr	rr	rr			
15	<i>Mulloidichthys flavolineatus</i>	Yellowstripe goatfish															r	r	r				
16	<i>Parupeneus multifasciatus</i>	Multibarred goatfish															rr	rr			rr		
17	<i>Parupeneus barberinus</i>	Dash-and-dot goatfish																					rr
18	<i>Chaetodon auriga</i>	Threadfin butterflyfish		rr			rr	rr				rr					rr		r	r	rr		
19	<i>Chaetodon ephippium</i>	Saddled butterflyfish															rr				rr		
20	<i>Chaetodon citrinellus</i>	Speckled butterflyfish															rr						
21	<i>Chrysiptera biocellata</i>	Twospot demoiselle	rr	rr																			
22	<i>Pomacentrus pavo</i>	Blue damsel															rr	+	cc	cc	cc		
23	<i>Stegastes nigricans</i>	Dusky gregory																+	c	+			
24	Pomacentridae	DAMSELFISHES			+	+	+	+	+	+	+	c	c	c	c	c	c	cc	r	+	+		
25	<i>Stethojulis bandanensis</i>	Red-shoulder wrasse														r	r	rr					
26	<i>Thalassoma hardwickii</i>	Sixbar wrasse																			rr		
27	<i>Halichoeres trimaculatus</i>	Three-spot wrasse	rr	r	r	r	r	r	r	r	r	r	r	r	+	r	+					r	r
28	<i>Halichoeres margaritaceus</i>	Weedy surge wrasse												rr	rr	rr							
29	<i>Cheilinus undulatus</i>	Humphead wrasse ;Napoleonfish																				rr	
30	<i>Chlorurus sordidus</i>	Bullthead parrotfish																+	r				
31	<i>Scarus</i> spp.	Parrotfishes					r			r	r	r				r						r	
32	<i>Valenciennesa sexguttata</i>	Six-spot goby			rr		rr															rr	r
33	<i>Amblygobius phalaena</i>	Brown-barred goby			rr	rr	rr	r	r	r	r	rr	rr										r
34	<i>Asterropteryx</i> sp.					rr					rr		rr										
35	Gobiidae	GOBIES																					cc
36	<i>Ptereleotris microlepis</i>	Pearly dartfish													rr								
37	<i>Zanclus cornutus</i>	Moorish idol															rr	rr					
38	<i>Naso unicornis</i>	Bluespine unicornfish															r						
39	<i>Zebrasoma veliferum</i>	Sailfin tang																				rr	
40	<i>Ctenochaetus striatus</i>	Striped bristletooth														rr	+	c	+				
41	<i>Acanthurus</i> spp.	Surgeonfishes					rr		rr														
42	<i>Balistoides viridescens</i>	Moustache triggerfish																					rr
43	<i>Canthigaster</i> sp.	Tobies																				rr	

rr : 1~2N    r : 3~10N    + : 11~20N    c : 21~50N    cc : over 51N    (N= number of individuals)

Table 3-3 The results of observation about fish appearance in Funafuti 3

No.	Scientific name	No. of species	distance from shoreline(m)																													
			0	1	1	1	0	2	10	17	12	14	11	9	9	14	12	10	11	11	11	9	11	12	11	10	15	12	12	8	6	
1	<i>Chanos chanos</i>	Milk fish	c																													
2	<i>Fistularia commersonii</i>	Cornetfish									rr							rr														
3	<i>Epinephelus howlandi</i>	Blacksaddle grouper																														
4	<i>Epinephelus merra</i>	Honeycomb grouper								rr	r	rr	rr																		rr	rr
5	<i>Cheilodipterus quinquefasciatus</i>	Five-lined cardinalfish											+		rr																	
6	<i>Lutjanus fulvus</i>	Flametail snapper														rr	rr															
7	<i>Gnathodentex aureolineatus</i>	Yellowspot emperor																														
8	<i>Monotaxis grandoculis</i>	Bigeye emperor																														
9	<i>Lethrinus ramak</i>																															
10	<i>Lethrinus sp.</i>																															
11	<i>Mulloidichthys flavolineatus</i>	Yellowstripe goatfish																														
12	<i>Parupeneus bifasciatus</i>	Two-barred goatfish																														
13	<i>Parupeneus multifasciatus</i>	Multi-barred goatfish																														
14	<i>Parupeneus barberinus</i>	Dash-and-dot goatfish																														
15	<i>Chaetodon trifasciatus</i>	Chevroned butterflyfish																														
16	<i>Chaetodon auriga</i>	Threadfin butterflyfish																														
17	<i>Chaetodon ephippium</i>	Saddled butterflyfish																														
18	<i>Chaetodon citrinellus</i>	Speckled butterflyfish																														
19	<i>Chaetodon sp.</i>	Butterflyfishes																														
20	<i>Chromis viridis</i>	Blue-green chromis																														
21	<i>Dascyllus aruanus</i>	Humbug dascyllus																														
22	<i>Pomacentrus pavo</i>	Blue damsel																														
23	<i>Stegastes nigricans</i>	Dusky gregory																														
24	Pomacentridae	DAMSELFISHES																														
25	<i>Stethojulis bandanensis</i>	Red-shoulder wrasse																														
26	<i>Thalassoma hardwickii</i>	Sixbar wrasse																														
27	<i>Halichoeres trimaculatus</i>	Three-spot wrasse																														
28	<i>Halichoeres margaritaceus</i>	Weedy surge wrasse																														
29	<i>Cheilinus undulatus</i>	Humphead wrasse / Napoleonfish																														
30	<i>Scarus longiceps</i>																															
31	<i>Chlorurus sordidus</i>	Bullhead parrotfish																														
32	<i>Scarus oviceps</i>	Dark-capped parrotfish																														
33	<i>Scarus ghobban</i>	Bluebarred parrotfish																														
34	<i>Scarus spp.</i>	Parrotfishes																														
35	Callionymidae	DRAGONETS																														
36	<i>Valenciennesa sexguttata</i>	Six-spot goby																														
37	<i>Amblygobius phalaena</i>	Brown-barred goby																														
38	Gobiidae	GOBIES																														
39	<i>Zanclus cornutus</i>	Moorish idol																														
40	<i>Zobrasoma veliferum</i>	Sailfin tang																														
41	<i>Otenochaetus striatus</i>	Striped bristletooth																														
42	<i>Acanthurus triostegus</i>	Convict surgeonfish																														
43	<i>Acanthurus blochii</i>	Ringtail surgeonfish																														
44	<i>Acanthurus spp.</i>	Surgeonfishes																														
45	<i>Bothus mancus</i>	Peacock flounder																														
46	<i>Rhinecanthus aculeatus</i>	Picassofish / Humuhumu																														

rr : 1~2N r : 3~10N + : 11~20N c : 21~50N cc : over 51N (N= number of individuals)

Table 3-4 The results of observation about fish appearance in Funafuti 4

No.	Scientific name	distance from shoreline(m)	No. of species																							
			0	18	8	3	16	11	2	6	3	13	10	10	14	16	3	0	0	5	8	4	12	4	2	
1	<i>Sargocentron spiniferum</i>	Long-jawed squirrelfish																						rr		
2	<i>Sargocentron</i> sp.	Squirrelfishes	r																							
3	<i>Neoniphon sammara</i>	Bloodspot squirrelfish	r																							
4	<i>Myripristis</i> sp.	Soldierfishes	r																				r			
5	<i>Epinephelus merra</i>	Honeycomb grouper	rr										rr							rr				r		
6	<i>Chelodipterus quinquelineatus</i>	Five-lined cardinalfish					+	r				+								c	c	r		r		
7	<i>Lutjanus monostigma</i>	Onespot snapper	rr																							
8	<i>Lutjanus fulvus</i>	Flametail snapper	+	r		r	rr		rr		r															
9	<i>Monotaxis grandoculis</i>	Bigeye emperor												rr	r											
10	<i>Lethrinus harak</i>	Blackspot emperor	r	rr																						
11	<i>Lethrinus ramak</i>		r			rr						rr	r													
12	<i>Lethrinus</i> sp.				r	r	r	+	r	r	r	r														
13	<i>Mulloidichthys flavolineatus</i>	Yellowstripe goatfish	cc																							
14	<i>Parupeneus multifasciatus</i>	Multibarred goatfish												rr									rr			
15	<i>Parupeneus barberinus</i>	Dash-and-dot goatfish	rr			r	r				r										r					
16	<i>Chaetodon auriga</i>	Threadfin butterflyfish	r	rr										r	rr								r			
17	<i>Chaetodon ephippium</i>	Saddled butterflyfish													rr											
18	<i>Chaetodon vagabundus</i>	Vagabond butterflyfish												rr	rr											
19	<i>Chaetodon trifasciatus</i>	Redfin butterflyfish													rr											
20	<i>Chaetodon ulietensis</i>	Pacific double-saddle butterflyfish												rr	rr											
21	<i>Chromis viridis</i>	Blue-green chromis											+							r	cc			c		
22	<i>Abudefduf sordidus</i>	Black-spot sergeant	r																							
23	<i>Chrysiptera biocellata</i>	Twospot demoiselle	r																							
24	<i>Pomacentrus pavo</i>	Blue damsel	c	rr		cc	cc				cc	c	+	c						cc	c		c	+		
25	<i>Stegastes nigricans</i>	Dusky gregory											+	+	c	c							cc	+	c	
26	Pomacentridae	DAMSELFISHES	c	r		c	c		r		+	c	c	cc	cc											
27	<i>Stethojulis bandanensis</i>	Red-shoulder wrasse												rr												
28	<i>Thalassoma hardwickii</i>	Sixbar wrasse											rr													
29	<i>Halichoeres hortulanus</i>	Checkerboard wrasse													rr											
30	<i>Halichoeres trimaculatus</i>	Three-spot wrasse	r	r		+	+		rr	rr	r	+	+	c	c					r	r	r	r	r		
31	<i>Halichoeres margaritaceus</i>	Weedy surge wrasse					rr					rr	rr													
32	<i>Cheilinus trilobatus</i>	Tripletail wrasse													rr											
33	<i>Chlorurus sordidus</i>	Bullhead parrotfish										r	+	r	r											
34	<i>Scarus ghobban</i>	Bluebarred parrotfish	rr																							
35	<i>Scarus</i> spp.	Parrotfishes				r					r	c	c	+	+								r			
36	<i>Petrosirtes mitratus</i>	Floral fangblenny							rr			rr														
37	Callionymidae	DRAGONETS			rr																					
38	<i>Valenciennesa sexguttata</i>	Six-spot goby					rr									rr						r				
39	<i>Amblygobius phalaena</i>	Brown-barred goby		r	r	r	r		r	r	+				rr	rr				r	rr	+	r	rr		
40	<i>Asterropteryx</i> sp.					rr																				
41	<i>Gunnellichthys</i> sp.	Wormfishes																			rr					
42	<i>Ptereleotris microlepis</i>	Pearly dartfish				r	c		rr		r															
43	<i>Zebbrasoma veliferum</i>	Sailfin tang																						rr		
44	<i>Otenochaetus striatus</i>	Striped bristletooth										rr	rr	+	c									+		
45	<i>Acanthurus triostegus</i>	Convict surgeonfish					rr																			
46	<i>Acanthurus lineatus</i>	Striped surgeonfish												rr	rr											
47	<i>Acanthurus blochii</i>	Ringtail surgeonfish	r																					rr		
48	<i>Acanthurus</i> spp.	Surgeonfishes					r					rr														
49	<i>Rhinecanthus aculeatus</i>	Picassofish : Humuhumu				rr	rr									rr										

rr : 1~2N r : 3~10N + : 11~20N c : 21~50N cc : over 51N (N= number of individuals)

Table 3-5 The results of observation about fish appearance in Funafuti 5

No.	Scientific name	Common name	distance from shoreline(m)																			
			0	50				100				150				200						
			No. of species																			
			8	16	18	17	12	9	11	11	9	13	7	7	8	10	14	12	10	14	8	20
1	<i>Spratelloides</i> sp.	Blue sprat					cc										cc					
2	<i>Epinephelus merra</i>	Honeycomb grouper			rr				rr	rr		rr										rr
3	<i>Gnathodentex aureolineatus</i>	Yellowspot emperor			r																	
4	<i>Monotaxis grandoculis</i>	Bigeye emperor		rr	r	r	r															
5	<i>Mulloidichthys flavolineatus</i>	Yellowstripe goatfish		r	r	r	r	+														
6	<i>Mulloidichthys vanicolensis</i>	Yellowfin goatfish				r																
7	<i>Parupeneus multifasciatus</i>	Multibarred goatfish		rr		rr															rr	r
8	<i>Parupeneus barberinus</i>	Dash-and-dot goatfish																				rr
9	<i>Chaetodon trifascialis</i>	Chevroned butterflyfish			rr		rr	rr		rr		rr										
10	<i>Chaetodon auriga</i>	Threadfin butterflyfish		rr		rr							r		rr			rr	r	rr		rr
11	<i>Chaetodon ephippium</i>	Saddled butterflyfish				rr			rr		rr				rr	rr	rr				r	rr
12	<i>Chaetodon lunula</i>	Racoon butterflyfish				rr																
13	<i>Chaetodon vagabundus</i>	Vagabond butterflyfish							r	rr	rr		rr	rr	rr	rr	rr					rr
14	<i>Chaetodon trifasciatus</i>	Redfin butterflyfish														rr						
15	<i>Chaetodon ulietensis</i>	Pacific double-saddle butterflyfish				rr		r		rr											rr	rr
16	<i>Chaetodon</i> sp.	Butterflyfishes													rr							
17	<i>Chromis atripectoralis</i>	Black-axil chromis			rr		cc															
18	<i>Dascyllus aruanus</i>	Humbug dascyllus			+																	
19	<i>Plectroglyphidodon lacrymatus</i>	Jewel damsel								rr												
20	<i>Chrysiptera biocellata</i>	Twospot demoiselle										r	r									
21	<i>Amblyglyphidodon leucogaster</i>	White-belly damsel		+	c	r	+	r														r
22	<i>Pomacentrus pavo</i>	Blue damsel	+	+																		c
23	<i>Stegastes nigricans</i>	Dusky gregory		c	cc	cc	cc	cc	c	+												+
24	Pomacentridae	DAMSELFISHES								c	+	r	c	+	+		+	+	c	c	c	c
25	<i>Gomphosus varius</i>	Bird wrasse																	rr			
26	<i>Labrichthys unilineatus</i>	Tubelip wrasse							rr													
27	<i>Stethojulis bandanensis</i>	Red-shoulder wrasse									rr	r	r	+		r	r	r	r	r	+	
28	<i>Thalassoma hardwickii</i>	Sixbar wrasse			rr		rr	rr	rr	rr	rr	r	r	rr	r	r	rr	rr	r	r		
29	<i>Thalassoma quinquevittatum</i>	Fivestripe wrasse															rr					
30	<i>Thalassoma lunare</i>	Crescent wrasse		rr	rr									rr	rr	rr	r	r	rr	r	rr	
31	<i>Halichoeres hortulanus</i>	Checkerboard wrasse							rr													
32	<i>Halichoeres trimaculatus</i>	Three-spot wrasse								rr	r	r	r	r	r	r					r	
33	<i>Halichoeres margaritaceus</i>	Weedy surge wrasse																		rr		
34	<i>Epibulus insidiator</i>	Slingjaw wrasse		rr		rr						rr					rr					
35	<i>Cheilinus undulatus</i>	Humphead wrasse ; Napoleonfish		r	rr		rr		rr					rr		rr						
36	<i>Cheilinus trilobatus</i>	Tripletail wrasse									rr	rr	rr			r	rr		rr			
37	<i>Cheilinus fasciatus</i>	Red-banded wrasse		r			r	r											rr			r
38	<i>Oxycheilinus unifasciatus</i>	Ringtail wrasse			rr																	
39	<i>Scarus longiceps</i>																					rr
40	<i>Chlorurus sordidus</i>	Bullhead parrotfish		r	r	r	r			r		r			r	r	r	c	c	cc	+	r
41	<i>Chlorurus microrhinos</i>	Steephead parrotfish			r	r	r															
42	<i>Scarus frenatus</i>	Birdled parrotfish															rr					
43	<i>Scarus oviceps</i>	Dark-capped parrotfish		rr	rr		r											rr				
44	<i>Scarus ghobban</i>	Bluebarred parrotfish				r																
45	<i>Scarus altipinnis</i>	Filament-fin parrotfish			r	c																rr
46	<i>Scarus</i> spp.	Parrotfishes								r	+		+							cc		
47	<i>Valenciennesa sexguttata</i>	Six-spot goby		r																		
48	<i>Eviota</i> sp.			r																		
49	<i>Otenogobius feroculus</i>	Sandy prawn-goby		c	+																	
50	<i>Amblygobius phalaena</i>	Brown-barred goby		r	r																r	
51	Gobiidae	GOBIES		c																		
52	<i>Ptereleotris microlepis</i>	Pearly dartfish		+															cc			
53	<i>Zanclus cornutus</i>	Moorish idol				rr													rr			
54	<i>Zebrasoma scopas</i>	Brushtail tang																				rr
55	<i>Otenochaetus striatus</i>	Striped bristletooth		r	r	r		r	c	+	r	r				rr	+	c		r	+	c
56	<i>Acanthurus lineatus</i>	Striped surgeonfish															rr	r		r	r	rr
57	<i>Sufflamen chrysopterus</i>	Halfmoon triggerfish																				rr
58	<i>Rhinecanthus aculeatus</i>	Picassofish ; Humuhumu		rr																		
59	<i>Arothron nigropunctatus</i>	Blackspotted puffer										rr										rr

rr : 1~2N r : 3~10N + : 11~20N c : 21~50N cc : over 51N (N= number of individuals)

Table 3-6 The results of observation about fish appearance in Funafuti 6

No.	Scientific name	Common name	distance from shoreline(m)																	
			0			50			100						160					
			No. of species																	
			9	25	3	3	3	1	1	3	4	2	13	12	12	12	12	18		
1	<i>Fistularia commersonii</i>	Cornetfish	rr																	
2	Atherinidae	Silversides	cc	cc																
3	<i>Epinephelus howlandi</i>	Blacksaddle grouper												rr						
4	<i>Epinephelus merra</i>	Honeycomb grouper											rr	r			rr	r		
5	<i>Cheilodipterus quinque-lineatus</i>	Five-lined cardinalfish	cc									r				r		r		
6	<i>Apogon</i> sp.	Cardinalfishes																rr		
7	<i>Kaiwarinus</i> sp.		r																	
8	<i>Lutjanus monostigma</i>	Onespot snapper	rr																	
9	<i>Lutjanus fulvus</i>	Flametail snapper	rr	rr									rr		rr		r	+		
10	<i>Caesio</i> spp.	Fusiliers	r																	
11	<i>Pterocaesio trilineata</i>	Three-striped fusilier	r																	
12	<i>Monotaxis grandoculis</i>	Bigeye emperor	r															rr		
13	<i>Lethrinus harak</i>	Blackspot emperor	rr																	
14	<i>Lethrinus ramak</i>																	r r		
15	<i>Lethrinus</i> sp.		r		r								r	r	r	r	+	+		
16	<i>Mulloidichthys flavolineatus</i>	Yellowstripe goatfish	r																	
17	<i>Parupeneus multifasciatus</i>	Multibarred goatfish												rr						
18	<i>Parupeneus barberinus</i>	Dash-and-dot goatfish											rr	r	r	+	r			
19	<i>Chaetodon auriga</i>	Threadfin butterflyfish	r										rr	r			rr	r		
20	<i>Chaetodon ephippium</i>	Saddled butterflyfish	rr											rr				rr		
21	<i>Chaetodon lunula</i>	Racoon butterflyfish	rr																	
22	<i>Chaetodon vagabundus</i>	Vagabond butterflyfish	rr	r																
23	<i>Chaetodon citrinellus</i>	Speckled butterflyfish															rr			
24	<i>Abudefduf sordidus</i>	Black-spot sergeant	rr																	
25	<i>Abudefduf septemfasciatus</i>	Banded sergeant	r	r																
26	<i>Chrysiptera biocellata</i>	Twospot demoiselle	+																	
27	<i>Pomacentrus pavo</i>	Blue damsel	cc	+									c	cc	c	cc	cc	cc		
28	Pomacentridae	DAMSELFISHES	c										r		+		+	+		
29	<i>Stethojulis bandanensis</i>	Red-shoulder wrasse	rr															rr		
30	<i>Halichoeres trimaculatus</i>	Three-spot wrasse	r	+									r	+	r	r	r	+		
31	<i>Cheilinus trilobatus</i>	Tripletail wrasse																rr		
32	<i>Scarus longiceps</i>													r						
33	<i>Chlorurus sordidus</i>	Bullhead parrotfish																r r		
34	<i>Scarus</i> spp.	Parrotfishes	+										r	+	+	+	c	c		
35	Callionymidae	DRAGONETS								r	r	+								
36	<i>Valenciennesa sexguttata</i>	Six-spot goby	rr							rr	r		rr		r	r		r		
37	<i>Oplopus</i> sp.						r													
38	<i>Ctenogobius feroculus</i>	Sandy prawn-goby																r		
39	<i>Amblygobius phalaena</i>	Brown-barred goby	r	r	r	c					rr		r	r	+	r		r		
40	<i>Asterropteryx</i> sp.																	rr		
41	Gobiidae	GOBIES					+	+	c	r	+	+	+							
42	<i>Ptereleotris microlepis</i>	Pearly dartfish													r	r				
43	<i>Zebriasoma veliferum</i>	Sailfin tang												rr						
44	<i>Ctenochaetus striatus</i>	Striped bristletooth	rr																	
45	<i>Acanthurus triostegus</i>	Convict surgeonfish	rr																	
46	<i>Acanthurus lineatus</i>	Striped surgeonfish	r																	
47	<i>Acanthurus blochii</i>	Ringtail surgeonfish	r														rr			
48	<i>Rhinecanthus aculeatus</i>	Picasso fish ; Humuhumu				rr												rr		

rr : 1~2N r : 3~10N + : 11~20N c : 21~50N cc : over 51N (N= number of individuals)



4) Results of Algae Survey

Table 4-1 The results of observation about algae appearance in Funafuti 1

No.	Scientific name /No. of species	distance from shoreline(m)																			
		0				50				100				150				200			
1	CYANOPHYCEAE sp.	r	r	+	+	10	+	+	+		r				r	r	r	r	r	+	r
2	<i>Boodlea</i> sp.		+	+	r																r
3	<i>Boergesenia forbesii</i>			r																	
4	<i>Caulerpa cupressoides var. lycopodium f. amicorum</i>									r											
5	<i>Caulerpa racemosa var. clavifera f. macrophysa</i>			r	r	10	5	r	r												
6	<i>Caulerpa racemosa var. lamourouxii</i>				r	r	r	r	r	r	r	+	r	+	r		r	r	r		
7	<i>Caulerpa serrulata var. serrulata f. lata</i>							r													
8	<i>Caulerpa sertularioides f. longipes</i>			r			r	r	r	r	r	r									
9	<i>Caulerpa taxifolia</i>							r													
10	<i>Halimeda macroloba</i>			r	r	r	r	r	r	+	r	r	r	r	r	r	r	r	r	r	r
11	<i>Halimeda</i> spp.				r	r	r	r	r		r				r		r	r	r	r	r
12	<i>Neomeris</i> sp.			r	r																
13	<i>Dictyota</i> sp.			r	+	20	35	50	20		r	r	r	r	+	+	+	+	+	+	r
14	<i>Lobophora variegata</i>					r	r	r	r		r				r		r	r	r		
15	<i>Padina</i> sp.		+	10	25	25	25	25	40		r	10	5	+	+	15	45	75	75	35	+
16	<i>Rosenvingea</i> sp.												r								
17	<i>Galaxaura</i> sp.						r	r													
18	Corallinaceae sp.	r	r	r	r	r	r	r	r		r				r	r	r	r	r	r	r
19	<i>Jania</i> sp.														r						
20	Gelidiaceae sp.						r	r													
21	<i>Hypnea</i> sp.			r	r	r	r	r	r												
22	Peyssonelliaceae sp.					r	r	r	r					r		r	r	r	r		
23	<i>Gelidiopsis</i> sp.				r																
24	<i>Ceramium</i> sp.		5	+																	
25	<i>Spyridia filamentosa</i>						r	+													
26	Ceramiaceae sp.																				+
27	<i>Acanthophora spicifera</i>																				
28	<i>Tolypoclada</i> sp.		r	5	30	5	+	5	+						r						
all of coverage (%)		r	10	20	65	80	75	85	70	+	+	15	10	5	5	20	50	80	80	40	5

+ : under 5%

Table 4-2 The results of observation about algae appearance in Funafuti 2

No.	Scientific name /No. of species	distance from shoreline(m)																			
		0			50				100				150				200				
1	CYANOPHYCEAE sp.	r	r	r	r	r	+	r	+	+	+	+	+	+	5	5	+	+		+	
2	<i>Ulva</i> sp.	r	r																		
3	<i>Cladophora</i> sp.		r	r						r											
4	<i>Boodlea</i> sp.		r	r	r	r	r	r	r	r	r			r							r
5	<i>Boergesenia forbesii</i>		+	r	+	+	+	r	r												
6	<i>Dictyosphaeria cavernosa</i>														r						
7	<i>Caulerpa cupressoides var. lycopodium f. amicorum</i>			r	r	r	r	r	r	r	r	r	r						r	r	
8	<i>Caulerpa racemosa var. clavifera f. macrophysa</i>		r	+	r	r	r	r	r	r	r	r	r								
9	<i>Caulerpa racemosa var. lamourouxii</i>										r	+	r	r	+	+	+	+			r
10	<i>Caulerpa sertularioides f. longipes</i>			r	r	r	r		r	r	r	r	r		r						r
11	<i>Halimeda macroloba</i>			r	+	+	+	r	r	r	r	r	r	r	r	r	r				r
12	<i>Halimeda</i> spp.		r	r	r	r	r	r	r	r	r	r	+	r	+	+	+	r	r	r	
13	<i>Neomeris</i> sp.								r												
14	<i>Dictyota</i> sp.			r	r	+	r	r	5	5	10	10	15	15	25	30	40	40	70	20	+
15	<i>Lobophora variegata</i>											r	r	r	r	r	r	r	r		r
16	<i>Padina</i> sp.		r	5	5	5	5	5	5	5	10	5	10	10	15	10	15	10	15	15	r
17	<i>Sargassum</i> sp.													r							
18	<i>Galaxaura</i> sp.													r	r	r	+	+	r		r
19	Corallinaceae sp.	r	r	r	r	r	r	r	+	+	+	+	+	+	+	10	5	r	r	r	r
20	<i>Jania</i> sp.			r	r	r	r	r	r	r	r	r									
21	Gelidiaceae sp.													r	r	r	r	r	r		
22	<i>Hypnea</i> sp.			r	r	r	r	r	r					r	r	r	r	r	r		
23	Peyssonelliaceae sp.									r	r	r	r	r	r	r	r	r			r
24	<i>Gelidiopsis</i> sp.													r							
25	<i>Ceramium</i> sp.		+			r	r														
26	<i>Spyridia filamentosa</i>															r	5	r			
27	Ceramiaceae sp.																15	r			
28	<i>Acanthophora spicifera</i>			5	r	r	r	r	r	r	r	r		r	r			r	r		
29	<i>Laurencia</i> sp.			r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r		
30	<i>Tolypoclada</i> sp.			+	+	+	+	+	10	20	20	25	35	30	35	5	r				r
31	RHODOPHYCEAE sp.									r											
all of coverage (%)		r	5	20	15	15	15	20	30	50	45	60	70	80	85	85	90	95	40	r	+

+ : under 5%



Table 4-5 The results of observation about algae appearance in Funafuti 5

No.	Scientific name /No. of species	distance from shoreline(m)																						
		0					50					100					150					200		
		4	9	14	13	14	15	9	8	10	10	11	8	8	8	10	8	8	10	15	11			
1	CYANOPHYCEAE sp.		+	15	5	10	10	25	50	75	75	80	80	80	75	60	40	55	+	+	r			
2	<i>Boodlea</i> sp.		r	r	r	r	r				r	r				r					r			
3	<i>Dictyosphaeria cavernosa</i>						r				r					r								
4	<i>Caulerpa racemosa</i> var. <i>clavifera</i> f. <i>macrophysa</i>						r														r			
5	<i>Caulerpa racemosa</i> var. <i>lamourouxii</i>																				r			
6	<i>Caulerpa racemosa</i> var. <i>occidentalis</i>							r																
7	<i>Caulerpa racemosa</i> var. <i>peltata</i>						r			r	r					r								
8	<i>Caulerpa serrulata</i> var. <i>serrulata</i> f. <i>lata</i>																				r			
9	<i>Caulerpa taxifolia</i>		r	r	r	r	r			r											r			
10	<i>Halimeda</i> spp.			r	r	r	r														r			
11	<i>Dictyota</i> sp.	+	5	20	25	10	10	50	20	+	+	r	r	r	r	+	+	5	10	40	25			
12	<i>Lobophora variegata</i>		r	5	r	+	r					r	r	r	r	r					r			
13	<i>Padina</i> sp.			+	+							r									5			
14	<i>Galaxaura</i> sp.			r	r	r	r																	
15	Corallinaceae sp.	+	r	r	+	+	+	5	5	r	r	+	+	+	+	5	20	+	15	15	+			
16	<i>Jania</i> sp.			r																	r			
17	Gelidiaceae sp.	r	r	r	+	+	+	r	r	+	+	+	+	+	+	+	+	+	+	+	r			
18	<i>Hypnea pannosa</i>										r	r												
19	<i>Hypnea</i> sp.			r	r	+	+	r	r			r	r	r	+	10	10	+	r	r				
20	Peyssonneliaceae sp.	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r			
21	<i>Gelidopsis</i> sp.																				r			
22	<i>Spyridia filamentosa</i>					r						+												
23	Ceramium sp.		+	20	20	30	40	+	r								+				5			
24	<i>Laurencia</i> sp.						r	+	r	+	+	+	+	+	+	r	+	10	20	10	r			
all of coverage (%)		+	10	70	60	60	70	90	85	85	85	90	90	90	85	85	90	90	45	70	76			

+ : under 5%

Table 4-6 The results of observation about algae appearance in Funafuti 6

No.	Scientific name /No. of species	distance from shoreline(m)																
		0			50				100				160					
		7	11	3	7	3	3	1	5	4	3	9	14	9	13	12	13	
1	CYANOPHYCEAE sp.	10	r							r	r			r	r	r	r	
2	<i>Ulva</i> sp.	r																
3	<i>Boodlea</i> sp.	r																
4	<i>Caulerpa cupressoides</i> var. <i>lycopodium</i> f. <i>amicorum</i>																r	
5	<i>Caulerpa racemosa</i> var. <i>clavifera</i> f. <i>macrophysa</i>		r		r								r	r				
6	<i>Caulerpa racemosa</i> var. <i>lamourouxii</i>		r		r	r							r	r	r	r	r	
7	<i>Caulerpa sertularioides</i> f. <i>longipes</i>												r	r	r	r	r	
8	<i>Halimeda macroloba</i>		r	r	+	+	+	r	r	r	r	r	r	r	r	r	r	
9	<i>Halimeda</i> spp.		r			10				r			r	r	r	r	r	
10	<i>Dictyota</i> sp.		10	r	5			r		r	r	r	+	20	r	5	5	20
11	<i>Lobophora variegata</i>		+										r	r	r	r	+	5
12	<i>Padina</i> sp.	5	20	r	+			r		r	r	r	+	5	+	15	15	10
13	<i>Rosenvingea</i> sp.												r				r	r
14	<i>Galaxaura</i> sp.												r			r		
15	Corallinaceae sp.	r	r										r	r	r	r	r	r
16	Gelidiaceae sp.	r	r															
17	<i>Hypnea</i> sp.				r	r								r		r		
18	Peyssonneliaceae sp.		r											r		r	r	r
19	<i>Ceramium</i> sp.	r																
20	<i>Tolypocladia</i> sp.												r	5	r	r	r	+
all of coverage (%)		20	40	r	25	+	+	r	r	r	r	r	5	35	+	25	25	50

+ : under 5%

(2) Distribution Conditions

1) Classification for sediments, corals and algae

Table 5: Classification for sediments

<b>sediment</b>	<b>color</b>	<b>note</b>
rock	red	mainly rock bottom area
gravel	blue	mainly gravel bottom area
sand	yellow	mainly sand bottom area
shoreline	black line	shoreline of estimate for satellite images

Table 6

Classification for corals

<b>coral coverage</b>	<b>color</b>	<b>note</b>
50%<	red	coral coverage 50%over
20-50%	blue	coral coverage 20-50%
5-20%	green	coral coverage 5-20%
1-5%	yellow	coral coverage 1-5%
<1%	white	coral coverage under1%

Table 7 Classification for algae

	<b>color</b>	<b>note</b>
argae	brown	argae zone

2) Distribution Conditions for sediments, corals and algae

Sediments

Table 8 Trend of sediments

<b>Fongafale(Coastal area)</b>			<b>Fongafale(Offshore area)</b>		
	<b>m2</b>	<b>%</b>		<b>m2</b>	<b>%</b>
Rock	307,378	41.5	Rock	103,731	17.4
Gravel	0	0	Gravel	0	0
Sand	433,146	58.5	Sand	492,300	82.6
total	740,524		total	596,031	

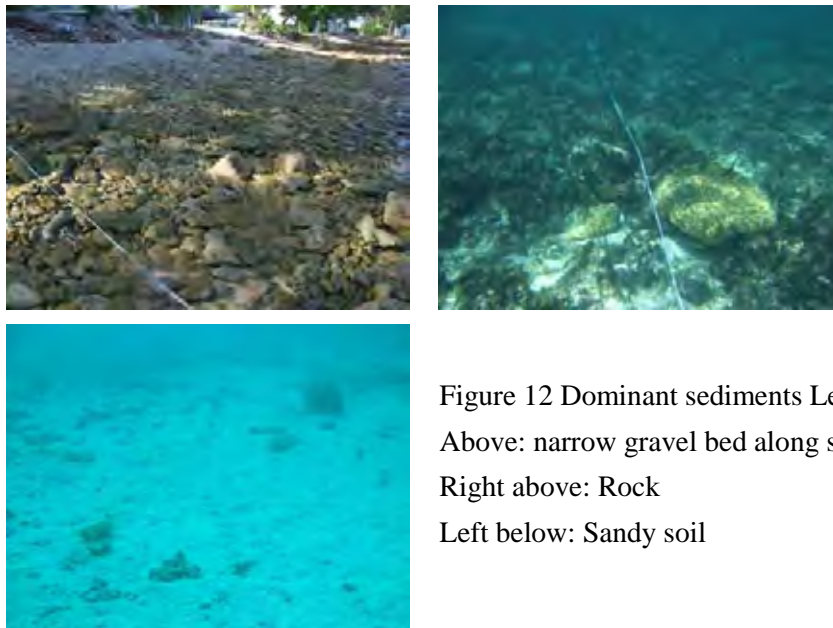


Figure 12 Dominant sediments Left  
Above: narrow gravel bed along shoreline  
Right above: Rock  
Left below: Sandy soil



Figure 13 Distribution of sediments in Fongafale

Coral

Table 9 Trend of coral cover degree in Fongafale.

Fongafale(Coastal area)			Fongafale(Offshore area)		
	m2	%		m2	%
50%<	0	0.0	50%<	0	0.0
20-50%	0	0.0	20-50%	0	0.0
5-20%	1,604	0.2	5-20%	22,740	3.8
1-5%	27,560	3.7	1-5%	29,340	4.9
<1%	711,200	96.1	<1%	544,300	91.3

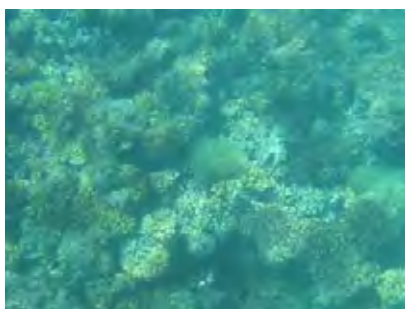


Figure14 Dominant corals  
Left above : *Pocillopora* sp.  
Right above : *Acropora* sp.  
Left below : *Porites* sp.

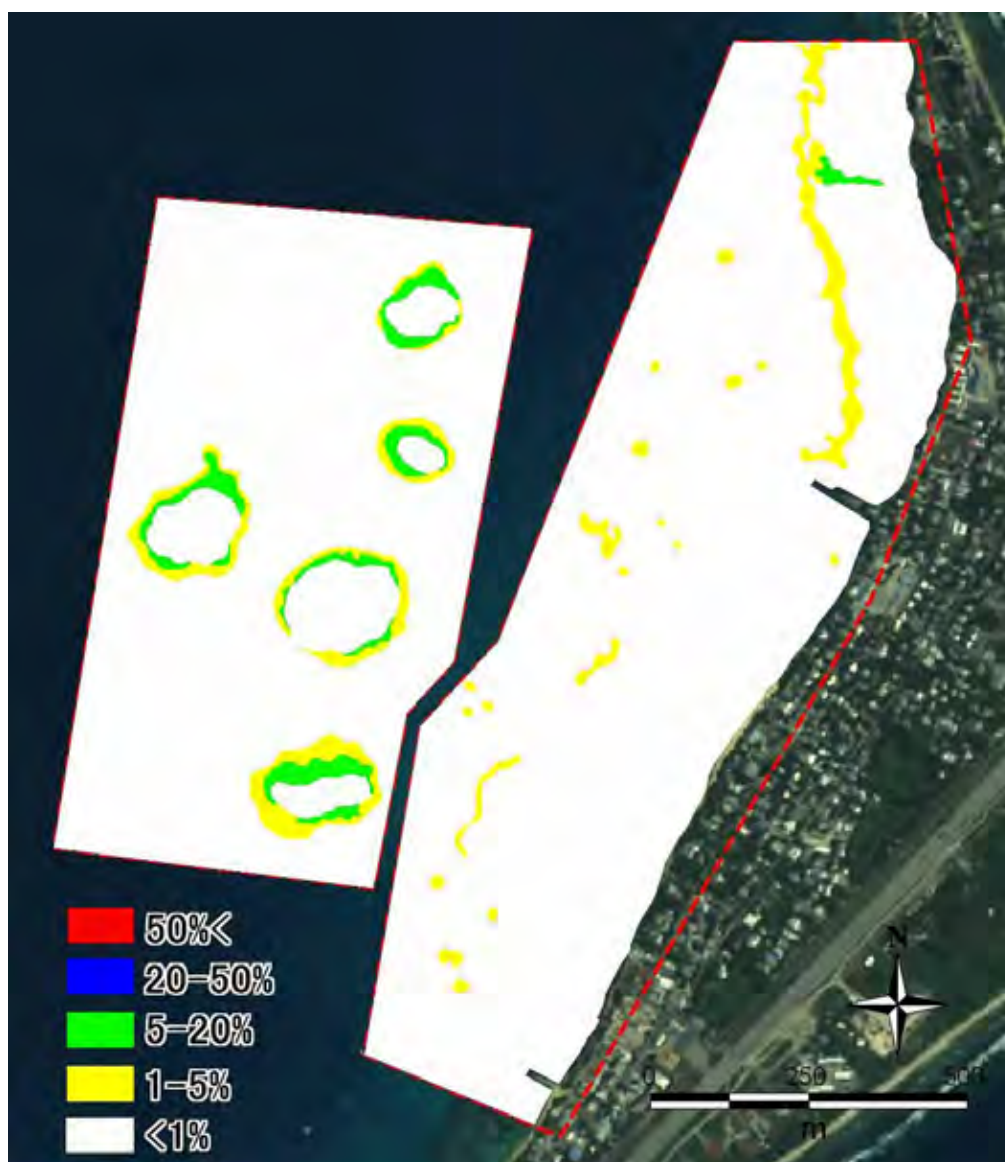


Figure15 Distribution of corals in Fongafale

Algae

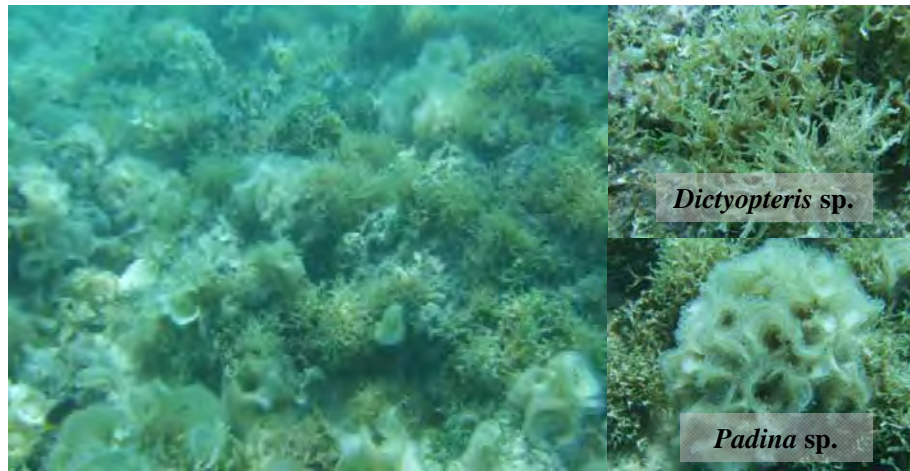


Figure 16 Condition of algae and dominant species



Figure 17 Distribution of algae



### 4.2.2 Target Zone for Required Gravel Materials

#### (1) Line Survey Results

##### 1) Location of Line Survey

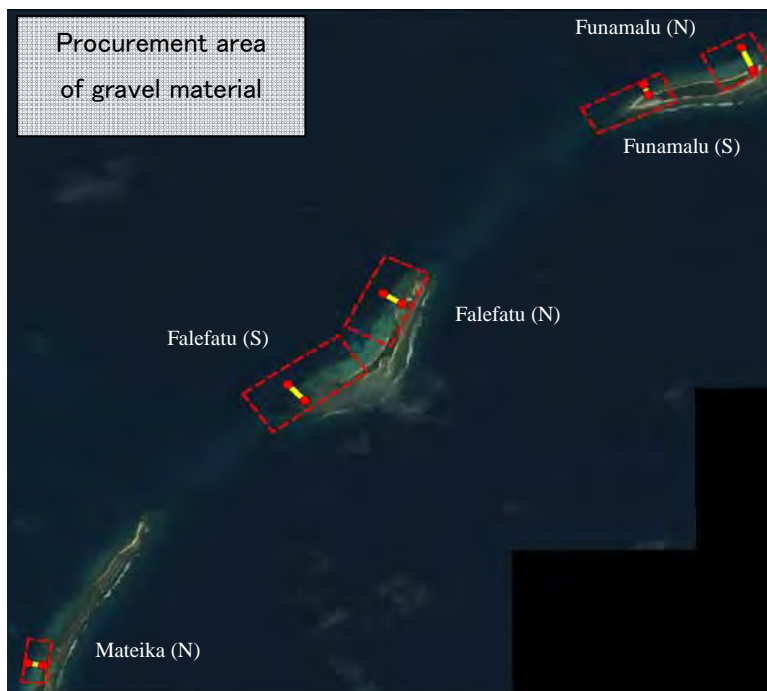


Figure 18 The position of survey line. Red circles represent start and end of the line.

Table 10 Coordinate value of survey lines (Geographical coordinate system: WGS84)

		LAT	LNG
Funamalu(N)	start	-8° 33' 50.5"	179° 08' 09.4"
	end	-8° 33' 45.8"	179° 08' 07.2"
Funamalu(S)	start	-8° 33' 55.7"	179° 07' 50.4"
	end	-8° 33' 53.6"	179° 07' 49.5"
Falefatu(N)	start	-8° 34' 38.9"	179° 07' 05.4"
	end	-8° 34' 36.8"	179° 07' 02.0"
Falefatu(S)	start	-8° 34' 59.1"	179° 06' 47.7"
	end	-8° 34' 55.8"	179° 06' 44.6"
Mateika(N)	start	-8° 35' 54.0"	179° 06' 00.0"
	end	-8° 35' 53.5"	179° 05' 57.2"

2) Profiles of Ecological Survey by Line Survey

Funamanu (N)

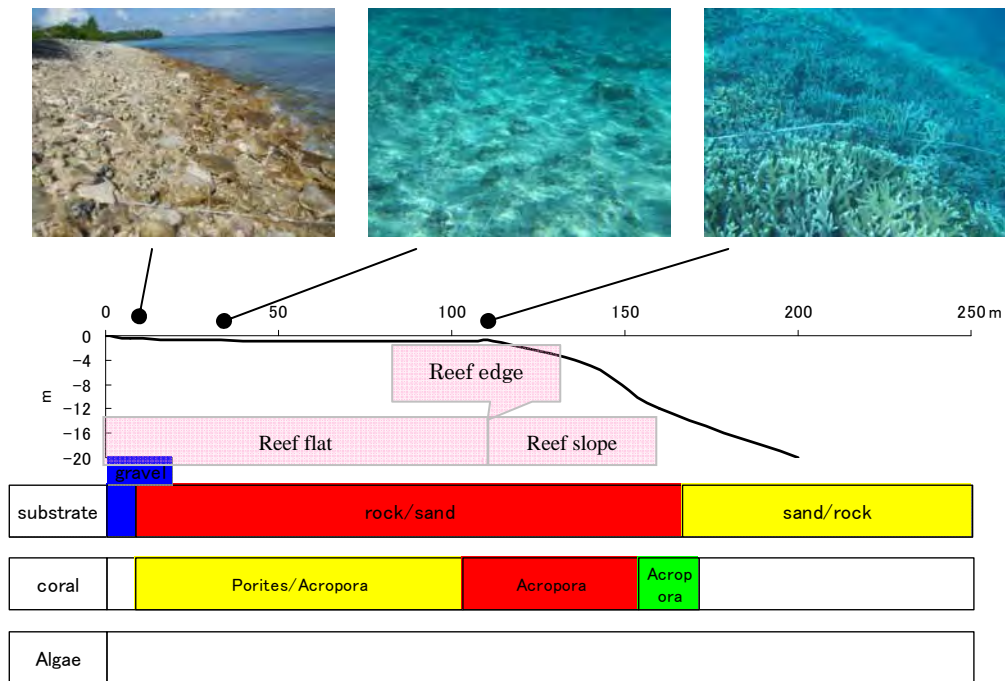


Figure 19 Profile in Funamanu (N) survey line

Funamanu (S)

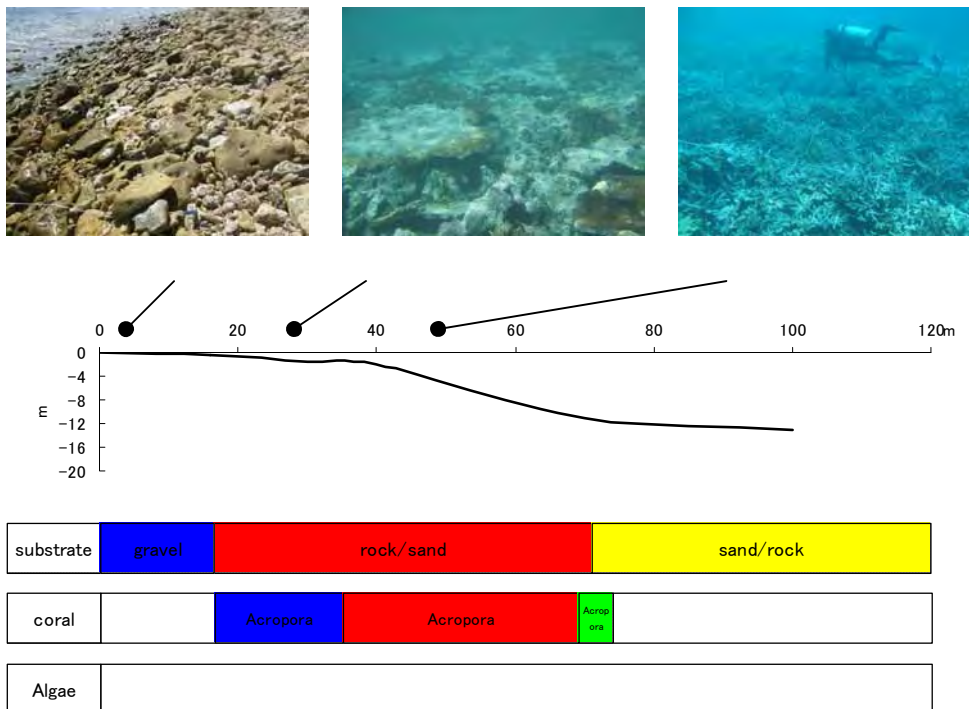


Figure 20 Profile in Funamanu (S) survey line

Falefatu (N)

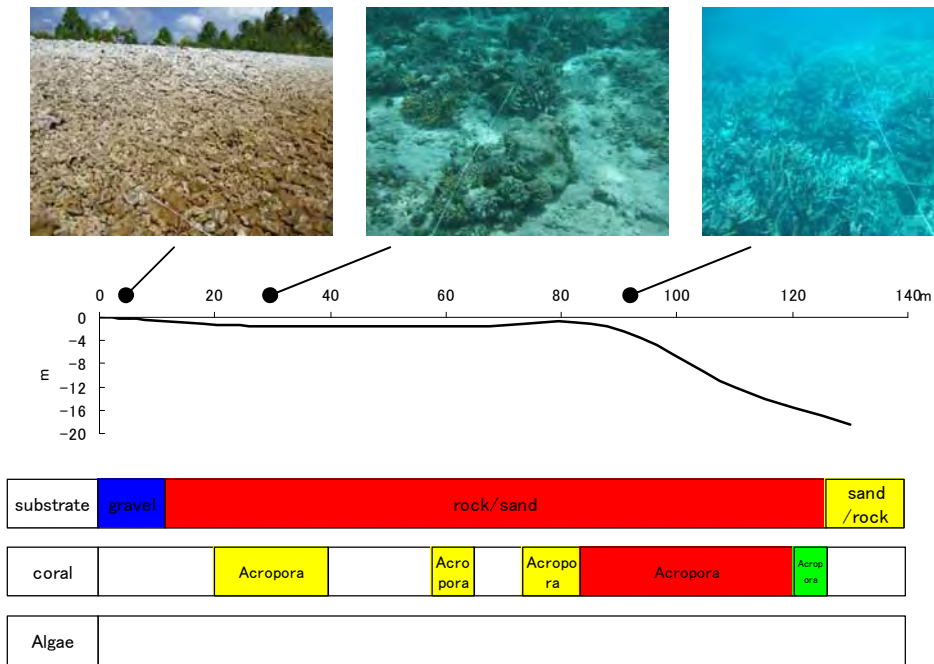


Figure 21 Profile in Falefatu (N) survey line

Falefatu (S)

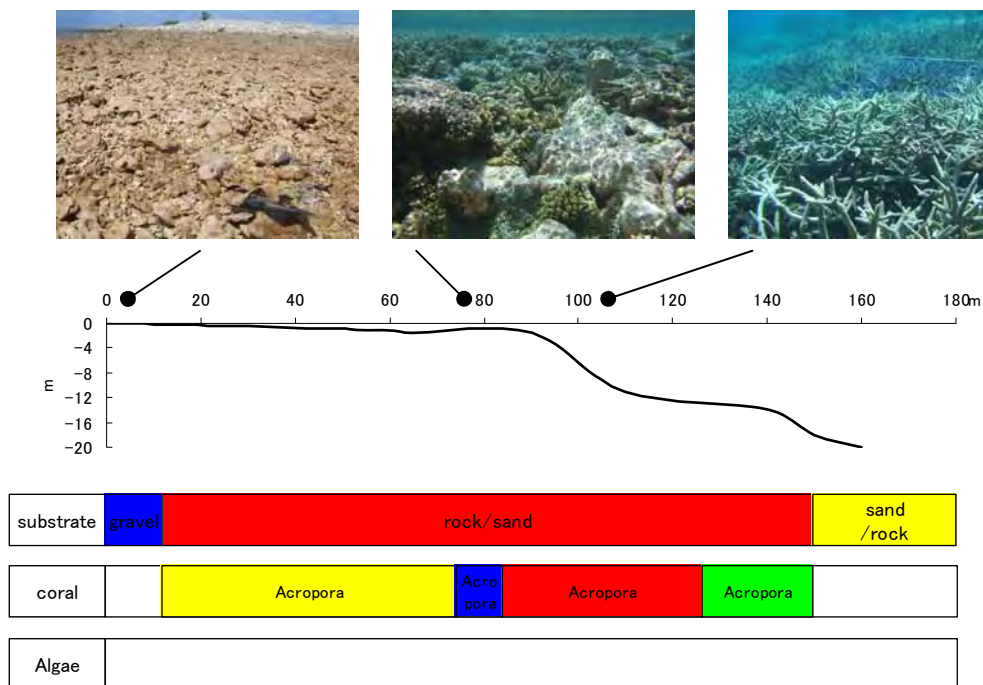


Figure 22 Profile in Falefatu (S) survey line

Mateika

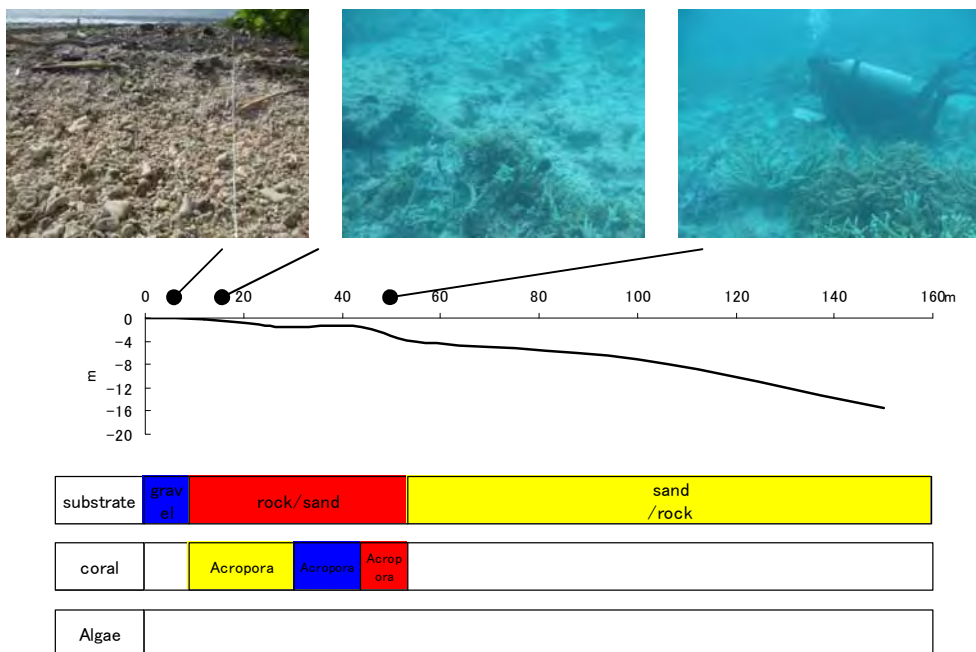


Figure 23 Profile in Mateika survey line

3) Results of Fish Survey

Table 11 Trend of the appearance of coral species

	Number of the appearance of fish species	Average number of fish species per quadrat
Funamanu N	69	13.9
Funamanu S	69	18.0
Falefatu N	66	13.5
Falefatu S	50	7.6
Mateika	52	11.0
Fongafale 1	47	10.5
Fongafale 2	43	7.4
Fongafale 3	46	9.2
Fongafale 4	49	7.3
Fongafale 5	59	11.7
Fongafale 6	48	8.3



Table 12-2 The results of observation about fish appearance in Funamanu (S)

No.	Scientific name	Common name	distance from shoreline(m)						
			0	50	70	No. of species			
			4	14	13	21	20	33	21
1	<i>Myripristis</i> sp.	Soldierfishes					rr		
2	Mugilidae	MULLETS	r	r					
3	<i>Plectropomus laevis</i>	Saddleback coral grouper						rr	
4	<i>Cephalopholis argus</i>	Peacock grouper						rr	
5	<i>Anypserodon leucogrammicus</i>	Slender grouper						rr	
6	<i>Epinephelus merra</i>	Honeycomb grouper						rr	
7	<i>Lutjanus gibbus</i>	Humpback or Paddletail snapper							rr
8	<i>Pterocaesio trilineata</i>	Three-striped fusilier						cc	
9	<i>Monotaxis grandoculis</i>	Bigeye emperor					rr	rr	r
10	<i>Parupeneus bifasciatus</i>	Two-barred goatfish					rr		
11	<i>Parupeneus multifasciatus</i>	Multibarred goatfish					r		
12	<i>Parupeneus cyclostomus</i>	Goldsaddle goatfish							rr
13	<i>Chaetodon trifascialis</i>	Chevroned butterflyfish		rr		r	rr	rr	rr
14	<i>Chaetodon auriga</i>	Threadfin butterflyfish						rr	
15	<i>Chaetodon reticulatus</i>	Reticulated butterflyfish		rr		r	r		
16	<i>Chaetodon trifasciatus</i>	Redfin butterflyfish					r	r	
17	<i>Chaetodon ornatissimus</i>	Ornate butterflyfish						rr	
18	<i>Pygoplites diacanthus</i>	Regal angelfish					rr		
19	<i>Centropyge flavissima</i>	Lemonpeel angelfish						rr	
20	<i>Centropyge bicolor</i>	Bicolor angelfish							rr
21	<i>Paracirrhites arcatus</i>	Arc-eye hawkfish			rr				
22	<i>Chromis iomelas</i>	Half and half chromis						rr	
23	<i>Chromis ternatensis</i>	Ternate chromis						cc	c
24	<i>Chromis atripectoralis</i>	Black-axil chromis					rr		+
25	<i>Plectroglyphidodon lacrymatus</i>	Jewel damsel						+	r
26	<i>Plectroglyphidodon dickii</i>	Dick's damsel		r	r	r	r	r	r
27	<i>Abudefduf sordidus</i>	Black-spot sergeant		r					
28	<i>Abudefduf vaiigiensis</i>	Indo-pacific sergeant						r	
29	<i>Chrysiptera biocellata</i>	Twospot demoiselle	+	+					
30	<i>Amblyglyphidodon leucogaster</i>	White-belly damsel					rr	r	r
31	<i>Pomacentrus pavo</i>	Blue damsel							c
32	<i>Pomacentrus</i> sp.						r		
33	<i>Stegastes nigricans</i>	Dusky gregory		r			r	c	
34	Pomacentridae	DAMSELFISHES			r	r			
35	<i>Kyphosus</i> spp.	Rudderfishes		r	r				
36	<i>Labroides dimidiatus</i>	Bluestreak cleaner wrasse				rr	rr	rr	
37	<i>Labroides bicolor</i>	Bicolor cleaner wrasse					rr	rr	
38	<i>Labrichthys unilineatus</i>	Tubelip wrasse					rr		
39	<i>Thalassoma hardwickii</i>	Sixbar wrasse					r		
40	<i>Thalassoma quinquevittatum</i>	Fivestripe wrasse		rr	r	rr			
41	<i>Halichoeres hortulanus</i>	Checkerboard wrasse					rr		rr
42	<i>Halichoeres trimaculatus</i>	Three-spot wrasse							r
43	<i>Epibulus insidiator</i>	Slingjaw wrasse			rr	rr		rr	
44	<i>Cheilinus fasciatus</i>	Red-banded wrasse						rr	
45	<i>Cetoscarus bicolor</i>	Biocolor parrotfish							rr
46	<i>Scarus longiceps</i>							r	r
47	<i>Scarus schlegelii</i>	Schlege's parrotfish						rr	
48	<i>Chlorurus sordidus</i>	Bullhead parrotfish				rr	r	r	
49	<i>Chlorurus microrhinos</i>	Steephead parrotfish					r	r	
50	<i>Scarus rubroviolaceus</i>	Redlip parrotfish							rr
51	<i>Scarus oviceps</i>	Dark-capped parrotfish			rr	r	r	r	
52	<i>Scarus ghobban</i>	Bluebarred parrotfish						r	
53	<i>Scarus altipinnis</i>	Filament-fin parrotfish							rr
54	<i>Scarus niger</i>	Swarthy parrotfish						rr	
55	<i>Scarus</i> spp.	Parrotfishes	+	c	c				
56	<i>Plagiotremus laudandus laudandus</i>	Poison-fang blenny mimic						rr	
57	<i>Valenciennea puellaris</i>	Maiden goby							rr
58	<i>Valenciennea strigata</i>	Blue-streak goby							rr
59	<i>Amblygobius phalaena</i>	Brown-barred goby							r
60	<i>Naso lituratus</i>	Orangespine unicornfish						rr	
61	<i>Zebbrasoma scopas</i>	Brushtail tang			rr		rr	+	
62	<i>Ctenochaetus striatus</i>	Striped bristletooth		+	+	+	r	r	
63	<i>Acanthurus triostegus</i>	Convict surgeonfish	+	+	r				
64	<i>Acanthurus lineatus</i>	Striped surgeonfish		r	+	r			
65	<i>Acanthurus nigricans</i>	Whitecheek surgeonfish		r	r	r	+	r	
66	<i>Acanthurus</i> spp.	Surgeonfishes							+
67	<i>Sufflamen chrysopterus</i>	Halfmoon triggerfish							rr
68	<i>Oxymonacanthus longirostris</i>	Longnose filefish					rr		
69	<i>Canthigaster</i> sp.	Tobies						rr	

rr : 1~2N r : 3~10N + : 11~20N c : 21~50N cc : over 51N (N= number of individuals)

Table 12-3 The results of observation about fish appearance in Falefatu (N)

No.	Scientific name	Common name	distance from shoreline(m)															
			0			50				100				130				
			No. of species															
			4	11	8	11	10	19	15	14	15	22	18	21	7			
1	<i>Spratelloides</i> sp.	Blue sprat								c	cc		cc					
2	<i>Aulostomus chinensis</i>	Trumpetfish											rr					
3	<i>Cephalopholis argus</i>	Peacock grouper							rr		rr							
4	<i>Anypserodon leucogrammicus</i>	Slender grouper												rr				
5	<i>Epinephelus merra</i>	Honeycomb grouper		rr		rr		rr		rr								
6	<i>Aphareus furca</i>	smalltooth jobfish											rr					
7	<i>Caesio teres</i>	Yellowback fusilier												cc				
8	<i>Caesio</i> spp.	Fusiliers														c		
9	<i>Gnathodentex aureolineatus</i>	Yellowspot emperor											+					
10	<i>Monotaxis grandoculis</i>	Bigeye emperor						rr								r		
11	<i>Parupeneus bifasciatus</i>	Two-barred goatfish					rr											
12	<i>Parupeneus multifasciatus</i>	Multibarred goatfish				rr										rr		
13	<i>Parupeneus barberinus</i>	Dash-and-dot goatfish														r		
14	<i>Chaetodon trifascialis</i>	Chevroned butterflyfish										r	rr	r	r	r		
15	<i>Chaetodon reticulatus</i>	Reticulated butterflyfish											rr					
16	<i>Chaetodon trifasciatus</i>	Redfin butterflyfish											rr			rr		
17	<i>Chaetodon ornatissimus</i>	Ornate butterflyfish								rr		rr						
18	<i>Chaetodon ulietensis</i>	Pacific double-saddle butterflyfish							rr						rr			
19	<i>Centropyge flavissima</i>	Lemonpeel angelfish							rr									
20	<i>Chromis ternatensis</i>	Ternate chromis											cc	cc				
21	<i>Chromis viridis</i>	Blue-green chromis										c	c					
22	<i>Chromis atripectoralis</i>	Black-axil chromis											+					
23	<i>Plectroglyphidodon lacrymatus</i>	Jewel damsel								+	c	r	r					
24	<i>Plectroglyphidodon dickii</i>	Dick's damsel										+	r	r				
25	<i>Abudefduf septemfasciatus</i>	Banded sergeant	+	+														
26	<i>Chrysiptera biocellata</i>	Twospot demoiselle			r													
27	<i>Amblyglyphidodon leucogaster</i>	White-belly damsel											r	+				
28	<i>Stegastes nigricans</i>	Dusky gregory						r										
29	Pomacentridae	DAMSELFISHES	r	c	c	r	r	+				r	cc	c				
30	<i>Gomphosus varius</i>	Bird wrasse		rr				rr	rr									
31	<i>Labroides dimidiatus</i>	Bluestreak cleaner wrasse						rr	rr									
32	<i>Labroides bicolor</i>	Bicolor cleaner wrasse											rr		rr			
33	<i>Labrichthys unilineatus</i>	Tubelip wrasse													rr			
34	<i>Stethojulis bandanensis</i>	Red-shoulder wrasse				r	r											
35	<i>Thalassoma hardwickii</i>	Sixbar wrasse	rr	r				r		rr	rr	rr						
36	<i>Thalassoma quinquevittatum</i>	Fivestripe wrasse						rr		rr								
37	<i>Thalassoma purpuraceum</i>	Surge wrasse		rr														
38	<i>Halichoeres hortulanus</i>	Checkerboard wrasse		rr			rr	r	r	rr					rr			
39	<i>Halichoeres trimaculatus</i>	Three-spot wrasse	rr	r	r	r	r	r	rr							r		
40	<i>Halichoeres margaritaceus</i>	Weedy surge wrasse			r	rr												
41	<i>Epibulus insidiator</i>	Slingjaw wrasse							rr							rr		
42	<i>Cheilinus fasciatus</i>	Red-banded wrasse					rr									rr		
43	<i>Oxycheilinus diagrammus</i>	Linedcheeked wrasse			rr				rr							rr rr		
44	<i>Scarus longiceps</i>															r		
45	<i>Scarus schlegelii</i>	Schlege's parrotfish					r					r				r rr		
46	<i>Chlorurus sordidus</i>	Bullhead parrotfish		rr		r	r	r	r	+	+	+	+	+	+	r		
47	<i>Chlorurus microrhinos</i>	Steephead parrotfish											r	r				
48	<i>Scarus spinus</i>	Pygmy parrotfish									rr	rr						
49	<i>Scarus oviceps</i>	Dark-capped parrotfish							rr		rr	rr						
50	<i>Scarus niger</i>	Swarthy parrotfish						rr							r			
51	<i>Scarus</i> spp.	Parrotfishes					r					+	+	c	+	r		
52	<i>Meiacanthus atrodorsalis</i>	Yellowtail poison-fang blenny													+	r		
53	<i>Zanclus cornutus</i>	Moorish idol											rr					
54	<i>Naso lituratus</i>	Orangespine unicornfish												+	c			
55	<i>Zebrasoma scopas</i>	Brushtail tang						r	r	r	+					rr		
56	<i>Ctenochaetus striatus</i>	Striped bristletooth				+	+	c	+	c	r			r	r			
57	<i>Acanthurus triostegus</i>	Convict surgeonfish	r	r	+	r		r										
58	<i>Acanthurus nigrofuscus</i>	Dusky surgeonfish						r								r		
59	<i>Acanthurus lineatus</i>	Striped surgeonfish		rr		r			r	r	rr							
60	<i>Acanthurus pyroferus</i>	Mimic surgeonfish													rr	rr		
61	<i>Acanthurus leucopareius</i>	Whitebar surgeonfish											r					
62	<i>Acanthurus nigricans</i>	Whitecheek surgeonfish						r	r		r		rr					
63	<i>Acanthurus</i> spp.	Surgeonfishes														r		
64	<i>Rhinecanthus rectangulus</i>	Wedge picassofish			rr	rr												
65	<i>Oxymonacanthus longirostris</i>	Longnose filefish														r		
66	<i>Arothron nigropunctatus</i>	Blackspotted puffer														rr		

rr : 1~2N r : 3~10N + : 11~20N c : 21~50N cc : over 51N (N= number of individuals)

Table 12-4 The results of observation about fish appearance in Falefatu(S)

No.	Scientific name	Common name	distance from shoreline(m)															
			0					50				100				140		
No. of species			1	2	9	7	6	9	3	4	12	10	12	9	12	10		
1	<i>Heteroconger</i> sp.	Garden eels														+		
2	<i>Spratelloides</i> sp.	Blue sprat									cc							
3	<i>Sargocentron spiniferum</i>	Long-jawed squirrelfish														rr		
4	<i>Plectropomus areolatus</i>	Squaretail coralgroup												rr				
5	<i>Cephalopholis argus</i>	Peacock grouper														rr		
6	<i>Cephalopholis urodeta</i>	Flagtail grouper												rr				
7	<i>Epinephelus merra</i>	Honeycomb grouper					r											
8	<i>Pterocaesio trilineata</i>	Three-striped fusilier										cc		cc	cc			
9	<i>Monotaxis grandoculis</i>	Bigeye emperor										r		r				
10	<i>Mulloidichthys flavolineatus</i>	Yellowstripe goatfish										c				r		
11	<i>Parupeneus barberinus</i>	Dash-and-dot goatfish											r					
12	<i>Chaetodon trifascialis</i>	Chevroned butterflyfish				rr						r			rr	rr		
13	<i>Chaetodon auriga</i>	Threadfin butterflyfish														r		
14	<i>Chaetodon unimaculatus</i>	Teardrop butterflyfish										rr	rr					
15	<i>Chaetodon reticulatus</i>	Reticulated butterflyfish								rr	r							
16	<i>Chaetodon lunula</i>	Raccoon butterflyfish										rr						
17	<i>Chaetodon trifasciatus</i>	Redfin butterflyfish									r							
18	<i>Chaetodon ornatissimus</i>	Ornate butterflyfish										rr						
19	<i>Chaetodon citrinellus</i>	Speckled butterflyfish			rr													
20	<i>Chromis ternatensis</i>	Ternate chromis											cc	cc	cc			
21	<i>Chromis atripectoralis</i>	Black-axil chromis				rr	rr						r					
22	<i>Dascyllus reticulatus</i>	Reticulated dascyllus													r			
23	<i>Plectroglyphidodon lacrymatus</i>	Jewel damsel									r	r						
24	<i>Plectroglyphidodon dickii</i>	Dick's damsel							rr		r	r	rr					
25	<i>Chrysiptera biocellata</i>	Twospot demoiselle	r															
26	<i>Amblyglyphidodon leucogaster</i>	White-belly damsel											r	r				
27	<i>Pomacentrus pavo</i>	Blue damsel														+		
28	<i>Stegastes nigricans</i>	Dusky gregory			c	+	+	c							r			
29	Pomacentridae	DAMSELFISHES			r			r		r								
30	<i>Labroides dimidiatus</i>	Bluestreak cleaner wrasse									rr							
31	<i>Labroides bicolor</i>	Bicolor cleaner wrasse														rr		
32	<i>Stethojulis bandanensis</i>	Red-shoulder wrasse		rr		r												
33	<i>Macropharyngodon negrosensis</i>	Black leopard wrasse						rr										
34	<i>Thalassoma hardwickii</i>	Sixbar wrasse			r		rr	r		r	r	r						
35	<i>Halichoeres hortulanus</i>	Checkerboard wrasse				rr					rr		rr					
36	<i>Halichoeres trimaculatus</i>	Three-spot wrasse		r	+	r	r	r						r	r			
37	<i>Cheilinus fasciatus</i>	Red-banded wrasse										rr			rr			
38	<i>Scarus longiceps</i>												r	r				
39	<i>Scarus schlegeli</i>	Schlege's parrotfish												rr	rr			
40	<i>Chlorurus sordidus</i>	Bullhead parrotfish			r	r		r	r		r	r						
41	<i>Chlorurus microrhinos</i>	Steephead parrotfish											r					
42	<i>Scarus oviceps</i>	Dark-capped parrotfish						rr				r						
43	<i>Scarus</i> sp.	Parrotfishes			r									r	r			
44	<i>Naso lituratus</i>	Orangespine unicornfish														r		
45	<i>Ctenochaetus striatus</i>	Striped bristletooth			rr	r	rr	r	r		r							
46	<i>Acanthurus lineatus</i>	Striped surgeonfish									rr							
47	<i>Acanthurus nigricans</i>	Whitecheek surgeonfish						rr			r	r						
48	<i>Acanthurus</i> spp.	Surgeonfishes													r			
49	<i>Oxymonacanthus longirostris</i>	Longnose filefish											rr					
50	<i>Arothron nigropunctatus</i>	Blackspotted puffer														rr		

rr : 1~2N r : 3~10N + : 11~20N c : 21~50N cc : over 51N (N= number of individuals)



Table 12-5 The results of observation about fish appearance in Mateika

No.	Scientific name	Common name	distance from shoreline(m)													
			0		50			70								
		No. of species	0	0	17	15	13	10	16	17						
1	<i>Spratelloides</i> sp.	Blue sprat			cc		cc									
2	Atherinidae	Silversides			cc											
3	<i>Plectropomus areolatus</i>	Squaretail coralgroup						rr								
4	<i>Anypserdon leucogrammicus</i>	Slender grouper												rr		
5	<i>Cheilodipterus quinquelineatus</i>	Five-lined cardinalfish												cc		
6	<i>Pterocaesio trilineata</i>	Three-striped fusilier												cc		
7	<i>Gnathodentex aureolineatus</i>	Yellowspot emperor												c		
8	<i>Monotaxis grandoculis</i>	Bigeye emperor						r		r						
9	<i>Mulloidichthys flavolineatus</i>	Yellowstripe goatfish					r	r								
10	<i>Mulloidichthys vanicolensis</i>	Yellowfin goatfish												r		
11	<i>Parupeneus barberinus</i>	Dash-and-dot goatfish								rr						
12	<i>Parupeneus pleurostigma</i>	Sidespot goatfish								rr						
13	<i>Parapriacanthus ransonneti</i>	Pygmy sweeper												cc		
14	<i>Forcipiger longirostris</i>	Big long-nosed butterflyfish						r								
15	<i>Chaetodon trifascialis</i>	Chevroned butterflyfish				rr	r		r							
16	<i>Chaetodon auriga</i>	Threadfin butterflyfish			rr			rr								
17	<i>Chaetodon reticulatus</i>	Reticulated butterflyfish						rr								
18	<i>Chaetodon trifasciatus</i>	Redfin butterflyfish				r	r									
19	<i>Chaetodon ulietensis</i>	Pacific double-saddle butterflyfish				rr										
20	<i>Chaetodon citrinellus</i>	Speckled butterflyfish			rr											
21	<i>Chromis viridis</i>	Blue-green chromis								cc						
22	<i>Dascyllus aruanus</i>	Humbug dascyllus								c	r					
23	<i>Abudefduf septemfasciatus</i>	Banded sergeant			r											
24	<i>Chrysiptera biocellata</i>	Twospot demoiselle				r			rr							
25	<i>Amblyglyphidodon leucogaster</i>	White-belly damsel												rr		
26	<i>Pomacentrus pavo</i>	Blue damsel								c	cc					
27	<i>Stegastes nigricans</i>	Dusky gregory			+	c	c	r	r	r						
28	<i>Thalassoma hardwickii</i>	Sixbar wrasse			r	r										
29	<i>Halichoeres hortulanus</i>	Checkerboard wrasse			rr											
30	<i>Halichoeres trimaculatus</i>	Three-spot wrasse			+	r				r						
31	<i>Epibulus insidiator</i>	Slingjaw wrasse			rr											
32	<i>Cheilinus undulatus</i>	Humphead wrasse :Napoleonfish												rr		
33	<i>Oxycheilinus unifasciatus</i>	Ringtail wrasse			rr	rr										
34	<i>Oxycheilinus diagraphmus</i>	Linedcheeked wrasse						rr								
35	<i>Scarus longiceps</i>								rr	rr						
36	<i>Chlorurus sordidus</i>	Bullhead parrotfish			r	r	r									
37	<i>Chlorurus microrhinos</i>	Steephead parrotfish					r									
38	<i>Scarus oviceps</i>	Dark-capped parrotfish			r	r	r									
39	<i>Scarus ghobban</i>	Bluebarred parrotfish												rr		
40	<i>Scarus</i> spp.	Parrotfishes						+	+							
41	<i>Valenciennea sexguttata</i>	Six-spot goby								r	r					
42	<i>Ctenogobiops feroculus</i>	Sandy prawn-goby								r	r					
43	<i>Amblygobius phalaena</i>	Brown-barred goby								r	r					
44	<i>Ptereleotris microlepis</i>	Pearly dartfish									rr					
45	<i>Zanclus cornutus</i>	Moorish idol			rr											
46	<i>Ctenochaetus striatus</i>	Striped bristletooth			r	+	+	+								
47	<i>Acanthurus triostegus</i>	Convict surgeonfish			+	+	r									
48	<i>Acanthurus lineatus</i>	Striped surgeonfish			r	r	r									
49	<i>Acanthurus nigricans</i>	Whitecheek surgeonfish					rr									
50	<i>Acanthurus</i> spp.	Surgeonfishes									r	r				
51	<i>Oxymonacanthus longirostris</i>	Longnose filefish					r									
52	<i>Arothron nigropunctatus</i>	Blackspotted puffer												rr		

rr : 1~2N r : 3~10N + : 11~20N c : 21~50N cc : over 51N (N= number of individuals)





4) Results of Algae Survey

Table 14-1 The results of observation about algae appearance in Funamanu (N).

No.	Scientific name /No. of species	distance from shoreline(m)															
		0					50					100					160
		7	7	7	8	9	10	10	7	8	11	12	13	10	10	10	8
1	CYANOPHYCEAE sp.	15	5	5	5	5	10	5	10	5	10	10	5	+	+	10	+
2	<i>Boodlea</i> sp.										r	r	r				
3	<i>Dictyosphaeria cavernosa</i>											r					
4	<i>Ventricaria ventricosa</i>								+								r
5	<i>Caulerpa racemosa</i> var. <i>clavifera</i> f. <i>macrophysa</i>	+	r	+	+	r	r	r									
6	<i>Caulerpa serrulata</i> var. <i>serrulata</i> f. <i>lata</i>	r	r					r			r						
7	<i>Halimeda</i> spp.	r	r	+	5	5	5	10	15	5	+	+	+	10	10	15	30
8	<i>Neomeris</i> sp.					r	r	r	r								
9	<i>Dictyota</i> sp.											r	r	+	+	10	5
10	<i>Lobophora variegata</i>	r	+	+	r	r	r	r	r	r	r	r	+	+	5	5	5
11	<i>Turbinaria</i> sp.						r	r	r	r	r	r	r	r	r	r	r
12	Corallinaceae sp.	+	+	r	r	r	r	r	r	5	10	+	+	r	+	r	+
13	<i>Jania</i> sp.											r	r				
14	Gelidiaceae sp.										r	+	r	r			
15	<i>Asparagopsis taxiformis</i>													r	r		
16	<i>Hypnea</i> sp.										r						
17	Peyssonneliaceae sp.	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r
18	Ceramiaceae sp.												+	+	r	r	+
19	<i>Laurencia</i> sp.			r	r	r	+	+	+	+	r						
20	RHODOPHYCEAE sp.				r	r				5	10	+	+	r	+	+	+
all of coverage (%)		20	10	15	15	15	20	20	30	35	40	20	15	20	25	50	80

+ : under 5%

Table 14-2 The results of observation about algae appearance in Funamanu (S)

No.	Scientific name /No. of species	distance from shoreline(m)							
		0		50				70	
		3	6	13	17	14	8	5	
1	CYANOPHYCEAE sp.	50	15	+	15	+	+	r	
2	<i>Boodlea</i> sp.					r	r		
3	<i>Ventricaria ventricosa</i>					r	r		
4	<i>Caulerpa racemosa</i> var. <i>clavifera</i> f. <i>macrophysa</i>					r	r		
5	<i>Caulerpa racemosa</i> var. <i>peltata</i>					r	r		
6	<i>Caulerpa serrulata</i> var. <i>serrulata</i> f. <i>lata</i>					r	r		
7	<i>Halimeda</i> spp.	r	+	r	r	r	10	+	
8	<i>Bryopsis</i> sp.					r			
9	<i>Dictyota</i> sp.			r	r	r	r	r	
10	<i>Lobophora variegata</i>			+	r	+	+	+	r
11	<i>Turbinaria</i> sp.					r			
12	Corallinaceae sp.	20	50	50	15	+	+	+	
13	<i>Jania</i> sp.					r			
14	Gelidiaceae sp.				r	+			
15	<i>Hypnea</i> sp.				r	r	r		
16	Peyssonneliaceae sp.				r	r	r	r	
17	Gelidiopsis sp.				r	r			
18	Ceramiaceae sp.				r	+	5	+	
19	RHODOPHYCEAE sp.				r	10	+	5	
all of coverage (%)		70	70	60	55	20	35	+	

+ : under 5%

Table 14-3 The results of observation about algae appearance in Falefatu (N).

No.	Scientific name /No. of species	distance from shoreline(m)													
		0				50				100				130	
		3	4	5	7	6	9	12	10	8	7	7	5	6	
1	CYANOPHYCEAE sp.	15	10	10	5	5	r	r	r	r	r	r	r	r	
2	<i>Microdictyon japonicum</i>							r							
3	<i>Dictyosphaeria cavernosa</i>							r	r	r					
4	<i>Valonia utricularis</i>								r	r					
5	<i>Ventricaria ventricosa</i>										r				
6	<i>Caulerpa</i> sp.			r	r	r	r	r							
7	<i>Halimeda</i> spp.	r	+	r	r	r	r	r	+	r	+	10	r	r	
8	<i>Neomeris</i> sp.				r	r		r							
9	<i>Dictyota</i> sp.											r			
10	<i>Lobophora variegata</i>				r	r	r	r			r	5	r	r	
11	Corallinaceae sp.	r	5	5	25	50	60	35	55	25	r	+	r	r	
12	Gelidiaceae sp.						r	r	r	r					
13	Peyssonneliaceae sp.		r	r	r	r	r	r	r					r	
14	Ceramiaceae sp.						+	r			r	r			
15	<i>Laurencia</i> sp.								r	r					
16	RHODOPHYCEAE sp.						10	30	30	10	r	+	r	r	
all of coverage (%)		15	25	20	35	60	75	70	90	40	+	20	+	+	

+ : under 5%

Table 14-4 The results of observation about algae appearance in Falefatu (S).

No.	Scientific name /No. of species	distance from shoreline(m)														
		0			50				100			140				
		3	5	6	6	7	7	5	5	7	4	4	5	6	4	
1	CYANOPHYCEAE sp.	5	5	+	+	+	+	10	5	5	r	r	r	r	r	
2	<i>Caulerpa cupressoides</i> var. <i>lycopodium</i> f. <i>amicorum</i>		r													
3	<i>Caulerpa</i> sp.					r										
4	<i>Halimeda</i> spp.		r	10	10	5	+	r	r	r	r	r	r	r		
5	<i>Bryopsis</i> sp.									r						
6	<i>Lobophora variegata</i>			r	r	r	r							r	r	
7	Corallinaceae sp.	10	45	35	35	55	60	10	70	35	r	r	r	r	r	
8	<i>Jania</i> sp.							r	r	5						
9	Gelidiaceae sp.									+						
10	<i>Peyssonneliaceae</i> sp.						r			r	r	r	r	r		
11	Ceramiaceae sp.			5	5	5	r						r	r		
12	<i>Laurencia</i> sp.		r													
13	RHODOPHYCEAE sp.			+	r	r	r	+	5					r	r	
all of coverage (%)		15	55	60	55	70	70	75	80	60	r	r	r	r	+	r

+ : under 5%

Table 14-5 The results of observation about algae appearance in Mateika.

No.	Scientific name /No. of species	distance from shoreline(m)							
		0		50				70	
		2	2	6	6	6	7	5	5
1	CYANOPHYCEAE sp.	r	+	+	r	r	5	r	r
2	<i>Caulerpa serrulata</i> var. <i>serrulata</i> f. <i>lata</i>							r	
3	<i>Caulerpa</i> sp.						r		
4	<i>Halimeda</i> spp.			+	+	+	5	+	r
5	Corallinaceae sp.	r	r	+	5	5	5	r	r
6	Gelidiaceae sp.			r					
7	<i>Hypnea</i> sp.			r					
8	<i>Peyssonneliaceae</i> sp.				r	r	r		r
9	Ceramiaceae sp.				+	r	+		r
10	RHODOPHYCEAE sp.			5	r	r	r	r	
all of coverage (%)		r	+	15	15	15	25	+	r

+ : under 5%

Table 15 A list and trend of appearance species of algae

No.	PHYLUM	ORDER	CLASS	Family	Scientific name	Fongafale(1)	Fongafale(2)	Fongafale(3)	Fongafale(4)	Fongafale(5)	Fongafale(6)	Funamanu(N)	Funamanu(S)	Falefatu(N)	Falefatu(S)	Mataika		
1	CYANOBACTERIA	CYANOPHYCEAE	—	—	CYANOPHYCEAE sp.	○	○	○	○	○	○	○	○	○	○	○		
2	CHLOROPHYTA	CHLOROPHYCEAE	ULVALES	Ulvaaceae	<i>Ulva</i> sp.		○				○							
3			CLADOPHORACEAE	Anadyomenaceae	<i>Microdictyon japonicum</i>										○			
4				Cladophoraceae	<i>Cladophora</i> sp.			○		○								
5				SIPHONOCALDALSIS	Boodleaaceae	<i>Boodlea</i> sp.	○	○	○	○	○	○	○	○	○			
6					Siphonocladaceae	<i>Boergesenia forbesii</i>	○	○	○	○								
7					Valoniaceae	<i>Dictyosphaeria cavernosa</i>						○		○		○		
8						<i>Valonia utricularis</i>										○		
9						<i>Valonia</i> sp.					○							
10						<i>Ventricaria ventricosa</i>								○	○	○		
11					CAULERPALES	Caulerpaceae	<i>Caulerpa cupressoides</i> var. <i>lycopodium</i> f. <i>amicorum</i>	○	○		○		○				○	
12							<i>Caulerpa racemosa</i> var. <i>clavifera</i> f. <i>macrophysa</i>	○	○	○	○	○	○	○	○			
13							<i>Caulerpa racemosa</i> var. <i>lamourouxii</i>	○	○	○	○	○	○					
14							<i>Caulerpa racemosa</i> var. <i>occidentalis</i>											
15							<i>Caulerpa racemosa</i> var. <i>peltata</i>			○	○	○			○			
16							<i>Caulerpa serrulata</i> var. <i>serrulata</i> f. <i>lata</i>	○			○	○		○	○			○
17							<i>Caulerpa sertularioides</i> f. <i>longipes</i>	○	○		○							
18							<i>Caulerpa taxifolia</i>	○			○	○						
19							<i>Caulerpa</i> sp.									○	○	○
20						Udoteaceae	<i>Halimeda macroloba</i>	○	○	○	○		○					
21							<i>Halimeda</i> sp.	○	○	○	○	○	○	○	○	○	○	○
22					BRYOPSIDALES	Bryopsidaceae	<i>Bryopsis</i> sp.								○		○	
23					DASYCLADALES	Dasycladaceae	<i>Neomeris annulata</i>				○							
24							<i>Neomeris</i> sp.	○	○					○		○		
25			PHEOPHYTA	PHEOPHYCEAE	DICTYOTALES	Dictyotaceae	<i>Dictyota</i> sp.	○	○	○	○	○	○	○	○	○	○	
26	<i>Lobophora variegata</i>	○					○	○	○	○	○	○	○	○	○	○		
27	<i>Padina</i> sp.	○					○	○	○	○	○	○	○					
28	SCYTOSIPHONALES	Scytosiphonaceae			<i>Rosenvingea</i> sp.	○			○			○						
29	FUCALES	Sargassaceae			<i>Sargassum</i> sp.			○	○	○								
30					<i>Turbinaria</i> sp.									○	○			
31	RHODOPHYTA	RHODOPHYCEAE	NEMALIALES	Galaxauraceae	<i>Galaxaura</i> sp.	○	○	○	○	○	○							
32			CORALLINALES	Corallinaceae	<i>Corallinaceae</i> sp.	○	○	○	○	○	○	○	○	○	○	○	○	
33					<i>Jania</i> sp.	○	○		○	○	○	○	○	○	○	○		
34			GELIDIALES	Gelidiaceae	<i>Pterocladia</i> sp.				○									
35					<i>Gelidiaceae</i> sp.	○	○	○	○	○	○	○	○	○	○	○	○	
36			BONNEMAISSIONALES	Bonnemaisoniaceae	<i>Asparagopsis taxiformis</i>								○					
37			GIGARTINALES	Hypneaceae	<i>Hypnea pannosa</i>							○						
38					<i>Hypnea</i> sp.	○	○	○	○	○	○	○	○	○	○	○		
39				Peyssonneliaceae	<i>Peyssonneliaceae</i> sp.	○	○	○	○	○	○	○	○	○	○	○	○	
40			RHODYMENIALES	Rhodymeniaceae	<i>Gelidiopsis</i> sp.	○	○		○	○	○				○			
41			CERAMIALES	Ceramiales	<i>Ceramium</i> sp.	○	○						○					
42					<i>Spyridia filamentosa</i>	○	○	○	○	○								
43					<i>Ceramiales</i> sp.	○	○	○	○	○					○	○	○	○
44					Rhodomelaceae	<i>Acanthophora spicifera</i>	○	○	○	○								
45						<i>Chondria</i> sp.				○								
46						<i>Laurencia</i> sp.				○				○			○	○
47				<i>Tolyptocladia</i> sp.	○	○	○	○	○				○					
48				—	—	RHODOPHYCEAE sp.				○	○	○	○	○	○	○	○	
						28	31	23	33	24	20	20	19	16	13	10		

(2) Distribution Conditions

1) Classification for sediments, corals and algae

Table 16 Division of sediments

Sediments	color	note
rock	red	mainly rock bottom area
gravel	blue	mainly gravel bottom area
sand	yellow	mainly sand bottom area
shoreline	black line	shoreline of estimate for satellite images

Table 17 Division of corals

Coral coverage	color	note
50%<	red	coral coverage 50% over
20-50%	blue	coral coverage 20-50%
5-20%	green	coral coverage 5-20%
1-5%	yellow	coral coverage 1-5%
<1%	white	coral coverage under1%

2) Distribution Conditions for sediments and corals

Sediments

Table 18 Trend of sediments cover degree in each site

<b>Funamanu(N)</b>			<b>Falefatu(N)</b>			<b>Mateika</b>		
	m2	%		m2	%		m2	%
Rock	47,110	68.8	Rock	84,910	66.6	Rock	19,210	57.5
Gravel	5,853	8.5	Gravel	5,230	4.1	Gravel	1,849	5.5
Sand	15,550	22.7	Sand	37,340	29.3	Sand	12,390	37.0
total	68,513		total	127,480		total	33,449	

<b>Funamanu(S)</b>			<b>Falefatu(S)</b>		
	m2	%		m2	%
Rock	43,510	74.6	Rock	103,800	61.3
Gravel	7,043	12.1	Gravel	12,100	7.1
Sand	7,741	13.3	Sand	53,450	31.6
total	58,294		total	169,350	

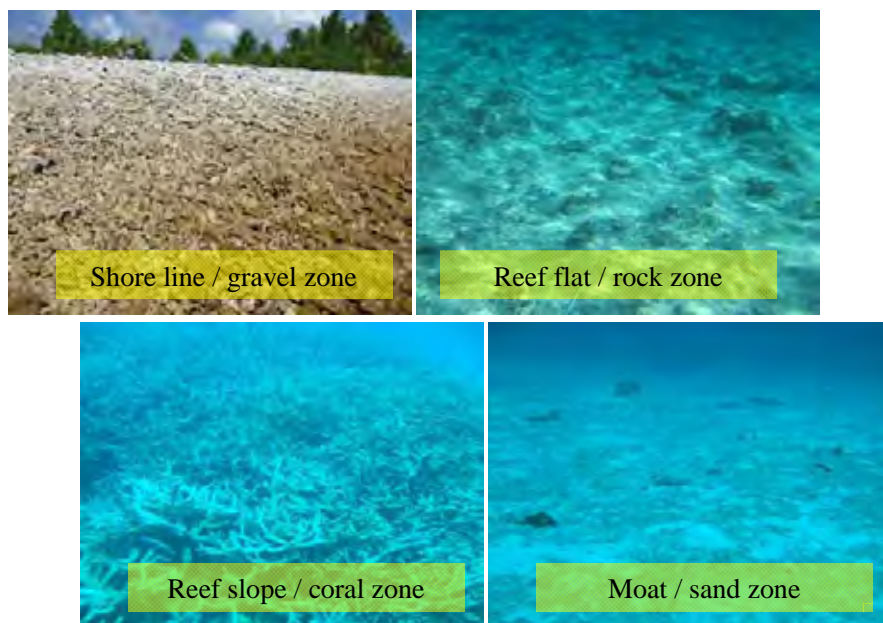


Figure 24 Typical landscape



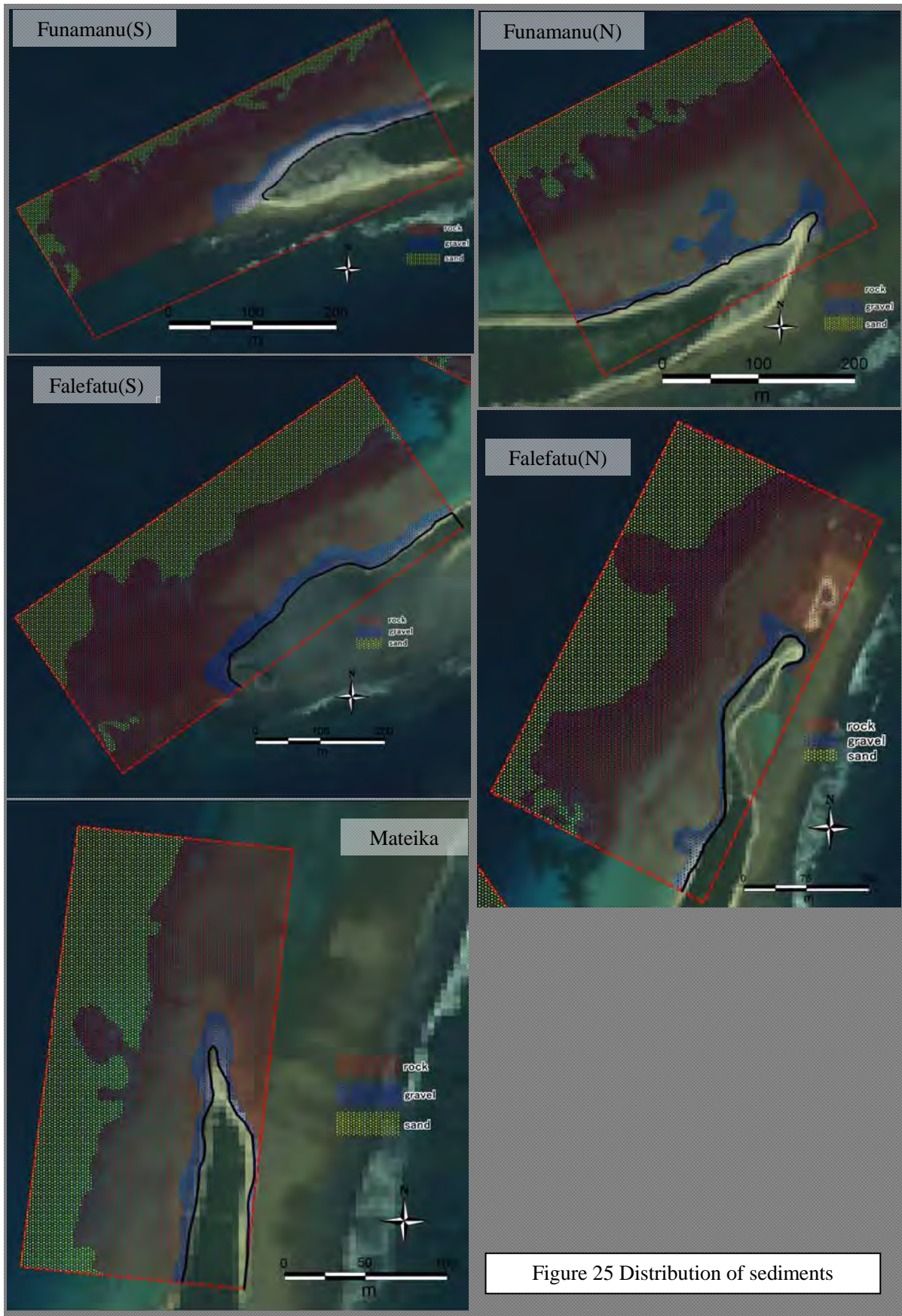


Figure 25 Distribution of sediments

Corals

Table 19 Trend of coral cover degree in each site.

<b>Funamanu(N)</b>			<b>Falefatu(N)</b>			<b>Mateika</b>		
	m2	%		m2	%		m2	%
50%<	13,040	19.3	50%<	18,000	14.1	50%<	2,625	7.8
20-50%	0	0.0	20-50%	0	0.0	20-50%	3,695	11.0
5-20%	5,859	8.7	5-20%	14,720	11.5	5-20%	3,078	9.2
1-5%	27,280	40.3	1-5%	11,440	9.0	1-5%	9,816	29.3
<1%	21,400	31.7	<1%	83,310	65.4	<1%	14,240	42.7

<b>Funamanu(S)</b>			<b>Falefatu(S)</b>		
	m2	%		m2	%
50%<	13,160	22.6	50%<	31,130	18.4
20-50%	13,210	22.7	20-50%	9,496	5.6
5-20%	9,919	17.0	5-20%	28,120	16.6
1-5%	3,902	6.7	1-5%	35,190	20.8
<1%	18,060	31.0	<1%	65,580	38.6

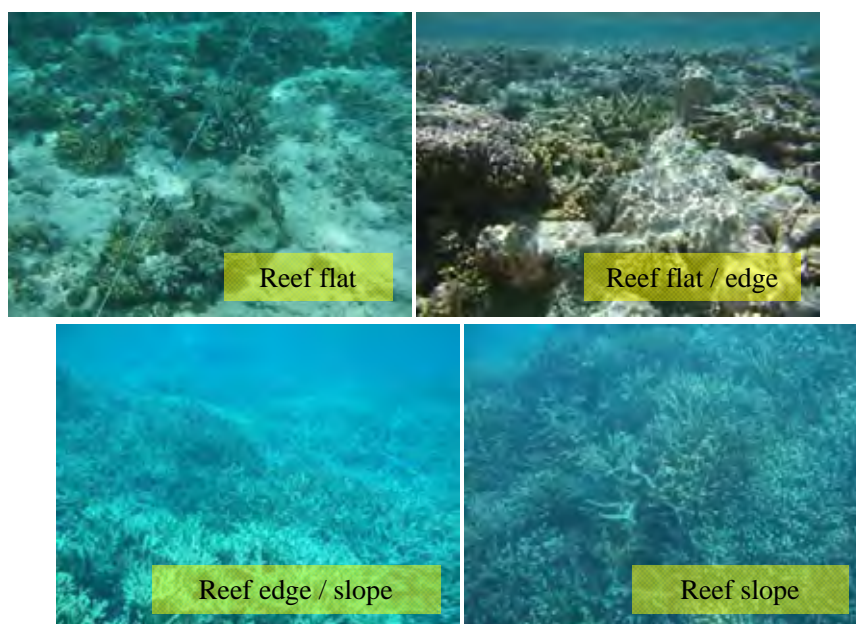


Figure 26 Typical landscape

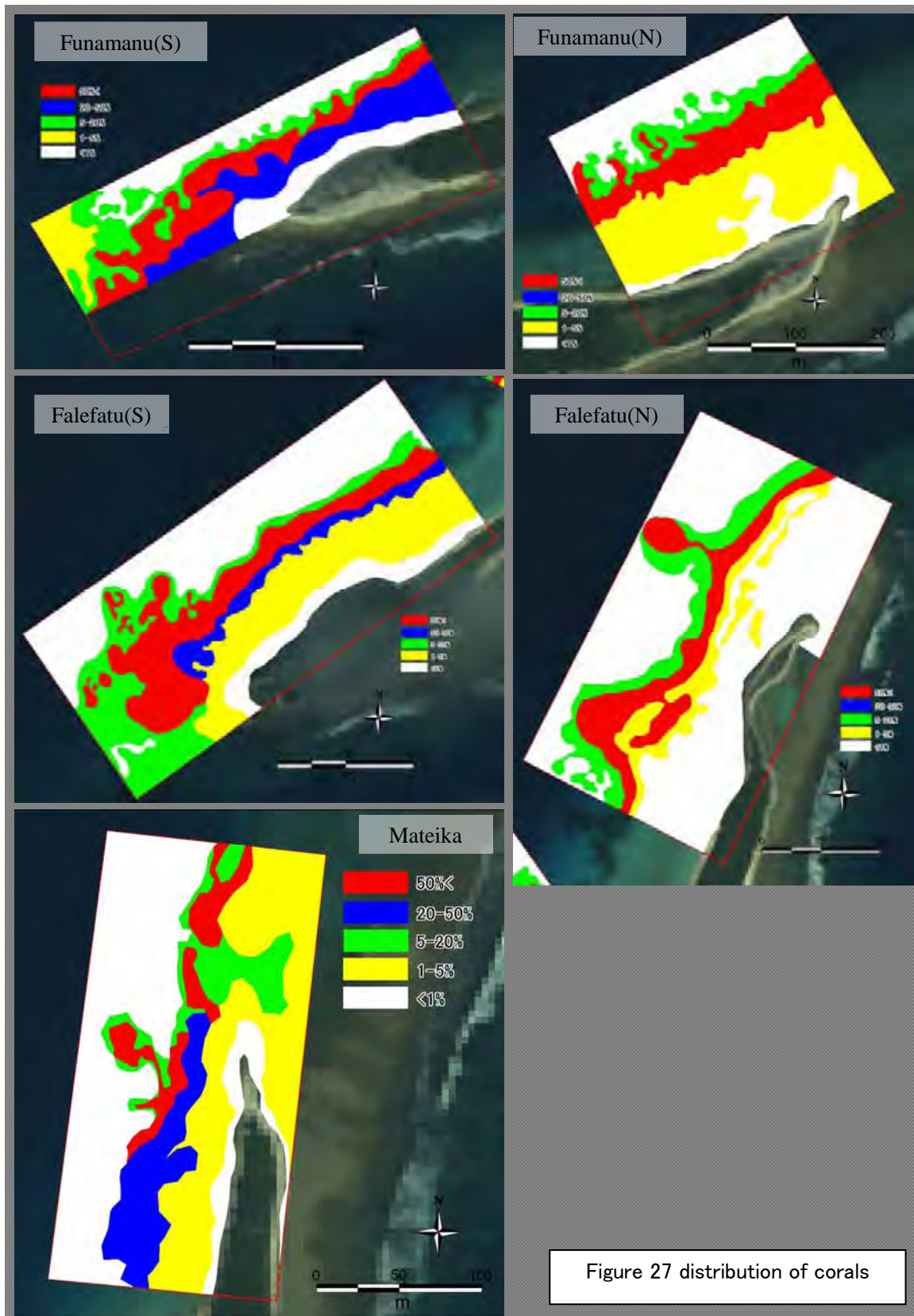


Figure 27 distribution of corals

### 4.3 Regional fish biodiversity

We used the Shannon-Weaner function ( $H'$ ) to compare fish biodiversity in the regions in Tuvalu. If many species exist in the object region, number of the function becomes high. Therefore, the more number of the function becomes high, the more fish community is complex and productive. The Shannon-Weaner function ( $H'$ ) by the following mathematical expression:

$$H'_{bit} = -\sum_{i=1}^S P_i \log_2 P_i$$

$$H'_{max} = -\sum_{i=1}^S \frac{1}{S} \log_2 \frac{1}{S}$$

$P_i$  here is simply the fraction of individuals in the  $i$ th species. In this research, we investigated inhabitation of fishes in the regions using CR method. Therefore,  $P_i$  is average of lower limit of the fish inhabitation.  $S$  is a number of species.  $H'_{bit}$  is calculated by the logarithm to base 2.  $H'_{max}$  is the maximum value that  $H'_{bit}$  can take.

Table 20 represents fish biodiversity on each survey line.  $H'_{max}$  can vary among number of species. In this case, number of species is 156, so  $H'_{max}$  becomes 7.285 (Table 20).

Table 20  $H'_{bit}$  and  $H'_{max}$  on each survey line from the piscifauna standpoint

	H'bit	note
Fongafale(1)	3.782	coastal area
Fongafale(2)	3.761	coastal area
Fongafale(3)	3.686	coastal area
Fongafale(4)	3.795	coastal area
Fongafale(5)	4.306	offshore area
Fongafale(6)	3.786	coastal area
Funamanu(N)	4.188	other islands
Funamanu(S)	4.913	other islands
Falefatu(N)	4.694	other islands
Falefatu(S)	3.918	other islands
Mateika	4.471	other islands
Max	7.285	

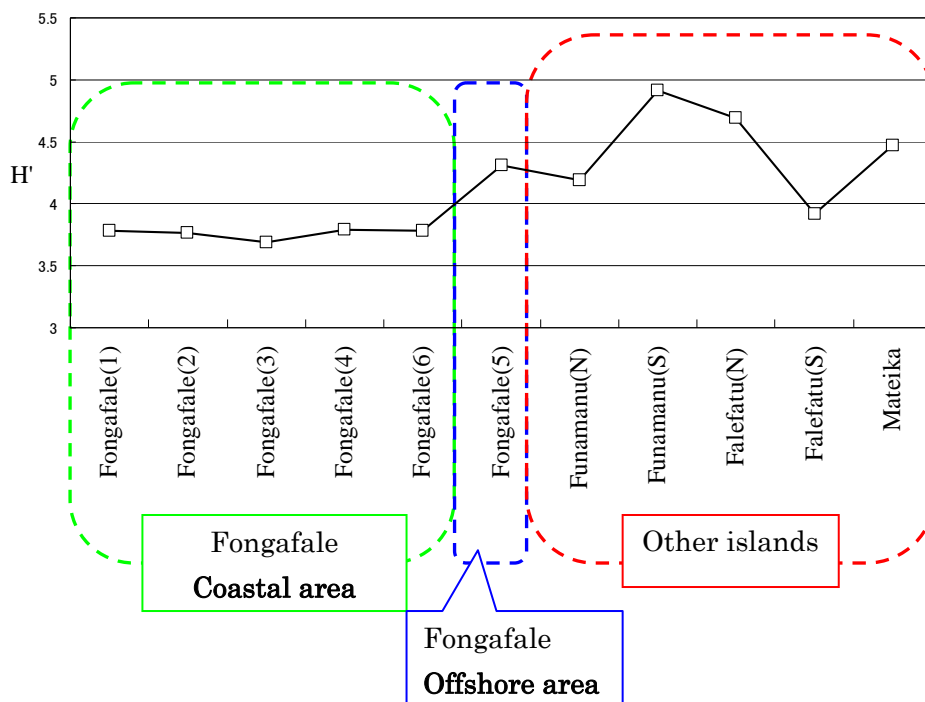


Figure 28 Fish biodiversity ( $H'_{bit}$ ) on each survey line

Figure 28 represents fish biodiversity ( $H'_{bit}$ ) on each survey line. The biodiversities indicate low values which are located in coastal area in Fongafale (the green line group in Fig. 26). In contrast, the biodiversities in offshore area of Fongafale (the blue line group) become high as in the case of other islands (the red line group).

Fongafale coastal area which has low biodiversity has not been the comfortable environment for fishes. Fishes which have high mobility capability can migrate to the comfortable environment, if the environment deteriorated. Therefore other regions which have high biodiversity are comfortable environment for fishes.

These results are supported by the distribution of corals in Tuvalu. Coral community in coastal area in Fongafale has been poor. And other areas have rich coral community in Tuvalu. In coral reefs, many fishes live in coral reefs which grow well. Because the corals that grow healthily can make rich community. And there are the feeding location, the retreat, the spawning ground and the nursery in such coral community.

It is difficult to know when the change of fish community occurs. To avoid such deterioration of fish diversity, we need to be aware of the change.

#### **4.4 The practical effects of priority project and countermeasure**

A salvage barge of 2 meter draft with 30 meter width comes alongside the pier in Funamaru, Falefatu and Mateika. We considered the physical effect and countermeasure for corals in this situation.

##### Effect:

Access of a salvage barge can damage the corals.

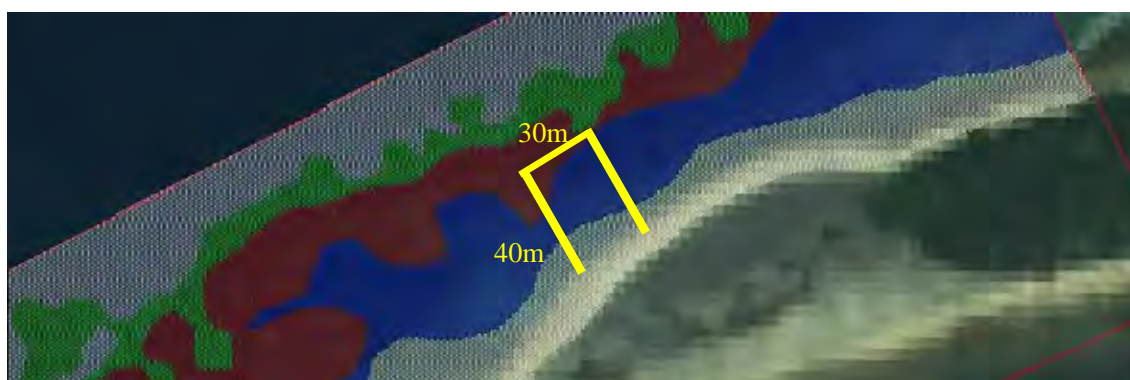
##### Measures 1:

We will transplant corals from the area which is damaged by the access of the barge. And we will put the corals back after completion of work.

Below is a chart that the planned berth of the barge on the south of Funamanu (Yellow lines ). We calculated the area of transplant corals in every cover degree in the berth. The results are

- More than 50% cover degree is 187.6m<sup>2</sup>
- Cover degree 20 – 50% is 681.7 m<sup>2</sup>
- Less than 1% cover degree is 211.4 m<sup>2</sup>.

Therefore, the total area of transplant corals is at least 229.3 m<sup>2</sup>



Corals which is clipped in the area put in the strage on the reef bottom. The strage is made using metallic pipes and wire mesh. The strage is very simple and the shape similar to the beehive. If the strage is 4m square by 4m height with 4 racks, corals on the 64 square meters can be caught in the strage. Corals on the 229.3 square meters can be caught in the 4 strages.

Corals are clipped by divers. If a diver cut the corals about 10 square meters per day, the work should take 23 days by simple arithmetic. It is worth while to consider about role-sharing arrangement and transportation method of corals.

We transplant corals using a bond which suitable for use under water. The work should take 46 day per one diver. The tools which needs to tackle the work are diving devices, workboats, cutting devices, transport platforms, strages and bonds, etc.

We planed on the assumption that divers have enough skills under water. Skills in this work mean experiences about underwater structural work, transplant corals and underwater survey. The most important skill is a good deal of knowledge about corals.

Expected cost per 1 section

- 5 Divers : 15 days ¥5,000,000
- Daily wage, accommodation charge ¥1,500,000
- Travel cost ¥2,000,000
- Charter fee 2 ships/day ¥1,000,000
- Diving and survey devices, ¥300,000
- Consumables ¥700,000
- Bond ¥2,000,000

Total ¥12,500,000

Measures 2:

We suppress the influence to the corals by salvage barge shaking using berthing ropes.