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Ministry of Communication, Works and Energy,
Government of the Republic of the Fiji Islands

PREPARATION OF NAUTICAL CHARTS IN THE NORTHERN LAU ISLANDS REGION IN THE REPUBLIC OF THE FIJI ISLANDS

Main Report - Volume II

Study Progress Report

March 1999

Aero Asahi Corporation
Asia Air Survey Co. Ltd.

Ministry of Communication, Works and Energy, Government of the Republic of the Fiji Islands
Preparation of Nautical Charts in the Northern Lau Islands Region
Main Report Volume II Study Progress Report
March 1999

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List of Reports

MAIN REPORT

VOLUME I : Recommendations for the Improvement of Operation and Management System of Hydrographic Surveying and Nautical Charting in Fiji

VOLUME I SUMMARY : Recommendations for the Improvement of Operation and Management System of Hydrographic Surveying and Nautical Charting in Fiji

VOLUME II : Study Progress Report

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PREPARATION OF NAUTICAL CHARTS
IN
THE NORTHERN LAU ISLANDS REGION
OF
THE REPUBLIC OF THE FIJI ISLANDS

Main Report - Volume II
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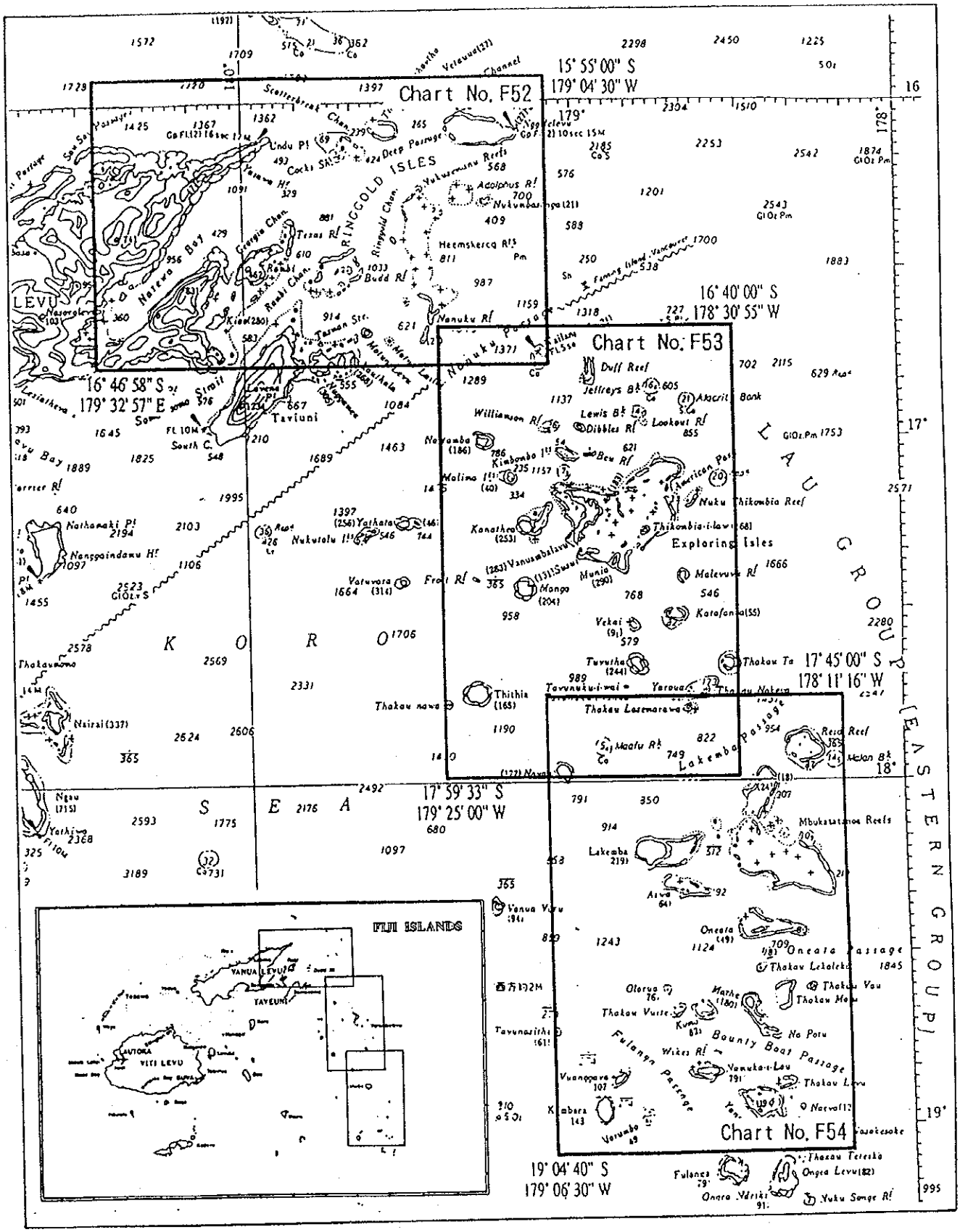

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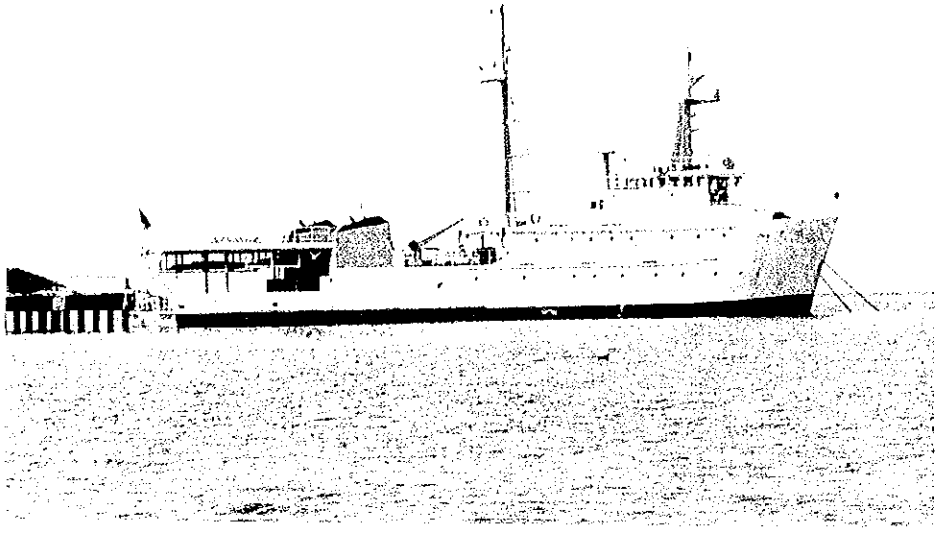

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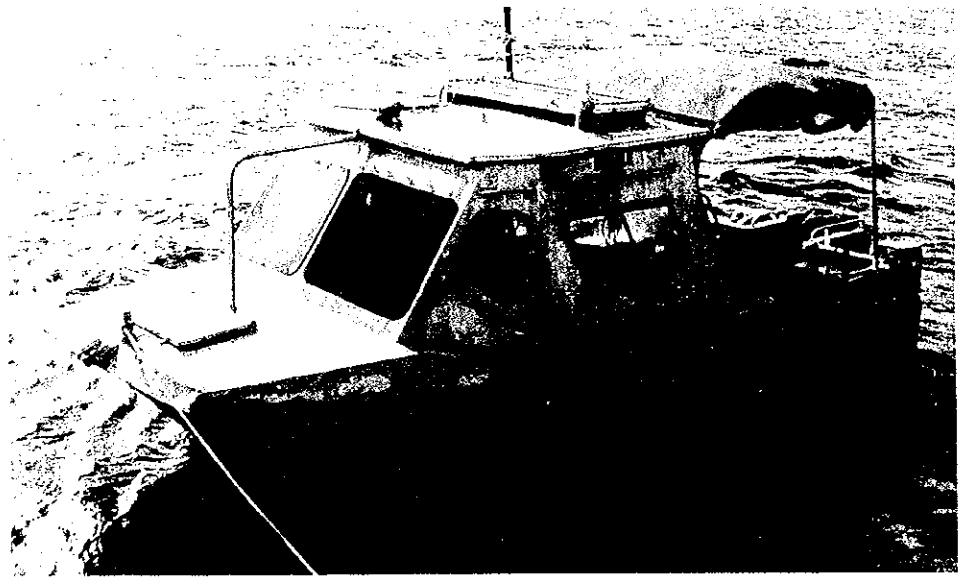

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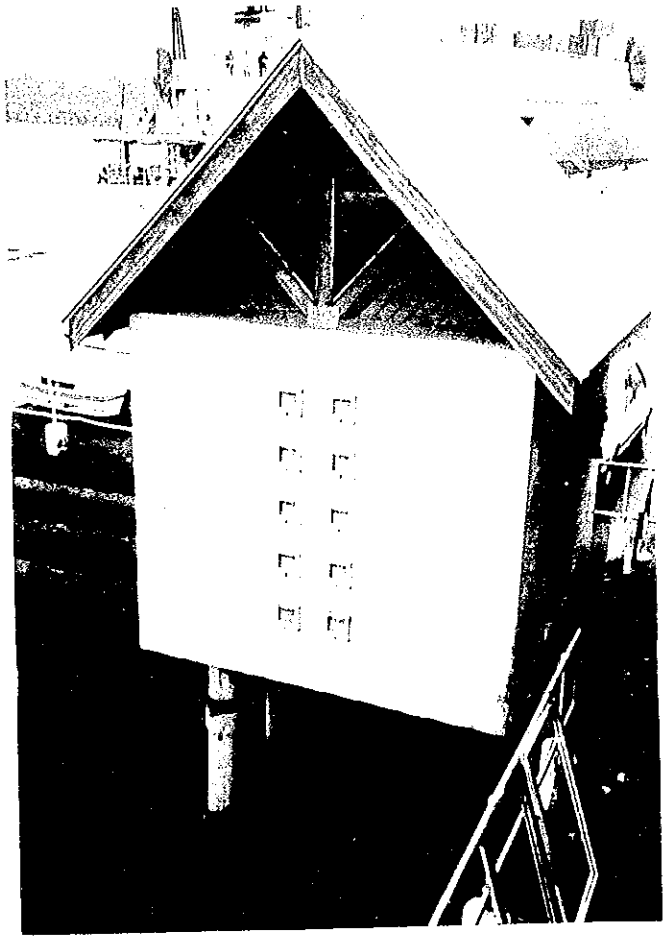

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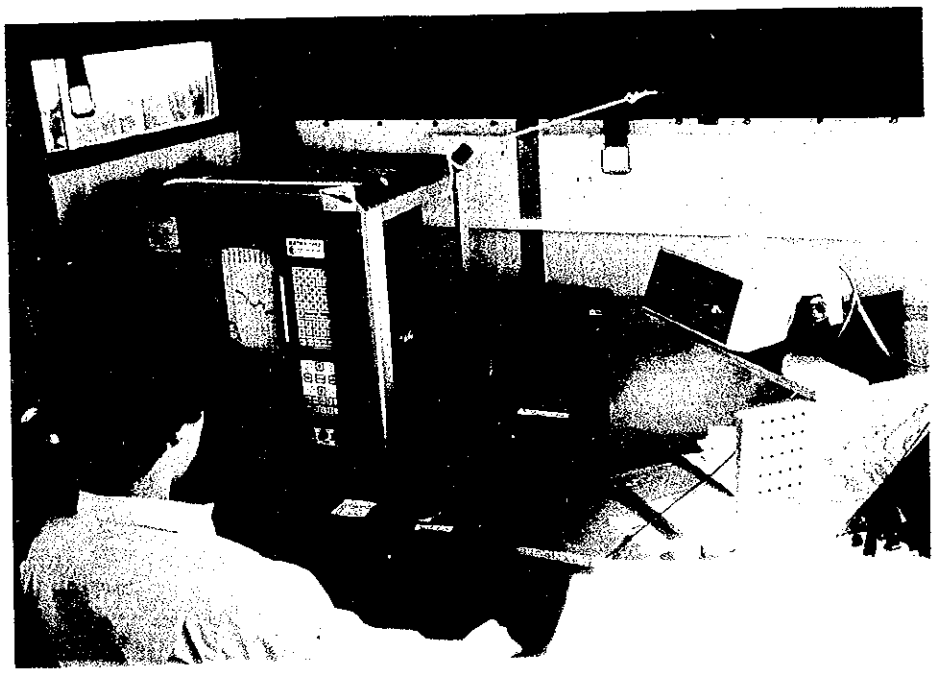

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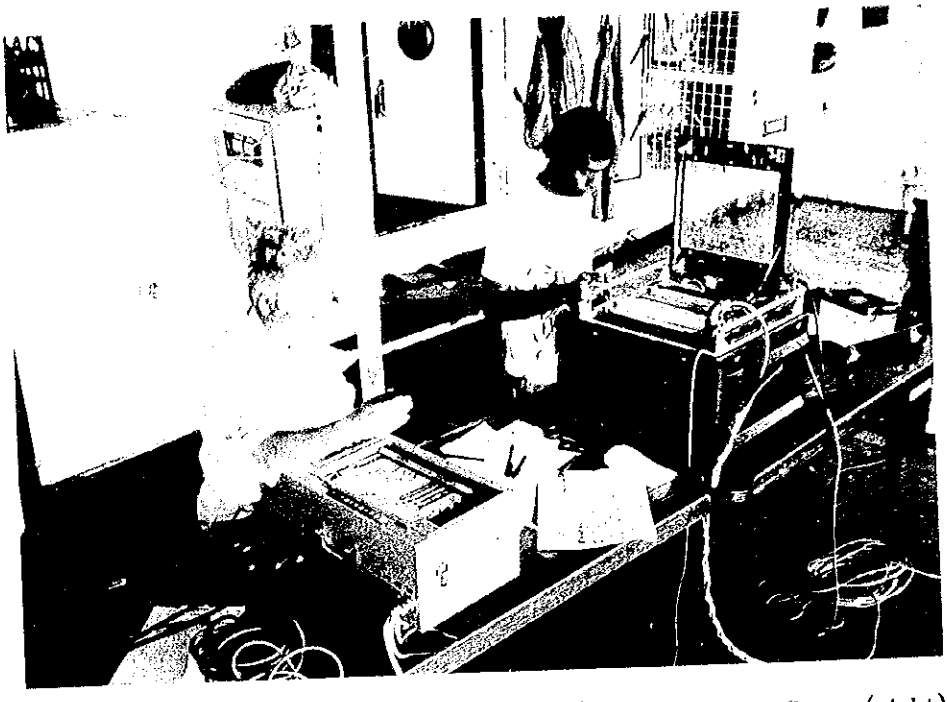

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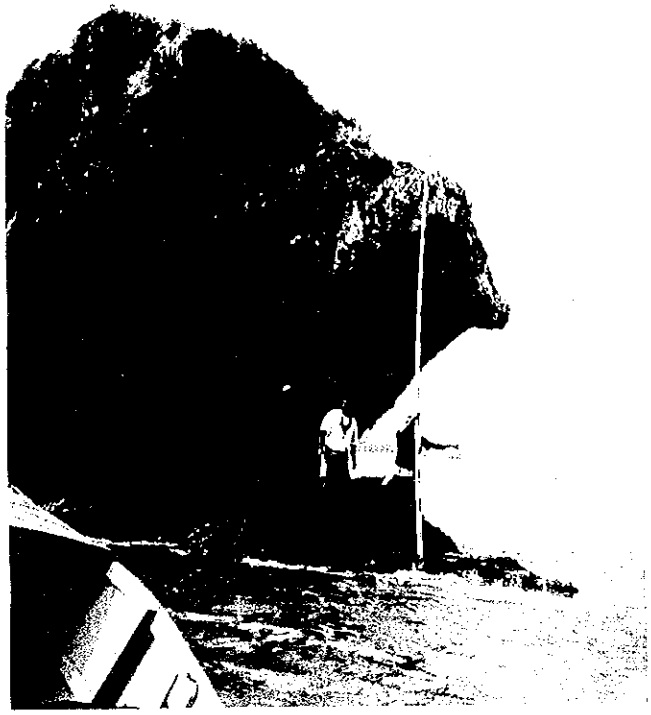

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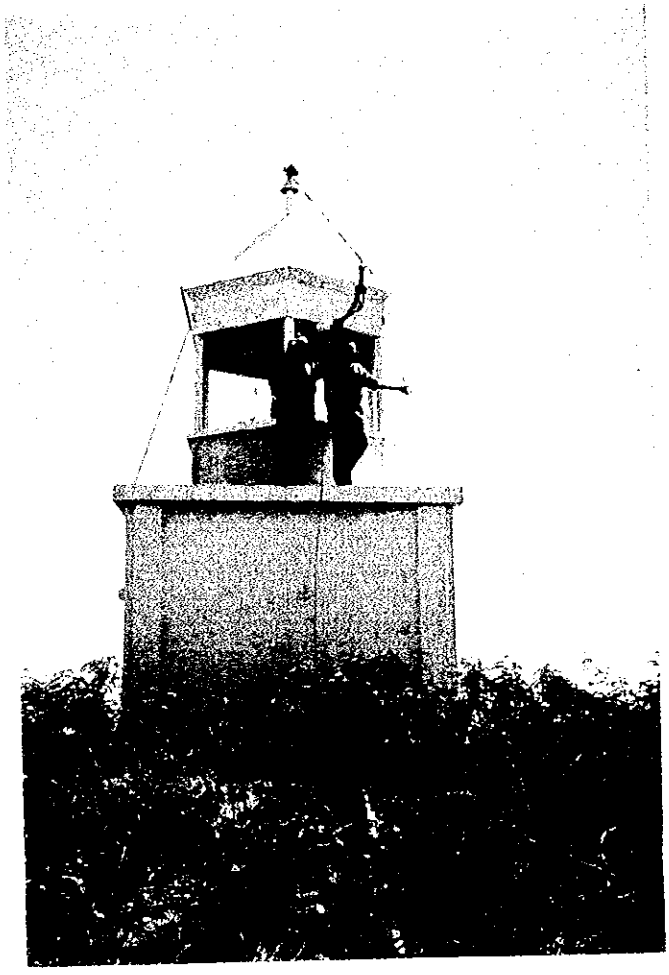

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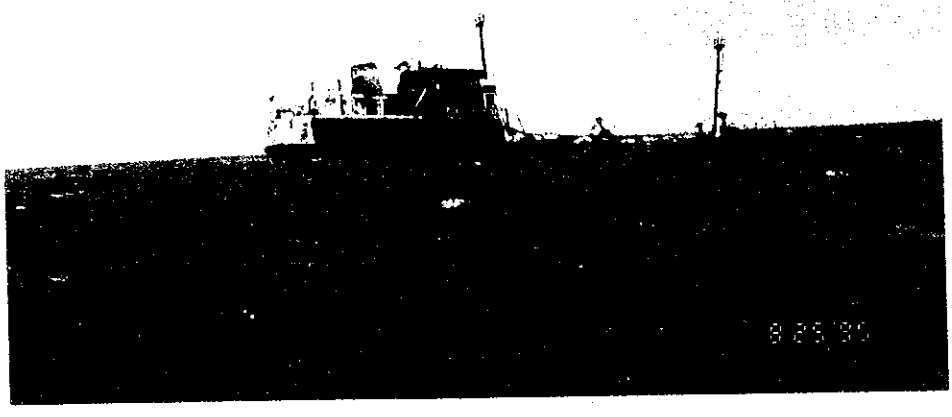

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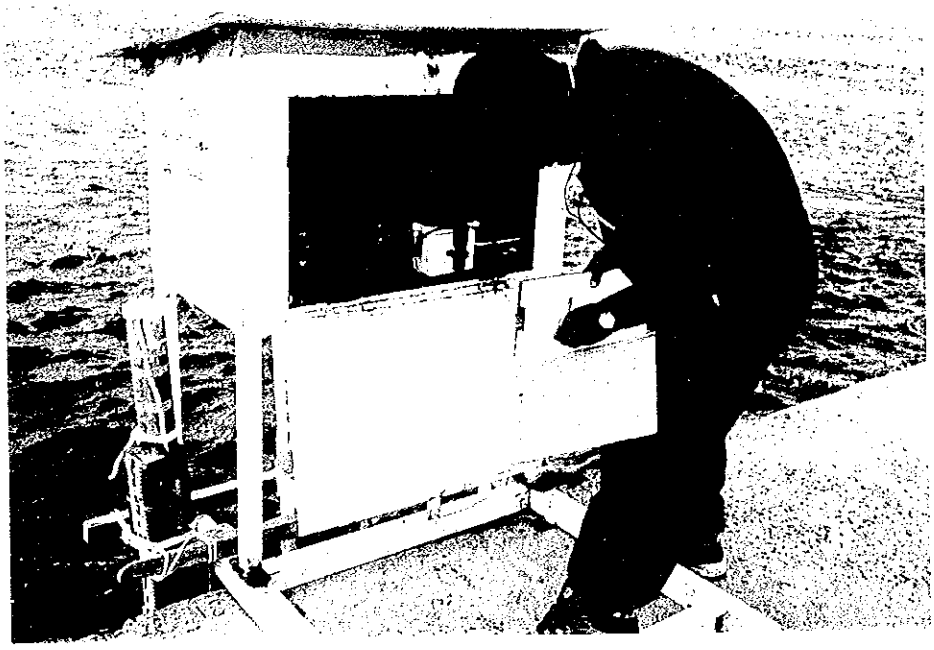

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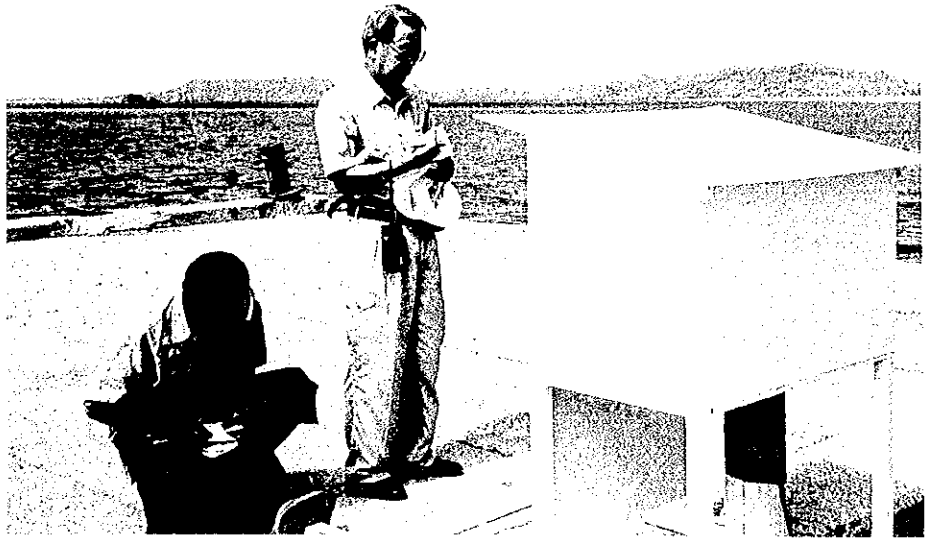

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MAIN REPORT - VOLUME II
STUDY PROGRESS REPORT

1. INTRODUCTION

1-1. Background

The island nation of Fiji, consisting of more than 300 islands situated between latitudes 12.5° and 22° S. and between longitudes 174° E. and 177° W., is situated at the hub of traffic in Southwest Pacific, thus Fiji has become the crossroads of shipping services between North America/Hawaii and Australia/New Zealand, between South America.and Southeast Asia as well as between Fiji and Samoa/Tonga.

The Northern Lau Islands region, through which principal shipping routes are frequented by vessels navigating in the Southwest Pacific via ports of Fiji, is mostly charted with rather outdated hydrographic surveys of late 19th to early 20th Century. It has been demanded that, for the sake of navigational safety; such situation should be improved by introducing modern, updated navigational charts.

On the other hand, Fiji has rather limited resources on land so that development of marine resources including fisheries and tourism has been promoted as one of the most urgemt and substantial policies for social and economic development of the nation.. In particular, the areas with islands and islets surrounded by coral reefs located in the region have a great potentiality for tourism development. Towards such activities the nautical chart plays an important role.

With such situation as a background, the Government of the Republic of the Fiji Islands requested the Government of Japan for technical cooperation in preparation of nautical charts in the region by modern technique and instruments.

In response to the request, the Japan International Cooperation Agency (JICA), the official agency responsible for implementation of the technical cooperation programmes of the Government of Japan, decided to conduct the Study on the Preparation of Nautical Charts in the Northern Lau Islands Region in the Republic of Fiji (hereinafter referred to as "the Study"), and dispatched a Preparatory Study Team to Fiji from 15 February to 15 March 1994. The Team consulted with its counterpart organization, the Fiji Hydrographic Service (FHS) of the Ministry of Infrastructure, Public Works and Transport (renamed "Ministry of Communications, Works and Energy" as of August 1997) of the Government of the Republic of the Fiji Islands.

After exchange of views and discussions, the Scope of Work (S/W) for implementation of the Study was agreed between JICA and the Government of Fiji on 15 March 1994.

The Study was conducted in accordance with S/W for five years from fiscal year 1994. The Study resulted in preparation of three nautical charts of the region through technology transfer to the Fiji counterpart personnel as well as of recommendations for improvement of hydrographic surveying and nautical charting in Fiji.

2. GEOGRAPHICAL ASPECTS OF THE STUDY AREA

2-1. Geographical facts of the Fiji Islands

The 320 islands, of which at least 100 are inhabited, comprising Fiji are spread over an area of 709,700 .km^2 - 97 per cent of it is ocean - between latitudes of 12.5° and 22° S., and lying on either side of the 180th meridian, between 177° W and 174° E. The actual land area, however, is about 18,376 km^2. The largest island, Viti Levu, is 10,429 km^2 in area, where the nation's capital Suva is situated. Vanua Levu is next with 5,538 km^2, followed by Taveuni, 435 km^2, Kadavu, 409, Gau, 140, Ovalau, Koro, Rabi, Rotuma, and Beqa.

These and other islands of the Fiji group are high islands, volcanic in origin, though no longer active, and rising to heights of over 1,000m in the case of the three main islands. Rock structures of volcanic origin, however, combine on the large islands with those of sedimentary formation, a clear indication that the processes of land building took place both above and below the surface of the ocean.

The group is positioned in the southern tropics, and the southeast trade winds prevail for most of the year. Due to this effect, the rainfall in the eastern part of Viti Levu reaches about 3,000mm a year, while the western part is rather dry, the precipitation is 1,900mm a year. During the rainy season from November to April, the group is sometimes visited by cyclones causing more rain and violent damages.

2-2. Geographical features of the Study Area

The Lau Group consists of about 80 islands and atolls extending between Lat. 17° to 19° S and Long. 179° 30' to 178° W. Those islands are made of volcanic rocks but there is no volcanic activities. Most of the islands are not steep but their coasts are mostly steep without flat areas. Coral reefs are developing on the basis of those volcanic rocks in the forms of fringing reef, barrier reef and atoll. There are several huge atolls ranging 50km in diameter.

Within this area pass important shipping routes between North America/Hawaii and Australia/New Zealand, and between South America and Southeast Asia, and also between Fiji and Samoa/Tonga. Those passages frequented by large-sized vessels are Nanuku Passage, Lakeba Passage, Oneata Passage, Bounty Boat Passage and Fulaga Passage. These passages have been used by navigators since ancient times, and this locality is known as "Crossroad of the South Pacific".

The Exploring Isles situated in the middle of the area consists of 7 islands and a number of islets and coral reefs, forming a vast lagoon covering an area of about 518km^2 with circumference of about 130km. The largest island is Vanua Balavu with an area of 52km^2 located at the western end of the lagoon. Th is is the second largest island of the Lau Group with population of about 1,400, and is a core of the economic activities in the Lau Group. Lomaloma village is located on this island.

The lagoon of Exploring Isles has been used as maritime traffic and fishing grounds since early times, and has recently becoming the object of tourism development for marine resort and yacht havens.

The largest island in the area is Lakeba in the south of Exploring Isles with an area of

54km^2 and population of about 2,400. This island plays an important role in social and economic ties between Fiji and Tonga.

An airport is located at Vanua Balavu, Lakeba and Cicia in the Lau Group, and air traffic is available between Suva and these islands. For other islands, maritime transportation is the only means of travel.

3. OBJECTIVES AND OUTLINE OF PROGRESS OF THE STUDY

3-1. Objectives of the Study

(1) To prepare three Fiji nautical charts Nos.F52, F53 and F54, each on the scale of 1/150,000, covering the Northern Lau Islands region;

(2) To report the recommendation for improvement of operation and management system of hydrographic surveying and nautical charting in Fiji; and

(3) To promote technology transfer through the implementation of the Study with a view to enabling the Fiji counterpart personnel to improve their technique in hydrographic surveying and nautical charting.

3-2. Outline of progress of the Study

The Study was implemented from Phase I to Phase V as follows:

First Year (Phase I) (From 13 January to 30 March 1995)

- Work in Fiji (23 January ~ 21 February 1995):

(1) Consultation of the Plan of Operation for Phase I (P/O-I) with the Fiji Hydrographic Service, Marine Department, Ministry of Infrastructure, Public Works and Transport (hereinafter referred to as "FHS"), and agreement thereof;

(2) Selection of survey equipment to be used;

(3) Acquisition of aerial photographs and other source materials;

(4) Reconnaissance of survey sites for Phase II work; and

(5) Confirmation of survey implementation and support systems.

- Work in Japan (13 ~ 22 January 1995 and 22 February ~ 30 March 1995):

(1) Tentative drawing of coastlines of islands and atolls of the whole Study area.

(2) Preparation of the Progress Report of Phase I(PR/R-I), which was then submitted to the Government of Fiji from JICA.

Second Year (Phase II) (From 13 June 1995 to 29 March 1996)

- Work in Fiji (26 July ~ 14 October 1995):

(1) Consultation and agreement on the Plan of Operation for Phase II (P/O-II);

(2) Hydrographic survey in the Study Area F52; and

(3) Technology transfer to FHS counterpart personnel.

- Work in Japan (15 October 1995 ~ 19 March 1996):

(1) Processing of survey data and preparation of the smooth sheet of survey for Area F52.

(2) Preparation of the Progress Report of Phase II (PR/R-II), which was then submitted to the Government of Fiji from JICA.

Third Year (Phase III) (From 23 April 1996 to 21 March 1997)

- Work in Fiji (8 May ~ 12 October 1996):

(1) Consultation and agreement on the Plan of Operation for Phase III (P/O-III);

(2) Hydrographic survey in the Study Area F53; and

(3) Technology transfer to FHS counterpart personnel during the survey, in particular, the large-scale survey in Vanua Balavu lagoon to be conducted by FHS.

- Work in Japan (23 April ~ 7 May 1996 and 13 October 1996 ~ 31 March 1997):

(1) Processing of survey data and preparation of the smooth sheet of survey for Study Area F53.

(2) Preparation of the Nautical Chart No. F52 by JHD with participation of a Fiji counterpart personnel as on-job training.

(3) Preparation of the Progress Report of Phase III (PR/R-III), which was then submitted to the Government of Fiji from JICA, together with the printed copies of Chart No.F52.

Fourth Year (Phase IV) (From 15 April 1997 to 31 March 1998)

- Work in Fiji (1 May ~ 9 September 1997):

(1) Consultation and agreement on the Plan of Operation for Phase IV (P/O-IV);

(2) Hydrographic survey in the Study Area F54; and

(3) Technology transfer to FHS counterpart personnel.

- Work in Japan (15 ~ 30 April 1997 and 10 September 1997 ~ 20 March 1998):

(1) Processing of survey data and preparation of the smooth sheet of survey for Study Area F54.

(2) Preparation of the Nautical Chart No. F53 by JHD with participation of a Fiji counterpart personnel as on-job training.

(3) Preparation of the Progress Report of Phase IV (PR/R-IV), which was then submitted to the Government of Fiji from JICA, together with the printed copies of Chart No.F53.

Fifth Year (Phase V) (From April 25, 1998 to March 31, 1999)

- Work in Fiji (25 May ~ 1 July and 2 ~ 8 November 1998):

(1) Consultation and agreement on the Plan of Operation for Phase V (P/O-V).

(2) Survey, analysis and assessment of the existing status of the organization and functions of FHS.

(3) Preparation of Draft Final Report including the results of the analysis, and concluding recommendations for possible improvement of the system after discussions with FHS.

(4) Discussions on the Final Report including the recommendations and the comprehensive report on the whole Study.

- Work in Japan (15 ~ 24 May 1998 and 9 November 1998 to 31 March 1999):

(1) Compilation and editing of Draft Final Report as well as Final Report.

(2) Preparation of Fiji Nautical Chart No.F54 with participation of a Fiji counterpart personnel.

(3) Submission of the Final Report and printed copies of the Nautical Chart No.F54 to the Fiji Government from JICA.

4. GENERAL SPECIFICATIONS AND PROCEDURES OF HYDROGRAPHIC SURVEYING AND NAUTICAL CHARTING

4-1. Hydrographic survey specifications and procedures

As for hydrographic survey specifications, those standards specially provided for in the Study were described in the following. Unless otherwise stated, the International Hydrographic Organization (IHO) Standards for Hydrographic Surveys (S-44) have, in principle, been applied.

4-1-1. Control point survey

(1) The standard of survey were as follows:

Ellipsoid of reference : WGS-72
Grid system : FMG (Fiji Map Grid)
Origin of coordinates : 17° 00' 00" S, 178° 45' 00" E
Values of coordinates : 2,000,000mE and 4,000,000mN
Scale factor : 0.999850
Projection : Transverse Mercator (TM) projection

(2) A primary geodetic shore control point for fixing positions of auxiliary geodetic shore control points and the survey vessel position were established by DGPS observation with two or more existing geodetic control points.

(3) Auxiliary shore control points to be used for coastlining and fixing positions of conspicuous objects were established by open DGPS observations with an existing control point or the primary shore control point.

(4) Auxiliary shore control points for coastlining were selected one to three per an island or an atoll where landing is feasible, where open DGPS observations were be conducted. In the case of an extensive island or atoll, selection of auxiliary control points were be made at a rate one in every 10cm at the scale of survey, in principle.

(5) Transformation parameters from WGS-84 to FMG were as follows:

Parameter	Value
Shift dX	79.027m
Shift dY	-70.749m
Shift dZ	-102.333m
Rotation about X	-0.852520"
Rotation about Y	-3.876562"
Rotation about Z	2.648162"
Scale	7.420964ppm

(6) Specifications for GPS observation were as follows:

1) Performance of GPS receiver
Model : Trimble 4000SSE (3 sets)
Receivable frequency : 1,575.42MHz (L1) and 1,227.6MHz (L2)
Capability : $\pm(5mm + 1 \times 10^{-6} \times D)$ or more, where D is distance (km)

2) Observations were made to more than four satellites of good health status at elevation angles of more than 15 degrees.

3) Duration of observations were as follows:

Primary control point : 90 minutes or more.
Auxiliary control point : 20 minutes or more.

4) The accuracy of the primary control point was no more than 1/10,000. The relative positioning error was no more than 0.25mm at the scale of survey in case where the survey may cover an extensive area.

The accuracy of an auxiliary control point was no more than 0.5mm at the scale of survey.

4-1-2. Coastlining

(1) For delineation of coastlines, pricking was dome at selected points on the contact print aerial photographs (scale : 1/50,000) after confirming the conformity between picture and actual topography.

(2) Coastlining was carried out at such coasts where considerable changes had been found between the aerial photography and actual topography. It was carried out in such places where tentative drawing of coastline had been found difficult during the work in Phase I due to clouds, halation or other reasons.

(3) For a conspicuous object useful to navigation with unknown height, measurement of the height was carried out as far as possible.

4-1-3. Tidal observation

4-1-3-1. Tide station at standard port

It was decided that the tide station established by NOAA at Port of Suva should be adopted as the tide station at standard port. The tidal data observed at the station during the survey period were retrieved as necessary by connecting a personal computer, and used for calculation of various reference levels at the survey sites..

4-1-3-2. Tide stations at survey sites

(1) A tide station with a self-recording tide gauge was set on a jetty at Lomaloma, Vanua Balavu in Phases II and III, and on a jetty at Tubou, Lakeba, in Phase IV.

(2) Continuous observation of tide was conducted throughout the period of sounding operation.

(3) The type and specifications of the tide gauges used were as follows:

Type : Pressure type tide gauge YEO-KAL Model 610
Recording mode : Digital
Accuracy : 0.0025m at 0-10m range

Resolution : 0.001m at 0-10m range
Data logging rate : Every 5 minutes

(4) In parallel with the tide gauge above, the following tide gauge was set as a backup:

Type : Floating type tide gauge model PFT-II
Recording mode : Analogue
Reduction ratio : 1/20
Paper speed : 20mm/h
Recording interval : Continuous recording
Minimum graduation : 1cm

(5) In order to determine the zero of tide gauge, a bench mark (BM) was firmly established nearby on land, and levelling was carried out between the tide gauge and the BM.

(6) The time kept on the recording paper of PFT-II was checked with the correct local time at least once a day.

(7) Mean Sea Level (MSL) and Datum Level (DL) of sounding were determined as follows:

- Suva being the standard port, the necessary tidal data recorded at Suva tide station were retrieved by connecting a personal computer to it.
- The MSL at the local tide station was computed by using the following equation:

$$A = A' + (A_o - A_o')$$

where A_o : MSL at Suva tide station
A_o' : Short term MSL at Suva tide station
A : MSL at local tide station
A' : short term MSL at local tide station

- For computation of short term MSL, tidal data from more than one-month observation were used.
- The DL at local tide station was obtained by harmonic analysis of the tidal data and compared to the existing value.

4-1-4. Sounding operation

4-1-4-1. Position fixing

(1) Ship's positions were fixed by DGPS observation with the primary shore control point. Real time processing was done for the observation.

(2) The following DGPS receivers were used:

(a) Main : Sercel NDS200/NR103
(b) Backup : Del Norte 1009/4012

(3) The interval between the position fixes at the scale of survey was 2cm or less in case of a linear sounding line, and in case of a curved one, was such that maintained the plotting error of any cut-in sounding to be within a circle with a 1.5mm radius on the sheet.

4-1-4-2. Sounding

(1) The sounding lines planned in the Study areas for Phases II, III and IV were as shown in figures 1, 2 and 3, respectively.

(2) The vessel to be used for sounding was R/V TOVUTO, and in such shallow waters where R/V TOVUTO was unable to navigate, SMB BABALE was used for sounding.

(3) The standard sounding line intervals were as follows:

Deep water areas : 3M
Shipping routes : 1.5km
Around islands and atolls : 1M
Reported shoals, shoals and banks : 200m or less (with Side Scan Sonar)

(4) The ship's speed during sounding operations was principally as follows:

Deep water areas and shipping routes: 8-10 knots
Other areas : 4-6 knots.

However, the speed was reduced to ensure accurate sounding owing to circumstances.

(5) The backup echo-sounder Model Bathy-1000 installed on board R/V TOVUTO was mainly used because of late delivery and operational failure of the main echo-sounder Model Bathy-2000P.

For confirmation of the least depth of a shoal, the four-beam echo sounder for shallow water use, Model PDR 601, was used. Specifications of these echo-sounders are as follows:

Model	Bathy-1000	Bathy-2000P	PDR 601
Depth range	0.5 - 6,000m	0.5 - 6,000m	0 - 140m
Frequency	12/200kHz	12/200kHz	90 - 230kHz
Sound velocity	1,400 - 1,540m/sec	1,400 - 1,540m/sec	1,500m/sec
Accuracy	10cm to 100m depth, 0.3% to 6,000m depth	10cm to 100m depth, 0.3% to 6,000m depth	(0.3 D 1/500)
Resolution	1/2400 over paper width	180 DPI	---
Minimum reading	---	---	0.1m

(6) Correction to soundings

i) Tidal reduction to soundings was made to the depths of 200m or less.

ii) Correction to soundings for underwater sound velocity was made by bar-check method down to depths of 50m, and by the echo-sounding correction tables to deeper depths.

(7) The accuracy of sounding was as follows:

Depths 30m and shallower : Less than 0.3m
Depths deeper than 30m : Less than 1% of the depth

(8) For confirmation of the least depth of a shoal, recordings of echo-sounder and Side Scan Sonar were compared, and where any shallower water was likely to exist, interlines were sounded.

The following Side Scan Sonar was used:
EG&G Model 260 Image Correcting Side Scan Sonar

Range (m) : 25 50 75 100 150 200 300 400 600 (each side)
Scale : 1/(10 X range)
Resolution: 1/400 of range

Another same type Side Scan Sonar was used as a backup.

(9) Supplementary sounding or resounding was conducted as follows:

1) In case where sounding line intervals had become more than 20% wider than the planned interval, supplemental interline sounding was conducted.

2) In case where a depth of less than 30m considered to be dangerous to navigation was likely to exist in between the sounding lines, supplementary sounding was conducted to confirm its least depth.

3) Resounding was conducted in such waters where the sounding record on the echogram was abnormal, illegible or lacking.

4) In case where the difference between soundings at the crossing point of a principal sounding line and a cross-check sounding line exceeded twice the value of the accuracy of sounding, resounding was carried out when the previous sounding data were considered to have exceeded an allowable error.

4-1-5. Field inspection

Inspection of the field work was conducted three times every year by qualified hydrographers of JHA.

4-1-6. Data processing

4-1-6-1. Control point survey

(1) Computation of control points was performed by a computer with an approved programme.

(2) Results of control point survey for preparation of manuscript sheets are shown on rectangular coordinates with the standards of survey (cf. 4-1-1(1)).

(3) Latitudes and longitudes of the primary shore control point and auxiliary control points were computed. Such computations were also made to graticule points at every 10cm from the origin of coordinates.

(4) The results of control point survey were stored in floppy disks and compiled into final results of control point survey, list of geographical coordinates and index sheet of

geographical positions, data list of control point survey and geodetic station records.

4-1-6-2. Coastlining

Coastlines were drawn by adopting those on the existing nautical charts and topographic maps as far as possible. The rest were drawn according to the coastline drawings prepared during Phase I, which were based on the results of coastlining conducted in the field.

4-1-6-3. Tidal observation

The mutual relationship between the zero of tide gauge, MSL, DL and BM at the local tide stations (Vanua Balavu in Phases II and III and Lakeba in Phase IV) were compiled into the results of reference measurements of the tide stations and data of measurements.

4-1-6-4. Sounding

(1) Soundings were read out to 0.1mm order for those shallower than 31m, and to 1m order for deeper ones, disregarding fractions.

(2) Soundings of shallower than 200m were corrected for tidal heights.

(3) In reading out the soundings shallower than 50m for which bar-check was carried out, the reading-scale prepared from the results of bar-check were used for correction of underwater sound velocity. For the correction to deeper soundings, the correction tables were used.

(4) Positions of soundings were selected on the echogram with priorities given to summits and bottoms of seabed undulations and transition points of slopes.

(5) Intervals of cut-in soundings to be read out were so selected that they might be less than 10mm on the flat bottom and less than 5mm elsewhere on the sheet.

4-1-7. Preparation of manuscript sheets

4-1-7-1. Control point sheet

Projection : Transverse Mercator (TM) projection

Scale : 1/150,000

Material : Plastic sheet with a thickness of 0.125mm or more

Items shown :

i) Existing and new control points and auxiliary control points with symbols and names
ii) Origin of coordinates, coordinate points at intervals of 10cm based on the origin
iii) Graticule points of every 15 minutes of latitude and longitude
iv) Positions and symbols for the four corners of the neat line
v) Metric scale

Plotting error : Less than 0.2mm on the sheet

4-1-7-2. Coastline sheet

Scale and material : Same as the control point sheet (par. 4-1-7-1).

Items shown:

i) Existing control points and those auxiliary control points necessary for delineation of coastlines.
ii) Coordinate points at 10cm intervals
iii) Every 15-minute graticule points
iv) Coastlines taken from aerial photographs and existing source materials, for which any correction to scale and distortion in topography has been rectified by using common points on the coastline sheet.

Symbols and abbreviations : In accordance with those adopted by the Hydrographic Department of Japan Maritime Safety Agency (JHD) for the smooth sheet.

Elevation : Elevation of an object measured in the field is shown to 0.1m order for less than 10m and to 1m order for 10m or higher.

4-1-7-3. Sounding sheet

Scale, projection and material : Same as the control point sheet (par. 4-1-7-1).

Items shown:

i) Existing control points and those control points and auxiliary control points necessary for sounding operation.
ii) Coordinate points spaced at 10cm
iii) Graticule points spaced at every 15 minutes
iv) Planned sounding lines and outline of coastlines drawn in pencil.
v) All of the positions fixed are be shown. However, in such an area where dense survey for searching a shoal was conducted so that plotting all of the fixed positions was not possible, they are shown on a separate larger-scale sheet.
vi) Sounding positions are connected with a firm line according to a chronological order, and the position fix number is marked against every fifth sounding position.
vii) The position of a cut-in sounding is marked with a 1mm-long dash crossing the sounding line at right angles.
viii) The plotting error of sounding positions is less than 0.5mm on the sheet.
ix) Navigational aids such as buoys and beacons existed within the survey area are shown with their positions and shapes.

4-1-7-4. Bathymetric plotting sheet

Scale and projection : Same as the control point sheet (par. 4-1-7-1).

Material : Plastic sheet with a thickness of 0.075mm or more.
Items shown :

i) Control points, coordinate points, graticule points spaced at every 15 minutes and four corners of the neat line.

ii) Positions of soundings transferred from the sounding sheet (par. 4-1-7-3), each of which is shown with a red point, and the corresponding sounding value are marked against it.

iii) All of those soundings selected on the sounding sheet (par. 4-1-7-3). As to such a protruded echo of an object not constituting the sea bottom, it is marked with an identification note when it was identified, or not identified, with an abbreviation "eO".

iv) In case where there are charted on existing source materials any sounding, wreck or fishing reef which is shallower than the sounding in iii) above and considered dangerous to surface navigation, the one adopted was determined after careful examination of the previous report concerned and the results of survey conducted in this study.

v) The depth contours shown on the bathymetric plotting sheet are those of 2m, 5m, 10m, 20m, 200m, 1000m and every 1000m for deeper waters.

4-1-8. Preparation of smooth sheet of survey

4-1-8-1. Smooth sheet of survey

Projection : Transverse Mercator projection

Scale : 1/150,000

Items shown:

i) Control points, graticule points and neat line corner points transferred from the control point sheet.

ii) The neat lines of the smooth sheet drawn to be in parallel with the lines joining the coordinate points in S-N and E-W directions.

iii) Coastlines transferred from the coastline sheet.

iv) Soundings in slant figures based on the bathymetric plotting sheet. Standard intervals for soundings shown are 10-20mm on the sheet. Soundings were so selected that they might well represent the sea bottom configurations.

v) The depth contours shown are 2m, 5m, 10m, 20m, 200m, 1000m and every 1000m for deeper waters.

Checking : The contents shown on the smooth sheet were thoroughly checked with manuscript sheets and source materials used for any erroneous or lacking indication.

Colouring : Colouring of symbols shown on the smooth sheet are in accordance with those prescribed in the Regulations of the Law for Hydrographic Surveys and Detailed Regulations for the Application of the Law for Hydrographic Survey specified by JHD.

4-1-8-2. Inspection

The smooth sheets of survey thus prepared underwent due inspection by the Japan Hydrographic Association (JHA), which included on-the-spot inspection by a member of the staff of JHA during the survey operations in the field (cf. par. 4-1-5 above).

4-1-9. Survey equipment and instruments used

4-1-9-1. Survey vessel

(1) R/V TOVUTO (cf. figure 4)
Gross tonnage : 912 tons
Length overall : 51.39m
Width moulded : 11.82m
Depth moulded : 3.00m
Complement : 3 officers and 18 crew
Accommodation : For about 15 persons
Speed : 12 knots (maximum)
Navigational instruments : Autopilot/Gyrocompass, GPS, Radar, Compass, Radio(HF and VHF)
Crane : 5-ton crane and a crane for loading and unloading a small boat.
Remarks : Transducer of echo-sounder Bathy-2000P/Bathy-1000 is equipped at the bottom of the hull, while those of PRD601 on the either side of the hull.

(2) Survey Motor Boat BABALE (cf. figure 5)
Type : Catamaran type aluminium boat
Length : 6.8m
Width : 2.6m
Engine : 40HP outboard engine x 2

4-1-9-2. Survey instruments

(1) Control point survey

GPS receiver : Trimble 4000SSE	3 sets
Total Station : Nikon Model DTM-1	1 set
Distance meter : Atlas Model LARA 90/205	1 set

(2) Coastlining
GPS receiver : Same as in (1) above

(3) Tidal observation

Tide gauge : YEO-KAL 610	1 set
Kyowa Shoko Model PFT-II	1 set
Rigosha Model RMD 5225	1 set (Phase IV)
Level : Sokkia Model B-2	1 set

(4) Sounding

DGPS receiver : Sercel NDS200/NR103	1 set
Del Norte 1009/4012	1 set
Navigation	1 set
Echo-sounder : Ocean Data Bathy-2000P	1 set
Ocean Data Bathy-1000	1 set
Senbon Denki Model PDR 601	2 sets
Side-scan Sonar : EG&G Model 260	2 sets
Plotter : Graphtec Model FP9100	1 set
Graphtec Model SF3100	1 set (Phase IV)

4-1-9-3. Others

Personal computer : NEC Versa V50 Notebook	1 set
Laser printer : HP Laser Jet IVL	1 set
Radio set : Barrett 550	3 sets
Battery charger : Dengen	2 sets
Power generator : Robin Model RGD3300	3 sets
Copying machine : Sharp SF7800	1 set
AC power conditioner : Sola 210-26-650-00	2 sets
Facsimile machine : Codan 9001	1 set
Autopilot/Gyrocompass : Tokimec RESCO PR-2000/TG-5000	1 set
Outboard engine : Yamaha E60HML	1 set

4-2. Chart specifications, basic factors and procedures

(1) Projection : Mercator Projection

(2) Geodetic system : Fiji Geodetic Datum (FGD), which is equivalent to WGS 72

(3) Scale : 1:150,000

(4) Graticules : Every 15 minutes of latitude and longitude

(5) Graduation on the borders : Every 0.2 minute of latitude and longitude

(6) Chart paper : The same full-size paper as currently used by JHD, weight 140g/m

(7) Unit of measure for depths : In metres and reduced to Chart Datum, which is approximately the level of Lowest Astronomical Tide (LAT)

(8) Unit of measure for heights : In metres and above Mean High Water Springs

(9) Title block including:
- Title of the chart
- FHS seal
- General geographical area and specific geographical reference
- Chart scale
- Unit of measure for depths and heights
- Name and date of the horizontal datum used
- Name of the projection used

(10) Source diagram : Showing source material data

(11) Conversion table : For metres/fathoms/feet

(12) Compass roses : Three compass roses on the chart

(13) Existing source materials to be adopted : Existing smooth sheets covering the area concerned, Fiji Charts and/or BA Charts other than those where the hydrographic survey was carried out during the Study.

4-2-1. Compilation planning

(1) Confirmation of basic specifications of the chart

(2) Confirmation of all available source materials collected for the compilation

(3) Examination and evaluation of the source materials

(4) Preparation of the planning note listing the source materials and indicating parameters for projection computation

(5) Computation and plotting of the border of the chart

(6) Preparation of the compilation sheet indicating coastlines, limits for adoption of source materials, geographical names, title block, cautionary notes, source diagram, etc.

(7) Proofreading of the compilation sheet and the compilation note

(8) The compilation sheet and the compilation note thus prepared were duly approved by the Director, Coastal Surveys and Cartography Division of JHD.

4-2-2. Preparation of drawing guide

Based on the planning sheet and the planning note prepared, a drawing guide was prepared on the plastic film, in which the following items of work were carried out:

(1) Preparation and drawing of the border of the chart

(2) Adjustment of source materials including one smooth sheet of survey and five topographic maps

(3) Compilation and drawing of the drawing guide after selection of coastlines, soundings, depth contours, geographical names, etc.

(4) Proofreading of the drawing guide

4-2-3. Preparation of chart originals

(1) Drawing of coastlines, depth contours and other line information by scribing method on a scribing base on which a positive image of the compilation sheet was printed.

(2) Sticking up of phototypeset figures and letters of soundings, geographical names, cautionary notes, compass roses, etc. on positive films prepared from (1) above. Thus, two kinds of the chart originals (black colour and magenta colour)were prepared.

(3) Proofreading of chart originals for checking of consistency, accuracy and adequacy according to the contents of the drawing guide. The chart representation was also examined.

4-2-4. Examination of chart originals

The contents of chart originals were examined from the viewpoint of navigational safety

and comprehensiveness by users.

4-2-5. Preparation of block correction

Explanation on possible preparation of block correction of the chart for updating was explained to the counterpart.

4-2-6. Preparation of printing plates

(1) Preparation of negative films of black colour and magenta colour plates

(2) Negative film correction by opaquing and masking

(3) Printing of guide image (black line chart original) to stripping coat films

(4) Stripping off the coat for production of an original plate for buff colour (land tint) and another for blue colour (for water tint)

(5) Preparation of machine plates by using each of the four original plates by printing negative images on the PS plates, for which the final checking and inspection were made

(6) Trial printing

4-2-7. Chart printing

Using the printing plates thus prepared, 200 copies of Nautical Charts Nos. F52, F53 and F54 were printed in 1997, 1998 and 1999, respectively.

4-2-8. Inspection of printed charts

The contents of each and every copy of the printed charts were inspected by JHA for any defect in chart printing.

5. PROGRESS OF WORK

5-1. FIRST YEAR (PHASE I) (F.Y. 1994)

5-1-1. Period of Study

From 13 January to 30 March 1995.

5-1-2. Objectives

(1) Collection and study of relevant information and data for working out a detailed plan of the hydrographic survey to be conducted.

(2) Preparation of Plan of Operation (hereinafter referred to as "P/O").

(3) Explanation of P/O to the Fiji Government and agreement thereof.

(4) Acquisition of source materials

(5) Confirmation of survey implementation and support systems.

(6) Reconnaissance of survey site.

(7) Drawing of coastlines.

(8) Preparation of PR/R.

(9) Transfer of technology to Fiji counterpart personnel.

5-1-3. Pre-work in Japan (From 13 to 22 January 1995)

5-1-3-1. Collection and study of relevant information and data.

All available information and data were collected and studied to work out a detailed plan of hydrographic surveys to be conducted in the forthcoming Phases.

5-1-3-2. Preparation of P/O.

The P/O was prepared to cover the whole operation and work to be conducted for the Study, products to be resulted from overall period of five years and the implementation plan of the Study in Phase I (First year - F.Y.1994) as well as the undertakings of both the Government of Fiji and JICA.

5-1-4. Work in Fiji (From 23 January to 21 February 1995)

5-1-4-1. Composition of Study Team

The Study Team consisting of the following personnel was despatched to Fiji to carry out the work in line with the objectives as aforementioned:

Leader : Mr. Yasuhiro Oyamada
Member : Mr. Masao Kuga

Mr. Masashi Saito
Adviser : Mr. Hiromi Hamasaki (to February 2)
Mr. Hideo Tanaka (to February 6)
Mr. Mitsuyoshi Kawasaki (to January 29)

5-1-4-2. Diary of work

The diary of the work carried out by the Study Team appears as in Appendix 1-1.

5-1-4-3. Explanation of P/O to Fiji Government and agreement thereof

The P/O was explained to the counterpart organization, Fiji Hydrographic Service, Marine Department of the Ministry of Infrastructure, Public Works and Transport, and discussion followed to reach agreements on the P/O. The Minutes of Meeting (hereinafter referred to as "M/M") was prepared to describe the matters agreed upon, which was then signed by the representatives of both parties on 27 February 1995. The copies of the P/O and the M/M are attached herewith as Appendices 1-2 and 1-3, respectively.

(1) The major amendments made in the original P/O were as follows:

(i) The numbers of Fiji nautical charts to be produced under the Study, and accordingly the numbers of Study areas, were renumbered as follows due to duplication of the existing Fiji charts:

For:	To read:
F2	F52
F6	F53
F7	F54

(ii) As for the instruments to be provided by JICA, the number of both battery charger and AC power conditioner was changed from 3 to 2.

(iii) For drawing of coastlines of the northeastern part of Vanua Levu, topographic maps were also adopted in addition to the existing nautical charts.

(2) It was understood that the titles of the charts be as follows:

Chart No.	Title
F52	FIJI ISLANDS VANUA LEVU-NORTHERN PORTION NATEWA BAY TO NANUKU PASSAGE
F53	FIJI ISLANDS LAU GROUP-NORTHERN PORTION NANUKU PASSAGE TO LAKEBA PASSAGE
F54	FIJI ISLANDS LAU GROUP-SOUTHERN PORTION LAKEBA PASSAGE TO KABARA

5-1-4-4. Selection of equipment

For selection of equipment to be procured by JICA in Fiji, minimum requirements were

set in consultation with FHS. Based on the requirements as well as quotations collected, the selection of equipment was made by the Study Team in collaboration with FHS. The list of equipment thus selected was submitted to JICA through JICA Fiji Office. Appendix 1-4 shows the list of equipment selected.

5-1-4-5. Acquisition of source materials

The source materials and data obtained from FHS, the Department of Lands and Survey (hereinafter referred to as "DLS") and the Department of Mineral Resources are listed as in Appendix 1-5.

5-1-4-6. Confirmation of survey implementation and support equipment and facilities

(1) Survey vessel

R/V TOVUTO, the survey vessel to be used for the Study, was under repair while the Study Team was in Fiji, and the repair was scheduled to be finished by the end of March 1995. Accordingly, the performance test on the echo sounder and other survey and navigation instruments on board was not conducted. It was agreed that FHS would carry out the test upon completion of the repair and duly inform the Study Team of the results.

Apart from this, the survey operation space and data processing rooms and living quarters of the vessel were confirmed satisfactory for execution of the survey.

(2) Suva Tide Station

It was confirmed that, by using a personal computer and the software obtained from NOAA, U.S.A, the tidal data on daily, monthly and yearly bases can be retrieved directly from the tide station for determination of mean sea level and datum level for soundings in the Study.

(3) As for equipment, materials and consumables to be used in the Study work, such as generators, PBC pipes, steel bars, wires, cement, etc., it was found that they would mostly be purchasable at various stores in Suva.

5-1-4-7. Reconnaissance of survey sites

From 7 to 15 February 1995, the Study Team members Messrs. Kuga and Saito accompanied by the counterpart from FHS, Mr. Aca Silatolu, Senior Hydrographer, made a reconnaissance of Vanua Balavu, Rabi and Taveuni to find possibility of establishing a field survey base, tide station and control points for the Phase II work. Their findings were as in the following:

(1) Vanua Balavu

(i) The site for establishing a tide station with a tide gauge was selected as shown in figure 6, and permission thereof was obtained from the local authorities.

(ii) The accommodation facilities for tide observers was confirmed.

(iii) A control point to be used for Phase III work was confirmed.

(2) Rabi

(i) The site for setting a tide pole was selected as shown in figure 7 , and permission thereof was obtained from the local authorities.

(ii) The accommodation for tide observers was confirmed.

(iii) It was found that the known control point existed atop a high, steep and densely wooded hill so that transportation of survey equipment would be very difficult, and that the access to the island would not be convenient due to lack of regular air service. Accordingly, it was considered that a long-term DGPS observation on the island would be not be feasible and a survey base not be established except the accommodation for short stay of tide observers.

(3) Taveuni

(i) The known control points and location of primary shore controls to be used for DGPS observations were confirmed. The coordinates of known control points were obtained from DLS.

(ii) The accommodation facilities for surveyors were confirmed and secured.

(iii) It was considered that DGPS observation would be carried out at Taveuni with establishing a survey base.

(4) Collaboration by FHS counterpart

Mr. Aca Silatolu, the counterpart from FHS participated in the reconnaissance, actively assisted the Study Team in such matters as finding control points, negotiations with local authorities and persons for arranging accommodations, hiring transportation, obtaining permission, etc. and thus contributed greatly to the smooth progress of the reconnaissance.

5-1-4-8. Other matters consulted

With the Chief Hydrographer of FHS and the Master of R/V TOVUTO, consultations were held as to the matters related to Phase II work, including the following items:

(a) Allocation of counterparts from FHS.
(b) Establishment of the headquarters of Study Team at FHS.
(c) Working hours for Study Team on board R/V TOVUTO.
(d) Daily life of Study Team members on board R/V TOVUTO.

The results of the consultations would be incorporated in the P/O for Phase II work.

5-1-5. Post-work in Japan (From 22 February to 30 March 1995)

5-1-5-1. Drawing of coastlines

Utilizing the aerial photographs collected from DLS, coastlines of various islands and atolls in the Study areas F52, F53 and F54 were drawn on transparent plastic sheets on the scale of about 1/50,000, and then reduced to the scale of 1/150,000. They constituted part of

the products resulted from Phase I work.

5-1-5-2. Preparation of PR/R

The PR/R was prepared to describe the progress of the work carried out during the Phase I of the Study, materials and data collected, results of reconnaissance of survey sites, problems encountered and suggestions to the work in Phase II.

5-1-6. Problems encountered and suggestions to the work in Phase II

(1) Survey equipment

(i) Echo sounder

It was found that the performance of Echotrac DF3200 aboard R/V TOVUTO in deep waters would not be satisfactory for the Study. Accordingly, the echo sounder, Bathy-2000P, to be provided by JICA, would principally be used. In such a case, another echo sounder for deep water use would necessarily be provided as a backup.

(ii) Survey vessel

The survey vessel to be used in the Study, R/V TOVUTO, was under repair while the Study Team was in Fiji, so that any performance test was not made as to survey instruments nor navigational equipment on board. It was agreed that FHS would carry out the performance test of the following equipment aboard survey vessel upon completion of the repair, which was scheduled to be towards the end of March 1995, and inform the Study Team of the results:

(a) Radar
(b) Radio
(c) Crane
(d) Other navigational instruments

As for the new equipment to be installed aboard R/V TOVUTO, i.e. echo-sounder Bathy-2000P and autopilot/gyrocompass, the test would also be conducted by FHS when they are installed and inform the Study Team of the results without delay.

(iii) Field tests for new equipment

Prior to the commencement of Phase II work in the survey site, it would be indispensable for the Study Team to carry out, based at Port of Suva for several days, field tests of the newly provided echo-sounder Bathy-2000P and DGPS Sercel NDS 200/NRS 103 on board R/V TOVUTO to find any possible malfunctioning or defect that should immediately be remedied or adjusted to avoid unnecessary delay in the survey site.

(2) Drawing of coastlines

In cases of extensive islands and atolls where tracing of coastlines were made by using aerial photographs along more than two strips, there were found that coastlines or reefs did not exactly coincide each other due to slight differences in photo scales by flight. Also, there were some other cases where due to clouds or halation appearing on the

photograph accurate drawing of features could not be done. In such cases, appropriate location of control points corresponding to photographed features were not feasible in carrying out the control point survey in Phase II and onwards. Therefore, in order to obtain accurate photo scales and correct positions of coastlines, aerial triangulation were performed to determine control points in the sea and other places. As for the areas where topographic features were ambiguous on the picture, a stereo plotting instrument were used to draw coastlines.

(3) Living environment of Study Team members

Study Team members should be well informed of the Fijian customs, traditions and regulations observed and followed at the islands and atolls in the Study area for their working smoothly in the survey site in harmony with the local authorities and people.

5-1-7. Counterpart training in Japan

Counterpart training was conducted in Japan as follows:

Name of counterpart : Mr. Aca Silatolu, Acting Senior Hydrographer, FHS
Period of training : From 20 February to 28 March 1995.
Training conducted by : JICA, Hydrographic Department of Maritime Safety Agency, Aero Asahi Corporation and Asia Aerial Survey Co. Ltd.
Training schedule : As shown in Appendix 1-6.

5-1-8. Impressions

It was noted with great appreciation that the Fiji counterpart organization, FHS, was most cooperative and greatly contributed to the smooth progress of the work. Acknowledgement is also extended to the cooperation of DLS for their smooth provision of necessary aerial photographs, land maps and other data regarding control points.

Although R/V TOVUTO could not go out to the sea this time, the preparedness of her officers and crew were highly commendable.

5-2. SECOND YEAR (PHASE II) (F.Y. 1995)

5-2-1. Period of Study

From 13 June 1995 to 19 March 1996.

5-2-2. Objectives

(1) Preparation of P/O-II.

(2) Explanation of P/O-II to the Fiji Government to reach agreement thereof.
(3) To conduct hydrographic survey in Study Area F52.

(4) To prepare a smooth sheet of survey for production of Fiji Nautical Chart No.F52.

(5) To promote technology transfer to Fiji counterpart personnel.

5-2-3. Pre-work in Japan (From 13 June to 25 July 1995)

5-2-3-1. Preparation of P/O-II

Based on P/O-I and PR/R-I, P/O-II was drawn up, giving a detailed plan of hydrographic survey to be conducted for Study Area F52 as well as of the pre-work and the post-work to be carried out in Japan.

5-2-3-2. Preparations for survey

Necessary instruments and materials for the survey were made available, tested and sent to Fiji by air.

Computer programmes and boat sheets for facilitating field operation of the survey were also prepared.

Orientations to Study Team members were conducted for their acquiring acquaintances not only with closer technical aspects of the Study but also with daily lives, manners and customs in Fiji.

5-2-4. Work in Fiji (From 26 July to 14 October 1995)

5-2-4-1. Composition of Study Team

The Study Team consisting of the following personnel was dispatched to carry out the work in line with the objectives as aforementioned.

Leader : Mr. Yasuhiro Oyamada
Member : Mr. Masao Kuga
Mr. Masashi Saito
Mr. Toshiki Kuroiwa (31 July - 14 October 1995)
Mr. Shuhei Hatake (as above)
Mr. Toshiaki Watanabe (as above)
Mr. Yoshikazu Ogasawara (as above)
Mr. Takashi Yashiro (26 July - 5 August 1995)
Mr. Shinichi Yamaoka (27 September - 14 October 1995)

5-2-4-2. Diary of work

The diary of the work carried out by the Study Team appears as in Annex 2-1.

5-2-4-3. Explanation of P/O-II to Fiji Government and agreement thereof

The Study Team explained P/O-II to FHS, and discussions followed to reach agreements on P/O-II in principle. The Minutes of Meeting was prepared to describe the matters agreed upon, which was then signed by the representatives of both parties on 31 July 1995. The copies of the P/O-II and the Minutes of Meeting are attached herewith as Appendices 2-2 and 2-3, respectively.

5-2-4-4. Installation of equipment on board R/V TOVUTO and test

Survey equipment, such as echo-sounders, GPS receivers, antennas, radio sets, etc. were properly installed on board R/V TOVUTO, and necessary tests were carried out by the time when the survey vessel departed Port of Suva on 7 August 1995.

5-2-4-5. Field work

5-2-4-5-1. General

All the field work was conducted in accordance with the methods, standards and specifications as described in P/O-II.

5-2-4-5-2. Establishment of survey base

A survey base was established close to the shore at Matei, northern coast of Taveuni, on 4 August 1995.

5-2-4-5-3. Control point survey

(1) Primary shore control point

Control point survey by closed DGPS observation to establish a primary shore control point (fixed station) was carried out at three stations, one at the proposed station at the survey base and at two nearby existing triangulation stations, one at a hilltop southward and the other at Korolevu Islet off Somosomo, Taveuni.

At the primary shore control point, DGPS observation for fixing positions of the survey vessel as well as of auxiliary shore control points and others started from 8 August 1995 and continued throughout the period during which the survey vessel was in operation in the survey area.

(2) Lighthouses and auxiliary shore stations

Open DGPS observations were conducted for fixing positions of lighthouses and auxiliary control points and others as follows:

Lighthouses : Qelelevu on 16 August, Wailagilala Island on 23 September and Udu Point on 28 September 1995.
Auxiliary shore control points : 47 points
Beacons : 13 points
Stranded wreck : 1 point

(3) The instrument used was DGPS Trimble 4000SSE.

(4) Duration of observation was as follows:

Primary shore control point/lighthouses : 90 minutes or more
Auxiliary control points and others : 20 minutes or more

5-2-4-5-4. Coastlining

Coastlining was carried out according to the procedure described in para.4-1-2.

5-2-4-5-5. Tidal observation

(1) A tidal observation hut was constructed on the pier of Lomaloma, Vanua Balavu, on 5 August 1995, in which two sets of self-recording tide gauges were housed.

The site of the station is as shown in figure 6.

(2) The following tide gauges were used:
(i) Pressure type tide gauge YEO-KAL Model 610 (digital record)
(ii) Floating type tide gauge model PFT-II (analogue record)

(3) For determination of zero of tide gauges, a tide pole was fixed beside the pier near the hut and a bench mark (BM) was firmly established on a monument on the beach about 150m eastward of the tidal hut and a temporary BM was also established beside the hut. Levelling was carried out between the tide pole and BMs.

(4) A continuous 57-day record was obtained from the tide gauges.

(5) A tide pole was fixed beside a pier at Nuku village, Rabi, on 10 August, and continuous observation of tide either from high water to low water or vice versa were conducted three times during spring tide, i.e. on 10 and 26 August and 26 September 1995.

The site of the tide pole was as shown in figure 7.

5-2-4-5-6. Sounding operation

(1) All sounding operation was conducted by R/V TOVUTO with using the following echo-sounders:

For general use : Bathy-1000
For shallow water use : PDR 601

(2) The periods of sounding operation were as follows;

First half : From 10 August to 7 September 1995.
Second half: From 13 to 27 September 1995.

(3) The sounding distances covered were as follows:

General area : 508km
Passage area : 862km
Around islands and reefs: 1,572km
Shoals reported or found: 185km
Total distance sounded : 3,127km

5-2-4-5-7. Newly found shoal and search for reported shoal

(1) During the course of sounding, the following shoal was revealed to exist:

Position : Lat. 15° 56.4' S, Long. 179° 17.1' W (approx.)
Least depth : 11.5m

Bottom characteristics : Coral and sand

The information on this shoal was channelled on 8 September 1995 to New Zealand Hydrographic Office, responsible hydrographic office for IHO/IOC World-wide Navigational Warning System NAVAREA XIV. It was later named as "Tovuto Shoal" and indicated as such on the smooth sheet of survey and Chart No.F52.

(2) The shoal with a depth of 14.8m reported in 1981 charted in position Lat. 16° 00.0' S, Long. 179° 17.5' W (approx.) was found non-existent as a result of detailed hydrographic survey, the soundings obtained thereabouts ranging from around 500m to 600m.

5-2-4-5-8. Field inspection

Inspection of the field operation for survey methods and instruments on board R/V TOVUTO as well as for the primary shore control point and tide stations, were carried out by the staff members of the Japan Hydrographic Association (JHA) three times as follows:

(1) First time
Inspector : Mr. Motoji Kawanabe, Director, Research Division, JHA
Period : From 7 to 17 August 1995

(2) Second time
Inspector : Mr. Masayoshi Hirao, Deputy Director, Research Division, JHA
Period : From 30 August to 9 September 1995

(3) Third time
Inspector : Same as (2) above.
Period : From 25 September to 5 October 1995

5-2-4-5-9. Meeting for conclusion of field work

On 10 October 1995, a meeting for conclusion of the field work in Phase II was held at FHS, which was attended by the Study Team members, FHS staff and the Master of R/V TOVUTO.

The Minutes of Meeting was prepared and signed by the Leader of Study Team and the Chief Hydrographer of FHS.(Appendix 2-4)

5-2-4-5-10. Dismantling of survey instruments and concluding work

From 5 to 11 October, R/V TOVUTO was dismantled of survey instruments, which were then either packed and returned to Japan with data obtained from the survey or stored in FHS.

5-2-5. Post-work in Japan (From 15 October 1995 to 19 March 1996)

5-2-5-1. Data processing and preparation of manuscript sheets

5-2-5-1-1. Control point survey

The results of control point survey were processed as described in par. 4-1-6-1, and the control point sheet was prepared in accordance with the specifications described in par. 4-1-7-1.

5-2-5-1-2. Coastlining

For those control points with which aerial triangulations were performed, the results were compiled into the final results of aerial triangulation.

The coast line sheet was prepared accordingly with the specifications described in par. 4-1-7-2.

5-2-5-1-3. Tidal observation

For corrections to soundings and heights to be applied in the Study Area F52, the observed values at the Vanua Balavu tide station were corrected for the time and height of tide in comparison with the values obtained from the tide pole at Rabi.

As for MSL and DL for soundings, the reference level determination book including computation method and data was compiled. (cf. par. 4-1-6-3)

5-2-5-1-4. Sounding

The sounding data were processed accordingly with the specifications described in par. 4-1-6-4.

Based on the sounding data thus processed, the sounding sheet and the bathymetric plotting sheet were prepared in accordance with the specifications described in par. 4-1-7-3 and par. 4-1-7-4, respectively.

For the areas where close sounding for searching shoals was conducted which made plotting of all fixed positions impossible, they were shown on two separate sheets on the scale of 1/15,000 each.

5-2-5-2. Preparation of smooth sheet of survey

The smooth sheet of survey was prepared in accordance with the specifications described in par. 4-1-8, with the title of the smooth sheet as follows:

FIJI ISLANDS
VANUA LEVU-NORTHERN PORTION
NATEWA BAY TO NANUKU PASSAGE

5-2-5-3. Preparation of survey report

The progress and results of survey operations were compiled into the report on the hydrographic survey for the Study in Phase II and submitted to the Fiji government together with the final products of the survey as listed in Appendix 2-5.

5-2-5-4. Inspection of smooth sheet of survey

The smooth sheet of survey for Study Area F52 thus prepared was officially inspected by JHA.

5-2-6. Counterpart training in Japan

Counterpart training on survey data processing and preparation of smooth sheet of survey was conducted in Japan as follows:

Name of counterpart : Mr. Philip Ronald Hill, Hydrographer, FHS.
Period of training : From 6 November to 15 December 1995.
Training conducted by : JICA, Hydrographic Department of Maritime Safety Agency, Aero Asahi Corporation and Asia Air Survey Co., Ltd.
Training schedule : As shown in Appendix 1-6.

5-2-7. Problems encountered and suggestions to the future work

5-2-7-1. Survey equipment

(1) During the course of coastline survey, it was often found difficult for R/V TOVUTO to lower or pick up the survey boat or the small boat aboard, and for the survey team to land a reef or a small islet for GPS observation carrying the equipment by overcoming strong wind and rough sea and swell. Accordingly, it was suggested that a small, light aluminium boat would be provided for the sake of safer and faster operation and manoeuvring.

(2) For Vanua Balavu large-scale hydrographic survey to be conducted by FHS in which two Japanese experts would be joining, it would be most desirable that a plotter be provided for data processing at the survey site, so that the same technology as used on board R/V TOVUTO might also be transferred to Fiji survey team members for their effective use of this method to improve their future survey work.

5-2-7-2. Survey schedule

Taking into account the possibility that the Survey Team would sometimes be exposed to rough weather continuing for several days in July-September as experienced during Phase II, it was suggested that the field operation in Phase III should start as early as possible, preferably from early May, to make use of comparatively calm weather in April-June.

5-2-8. Impressions and remarks

Thanks to the whole-hearted cooperation and strenuous efforts of all the personnel concerned, the hydrographic survey in the Study Area F52 was completed successfully to obtain all the necessary data for preparation of the smooth sheet of survey, based on which

Fiji Nautical Chart No.F52 would be compiled.

The experience and knowledge obtained throughout the work in Phase II would effectively be utilized in the work in Phase III, to be focused, in particular, on the technology transfer. For this purpose it was considered most desirable that provision of the equipment suggested in par. 5-2-5-1 above would be materialized.

5-3. THIRD YEAR (PHASE III) (F.Y. 1996)

5-3-1. Period of Study

From 23 April 1996 to 31 March 1997.

5-3-2. Objectives

(1) Preparation of P/O-III.

(2) Explanation of P/O-III to the Fiji Government to reach agreement thereof.

(3) To conduct hydrographic survey in Study Area F53.

(4) To prepare Fiji Nautical Chart No.F52.

(5) To render technology transfer to Fiji counter personnel during the survey and data processing for Study Area F53 as well as during the large-scale survey in Vanua Balavu Lagoon by FHS.

5-3-3. Pre-work in Japan (From 23 April to 7 May 1996)

5-3-3-1. Preparation of P/O-III

Based on P/O-I, P/O-II and PR/R-II, P/O-III was drawn up, giving a detailed plan of hydrographic survey to be conducted for Study Area F53, of the pre-work and post-work to be carried out in Japan, as well as of the preparation of Fiji Nautical Chart No.F52.

5-3-3-2. Preparations for survey

Necessary instruments and materials for the survey were made available, tested and sent to Fiji by air.

Computer programmes and boat sheets for facilitating field operation of the survey were also prepared.

5-3-4. Work in Fiji (From 8 May to 12 October 1996)

5-3-4-1. Composition of Study Team

The Study Team consisting of the following personnel was dispatched to Fiji to carry out the work in line with the objectives as aforementioned:

Leader : Mr. Yasuhiro Oyamada

Member : Mr. Masao Kuga
Mr. Masashi Saito (13 May to 12 October 1996)
Mr. Toshiki Kuroiwa (13 May to 25 June 1996)
Mr. Toshiaki Watanabe (13 May to 12 October 1996)
Mr. Shuhei Hatake (13 May to 9 October 1996)
Mr. Yoshikazu Ogasawara (as above)
Mr. Shinji Iki (13 May to 25 June 1996)
Mr. Kazuhiro Hasegawa (13 May to 9 October 1996)
Mr. Shinichi Yamaoka (6 September to 12 October 1996)

5-3-4-2. Diary of work

The diary of the work carried out by the Study Team appears as in Appendix 3-1.

5-3-4-3. Explanation of P/O-III to Fiji Government and agreement thereof

On 9 and 10 May 1996, the Study Team explained P/O-III to FHS, and discussions followed to reach agreements on P/O-III in principle. The Minutes of Meeting was prepared to describe the matters agreed upon, which was then signed by the representatives of both parties on 13 May 1996. The copies of the P/O-III and the Minutes of Meeting are attached herewith as Appendices 3-2 and 3-3, respectively.

5-3-4-4. Installation of equipment on board R/V TOVUTO and test

Survey equipment, such as echo-sounders, GPS receiver antennas, radio sets, etc. were properly installed on board R/V TOVUTO, and necessary tests were carried out by the time when the survey vessel departed Port of Suva on 23 May 1996, three days later than the scheduled date due to the repair of both of the on-board generators which had been unexpectedly broken down.

5-3-4-5. Field work

5-3-4-5-1. General

All the field work was conducted in accordance with the methods, standards and specifications as described in P/O-III.

5-3-4-5-2. Establishment of survey base

A survey base was established near the pier at Lomaloma village on Vanua Balavu on 20 May 1996.

5-3-4-5-3. Control point survey

(1) Primary shore control point

Control point survey by closed DGPS observation to establish a primary shore control point (fixed station) was carried out at three stations, one at the proposed station at the survey base and at two nearby existing triangulation stations, one at a hilltop westward and the other at Lomaloma.

At the primary shore control point, DGPS observation for fixing positions of the survey

vessel as well as of auxiliary shore control points and others started from 22 May 1996, and continued throughout the period during which the survey vessel was in operation in the survey area.

(2) Auxiliary shore stations

Open DGPS observations were conducted for fixing positions of auxiliary control points and others as follows:

Primary shore control points : 3.
Auxiliary shore control points : 130.
Beacons : 41.

(3) The instruments used were DGPS Trimble 4000SSE.

(4) Duration of observation was as follows:

Primary shore control points : 90 minutes or more.
Auxiliary control pints and others : 20 minutes or more.

5-3-4-5-4. Coastlining

Coastlining was carried out according to the procedure described in par. 4-1-2.

5-3-4-5-5. Tidal observation

(1) A tidal observation hut was built at the same place in the last year on the pier of Lomaloma, Vanua Balavu, on 20 May 1996, in which two sets of self-recording tide gauges were housed.

(2) The following tide gauges were used:

(i) Pressure type tide gauge YEO-KAL Model 610 (digital recording).
(ii) Floating type tide gauge model PFT-II (analogue recording).

(3) A tide pole was erected beside the pier near the hut. The bench marks established last year were both found in good conditions. For determination of the zero of tide gauges, levelling was carried out between the tide pole and the BMs.

(4) A continuous 127-day tidal record was obtained from the tide gauges. These tidal records, together with the tidal record obtained from Suva tide station, were used for confirmation of MSL and DL obtained last year, as well as for tidal reductions to soundings.

5-3-4-5-6. Sounding operation

(1) The vessel used for sounding was R/V TOVUTO of Marine Department, Ministry of Infrastructure, Public Works and Transport. In shallow waters where R/V TOVUTO was unable to enter, SMB BABALE was used for sounding.

(2) For ship's position fixing, the following DGPS receivers were used:

Main : Sercel NDS200/NR103.

Backup : Del Norte 1009/4012.

(3) For sounding operation, the following echo-sounders were used:

R/V TOVUTO : Bathy-2000P or Bathy-1000 in deep waters,
PDR 601 in shallow waters.

SMB BABALE : PDR 601.

(4) For sounding in shallow water areas, the Side-Scan Sonar EG&G Model 260 was concurrently used.

(5) For correction to soundings for underwater sound velocity, bar-checks in shallow waters and STD measurements in other areas were carried out everyday down to the depth of 50m, and in such cases considered necessary, down to the depth of 200m.

(6) The sounding distances covered were as follows:

General area : 1,760km.
Passage area : 803km.
Around islands and reefs : 2,779km.
Shoals reported or found : 677km.
Total distance sounded : 6,019km.

(7) The periods of sounding operation were as follows:

1st voyage : From 27 May to 20 June 1996.
2nd voyage : From 26 June to 6 July and from 15 to 24 July 1996. (R/V TOVUTO returned to Port of Suva for repair of a generator from 8 to 13 July 1996.)
3rd voyage : From 31 July to 17 August 1996.
4th voyage : From 5 to 23 September 1996.

5-3-4-5-7. Newly found shoal and search for reported shoals

(1) During the course of sounding, the following shoal was revealed to exist, which was named as "Cakau-i-Qalitu":

Position : 16° 52.5' S., 178° 43.1' W.
Least depth : 24.7m.
Bottom characteristics : Rock.

(2) The depths of charted banks and shoals were confirmed as follows:

(a) Reported shoal (16° 39.9' S., 178° 37.5' W.).
Charted depth : 33m.
Least depth confirmed : 22.9m.

(b) Jeffreys Bank (16° 51.5' S., 178° 45.5' W.).
Charted depth : 16.4m.
Least depth confirmed : 16.5m.

(c) Alacrity Bank (16° 54.2' S., 178° 39.0' W.).
Charted depth : 22m.
Least depth confirmed : 18.4m.

(d) Lewis Bank (16° 56.2' S., 178° 48.2' W.).
Charted depth : 14.6m.
Least depth confirmed : 11.1m.

(e) Rep.(1980) shoal (16° 59.9' S., 178° 46.8' W.).
Charted depth : 9.1m.
Least depth confirmed : 6.0m.

(f) Trigger Rock (17° 06.3' S., 179° 02.1' W.).
Charted depth : 7.3m.
Least depth confirmed : 7.8m.

(g) Rep.(1967) shoal (17° 08.2' S., 178° 33.3' W.).
Charted depth : 18m.
Least depth confirmed : 16.0m.

(h) Shoal (17° 17.4' S., 178° 42.6' W.).
Charted depth : 16m.
Least depth confirmed : 363m. (The shoal non-existent)

(i) Ma'afu Rock (17° 53.9' S., 178° 56.1' W.).
Charted depth : 5.5m.
Least depth confirmed : 8.8m.

5-3-4-5-8. Field inspection

Inspection of the field operation for survey methods and instruments on board R/V TOVUTO as well as for the primary shore control point and the tide station, were carried out three times by the staff members of JHA as follows:

(1) 1st time
Inspector : Mr. Motoji Kawanabe, Director, Research Division, JHA.
Period : From 30 May to 9 June 1996.

(2) 2nd time
Inspector : Mr. Masayoshi Hirao, Deputy Director, Research Division, JHA.
Period : From 29 July to 8 August 1996.

3) 3rd time
Inspector : Same as (2) above.
Period : From 5 to 15 September 1996.

5-3-4-5-9. Co-operation in technology transfer for Vanua Balavu Lagoon survey by FHS

(1) Period of survey : From 19 May to 19 June 1996.

(2) Scale of survey : 1/50,000.

(3) Japanese experts participated : Mr. Toshiki Kuroiwa and Mr. Shinji Iki.
(4) Survey launch used : Motor launch SCUBA QUEEN hired from 24 May to 22 June 1996.
(5) Instruments used

(i) Position fixing : Trisponder Master (2) and Remote (6).
(ii) Sounding : Dual-channel echo sounder Echotrac DF3200.
Four 4-beam echo sounder PDR 601.
Side Scan Sonar EG&G Model 260.
(iii) Plotter : Graphtec FP9200.

(6) Technology transfer mainly focused on:
(i) Computer-aided guiding of the survey launch along the planned sounding lines, and
(ii) Computer-aided plotting soundings and sounding tracks for preparation of a smooth sheet of survey.

5-3-4-5-10. Meeting for conclusion of field work

On 9 October 1996, a meeting for conclusion of the field work in Phase III was held at FHS, which was attended by the Study Team members, FHS staff and counterpart personnel and the Master of R/V TOVUTO.

The Minutes of Meeting describing items discussed and agreed was prepared and signed by the Leader of Study Team and the Chief Hydrographer of FHS on 9 October 1996. (Appendix 3-4)

5-3-4-5-11. Dismantling of survey instruments and concluding work

From 2 to 3 October 1996, R/V TOVUTO was dismantled of survey instruments, which were then either stored in FHS or packed and returned to Japan with data obtained from the survey.

5-3-5. Post-work in Japan (From 13 October 1996 to 31 March 1997)

5-3-5-1. Data processing and preparation of manuscript sheets

5-3-5-1-1. Control point survey

The results of control point survey were processed as described in par. 4-1-6-1, and the control point sheet was prepared in accordance with the specifications described in par. 4-1-7-1.

5-3-5-1-2. Coastlining

For those control points with which aerial triangulations were performed, the results were compiled into the final results of aerial triangulation.

The coast line sheet was prepared accordingly with the specifications described in par. 4-1-7-2(1)

5-3-5-1-3. Tidal observation

(1) Tidal corrections

Tidal corrections to soundings and heights were applied based on the tidal data observed at the Vanua Balavu tide station.

(2) Confirmation of MSL and DL

The reference level determination book including computation method and data was compiled. As the result, the MSL and DL determined in Phase II were confirmed to be within 0.1m respectively, so that those values used in Phase II were also applied to Phase III Study.

5-3-5-1-4. Sounding

The sounding data were processed accordingly with the specifications described in par. 4-1-6-4.

Based on the sounding data thus processed, the sounding sheet and the bathymetric plotting sheet were prepared in accordance with the specifications described in pars. 4-1-7-3 and 4-1-7-4, respectively.

For the areas where close sounding for searching shoals was conducted which made plotting of all fixed positions impossible, they were shown on separate sheets on the scale of 1/1,000, 1/2,000 or 1/15,000.

5-3-5-2. Preparation of smooth sheet of survey

The smooth sheet of survey was prepared in accordance with the specifications described in par. 4-1-8, with the title of the smooth sheet as follows:

FIJI ISLANDS
LAU GROUP-NORTHERN PORTION
NANUKU PASSAGE TO LAKEBA PASSAGE

5-3-5-3. Preparation of survey report

The progress and results of survey operation were compiled into the report on the hydrographic survey for the Study in Phase III and submitted to the Fiji government together with the final products of the survey as listed in Appendix 3-5.

5-3-5-4. Inspection of smooth sheet of survey

The smooth sheet of survey for Study Area F53 thus prepared was duly inspected by JHA for preparation of Fiji Nautical Chart No.F53.

5-3-5-5. Preparation of Fiji Nautical Chart No.F52

For preparation of Fiji Nautical Chart No.F52, all the work from the planning, compilation and drafting work to make the printing plates of Chart No.F52 were conducted by JHD in which a Fiji counterpart was participating on the OJT basis for 183 days.

5-3-5-5-1. Chart specifications, basic factors and procedures (cf. par. 4-2)

(1) Chart No. : F52.

(2) Title : FIJI ISLANDS
VANUA LEVU-NORTHERN PORTION
NATEWA BAY TO NANUKU PASSAGE

(3) Corner coordinates : 16° 46' 58" S, 15° 55' 00" S
179° 32' 57" E, 179° 04' 30" W

(4) Chart format (Neat line dimensions) : 980.1 × 639.0mm

(5) Scale : 1:150,000 (at Lat.16° 20' S)

(6) Graticules graduated : Parallel of 16° 15' S and Meridians of 180° and 179° 30' W

(7) Chart paper : The same paper as currently used by JHD; size 1,040 × 765mm, weight 140g/m^2

(8) Existing source materials to be adopted : Existing smooth sheets covering the area concerned, Fiji Charts Nos.F50 and F51 and BA Chart No.495 were adopted for the areas other than those where the hydrographic survey was carried out during Phase II of the Study.

5-3-5-5-2. Compilation planning

Compilation planning of Chart No.F52 was conducted from 19 June to 2 July 1996, in which those items of work described in par. 4-2-1 were carried out.

5-3-5-5-3. Preparation of drawing guide

Based on the planning sheet and the planning note prepared, a drawing guide was prepared on the plastic film from 3 July to 9 September 1996, in which those items of work described in par. 4-2-2 were carried out.

5-3-5-5-4. Preparation of chart originals

The chart originals (original drawings) of the black colour plate and magenta colour plate were prepared based on the drawing guide from 10 September to 18 November 1996, in accordance with the procedure described in par. 4-2-3.

5-3-5-5-5. Examination of chart originals

From 19 to 25 November 1996, the contents of the chart originals were examined from the viewpoint of navigational safety and comprehensiveness by users.

5-3-5-5-6. Preparation of block correction

Explanation on possible preparation of block correction of the chart for updating was given to the counterpart from 26 November to 2 December 1996.

5-3-5-5-7. Preparation of printing plates

From 3 December to 11 December, platemaking was processed in accordance with the procedure described in par. 4-2-6.

5-3-5-5-8. Printing of Chart No.F52

Using the printing plates thus prepared by JHD, 200 copies of the Chart No.F52 were printed.

5-3-5-5-9. Inspection of printed Chart No.F52

Each and every 200 copies of the printed Chart No.F52 was duly inspected by JHA.

5-3-5-6. Counterpart training in Japan

Counterpart training were conducted in Japan as follows:

(1) Counterpart training in preparation of nautical chart

Name of counterpart : Mr. Filimoni W. Tirikula, Senior Technical Assistant (Cartography)
Period of training : From 17 June to 16 December 1996.
Training conducted by : JICA, Maritime Safety Agency, Aero Asahi Corporation and Asia Air Survey Co., Ltd.
Training schedule : As shown in Appendix 3-6-1.
Training subjects : As shown in Appendix 3-6-1. The training was mainly conducted at JHD on the whole process of preparation of Fiji Nautical Chart No.F52.

(2) Counterpart training in preparation of smooth sheet of survey

Name of counterpart : Mr. Pio Naboseyawa, Senior Technical Assistant.
Period of training : 11 November to 19 December 1996.
Training conducted by : JICA, Maritime Safety Agency, Aero Asahi Corporation and Asia Air Survey Co., Ltd.
Training schedule : As shown in Appendix 3-6-2.
Training subjects : As shown in Appendix 3-6-2. The training was mainly conducted at Aero Asahi Corporation and Asia Air Survey Co. It was particularly focused on sounding data processing by computer.

5-3-6. Problems encountered and suggestions to the future work

5-3-6-1. Survey vessel

Due to unforeseen problems with the generators on R/V TOVUTO prior to her first voyage to the survey site, as well as in the early part of her second voyage, the period of field work was disrupted by almost two weeks.

Further disruption occurred when R/V TOVUTO had to be directed to transport Fiji Government dignitaries to and from Rotuma island for attendance to certain religious

ceremonies.

Accordingly, the survey had to be rescheduled to accommodate this ten days' disruption resulting in extending the survey period by one week.

These disruptions, however, were well overcome by the efforts of all concerned in acquiring enough data to prepare the smooth sheet of survey and other survey results.

For the survey in the next Phase, it was strongly suggested that the survey ship be given special attention to maintenance such that the survey be progressed with more smoothness.

5-3-6-2. Survey instruments

(1) At the early stage of the survey the main echo-sounder Bathy-2000P became unserviceable and replaced by the backup Bathy-1000 with having no further backup echo-sounder. The Bathy-2000P was then sent to the manufacturer in U.S.A. for repair. It was, however, not repaired on time and the survey was completed using the Bathy-1000.

(2) The reception of Sercel DGPS correction data by the survey ship was sometimes obscured in certain areas due to unknown reasons which required the Study Team to carry out resounding more than expected.

5-3-6-3. Weather

Compared to the Phase II, the weather in the survey area was slightly better so that there were no significant delay in the survey work due to unfavourable sea conditions.

It was suggested, however, that the same condition of allowance as in the last year would also be given to the field work schedule for the next year.

5-3-6-4. Tidal observation

The tide levels at Vanua Balavu were observed during the survey periods of the last two years, finding no significant differences in MSL and DL.

Accordingly, it was suggested that for the Phase IV work a tide station would be established at Lakeba in the Study Area F54 so that more accurate reference levels of tide might be obtained for construction of the chart.

5-3-6-5. Plotter

During the work for the last two years it was found that the plotters brought by the Study Team were very effectively used in preparing survey manuscript sheets and smooth sheets of survey.

Accordingly, it was suggested that a similar plotter would be provided to FHS by JICA to improve and enhance their data processing work in the future.