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THE RECONNAISSANCE SURVEY PROJECT FOR THE ESTABLISHMENT OF AN EMERGENCY REHABILITATION AND RECONSTRUCTION OF THE KINGDOM OF CAMBODIA

FINAL REPORT

MARCH 1999

INFRASTRUCTURE DEVELOPMENT INSTITUTE
PASCO INTERNATIONAL Inc.

Japan International Cooperation Agency
Ministry of Public Works and Transportation

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Preface

In response to a request from the Government of the Kingdom of Cambodia, the Government of Japan decided to conduct the study on the Reconnaissance Survey for the Establishment of an Emergency Rehabilitation and Reconstruction of the Kingdom of Cambodia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Dr. Yoshitake Egawa of Infrastructure Development Institute, consisting of Infrastructure Development Institute and Pasco International Inc., to Cambodia, four times between November 1996 to March 1999.

The Team held discussions with the officials concerned of the Government of the Kingdom of Cambodia, and conducted surveys at the study area. Consequently, the present results were prepared based on these surveys.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I with to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Cambodia for their close cooperation extended to the team.

March 1999

Kimio Fujita

President

Japan International Cooperation Agency

Letter of Transmittal

Mr. Kimio Fujita
President
Japan International Cooperation Agency

March 1999

Dear Sir,

It is a great honour for me to submit herewith the final report of the Reconnaissance Survey Project for the Establishment of an Emergency Rehabilitation and Reconstruction of the Kingdom of Cambodia.

A study team, which consists of Infrastructure Development Institute and Pasco International Co., Ltd. headed by myself, conducted surveys and data analysis based on the terms of references instructed by the Japan International Cooperation Agency (JICA), from November 1996 to March 1999.

The study team held thorough discussions and investigations with officials concerned of the Royal Government of Cambodia.

The results were collected in the final report.

On behalf of the team I wish to express my heartfelt appreciation to the Officials concerned of the Government of the Kingdom of Cambodia for their warm friendship and cooperation extended to us during our stay in Cambodia.

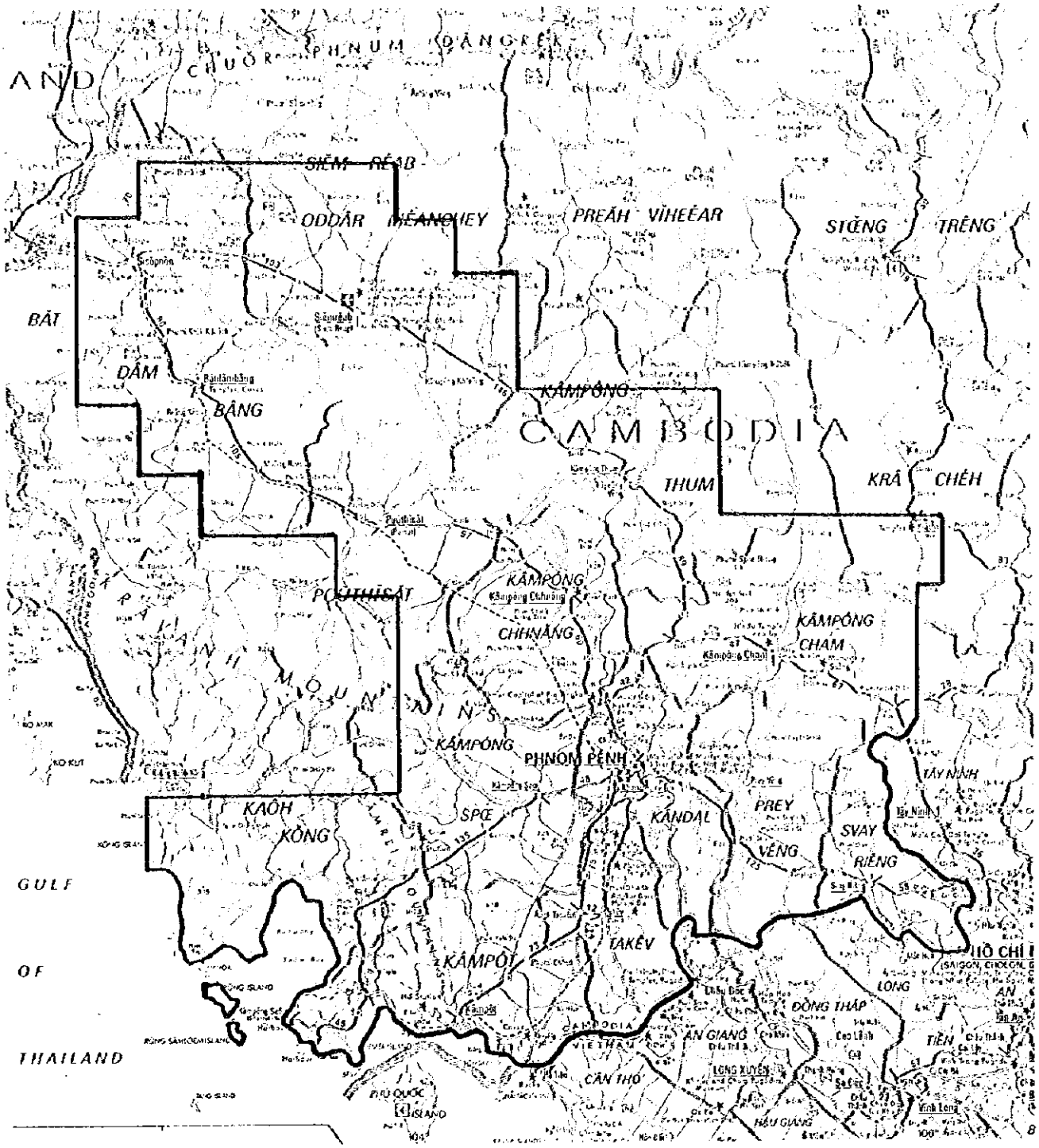
Also, I wish to express my sincere appreciation to JICA, the Ministry of Foreign Affairs, the Ministry of Construction, the Embassy of Japan in Cambodia and other concerned government authorities for their valuable advice and cooperation given to us in the course of the site surveys and preparation of the final report.

Yours Faithfully,

Y. Egawa

Yoshitake Egawa
Team Leader
The Reconnaissance Survey Project
for the Establishment of
an Emergency Rehabilitation
and Reconstruction
of the Kingdom of Cambodia

Study Area


PHNUM DANGREK
SIEM REAB
ODDAR MEANCHEY
PREAH VIHEAR
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BATI
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CAMBODIA
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KANDAL
PREY VENG
SVAY RIENG
TAKEV
KAMPOT
GULF OF THAILAND
DONG THAP
AN GIANG
CAN THO
LONG XUYEN
HAU GIANG
PHU QUOC ISLAND

Executive Summary

1. Study Background

Recovery and reconstruction from the civil war is the most important national issue in the Kingdom of Cambodia. To successfully implement the reconstruction work, it is essential to prepare up-to-date geographic information with uniform accuracy. However, maps that are available in the country are only at a scale of 1/50,000, initially produced in the 1960s by the United States and adjusted by the Vietnamese about 20 years ago. Their commercial availability is also limited. Even worse, the originals of the maps have been lost, and editing, updating, and re-printing work became impossible.

Necessity of updated topographic maps and thematic maps for the government of Cambodia is apparent; however, the government's its own capability is not sufficient to conduct the work of national importance because of organizational weakness resulted from the civil war and due to reduction in the number of technical staff. The government of Cambodia, therefore, requested, in September 1994, a topographic mapping project for rehabilitation and reconstruction of Cambodian land to the government of Japan.

The government of Japan, responded to the request, and dispatched a preliminary-study team to Cambodia in March 1996. The team and the Ministry of Public Works and Transportation (MPWT), a counterpart agency, discussed and negotiated to realize the project. After a thorough discussion, in March 1996, the project's scope was finally agreed, and both parties signed the Scope of Work (S/W).

Infrastructure Development Institute and Pasco International from November 1996 to March 1998 conducted the Reconnaissance Survey Project for the Establishment of an Emergency Rehabilitation and Reconstruction, in accordance with the S/W. The schedule, however, was changed and extended due to the political upheaval in July 1997. In March 1999, the Study was finally completed.

2. Contents of the Study

The study area covers some 80,000 km^2, nearly all of the flat alluvial plain area of the country including its peripheral areas. It includes socially and economically active areas of the country and covers approximately 45% of the total land area of Cambodia.

The Study outputs were provided in prints and in digital format stored in CD-ROM. Final products are:

1) Topographic maps (1/100,000)
2) Land Use Data (1/100,000)
3) Geology/Geomorphology Data (1/500,000)

3. The Basic Policies of Study Implementation

The objective of the Study is to produce basic geographic data. Following policies were set forth in conducting the Study:

1) Satellite images, aerial photographs and existing data and information such as existing topographic maps shall be used as much as possible to eliminate field study because of the security conditions in the area. During data and information collection, safety of team members shall be secure tightly.

2) The Study area is large, but the cost of the work and the work period shall be minimized as much as possible.

3) In order to achieve the policies in 1) and 2), a data acquisition method using satellite images, which is first to be employed in the mapping industry, shall be used. The latest computer technology shall also be utilized in data processing.

4) To ensure data quality, existing aerial photographs and existing topographic maps shall be used.

5) To enhance capability of the government in mapping projects, technology transfer shall be undertaken.

6) The Study Team shall maintain close relationship with the counterpart agency, and both sides shall exchange information and resolve issues during the course of the Study.

4. Study Implementation

The study period was extended for one year, because of the political upheaval. Besides the extension, the Study was conducted in accordance with the policies set forth. The policy of no-field study usually affects the quality of work negatively; however, with assistance from the local technical staff, who was familiar with the field conditions, the quality was ensured. And at the same time, the objective of technology transfer was achieved as the staff was exposed more to opportunities of conducting the work.

5. Utilization of the Output

The output of the Study could be utilized as base data in using Geographical Information Systems (GIS). MPWT has already started using the output in applying GIS for "Agricultural Land Allocation to Former Pol Pot Soldiers" and "Analysis of Road Alignment Study of Route 5". These trials have proved potential of future development of GIS using the output.

6. Information Dissemination

A seminar titled "Exhibition on the Fist Full-Scale GIS Database in Cambodia" was held to facilitate technology transfer and information dissemination. To ensure that the results of the study be fully utilized, they should be widely disseminated to the relevant agencies in Cambodia.

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1. Introduction

In accordance with the Paris Peace Accord of 1991, general elections were held in Cambodia in 1991 under the supervision of the United Nations Transitional Authority in Cambodia to mark the birth of the new Kingdom of Cambodia. The present priorities of the Cambodian Government's policy are reconstruction of economy, the rebuilding of social and economic infrastructure, such as for transportation, power supply, agriculture, and so on, which were destroyed in the prolonged instability, and providing stable livelihood for 370,000 refugees who have returned home.

To successfully implement the reconstruction work, it is essential to prepare up-to-date geographic information with uniform accuracy. But such geographic information is not available now in Cambodia since topographic, land use, geology/geomorphology maps and other necessary geographic data have never been updated or generated to date. Because of this reason, the government of Cambodian decided to acquire the latest geographic data with the assistance from the Japanese Government.

In response to the request of the Royal Government of Cambodia, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programs of Japan, under took the preliminary study to identify conditions and discussed realization of a technical cooperation study with concerned agencies of the Cambodian government. The Government of Japan decided to conduct the Reconnaissance Survey Project for the Establishment of an Emergency Rehabilitation and Reconstruction (hereinafter referred to as "the Study") as a Japan's Overseas Technical Cooperation Program.

The Ministry of Public Works and Transportation (hereinafter referred to as "MPWT") has served as a counterpart agency and appointed the Cambodia National Mekong Committee (CMNC) as the coordinating body for smooth implementation of the Study.

The objective of the Study is to create topographic maps and land use maps at a scale of 1:100,000 and geology/geomorphology maps at a scale of 1:500,000 along with digital database for establishing a geographic information system. The study area covers some 80,000 km^2, nearly all of the flat alluvial plain area of the country including Phnom Penh. The geographical information generated under the Study covers approximately 45% of the total land area of Cambodia (181,000 km^2).

The Study was commenced in November 1996 and was scheduled to be completed in two years. However, because of the political upheaval in 1997, the Study period was extended for one year, and completed in March 1999.

2. Outline of the Study

2.1 Specifications of the Study

The specification of the Study is shown in Table 1.

Table 1 Basic Specifications

Item	Description
Products	
Topographic mapping	Scale - 1:100,000 Printed maps:36 map sheets in 4 colors 2,000 copies each map sheet (English 1,500 and Khmer 500) Topographic digital data files (CD-ROM) 1 Master File 100 copies
Landuse mapping:	Scale - 1:100,000 Printed maps: Multi-colors; about 36 map sheets 20 copies each map sheet Land use digital data files (CD-ROM) 1 Master File 100 copies
Surface geology/geomorphology mapping:	Scale - 1:500,000 Printed maps: Multi-colors; about 4 map sheets 20 copies each map sheet Surface geology/geomorphology digital data files: 1 Master File 100 copies
Map symbols	To be agreed with Cambodia
Mapping standards	Reference ellipsoid : Everest 1830 Projection: UTM Neat lines: 30'x30' Contour lines: 40m principal contour lines;
Inspection	The final results to be inspected by JICA.
Special	The following notations to be printed notations in the margin of each map sheet. "This map was prepared by the Japan International Cooperation Agency (JICA) under the Japanese Government Technical Cooperation Program and the Government of Cambodia." "This map was compiled to meet the urgent need for recovery of Cambodia based SPOT imagery without field survey."

2.2 Outline of the Study

The flow of the Study is shown in Figure 1.

2.2.1 Topographic Mapping

New satellite imagery, which covered large areas, was used. The digital photogrammetry method using analytical plotters was used instead of the conventional analogue method. The production process followed: auto-spatial triangulation, preparation of digital terrain model, auto-extraction of topographic contour lines, production of ortho-imagery, and editing ground features. For security reasons, the aerial photograph interpretation replaced the general process of field verification.

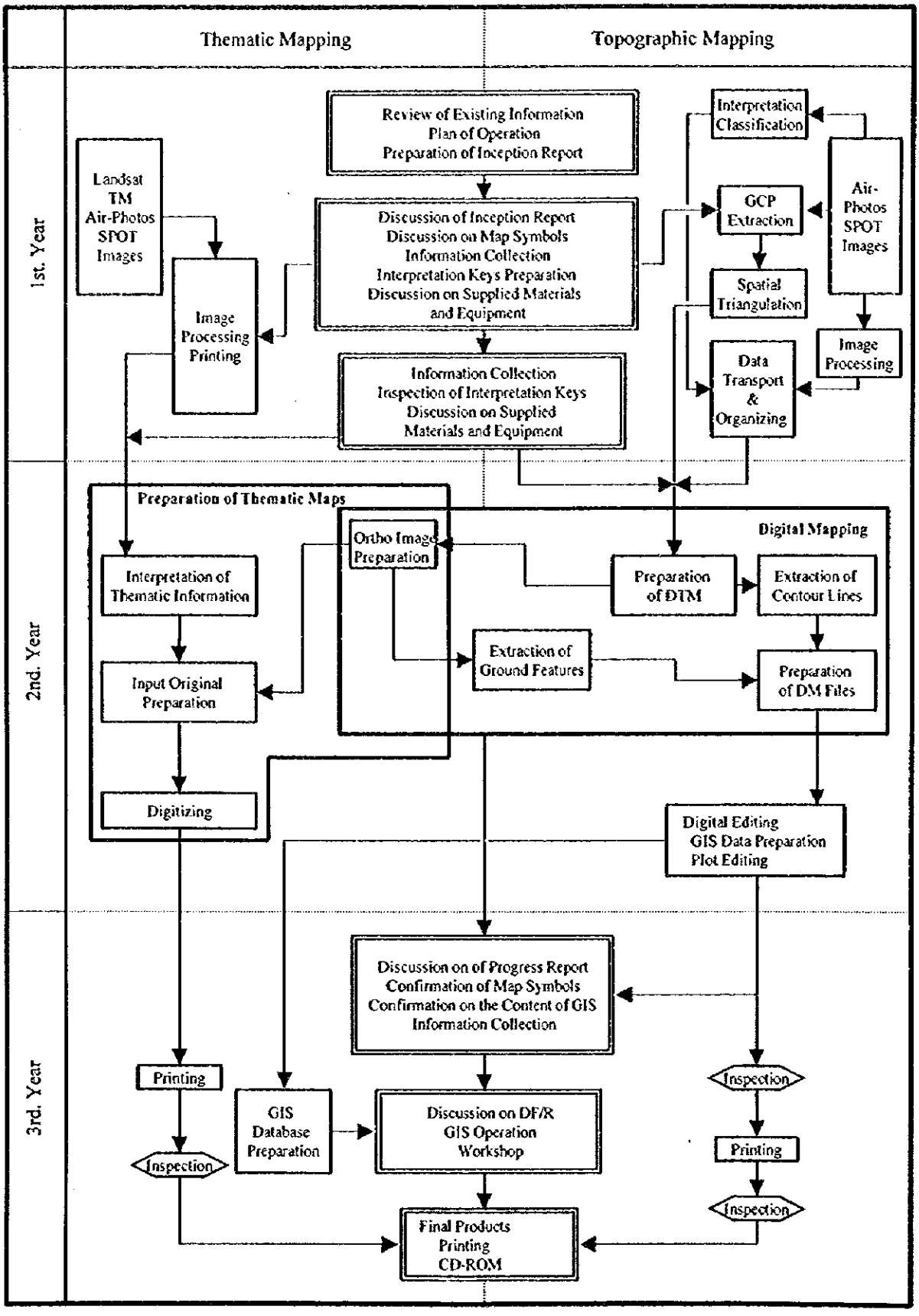
2.2.2 Thematic Mapping

As in the topographic mapping, land use maps (1/100,000) and geology/geomorphology maps (1/500,000) needed to be produced in a large area within a limited period, satellite remote sensing imagery was used. Ortho-images produced from SPOT technology were used as the base maps. Prints of TM Landsat imagery were interpreted to identify vegetation and other land use. To enhance accuracy of the interpretation, existing aerial photographs were also interpreted.

2.2.3 Database for Geographic Information System (GIS)

The data obtained under the study were systematically organized into database to manage the data comprehensively. Therefore, all the topographic and thematic data were stored in Arc/Info compatible format and structure.

Figure 1 Study Flow Chart



2.3 Study Team

Only limited field verification was conducted under the Study, because of the limited time of the Study and security consideration. Therefore, satellite imagery and existing information including aerial photographs were used as much as possible to complement the limited fieldwork. Qualified engineers with expertise in the respective fields of sophisticated technologies were involved. For those parts implemented in Japan, consideration was given that engineers who are familiar with the status of the Study in Cambodia should be assigned. The members of the Study Team are shown as follows:

Team Leader:	Dr. Yoshitake EGAWA
Deputy Team Leader:	Mr. Takeshi HIRAI
	Mr. Yoshiaki OTOKU
Mapping Planner:	Mr. Tetsuro IMAKIIRE
	Mr. Hiroyuki MATSUDA
Topo-Mapping, Chief Engineer:	Mr. Fujio ITO
Land Use Mapping:	Mr. Awadh Kishor SAH
Geology/Geomorphology:	Mr. Eiichi HAYAKAWA
	Mr. Hideaki UMEDA
GIS Planner:	Mr. Reese W. PLEWS
	Mr. Myo THANT
Database Engineer:	Mr. Kazushi ENDO

2.4 Concerned Agencies

2.4.1 Counterpart Agency

Despite the fact that detailed and precise information was necessary, the field verification could not be conducted. Although major sources of information were satellite images and aerial photographs, intensive search of existing information was necessary more than the cases in the ordinary topographic mapping projects. For this reason, good relationship with the counterpart agency, which coordinated search of information store in other agencies, and negotiated uses of information, was important. It was meaningful that the Study Team maintained good relationship with the counterpart agency not only on search of existing information but also other tasks involved in conducting the Study during the whole study period.

2.4.2 Other Agencies

Cooperative relationships established with other agencies were meaningful. The National Geography Department cooperated in the demarcation of boundaries, location of settlements, toponomy and other information. The Ministry of Agriculture provided staff for interpretation of land use. The Geology Department assigned geologist to conduct the interpretation of geology/geomorphology. Other agencies concerned with irrigation,

flooding, river control, and forest management/conservation have been contacted for information.

2.4.3 Training in Japan

Personnel of the counterpart agency have attended training courses in Japan as part of the technology transfer under the Study. They learned the skills involved in each process of from creating and managing geographic data.

The following engineers participated in the training:

Mr. Nuon Kunthea

Technical background :	GIS
Duration:	17 Mar ~ 15 May '97
Training content:	Digital Mapping and GIS

Mr. Khum Ponnaban

Technical background:	Geodesy and Photogrammetry
Duration:	14 Oct ~ 9 Dec '97
Training content:	Digital Mapping, compilation and GIS

Dr. Khun Sokha

Technical background:	Project coordinator, Hydrology
Duration:	18 Jan ~ 17 Feb '98
Training content:	Digital Mapping, compilation and GIS

2.4.4 Training in Cambodia

Throughout the Study period, the Study Team conducted on the job training (OJT) in the following areas:

Aerial photo and satellite image interpretation;
GIS data structuring;
Map annotations and toponomy;
Map editing and formatting;
Map Digitizing

The participants of the OJT were as follows:

Name	Field of Study
KHUN Sokha	ANPC
TENG Peng Seang	GIS Application
MAO Phannarith	Mapping
SAN Sophat	Mapping
MENG Sakheara	Geology
BIN Yoy	Geology
SOUS Samouth	Geology
NUON Chamnes	Geology
MAK Sophearktra	Geology
Oey David T.	Assistant of Dr Heng Thung
PHOK Monica	Archiology

2.4.5 Organizing Workshop

As part of the technology transfer, a workshop was held when the draft final report was presented to the counterpart agency. Contents of the workshop were carefully planned and organized so that engineers of the counterpart agency and other agencies who are not directly involved in the Study could benefit from the seminar. The total number of participants including GIS users in other agencies reached seventy.

3. Detail of the Study

3.1 First Year

3.1.1 Preliminary Study

(1) Preparation of the Work Plan

1) Preliminary Work

The detailed work plan was prepared after studying and evaluating work methods. The plan included:

- Basic policy for the Study;
- Study methodology;
- Work processes;
- Undertakings by the counterpart government; and
- Map symbol designing.

2) Preparation of the Inception Report

The Inception Report, which explains the work plan and organization of the Study, was prepared. The report was reviewed by MPWT and modified based on its comments.

3.1.2 Acquisition of SPOT Data

SPOT 3 data was acquired based on red programming as required for this project. However, the SPOT 3 broke down in November 1996. Therefore SPOT 1 and SPOT 2 images were used to recover missing frames. 48 stereo pairs were acquired with the following specifications:

- Red programming
- Three attempts
- Less than 10% cloud cover in each scene
- Overlap (between scenes): 10%
- B/H ratio: 0.7

3.1.3 Acquisition Aerial Photography

Existing 1:25,000 aerial photographs were obtained through the assistance coordination of MPWT for the photo-interpretation.

Figure 2 SPOT Imagery Index Map

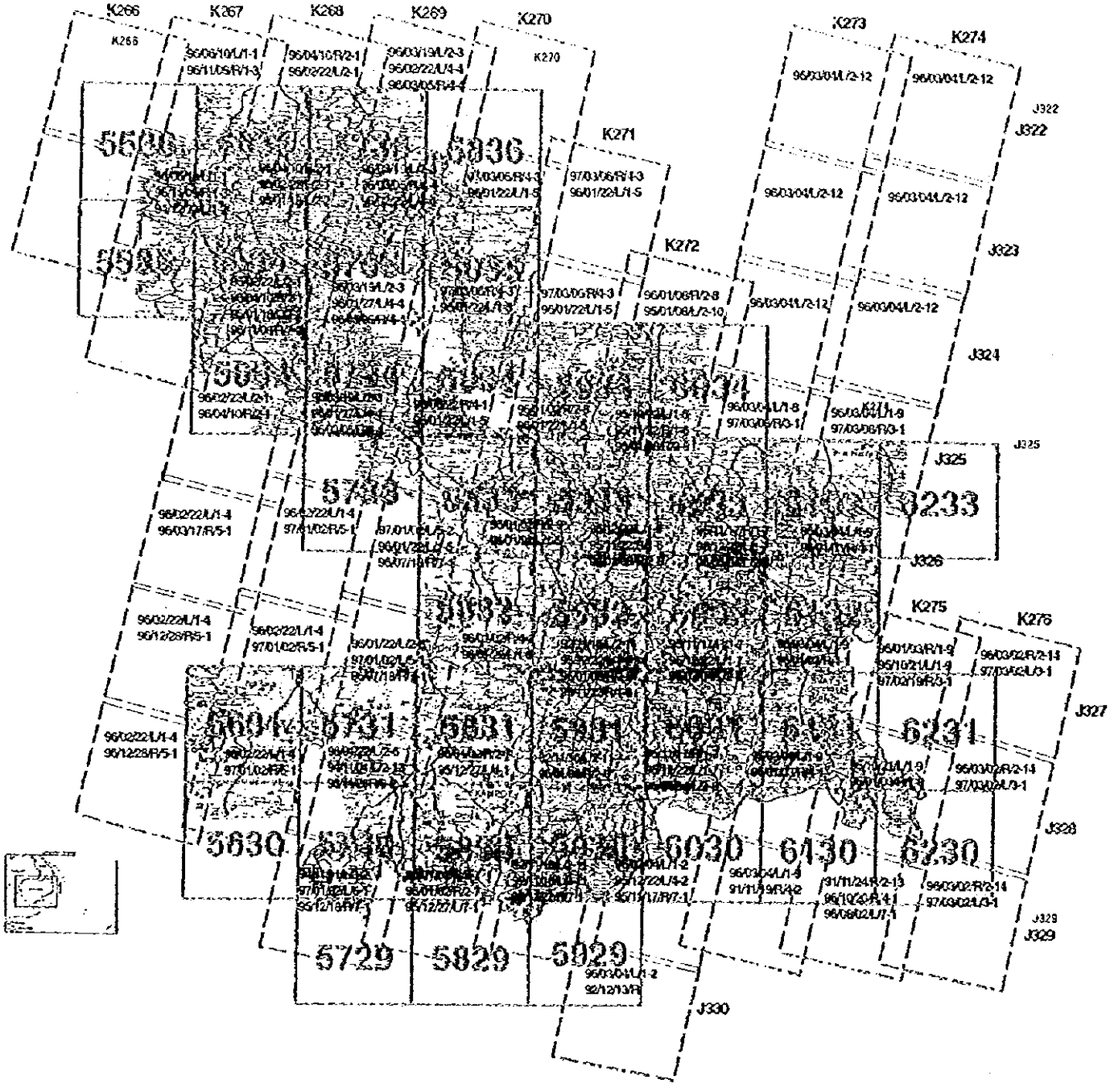


Table 2 Spot Image Data List

	K	J	Date		K	J	Date		K	J	Date
1	267	322	1996/6/10	44	270	325	1996/6/22	87	273	324	1996/3/4
2	267	322	1996/11/9	45	270	325	1996/1/22	88	273	325	1996/3/4
3	267	323	1996/6/10	46	270	326	1997/1/2	89	273	325	1997/3/8
4	267	323	1996/11/9	47	270	326	1996/1/22	90	273	326	1995/11/17
5	267	323	1994/12/23	48	270	327	1996/1/22	91	273	326	1995/12/22
6	268	322	1996/4/10	49	270	327	1997/1/2	92	273	326	1996/3/4
7	268	322	1996/2/22	50	270	328	1996/1/22	93	273	327	1995/11/17
8	268	323	1996/4/10	51	270	328	1994/11/1	94	273	327	1995/12/22
9	268	323	1996/2/22	52	270	328	1993/11/26	95	273	327	1996/3/4
10	268	323	1995/1/18	53	270	329	1994/11/1	96	273	328	1995/11/17
11	268	324	1996/2/22	54	270	329	1994/1/2	97	273	328	1995/12/22
12	268	324	1996/4/10	55	271	323	1997/3/6	98	273	328	1996/3/4
13	268	324	1995/1/18	56	271	323	1996/1/22	99	273	329	1996/3/4
14	268	325	1996/2/22	57	271	324	1997/3/6	100	273	329	1995/12/22
15	268	325	1996/4/10	58	271	324	1996/1/22	101	273	330	1996/3/4
16	268	326	1996/2/22	59	271	325	1996/1/2	102	273	330	1992/12/13
17	268	326	1996/3/17	60	271	325	1996/1/22	103	274	322	1996/3/4
18	268	327	1996/2/22	61	271	326	1996/1/2	104	274	323	1996/3/4
19	268	327	1996/12/28	62	271	326	1996/1/22	105	274	324	1996/3/4
20	268	328	1996/2/22	63	271	327	1996/1/2	106	274	325	1996/3/4
21	268	328	1996/12/28	64	271	327	1996/1/22	107	274	325	1997/3/8
22	269	322	1996/3/19	65	271	328	1996/1/2	108	274	326	1996/3/4
23	269	322	1996/2/22	66	271	328	1995/12/27	109	274	326	1996/1/3
24	269	322	1996/3/5	67	271	329	1996/1/2	110	274	327	1996/3/4
25	269	323	1996/3/19	68	271	329	1996/1/2	111	274	327	1996/1/3
26	269	323	1996/3/5	69	272	324	1996/1/8	112	274	328	1996/3/4
27	269	323	1996/2/22	70	272	324	1995/1/8	113	274	328	1996/1/3
28	269	324	1996/3/19	71	272	325	1995/12/22	114	274	329	1996/3/4
29	269	324	1996/1/27	72	272	325	1995/11/22	115	274	329	1991/11/19
30	269	324	1996/3/5	73	272	325	1996/1/8	116	275	327	1996/1/3
31	269	325	1996/3/19	74	272	326	1995/12/22	117	275	327	1995/10/21
32	269	325	1996/1/27	75	272	326	1995/11/22	118	275	327	1997/2/19
33	269	325	1996/3/5	76	272	326	1996/1/8	119	275	328	1995/10/21
34	269	326	1996/2/22	77	272	327	1992/11/16	120	275	328	1996/1/3
35	269	326	1997/1/2	78	272	327	1995/12/22	121	275	329	1991/11/24
36	269	327	1996/2/22	79	272	327	1996/1/8	122	275	329	1996/10/20
37	269	327	1997/1/2	80	272	327	1995/11/22	123	276	327	1996/3/2
38	269	328	1996/2/22	81	272	328	1992/11/16	124	276	327	1997/3/2
39	269	328	1997/1/2	82	272	328	1996/1/8	125	276	328	1996/3/2
40	270	323	1997/3/6	83	272	329	1992/11/16	126	276	328	1997/3/2
41	270	323	1996/1/22	84	272	329	1992/11/16	127	276	329	1996/3/2
42	270	324	1997/3/6	85	273	322	1996/3/4	128	276	329	1997/3/2
43	270	324	1996/1/22	86	273	323	1996/3/4				

3.1.4 Preparation of SPOT Images

The aerial photographs were interpreted to extract ground features to produce topographic maps. In order to transfer and organize the results, SPOT images were printed directly on high quality paper at a scale of about 1:75,000.

3.1.5 Production of Landsat Imagery

The Landsat TM data were rectified by means of a digital image processing, and false color composite images were produced. A total of 7 full scenes and 4 sub-scenes imagery data needed to be supplied to cover the whole study area. Those data were acquired and controlled by the receiving station in Bangkok, Thailand.

Table 3 Landsat TM Data List

S.No.	Path-Row	Required Quadrant	Acquired Date
1	128-050	4	24 Dec 95
2	127-050	All	18 Jan. 96
3	128-051	2	06 Nov. 95
4	127-051	All	18 Jan. 96
5	126-051	All	27 Jan. 96
6	125-051	3	05 Feb. 96
7	127-052	All	22 Mar. 96
8	126-052	All	26 Dec. 95
9	125-052	All	21 Feb. 96
10	127-053	2	31Jan. 95
11	126-053	All	26 Dec. 95

The combination of red, green and blue bands of the Landsat TM sensor (Bands 4, 3, and 1 or 5, 4 and 1) was considered the most appropriate for interpreting the vegetation coverage in the humid tropical lands in the Study area. Therefore, the spectral bands were used for land use and geology/geomorphology interpretation. The color composite negatives were produced at a scale of 1:100,000.

3.1.6 Interpretation for Topographic Map

Interpretation and classification was performed in as much as possible on the satellite imagery. The high resolution aerial photographs of 1:25,000 scale, existing topographic maps and other materials were used to verify the satellite interpretation in order to minimize the field verification. Some field works were conducted only to gather reference keys for interpretation. Roads, missing parts of waterways, villages, and small features (schools, temples, etc.) were identified and classified on the aerial photographs by referring to the keys and using reflective mirror stereoscopes and outlined on the photos with a drawing pen. The items interpreted and classified above were used to correct the data on the enlarged photos of SPOT images (scale: 1:75,000). They were represented in accordance with the rules of map symbol application.

The main items interpreted were:

- Public facilities (government buildings, schools, temples, public organizations)
- Roads
- Vegetation
- Water bodies and streams

3.1.7 Collection and Updating of Existing Information

The existing data for topographic map were provided by the following government agencies concerned.

Village data:	Land Use Mapping Office in Ministry of Agriculture
Drainage and irrigation data:	Land Use Mapping Office in Ministry of Agriculture
Road network and other infrastructure data:	MPWT
Geographical names:	National Geographic Department
Administrative boundaries:	National Geographic Department
Existing geodetic control points:	National Geographic Department

Those original data were updated using aerial photos and satellite imagery, and some were further checked in the field.

3.2 Second Year

3.2.1 Production of Topographic Maps

(1) Major instrument used

Hardware:	Lica-Helva DPW
Software:	Socet Set Ver. 3.2.0
	V3D/Arc Info

(2) Space block triangulation

About 170 ground control points (GCPs) were selected from existing topographic maps (1/50,000). The tie-points were automatically selected using the SOCET SET software. The space block triangulation was conducted using the data. The optimum values of the parameters relating to each image, segment, data strip, etc. are computed by Gauss-Newton type algorithm. The accuracy of the space block triangulation was set in accordance with the three classes reported by European Organization for Experimental Photogrammetric Research (OEEPE) after thorough discussion with the MPWT.

The following table shows the residual error on the control point survey.

Table 4 Class of GCP Residuals

Class	Planimetric residuals	Elevation residuals
I	10m or less	Approx. 6m
II	approx. 15m	Approx. 8m
III	approx. 20m	Approx. 10m

As a result of considering the POT resolution, Class II was proposed for this Study. As soon as full stereo coverage was available, the different stereo models were set by setting the coordinates of specific GCPs (model-setting points) which were picked from the existing topographic maps. Accordingly, planimetric and elevation accuracy were depended on the accuracy of the existing topographic maps.

The following table shows the residual error on the control point survey.

Table 5 Root Mean Squires on Selected GCPs

	RMS (m)
X	21.22
Y	20.11
Z	4.94

· Number of control points :170

The above result lied within the required tolerance, and the control points were good enough to be applied for this study.

(3) Generation of Digital Terrain Models

In order to capture terrain data, automatic measurement of elevations was conducted using stereo matching technology applying the theory of image relativity based on both right and left images. The results of the previous space triangulation were applied to all stereo-pairs. All images covering the whole study area were rectified by pair-wise, and DTM was generated from each stereo-pair of SPOT scenes in 20 m grid resolution. Those DTMs serve as basic models for automatic delineation of contour lines. As the quality of ortho images depend on the quality of DTMs, the work was carried out carefully.

(4) Generation of SPOT ortho-images

Based the DTMs, the SPOT ortho-images were produced to serve as basic images for thematic mapping. The ground sample distance of the ortho images was 10 meters.

(5) Preparation of Map Symbols and Application Rules

The map symbols and the application rules were determined and prepared jointly with MPWT as agreed in February 1997.

(6) Extraction of contour lines and spot heights

Using DTMs as basic data, contour lines were generated automatically based on TIN (Triangle Irregular Network) models, superimposed on three dimensional images and edited using an interactive computer through visually confirming terrain features. As the Study area includes flat land area, 20m contour lines were drafted. At the same time, 10m-contour lines for the flat area were also added referring to existing 1:50,000 topographic maps.

The elevation data were prepared using the DTM images at locations of road intersections, depression/mound, and other locations that represented the areas' elevations.

(7) Extraction of linear and ground features

Linear features were extracted from the ortho-images for the respective layers in accordance with the map symbol application rules using software for vector-extraction from raster images. Layers were prepared for point, line and polygon data in accordance with geographic features. By interpreting geographic features on screen, the interpreter extracted geographic features by tracing them on-screen. The aerial photographs and results of interpretation were also reviewed in this process.

The vector data were then converted to the ARC/INFO format, since ARC/INFO was to be used to create geographic information under the subsequent work.

Table 6 Number of Layers by Features by Topology

(unit: layer)

	Point	Line	Polygon
Road and Related Road Data	7	9	0
Buildings and Populated Places	16	0	8
Water and Water Related Features	9	9	6
Topography	2	3	3
Control Points	4	0	0
Contours	0	5	0
Boundaries	0	4	0
Vegetation	0	0	15

(8) Vegetation Information

Vegetation boundaries were re-classed based on the land use classification of the topographic maps. Boundaries were modified to adjust differences in satellite data.

(9) Data Conversion

The GIS is used to store and manage the topographic map data. The various data layers were selected from the database and each specific feature type was then exported to a common file format which can be read by Desk Top Publishing (DTP) software. These features were selected using the attribute codes which have been associated to each group of features in the GIS. A series of commands to control the selection procedure, drawing and saving of the data was programmed for the GIS. Approximately 100 individual files were created for each map sheet.

(10) Map Editing Preparation

The layers created under the data conversion process were transferred to Macintosh and PC environments in which the DTP software operates. The individual layers, output from the GIS, have been merged into one single drawing to facilitate editing within the DTP software.

(11) Symbols and Coloring

The data layers converted from the GIS were displayed in the DTP software simply as raw lines, points or text strings. The layers were then edited to add colors and line symbols to match the feature types.

(12) Text Annotation

The GIS also stores annotation data for many features such as lakes, rivers, mountains and village names. The amount of data became quite large, since the data was based on the information from 1/50,000 topographic maps. The annotation strings were stored in the form of individual points. The annotation strings in Khmer were provided by the counterpart agency in the compatible format. By installing Khmer fonts to the DTP system, the annotation texts in Khmer were produced.

(13) Graticules

Graticule and grid information for each map sheet was created using specific map projection and graticule commands within the GIS. Both a UTM grid and latitude/longitude references were used.

3.2.2 Production of Thematic Maps

(1) Major Instrument Used

Hardware:	Sun SS Workstation
Software:	Erdas Imaging Version 8.3
	Arc/Info Version 7.1

(2) Land Use

As shown in Table 7, land use types were categorized into 40 classes.

In order to create land use data at a scale of 1:100,000, the manual interpretation of Landsat TM satellite imagery has been conducted. In addition, aerial photographs were interpreted, and some field survey was conducted to prepare interpretation keys.

1) Creation of Landsat TM imagery at a scale of 1:100,000.
2) Establishment of Interpretation Keys.
3) Interpretation/Classification into Land Use Classes.

1) Creation of Landsat TM imagery (scale 1:100,000)

Altogether 11 Landsat TM scenes (7 full and 4 quarter) covering the full study area have been acquired in digital form. All scenes have been processed first for geometric correction. After that, applying necessary enhancement, color composite of the imageries have been created at a scale of 1:100,000 from the bands 4, 5, 3 (as R, G, B).

2) Establishment of Interpretation Keys:

Prior to the interpretation of TM imagery, the interpretation keys for the proposed classes have been established by considering their color, texture, pattern, shape, and so on. For this, field surveys have been also carried out at two occasions. Besides these, aerial photographs have been also used as supplementary information.

3) Interpretation for land use classes:

The interpretation of TM imagery has been carried out for all the proposed land use classes. While interpreting, some of land use classes were modified as shown in Table 7. It has been difficult distinguishing the class no. 40 as Barren lands (B) and class no. 43 as Others (Bare soil, areas after mining, etc.) (Bo). Thus, both classes were to be merged into one naming as Barren land (B).

Four Settlement classes; as Built-up area, and Village level I, II, and III, have been delineated as polygon data for topographic map out of which the village level II and village level III have majority of area under other land use than settlement. Considering this, the Cities/Towns and Villages classes of Land use should be combined into one naming as settlement (U). This new class then includes the Built-up, and Village level I area so delineated for topographic map.

Similarly, in order to incorporate only those infrastructures that have been expressed as polygon, the class no. 3 and 4 belonging to infrastructures in Land use mapping has been merged to one naming simply as infrastructure (I) under the main category of Urban, Built-up Areas. This class includes the specific type of infrastructures such as playground, airfield, cemetery that could be delineated as polygons.

Thus along with the above modifications, the total number of earlier proposed 43 land use mapping classes has became as 40.

For land use mapping, only the river and ocean (class 37) that could be delineated as polygons have been taken into consideration. This has been adopted from topographic map to increase the fineness of feature boundary. The interpreted result of all other classes, which derived from Landsat TM imagery, has been kept as such.

(3) Conceptual Criteria Set for Modified 40 Land Use Classes for Cambodia Project (Map Scale 1:100,000)

Urban Built-up Areas: These refer to areas with settlements and specific type of infrastructures:

1) Settlement (U): This includes the densely inhabited permanent settlements such as towns and villages. In general, these areas have too little space for agricultural activity.

2) Infrastructure (I): This includes specific infrastructures such as airfield, playground, cemetery etc. that could be delineated as polygon at this scale.

Agricultural Lands: These refer to lands used for agricultural purposes.

3) Paddy field (Ar): This refers to the land permanently used for rice cultivation. Most of paddy fields occur in flat low lying areas, such as on the plain or in the delta of basin. However, some of them can also be found at the valley bottom of hill where rice is cultivated along the streams in small plots.

4) Receding and Floating rice fields (Af): These are mainly found in flood plain, especially along the Tonle Sap Lake (a Khmer traditional rice cultivation around the Great Lake) and major rivers

5) Field crop (Au): It refers to agricultural land typically occurring above the seasonally inundated (during monsoon) area, from plain to high terrace area. Crops in this category are generally other than paddy and may include corn, beans, tobacco and sugarcane.

6) Swidden agriculture (Slash and burn) (As): It refers to area where the forest or other vegetation cover has been cut and burnt for temporary agricultural cultivation. Thus, in general, this zone occurs in between agricultural and forest/shrub lands, with more likely adjacent to the latter in the region of high terrace to hill and mountain. Cultivation activity is recognizable, because these lands are typically used for few years and afterwards, the plot will remain fallow, allowing for growth of secondary vegetation, until next rotation begins. Crops in such area may include hill rice, cassava and beans.

Table 7 Legend for Land Use Map of Cambodia (Scale 1/100,000)

Previous 43 LU Legend		Modified 40 LU Legend	
S. N. Code	*Class Name*	*S. N. Code*	*Class Name*
Urban, Built-up Areas:		**Urban, Built-up Areas:**	
1 U	Cities, towns	1 U	Settlement
2 V	Villages	2 I	Infrastructure (Airfield, Playground, Cemetery, etc.)
Infrastructures:		**Infrastructures:**	
3 Ip	Airfields, harbors		
4 Io	Other (Playgrounds, stations, schools, etc.)		
Agricultural lands:		**Agricultural lands:**	
5 Ar	Paddy field	3 Ar	Paddy field
6 Al	Receding and Floating rice fields	4 Al	Receding and Floating rice fields
7 Au	Field crop	5 Au	Field crop
8 As	Swidden agriculture (Slash and burn)	6 As	Swidden agriculture (Slash and burn)
9 Ao	Orchard	7 Ao	Orchard
10 Ap	Plantation (Rubber plantation)	8 Ap	Plantation (Rubber plantation)
11 Av	Village garden crops	9 Av	Village garden crops
12 Ag	Garden crops	10 Ag	Garden crops
13 Arv	Paddy field with villages	11 Arv	Paddy field with villages
Grasslands:		**Grasslands:**	
14 G	Grassland (Undifferentiated)	12 G	Grassland (Undifferentiated)
15 Ga	Abandoned field covered by grass	13 Ga	Abandoned field covered by grass
16 Gf	Flooded grassland	14 Gf	Flooded grassland
17 Gs	Grass savannah	15 Gs	Grass savannah
18 Gm	Grass with termite mounds	16 Gm	Grass with termite mounds
19 Ms	Marsh and Swamp	17 Ms	Marsh and Swamp
Shrublands:		**Shrublands:**	
20 S	Shrubland (Undifferentiated)	18 S	Shrubland (Undifferentiated)
21 Sa	Abandoned field covered by shrub	19 Sa	Abandoned field covered by shrub
22 Sf	Flooded shrub	20 Sf	Flooded shrub
23 St	Woodland (C < 10%)	21 St	Woodland (C < 10%)
Forest covers:		**Forest covers:**	
24 Fe	Evergreen broad leafed forest	22 Fe	Evergreen broad leafed forest
25 Fc	Coniferous forest	23 Fc	Coniferous forest
26 Fd	Decidous forest	24 Fd	Decidous forest
27 Fdo	Dry decidous (Open) forest	25 Fdo	Dry decidous (Open) forest
28 Fx	Mixed forest	26 Fx	Mixed forest
29 Fr	Riparian forest	27 Fr	Riparian forest
30 Fs	Bamboo and Secondary forests	28 Fs	Bamboo and Secondary forests
31 Ff	Flooded forest	29 Ff	Flooded forest
32 Fm	Mangrove forest	30 Fm	Mangrove forest
33 Fmd	Degraded mangrove forest	31 Fmd	Degraded mangrove forest
34 Fp	Forest plantation	32 Fp	Forest plantation
Water features:		**Water features:**	
35 Wl	Lake (>8 ha)	33 Wl	Lake (>8 ha)
36 Wp	Pond (< 8 ha)	34 Wp	Pond (< 8 ha)
37 Wr	Reservoir	35 Wr	Reservoir
38 Ws	Shrimp/Fish farm and Salt pan	36 Ws	Shrimp/Fish farm and Salt pan
39 Wo	Others (Sea, Bay, etc.)	37 Wo	Others (Sea, Bay, etc.)
Soils and Rocks:		**Soils and Rocks:**	
40 B	Barren land	38 B	Barren land
41 Bs	Sand bank	39 Bs	Sand bank
42 Br	Rock outcrop	40 Br	Rock outcrop
43 Bo	Others (Bare soil, areas after mining, etc.)		

7) Orchard (Ao): This refers to area used for fruit tree cultivation, often located near the settlement. This is found mainly in the plain, delta and moderate hills.

8) Plantation (Ap): It refers to area with Rubber plantation.

9) Village garden crops (Av): These include the agri-activity occurring in the proximity of village which get seasonally inundated likes in riverine floodplain. The plot may be combination of fruit trees and field crops. The field crops, especially along the Mekong main stream, consist of sugarcane.

10) Garden crops (Ag): These include the agri-activity occurring along the Mekong main stream which gets seasonally inundated. Plots generally lie in perpendicular to rivers and consists of vegetables and field crops, consisting of beans, corns, sugarcanes, and tobacco.

11) Paddy field with villages (Arv): This class is similar to that of paddy fields. The only difference is that there are clusters of villages scattered in area of this class, which makes the delineation of villages from paddy fields difficult at this scale of Landsat TM imagery.

Grasslands: These include the areas covered by grasses.

12) Grassland (Undifferentiated): It refers to infertile or degraded land on which no tree or shrub can grow. It might be an area that is too dry to support trees but has been more or less covered by grasses under the prevailing environment. This category of grasslands can also be found on deep sand with high moisture.

13) Abandoned field covered by grass (Ga): It refers to the agricultural fields left uncultivated for sufficient period which has favored to grow grasses significantly. Otherwise, such fields are potential for agricultural cultivation.

14) Flooded grassland (Gf): This refers to the grass area that gets seasonally flooded, such as along the Mekong river and in the delta, especially around the Tonle Sap lake. This also includes the floating grassland found especially around the Tonle Sap Lake.

15) Grass savannah (Gs): It refers to the grassland with soil conditions unsuitable, such as shallow soil, less fertile, etc. for either tree growth or agriculture production. Tree cover is at least 1%, but not more than 10%. The trees are drought resistant and mostly short with grasses forming an understorey. Normally, the savannah does not occur on steep slopes, but in plains.

16) Grass with termite mounds (Gm): This category of grassland has termite mounds scattered covering the significant area. It is usually found in highland above the flooding zone.

17) Marsh and Swamp (Ms): Marsh is muddy area along the seashore or lakes, often associated with grass. Swamp is the area with excessive saturated with water. The soil basically may be fertile but the lack of oxygen limits its agricultural or forest production capacity. In general, swamps are found in inland zone around the Tonle Sap Lake.

Shrublands: These include areas where the dominant woody elements are shrubs.

18) Shrubland (Undifferentiated): This is mainly found in the zone between permanent agriculture and forest, and along the tributaries of main rivers. This can be natural or regenerated after forest destruction or slash and burn.

19) Abandoned field covered by shrub (Sa): It refers to shrubland resulted from the abandoning of paddy or other crop fields for several years.

20) Flooded Shrub (Sf): It refers to shrubland that gets seasonally flooded. This class of land is mainly concentrated within the Mekong corridor and in the delta, especially around the Tonle Sap lake.

21) Woodland (St): This refers to area with scattered trees, but with crown closure less than 10% (naturally or artificially). Under natural condition, this class generally occurs on poor soil and older stands of undisturbed shrubland while artificially this might have resulted due to logging of trees from forest.

Forest covers: These include the areas with significant tree covers:

22) Evergreen broad leafed forest (Fe): It refers to the multi-story forest dominated by evergreen species. This category of forest is found in areas usually not subjected to inundation, such as hillsides and mountainous region. However, broad-leafed evergreen habitat may also occur in plains where flooding is minimal. In the study area, this type of forests is found as solid block.

23) Coniferous forest (Fc): It refers to Pine forest. it occurs in some high elevated areas of the lower Mekong basin. Such forest often covers the hill slopes and along the streams.

24) Deciduous forest (Fd): This includes dry deciduous Dipterocarp forest with nearly more than 40% crown cover. Most of characteristic species are fire resistant and have thick bark.

25) Dry Deciduous (Open) forest (Fdo): It refers to the similar species as in 26 but with less crown closure coverage. Poor growth environment such as shallow soil, low fertility, may be major cause for their less crown closure which emphasizes for their possible distribution above the plains or highlands slopes.

26) Mixed forest (Fx): This refers to the forest with mixed deciduous and evergreen species, of which deciduous species represent more than 50% of the stand. This typically occupies as the transition zone between evergreen (24) and deciduous forest (26).

27) Riparian forest (Fr): It refers to the forest occupying the bank of rivers or lakes, etc. which is typically in stripe form.

28) Bamboo and Secondary forests (Fs): Bamboo forest occurs in some areas of the lower Mekong basin. It forms either a pure bamboo stands or mixes with woody trees keeping its dominance under the storey of broad leaf forest. Secondary forest is resulted from primary forest due to logging, shifting cultivation, or forest fire. It often occurs in the zone between agricultural land and closed forest, and near to settlement areas. This forest is often mixed with small parcels of other forest types and will not be separately delineated, rather grouped.

29) Flooded forest (Ff): It includes the forest that gets seasonally flooded. A large area of the flooded forest occurs around the Tonle Sap Lake and around the Mekong corridor. Flooded forest adjacent to agricultural land and settlement area, in Cambodia, is badly degraded due to its clearing for agriculture that may be called as degraded flooded forest.

30) Mangrove forest (Fm): This refers to forest type which grows either on saline tidal water along the sea shore (tidal mangrove) or on seasonal flooded acid sulfate soil in the inland (rear mangrove). Mangrove forest, based on its species composition, can be further subdivided into various subtypes, such as Rhizophora forest, Nipa stand and Melaleuca forest.

31) Degraded mangrove forest (Fmd): It refers to mangrove forest that is destroyed and degraded.

32) Forest plantation (Fp): This refers to man-made forests. Such forests are mostly established with fast growing or valuable exotic species. These are often established in easy accessible areas, such as along roads, tracks or near built up area.

Water features: These include water bodies in various forms:

33) Lake (Wl): This includes in-land natural water bodies that are larger than 8 hectare.

34) Pond (Wp): This also refers to in-land water bodies but with size smaller than 8 hectare. Ponds may be natural or man-made. The man-made ones can be found in agricultural areas or close to houses.

35) Reservoir (Wr): This refers to man-made water bodies that serve the purpose of irrigation. Dikes, which usually appear as straight lines on the imagery, are indirect recognition of reservoirs.

36) Shrimp/Fish farm, and Salt pan (Ws): Shrimp farms are generally located in the mangrove areas.

37) Others (Wo): These refer to natural water bodies that have generally openings, such as rivers, seas, etc.

Soils and Rocks: These include the degraded lands in various forms.

38) Barren land (B): This includes non-productive lands which may be as result of chemical, physical or man-induced stresses. Limitations create an area very often devoid of much vegetation, and consequently easily recognizable on TM imagery where they appear as very light grey plots on the hill side or along the river, etc.

39) Sand bank (Bs): It refers to sand deposited areas along rivers and seashores.

40) Rock outcrop (Br): It includes areas with major portion as exposed rocks.

(4) Interpretation of the shoreline of Tonle Sap Lake in the rainy season

The shoreline of Tonle Sap Lake changes between the dry and the rainy seasons due to the difference in amount of the water inflow from the Tonle Sap River and the Mekong River. Therefore the shoreline of the dry season was delineated from the land use data of dry season, while the interpretation of JERS-1 SAR imagery was used to delineate the one of the rainy season. SAR data is considered as better one for this purpose as it yields clear-cut boundary between land and water, and also with cloud penetration capacity, is more convenient for tropical area. JERS-1 SAR data (that were made available by NASDA) listed below are applied in this project.

Table 8 List of JERS-1 SAR data taken in the rainy season

Path/Row	Date	Path/Row	Date
123-278	26-Aug-97	119-281	22-Aug-97
122-277	21-Nov-97	119-282	22-Aug-97
122-278	21-Nov-97	119-283	22-Aug-97
122-279	21-Nov-97	118-279	21-Aug-97
121-277	24-Aug-97	118-280	21-Aug-97
121-278	24-Aug-97	118-281	21-Aug-97
121-279	24-Aug-97	118-282	21-Aug-97
120-277	23-Aug-97	118-283	21-Aug-97
120-278	23-Aug-97	117-280	3-Oct-97
120-279	23-Aug-97	117-281	3-Oct-97
120-280	23-Aug-97	117-282	3-Oct-97
120-282	23-Aug-97	117-283	3-Oct-97
120-283	23-Aug-97	116-280	2-Oct-97
119-278	22-Aug-97	116-281	2-Oct-97
119-279	22-Aug-97	116-282	2-Oct-97
119-280	22-Aug-97	115-282	18-Aug-97

The shoreline in the rainy season has been delineated by the manual (visual) interpretation method and after converting to digital form, has been overlaid on shoreline delineated for land use. The result has shown not significant difference. This may be because the time of JERS-1 SAR data was corresponding to just early rainy season.

(5) Geology / Geomorphology

The reason for mapping geology/geomorphology or surface geology and geomorphology mapping was that the urgent need for land capability, suitability analysis, agricultural planning requires soils maps. However, the production of usable soil maps would not be possible in the short time available. Therefore the geomorphological mapping was conducted to substitute for the missing soil maps. The landform can often be correlated with some of the soils. Such as lakebeds usually have clay type soils, while floodplains have mixed soils due to the meandering, the mixing effect of the deposition process. Old terraces have either sand or gravel deposits, while ancient terraces are covered by infertile laterite soils, which are good for rubber and other tree cropping.

Landforms reference keys were developed for interpretation of satellite images, like Landsat and SPOT and aerial photos using existing data and field observation. The detailed geologic maps were used as guide, although these maps primarily covered the rock outcrops, while the important soils covered areas are indicated only as alluvium. It is this area of alluvium which is

important for the land development of Cambodia as the type of soils is important whether it can be opened up for agricultural expansion for new settlement or whether these should be conserved as they are not fertile or too steep or full of rocks.

Landform interpretation, as in land use interpretation, required field observation to verify the keys. Reference keys for interpretation of the satellite images were developed to finally produce the classification maps, by referring to the existing topographic, geology, and soil maps and by detailed observation and interpretation of aerial photos. Field observations were conducted in the vicinity of Phnom Penh. The correlation of 600 boreholes are being conducted to further verify the soil and shallow bedrock. The landform classes are shown in Table 8.

Geology / Geomorphology was analyzed by the manual interpretation of Landsat TM imageries for the entire area as well as aerial photos for the some parts. This activity was conducted by a team of both Japanese and Cambodian geologists of the Cambodian Department of Geology. The interpretation results are shown at a scale of 1:100,000. The data was then reduced to 1:500,000 and edited to create the Geology/Geomorphology maps. The original data of 1:100,000 scale was entered into the GIS database for correlation with other information.

The procedure was to map the geology/geomorphology on the Landsat imagery, the 1:25,000 aerial photographs were used to spot check the topographic forms by using the stereoscopic 3-dimensional image to facilitate the interpretation and obtain greater detail. The SPOT imagery was further used to verify the above procedure and to correlate over a large area.

The classification was based on the interpretation of Landsat and SPOT imageries along with aerial photos to make accurate delineation of the land form boundaries. This classification is not a classical geologic or geomorphic classification as it is based on the interpretability of the data, and also to determine the type of material to substitute the soils maps.

The interpretation was verified and checked by the supervision and the advisor before being released and sent for digitizing.

Table 9 Legend for Landform (Geology/Geomorphology) Map of Cambodia
Scale: 1/500,000

Code	Geologic Era	Deposits,Sediments,Rocks
[Unconsolidated material]		
(Remarks : shall be only used existing deposits in study area within following list)		
W	Quaternary	Water
Fp	Quaternary	Floodplain
Af	Quaternary	Alluvial fan
Co	Quaternary	Colluvium(Tallus cones)
Pd	Quaternary	Pediment
Lb	Quaternary	Lake bed deposits
Dd	Quaternary	deltaic deposits
Ft	Quaternary	Tidal flats deposits
Br	Quaternary	Bearch ridge deposits
Sw	Quaternary	Organic deposits
Va	Quaternary	Volcanic deposits
Cp	Quaternary	Costal Plains deposits
Ta	Quaternary	terrace laterite deposits
Pi	Quaternary	Basaltic plateau deposits
[Sedimentary Rocks]		
Mesozoic		
Jurassic-Cretaceous		
Jca	Jurassic-Cretaceous	claystone
JCg	Jurassic-Cretaceous	sandstone
JCg	Jurassic-Cretaceous	conglomerate
J	Jurassic	sandstone
J1-2	Lower-Middle Jurassic	formation
Triassic		
T	Triassic	formation
Tg	Triassic	formation(sandstone and microbreccias)
Tx	Triassic	siltstone,shists and marl
Paleozoic		
Permian-Carboniferous		
C-T	Upper Carboniferous - Lower Triassic	sandstone
CP	Ouralo - Permian	limestone
P	Permian	limestone
Carboniferous - Devonian		
CD	Carboniferous - Devonian	black shists,phtanites,sandstone
Devonian		
DHj	Devonian	phtanites
DHx	Devonian	schists and sandstone faces
DHm	Devonian	marl faces
DHcg	Devonian	conglomerate faces
al/DC	Devonian	DC formation covered by a thin layer of old alluviun

Cambrian - Silurian		
CScg	Silurian	metaconglomerate
CS2q	Cambrian - Upper Silurian	quartzites
CSq	Cambrian - Silurian	quartzites
CSx	Cambrian - Silurian	schists
Archean		
AnteCambrian		
Pt	AnteCambrian	formation
Unknown Geologic Era		
C		Hornfelds,meta-arkose and meta-andesites
Ce/Cm/Cog		Skarn deposit,Marble,Metamorphic conglomerate
[Igneous Rocks]		
Volcanic Rocks		
Basic Rocks		
B1/B	Quaternary / Pliocene - Quaternary	Basalts
Acidic Rocks		
p2/p2b	Jurassic - Cretaceous	Rhyolites
b	Jurassic - Cretaceous	Dacites
p1	Lower-Middle Triassic	Rhyolites
p	Antepermian	Rhyolites(Old Rhyolites)
Intermediate Rocks		
α 1	Jurassic-Cretaceous	Andesites and tuffs
α	Permian	Andesites and their relative rocks
Volcanic sediments		
r2t	Jurassic-Cretaceous	volcanic breccias and acidic tuffs
r1t	Devonian	acidic tuffs
Pultonic Rocks		
Q4	unknown geologic Era	High alumina Granite
g3/g3-4	Post Triassic(Late Jurassic - Cretaceous)	Granites/coarse grained Granites
g3-1	Post Triassic(Late Jurassic - Cretaceous)	aplititic Granites,Aplite
g3-2	Post Triassic(Late Jurassic - Cretaceous)	fine grained Granites
g2	Early - Mid Triassic	Granite
g1	Early - Middle Paleozoic	Granite
g/gb	Late Triassic - Early cretaceous(Post Tria	Granodiorite
	unknown geologic Era	undiscriminated Pultonic rocks
d	Late Cretaceous - Paleogene	Diorite,Gabbro,gabbroic Diorite
[Others]		
	faults	
	proposed faults	

The explanation of each landform unit in the legend is described as follows:

1) Floodplains: A part of river valley, adjacent to the channel, over which a river flows in times of flood.

   It is a zone of low relief and gentle gradients and may incorporate oxbow lakes, point bars, abandoned channels and scrolls, all indicative of the fact that the river channel has shifted its position continuously during the present regime of the stream. The floodplain is composed of alluvium, which generally buries the rock floor of the valley to variable depth.

   Flood plains are mainly formed around the Mekong and Tonle Sap river corridors.

2) Alluvial fans: A fan or cone-shaped mass of material, usually of sand and gravel, deposited by a stream where it emerges from the constriction of a narrow valley at a mountain front and debouches on a plain or into a wide trunk valley.

   The mass is the thickest at the apex of the fan, and the deposits become thinner as traced outwards and downwards. Viewed from the apex of the mass, it has shape of an open fan. Over a period of time adjacent fans may coalesce and extend some distance from the mountain front. Alluvial fans are widely formed around the Cardamom Mountains and the Elephant Mountains.

3) Colluviums (Talus cones): A general term applied to loose and incoherent deposits, usually at the foot of slope or cliff and brought there chiefly by gravity.

   Tales and cliff debris are included in such deposits.

4) Pediments: A broad gently sloping erosion surface or plain of low relief, partly covered by a skin of rock debris, typically developed by running water, in an arid or semiarid region at the base of an abrupt and receding mountain front.

   It is underlain by bedrock that may be bare but is more often mantled with a thin discontinuous veneer of alluvium derived from the upland mass and in transit across the surface.

5) Lake beds (Lacastrine sediments, Lake deposits): A sediment constituted a lake plain.

The lake plains are flat lowlands or former lake beds bordering an existing lake. The lake beds develops extensively around the Tonle Sap Lake.

6) Deltas: A fan-shaped alluvial deposit at a river mouth formed by the deposition of successive layers of sediment.

As the river current enters the sea or lake, the bulk of the coarsest fraction of the load is deposited immediately, but the finer material is carried farther out by the divergent river channels. Fine clays, carried in suspension, are deposited by flocculation when they enter saline water. Deltas will only form where the amount of river-deposited sediment exceeds the amount removed by coastal processes. The name is derived from the Greek letter Δ, which resembled the form of the Nile delta, but not all deltas have this shape, depending on such variable as tidal currents, wave action, supply of material, etc. Most deltas are partly sub-aerial and partly below water.

7) Tidal flats: An area of inter-tidal sand flat, mud flat and marsh developed in some lagoons in middle tidal areas, and in protected bays and estuarine areas along macro tidal coasts.

In tropical areas tidal flats tend to be colonized by mangrove swamps.

8) Beach ridges: A low, essentially continuous mound of beach and dune material heaped up by the action of waves and currents on the back-shore of a beach beyond the present limit of storm waves or of ordinary tides, and occurring singly or as one of a series of approximately parallel deposits.

The ridges represent successive positions of an advancing shoreline. A ridge or embankment of sand and silt, built by a stream on its flood plain along both banks of its channel, especially in time of flood when water overflowing the normal banks is forced to deposit the coarsest part of its load.

9) Organic deposits (swamps): Marshes and swamps are in general, wet spongy land saturated with water for much of the time. Marshes are muddy areas along the sea shore or lakes, often associated with grass. Swamps are the areas with excessive saturated with water.

The soil basically may be fertile but the lack of oxygen limits its agricultural or forest production capacity. In general, swamps are found in inland zone around the Tonle Sap lake.

10) Volcanic ash

A depositional surface of aeolian processes, which is not so widely identified in this area.

11) Alluvial plain: A broad flat depositional surface of considerable area, which has been produced by the riverine alluvial processes.
No dissection is identified on the surface because the landform was completed in more recent age.

12) Coastal plains: A low, broad plain that has its margin on an oceanic shore and its strata either horizontal or very gently sloping toward the water, and generally represents a strip of recently emerged sea-floor.

13) Terrace Alluvial
In general, an alluvial terrace is regarded as being synonymous with a river terrace. In topographic form, the alluvial terrace resembles the river terrace and was formed in the same way - by the down-cutting action of a river following rejuvenation, leaving at higher levels portions of its former floodplain as terraces.

14) Terrace Laterite: A highly weathered red subsoil or material rich in secondary oxides of iron, aluminum, or both, nearly devoid of bases and primary silicates, and commonly with quartz and kaolinite.

It develops in a tropical or forested warm to temperate climate, and is a residual product of weathering. Crushed laterite is an important road-building material in tropical countries while lateritic clay are extensively used for brick-making.

15) Peneplains: A low, nearly featureless, gently undulating land surface of considerable area, which presumably has been produced by the processes of long-continued mass-wasting, sheetwash, and stream erosion almost to base level in the penultimate stage of a humid, fluvial geomorphic cycle, also, such a surface uplifted to form a plateau and subjected to dissection.

16) Rocks
All rocks are classed as one at this time, though those are composed of sedimentary, metamorphics and intrusive.

3.2.3 Progress Report

The Progress Report is submitted to MPWT. It covers the period from November 1996 until February 1998, and shows the activities, results and actions taken as of this date.

3.3 Third Year

3.3.1 Printing

Final topographic maps were printed by automatic offset printing. The procedure was as follows:

1) Preparation of film for plate making
4 sheets of positive film for plate making were prepared for each map sheet.

2) Printing Plates
Printing plates for the respective colors were made from the positive film using aluminum PS plates.

3) Proof prints
Proof prints from the printing plates were made by a flatbed offset machine.

4) Proofing
The proof prints were checked for the quality of coloring and matching. Defective sheets in matching were corrected and reprinted. The proof prints were approved by MPWT when the draft final report was discussed.

5) Printing
Printing paper was chosen in terms of representation and endurance. High quality printing ink was used that had good color tones and less change.

6) Inspection
Each printed map sheet was checked for any presence of smears from printing, blurs, missing lines, matching, color tones, etc.

3.3.2 GIS Database

The resulting data are being transforemd into a spatial database. In the Study, all the geographic information captured are transferred onto SPOT ortho images with a uniform scale into a digital output for the geographic information system to allow comprehensive analysis. The geographic information thus created is expected to offer a range of multi-layer analysis through computer applications, which are not possible using paper maps.

This section of the progress report provides and overview of the data integration work which is being carried out in Japan and will give an overview of the procedural flow for converting and integrating the three groups (Topographic data, Land use data and Geomorphology/Geology) in addition to describing the current status of each group. Data integration may be thought of as a gathering together of all of the various types of spatial and non-spatial data which is being created or will be used for map production and stored within the GIS database. Initially this integration involves a variety of hardware and software components, however upon completion of this process, a fully structured, theme oriented GIS database will exist, which can be used for topographic and thematic map preparation, and data update, display, query and analysis functions.

(1) Topographic Data Integration

The following sub-sections describe the integration procedures and current status for the Topographic data. As described in previous reports, Topographic data for the project is being collected with the use of 10 meter ortho-rectified satellite images taken by the French SPOT Satellite at a scale of 1:100 000.

<Data Input Overview>
The main method for topographic data collection is via a process called "heads-up-digitizing." In this process, a spatially corrected satellite image is displayed on the screen of a computer and using special software tools, the user can create vector data over the top of the image by visually looking at the screen and tracing the features with the mouse cursor. As the user is mostly looking at the computer screen this is called "heads-up" as opposed to the use of a digitizing tablet where the user's head is looking away from the screen, or down at the tablet. As described in a previous section, this work is being carried out using a software package called Vue3D which runs in a workstation environment. The vector data which is created in this process has coordinates which are the same as the ortho-rectified image, which has been rectified to a Universal Transverse Mercator (UTM) projection.

<Geodetic Information>
In order to maintain spatial correctness throughout the project, the following geodetic parameters have been agreed upon and have been used to rectify the

various satellite images used for data collection, and they are also used during the data integration procedures. These parameters are:

Map Projection:	Universal Transverse Mercator (UTM)
UTM Zone:	Zone 48 (specified)
Horizontal Datum:	Indian 1954
Ellipsoid:	Everest 1830
Units:	Meters

<Data Conversion Overview>

The following paragraphs describe the various data conversion procedures which are being used to convert and integrate various sources of topographic data which will be used in the project.

< Data from Vector Input Software with Raster Image (Vue3D) >

Vue3D data describes the vector files which are created by "heads-up-digitizing" using the Vue3D software. There are three main types of data created with Vue3D:

Point data:	single x,y points
Line data:	a group of x,y point pairs
Polygon data:	a group of x,y point pairs with a common starting/ending point

These files are further grouped into layers. Each layer has an associated code number. The functioning of the Vue3D software works by this layer method. The code numbers for the Vue3D layers will be described in the future (See Chapter 9; Table and code).

After the data for a specific map sheet been created using VUE3D, these individual layers are converted to the ARC/INFO generate format. This data is then read into ARC/INFO using the generate command. After this step, ARC/INFO coverage format data exists for the layers which were created for a specific map sheet.

<Contour Lines and Spot Elevations>

Contour line data and Spot Elevation points have been made by TIN Model and are generated automatically from two SPOT stereo panchromatic images. The Spot Elevations are taken from known geodetic benchmarks verified from existing 1:50 000 topographic maps. The contour line files are then edited by hand, and output in final form as Vue3D binary format (.g) files. Contour intervals are 20 meters for regular contours and 10 meters for supplementary contours. The Spot Elevations are in meters and are also delivered in final form as Vue3D binary format (.g) files. Both the Contour Line and Spot Elevation data are in the UTM projection system. These files are then converted into ARC/INFO data and further manipulated within the GIS.

These files are now being cut into map sheet squares and exported from ARC/INFO back into VUE3D where corrections for streamline correlation are taking place.

<Administration Boundaries>

The administration boundary data has been received from the Cambodian Geographic Survey Institute in the form of PC ARC/INFO coverages and external database files on a CD-ROM. The PC ARC/INFO data has been converted to workstation ARC/INFO format. Due to the political uncertainties of the current boundary situation within the project area, it is expected at this time that no editing of the political boundaries will take place.

<City and Village Annotations>

The City and Village Annotation data was also received from the Cambodian Geographic Department on the same CD-ROM.

<Feature Annotations>

Feature Annotation data was also received from the Cambodian Geographic Department in the form of a PC ARC/INFO point coverage and associated external file.

During processing and check plotting, a number of duplicate records have been identified. There are also a number of records which appear to have the wrong code for the type of annotation description. All of the annotation has been checked again, and the subsequent duplicate or erroneous records have been removed or corrected.

<Plotting and Checking>

Then, from within ARC/INFO, check plots were produced for quality and accuracy control of the initial input data. After making corrections on the check plots, the original data was then edited again in VUE3D and then the ARC/INFO conversion process was performed again. This cycle was repeated until no more edits on the topographic features where needed. On average each map sheet has about 40 to 60 layer files, and each sheet was checked and edited on average, about five to eight times. Presently, topographic feature datasets exist in final form for all of the map sheets defined by the project area.

(2) Land use Data Integration

<Data conversion>

A total of 40 individual 1:100,000 scale interpreted land use maps were created. Interpretations which were directly marked on clear film overlaid on the 1:100,000 color composite landsat image maps were then retraced onto a stable mylar base for data conversion. The final re-drafted mylars were examined by the land use specialist and checked for coding accuracy of

interpretation, coding errors and omissions, and cross-sheet code correlation. Errors and ambiguities which were found were re-checked and corrected.

<Digitization>

Data conversion of the mylar sheets was done using a scanning technology. First the mylar sheets were scanned on a large format monochrome scanner and a resolution of 400 dots per inch (DPI). The resulting one bit image files were checked for un-connected lines, extraneous noisy pixels, unclear registration points and any dust particles which may have been present on the mylar when it was scanned. These anomalies were corrected by use of a raster editing software package.

After the scanned images were cleaned up, each one was processed in an auto-vectorizing software package. This package converted the raster data pixels into vector data. The vector data was then super-imposed over the scanned image and then edited. During this editing process, the vector data was corrected of various auto-vectorizing errors and extraneous data. The closing of polygons was also performed. Labels were created for the polygons, and land use codes were input based on the same land use codes visible in the scanned image, shown in the background.

Registration points were input at the same coordinates in the vector data as were visible on the scanned image in the background. At least eight points were collected from each scanned image. These registration points were then used to transform the Cartesian vector data into geo-referenced vector data, based upon the geodetic criteria for this project, shown in 3.3.2..

After geo-referencing, the converted land use data for each map sheet was printed out and checked with the original mylar for coding and closure errors. Any errors found were corrected and subsequent final check plots were created.

Continuing in a parallel schedule, the land use data is being checked and verified against the topographic features collected from heads-up-digitizing of the SPOT Ortho-rectified satellite images. Dense urban and infrastructure areas, collected with the topographic features, are updated into the land use data. Perennial water features are correlated and updated to the land use data. Temporal water features and areas that are inundated are correlated and updated within the topographic feature base.

A tentative legend color scheme has been designed and is being checked and revised. The final version of this legend will be used for the printing of a small quantity of each land use map after final editing is complete.

(3) Geology Data Integration

A process similar to the data conversion of the land use data was made for the interpreted geology/ geomorphology maps.

(4) GIS Data Structure Preparation

The final GIS database structure is presently in prototype form. Careful consideration has been taken in designing the structure and format of the data which will be written to CD-ROM and supplied to the Counterpart.

Based on discussions with counterpart members, local experts and project team members, it has become evident that data in both native PC ARC/INFO and Rev 7.0 important for this project database.

The final GIS database structure will be a grouping of like feature layers. This grouping will facilitate ease of data query, output and management in final form. Simply reproducing the individual VUE3D layer files for each sheet is not an optimal consideration for the final GIS database structure.

The prototype grouping, which is currently under consideration, divides data layers into spatial features and cartographic features. In order to complete the pre-press topographic map processing which the GIS software is doing, both the spatial features and the cartographic features need to be used. However, the data will be used for analysis, it is not necessary to work with the cartographic features. Grouping the features in this fashion will provide for easier management and access.

In addition to the feature grouping, the actual structure of the final database is dependent on which type of ESRI software we use for accessing it. Currently, both PC ARC/INFO, Rev 7.0 ARC/INFO for WinNT, and ArcView 3.0 GIS for Windows have been proposed for installation. Rev 7.0 ARC/INFO contains a suite of functions called the Map Librarian. The Map Librarian is designed to handle large datasets, such as adjoining map sheets with minimum overhead to the user. Map Librarian datasets can be accessed directly by both Rev 7.0 ARC/INFO and ArcView 3.0 GIS. PC ARC/INFO cannot directly access the Map Librarian, therefore a separated tiled scheme with individual covers in PC ARC/INFO format is presently being examined.

Figure 3 System Configuration

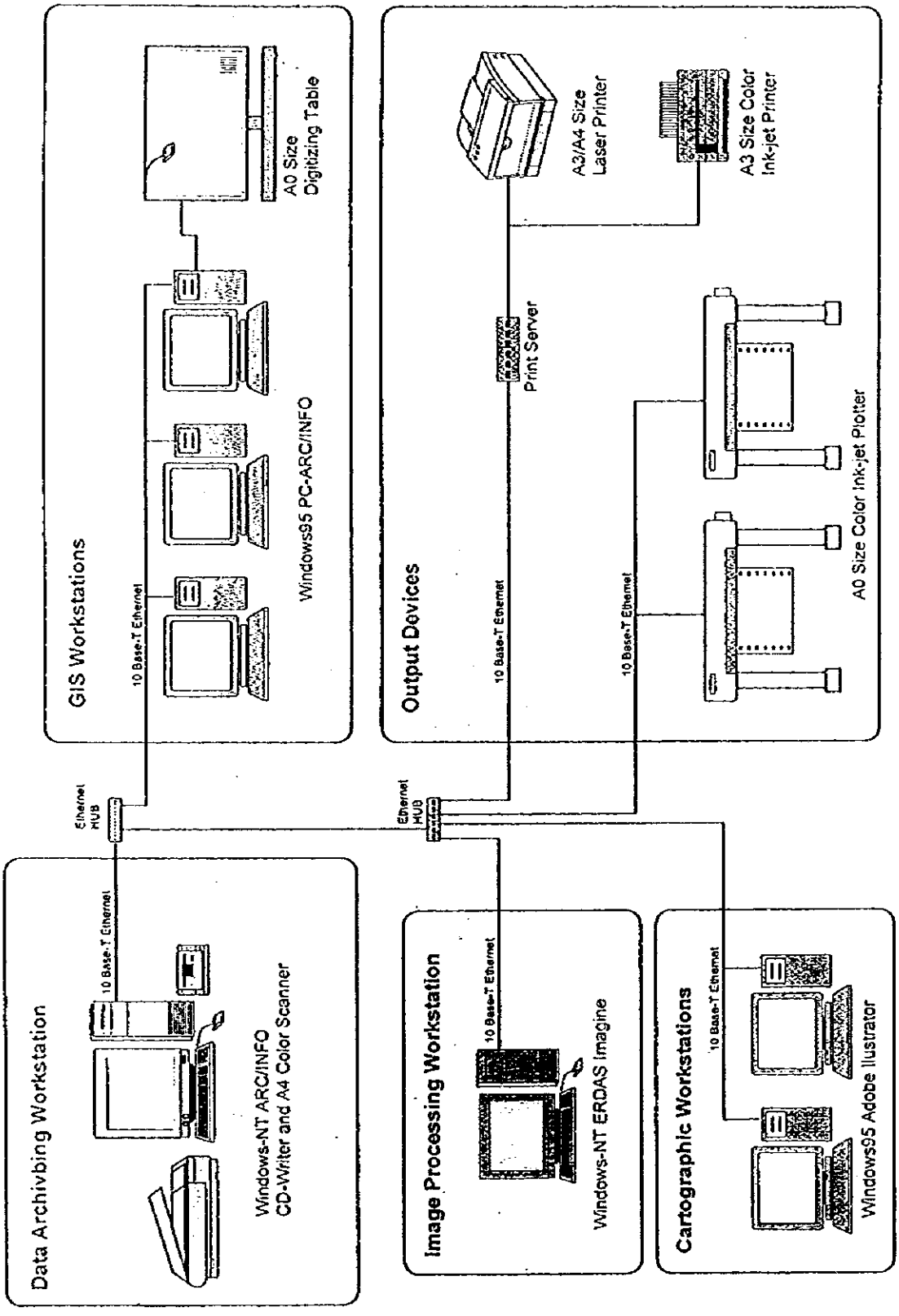


Table 10 List of Hardware (1)

Item	Description	QTY
1.1	**Computer (GIS Data Digitizing, Editing, Analyzing)** COMPAQ DeskproEP Equivalant, Win95 pre-installed Pentium II 350 Mhz 128MB RAM 8MB VRAM 32x Internal CD-ROM Internal FD 6GB HDD 10 Base-T Ethernet 17" Color Monitor(Trinitiron or Diamondtron Type)	3
1.1.1	CD-Writer with SCSI kit CDR-600MB Media(10 units per Box)	1 20
1.2	**Computer (Map Preparation)** COMPAQ DeskproEP Equivalant, Win95 pre-installed Pentium II 350Mhz 128MB RAM 8MB VRAM 32x Internal CD-ROM Internal FD 6GB HDD 10 Base-T Ethernet 17" Color Monitor(Trinitiron or Diamondtron Type)	2
1.3	**Computer (Image Processing)** COMPAQ DeskproEP Equivalant, Win-NT workstation pre-installed Pentium II 450 Mhz 256MB RAM 8MB VRAM 32x Internal CD-ROM Internal FD 6GB HDD 10 Base-T Ethernet 20" or 21" Color Monitor, COMPAQ P110 Equivalant (Trinitron or Diamondtron Type)	1
2	**Computer (NT ARC/INFO Data Serving/Archiving)** COMPAQ DeskproEP Equivalant, Win-NT workstation pre-installed Pentium II 450 Mhz 256MB RAM 8MB VRAM 32x Internal CD-ROM Internal FD 10GB HDD 10 Base-T Ethernet 20" or 21" Color Monitor, COMPAQ P110 Equivalant (Trinitron or Diamondtron Type)	1

Table 11 List of Hardware (2)

Item	Description	QTY
3	**Ethernet 10 Base-2/T LAN**	
	Hub 8 ports(BNC x1, RJ45 x7)	2
	USTP Cable (Category 5, 100m)	
4	**Digitizing**	2
	Calcomp A0 size with 16 Button Pack	
5	**Printers and Plotters**	
5.1	**Laser Printer A3/A4**	1
5.2	**A3 size Color Inkjet Printer**	1
5.3	**HP DesignJet 750c Plus**	2
	32MB SIMM RAM	
	10 Base-T	
	Stand	
5.4	**A4/A3 Size Monochrome Photo Copy Machine**	1
5.5	**Paper, Toner and Ink enough for one 1.5 year**	
	*for Item 5.1	
	Toner Cartridge	3
	*for Item 5.2	
	Black Ink 8 pcs./unit	3
	Color Ink 8 pcs./unit	3
	*for Item 5.3	
	Ink Cartridge-Black	10
	Ink Cartridge-Cyan	10
	Ink Cartridge-Magenta	10
	Ink Cartridge-Yellow	10
	High Res. Color Bond Paper A1	6
	Economy Bond Paper A1	8
	Translucent/Tracing A1	4
	High Res. Color Bond Paper A0	6
	Economy Bond Paper A0	8
	Translucent/Tracing A0	4
	*for Item 5.4	
	A4 size Paper	4
	A3 size Paper	4
	Toner Cartridge	2
5.6	**Printer Server 3 parallel ports(HP J2593A)**	1

Table 12 List of Hardware (3)

Item	Description	QTY
6	**Softwares**	
	GIS Softwares	
	ARC/INFO for Win-NT	1
	TIN for ARC/INFO	1
	GRID for ARC/INFO	1
	NETWORK for ARC/INFO	1
	ARCPress for ARC/INFO	1
	PC-ARC/INFO	3
	ARCVIEW3	5
	AV3 NETWORK ANALYST	1
	AV3 SPATIAL ANALYST	1
	AV3 3D ANALYST	1
	ARCPress for ARCVIEW	1
	ERDAS Imagine 8.3 professional	1
	DTP-Softwares	
	Adobe Illustrator for PC	2
	Adobe Photoshop for PC	1
	Virus checking software for win & NT	7
7	**A4 Color Scanner 600 dpi, SCSI Connect**	1
8	**Instillation for item 1-7**	1
9	**Airphoto Interpretation Equipment** Mirror Stereo-scope with 3x binocular and table slide bracket	6
10	**Electrical Power Resources**	
10.1	Generator (45KVA 230/240V AC, 50Hz, 0.8pf)	1
10.2	8KVA Isolated Transformer Line Conditioner	1
10.3	Surge Suppessors (3pins, 4 Pullets)	6
10.4	APS Smart-UPS 1000, 1KVA UPS	7
11	**Air Conditioner Split Type, 18,000BTU**	2

(5) Final Report

The Draft Final Report is prepared for submission at the end of the study, including application examples to show the results and demonstrate the systems for use by the participating Government agencies. After presentation and discussion with the MPWT, the Draft Final Report will be finalized as the Final Report.

(6) Map Library and Final Digital Data Preparation

As with any major mapping project, the amount of data collected is very large. This project made use of a number of diverse data sets and types. Data capture and management for this project up until now has divided the data along map-sheet boundaries. While this type of subdivision is a convenient method for understanding and working with the data sets early on, final management of so many map-sheets can become very cumbersome.

1) Initial Data Set Preparation

In order the easily manage the final data sets, each individual layer was joined together into its respective single layer set. After joining, each data set was checked for edge-matching accuracy. Errors in both graphic connectivity and attribute matching were checked and when encountered were edited and corrected. When joining the individual data sets, slight variations in the coordinate precision of the individual data sets needed to be adjusted and checked. This variation occurs normally from numerous editing sessions and topologic processing. These variations sometimes create small remnant polygons, sometimes referred to as "sliver polygons" which also need to be checked and corrected. Finally, the joined data sets were checked for coding accuracy and omissions overall.

These basic processing procedures were carried out for all data layers within the project. The edgematching and connectivity checking pertains only to line and polygon data sets. Point data sets do not require these two quality assessment steps.

2) Map Library Setup

On the simplest terms, a "map library" or "library" can be thought of as a collection of many individual maps that are organized and divided into groups that can be accessed in a simple manner. Unlike a regular library, this digital "map library" facilitates the access all or some of the maps at one time. From a software perspective, a "map library" may have special meaning depending on the software environment used. Such differences may be data creation and storage access methods, viewing and query procedures, data editing and upgrading situations.

For this project, a map library has been chosen as a method of management for the large amount of data which has been created.

Within the context of this project, the term "Map Library" refers to the "Map Librarian" or "LIBRARIAN" software module and related functionality of the ARC/INFO GIS (geographic information system) software package produced by ESRI, Inc. (Redlands, CA. USA; http://www.esri.com). This project will make use of both the ARC/INFO GIS software package, in addition to another software package called ArcView also produced by ESRI. Inc. Both of these packages can be used for the display and query of spatial data contained within the Map Library framework, however only the ARC/INFO package can actually create and manage the "back-end" of the map library.

The LIBRARIAN is centered around the concept of partitioning and distributing the spatial data on the computer or over a network. The data within the library are divided in two ways, by spatial area (a tile) and by theme (a layer). For this project the tiles of the library are based on the map-sheet boundaries (30 minutes x 30 minutes) of the 1:100,000 map sheet series. The map-sheets boundaries produce a very regular tiling scheme. Although the sheet boundaries are 30 minutes x 30 minutes, the tile structure (INDEX) and all of the data layers within the library are stored in UTM values, based on the map projection defined for this project. The layers for the map library are based upon groupings of the topographic and landuse data that were collected for this project. Detailed descriptions of the data layers can be found in Appendix (App.- IV). There are forty-one tiles defined for the map library in this project. The amount of data contained within each tile depends upon the defined study area of the project. Thus, not all of the tiles appear to be "full" when displaying the data. It is more desirable to maintain a regular sized tiling scheme within the library. The display and query of the data is achieved by using the layer names, not the individual data sets in each tile, therefore greatly simplifying working with such a large amount of data sets.

3) Available Data Sets

During the course of this project, consideration was given on how to structure the data in the best format for the Counterpart agency. Although the library is very suitable for most applications, it is sometimes useful to have access to each data layer as a single data set (map-joined) covering the whole project area. Thus, on the data CD-ROM, the data sets for this project exist in both LIBRARIAN and map-joined formats.

The geology/landform data set, which was created for this project, has not been added to the map library because the map scale of the final data product, is 1:500,000. The geology/landform data is available on the CD-ROM as a map-joined data set.

During the course of the project, various data sets (ancillary data) were obtained from the Counterpart agency. These data sets were used in compiling the topographic map sheets. Often times this ancillary data needed to be converted for use by the GIS and sometimes additional attribute items were added to these data sets.

During the final preparation of the project data, it was decided that there would be much merit to provide the ancillary data along with the project data. However, total integration of the ancillary data into the map library was not considered due to various factors relating to the accuracy, content and coverage of the ancillary data. Usually each of the ancillary data sets are already "map-joined" and can be easily worked with inside of the GIS. These ancillary data sets are also described in App.-IV.

3.3.3 Interpretation of Old and New Topographic Maps

The new topographic maps were qualitatively compared to the old topographic maps to assess land use changes of the country. The preliminary analysis shows a pattern of land use change due to agricultural development, infrastructure development (road/rail), and conglomeration of population.

Overall analysis of the changes are summarized in the following table, also samples of new and old topographic maps were selected to show differences in land use and facility development in the Appendix II.

3.3.4 Workshop

At the end of the fourth consultation meeting a workshop and presentation were executed.

The workshop was to introduce the database produced by RSP, and showed the possible applications to the user community.

The executive presentation was designed to show executives at ministerial and department level the potential applications for GIS, and proposal for institutionalization of a network of GIS programs in Cambodia.

Table 13 Summary of Comparison Between New and Old Topographic Maps

Sheet #	Sheet Name	Road						Rail	Facility						Water system				
		Foot Paths	Road for Light Vehicles	Unpaved Road (dry season)	Major Road	Bridge	Collector Road	Bridge	Built-up Area	Village	School	Temple	Airport	Sea port	Man-made River	Canal	Lake and Pond	Dry River	Dike
5634	Mong	>>>								>						>>>		>	>>>
5635	Bat Tam Bang	>								>>	>>		*2		>	>>	>>>	>	
5636	Si So Shon	>								>>						>>	>		>
5730	Krong Preah Sianou	>						>	>	>			*3	*2			*4		
5731	Xre Am Ben	>>						*1	>>	>>					>		>		
5734	Po Xat	>				>			>							>	>		
5735	Xiem Rep	>								>>	>>				<<	>	>>		>
5830	Cam Pot	>								>						>			
5831	Tang Sralau	>>								>>						>			
5832	Prich Khpuos	>								>					>				>
5833	Bo Ri Bo	>>								>					>				>
5834	Cro Co	>								>					>	>	>		>
5835	Kampong Kdei	>>																	
5930	Takeo									>						>	>		>
5931	Kampong Spoe	>	>							>	>	>				>			
5932	Phnom Penh	>		>	>		>			>			*2			>	>		
5933	Cong Pong Cho Nang	>								>			*2		>	>	>	>	>
5934	Cong Pong Thom	>>							>								>		
6031	Pray Veng	>							>								>		
6032	Cong Pong Cham	>							>								>		
6033	Skon	>				>			>								>		
6034	Santuk	>>	>	>						>	>					>	>		
6131	Xvay Rieng	>								>						>			
6132	Phum Sup	>>	>>	>>						>					>	>			
6133	Krouch Chhmar	>>							>	>							>		
6231	Nui Ba Den	>>			>>				>	>						>	>		

>>> remarkably increased >> increased > slightly increased << decreased

*1: ten added, *2: one added, *3: area expanded, *4: two added

4. Recommendations

The objective of the Study is to create topographic maps land use maps and surface geology/geomorphology maps along with digital database for establishing a geographic information system to contribute to the nation's reconstruction efforts.

The data prepared under the Study help in regional analyses, preparation and implementation development plans through the applications of the GIS or through linking the data and information with other agencies concerned. Therefore, the results of the Study shall not end with transferring the data to the counterpart agency, but enhance the uses by all government agencies.

It would be necessary to share data among government agencies, and to establish systems of coordinating production and management of the data. In order to avoid duplicating efforts by different agencies, common data and information need to be shared.

5. Application Examples

Three experimental applications of GIS were developed using the data prepared under the Study. Although these examples are preliminary, they show potential of the GIS application development. The full texts are attached to Appendix III.

5.1 Agricultural Land Allocation to Former Pol Pot Soldiers

To evaluate agricultural development potential, a "Land Availability Ranking" map, which shows priorities of development, was produced in a selected area having about 4,000km^2. Land use, geology/geomorphology, land mine distribution data were used.

5.2 Road Alignment of Route 5

Route 5 from Kampong Chhnang provincial center to Bat Dambang provincial center become impassable during the rainy season. A model was developed to find an alternative route less affected by rain. The analysis using the data on elevation, slope, geology, and the shoreline data of the Tonle Sap Lake during the rainy season resulted the best route along the existing railway route.

5.3 Changes in Topographic Information

In a sample area of 3600 km^2, an automatic identification of land use changes was conducted using the topographic maps produced in 1960 and the data produced under the Study. Major changes were identified on villages, roads, and canals.

Appendix I

Scope of Work and Minutes of Meeting for the Reconnaissance Survey Project for the Establishment of an Emergency Rehabilitation and Reconstruction of the Kingdom of Cambodia Agreed upon between Ministry of Public Works and Transportation and Japan International Cooperation Agency

SCOPE OF WORK

FOR

THE RECONNAISSANCE SURVEY PROJECT

FOR THE ESTABLISHMENT

OF AN EMERGENCY REHABILITATION AND RECONSTRUCTION

OF THE KINGDOM OF CAMBODIA

AGREED UPON BETWEEN

MINISTRY OF PUBLIC WORKS AND TRANSPORTATION

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

PHNOM PENH, MARCH 12th, 1996

H.E. YOU HOCKRY
for, H.E. ING KIETH
DEPUTY PRIME MINISTER,
MINISTER OF PUBLIC WORKS AND
TRANSPORT
OF THE KINGDOM OF CAMBODIA

MASATOSHI NAGAOKA
LEADER OF
THE PREPARATORY STUDY TEAM
JAPAN INTERNATIONAL
COOPERATION AGENCY

I. INTRODUCTION

In response to the request of the Government of the Kingdom of Cambodia the Government of Japan has decided to conduct the Reconnaissance Survey Project for the Establishment of an Emergency Rehabilitation and Recconstruction (hereinafter referred to as "the Study") in accordance with the relevant laws and regulations in force in Japan.

Accordingly, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programmes of the Government of Japan, will undertake the Study in close cooperation with the authorities concerned of the Government of the Kingdom of Cambodia.

Ministry of Public Works and Transport (hereinafter referred to as "MPWT") shall act as counterpart agency to the Japanese Study team (hereinafter referred to as "the Team") and also as coordinating body in relation with other governmental and non-governmental organizations concerned for the smooth implementation of the Study.

The present document sets forth the Scope of Work with regard to the Study.

II. OBJECTIVES OF THE STUDY

The objectives of the study is to prepare the topographic and thematic information covering an area of approximately 80,000km², and to transfer thetechnology.

III. SCOPE OF THE STUDY

In order to achieve the objective mentioned above, the Study shall cover following items. (The technical details are shown in Appendix-1)

1. Satellite Images

New SPOT-3 Images and existing Landsat Images shall be used.

Horizontal and vertical control points shall be based on existing topographic maps.

2. Stereo Plotting

Stereo Plotting shall be carried out using computers by satelite images.

3. Compilation

Compilation shall be carried out based on restitution manuscripts.

4. Thematic map data acquisition

Land use, surface geological/geomorphological information shall be interpreted using satellite images.

These thematic information shall be verified by Cambodian side.

5. Printing of maps

Topographic map and land use map shall be printed at 1/100,000 scale.

Surface geological/geomorphological map shall be printed at 1/500,000 scale.

IV. STUDY SCHEDULE

The whole work will be conducted in accordance with the attached tentative schedule (Appendix-2).

V. REPORTS AND FINAL RESULTS

A report shall be presented to MPWT by JICA every fiscal year (from April to March). The materials mentioned in Appendix-1 will be submitted to MPWT by the Government of Japan.

All maps produced under the Study shall bear at the lower margin the following:

"This map was prepared jointly by Japan International Cooperarion Agency (JICA) under the Japanese Government Technical Cooperation Program and the Government of the Kingdom of Cambodia."

VI. UNDERTAKING OF THE GOVERNMENT OF CAMBODIA

1. To facilitate smooth conduct of the Study, the Royal Government of Cambodia shall take necessary measures for the Team.

(1) to secure the safety of the Team

(2) to permit the members of the Team to enter, leave and stay in Cambodia for the duration of their assignment therein, and exempt them from foreign registration requirements and consular fees,

(3) to exempt the members of the Team from taxes, duties and any other charges on equipment, machinery and other materials brought into and out of the Kingdom of Cambodia for the conduct of the Study,

(4) to exempt the members of the Team from income tax and charges of any kind imposed on or in connection with any emoluments or allowances paid to the members of the Team for their services in connection with the implementation of the Study,

(5) to provide necessary facilities to the Team for remittance as well as utilization of the funds introduced into the Kingdom of Cambodia from Japan in connection with the implementation of the Study,

(6) to secure permission for the Team to take all data and documents (including maps and photographs) related to the Study out of the Kingdom of Cambodia to Japan, and

(7) to provide medical services as needed. Its expenses will be chargeable on members of the Team.

2. The Royal Government of Cambodia shall bear claims, if any arises, against the members of the Team resulting from, occurring in the course of, or otherwise connected with, the discharge of their duties in the implementation of the Study, except when such claims arise from gross negligence or willfull misconduct on the part of the members of the Team.

3. MPWT shall act as counterpart agency to the Japanese Study team and also as coodinating body in relation with other governmental and non-governmental organizations concerned for the smooth implementation of the Study.

4. MPWT shall, at its own expense, provide the Team with the following, in cooperation with other organizations concerned:

(1) available data and information (such as interpretation key) related to the Study,

(2) counterpart personnel,

(3) suitable office space with necessary equipments in Phnom-Pehn.

(4) credentials or identification cards to the members of the Team,

(5) administrative and technical support,

(6) information of necessary administrative boundaries, geographical names and other necessary information on the maps, at its full responsibility,

(7) annotation sheets in the Kingdom of Cambodia.

VII. UNDERTAKING OF JICA

For the implementation of the Study, JICA shall take the following measures:

1. to dispatch, at its own expense, the Study team to the Kingdom of Cambodia and
2. to pursue technology transfer to the Cambodian counterpart personnel in the course of the Study.

VIII. OTHERS

JICA and the MPWT shall consult with each other inrespect of any matter that is not agreed upon in this document and may arise from or in connection with the Study.

APPENDIX-1

Principal Technical Specification

1. Topographic Mapping

(1) Projection	: UTM Projection
(2) Sheet Line	: 30' in Longitude × 30' in latitude
(3) Reference Ellipsoid	: Everest 1830
(4) Main Contour Interval	: 40 m
(5) Number of Colors	: 4 colors

FINAL RESULTS

1. Satellite Image

(1) satellite image used in the Study

2. Topographic Mapping

(1) 100 copies of digital data files (ex. CD-ROM)

(2) 2000 copies of printed topographic maps for each sheet

3. Thematic Mapping

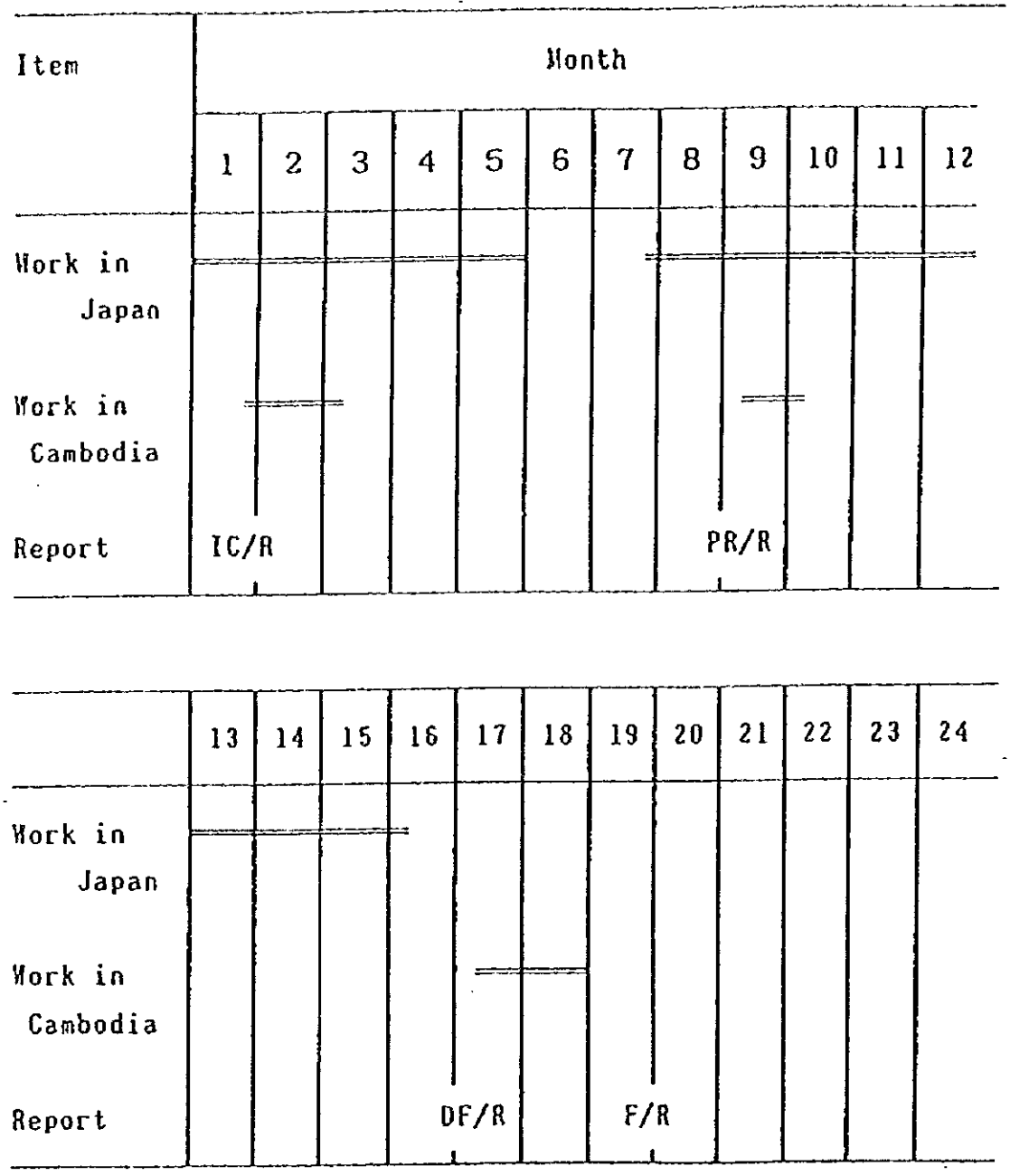
(1) 100 copies of digital data files (ex. CD-ROM)

(2) 2000 copies of printed land use maps for each sheet

(3) 1000 copies of printed surface geological/ geomorphological maps

APPENDIX-2

TENTATIVE STUDY SCHEDULE



Note: IC/R :Inception Report DF/R :Draft Final Report
PR/R :Progress Report F/R :Final Report

MINUTES OF MEETING
ON
THE SCOPE OF WORK
FOR
THE RECONNAISSANCE SURVEY PROJECT
FOR THE ESTABLISHMENT
OF AN EMERGENCY REHABILITATION AND RECONSTRUCTION
OF THE KINGDOM OF CAMBODIA

AGREED UPON BETWEEN
MINISTRY OF PUBLIC WORKS AND TRANSPORTATION
AND
JAPAN INTERNATIONAL COOPERATION AGENCY

PHNOM PENH, MARCH 12th, 1996

H.E. YOU HOCKRY
for, H.E. ING KIETH
DEPUTY PRIME MINISTER,
MINISTER OF PUBLIC WORKS AND
TRANSPORT
OF THE KINGDOM OF CAMBODIA

MASATOSHI NAGAOKA
LEADER OF
THE PREPARATORY STUDY TEAM
JAPAN INTERNATIONAL
COOPERATION AGENCY

The Preparatory Study Team (hereinafter referred to as "the Team"), for The Reconnaissance Survey Project for the Establishment of an Emergency Rehabilitation and Reconstruction in the Kingdom of Cambodia (hereinafter referred to as "the Study") organized by Japan International Cooperation Agency (hereinafter referred to as "JICA") visited the Kingdom of Cambodia from March 5th to March 12th, and had a series of discussions with the Cambodian side represented by Ministry of Public Works and Transport (hereinafter referredto as "MPWT") and Integrated Resources Information Center (hereinafter referredto as "IRIC").

The list of the attendants of the meetings is shown in attached Appendix-1.

The contents of the Study discussed through the meetings are as mentioned below.

(1) Mapping Area and Scale

Both sides agreed that the mapping area shall be approximately 80,000km^2, and it can be changed depend on the estimated cost of the Study.

Projected area is shown in attached map roughly, and it shall be decided at the beginning of the full scale Study.

(2) Surface geological/geomorphological map

MPWT stated that Cambodia will make surface geological/geomorphological interpretation at 1/100,000 by themselves.

(3) Satellite Images

The Japanese side agreed that one copy of SPOT and Landsat Image at 1/100,000 scale shall be provided to Cambodia.

(4) Interpretation keys

MPWT agreed that the interpretation keys for land use map data, surface geological/geomorphological map data shall be prepared by the beginning of the full scale Study by MPWT.

(5) Verification of Land Use Map

MPWT agreed that Land Use Map data shall be verified by MPWT within two(2) months after the preparation of land use draft map.

(6) Distribution

Both side agreed that every map sheets and data shall be distributed to public which need to use these map sheets and data.

(7) Technical Transfer

MPWT requested the Japanese side to receive the Cambodian counterparts training in Japan and also requested to hold a workshop and on the job training at the end of the Study for the technology transfer.

The Team promised to convey the request to JICA.

(8) Equipment

The Cambodian side requested the Japanese side to provide a computer with necessary equipment and software for operating digital map data.

The Team promised to convey the request to JICA.

Appendix-1.

Attendance List

The Cambodian side

1. H.E.Khy Taing Lim	Represent of Minister of Public Works and Transport
2. Chea Sieng Hong	Director of IRIC
3. Dr. Heng Thung	Adviser for MPWT
4. Dirk Vanderstighelen	Adviser for IRIC

The Japanese Side

1. Masatoshi Nagaoka	Leader
2. Shigeru Ushio	Cooperation Policy
3. Yoshikazu Fukushima	Survey Planning
4. Yuji Ikeda	Study Planning
5. Takashi Harada	Digital Mapping
6. Yuji Ouchi	Photogrammetry
7. Shigemitsu Tsukamoto	First Secretary, Embassy of Japan
8. Koji Sakane	Assistant Resident Representative, JICA Cambodia Office

QUESTIONNAIRE

OF

JICA PREPARATORY STUDY TEAM

FOR

THE RECONNAISSANCE SURVEY PROJECT FOR THE ESTABLISHMENT

OF

AN EMERGENCY REHABILITATION AND RECONSTRUCTION

OF THE KINGDOM OF CAMBODIA

MARCH, 1996

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

SS(FAX)427号 2/5

This questionnaire is prepared by the JICA preparatory Study Team for the Reconnaissance Survey Project for the Establishment of an Emergency Rehabilitation and Reconstruction (hereinafter referred to as "the Study") so as to obtain basic information and data required for the Study.

Please try to answer all the questions in English and also identify materials requested in this questionnaire.

It would be highly appreciated if you could prepare replies for all questions listed hereunder before the Study Team's arrival in the Kingdom of Cambodia.

Based on the filled-in questionnaire, the Study Team hopes to ask for additional data/information for further clarification during the mission.

Thank you for your kind cooperation in advance.

I. GENERAL

The Prepataroty Study Team would like to receive general explanation and related information on the following issues at the occasion of 1st meeting:

(1) Background and priority of the Project
(2) Conditions of existing maps and aerial photographs
(3) Actions / discussions having been undertaken / being undertaken between the Royal government of Cambodia and international organizations (such as World Bank, UNDP etc.) in connection with the Project or Survey of the Kingdom of Cambodia.
(4) Mapping project by the Royal government of Cambodia and international organizations (such as World Bank, UNDP etc.) .
(5) Budgetary / manpower / survey equipment situations of Survey Department of the Kingdom of Cambodia for the past five years.
(6) Details of existing and on-going mapping / survey project

II. Confirmation of contents of your request

(1) Area and Scale of aerial photography, topographic mappinhg
(2) Contour interval
(3) Projection
(4) Reference Ellipsoid
(5) Sheet line
(6) Number of colors

III. AVAILABLE DATA/INFORMATION ORGANIZATIONS AND FACILITIES

ITEM OF NECESSARY DATA	AVAILABILITY		NAME OF MATERIALS
	AVAILABILITY	PLACE OF DATA AVAILABLE	
1. Central Government Organzation			
(1) Organization chart			
(2) Related organizations of this project			
2. Annual national budget with breakdown			
3. Organzation of Institute of Geography			
(1) Organization chart			
(2) Number of employees			
(3) Trainning system			
(4) Annual report			
4. List of equipments			
(1) EDM			
(2) Theodolite			
(3) Level			
(4) Comparator			
(5) Plotter			
(6) Computer			
(7) GPS			
(8) Others			

SS(FAX)4278 5/5

TECHNICAL DATA/INFORMATION

ITEM OF NECESSARY DATA	AVAILABILITY		NAME OF MATERIALS
	AVAILABILITY	PLACE OF DATA AVAILABLE	
1. Control point survey (horizontal and vertical (1) Index maps, description of points, control data (2) Number and location of real existing points (3) Datum			
2. Maps (1) Existing topografic and thematic maps (2) Specification of topografic mapping (3) Laws and regulation of map			
3. Aerial photography (1) Existing aerial photographs for the proposed area (2) Facilities for aerial photo processing			
4. Meteotological data in the proposed area (1) Rain fall and Temperature by months (2) Amount of cloud by months			

SS(FAX)ﾒｰﾙ 5/5

（収集資料）

1．縮尺１：５０，０００　　（対象地域のほぼ全域をカバー）

1)	SHEET	5535	I			
2)		5536	I	II	III	
3)		5634	I	II	III	IV
4)		5635	I	II	III	IV
5)		5636	I	II	III	IV
6)		5630		II		
7)		5729	I			IV
8)		5730	I	II	III	IV
9)		5731	I	II	III	IV
10)		5733	I			
11)		5734	I	II	III	IV
12)		5735	I	II	III	IV
13)		5736		II	III	
14)		5829	I			
15)		5830	I	II	III	IV
16)		5831	I	II	III	IV
17)		5832	I	II	III	IV
18)		5833	I	II	III	IV
19)		5834	I	II	III	IV
20)		5835	I	II	III	IV
21)		5836			III	
22)		5929				IV
23)		5930	I	II	III	IV
24)		5931	I	II	III	IV
25)		5932	I	II	III	IV
26)		5933	I	II	III	IV
27)		5934	I	II	III	IV
28)		5935			III	
29)		6030	I	II		IV
30)		6031	I	II	III	IV
31)		6032	I	II	III	IV
32)		6033	I	II	III	IV
33)		6034	I	II	III	IV
34)		6130	I			IV
35)		6131	I	II	III	IV
36)		6132	I	II	III	IV
37)		6133	I	II	III	IV
38)		6230				IV
39)		6231			III	
		合　計				121図葉

2．縮尺１：５０，０００インデックスマップ

3．縮尺１：５００，０００土地被覆分類図（１９９２／９３）

4．点の記（プノンペン，シェムリアップ地区－１９９３／９４）

MINUTES OF MEETING

ON

THE RECONNAISSANCE SURVEY PROJECT

OF

AN EMERGENCY REHABILITATION AND RECONSTRUCTION

OF

THE KINGDOM OF CAMBODIA

AGREED UPON BETWEEN

MINISTRY OF PUBLIC WORKS AND TRANSPORTS

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

PHNOM PENH, DECEMBER 6th, 1996

H. E. Khy Taing Lim
REPRESENTING
THE MINISTRY OF PUBLIC
WORKS AND TRANSPORTS
OF THE KINGDOM OF CAMBODIA

Dr. Yoshitake Egawa
LEADER OF THE STUDY TEAM
JAPAN INTERNATIONAL
COOPERATION AGENCY

The Study Team headed by Dr. Yoshitake Egawa for The Reconnaissance Survey Project for the Establishment of an Emergency Rehabilitation and Reconstruction in the Kingdom of Cambodia (hereafter referred to as "the Study") organized by Japan International Cooperation Agency (hereafter referred to as "JICA") visited the Kingdom of Cambodia on November 28th, 1996, and had a series of discussion on the Inception Report on the Study with the team of the Ministry of Public Works and Transports (hereafter referred to as "MPWT") headed by Mr. Khy Taing Lim.

The list of the attendants of the meeting is shown in attached Appendix-I

(1)Overview

The Inception Report proposed by the Study team was discussed during the meetings and agreed basically by MPWT.

It is agreed that some contents of the Study described in the Inception Report, that are mentioned below to be modified or to be discussed further.

(2)Mapping Area

Both sides agreed that the mapping area shall be approximately 80,000km^2.

MPWT requested to change the outline of the area for the Study slightly from the preliminary map proposed in the Inception Report as shown on the attached map in Appendix-II.

The Study team replied that the team will inform their request to JICA headquarters to decide on the new Study area before the Study team leaves Cambodia.

(3)Landuse Map and Surface Geological/Geomorphological Map

The Study team proposed that the number of printed sheets of the Landuse Map and Surface Geological/ Geomorphological Map should be reduced to save the cost of printing. The Study team offered to provide those thematic maps printed by color ink-jet plotter. The number of each map sheet should be about 20 sheets.

MPWT agreed to this proposal under the condition that additional \ink-jet plotters and supplies for printing such thematic maps will be supplied in exchange to allow Cambodian agencies produce maps by themselves.

(4)JERS-1 Images

The Study team proposed that SAR(Synthetic Aperture Radar) image taken by JERS-1(Japan Earth Resources Satellite) will be used to obtain the shore line of the Tonle Sap Lake during the rainy season even though this was not been mentioned in the Scope of Works agreement.

MPWT accepted this offer.

(5)Legend and Map Symbols

Both sides agreed to determine the map legends and map symbols before the Study team leaves Cambodia.

MPWT accepted the contents of notation to be printed in map sheets proposed in the Inception Report after a minor change of words.

(6)Cooperation

MPWT stated that cooperation between MPWT and other organizations is quite important for the Study, therefore they would do their best to coordinate this effort.

MPWT stated that they will assist in collecting existing maps and other information needed for the Study.

(7)Technology Transfer

MPWT accepted the basic concept of technology transfer described in the Inception Report.

MPWT asked that on-the-job training(OJT) during the Study is to be considered.

The Study team replied to make effort to provide technology transfer as OJT as much as possible.

(8)Training in Japan

MPWT asked to provide maximum possible numbers of trainees to be invited to Japan during the Study period to learn the skills related the creation of geographical data sets as well as operation and management of GIS.

The Study team replied that the request will be conveyed to JICA headquarters.

(9)Equipment

Both sides agreed to continue discussions to establish the equipment requirements to be donated to Cambodia during this Study, including ink-jet plotters and supplies mentioned in term (3)

Appendix-I

Attendants List

The Cambodian Side

1. H.E. Khy Taing Lim	Represent of the Ministry of Public Works and Transports
2. Mr. Chea Sien Hong	Director of IRIC
3. Dr. Heng Thung	Adviser for MWPT
4. Mr. Khun Sokka	Technical Staff of CNMC

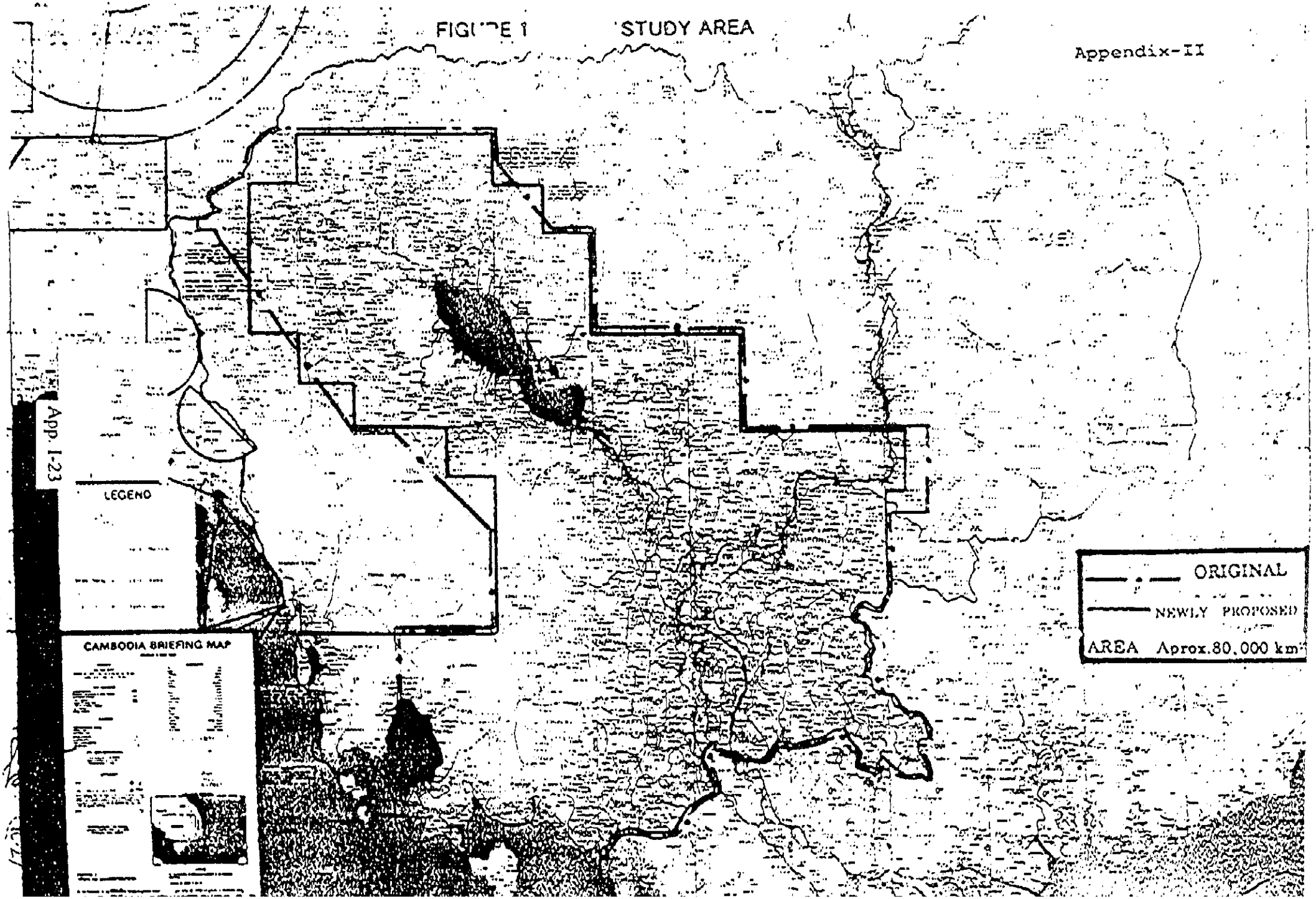
The Japanese Side

1. Dr. Yoshitake Egawa	Leader
2. Dr. Yu Hirai	Deputy Leader
3. Mr. Tetsuro Imakiire	Map information planning
4. Mr. Fujio Ito	Chief Engineer, (Topographic Map)
5. Mr. Eiichi Hayakawa	Chief Engineer, (Thematic Map)
6. Mr. Awadh Kishor Sah	Engineer, (Landuse)
7. Mr. Hiroshi Enomoto	JICA Cambodia Office

(Advisory Group)

1. Mr. Yoshikazu Fukushima	Geographical Survey Institute
2. Mr. Kazumasa Haraguchi	Geographical Survey Institute
3. Mr. Toru Hayakawa	JICA Headquarters

FIGURE 1 STUDY AREA



INCEPTION REPORT

FOR

THE RECONNAISSANCE SURVEY PROJECT

FOR THE ESTABLISHMENT

OF

AN EMERGENCY REHABILITATION AND RECONSTRUCTION

OF THE KINGDOM OF CAMBODIA

NOVEMBER 1996

JAPAN INTERNATIONAL COOPERATION AGENCY

MINUTES OF MEETING

ON

THE RECONNAISSANCE SURVEY PROJECT

OF

AN EMERGENCY REHABILITATION AND

RECONSTRUCTION

OF

THE KINGDOM OF CAMBODIA

AGREED UPON BETWEEN

MINISTRY OF PUBLIC WORKS AND TRANSPORTS

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

PHNOM PENH, DECEMBER 13th, 1996

H.E. ING KIETH
DEPUTY PRIME MINISTER,
THE MINISTRY OF PUBLIC
WORKS AND TRANSPORTS OF
THE KINGDOM OF CAMBODIA

Dr. Yoshitake Egawa
LEADER OF THE STUDY TEAM
JAPAN INTERNATIONAL
COOPERATION AGENCY

The JICA Study Team (referred to as the Team hereafter) headed by Dr. Yoshitake Egawa visited the Kingdom of Cambodia on the 28th of November,1996 to carry out the first consultation with the team of the Ministry of Public Works and Transports (hereafter referred to as "MPWT") headed H.E Ing Kiet, represented by Mr. Khy Taing Lim for the Reconnaissance Survey Project for Establishment of an Emergency Rehabilitation and Reconstruction in the Kingdom of Cambodia (hereafter referred to as "the Study") organized by Japan International Cooperation Agency (hereafter referred to as "JICA")
A series of technical discussion were held at MPWT during the 6th-13th of December,1996 based on the Inception Report.
The following items were discussed and mutually agreed upon between MPWT and the Team.
The list of the Attendants is shown in Annex I.

(1) Mapping Area

Proposed Area from MPWT was accepted by the Team as shown on the attached map in Appendix-II.

(2) Legend and Map Symbols

MPWT provided the map legends and symbols for Land-use and geology/geomorphology. The team stated that a new map legends and symbols will be proposed to MPWT on the second consultation.

MPWT asked to the Team to make the design of map symbols and margin information to be used in the topographic maps. The team stated that a new map legend and symbols of the topographic maps will be proposed to MPWT on the second consultation.

(3) Discussion on equipment to be supplied

MPWT submitted a list of equipment to the Team that will be used for implementation of the project.

The Study team will inform the request above to JICA headquarters.

Appendix-I

Attendants List

The Cambodian Side

1. H.E. Khy Taing Lim	Represent of the Ministry of Public Works and Transports
2. Mr. Chea Sren Hong	Director of IRIC
3. Dr. Heng Thung	Adviser for MPWT
4. Mr. Khun Sokka	Technical Staff of CNMC

The Japanese Side

1. Dr. Yoshitake Egawa	Leader
2. Dr. Takeshi Hirai	Deputy Leader
3. Mr. Tetsuro Imakiire	Map information planning
4. Mr. Fujio Ito	Chief Engineer, (Topographic Map)
5. Mr. Eiichi Hayakawa	Chief Engineer, (Thematic Map)
6. Mr. Awadh Kishor San	Engineer, (Landuse)

PROVINCE AND DISTRICT BOUNDARIES
FIGURE 1 FINAL STUDY AREA
LEGEND
TAKEO
CAMBODIA BRIEFING MAP

MINUTES OF MEETING
FOR
THE RECONNAISSANCE SURVEY PROJECT
FOR THE ESTABLISHMENT
OF
AN EMERGENCY REHABILITATION AND RECONSTRUCTION
OF THE KINGDOM OF CAMBODIA

AGREED UPON BETWEEN
MINISTRY OF PUBLIC WORKS AND TRANSPORTS
AND
JAPAN INTERNATIONAL COOPERATION AGENCY

At Phnom Penh, Feburuary 28th, 1997

H.E.KHY TAING LIM
REPRESENT OF MINISTERY
OF PUBRIC WORKS AND
TRANSPORTS OF
THE KINGDOM OF CAMBODIA

TETSURO IMAKIIRE
for, Dr. YOSHITAKE EGAWA
TEAM LEADER OF
THE JICA STUDY TEAM

The Study team for "The Reconnaissance Survey Project for the Establishment of an Emergency Rehabilitation and Reconstruction in the Kingdom of Cambodia" (hereafter referred to as "the Study") organized by Japan International Cooperation Agency (hereafter referred to as "JICA") headed by Mr. Tetsuro IMAKIIRE as a representative of the team leader Dr. Yoshitake EGAWA visited the Kingdom of Cambodia on the 20th of February, 1997 to carry out the second stage of survey work for aerial photo and satellite image interpretation in technical cooperation with the Integrated Resource Information Center (hereafter referred as IRIC) managed by the Cambodia National Mekong Committee for the Ministry of Public Works and Transports(hereafter referred to as MPWT).

The meetings were held at National Mekong Committee and IRIC offices from the 24th February to 28th of Feburuary, 1997. The Study team explained the current status of the project. The MPWT accepted the study result and appreciated their effort and technical transfer.

The following items were discussed and mutually agreed upon by MPWT and Study team.

The list of attendants is shown in Annex 1.

1. (Map Symbols)

The Study team presented a draft of the map symbols legend for topographic mapping. MPWT accepted this draft for the printed topographic maps in scale of 1:100,000. The legend of map symbols are shown on Annex-2.

2.(Land Use and Landform Legends)

The Study team presented a draft of the land use and surface geology/ geomorphology legends. MPWT accepted this draft and those are shown on Annex-3 and Annex -4

3.(Hardware and Software Configuration of Equipment installed in future)

MPWT presented a draft of the proposed hardware and software configuration for the equipment to be installed to manage the GIS and the data provided by this study in the future. Study team promised to convey their request. The configuration of hardware and software is shown on Annex-5.

4.(Data Acquisition of SPOT Image)

The Study team reported the current status of data acquisition. Because of weather conditions, the acquisition of SPOT images is a little behind the schedule. The Study team explained that this delay will cause no problem because at least one image of each stereo pair has been taken for whole study area, therefore the ortho-image can be created using the existing topographic data. MPWT accepted this explanation. The current status of SPOT data acquisition is shown on Annex-6

5.(Request from MPWT)

MPWT requested three items to the Study team for the next step of technical cooperation.

First, MPWT requested to complete the geographic data covering the whole land area of Cambodia in next stage of the project.

Second, MPWT requested to the Study team to dispatch a long term expert to supervise the management of GIS established by this project.

Third, MPWT requested a further study of Tonle Sap shore line using radar remote sensing of different periods so that the dynamics of the flooding can be studied.

The Study team agreed to convey these requests to JICA headquarters.

ANNEX-1

Attendants List

The Cambodian Side

1. H. E. Khy Taing Lim	Represent of the Ministry of Public Works and Transports
2. Mr. Chea Sien Hong	Director of IRIC
3. Dr. Heng Thung	Adviser for MPWT
4. Mr. Khun Sokka	Project Assistant Coordinator

The Japanese Side

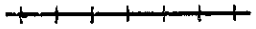
1. Mr. Tetsuro Imakiire	Map Information Planning
2. Mr. Fujio Ito	Chief Engineer, (Topographic Map)
3. Mr. Eiichi Hayakawa	Chief Engineer, (Thematic Map)
4. Mr. Hiroshi Enomoto	JICA Cambodia Office

ANNEX-2

CAMBODIA 1/100,000 MAP SYMBOLS

Items	No.	Designation	Symbols	Specifications	Color	
ROADS AND RELATED ROAD DATA	1	All weather Hard surface, two or more lanes wide.		Line weight 0.15 Width 0.8		
	2	All weather Hard surface, one lane wide.		Line weight 0.1 Width 0.6		
	3	All weather Loose surface, two or more lanes wide.		Line weight 0.15 Width 0.8		
	4	All weather Loose surface, one lane wide.		Line weight 0.1 Width 0.6		
	5	Dry weather Loose surface		Line weight 0.1 Width 0.6		
	6	Cart track		Line weight 0.2		
	7	Footpath		Line weight 0.15 Dash 2.0 , 0.5		
	8	Streets in Built-up Areas		Line weight 0.1 Width 0.4		
	9	Route Maker: National; other national	26 33	Line weight 0.15 Height 3.5		
	10	Traffic circle		same as double line roads line weight		

CAMBODIA 1/100,000 MAP SYMBOLS

Items	No.	Designation	Symbols	Color	Specifications
RAIL WAY	11	Railroad, Station			
	12	Railroad Light			
TRANSMISSIONS	16	Power transmission line			
	17	Power station			

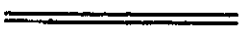
CAMBODIA 1/100,000 MAP SYMBOLS

Items	No.	Designation	Symbols	Color	Specifications
BUILDINGS AND STRUCTURES	21	Built-up area			
	22	Village			
	23	Khet office Srok office Khum office			
	24	Temple			
	25	School			
	26	Church			
	27	Mosque			
	28	Stupa			

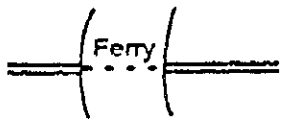
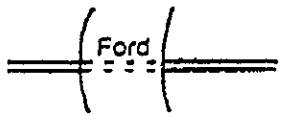
CAMBODIA 1/100,000 MAP SYMBOLS

Items	No.	Designation	Symbols	Color	Specifications
BUILDINGS AND STRUCTURES	29	Post office			
	30	Airfield			
	31	Cemetery			
	32	Lighthouse			

CAMBODIA 1/100,000 MAP SYMBOLS

Items	No.	Designation	Symbols	Color	Specifications
WATER AND ASSOCIATED FEATURES	41	River, stream, direction of flow			
	42	Intermittent stream			
	43	Lake or pond: Perennial			
	44	Lake or pond: Intermittent			
	45	Salt evaporator			
	46	Canal or ditch Less than 15 meters wide			
	47	Canal or ditch Over 15 meters wide			
	48	Water fall			

CAMBODIA 1/100,000 MAP SYMBOLS

Items	No.	Designation	Symbols	Color	Specifications
WATER AND ASSOCIATED FEATURES	49	Rapid			
	50	Undercut slope			
	51	Ferry			
	52	Ford			
	53	Bridge, wood			
	54	Bridge, steel			
	55	Bridge, concrete			
	56	Footbridge			

CAMBODIA 1/100,000 MAP SYMBOLS

Items	No.	Designation	Symbols	Color	Specifications
WATER AND ASSOCIATED FEATURES	57	Masonry dam			
	58	Earthen dam			
	59	wall; Levee			
	60	Concrete or stone revetment			
	61	Water pipeline			
	62	Spring			
	63	Water tower / tank			
	64	Well, Pump			

CAMBODIA 1/100,000 MAP SYMBOLS

Items	No.	Designation	Symbols	Color	Specifications
VEGETATION	71	Dense forest or jungle			
	72	Clear forest			
	73	Brushwood			
	74	Bamboo area			
	75	Scattered sugar palm			
	76	Plantation			
	77	Land subject to inundation			
	78	Marsh or swamp			

CAMBODIA 1/100,000 MAP SYMBOLS

Items	No.	Designation	Symbols	Color	Specifications
VEGETATION	79	Rice field			
	80	Nipa			
	81	Mangrove			
LANDSCAPE	82	Sand terrain			

CAMBODIA 1/100,000 MAP SYMBOLS

Items	No.	Designation	Symbols	Color	Specifications
GEOGRAPHY	91	Monolith, Scattered rocks rock outcrop			
	92	Rock wall, cliff			
	93	Earth crumbling			
	94	Small hill			
	95	Hole			
	96	Contour line, Contour line value			

CAMBODIA 1/100,000 MAP SYMBOLS

Items	No.	Designation	Symbols	Color	Specifications
CONTROL POINTS	101	Horizontal control point: Primary			
	102	Horizontal control point: Other			
	103	Bench mark	BM × 792		
	104	Spot elevation in meters	321		

CAMBODIA 1/100,000 MAP SYMBOLS

Items	No.	Designation	Symbols	Color	Specifications
BOUNDARIES	111	International boundary			
	112	Khet boundary			
	113	Srok boundary			