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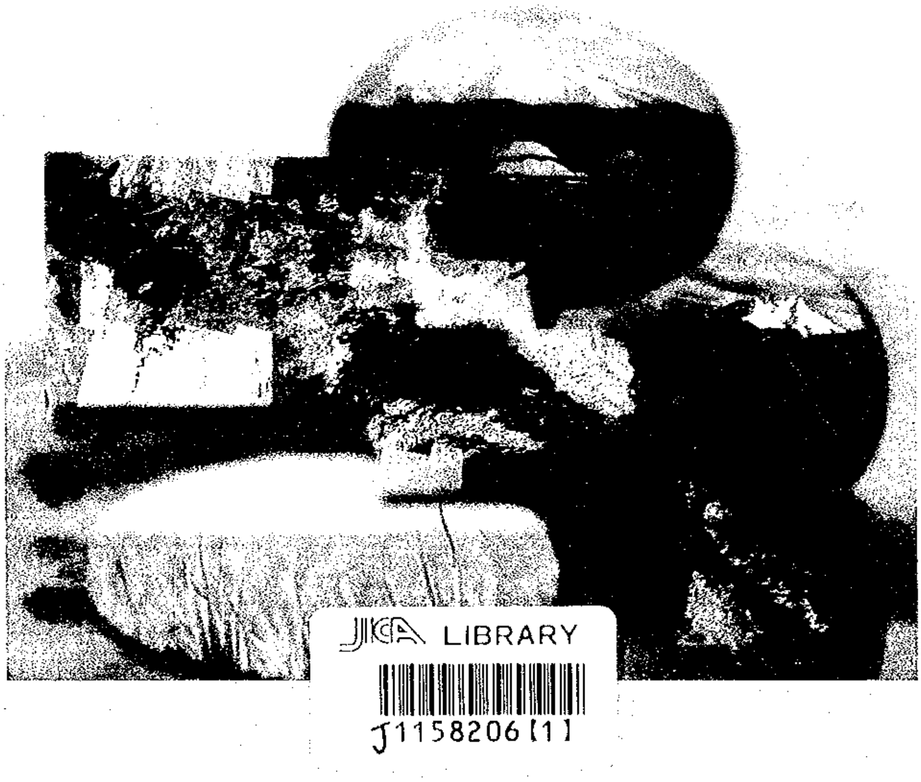


Exchange Rate

US$=T.139.40=J.Yen 109.80 (As of January 2000)

Japan International Cooperation Agency (JICA)

Agency of Republic of Kazakstan
on Land Resources Management

FINAL REPORT

THE STUDY
ON
THE URGENT ESTABLISHMENT
OF
NATIONAL BASIC GEOGRAPHIC DATA
IN
SOUTHERN AREA
OF
THE REPUBLIC OF KAZAKSTAN

February 2000

Aero Asahi Corporation

1158206 (1)

PREFACE

In response to a request from the Government of the Republic of Kazakstan, the Government of Japan decided to conduct a study on urgent establishment of national basic geographic data in the southern area of the Republic of Kazakstan and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Shigehiko Shino of the Aero Asahi Corporation three times between January 1997 and February 2000.

The team held discussions with the officials concerned of the Government of Kazakstan and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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 wish to express my sincere appreciation to the officials concerned of the Government of Kazakstan for their close cooperation extended to the Team.

February 2000

Kimio Fujita
President
Japan International Cooperation Agency

February 2000

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Mr. Fujita,

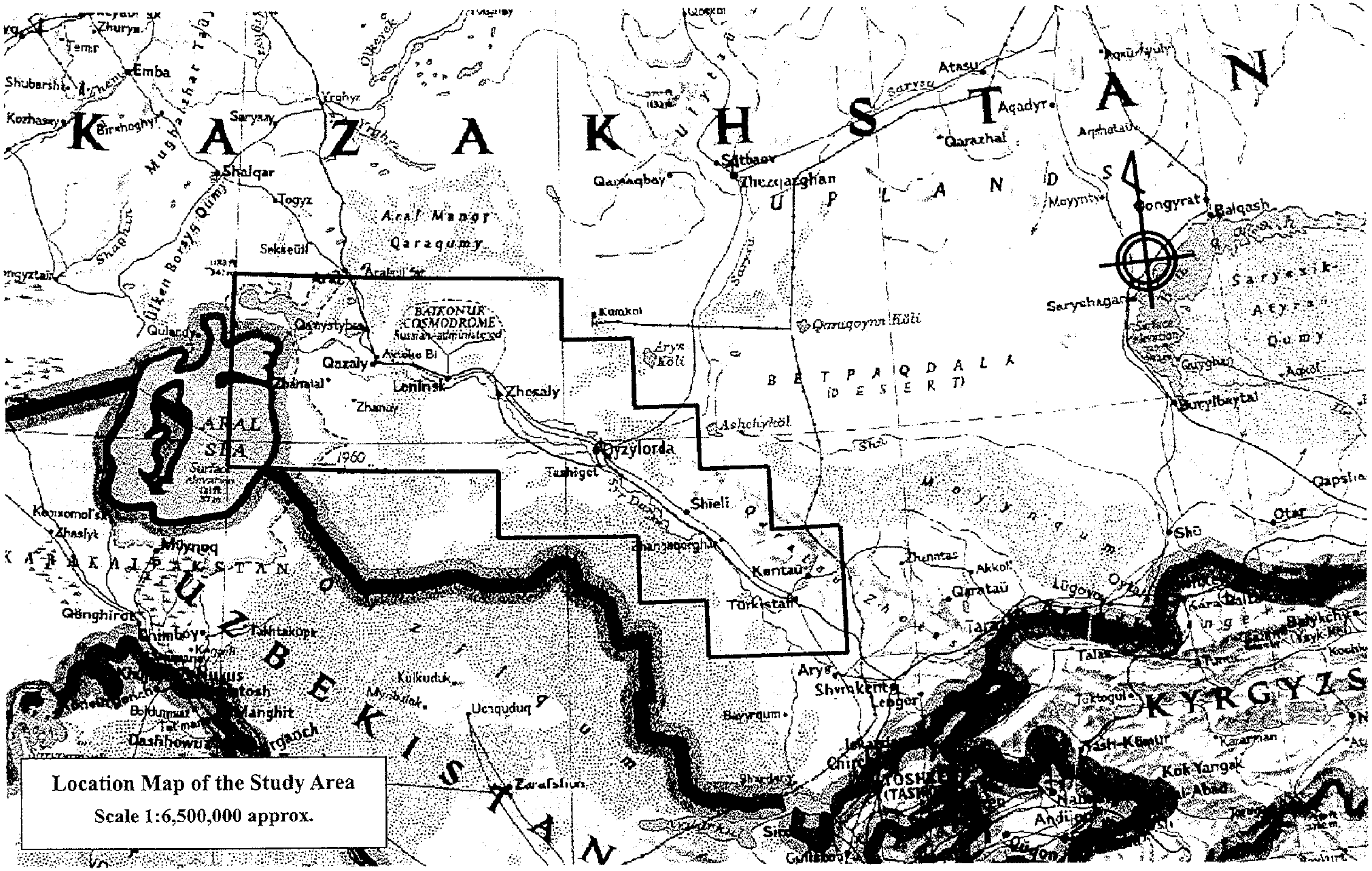
We are pleased to submit to you the final report on the Study on the Urgent Establishment of National Basic Geographic Data in Southern Area of the Republic of Kazakstan. The report contains the results of study for establishment of geographic information data, which was conducted from January 1998 to February 2000 for three years. The area of the study covers a part of Syrdaryra River Basin in Kyzylorda and South Kazakstan provinces located in southern area of the Republic.

In this report, method for development of digital geographic data and printed maps corresponding to topographic map in the scale of 1:100,000, digital geographic framework data corresponding to topographic map in the scale of 1:200,000 and chronological digital land cover data, technological transfer on the development of the data to Kazakstan counterparts as well as recommendation on utilization of the results in future are mentioned. The output of this study expects to be supplied as basis for various plans in future and utilized as basic data for geographic information systems (GIS).

Finally, we greatly appreciate the persons concerned of JICA, Ministry of Foreign Affairs, Ministry of Construction as well as Geographical Survey Institute, Japan. Also we acknowledge that we have granted considerable cooperation from Embassy of Japan in the Republic of Kazakstan, Agency of Republic of Kazakstan on Land Resource Management and other organizations concerned.

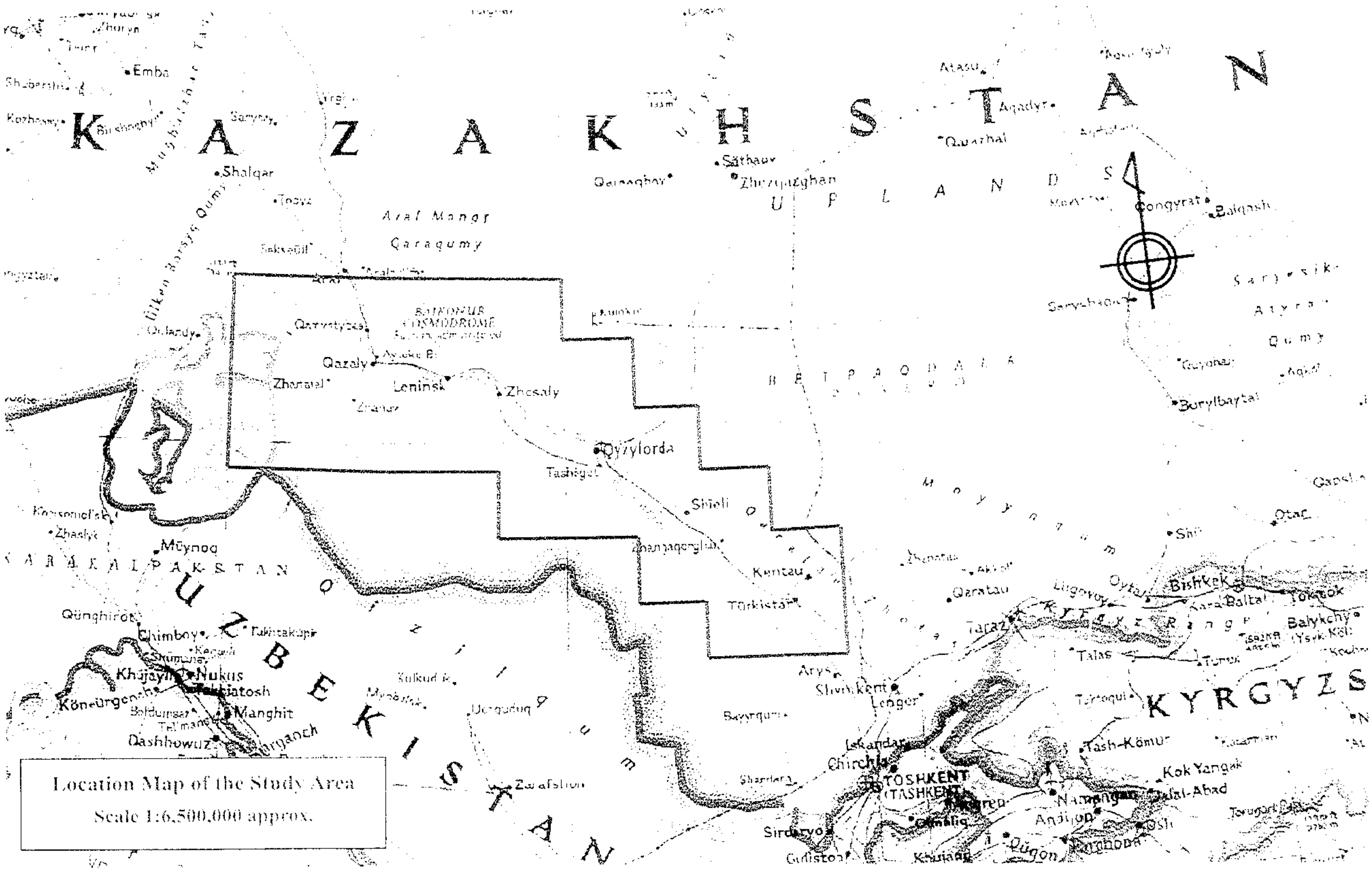
Very truly yours,

Sigehiko Shino
Team Leader
JICA Study Team



Location Map of the Study Area

Scale 1:6,500,000 approx.



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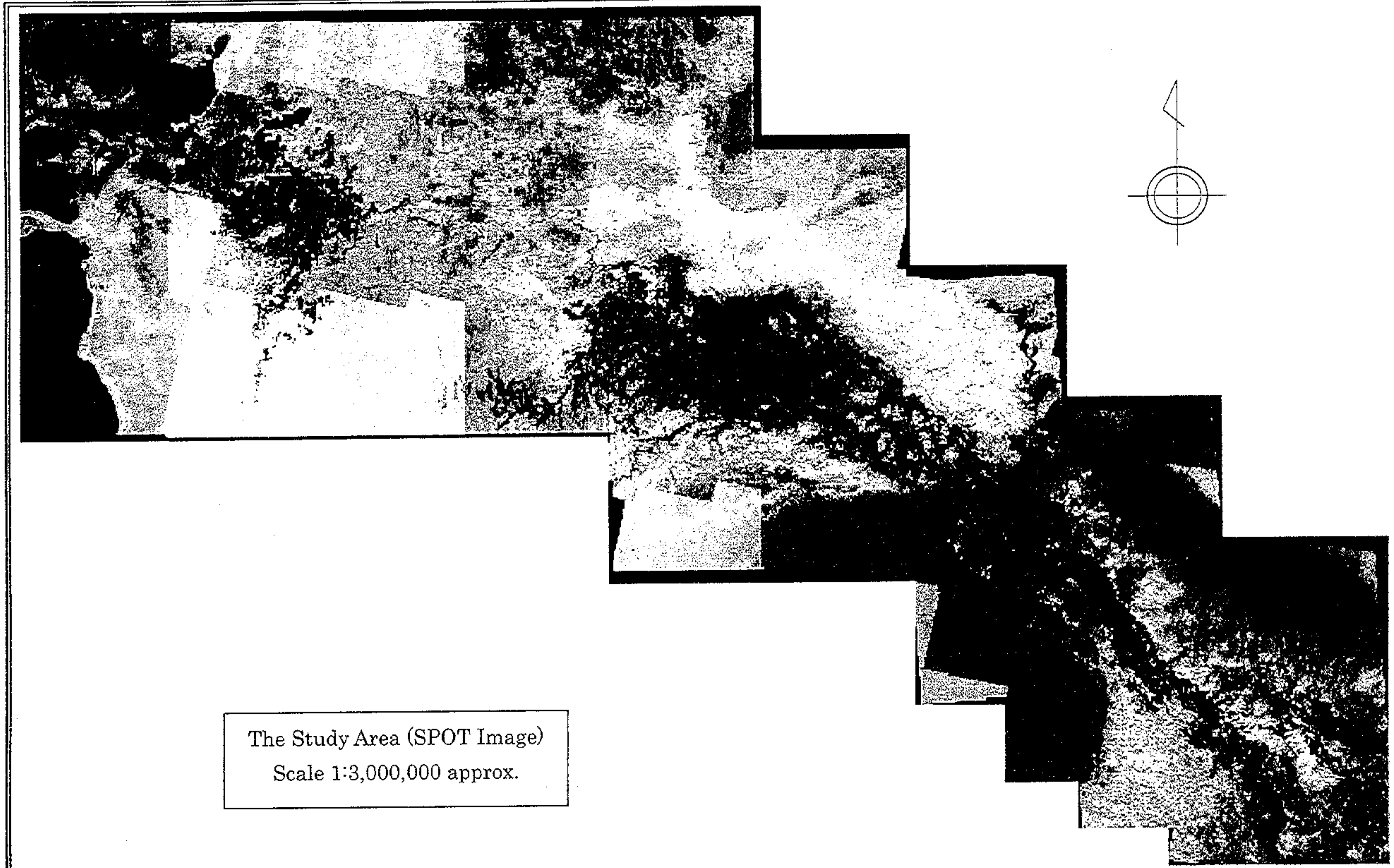


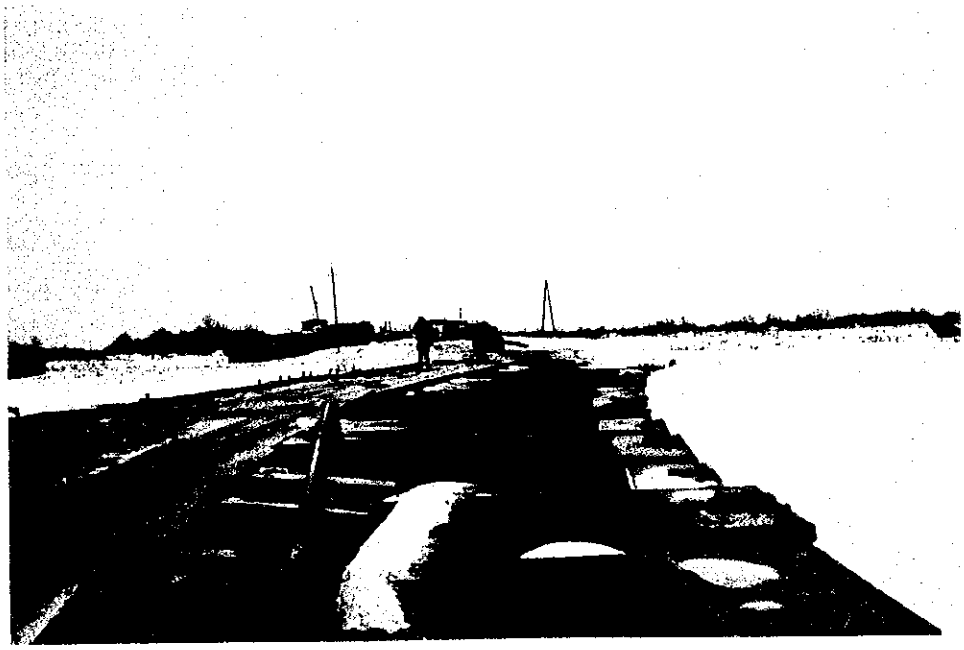
The Study Area (SPOT Image)
Scale 1:3,000,000 approx.

Explanation and discussion on the draft final report in Astana City

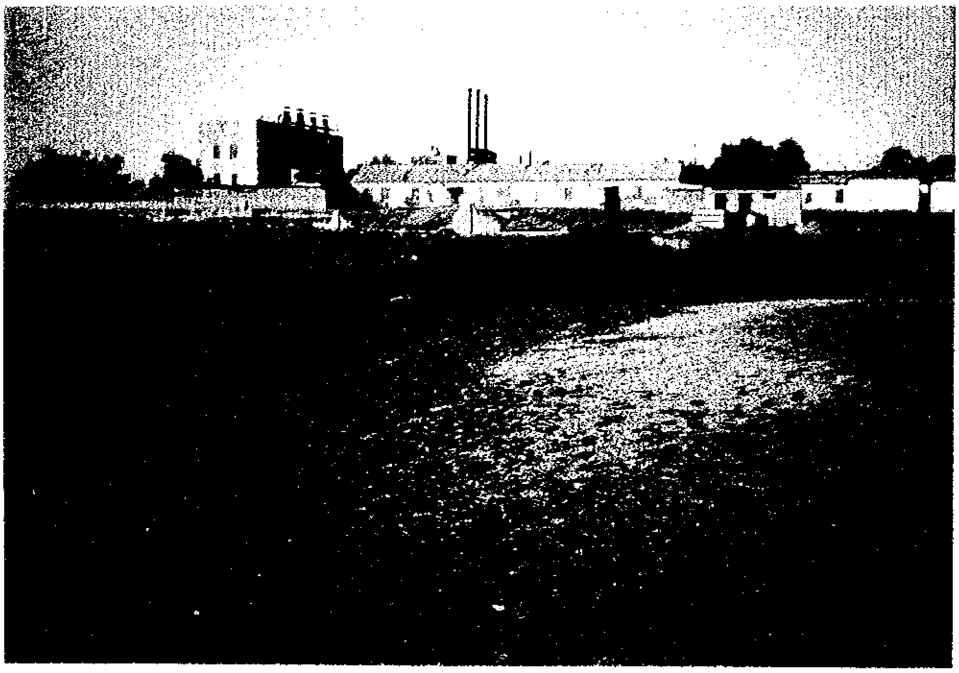
Takyr and Solonchak

The Aral Sea(Right side; the Small Aral, left side; the Large Aral

Syrdarya River (Summer)



Pontoon bridge over Syrdarya River (Winter)



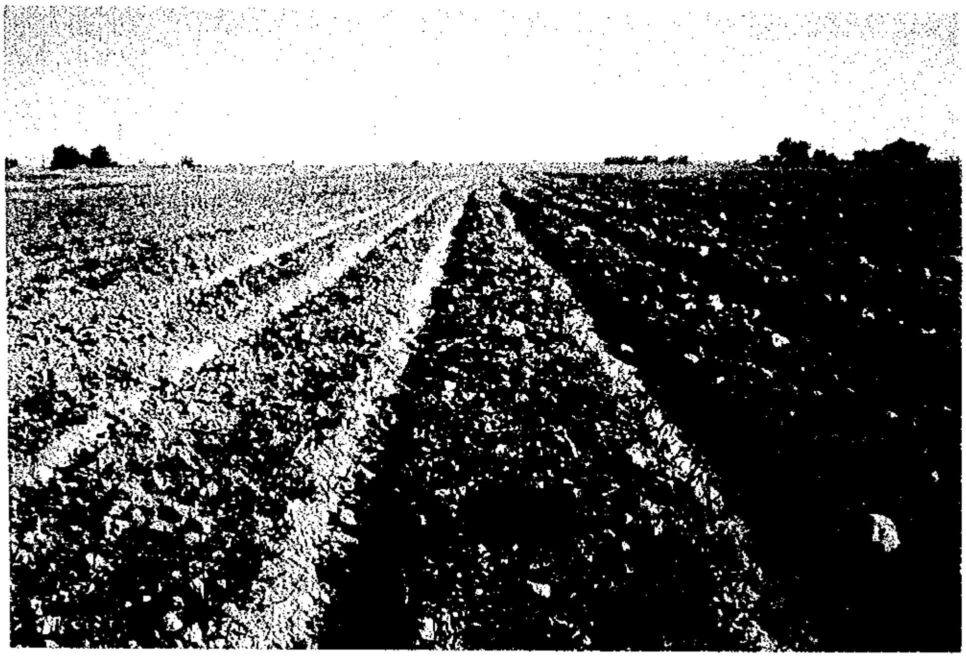
Aralisk Port

Shoreline of the Aral Sea

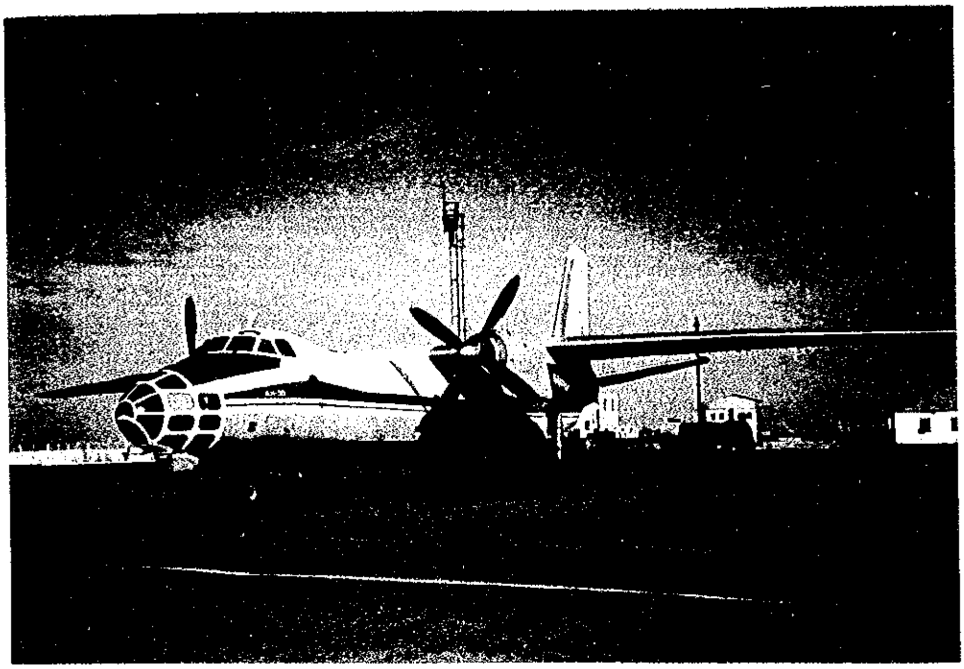
Cotton field

Watermelons (Local products)

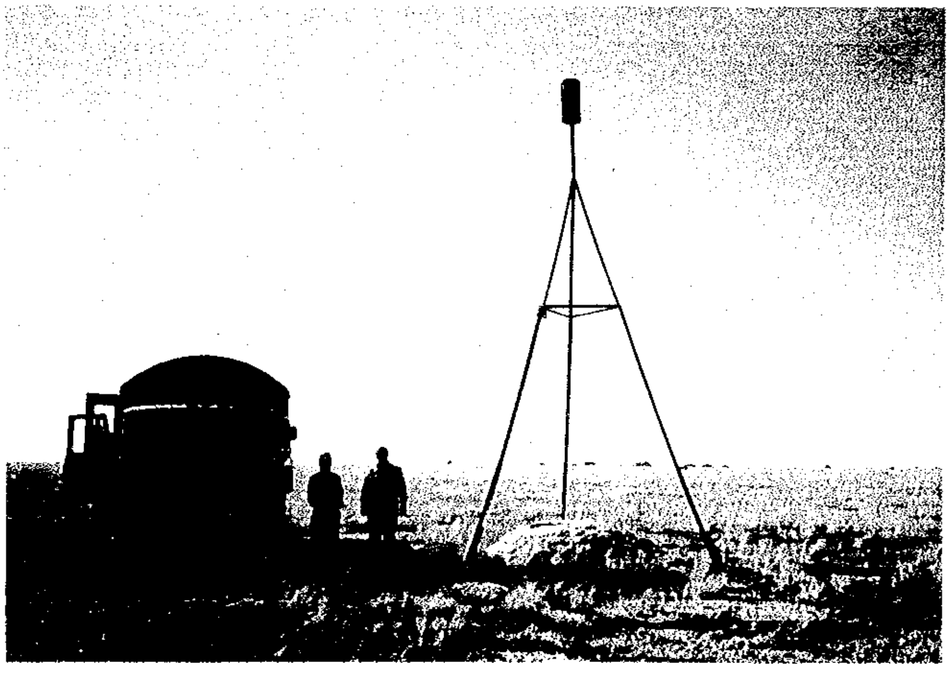
A reservoir in marshy land



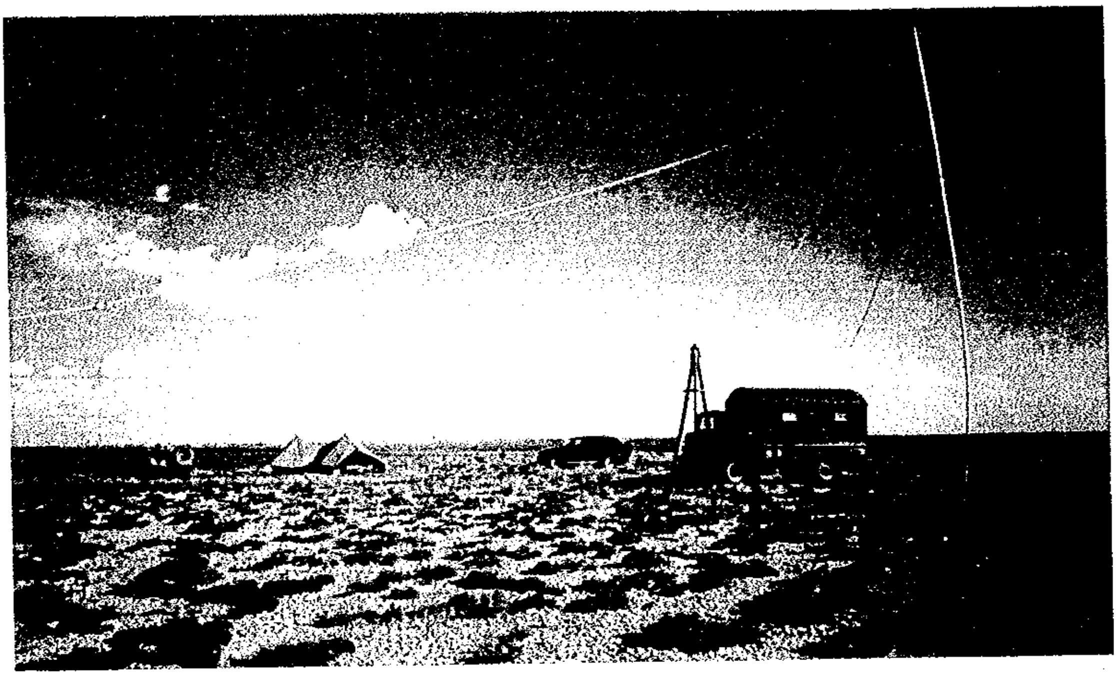
Wheat field



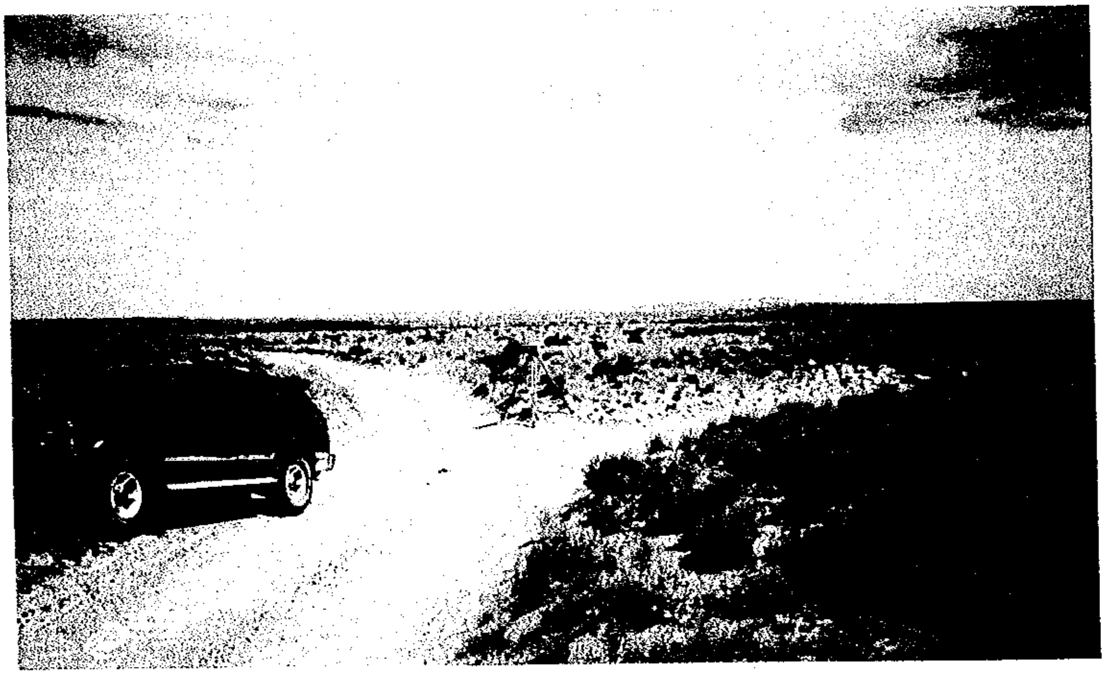
Antonov AN30 (Survey aircraft)



Triangulation station



Field camp



Geodetic control point survey by using GPS

Abbreviations

ALRM	Agency of Republic of Kazakstan on Land Resources Management
AN30	Antonov 30
B / W	Black and White
CAD	Computer Aided Design
CD-ROM	Compact Disk Read Only Memory
CK1942	Coordinate System 1942
DEM	Digital Elevation Model
DLL	Dynamic Link Library
DTM	Digital Terrain Model
F /Y	Fiscal Year
GCP	Ground Control Point
GCP-GPS	Ground Control Points derived from GPS observation
GCP-MAP	Ground Control Points derived from a Map
GIS	Geographic Information System
GPS	Global Positioning System
JICA	Japan International Cooperation Agency
JS	Joint Stock company
Lat.	Latitude
Long.	Longitude
MDL	MicroStation Development Language
MM^3	Million Cubic Meter
MO	Magnet Optical Disk
NDVI	Normalized Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
NVI	Normalized Vegetation Index
OJT	On the Job Training
pH	Potential of Hydrogen
Rainfl.	Rainfall
Rel. Hu.	Relative Humidity
RMS	Root Mean Square
SPOT	Systeme Probatoire d'Observation de la Terre
SPOT P	SPOT Panchromatic image
SPOT XI	SPOT Multispectral image
TAB	TABle file format of MapInfo system
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USA	United States of America
USSR	Union of Soviet Socialist Republics

Contents

Chapter 1. Introduction

1. Background to the Study

The total extent of the Republic of Kazakstan is approximately 2,717,500 km^2 which is covered by national base maps that were produced in the time of the former USSR. This series of national maps that are currently possessed and managed by the Department of Geodesy and Cartography, the Agency of Republic of Kazakstan on Land Resources Management are as follows:

(Maps)	(Quantities)	
1:1,000,000	:	19 sheets
1:200,000	: approx.	300 sheets
1:100,000	: approx.	1,200 sheets
1:50,000	: approx.	4,800 sheets
1:25,000	: approx.	19,200 sheets

These base maps used to be corrected and revised every five to eight years. However, since the latter part of the 1980-s such revision has not been undertaken due to practical reasons of financial stringency within the USSR. The situation after the independence of the Republic has also remained much the same as before. The excessive development of arable lands in the Syrdarya River basin, in the southern part of the Republic, has been ensued in a short period of time since 1950 under the agricultural policy imposed by the USSR. As a result of the development, substantial deterioration of agricultural productivity and the rural environment has occurred, including such changes as alternative land use development through civil works for irrigation, drying up and desertification of agricultural lands, lowering of ground water levels and salinization of soils.

These environmental changes have focused world attention on the ecological problems of the Aral Sea with the appeal "Save the Aral Sea!" Under the current situation a lot of projects have been proposed, such as restructuring of agricultural land use, improvement of the actual environment etc., by the neighboring countries, World Bank, UNDP, UNEP etc. The realization of these multi-framework environmental resource management programs and long-term projects however has in many instances become very difficult due to the lack of up to date base maps.

Taking into consideration the serious deterioration of the environment, the Government of Kazakstan requested Government of Japan technical cooperation for urgent revision of the national 1:200,000 scale topographic maps covering approximately 150,000 km^2 of the Syrdarya River basin in the southern part of the Republic and 1:100,000 scale topographic maps covering approximately 22,500 km^2 of those areas where substantial environmental changes can be observed.

In response to the request of the Government of Kazakstan, a contact mission was dispatched to Kazakstan from March to April 1997 to confirm the background and scope of work for the study by the Japan International Cooperation Agency (JICA). In June 1997 the preparatory study mission organized by JICA visited Kazakstan to conduct the preparatory study and finalize the scope of work for "Urgent Establishment of National Basic Geographic Data in the Southern Area of Kazakstan",(Appendix 1).

The study was carried out by Aero Asahi Corporation who were appointed and authorized by JICA as a trustee, from January 1998 to March 2000 in accordance with the determined scope of work.

2. Objective of the Study

The study was implemented by using satellite images and new 1:50,000 scale aerial photography covering 150,000 km^2 of the study area. The study was thus to include:

(1) Development of digital geographic data and printed maps corresponding to national topographic maps at the scale of 1:100,000 (area: approx. 22.500 km^2)

(2) Development of digital geographic framework data corresponding to national topographic maps at the scale of 1:200,000 (area: approx. 150,000 km^2 including the above mentioned 22,500 km^2)

(3) Development of chronological digital land cover data (area: approx. 150,000 km^2)

(4) Technology transfer by OJT to the Kazakstan counterpart personnel engaged in the respective stages of the study.

3. Relevance of the Study

(1) Location

The selected study area of 150,000km^2 has many problems needing in depth study and urgent solutions. Foremost of these are such ecological problems of the diminishing Aral Sea, and desertification of the most vital irrigated agricultural lands of the Republic.

(2) Satellite image digital mapping

The study enables Kazakstan to develop new geographic data for other priority areas of the Republic by using new satellite image data and the latest digital mapping technology. This was to be achieved through technical transfer and supply of relevant equipment to Kazakstan whereby new map information can be generated of vast areas in a short period of time.

(3) Digital geographic framework data and its future utilization in Geographic Information System

The digital geographic framework data covering 150,000km^2 of the Syrdarya River basin is a geo-referenced one which thereby makes it possible to develop topographic maps, various thematic maps as well as Geographic Information Systems by adding the required additional data from the Kazakstan beneficiary. This is significantly different to analogue paper maps which now obviously have a more limited value. The digital geographic framework data can therefore provide a strong tool for administrations to appreciate the current status, undertake planning and analysis and conduct decision-making in specific areas of interest.

(4) Outputs from the study will also contribute to planning and implementation of various projects of interest to concerned organizations in the Republic and international organizations and should open the digital data produced by the study to the public.

Chapter 2. Outline of the Study Area

1. History, Society and Economy of Kazakstan

The territory of Kazakstan provided life space for people in ancient times who came to this land. In the 18th century the immigration from Russia became significant and by the 1860-s it was occupied and controlled by Tzarist Russia. After the Great October Socialist Revolution of 1917 and the civil war, Kazakstan became part of the Russian Federal Republic. In 1925, Kazakstan acquired the status of the Kazak Autonomous Republic. Later it became the Kazak Soviet Socialist Republic as a member of the Union of Soviet Socialist Republics (USSR). The Republic of Kazakstan became independent in December 1991 after the collapse of the USSR.

The population of the Republic is about 17 million, composed of 131 different ethnic groups comprising 50% Kazaks, 35% Russians, 5% Ukrainians, 3% Germans, 2% Uzbeks and 9% others (including Korean). The national language is Kazak, but Russian is used equally as a national language too.

Almaty City was the capital of Kazakstan for many decades, located at the northern foot of the Alatau mountains forming one of the branch ranges of the Tien-Shan mountains.

The capital however, has been recently transferred to Astana City located in the central part of the nation which is divided into four districts, fourteen oblasts and two hundred and twenty administrative units.

The main agricultural product is wheat which occupies 20% of arable land in the former USSR making the country a major grain growing centre. Although the Republic could produce more than 10% of the wheat share in the former USSR, this production has now rapidly declined since independence due to decreasing soil fertility and the stringent economic climate. Furthermore, as a result of continuous excessive consumption of irrigation water from the Syrdarya River contributing to the drying-up of the Aral Sea by 30 %, it is no surprise that serious environmental problems have arisen such as significant soil salinization and land degradation.

The economy of the nation is based on natural mineral resources such as coal, oil, etc. and in this respect an oil field on the east coast of the Caspian Sea recently has attracted attention due to its potential although problems of export will have to be overcome.

2. Physical Geography of the Study Region

(1) Topography

The study area is situated in an alluvial plain constituting the major part of the Syrdarya River basin. Ground elevation from mean sea level in the headwaters of the study area is 200 m and at the river-mouth in the Aral Sea is 40m. The area is almost flat except for the Karatau mountain range located in the eastern part of the study area whose elevation varies from 1,500 to 2,000m.

(2) Climate

The climate of the study area is temperate continental and characterized by intense heat in summer with relatively cold winters.

Average Monthly & Annual Meteorological Data in Syrdarya Basin

Month / Station	1	2	3	4	5	6	7	8	9	10	11	12	1~12
Turkestan													
Temp, ℃	-2.5	-1.4	5.4	14.6	20.5	26.2	29.2	26.6	19.8	10.6	4.0	-1.4	12.6
Rel.Hu. %	78	72	65	49	44	33	32	33	38	54	69	79	53.8
Rainfl.mm	22.2	23.6	26.0	23.0	23.0	4.4	3.2	1.5	3.1	11.8	22.4	31.7	*202.8
Kyzylorda													
Temp, ℃	-8.2	-7.3	0.8	12.9	19.7	28.2	27.6	24.5	17.9	9.1	1.1	-4.8	10.1
Rel.Hu. %	79.2	77.3	71.7	50.1	41.0	35.4	35.3	35.7	40.4	53.5	72.1	80.3	56.0
Rainfl.mm	16.7	14.1	18.9	19.2	19.3	8.6	4.7	3.5	3.6	11.9	17.2	18.7	*156.4
Zhusali													
Temp, ℃	-8.5	-9.8	-1.7	11.7	19.2	25.5	28.7	25.4	17.8	8.1	0.2	-5.5	9.3
Rel.Hu. %	83	81	79	51	42	33	31	34	41	57	76	83	57.6
Rainfl.mm	13.7	10.4	15.5	19.8	11.0	9.0	6.4	5.5	4.8	8.6	13.6	15.7	*135.4
Kazalink													
Temp, ℃	-8.4	-9.5	-2.1	11.3	19.0	25.0	27.9	24.6	17.2	8.0	0.3	-5.3	9.0
Rel.Hu. %	80	76	74	53	46	41	42	44	49	62	77	81	60.4
Rainfl.mm	11.2	6.6	15.2	17.1	9.8	5.4	4.7	7.4	5.9	13.1	15.4	15.2	*128.5

* Annual total rain fall

(3) Hydrology

The observed value for the annual average flow (1970-1993) of the Syrdarya River at Kyzylorda headworks is 180 m^3/sec. The fluctuation of water flow through the year is extremely small, averaging between 133 m^3/sec (October) and 459 m^3/sec (May).

Average Monthly Discharge of Syrdarya (cu.m/sec.)

Month / Station	1	2	3	4	5	6	7	8	9	10	11	12	1~12 Vol. *MM3
Chardara (1970-95)	190	203	292	591	855	745	676	359	182	171	189	202	12,272
Tomenariyk (1970-1993)	185	195	242	363	612	543	469	336	201	163	164	178	9,619
K-Orda H (1970-1995)	169	183	216	266	459	453	392	310	169	133	149	165	8,076
Karaozek (1970-1995)	137	152	179	190	243	225	184	173	168	139	132	108	5,272
Zhusali (1970-1993)	109	127	172	175	180	173	135	143	151	124	115	113	4,484
Kazalinsk (1970-1995)	134	145	162	150	109	95	74	97	132	116	111	121	3,795
Karataren (1993-1995)	302	288	315	265	198	154	119	137	232	224	224	236	7,186
Karaozek-F (1975-1995)	41	49	54	35	18	18	13	13	13	16	21	20	642
Kales Mou. (1971-1994)	12	13	17	25	22	10	8	9	12	13	13	13	437
Ariys RW.St (1970-1994)	18	28	47	57	27	12	7	6	8	8	10	15	637

* MM^3 : Million Cubic Meter

(4) Soils

Soils of the study area belong to the arid grassland type which contain alkali salts. The accumulation of such salts in the soil makes cultivation impossible while insufficient drainage facilities and poor water management give rise to soil salinization.

(5) Agricultural land use

Throughout the entire nation about 80% of land use is devoted to agriculture and within the study area nearly half of the total area is occupied by agricultural lands. The proportion of agricultural lands in the study area is therefore much lower than the whole country. Grassland (12.7 million ha in Kyzylorda oblast) occupies the greater part of those lands used for agriculture, while the area under arable cultivation is extremely small (0.26 million ha in Kyzylorda oblast). Rice, wheat and corn are the main farm products of the study area and the greater part of the non-agricultural lands consists mainly of desert and steppe with some marshy areas.

3. Aral Sea Environmental Issues

Although the Aral Sea once existed as the fourth largest inland water surface area in the world, presently the water surface area has shrunk from two thirds of its former volume due primarily to decreases in river inflow. The decline of the water surface level is about 15m and as a result, the Aral Sea is divided into Large Aral (Amudarya River basin) and Small Aral (Syrdarya River basin).

Change in Aral Sea Parameter (after L.V. Ivanova)

	1960	1965	1970	1975	1980	1985	1988	1989	1990	1991	1992	1993
Height (m)	53.3	52.5	51.5	49.4	46.3	42.2	39.8	38.6	38.3	37.6	37.3	37.0
Vol. (km^3)	1090	1040	975	845	675	470	370	329	298	278	268	259
S (1000 km^2)	67.6	64.4	61.2	57.4	52.1	45.0	39.4	36.5	35.8	34.0	33.4	32.8

* S (1000 km^2) : Surface in thousand square kilometers

A factor in the overall decline of this water body is thought to be related to environmental global change brought by the Earth's greenhouse effects. The governmental policy, however, for concentrated and excessive irrigation development in the Amudarya and Syrdarya River Basins is reckoned as one of the foremost causes.

The environmental impact associated with the reduction in area of the Aral Sea is difficult to estimate with respect to productivity of agriculture and fisheries, the social economy and other concerns such as biodiversity loss. Dust, for example, containing poisonous salts brought by westerly winds from the newly exposed Aral Sea ground surface, not only deteriorates the environment, but also contributes to desertification and degradation of agricultural lands. It also can give rise to chronic health problems in the local inhabitants as well as seriously affecting local ecosystems.

Environmental degradation issues therefore concern both the problems of water volumes flowing into the Aral Sea as well as the water quality, resource management and economic aspects of the Syrdarya River basin which also include consideration of such factors as industrial utilization, communal water use and ground water depletion.

Chapter 3. Plan of the Study

1. Components of the Study

(1) Development of digital geographic data and printed maps corresponding to topographic maps at the scale of 1:100,000 (area: approx. 22.500 km^2)

Numbers of Maps: L-41-105, 106, 107, 108, 117, 118, 119, 120, 131, 132, 143, 144
L-42-109, 121, 133 Total 15 sheets

(2) Development of digital geographic framework data corresponding to topographic maps at the scale of 1:200,000 (area: approx. 150,000 km^2 including above mentioned area of 22,500 km^2)

Numbers of Maps: L-41- XIII, XIV, XV, XVI, XVII, XIX, XX, XXI, XXII, XXIII, XXIV, XXV, XXVI, XXVII, XXVIII, XXIX, XXX, XXXV, XXXVI
L-42- XXV, XXXI, XXXII
K-42- I, II, III, VIII, IX Total 27 sheets

(3) Development of chronological digital land cover data (area: approx. 150,000 km^2)

(4) Technology transfer by OJT to Kazakstan counterpart personnel for the respective stages of the study

2. Annual Plans

The study was carried out over three years and the activities of the respective phases were as follows: (Note: fiscal year (F/Y) of Japan starts from 1st of April and ends on 31st of March.)

The study was planned so that Phase I started from January 1998 (F/Y 1997) and Phase III, the final stage of the entire study was to be completed by March 2000 (F/Y 1999). The total period for the study was therefore planned as twenty-seven months.

(1) Phase I Study (F/Y 1997)

This involved undertaking the preparatory planning of operations and other work, such as the reproduction of satellite images, etc. which was accomplished in January 1998. Field work was executed between early February and the middle of March and included field reconnaissance, data collection and explanation and discussions on such issues as the plan of operation and progress report, map symbol applications, standard of digital data and drafted design of mapping systems. In parallel to the field work, the original printing plate duplicates of old series maps were reproduced as the basis for digitizing collected information and old series maps involving work in Japan and Kazakstan as part of Phase II of the study. By the end of March 1998, selection of ground control points (GCPs) was also completed as part of domestic work.

1) Work in Japan

- Collection and study of available relevant materials and data
- Preparation of plan of operation 1
- Acquisition of SPOT (Panchromatic) images
- Selection of image control points on SPOT images
- Drafting of standards for digital data and map symbol applications
- Preliminary design of computer hardware and software system

2) Work in Kazakstan

- Explanation and consultation on plan of operation 1
- Collection of relevant data/materials and field reconnaissance
- Final completion of the digital data standards
- Confirmation of map symbol applications and basis for the survey
- Preparation and review of progress report 1
- Reproduction of original printing plate duplicates of old series topographic maps

(2) Phase II Study (F/Y 1998)

Explanations and discussions were undertaken in Kazakstan on the plan of operation and fieldwork from the beginning of May to the end of July 1998. The field ground control survey was carried out from the beginning of May to the end of July and aerial photography was completed in June and July. After the conclusion of the sub-contract for the aerial photography, the mobilization of aircraft was completed by the middle of May. Collection of data/materials for digitizing of relevant information started in June, with the actual digitizing beginning in November. The first ground truth survey for land cover classification was carried out in June, and completed within one month.

Work in Japan included, digitizing of old series maps which was conducted from the middle of June to the middle of August. Interpretation of land use from old series topographic maps for the land cover classification, digitizing/compilation of old series thematic maps and the first image analysis activities were conducted from the middle of May to the beginning of September. By the end of May, a cost estimation of computer systems had been made and reports prepared for introduction of the system by JICA.

Based upon the results of the ground control point survey in the first stage of work in Kazakstan, geometric correction of satellite image (partial ortho-images were generated) and image-mosaic production activities started from the beginning of August in order to complete these requirements by the start of the second stage of work in Kazakstan in September.

The second phase of work in Kazakstan was carried out in the period between early September and the end of November. This included preparation of interpretation keys and image interpretation from early September to the end of November. At the same time, the second ground truth survey was carried out from the middle of September to late October. During this work in Kazakstan a progress report was prepared upon which explanations and discussions were held. The results from digitizing the collected information became available in early November and were inspected and received by late February 1999.

Using the results of the image interpretation in the Kazakstan work, digital mapping for the entire 15 sheets of digital geographic data, corresponding to the topographic maps at the scale of 1:100,000, was subsequently completed in Kazakstan. As undertaken for the development of digital geographic framework data, corresponding to topographic maps at the 1:200,000 scale, the digital mapping was partially completed for 13.25 sheets. Digital compilation and structuring of digital geographic data, corresponding to topographic maps at the scale of 1:100,000, were initiated from early December 1998 and completed in the middle of March 1999. Customization of computer hardware and software was implemented between November and December, within a period of two months.

1) Work in Japan

- Preparation of plan of operation 2
- Vectorization of the contour lines from old series topographic maps
- Land cover interpretation from old series maps selected from two periods
- Vectorization and editing of old series thematic maps
- Geometric correction and digital mosaicking of SPOT images
- Acquisition of SPOT (multispectral) image data
- Preliminary analyses of land cover classification
- Vectorization of 1:100,000 and 1:200,000 scale geographic data (partial)
- Compilation/Structuring of 1:100,000 scale geographic data

2) Work in Kazakstan

- Explanations and consultations on plan of operation 2
- Aerial photograph
- Vectorization of collected materials and data
- Ground control point survey by GPS observations
- Preparation of image interpretation keys and image interpretation for 1:100,000 and 1:200,000 scale geographic data
- Implementation of ground-truth survey for land cover classification
- Preparation of progress report 2 and associated consultations

(3) Phase III Study (F/Y 1999)

OJT undertaken in Kazakstan for the production of digital map data using satellite image, i.e., digital mapping and it's compilation, and the revision of map data, were carried out from early February to March 2000. OJT included installation of equipment/instruments for the computer systems, orientation and geometric correction of satellite imagery and digital mapping/compilation. Multicolor printing of 1:100,000scale topographic maps was carried out from early December 1999 to the middle of February 2000 by using positive films for production of printing plates developed during work in Japan.

Activities in Japan, from early May to early November included compilation and structuring of 1:200,000 scale digital framework data and symbolization of 1:100,000 scale digital geographic data. CD_ROMs for 1:200,000 scale digital framework data, 1:100,000 scale digital geographic data, digital thematic map data and chronological land cover classification data were developed in the period from the beginning to the end of November. Master films for the printing of 1:100,000 scale topographic maps were also generated. In parallel to these activities, a draft final report was also prepared in the

middle of November for review by the Kazakstan beneficiary. On the basis of these discussions with the Kazakstan beneficiary a final report was produced.
Explanations and discussions on the final report were held in Kazakstan from the middle to the end of February 2000. In late February after final printing, the finished 1:100,000 scale topographic map was inspected and delivered to the study team.

A conference on technology transfer was held in Kazakstan after completion of the study in early March 2000 in order to summarize and review the final results of the study. The purpose of the conference was to announce that the final results of the study can be used from that moment on by various sectors of the national economy in Kazakstan.

1) Work in Japan

- Preparation of draft final report
- Vectorization of 1:200,000 scale geographic data
- Editing of 1:200,000 scale geographic data
- Symbolization of 1:100,000 scale geographic data
- Development of CD-ROM for 1:100,000 scale geographic data (Structured and symbolized data)
- Development of CD-ROM for 1:200,000 scale geographic data (Structured data)
- Development of CD-ROM for chronological digital land cover data including the digital data from the old series thematic maps
- Production of master films for printing of the 1:100,000 scale topographic maps
- Secondary analysis of land cover classification and it's vectorization and editing
- Preparation of final report

2) Work in Kazakstan

- Explanation and Consultation of Draft Final Report
- Multi-color printing of 1:100,000 topographic maps
- OJT for technology transfer
- Conference on technology transfer

The entire program for project implementation is arranged as follows:

- Work flow of the study (Appendix 3)
- Volume of work for the study (Appendix 4)

Chapter 4. Description of the Study

1. General Administrative Principles for Study Implementation

(1) Key aspects of the study:

1) Understanding the importance and utilization of JICA's experience and know-how.

The project study area is one of the world ecological interest. This project is therefore likely to be recognized as having international importance and value, due to the fact that the final results of the study may contribute to the implementation of expected future projects in different multidisciplinary fields in this region.

2) Appointment of the study team members

In order to achieve a smooth and efficient implementation and minimize the period for the entire project, as many personnel as possible who had good experience in overseas projects were appointed.

3) Local enterprises

As the Republic of Kazakstan possesses high-level capabilities in surveying technology and sound experience in the study area since the time of the former USSR, effective and economic operations were achieved on the study by employing this expertise.

Consequently Kazakstan local enterprises were engaged to conduct the following works:

- Reproduction of original printing plate duplicates (Phase I)
- Ground control point survey (Phase II)
- Aerial photograph (Phase II)
- Vectorization of collected material and data (Phase II)
- Preparation of image interpretation keys and image interpretation (Phase II)
- Multi-color printing of 1:100,000 scale topographic maps (Phase III)

4) Project offices

The main office, arranged and supplied by ALRM (Agency on Land Resources Management) in Almaty, was the headquarters of the study team throughout the entire study period. For the work in Kazakstan, a main base office was also set up in Kyzylorda City. As the study area extends for nearly 900 km from east to west, necessary sub-bases were additionally set up in Turkestan, Dzhanakorgan, Dzhusaly, Baikonur, Novokazalinsk and Aralsk.

5) Composition of the study team

The composition of the study team was planned to take account of the scope of study, volume of work, area of study and requirements for sub-contractors.

6) Operations (Equipment / personnel)

The work requirements of the study in Kazakstan were basically fulfilled by local enterprises and engineers engaged on a sub-contract basis. The study team members carried out the principle supervising and management of the sub-contractors' work. In case of necessity however, they proved capable of working in an unsupervised capacity.

7) Quality and accuracy control

In principle, the quality and accuracy of the old series 1:200,000 and 1:100,000 scale topographic maps were maintained in each process of the operation.

(2) Technology Transfer

1) OJT(On the Job Training)

The technology transfer was implemented by means of OJT in the respective working processes executed by the study team.

2) Counterpart training in Japan

The technology transfer was additionally carried out by means of JICA's project counterpart program of work in Japan.

2. Technical Principles for Study Implementation

(1) Key aspects of the study:

1) The following standards were used for the surveying and mapping:

Reference Ellipsoid	: Krassovsky 1940
Semi-Major Axis	: 6378245.00
Flattening	: 1/298.26
Projection	: Gauss-Kruger conformal projection
Coordinate System	: CK1942 Zone11(Central meridian E 63 degree) Zone12(Central meridian E 69 degree)
Scale Factor	: 1.000 on the central meridian
Elevation	: from 1/100,000 and 1/200,000 topographic map's elevations, those were derived from Baltic Mean Sea Level
Contour Interval	: 20 meter
Unit	: Meter

2) Images and topographic maps used:

- 1:50,000scale aerial photographs taken in May, June and July 1998
- SPOT Panchromatic image data acquired in June, July and August 1997 (71 scenes)
- SPOT Multispectral image data acquired in May, June and July 1998 (31 scenes)
- Printed maps and reproduced positive films of the latest old series topographic maps at scales of 1:50,000, 1:100,000 and 1:200,000
- Historical topographic maps at scales of 1:100,000 and 1:200,000 (from 1950s and 1970s through to the 1980s)

3) Planimetric accuracy of 1/100,000 and 1/200,000 scale digital geographic data

The planimetric accuracy of well-defined features in digital geographic data is equivalent to old series topographic maps at 1/100,000 and 1/200,000 scales which conform to JICA overseas topographic map specification category A. Geometric correction of satellite image however, is based on ground control points derived from GPS locational positioning and old series topographic maps. The planimetric accuracy of the digital geographic data depended therefore on the planimetric accuracy of the old series maps.

4) Digitizing of collected data/materials

Field identification and verification surveys were not carried out, due to their onerous consumption of time and manpower resources and the limited amount of time available for completion of the whole study. It was agreed therefore with the Kazakstan beneficiary that the digitizing of collected data would be undertaken by local sub-contractors using the most up to date and old series maps. The Kazakstan beneficiary was thus responsible for data supply to the study team. These data included geographic names, administrative boundaries, ground features, structures, data on water use, etc., that could be displayed by means of maps.

5) Ground control points for geometric correction of satellite images

Well defined planimetric features on old series topographic maps and those which could be clearly interpreted on satellite images were adopted as "ground control points derived from a map"(GCP-MAP). The coordinates of these points were measured on the reproduced printing plates. Where significant planimetric features did not exist on a map, ground control points were defined on the basis of accessibility by GPS locating. On SPOT images ground control points were selected as "ground control points derived from GPS"(GCP-GPS). GPS observations were carried out by placing GPS antenna at selected point locations.

The average allocation of control points was four per SPOT scene. In the Karatau Khrebet mountains the number of ground control points was increased to enable the generation of a digital elevation model (DEM).

6) Geographic names and administrative boundaries

Geographic names, including those of facilities, administrative boundaries and their location were provided by the Kazakstan counterpart as part of their responsibilities to the project.

Special attention was paid to official orthography as some changes had been made since the Republic became independent.

7) Map symbols and their representation

Map symbols and their applications were based principally on the Kazakstan specification currently in effect, although, due to computer mapping technology, some modifications and simplifications had to be adopted.

Computer symbolization of features not applicable in the project area were omitted from the study.

8) Interpretation Keys

In consideration of such a vast project territory, field verification surveys of the entire area were not physically possible. Interpretation keys were therefore required to be prepared for typical landmarks, features, facilities, vegetation and topography of the project area so as to make possible object identification from satellite images and/or aerial photographs.

These interpretation keys are likely to prove useful for the Kazakstan counterparts when involved with the processes of topographic map production for other areas with the use of satellite images.

9) Indistinct features on satellite images and aerial photographs

Features which could not be recognized on satellite images and aerial photographs by size or width were neither digitized or shown on the map. If a small feature was of importance and required to be represented on a map at a respective scale, it was digitized with data provided by the Kazakstan counterpart after confirming its existence.

10) Digital map data equivalent to the 1/100,000 scale topographic map

Digital map data were produced which enabled the possible output of new topographic maps, from which topographic map printing was undertaken in Kazakstan.

11) Digital geographic framework data equivalent to 1/200,000 scale topographic mapping

This data can provide Geographic Information System (GIS) framework information and be processed with any topical data in a GIS environment for applications interests.

12) System construction

The computer mapping system is constructed so that the Kazakstan specialists will be able to use it easily in future.

13) Chronological (temporal) land cover classification features

Level 1 classification	: Urban Area, Vegetation, Bare Land and Hydrology.
Level 2 classification	: Contains more detailed features which were classified in relation to the land cover characteristics of the study area

14) Acquisition of ground truth data

Ground truth data was acquired in the field for verification of the satellite image (panchromatic and color) analysis.

3. Acquisition of Satellite Images and Aerial Photographs

(1) Acquisition of Satellite Images

Seventy-one scenes of panchromatic images acquired by SPOT Image in June, July and August 1997 were utilized for image interpretation and digital mapping. Thirty-one scenes of multispectral images acquired by SPOT Image in June, July and August 1998 were used for the analysis in land cover classification. (Appendix 5, 6)

(2) Aerial photographs

The purpose of undertaking aerial photography was to supplement the identification and interpretation of features at mapping scales of 1:100,000 and 1:200,000 which could not be interpreted on satellite images due to their limited spatial resolution. B/W aerial photography at the scale of 1:50,000 was executed by the sub-contractor - JS "BURUNDAYAVIA". The area for aerial photographic coverage was about 150,000 km^2, which constitutes the whole study territory. The photography was completed in June and July – the season of maximum vegetation cover.

1) Sub-contractor and equipment employed

Name of sub-contractor: JS "BURUNDAYAVIA", Burunday Airport, Almaty

Aerial Camera: TAFA-10, Precision Photogrammetric Camera

Lens	: Ortogon-5A
Focal length	: 100,6943 mm, 100,2633 mm
Image format	: 18 x 18 cm

Platform: AN-30 Survey Aircraft (2 units)

Serial Number of aircraft	: N30003, N30038
Navigation method	: Autopilot, GPS Navigation system
Cruising time	: 5 hours and 30 minutes

2) Photographic mission plan

Area	: approx. 150,000 km^2
Photo-scale	: 1/50,000
Ground level	: 80m to 1,370m (above mean sea level at Baltic Sea)
Flying altitude	: 5,080m to 6,370m (- do -)
Successive overlap	: 60%
Lateral overlap	: 30%
Number of flying lines	: 72 (145 lines of total for dividing to pieces of block areas)
Total line length	: 26,500 km (not including area overlapping between respective blocks)

3) Summary of aerial photography

Two survey aircraft were required to complete the aerial photography as the area to be covered was so vast. The aerial photography was arranged in such a way that surveys were undertaken simultaneously, effectively and safely on divided seven block areas. The extent of the entire area was 150,000 km^2 and the distance between the most eastern and western point attained approximately 900 km. Each block was preliminarily allotted to the respective aircraft.

After mobilization of aircraft to Kyzylorda Airport on 4th June, the first aerial photography started on 7th June. The entire line length was completed by 23rd June, including repeat photography. The aerial photography was carried out in 11 days with 7,695 frames (39 rolls) of aerial photographs being acquired during this mission in a total of 126 hours of flying.

4) Quality inspection

Exposed films were forwarded immediately to JS "BURUNDAYAVIA" to be developed, annotated and printed. As the total number of aerial photographs was quite huge, a quality inspection for the presence of cloud/shadow and overlaps had to be made on uncontrolled photo-mosaics prepared block by block. If any errors were found beyond the specified quality then re-flying was instructed. (Appendix 7)

4. Ground Control Points for Geometric Correction of Satellite Images

The development of map data is an important element for obtaining the guaranteed accuracy of the position and precise representation of map information. In this context a vast area was to be covered on the project with map data for which accuracy of positions was required to correspond to topographic maps at 1:200,000 and 1:100,000 scale. Therefore, instead of a strict geodetic control survey, only control points (Ground Control Points: GCPs) needed for geometric correction of satellite image were employed. The selection of GCPs, referenced to satellite images, was conducted as indicated below:

- GCP-MAP, coordinates were calculated from available topographic maps
- GCP-GPS, coordinates were obtained by GPS survey in the field where calculation from available maps proved problematic.

Duplicated films of original printing plates were used as old series maps for calculation of these coordinates.

(1) Selection of control points on SPOT satellite images

To avoid any distortions of the satellite image data (SPOT) generated by processing, point coordinates on the images, which were able to be calculated from old series 1:100,000 scale topographic maps, were adopted as GCPs.

Features clearly identified on satellite images and old series topographic maps, such as crossings of roads, bridges, prominent structures, etc., were adopted as GCPs. If any identifiable features were not available on old series maps, but needed for geometric correction on satellite images, GCPs were obtained by selecting and observing coordinates of some points in the field. These points could be clearly recognized on satellite images and included, for example, crossings of roads, bridges, prominent structures, vegetation boundaries and topographic features etc. In the process of selecting points a key issue was available access to the objects for GPS observations.

(2) GCP-MAP (Ground Control Point derived from maps)

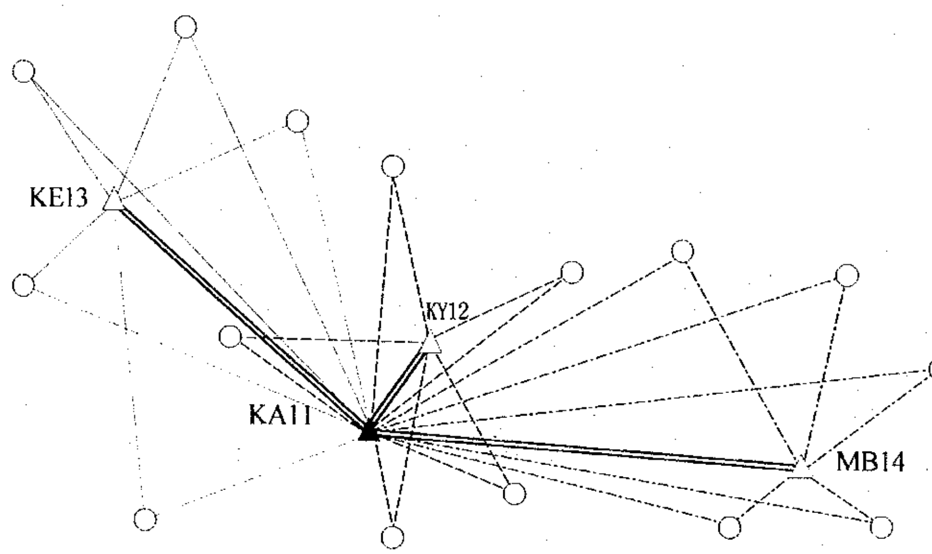
Coordinates of selected point positions from 1:100,000 and 1:200,000 scale topographic maps, which were utilized in the Phase 1 study, were measured by precise digitizers. The results were presented in appropriate Result Tables in addition to a description of points also being prepared. The maximum permissible discrepancy on the map was less than 0.2 mm.

(3) GCP-GPS (Ground Control Point derived from GPS observation)

1) Observation Planning

The study area was divided into three blocks for purposes of surveying, i.e. Kyzylorda Central, Novokazali West and Turkestan East, the distance between the most eastern and western point of the area reaching approximately 900 km. To obtain homogeneous accuracy and rationality of existing geodetic coordinate systems, GPS observations were carried out so that:

Successive observations of a fixed station could be obtained by using one unit of a duel-frequency (LA1/LA2) GPS receiver through the entire observation period at the 1st- order triangulation point, KA 11. Furthermore the use of duel-frequency (LA1/LA2) GPS receivers made successive observations through the entire observation period at the 1st- order triangulation points (KY12, KE13 and MB14) located in the centers of respective blocks. They also enabled the execution of a base-line solution with KA11 and required points for which single-frequency (LA1 only) GPS receivers were employed.



Concept of GPS Observation

2) GPS observations

The State enterprise "ZHAMBYLGEODESY" carried out the required observations under a sub-contract with the study team. Specialists of "ZHAMBYLGEODESY" had a sound knowledge of the topographic conditions in the study area. An appropriate specialist of the study team also participated in technology transfer through supervision and computation activities to obtain the final adjustment. Seven specialists made up the field party which used large 4-wheel drive automobiles for carrying survey instruments and camping equipment in the study area.

Devices used for observation:	Trimble GPS 4000 SSI	2 sets
	Trimble GPS 4000 SE	6 sets

3) Period of field observation

A period of 35 days from the 4th June 1998 to the 8th July 1998.

4) Selection of points on satellite images

One hundred and nine points, including spare additional points, were selected in Japan on the satellite image. It was however difficult for the study team to make point selections on the area covered by steppe to the south of Kyzylorda and Kzyl-Kum desert and coastal zone of Aral Sea, as no sufficient preliminarily knowledge existed in Japan about local environmental conditions. Those places which proved difficult for point selection required re-selection based upon the old series maps and information provided by Kazak engineers who had a sound working experience of this area. In the course of this work, A4 size (1:25,000 scale) hard copy satellite image outputs were utilized for presentation of the results of the points selection in order to show locations for GPS observations and pricking of observed points.

5) GPS receivers and operating manual for GPS analysis program

Before mobilization to the study area, all geodetic engineers involved on the project in Taraz City were trained in the use of GPS technology. The study team gave instructions on work procedures, methods of interference GPS positioning and GPS receiver operation. Trainees also participated in making trial observations, downloading of data and derivation of base-line solutions.

6) Evaluation of GPS receivers and software for Base-line Solution

A trial observation was carried out on the last training day at 3 triangulation stations near Taraz City. On the basis of these data, a base-line solution and net adjustment computation were made. The discrepancy between the results of the adjustment computation on these 3 arbitrated same-class triangulation stations was fixed and the existing results obtained were as follows:

X= - 0.078m
Y= - 0.102m
H= - 0.054m

7) Preparatory work

Local engineers were instructed on how to make a pre-selection of ground control points in the process of geometric correction of satellite image based on the image data and collected data/materials of the Phase I study. This was a necessary requirement for GPS observations.

8) GPS observation

Kyzylorda Block

a. Fixed station	: Kar Aruick, pir (KA11) 1st- order
b. Fixed station	: Karauzeck (KY12) 1st- order
c. GCPs	: Observation points at 58 stations (including additional), 7 stations were re-selected.

Novokazalinsk Block

a. Fixed station	: Kar Aruick, pir (KA11) 1st- order
b. Fixed station	: Kenges (KE13) 1st- order
c. GCPs	: Observation points at 48 stations (including additional), 10 stations were re-selected

Turkestan Block

a. Fixed station	: Kar Aruick, pir (KA11) 1st- order
b. Fixed station	: Mai-Balyk (MB14) 1st- order
c. GCPs	: Observation points at 55 stations (including additional), 8 stations were re-selected.

9) Computation (GPS Base-line Solution) procedures

a. Result of triangulation stations in Kazakstan and parameters for conversion

The existing results of triangulation stations survey data were acquired from the Central Fund of Geodesy and Cartography. Subsequently the following values were applied for parameter conversion from WGS-84 into Krassovsky 1940, the Kazakstan reference ellipsoid:

Coordinate System and Geodetic Parameters

Reference Ellipsoid	: Krassovsky 1940		
Projection	: Gauss-Kruger conformal projection		
Coordinate System	: Pulokovo 1942 (Coordinate System 1942, CK-1942)		
Zone (in project area)	:	Zone 11	Zone 12
Central Meridian	:	63°00'00" E	69°00'00" E
West bounding Meridian	:	60°00'00" E	66°00'00" E
East bounding Meridian	:	66°00'00" E	72°00'00" E
Origin ; X at Equator	:	0.00 m	0.00 m
Y at Central Meridian	:	11 500 000.00 m	12 500 000.00 m

Transformation Parameter between Krassovsky 1940 and WGS-84

- World Geodetic System 1984 (WGS-84)

Reference Ellipsoid	:	WGS-84
Coordinate System	:	WGS-84
Semi-major axis	:	6 378 137.000 m
Flattening 1/f	:	1/298.257 223 563
Eccentricity Squared e^2	:	0.006 694 380

- Krassovsky 1940

Reference Ellipsoid	:	Krassovsky 1940
Coordinate System	:	Pulkovo 1942
Semi-major axis	:	6 378 245.000 m
Flattening 1/f	:	1/298.26
Eccentricity Squared e^2	:	0.006 693 421 6

- Adopted Transformation Parameters (Krassovsky 1940 to WGS-84)

Transformation Method – Bursa/Wolfe Seven Parameter

X Shift (DX) to WGS-84	: + 43.822 m	, X Rotation(ω X) : +1.455"
Y Shift (DY) to WGS-84	: -108.842 m	, Y Rotation(ω Y) : -0.701"
Z Shift (DZ) to WGS-84	: -119.585 m	, Z Rotation(ω Z) : +0.737"

Scale Correction to WGS-84 : 0.549^{-6}

b. Result of GPS base-line solution and closure error

The detailed results of the GPS base-line solution are presented in accuracy control sheets for which the following table shows some values:

Inspected base-lines	Discrepancy of DX	Discrepancy of DY	Discrepancy of DZ	Slope distance	Discrepancy of Slope distance
KA11→KY12	0	-0.007	+0.003	39953.301	-0.003
KA11→KE13	-0.018	+0.040	-0.028	303787.035	+0.006
KA11→MB14	+0.015	-0.081	+0.023	291609.319	-0.038
KA11→H5G4-1	-0.179	-0.036	+0.069	141814.809	-0.171
KE13→B3G5	+0.128	+0.308	+0.164	127899.602	+0.221
MB14→Q8G6	+0.026	-0.048	-0.079	59820.486	+0.025
KA11→C1G2-2	+0.114	-0.439	+0.239	359728.356	-0.164

Parts of duplicated base-line vectors are shown in the above table. All of KY12, KE13 and MB14 show the values between geodetic control stations. As a result of observations for more than 12 hours, the fix solution (Double-Difference L1/L2, Ion-Free Fixed Phase) was able to apply even with large distances between the points. Each discrepancy was also very small.

c. Shift value induced by temporary adjustment computation of WGS-84 as reference ellipsoid with the use of one (1) fixed station (KA11).

Fixed stations	DX (m)	DY (m)	DS (m)
KY12	0.278	0.479	0.554
KE13	-0.285	-1.636	1.660
MB14	2.643	2.265	3.481

The discrepancy between 1st- order triangulation points, on average about 40 km from each other, is presumed to be from 30 to 50 cm. At a distance of 300 km the discrepancy is assumed to be from 1 to 2 m. The above statement however cannot be asserted as it is difficult to make an evaluation only with the given result. MB14 has a discrepancy of 2 to 3m, not only because of observation error but also due to additional adjustment for the different coordinate system.

d. Computation of final result and relative accuracy

In taking into account the specified accuracy of this study, the final computed result, as shown above, sufficiently meets this required accuracy. Therefore, the final result was obtained by converting values, computed with fixed stations, into the reference ellipsoid applied in Kazakstan. The presumed relative accuracy was estimated from 1 to 2 m at GCPs in the system Zone 11, as the observation error was very small. In this estimation the reasonable distance between triangulation stations was taken into consideration. As for Zone 12, the relative accuracy is estimated from 2 to 3 m. Eventually it was confirmed that the relative accuracy of triangulation stations has been met for the accuracy needs of the GCPs.

10) Geodetic coordinate system in Kazakstan and WGS-84

To secure the accuracy of observation at fixed points at KA11 in Kyzylorda, it was decided to continue 12-hour successive observations.

The Geographical Survey Institute of Japan submitted the data using the following discrepancy: at KA11 between Krassovsky1940 and WGS-84, induced by the base-line solution with successive observation data at KA11 and the observation data at IRKT (Irkutsk), belonging to the successive observation net of IGS (International GPS Service)

Longitude & Latitude	KA11 (Krassovsky 1940)	KA11 (WGS 1984)
Latitude : (Degrees)	44 41 25.99N	44 41 26.83 N
Longitude : (Degrees)	65 32 08.24E	65 32 05.06 E

The above results show that the Kazakstan coordinate system is displaced approximately 22 m towards the south and approximately 67 m towards the east from WGS-84. This does not mean that the coordinate system in Kazakstan has a discrepancy but shows the difference from the employed reference ellipsoid and horizontal datum.

11) Technology transfer

The engineers of ZHAMBYLGEODESY have gained relevant knowledge and experience of conventional surveying technology. The study team were also to instruct and provide training on fundamental satellite geodesy as well as the orbital information of satellites and the downloading of observed data.

5. Geometric Correction of Satellite Image, Digital Mosaicking and Sheet-by-sheet Clipping

SPOT image data does not correspond geometrically to a topographic map. To obtain this correspondence, geometric correction of satellite data was undertaken. This pre-processing proved necessary for the digital mapping, image interpretation and image analysis. Subsequently digital mosaic and sheet-by-sheet cutting were executed for the effective operation of succeeding activities.

(1) Geometric Correction of satellite images

All satellite images were geometrically corrected on the basis of GCP coordinates taken from 1:100,000 scale topographic maps with identification on satellite data and GCP's observed and determined by GPS survey which could not be identified on satellite images but specified on topographic maps.

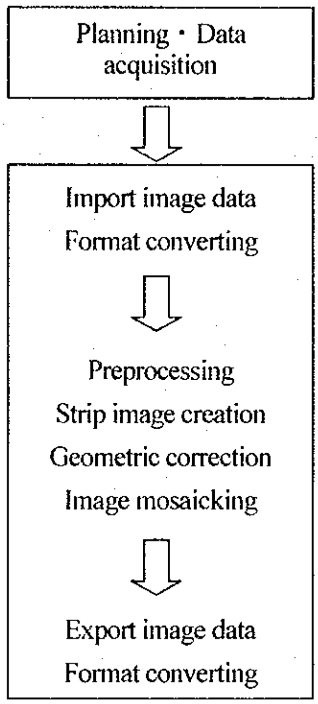
There is a difference between the acquisition modes of SPOT P (B/W) and XI (Multispectral) data. In the first instance P-mode data was corrected and subsequently applied for the XI-mode.

1) Almost the whole study area had no significant difference in ground elevation and generation of orthogonal images had to be conducted without considering ground height correction.

2) Differences in ground elevation within the Karatau Mountains, located in the eastern part of the study area, were large and ground height correction was thus taken into consideration in the generation of orthogonal images. A DTM was generated by using digitized contour lines taken from the topographic maps at 1:100,000 and 1:200,000 scale and the GCPs.

(2) Mosaicking

As the size of satellite image used at respective stages was not equivalent to a normal scene but the size of a sheet of a topographic map, a digital mosaic was made to develop map sheet-unit mosaic images. Subsequently the mosaic image was clipped into pieces and printed out sheet by sheet. Image enhancement was additionally undertaken to improve the quality of the images.



Flow chart of Mosaicking

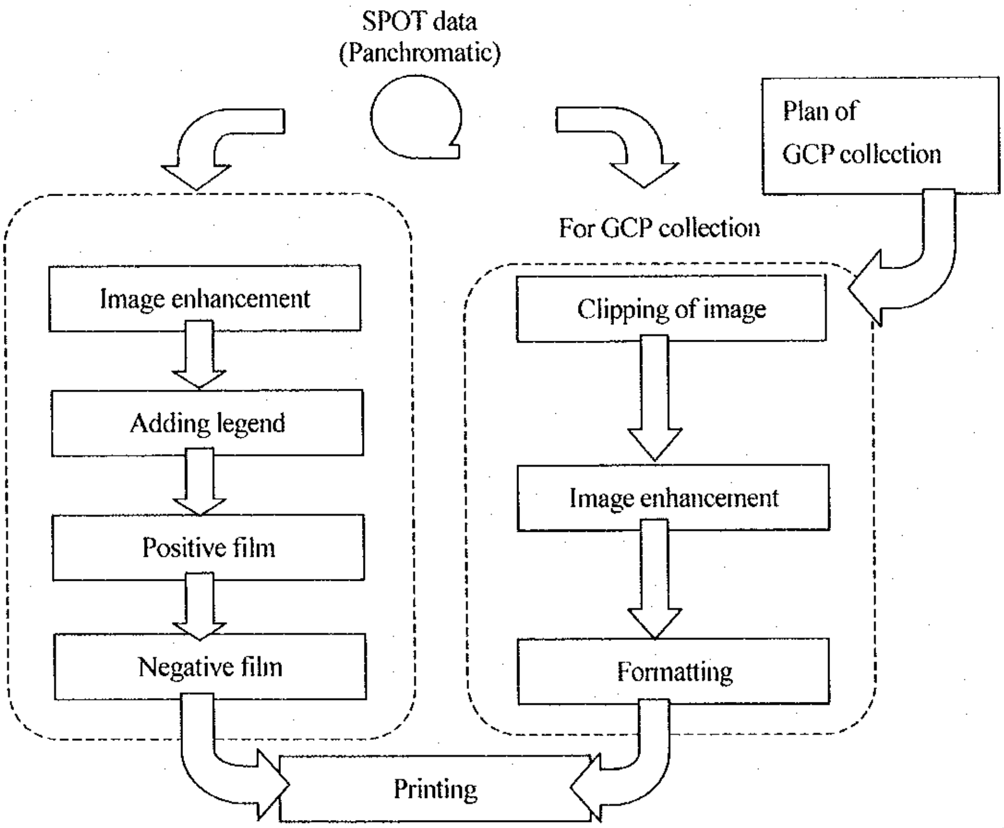
After the reproduction of SPOT P images, a checking was undertaken of cloud effect and scene overlapping. Images were then produced for consultations with the Kazakstan beneficiary and pre-selection of GCPs.

1) Reproduction of Images

Reproduction of satellite images was completed for:

Items	For confirmation of images		For pre-selection of GCPs	
Area	Scene		Surroundings of GCP	
Size	A4		Distant view/close view	
Volume	Work in Japan	2 sets	Work in Japan	1 set
	Present to Kazak side	1 set	Spare of Kazak side	1 set
	Work in Kazakstan	1 set	Work in Kazakstan	1 set

2) Procedure of images reproduction:



Flow chart of Image Production

3) Geometric Correction and Image Mosaicking

1) Processing Methodology

Geometric Correction and Image Mosaicking includes the following:

a. Generation of image strips

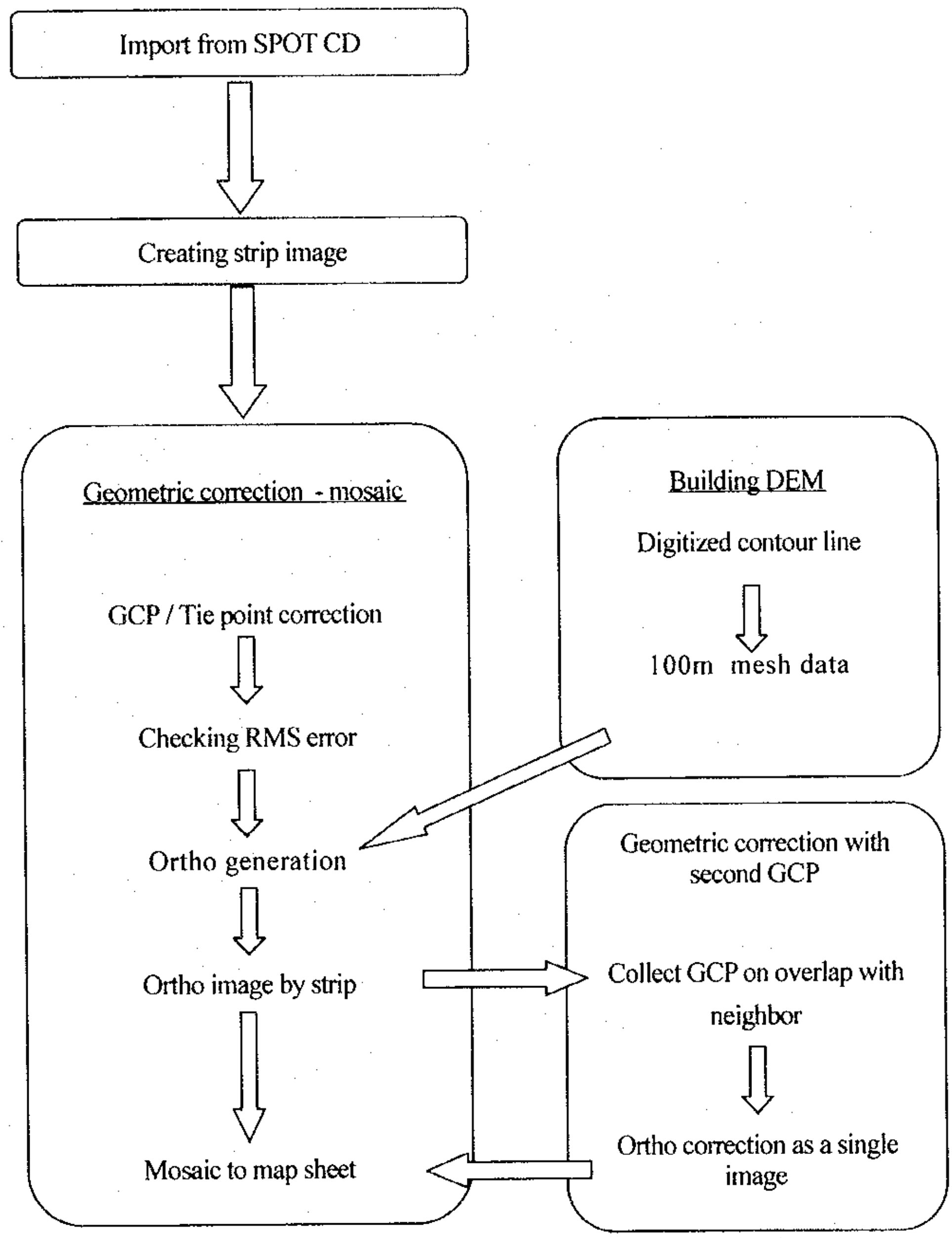
Editing and data re-sampling were carried out on strips of images taken in the same orbits and the same day to reach maximum accuracy and efficiency of processing.

b. Geometric Correction of SPOT Images

Geometric Correction of SPOT images was undertaken with the use of GCPs. The correction was executed in Zone 11 and 12 respectively employing data which included GCP-MAP, GCP-GPS and a DEM (Digital Elevation Model) generated from old series maps.

c. Development of sheet-unit images (Mosaicking + Clipping)

The unit size for all satellite SPOT image interpretation was that of the map-sheet. Therefore, mosaicking and clipping of geometrically corrected image data was carried out to change the unit of image size from scene-by-scene to sheet-by-sheet.



Flow chart of Geometric Correction of SPOT Satellite Images

d. Production of Reseau marks

It was necessary to express known points as coordinates on the developed sheet by sheet data in order to facilitate orientation with the base maps for image interpretation. Reseau marks were then placed at the four corners of each sheet.

e. Printing of images for Image Interpretation

To maintain image interpretation accuracy, the scale of printed images was determined in accordance with the corresponding topographic map scale. Each sheet was allocated space for overlapping with adjacent sheets so as to cover joining space outside the neat cartographic format line on 4 sides.

2). Result of processing

a. Image strips

Twenty-five strips of images were generated from seventy-one scenes of SPOT P data. In this way the scope of work was reduced by a third.

b. Geometric Correction of SPOT Images

The correction was executed at Zones 11 and 12 and mean errors attained were less than 3.0 pixels (30m) in X and Y (latitude and longitude) directions.

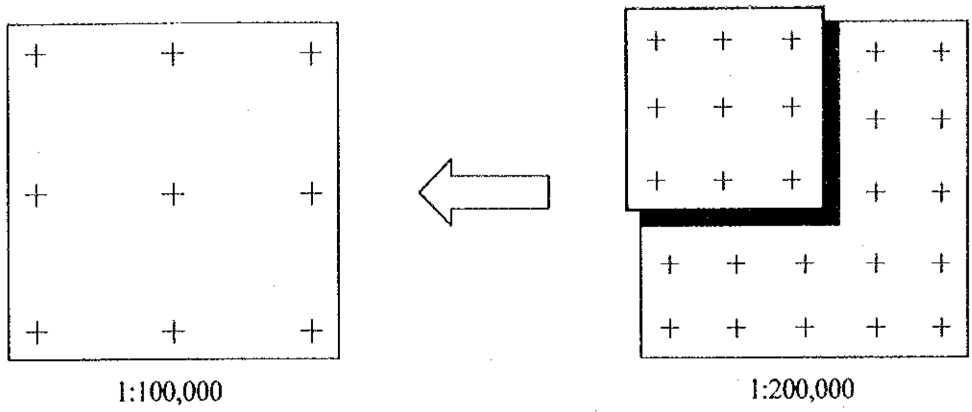
c. Development of sheet-unit images (Mosaicing + Clipping)

Twenty-seven frames of sheet-unit image size were produced while the spatial resolution of images was maintained at 10m, equivalent to the original data. Therefore such images can be used for interpretation of digital geographic data corresponding to a 1:100,000 scale topographic map.

d. Development of Reseau marks

A number of Reseau marks were produced and given to corresponding topographic map scales. To establish numbers the size of printed images for image interpretation was considered.

Map scale	Reseau Numbers
1/100,000	9 points
1/200,000	25 points

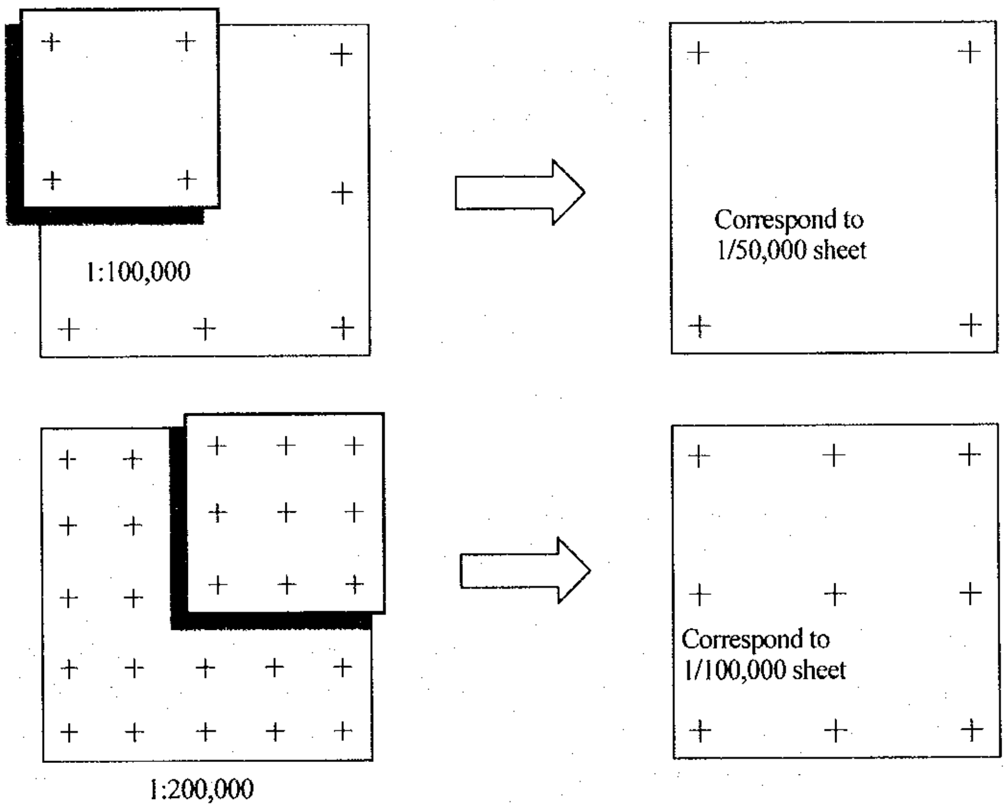


Development of Reseau marks

e. Printing of images for Image Interpretation

Sheets, enlarged 2-times for image interpretation, were printed based on Reseau marks. Each sheet was divided into quarters with the number of printed images as follows:

Map Scale	Number of images
1/100,000	60 frames
1/200,000	93 frames



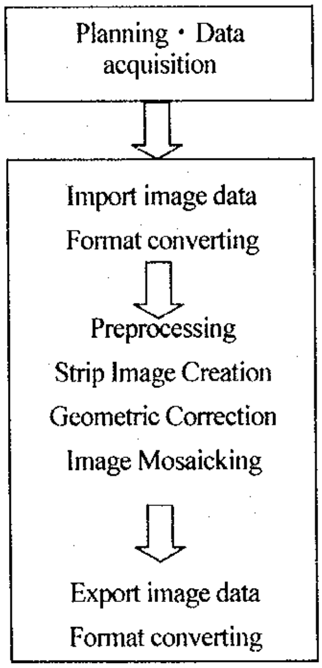
Concept of Images Printing

(4) Technology Transfer

OJT on orientation and geometric correction of satellite imagery were held for counterpart personnel in Japan. Training was conducted by means of soft-and-hardware supplied by JICA to the Kazakstan Government. The activity flow for this program is shown in Fig.

Technology transfer included:

- Basic knowledge of satellite imagery
- Acquisition of satellite image data
- Import of data into systems
- Geometric correction of satellite imagery
- Mosaicing
- Image processing



Work Flow : Technology Transfer

6. Development of mapping keys for image interpretation

(1) Interpretation Keys

Image interpretation keys were developed as a basis for the interpretation and mapping of topography, ground features, vegetation, etc. from satellite imagery and aerial photography in conjunction with available collected data/materials. These units were subsequently digitized to provide the final mapping data. This methodology replaced the need for field verification surveys referenced in Chapter 3.

The specified features for the interpretation key were assigned mapping symbols agreed in consultation with the Kazakstan beneficiary.

Interpretation Keys were furthermore designed so as to give interpreters a common understanding of

image analysis with respect to both satellite imagery, aerial and terrestrial photography.
These data were collected by the sub-contractors ZHAMBYLGEOGESY from which the Study team compiled and developed the relevant interpretation keys.

The development of Interpretation Keys required:

- Naming of map symbols (Japanese, Russian and English)
- Explanation of symbols(Japanese, Russian and English)
- Applications description (Japanese, Russian and English)
- Analysis of SPOT Satellite Images (Mono-scene, 1:100,000)
- Analysis of Air-photos (Stereo, 1:50,000)
- Analysis of ground photographs (Distant view)
- Analysis of ground photographs (Close view)
- Description of interpretation
- Description of plotting and compilation
- Categorization of map layering
- Definition of symbols (Symbolization)
- Definition of map scale (1:100,000, 1:200,000)

Thirty (30) sets of interpretation keys were produced as a final delivery which will be important tools for subsequent satellite image mapping in Kazakstan, (Appendix 8).

(2) Image Interpretation

Satellite Imagery complemented by 1:50,000 scale stereographic aerial photography provided the main source of mapping information. Field verification covering the vast and entire study area was replaced by an interpretative analysis of these materials. The actual work on interpretation was sub-contracted to "KARTOGRAFIYA". Interpretation results were presented on a polyester base overlaid on geometrically corrected satellite images enlarged twofold. The mapping data were then subsequently classified in colors according to selected symbols and applications. The scale of satellite imagery covering the area mapped at a 1:100,000 scale was enlarged to 1:50,000 and for the area mapped at 1:200,000 scale it was produced at a scale of 1:100,000.

The image interpretation work consisted of the following procedures:

- Reseau marks were inserted onto the satellite images
- The positions of the reseau points were marked at the four (4) corners of the images
- The size of each reseau mark depended on the scale of the output imagery.
- Image scale used for interpretation was twice that of the corresponding maps
- Polyester base material, less subject to expansion and contraction, was used as a base map for measurement
- Reseau marks on reproduced images were plotted on base maps for measurement and then overlaid and fixed on the satellite images. Images were placed on drawing boards.
- Features selected for digitizing were drawn on base maps overlain on the images.
- Interpretation drawing was carried out with hard color pencils and results systematically

classified.

- Interpretation of satellite image was assisted by complementary interpretation of stereoscopic examination of 1:50,000 scale aerial photographs.

7. Digital Map and Geographic Framework Data

(1) Review of map symbol specifications and their applications

1) Symbols and their applications were initially studied based on the former Soviet topographic map symbols for which a JICA preliminary study team collected:

- Symbols and application for 1:100,000 topographic map
- Symbols and application for 1:200,000 framework map

2) The main symbols for the 1:100,000 scale topographic maps conformed to the existing symbols of current 1:100,000 scale topographic maps and after due consideration were revised as follows:

- To extract information on important items for modern civil life
- To unify and separate symbols in accordance with changes in civil life
- To ignore small objects, etc. for which field identification was necessary

3) Symbolization compatible for utilization with computers was considered necessary for symbols on 1:100,000 scale topographic maps

4) A draft document of symbols compatible with computer utilization was prepared as follows:

a. Formats of computer symbols were discussed with the Kazakstan beneficiary which corresponded to those selected at the earlier consultation stage.
b. The suitable representation of computer symbol design was selected.
c. The newly specified font was more appropriate than the existing one.
d. Symbol color was investigated with respect to film color separation for printing plate production.

5) Framework objects effective for GIS use were extracted for symbolization design on the 1:200,000 scale mapping and arranged as draft study symbols which were discussed and agreed with the Kazakstan beneficiary.

(2) Standardization study of digital data formats

1) Based upon the draft symbols and application documentation prepared in Japan, the digital data standards were drafted and formalized.

2) Main draft items included:
   - Layer construction for GIS data (Feature code)
   - Data format of digitizing of collected material (vector type)
   - Data format of structured data for GIS input (vector type)
   - Data format of symbolized data for printing (raster type)

a. Feature code

- Feature codes were assigned for map symbols specified at the consultant stage of study on this subject with the Kazakstan beneficiary.
- Feature codes were unique numbers for each map symbol.
- Feature codes were classified into three categories consisting of class, subdivision class and figure division.
- Class was assigned a code of two digits according to topographic characteristics.
- Subdivision class was assigned a code of two digits for each class of map symbols.
- Figure division was assigned a code of two digits in case of the necessity to make the subdivision class more detailed.
- All features not needed to be classified were represented as "0".

b. Digitizing of collected data/materials

- The basic data for map data, supplied mainly by Kazakstan side:
  - Geographic names
  - Administrative boundaries
  - Facilities
  - Data considered necessary by the Kazakstan beneficiary
- Collation and design of forms for the description of collected data/materials were implemented as a first stage of this work
- Collected data/materials were digitized in vector form.
- The data structure was determined for each map to be digitized.
- Coordinate values were expressed in meters.
- Data exchange formats of digitized collected materials were studied between Kazakstan and Japan.

c. Structured data

- Structured data comprise of layers of digital information which can be easily utilized in GIS facilities and applications.
- Structured data was produced in a vector form.
- Data structure was determined for each map symbol to be utilized.
- Coordinate values were expressed in meters.
- Exchangeable format was studied of structured data between Kazakstan and Japan.

d. Symbolized data

- Symbolized data is that pattern when plotted which represents one or more ground features.

- Symbolized data was produced in raster form.
- Color and representation were determined of each map symbol.
- Symbol color was designated by evaluation of color separation for printing.
- Pixel size was determined of symbolized data
- Exchangeable format of symbolized data was studied between Kazakstan and Japan.

(3) Consultation on standardization of digital data formats with Kazakstan beneficiary

Sufficient discussions and coordination on standardization of digital data formats with the Kazakstan beneficiary enabled a smooth implementation of the succeeding digitizing of map information.

1) Survey of CAD and/or GIS

a. Investigations were made of the CAD and GIS systems available in Kazakstan, including their hardware and software configuration and digitizing methods and accuracy. MapInfo with a Windows computer operating system was selected as the basic GIS facility. It was also decided to use 300dpi for digitizing the collected data/materials.

b. Comparative investigations were also made on the use of similar computer character fonts in Kazakstan and Japan . The letters of the Windows computer software standard true type fonts were subsequently adopted whose shape resembles that also used in Kazakstan.

2) Data Conversion

The formats of CAD and GIS facilities available in Kazakstan were investigated and the possibility of data conversion to CAD systems used in Japan evaluated. The TAB format of MapInfo was subsequently adopted. The need for data conversion was further eliminated as the same GIS facilities were also used in Japan thus helping to preserve the accuracy and information content of digitized collected materials data.

3) Standardized formatting of digital data

a. Standardization and formatting of digital map data were discussed and determined with the beneficiary in Kazakstan based on map symbols agreed at the previous consultation stage of the project.

b. Standardization included:

- Layer construction and designs for the GIS structured data
- Data formats for the GIS structured data (MapInfo TAB, original text)
- Data formats of symbolized data for printing (MapInfo TAB)

(4) Digitizing of collected data/materials

The work was undertaken by the Kazakstan sub-contractor.

1) Digitizing categories

a. Digitizing categories consisted of the following:

- GCP map from 1/100,000 scale topographic mapping
- Map symbols agreed with Kazakstan beneficiary
- Unchanged map symbols based on interpretation of SPOT image

b. Map symbols on each 1/100,000 and 1/200,000 scale topographic map series were discussed.

c. Main map symbols:

- Geographic names
- Administrative boundaries
- Facilities
- Annotations
- Items considered necessary by Kazakstan beneficiary

d. Modification of administrative boundaries and boundary lines were completed before digitizing.

e. Consultations were held with the Kazakstan beneficiary on the necessity of annotation required with the digitizing process and consequently appropriate modifications were made for officially changed annotation prior to the digitizing program.

2) Character font

Investigations were also made on annotation character fonts used on Kazakstan and Japanese computers from which agreement was reached to adopt the true font of the Windows operating system.

3) Operations

- Copy of original printing plates were used as a base map for measurement
- Dimensionally stable polyester material was used as a base map for digitizing.
- A raster scanned base map was prepared using a 300dpi sampling rate.
- Digitizing was taken using the background raster base map.
- Each map sheet information features and classifications were digitized.
- Digitized map categories were output by plotters in color and then inspected.
- Content of inspected and collected map data were confirmed and arranged with data being recorded onto an electronic recording device.

4) Tying of sheet blocks

a. During digitizing, tying of sheets was accomplished by superimposing the data of adjacent sheets.

b. In case of unconformity it was remedied by the Kazakstan beneficiary.

5) Data inspection

a. Categorized data was collated with the collected data/materials by means of cartographic output.

b. Accuracy of map data positioning was checked by superimposing mapped output results on geometrically corrected satellite images.

6) Digitizing of contour lines

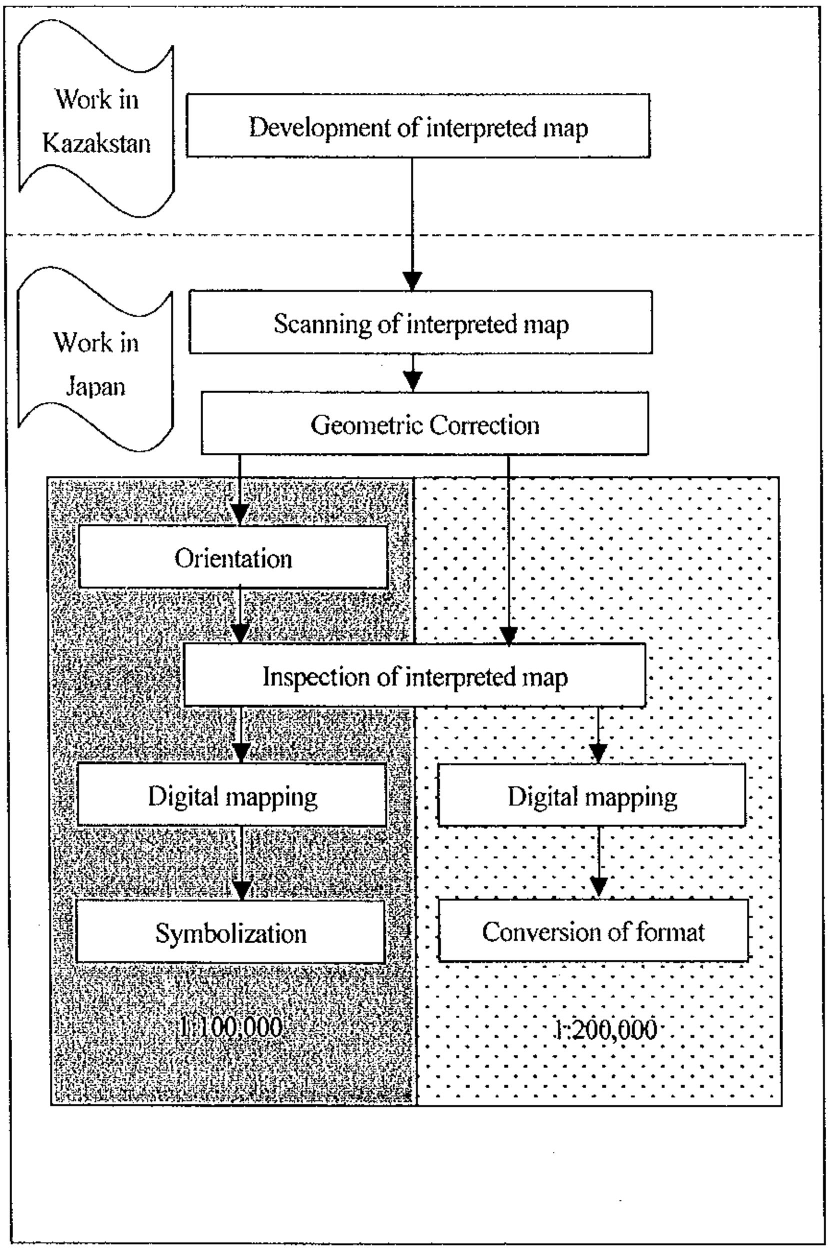
Map sheet contour lines, rasterized by scanners, were edited and subsequently vectorized through digitizing after which being allocated attribute information such as height data etc. they became GIS compatible and ready for utilization.

A DTM (Digital Terrain Model) was generated from ground elevation data through which contour lines were validated and relevant information stored.

The reproduced 1:100,000 scale contour line plate was then used for digital base map at the same scale and at a scale of 1:200,000 for digitizing of other areas.

7) Digital Mapping

Digitizing of map categories derived from satellite image interpretation was undertaken with CAD software.



Flow chart of Digital Mapping

a. Map symbol registration and development of compilation support software
    - Map symbols, previously agreed at the consultation stage were registered in CAD.
    - The data structure of line and surface map symbols were derived in order to generate symbol components automatically and also for supporting post-processing symbolization. Line map symbols contain line data and part of a symbol which relates to it. Surface map symbols are

represented by area patterns filling a potential surface.

- Support software has also been developed which recognizes digital map symbols and provides an account of the data structure constructed.
- Software for error inspection was further developed including classification and data structure.

b. Digital Mapping

- Coordinate values are expressed in meters.
- Satellite images, after geometric correction and division into sheet blocks, were converted into CAD format.
- Ground control points and sheet lines were input to CAD files by a given coordinate system and specification.
- Digitized collected material data was input to CAD files.
- Geometrically corrected images were oriented to neat line data of CAD files.
- Images were oriented and geometrically corrected by means of control points.
- Map categories and associated classification symbols derived from the interpretation of geometrically corrected satellite images were digitized. As geometrically corrected satellite images contain location information the interpretation results could be used for obtaining map classification data.
- Map categories and associated classification symbols derived from the interpretation of geometrically corrected satellite images were digitized. As geometrically corrected satellite images contain location information the interpretation results could be used for obtaining map classification data.
- Digitized map data, including classification categories, data structures, etc. were checked by validation software.
- Symbolized data was plotted and checked manually.

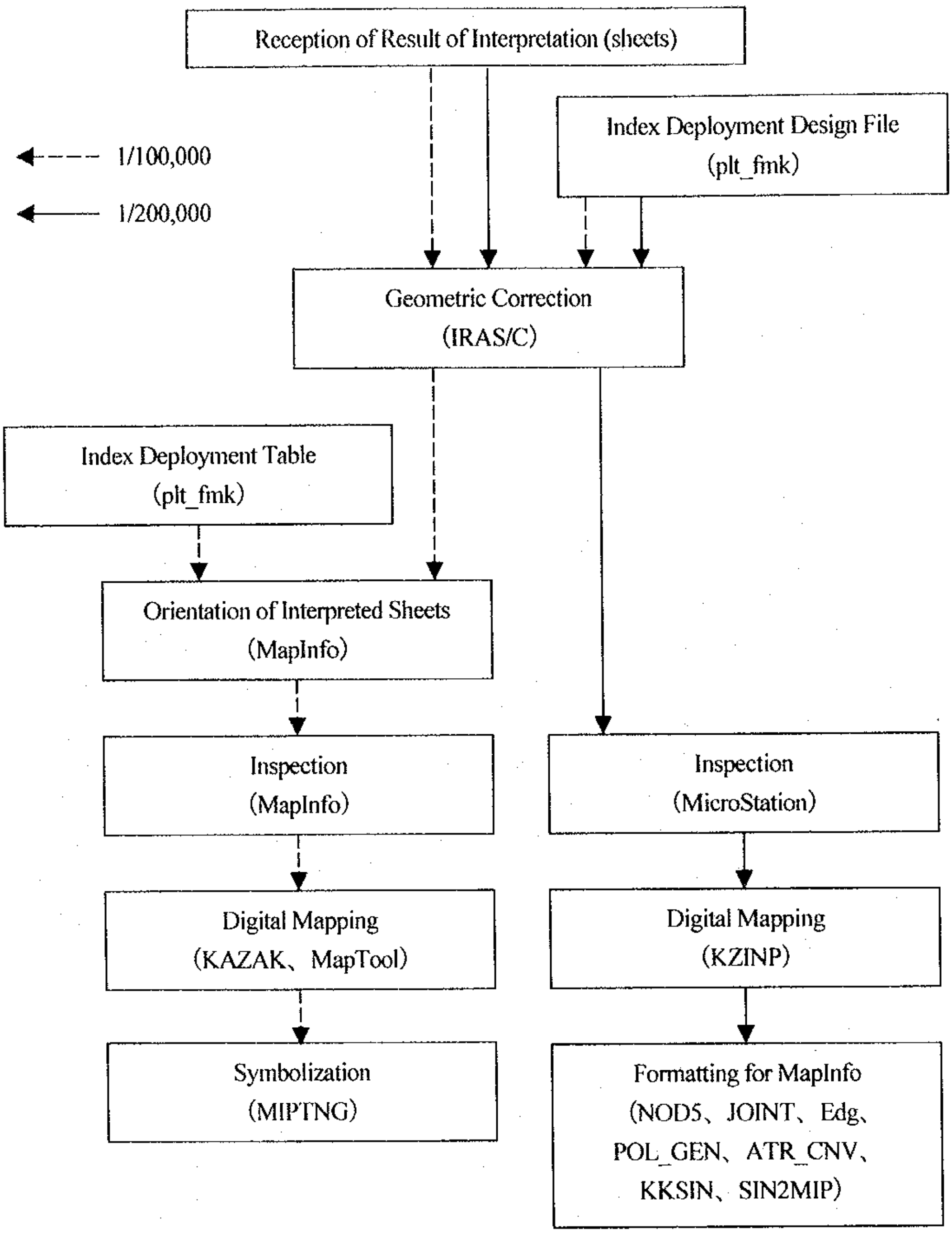
c. Production of CD-ROMs:

with 1:100,000 scale topographic map data

- Structured vector data
- Symbolized raster data

with 1:200,000 scale topographic map data:

- Structured vector data



Flow chart of Digital Mapping Procedure

8) Reproduction of positive films for printing

Positive printing plates were produced by laser plotters on the basis of symbolized raster data.

(5) Quality Control

Quality Control in digital mapping process was carried out with the followings:

Item	Evaluation	Correction
Position	①Check discrepancy with geometrical corrected interpretation image and digitized data in whole sheet ②Check discrepancy partly with geometrical corrected SPOT image and digitized data	①Correct more than 1 line width (about 0.2mm) discrepancy ②Correct more than 2 pixels (about 20m) discrepancy
Height	Compare digitized elevation data with digital elevation model (DEM) generated from elevation	Correct deviation of irrelevant elevation data
Cartographic expression	Compare symbolized digital mapping data and interpretation image	Correct input error and irrelevant cartographic expression
Attribute	Compare collected data and digitized data	Check and correct unfit data
Data structure	Verify structure definition table and data	Check and correct unfit data

8. Printing of 1/100,000 Scale Topographic Maps

Printing of 1/100,000 scale topographic maps was carried out by means of a sub-contract with KARTOGRAFIYA. Five hundred prints for each sheet of a topographic map were produced by offset printing. Printing plates were also prepared for respective colors.

9. Land Cover Information

(1) Preparatory work

The data/materials collected by the JICA preliminary study team and relevant data/information available in Japan were collated and analyzed.

The main work included:

1) Preparation of Chronological Land Cover Digital Data

Employed data : SPOT data of 1997-1998

Old series maps : 1970-1980 and 1950s

2) Preparation of Thematic Geographic Digital Data

Employed data : Geologic map, Soil map, Vegetation map and Geomorphological map, 1:5,000,000 scale from Atlas.

(2) Land Cover Interpretation of past available maps

Information on such features as distribution of lands, planting area and irrigation were important for assessing chronological changes in the study area and explaining causes of environmental change. Past conditions were studied by means of maps produced from previous decades in order to evaluate the chronological change of land cover, including irrigation.

1) Data

The following old maps at a 1:200,000 scale, produced in two different periods, were used for data acquisition.

A. 1943 – 1958: 27 sheets

B. 1978 – 1991: 27 sheets

Table : List of Used Maps

Sheet No.	Year "A"	Year "B"
L 41 - 13	1944	1981
L 41 - 14	1957	1981
L 41 - 15	1958	1980-83
L 41 - 16	1944	1980
L 41 - 17	1958	1982
L 41 - 19	1957	1978-82
L 41 - 20	1957	1981
L 41 - 21	1957	1980
L 41 - 22	1957	1978-83
L 41 - 23	1958	1982
L 41 - 24	1958	1982
L 41 - 25	1954	1983
L 41 - 26	1943	1983
L 41 - 27	1958	1979
L 41 - 28	1957	1981
L 41 - 29	1944	1981
L 41 - 30	1944	1980
L 41 - 35	1958	1981
L 41 - 36	1943	1980
L 42 - 25	1945	1980
L 42 - 31	1944	1985
L 42 - 32	1944	1985
K 42 - 1	1943	1979
K 42 - 2	1943	1978
K 42 - 3	1944	1979
K 42 - 8	1943	1979
K 42 - 9	1944	1980

2) Interpretation

Feature classification for interpretation was based on using the principle of Level 1, Land Cover Feature Classification. This was applied in the interpretation of satellite image which also made use of supervised automatic image classification methods. Finally a re-evaluation of interpretation results was undertaken to show changes distinguished in the classified features studied and to emphasize issues of environmental aspect.

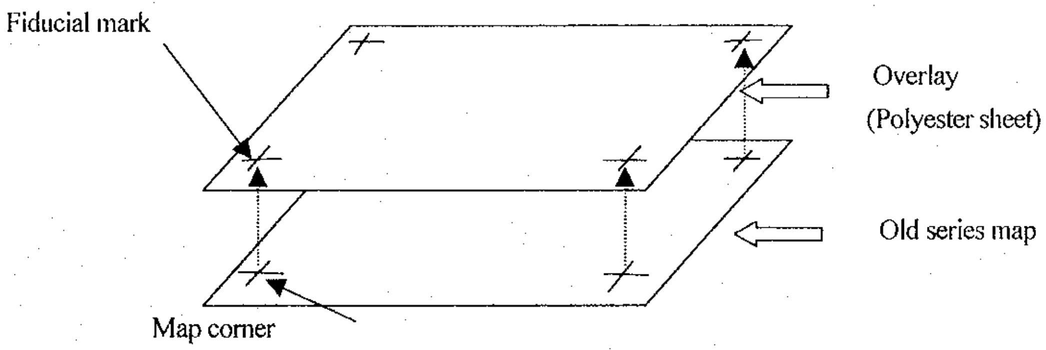
Table : Land Cover Items Classification

Category	Level 1	Level 2
Artificial feature	1.Urban area	11.Low level housing
		12.Medium and high level buildings
Vegetation	2.Vegetation area	21.Crop land
		22. *Grass land
		23.(Bush and) Forest
Bare land	3.Bare land	31.Desert
		32.Rocky land
		33.Salinity covered land
Hydrology	4.Hydrology	41.River, Canal
		42.Lake, Reservoir, Pond, Swamp

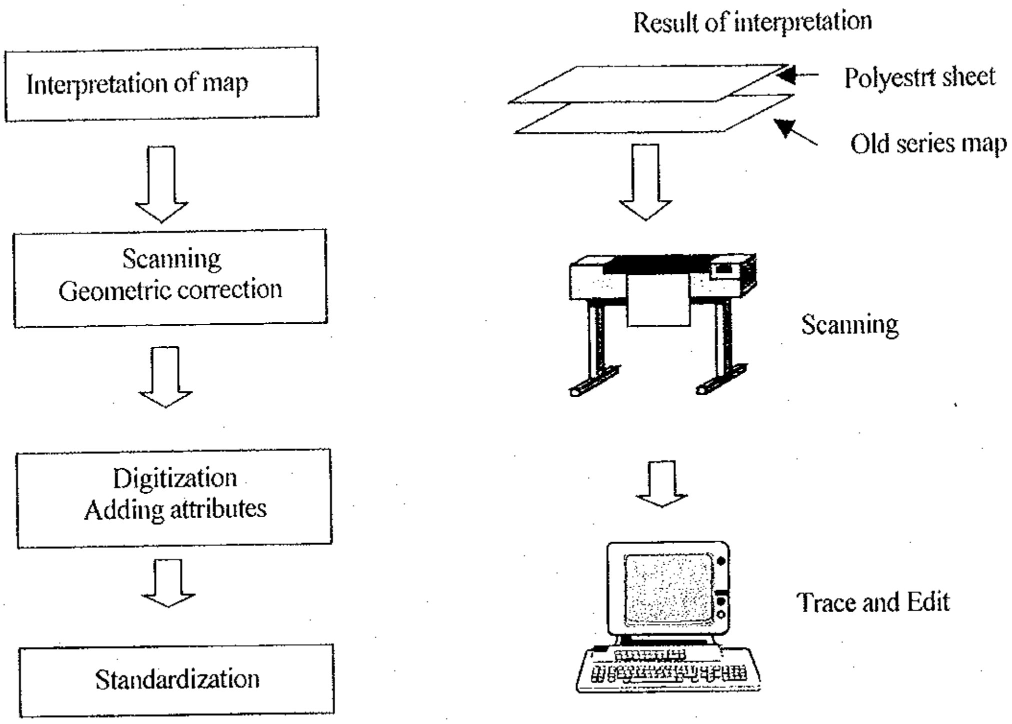
* Includes desert with seasonal vegetation

3) Interpretation methodology and work flow

- Printed maps of each period were used as base maps.
- Polyester base was overlaid on each base map on which the coordinates at four (4) corners were traced.
- Symbols illustrating derived interpretation were traced on these overlay sheets.



Manner of Interpretation



Flow chart of Interpretation

(3) Digitizing and editing of Thematic Maps

In order to assist decision-making, planning and recognition of the current status of ecological, development and natural conditions, the following available thematic maps were digitized and edited. Four additional themes were specified as a result of consultations with the Kazakstan beneficiary.

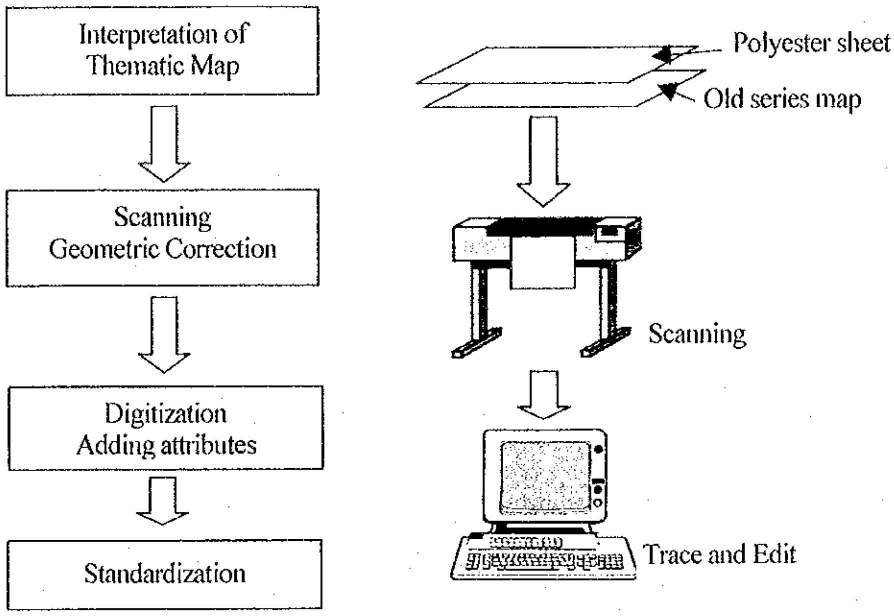
1) Digitized Data

The following thematic maps were selected for digitizing from the national atlas:

- Geologic map
- Soil map
- Vegetation map
- Geomorphological map

2) Work Flow Methodology

The preliminary stage of digitizing involved scanning the image to produce a map subsequently used for further digitizing.



Flow chart of Digitizing

(4) First stage of Satellite Image Analysis

The objective of the first stage of satellite image analysis was to improve the accuracy of current land cover classification by using SPOT Multispectral (XI) data acquired in 1998.

1) Acquired Data

Thirty-one scenes of SPOT XI were used. Panchromatic (P) data was acquired for the area not covered with XI data. A listing of SPOT XI data is shown below:

Table : SPOT XI Data

K_J	Year/Month/day	K_J	Year/Month/day	K_J	Year/Month/day
163_257	1998/08/11	169_258	1998/06/21	174_261	1998/07/12
164_257	1998/07/11	169_259	1998/07/22	175_261	1998/06/26
164_258	1998/07/11	170_258	1998/06/21	175_262	1998/06/26
165_257	1998/08/16	170_259	1998/06/07	177_261	1998/06/26
165_258	1998/06/25	170_260	1998/06/07	177_262	1998/06/26
166_257	1998/07/22	172_259	1998/06/07	177_263	1998/06/26
166_258	1998/06/25	172_260	1998/06/07	178_262	1998/06/27
168_257	1998/07/11	173_259	1998/07/07	178_263	1998/06/27
168_258	1998/07/11	173_260	1998/07/12	179_263	1998/06/27
169_257	1998/06/21	174_260	1998/07/07	179_264	1998/06/27
				180_264	1998/07/02

2) Area for Analysis

The study area was divided into the following two parts:

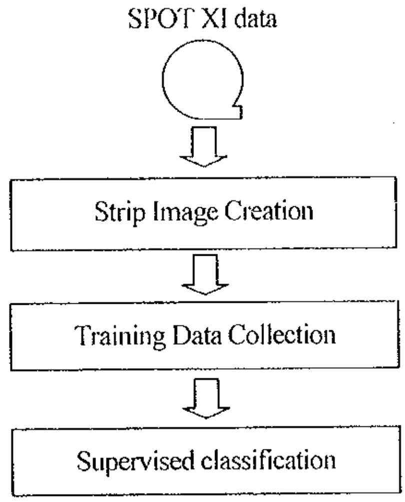
- Area along Syrdarya River with significant observed chronological changes (Area "A")
- Area with minor chronological changes (desert, steppe . etc.) (Area "B")

3) Acquired data for Analysis

- Area "A": Automatic classification of SPOT XI data
- Area "B": Manual interpretation of SPOT P data

4) Work flow of Image Analysis

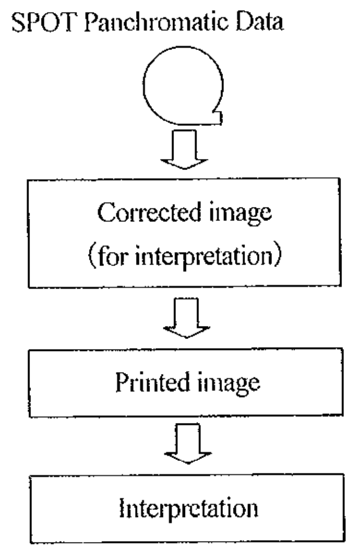
a. Supervised automatic image classification with SPOT XI data



Flow chart of Data Analysis

b. Interpretation of SPOT P Data

Interpretation was carried out on the basis of Level 1 feature classification also taking account of other typical land cover.



Flow chart of Data Analysis