6 PROCESSES OF TOPOGRAPHIC MAPPING (1/5,000)

6-1 Existing Data Collection

The Study Team collected data and information to be needed for 1/5,000 topographic map preparation with cooperation of INETER in the process.

Table 6-1 Collected Information

Collection data	Quantity	Receiving agency	Note
1/5,000 color aerial photograph	623 sheets about $200km^2$	Managua municipal government	Photographs in the year 2000
Aerial-triangulation results	One set	Managua municipal government	PAT-M
Digital color ortho-photographs	One set	Managua municipal government	NAD27 system

The Study Team found that the seven photographs of the course 11, frame numbers 1902-1908 were missing during the information collection process. The Study Team could not obtain the missing photographs, since the Spanish corporation of aerial photography, which had produced the aerial photographs, did not cooperate to provide them. The missing models for plotting were supplemented using 1/40,000 aerial photographs taken in the previous year.

Since the observation precision of the altitude at a single point is 40-70 cm, it was judged that the precision for mapping would not be affected for the intermediate -contour-line interval of two meters.

There were some models that did not have a 50% overlap. For those models, 1/40,000 aerial photographs were used to fill the gaps between models.

6-2 Ground Control Point Survey

In the initial plan, although the control point surveying using GPS was planned. But since it became clear that the Managua municipal government owned aerial-triangulation results, the GPS survey seemed unnecessary. However, the existing aerial-triangulation results were later found to be inadequate for 1/5,000 topographic mapping, since it was based on the ortho-metric heights using results from the geoid model. Therefore, leveling was decided to be implemented.

The Study Team used the direct leveling method using the levels, and conducted pricking onto the aerial photographs at an interval of 200 m. Upon observation, precision control was conducted by linking four previous bench marks that were based on the average sea level existed in Managua Municipality. The observation error of closure was set at $\sqrt{S}$ X D (km), and the work was carried out about 110 km in total length. The existing leveling network, precision control results on former benchmarks, and the results of leveling are shown in the following figure.

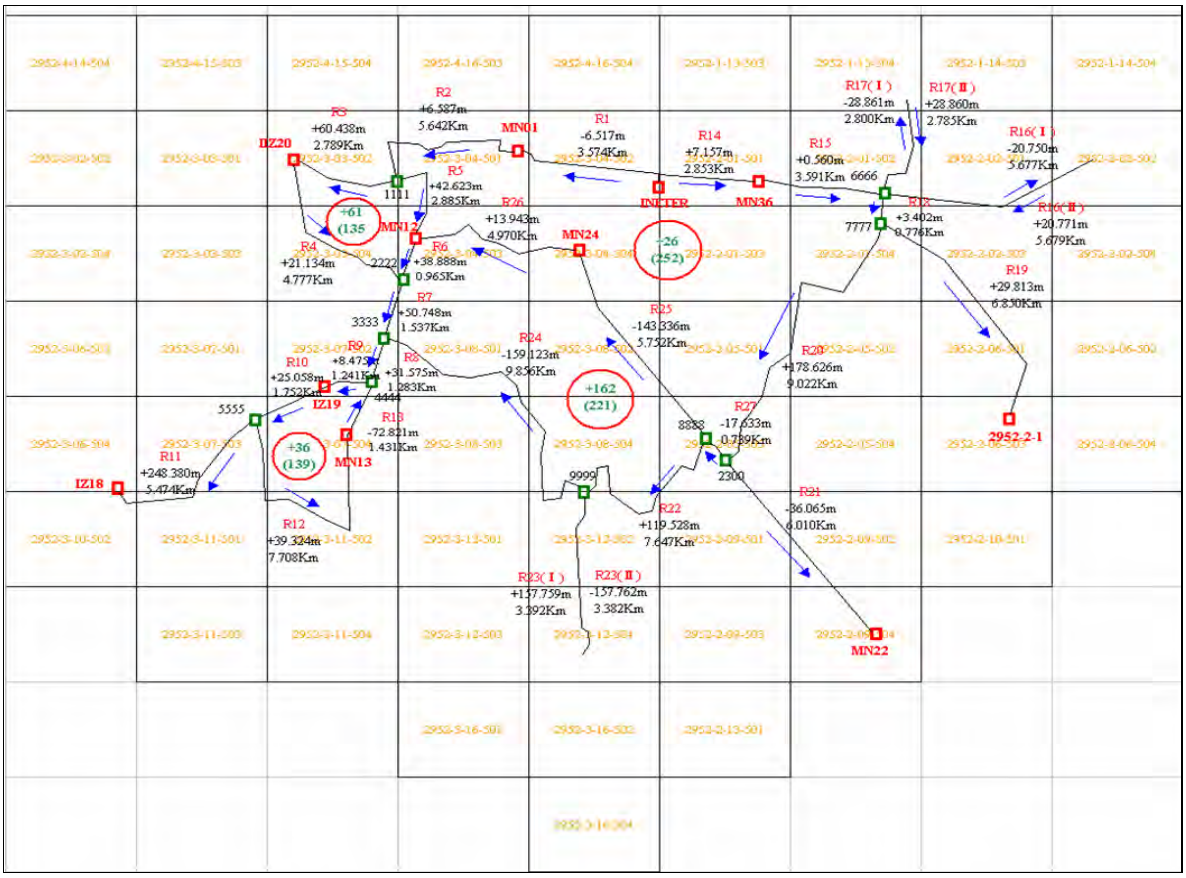

Figure 6-1 Leveling-Network and Quality Control

6-3 Changes of Mapping Scope

INETER had requested the southern mountainous area of Managua Municipality which had about 100 km^2 in addition to the originally planned 200 km^2 to be included in the 1/5,000 topographic mapping area. It was pointed out that the area included dam and reservoir development projects in the flood control plan of Managua Municipality. During the workshop held by the Study Team in Managua, there was a strong request from the Nicaragua side. The Study Team responded to the request and presented a proposal to compile the data of 1/50,000 prepared in the first year for the purpose. The INETER side accepted the proposal. 300 km^2 finally became the area for1/5,000 topographic mapping area. Figure 6-2 and Figure 6-3 show the change of the area.

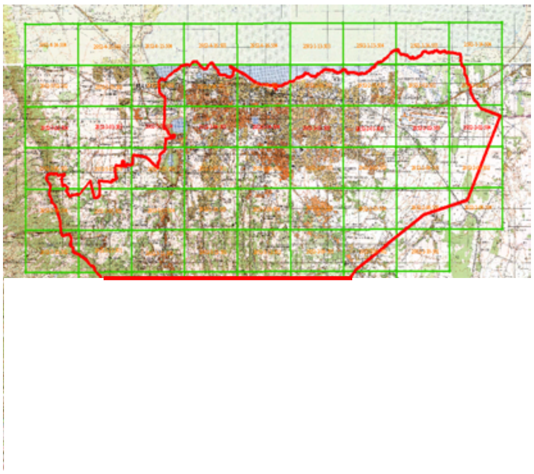

Figure 6-2 Originally Planned Area

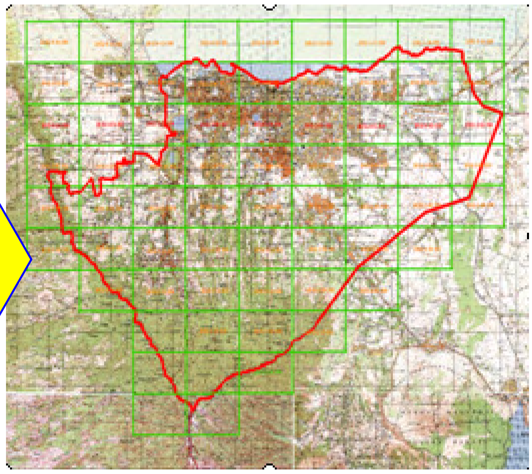

Figure 6-3 Final Mapped Area

6-4 Aerial Triangulation

The aerial-triangulation results provided by Managua Municipality were in the PAT-M format. However, since the ellipsoid adopted was NAD-27 and the calculated orthometric heights were used, it seemed that the results did not match the average sea level. Therefore, WGS84 was adopted as the ellipsoid used for the 1/5,000 topographic maps. Moreover, the leveling results, which have the adjustment results with the average sea level, needed to be used to perform aerial triangulation again.

New aerial triangulation was conducted based on the existing results of aerial triangulation and the results of the control point survey. 623 aerial photographs for the scale of 1/5,000 were used and 610 models were observed.

The coordinates of principal points of aerial photographs calculated from the former aerial triangulation and pricking points of leveling were treated as given data, pass/tie points were selected and observed. The block adjustment was conducted by the bundle method (PAT-B). The standard of precision was based on the specifications agreed with the INETER side. As for the limiting value of the control-point residual in the same block, the standard deviation for both coordinates and elevations is 0.02% of the flight heights above ground, and the maximum value is 0.04%. As for the discrepancy of pass/tie points, the standard deviation was 15 microns and the maximum value was set at 30 microns. Figure 6-4 shows the distribution of selected points for aerial triangulation. Table 6-2 to Table 6-5 shows the results of aerial triangulation.

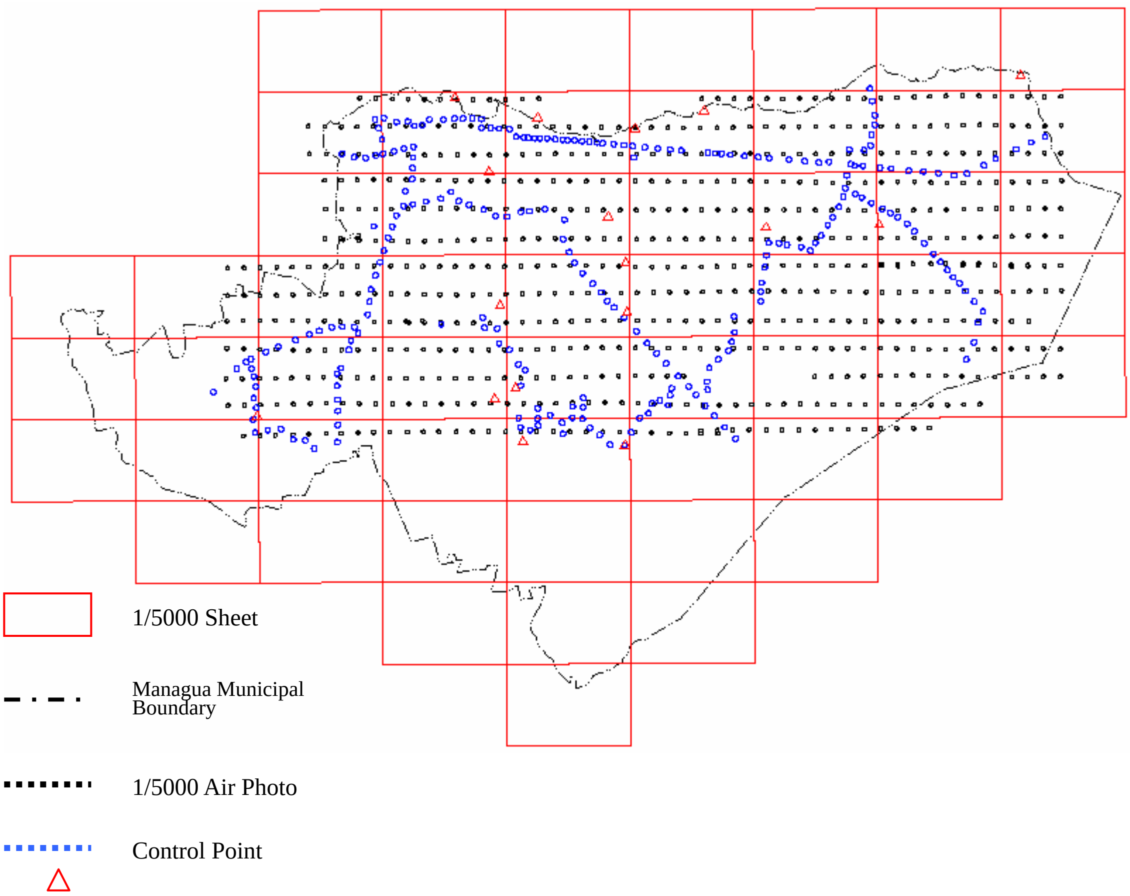

Figure 6-4 Selected Points for Aerial-triangulation

Table 6-2 Accuracy of Aerial Triangulation

No of photos	No of strips	No of point measurements	R.M.S. values(x)	R.M.S. values(y)
623	13	27716	4.8 micron	5.6 micron

Table 6-3 Control-Point Residual (RMS)

	RMS control points in photo	Specified RMS
X	0.108 meter	0.160m
Y	0.117 meter	-ditto-
Z	0.123 meter	-ditto-

Note: Specified accuracy is 0.2‰X Flight altitude (800m)

Table 6-4 Control-Point Residual (maximum)

	Max. Residual
X	0.286 meter
Y	0.255 meter
Z	0.297 meter

Note: Specified accuracy is 0.4‰X Flight altitude (800m)

Table 6-5 Pass-point/Tie-point Residual (RMS)

	RMS	Specified Residuals
X	4.8 micron	20 micron
Y	5.6 micron	

6-5 Field Identification

The field identification for 1/5,000 topographic mapping was carried out in accordance with the discussed map symbols. It was conducted using digital-ortho maps, which were provided by Managua Municipality. The work was conducted for annotating for public buildings, churches, factories, schools and other small objects and for identifying geographic names. The conventional method of noting local information onto photographs was used, since the accuracy of a Handy-GPS (10-50 m) did not satisfy the required precision the mapping scale of 1/5,000. Figure 6-6 shows a sample of the field-identification results. Fieldwork was carried out from 11th of October 2004 to 24th of November

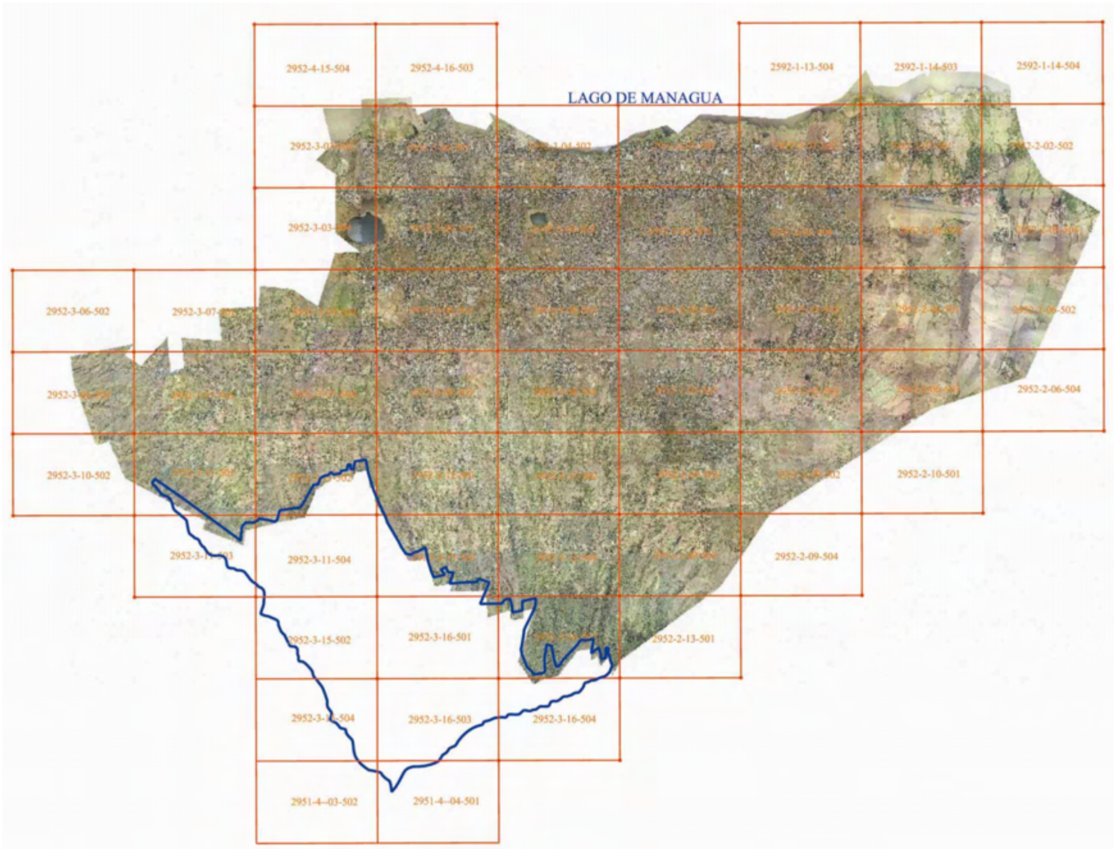

Figure 6-5　Managua 1/5,000 Index Map

The field identification work was conducted using color-ortho-images produced by Asimut, Spain in 2000.　Each map sheet was printed.　For the southern areas of Managua indicated in the white parts, ortho-images produced from the aerial photographs (1/40,000) taken in 2004 were used.　Before the field identification, plotting symbols were discussed and after determining the symbols to be used in the field, the field identification was conducted.　The results of the field identification were organized onto the ortho-images using CAD software.　(Figure 6-7)

Following four counterpart members in INETER took part in the work:

Table 6-6　 List of Trainees (Field Identification)

Name	Affiliation
Nestor Rodriguez	Department of Geodesy & Cartography
Alberto Orozco	Department of Geodesy & Cartography
Fernando Osorio	Department of Geodesy & Cartography
Francisco Javier Hernández	Department of Geodesy & Cartography

Photo 6-1 Field Identification

Figure 6-6 Results of Field Identification

Figure 6-7 Results Organized using CAD Software

For the central part of Managua, aerial photographs taken in 2000 were used; there were some parts where secular changes were recognized. For those areas, the aerial photographs taken in 2004 were used as supplementary data for the field identification.

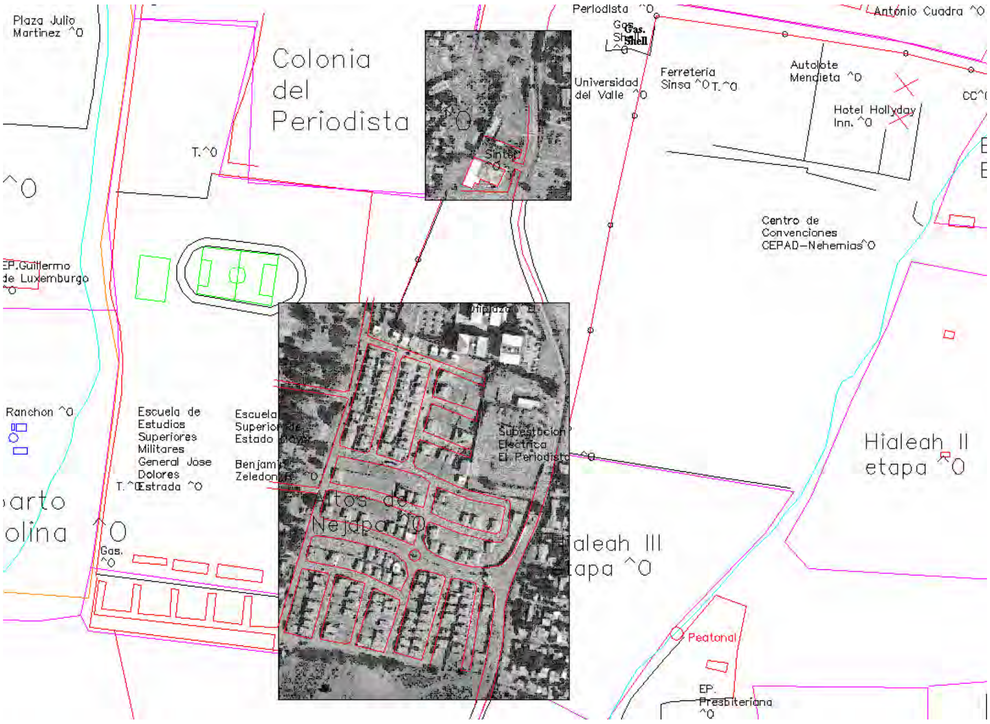

Figure 6-8 Secular Change

6-6 Plotting

Based on the "1/5,000 New Map Symbols and Application Rules" agreed in the Second Year Study in 2005, detailed plotting was performed, using base data from the results of former and new aerial triangulation, aerial photography interpretation, and field identification. By viewing the images three dimensionally using the analytical plotter, detailed digital plotting was carried out to acquire planimetric features, contour lines, etc. required for 1/5,000 topographic mapping. The interval of the intermediate contour was two (2) meters. Where distances between the intermediate contour lines become wide in flat areas, supplementary contour lines with an interval of one (1) meter were inserted. Since the mapping areas are urban areas and the scale was 1/5,000, the plotting was manually conducted; the automatic-contour-line generation using the DTM method was not used. The spot heights were selected at summits of major mountains, major junctions of roads, inlets of valleys, juncture of rivers, critical points of main inclinations, etc., and were distributed evenly in general. In plotting planimetric features, the plotted data were overlaid onto the color-ortho- photographs of 1/5,000 to inspect possible omission of data and as a result to raise the quality of data. The format of final data to be delivered was the dxf format which was the general format commonly accepted by end users such as INETER, the Municipality of Managua, and ENACAL and others. Figure 6-9 shows a sample of the 1/5,000 topographic map of the Managua International Airport and surrounding areas.

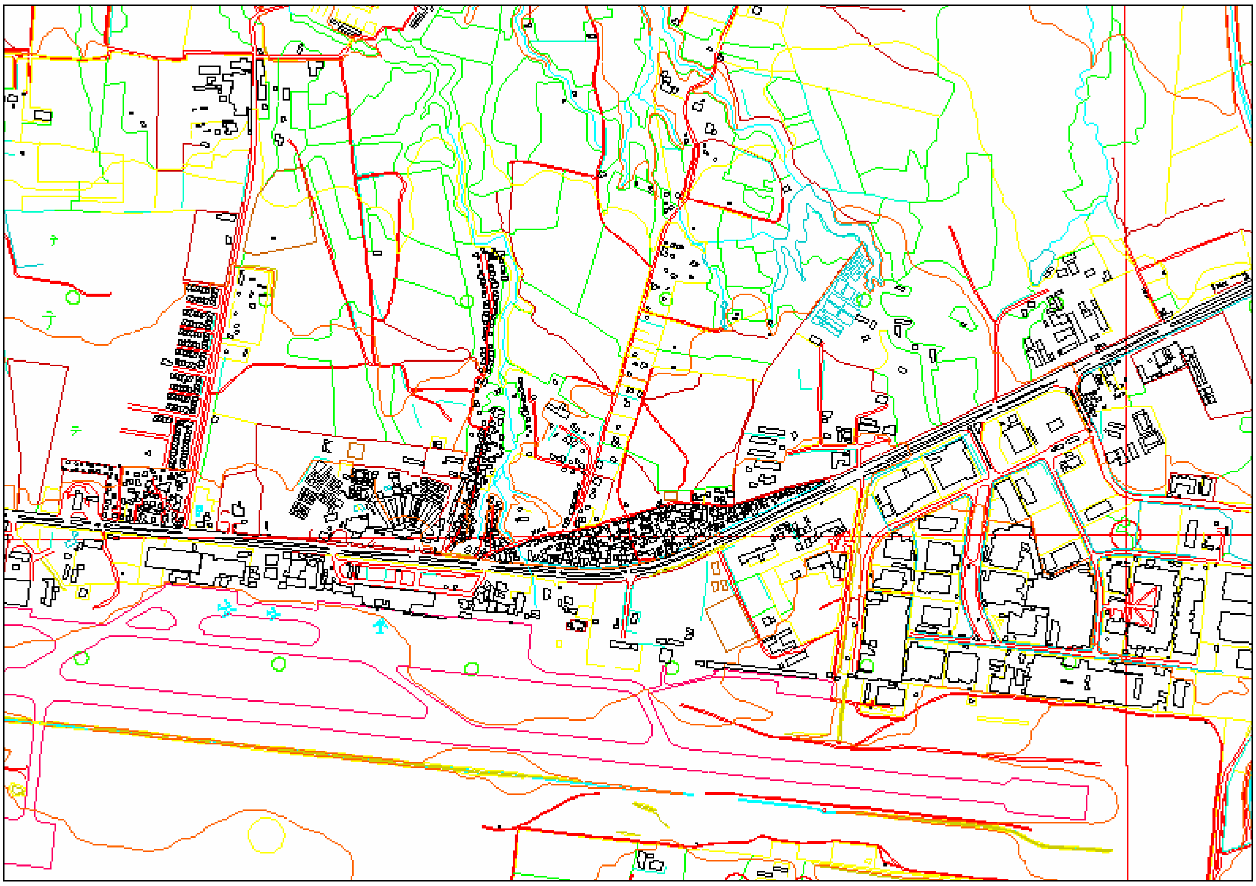

Figure 6-9 Sample Map (1/5,000), Managua Municipality
(Managua International Airport and Surroundings)

6-7 Field Completion for Topographic Mapping

The field completion was performed in interrogative parts, discrepancies, and inconsistencies with reference materials. The annotations were very important information; therefore, spelling, location, and types were carefully examined. The secular changes were examined using the aerial photographs taken in 2004 and other reference materials to reflect the current situations. The work was conducted from May 9, 2005 to June 22, 2005.

Four members from the counterpart took part in the work. The members conducted the field identification work; therefore, the assignment was considered appropriate.

Table 6-7 List of Trainees (Field Completion)

Name	Affiliation
Nestor Rodriguez	Department of Geodesy & Cartography
Alberto Orozco	Department of Geodesy & Cartography
Fernando Osorio	Department of Geodesy & Cartography
Francisco Javier Hernández	Department of Geodesy & Cartography

The ortho-images and edited draft maps were used during the work. The editing originals were used mainly for topographic and planimetric feature examination, and ortho-images were used to inspect annotations.

Figure 6-10 Topographic and Planimetric Feature Inspection Sheet

Figure 6-11 Inspection on Notes

The counterparts seemed comfortable working with the large-scale topographic maps. However, some of the counterparts had difficulties understanding topographic symbols. Some of notes that were not specified during the discussion on plotting needed examination. The Study Team instructed the work methods according to the scale of maps. When unnecessary information was acquired more than required, the pieces of information were disregarded.

In 1/5,000 topographic-map-symbol discussions, polygon data, such as high density built-up areas, durable structures, vegetation, road, river, and lake were decided to be smeared with each color. However, for high density residential areas, two layers, generalization layer and independent house layer were prepared, since they were considered useful GIS base data for end users. The annotation on major buildings showed the reference numbers in the maps; the reference numbers and reference grids and structure names were decided to be placed in the margin.

6-8 Final Data of Topographic Maps (1/5,000)

The Study Team delivered the final digital data of topographic map at a scale of 1/5,000 for examination by INETER in November, 2005. The Study Team and INETER discussed the annotation of toponymy which was provided by INETER in June, 2005. The Study Team explained difficulty of editing work for these annotations. INETER accepted topographic mapping data and agreed to edit annotation of toponymy by INETER side using MicroStation software. The Study Team delivered two types of Topographic mapping data. One type of data showed all the outlines of buildings. The other type showed built-up areas as polygon data. School, church and other public buildings were filled in red and black. For those two types, major buildings were numbered as annotation and the names and the numbers were placed right side out of the neat lines.

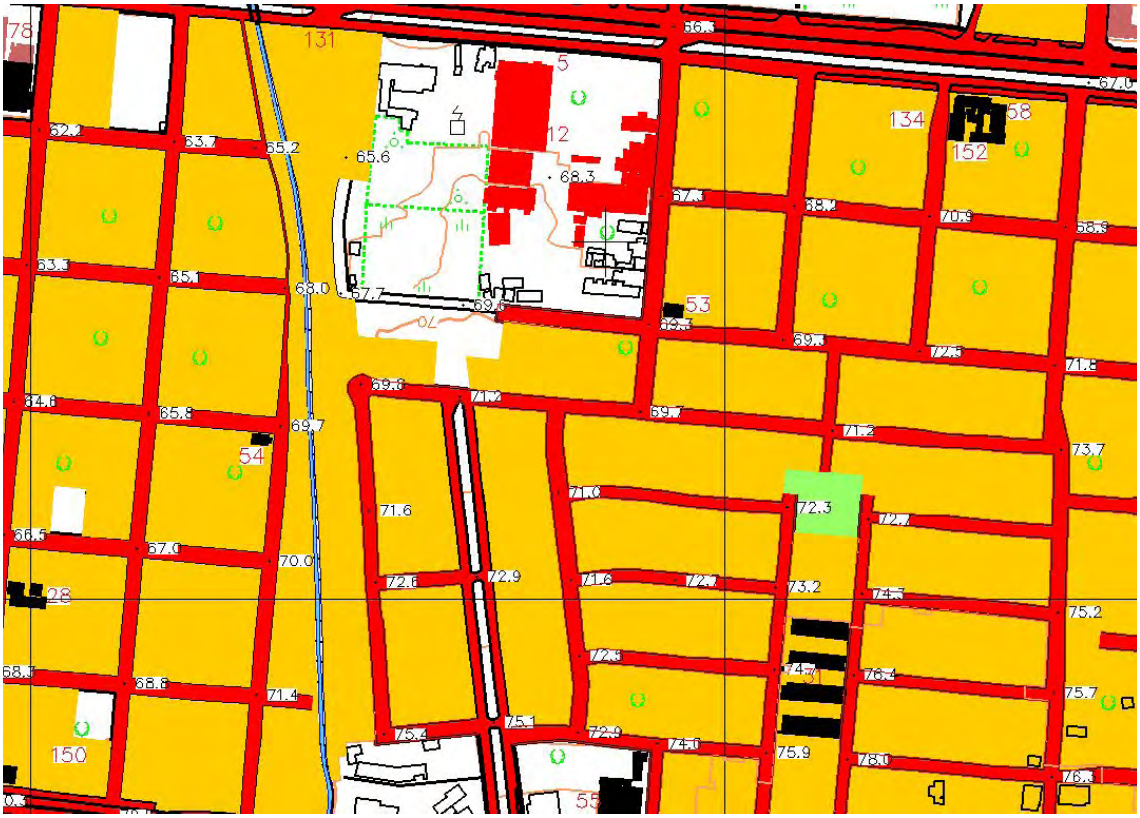

Figure 6-12 Generalized Built-Up Area

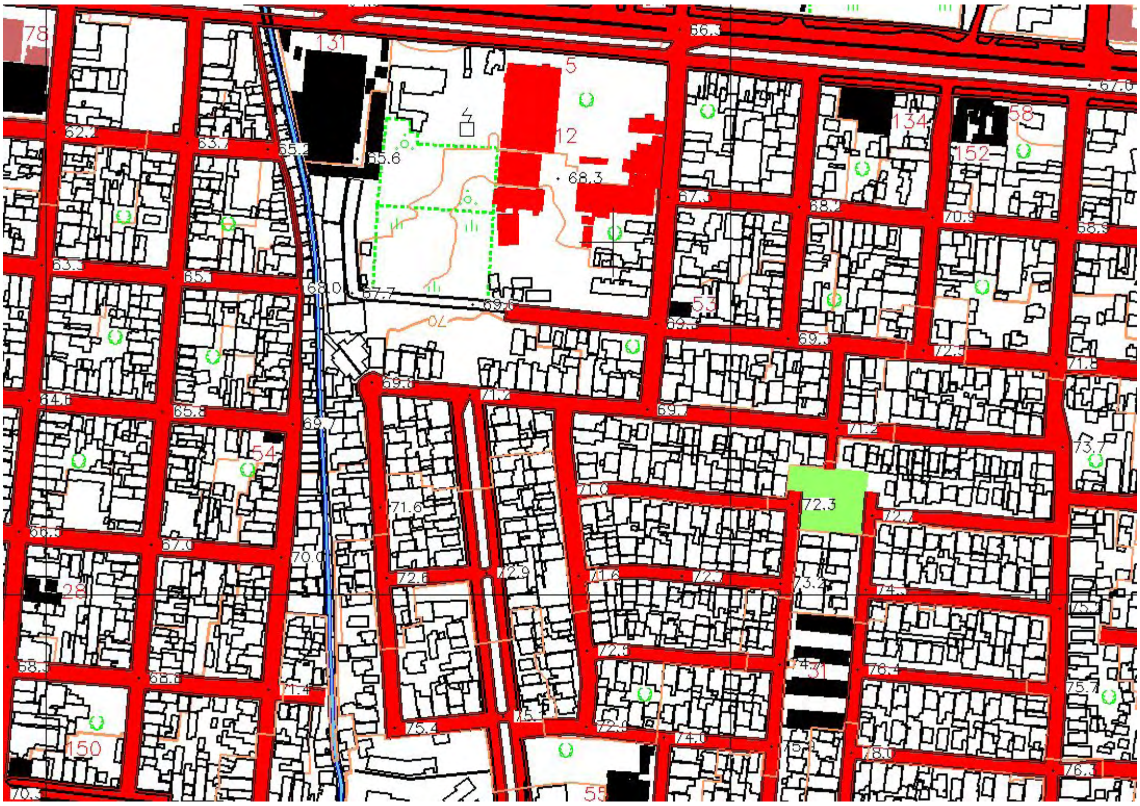

Figure 6-13 Built-Up Area with Building Foot Prints

7 GIS DATABASE OF INFRASTRUCTURES FOR DISASTER MITIGATION

7-1 Preparation and Organization

Considering the purpose of the Study, all of the procedures and processes to be followed were defined and refined during various meetings with the counterpart (INETER) personnel. Following infrastructures were finally included for creation of GIS database:

- City halls
- Fire stations
- Red Cross
- Hospitals
- Schools
- Police stations
- Roads
- Gas stations
- Wells
- Bridges

The overall adopted methodology is presented below:

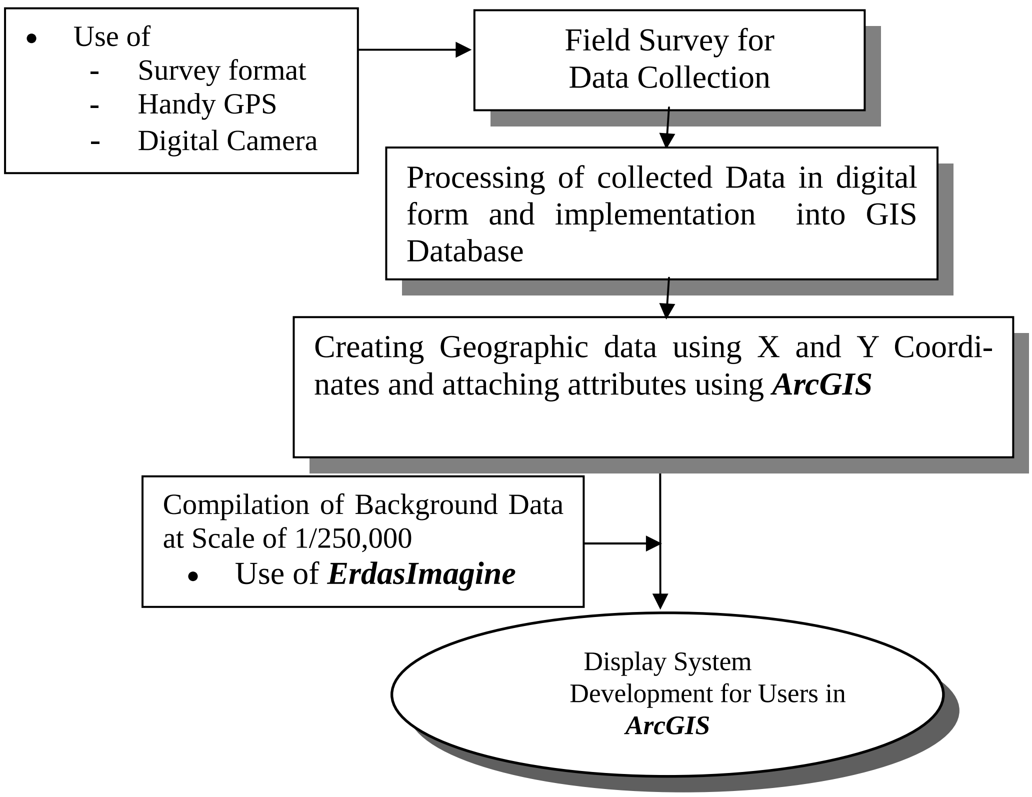

Figure 7-1 Workflow for GIS Database Creation for Disaster Mitigation Infrastructures

As clarified in the flow chart, the field survey was conducted first to collect the information and in order to keep the consistency among the various types of the collected data, a specific format was finally established for each type of the infrastructures.

To collect the data, two Task Teams were formed, each one of which is comprised from two technicians from INETER to collect the information. The work was supervised in the field by the Japanese experts. After a week from the start of the work, some corrections were made in instruction sheet of data collection. For example, prior to the start of the fieldwork, the initial idea was to collect the data on all schools. However, in the field, some of schools were found to have only a few rooms, too small to accommodate significant number of people at the time of disaster. Many of the schools were small, and therefore the operation was time consuming. Considering this situation, the Study Team limited the collection of data to such schools that have more than ten rooms. Similarly, the data collection of bridges was limited to such bridges that have length ten (10) meters or more. The measurement of road width was performed only at one point (at about middle location). The work was developed in the whole study area on the Pacific region covering approximately an area of 20,000 square kilometers.

The utmost efforts were paid to collect as much information as possible on each infrastructure. The Team used a handy GPS to record locations (coordinates) of infrastructures and took photos using a digital camera.

The collected data was transferred to digital form using Microsoft Excel, then implemented into GIS database. Finally, along with a 1/250,000 scaled topographic raster data as background, all information were placed together to achieve legible and appealing display system by using ArcGIS Version 9.0 Software. The system is able to display all the information by clicking a planimetric feature including X and Y coordinates. Moreover, when new object were added in form of a photo, it can be displayed also on GIS display.

7-2 Field Survey for Data Collection

The field survey for data collection for the “Creation of GIS Database of Infrastructures for Disaster Mitigation” was carried out in the 2nd and the 3rd years, during the work in Nicaragua.
The Study Team collected following major information.

Table 7-1 Major Data Items Collected During Field Survey

Types	Infrastructures	Major Attributes
Core Infrastructures for Disaster Mitigation	City Halls	Responsible person's name, contact telephone, number of emergency and other vehicles and lifeguards.
	Fire Stations	Responsible person's name and contact telephone, numbers of fire engines and ambulances.
	Red Cross	Responsible person's name and contact telephone, numbers ambulances, rescuers, and special vehicles.
	Schools	Number of classrooms, schoolyard area, number of wells within 1 km radius.
	Hospitals	Number of available beds, doctors and nurses, Number of ambulances, available various medical sections.
	Police Stations	Office chief’s name and contact telephone, numbers of Police, petrol cars, other vehicles.
Related Infrastructures for	Roads	Number of lane, type of surface, administrator, driving speed, period of maintenance.

Types	Infrastructures	Major Attributes
Disaster Mitigation	Gas Stations	Owner name and contact telephone, available various classes of gasoline, and other services.
	Wells	Type of construction, condition, capacity, water quality.
	Bridges	Type of construction, width, length, capacity.

The staff went to the field starting their work in the department of Chinandega and finishing in the department of Rivas. At each site, the members recorded geographic coordinates using a GPS receiver, taking photographs, and filling the format. In some cases, they used measuring tapes for measurements.

Photo 7-1 A Technician Recording X, Y Coordinates with GPS Data

Photo 7-2 Two Technicians Measuring the Length of a Bridge

Information was collected directly from the directors or responsible personnel. When responsible personnel were not available, the staff had either waited for some time or visited again to obtain data. Despite of such efforts, some of required information could not be obtained during the time of the project. Some of the formats remained empty for those items. It is expected that the remaining data would be collected in future.

In addition, as the quantity of collected data was very large, a laptop was used in the field to download the collected data from the GPS and from the digital cameras. This helped largely minimize the loss of collected information.