PART 3 PRE-FEASIBILITY STUDY

8. Field Investigation Works

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8. Field Investigation Works

8.1 Topographic Survey

8.1.1 Outline

In order to execute the pre-feasibility study, a topographic survey by aerial photogrammetry was carried out for the selected projects among the hydropower potential study as follows.

Se Kong No.4 dam site and reservoir area
Xe Kaman No.1 dam site and reservoir area
Xe Namnoy Mid-stream dam site and reservoir area, including downstream site

Ground survey for the aerial photogrammetry such as monumentation, signalization, control point survey, leveling and verification were also carried out on the field.

Based on the these works, topographic maps of 1/10,000 scale were prepared for the pre-feasibility study purpose. The topographic maps were prepared for the all reservoir area of Xe Namnoy site including the downstream site, and a part of reservoir including dam areas of Se Kong No.4 and Xe Kaman No. 1 sites.

Though the aerial photo has been taken for all reservoir areas of Se Kong No.4, Xe Kaman No.1 and Xe Namnoy sites, the topographic maps, however, were prepared only limited areas for the pre-feasibility study purpose. Topographic maps of the remaining areas will be prepared depending on the progress of the study stages on the projects in future, if required.

Survey areas of the aerial photogrammetry and the mapping areas are as shown in **Figs. 8.1-1 - 8.1-7.**

8.1.2 Work Quantity

Work quantity of the topography mapping including aerial photogrammetry is shown below.

Work item	Se Kong	Xe Kaman	Xe Namnoy	Total
Aerial photogrammetry				
Flight distance (km)	354	365	261	980
Area (km^2)	1,930	2,000	1,570	5,400
Posi. film (sheet)	193	238	117	548
Ground survey				
Signalization (point)	16	11	10	37
Control point (point)	16	11	10	37
Leveling (km)	179	227	204	610
Mapping				
Mapping area (km^2)	80	80	170	330
Map sheet (sheet)	4	5	16	25

8.1.3 Aerial Photogrammetry

Aerial photogrammetry work was carried out by Kevron Aerial Survey Pty.Ltd., Australia, from November 1993 to January 1994 in accordance with Technical Specification prepared by the study team. The aerial photogrammetry was done with scale of 1/25,000 along the flight courses which were approved by the government of Lao P.D.R.

All photographs were inspected and accepted by the topographic survey specialists of the study team during their stay in Vientiane, Laos.

8.1.4 Ground Survey

37 points of signalization and control point for the aerial photogrammetry were installed, and surveyed its location and height, by GPS (Global Positioning System) and leveling.

The ground survey was carried out by Lao Survey & Exploration Services Co., Laos, from October 1993 to February 1994 in accordance with Technical Specification prepared by the study team. All results and survey field data were inspected and accepted by the topographic survey specialist of the study team.

GPS survey were adopted 4 receivers (Type 4,000 SSE, Trimble Navigation Co.) which can receivable two frequencies at the same time from the satellites. The GPS survey connected to the existing GPS point at Pakse installed by Mekong Committee.

The leveling was carried out 610 km in total starting from the existing National Bench Mark (2nd and/or 3rd order) and connected to the GPS stations.

The following procedures were adopted to achieve the required accuracy.

$50 \text{ mm} \times \sqrt{D}$, where D is distance in km

The results of the leveling measurement were satisfying the precision required. The maximum closure is 113 mm in 118 km (allowance=543 mm) and minimum closure is 1 mm in 47 km (allowance=342 mm).

The point descriptions (location, elevation, photograph and etc.) of the signalization and control points are shown in **Appendix 3.1**.

8.1.5 Plotting/Compilation

The plotting and compilation works were carried out in Japan from March 1994 to August 1994. Using the diapositives of aerial photographs, the results of aerial triangulation and field verification, necessary items such as contour line, vegetation boundary, road, river, water fall, rapid, house, bridge and etc. were described in accordance with the drawing guideline.

8.1.6 Drawings

After compilation, fair drawings were carried out on the transparent polyester film sheets by using the compilation manuscript in compliance with the specifications as a final process. Topographic maps for each project were made drawings in AO size.

Fig. 8.1-1 Flight Line and Ground Control Survey

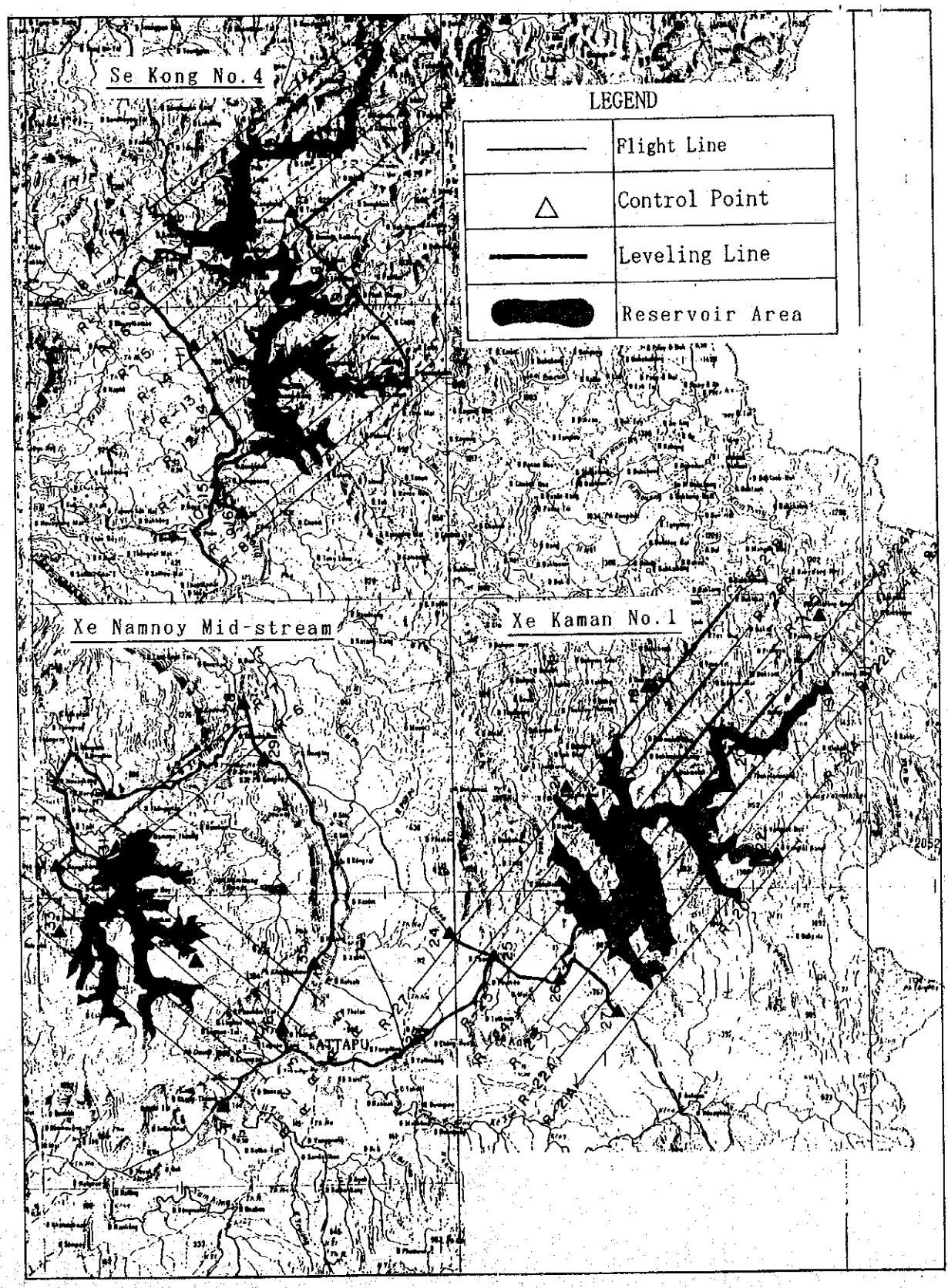


Fig. 8.1-1 Flight Line and Ground Control Survey

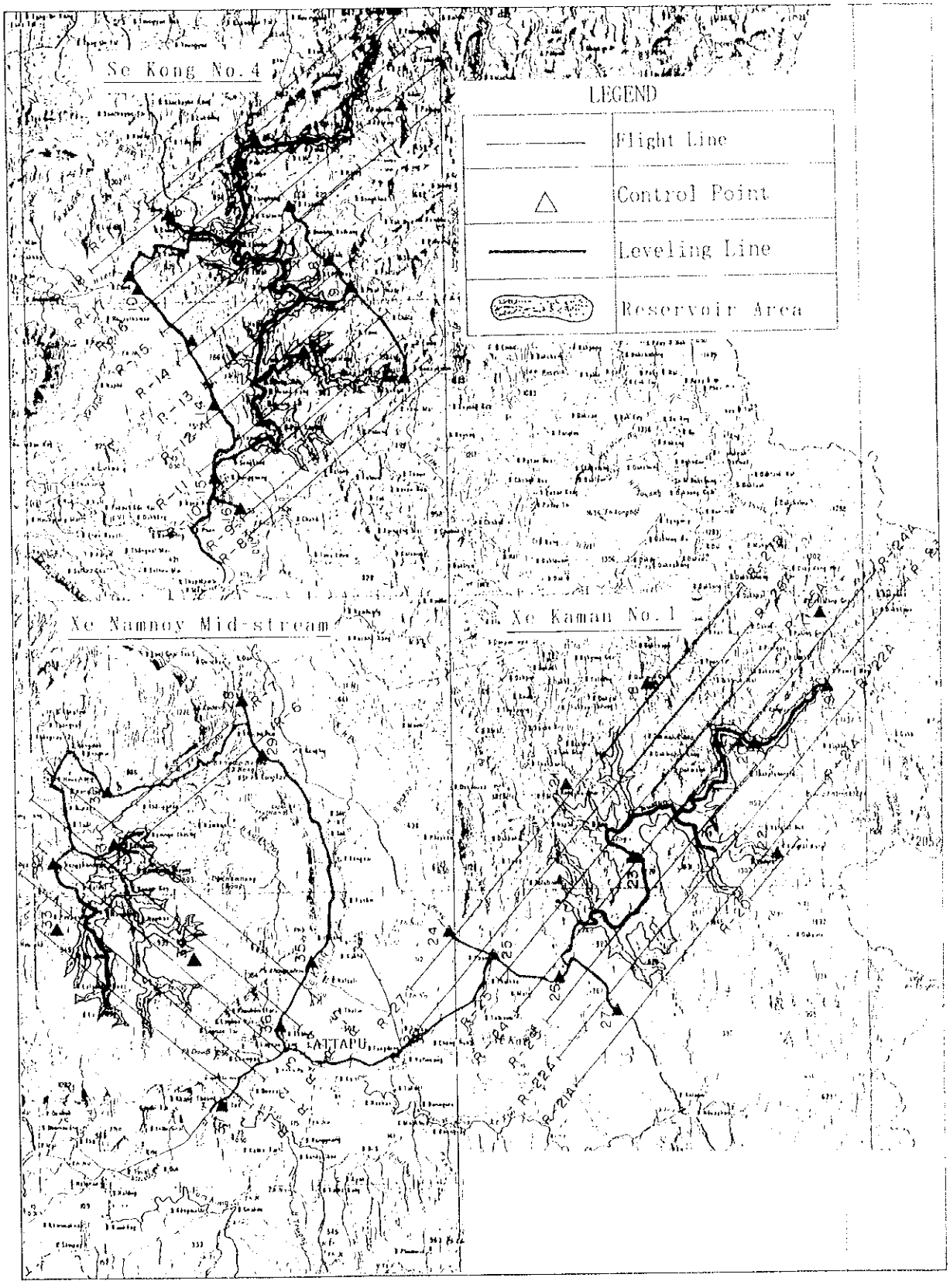


Fig. 8.1-2 Flight Line and Ground Control Survey (Se Kong No. 4)

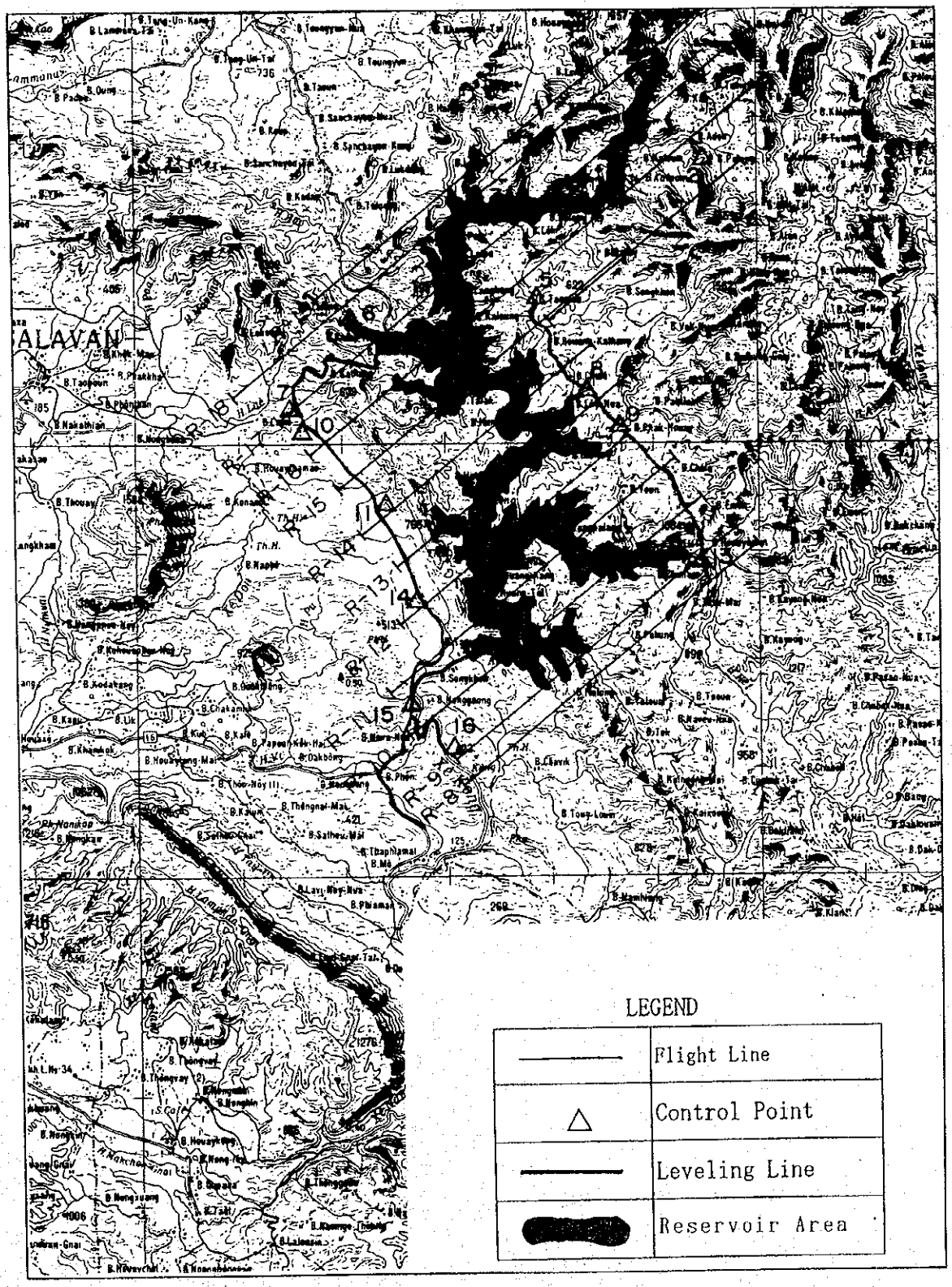


Fig. 8.1-2 Flight Line and Ground Control Survey (Se Kong No. 4)

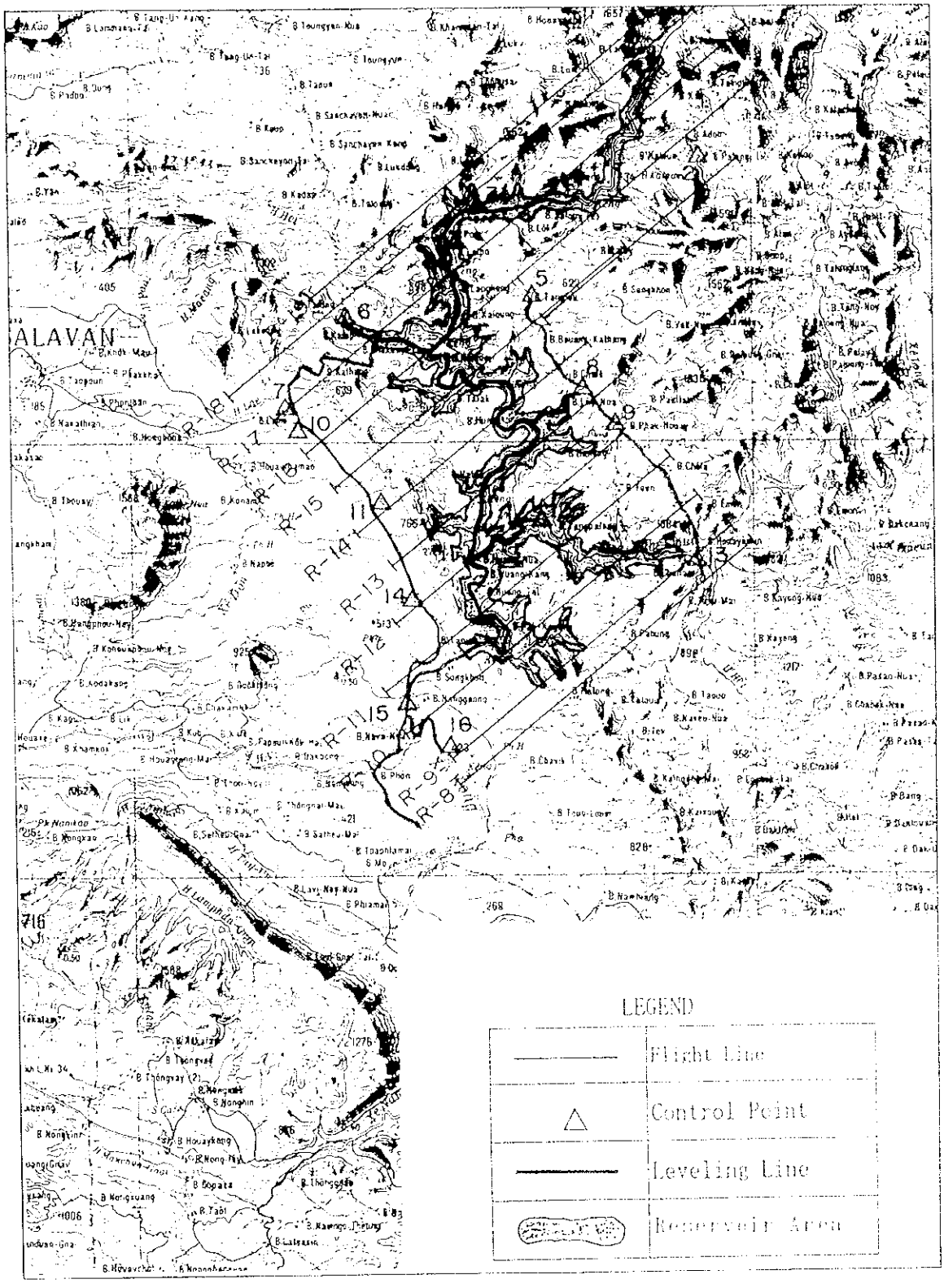


Fig. 8.1-3 Flight Line and Ground Control Survey (Xe Kaman No. 1)

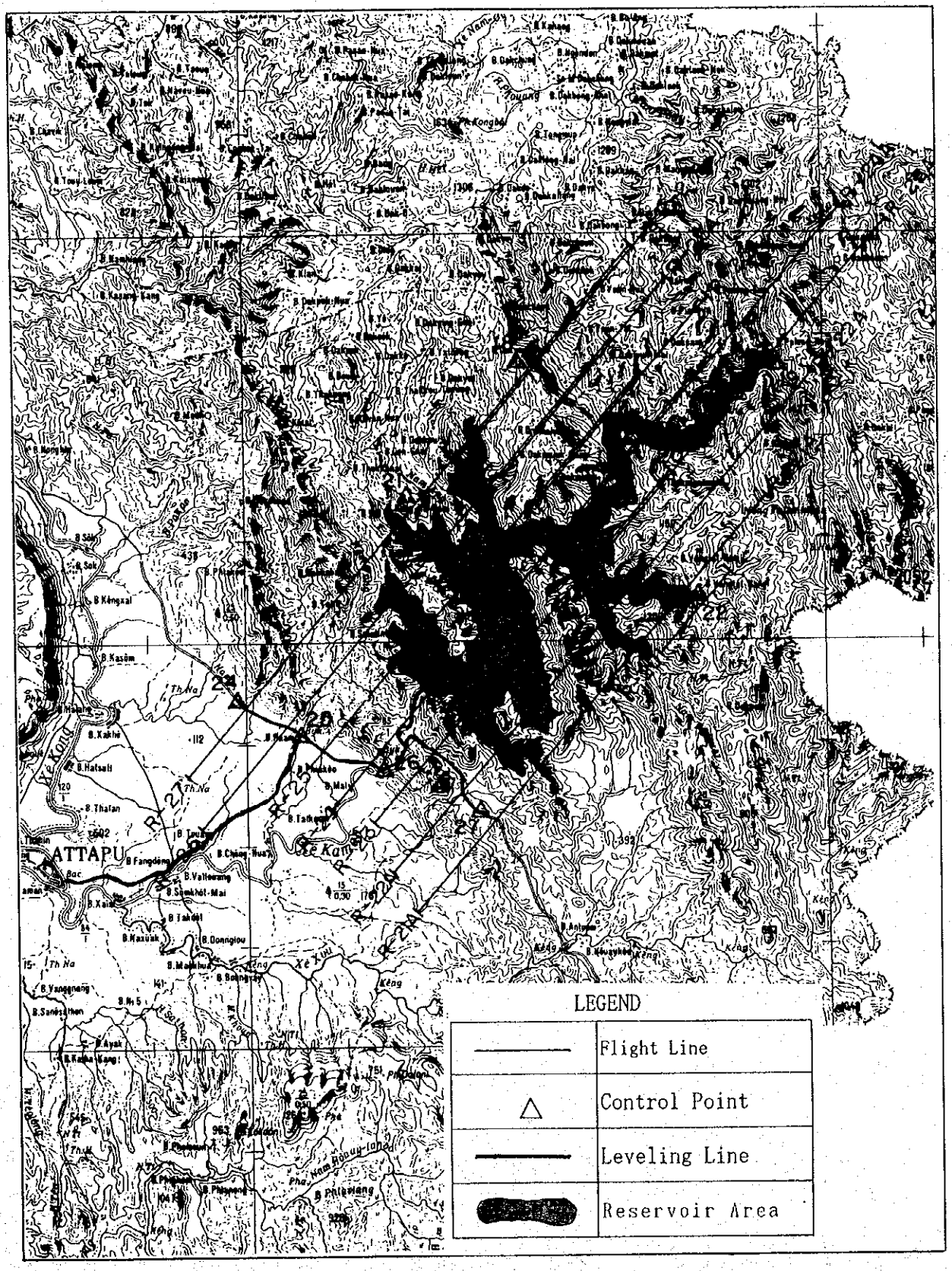


Fig. 8.1-3 Flight Line and Ground Control Survey (Xe Kaman No. 1)

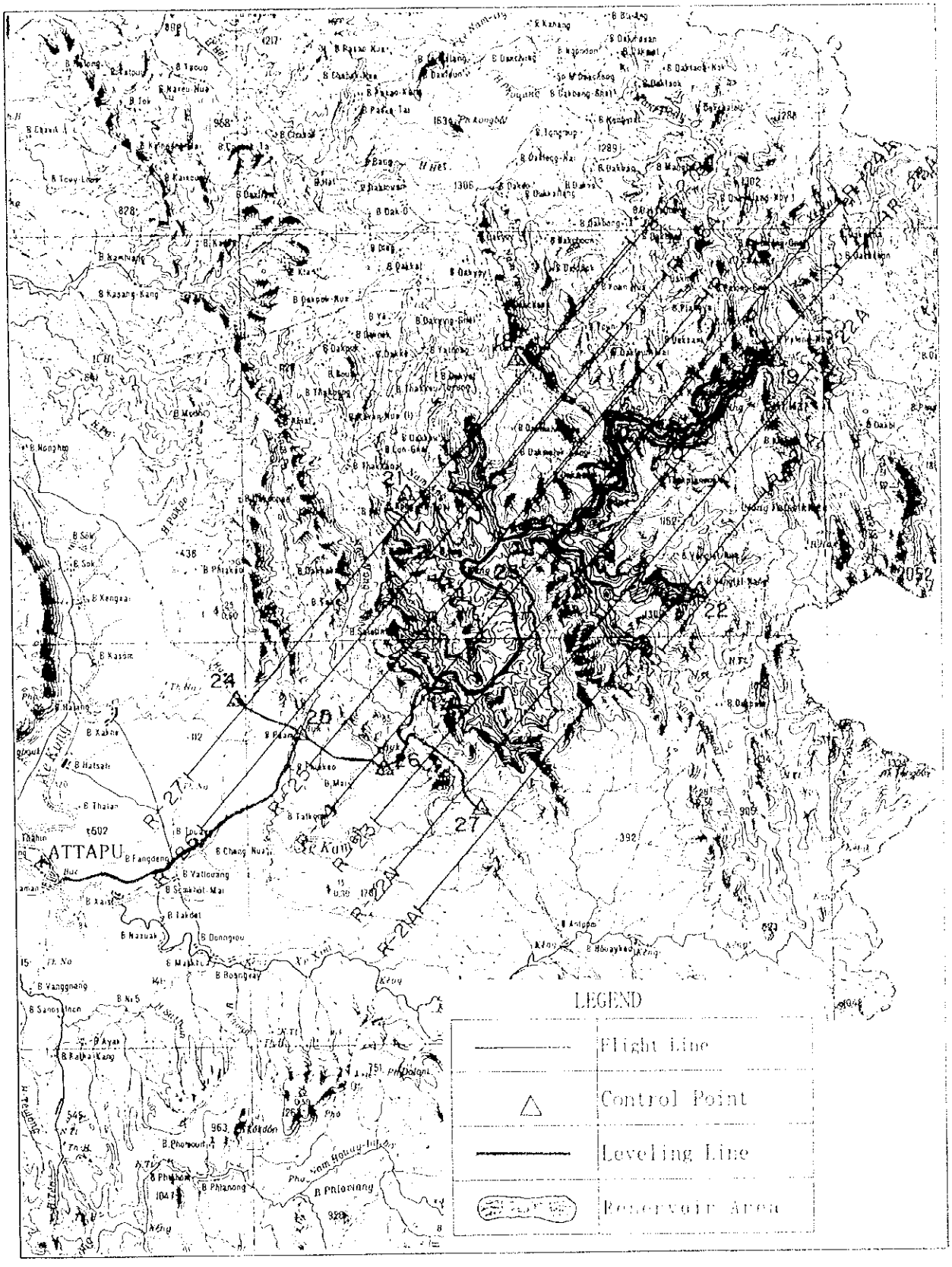


Fig. 8.1-4 Flight Line and Ground Control Survey (Xe Namnoy)

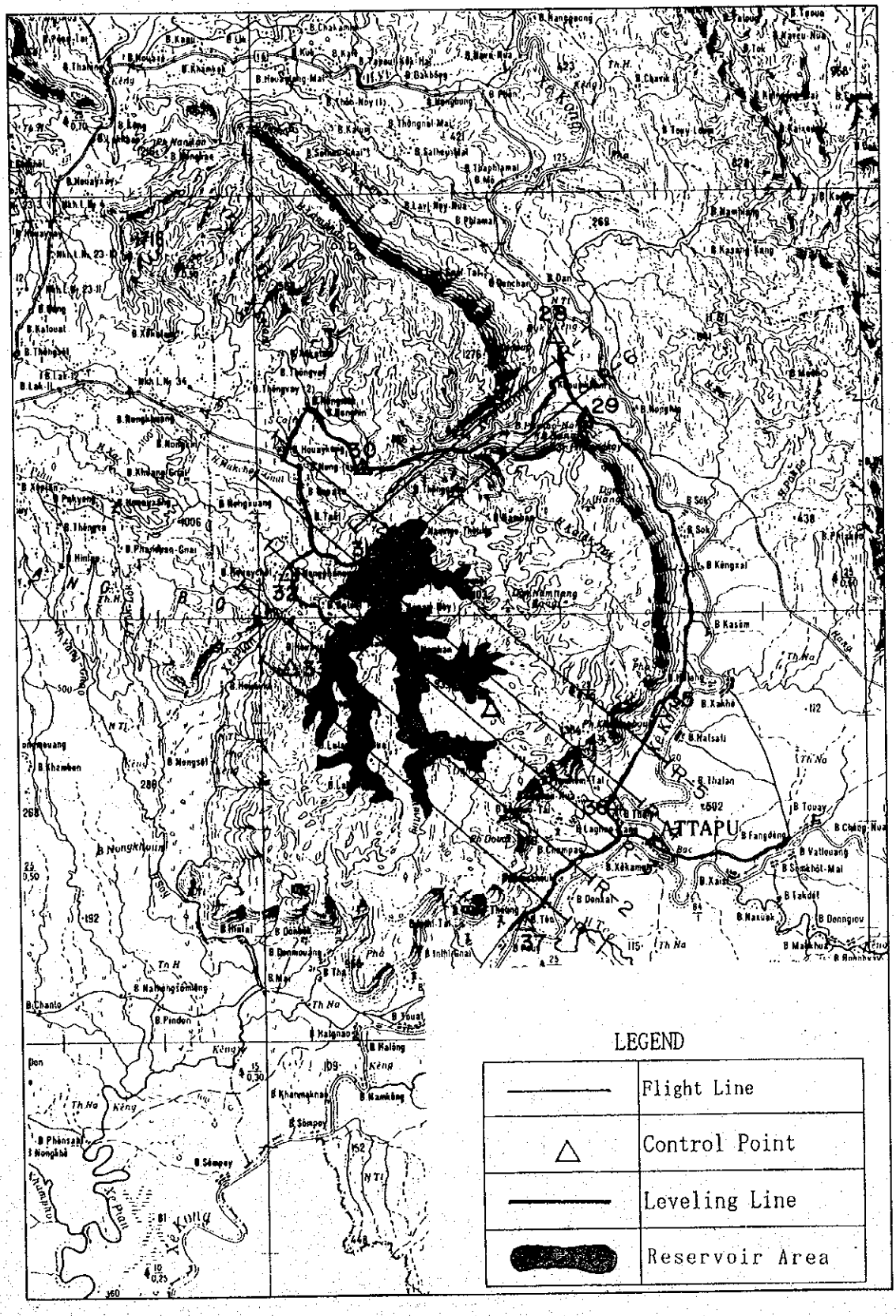


Fig. 8.1-4 Flight Line and Ground Control Survey (Xe Namnoy)

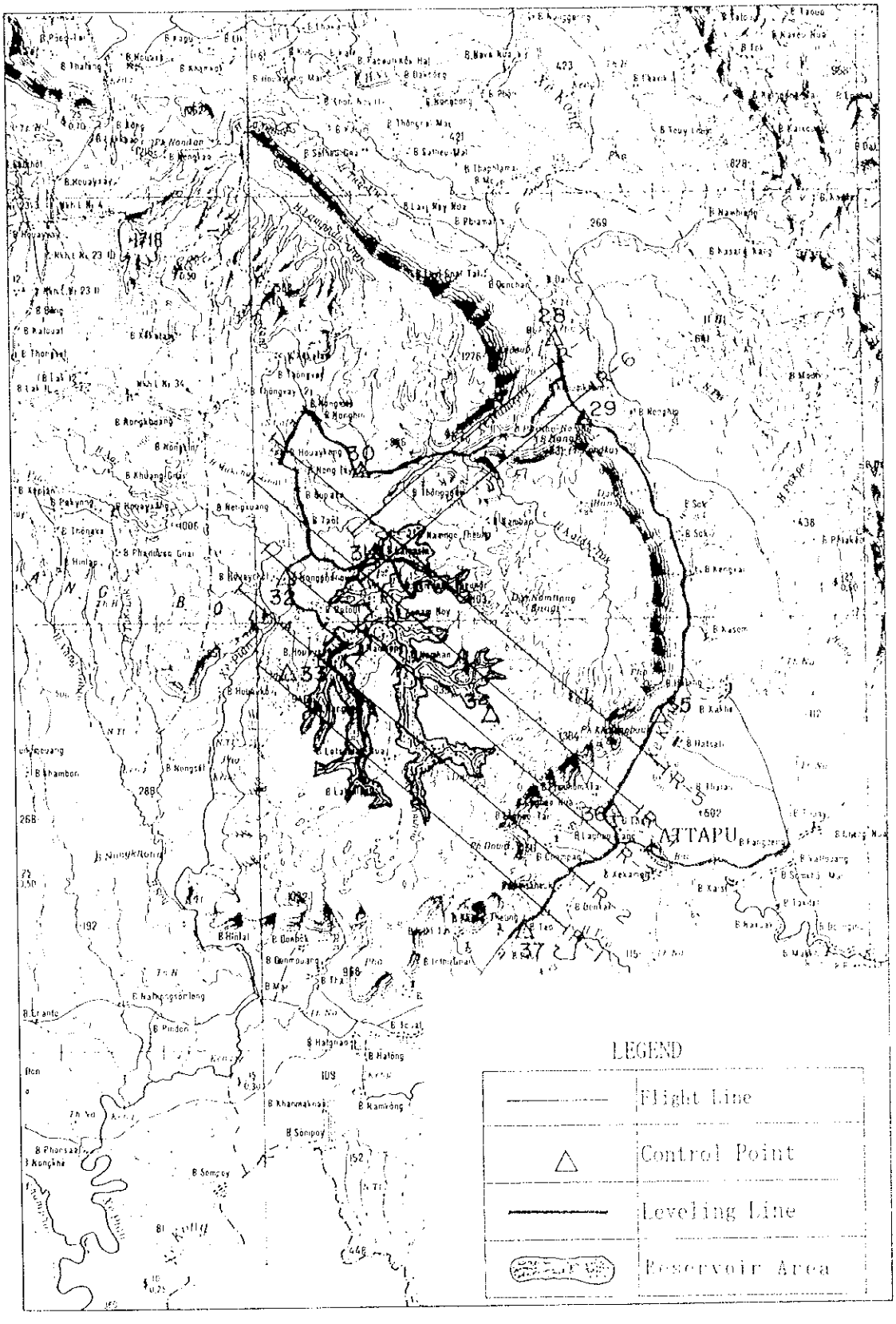


Fig. 8.1-5 Mapping Area (Se Kong No. 4)

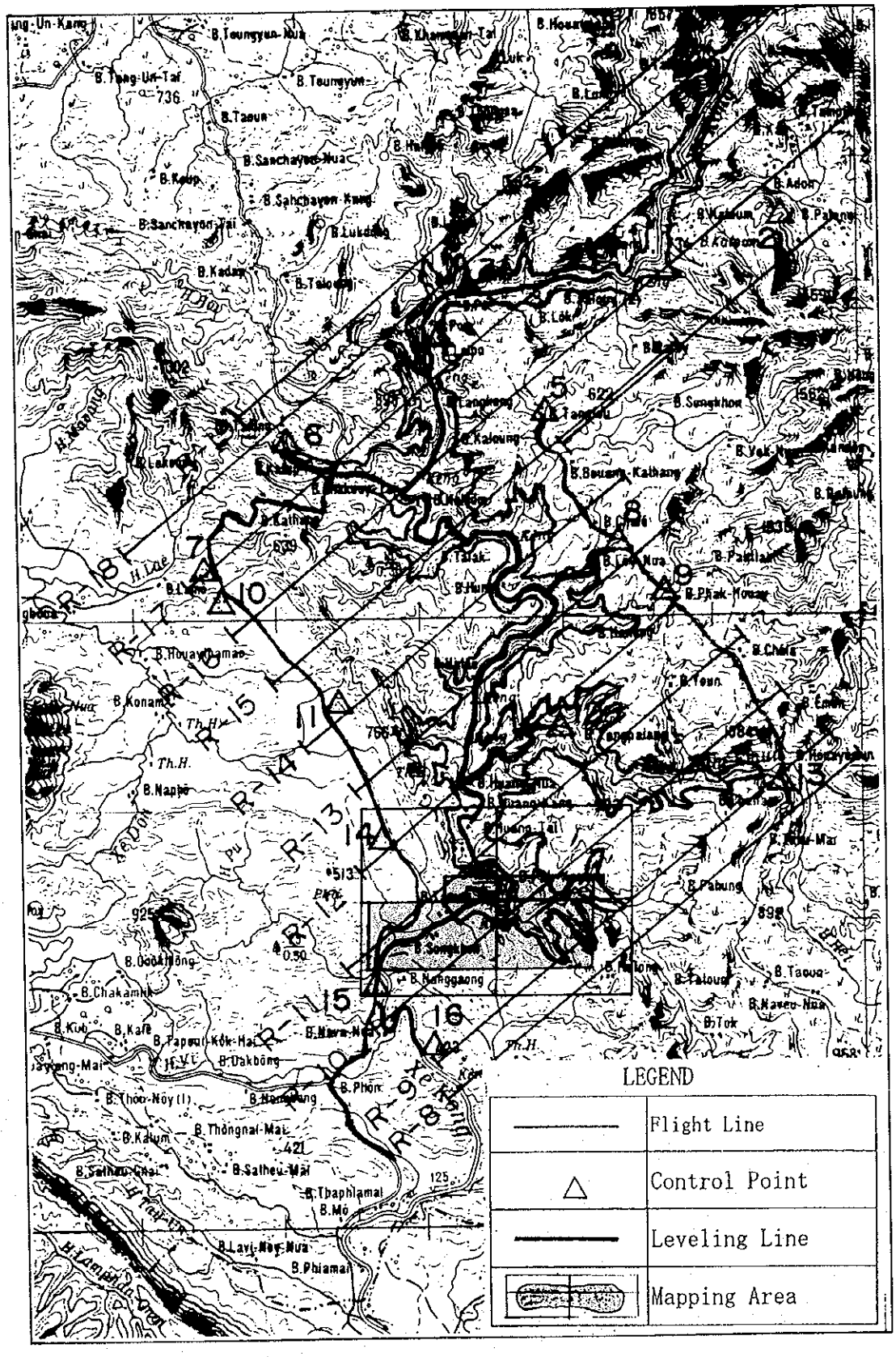


Fig. 8.1-6 Mapping Area (Xe Kaman No. 1)

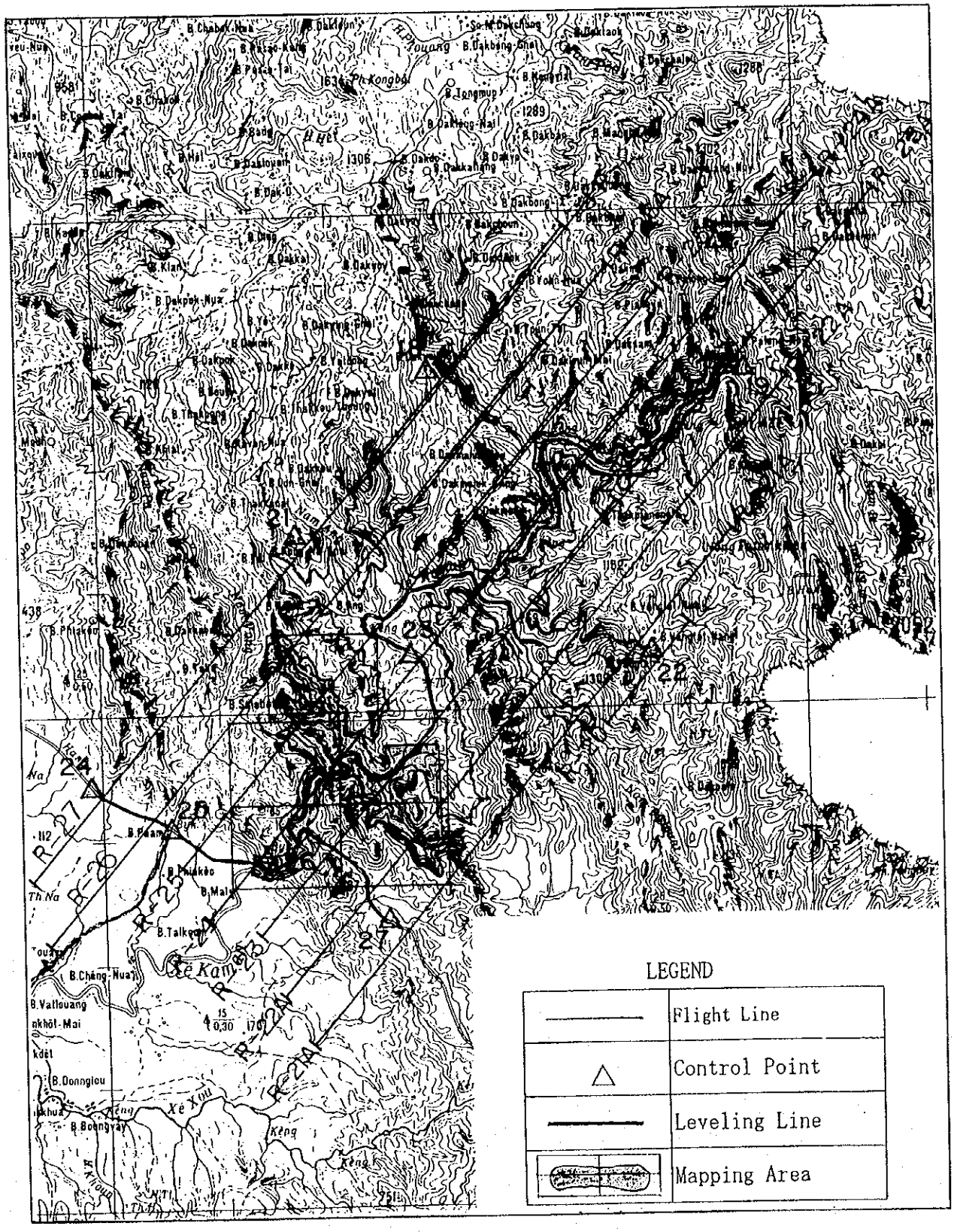
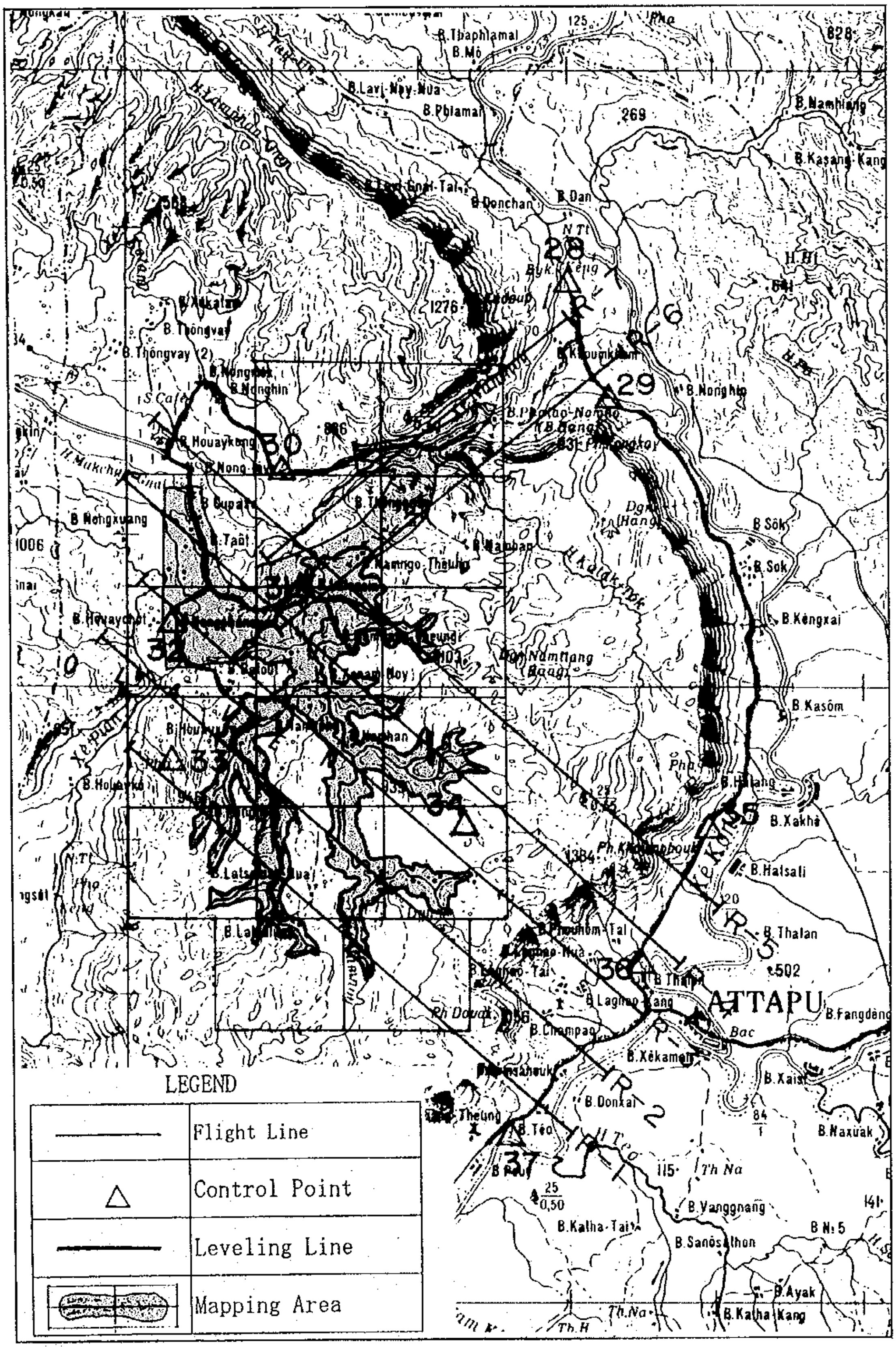


Fig. 8.1-7 Mapping Area (Xe Namnoy)



8.2 Seismic Prospecting Survey

8.2.1 Outline

Seismic prospecting survey was executed at 3 project sites selected in the hydropower potential study stage. They are Xe Namnoy, Se Kong No. 4 and Xe Kaman No. 1. This survey was carried out from November 1993 to December by the seismic prospecting specialists of JICA study team.

Seismic prospecting survey was executed by the refraction method in the area to make clear the distribution of seismic wave velocity through the foundation. The results, together with the results of core drilling and field geological survey, were revealed the geological conditions in the area, such as the thickness of overburden or the weathered zone, geological structure, and location and width of faults or sheared zones.

The seismic prospecting survey using artificial seismic wave is one of geophysical exploration methods. Seismic waves occurred at a shot point on the ground surface spread through the ground, and received by the geophones set along the prospecting line on the ground surface. The wave form with traveltime is amplified and recorded by the instruments. By analysing the set of traveltimes, velocity layer profiles along the prospecting line were obtained.

8.2.2 Location and Quantity

Location of the works was decided by JICA team member on the each dam sites. The outline of location is shown in **Fig. 8.2-1** to **Fig. 8.2-3.** Quantity of the works is as shown in **Table 8.2-1.**

8.2.3 Operation and Analysis

Working procedure are as shown in **Fig. 8.2-4**, and the equipment used on the prospecting are listed in **Table 8.2-2.**

(1) Setting of Prospecting Lines

One prospecting lines was set at the both dam sites of Se Kong No. 4 and Xe Namnoy Midstream, and two lines at Xe Kaman No. 1. Each line is strictly straight. Two lines of the former and one of the latter were located in the direction of crossing the river, and another line

of the latter was along the riverside. The detailed locations of prospecting lines were decided by the ground surface condition and other condition of the sites.

(2) Surveying and Felling

The locations of a prospecting line and shot points were surveyed from the surveying datum point by use of a electro-optical distance meter. Receiving points were laid out on the prospecting line at 10 m intervals in horizontal distance, including ends of the line, and were indicated by wooden pegs with successive number from the beginning to the end of the line. The wooden page of about 5 x 1 x 40 cm were installed at the receiving points. The locations and elevations of receiving points were measured by use of a theodlite and a transit compass.

Felling of about 1 meter in width, in case of required, had been done in order to get satisfactory forward view of the line.

(3) Setup of Instruments

In order to make one spread, twenty-four geophones were set rightly on the ground at each receiving point. One spread is 230 meter in maximum length. Those geophones were connected with the recorder through the amplifier by a take-out cable with multi-core.

(4) Seismic Sources

The seismic sources were used weight dropping and hammering. The hammering was used in case that seismic data for shallow zone that was needed.

The implements of the weight dropping consist of a monkey of 63.5 kilograms, a steel plate, a tripodal turret of 3 meters in minimum height, steel rods of 3 meters in total length, three pulleys, three strong ropes of 30 meters in total length. In measurement, the hammer switch was installed to the steel plate and was connected with the recorder by a lead cable. The implements of the hammering are a wooden hammer with electric switch and a wooden plate. The implements of the weight dropping and the hammering were prepared two sets of each for alternate using in both sides of one spread line.

(5) Shot Operations and Measurement

Arrangement of the shot points was for a minimum of three points on each spread with the maximum spacing of 50 meters. The shot points were provided at both ends of a prospecting

line without fail in order that the vicinities of such points are not blind spots in analysis. Furthermore, remote shot points were provided to improve the accuracy of analysis.

On the shot operation, two groups of three workers were provided for weight dropping, and two workers for hammering.

In the weight dropping, seismic waves were generated by impulsion when the monkey pulled up to the top of the tripod by the workers fall on the plate on the ground. In the hammering, seismic waves were generated by impulsion when a operator strike the plate on the ground by the hammer. Those weight dropping and hammering were repeated until satisfactory shapes of seismic wave is obtained on the monitor of recorder.

(6) Analysis of the Measurement Results

In analyses on measurement results, the most appropriate calculation method, mainly Hagitori method by Hagiwara, was applied in accordance with the purpose, topographic condition of the lines, and condition of the travel-time curve. Other data, such as results of the core drilling, field geological survey, were referred to in this analyses.

The results of analyses are shown by the velocity layer profiles and travel-time curves.

8.2.4 Results

(1) Se Kong No. 4 Project

The prospecting lines are located at the dam site.

The seismic waves generated by weight dropping were observed by geophones up to 370 m away from shot points. The analysed depth has reached 37 to 61 m.

Results of analysis are shown in **Table 8.2-3** and **Appendix 3.2**.
This site has 4 velocity layers.

The first layer is 250 m/sec in velocity. This layer is up to 2 meters thick. This layer is inferred to be loose soil and gravels, which are mainly of talus and alluvial deposits.

The second layer is 700 m/sec. This layer is 1 to 4 meters thick, but is absent at the valley bottom. This layer corresponds to strongly weathered rock or unconsolidated talus deposit.

The third layer is 1,500 m/sec. This layer is 4 to 11 meters thick. This layer is correlative with weathered rock.

The fourth layer is 3,600 to 5,000 m/sec and is basement layer in refraction method. This layer lies below 6 to 15 meters from the surface. This basement layer is estimated to be almost fresh rock.

Two low velocity zones are distinguished in the basement layer on the river bed and in the lower part of right bank. These zones are respectively 3,000 m/sec and 2,200 m/sec in velocity and is 110 meters and 60 meters in width respectively. These zones might be geological boundaries or fractured zones.

(2) **Xe Kaman No. 1 Project**

The prospecting line is along the dam axis. The seismic waves were observed by geophones less than 200 m away from shot points because of strong seasonal winds. The analysed depth reached 20 to 33m.

Results of analysis are shown in **Table 8.2-4** and **Appendix 3.2**.
This site has 4 velocity layers.

The first layer is 250 m/sec in velocity. This layer is 2 meters in maximum thickness. This layer is inferred to be loose soil and gravels.

The second layer is 700 m/sec in velocity. This layer is 1 to 8 meters thick, but is absent at valley bottom. This layer corresponds to strongly weathered rock or unconsolidated talus deposit.

The third layer shows 1,400 m/sec of velocity on the left bank and 1,700 m/sec on the right bank. This layer is 4 to 12 meters thick. This layer is correlative with weathered and cracky rock.

The fourth layer is 5,000 m/sec of velocity on the left bank, 3,200 m/sec of velocity on the right bank and is regarded as basement layer in refraction method. This layer lies below 6 to 20 meters from the surface. This basement layer is estimated to be almost fresh rock.

Two low velocity zones are distinguished in the upper part of the right bank and the left bank in the basement layer. These zones are 3,000 m/sec and 2,000 m/sec in velocity and is 70

meters and 22.5 meters in width respectively. These zones might be geological boundaries or fractured zones.

(3) Xe Namnoy Midstream Project

The prospecting line is located across the valley about 400 m downstream of the dam site. Seismic waves were picked up by geophones up to 300 m away from shot points. The reach of analysis is 30 to 50 m below ground surface. Results are shown in **Table 8.2-5** and **Appendix 3.2**.

This site has 4 velocity layers.

The first layer is 250 m/sec in velocity. On the left bank, this layer is 1 to 2 meters thick. On the right bank, it is less than 1 meter thick. This layer is inferred to be loose soil and gravels, which are mainly of very strongly weathered rock.

The second layer is 600 m/sec. This layer is 2 to 8 meters thick but is absent at both riversides of the Xe Namnoy. This layer corresponds to strongly weathered rock or unconsoidated deposits.

The third layer is 1,300 m/sec. This layer is 4 to 17 meters thick. This layer is correlative with weathered rock.

The fourth layer is 3,000 to 3,500 m/sec in velocity, and is regarded as basement layer. This layer lies 4 to 25 meters below the ground surface. This basement layer is estimated to be fresh but cracky rock or weakly weathered rock, because the velocity of this layer is smaller than the average velocity of fresh and intact rock.

One low velocity zone is distinguished on the left bank in the basement layer. This zone is 2,300 m/sec in velocity and is 70 meters in width. This zone might be geological boundary or a fractured zone.

Table 8.2-1 Quantity of Seismic Prospecting

Project	Line Name	Length (m)	Coordinates of Line End	
			N	E
Se Kong No. 4 (Damsite)	SSK-1	1,000	1,715,021 1,716,020	692,135 692,093
Xe Kaman No. 1 (Damsite)	SXK-1	700	1,654,467 1,655,098	732,112 732,405
	SXK-2	300	1,654,847 1,654,821	732,133 732,432
Xe Namnoy Midstream (Downstream of Damsite)	SXN-1	1,000	1,663,217 1,663,943	673,065 673,752
Total	4 lines	3,000		

Table 8.2-2 List of Equipment

Item	Quantity	Manufacture	Type/specification
Seismic graph	2 sets	Oyo Corporation	MacSeis160 24 Ch.
Battery	2 sets	Yuasa Corporation	12V
Geophone	26 sets	Geo Space Corporation	28 Hz
Take-out Cable	2 sets	Geo Souce Corporation	Lc-12, 200m x 2 x 2
Lead Cable	5 sets	Yazaki Corporation	200m x 5
Monkey (Iron ingot)	8 sets	Kano Boring Corporation	Km-2, 60kg x 2
Kakeya	2 sets	Home-made	Wood hammer
Theodlite	2 units	Topcon Corporation	TL-20M, DM-A5
Transit Compass	1 set	Usikata & company	Packet compass S-25
Others	1 set	Measuring tape and staff, hammer switch etc.	

Table 8.2-3 Velocity Layers at Se Kong No. 4 Dam Site

Velocity layer	Velocity (m/sec)	Thickness (m)	Inferred geology
First	250	0 ~ 2	soil and gravels
Second	700	1 ~ 4	unconsolidated deposits or strongly weathererd rock
Third	1500	4 ~ 11	weathered rock
Fourth	3600 ~ 5000	6 ~ 15 m deep	fresh rock
Low velocity zone	2200	60 m wide	geological boundary or fractured zone
	3000	110 m wide	

Table 8.2-4 Velocity Layers at Xe Kaman No. 1 Dam Site

Velocity layer	Velocity (m/sec)	Thickness (m)	Inferred geology
First	250	0 ~ 2	soil and gravels
Second	700	1 ~ 8	unconsolidated deposits or strongly weathererd rock
Third	1400 ~ 1700	4 ~ 12	weathered rock
Fourth	3200 ~ 5000	6 ~ 20 m deep	fresh rock
Low velocity zone	2000	22.5 m wide	geological boundary or fractured zone
	3000	70 m wide	

Table 8.2-5 Velocity Layers in the Vicinity of Xe Namnoy Midstream Dam Site

Velocity layer	Velocity (m/sec)	Thickness (m)	Inferred geology
First	250	0 ～ 2	soil and gravels
Second	600	2 ～ 8	unconsolidated deposits or strongly weathererd rock
Third	1300	4 ～ 17	weathered rock
Fourth	3000 ～ 3500	6 ～ 25 m deep	fresh but cracky rock
Low velocity zone	2300	75 m wide	Geological boundary or fractured zone

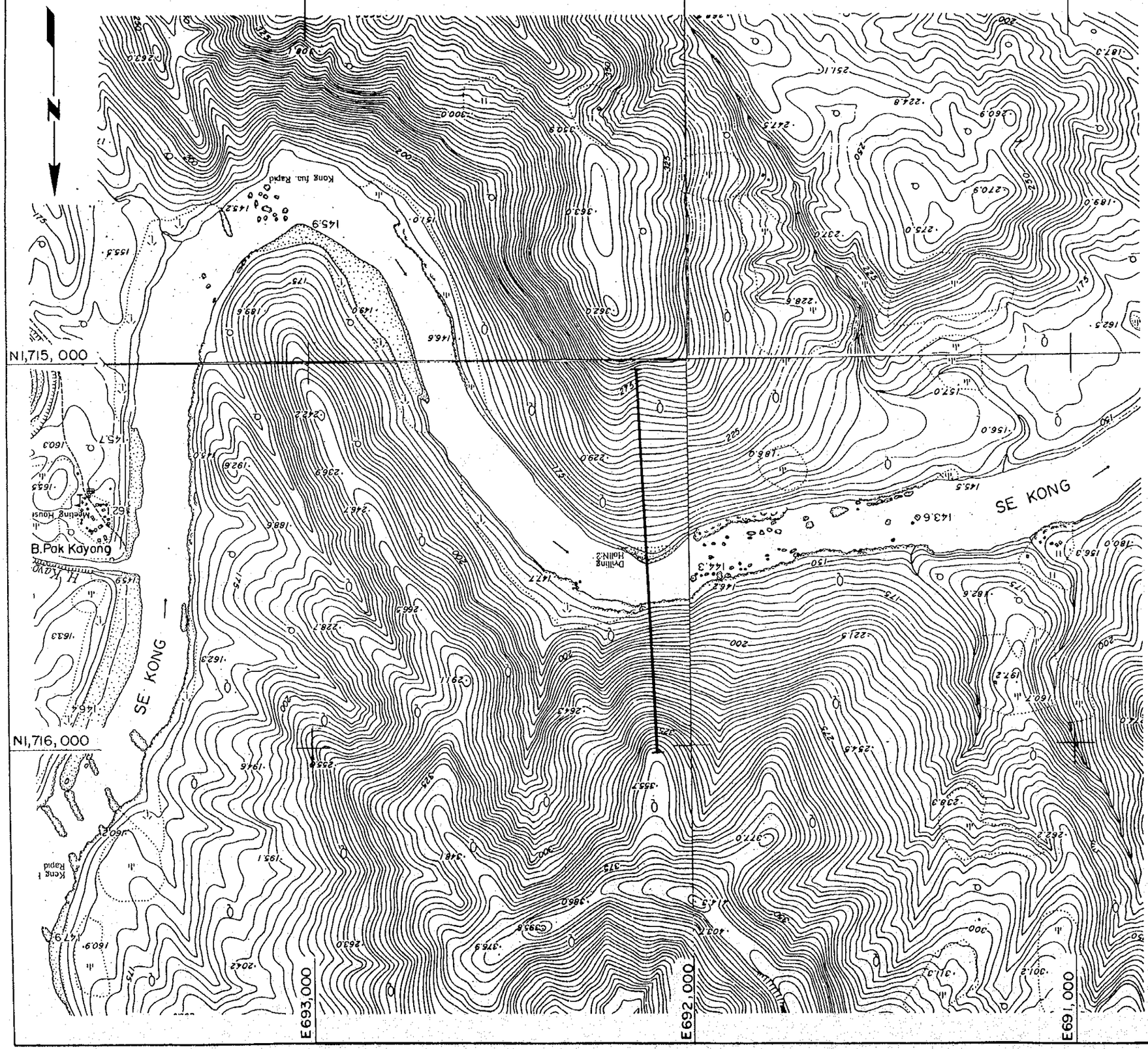


Fig. 8.2 – 1

Location of Seismic Prospecting at Se Kong No.4 Dam Site

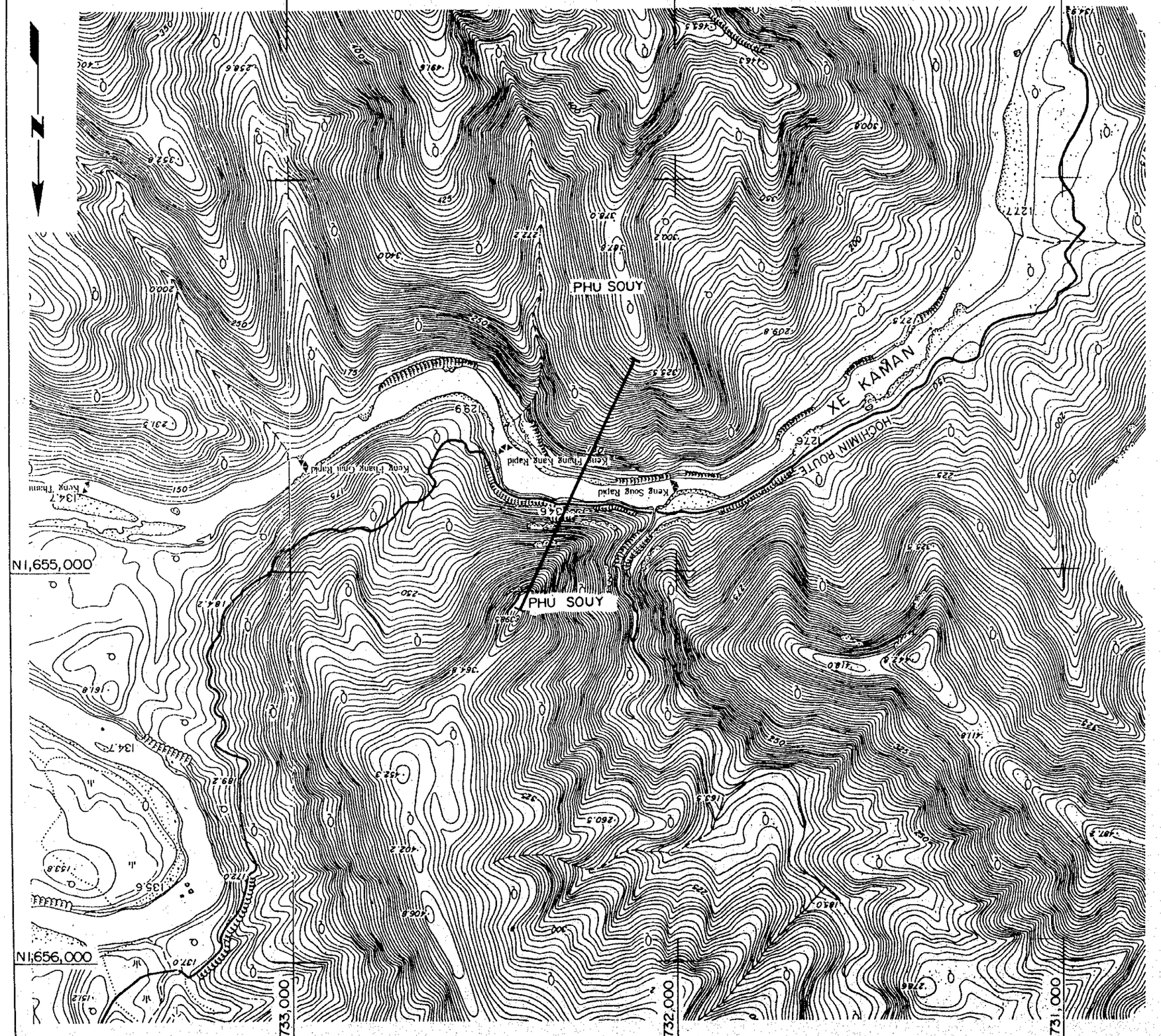


Fig. 8.2 - 2

Location of Seismic Prospecting at Xe Kaman No.1 Dam Site

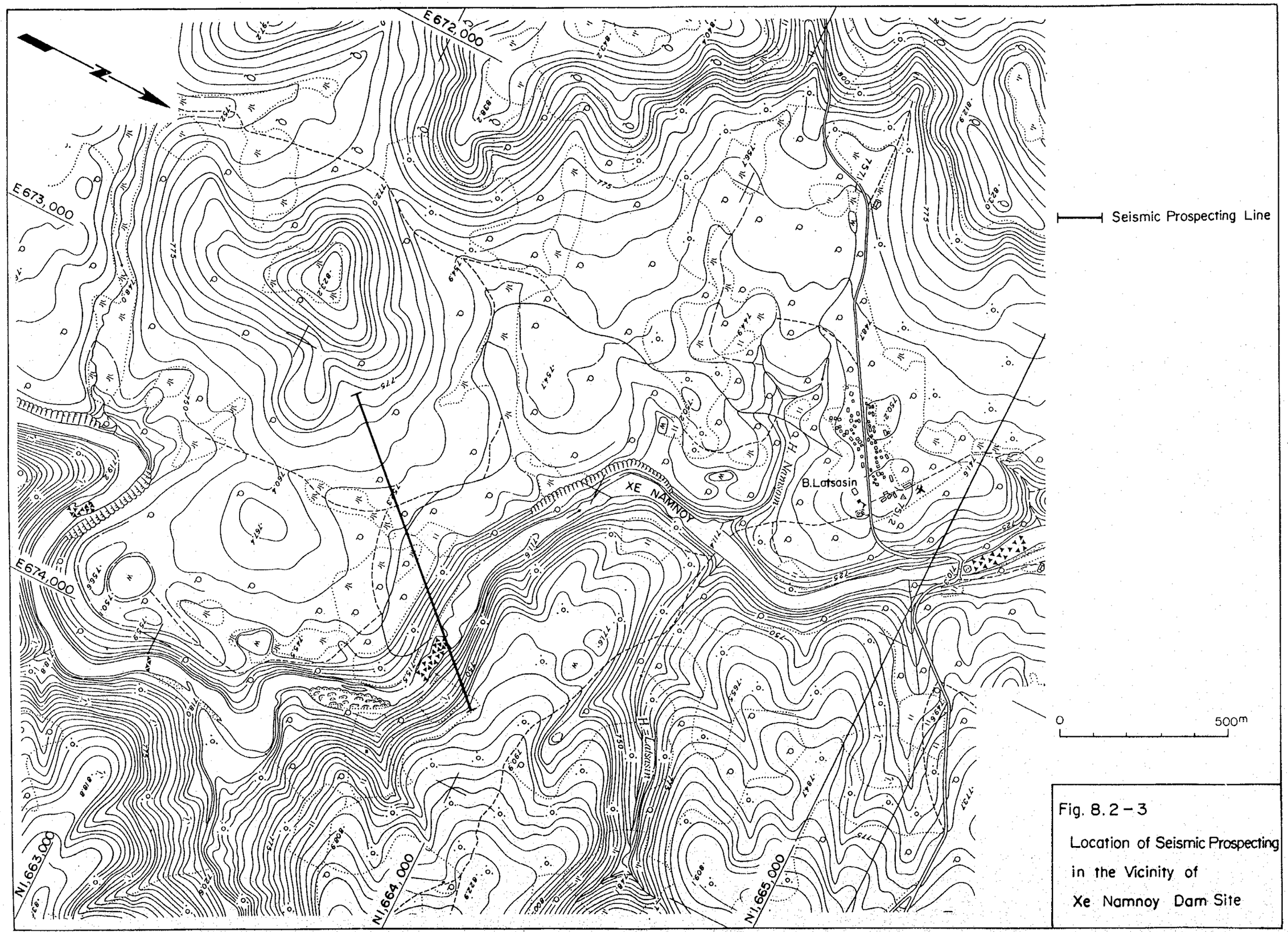


Fig. 8.2 – 3

Location of Seismic Prospecting in the Vicinity of Xe Namnoy Dam Site

Fig. 8.2-4 Flow of Seismic Prospecting