10.4 Xe Namnoy Project

Xe Namnoy river has 2 projects, Midstream Project and Downstream Project. Midstream Project is described in following (1) to (5), and outline of Downstream Project in (6).

(1) General Topography and Geology

Xe Namnoy Midstream Project area is located on the midstream of Xe Namnoy river, which rises in the southern part of Bolaven Plateau. The dam site is located on the Bolaven Plateau where elevation of the mountains are about 800 m and that of Xe Namnoy river is from 700 to 720 m. The valleys of that river are shallow but their system is complicated. On the left bank of the river in the vicinity of the dam site, there is a terrace of 750 m in elevation which has maximum width of about 500 m near B. Latsasin and extends 3 km upstream of the dam site. The slopes between this terrace and the river are steep and with cliffs exposing section of lava flow. On the right bank, no terrace are observed on the slopes which are generally gentle above 750 or 800 m in elevation.

Xe Namnoy river has many rapids and waterfalls between 650 m in elevation 4 km downstream of the dam site and 300 m in elevation near the junction of Xe Katan river where about 2 km upstream of the power station site.

The project area is underlain by Cretaceous sandstone and shale of Champa Formation and Quaternary basalt unconformably overlaying Champa Formation. Surface deposits in the project area are talus deposits and recent river deposits.

Sandstones of Champa Formation are grey in color, medium grained in general. Each bed is one to several meteres in thickness. Sandstone dominant layers having few thin shale beds are generally less than 10 m in thickness, and erosion resistant which typical example is represented by the sandstone layers locating on the top of high cliffs bounding the Bolaven Plateau.

Shales are reddish in color. Shale dominant layers are up to 20 m in thickness, easily weathered and disintegrated into small pieces.

Most outcrops in the project area are of sandstone, whereas shale are founded in drillholes and on recent road cuts. Exposed rocks are weathered except river bed and its vicinity and laterites are observed on the upper slopes.

Sandstone and shale of Champa Formation gently dip at less than 10° to the west.

Basalts form terraces on the left bank of the river. On the marginal cliff of the terrace, basalts have a zone of block joints underlaine by the other zone of columnar joints which are common in lava flow. Drillholes disclosed the bottom of the basalt flow to be lower than recent river bed, that means the ancient river bed was covered by the basalt flow. Because the basalt terrace keeps about 750 m in elevation and ends 3 km upstream of the dam site, basalt lava is concluded to come from downstream and supposed to from near Paksong where is the highest area covered by basalt.

Thin talus deposits are supposed to cover the lower slope behind the basalt terrace. Recent river deposits along Xe Namnoy river are thin.

(2) **Dam site**

At the dam site, river bed is at about 715 m in elevation and 80 m wide. The width of the valley at high water level (El.765 m) is about 900 m. On the left bank, valley slope up to basalt terrace at 745 m and 200 m wide is steep, but the slopes beyond that terrace are gentle less than 5° climbing up to the hill of 767.4 m in elevation, behind which there is a saddle of elevation 765 m. (lower than high water level) On the right bank, slopes below elevation 790 m is about 25° and more gentle of about 10° above that elevation.

The dam site is underlain by sandstone, shale and basalt. The information at the dam site is obtained from topography and field survey, and supplied by the seismic prospecting and core drillings 400 m and 1.8 km downstream of the dam site.

Sandstone and shale distribute on the river bed, right bank and upper slope on the left bank. The hill elevation 767.4 m on the left bank is supposed to be formed by sandstone and shale. The strata incline to the left bank gently. Sandstone layers exposed on the river bed widely are fresh but with open cracks. Drillhole XN-2 at river bed 400 m downstream of the dam site met sandstone of more than 20 Lu down to 20 m depth and less than 2 Lu below that depth. Drillhole XN-5 and 6 located 1.8 km downstream of the dam site provide 3 to 10 m thick weathered layer and XN-3 drilled 400 m downstream on the right bank found 27 m thick weathered layer mainly composed by shale, which bottom is as low as river bed. These drillholes obtained the permeable bed rock of more then 20 Lu down to about same elevation of river bed.

Basalt is distributed on the left bank with width of about 200 m and with thickness up to 40 m, which bottom is confirmed at least 10 m lower than recent river bed by the Drillhole XN-1 located 400 m downstream of the dam site. Basalt is characterized by cooling joints and some porous horizones. The rock mass of this basalt is fresh and hard except the weathered zone of about 5 m thick. The seismic wave velocity of this basalt does not exceed 3,000 m/sec. Permeability is high. Though the upper layer has relatively low permeability and keeps shallow water level during drilling, lower part is highly permeable where most lugeon test sections refused the increase of water injection pressure, and failed in keeping water level several meters above the river level. Moreover, unconsolidated ancient river deposit is recovered below the basalt flow in XN-1, 400 m downstream of the dam site.

Talus deposits and recent river deposits are thin and limited in distribution.

(3) Reservoir Area

The reservoir area covers upper course of Xe Namnoy river and surrounded by the gentle mountains of about 1,000 m in elevation, which are less than 250 m above high water level of the reservoir. There is no unstable topography such as landslide on the slopes surrounding this reservoir.

The most of reservoir area is underlain by sandstone and shale of Champa Formation which strata are horizontal to gently dipping west. The Champa Formation intercalating many shale beds is expected to be watertight. Permeable basalt is limited to the narrow area below elevation 750 m near the dam site. Basalt at dam site will be treated so as to stop the leakage from the reservoir to downstream. Then the watertightness of the reservoir will be achieved.

(4) Waterway and Powerhouse

The headrace tunnel route is located on the right bank of Xe Namnoy river, the maximum depth below the ground surface (Bolaven Plateau) is about 200 m. The tunnel pass some 20 m below a deep valley. The tunnel will penetrate same sandstone and shale that is distributed at the dam site. Sandstone beds are supposed to be massive and favorite for tunnel excavation. Shale beds are also massive but require careful excavation because of intercalation of easily slaking layers. Because the strata are almost horizontal, the tunnel face will trace the same bed for long distance.

The penstock site is located on the slope rising about 500 m above Xe Namnoy river. This slope is 30° in average and 45° in upper slope above elevation 570 m. The slope is underlane by sandstone and shale which strata are near horizontal. Topographic expression indicate that sandstone dominant layers distribute close to the top of the slope and near elevation 380 m. Loosening of bedrock will require more caution than talus deposits which is expected to be thin in general.

The power house site is on the gentle slope at the foot of high penstock slope. This gentle slope is suppose to be covered by talus deposits. A horse-shoe shaped scarp, indicating large landslide is observed on the neighboring slope. The top of that scarp is about 400 m in elevation and its toe extends downstream for about 800 m from 200 m downstream of the power house site. Topographical expression provides few information on the thickness of surface deposits and lithology of the power house site.

(5) Xe Pian River Diversion

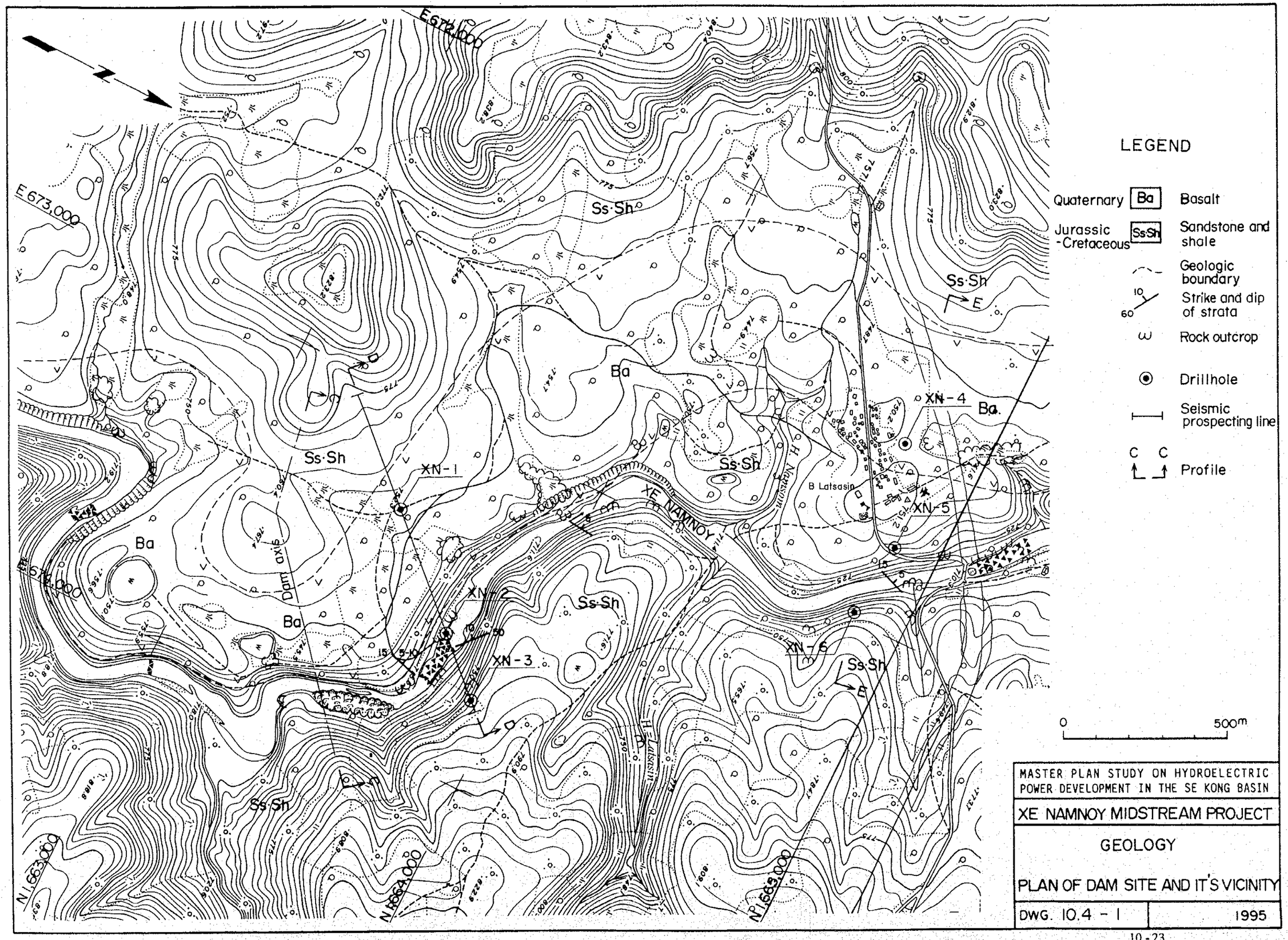
This diversion route is on the Bolaven Plateau and the land profile is gentle. Upstream portion of the diversion route is along Houay Liang river where some basalt outcrops are observed. Remaining downstream portion is underlain by sandstone and shale. Further information such as depth of surface deposits and weathering will be obtained in following stage.

(6) Xe Namnoy Downstream Project

Xe Namnoy Downstream Project Area is located immediate downstream of Xe Namnoy Midstream Project Area. The dam site is 2 km downstream of the power station site of the Midstream Project. The power station is on the right bank about 5 km downstream of the dam site. The waterway is on the right bank.

This project area is in the valley franked by the slopes rising up to El. some 1,000 m. the lower slope on the both banks are gentle, and have terraces about 30 m and 100 m above the river bed on the left bank of the dam site and on the right bank of the power station site respectively.

Field geological investigations are not carried out yet. This project area is supposed to be underlain by sandstone and shale of Cretaceous Champu Formation.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XN-5
XN-6
Dam axis
XE NAMNOY
H. Namnoy
H. Latsasin
B Latsasin
LEGEND
Quaternary
Ba
Basalt
Jurassic -Cretaceous
Ss·Sh
Sandstone and shale
Geologic boundary
Strike and dip of strata
Rock outcrop
Drillhole
Seismic prospecting line
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XE NAMNOY MIDSTREAM PROJECT
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PLAN OF DAM SITE AND IT'S VICINITY
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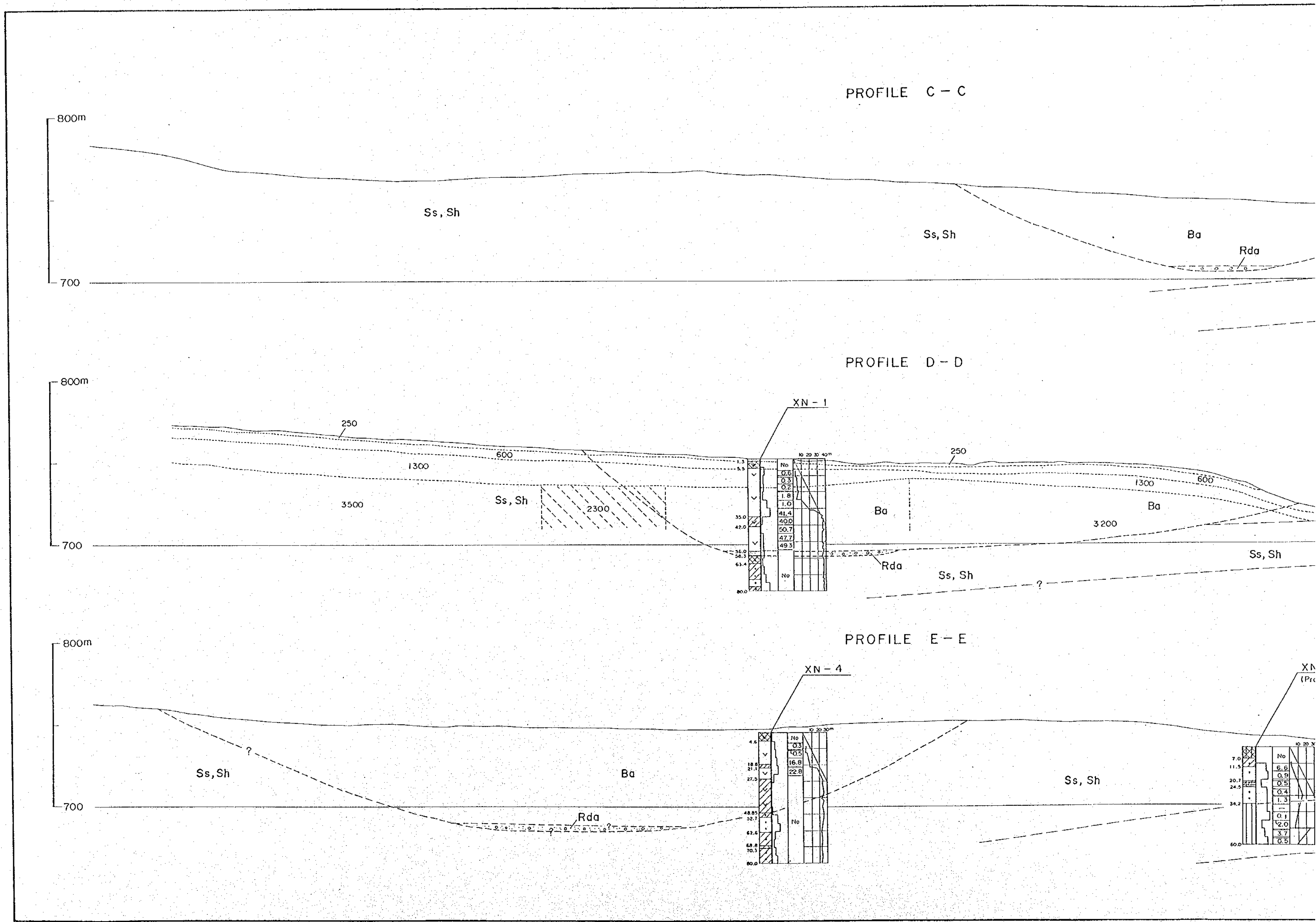
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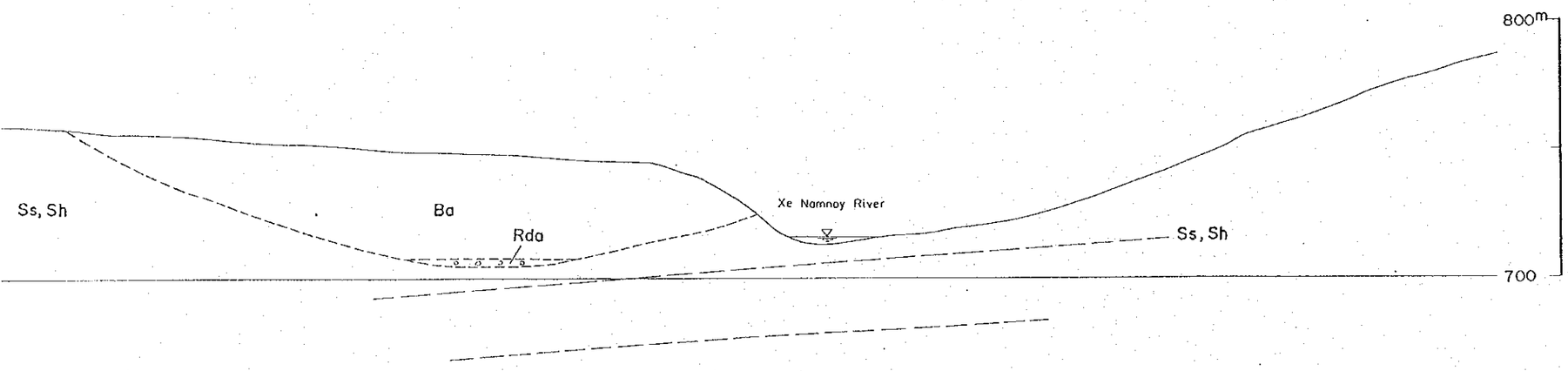

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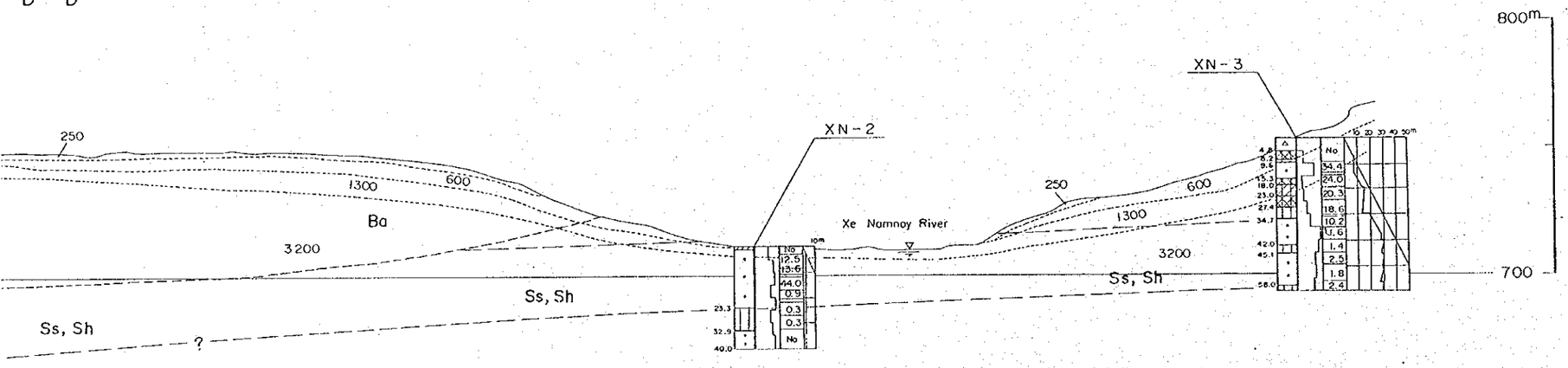

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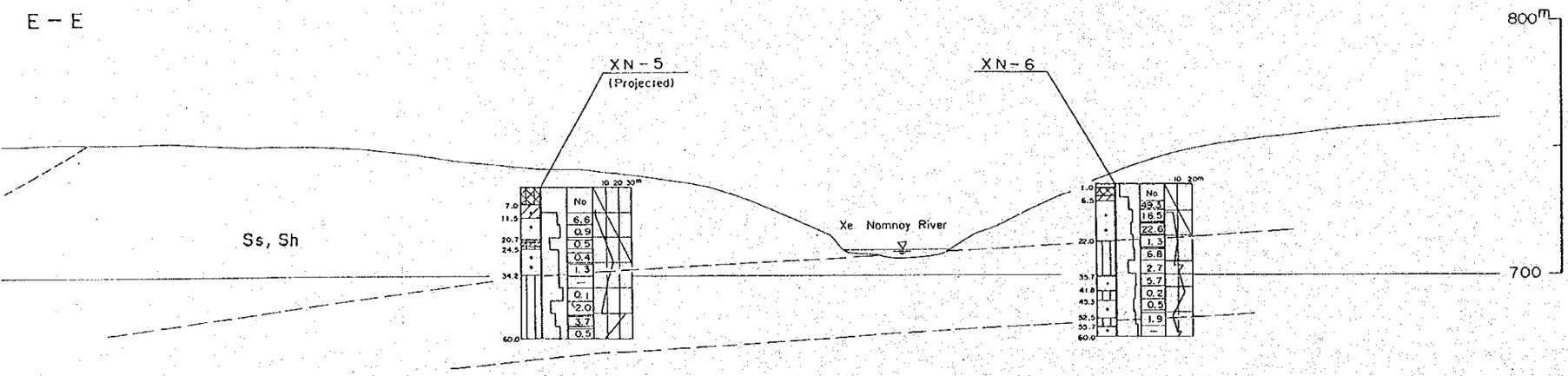
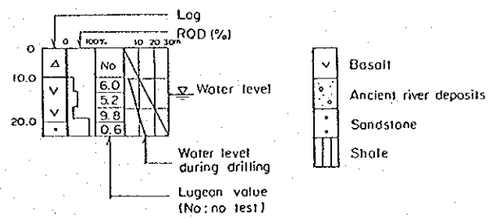


LEGEND

- Ba — Basalt
- Rda — Ancient river deposits
- Ss.Sh — Sandstone and shale
- Geologic boundary
- Inferred bedding plane
- 1300 / 3500 — Velocity layer and its velocity (m/sec)
- Low velocity zone

Log of Drillhole



Evaluation of drilled core

- c. class : Strongly weathered, cracky or soft
- b. class : Weathered or sheared, brittle and cracky
- a. class : Fresh, hard, cracky in part

0 — 100m

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11. Environmental Impact and Compensation

11. Environmental Impact and Compensation

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11. Environmental Impact and Compensation

11.1 Outline

This chapter provides an overview of the preliminary survey results. Details of the survey data are contained in the "Report on Environmental Impact and Compensation" (below, "EIC Report").

As the three surveyed locations have many environmental similarities, this chapter shall as a rule discuss all locations comprehensively, and discuss the characteristic elements of each individual location when necessary.

11.2 Environmental Impact

11.2.1 Population and Communication

(1) Current State of the Environment

The Se Kong river basin is one of the least densely populated areas in Laos, for it has 7 per km^2 (Sekong, Attapu Provinces average, EIC Report), while the national average is 18 per km^2 (UNDP 1,991 Report). Settlements of 20 to 30 homes are sparsely located throughout steep mountainous valleys in the upstream areas, which include the project locations.

The following table shows the populations and other characteristics of the project locations' basins and reservoir areas.

	Se Kong No. 4		Xe Namnoy Mid.		Xe Kaman No.1	
	Basin	Reservoir Area	Basin	Reservoir Area	Basin	Reservoir Area
No. of Settlements	104	24	10	[1] 4	142	5
No. of Households	2,049	438	350	[1] 180	6,111	74
Population	13,504	3,557	1,380	[1] 899	31,970	589
Area (km^2)	5,255	145	509	20	3,578	222
Population Density (persons/km^2)	3	25	3	45	9	3

Note 1): The number of settlements and population of the reservoir area in the Xe Namnoy Mid-stream project are from a different survey, and the number of households is estimated.

Note 2): Figures for basins do not include reservoir areas.

According to the EIC Report, most of these settlements are permanent, but they are inhabited by ethnic groups that practice slash-and-burn agriculture, which means they move each year in search of new lands to cultivate. Local government officials express the opinion that the population fluctuates considerably from year to year. **Fig. 11.2-1~11.2-3** show the location of villages in the reservoir.

Although these inhabitants are composed of many minority ethnic groups, almost all these groups belong to the Lao Theung.[3)] The Lao Theung tribal people living in the hinterlands have peculiar customs.

Note 3): Laos has 47 linguistic ethnic groups, but these are divided roughly into the three tribal groups of the Lao Lum (lowland tribes), Lao Theung (midland tribes), and Lao Soung (highland tribes). It is said that different tribes cannot intermarry or live together because of differences in lifestyle and customs. This means that when a reservoir area is home to more than one tribe, the resettlement plan will have to prepare different substitute lands for them.

(2) Environmental Impacts and Measures

Needless to say, the biggest impact of these projects on the inhabitants and local societies will be the submersion of dwellings, settlements, farmland, and other elements of their livelihood, and the relocation of these.

Almost all the inhabitants of the reservoir areas are minorities who practice slash-and-burn agriculture, and even now they maintain a traditional lifestyle. They also prefer living in small, dispersed settlements.

On the other hand, while the government's scheme in moving these inhabitants is to encourage them to till low-lying farmland and give up slash-and-burn agriculture, an attempt to follow this scheme and additionally provide schools, medical care facilities, and other social infrastructure will mean that, in order to ensure investment efficiency, resettlement areas must be large-scale, intensive settlements on flat land. In view of this, it is anticipated that the resettled people's lifestyles will change considerably.

However, it is conceivable that adapting to a new kind of lifestyle in large communities, and incorporating a different agricultural method, will force these people to endure considerable mental, economic, and other burdens. A certain amount of time will be needed for their new lives to start along the right track, and they might experience food shortages due to a temporary decline in agricultural production. During that time it will perhaps be necessary to implement carefully thought-out measures such as economic aid and food supplies.

Resettlement will make it difficult for people who have moved to communicate with those remaining in the mountains, and they may be inconvenienced in some instances. The resettlement plan will have to take this into consideration.

(3) Surveys Needed in Future

It will be necessary to conduct on-site surveys of all settlements in the reservoir areas and their peripheries to check population, assets such as houses and farmland, types of ethnic groups, the state of regional interchange, the inhabitants awareness and desires with regard to resettlement, and other matters. Consideration is also needed so the resettlement plan lessens the burden on the inhabitants as much as possible.

11.2.2 Industry and Economy

(1) Current State of the Environment

As there are almost no secondary and tertiary industries in the project areas, the local economy is nearly totally dependent upon agriculture. The main agricultural products are rice and coffee (Xe Namnoy region only). In addition the people keep such domestic animals as cattle and pigs, and conduct logging or other activities during the agricultural off-season. The main source of income is coffee; wood also brings in some income. They do not produce enough rice even for their own consumption, and while animals are sometimes sold, they are usually consumed at home. Coffee production in this region, mainly on the Bolaven Plateau, accounts for 93 percent of Laos' coffee, thus making it a crucial export item for the area.

People living on the periphery of the project areas are almost all farmers, in addition to a few public officials. Average yearly incomes are, in the Xe Namnoy area, 100,000-200,000 kip (US$140-180), and in the Se Kong No. 4 and Se Kaman No. 1 areas, 50,000-100,000 kip (US$70-140). Except for the Xe Namnoy area, these incomes are far below

the national average of US$180 (Socio-Economic Development Strategies, Government of Lao PDR, 1,990).

(2) **Environmental Impacts and Measures**

As stated in section 11.2.1, even assuming that after resettlement the people shift from their former slash-and-burn agriculture to sedentary farming, a certain amount of time will be needed until the new farming method begins to operate smoothly. Because agricultural production will probably decline during that time, the resettled people will require attentive aid in areas such as economic assistance and guidance on farming practices.

Mineral resource list in the EIC Report states that no minerals are located in the reservoir areas. But as information on mineral resources in this region is greatly limited, more detailed surveys are hoped for. Some information related the mineral reasources is described in 6.4.2 (g).

Another impact will be the submersion of trees with commercial value, which will make it necessary to cut and remove them before impoundment.

(3) **Surveys Needed in Future**

- Discussion of a program for guidance on sedentary agriculture
- Surveys of mineral resources
- Surveys of forest resources

11.2.3 Land Use

The state of land use in the project areas shows that 80 to 100 percent of the land is forested (including potential forests such as slash-and-burn sites), and that 20 to 50 percent of this is present or past sites of slash-and-burn agriculture.

Implementation of the projects will make the submersion of these forest lands unavoidable, but if this submersion of land and resettlement of the inhabitants is used as an opportunity to carry out the government's policy to abolish slash-and-burn agriculture, by which it is possible for the resettled people and those in peripheral areas to make the transition to sedentary farming, then in the long run it is possible this will offset the negative effects of impoundment.

While almost all existing forests are in higher elevations, the slopes and terraces tend to be given over mainly to present and past sites for slash-and-burn farming. Thus, from the perspective of protecting existing forests, it is desirable to survey the distribution of forests and other items in detail, and on that basis lower the reservoirs to appropriate levels. The lower reservoir, however, will be reduced the project economic aspect. Further study is required in the next stage. **Fig. 11.2-4~11.2-6** show the land use classification in the reservoir.

11.2.4 Water Areas and Their Utilization

(1) Current State of the Environment

The rivers in the project areas are used for a variety of purposes including transport, fishing, drinking water (river water is used as is), bathing, and laundry.

There is a public water supply in Sekong Town only, and its water is taken from a tributary. A public water supply project by the Water Supply Public Corporation is now in progress for Sekong Town and Attapu Town.

Except for very small facilities (it is not known if water is taken from main streams or tributaries), no water is taken for irrigation.

There are also no existing hydropower generating plants.

All fishing is by settlements along the rivers, and fishing is active particularly during the November-May dry season. Fish caught account for most of the inhabitants' protein, and are therefore a critical food source. Apparently there is nothing that might be called a fishing right.

(2) Environmental Impacts and Measures

It is anticipated that constructing these reservoir type hydropower projects will increase the downstream flow discharge during the dry season (generally considered a favorable effect), while the water level will fall at night (and sometimes on holidays) during peak use when daily plant operation and shutdown are repeated.

Because hardly any water is at present drawn from the rivers downstream, it is thought the dam will have little effect, but remedial measures will be necessary when it is anticipated

that the night time water level decrease will affect water use for drinking and household use. In the study, a river retaining flow to the downstream was planned at the dam site as shown in 12.3.2. And when there are specific plans for water supply projects, dam impact will have to be investigated.

(3) **Surveys Needed in Future**

- Detailed survey of water use in downstream areas.
- Studies on specifics of water supply projects.

11.2.5 Social Capital

The only reported infrastructure in the project areas consists of main roads on the peripheries. Needed is an on-site survey of social capital within the reservoir areas.

11.2.6 Transportation

(1) **Xe Namnoy Mid-Stream Area**

A road leads to the main settlements near the project sites, but settlements in the inner recess of the site are accessible only by footpath. Apparently boats are not used.

The project will immerse areas whose roads lead to settlements upstream from the reservoir, so it will be necessary to prepare alternate footpaths or boats.

(2) **Se Kong No. 4, Xe Kaman No. 1**

The only means of transportation linking the settlements upstream from the project locations with either Sekong Town or Attapu Town, which constitute the primary part of the downstream area, is boat transport.

The dam will hinder upstream-downstream boat links, but, as noted in section 11.2.1, there is a large population in the upstream area that will be left mostly as is even after project completion, which means that upstream-downstream transportation will continue to be of great importance.

Some conceivable remedial measures might include construction a boat landing on the dam's upstream side, where people who arrive by boat from upstream would disembark and

switch to buses or other public transportation that would use the dam access road, which would be made available for use. Alternatively, downstream-side public boat transport might also be prepared. And because boat transport will be hindered even during construction, alternative transportation will have to be provided during this time as well.

Additionally, when it is anticipated that the downstream water level will change rapidly due to turbine use, this will necessitate measures such as advance warnings to inform people that boat transport is dangerous.

There will also be an advantage. While at present there are many shallows and rock reefs, which make boat transport particularly difficult during the dry season, dam construction will eliminate these obstructions in the reservoir area, and also average the downstream flow throughout the year, thus making the improvement of river transport a possibility.

11.2.7 Health

(1) Current State of the Environment

A UNDP report (UNDP 1,990) makes the following observation on the current state of public health care in Laos.

"In many areas health needs to be improved. Half the children under five suffer moderate malnutrition, and about 90 percent of the population cannot get basic medical care and other services. Diarrhea, and respiratory and intestinal disorders are as widespread as malaria."

In terms of numbers, bronchial/pulmonary disorders, including tuberculosis, are the most salient illnesses in Laos, followed by malaria and infectious intestinal disorders. But as causes of death malaria is first, followed by bronchial/pulmonary disorders, and then infectious intestinal disorders.

People still have a weak conception of hygiene, and almost all Laotians like eating things in their uncooked, natural state, such as raw meat and raw fish. In the country, people use river water as is for drinking and household uses, and hardly anyone uses mosquito netting. Toilets are limited to the larger cities and towns, and even when they exist in other places, people do not use them, preferring to go outdoors in the belief that it is cleaner. It is thought that if such dietary and hygienic customs can be changed, it will be possible to reduce the occurrence and serious spread of many diseases.

Vaccinations to prevent communicable diseases in children are still not widespread, and estimates indicate that only 20 to 30 percent of children receive them.

A survey of seven settlements in the project areas shows the following about health.

- The only generally practiced cures for illness are spiritual methods related to traditional medical arts.
- There are no health facilities or health workers in the seven settlements.

When inhabitants come down with serious illnesses, they are faced with the need to go to the regional hospital, but this presents various problems related to financial difficulties and traveling while ill.

The main illnesses in the region are malaria, infectious intestinal disorders such as dysentery, and skin diseases. The primary cause of death is malaria, just as it is nationwide, followed by infectious intestinal diseases and tuberculosis.

Inhabitants in the upstream areas of Se Kong No. 4 and Xe Kaman No. 1 live in remote regions, so they have received no vaccinations at all.

(2) Environmental Impacts and Measures

Creation of the dam reservoir could have both positive and negative effects on public health, but the lack of accurate statistical data on public health in the region means this is a generalized and qualitative forecast. The possible negative effect is the occurrence of water-related epidemics through the creation of new stagnant water areas that would serve as the habitat for mosquitoes and other disease vectors. On the positive side, it is possible that construction will bring about improved access to existing hospitals and other facilities, the building of new medical facilities, the posting of more medical personnel, and other improvements. Additionally, one of the major health problems at present is the lack of clean drinking water, and it is therefore highly desirable that appropriate public water facilities be prepared in the resettlement areas.

The key to dealing with the negative effects are the prevention and control of epidemics. By also implementing the existing prevention methods, it will probably be possible to offset the adverse effects of the hydropower projects.

During construction there will be an influx of construction workers and other associated personnel into the project areas. It is possible that they will bring new infectious diseases,

and that hygienic conditions in the surrounding area will worsen. It will therefore be necessary to provide water supplies, waste disposal facilities, medical facilities, and facilities, and to maintain them in good condition, as well as to see that construction personnel receive adequate guidance in hygiene.

It is said that construction of the existing Nam Ngum reservoir did not bring about increases in water-related, mosquito-, and snail-related epidemics or other adverse effects, which might be useful knowledge in this case.

Such considerations should not be limited to the foregoing discussion of physical illness. Future surveys must also involve an examination of some kind concerning the mental effects on the inhabitants. Conceivably, different living quarters and various other attendant changes will saddle the resettled people with a large mental burden.

(3) Surveys Needed in Future

- Detailed surveys on the state of health and hygiene (including mental health) among people in the project areas, and on matters including past cases of epidemics.

11.2.8 Scenic View

The three areas planned for the projects are remote mountainous regions through which tourists and people other than the local inhabitants rarely pass. For this reason, it seems there is little possibility that dams, hydropower stations and other project structures will ruin the scenery. However, it will be desirable to accord maximum consideration to the scenery in planning and design, and to provide for the repair and replanting of the sites after construction. This also offers the promise that the dams, reservoirs, and their surrounding areas will become new tourism resources.

On the other hand, there are reportedly 16 special scenic areas on the project peripheries, and places that might be affected by the projects include Keng Louang (rapids on the Se Kong river), which is downstream from Se Kong No. 4, and Tat Houakon (a waterfall), which is downstream from the Xe Namnoy Mid-stream site. It will be necessary to further investigate their scenic value and the extent to which they will be affected by the project.

11.2.9 Cultural Assets

Some of the representative cultural and other assets in southern Laos are the ruins at Watphu, a famous stone temple, and Champasack Town, which was the capital of the ancient Champasack kingdom.

Surveys of cultural assets and the like have never been conducted in the Se Kong river basin. As part of this environmental survey, a preliminary survey was conducted for the first time in the form of interviews at local government offices. The survey revealed several sites that are possibly assets of cultural or other value, and it was found that, of those sites within the project area, the primitive stone implement and earthenware site within the Se Kong No. 4 reservoir area might be affected by the project. It will be necessary to further study its archeological value.

11.2.10 Induction of Earthquakes

It is said that when impounding a reservoir, the increased load on the earth's crust and increased seepage water pressure sometimes induce earthquakes. But the relationship between the impounding of reservoirs and induced earthquakes has yet to be elucidated, and prediction is difficult. In terms of experience, if the amount of impounded water does not exceed one billion m^3, there is hardly any possibility of an earthquake, but Se Kong No. 4 (total pondage: 7.7×10^9 m^3) and Xe Kaman No. 1 (total pondage: 16.2×10^9 m^3) exceed this amount. However, because these reservoir areas have no faults of the type that would trigger earthquakes, it is thought that, while the possibility of tremors remains, the possibility of induced earthquakes that would cause damage is slight.

As a means of minimizing the possibility of induced earthquakes, it is desirable to avoid rapid impounding of the reservoirs.

Tremors occurred when impounding the Nam Ngum reservoir (total pondage: 8.5×10^9 m^3), but apparently there was no damage in particular.

11.2.11 Slope Collapse

Detailed geological surveys will be needed to assess the stability of slopes around the reservoirs, but these have not been conducted because such surveys are beyond the scope of the pre-feasibility study stage in terms of both time and budget. These studies should be carried out as part of future geological and other surveys.

11.2.12 Sedimentation in Backwater Areas

Because the upstream portions of the projects' reservoirs are all rather steep valleys, even if sedimentation occurs in the backwater areas and reservoirs attain flood level, it is anticipated that the effects will be restricted to a comparatively small area.

It will be necessary to predict what kind of sedimentation would occur in the future, calculate the backwaters based on those predictions, and determine the areas from which people must be relocated by including the anticipated immersed lands.

11.2.13 Impacts on Downstream Channels and Coastal Topography

The effects of reservoirs on downstream channels consist mainly in scouring the foundations of existing structures, which happens because the river bed is lowered due to a decrease in sand and gravel transported from upstream. But except for the bridge just below the Xe Namnoy Mid-stream dam constructed in 1994, the Se Kong river basin has no other bridges, water intakes, dikes, or other structures (there is no information about structures on the Cambodian side). Thus, in this respect, there is perhaps hardly any impact on the Se Kong river basin. The impact on the Xe Namnoy bridge will have to be investigated.

It is hard to forecast river bank erosion, but because most of the entire banks along downstream channels are uninhabited old growth forest, it is assumed there is little possibility of impact on inhabitants and their assets in this respect. If in the future such impacts occur, they will probably be dealt with at that time by construction protective embankments, or other means as necessary.

Meanwhile, impacts on the channel of the Mekong river's main stream and on coastal topography around the river's mouth are thought to be negligible because the basin area of the three projects (about 10,000 km^2) accounts for about 1 percent of the Mekong's total basin area (795,000 km^2), and because the amount of transported sand will decrease to a certain degree.

Other conceivable impacts are changes in flow characteristics, particularly localized sedimentation, river mouth obstruction, and other phenomena caused by a drop in the flood-time discharge, but in this respect these projects will have hardly any effect. Because the three projects' river basin accounts for a small part of the total river basin.

11.2.14 Soil Erosion

The upstream areas of all project sites are rather steep mountainous areas where there is often heavy rainfall during the rainy season. Also, parts of the forests have been degraded by slash-and-burn agriculture and other practices. At present, the river turbidity is relatively low. And big soil erosion are not observed. These basins are generally prone to soil erosion.

Remedial measures within the basins, which are probably the domain of administrative authorities, should involve promoting the transition from slash-and-burn farming to sedentary agriculture, and the management and preservation of forests, including afforestation of the degraded areas.

11.2.15 Soil Contamination

It is possible that in conjunction with construction, the disposal of waste oil and other harmful substances directly into the environment will contaminate the soil. It will therefore be necessary to strictly manage the processing and disposal of harmful substances during construction.

Because neither in the past nor present have mines in the vicinity of the project sites existed, there is no possibility that harmful minerals will be washed out or dispersed.

11.2.16 Inter-basin Diversion

Of the three projects, the Xe Namnoy Mid-stream project is to divert the Xe Pian river basin. The result will be a decreased amount of water in the Xe Pian river over the 20 km area from the intake dam to the confluence with the Houay Soy river. This means possible impacts on the fishing and water use by the approximately 60 households in two settlements along the river, as well as on the ecosystems, water quality, and the like.

Further, because the Xe Namnoy Mid-stream project is a dam-waterway type, there will be less water in the Xe Namnoy river between the dam and outlet, which raises the possibility of the same kind of impacts.

This makes it necessary to conduct detailed surveys and investigations concerning these potential problems, and enact, in accordance with the need, remedial measures such as releasing the amount of water needed as the discharge to maintain the river.

11.2.17 Impacts on Groundwater

It is possible that topographical changes by construction, the creation of reservoirs, and other such events will induce changes in groundwater reserves and flow attributes, but it is possible to prevent leaks from reservoirs and the resulting rise of groundwater levels by careful seepage control work. On the other hand, it is conceivable that seepage control will block previously existing groundwater arteries and lower groundwater levels, thereby affecting to a degree the nearby vegetation and the like. But as local inhabitants make hardly any use of groundwater, little impact is expected in this respect.

As there is very little groundwater utilization along the rivers' downstream portions, it is thought it is very unlikely that changes in flow characteristics will affect groundwater in these places.

11.2.18 Changes in Flow Characteristics

(1) Environmental Impacts and Measures

The construction of these reservoir type hydropower projects offers hope of favorable effects, specifically that in the downstream regions the river flow rate will increase in the dry season, and that in the rainy season floodwaters will decrease (because these dams are currently not meant for water conservation, the extent to which floodwaters decrease is dependent on flood-time reservoir water levels and the extent of flooding).

On the other hand, during peak use when daily plant operation and shutdown are repeated, it is possible that rising downstream water levels during operation start-up and output changes will present danger to people using boat transport, fishing, bathing, doing laundry, and the like. The requisite future surveys and studies may indicate the need for measures to deal with this, such as installing discharge warning devices to be used when danger is anticipated, limiting the speed at which output is increased, and in certain instances construction re-regulating reservoirs.

(2) Surveys Needed in Future

- Surveys of downstream river configurations (longitudinal and transverse), water levels, and the like.
- Examination of water level fluctuation at times such as when operation is started, as in the situation noted above.

11.2.19 Change in Water Temperature

It is said that in the tropics, reservoir temperatures are generally maintained at high levels throughout the year, and that water temperature change has almost no environmental impact.

11.2.20 Eutrophication, Changes in Composition of Bottom Material, and Other Changes

There are extremely low population densities of both humans and domestic animals in the basin encompassing the project locations, so the supply of nutrient salts is likely to be small, and the possibility of eutrophication thus caused is thought to be low. On the other hand, owing to the low replacement rates (total annual inflow/gross storage capacity) in the reservoirs at all three project locations, and to their location in the tropics, such a possibility cannot be totally disregarded.

	Se Kong	Xe Namnoy	Xe Kaman	Nam Ngum
Q: Annual Inflow (10^6 m^3/year)	6,443	1,151	4,177	9,596
V: Gross Storage Capacity (10^6 m^3)	7,716	323	16,208	8,500
Q/V: Replacement Rate (1/year)	0.85	3.56	0.26	1.13

Additionally, when trees within the reservoir area are submersed, they become sources of organic material, and they may cause eutrophication and degradation of bottom material, which in turn cause offensive odors. Thus, before impounding the reservoirs the trees will have to be cut and removed, and the reservoir interiors cleaned.

It is thought that various factors are involved in eutrophication and bottom material degradation, including the quality of inflow, the amounts of plankton and other organic material generated, and the stratification and flow configuration within reservoirs. While these are difficult to accurately predict, it will henceforth be necessary to investigate and ascertain river water quality, including nitrogen and phosphorus content, bottom material, and other characteristics. For purposes of comparison it will be useful to check similar, nearby reservoirs (such as the Nam Ngum reservoir).

There is probably next to no possibility of harmful heavy metal inflow, but it is best to check to be sure.

Grain size composition could change because, due to capture of the course-grained portion in the reservoir, there is a general tendency after dam construction for bottom material in the downstream river channel to become finer than before. Even within reservoirs composition changes depending on location, because the grading effect created by current velocity differences makes for a high proportion of coarse particles near the backwater end where current velocity is comparatively fast, and a high proportion of fine particles near the downstream end, where current velocity is slow.

11.2.21 Turbidity

Because all three projects' reservoirs are large in comparison to their inflows, there is a possibility of long-term turbidity, but relatively low. Except for the Xe Namnoy river, however, the rivers in this region are always turbid a little, so their fish and other life forms are adapted to turbid water. It is therefore unlikely that this will be a problem with the Se Kong No. 4 and Xe Kaman No. 1 sites as well.

But as the Xe Namnoy river ordinarily has low turbidity, and because the Tat Houakon waterfall is downstream from the project, long-term turbidity caused by the Xe Namnoy Mid-stream project could cause problems. Having carried out the requisite future surveys and studies, it may be necessary to alleviate this problem (by, for example, using selective water intake facilities).

Turbid water that is produced on site while construction is in progress should be discharged after being processed with the proper equipment.

11.2.22 Impacts on Flora

The state of remaining forests in the project areas are as described in section 11.2.3, which indicated that a considerable percentage of forested land has been lost to slash-and-burn agriculture. The further loss of considerable forested area to flooding by the projects is unavoidable, but if this submersion of land and relocation of the inhabitants is used as an opportunity to follow the government's policy of abolishing slash-and-burn agriculture, which would make it possible for the resettled people and those in peripheral areas to switch to sedentary farming, then in the long run it is possible this will offset the negative effects of flooding.

More detailed surveys will be needed to determine the current state of vegetation and the existence of irreplaceable species.

11.2.23 Impacts on Fauna

Reports say that many kinds of rare animals, including those rarely seen and those seen only in the past, exist in the project areas.

Conceivable project impacts on animals include the submersion of forests, which provide habitat and food, and the blockage of migratory routes by the reservoirs. Special consideration will be needed for the young of animals and birds, and for some insects and the like, which have difficulty in moving to new locations. It will be necessary to consider holding down the speed of logging, drilling, and other operations and to proceed with construction from one side of a site to another so as to leave escape routes. Especially when there are rare species and other organisms whose ability to move is limited, it will be necessary to consider measures such as capture and removal to appropriate locations. It would perhaps be effective to provide wildlife protection areas on the peripheries of reservoirs in order to compensate for the flooding of habitats.

On the other hand, it is possible that reservoirs will become habitat for waterfowl and other wildlife, which is one favorable impact of the projects.

11.2.24 Impacts on Aquatic Organisms

It is possible that changes engendered by dam construction such as in flow characteristics including water depth and current velocity, as well as in water quality, bottom material, and the like, will affect the lives of aquatic organisms. While it is difficult to clearly predict exactly what those impacts will be, for migratory fishes the dams will affect spawning by hindering their ascent and descent of rivers. The project may therefore bring about a decline in their numbers.

On the other hand, in the case of the Nam Ngum dam construction greatly increased the numbers of fish inhabiting the reservoir, so there is at least a possibility that these new projects will increase the production of fish in their reservoirs. More detailed surveys will be needed on the current state of fish stocks.

There are also reports that, although rarely, local inhabitants see river dolphins in the Se Kong river. Apparently either some of the Mekong dolphins living near the Khon waterfall on the Mekong river's main stream have moved to the Se Kong river, or these dolphins have the same origin. Currently, there is no scientific literature on these dolphins, and their ecology is unknown, but a project has recently been started with funding from

other countries to protect fishing and dolphins in southern Laos, and a survey is under way. It will be necessary to carefully assess project impacts with reference to this survey's results.

11.2.25 Air Pollution, Noise, Vibration, and Other Forms of Pollution

Because these are hydropower projects, there is almost no possibility of their creating air pollution, noise, and vibration through operation after their completion. However, the main transformers and some types of breakers will be installed outdoors, making it necessary to be cautious of noise if they are near dwellings. But because there are no dwellings near any of these hydropower station sites, this should not be a problem.

During construction there will likely be exhaust gases, offensive odors, dust, and noise from construction vehicles and machinery, noise produced by vibration and blasting, vibration, and other forms of pollution. Assessing their impacts on settlements near project sites will have to wait until specific construction plans, including temporary facilities, site access roads, and the like, have been finalized. If impacts on settlements are anticipated, it will be necessary to make remedial changes in construction methods, such as using low-noise construction machinery, setting up soundproofing panels, and adjusting working hours. When transporting materials and machinery along public roads, impacts on settlements along roads must be alleviated by, for example, limiting vehicular speed and sprinkling water on roads.

To prevent vehicular accidents, it is desirable to implement safety measures such as limiting speed on public roads and within construction sites, and installing traffic signals.

11.2.26 Microclimatic Changes

Localized climatic changes could occur when a reservoir area is several hundred square kilometers or more, but the possibilities for these projects are slight because of the small areas of the reservoirs, as shown below.

Se Kong No. 4	145 km^2 (at HWL 300 m)
Xe Namnoy Mid-stream	20 km^2 (at HWL 760 m)
Xe Kaman No. 1	222 km^2 (at HWL 280 m)

Apparently the construction of the Nam Ngum dam, whose reservoir area is about 440 km^2, brought about no climatic change in particular. This nearby example will serve as a useful reference.

11.2.27 Overall Assessment

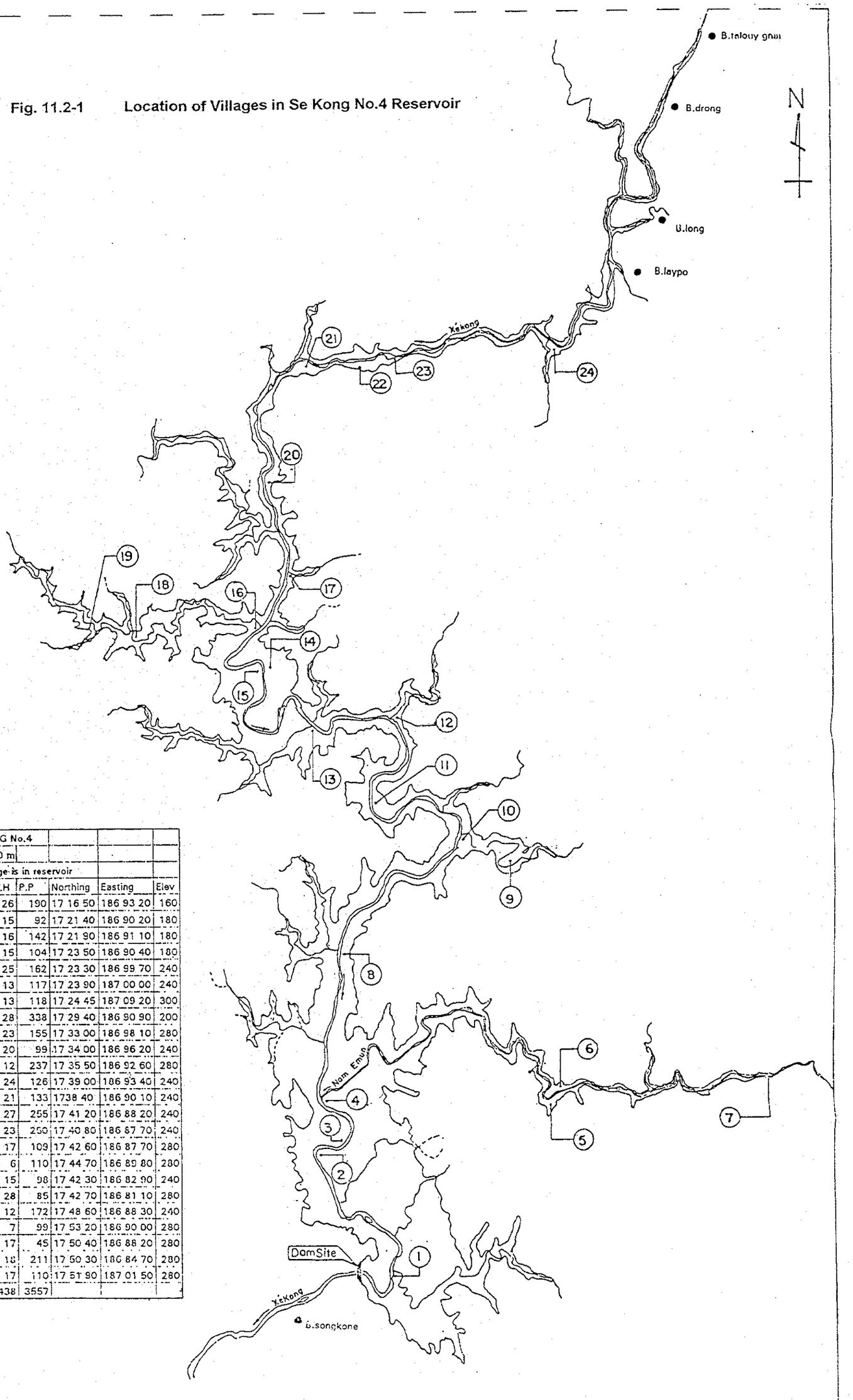
If measures to alleviate impacts are not implemented, environmental impacts might be comparatively large in areas such as the following.

- Impacts of submersion and relocation on regional societies, the inhabitants' livelihoods, agriculture, etc.
- Impacts of forest submersion on wildlife, etc.
- The possibilities of waterborne epidemics caused by creation of the reservoirs, or new epidemics introduced by the entrance of construction workers into the areas.
- Impacts on boat transport, use of waterways, and fish due to creation of the reservoirs and changes in flow characteristics.
- Impacts caused by inter-basin diversion and a low-water area in the Xe Namnoy Mid-stream project.

However, it is anticipated that these environmental impacts can be adequately diminished by implementing the moderating measures noted in the foregoing sections, or by other measures considered necessary on the basis of future surveys and impact assessments.

Finally, as this is a preliminary survey at the pre-feasibility study stage, it does not adequately determine the current state of the environment, for which reason some matters must wait until future surveys. However, an overall consideration on the basis of survey results and other information to date suggests that implementing appropriate measures to alleviate impacts will forestall the occurrence of environmental impacts that would hinder these projects.

Fig. 11.2-1 Location of Villages in Se Kong No.4 Reservoir

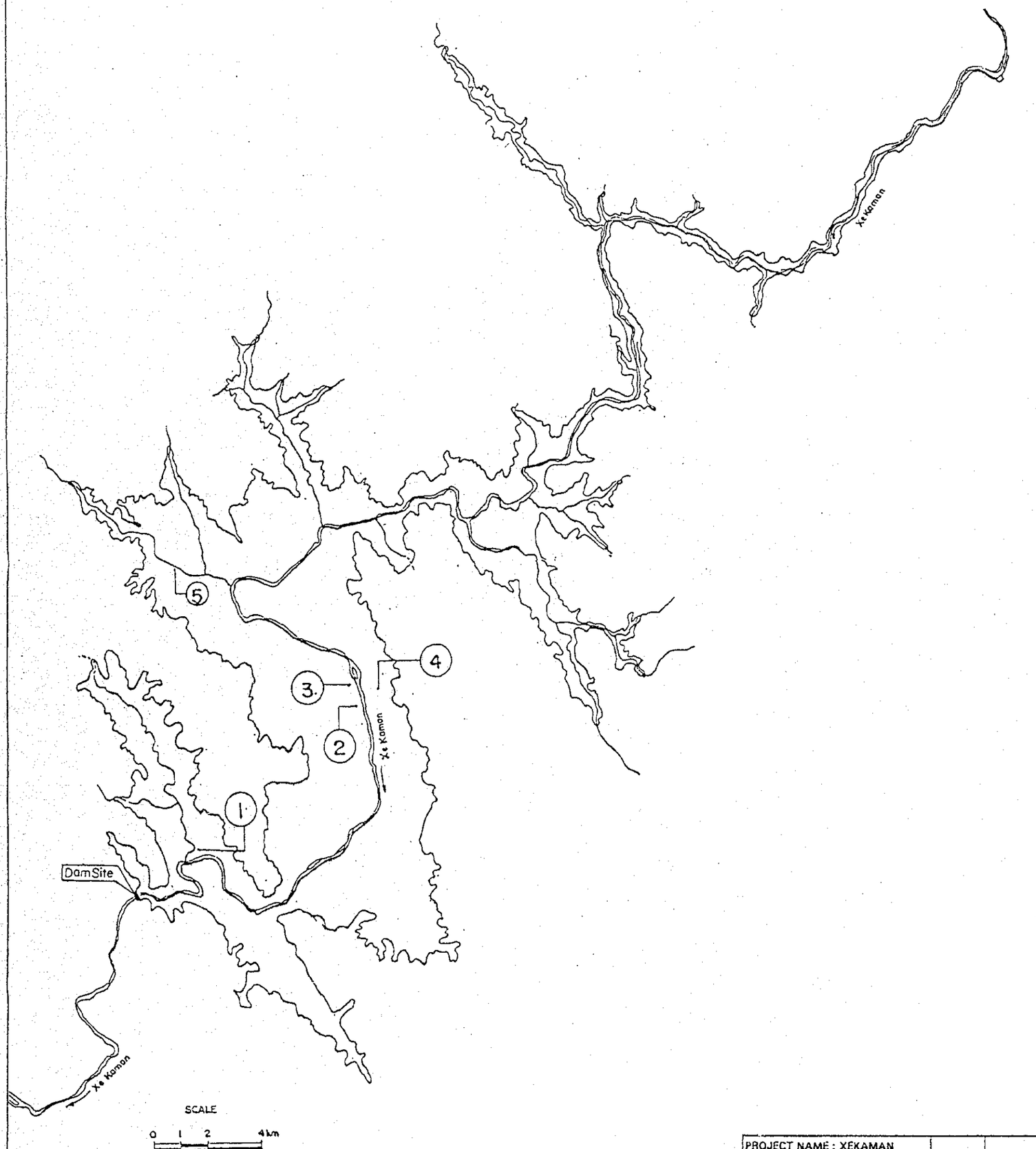


PROJECT NAME : XEKONG No.4						
Xekong water level 320 m						
Table of the number village is in reservoir						
No.	Village name	H.H	P.P	Northing	Easting	Elev
1	B. pakkayong	26	190	17 16 50	186 93 20	160
2	B. hungtai	15	92	17 21 40	186 90 20	180
3	B. hungkang	16	142	17 21 90	186 91 10	180
4	B. hungnua	15	104	17 23 50	186 90 40	180
5	B. houaylong	25	162	17 23 30	186 99 70	240
6	B. tangkat	13	117	17 23 90	187 00 00	240
7	B.sathone	13	118	17 24 45	187 09 20	300
8	B.hatvi	28	338	17 29 40	186 90 90	200
9	B. hanong	23	155	17 33 00	186 98 10	280
10	B. paktray	20	99	17 34 00	186 96 20	240
11	B. hatpo	12	237	17 35 50	186 92 60	280
12	B. pakphuong	24	126	17 39 00	186 93 40	240
13	B. trok	21	133	1738 40	186 90 10	240
14	B. kongtrok	27	255	17 41 20	186 88 20	240
15	B. kaleum	23	250	17 40 80	186 87 70	240
16	B. hountan	17	109	17 42 60	186 87 70	280
17	B. kloung	6	110	17 44 70	186 89 80	280
18	B. tongkay	15	98	17 42 30	186 82 90	240
19	B. paksay	28	85	17 42 70	186 81 10	280
20	B. bak	12	172	17 48 60	186 88 30	240
21	B. longkong	7	99	17 53 20	186 90 00	280
22	B. ploy nua	17	45	17 50 40	186 88 20	280
23	B. ploy tai	18	211	17 50 30	186 84 70	280
24	B. kado	17	110	17 51 90	187 01 50	280
	total	438	3557			

SCALE

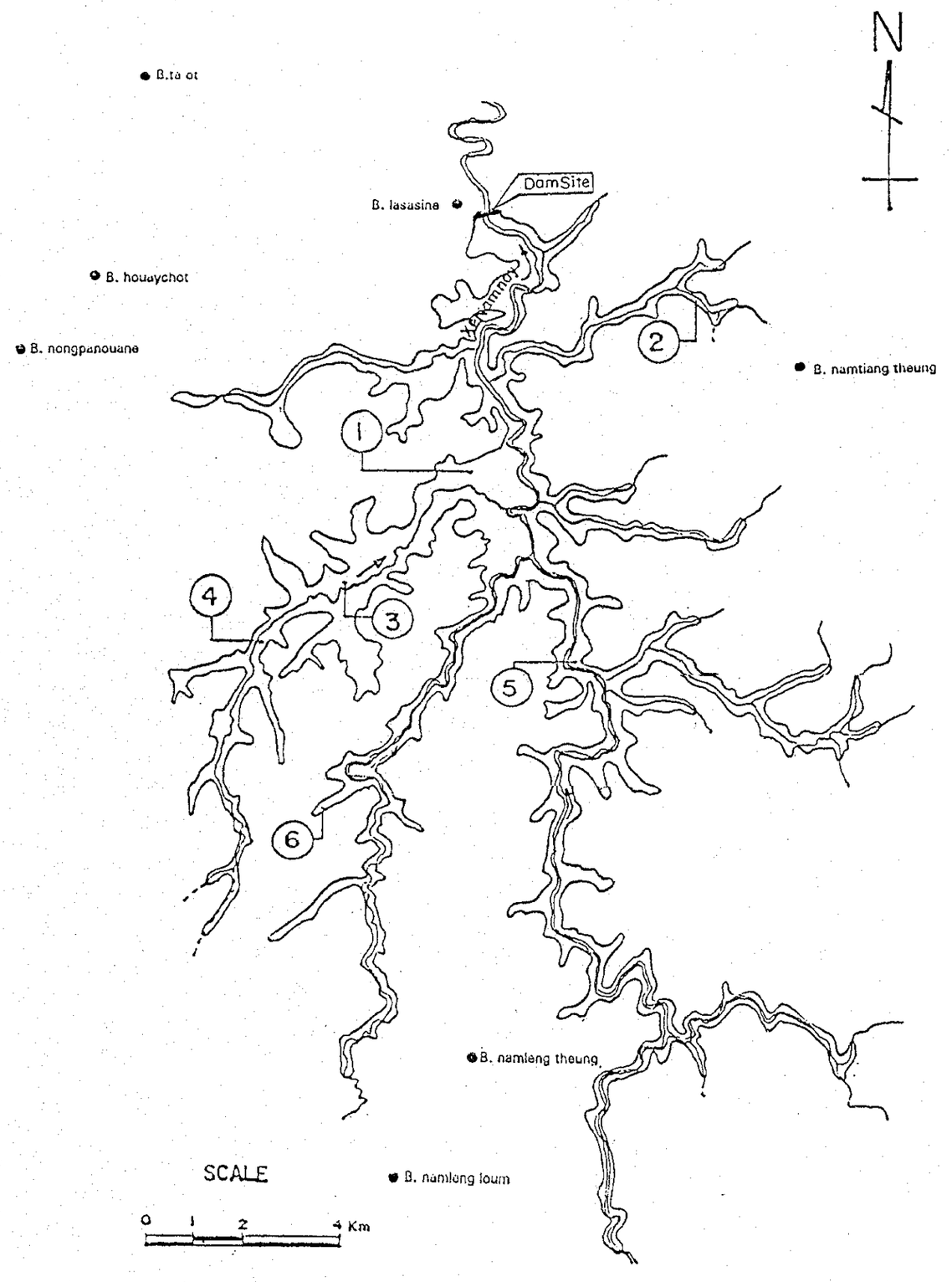
0 1 2 4 Km

Fig. 11.2-2 Location of Villages in Xe Kaman No.1 Reservoir



PROJECT NAME : XEKAMAN						
Water level 300 m						
Table of the number village is in reservoir						
No.	Village name	H.H	P.P	Northing	Easting	Elev
1	B. hindam	20	151	16 57 40	187 33 55	150
2	B. donekhene1	8	93	16 63 30	187 39 50	140
3	B. donekhene2	10	103	16 63 30	187 39 55	140
4	B. donekhene3	7	75	16 63 70	187 40 15	140
5	B. daklom	29	167	16 68 20	187 32 50	200
	Total	74	589			

Fig. 11.2-3 Location of Villages in Xe Namnoy Reservoir



PROJECT NAME : XENAMNOY						
Water level 780 M						
Table of the number village is in reservoir						
No.	Village name	H.H	P.P	Northing	Easting	Elev
1	B. xenamnoy	24	108	16 95 80	186 72 40	760
2	B. namtiangloum	25	150	16 63 50	186 70 90	760
3	B. namkong	42	171	16 57 50	186 [illegible]70	740
4	B. nonghom	26	150	16 52 50	186 70 30	760
5	B. keokhounmoua	21	89	16 55 90	186 74 50	740
6	B. houaysoy	72	350	16 56 30	186 66 00	760
	Total	210	1018			

Fig. 11.2-4 Land Use Classification in Se Kong No. 4 Reservoir

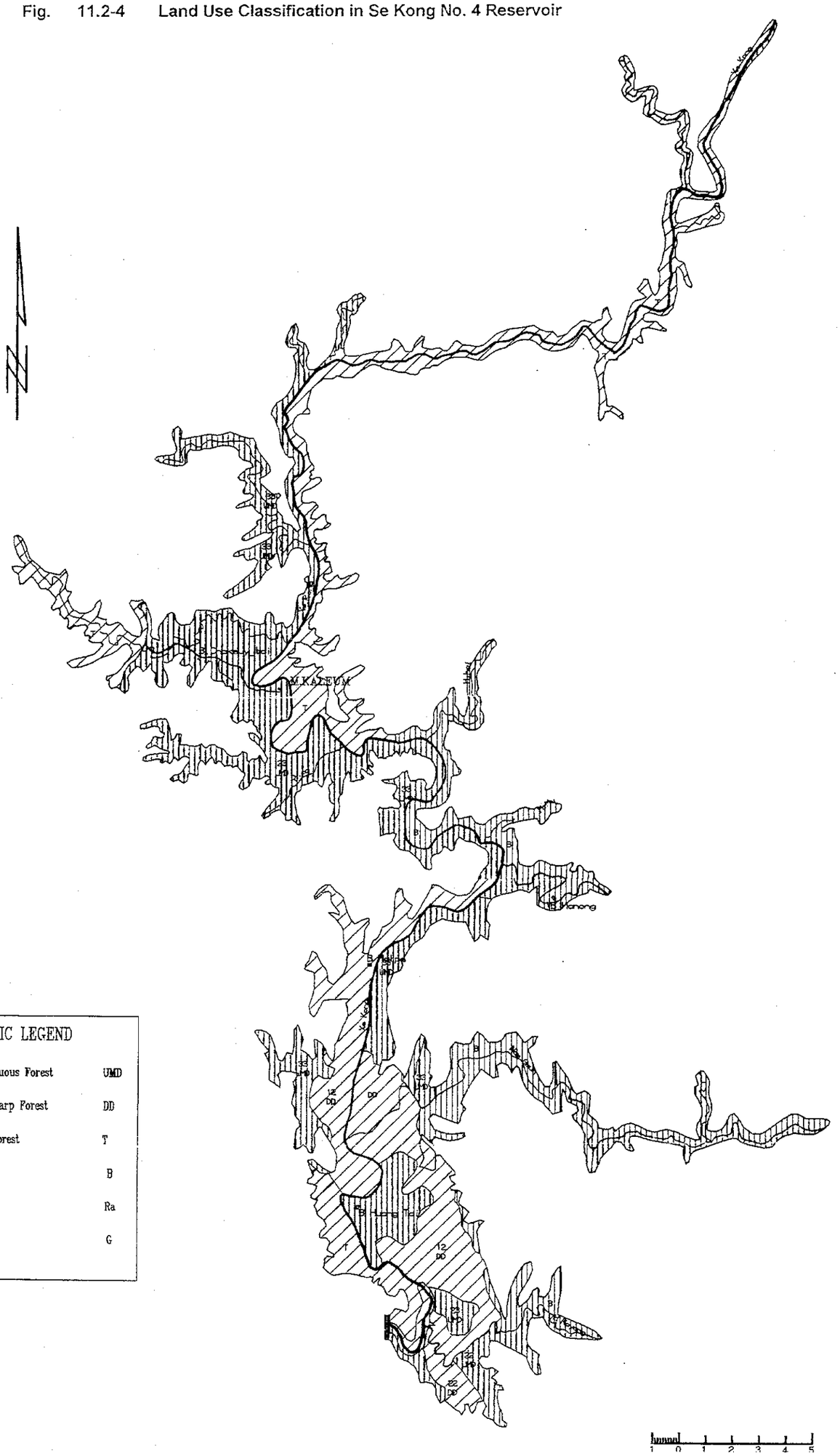


Fig. 11.2-5 Land Use Classification in Xe Kaman No. 1 Reservoir

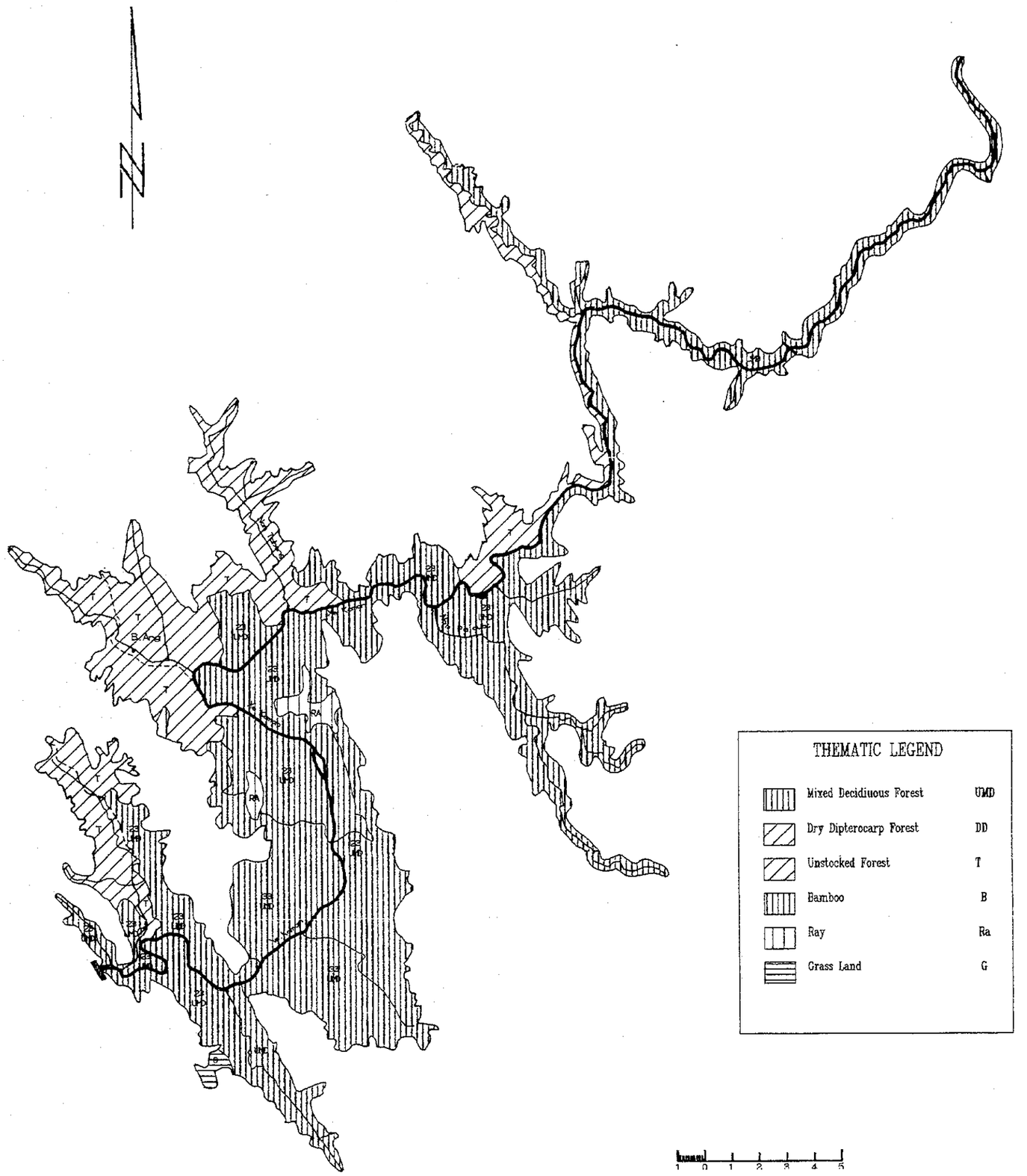
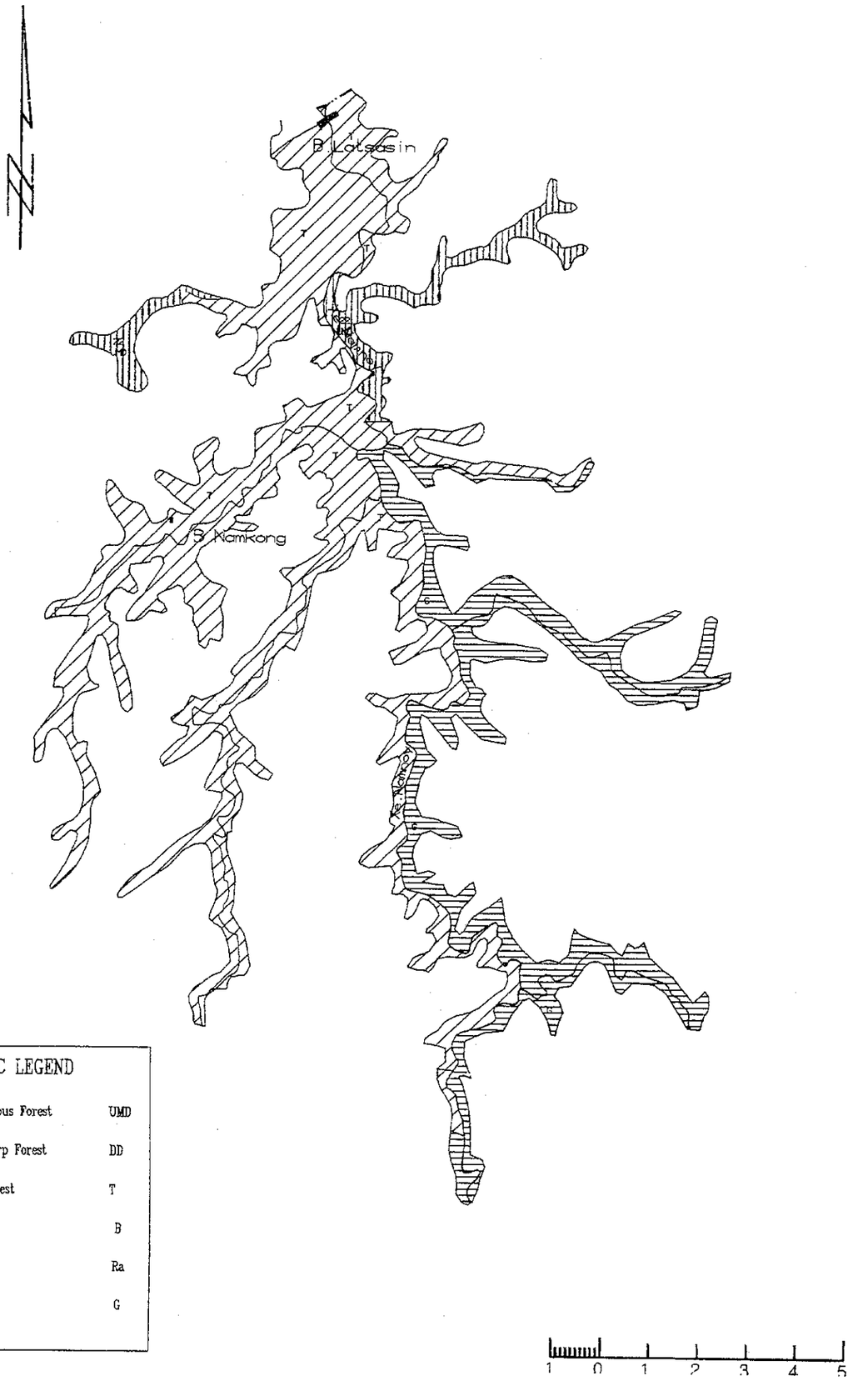


Fig. 11.2-6 Land Use Classification in Xe Namnoy Reservoir



11.3 Compensation

Compensation costs were calculated according to the following guidelines and preconditions. However, as these are approximate amounts that include many assumptions, they will have to be reassessed after conducting surveys of the populations, assets including houses and farmland, social capital, types of ethnic groups and other matters regarding all the settlements in and around the submersion areas, and surveys covering the perceptions, hopes, and other feelings of the inhabitants concerning resettlement, as well as after incorporating the opinions of central and local government authorities.

At present only the settlements within reservoir areas are planned for relocation. But, future surveys of inter-settlement interchanges and other circumstances within these areas may indicate the need to relocate peripheral settlements as well.

11.3.1 Guidelines of Compensation Cost Calculation

The government's policy is to use the occasion of resettlement to have the inhabitants give up slash-and-burn agriculture and promote sedentary agriculture. To this end and for the calculation of compensation costs in this resettlement plan as well, we assumed that resettlement areas would be flat land suited to agriculture including wet rice cultivation. Further, in consideration of matters such as the efficiency of building social capital in the resettlement areas, we decided upon a group resettlement plan with one resettlement area per project.

Compensation for submerged dwellings, farmland, and other assets would consist in offering resettled people compensation in kind at their new locations.

11.3.2 Preconditions for Calculating Compensation Costs

- Land in new settlements would be provided free of charge by the government.
- 1.0 ha. of land would be prepared as the property of each household.
- An average per-household budget of 750,000 kip would be set aside as living costs and food aid for the first two years after resettlement.
- The following basic infrastructure would be built. Although apparently the settlements within the reservoir areas have hardly any infrastructure such as this, these items would be constructed because the resettlement areas will be large due to group relocation, and because it would provide the inhabitants with an incentive to resettle.

Meeting halls, temples, schools, medical care facilities, government offices, markets, wells, electric power, irrigation equipment, roads (unpaved; we assumed that the resettlement areas would be closed to existing roads, and appropriated funds only for roads within the resettlement areas).

11.3.3 Compensation Cost Calculation Results

Compensation costs were calculated for the H.W.L. in three cases for each project. Results are shown in **Tables 11.3-1** through **11.3-4**.

Table 11.3-1 Summary of Estimated Compensation Cost

Item	Unit	Unit Price (kip)	Se Kong No.4 (HWL 290m)		Xe Namnoy Mid. (HWL 765m)		Xe Kaman No.1 (HWL 260m)	
			Qty	Cost (1000 kip)	Qty	Cost (1000 kip)	Qty	Cost (1000 kip
Population	No.	-	3,439	-	681	-	589	-
Household	No.	-	425	-	140	-	74	-
Acquisition Land	ha	-	85	-	28	-	5	-
1. Village								
Land Clearing & Grubbing	ha	100,000	85	8,500	28	2,800	15	1,500
House Construction	No.	3,500,000	425	1,487,500	140	490,000	74	259,000
2. Agriculture Land								
Rice Field Construction	ha	750,000	425	318,750	140	105,000	74	55,500
Irrigation System	ha	200,000	425	85,000	140	28,000	74	14,800
3. Supplementary Wages	No.	750,000	425	318,750	140	105,000	74	55,500
4. Infrastructures								
Unpaved Road	km	7,000,000	4	28,000	1.5	10,500	1	7,000
Power Line	km	11,500,000	10	115,000	4	46,000	3	34,500
Village Hall/Temple	m^2	100,000	400	40,000	250	25,000	200	20,000
School	m^2	75,000	400	30,000	250	18,750	200	15,000
Hospital/Health Center	m^2	100,000	200	20,000	100	10,000	100	10,000
Public Administration	m^2	75,000	200	15,000	100	7,500	50	3,750
Market	m^2	65,000	500	32,500	-	-	-	-
Deep Well	No.	2,500,000	4	10,000	2	5,000	1	2,500
Shallow Well	No.	50,000	20	1,000	6	300	4	200
5. Contingency				637,500		210,000		111,000
Total				3,147,500		1,063,850		590,250
Total (US$)				4,500,000		1,500,000		900,000

Table 11.3-2 Estimated Compensation Cost (Se Kong No.4)

Item	Unit	Unit Price (kip)	H.W.L. El. 280m		H.W.L. El. 300m		H.W.L. El. 320m	
			Qty	Cost (1000 kip)	Qty	Cost (1000 kip)	Qty	Cost (1000 kip
Population	No.	-	3,439	-	3,557	-	3,557	-
Household	No.	-	425	-	438	-	438	-
Acquisition Land	ha	-	85	-	88	-	88	-
1. Village								
Land Clearing & Grubbing	ha	100,000	85	8,500	88	8,800	88	8,800
House Construction	No.	3,500,000	425	1,487,500	438	1,533,000	438	1,533,000
2. Agriculture Land								
Rice Field Construction	ha	750,000	425	318,750	438	328,500	438	328,500
Irrigation System	ha	200,000	425	85,000	438	87,600	438	87,600
3. Supplementary Wages	No.	750,000	425	318,750	438	328,500	438	328,500
4. Infrastructures								
Unpaved Road	km	7,000,000	4	28,000	4	28,000	4	28,000
Power Line	km	11,500,000	10	115,000	10	115,000	10	115,000
Village Hall/Temple	m^2	100,000	400	40,000	400	40,000	400	40,000
School	m^2	75,000	400	30,000	400	30,000	400	30,000
Hospital/Health Center	m^2	100,000	200	20,000	200	20,000	200	20,000
Public Administration	m^2	75,000	200	15,000	200	15,000	200	15,000
Market	m^2	65,000	500	32,500	500	32,500	500	32,500
Deep Well	No.	2,500,000	4	10,000	4	10,000	4	10,000
Shallow Well	No.	50,000	20	1,000	20	1,000	20	1,000
5. Contingency				637,500		657,000		657,000
Total				3,147,500		3,234,900		3,234,900
Total (US$)				4,500,000		4,600,000		4,600,000

Table 11.3-3 Estimated Compensation Cost (Xe Kaman No.1)

Item	Unit	Unit Price (kip)	H.W.L. El. 260m		H.W.L. El. 280m		H.W.L. El. 300m	
			Qty	Cost (1000 kip)	Qty	Cost (1000 kip)	Qty	Cost (1000 kip
Population	No.	-	589	-	589	-	589	-
Household	No.	-	74	-	74	-	74	-
Acquisition Land	ha	-	15	-	15	-	15	-
1. Village								
Land Clearing & Grubbing	ha	100,000	15	1,500	15	1,500	15	1,500
House Construction	No.	3,500,000	74	259,000	74	259,000	74	259,000
2. Agriculture Land								
Rice Field Construction	ha	750,000	74	55,500	74	55,500	74	55,500
Irrigation System	ha	200,000	74	14,800	74	14,800	74	14,800
3. Supplementary Wages	No.	750,000	74	55,500	74	55,500	74	55,500
4. Infrastructures								
Unpaved Road	km	7,000,000	1	7,000	1	7,000	1	7,000
Power Line	km	11,500,000	3	34,500	3	34,500	3	34,500
Village Hall/Temple	m^2	100,000	200	20,000	200	20,000	200	20,000
School	m^2	75,000	200	15,000	200	15,000	200	15,000
Hospital/Health Center	m^2	100,000	100	10,000	100	10,000	100	10,000
Public Administration	m^2	75,000	50	3,750	50	3,750	50	3,750
Market	m^2	65,000	-	-	-	-	-	-
Deep Well	No.	2,500,000	1	2,500	1	2,500	1	2,500
Shallow Well	No.	50,000	4	200	4	200	4	200
5. Contingency				111,000		111,000		111,000
Total				590,250		590,250		590,250
Total (US$)				900,000		900,000		900,000

Table 11.3-4 Estimated Compensation Cost (Xe Namnoy Midstream)

Item	Unit	Unit Price (kip)	H.W.L. El. 740m		H.W.L. El. 760m		H.W.L. El. 780m	
			Qty	Cost (1000 kip)	Qty	Cost (1000 kip)	Qty	Cost (1000 kip
Population	No.	-	379	-	681	-	845	-
Household	No.	-	80	-	140	-	170	-
Acquisition Land	ha	-	16	-	28	-	34	-
1. Village								
Land Clearing & Grubbing	ha	100,000	16	1,600	28	2,800	34	3,400
House Construction	No.	3,500,000	80	280,000	140	490,000	170	595,000
2. Agriculture Land								
Rice Field Construction	ha	750,000	80	60,000	140	105,000	170	127,500
Irrigation System	ha	200,000	80	16,000	140	28,000	170	34,000
3. Supplementary Wages	No.	750,000	80	60,000	140	105,000	170	127,500
4. Infrastructures								
Unpaved Road	km	7,000,000	1.0	7,000	1.5	10,500	2.0	14,000
Power Line	km	11,500,000	3	34,500	4	46,000	5	57,500
Village Hall/Temple	m^2	100,000	200	20,000	250	25,000	300	30,000
School	m^2	75,000	200	15,000	250	18,750	300	22,500
Hospital/Health Center	m^2	100,000	100	10,000	100	10,000	150	15,000
Public Administration	m^2	75,000	50	3,750	100	7,500	150	11,250
Market	m^2	65,000	-	-	-	-	-	-
Deep Well	No.	2,500,000	1	2,500	2	5,000	3	7,500
Shallow Well	No.	50,000	4	200	6	300	8	400
5. Contingency				120,000		210,000		255,000
Total				630,550		1,063,850		1,300,550
Total (US$)				900,000		1,500,000		1,900,000

12. Operation Plan

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12. Operation Plan

12.1 Review of Electric Power Development Programs

12.1.1 Current Status of Electric Power Development Plans in Laos

(1) Domestic Power Supply Plan

As outlined in Chapter 3, domestic electric power supply in Laos is achieved via independent systems in the capital, Vientiane, and other major areas. Currently, effective distribution system is in place only in the capital city and environs of major cities and towns. Nam Ngum Hydropower (150 MW) serving the Vientiane system, Selabam Hydropower (5 MW) and Xe Set Hydropower (45 MW) serving the Pakse area system are the major domestic supply sources. In addition, power systems of Savannaket and Thakhek regions are depending their energy source on imported electricity by linkage with Thailand's system.

Other regions rely on mini or micro-hydropower plants (less than 1 MW) and diesel generators for electricity supply. In areas that rely on diesel power plant for electricity supply, however, the cost is so high that output does not exceed levels required to run electric lights for 3 hours or so at night. Sekong Town and Attapu Town, the central townships of Sekong and Attapu provinces respectively, are at this level of electricity supply.

In more rural mountainous regions, only very few areas are supplied with electricity from local micro hydropower plants while most areas remain without public electric supply. However, even in areas without public electric power supply, some households have engine generators for self power supply.

With this present situation, the following two approach may be considered in planning of future electric development in Laos as a basic policy.

a) Medium to large scale development

The first approach is to satisfy domestic demand by medium to large-scale project developed mainly for power export developping domestic substations and transmission line systems.

This approach of electric power development are currently taking in high demand regions by constructing transmission and distribution systems and therefore expanding the area of supply. Two example projects just now getting under way are the construction of transmission lines linking Luang Prabang and the Nam Ngum Hydropower plant and the development of transmission lines and a substation to link Xe Set Hydropower plant with the Saravanne region.

Also, studies for further power development are being carried out not only by official technical cooperation of developed countries and international agencies but also developpers from private sector.

b) **Isolated small-scale development**

The second strategy is to develop small scale stand alone power sources for electricity supply to mountainous rural areas. Since the level of electricity demand is low comparing with required investment cost for constructing the transmission lines and substations the first strategy outlined above would be too inefficient for electrification of rural areas remoted from demand centers. In order to avoid this inefficiency, a policy to supply electricity with mini stand-alone generators has been taken for remote areas. In addition, mini hydropower model plant projects are being planned with the cooperation of the Mekong Committee.

(2) **Plan for Export of Electricity**

Laos is blessed with many tributaries to the Mekong River, offering plentiful hydropower potential. However, as population is low and domestic industrial structure is mainly defined by primary industries, domestic demand for electric power is far below the supply potential.

Therefore, medium and large hydroelectric power projects in Laos are not developed solely for domestic supply, but with export to neighboring countries as their primary purpose. And, some areas around Laos have a large and rapidly increasing electric power demand. Taking advantage of these conditions, future strategy for economic growth of Laos will center on the development of domestic hydropower potentials for export.

In this connection, the development of a 1,500 MW power plant in Laos for export to Thailand by the year 2,000 was agreed upon by the two governments in 1993. The Nam Ngum hydropower plant and 3 other power systems in Laos are now connected to the

electrical power system of Thailand and import-export is already taking place. Also, in geographical terms, other regions of Laos can be easily connected to the Thai system. Taking these conditions into account, it is expected that, for the short term, hydropower development focusing energy export to Thailand will take place in Laos.

Practically, the Nam Theun Hinboun hydropower plant (210 MW) on the Nam Theun river in central Laos and other electric power development projects (mainly hydro) are going to be developed in Laos by the year 2000 for the purpose of export to Thailand.

On the other hand, Laos shares borders not only with Thailand, but also with China, Vietnam, Cambodia and Myanmar. Due to the introduction of market economies, these countries are also beginning to show rapid economic growth and commensurate increases in electric power demand. While there are no exact plans, the possibility of energy export to these countries holds promise for the future.

12.1.2 Clarification of Hydropower Development in Se Kong River Basin

(1) Clarification as Source of Domestic Electricity Supply

The Se Kong Basin is located in the south of Laos. As outlined about the domestic electric power supply plan in section 12.1.1 (1) above, supply area of the hydropower development in the Se Kong Basin will be the southern region of Laos.

There are five provinces, Champasak, Saravane, Attapu, Sekong and Savannakhet, in the south of Laos. Of these, two provinces, Champassak and Saravanne, have an electric power supply system with the Xe Set (45 MW) and Selabam (5 MW) hydropower plants supplying electricity to the center of these two provinces, Pakse City and Saravane Town, respectively. The peak domestic demand on this system in 1993 was only about 4 MW, and therefore most of the output is exported to Thailand in the rainy season. However, in the dry season, output of the Xe Set powerplant drops to below 3 MW, and electric power is imported from Thailand. As for the Sekong and Attapu provinces, both Sekong Town and Attapu Town currently have only more or less 200kW diesel generators which supply electricity for lighting for only 3 hours at night. Further in the province of Sevannakhet, electric power is imported from Thailand due to the lack of domestic electric power source in its power system.

In short, southern region of Laos is in situation without a reliable system for the domestic supply of electric power and in initial stage of power system development. However,

hydropower potentials in this region are significant, and especially the hydropower potential in the Se Kong Basin is very large and important for the region. These will play an important role not only on power export, but also on improving domestic electric power supply in the south of Laos.

The northernmost of the 5 southern provinces, Savannakhet province, is located far from the Se Kong Basin. Considering the high construction cost of transmission lines from the Se Kong valley and the level of power demand in this region, the most economical solution for the short term is to continue importing electricity from Thailand. On the other hand, Savannakhet province is closer to hydropower project sites planned in the Nam Theun river basin in central Laos, and therefore the electricity demand in the area will be supplied by those hydropower projects. Taking this condition into account, the Sevannakhet province will not be the area of power supply from hydropower projects in the Se Kong Basin. However, due to proximity, Champasak, Saravane, Sekong and Attapu provinces will be most efficiently supplied with electricity from hydropower projects planned in the Se Kong Basin.

From the conditions outlined above, development of medium to large-scale projects in the Se Kong Basin will be planned both for power export to neighboring countries and for domestic supply to the four provinces in the southern region of Laos.

(2) Clarification as Electric Power Export Project

As outlined in 12.1.1 (2) above, medium to large-scale hydropower development projects in Laos will rely on exports to Thailand for the time being. Currently, several projects for this purpose are scheduled for commissioning by year 2000. These projects are planned to satisfy an agreement by the two governments to export 1,500 MW by 2000. If the projects are developed according to schedule, they will satisfy the agreed export power capacity.

However, annual growth rate of electric power demand in Thailand is estimated to be 8%, meaning that they must develop more or less an additional 1,000 MW of power each year to meet this growing demand. Thailand plans to meet part of growing demand with imports, which means that demand for electric power development in Laos will continue beyond the current projects planned for 2000. Therefore, the hydropower development projects in the Se Kong Basin are clarified to be those developed after the current group of projects set for commissioning by 2000.

Including new projects near the existing Nam Ngum hydropower plant in the Nam Ngum Basin, there are may proposed power development projects in Laos. Projects in the Se Kong Basin will have to compete with those projects in national wide hydropower development. When determining development schedule of each project, many factors are taken into consideration. An evaluation method which provides a long term least cost of entire power system by considering development capacity and construction, maintenance and operation costs of each candidate project and power supply reliability of power system is applied in power development planning.

Since export is the principal purpose of electric power development in Laos, it is necessary to consider the situation of power system in the importing country over and above the domestic situation. However, proposed projects in Laos are mostly still in the initial stage of development study and investigation, so that it is difficult to compare the relative merits and decide the development order of projects. Also, in the case of electric power development in Laos, most projects involve the introduction of private investors. Therefore, it is difficult to consider all projects and objectively determine the most favorable order for development.

Accordingly, for the time being the three project in the Se Kong Basin chosen in Chapter 7 will all be earmarked for development after the year 2000 mainly for energy export to Thailand. The details such as order and commissioning schedule of development will be determined in the next stage in future.

Also, since the Se Kong River Basin is very close to the Yali hydropower project now under construction in Vietnam, it may be possible in the future to connect via there to Vietnam's North-South interconnecting transmission line system (completed in 1994) to supply electric power to Vietnam's southern high-demand area centering on Ho Chi Minh City. Due to their favorable geography, electric power development projects in the Se Kong Basin must also be clarified as possible sources of export to Vietnam.

12.2 Transmission Line Plan

12.2.1 Current Status of Transmission Line Expansion Plan in Laos

The major power system in Laos at present is divided into the Vientiane system supplying to Vientiane area, the southern system supplying to Pakse City and Saravane Town, and power systems of Thakhek City and Savannakhet City receiving electricity from the Thailand power transmission network. And, the power supply is limited to the principal cities, towns and their vicinities. The power transmission network linking the whole country has not built yet.

The Southern Laos power system consists of 22 kV distribution line with 40 km in length from the Selvabam hydropower plant (5 MW) which started operation in 1961 and was expanded with additional 3 MW in 1994 to Bangyo substation (16 MVA), the distribution line serving electricity directly to Salavane Town from the Xe Set hydropower plant (45 MW) which was developed at 70 km northeast of Pakse and started operation in 1991, and 115 kV transmission line connecting the Xe Set hydropower plant and the Bangyo substation in Pakse.

Also the Bangyo substation is connected with EGAT Sirindhorn hydropower plant in Thailand through 115 kV international transmission line. Accordingly, there are four international linkage lines with Thailand, namely 115 kV Vientiane - Udon Thani, 115 kV Bangyo - Sirindhorn, 22 kV Thakhek - Nakone Phanom, and 22 kV Savannakhet - Mukadahan transmission lines.

As for the power system expansion plan in Laos, 230 kV and 115 kV transmission line for the expansion of domestic power supply, and interconnection lines for power export of 500 kV for Thailand, and 230 kV for Cambodia and Vientnam respectively as shown in Fig. 12.2-1.

12.2.2 Plan of Transmission Lines for Projects in Se Kong River Basin

(1) Transmission Line Plan for each Project

The routes for the transmission liens for the three projects (four power plants) in the Se Kong Basin are planned based on the topographical maps and reconnaissance by car on the existing roads and helicopter at site.

Fig. 12.2-2 shows the existing transmission lines of the Southern Laos and the plan of transmission lines in Se Kong Basin proposed in this study. It is considered that the power from the planned power stations will be connected to Ban Houaykong Substation located 80 km east from Pakse City. The 230 kV transmission lines of each project are specified as follows:

Line	Route Length (km)	Voltage/Circuit (kV)	Conductor size	Construction Cost (M.US$)
Se Kong No.4	80	230/1	795 MCM × 2	12.6
Xe Kaman No.1	140	230/1	1,272 MCM × 1	17.2
Xe Namnoy (Midstream)	10	230/1	1,272 MCM × 1	1.3
Xe Namnoy (Mid. + Downstream)	20	230/1	1,272 MCM × 1 + 795 MCM × 1	2.6

(2) International Linkage Line Plan

The international linkage with 500 kV transmission line of 450 km in length connecting to the Roi Et substation of EGAT power system in Thailand is proposed in this study for power export from the power plants of the above projects. The construction cost of this interconnection line is estimated to be 200 M.US$. Other interconnection lines by 230 kV line are also planned in this study to connect to the Phnum Pench City in Cambodia and to the Yali hydropower plant in Vietnam respectively.

As for the international linkage line route to the Thailand, several routes have been studied by the EDL and other authorities. In the Southern Laos, for example, a route to Ubon Rachatani in Thailand, by constructing substation on the Boleven Plateau is considered. In this study, however, a route to the Roi Et substation is adopted based on discussion with MIH. A study for the final selection of the route in detail will be required considering other development projects proposed in Laos.

EHV substation at Ban Houaykong is specified in 2 circuit bays and 2 units of 400 MVA transformers for 500 kV, 7 circuit bays and 1 unit of 50 MVA transformer for 230 kV, and 1 circuit bay for 115 kV. Construction costs of this substation is estimated to be 50 M.US$.

(3) Comparative Study of the Transmission Line Cost up to the Thai Border

As mentioned in the above (2), each project costs are not included of 500 kV substation and 500 kV transmission line. However, as comparative plans, two cases for transmission line construction costs up to the Thai border are studied as the following table.

(Unit: Million US$)

	Se Kong No.4	Xe Kaman No.1	Xe Namnoy	Total
Base	12.6	17.2	2.6	32.4
Case-1	56.7	42.7	33.0	132.4
Case-2	53.8	50.8	26.8	131.4

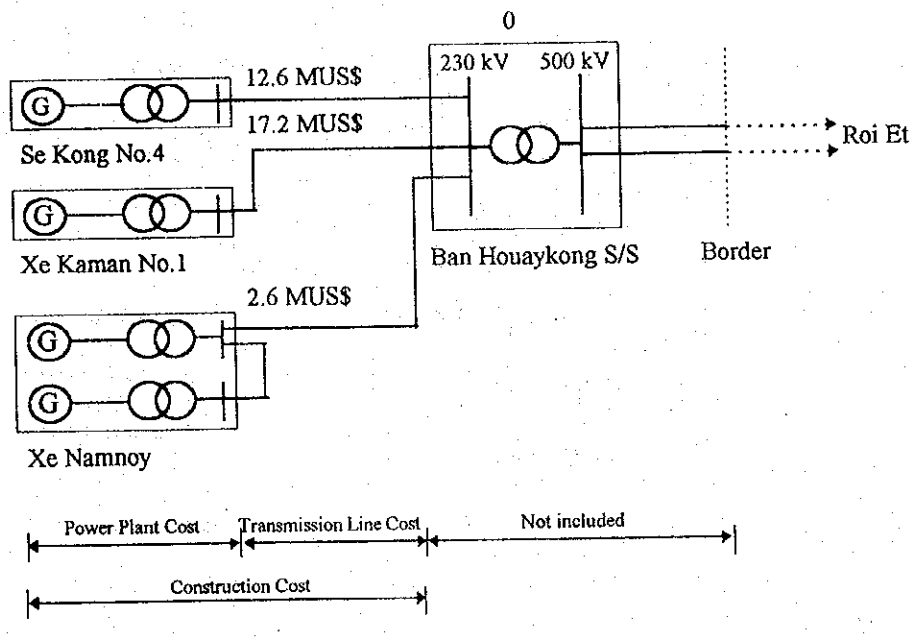
Case-2 includes 1 circuit of terminal equipment (CB, LS, and others) for the 2nd transmission line.

a) Base

230 kV transmission line will be applied from each power plant to the Ban Houaykong substation. 500 kV transmission line with two circuits will be required from the Ban Houaykong substation to the Thai border.

The construction cost of the each power plant included the 230 kV transmission lines from power plant to the substation. The construction cost of common 500 kV transmission line and 500 kV substation are not included in the construction cost of each power plant.

(Unit: MUS$ = Million US$)

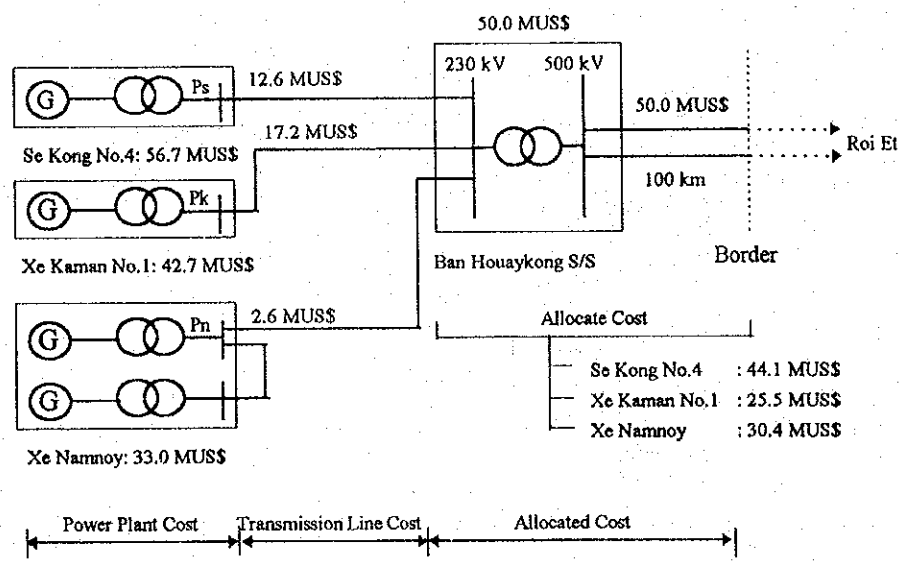


b) Case-1: Allocation Transmission Line

230 kV transmission lines will be applied from each power plant to the Ban Houaykong substation. 500 kV transmission line with two circuits will be applied from the Ban Houaykong substation to the Thai border. The construction cost of the each power plant is included the 230 kV transmission lines from power plant to the substation system.

The construction costs of the 500 kV transmission line and 500 kV substation are allocated by the installed capacity of each power plant.

(Unit: MUS$ = Million US$)



Total Transmission Line Cost = 230 kV Transmission Line Cost
+ 500 kV Transmission Line and Substation Cost x Capacity/Total Capacity

In case of Se Kong No.4

Total Transmission Line Cost = 230 kV Transmission Line Cost
+ 500 kV Transmission Line Cost x Ps/(Ps+Pk+Pn)
= 12.6 MUS$ + 44.1 MUS$
= 56.7 MUS$

In case of Se Kong No.1

Total Transmission Line Cost = 230 kV Transmission Line Cost
+ 500 kV Transmission Line Cost x Pk(Ps+Pk+Pn)
= 42.7 MUS$

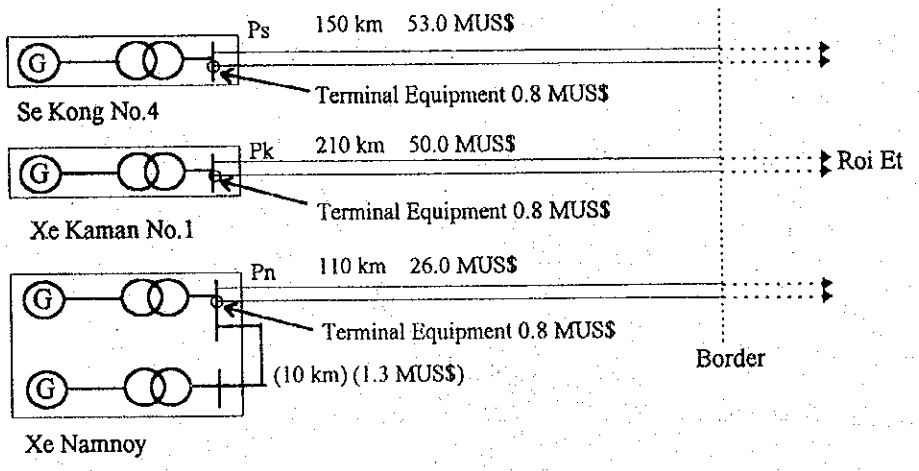
In case of Se Kong No.4

Total Transmission Line Cost = 230 kV Transmission Line Cost
+ 500 kV Transmission Line Cost x Pn/(Ps+Pk+Pn)
= 33.0 MUS$

c) Case-2: Independent Transmission Line

Independent 230 kV transmission line will be applied from each power plant to the Thai border. The construction cost of each project is included the transmission line and the cost of terminal equipment (CB, LS and others) for the transmission line.

(Unit: MUS$ = Million US$)



(4) Local Power Supply in Project Area

Domestic power supply for the project area is planned to be supplied directly from the power plant of each project as mentioned in 4.2, Chapter 4.

Fig. 12.2-1 Future Plan of Power System in Laos

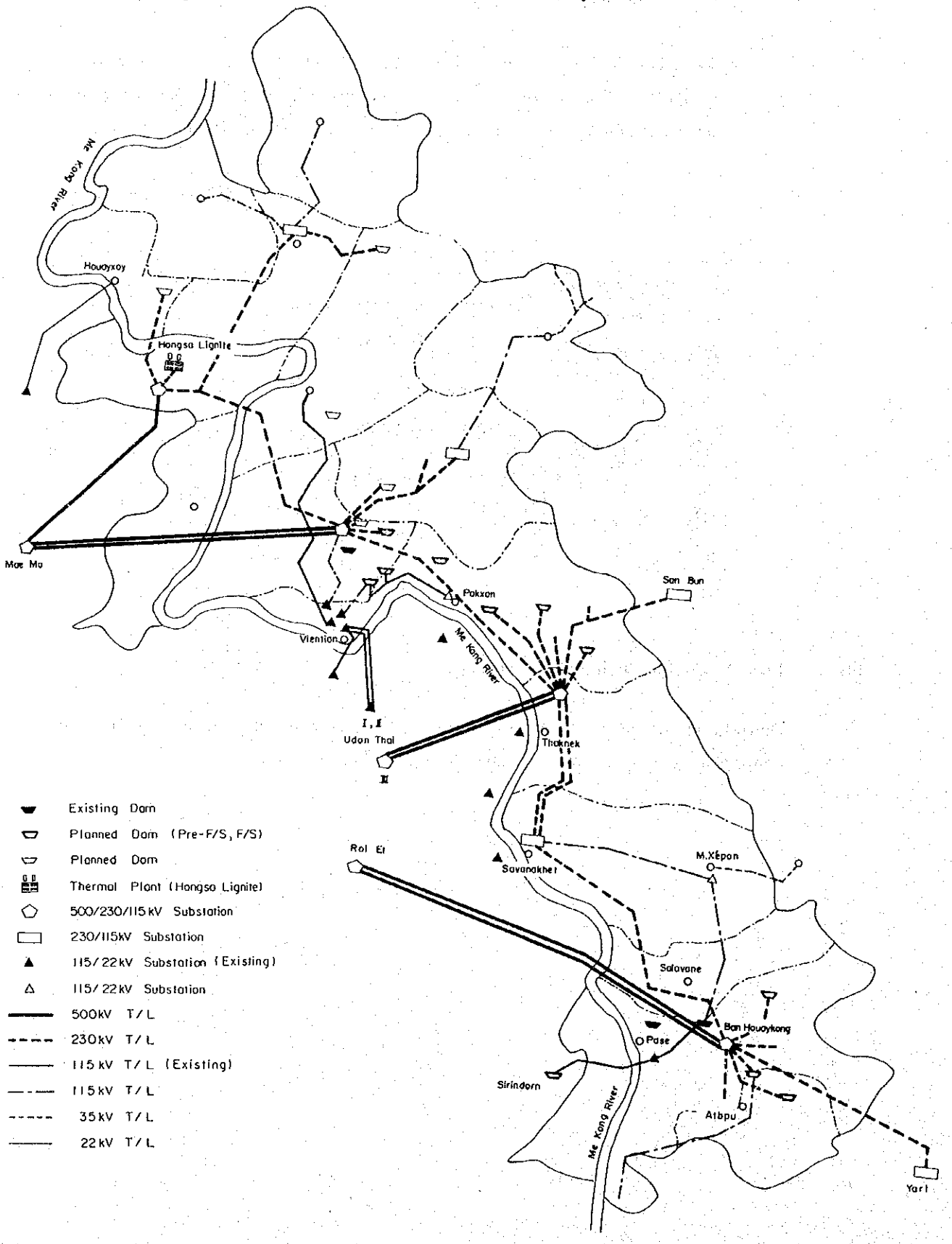


Fig. 12.2-2 Future Plan of Power System in the Se Kong Basin