7.6.4 RESETTLEMENT ACTION PLAN (RAP)

(1) Resettlement Objectives and Principles

The resettlement objectives of the NNHP RAP, as it is developed, will be in accordance with the *Draft National Resettlement Policy for Major Projects in the Lao PDR*, as developed through preparation of the Nam Theun 2 (NT2) resettlement policy. This policy has been reviewed by the World Bank and found in accordance with international best practice.

Accordingly, the main objectives of the NNHP RAP will ensure that (a) the population to be resettled materially improves its standard of living after resettlement and that (b) those compensated under the policy are compensated adequately.

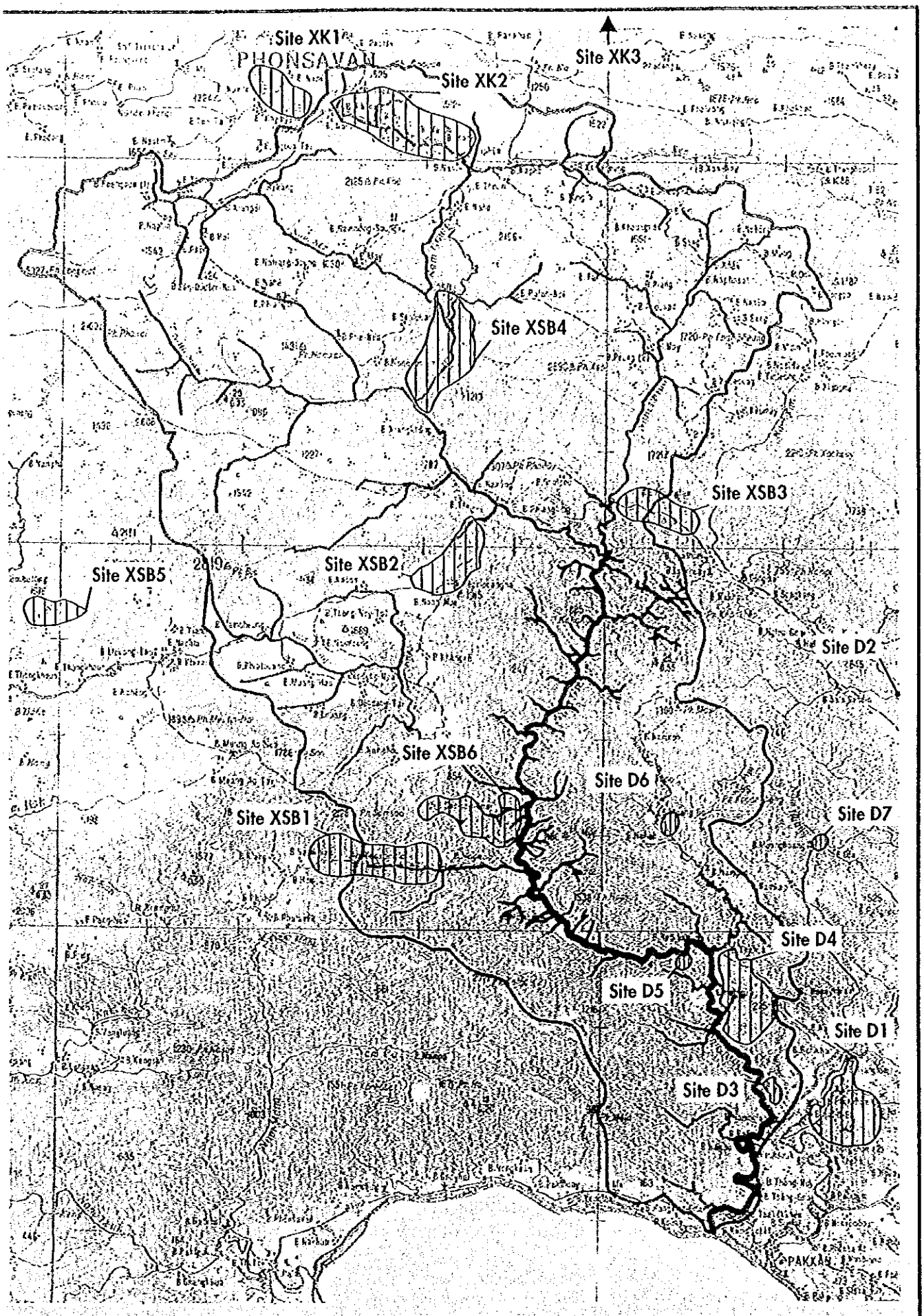
(2) Identification of Potential Resettlement Sites

The Study Team and the counterparts carried out a preliminary inventory of 16 potential resettlement sites from mid July to mid October 1999 as shown in Figure 7.6.6. Most of the sites were recommended through interviews with officials of Xieng Khouang and Bolikhamsay Provinces, of Borikhan District within Bolikhamsay Province, and of the Xaysomboon Special Zone. An assessment of the sites was also made through use of aerial photos (1:30,000 taken in 1998) for identifying land use at each site. The photo interpretation was backed up with topographic maps at a 1:100,000, 1:50,000 and 1:25,000 scale, depending on availability, to study the topographic conditions.

A prioritizing of resettlement areas was carried out, based on the cultural preference of rural Laotians for rice cultivation. Resettled households are assumed to need 1.0ha of paddy field and 0.5ha for housing, gardens and other facilities. This is about 15% higher for land holding than that currently prevailing in the Reservoir Area, at 0.83ha/hh for irrigated and rainfed paddy (0.18ha/hh for wet season irrigated paddy alone). The Study Team generally assumed that about 50% of relatively flat land classified as 'unstocked' forest would be suitable for paddy development. On October 2, 1999, a helicopter reconnaissance was also carried out for the proposed resettlement sites to the South of the proposed reservoir.

The preliminary inventory of potential Resettlement Sites for the NNHP has indicated that out of 16 sites proposed by Local Government officials, resettlement might be possible in 14 sites. Three (3) of the sites were judged to be most attractive: Sites D1 and D2 in the Bolikhan District, Bolikhamsay Province and XK3 in Kham District, Xieng Khouang Province as shown in Figure 7.6.6. Because they: have greater potential for paddy development; are located close to the administration center and near populated areas that could provide other earning opportunities; are within the FARD of either the concerned District or Province; and have been suggested by local authorities. Although all of the sites will be studied, these 3 sites alone, it is thought, could accommodate 3,250 households.

The Resettlement Site Inventory is a desk study, and its conclusions are preliminary and indicative. The scope of study for future investigations will include, *inter alia*, technical investigation of soil suitability and water availability for agricultural development, particularly of irrigation development; the prevailing socioeconomic, tenure and cultural conditions of the proposed sites; and other feasibility of additional livelihood packages at the sites.



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC JAPAN INTERNATIONAL COOPERATION AGENCY	PRELIMINARY RESETTLEMENT PLAN	Figure 7.6.6
	POTENTIAL RESETTLEMENT SITES	

(3) Income Restoration

Reassembling lost production systems is a complex and difficult task that requires specialists from a diverse set of backgrounds and, in order to work, will require the full participation of the resettlers themselves, not only in implementing the schemes but in planning them as well.

The NNPP will explore a range of livelihood options, each described in more detail in the main text of the PRP. The option of irrigated rice paddy appears to be one that most resettlers from the Reservoir Area are familiar with, given the amount, thanks to Government development programs, of irrigated land that already exists in the affected communities. Forestry management seems to be a concept that is also familiar, at least to those communities in the Lower Reservoir, though more needs to be known about this. Other livelihood options are floating net aquaculture, dairy and/or livestock cattle using grass on some 45km^2 of the reservoir draw-down area, fruit orchards, eco-tourism, and technical skills training. The project will explore using the services of NGOs specializing in rural development to assist in preparing these livelihood packages, through an extensive public consultation program to on the one hand understand villagers' desires and requirements and on the other to inform them about the proposed livelihood packages. This is so that the resettler's desires will be fully incorporated into the RAP at all levels.

(4) Rehabilitation of Indigenous and Vulnerable People

The Project will follow WB and ADB policies on indigenous peoples, which require in the cases of impacted vulnerable minorities, preparation of an Indigenous Peoples Development Plan (IPDP).[3] During the Reservoir Area census carried out as part of the final RAP preparation, identification of other vulnerable groups (elderly, poor, handicapped, etc.) will be made and plans put together accordingly to assist them in making a successful transition to the new Resettlement Sites.

(5) Institutional Organization

In response to the NT2, the largest and most complex development project involving significant resettlement with which GOL has had to deal, GOL has established a comprehensive resettlement organizational structure that may be expected to function as well for the NNHP.

This comprises a Resettlement Committee (RC), a Resettlement Management Unit (RMU), District Resettlement Working Groups (DRWG), and Village Resettlement Committees (VRC). Collectively, these organizations will be given the responsibility for implementing the NNHP's RAP. Other Implementing Organizations will include the Provincial Authorities, the Lao Women's Union (LWU), Village Organizations, the Ownership Company, and Consultants, Contractors and NGOs.

During the resettlement implementation, the RMU and district working groups will play important roles. In order to strengthen their institutional capacity, a training program will be needed for their resettlement staff to have a clear understanding of resettlement policy objectives, the detailed resettlement program, and resettlement entitlements. In addition, workshops and on-the-job training will introduce a wide range of new skills for implementing livelihood and

[3] Asian Development Bank. 1995 "Policy on Involuntary Resettlement," First Annual Report to the Board of Directors. Manila, Philippines. November. World Bank. 1991. OD 4.20: *Indigenous Peoples.* Washington, DC. September 17. In the case of the NT2, a 'culturally sensitive' RAP was judged acceptable, without the necessity to prepare a separate IPDP.

community development programs.

(6) Participation and Consultation

To obtain WB or other international donor funding requires that high social, environmental and economic standards be met in Project design and implementation. One such requirement is that the Project development process should involve the stakeholders – those people and institutions who have an interest in the Project, who will be directly or indirectly affected by it – and that their involvement should be integrated into the decision-making for the Project.[4]

At the RAP preparation phase, the Study Team has carried out environmental and social studies prior to a decision on the project design, so that these factors are incorporated at the earliest possible stage into the project design itself. As part of the feasibility process for the Project, public consultations in the Project Area will be conducted separately during the Scoping, carrying out of EIA and SIA Studies, and Finalization of the EIA and SIA Reports. The Study Team will engage an NGO or subcontract to a local consultant to design and facilitate the implementation of the Public Consultation Process.

To ensure the basic rights and interests of resettlers are protected, concerns are adequately addressed and entitlements delivered, a Grievance and Appeals Procedure will be designed for the Project during preparation of the RAP. At present, an established procedure has been developed by the NT2 and will be the starting point for the NNPP, as described in detail in the main text of the PRP.

Monitoring will be carried out to ensure that the resettlement implementation is successful and that the villagers materially improve their livelihood after resettlement. Monitoring will be both internal and external. Internal monitoring will focus on the physical progress of resettlement implementation against the schedule in the approved RAP. Independent external monitoring will be on the change of livelihood and standard of living among the relocated people.

(7) Budget and Inundation Costs

Actual costs will be determined in the RAP preparation phase, based on a more comprehensive inventory of inundated assets. The current estimate is for FSL.320m dam RAP to cost just over US$5 million and FSL.360m dam RAP to cost in the vicinity of US$ 18 million including 15% of contingency. This compares well with international standards for resettlement budgeting, at about $3,600 per person,[5] or about ten times the per capita GDP of about US$350.[6] Including 30% added for population growth over ten years, these estimated total RAP figures will be around US$7 and US$23 million respectively as shown in Table 7.6.4.

[4] Franklin. Barbara A.K. 1997. *A Review of Local Public Consultations for the Nam Theun 2 Hydroelectric Project.* Vientiane, Lao PDR. September 30. pp. 2-3.

[5] This is comparable with the approximately $3,352 per capita quoted for NT2. The NT2 RAP has not added 30% to the RAP budget to account for natural population growth and in-migration, and the NT2 reservoir area is not a FARD and has not received the in-migration that the NNHP Reservoir Area has already received.

[6] The World Bank's 1994 review of resettlement worldwide noted that there is a close correlation between investment levels and project capabilities for dealing successfully with resettlement. None of the projects with a ratio of per capita resettlement costs to per capita national GDP of 3.5 or higher has reported major resettlement difficulties. In contrast, virtually all of the projects with a ratio lower than 2.0 are experiencing serious implementation difficulties. "Throwing money at resettlement will not solve all resettlement problems, but starving resettlement of resources is clearly the first step towards resettlement failure." World Bank 1994. *Resettlement and Development: The Bankwide Review of Projects Involving Involuntary Resettlement, 1986-1993.* Washington, DC. April 8. p. 5/19 – 5/20.

Table 7.6.4 Preliminary Summary of Resettlement Costs

No.	Items	Unit	Unit Costs	FSL.360m		FSL.320m		Source
				Q'ty	Amount	Q'ty	Amount	
A	RESETTLEMENT							
1.	Houses	House	$2,120	853	$1,808,360	260	$551,200	HDP
2.	Infrastructure	HH	$1,300	853	$1,108,900	260	$338,000	PSPS
3.	Resettlement Costs (moving)	HH	$200	853	$170,600	260	$52,000	NT2 ALT
4.	Miscellaneous	HH	$130	853	$110,890	260	$33,800	-
	Sub-Total				$3,198,750		$975,000	
B	LIVELIHOOD COMPONENT							
1.	Lowland Paddy Irrigation Development (1.0ha/HH)	ha	$5,000	853	$4,265,000	260	$1,300,000	Pan Piao
2.	Upland Rice Field (0.5ha/HH)	ha	$1,000	427	$427,000	130	$130,000	-
3.	Garden (0.15ha/HH)	ha	$1,000	128	$128,000	40	$40,000	-
4.	Forestry Management Program	HH	$625	853	$533,125	260	$162,500	NT2 RAP
5.	Livestock Improvement Program	HH	$625	853	$533,125	260	$16,2500	NT2 RAP
6.	Reservoir Develop.(Transport/Fishing)	HH	$625	853	$533,125	260	$162,500	NT2 RAP
7.	Agro Industry and Handicrafts Center	HH	$625	853	$533,125	260	$162,500	NT2 RAP
8.	Miscellaneous	HH	$150	853	$127,950	260	$39,000	-
	Sub-Total				$7,080,450		$2,159,000	
C	COMMUNITY DEVELOP.& MANAGE.							
1.	Skills Training	HH	$200	853	$170,600	260	$52,000	NT2 RAP
2.	Technical Support	HH	$200	853	$170,600	260	$52,000	NT2 RAP
3.	Community Development	HH	$225	853	$191,925	260	$58,500	NT2 RAP
4.	Income Support Program	HH	$720	853	$614,160	260	$187,200	NT2 RAP
5.	Resettlement Manage. Unit for 8 Years	HH	$4,065	853	$3,467,445	260	$1,056,900	NT2 RAP
6.	Health Program	HH	$477	853	$406,881	260	$124,020	NT2 RAP
7.	Miscellaneous	HH	$360	853	$307,080	260	$93,600	-
	Sub-Total				$5,328,691		$1,624,220	
I	Total (A+B+C)				$15,607,891		$4,758,220	
II	Contingencies (15% of I)				$2,341,184		$713,733	
III	TOTAL (I+II)				$17,949,075		$5,471,953	
IV	Possible Population Growth (30% of III)				$5,384,722		$1,641,586	
V	TOTAL (III+IV)				$23,333,797		$7,113,539	

(8) Environmental Impacts and Restoration

In addition to a Population Carrying Capacity Survey of the identified Resettlement Sites, the Project will carry out EIA studies of the sites. The EIA will identify the beneficial and adverse impacts arising from the Project's resettlement activities, in terms of both the natural and human environment, and will propose mitigative measures to minimize adverse impacts while maximizing the beneficial impacts. An important aspect of the EIA in northern Laos will also be a reconnaissance survey of UXO and defoliants contamination at the Resettlement *Sites*.

7.6.5 NAM NGUM WATERSHED MANAGEMENT PLANNING

(1) General

An ADB financed Watershed Management Planning Study has recently been completed for the neighboring Nam Ngum Watershed. It has developed a strategy that would improve the lives of the population from the existing Nam Ngum 1 HEPP and simultaneously protect the watershed

for it the other hydropower projects being planned for the watershed, primarily the Nam Ngum 3 & 4 HEPP. While so far only the relatively small Nam Pot HEPP is planned for the Nam Ngiep watershed, very little work has been done to develop it.

Nevertheless, the Watershed Management Plan for the Nam Ngum is a model that may be applied to the Nam Ngiep HEPP as well.

In summary, the Nam Ngum Watershed Management Strategy is to promote the following issues:

(i) Multipurpose development to exploit Lao PDR's comparative advantages in natural resources with emphasis on increasing resource mean and marginal values,

(ii) Protection and conservation of natural resources and bio-diversity through improved spatial zoning, remedial measures (afforestation and erosion control) and strengthening community management systems,

(iii) Rural Poverty Alleviation to enhance life quality indicators and create a favorable socioeconomic environment conducive to sustainable natural resource management benefiting all major NNWS stakeholders, and

(iv) Strengthening and establishing key institutions at particularly the provincial, district and village levels to enhance GOL service delivery and driven watershed management systems.

(2) Nam Ngum Watershed Management Strategy

The Strategic targets are to carry out the following issues:

(i) Upgrade rural living standards by developing diversified, sedentary agricultural systems in upland and flat land areas that increase overall agricultural production, creating a range of income generating opportunities that significantly improve socioeconomic conditions of families and villages:

- Integrate the populated areas of watershed by rehabilitating feeder roads and trails to link presently isolated villages to intra and inter-regional and input factor and product markets; Link villages with villages and villages with local markets,
- Set up agriculture, agro-forestry, fisheries/livestock demonstration centers and village sites,
- Improve agricultural water use efficiency for subsistence and diversified cash cropping by expanding the watershed irrigated agricultural base,
- Progressively introduce promising, permanent, sustainable and diversified production systems that gradually replace shifting systems of upland rice cultivation and low productivity flat land agricultural systems through widespread trials and demonstrations. This is to offer farmers a field tested menu of technology choices in livestock, aquaculture, highland crops and other products of marketable value; the range will include sources of incomes for families derived from agricultural, industrial and horticultural crops, forestry and livestock/fisheries activities, depending on local agro-ecological landscape conditions,

- Providing agricultural investment cash credit facilities through the provincial agricultural promotion banks for intermediate to long term investments and through in kind credit facilities to support rice and cattle banks at the village level, and
- Accelerated and replicate the issuance of land allocation documents to enhance tenure security and create incentives for technology investment.

(ii) Preserve and accelerate the forest regeneration and bio-diversity conservation and improve land use regimes.

- Spatial zoning to conserve existing large forest fragments in the unpopulated areas of the watershed,
- Watershed classification zoning in populated areas of the watershed for improved land management according to erodability: zones for forest protection and conservation under local village management; a zone for upland agriculture and sloping agricultural land technology (SALT) interventions; and other zones for irrigated crop diversification,
- Afforestation of high erosion areas,
- Soil conservation measures such as contour bunding, contour planting, drop structures and other treatments,
- Establish tree nurseries; Surveillance and monitoring of forest protection and conservation areas,
- Improvement of social and economic infrastructure and services,
- Extend schools and dispensaries to all villages in the watershed,
- Establish maternal-child health delivery systems,
- Implement birth spacing programs,
- Non-formal education,
- Install potable water systems in all villages, and
- Set up and support feeder road maintenance.

(iii) Institutional strengthening and development of key watershed management local agencies. Upgrade and strengthen the Deputy Governors' offices as the focal point of provincial level watershed management activities:

- Train, equip, provide logistical support and offer incentives to PAFS and DAFO. The former is to become Subject Matter Specialists; the latter will be Farming Systems Extension Workers. Their role is to provide problem solving extension and conduct technology trials and demonstrations,
- Train, equip, provide logistical support and offer incentives to provincial Land Use Planning and Allocation Committees (LUPACs). LUPACs will be trained and equipped to conduct participatory land use planning and allocation in all watershed villages. Land allocation will be recorded by GPS readers, and GIS systems will capture land holdings and land use and village desires for future land use and allocation. Land allocations will be incorporated into a basin-wide registry system and land use right documents will be issued to holders,

- Train, equip, provide logistical support and offer incentives to Provincial Planning Committees (PPCs). PPC to be trained in watershed management and bio-physical regional planning systems; (a) establish, train and equip a new Nam Ngiep Watershed Management Authority (WMA). WMA will manage and coordinate all program planning, implementation, monitoring and evaluation and coordinate hydraulic management at the watershed level; (b) train Provincial Agricultural Promotion Bank and Village Administrative Committees in cattle and rice bank and general rural credit administration.

(iv) Provide financial assistance to the poorest segment of the watershed population (those households practicing exclusive shifting cultivation) by hiring household members to perform essential conservation and environmental management services at the village level;

- Hiring villagers as fire wardens to monitor and control dry season burnings,
- Hiring villagers for UXO training and supervised clearance of contaminated areas, common in Lao PDR. At UXO Lao's new training center Naysaythong District, Vientiane Municipality, a 9-week course conducted by US and Lao instructors. Trainees return to provinces having completed courses for de-mining technicians, medics, community awareness specialists, UXO team leaders, and instructors, and
- Hiring villagers for tree planting for badly eroded areas. The proposed watershed management strategy also includes resettlement of villagers from the proposed hydropower projects. By international guidelines, this should be fully internalized in project costs and would not be considered as part of an externally funded watershed management program for the Nam Ngiep.

(3) Local Development Fund and Regional Development Action Plan

Funding for the 40-year Nam Ngum Watershed Management Project would come from 1-2% of hydropower royalties. The legal basis would be Article 24 of the Water and Water Resources Law, which stipulates that benefits of resource use flow back to residents of the areas from which resources have been tapped. Development bank loan financing and donor agency grants would cover the high priority front-end program needs until the Nam Ngum Watershed Management Fund was activated.

From Chinese experience with local development funds, 1-2% of hydropower royalties may not be necessary to generate considerable finances to benefit the local region. However, this will need to be a matter of review for the second phase feasibility study and for the detailed design of the project. It is certain that multilateral or bilateral funding will be required to assist in setting up such a management plan and watershed or local development fund for the NNHP, as it would for most hydropower projects.

7.6.6 CONCLUSIONS

The following conclusions may be drawn from the preliminary resettlement plan:

(i) Possible Involuntary Resettlement

According to the socioeconomic surveys of the Project area conducted December 1998 through March 1999, overall, including both Upstream and Downstream areas of the proposed dam site, nearly 2,000 households and 12,000 persons may be affected to one degree or another by the Project. About 660 households and 5,000 persons in 14 villages are in the Upper Reservoir and another 200 households and 1,200 persons in 4 villages the Lower Reservoir could potentially be affected by involuntary resettlement. For Downstream area about 1,300 households and 6,800 people in 15 villages would be affected through changes in the Nam Ngiep River flow and water.

(ii) FSL.360m Alternative

While not all villages within the proposed reservoir area would be submerged even by FSL.360m, their rice lands are all situated along the Nam Ngiep River and its territories at low levels. So it can be assumed that virtually all the villages would require resettlement, if FSL.360m is chosen for implementation. Generally speaking, mitigation includes minimizing resettlement to the extent possible, carrying out an international standard of resettlement planning and implementation if unavoidable, and fair compensation for the displaced population.

(iii) FSL.320m Alternative

The recommended design mitigation at this time is to consider the medium-scale dam alternative. The initial thinking was that lowering the FSL to EL 320m would reduce the number of affected villages down to 5 villages. There is not enough information at this time, however, to determine what the amount of backwater effect would be, i.e., how much higher the water at the back of the reservoir will be than at the front end. Two (2) meters would be assumed, including a safety margin. Therefore, consideration of the backwater effect indicates that EL.318m might be necessary to protect the majority of irrigated paddy land belonging to the Upper Reservoir villages, nearly 300ha of the total reservoir paddy land. This FSL.318m dam would more surely reduce the affected population down to 260 households and about 1,600 people.

(iv) Preparation of Full Resettlement Action Plan

The Preliminary Resettlement Plan (PRP) is prepared without the final design of the Project having been decided. Once the alternative is selected, a full Environmental Impact Assessment (EIA) and Social Impact Assessment (SIA) will be required by internationally accepted guidelines, as well as preparation of a full Resettlement Action Plan (RAP) and a Social Action Plan (SAP) for mitigating other social impacts. During preparation of a draft RAP, the following studies will take place:

- Socio-Cultural Assessment of Resettlement and Host Communities (Part of SIA),
- Preparation of a Public Consultation Framework,
- Capacity Assessment of Resettlement Sites,
- Backwater and Sedimentation Modeling,
- Archeological Review and Field Survey, and
- Technical Resources explored and detailed TOR for development of Livelihood Packages prepared

(v) Further Final RAP

Upon completion of the draft RAP, the F/S should also come to an end, and the Project preparation including a detailed design and a final RAP, should coincide with the process of securing finance and international guarantees for the Project.

8. PRELIMINARY DESIGN

8.1 GENERAL

As the results of the alternative studies, two (2) dam-scales of FSL.320m and FSL.360m were selected respectively as the medium-scheme and the large-scheme alternative. Hereinafter the concept of the preliminary design of these two (2) development scales for the Nam Ngiep-1 Hydroelectric Power Project is explained. The major final salient features of promising scheme at this stage are shown in Table 8.1.1:

Table 8.1.1 Final Salient Features of Promising Scheme

Place	Particular	Unit	FSL.320m	FSL.360m
Reservoir	Catchment area at dam site	km^2	3,700	3,700
	Annual basin rainfall	mm	2,470	2,470
	Annual mean runoff	m^3/s	162.3	162.3
	Annual mean runoff	mill. m^3	5,118	5,118
	Average run-off coefficient	-	0.56	0.56
	Probable max. flood, PMF	m^3/s	15,900	15,900
	Mean annual sediment flow	$t/km^2/yr$	413.4	413.4
	Reservoir area at FSL	km^2	73.9	148.2
	Gross reservoir capacity	10^6m^3	2,279	6,782
	Min. operation level (MOL)	EL.m	280	335
	Draw-down	m	40	25
	Effective storage volume	10^6m^3	1,779	3,092
Main Dam	Dam type	-	CFRD	CFRD
	Dam height	m	157	197
	Dam crest length	m	524	662
	Dam volume	10^6m^3	6.9	12.7
	Dam crest level	EL.m	325	365
Spillway	Spillway crest level	EL.m	306.5	346.5
	Design flood capacity	m^3/s	8,730 (Q=10,000yr)	8,730 (Q=10,000yr)
Waterway	Intake sill level	EL.m	247	312
	Design discharge	m^3/s	221	224
	Headrace tunnel diameter	m	9.0	9.0
	Headrace tunnel length	m	420	490
Power Plant	Powerhouse type	-	Surface type	Surface type
	Size of powerhouse	m	58(L) 31(W) 58(H)	81(L) 29(W) 52(H)
	Design flood discharge	m^3/s	4,519 (Q=100yr)	4,519 (Q=100yr)
	Rated head	m	131.8	176.8
	Type of turbine	-	Vertical Francis	Vertical Francis
	Number of unit	No.	2	4
	Plant capacity	MW	240	360
	Annual energy	GWh	1,349	1,905
Re-regulation Facility	Max. pond level	EL.m	173	173
	Required storage capacity	mill. m^3	4.7	4.7
	Design flood discharge	m^3/s	4,519 (Q=100yr)	4,519 (Q=100yr)

8.2 OVERALL PROJECT LAYOUT

8.2.1 GENERAL LAYOUT

The main dam and its appurtenant structures, such as river diversion facilities (including bottom outlet facilities), spillway, power waterway, power station and re-regulation facilities were preliminary located on the topographic map of 1:2,000, which was enlarged from the original map of 1:25,000.

Its ground plan is as shown in Figure 8.2.1 and Figure 8.2.2 for the two (2) selected scales: FSL.320m and FSL.360m alternatives.

8.2.2 TEMPORARY FACILITIES

Major temporary facilities for construction will be located downstream of the main dam site. There are several conceivable sites between the main dam site and re-regulation weir site where rather flatter river shores are developed along the left bank, 1 to 2 km downstream and 4 km downstream of the dam site as shown in Figure 8.2.3.

At these sites, contractor's offices and residential quarters and other temporary buildings (warehouse, motor pool, repair shop, etc.) are to be located.

Two (2) concrete batching plants will be located at the powerhouse site and spillway fore-bay area. Two prospective quarries: Quarry (i) and Quarry (ii) and spillway site: Quarry (iii) will be developed as main rock quarry.

Because of the steep dam abutments, available areas for stockpile and spoil bank are very scarce at the upstream area of the dam site. Therefore, some of the spoil bank may have to be located at the downstream area with a proper foundation drainage system and slope protection.

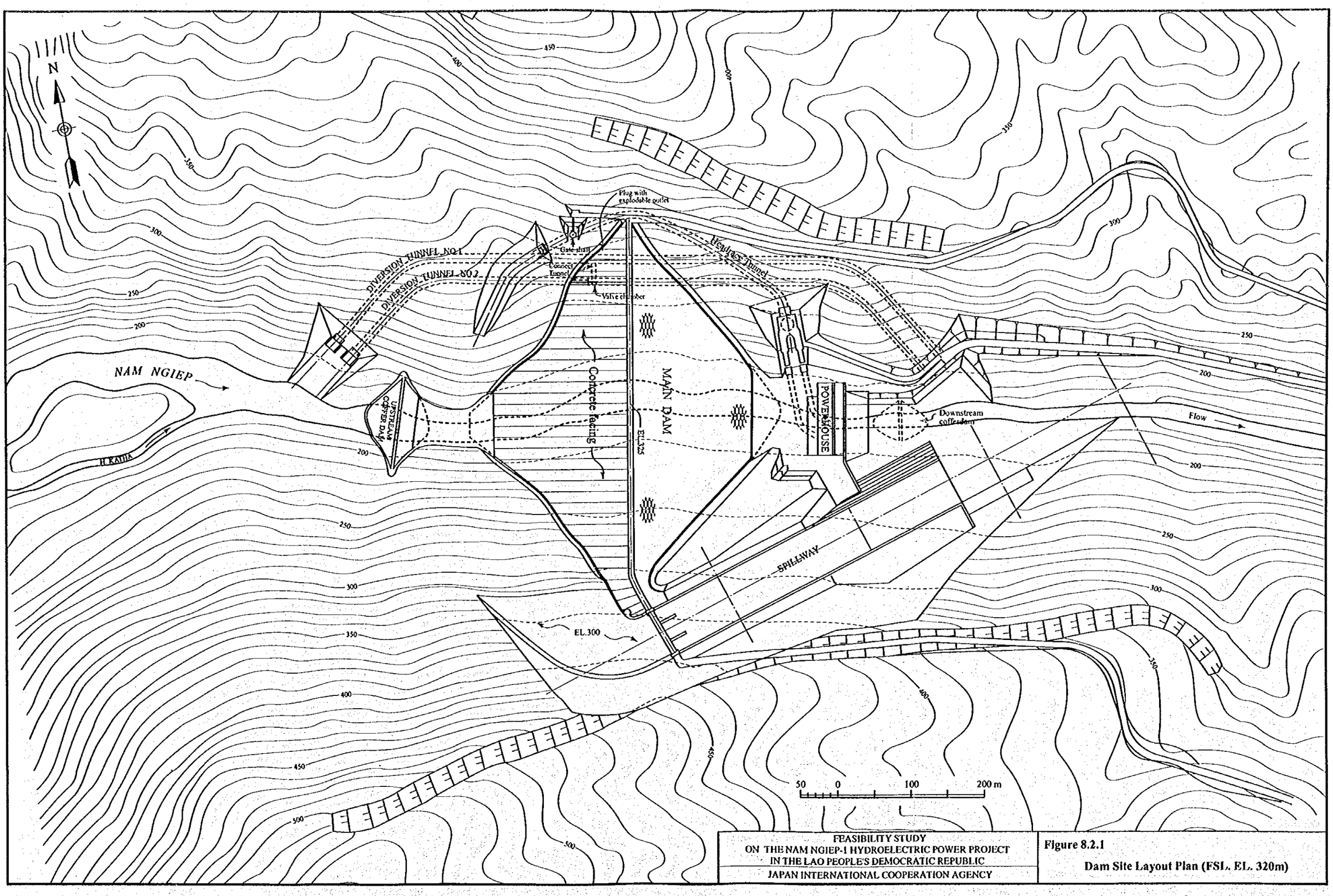
A preliminary layout of the temporary facilities at the dam site is shown in Figure 8.2.3.

The main project office may be located at Pakxan to mediate the administrative communication between the dam site and Vientiane probably with a computer on-line system.

8.2.3 CONSTRUCTION ACCESS ROAD

The dam site is located in Bolikhamxay Province, but far from Pakxan, the capital of the Province, about 50km via. National Route-4 and passes through a non-paved provincial road.

Existing road conditions between Pakxan and dam site are as shown below:



FEASIBILITY STUDY
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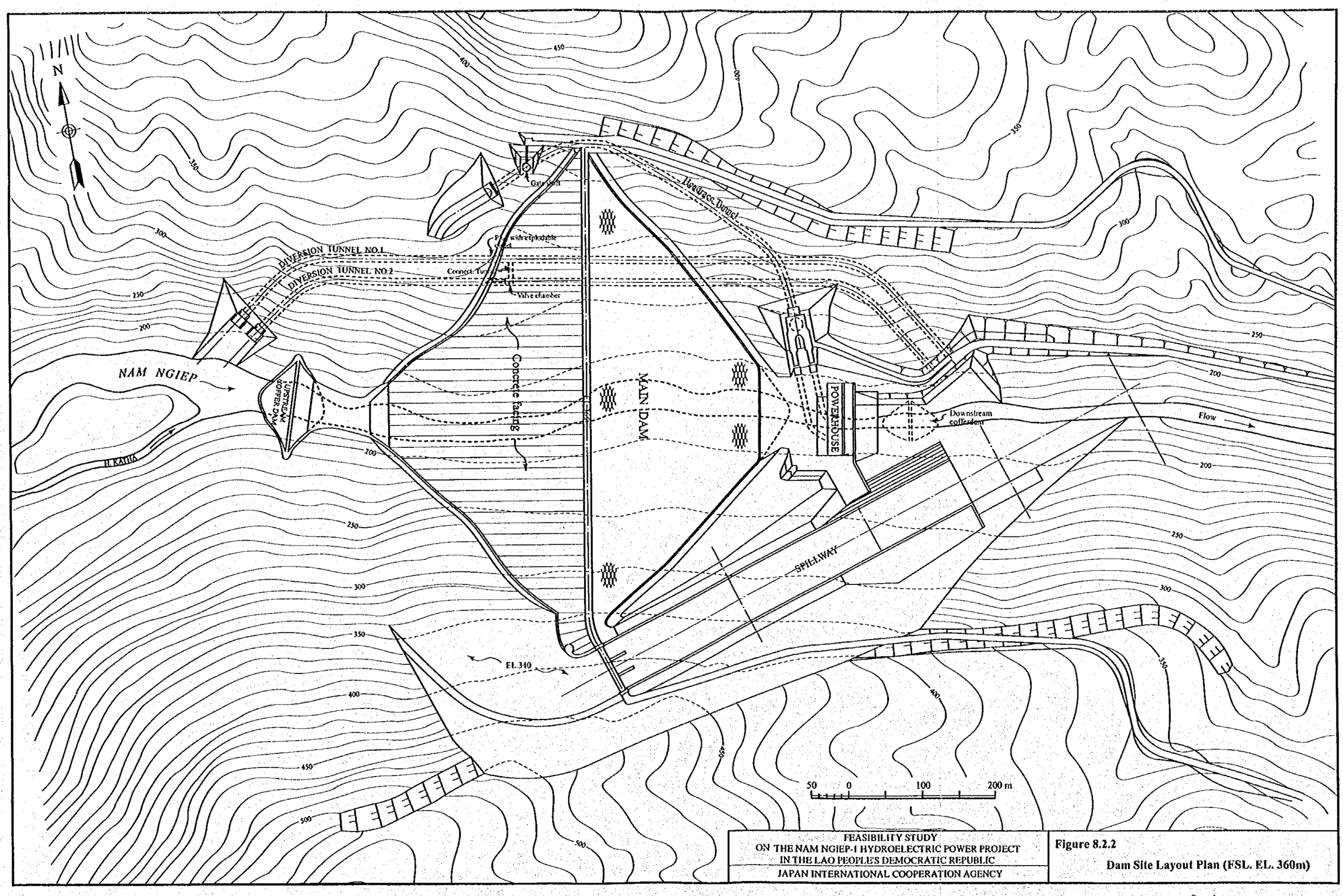
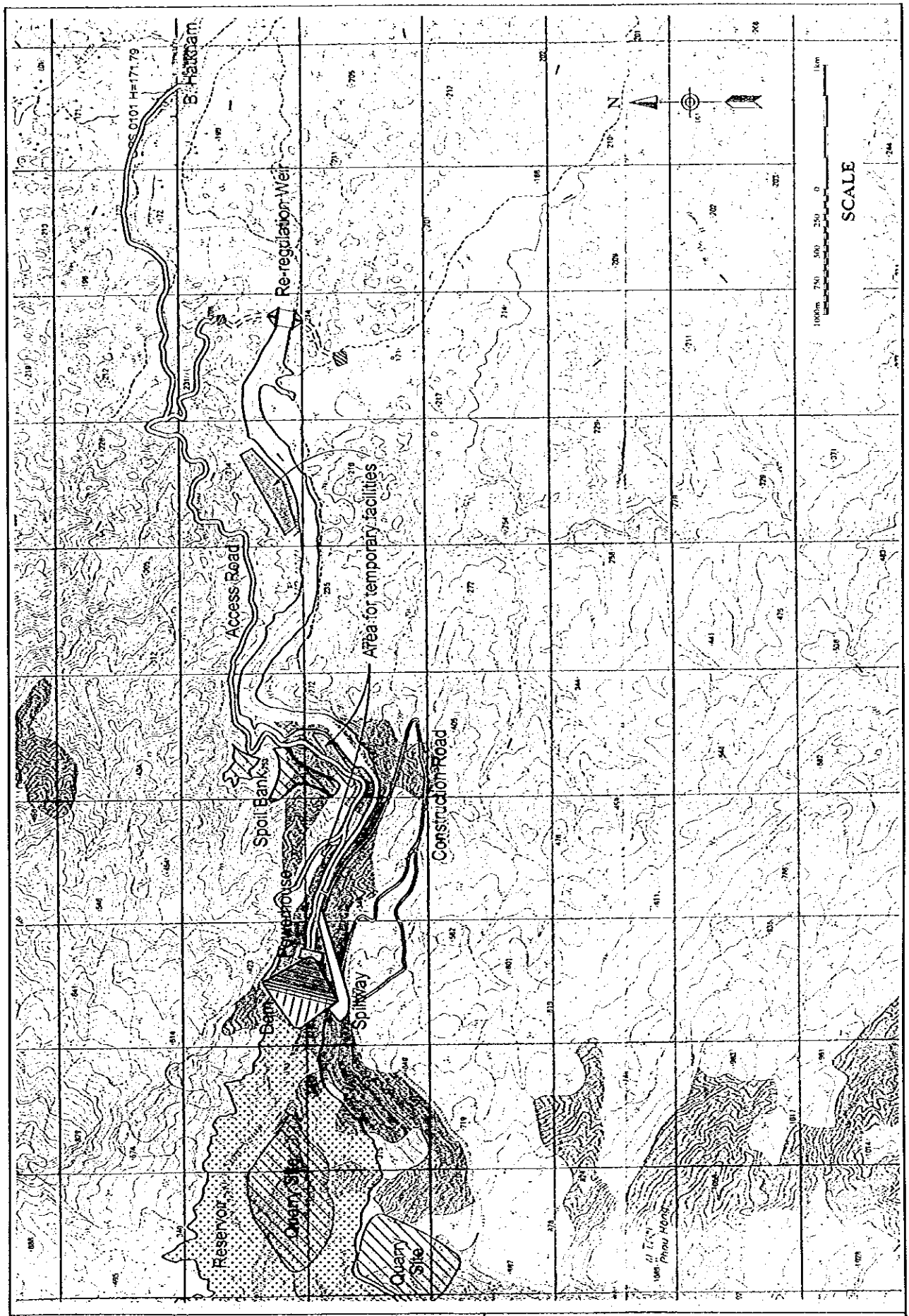
Figure 8.2.1
Dam Site Layout Plan (FSL. EL. 320m)



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 8.2.2** **Dam Site Layout Plan (FSL. EL. 360m)**



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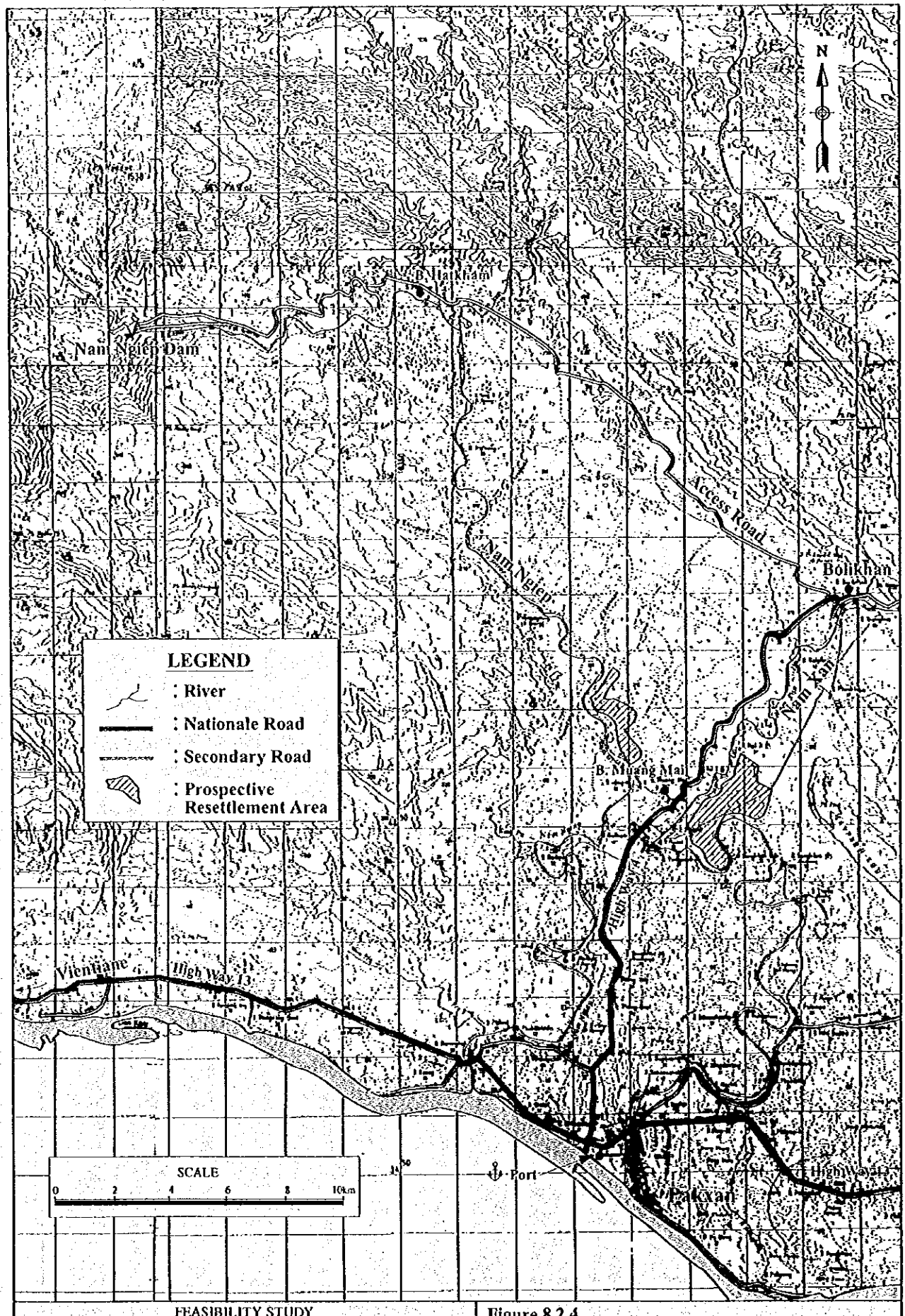
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 8.2.3

Temporary Facilities and Access Road



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 8.2.4** **Rout of Access Road to Dam Site**

Table 8.2.1 Existing Road Conditions between Pakxan and Dam Site

No.	Existing Road	Road Condition
1	Beginning 3km section from Pakxan (Route No.4)	6.0m wide asphalt paved road
2	Remaining 20km to Borikhan (Route No.4)	6.0m wide laterite paved road
3	20km between Borikhan and B, Thahua (Prov. Road)	3.5m wide non-paved road
4	10km between B. Thahua and B. Hatkham (Prov. Road)	1.5-2.0m wide non-paved road

Minor improvement of the road surface between Pakxan and Borikhan, and widening and paving between Borikhan and B.Hatkham will be required.

A new road is required for a 10km long stretch from B.Hatkham to the dam site, which has to be constructed along the left bank of the Nam Ngiep River. Half of the route from B.Hatkham will pass through hilly land and the other half has to pass the steep slopes of a mountainous area to climb up to the crest of the main dam.

On the existing road between B.Thahua and B.Hatkham, two (2) bridges will be required to to constructed, one for crossing the Nan Xao River and another one for small gully near B. Hatkham.

The route of the access road to the dam site is as shown in Figure 8.2.4 from Pakxan to the dam site, and detail of the access road near the dam site is shown in Figure 8.2.3 in which construction roads around the dam site are also shown.

8.3 PRELIMINARY DESIGN OF MAJOR STRUCTURES

8.3.1 DESIGN FLOOD DISCHARGES

In the Pre-F/S Study, flood discharge characteristics were analyzed for the locations: Muangmai, B. Hatkham and the dam site of which flood discharges are shown in the table below:

Table 8.3.1 Flood Discharge at Dam Site

Flood	10 Year	20 Year	25 Year	50 Year	100 Year	1,000 Year	10,000 Year	PMF
m^3/s	2,704	3,230	3,385	3,956	4,519	6,530	8,730	15,900

The probable flood inflows just the same as the above will be adopted in this preliminary design.

PMF will be used for the determination of the dam crest level, a 10,000-year flood discharge for spillway sizing and a 25-year flood discharge ($3,385m^3/s$) for the design of river diversion facilities.

8.3.2 RESERVOIR OPERATION LEVELS

The optimum MOL of the reservoir is selected to be the level that the prospective total energy

becomes the maximum for the period of the analyzed 30 years. The result of the reservoir routing, MOL was preliminary selected as follows:

Table 8.3.2 Reservoir Water Levels for each Alternative

No.	Items	Medium-Scale	Large-Scale
1.	FSL	EL.320m	EL.360m
2.	MOL	EL.280m	EL.335m
3.	Draw-Down	40m	25m

Note: Although the present MOLs were tentatively determined to maximize GWh, it should be reviewed in the next stage F/S to give an essential MOL, which maximizes benefit of the Project.

8.3.3 MAIN DAM

(1) Dam Design

(i) Type of Dam

As described in an authoritative report on rockfill dams with concrete facing[1], the concrete faced rockfill dam (CFRD) is now generally accepted and it is being considered as an alternative at most sites with rock foundation. It generally competes with the earth core rockfill dam (ECRD), the common alternative type considered, in cost and schedule, as well as with the concrete arch dam. Since the CFRD relies mainly on gravity for stability and, as recently built CFRDs prove, it does not require high strength rock abutments.

On the other hand, according to the seismic refraction survey carried out for the dam site at Pre-F/S stage, it was revealed that the site is covered by about 10m thick highly decomposed overburden of the seismic velocities some 500m/s-700m/s. The substratum (intermediate zone) is slightly weathered with seismic velocities ranging 1,500m/s-2,400m/s, which is developed in the thickness from 10m at the river course to 15m-25m and exceptionally 40m on the river banks.

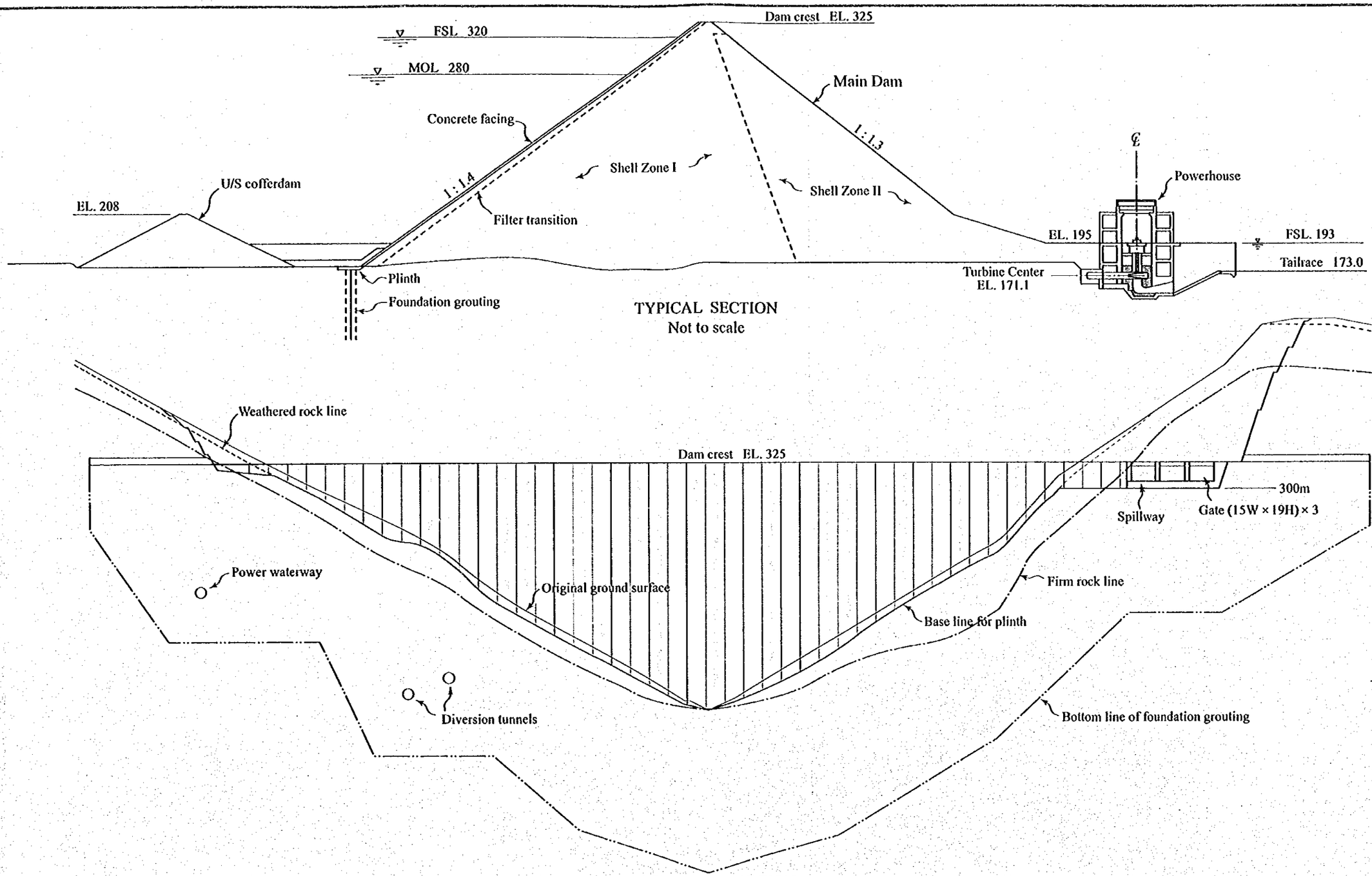
A rockfill dam could be founded on the above intermediate zone, while any large concrete structure must, therefore, be founded beyond the intermediate zone, thus a concrete dam will be accompanied with considerable excavation and concrete works.

Among fill type dams, an earth fill dam or a center-core type rockfill dam, which require a lot of soil for embankment, is not economical, because sufficient soil material seems not available nearby dam site.

Based on the above circumstance, the type of dam for the Nam Ngiep-1 HEPP was determined to be the concrete faced rockfill dam (CFRD).

Both the typical dam section and the profile along the dam axis for the medium-scale dam scheme are shown in Figure 8.3.1.

[1] "Rockfill Dams With Concrete Facing, State of the Arts." published under the Committee on Materials for Fill Dams



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLES DEMOCRATIC REPUBLIC JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 8.3.1** **Typical Dam Section and Profile along Dam Axis (FSL. EL. 320m)**

(ii) Dam Axis

To place a 190m-high class CFRD on the narrow dam site, an adequate dam axis was carefully studied and determined, taking into consideration site topographic condition and geological condition.

(iii) Dam Slopes

It is known that the embankment of CFRD has a factor of safety against sliding of approximately 7 under reservoir load under the drained condition[2]. Therefore, no stability analysis is required, unless unfavorably oriented clay joints are present in the foundations.

The face slopes of the worldwide CFRDs recently constructed range between 1.3 to 1.4 for the upstream slope and 1.3 to 1.5 for the downstream slope as shown below:

Table-8.3.3 Partial List of CFRD H>100M Under-Construction/Completed After 1980

No.	Name	Country	Height	Year	U/S Slope	D/S Slope	Fill -Rock Type
1.	Areia	Brazil	160	1980	1.4	1.4	CR-Basalt
2.	N-Turimiquire	Venezuela	115	1981	1.4	1.5	CR-Limestone
3.	Yacambu	Venezuela	150	1982	1.5	1.5	CG-Gravels
4.	Khao Leam	Thailand	130	1884	1.4	1.4	CR-Limestone
5.	Shiroro	Nigeria	130	1984	1.3	1.3	CR-(?)
6.	Salvajina	Colombia	148	1985	1.5	1.3-1.4	CG-Dredger Tailings
7.	Reece	Australia	122	1986	1.3	1.3-1.5	CR-Diorite
8.	Cirata	Indonrsia	125	1987	1.3	1.4	CR-Breccia-Andesite
9.	Alder	USA	100	1990	1.4	1.4-1.6	CR-Granite-Volcanics
10.	Segredo	Brazil	145	1991	1.3	1.2 & 1.4	CR-Basalt
11.	Xingo	Brazil	140	1992	1.4	1.3	CR-Granite-Gneiss
12.	Machadinho	Brazil	124	1993	1.3	1.3	CR-Basalt
13.	Ita	Brazil	123	U/C	1.3	1.3	CR-Basalt
14.	La Miel	Colombia	180	U/C	1.5	1.5	CR-Diorite
15.	Tianshengqiao	China	180	U/C	1.4	1.4	CR-Limestone

Note; U/C: Under construction, CR: Compacted rockfill, CG: Compacted gravel fill
Source; International Water Power & Dam Construction, 1997 Year Book

The Nam Ngiep dam will be provisionally determined to be 1:1.4 for the upstream slope and 1:1.3 for the downstream slope.

(iv) Toe Slab (Plinth)

Construction of the plinth will create a watertight seal between the face slab and the rigid foundation rock. For this purpose, the plinth serves as a grout cup and as a starting base for the equipment of face slab slip-forms.

The plinth is normally built on hard and non-erodible fresh rock that is groutable, because high hydraulic gradient develops along the short seepage path under the plinth. However, with proper engineering, weathered and jointed rock, fault zones, soil-filled joints and materials susceptible to possible erosion and piping are also acceptable[3].

[2] Guidelines On Concrete-Faced Rockfill Dams 1991, Australian National Committee On Large Dams
[3] COOKE, J.B., "Progress in Rockfill Dams" The Eighteenth Terzaghi Lecture presented at ASCE, 1982 Annual Convention Journal of Geotechnical Engineering. ASCE, Vol. 110, No.10, October, 1984.

A hard rock with a velocity of more than 4,000m/s is deep at the dam site especially at both abutments. Therefore, the plinth will be put on the weathered rock foundation consisting of an alteration of sandstone and mudstone, which is laid below the surface talus deposits with a thin (4m-6m deep) layer, where seismic velocities range between 1,350m/s-2,400m/s.

Plinth is designed with a 4.0m wide base, taking into consideration the minimum space for foundation drilling and grouting and practical thickness of apron slab (500mm) for high dams.

(v) Face Slab

There are several factors affecting the determination of the thickness of face slab, such as the height of the dam, spaces for waterstops at joints, construction easiness, and so on.

The design thickness of the face slab has been established for many years as 300mm at the top and increasing below at some rate in proportion to the head of water, though some existing dams have been covered by the slab with constant thickness of 250mm-300 mm.

For the Nam Ngiep dam, the face slab is designed by applying the most popular equation (0.3 + 0.003 x H) in meter.

(vi) Sealing Zone on Upstream Face of Dam

Many successful high dams provide an extra precaution against emergency cases of perimeter-joint leakage through the face slab. At the river section between the upstream cofferdam and the plinth, where the case is strongest and the provision is convenient and economical, a well-graded material from gravel to silt sizes is placed over the joint to flow into and limit leakage though any water-stop rupture. Available random fill will cover the sealing material.

(vii) Transition Zones

Transition zone will be divided into two zones in the up- and downstream direction.

The upstream transition zone is designed to support the face slab with processed (crushed) small rock in the width of generally 3m-5m, which is convenient for placing and compaction of the material by vibratory rollers. Layer thickness is 40cm-50cm with the materials at the maximum of 75mm in size.

For large dams and on particularly steep abutments, the transition zone may be wider at the foundation-contact to provide additional leakage control behind the perimeter-joint. However, thickness of the zone was assumed to be constant 4m for the Nam Ngiep dam.

Immediately behind the upstream transition zone, the downstream transition zone of a layer with selected rockfill of 3m-5m wide will be placed to fulfill the role of a filter between the upstream transition zone and the main rockfill zone.

This zone will be constructed with selected rock which is intermediate sizes between its upstream and downstream zones and to be placed in the same width and the same layer thickness as the upstream transition zone.

(viii) Main Rockfill Zone

The main rockfill zone is of a rockfill with basically pervious and capable of carrying the imposed reservoir load.

This zone will be divided into the upstream shell and the downstream shell. The upstream two-thirds of the zone will be designed as the upstream shell and the remainder will be designed as the downstream shell to transfer water load to the foundation level moderately.

Conglomerate (medium strength) and sandstone (low to medium strength) may be used as embankment material for the Nam Ngiep dam. Better conglomerate may be utilized for the upstream zone to minimize settlement and hence displacement and cracking of the concrete surface slab and sandstone will be used for the less critical downstream zone in which layer thickness may be increased and compaction requirements reduced.

(2) Dam Foundation Treatment

To improve the fractured rock and to seal the open joint under the toe slab to an acceptably low permeability level, low pressure consolidation grouting is carried out throughout the entire slab foundation. The grouting will be provided in a single stage of 5 and 10m depending on rock quality.

Depth of the deep curtain grouting is defined on a geological basis, but a conservative 2/3H will be taken into account for the Nam Ngiep dam. The sprit-spacing method will be used to locate additional holes.

All exposed rock slopes resulting from excavation for the plinth, and upstream of it, will be covered with a layer of steel-mesh-reinforced shotcrete to extend somewhat the seepage path in the upstream direction.

(3) Dam Instrumentation

Instrumentation will be provided in the Nam Ngiep dam for better understanding of its behavior and data acquisition for further CFRD dam design. It is also desirable to establish proper monitoring during operation and to decide upon remedial measures in case problems develop.

For these purposes, the main dam will be provided with the following instrumentation:

Table 8.3.4 Instrumentation for Main Dam

No.	Name of Instrumentation	Purpose of Instrumentation
1.	Joint meters	to measure movements of the concrete face relative to the toe slab
2.	Strain meters	to measure strains in the concrete face
3.	Vertical settlement devices	to know the influence of fill settlements on the concrete face behavior (hydraulic type)
4.	Earth pressure meters	to measure stress in the fill and to correlate strain with stress at each point and various directions
5.	Pore pressure meters	to measure pore pressure in the embankment and the rock foundation
6.	Others	such as surface settlement monuments and leakage weirs

(4) River Diversion Facilities

A tunnel type diversion system will be adopted for the Project. Separate main cofferdams will be provided at the upstream and downstream sides of the main dam.

As the design discharge for the river diversion is large for the Project, the Nam Ngiep River will be diverted by two (2) lanes of concrete-lined tunnel. The design discharge was equal to the 25-year recurrence flood of 3,385m^3/s for each scheme.

Tunnel diameter and the required crest level of the upstream main cofferdam were tentatively determined on an assumption that around 20% of the flood peak will probably be regulated due to a reservoir storage function at the upstream of the cofferdam. The results are as follows, and the profile of diversion tunnel is shown in Figure 8.3.2.

Table 8.3.5 Major Dimension of River Diversion Tunnel

No.	Items	Medium-Scale (FSL.EL.320m)	Large-Scale (FSL.EL.360m)
1.	Dia. of Tunnel	10.4m	10.4m
2.	Elevation of u/slab	EL.208m	EL.208m
3.	Tunnel Length	1,000m	1,100m

8.3.4 SPILLWAY

Spillways are provided for storage and detention dams to release safely surplus of floodwater, which cannot be contained in the allotted storage space.

The spillway for the Project will be designed as a gated overflow type having three 19m wide and 15m high gates, which may be located on the right abutment. The excavated material from the spillway construction will be used for the main dam embankment.

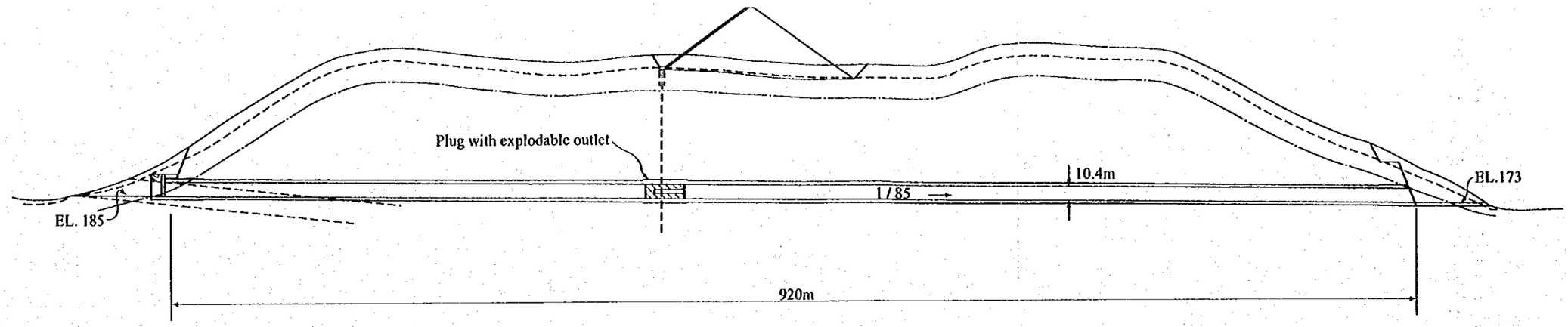
Approach bay may be located at EL.300m and EL.340m, respectively for FSL.320m and FSL.360m.

Floodwater will be conveyed to the downstream of the dam by an open square concrete chuteway and dissipated by the flat-apron type stilling basin to be located sufficiently away from the dam and its appurtenant structures.

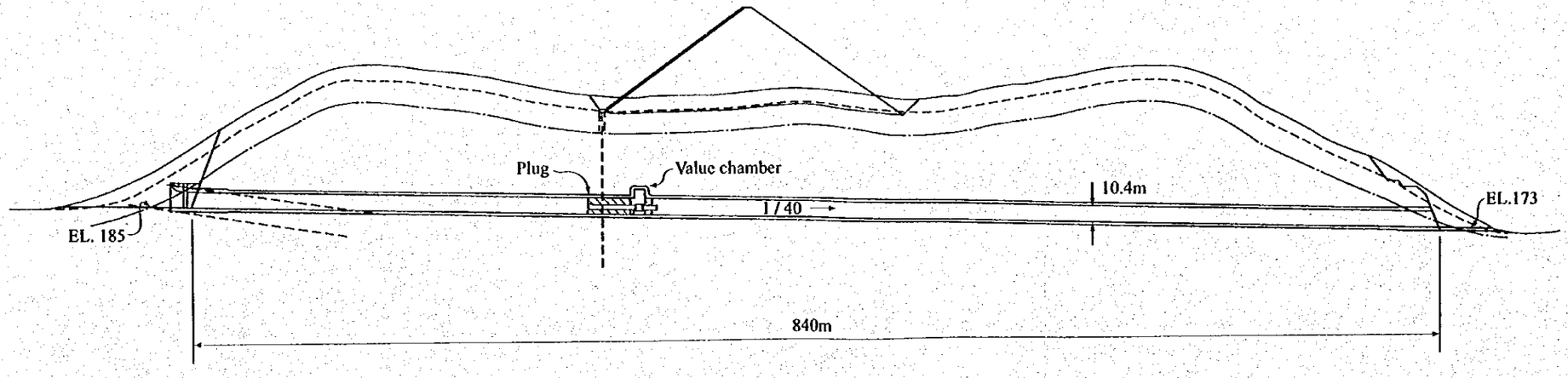
Hydraulic dimensions of the stilling basin will be based on the 100-year flood of 4,519m^3/s and stability of the structure will be confirmed for a 1,000-year flood of 6,530m^3/s.

Final dimensions of the spillway should be determined by hydraulic model testing.

A typical profile of the preliminary spillway design is as shown in Figure 8.3.3.



NO.1 DIVERSION TUNNEL



NO.2 DIVERSION TUNNEL (BOTTOM OUTLET)

0 50 100 m

SCALE

FEASIBILITY STUDY
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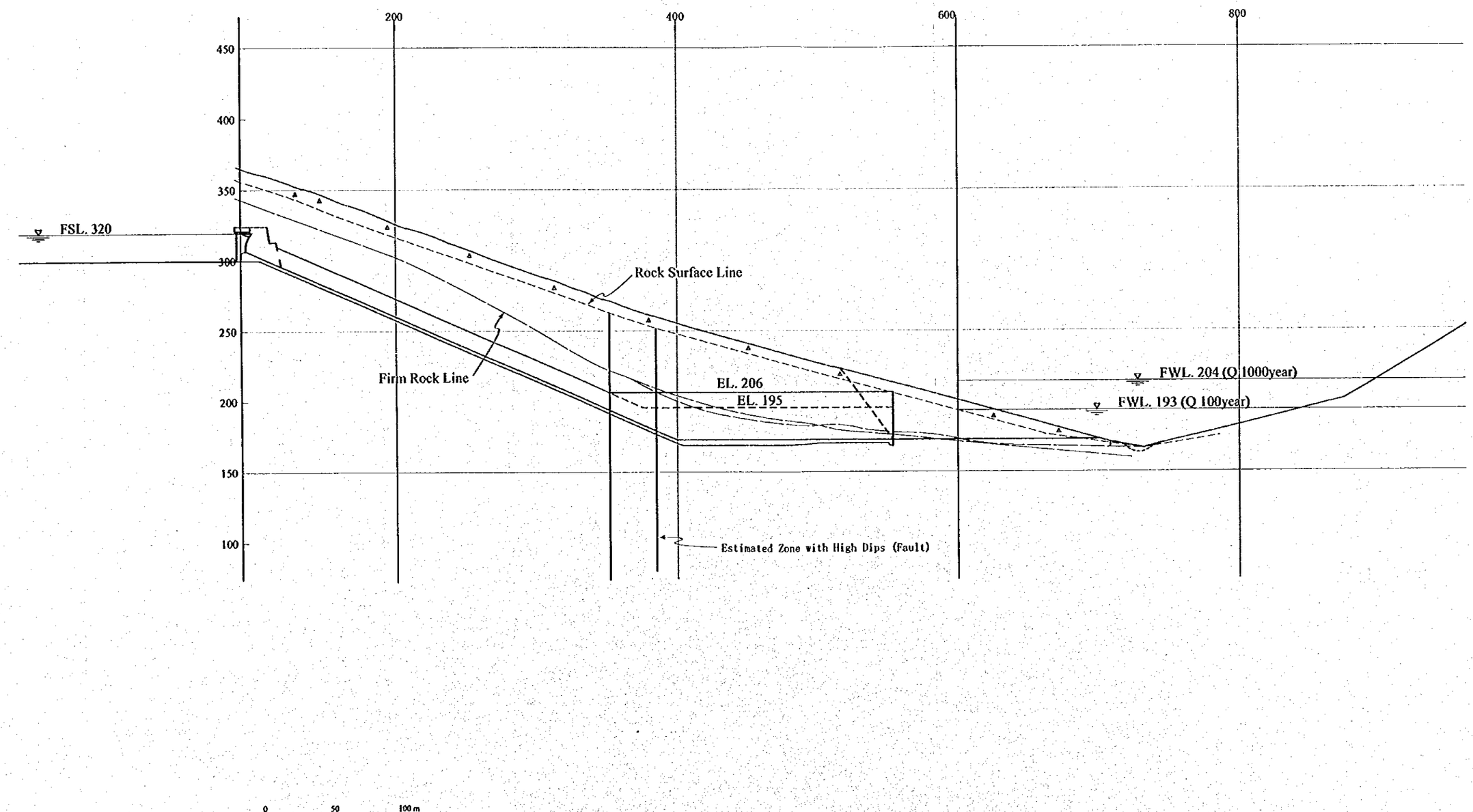
IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 8.3.2
River Diversion, Profile (FSL. EL. 320m)



FEASIBILITY STUDY ON THE NAM NGIEP-I HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 8.3.3** **Spillway, Profile (FSL. EL. 320m)**

8.3.5 OUTLET WORKS

Outlet facilities are usually provided for retardation of reservoir-rise during impoundment, releasing riparian flow to the downstream reach, emergency draw-down, and so on.

The Nam Ngiep dam has a huge storage volume of 7 billion m^3. Therefore, it seems not realistic to provide a full-scale function for emergency draw-down, which will require extremely large facilities and huge costs for such a large reservoir. On the other hand, it is preferable for fill type dams to release incoming flows at a retarded rate while the reservoir is impounded. Such water rise restriction is specifically important to maintain the stability of upstream face slab of CFRD.

Therefore, outlet facilities for the Project will be designed at a practical and realistic size to function as retardation of water-rise in reservoir impoundment as the main role. Its discharge capacity was provisionally determined to be 400m^3/s, which is equal to about twice the basin average run-off and is sufficient to control reservoir water level.

For the large-scale scheme, a speedy draw-down in an emergency case cannot be expected by the above size of outlet, but in the case of a medium scale, draw-down from FSL320m to MOL280m will be enabled by 50 days and the draw-down from MOL to 1/3 depth (WL.220m approx.) will need about 20 days only.

An outlet will be provided in the diversion tunnel No.2, which will be closed after the completion of the main dam. Valve chamber will be provided in the main plug portion of the tunnel, which will be constructed at the middle of the tunnel stretch. The downstream of the valve chamber will be repaired and reinforced for an energy dissipater. Approach to the valve chamber will be made from the diversion tunnel No.1.

The drawing of outlet works is shown in previous figures for the river diversion tunnel Figure 8.3.2.

8.3.6 INTAKE STRUCTURE AND POWER WATERWAY

Power intake will be located on the left abutment. Intake sill has to be located above the final sediment level, which was assumed for the Nam Ngiep-1 HEPP to be EL.200m for the project lifetime of 100 years.

In addition to the above, the intake sill-level will be located 2.5 x D (D: diameter of headrace tunnel) below the minimum operation level (MOL) of the reservoir to avoid entrapping air in the tunnel system.

Moreover, the headrace tunnel will be designed with a single lane. Its tunnel diameter will be around 9.0m to satisfy the given conditions that the average flow velocity in the tunnel is limited to 3.5m/s and number of the tunnel is increased if diameter of the tunnel becomes bigger than 10m for the design discharge.

On the other hand, the size of the intake opening will be determined based on the following requirements: Inlet flow velocities are to be within 1.0m/s at the maximum discharge to

minimize destructive vibration, which may be induced on the metal works (gates, trash rack, etc.) of the intake structure.

Based on the above requirements, an intake opening of 15m(B) x 15m(H) divided by a 2m thick center pier will be required for both schemes.

Penstock line will be designed as an inclined cut-and-cover conduit type, which will be bifurcated at the downstream end of the headrace tunnel in the concrete anchor block and buried in the deep trench excavated behind powerhouse. Penstock lines will be of steel pipe encased for its entire stretch with the reinforced concrete structure.

Major dimensions to satisfy the above conditions are shown as follows, and the profile of intake structure and headrace tunnel are shown in Figure 8.3.4.

Table 8.3.6 Major Dimensions of Intake and Headrace Tunnel

No.	Items	Medium-Scale (FSL320m)	Large-Scale (FSL360m)
1.	MOL	EL.280m	EL.335m
2.	Intake sill elevation	EL.247m	EL.312m
3.	Maximum discharge of power waterway	221m³/s	224m³/s
4.	Total length of headrace tunnel	420m	490m

8.3.7 POWER STATION

Because of the gentle downstream river profile, a surface type powerhouse will be proposed and located immediately downstream of the main dam to pass the intake water as simple and short.

The surface plants in close association with fill type dams are frequently located at the downstream end of tunnels through one of the abutments. At the Nam Ngiep dam site, however, the dam site abutments are very steep such that the excavation for powerhouse will expose extremely high cut slopes, which might have to be protected and maintained against the prospective slope failure. Therefore, the powerhouse may be located in the river course aiming at economic design.

To meet the 16-hr power generation, which is a given condition provided by EGAT, the powerhouse will be equipped with two generating units of 120MW for the scheme of FSL.320m and four units of 90MW for the scheme of FSL.360m. The penstock lines for the scheme of FSL.360m will be further bifurcated near the powerhouse to be connected with 4-units of generating units.

The particulars, which will be given as the result of the preliminary power plant design, are as follows:

Table 8.3.7 Major Dimensions of Power Station

No.	Dimensions	Unit	Medium-Scale	Large-Scale
1.	FSL	EL.m	320	360
2.	MOL	EL.m	280	335
3.	Draw-down	m	40	25
4.	Plant Discharge	m^3/s	221	224
5.	Rated Head	m	131.8	176.8
6.	Number of Unit	nos.	2	4
7.	Unit Capacity	MW	120	90
8.	Plant Capacity	MW	240	360

In light of the above heads and outputs, the water turbine will be of a vertical-shaft Francis type for both schemes. The number of units was so determined that the rated output of a turbine is limited to 150MW at the maximum and the unit number is restricted to be an even-number.

Unit distance will require 18m for FSL.320m scheme and 15m for FSL.360m scheme between center to center while the turbine setting level was determined at EL.171.1m and EL.171.7m each to secure the required draft head under the assumed rated TWL.175m.

Ground elevation for the powerhouse yard will be located at EL.195m, which is 2m above the maximum TWL.193m of the 100-year recurrence flood: 4,519m^3/s.

On the above conditions, the required size of the powerhouse will be as follows:

(i) FSL.320m alternative: 58m (L) x 31m (W) x 58 m (H), and

(ii) FSL.360m alternative: 81m (L) x 29m (W) x 52m (H).

Main transformers will be located on the back-filled open space secured behind the powerhouse aiming at economic design.

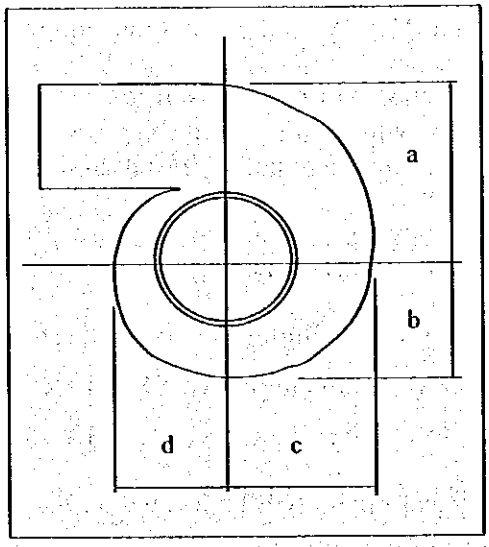
The outdoor switchyard will be also located behind the powerhouse for housing indoor type gas insulated metal enclosed switch-gears.

Detailed figures preliminary assumed for powerhouse sizing are as given in Table 8.3.8. Typical section and transverse and longitudinal sections of the powerhouse are shown in Figure 8.3.4.

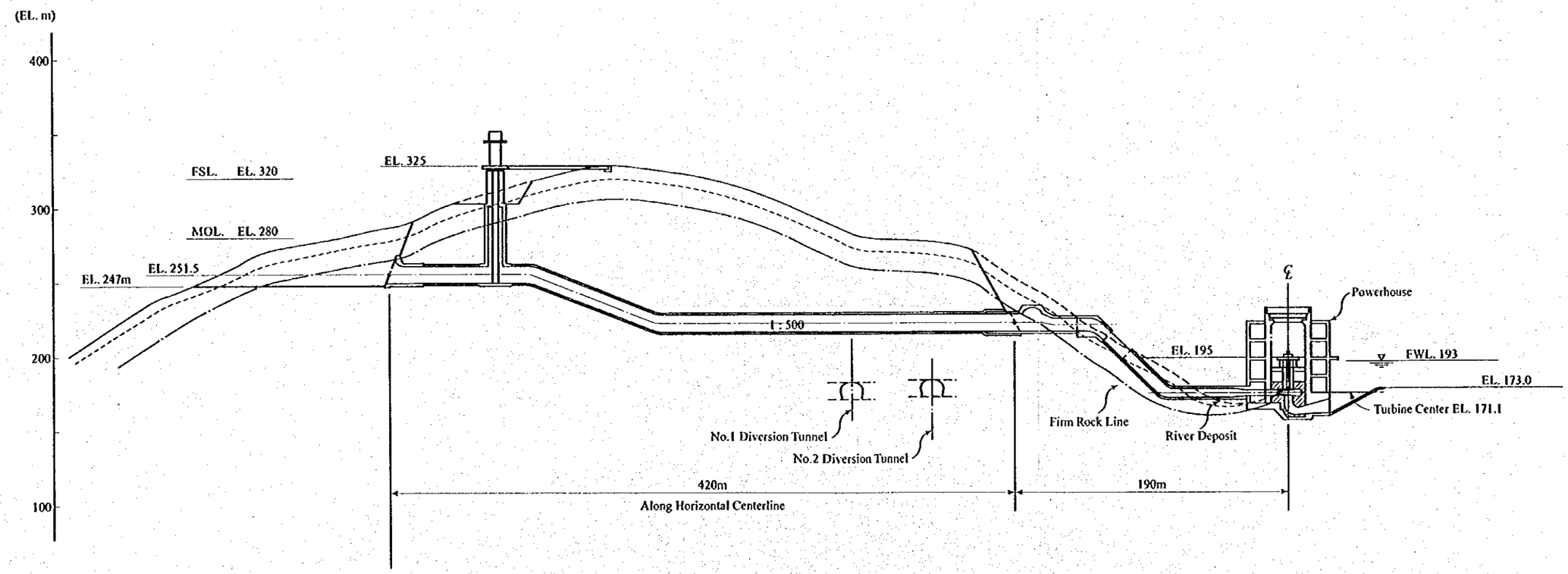
Table 8.3.8 Preliminary Sizing for Nam Ngiep-1 Powerhouse

No.	Dimensions	Unit	Medium 320m	Large 360m
1.	Specific speed (Ku)	m-kW	0.8	0.8
2.	Specific speed (Ns)	m-kW	160	130
3.	Rated speed (N)	rpm	200	290
4.	Net rated head (Hd)	m	131.8	176.8
5.	Runner inlet dia.D1	m	3.7	2.9
6.	Runner outlet dia.D2	m	4.1	3.2
7.	No. of unit	no.	2	4
8.	Turbine rated output	MW	120	90
9.	Casing size (a)	m	7.3	5.9
10.	Casing size (b)	m	6.4	5.3
11.	Casing size (c)	m	7.2	5.9
12.	Casing size (d)	m	5.4	4.4
13.	Unit interval	m	17.6	15.2
14.	Unit bay length	m	38	63
15.	Assembly bay length	m	20	18
16.	Turbine unit weight	t	89	55
17.	Powerhouse length	m	58	81
18.	Powerhouse width	m	31	29
19.	Powerhouse height	m	58	52
20.	Generator output	MVA	146	101
21.	Generator unit weight	t	767	490
22.	Generator shaft height	m	8.2	7.1
23.	Crane span	m	16	13
24.	Roof H above c/rail	m	9.2	7.4
25.	H of crane rail/GL	m	9.2	8.1
26.	Cavitation factor (σ p)		0.1041	0.0741
27.	Draft head (Hs)	mAq	-3.8	-3.1
28.	Draft head (Ha)	mAq	10.1	10.1
29.	Draft head (Nv)	mAq	0.17	0.17
30.	River bed	EL.m	173	173

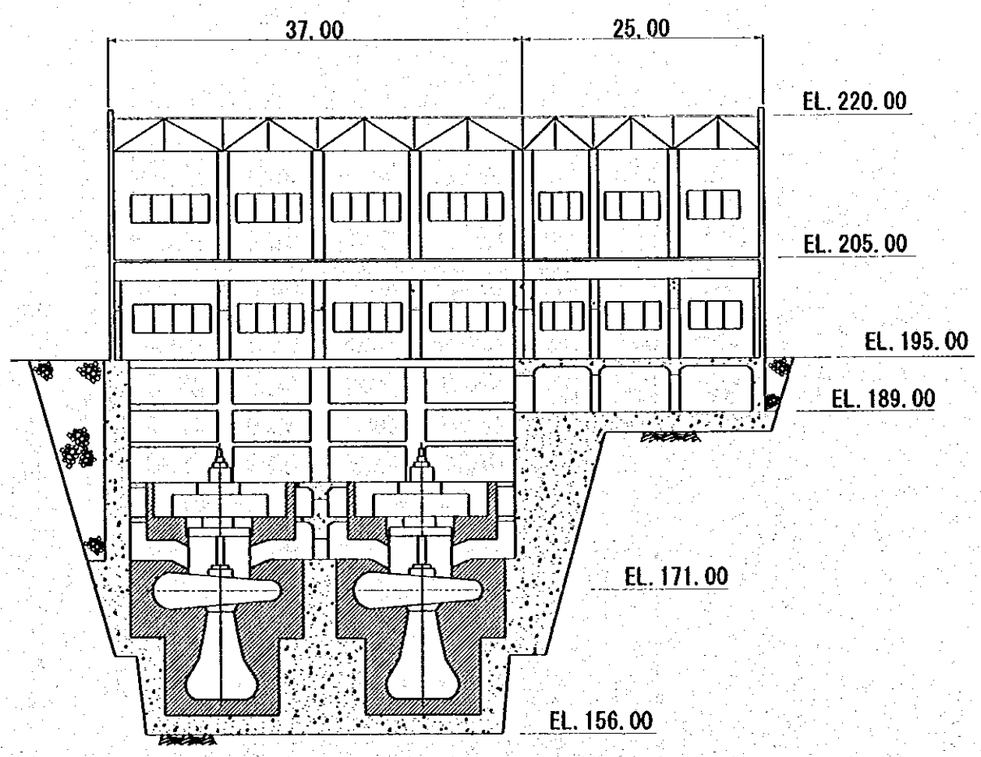
No.	Dimensions	Unit	Medium 320m	Large 360m
31.	Water temperature (T)	°C	15	15
32.	Turbine center	EL.m	171.1	171.7
33.	Draft T pit bottom	EL.m	156.7	159.6
34.	Rated (TWL)	EL.m	175	175
35.	Flood TWL (Q_{100})	EL.m	193	193
36.	Powerhouse (GL)	EL.m	195	195
37.	Substructure height	m	39	36
38.	Superstructure height	m	19	16



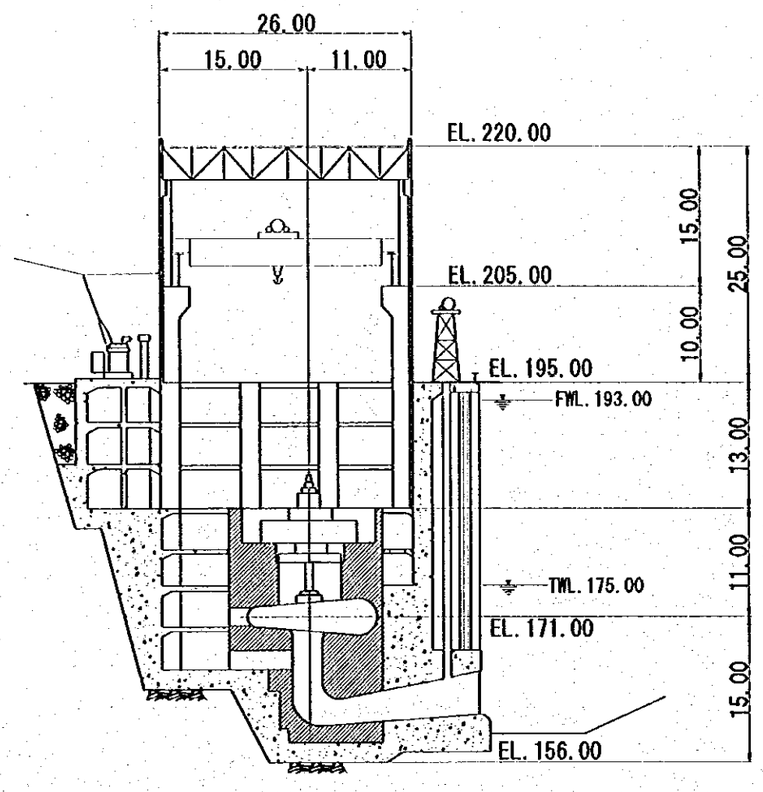
Dimension of Casing



FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 8.3.4** **Intake and Headrace Tunnel, Profile (FSL. EL. 320m)**



PROFILE



SECTION

Note : Not to scale, all dimensions are in meter.

FEASIBILITY STUDY ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC	Figure 8.3.5 Powerhouse, Profile and Section (FSL.EL.320m)
JAPAN INTERNATIONL COOPERATION AGENCY	