E3 THE ALTERNATIVE PLANS COMPARED

E3.1 Major Engineering Issues Clarified for the Preliminary Optimization Study

E3.1.1 General

In the preliminary optimization study carried out in the First Field Investigation (the preliminary Investigation Stage), the following technical issues and points were examined prior to setting up the alternative project layout plans:

i) Potential landslide area located at the right bank about 500m upstream of the Dong Nai No.3 dam site adopted in previous pre-feasibility study by EVN,

ii) Location of Dong Nai No.3 powerhouse and route of waterway

iii) Location of Dong Nai No.4 dam site

iv) Type of dam for use for the preliminary optimization study

E3.1.2 Potential Landslide

(1) General

The potential landslide area located at the right bank about 500m upstream of the Dong Nai No.3 dam site adopted in the previous pre-feasibility study by EVN was the restriction to locate the No.3 dam downstream of the landslide in the JICA's master plan study performed before the EVN's pre-feasibility study. However, the grounds described in the following paragraph (2) had removed this restriction, which were derived through the geological assessments made in the First Field Investigation. The area that was suspected to be landslide area in the Preliminary Investigation Stage is shown in Figure E3.1.

(2) Assessment of potential landslide risks near downstream Dong Nai No.3 dam site

A land of gentle slope at 15 degrees and less from horizontal is developed in a 600m wide and 700m long area between two alternative dam sites for the Dong Nai No.3. It is located on the right bank of the Dong Nai River and more than 500 metres upstream of the downstream alternative dam site. Landslide was suspected in this area in the JICA's master plan study as was suggested from its topographic feature and colluvial deposits as usually seen in landslide areas. In the previous studies, however, the possibility of a landslide has never been positively proved through detailed investigation.

An unusual feature of this potential landslide area is that it is blocked at its foot by a low ridge stretching from the upstream side, forming a sort of barrier against the slide with a constricted outlet to the river. There could be some doubt against the interpretation of the landslide. It is duly conservative to assume existence of an old landslide.

Trunks of trees remaining after a burning-and-cultivating operation by the local inhabitants are all straight and vertical in this potential landslide area, indicating that the land has been stable at least for a few decades. Even if it had once stabilized, the

balance would be lost and a slide movement might be resumed on the reservoir impounding up to the high water level, that is, the middle height of the landslide area.

Resumption of the landslide, however, would not cause any serious trouble upon the safety of the reservoir or the dam. Added volume of the colluvial deposit entering in the reservoir in case when the land is fully slid is estimated at approximately 10 million cubic metres (10,000,000 m3) or less, which will replace only a minor part of the dead water that has about 70 m of thickness between the reservoir minimum operation level (El.560 m) and the river bed (El. 486.3m) in front of the landslide area. The sliding volume may actually be far less because of the said barrier ridge hindering the movement. Slide of the colluvial deposit on a low-angled sliding surface, if occurs, can be too slow to jeopardize the safety of the reservoir and the dam by rapidly raising the water surface or generating high waves.

This potential landslide, therefore, has no significance to control the safety of the structures and the comparison of alternative dam sites. For the reasons mentioned above, both dam sites of Dong Nai No.3 in the JICA's master plan study and EVN's pre-feasibility study were taken up as the alternative dam sites in preliminary optimization study. The alignment of the Dong Nai No.3 dam in each of the upstream and downstream sites is shown in Figure E3.2.

E3.1.3 Location of Dong Nai No.3 Power Station and Route of Waterway

In the course of the alternative studies, the JICA Study Team was informed that the tailrace elevation for No.3 Power Station had to be modified based on a new information from the actual survey approximately 25m higher than originally adopted in the EVN's pre-feasibility study. Based on this information, the Study Team had to change the location of the Dong Nai No.3 powerhouse and the waterway (see Figure E3.5).

For the upstream alternative of Dong Nai No.3 dam, the tailrace elevation for No.3 powerhouse could be located at around El.440m, although the waterway required extensive penstock arrangement (see Figure E3.4). However, it was not physically possible to locate the waterway on the left bank for the downstream alternative site of Dong Nai No.3 dam because of existence of deep ravines and therefore it was unavoidable to locate the waterway on the right bank. Further, the location of No.3 powerhouse had to be selected to have a tailrace elevation of around El.445m.

E3.1.4 Location of Dong Nai No.4 Dam

Because of highly weathered rock foundation to 20-30m or more at the dam sites selected in the JICA's master plan study as well as in the EVN's pre-feasibility study, an alternative site for the Dong Nai No.4 dam site was selected approximately 700m downstream of the downstream dam site selected in the EVN's pre-feasibility study and compared with 1 to 10,000 scaled topographic maps and geological information that were made available in the preliminary Investigation Stage, as shown in Figures E3.1 and E3.3.

Although there was no significant cost difference between alternatives as shown below, No.4-3 site was slightly superior to other alternative sites. In addition it would be more

preferable in geology than No.4-1 and 4-2 although the same deteriorated geology was assumed in the Preliminary Investigation Stage. Thus, No4-3 dam site was selected for Dong Nai No.4 dam site (Alternatives 1. 2 and 3 described below).

Cost comparison of main civil structures for each dam site
(rockfill dam with earth core)

(Unit:10³ US$)

Main Components	Alternative Sites of Dong Nai No.4 Dam		
	No.4-1(M/P)	No.4-2 (Pre-F/S)	No.4-3 (New)
- Dam	45,727	55,158	52,948
- Diversion	26,452	19,264	23,577
- Spillway	50,715	45,954	43,119
Total	122,894	120,376	119,644

Note
The above cost comparison was made in the First Field Investigation (January-March 1999) through the preliminary design and costing with 1 to 10,000 scaled topographic maps and geological information, etc. that were made available in the study stage.

3.1.5 Type of Dam for Use for Preliminary Optimization Study

The Dong Nai No.3 and No.4 dam sites to be selected for the alternative studies were technically qualified for design and construction of both concrete and rockfill dams of 100 m high level or more through the geological investigation including site reconnaissance preformed in the First Field Investigation. For this reason, rockfill dam schemes were adopted for both of Dong Nai No.3 and No.4 schemes in order to simplify the preliminary optimization study to select the optimum project layout plan, for which the detailed field investigations were scheduled to be performed in the subsequent study stages. The optimization study for the dam type as well as its scale were scheduled to be carried out at the later study stage by incorporating the results of the detailed field investigation.

E3.2 Examination of Alternative Project Layout Plans and Preliminary Cost Estimate

E3.2.1 Alternative Project Layout Plans Selected for the Preliminary Optimization Study

As the basic alternative project layout plans to be examined in the preliminary optimization study, the five (5) alternative project layout plans were worked as shown in Figure E3.4 to Figure E3.8, respectively. Their longitudinal profiles along the Dong Nai mainstream are schematically illustrated in Figure E3.9 to Figure E3.13, respectively

The alternative project layout plans set up in the Preliminary Investigation Stage are explained below and the salient features for the selected 5 Alternatives are tabulated in Table E3.1.

E3.2.2 Brief Explanation for Each Alternative

(1) Alternative 1 (see Figures E3.4 and E3.9)

The Dong Nai No.3 dam height was planned be about 113.5m for FSL 590m. The waterway route was selected on the left bank from the intake site with FSL 590m to the middle reach of the valley where the water level is EL.440m and its length is about 4800m. It is not difficult to find a reasonable alignment for an open-air type penstock, because there is wide ridge and topographic condition are not so complex between the surge tank and powerhouse sites. From the geological investigation carried out in the previous pre-feasibility study, however, the thickness of weathered layers was expected to be very deep with 10m to 30m, partially deeper in the mountain area. Therefore, a buried type penstock was adopted to avoid huge excavation works for open-air type penstock.

For the Dong Nai No.4 dam site approximately 700m downstream of the proposed in the previous pre-feasibility study, the dam height was planned to be 109.5m for FSL of El.440m. The waterway route was selected on the left bank from the intake site with FSL 440m to the middle reaches of the valley where the water level is El.290m and its length is about 5,440m. Its layout was arranged so as to provide a short cut at the bend of a river that would give a relatively high head in a short waterway. A buried type was selected by the same reason as that for Dong Nai No.3 mentioned above.

(2) Alternative 2 (see Figures E3.5 and E3.10)

In succession to the JICA's master plan study, EVN performed a pre-feasibility study on the Dong Nai No.3 and No.4 Combined Hydroelectric Power Project in 1998.

Because of the reasons mentioned in the foregoing Section E3.1, the Dong Nai No.3 dam site selected in the EVN's pre-feasibility study was retained and the waterway and power station arrangements were changed from the left bank to the right bank. Accordingly, a FSL for the Dong Nai No.4 scheme was changed from El.440m to El.445m.

The dam height was planned to be 117.5m for the Dong Nai No.3 scheme with FSL of El.590m of and 114.5m for the Dong Nai No.4 scheme with FSL of El.445m.

(3) Alternative 3 (see Figures E3.6 and E3.11)

Dong Nai No.4 dam was planned to be much smaller than that of the said Alternatives 1 and 2 in order to reduce the No 4 dam cost that accounted for a large portion of the total project cost. The head lost by the scale-down of No 4 dam size was considered to be recovered by extension of headrace tunnel to No.3 power station.

For the Dong Nai No.3 scheme, the dam height was kept as about 117.5m for FSL of El.590m. The waterway route was selected on the left bank from the intake site with FSL of El.590m to the middle reach of the valley where the water level is EL.407m and its length is about 10,620m. A buried type penstock was selected by the same geological reason for that of the Alternative 1 as described above.

For the Dong Nai No. 4 scheme, the dam height was planned to be about 87.5m for FSL of El.407m. The waterway route was planned to take approximately the same one as the Alternative 1 and a buried type penstock was selected by the same geological reason as that described above.

(4) Alternative 4 (see Figures E3.7 and E3.12)

Dong Nai No.4 dam site in this Alternative 4 was moved about 5km upstream of the No.4 dam site for the said Alternatives 1,2 and 3 to reduce No.4 dam scale. The headrace tunnel to No 4 powerhouse was extended in compliance with this change.

The dam height for the Dong Nai No.3 was also kept as about 117.5m for FSL of El.590m. The waterway route was almost same as that for the Alternative 2 and a buried type penstock was selected by the same reason as that described above.

For the Dong Nai No.4, the dam height was planned to be about 80.5m for FSL of El.445m. The waterway route was selected on the left bank from the intake site to the middle reach of the valley where the water level is EL.290m and its length is about 10,180m. A buried type penstock was selected by the same geological reason as that for the Alternative 1.

(5) Alternative 5 (see Figures E3.8 and E3.13)

In this case, the mode of power generation on No.4 project is planned to be modified from the storage type to the run-of-river type. Therefore, this case was regarded as the extreme case to pursue the cost minimum of the Project without function of regulating capability of discharge from No.3 power station in comparison with other 4 Alternatives (Alternative 1 to Alternative 4).

The dam height of Dong Nai No.3 was also kept as about 117.5m for FSL of El.590m. The waterway route was almost same as that for the Alternative 3. For the Dong Nai No.4 scheme, the dam height was planned to be about 38m. The waterway route was selected on the left bank from the intake site to the middle reach of the valley where the water level is EL.290m and its length is about 10,050m. A buried type penstock was selected by the same geological reason as that for the Alternative 1.

E3.2.3 Preliminary Cost Estimate

The preliminary design and quantity calculation for each alternative layout plan was made using 1 to 10,000 scaled topographic maps, geologic information and site conditions clarified through the field reconnaissance. The 1 to 10,000 scaled topographic maps used for the preliminary design were those produced in the previous pre-feasibility study by PECC2 and the feasibility study on the Dong Nai No.4 scheme by PECC1, respectively. The cost estimate was performed applying unit prices of major work items which were determined based on the relevant data collected in the First Field Investigation.

E4 SELECTION OF OPTIMUM PROJECT LAYOUT PLAN

E4.1 Selection of Optimum Development Scale from Development Cases for Alternative 1 and Alternative 2

E4.1.1 Development Cases Examined for Alternative 1 and Alternative 2

With regard to the Alternative 1 and Alternative 2, which were originally proposed in the previous JICA master plan study and pre-feasibility study, the optimum development scale was attempted to be preliminarily selected from among the conceivable development scales thereof. These two alternatives are shown in the corresponding Figures E3.4 and E3.5. For both of Alternative 1 and Alternative 2, some modifications were made for their original plans of the previous studies based on mainly the topographic data and information made available in the study stage as discussed in the foregoing Chapter E3. The following eight cases for these two alternatives were set up:

Development Cases Set up for Alternative 1 and Alternative 2

Alternative Layout Plan	Develop. Case	Reservoir Water Level (El. m)			
		Dong Nai No. 3		Dong Nai No.4	
		FSL	MOL	FSL	MOL
i) Alternative 1	Case 1-a	600	550	550	440
	Case 1-b	590	550	550	440
	Case 1-c	580	550	550	440
	Case 1-d	570	550	550	440
	Case 1-e	560	550	550	440
ii) Alternative 2	Case 2-a	600	560	560	445
	Case 2-b	590	560	560	445
	Case 2-c	580	560	560	445

Notes

1. The above alternative development cases were set up for the preliminary optimization study to select the optimum project layout plan, that was carried out in the First Field Investigation (January- March 1999)
2. FSL of Dong Nai No.3 dam in Case 1-b of Alternative 1 above corresponds to the FSL optimized in the previous JICA master plan study.
3. FSL of Dong Nai No.3 dam, Case 2-b of Alternative 2 above corresponds to the FSL optimized in the previous pre-feasibility study carried out by the Vietnamese Government.

E4.1.2 Available Discharge for Hydropower Generation

For each of the alternative development cases above, the reservoir operation study was performed to calculate the dependable peak power and annual firm/secondary energy outputs applying the mean monthly discharge data at the Dong Nai No.3 dam site and residual catchment of the Dong Nai No.4 dam.

With regard to the two hydropower projects situated upstream of the Project, namely Da Nhim and Dai Ninh Hydropower Projects with drainage area of 775 km2 and 1,933 km2, respectively, they are characterized by the trans-basin project in which river water of the Dong Nai is to be conveyed to the other basin to the east. Based on the past reservoir operation records of existing Dran Dam (Da Nhim HPP) and planned reservoir operation

for the Dai Ninh HPP, it was assumed that no flow would be released from these upstream catchments.

Concerning the aforesaid development cases, a reservoir operation study was carried out for each of the Dong Nai No.3 and No.4 reservoirs. The minimum plant factor was determined to be 0.33. The dependable peak power is taken to be a power output that can be guaranteed over 90 % of the entire hydrologic period.

The dependable peak power and annual firm and secondary energies for the respective alternative development cases, which were calculated through the above reservoir operation study, are listed in Table E4.1.

E4.1.3 Estimate of Economic Annual Net Benefit and Selection of Optimal Development Scale for Alternative 1 and Alternative 2

(1) Economic Benefit

In the preliminary optimization study, the economic benefits for the alternative development cases were estimated by means of the least cost alternative method. As the least cost alternative to the hydropower plant, the coal-fired thermal power plant was preliminarily selected. The economic costs of the coal-fired thermal plant were derived based on the data obtained from EVN during the First Field Investigation period summarized below:

- Capital cost : 973 US$/kW
- Fixed O&M cost : 48.7 US$/kW
- Fuel cost per kWh : 0.014 US$/kWh

For each development case, the present worth of the economic benefits was calculated assuming the adjustment factors to compensate the difference between hydropower and coal-fired thermal with respect to transmission loss, etc. Thereafter, the annual benefits were derived applying the following capital recovery factor at a discount rate of 10 %.

- Capital Recovery Factor at a discount rate of 10 % : 0.1009

(2) Economic Cost

The total present-day costs for the respective alternative development cases that are estimated at a preliminary level to be converted to the total economic costs, assuming that 10 % of the local currency portion is equivalent to transfer payment cost. To estimate the present worth of the economic costs, the total economic cost was disbursed over the construction period including the detail design period. In the Preliminary Optimization Study, the construction period was assumed to take 9 years including the detailed design period of 1.5 years.

(3) Economic Comparison of Alternative Development Cases

The annual net benefits for the respective development cases of Alternative 1 and Alternative 2 were estimated through the above procedures as shown in Table E4.1 and Figure E4.1. Besides, economic construction cost per kWh for each of the development cases was estimated on the condition of project life of 50 years and a discount rate of

10 % as shown in Table E4.2 and Figure E4.2.

As a result of the above examination on Alternative 1 and Alternative 2, the following points were clarified:

i) It is obvious that the Alternative 2 is more viable than Alternative 1 from the economic aspect.

ii) In relation to the optimum development scale for Alternative 2, there is a tendency that the annual benefit increases with rise of a Full Supply Level (FSL) of the Dong Nai No.3 reservoir as seen in Figure E4.1. From a viewpoint of the annual net benefit, the optimum development scale of the Alternative 2 would be in a range between El. 590 and 610 m in the Dong Nai No.3 reservoir FSL. On the other hand, the economic cost per kWh decreases when the FSL lowers, as depicted in Figure E4.2. In the Preliminary Optimization Study, FSL of El. 590 (Development Case 2-b) was provisionally selected as the optimum scale, although the optimization study is to be further refined in the subsequent study stages based on the data and information to be made available in the detailed field investigations. FSL of 590 m in the optimal case was almost identical to that optimized in the pre-feasibility study, although the location of the Dong Nai No.3 power station which was shifted from the original site to the downstream new site based on the data of ground elevations along the Dong Nai mainstream provided by EVN.

E4.2 Selection of Optimum Project Layout Plan from Alternative 2 to Alternative 5

As mentioned above, the Development Case 2-b of the Alternative 2 was selected as the optimum case out of those for the Alternative 1 and Alternative 2. In succession, the Alternative 2 (Development Case 2-b) was compared with the other alternatives, namely Alternative 3, Alternative 4 and Alternative 5. As described in the foregoing Chapter E3, theses three alternatives were preliminarily designed as follows:

i) As for the Dong Nai No.3 Scheme, these alternatives have the same features as those of the Development Scale 2-b, which was provisionally selected to be the optimum scale of the Alternative 1 and Alternative 2 as discussed above. Thus, a FSL of the Don Nai No.No.3 of these alternatives was commonly set at El. 590 m.

ii) As for each the Alternative 2 (2-b), Alternative 3 and Alternative 4, the development plan was worked out for the following two different operation modes:

OPM-1: Operation mode with a minimum plant factor of 0.33, that was similar to that of the Dong Nai No.3 power station,

OPM-2: Constant peak operation during a day with a plant factor of 1.0. In this case, the Dong Nai No.4 reservoir was planned to function to regulate the outflow from the upstream Dong Nai No.3 and run-off from remaining catchment downstream of the Dong Nai No.3 dam site.

Thus, the Dong Nai No.4 scheme was developed as the so-called afterbay type (or re-regulation type) for the Dong Nai No.3 scheme.

The reservoir operation study for each of the development cases of Alternative 2 to Alternative 5 was carried out in order to estimate the project outputs consisting of dependable peak power, firm energy and secondary energy. Table E4.3 shows the results of reservoir operation study for Alternative 2 to Alternative 5, that was carried out in the Preliminary Optimization Study. The results of the computation are tabulated in Table E4.4 and summarized below:

Economic Comparison of Alternative 2 to Alternative 5

Alternative Layout Plan	Mode of Power Operation	Reservoir Water Level (El. m) of Dong Nai No.4		Annual Net Benefit
		FSL	MOL	(Mill. US$/year)
i) Alternative 2 (2-b)	OPM-1	445	437	26.16
	OPM-2	445	437	-2.53
ii) Alternative 3	OPM-1	407	403	22.33
	OPM-2	407	403	1.86
iii) Alternative 4	OPM-1	445	436	21.27
	OPM-2	445	436	-3.36
iv) Alternative 5	OPM-1	407	406	17.48

Notes

1. The above comparison study were carried out for the preliminary optimization study to select the optimum project layout plan, that was carried out in the First Field Investigation (January-March 1999)
2. Power operation mode: OPM-1; a minimum plant factor of 33.3 %, OPM-2; 24-hour operation (plant factor of 1.0).
2. For every development plan above, the main features of the Dong Nai No.3 scheme are coincident to those of Development Case 2-b (Alternative 2).

It was found through the above examination that the Case 2-b of the Alternative 2 would be the most economically viable in terms of annual net benefit. Furthermore, the development of the Dong Nai No.4 was recommended to develop a peak-power station rather than the base-load power station from the economic point of view.

E5 CONCLUSION OF SELECTION OF OPTIMUM PROJECT LAYOUT PLAN

As mentioned above, in conclusion, the Alternative 2 was finally selected as the most economically viable project layout plan among the five alternatives through the preliminary optimization study carried out in the preliminary optimization study in the First Field Investigation of the Preliminary Investigation Stage. All of the results of the preliminary optimization study carried out in the First Field Investigation of the Preliminary Investigation Stage are incorporated in the Progress Report No.1 submitted to EVN on 15th March 1999.

Thus, the preliminary optimization study recommended to perform the detailed field investigation works for the Alternative 2 of the Dong Nai No.3 & No.4 Combined Hydropower project in the subsequent Second and Third Field Investigations scheduled to start in the middle of May 1999.

In accordance with the results of the preliminary optimization study carried out in the First Field Investigation of the Preliminary Investigation Stage, the JICA Study Team prepared the tender documents for the detailed field investigation works for the Alternative 2. Actually, the detailed field investigations such as topographic survey, geological investigation, environmental survey were executed for the period from June 1999 to November 1999, that corresponds to the period of the Second and Third Field Investigations.

This Draft Final Report has been prepared based on the results of the detailed field investigations.

Appendix E

Tables

Table E3.1 Outline of Alternative Plans

Development Plan	FSL	Dam Height (m)	Headrace (m)	Penstock (m)	Gross head (m)
Alternative.1 No.3	590	113.5	4,800	1,730	150
No.4	440	109.5	5,440	440	150
Alternative.2 No.3	590	117.5	7,120	450	145
No 4	445	114.5	5,380	470	155
Alternative.3 No 3	590	117.5	10,620	740	183
No.4	407	87.5	5,780	310	117
Alternative.4 No.3	590	117.5	7,120	450	145
No.4	445	80.5	10,180	520	155
Alternative.5 No 3	590	117.5	10,620	740	183
No.4	407	37.5	10,050	390	117

Table E4.1 Results of Economic Comparison of 8 Development Cases of Alternative 1 and Alternative 2

Alternative Layout Plan		Alternative 1					Alternative 2		
Development Case		1-a	1-b	1-c	1-d	1-e	2-a	2-b	2-c
Dong Nai No.3	Dam Site Alternative	Upst. Site (Proposed in M/P study)					Dst. Site (Proposed in Pre-F/S)		
	Catchment Area (km^2)	2,428					2,441		
	FSL (El. m)	600	590	580	570	560	600	590	580
	MOL (El. m)	550					560		
	Effective Storage Capacity ($10^6 m^3$)	2,110	1,480	963	550	232	1,877	1,248	730
	TWL (El. m)	440					445		
Dong Nai No.4	Dam Site Alternative	Proposed Site in this study					Proposed Site in this study		
	Catchment Area (km^2)	169					156		
	FSL (El. m)	440					445		
	MOL (El. m)	430					437		
	Effective Storage Capacity ($10^6 m^3$)	30					30		
	T.W.L. (El. m)	290					290		
Project Output	Installed Capacity (MW)	518	484	405	301	164	512	457	367
	Firm Energy (GWh/yr)	1,471	1,374	1,159	861	471	1,449	1,306	1,057
	Secondary Energy (GWh/yr)	104	139	283	381	345	101	186	331
	Total Energy (GWh/yr)	1,575	1,513	1,442	1,242	817	1,550	1,493	1,388
	Project Cost (10^3 US$)	830,026	780,527	712,157	629,587	527,111	755,329	709,953	648,964
Economic Comparison	Economic cost per kWh (US Cent/kWh)	7.10	6.95	6.64	6.81	8.64	6.54	6.39	6.27
	Annual Economic Net Benefit (B-C) (M.US$/yr)	24.18	22.30	12.73	-1.21	-22.87	32.86	26.16	13.57

Notes: 1 The above alternative project layout plans were worked out and compared in the First Field Investigation (January - Maarch 1999). The results of the comrison study are described in the Progress Report No.1 submitted to EVN in March 1999.

2 A discount rate of 10 % is applied to estimate the annual economic benefit (B) and cost (C) as well as the conomic cost per kWh. The economic benefit was measured tentatively assuming that the alternative thermal to the Project would be a coal-fired thermal plant.

Table E4.2 Economic Comparison of 8 Development Cases of Alternative 1 and Alternative 2

Layout Plan	Develop. Case	Total of Dong Nai No.3 and No.4					Annual Economic Benefit (B) (M.US$/yr)	Annual Economic Cost (C) (M.US$/yr)	Annual Economic Net Benefit (B-C) (M.US$/yr)
		Installed Capacity (MW)	Firm Energy (GWh/yr)	Secondary Energy (GWh/yr)	Total Energy (GWh/yr)	Project Cost (M.US$)			
Alt. 1	1-a	518	1,471	104	1,575	830,026	135.97	111.79	24.18
	1-b	484	1,374	139	1,513	780,527	127.45	105.15	22.30
	1-c	405	1,159	283	1,442	712,157	108.52	95.79	12.73
	1-d	301	861	381	1,242	629,587	83.36	84.57	-1.21
	1-e	164	471	345	817	527,111	47.70	70.57	-22.87
Alt. 2	2-a	512	1,449	101	1,550	755,329	134.31	101.45	32.86
	2-b	457	1,306	186	1,493	709,953	121.47	95.31	26.16
	2-c	367	1,057	331	1,388	648,964	100.54	86.97	13.57

Notes: 1. The above alternative project layout plans were worked out and compared in the First Field Investigation (January - Maarch 1999). The results of the comrison study are described in the Progress Report No.1 submitted to EVN in March 1999.

2. A discount rate of 10 % is applied to estimate the annual economic benefit (B) and cost (C) as well as the conomic cost per kWh. The economic benefit was measured tentatively assuming that the alternative thermal to the Project would be a coal-fired thermal plant.

Table E4.3 Results of Economic Comparison of Alternative2 to Alternative5

Power Operation Mode of Dong Nai No.4 Powerstation		OPM-1				OPM-2		
Alternative Layout Plan		Alternative 2 (2-b)	Alternative 3	Alternative 4	Alternative 5	Alternative 2 (2-b)	Alternative 3	Alternative 4
Dong Nai No.3	Dam Site Alternative	Dst. Site (Proposed in Pre-F/S)				Dst. Site (Proposed in Pre-F/S)		
	Catchment Area (km^2)	2,441				2,441		
	FSL (El. m)	590				590		
	MOL (El. m)	560				560		
	Effective Capacity (10^6m^3)	1,248				1,248		
	TWL (El. m)	445	407	445	407	445	407	445
Dong Nai No.4	Dam Site Alternative	Proposed Site in this study		Approx. 6.5km upst. of proposed site		Proposed Site in this study		Approx. 6.5km upst. of proposed site
	Catchment Area (km^2)	156		110		156		110
	FSL (El. m)	445	407	445	407 (397)	445	407	445
	MOL (EL.m)	437	403	436	-	437	403	436
	Effective Capacity (10^6m^3)	30	6	6	-	30	6	6
	TWL (El. m)	290				290		
Project Output	Installed Capacity (MW)	457	444	442	409	282	312	271
	Firm Energy (GWh/yr)	1,306	1,249	1,240	1,189	1,228	1,205	1,139
	Secondary Energy (GWh/yr)	186	196	198	154	101	107	98
	Total Energy (GWh/yr)	1,493	1,445	1,438	1,343	1,329	1,312	1,237
	Project Cost (10^3 US$)	709,953	711,743	716,637	682,680	623,716	636,749	601,721
Economic Comparison	Annual Economic Net Benefit (B-C) (M.US$/yr)	26.16	22.33	21.27	17.48	-2.53	1.86	-3.36

Notes: 1 The above alternative project layout plans were worked out and compared in the First Field Investigation (January - March 1999). The results of the comrison study are described in the Progress Report No.1 submitted to EVN in March 1999.

2 A discount rate of 10 % is applied to estimate the annual economic benefit (B) and cost (C) as well as the conomic cost per kWh. The economic benefit was measured tentatively assuming that the alternative thermal to the Project would be a coal-fired thermal plant.

3 OPM-1 means the Peak Operation Mode for Dong Nai No.4 Powerstation (Minimum Plant Factor of 0.33).

4 OPM-2 means the Base Operation or Re-regurating Operation Mode for Dong Nai No.4 Powerstation (Minimum Plant Factor of 1.00).

Table E4.4 Economic Comparison of Alternative 2 to Alternative 5

1) OPM-1 : Peak Operation Mode for Dong Nai No.4 Powerstation (Minimum Plant Factor of 0.33)

Alternative Layout Plan	Total of Dong Nai No.3 and No.4					Annual Economic Benefit (B) (M.US$/yr)	Annual Economic Cost (C) (M.US$/yr)	Annual Economic Net Benefit (B-C) (M.US$/yr)
	Installed Capacity (MW)	Firm Energy (GWh/yr)	Secondary Energy (GWh/yr)	Total Energy (GWh/yr)	Project Cost (M.US$)			
Alternative 2 (2-b)	457	1,306	186	1,493	709,953	121.47	95.31	26.16
Alternative 3	444	1,249	196	1,445	711,743	117.92	95.59	22.33
Alternative 4	442	1,240	198	1,438	716,637	117.41	96.14	21.27
Alternative 5	409	1,189	154	1,343	682,680	108.82	91.34	17.48

2) OPM-2 : Base Operation or Re-regurating Operation Mode for Dong Nai No.4 Powerstation (Minimum Plant Factor of 1.00)

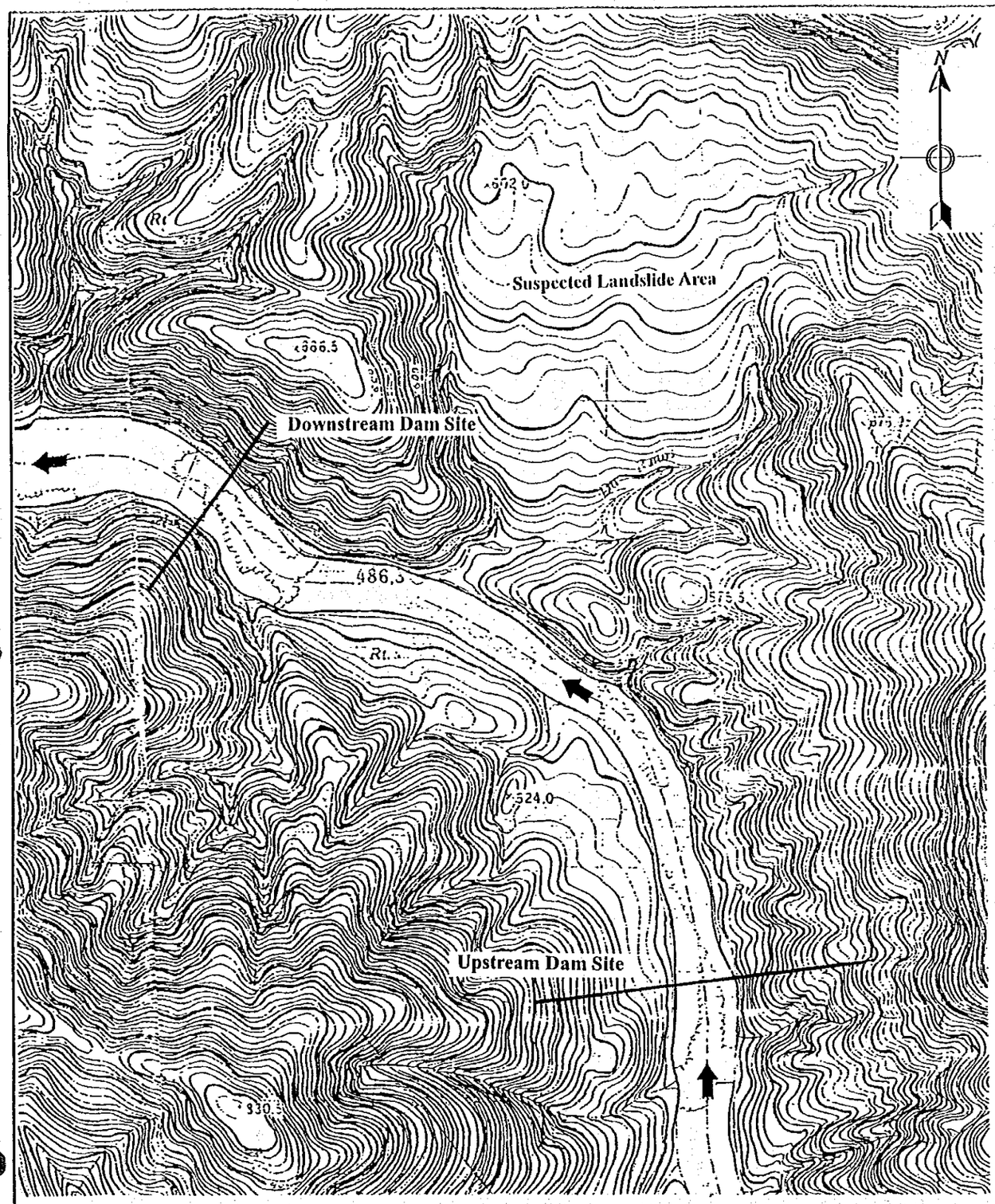
Alternative Layout Plan	Total of Dong Nai No.3 and No.4					Annual Economic Benefit (B) (M.US$/yr)	Annual Economic Cost (C) (M.US$/yr)	Annual Economic Net Benefit (B-C) (M.US$/yr)
	Installed Capacity (MW)	Firm Energy (GWh/yr)	Secondary Energy (GWh/yr)	Total Energy (GWh/yr)	Project Cost (M.US$)			
Alternative 2 (2-b)	282	1,228	101	1,329	623,716	80.90	83.43	-2.53
Alternative 3	312	1,205	107	1,312	636,749	87.21	85.35	1.86
Alternative 4	271	1,139	98	1,237	601,721	77.16	80.52	-3.36

Notes: 1. The above alternative project layout plans were worked out and compared in the First Field Investigation (January - Maarch 1999). The results of the comrison study are described in the Progress Report No.1 submitted to EVN in March 1999.

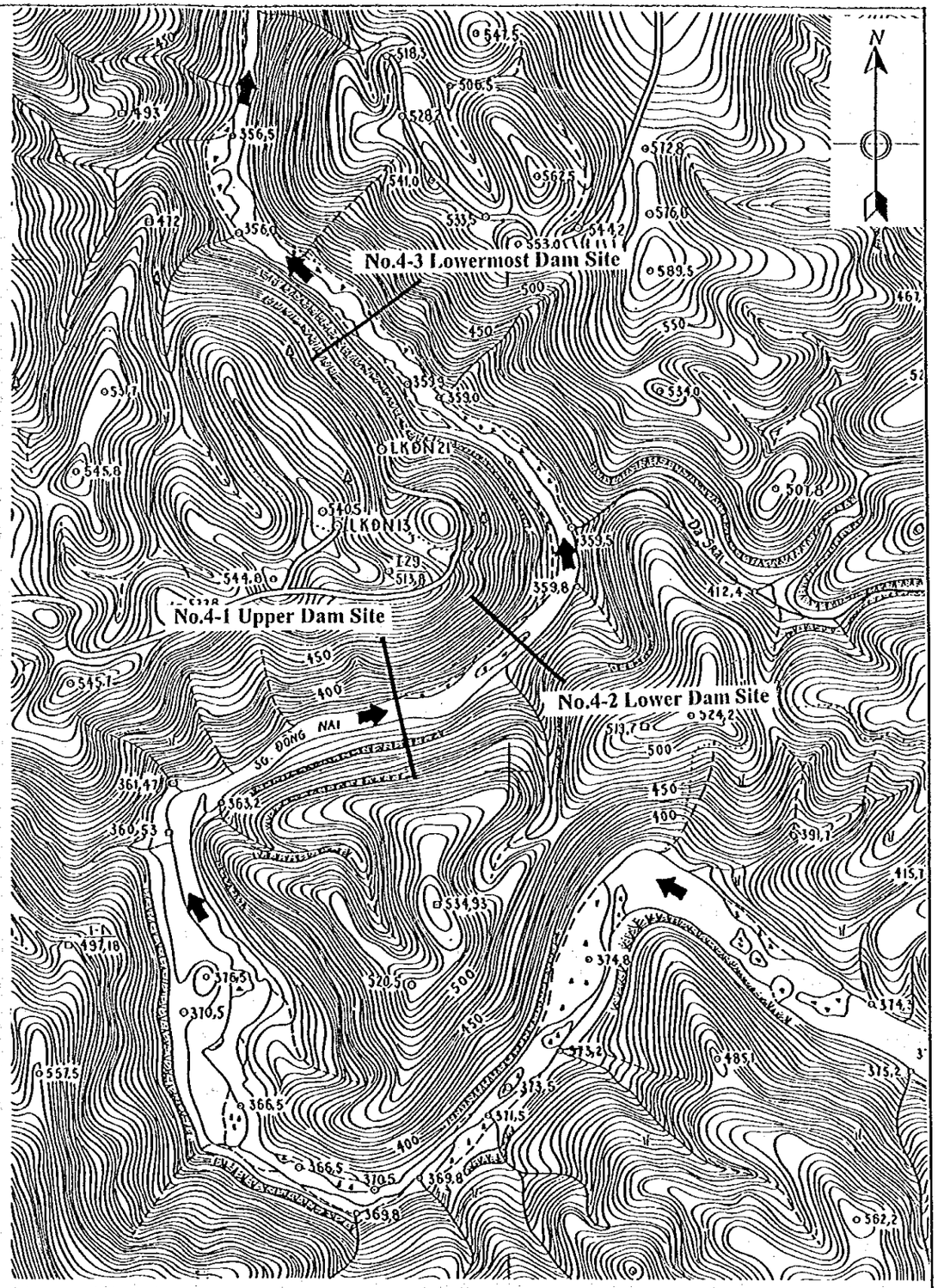
2 A discount rate of 10 % is applied to estimate the annual economic benefit (B) and cost (C) as well as the conomic cost per kWh. The economic benefit was measured tentatively assuming that the alternative thermal to the Project would be a coal-fired thermal plant.

Appendix E

Figures

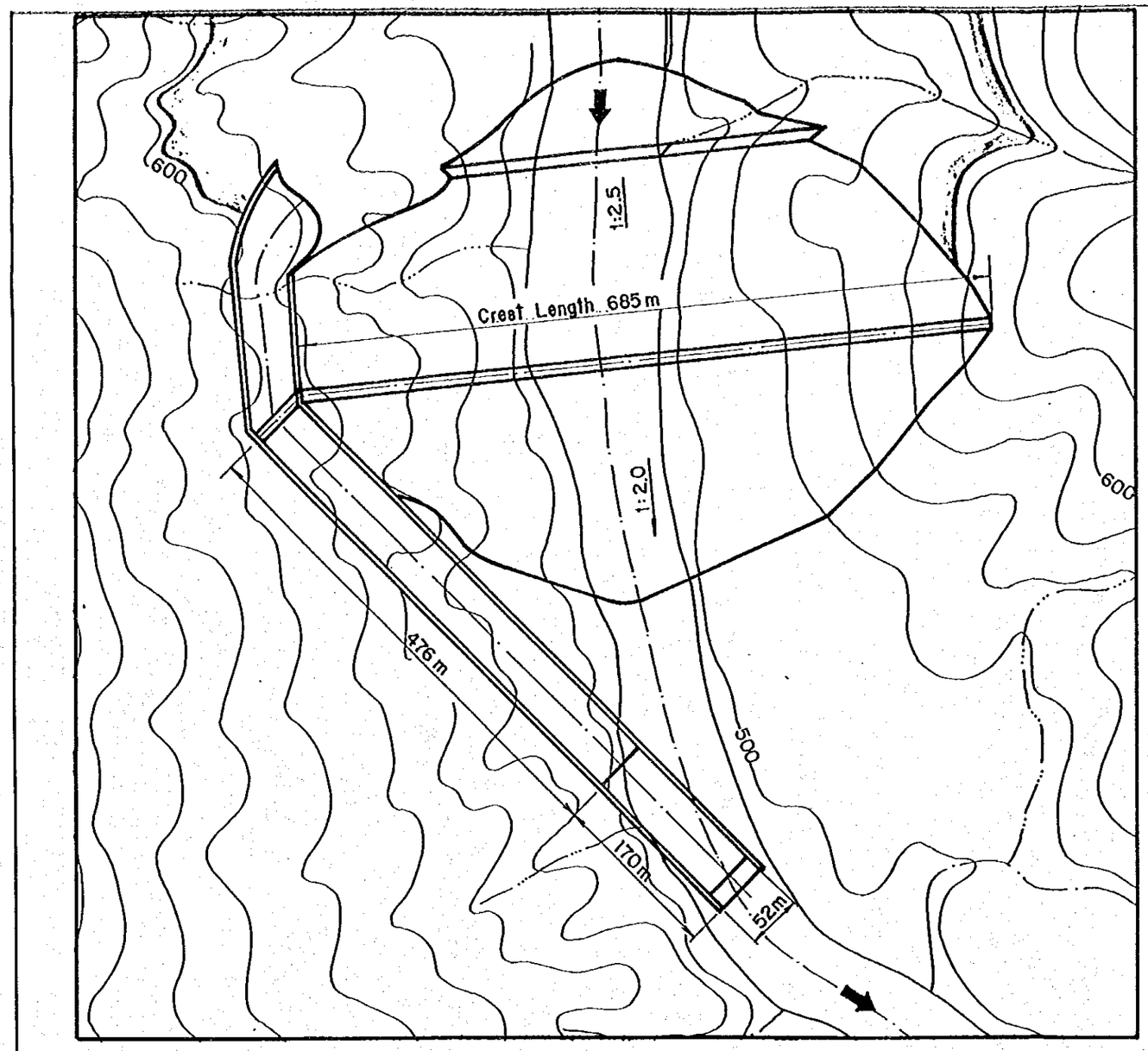


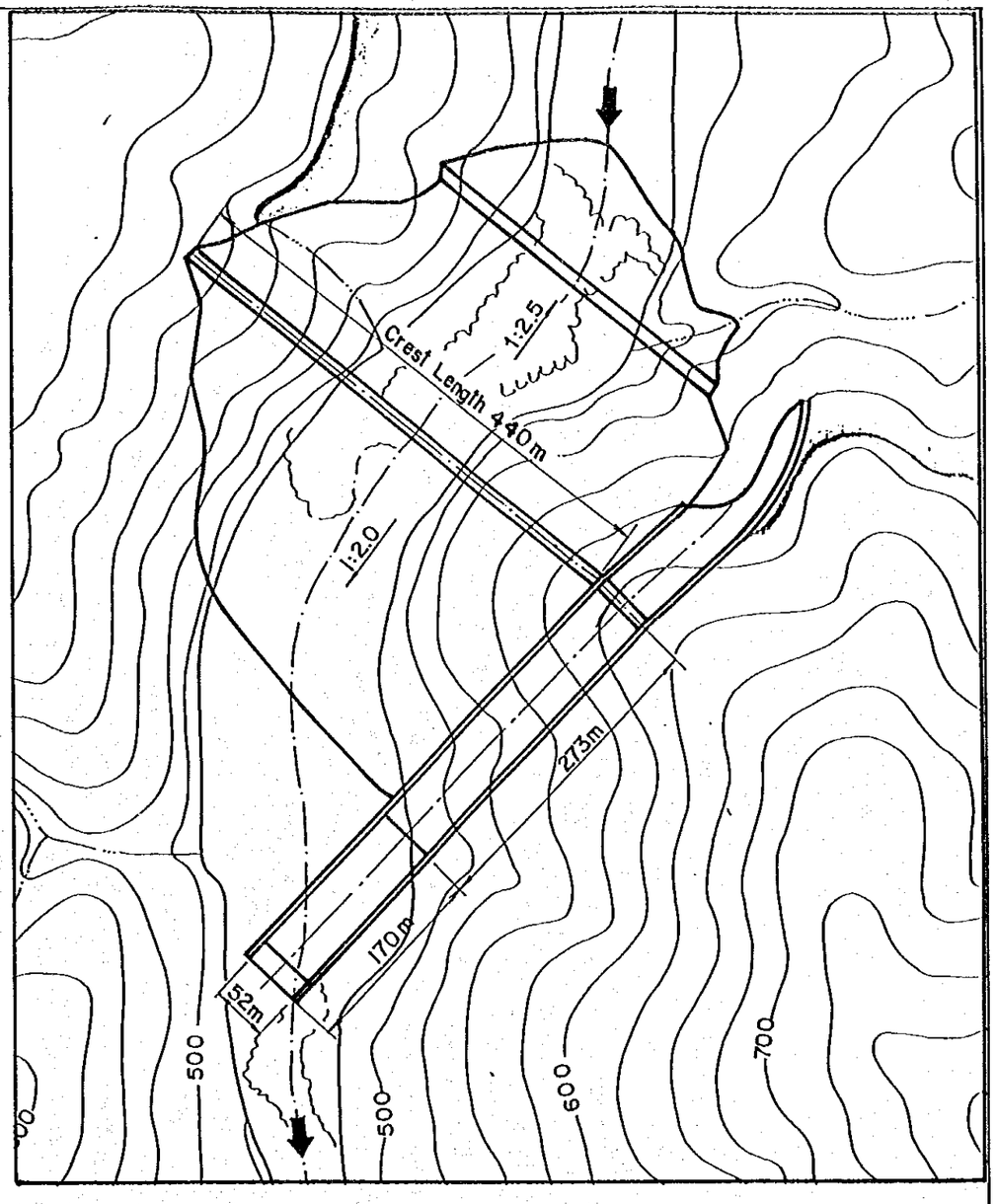
Dong Nai No.3

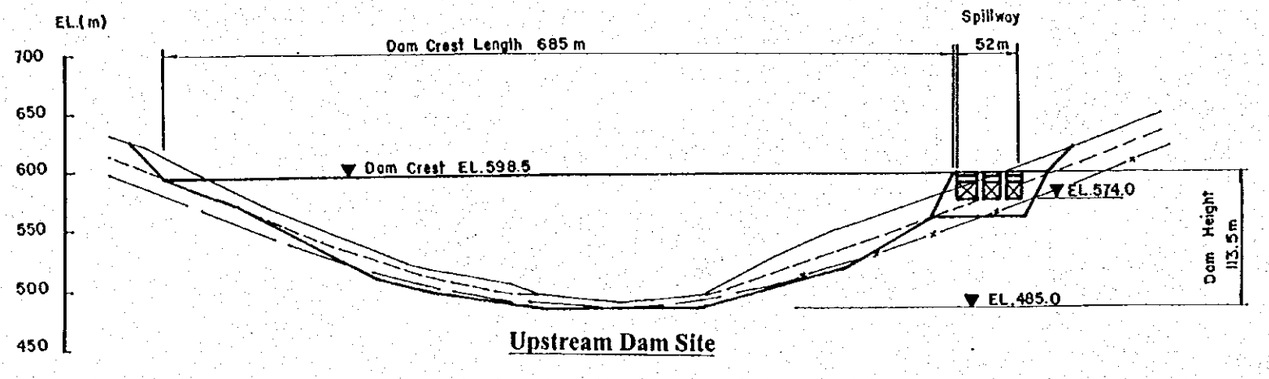


Dong Nai No.4

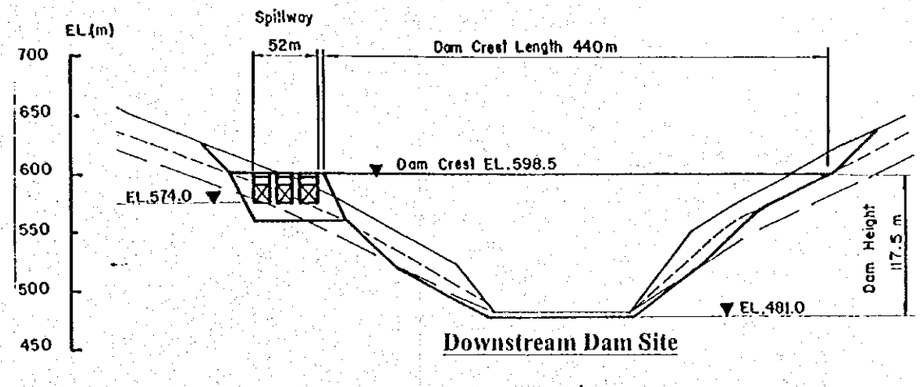
Figure E3.1 Location of Alternative Dam Axes (Scale 1:10,000)





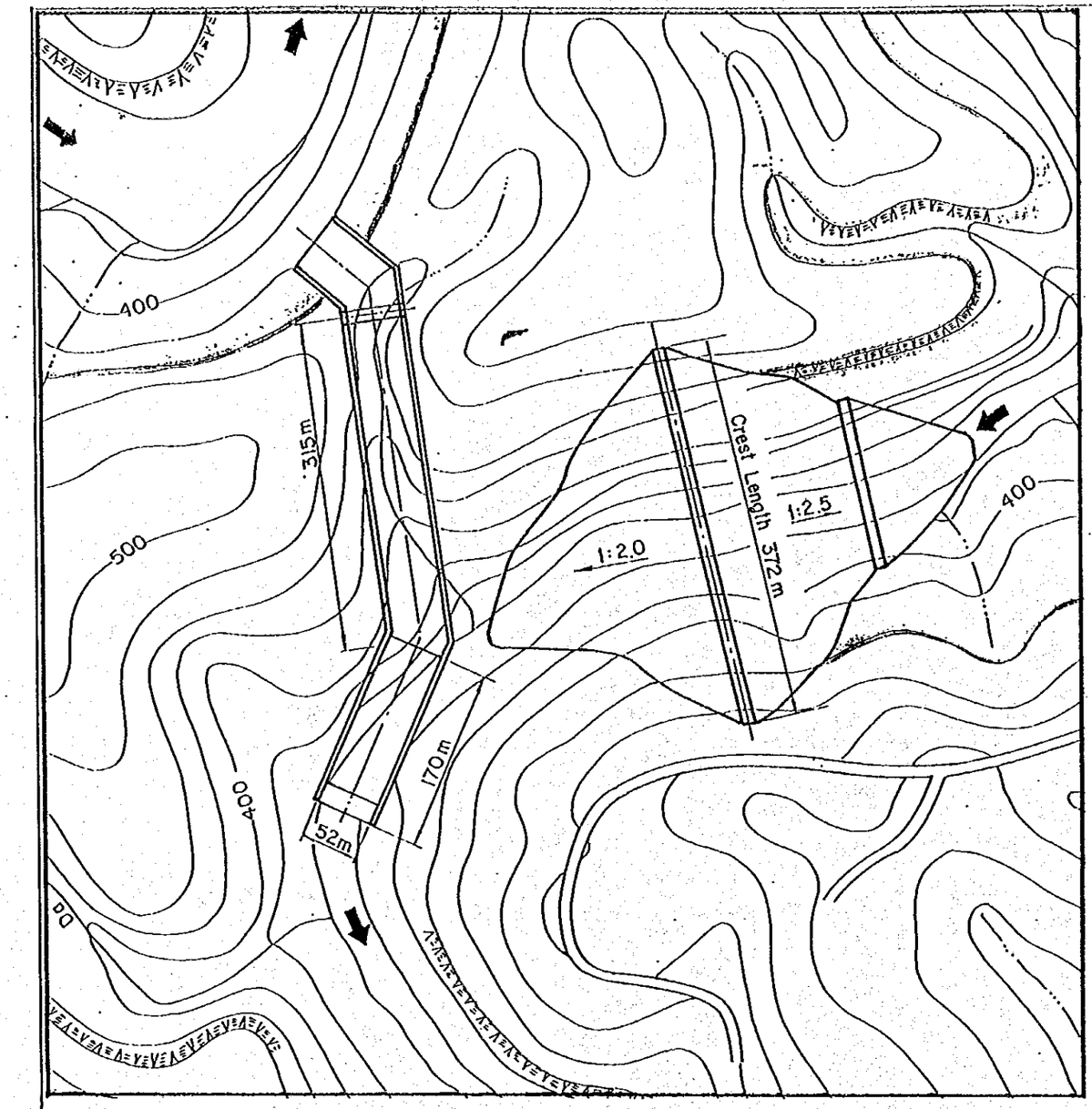


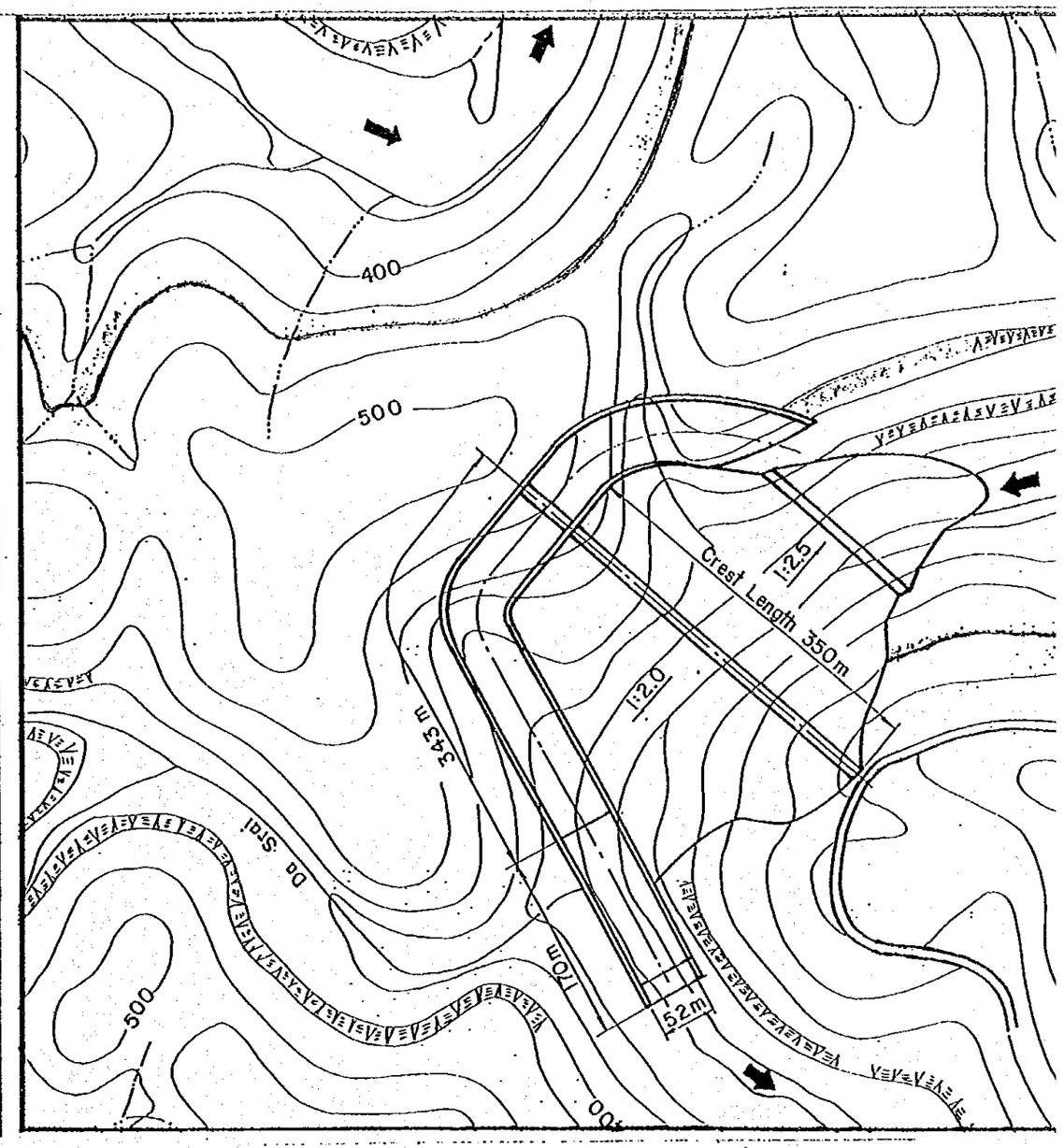
Upstream Dam Site

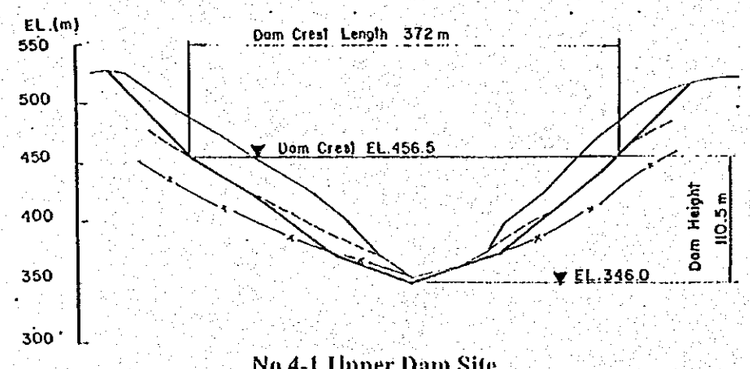


Downstream Dam Site

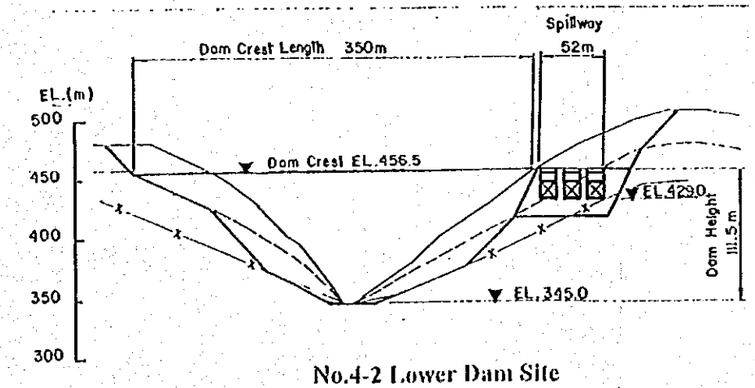
Figure E3.2 Comparison of Dam Axis Selection and Plan (Dong Nai No.3) (1/5,000 based on original 1/10,000 scale map)





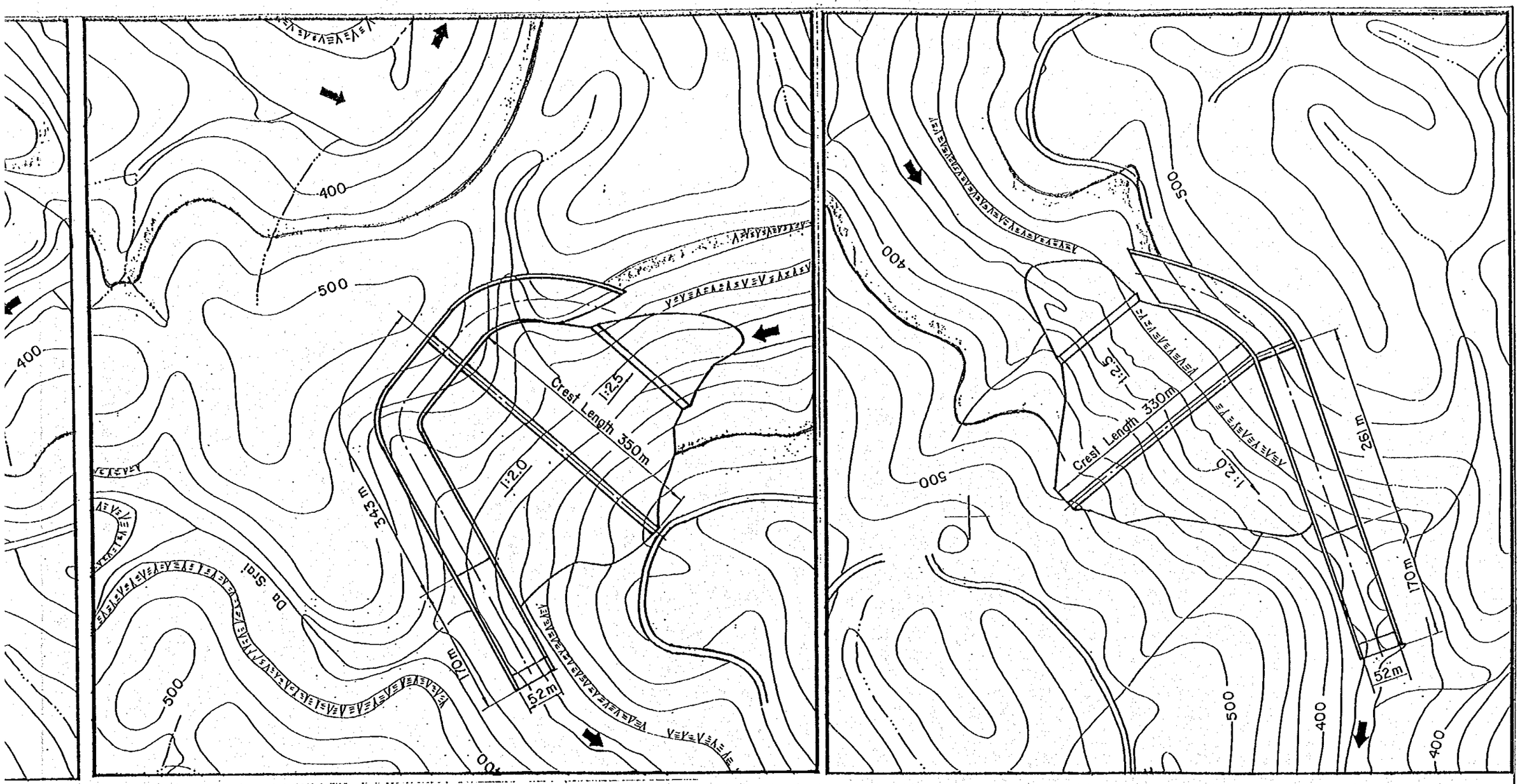


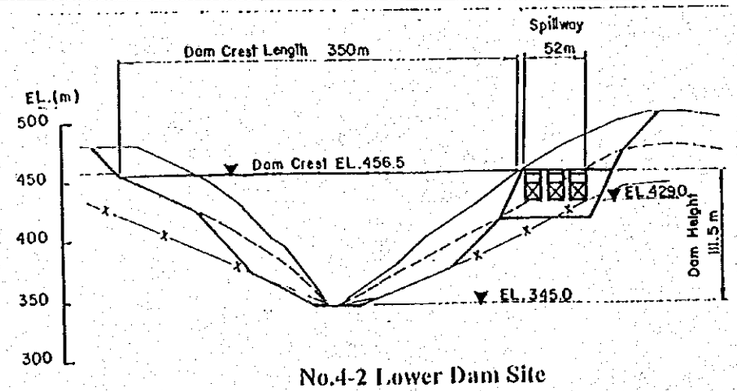
No.4-1 Upper Dam Site



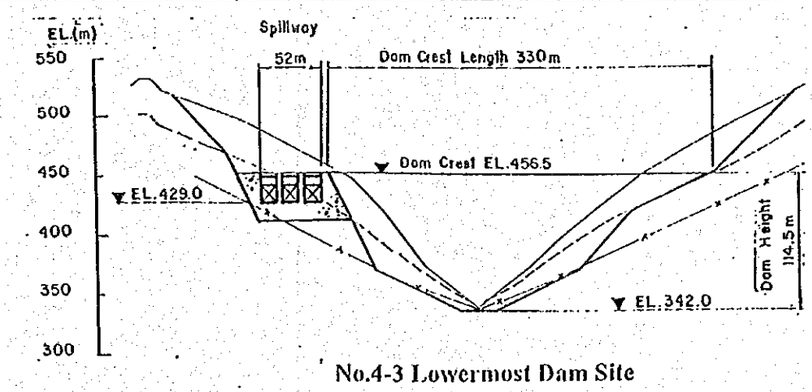
No.4-2 Lower Dam Site

Figure E3.3 Comparison of Dam Axis S





No.4-2 Lower Dam Site



No.4-3 Lowermost Dam Site

Figure E3.3 Comparison of Dam Axis Selection and Plan (Dong Nai No.4) (1/5,000 based on original 1/10,000 scale map)

PLAN (Scale

Power Intake

Reservoir

Headrace Tunnel

Surge Tank

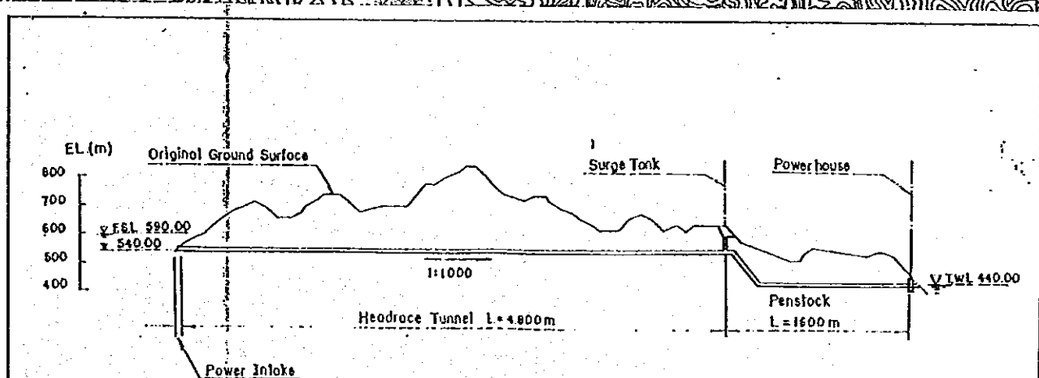
Penstock

Dong Nai No.3

Dam

Powerhouse

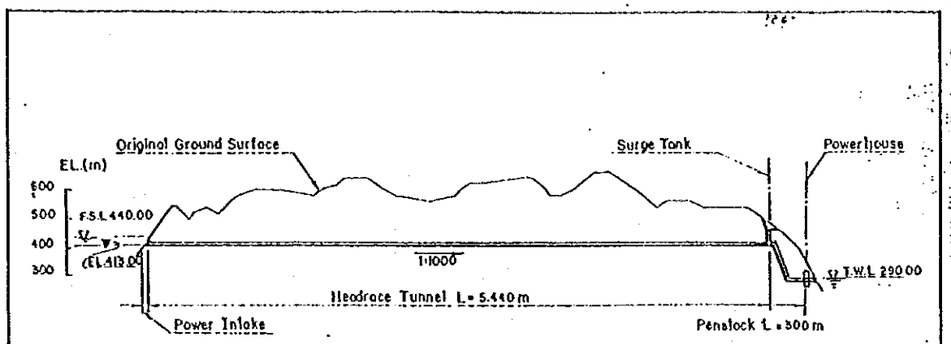
Reservoir



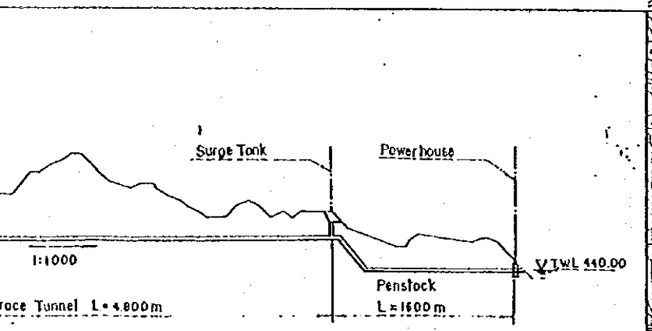
PROFILE OF WATERWAY (DONG NAI No.3)

Scale 1:50,000(H), 1:20,000(V)

PLAN (Scale 1:50,000)



PROFILE OF WATERWAY (DONG NAI No.4)
Scale 1:50,000(H), 1:20,000(V)



PROFILE OF WATERWAY (DONG NAI No.3)
Scale 1:50,000(H), 1:20,000(V)

Reservoir
Surge Tank
Penstock
Powerhouse
Power Intake
Headrace Tunnel
Surge Tank
Powerhouse
Dong Nai No.4
Penstock
Dam