

LEGEND

Symbol	Rock Unit (Member)	Corresponding formation in geologic map	Age
[Blank box]	Riverbed Deposit (Unconformity)		Recent
[Dotted pattern]	(BN-Q ₁) (Unconformity)		Quaternary
[Cross-hatched pattern]	Horblende granodiorite (VpJ3dq)		Proterozoic
[Stippled pattern]	Sandstone, siltstone shale, hornfels (J2ln)		Mesozoic
		Recent	
		Tuo Trung formation	Upper Jurassic
		Dinh Quan formation	Upper Jurassic
		Large formation	Middle Jurassic

- Boundary of strata
- Fault
- Strike and dip of fault
- Strike and dip of sedimentary rock
- Synclinal axis
- Anticlinal axis
- BQ901U --- Geologic prospecting line
- BQ903U ● F/B Bore hole
- 28 --- National road
- Path

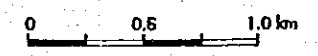
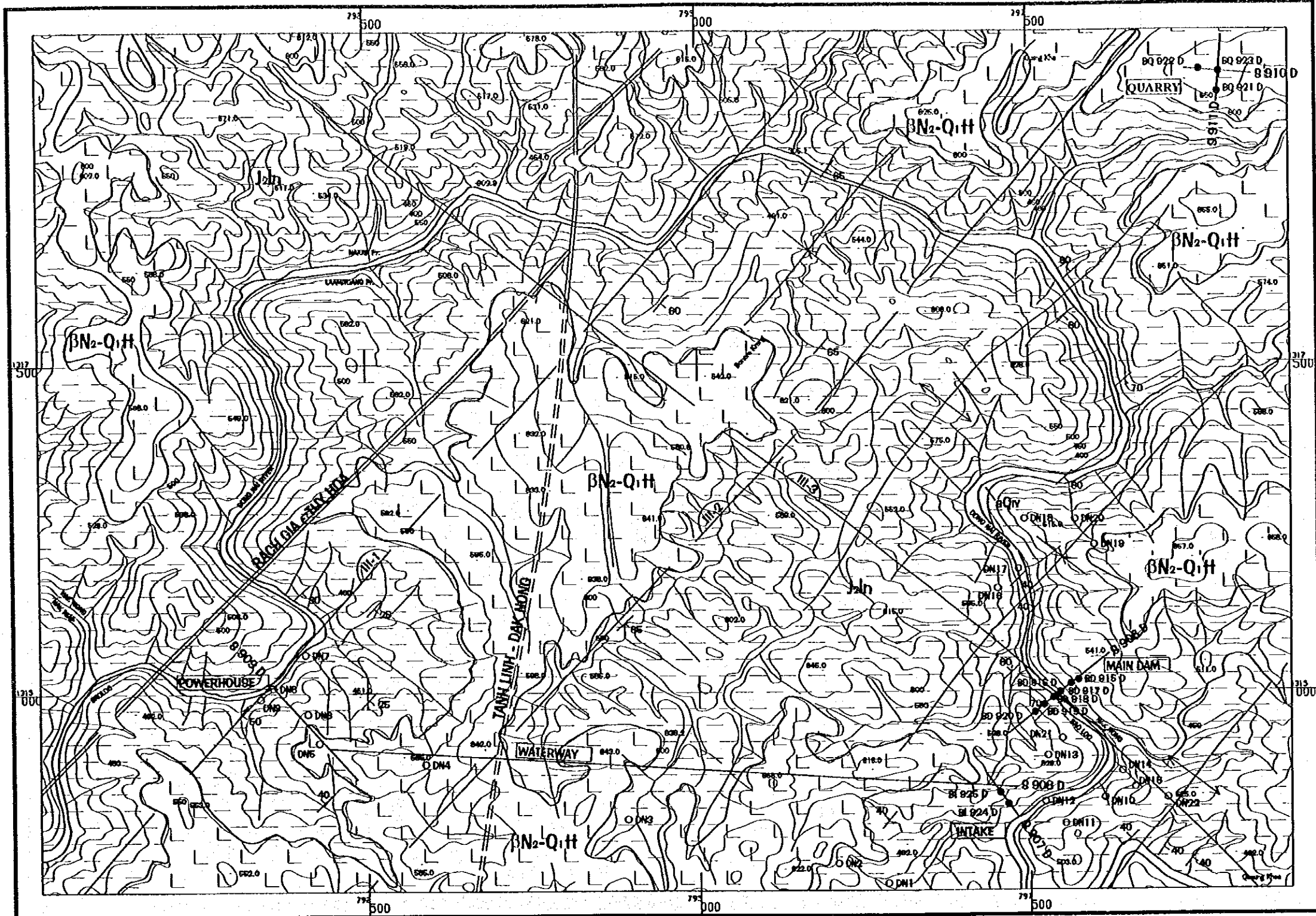


Figure 3.22 Geologic Map of Dong Nai No.3 Site



LEGEND

Symbol	Rock Unit (Member)	Corresponding formation in National geologic map	Age
	Riverbed Deposit (RQ1)		Quaternary
	(Unconformity)		
	Basalt Lava (BN2-Q1H)	Tuo Trung formation	Pli-Pleistocene (Pleistocene)
	(Unconformity)		
	Sandstone, siltstone, shale, hornfels (Jahn)	Large formation	Miocene

- Boundary of strata
- Fault
- Strike and dip of fault
- Strike and dip of sedimentary rock
- Synclinal side
- Anticlinal side
- Seismic prospecting line (F/S)
- Bore hole (Pre-F/S)
- Bore hole (F/S)

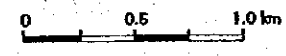
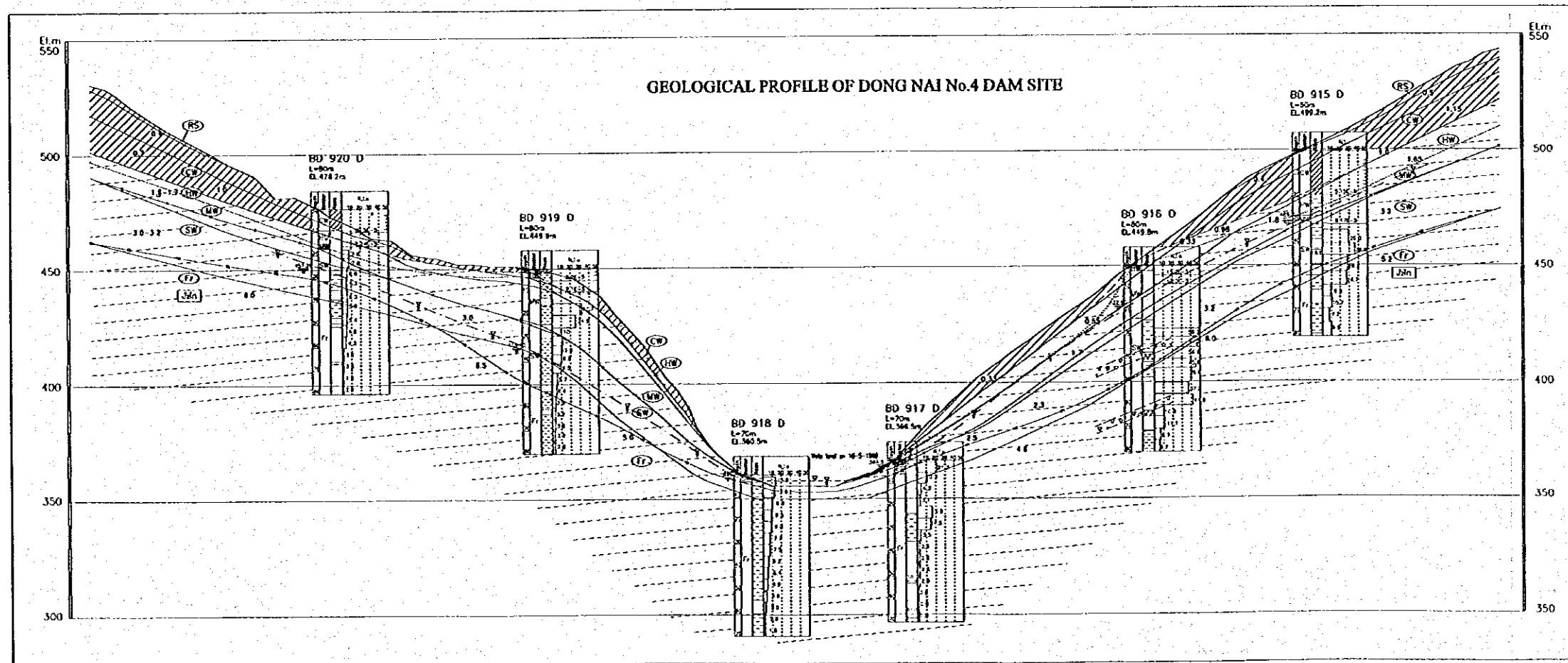
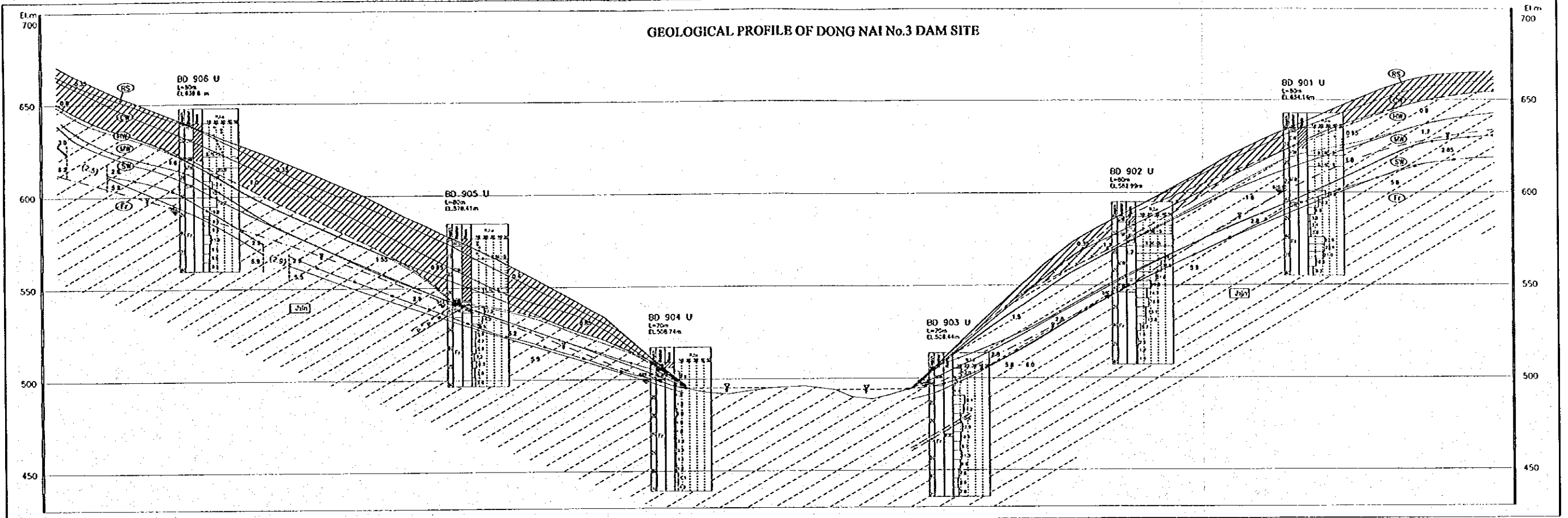






















Figure 3.23 Geologic Map of Dong Nai No.4 Site



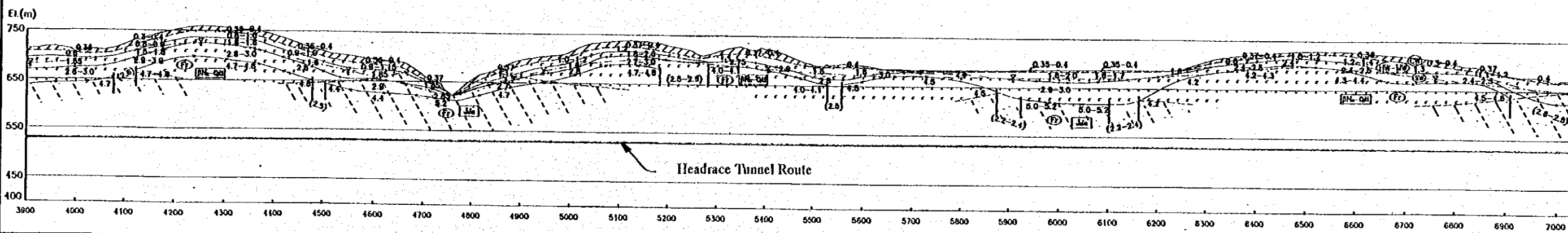
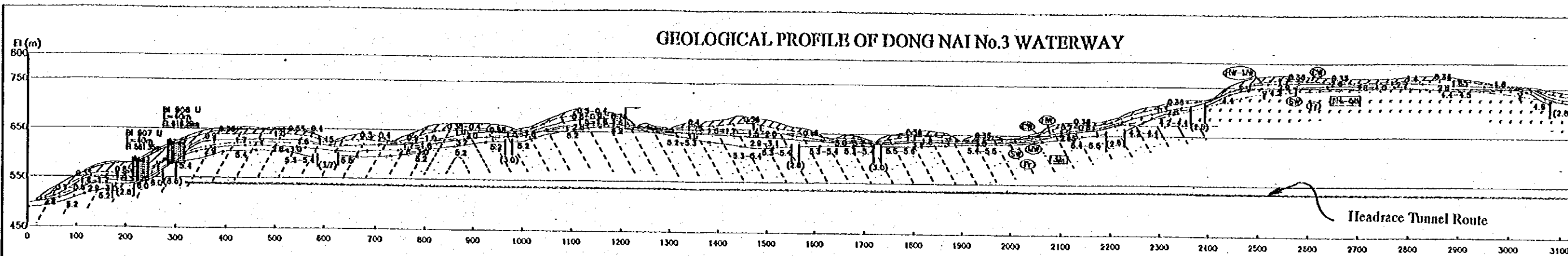
LEGEND

-  Residual soil
-  Completely weathered
-  Highly weathered
-  Moderately weathered
-  Slightly weathered
-  Fresh rock
-  Contact fault
-  Strike slip fault
-  Normal fault
-  Thrust fault
-  Boundary of different rock zone
-  Low velocity zone
-  High velocity zone
-  Geological structure
-  Geological structure
-  Geological structure
-  Geological structure
-  Geological structure
-  Geological structure
-  Geological structure

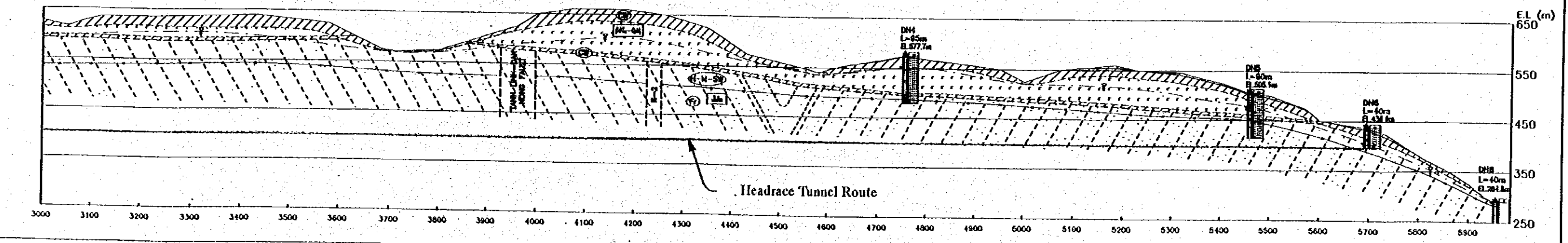
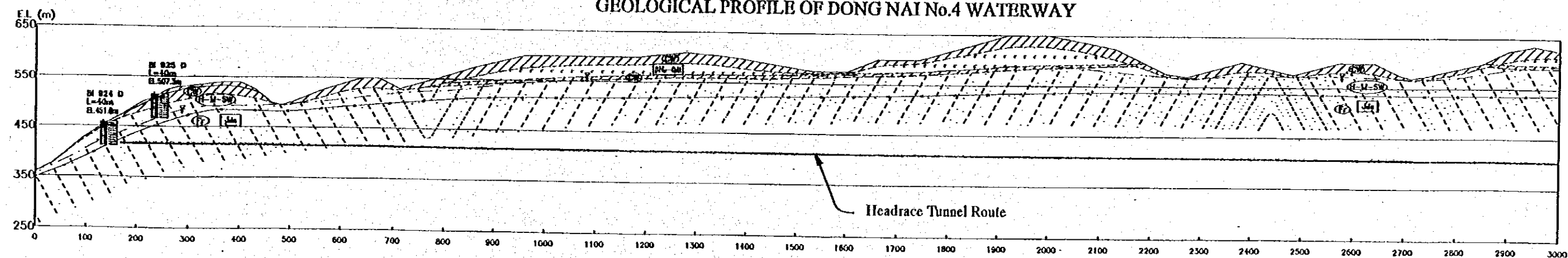
Location of profile line referred to Pa. 3.23, Figure 3

Figure 3.24
Geological Profile of Dong Nai No.3 and No.4 Dam Site

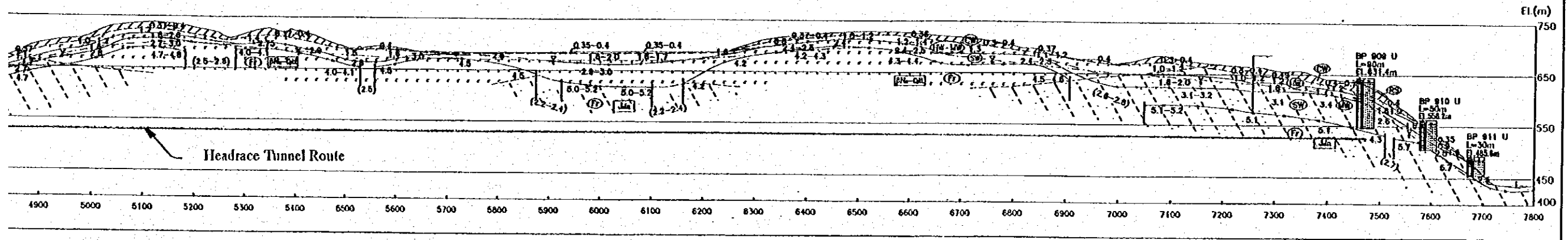
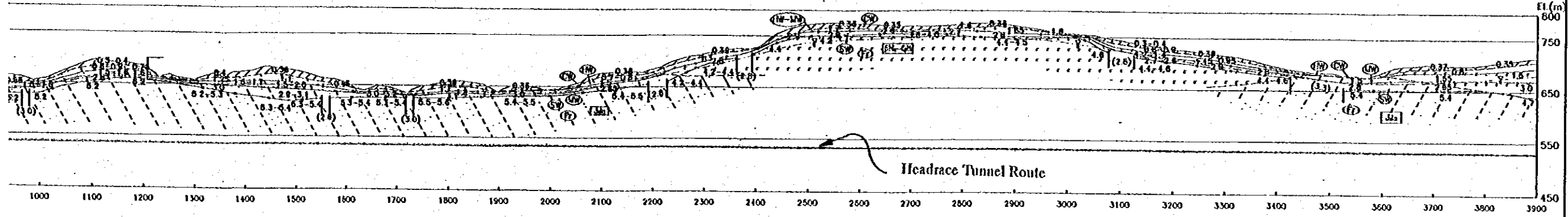
GEOLOGICAL PROFILE OF DONG NAI No.3 WATERWAY



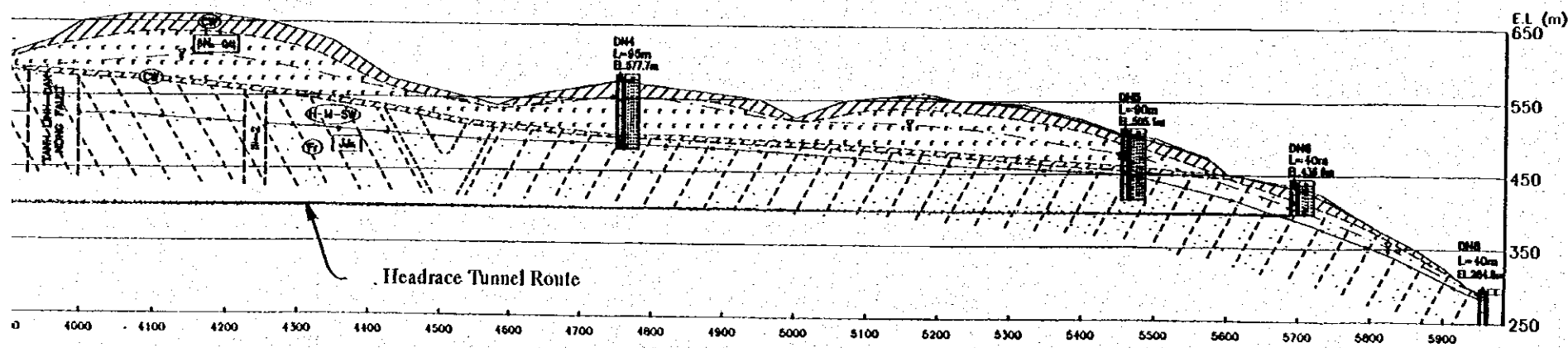
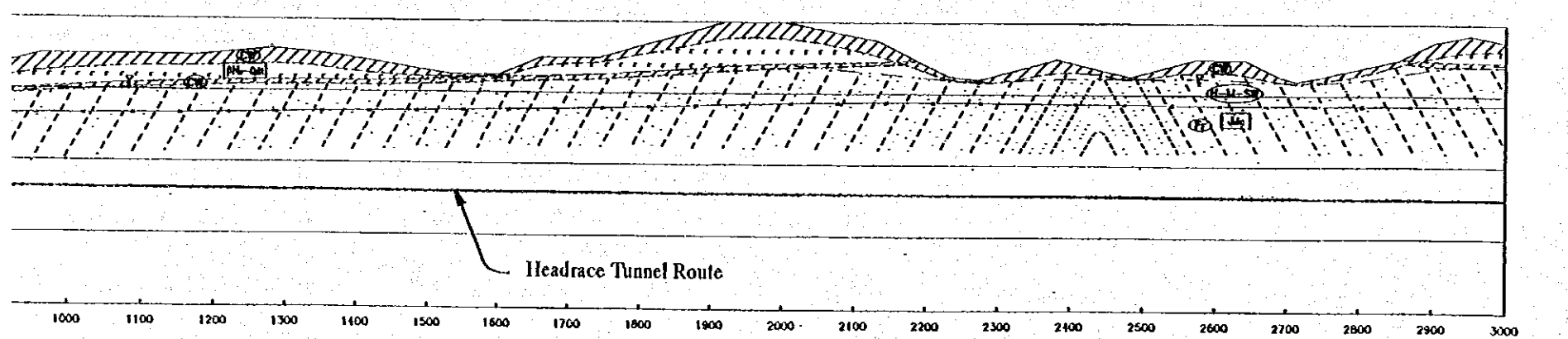
GEOLOGICAL PROFILE OF DONG NAI No.4 WATERWAY



GEOLOGICAL PROFILE OF DONG NAI No.3 WATERWAY



GEOLOGICAL PROFILE OF DONG NAI No.4 WATERWAY



LEGEND

- Top soil, residual soil, completely weathered
- Tuc trung formation : Basalt Lava
- La Nga formation : Sandstone interbedded with shale and siltstone
- Groundwater level
- Fault
- Geological boundary
- Seismic velocity, km/sec
- Low velocity zone, km/sec

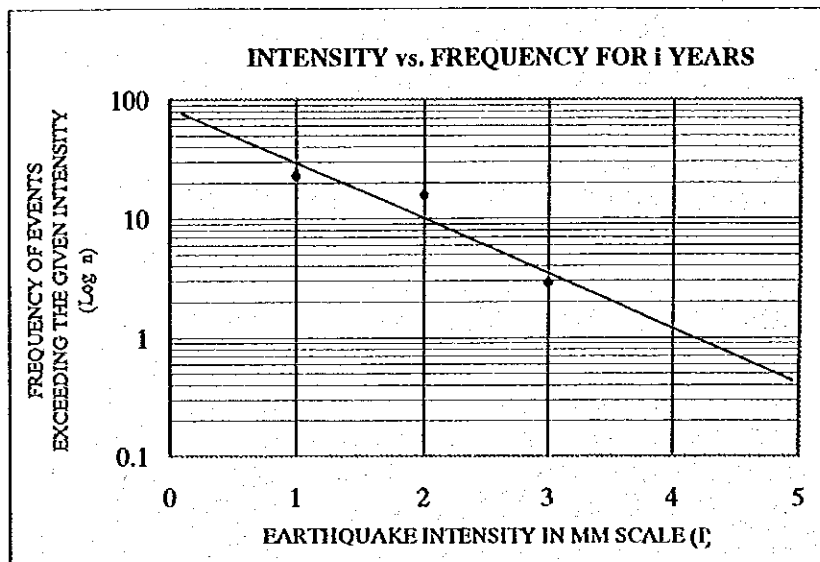
ROCK MASS WEATHERING

- Residual soil
- Completely weathered.
- Highly weathered.
- Moderately weathered.
- Slightly weathered.
- Fresh rock.



Figure 3.25 Geological Profile of Dong Nai No.3 and No.4 Waterway

Intensity	n/70 years	n/100 yrs
1	16	22.85
2	11	15.71
3	2	2.86



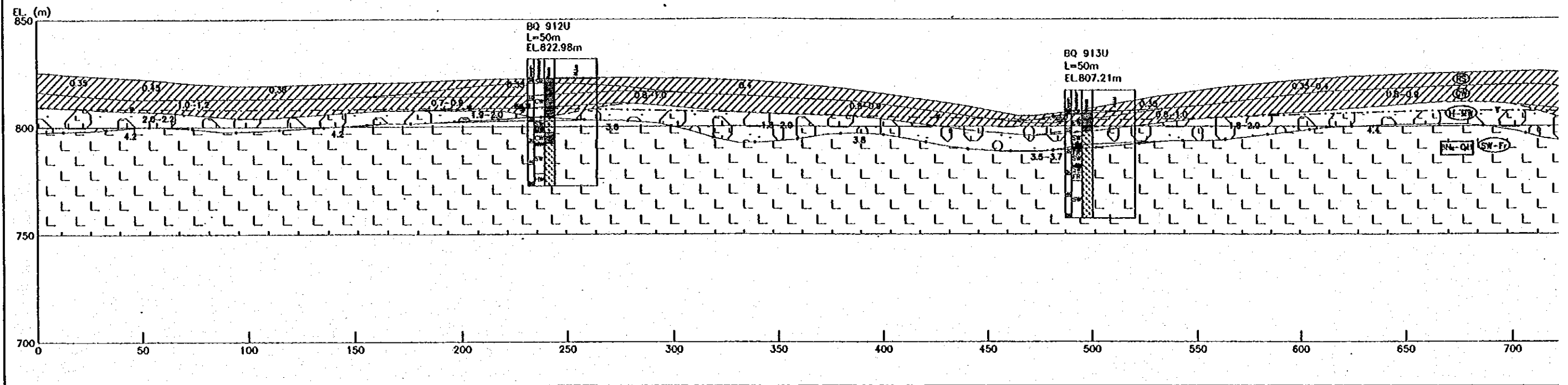
The Probable Maximum Earthquake Intensity (I_{max})
 for 100 years of return period: 4.3
 for 200 years of return period: 4.9

The Probable Maximum Peak Acceleration (a)
 for 100 years of return period: 8.5 gal = 0.009g
 for 200 years of return period: 13.8 gal = 0.014g

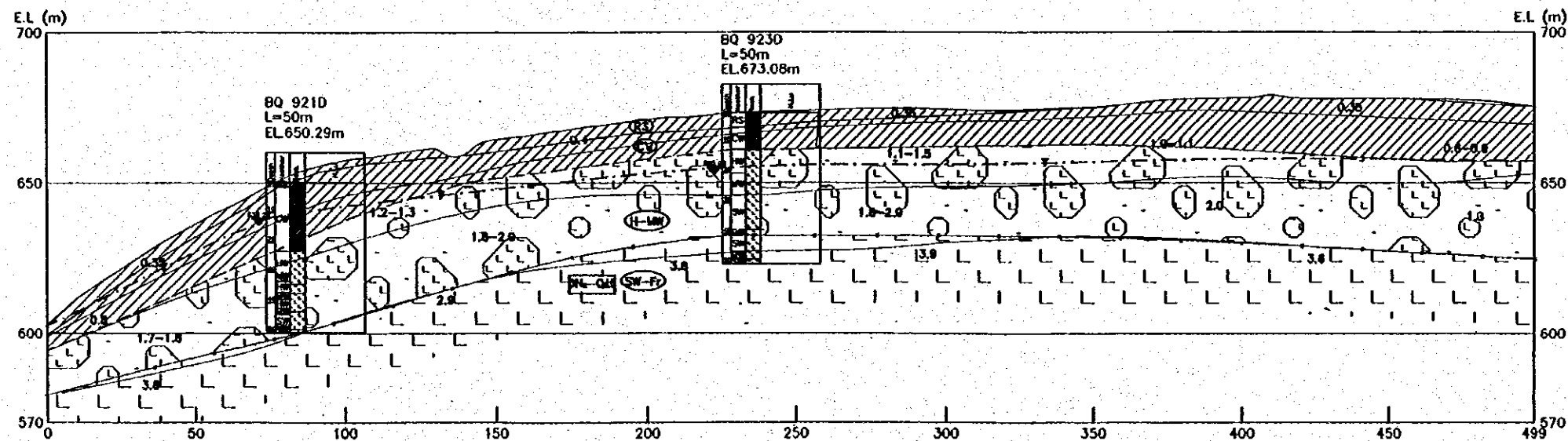
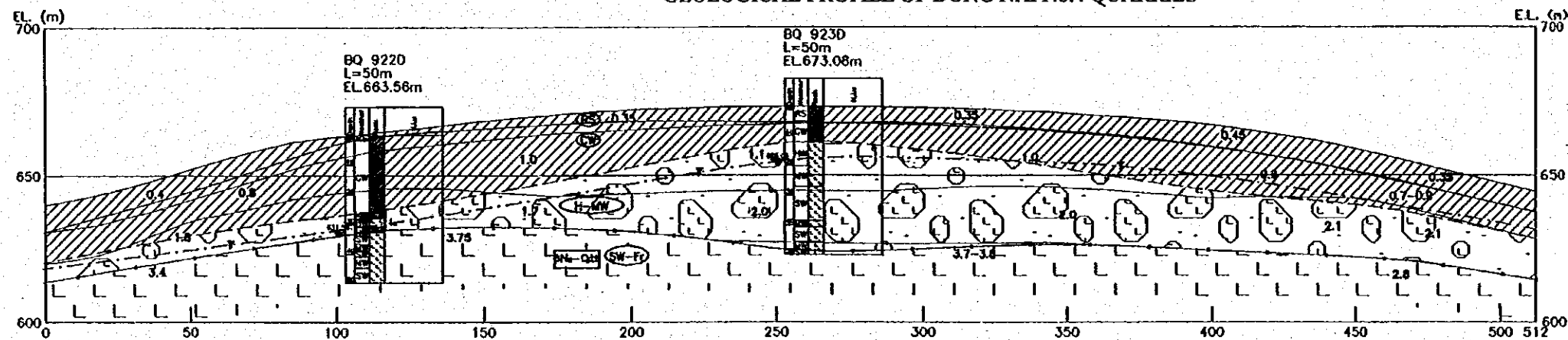
c) $a = I_{max}/3 - 0.5$

Figure 3.26 Earthquake Frequency Analysis for Dong Nai No.3 and No.4 Dam Sites

GEOLOGICAL PROFILE OF DONG NAI No.3 QUARRY

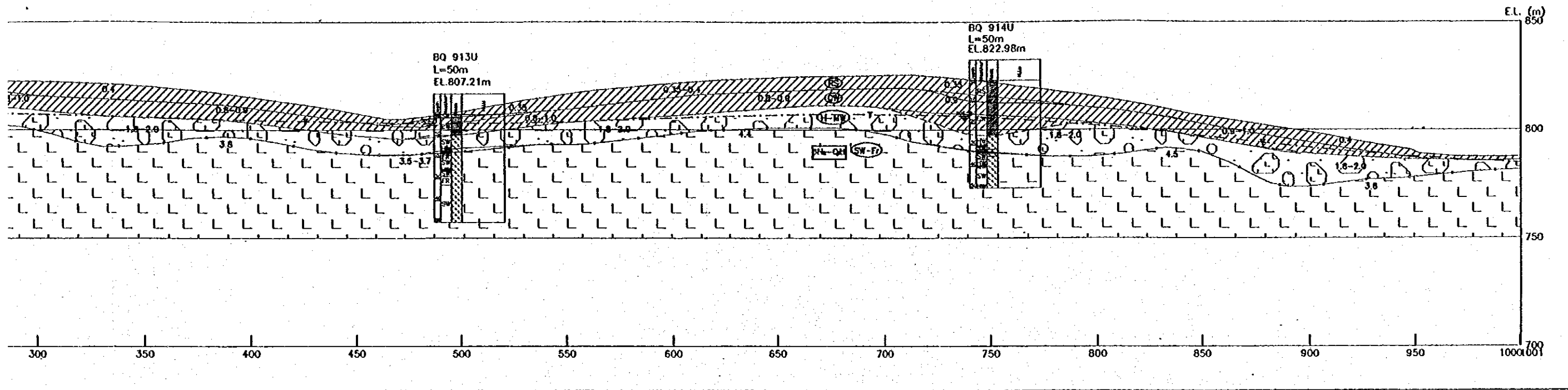


GEOLOGICAL PROFILE OF DONG NAI No.4 QUARRIES

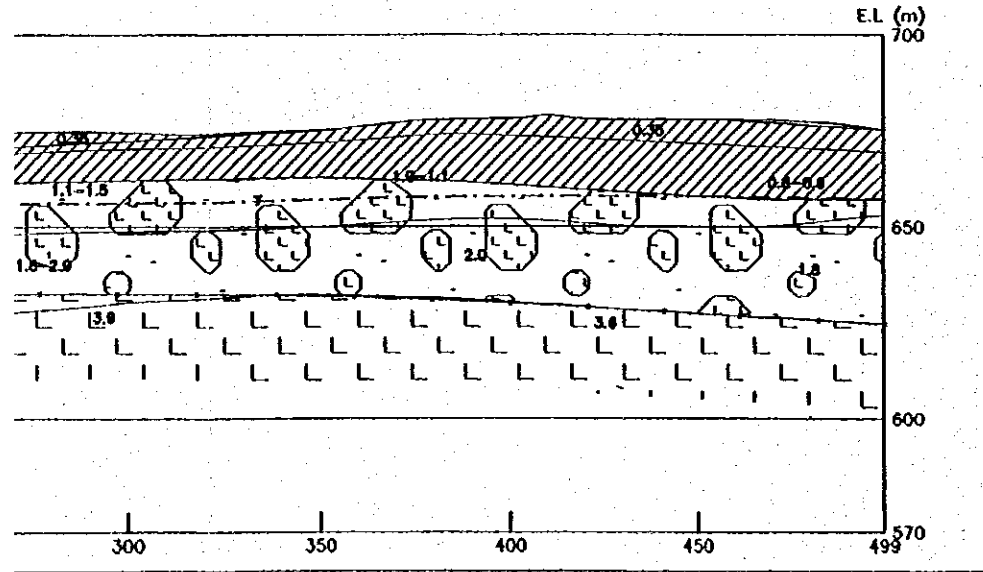
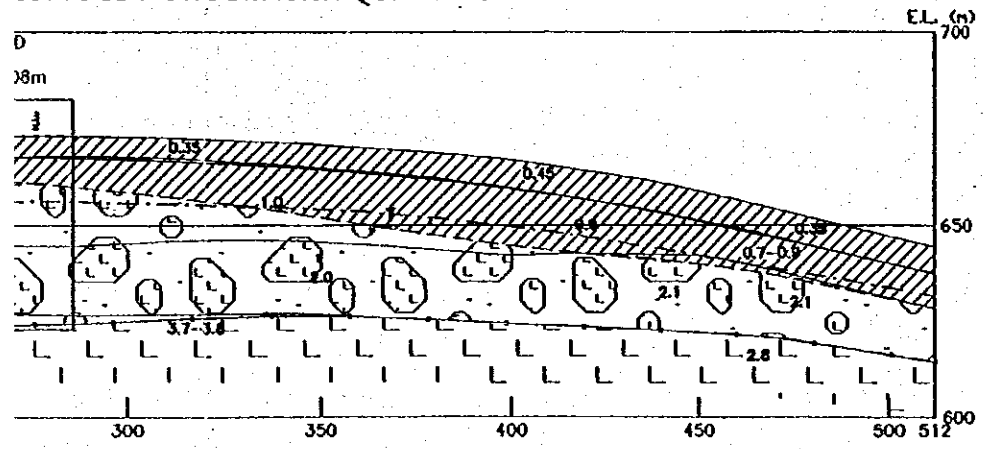


- LEGEND**
- Top soil, residual
 - Tuc trung format
 - Groundwater level
 - Boundary of diffe
 - Seismic velocity,

GEOLOGICAL PROFILE OF DONG NAI No.3 QUARRY



PROFILE OF DONG NAI No.4 QUARRIES



LEGEND

- Top soil, residual soil, completely weathered.
- Tuc trung formation: Basalt Lava
- Groundwater level.
- Boundary of different velocity zone.
- Seismic velocity, km/sec

ROCK MASS WEATHERING

- Residual soil
- Completely weathered.
- Highly-Moderately weathered.
- Slightly Weathered-Fresh rock.

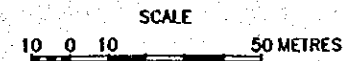
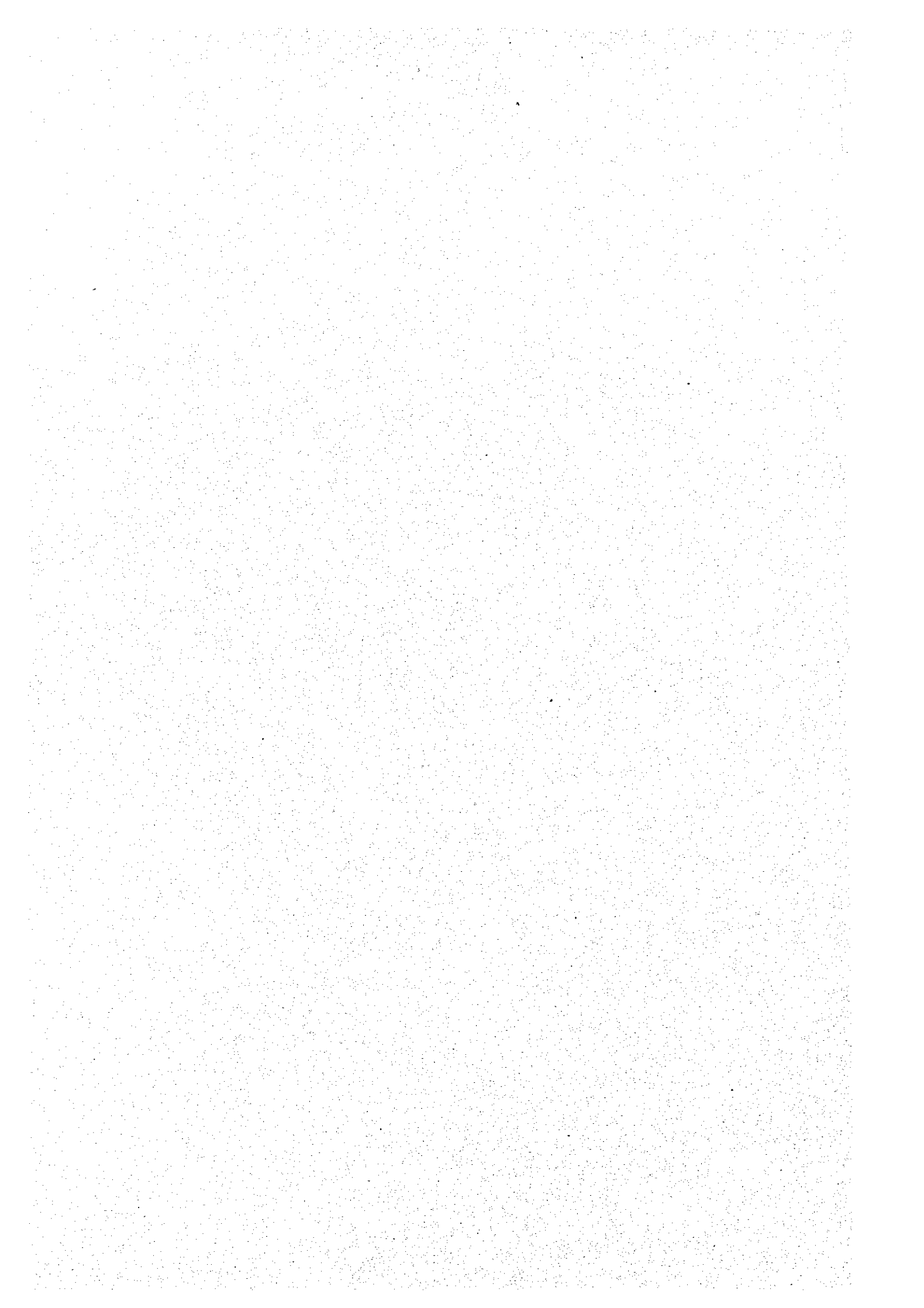
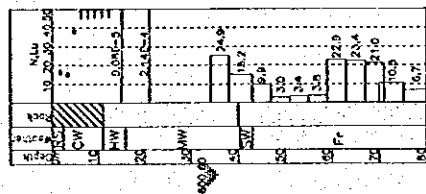


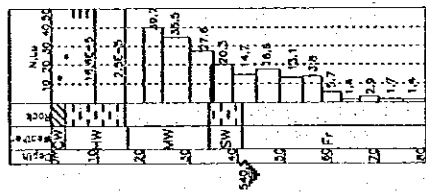
Figure 3.27 Geological Profile of Dong Nai No.3 and No.4 Quarries



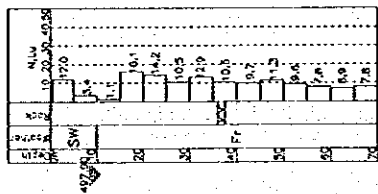
BD 901 U
L=80m
EL.634.14m



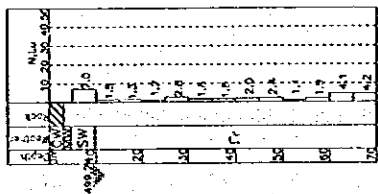
BD 902 U
L=80m
EL.582.99m



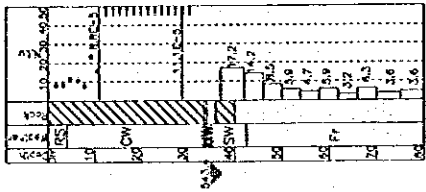
BD 903 U
L=70m
EL.506.44m



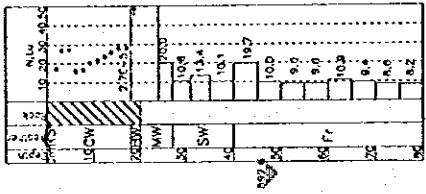
BD 904 U
L=70m
EL.508.74m



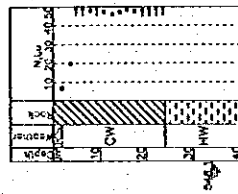
BD 905 U
L=80m
EL.578.41m



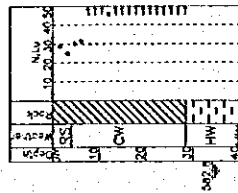
BD 906 U
L=80m
EL.639.8 m



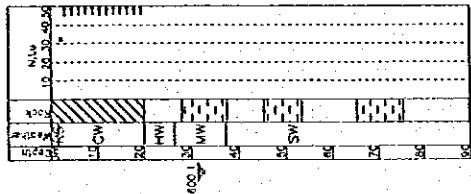
BI 907 U
L=40m
EL.581.34m



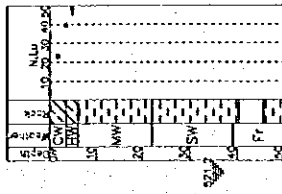
BI 908 U
L=40m
EL.616.29m



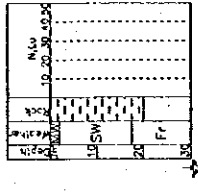
BP 909 U
L=80m
EL.631.4m



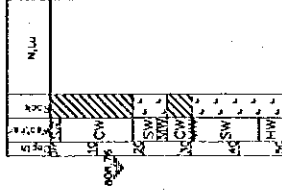
BP 910 U
L=50m
EL.556.2m



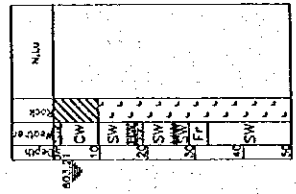
BP 911 U
L=30m
EL.485.6m



BQ 912 U
L=50m
EL.822.36m



BQ 913 U
L=50m
EL.807.21m



BQ 914 U
L=50m
EL.822.98m

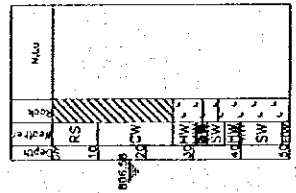
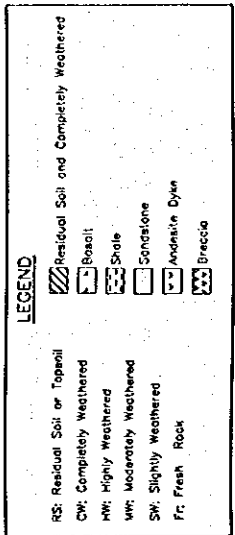


Figure 3.28
Summary of Drilling Result
Including Permeability Test
(1/2)



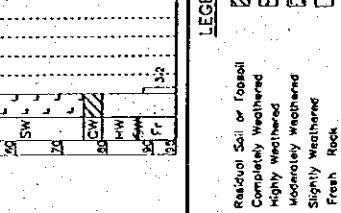
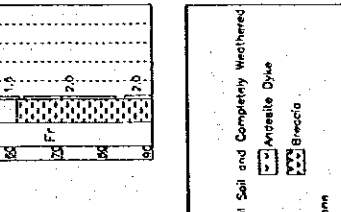
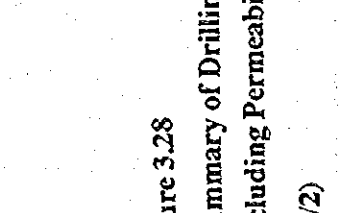
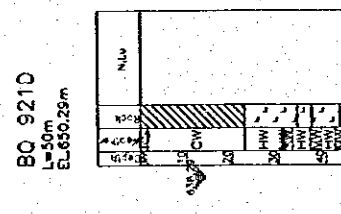
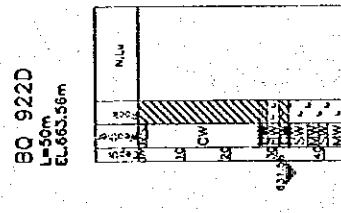
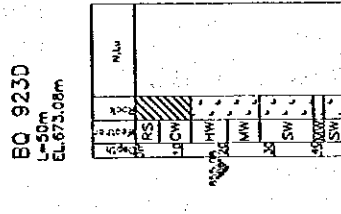
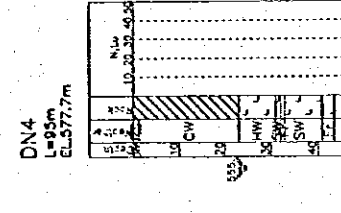
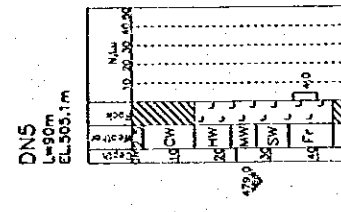
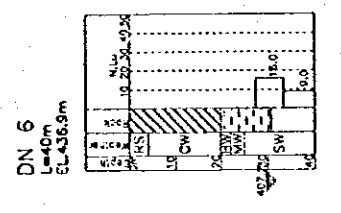
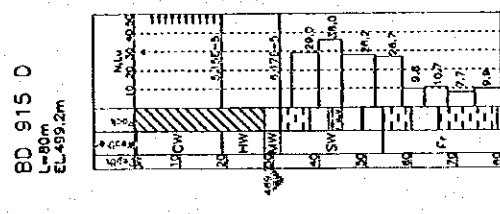
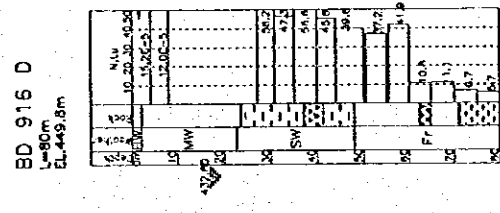
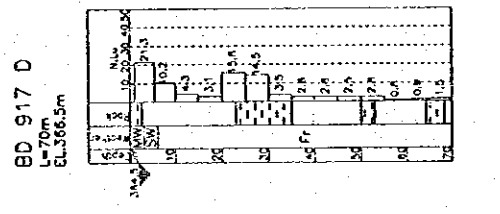
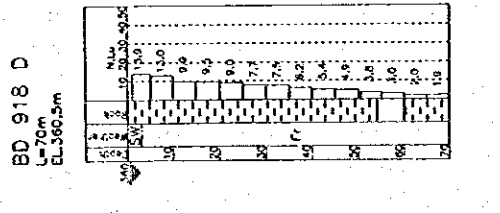
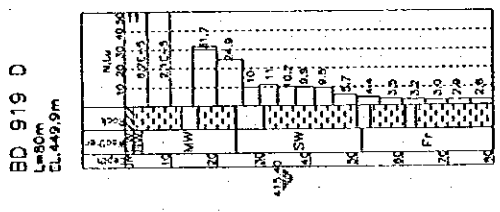
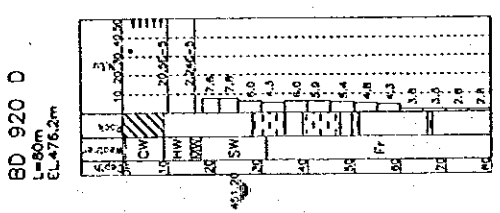


Figure 3.28
Summary of Drilling Result
Including Permeability Test
(2/2)

LEGEND

RS: Residual Soil or Fossil	Residual Soil and Completely Weathered
CW: Completely Weathered	Basalt
HW: Highly Weathered	Shale
MW: Moderately Weathered	Sandstone
SW: Slightly Weathered	
Fr: Fresh Rock	

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 Breccia

CHAPTER 4 ENVIRONMENTAL ASSESSMENT

4.1 General

4.1.1 Approach Adopted for Environmental Assessment

In the First Field Investigation that spanned between the middle of January and middle of March 1999, the environmental survey for the initial environmental examination (IEE) including the field reconnaissance to the Project site was carried out. The initial field survey framed the key environmental items on which the detailed field investigations were scheduled to be performed in the subsequent field investigation stages.

In the Second and Third Field Investigations, the environmental assessment and resettlement studies for this Feasibility Study were carried out taking a full account of the results of the IEE in the First Field Investigation and to satisfy requirements of the relevant laws and regulations of Vietnam as well as various guidelines of international lending agencies as much as possible.

In this regard, the field investigations by the local contractor (PECC2) under subcontract from the JICA Study Team during this investigation stage were a key factor to satisfy requirements of the relevant laws and regulations of Vietnam while specialist review of the field investigation results by the Environmental Expert of the JICA Study Team was another important commitment to brush up the results and satisfy requirements of the Vietnam side as well as international lending agencies.

Appendix D in Supporting Report contains a summary of the data that was collected in desk-top and field studies by the local contractor (PECC2) during the Second and Third Field Investigations. These study results were reported in the EIA and RAP reports prepared by the local contractor. It is envisaged that the Vietnamese version of these reports is expected to be prepared by EVN, with necessary revisions thereafter and through incorporation of the final results of this feasibility study. It would be utilized by the pertinent regulatory authorities during their consultation period to approve the Environmental Impact Assessment (EIA) and the Resettlement Action Plan (RAP).

The Appendix in Supporting Report is also prepared so as to supplement additional detailed information to assist understanding of this Chapter.

4.1.2 Historical Perspective

The Tri An dam lies 200 km downstream of the planned Dong Nai No.4 reservoir. Ham Thuan and Da Mi dams, presently under construction, lie on tributaries of the Dong Nai River.

The planned Dong Nai No.3 reservoir and dam will result in the flooding of some homes and some agricultural fields of only three communes, namely, the Dinh Trang Thuong commune (Di Linh District, Lam Dong Province) and the Dak Plao/Dak Som commune (Dak Nong District, Dak Lak Province). In 1998, the Dak Plao commune was subdivided into the Dak Plao and Dak Som communes. This was a consequence of the growing population of Dak Plao, mainly from immigrants entering the area. Over 90% of the population belong to the Ma minority ethnic group. This ethnic group originates

from the southern central plateau area of Vietnam and colonised the commune areas in 1975 after the cessation of war hostilities. They are historically semi-nomads who practice a non-sustainable shifting agricultural regime (slash and burn).

The planned Dong Nai No.4 reservoir and dam would be located within commune land belonging to the Loc Bac commune (Bao Lam District, Lam Dong Province) and the Quang Khe commune (Dak Nong District, Dak Lak Province). Impoundment of the reservoir would not lead to the flooding of any homes or privately owned or managed land belonging to these communes as shown in Figure 4.1.

Gia Nghia is the nearest town to the proposed Dong Nai No.3 and No.4 Combined HPP. The town is about 150 km north of HCMC and reached via National Highway No.13 and 14. The National Highway No.28 connects Gia Nghia with the eastern margins of the Dong Nai No.3 proposed reservoir.

4.1.3 Dong Nai No.3 Reservoir Area

The Dong Nai River flows through the planned Dong Nai No.3 reservoir area at an elevation of about 500 +/- 20m. At a FSL of El.590 m, the reservoir would occupy an area of about 56 km². The only communes impacted by flooding of the reservoir are the Dak Plao, Dak Som and Dinh Trang Thuong. Almost all of the Dak Plao/Dak Som commune infrastructure will be flooded. The main commune area of Dinh Trang Thuong is situated about 12 km upstream of the planned reservoir and outside of the flooded area. The impacted members of this commune are seasonal migrants who enter the planned reservoir area to grow rice, coffee, fruit, and vegetables. Almost all of the Dak Plao/Dak Som communes live below the 550m elevation, as crops grow best below this contour. In 1998 the district census indicated that 168 households (comprising 1,065 persons) would lose both home and agricultural fields. A further 98 households (comprising 651 persons) would lose fields but not homes. In 1998 the district census for Dinh Trang Thuong shows that 89 households (comprising 318 persons) would lose homes and fields. A further 29 households (comprising 112 persons) would lose fields. The average size of field plots per household is 2 to 10 ha. Within the Dak Plao/Dak Som commune there is widespread forest destruction and the cleared land is used for agricultural production, mostly coffee. Remnant (highly disturbed) gallery forest still persists alongside the Dong Nai River, and it is not expected to survive the next decade owing to the excessive exploitation of this resource in the area. Above 600 m elevation there is still widespread distribution of forest, owing to the smaller concentration of inhabitants above this elevation.

Northeast of the planned reservoir area, the land rises first gradually and then steeply to 1,500 m and peaks at the top of mount Ta Dung, which has an elevation of El. 1,982m as shown in Figure 4.2. Much of this escarpment rising to 1,500 m is covered by pine forest.

However, to the west of the planned reservoir area much of the forest is bamboo, which is representative of degraded, and what was previously, hard wood Dipterocarp forest. To the west of the Dong Nai No.3 reservoir, better quality evergreen/mixed deciduous Dipterocarp forest is still widespread.

Flooding of the reservoir, in addition to requiring the relocation of about 257 households

(representing 1,383 persons), almost all of whom live below 550 m elevation, will result in the destruction of remnant gallery hard wood forest, which is important animal habitat, and degraded bamboo forest. The number of households that need to be relocated is small in comparison to similar sized hydropower projects elsewhere in the world. The resettlement plan and compensation measures will significantly reduce the impacts on the affected population, and provide them with better living conditions and a sustainable agricultural regime. The loss of mostly river gallery forest is an impact common to any hydropower project. However, as the river basin of the Dong Nai No.3 area is excessively exploited by shifting agriculture, and has no significant populations of endangered animals or birds, which have either left the area or been hunted to destruction, the potential environmental impacts are limited both in space and scale.

4.1.4 Dong Nai No.4 Reservoir Area

The Dong Nai No.4 reservoir development potential impacts differ significantly both qualitatively and quantitatively and require careful consideration as compared with the Dong Nai No.3.

In comparison to the Dong Nai No.3, the Dong Nai No.4 reservoir adjoining areas are thickly forested and consequently accessibility is poor resulting in very low human population numbers and density. The general area of Dong Nai No.4 contains the boundaries of only two communes, namely the Loc Bao (close to the dam site) and Quang Khe (north of the proposed location of the powerhouse). Impounding the Dong Nai No.4 reservoir would submerge only government owned land, amounting to about 4 km².

The Dong Nai River flows within a steeply sided and inclined narrow gorge with the maximum width of about 40m, which descends about 160 m in 30 km. Within the planned reservoir area, the river descends from about the 445m elevation to 360m elevation in a longitudinal distance of about 19km. At the FSL of 440m, the reservoir would occupy an area of 4.2 km². To the southwest of the gorge, its escarpment rises steeply to a maximum elevation of about 1,100m. To the northeast of the gorge, its escarpment rises to about 730m as shown in Figure 4.3. The faces of the southwest and northeast escarpment are covered in dense Dipterocarp (evergreen) forest.

4.2 Reservoir Population and Resettlement Plan

4.2.1 Socio-Economic Situation of Villages in the Dong Nai No.3 and No.4 Reservoir Areas

(1) Dong Nai No.3 Reservoir Area

(i) General

The impounded area for the planned Dong Nai No.3 reservoir contains the boundaries of 7 communes as shown in Table 4.1 and Figure 4.1. However, not all of the communes own homes or other assets within the planned No. 3 reservoir area.

During 1997/1998, the Dak Plao commune was split into the Dak Plao and Dak Som communes, and the Loc Lam commune was subdivided into the Loc Lam and Loc Phu communities. The subdivision was necessary for administrative purposes owing to the increase in the population size due to immigration from outlying locations. The immigrants comprised shifting agriculturists practicing slash and burn agriculture.

The Dak Plao and Dak Som communes are the largest public group that will be affected by the Dong Nai No.3 reservoir impoundment. They own land, homes and other assets that will be flooded by the reservoir impoundment. The Dinh Trang Thuong hamlets comprise a small splinter semi-nomadic group, which seasonally migrates away from the main commune location. This splinter group has temporary homes and shifting agricultural fields in the Dong Nai No.3 reservoir area to plant and harvest cash crops such as coffee and groundnuts, and to grow rice and vegetables as the staple crop. The main residential area of the Dinh Trang Thuong commune is about 12 km upstream of planned Dong Nai No.3 reservoir.

The Phoc Tho commune, which is generally upstream of the planned Dong Nai No.3 reservoir, has a boundary that slightly penetrates the reservoir area. This commune's boundary occupies only 1.5 km² of the planned reservoir area and the land taken by impounding the Dong Nai No.3 reservoir is all forested land, which is owned by the government. No individual from this commune will lose any asset due to impounding the Dong Nai No.3 reservoir. Likewise, no individual from the Quang Khe commune will lose any land due to impounding the Dong Nai No.3 reservoir. Only 17.7 ha of the commune's area, comprising mostly government owned forest, will be impounded by the Dong Nai No.3 reservoir. No individual from the Loc Lam and Loc Phu communes owns homes or land within the planned area of Dong Nai No.3 reservoir.

It might be noted that the Quang Khe commune boundary straddles both the planned the Dong Nai No.3 and No.4 reservoir areas (see Figure 4.1).

The range of compensation items owned or belonging to inhabitants living in the Dak Plao, Dak Som and Dinh Trang Thuong communes in the planned Dong Nai No.3 reservoir area is summarised in Tables 4.2 to 4.4.

Almost all of the impacted households (flooded households) and owned agricultural fields lie below 550 m elevation and impounding Dong Nai No.3 would require the resettlement of about 257 households (representing about 1,383 persons). The diversion tunnels, waterway tunnels and powerhouses would not require the purchase of any privately owned property. It might be appreciated that the numbers of households that need to be

resettled are very small in comparison to similar sized hydropower projects constructed elsewhere in the world.

About 85% of the population living in the communes affected by Dong Nai No.3 and No.4 developments belong to the Ma ethnic minority tribe as shown in Tables 4.5. The Ma ethnic minority tribe predominates in the rural areas. The majority tribe in the Districts is the Kinh. The Kinh are predominantly town-dwelling people, with jobs in the service and industry sectors. Very few live among the rural impoverished communes. The Kinh tribe represents about 5% of the population in the rural communes, but over 60% of the population at the level of the District as shown in Table 4.6.

The Ma tribe is historically nomadic and practiced slash and burn agriculture on the southern western plateau area. Traditionally they relied on harvesting timber from forests to build homes and prepare fields for growing rice and other staple foods. In 1975, after the cessation of war hostilities, the tribe migrated into the central highlands and gradually moved southwards into the southern central highlands. Members of the tribe colonised the Dong Nai No.3 reservoir area after 1975, and the population has increased steadily since the 1980's mainly from immigration and not from the birth rate. The Ma tribe is not indigenous to the Dong Nai No.3 reservoir area.

Agricultural production throughout the three relevant districts and the 7 communes is based on rice, sweet potato, yams and maize as the staple food item, and coffee and tea as the cash crop. About 10% of the land area is under agricultural management.

From the demographic data available for the 7 communes, apparently 9,444 persons live within the close proximity of the proposed Dong Nai No.3 reservoir, and 3,530 live within close proximity of the proposed Dong Nai 4 reservoir. The large population living close to the Dong Nai No.3 reservoir has a significant impact on the forests. About 80% of the commune area is covered by forest. However the forest is low value bamboo, and bamboo is an indicator of disturbed forest. Bamboo develops as a direct result of commercial forest clearance and managed agriculture.

(ii) Socio-economic survey done at this stage

The District and Provincial Statistical Yearbooks provide only basic qualitative and quantitative estimations of the socio-economic conditions within the communes. The data are not substantive. A detailed socio-economic survey, comprising sampling 20% of the population, was undertaken between February 1999 and August 1999 by the local contractor (PECC2) under the contract with JICA Study Team. The results of the census are shown in Table 4.7.

The data show that the number of persons per household ranges from 6 to 8 persons. The average home is built of wood or thatch and has an average floor space of 30 m².

Typically each family has 2 to 10 ha of cultivated land, commonly comprising coffee, rain-fed rice, tubers and fruit. Livestock rearing is also practiced (chickens, cattle, goats and pigs). Arable land is prepared from cleared forests. Fishing has no importance to the livelihood of the communes, and they wish to remain as agricultural workers.

The major cause of illness and death is malaria and diarrhea. Malaria, dengue fever, diarrhea, measles, mumps and whooping cough are common diseases in children.

Medical facilities are very basic, and medicines are not readily available in the communes. Dak Plao has a health center, which serves the entire community. Three paramedics staff the center and a doctor visits the commune on a monthly basis. The closest medical centre to Dak Plao and Dinh Trang Thuong is at Gia Nghia, but this too can only provide basic health care. The Dal Lak province has only one general hospital with 500 beds, and Da Lat (Lam Dong Province provincial center also has a general hospital). These general hospitals are not easily accessible to the communes at the Dong Nai No.3 reservoir, who would need to travel over a 100 km to reach the general hospitals. The Loc Phu /Loc Lam commune is served by 3 paramedics.

The availability of public transport is seasonal, that is mainly in the dry season. In the rainy season the poor state of the flooded non-tarred roads prevents buses from operating in and out of the communes.

Most children attend primary school up to the age of about 14, whilst older children help the parents in the fields. The existing primary school facilities are close to the commune. Each commune has at least one primary school. Secondary schools are restricted to areas having a Kinh majority as for example in the larger towns such as Gia Nghia. Almost all children receive an elementary (primary) school education up to the age of 12 or 14. Subsequently children will follow their parents into the family labour market (mainly agricultural production).

The communes are not connected to the electricity grid. Diesel generators supply electricity to some homes and threshing machines.

Tube wells and dug wells are the main source of water for drinking and irrigation. Groundwater is not polluted and the quality is considered good.

There are no archaeological, historic and cultural assets in the commune. Further the planned Dong Nai No.3 and No.4 reservoir areas do not have any archaeological or historical cultural assets.

The annual average income per household is about 12 million Vietnam Dong (equivalent to about 850 US\$ at an exchange rate of 14,000 Dong to 1US\$). In summary, the communes are essentially subsistence farmers, and they are able to accumulate some annual surplus income.

(2) Dong Nai No.4 Reservoir Area

Communes do not inhabit the impoundment area of the planned Dong Nai No.4 reservoir. All of the land destined for this reservoir is government owned. Therefore no communes and no private individual will be affected by land taken to develop the Dong Nai No.4 reservoir.

The Dong Nai No.4 reservoir will occupy about 4.0 km² of land, derived from the Quang Khe and the Loc Bao communes. No individual from either of the communes will lose land or any other asset from impounding the Dong Nai No.4 reservoir.

To summarize then, all of the proposed impounded land of the Dong Nai No.4 scheme is government owned and owing to the dense forest and steep slope of the land there are no inhabitants, no farmland and no private assets within that area. Thus resettlement and compensation is not relevant to the development of Dong Nai No.4. In contrast the

forest within the commune boundaries lying adjacent to the proposed Dong Nai No.4 reservoir area is essentially Dipterocarp (hard wood trees), and is essentially virgin forest where it is not disturbed by human activities.

4.2.2 Affected Households' Perception and Concerns about Resettlement

A poll, structured on collecting information concerning the communes' opinions on resettlement, was conducted between February and August 1999. The opinion poll was undertaken in the Dinh Trang Thuong (Lam Dong Province) and Dak Plao/Dak Som communes (Dak Lak Province). These are the three communes that will be flooded by impounding the Dong Nai No.3 reservoir. The communes are fully aware of resettlement implications. The older generation experienced forced relocation many times before 1975, and recently the government resettled a number of households away from the area to provide a more stable and secure livelihood for the families. On the other hand, the impoundment of Dong Nai No.4 reservoir would not flood any homes or privately owned or managed land.

Prior to peace in the south central region, the Ma tribe was commonly moved from location to location to preserve military security in the wider region. The communes are not opposed to resettlement, as long as the families are compensated for the loss of fields and homes on a like-for-like basis. They desire good homes, adequate education and health facilities, good roads, reliable transport means, and sustainable agricultural capability in the resettlement areas. They also desire guarantees on obtaining new fields and subsistence (cash subsidy) whilst the new homes are built. They also require guarantees on subsidies to ensure sustenance during the period between preparing the new fields and the first harvest. They wish to safeguard against families becoming disintegrated due to the resettlement; that is the extended family (brothers, sisters, parents, grandparents) should relocate at the same time.

Any family extended member living above the FSL should also be offered resettlement, so as to ensure the integrated family unit. This is important to the Ma tribe, as well as to other minority tribes.

The community realizes from existing government relocation programmes, involving neighboring communes, that resettlement into new locations is often accompanied with prospects for better homes and better infrastructure provisions. The Resettlement Action Plan (RAP) makes allowances for all of these aspects and it complies with reasonable wishes and aspirations expressed by the affected households.

4.2.3 Potential Resettlement Areas

The location of the currently considered resettlement areas is shown in Figure 4.1. Initial thought is given to resettling the affected Dinh Trang Thuong commune households (89 households as of recorded in September 1999) at hamlet 9 location. Hamlet 9 is within the confines of the existing commune area. It lies alongside the Dong Nai River, and it is about 2 to 12 km upstream of the planned reservoir. About 4.5 km long road is required to connect the hamlet to the main National Road No.28. The soil conditions in the area are comparable to the type existing at the households' present location. As part of the National Road No.28 will be flooded, it should be possible to reconstruct the new road through the relocation area, then across the Dong Nai towards the

resettlement area of the Dak Plao/Dak Som commune.

Consideration is given to relocating the affected Dak Lak and Dak Som commune households to Buon Bang Ra (Yuk Dampout). The National Road No.28 passes alongside the southwestern portion of this proposed relocation area. Buon Bang Ra lies within the existing Dak Plao commune boundary, and it is about 6 km north from the existing hamlet location. A new road is required to connect the resettlement center to the National Road No.28.

Irrigation water would be from the Dong Nai in the dry season, with rain-fed supply in the wet season. The existing resettlement plan considers erecting 73 wells for the Dinh Trang Thuong commune and 168 wells for the Dak Plao commune.

The resettlement areas will be designed so as to connect homes to the national power grid. Other planned infrastructure comprise schools, health centers, markets, improved transport routes and so on.

The resettlement locations are selectively chosen on the basis of the following main criteria, namely: availability of land; land topography; accessibility to medical, educational, transport, water, electrical infrastructure and services; water resources; land cover and vegetation structure; and the suitability of soils for developing agricultural and supporting animal husbandry.

- the land shall be suitable for agricultural development (good soil quality, topography, irrigation, etc);
- the area shall be easily accessible with good transport links;
- availability of medical and educational services;
- availability of all year uninterrupted water supply;
- location as close as possible to the reservoir area, if possible,

Each of the two resettlement areas provides more than three times the minimum area of land required.

4.2.4 Qualitative Compensation Costs

A summary of the number of impacted households, comprising those that will lose homes and/or agricultural plots is shown in Table 4.3. Almost all of the impacted households (flooded households) and their agricultural fields lie below the 550 m elevation. Thus, the costs amounting from resettling and compensating households for lost assets do not increase significantly above this level.

All of the costs for resettlement and compensation arise from impounding the Dong Nai No.3 reservoir. The impoundment of the Dong Nai No.4 reservoir does not attract any resettlement or compensation costs. The Dong Nai No.4 reservoir will incorporate an area of about 4 km² of forest, which is not inhabited by communes and all of the land is State owned. The diversion tunnels, waterway tunnels and powerhouses would not require purchase of privately owned property.

Direct compensation is required to replace flooded homes, flooded agricultural lands, animal pastures, other owned assets, and commune infrastructure such as market places, schools, medical centers, transport connections and so on.

A summary of the main compensation measures and their schedule for implementation is shown in Table 4.8 and the measures are evaluated in detail within the main RAP report in the Appendix D. Only the points obtained so far are referenced in Subsection 4.2.5 below.

4.2.5 Requirement of Resettlement Action Plan (RAP)

General considerations for the RAP comprise setting up a Resettlement Action Committee (RAC), comprising relevant provincial authorities, responsible NGOs, socio-economists, health authorities, commune leaders and EVN.

The role of EVN is essentially to develop the plan and appropriate compensation measures in consultation with the relevant Provincial Authorities and to undertake to carry out the plan.

The RAC shall ensure the effective and timely design, the planning and implementation of the RAP, as well as monitoring its progress, failures and the scope and scale of the RAP.

The RAP would also be evaluated and monitored by an external "watchdog" Independent Monitoring Organization (IMO). These Institutional arrangements would ensure the effective and timely design, planning and implementation of the RAP and provision of the compensation measures.

A detailed RAP was prepared in consultation with the relevant Provincial Authorities and Government Ministries for assistance of EVN. As soon as the RAP is approved by the pertinent Provisional Authorities and Central Government, it would become a legally enforceable and binding document.

4.2.6 Archaeological, Historical and Cultural Assets

The human population within and immediately bordering the planned Dong Nai No.3 impoundment area are recent immigrants. Prior to 1975, most of the area was covered in thick forest, and it was mostly uninhabited apart from a few isolated households. Following the cessation of war hostilities in 1975, migrants from the central plateau region rapidly colonized the area. In the short period of time since 1975, the shifting population has not established or built assets that are considered to have significant cultural or historical value. This is a common observation within young and immature settlements. Consequently, as reported in Subsection 4.2.1, there are no archaeological, historical or cultural assets in the proposed impoundment areas of Dong Nai No.3 and No.4 reservoirs, or at the locations of the dams and powerhouses.

4.3 Natural Reservoir Environment

The natural resources of the reservoir environment comprise the physical (topographical, climate and water), the biological (vegetation and animal species, as well as protected nature reserves), and human settlement aspects.

4.3.1 Verbal Comments by the World Wide Fund for Nature (WWF)

This narrow and steeply sided gorge topography is a rare and rapidly diminishing feature within Vietnam, as it is elsewhere in the world owing to hydropower and reservoir resource developments. Thus, the Dong Nai No.4 reservoir inundated area is significant in international as well as national terms. The WWF has verbally commented that the Dong Nai No.4 reservoir inundated area is one of rare global outstanding natural beauty, with high visual and aesthetic appeal arising from the rugged topography, the surrounding dense vegetation cover, and the absence of significant human population. Also the WWF commented that the area is typical "type" habitat for many endangered species such as the tiger. The WWF also commented that this area contains the type of habitat that is common in the Cat Loc part of the Cat Tien National Park. A subspecies of the extremely endangered Java rhinoceros inhabits Cat Loc. By inference, the WWF believe that the forest bordering the planned Dong Nai No.4 reservoir area may have significance to this species. Although the inundation of Dong Nai No.4 reservoir will flood less than 6 km² of mainly bamboo forest, which is low quality forest, the main concerns of the WWF are the loss of the aesthetic visual appeal of the gorge. Additionally the WWF comments that the surrounding (Dipterocarp) forest is of high value to many species of animals, which owing to the isolated environment have not suffered previously from hunting or other exploitation. The WWF has also commented that the access roads would allow the human population easier access into the dense forest, which in turn could result in severe threats to the safety and survival of many species of animals and the depletion of the forests above the gorge.

4.3.2 Administrative Arrangements by MoARD

The Ministry of Agriculture and Rural Development (MoARD) has not assigned protection status to any forest growing within the municipal districts bordering the planned Dong Nai No.3 and No.4 reservoirs, or which will be impounded by the reservoirs. However, MoARD continuously reviews its policies and the necessity to allocate protection status to forests. In so doing, the Ministry acts on the advice and recommendations of the Provincial and District Forest Departments.

4.3.3 Water Quality and Sediment Loads

During July 1999, the Don Nai River water was sampled within the planned Dong Nai No.3 and No.4 reservoir areas to carry out the water quality analyses. The results of the water quality analyses, which were done for the samples taken during the rainy season, are shown in Table 4.9.

Overall, the results showed water of good to high quality, with high dissolved oxygen (generally better than 6.0 mg/l) and low nutrient concentration (total P, N-NO₂ and N-NO₃). Water of this quality is considered generally unpolluted, and all parameters are within the government standard tolerable limits. The suspended solid concentrations

were lower than expected for the rainy season, which is normally accompanied by high runoff entraining surface sediments. Dioxin and other forest defoliants were not detected in any water or soil sample.

4.3.4 Natural and Managed Vegetation

The Institute of Tropical Biology (HCMC) carried out a detailed survey of vegetation bordering the Dong Nai River within the planned impoundment areas. The areas and percentage of ground cover by natural vegetation (tree and shrub species) and cropped vegetation up to the full supply level for Dong Nai No.3 and up to the full supply level for Dong Nai No.4 are given in Table 4.10.

Bamboo forest covers about 90% of the proposed impoundment area of the Dong Nai No.3 reservoir. It is an indicator of the shifting (slash and burn) agriculture, which is very common feature of the land rising above the Dong Nai River at this location. The lower slope of the land here in comparison to the very steep slope of the Dong Nai No.4 location encourages logging and loggers. Some remnant Dipterocarp forest still exists along some parts of the Dong Nai River within the planned Dong Nai No. 3 reservoir, forming a gallery forest. However, its future is most uncertain as recent observations show that this remnant hardwood gallery is under current exploitation to provide wood for construction and firewood purposes, and land for agricultural production.

Throughout the planned Dong Nai No.3 reservoir area, large areas of recently felled trees, burnt ground and new cash crop plantations are clearly observed, especially below the 550 m elevation. Consequently, the Dong Nai No.3 natural vegetation is of low ecological value, and of limited importance to animals. In contrast, land adjoining the Dong Nai No.4 reservoir is covered by a dense vegetation of mostly undisturbed evergreen/semi-evergreen forest. This type of vegetation is a prime animal habitat for many animal species.

During construction and operations of the Dong Nai No.4 reservoir, mitigation measures to minimize land development, human settlement and hunting is one compulsory priority measure. Control of access roads is entirely within the powers of the project proponents. Roads should be sited as sensitively as possible to minimize the areas that could be impacted by hunters and shifting settlers. Access to roads should be controlled in some way, by manned road barriers, forest wardens, site security staff, the police, etc. After construction some roads could be decommissioned totally and their previous routes recovered with soil and planted with vegetation. It is certainly appropriate in the long term to pursue measures to protect equivalent habitat and the habitat remaining after inundation.

4.3.5 Mammals, Birds and Reptiles

The Institute of Tropical Biology surveyed the project district areas between May 1999 and August 1999. Endangered mammals and birds that have been recorded during the last 50 or so years in the Dong Nai No.3 and No.4 areas are shown in Tables 4.11 and 4.12. Owing to the intense human pressure around Dong Nai No.3 and the widespread destruction of forest habitat, this area is unlikely to have endangered animals. None were recorded during the surveys. Reptiles recorded in the project area comprise: toads, frogs, lizards, geckos, snakes, tortoises, and the varan. The forest bordering the planned

Dong Nai No.4 reservoir area is dense, with no access roads and there is insignificant human habitation in the forest. Consequently it was not possible to survey the animals of this area comprehensively.

The reservoir area of Dong Nai No.3 is highly impacted by human communes and consequently, its area inherently has limited importance to natural animal communities. The natural condition regarding Dong Nai No.4 is more problematical. Most of the area bordering the Dong Nai River is inaccessible to humans, owing to the dense forest and the steep slope. Mammals, birds, and reptiles inhabit this area. Some of these animals would be endangered species and require protection from hunters, loggers and settlers.

As briefed in Subsection 4.3.1, the WWF verbally commented that the Dong Nai No.4 area forest vegetation seems to be favorable habitat for elephants, tigers, other large and smaller cats, primates, otters and birds. Impounding the reservoir (area less than 6 km²) would have a small impact on the animals, as they are unlikely to live on the steep slope of the gorge, which has a less dense cover of vegetation. However, as verbally commented by WWF, access roads to the structure sites of the Dong Nai No.4 scheme, and later developments arising from the reservoir, could facilitate increasing human immigration into the area. This could result in a cascade of impacts arising from hunting and the destruction of the virgin forests. These are significant considerations for the Dong Nai No.4 area, which presently is largely unpopulated by human settlements. In constructing and operating the planned Dong Nai No.3 reservoir, the contractors and station operators must locate roads as sensitively as possible, to minimize possible threats arising from hunters and potential immigrants. Access to roads should be regulated and monitored by the wildlife protection authorities and/or the police. After construction is completed, roads that are no longer required should be bulldozed and the ground surface rehabilitated with a natural cover of soils and vegetation.

4.3.6 Aquatic Vegetation and Animals

The Institute of Tropical Biology surveyed the plankton, river bed animals and fish in the Dong Nai River project area during May to August 1999.

The survey reported about 70 species of fish, belonging mostly to the carp family. The species of fish are characteristic for this area and of running water. Fish species recorded in the Dong Nai River within the locations of the planned Dong Nai No.3 and No.4 reservoirs are listed in Table 4.13. Most of these fish species can live in large lakes and rivers.

4.4 Downstream Effects

The principal downstream hydrological effects comprise:

- a) changes in water flow between the dam and the power house outlet;
- b) water discharges from the powerhouse;
- c) river channel and river bed erosion;
- d) availability of water for abstraction to serve other needs; and
- e) changes in the availability of water required by sensitive ecosystems such as national parks.

4.4.1 Water Flow between Dam and Powerhouse

Immediately downstream of the dams, river discharge will be reduced to zero. The river bed, during the dry season, will in all probability remain dry as far down as the next lateral confluent. This is a fact that is relevant to any and all dam constructions. The loss of habitat immediately downside of the dam and up to the next confluence is of minor importance compared to the habitat flooded during impoundment. For aesthetic, rather than ecological reasons, it would be beneficial to restore the aquatic habitat immediately downside of the dam accepting that any such restoration would be of minor ecological importance to the localized area.

4.4.2 River Channel and River Bed Erosion

The riverbed of the Dong Nai is essentially composed of metamorphic sedimentary sandstone/silt stone (Jurassic age) rock overlying basaltic rock. This is hard rock that is highly resistant to mechanical abrasion. Currently, the bed is swept clean of sediment and there are no significant sediment deposits in the river. Consequently as the bedrock and river channels are highly resistant to erosion, the envisaged release of water from the power house (about 200 m³/sec) will not change the river morphology or increase suspended sediment concentrations. The "with project" 200 m³/sec value is of smaller magnitude than the wet season "without project" 250 m³/sec.

The Dong Nai River passes through considerable sand deposits at and downstream of the south western boundary of Cat Loc. Here, a thick blanket of sand covers the river bedrock and sand dunes and sand deposits occur on either side of the river. The gentle slope of the land in this region affects the current velocity allowing a net depositional regime for suspended solids. The sand material is particulate quartz originating upstream of the Dong Nai No.3. The construction of the dams will trap the suspended particulate sands. Therefore, as a consequence of the diminishing supply of suspended particulate sand in the river flow, there might be some erosion of the river bed sands and sandy banks at this location. This requires further detailed study to assess any future impact on changing morphology of the Dong Nai bordering the southwestern part of Cat Loc (which is part of the Cat Tien National Park) and the north and northeastern part of Nam Cat Tien (which also is a part of the Cat Tien National Park).

4.4.3 Water Availability for Abstraction Downstream of Dong Nai No.4 Power Station

The Irrigation and Land Use Departments of the Lam Dong and Dak Lak Provincial Authorities commented that the Dong Nai has no significance to agricultural production

in the buffer zones. The Lam Dong Provincial Authority stated that it is aware of only two locations where water is occasionally pumped from the river to irrigate paddies. As the river bed will never be dry after the dam constructions, there will always be a supply of water for these two paddies.

After commissioning of the Dong Nai No.3 and No.4 Combined HPP, there will be an enhanced flow of water in the Dong Nai during the dry season. This will be beneficial to irrigation and other water requiring needs during this season. On the other hand, there is a possibility that the peak operation of the Dong Nai No.4 power station will have an adverse effect on the downstream occasional water use mentioned above. This matter is discussed in Section 4.5 with reference to the development option of the Project.

There would be of course no impact on the availability of water for abstraction during the wet season.

The Field Investigations undertaken for the EIA did not reveal any significant abstraction of water from the Dong Nai River for any purposes related to irrigation, drinking and industrial manufacture between the proposed Dong Nai No.4 powerhouse and the existing Tri An reservoir. Paddy and vegetable fields are common in the area between the north of Nam Cat Tien and south of Cat Loc, and to the east of Nam Cat Tien towards the Tri An reservoir. Within this area there are about 6,200 hectares of paddy and vegetable fields. The fields are at a much higher elevation than the mean flow of water in the Dong Nai River. The sources of water for these fields, and the communes, are tributaries that drain into the Dong Nai River. For the reasons discussed above, the proposed Dong Nai No.3 and 4 developments would and could not impact these agricultural fields.

4.4.4 The Cat Tien National Park and Bau Sau Wetland

The Bau Sau wetland is in hydraulic connection with the Dong Nai River and for about 350 days of the year the flow of water is from the wetland to the river. However during the monsoon season peak flood period, the water flows from the Dong Nai River into the wetland via a stream. This reversal of flow lasts for about 10 days. During particularly severe monsoon flood periods, which occur about every 20 to 30 years, the back flow lasts for a longer period and the wetland is then covered by about 5 metres of water instead of the usual 2 metres. These severe floods might be detrimental to the wetland vegetation (and thus ecosystem), and construction of the dams would eliminate that nuisance. The relationship between the Bau Sau wetland and the Dong Nai River is considered in this Report. As the back flow of water during the normal monsoon season lasts for less than 15 days in the year, the Dong Nai River appears to have little significance to the maintenance of the wetland hydrology during "normal monsoon season" years.

4.4.5 The Cat Tien National Park Buffer Zone

Just downstream of the proposed Dong Nai No.4 dam, the Dong Nai River forms the northern most boundary of the Lam Dong Province buffer zone. The Dong Nai No. 4 reservoir will not flood any protected forest in the Lam Dong Province. The Dong Nai No.4 powerhouse will be a small building constructed on the edge of the Lam Dong buffer zone boundary with the Dong Nai River. The powerhouse and its associated

infrastructure (the switchyard, etc.) will be constructed on cleared and leveled ground and an access road is required. The headrace and penstock tunnels are bored channels below the ground surface. The powerhouse grounds and switchyard will occupy a small amount of land, generally less than a maximum of 30 hectares. As the powerhouse will occupy only a small area of land, at the junction of the Lam Dong Province buffer zone with the Dong Nai River, its overall environmental impacts would be of little environmental consequence. The construction of the powerhouse and its associated infrastructure does not conflict with the MoARD (World Bank funded) planned spirit of improving the buffer zone socio-economy by developing and constructing better roads, irrigation networks, education facilities, water supplies, electrical connection, etc., serving the communes in the buffer zone.

4.5 Alternative Options for Least Environmental Damage

4.5.1 General

All of the various design options carry the same potential environmental impacts. This means that all of the design options are equable with regard to environmental impact. None of the design options have significant environmental advantages over another option. All of the households at the Dong Nai No.3 reservoir area live below the 550 m elevation. Thus if the reservoir full supply level would be higher than 590 m, it would not require further resettlement costs. However, there might be a need to compensate a very small number of households for impounding fields above the 590 m elevation. The main environmental impact from impounding the Dong Nai No.3 reservoir is the loss of the relic hardwood forest remaining on the banks of the river. The communes are currently encroaching on this remaining forest for timber and they are clearing at the river bank for agricultural production. Consequently the forest has now little relevance for wildlife, and most of the former wildlife population has emigrated from the area. This remaining forest, which now has little importance to wildlife, will be destroyed by all of the alternatives.

The Dong Nai No.4 reservoir has extremely steep slopes, forming a gorge. The gorge has poor vegetation cover comprising bamboo and some hardwoods. All of the alternatives will result in the destruction of the bamboo and bamboo secondary forest growing on the steep gorge. All of the alternatives will result in a change of habitat from a fast running narrow river to a narrow lake. Selection of any one of the alternatives will require construction of access roads and dam infrastructure. It is primarily the construction of access roads through the adjacent thick virgin forests as alarmed by the WWF. The roads would potentially provide easier access into the virgin forest, which could, if unregulated, result in the exploitation of the forest and its animals. However it is relatively easy to mitigate and control immigration along the access roads, so that potential dangers to the existing forest and wildlife can be minimized. All of the alternatives will require the positioning of a powerhouse at the side of the Dong Nai River, at the border of the Lam Dong Buffer zone, and of course the construction of an access road. The countermeasures to mitigate the issues are discussed in the following Subsection 4.5.2. In addition, the hydrological environmental influence on Cat Tien National Park and the environmental influence on downstream water use as well as the necessity of the new development option in relation thereto are described in the succeeding Subsections 4.5.3 and 4.5.4, respectively.

4.5.2 Conceivable Environmental Issues

As discussed above, the environmental survey performed in the field investigation clarified that a total of 257 families need to be resettled to the new resettlement areas due to the creation of the Dong Nai No.3 reservoir. As a result of the public consultation, the people consent to be resided at the new resettlement areas proposed in the resettlement action plan prepared in the course of the environmental survey. Hence, no critical issue would take place in relation to the resettlement of the people living in the Dong Nai No.3 reservoir area, as long as the resettlement action plan is to be implemented by the concerned governmental organizations on a like-for-like basis.

On the other hand, the following issues might be caused by the implementation of the Dong Nai No.3 and No.4 Combined HPP:

- a) The access roads to the structures sites of the Dong Nai No.4 scheme would have significant impact on the virgin forest adjoining the Dong Nai 4 site, if not regulated and optimally planned. The forest vegetation seems to be favorite habitat for various animals and birds. This issue was pointed out by the WWF as described in the foregoing Section 4.3.
- b) There is a possibility that adverse effect on ecosystem of the Cat Tien National Park, might be caused by reduction of the wet season flow, as well as the downstream reach due to the daily peak power operation (7.5 hours on and 16.5 hours off) of the Dong Nai No.4 Power Plants during the dry season.
- c) Adverse effect on irrigation and potable water use in the downstream reach, which might be caused by daily peak power operation during the dry season.

With regard to item a), it is considered that the environmental adverse effects on the virgin jungle can be avoided to a minimum extent through implementing the following countermeasures:

- The temporary access roads provided for the purpose of construction are to be restored to the original sites after completion of the construction,
- It is strictly prohibited for anybody to pass the permanent access roads without official permission after the completion of construction, and even during the construction. To ensure this, check gates and guardsmen are provided along the permanent access roads to the structures of the Dong Nai No.4 scheme.

As to item c), the necessity of the countermeasures as well as the environment-free options are discussed in the following Subsections.

4.5.3 Environmental Influence on Bau Sau Wetland of Cat Tien National Park

(1) Hydrological Analysis

Figure 4.4 shows the monthly inflow into the Dong Nai No.3 reservoir and monthly outflow from the Dong Nai No.4. The annual reduction rate which represents a ratio of annual maximum outflow from the Dong Nai No.4 dam/powerhouse to annual maximum monthly inflow to Dong Nai No.3 dam is shown in Table 4.14. As seen in Figure 4.4 and Table 4.14, it is foreseen that the annual monthly maximum outflow of the Dong Nai No.4 reservoir would be reduced, especially in the drought years to a considerable extent, when flowing from the Dong Nai No.4 power station, because of the regulation effects of the Dong Nai No.3 and No.4 reservoirs.

Considering the natural inflow from the tributaries in a river section between the Dong Nai No.4 power station and Cat Tien National Park, on the other hand, it appears that the reduction of the wet season flow would not result in occurrence of the significant environmental issue to be caused by the Project. The proposed Dong Nai reservoir has an effective storage volume of 1,248 million m³, which corresponds to about 55% of the annual inflow volume. The smaller effect by the Dong Nai No.3 reservoir is seen from Figure 4.5 which shows the monthly hydrographs of the Dong Nai River at Cat Tien

National Park, revealing that the flood peak reduction is not so significant. Table 4.15 shows annual ratios of maximum monthly discharge of the Dong Nai at the Cat Tien National park under the condition with the Project to that under the without Project condition.

(2) Hydrological Phenomenon in the Cat Tien National Park

In the Bau Sau wetland of Cat Tien National Park (CTNP), daily water level observation was continued since July 1999 at three water level gauging stations (WLGS) where staff gauges were installed during the field investigation. Location of these three WLGS is shown in Figure 4.6. Besides, the leveling survey was conducted during the Third Field Investigation in order to relate the elevations of stage heights of staff gauges at those WLGS.

Figure 4.7 shows the mean daily water levels at those WLGS between June and November 1999. As seen in the Figure, the water level in Bau Sau wetland becomes lower than that at the Junction WLGS located near the confluence of the Dong Nai mainstream and Dak Lua stream five times during the observation period. However, it appears that the rapid drawdown of water level of the Bau Sau wetland that was observed in the middle of July 1999 is doubtful unless the inland water of Bau Sau wetland was drained to the Dong Nai mainstream through any artificial drainage structures. From the water level records, it was assessed that the large-scale reverse flow in the Dak Lua stream during the observation period (water of the Dak Lua stream flows in a direction from Bau Sau wetland to the Dong Nai mainstream through the Dak Lua stream for most periods of the year) happened over other four periods. After July 28, high stage heights of more than 134 m at the Bau Sau WLGS lasted between July 31 and August 10, 1999.

With regard to the large-scale flood which hit the Bau Sau wetland in July to August 1999, it was reported by local people in the field reconnaissance conducted in September 1999 that the plain land spreading along the Dak Lua stream was completely inundated to roof of existing houses therein. It is roughly estimated that a flood equivalent to 20-year return period occurred both in the Dong Nai mainstream and the Bau Sau wetland. In the event of large-scale flooding in the Bau Sau wetland, the water level of the Dong Nai mainstream also became very high so that water levels exceeded the highest stage heights of staff gauges at the Dak Lua and Junction water level gauging stations. Consequently, the water level observation could be continued only at the Bau Sau water level gauging station for the period from the end of July to the middle of August 1999.

Judging from the hydrological phenomenon observed during the field investigation, the reverse flow in the Dak Lua stream tends to take place when stage height at the Junction WLGS exceeds 131 m in a rising portion of flood hydrograph on the Dong Nai mainstream. Figure 4.7 also depicts mean daily water levels at the downstream Ta Lai SGS for the corresponding period. As a matter course, the flood hydrograph at Ta Lai SGS exhibits a synchronized pattern with that at SGS at the junction of Dak Lua stream and Dong Nai mainstream. On the basis of the water level records observed at both SGSs, it was found out that the stage height of 131m at SGS at the Junction almost corresponded to that of about 111.75 m at Ta Lai SGS.

The annual frequency of occurrence of the reverse flow in the Dal Lua stream was estimated based on the water level records at Ta Lai SGS between 1979 and 1995 by

counting the number of days when the water level exceeds 117.5m. As a result of the examination, the yearly average number of days of occurrence of the reverse flow was estimated at about 10 days. The result of the examination on occurrence of the reverse flow was endorsed by the information obtained from the local inhabitants. On the basis of the information collected during the field reconnaissance as well as the results of the examination mentioned above, the outstanding reverse flow would have taken place so far when a large-scale flood occurred over the whole Dong Nai River basin.

(3) Further study

As the result of the interviews to the local inhabitants conducted in the field survey, the people living in the nearby location of the Bau Sau wetland wish the floods to be mitigated. In this regard, the Dong Nai No.3 No.4 Combined HPP would contribute to the mitigation of flood in the downstream reach.

As far as the examination made so far shows, no artificial floods from the Dong Nai No.3 and No.4 Combined HPP would be required. Despite this initial conclusion, the water level gauging on the Dak Lua stream will continue beyond 2000. Based on the hydrological data, the hydrological analysis will be carried out to correlate them with the daily water levels at the downstream Ta Lai SGS in order to clarify the hydrological phenomenon of the Bau Sau wetland more consistently. This comparison and correlation of data will allow a more comprehensive and longer-period explanation of the hydrological phenomenon at the Bau Sau wetland.

4.5.4 Environmental Influence on Downstream Water Use and Recommended Development Option for the Dong Nai No.4

As mentioned above, the peak power operation of the Dong Nai No.4 power operation might lead to adverse effects on downstream ecosystems. However, as mentioned in Section 4.4.3, there is no significant water abstraction from the Dong Nai River between the Dong Nai No.4 powerhouse and the Tri An reservoir. This was confirmed from the reconnaissance surveys conducted during the first field investigation. Therefore, no large-scale countermeasures would need to be adopted to cope with the changes of water flow in the downstream environment. Nevertheless, it is more preferable for the Dong Nai No.4 power plants to be operated within a daily minimum plant factor of about 31 % with three units. With such a regime, it can be guaranteed that one unit of the Dong Nai power plants releases a tail water for continuous 15 hours daily, even in the driest period. Consequently, it is anticipated that such a mode of operation would further diminish and minimize any adverse effects on the downstream reach. Besides, the Dong Nai No.4 power station might need to be operated over 24 hours a day, especially in the dry season, in case that the downstream water requirement becomes significantly large and/or due to necessity of the constant water release from the environmental aspects in the future.

Thus, it is anticipated that the adverse effects on the downstream reach, if any, would be minimized through adopting the 3-units option for the Dong Nai No.4 scheme. Furthermore, the three units option can cope with the increase of water-intake from downstream reach of the Dong Nai mainstream, which might take place in the future through new developments of irrigation areas and residential areas along the riverine areas. Also from the aspects of power generation mode in the power system, the 3-units

option for the Dong Nai No.4 scheme is expected to enable the flexible power operation in compliance with the change of power demand and supply condition of the power system in the future.

Accordingly, this Feasibility Study strongly recommends developing the Dong Nai No.4 power station with the three-units from the environmental and socio-economic aspects, although it incurs the higher cost than that of the 2-unit option.

4.5.5 The Transmission Line's Route

The succeeding Section 7.4 discusses three alternative options for the transmission line route. In the Alternative 1, a new line consisting of two 220 kV lines would lead from the Dong Nai 4 to the Dong Nai 3 switchyard and link up with the 500 kV/200 kV line at Di Linh station some 48 km away. In the Alternative 2 and Alternative 3, 500 kV lines would link up with the Pleiku and Phu Lam station lines. Finally, the Alternative 3 was selected as the most favorable transmission route through the comparison study of these three alternatives as mentioned in the succeeding Section 7.4.

Most of the Alternative 3 transmission line route is aligned on the right bank with the least environmental sensitivity as compared with the left bank side. Accordingly, the transmission line to be constructed for the Dong Nai No.3 and No.4 Combined HPP have not any environment effect on the sensitive area.

4.5.6 Quarry Areas and Borrow Pits

The foregoing Chapter 3 proposes the locations of quarries and borrows pits. The right bank of the Dong Nai River, in the region of the proposed reservoirs and their dams, is the preferred location for the borrow pits and quarries owing to the easier access onto and from the National Highway Road No.28. The proposed quarry and borrow sites on the right bank were selected also on the basis of the least environmental sensitivity.

4.6 Fisheries Development for Utilization of Reservoirs

The Dong Nai No.4 reservoir would have a surface area of less than 6 km², which is too small to develop a meaningful aquaculture industry. Its very steep slope is also a disadvantage for gaining access to the surface water. The Dong Nai No.3 with a surface area of about 56 km² and the gentle slope of the land facilitates access to the surface water, is more suitable for developing fish culture. The fish species currently inhabiting the Dong Nai River (mostly species of carp and catfish) are commonly farmed in reservoirs throughout East Asia.

In the environmental survey in this Feasibility Study that was performed on a local contract basis, the potential for fish farming was comprehensively reviewed.

The development of sustainable and economical fish farming is dependent on good water quality and adequately trained fishermen. The potential of the Dong Nai No.3 reservoir to support fish farming would be entirely dependent on the water quality. Water quality could be good for two years after impounding the reservoir. It may be technically possible to develop fish farming on Dong Nai No.3, which has the easiest slope for access and roads for transporting the produce and the fish farming infrastructure. One major obstacle in setting up fish farms is the capital cost required to construct the cages, and maintain pregnant female fish and their young babies.

At present, communes living alongside the Dong Nai River opportunistically catch fish to supplement the diet. Fishing is not a commercially organized activity or enterprise. However, fishing is not an important activity for the communes, and this activity forms an insignificant role in the socio-economy. Fishing is undertaken on an opportunistic basis rather than as a set and well defined initiative.

As a result of interview to the local inhabitants, it is found that the communes are reluctant to embark on an economy based on fish farming, having heard of the recent problems experienced at the Tri An reservoir. However, it might attract a large commercial enterprise with capital to construct the fish cages and the fish-rearing infrastructure. A large commercial enterprise would be better adapted in absorbing financial losses arising out of catastrophic fish deaths. Nevertheless, the communes prefer to retain their existing agricultural life styles (e.g. mixed coffee, fruit and rice cultivation) and were not enthusiastic about the possibilities for farming fish in those reservoirs. Thus, the communes show little enthusiasm for embarking on an economy based on fish farming. The local communes are aware of the problems existing in fish farms at Tri An reservoir, which have experienced significant losses in stock from disease and poor water quality. The capital costs required to set up fish farms is certainly beyond the reach of all the households, who are essentially subsistence farmers having insignificant capital reserve or savings.

Appendix D contains a more detailed discussion on the issue raised above.

4.7 Environmental Management and Monitoring

The Resettlement Action Committee and the appointed independent external monitoring organization, as discussed in Subsection 4.2.5 above, would monitor and implement the Resettlement Action Plan's provisions and ensure that the affected persons receive the agreed levels of compensation and allowances.

A summary of potential environmental impacts, which might arise during the construction phases of the Project is shown in Table 4.16. A more detailed analysis of the potential environmental impacts is provided in Appendix D. As mentioned in Table 4.17, the main potential impacts concern water quality and the forest habitat on the left bank of the Dong Nai No.4 reservoir.

The Dong Nai River water quality could be impacted from many construction sources. The frequency of the water monitoring program and the list of measured parameters are given in Table 4.17. Two stations would be selected. One would be upstream of the Dong Nai No.3 dam site, and the other would be downstream of the Dong Nai No.4 powerhouse. The program should commence well in advance of the construction phase and continue during the operational phase. All data would and should be stored for reference and benchmark purposes. The results would indicate whether excessive amounts of sediment and sewage from the construction sites and from the camps are polluting the River.

Sections 4.3 above reported an intrinsic sensitivity of the forest bordering the left bank of the Dong Nai River at the location of the proposed Dong Nai No.4 reservoir. In view of the national and perhaps international significance of this area's resources, monitoring should continue before and during the period of construction.

Appendix D contains a more substantial list of possible environmental impacts and mitigation measures arising out of the construction, commissioning and operations of the Project. The need for other measures might develop from and during the detailed design stage. Any such measures recognized during the detailed design would need to be integrated, perhaps with costs, into the final monitoring program. All aspects of environmental monitoring would be undertaken through the EVN environmental departments, which would tender some studies, such as water quality monitoring and ecological surveys, to local contractors. The majority of the monitoring requirements would be carried out by EVN without recourse to assistance from outside contractors.

4.8 Costs of Land Compensation and Environmental Mitigation

The cost for resettlement compensation and land acquisition was estimated by PECC 2 under the subcontract with the JICA Study Team during the period of May to October 1999. Major items surveyed including relocation of the National Highway Road No.28 of 50km comprise farm products, land, buildings, preparation of resettlement areas and other costs such as Resettlement Committee costs and Monitoring the RAP which may be categorized as "environmental mitigation cost". Summary of the cost estimate is shown below. All the details are provided in Table D15 of Appendix D.

Item	Amount (US\$ Million)
(1) Land Registration	0.05
(2) Compensation	
• Cops, trees and shrubs	1.62
• Land	0.48
• Buildings	6.00
(3) Preparation of resettlement areas	1.90
(4) Other costs	0.62
Total	10.67

Table 4.1 Communes with Boundaries Occupying the Planned Dong Nai No.3 and No.4 Reservoir Areas

	Province	District	Commune Name
1	Lam Dong	Bao Lam	Loc Lam (penetrating into the reservoir 3 area)
2	Lam Dong	Bao Lam	Loc Phu (penetrating into the reservoir 3 area)
3	Lam Dong	Bao Lam	Loc Bao (penetrating into the reservoir 4 area)
4	Lam Dong	Lam Ha	Phuc Tho (penetrating into the reservoir 3 area)
5	Lam Dong	Di Ling	Dinh Trang Thuong (penetrating into the reservoir 3 area)
6	Dak Lak	Dak Nong	Dak Plao (penetrating into the reservoir 3 area)
7	Dak Lak	Dak Nong	Dak Som (penetrating into the reservoir 3 area)
8	Dak Lak	Dak Nong	Quang Khe (penetrating into the reservoir 3 and 4 area)

Source : RAP prepared under contract in the Field Investigation Stages June – September 1999

Table 4.2 Summary of the Number of Households and Other Assets Impacted by Impounding the Dong Nai No. 3 Reservoir Area with a FSL of 590 m

Parameter	Unit	Commune					Total
		Quang Khe	Dak Plao Dak Som	Phuc Tho	Dinh Tr Thuong	Loc Phu Loc Lam	
Households Loosing Homes and Fields							
Relocated Households	No.	0	168	0	89	0	257
Relocated Persons	No.	0	1065	0	318	0	1383
• Kinh Ethnic Group Households	No.	0	12	0	5	0	17
• Kinh Ethnic Group Persons	No.	0	46	0	12	0	58
• Ma Ethnic Group Households	No.	0	124	0	84	0	208
• Ma Ethnic Group Persons	No.	0	853	0	306	0	1159
• Tay Ethnic Group Households	No.	0	15	0	0	0	15
• Tay Ethnic Group Persons	No.	0	72	0	0	0	72
• H'Mong Ethnic Group Households	No.	0	13	0	0	0	13
• H'Mong Ethnic Group Persons	No.	0	73	0	0	0	73
• Other Recorded Households	No.	0	4	0	0	0	4
• Other Recorded Persons	No.	0	21	0	0	0	21
Households Loosing Fields Only							
• Total Households			98		29		127
• Total Persons			651		112		763
Affected Totals							
• Total of all Households Affected							384
• Total of all Persons Affected							2146
Impacted Homes (Dwellings)							
• Type 4 Homes (Areas)	ha	0	0.2284	0	0.0148	0	0.2432
• Thatched Homes / Shelters	ha	0	0.2580	0	0	0	0.2580
• Bamboo Homes / Shelters	ha	0	0.3675	0	0.2106	0	0.5781
Major Infrastructure							
• School / health center / public hall	ha	0	0.1490				0.1490
• National Road 28	km	0	5	0	7	0	12
• Unmade Road	km	0	4	0	0	0	4
• Culvert (drainage)	No.	0	2	0	2	0	4
Minor Infrastructure							
• Water Wells	No.	0	11		4	0	15
• Cemeteries	No.	0	633	0	446	0	1079
Private Land Use Area							
• Paddy	ha	0	81.27	0	37.45	0	118.71
• Shifting Cropped Land	ha		25.35	0	10.20	0	35.54
• Perennial Cropped Land	ha	0	231.55	0	67.553	0	299.10
• Residential Land	ha	0	9.50	0	4.20	0	13.70
Total Private Land Use Area	ha		347.67	0	119.43	0	467.06
Government Land							
• Special Purpose Land	ha	0	4.0	0	0	0	4.00
• Owned Forestry Land	ha	14.16	1867.24	117.8	777.2	1116.3	3892.70
• Other Land	ha	3.54	465	29.5	210.1	279.1	987.24
Total Government Land Area	ha	17.7	2336.24	147.3	987.3	1395.4	4883.94
Total Land Area	ha	17.70	2683.91	147.3	1106.7	1395.4	5351

* Footnote : Government owned land is not subject to monetary or any other means of compensation
Source : RAP prepared under contract in the Field Investigation Stages June – September 1999

Table 4.3 Summary of the Number of Households Impacted by Impounding the Dong Nai No.3 Reservoir Area with a FSL of 590 m

Parameter	Dong Nai 3 Reservoir and Dam Construction (at FSL of 590 m)
Flooded Area (ha)	5,351
• Flooded Households (number to be relocated)	257
• Non flooded households losing land (number)	127
(Total Number of Impacted Households)	(384)
• Head count (numbers to be relocated)	1,383
• Head count non-flooded households losing land	763
(Total Impacted Head Count)	(2,146)
Composition of Flooded Ethnic Households	
i) Ma Minority Ethnic Group	
• Ma (number flooded households)	208
• Ma (head count in flooded households)	1,159
ii) Kinh Majority Ethnic Group	
• Kinh (number flooded households)	17
• Kinh (head count in flooded households)	58
iii) Miscellaneous Ethnic Groups	
• Other (number flooded households)	32
• Other (head count in flooded households)	166

Source : RAP prepared under contract in the Field Investigation Stages June – September 1999

Table 4.4 Area of Land Flooded by Impounding Dong Nai No.3 Reservoir with a FSL of 590 m

Type of Land Impounded	Unit	Commune					Total
		Quang Khe	Dak Plao and Dak Som	Phuc Tho	Dinh Trang Thuong	Loc Phu and Loc Lam	
Household Land							
• Paddy Fields	ha	-	81.27		37.45		118.71
• Fruit and vegetable crops	ha	-	25.35		10.2		35.55
• Rice – perennial crops	ha	-	231.55		76.553		299.1
• Residential land	ha	-	9.5		4.2		13.7
Total Household Land	ha		347.67		119.43		467.06
*Government Owned Land							
• Special purpose land	ha	-	4.0		-		4.0
• Forestry land	ha	14.16	1867.24	117.8	777.2	1116.3	3892.7
• Other land	ha	3.54	465	29.5	210.1	279.1	987.24
Total Government Land	ha	17.70	2336.24	147.3	987.3		4883.94
Total Land Area	ha	17.7	2683.9	147.3	1106.7	1395.4	5351

* Footnote : Government owned land is not subject to monetary or any other means of compensation

Source : RAP prepared under contract in the Field Investigation Stages June – September 1999